Record of Cretaceous through Paleogene Gulf of Mexico Drainage Integration from Detrital Zircons*

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Search and Discovery Article #30422 (2015)**
Posted October 19, 2015

*Adapted from oral presentation given at AAPG Annual Convention & Exhibition, Denver, Colorado, May 31-June 3, 2015. See similar article 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, **Search and Discovery Article #30421 (2015)**

Winner of the 2016 John W. Shelton Search and Discovery Award for "Best Paper of 2015" posted on Search and Discovery.

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Abstract

Published analysis of scaling relationships between sediment-dispersal system components imply that reconstruction of the length-scales of drainage basins and fluvial systems can assist prediction of the dimensions of basin-floor fans. This paper is the first of three to address this overall goal, and provides a summary reconstruction of mid-Cretaceous to Paleogene Gulf of Mexico (GoM) drainage integration and drainage-basin scales from detrital zircons (DZs). GoM DZ data include >6000 U-Pb and Pb-Pb ages from ~60 samples of Cenomanian Tuscaloosa-Woodbine, Paleocene Wilcox, and Oligocene Frio-Catahoula, fluvial deposits: samples were collected across each outcrop belt, from Alabama to Texas. Complementary DZ data comes from Aptian to Cenomanian fluvial deposits of the Great Plains, the US Rocky Mountain Front Range, and Aptian-Albian deposits of the Alberta foreland. Collectively, these data show that much of early-mid Cretaceous North America was part of a continental-scale drainage that originated in the Appalachian-Ouachitas, and flowed north and west across the Great Plains to the Alberta foreland and Boreal Sea. GoM drainage was restricted to south of the Appalachian-Ouachitas through at least the Cenomanian: Tuscaloosa-Woodbine fluvial deposits contain no DZ signatures from the Western Cordillera, fluvial systems were of regional scale only ($<<10^6$ sq. km), and the largest system is interpreted to represent a paleo-Tennessee River that discharged to the eastern Mississippi embayment. By the Paleocene, much of southern North America, from the Appalachians to the Sierra Nevada, was re-routed to the GoM through a series of major fluvial axes that remain extant today. These included the paleo-Tennessee and its Appalachian source terrain, and an ancestral Mississippi-Arkansas system with an estimated drainage area $>10^6$ sq. km that encompassed the central and northern Rockies. However, large axes were also located farther west in Texas, and included an ancestral Colorado-Brazos system with headwaters in the Sierra Nevada, Sevier orogen, and Laramide Rockies, and an ancestral Rio Grande with headwaters in the Mexican Cordillera: the paleo-Colorado-Brazos axis had an estimated drainage area $>>10^6$ sq. km, and length scales >2000 km. Beginning in the Oligocene, far western sources were tectonically dismembered, and GoM drainage areas extended no farther west than the eastern Laramide Rockies, heralding development of the Neogene to present continental divide.

Selected References

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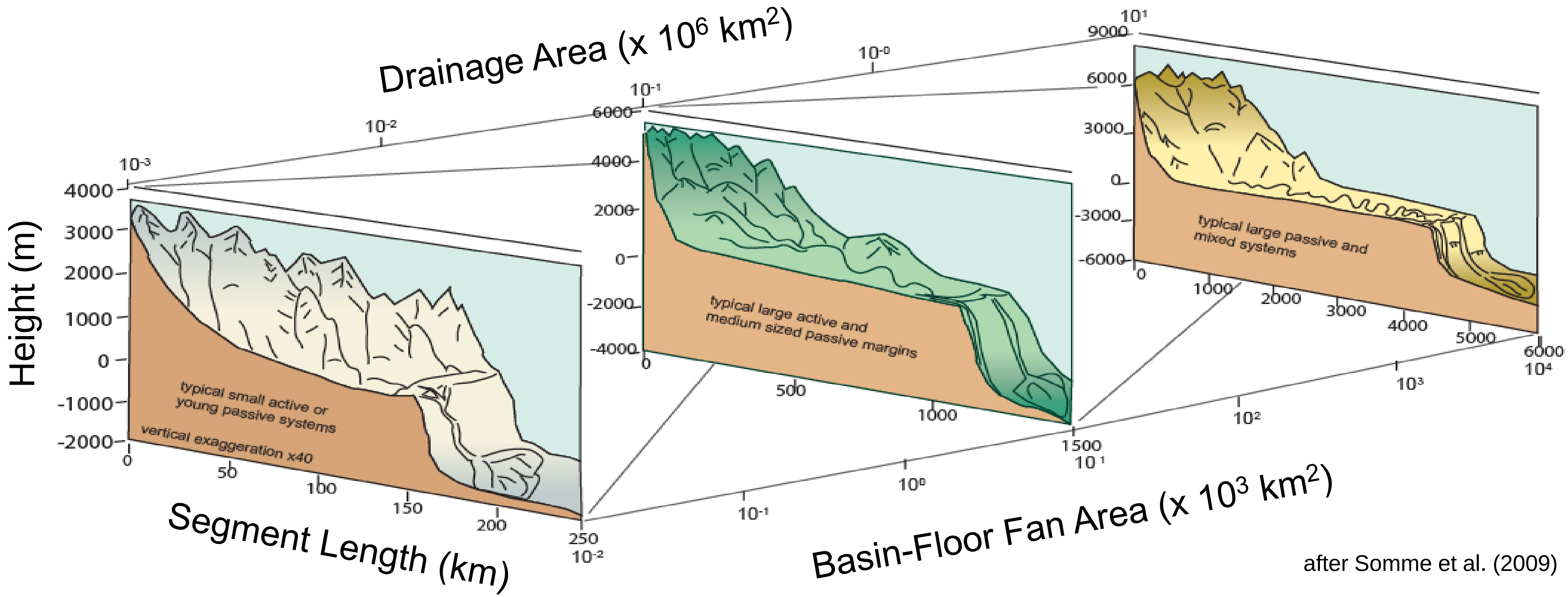
Special thanks to Imperial Oil and Exoxnmobil,
and Mark Pecha, University of Arizona

Key Topics

- *Source-to-sink concepts and scaling relationships from modern systems*
- *Detrital-Zircon Record of Mid-Cretaceous through Paleogene Gulf of Mexico Drainage Integration*
- *Implications for Predicting Basin-Floor Fan Scales in GoM and elsewhere*

GULF OF MEXICO DRAINAGE INTEGRATION

Summary of 1st-Order Scaling Relations



after Somme et al. (2009)

Scaling relationships between drainage-basin area, length of fluvial system, thickness of fluvial sand bodies, length of basin-floor fans, and basin-floor fan area

	Drainage basin area (km^2)	Fluvial system length (km)	Fluvial sand body thickness (m)	Backwater Length (km)	Fan Length (km)	Fan Width (km)	Fan Area (km^2)
Small	10,000	75-100	5-7	10-30	<25	25-50	<1000
Moderate	100,000	750-1000	10-15	50-100	100-200	100-200+	100,000
Large	1,000,000+	2000-4000	25+	300-500+	500-1000	500-1000+	10,000,000

after Somme et al. (2009) and Blum et al. (2013)

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Modern North American Drainage and Sediment Routing

