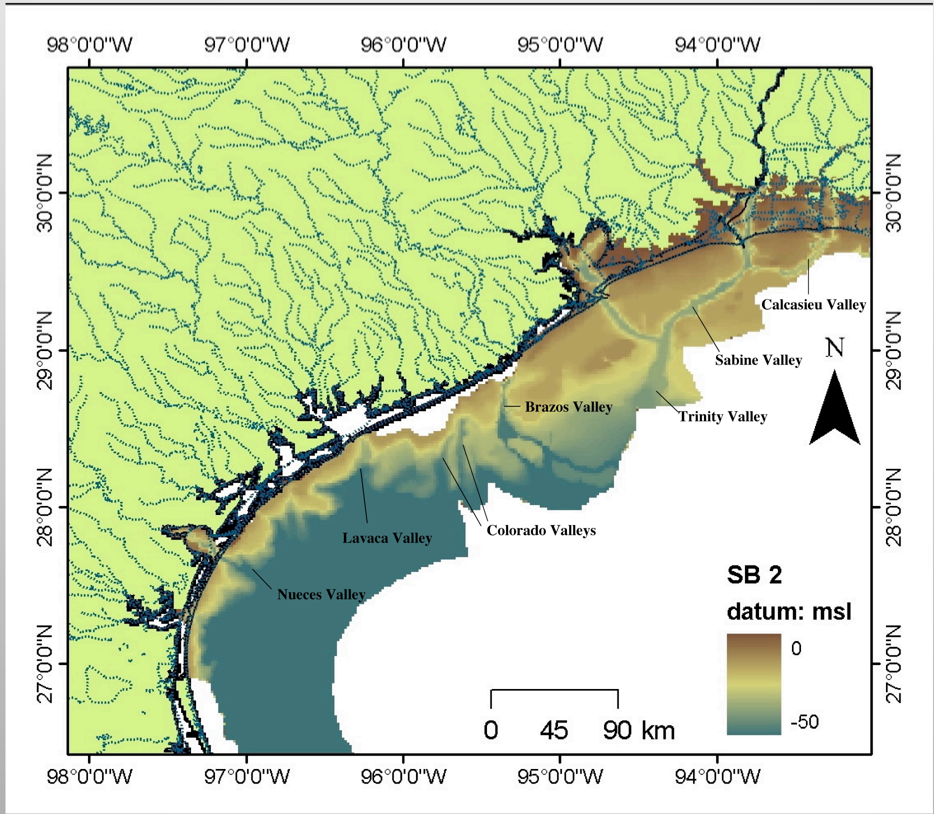
Different Stratigraphic Architectures offshore Texas Reflect Spatial and Temporal Variability in Sediment Supply and Dispersal



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Julia Wellner
Heather McKowen
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Lou Bartek
Laura Banfield
Patrick Taha
Robert Weight
Brenda Ecklels
Mark Thomas

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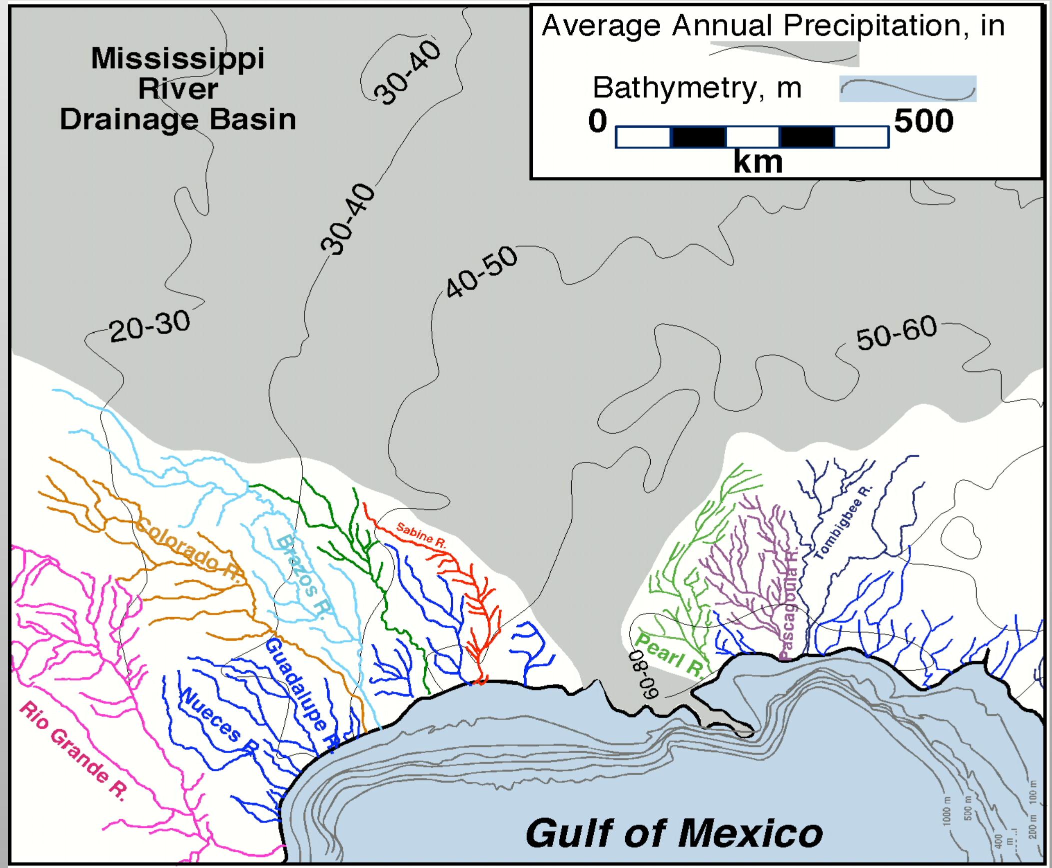
Rice University

2011 Chapman Conference

RICE

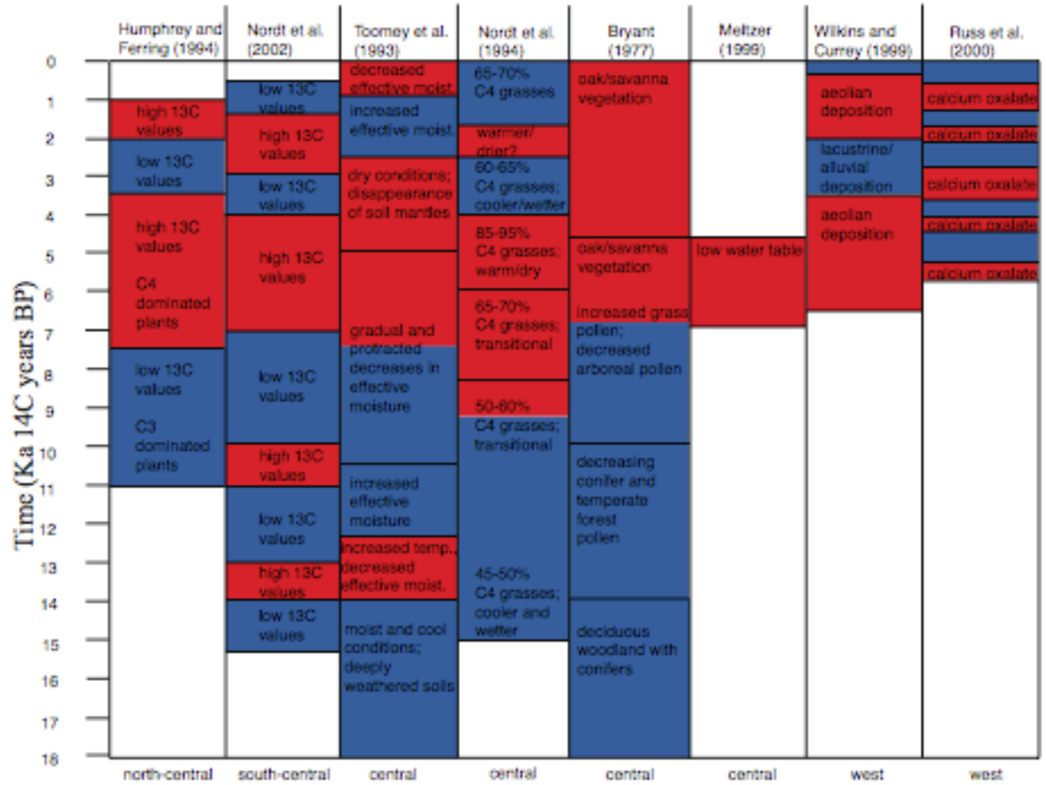
Gulf of Mexico as a Site for Stratigraphic Modeling

- *Variable climatic settings and rivers with different drainage basin sizes and gradients.*
- *Subsidence rates are well constrained and relatively high compared to most passive margins.*
- *Variable physiography*
- *Abundant drill core*

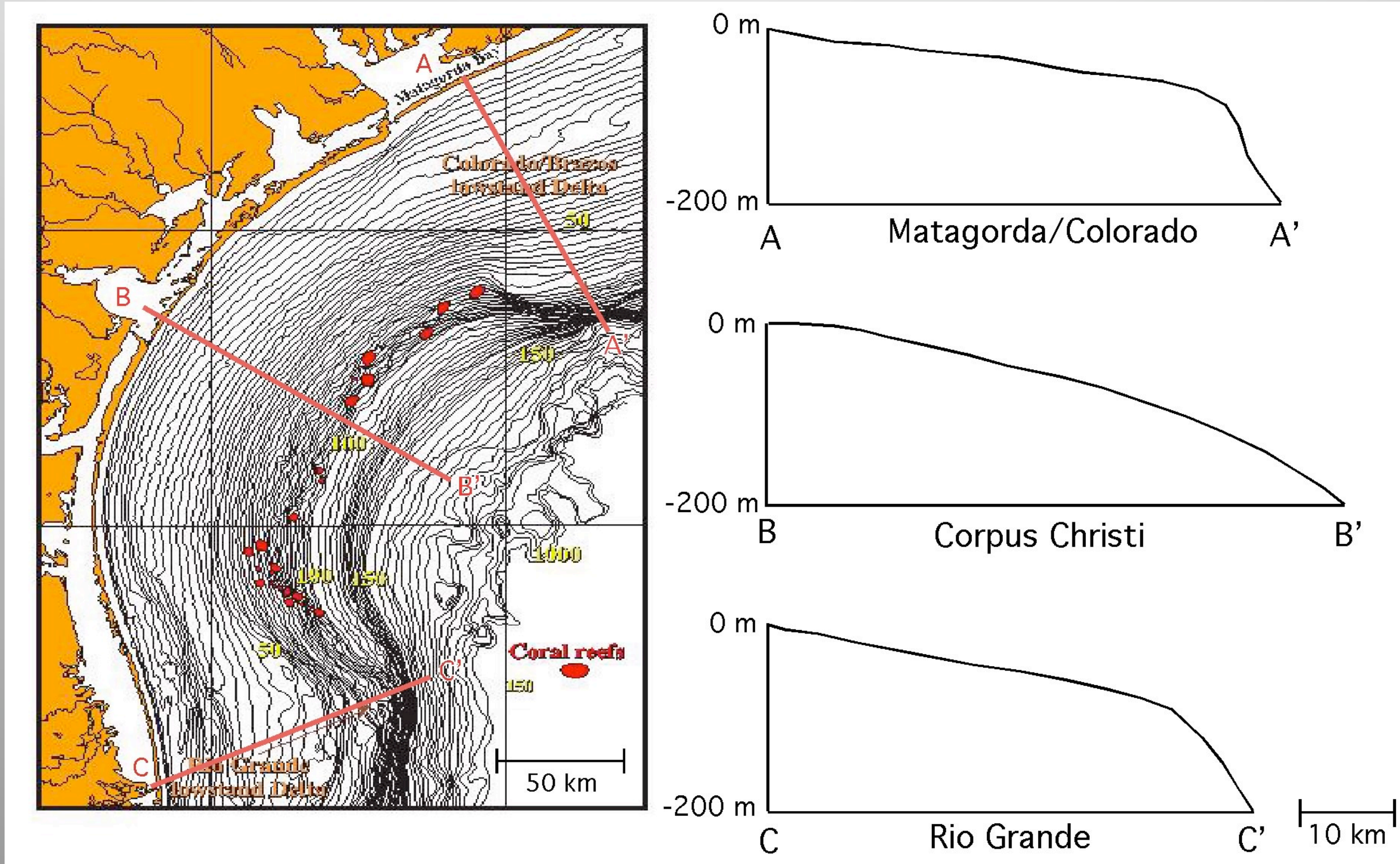


Climate Variability

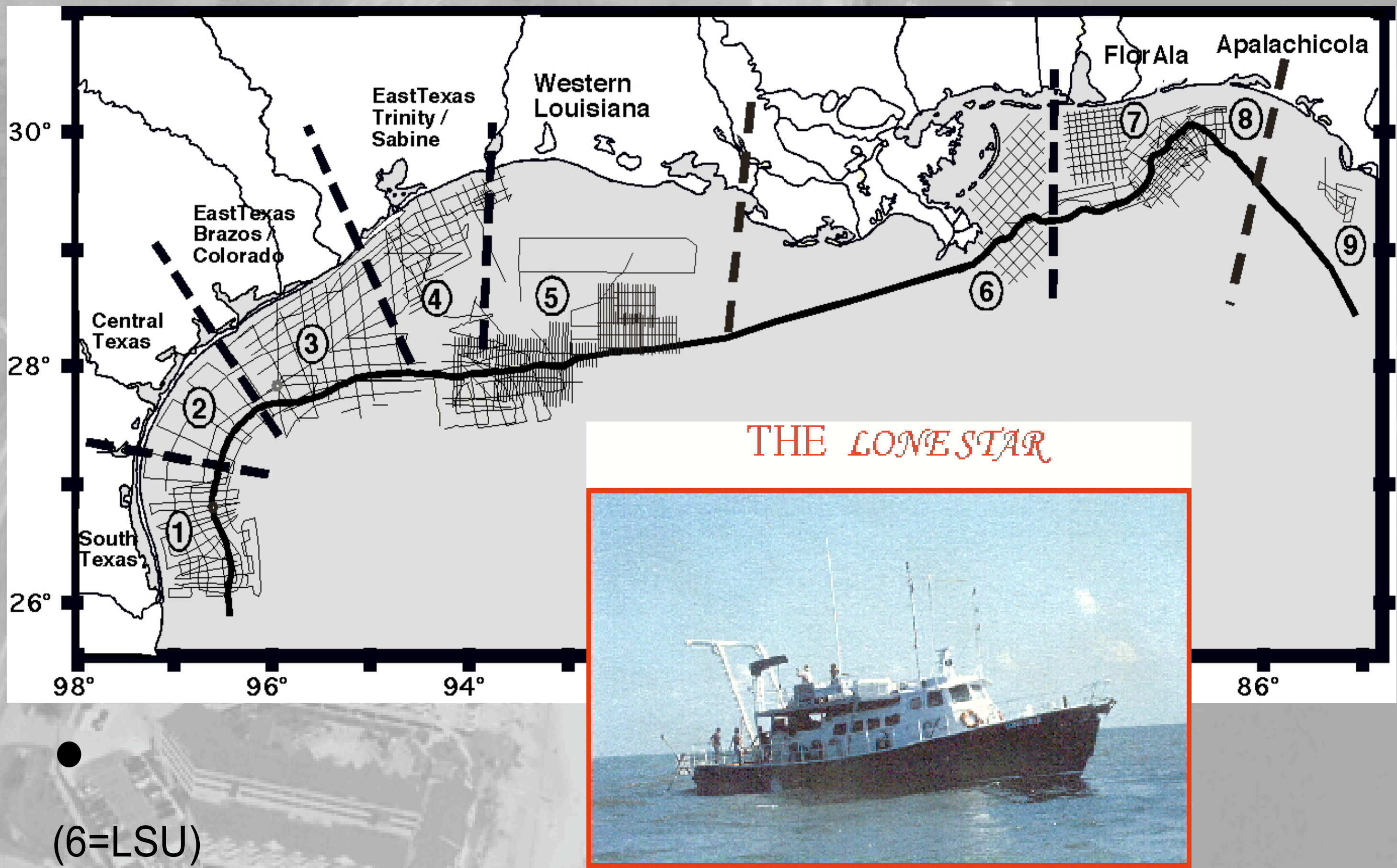
Figure DR3- Texas paleoclimate summary



Long-term depositional patterns reflected in margin physiography.



