Utilizing Channel-Belt Scaling Parameters to Constrain Discharge and Drainage Basin Character with Application to the Cretaceous to Tertiary Evolution of the Gulf of Mexico*

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Abstract

Fluvial systems possess a range of scaling relationships that reflect drainage-basin controls on water and sediment flux. Quaternary channel-belt thickness (as controlled by bank-full water discharge) has been documented as a reliable first-order proxy for drainage basin size if climatic regimes are independently constrained. In hydrocarbon exploration and production, scaling relationships for fluvial deposits can be utilized to constrain drainage basin size with implications for sequence-stratigraphic interpretations. This study documents the scales of channel belts within Cretaceous to Tertiary fluvial successions from the Gulf of Mexico. Data on single-storey channel-belt scales were compiled from well logs and utilized to constrain contributing catchment areas of Cretaceous, Wilcox, and Oligocene fluvial systems. The data indicate that the Wilcox and Oligocene fluvial systems were significantly larger than the Cretaceous fluvial systems which can be related to drainage basin reorganization. Furthermore the Wilcox fluvial systems were relatively larger than the Oligocene fluvial systems. This could reflect either smaller drainage basins or climatic aridification. These scaling relationships can be validated by regional paleogeographic maps and provide additional insight to the sediment routing systems through time.

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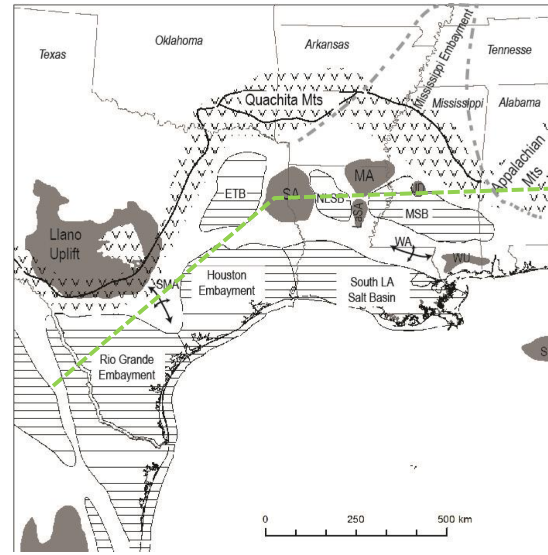
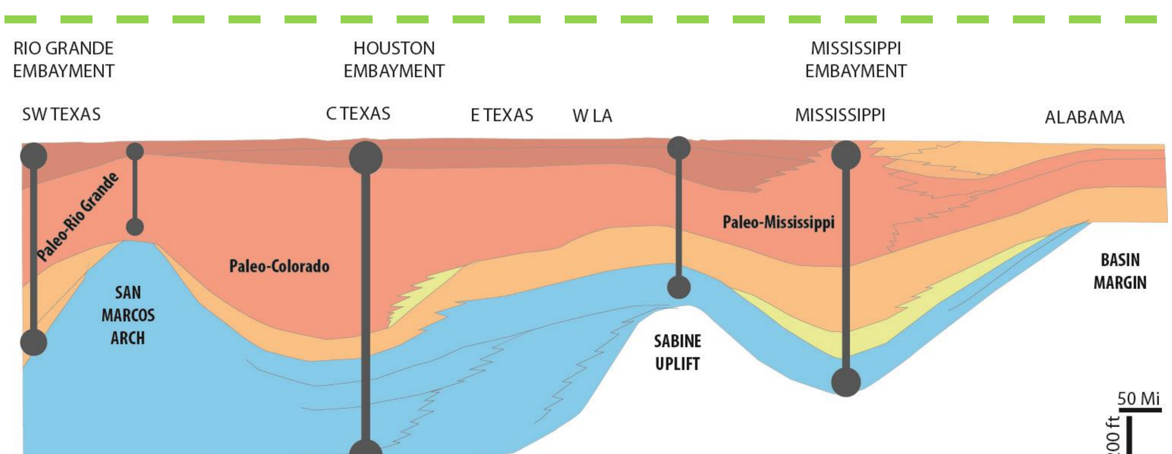
Northern Gulf of Mexico Tectonic Framework

- Basement influenced tectonic elements influence stratigraphy throughout the Mesozoic to Cenozoic
- Interior salt basins (East Texas, North Louisiana, and Mississippi) cradled between Paleozoic-originated uplifts and arches (e.g. Sabine uplift, Monroe arch, La Salle Arch, Wiggins Arch)
- Houston, Rio Grande, and Mississippi Embayments funneled clastic sediment between Paleozoic-originiated uplifts/arches (e.g. Llano Uplift, San Marcos Arch, Sabine Arch, Monroe Uplift)
- Cenomanian through Eocene clastic sediment onlap Arches and Uplifts



Modified from Ewing, 1991

Example regional cross section- Eocene time



Modified from Jung Echols and Malkin, 1948

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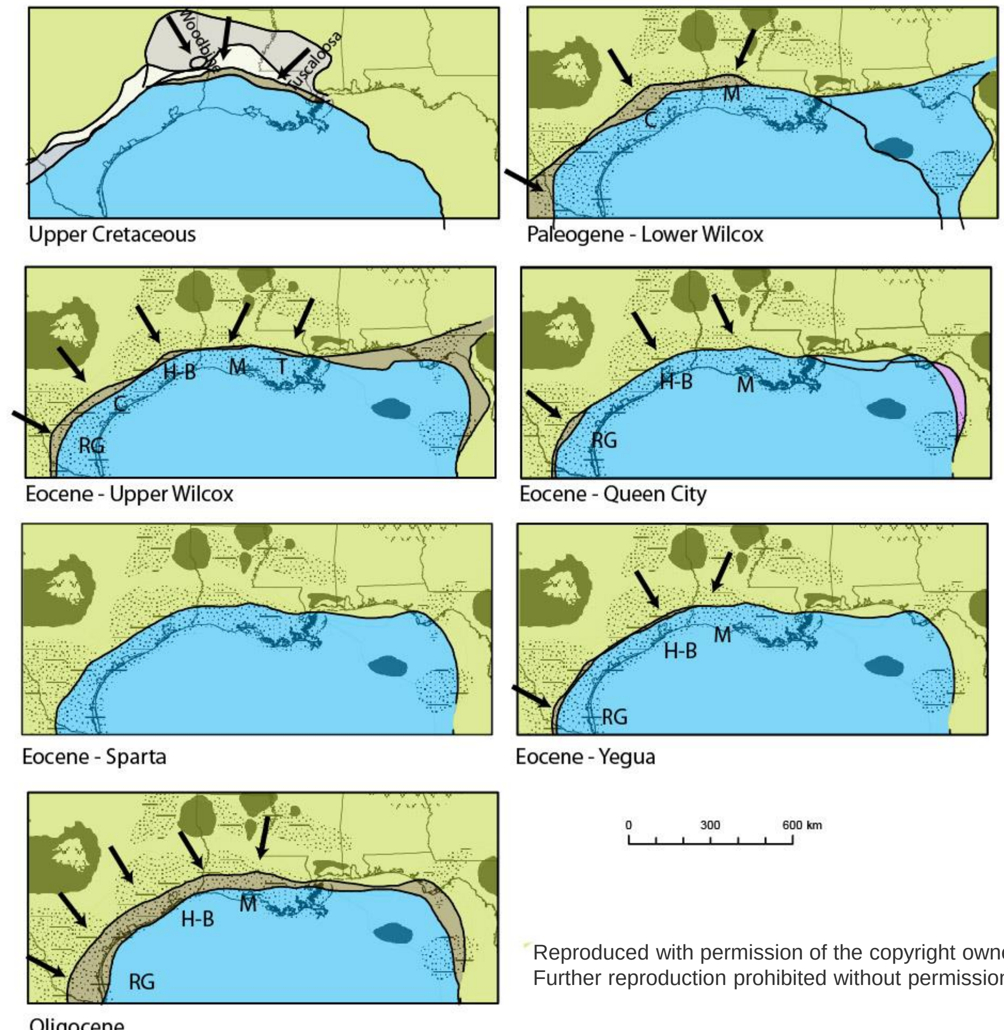
Fluvial Input Locations and Shelf Margin Progradation

- Gulf Basin fluvial/deltaic depocenters and shelf progradation documented over past 4+ decades
- Fluvial input and deltaic depocenters linked to locations of shelf progradation

