# Examples of Shelf to Basin Modern Turbidite System Depositional Patterns in the Gulf of Mexico: Potential Analogues for Subsurface Petroleum Systems*

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## Abstract

A variety of depositional patterns have been observed in modern turbidite systems of the northern Gulf of Mexico continental margin. Our study utilizes high-resolution seismic profiling, side-scan sonar, swath bathymetry and cores. Bryant Canyon mini-basins exhibit patterns of: 1) MTD's consisting of wedges of chaotic mud and sheets of chaotic mud and sand, 2) incised, ponded and perched turbidites, and 3) bypass channelized facies. Modern submarine fans exhibit three typical distributary channel patterns: braided channel system (Rio Grande Fan), single un-bifurcated channel with distal lobe (Bryant Fan), and multiple bifurcated and splayed channels (Mississippi Fan). The multiple canyons that provide coarse-grained sediment from adjacent mountain sources result in the braided channel pattern in the surface and subsurface of the sand-rich Rio Grande Fan. The more sandy Western Ancestral Mississippi shelf margin delta and the mini-basin pathway of Bryant Canyon, which traps mud, have caused single aggrading channels that extend 200 km across the sand/mud-rich Bryant Fan to feed single distal depositional lobes of ~ 30 km in length. The muddy Mississippi River source of the late Pleistocene has resulted in multiple mid-fan channel bifurcations and outer fan channel splays in distal lobes of the mud-rich Mississippi Fan. Splays and distal lobes are composed of half MTD and half turbidite deposits in contrast to the predominantly turbidite deposits in Rio Grande and Bryant Fans. These depositional patterns and seismic facies suggest that: 1) similar mini-basin depositional patterns are common in modern and subsurface systems across the northern Gulf of Mexico slope, 2) the Rio Grande patterns may be analogues for some Paleogene subsurface systems, and 3) the Bryant mini-basin and fan patterns provide analogues for the Miocene systems in the Mississippi Canyon area.

# EXAMPLES OF SHELF TO BASIN MODERN TURBIDITE SYSTEM DEPOSITIONAL PATTERNS IN THE GULF OF MEXICO: POTENTIAL ANALOGUES FOR SUBSURFACE PETROLEUM SYSTEMS

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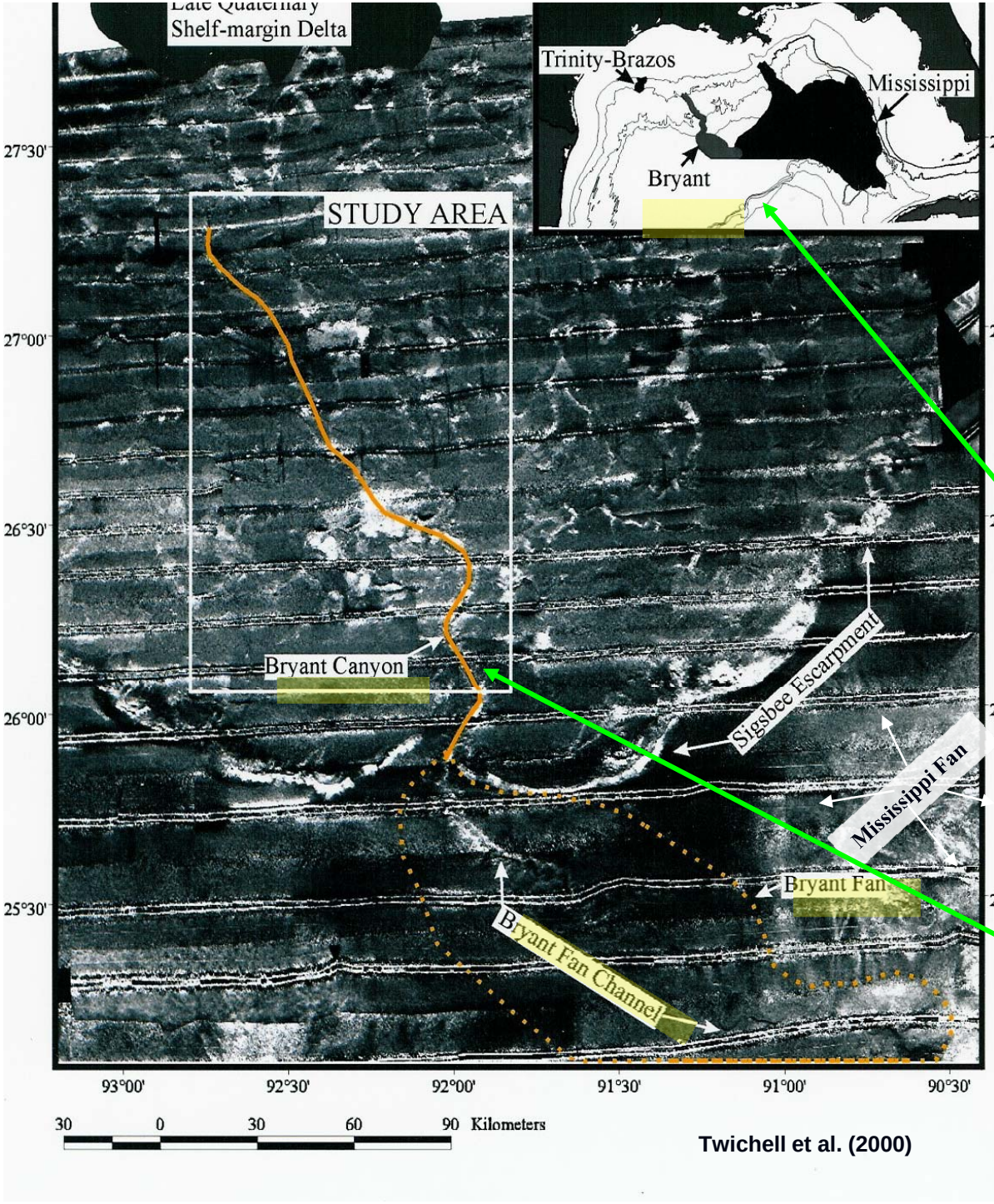
# TOPICS

- BRYANT CANYON MINI-BASIN AND FAN SAND-RICH TURBIDITE DEPOSITIONAL SYSTEM PATTERNS:
POTENTIAL ANALOGUES FOR MISSISSIPPI CANYON MINI-BASIN AND ABYSSAL FAN PLAYS

- RIO GRANDE FAN SAND-RICH BRAID PLAIN TURBIDITE SYSTEM:
POTENTIAL ANALOGUE FOR FRIO AND WILCOX PLAYS IN THE NORTHWESTERN GULF OF MEXICO

- MISSISSIPPI FAN TURBIDITE SYSTEM: EXAMPLE OF MIXED TURBIDITE AND MTD FAN DEPOSITIONAL PATTERN



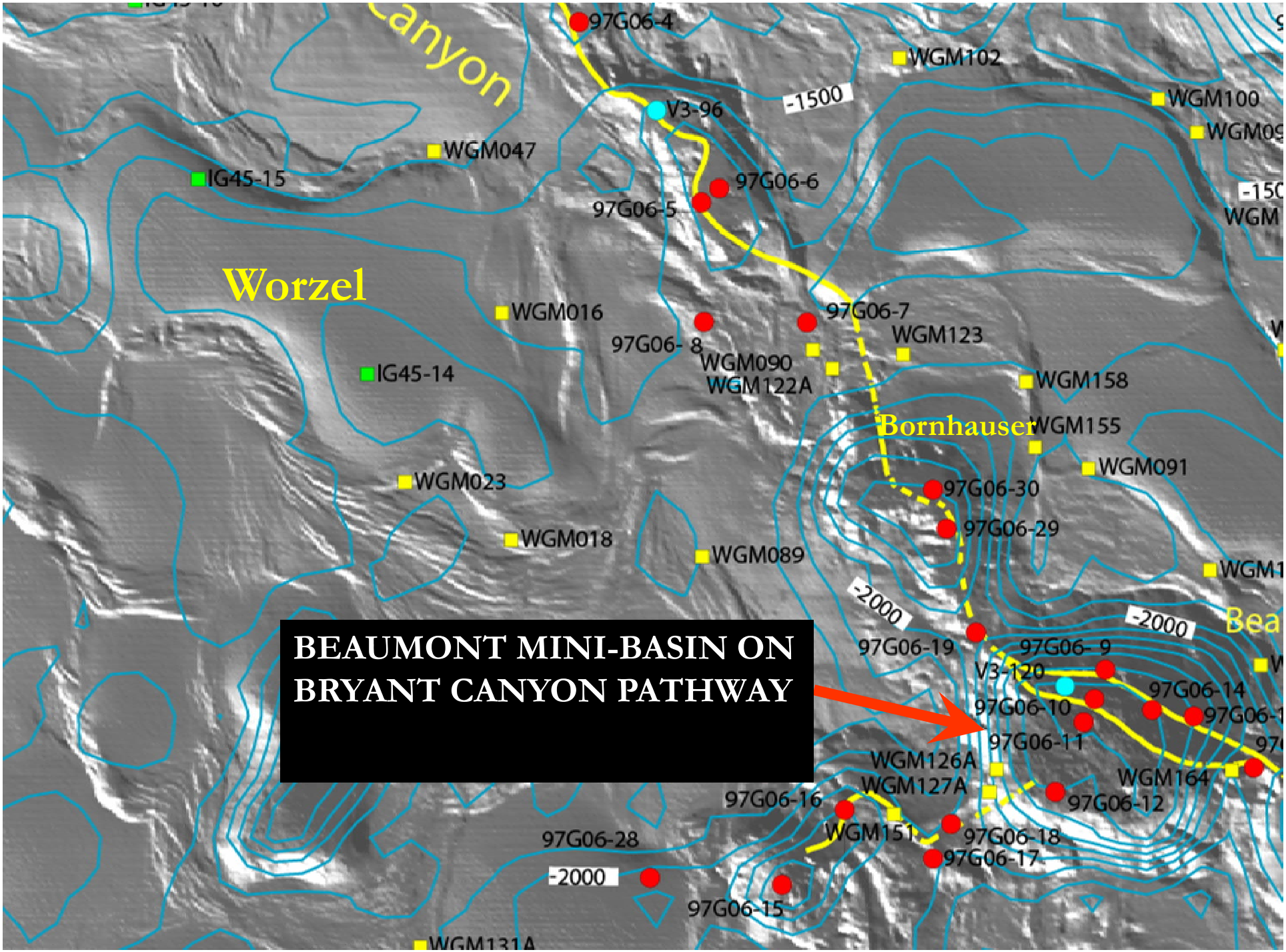

# BRYANT CANYON AND FAN STUDY AREA

CANYON STUDY AREA

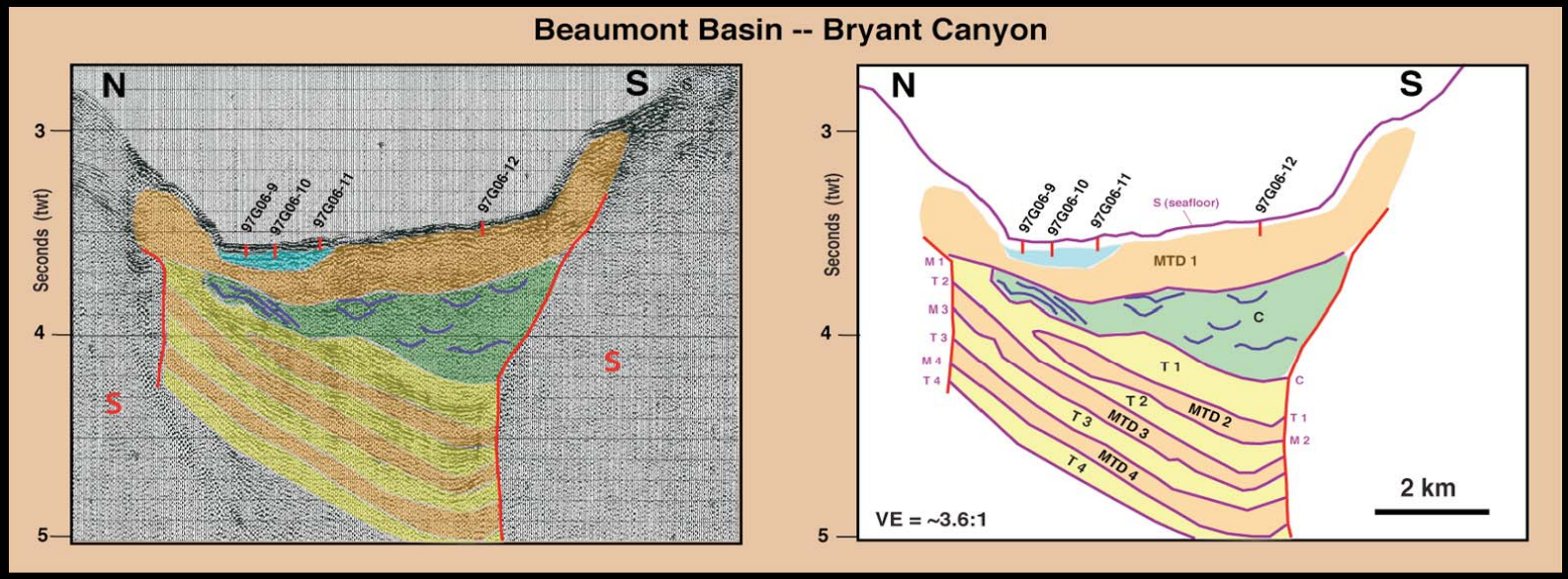
FAN STUDY AREA

Note location and scale of Bryant compared to Trinity Brazos and Mississippi Fan

See Bryant Canyon pathway (orange line) of linked mini-basins and bypass channels

