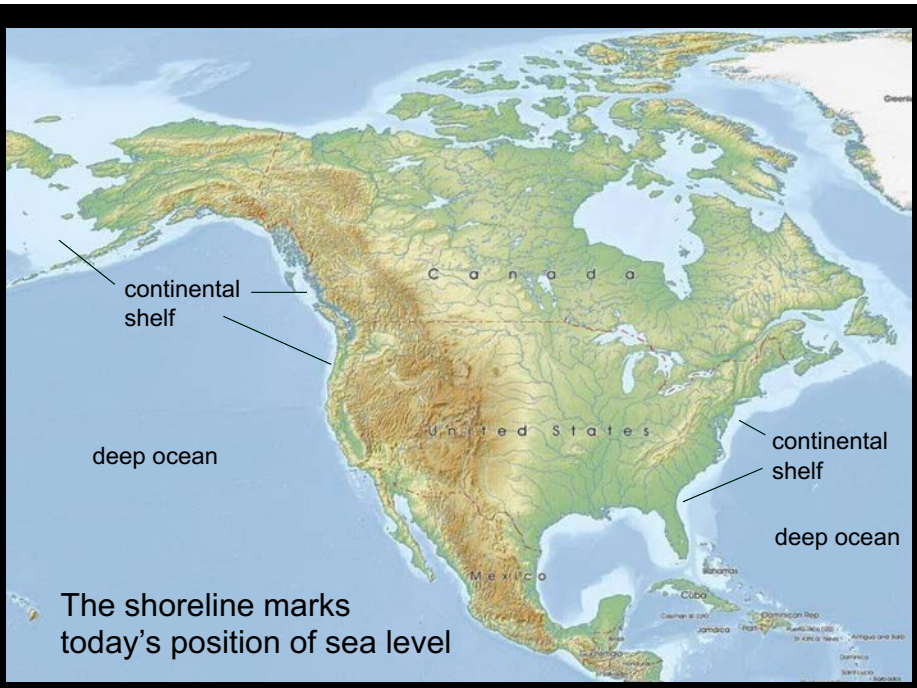
How do laterally extensive layers of rock form?
The seas come in, the seas go out . . .

Notes/images 1B, (Textbook: Chapter 3 (p. 40-48), Chapter 1 (p. 20-22)

1



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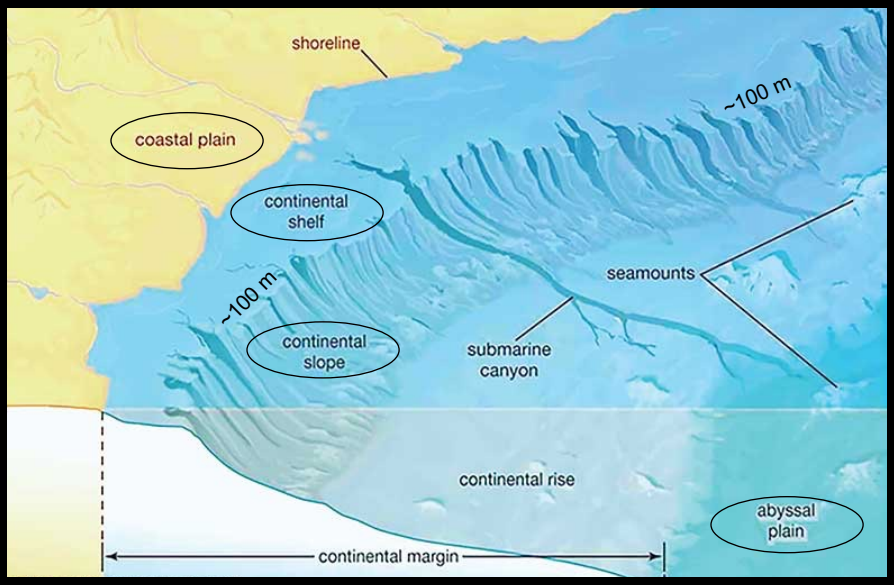
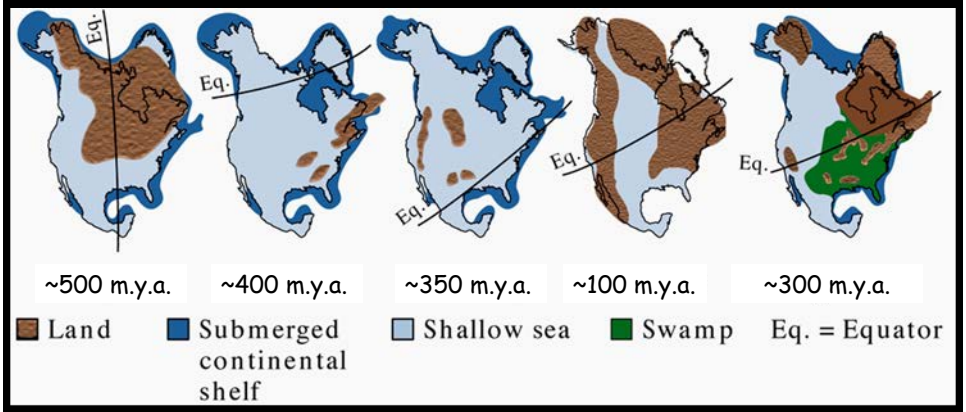


