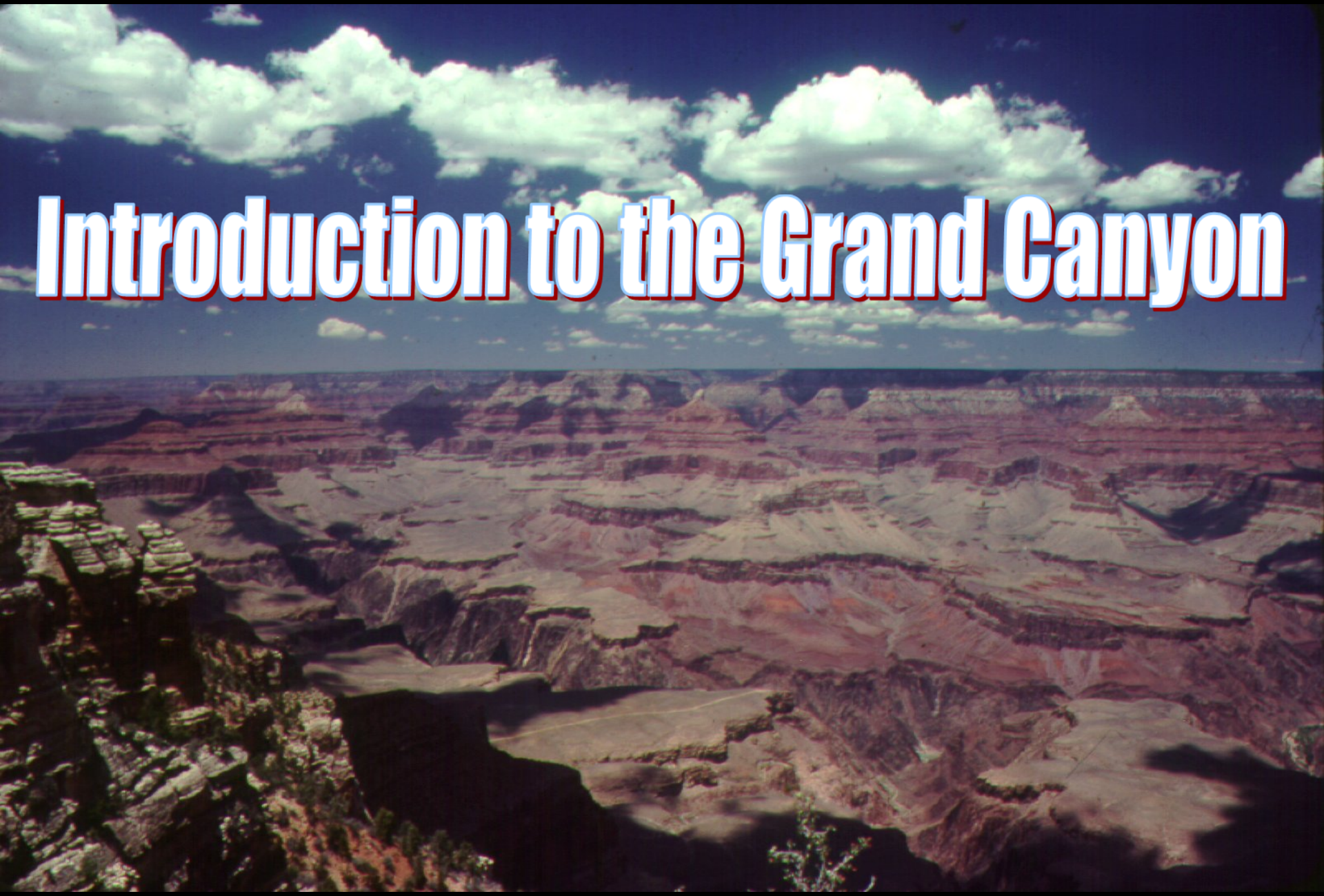
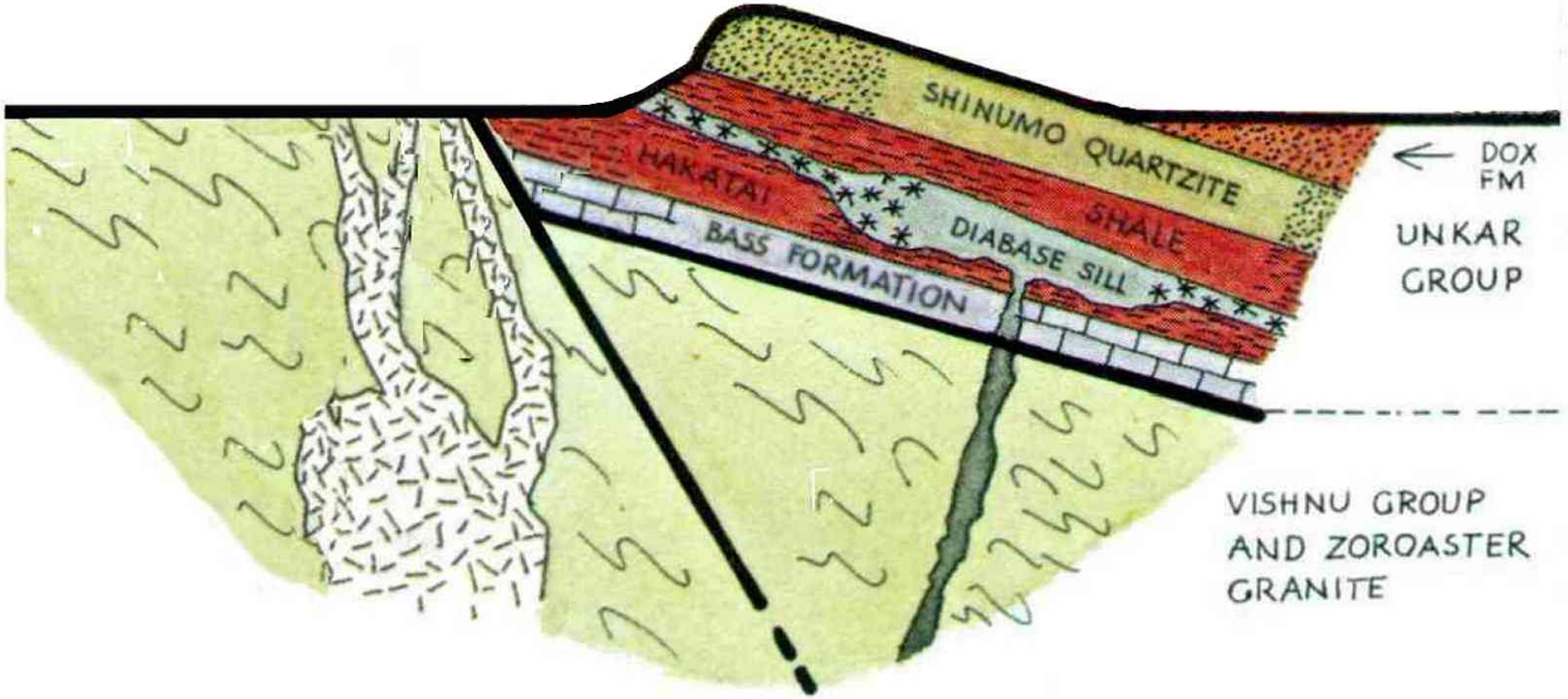

Introduction to the Grand Canyon

# Why Grand Canyon?

- One of the most spectacular geological displays in the world.
- Discussions about “How Long?” are common and important.
- Illustrates many geological principles that concern us.
- We have a lot to say about it.

# GEOLOGIC COLUMN

| ERA | SYSTEM OR PERIOD | SERIES OR EPOCH |
|---|---|---|
| CENOZOIC | QUATERNARY | HOLOCENE |
| | | PLEISTOCENE |
| | NEOGENE | PLIOCENE |
| | TERTIARY | MIOCENE |
| | | OLIGOCENE |
| | PALEOGENE | EOCENE |
| | | PALEOCENE |
| MESOZOIC | CRETACEOUS | U, L |
| | JURASSIC | U, M, L |
| | TRIASSIC | U, M, L |
| PALEOZOIC | PERMIAN | U, L |
| | CARBONIFEROUS | U, L |
| | DEVONIAN | U, L |
| | SILURIAN | U, M, L |
| | ORDOVICIAN | U, M, L |
| | CAMBRIAN | U, M, L |
| PRECAMBRIAN | | U, M, L |