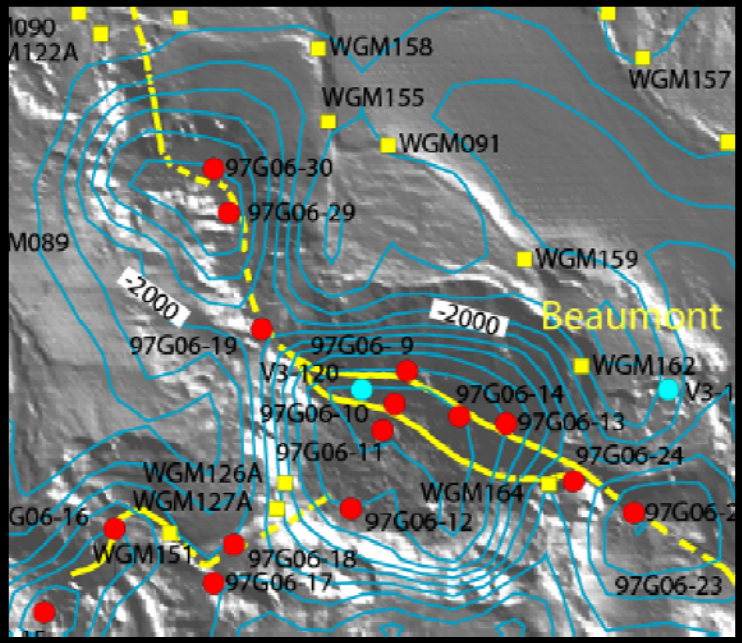

BEAUMONT MINI-BASIN ON
BRYANT CANYON PATHWAY
Worzel
Bornhauser
97G06-4
WGM102
WGM100
V3-96
-1500
WGM047
IG45-15
97G06-6
97G06-5
WGM016
97G06-7
97G06- 8
WGM123
WGM090
WGM122A
IG45-14
WGM158
WGM155
WGM091
WGM023
97G06-30
97G06-29
WGM018
WGM089
-2000
97G06-19
97G06- 9
V3-120
97G06-14
97G06-10
97G06-11
WGM126A
WGM127A
WGM164
97G06-16
97G06-12
WGM151
97G06-18
97G06-17
97G06-28
-2000
97G06-15

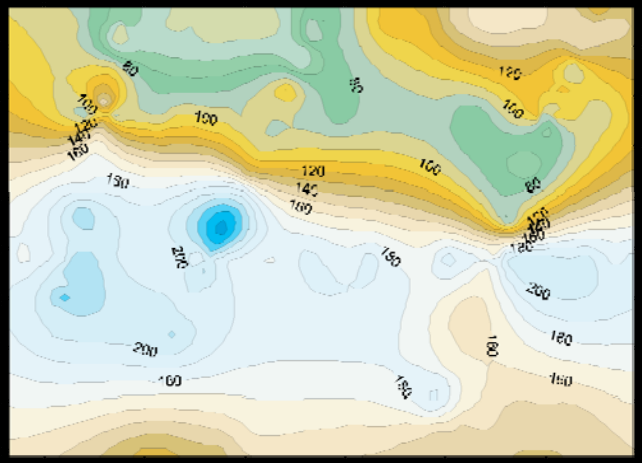
# Example of an Interpreted Seismic Line across Beaumont Basin along the Bryant Canyon Pathway

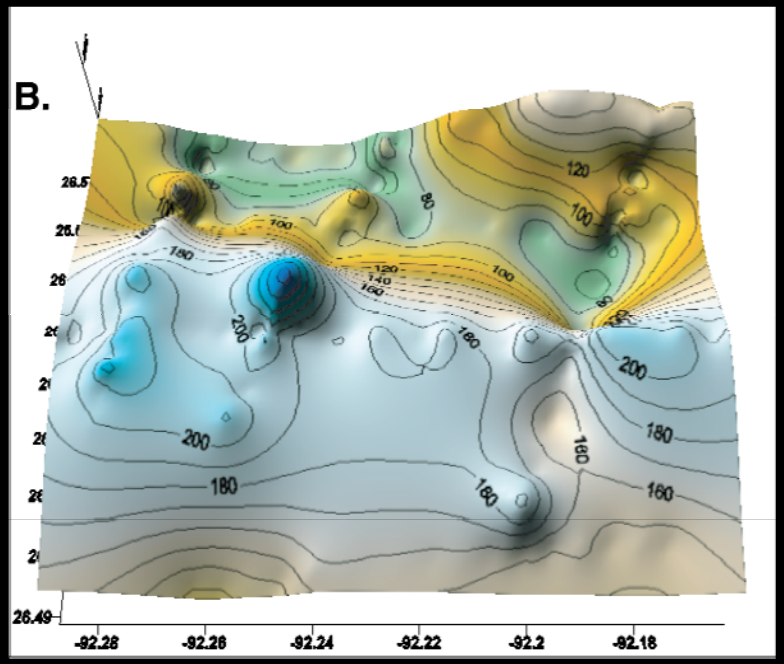



Damuth, Nelson and Olson (2006)

Example of an Isopach Map showing thickness of a Seismic Facies Unit (Incised Ponded Turbidite Facies) in the Beaumont Basin along the Bryant Canyon Pathway (map at right)

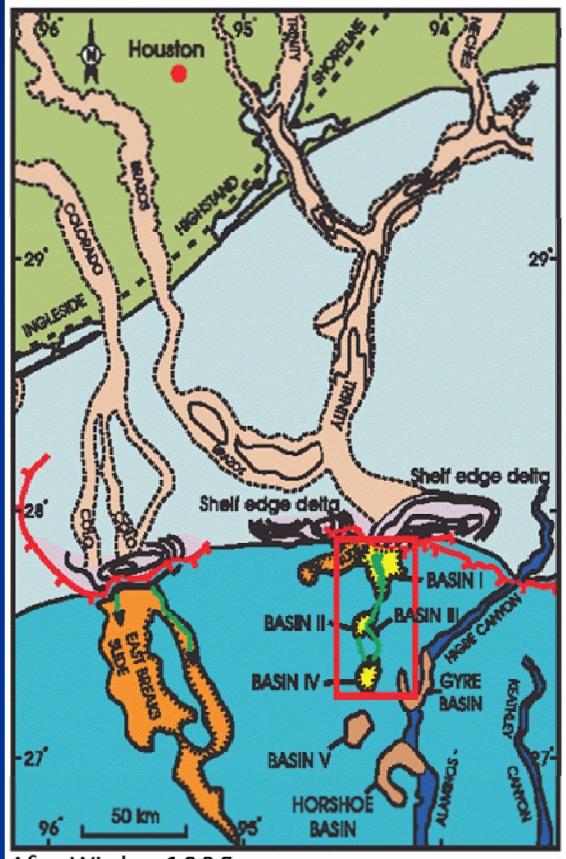




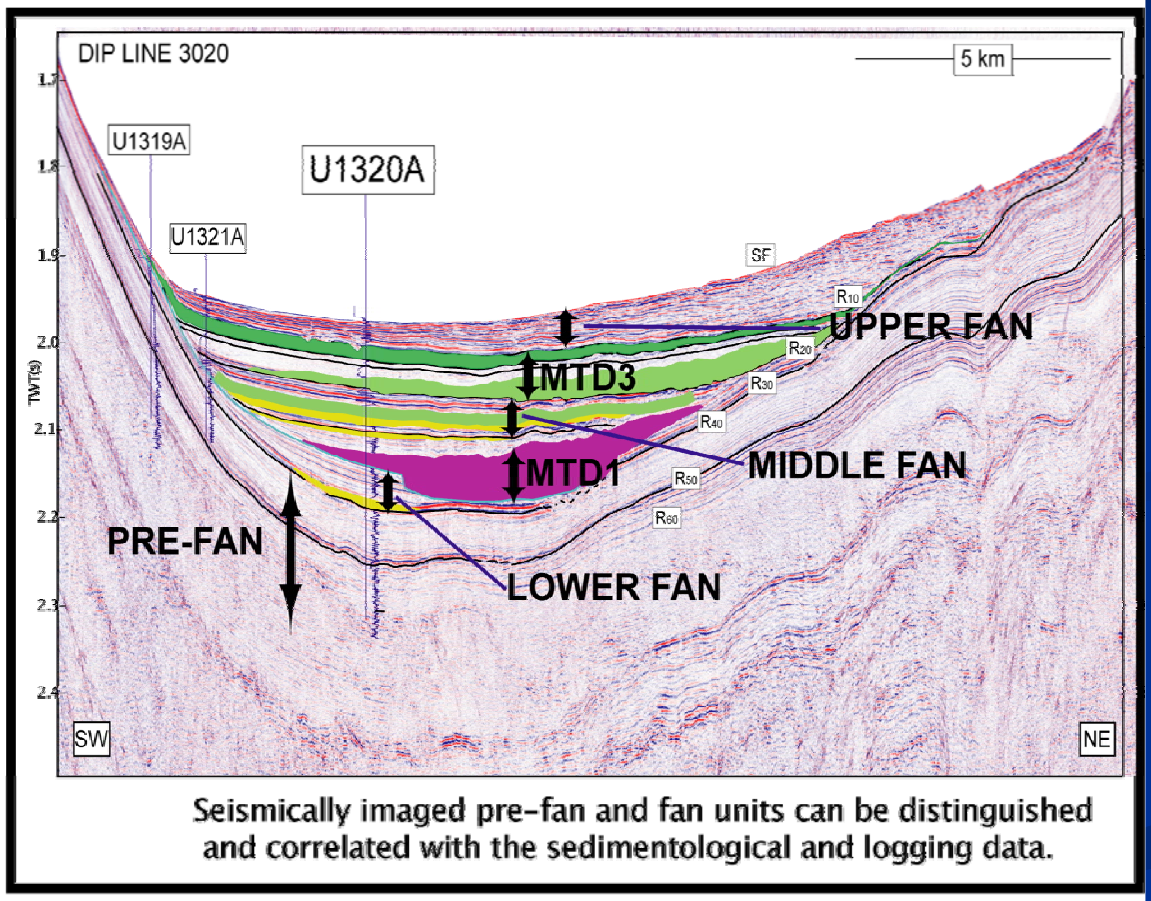
# ODP Expedition 308 -- Trinity-Brazos Basin IV

## A. GEOLOGICAL SETTING




AfterWinker, 1996

## B. SEISMIC SECTION OF BASIN IV




Seismically imaged pre-fan and fan units can be distinguished and correlated with the sedimentological and logging data.

