Hot Science Cool Talks

UT Environmental Science Institute

4

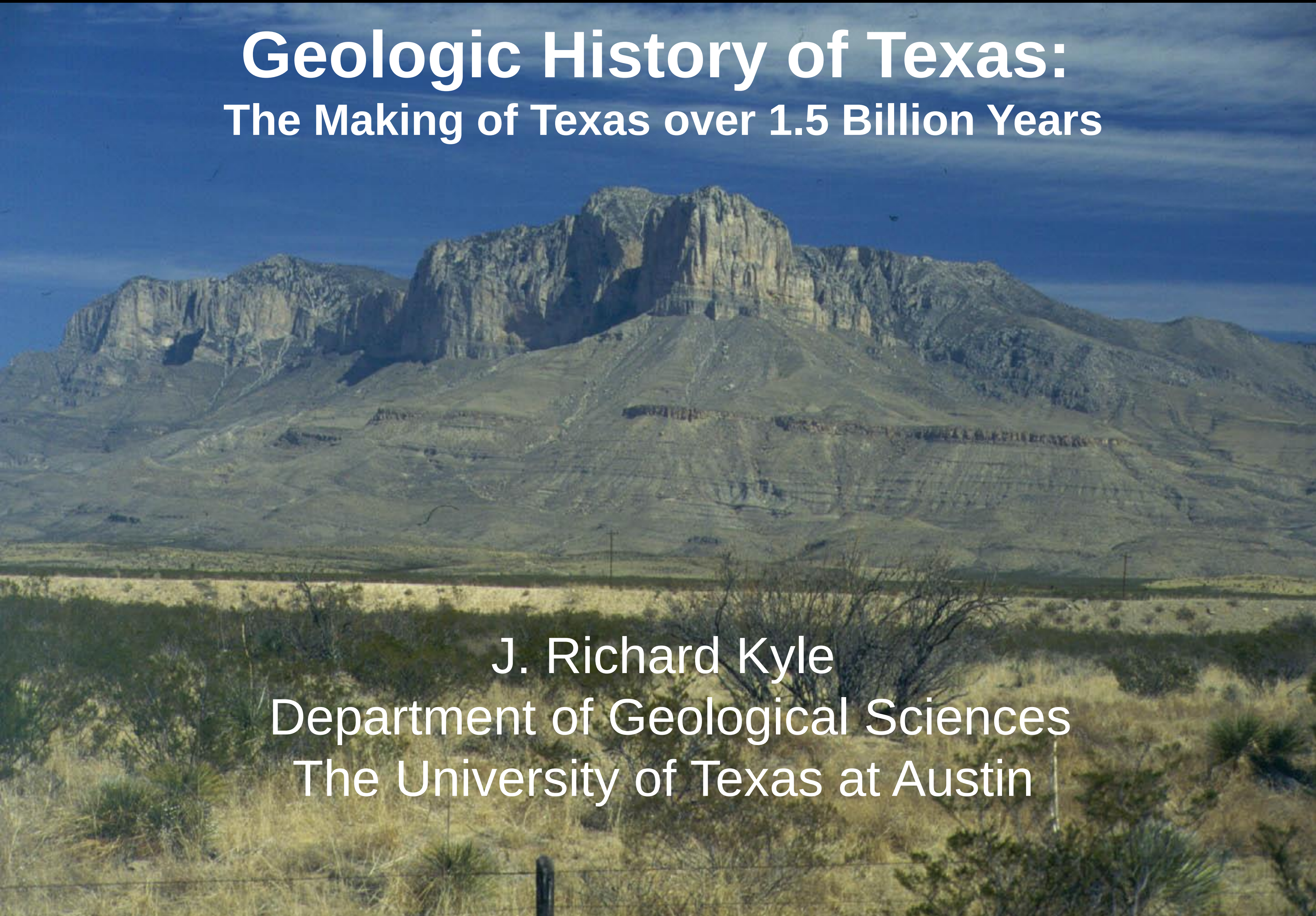
Geologic History of Texas: The Making of Texas Over 1.5 Billion Years

Dr. Richard Kyle

March 24, 2000

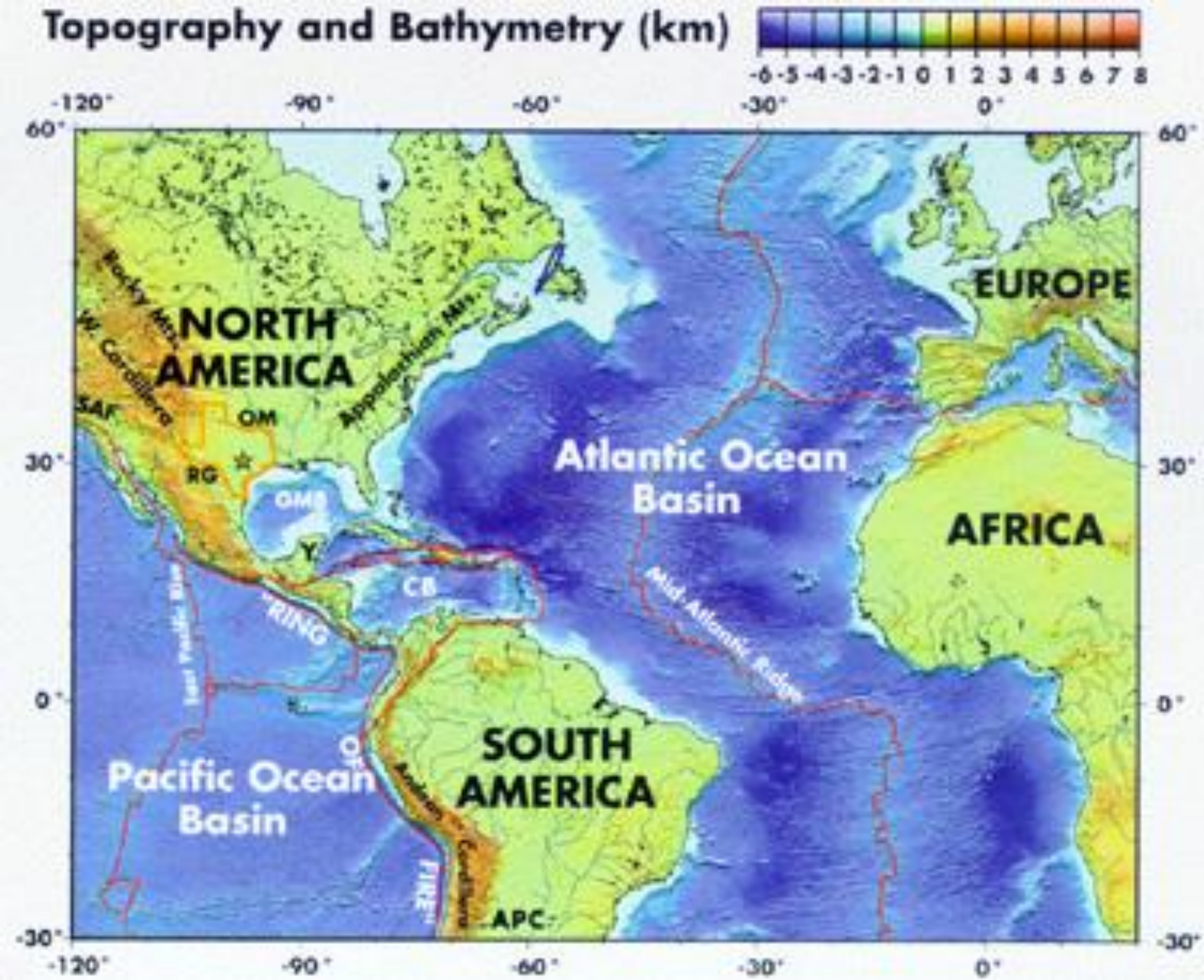
Geologic History of Texas:

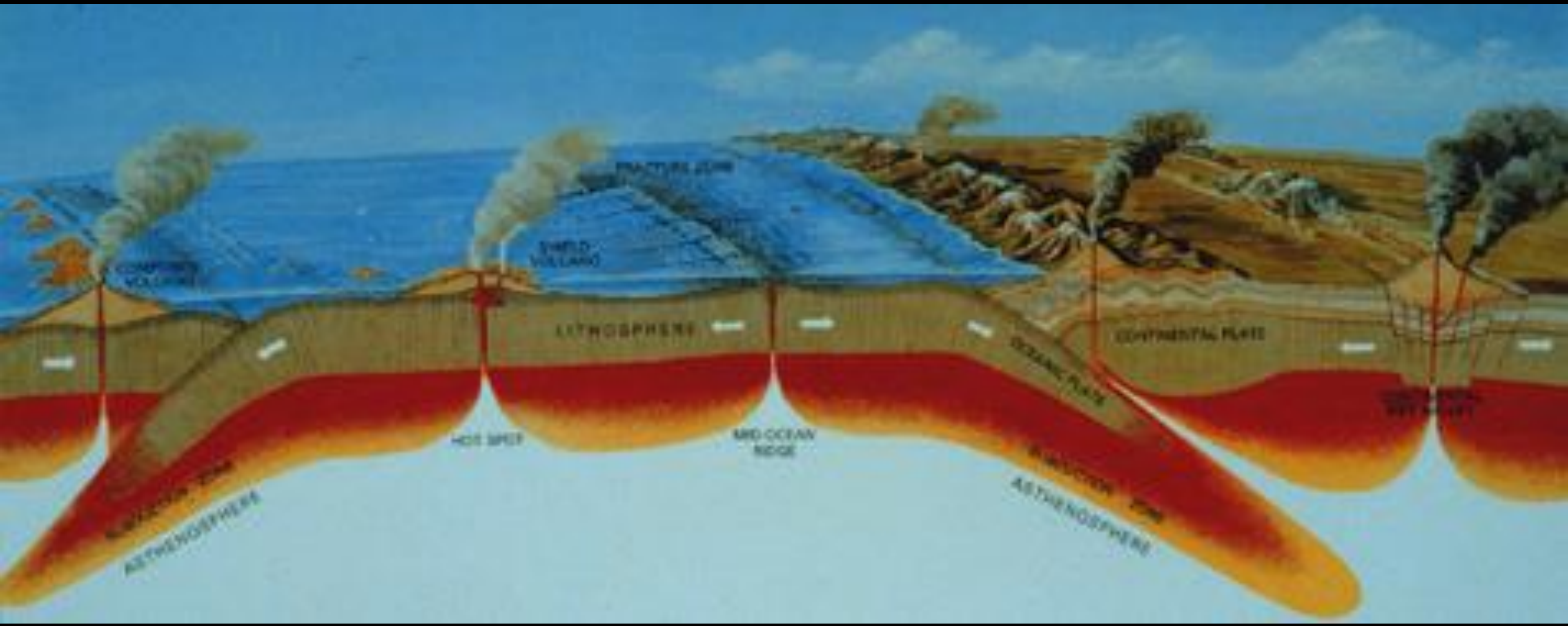
The Making of Texas over 1.5 Billion Years

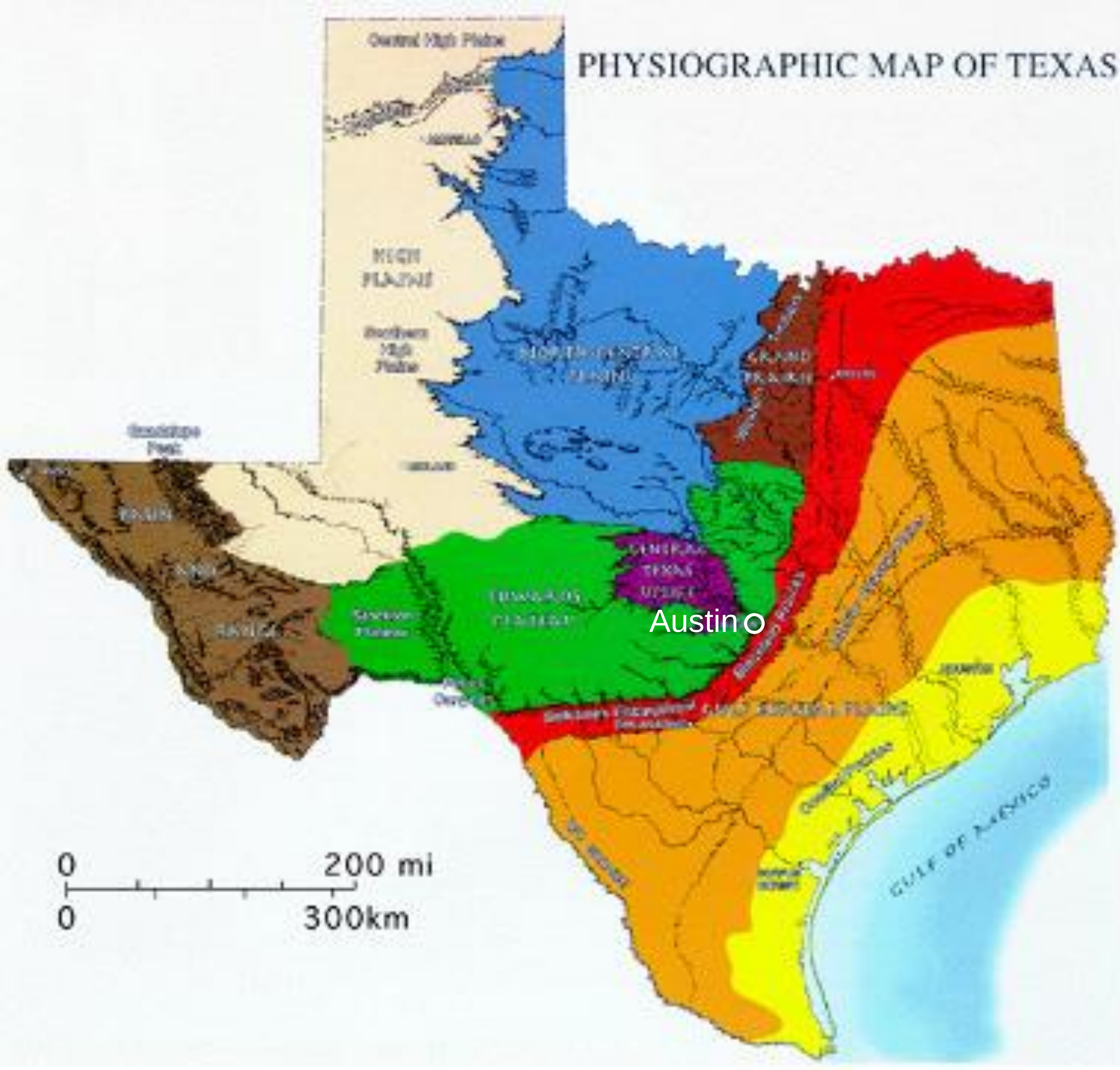


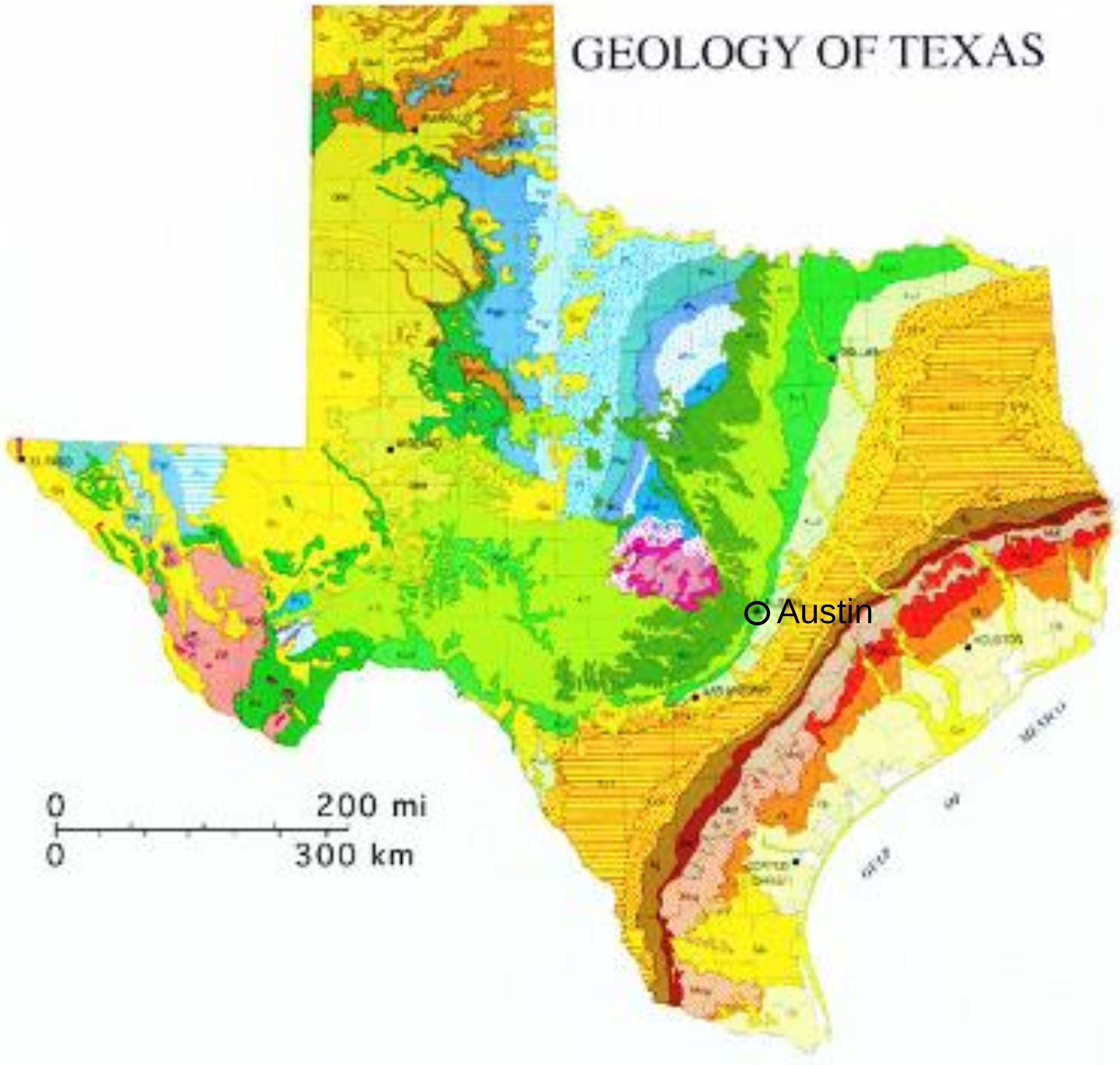
J. Richard Kyle
Department of Geological Sciences
The University of Texas at Austin

