Looking Back to See the Future: How Natural Cycles can Inform Sustainability

The Example of River Deltas

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Graphics and Geology by Chris McLindon, additional Geology by Kathy Haggar

Louisiana's coastline is disappearing at the rate of a football field an hour

Living on Earth

September 23, 2014 · 1:00 PM EDT

Writer Adam Wernick *(follow)*

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‘What took 7,000 years to create has been nearly destroyed in the last 85.’

Judge: Corps' MR-GO 'took' value of properties in St. Bernard, Lower 9th Ward

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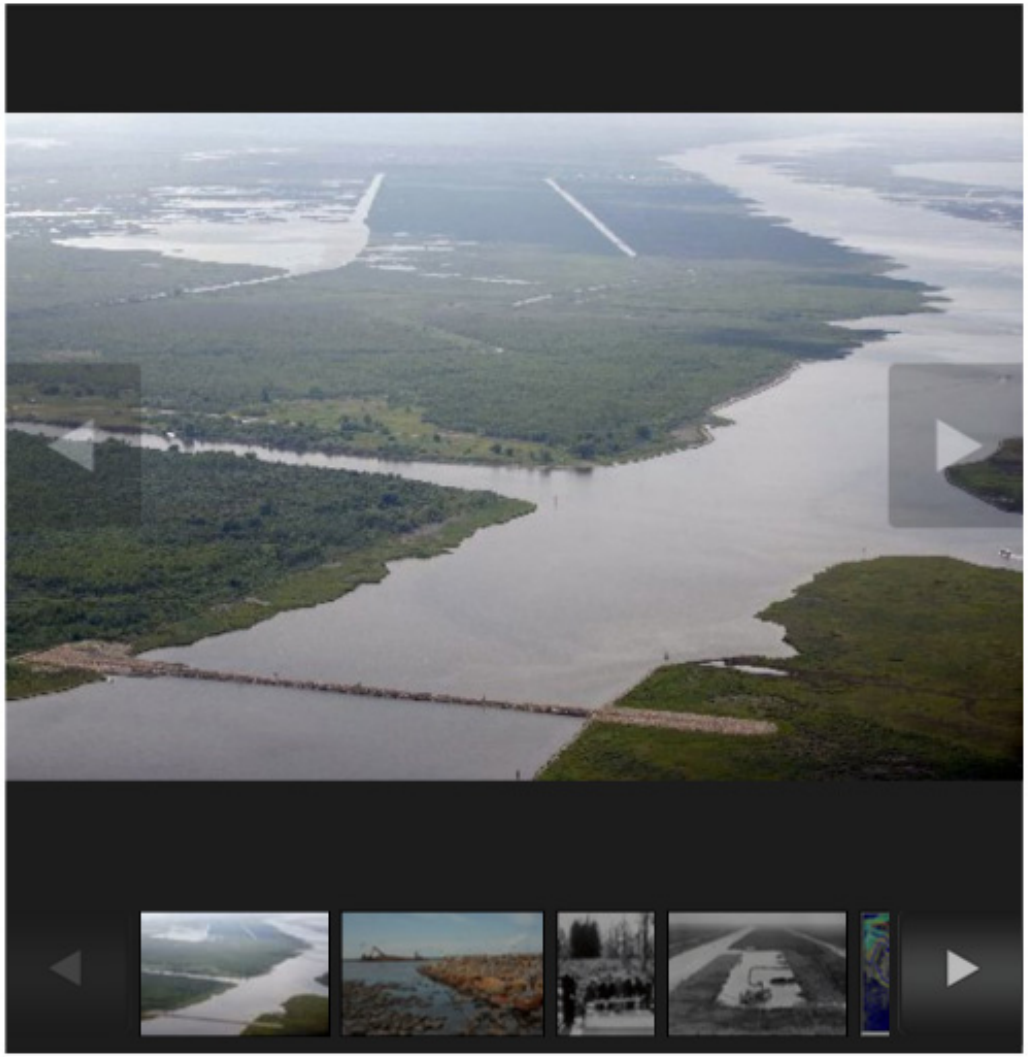

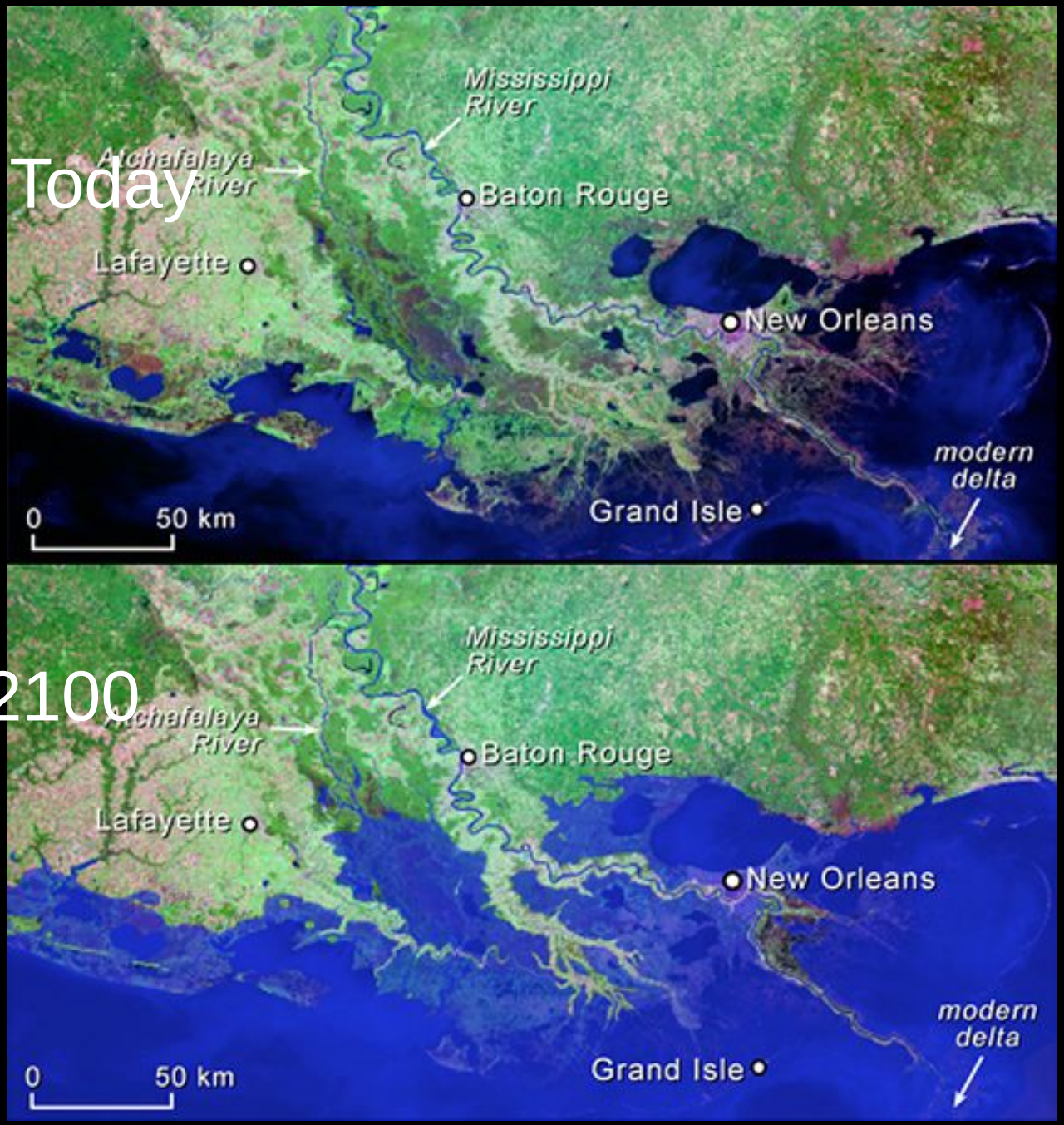
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Mississippi River
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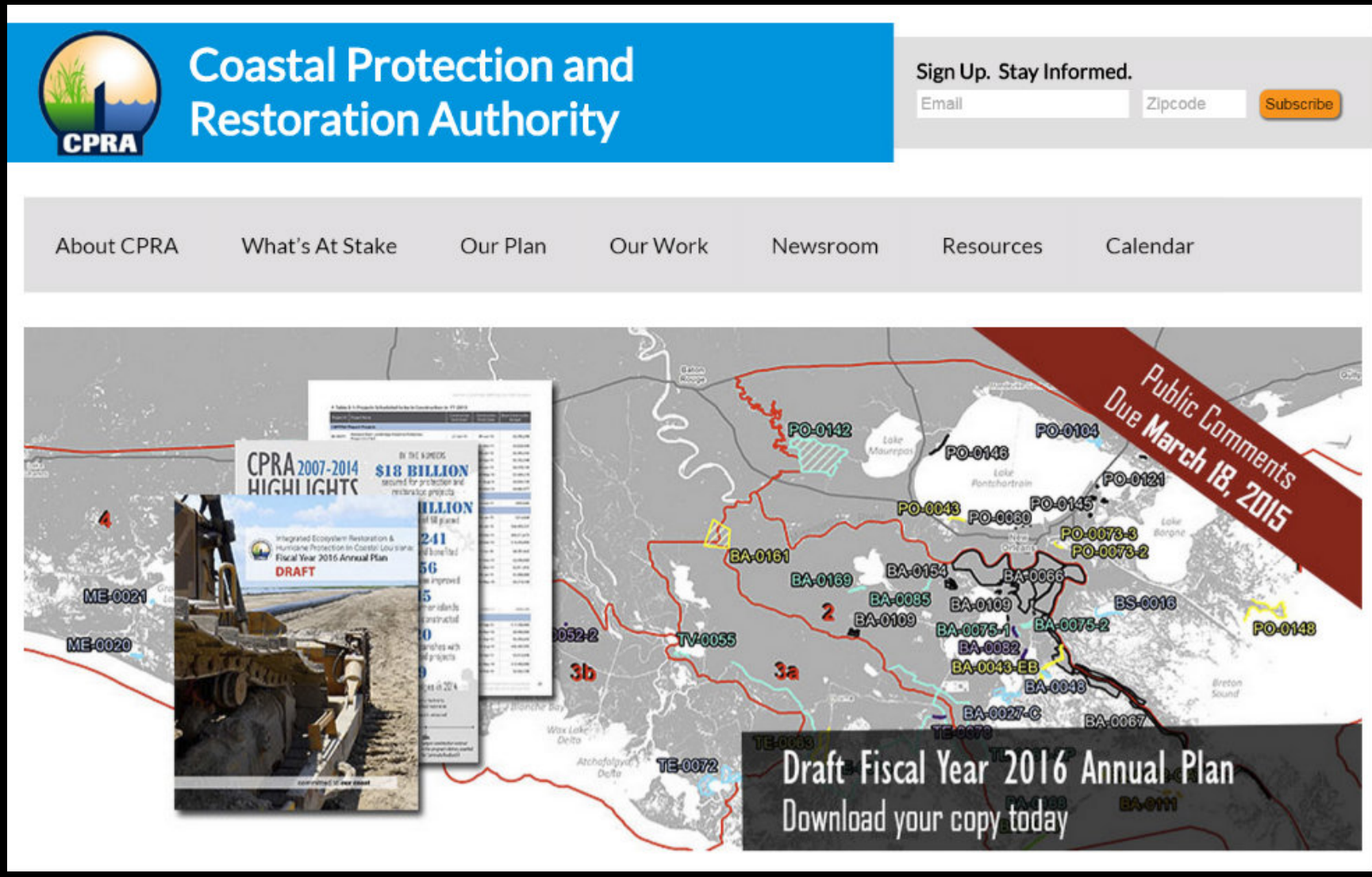
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Environmentalists argue that coastal restoration is a sustainable strategy for the Mississippi Delta

What does looking back tell us about whether coastal restoration makes sense looking forward?

The Natural Cycles

- Migration of Crustal Plates
- Sedimentation and crustal downwarping that form the Mississippi Delta.
- Sea level change driven by the glacial cycle.
- The waxing and waning of delta lobes driven by the movement of the river.

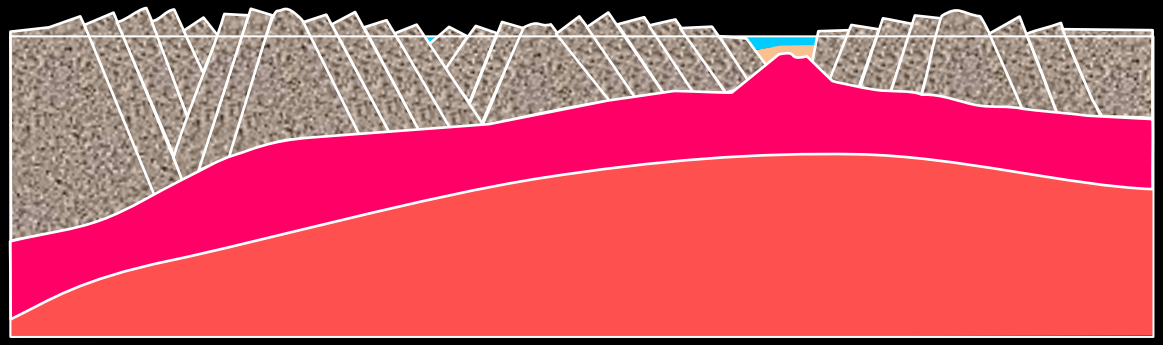
Temporal Timeframe

- Tectonic plates – 10m year increments.
- Sediment deposition – 1m year increments.
- Climate – 1,000 year increments (until recently).
- Delta lobes – 100 year increments.
- Coastal restoration plan – 10 year increments.
- Politicians – 4 year increments.
- Coastal planners should look at least 100 years ahead.

Geologic History of the Gulf of Mexico and the Mississippi River

The red line shows where the geologic section falls in the following slides. This shows how the sediment accumulates through time as the bed of Mississippi evolves while the continental plates move. The key geologic point is that the crust is weak so it will subside and form a place – the accommodation space – in which the river flows and the sediment accumulates.

22o mya



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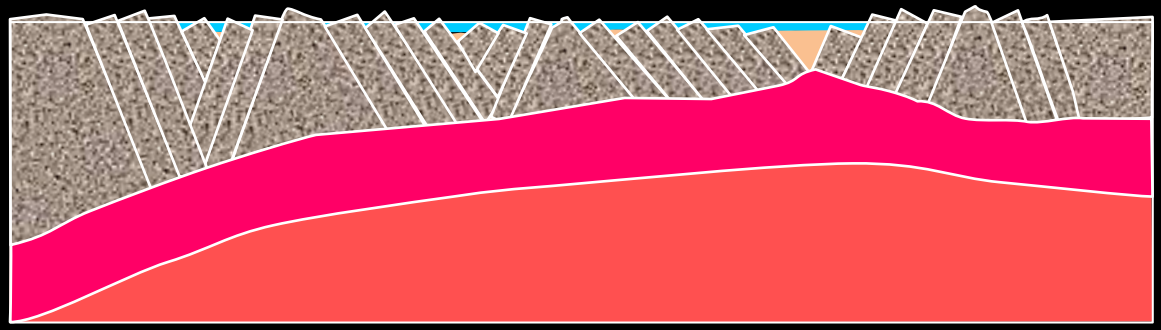

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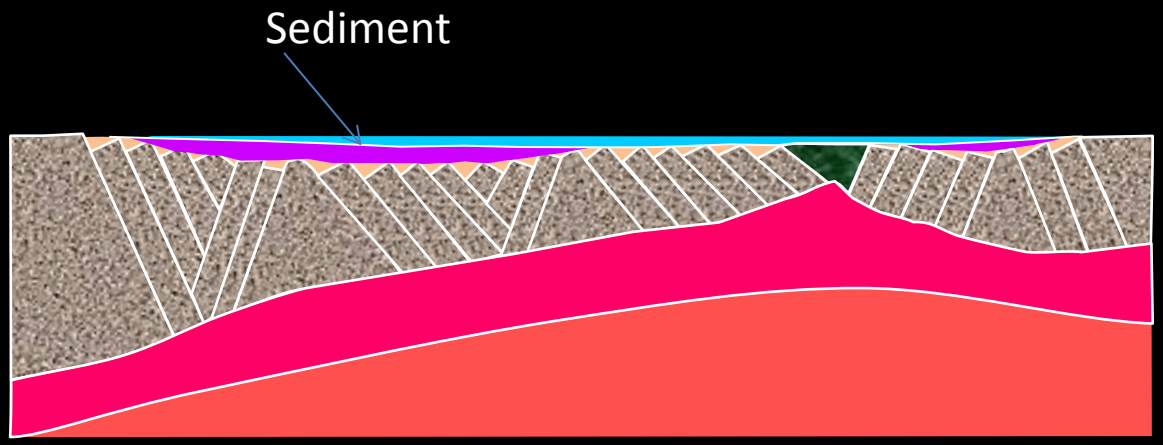

