

# OLIGOCENE-MIOCENE SEDIMENTATION RATES ON THE SW COLORADO PLATEAU: ARIDITY-DRIVEN AGGRADATION SUPPORTS A LATE NEOGENE COLORADO RIVER

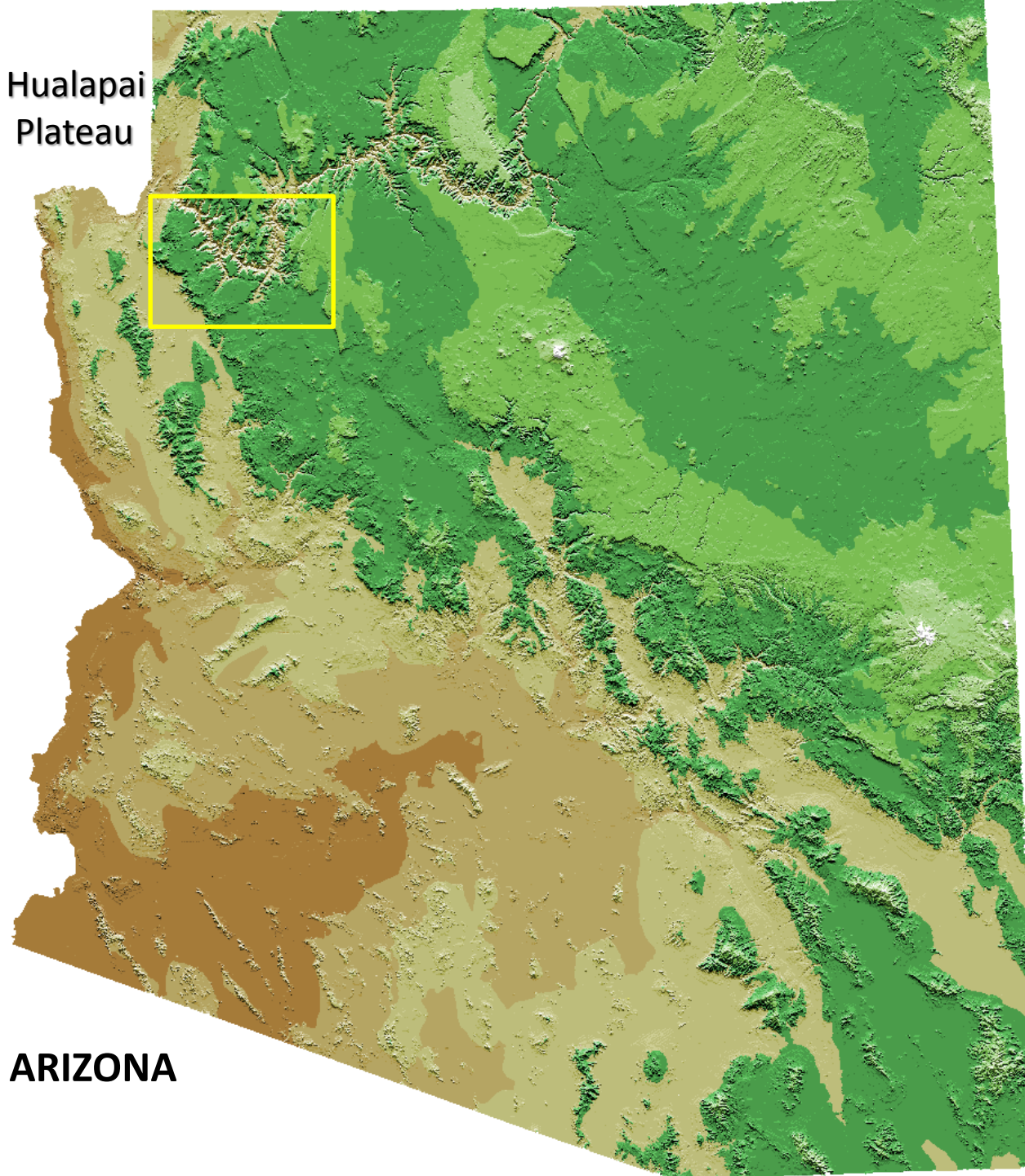
Hualapai Plateau

Shivwits Plateau

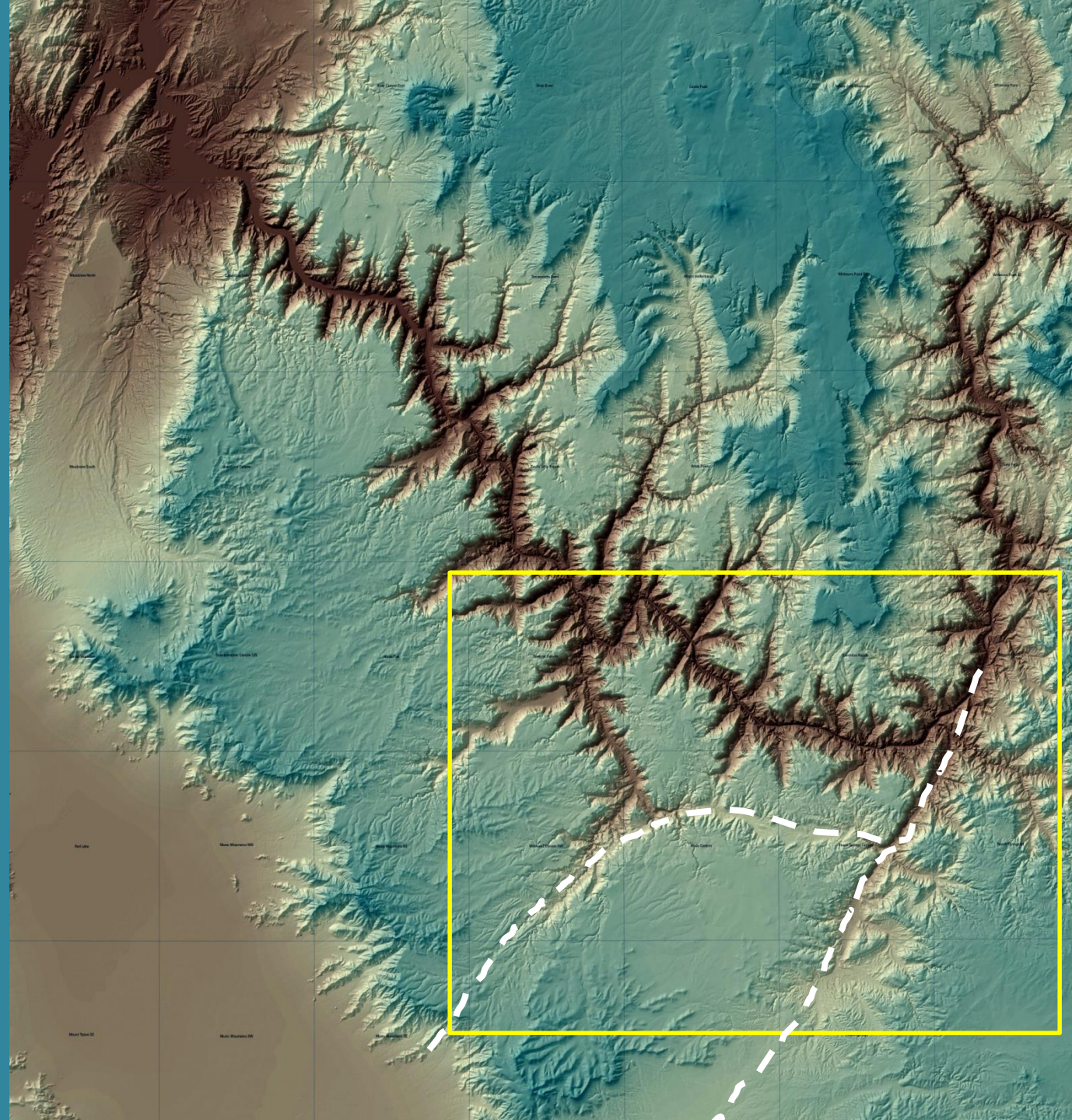


R.A. Young  
SUNY Geneseo  
GSA Phoenix  
Sept. 2019

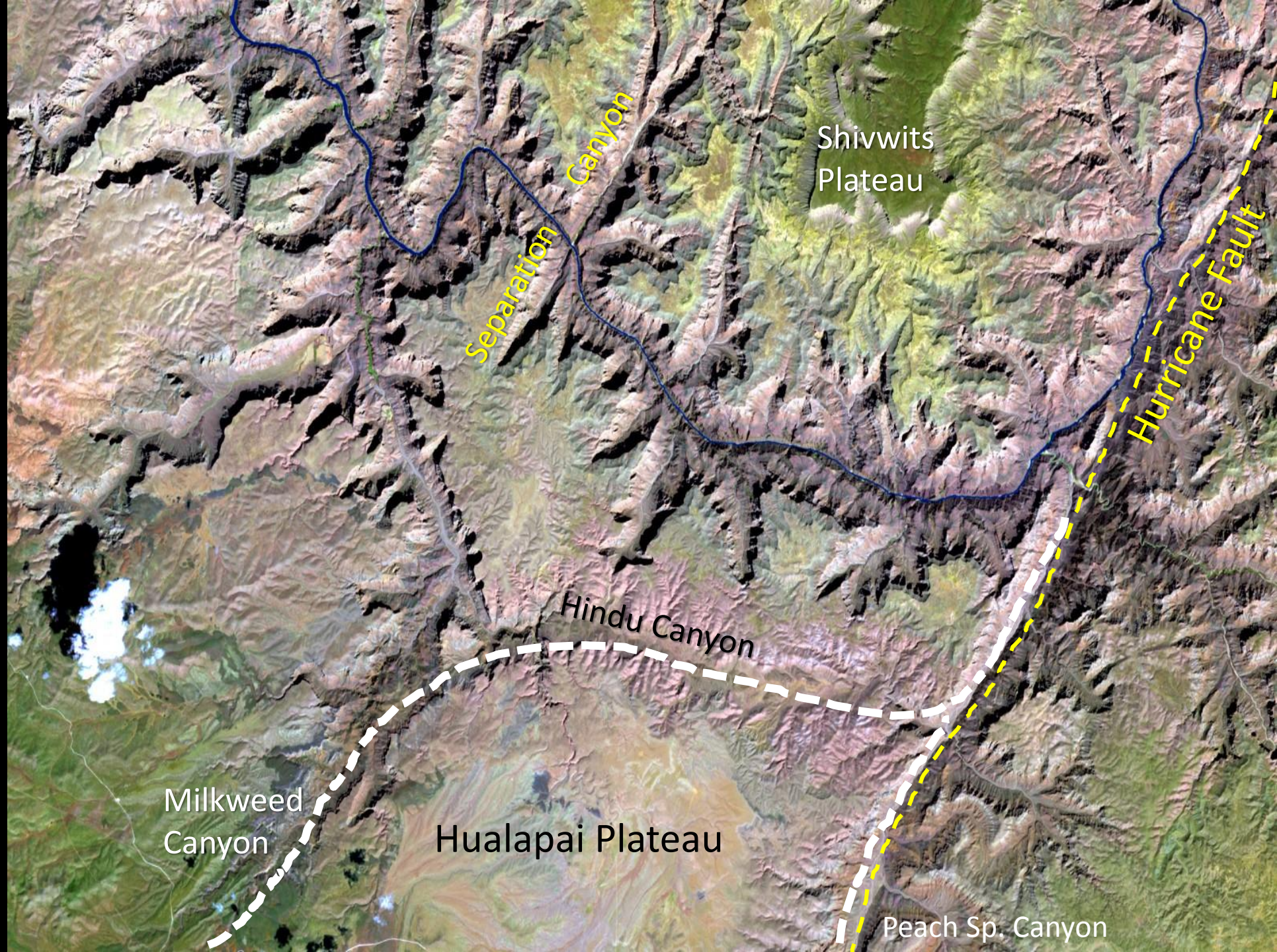
Hualapai  
Plateau



**ARIZONA**



# Hualapai Plateau Laramide Paleodrainage



Shivwits  
Plateau

Separation  
Canyon

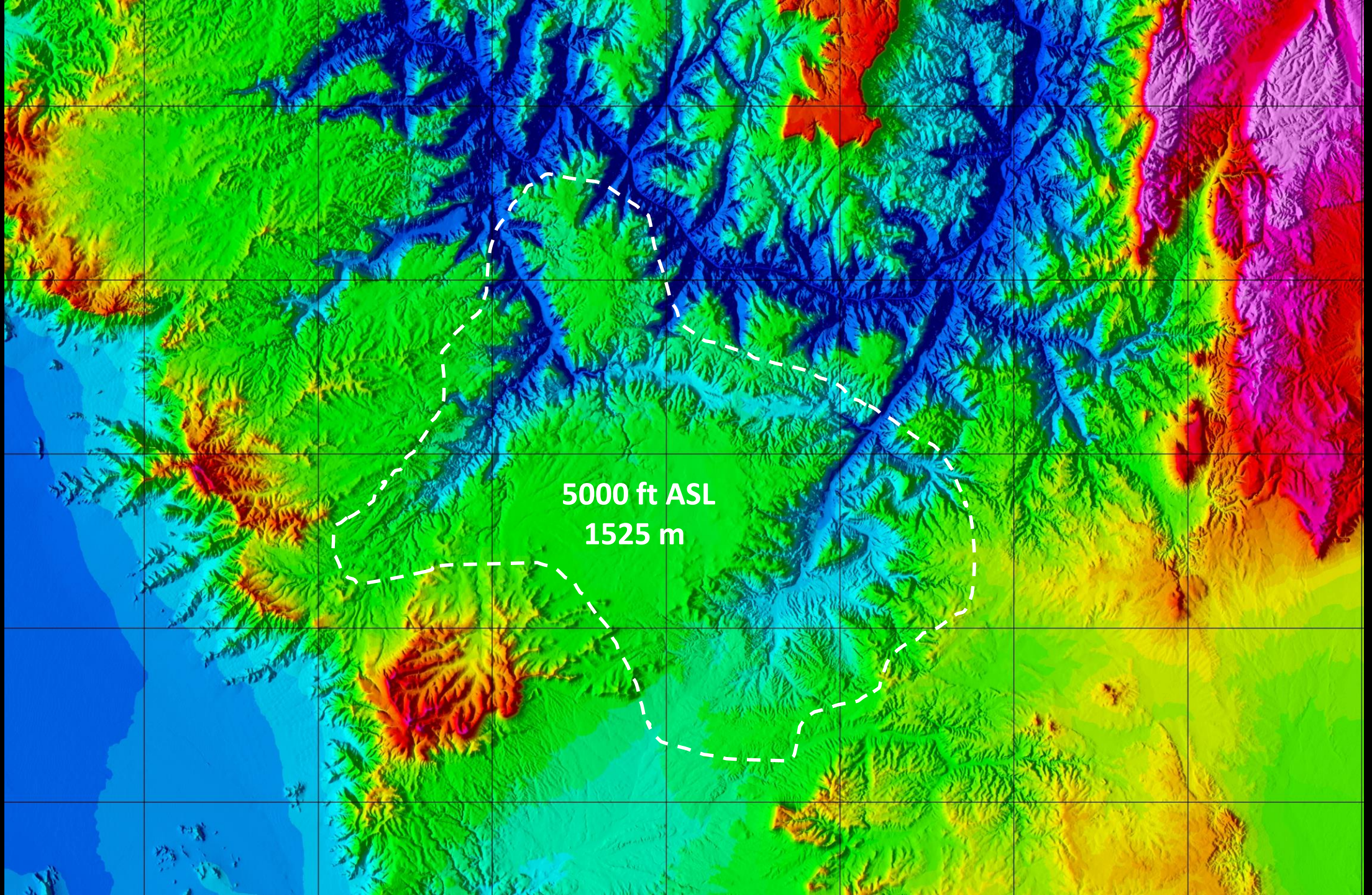
Hurricane Fault

Hindu Canyon

Milkweed  
Canyon

Hualapai Plateau

Peach Sp. Canyon



5000 ft ASL  
1525 m

NW

# Flat Surface of Fluvial Aggradation

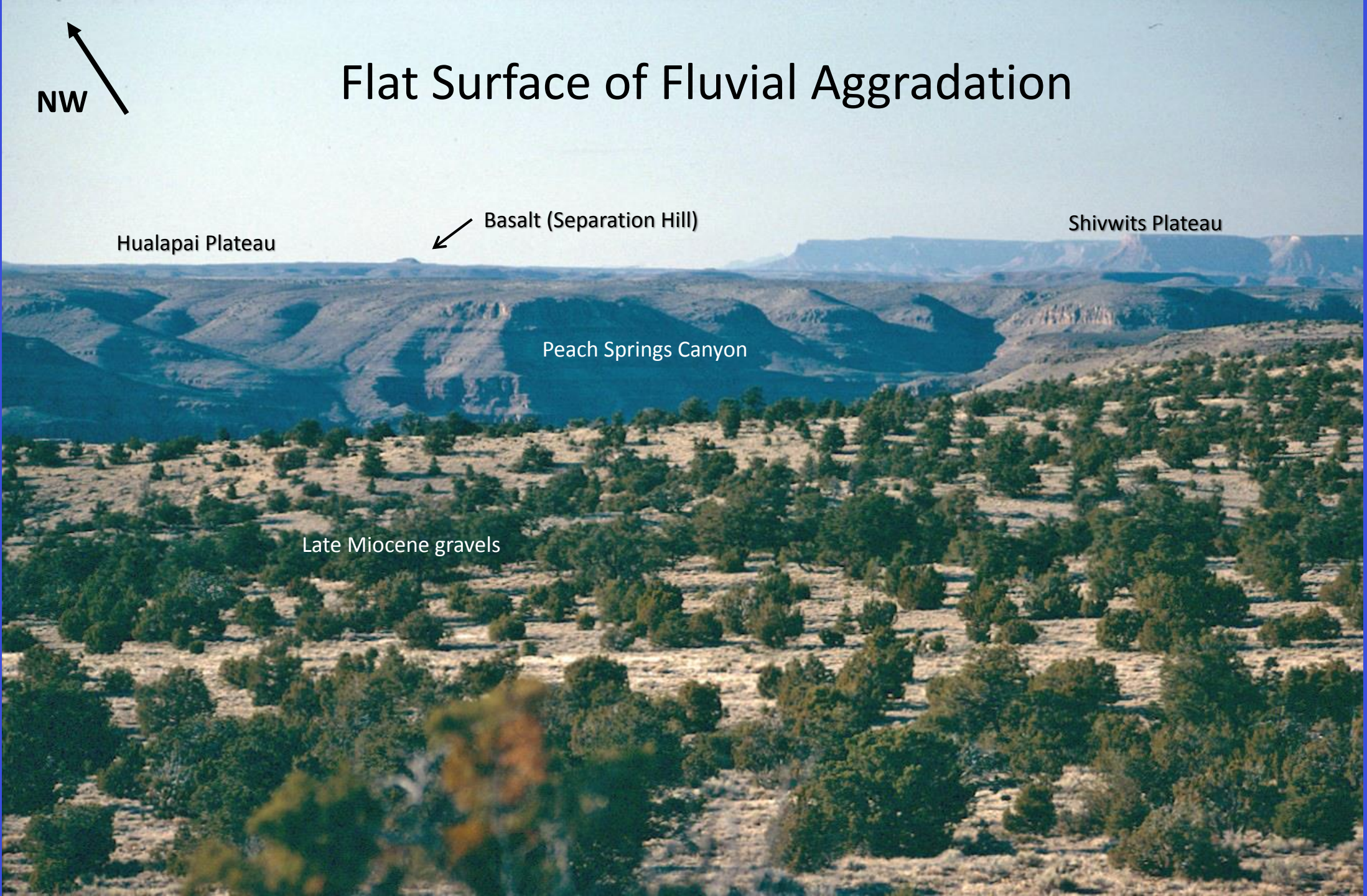
Hualapai Plateau

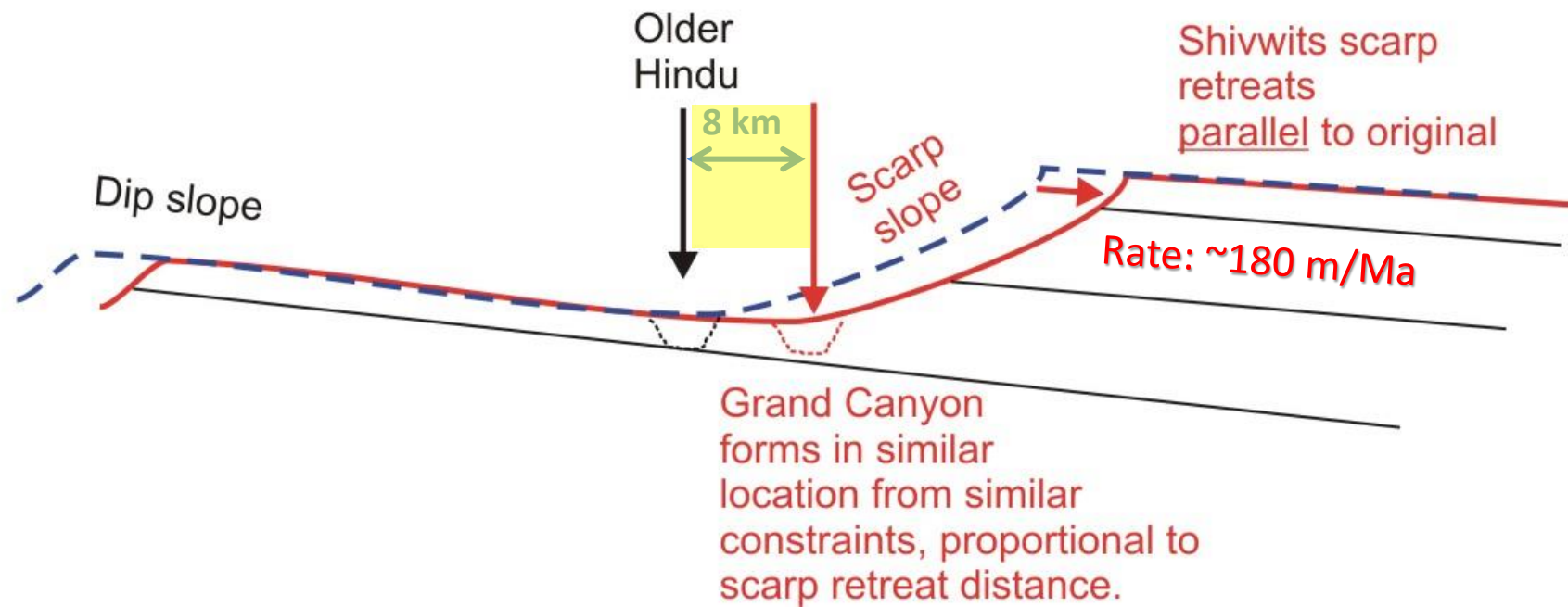
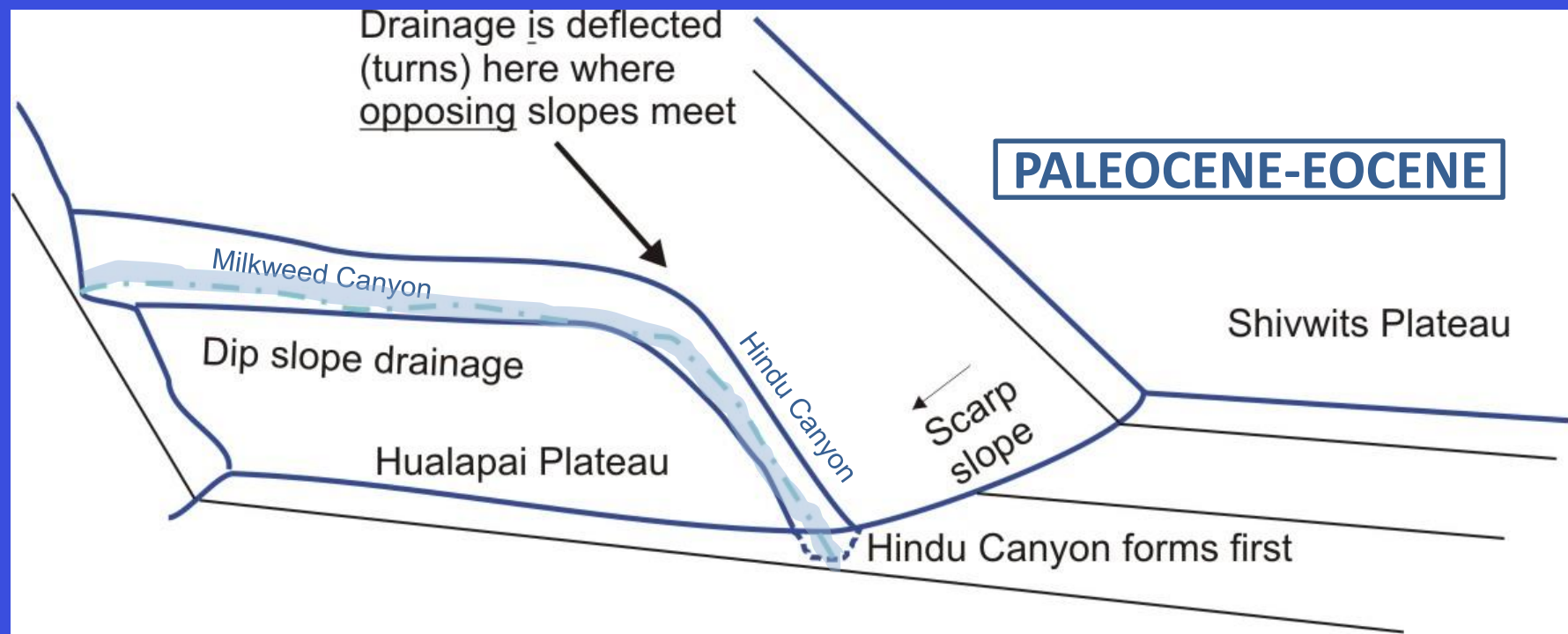
Basalt (Separation Hill)

Shivwits Plateau

Peach Springs Canyon

Late Miocene gravels









# SETTING & RELEVANT ISSUES

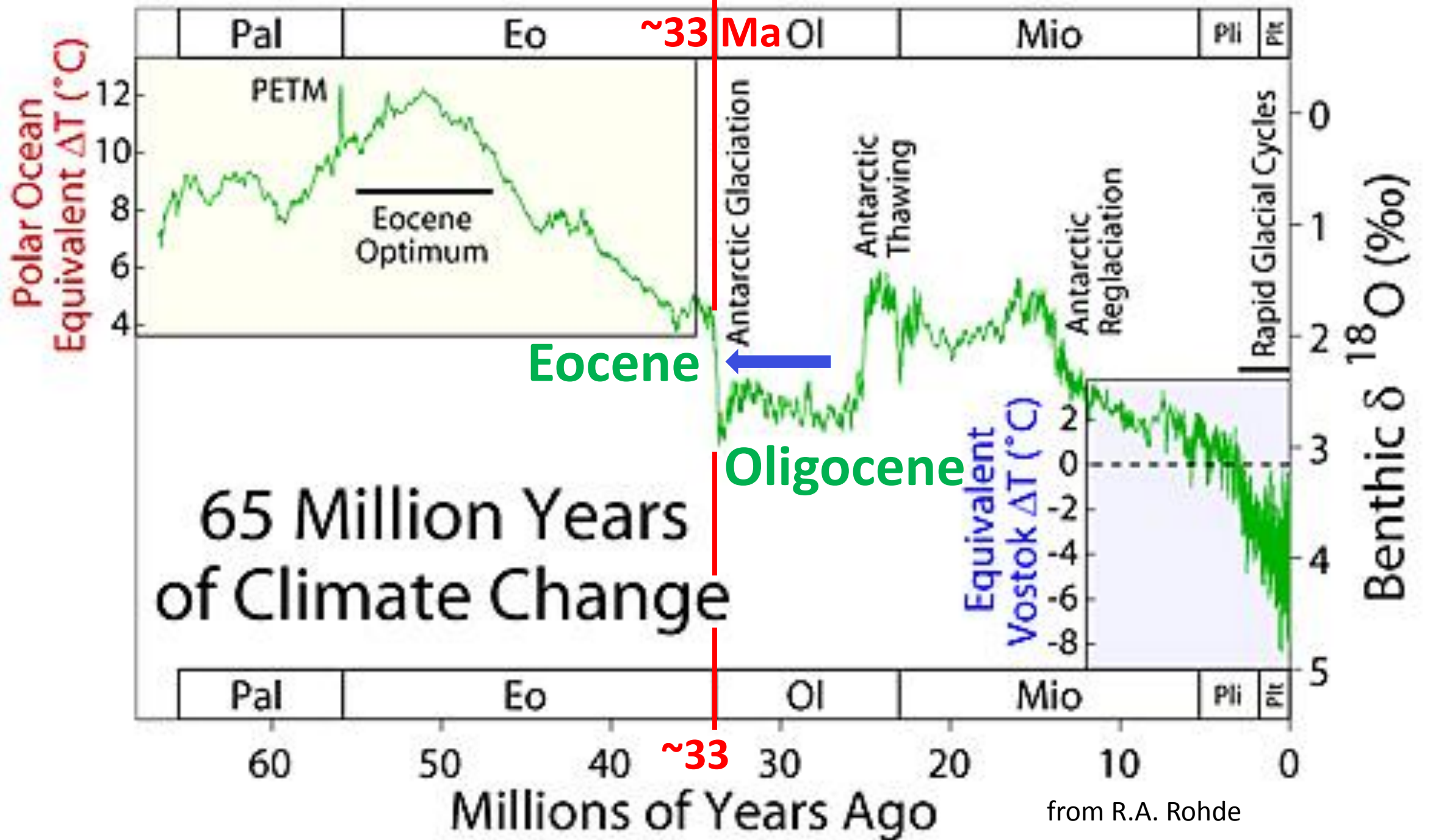
1. Hualapai Plateau is an erosional “cuestaform” bench of Laramide age
2. Disrupted Laramide canyons formed local depocenters that preserve Paleogene thru Late Miocene or Early Pliocene sedimentary record
3. Eocene-Oligocene boundary(~33Ma?) is clearly visible in the stratigraphy
4. Ave. sedimentation rates appear remarkably consistent for ~15 million Ma
