

The Rio Grande Fan: A Sand-Rich Braided(?) Distributive System in the Gulf of Mexico: A Modern Analog for the Frio and Wilcox Formations?*

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Abstract

Multiple canyons provide coarse-grained sediment from adjacent mountain sources to deposit the Rio Grande Fan on a continental-slope plateau. Multiple surface and subsurface channel pathways are influenced by salt diapirism and drainage into an enlarged channel entering the Perdido Canyon. The result is a widespread distribution of channels throughout the fan and then convergence of channels at the end of the fan. Echo character and cores suggest the potential for good connectivity in this sand-rich fan. The seismic and sedimentary facies, relatively steep fan gradient (1:250), and incised rather than leveed, channels, indicate that the Rio Grande Fan is probably a braided sand-rich fan. This type of fan is rare and contrasts with other mud-rich Gulf of Mexico (GOM) Fans. For example, Bryant Fan is fed by a chain of 15 mini-basins that exhibit seismic facies of: 1) mass transport deposit (MTD) wedges and sheets, 2) incised, ponded and perched turbidites, and 3) bypass channelized facies. The mini-basin pathway through Bryant Canyon traps MTD mud; this results in non-bifurcated, aggrading and stacked channel systems that extend across the Bryant Fan to feed single distal depositional lobes of ~ 30 km in length. The Rio Grande Fan distributive system also differs significantly from the Mississippi Fan, which is fed by massive failures of the 20 km-wide gullied Mississippi Canyon. The failures and mud-rich sediment source result in multiple mid-fan channel bifurcations, outer fan channel splays, and a fan composed of half MTD and half turbidite deposits. The distributive systems of the Rio Grande Fan may provide an analog for some Deepwater Paleogene Frio and Wilcox deposits in the northwestern GOM.

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**Gulf of Mexico
Intraslope Basins Project**

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TOPICS

RIO GRANDE FAN SAND BRAID PLAIN TURBIDITE SYSTEM

Potential Analog for Frio and Wilcox Plays in the Northwestern Gulf of Mexico

1. Morphology
2. Seismic Facies
3. Sediment Facies
4. Depositional Pattern cf to Bryant and Mississippi Fans

BRYANT FAN SAND-RICH TURBIDITE SYSTEM:

Potential Analog for Mississippi Canyon Abyssal Fan Plays

MISSISSIPPI FAN MUD-RICH TURBIDITE SYSTEM:

Example of Mixed Turbidite and MTD Fan
Depositional Pattern

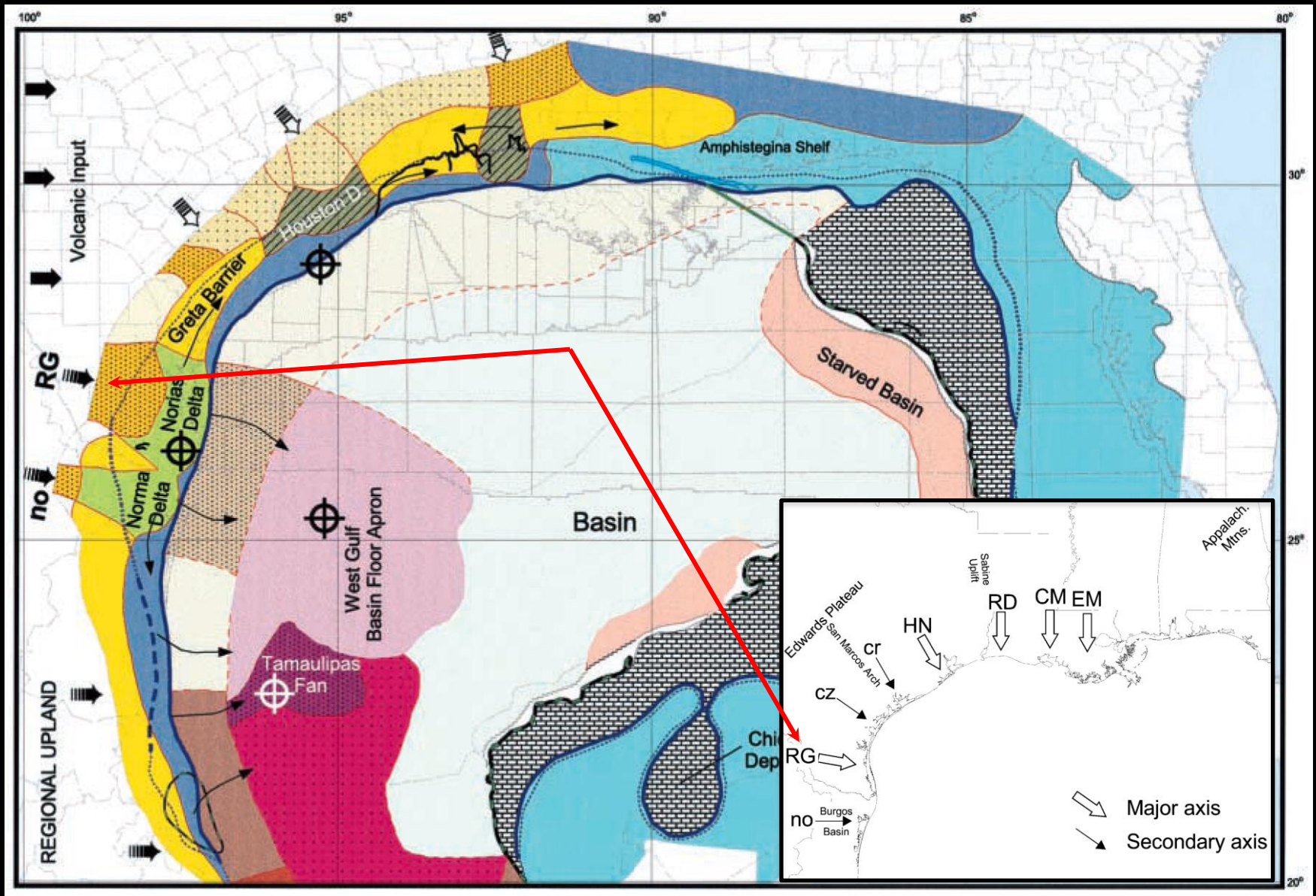


Why Study Rio Grande Fan?

- ➡ First modern analog study of braided channel submarine fan system in the Gulf of Mexico
- ➡ A potential key to western Tertiary Trend plays (Frio/ Wilcox)
- ➡ The best analog for scale of facies and channels in western Tertiary turbidite systems

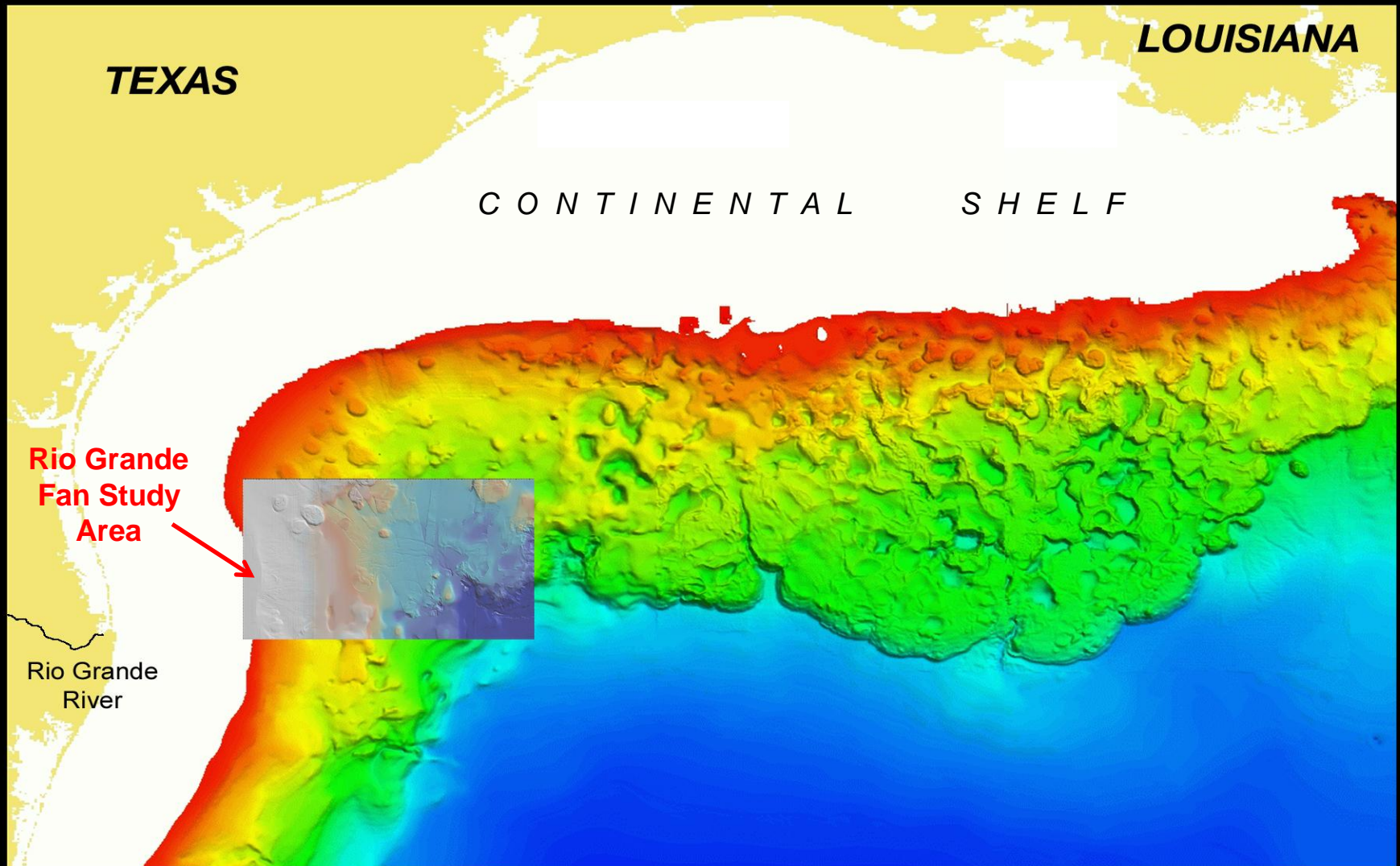


Rio Grande – A Major Sediment Fairway from Paleogene to Present



From Galloway et al. (2000)