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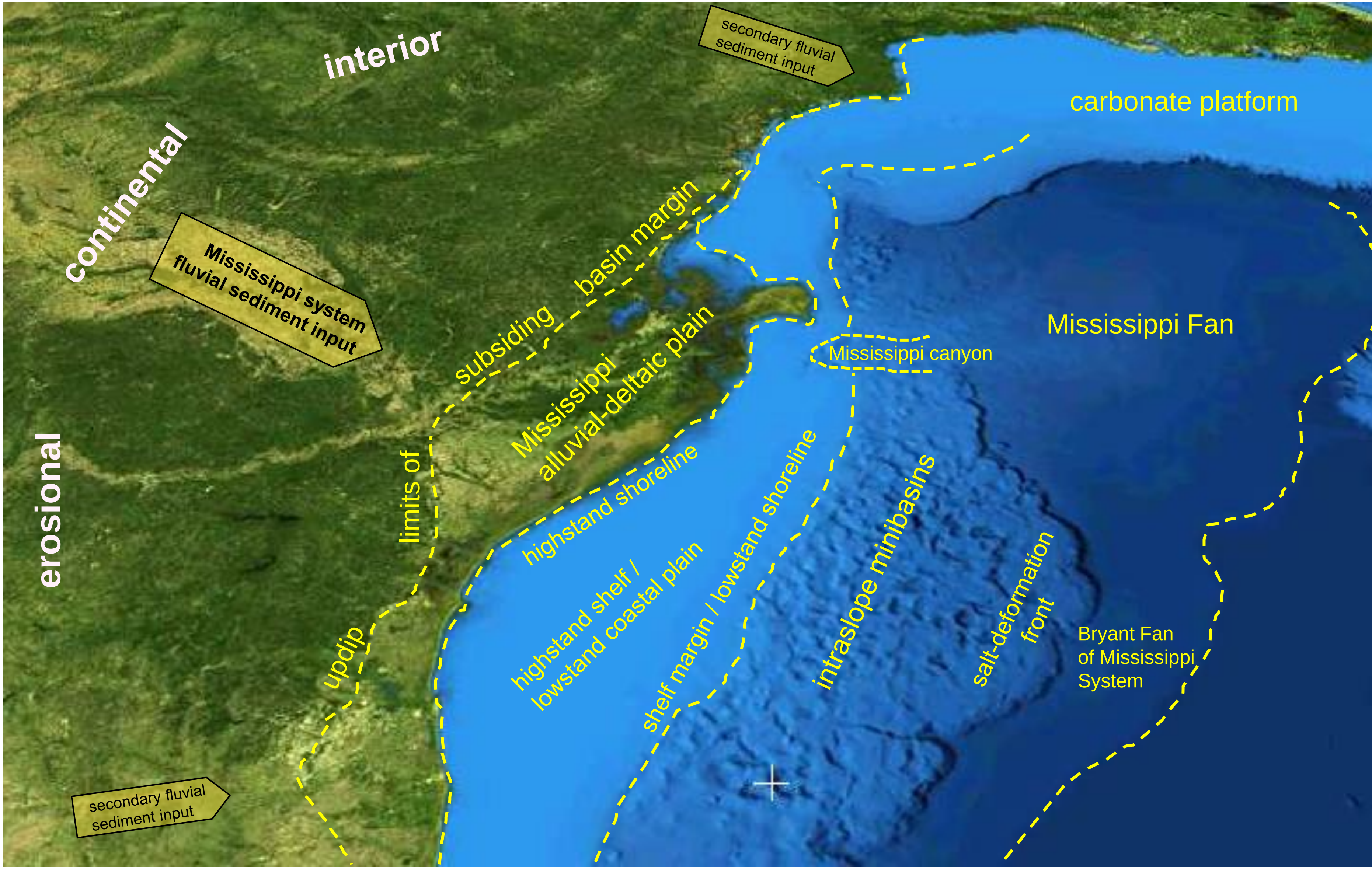
Modern Gulf of Mexico Sediment Dispersal System



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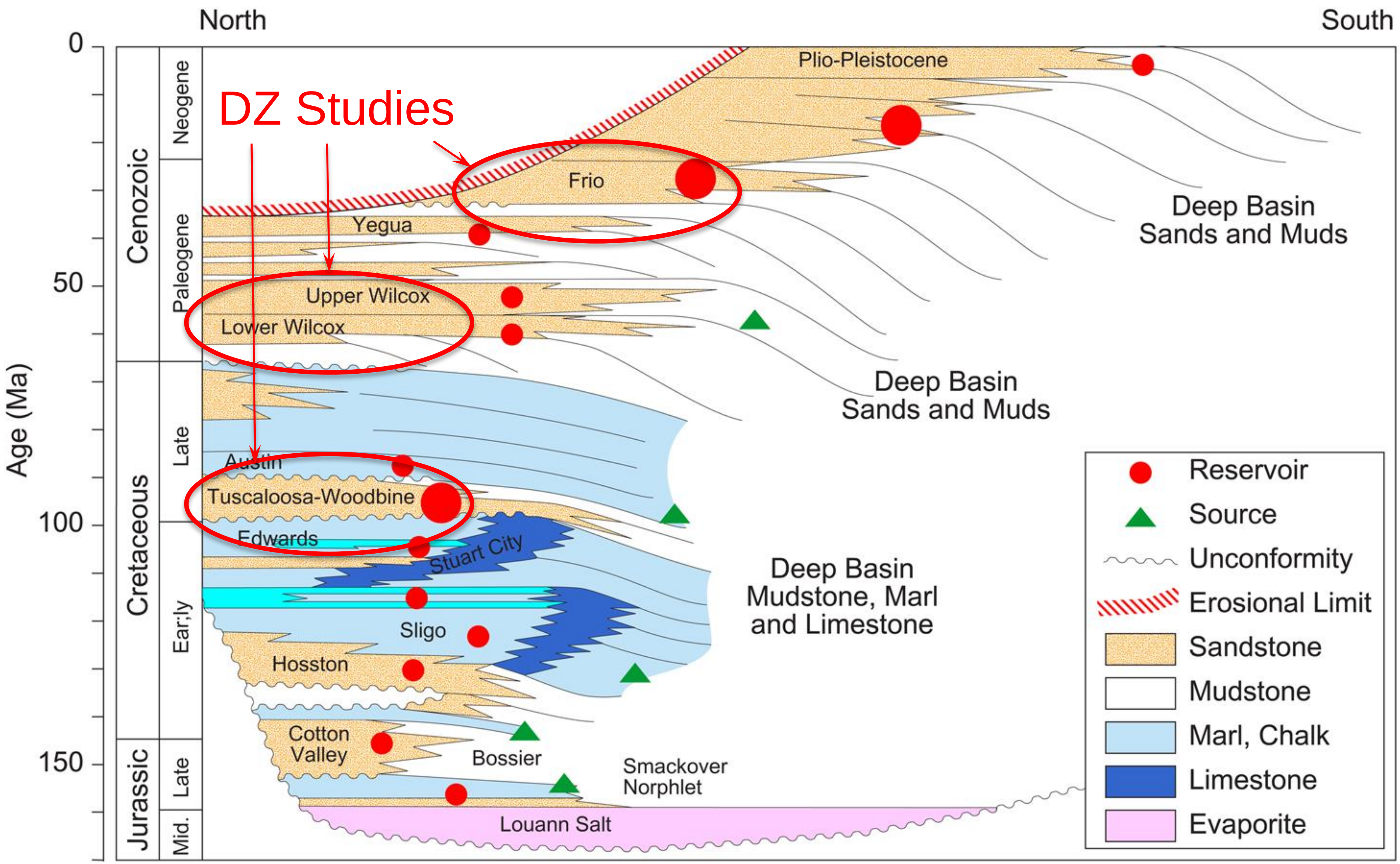
Gulf of Mexico Basin-Fill Stratigraphic Framework



modified from Galloway (2008)