SHINUMO QUARTZITE
HAKATAI SHALE
DIABASE SILL
BASS FORMATION
DOX FM
UNKAR GROUP
VISHNU GROUP AND ZOROASTER GRANITE


Kaibab
Coconino
Supai
Redwall
Muav
Bright Angel
Tapeats

# The Issue of Time

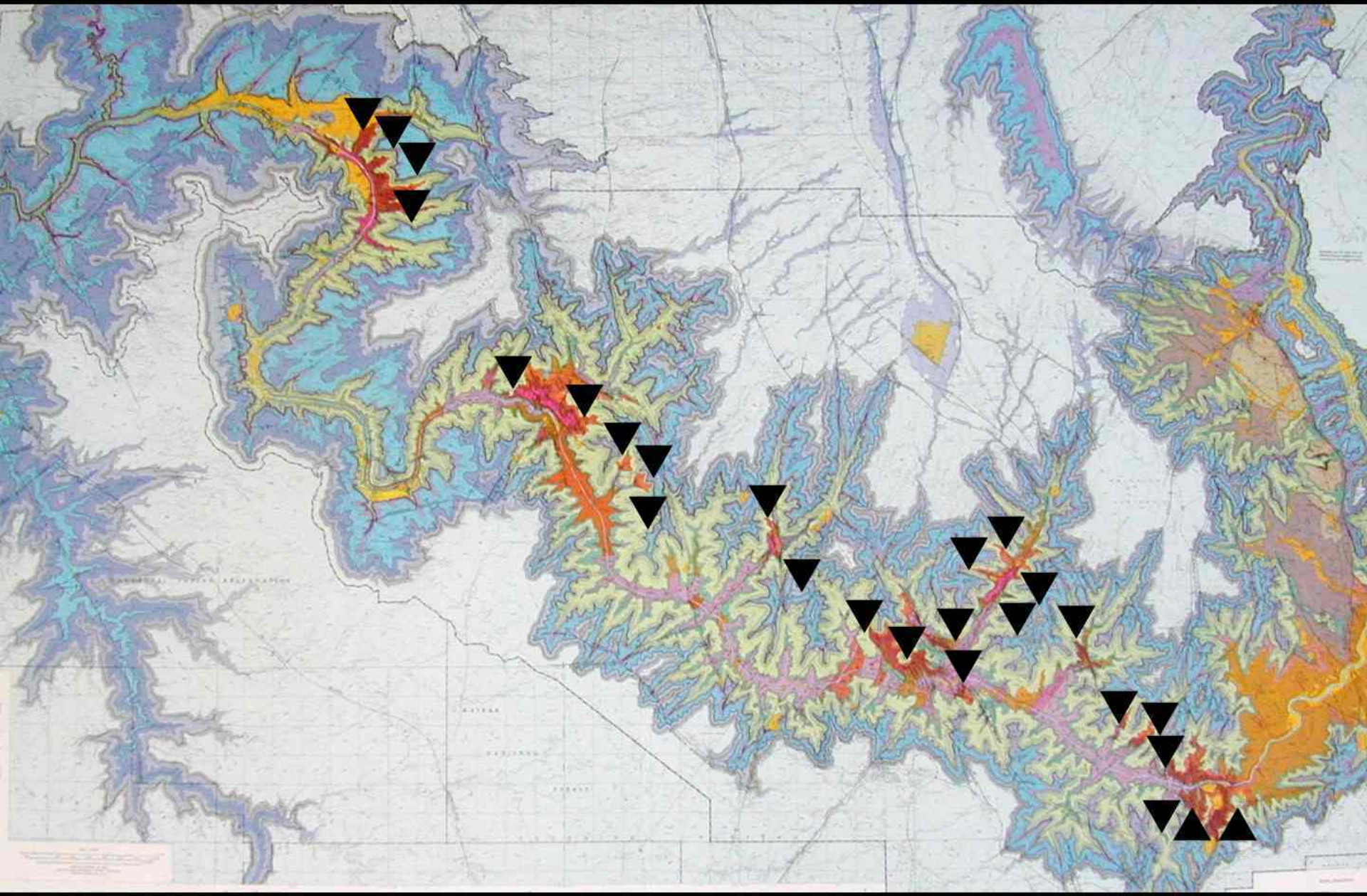
- Cutting the Canyon
  - 15, 000 to 15,000,000 years
  - Few hours
- Depositing the Sediments
  - 250,000,000 years
  - How certain are we?


Muav
Bright Angel
Tapeats

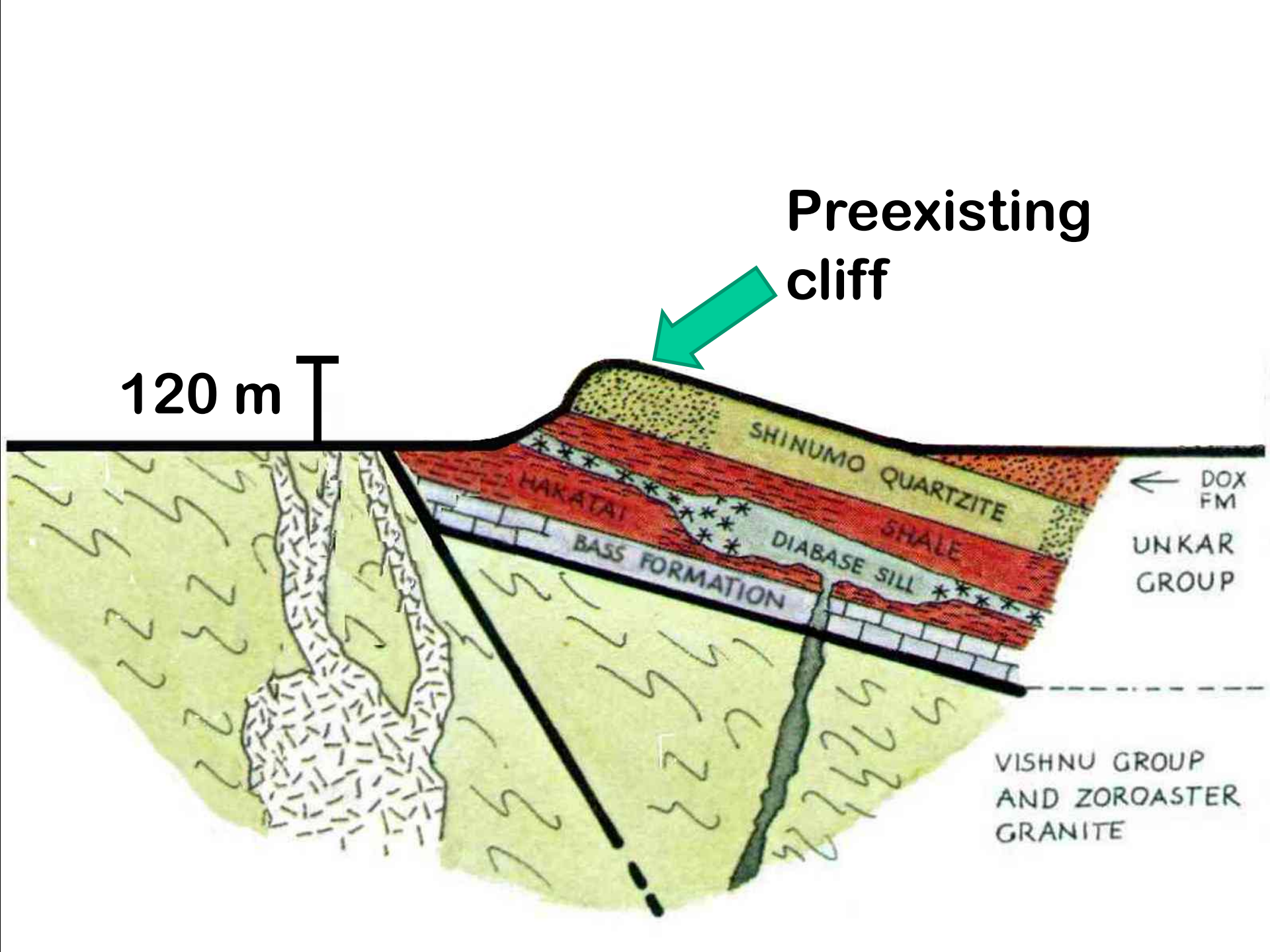
# Standard Model

- Shallow advancing sea
- Shallow water sedimentary structures
- Multiple advances and retreats of the sea over millions of years
- Based in large part on comparisons with modern environments

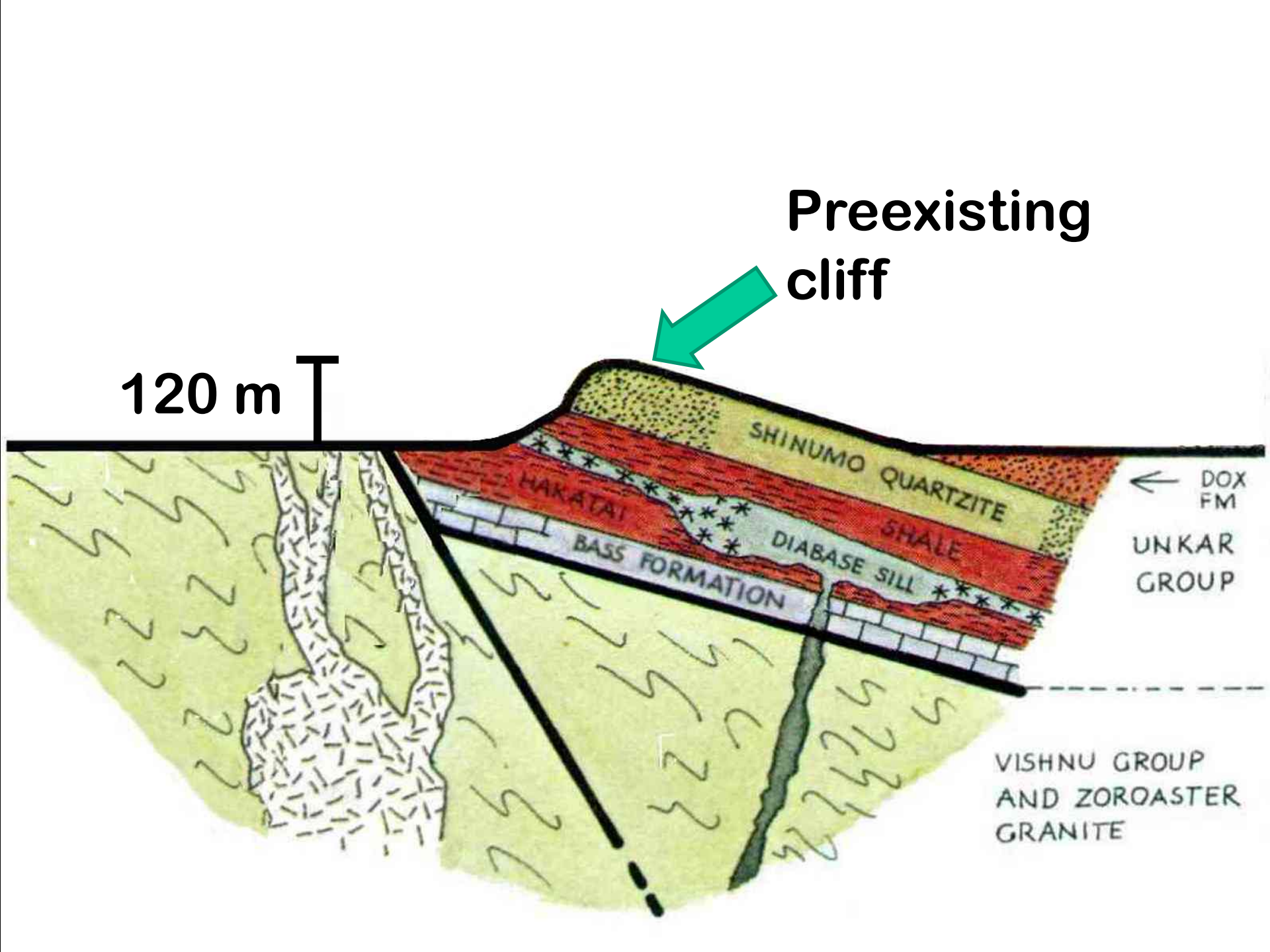
# Does Standard Model Work?