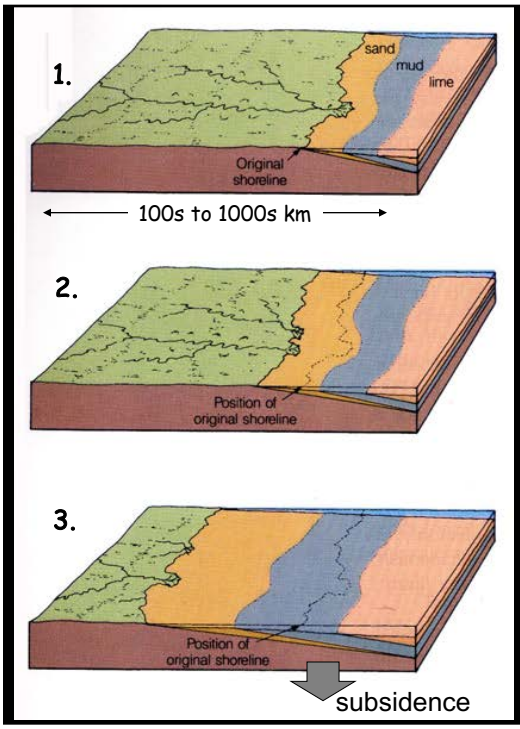
3

Paleogeographic maps of North America through time showing the distribution of shallow seas and land areas across the continent as sea level rose and fell.



The rise and fall of sea level is accompanied by the migration of the shoreline inland during sea level rise (submerging continents) and seaward during sea level fall (exposing continents).

4



How do laterally extensive layers of rock form?

Transgression - the landward movement of the shoreline due to rising sea level

Depositional environments migrate inland along with the transgressing shoreline, forming broad, extensive layers

Subsidence – sagging of the crust to accommodate the load of sediment above

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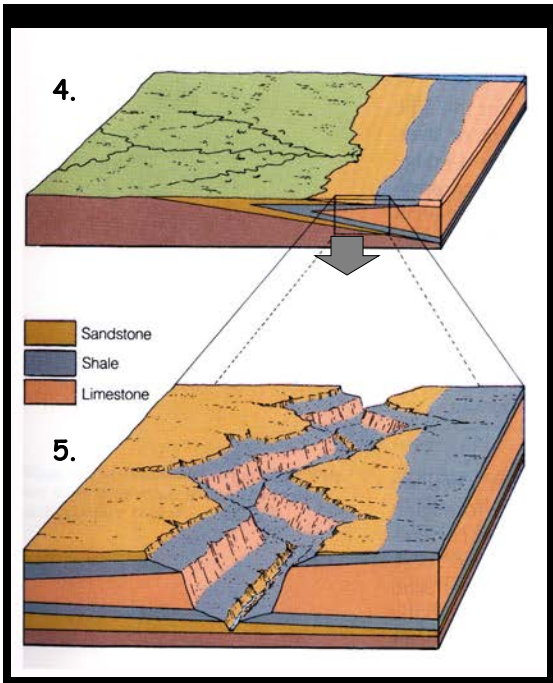

Regression - the seaward movement of the shoreline due to falling sea level
- depositional environments migrate seaward, forming layers of sediment