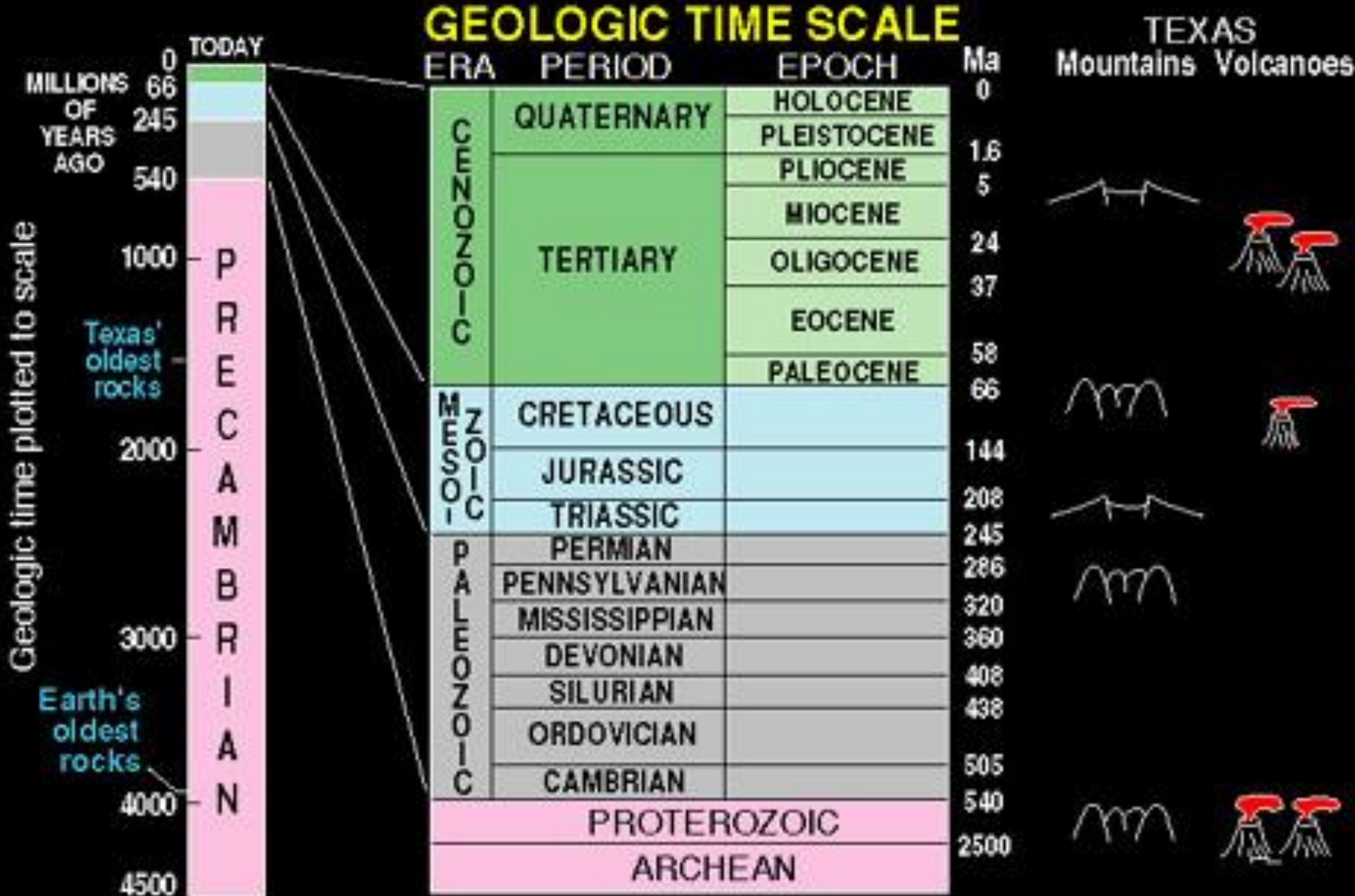
I am grateful to many individuals who have contributed to my understanding of the geologic history of Texas, particularly present and former colleagues at The University of Texas at Austin in the Department of Geological Sciences, the Bureau of Economic Geology, the Institute for Geophysics, and the Texas Memorial Museum. These individuals and institutions have contributed many of the illustrative materials contained in this CD-ROM.


Topography and Bathymetry (km)
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8
-120° -90° -60° -30° 0°
60° 30° 0° -30°
NORTH AMERICA
Rocky Mts.
W. Cordillera
Appalachian Mts.
SAF
OM
RG
GMB
Y
CB
RING
Atlantic Ocean Basin
Mid-Atlantic Ridge
EUROPE
AFRICA
SOUTH AMERICA
Pacific Ocean Basin
Andean Cordillera
FIRE
APC


SHIELD VOLCANO
LITHOSPHERE
HOT SPOT
MID OCEAN RIDGE
ASTHENOSPHERE
CONTINENTAL PLATE
OCEANIC PLATE
ASTHENOSPHERE


PHYSIOGRAPHIC MAP OF TEXAS
HIGH PLAINS
GRAND PRAIRIE
CENTRAL TEXAS UPLIFT
Austin
GULF OF MEXICO
0
200 mi
0
300km


GEOLOGY OF TEXAS
Austin
0
200 mi
0
300 km


GEOLOGIC TIME SCALE
TODAY
0
MILLIONS OF YEARS AGO
66
245
540
1000
2000
3000
4000
4500
Geologic time plotted to scale
Texas' oldest rocks
Earth's oldest rocks
PRECAMBRIAN
ERA
PERIOD
EPOCH
Ma
CENOZOIC
QUATERNARY
TERTIARY
HOLOCENE
PLEISTOCENE
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
MESOZOIC
CRETACEOUS
JURASSIC
TRIASSIC
PALEOZOIC
PERMIAN
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PROTEROZOIC
ARCHEAN
0
1.6
5
24
37
58
66
144
208
245
286
320
360
408
438
505
540
2500
TEXAS
Mountains
Volcanoes

8. Geologic Time Principles

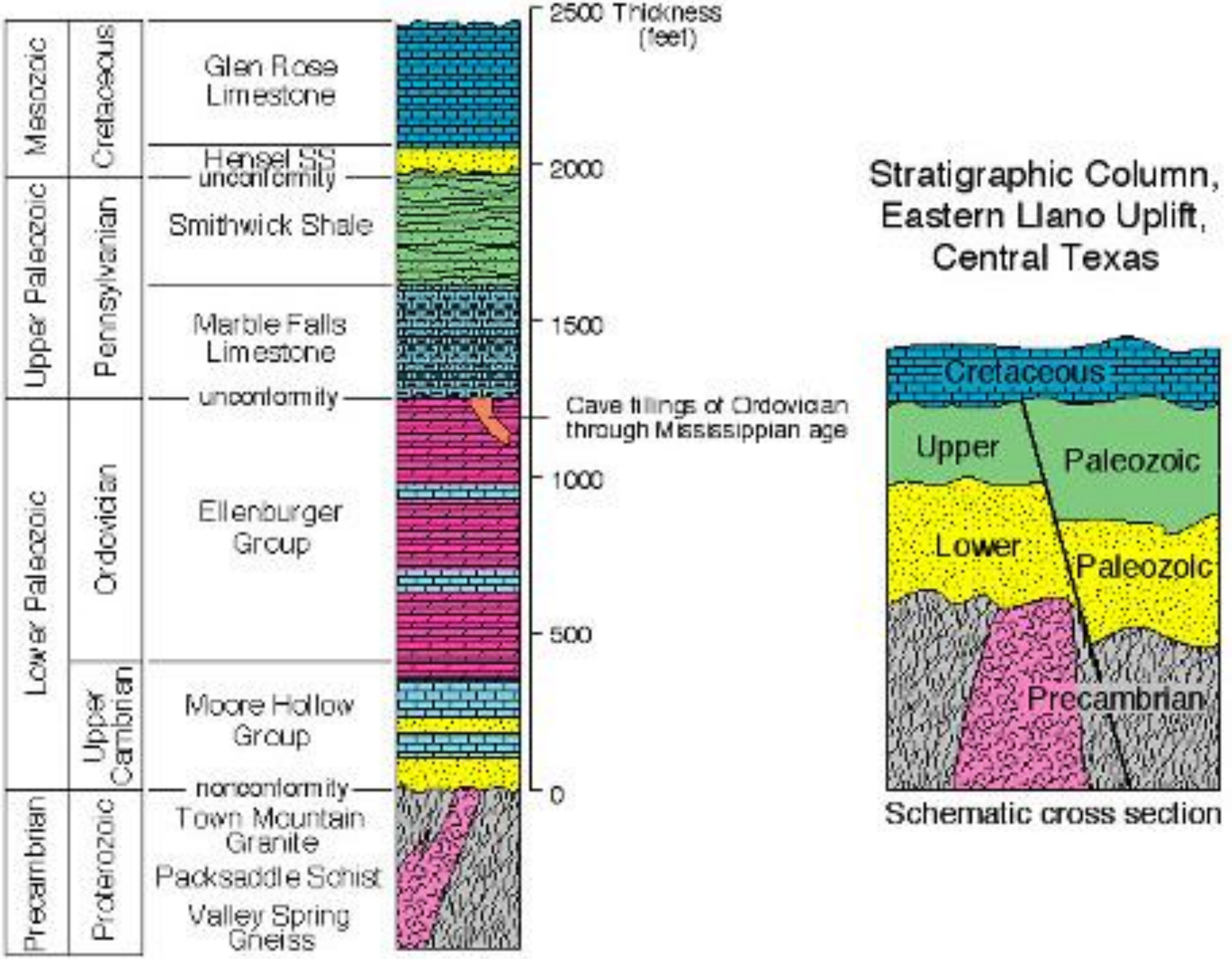
Several geologic principles are fundamental to using the rock record to interpret processes.

Original Horizontality: Most rocks that form at the Earth's surface are deposited in essentially horizontal layers. Therefore, when layered rocks are not horizontal, they probably have been affected by post-depositional processes such as a tectonic event.

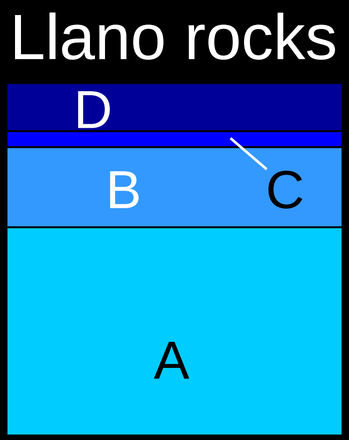
Superposition: When layered rocks are formed, they are deposited in an orderly sequence with the oldest being at the base of the sequence and the strata becoming progressively younger upward. Therefore when a sequence of rocks differs from the predicted sequence, or layers are missing, then an explanation for the cause of these differences is required.

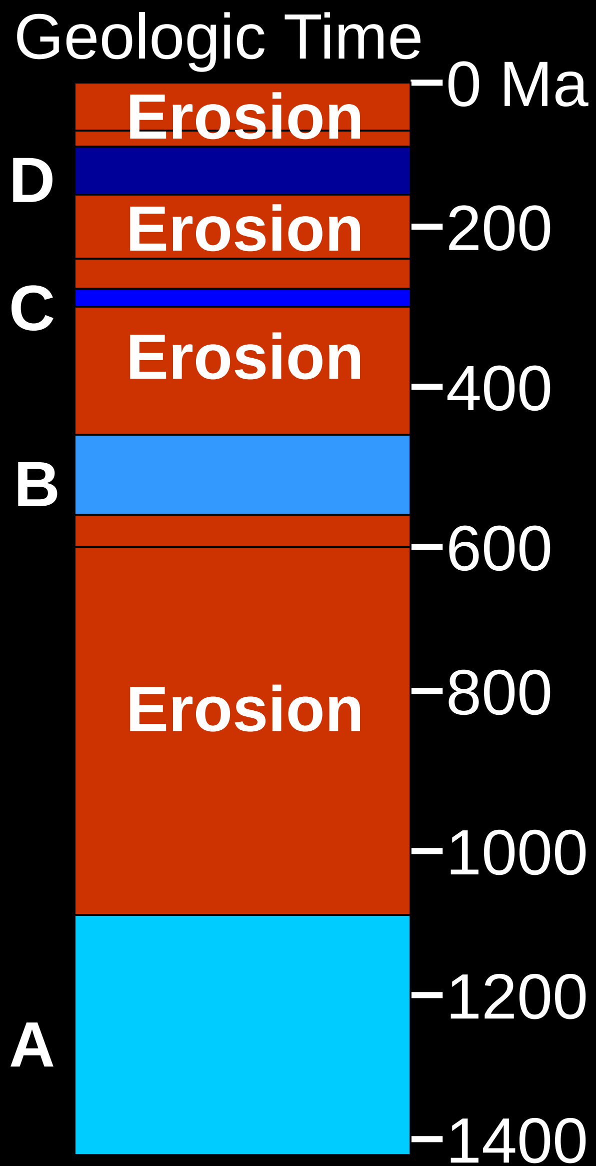
Cross-cutting Relationships: Features such as faults or igneous intrusions generally cross-cut or affect all rocks that were present locally at the time of the faulting or intrusive event.

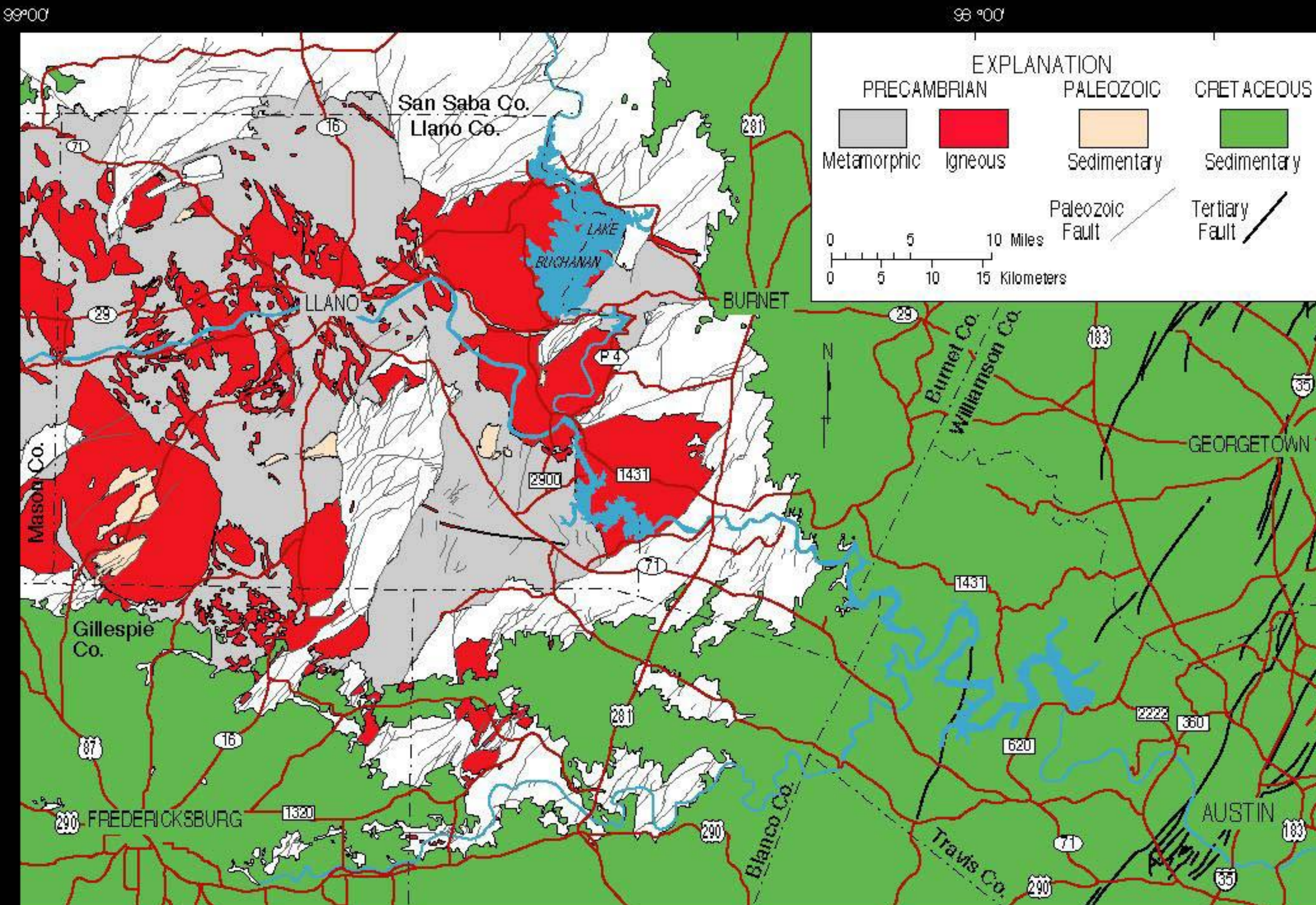
Uniformitarianism: Present Earth processes are useful in understanding the types and rates of processes that have affected the Earth during past periods of geologic history



