Subsurface mapping of the Trinity Group in west Texas

yields insights into the southern limit of the Santa Rosa sandstone, age of the Pecos River, location of Yates and Toborg fields, and magnitude of post-Cretaceous uplift of the Glass Mountains

TEXAS WATER DEVELOPMENT BOARD

WTGS Fall Symposium

9/18/2025

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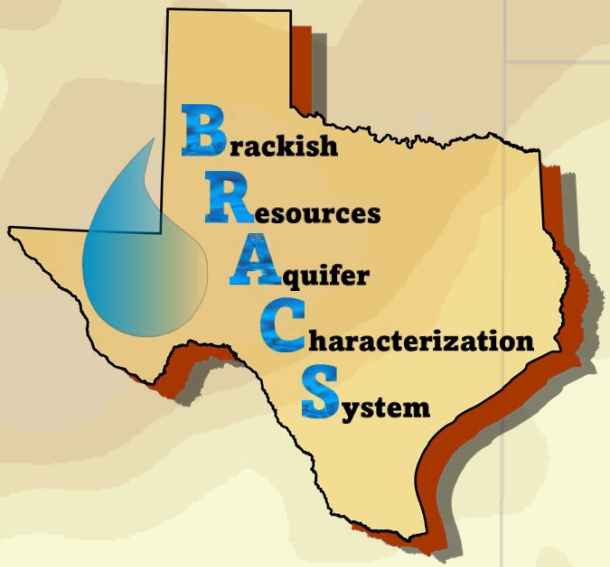
TWDB BRACS department



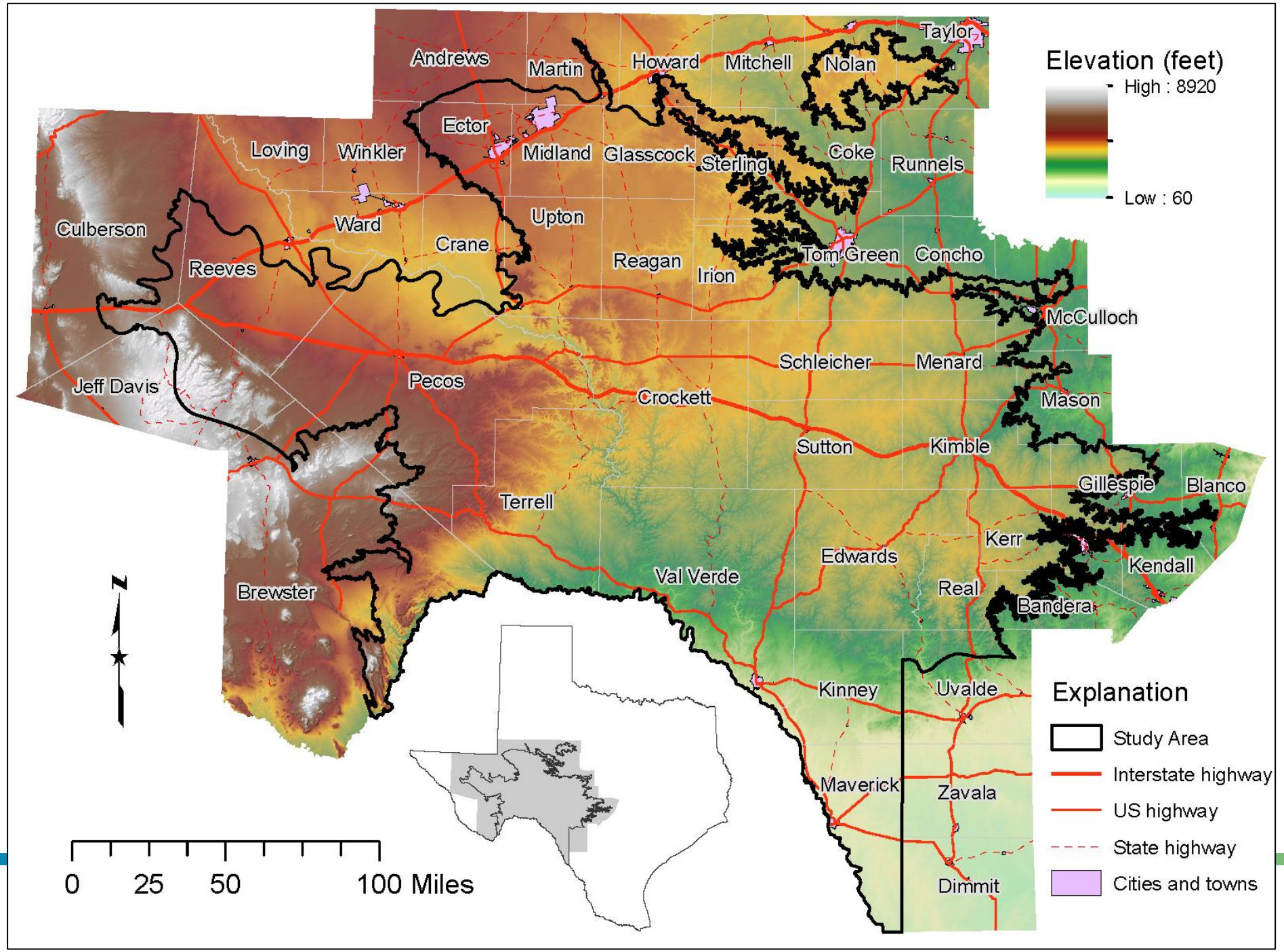
Disclaimer

The following presentation is based upon professional research and analysis but, unless specifically noted, does not necessarily reflect official Texas Water Development Board positions or decisions.

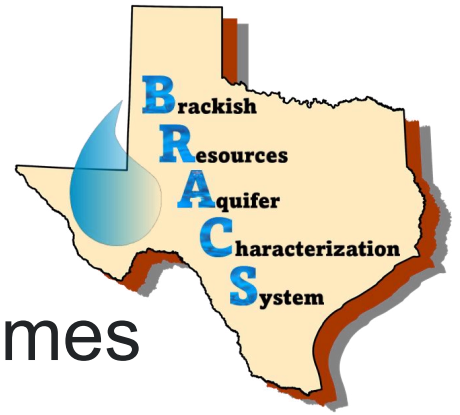
Study area

Modified boundary of Edwards-Trinity (Plateau) Aquifer

Includes brackish and previously unmapped portion of units

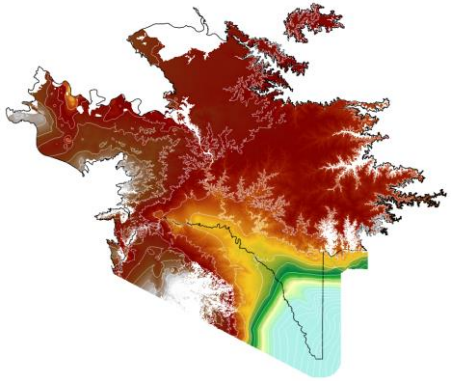


Edwards-Trinity (Plateau) Aquifer brackish groundwater study

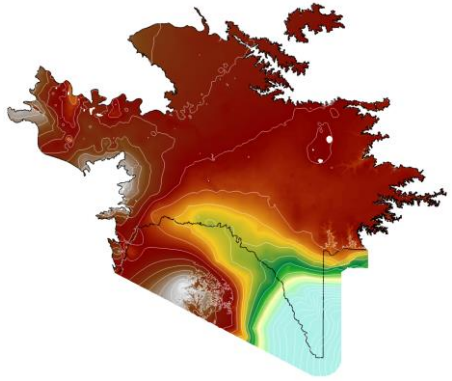


- Goal: Map the aquifer structure, salinity, and brackish volumes
- Completed: Surfaces, salinity maps

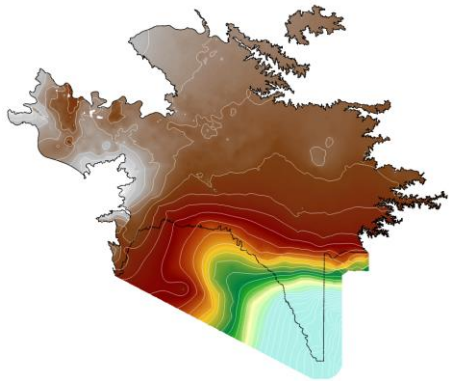
Edwards Group top elevation



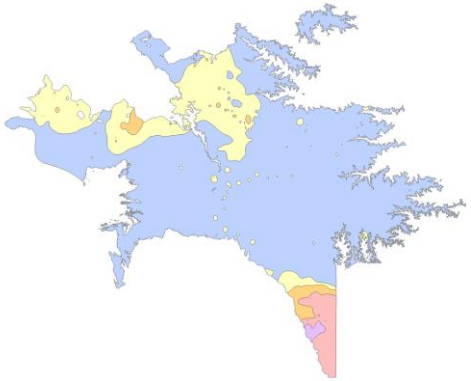
Trinity Group top elevation



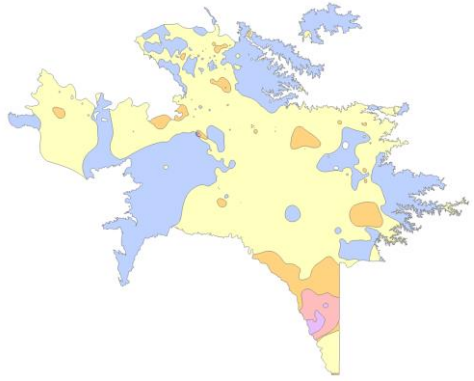
Cretaceous bottom elevation



Edwards Group salinity



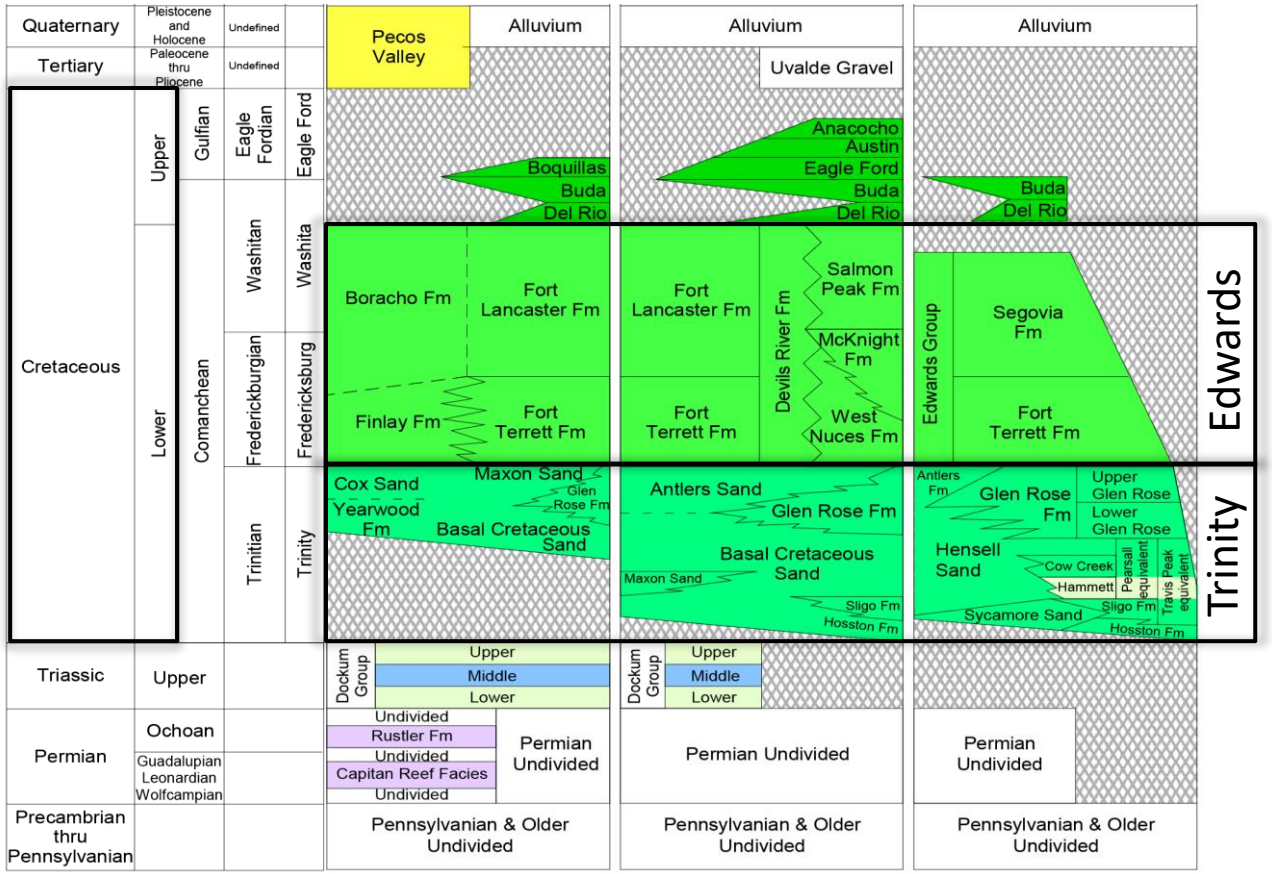
Trinity Group salinity

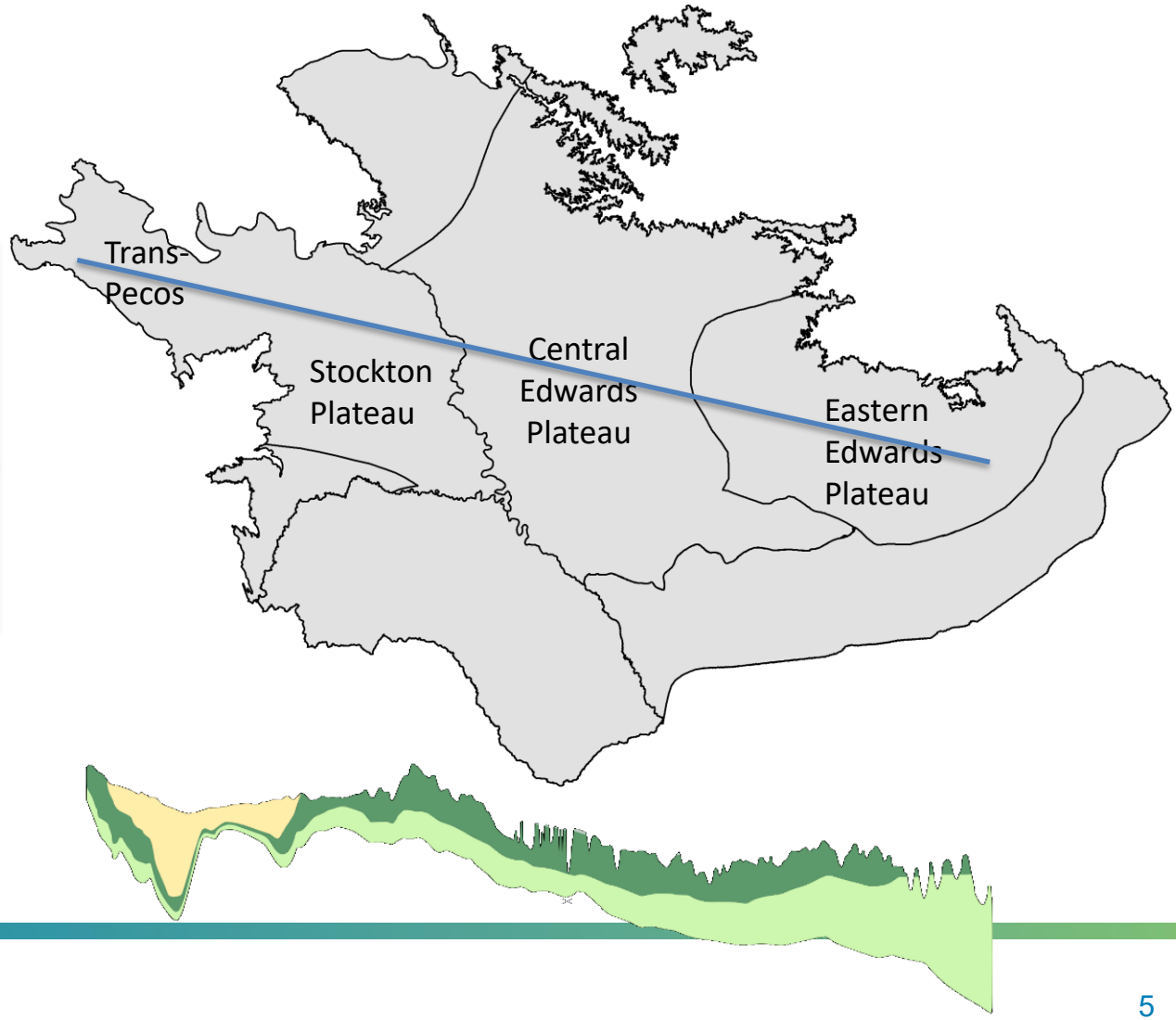


- Ongoing: Water levels, lithology, volumes

Stratigraphy

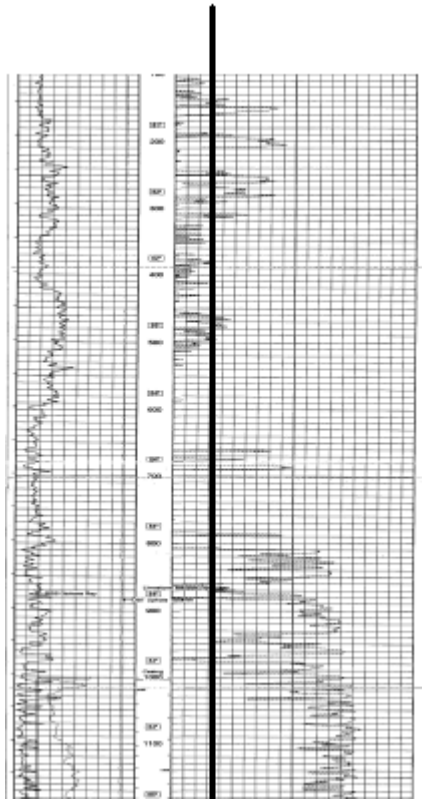
- Mapped Edwards and Trinity groups
- Trinity Group deposited on unconformity
- Edwards Group outcrops over plateau



