Subsidence and Uplift History of the West Texas Basin and its (Post-Paleozoic) Margins*

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Abstract

The present margins of the West Texas Basin are mostly defined by pre-Cretaceous erosion. On the east, the Llano Arch is marked by low-angle beveling of Permian and Pennsylvanian strata in North Texas that culminates in the exposed Llano Uplift. On the south, the Glass Mountains Homocline is a sharper feature with dips of 5 degrees northward into the basin below Cretaceous strata. Both features lie northwest of the Late Triassic to Middle Jurassic rifting that ultimately formed the Gulf of Mexico; they are inferred to represent a rift shoulder unconformity caused by crustal heating on the flanks of the main rift zone. On the southwest, the NW-trending Hueco Arch truncates Paleozoic strata beneath Mid-Cretaceous in far West Texas; it extends northwest into the Burro Arch of southwestern New Mexico. This uplift may be younger than the previous (Early Cretaceous) and related to rifting and subsidence of the Bisbee and Chihuahua troughs to the southwest.

After deposition of Cretaceous marine strata, the southern and western margins were deformed by Laramide (Early Paleogene) uplift and faulting including the Carta Valley Fault Zone, the Marathon Dome, and various features in Trans-Pecos Texas. The entire area was uplifted and tilted to its present elevation during Neogene time. Large-scale extensional faulting in the west formed the Salt Basin and Tularosa Valley, and Basin and Range features that are related to the Rio Grande Rift.

The effect of these episodes of uplift is a ‘freezing in’ of oil generated in Paleozoic strata. Lack of subsidence keeps substantial zones out of the gas window and helps to preserve liquid hydrocarbons. Large-scale uplift, however (as in the Kerr Basin) may raise strata in the gas window and cause depressuring and loss of reserves.

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Ewing, Thomas E., 2012, Geology and hydrocarbon resource potential of Cretaceous strata in the Jornada del Muerto, Sierra and Socorro counties, New Mexico: New Mexico Geological society Fall Field conference 63, p. 569-580.

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van Balen, R.T., P.A. van der Beek, and S.A.P.L. Cloetingh, 1995, The effect of rift shoulder erosion on stratal patterns at passive margins; implications for sequence stratigraphy: Earth and Planetary Science Letters, v. 134/3-4, p. 527-544.

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For presentation to the
Southwest Section AAPG
10 April 2013

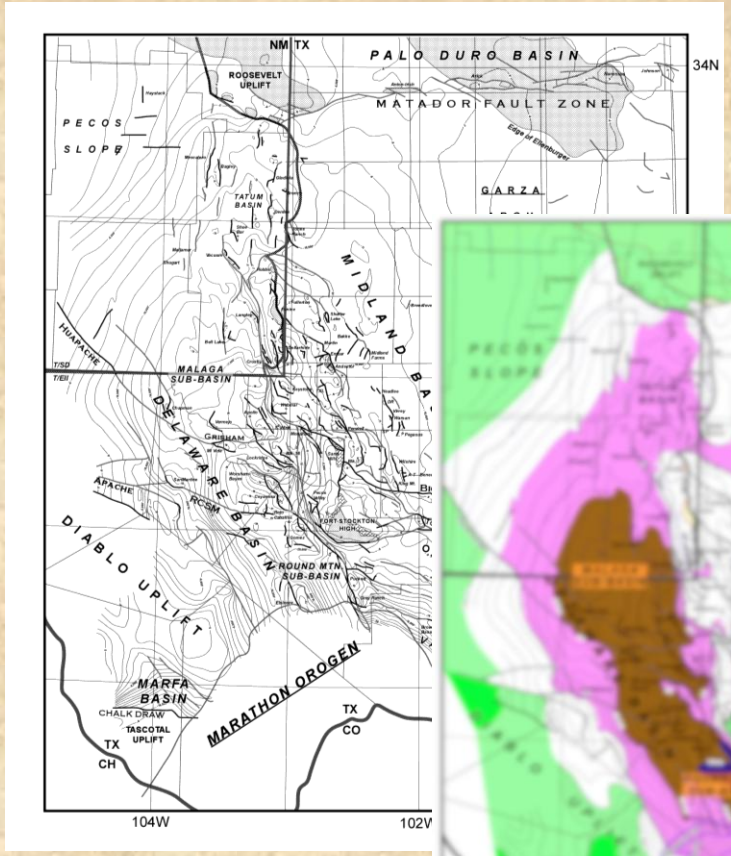
ABSTRACT

- The present margins of the West Texas Basin are mostly defined by pre-Cretaceous erosion. On the east, the Llano Arch is marked by low-angle beveling of Permian and Pennsylvanian strata in North Texas that culminates in the exposed Llano Uplift. On the south, the Glass Mountains Homocline is a sharper feature with dips of 5 degrees northward into the basin below Cretaceous strata. Both features lie northwest of the late Triassic to middle Jurassic rifting that ultimately formed the Gulf of Mexico; they are inferred to represent a rift shoulder unconformity caused by crustal heating on the flanks of the main rift zone. On the southwest, the NW-trending Hueco Arch truncates Paleozoic strata beneath mid-Cretaceous in far West Texas; it extends northwest into the Burro Arch of southwestern New Mexico. This uplift may be younger than the previous (early Cretaceous) and related to rifting and subsidence of the Bisbee and Chihuahua troughs to the southwest.
- After deposition of Cretaceous marine strata, the southern and western margins were deformed by Laramide (early Paleogene) uplift and faulting including the Carta Valley Fault Zone, the Marathon Dome, and various features in Trans-Pecos Texas.
- The entire area was uplifted and tilted to its present elevation during Neogene time. Large-scale extensional faulting in the west formed the Salt Basin and Tularosa Valley, Basin and Range features that are related to the Rio Grande Rift.
- The effect of these episodes of uplift is a ‘freezing in’ of oil generated in Paleozoic strata. Lack of subsidence keeps substantial zones out of the gas window and helps to preserve liquid hydrocarbons. Large-scale uplift, however (as in the Kerr Basin) may raise strata in the gas window and cause depressuring and loss of reserves.