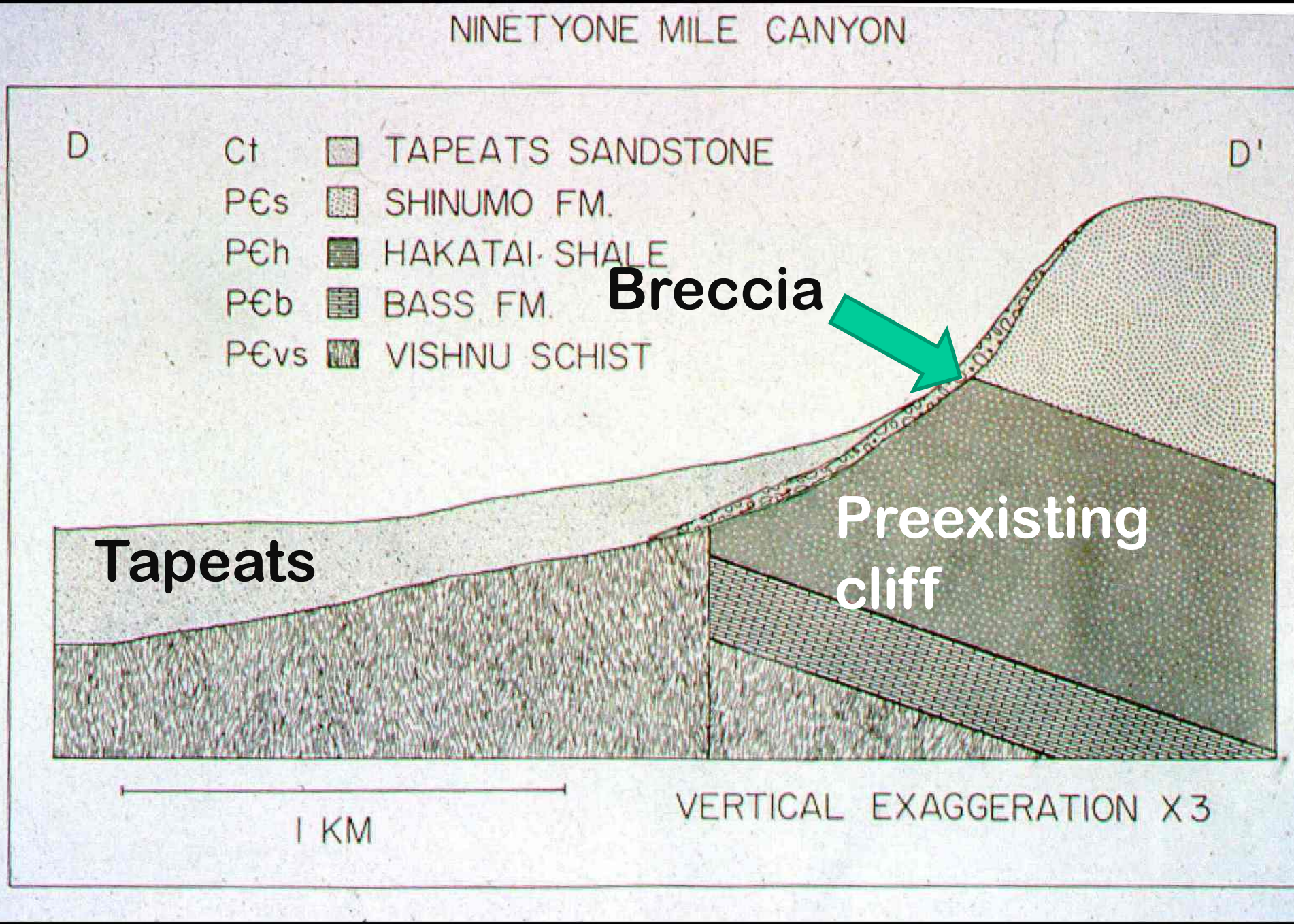


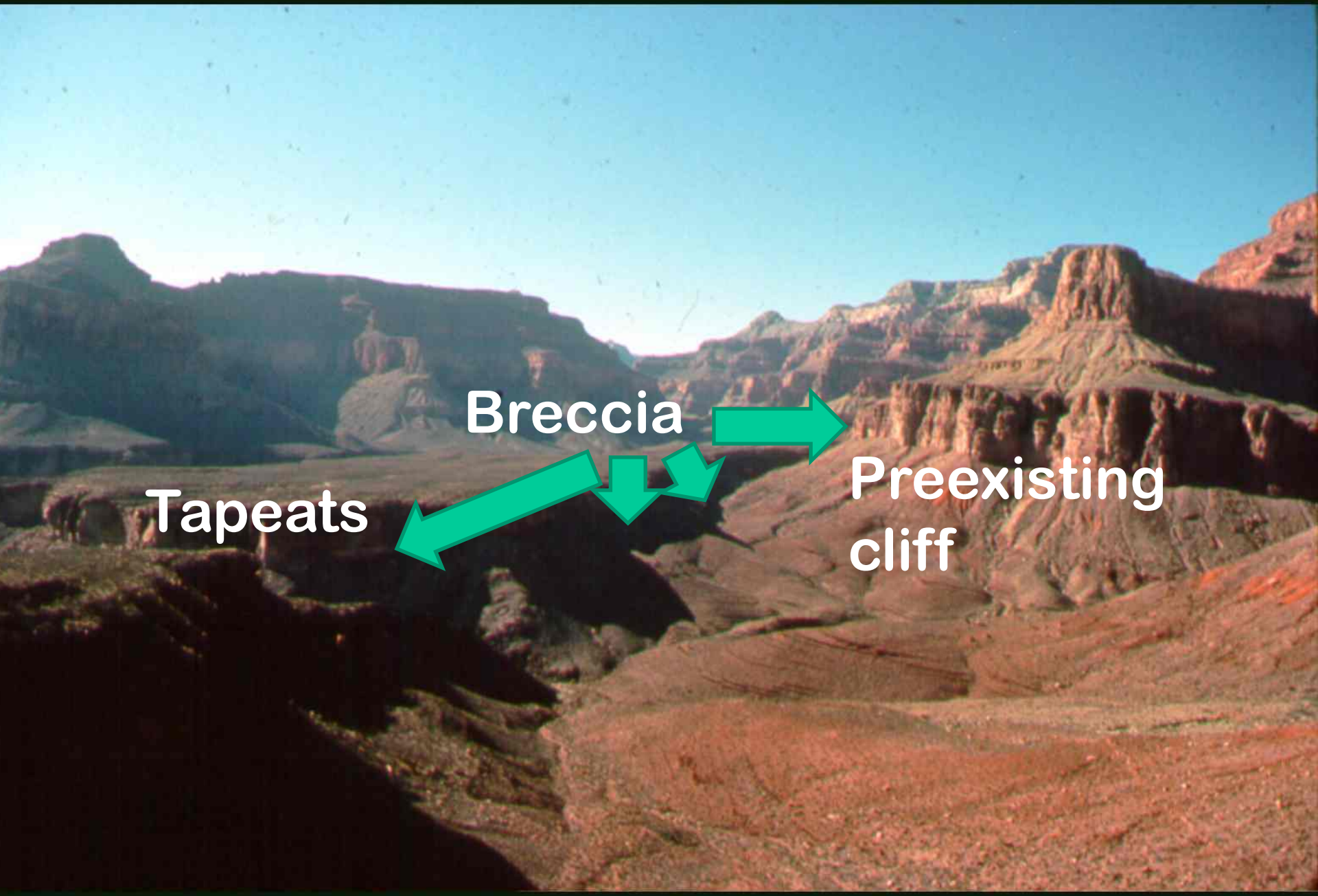
# Geometry of surfaces

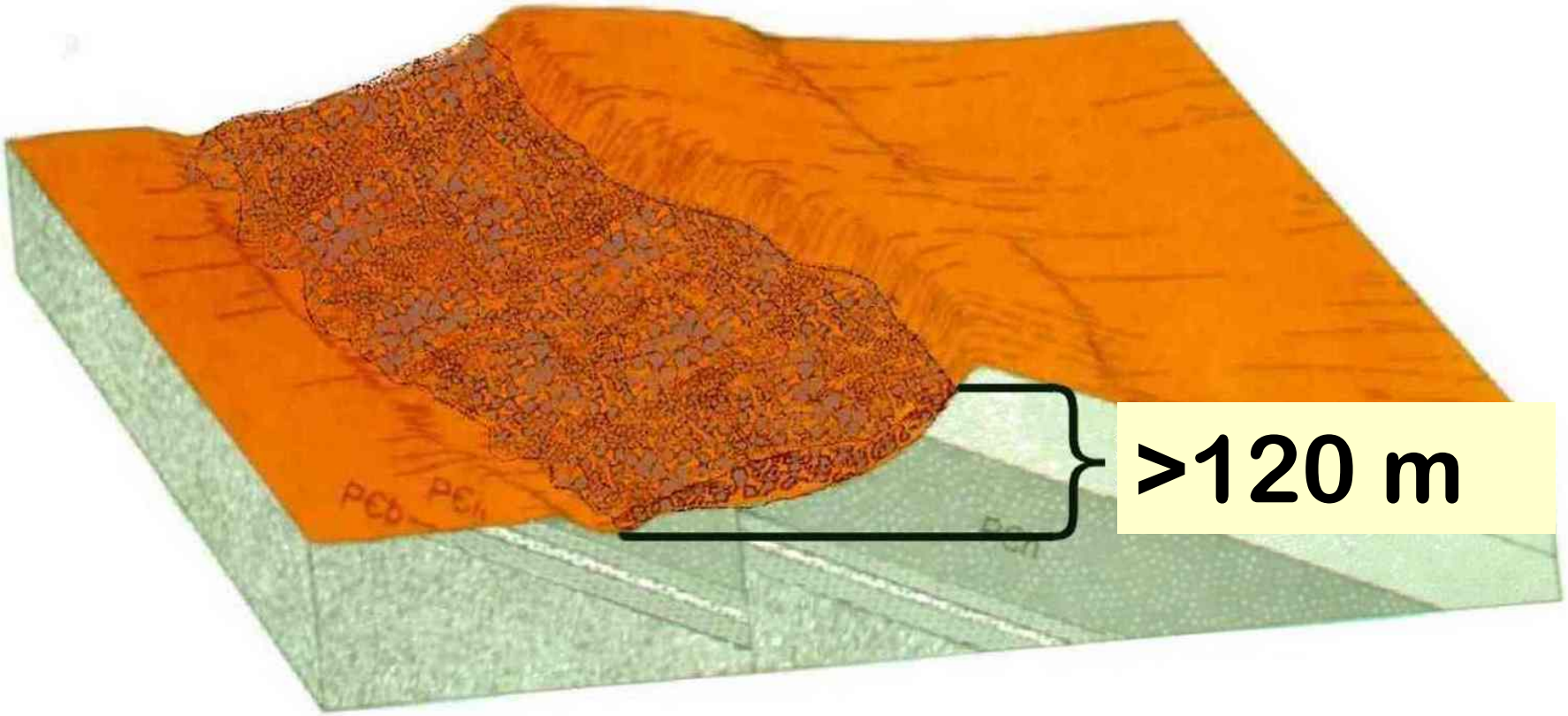

Preexisting cliff
120 m
SHINUMO QUARTZITE
HAKATAI SHALE
DIABASE SILL
BASS FORMATION
DOX FM
UNKAR GROUP
VISHNU GROUP AND ZOROASTER GRANITE