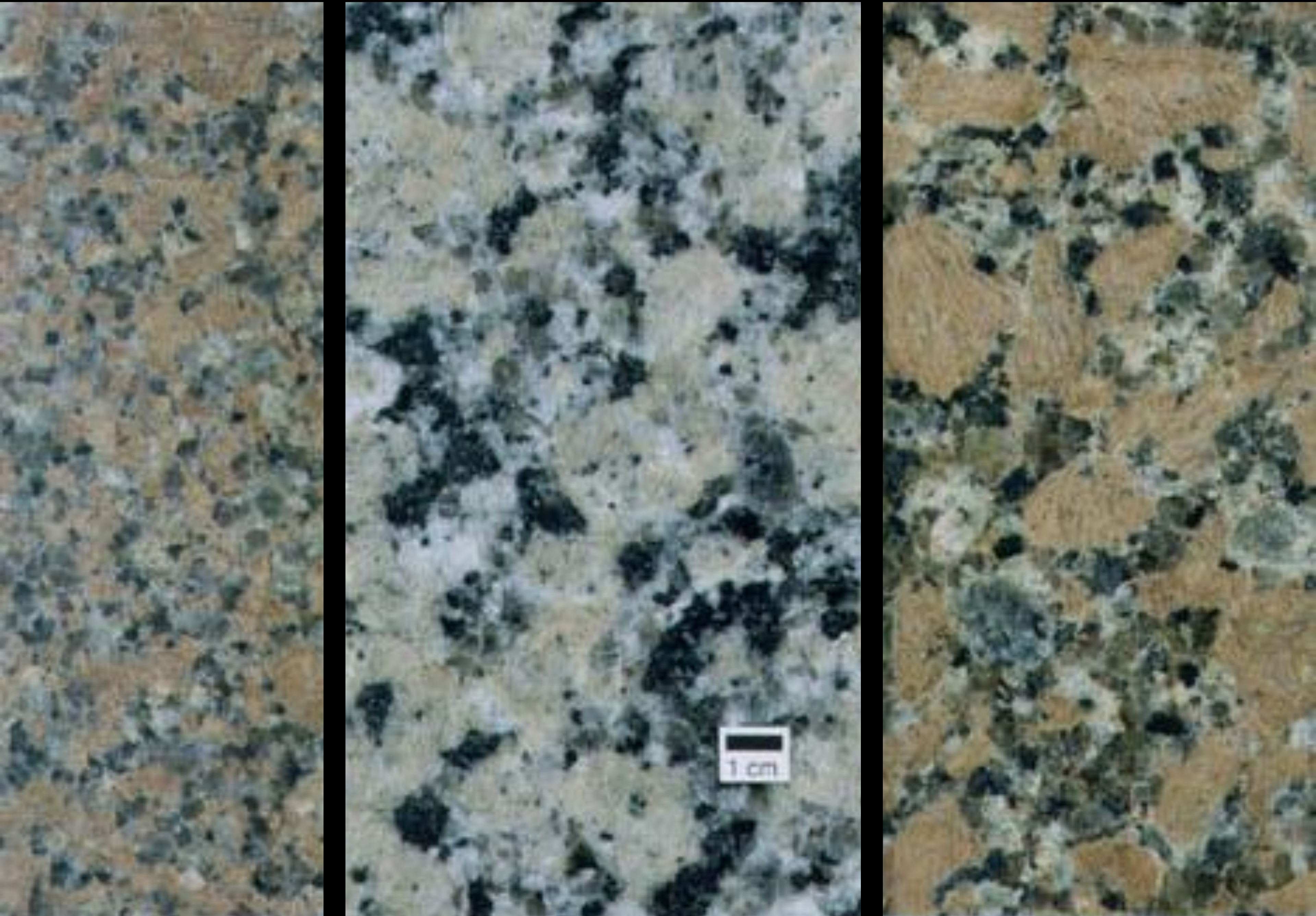
Stratigraphic Column, Eastern Llano Uplift, Central Texas
2500 Thickness (feet)
2000
1500
1000
500
0
Mesozoic
Cretaceous
Glen Rose Limestone
Hensel SS
unconformity
Upper Paleozoic
Pennsylvanian
Smithwick Shale
Marble Falls Limestone
unconformity
Cave fillings of Ordovician through Mississippian age
Lower Paleozoic
Ordovician
Ellenburger Group
Upper Cambrian
Moore Hollow Group
nonconformity
Precambrian
Proterozoic
Town Mountain Granite
Packsaddle Schist
Valley Spring Gneiss
Cretaceous
Upper
Paleozoic
Lower
Paleozoic
Precambrian
Schematic cross section

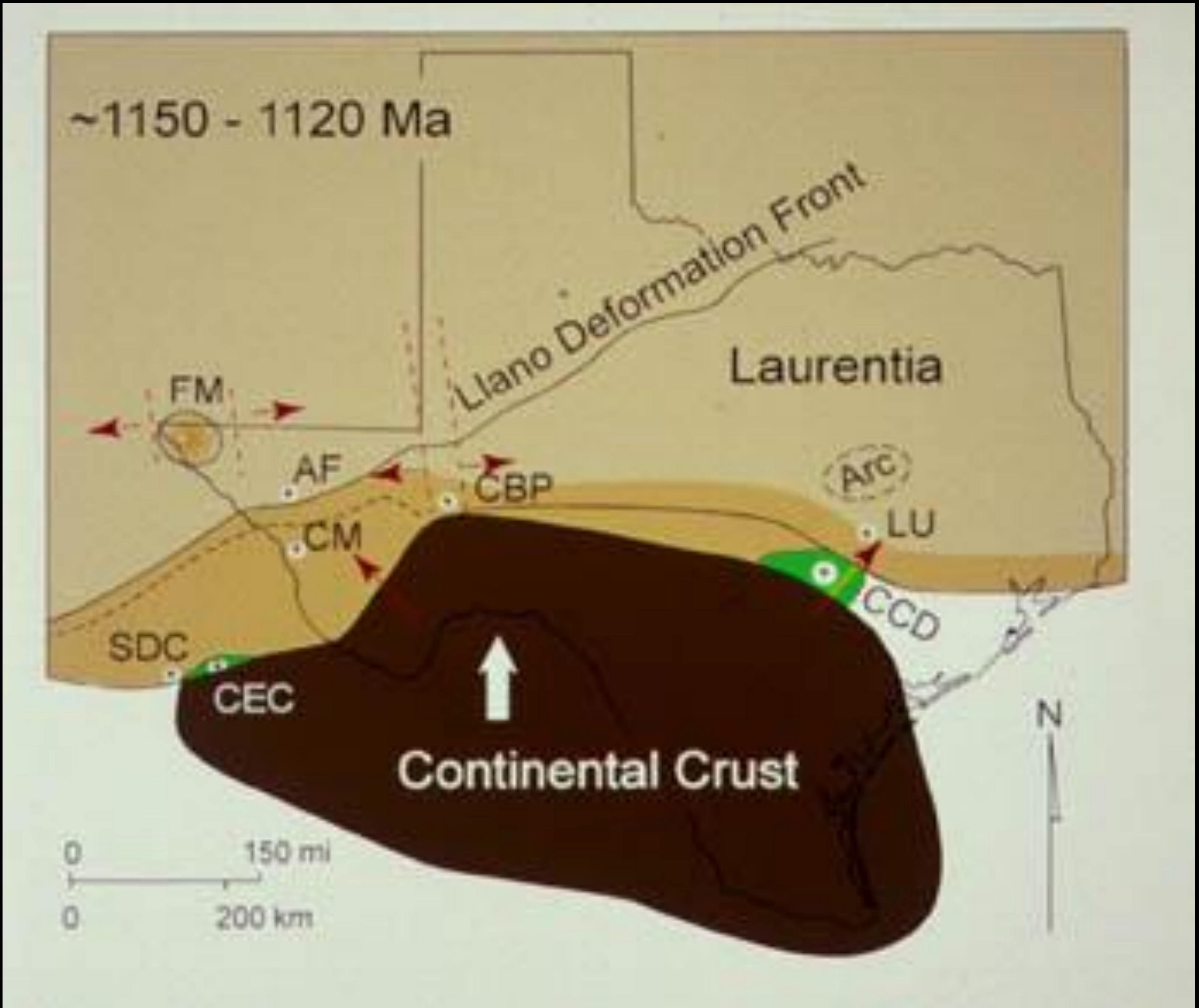

Llano rocks
D
C
B
A


Geologic Time
0 Ma
200
400
600
800
1000
1200
1400
Erosion
D
Erosion
C
Erosion
B
Erosion
A


99°00'
98 °00'
EXPLANATION
PRECAMBRIAN
PALEOZOIC
CRETACEOUS
Metamorphic
Igneous
Sedimentary
Sedimentary
Paleozoic Fault
Tertiary Fault
0 5 10 Miles
0 5 10 15 Kilometers
N
San Saba Co.
Llano Co.
Mason Co.
Gillespie Co.
Burnet Co.
Williamson Co.
Blanco Co.
Travis Co.
LAKE BUCHANAN
LLANO
BURNET
GEORGETOWN
FREDERICKSBURG
AUSTIN
16
71
29
281
183
35
P 4
2900
1431
1320
2222
360
620
87
290

Intrusive dike crosscutting folded metamorphic rocks.


1 cm


~1150 - 1120 Ma
Llano Deformation Front
Laurentia
FM
AF
CBP
Arc
LU
CM
CCD
SDC
CEC
Continental Crust
N
0
150 mi
0
200 km

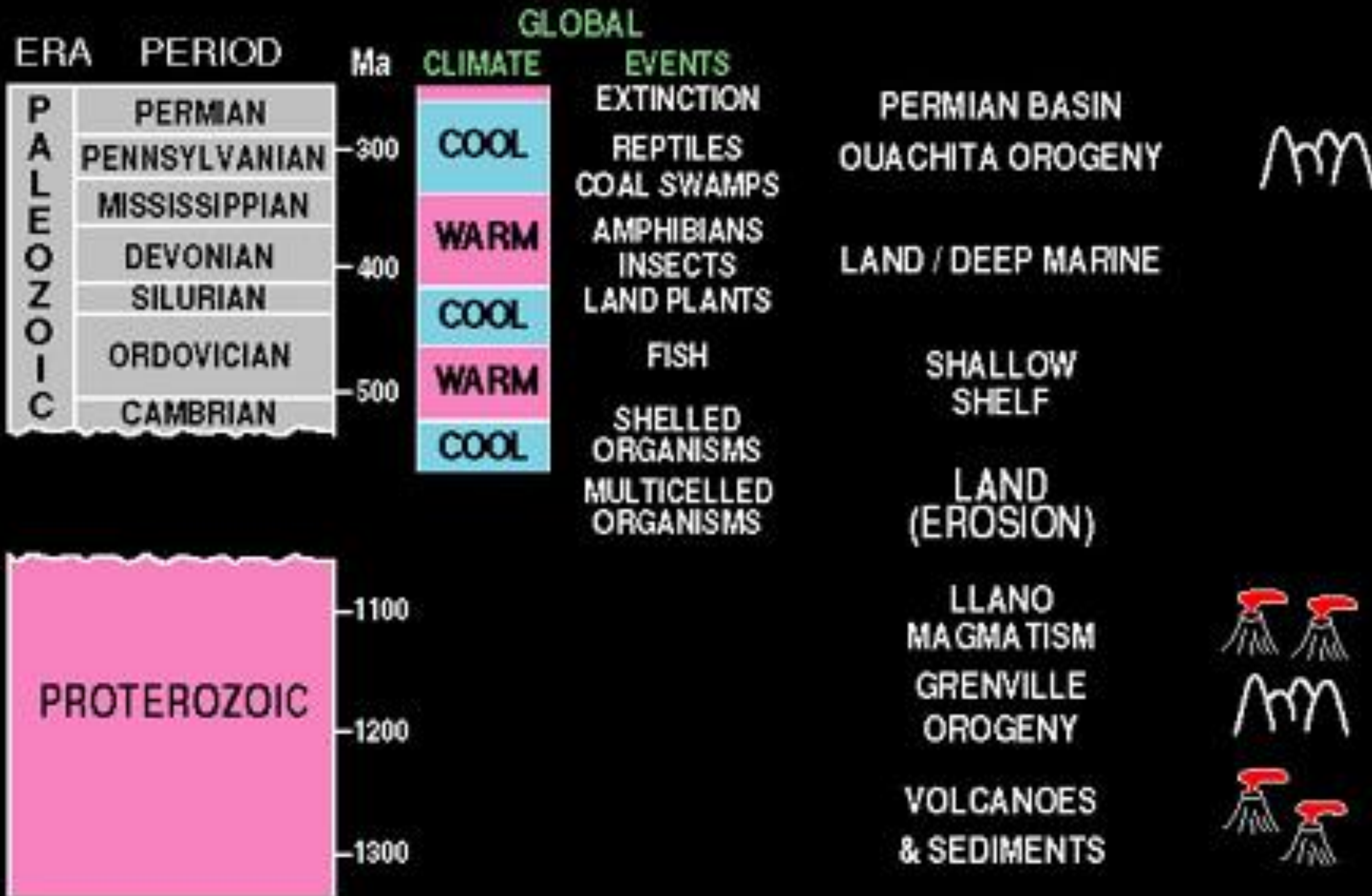

Tibet Plateau
Himalayas
India

RODINIA SUPERCONTINENT

EARLY NEOPROTEROZOIC,
1000-750 million years
Earliest development of macroscopic life

UTIG PLATES Project

TEXAS PROTEROZOIC – PALEOZOIC HISTORY



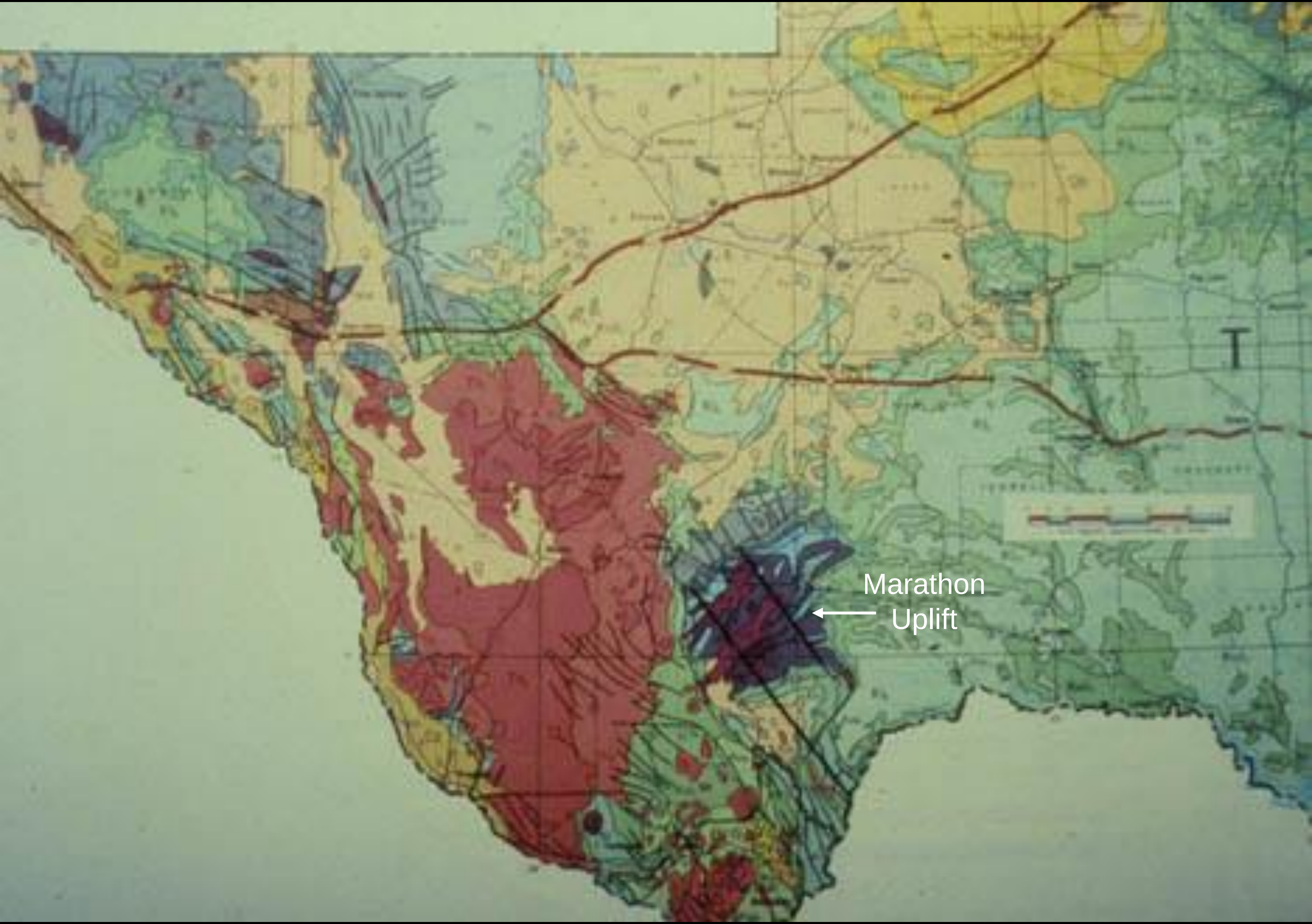

Tree Covered Island
Bird

PANNOTIA SUPERCONTINENT

END PRECAMBRIAN, 545 million years

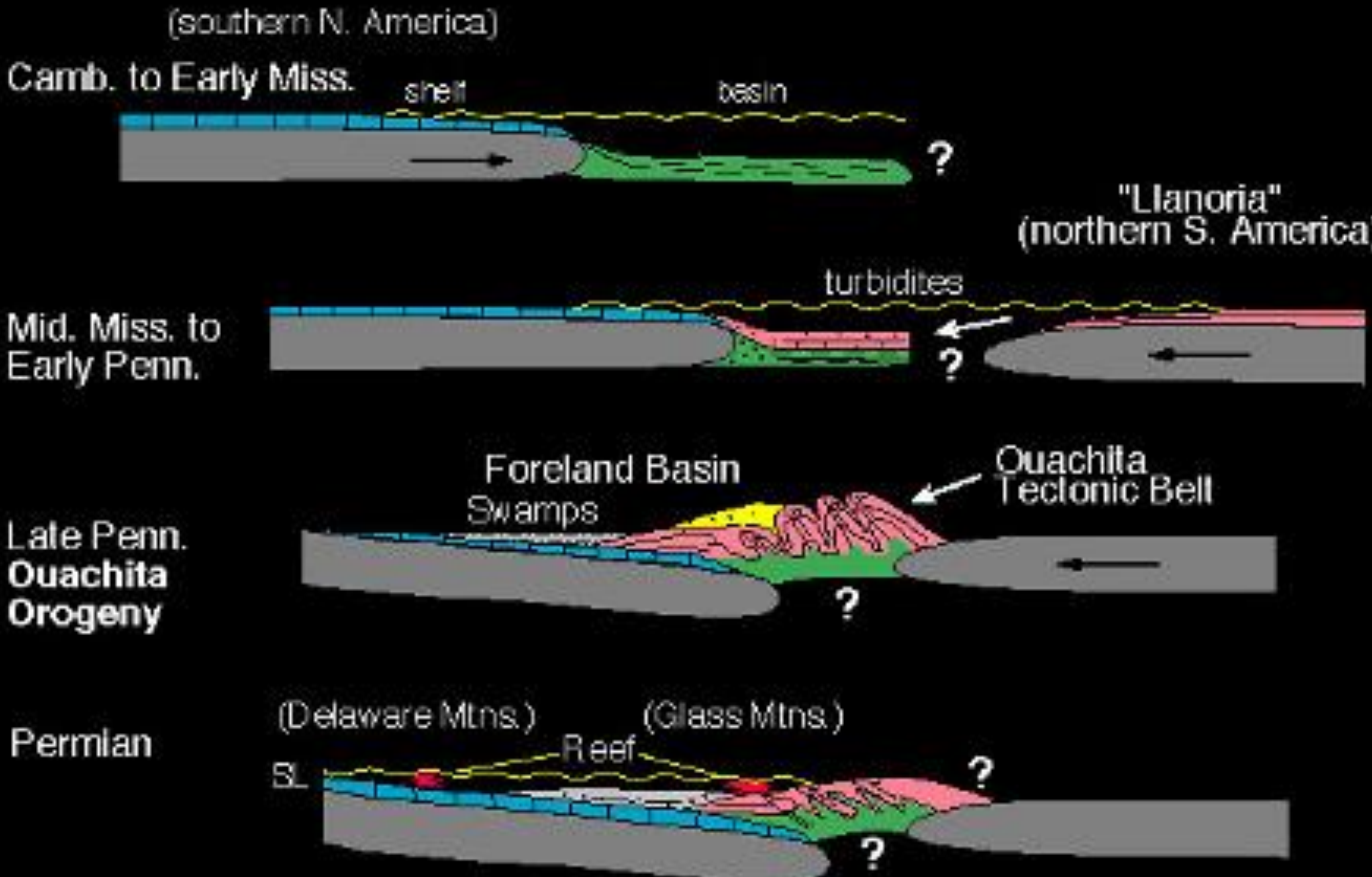
Cambrian "explosion" of macroscopic life