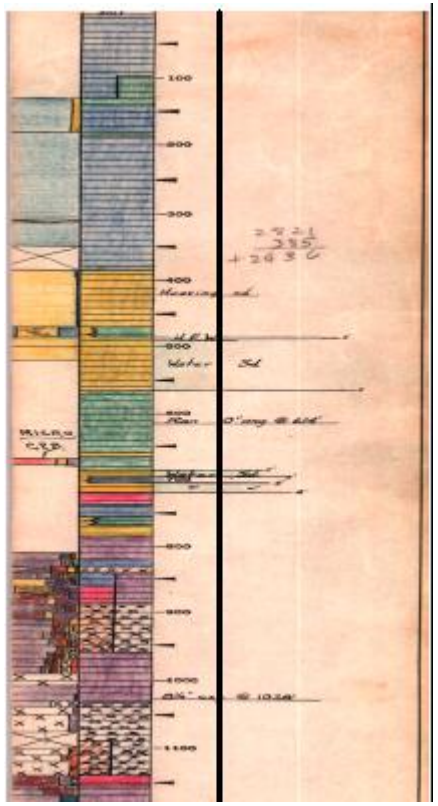


Data for stratigraphic mapping

Geophysical logs



Mud logs

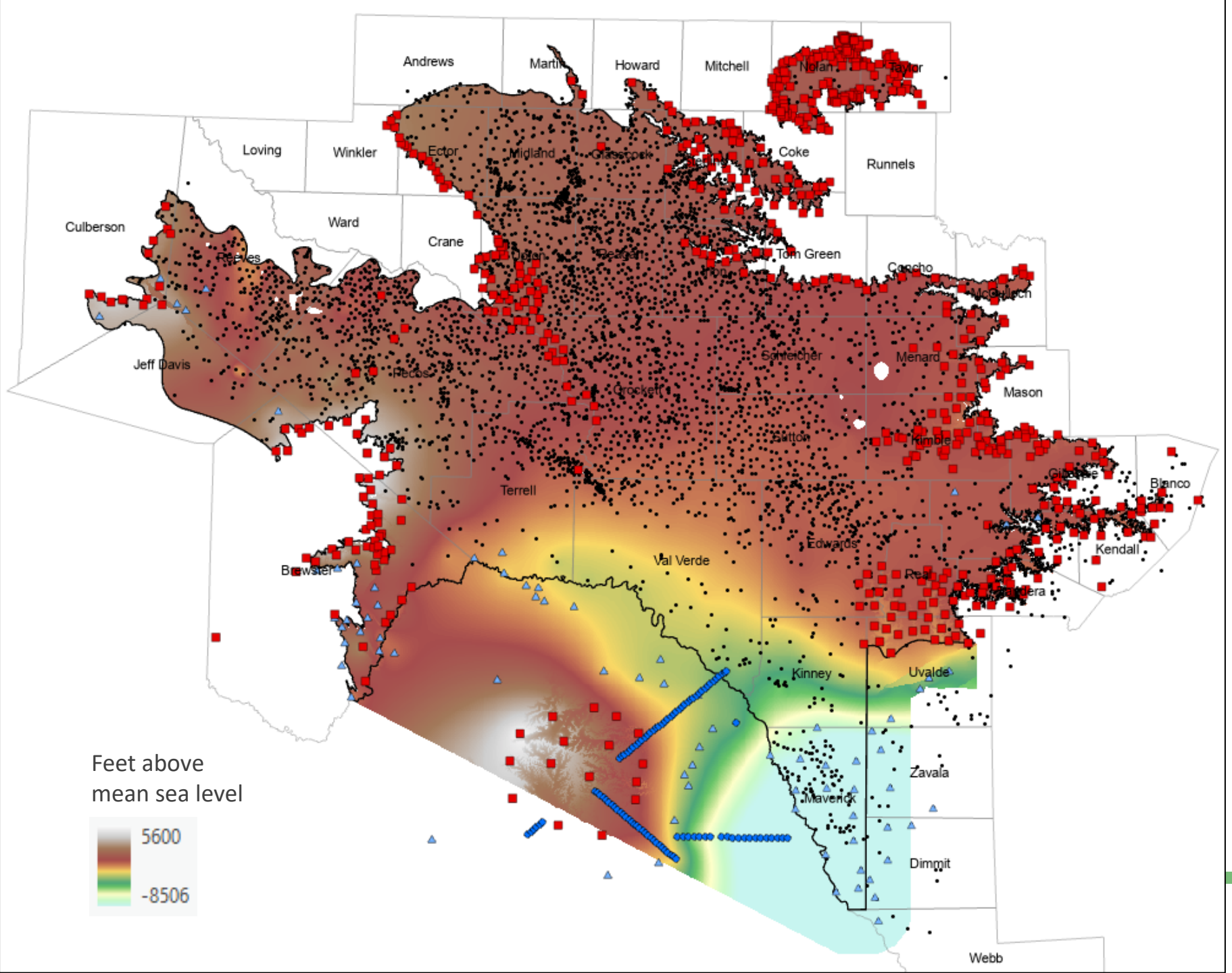


Outcrop elevations

- Used Geologic Atlas of Texas
- Precise location from imagery
- Elevation from USGS topo maps

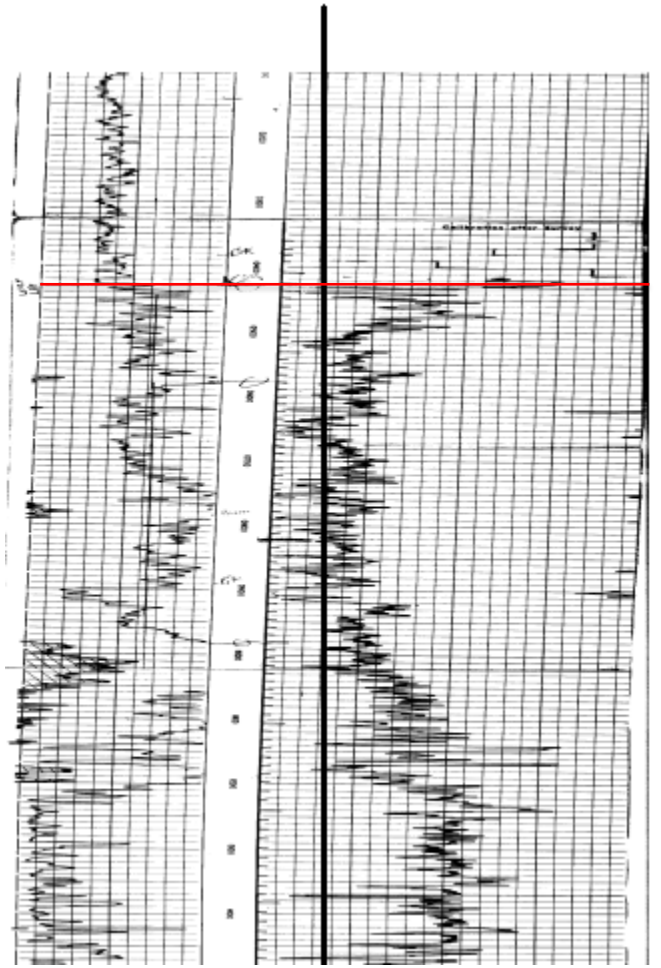
Top Trinity Group example

- Well picks:
  n = 3,268
- Outcrop picks:
  n = 658
- Control points:
  n = 181

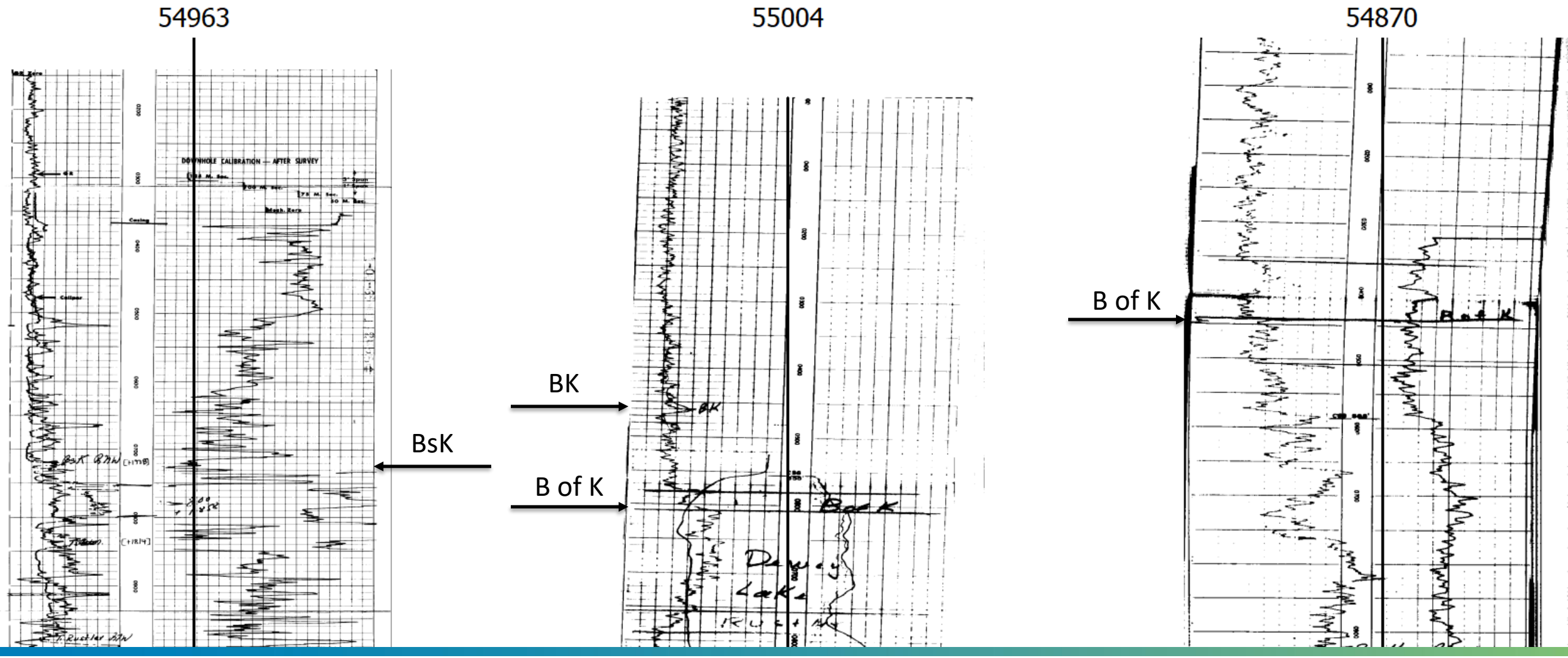


Challenges

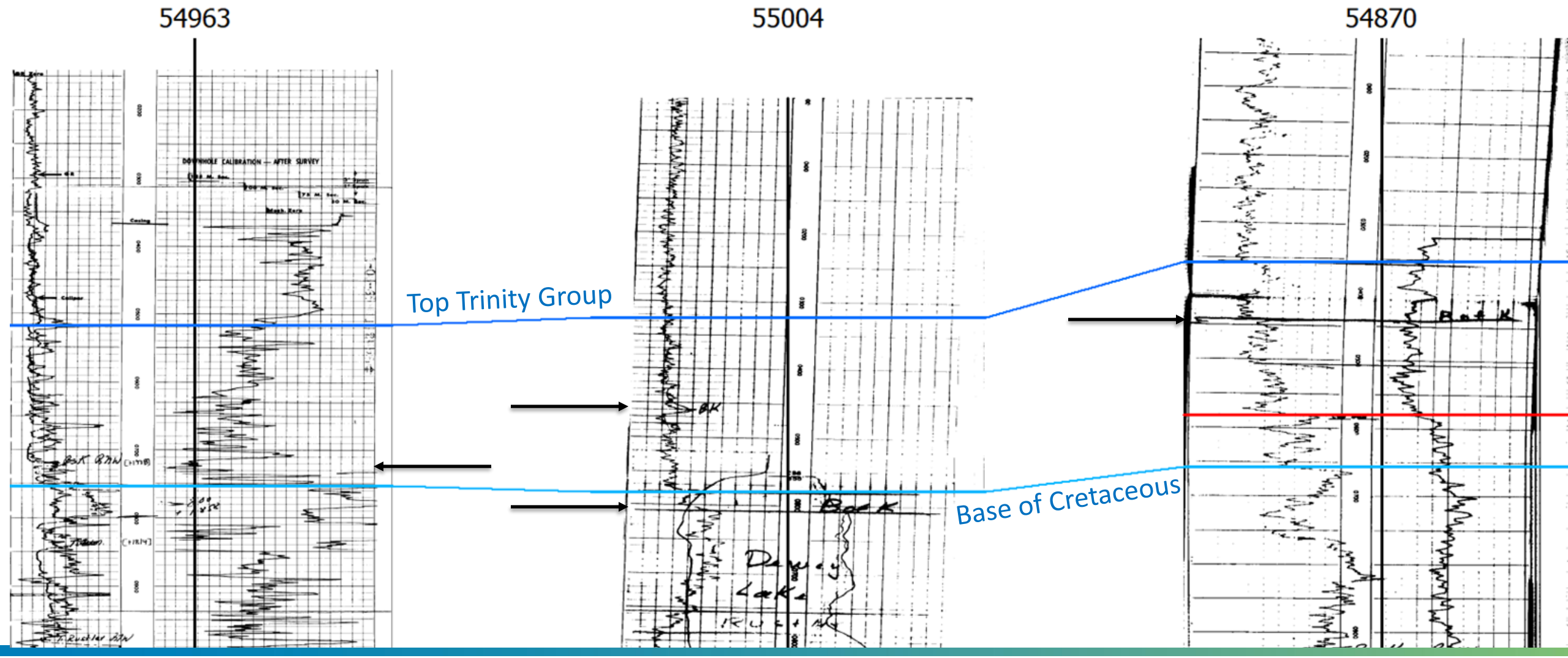
- Cased gamma ray logs
- Log quality highly variable
- Casing changes can muddle formation boundaries