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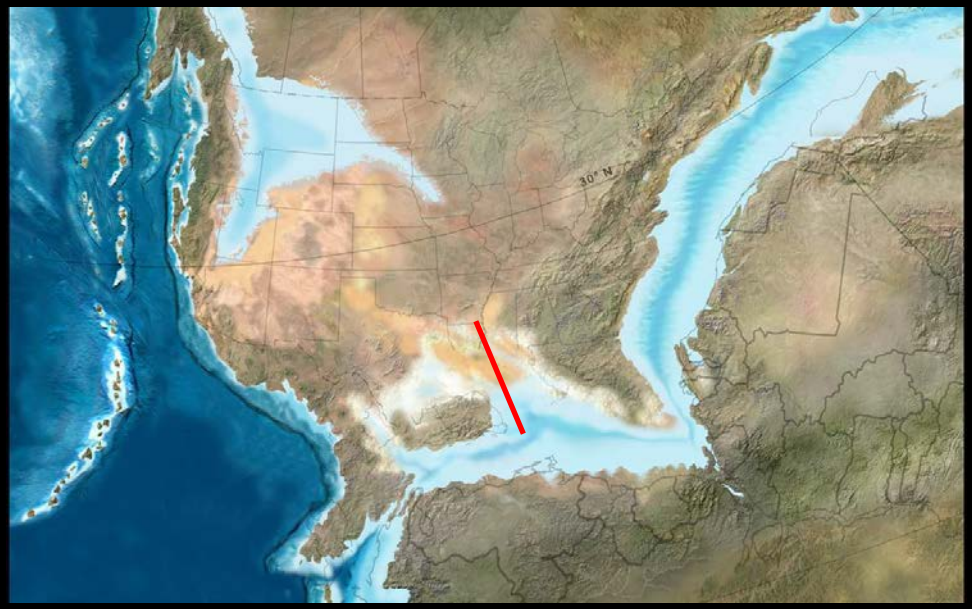

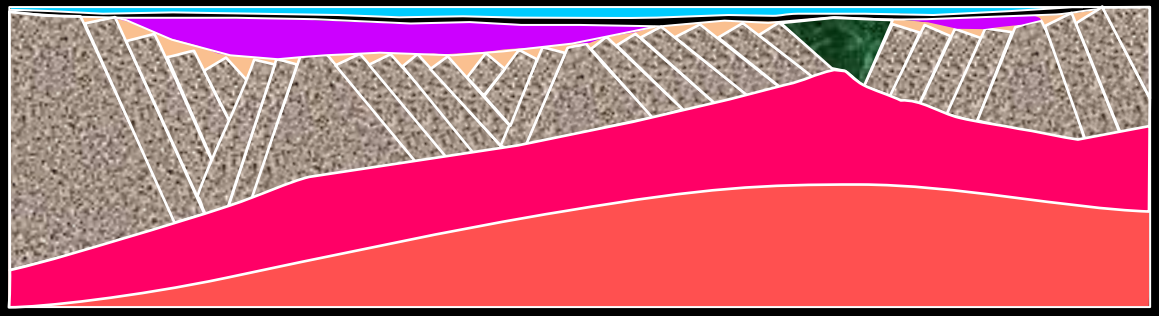

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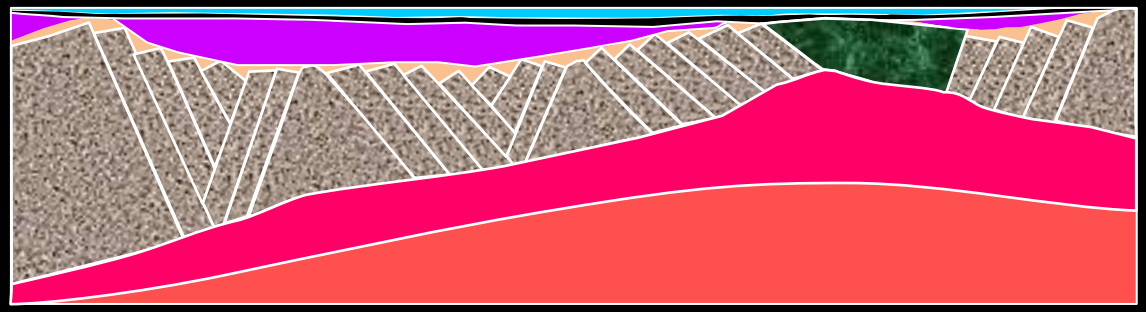

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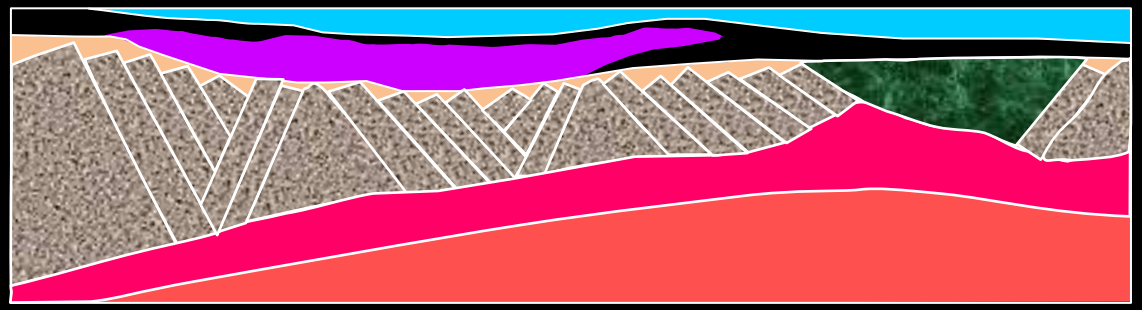

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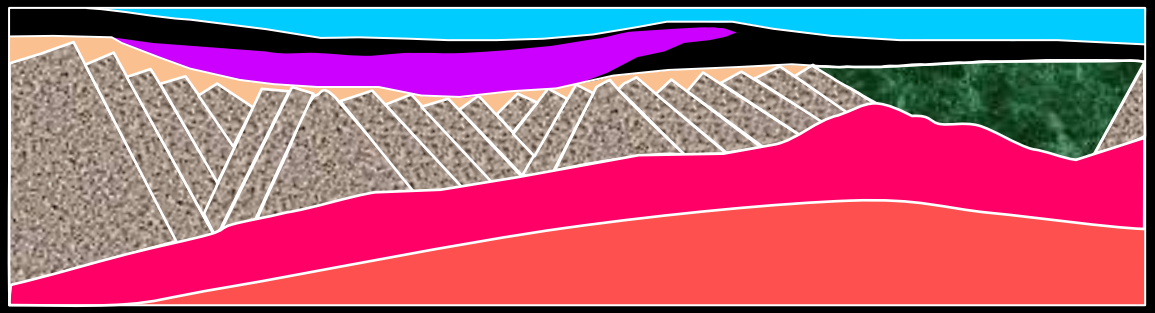

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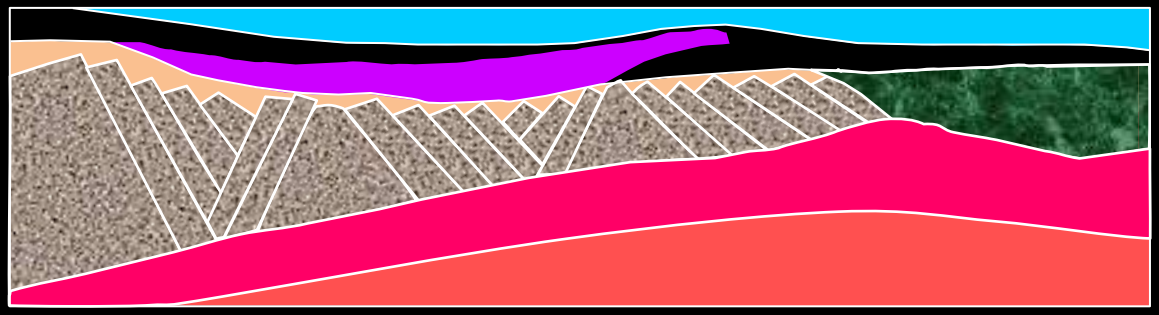

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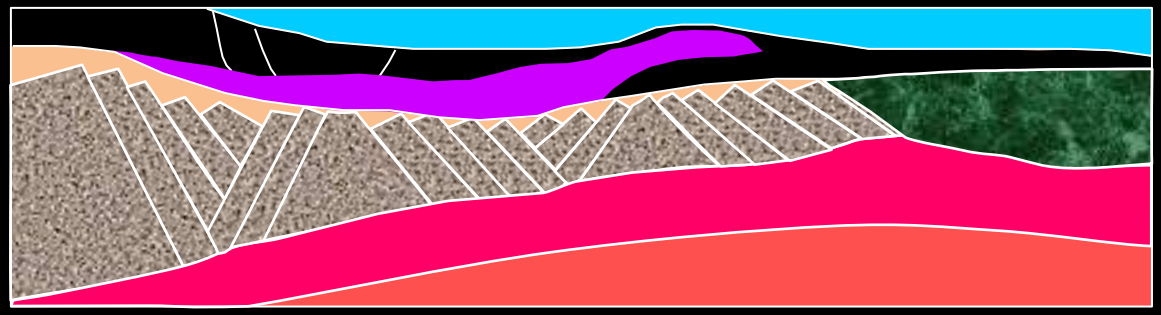

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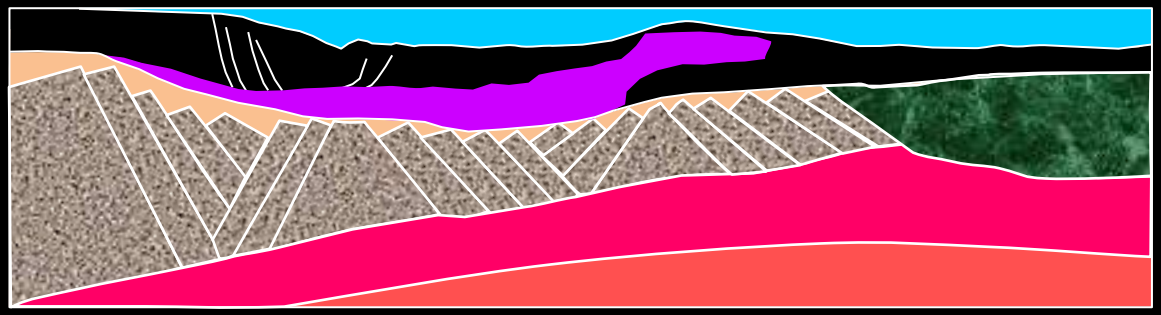

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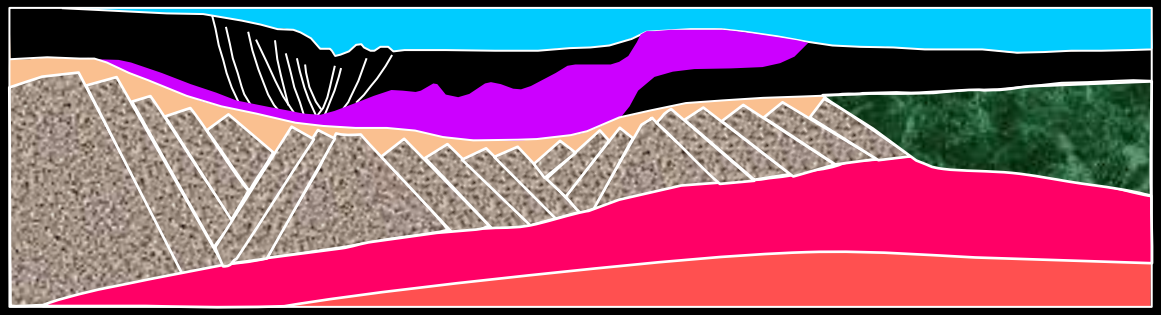

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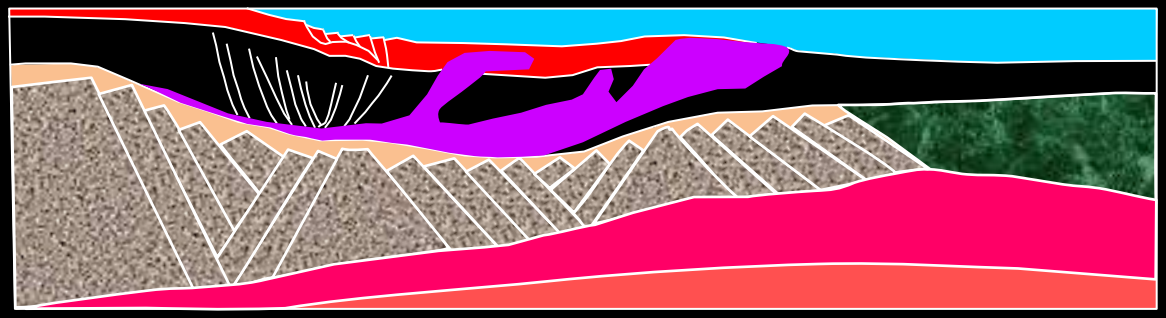

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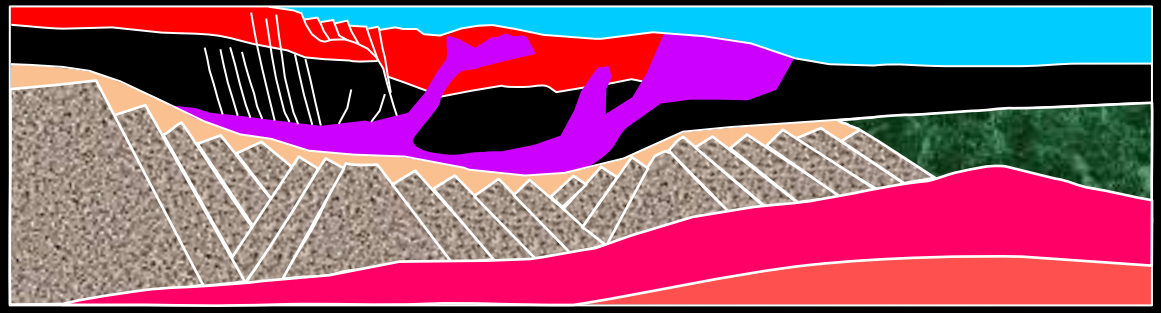

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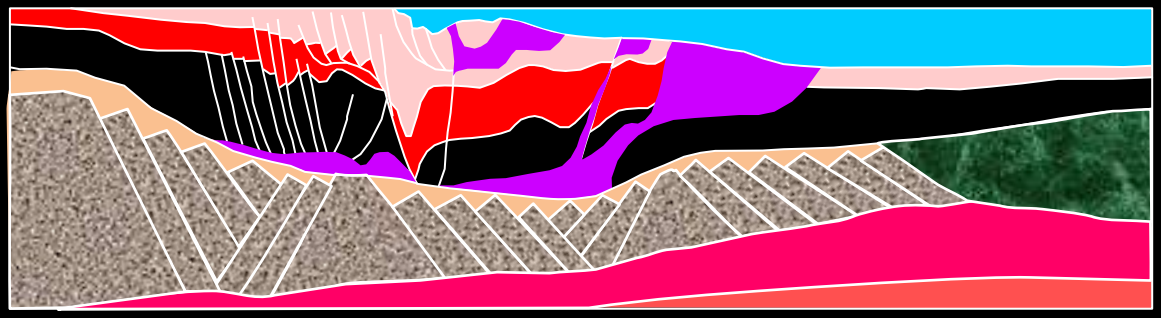

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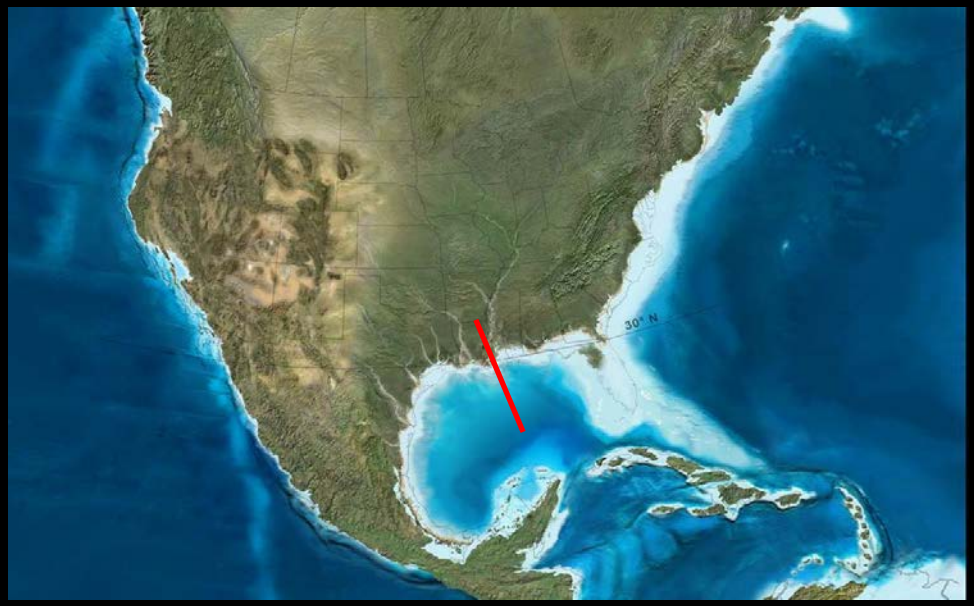