WEST TEXAS BASIN

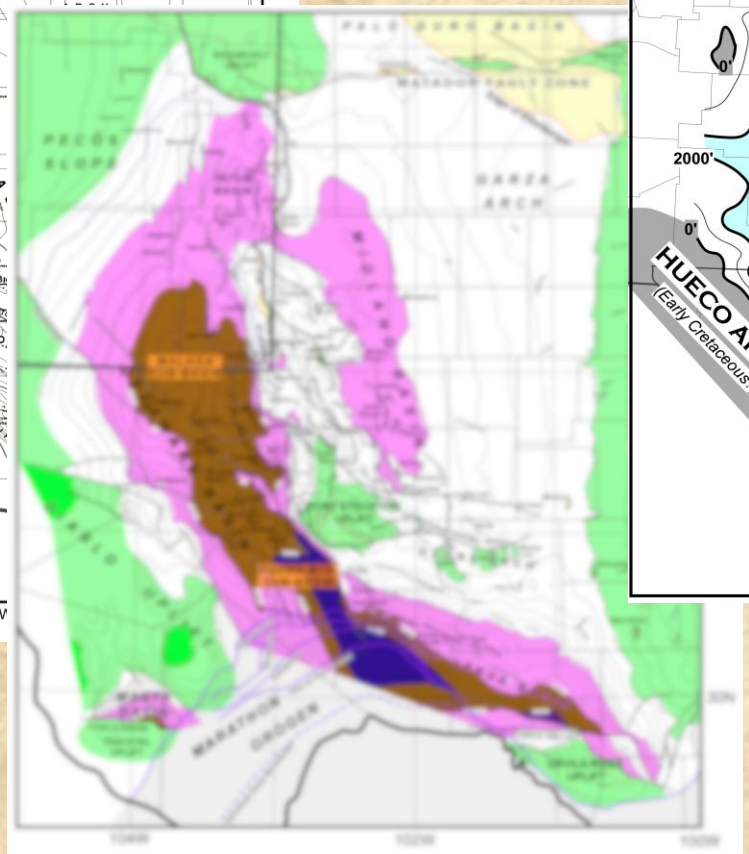
- Proterozoic basement (with rift center)
- Lower Paleozoic carbonates
  - 'Tobosa Basin'?
- Penn-Wolfcamp clastics and carbonates
- *FIRST THREE: faulted and folded…*
- Permian carbonates and clastics
  - 'Permian Basin' subsidence
- **Post-Permian: tilting and erosion of portions of basin, creation of present margins**

