

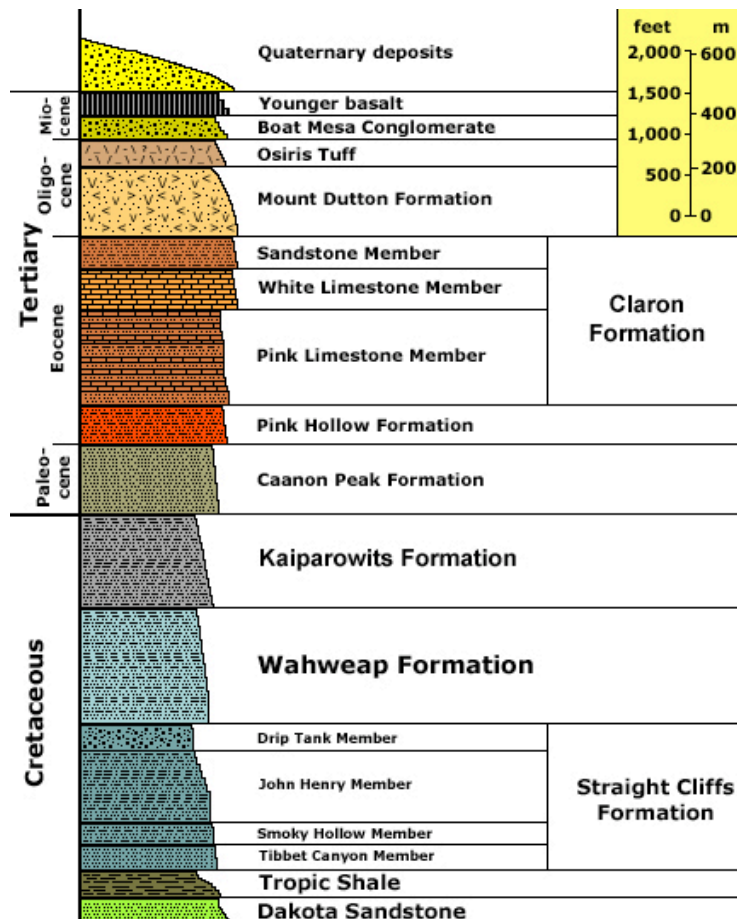
Erth 16 Lecture 6: Features in Zion, Bryce, Arches

Origin of selected geologic features

- Zion National Park
 - stratigraphy of Zion and paleogeography. Briefly review the lithologies found in the park, then discuss the significance of the transition from tropical setting in the Triassic to low latitude deserts in the Jurassic as Pangea broke apart and NA drifted northward.
 - Carmel Fm: Middle Jurassic marine limestone (White cliffs)
 - Temple Cap Fm: Middle Jurassic, fluvial red muds (White cliffs)
 - Navajo Sandstone: Lower to Middle Jurassic (190-140 Ma) (White cliffs)
 - thick quartz sandstone (dunes) that dominates cliffs in Zion
 - origin of frosted quartz grains from west (coastal dunes)
 - lower portion of Navajo is reddish, upper part white
 - reddish color is staining from overlying iron-rich Temple Cap Fm
 - why might water percolating downward stop at bottom of Navajo?
 - Kayenta Sandstone: Lower Jurassic, red, slope forming, fluvial sandstone and shale with dinosaur tracks. (Vermillion cliffs)
 - Moenave Fm: Jurassic, reddish fluvial sandstone, with lower portion containing lake sediments and fossil fish (Vermillion)
 - Chinle Fm (basal Shinarump conglomerate): Triassic, bright red (mainly) shales (tropical fluvial environment) (Vermillion cliffs)
 - petrified logs (see Petrified Forest National Park)
 - amphibian, reptile
 - U-enriched petrified bone and wood (U boom of 1950s)
 - Moenkopi Fm: Triassic slope former of fluvial sandstones, shales, with minor gypsum (coastal plain). Chocolate cliffs.
 - Kaibab Limestone: Upper Permian, found only in Hurricane cliffs above the Kolob Canyon visitor center
 - Slot canyon (Narrows) and importance of vertical (N\S) fractures
 - Markagunt plateau (which includes Zion) uplifted to about 10,000'
 - associated folding and faulting
 - recent earthquakes include 5.8 (Sept 2, 1992) that resulted in landslide (<http://www.seis.utah.edu/edservices/EES/SWUTAHCLOCK.shtml>)
 - Hurricane fault and ~N\S fractures
 - streams follow these fractures, rapid downcutting of Virgin river results in formation of narrow slot canyons
 - Narrows 1000' high and 20' wide