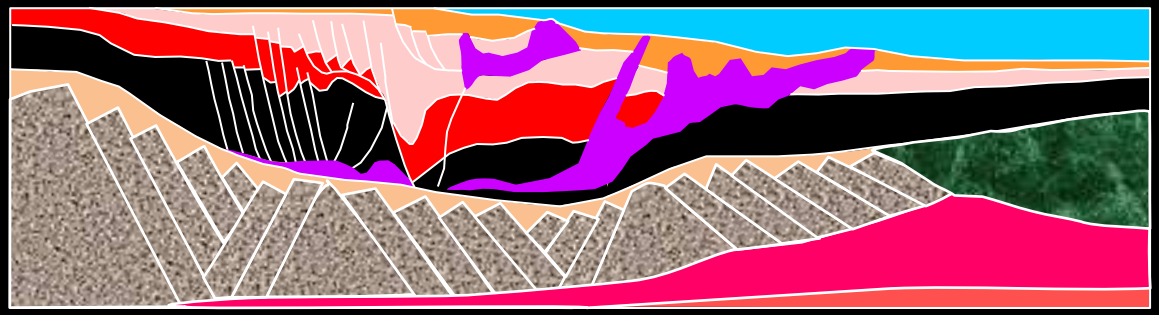

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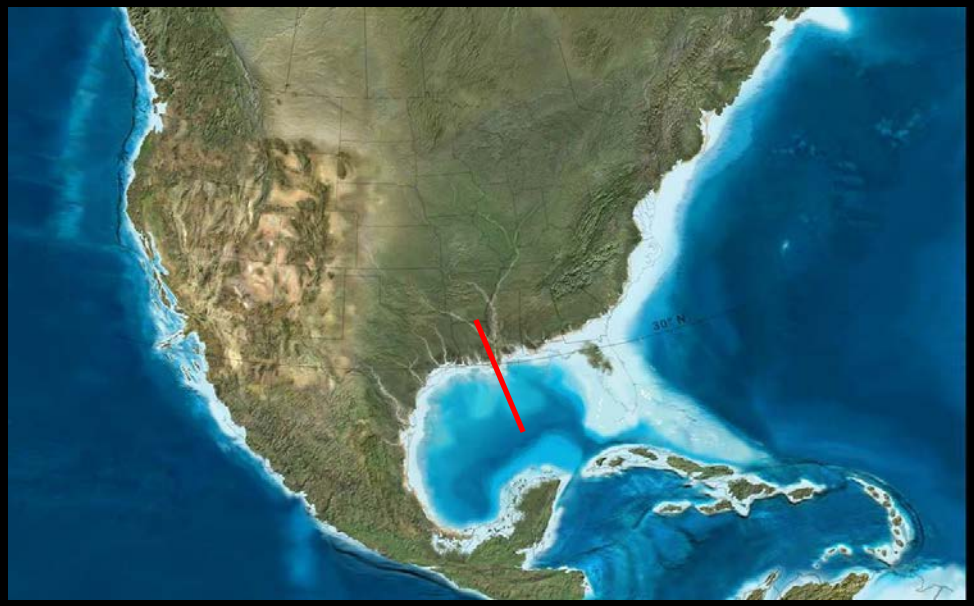

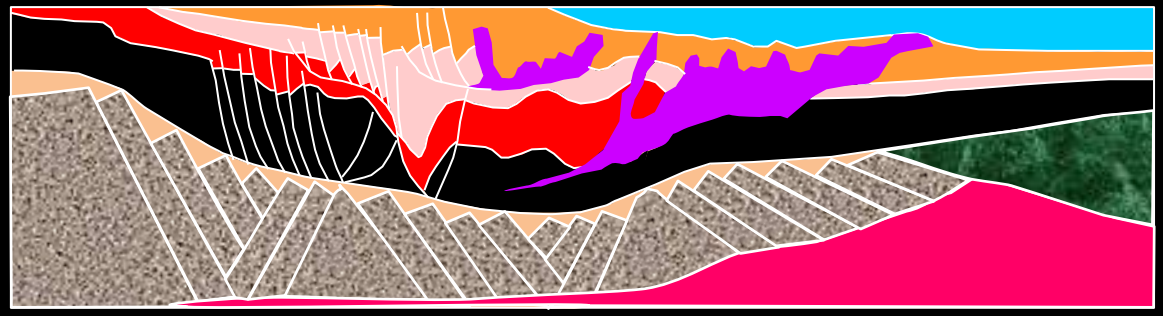

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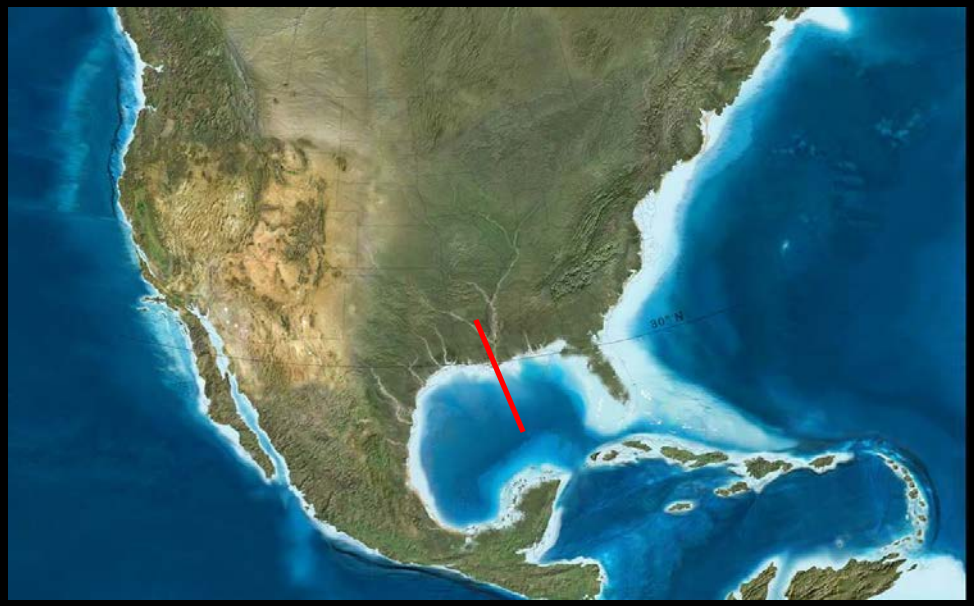
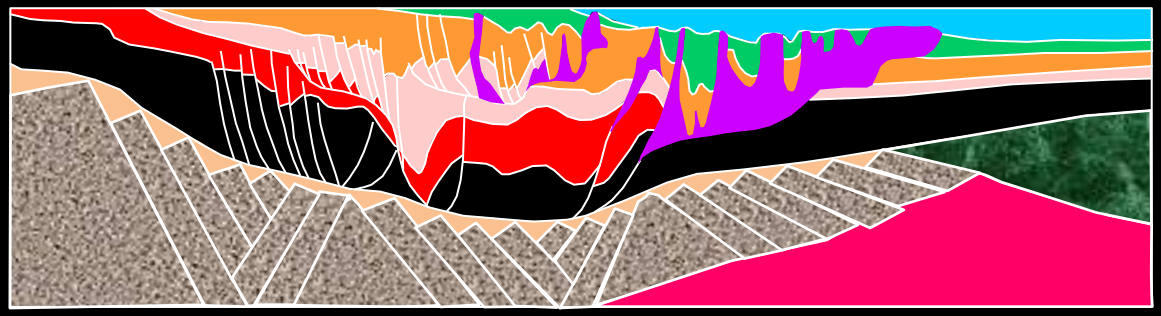
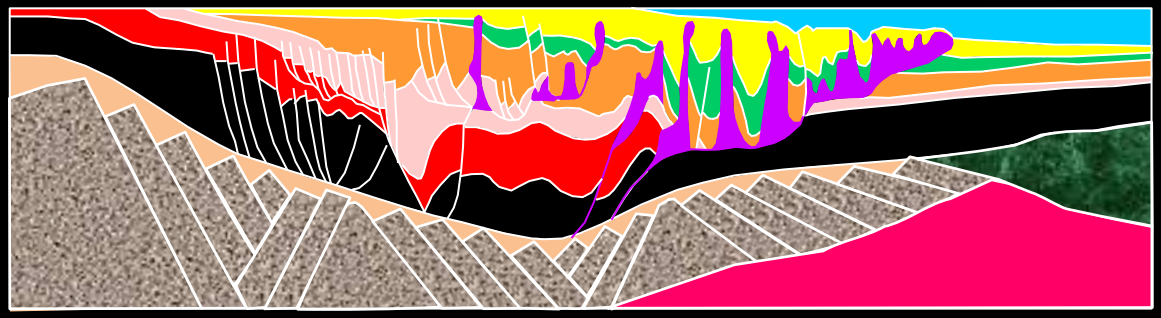
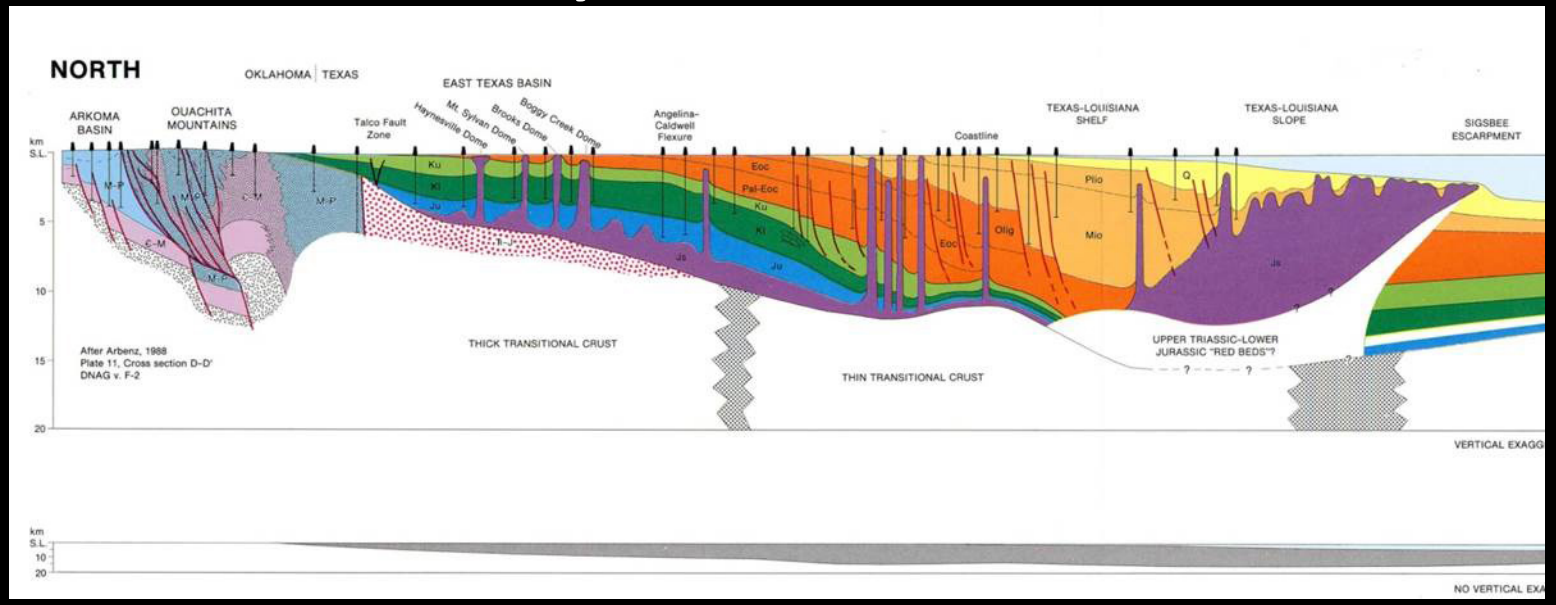




Present

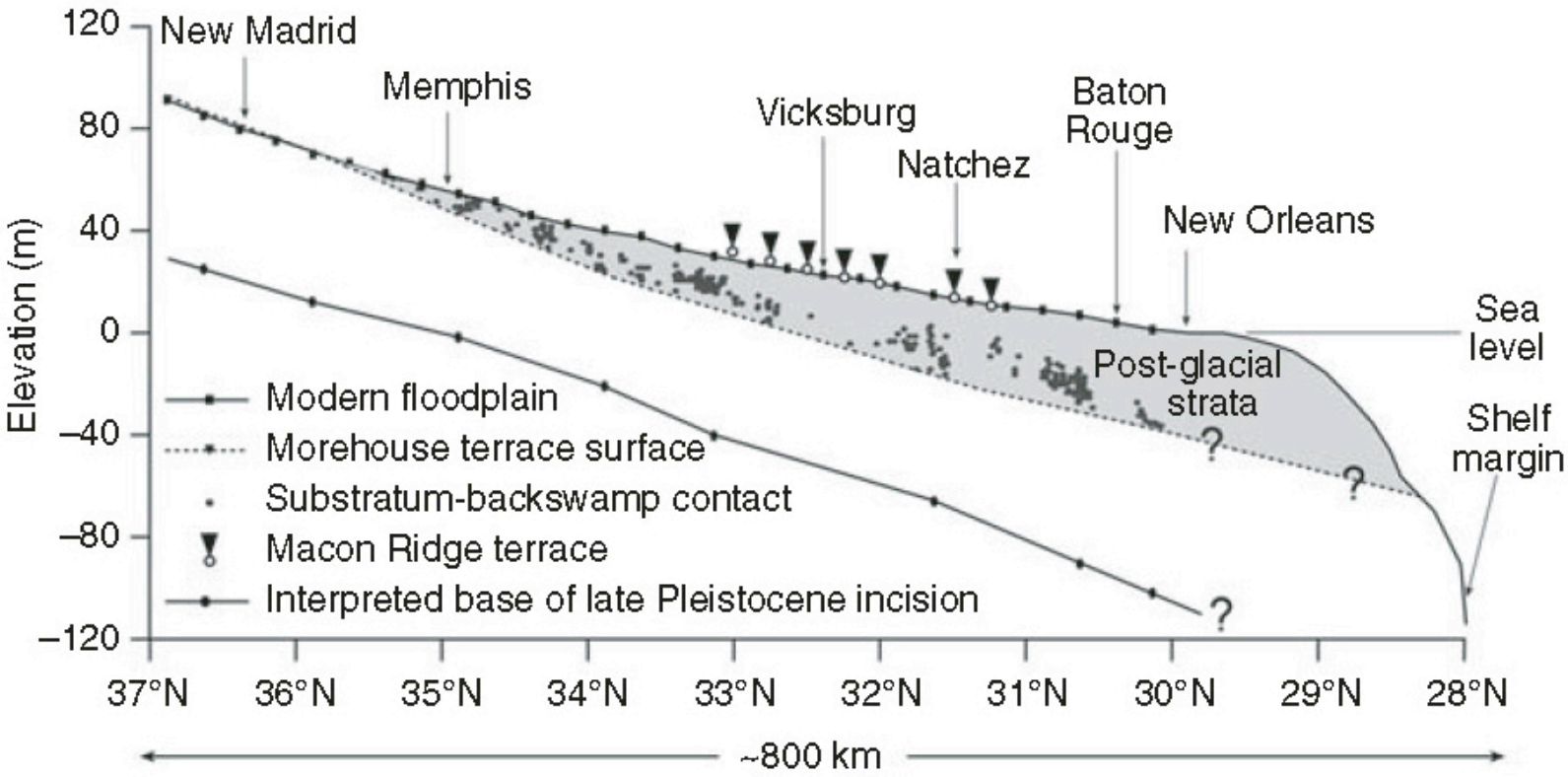


The geologic Delta is the product of 200 million years of sedimentation



- ~60,000 ft thick→stack of 10 Grand Canyon sections.
- The "Depositional Space Problem" – making room
  - ✓Sea level rise (range = ~1000 feet)
  - ✓Salt evacuation due to differential loading.
  - ✓Bending of the crust and flow of underlying mantle.