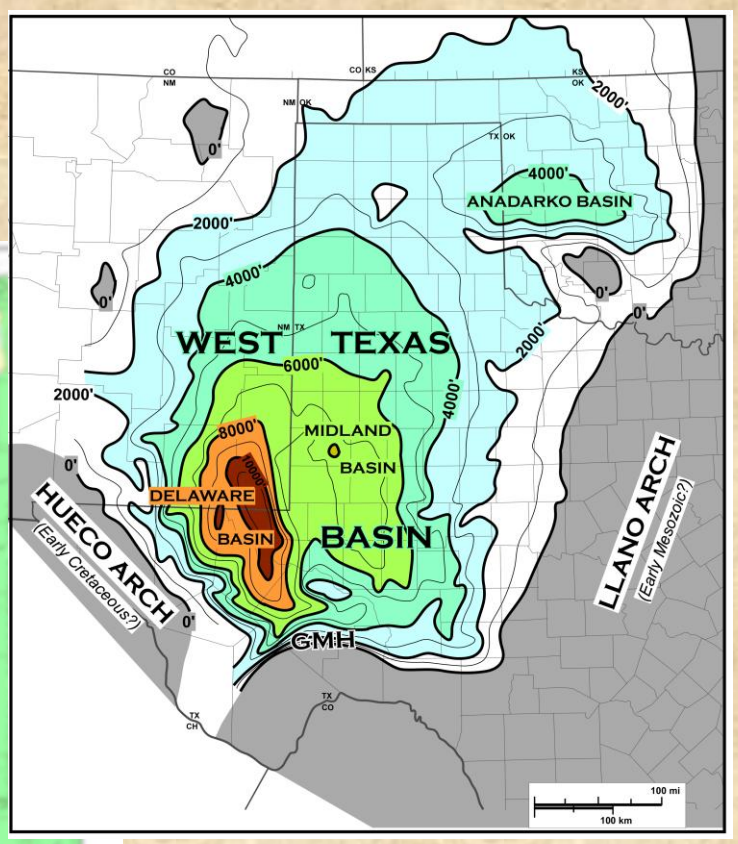
STRUCTURES AT THREE SCALES



Macro

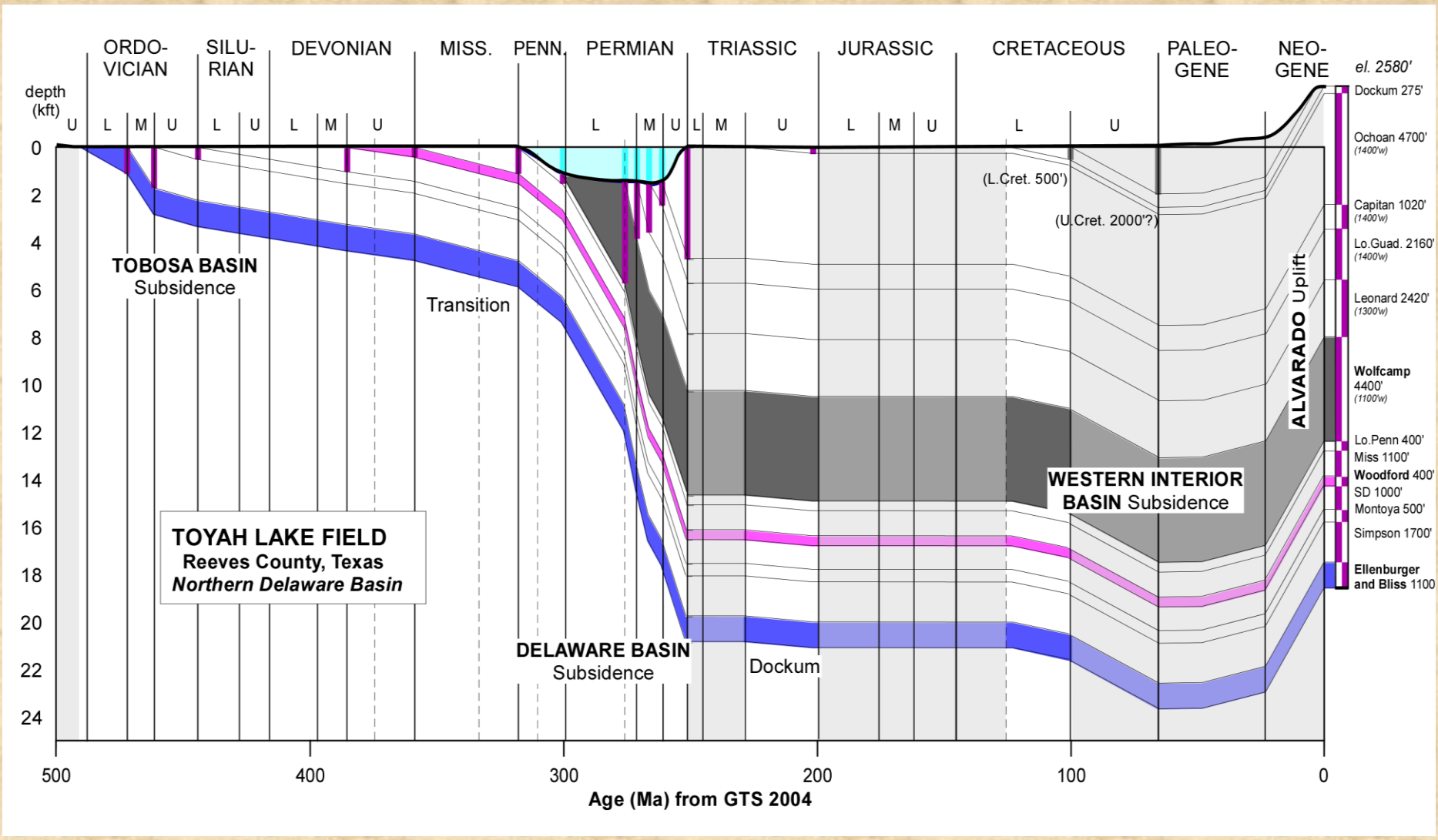
Mega





Giga

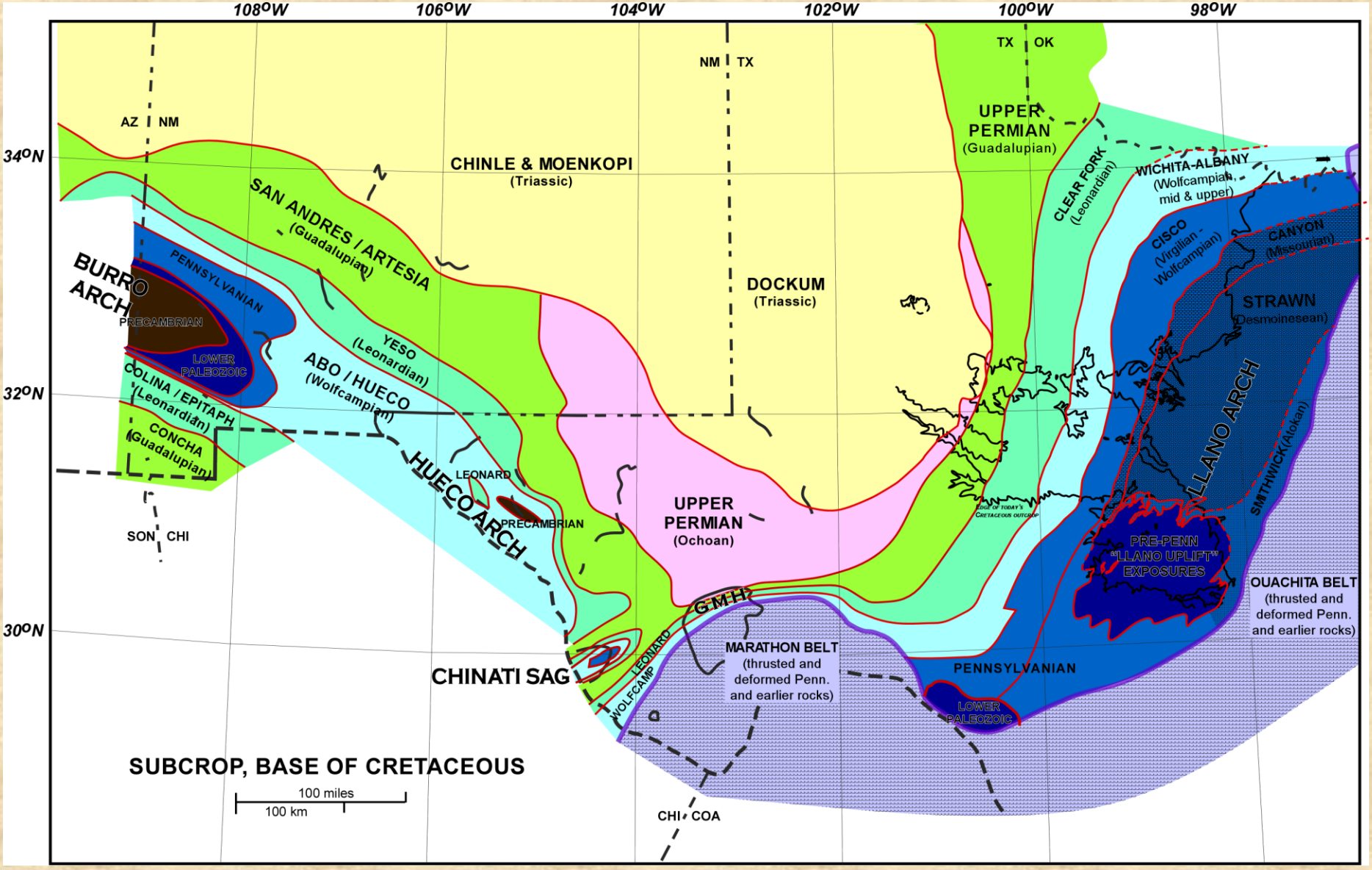
AND NOW… THE REST OF THE STORY

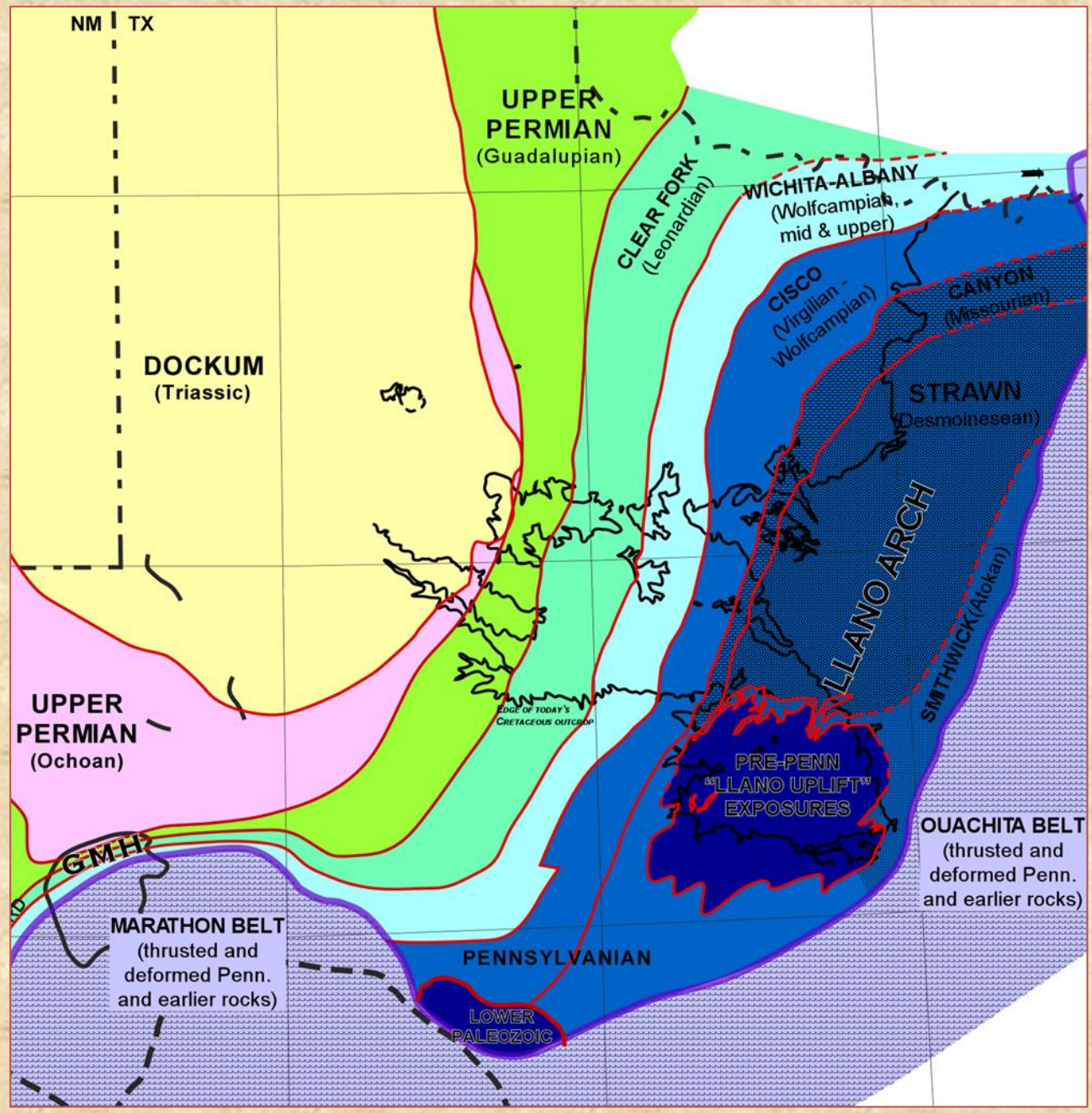


MESOZOIC BASIN MODIFICATION

- Eastern Margin: regional tilting to W, erosion of Llano Arch (pre-Cretaceous)
  - Some could be Permian, but not much clastic influx
- Southern Margin: Glass Mountains Homocline tilted to north (over 5^{o} in outcrop)
- Western Margin: Hueco Arch, tilting to NE
- So: three margins of WTB are shaped by Mesozoic erosion!
  - only northern reaches are depositional
- In center, NW – Triassic deposition