Time passes - sediments are buried and solidified to become layered beds of rock

Much later, **'uplift and erosion'** of these beds produces today's landscape

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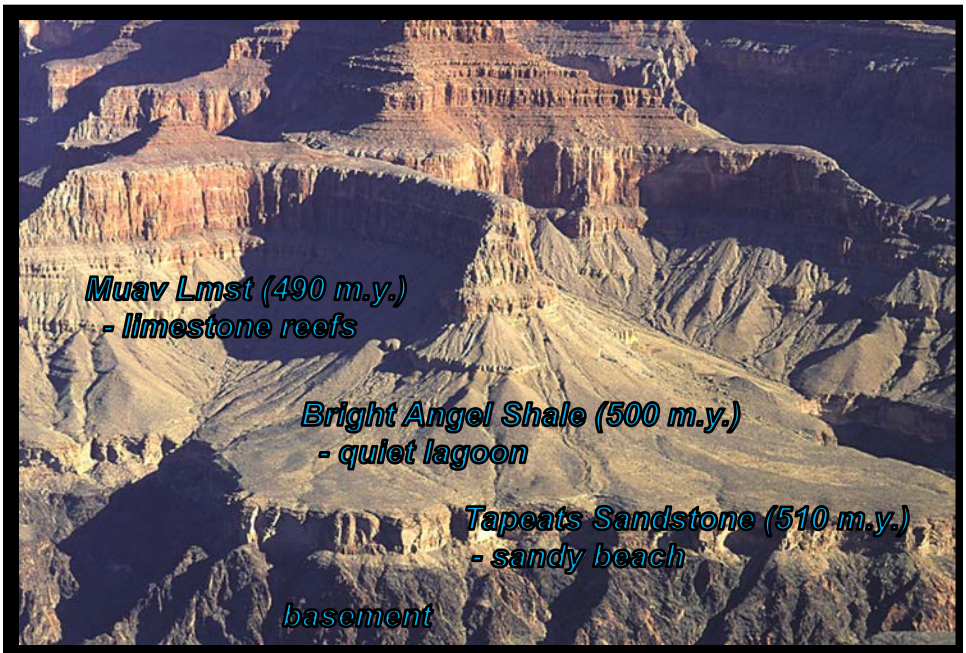

Tapeats-Bright Angel-Muav transgressive sequence

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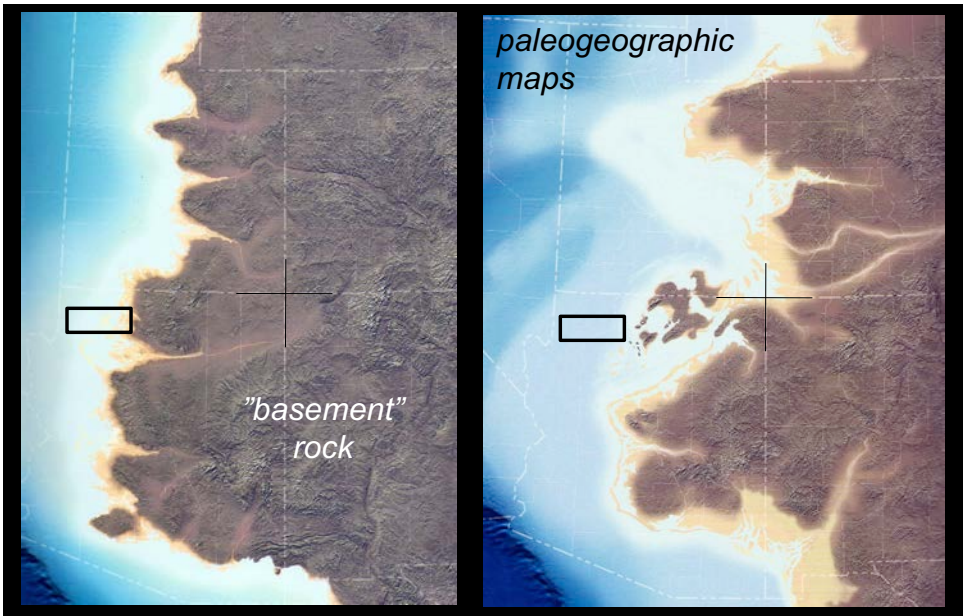

Tapeats 'beach' (~510 my) — *transgression* → **Bright Angel 'lagoon'** (~500 my)

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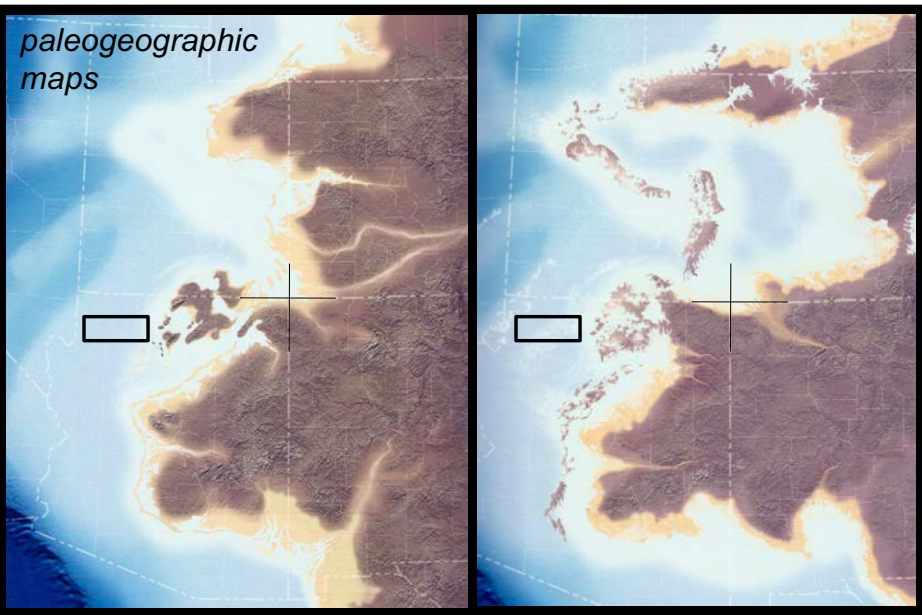

