

# Three Scales of Late Paleozoic Structures in the West Texas Basin - Description and Genesis\*

Thomas E. Ewing<sup>1</sup>

Search and Discovery Article #30273 (2013)

Posted June 30, 2013

\*Adapted from oral presentation given at AAPG Southwest Section meeting in Fredericksburg, Texas, April 6-8, 2013. Please refer to companion article by the author, "Subsidence and Uplift History of the West Texas Basin and its (Post-Paleozoic) Margins," [Search and Discovery Article #30272 \(2013\)](#).

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<sup>1</sup>Frontera Exploration Consultants, San Antonio, TX 78259 ([tewing@fontieraexploration.com](mailto:tewing@fontieraexploration.com))

## Abstract

The West Texas Basin displays three mappable scales of Late Paleozoic deformation: a macroscale (field-scale) web of structures (spaced 2-20 km), a megascale (trend-scale) pattern of uplift and subsidence (spaced 20-200 km), and a gigascale basin-wide subsidence. The three scales are remarkably separable, although they affect the same area.

Major faulting, folding and tilting during the Pennsylvanian and Early Permian (Atoka to Mid-Wolfcamp) created a web of macroscale (2-20 km half-wavelength) structural features including faulted uplifts, broad and narrow faulted ridges, flower structures and strike-slip and oblique-slip faults. Most features are consistent with distributed WNW-directed left-lateral strike-slip and ENE-directed compression; NE- to N-trending (right-lateral) strike-slip may also be present. Most structures involve basement, but may be detached in the upper crust; complex crustal layering is a feature of the region.

The macroscale web occurs both within zones of megascale (20-200 km half-wavelength) subsidence (Delaware and Midland basins) and also in zones of relative megascale uplift (Central Basin and Diablo axes). The megascale pattern may represent lower crustal thrusting along a Precambrian feature. Both the macroscale and megascale uplifts occurred within a basin-wide (gigascale) subsidence that outlasted macroscale deformation, continuing into Late Permian time (covering the structures with 2-3 km of sediment). This apparent bowl-shaped subsidence is similar to other major intracratonic basins, and may share a common origin (e.g. sinking of a mafic crustal root).

On its southern margin, the basin abuts and underlies the Marathon Fold and Thrust Belt, an allochthonous assemblage of Paleozoic oceanic/slope and foredeep deposits. Foredeep and forebulge features (Val Verde, Ozona) developed in the adjacent parts of the southern West Texas Basin, but did not extend farther north. The stress patterns indicated by macroscale and megascale uplifts are inconsistent with NNW-directed Marathon thrusting as an important driver of the deformation. The features form part of the Ancestral Rocky Mountains (ARM). The

West Texas Basin is anomalous in the ARM in its abundant detached macroscale structures, and the presence of a major intracratonic basin that buries and seals the uplifts.

### **References Cited**

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# ***Three Scales of Late Paleozoic Structures in the West Texas Basin – Description and Genesis***

**Thomas E. Ewing**, Frontera Exploration Consultants

*GSA South-Central Section Meeting, Austin TX  
Southwest Section AAPG Meeting, Fredericksburg TX  
April, 2013*

# ABSTRACT

- The West Texas Basin displays three mappable scales of Late Paleozoic deformation: a macroscale (field-scale) web of structures (spaced 2-20 km), a megascale (trend-scale) pattern of uplift and subsidence (spaced 20-200 km), and a gigascale basinwide subsidence. The three scales are remarkably separable, although they affect the same area.
- Major faulting, folding and tilting during the Pennsylvanian and Early Permian (Atoka to mid-Wolfcamp) created a web of macroscale (2-20 km half-wavelength) structural features including faulted uplifts, broad and narrow faulted ridges, flower structures and strike-slip and oblique-slip faults. Most features are consistent with distributed WNW-directed left-lateral strike-slip and ENE-directed compression; NE to N trending (right-lateral) strike-slip may also be present. Most structures involve basement, but may be detached in the upper crust; complex crustal layering is a feature of the region.
- The macroscale web occurs both within zones of megascale (20-200 km half-wavelength) subsidence (Delaware and Midland Basins) and also in zones of relative megascale uplift (Central Basin and Diablo axes). The megascale pattern may represent lower crustal thrusting along a Precambrian feature.
- Both the macroscale and megascale uplifts occurred within a basinwide (gigascale) subsidence that outlasted macroscale deformation, continuing into late Permian time (covering the structures with 2-3 km of sediment). This apparent bowl-shaped subsidence is similar to other major intracratonic basins, and may share a common origin (e.g., sinking of a mafic crustal root).
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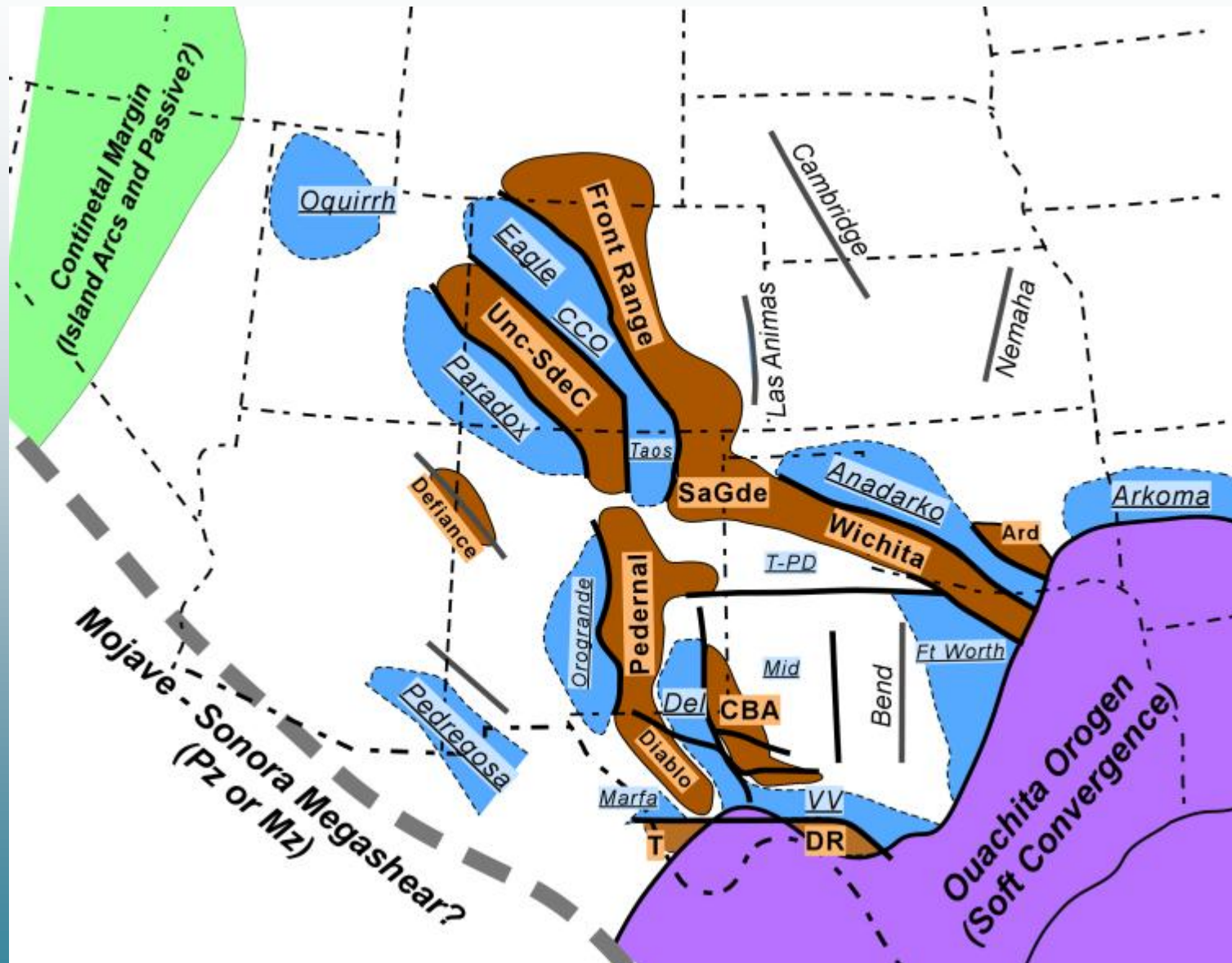
# WEST TEXAS BASIN