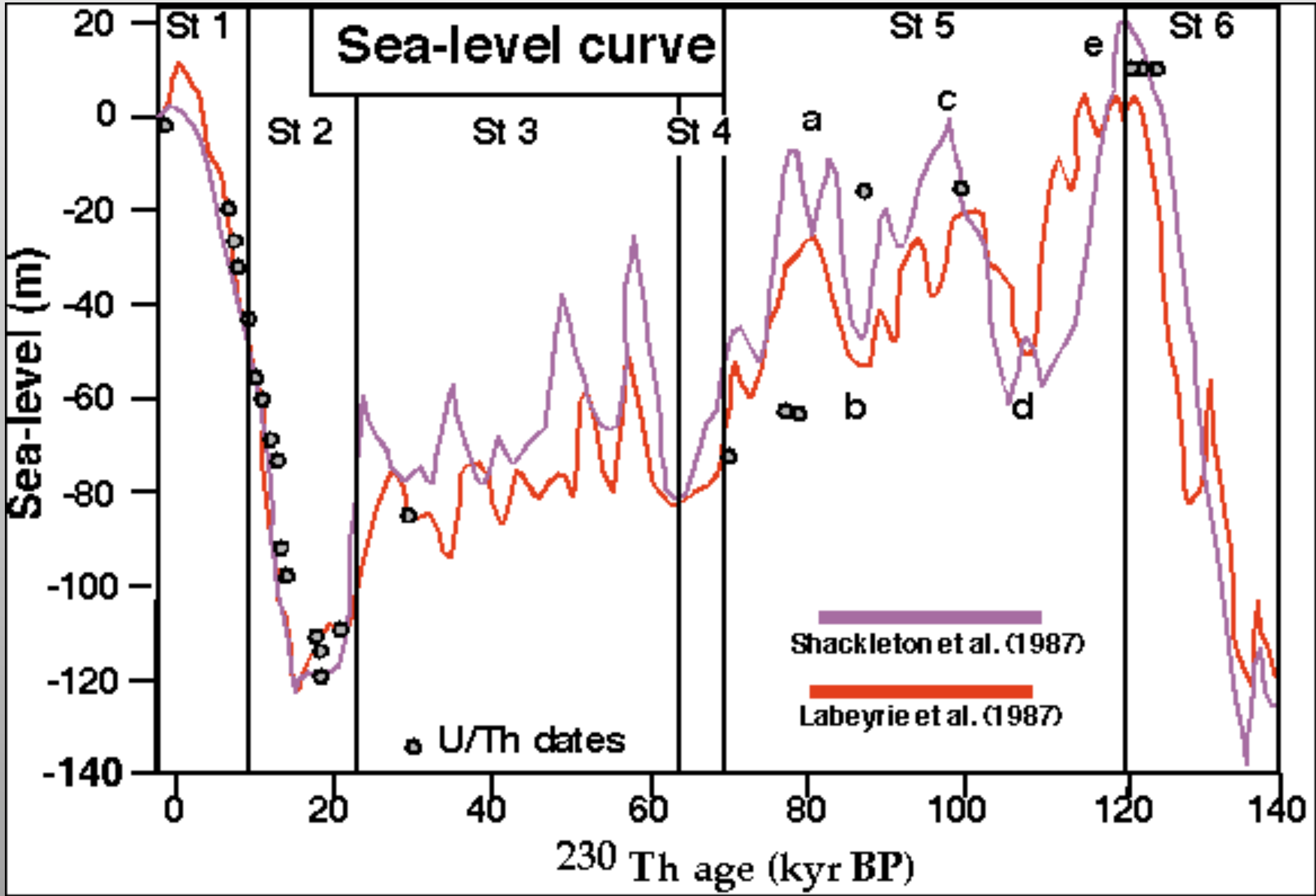
High-resolution seismic data



-

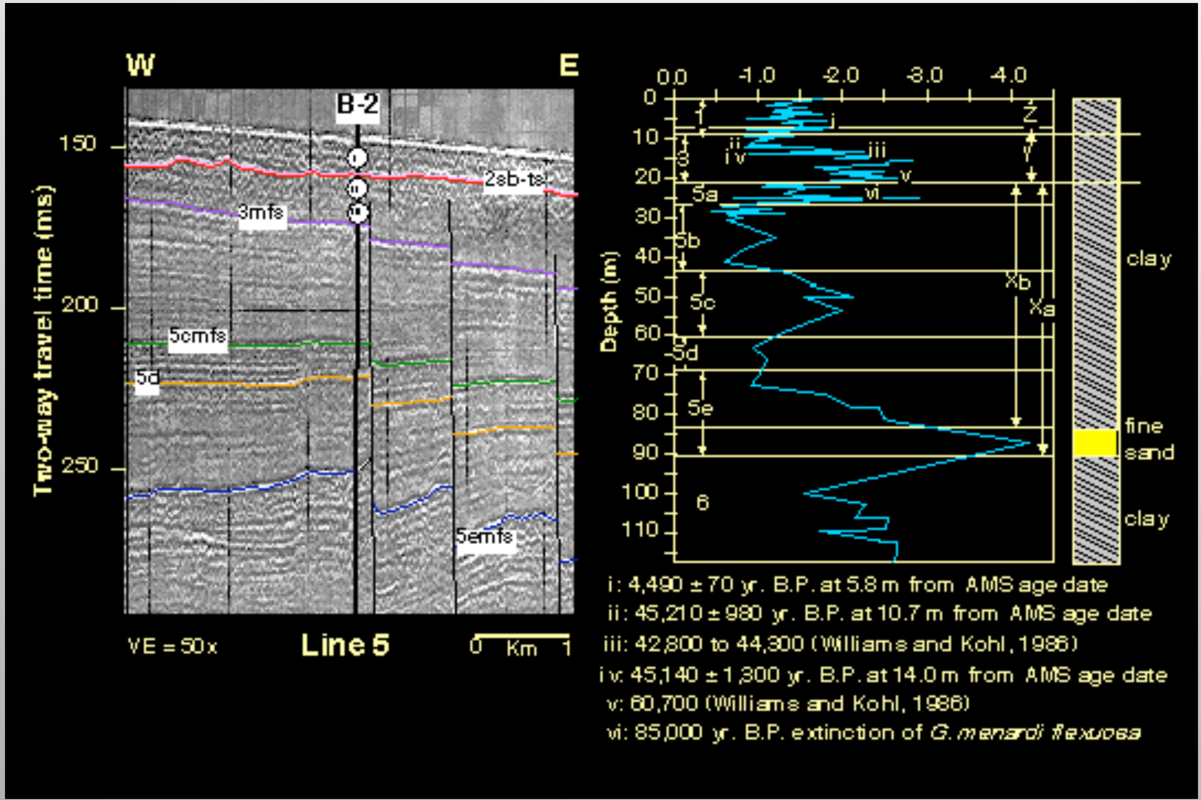
(6=LSU)
(7=University of Alabama)

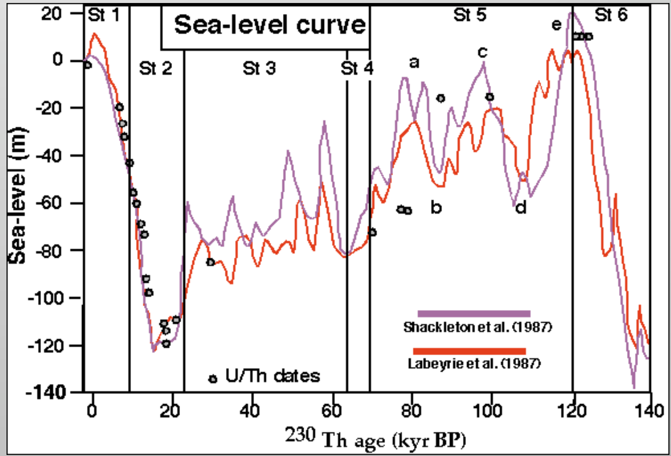
See Anderson and Fillon, 2004., SEPM Spec. Pub. 79)

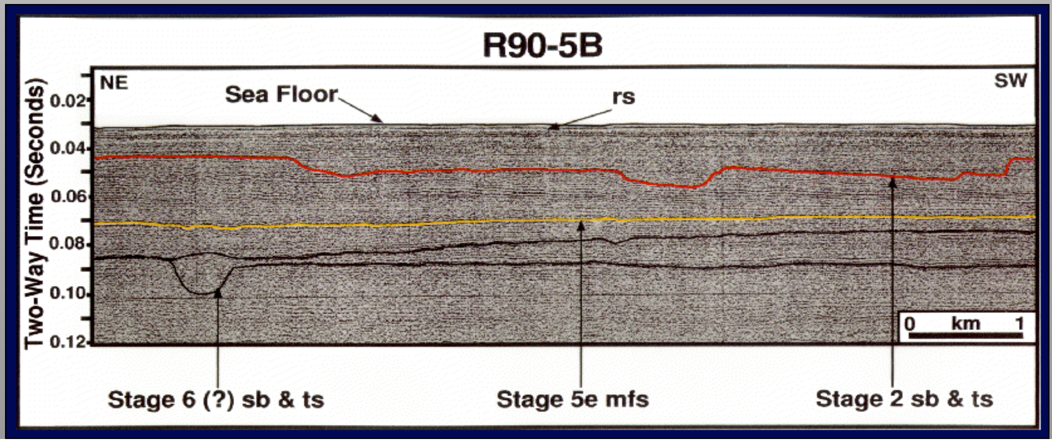


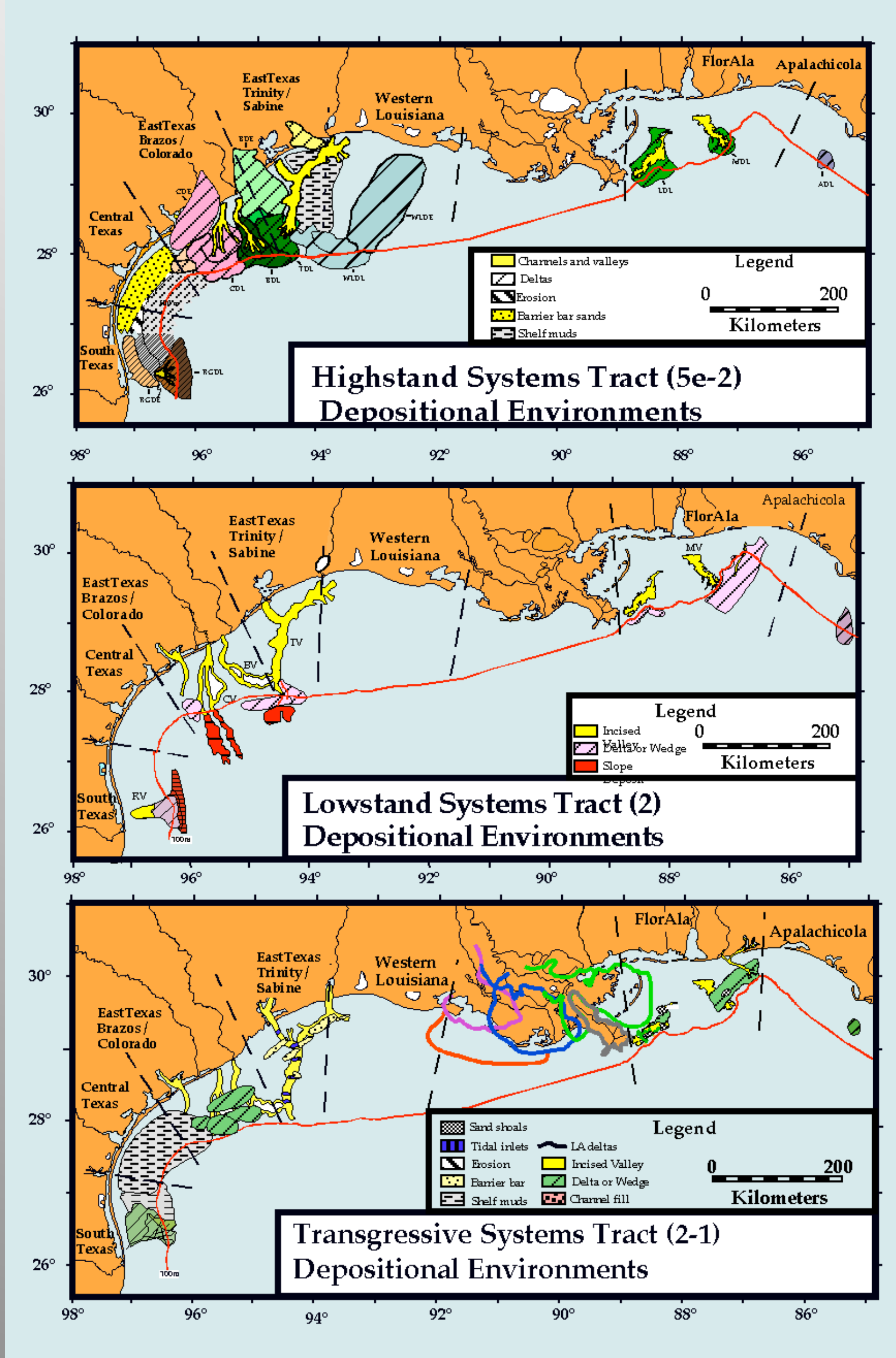
Sea-level curve
St 1
St 2
St 3
St 4
St 5
St 6
a
b
c
d
e
Sea-level (m)
20
0
-20
-40
-60
-80
-100
-120
-140
0
20
40
60
80
100
120
140
230 Th age (kyr BP)
U/Th dates
Shackleton et al. (1987)
Labeyrie et al. (1987)