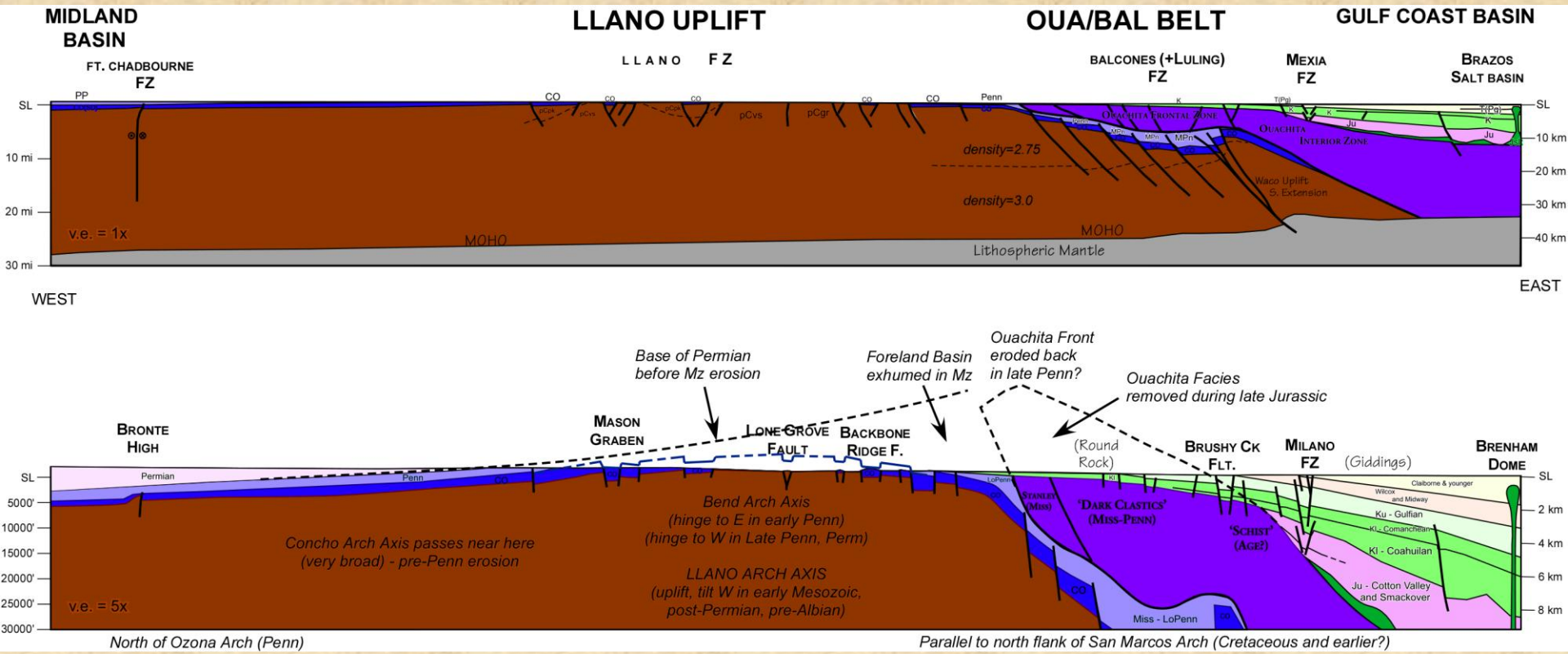
PRE-CRETACEOUS SUBCROP

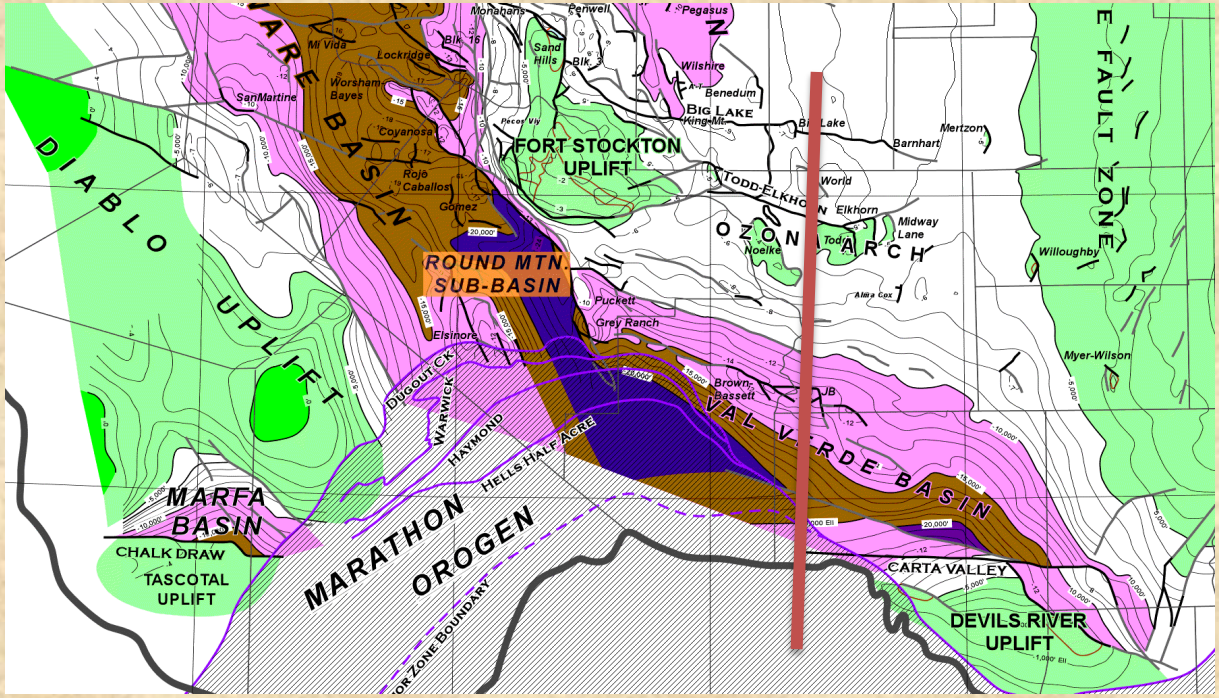


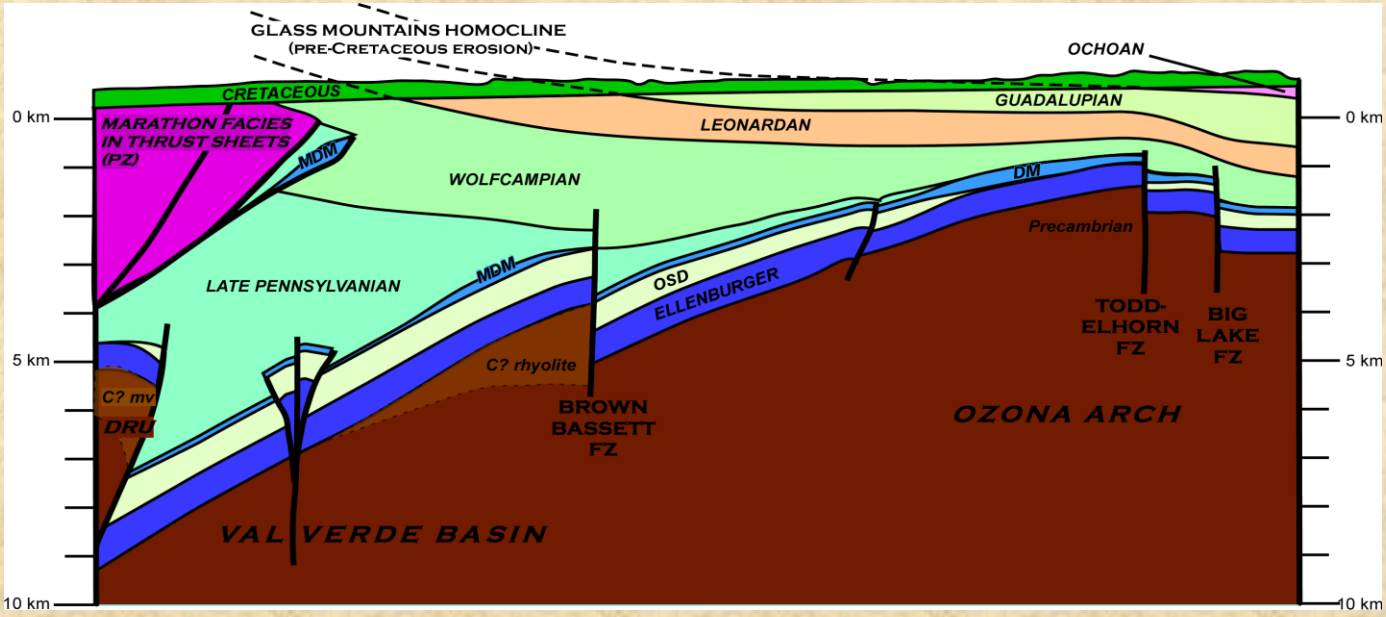


PRE-K CLOSE UP

LLANO ARCH W-E (Brady-Brenham)