**Shipboard Scientists IODP Expedition 308, (2005)**

# Part B

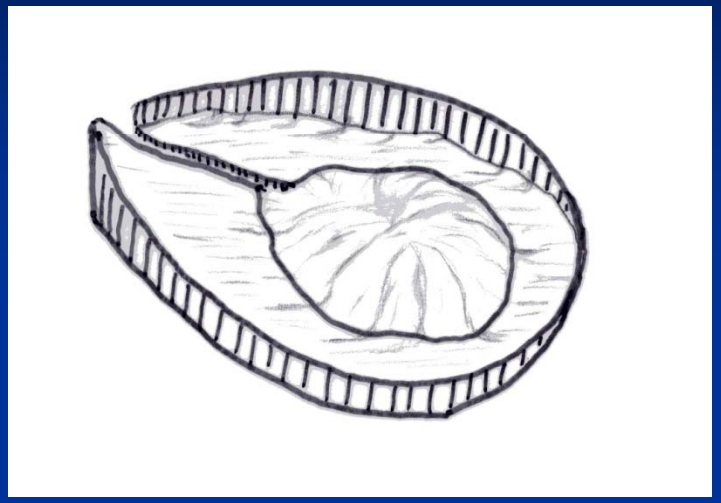
## GULF OF MEXICO MINI-BASIN SUBSURFACE CHANNEL THALWEG CHARACTERISTICS

| TURBIDITE SYSTEM | CHANNELS STUDIED | RELIEF (ms) max. | WIDTH (m) max. | SEISMIC FACIES Ponded | Channel | MTD |
|---|---|---|---|---|---|---|
| BRYANT | 75 | 50-100 | 1000-2400 | X | X | X |
| EAST CANYON | 20 | 50-90 | 1000-2000 | X | X | X |
| MISS. CANYON | 1 | 75 | 1000+ | X | X | X |
| TAHOE CHANNELS | 1 | 80-120 | 1100 | X | X | X |
| AUGER | 20 | | 750-2000 | X | X | X |
| SUM 16 BASINS | 50+? | 15-140 | 100-2500 | X | X | X |

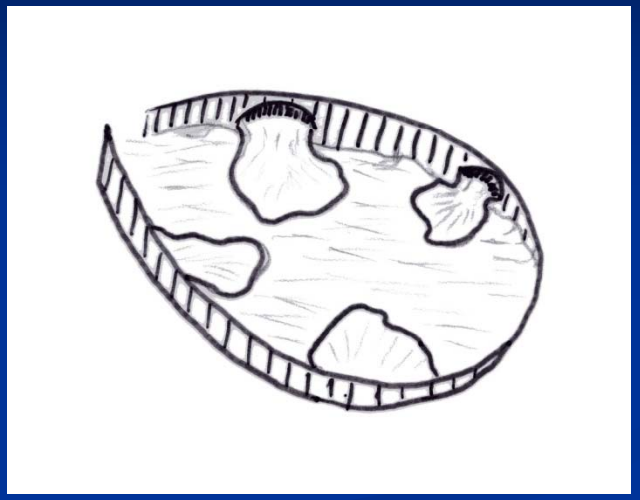
# MINI-BASIN DEPOSITIONAL PATTERNS

## MASS TRANSPORT DEPOSITS

### SHEETS

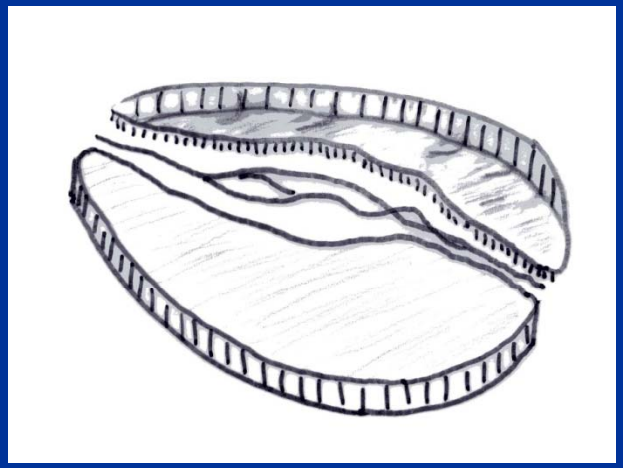


### WEDGES

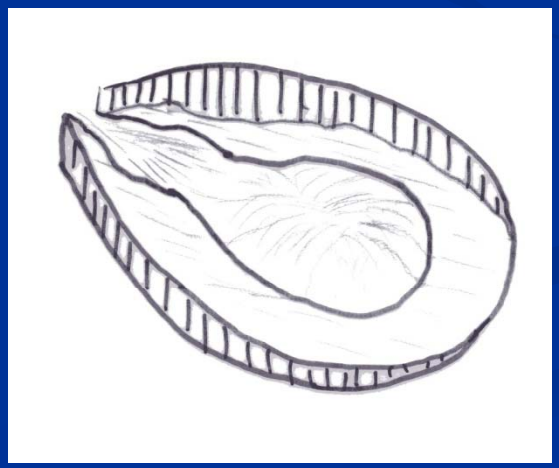


## PONDED TURBIDITE DEPOSITS

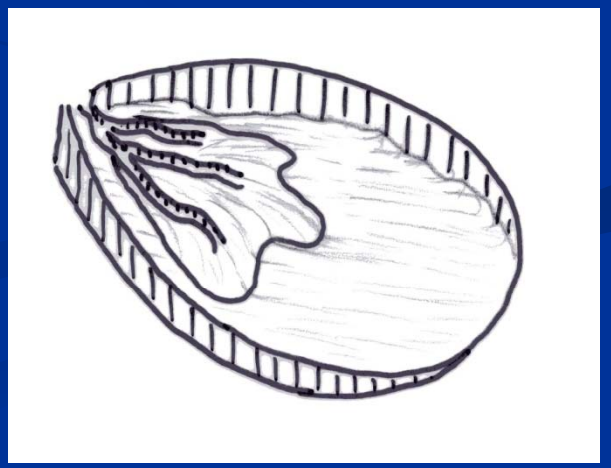
### INCISED

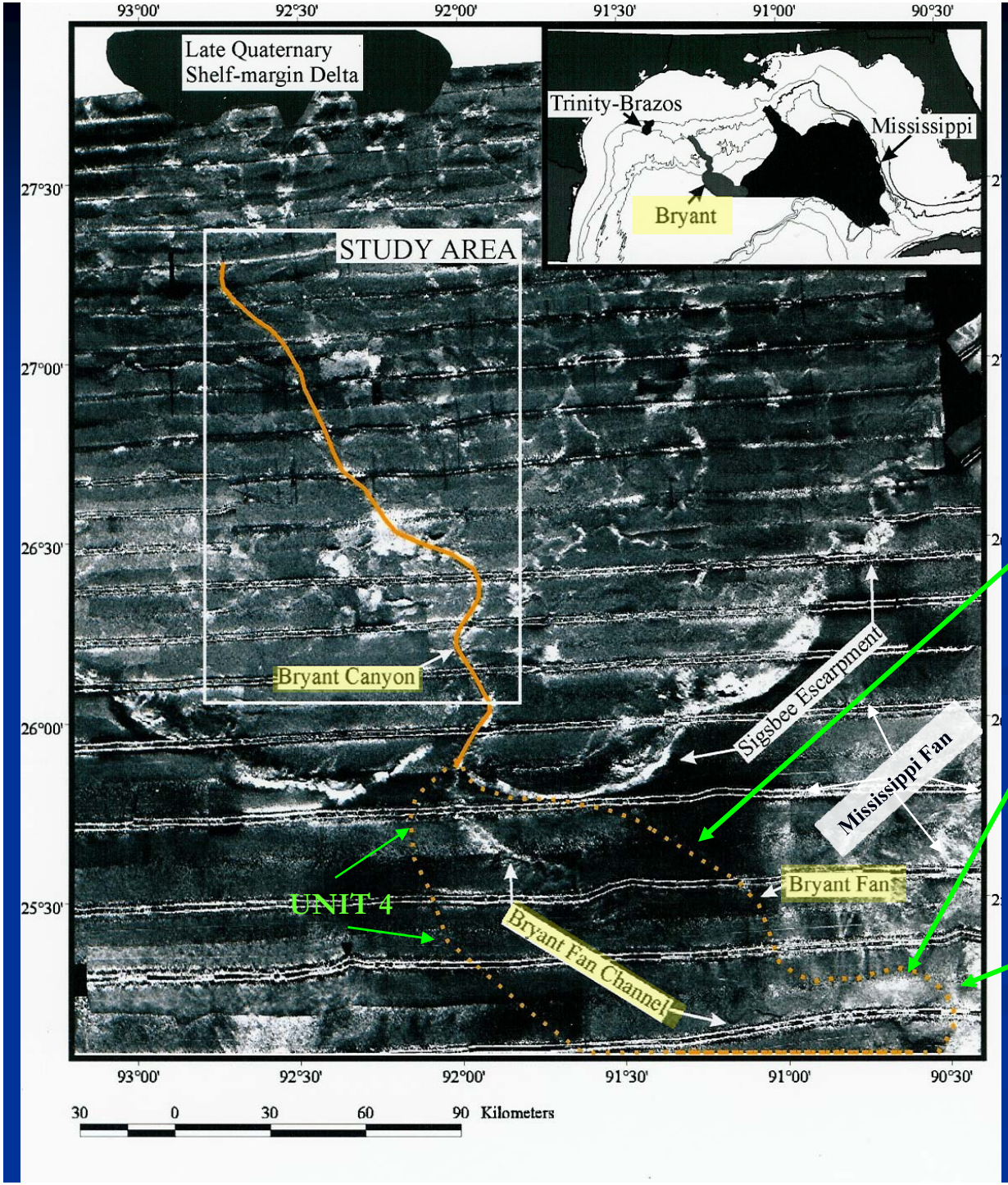


### PONDED



### PERCHED






# BRYANT CANYON AND FAN STUDY AREA

CANYON STUDY AREA

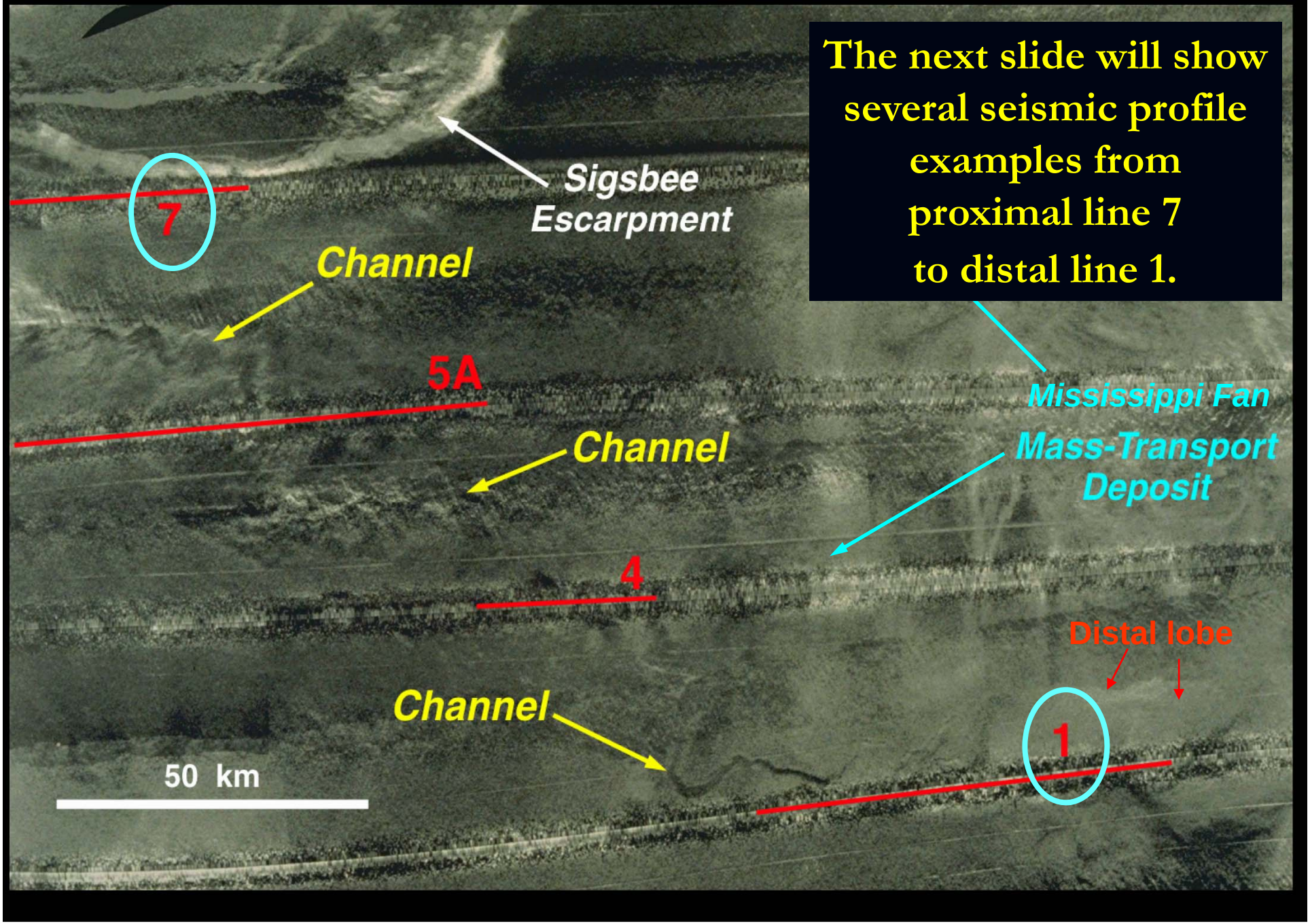
FAN STUDY AREA

Bryant Fan youngest (unit 4) channel levee complex is outlined (orange dots)