- Proterozoic basement (with rift center)
- Lower Paleozoic carbonates
  - ‘Tobosa Basin’?
- Penn-Wolfcamp clastics and carbonates
- **FIRST THREE: faulted and folded at 3 scales...**
- Post-mid Wolfcamp carbonates and clastics
  - Continued ‘Permian Basin’ subsidence

# WTB DEFORMATION IN THE ARM

- WTB is part of the Ancestral Rockies
- Unique section relative to other ARM, Laramide:
  - Abundant macroscale features, detached from larger uplifts and basins
  - Few megascale features (no Wichita, Uncompahgre uplifts)
  - Gigascale subsidence caused limited erosion of uplifts, so no 'granite wash' detritus

# ANCESTRAL ROCKY MTNS



# SCALES OF DEFORMATION

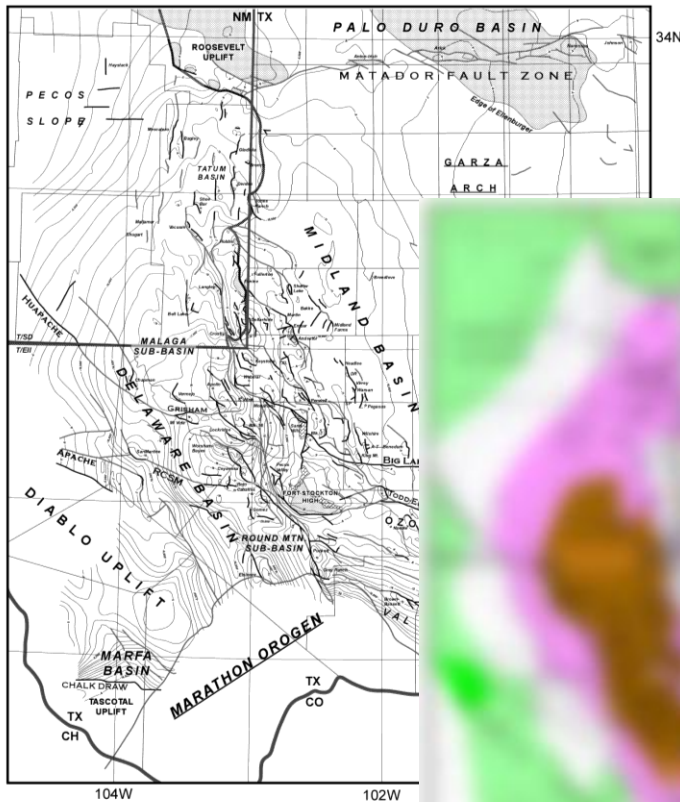
- Microscale (<2m)
  - ‘Microscope and hand-specimen scale’
- Mesoscale (2m-2km)
  - ‘Outcrop scale’
- **Macroscale** (2-20 km)
  - ‘Field scale’
- **Megascale** (20-200 km)
  - ‘Block scale’
- **Gigascale** (200-2000 km)
  - ‘Basin scale’



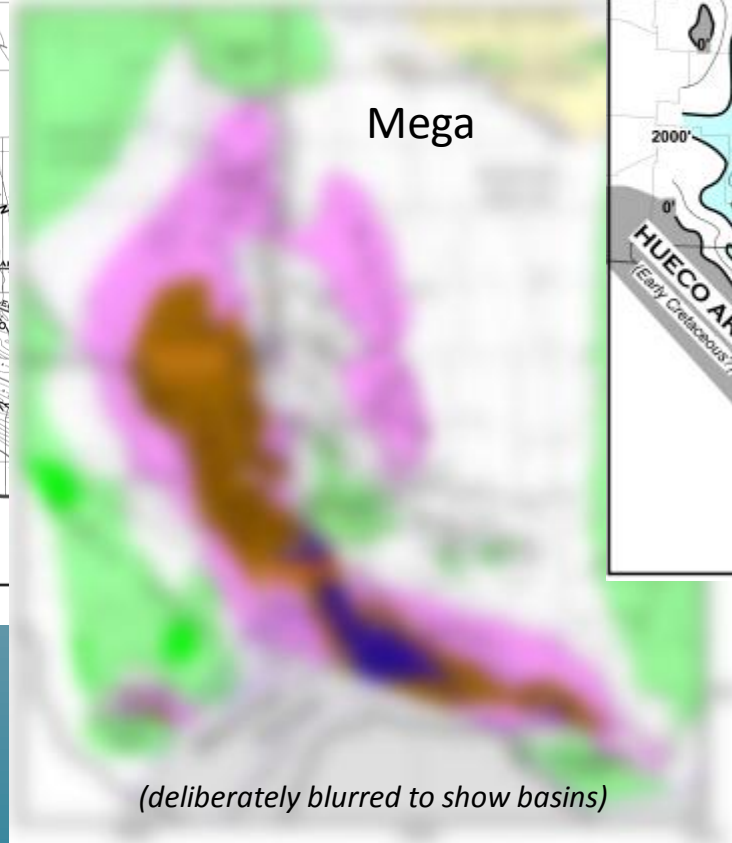
# SCALES IN WTB DEFORMATION

- Web of **Macroscale** structures
  - Complex uplift and basin geometries...
- Uplift and Basin geometry – **Megascale**
  - Midland and Delaware basins, Central Basin and Diablo uplifts / axes
- Basinwide subsidence – **Gigascale**
  - Subsidence beginning in Pennsylvanian, outlasts other deformation into late Permian