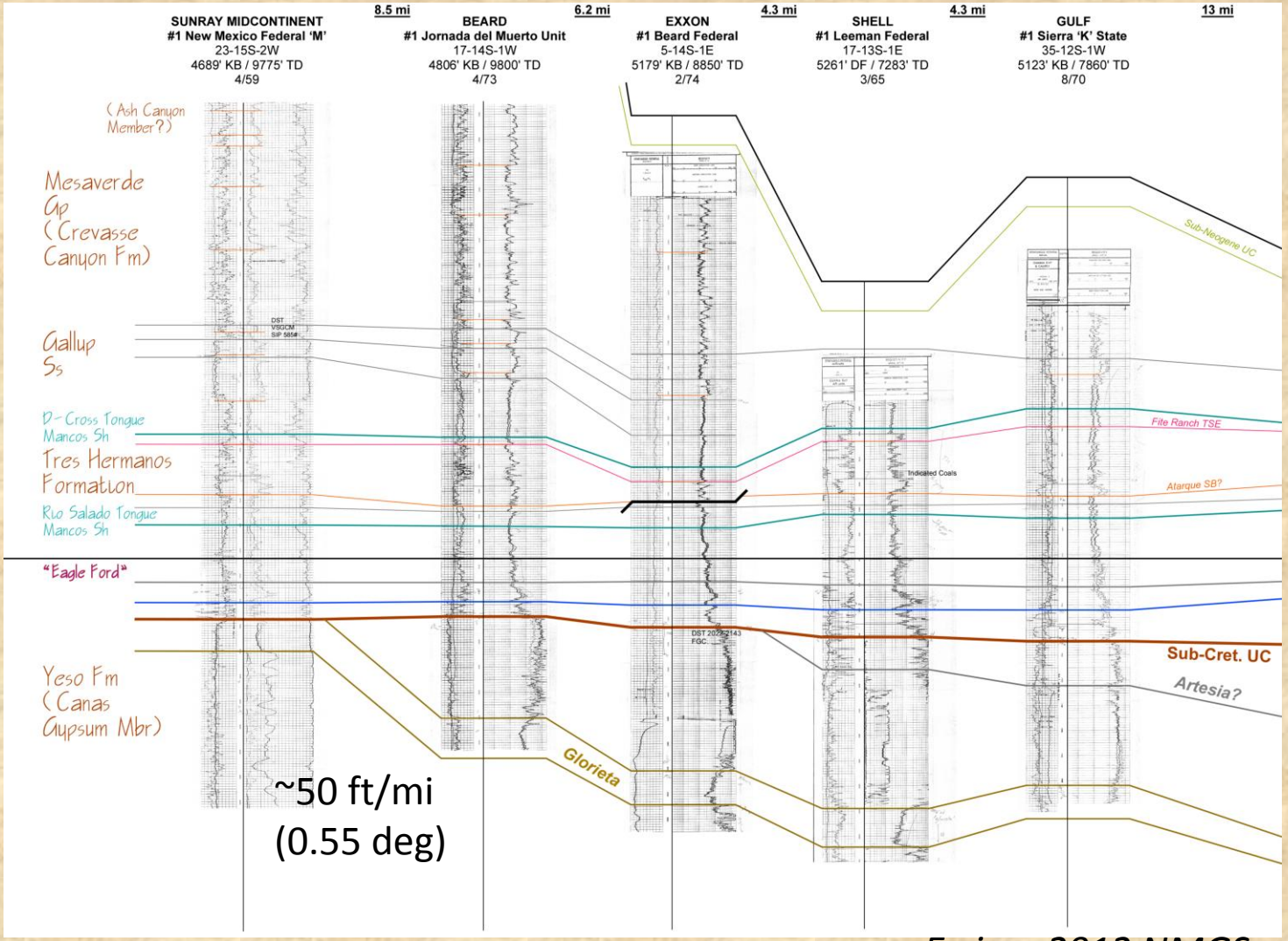




GLASS MTNS HOMO-CLINE

Part of N Side of Burro-Hueco Arch

- To S, lose Yeso and Abo;
- K on Hueco at Cookes Pk, El Paso area;
- K on Penn at Silver City;
- K on PC in Tyrone area

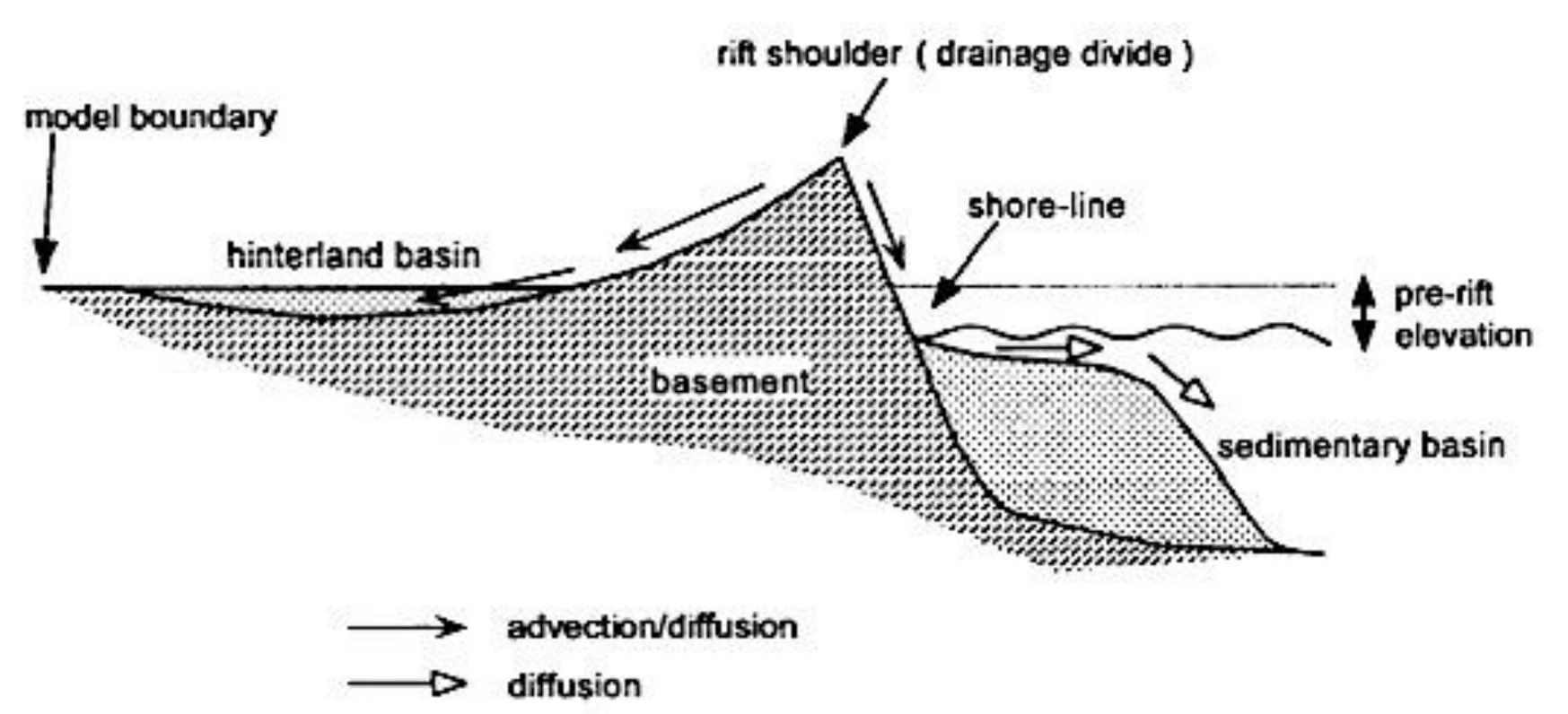


Ewing, 2012 NMGS

DIP RATES ON 3 ARCHES?

- Llano Arch – 0.40-0.57 degrees
  - 37-53 ft/mi (7-10 m/km), less than 1 in 100
- Glass Mountains – 5-6 degrees
  - 462-555 ft/mi (87-105 m/km), about 1 in 10
- Burro-Hueco Arch – 0.5-0.8 degrees
  - 50-80 ft/mi (9-15 m/km), about 1 in 100

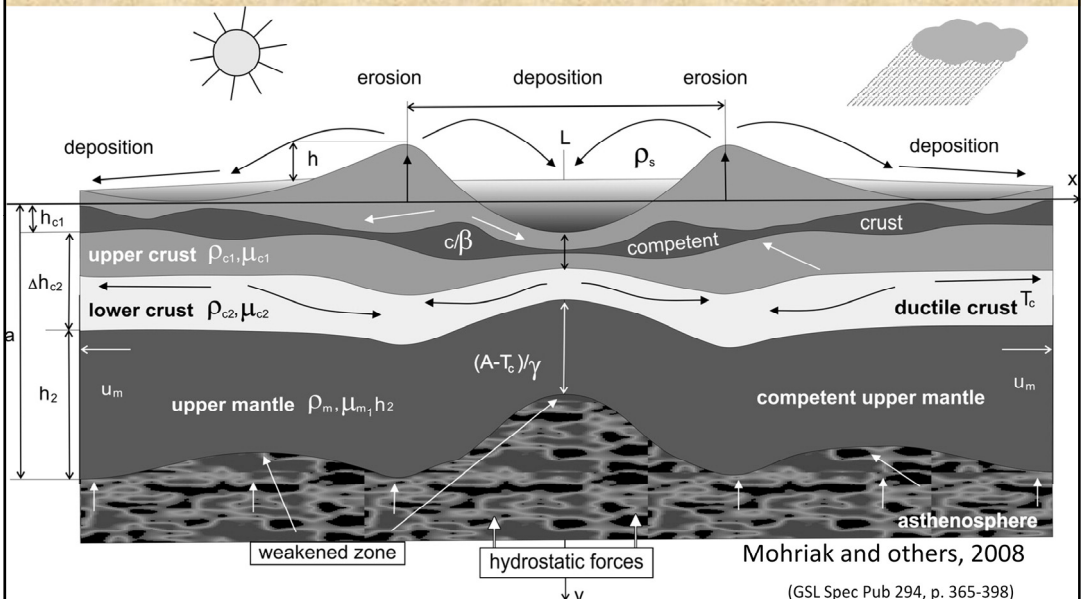
RIFTS AND RIFT SHOULDERS



Van Balen and others, 1995

EPSL v.134, p. 527-544

RELATIONSHIP OF ARCHES TO RIFTS



Presenter's notes: South Atlantic divergent margin evolution: rift-border uplift and salt tectonics in the basins of SE Brazil: GSL Spec Pub 294, p. 365-398 sp.lyellcollection.org/content/294/1/365/F21/large.jpg