Note high backscatter lobe with apparent high sand content

Mississippi Fan debris sheet with chaotic surface laps against distal Bryant Fan

# MODERN BRYANT FAN (UNIT 4) AND LOBE

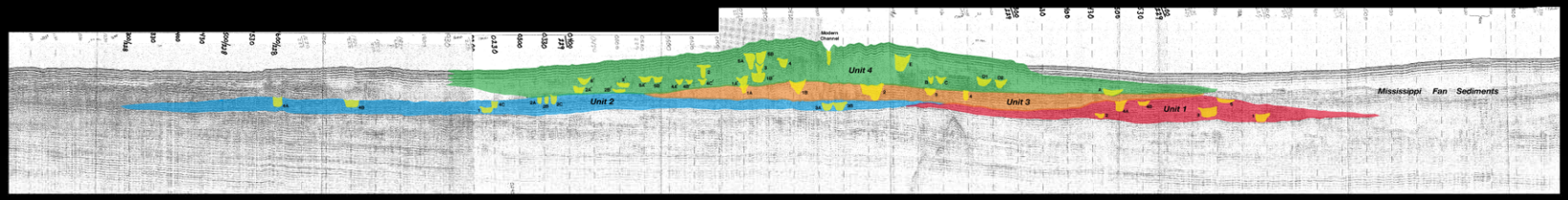


# Bryant Submarine Fan

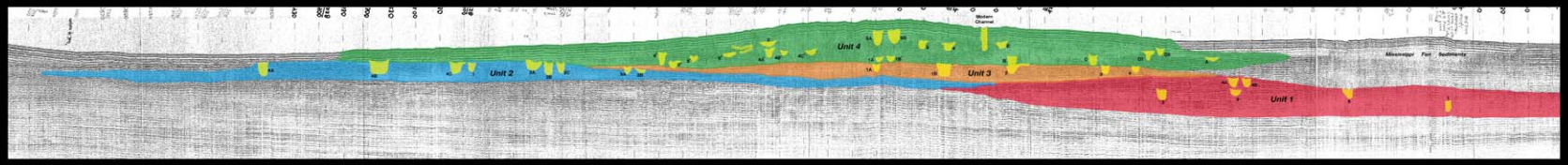
WEST

EAST

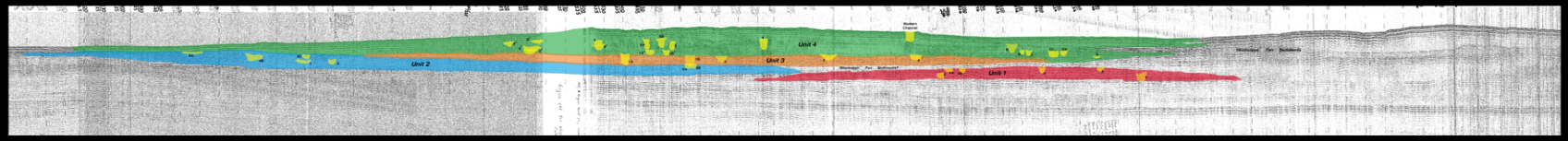
Line FRN 19 - 7



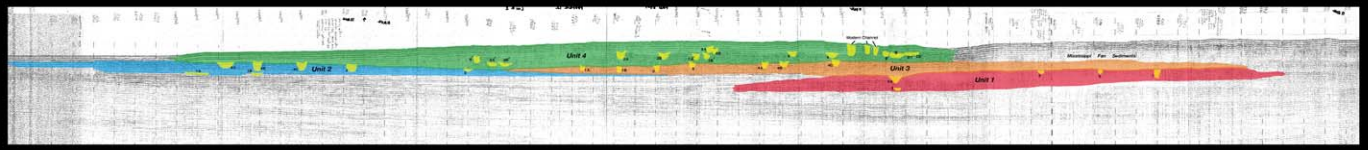

Line FRN 20 - 5A




Line FRN 21 - 4




Line FRN 22 - 1

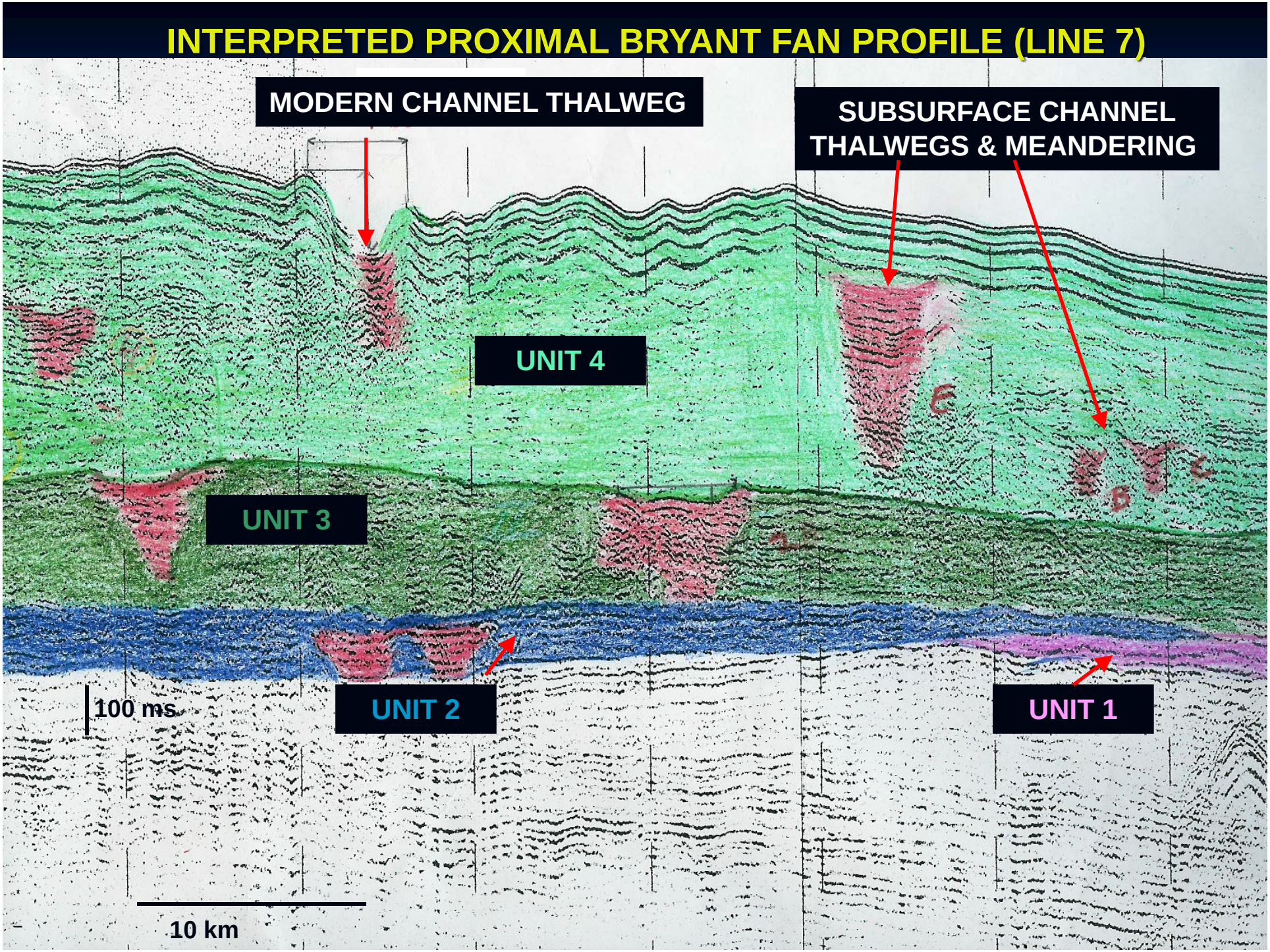



4 Sec

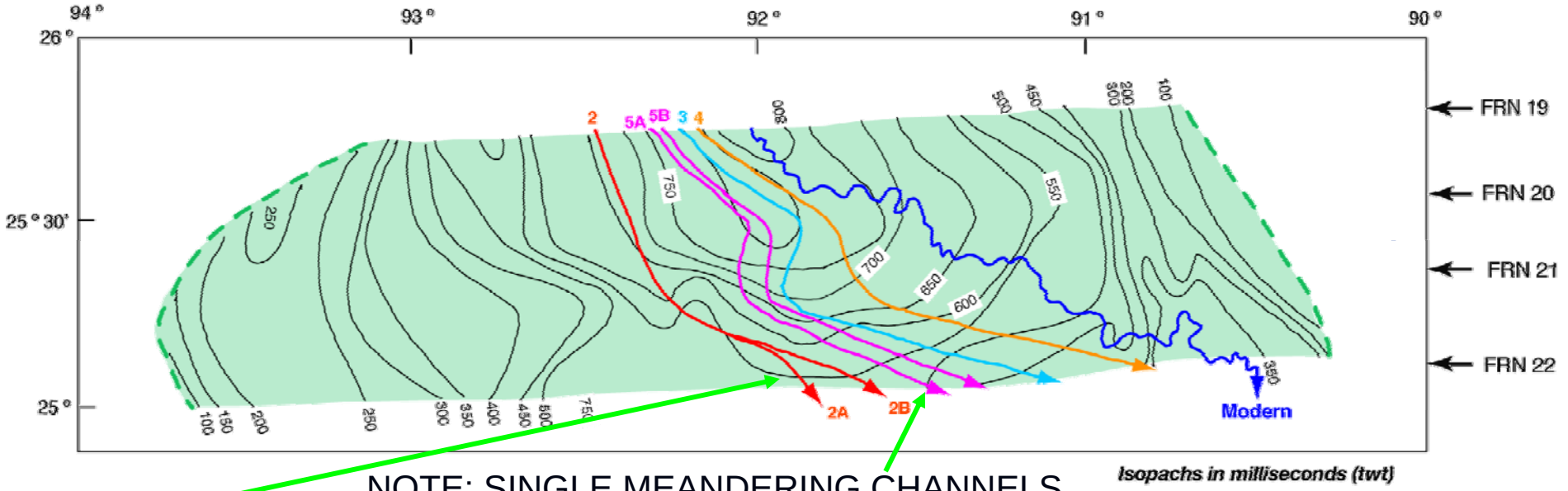
VE = ~20:1

100 km

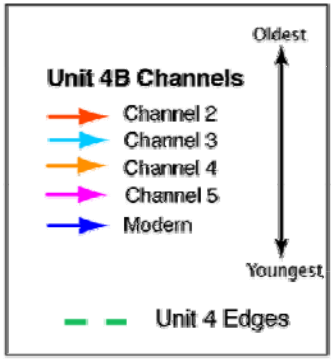
# INTERPRETED PROXIMAL BRYANT FAN PROFILE (LINE 7)