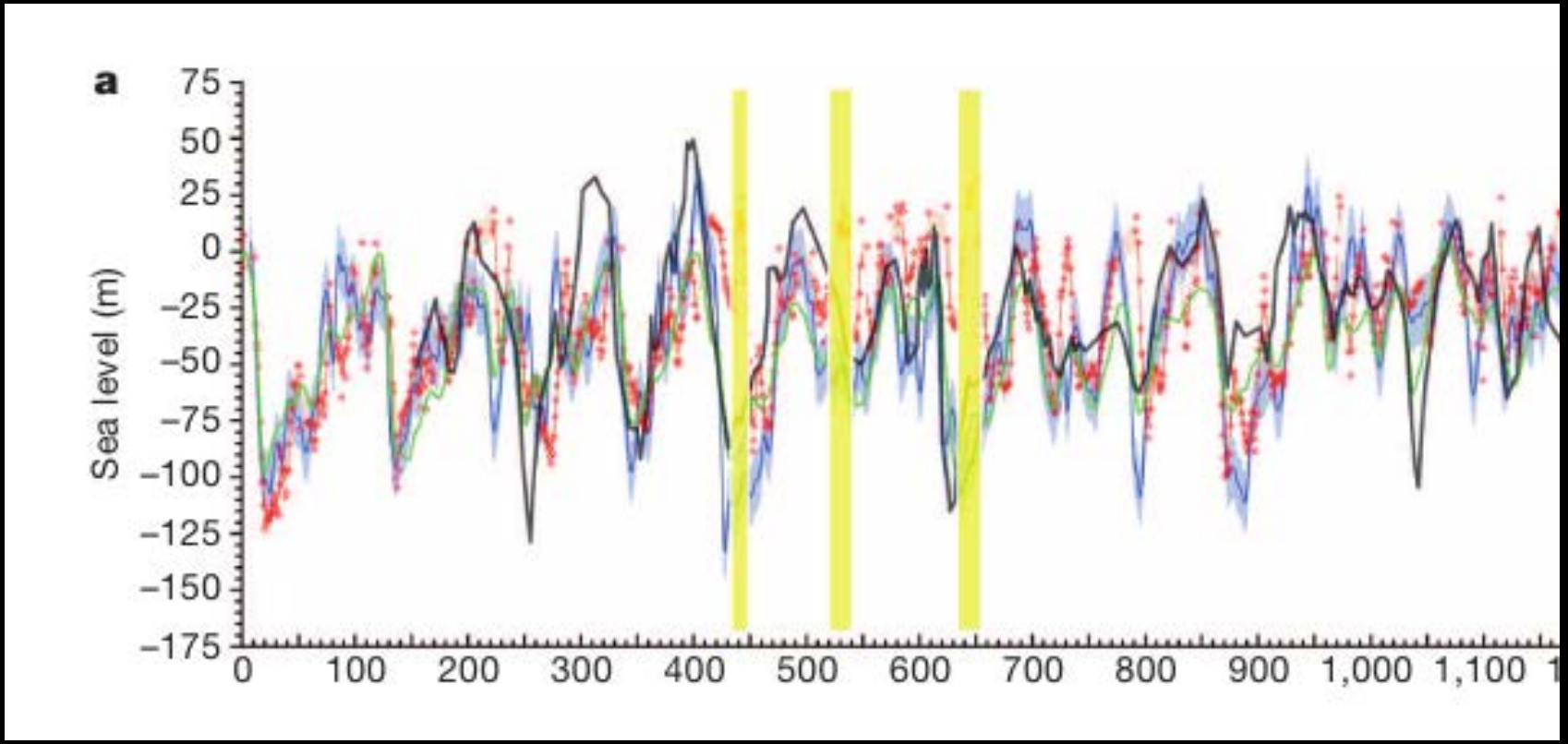
The Layman's Delta is the Intertidal Zone Defined by Current Sea Level. Sea Level, Not Sediment Defines this Delta.



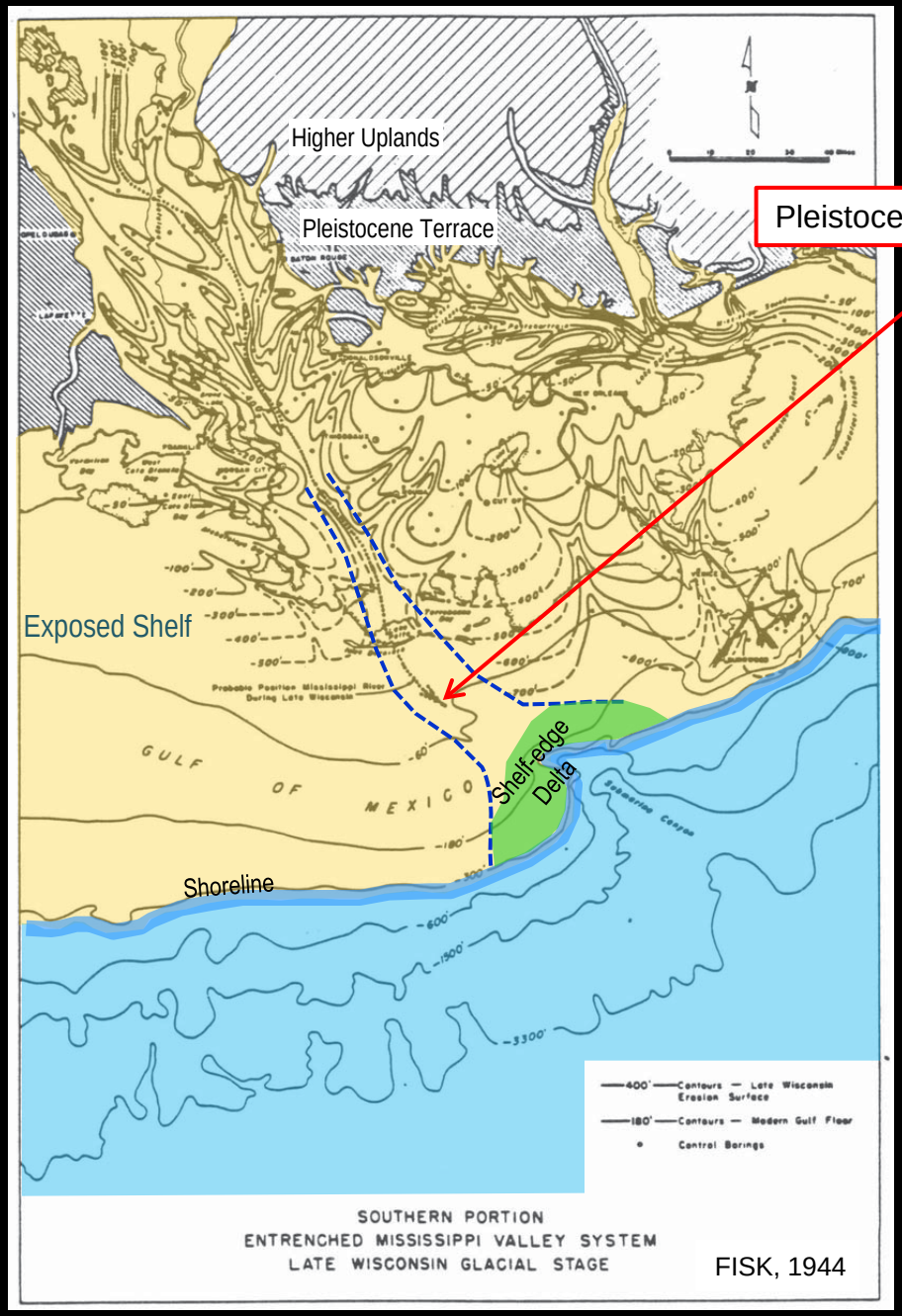
Blum MD, Tomkin JH, Purcell A, Lancaster RR. Ups and downs of the Mississippi Delta. Geology. 2008;36(9):675–8.

Climate cycles move the coast as sea level rises and falls. This is sea level for the last 1,000,000 years

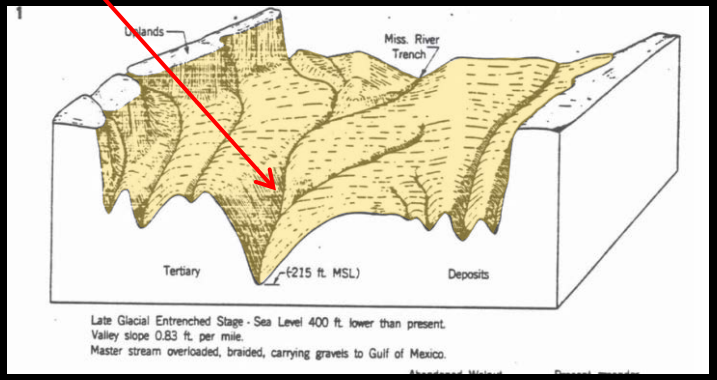
- Rohling, EJ, GL Foster, KM Grant, G Marino, AP Roberts, ME Tamisiea, and F Williams. “Sea-Level and Deep-Sea-Temperature Variability over the Past 5.3 Million Years.” *Nature*, 2014.

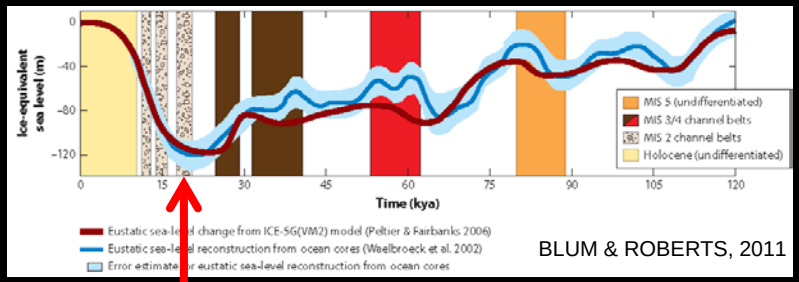


When Sea Level is Low, the Delta is Far out in the Gulf at the Continental Shelf



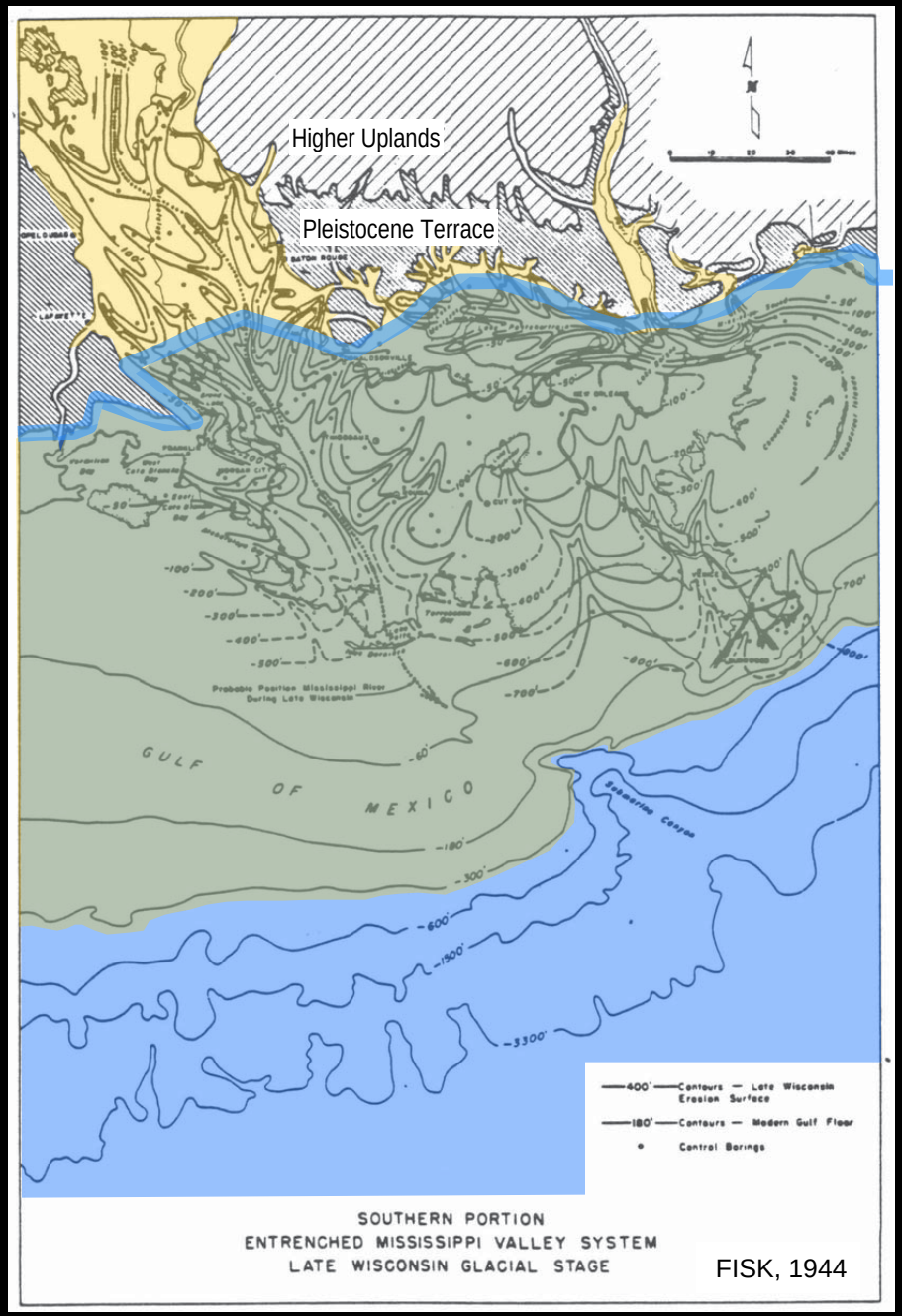
Pleistocene erosional surface





BLUM & ROBERTS, 2011

As Sea Level Rises, the Coast Migrates Inland



FISK, 1944

Braided stream aggradation

Holocene delta deposits

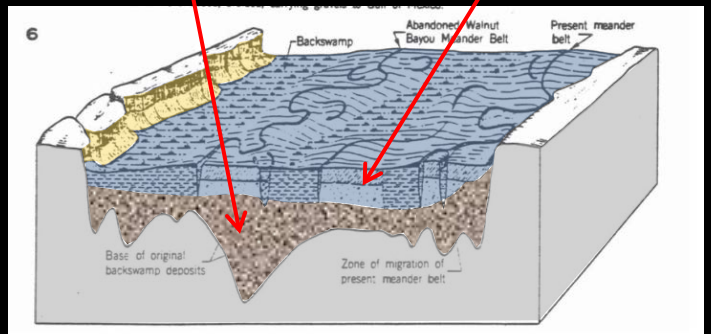
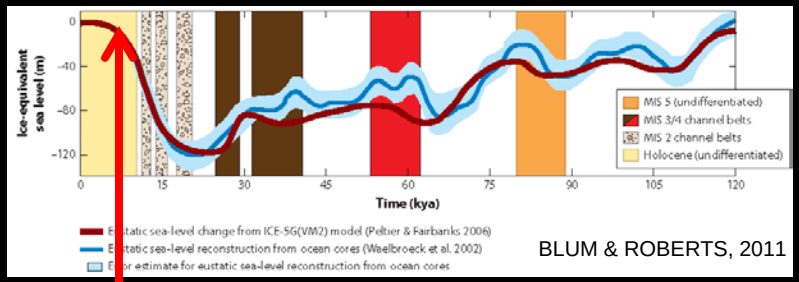
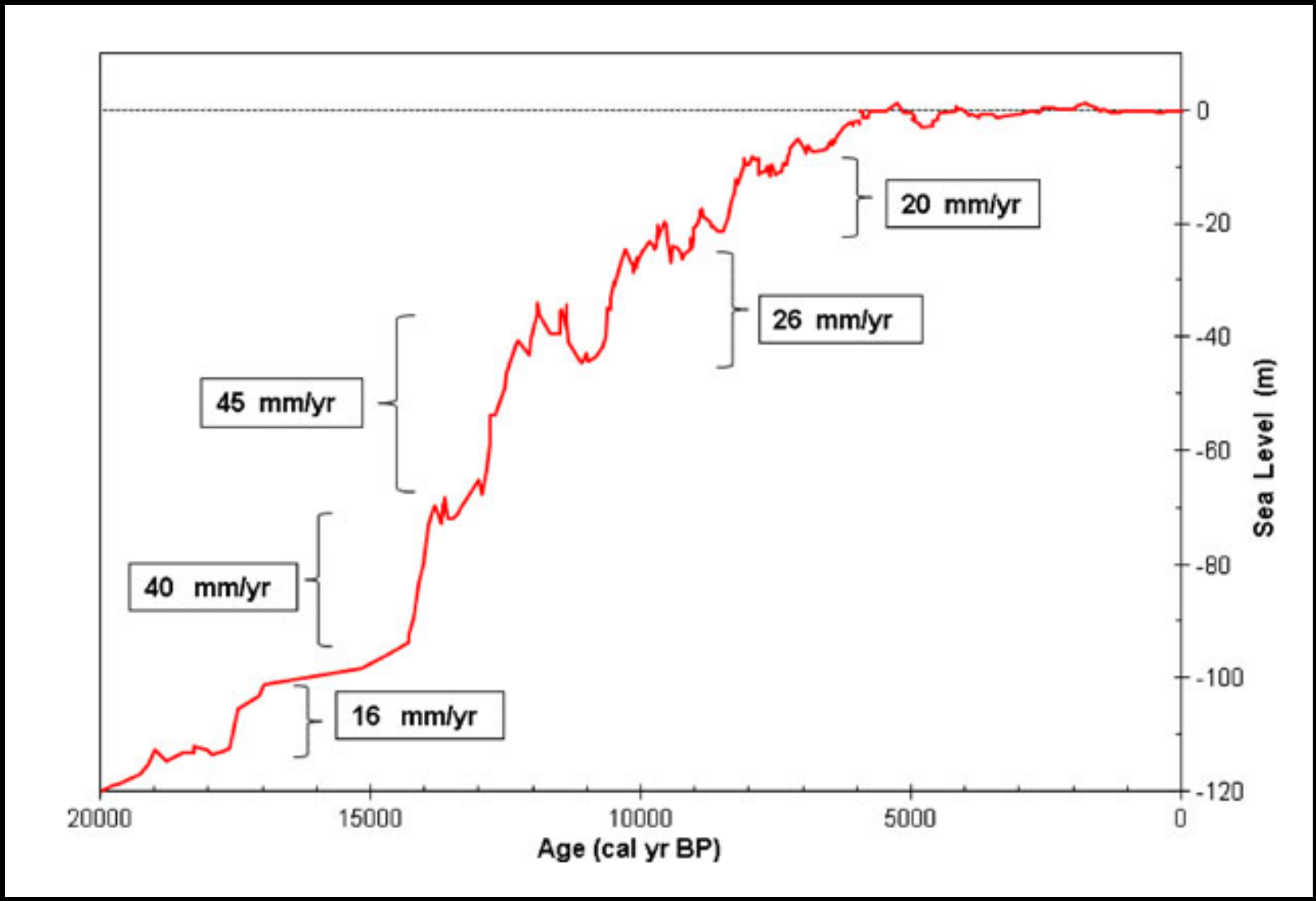


Figure 2.4. Schematic diagrams of the Mississippi River Valley fill. After Fisk (1947).