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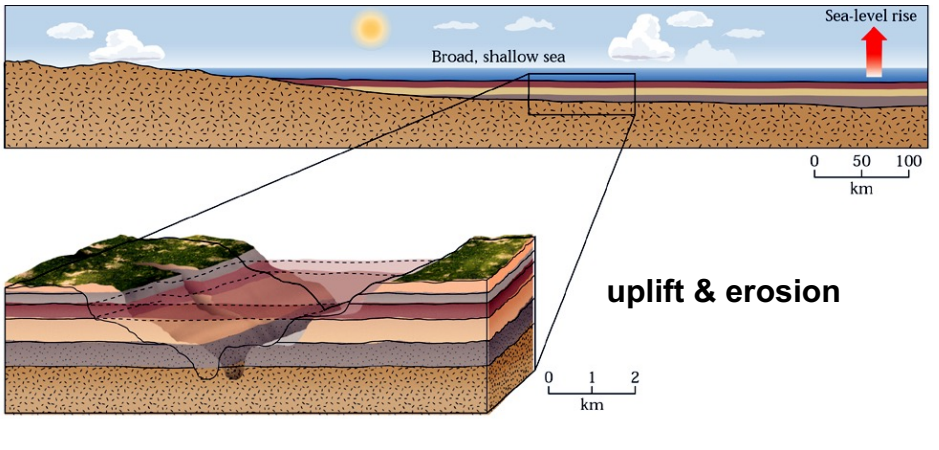

Principle of Lateral Continuity - horizontal layers of sediment produced during transgressions and regressions are relatively continuous over a broad region (100s to 1000s of sq km). Now exposed wherever uplift and erosion reveal them, but originally laterally continuous.

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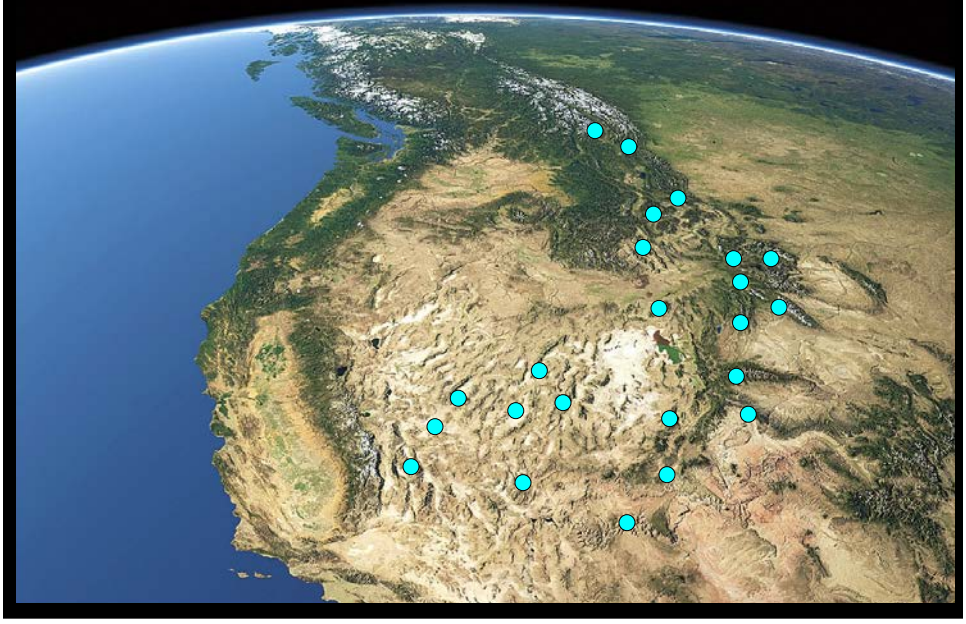
Exposures of the Tapeats sandstone in canyons and mountain ranges across the American West – infer lateral continuity