# BRYANT FAN UNIT 4
## Total Thickness and Subunit 4B Channel Locations




NOTE: SINGLE MEANDERING CHANNELS
& SPLAY INTO DISTAL LOBE



# BRYANT FAN GROWTH UNITS

Note: a low number of channel thalwegs (~6-9) except for thicker unit 4

The number of channel thalwegs is constant proximal to distal indicating a lack of channel bifurcation

| Channel Levee Units | Length (km) | Average Width (km) | Maximum Thickness (ms) | Average Thickness (ms) | Number of Thalweg Channels in Unit | Distal Lobe Length (km) |
|---|---|---|---|---|---|---|
| **UNIT 4** (youngest) | 190 | 289 | 706 | 476 | 15 | 30 |
| **UNIT 3** | 110+ | 205 | 294 | 182 | 6 | |
| **UNIT 2** | 97+ | 239 | 325 | 188 | 8 | |
| **UNIT 1** (oldest) | 139+ | 145 | 494 | 311 | 5 | |

110+ can not determine total length because of limited profile coverage

Damuth, Nelson and Olson (2006)

# MID-MIOCENE *MCAVLU FAN GROWTH UNITS

Note: size (length, width, thickness) of channel levee complexes similar to Bryant

Number of channel thalwegs similar to Bryant

| Channel Levee Units | Length (km) | Average Width (km) | Thickness (ms) | | | Number of Thalweg Channels in Unit | Distal Lobe Length (km) |
|---|---|---|---|---|---|---|---|
| | | | Max | Min | Average | | |
| SS 3 (youngest) | 125 | 150 | 400 | 100 | 250 | 7 | |
| SS 2 | 200 | 200 | 200 | 100 | 150 | 8 | 20 |
| SS 1 (oldest) | 200 | 140 | 285 | 100 | 190 | 9 | 38 |

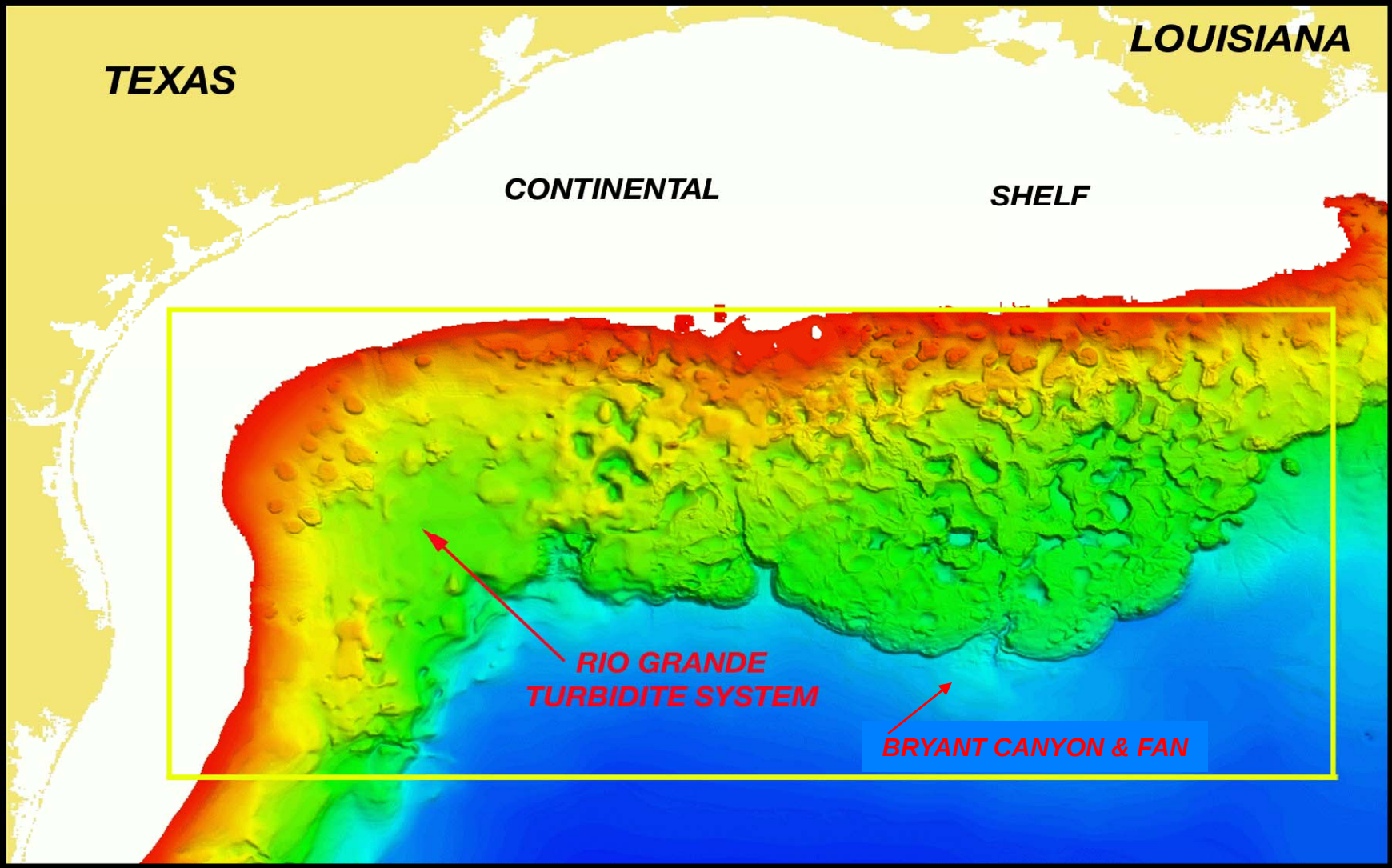
*MCAVLU FAN- POTENTIAL RESERVOIR SANDS FOR ATLANTIS, AND NEPTUNE FIELDS.

SS1-SS3 DATA SOURCE FROM COMBELLAS, 2003; COMBELLAS AND GALLOWAY,2006

# BRYANT CANYON & FAN SUMMARY

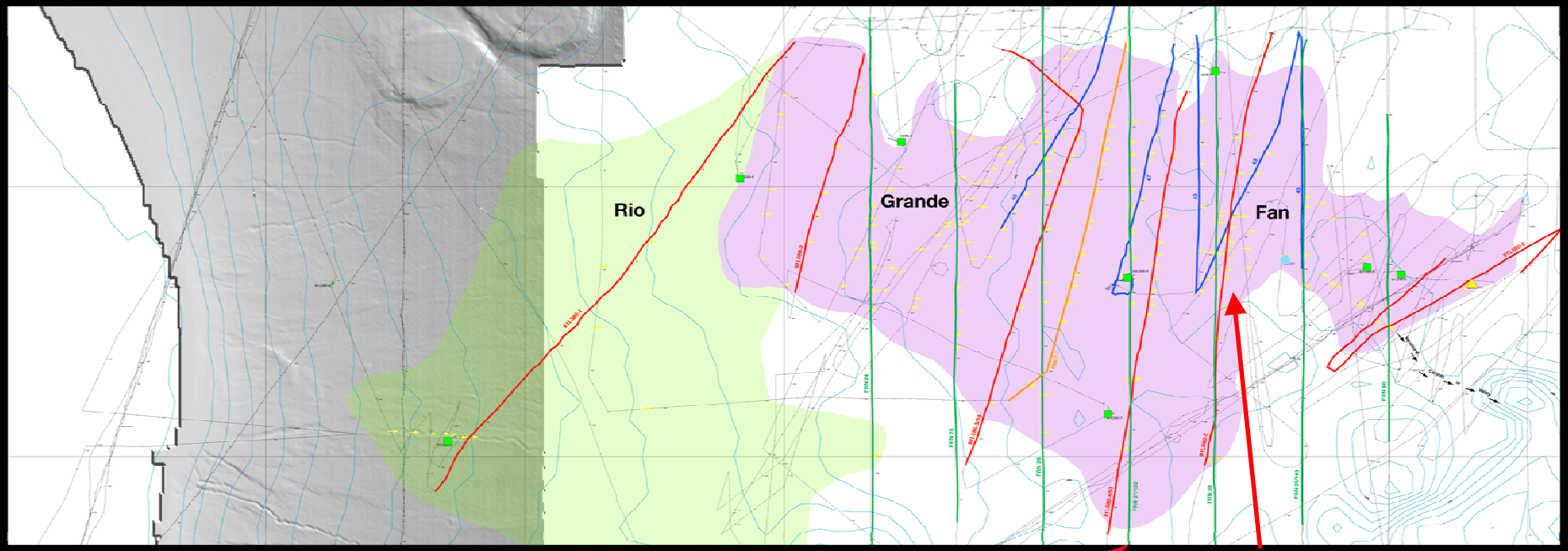
- SCALES, SEISMIC FACIES, ARCHITECTURE AND CHANNEL PATTERNS OF GOM TURBIDITE SYSTEMS VARY SIGNIFICANTLY
- BRYANT AND MID-MIOCENE FANS HAVE STACKED CHANNEL-LEVEE COMPLEXES OF ~ 200 KM LENGTH AND ~ 200 MS THICKNESS
- FAN CHANNEL THALWEGS (WIDTH OF 3 TO 10 KM , RELIEF OF 20-40 MS) ARE LIMITED IN NUMBER OF BIFURCATIONS, LOW SINUOSITY AND END IN DISTAL SAND-RICH LOBES OF ~ 30 KM LENGTH
- BRYANT FAN = MODERN ANALOGUE FOR MID-MIOCENE FAN RESERVOIR CHARACTERISTICS IN THE MISSISSIPPI CANYON AREA (E.G. ATLANTIS AND NEPTUNE FIELDS)
- BRYANT MINI-BASINS HAVE TYPICAL DEPOSITIONAL PATTERNS OF BYPASS CHANNELS, PONDED TURBIDITES, PONDED MTDs & MTD WEDGES
- BRYANT CANYON MINI-BASINS = ANALOGUE FOR MIOCENE-PLEISTOCENE MINI-BASINS ( E.G. THUNDER HORSE FIELD )

# RIO GRANDE FAN LOCATION




*Seafloor Relief Map by Lui and Bryant*
*(Texas Sea Grant College Program)*

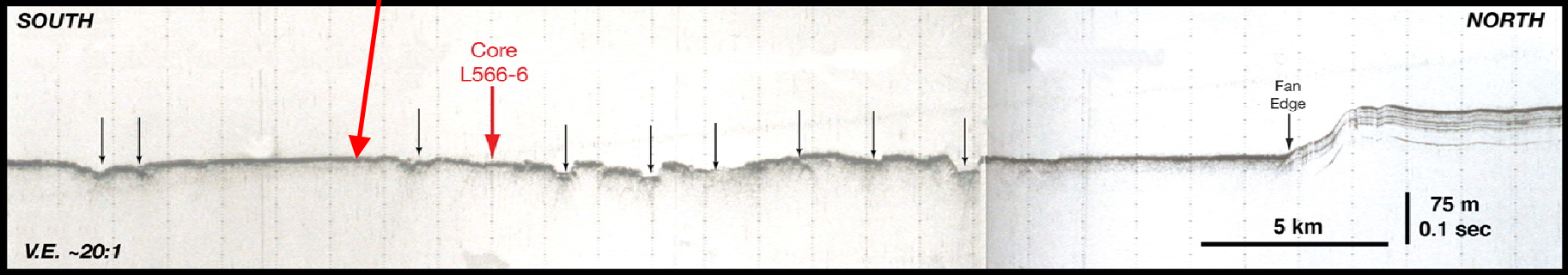
# Rio Grande Fan 3.5 kHz Seismic Facies




Rio Grande Fan Prolonged Echoes Suggest Sand Rich Fan

3.5 kHz Profile 102

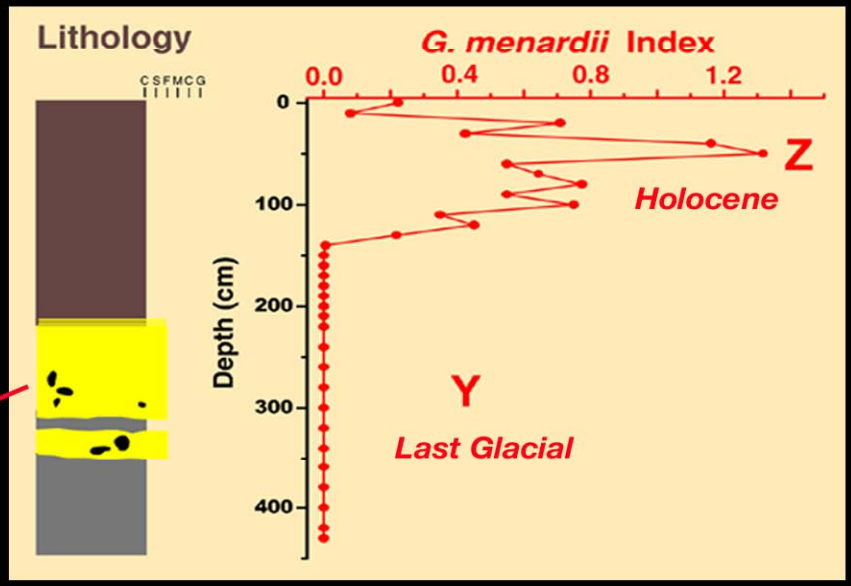
Yellow Arrows are Channels on the Fan Surface