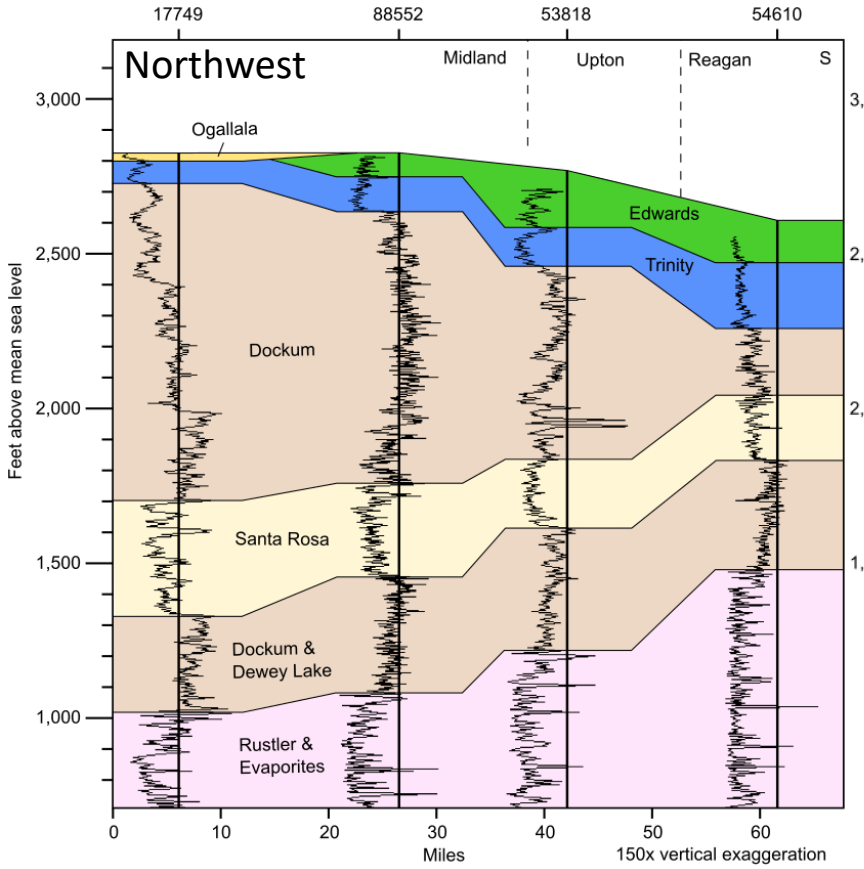
Challenges: many base Cretaceous interpretations

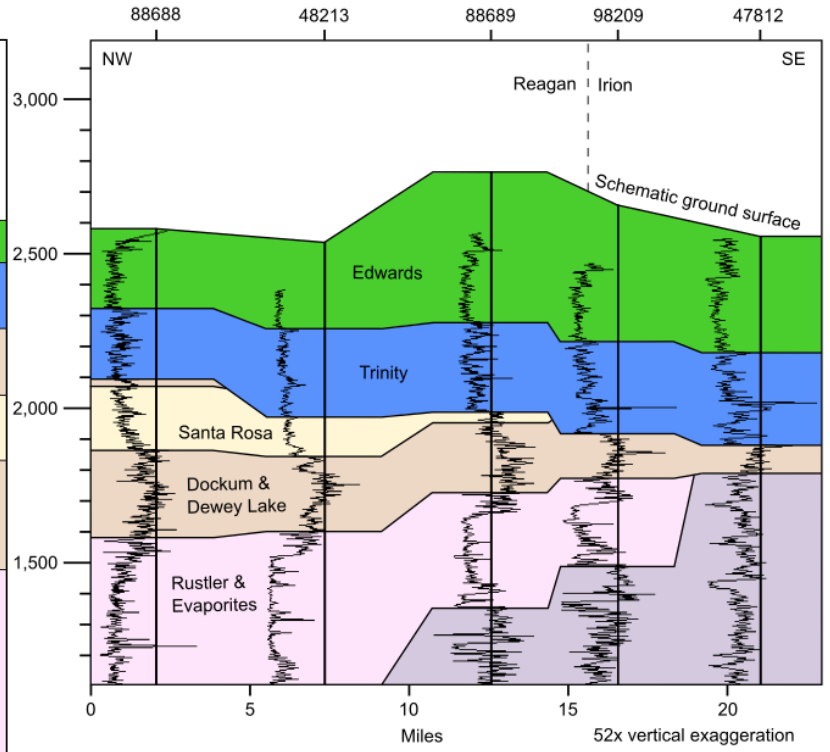


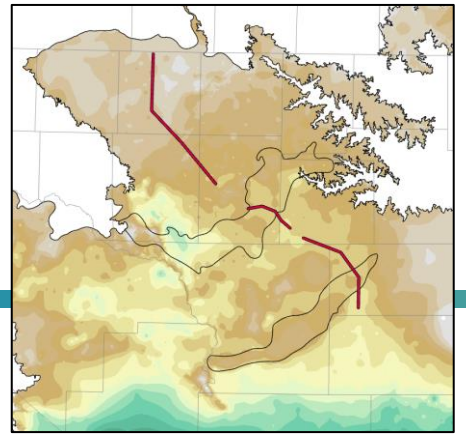
Challenges: many base Cretaceous interpretations

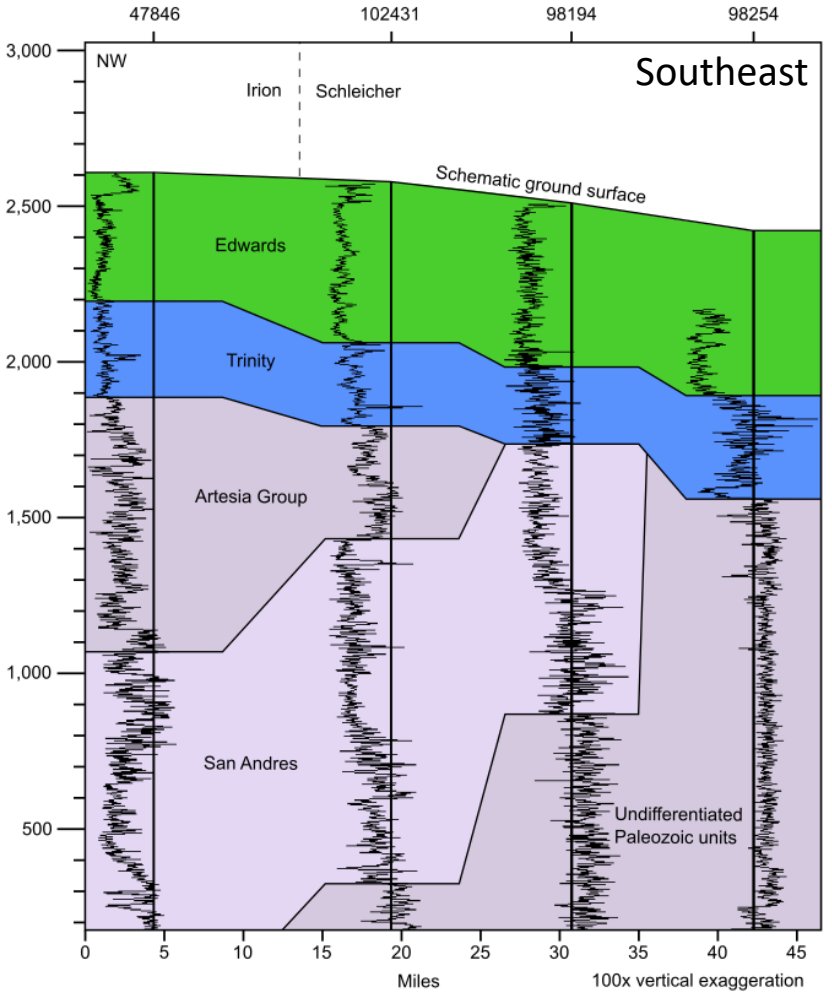


1. Southern limit of Santa Rosa sandstone









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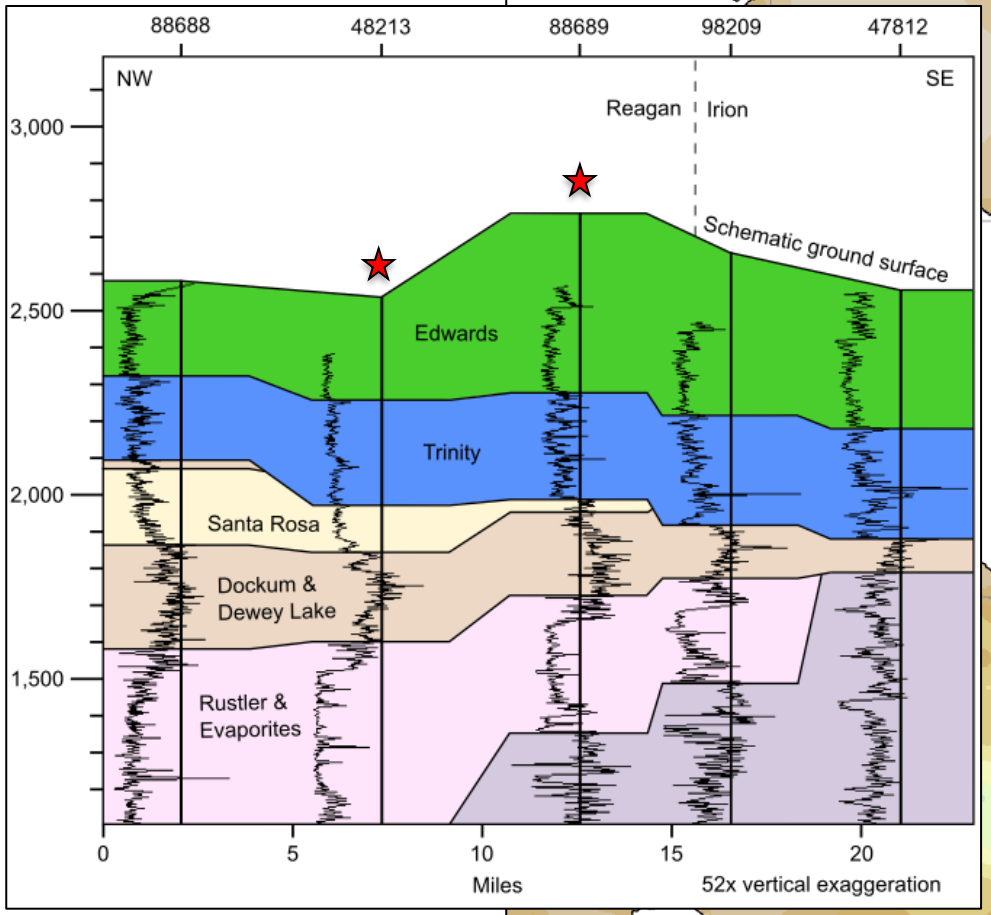