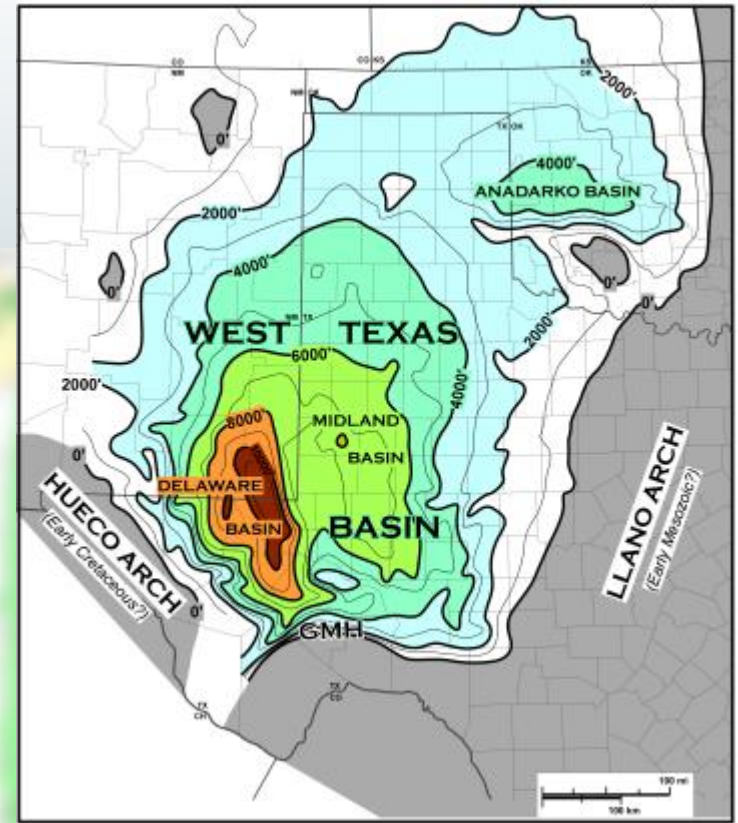
# WTB AT THREE SCALES



Macro



Mega

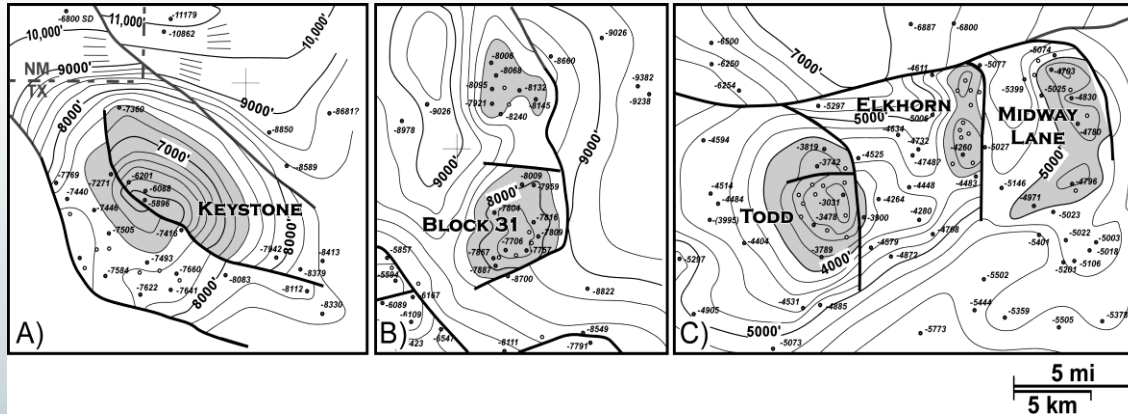


Giga

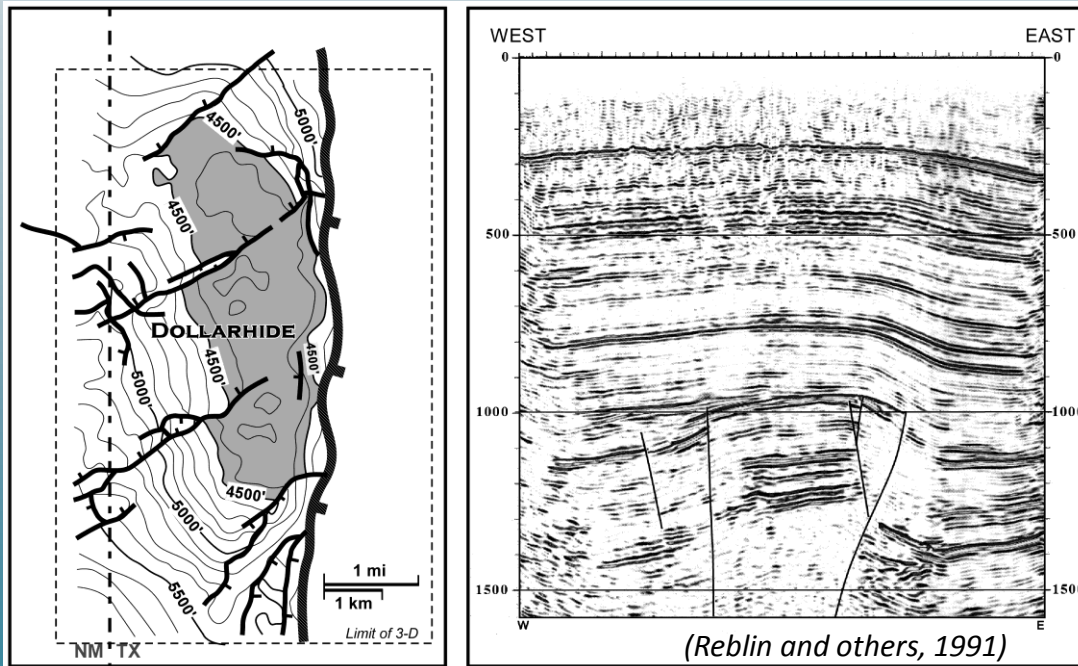
# MACROSCALE WEB

- Trapdoor uplifts
- Elongate ridges, faulted on one side
- Strike-slip features
  - Flower structures
  - Narrow ridges and basins
  - Offset steps
- Most features basement-cored (drilled to Ellenburger at least)
- Form a connected web of deformation (faults, folds)
- Kinematics consistent with ENE compression
  - Abundant left-lateral strike slip on EW, WNW trends
  - Possible right-lateral strike slip on NS trends

# MACROSCALE FEATURES (I)

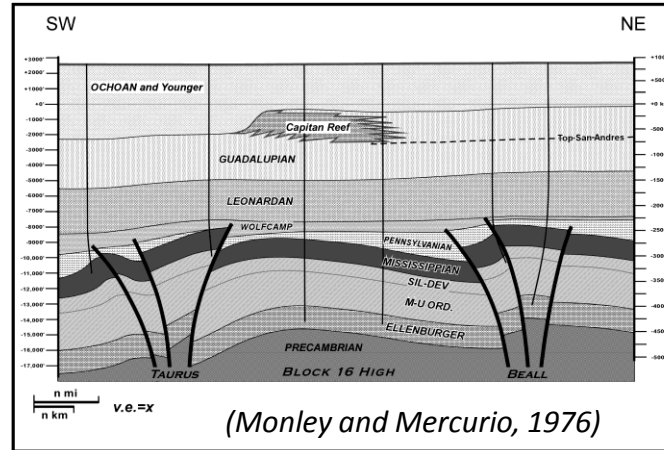
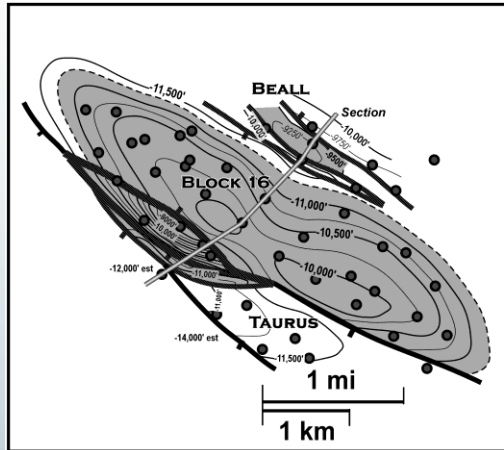