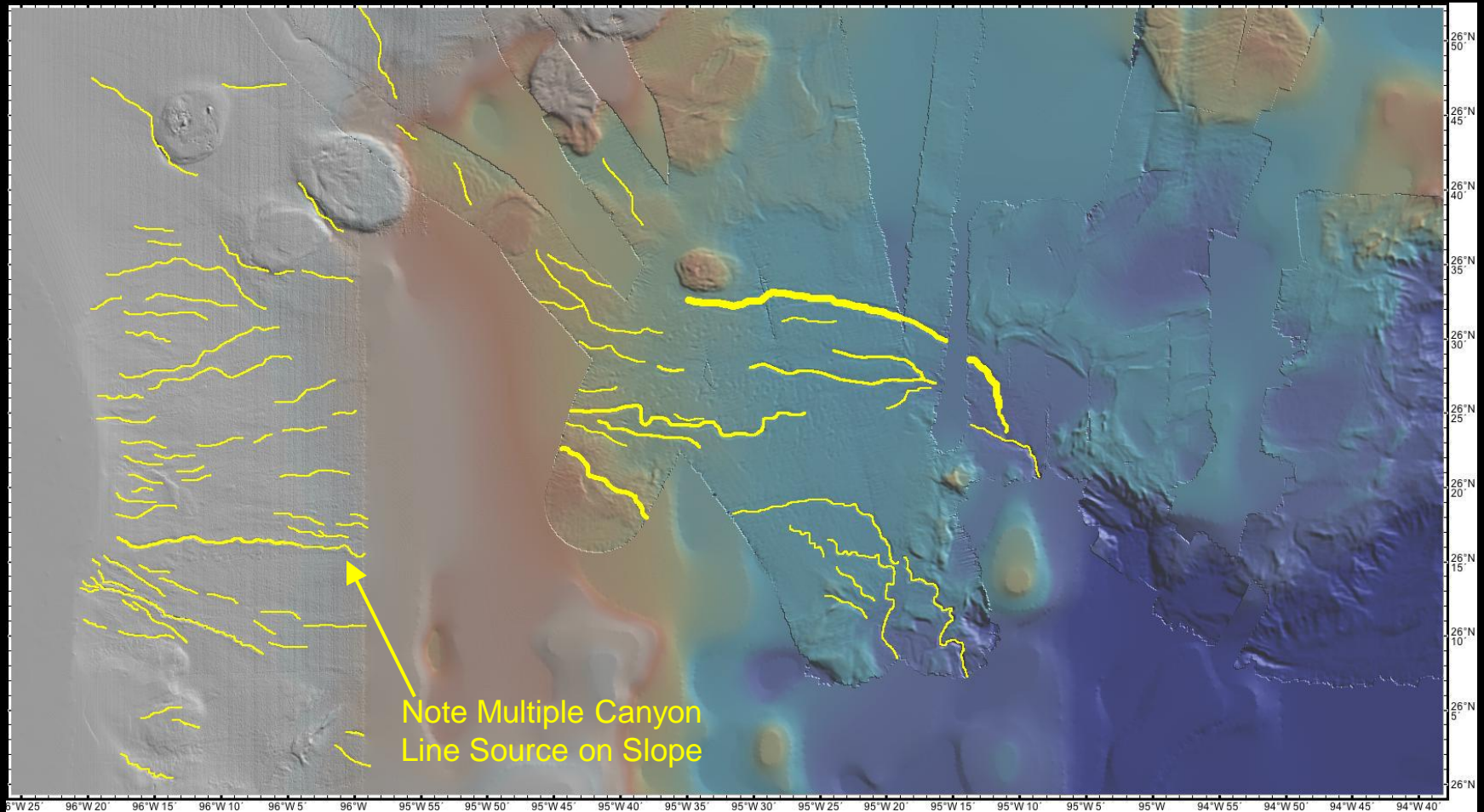
Location of Multi-Beam Swath Bathymetry on Rio Grande Fan and Margin



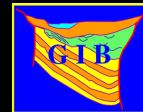
*Inset Map from: LDEO GeoMapApp
(www.geomapapp.org)*

*Seafloor Relief Map of Northern Gulf of Mexico Deep Water
by Lui and Bryant (1999)*

Multiple Canyons Feeding Multiple Channels on Rio Grande Fan

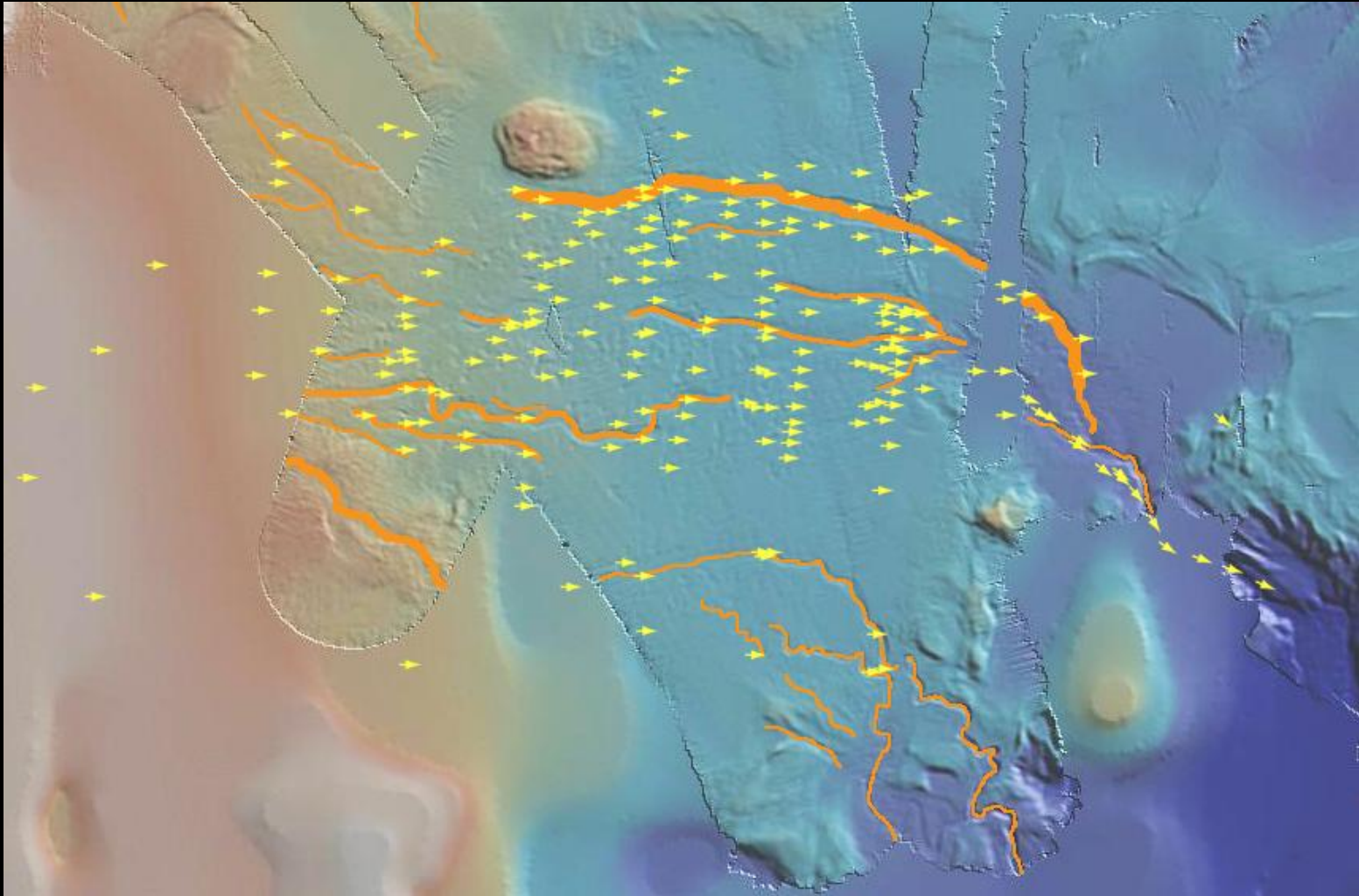


Channels Mapped on Multibeam Data



Map from: LDEO GeoMapApp
(www.geomapapp.org)

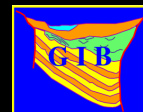
Multiple Channels Crossing the 1:250 Gradient Rio Grande Fan on the Continental Slope Platform; Note Channels Converge & Drain into Perdido Canyon



Channels Mapped on Multibeam Data

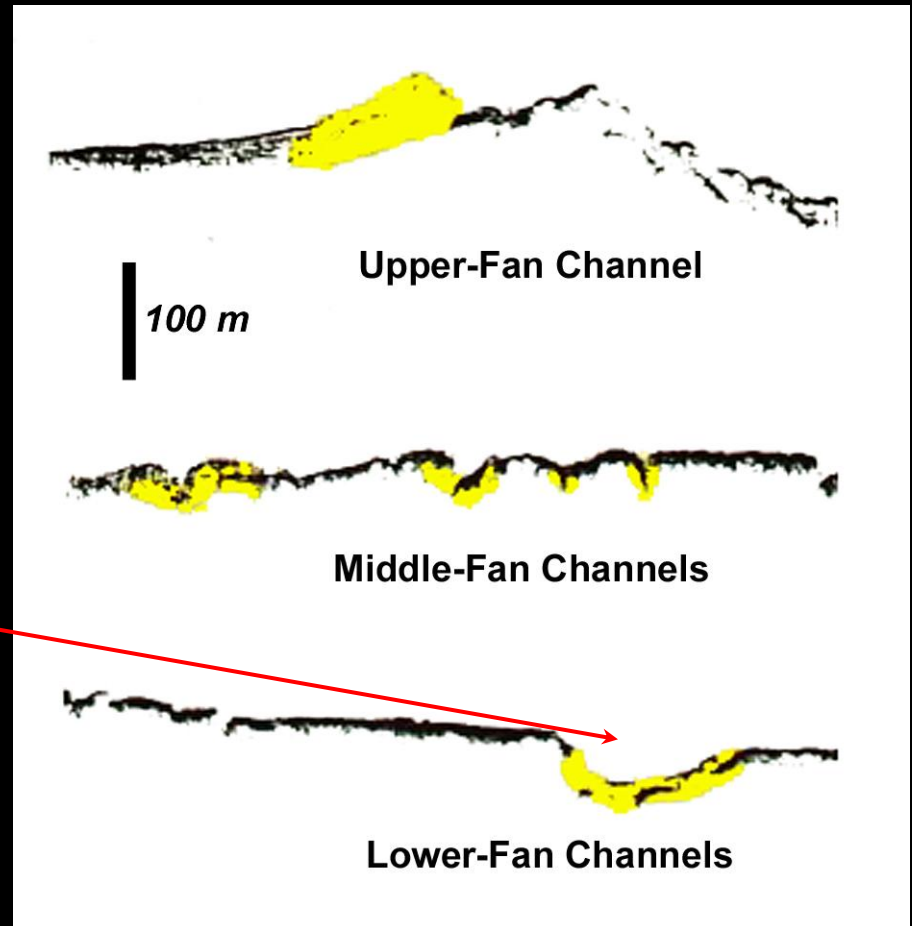
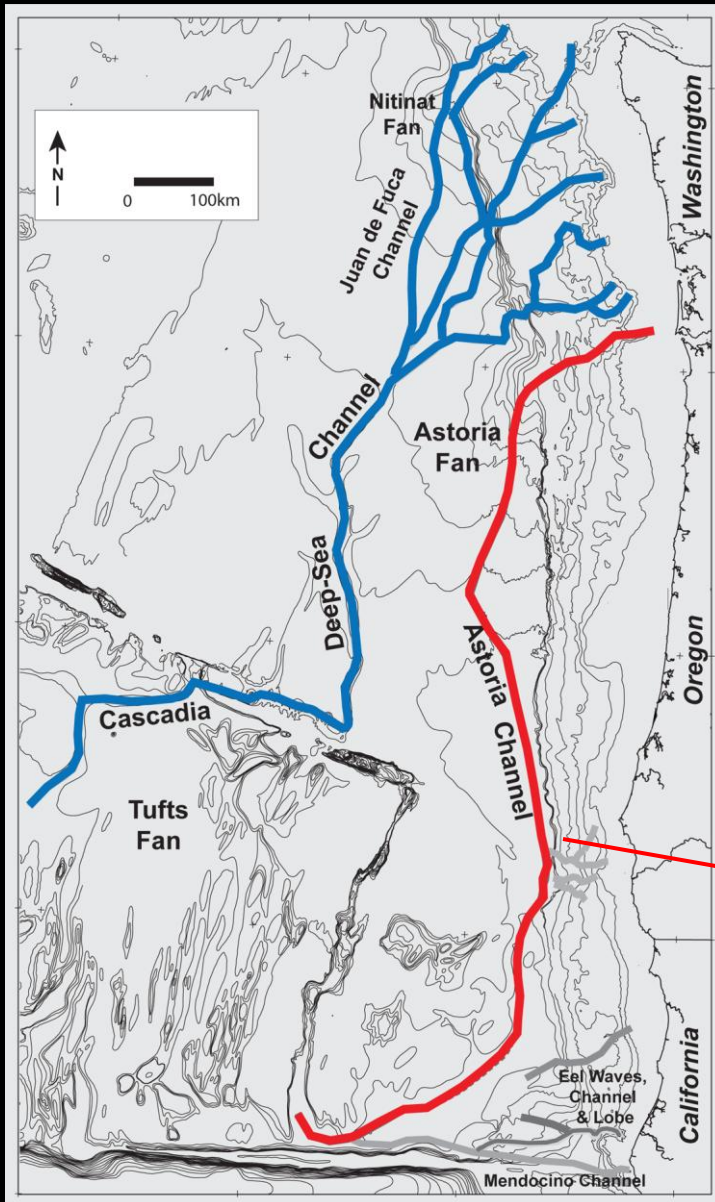