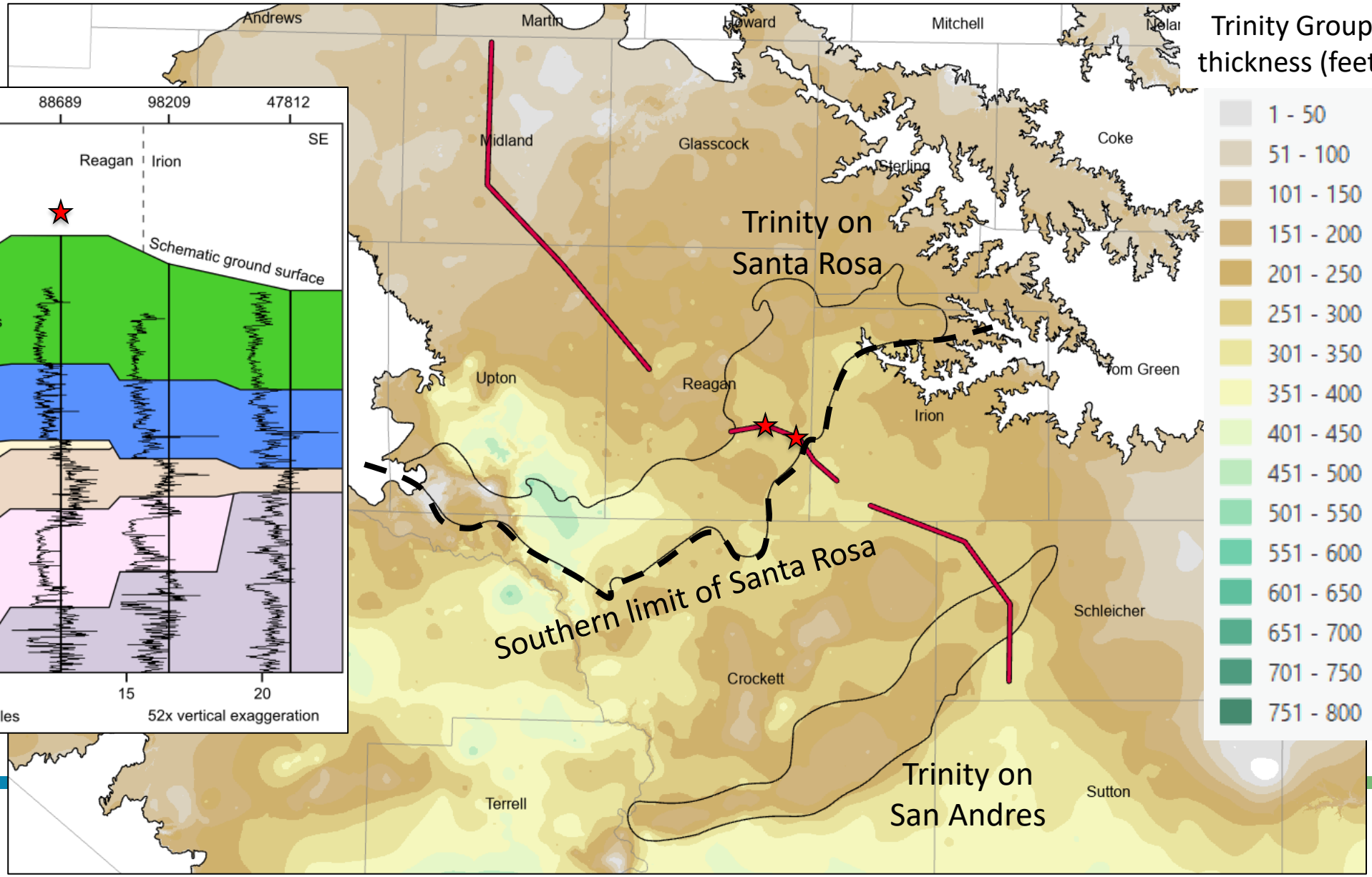

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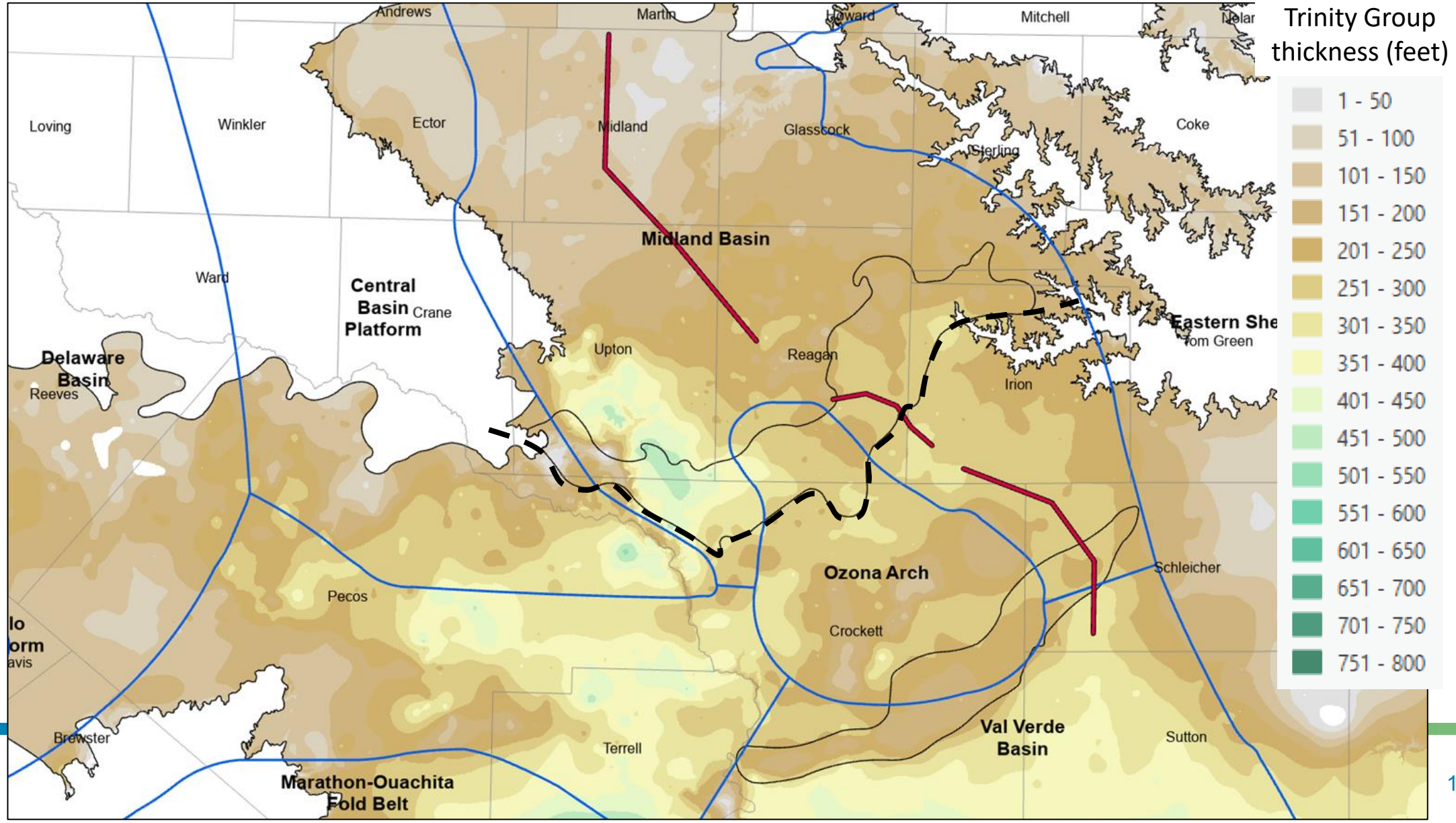
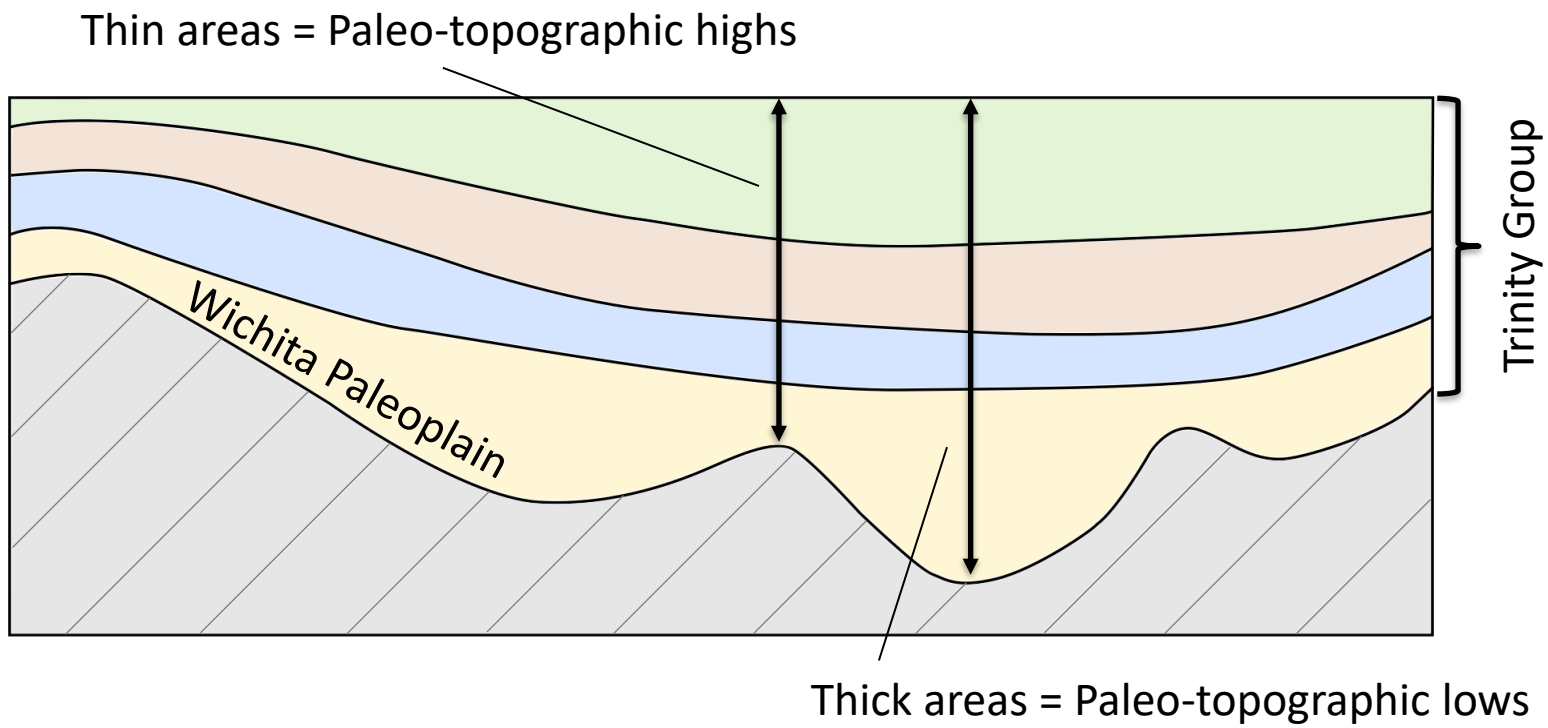
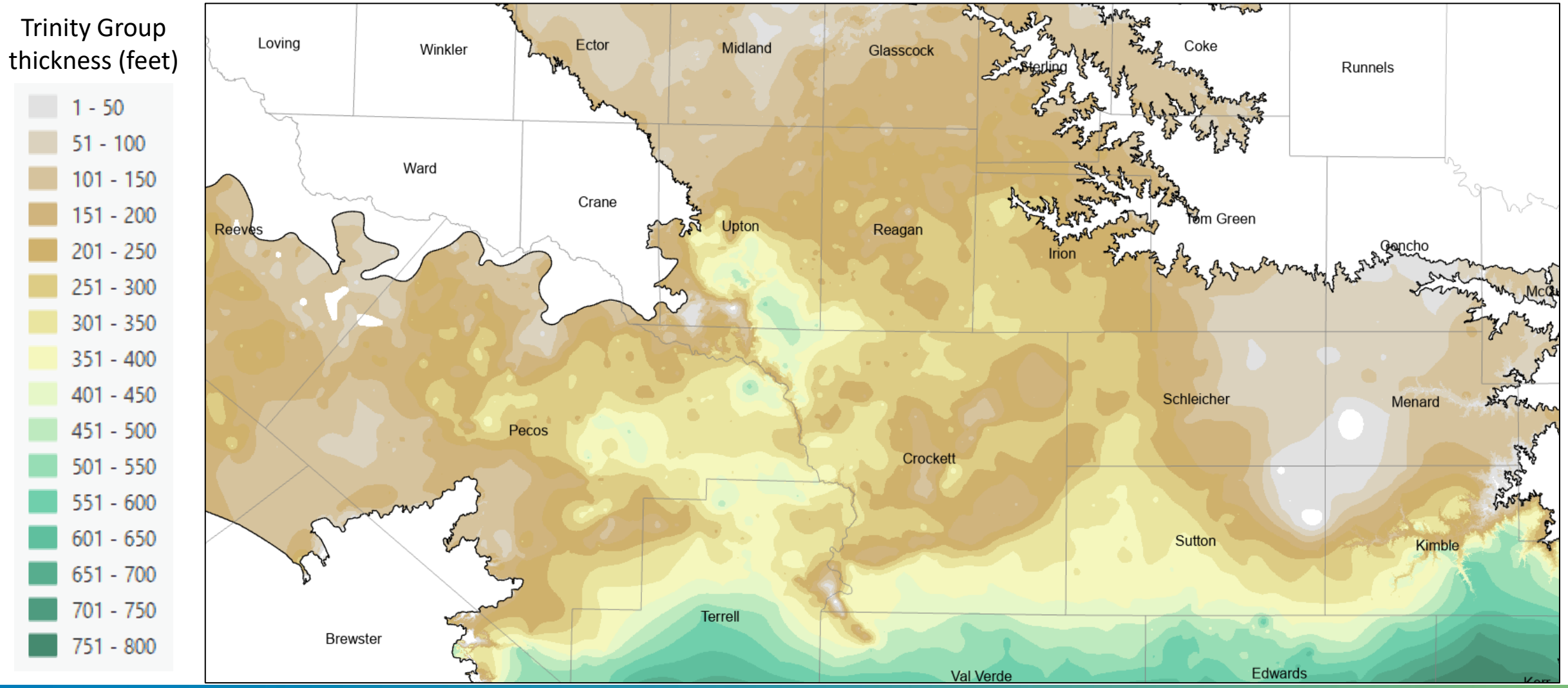


Trinity Group thickness and paleo-topography

- Trinity Group deposited on erosional surface (Wichita Paleoplain)
- Infilled pre-existing topography
- Thickness map approximates paleo-topography



Trinity Group thickness map



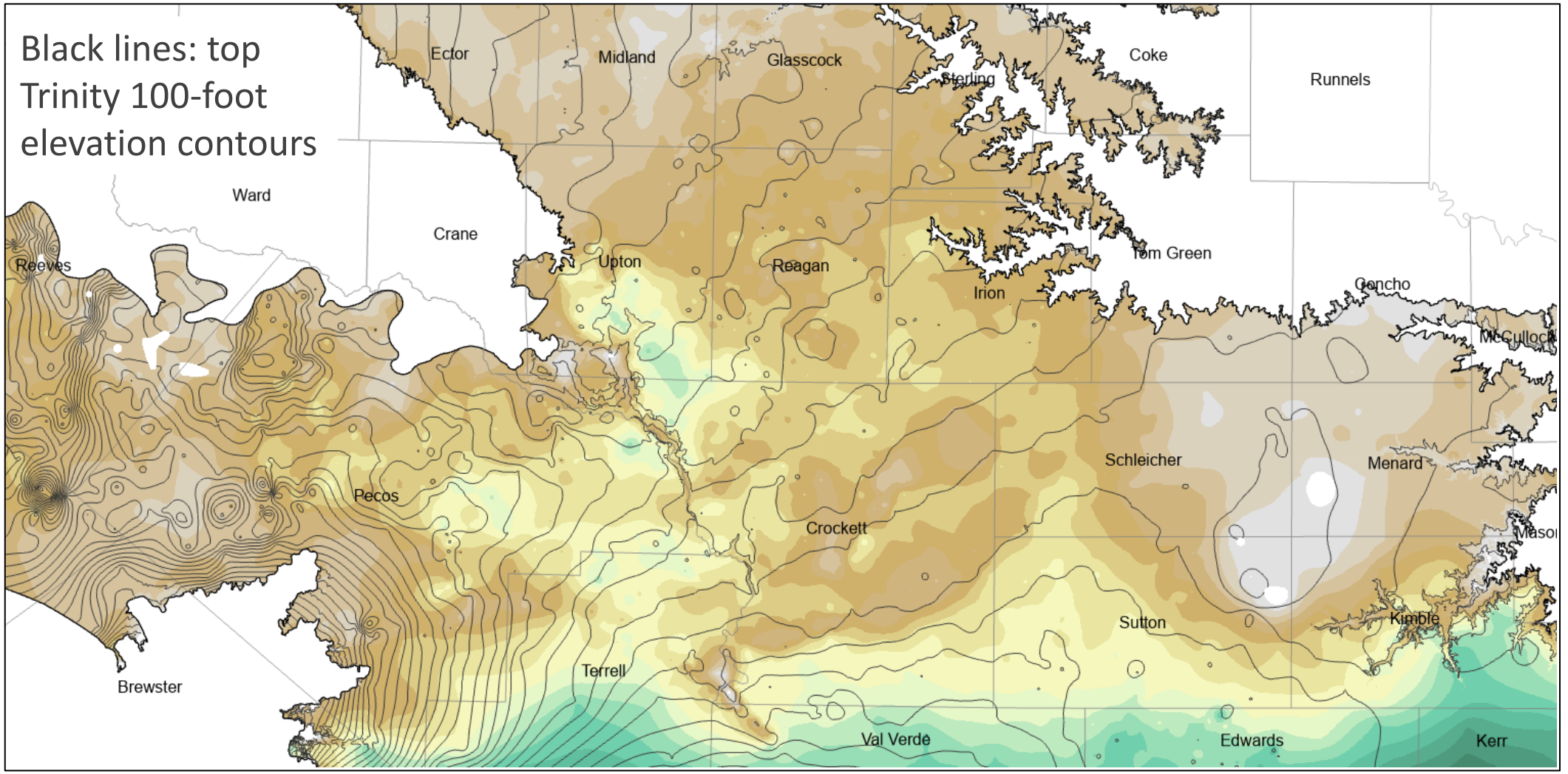
50-foot thickness contours

100 miles

Trinity Group thickness

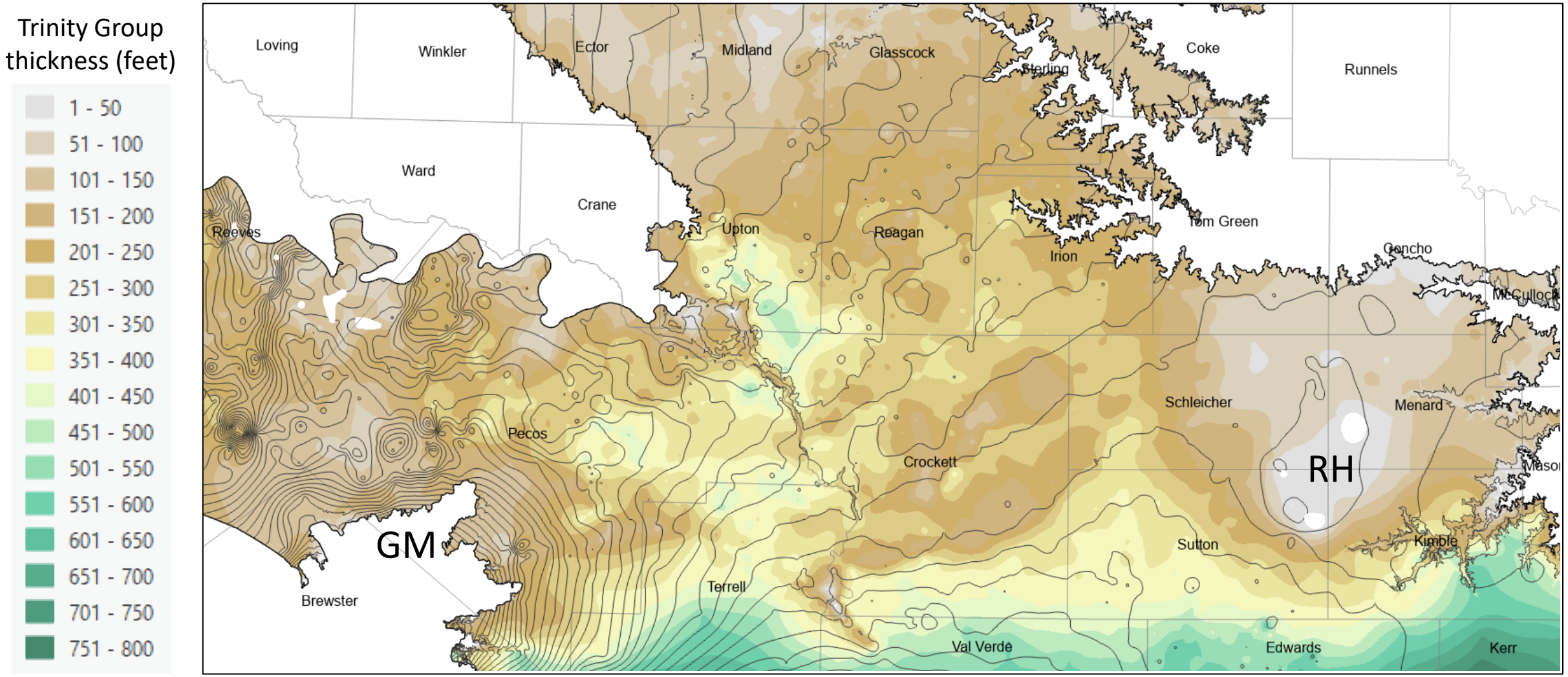
Trinity Group thickness (feet)