UTIG PLATES Project


Marathon
Uplift


Flat-lying Cretaceous Limestones
Dip direction
Haymond Formation

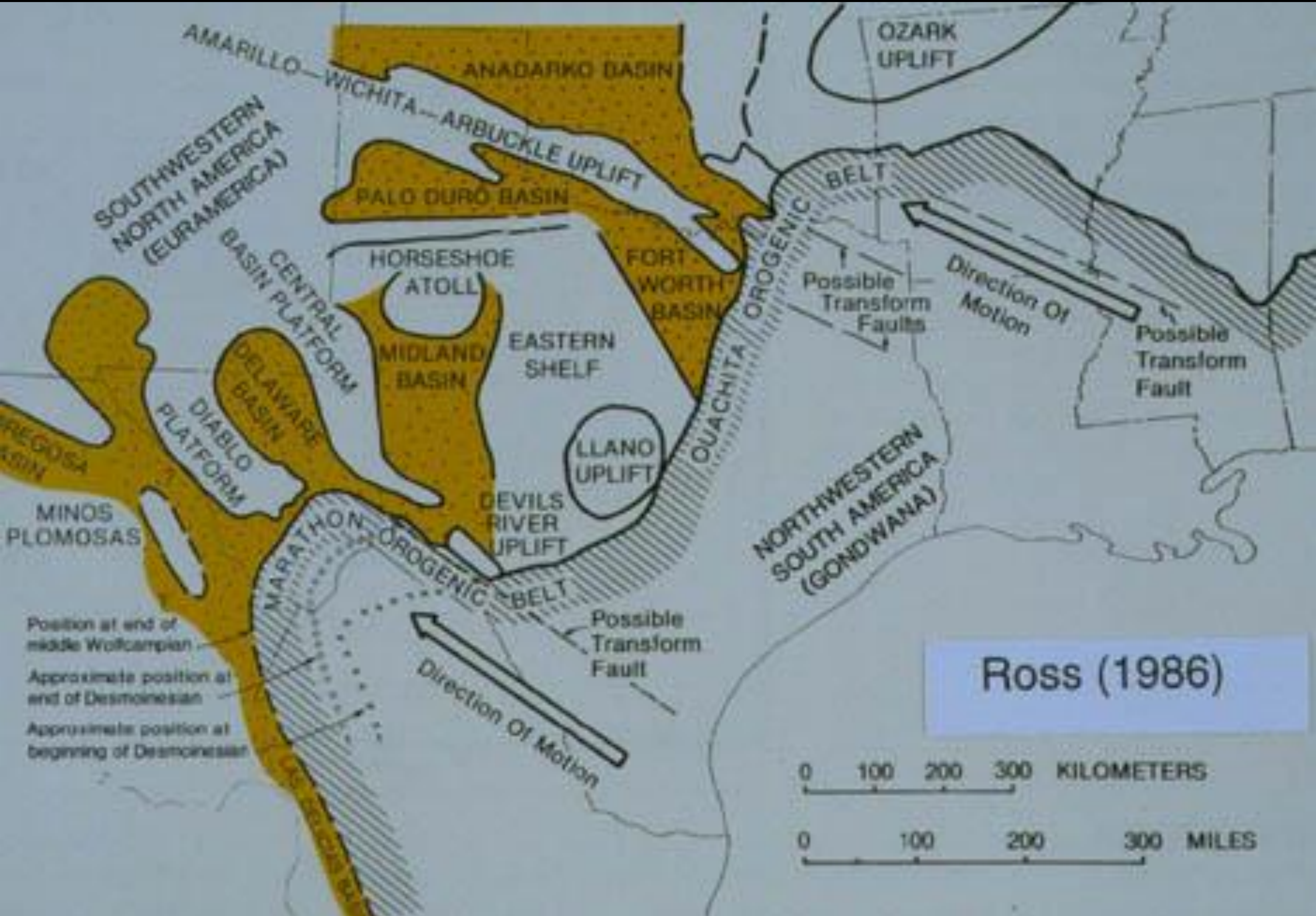
PALEOZOIC HISTORY OF THE MARATHON REGION



OUACHITA-APPALACHIAN OROGENY

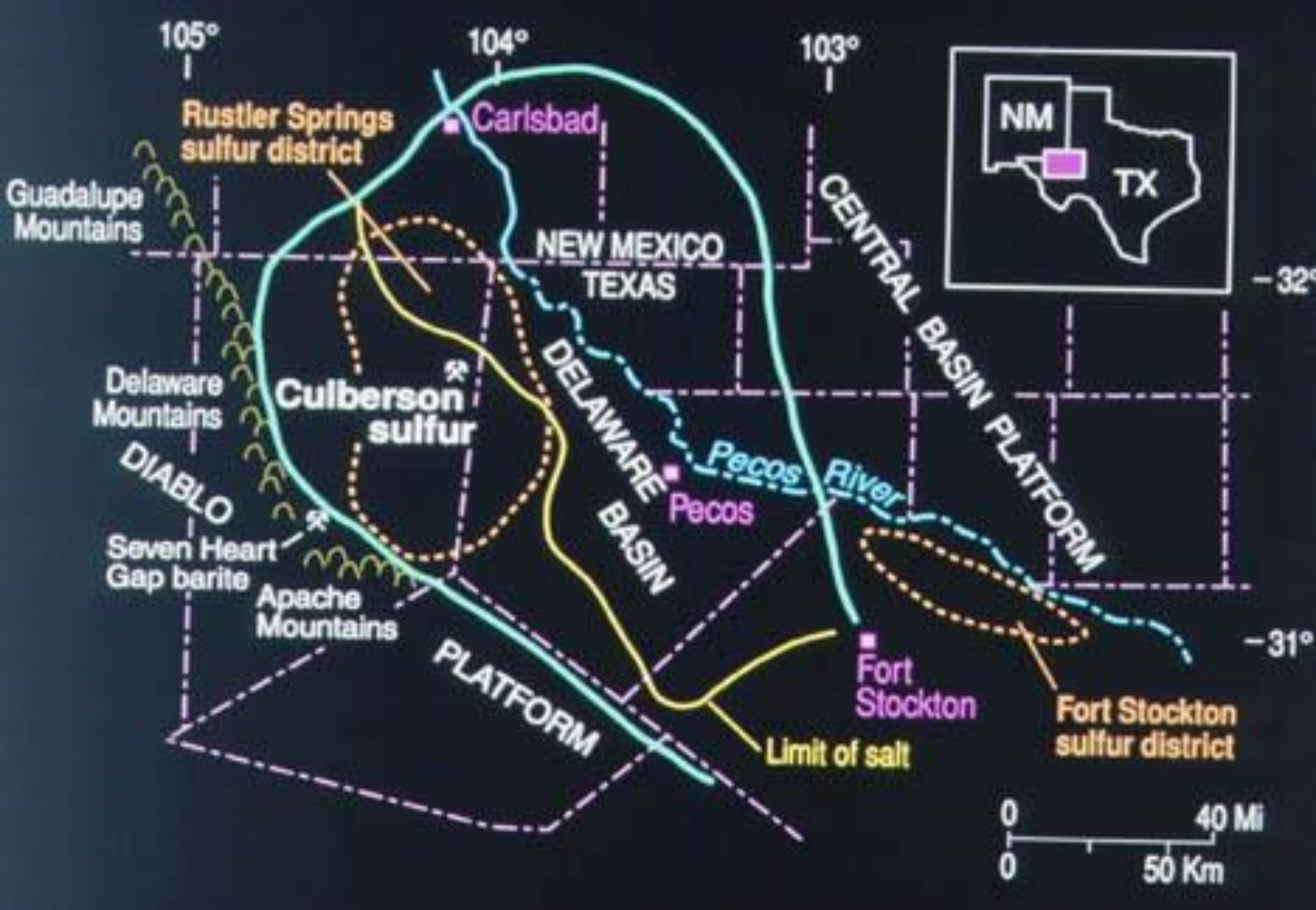
Early Pennsylvanian
320 million years

UTIG PLATES Project

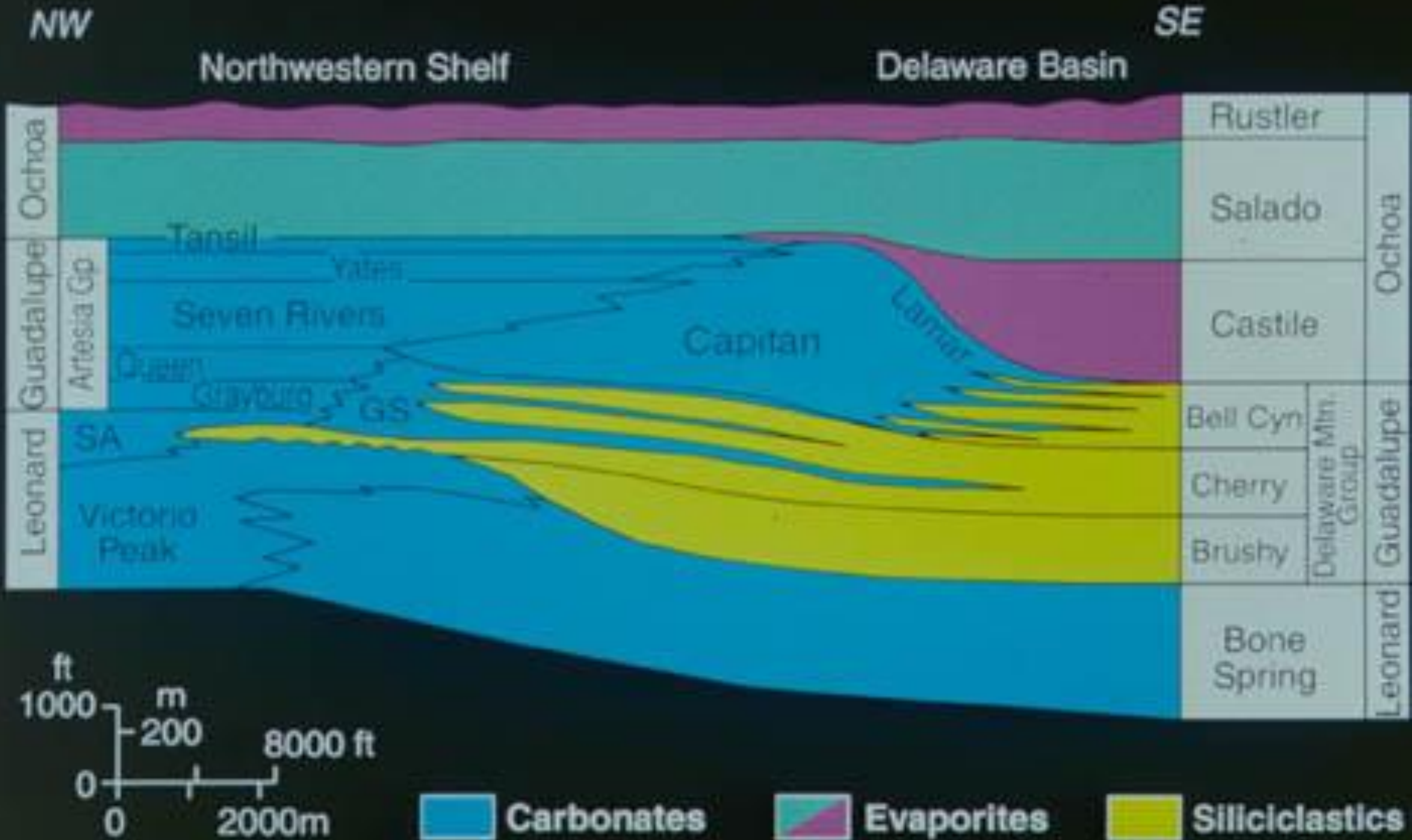


AMARILLO—WICHITA—ARBUCKLE UPLIFT
ANADARKO BASIN
OZARK UPLIFT
SOUTHWESTERN NORTH AMERICA (EURAMERICA)
PALO DURO BASIN
CENTRAL BASIN PLATFORM
HORSESHOE ATOLL
FORT WORTH BASIN
MIDLAND BASIN
EASTERN SHELF
DELAWARE BASIN
DIABLO PLATFORM
LLANO UPLIFT
OUACHITA OROGENIC BELT
Possible Transform Faults
Direction Of Motion
Possible Transform Fault
MINOS PLOMOSAS
DEVILS RIVER UPLIFT
MARATHON OROGENIC BELT
NORTHWESTERN SOUTH AMERICA (GONDWANA)
Possible Transform Fault
Direction Of Motion
Position at end of middle Wolfcampian
Approximate position at end of Desmoinesian
Approximate position at beginning of Desmoinesian
0 100 200 300 KILOMETERS
0 100 200 300 MILES

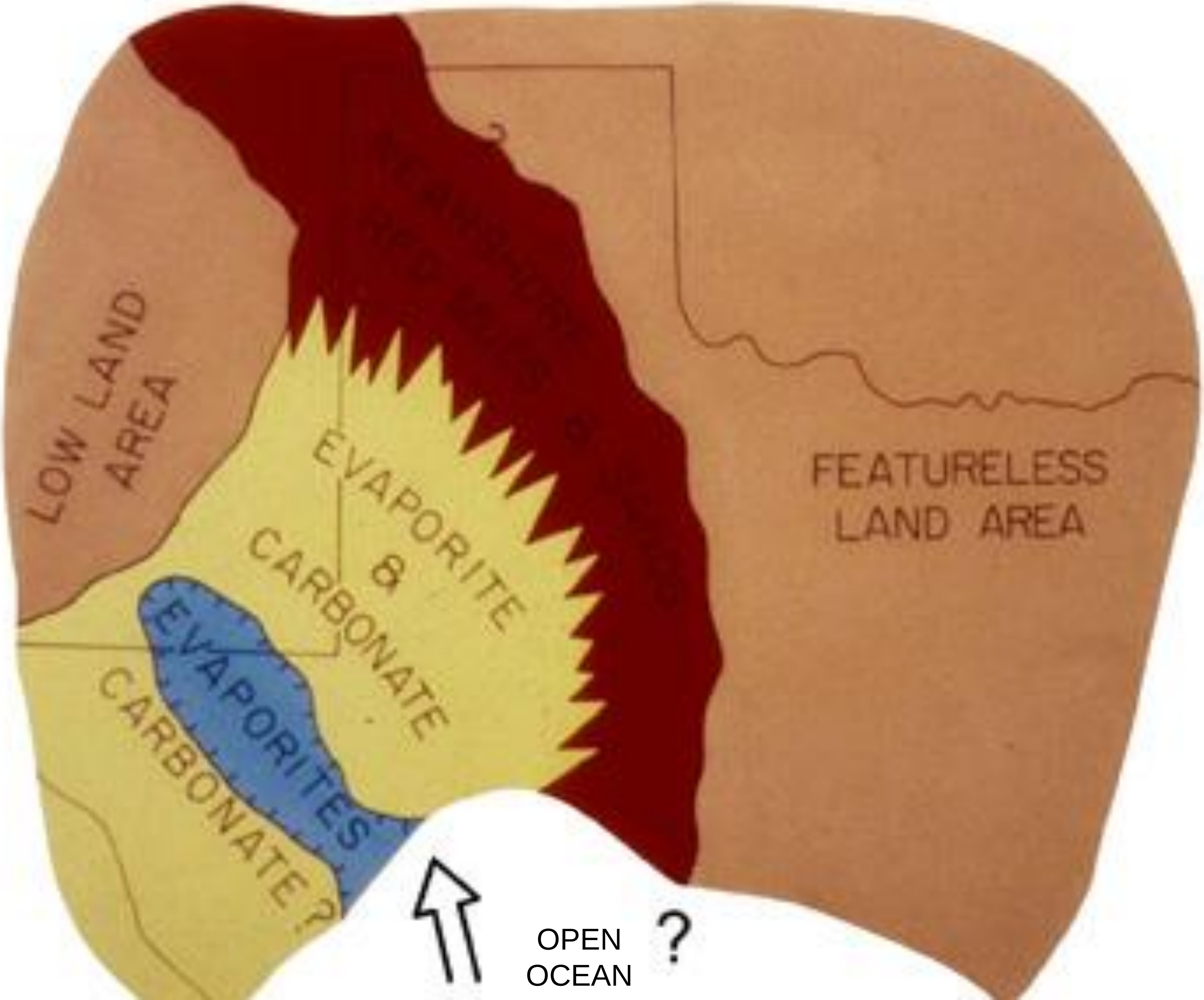
Ross (1986)

