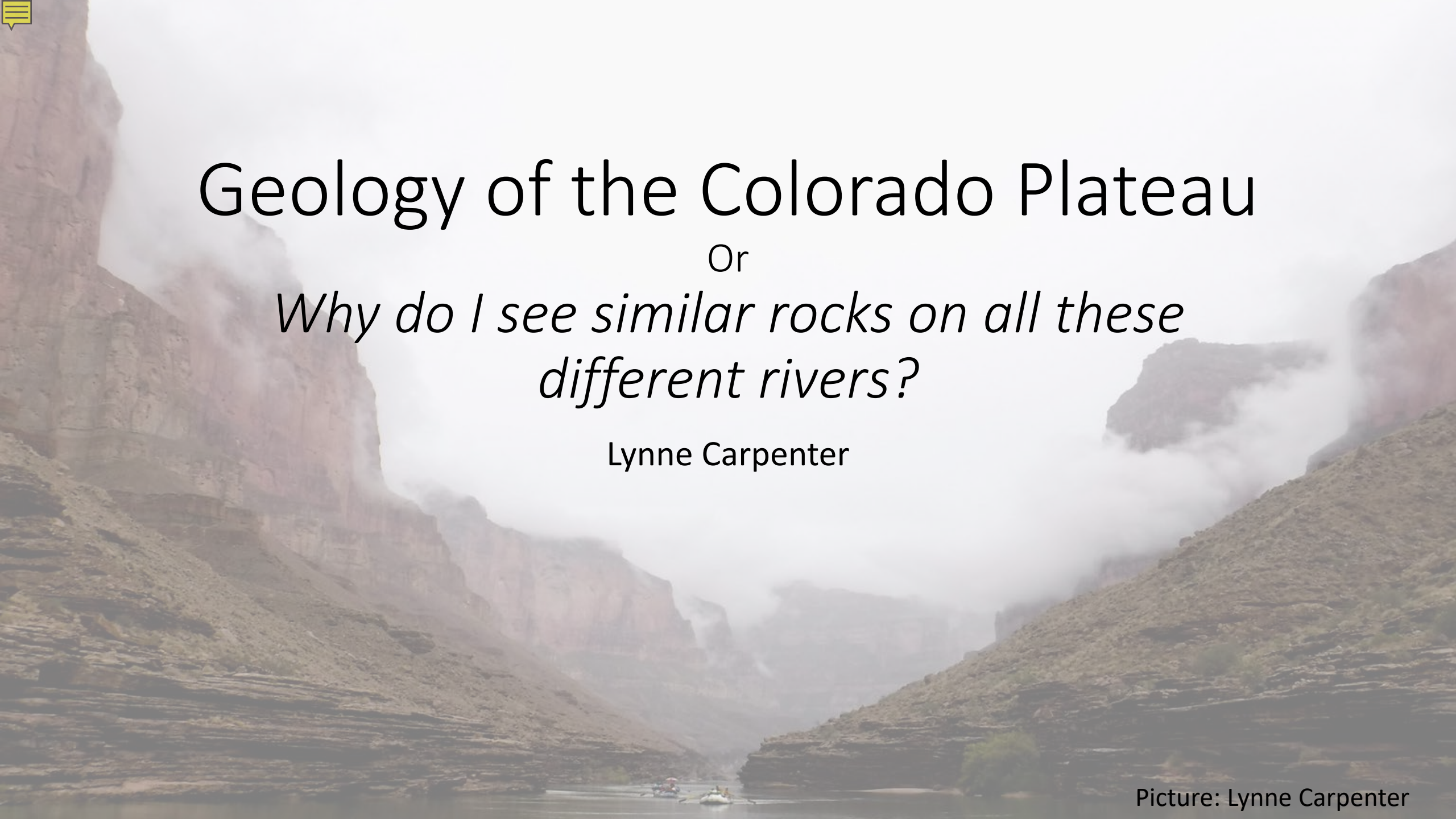
Geology of the Colorado Plateau

Or

Why do I see similar rocks on all these different rivers?

Lynne Carpenter

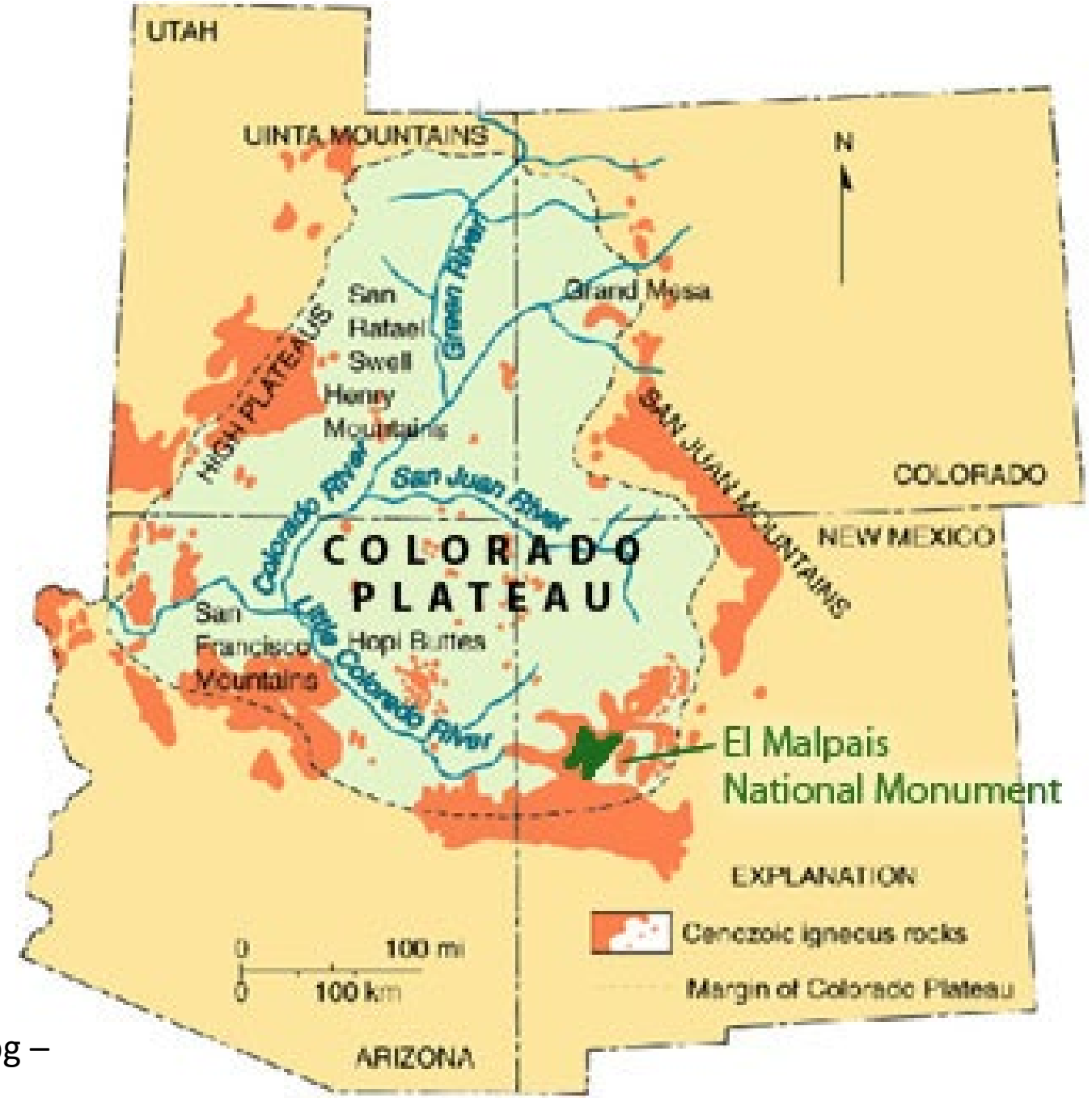


Picture: Lynne Carpenter

Talk Outline

- Where and what is the Colorado Plateau?
- What is Geology and Why do I care?
- Geology 101 – a quick introduction to geologic terms and concepts
- What is so special about the Colorado Plateau?
- A quick (and dirty! Ha!) geologic history of rocks of the Colorado Plateau.
- Special treat for you!
- Questions?

Where is the Colorado Plateau?



Colorado Plateau volcanism.jpg – Wikimedia Commons

Where is the Colorado Plateau?

Green River

Yampa River

White River

San Juan River

Colorado River

Little Colorado River

What is the study of Geology

MEANING OF GEOLOGY

GEOLOGY

Greek Earth Science

The word Geology is derived from Greek words "*GEO*" which means "*EARTH*" & "*LOGOS*" which means "*SCIENCE*".

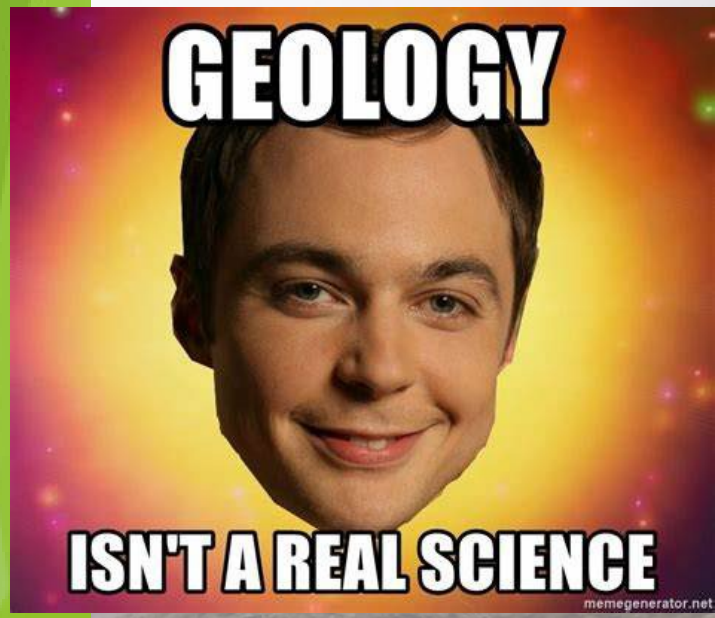
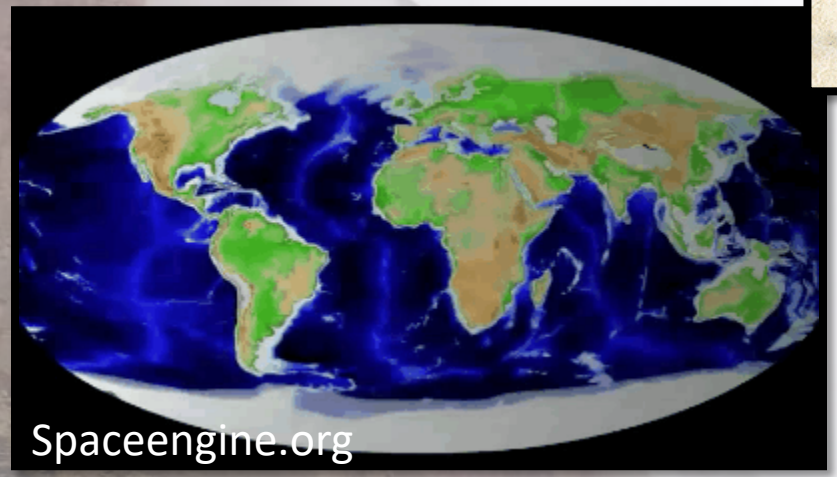


Image from Engineering Geology slideshare.net

Geology 101

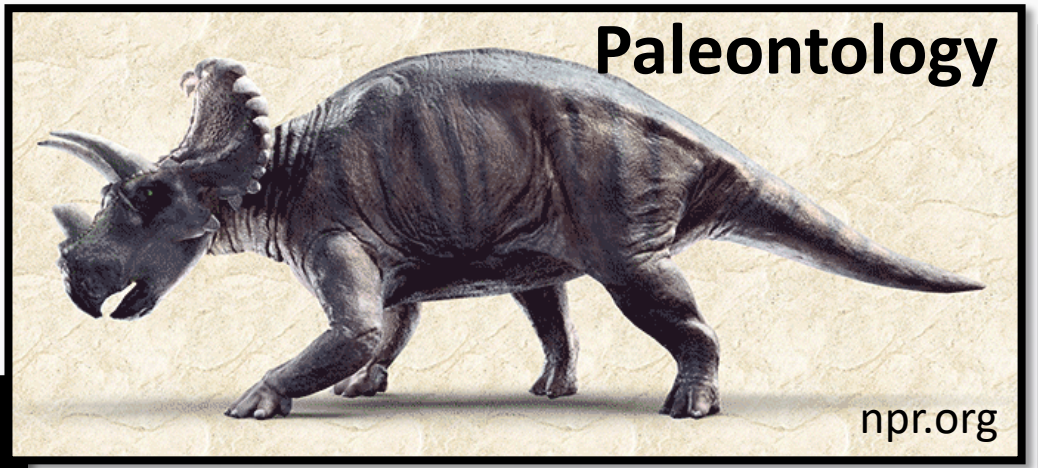
Plate Tectonics



Spaceengine.org

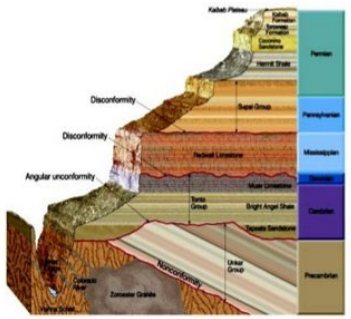
earthsurface.readthedocs.io

Paleontology



npr.org

Principles of Stratigraphy

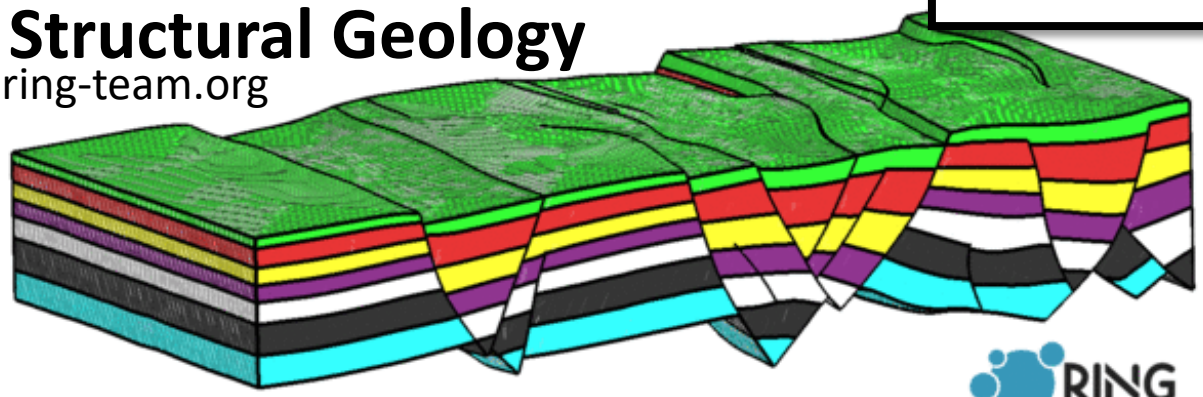


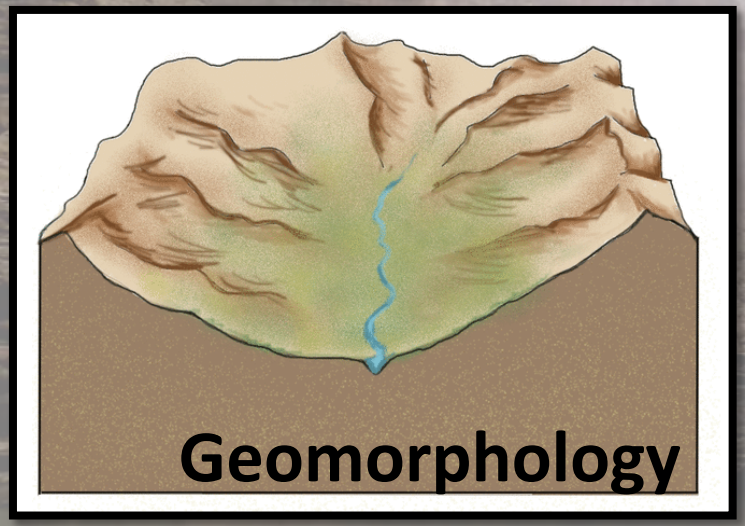
- Superposition
- Original Horizontality
- Lateral Continuity
- Crosscutting Relationships
- Inclusions
- Faunal (biological) Succession
- Incomplete record
- Base-level
- Accommodation
- Preservation Potential
- Cyclicity
- Walther's Law
- Correlation