Seismic and Chronostratigraphy

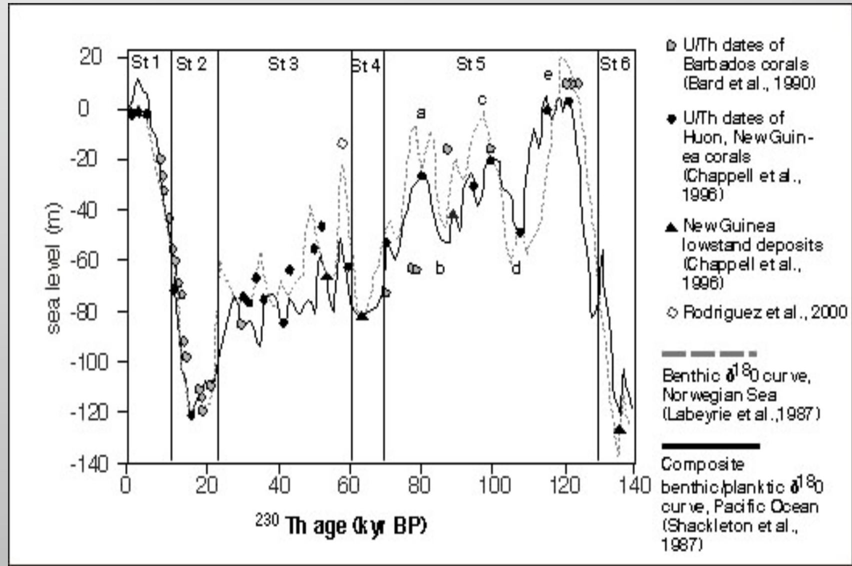








Paleogeography



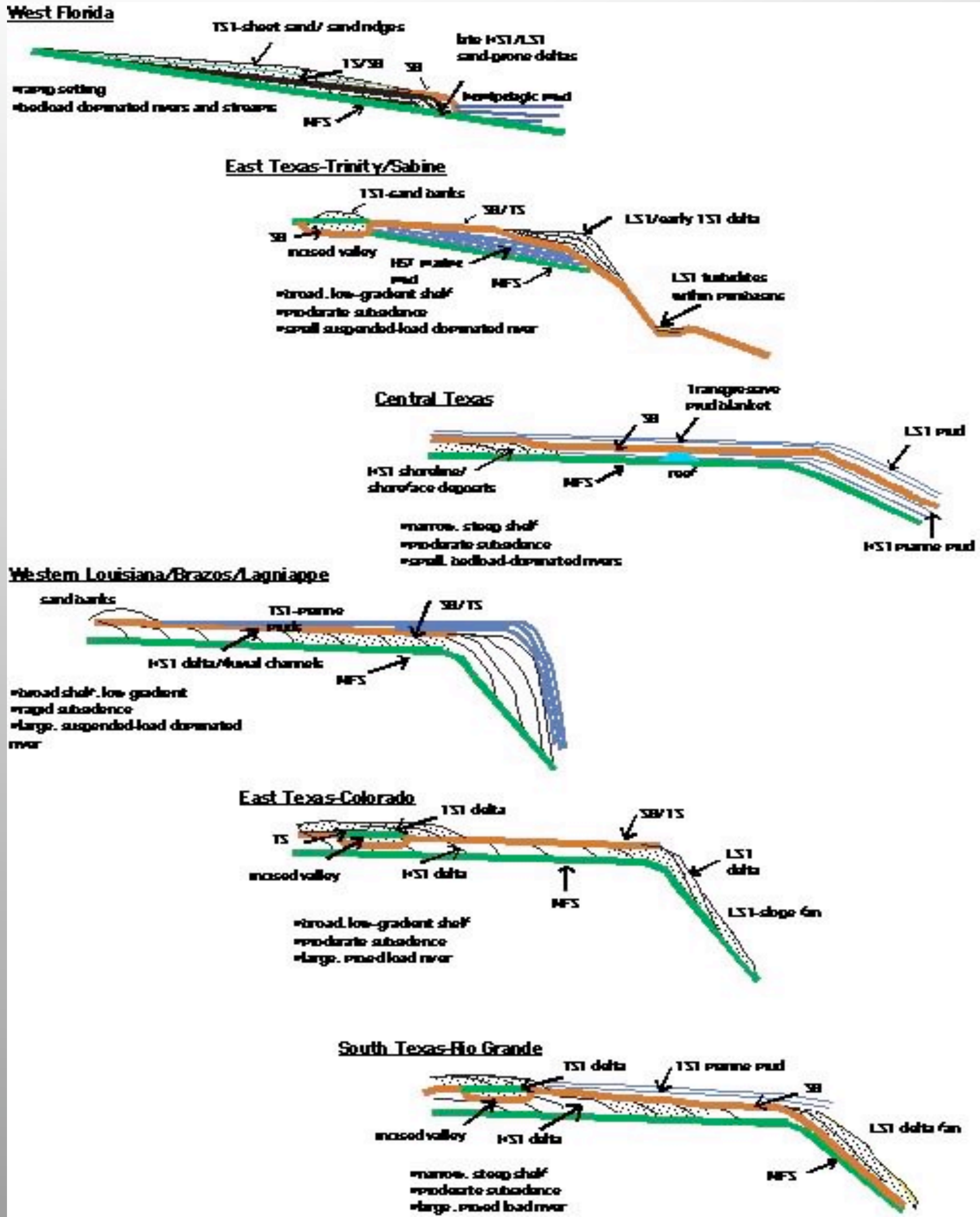
Anderson et al., 2004
SEPM Spec. Pub. 79

Variable stratigraphic architecture across the region

Bedload versus suspended load of main feeders in not reflected by the strata on the shelf and for any given system changes through time

Subsidence is a big factor

One source one sink



Anderson et al., 2004

	Drainage Area [km^2]	Qw [m^3/s]		Qs [MT/yr]
Mississippi	3,202,959	15452.0		427.9
Rio Grande	804,792	123.0		36.9
Brazos	115,040	189.0		12.4
Colorado	101,178	76.0		2.8

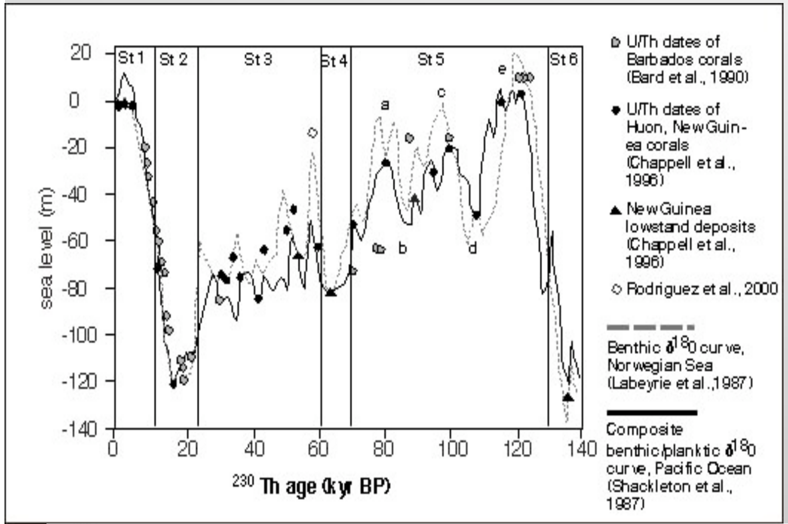
Estimation of Sediment discharge (Qs) using Syvitski and Milliman (2007) QBART mc

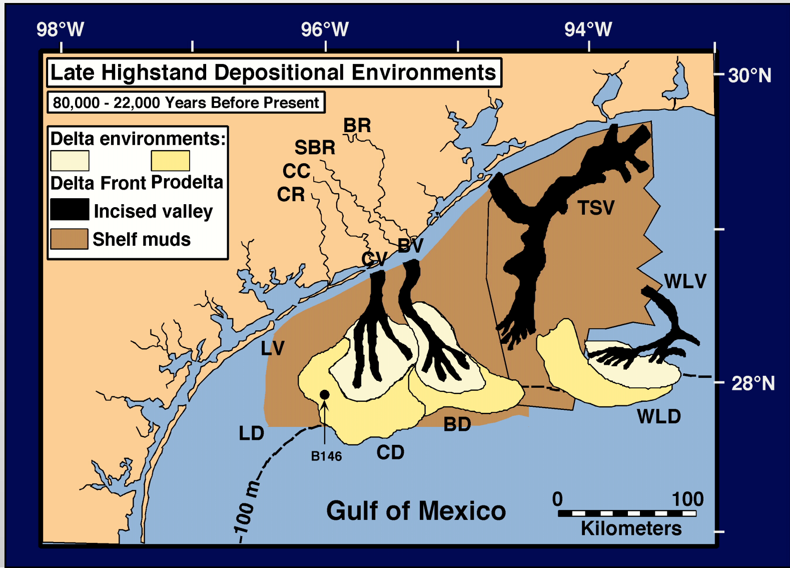
Qw	water discharge	Note: all the values of the parameters used to calculate Qs are
R	Relief	Qs=w*B*(Q^0.31)*(A^0.5)*R*T
T	temperature	
Te	trapping effect	
B	B=I*L*(1-Te)*Eh	
Qs	sediment discharge	

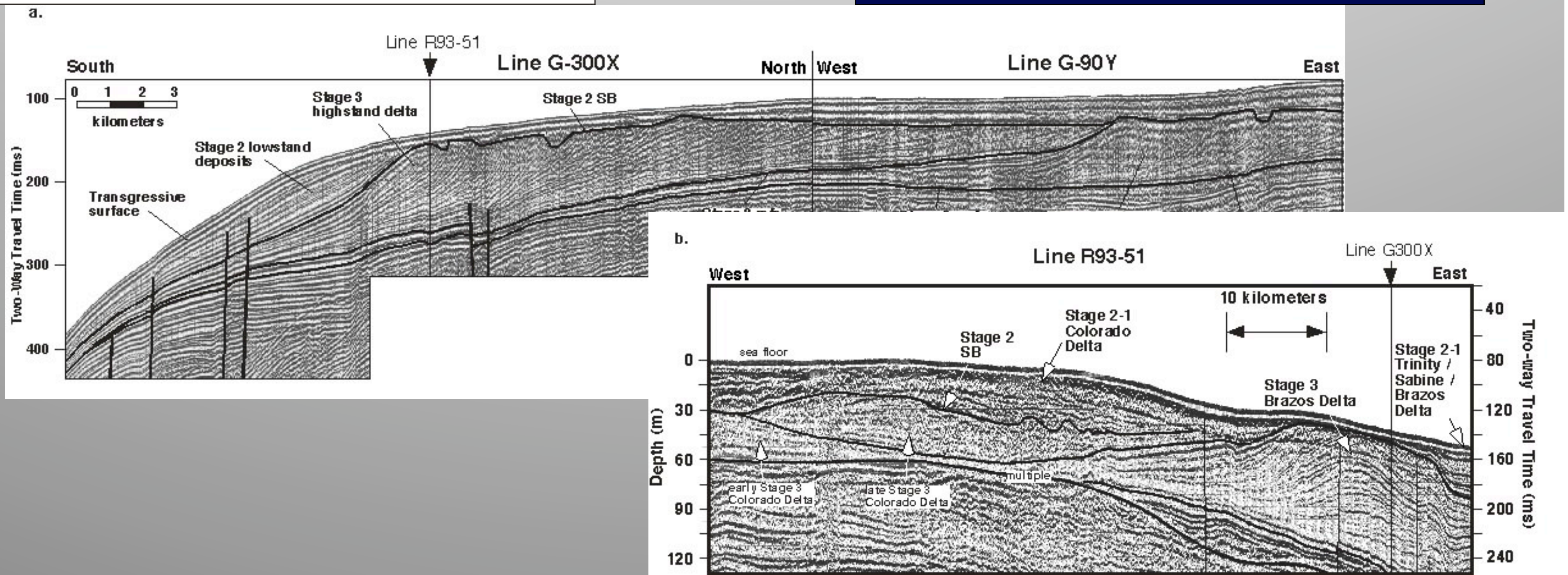
NOTE: the expresion to calculate the bulk sediment discharge from sediment volumes is:

Qs[kg/yr]= (Vol[m^3] * Sed. density[kg/m^3]) / time interval[yr]

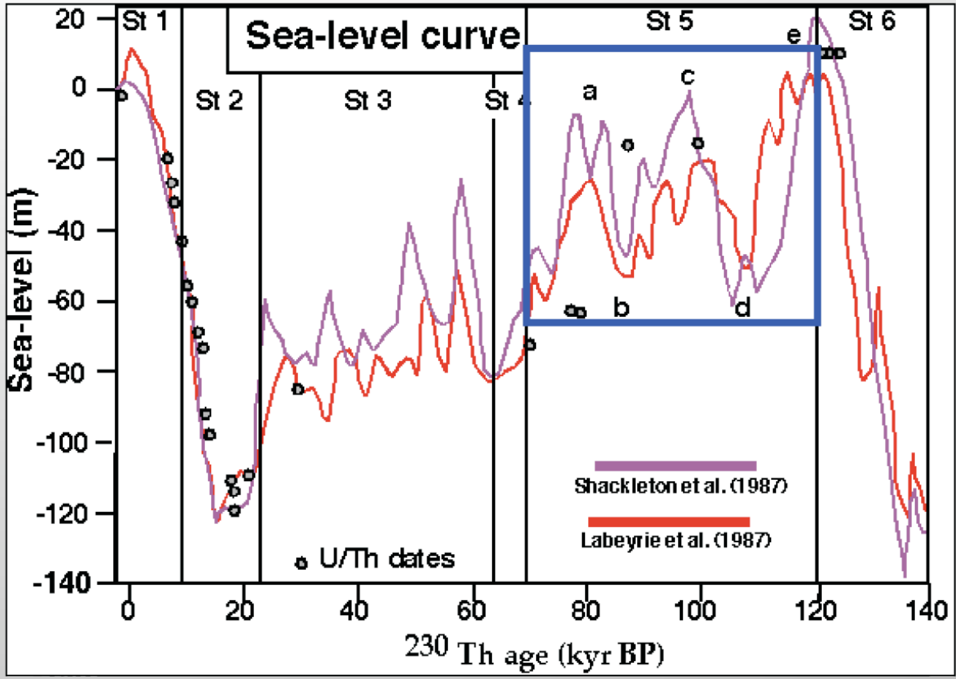
Brazos Delta ~200 km km^3 total volume with maximum flux during Stage 3 averaging between 8 km^3/ka to 40 km^3/yr (discharge of 20x10^6 t/yr to 100x10^6 t/y, or ~2 to 10 x current rate).