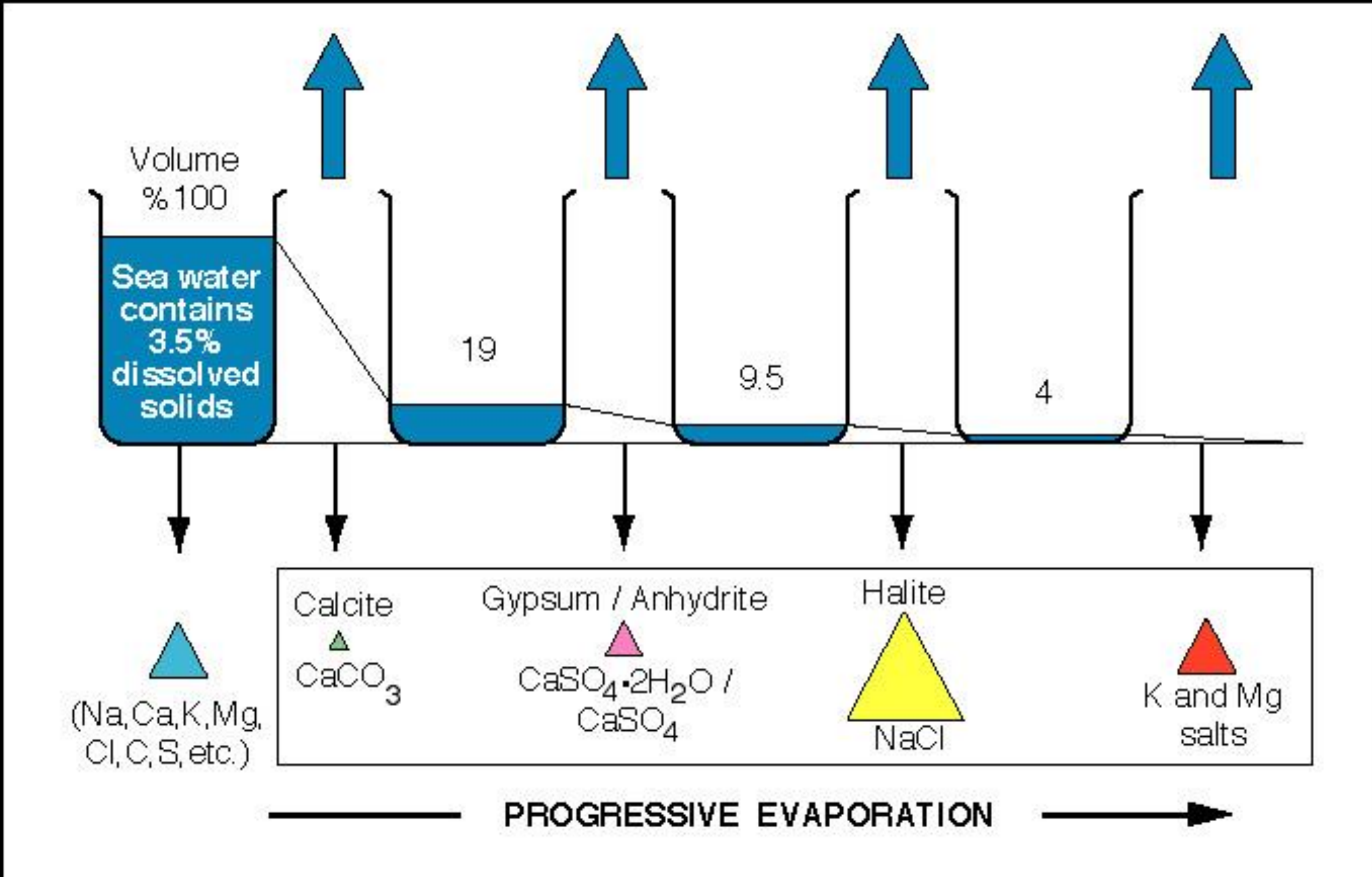


105°
104°
103°
-32°
-31°
Rustler Springs sulfur district
Carlsbad
Guadalupe Mountains
NEW MEXICO
TEXAS
CENTRAL BASIN PLATFORM
NM
TX
Delaware Mountains
Culberson sulfur
DELAWARE BASIN
DIABLO
Pecos
Pecos River
Seven Heart Gap barite
Apache Mountains
PLATFORM
Fort Stockton
Limit of salt
Fort Stockton sulfur district
0
40 Mi
0
50 Km

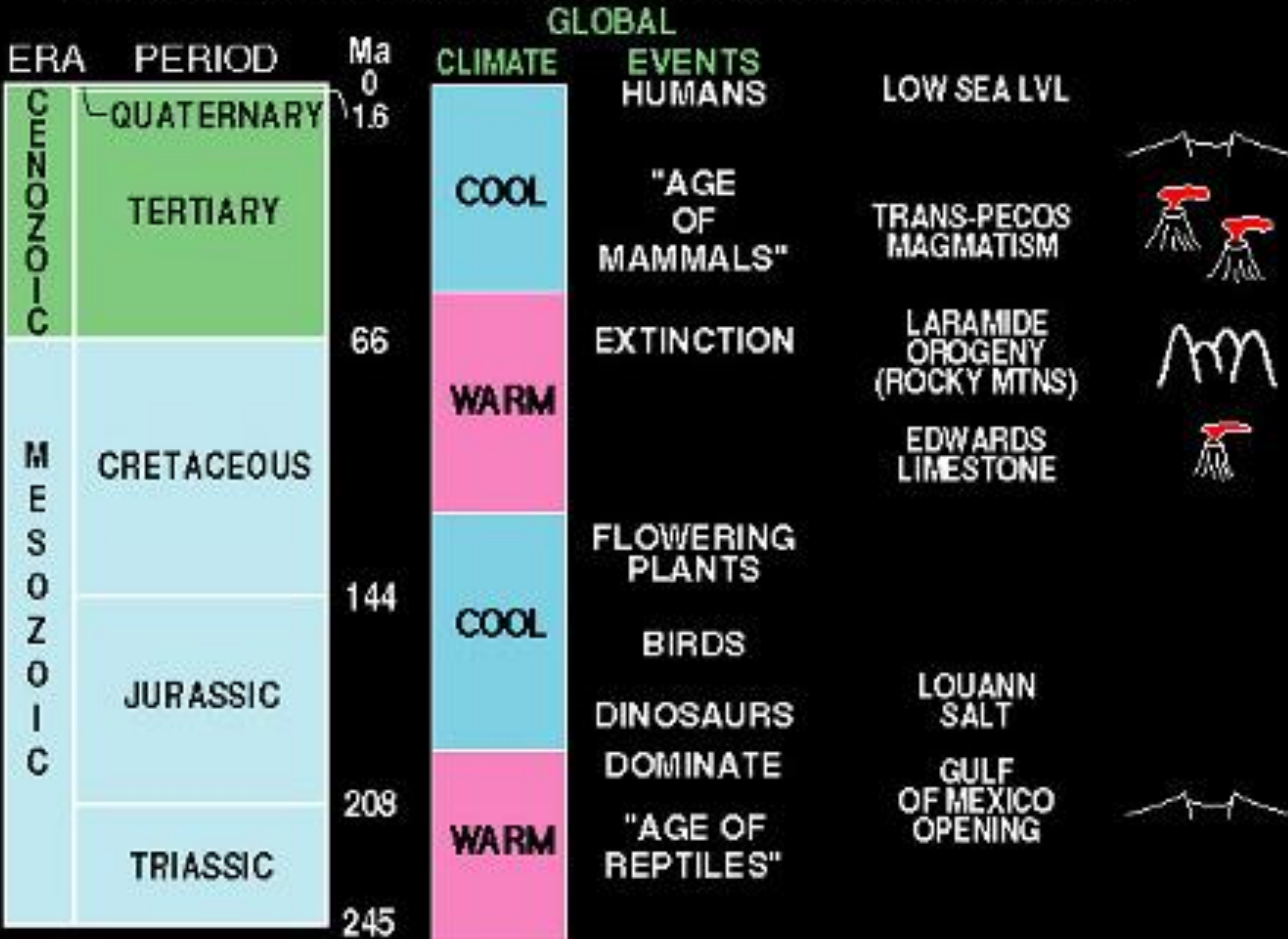

NW
SE
Northwestern Shelf
Delaware Basin
Ochoa
Guadalupe
Leonard
Artesia Gp
Tansil
Yates
Seven Rivers
Queen
Grayburg
GS
SA
Victorio Peak
Capitan
Lamar
Rustler
Salado
Castile
Bell Cyn
Cherry
Brushy
Delaware Mtn. Group
Bone Spring
Ochoa
Guadalupe
Leonard
ft
1000
m
200
8000 ft
0
0
2000m
Carbonates
Evaporites
Siliciclastics

LATE PERMIAN PALEOGEOGRPHY




Volume
%100
Sea water contains 3.5% dissolved solids
19
9.5
4
(Na,Ca,K,Mg, Cl,C,S,etc.)
Calcite
CaCO3
Gypsum / Anhydrite
CaSO4•2H2O / CaSO4
Halite
NaCl
K and Mg salts
PROGRESSIVE EVAPORATION

TEXAS MESOZOIC AND CENOZOIC HISTORY

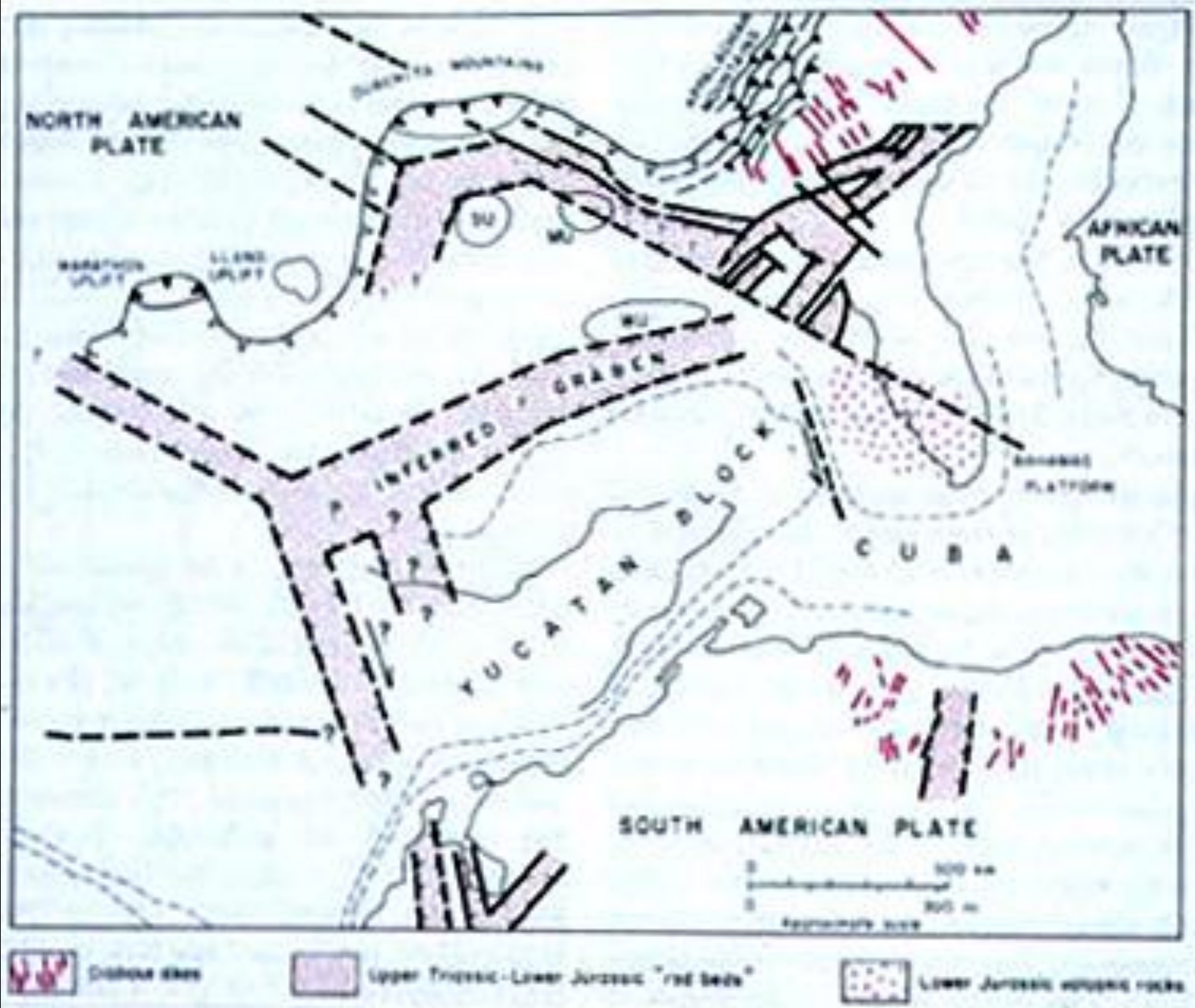


PANGEA SUPERCONTINENT

Triassic, 200 million years

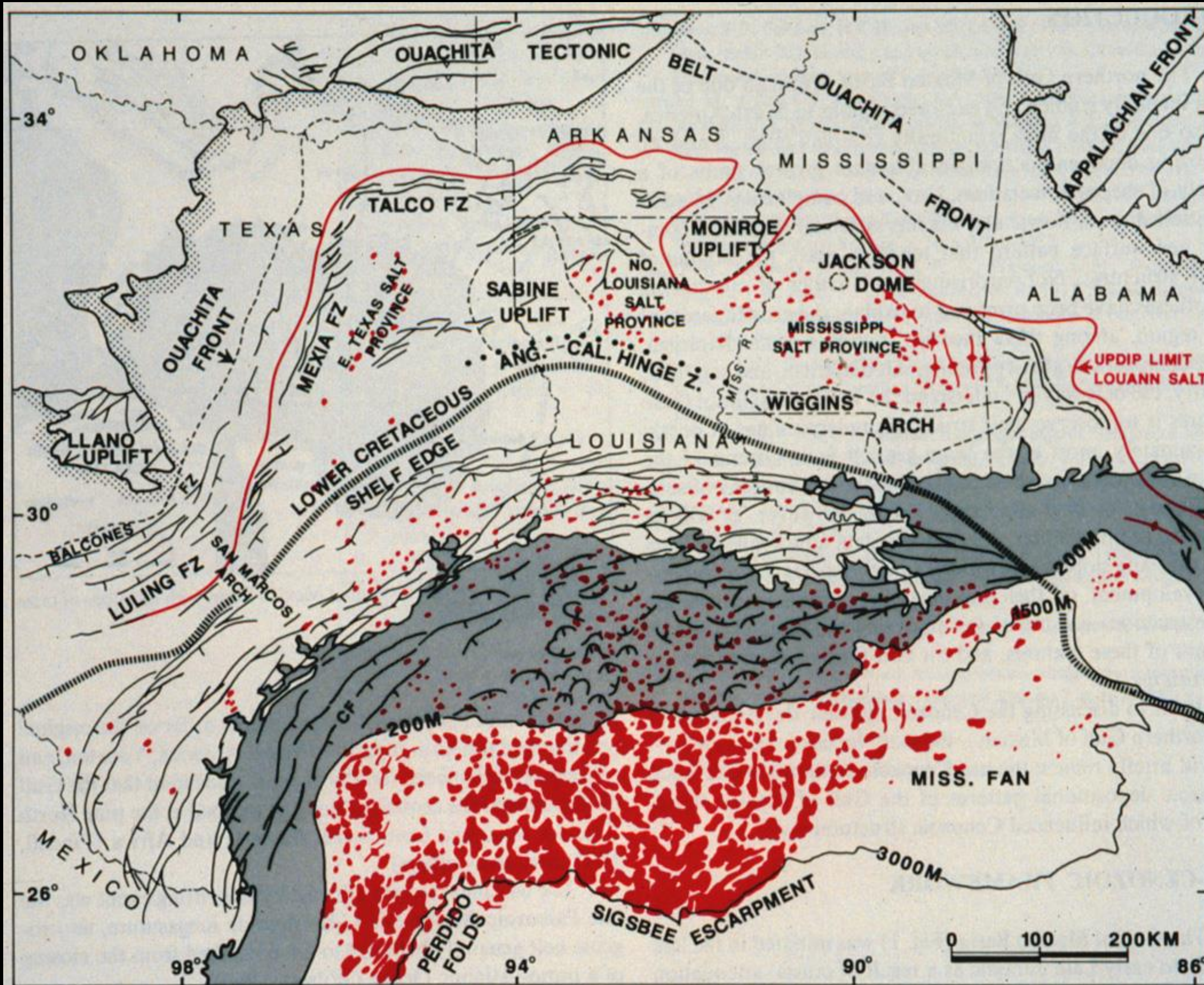
Earliest dinosaurs

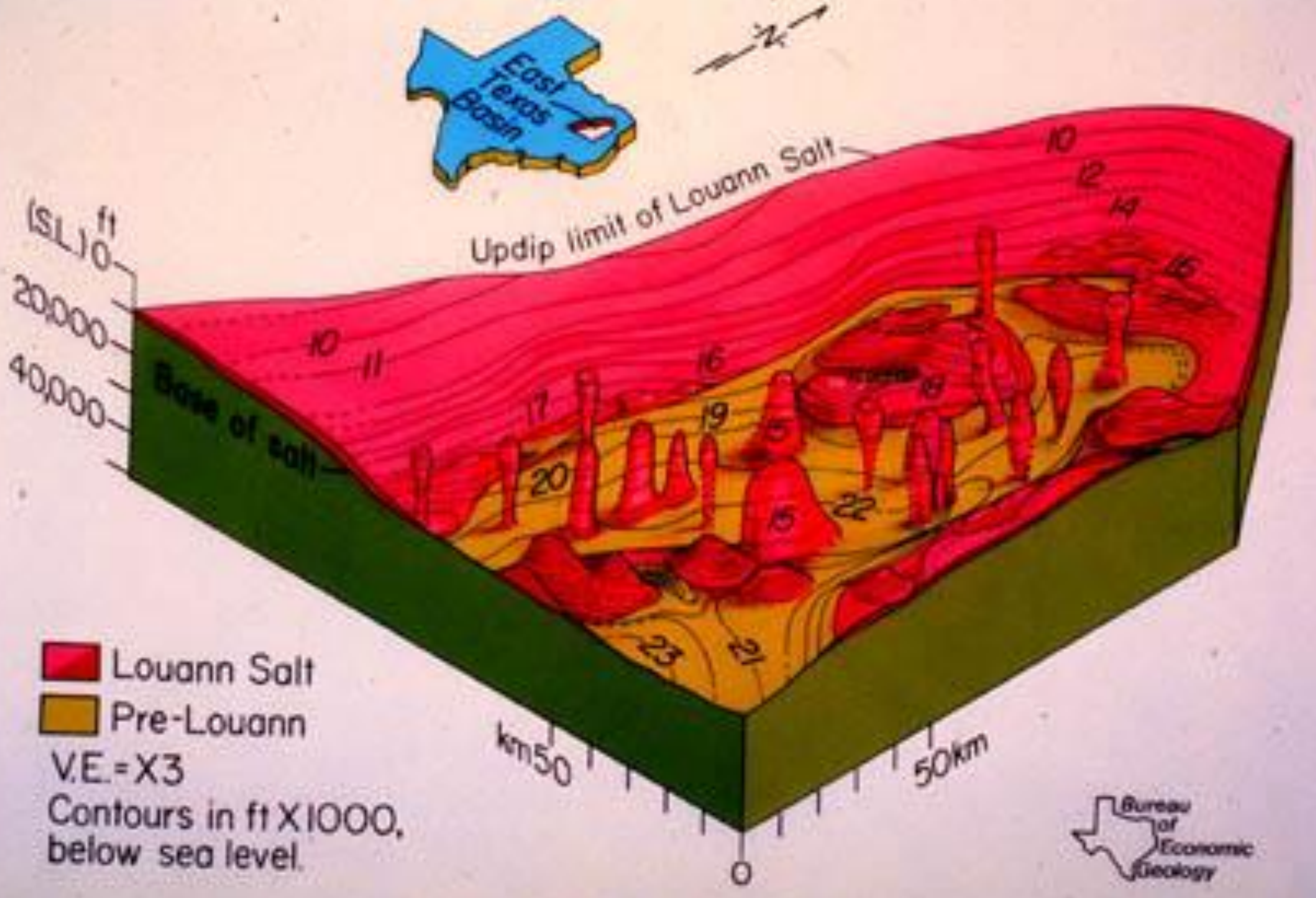
UTIG PLATES Project



NORTH AMERICAN PLATE
AFRICAN PLATE
INFERRED GRABEN
YUCATAN BLOCK
CUBA
SOUTH AMERICAN PLATE
Upper Triassic - Lower Jurassic "red beds"