TWO KINDS OF ‘RIFT SHOULDERS’

- Discrete flank uplift
  - Crustal response to faulting
  - Sandia, Sacramento, Delaware Mountains
- Broad uplifts and domes
  - Isostatic response to warm, less dense mantle beneath
  - East African rift shoulders today
  - Llano, Burro arches

TWO TYPES OF RIFT SHOULDERS

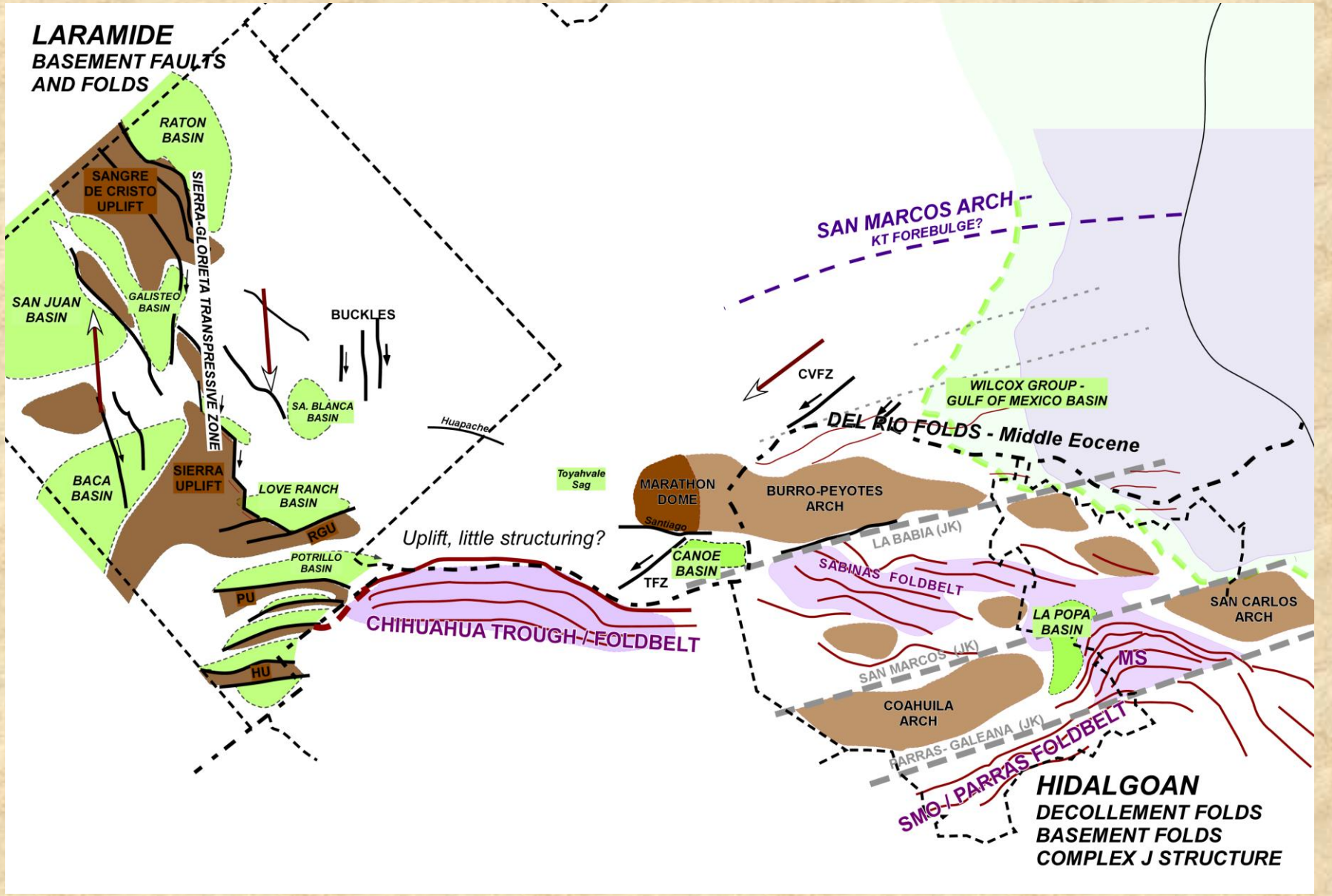
Flank Uplift – Sandia Mtns

Broad dome - Ethiopia

LARAMIDE DEFORMATION (KT)

- Deposition of Western Interior Seaway rocks (transitioning to Tethys)
- Laramide compression, transpression in trans-Pecos and strike-slip in west, south
  - And Marathon Dome
- Heart of WTB sheltered from most Laramide deformation (why?)
  - Speculate: Difference between US and Mexico Laramide; shielding by Chihuahua Trough