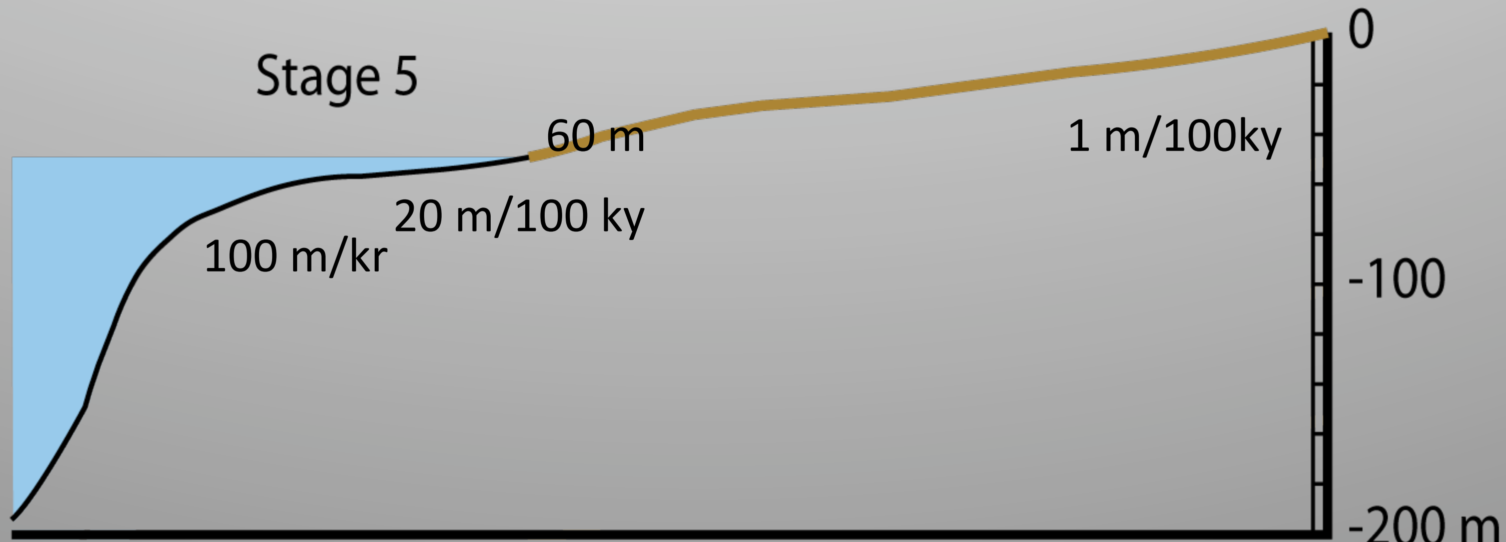


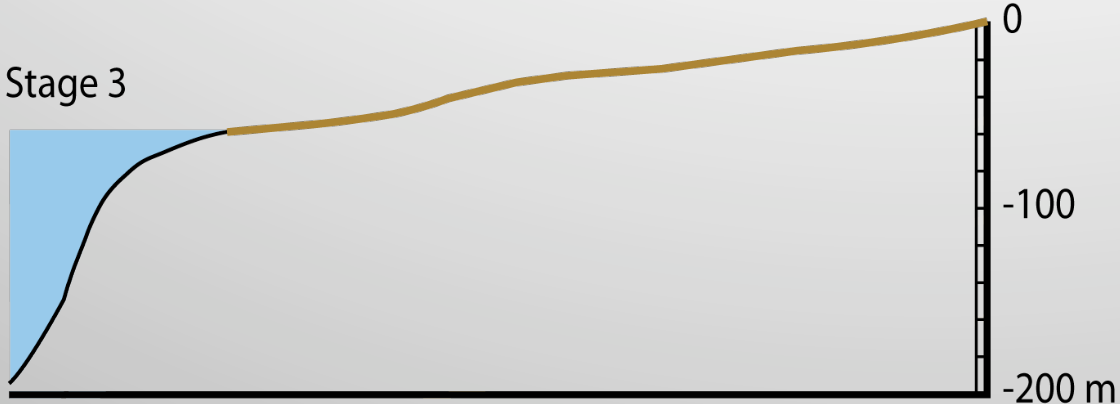


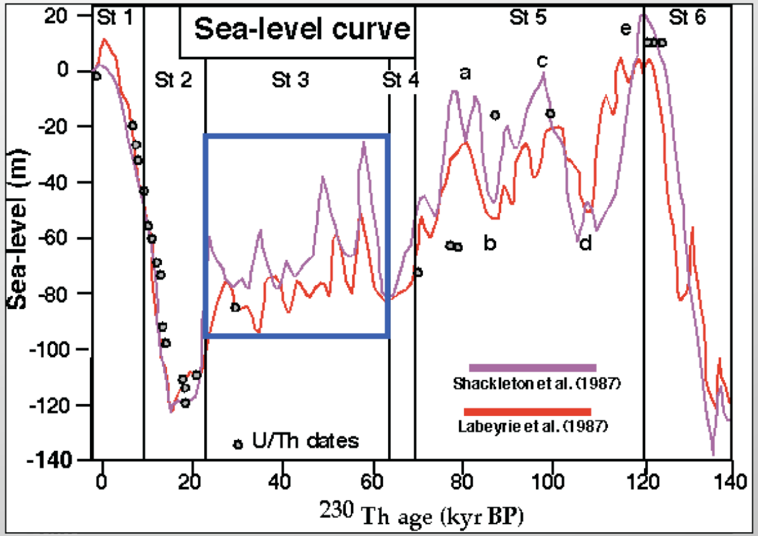


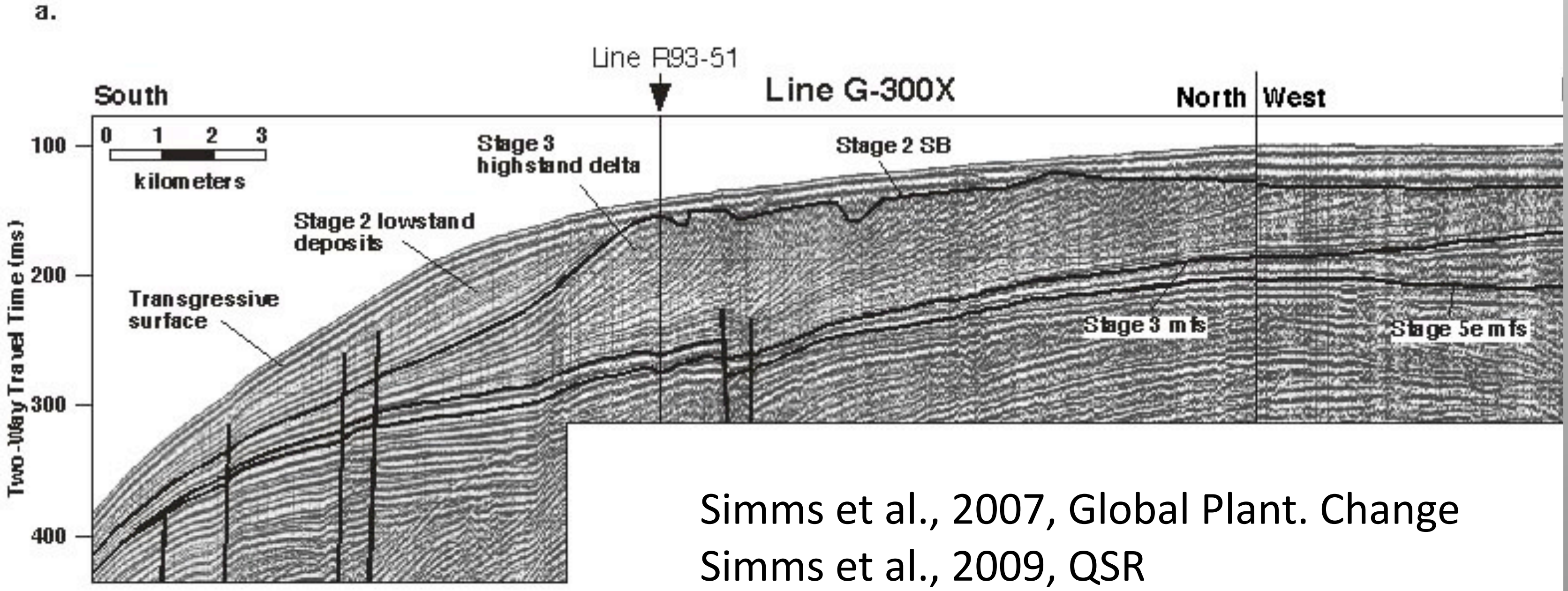
Subsidence versus sea-level











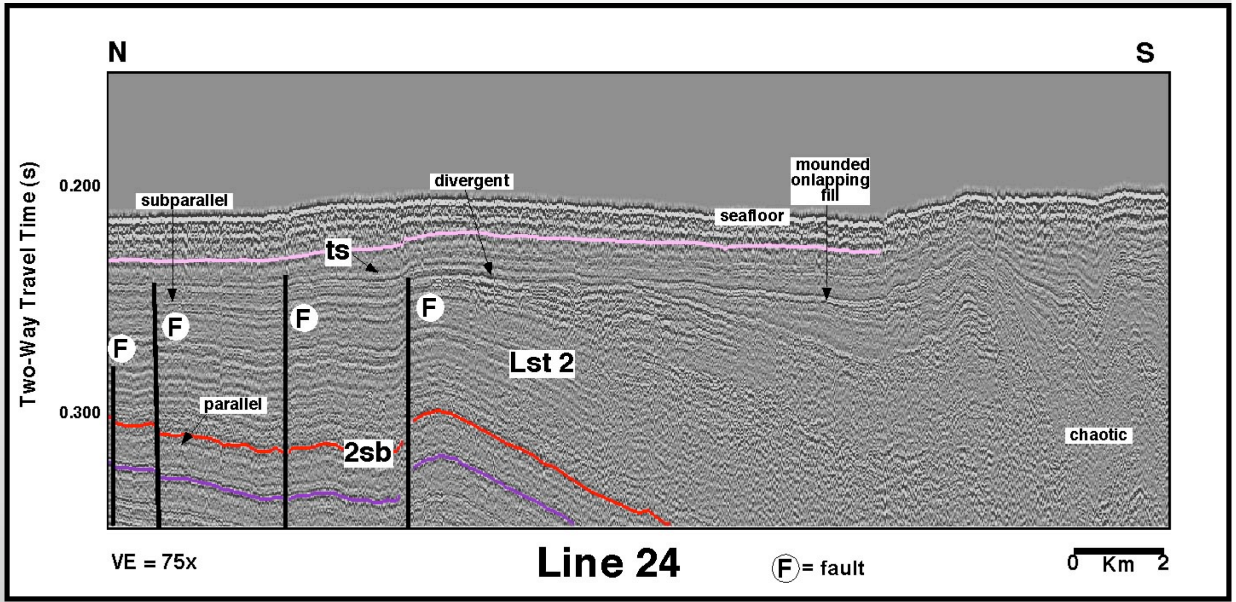
Simms et al., 2007, Global Plant. Change