5. Record of post-Eocene aggradation refutes pre-Pliocene Colorado River

# EOCENE – OLIGOCENE BOUNDARY IN SD BADLANDS



Brule (Oligocene)

Chadron (Eocene)



# Eocene-Oligocene Boundary Change (N.A.)

- Abrupt climatic deterioration (warm wet to cool dry)

- N.A. Record (Prothro & Berggren, 1992)

32 Ma Wooded grasslands

33 Ma Dry Woodlands

34 Ma Dry Forests

38 Ma Moist Forests

OLIGOCENE

EOCENE

## EOCENE-OLIGOCENE CLIMATIC AND BIOTIC EVOLUTION

EDITED BY DONALD R. PROTHRO AND  
WILLIAM A. BERGGREN





# INDIGENOUS PETRIFIED LOGS

## Peach Springs Canyon

Note Preserved Bark and Growth Ring Detail  
(Paleogene Music Mt. Formation)

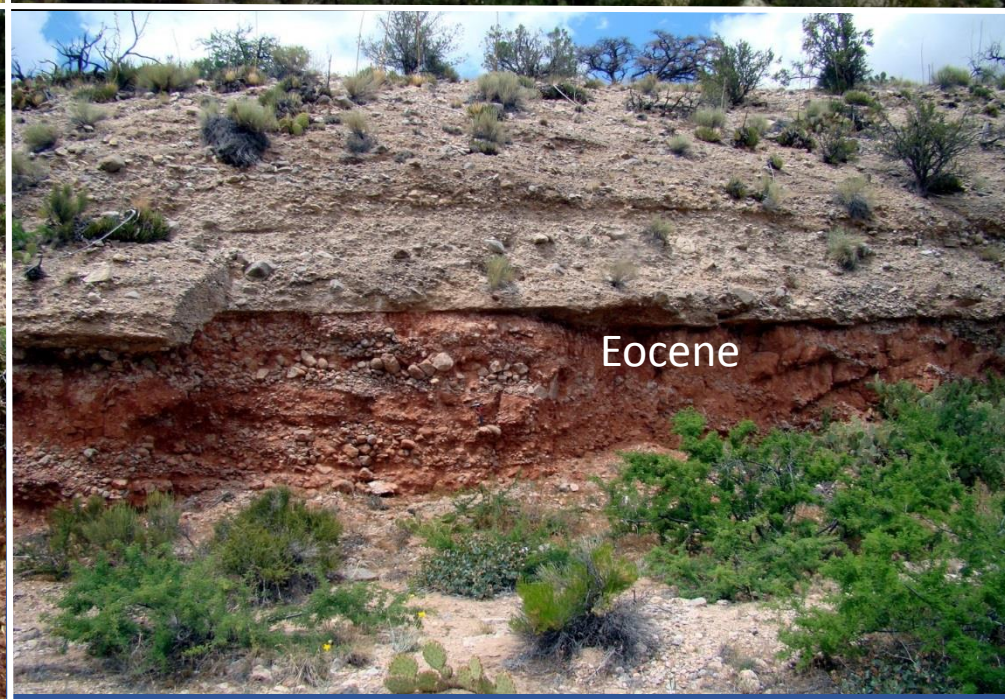
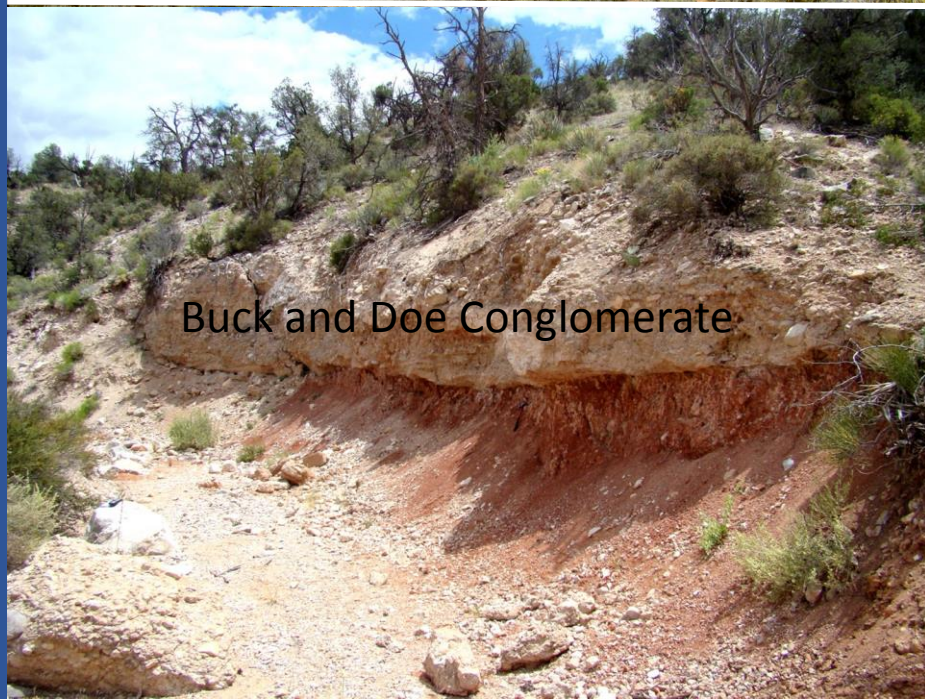
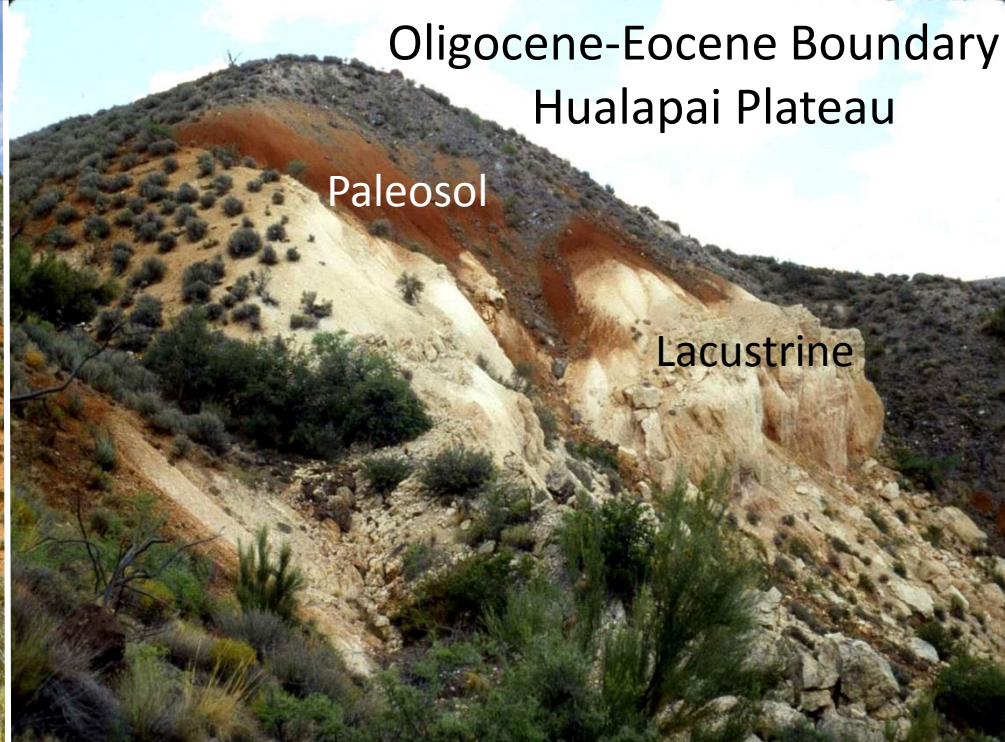



Growth  
Ring detail



# Compare Arizona Section with Eocene in S. Dakota Badlands







A photograph of a geological outcrop showing several distinct layers. At the top is a light-colored, textured layer. Below it is a dark, shadowed area. The middle section is a thick, reddish-brown layer. The bottom section is a light-colored, layered rock. Two people and a dog are visible on the left side of the outcrop, providing a sense of scale. The sky is blue in the upper right corner.