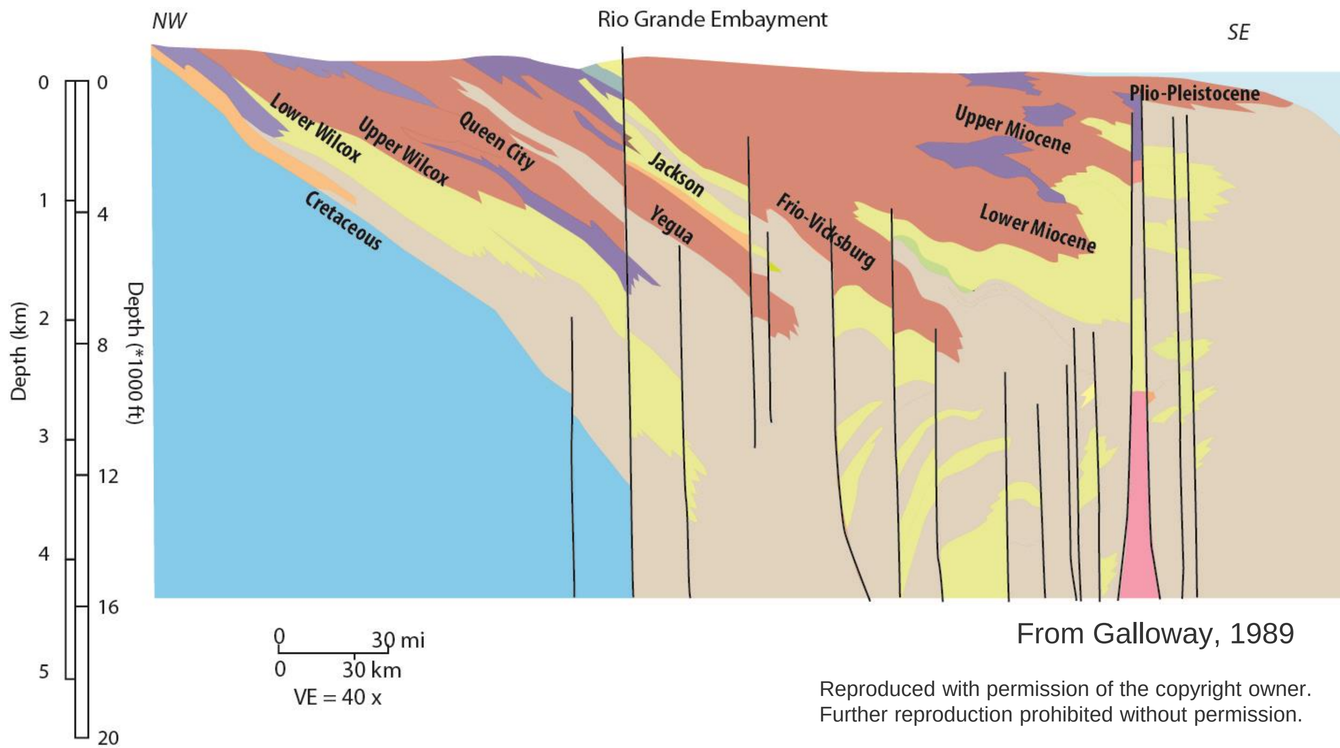


From: Galloway et al., 2000; Galloway, 2005; Galloway 2008

Gulf Basin Shelf Margin Development

- Genetic sequence development
- Siliciclastic shelf margin progrades by siliciclastic sediment

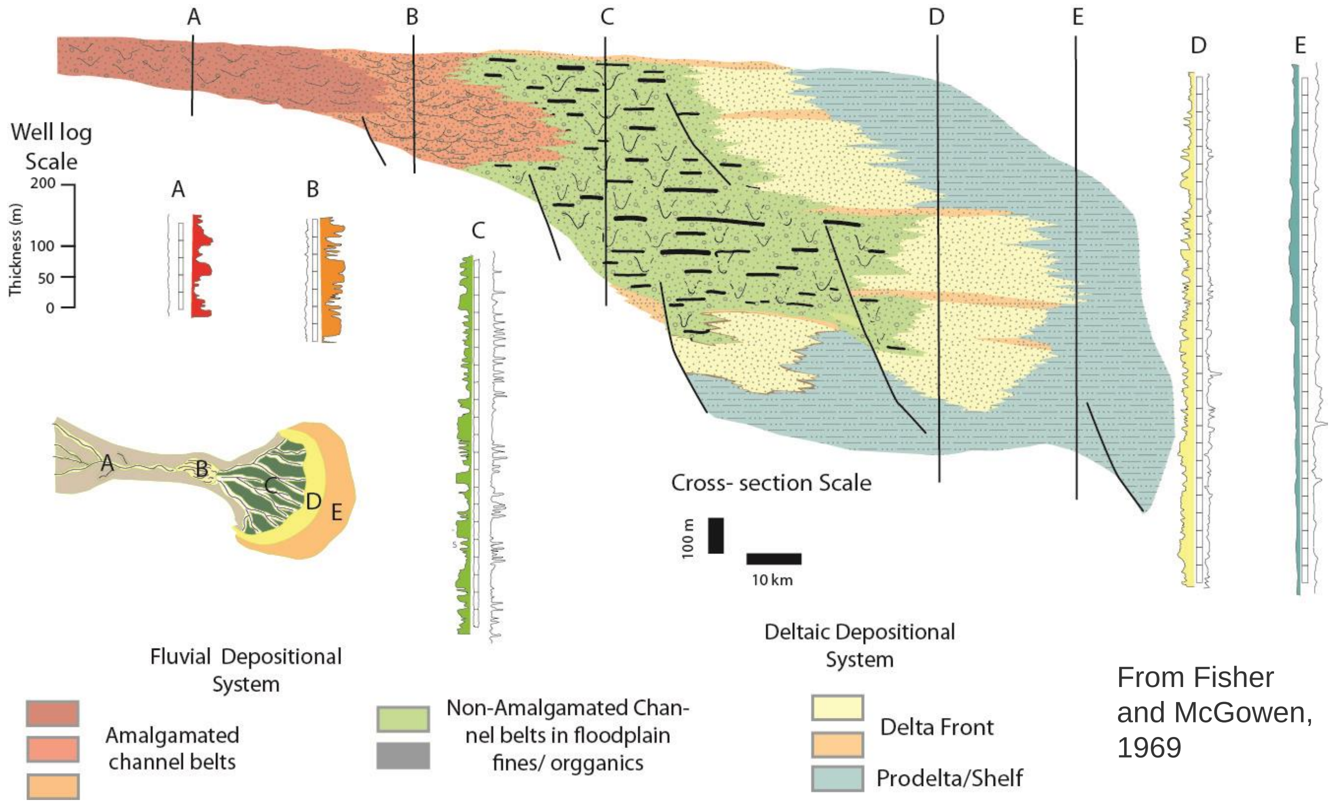
Example – South Texas Margin Progradation



From Galloway, 1989

Gulf Basin Passive Margin Offlap Sequences and Depositional Systems

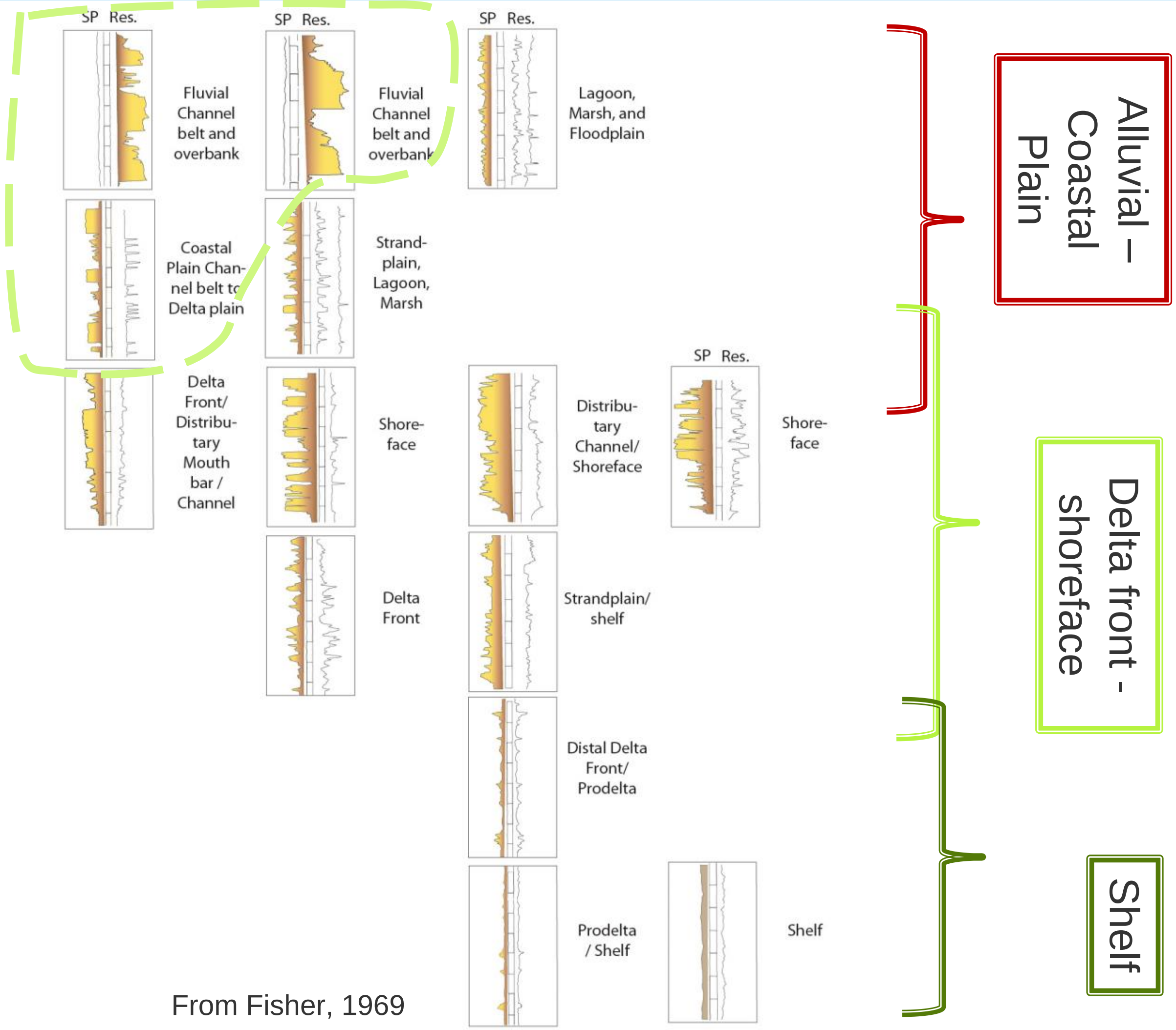
- On-shelf depsitional system/ facies variations from updip to downdip systematically vary from amalgamated fluvial to fluvial-deltaics to shallow marine



From Fisher and McGowen, 1969

Well Log – Fluvial Recognition

- Utilize classic studies that documented log pattern linkages to depositional environment
- Blocky to fining upward excursions on SP/ Resistivity/ Gamma differentiated from serrated or coarsening upward