quora.com

Structural Geology

ring-team.org

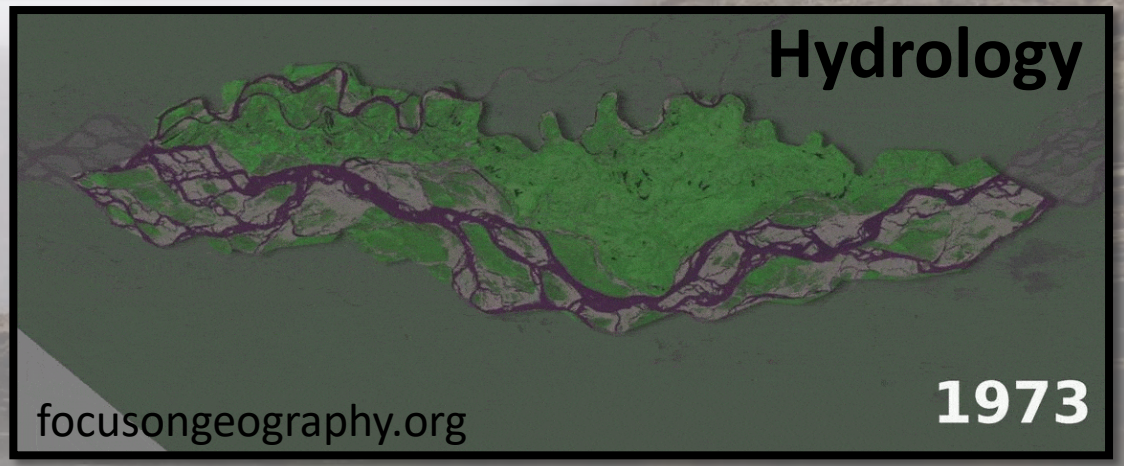




Economic Geology

bigriveralaska.com

Hydrology



focusongeography.org

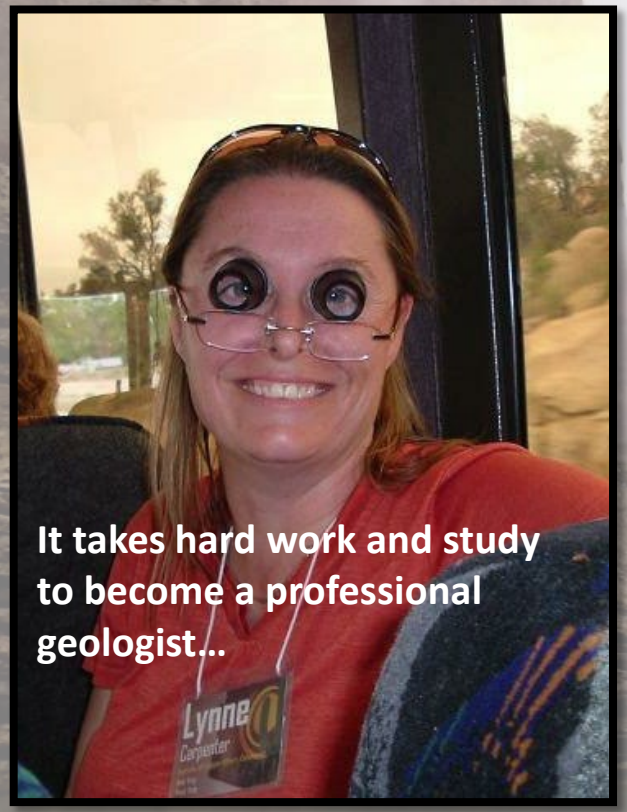
1973

What is a rock?

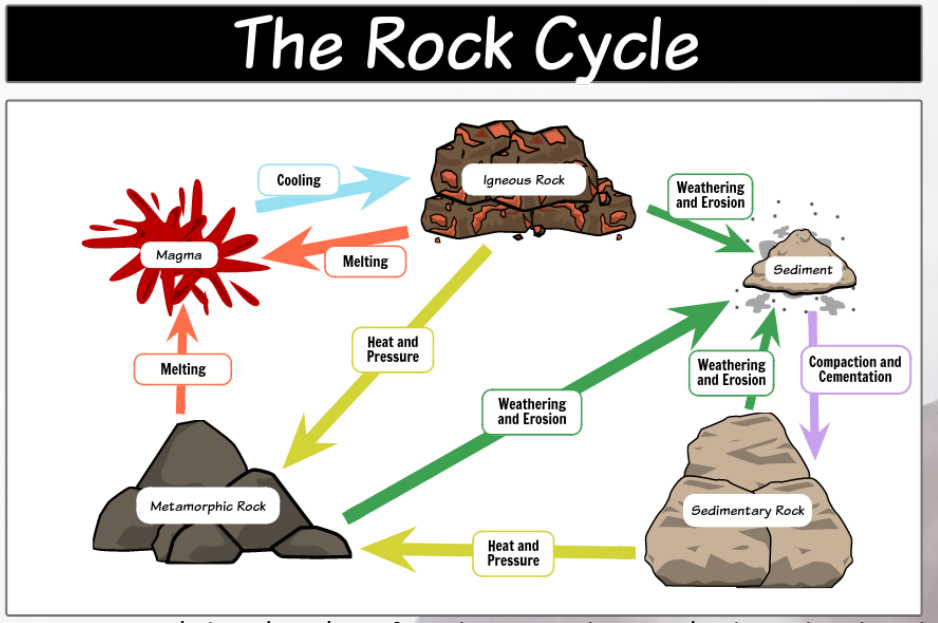
What is a mineral?

Types of rocks

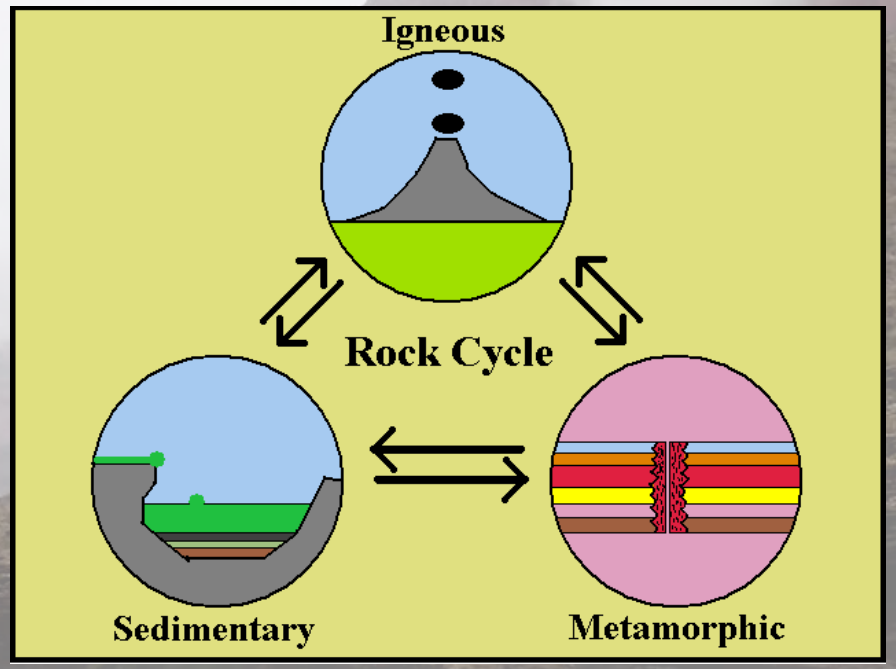
- Sedimentary,
- Igneous,
- Metamorphic



From: geoexpro.com/articles/2017/03/what-is-geology



From: quizizz.com/admin/quiz/6156f25e9b37e0001d506e23/rocks-and-rock-cycle



From: quizizz.com/admin/quiz/607e2d8e1e266e001fe4d76b/rocks-and-minerals-review

Types of rocks

Blacktail Canyon, Grand Canyon (personal photo)

Matkatamiba Canyon, Grand Canyon
Personal photo

Types of Rocks

Igneous Rocks

nypost.com/2020/08/01/sharkcano-documentary-sheds-light-on-sharks-that-live-in-volcanoes/

Intrusive

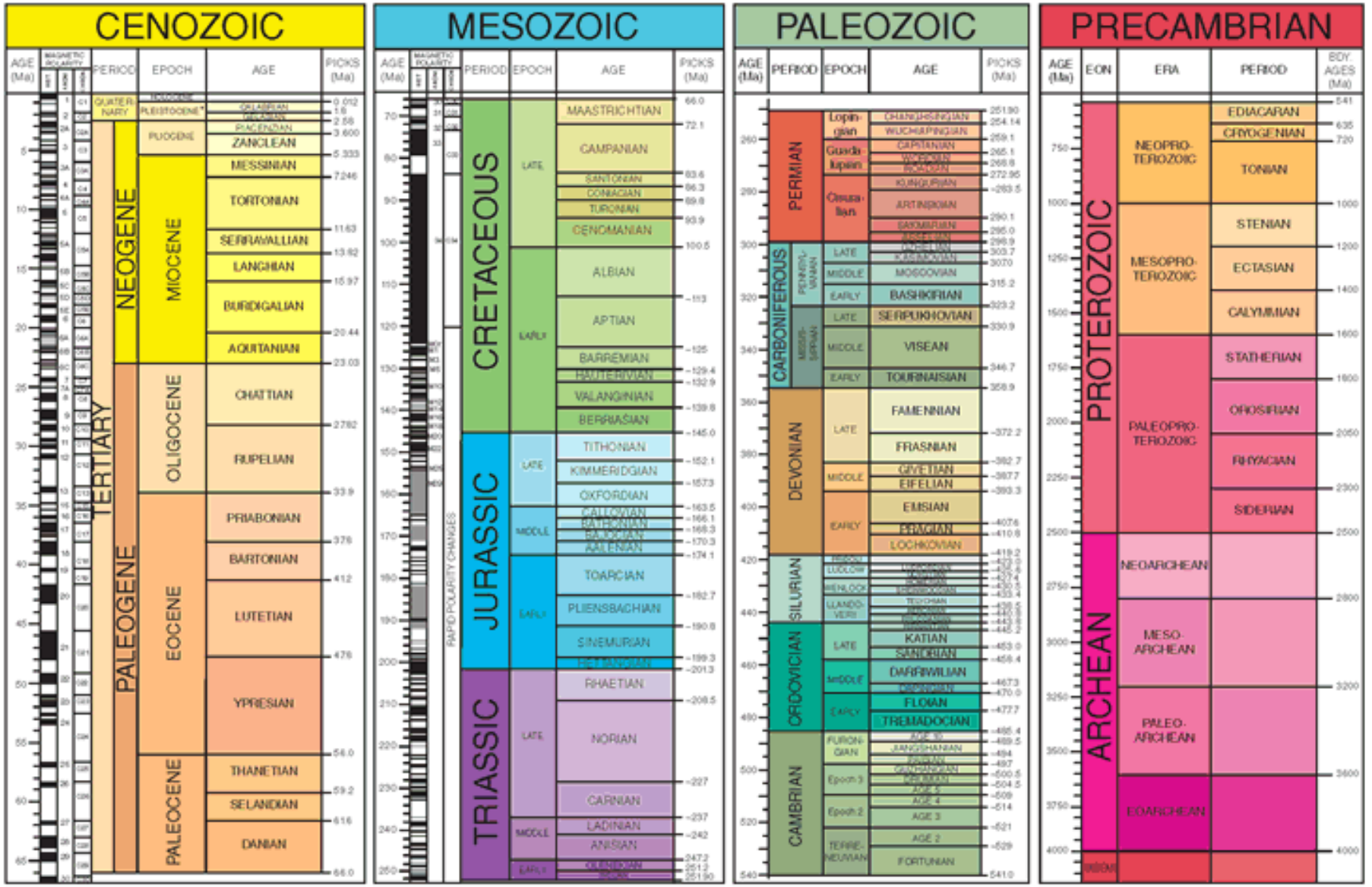
National Park Service Photo, Tina Kuhn
https://www.nps.gov/subjects/geology/igneous.htm

Extrusive

http://www.quickmeme.com/meme/3ohoue

Types of rocks
Metamorphic

GSA GEOLOGIC TIME SCALE v. 5.0



Walker, J.D., Geissman, J.W., Bowring, S.A., and Babcock, L.E., compilers, 2018, Geologic Time Scale v. 5.0: Geological Society of America, https://doi.org/10.1130/2018.CTS005R3C. ©2018 The Geological Society of America

*The Pleistocene is divided into four ages, but only two are shown here. What is shown as Calabrian is actually three ages—Calabrian from 1.80 to 0.781 Ma, Middle from 0.781 to 0.126 Ma, and Late from 0.126 to 0.0117 Ma.

The Cenozoic, Mesozoic, and Paleozoic are the Eras of the Phanerozoic Eon. Names of units and age boundaries usually follow the Gradstein et al. (2012), Cohen et al. (2012), and Cohen et al. (2013, updated) compilations. Numerical age estimates and picks of boundaries usually follow the Cohen et al. (2013, updated) compilation. The numbered epochs and ages of the Cambrian are provisional. A "~" before a numerical age estimate typically indicates an associated error of ±0.4 to over 1.6 Ma.

REFERENCES CITED

Cohen, K.M., Finney, S., and Gibbard, P.L., 2012, International Chronostratigraphic Chart: International Commission on Stratigraphy, www.stratigraphy.org [accessed May 2012]. (Chart reproduced for the 34th International Geological Congress, Brisbane, Australia, 5–10 August 2012.)

Cohen, K.M., Finney, S.C., Gibbard, P.L., and Fan, J.-X., 2013, The ICS International Chronostratigraphic Chart: Episodes v. 36, no. 3, p. 199–204 (updated 2017, v. 2; http://www.stratigraphy.org/index.php/ics-chart-timescale; accessed May 2018).

Gradstein, F.M., Ogg, J.G., Schmitz, M.D., et al., 2012, The Geologic Time Scale 2012: Boston, USA, Elsevier, https://doi.org/10.1016/B978-0-444-59425-9.00004-4.

Previous versions of the time scale and previously published papers about the time scale and its evolution are posted to http://www.geosociety.org/timescale.