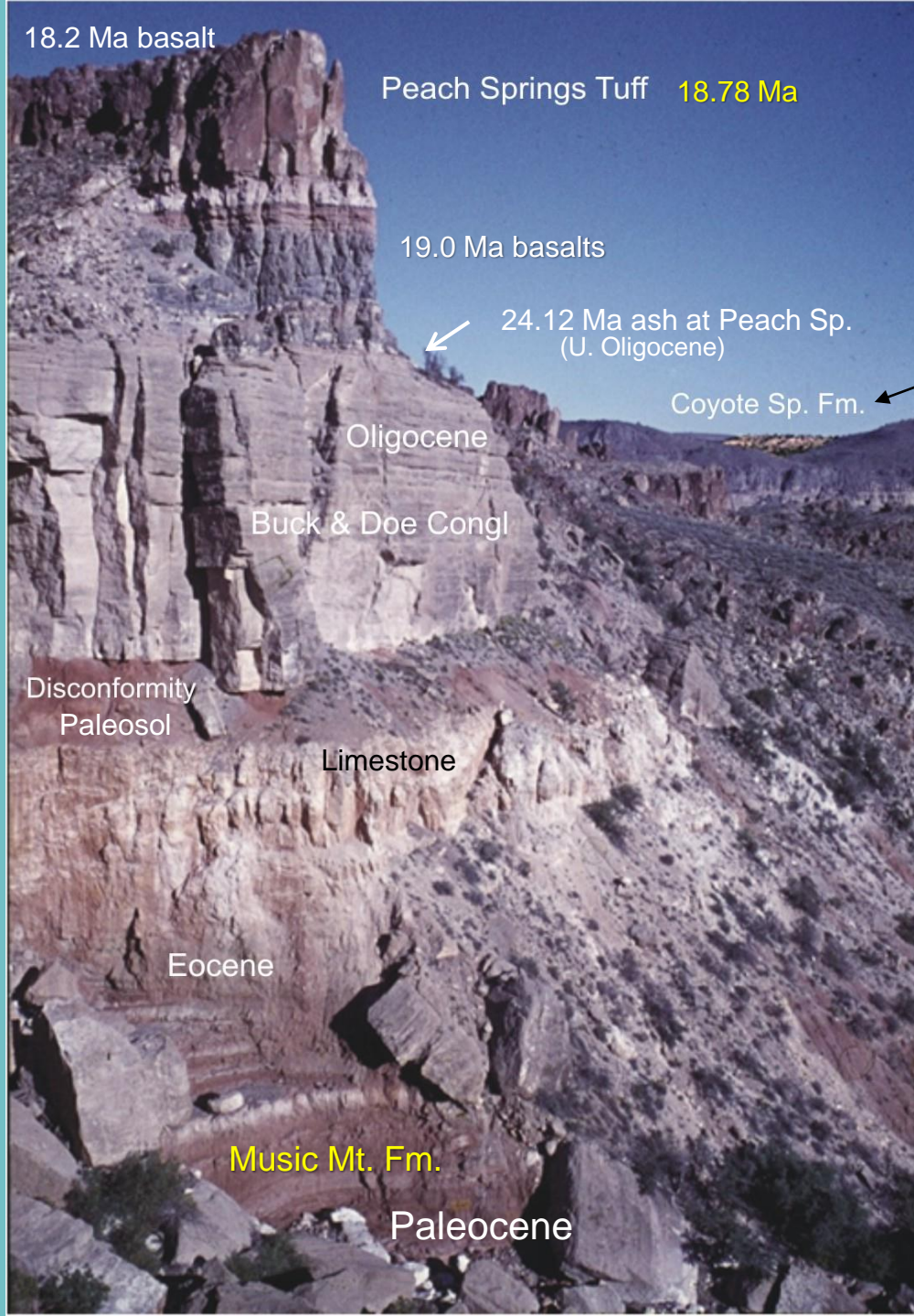
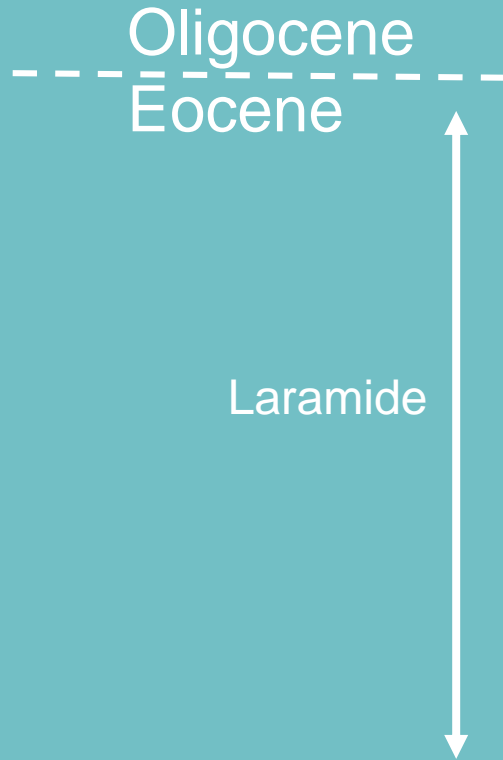
Buck & Doe  
Conglomerate  
(24 Ma at top)

Milkweed  
paleoCanyon

Subtropical(?) Paleosol (Eocene: ~33Ma)

Limestone

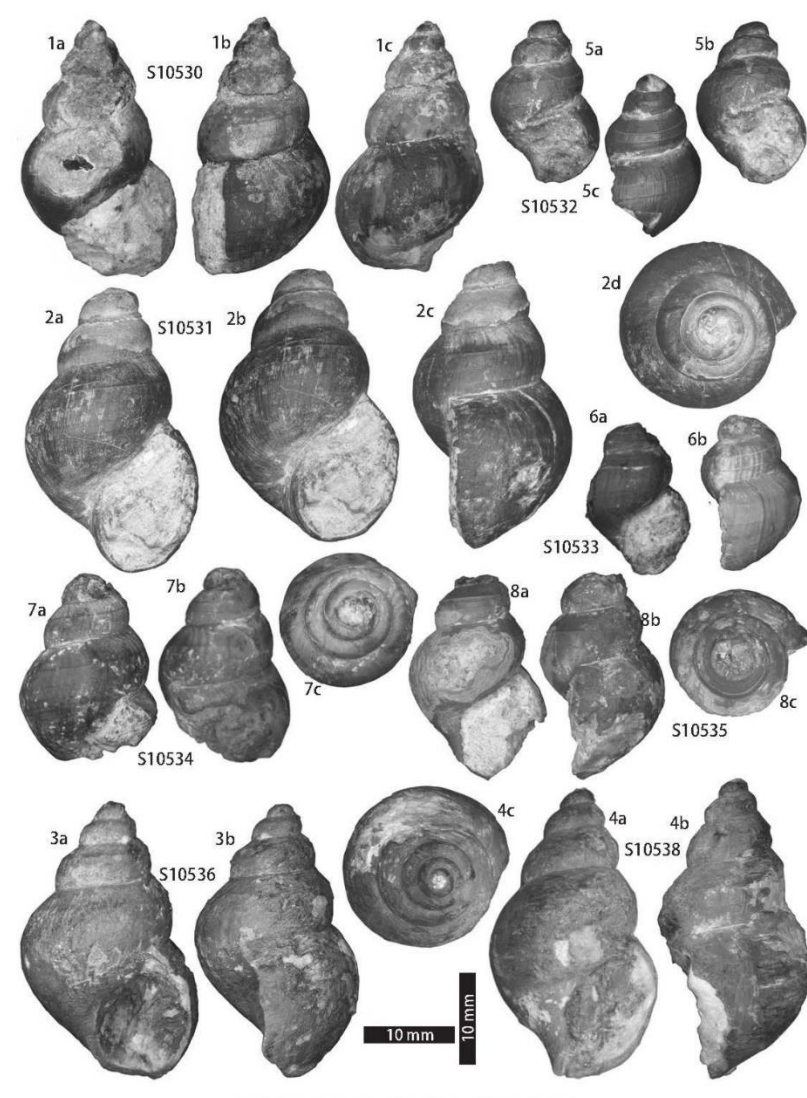
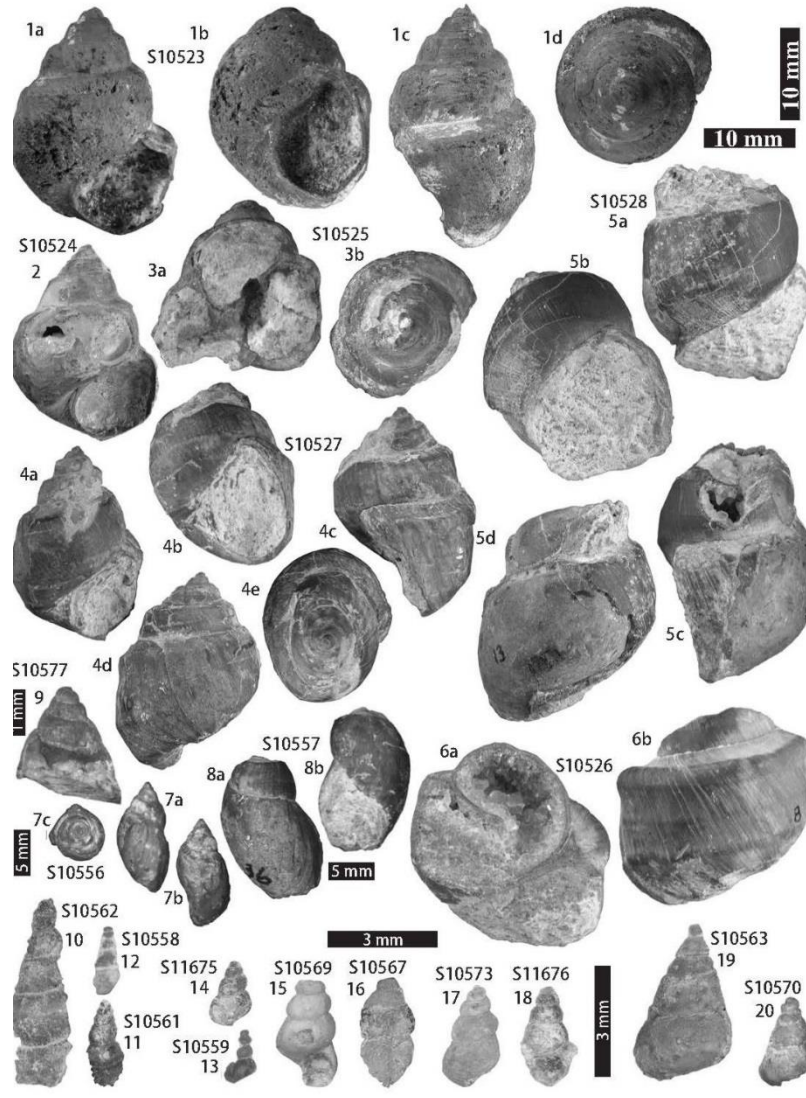
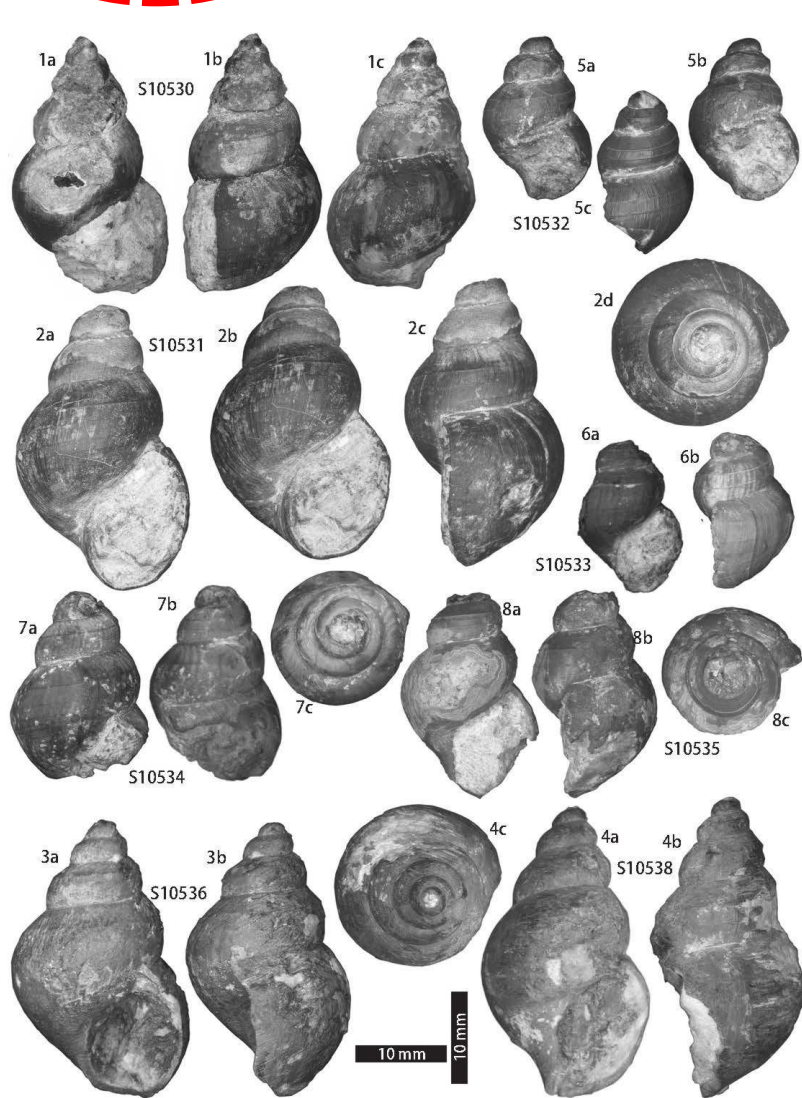
# MILKWEED CANYON TERTIARY SECTION



Post-Volcanic  
Late Miocene Gravels  
~17.5 Ma Basalts

## EOCENE AGE CONTROL?

**11 Taxa:** 2 viviparids, 2 pleurocerids, 1 planorbid, 4 hydrobioids, 1 physid, 1 ellobiid



GSA Geosphere Data Repository, Young and Hartman, 2014

GSA Geosphere Data Repository, Young and Hartman, 2014

GSA Geosphere Data Repository, Young and Hartman, 2014

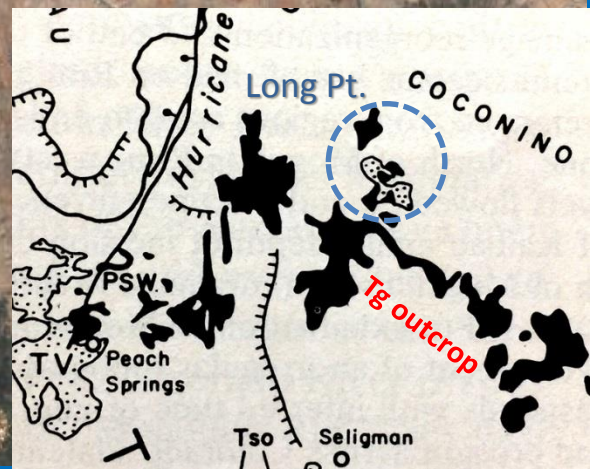
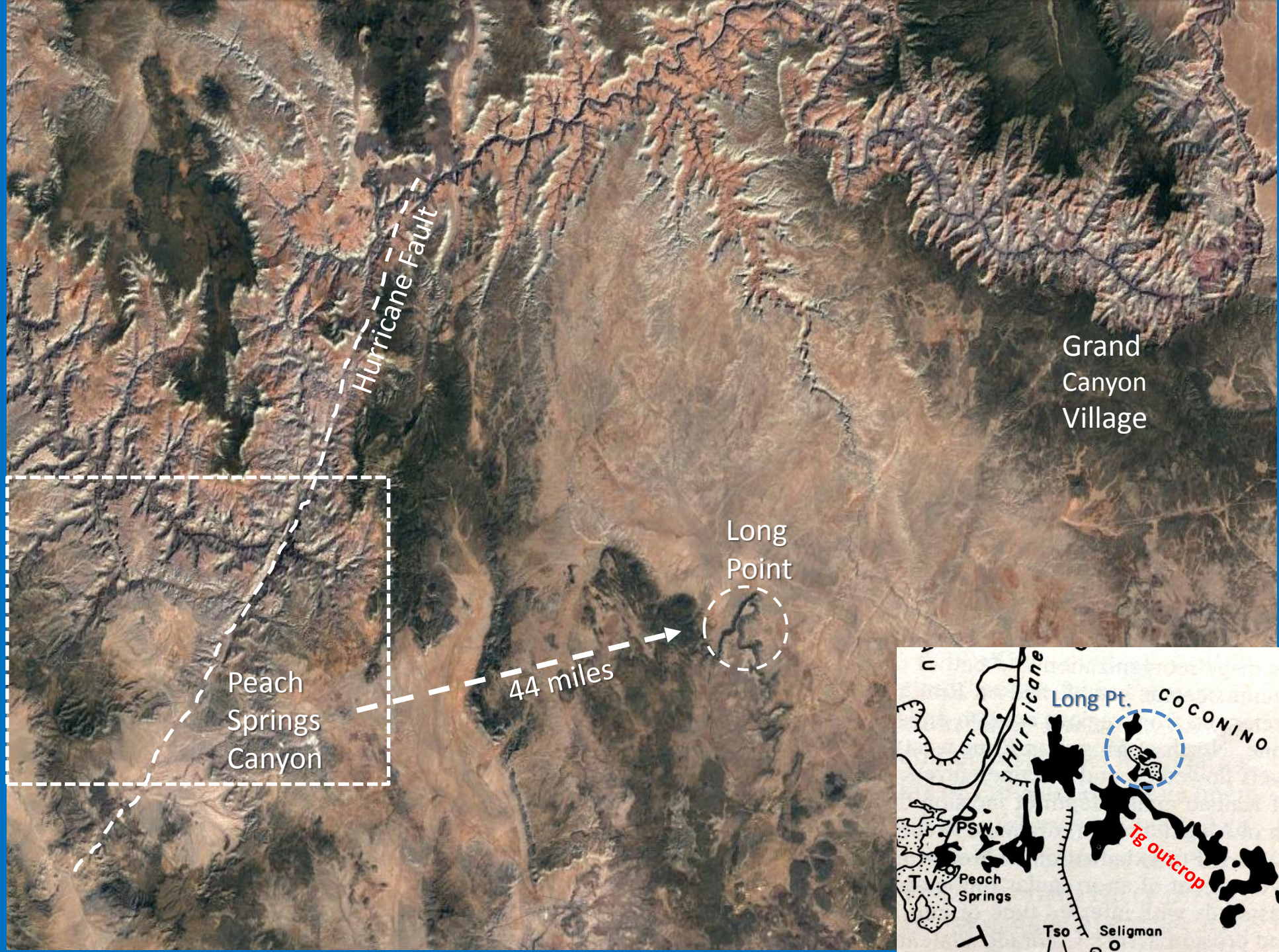
**EARLY EOCENE**