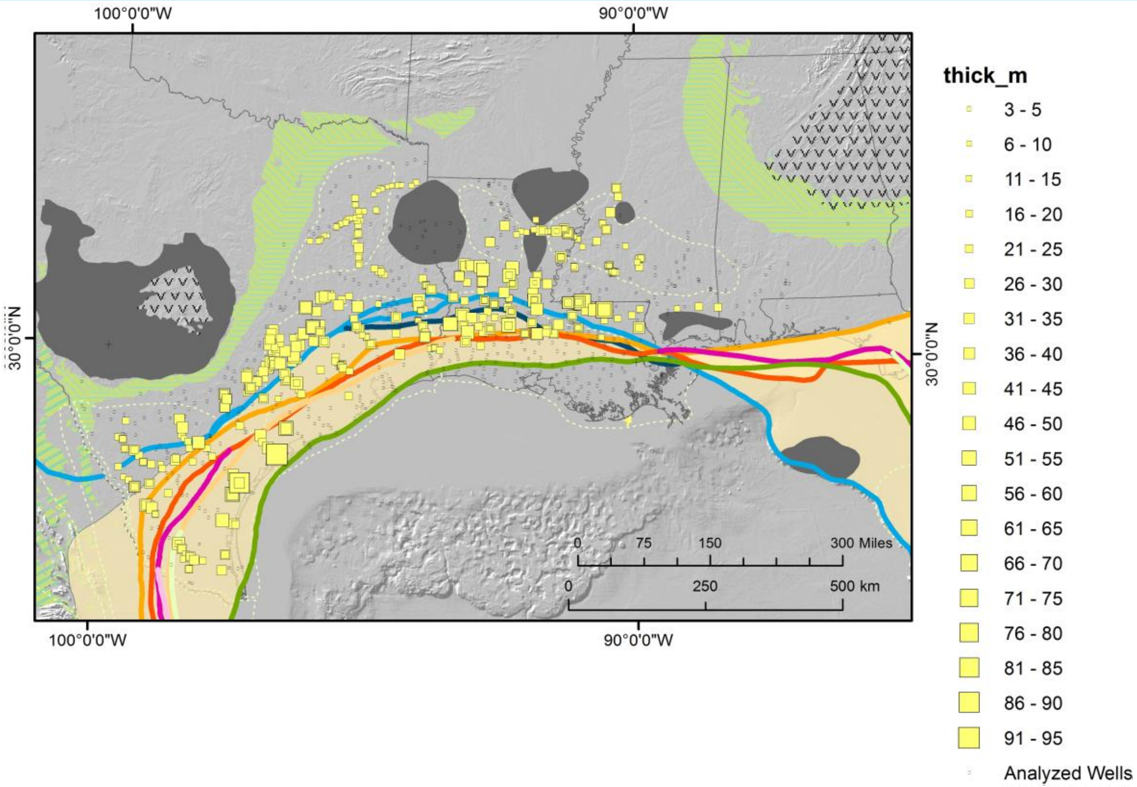


From Fisher, 1969

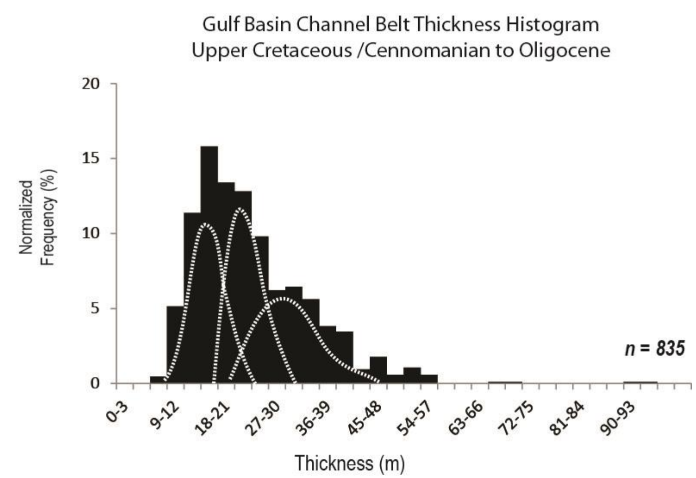
Modified from Fisher, 1969

Channel Belt Thickness Variations

Upper Cretaceous Cenomanian to Oligocene

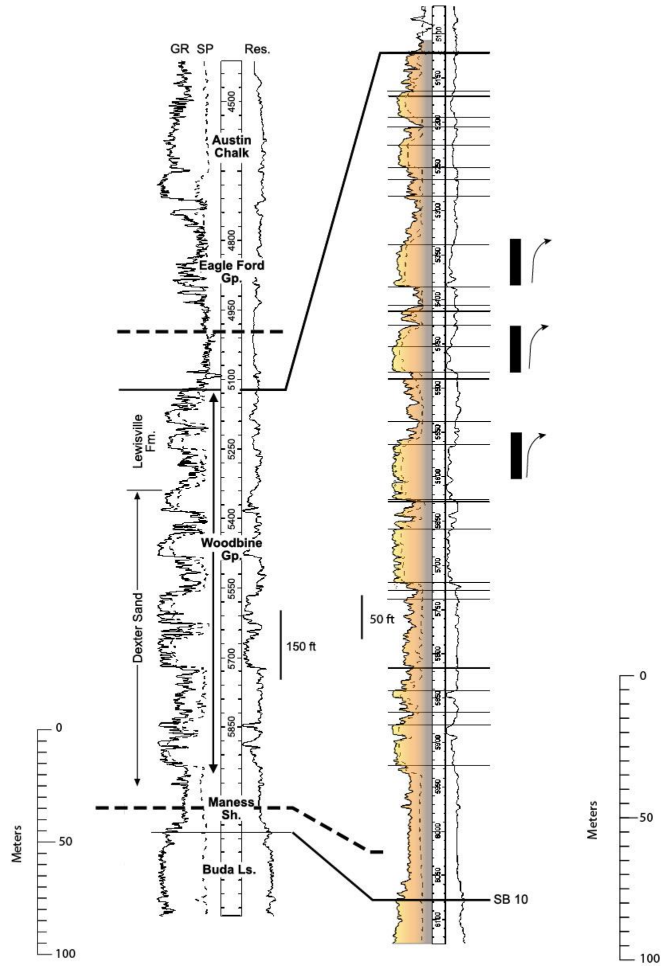


- Channel Belt thickness populations
- 12-15 m – moderate size rivers
- 18-24 m – large size rivers
- 30-42 m – continental size rivers



Cennomanian – Woodbine – East Texas Basin

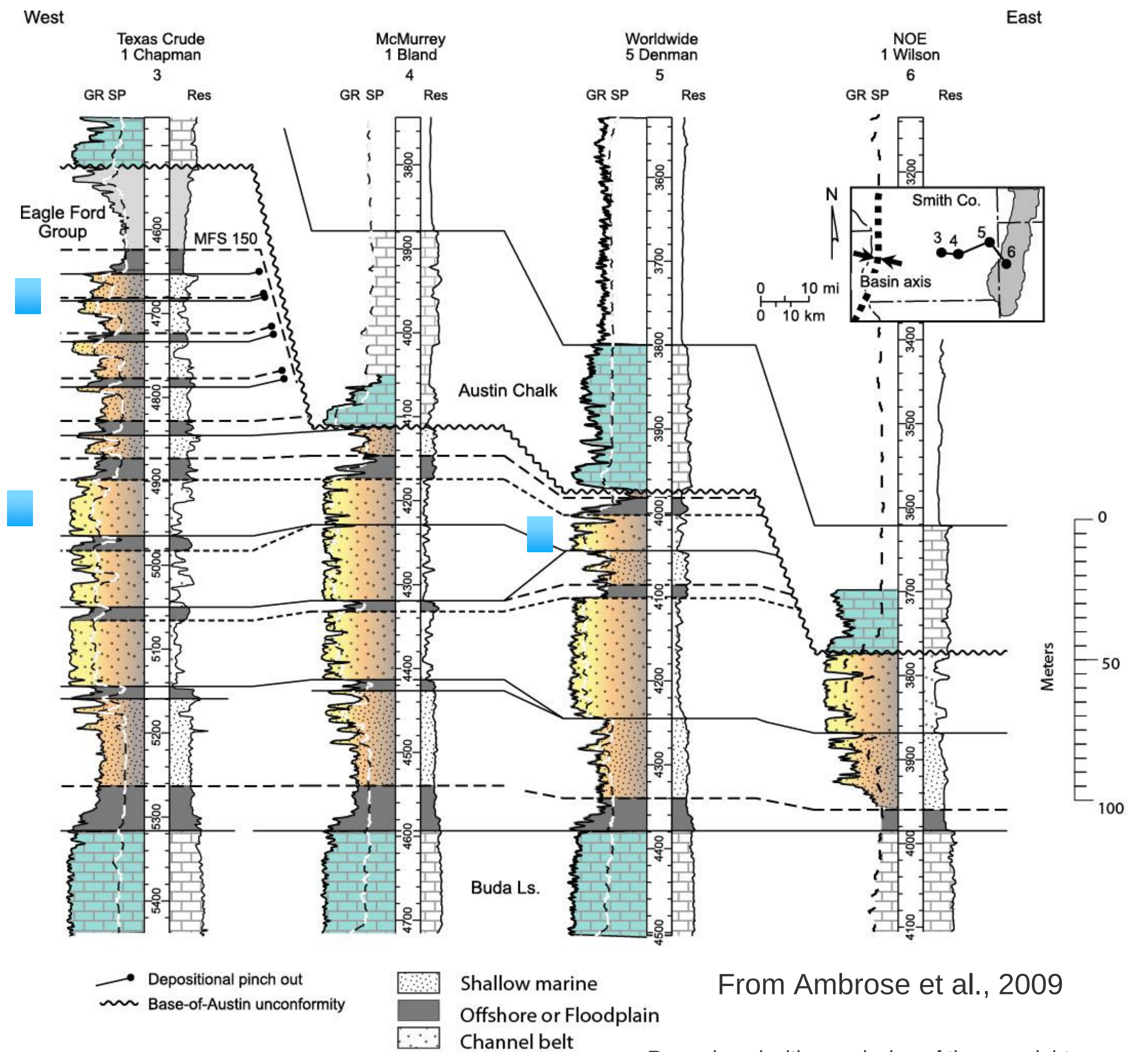
- ~15 m thick blocky to fining upward packages