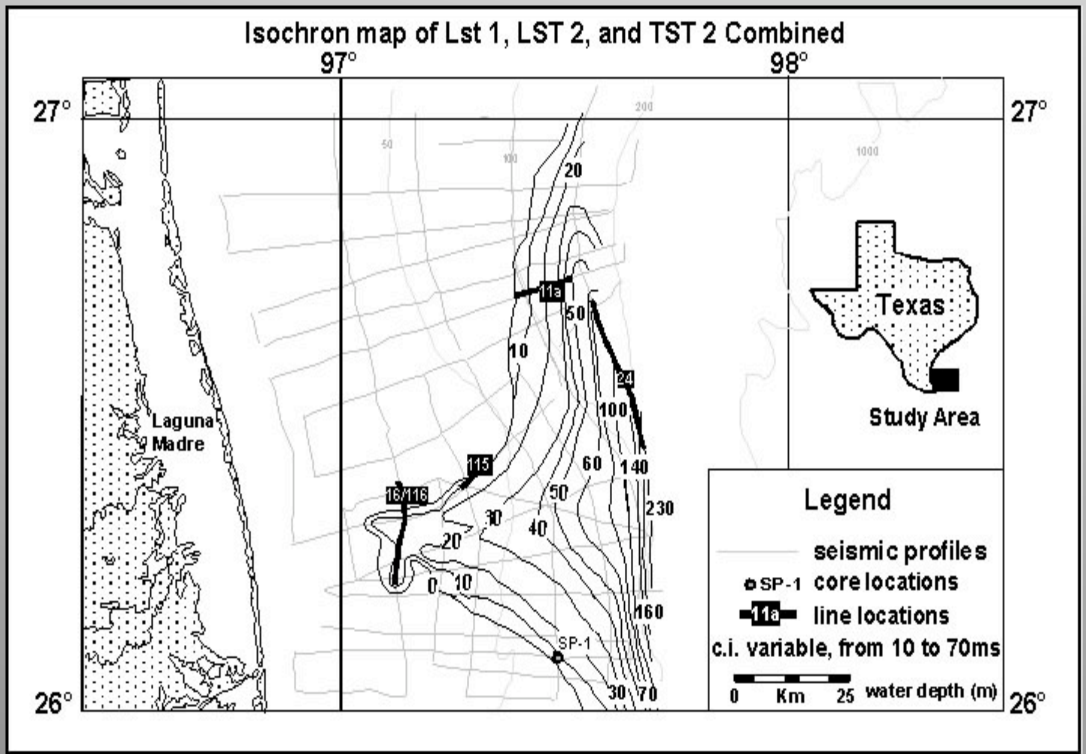
Simms et al., 2009, QSR

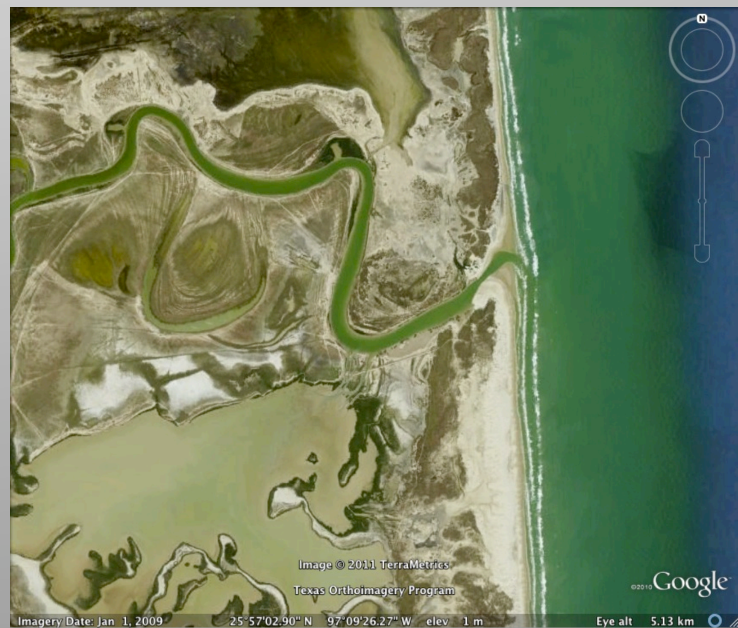
Rio Grande Delta

(~220 km$^{3)}$

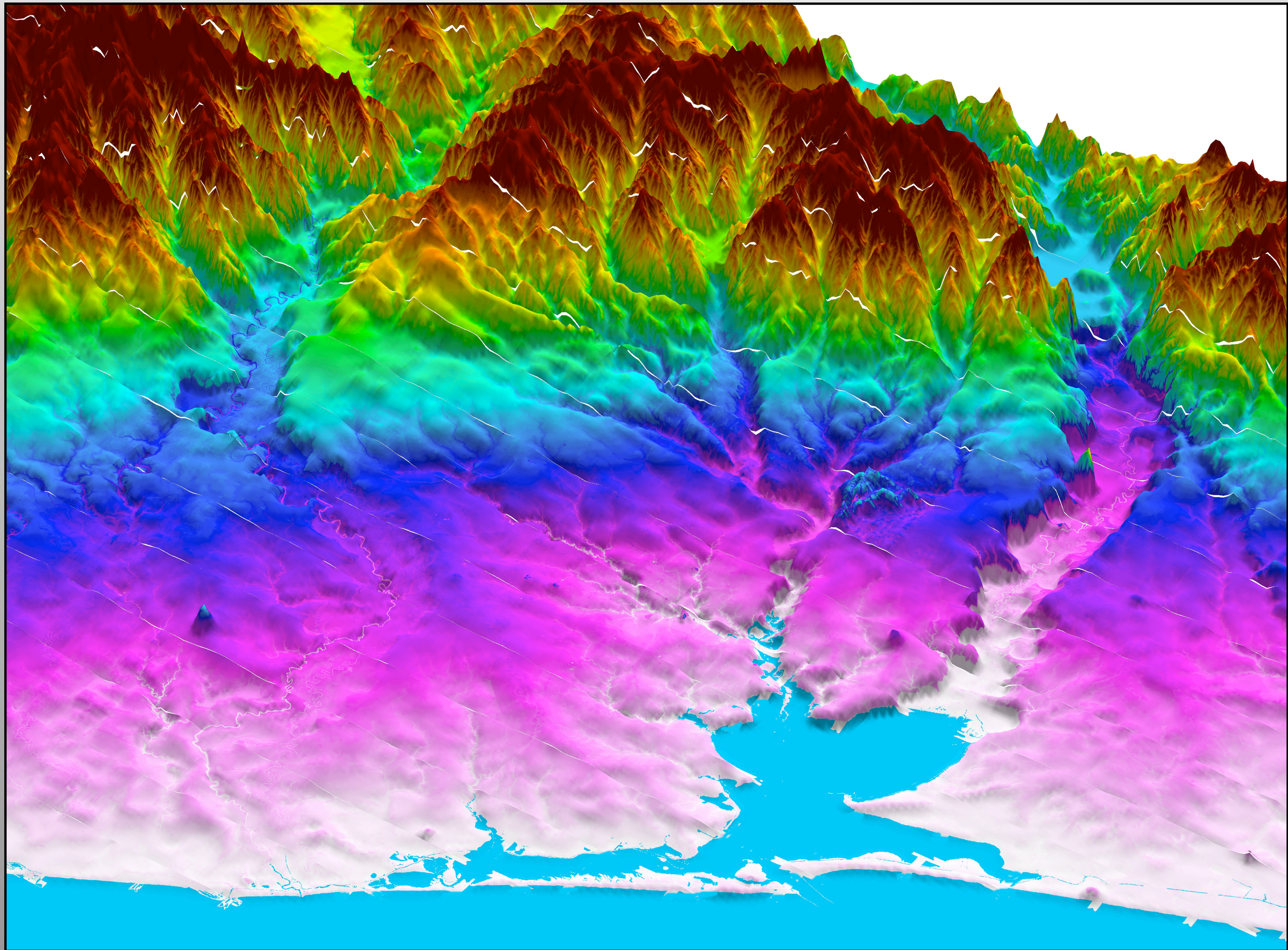
Minimum flux during lowstand of 30 km^3/ka (75×10^6 t/yr or just over twice the current rate)



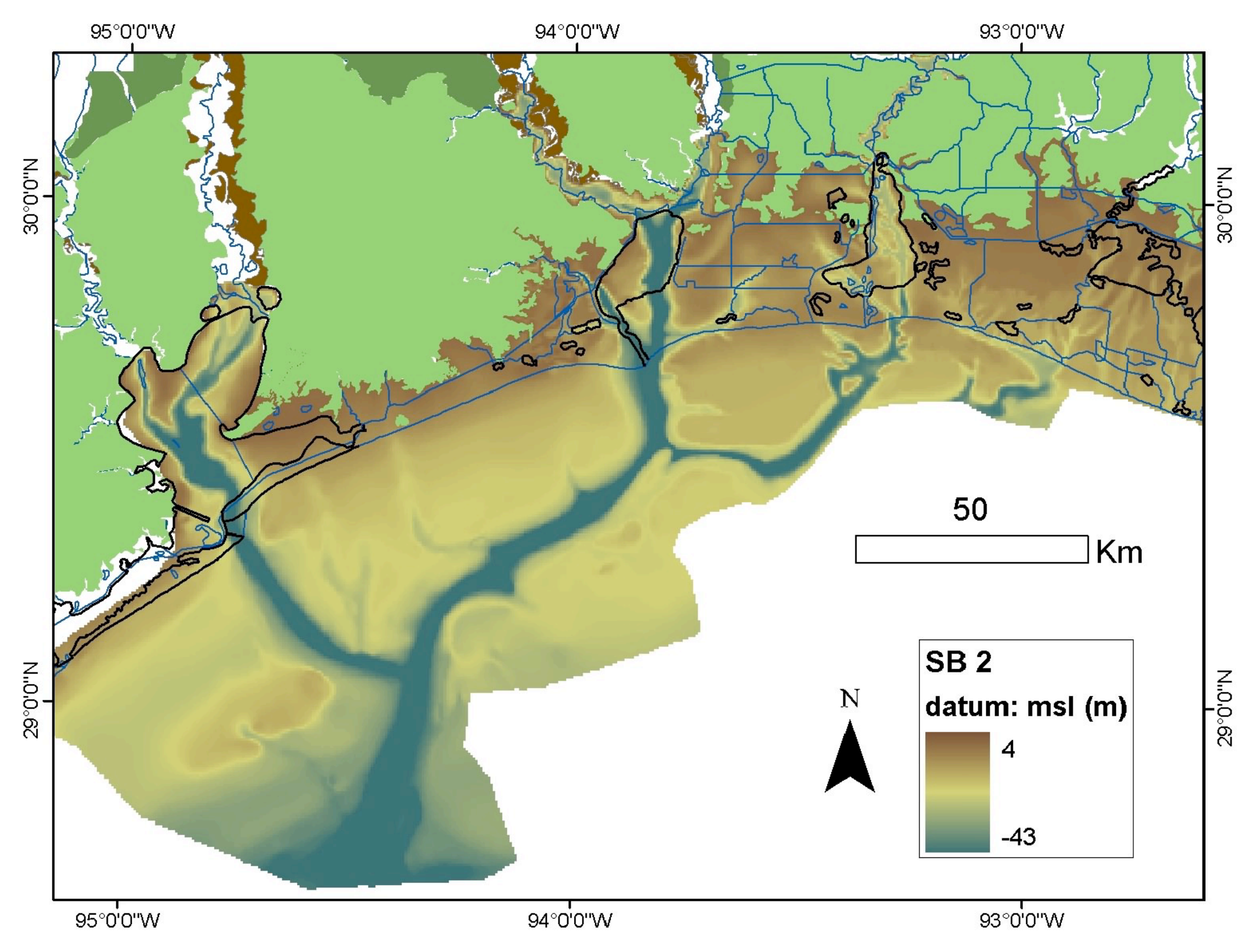




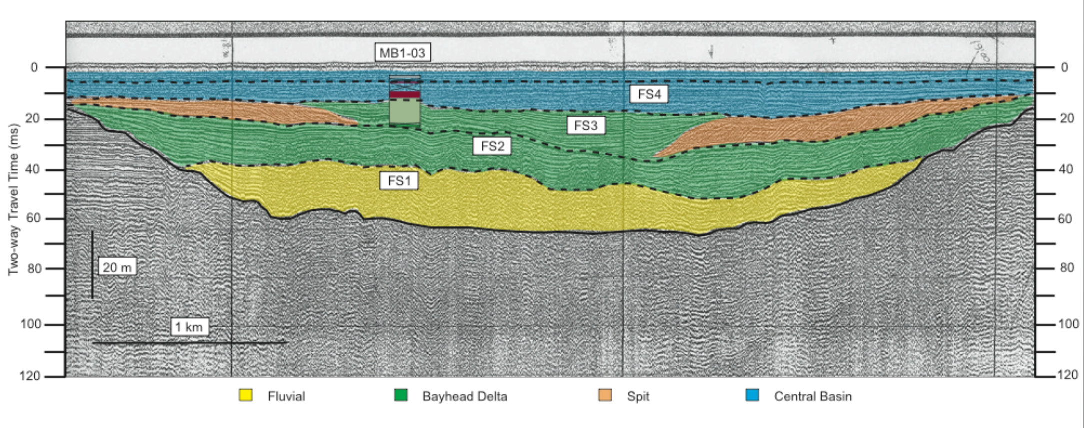
Over-filled versus under-filled valleys
Fill and Purge