(less possibly LATE PALEOCENE)

**Young & Hartman, 2014**  
**Geosphere**

(Gastropods)

Music Mountain Fm



Basalt 6.8 Ma

Long Pt. AZ  
Music Mt. Fm.

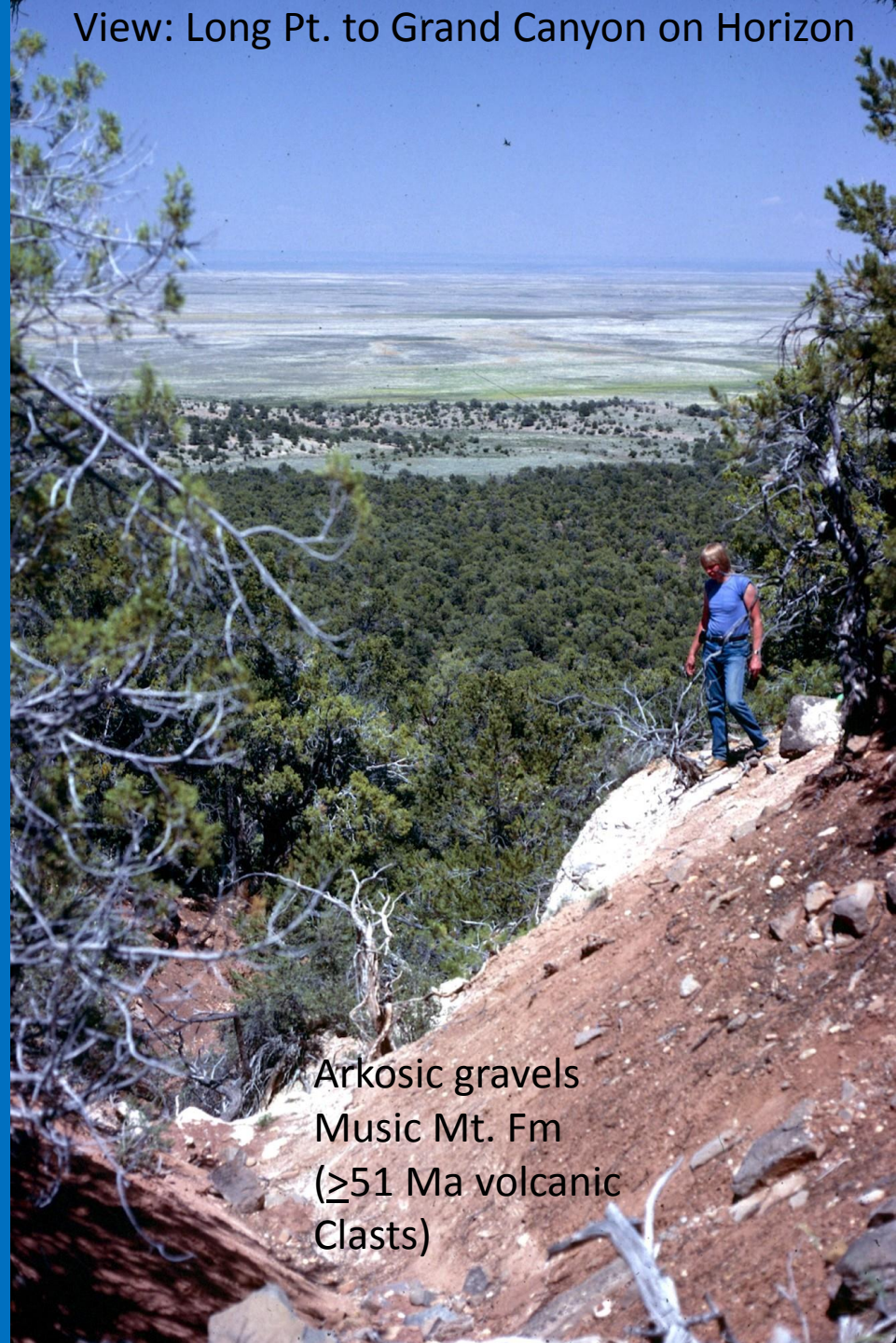




Long Pt.  
Limestone  
(Two Charophytes:  
**1 = Lower Eocene)**  
**Peckichara coronate**  
Flagstaff Limestone  
[M. Feist]

Slump  
Block

Long Point Limestone , Arizona  
(>30m. within Music Mt. arkose)  
(Hill et al. Questionable U/Pb age of 65 Ma ??)



View: Long Pt. to Grand Canyon on Horizon

Arkosic gravels  
Music Mt. Fm  
(≥51 Ma volcanic  
Clasts)



Music Mt.  
Arkosic Gravel  
(in situ)

Surficial (resistant) lag gravels  
V=Volcanic Clasts 163 Ma to 51 Ma  
↗  
Lower Eocene



Upturned West Edge of Colorado Plateau (view west)

Milkweed paleoCanyon

Tertiary Fill

Miocene basalt

Eocene

Buck & Doe



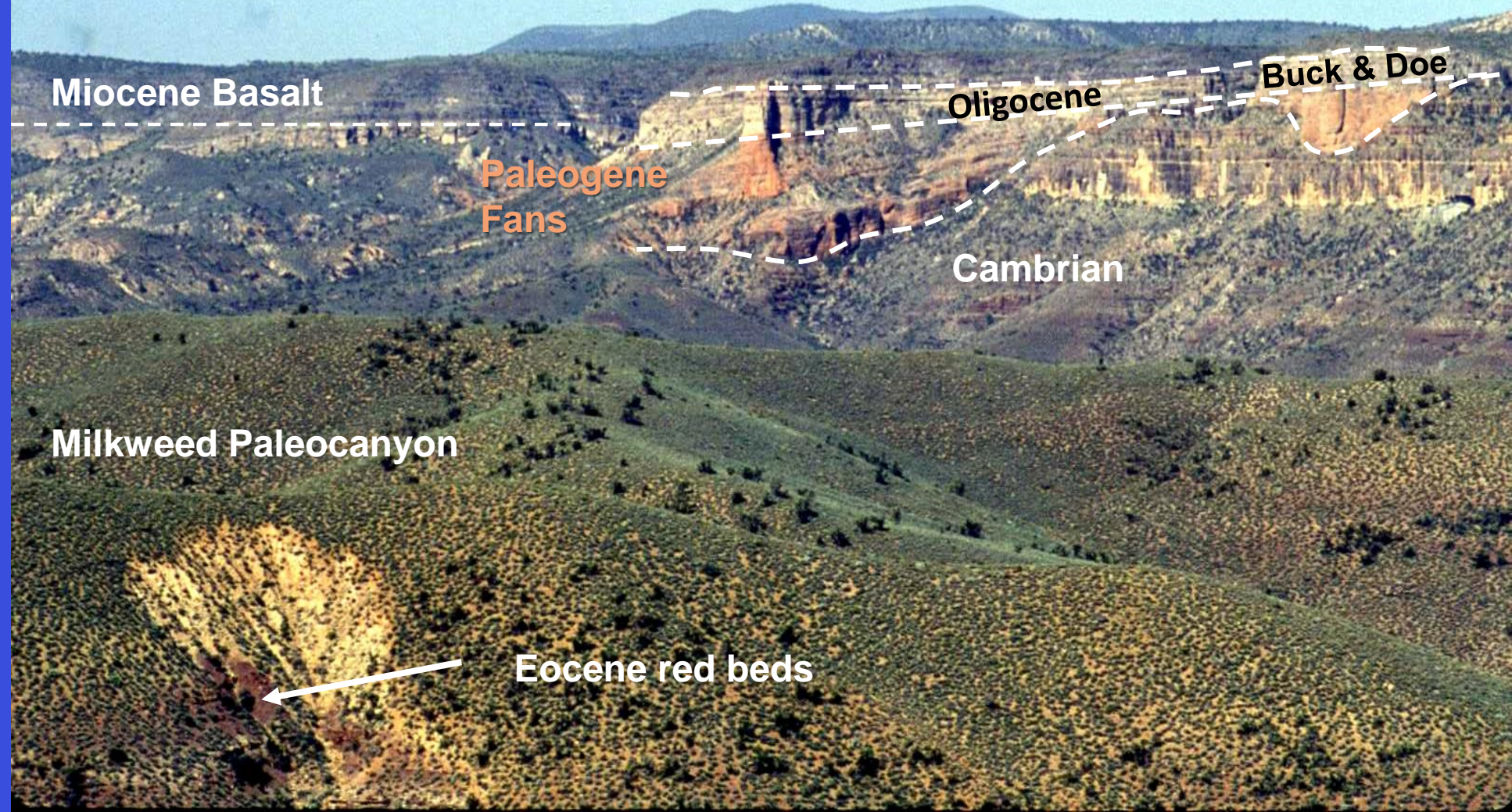
View to West

# Milkweed Canyon Tertiary Fill

Upturned West Edge Colorado Plateau



# Milkweed Paleocanyon Tertiary Fill

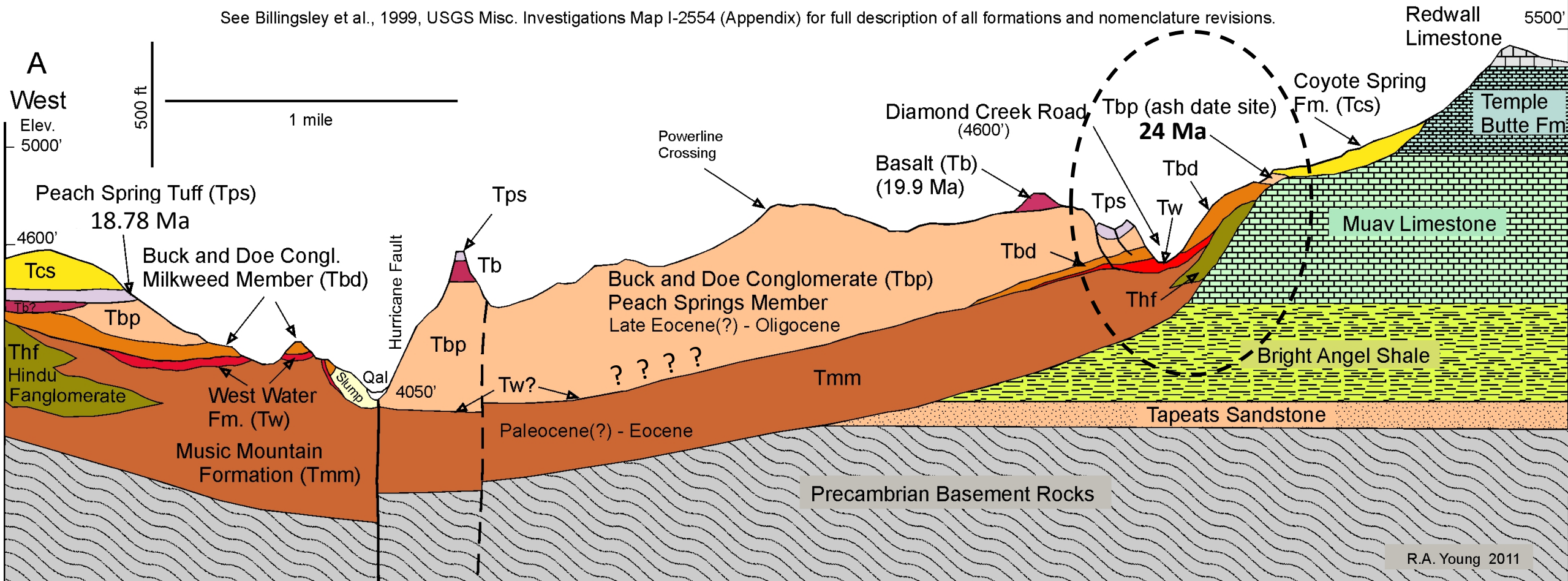


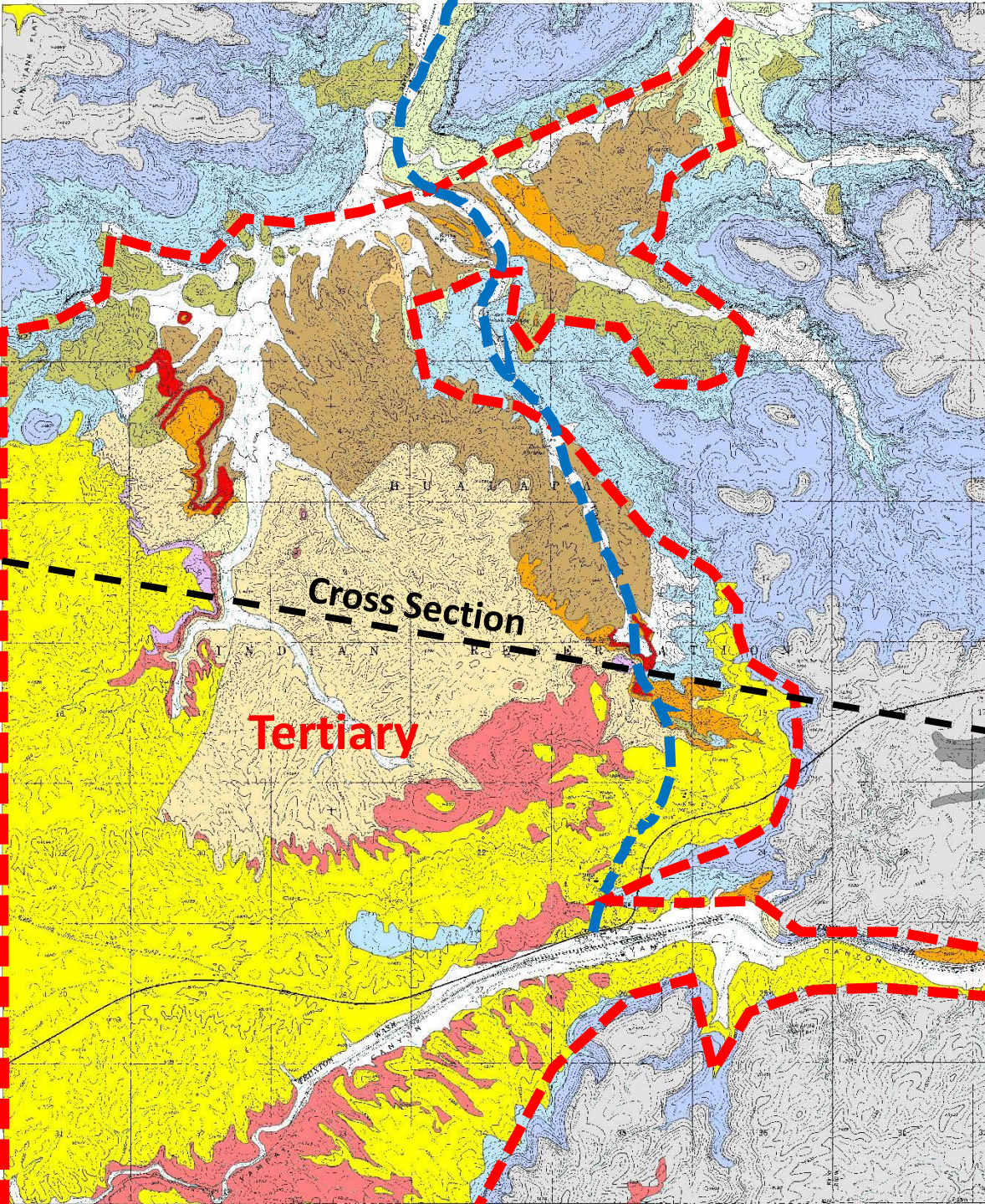
■ Tw = Eocene Soil Horizon (Top of Eocene section) **Peach Springs Canyon**

# Interpretative Geologic Cross Section (A-A'): Peach Springs Wash, Peach Springs Quadrangle, AZ

Vertical Exaggeration = 4.5x

See Billingsley et al., 1999, USGS Misc. Investigations Map I-2554 (Appendix) for full description of all formations and nomenclature revisions.