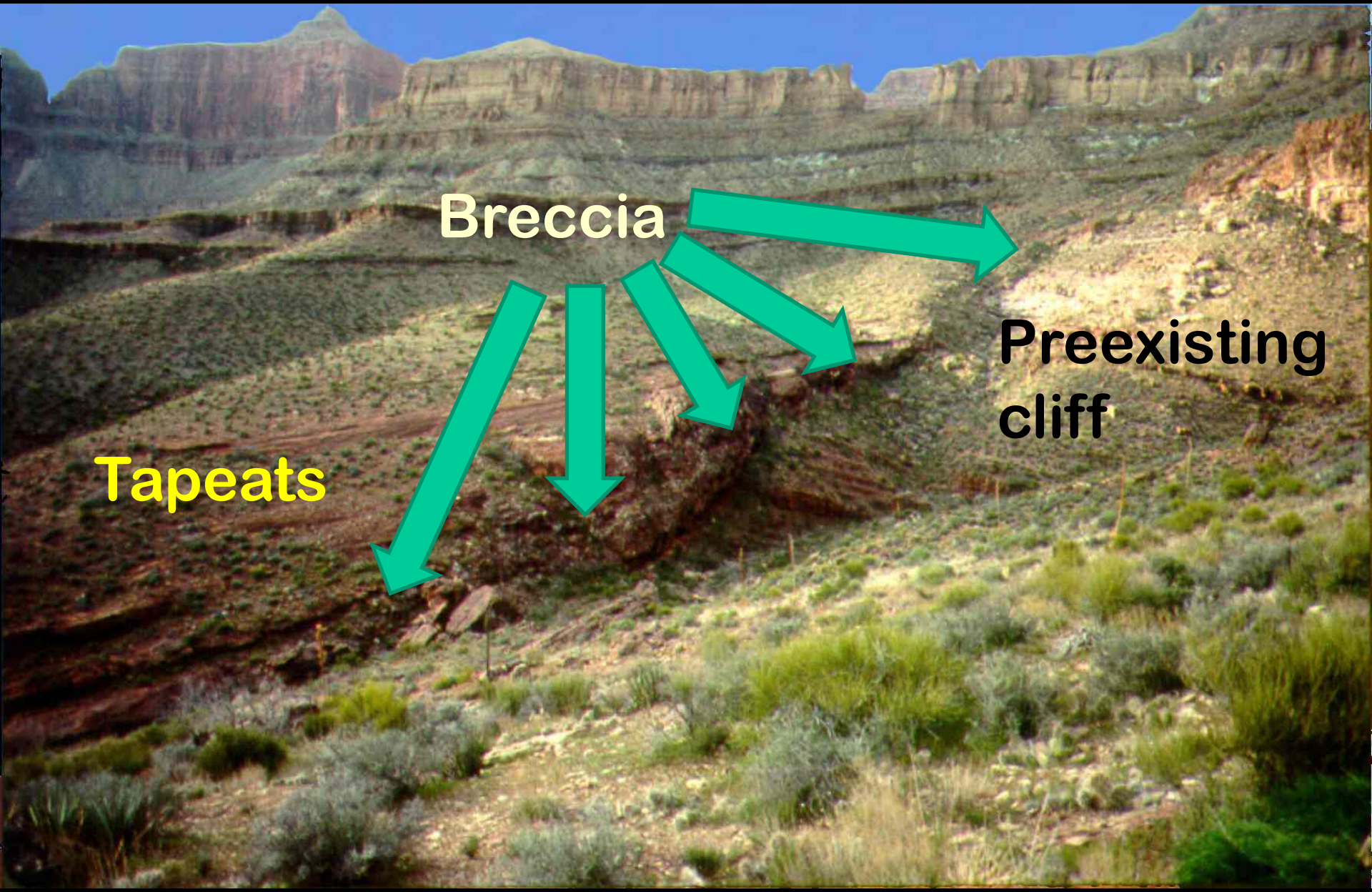

Tapeats
Breccia
Pre-existi
cliff


Preexisting cliff
120 m
SHINUMO QUARTZITE
HAKATAI SHALE
DIABASE SILL
BASS FORMATION
DOX FM
UNKAR GROUP
VISHNU GROUP AND ZOROASTER GRANITE


NINETYONE MILE CANYON
D
D'
Ct TAPEATS SANDSTONE
P€s SHINUMO FM.
P€h HAKATAI SHALE
P€b BASS FM.
P€vs VISHNU SCHIST
Breccia
Tapeats
Preexisting cliff
1 KM
VERTICAL EXAGGERATION X3


Breccia
Tapeats
Preexisting cliff

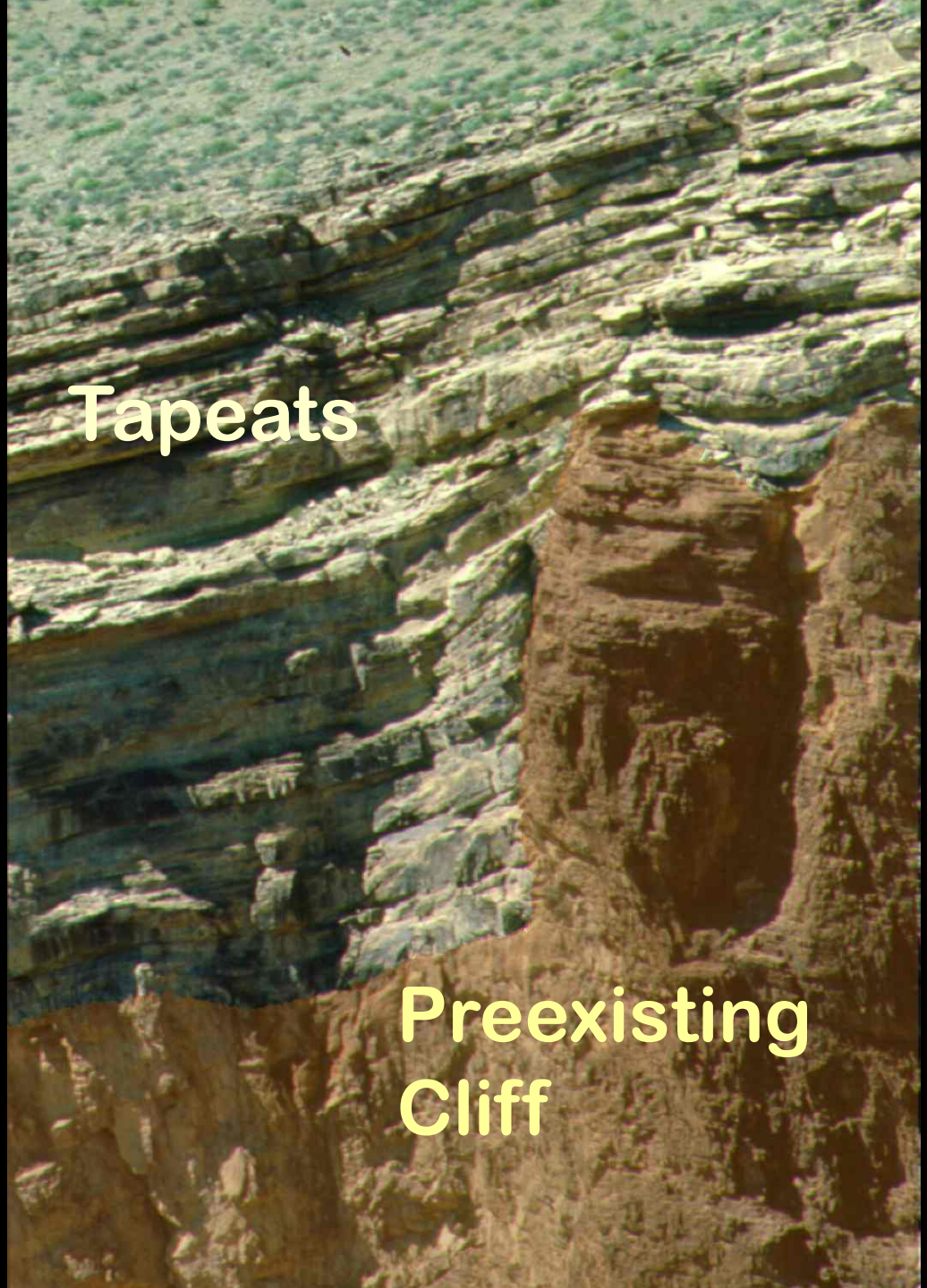

>120 m


Breccia
Preexisting cliff
Tapeats

# Conclusions based upon preservation of the basal breccia

- Preservation of basal breccia along cliff argues strongly that region was never subjected to erosion (I.e. shallow water) from time of breccia deposition till finally cliff covered.
- Water level deep enough so cliff was below storm wave base at all times.