TRAPDOOR  
UPLIFTS

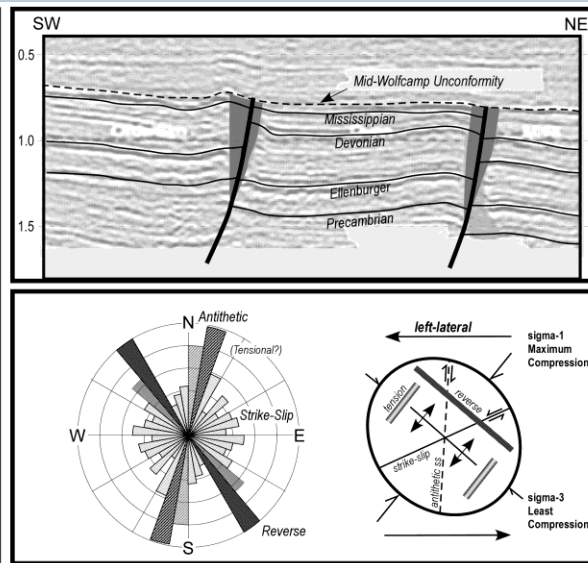
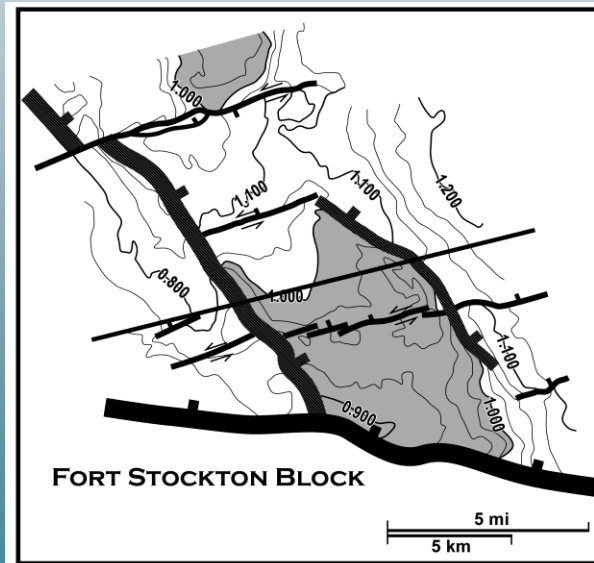


BROAD  
ASYMMETRIC  
RIDGES

# MACROSCALE FEATURES (II)



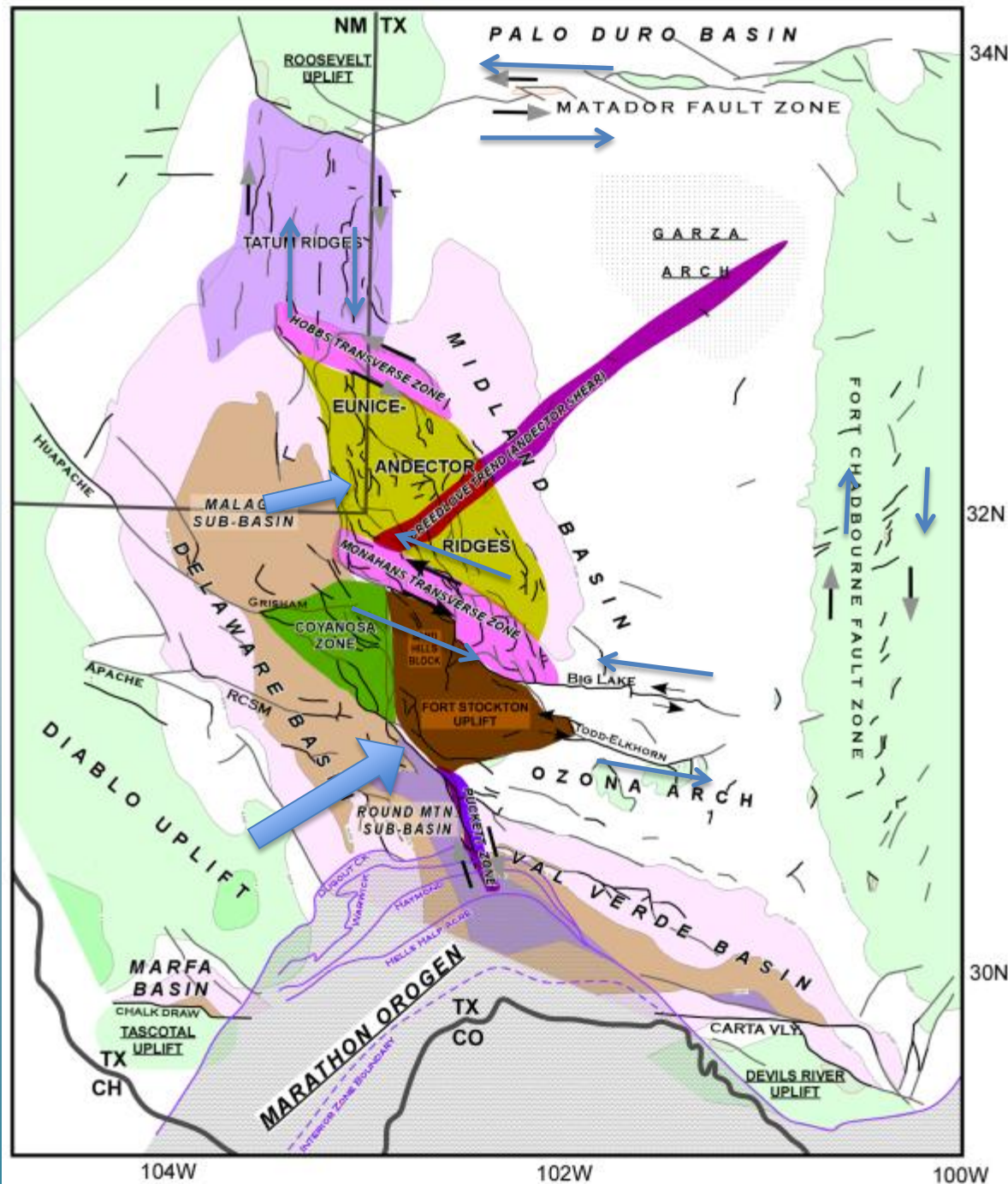
NARROW RIDGES  
INTERPRETED AS  
FLOWER STRUCTURES



LINKED RIDGES  
AND STRIKE-SLIP  
FAULTS; THE  
MACROSCALE WEB

(Blumentritt and others, 2006)