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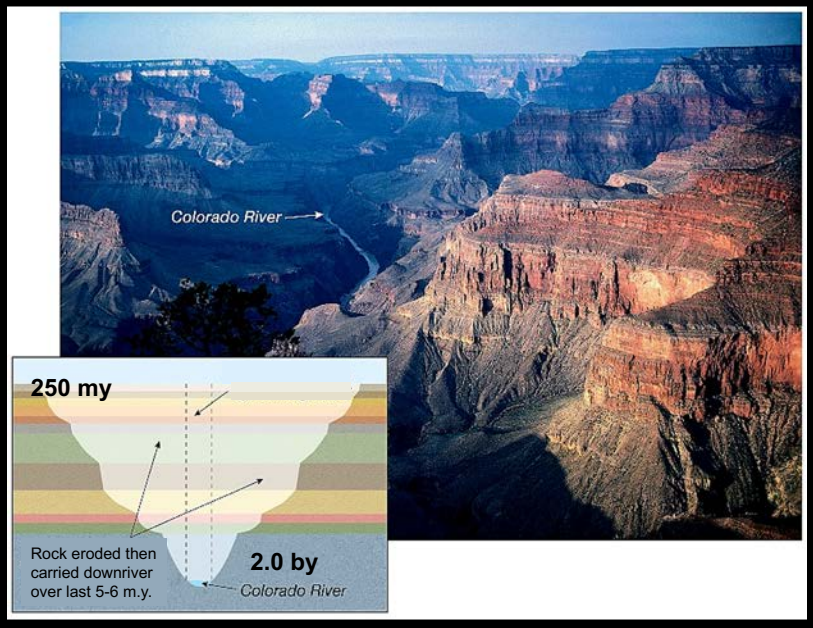

Principle of Lateral Continuity . . .

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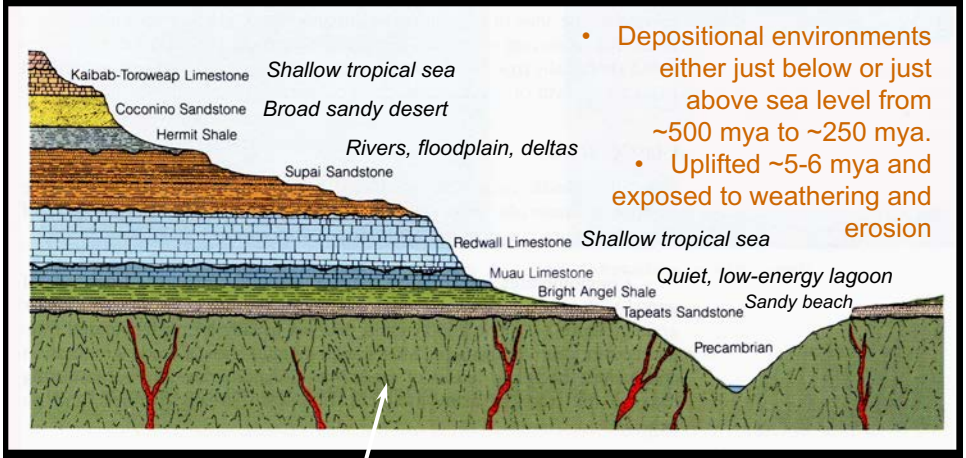
Sedimentary layers change upward as sea level fluctuates, climates change, and continents shift position over time



- Depositional environments either just below or just above sea level from ~500 mya to ~250 mya.
- Uplifted ~5-6 mya and exposed to weathering and erosion

Lower, complex, dark 'basement' of the "lower" Grand Canyon (igneous & metamorphic rocks)

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Trilobite from the Bright Angel shale

Fossils indicate:
1) depositional environment (trilobites were marine)
2) relative age of the rock (based on faunal change)
3) evidence for evolution

fossilization

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reptile tracks in Coconino Sandstone
- continental depositional environment

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Tree leaf fossils in Supai shale.
- *evidence for forests growing along floodplains of a river. species tell us about the climate at the time.*

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Redwall Limestone
- composed of sedimentary rock called limestone

nautiloid fossils – marine organisms

coral fossils

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Modern corals composed of $CaCO_3$ (calcite)
- accumulation of calcite remains of coral debris and other marine organisms (clams, oysters, algae, sponges) forms sedimentary rock called **limestone**

actualism

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Limestone composed entirely of broken shells of ancient marine organisms

microscopic view of fossiliferous limestone w/ calcite cement

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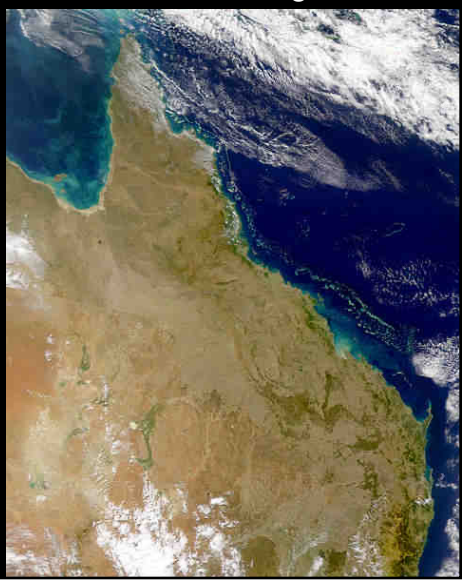
Bahamas - modern limestone forming today