From Ambrose et al., 2009

Channel Belt Interpretation Techniques

- Basin margin to Basin center – subsidence variation
- Basin margin: Amalgamated channel belts
- Basin center: Non-amalgamated channel belts
- ~15 m thick blocky to fining upward channel belts

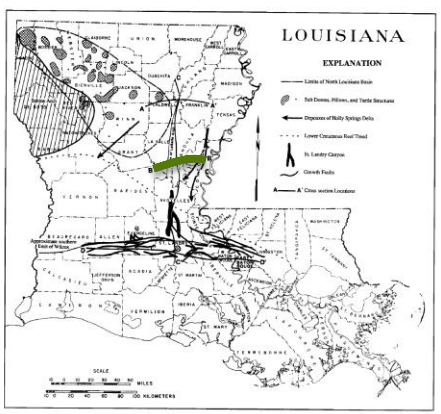


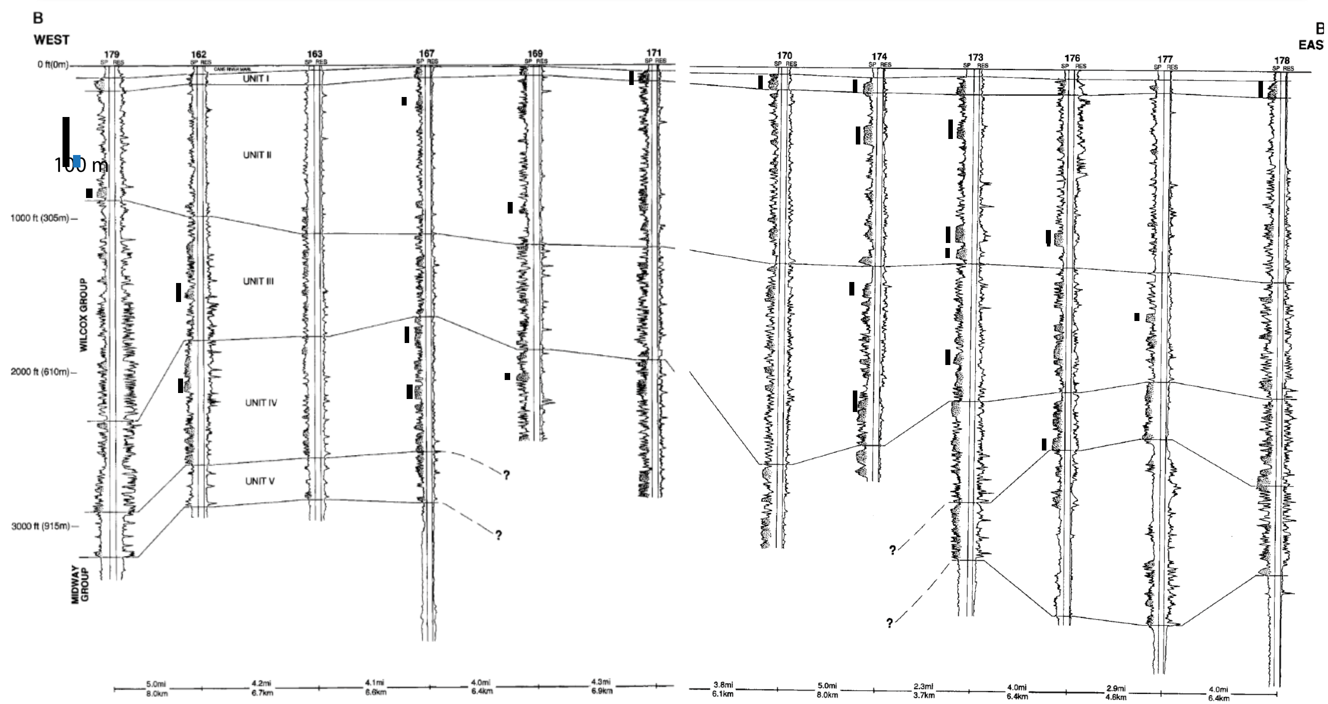
From Ambrose et al., 2009

Wilcox – Paleo Mississippi - Louisiana

- Published cross-sections provide cross check on depositional environment and correlations

Blue scale is 20 m





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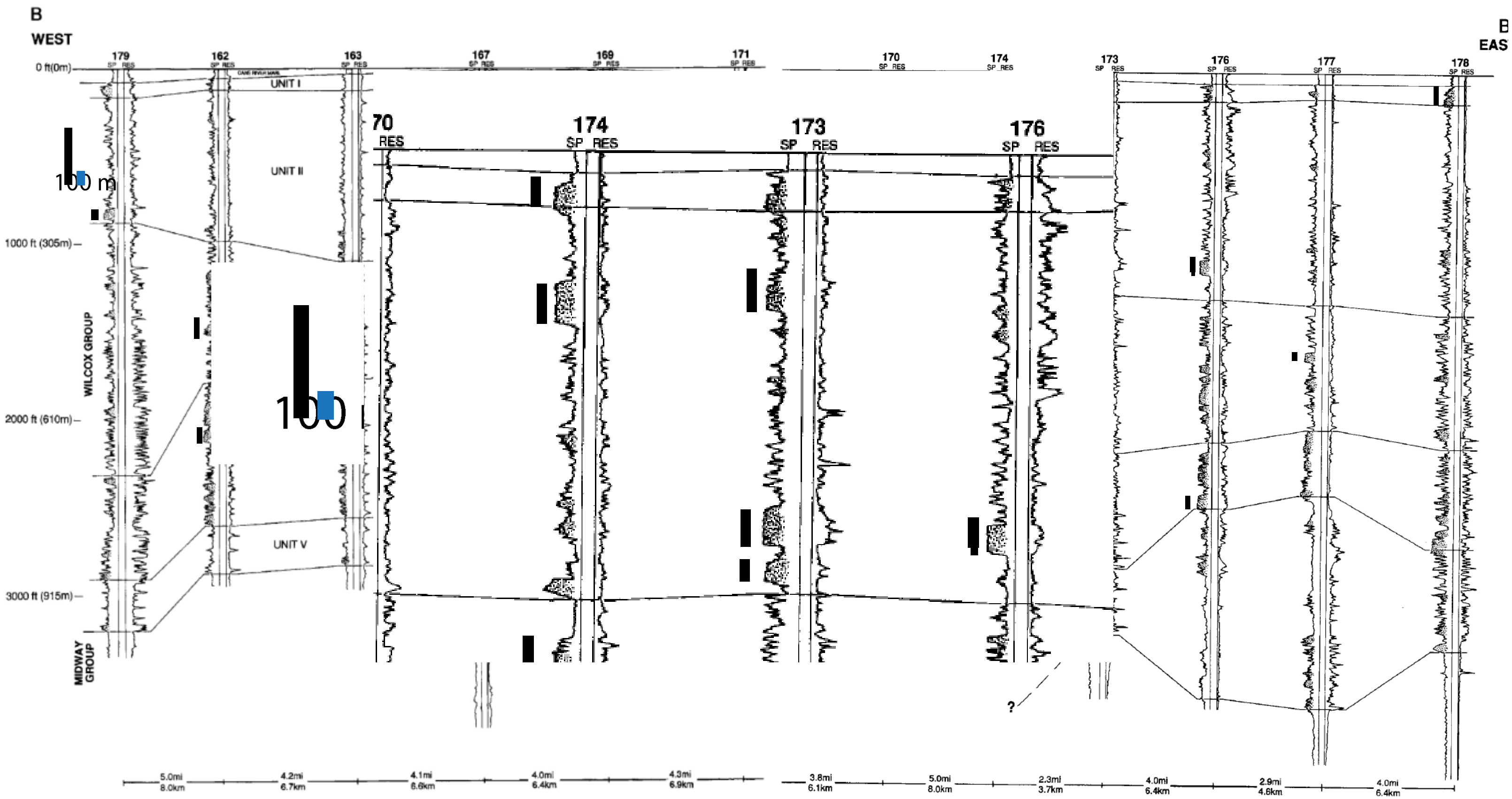