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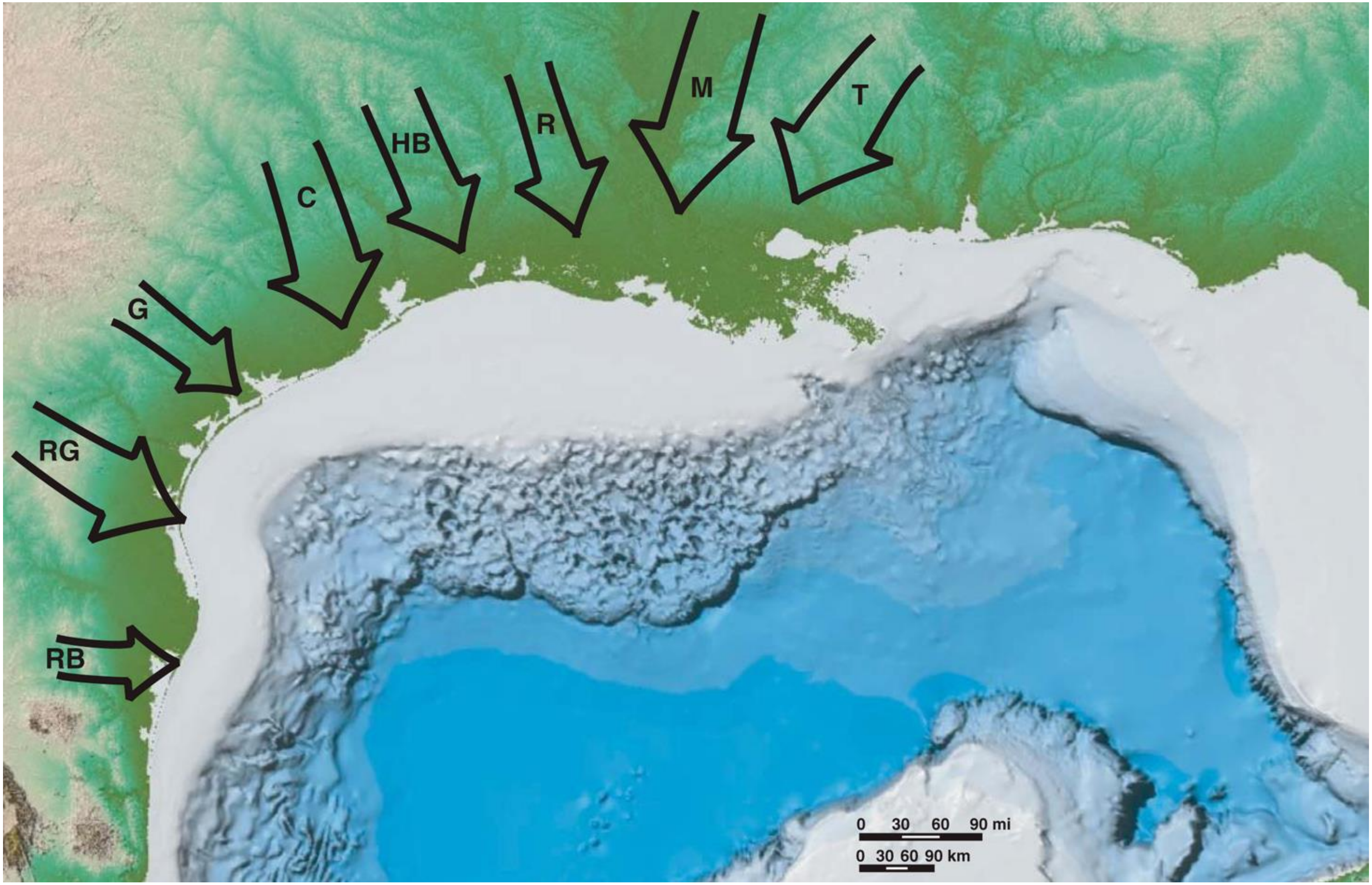
Gulf of Mexico Sediment Input – Long-Term Fluvial Axes



after Galloway et al., 2011

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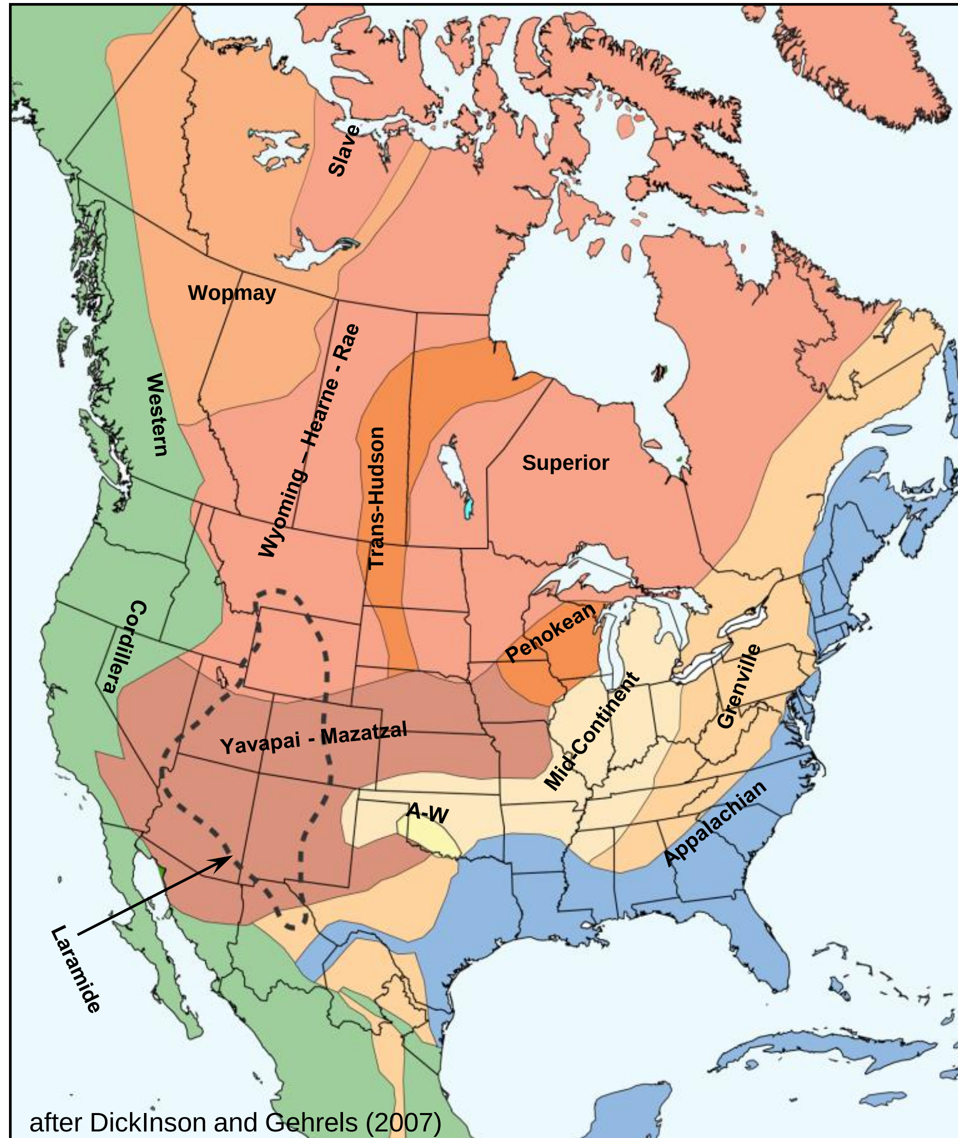
Detrital Zircon Provenance and Geochronology Studies

