Un paseo geológico por los Parques del SO de EEUU (Nevada, Utah y Arizona)

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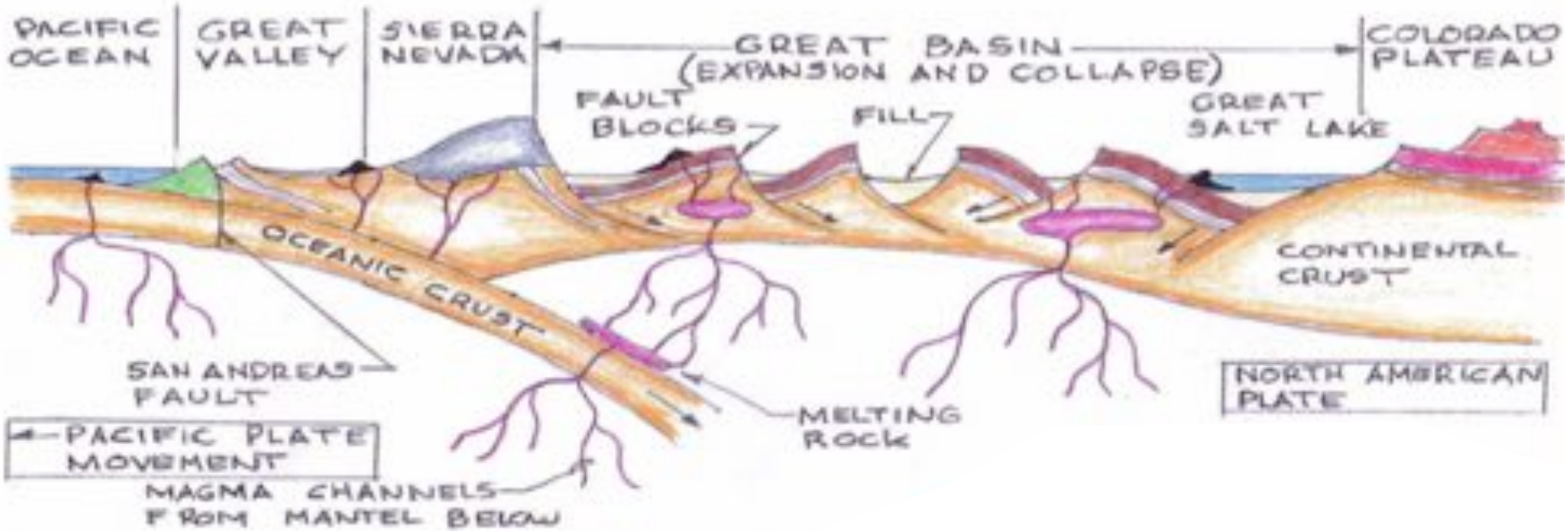
Aula 3201B de la Facultad de CC. Geológicas (UCM) 22 Febrero 2023 13h

UNIVERSIDAD COMPLUTENSE DE MADRID · GEOLÓGICAS

GEOSEN
Geología
Sociedad y Desarrollo

Columbia
plateau
Rocky
mountains
Williston
Basin
Michigan
Basin
Uinta mountains
Pacific mountains
Sierra Nevada mountains
Basin
and
Range
Sevier Thrust belt
Colorado
plateau
Great plains
Interior lowlands
Illinois
Basin
Appalachian mountains
Ouachita basin
Anadarko
Basin
Ouachita structural belt
Coastal plain
GEOLOGIC MAP
OF THE
UNITED STATES



GEOLOGIC CROSSECTION OF WESTERN NORTH AMERICA

© Jim Douglas 2011

Colorado Plateau

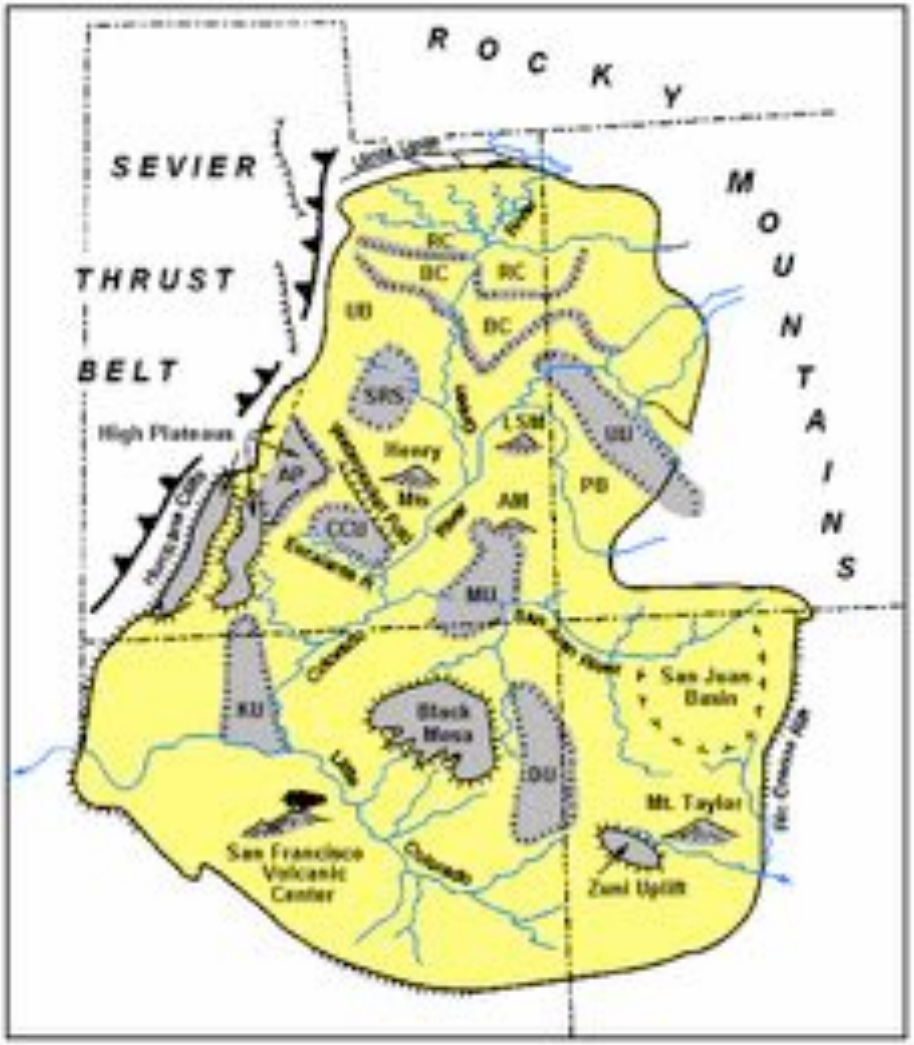
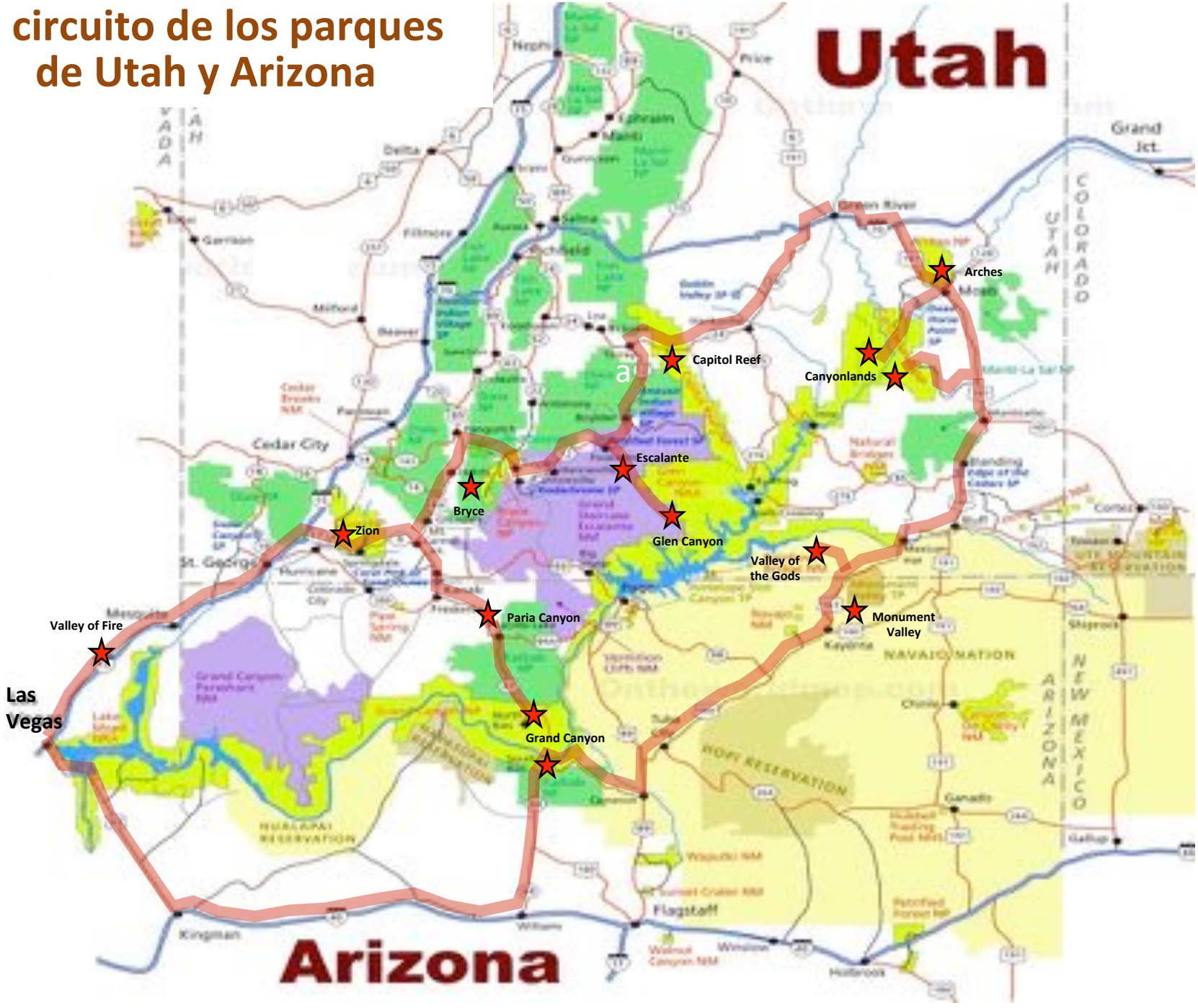


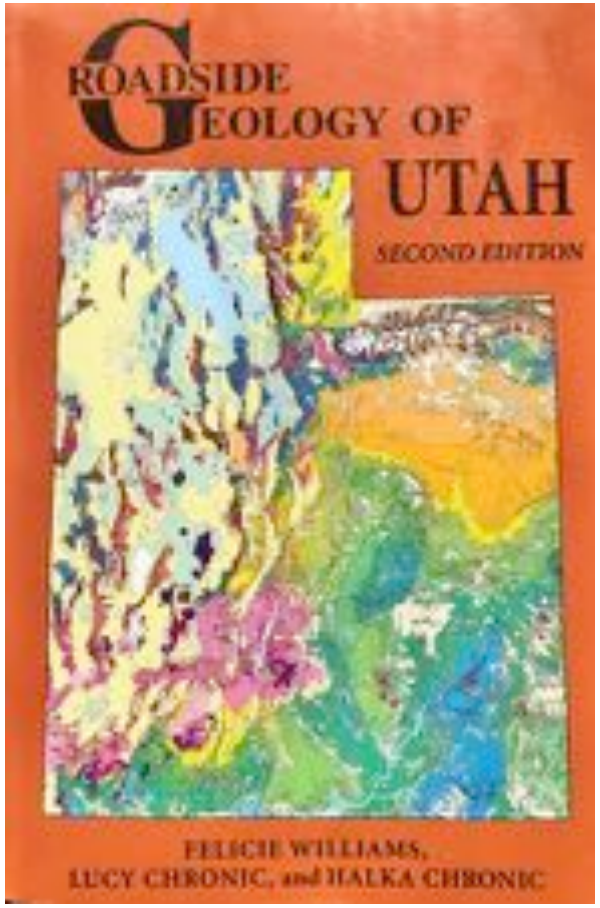
Figure 1. The Colorado Plateau physiographic province, showing some of the significant uplifts, basins, faults, volcanic centers, and rivers. High areas are shown in gray: AM, Abajo Mts.; AP, Aquarius Plateau; BC, Book Cliffs; CCU, Circle Cliffs Uplift; DU, Defiance Uplift; KU, Kaibab Uplift; LSM, La Sal Mts.; MU, Monument Upwarp; RC, Roan Cliffs; SRS, San Rafael Swell; UU, Uncompahgre Uplift. Basins: PB, Paradox Basin; UB, Uinta Basin. Capitol Reef National Park is located on the Waterpocket Fold. Leading edge of Sevier Thrust Belt is shown with sawteeth on upper, overriding thrust plate. Modified from Kiver and Harris, 1999.

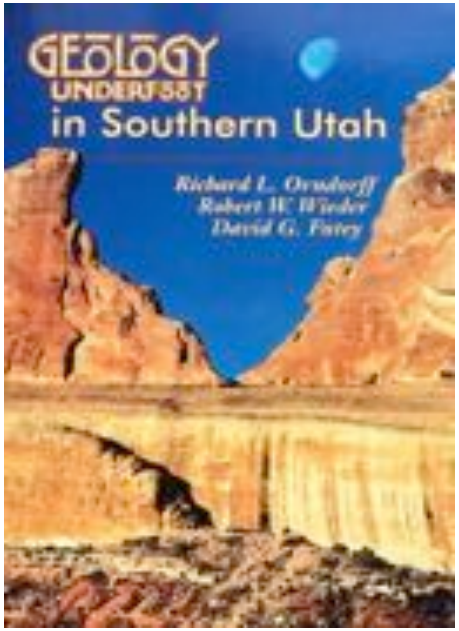
El circuito de los parques de Utah y Arizona

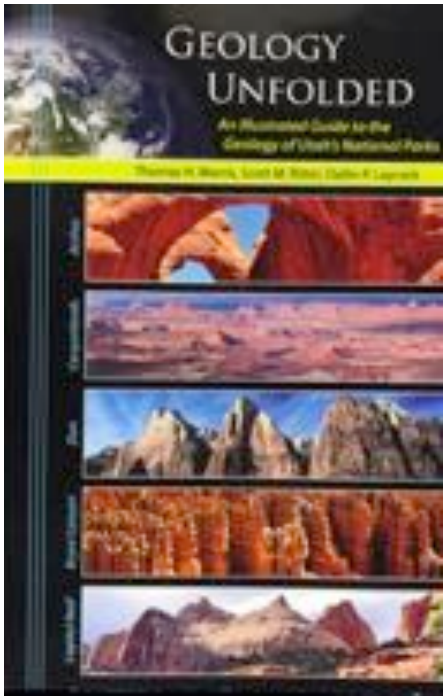


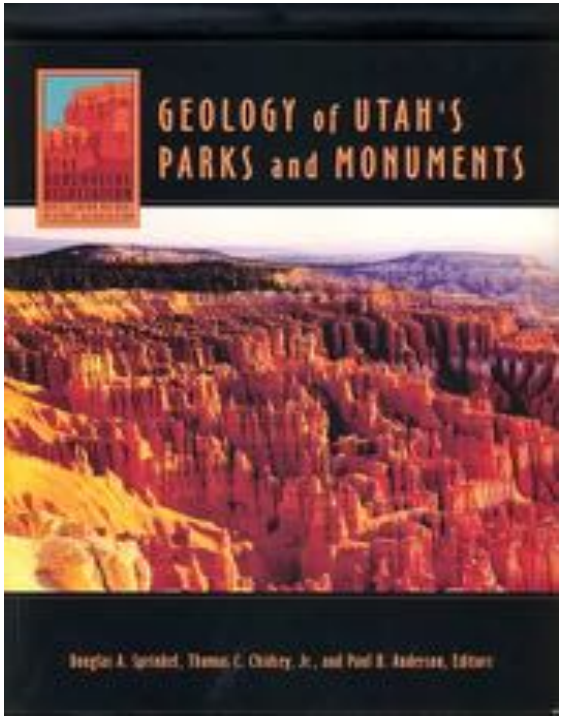
Coche y hotel

La base geológica

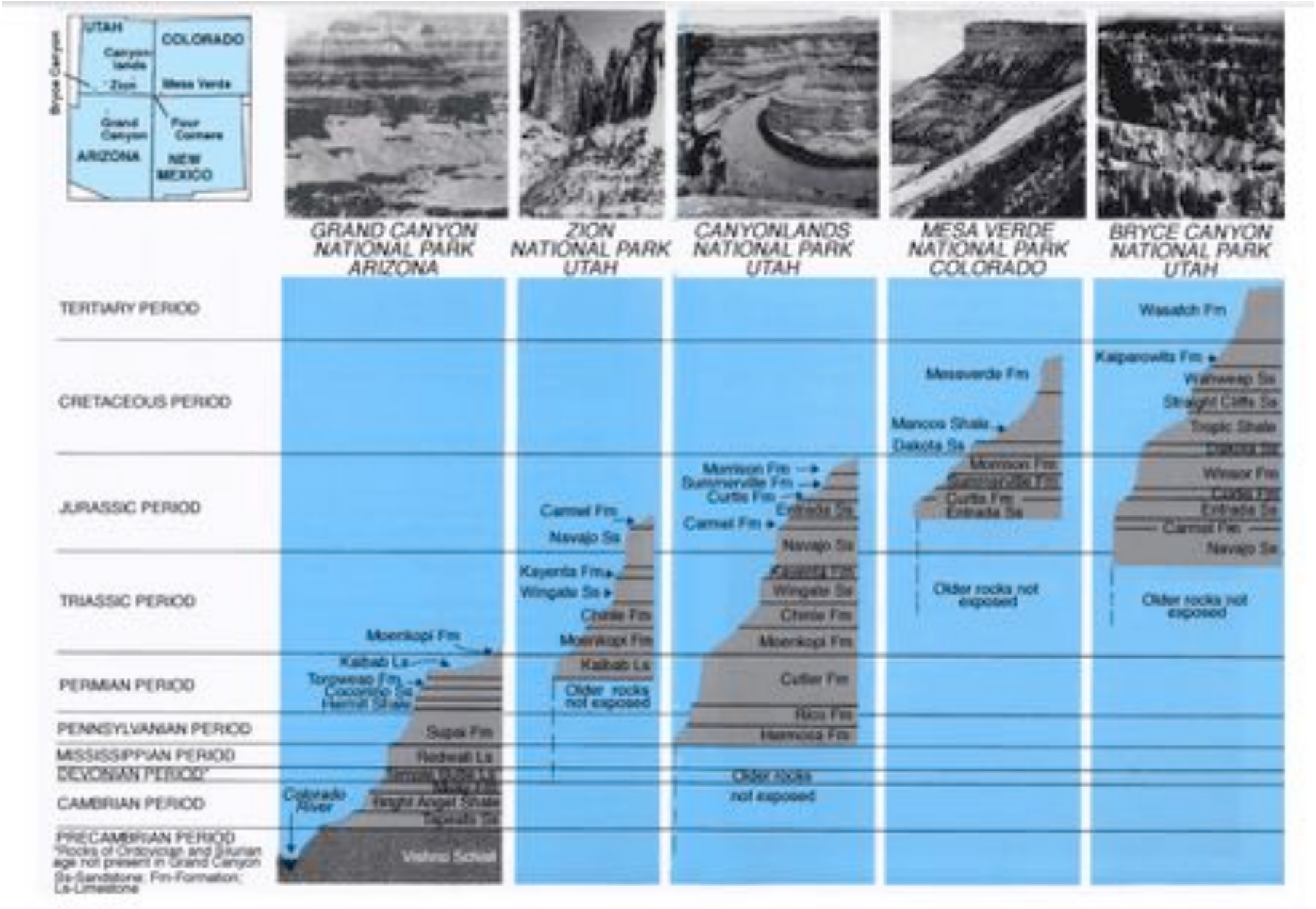






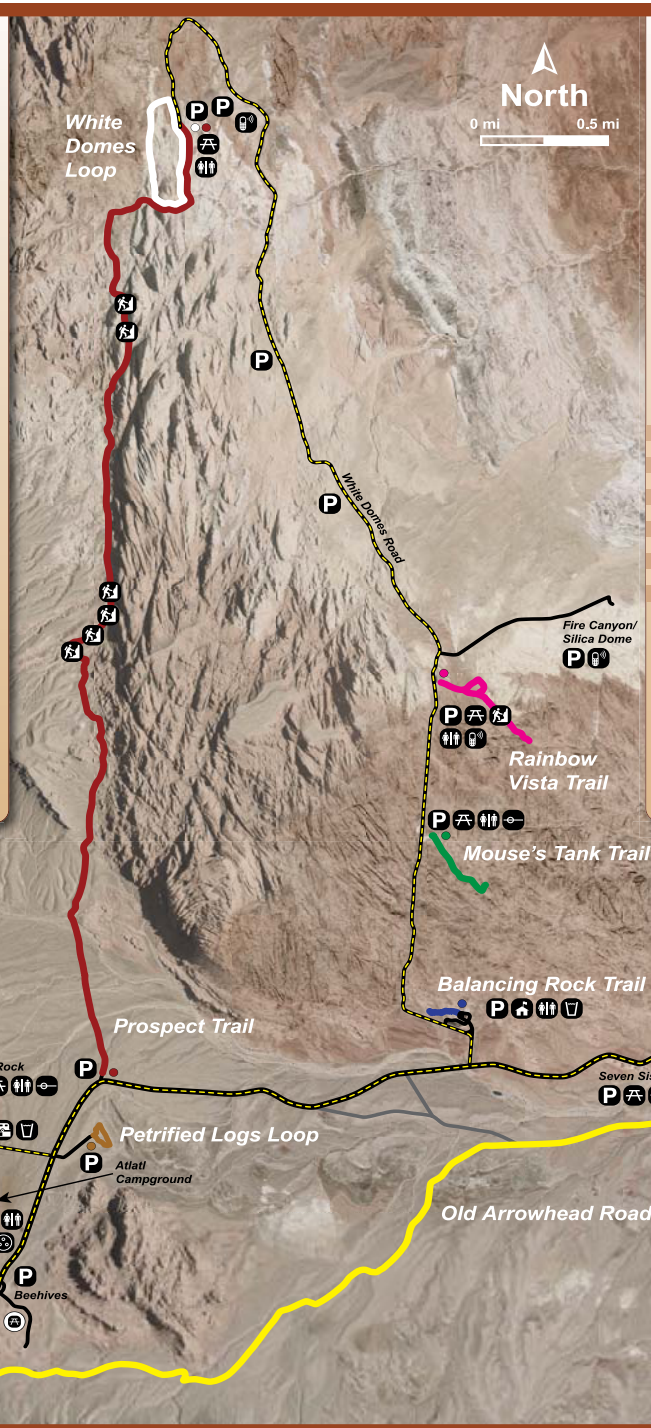


La estratigrafía de los parques



Valley of Fire Statal Park, Nevada

Valley of Fire State Park



TRAIL USE

- Hiking
- Dogs on Leash
- No Bicycles* *Allowed on Old Arrowhead Road
- No Equestrians* *Allowed on Old Arrowhead Road
- No Motor Vehicles

LEGEND

- Parking
- Showers
- Restroom
- Picnic Area
- Petroglyphs
- Campground
- Visitor Center
- Power Hookup
- Drinking Water
- Mobile Service
- Rock Scramble Area
- Group Reservation Area
- Sanitary Disposal Station
- Park Entrance Information
- Trail Access Information
- Gravel Road
- Paved Road
- Minor Trail

TRAIL ACCESS INFORMATION

Trail Name	Length	Typical Grade	Maximum Grade (Standard Ramp is 8.3%)	Typical Cross Slope	Maximum Cross Slope	Typical Tread Width	Minimum Clearance Width	Surface Type	Surface Firmness Typical	Surface Firmness Worst	Surface Stability Typical	Surface Stability Worst
White Domes Loop	1.0 mi	6.6%	176 ft is 26% - 44%	3.3%	77 ft is 21% - 32%	56 in	12 in	Sand/Soil	0.56	1.12	1.14	2.14
Old Arrowhead Road	6.8 mi	4.7%	87 ft is 31% - 39%	2.6%	374 ft is 12% - 20%	64 in	16 in	Soil/Sand	0.26	0.65	0.62	1.45
Natural Arches	2.5 mi	2.3%	106 ft is 11% - 21%	2.2%	148 ft is 11% - 13%	8 ft	2 ft	Sand	1.02	1.04	2.11	2.13
Petrified Logs Loop	0.3 mi	6.2%	69 ft is 21% - 35%	3.3%	27 ft is 11% - 13%	34 in	18 in	Soil	0.17	0.18	0.47	0.88
Rainbow Vista	1.0 mi	4.4%	70 ft is 21% - 31%	2.9%	163 ft is 11% - 20%	47 in	18 in	Sand	0.89	1.00	1.79	2.07
Prospect Trail	4.6 mi	5.5%	748 ft is 21% - 46%	3.0%	369 ft is 11% - 17%	6 ft	1 ft	Rock/Soil/Sand	0.39	1.11	1.09	2.08
Elephant Rock Loop	1.2 mi	9.4%	96 ft is 31% - 39%	4.1%	314 ft is 13% - 20%	37 in	16 in	Sand/Soil	0.29	0.65	0.70	1.52
Balancing Rock	0.1 mi	11.4%	94 ft is 21% - 31%	3.6%	26 ft is 11% - 22%	30 in	18 in	Crushed Stones	0.17	0.17	0.34	0.42
Charlie's Spring	4.7 mi	1.9%	321 ft is 11% - 23%	1.7%	55 ft is 11% - 17%	8 ft	2 ft	Sand	0.55	1.06	1.09	2.18
Mouse's Tank	0.7 mi	3.6%	71 ft is 21% - 31%	2.8%	72 ft is 11% - 12%	6 ft	2 ft	Sand	0.60	0.96	1.41	1.95
Pinnacles Loop	4.5 mi	4.8%	298 ft is 21% - 47%	3.2%	243 ft is 13% - 26%	63 in	18 in	Sand/Soil	0.79	1.05	1.65	2.08

Surface Firmness (in)

- <0.20 Hard
- 0.35 Firm
- 0.55 Moderately Firm
- >0.55 Not Firm

Surface Stability (in)