- 1 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 - 650
- 651 - 700
- 701 - 750
- 751 - 800



Elevation contours parallel thickness contours in east, not in west

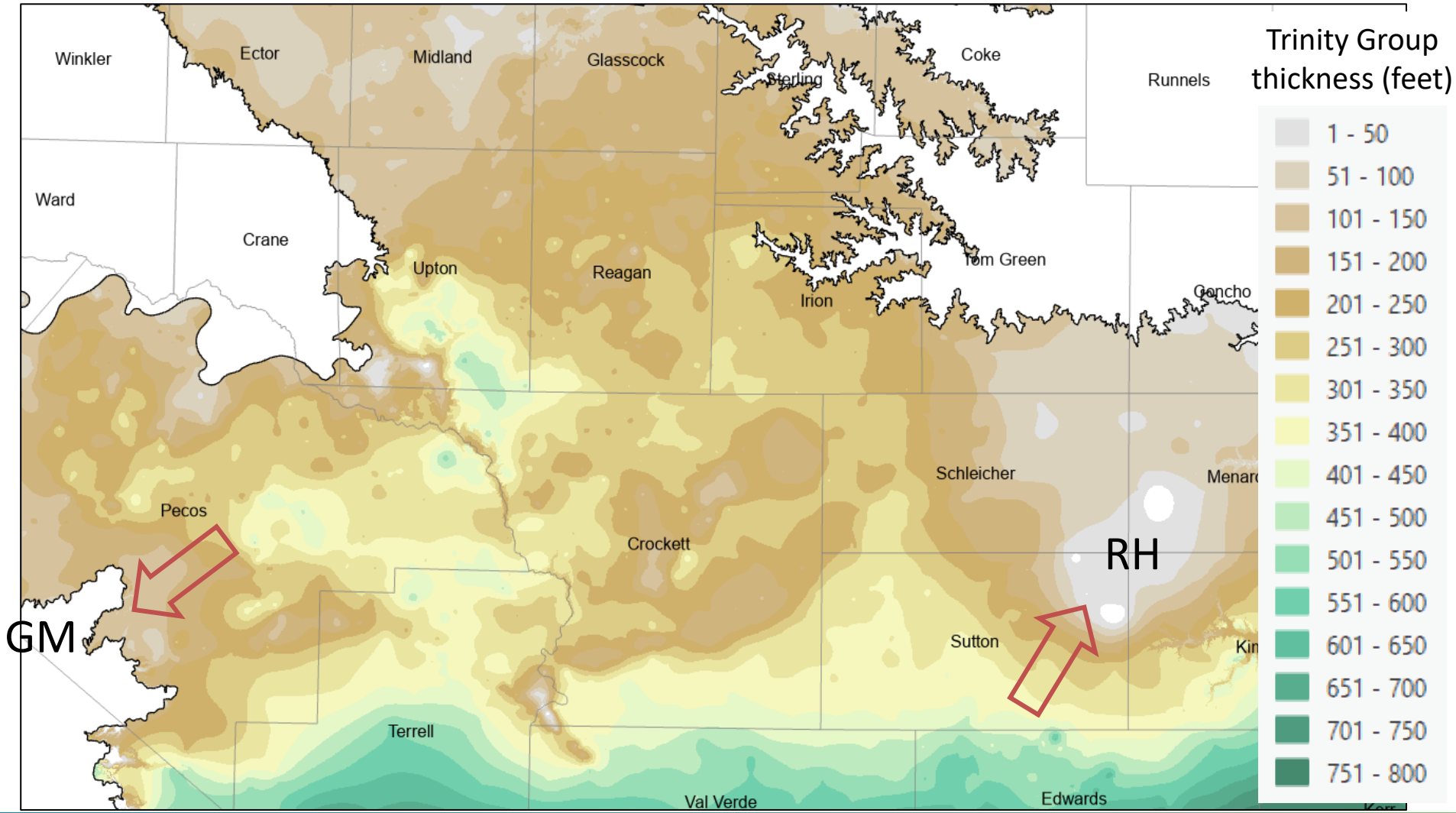
2. Post-Cretaceous uplift at Glass Mountains



Note Glass Mountains significantly higher than Roosevelt High

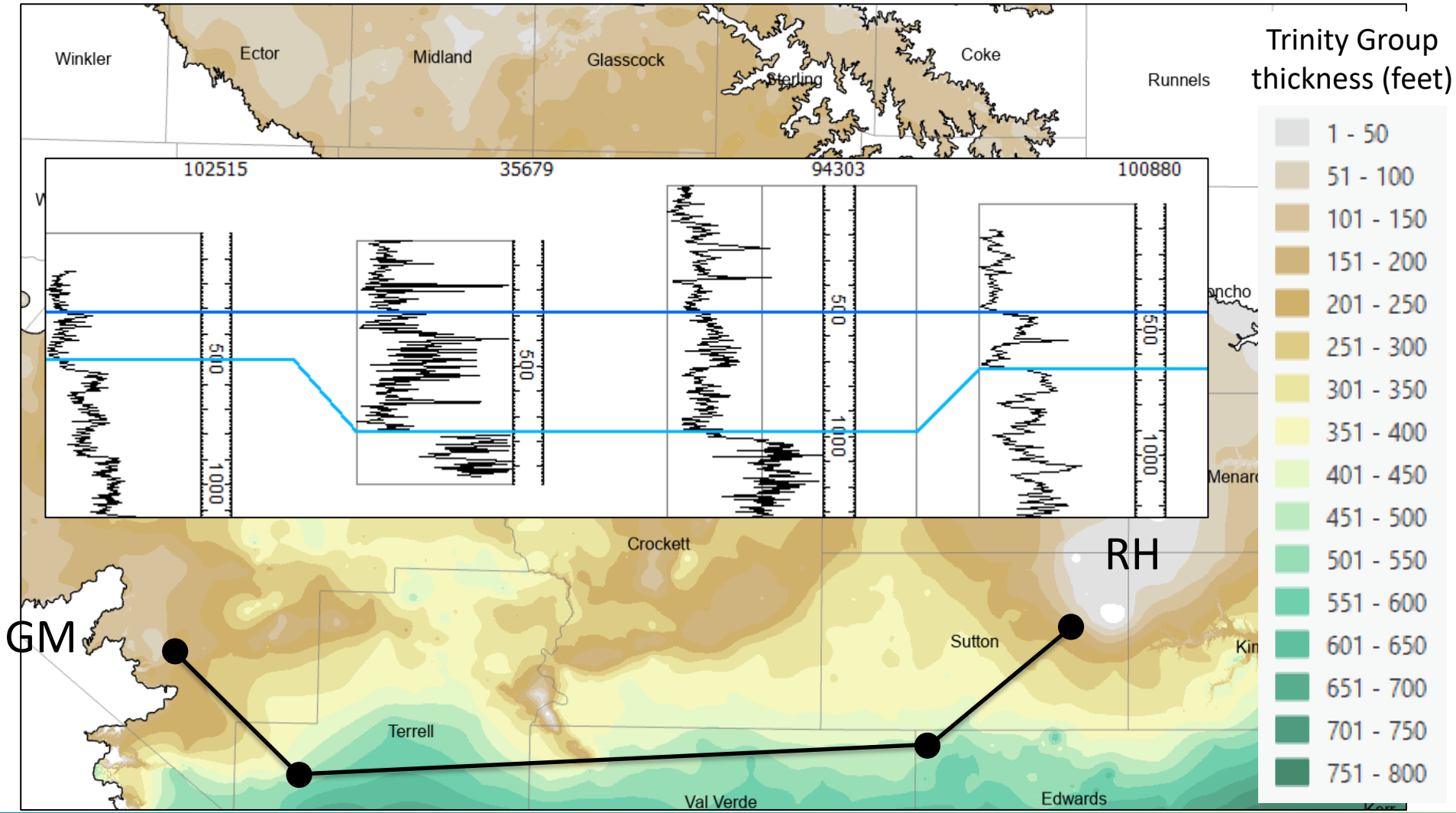
2. Post-Cretaceous uplift at Glass Mountains

- Trinity thins on flanks of Glass Mountains and Roosevelt High
- Glass Mountains was paleo-topographic high that was further uplifted (King, 1926)



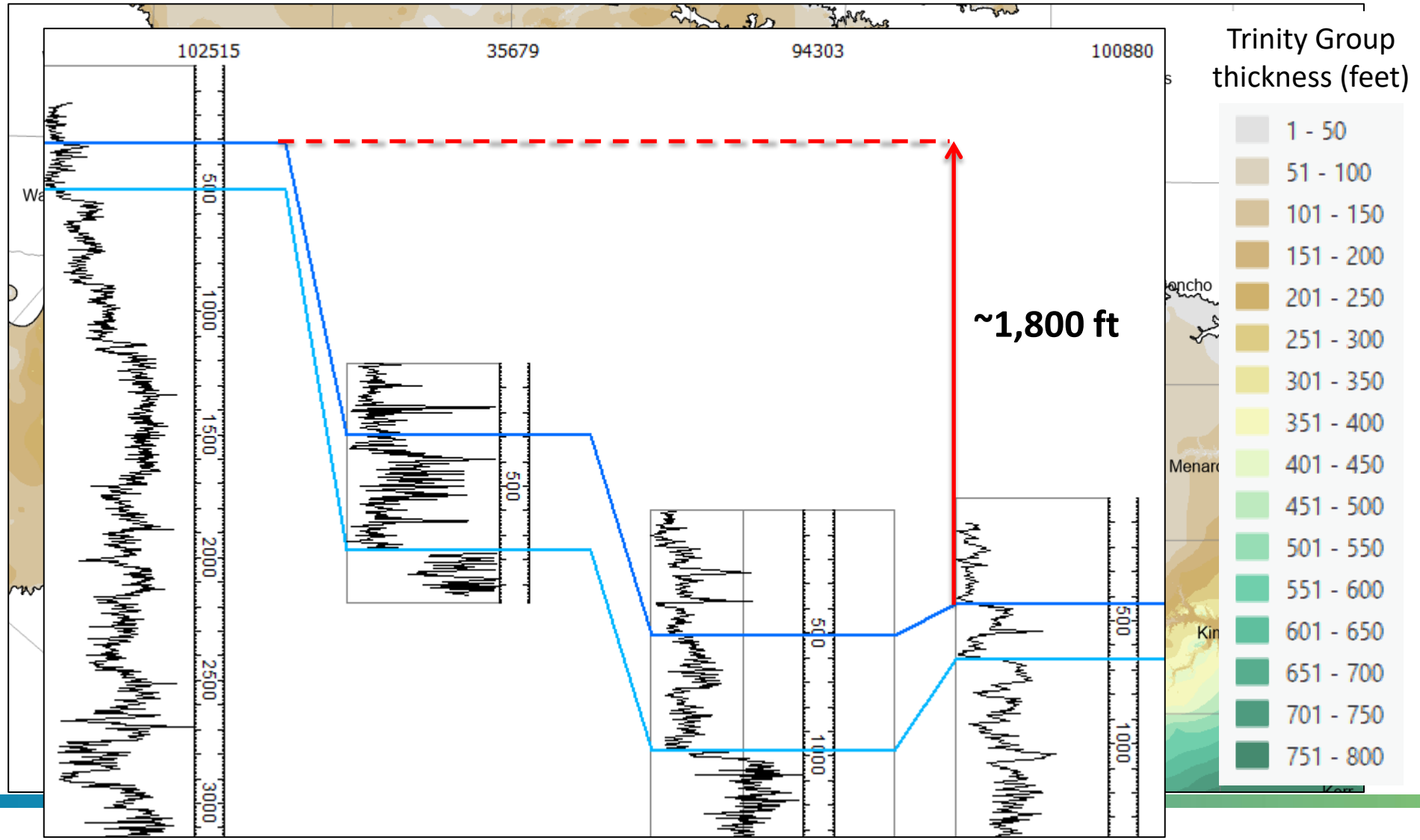
2. Post-Cretaceous uplift at Glass Mountains

- Flattened cross section: similar Trinity Group in both areas
- These points were deposited at approximately equal elevations



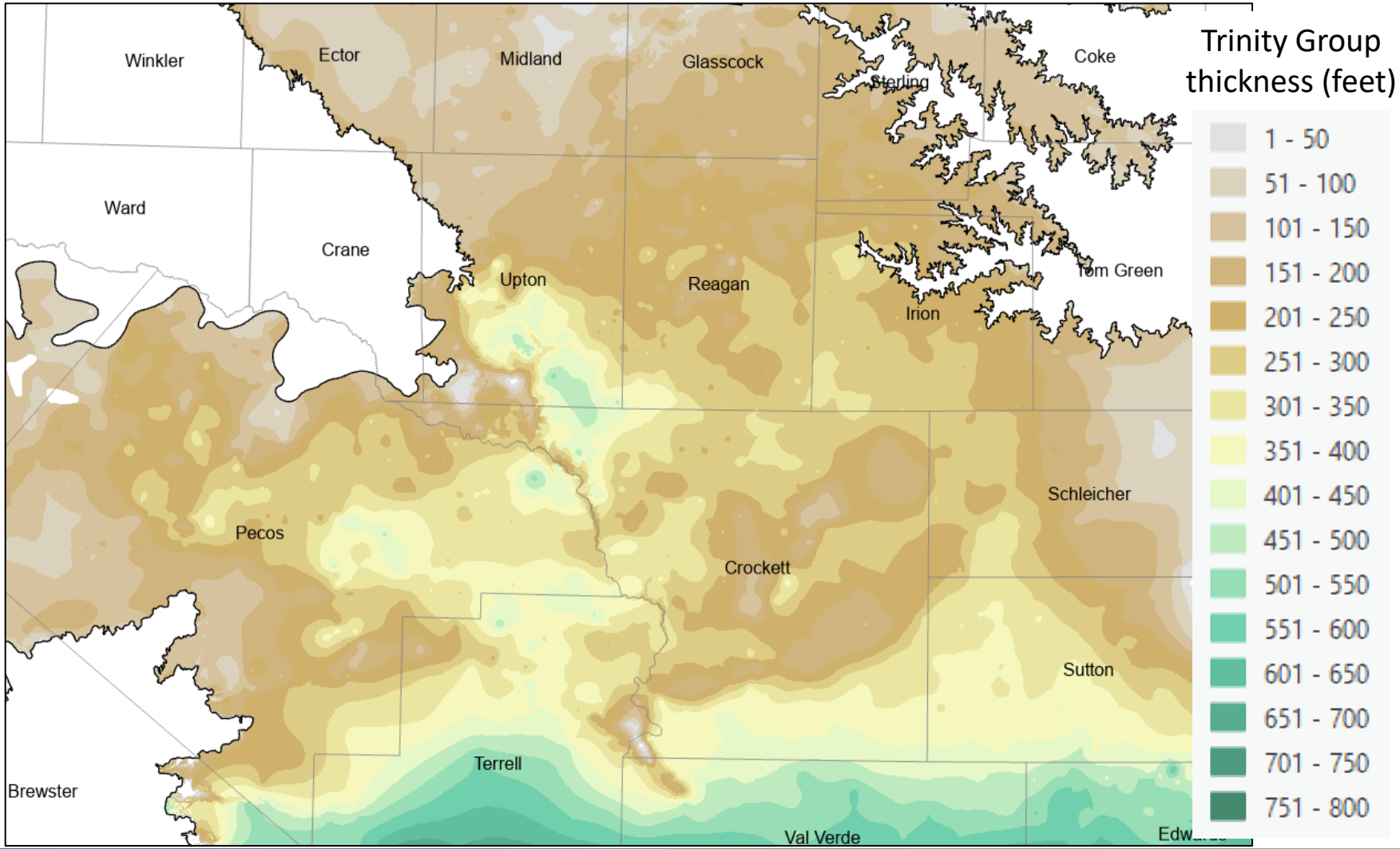
2. Post-Cretaceous uplift at Glass Mountains