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GeoSociety.org

Geological Society of America

Geologic Time Scale

All other rocks on the Colorado Plateau

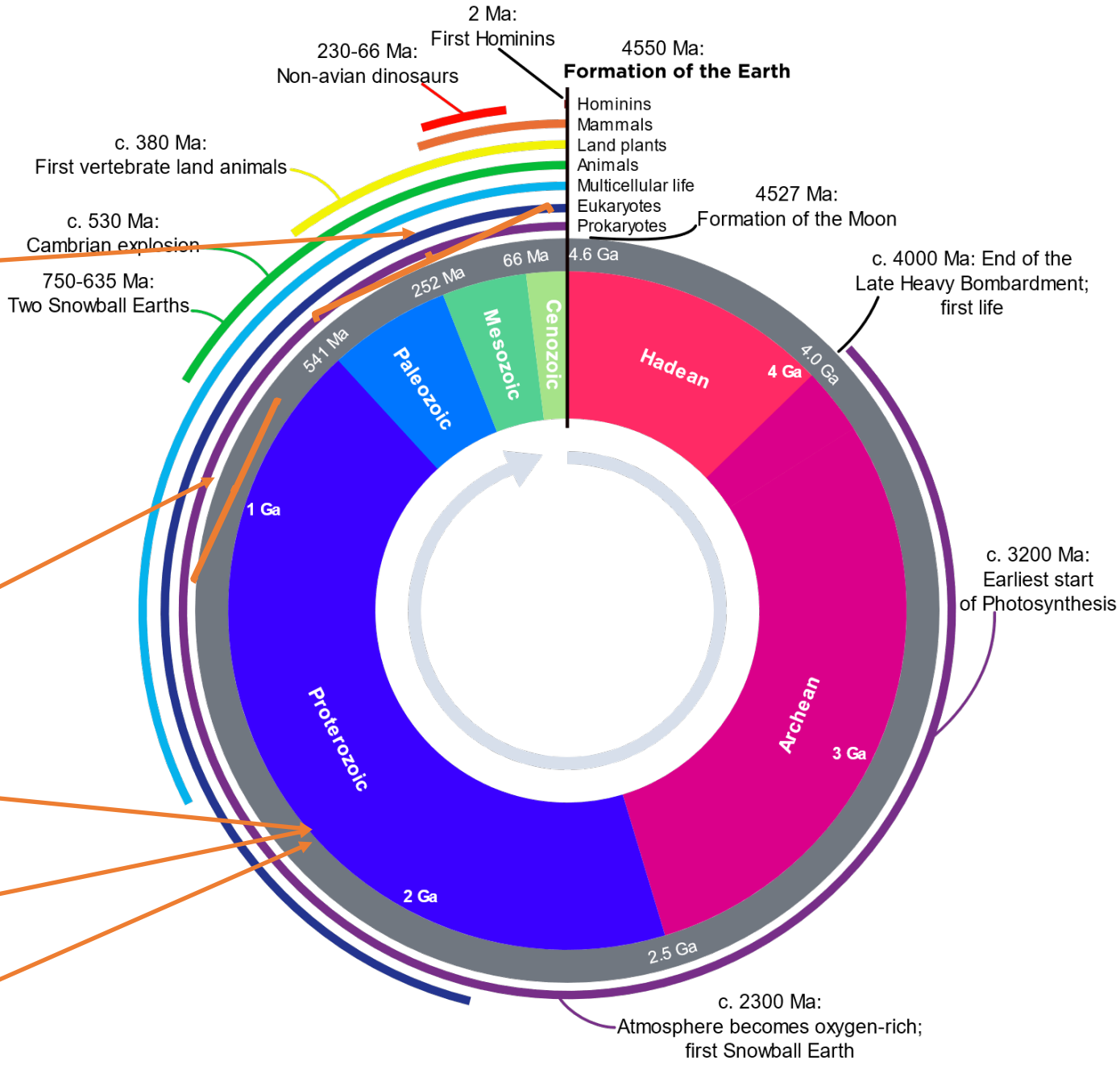
Note that the three million year long **Quaternary** period, the time of recognizable humans, is too small to be visible at this scale.

650 my – 1,250 my: Grand Canyon Supergroup, GC

1,700 my: Black Rocks Metamorphic Rocks, Westwater Cyn

1,700 my: Zoroaster Granite, GC

1,750 my: Vishnu, Brahma, and Rama Schists, GC



Graphic from: Wikipedia.org.

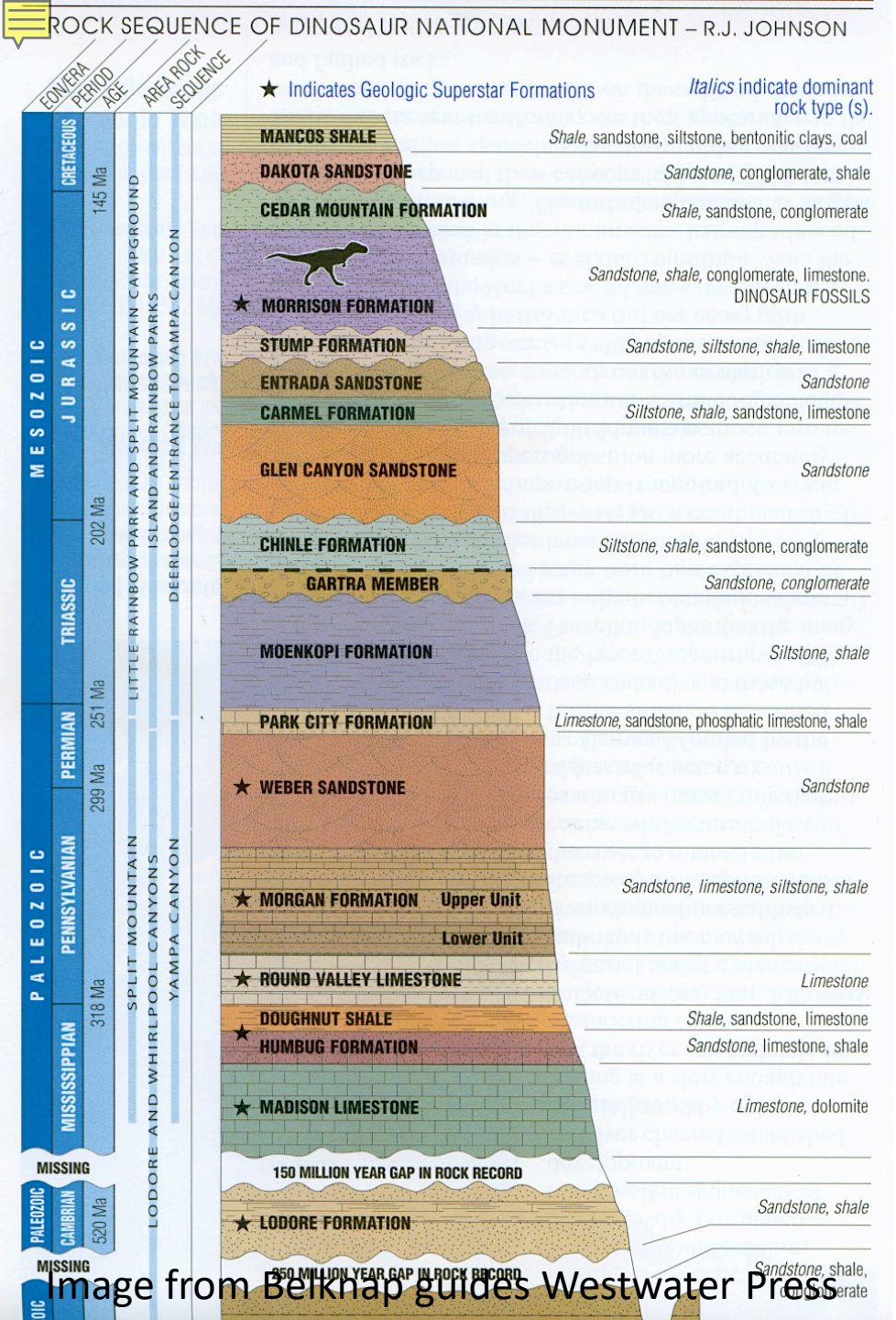
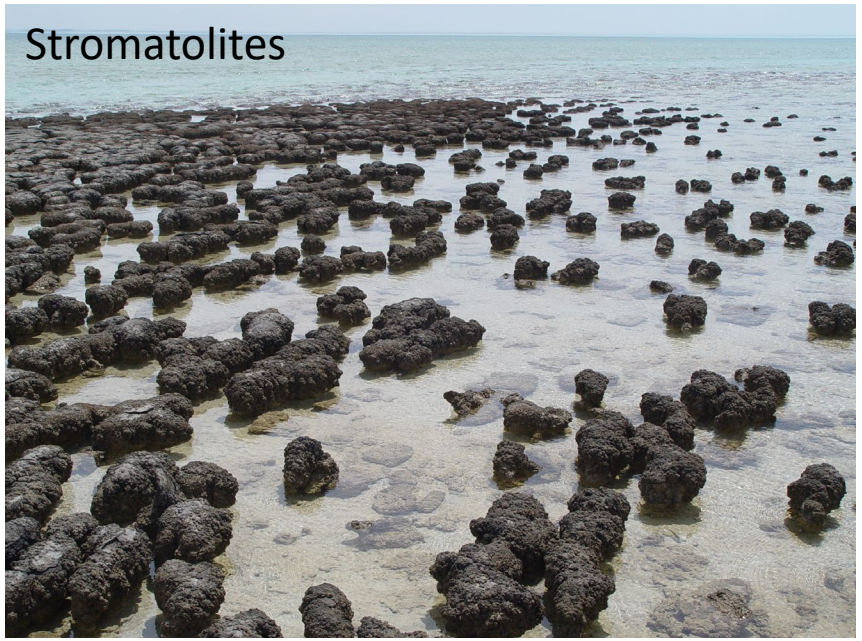


Image from Belknap guides Westwater Press

“The Present is the Key to the Past”

Stratigraphy

Stratigraphy - the description and classification of sedimentary rocks. The information is used to develop hypotheses of environments of deposition and how those environments change over time.

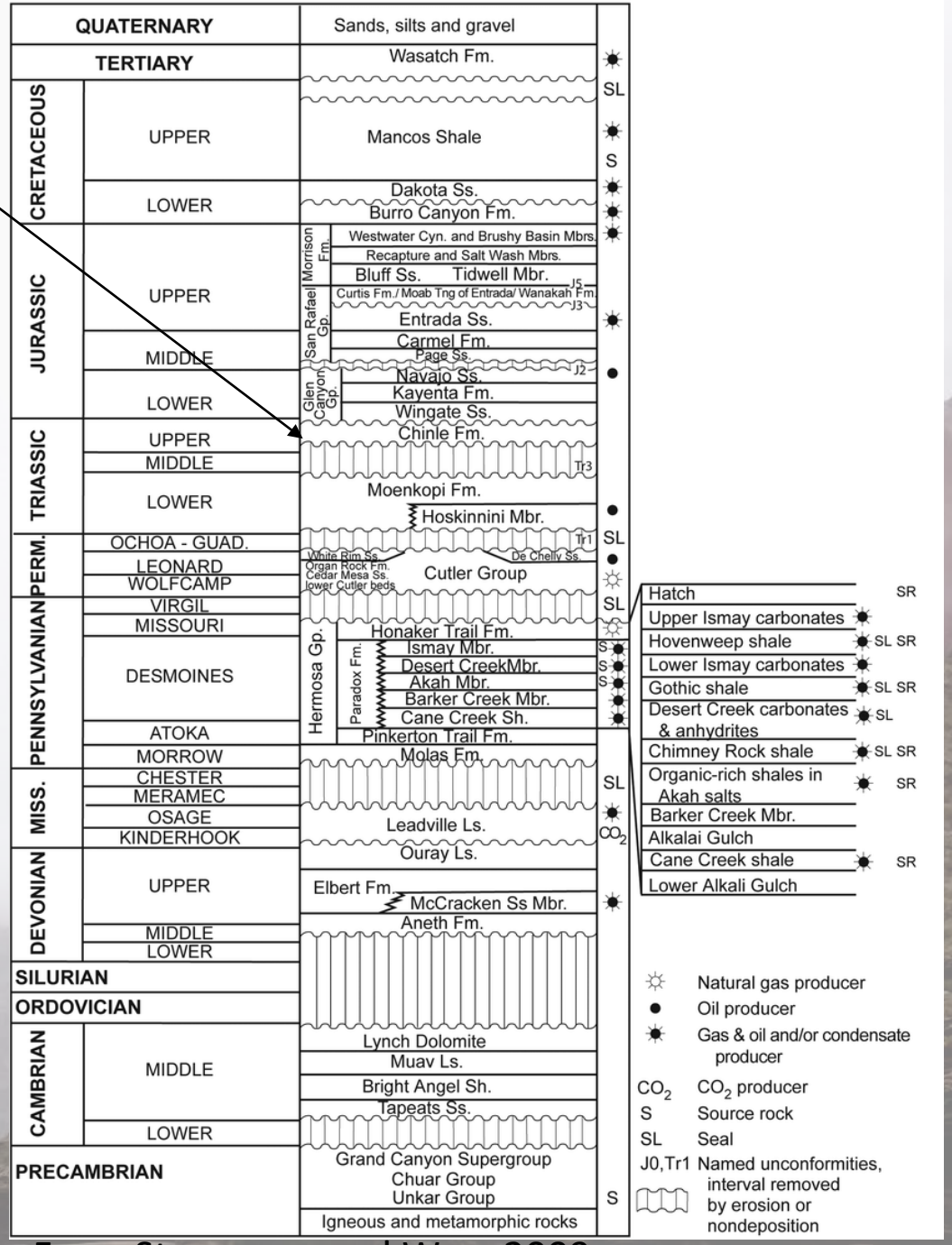


Photograph taken by Paul Harrison (Reading, UK) https://commons.wikimedia.org/w/index.php?curid=714512