GEOLOGIC MAP UNITS  
Peach Springs Quadrangle, AZ  
Richard A. Young, Mapping 1966-2010

Qal / Qc	Quaternary alluvium and Colluvium
QTI	Quaternary/Tertiary landslides (age uncertain)
Tcs	Late Miocene-Pliocene Coyote Springs Formation (locally derived fluvial conglomerate). Includes clasts from local Paleozoic and volcanic rocks. (Possibly Pleistocene in part?). Note: Where Tcs directly overlies Tbp (without volcanic clast source) contact may be transitional.
Tps Tb	Miocene basalts (Tb) with interbedded Peach Spring Tuff (Tps: Dated as 18.5 Ma regionally). Basalt sample dated as 19.9 Ma, from site along road 2.1 km north of Peach Springs. Includes volcanic agglomerate and reworked volcanic sediments below.
Tbp	Oligocene Buck and Doe Conglomerate; Peach Springs Member. Local Paleozoic and exotic clasts from Precambrian exposures in adjacent Truxton Valley. Contains $23.97 \pm 0.03$ Ma ash near top in Peach Springs Wash (Sect. 19, See "*" on map.)
Tbd	Oligocene-(& late Eocene?) Buck and Doe Conglomerate, Milkweed Member. Locally derived fluvial conglomerate; Paleozoic rock clasts.
Unconformity:	Significant post Laramide erosion interval
Tw	Eocene West Water Formation. Reddish soils, lacustrine clays, and white fresh-water limestone and marl; transitional with Music Mountain Formation below. Deeply weathered horizon with evidence of local lakes formed during late Laramide tectonism.

OLIGOCENE

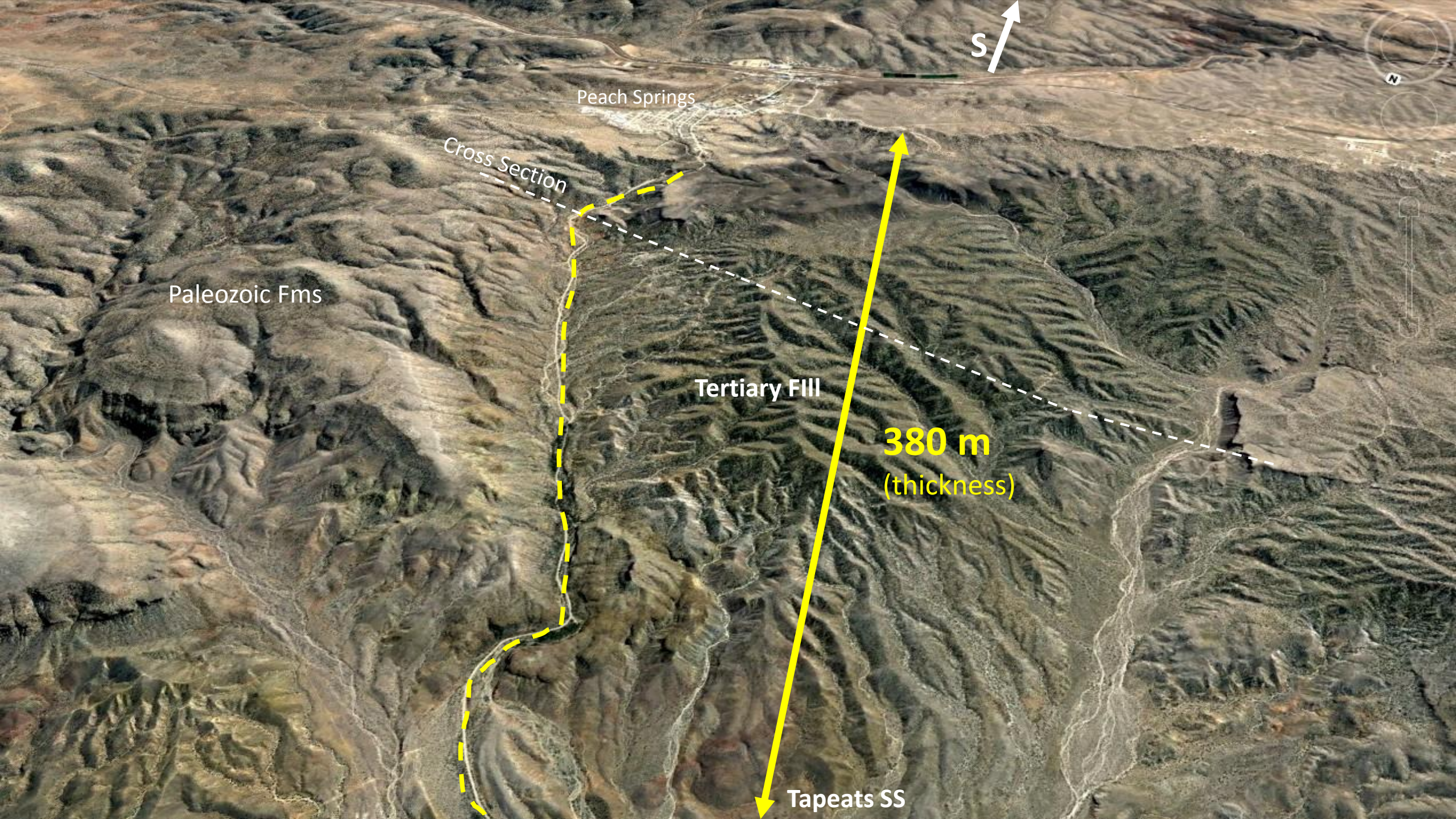
EOCENE

Thf Tmm	Tmm: Paleocene-Eocene Music Mountain Fm ("Arizona Rim gravels"); Exotic Precambrian rock clasts and Laramide volcanic clasts. Early Eocene gastropods near top of truncated exposure near Long Point, AZ. Thf: Hindu Fanglomerate; Locally derived fanglomerate with large meter-sized limestone blocks in orange matrix, mainly near fault scarps and steep canyon walls. DZ: Detrital zircon analysis sample site for Tmm (Section 2 near Peach Springs Spring).
------------	--

Unconformity	
Pm	Lower Supai Group: Manakacha and Watahomigi Formations undivided
Mr	Mississippian Redwall Limestone
Dt	Devonian Temple Butte Formation
Unconformity	
Cm	Cambrian Muav Limestone
Cb	Cambrian Bright Angel Shale
Ct	Cambrian Tapeats Sandstone

(See Billingsley and others, 1999, for details of Paleozoic stratigraphy and detailed Appendix describing Tertiary rocks.)

**Peach Springs 7.5 Geologic Quad**  
(Online: <http://repository.azgs.az.gov>)



Peach Springs

Cross Section

Paleozoic Fms

Tertiary Fill

380 m  
(thickness)

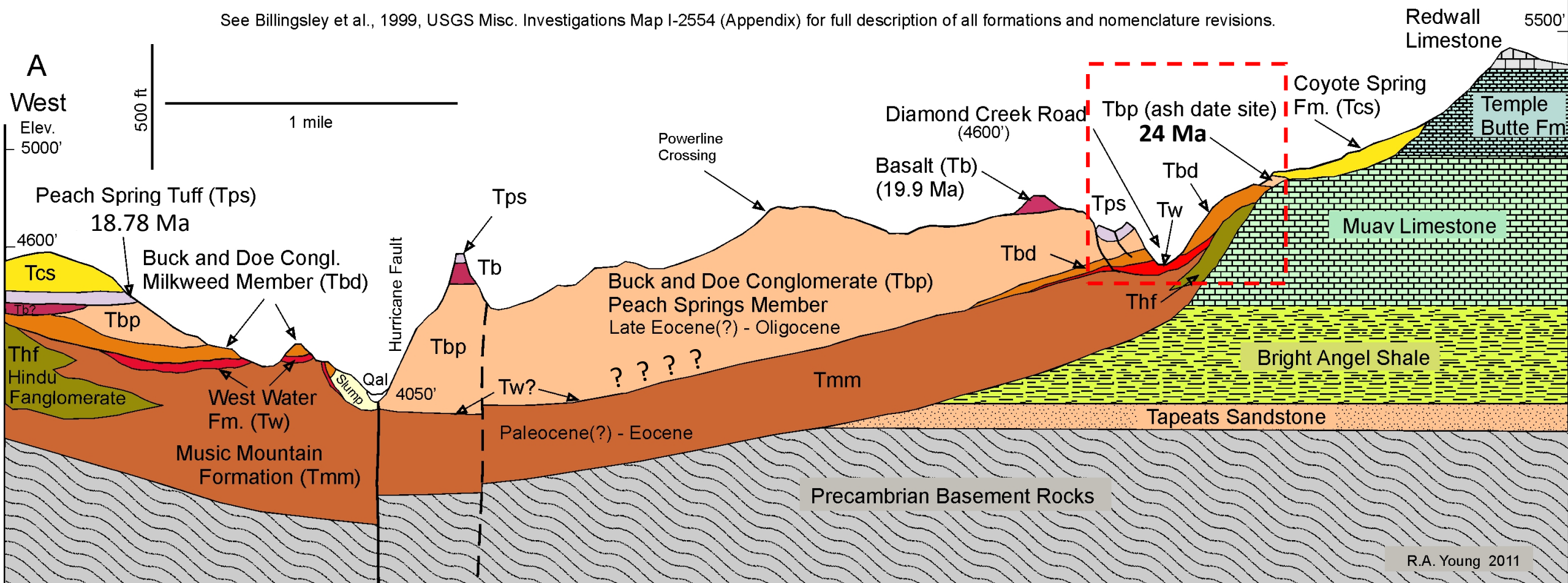
Tapeats SS

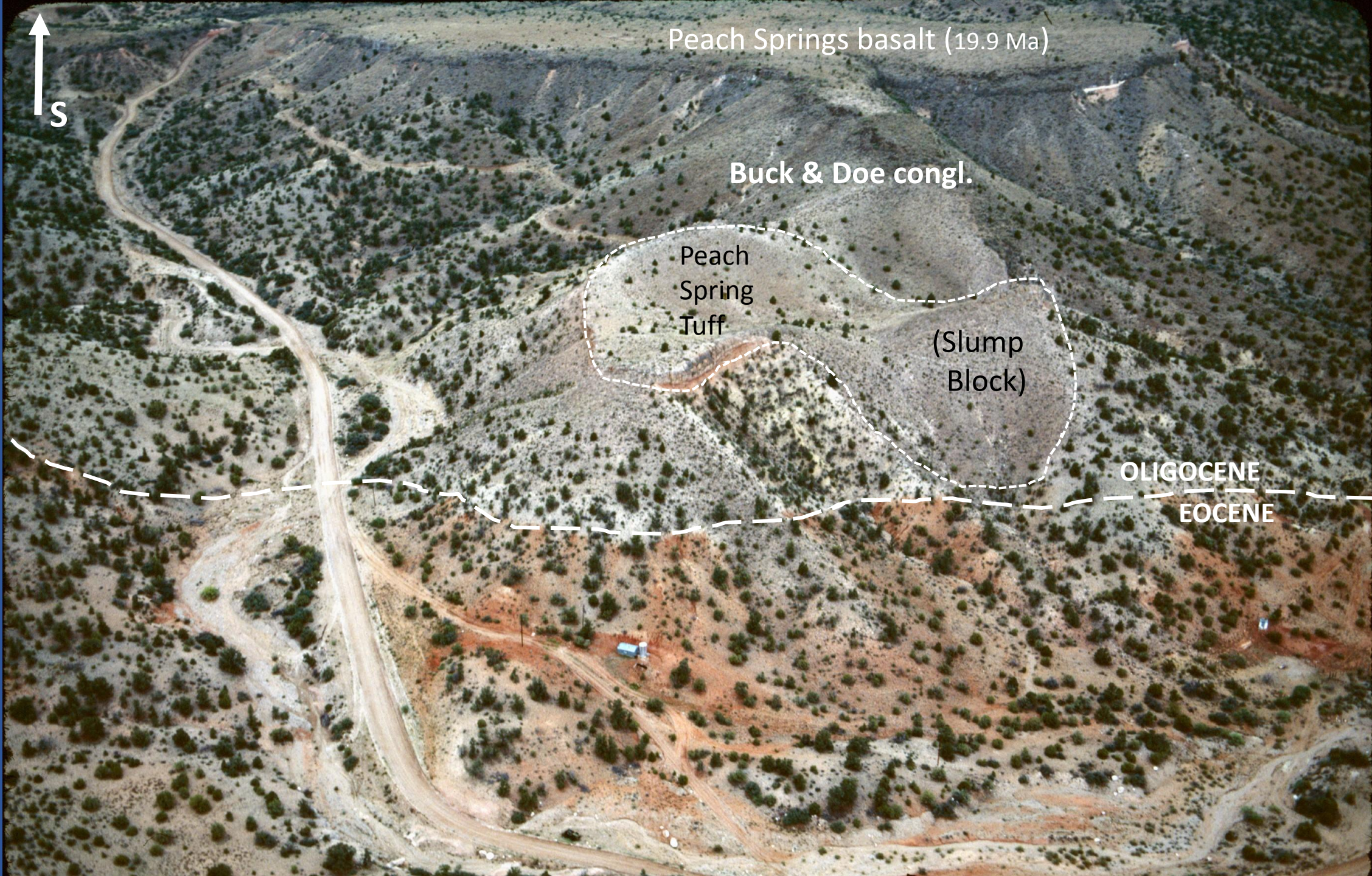
 Tw = Eocene Soil Horizon (Top of Eocene section)

## Interpretative Geologic Cross Section (A-A'): Peach Springs Wash, Peach Springs Quadrangle, AZ

Vertical Exaggeration = 4.5x

See Billingsley et al., 1999, USGS Misc. Investigations Map I-2554 (Appendix) for full description of all formations and nomenclature revisions.





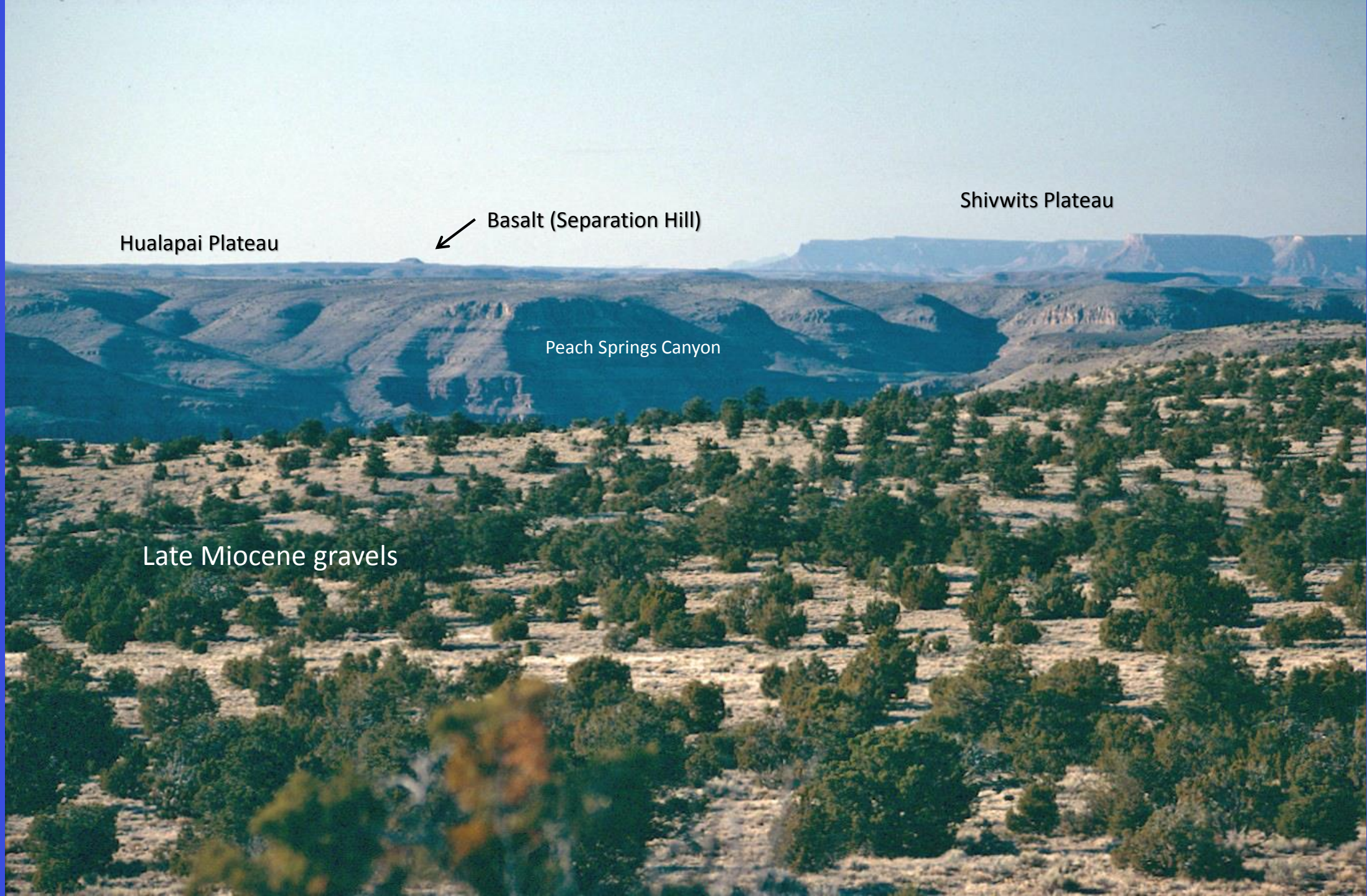
Peach Springs basalt (19.9 Ma)

Buck & Doe congl.