Great Barrier Reef, Northeast Australia continental margin



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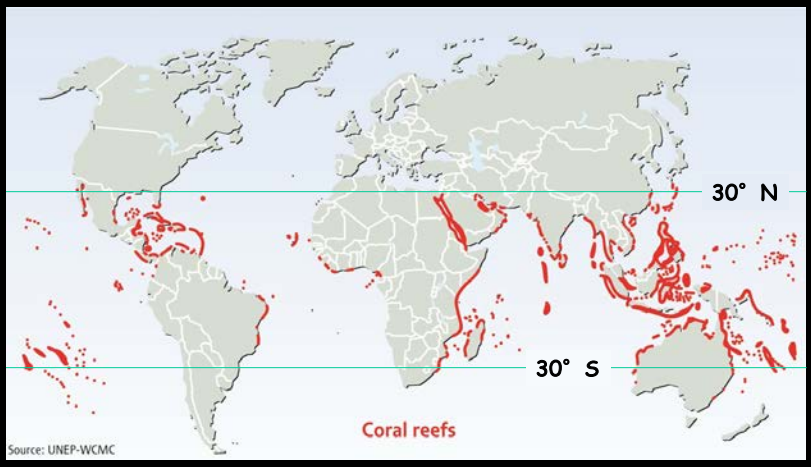

Modern limestone-forming regions occur in warm, shallow seas in tropical latitudes where corals and other calcite-shelled invertebrates prefer to live

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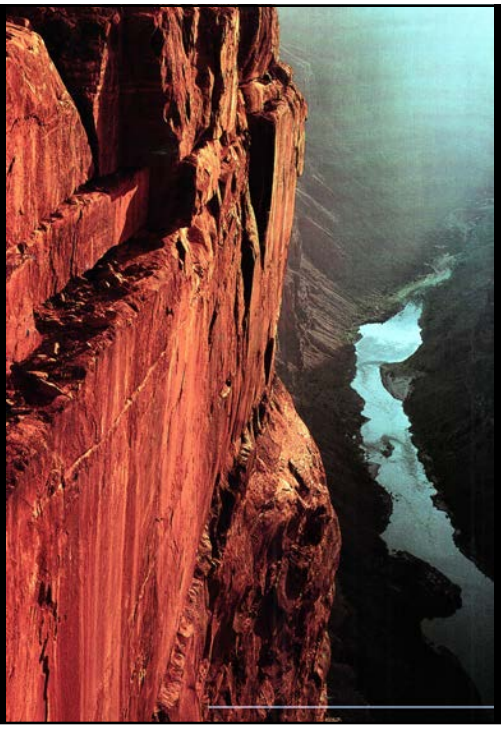
Redwall limestone

- **500-800’ thick**
- **390-350 m.y. old**
- **extends from Canada to Mexico**
- **very resistant to erosion in the semi-arid climate**
- **vertical fractures produce vertical cliffs**



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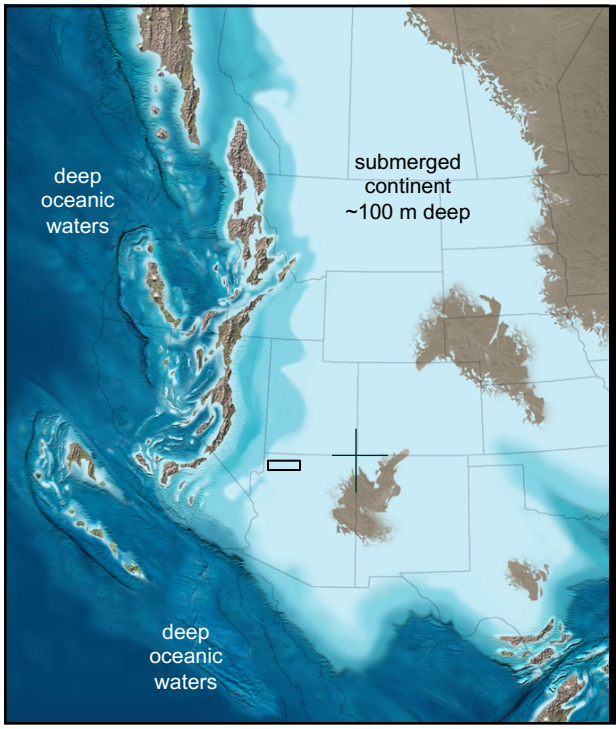

Paleogeographic map of American West during transgression and deposition of the Redwall Limestone (~350 Ma)
- warm, shallow tropical sea in an equatorial setting . . .