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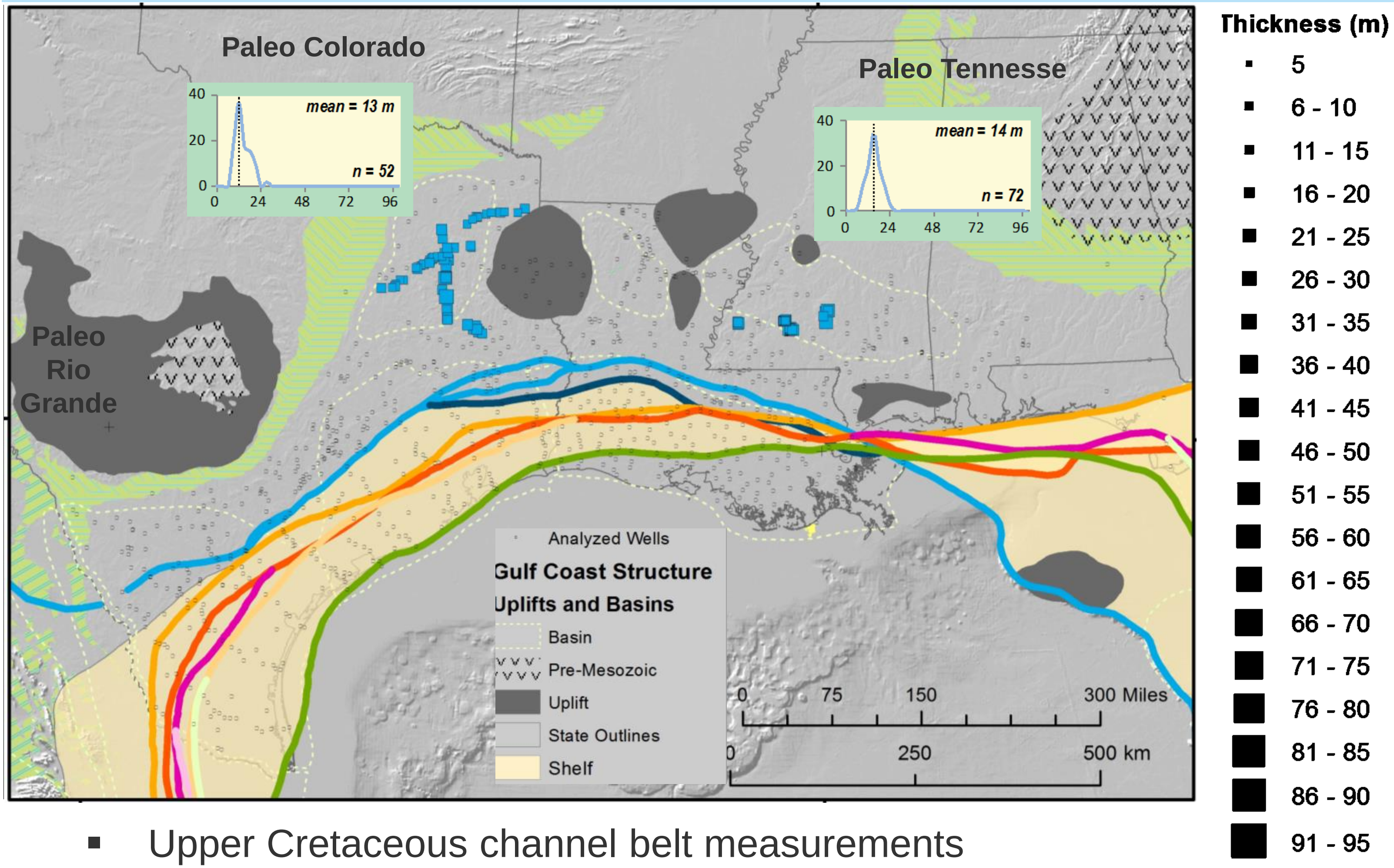
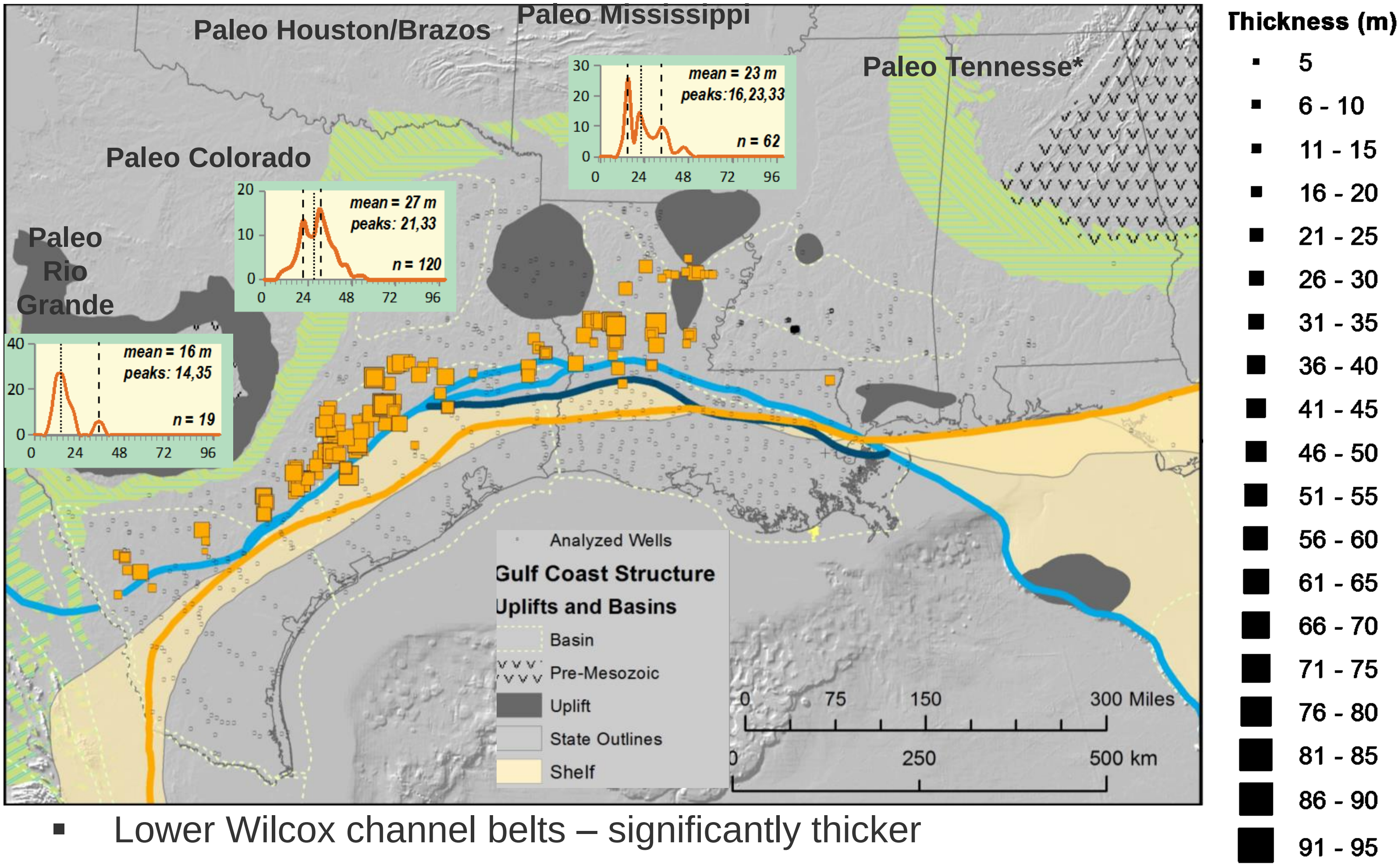
Channel Belt Scales
Cenomanian



- Upper Cretaceous channel belt measurements
- Fluvial systems – onshore basins – shelf edge location

Channel Belt Scales

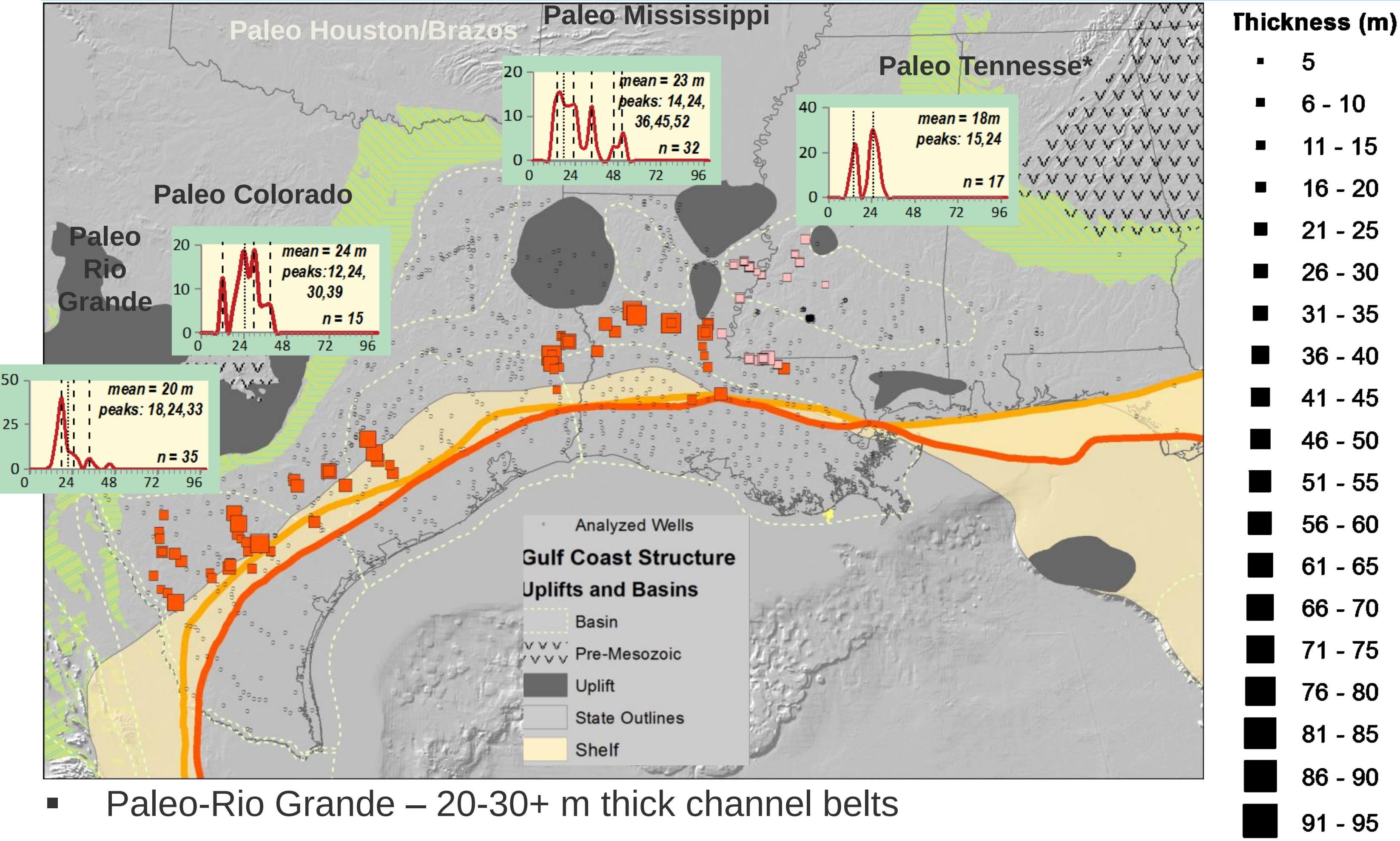
Lower Wilcox



- Lower Wilcox channel belts – significantly thicker
- Significant shelf progradation
- Mean Channel belt thickness not best indicator of distribution