Peach  
Spring  
Tuff

(Slump  
Block)

OLIGOCENE  
EOCENE



Hualapai Plateau

Basalt (Separation Hill)

Shivwits Plateau

Peach Springs Canyon

Late Miocene gravels



19 Ma

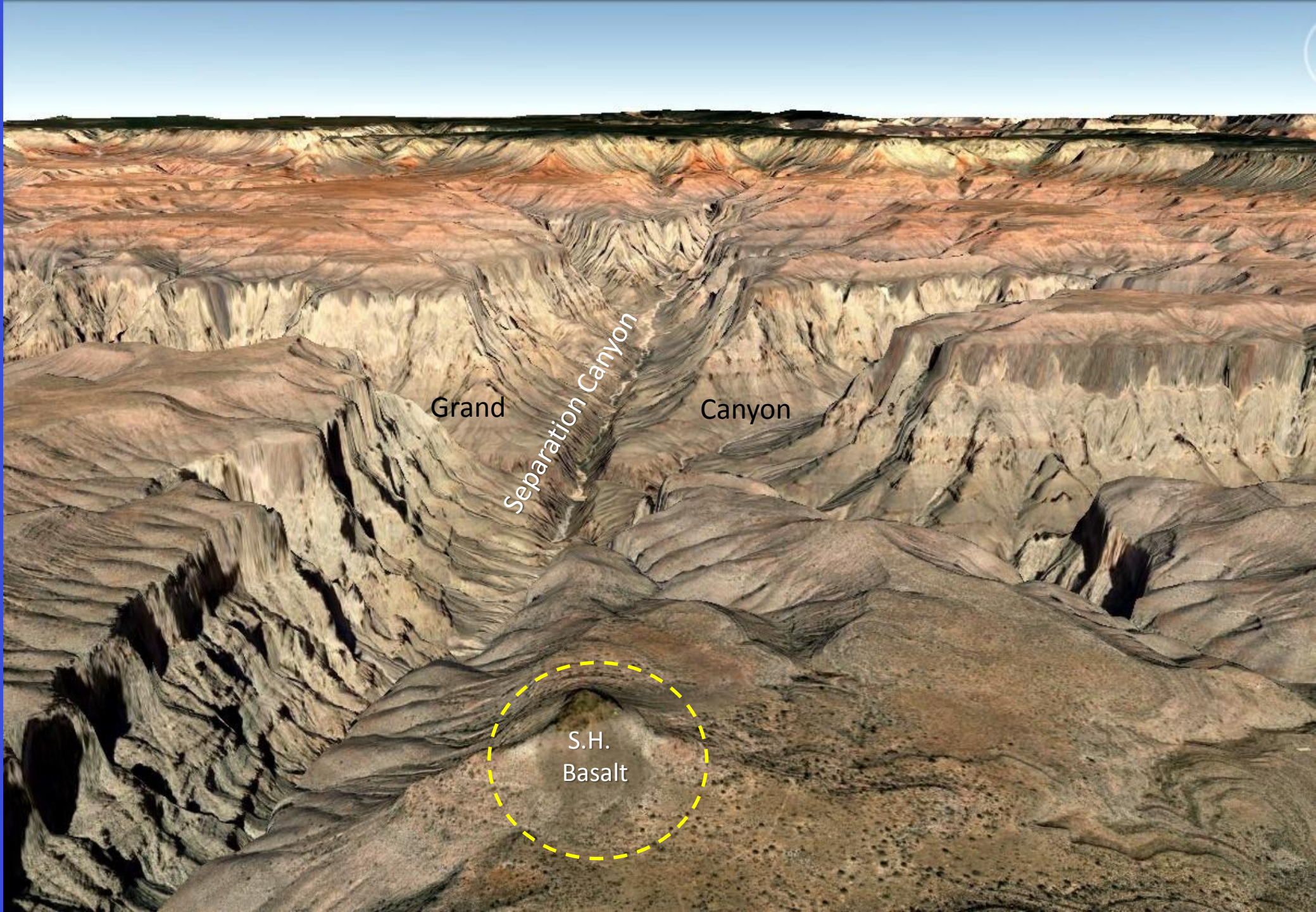
Separation Hill Basalt

Shivwits Plateau

Grand  
Canyon

South  
Separation  
Canyon

Supai Gp.



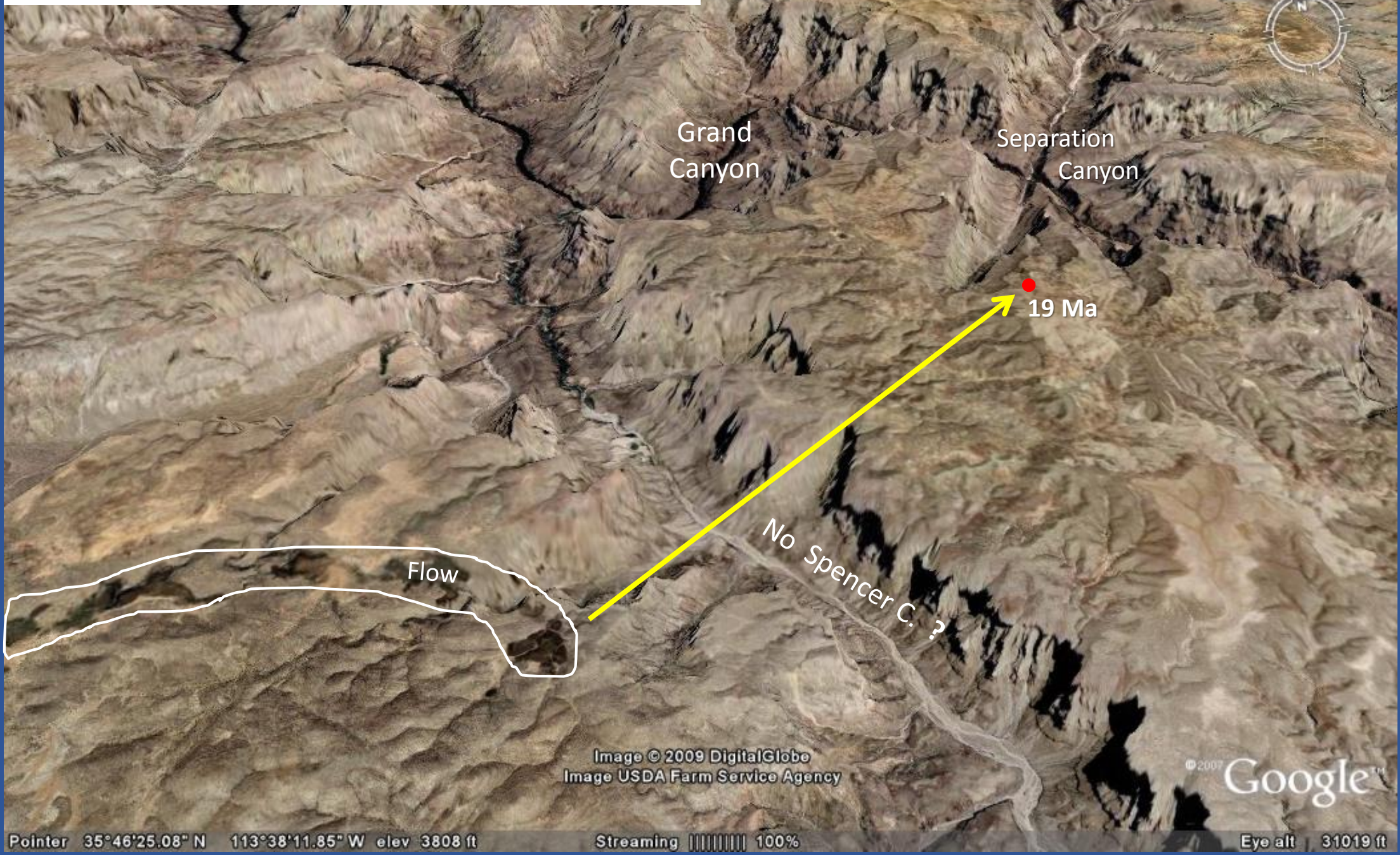
Grand

Canyon

Separation Canyon

S.H.  
Basalt

# SOURCE OF SEPARATION HILL **BASALT**



Separation Hill Basalt



Shivwits Plateau

Spencer Canyon  
(Modern Grand Canyon Drainage)





Separation Hill Basalt  
19 Ma

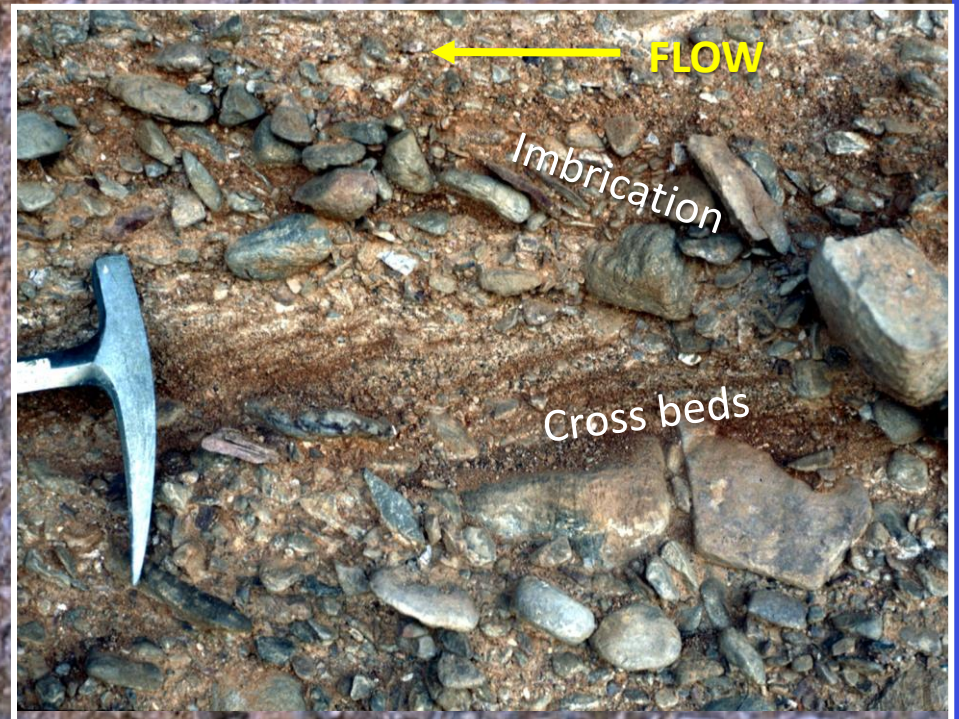
Shivwits Plateau

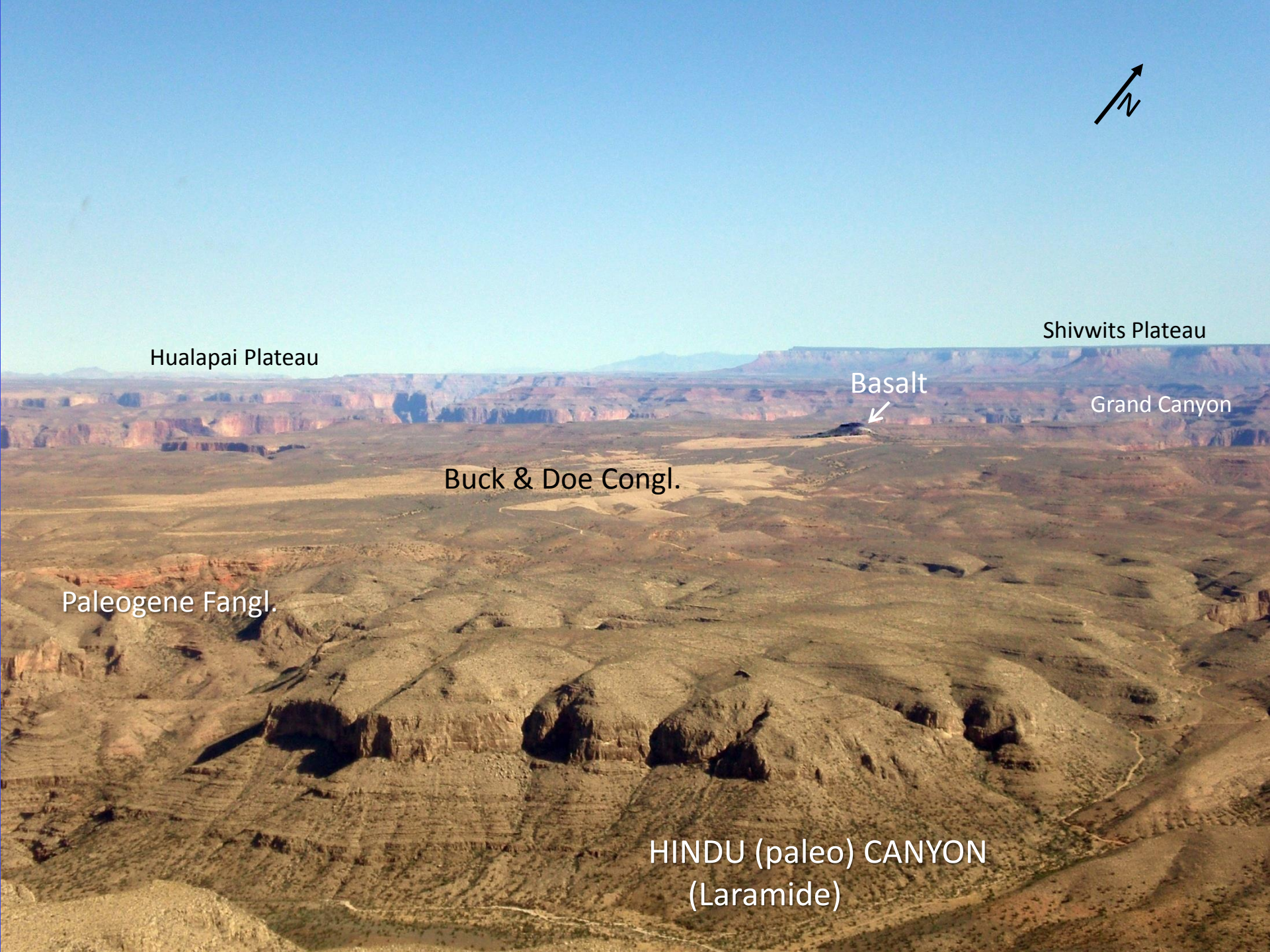
Grand  
Canyon

Buck & Doe  
Conglomerate  
(Oligocene)

Basalt

€ to M Limestone clasts





Hualapai Plateau

Shivwits Plateau

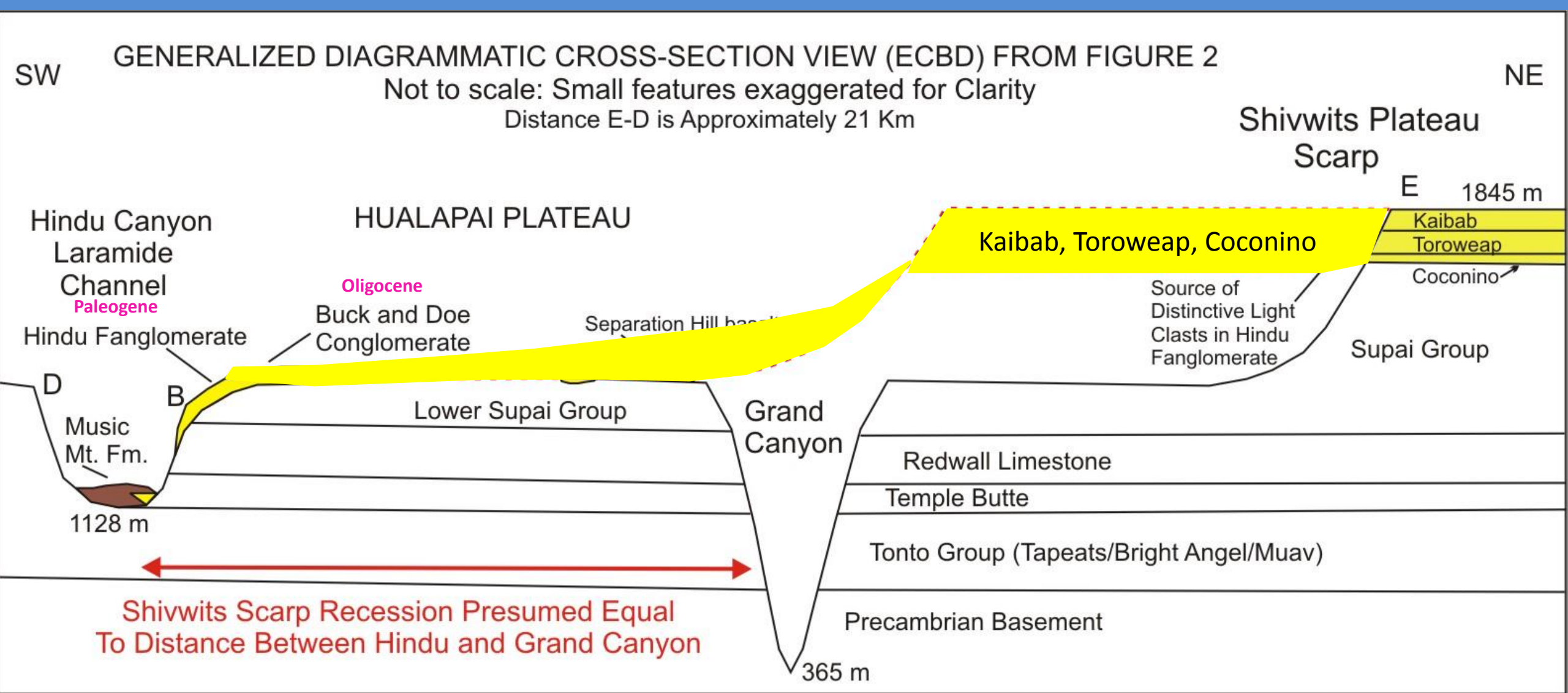
Basalt

Grand Canyon

Buck & Doe Congl.

Paleogene Fangl.