Channels Mapped on 3.5 kHz Data

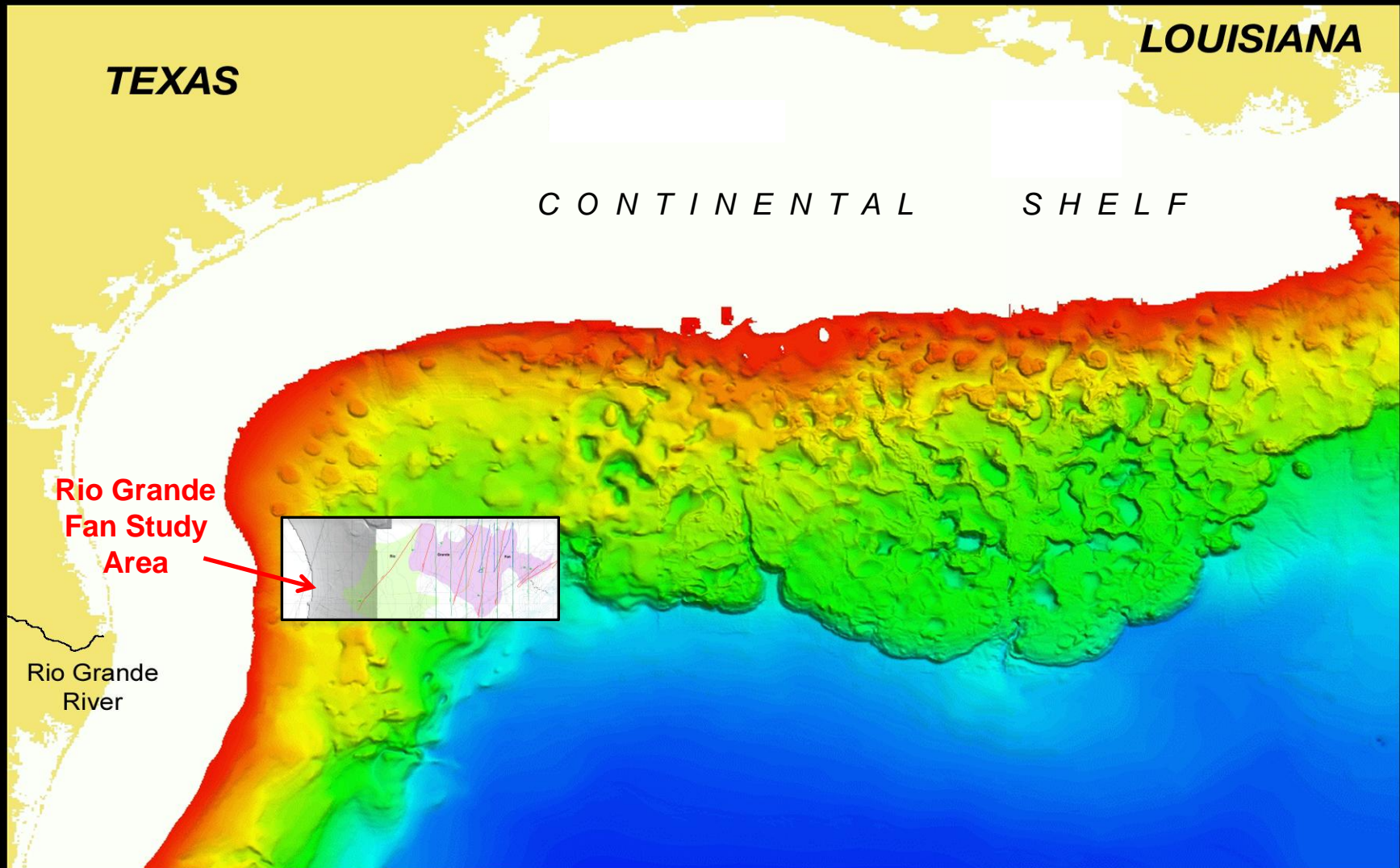


Map from: LDEO GeoMapApp
(www.geomapapp.org)

**Astoria Fan Channel Convergence
Draining Through Blanco Gap
Structure Similar to Rio Grande
Channels Draining Through Salt
Structures into Perdido Canyon**



Location of GIB Rio Grande Fan Study Area



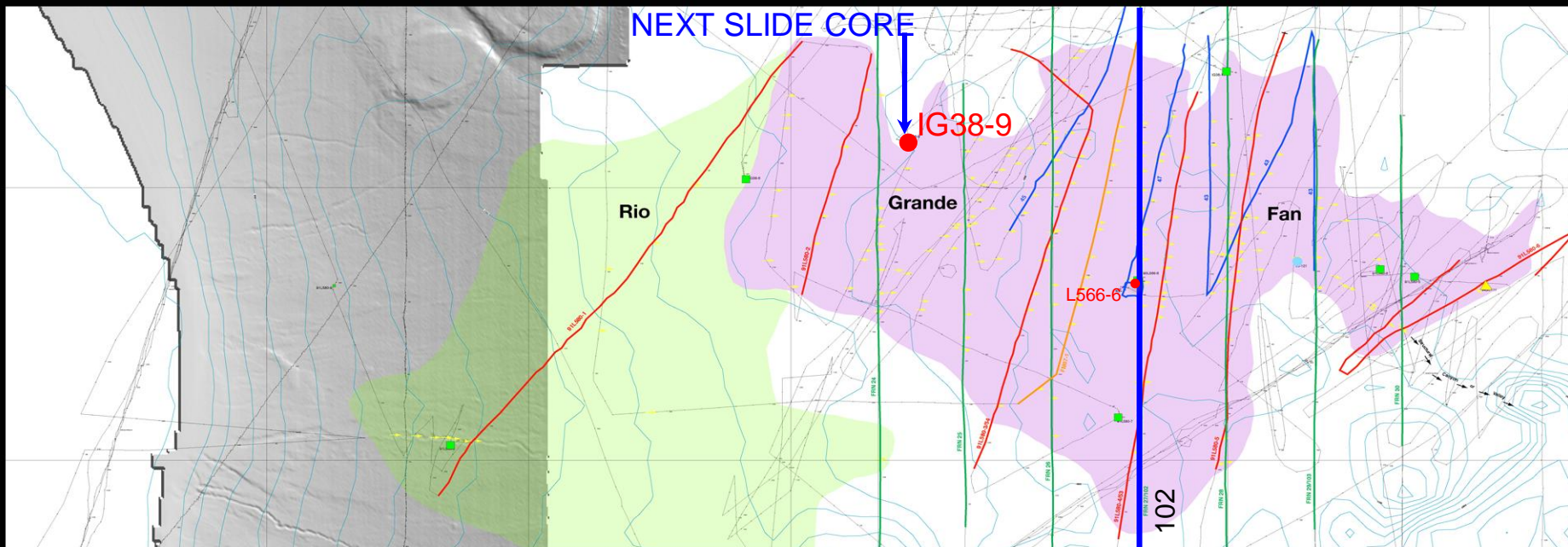
**Rio Grande
Fan Study
Area**

Rio Grande
River

Inset Map From: Damuth, Nelson & Olson (2006)

*Seafloor Relief Map of Northern Gulf of Mexico Deep Water
by Lui and Bryant (1999)*

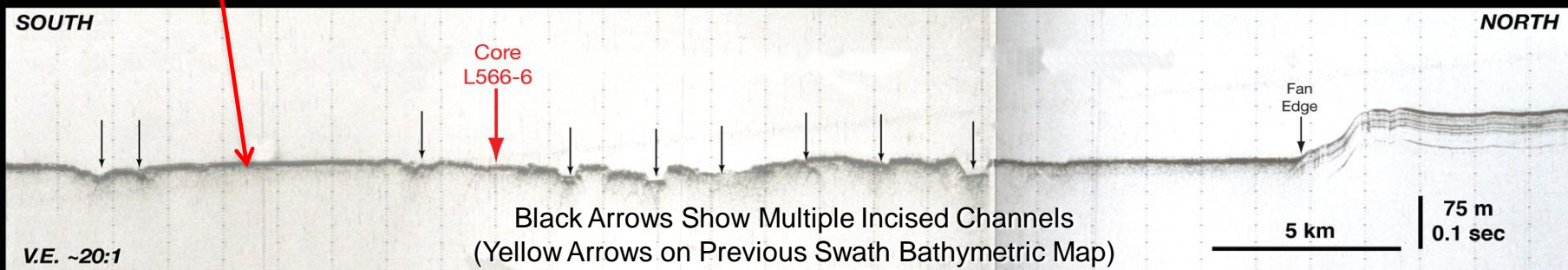
3.5 kHz Echo Character of Rio Grande Fan



Prolonged Echoes (Purple on Map)
Indicate Very Sandy Sediments

3.5 kHz Profile 102

Prolonged Echoes
(High Sand Content)