Channel Belt Scales

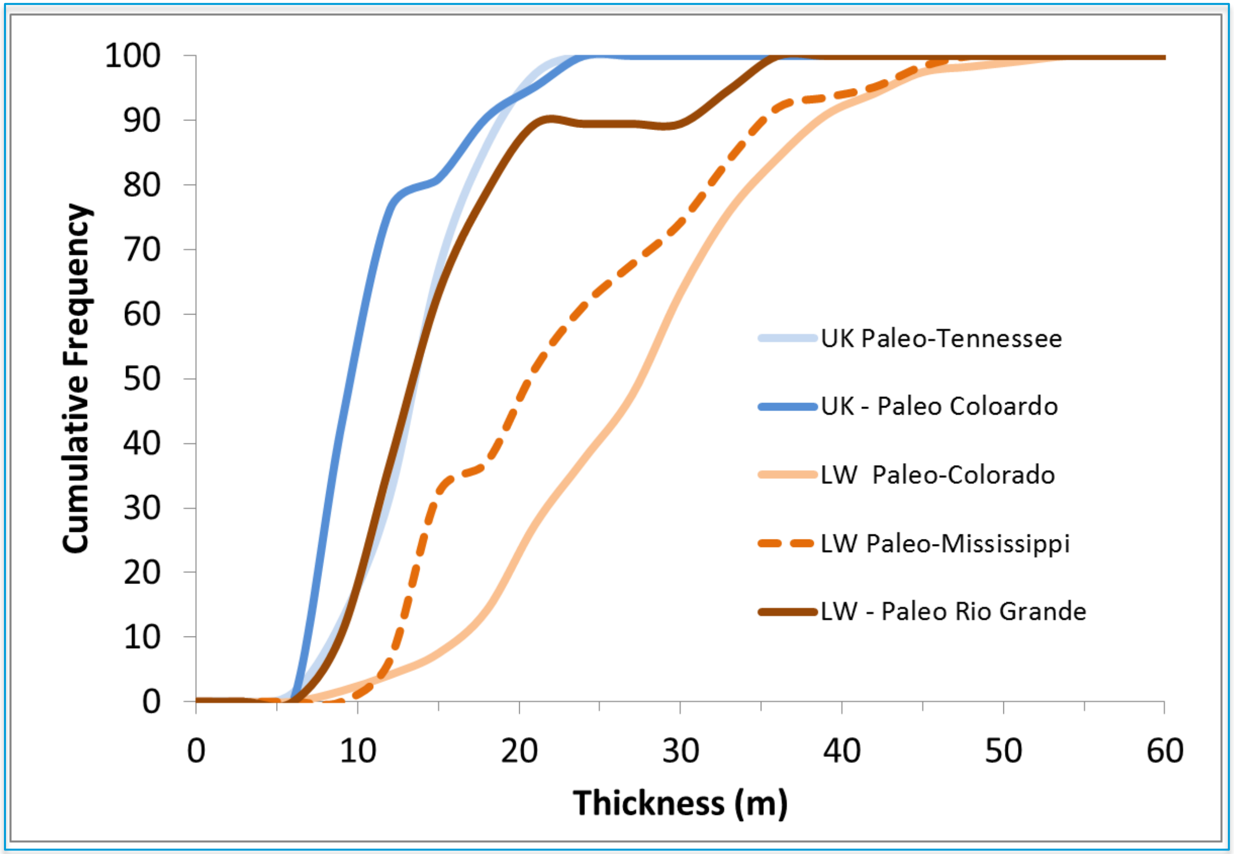
Undifferentiated and Upper Wilcox



- Paleo-Rio Grande – 20-30+ m thick channel belts
- Paleo Tennessee – 2 populations, 15m – Appalachians, 24 m Mississippi Embayment?

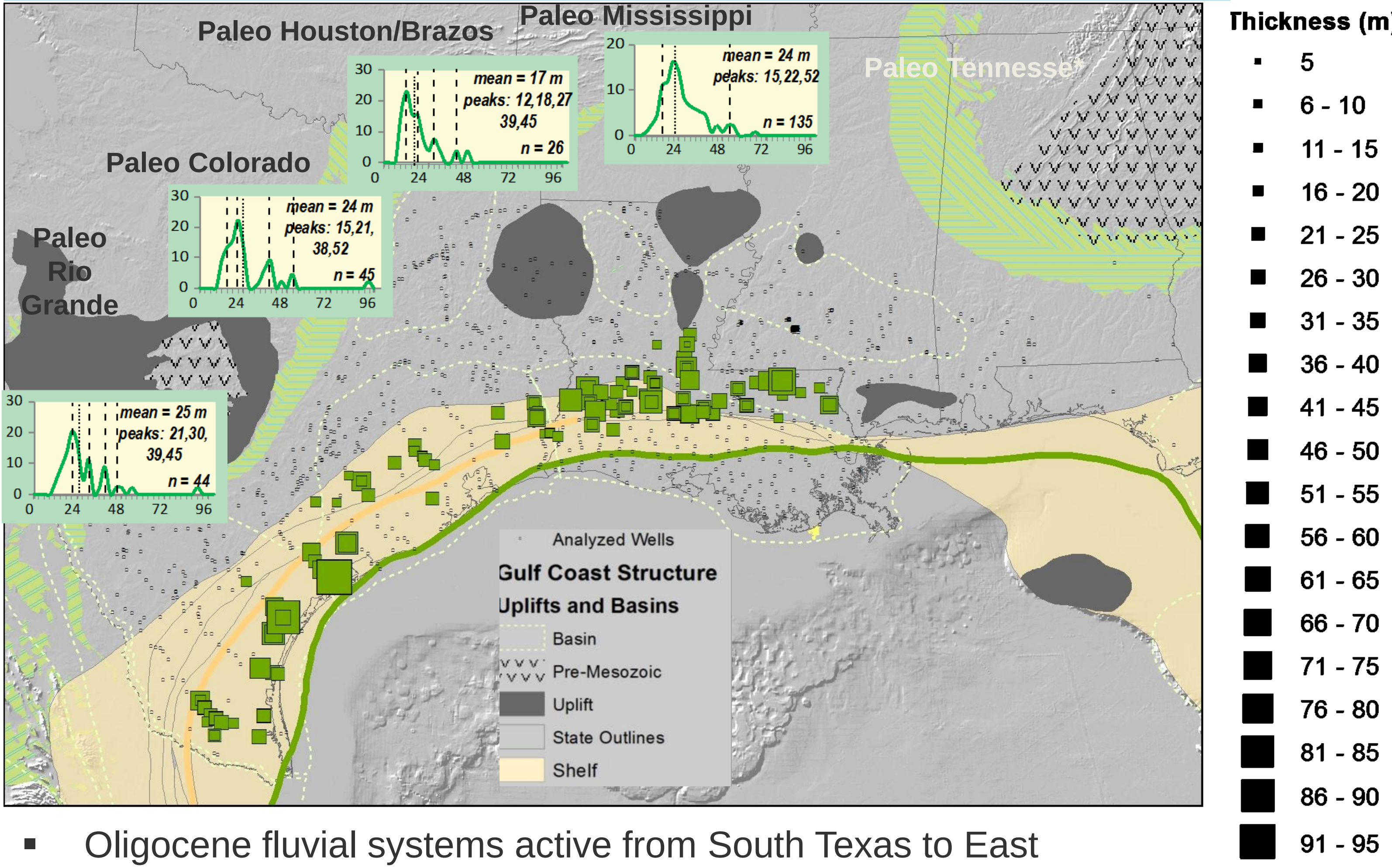
Quantitative Channel belt comparison:
Upper Cretaceous to Paleocene

- Upper Cretaceous Cenomanian fluvial system channel belt thickness are significantly thinner than Paleogene Wilcox fluvial system channel belts