HINDU (paleo) CANYON  
(Laramide)



**PERMIAN**

Kaibab

Toroweap

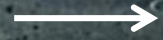
Coconino



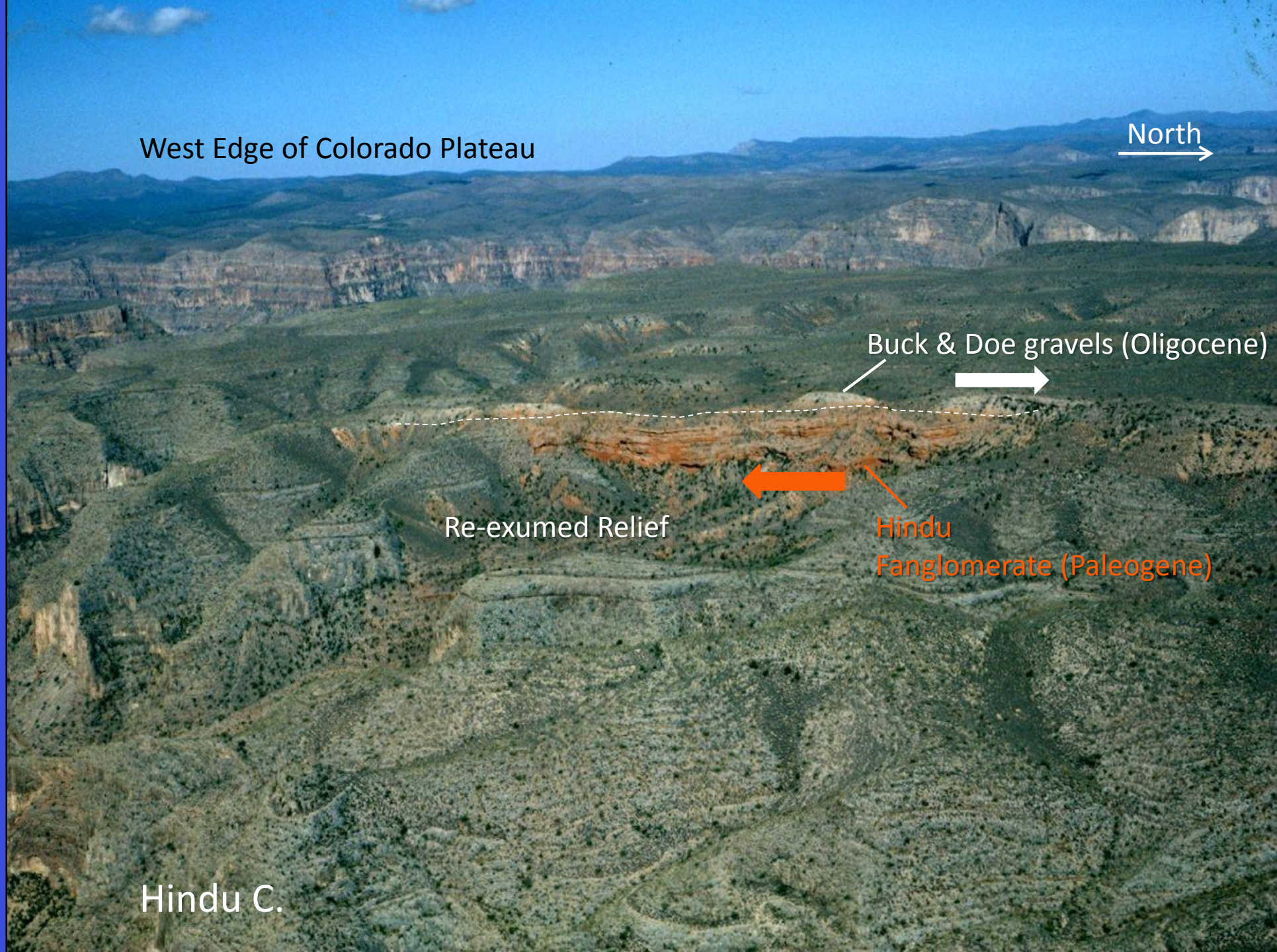


Grand Canyon

NORTH



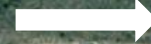
Paleogene  
Fanglomerate



West Edge of Colorado Plateau

North  
→

Buck & Doe gravels (Oligocene)



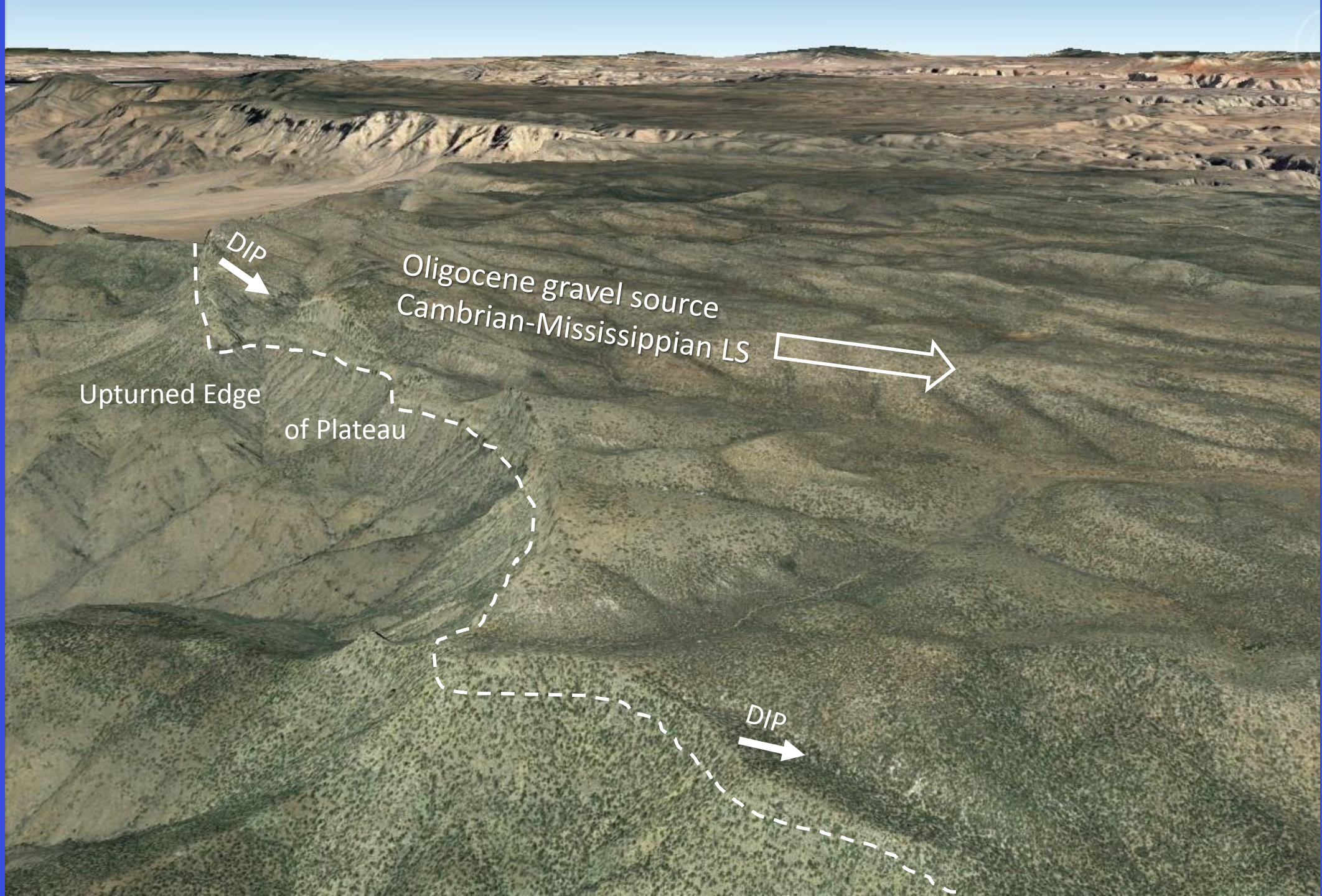
Re-exhumed Relief



Hindu  
Fanglomerate (Paleogene)

Flow  
← →  
Directions

Hindu C.



DIP

Oligocene gravel source  
Cambrian-Mississippian LS

Upturned Edge

of Plateau

DIP

SW

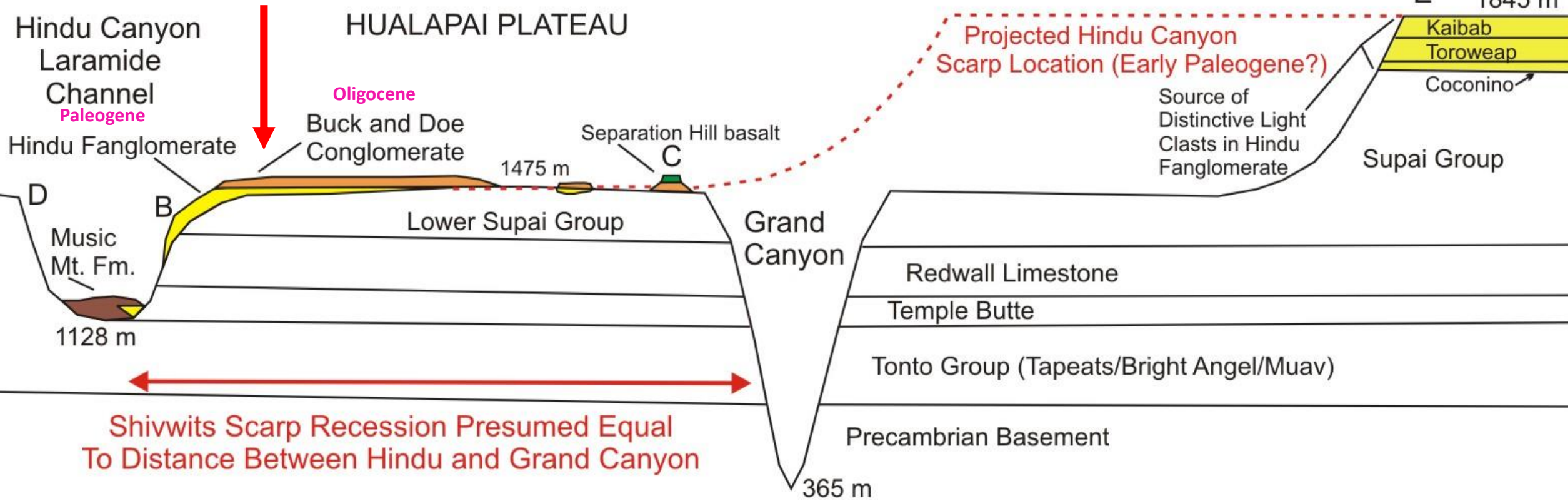
NE

# GENERALIZED DIAGRAMMATIC CROSS-SECTION VIEW (ECBD) FROM FIGURE 2

Not to scale: Small features exaggerated for Clarity

Distance E-D is Approximately 21 Km

**NEXT SLIDE**



NORTH

Buck and Doe



Fanglomerate



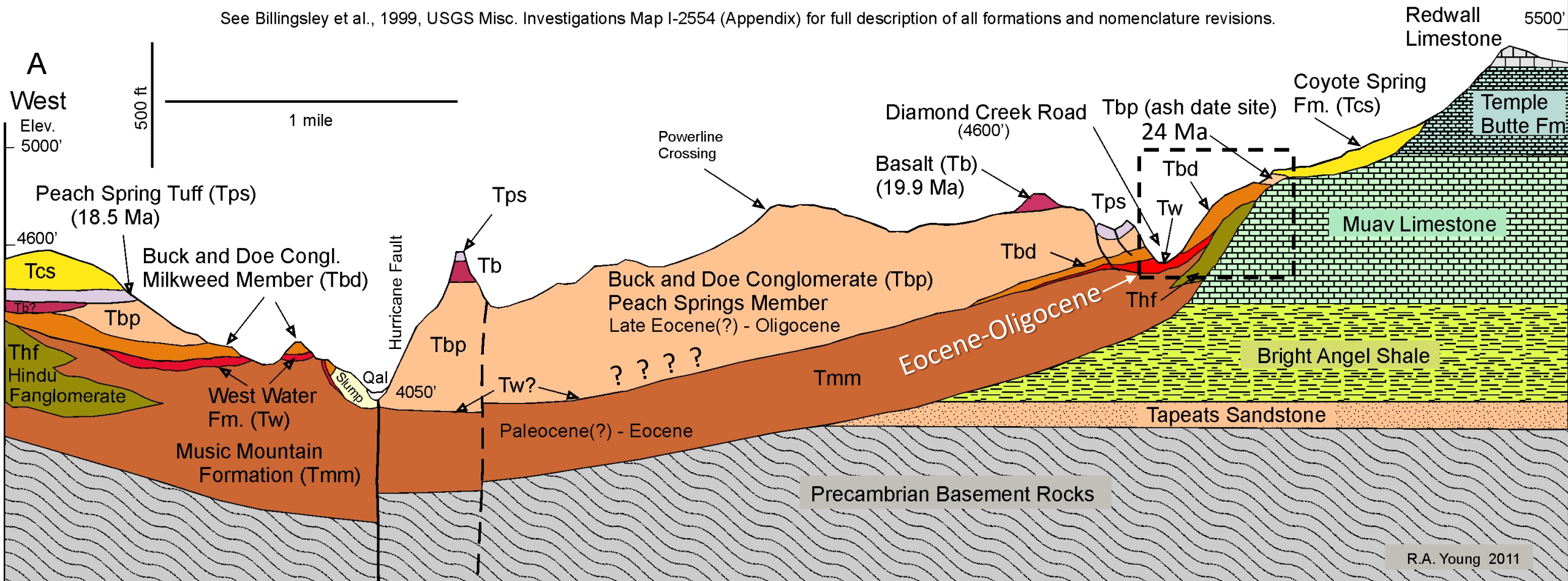
# Sediment Accumulation Rate

Peach Springs Canyon Sections

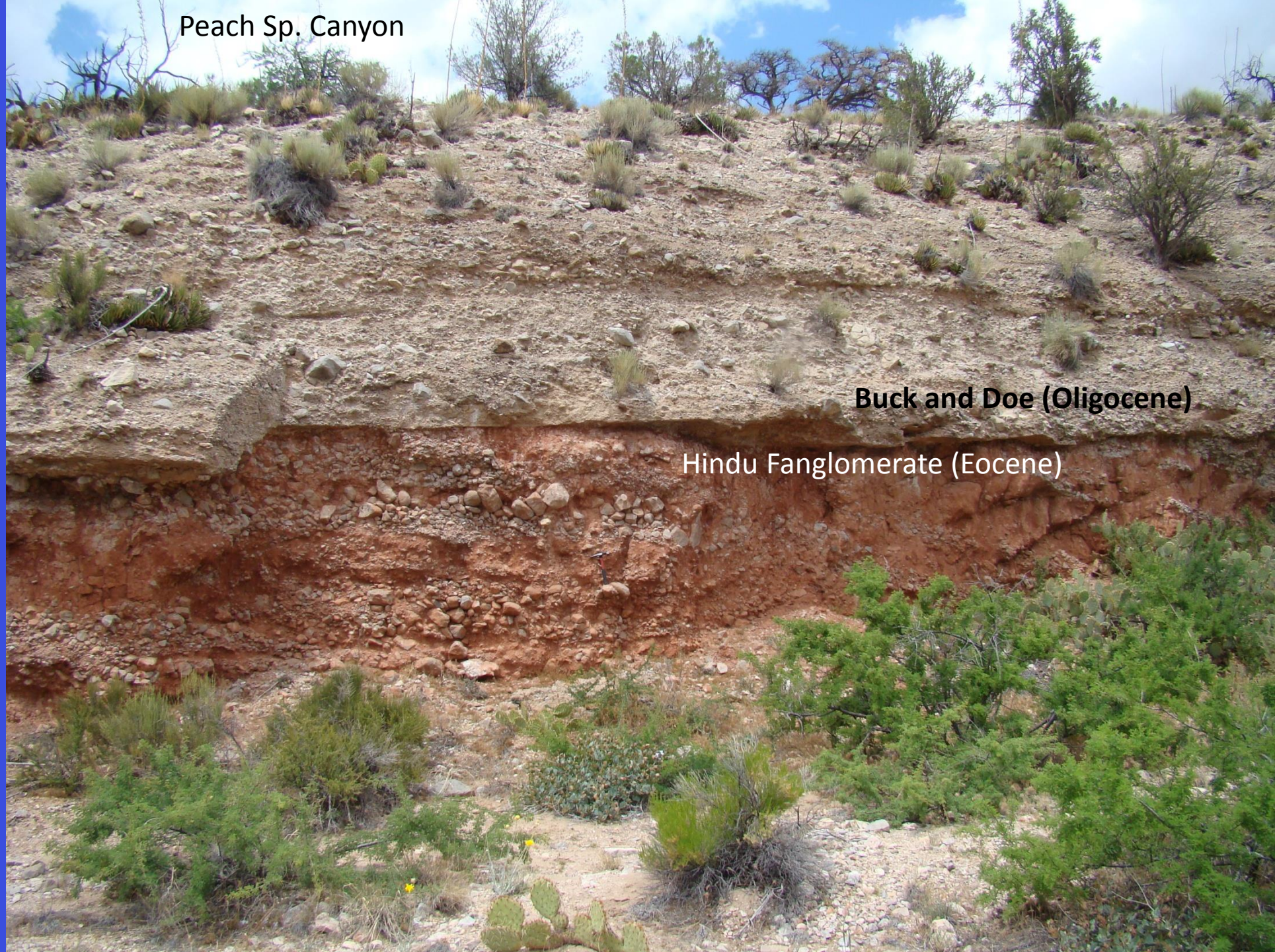
 Tw = Eocene Soil Horizon (Top of Eocene section) **Peach Springs Canyon**

Interpretative Geologic Cross Section (A-A'): Peach Springs Wash, Peach Springs Quadrangle, AZ  
Vertical Exaggeration = 4.5x

See Billingsley et al., 1999, USGS Misc. Investigations Map I-2554 (Appendix) for full description of all formations and nomenclature revisions.