BLUM & ROBERTS, 2011

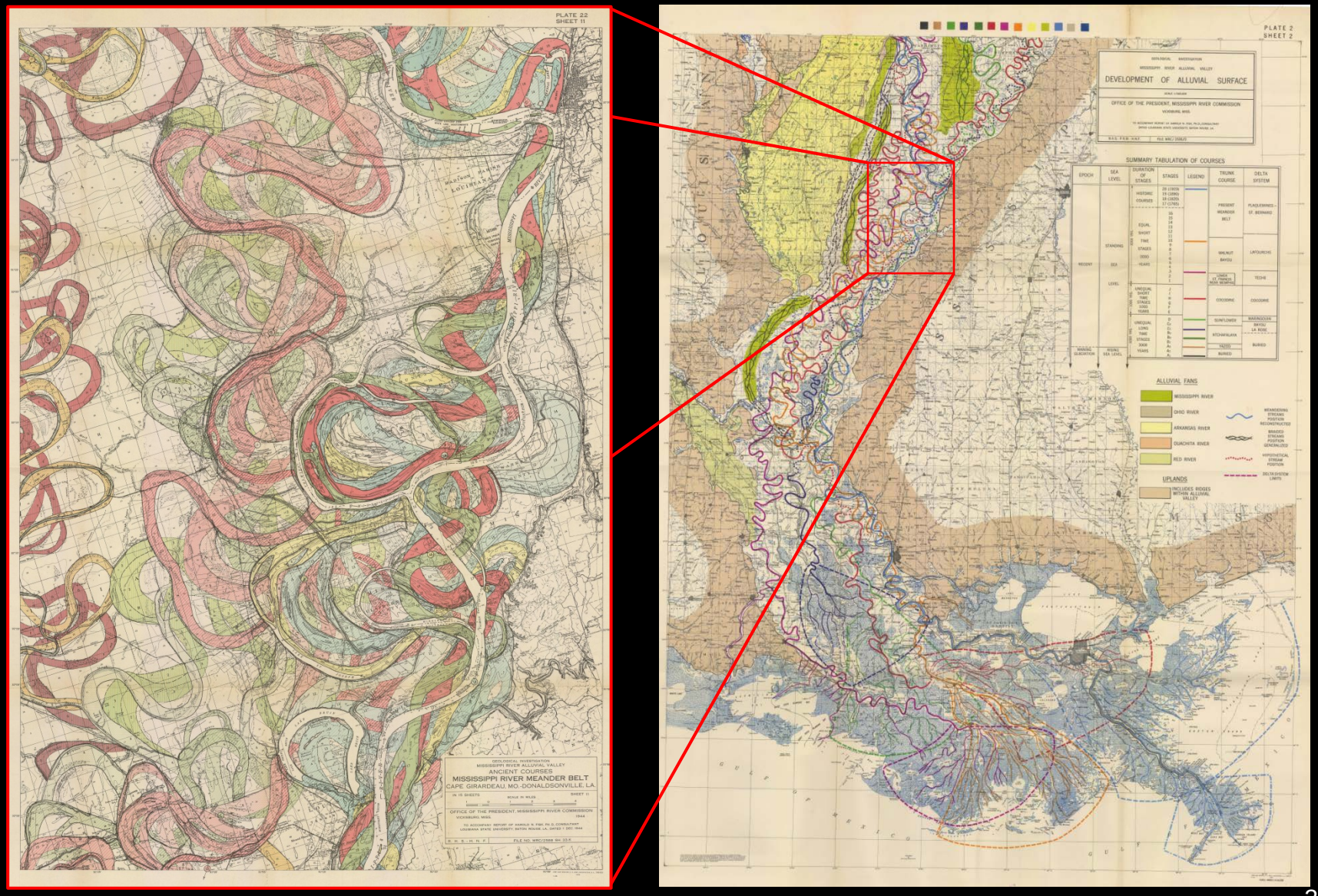
Broad, flat intertidal deltas can only build when sea level is stable.



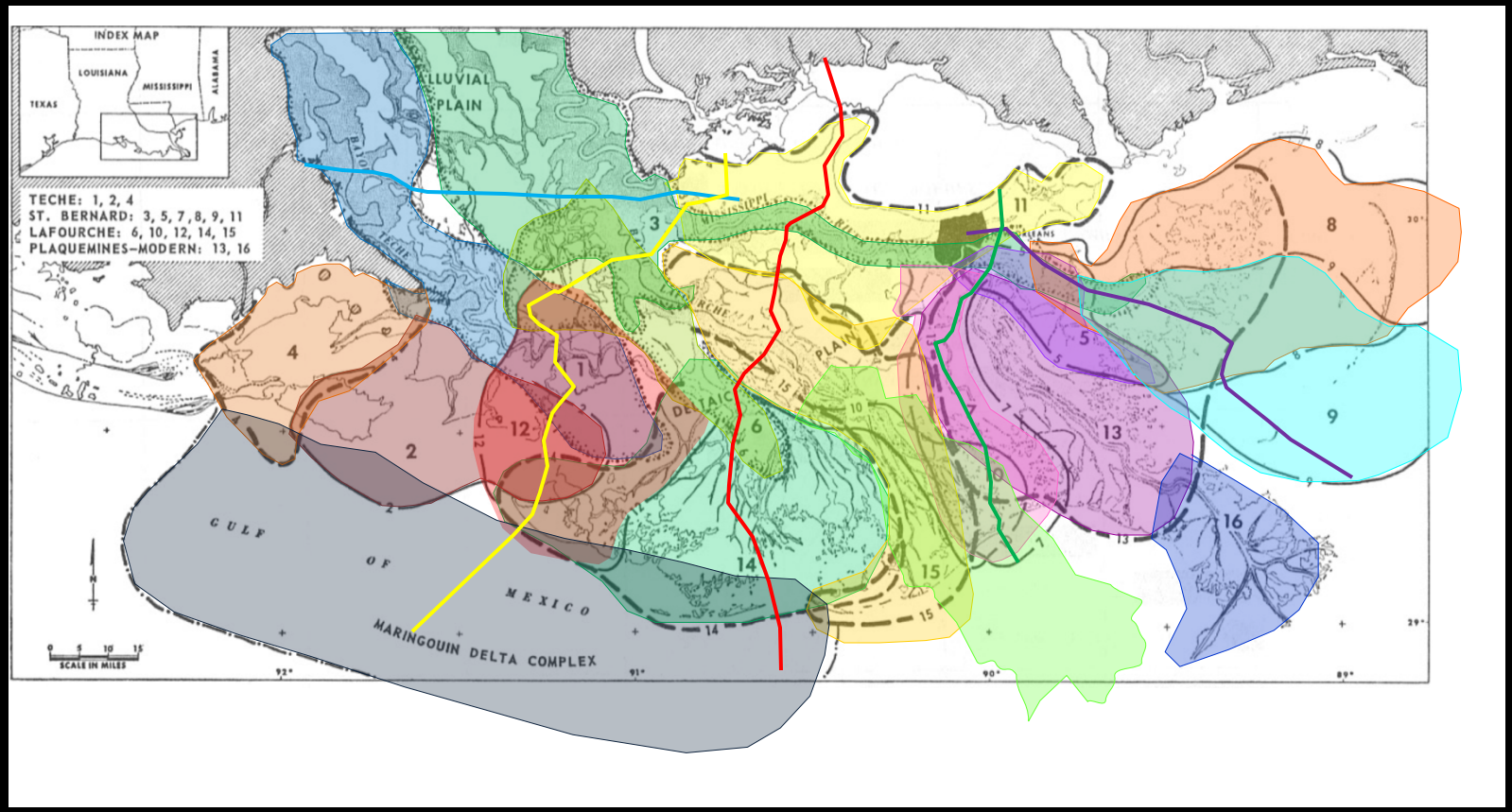
The Mississippi River Builds its Delta by Meandering

- When the river channel clogs with sediment, the river finds a new path.
- All of the paths are contained within the zone created by the weak spot (the red line) in the crust that allows subsidence.

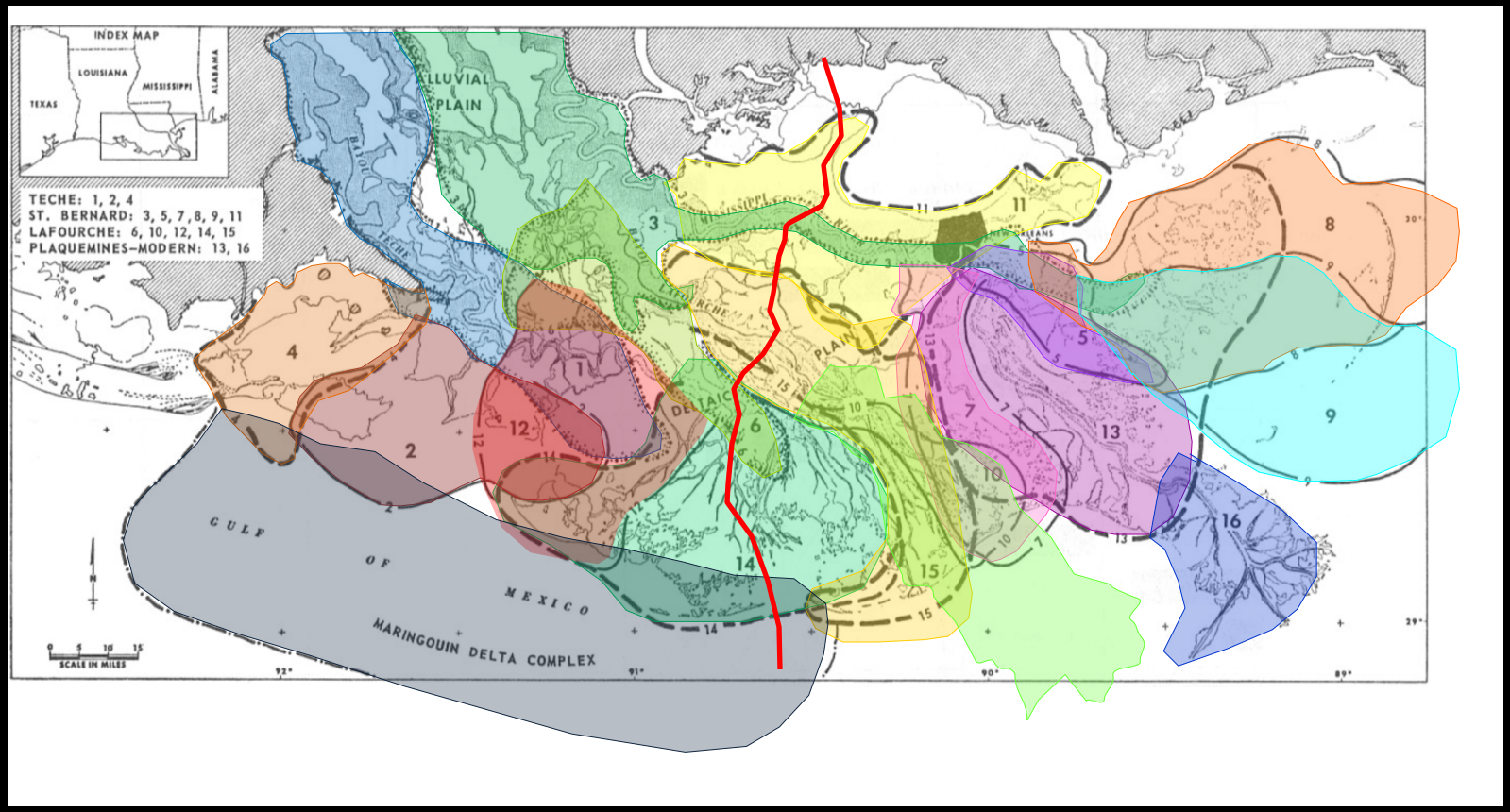
Upland Meanders

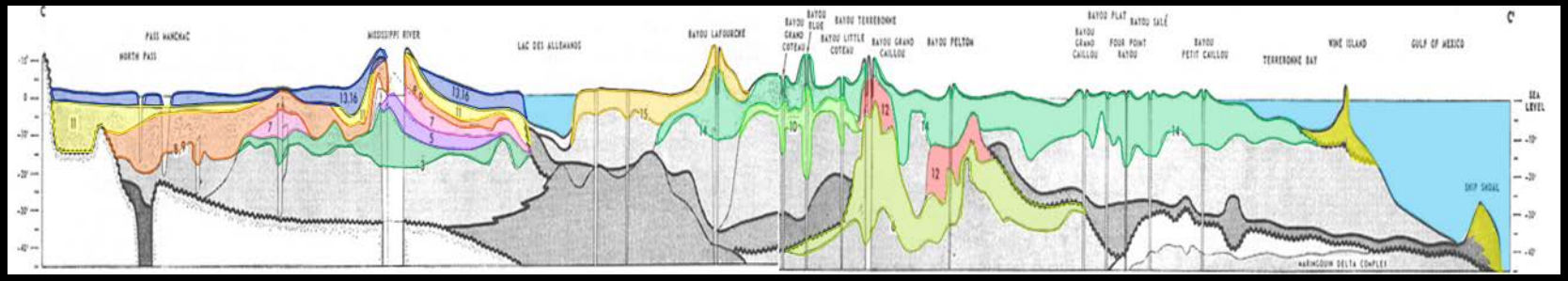


Meanders at the Coast Create Delta Lobes

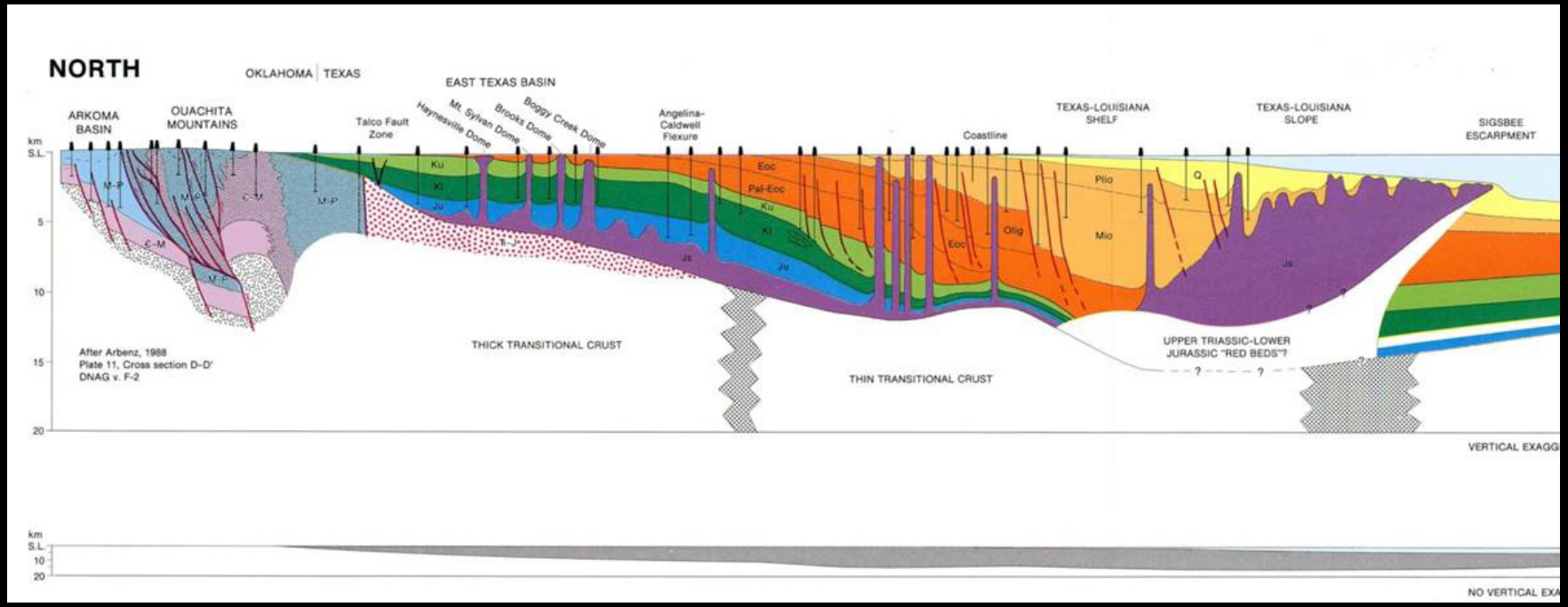


Subsidence is constant. Abandoned lobes sink below the water and new lobes can overlap them.