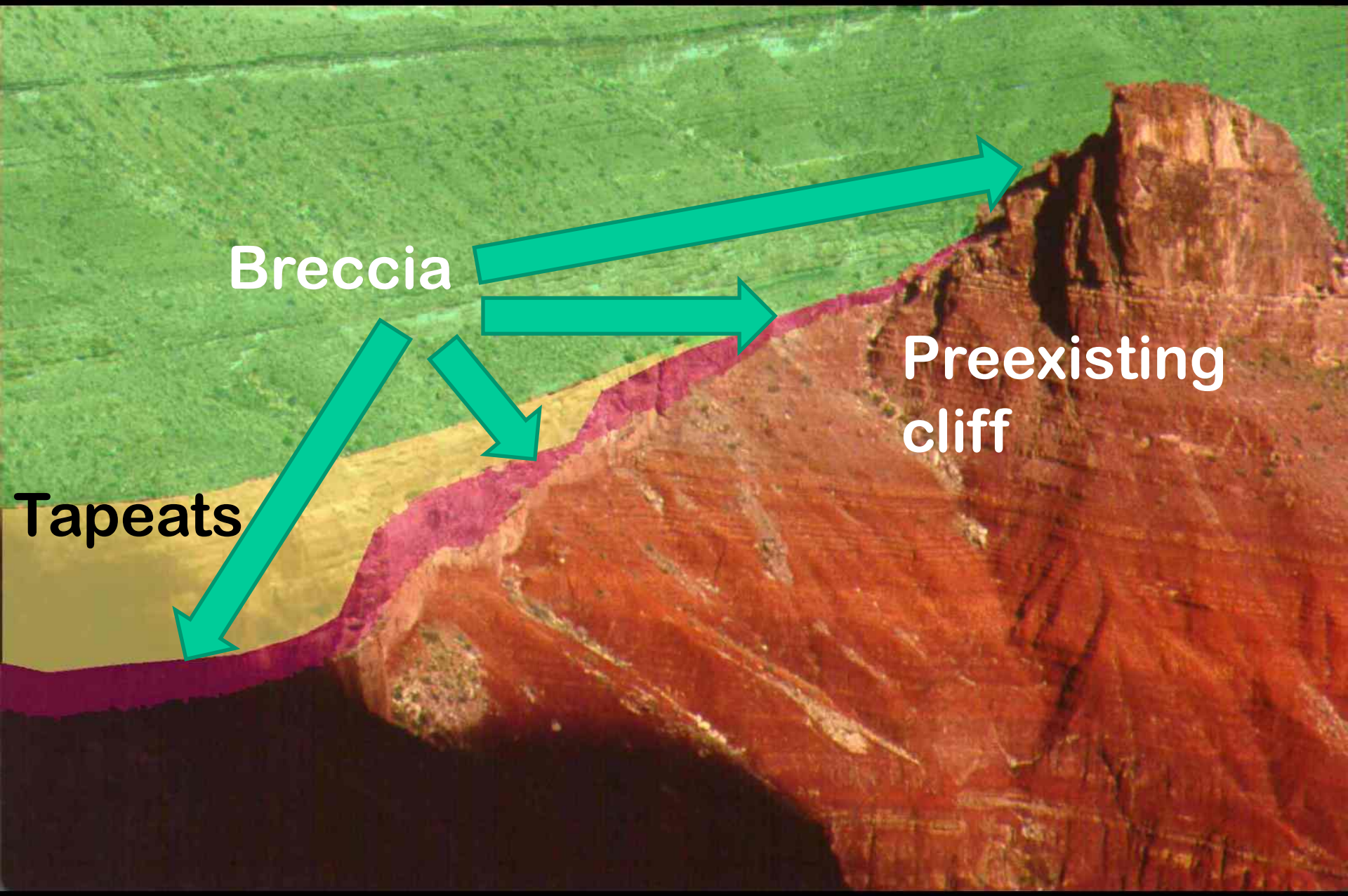
# Preservation of cliff face


Tapeats
Preexisting
Cliff

# Conclusions based upon preservation of cliff face

- Preservation of vertical cliff face argues strongly that region was never subjected to erosion (I.e. shallow water) from time of breccia deposition until finally cliff covered.
- Water level deep enough so cliff was below storm wave base (60 m) at all times.

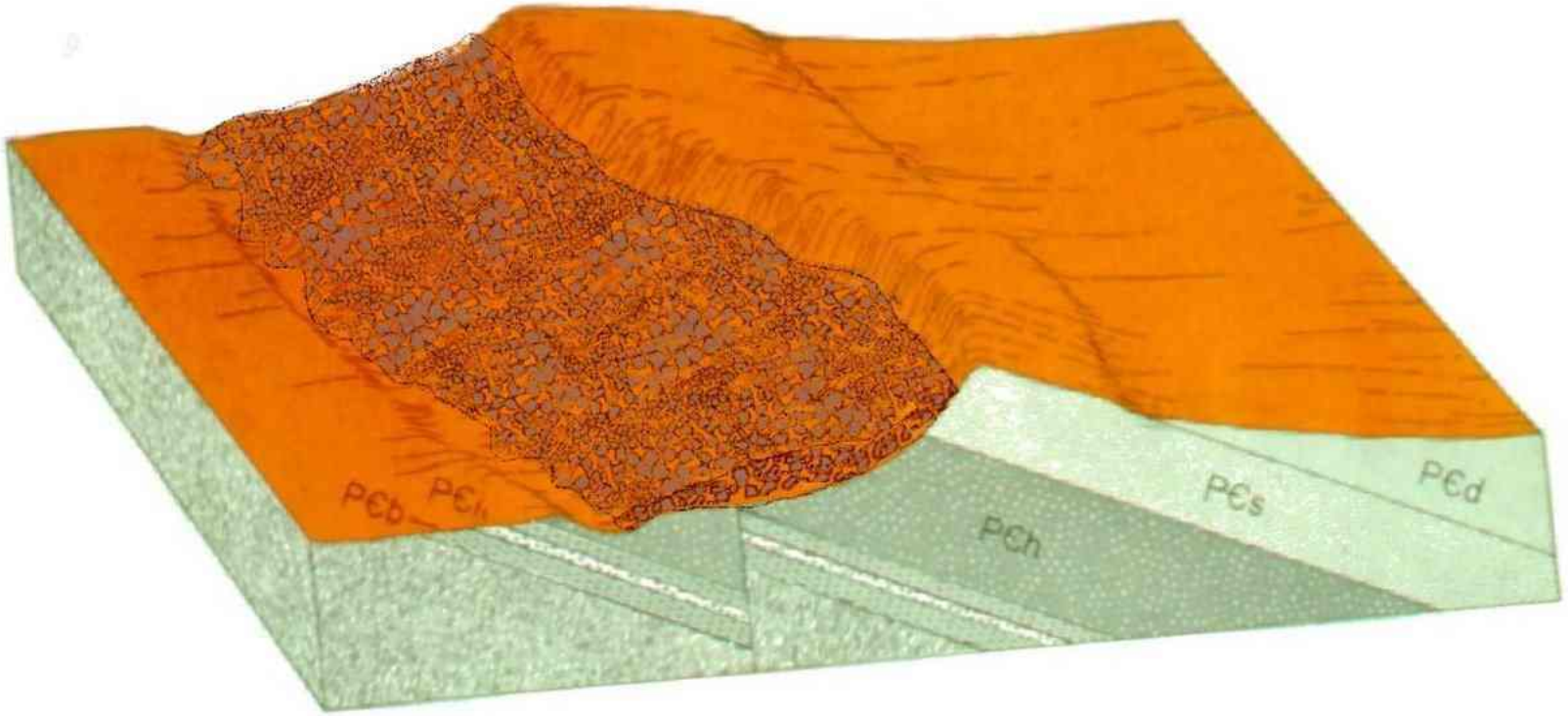
# Incorporation of underlying sediment into Tapeats


Breccia
Preexisting cliff
Tapeats

# Conclusions based upon absence of significant component of underlying sediment in the Tapeats

- Absence of red shale in the Tapeats sediment argues strongly that the underlying surface was never subjected to a high-energy environment (i.e. shallow water) from time of breccia deposition till finally red surface was covered by Cambrian sedimentation.
- Water level deep enough so underlying red shale was below storm wave base at all times.