DZ Study Areas

North American DZ Source Terrains



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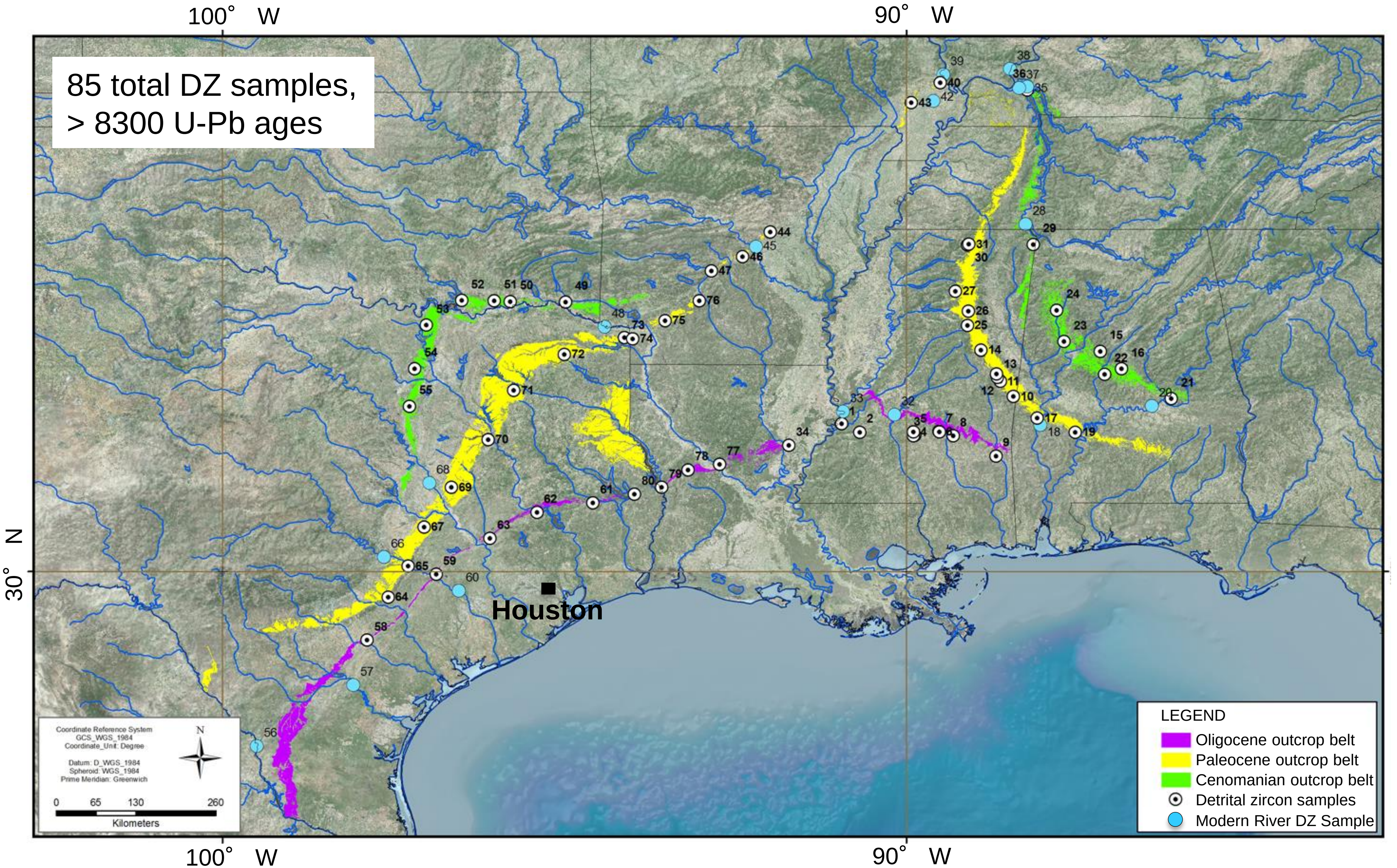
Gulf of Mexico Coastal-Plain Detrital-Zircon Samples



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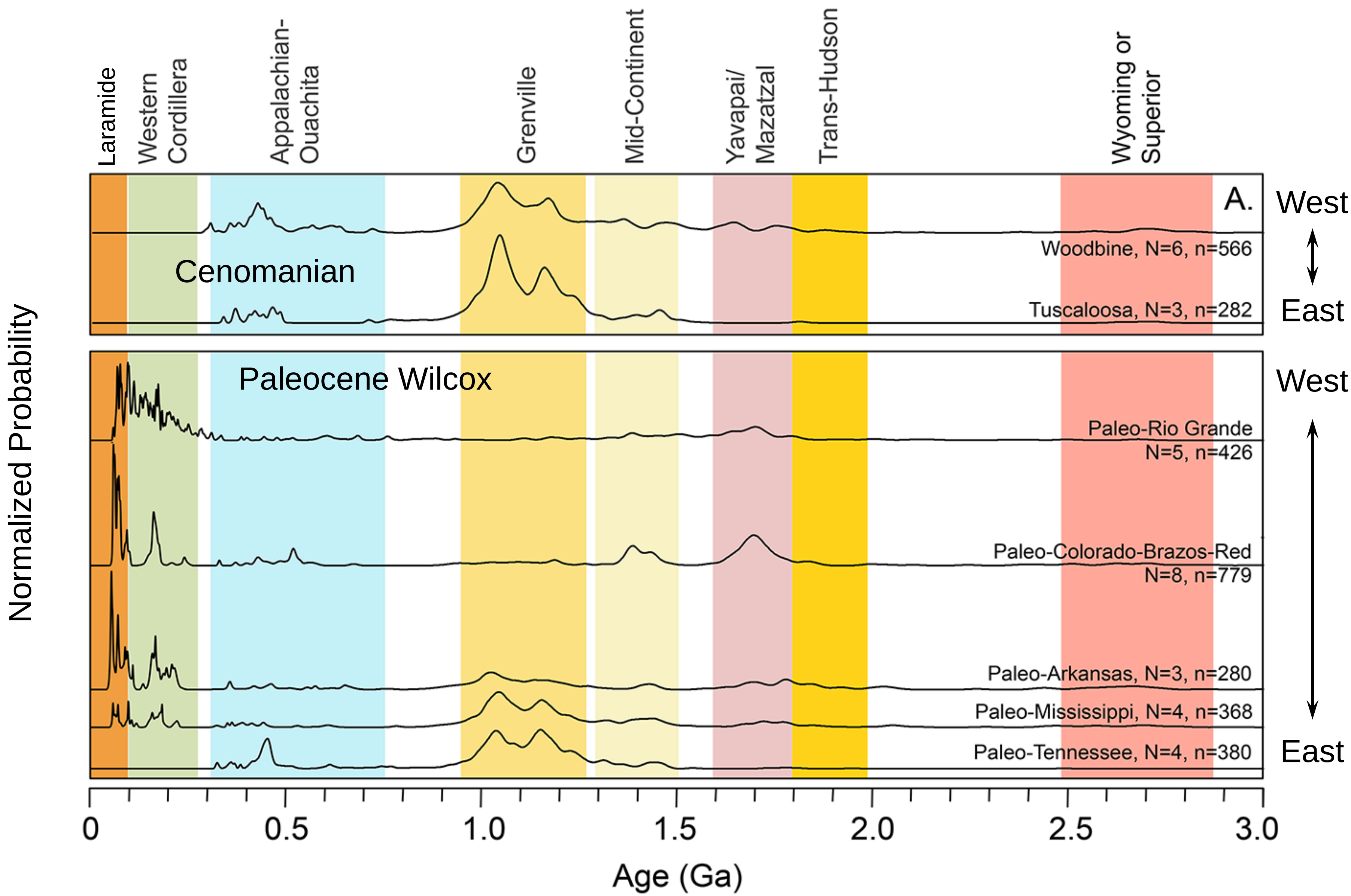
DZ Signatures – Cenomanian vs. Paleocene Fluvial Axes



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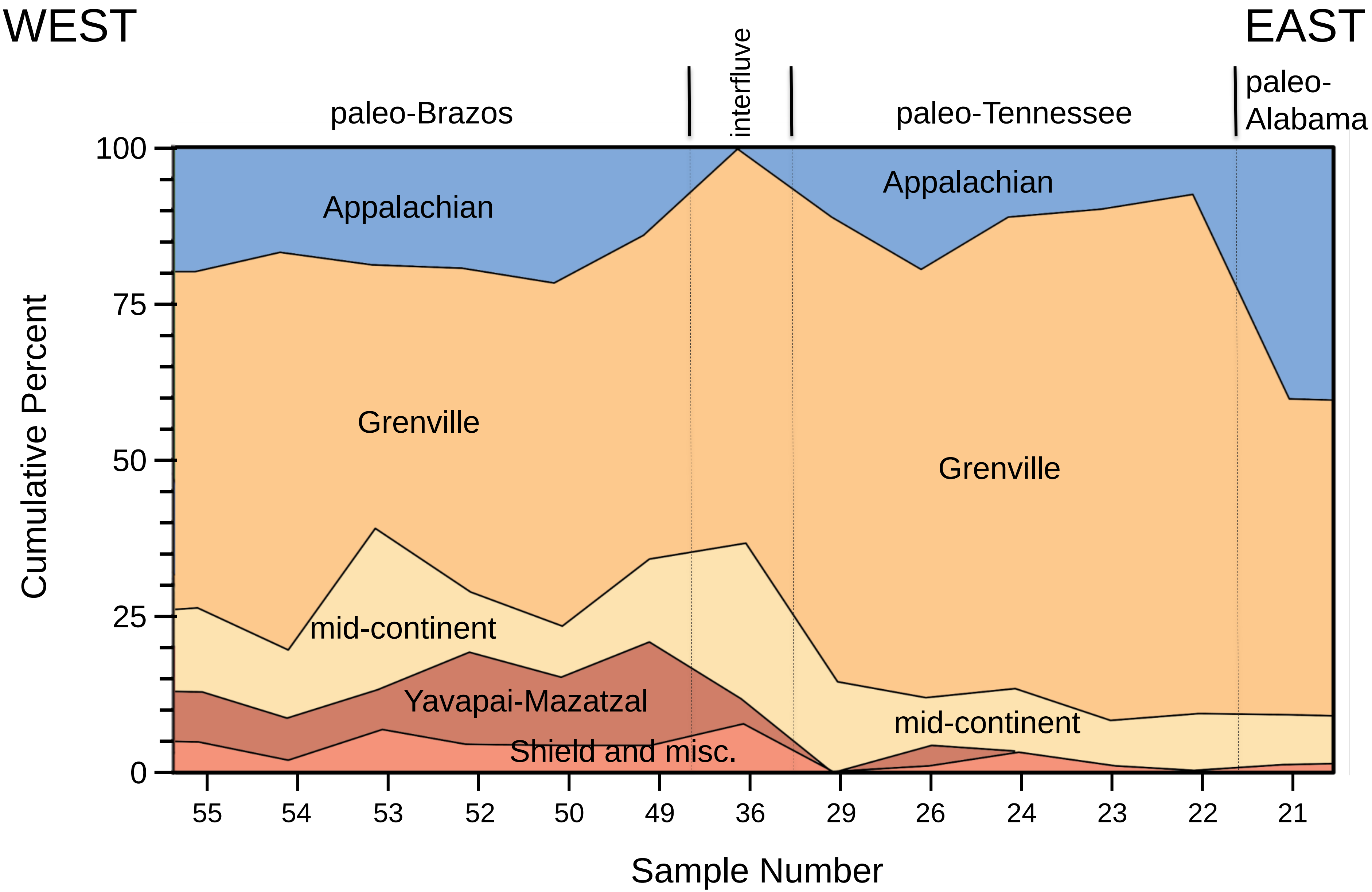
Longitudinal Change in GoM Cenomanian DZ Signatures