Unconformities

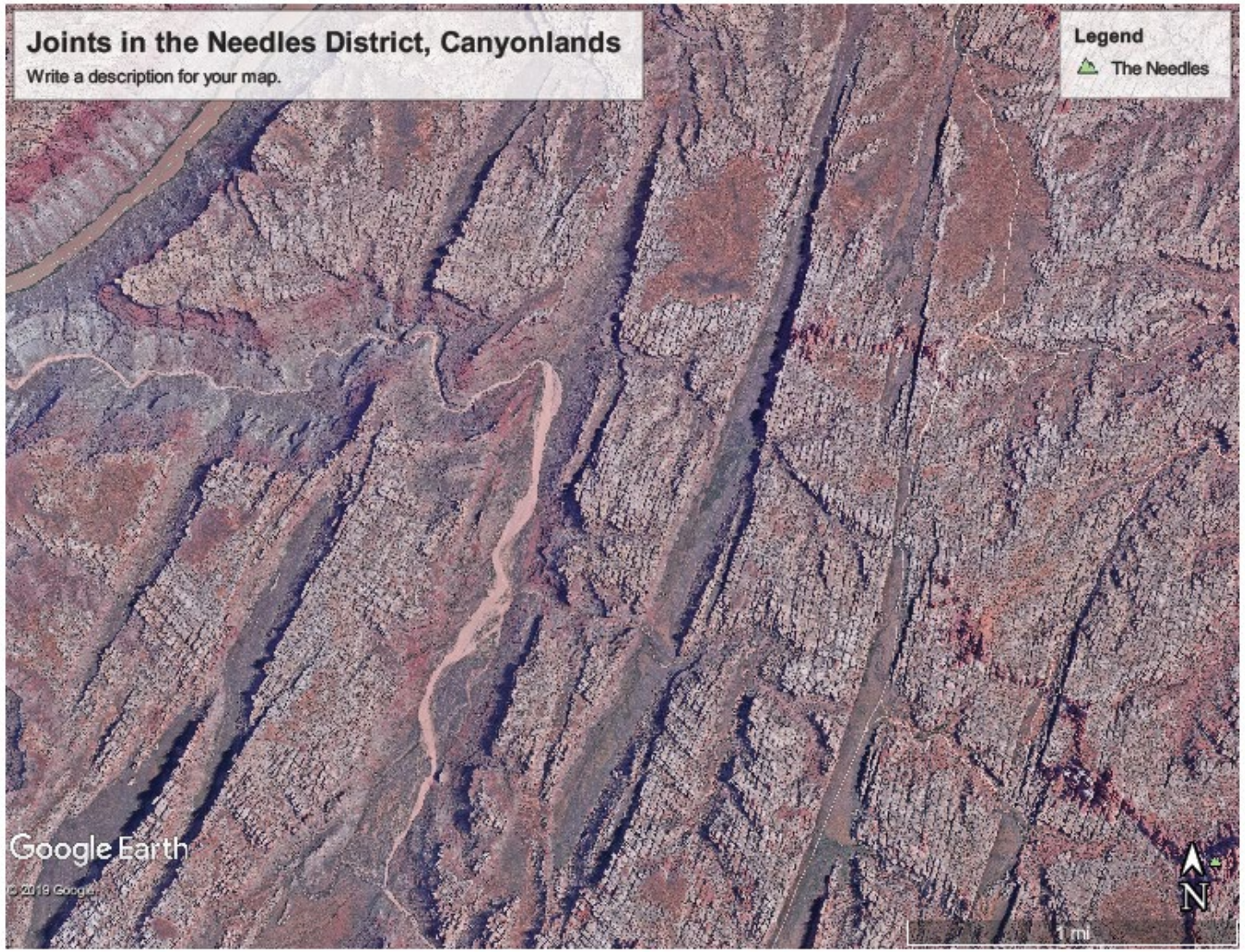
Unconformities are often shown by wavy lines in strat columns