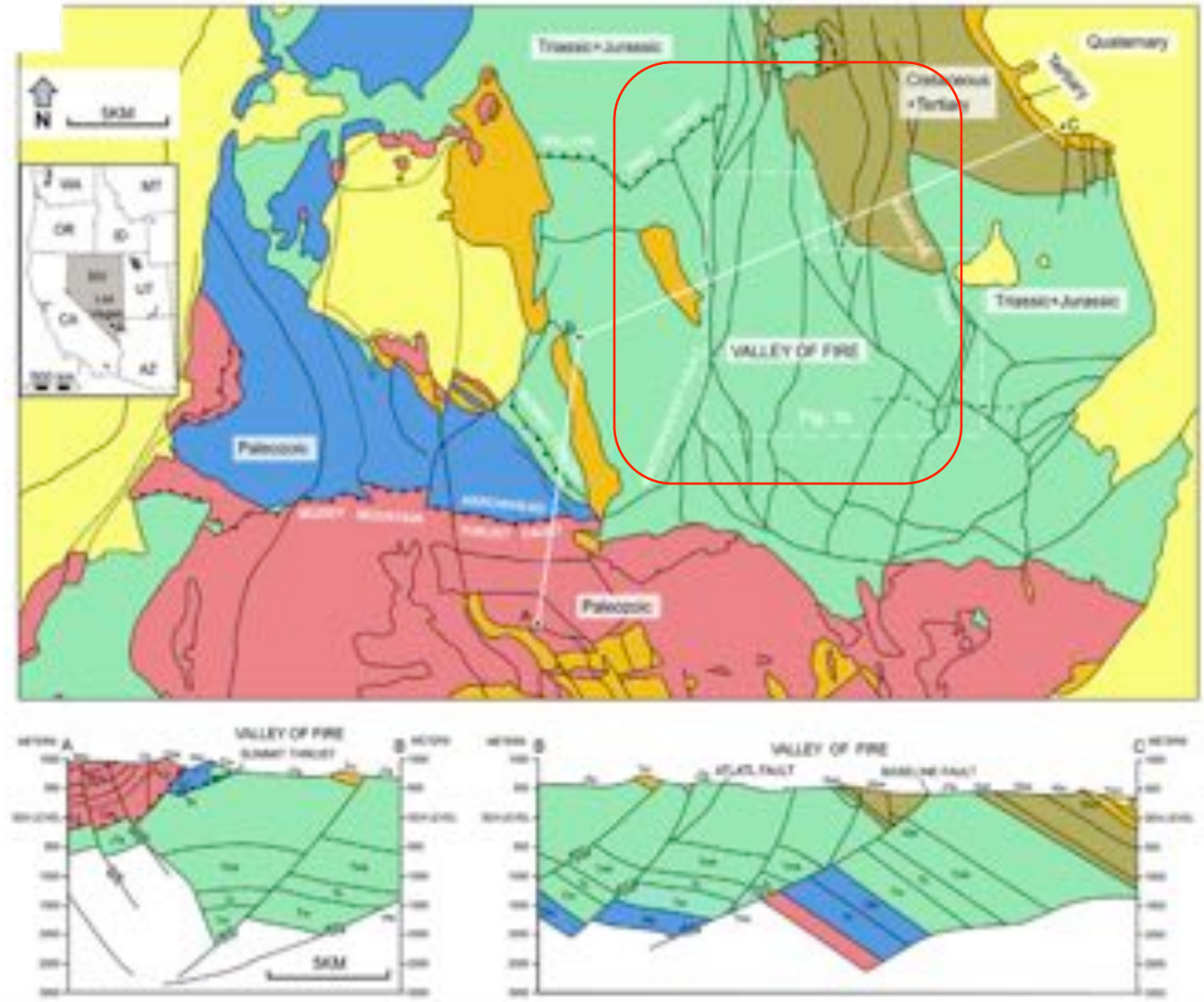
- <0.25 Hard
- 0.55 Stable
- 1.05 Moderately Stable
- >1.05 Not Stable

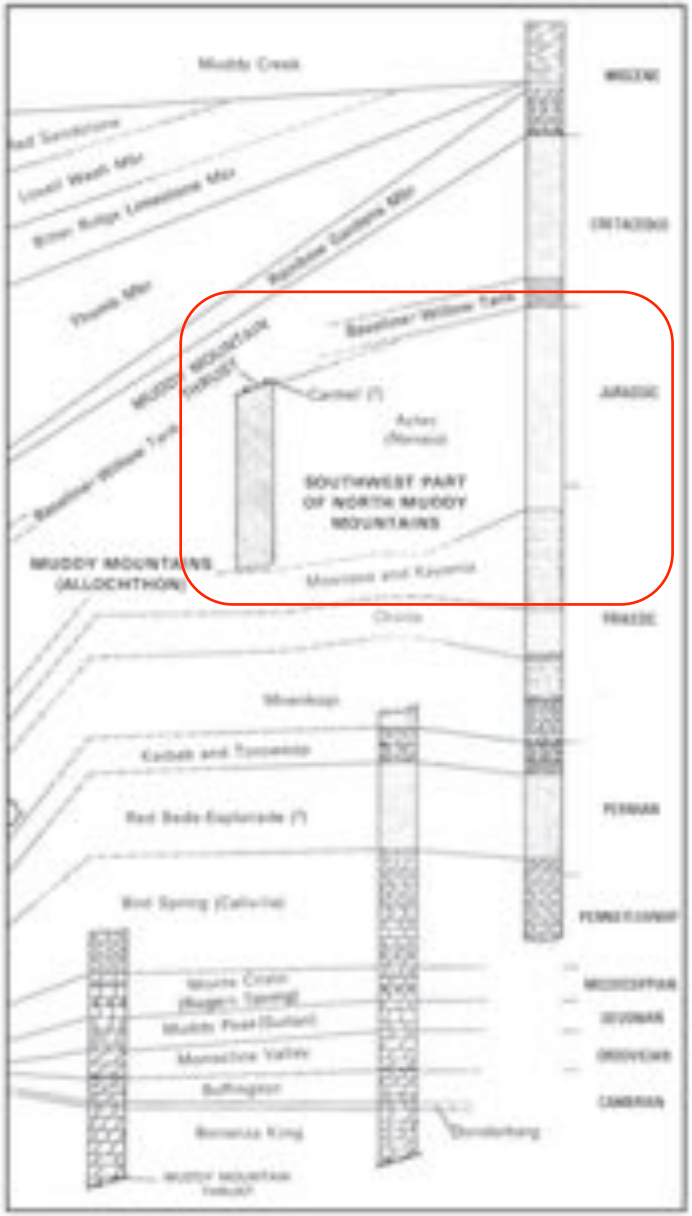
Funded by the **Nevada Recreational Trails Program**

WARNING:
Trail conditions may have changed since February 2011 when these trails were assessed. Secondary trails are shown as gray lines. Signage created by Beneficial Designs Inc. using trail data collected by a certified trail assessment coordinator.

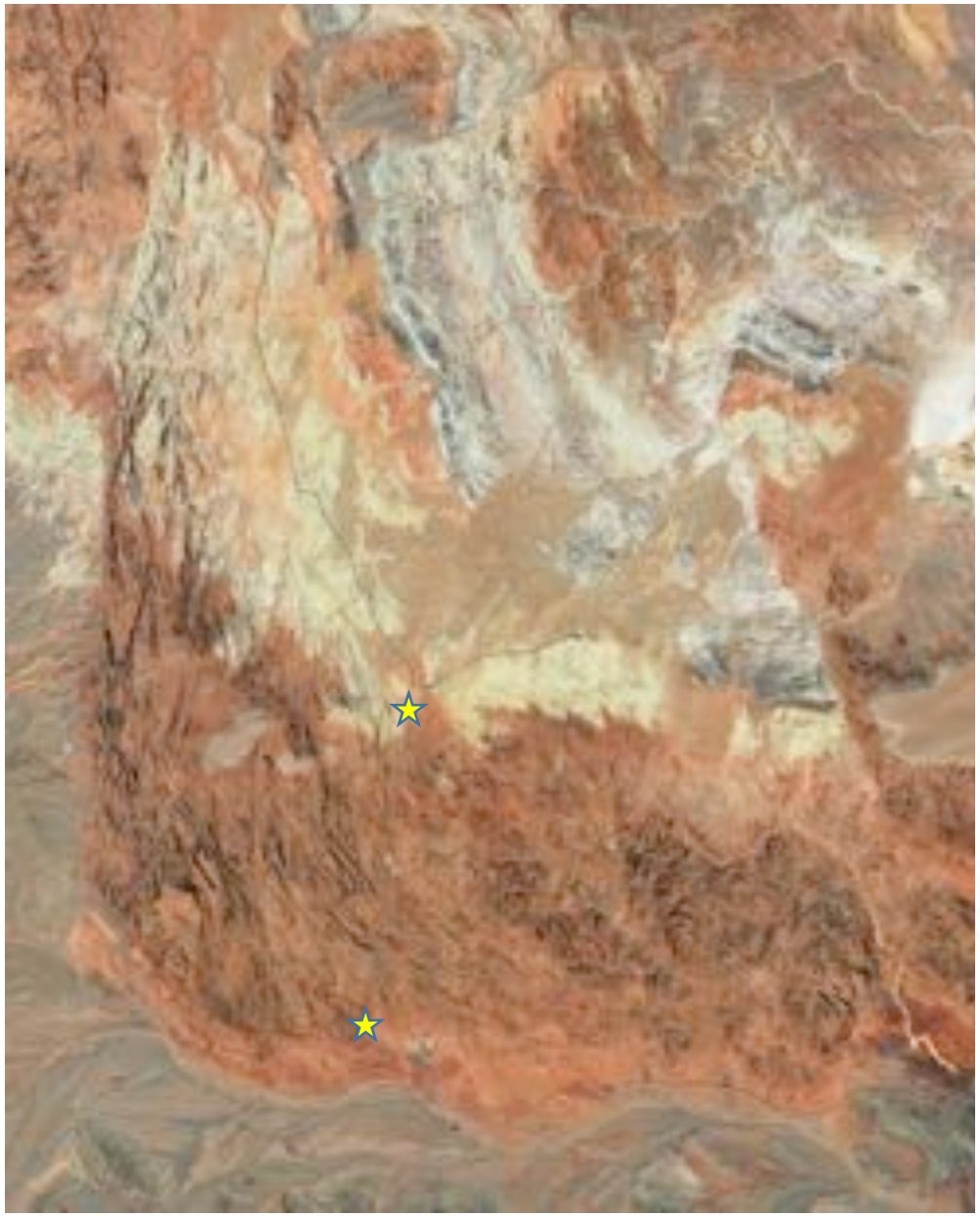
Signage by **Beneficial Designs Inc.**
www.beneficialdesigns.com
Nevada Office: 775.783.8822
"Designing beyond the norm to meet the needs of all people."

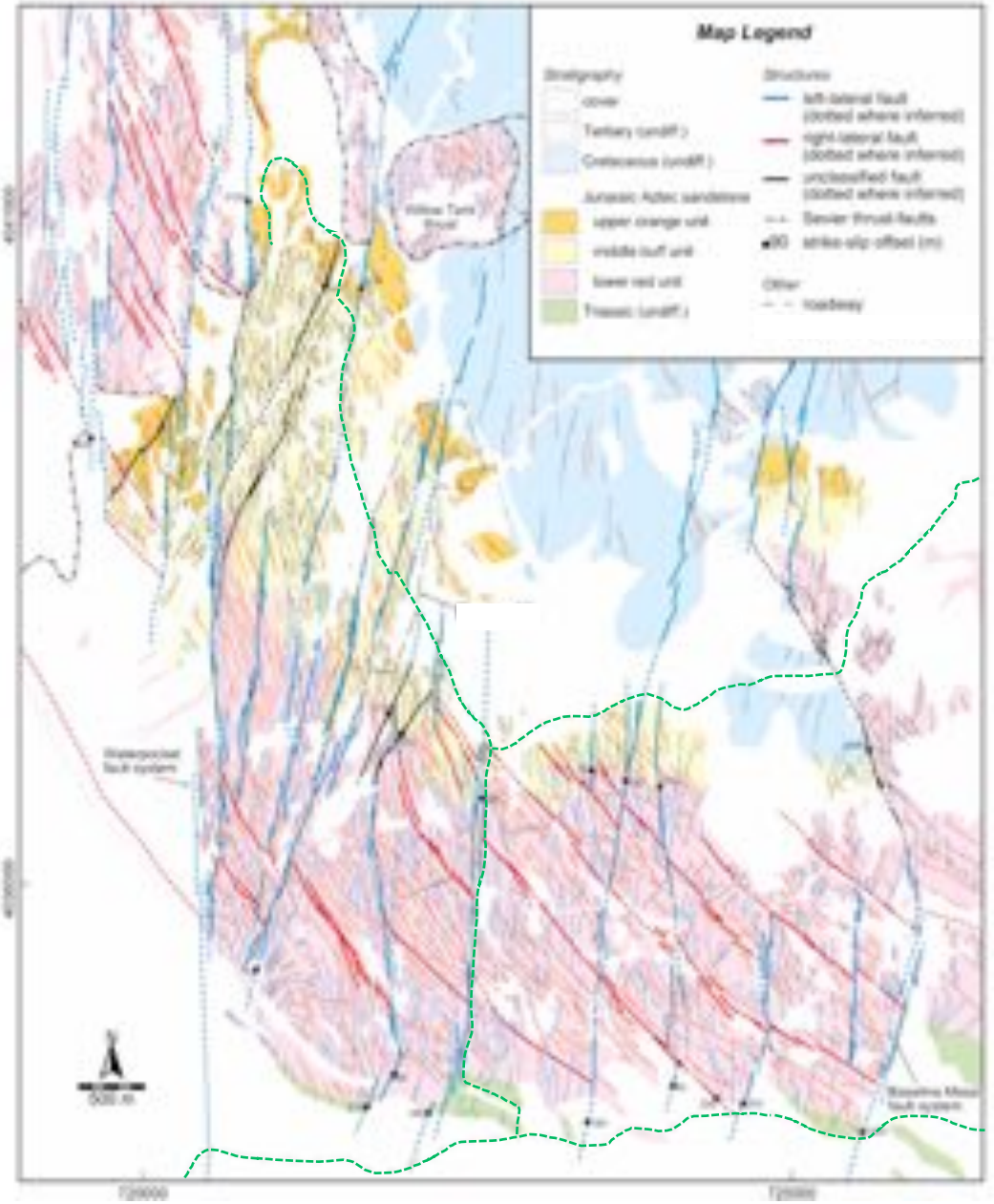
Valley of the Fire





STRIKE-SLIP FAULT NETWORK, VALLEY OF FIRE, SOUTHERN NEVADA



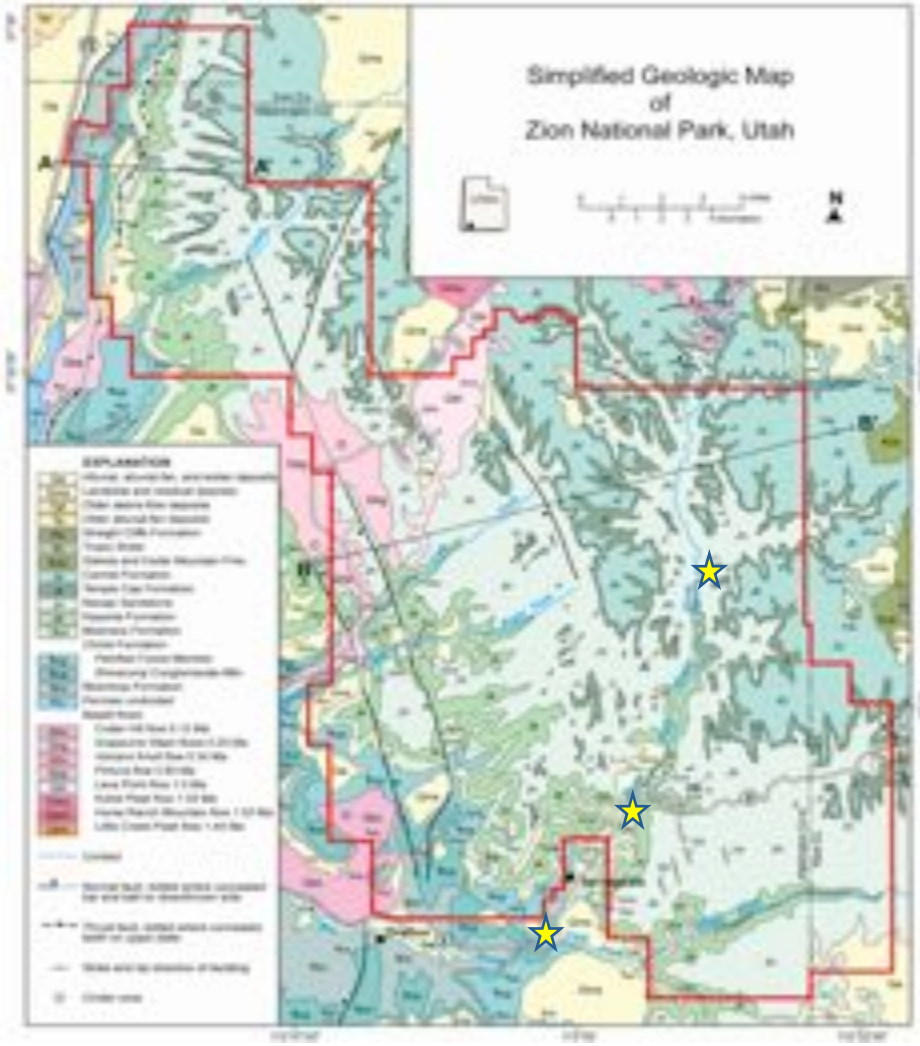


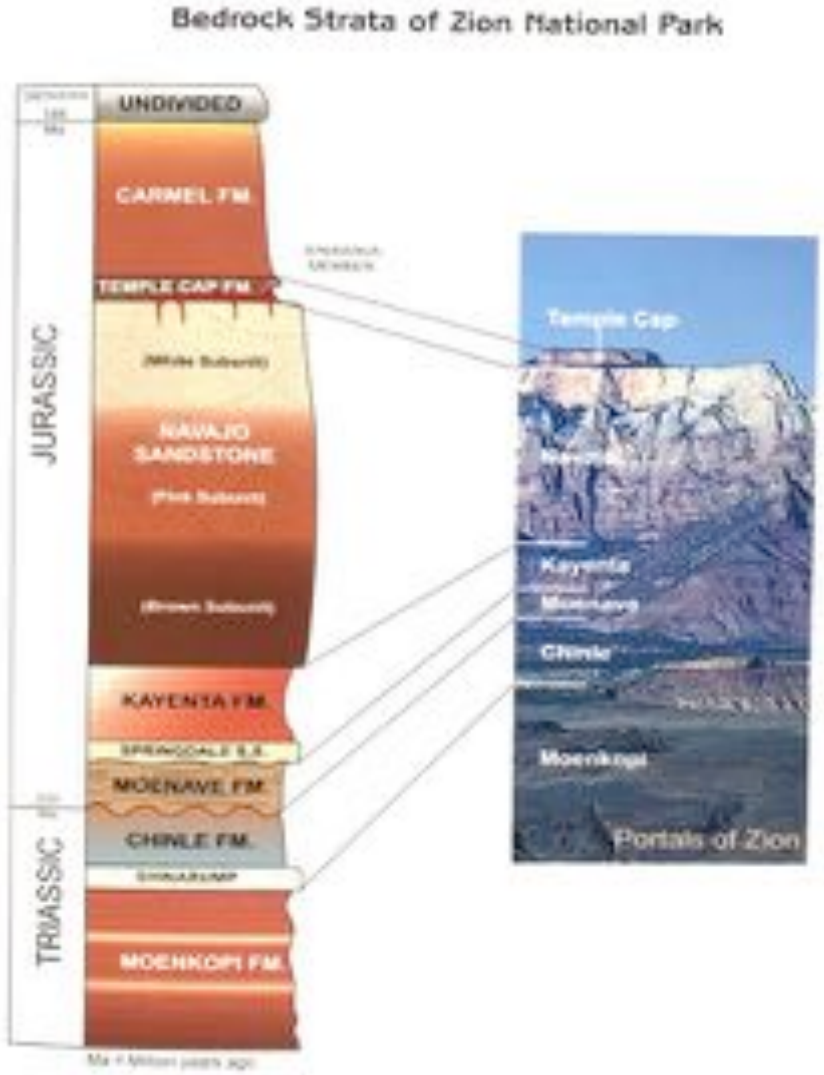
White domes road

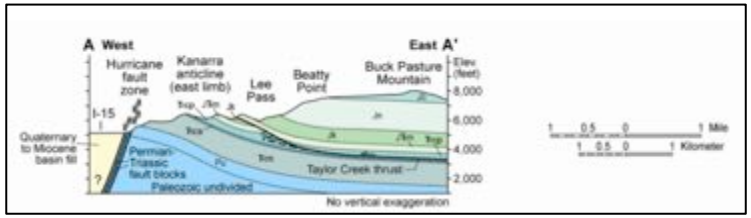
Aztec (Navajo) ss (J)

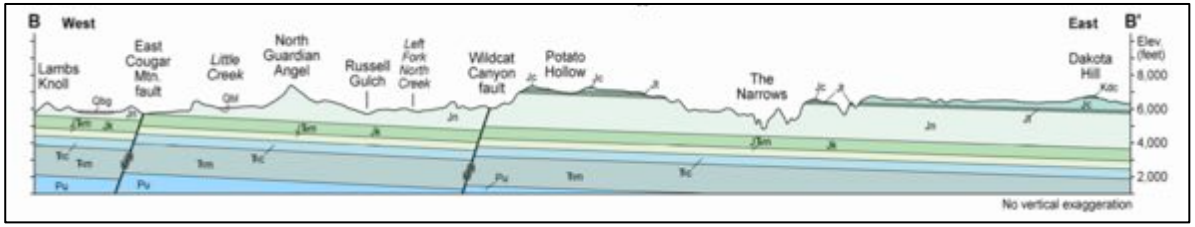
Zion National Park, Utah

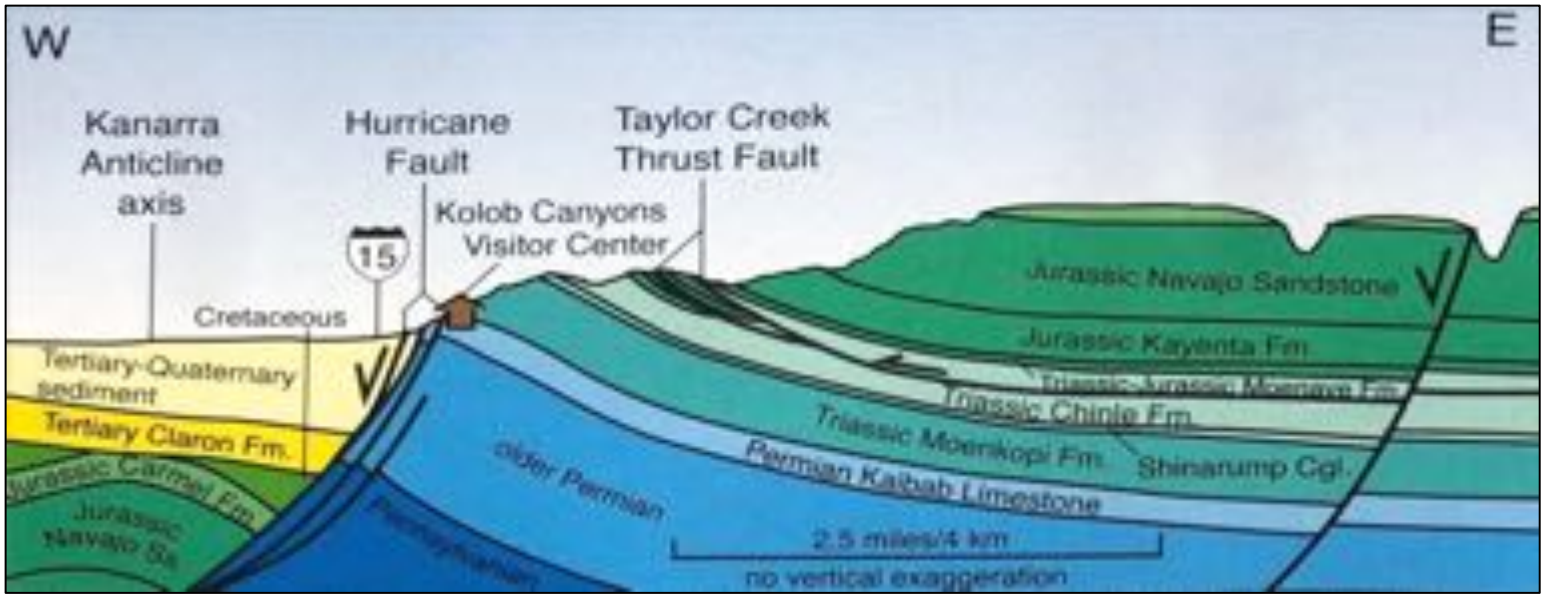
Mapa geológico y estratigrafía de Zion National Park, Utah










W
E
Kanarra Anticline axis
Hurricane Fault
Taylor Creek Thrust Fault
Kolob Canyons Visitor Center
15
Cretaceous
Tertiary-Quaternary sediment
Tertiary Claron Fm.
Jurassic Carmel Fm.
Jurassic Navajo Ss
older Permian
Jurassic Navajo Sandstone
Jurassic Kayenta Fm.
Triassic-Jurassic Moenave Fm.
Triassic Chinle Fm.
Triassic Moenkopi Fm.
Shinarump Cgl.
Permian Kaibab Limestone
2.5 miles/4 km
no vertical exaggeration

Temple Cat fm (J)
Navajo fm (J)
Kayenta fm (J)
Moenave fm (J)
Chinle fm (T)