- At least 1,800 feet of uplift after deposition
- Ewing (2019, pg. 93) cites approximately 1,500 feet of uplift



3. Age of the Pecos River

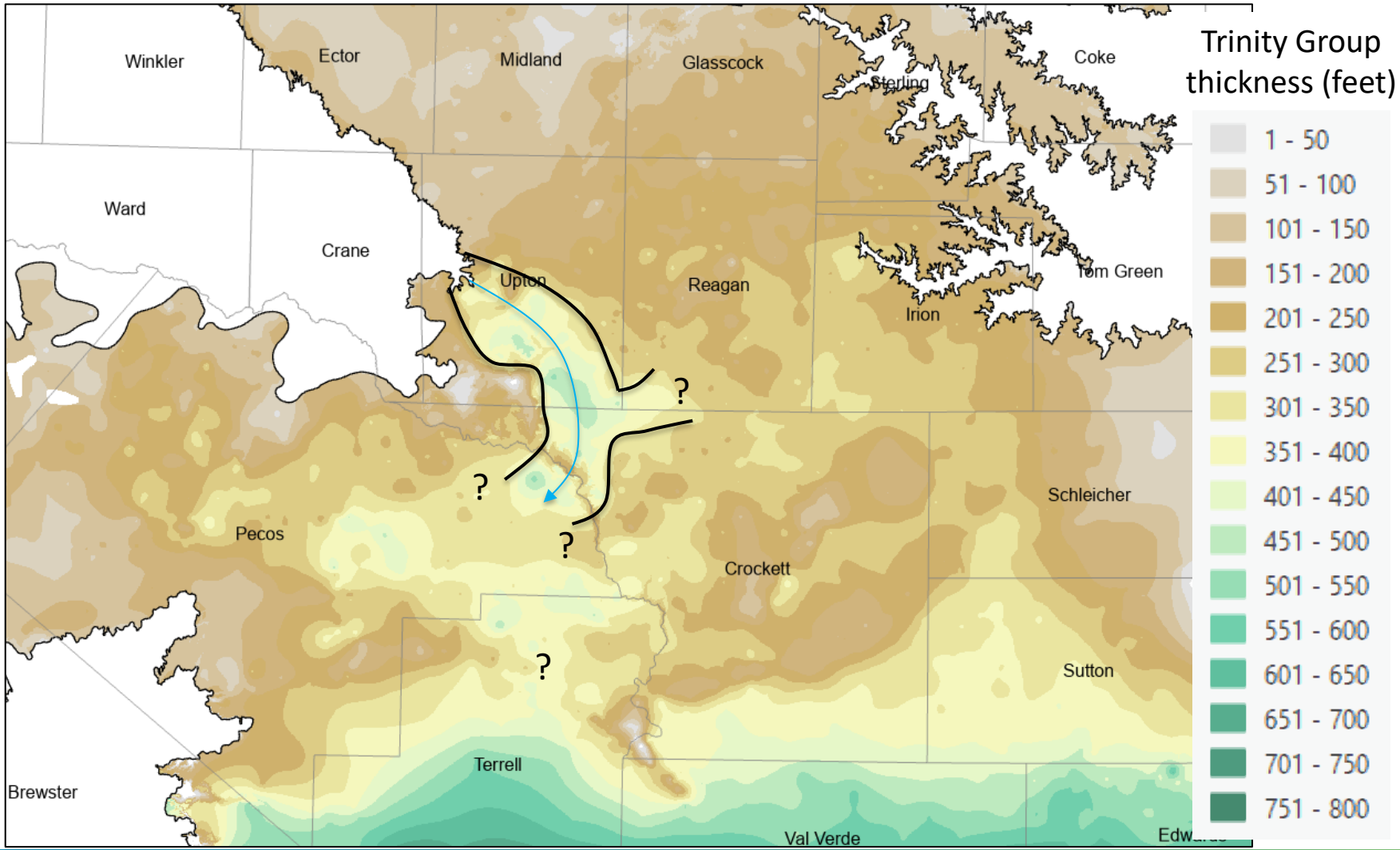
- Curvilinear area of relatively thick Trinity Group
- Upton down through eastern Pecos



50-foot thickness contours

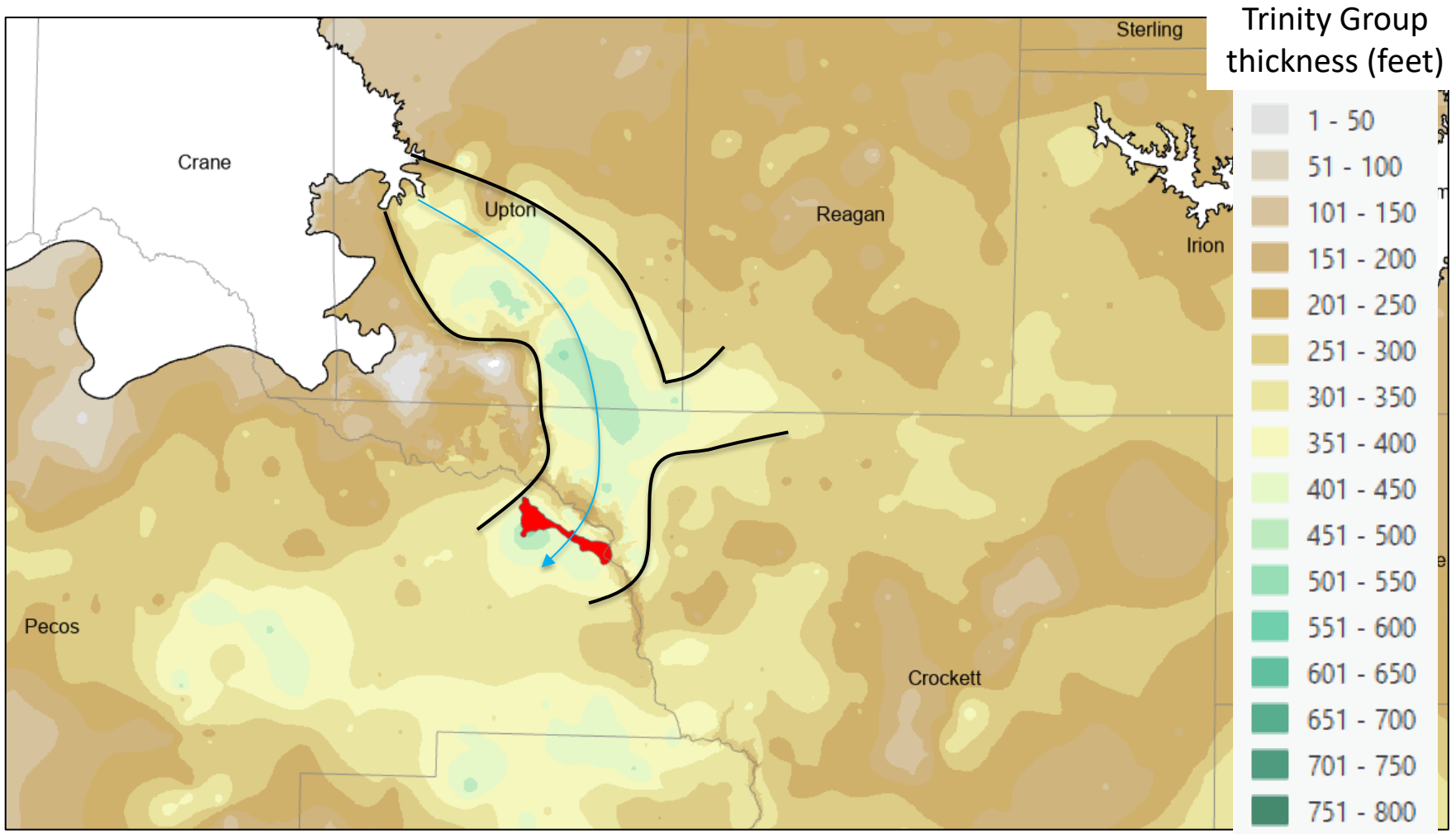
3. Age of the Pecos River

- Interpreted as paleo-river valley of Pecos River
- Rose (2021) and Jager (1942) similarly mapped paleo-river valleys for Pecos River
  - Our mapping more clearly shows original geometry
- Suggests Pecos River existed prior to Early Cretaceous



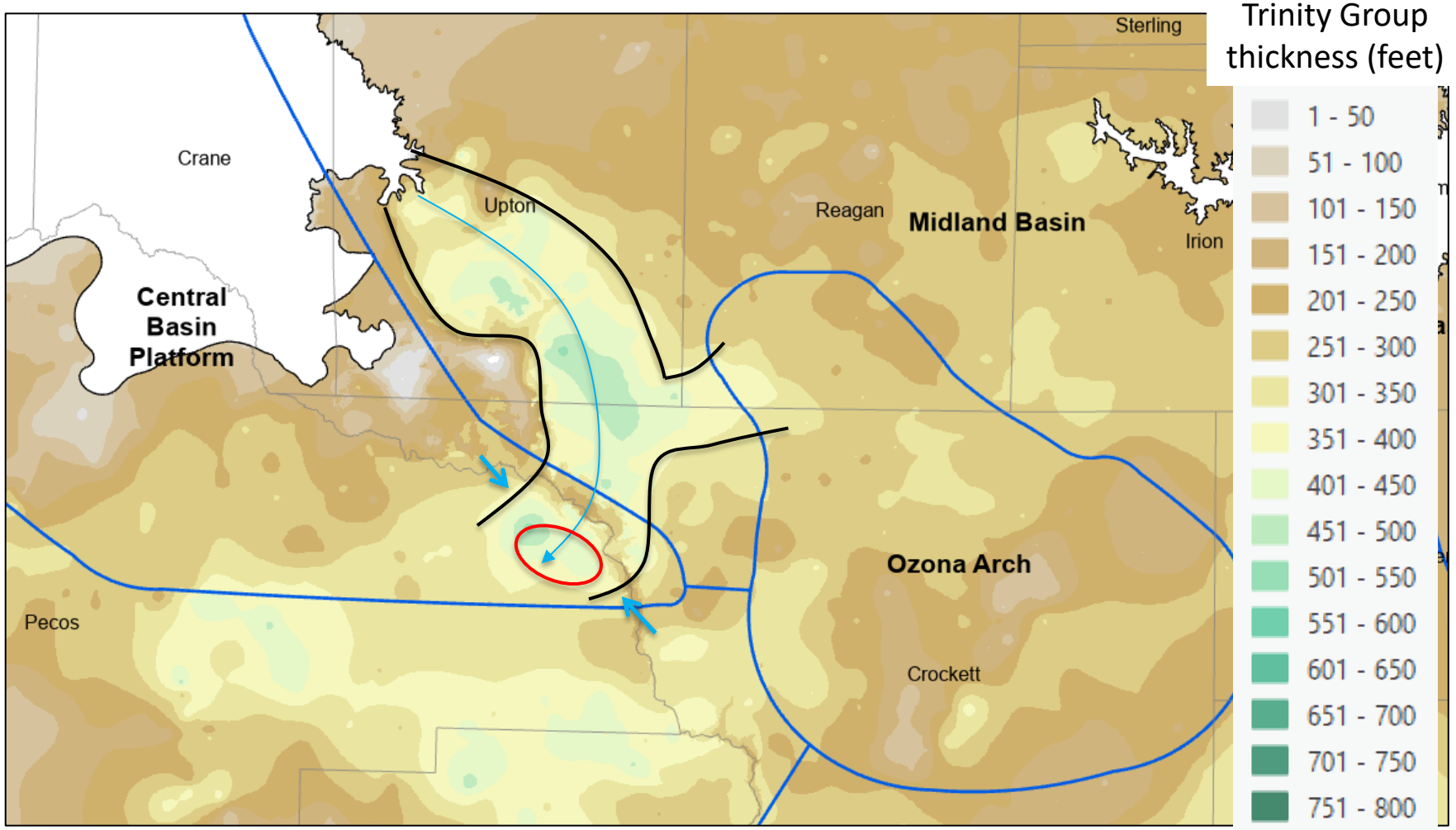
4. Insights into Yates and Toborg fields

- How I first learned about Trinity Toborg Field:
  - Intersected RRC Oil and Gas wells with Trinity surfaces
  - Red polygon is outline of wells in Trinity
- Located directly in middle of interpreted paleo-river valley
  - A coincidence?



4. Insights into Yates and Toborg fields

- Stafford et al. (2009) suggests the Pecos River and Yates field are directly related:
  - Argues Pecos River induced hypogene speleogensis at Yates Field



Yates and Toborg fields background

Field	Karst	Unit	Lithology
		Edwards Group	Carbonate
Toborg		Trinity Group	Sand
		Dockum Group?	Shale
		Dewey Lake Fm.	Shale
		Rustler Fm.	Evaporite
		Salado Fm.	Evaporite
		Tansil Fm.	Carbonate
		Yates Fm.	Sand
		Seven Rivers Fm.	Evaporite
Yates		Queen Fm.	Carbonate
Yates		Grayburg Fm.	Carbonate
Yates		San Andres Fm.	Carbonate

~1,000 feet deep

Stafford (2008): Mapped Yates Field karst distribution, suggests hypogene origin

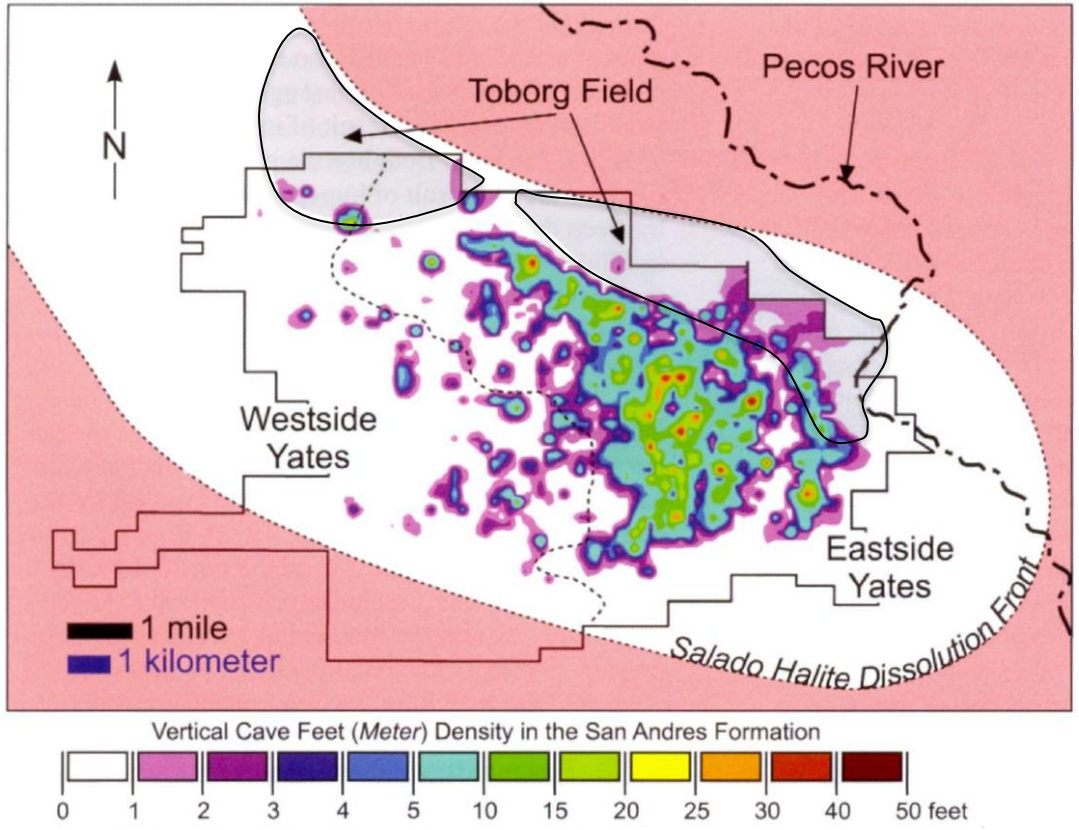
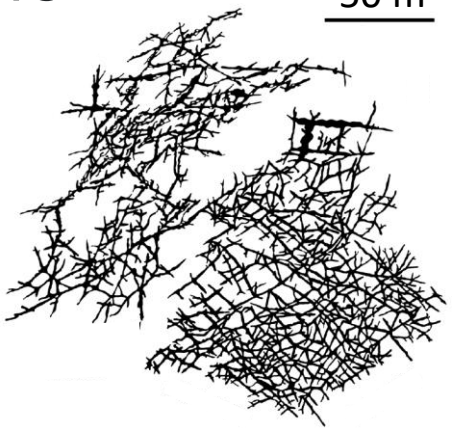