Lynne's picture of the Great Unconformity in the Grand Canyon



From Stevenson and Wray 2009

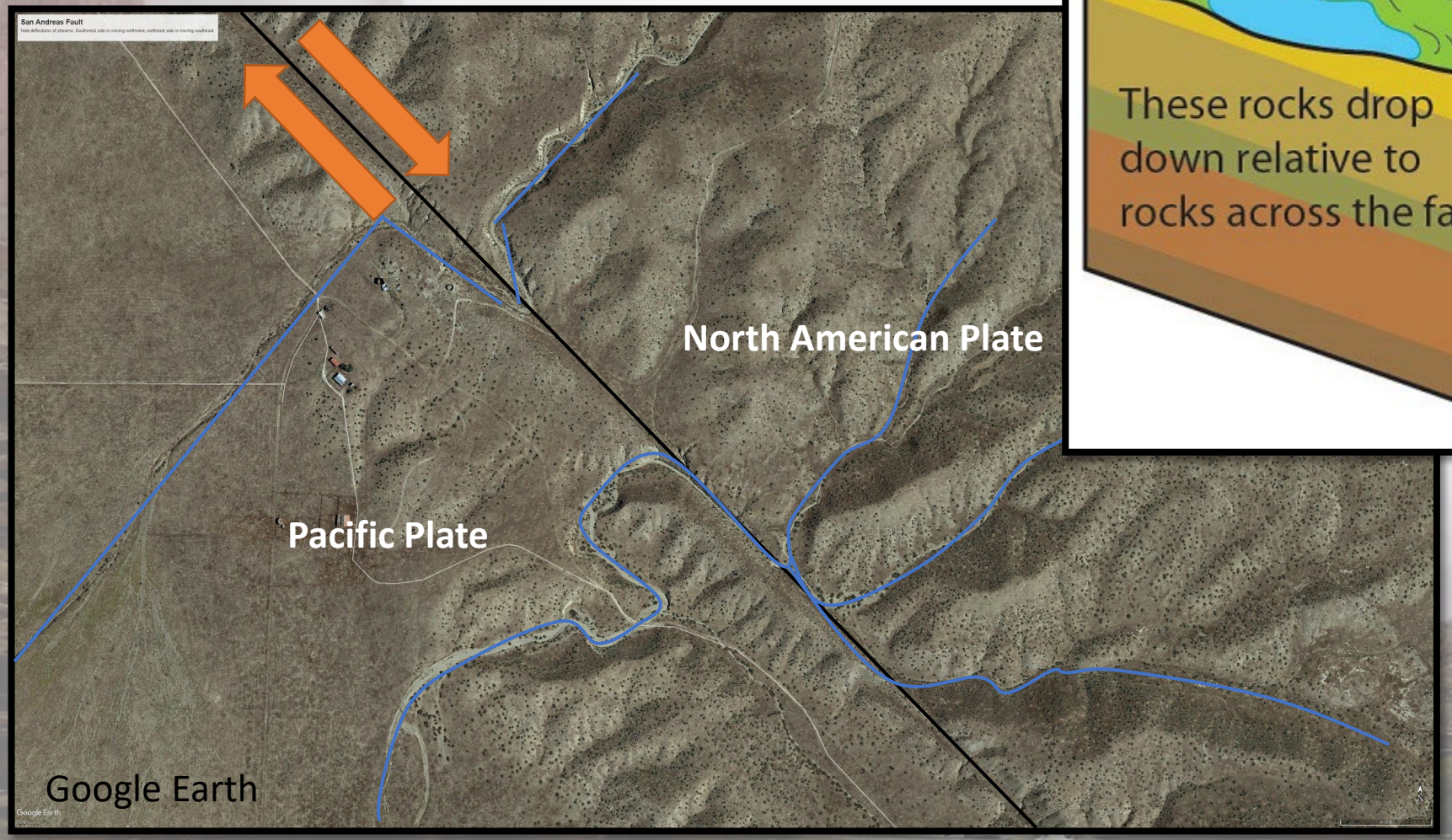
Structural Geology

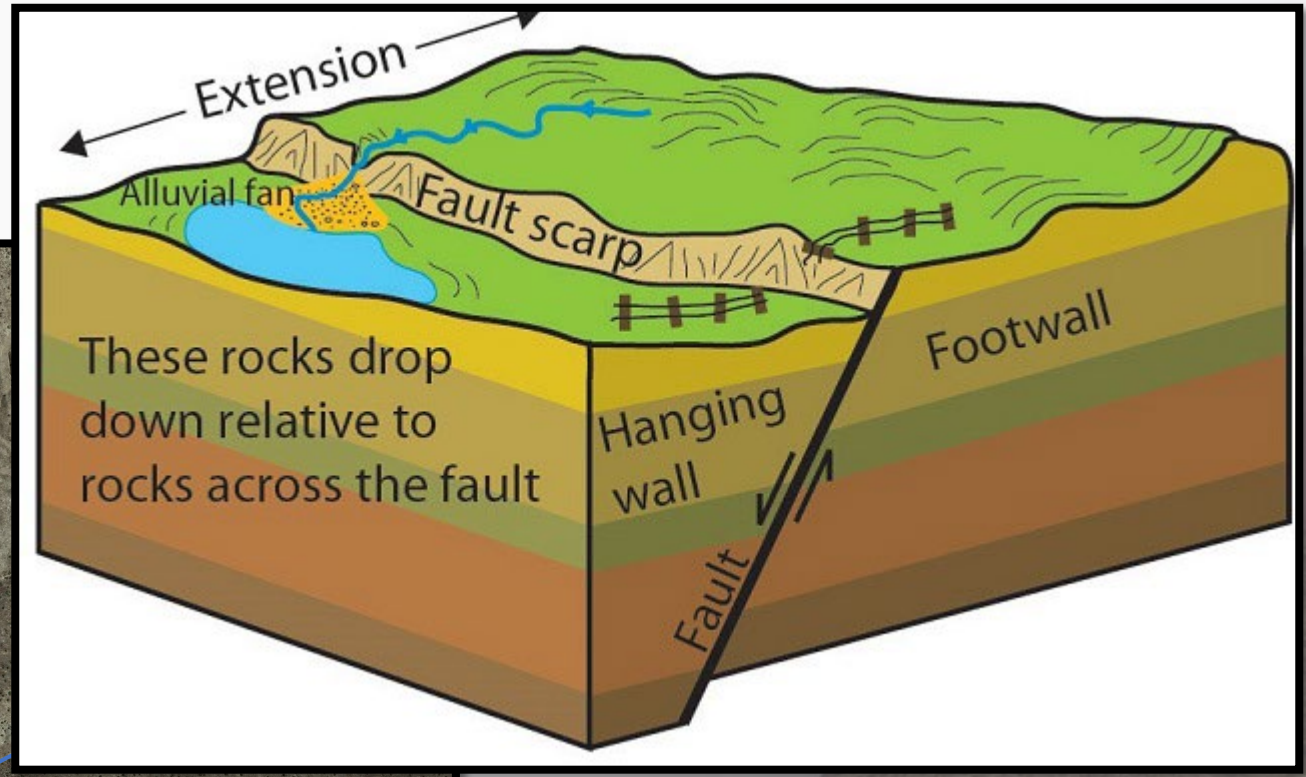


Joints

Structural Geology

Faults



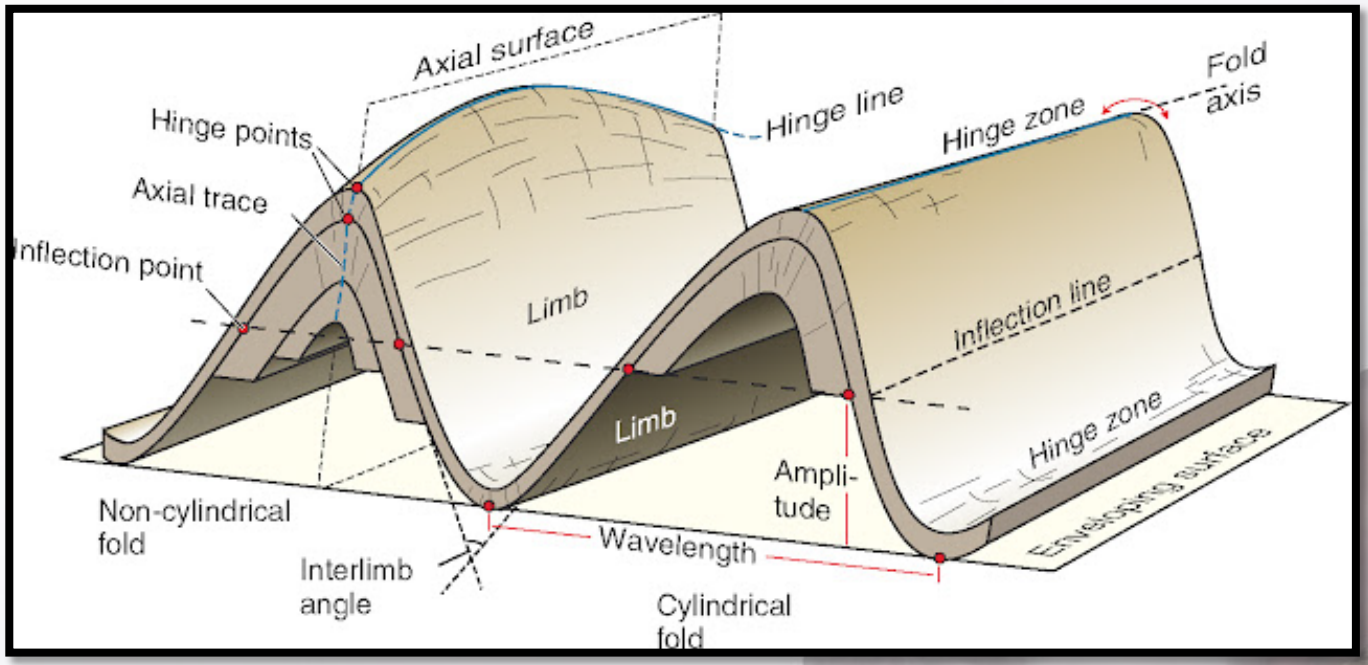


https://www.nps.gov/articles/faults-and-fractures.htm

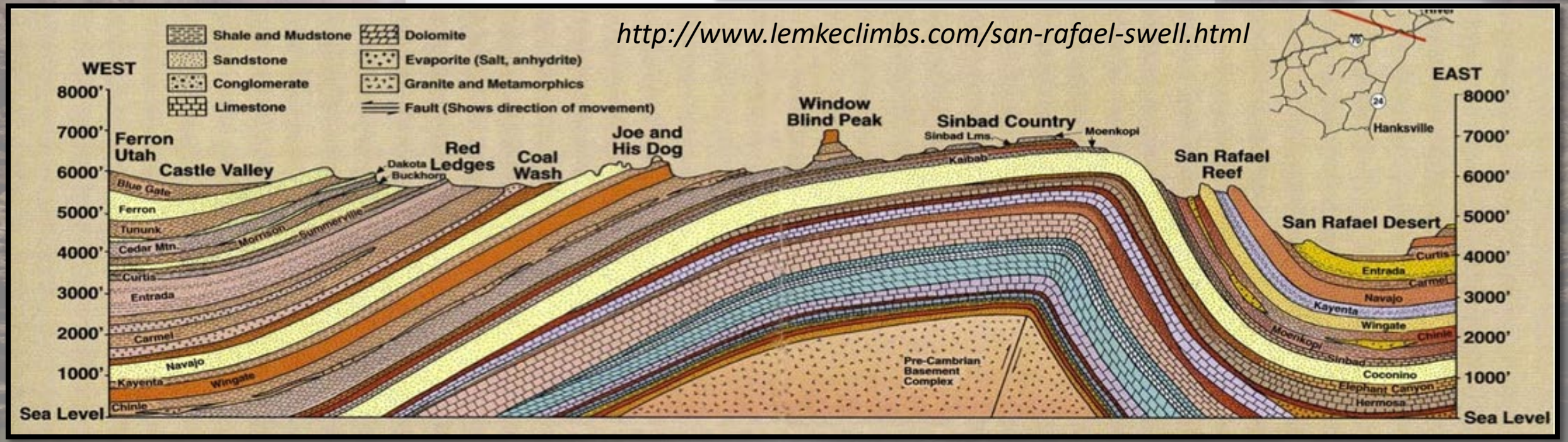
Structural Geology

Folds

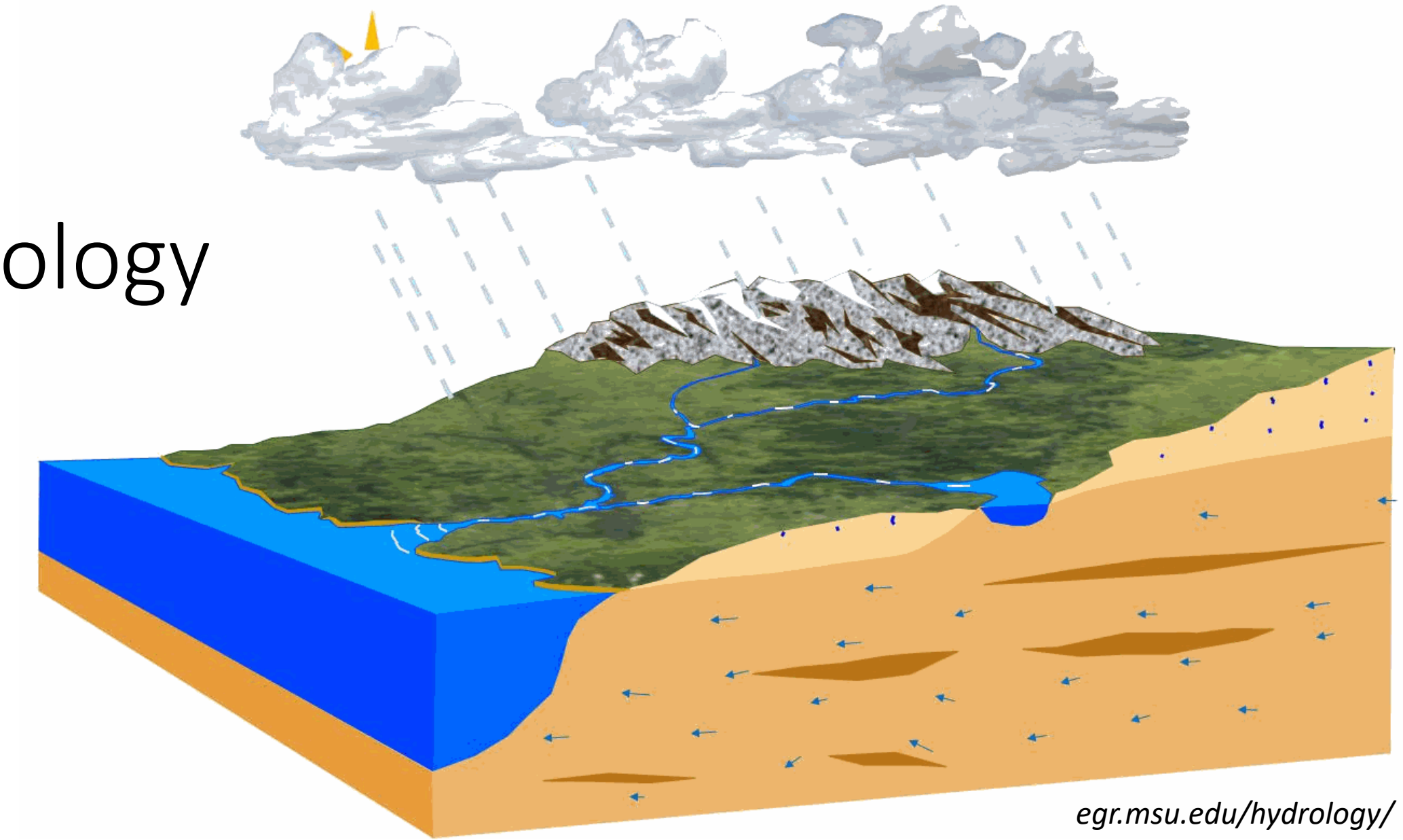
http://geologylearn.blogspot.com/2015/08/geometric-description-of-folds.html



http://www.lemkeclimbs.com/san-rafael-swell.html



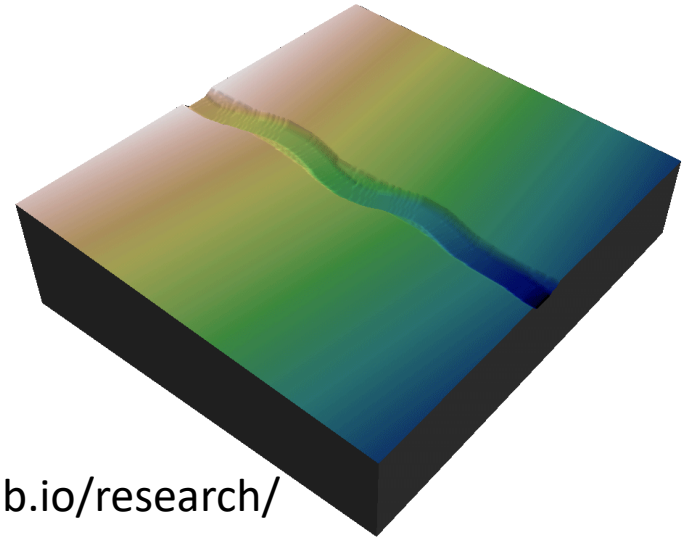
Hydrology



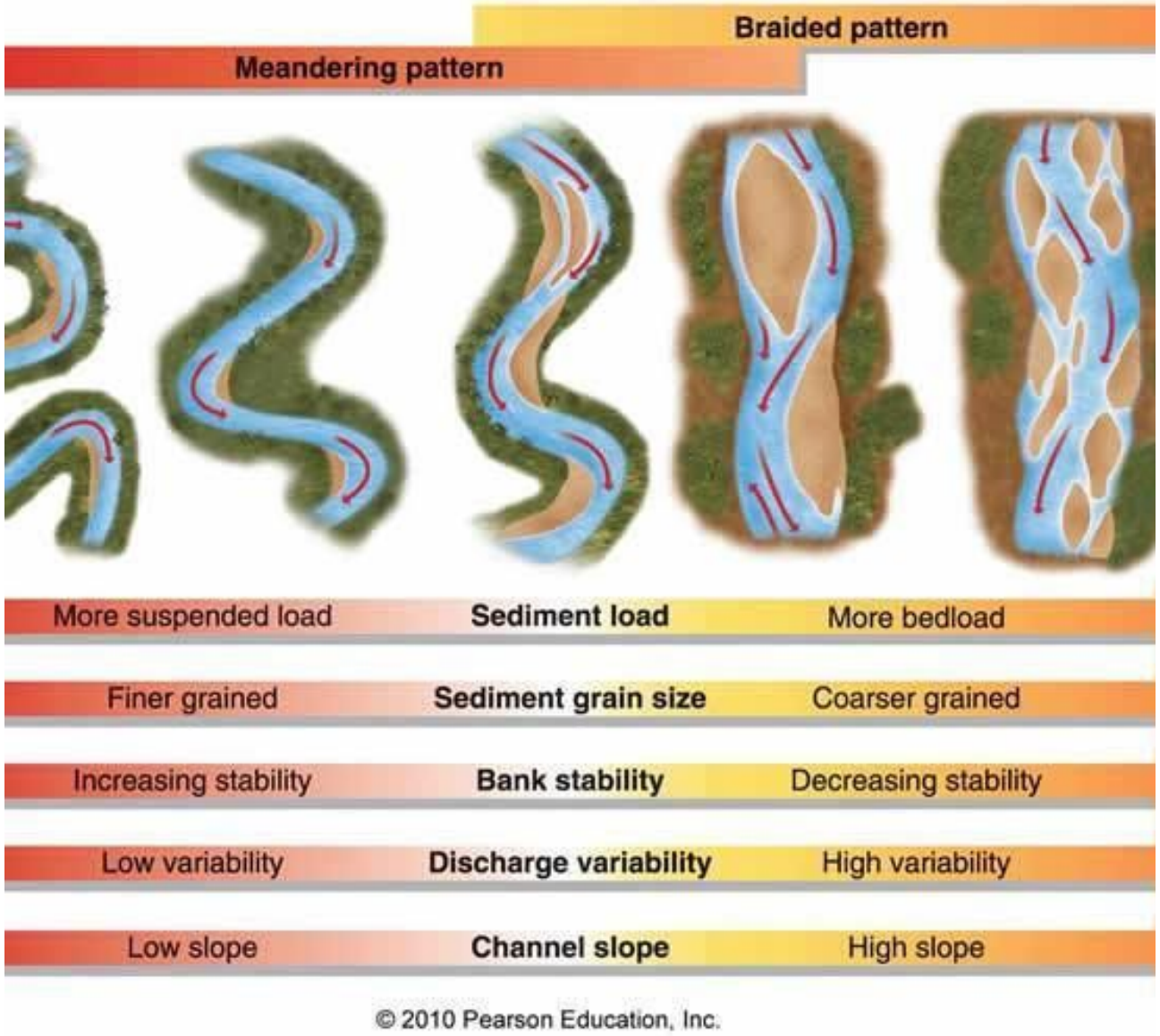
egr.msu.edu/hydrology/

Geomorphology

Grand Canyon National Park Facebook Page



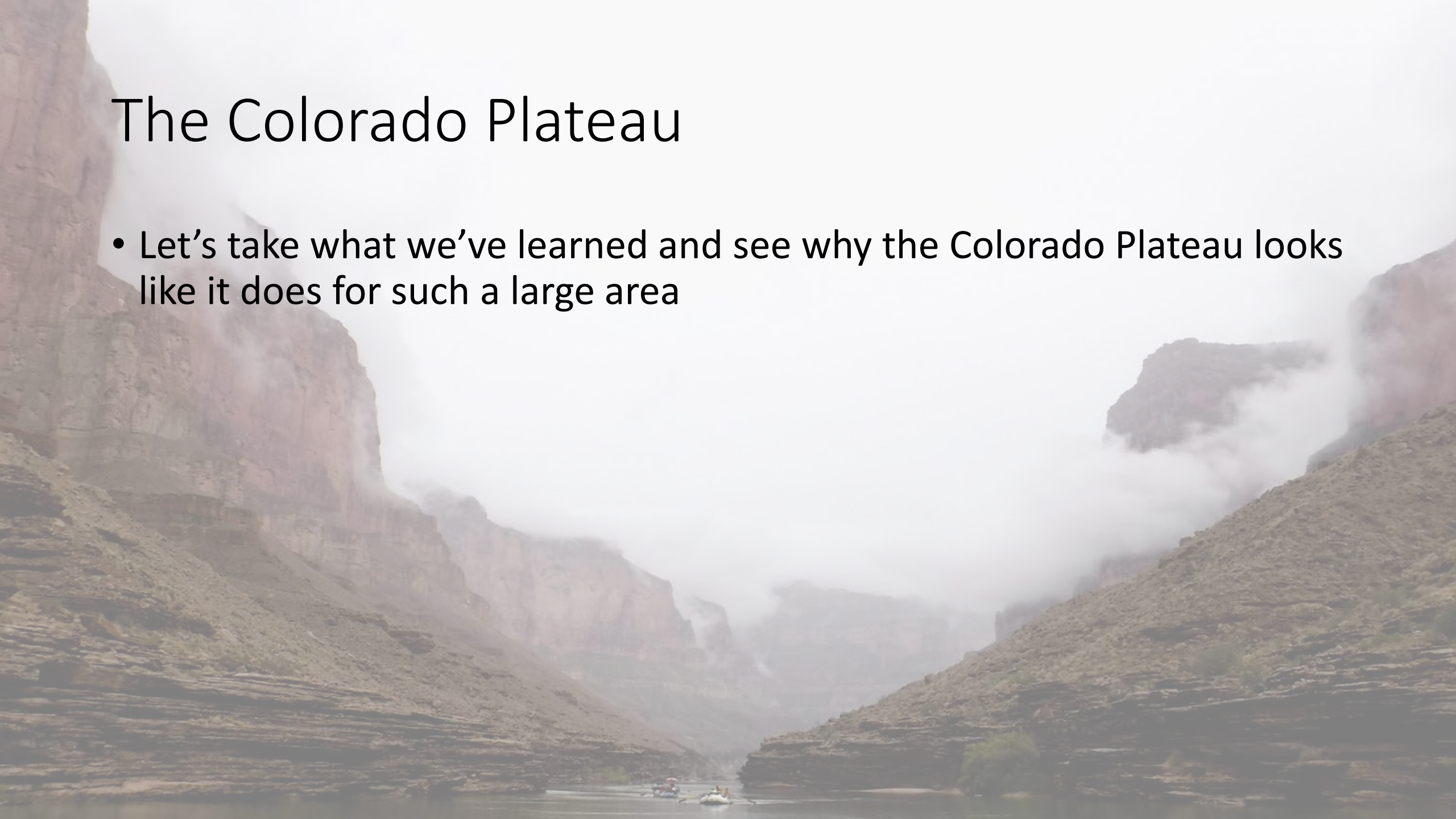
zsylvester.github.io/research/

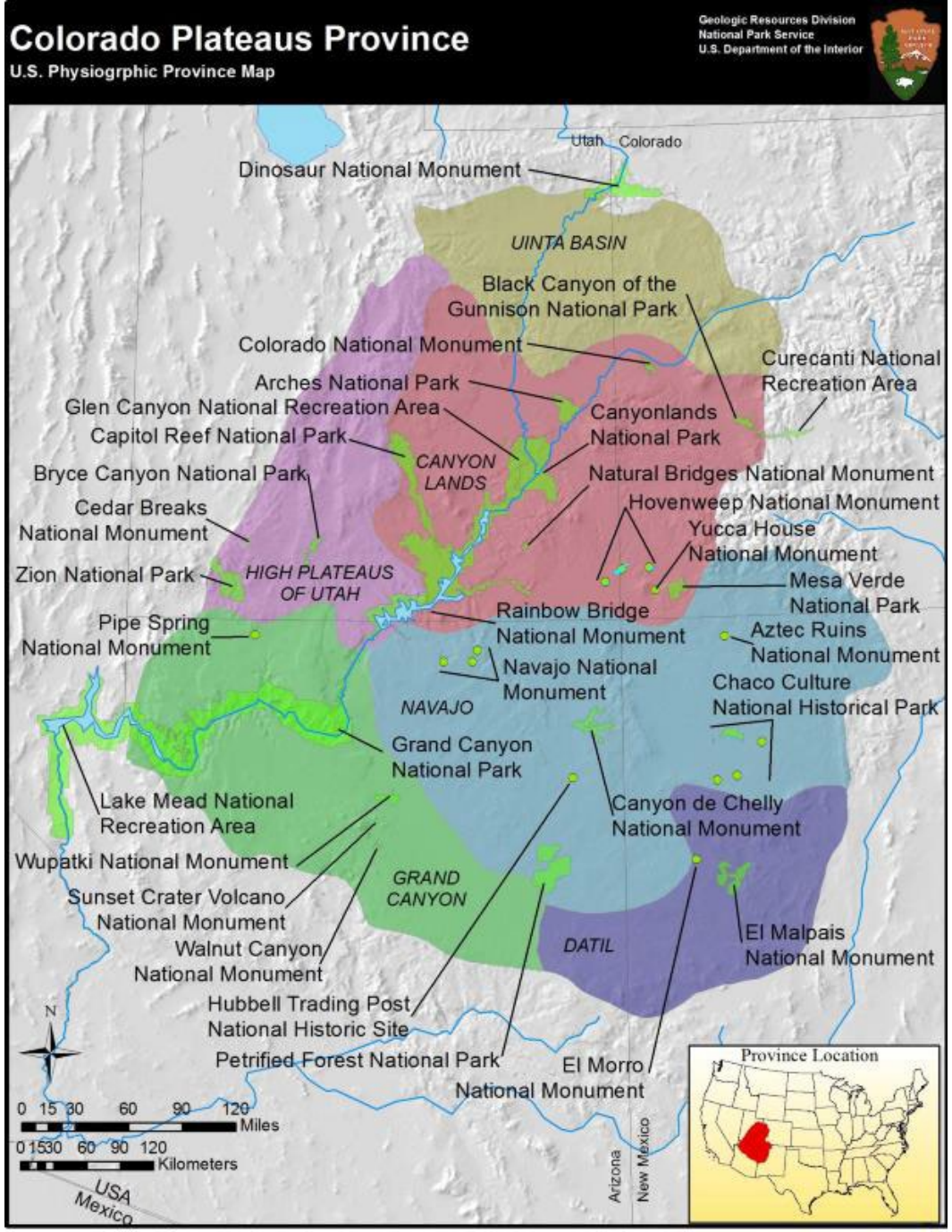


reddit.com/r/GeologySchool/comments/nybg4i/meandering_and_braided_patterns_for_fluvial/