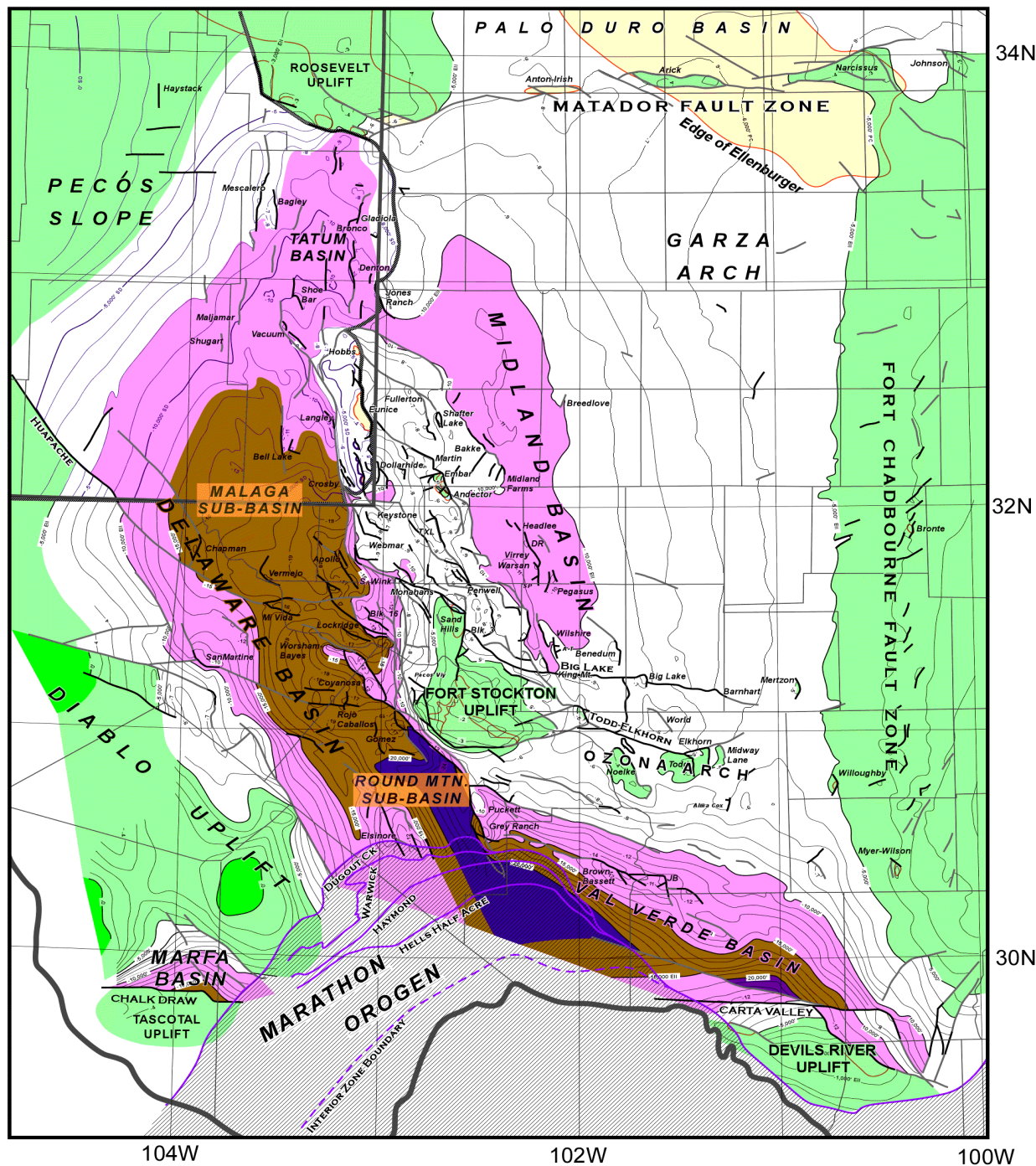




# MACROSCALE DOMAINS AND KINEMATICS

# MEGASCALE FEATURES

- Two basins and uplift
  - Delaware is only deep basin
  - Southern Delaware loaded beneath Fort Stockton High (S end of Central Basin Axis)
  - Midland basin as shallower back-basin
- Uplift trend may be inherited from Proterozoic rift trend (gravity high, mafic complex)
- Macroscale web continues over both uplifts AND basins!
  - Why? Delamination?

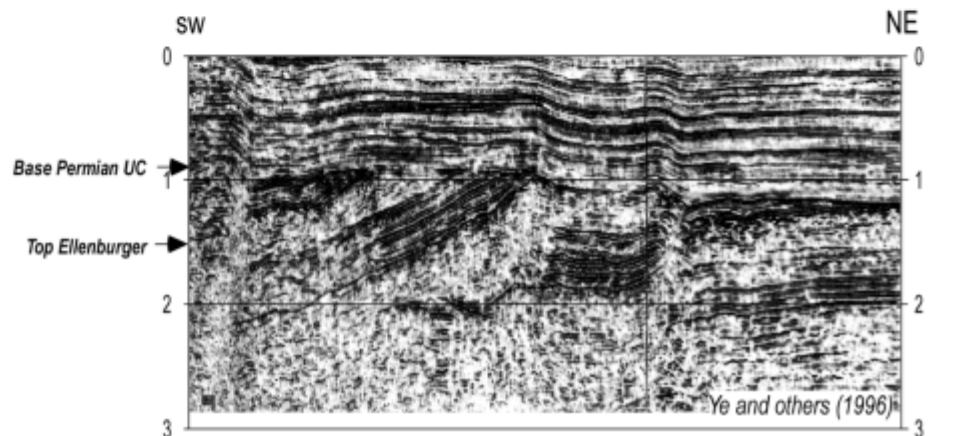
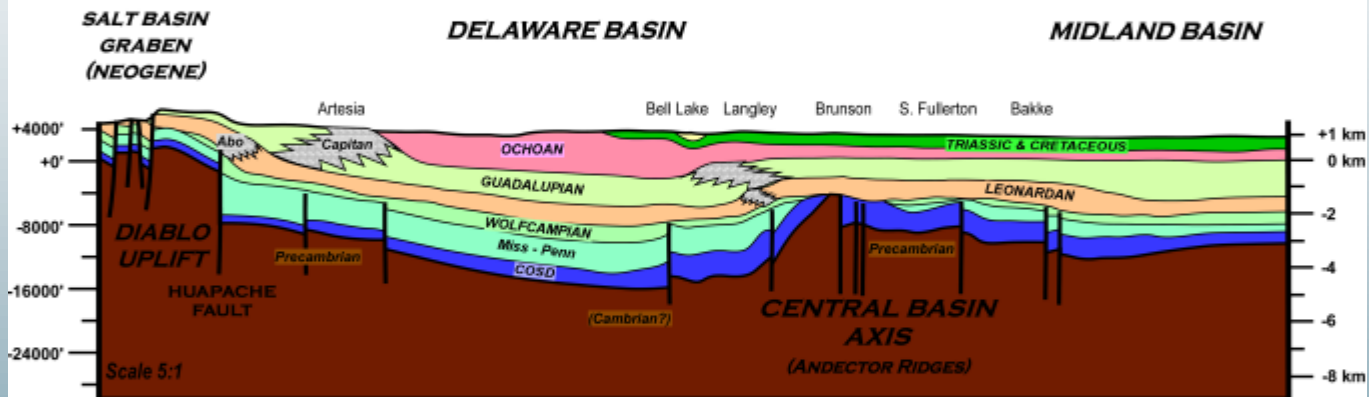
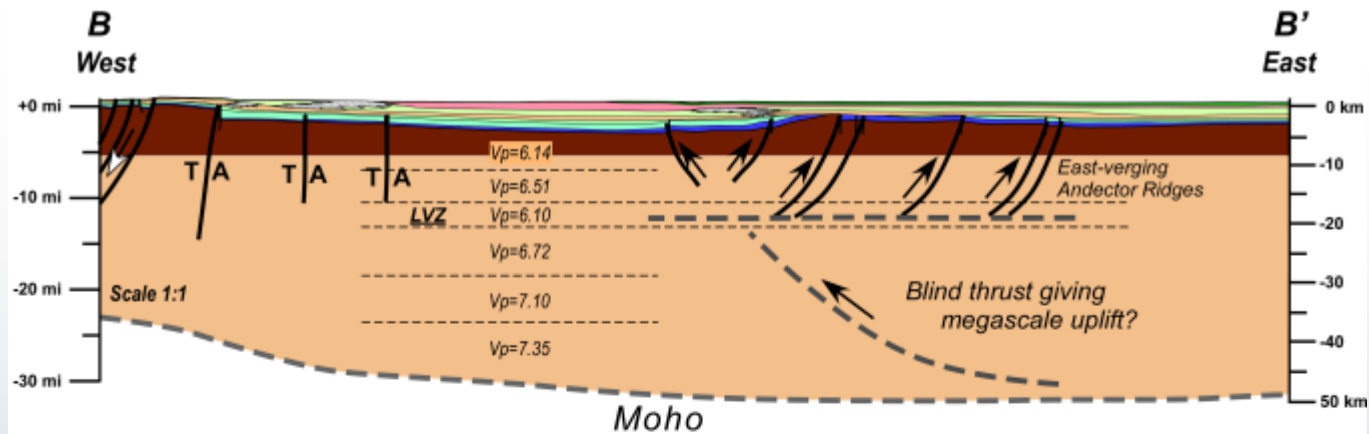