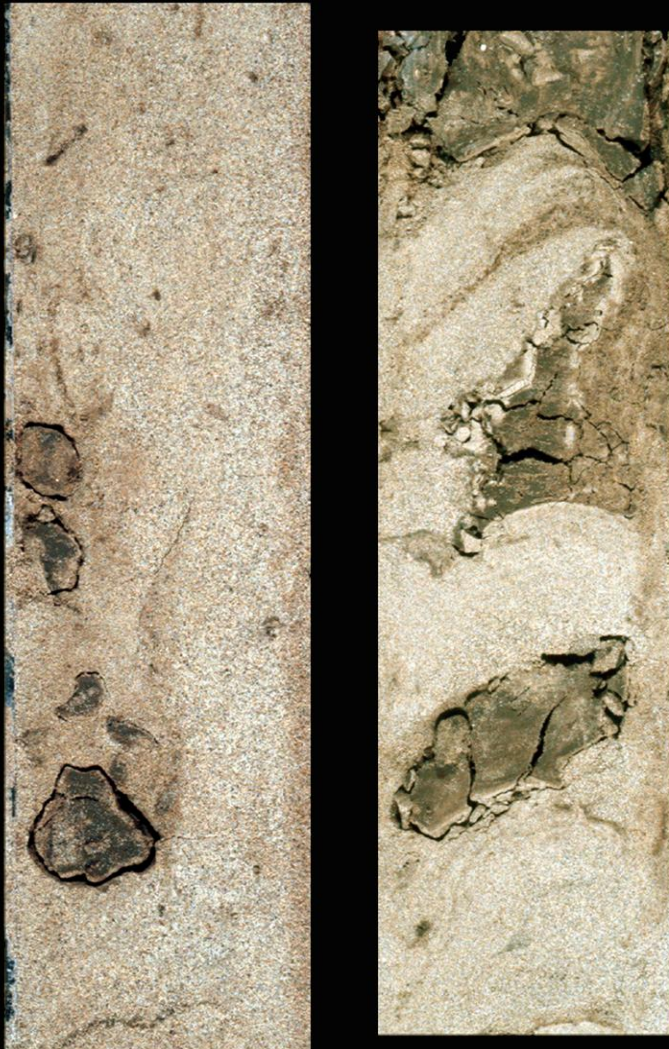


Black Arrows Show Multiple Incised Channels
(Yellow Arrows on Previous Swath Bathymetric Map)

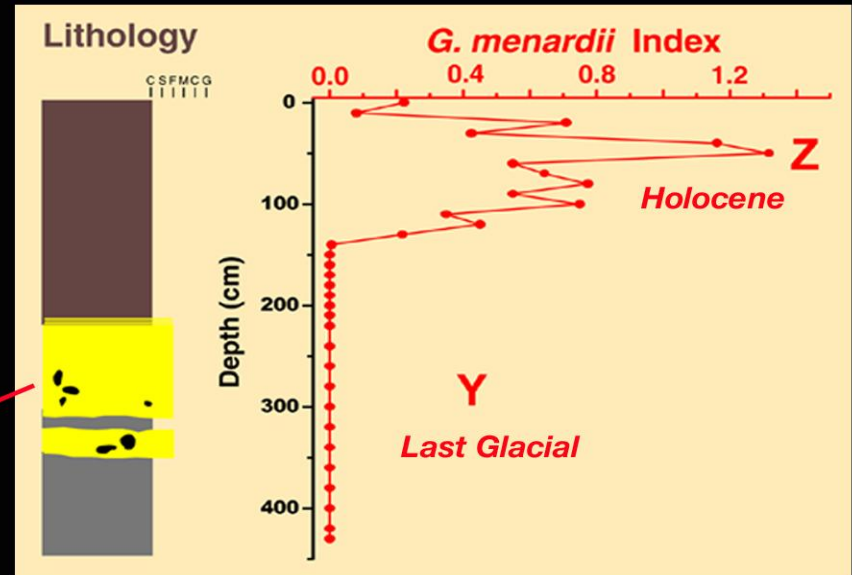
Modified from: Damuth, Nelson, & Olson (2006)

Core IG38-9

Northern Edge of Lower Rio Grande Fan

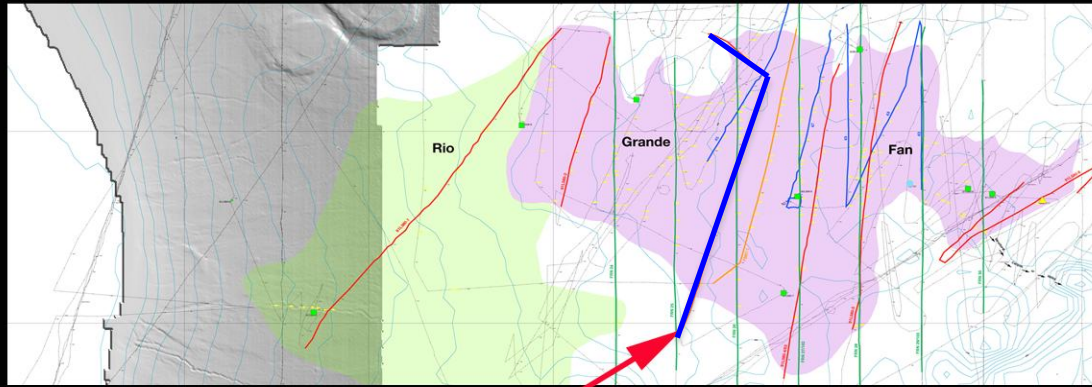


Deformed Sand Beds with Mud Clasts

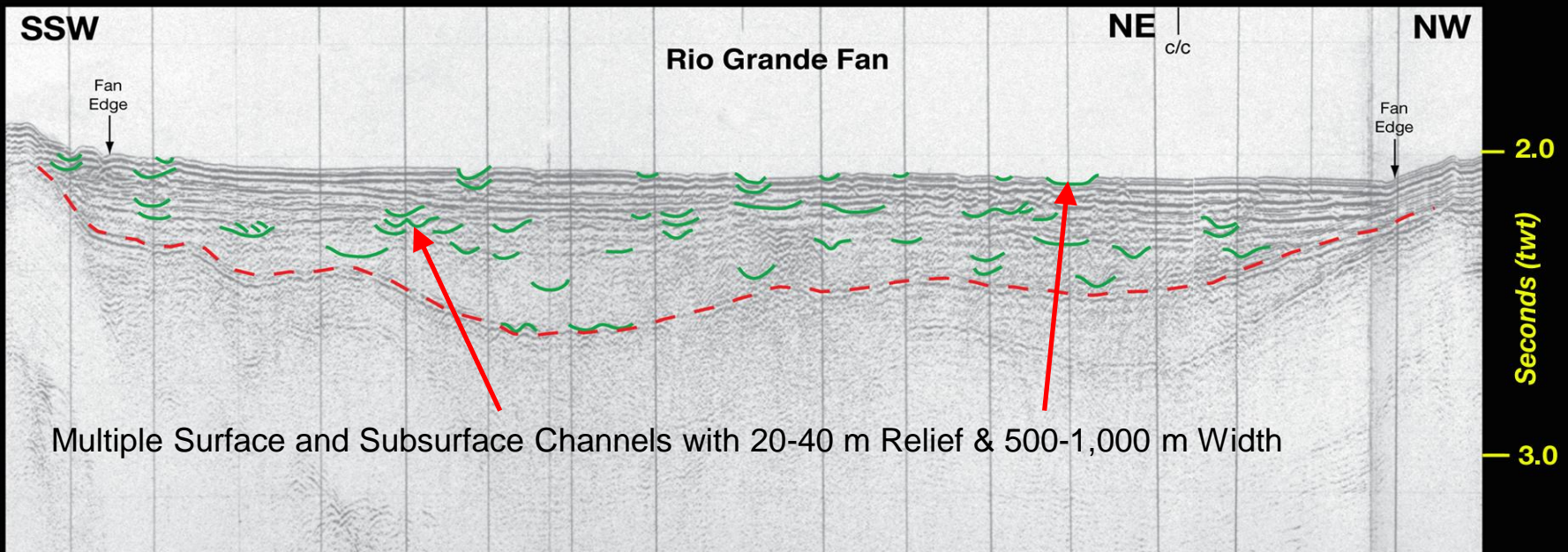


Damuth, Nelson and Olson (2006)

Middle Rio Grande Fan



Seismic Line 91L580-3

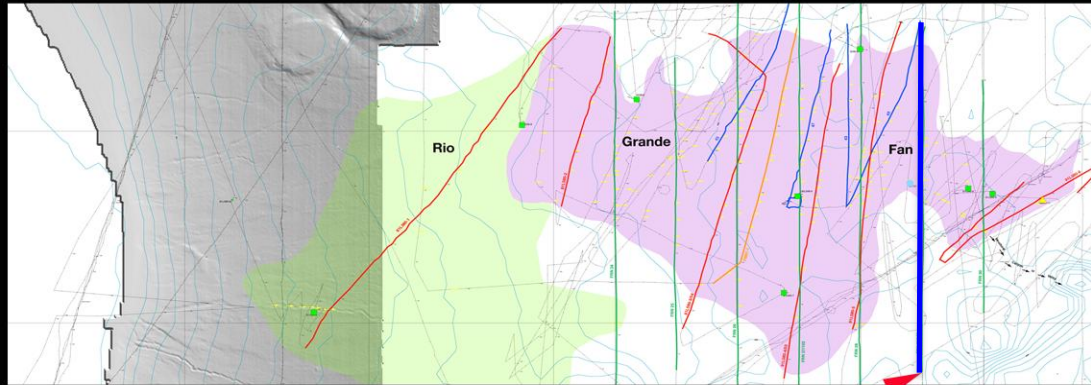


V.E. ~ 10:1

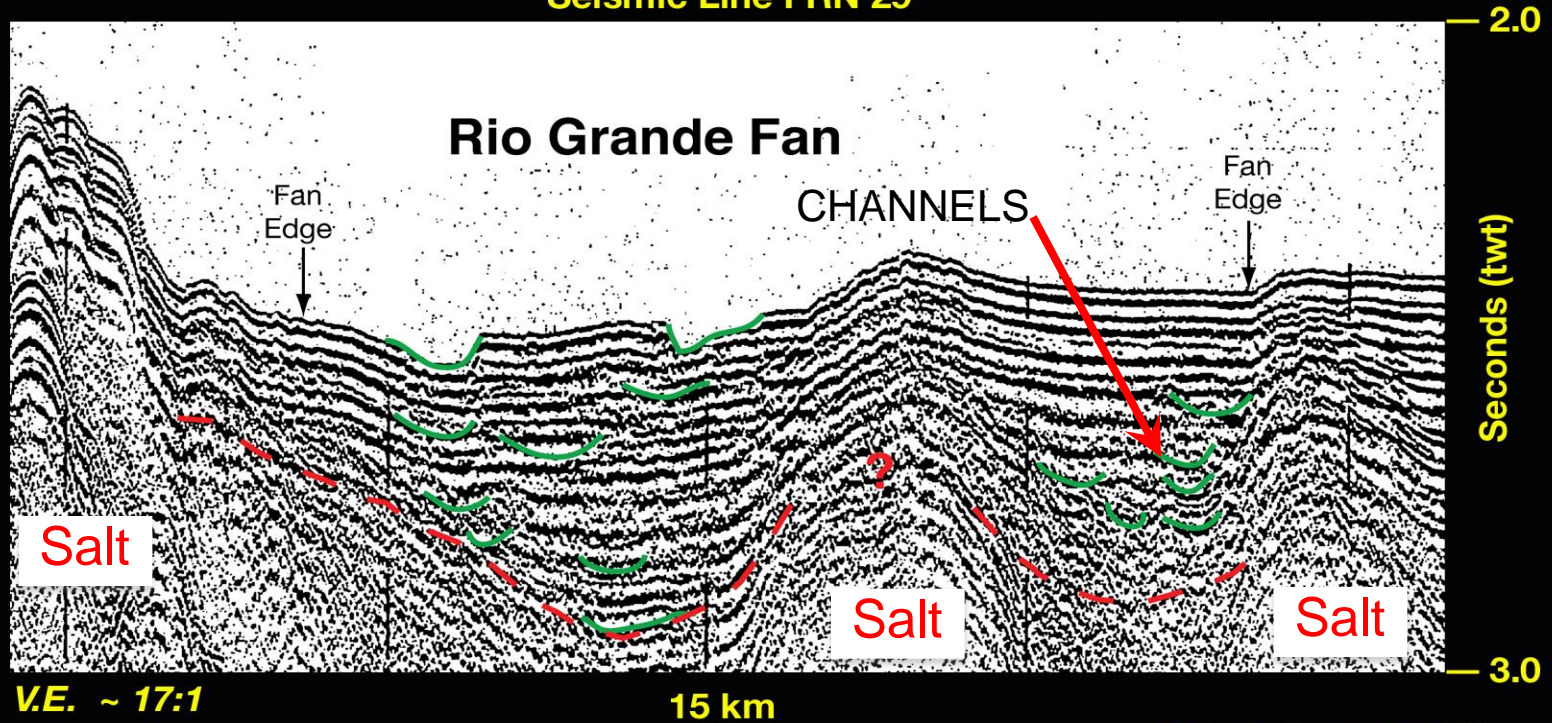
15 km

Damuth, Nelson and Olson (2006)