Valleys are filled with Holocene sediments



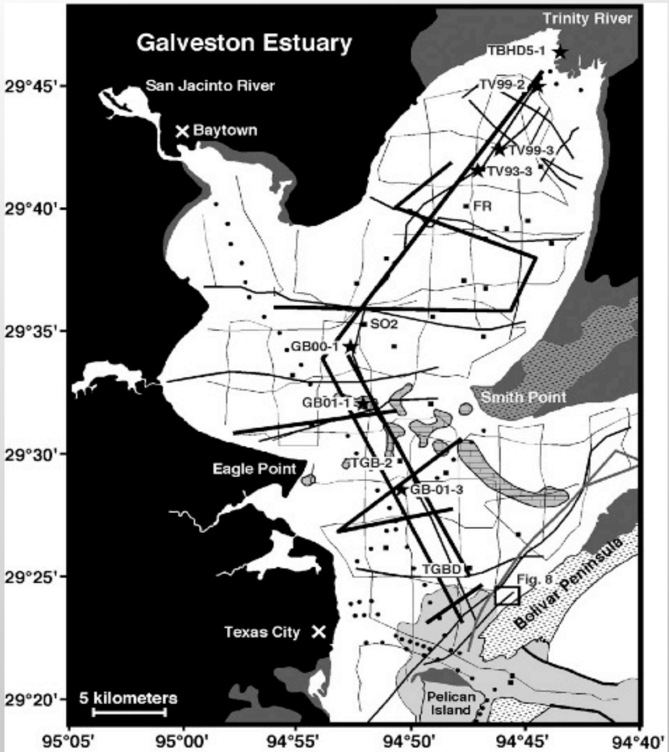
Simms et al., 2007

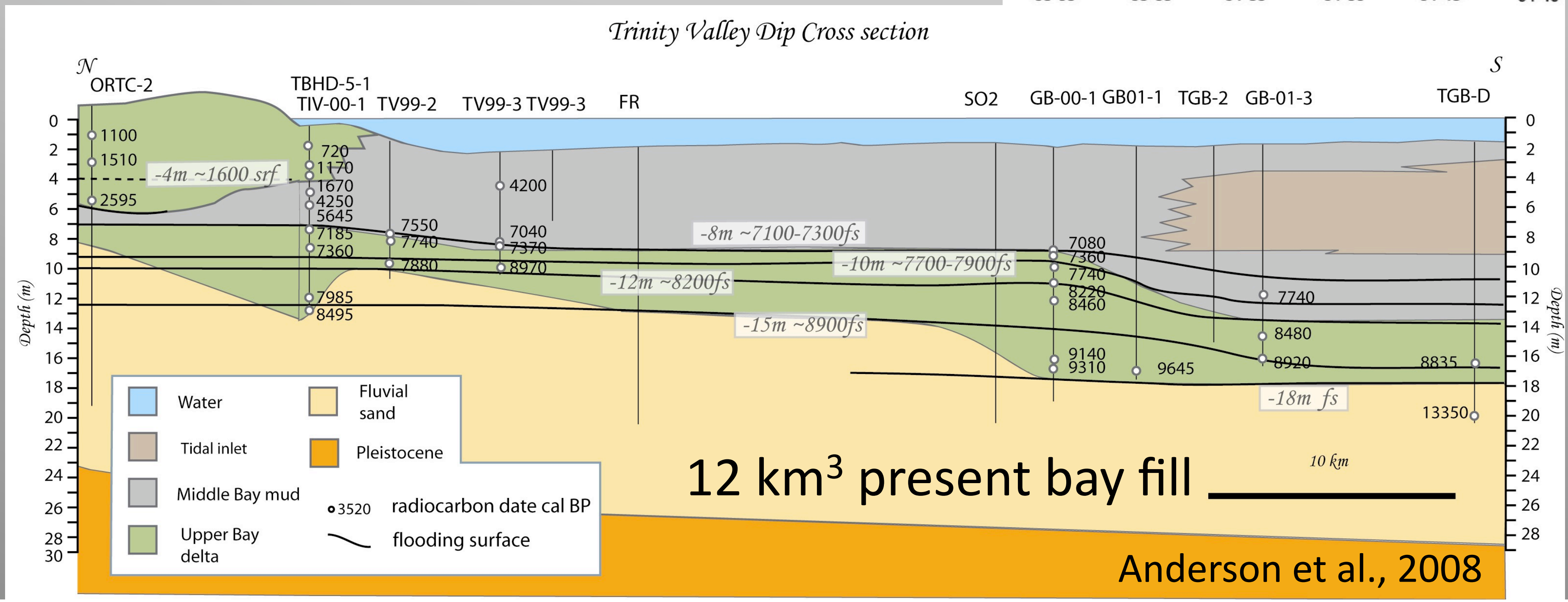


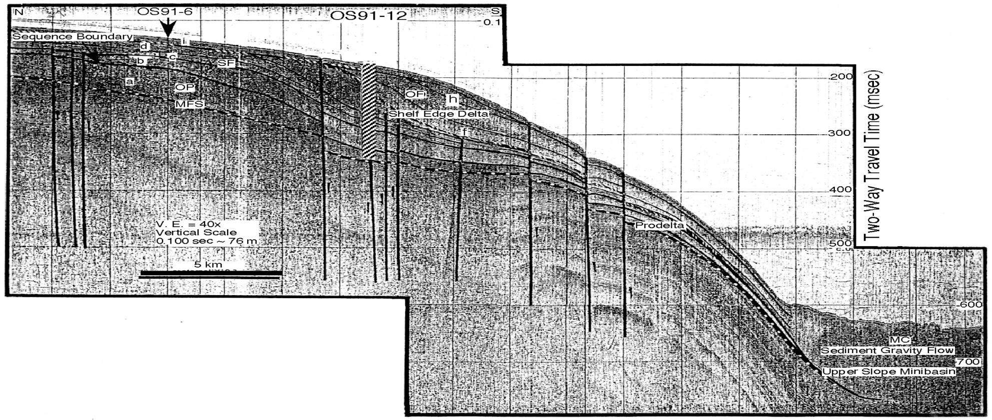
Trinity Valley
An under-filled valley

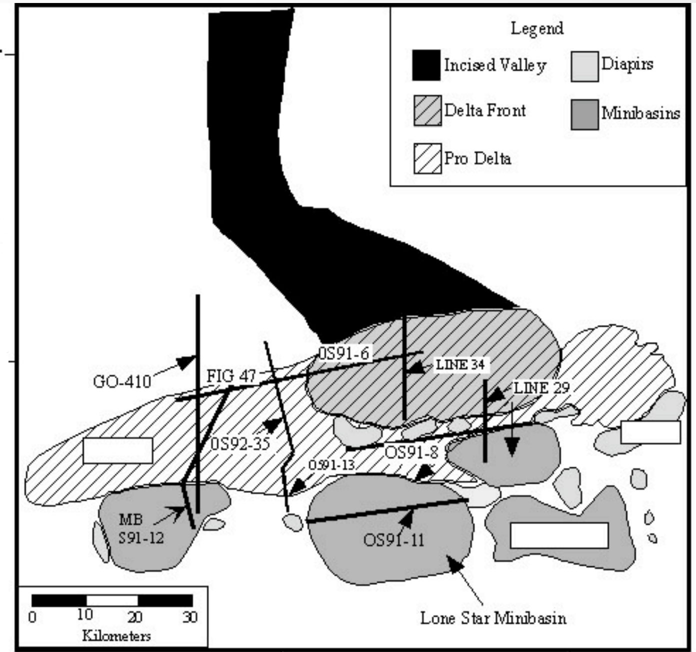
Note that sand is mainly in lower part of valley

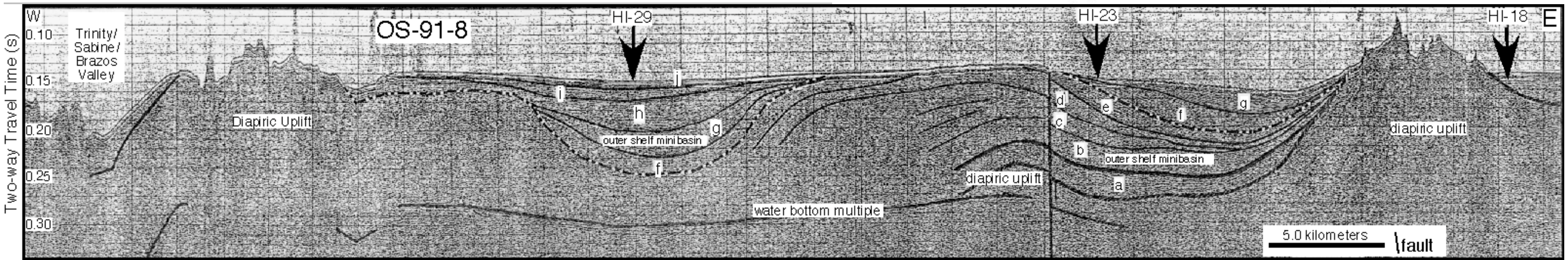
We use these data to estimate long-term (Holocene) sediment flux

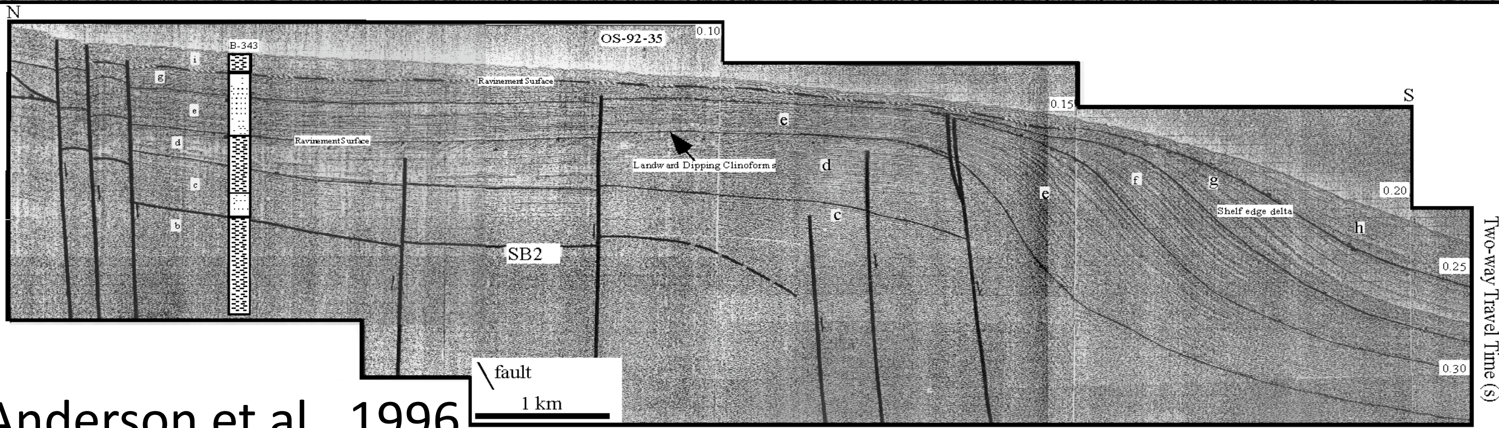








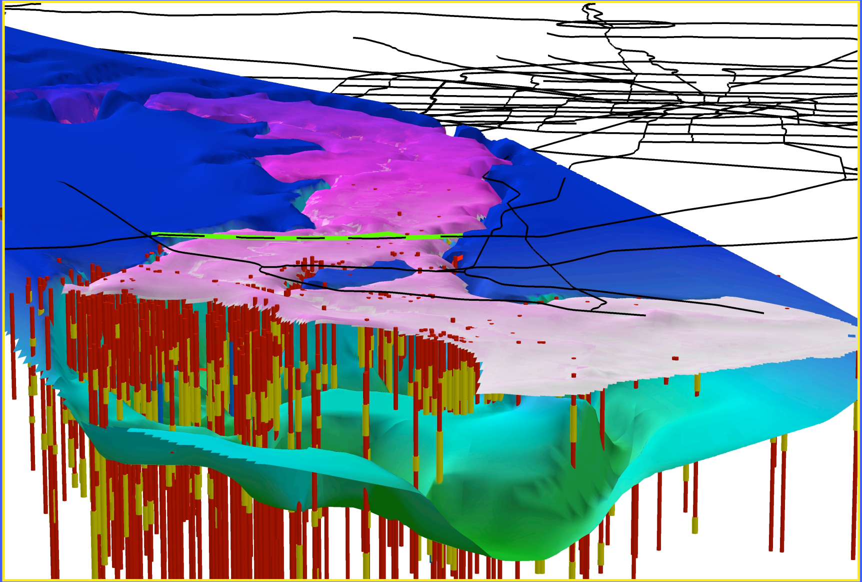


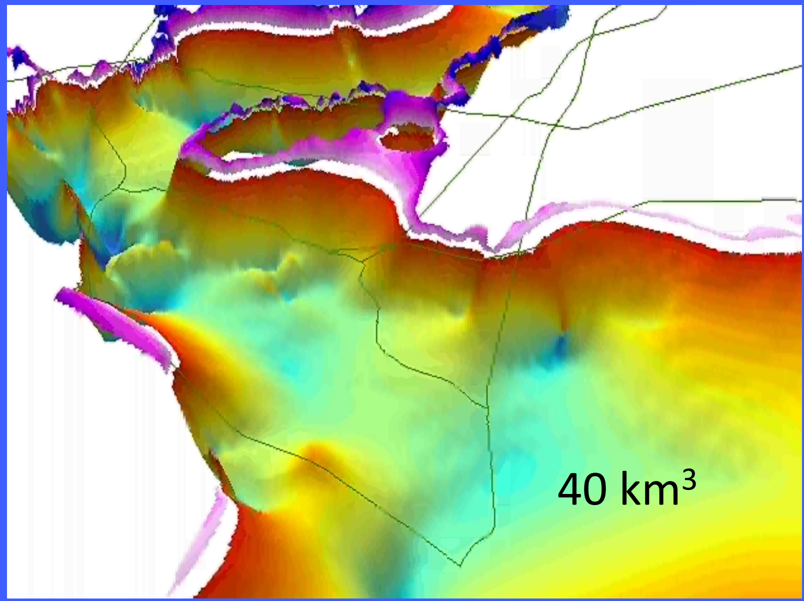


Wellner et al., Figure 19

Anderson et al., 1996

403 Digital Water Well Descriptions





Clay

Sand

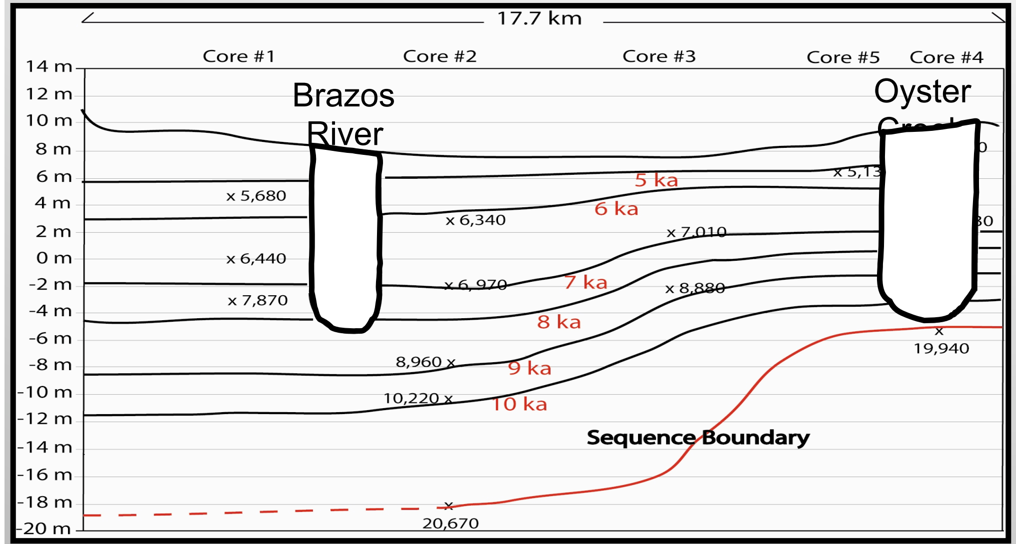
Note the distribution of clay and sand

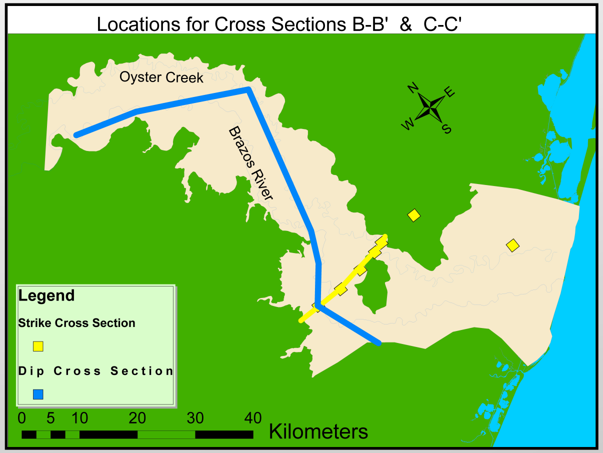
Taha and Anderson, 2007, Geomorphology

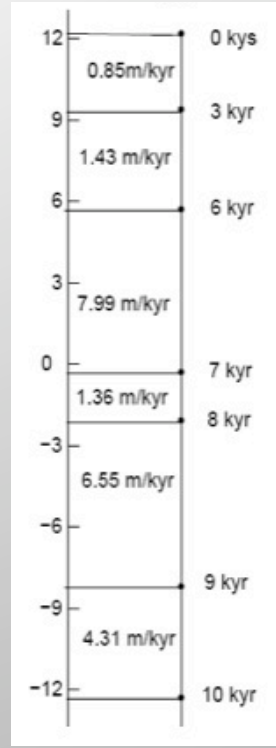
Vertical Exaggeration : 300

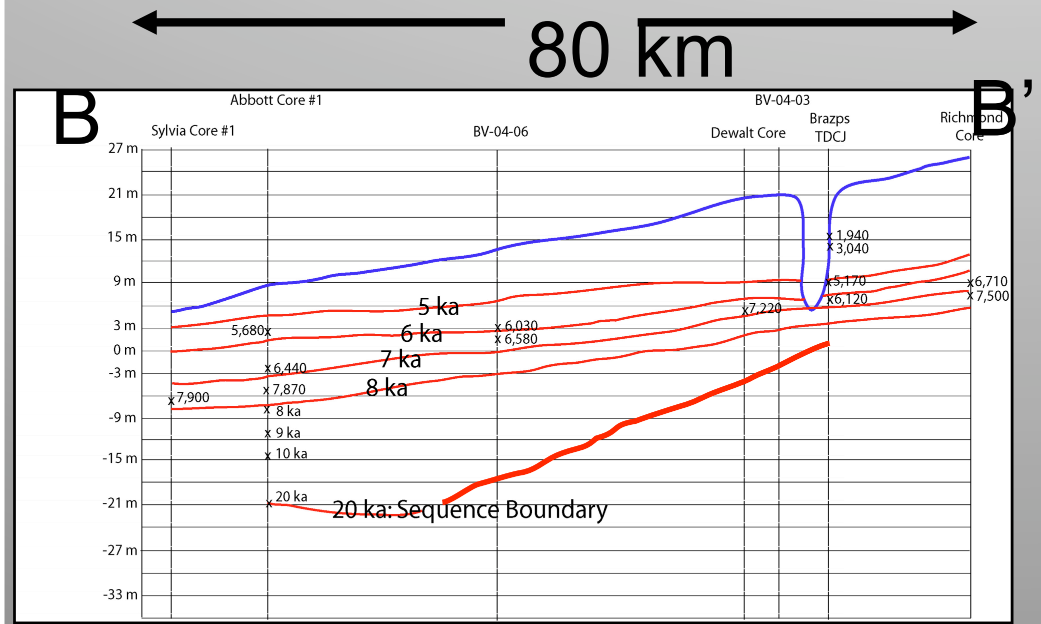
In lower valley, aggradation tracks sea-level rise