- during flash flood events, canyons can fill to very high levels (e.g. wood wedged in cracks 40' above base) and can transport large boulders
 - "ribbons of sandpaper" - high erosive power of Virgin river
 - *hanging valleys* - tributaries cannot downcut as quickly
 - why does the stream valley widen downstream of Narrows?
 - where river cuts down only in Navajo sandstone, canyon remains narrow
 - where stream cuts into underlying Kayenta mudstones and sandstones, the canyon widens
 - mechanically weak Kayenta removed by lateral wanderings of river and by the many springs at the Navajo/Kayenta contact
 - undercuts Navajo, leading to catastrophic collapse of the Navajo (maintaining vertical walls and in some cases forming inset arches)
- Arches National Park - origin of arches, fins
 - highest density of arches anywhere in the world. What accounts for this high density? how do the arches form?
 - stratigraphy of Arches NP
 - going to focus on just two units (Entrada sandstone, Paradox Fm)
 - Entrada - middle Jurassic (younger than Navajo sandstone of Zion)
 - streams and desert dunes
 - Moab Member - typically top of arches
 - Slick Rock Member - body/top of arches
 - Dewey Bridge - wavy contorted bedding
 - Paradox Fm (Pennsylvanian, ~300 Ma)
 - origin of *evaporites* and salt in isolated basin
 - uneven basin topography from faulting, more salt deposited in basins and less over highs
 - plastic deformation of salt
 - lighter (2.2 g/cc) than sandstone (2.5 g/cc)
 - with sufficient temperature (~100C) and burial, salt flows plastically forming *salt domes*
 - salt domes fracture overlying rocks
 - later, groundwater dissolves some of salt (particularly in anticlines) leaving unsupported blocks which are then downdropped
 - if weathering is most rapid along vertical fractures, produce fins (narrowed by mass wasting, exfoliation)
 - Dewey Bridge is less resistant to erosion, increased weathering undercuts upper portion of fin; exfoliation can lead to windows. Wind blasting (highest velocity <20 cm above ground) can also contribute
 - weathering on vertical cross joints >> pinnacles or balanced rocks
 - calcite cementation not uniform in Entrada, so weathering is faster in less well cemented or highly fractured areas
- Bryce Canyon National Park - differential erosion, hoodoos
 - general

- series of horseshoe-shaped amphitheaters carved into the eastern edge of the (narrow) Paunsaugunt Plateau - so not really a canyon at all
- higher elevation (highest point ~9000'; 11,000' in Cedar Breaks NM)
- Gray and Pink cliffs (Cretaceous and early Tertiary sediments exposed)
 - Cretaceous sediments (shales and sandstones) record the last shallow inland sea, followed by fluvial deposits
 - Claron formation (60-40 Ma)
 - system of lakes stretching from Wyoming to Colorado and Utah
 - carbonates are lake sediments. how do we know? although fossils rare there are aquatic snails, turtles, reptiles and overlying and underlying sediments are terrestrial



- origin of colorful topography in Bryce Canyon
 - rim is formed by resistant dolomite unit (carbonate with Mg as well as Ca); amount of calcite in sediments makes them variably resistant to weathering (less carbonate means more prone to weathering in this climate)

- fracturing and differential weathering produces most of the features in the park
 - hoodoos - harder caprocks protect the underlying sediment from erosion
 - resistant beds form layers that stand out from cliffs
 - how fast is the canyon eroding?
 - determine from tiptoe trees (vegetation is rare since erosion is faster than soil formation to support plants, but there are a few trees). Tiptoe trees grew on the plateau rim and are now perched with roots exposed. Tree rings give age - indicate a retreat rate of 9-48" per century.
 - Paunsaugunt Plateau is only 6 miles wide so will be breached in about 2 m.y. at this rate
 - origin of various colors
 - oxidation is responsible for most color variations
 - reds, pinks, browns from Fe oxidation
 - yellow by limonite (Fe hydroxide) - hydration
 - purples from MnO₂
 - white colors are relatively pure carbonate
- Canyonlands National Park - entrenched meanders
 - general

Useful links

- http://en.wikipedia.org/wiki/Geology_of_the_Zion_and_Kolob_canyons_area
 - General description of the sedimentary units, geomorphology and geologic history of Zion