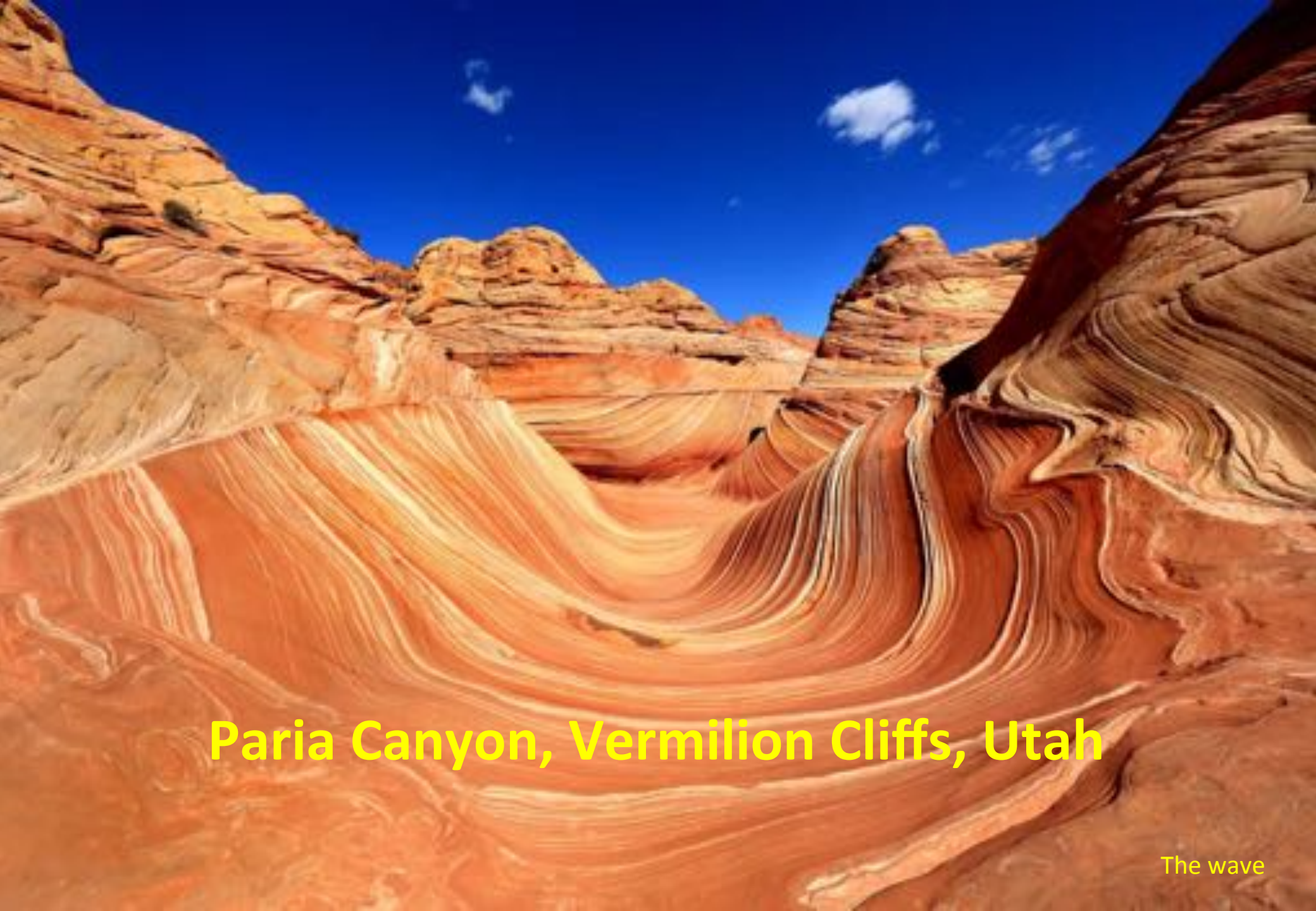
Temple Cat fm
Navajo fm
Kayenta fm

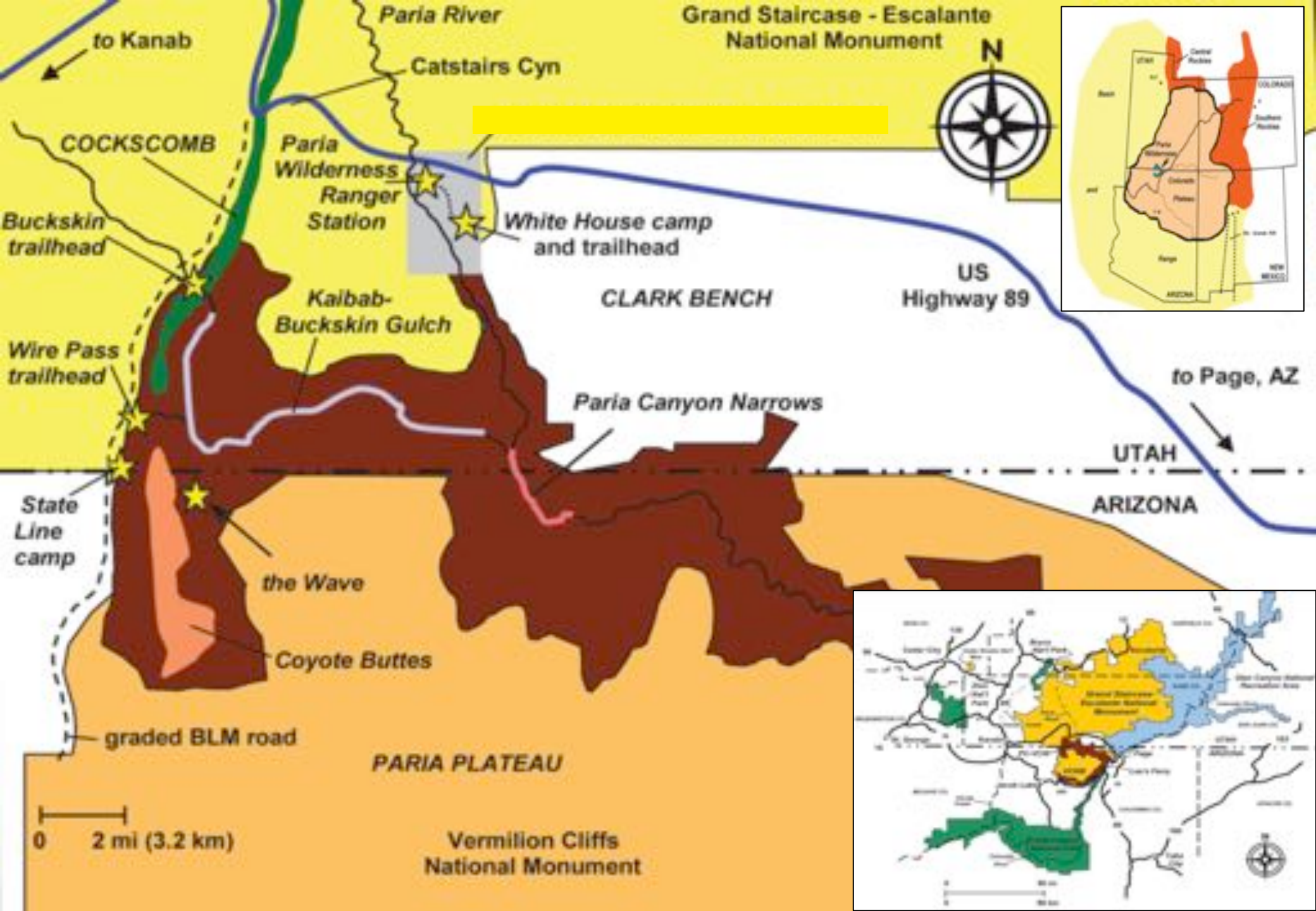
Towers of the virgin (2288m)

Navajo fm
Kayenta fm
Moenave fm

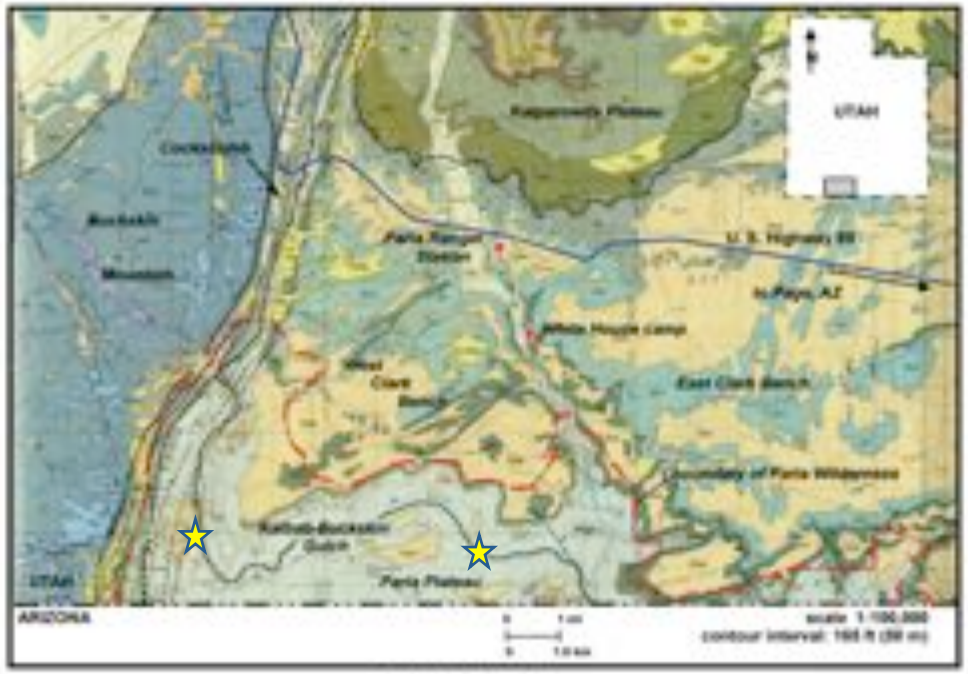
Navajo ss

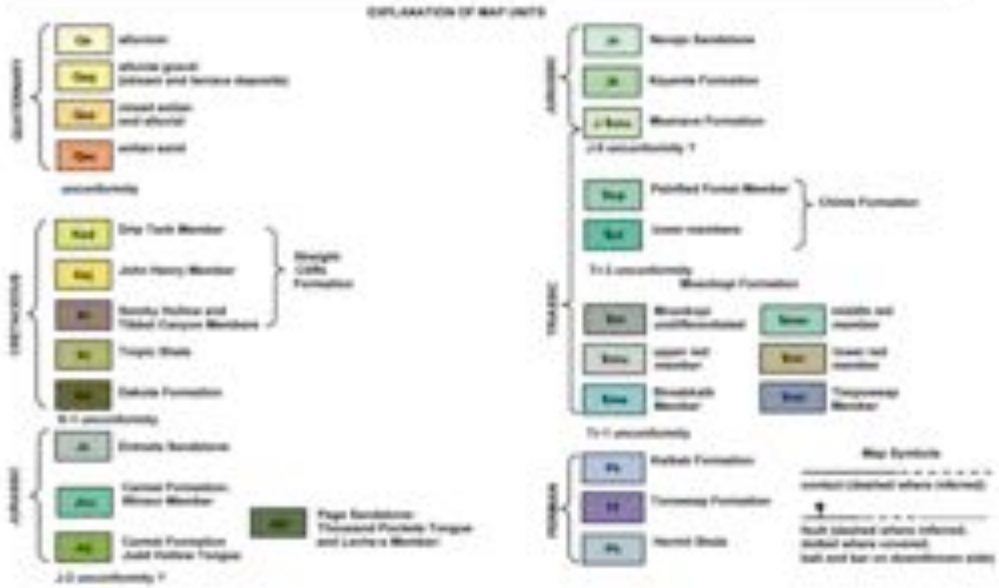
Virgin river

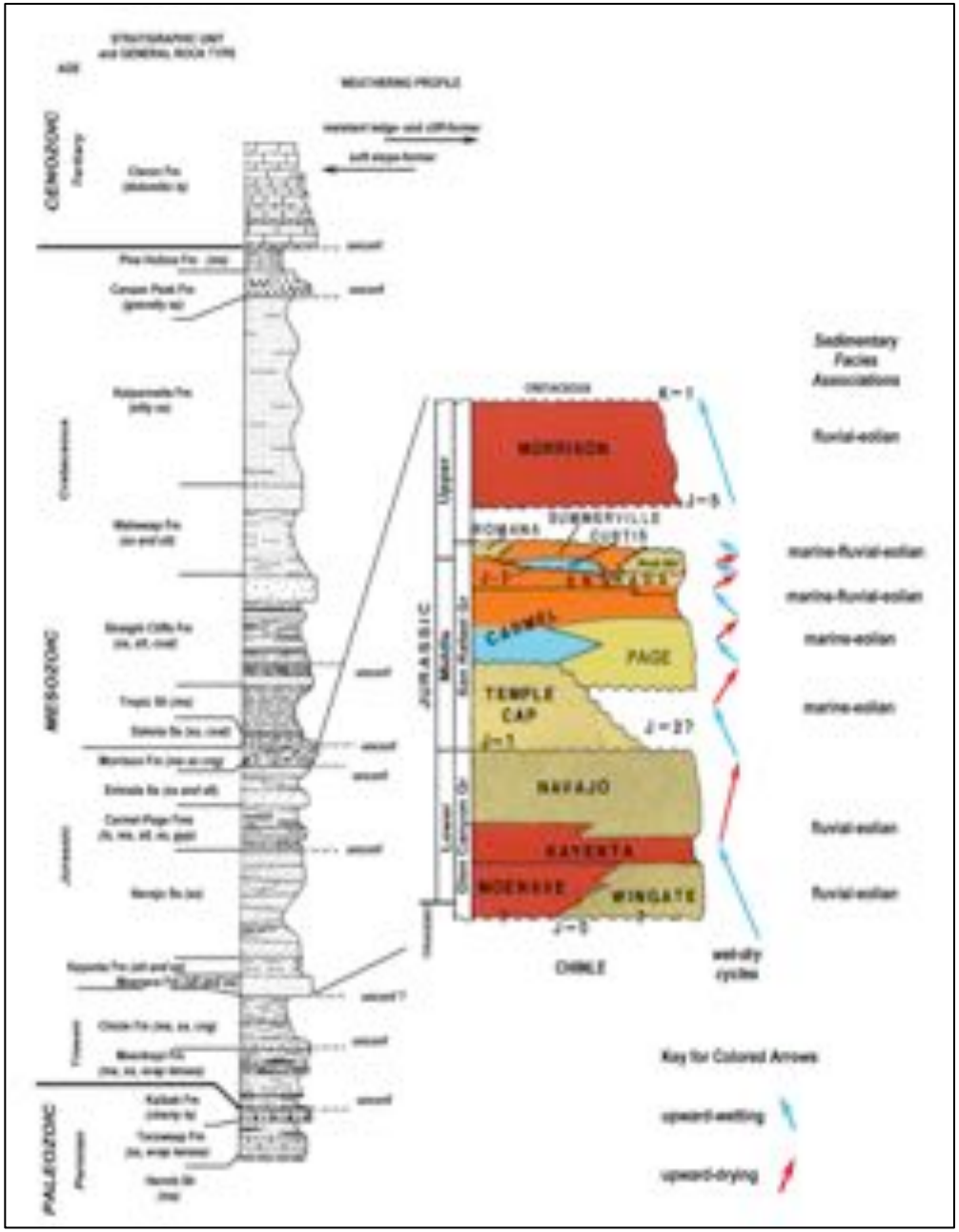

Paria Canyon, Vermilion Cliffs, Utah
The wave


Paria River
Grand Staircase - Escalante
National Monument
to Kanab
Catstairs Cyn
N
COCKSCOMB
Paria
Wilderness
Ranger
Station
White House camp
and trailhead
Buckskin
trailhead
US
Highway 89
CLARK BENCH
Kaibab-
Buckskin Gulch
Wire Pass
trailhead
to Page, AZ
Paria Canyon Narrows
UTAH
ARIZONA
State
Line
camp
the Wave
Coyote Buttes
graded BLM road
PARIA PLATEAU
0
2 mi (3.2 km)
Vermilion Cliffs
National Monument

Paria Canyon







Carmel
Navajo
Kayenta-Moenave
Triassic

Moenkopi fm (T)
Kayenta/Moenave(J)

Wire pass trailhead

Kayenta/Moenave(!)

Navajo ss

Kayenta (J)

Kaibab buckskin gulch

Paria Canyon Buckskin Gulch

Bryce Canyon National Park, Utah

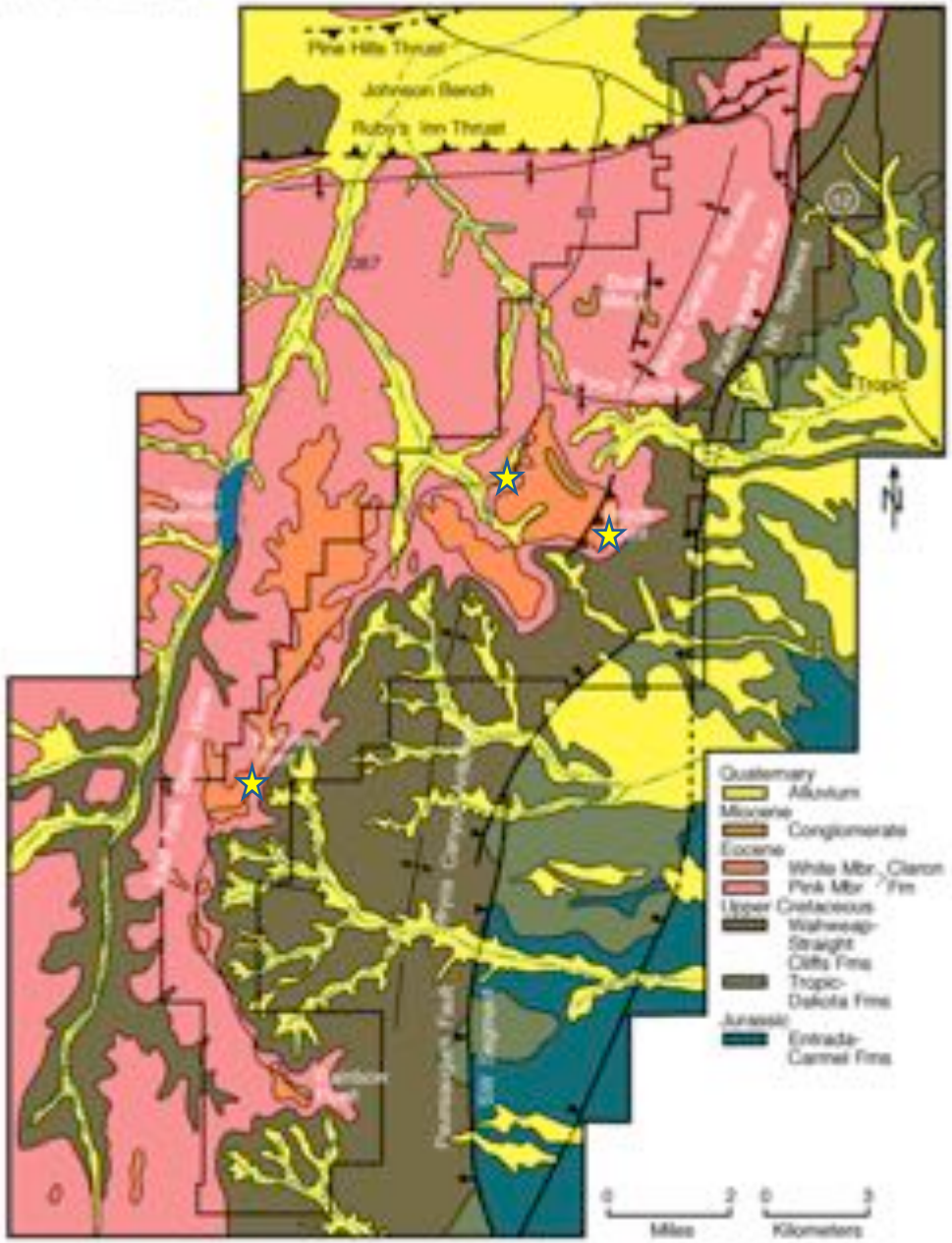
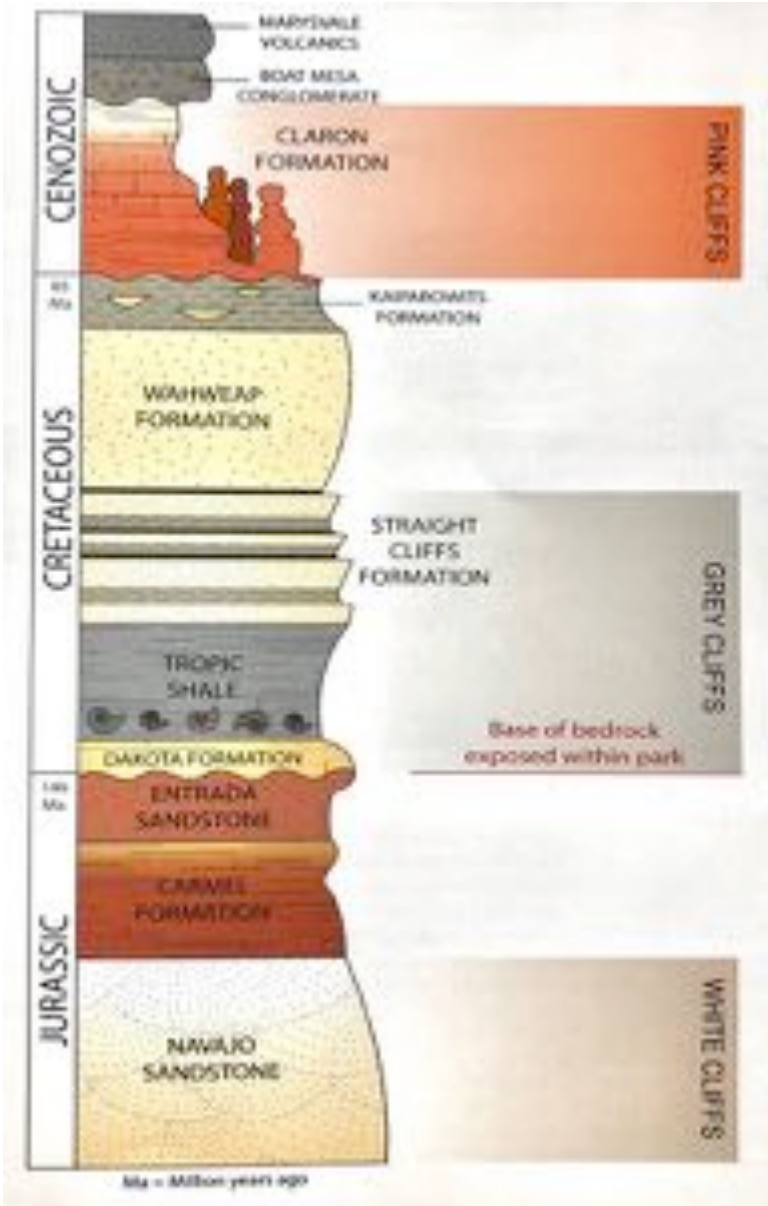


Figure 7. Simplified version of Bowers' (1991) geologic map of Bryce Canyon National Park and vicinity.

Bedrock Strata of the Bryce Canyon National Park



Claron fm (Cenozoic)
Straight Cliffs fm (C)
Paunsaugunt fault

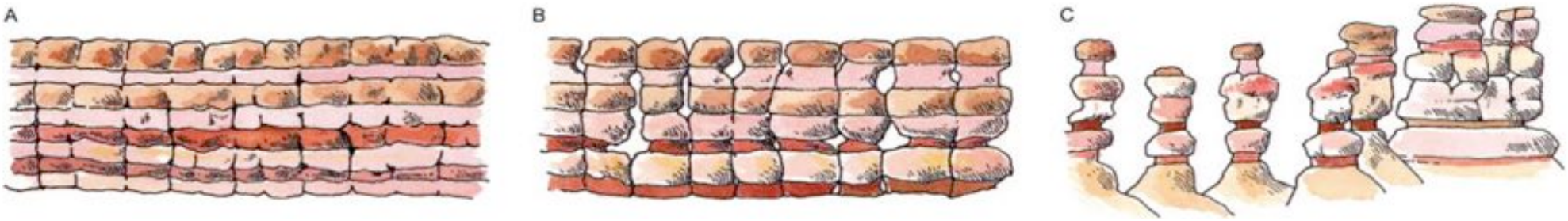
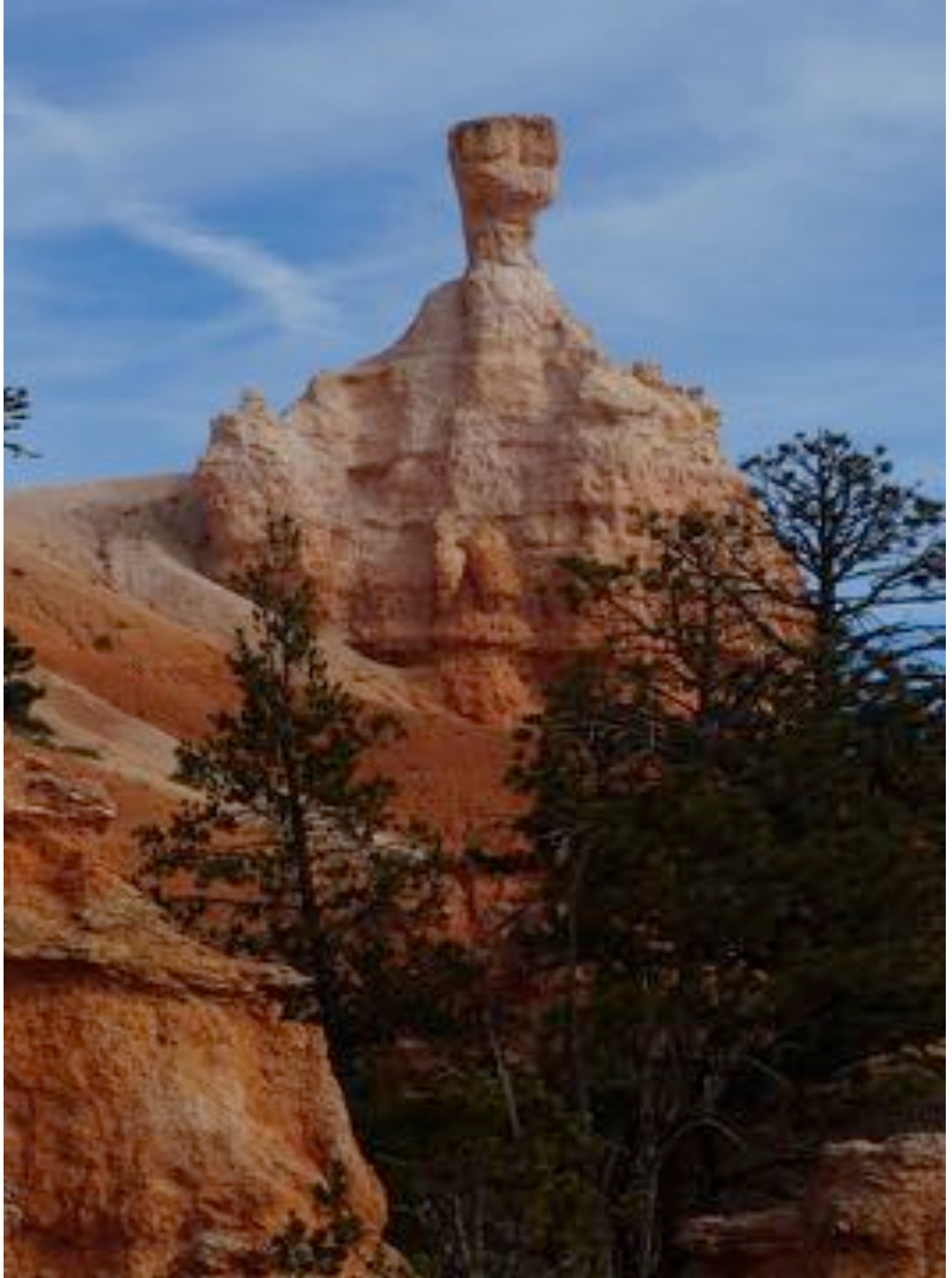


Figure 9. Origin of hoodoos, as depicted in an illustration in DeCourten (1994, p. 76). Weathering and erosion of fins is most effective along the near-vertical joints, and thus joint locations become widened, setting the stage for the creation of the hoodoos. The resistant rock layers within the Pink Member of the Claron Formation give the formation some integrity, and remnants of such layers ultimately serve as capstones on the tops of hoodoos.