(no Colorado Plateau yet, no Grand Canyon, no Rockies or Sierra or California)

Map created using field work and principle of lateral continuity

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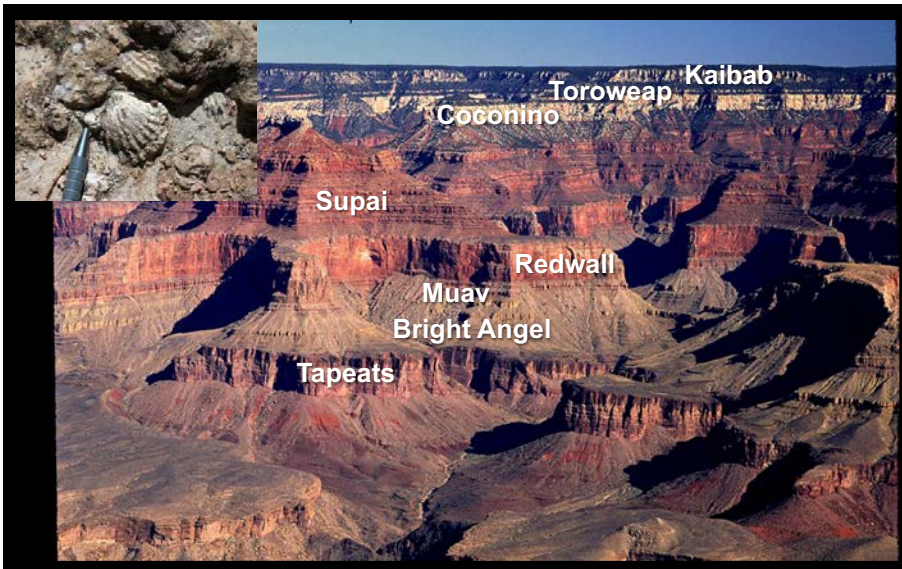

Muav, Redwall, Toroweap, and Kaibab limestone formations all represent times when shallow tropical seas transgressed across the western U.S.

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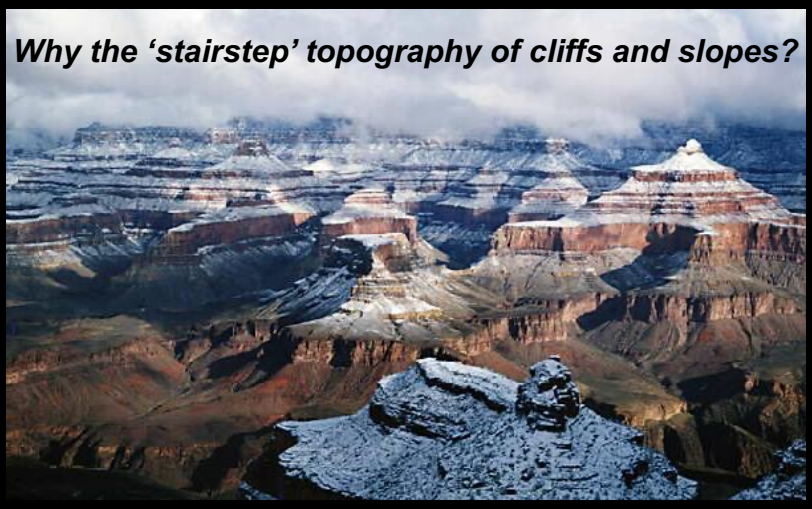
Topographic Features of the Grand Canyon Landscape



Differential erosion of various rock types creates 'stairstep' topography of alternating slopes and cliffs.

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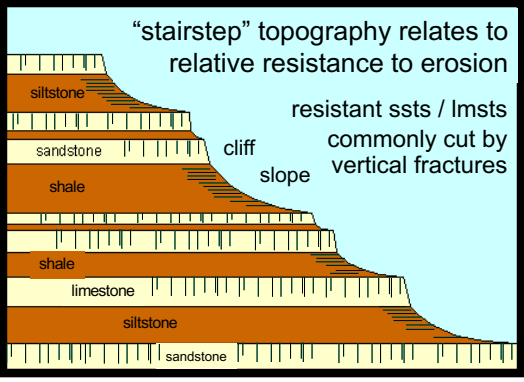
differential erosion

- **siltstones & shales form slopes**
- **sandstones & limestones form cliffs**



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Supai Group

Redwall Limestone

Why reddish color of the rocks?

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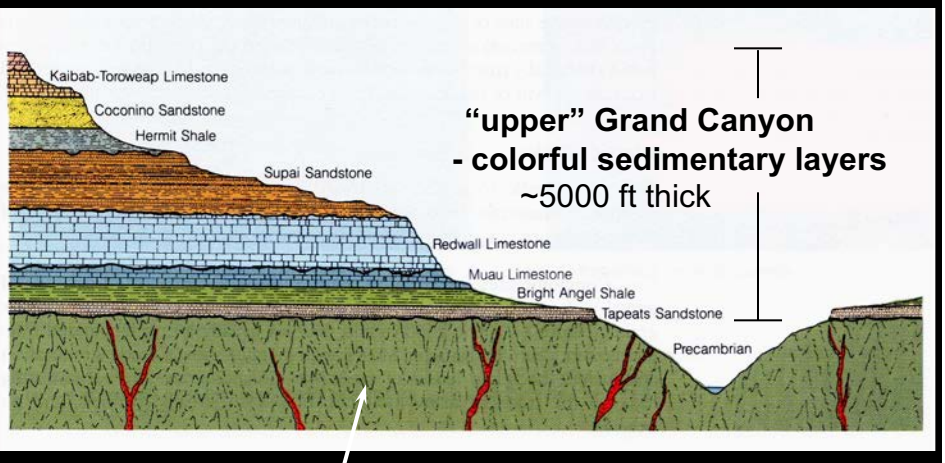