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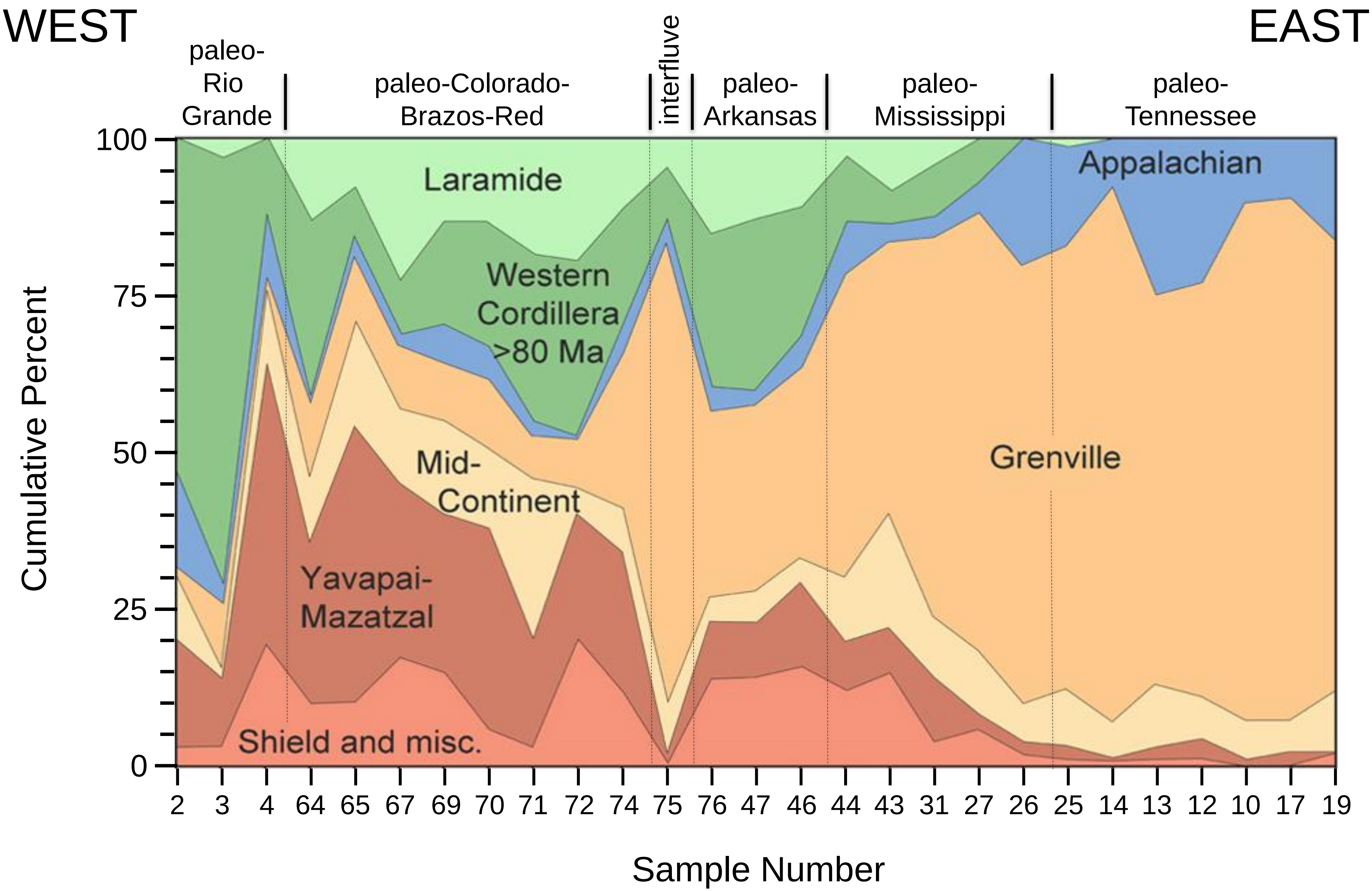
Longitudinal Change in GoM Paleocene-Eocene DZ Signatures



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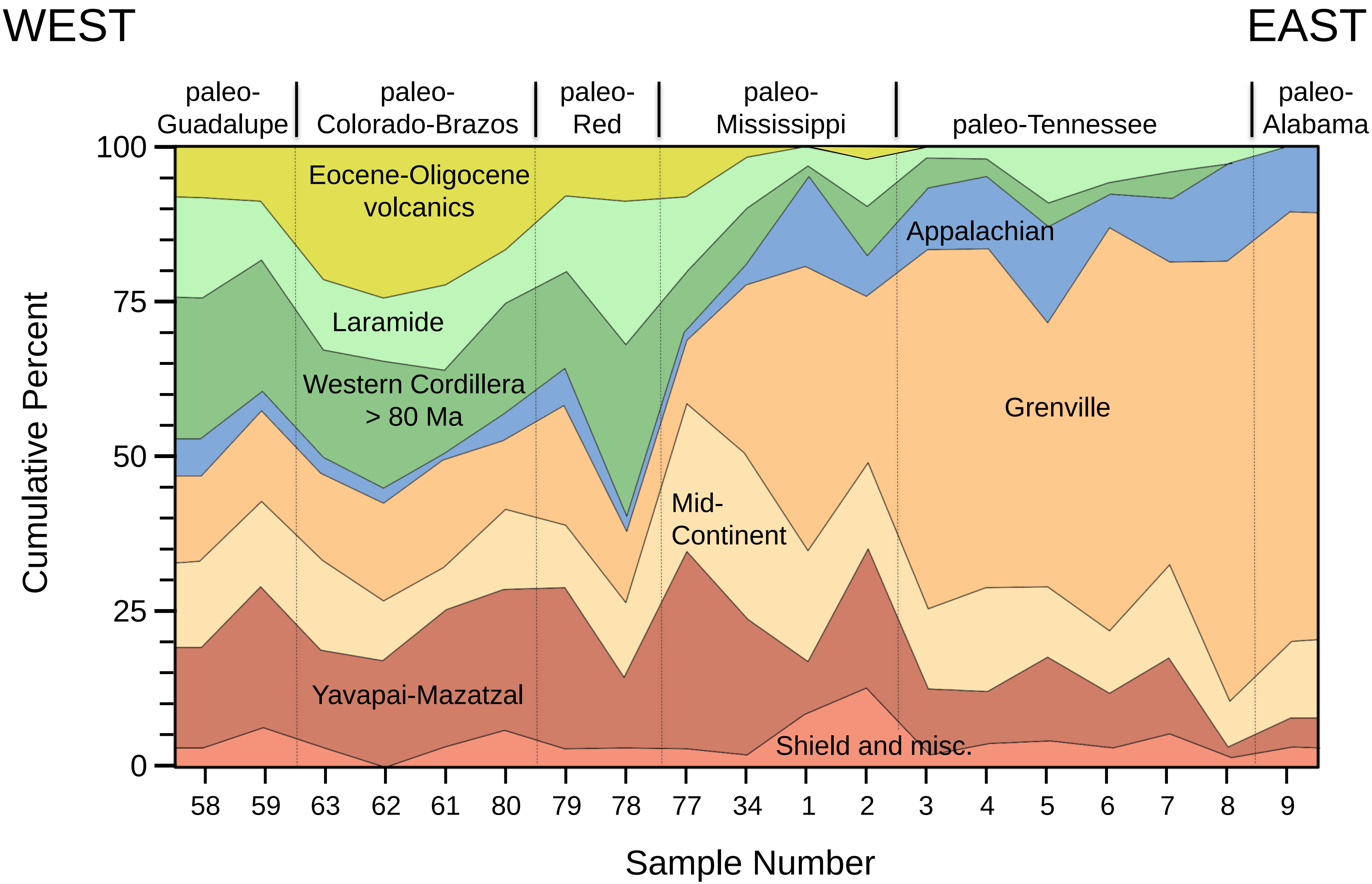
Longitudinal Change in GoM Oligocene DZ Signatures