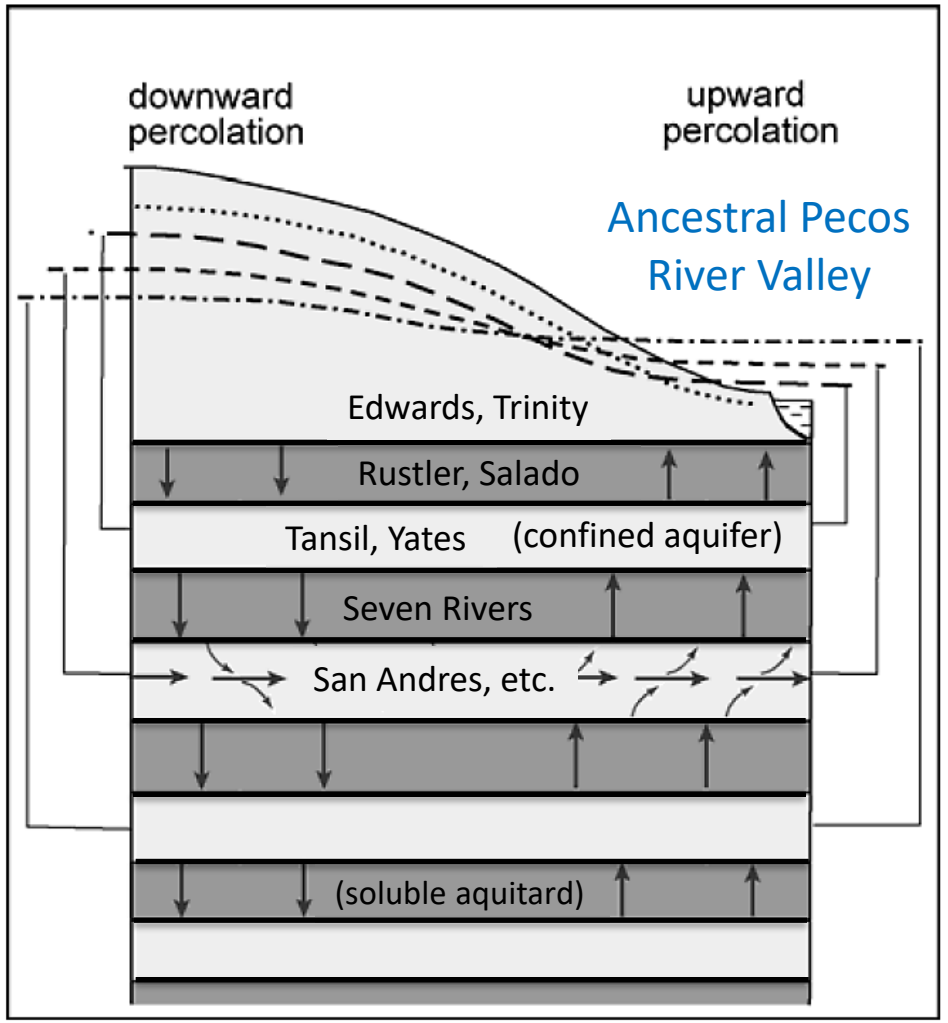
Figure from Stafford et al. (2009)

Hypogene speleogenesis

- Klimchouk (2007)
- Soluble confining units induce vertical water movement
  - It's a feature, not a bug!
- River valley is regional focus of upwelling
  - Circulation down to 1,000 meters
- Self-reinforcing process creates localized karstic porosity
  - Results in "maze-work" karst



Map of Amazing Maze Cave
(from Stafford and Byrd, 2018)

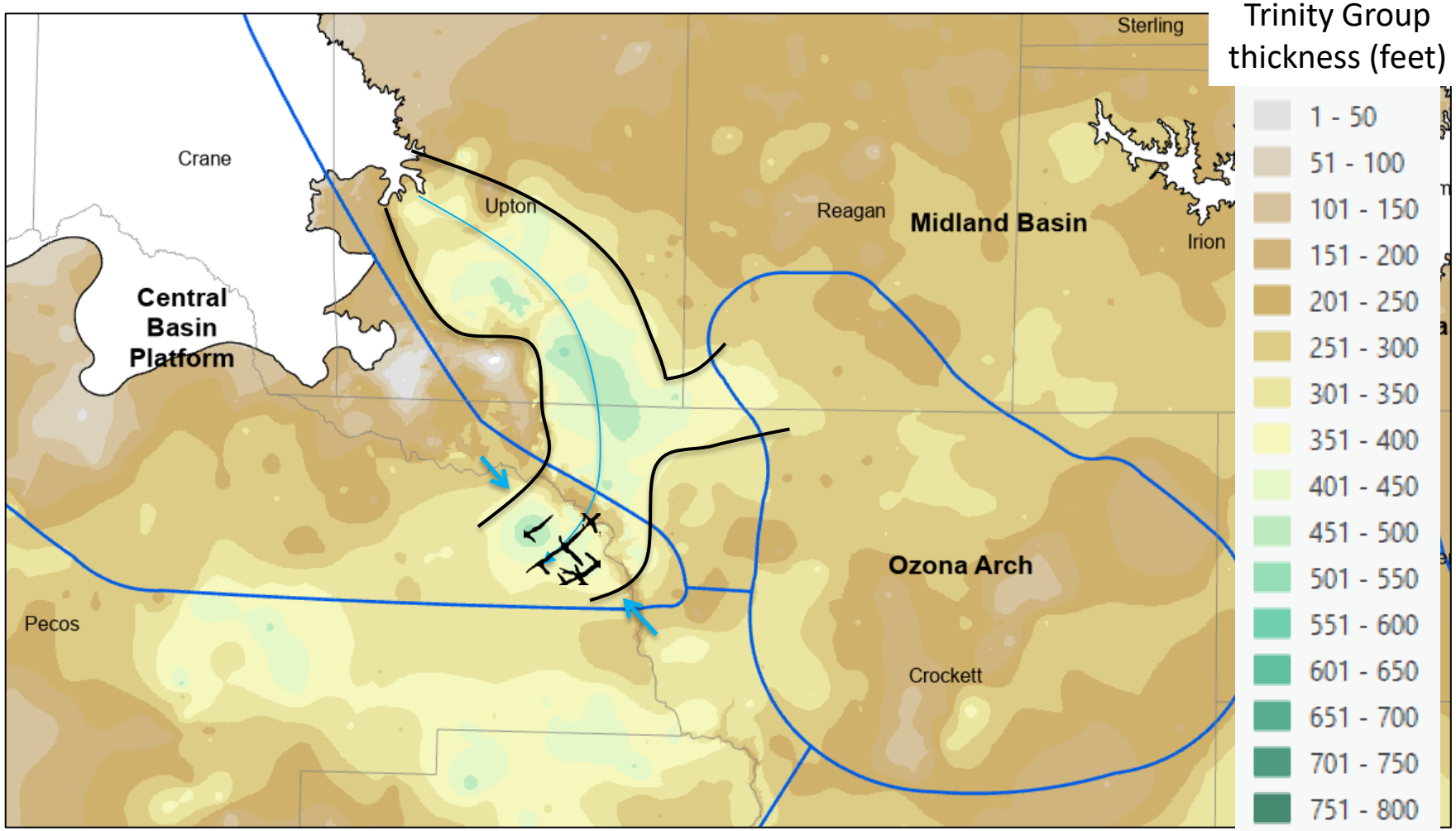


Modified from Klimchouk (2007)

4. Insights into Yates and Toborg fields

Development of Yates Field

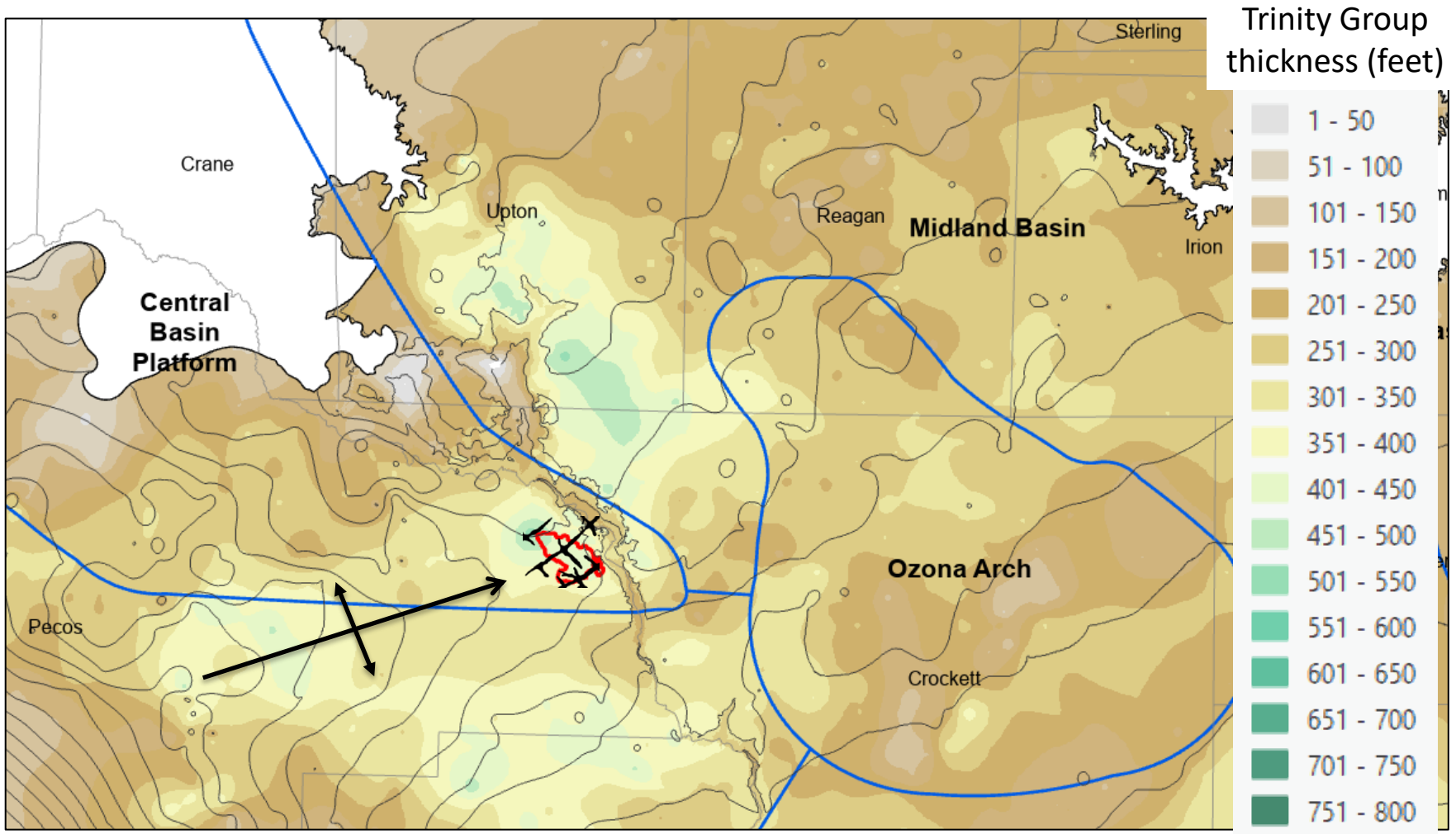
1. Pecos River induces hypogene speleogenesis at Central Basin Platform



4. Insights into Yates and Toborg fields

Development of Yates Field

1. Pecos River induces hypogene speleogenesis at Central Basin Platform
2. Laramide shortening arches Cretaceous and Permian units



Black lines: Trinity 100-foot elevation contours Red outline: Seven Rivers 1,200-foot contour

4. Insights into Yates and Toborg fields

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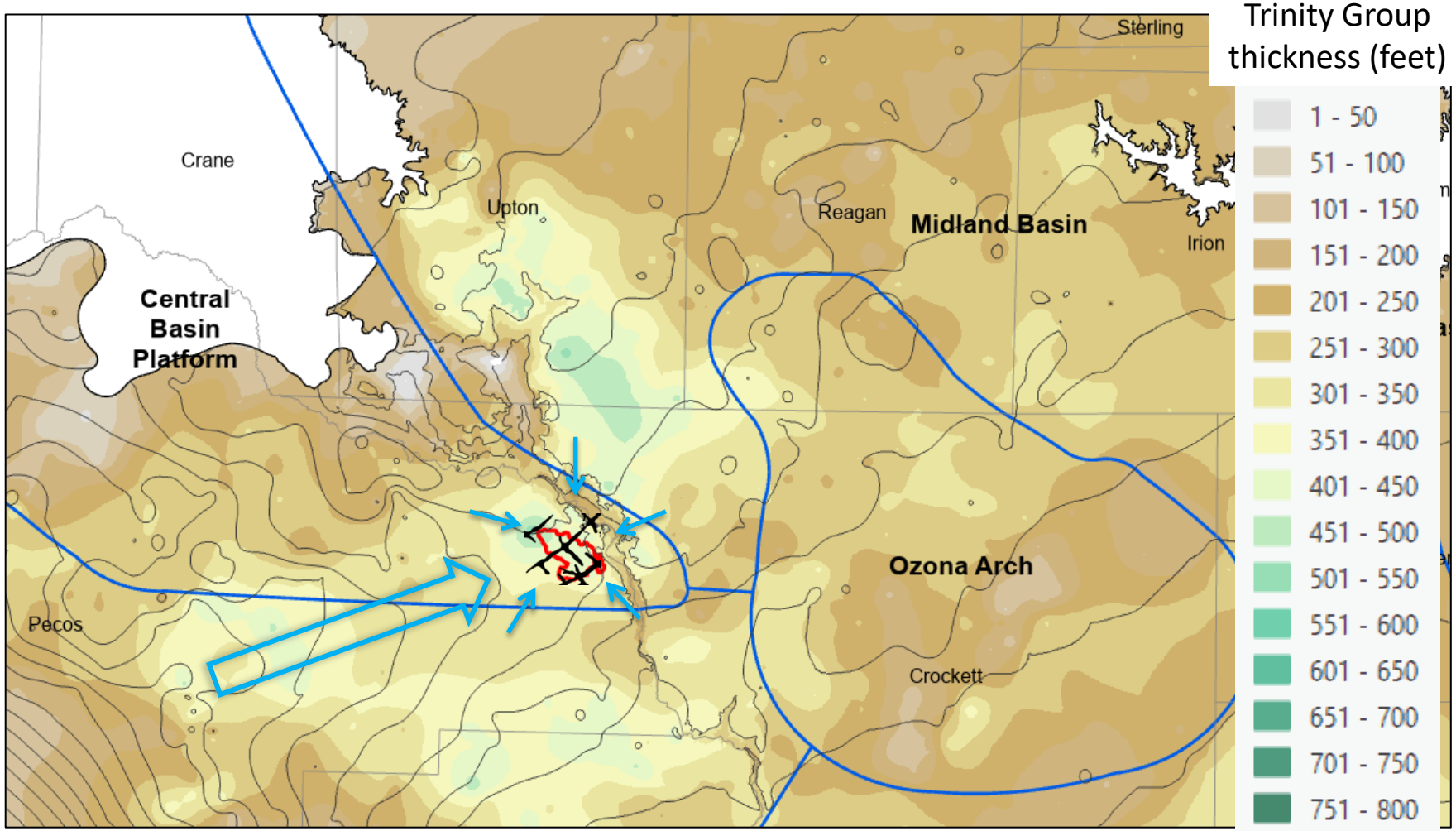
3. Uplift drives fluid along structure and up existing karstic porosity