The Colorado Plateau

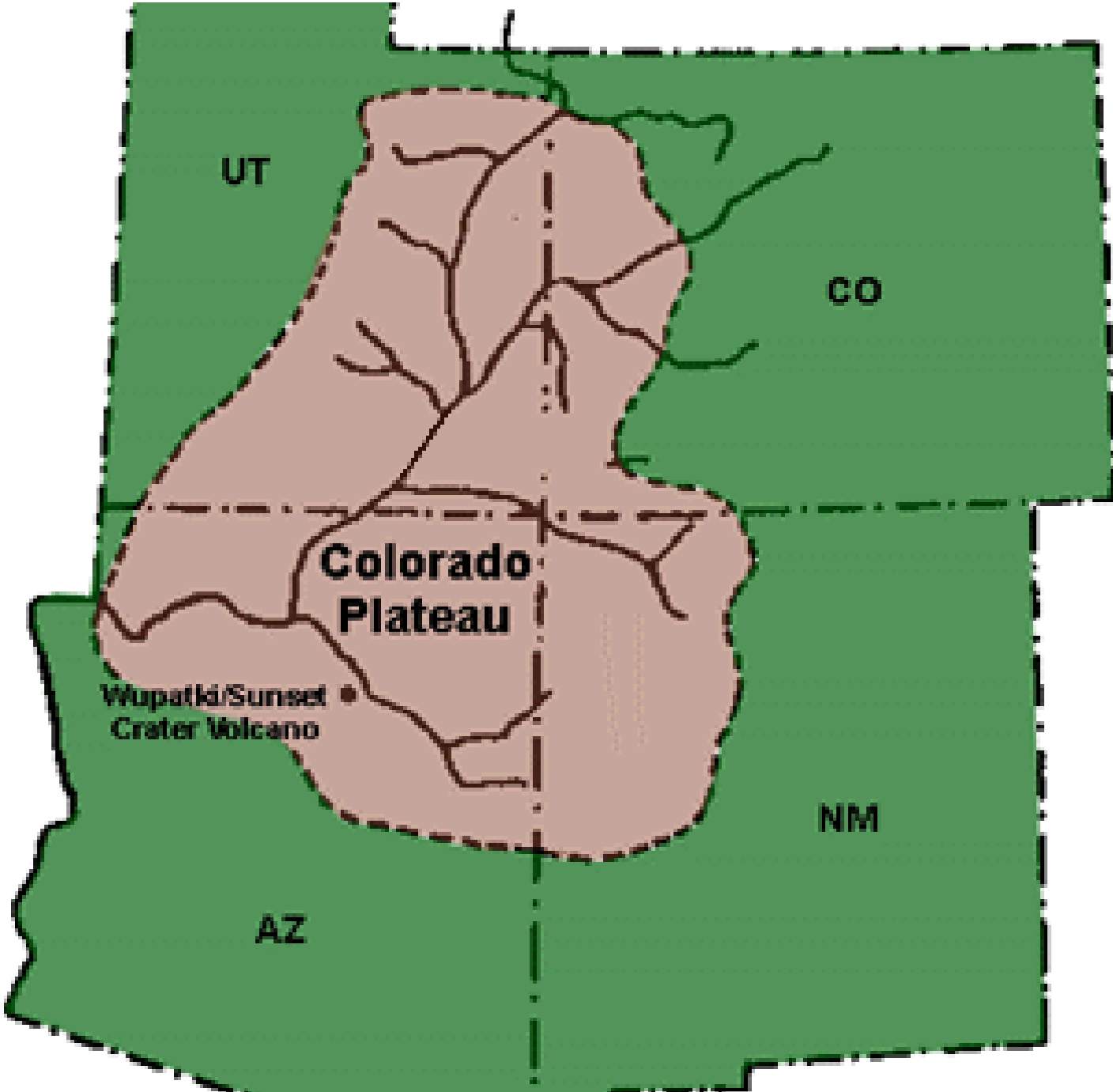
- Let’s take what we’ve learned and see why the Colorado Plateau looks like it does for such a large area



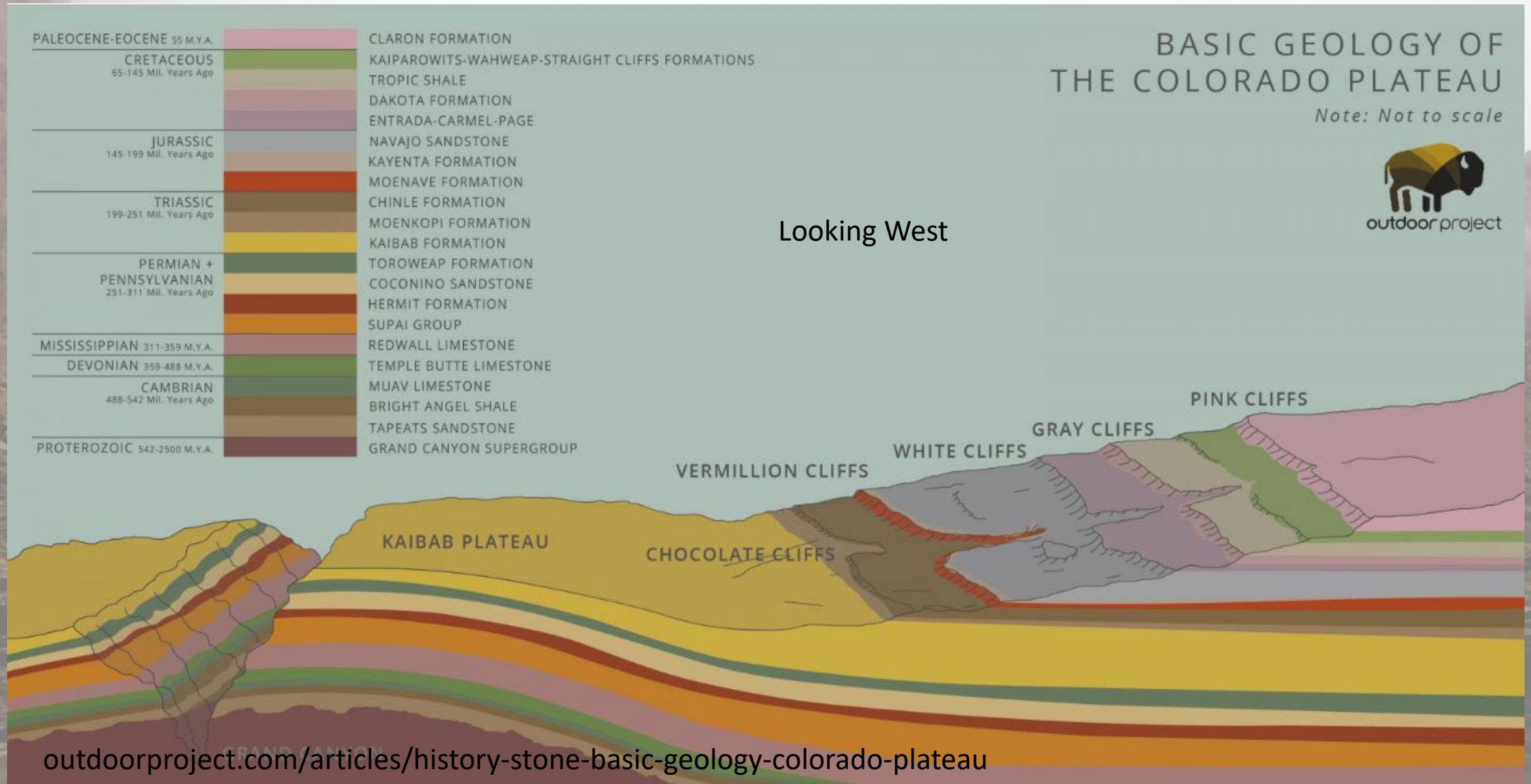


nps.gov/articles/coloradoplateaus.htm

en.wikipedia.org/wiki/Colorado_Plateau



Structural Geology of the Colorado Plateau

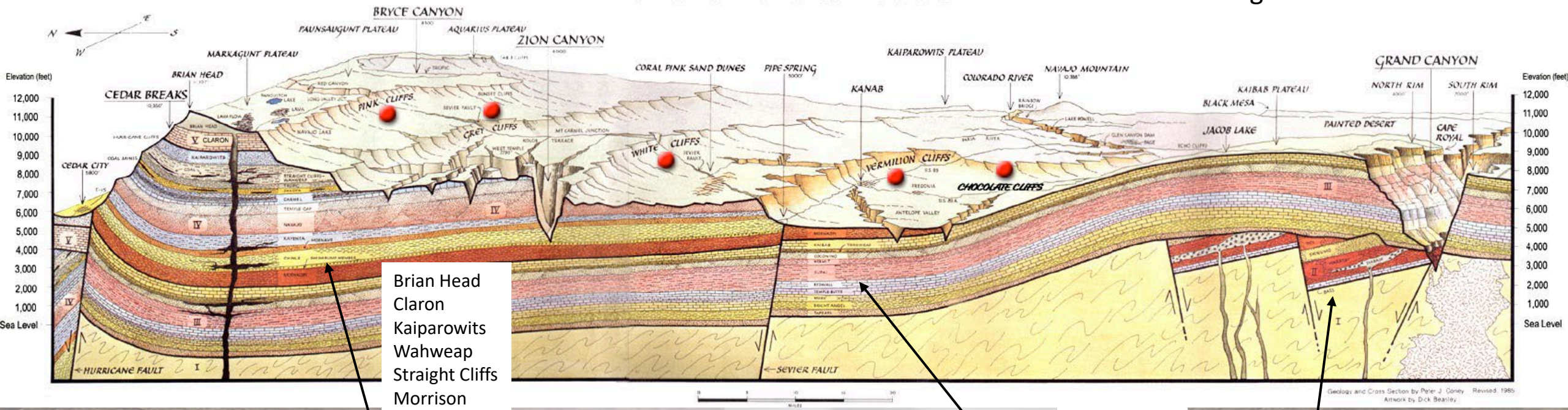


outdoorproject.com/articles/history-stone-basic-geology-colorado-plateau

Stratigraphy / History of the Colorado Plateau

The Grand Staircase

Looking East



https://geo.libretexts.org/Bookshelves/Geology/Book%3A_An_Introduction_to_Geology_(Johnson_Affolter_Inkenbrandt_and_Mosher)/07%3A_Geologic_Time/7.04%3A_Correlation

Brian Head
Claron
Kaiparowits
Wahweap
Straight Cliffs
Morrison
Summerville
Entrada
Carmel
Temple Cap
Navajo
Kayenta
Moenave
Wingate
Chinle
Moenkopi

Moenkopi
Kaibab
Coconino
Hermit
Supai
Redwall
Temple Butte
Muav
Bright Angel
Tapeats

Grand Canyon Supergroup

Stratigraphy / History of the Colorado Plateau

csmsgeologypost.blogspot.com/2012/04/moenkopi-formation.html

Generalized stratigraphic column of the Colorado Plateau and surrounding region

74 MY: Shallow marine, Lake, Floodplain - dinosaur, plant & early mammal fossils
76 MY: Shallow marine - fossils of clams, ammonites, burrows
78 MY: River floodplain, costal swamp - leaf impressions, etc.
81 MY: Shallow marine - fossils of clams, crustacians, driftwood
86 MY: Deep marine
100 MY: Marine beach
150 MY: Terrestial - Many fossils: Conifers, frogs, lizards turtles, dinosaurs (stegosaurus, sauropod)
165 MY: Alternating marine, tidal flats & sandstone - fossil bivalves and ammonites
180 MY: Terrestial - fossilized sand dunes
195 MY: Floodplains - fish fossils
200 MY: Terrestial - fossilized sand dunes
220 MY: Floodplains - gastropod, lungfish, bivalve fossils, petrified wood, coal, volcanic ash, conchostracans
240 MY: Shallow marine - shark, lungfish, coelacanth, ripple marks
250 MY: Marine - coral, mollusks brachiopods worms, fish teeth
260 MY: Terrestial - fossil tracks
265 MY: Terrestial - plant fossils
300 MY: Terrestial - amphibians, reptiles, plant fossils
335 MY: Marine - trilobite, clam brachiopod, coral, snail fossils
515 - 545 MY: Marine - trilobite, and brachiopod fossils; trilobite trails

The original image was modified using a variety of sources. All named strata are not necessarily found in each of the national parks listed - the upper and lower boundaries shown reflect the approximate age of the strata exposed in the parks.