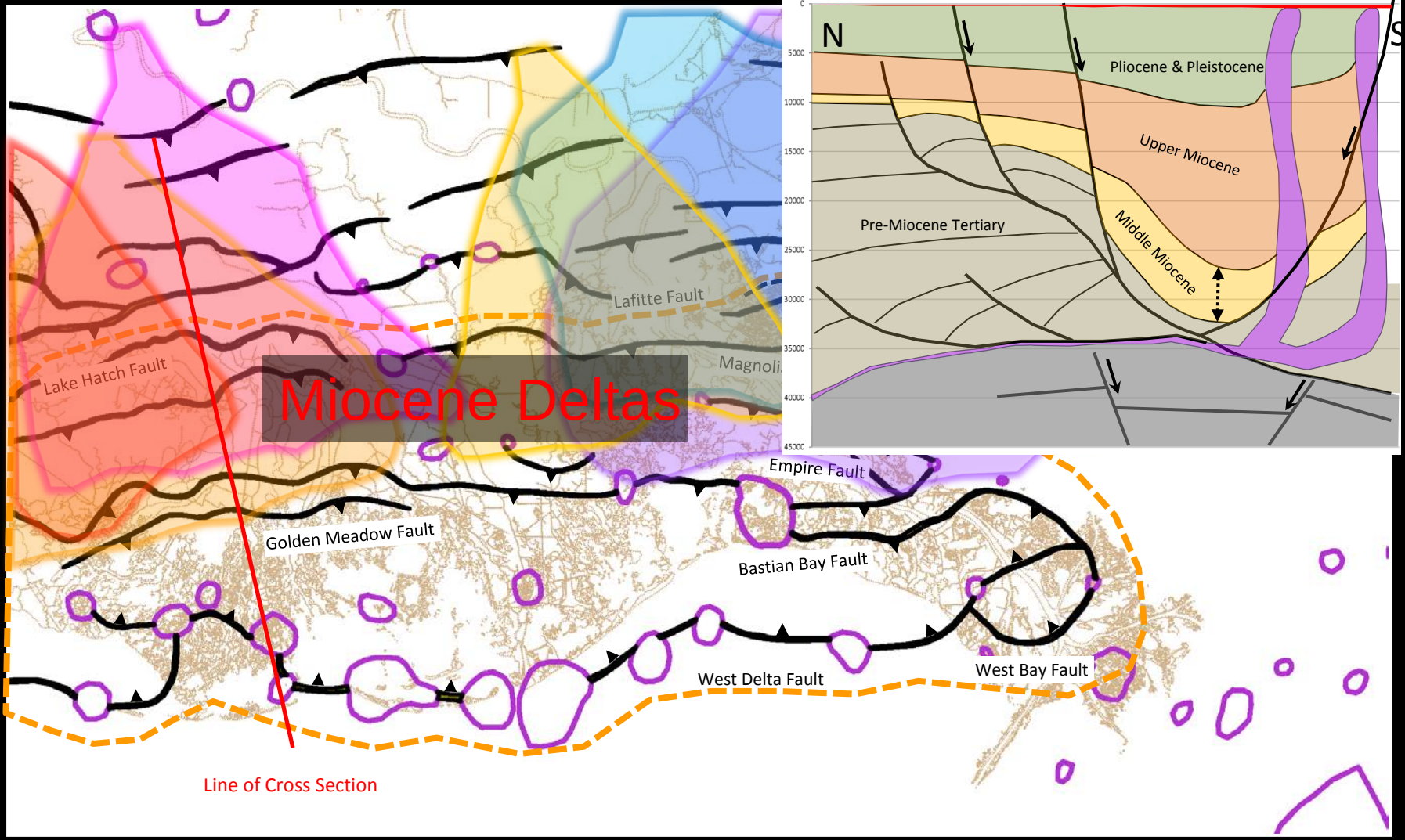


The Delta Lobe Cycle Repeats for Each Glacial Cycle, Building a Complex Stack

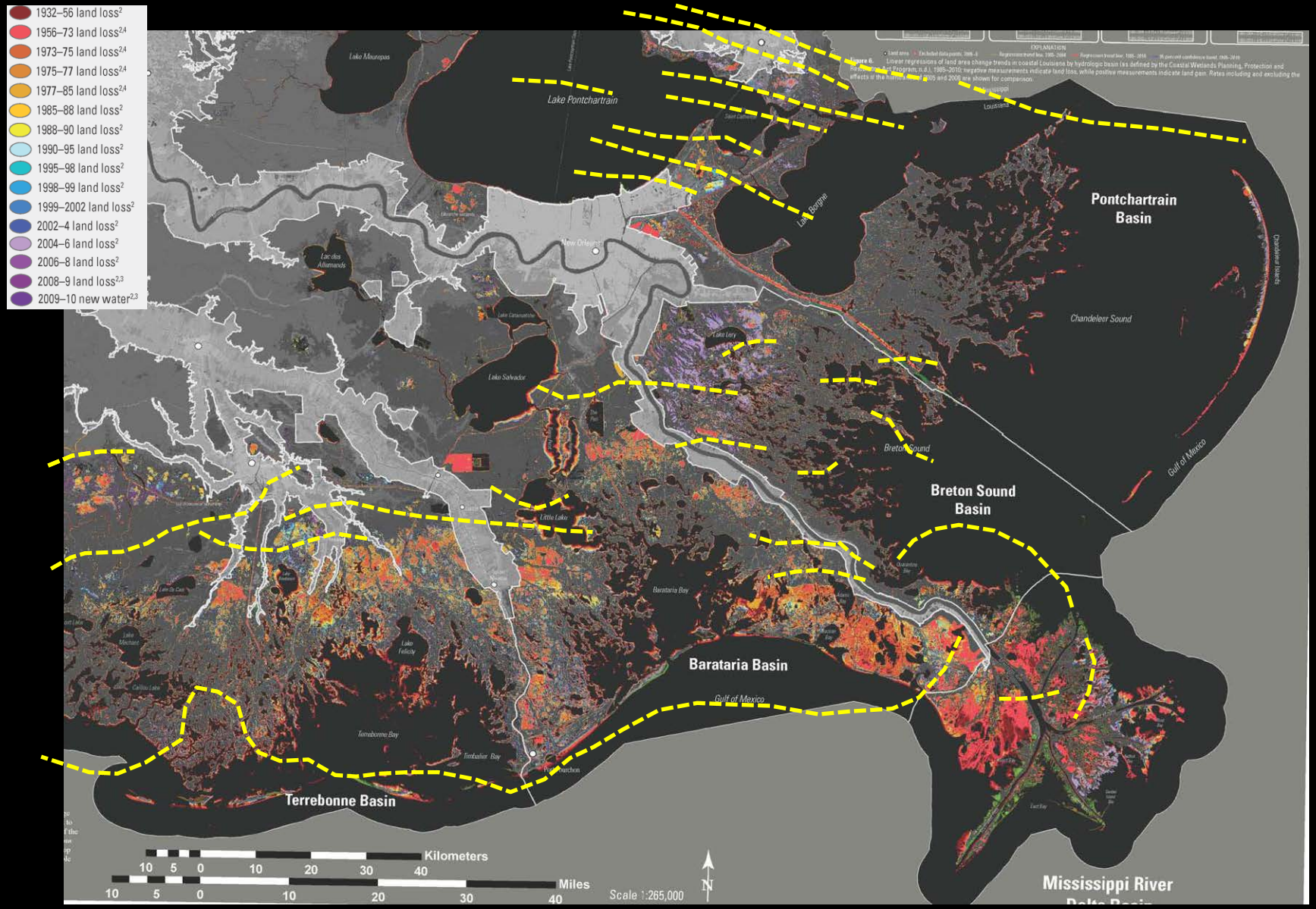


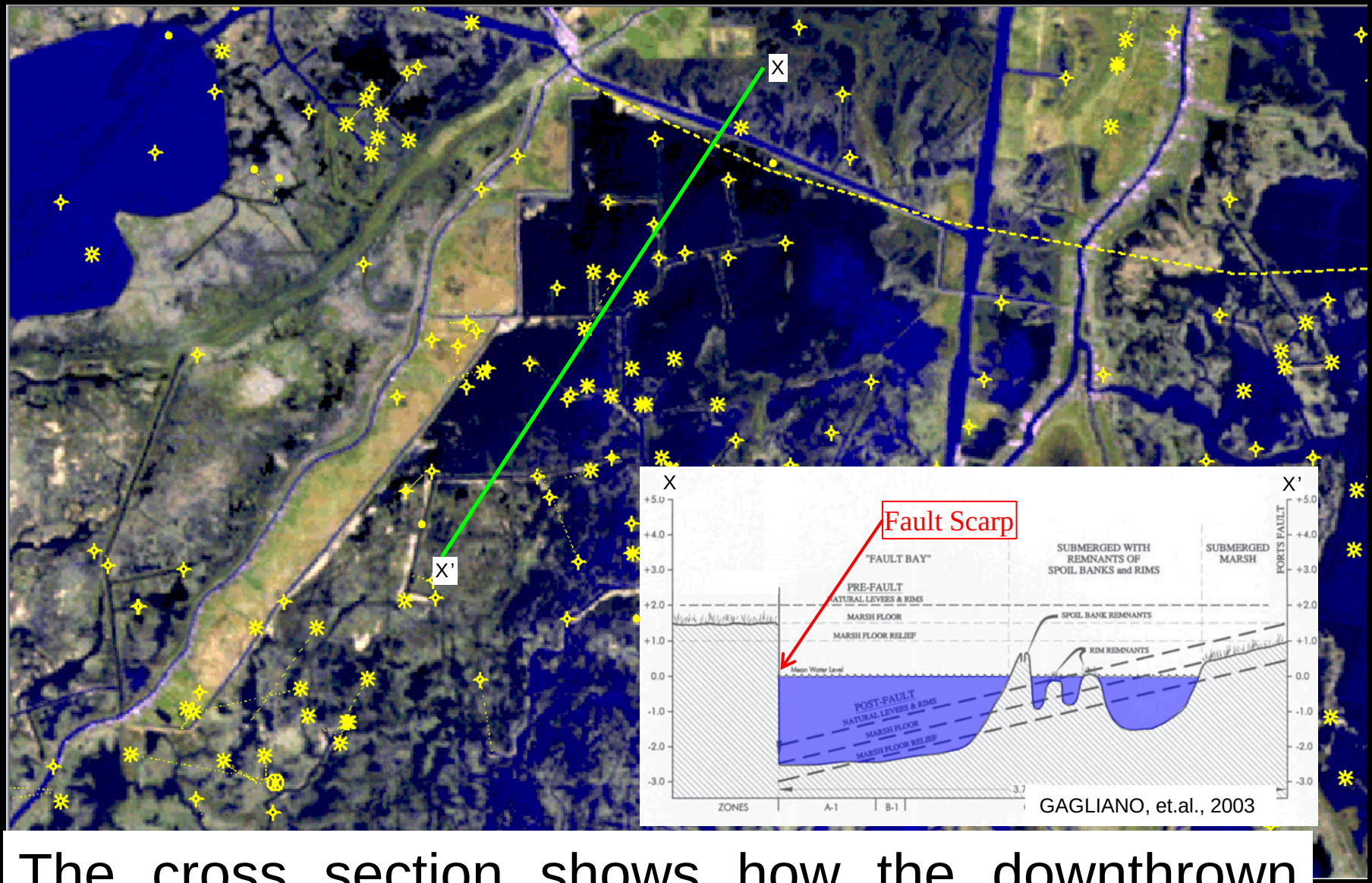
Each buried lobe represents millions of tons of organic matter that can form oil. Receding seas leave salt, which forms salt domes.

The stack breaks into fault lines, which trap the oil and gas.



The delta is riddled with wells which cluster on the faults.





The cross section shows how the downthrown block of a fault causes hot spots of wetland loss.

Animation of Marsh Loss Due to Faulting (Oil Wells?)

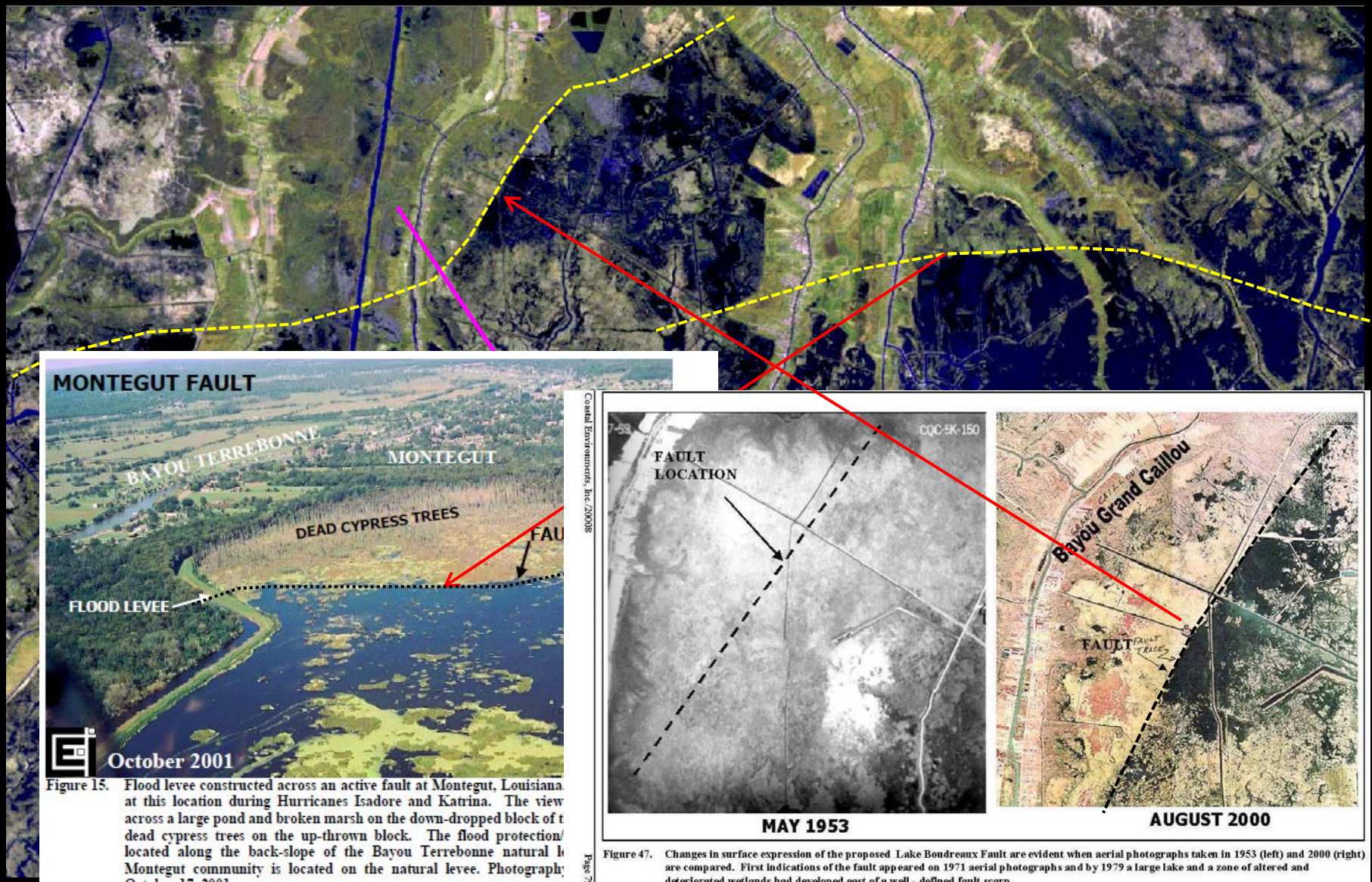


Figure 15. Flood levee constructed across an active fault at Montegut, Louisiana at this location during Hurricanes Isadore and Katrina. The view across a large pond and broken marsh on the down-dropped block of t dead cypress trees on the up-thrown block. The flood protection/ located along the back-slope of the Bayou Terrebonne natural l Montegut community is located on the natural levee. Photography October 17, 2001.