# STRUCTURE, TOP ELLEN- BURGER



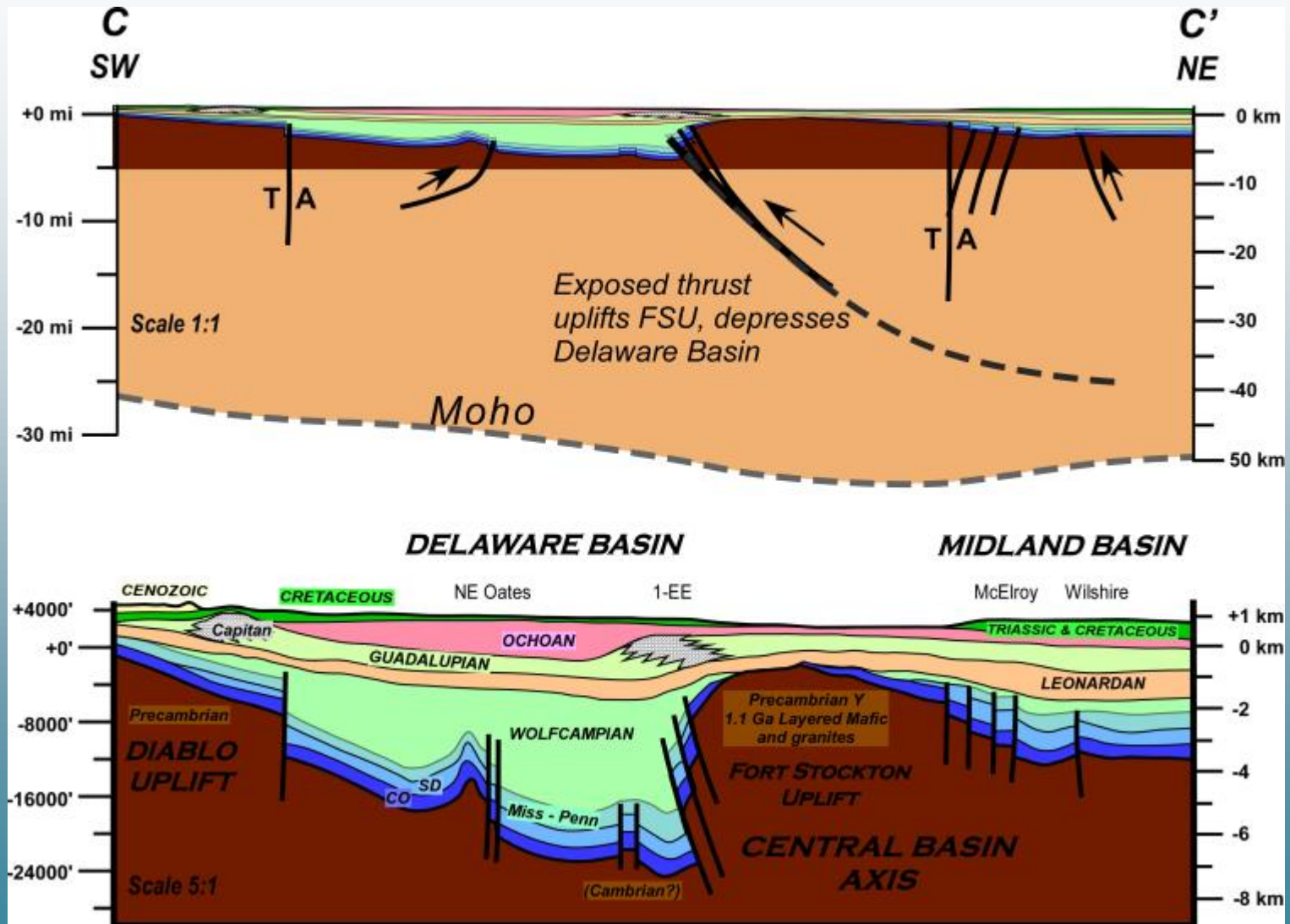
# DETACHMENT OF MACRO, MEGASCALE FEATURES

- IF scale of basement-cored features related to depth to detachment (i.e., sled-runner)...
- Macroscale features imply upper-crust detachments (<20 km)
- Megascale uplifts imply whole-crust involvement
- Detachment of scales implies a thrust of CBA over Delaware, blind except at FSU



## NORTHERN SECTION

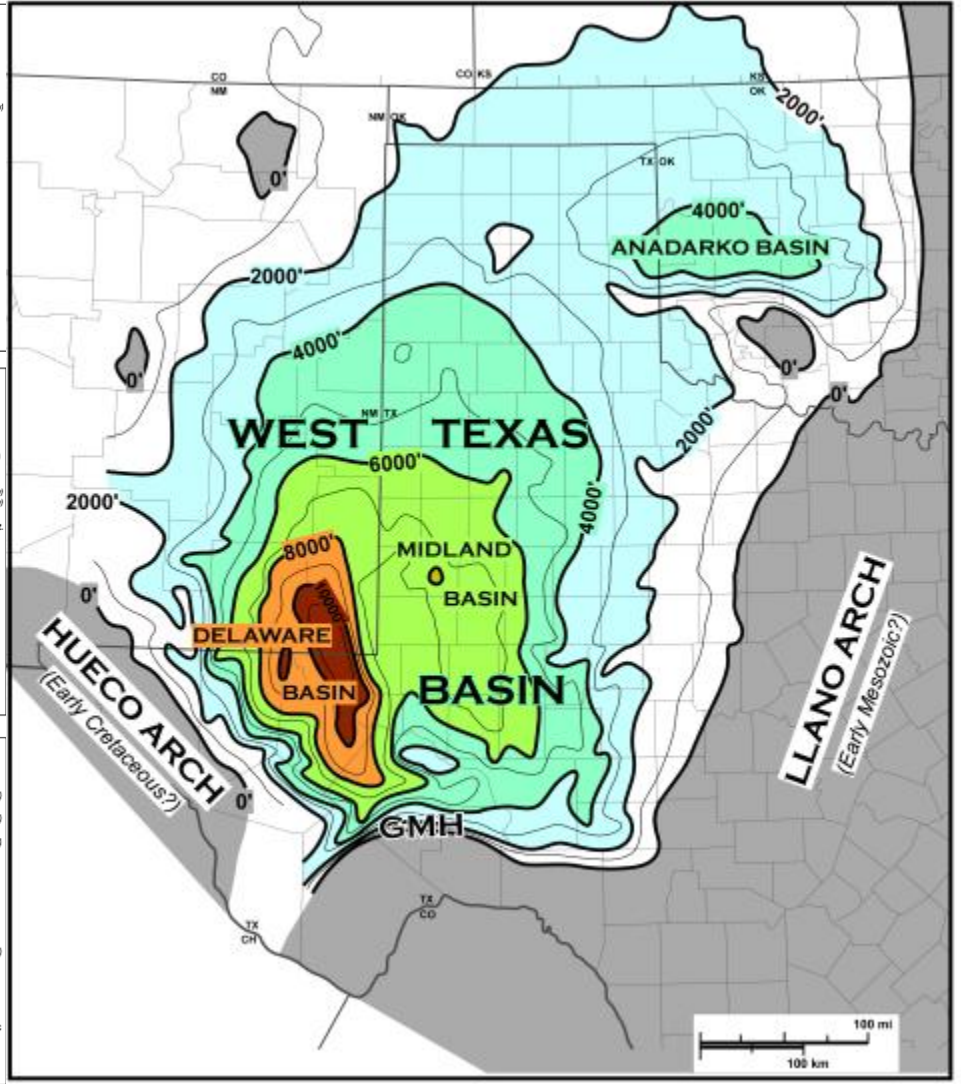
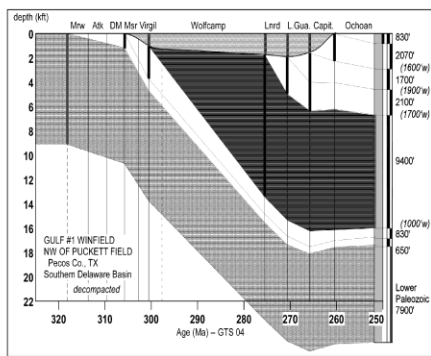
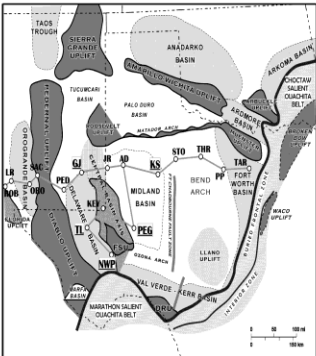
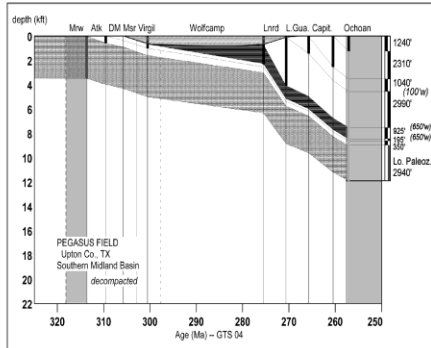
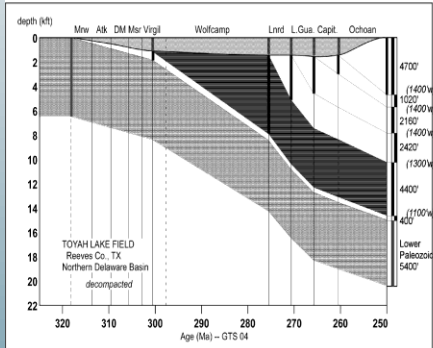
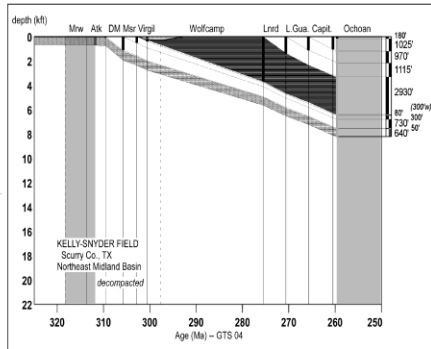
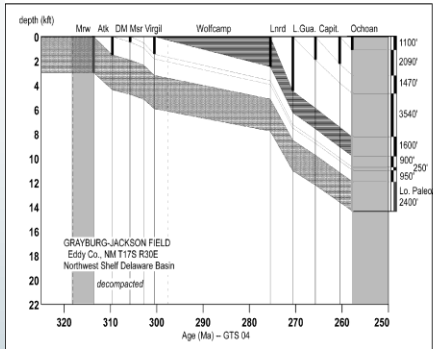
# CENTRAL SECTION (FT. STOCKTON UPLIFT)