Channel Belt Scales

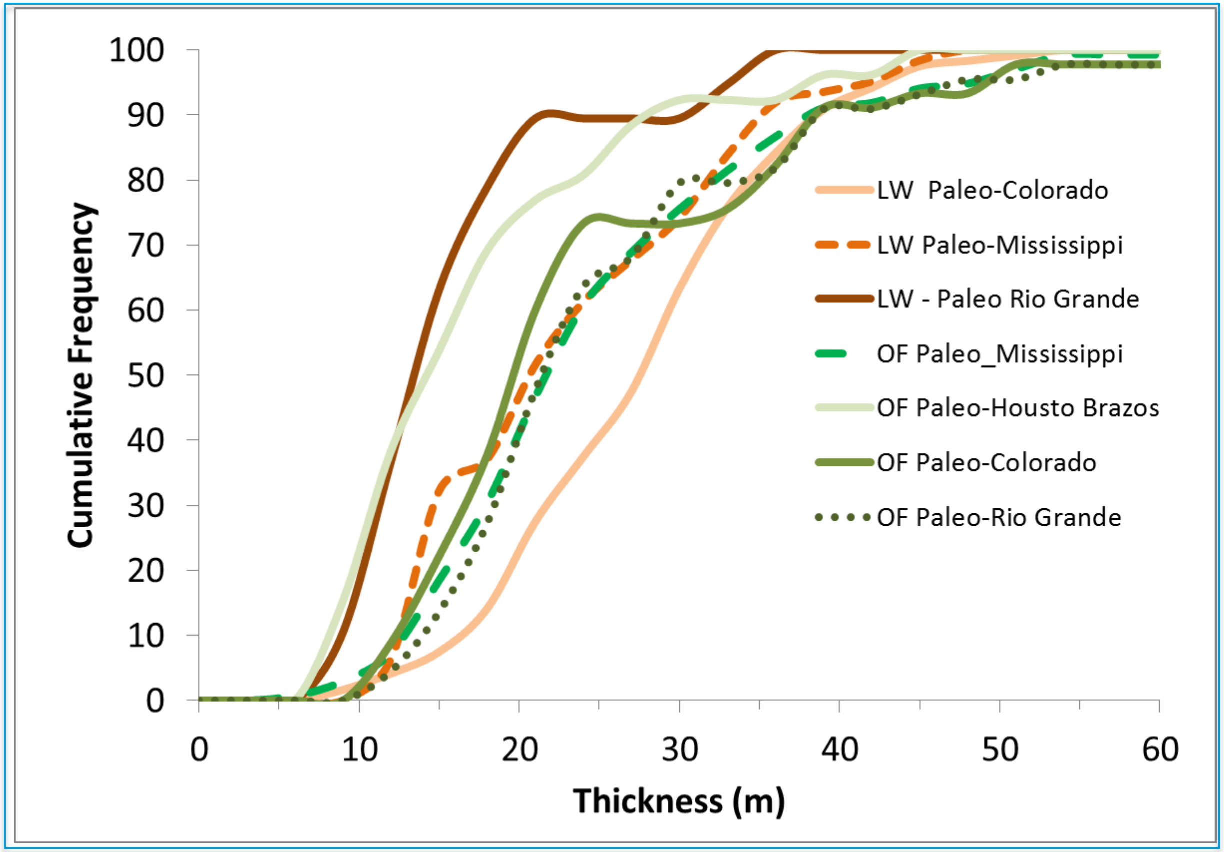
Oligocene



- Oligocene fluvial systems active from South Texas to East Louisiana – significant shelf progradation

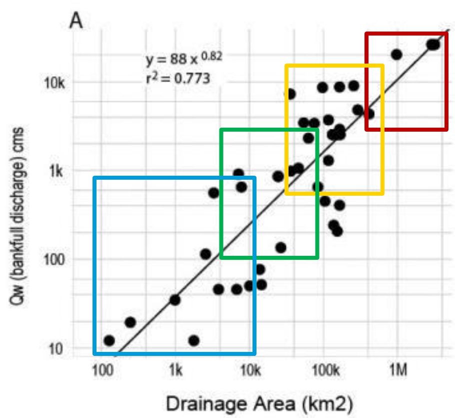
Quantitative channel belt comparison:
Lower Wilcox to Oligocene variations

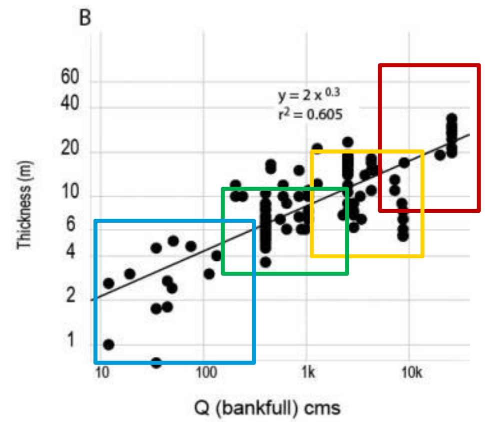
- Lower Wilcox Paleo-Colorado and Paleo-Houston Brazos channel belts are thickest
- Oligocene Paleo-Mississippi similar to LW Paleo-Mississippi

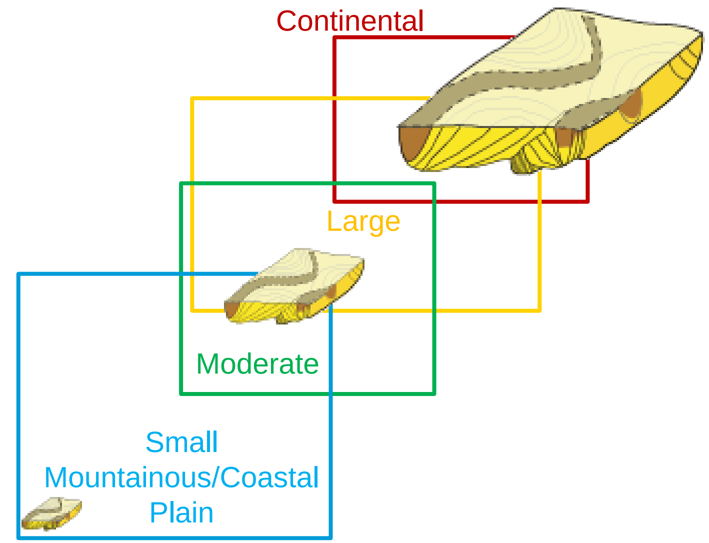


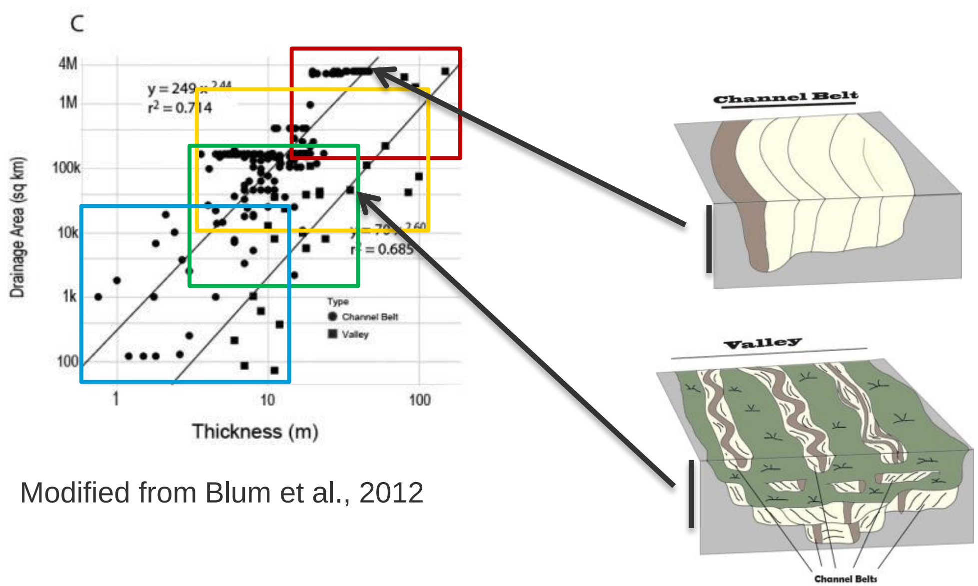
Calibration:

Quaternary Channel Belt Thickness to Drainage Size







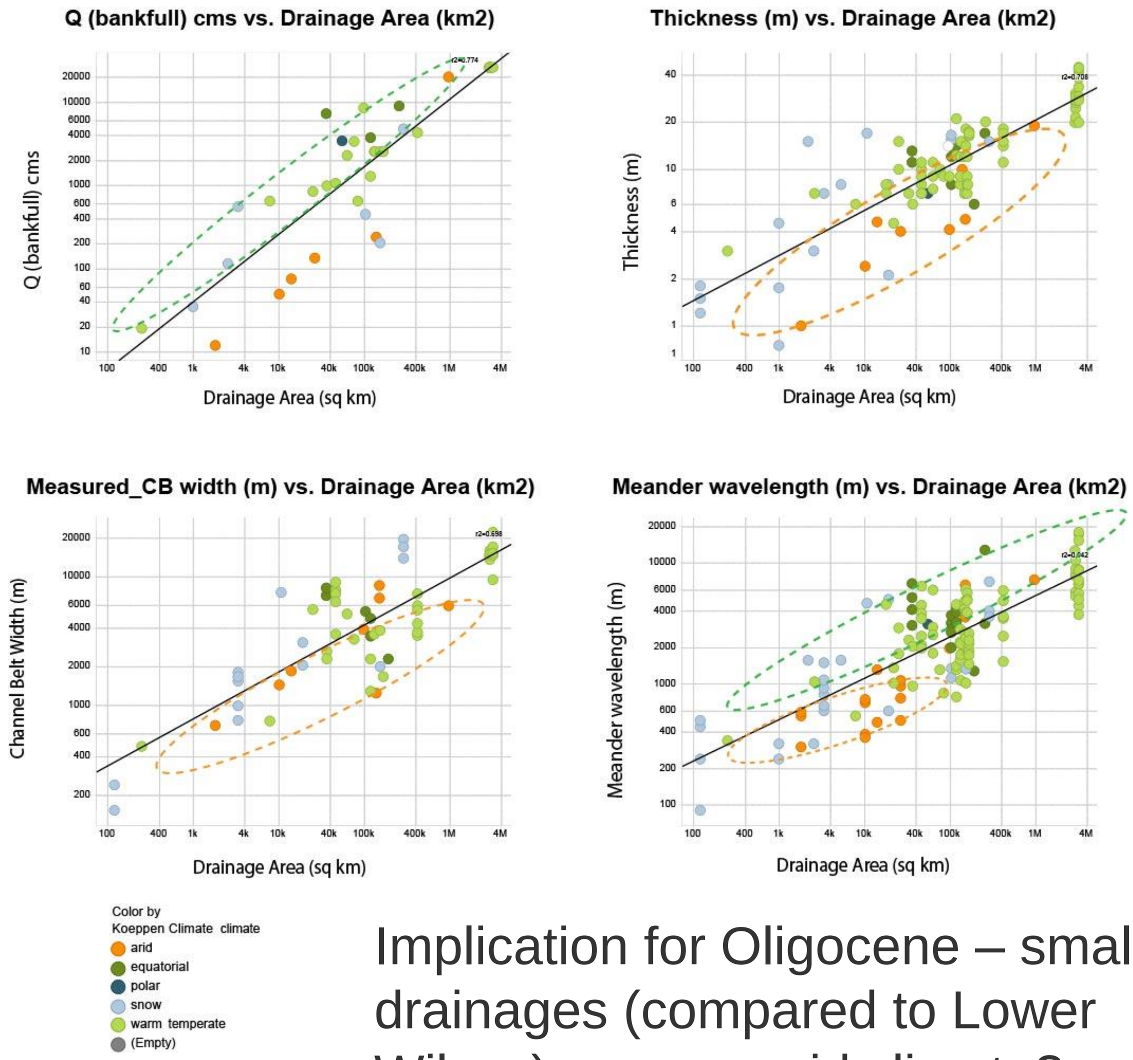


Modified from Blum et al., 2012

- Channel belt thickness as a proxy for drainage basin area

Climatic Impacts on Channel Belt Scaling

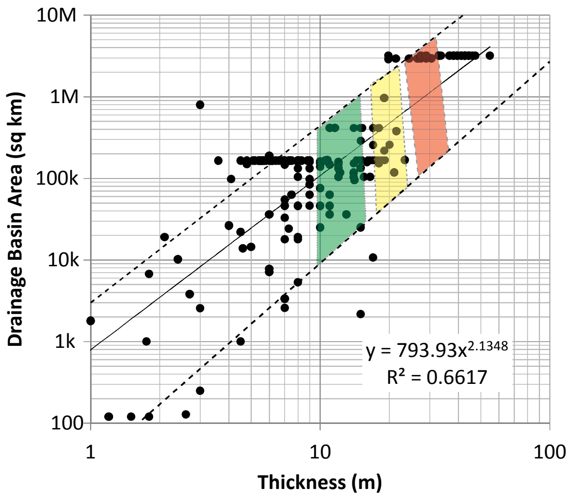
- For a give drainage basin size, channel belts developed in Arid climates are thinner
- Therefore, a thinner channel belt could be smaller catchment or more arid catchment



Implication for Oligocene – smaller drainages (compared to Lower Wilcox) or more arid climate?

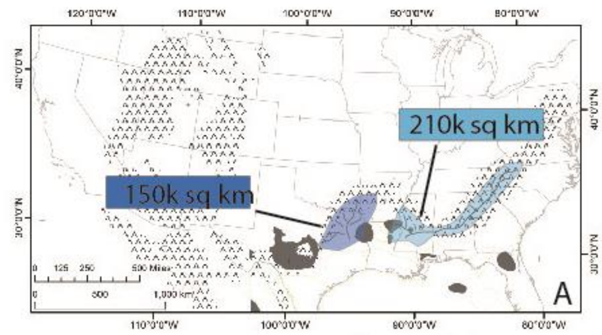
Quantitative Linkage:

Channel Belt Thickness and Paleo-Drainage Basin



Modified from Blum et al., 2012

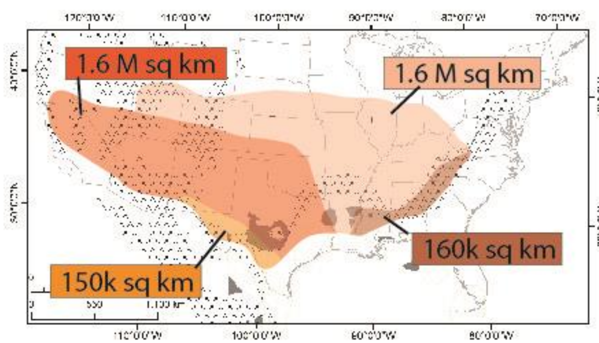
- Major drainage reorganization from Cennomanian to Paleocene/Eocene



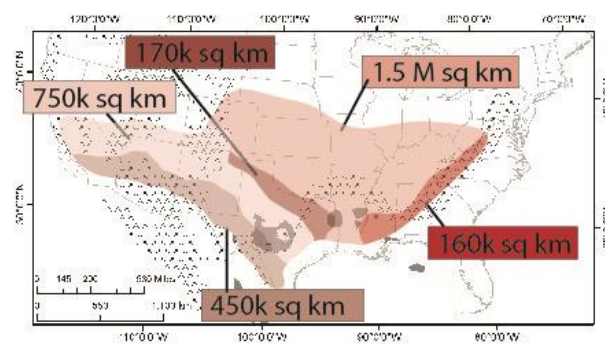
Upper Cretaceous

- Paleo-Tennessee independent at least through Eocene – Upper Wilcox time

- Channel Belt Thickness used to draw representative drainage basin



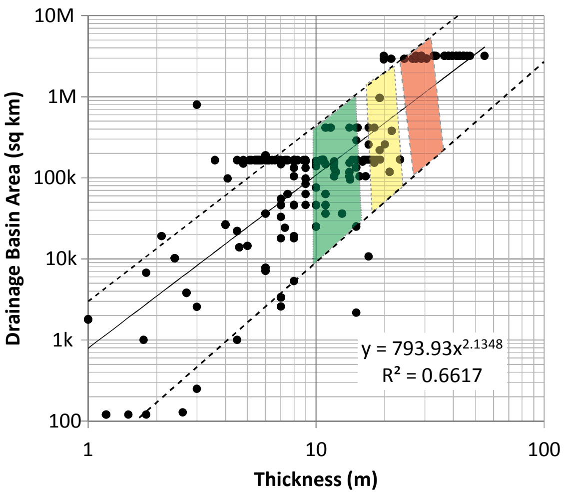
Paleogene - Lower Wilcox



Eocene - Upper Wilcox

Drainages modified from Galloway et al., 2011

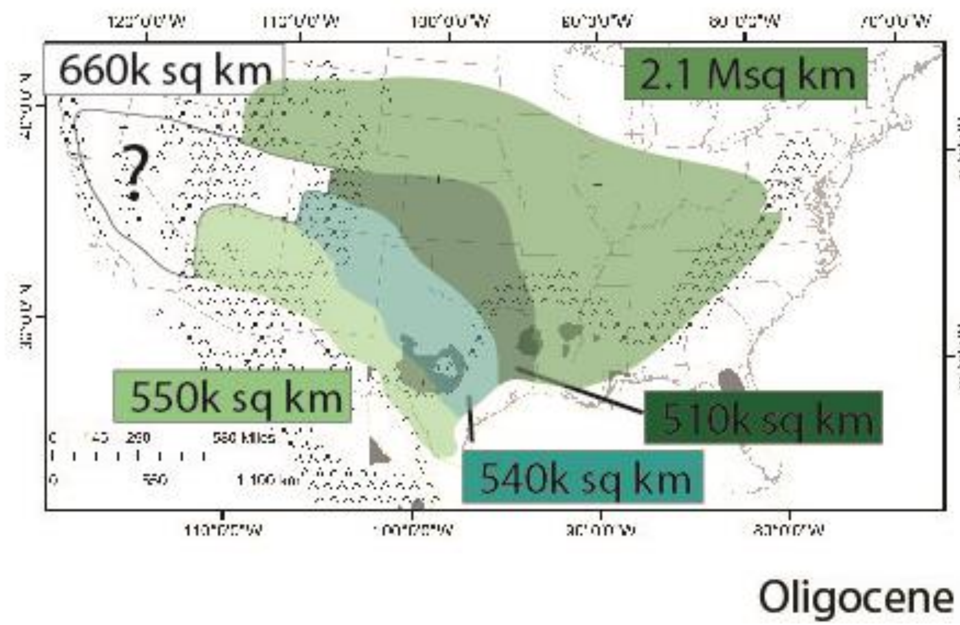
Quantitative Linkage:
Channel Belt Thickness and Paleo-Drainage Basin



Modified from Blum et al., 2012

- Channel Belt Thickness used to draw representative drainage basin

- Oligocene drainages likely larger than previously published paleo-drainages –
  - Paleo-Rio Grande and Paleo- Colorado



Drainages modified from Galloway et al., 2011

Summary and Conclusions

- Fluvial systems possess a range of scaling relationships that reflect drainage-basin controls on water and sediment flux.
- Quaternary channel-belt thickness (as controlled by bank-full water discharge) has been documented as a reliable first-order proxy for drainage basin size
- This study documents the scales of fluvial system channel belts within Cretaceous to Tertiary fluvial successions from the Gulf of Mexico.
  - This study focused on fully-fluvial deposition rather than parsing fluvial channel belts from shallow marine blocky sand bodies
  - Caveat: Recognition criteria for faithfully interpreting fluvial channel belts interspersed with shallow-marine/deltaics needs to be investigated
- The data indicate that the Wilcox and Oligocene fluvial systems were significantly larger than the Cretaceous fluvial systems which can be related to drainage basin reorganization.
- Furthermore the Wilcox fluvial systems were relatively larger than the Oligocene fluvial systems. This could reflect either smaller drainage basins or climatic aridification.

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