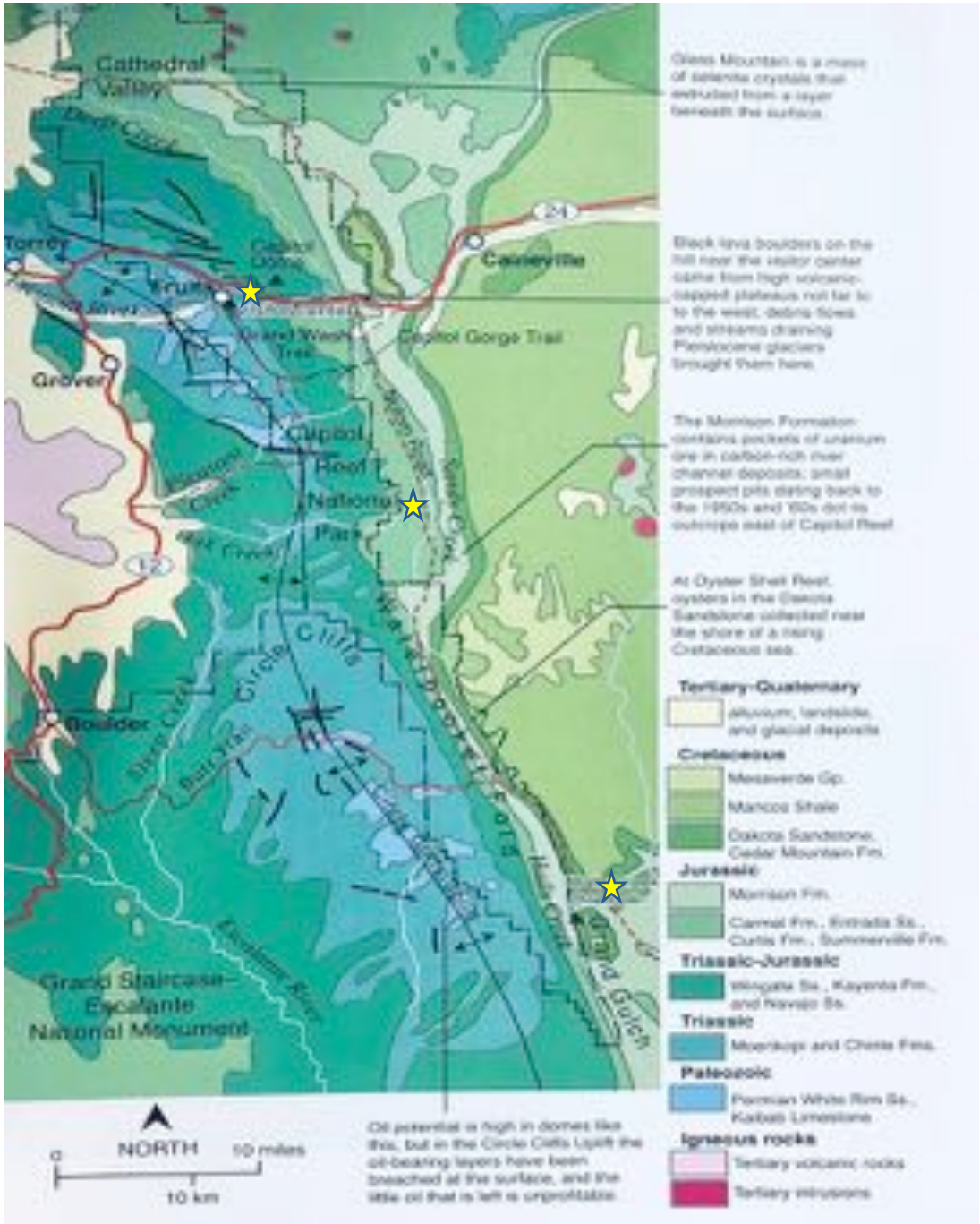
Claron fm

Under the rim trail

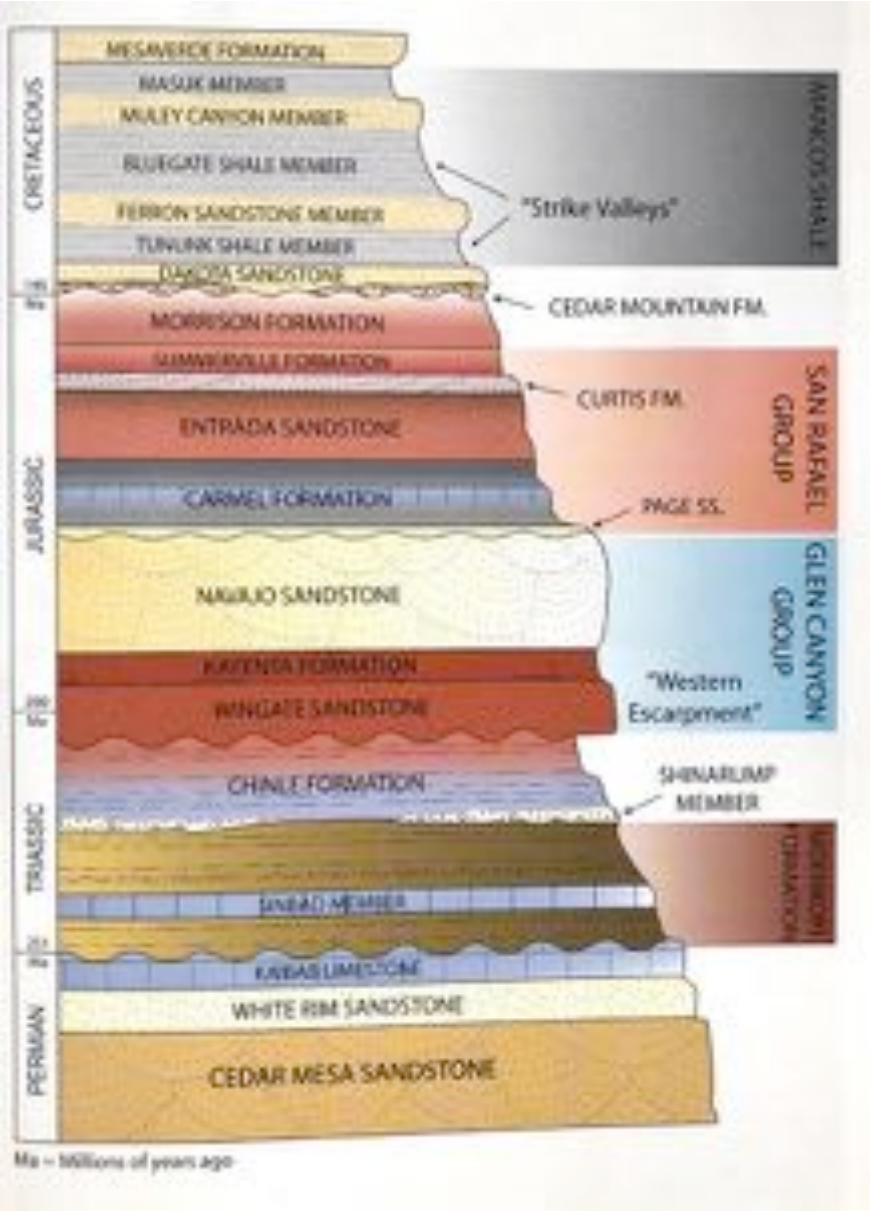


Capitol Reef National Park, Utah

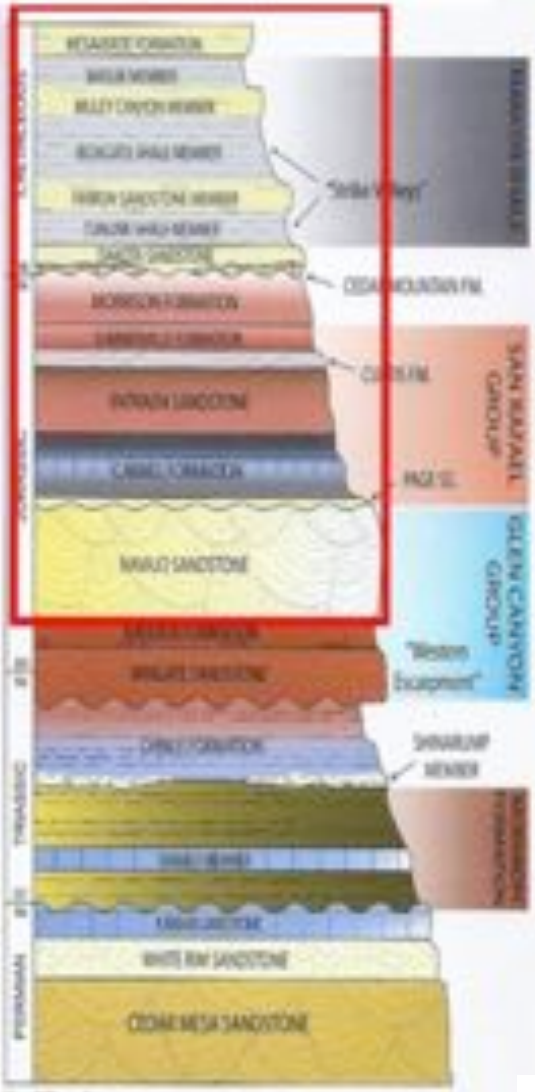
Capitol Reef National Park

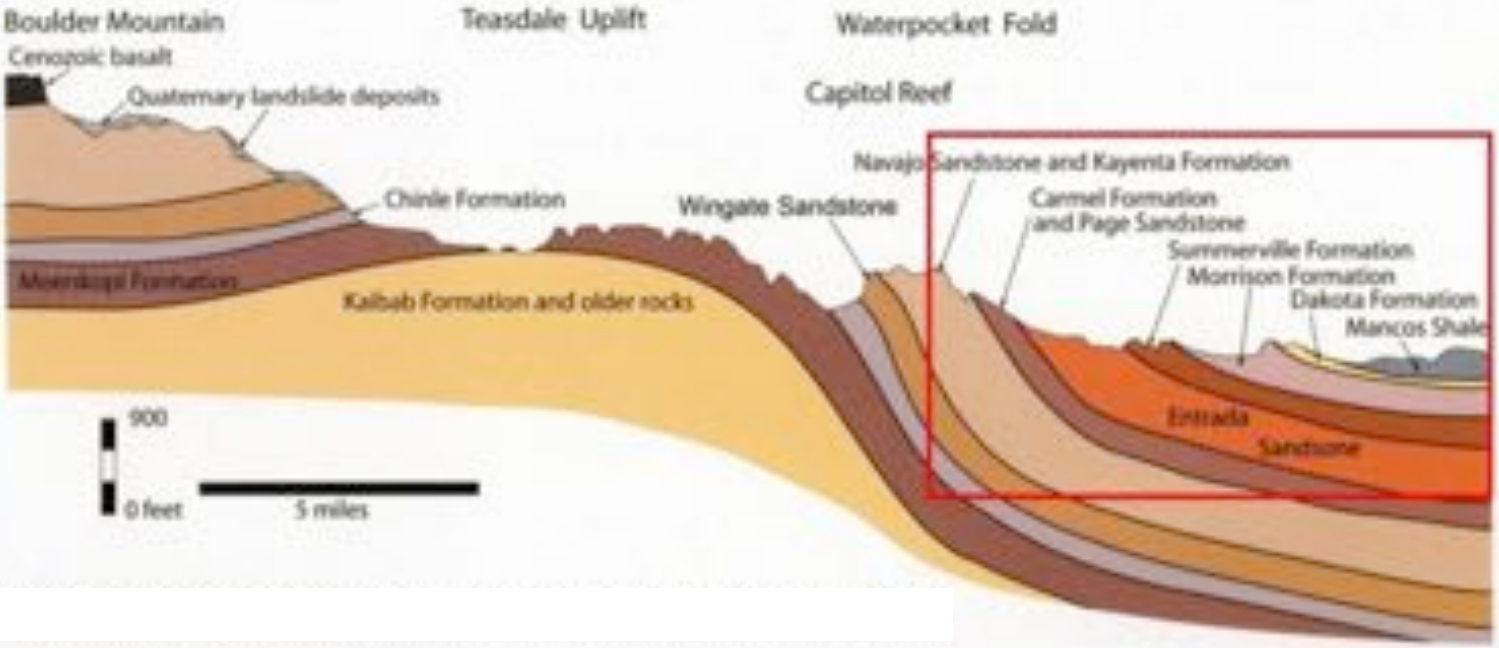


Bedrock Strata of Capitol Reef National Park



Water Pocket Fold





Waterpocket Fold

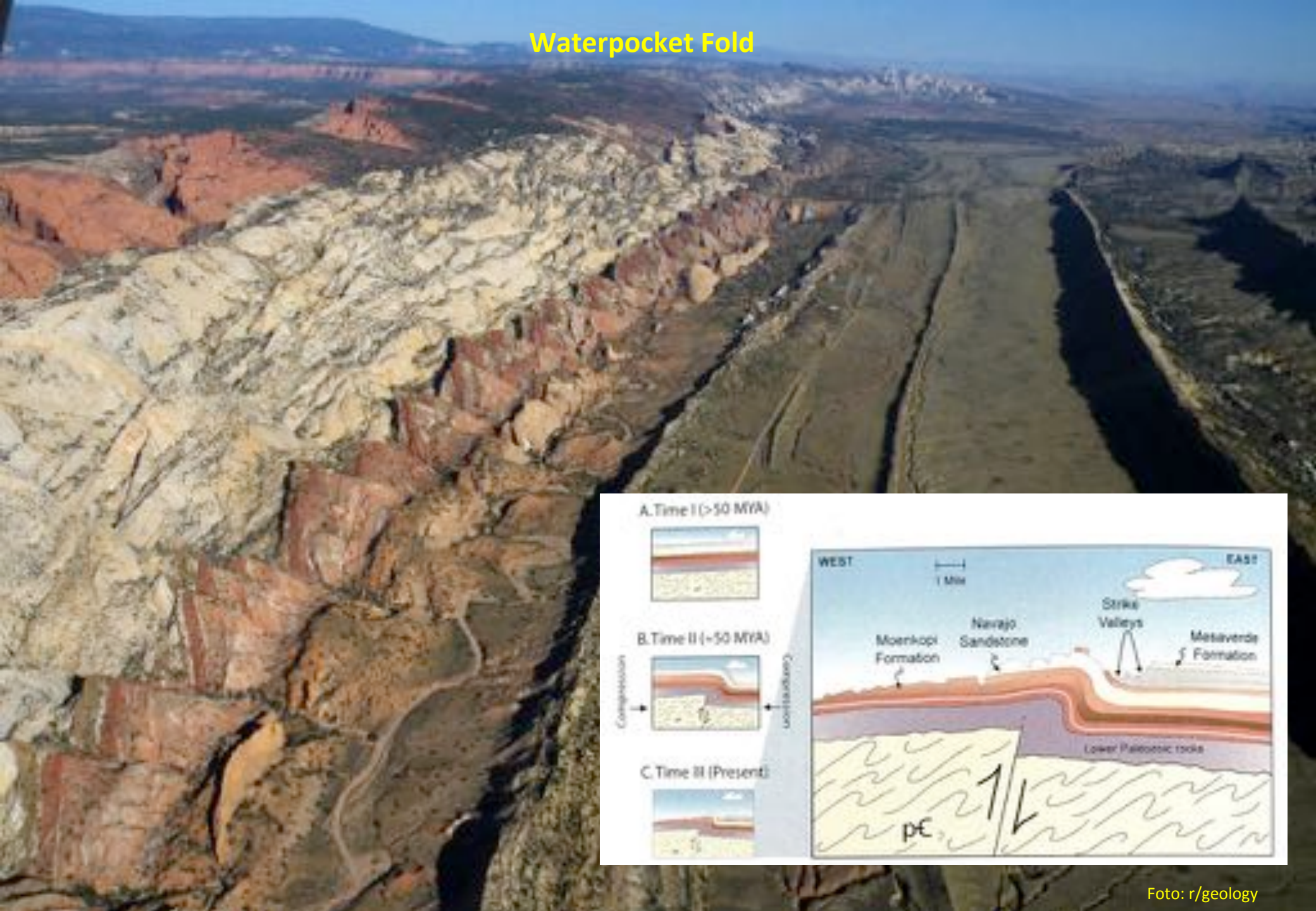


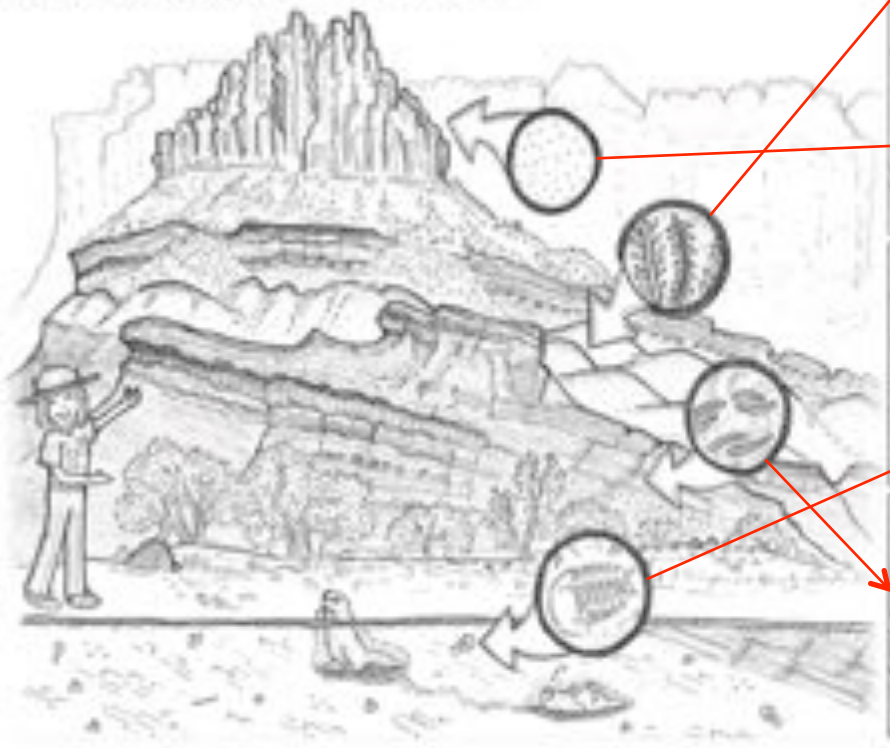
Foto: r/geology

ACTIVITY 8

Stories in Stone

Capitol Reef's rock layers were deposited from 275 to 74 million years ago and serve as an excellent record of the Mesozoic era. Studying rock layers helps us understand what the Earth was like long ago. Sandstones, mudstones, and limestones tell different stories of past weather conditions and environments. Fossils help us learn about the plants and animals that existed.

Directions: Find the Castle outside the visitor center. Use clues in the rock layers pictured below to determine what the environment was like when these layers formed. Draw a line between each rock layer and its ancient environment.



Ancient Environments

Rock Types

There are three main types of rocks on Earth. The layers of the Castle are **sedimentary**, made of tiny sediments deposited by erosion and cemented over time. Siltstones and mudstones typically form soft sloping layers that are easily eroded. Sandstones tend to form towering cliffs because they are harder and more resistant to weathering.

Rocks that have been altered by extreme heat and pressure are **metamorphic**. This type of rock cannot be seen in the park, but it exists deep underground.

The third rock type is formed by molten rock, like the black boulders in the park. What type of rock are they? Unscramble the bolded letters in the four rock layer names to fill in the blanks and find out.

I G N E O U S

Waterpocket fold

Chimney rock

Windgate cliffs

The castle

Capitol Gorge trail

Petroglifos

Grand Staircase-Escalante National Monument, Utah
Grey cliffs

Grand Staircase-Escalante National Monument, Utah

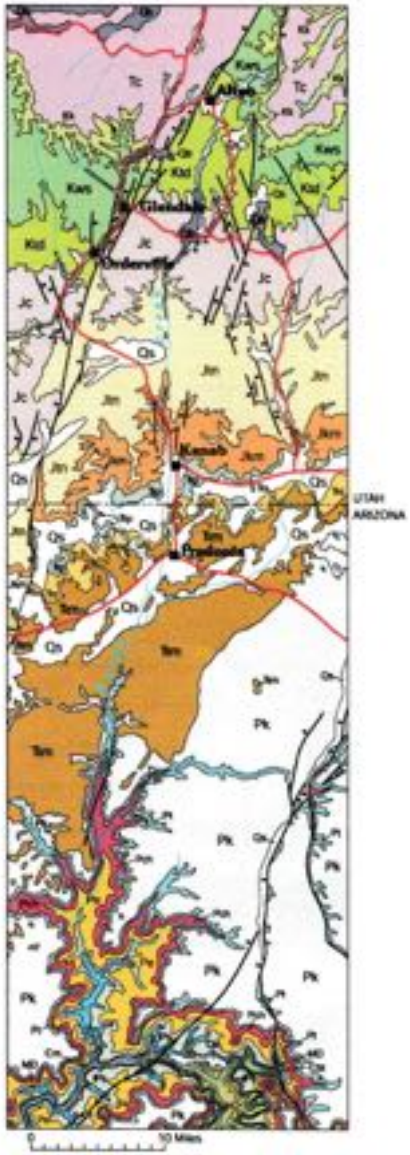
6 MILLION YEARS AGO TO TODAY

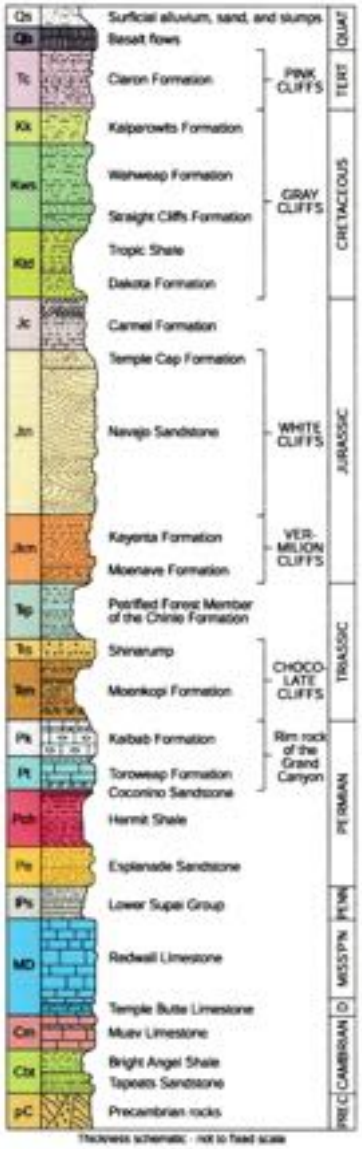
The Colorado River and its tributaries began rapidly carving through rock layers, carrying off sediments.

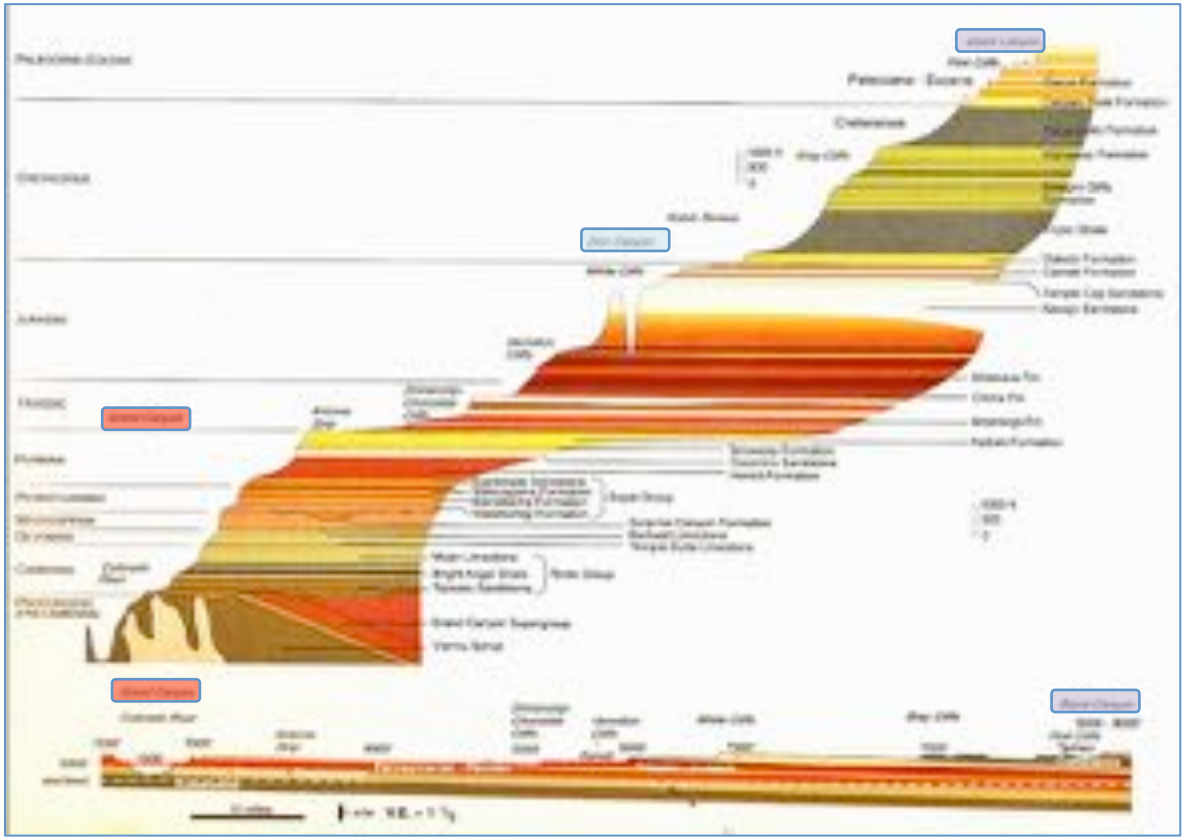
Left behind are the cliffs and plateaus of the Grand Staircase.

Today, the Grand Staircase continues to erode. The rate at which this occurs depends on changing climate conditions.