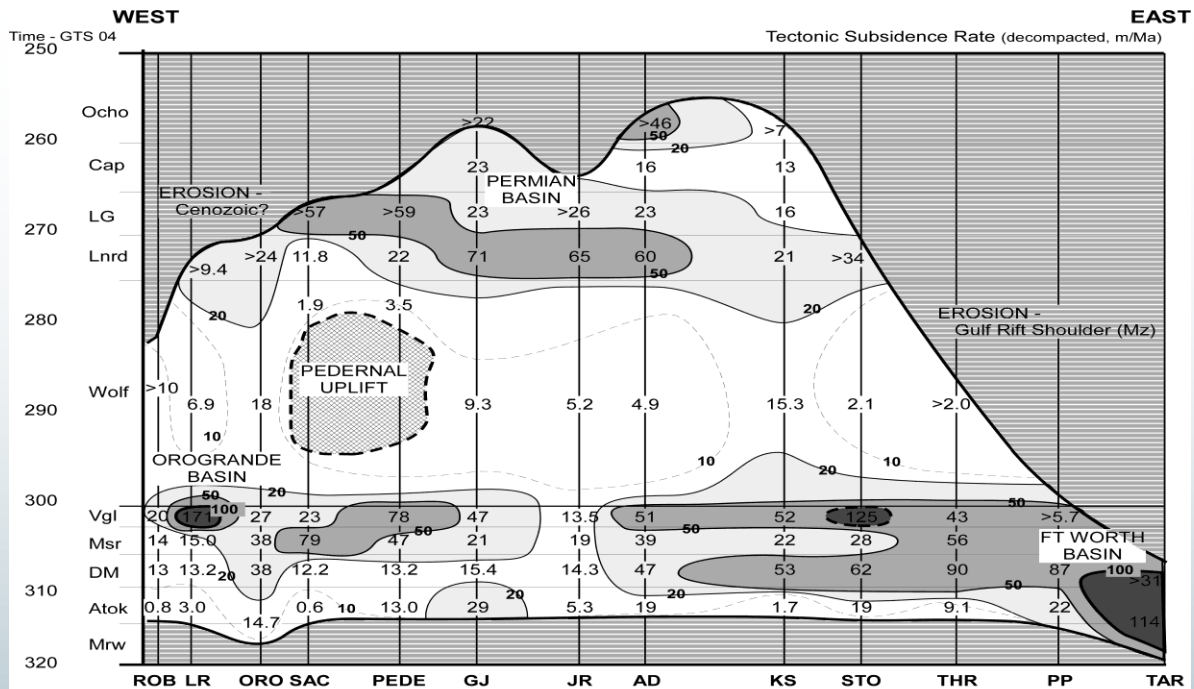
# GIGASCALE SUBSIDENCE

- Basinwide subsidence begins in Pennsylvanian
  - Responsible for very minor erosion of uplifts, lack of basement exposures
- Subsidence outlasts deformation into late Permian
  - Thick complex sedimentary package, finally sealed by Ochoan salt
  - Causes maturation of Devonian-Penn shales and charging of reservoirs