# Comparison of the models: Shallow marine deposition in transgressing sea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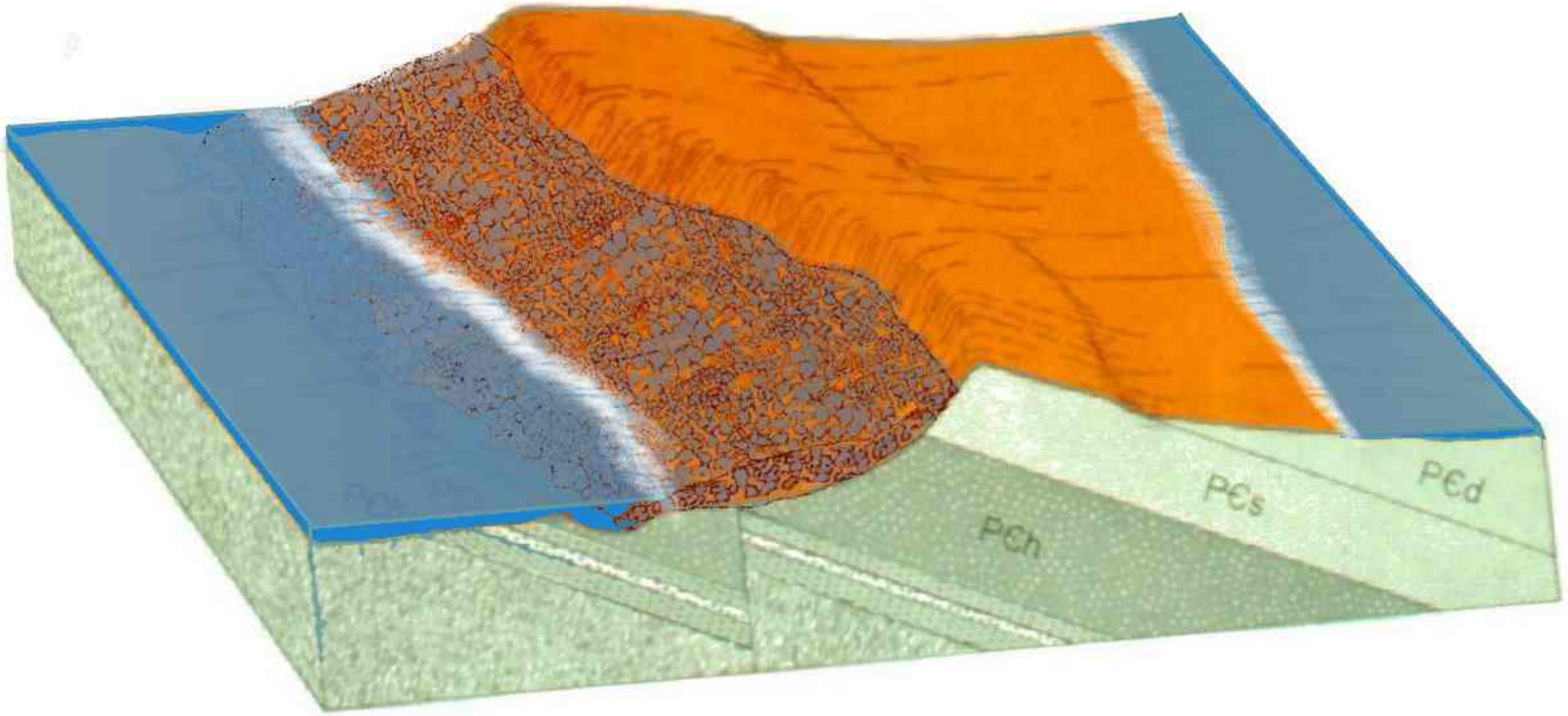
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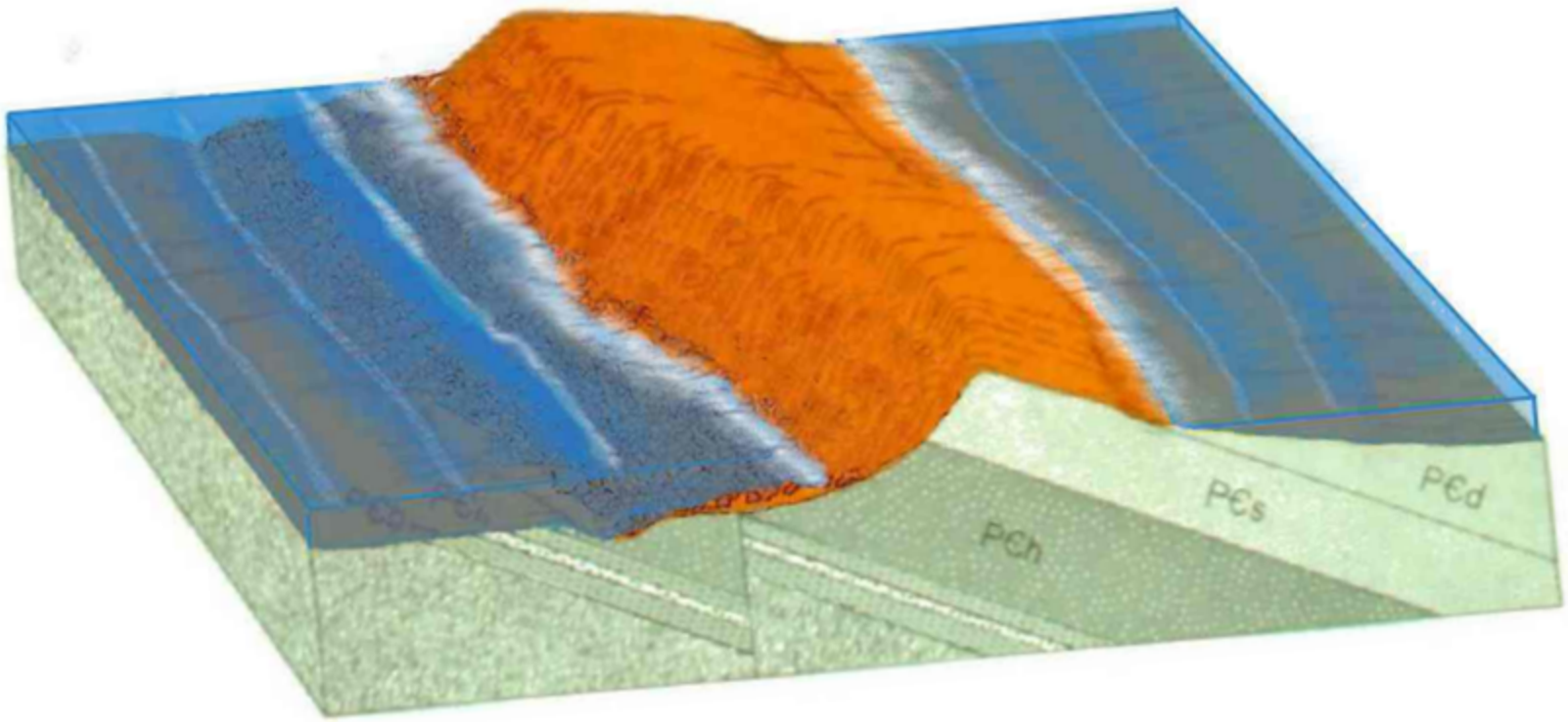
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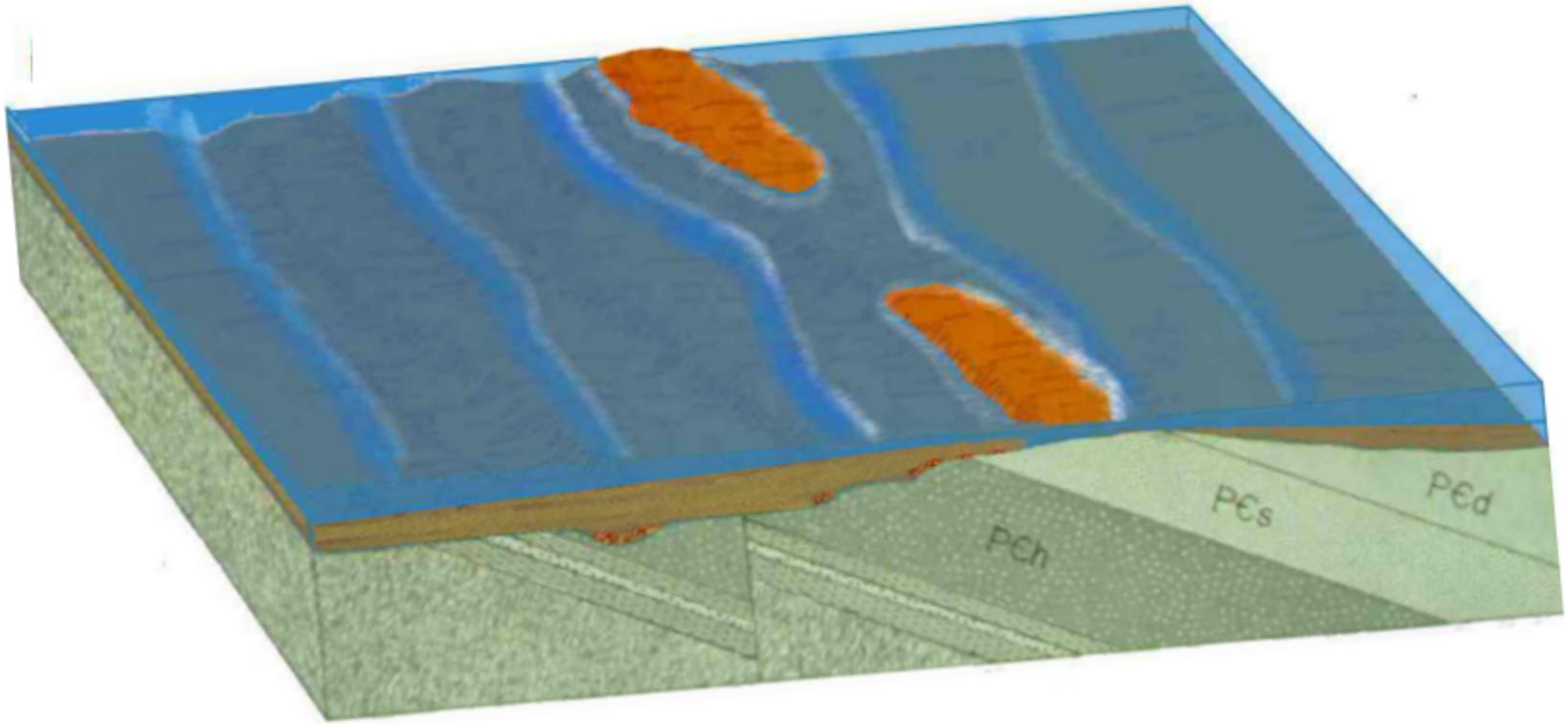
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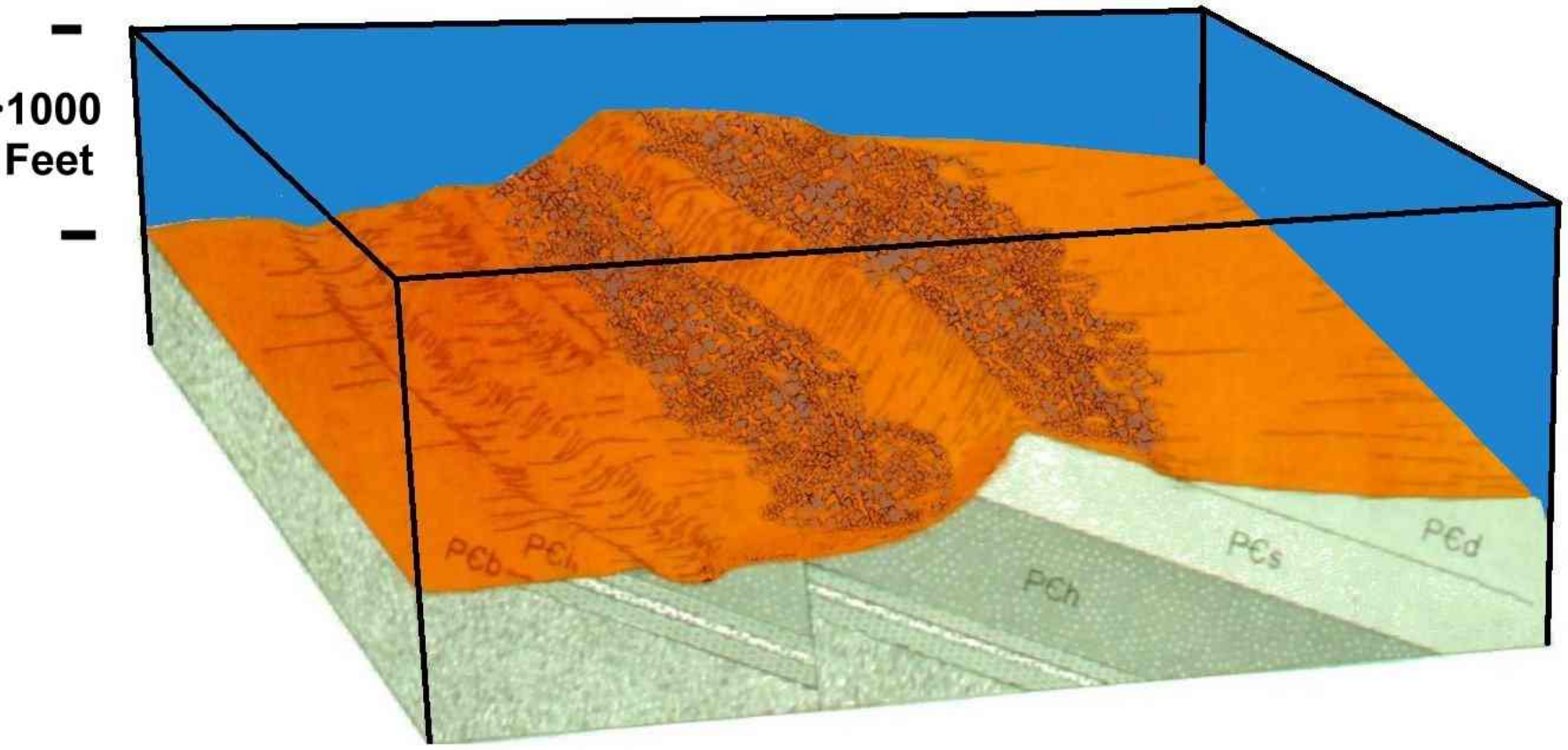