Figure 47. Changes in surface expression of the proposed Lake Boudreaux Fault are evident when aerial photographs taken in 1953 (left) and 2000 (right) are compared. First indications of the fault appeared on 1971 aerial photographs and by 1979 a large lake and a zone of altered and deteriorated wetlands had developed east of a well - defined fault scarp.

Coastal Environments, Inc./2008

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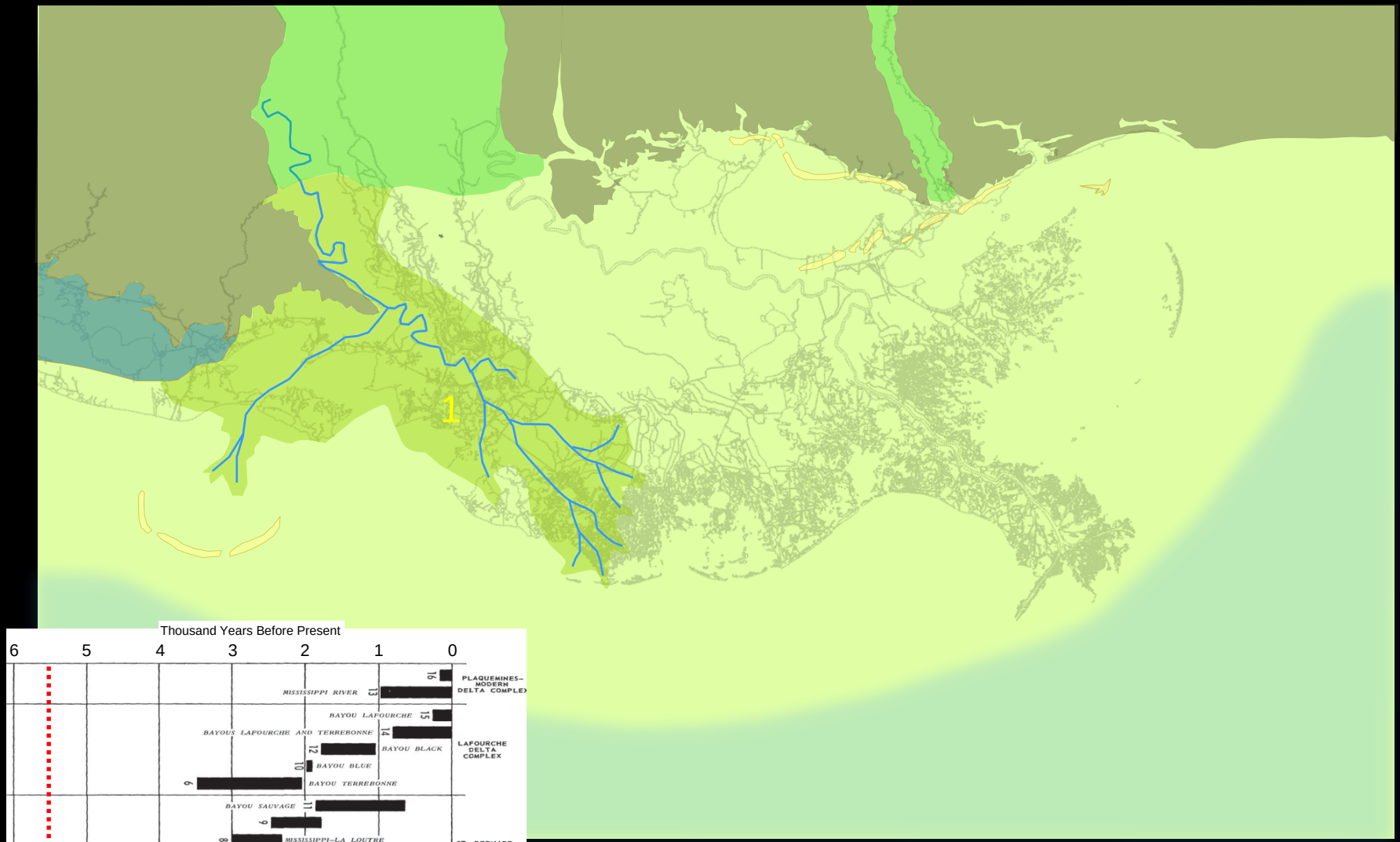
GAGLIANO, et.al., 2003

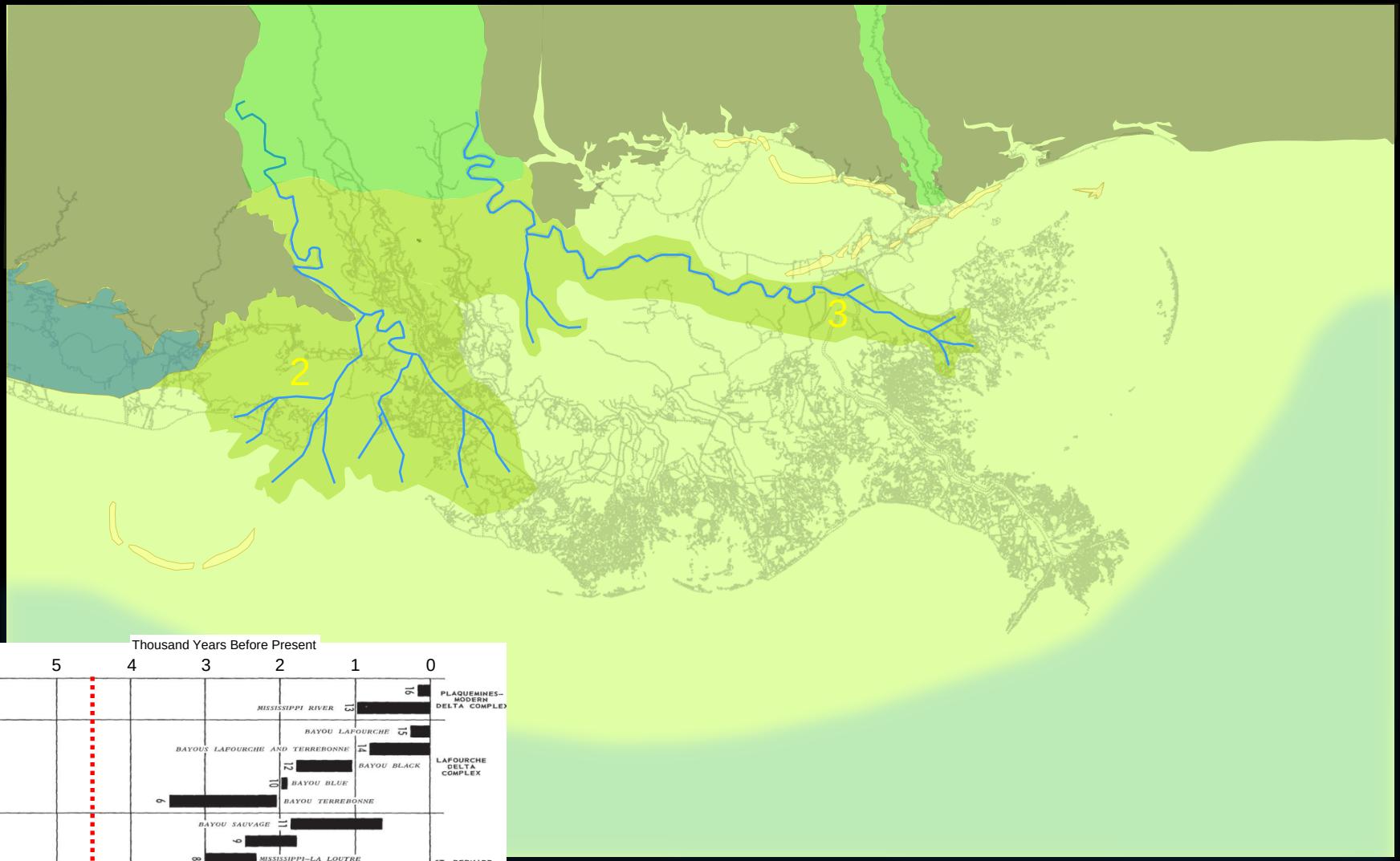
The Evolution of the Modern Delta in Human Terms

Watch the delta lobe east of New Orleans (St. Bernard) wax and wane before there is a single levee built.

5,500
years before present

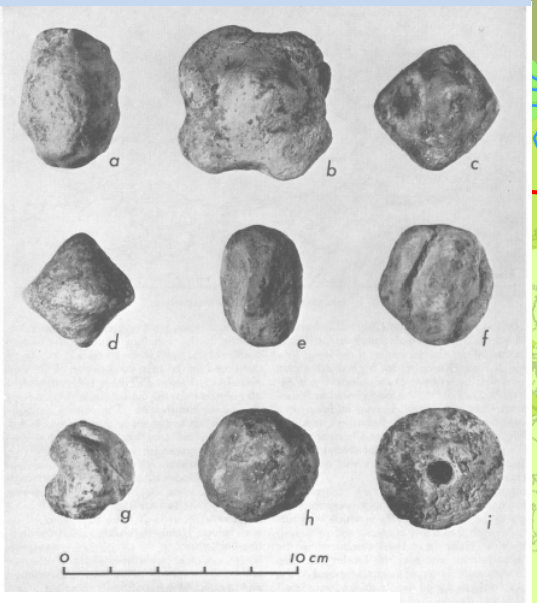


4,500
years before present

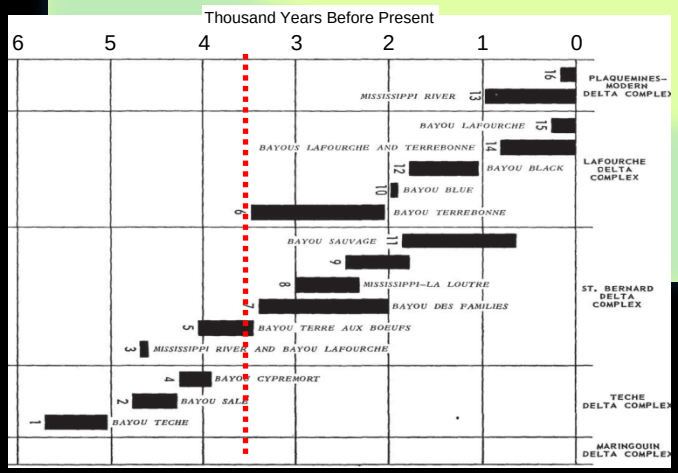


3,500
years before present

Linsley Archeological Site
Poverty Point objects ca. 1700 BC



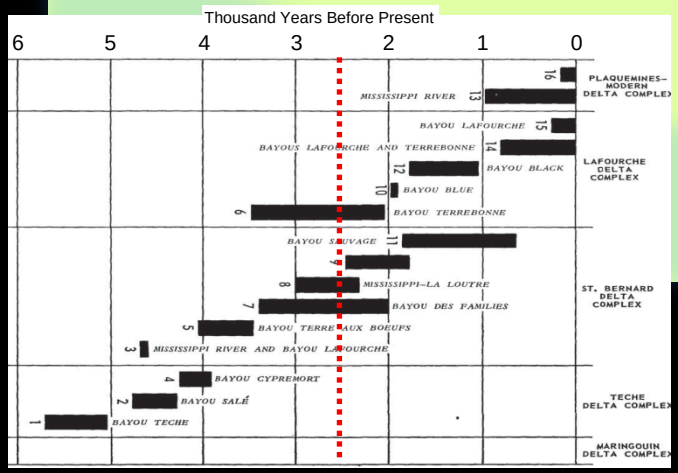
GAGLIANO & SAUCIER, 1963

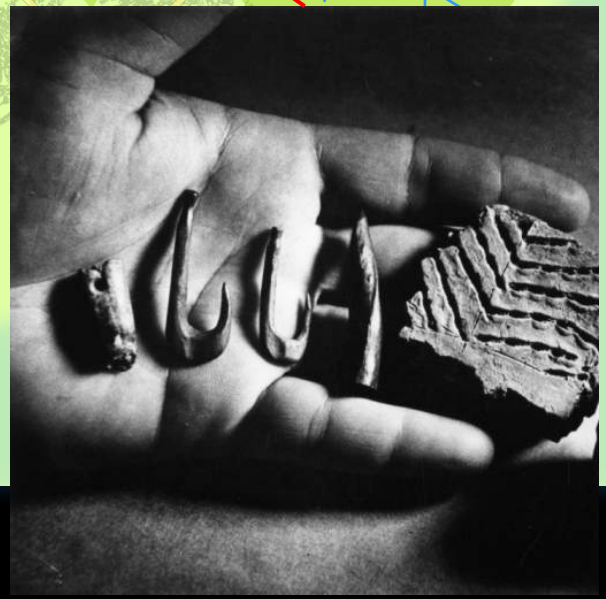


2,500
years before present

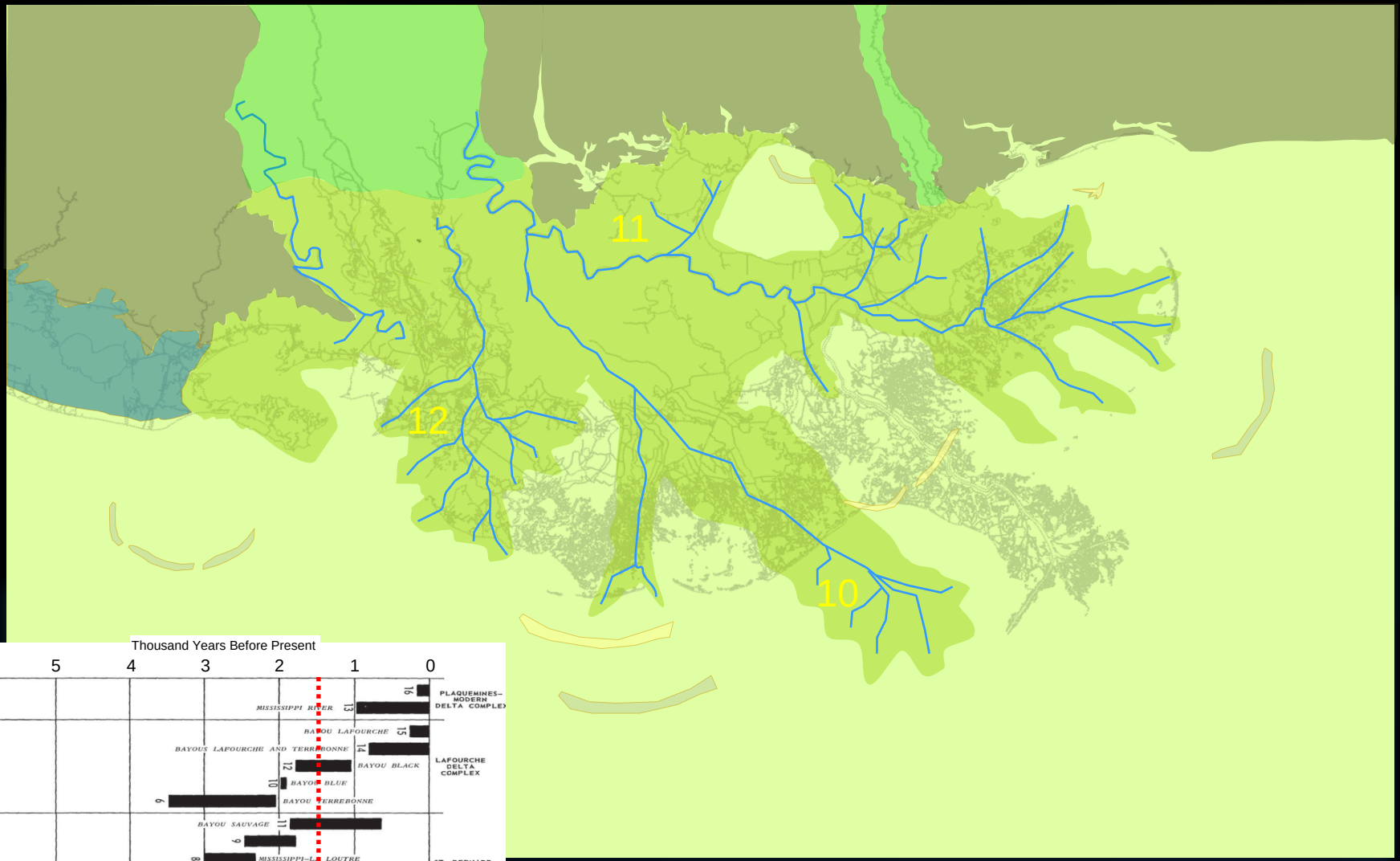
Bayou Jasmine Archeological Site
Twinned bag ca. 800 BC