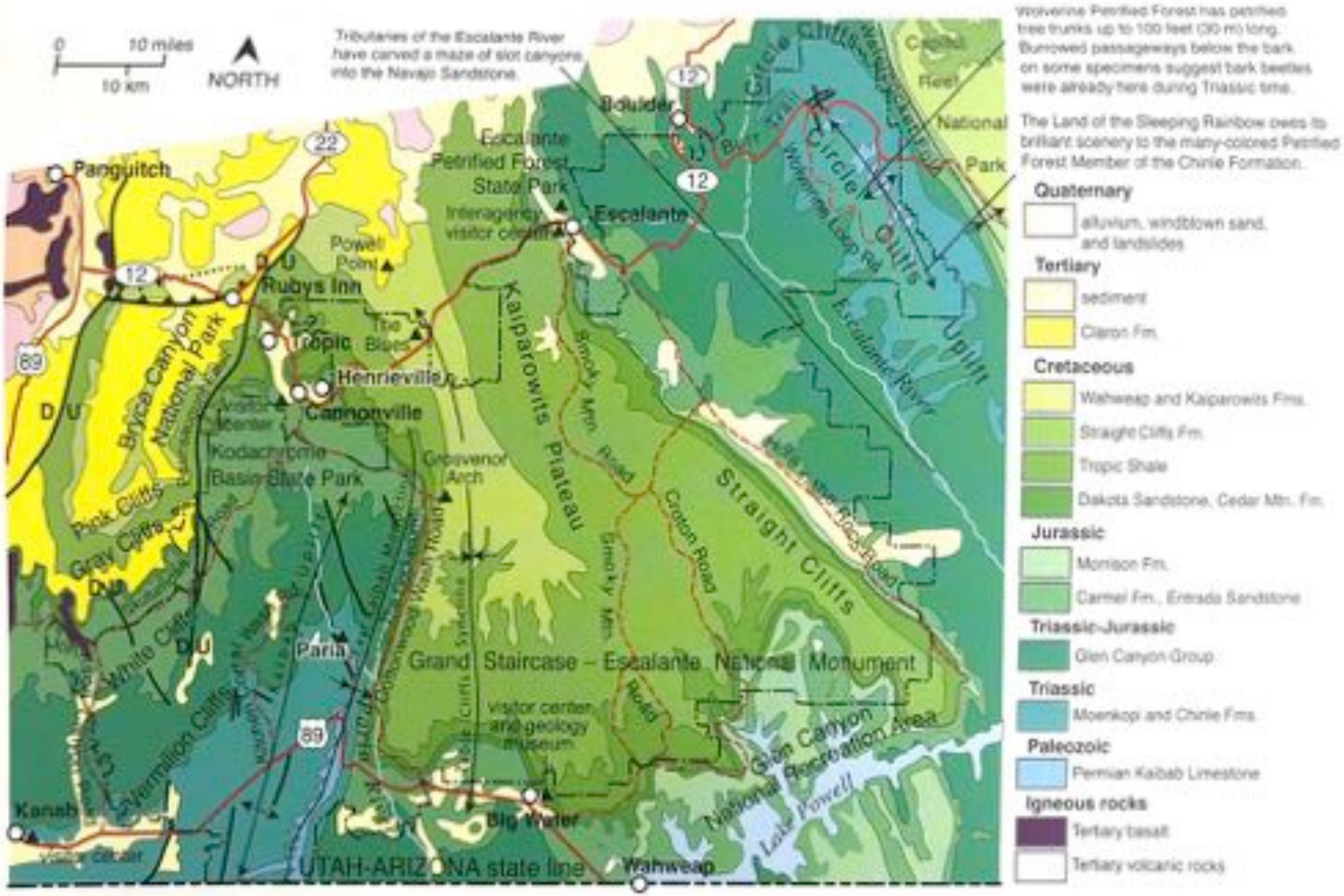
Grand Staircase-Escalante National Monument, Utah

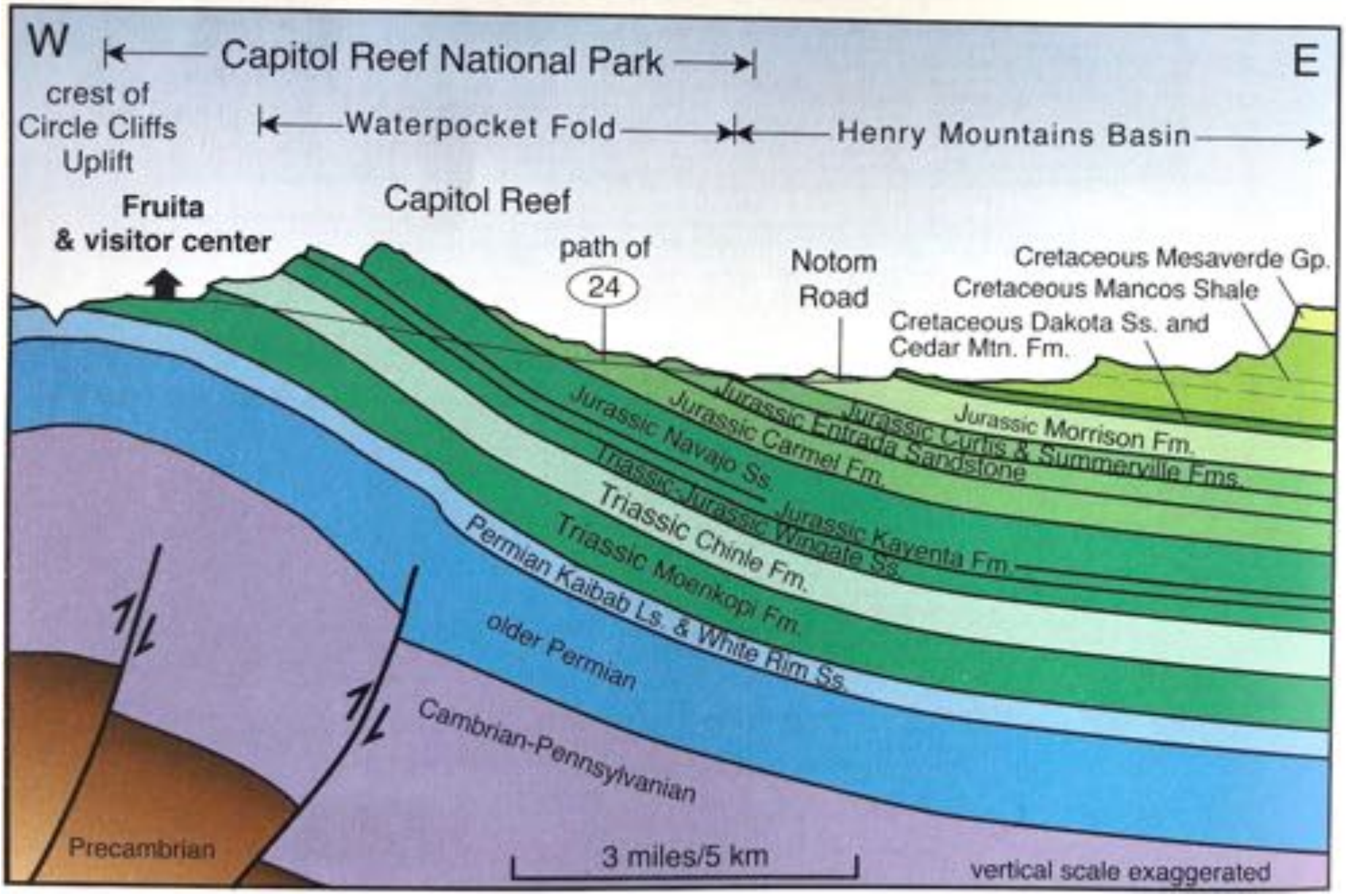






Grand Staircase-Escalante National Monument, Utah




W
Capitol Reef National Park
E
crest of
Circle Cliffs
Uplift
Waterpocket Fold
Henry Mountains Basin
Fruita
& visitor center
Capitol Reef
path of
24
Notom
Road
Cretaceous Mesaverde Gp.
Cretaceous Mancos Shale
Cretaceous Dakota Ss. and
Cedar Mtn. Fm.
Jurassic Morrison Fm.
Jurassic Curtis & Summerville Fms.
Jurassic Entrada Sandstone
Jurassic Carmel Fm.
Jurassic Navajo Ss.
Jurassic Kayenta Fm.
Triassic-Jurassic Wingate Ss.
Triassic Chinle Fm.
Triassic Moenkopi Fm.
Permian Kaibab Ls. & White Rim Ss.
older Permian
Cambrian-Pennsylvanian
Precambrian
3 miles/5 km
vertical scale exaggerated

Gray cliffs

Straight cliffs fm
Tropic shale (Cretaceous)

Straight cliffs fm. (Cretaceous)
Tropic shale (Cretaceous)

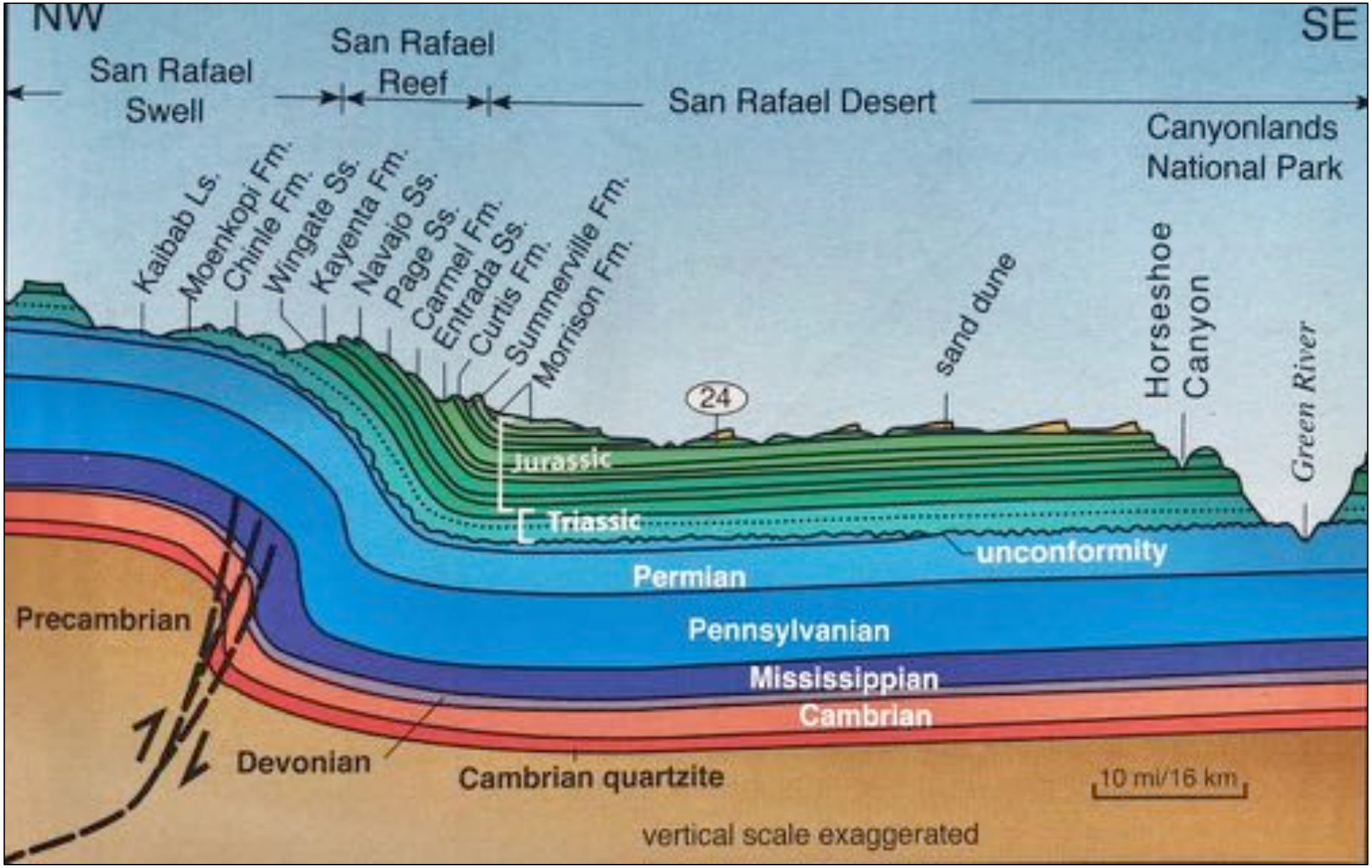
Morrison fm (Jurassic)

Morrison fm (Jurassic)

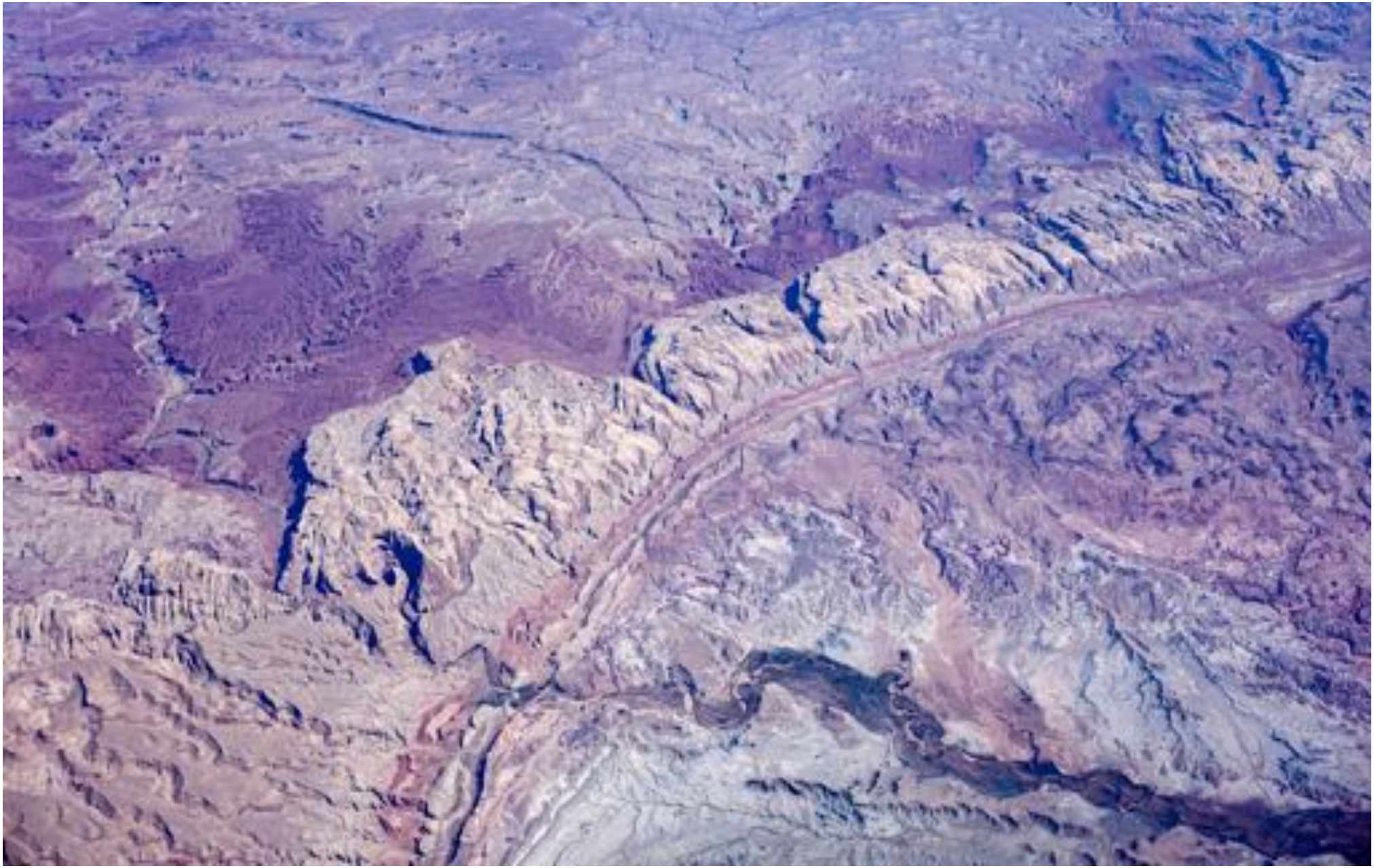
Bentonite hills (Jurassic Morrison fm)

Goblin Valley

Hillers Mountain (3260m)
Intrusión lacolítica de dioritas (Oligoceno)

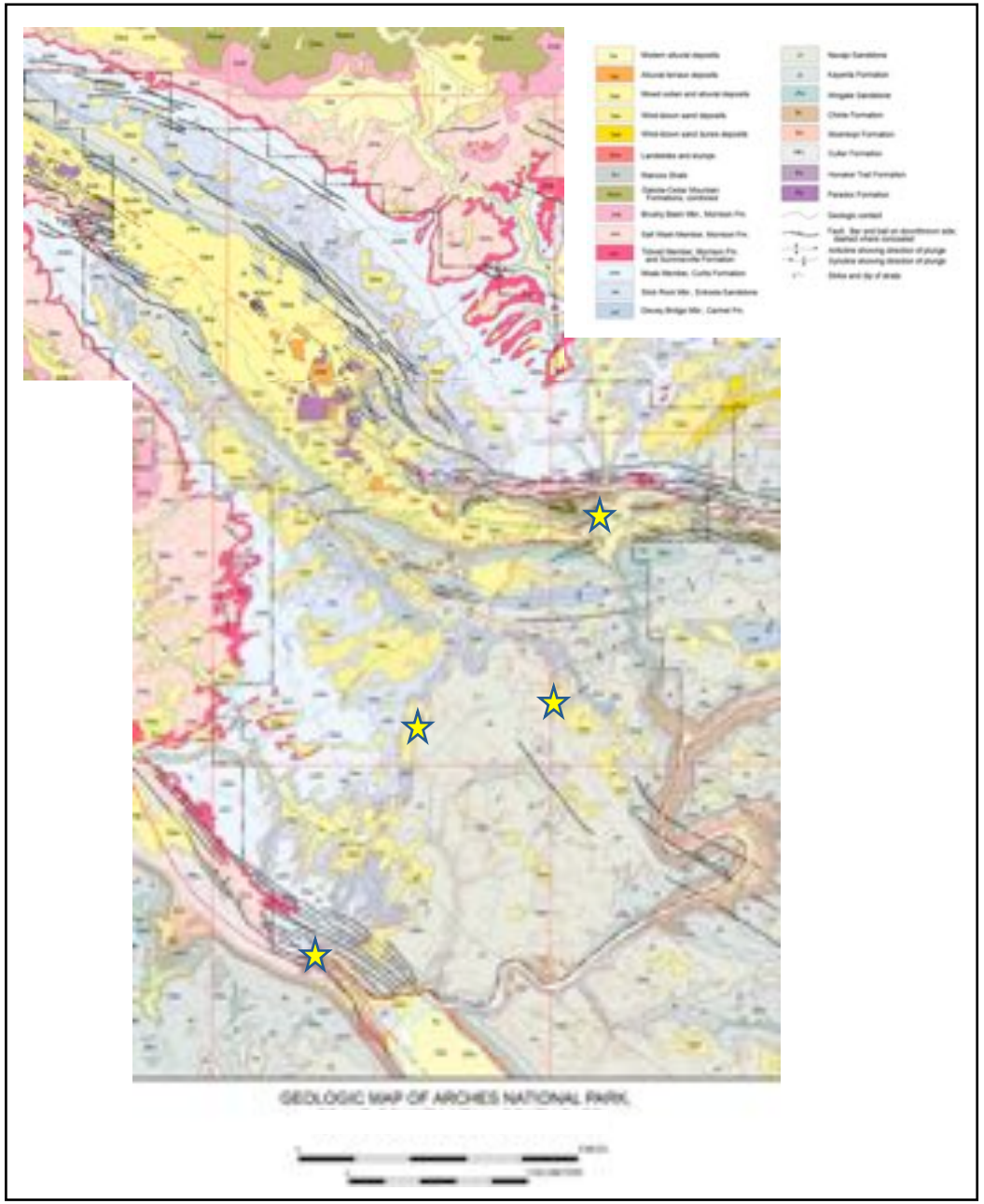

NW
SE
San Rafael Swell
San Rafael Reef
San Rafael Desert
Canyonlands National Park
Kaibab Ls.
Moenkopi Fm.
Chinle Fm.
Wingate Ss.
Kayenta Fm.
Navajo Ss.
Page Ss.
Carmel Fm.
Entrada Ss.
Curtis Fm.
Summerville Fm.
Morrison Fm.
sand dune
Horseshoe Canyon
Green River
24
Jurassic
Triassic
unconformity
Permian
Pennsylvanian
Mississippian
Cambrian
Precambrian
Devonian
Cambrian quartzite
10 mi/16 km
vertical scale exaggerated