# Comparison of the models: Deep marine deposition, collapsing shelf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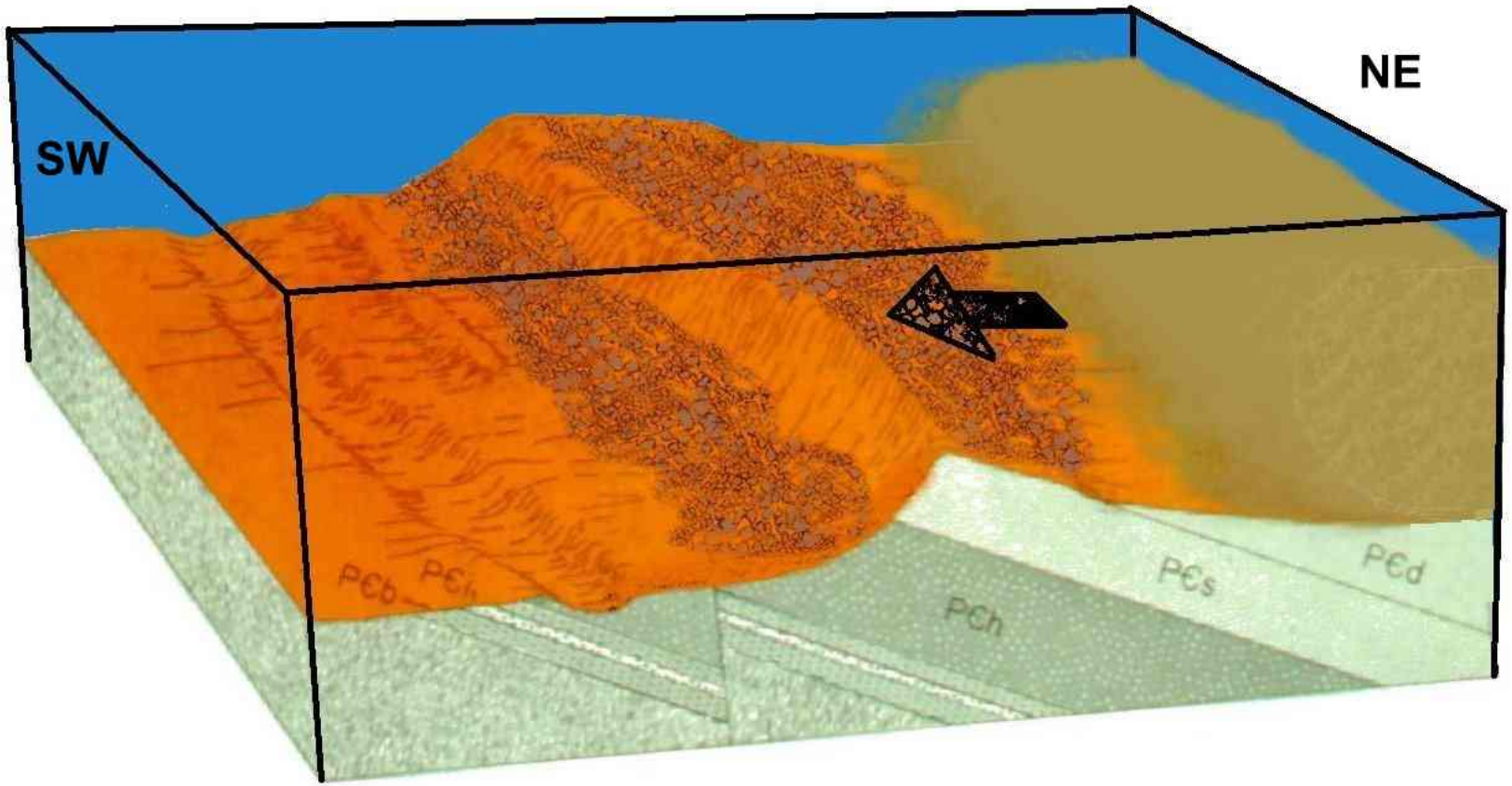
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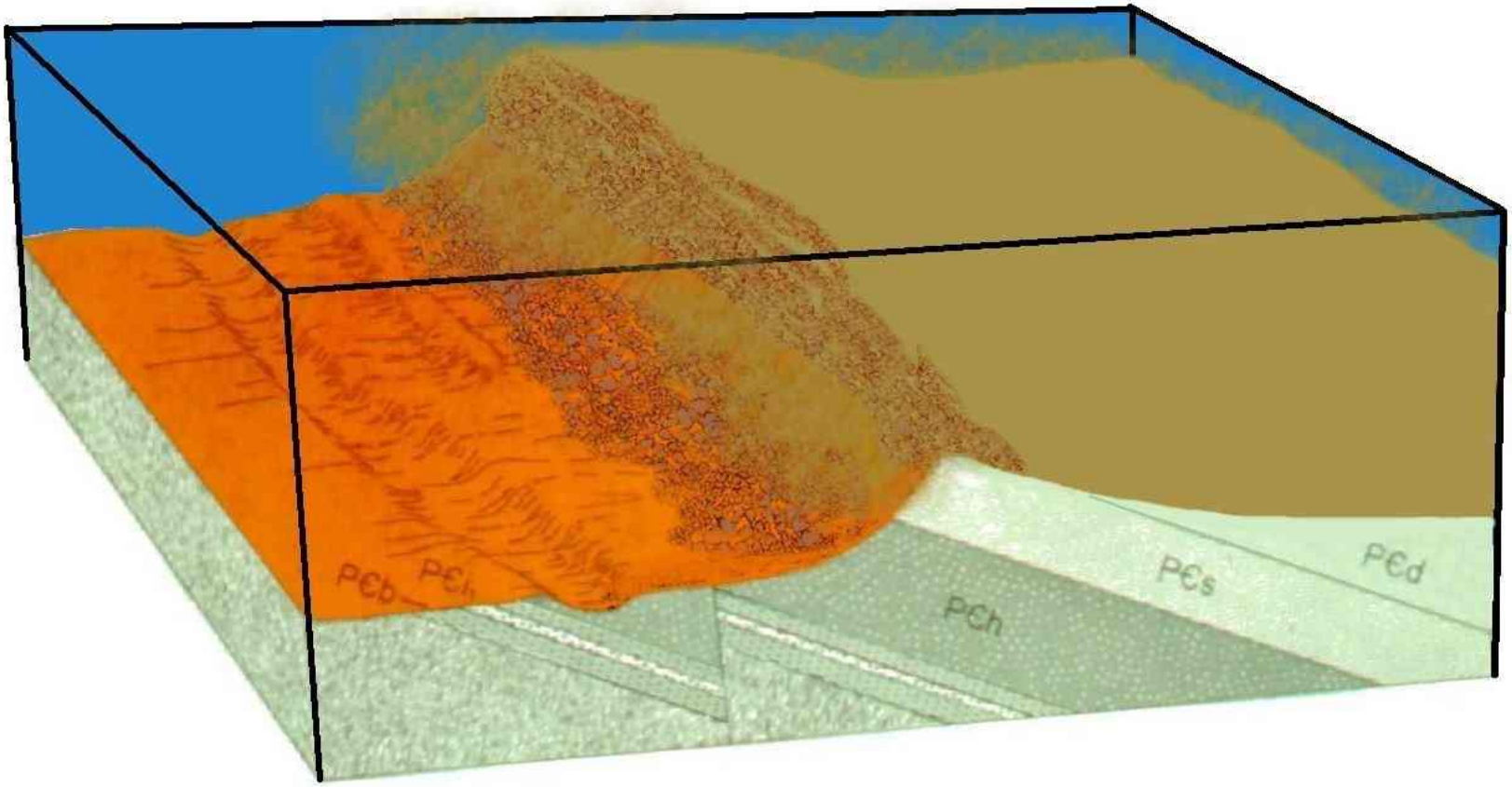
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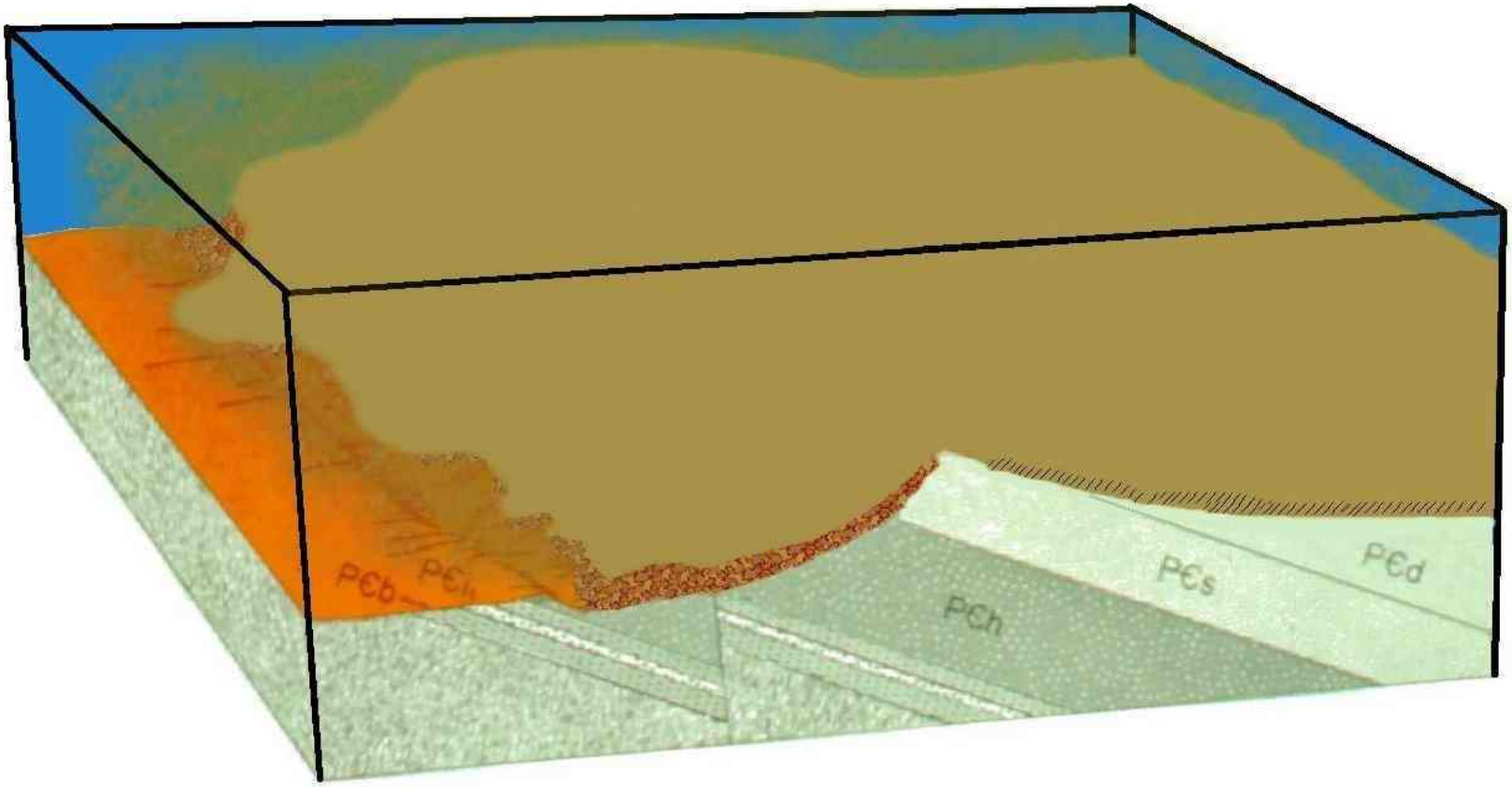
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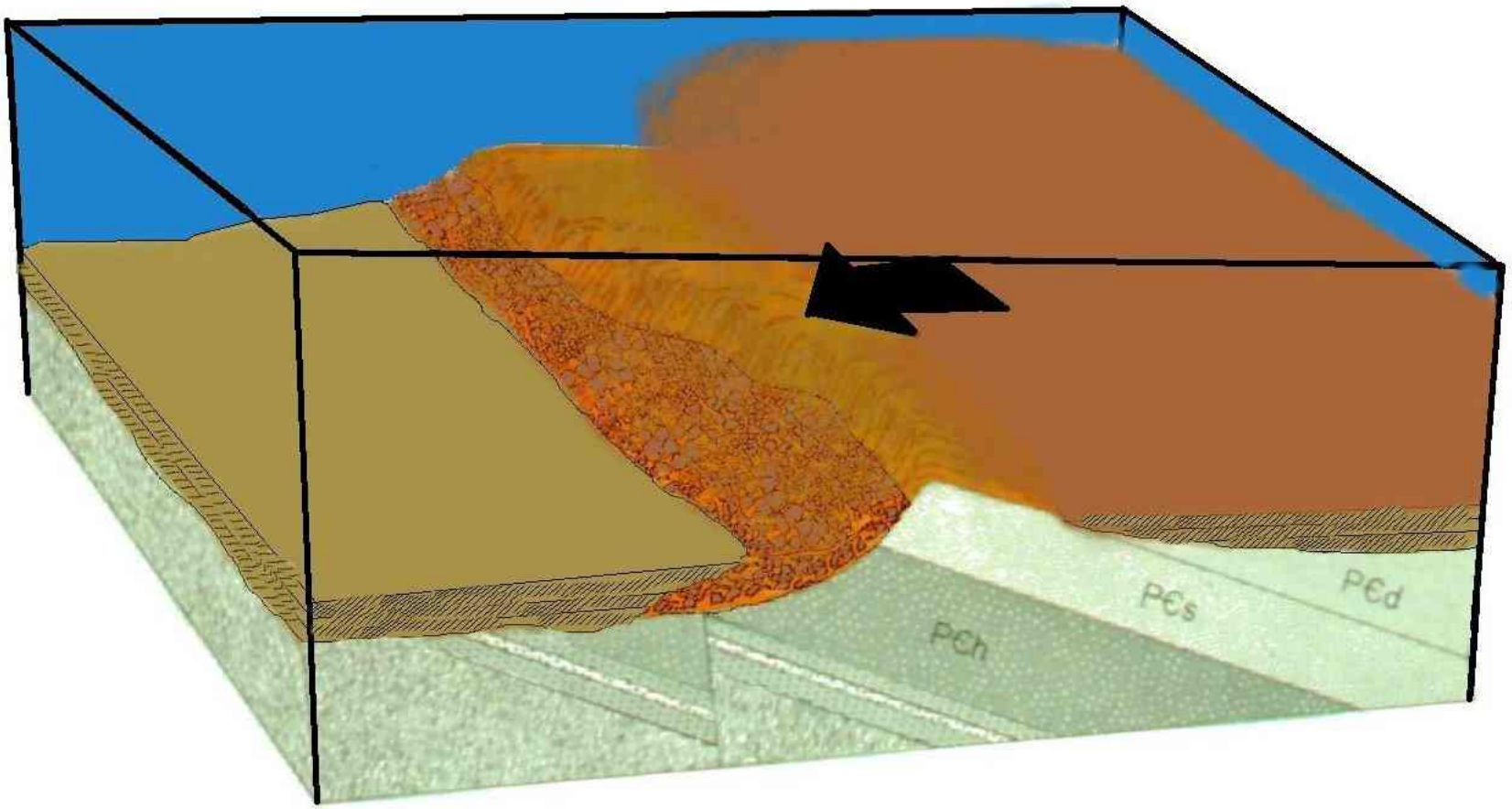