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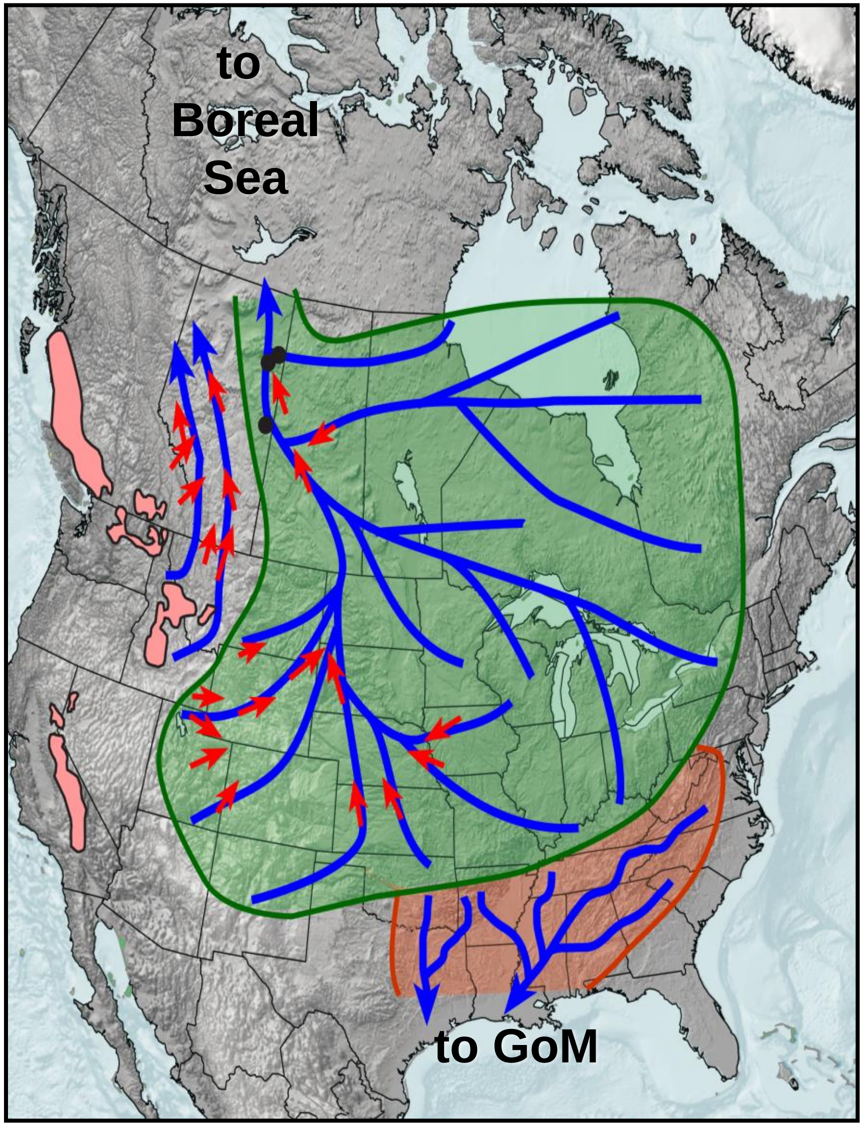
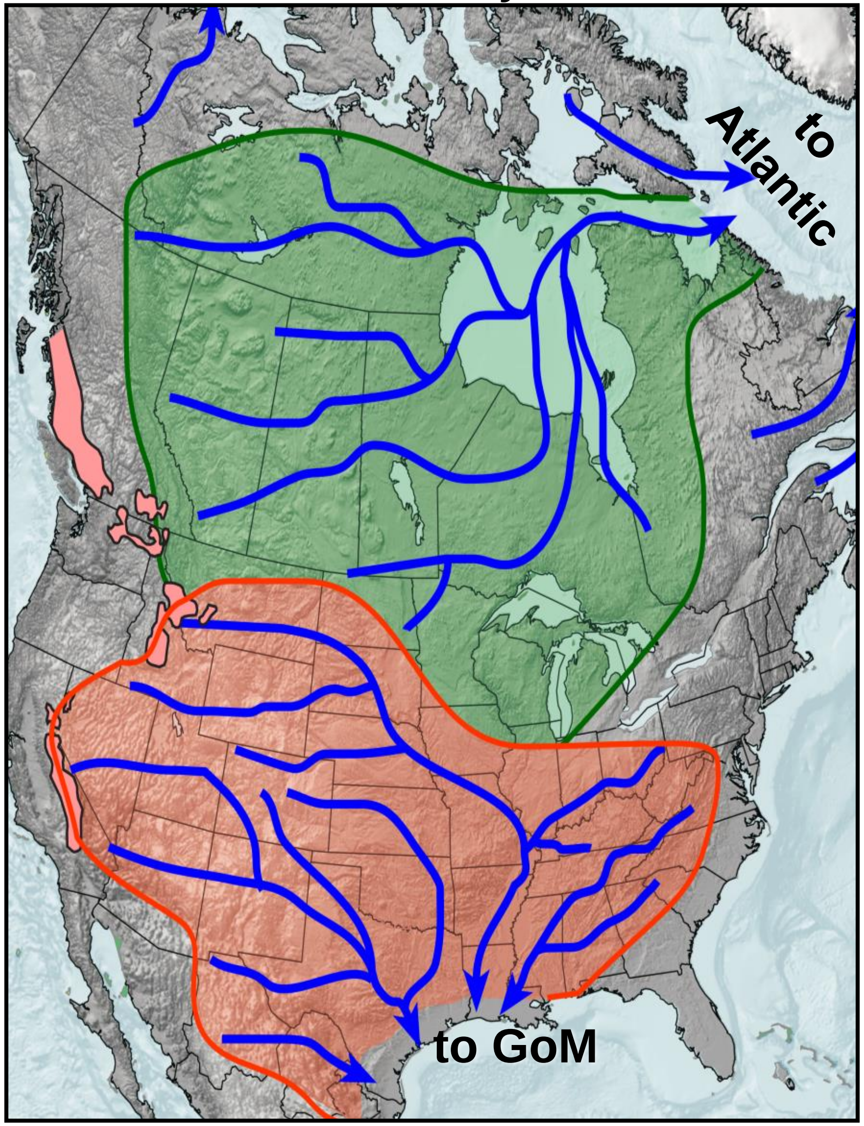
Cretaceous to Paleocene Drainage Reorganization

Mid-Cretaceous



Paleocene-Early Eocene



after Blum and Pecha(2014)