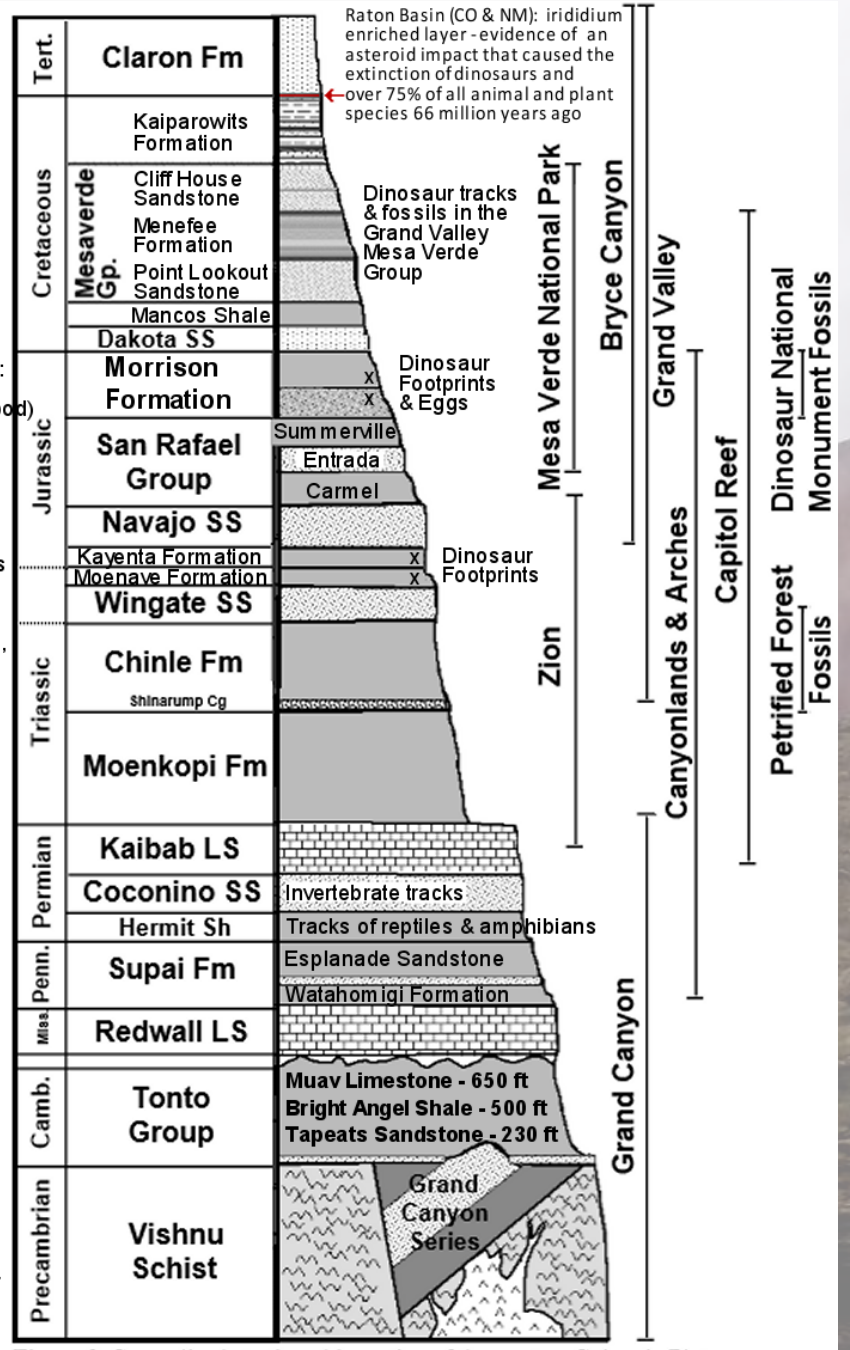
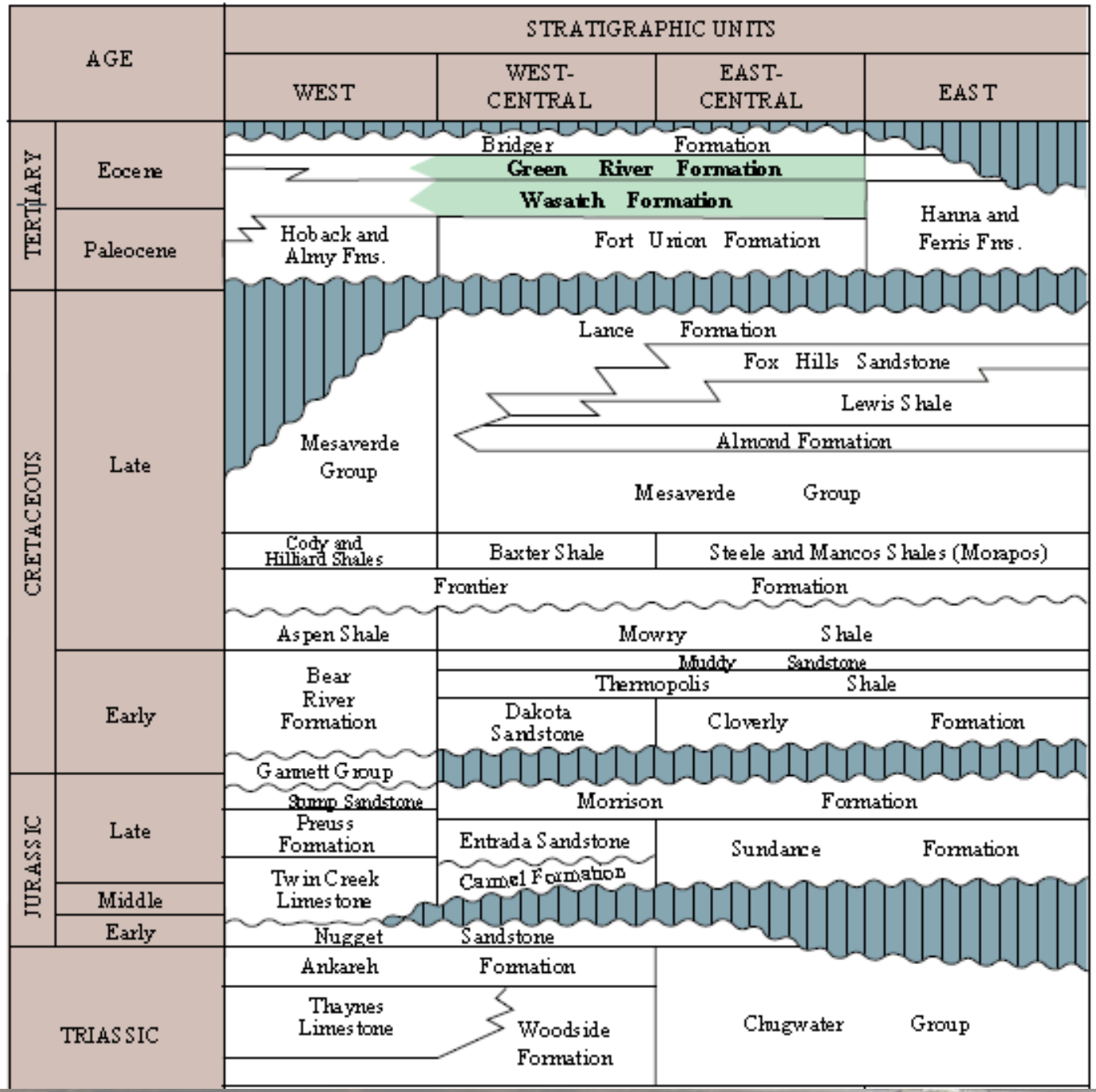


Figure 9. Generalized stratigraphic section of the western Colorado Plateau.
http://www.nature.nps.gov/geology/education/foos/plateau.pdf

Original image modified by data from https://commons.wikimedia.org/wiki/File:USGS_Stratigraphy.gif



Units change laterally (east to west, north to south) as well as vertically. Stratigraphic columns can be drawn to display the changes in rock type and name.

This graphic is from a study of Mesozoic and Cenozoic geologic units within the Colorado Plateau of Rocky Mountains provinces.

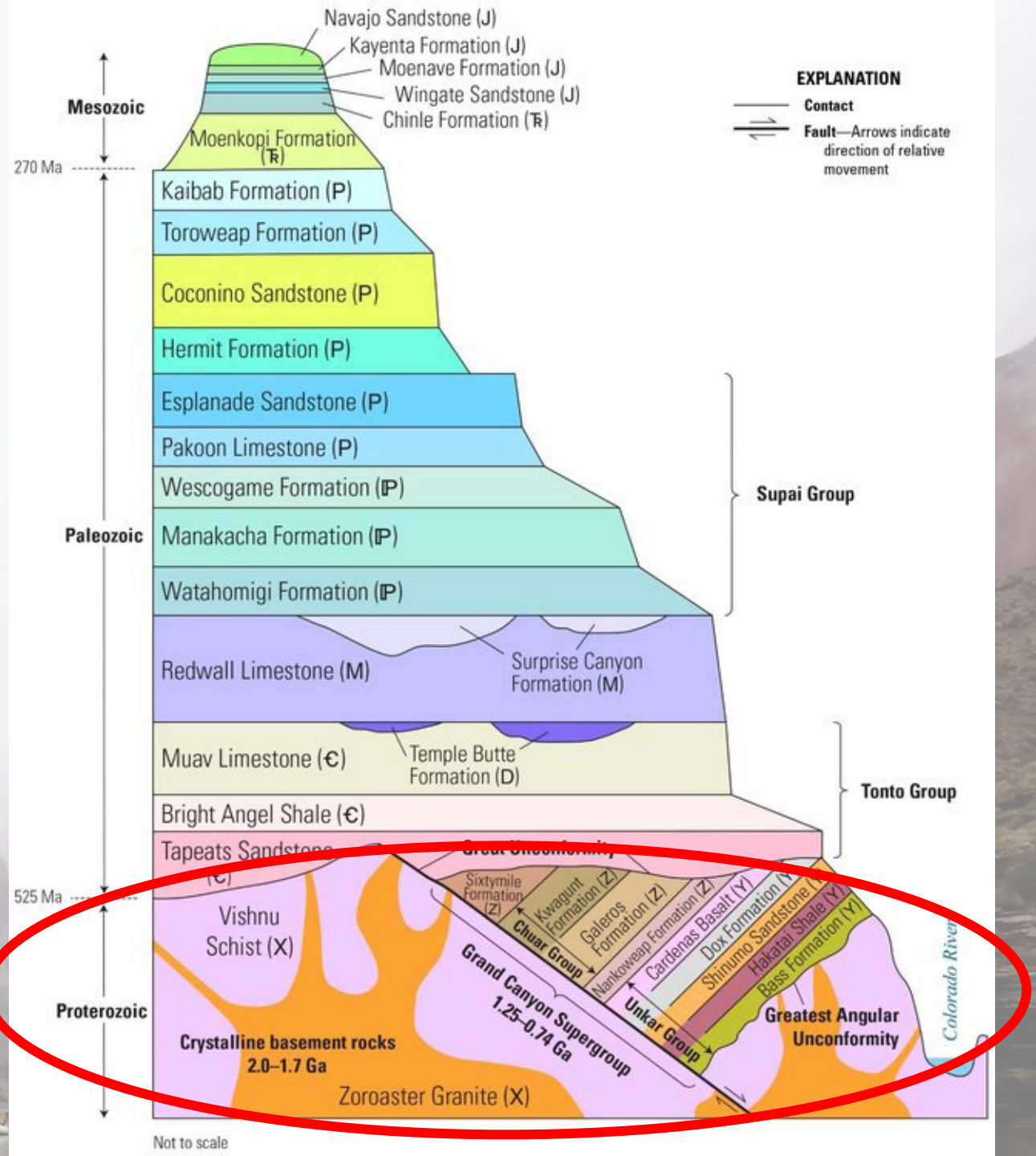
Graphic by Stephen B. Roberts - Geologic Assessment of Undiscovered Petroleum Resources in Wasatch-Green River Composite Total Petroleum System, Southwestern Wyoming, Colorado, and Utah, USGS Digital Data Series DDS-69-D, Public Domain, https://commons.wikimedia.org/w/index.php?curid=59499140

Evolution of the Colorado Plateau

The geologic history of the Colorado Plateau can be subdivided into six broad periods ranging from Precambrian to Recent.

Period 1: Two time periods – basement rocks from 1.7 to 2.0 billion years old and Grand Canyon Supergrjoup from 1.25 to 0.74 billion years old.

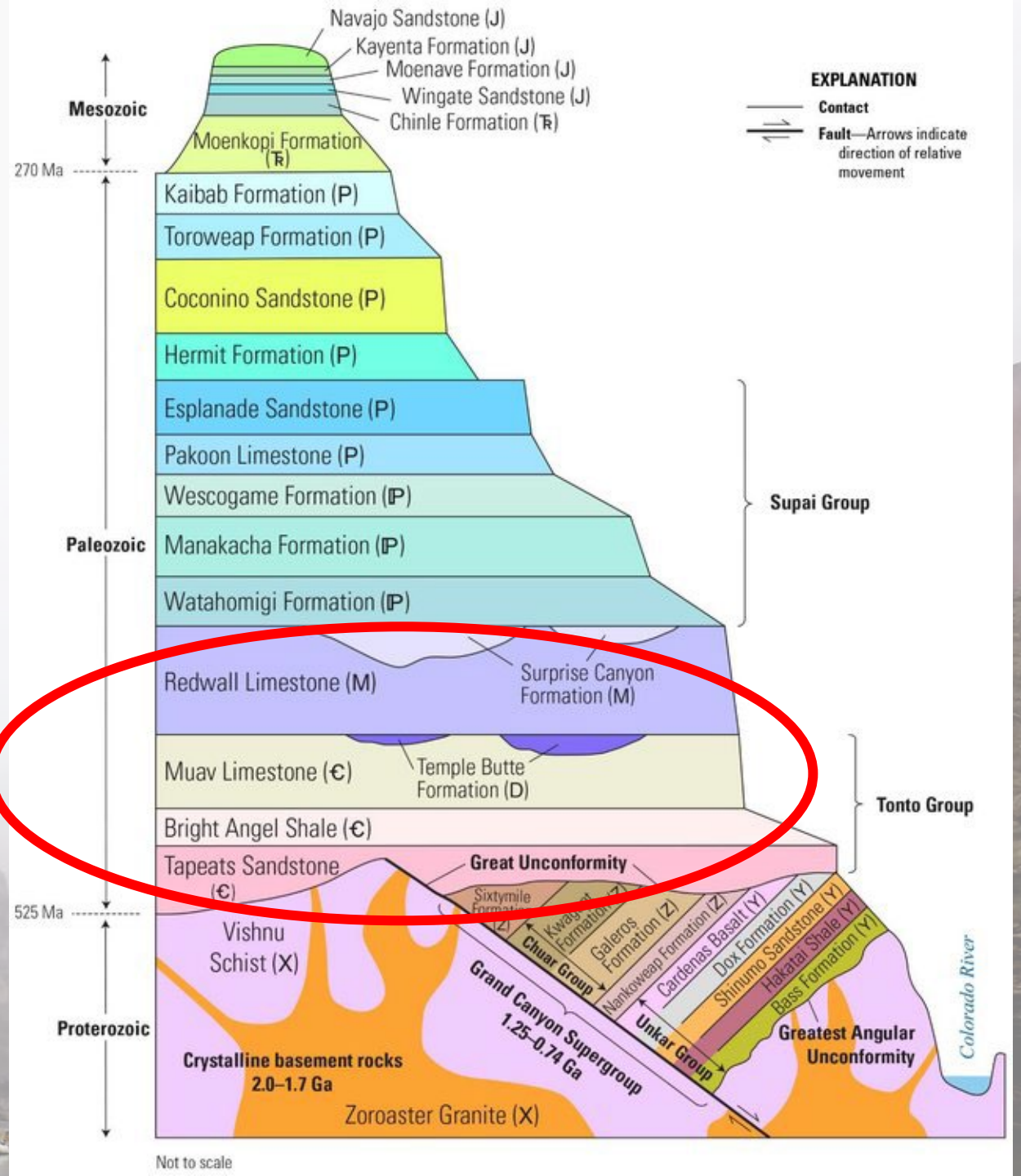
researchgate.net/publication/340550094_Chapter_3_Stratigraphy_of_Grand_Canyon_National_Park/figures



Evolution of the Colorado Plateau

Period 2 – Cambrian (525 million years) through Mississippian (325 million years) time.

