Geol 104 Geology of National Parks
Lecture 10: Geologic History of Grand Canyon

I. Introduction:

A. Recall: rocks exposed in the Grand Canyon span ~1.5 Ga (Proterozoic through Permian)

B. Now we want to use stratigraphy to develop history of Western NA continent

II. Proterozoic (late Precambrian) Basement

A. Supercontinents of Late Proterozoic NA

1. Nuna = accretion of many small protocontinents 2.5 to 1.6 Ga

a. Yavapai orogen formed basement rocks of southern portion of Nuna (today they extend beneath the American southewest to the mid-continent.

b. Including Vishnu Schist and Zoroaster Granite

- These formed very deep beneath the Mazatzal mountain chain formed during Yavapai orogenic event

2. During late Precambrian, a second supercontinent formed = Rodinia.

a. By accretion to eastern margin of Nuna

b. ~ 1 Ga Greenville orogeny

3. At some point, Vishnu and Zoroaster were brought to surface

a. Implies uplift and erosion of ~15 km of overburden

b. Grand Canyon Super Group

i. Sandy and muddy sediment from erosion of overburden

ii. Were deposited in marine environments lying offshore of Rodinia

4. Peneplain

a. More erosion followed

b. Reduced Proterozoic Rocks to flat surface covering a vast region (West Coast of Rodinia) = Peneplain

B. Rifting of Rodinia in late Proterozoic (~750 Ma)

1. Rifting of Rodinia Forms Laurentia (will be NA after Pangaea forms & breaks up)

2. Normal Faulting of Basement rocks

- Preserves down-dropped portions of the Super Group

3. Erosion - another peneplain = the GREAT unconformity! Up to ~1.5 Ga gap!

III. Rising sea level During Paleozoic

- Geologists recognize sea level changes from looking at the types of rocks deposited.

A. Why does sea level change?

1. Continents rise and fall
   a. Due to tectonic activity, continents move up and down
   b. Sea level rises when continents drop, and falls when continents rise
2. Volume of ocean basins change:
   a. Mid-ocean ridges are volcanic mountain chains
   b. As ridges grow, the occupy more volume
      i. Reducing the volume of the ocean basin
      ii. Causing sea level will rise on the continents
3. Volume of the oceans can change
   a. Warm the Earth: oceans expand thermally, and glacier melt - sea level rises
   b. Cool the Earth: oceans contract thermally, glaciers grow - sea level drops

B. Cambrian - Sea level rises (550 Ma)

1. Coastline move onto the Basement rocks
2. Tapeats Sandstone
   a. Basal Conglomerate = rocky coast as ocean invades
   b. Sand Dunes overly conglomerate = Beaches
3. Bright Angel Shale
   a. Fossil rich muds (Fossils of marine organisms)
   b. Deposition in deeper, offshore marine environment
4. Muav Limestone
   a. Fossils of planktonic organisms
   b. Deposition in offshore, warm water away from coastline
5. Sea level continues to rise and this sequence advances eastward
   - Shales over sands indicates rising sea level (transgressive sequence)

C. Another unconformity (Disconformity)

1. Period of erosion or non-deposition

- No rocks preserved from Ordovician through beginning of Devonian (~80 Ma)

2. Temple Butte Limestone – Oceans transgress again (Devonian ~400 Ma)

a. Shallow marine deposits directly onto Muav L.S.

b. Followed by 'short' period of erosion (small Disconformity)

D. Redwall Limestone (Mississippian ~ 330 Ma)

1. Fossils indicate deposition in a shallow tropical sea

2. Followed by period of uplift and erosion (another Disconformity)

E. Seas Regress (Pennsylvanian into Permian)

1. Supai Group (~300 Ma - Pennsylvanian)

a. Silty, muddy, sandy sediments with cross-bedding structures (indicates currents)

b. Fossils of terrestrial organisms (amphibians and plants)

c. So, this is a non-marine environment – likely a swampy, coastal delta

2. Hermit Shale (Permian) – similar rocks (and environment) to Supai

3. Coconino Sandstone

a. Well sorted, cross-bedded sands, frosted sand grains = wind blown

b. Coastal Dunes – very large

F. Permian seas transgress

1. Toroweap Formation

a. Sands, limestones and gypsum deposits

b. Indicates fluctuation between marine and non-marine setting in arid environment

2. Kaibab Limestone – Warm tropical seas again

G. Mesozoic

1. Continent rises and deposition ceases (mostly)
2. Laramide orogeny
   a. Uplifts the Rockies and forms the Colorado Plateau (previous lecture)
   b. Diverts Co. River and forms the canyon
3. Young lava flows – Quaternary ~ 1 Ma