Lower, complex, dark 'basement' of the "lower" Grand Canyon (~2 b.y. old)

The uppermost basement rocks in the Grand Canyon are the top of the crust that extends to depths of >18 mi

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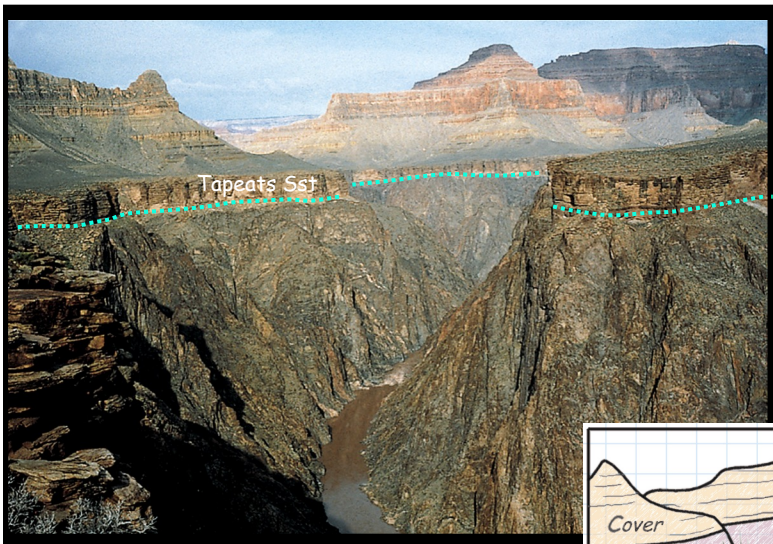
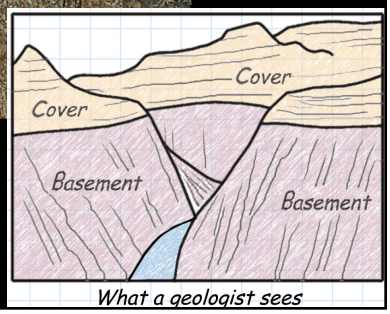


upper Grand Canyon

resistant 'basement' rocks of the Inner Gorge



Topography as a result of ***differential erosion*** *. . . .*

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- **Inner Gorge: unlayered igneous & metamorphic rocks**
- **"basement" – generic term for these rocks that compose the foundation of continents**

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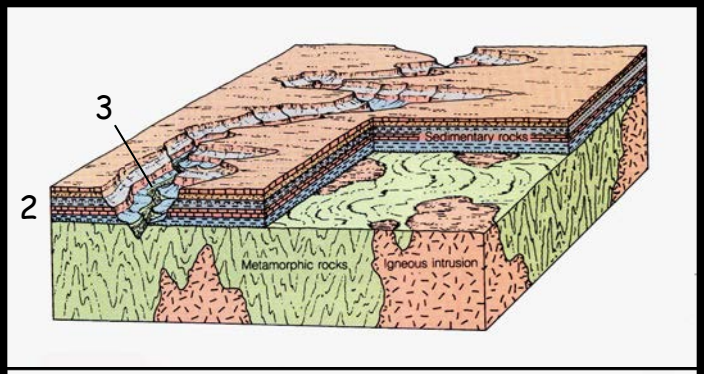
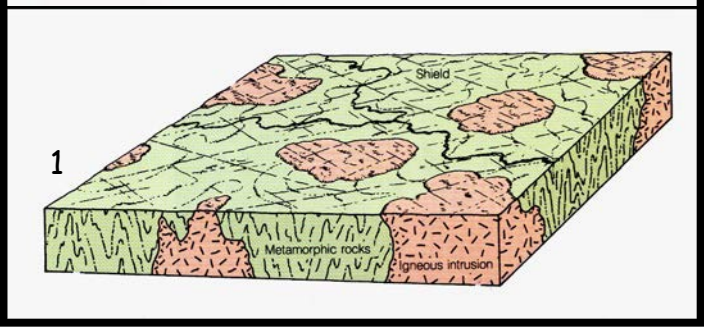
3) landscape created by erosion & river incision

2) layered sedimentary rocks



1) basement of igneous & metamorphic rocks – beveled smooth by erosion



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