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Development of Yates Field

1. Pecos River induces hypogene speleogenesis at Central Basin Platform
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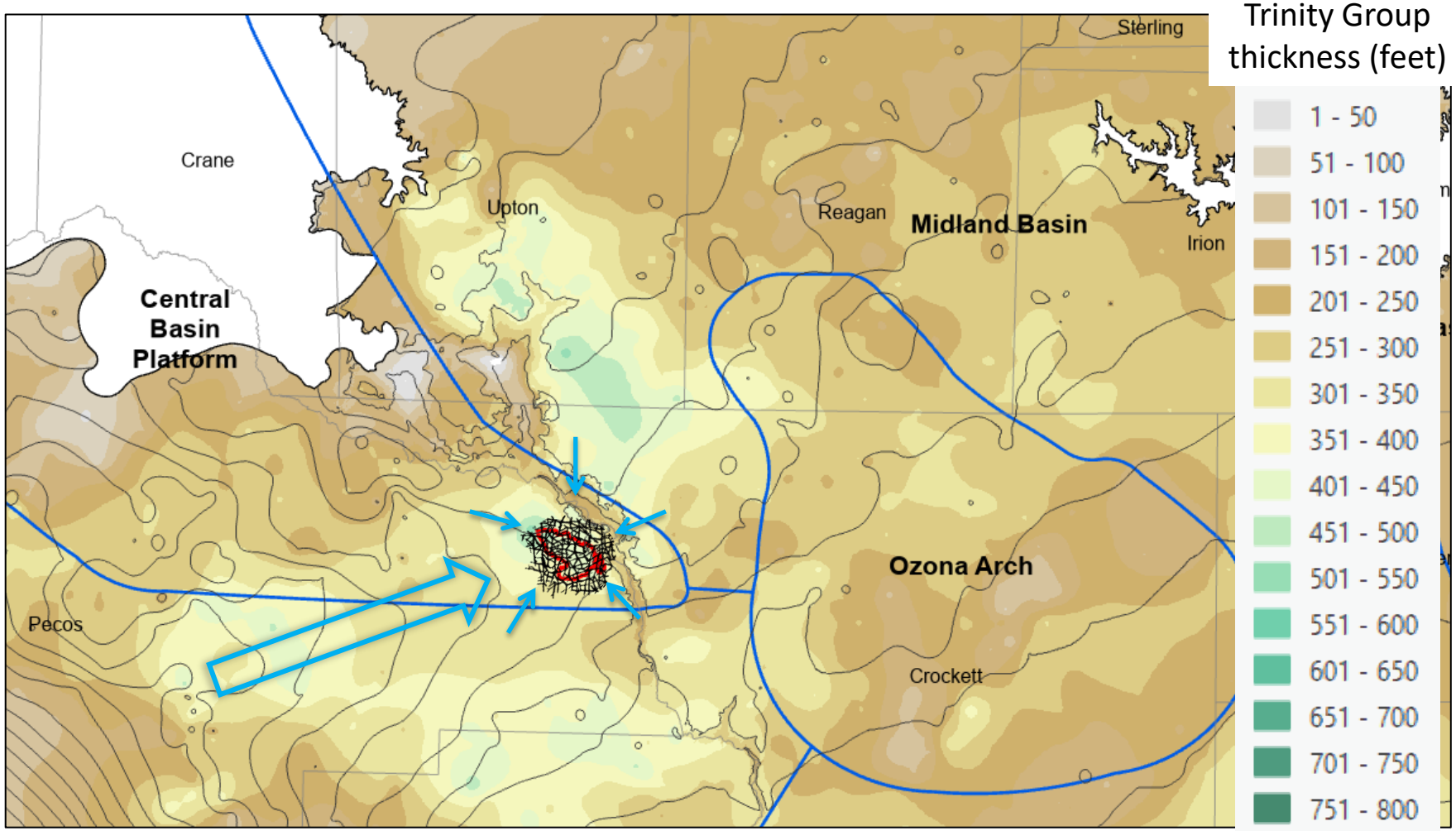
3. Uplift drives fluid along structure and up existing karstic porosity
4. Karstic porosity increases



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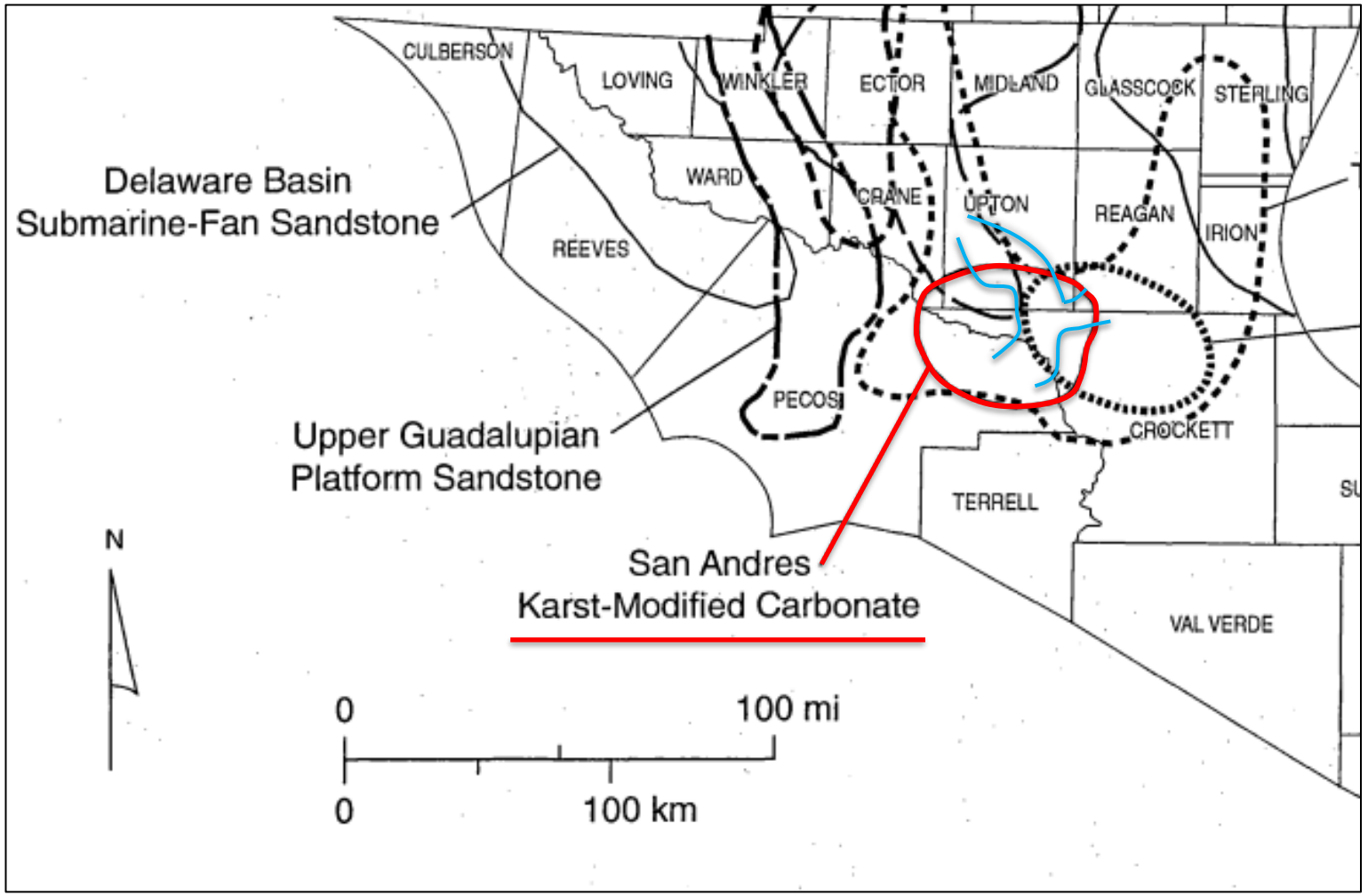
Exploration potential

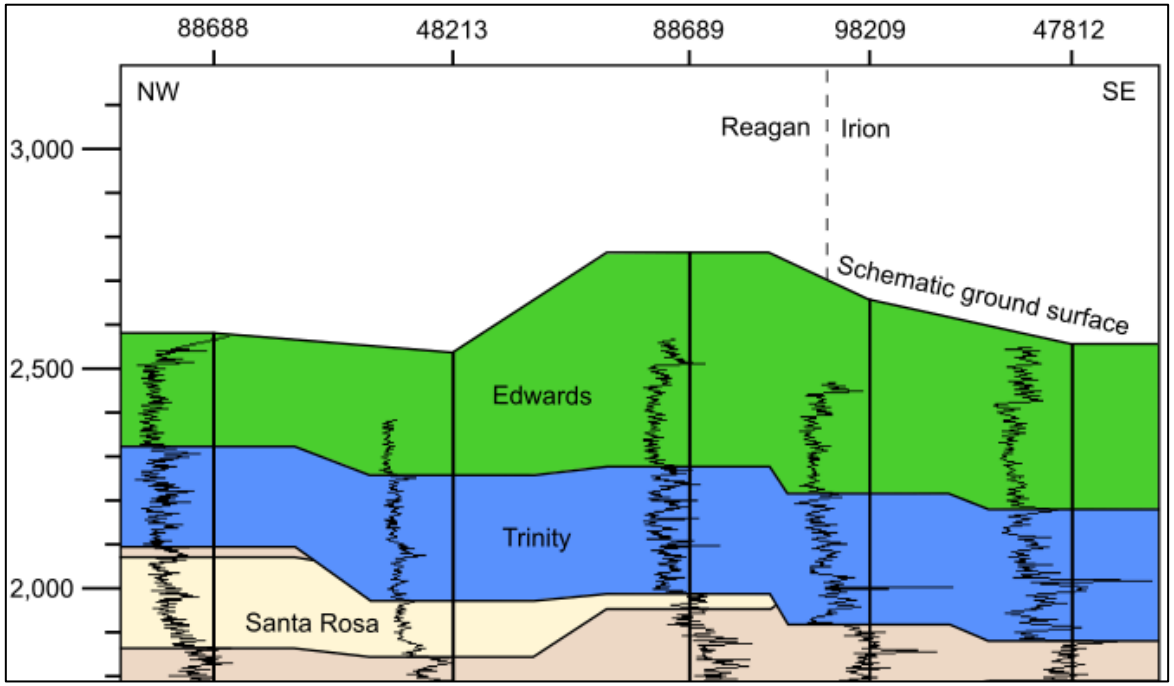
- Region identified as “San Andres Karst-Modified Carbonate”
- Any other significant karst zones in Permian units beneath paleo-valley?
- Could karst-modified area extend further north in Upton County?



From Dutton et al. (2000)

Future work

- My work here is done
  - Finishing brackish groundwater study
- Thesis idea:
  - Interpret vertical distribution of Trinity depositional environments
  - Confirm paleo-river valley with more detailed analysis
- Our data and interpretations are publicly available



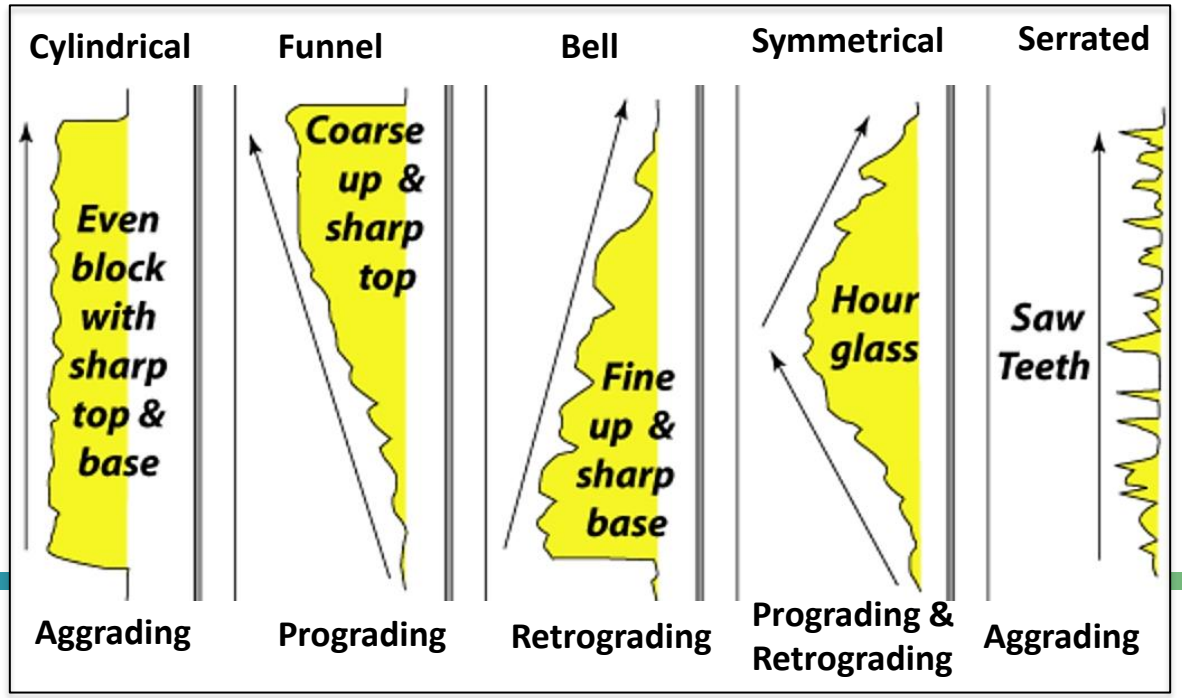


Figure from SEPMstrata.org

Conclusions

- Mapped southern extent of Santa Rosa sandstone
  - Northernmost Crockett and northwestern Irion counties
- From Trinity thickness, estimated at least 1,800 ft of post-Cretaceous uplift at Glass Mountains
- Interpreted an early or pre-Cretaceous paleo-river valley in Upton down through eastern Pecos counties
- Location of Yates Field in center of interpreted paleo-river valley suggests Pecos River induced hypogene speleogenesis

References

Dutton, S.P., Zirczy, H.H., Tremblay, T.A., and Scott, A.R., 2000, Update of Oil and Gas Reservoir Data Base, Permian and Fort Worth Basins, Texas: Bureau of Economic Geology, Order No. 99CRSA1102 to the United States Geologic Survey, 31 p.

Ewing, T.E., 2019, Tectonics of the West Texas (Permian) Basin – origins, structural geology, subsidence, and later modification: *in* Ruppel, S.C., ed., Anatomy of a Paleozoic basin: the Permian Basin, USA (vol. 1, ch. 4): The University of Texas at Austin, Bureau of Economic Geology Report of Investigations 285, AAPG Memoir 118, p. 63-96.

Jager, E.H., 1942, Pre-Cretaceous Topography of Wester Edwards Plateau, Texas: Association of Petroleum Geologists Bulletin 1942, vol. 26, no. 3, pp. 380-386.

King, P.B., 1926, The Geologic Structure of a Portion of the Glass Mountains of West Texas: Association of Petroleum Geologists Bulletin 1926, vol. 10, no. 9, pp. 877–884.

Klimchouk, A.B., 2007, Hypogene Speleogenesis: Hydrogeological and Morphogenetic Perspective: National Cave and Karst Research Institute, Special Paper 1, *KIP Monographs,* 13, 106 p.

Rose, P.R., 2021, The Wichita Paleoplain in Central Texas: Gulf Coast Association of Geological Societies Journal, v. 10, p. 97-122.

Stafford, K.W., and Byrd, B., 2018, Karst of the Stockton Plateau: West Texas, *in* Stafford, K.W. and Veni G., eds., Hypogene Karst of Texas: Texas Speleological Survey Monograph 3, pp. 51-63.

Stafford, K.W., 2008, Hypogene Karst and Sulfate Diagenesis of the Delaware Basin: Southeastern New Mexico and Far West Texas: New Mexico Institute of Mining and Technology, Ph.D. Dissertation, 307 p.

Stafford, K.W., Klimchouk, A., Land, L., and Gary, M.O., 2009, The Pecos River Hypogene Speleogenetic Province: A Basin-Scale Karst Paradigm for Eastern New Mexico and West Texas, USA: Stephen F. Austin State University ScholarWorks Faculty Publications 11, 15 p.