*Damuth, Nelson and Olson (2006)*

# Core IG38-9
# Northern Edge of Lower Rio Grande Fan

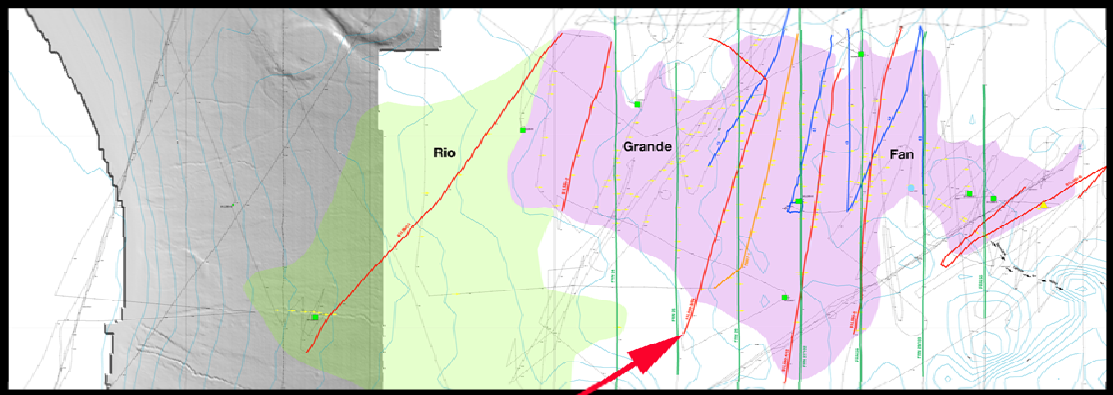
5 cm



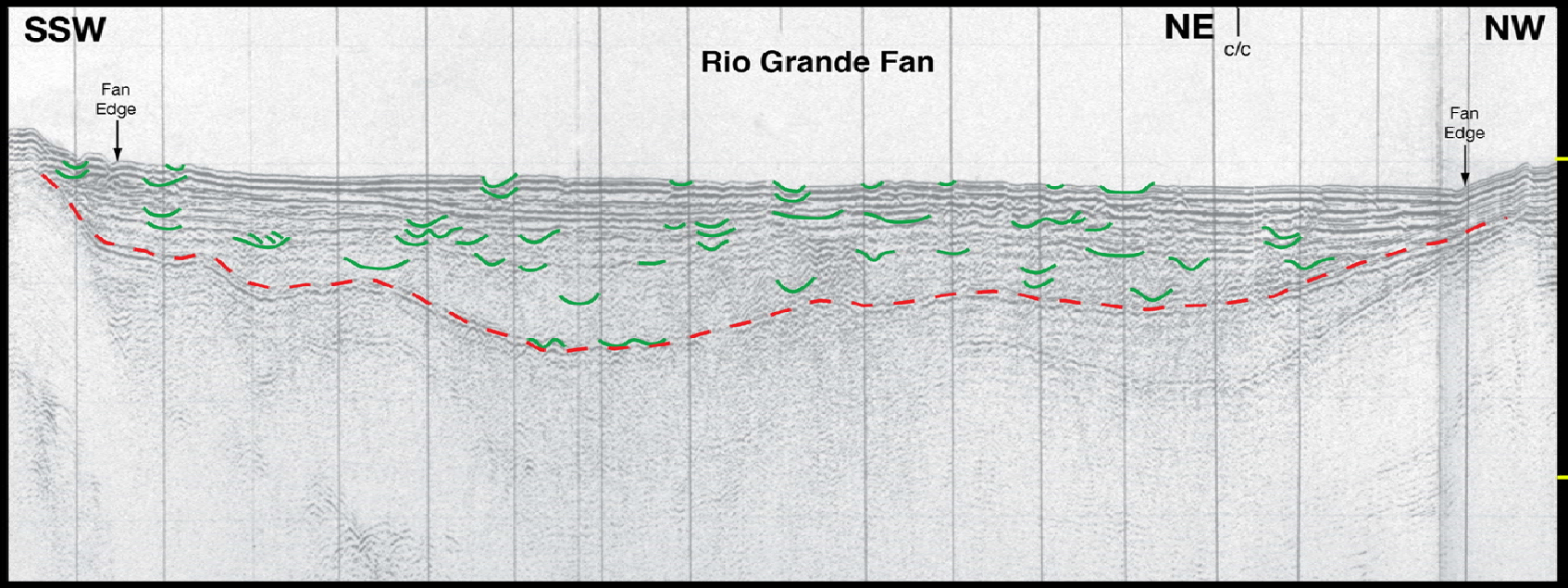

Deformed Sand Beds with Mud Clasts

*Damuth, Nelson and Olson (2006)*

# Middle Rio Grande Fan




Seismic Line 91L580-3




V.E. ~ 10:1

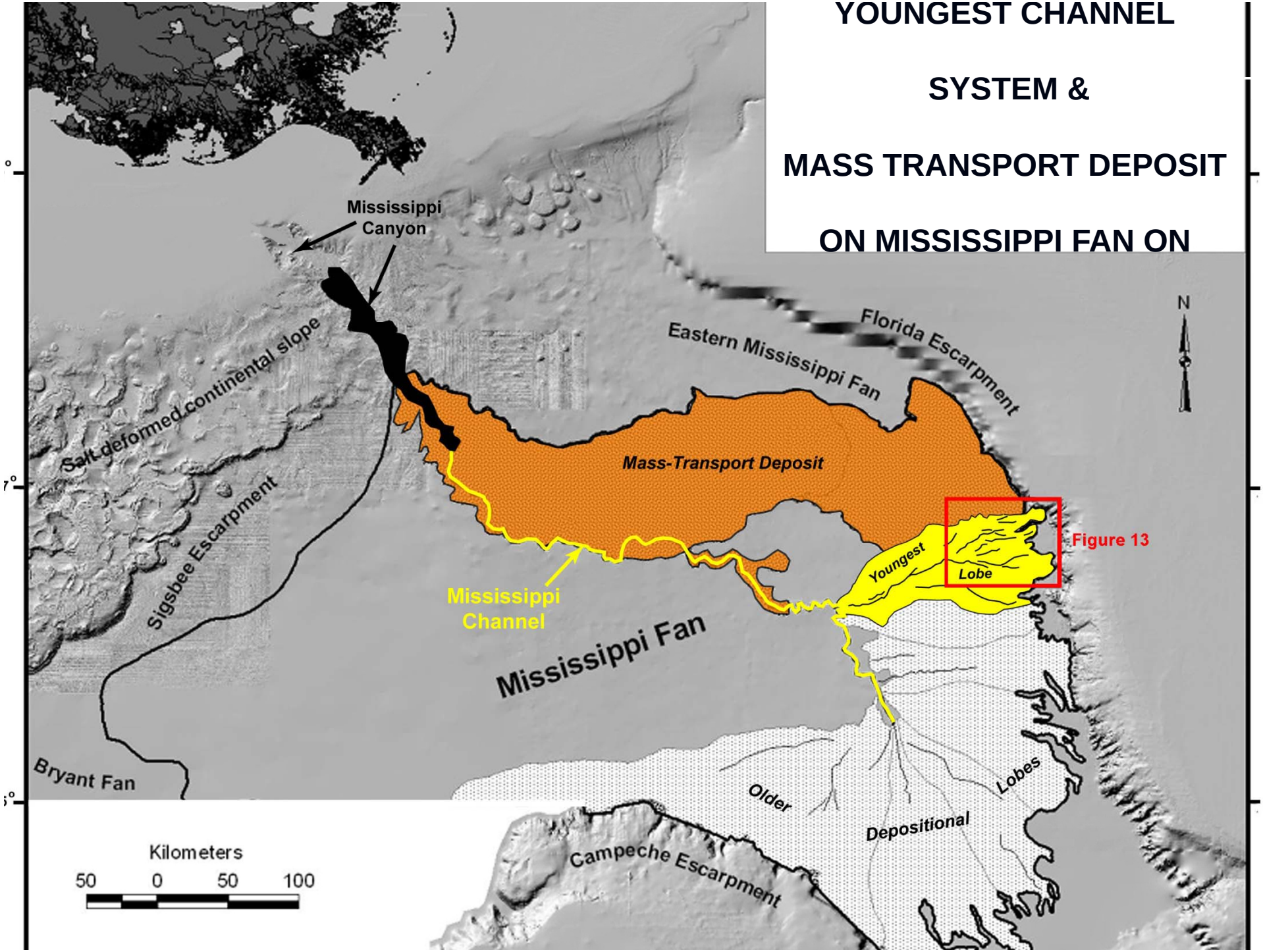
15 km

*Damuth, Nelson and Olson (2006)*

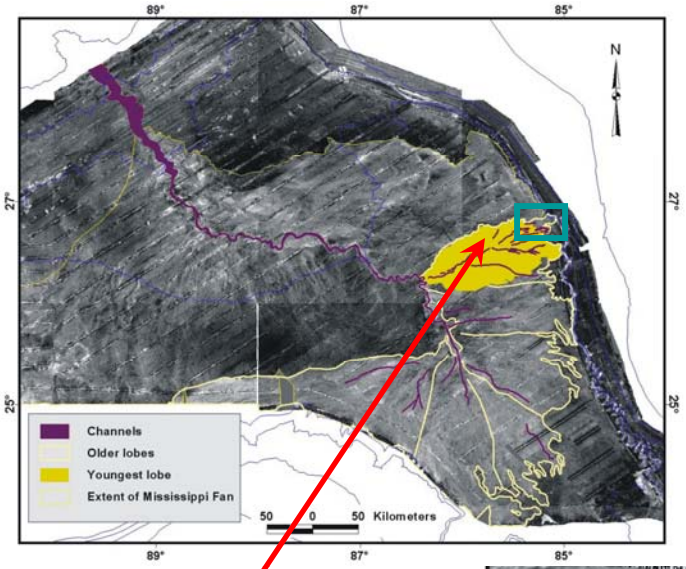
# RIO GRANDE FAN SUMMARY

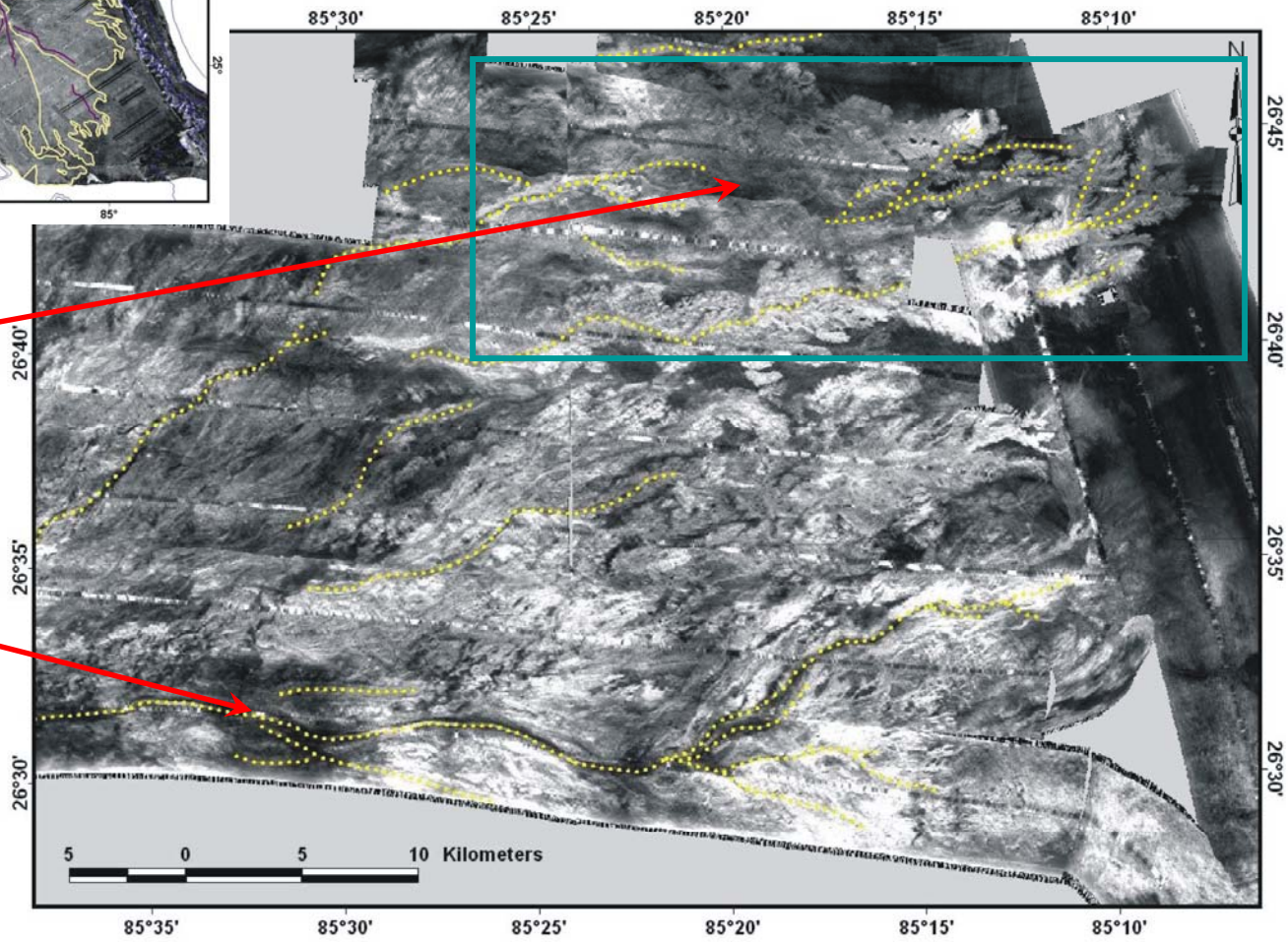
- The Rio Grande Fan is ~ 40 km wide and extends ~100 km across a continental slope plateau and provides a potential analogue for the Frio and Wilcox plays.