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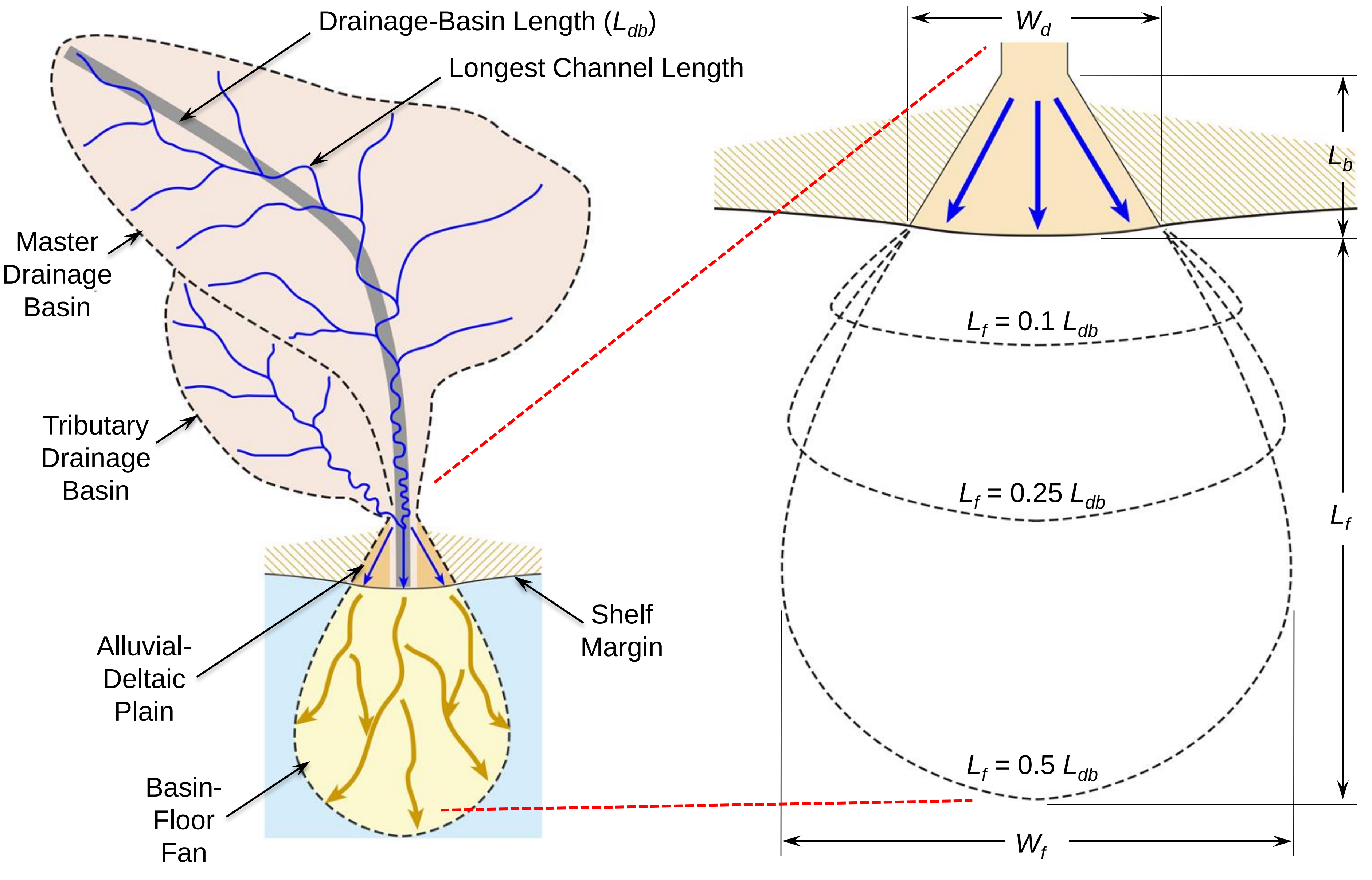
Predicting Scales of Basin-Floor Fans



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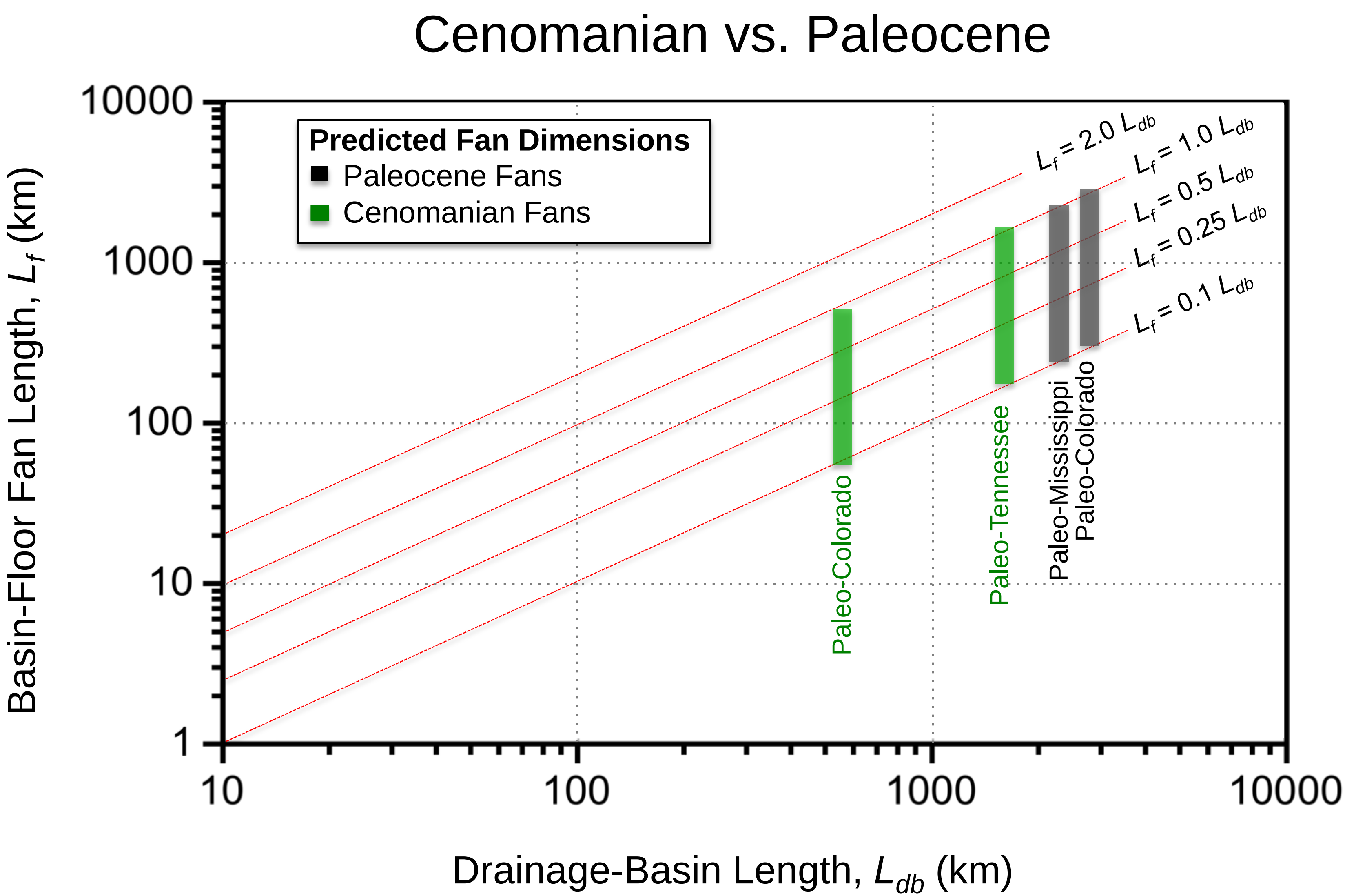
Predicted Scaling of Basin-Floor Fans to Drainage Area



scaling relationships after Somme et al. (2009)