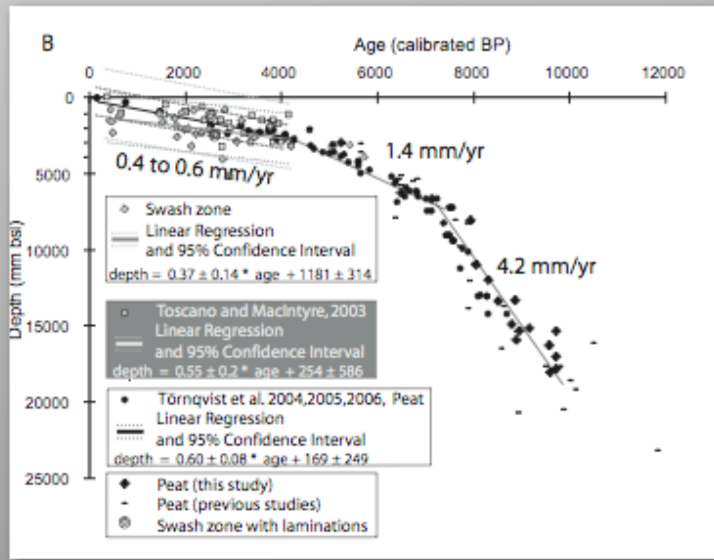
Lower Colorado Valley





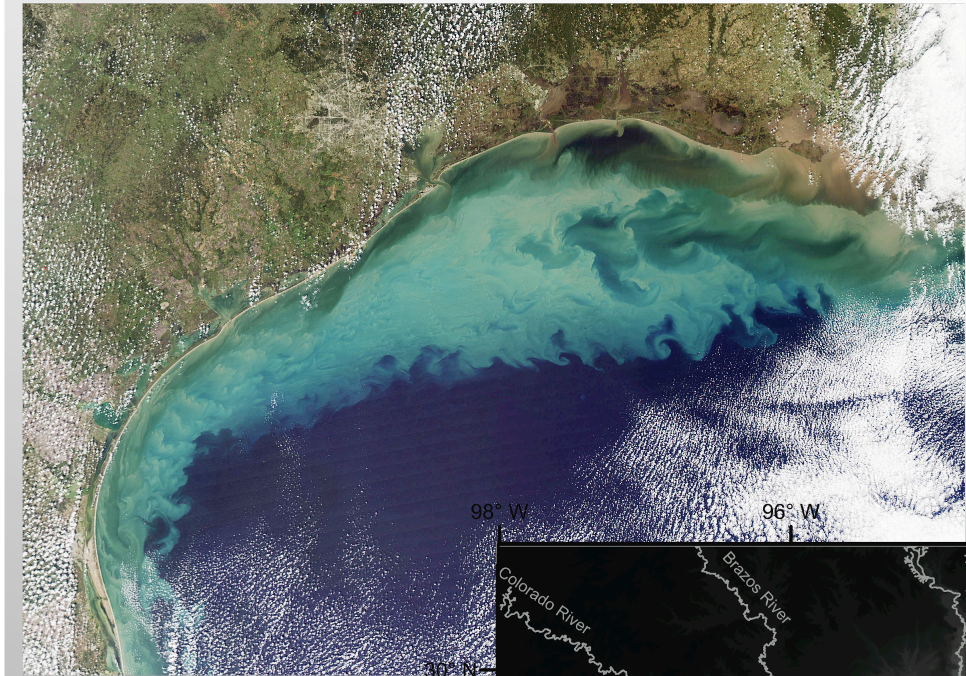


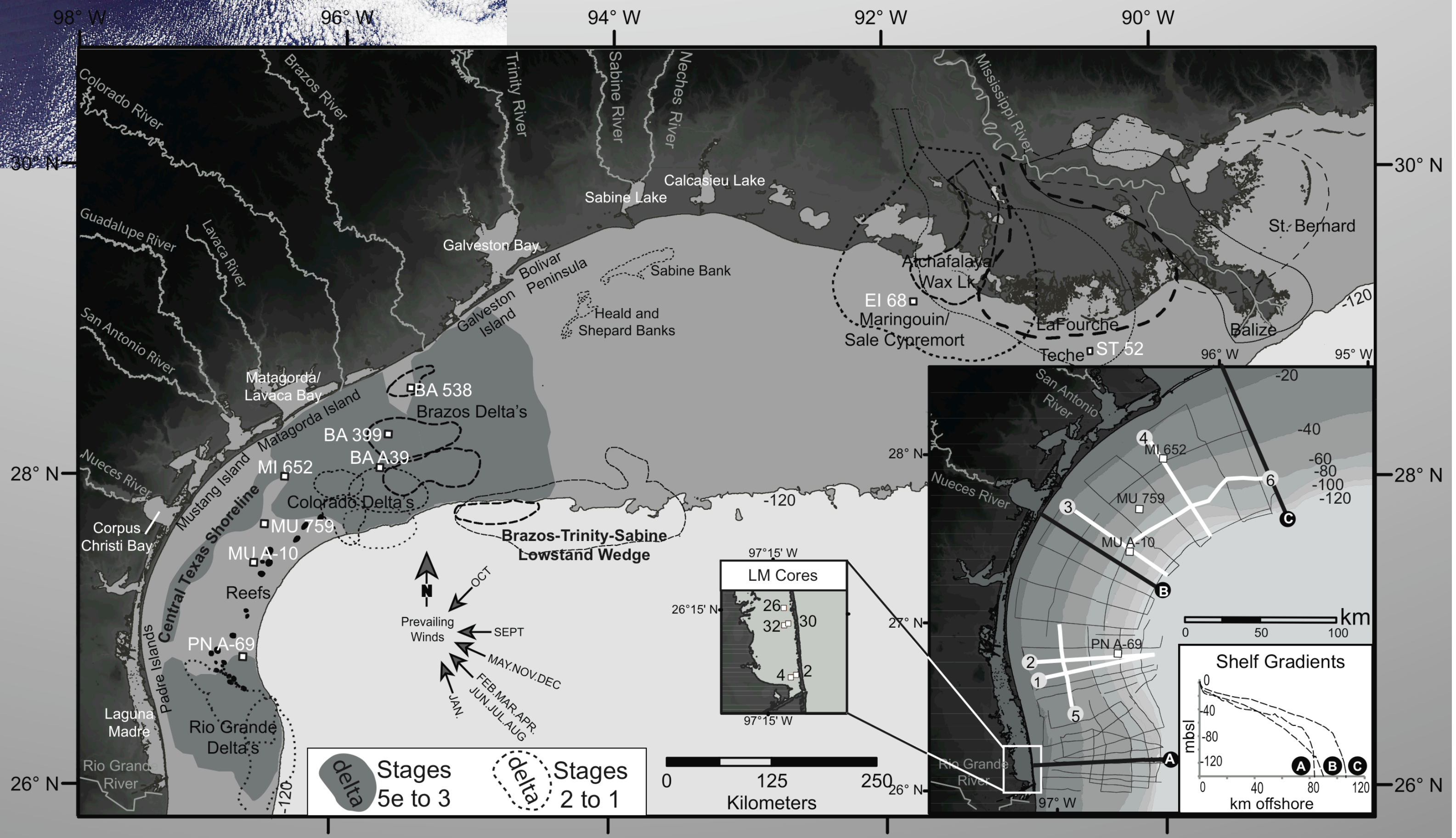


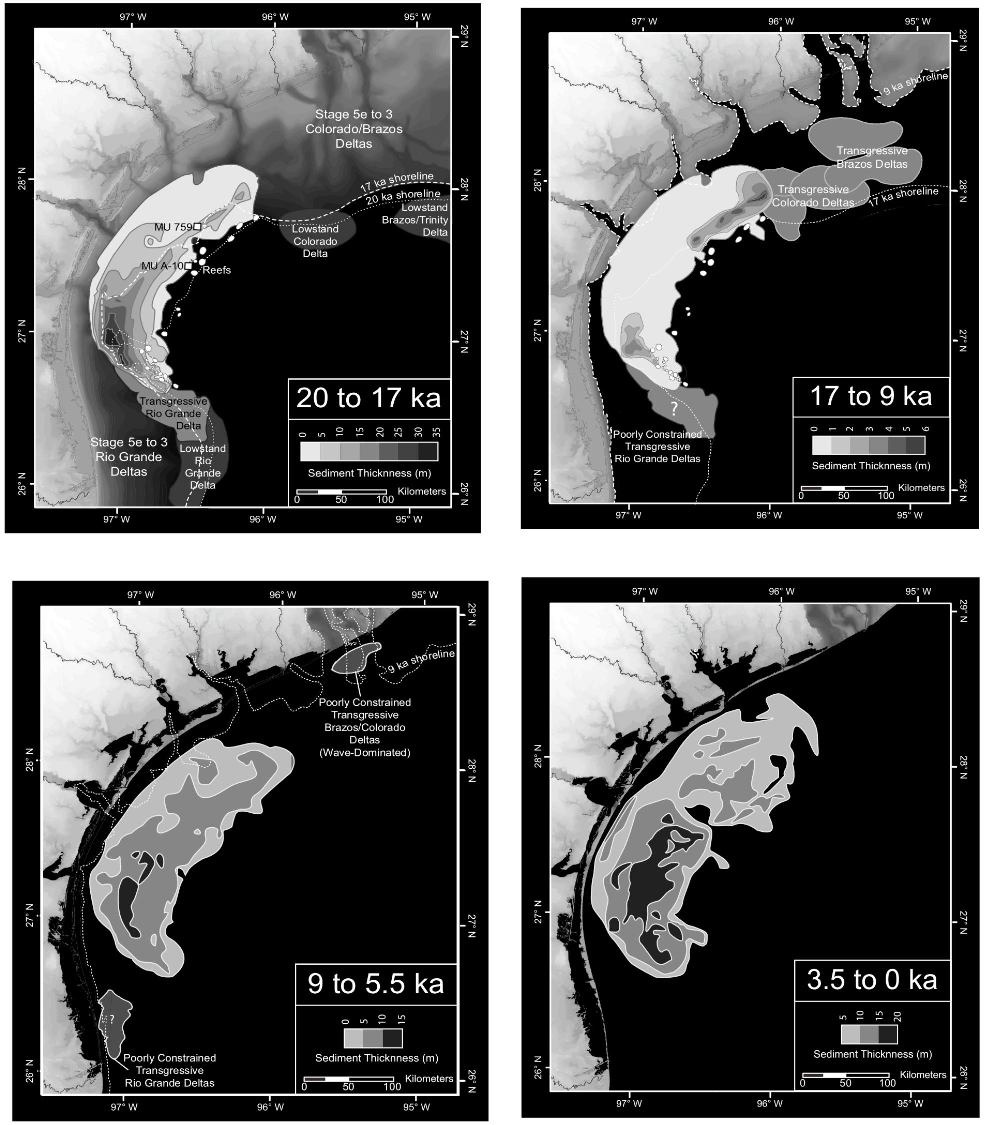


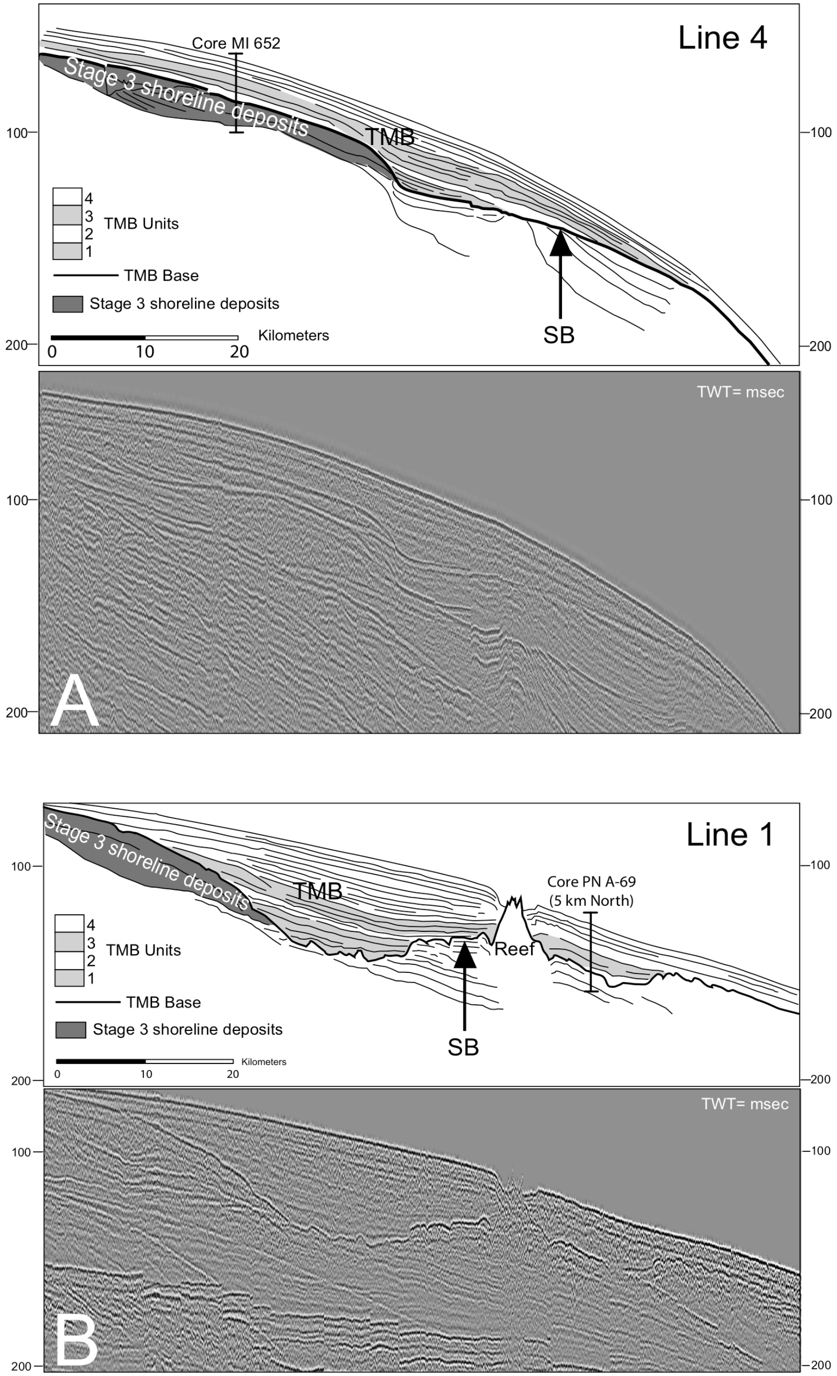
Milliken et al., 2008

The Texas Mud Blanket

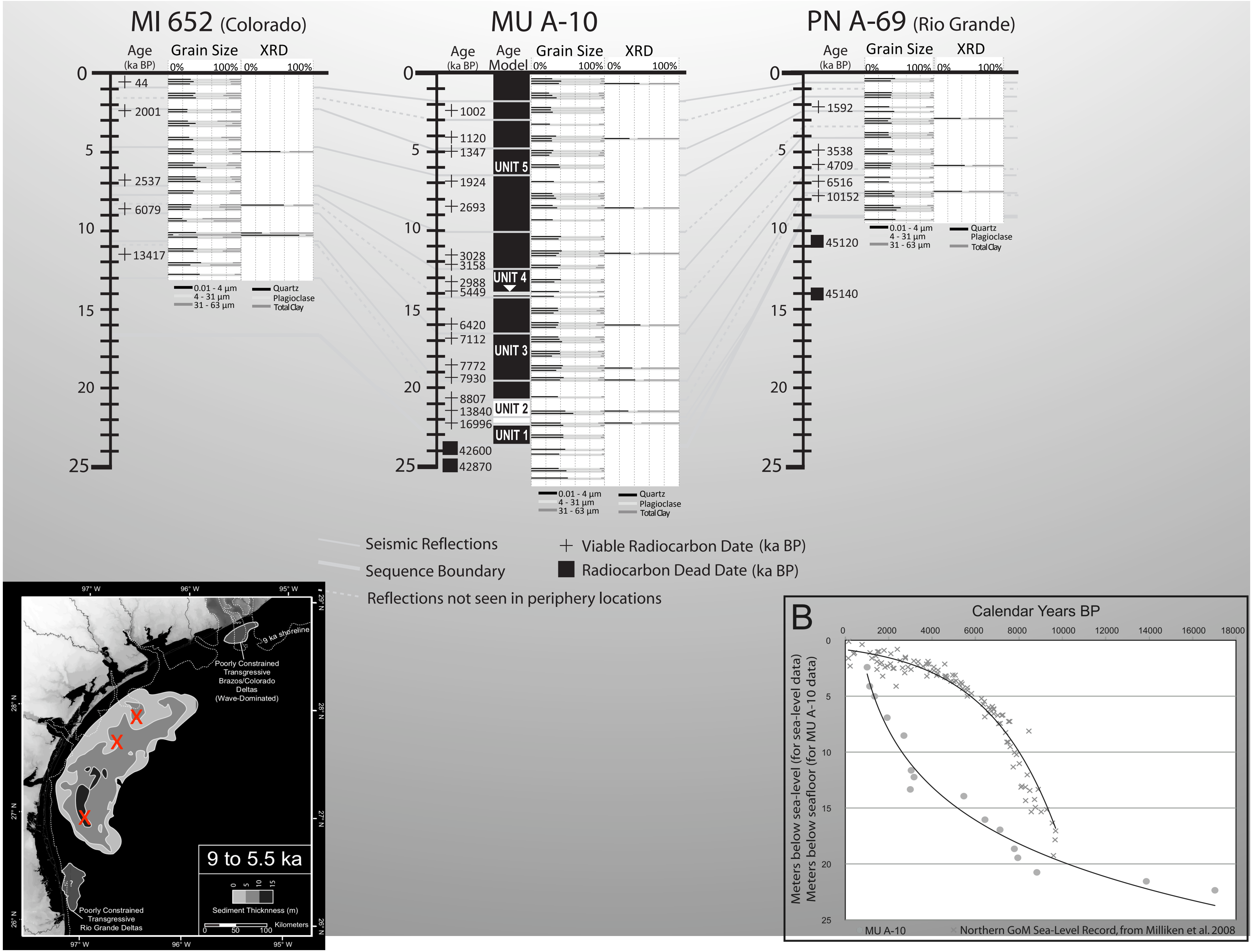






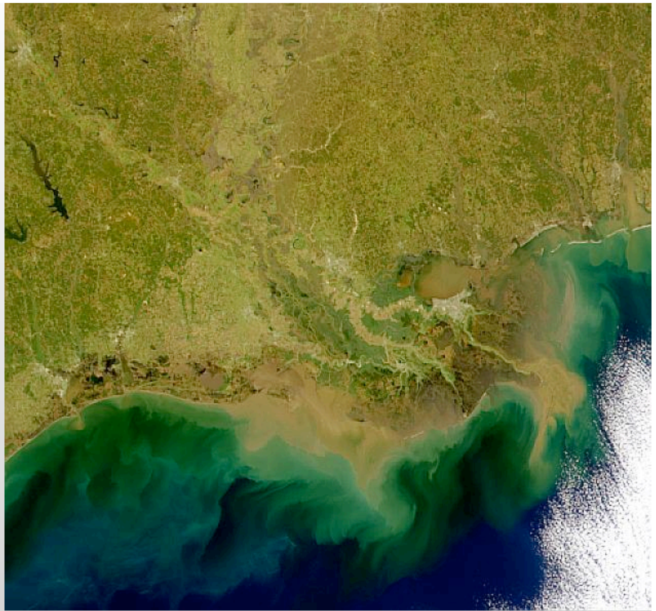


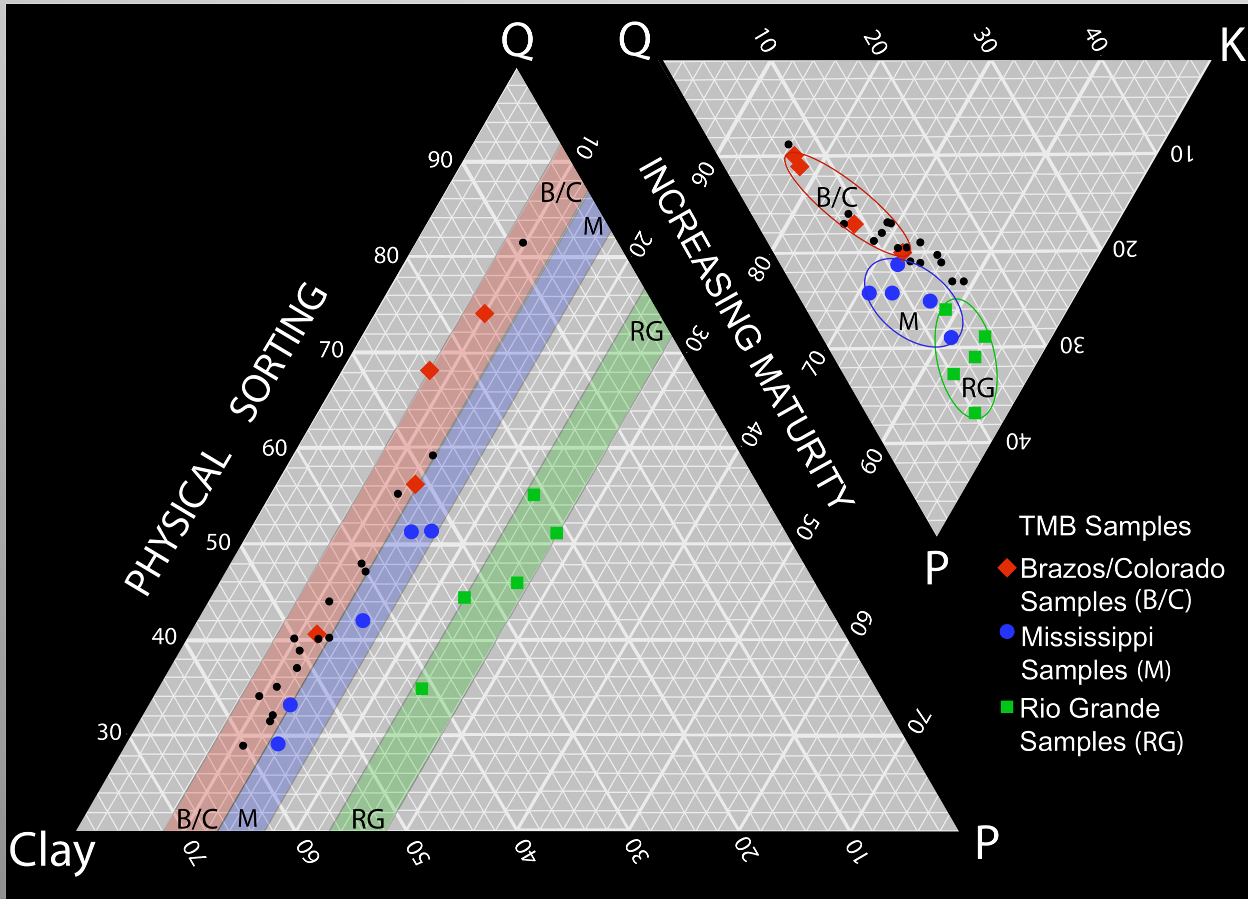
Weight et al., in revision, JSR

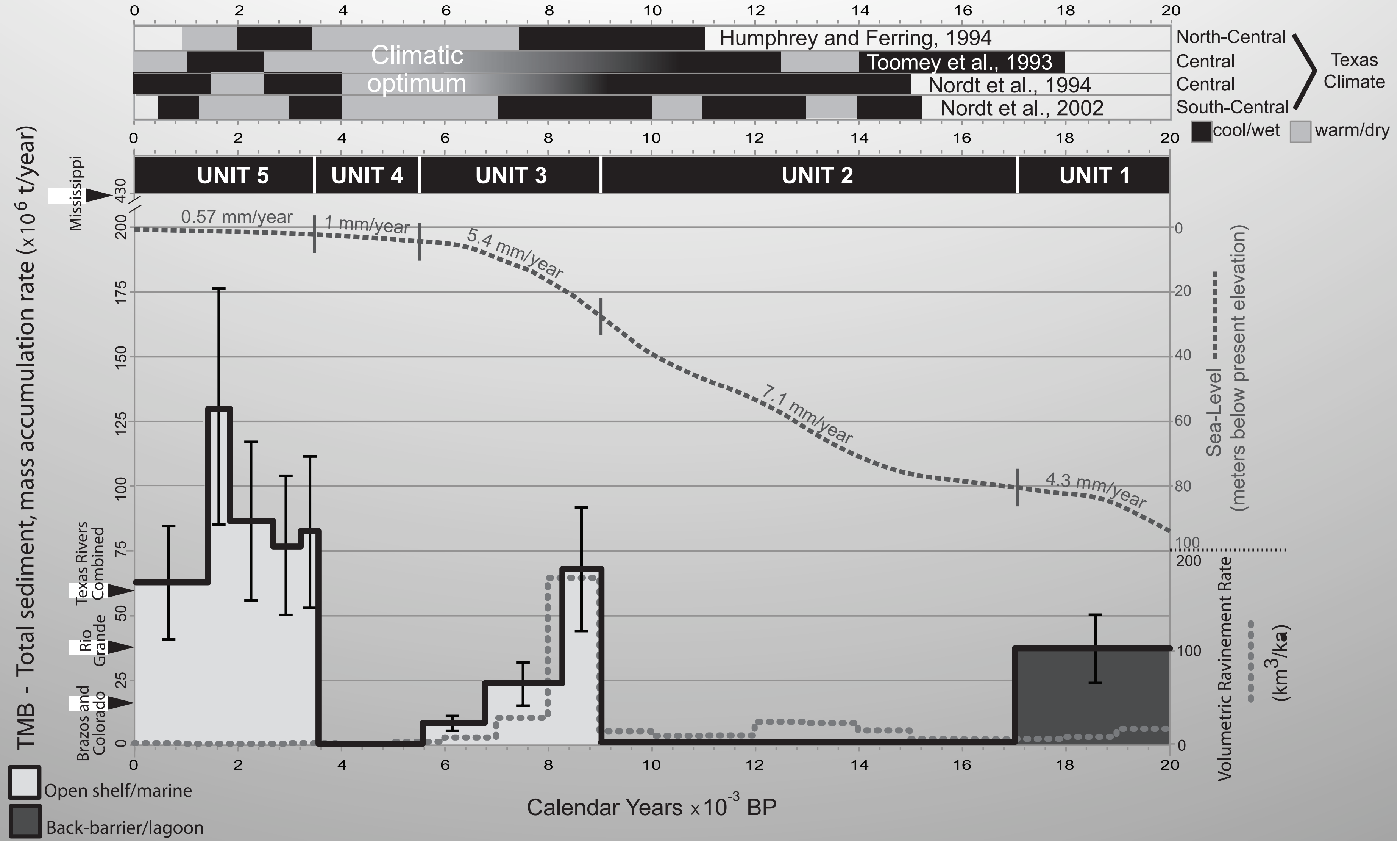


MI 652 (Colorado)
MU A-10
PN A-69 (Rio Grande)
Age (ka BP)
Age Model
Grain Size
XRD
0%
100%
0
5
10
15
20
25
44
2001
2537
6079
13417
1002
1120
1347
1924
2693
3028
3158
2988
5449
6420
7112
7772
7930
8807
13840
16996
42600
42870
1592
3538
4709
6516
10152
45120
45140
UNIT 5
UNIT 4
UNIT 3
UNIT 2
UNIT 1
0.01 - 4 µm
4 - 31 µm
31 - 63 µm
Quartz
Plagioclase
Total Clay
Seismic Reflections
Sequence Boundary
Reflections not seen in periphery locations
Viable Radiocarbon Date (ka BP)
Radiocarbon Dead Date (ka BP)
97° W
96° W
95° W
29° N
28° N
27° N
26° N
9 ka shoreline
Poorly Constrained Transgressive Brazos/Colorado Deltas (Wave-Dominated)
Poorly Constrained Transgressive Rio Grande Deltas
9 to 5.5 ka
0
5
10
15
Sediment Thickness (m)
Kilometers
0
50
100
B
Calendar Years BP
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
Meters below sea-level (for sea-level data)
Meters below seafloor (for MU A-10 data)
MU A-10
Northern GoM Sea-Level Record, from Milliken et al. 2008