Salt Tectonic Control of Rio Grande Fan's Shape & Channels



Seismic Line FRN 29

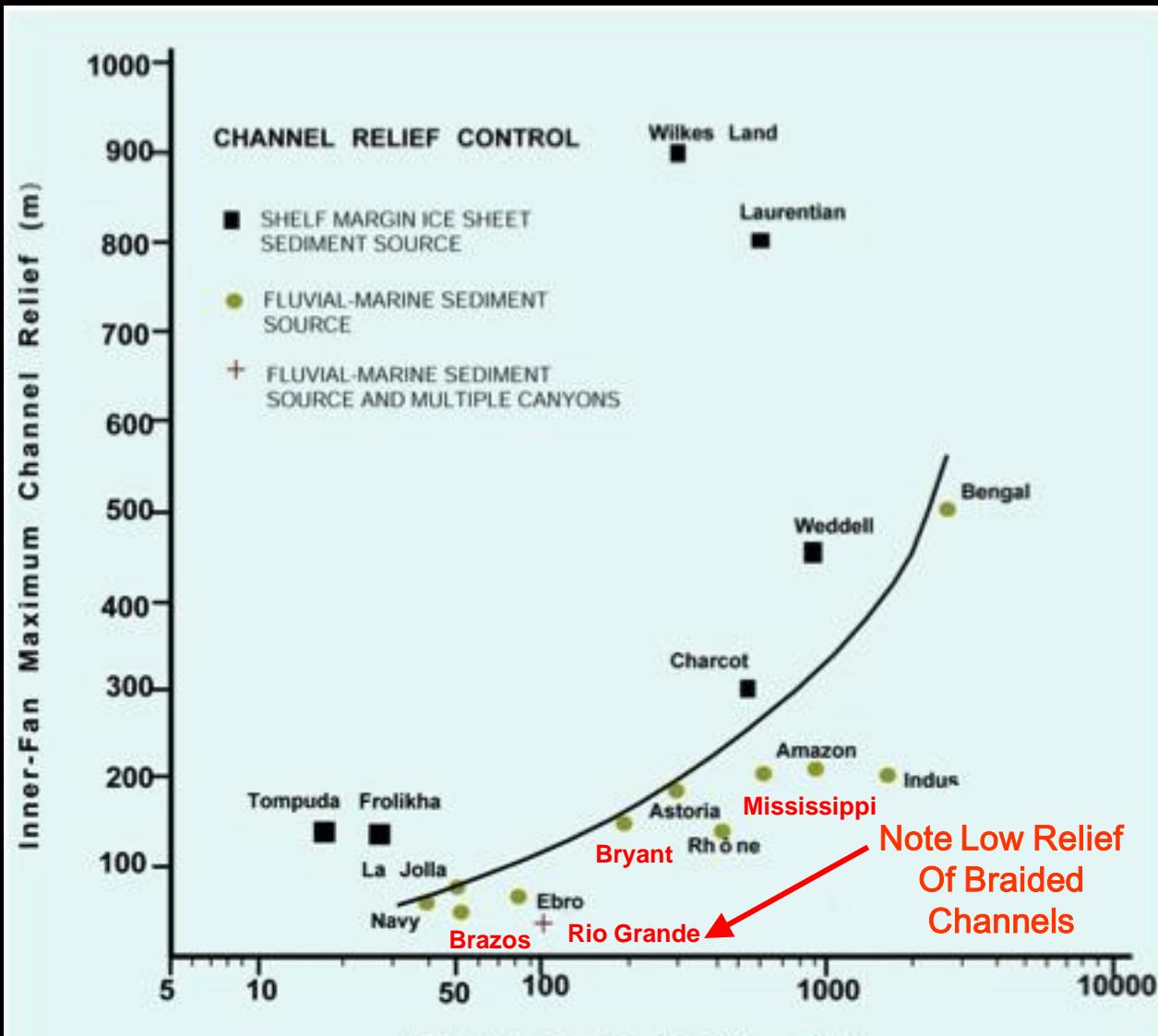


Number of Channels on Rio Grande Fan Observed on 3.5 kHz Profiles

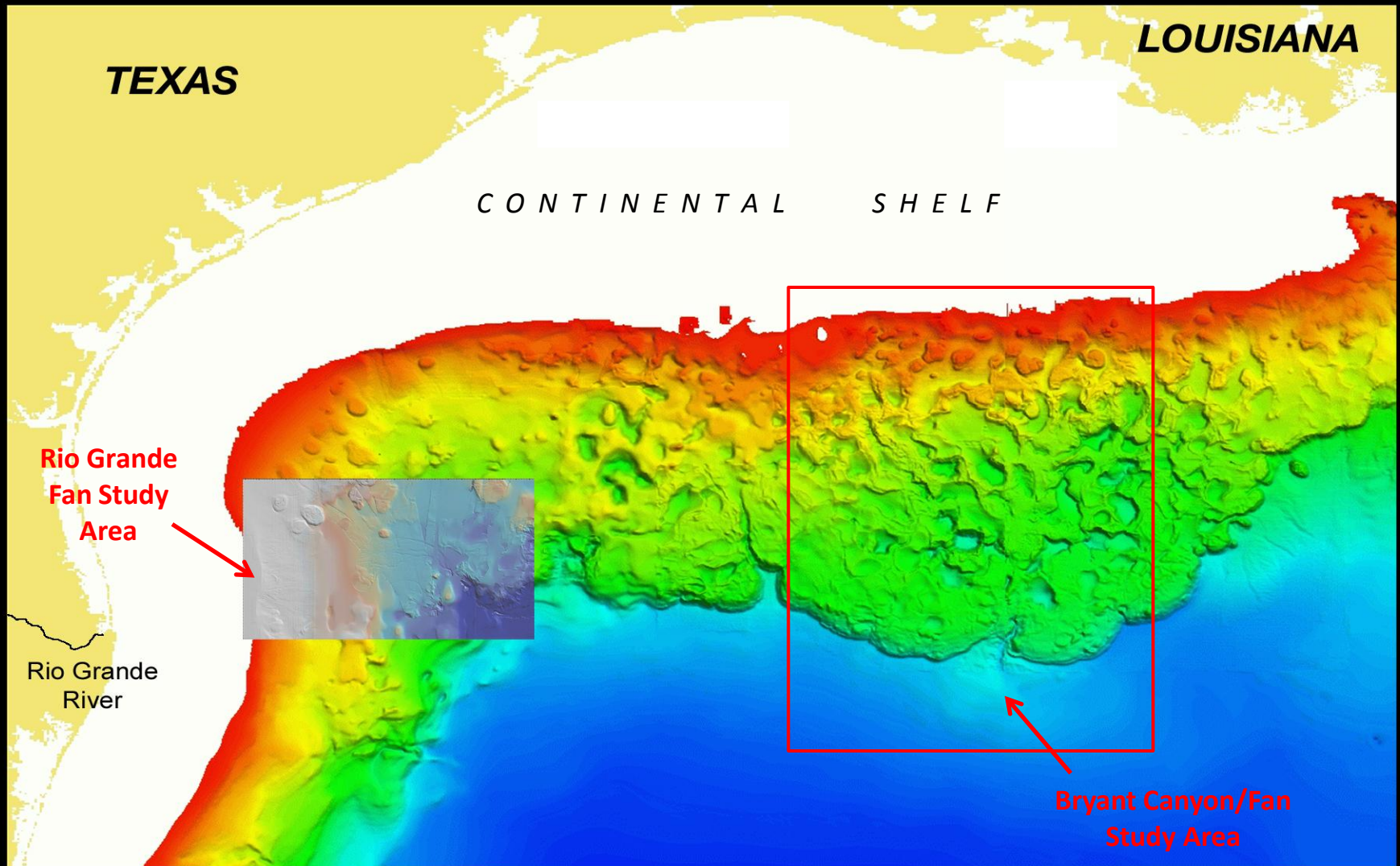
	<i>Proximal Fan</i>	<i>Mid-Fan</i>	<i>Distal Fan</i>
Seafloor Channels	5	7	2
Buried Channels	<u>15</u>	<u>28</u>	<u>9</u>
Total	20	35	11