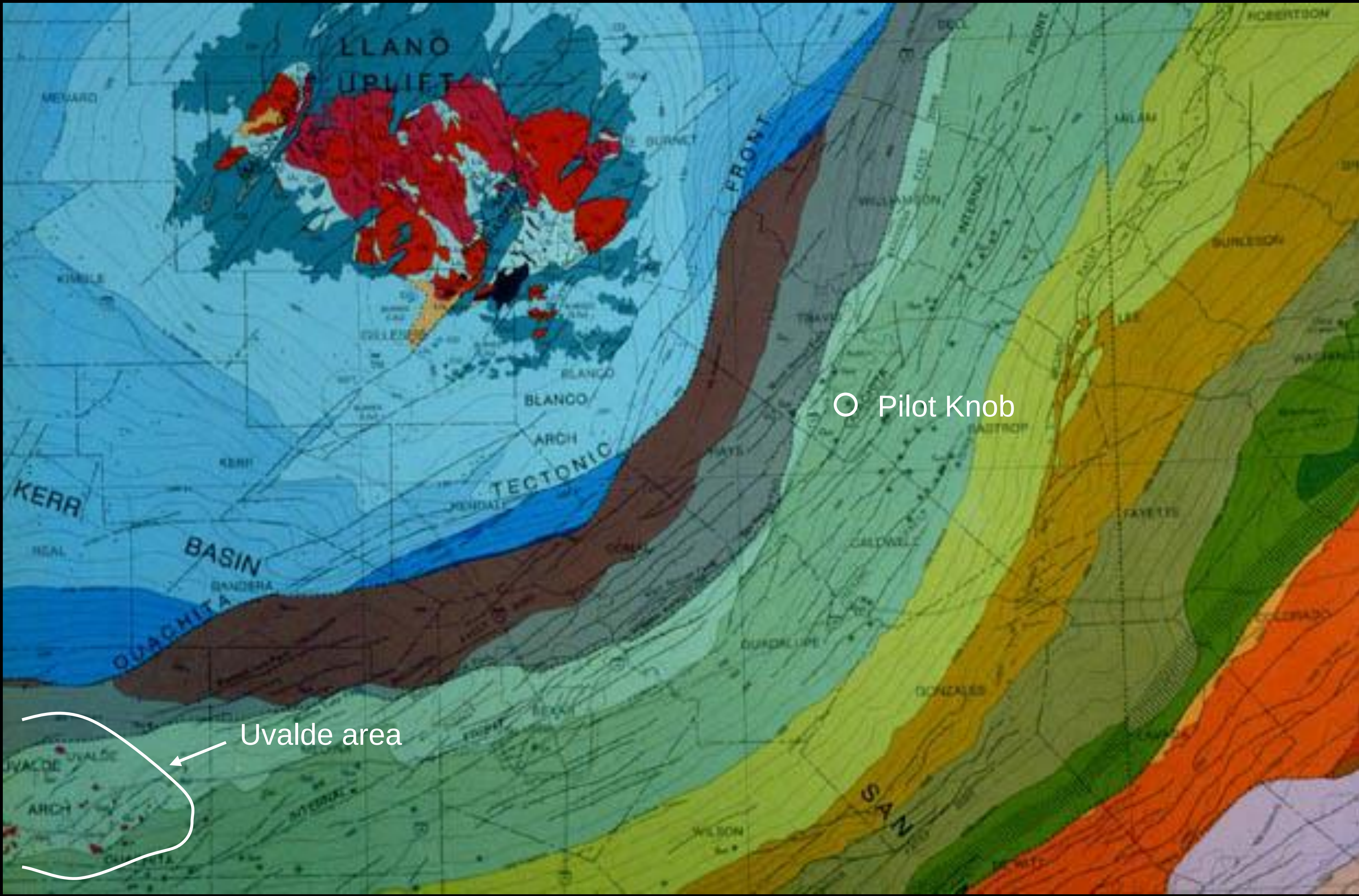

Volcano
Salt Lake
SEA LEVEL


OKLAHOMA
OUACHITA TECTONIC BELT
OUACHITA
FRONT
APPALACHIAN FRONT
ARKANSAS
MISSISSIPPI
TALCO FZ
TEXAS
MONROE UPLIFT
JACKSON DOME
ALABAMA
OUACHITA FRONT
MEXIA FZ
E. TEXAS SALT PROVINCE
SABINE UPLIFT
NO. LOUISIANA SALT PROVINCE
MISSISSIPPI SALT PROVINCE
UPDIP LIMIT LOUANN SALT
ANG. CAL. HINGE Z.
MISS. R.
WIGGINS ARCH
LOWER CRETACEOUS SHELF EDGE
LLANO UPLIFT
LOUISIANA
FZ
BALCONES
LULING FZ
SAN MARCOS ARCH
34°
30°
26°
200M
1500M
CF
200M
MISS. FAN
3000M
MEXICO
PERDIDO FOLDS
SIGSBEE ESCARPMENT
0
100
200KM
98°
94°
90°
86°

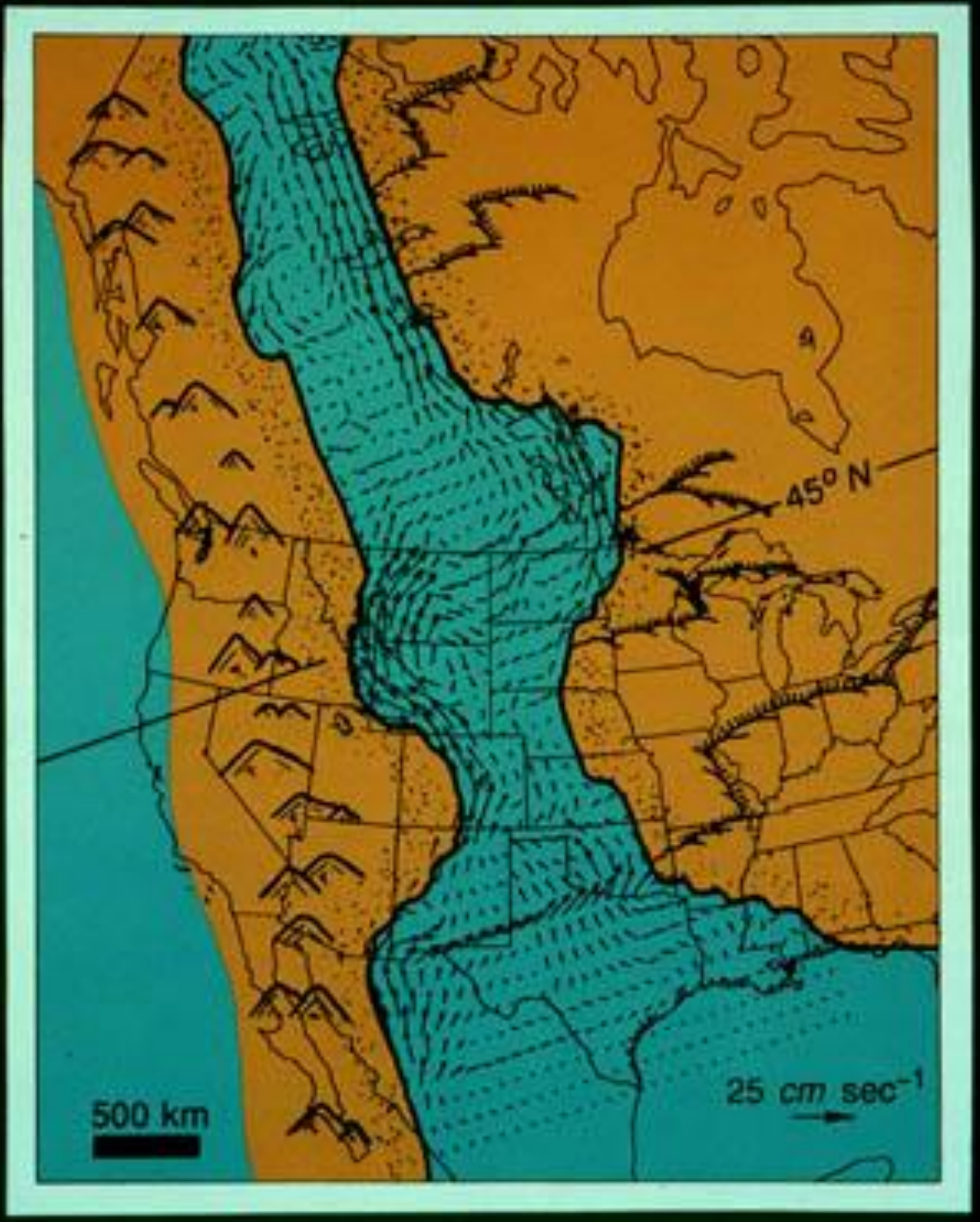


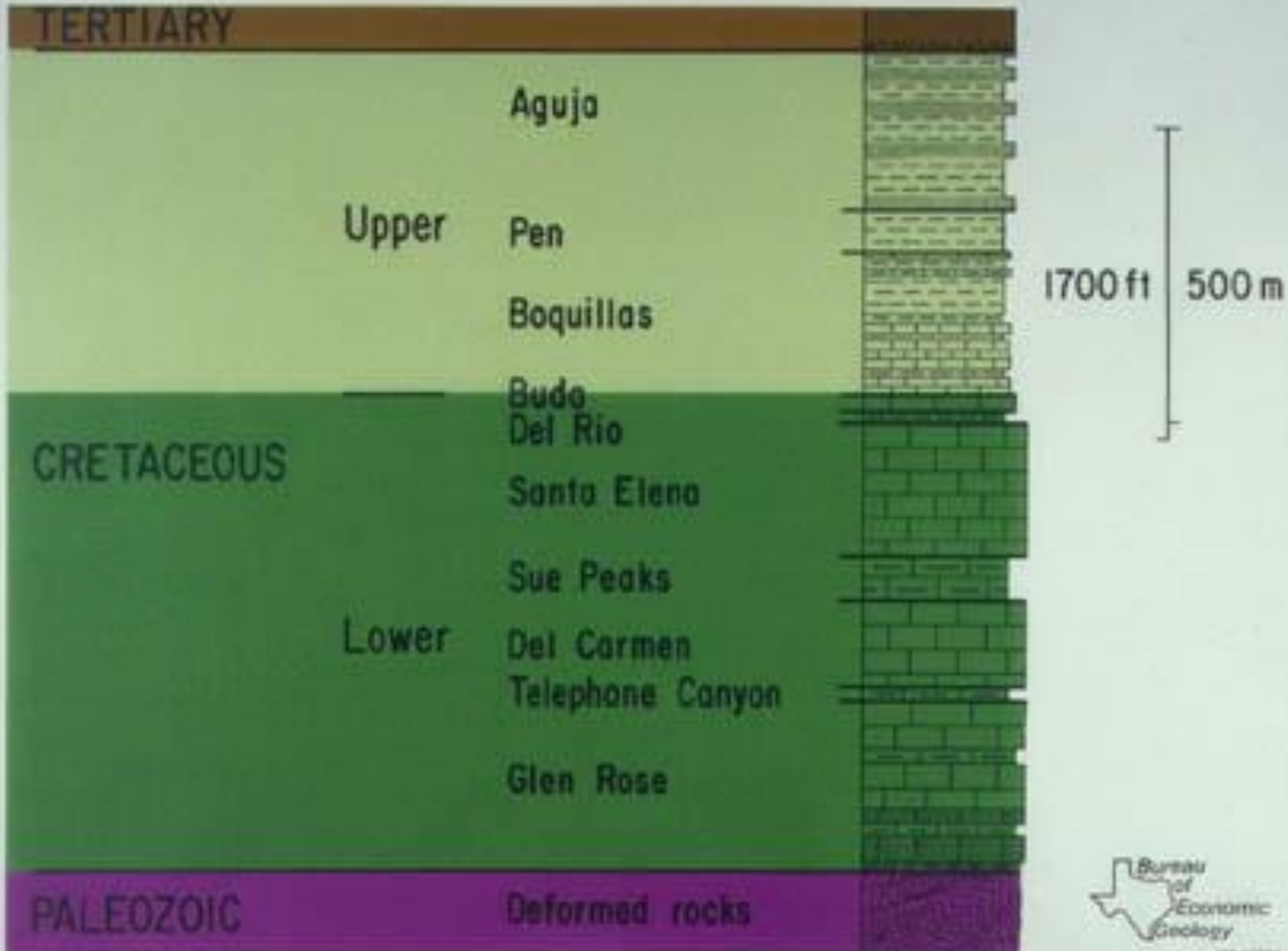
East Texas Basin
N
Updip limit of Louann Salt
(S.L.) 0 ft
20,000
40,000
Base of salt
10
11
12
14
16
17
18
19
20
21
22
23
Louann Salt
Pre-Louann
V.E. = X3
Contours in ft X 1000, below sea level.
km 50
0
50 km
Bureau of Economic Geology

CRETACEOUS
ROCKS
LOWER CRETACEOUS
UPPER CRETACEOUS



LLANO
UPLIFT
FRONT
BLANCO
ARCH
TECTONIC
KERR
BASIN
OUACHITA
Pilot Knob
Uvalde area
SAN