- The fan is fed by multiple canyons that provide coarse-grained sediment from the Sierra Madre and Guadalupe Mountains.
- High backscatter of side 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, pattern plus many surface and subsurface channels suggest a braid-plain submarine fan.
- Good potential for high content of sand beds with lateral continuity
- Large constricted channels in distal fan have potential vertical continuity

# YOUNGEST CHANNEL SYSTEM & MASS TRANSPORT DEPOSIT ON MISSISSIPPI FAN ON



# SIDESCAN SONAR IMAGES OF DISTAL MISSISSIPPI FAN



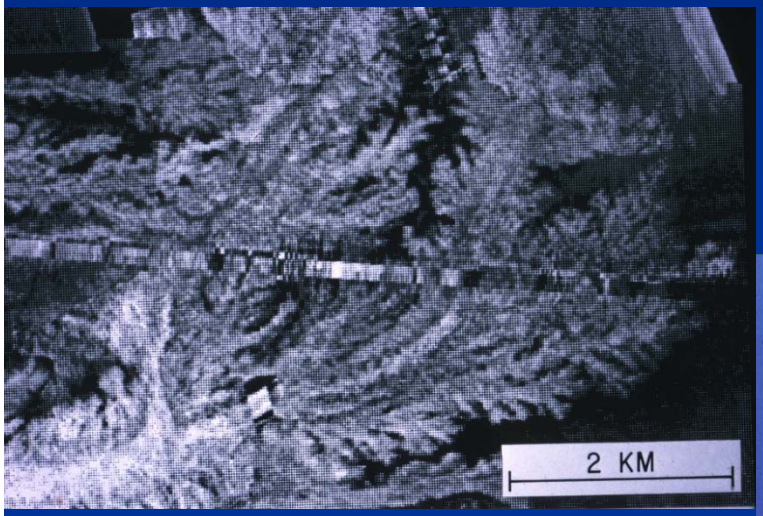

***YOUNGEST OUTER FAN LOBE***

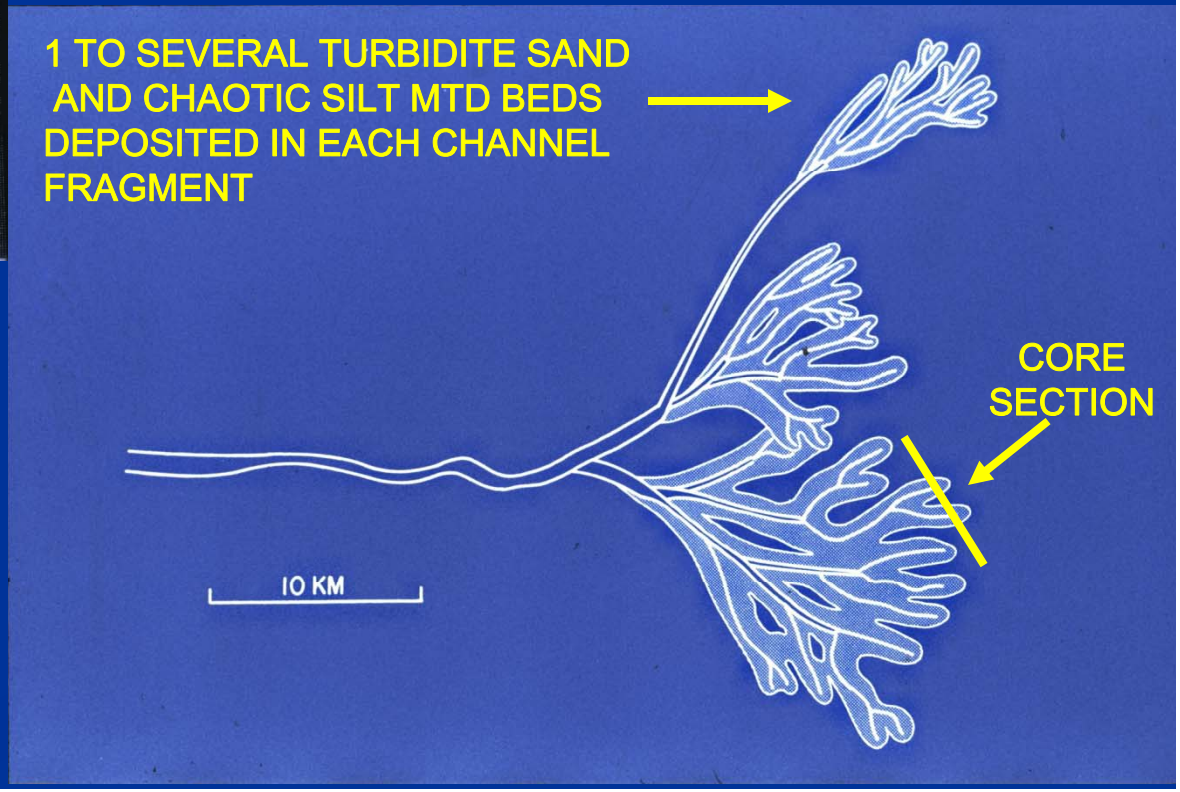
***CHANNEL SPLAYS***

Twichell et al. ( in press)