Channel Relief vs. Submarine Fan Length



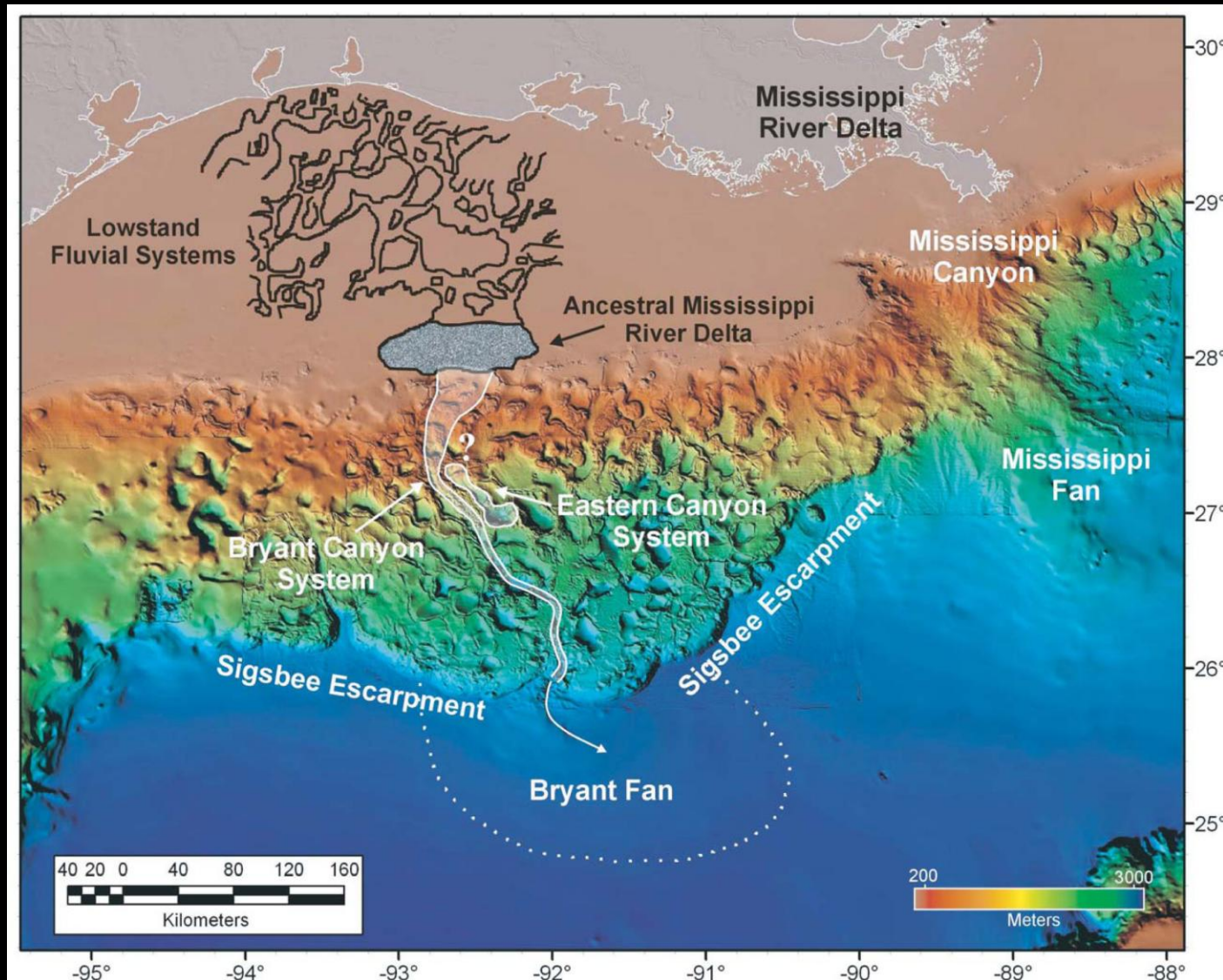
Location of Multi-Beam Swath Bathymetry on Rio Grande Fan and Margin



Inset Map from: LDEO GeoMapApp
(www.geomapapp.org)

Seafloor Relief Map of Northern Gulf of Mexico Deep Water
by Lui and Bryant (1999)

Location of the Bryant Canyon/Fan Turbidite System

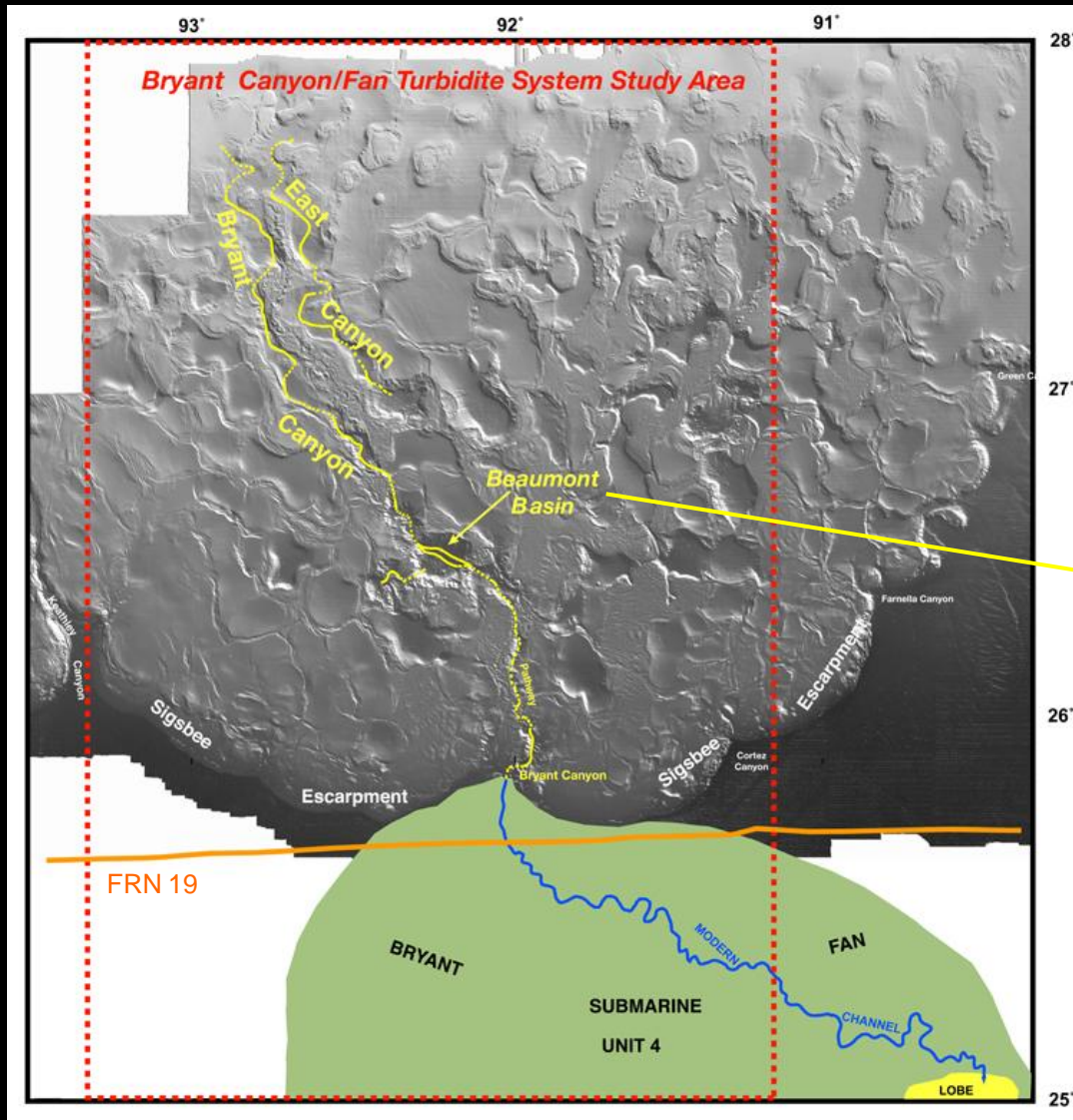


Deep Water Bathymetry from: Lui & Bryant (1999)

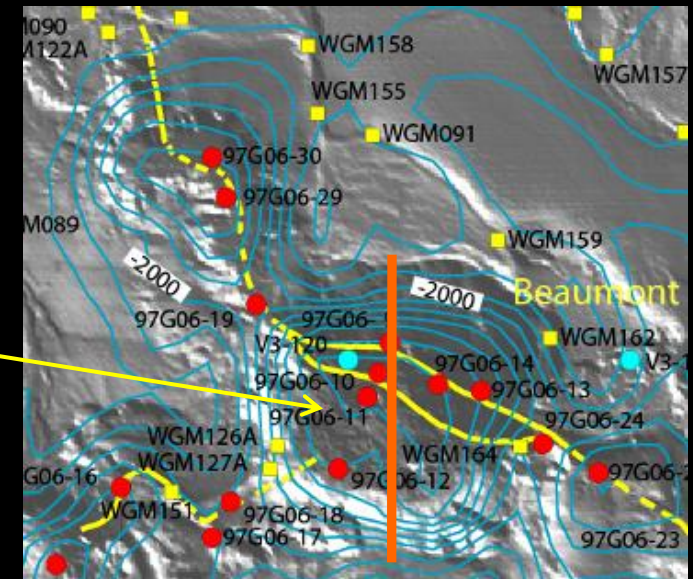
Fluvial Systems from: Sutter & Berryhill (1985)



Bryant Canyon/Fan Turbidite System



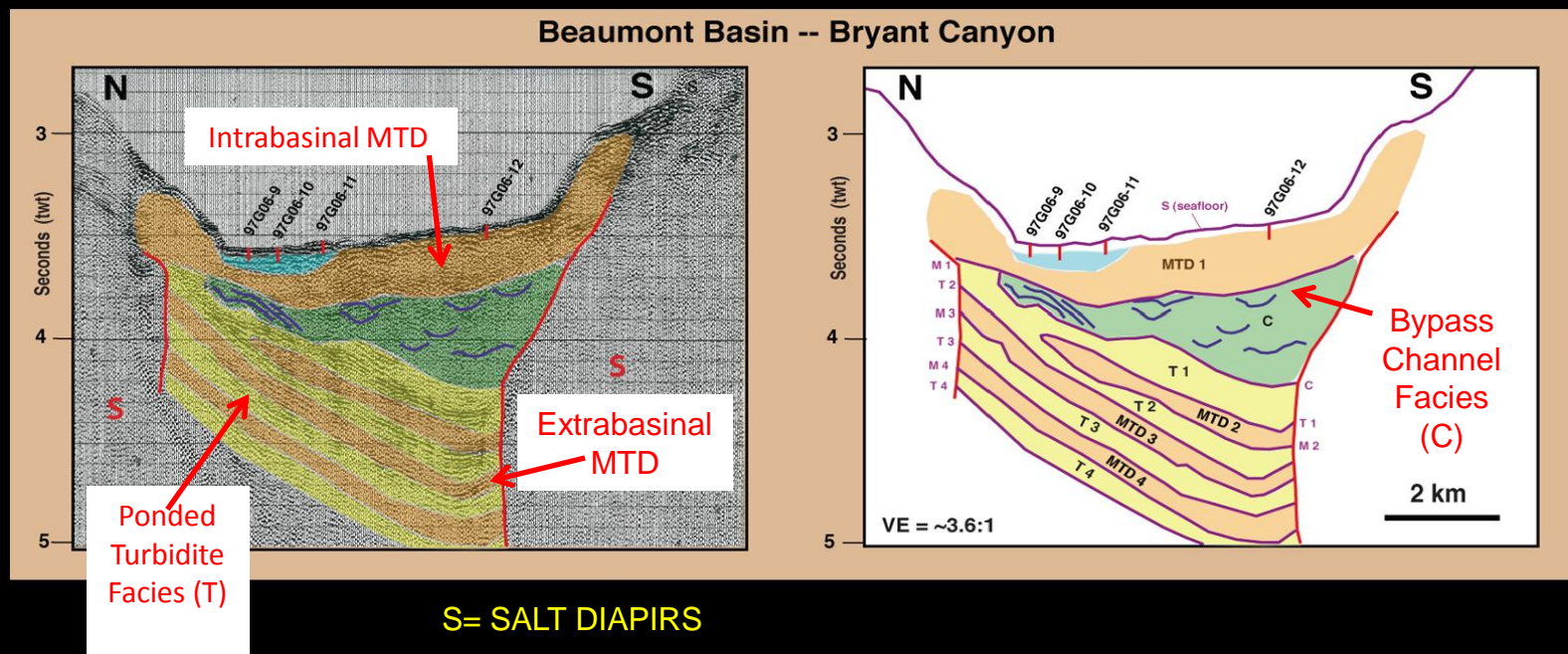
Beaumont Basin



Orange Lines Show Locations of Seismic Profiles in Upcoming Figures

Example of an Interpreted Seismic Line across Beaumont Basin along the Bryant Canyon Pathway