45° N
25 cm sec-1
500 km



Bureau of Economic Geology

MESOZOIC-CENOZOIC TECTONICS

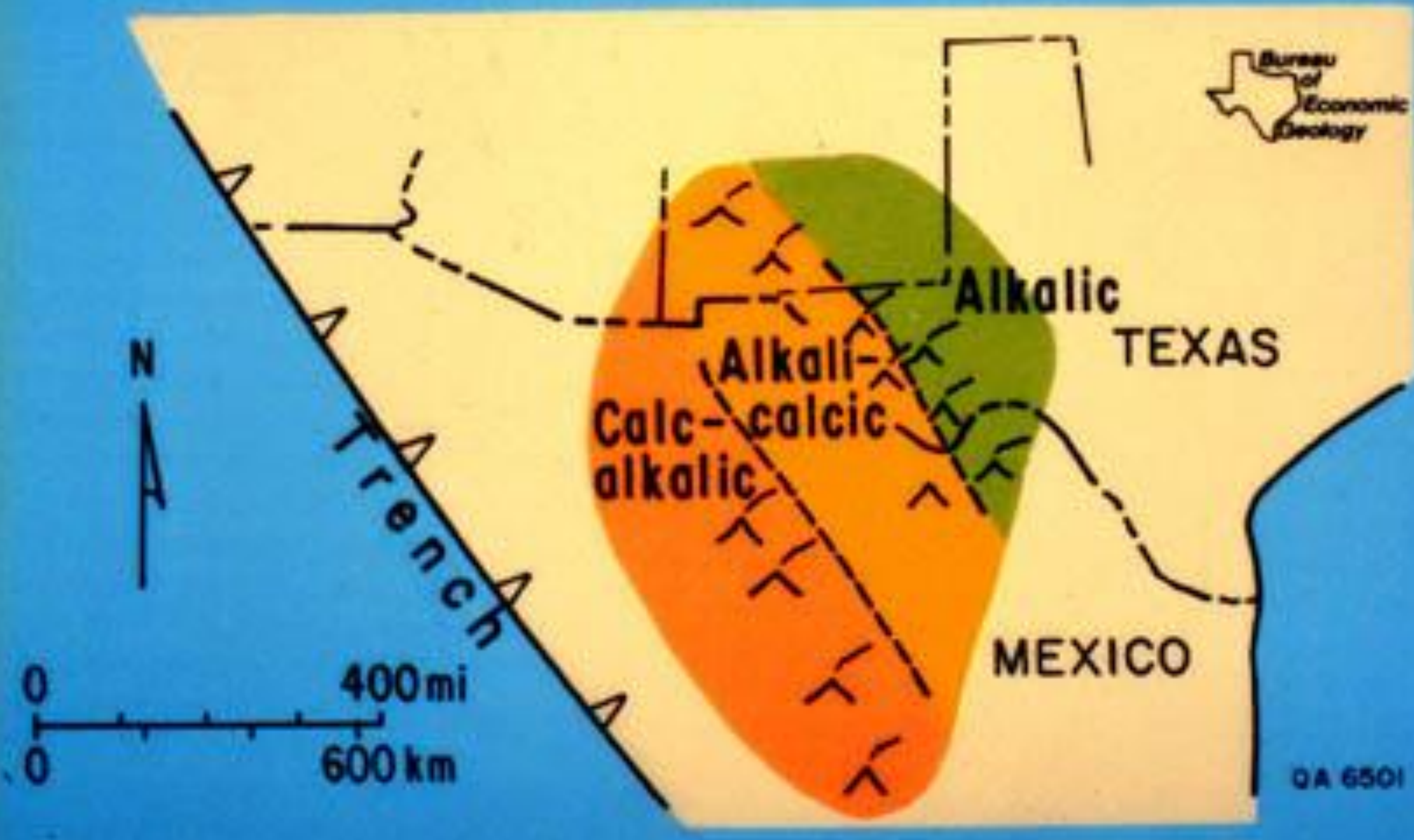
METEOR IMPACT AT CHICXULUB, YUCATAN

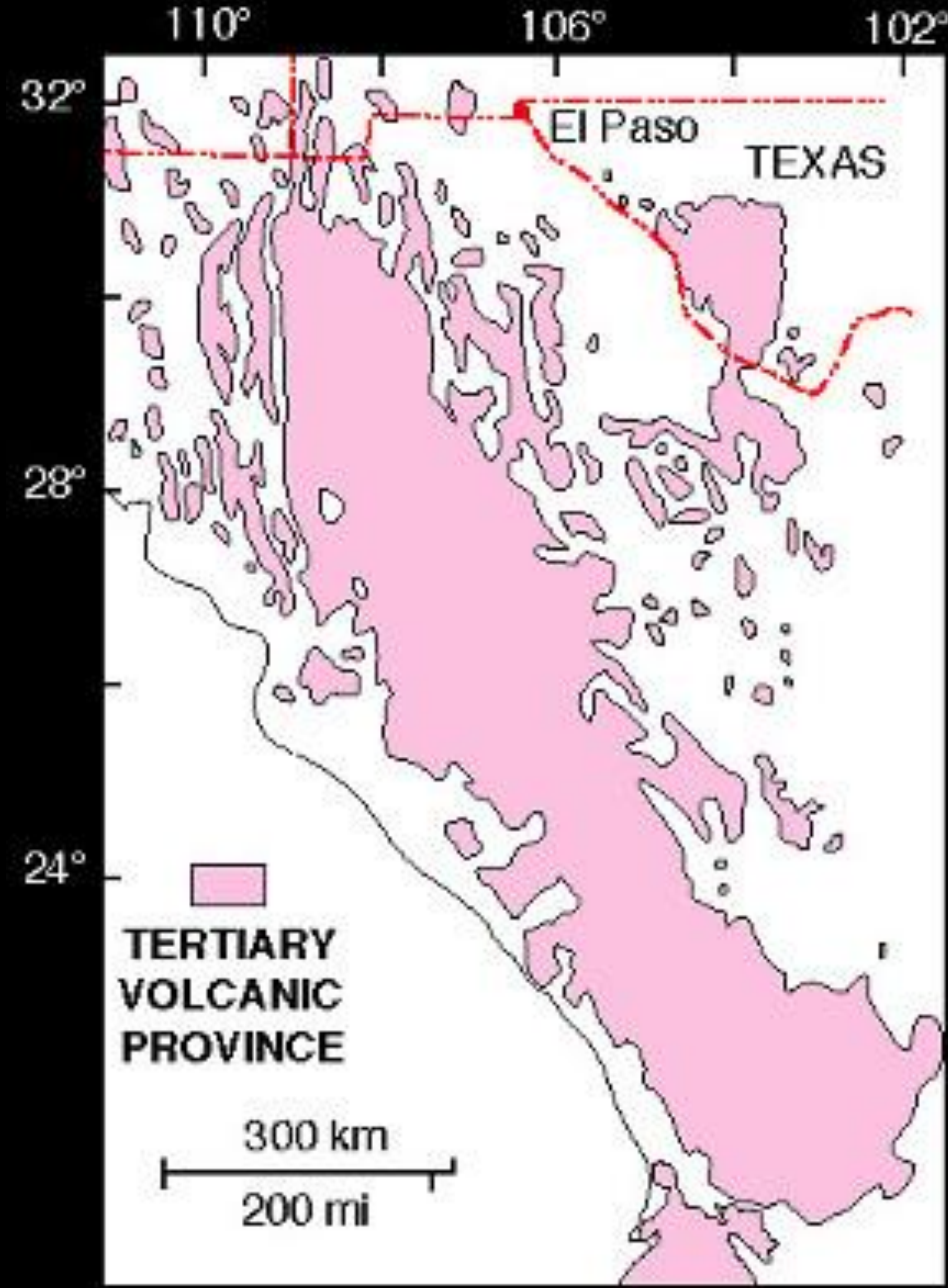
Cretaceous-Tertiary Boundary, 65 million years

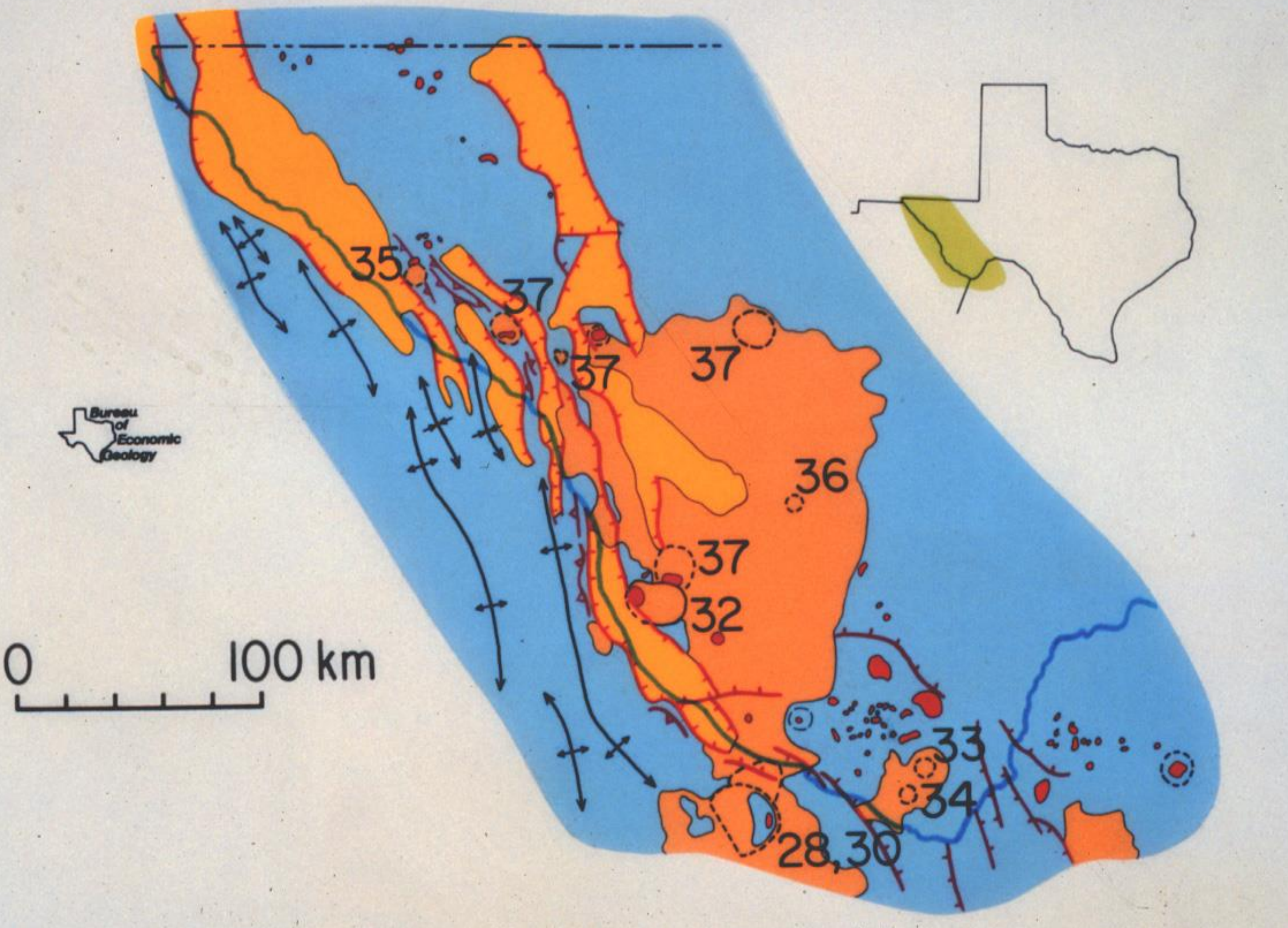
Extinction of dinosaurs

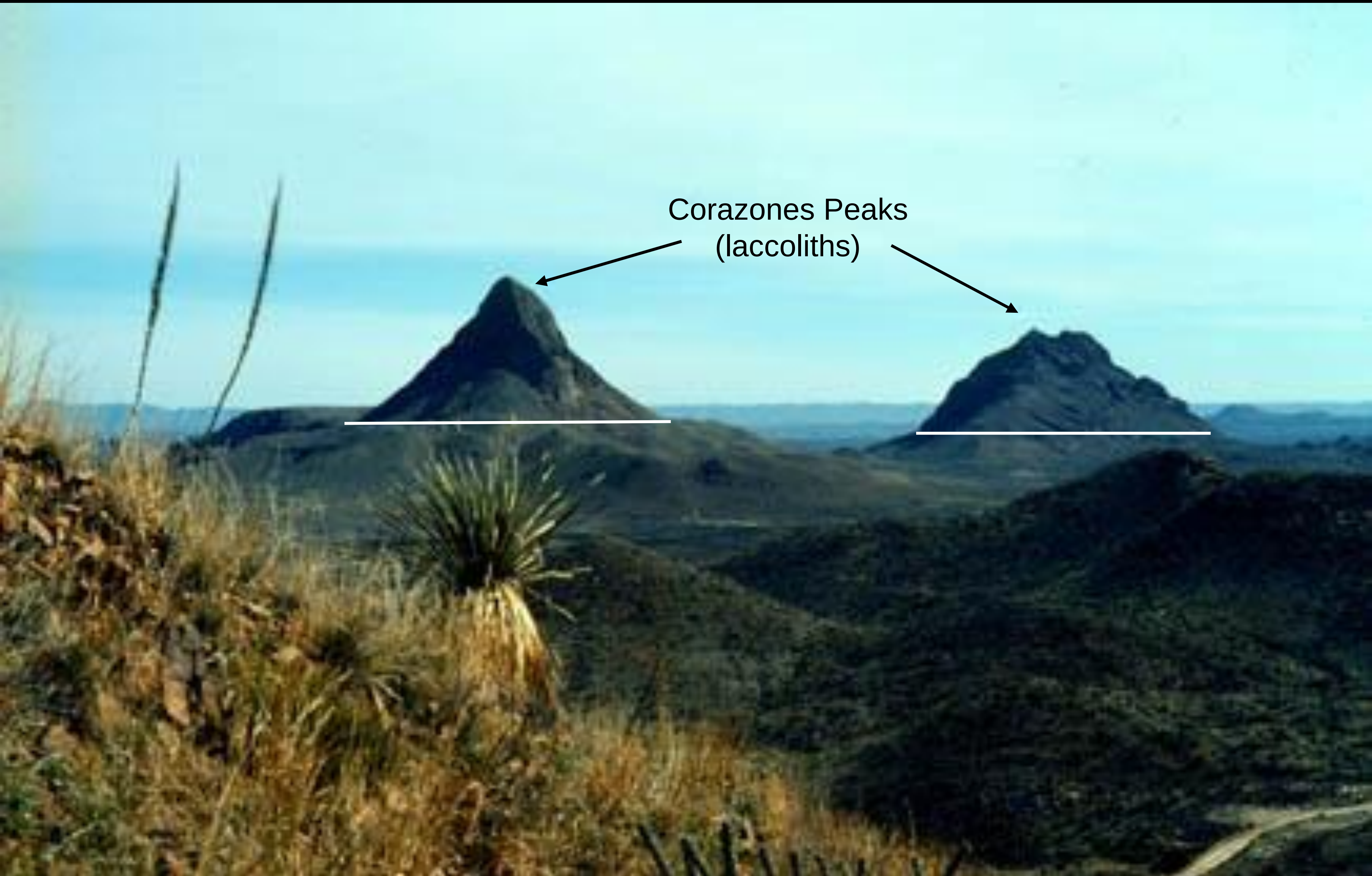
UTIG PLATES Project

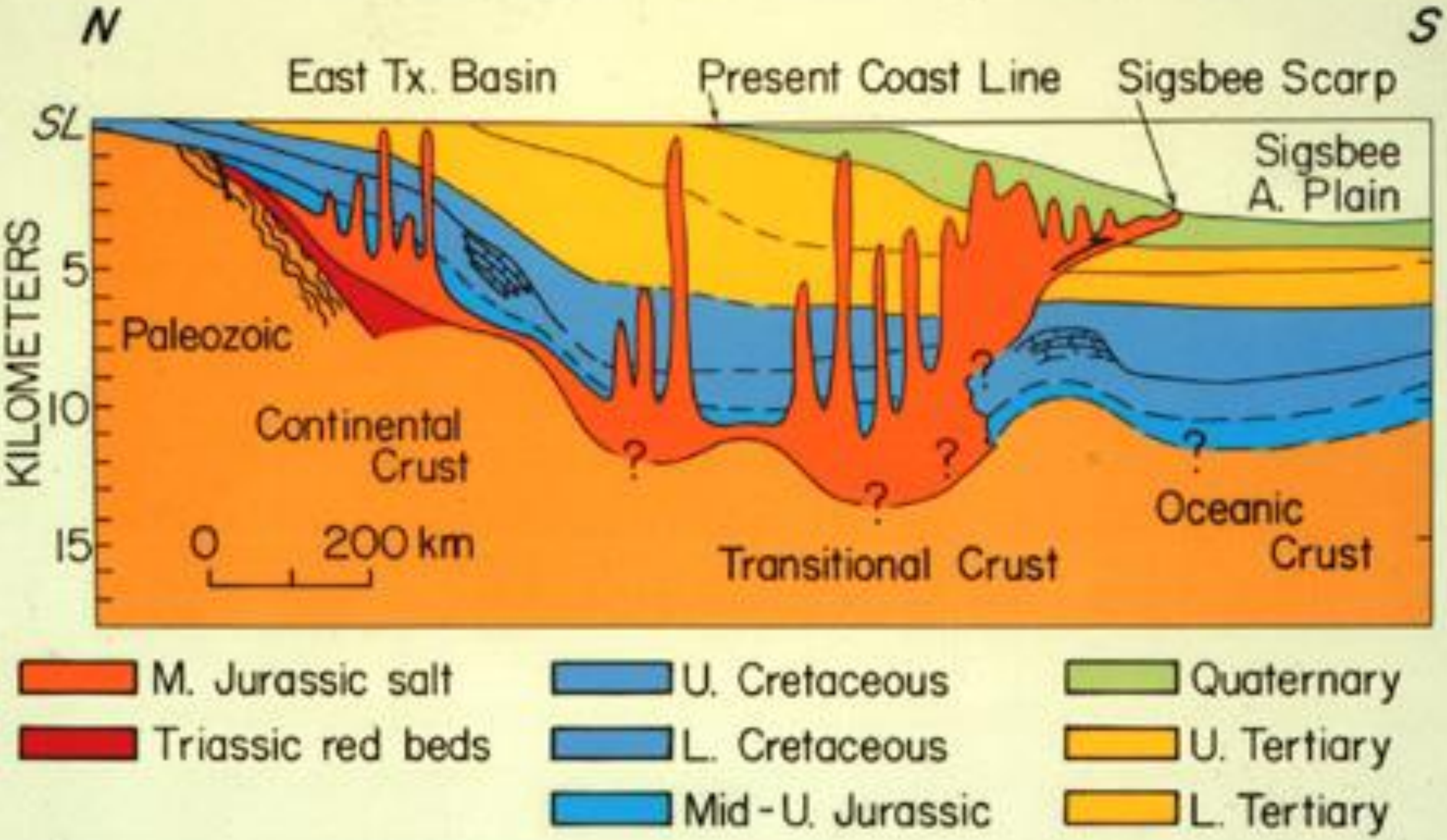
35 Ma


Bureau of Economic Geology
Alkalic
TEXAS
Alkali-calcic
Calc-alkalic
Trench
N
0
400 mi
0
600 km
MEXICO
QA 6501

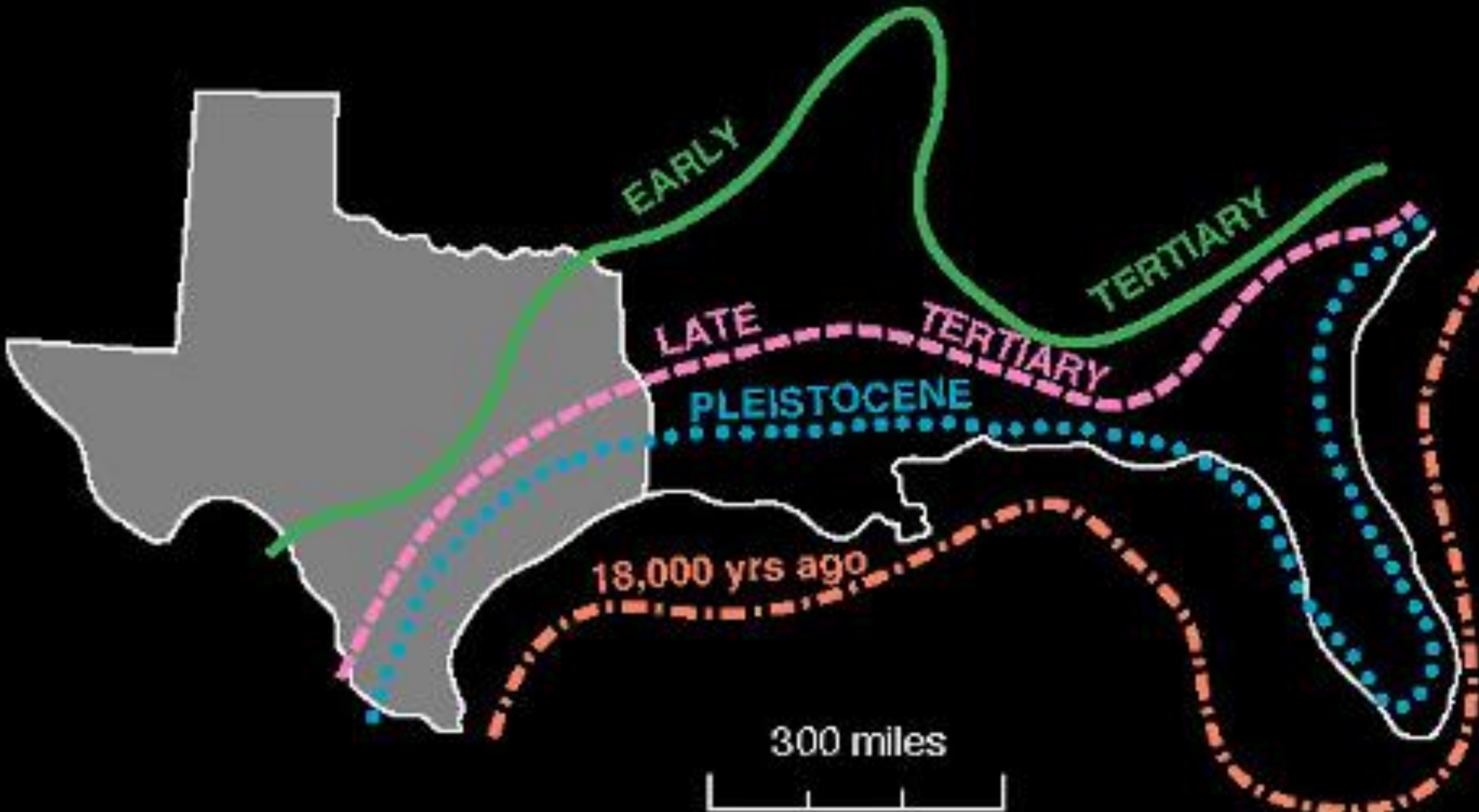

110°
106°
102°
32°
28°
24°
El Paso
TEXAS
TERTIARY
VOLCANIC
PROVINCE
300 km
200 mi