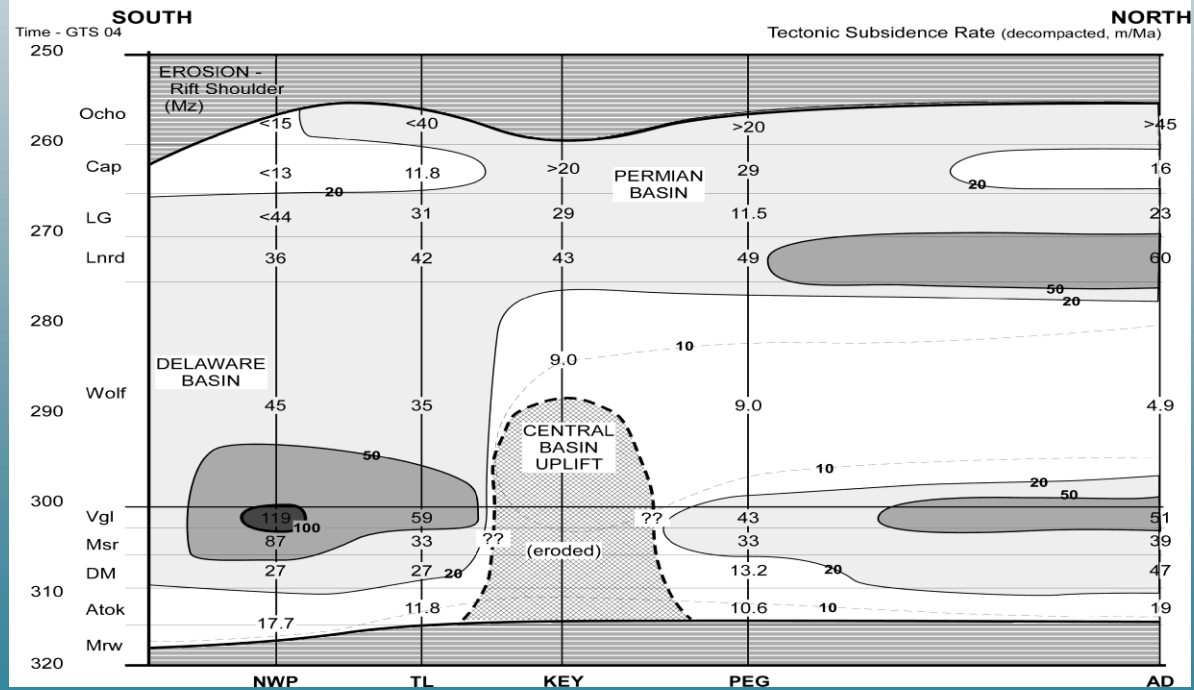
# BASINWIDE SUBSIDENCE







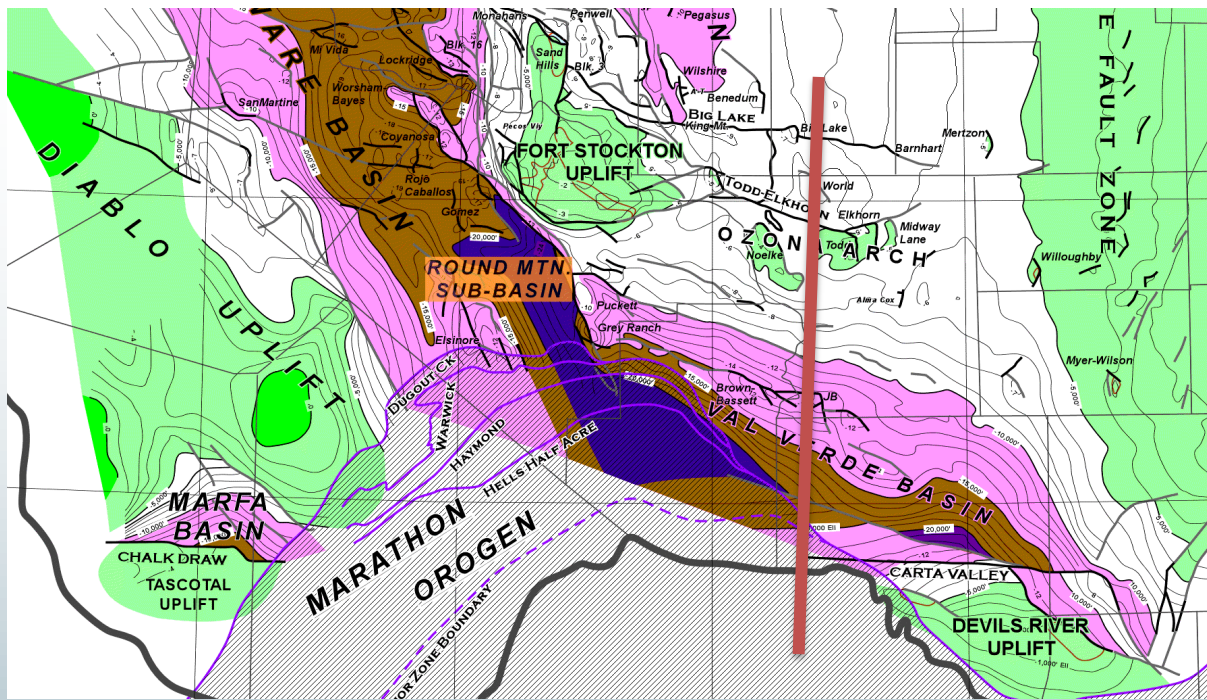
# SUBSIDENCE THROUGH TIME



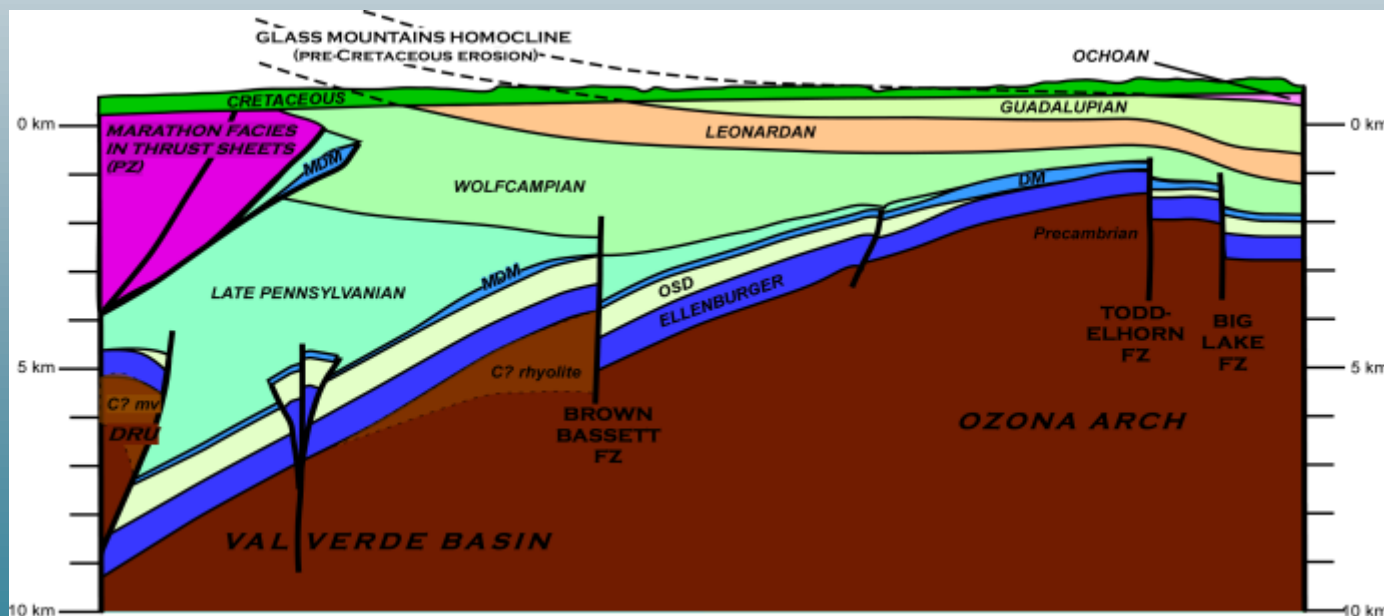
*(EW and NS  
Sections)*

# WHAT ABOUT THE MARATHON?

- Marathon orogen is thin-skinned, apparently NW-directed at south end of WTB
- Val Verde Basin modeled as foredeep; Ozona Arch as forebulge; Devils River uplift as subthrust high block (with older history)
- No good kinematic way to make Marathon impingement responsible for most WTB deformation!



# SOUTHERN MAP, SECTION





# SUMMARY

- WTB contains multiple scales of deformation
  - Overlap in space and time, but are separable!
- Macroscale web of structures cover most of basin
  - Responding to NE-SW compression, strike-slip
- Megascale Uplift (CBA) and Basin (Delaware)
  - West-verging, visible in part; blind to N?
- Gigascale Late Paleozoic subsidence
  - buries and seals ARM deformation
  - Causes maturation and charging of the basin