Sediment Sources







Unit 3 - 58.3 km^3, = two-order of magnitude increase (from 0.4 to 41.1 km^3/ka) in flux between ~9 and ~8 ka

Unit 5 – 172 km^3 = ~ 57% of the total TMB, discharge between 10.0 x 10^7 to 1.50 x 10^7 metric tons/year. This is equal to 50-75% of its modern Miss. R. discharge. If the sediment sources were solely the Brazos and Colorado rivers, their discharge would need to have been more than eight times their combined present-day discharge

Some Conclusions

1. During the previous fall of sea level, sediment discharge to the outer shelf increased significantly due to recycling of inner shelf sediments.
2. A key factor regulating sediment discharge to the shelf and slope is purging of sediment from fluvial drainage basins.
3. Rivers with greater sediment yield (e.g. Brazos, Lagniappe, and western Louisiana fluvial systems) are prone to avulsion, which means that a significant portion of the sediment they deliver to the basin is sequestered on the shelf. In contrast, smaller rivers tend to occupy the same channel throughout one or more eustatic cycles and act as point sources for slope sediment delivery.
4. The Texas Mud Blanket is the dominant depositional event of the shelf during the transgression and reflects a significant change in longshore sediment delivery and sediment discharge to the shelf in the late Holocene.
5. Transgressive ravinement has played a key role in sediment supply during Transgression.