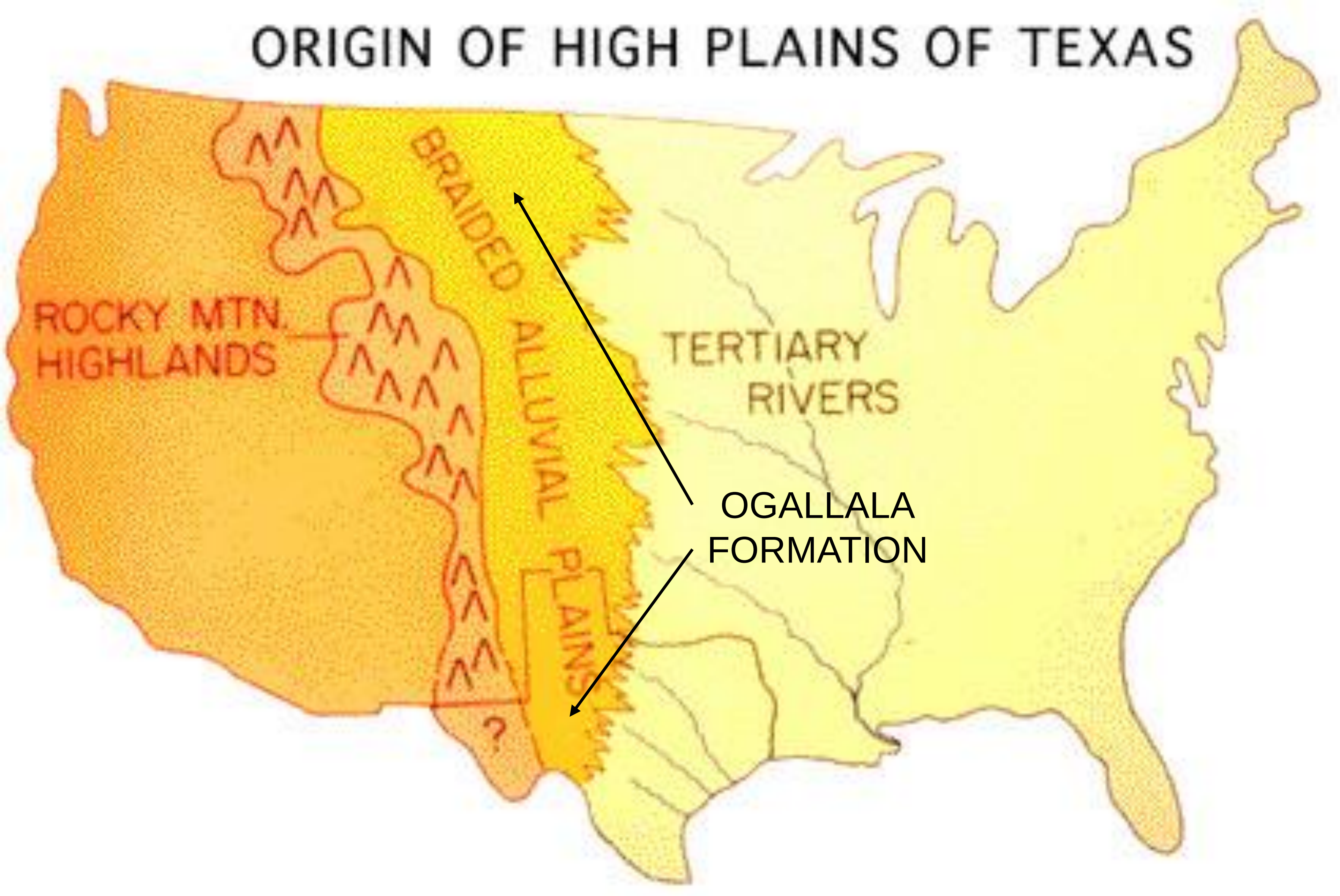

35
37
37
37
36
37
32
33
34
28,30
Bureau of Economic Geology
0
100 km


Corazones Peaks
(laccoliths)

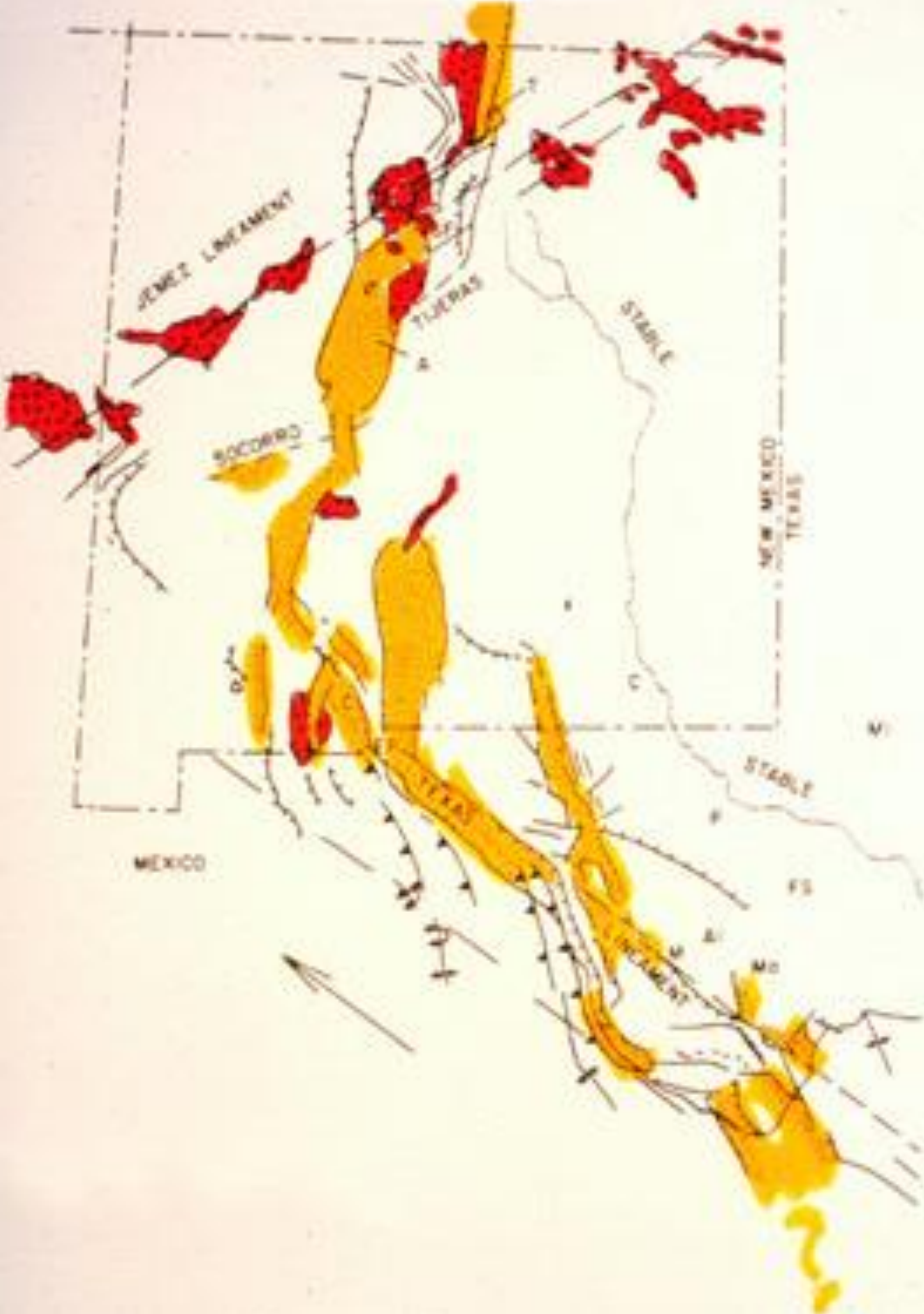

N
S
East Tx. Basin
Present Coast Line
Sigsbee Scarp
SL
Sigsbee A. Plain
KILOMETERS
5
10
15
Paleozoic
Continental Crust
0 200 km
Transitional Crust
Oceanic Crust
M. Jurassic salt
Triassic red beds
U. Cretaceous
L. Cretaceous
Mid-U. Jurassic
Quaternary
U. Tertiary
L. Tertiary

GULF COAST SHORELINE EVOLUTION




ORIGIN OF HIGH PLAINS OF TEXAS
ROCKY MTN. HIGHLANDS
BRAIDED ALLUVIAL PLAINS
TERTIARY RIVERS
?
OGALLALA FORMATION

LATE PLEISTOCENE DRAINAGE DEVELOPMENT

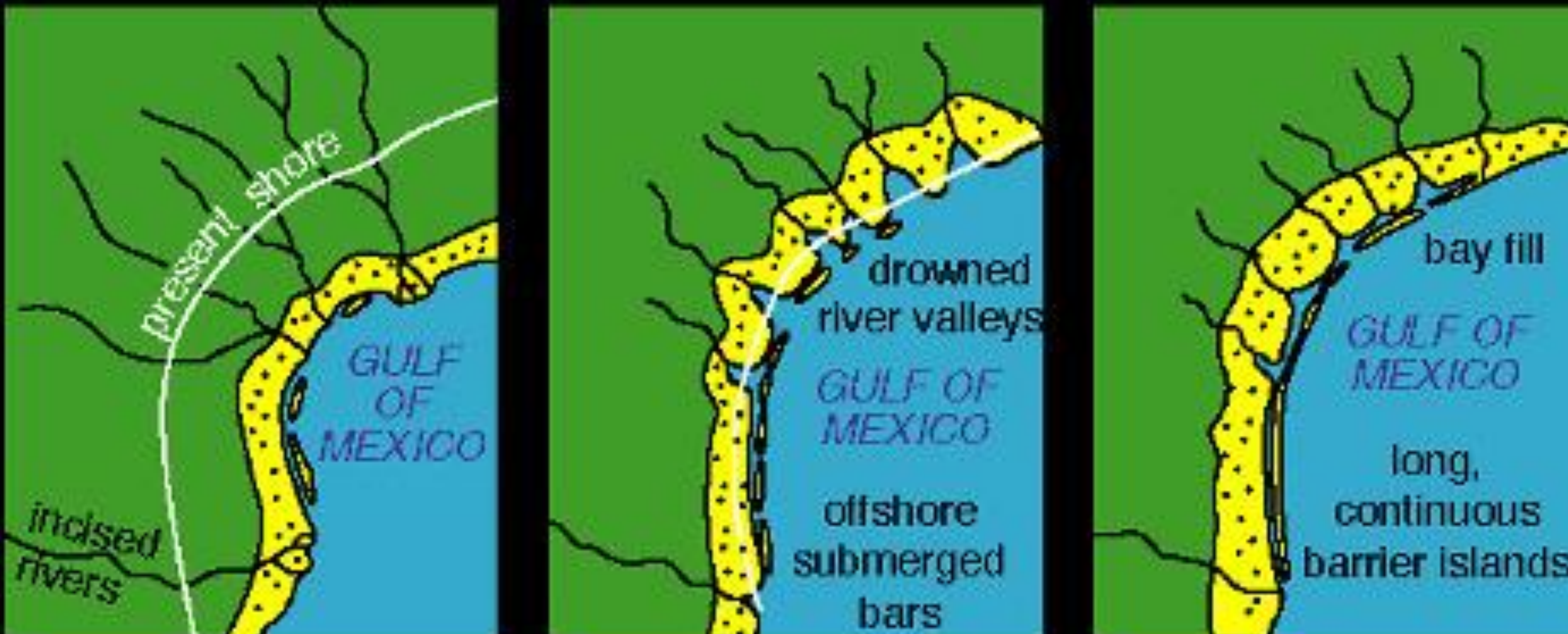


JEMEZ LINEAMENT
TIJERAS
SOCORRO
STABLE
NEW MEXICO
TEXAS
STABLE
MEXICO
TEXAS
LINEAMENT


Guadalupe
Peak
(8,749 feet)
El Capitan

LATE PLEISTOCENE

GULF COAST BARRIER ISLAND FORMATION



18,000 years ago (End of the Ice Age)

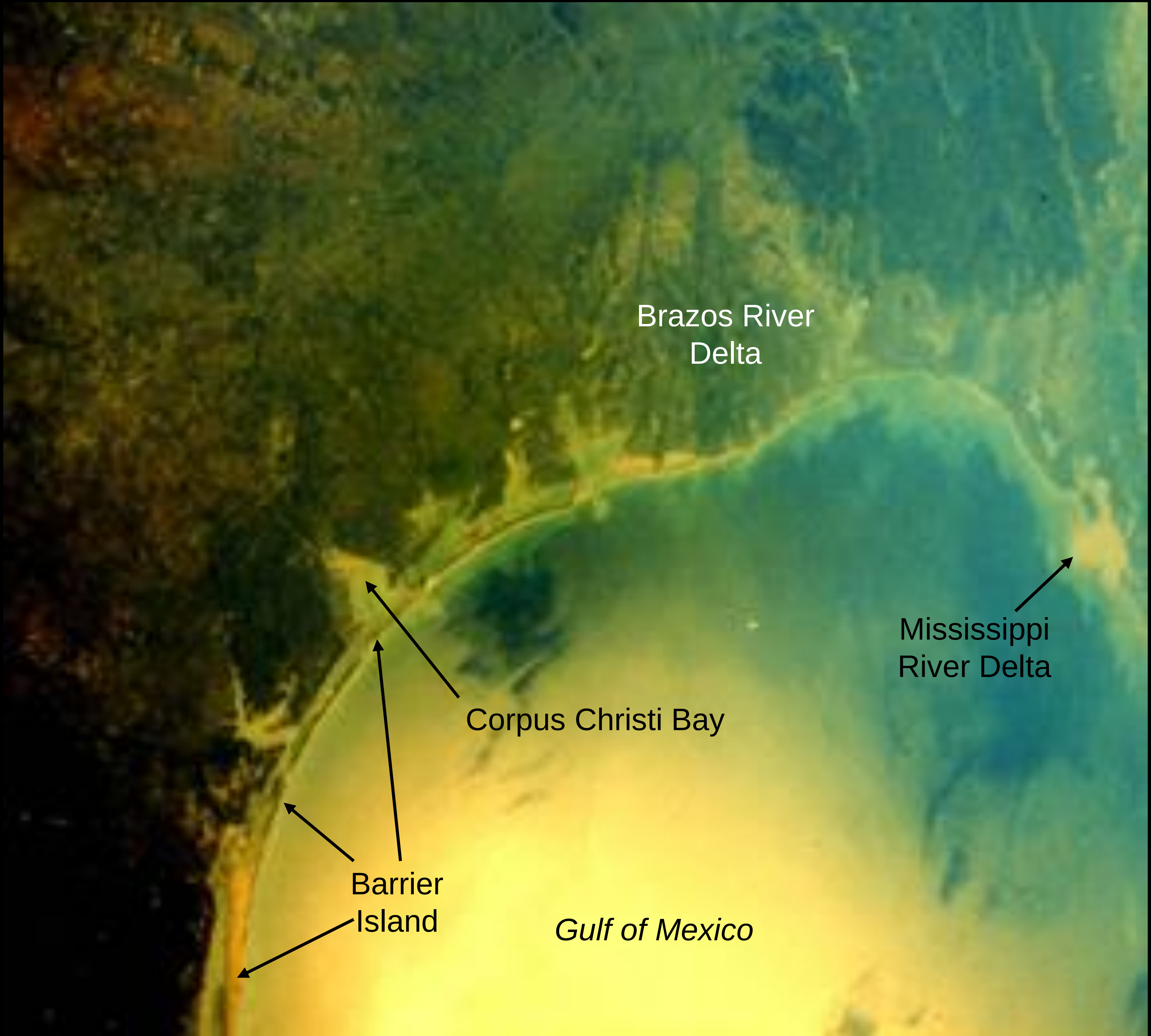
Sea level 300 feet lower than today

4,500 years ago

Sea level 15 feet lower than today

Today

(Gulf at present level 2,800 years ago)



Brazos River Delta
Mississippi River Delta
Corpus Christi Bay
Barrier Island
Gulf of Mexico

Conclusion:

The geologic history of Texas is recorded in rocks that are exposed throughout the state and fill sedimentary basins.

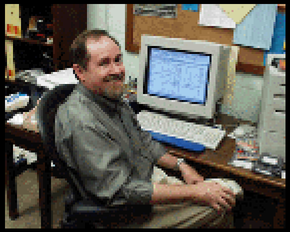
These rocks document more than a billion years of change.

Those changes include the building and erosion of major mountain ranges, explosive volcanoes, strong earthquakes, vast deserts, evaporating salt basins, tropical forests, river and delta systems, tropical seas and barrier reefs, and beaches and barrier islands.

Erosion of highlands filled subsiding sedimentary basins and adjacent continental margins. Colliding plates deformed, metamorphosed, and uplifted these materials to continue the rock cycle.

Texas' abundant and varied mineral resources are products of these geologic events.

Professor Richard Kyle



Richard Kyle is the Third C. E. Yager Professor of Geology at The University of Texas at Austin. He received a Ph. D. from the University of Western Ontario and worked as a minerals exploration geologist for several companies prior to joining the UT faculty in 1978. Kyle is the author of more than 75 publications, including writing or editing six books. His research contributions have been recognized by awards from regional and national professional societies. Professor Kyle is the Editor of Ore Geology Reviews, an international economic geology journal. His teaching responsibilities and research interests include Texas geology, ore deposits geology and geochemistry, minerals exploration, industrial minerals, and multimedia approaches to geoscience education. He has received departmental and college awards for teaching, program development, and student advising. Since1988, Kyle has taught a non-majors course on the Geology and Mineral Resources of Texas.