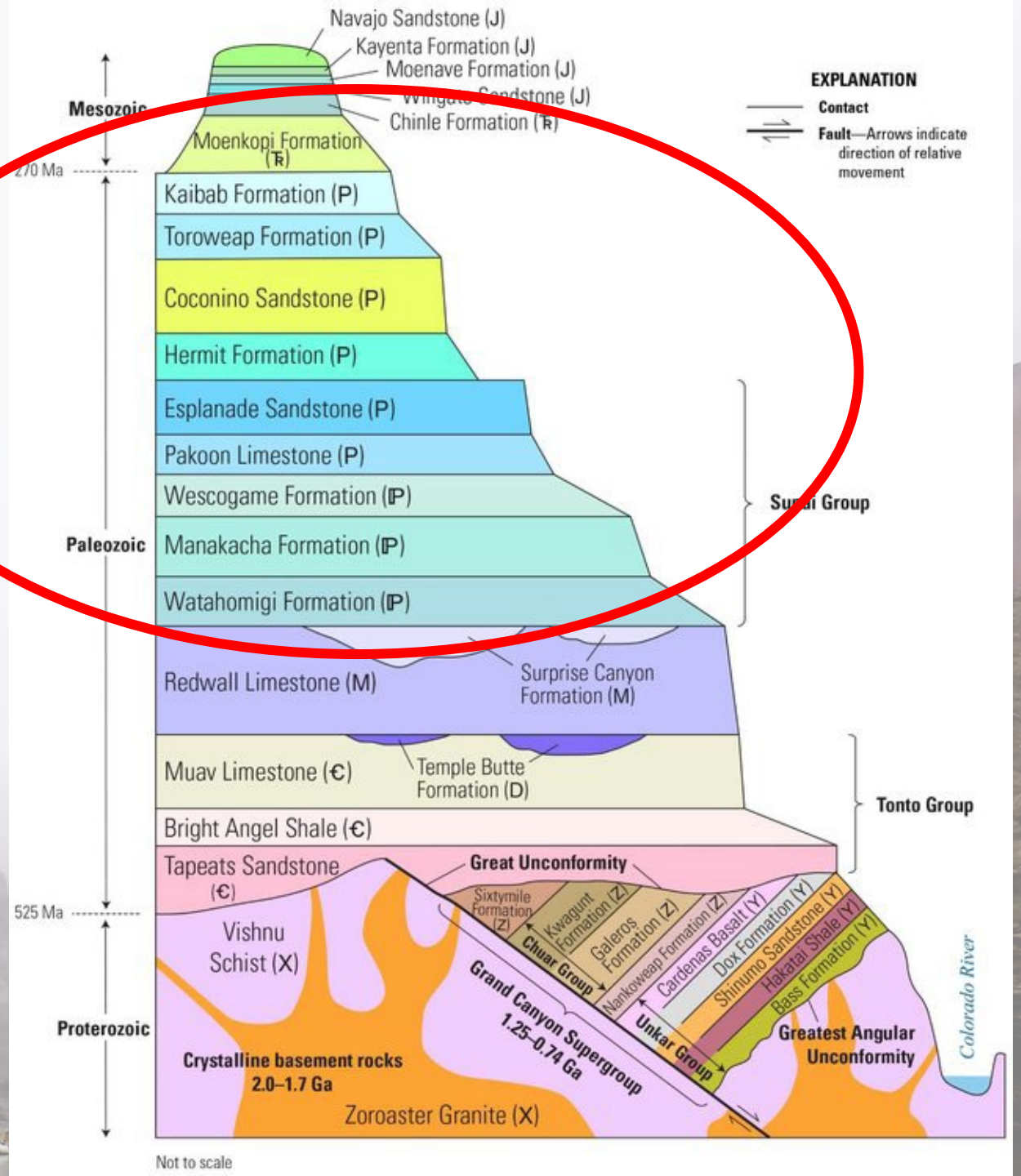
Includes the Tapeats Sandstone, Bright Angel Shale, Muav Limestone, Temple Butte Fm., Redwall Limestone, and Surprise Canyon Fm.



Evolution of the Colorado Plateau

Period 3: Permian (290 million years) through Triassic (200 million years). Note that we skipped the Pennsylvanian period!

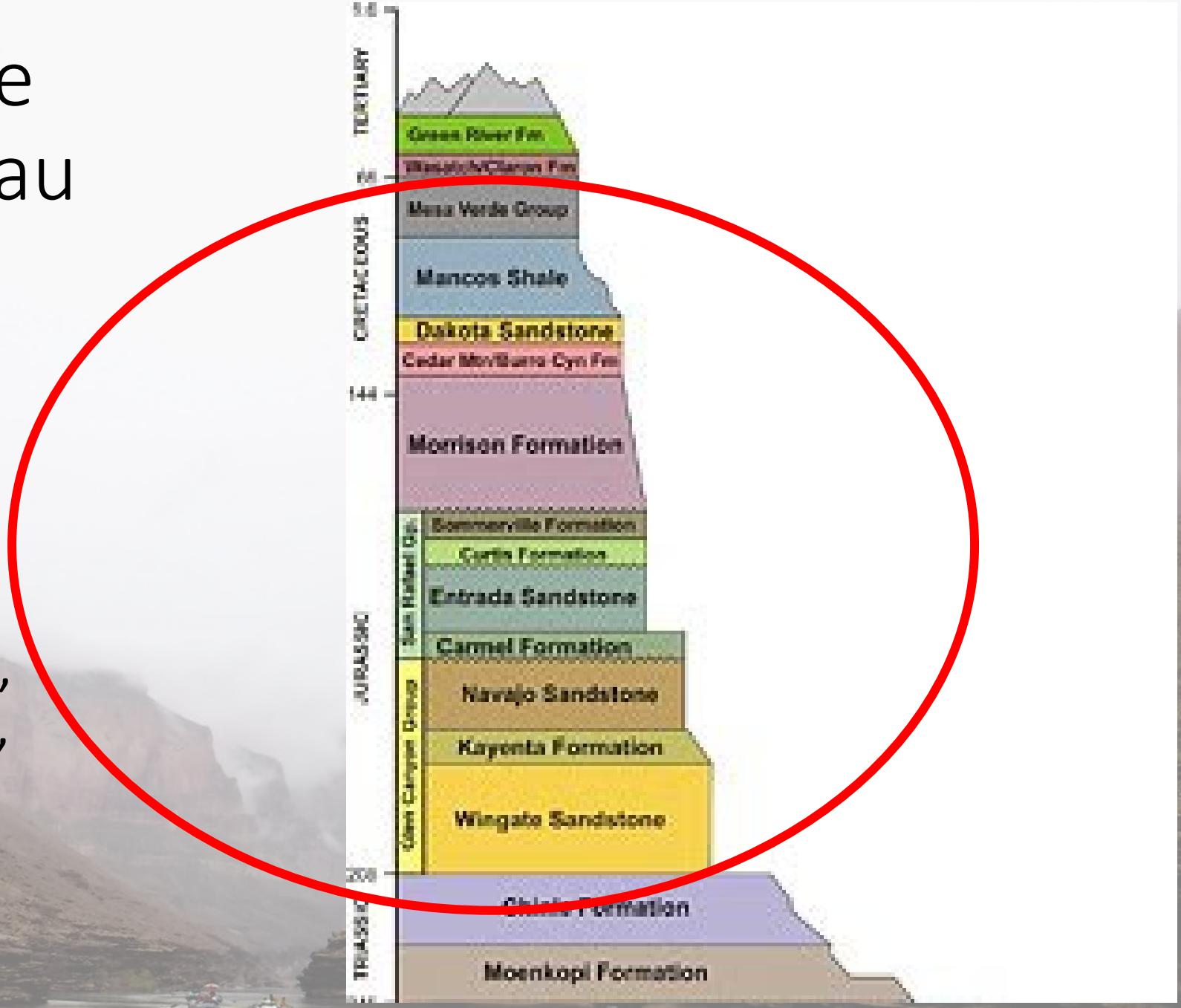
Includes the Supai, Hermit, Coconino. Toroweap, Kaibab, Moenkopi, and Chinle.



Evolution of the Colorado Plateau

Period 4: Jurassic (290 million years) through Cretaceous (80 million years).

Includes the Wingate, Kayenta, Navajo, Carmel, Entrada, Curtis, Summerville, Morrison, Dakota, Mancos, Mesaverde, and Kaiparowits formation.

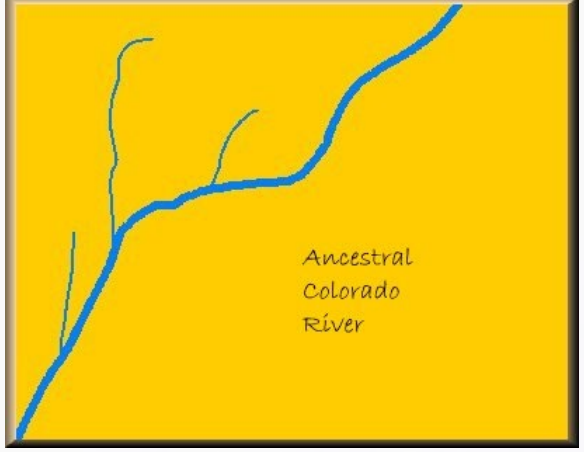


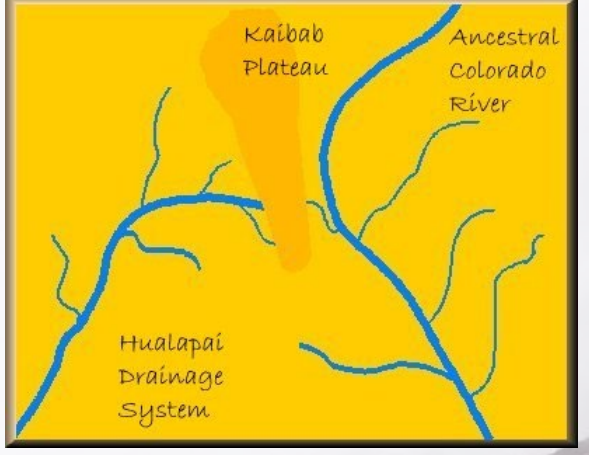
http://geologyhappens.blogspot.com/2012/

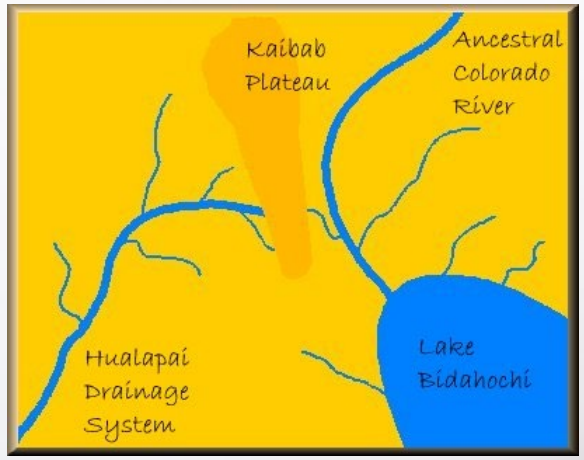
Evolution of the Colorado Plateau

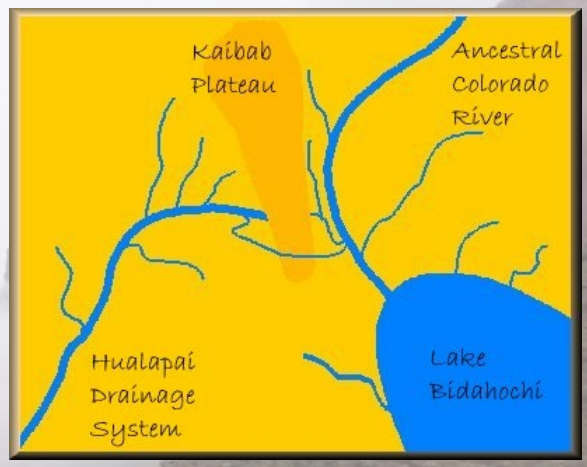
Period 5: Middle Tertiary (~40 million years) nearly until modern times.

Volcanism around periphery of Colorado Plateau and establishment of streams.









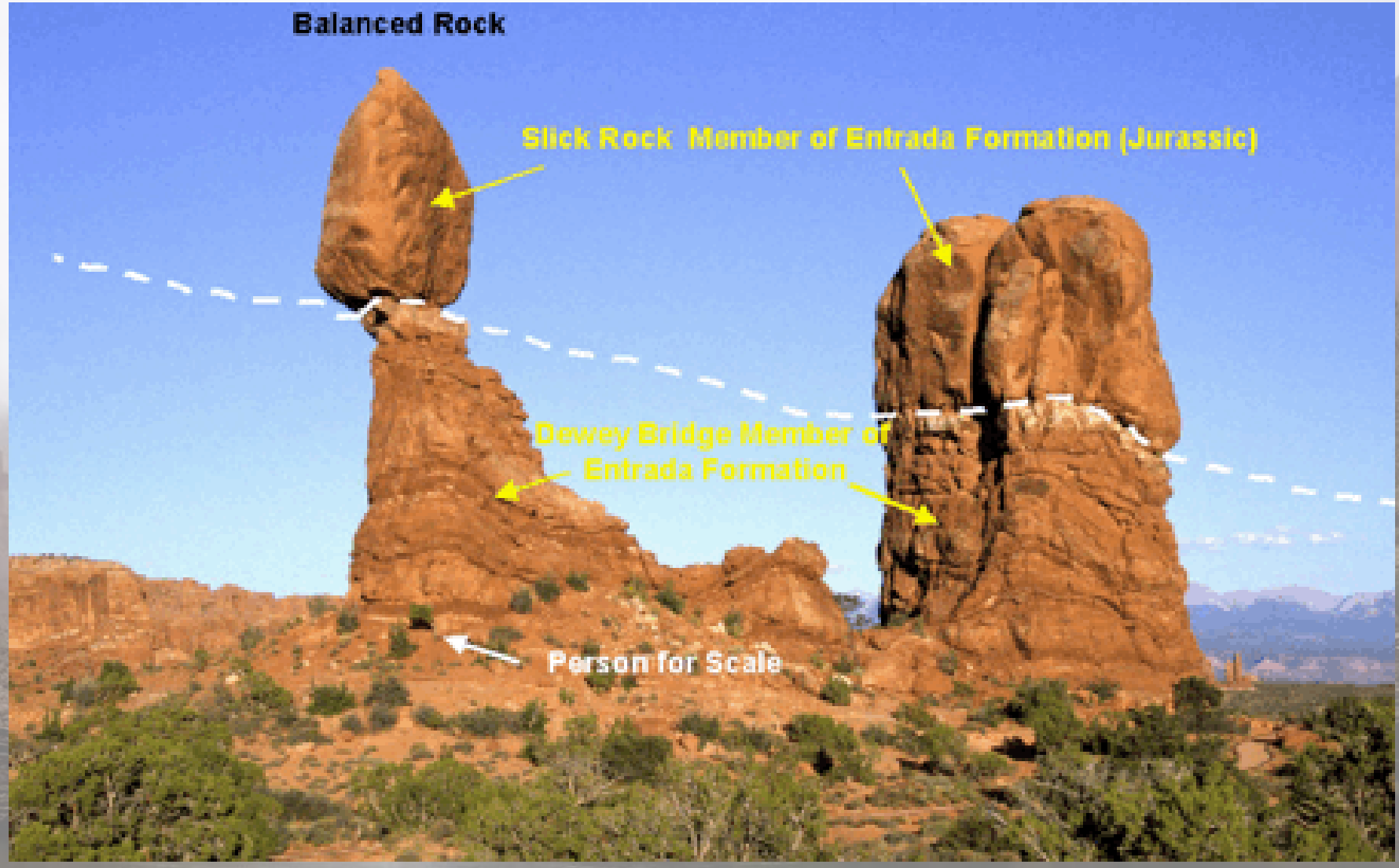
http://www.bobspixels.com/kaibab.org/geology/canform.htm

Evolution of the Colorado Plateau

jsjgeology.net/GeologyoftheNationalParks/Arches.htm

Period 6:
Modern times

Widespread erosion



So why do our rivers look so similar across the Colorado Plateau?

- Similar environment and ecosystem – high desert with scattered areas of forest.
- Underlain by thick stack of stratified rock laid down from Paleozoic through Cenozoic time - hundreds of millions of years.
  - Similar rocks throughout the region because of very similar geologic history (Cretaceous seaway extended from Canada to Mexico and Nevada to Kansas).
  - Vivid and varied color within the strata
- Relatively little structural geology over massive amounts of time – leading to similar structural geologic environment across vast expanses of land.
  - Widespread, gentle uplift such that the strata remain relatively flat-lying.
- Presence of large rivers and tributaries (despite the arid climate)

UNIQUE!