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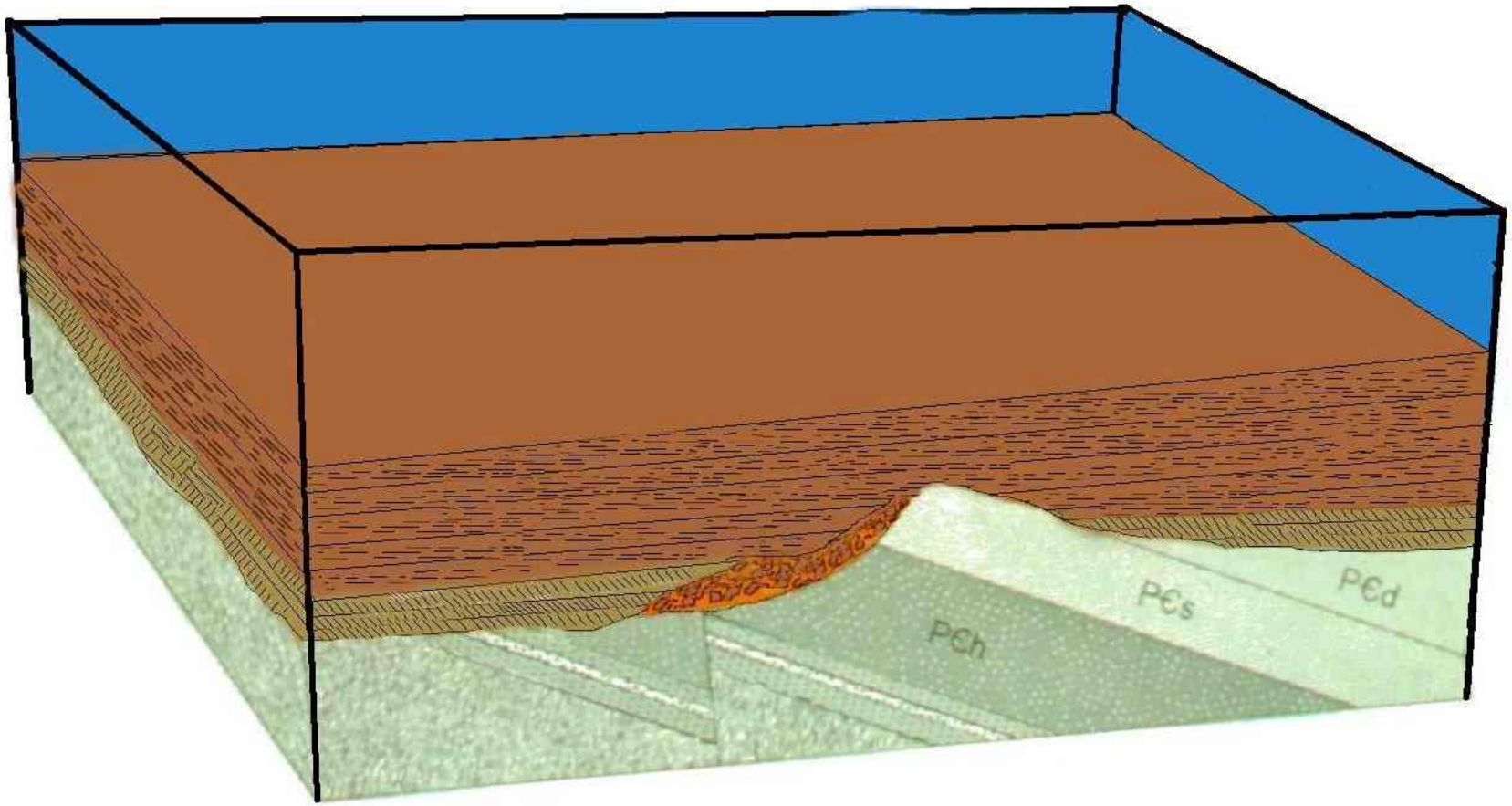
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# Conclusions:

- Tapeats was not deposited in a shallow setting.
- Deposition was in deep water, and was rapid. This is consistent with deposition in a global flood.
- Sedimentary structures used to define Tapeats as shallow marine must also be consistent with deep water deposition.