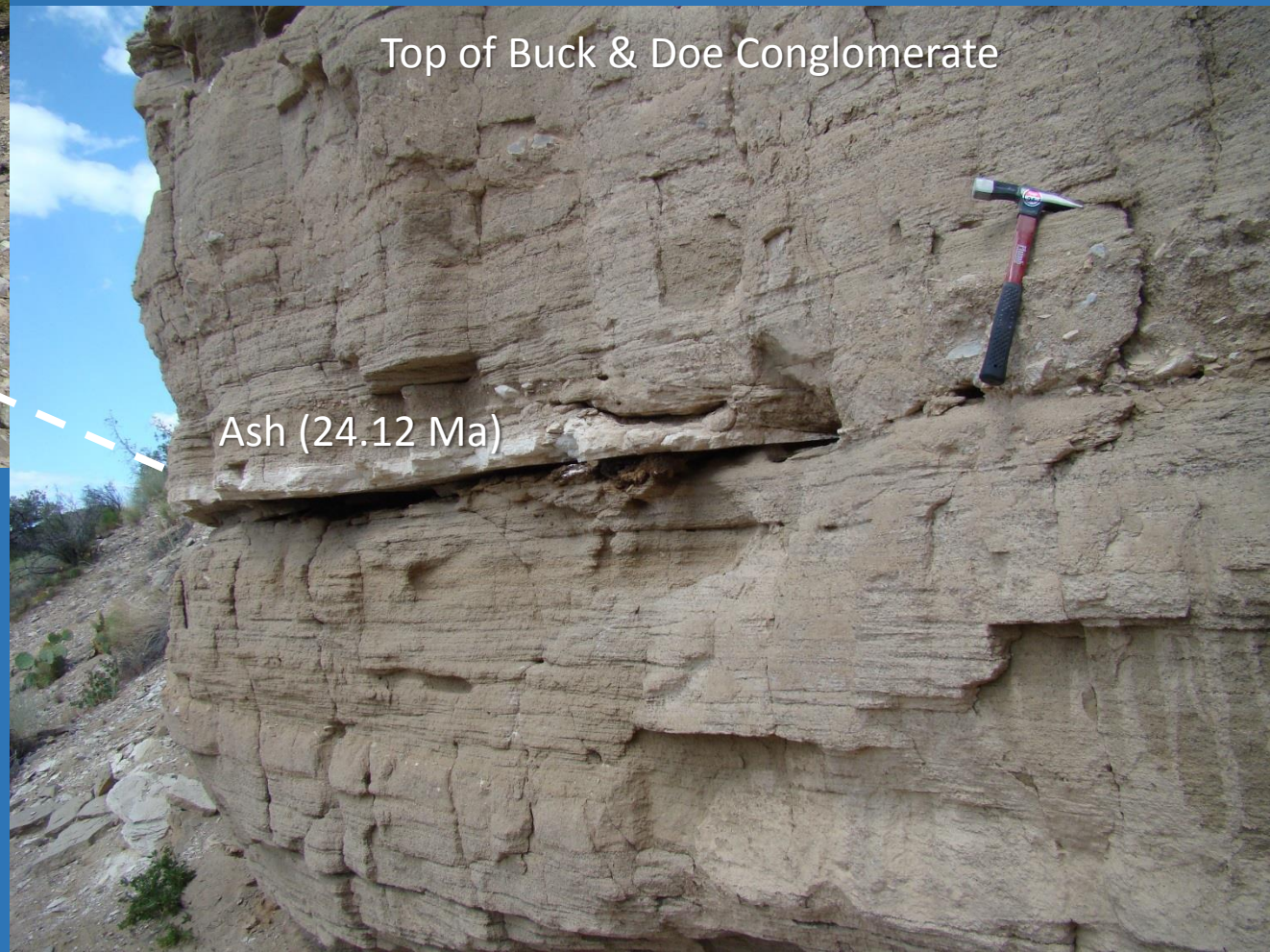
Peach Sp. Canyon



**Buck and Doe (Oligocene)**

**Hindu Fanglomerate (Eocene)**

## Oligocene Ash Bed at Peach Springs

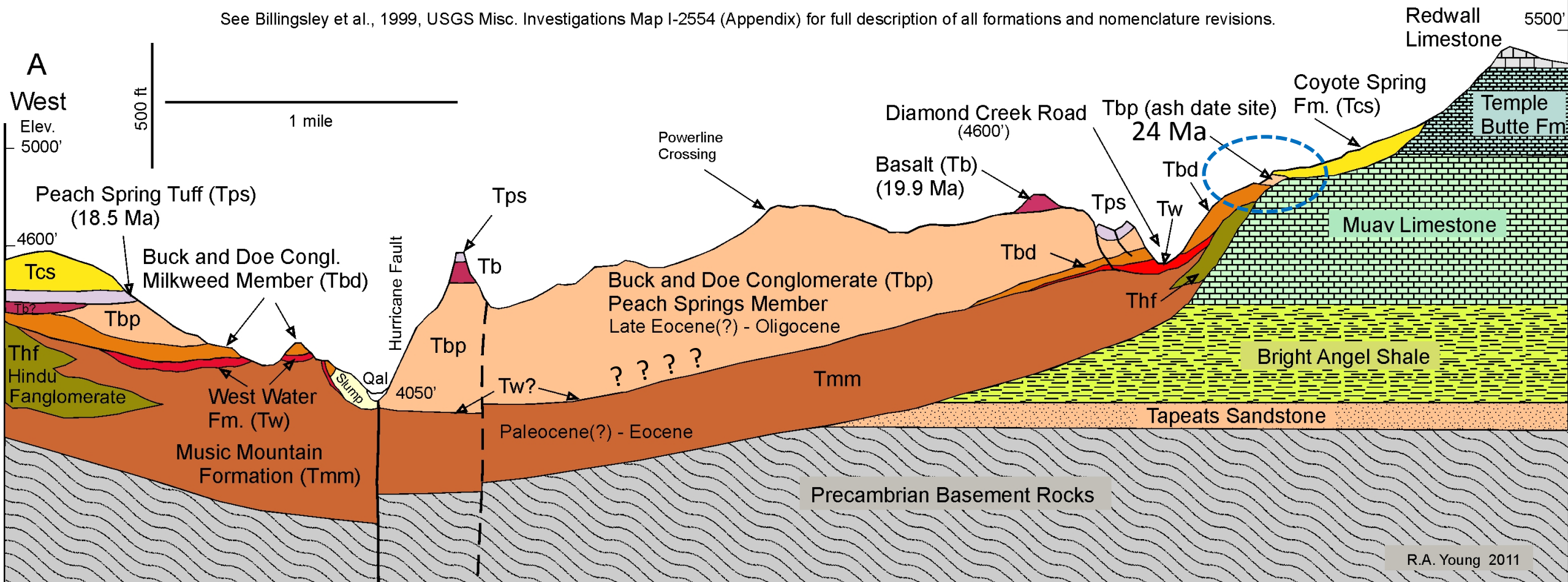


 Tw = Eocene Soil Horizon (Top of Eocene section) Peach Sp. Canyon

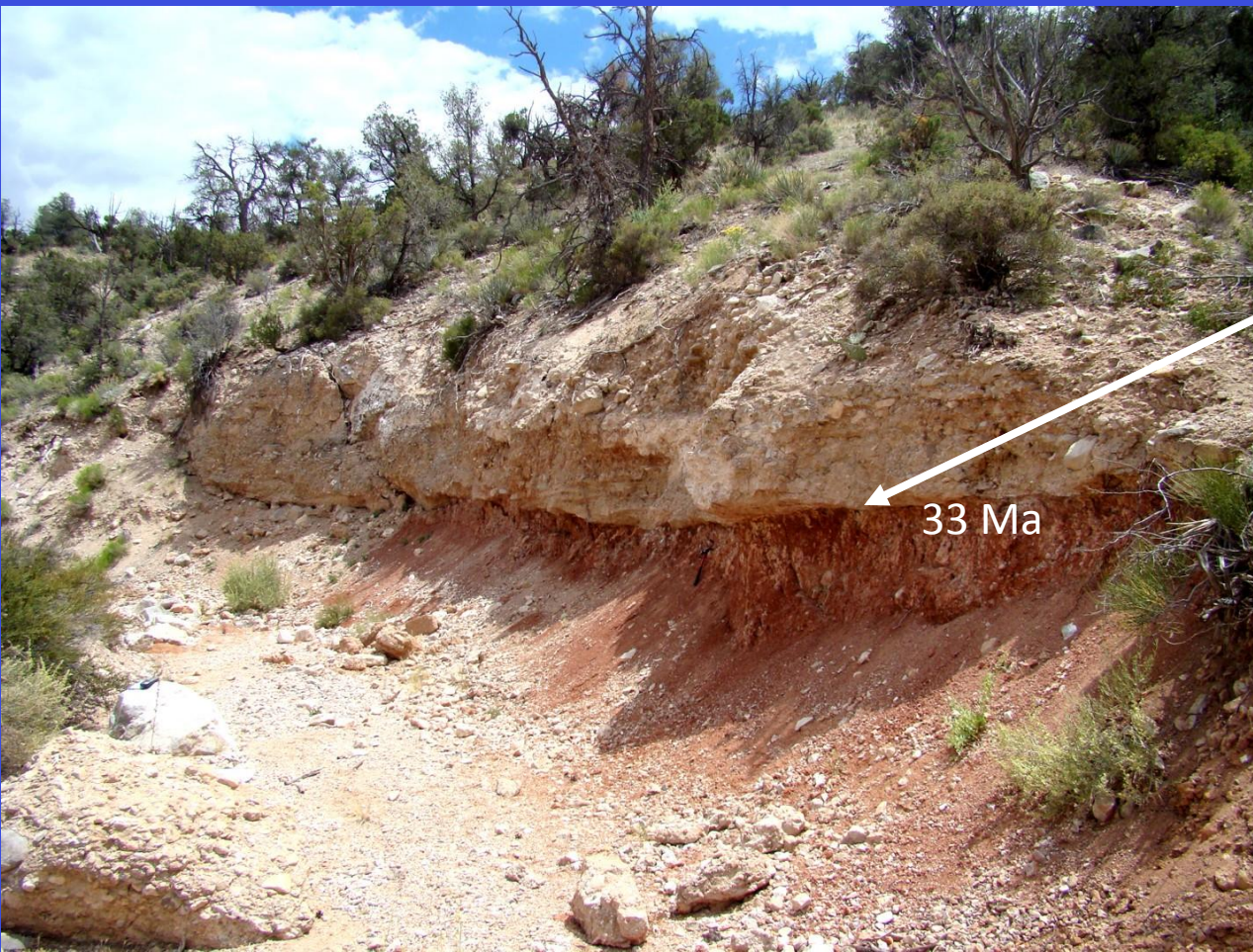
## Interpretative Geologic Cross Section (A-A'): Peach Springs Wash, Peach Springs Quadrangle, AZ

Vertical Exaggeration = 4.5x

See Billingsley et al., 1999, USGS Misc. Investigations Map I-2554 (Appendix) for full description of all formations and nomenclature revisions.



**Average Sedimentation Rate**  
 **$62.5 \text{ m} / 8.88 \text{ Ma} = 7.03 \text{ m/Ma}$**



**Peach Springs Wash**  
**Daimond Creek Road**



Basalt: 19.94 Ma

**Average Sedimentation Rate**

$$30.5 \text{ m} / 4.2 \text{ Ma} = 7.25 \text{ m/Ma}$$

**Peach Springs Wash  
Daimond Creek Road**



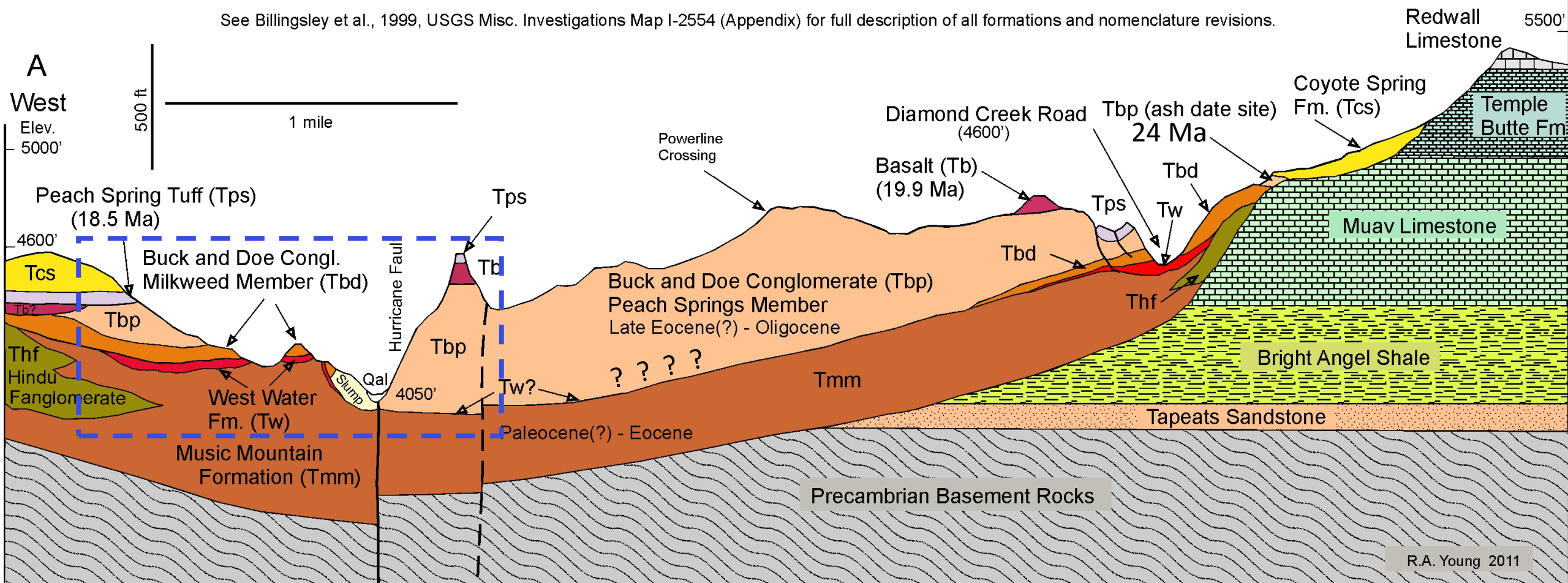
Ash 24.12Ma

■ Tw = Eocene Soil Horizon (Top of Eocene section) **Peach Springs Canyon**

## Interpretative Geologic Cross Section (A-A'): Peach Springs Wash, Peach Springs Quadrangle, AZ

Vertical Exaggeration = 4.5x

See Billingsley et al., 1999, USGS Misc. Investigations Map I-2554 (Appendix) for full description of all formations and nomenclature revisions.



South

Peach Springs Wash

Hurricane Fault

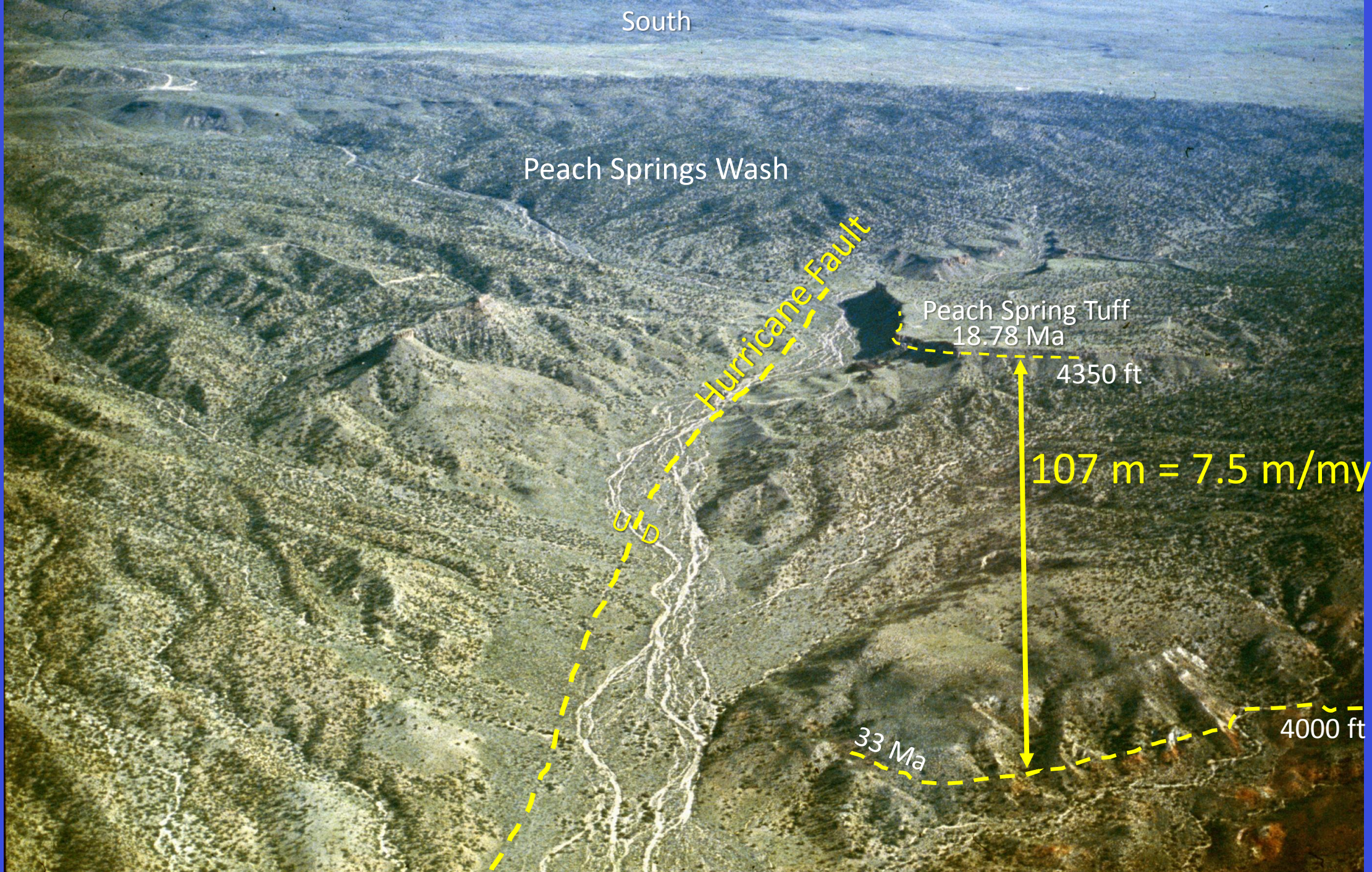
Peach Spring Tuff  
18.78 Ma

4350 ft

107 m = 7.5 m/my

33 Ma

4000 ft



## Peach Spring Tuff

Buck & Doe  
Conglomerate





Eocene

## Diamond Creek Road:

Lower Section: 7.03 m/Million Years

Upper Section: 7.25 m/Million Years

Hurricane Fault: 7.5 m/Million Years

(Ave.  $\approx 0.8$  cm/100 years) for 15 Ma

More Importantly:

Ongoing fluvial aggradation from E. Oligocene through Late Miocene or E. Pliocene Time

Refutes significant erosion of western Grand Canyon drainage prior to ~ 5-6 Ma (Pliocene)