LARAMIDE SKETCH



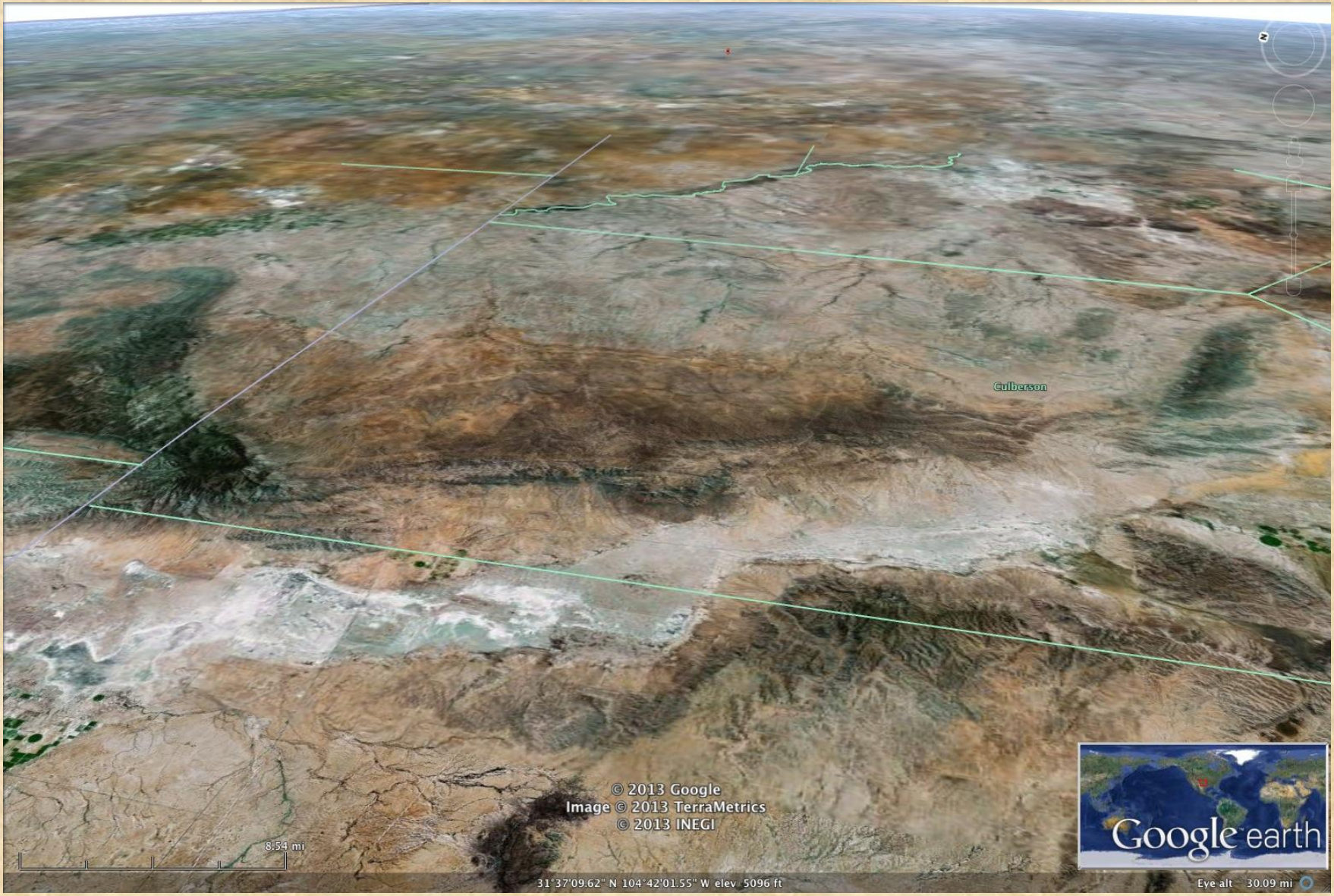
TERTIARY TILTING

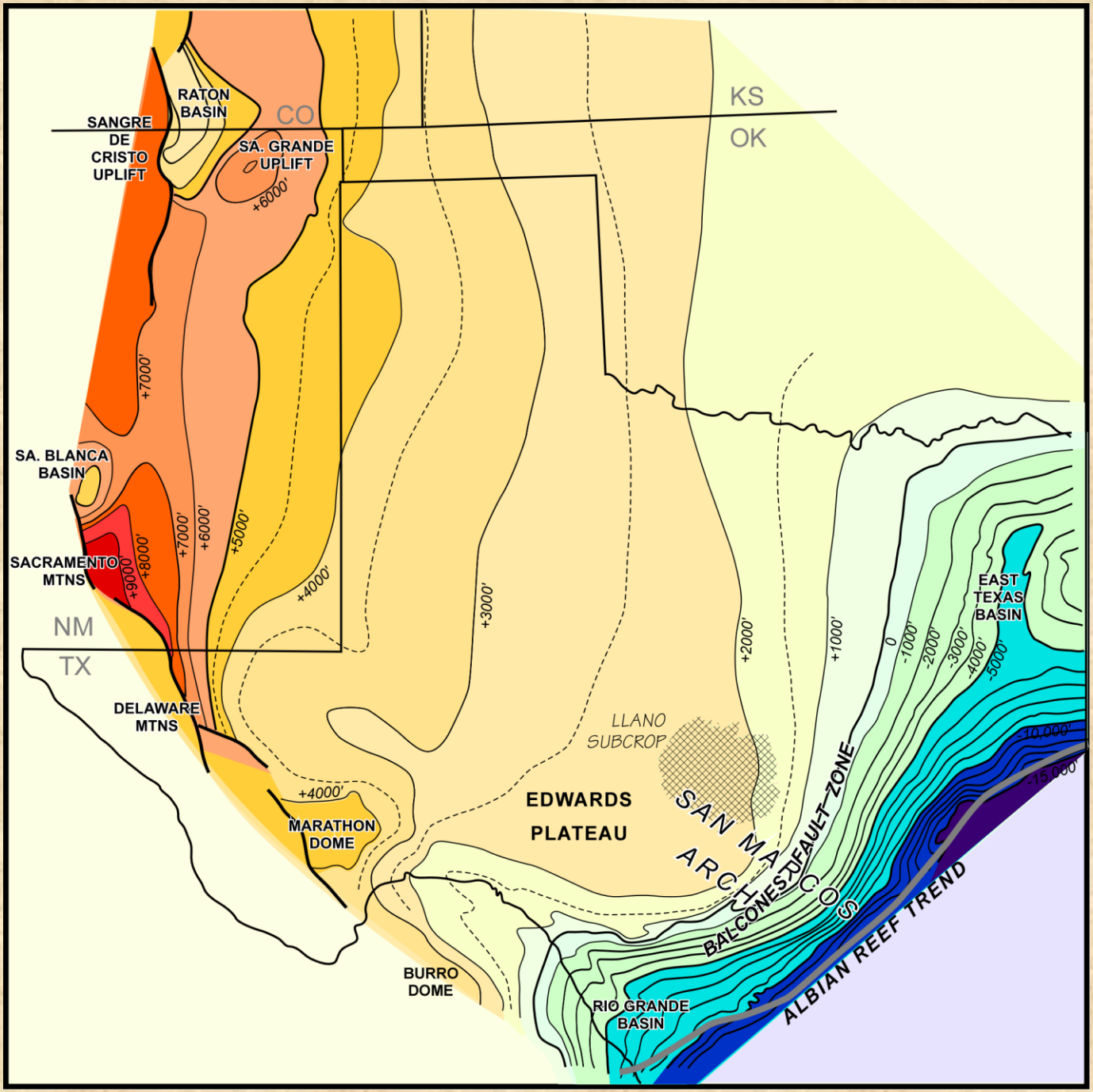
- Delaware Basin tilted to east and exhumed
  - Forming Sacramento, Guadalupe, Delaware, Apache Mtns
- Uplift on flanks of Salt Basin – the easternmost Basin and Range (Neogene) basin
- Entire region uplifted to present elevation and gently tilted east
  - Possibly causing active maturation to cease
  - Some tilting may be pre-Neogene…

DELAWARE TILTING

- East flank of Salt Basin (Neogene graben)
- Connects to Guadalupe Ridge and Sacramento Mtns (on E flank of Tularosa Valley graben)

DELAWARE TILTING





STRUCTURE, TOP LOWER CRETACEOUS

SUMMARY

- Early Mesozoic (Triassic – Early Cretaceous) rift shoulders shape the basin margins
- WTB core area is sheltered from Laramide deformation
- W, SW margins tilted and eroded in Neogene; whole basin uplifted
  - Probably causing active maturation to cease