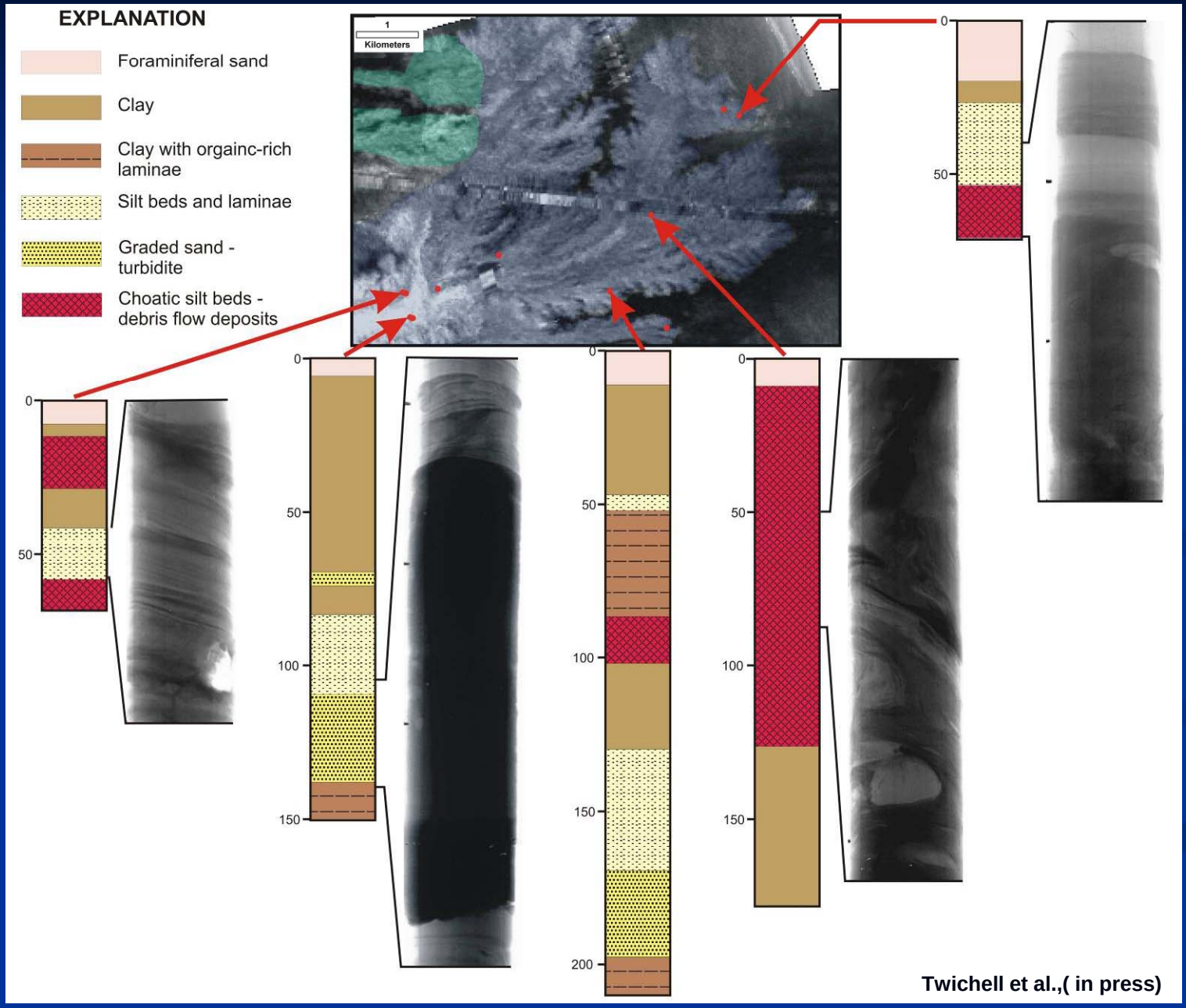
# MISSISSIPPI FAN FINAL CHANNEL SPLAYS 600km FROM CANYON MOUTH

**DEEP-TOW SEAMARC SONOGRAPH**

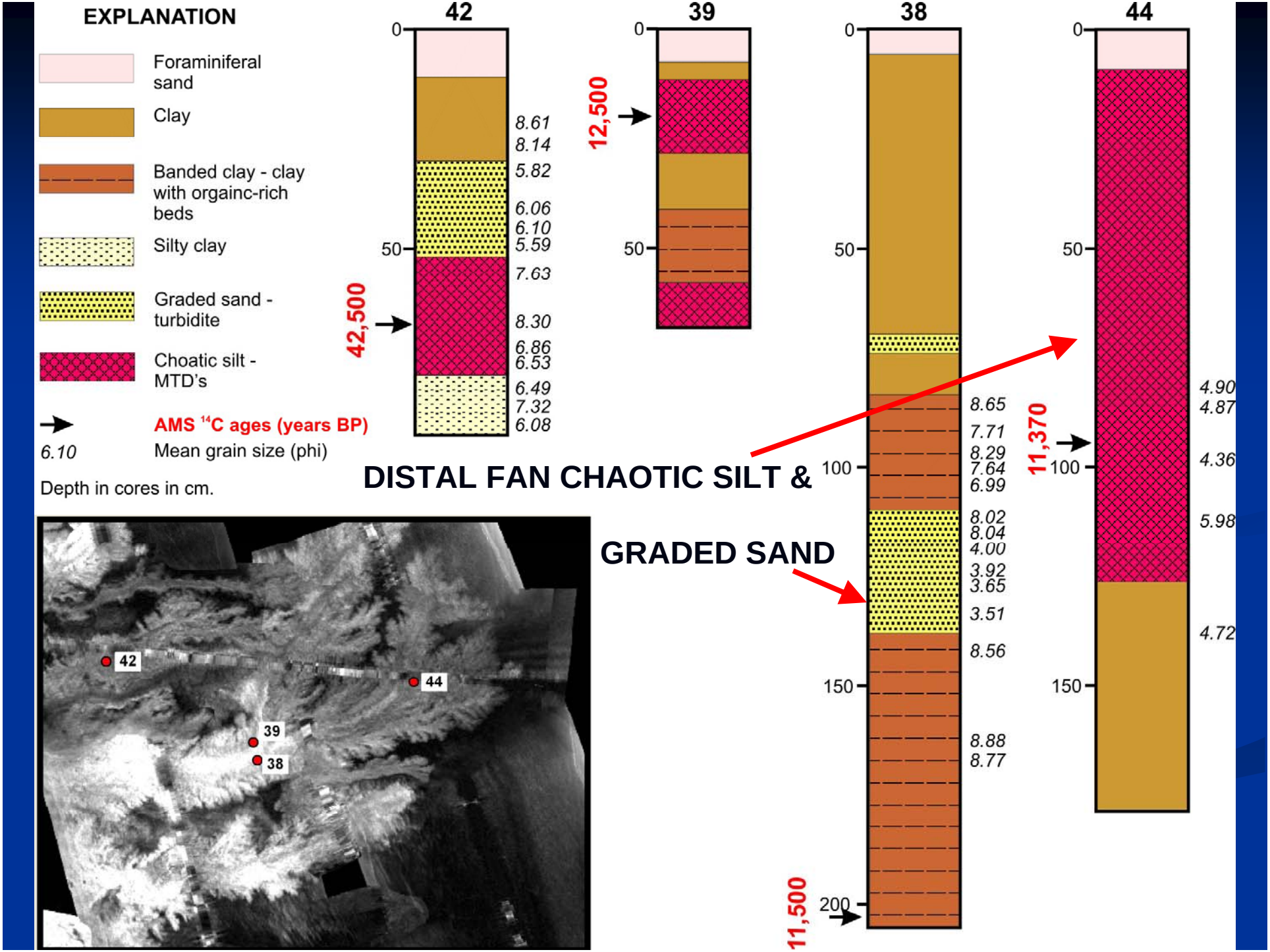


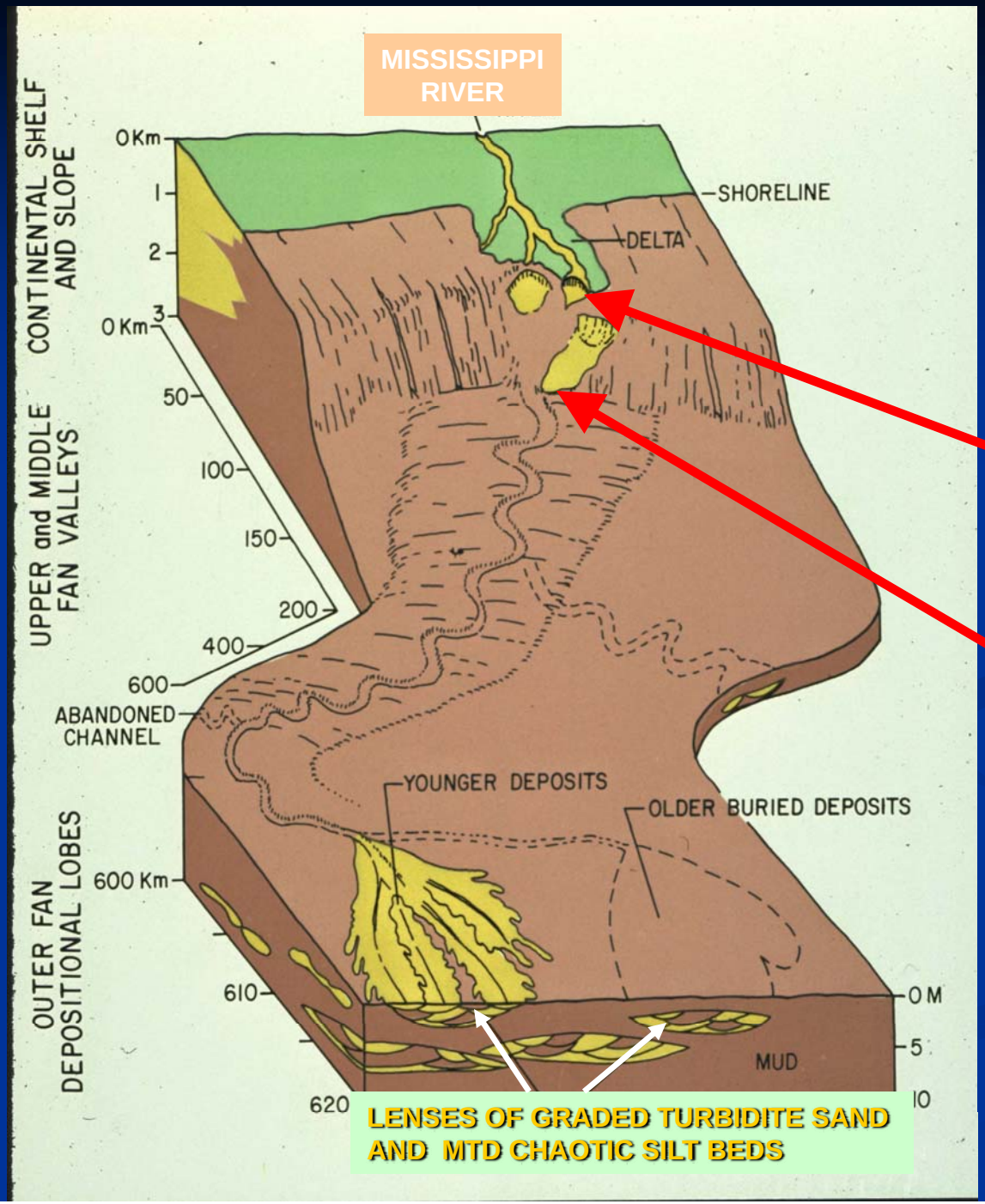



# RADIOGRAPHS OF DISTAL FAN SAND AND CHAOTIC SILT BEDS




Twichell et al.,( in press)


EXPLANATION
Foraminiferal sand
Clay
Banded clay - clay with orgainc-rich beds
Silty clay
Graded sand - turbidite
Choatic silt - MTD's
AMS 14C ages (years BP)
6.10
Mean grain size (phi)
Depth in cores in cm.
42
39
38
44
0
50
100
150
200
42,500
12,500
11,370
11,500
8.61
8.14
5.82
6.06
6.10
5.59
7.63
8.30
6.86
6.53
6.49
7.32
6.08
8.65
7.71
8.29
7.64
6.99
8.02
8.04
4.00
3.92
3.65
3.51
8.56
8.88
8.77
4.90
4.87
4.36
5.98
4.72
DISTAL FAN CHAOTIC SILT &
GRADED SAND
42
44
39
38



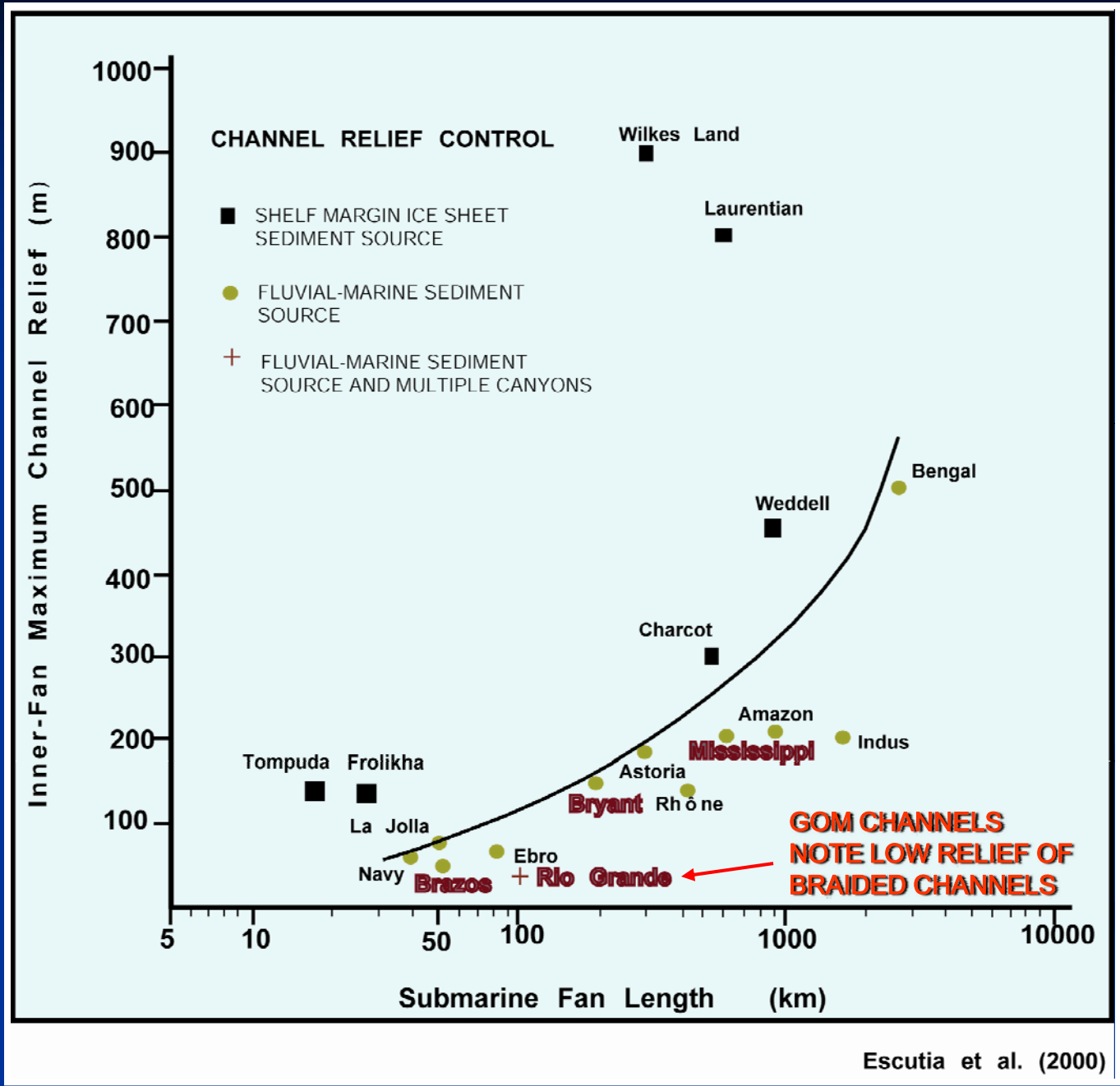

# MODEL SHOWING GENESIS OF DISTAL GRADED SAND AND CHAOTIC MTD BEDS

**DELTA FAILURES GENERATING TURBIDITY-CURRENT SAND BEDS**

**CANYON WALL FAILURES GENERATING CHAOTIC SILT MTD´S**

Nelson et al. (1992)

# FLUVIAL COMPARED TO GLACIAL-SOURCED SUBMARINE FAN VALLEY RELIEF




Escutia et al. (2000)

# NORTHERN GULF OF MEXICO SUBMARINE FANS


**BRYANT - SAND-RICH; FED BY CANYON WITH MINI-BASINS THAT TRAP MUDS; SINGLE SINUOUS CHANNEL AND 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 AND HALF MTD´S**

Damuth, Nelson and Olson (2006)

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