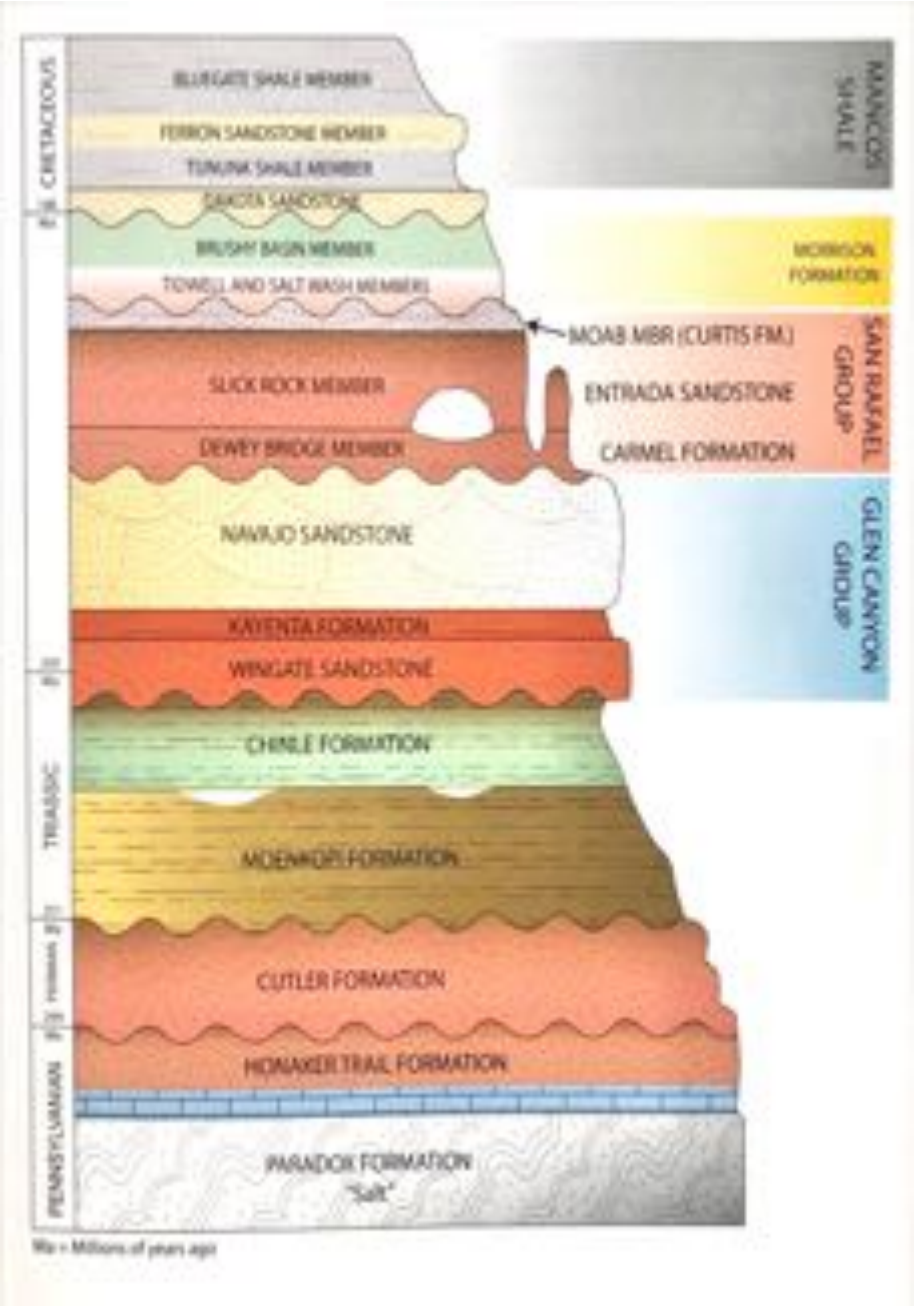
San Rafael Swell

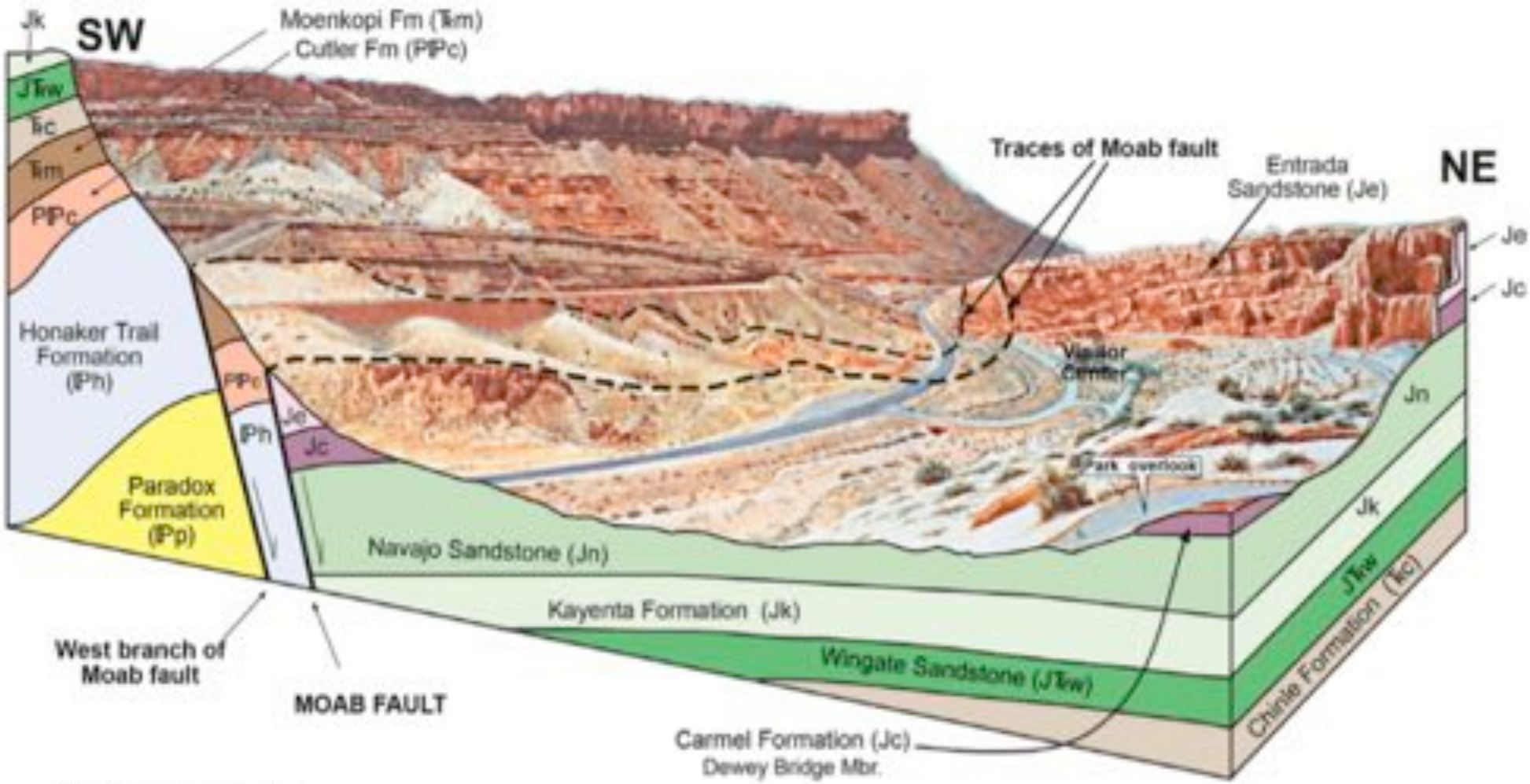


Arches National Park, Utah

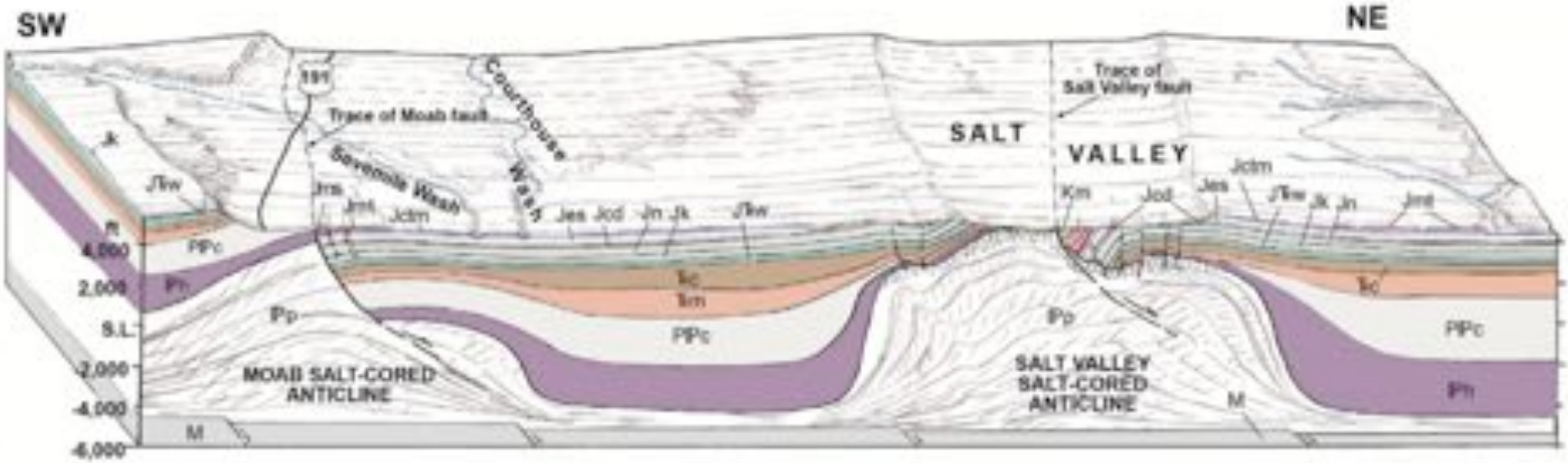
Bedrock Strata of Arches National Park



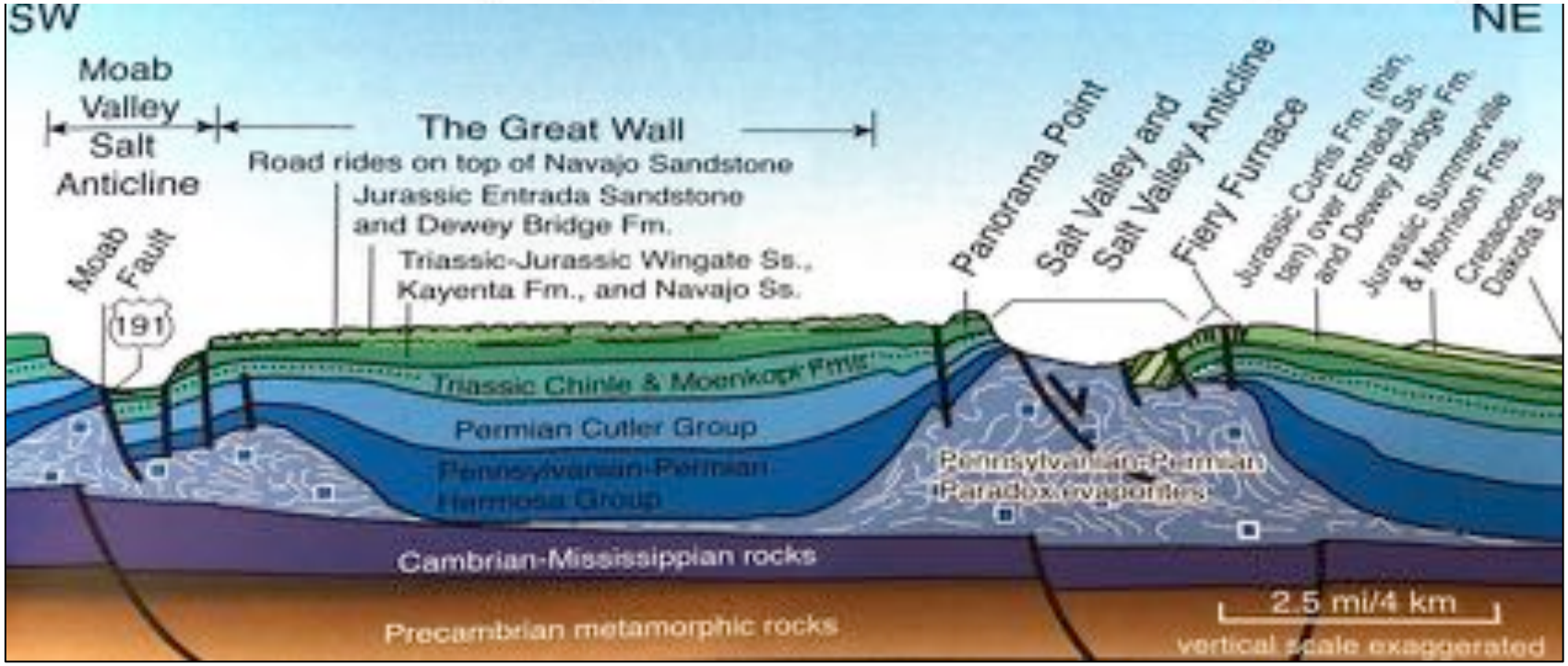




Looking northwest near the park visitors center. The Moab fault has a total displacement down to the east of 2400 feet across the fault zone. The dashed lines show the approximate traces of the fault.



Cross-sectional block diagram of the Arches National Park area drawn approximately to scale.



Moab member (Curtis fm)
Slick rock member (Entrada ss)

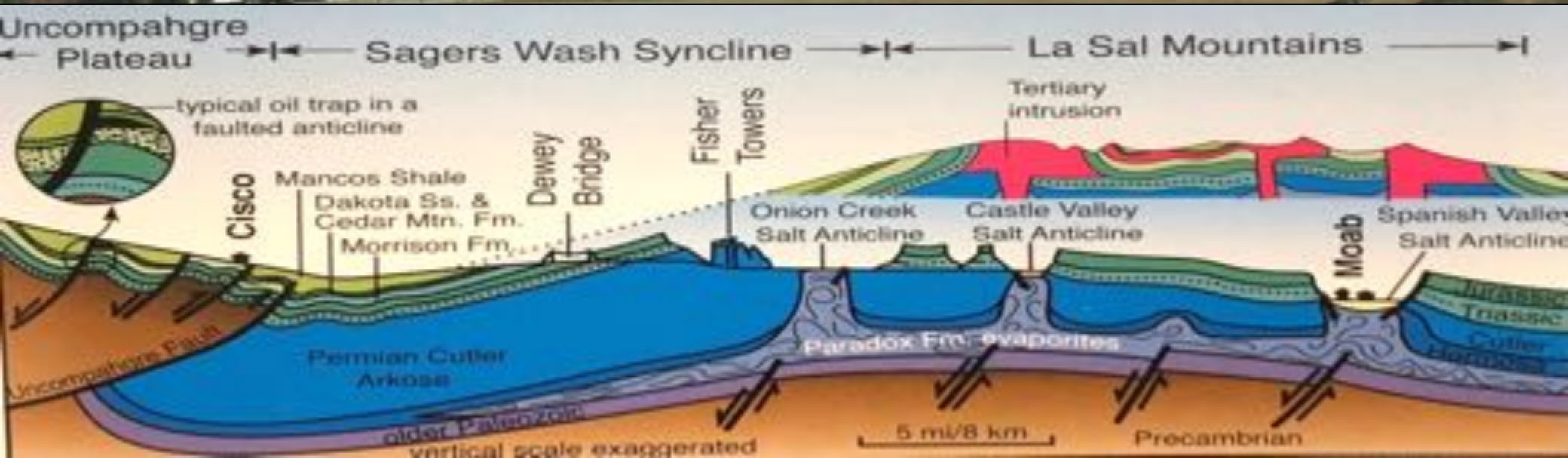
Delicate Arch

Balanced rock

Turret arch

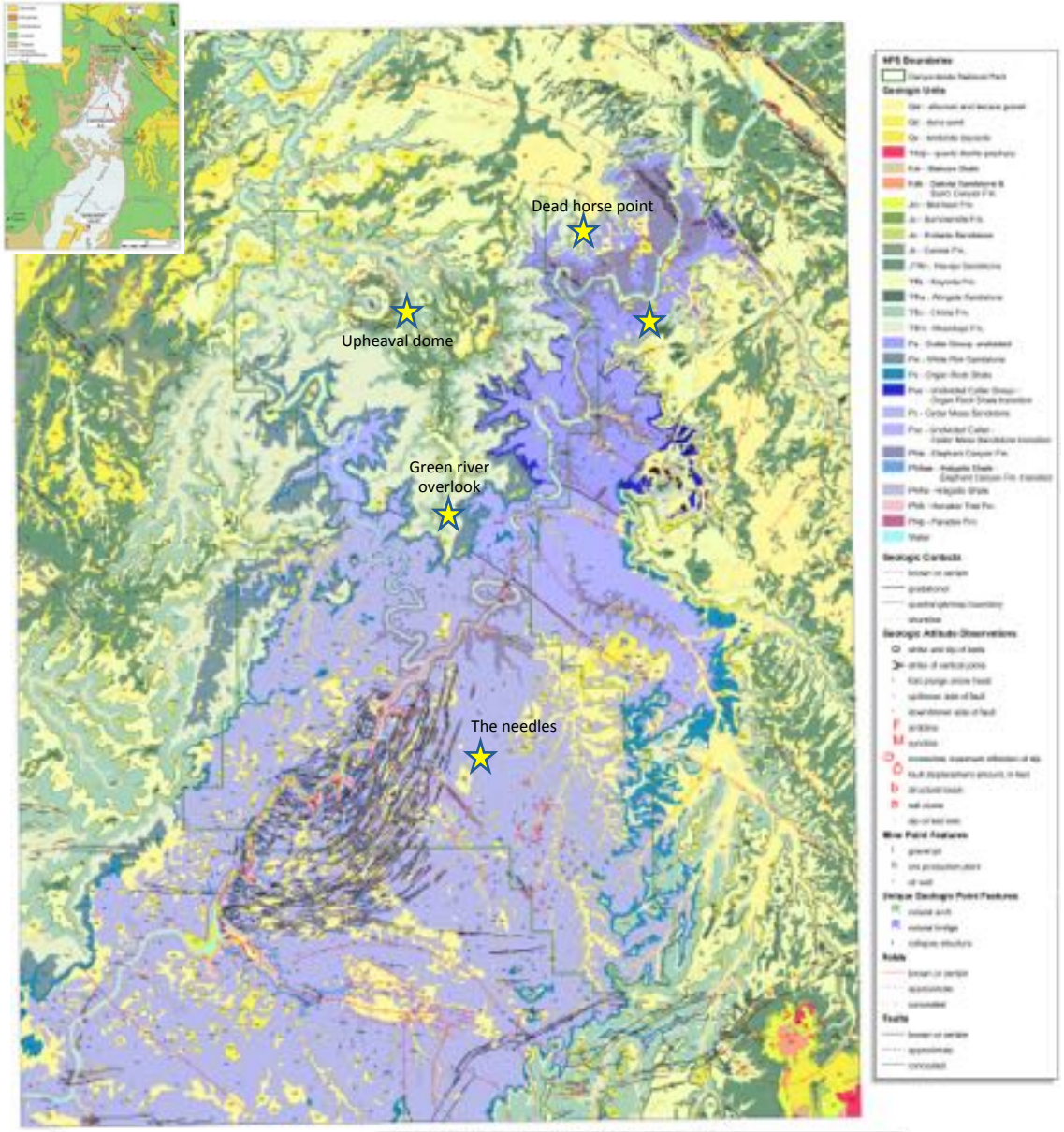
Double arch

La Sal Mountains


Uncompahgre Plateau
Sagers Wash Syncline
La Sal Mountains
typical oil trap in a faulted anticline
Cisco
Mancos Shale
Dakota Ss. & Cedar Mtn. Fm.
Morrison Fm.
Dewey Bridge
Fisher Towers
Tertiary intrusion
Onion Creek Salt Anticline
Castle Valley Salt Anticline
Moab
Spanish Valley Salt Anticline
Permian Cutler Arkose
Paradox Fm. evaporites
Triassic
Cutler Formation
Precambrian
5 mi/8 km
vertical scale exaggerated

Canyonlands National Park, Utah

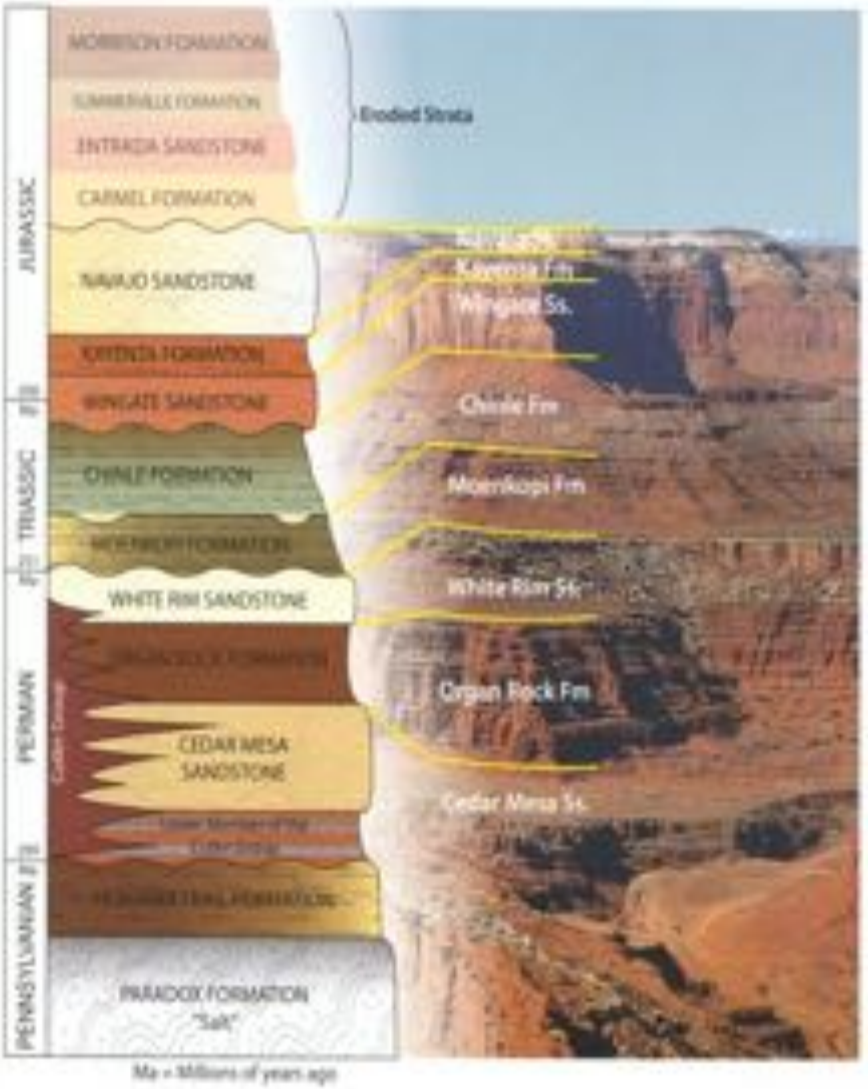
Bedrock Strata of Canyonlands National Park

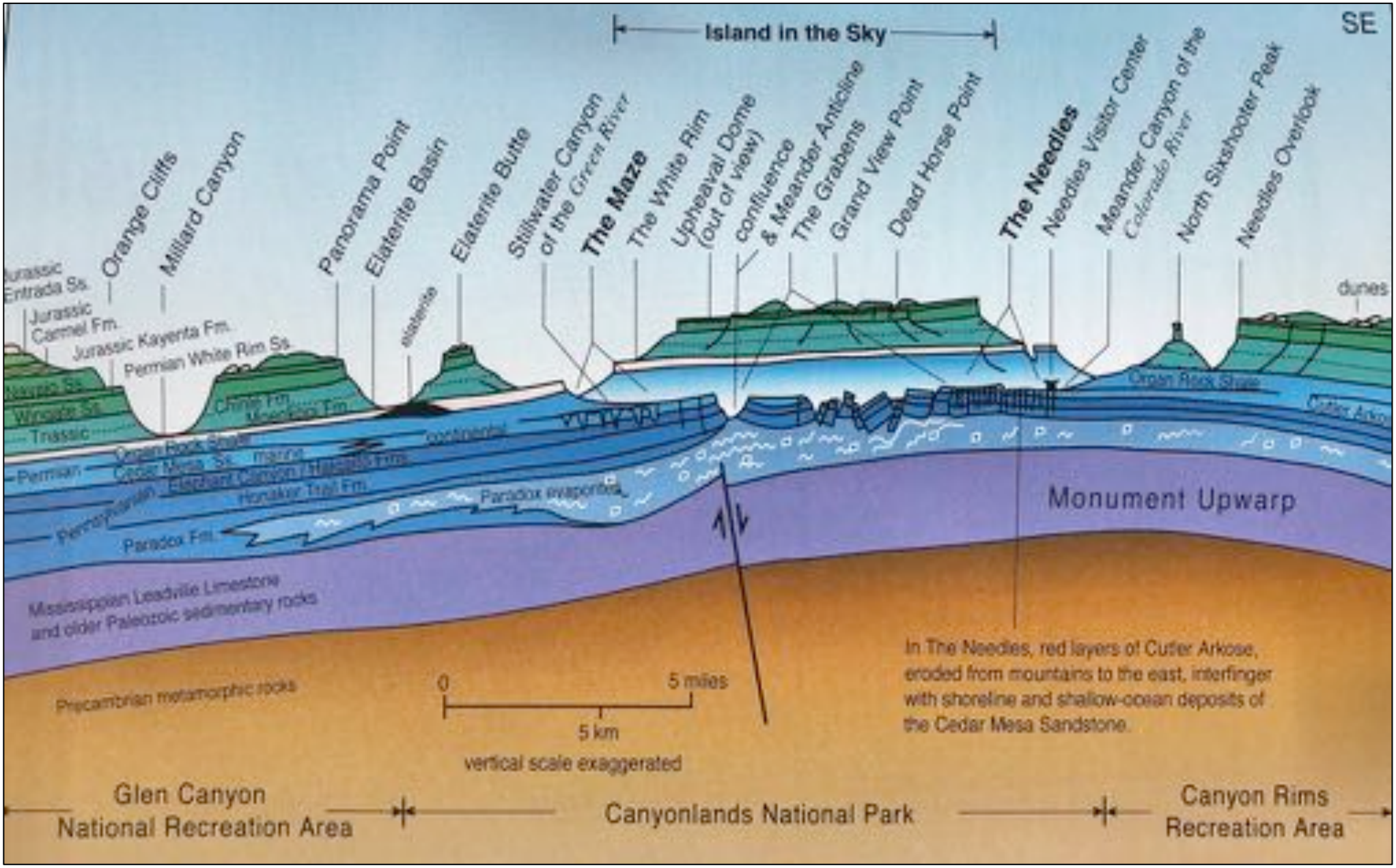


The original map digitized by NPS staff to create this product was:

Billingsley, George H., Block, Debra L and Felger, Tracey J., 2002, Surficial geologic map of The Loop and Druid Arch Quadrangles, Canyonlands National Park, Utah, U.S. Geological Survey, MF-2411, 1:24000 scale.

Digital geologic data and cross sections for Canyonlands National Park, and all other data produced as part of the NPS geologic Resources Divisions Geologic Resource Evaluation are available through the NPS Natural Resource - GIS metadata and data store: http://science.nature.nps.gov/nrdata




Island in the Sky
SE
Orange Cliffs
Millard Canyon
Panorama Point
Elaterite Basin
Elaterite Butte
Stillwater Canyon of the Green River
The Maze
The White Rim
Upheaval Dome (out of view)
confluence & Meander Anticline
The Grabens
Grand View Point
Dead Horse Point
The Needles
Needles Visitor Center
Meander Canyon of the Colorado River
North Sixshooter Peak
Needles Overlook
dunes
Jurassic Entrada Ss.
Jurassic Carmel Fm.
Jurassic Kayenta Fm.
Permian White Rim Ss.
elaterite
Navajo Ss.
Wingate Ss.
Triassic
Chinle Fm.
Moenkopi Fm.
Cutler Rock Shale
Permian
Cedar Mesa Ss.
Elephant Canyon / Halgaito Fms.
Honaker Trail Fm.
Pennsylvanian
Paradox evaporites
Paradox Fm.
Monument Upwarp
Mississippian Leadville Limestone and older Paleozoic sedimentary rocks
Precambrian metamorphic rocks
0
5 miles
5 km
vertical scale exaggerated
In The Needles, red layers of Cutler Arkose, eroded from mountains to the east, interfinger with shoreline and shallow-ocean deposits of the Cedar Mesa Sandstone
Glen Canyon National Recreation Area
Canyonlands National Park
Canyon Rims Recreation Area

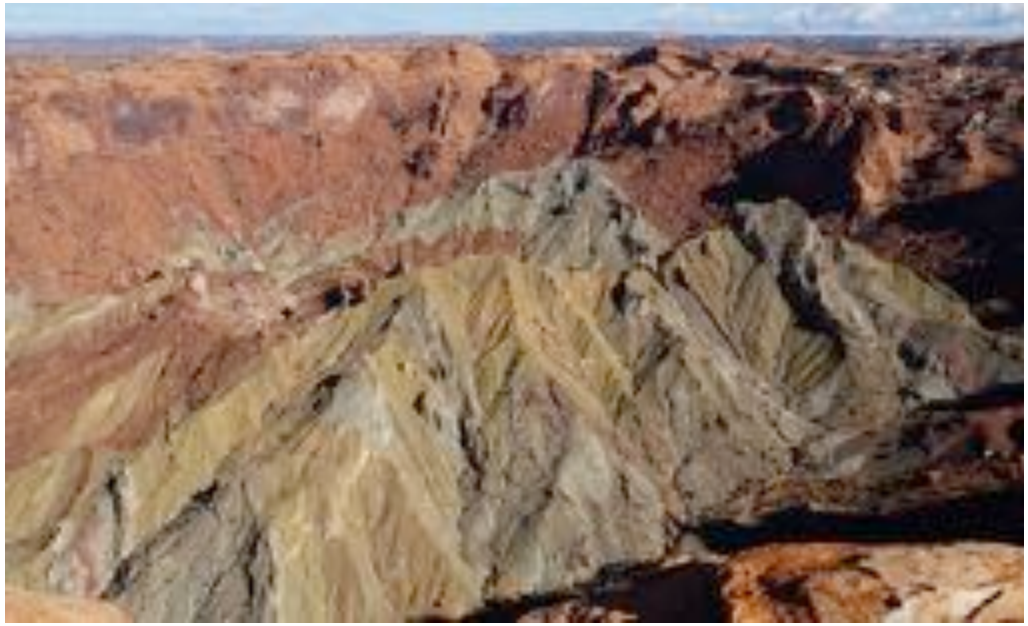
Dead Horse Point

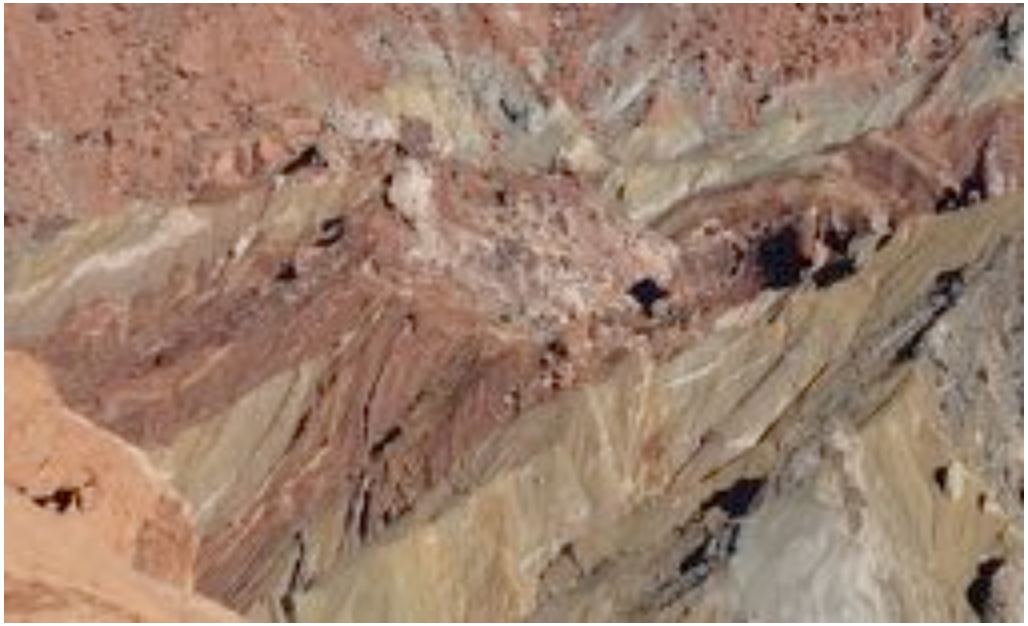
Green river overlook of the “Island in the Sky”

Wingate ss (J)
Moenkopi fm (T)
White rim ss (P)

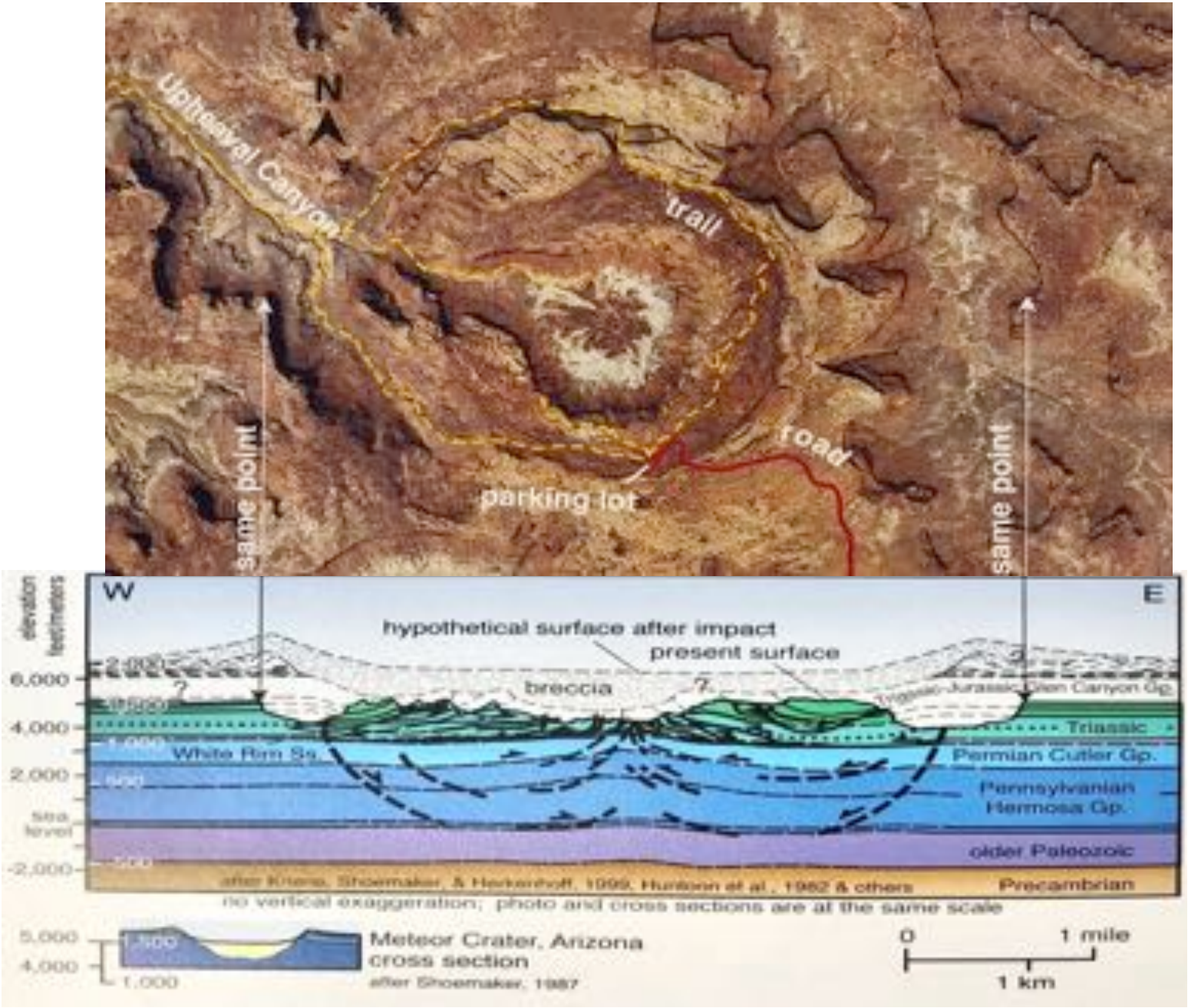
Wingate ss (J)
Moenkopi fm (T)
White rim ss (P)
Organ rock fm (P)