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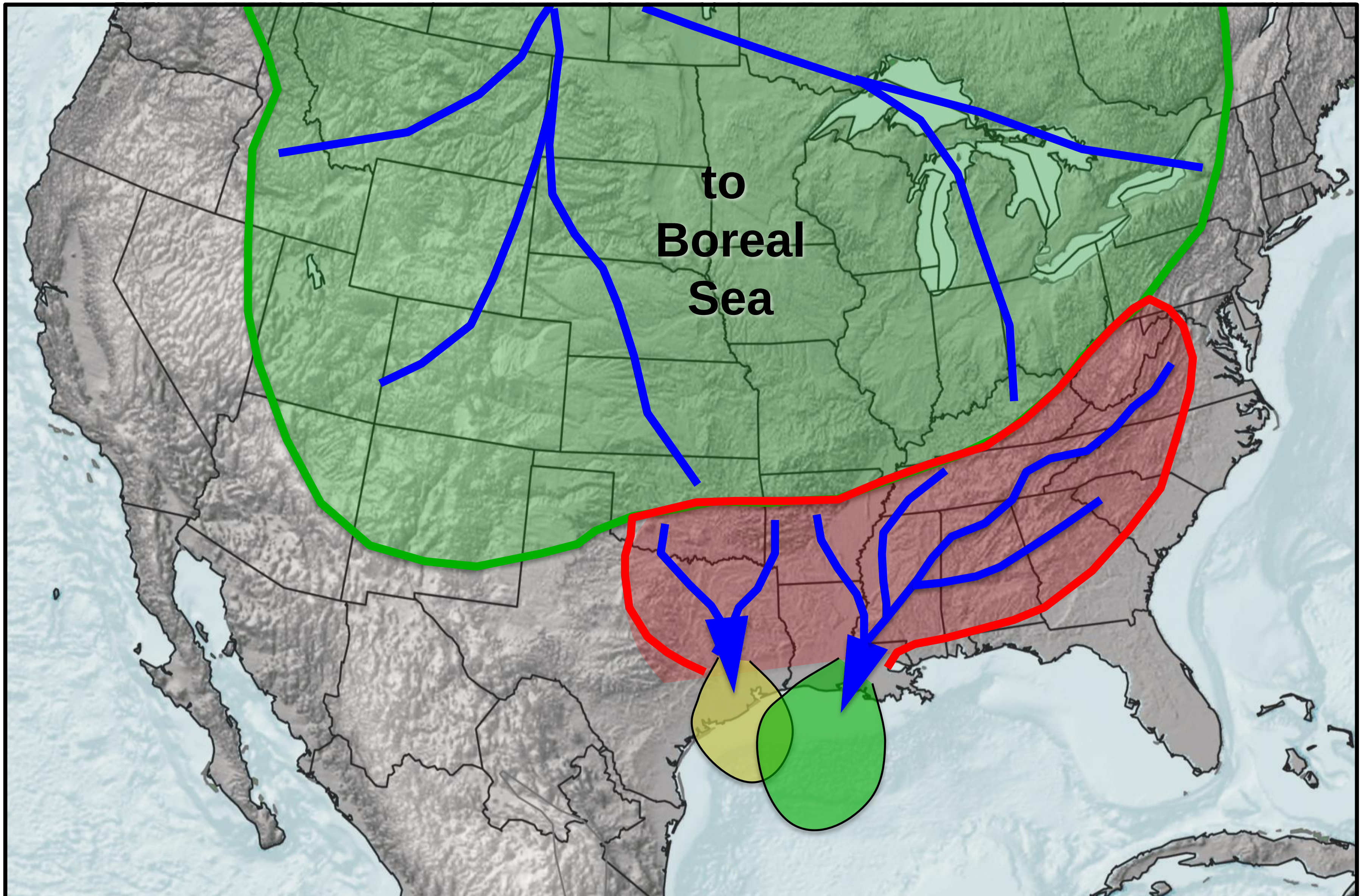
GoM Cenomanian Drainage and Sediment Routing



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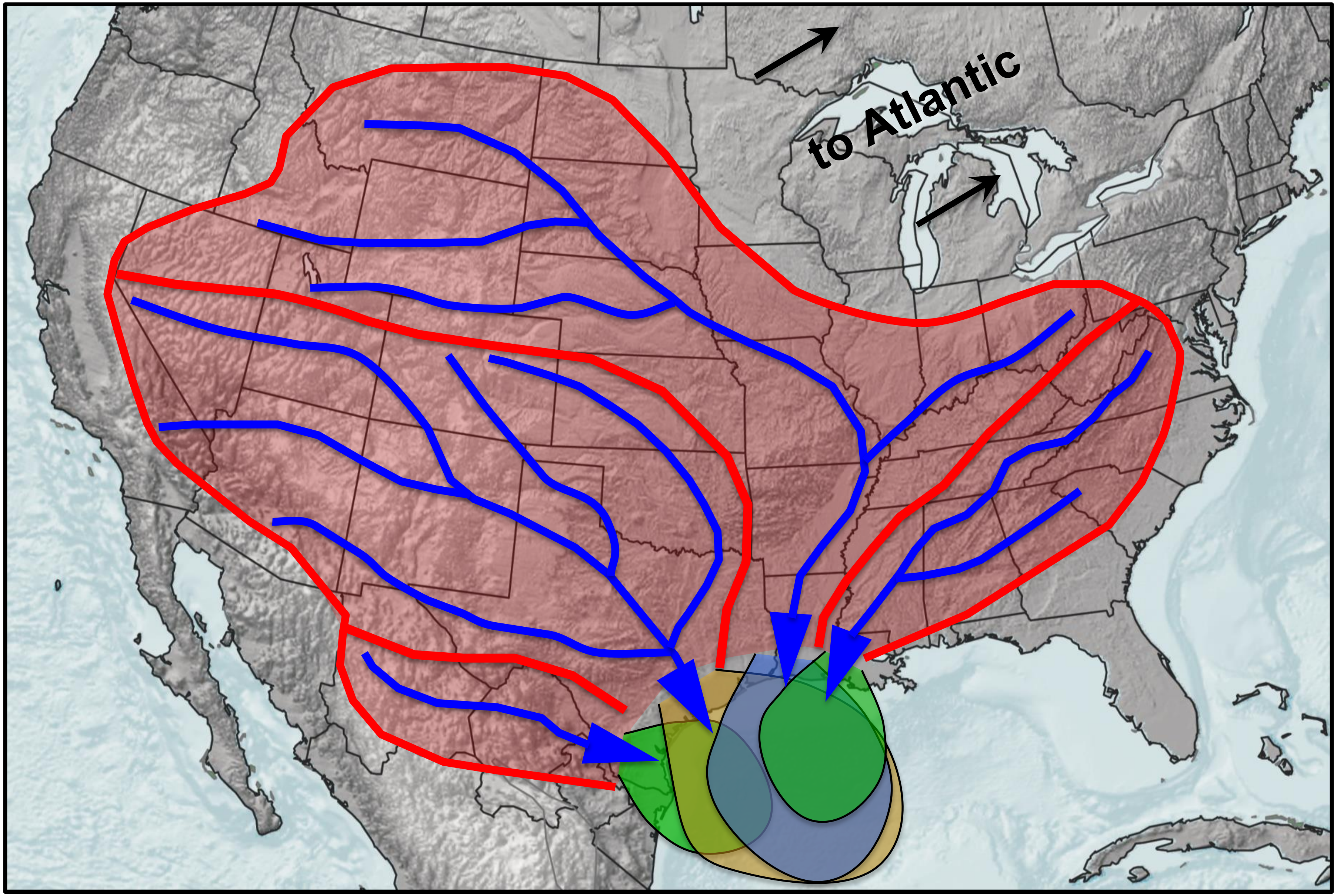
GoM Paleocene Drainage and Sediment Routing



SUMMARY

During the Mid-Cretaceous, much of North America drained to the Boreal Sea, and the Gulf of Mexico was fed by small regional fluvial systems, with the Paleo-Tennessee as the dominant sediment routing system

Western US tectonics and flooding of the Western Interior Seaway drove continental-scale drainage reorganization - by the Paleocene most of the southern half of North America was routed to the Gulf of Mexico

- **The largest fluvial system drained the Sierra Nevada and central to southern Rockies, and delivered sediments to the western GoM, south of present-day Houston (Rockdale depocenter)**
- **The Paleo-Mississippi had integrated with the northern Rockies by this time, and fed the Holly Springs depocenter, but was likely not of the scale it is today.**

Because basin-floor fans scale to drainage area, paleodrainage reconstruction using detrital zircons permits prediction of basin-floor fan scales that can be tested with empirical data, or used to predict extent of basin-floor systems in frontier areas with limited data.