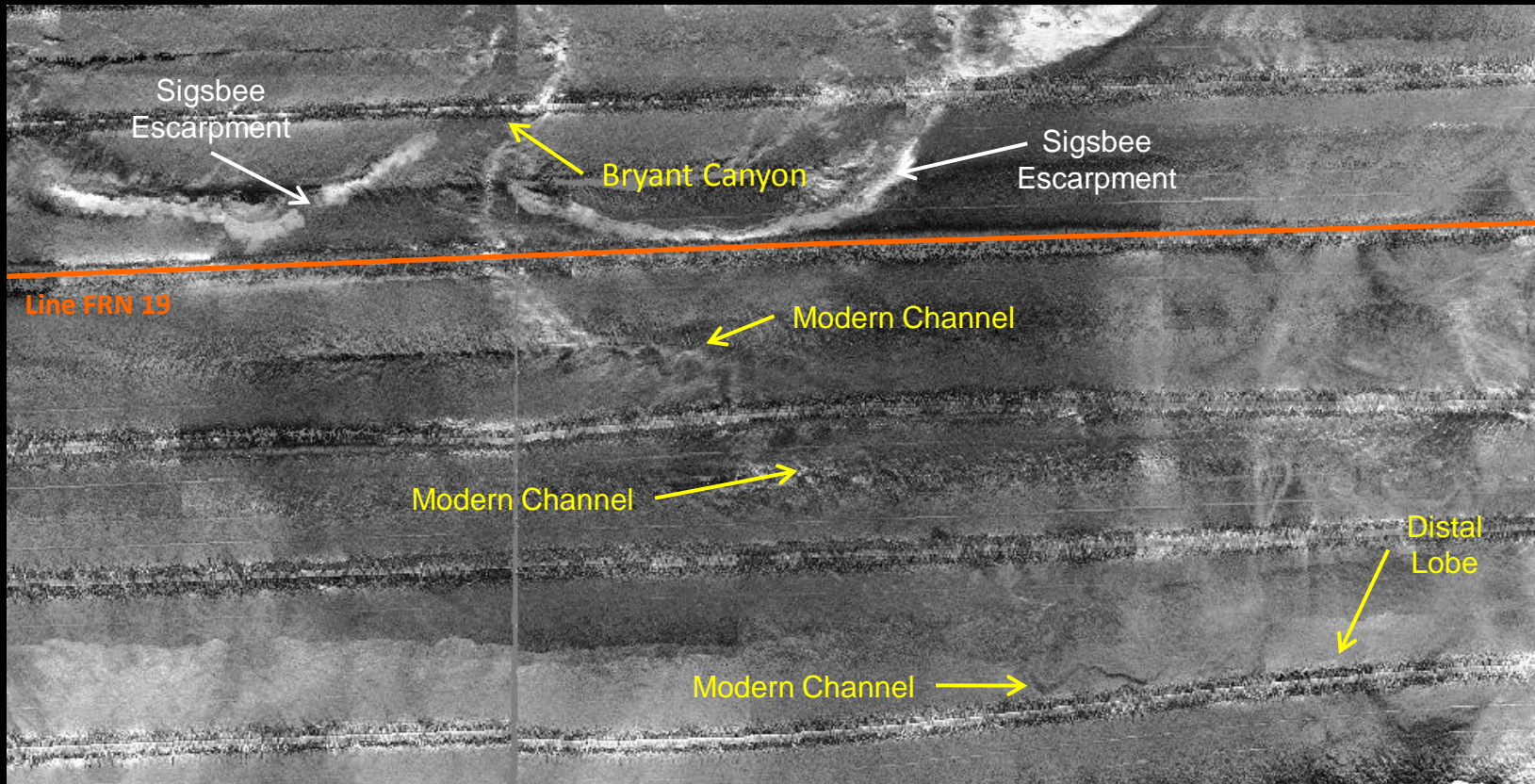
MASS TRANSPORT DEPOSIT (MTD) SEISMIC FACIES



Note: Mini-Basins Trap both Intrabasinal & Extrabasinal MTDs

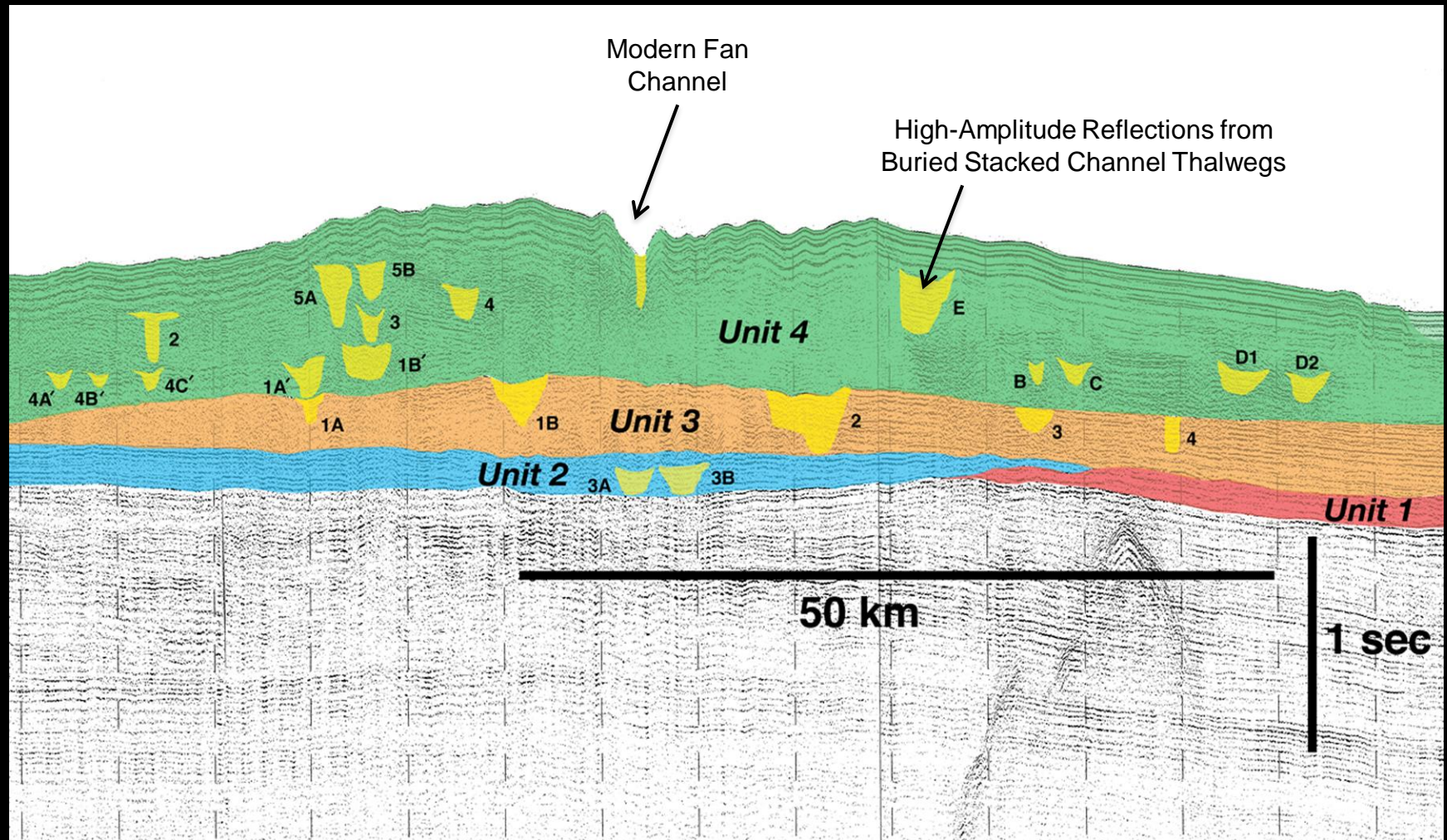


Side-Scan Sonar Mosaic of Bryant Submarine Fan Showing Single Channel without Bifurcations Feeding Lobe

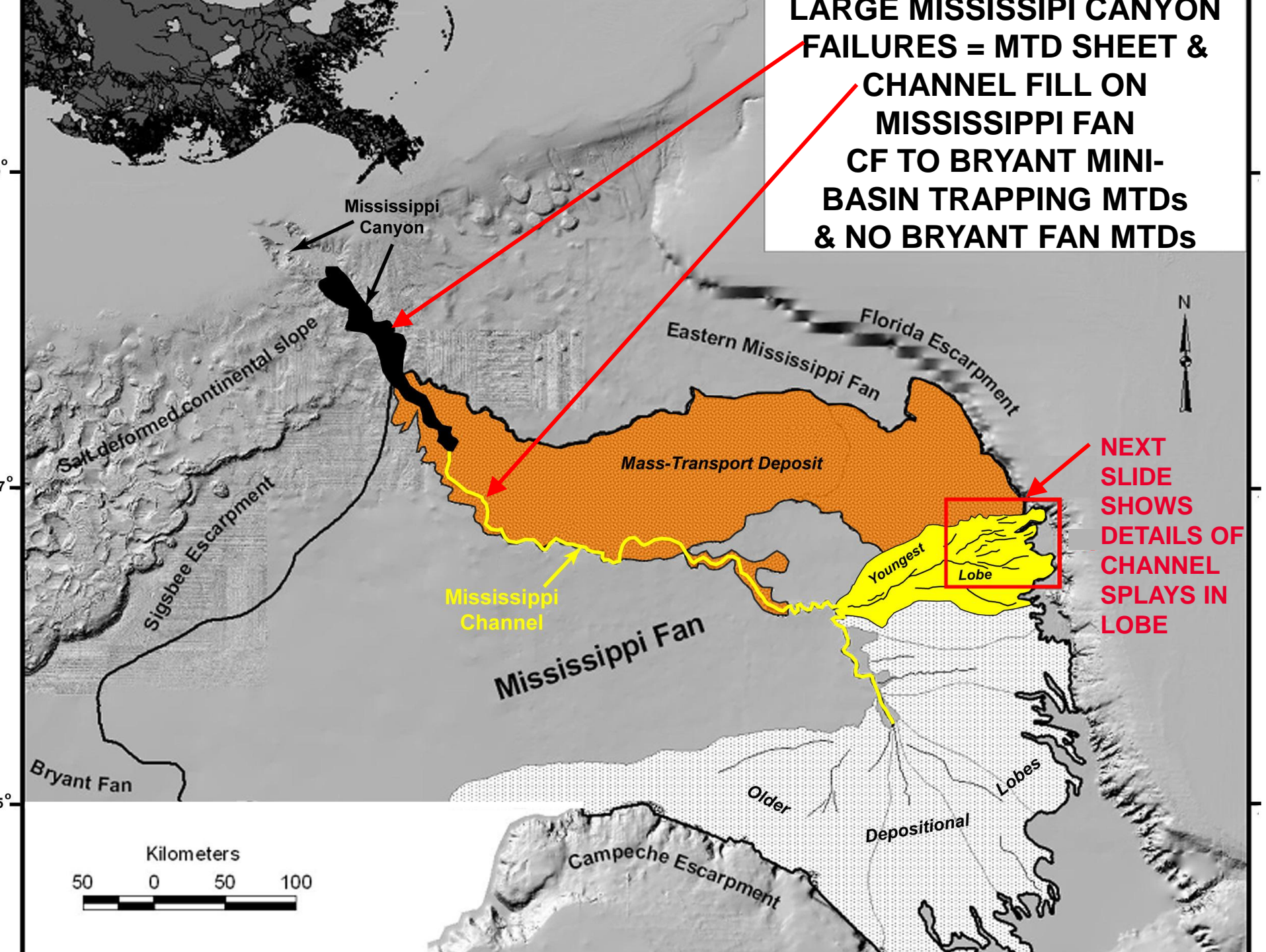


GLORIA Mosaic from: EEZ-SCAN 85 Scientific Staff (1987)