Upheaval Dome





Upheaval Dome

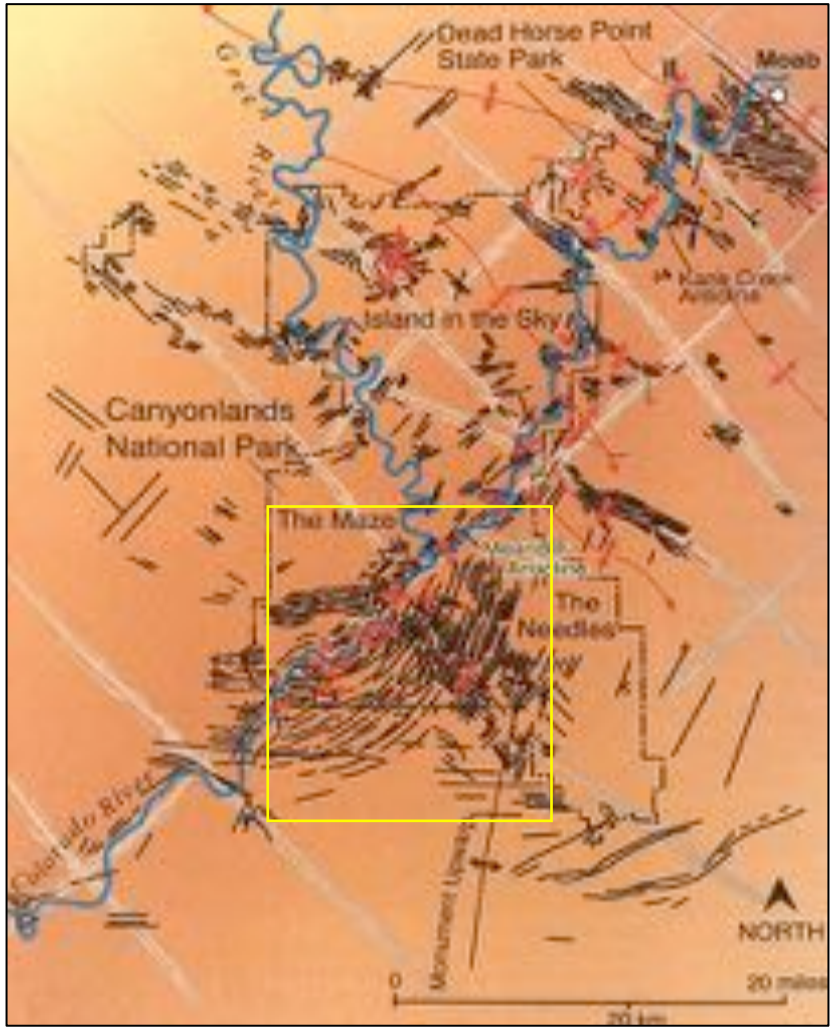


Petroglifos

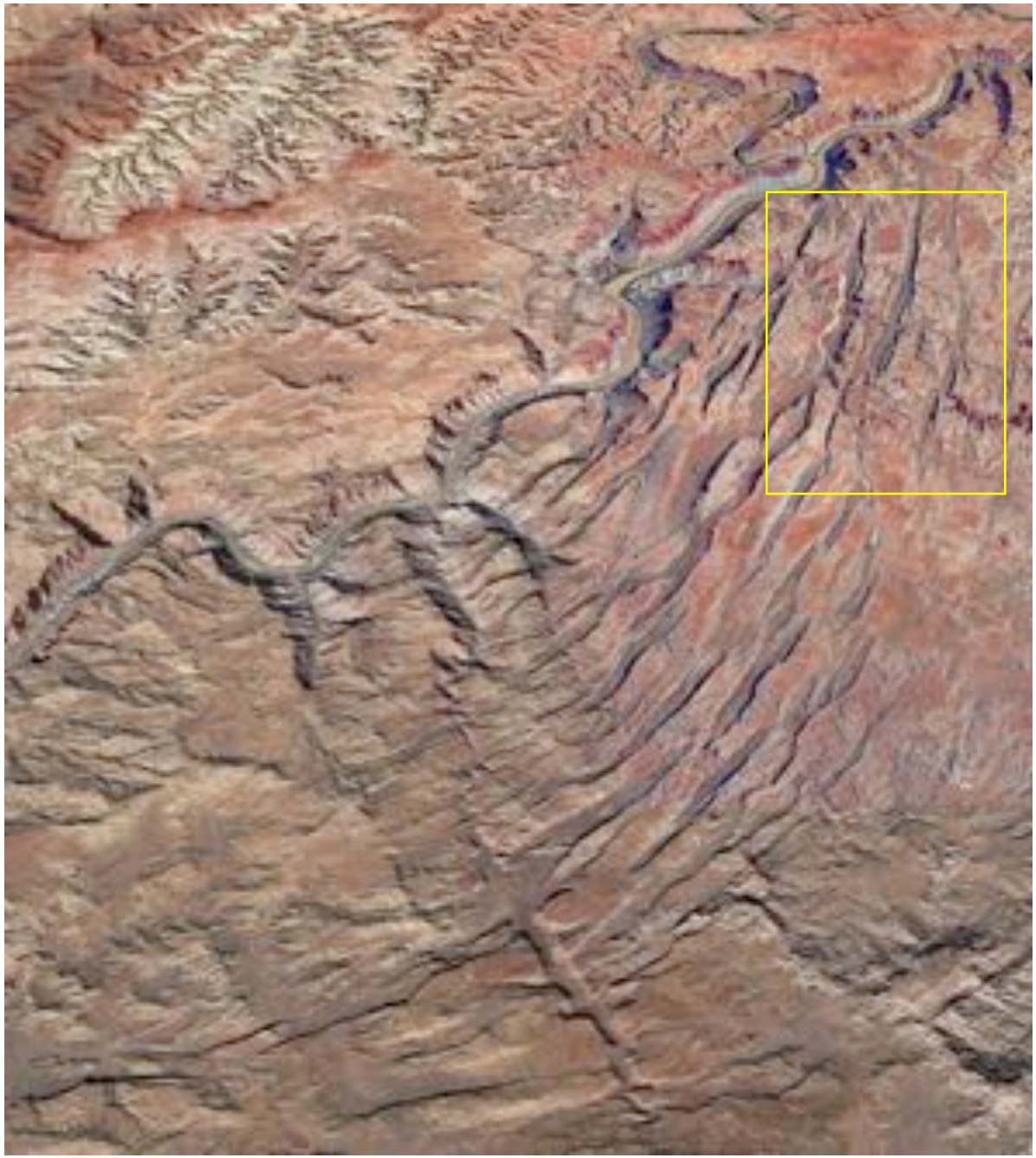
Mesa Arch

PermianWhite rim fm

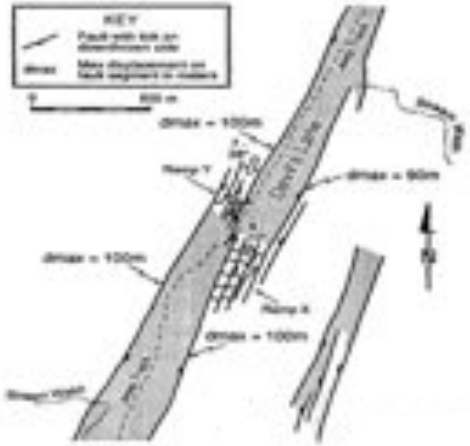
The needles

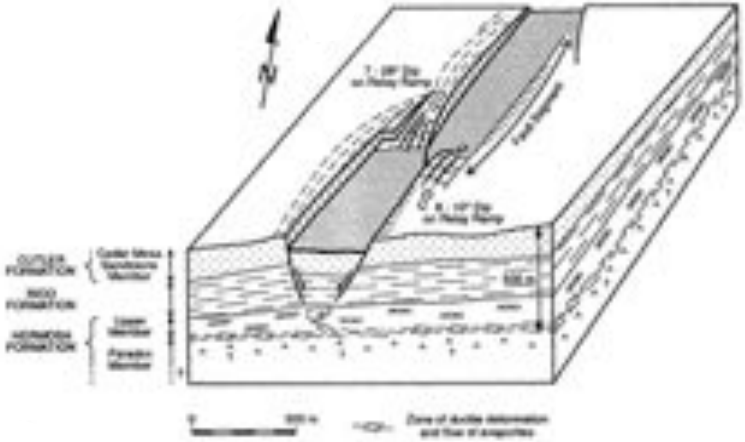


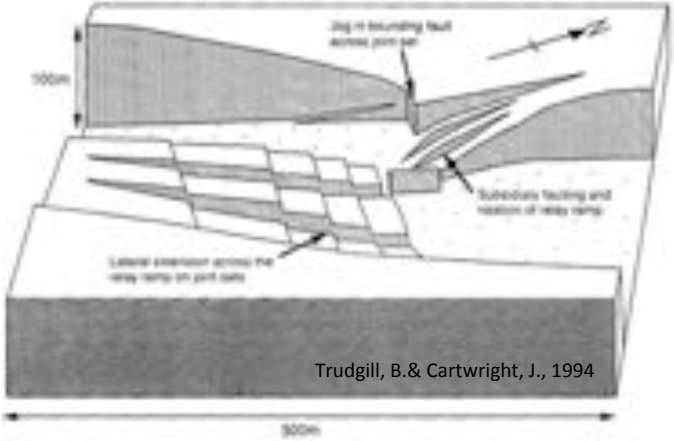
Precambrian faults ⟶ *controlled the location of Pennsylvanian and later folding* ↕ *, related to the movement of salt, and upwarping* ↕ *, related to the Laramide Orogeny. The folding and upwarping caused jointing* ⫽ *, and the salt created instability that allowed the joints to extend downward, fragmenting the rock layers so individual pieces could move.*



Relay-ramp forms The Needles (Canyonlands)

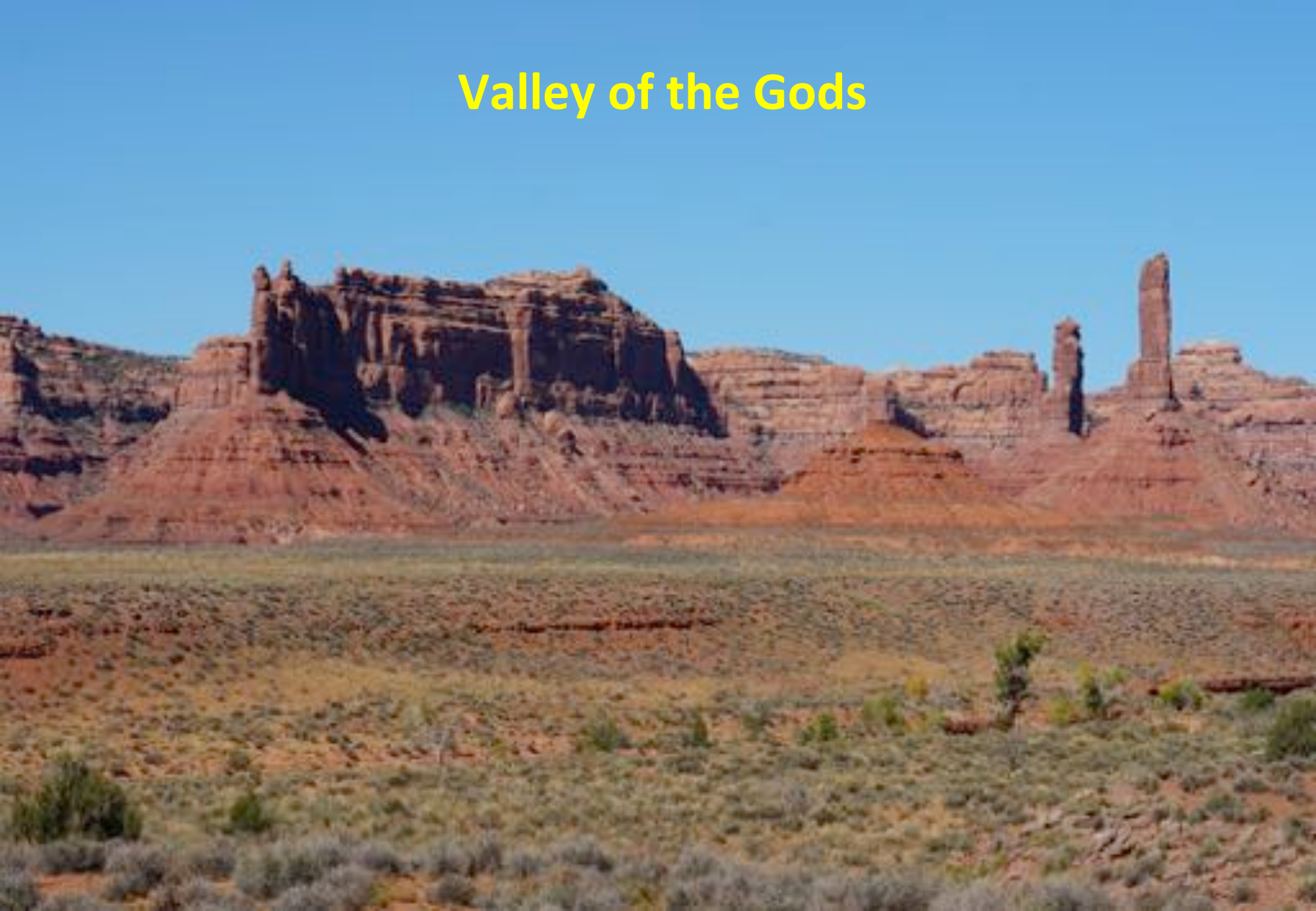






Trudgill, B.& Cartwright, J., 1994

Valley of the Gods



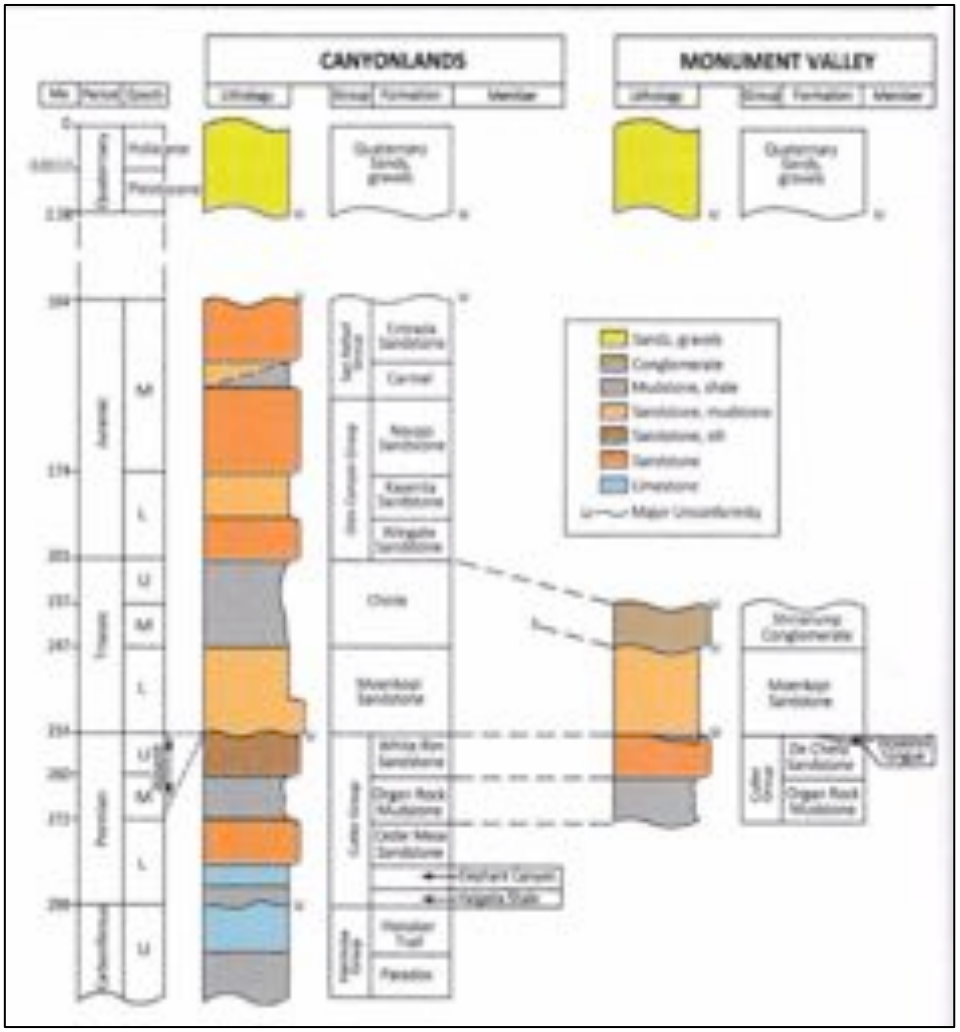
Cedar Mesa ss (P)
Halgaito sh (P)

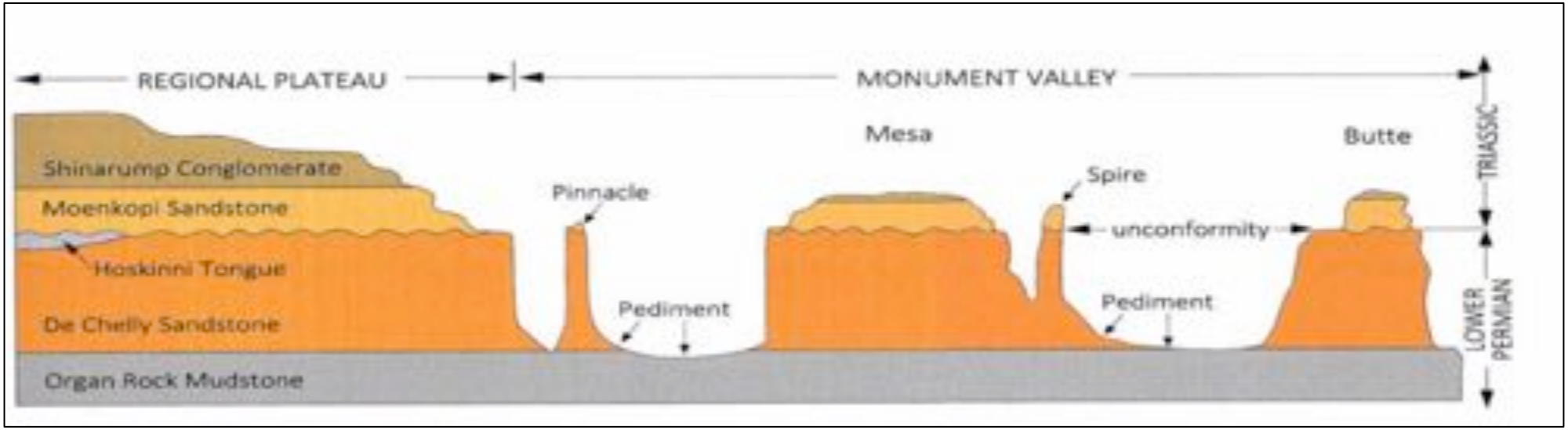
Butte
Mesa
Spire

Lower Permian in the flanks of the Monument uplift

Monument Valley Navajo Tribal Park
Utah and Arizona

Monument Valley




REGIONAL PLATEAU
MONUMENT VALLEY
Mesa
Butte
Shinarump Conglomerate
Moenkopi Sandstone
Hoskinni Tongue
De Chelly Sandstone
Organ Rock Mudstone
Pinnacle
Pediment
Spire
unconformity
Pediment
TRIASSIC
LOWER PERMIAN

Shrinarump cg (T)
Moenkopi ss (T)
De Cheli ss (P)
Organ rock ms (P)

Mitten Buttes

Centauros del desierto
John Ford, 1961

Three sisters
Mitchel Mesa

Totem Pole

Grand Canyon
South rim, Arizona

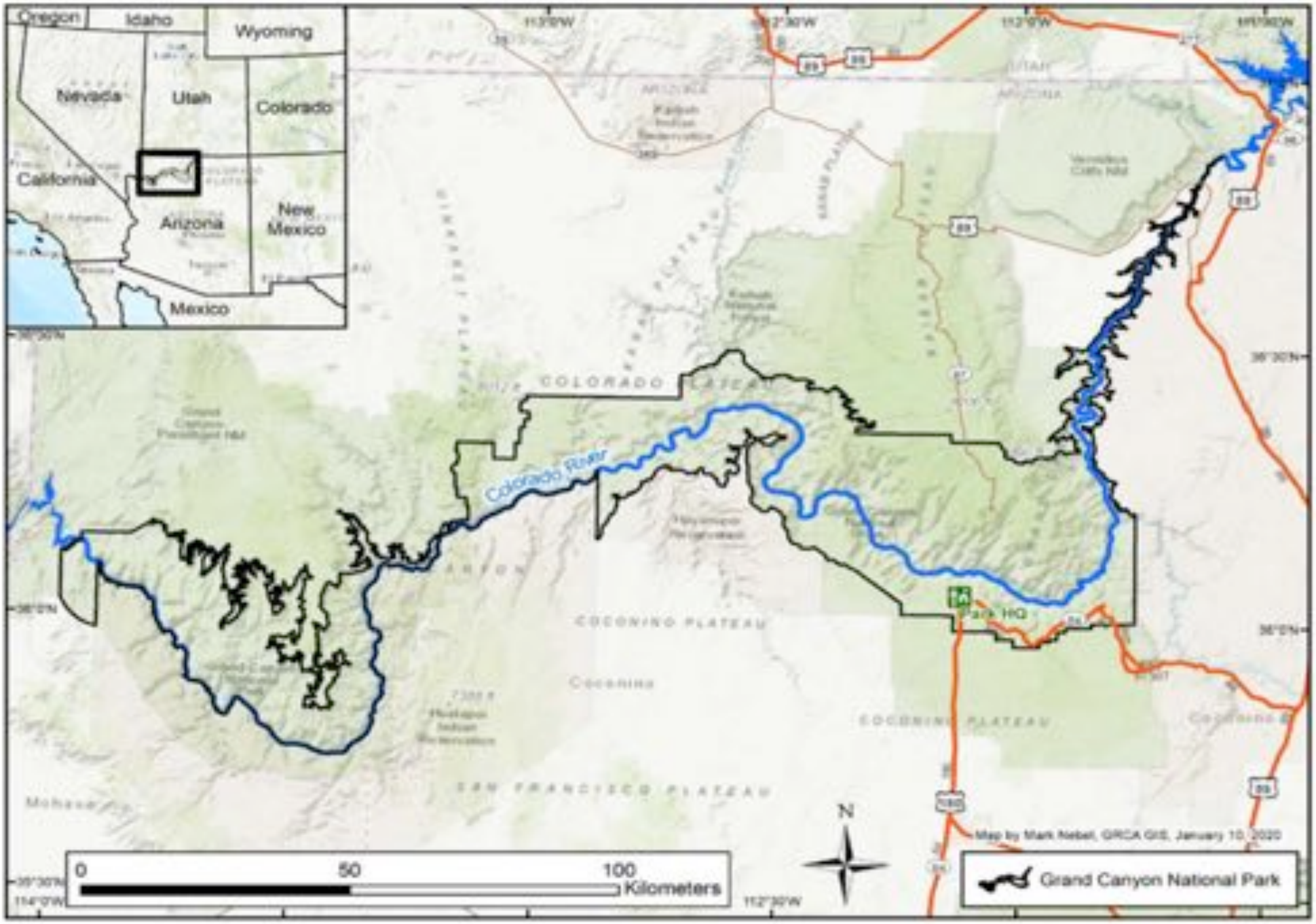
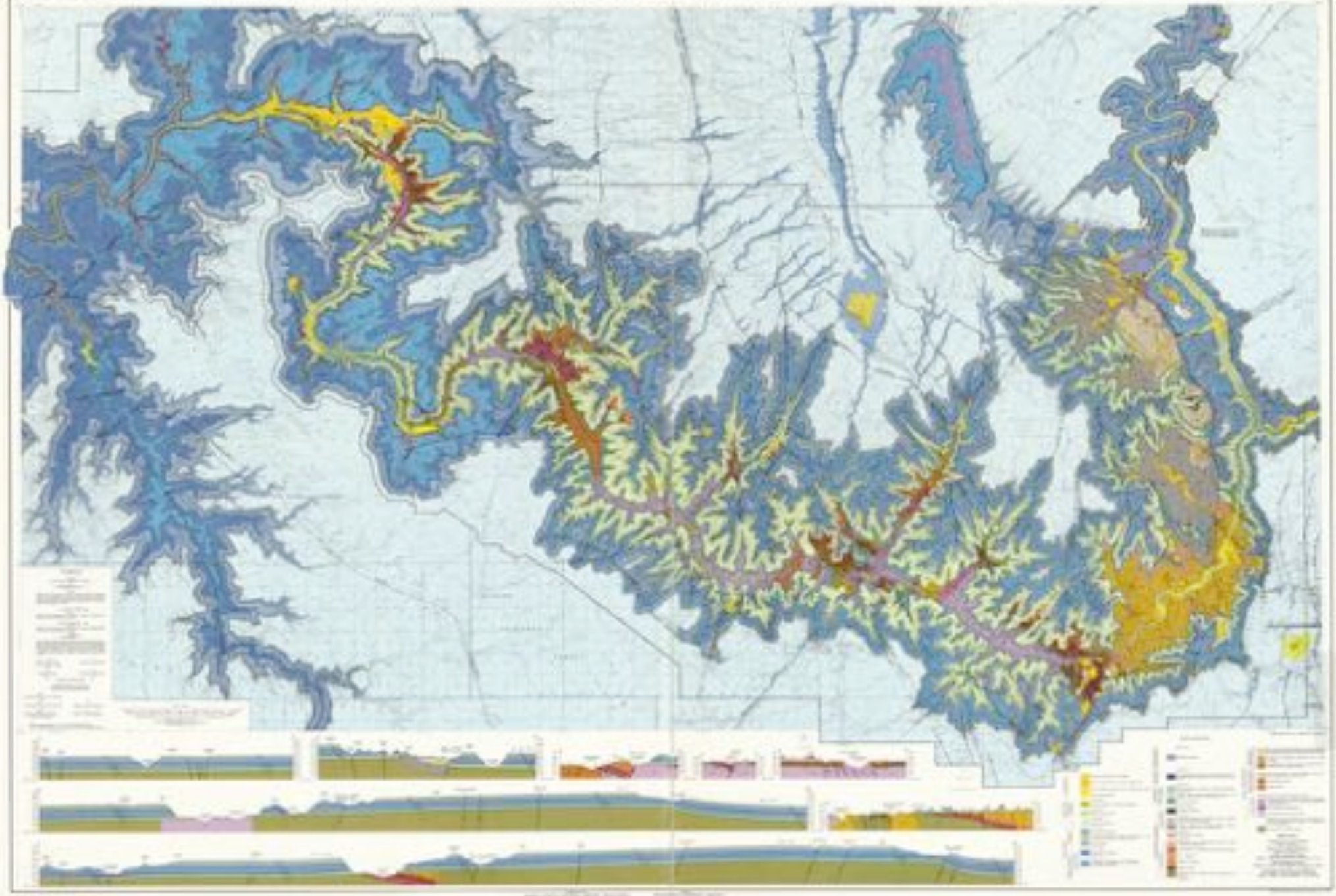
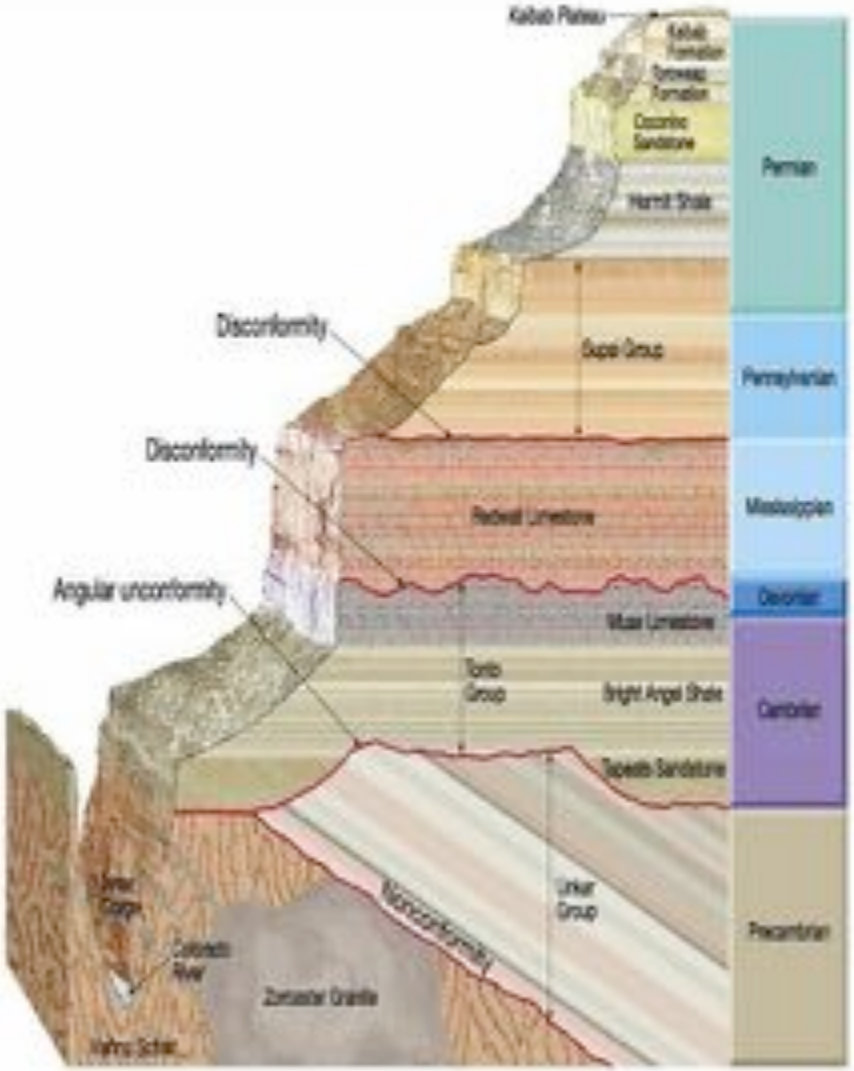


