Erth 16 Lecture 1: Grand Canyon - a geologic view of time

Introduction

Goals

- How is scenery of national parks formed?
- Appreciation of natural processes at work. Why do earthquakes and volcanoes occur where they do? Why are there mountains on east and west coasts of the US? Why are the mountains on the west coast higher?
- Learn how to interpret geologic history from rock record. Deductive reasoning.
- Enjoy and help preserve natural parks

Logistics

Colorado Plateau

- We're going to begin by looking at several parks in the western US - a region called the Colorado Plateau.
- 130,000 square mile region at surrounding the 4 corners (UT,AZ,NM,CO)
- Why should these be lumped together?
    - flat lying sedimentary rocks (up to 6 km thick)
    - uplifted by 5-13,000', dissected by rivers
    - erosion in arid climate of desert SW responsible for many features

Grand Canyon

- facts about the Grand Canyon
    - John Wesley Powell – Surveyed the canyon in1869. A Civil war vet.
    - First set aside as a forest reserve in 1893 (national preserve 1906; national park in 1919)
    - Spans 1,217,403.32 acres / 1,904 square miles
    - max width (rim to rim) - 18 miles
    - deepest point = 1 mile below rim (7000-8000')

- what are the rocks in the canyon?
    - what is the dominant feature?
        - layering - indication of sedimentary rocks
        - particles (from weathering, erosion) deposited from medium (air, water, ice) at surface, characteristic layering = bedding = stratification
        - two types of sedimentary rocks
            - clastic
            - chemical

Principles for interpreting sedimentary rock history

- *original horizontality* = all sediments exhibit stratification as a result of being deposited at surface. These sedimentary layers are originally horizontal, reflecting the influence of gravity at the time of deposition.

- *superposition* = in a sequence of sedimentary rocks (if not overturned), younger beds overlie older beds

- These two laws allow us to reconstruct the relative ages of events in the Grand Canyon. If we want to put this into a broader context then we need to be able to correlate over broader area (say over the entire Colorado Plateau)
    - lithological correlation - not very good
    - temporal markers in rock record (e.g. ash beds)
    - fossils and faunal succession
        - assemblages of plants and animals follow or succeed each other in time in a predictable manner
        - analogy with music
            - LPs vs CDs
            - Rolling Stones vs Sex Pistols (1978-1979)

Geologic time

- faunal succession and principles above used to construct geologic time scale
- need absolute age information (radiometric techniques) talk about this later
- events in earth history
    - 4.6 Ga – Age of earth
    - 4.0 Ga – oceans and atmosphere forms
    - ~4 Ga – oldest rocks on earth
    - 3.5 Ga – oldest fossils on earth (bacteria)
    - 1.8 Ga – oxygenated atmosphere
    - 543 million – explosion of multicellular life
    - 206-65 million - age of dinosaurs
    - 2 million years – the beginning of the most recent glacial cycle
    - 130,000 years – earliest modern humans
    - 10,000 years – end of last glaciation
- tough to get your mind around the vast expanse of time, calendar analogy
    - Get an ocean and atmosphere in mid february
    - The first rocks appear early march
    - The explosion of life occurs around Thanksgiving
    - All of recorded human history – Dec 31 11:58:52 p.m. (last 70 sec)

Geologic time scale

- 4 eons
    - Hadean (4.6-3.8 Ga) - Greek for "beneath the Earth"
    - Archean (2.5-3.8 Ga)- Greek for "ancient"
        - reducing atmosphere of methane and ammonia, oxygen 1% of present value
        - 3.5 Ga oldest bacteria fossils
    - Proterozoic (2.5-0.545) - "earlier life"
        - 1.8 Ga oxygen levels reached 15% of present value and rising
        - evidence for higher oxygen levels (Fe oxides in paleosols, red beds)

        - Vendian (650-540 Ma) soft bodied organisms

    - Phanerozoic (545 Ma - 0) - "visible life" divided into three eras
        - Paleozoic "early animals" 545-245
            - bracketed by two of the most important events in animal life
            - Cambrian explosion - within few m.y. almost all living phyla developed
            - Permian extinction - wiped out 90% of all marine species
        - Mesozoic "middle animals" 245-65
            - Cretaceous-Tertiary extinction
        - Cenozoic
            - sometimes called age of mammals (but a bit of a misnomer)
            - flowering plants, insects, birds, teleost fish
    - ERAS divided into 12 PERIODS – Cambrian, Ordovician, Silurian, Devonian (age of fishes), Mississippian, Pennsylvanian (CARBONIFEROUS), Permian, Triassic, Jurassic, Cretaceous, Tertiary, Quaternary
    - Tertiary and Quaternary Divided into 7 EPOCHS – Paleocene (first large mammals and primitive primates), Eocene (primative whales), Oligocene, Miocene, Pliocene (first hominids), Pleistocene (last ice age) , Holocene (11,000 to today)
    - *Camels Often Sit Down Carefully. Perhaps Their Joints Creak. Possibly Early Oiling Might Prevent Permanent Rheumatism.*

Unconformities

- In some places in the G.C. you can take a single step and decend through 200,000 years of history recorded in rocks. In other places you can't find 1 billion years of history. THE ROCK RECORD IS INCOMPLETE
- *angular unconformity* – in the Grand Canyon mountain building, the Grand Canyon Orogeny, tilted the initially horizontal layers, like a set of dominoes. The mountains erode leaving a flat surface on top of the tilted layers. When the ocean comes back in, it deposits more horizontal bed on top. This process is like creating
- *nonconformity* – the first major unconformity in the Grand Canyon is a nonconformity created by the Mazatzal Mountain building event. This uprooted deeper crystalline rocks – igneous and metamorphic – that do not have layering. Erosion of these rocks occurs, and then sedimentary, layered rocks, are deposited on top.
- *Disconformity* – This occurs between the redwall and temple butte limestones. It's very difficult to see between 2 sets of flat lying sedimentary rocks! **How do we know it's there?**