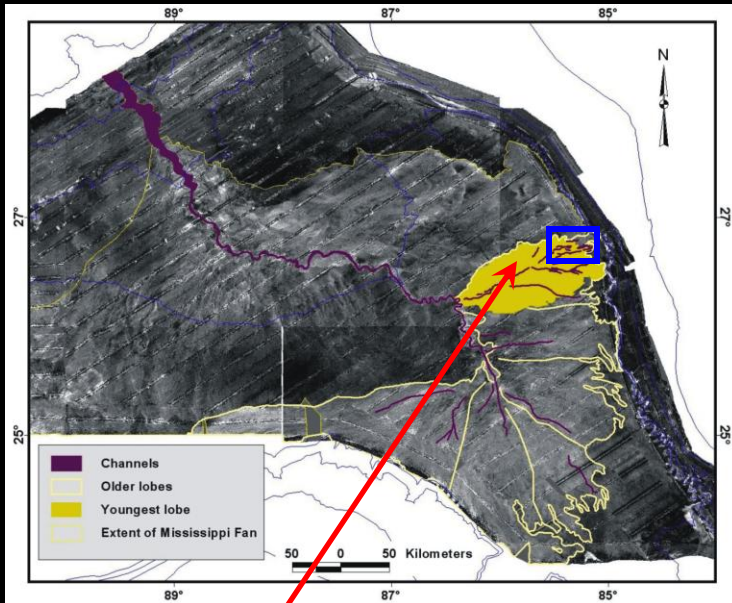
Seismic Profile Line FRN 19 from Proximal Bryant Fan, Showing Single Subsurface Channels & Lack of MTDs Because MTD Sediment Supply Is Trapped Upstream in Multiple Mini-Basins along Bryant Canyon Pathway



**LARGE MISSISSIPPI CANYON
FAILURES = MTD SHEET &
CHANNEL FILL ON
MISSISSIPPI FAN
CF TO BRYANT MINI-
BASIN TRAPPING MTDs
& NO BRYANT FAN MTDs**

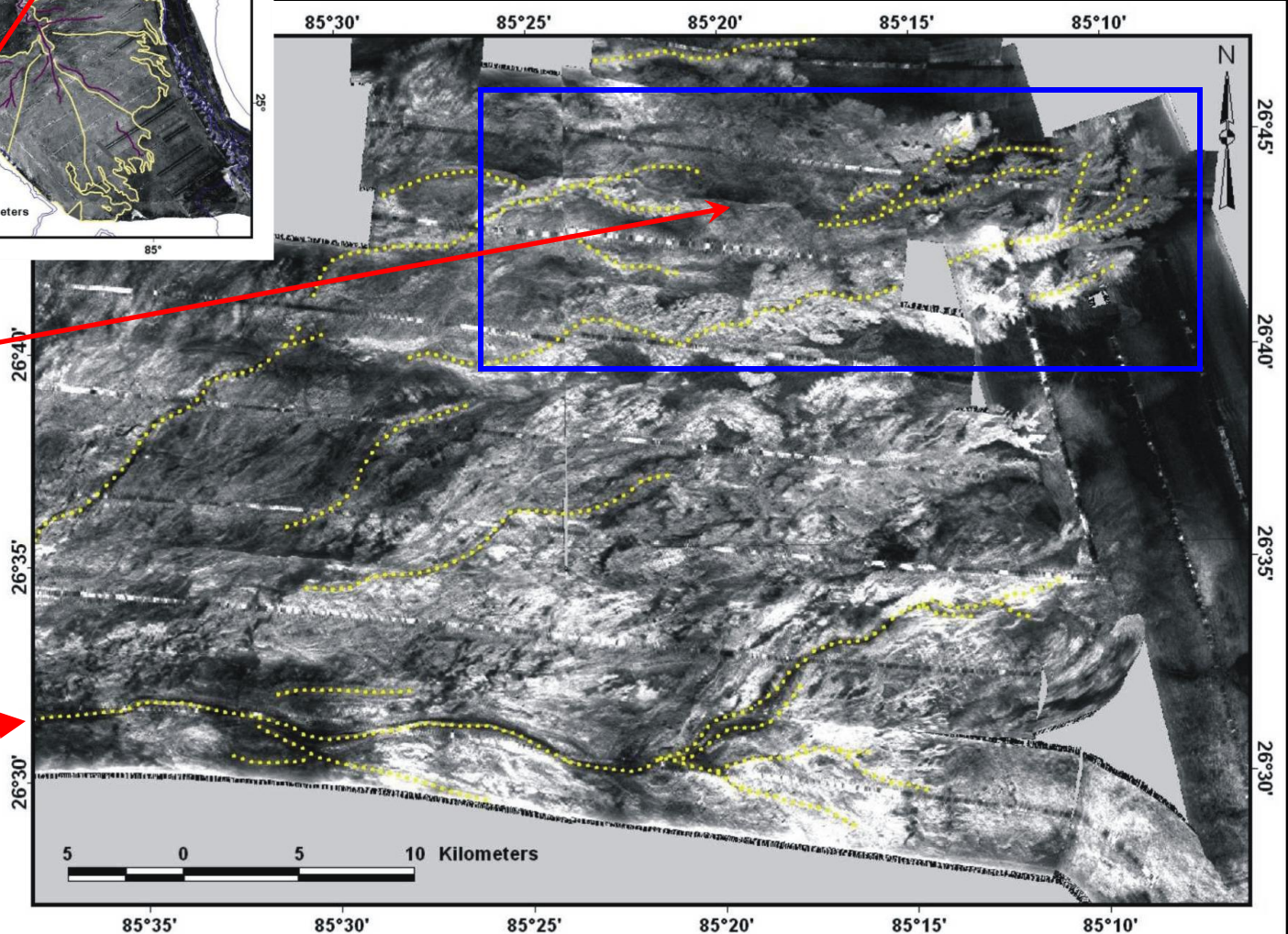


MISSISSIPPI OUTER FAN WITH = AMOUNTS OF MTD & SAND LOBES FED BY MULTIPLE CHANNEL SPLAYS (BELOW see deep-tow sidescan sonar image of youngest lobes & Splays)

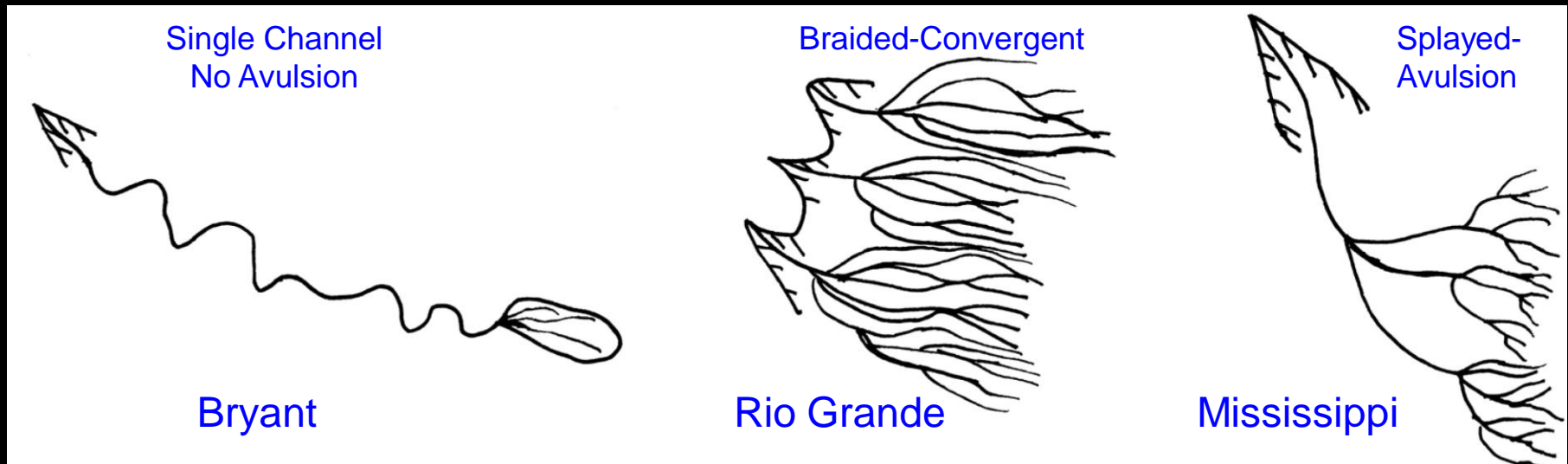


YOUNGEST OUTER
FAN LOBES

YELLOW DOTTED
LINES TRACE
CHANNEL SPLAYS



Types of Northern Gulf of Mexico Submarine Fans Based on Channel Depositional Patterns



Bryant - Sand-rich; Fed by Canyons with Mini-basins that Trap Muds; Single Sinuous Channel & Lobe; Limited MTD's & Splays

Rio Grande - Sand-rich from Mountain Sources; Multiple Canyons & Braided Channels; Lacks Lobes & MTD's

Mississippi - Mud-rich; Gullied Canyon; Meandering Channels; Multiple Splays & Lobes; Half Turbidites & Half MTD's



CONCLUSIONS

- The Rio Grande Fan is ~ 40 km wide and extends ~100 km across a continental slope plateau of the NW GOM Texas/Mexico border area.
- The fan is fed by multiple canyons that provide coarse-grained sediment from the Sierra Madre and Guadalupe Mountains.
- High backscatter of side-scan images, prolonged echo character, incised rather than leveed channels, steep fan gradient (1:250) and lithology indicate a sand-rich fan.
- Multiple canyon sources, sand-rich lithology, plus many surface (4-10) and subsurface (12-30) channels suggest a braid-plain submarine fan.
- Average channel width is ~ 1100m and relief of 20-30 m is low for fan size, perhaps because of high channel density compared to non-braided fans.
- Salt diapirs control shape of the fan, channel pathways, pre-depositional onlap of fan deposits, syn-depositional tectonics and post-depositional uplift of earlier fan deposits.
- Rio Grande turbidite systems have good potential for high content of sand beds with lateral and vertical connectivity.
- The Rio Grande has been a consistent Cenozoic sediment fairway and the modern fan is a possible analog for Frio and Wilcox petroleum plays in the northwest Gulf of Mexico