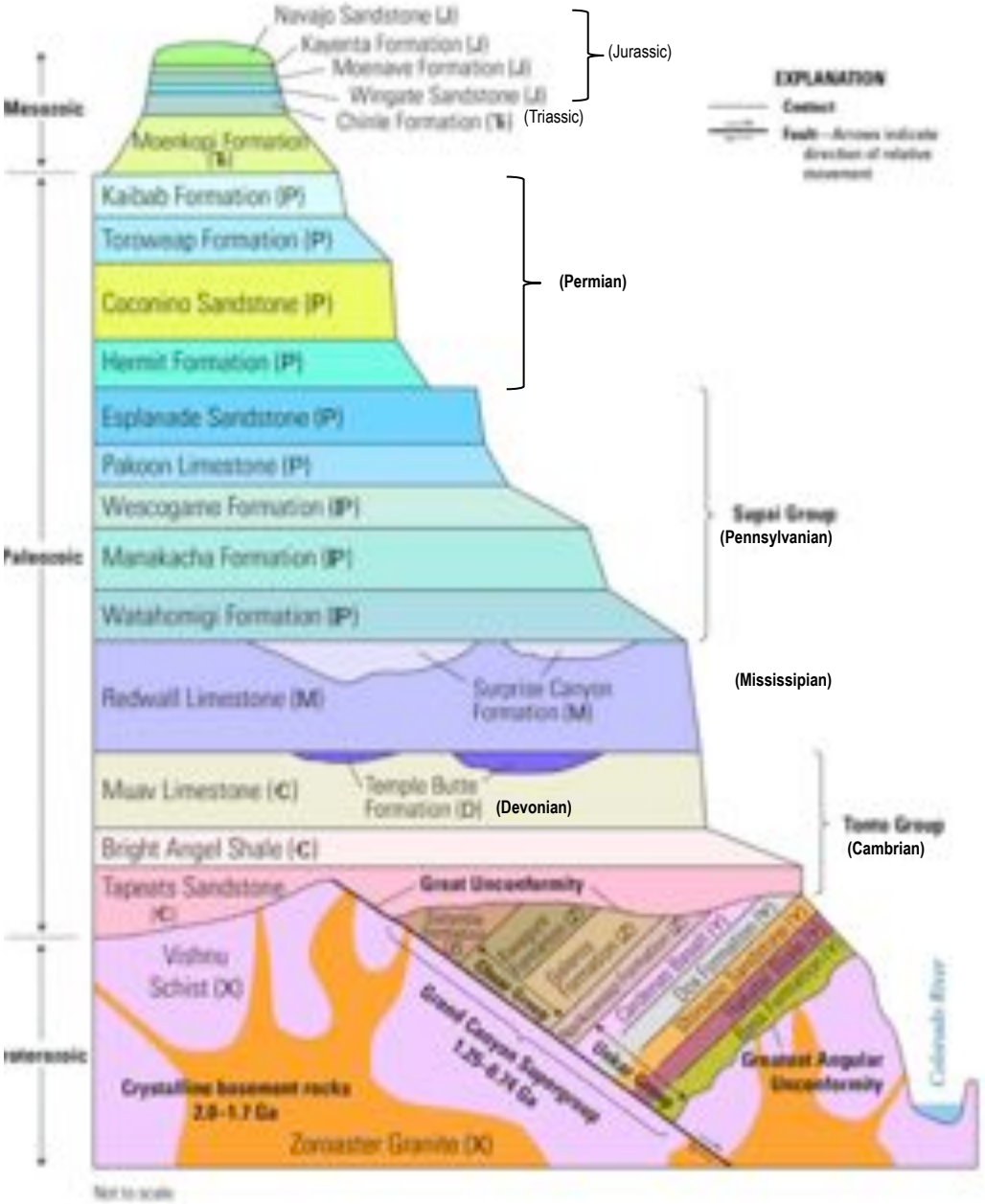
Figure 1. *Map of Grand Canyon National Park (NPS/MARK NEBEL).*

GEOLOGIC MAP OF THE EASTERN PART OF THE GRAND CANYON NATIONAL PARK, ARIZONA

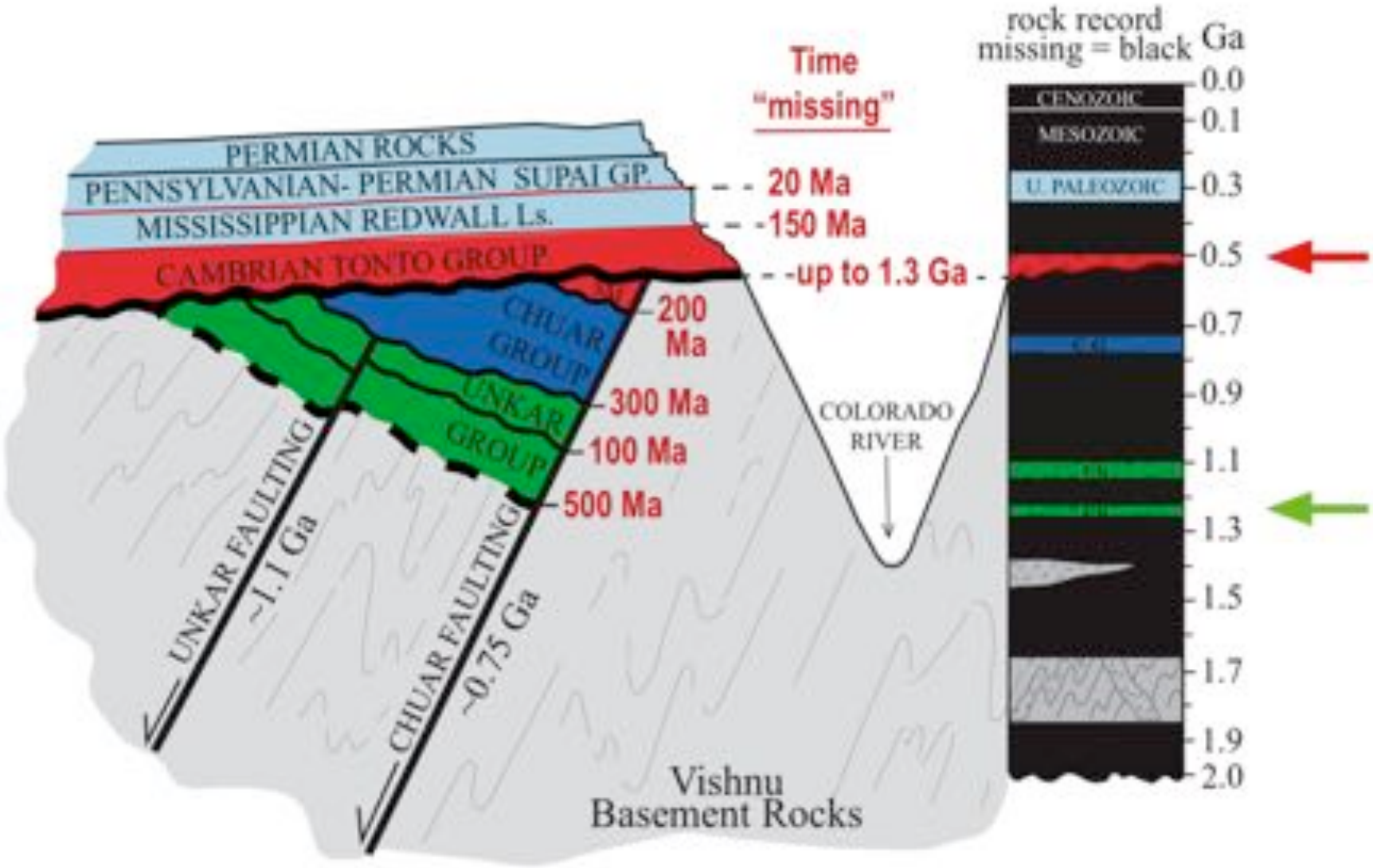


Grand Canyon Stratigraphy





The Great Unconformity of the Grand Canyon



80% of the past 2 billions years of time is missing (not recorded) at Grand Canyon, still one of the world´s best rock records!

Figure 2. Mesoproterozoic rocks of the Unkar Group (Grand Canyon Supergroup) in eastern Grand Canyon. Yc=Hotauta Conglomerate Member; Yb=Bass Formation; Yt=Cardenas Basalt; Yh=Hakatai Shale; Ys=Shinumo Sandstone (Billingsley and others, 2019; figure 3).

Figure 4. Upper Tonto Group (Cm=Muav Limestone; Cu="undifferentiated dolomites", now the Frenchman Mountain Dolostone), Temple Butte Formation (Ztt), and Redwall Limestone (Mtw=Whitmore Wash Member; Mtt=Thunder Springs Member; Mmw=Mooney Falls Member) in eastern Grand Canyon (Billingsley and others, 2019; figure 5).

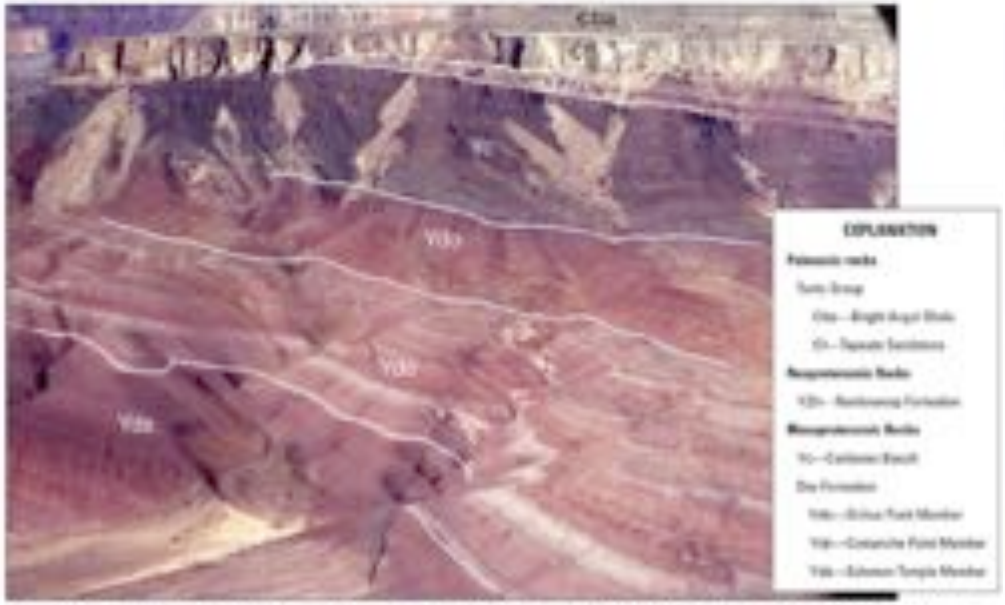


Figure 3. Mesoproterozoic rocks in contact with lower Tonto Group (Tapeats Sandstone and Bright Angel Shale) in eastern Grand Canyon (Billingsley and others, 2019; figure 4).

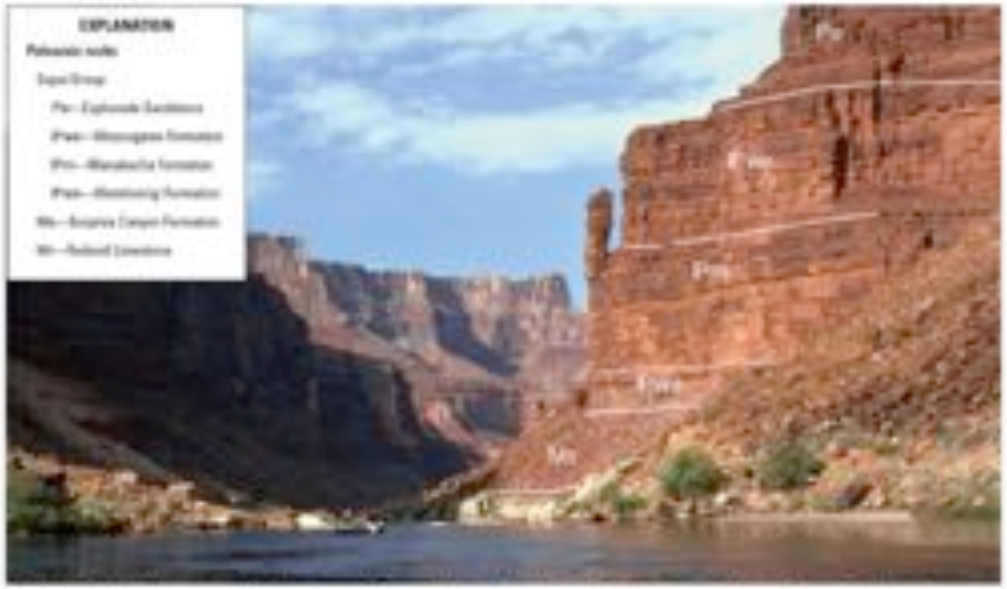
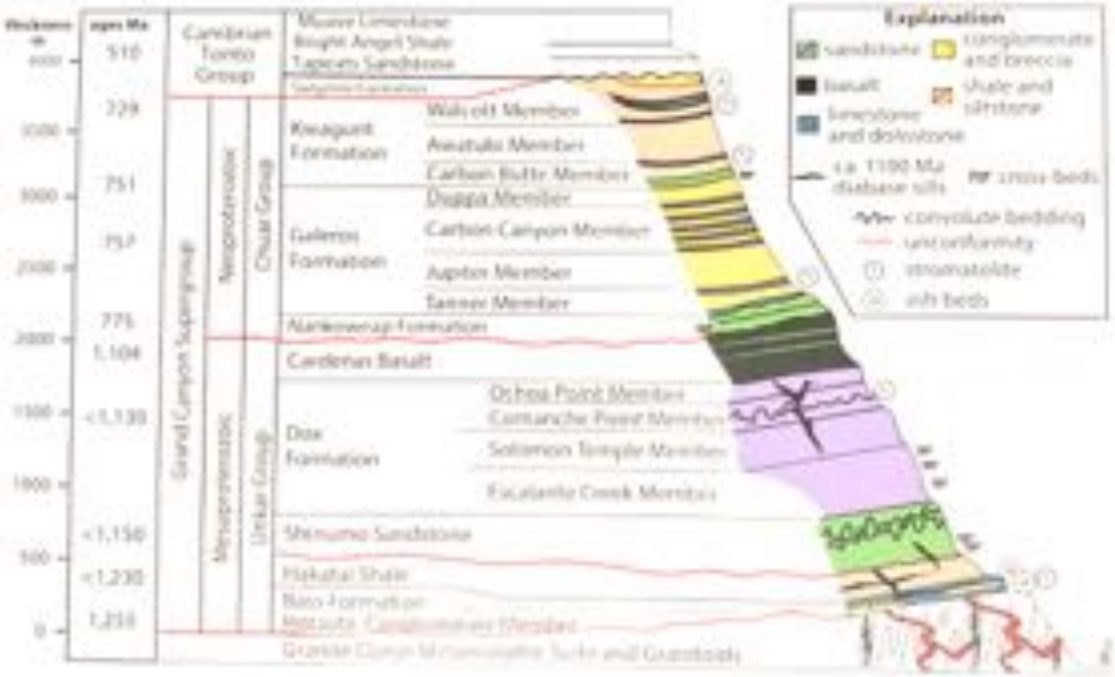


Figure 5. Redwall Limestone (Mr), Surprise Canyon Formation (Mc), and overlying Supai Group (Pwa=Watahomigi Formation, Pm=Manakacha Formation, Pwa=Wescogame Formation, Pe=Esplanade Sandstone) (Billingsley and others, 2019; figure 6).

Tre Great Unconformity

Looking north from Lipan Point in eastern Grand Canyon, flat-lying Tapeats Sandstone (508 Ma) rests on tilted Unkar Group (1250 to 1100 Ma). Up to 750 million years of history are missing between them. This is called an angular unconformity because the Unkar Group was tilted and eroded before the Tapeats Sandstone of the Tonto Group was deposited.

Grand Canyon´s oldest fossils, 1,25 billion year old stromatolites, formed from algal colonies in a shallow sea



Kaibab fm
Coconino fm
Hermit fm
Supai Gp (Pennsylv.).
Redwall lms
Tonto gp. (Cambrian)
Tapeats ss
Galeros fm
Nankoweap fm
Cardenas basalt
Dox fm

Tapeats ss (Cambrian)
Vishnu schists (Proterozoic)

Tapeats ss (Cambrian)
Vishnu schists (Proterozoic)

The Trail of Time

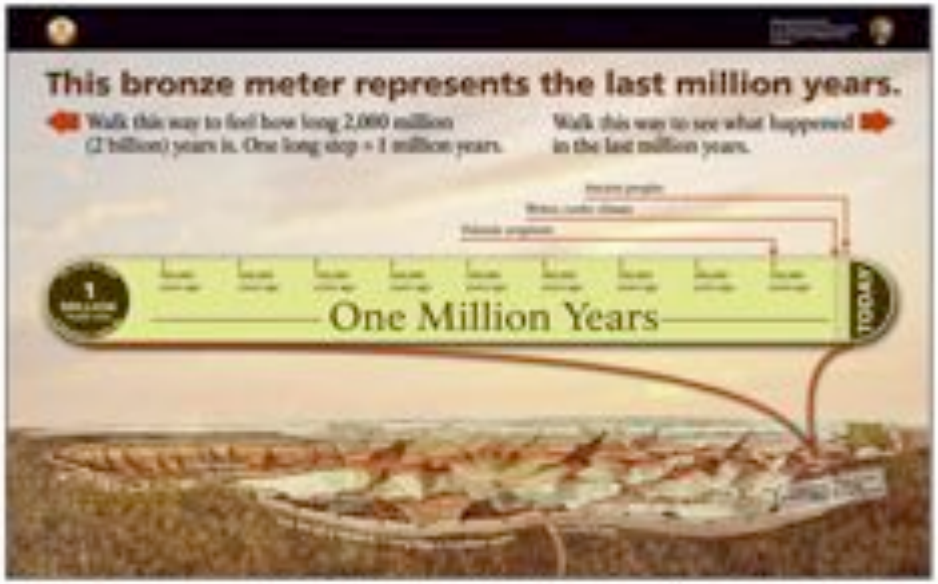


Figure 17. How to walk the Trail of Time geology timeline? It has 3 segments: 1. Million Year Trail, 2. Main Trail of Time, and 3. Early Earth Trail. The walk on the Main Trail of Time, marked at 1 m equals one million years, is 2 km long; the Early Earth Trail takes you to the age of the Earth at the 4560 million year marker near Maricopa Point.

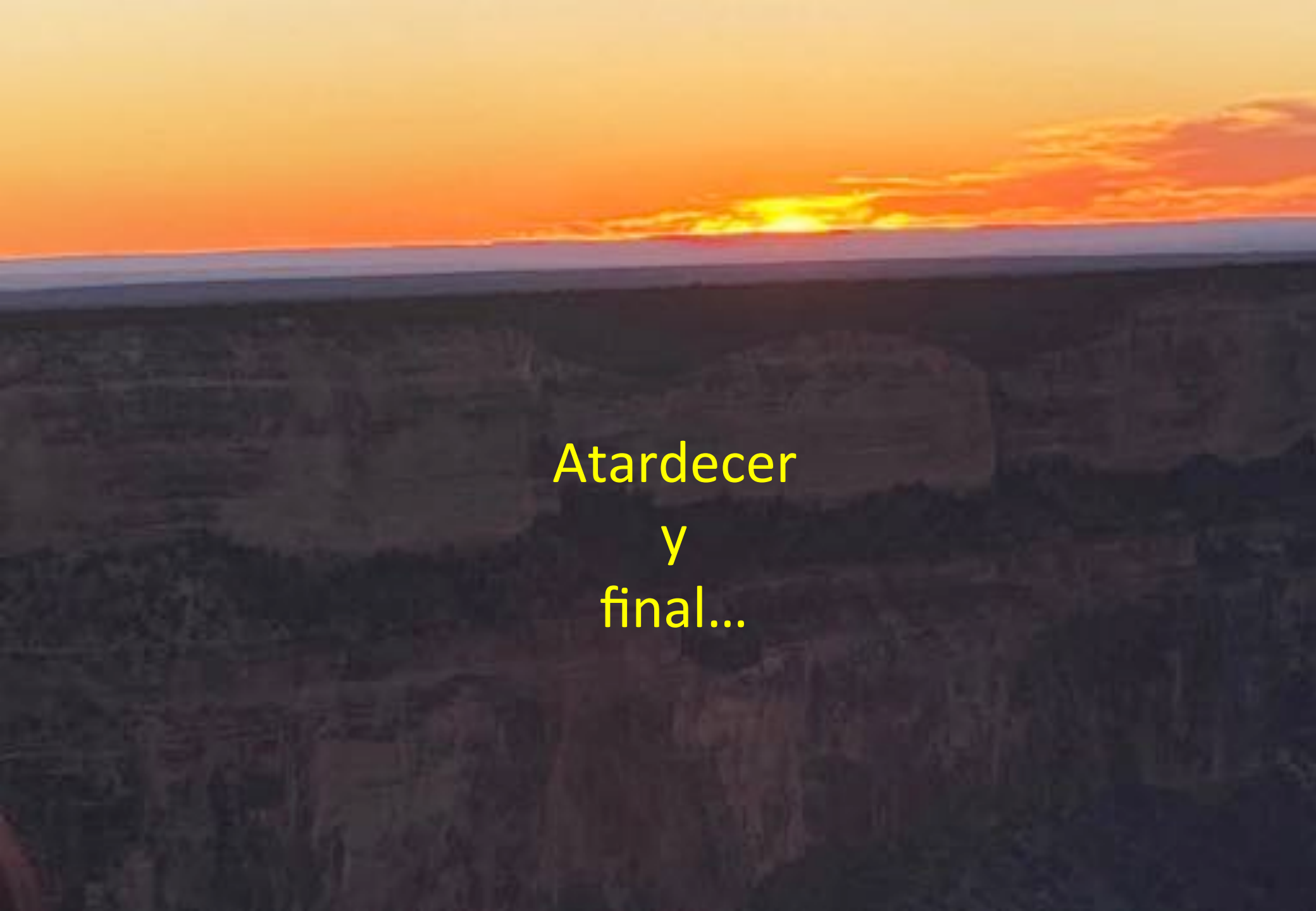
Colorado river

Colorado river

Kaibab fm
Coconino fm

Bright Angel Trail

Luces del Grand Canyon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y
final…