LSU TEXTILE MUSEUM

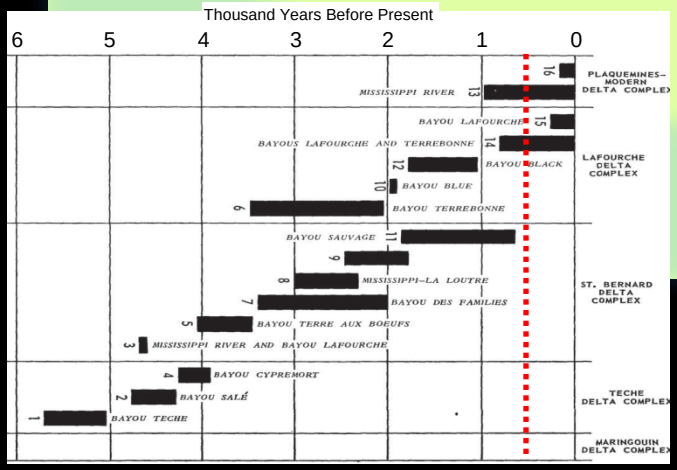




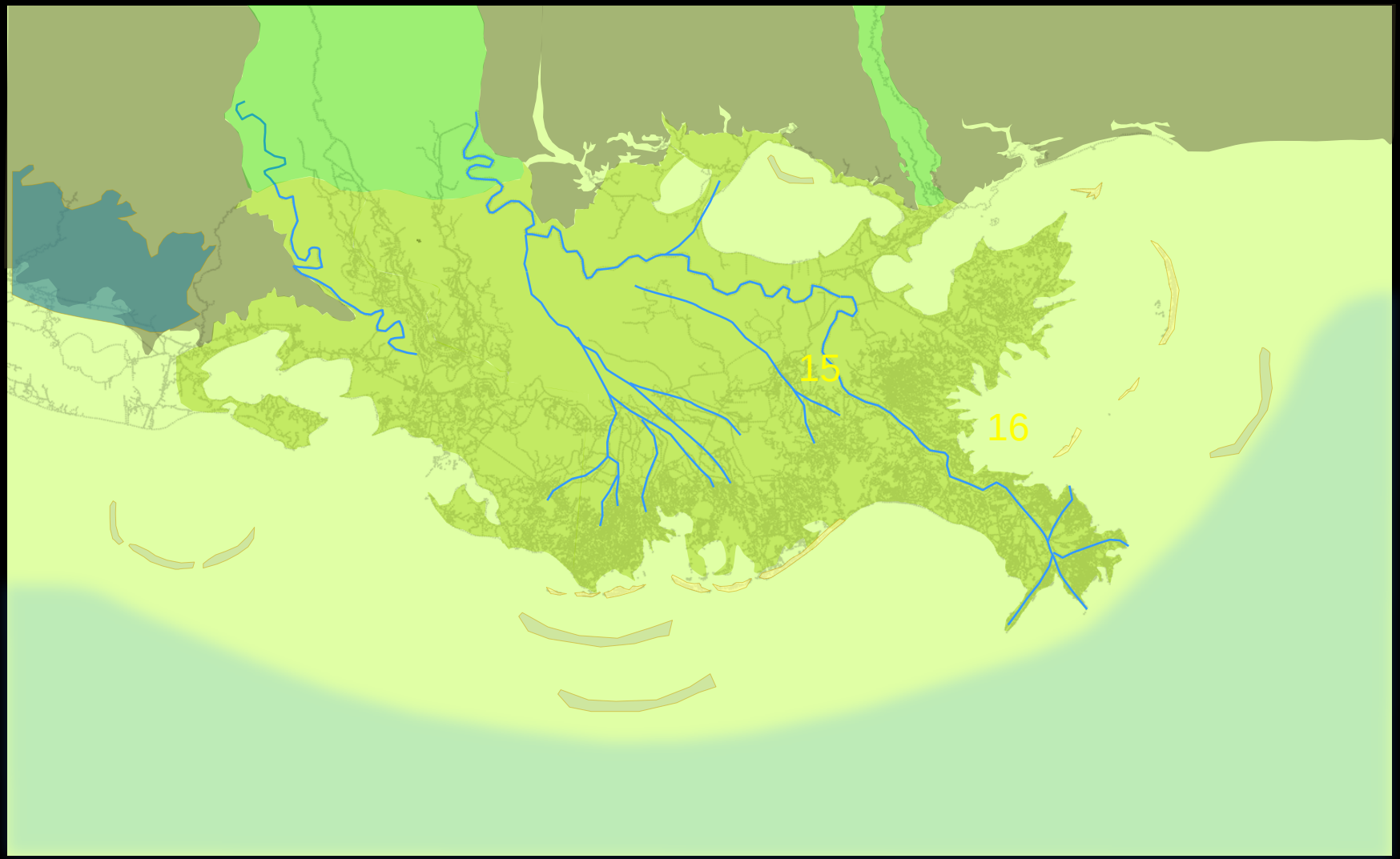
1,500
years before present



500
years before present



Today - Levees and the Old River Control Structure Prevent the River from Abandoning New Orleans



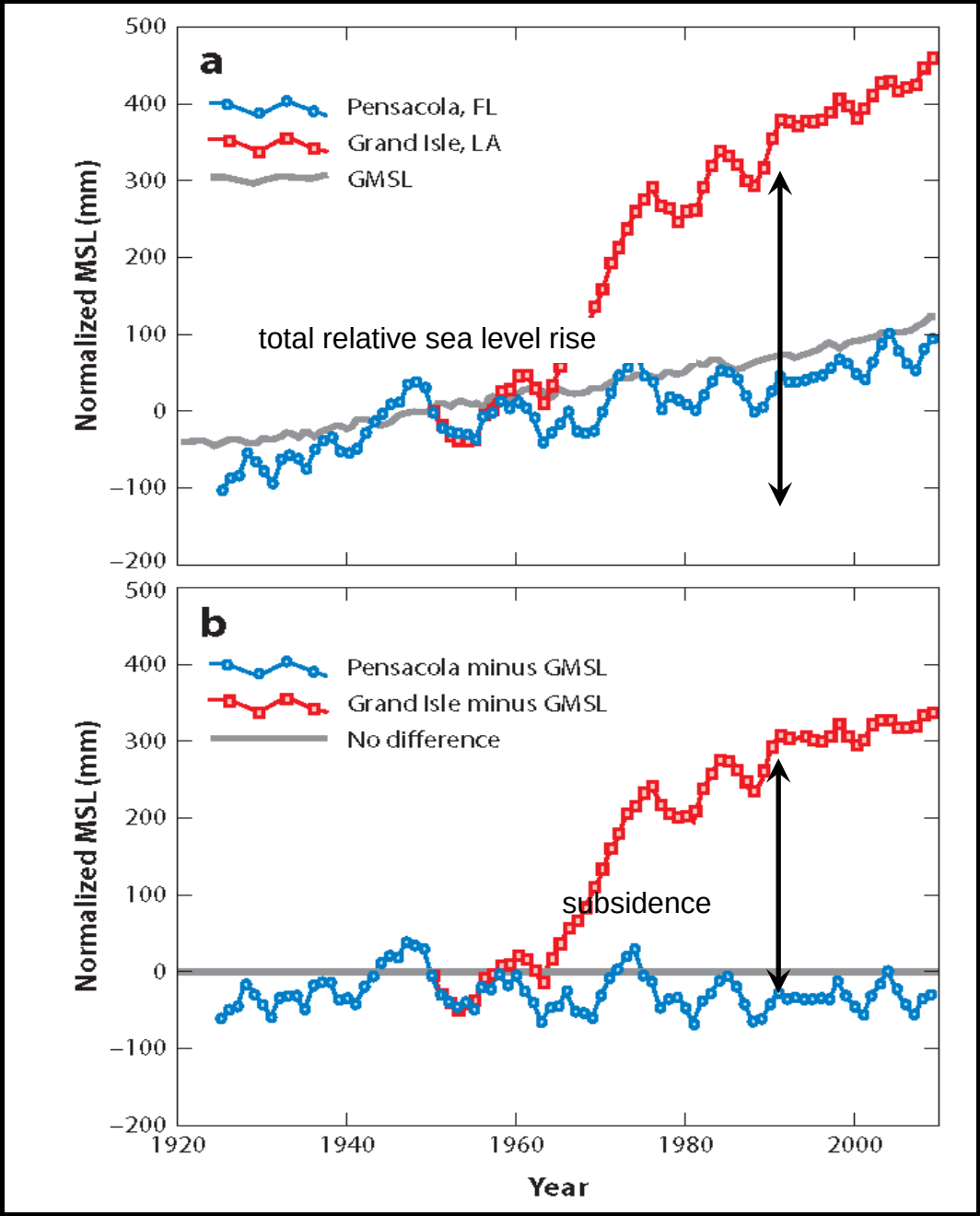
Quantifying Subsidence

The Subsidence that Created the Mississippi Basin is Always Working

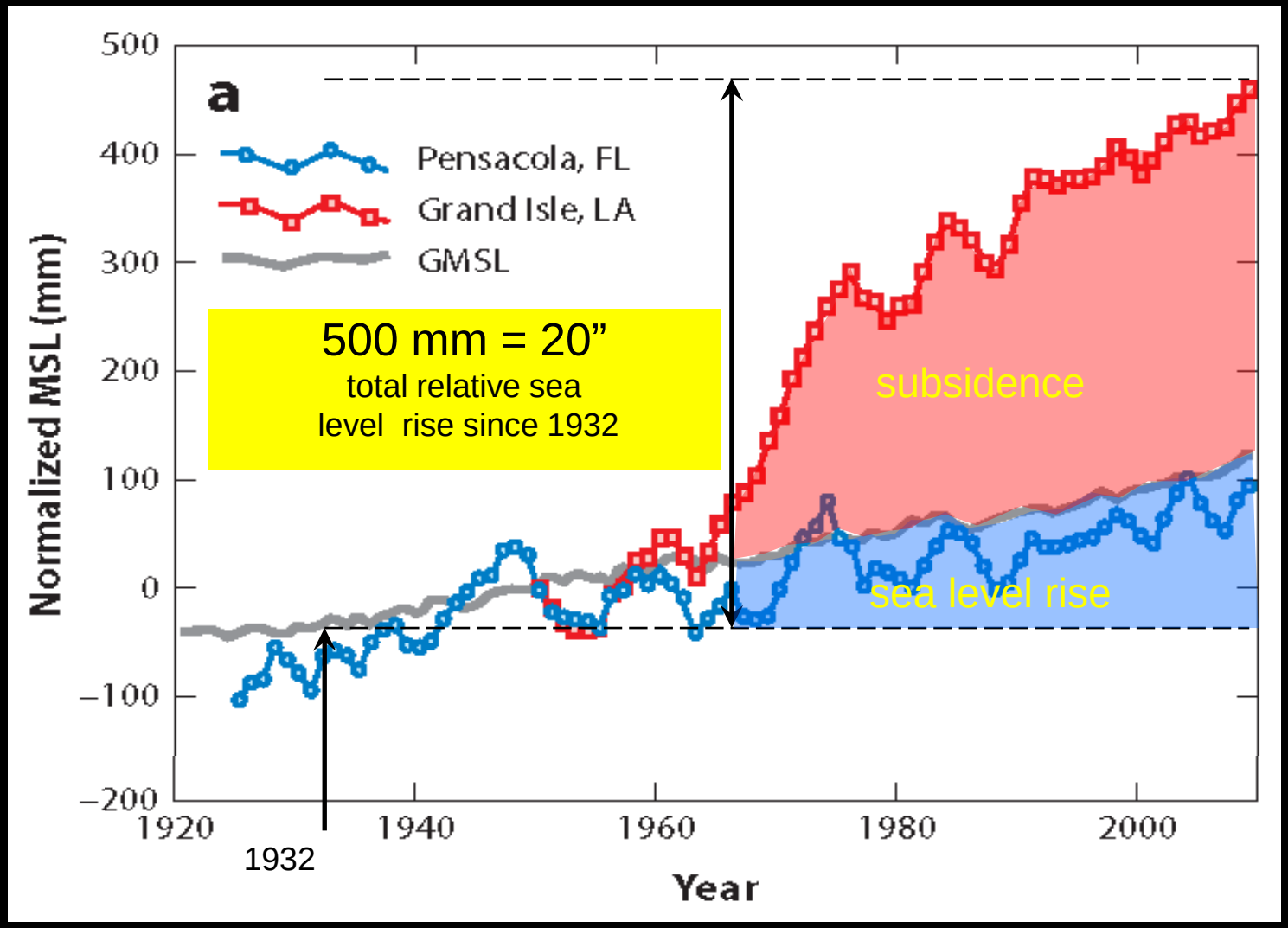
Relative sea level from tidal gauge data.

Blue is Pensacola, FL (stable)

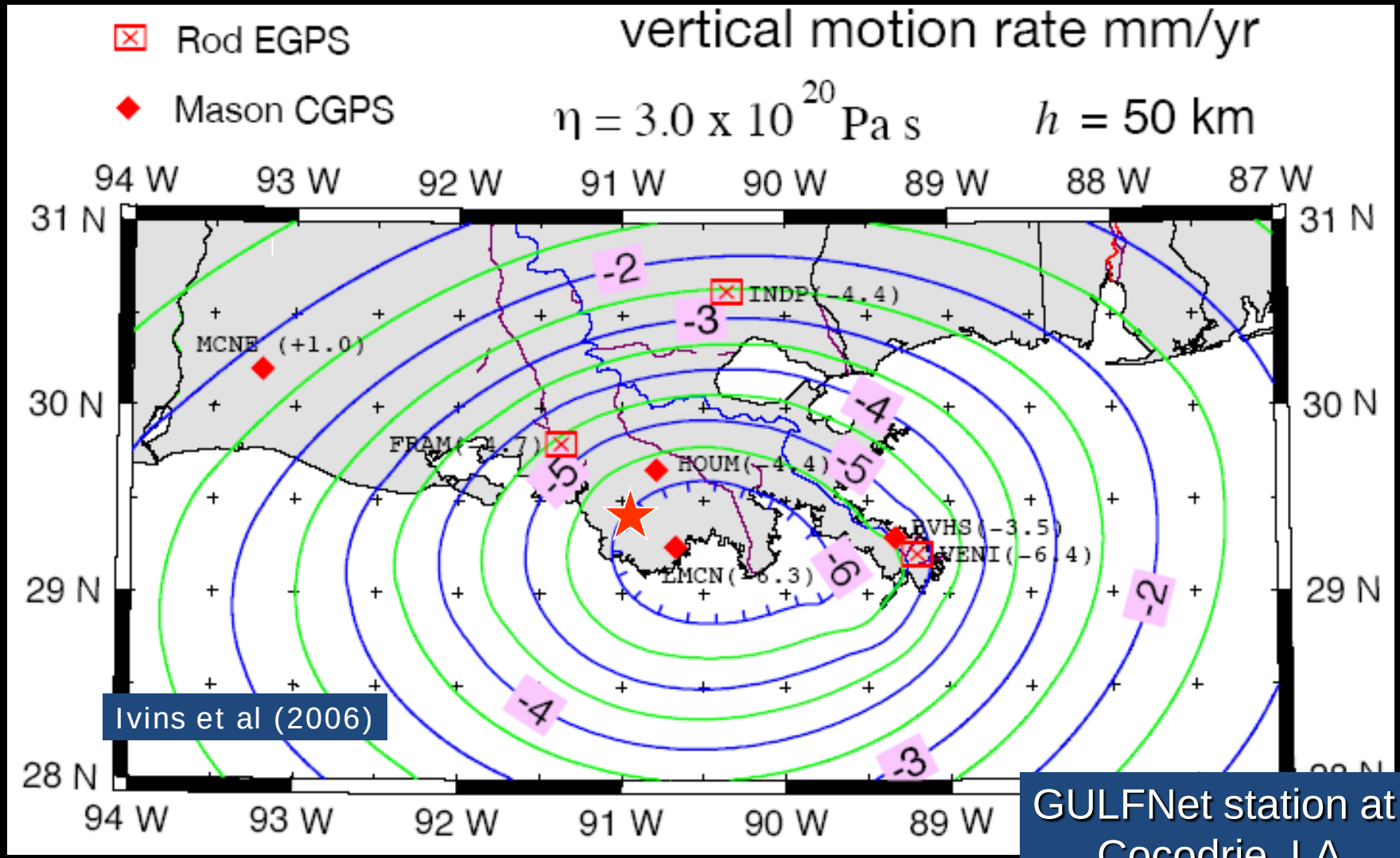
Red is Grand Isle, LA (subsiding)



20” of Relative Sea Level Rise at Grand Isle Since 1932



Subsidence by CORS GPS, ***excluding*** faulting.



Today – Continued Loss of Land, but No New Lobe Because the River is Trapped


Port Fourchon

1932

Grand Isle

LA-1 Expressway

Gulf of Mexico

Port Fourchon

GILL, 2013

2010

Grand Isle

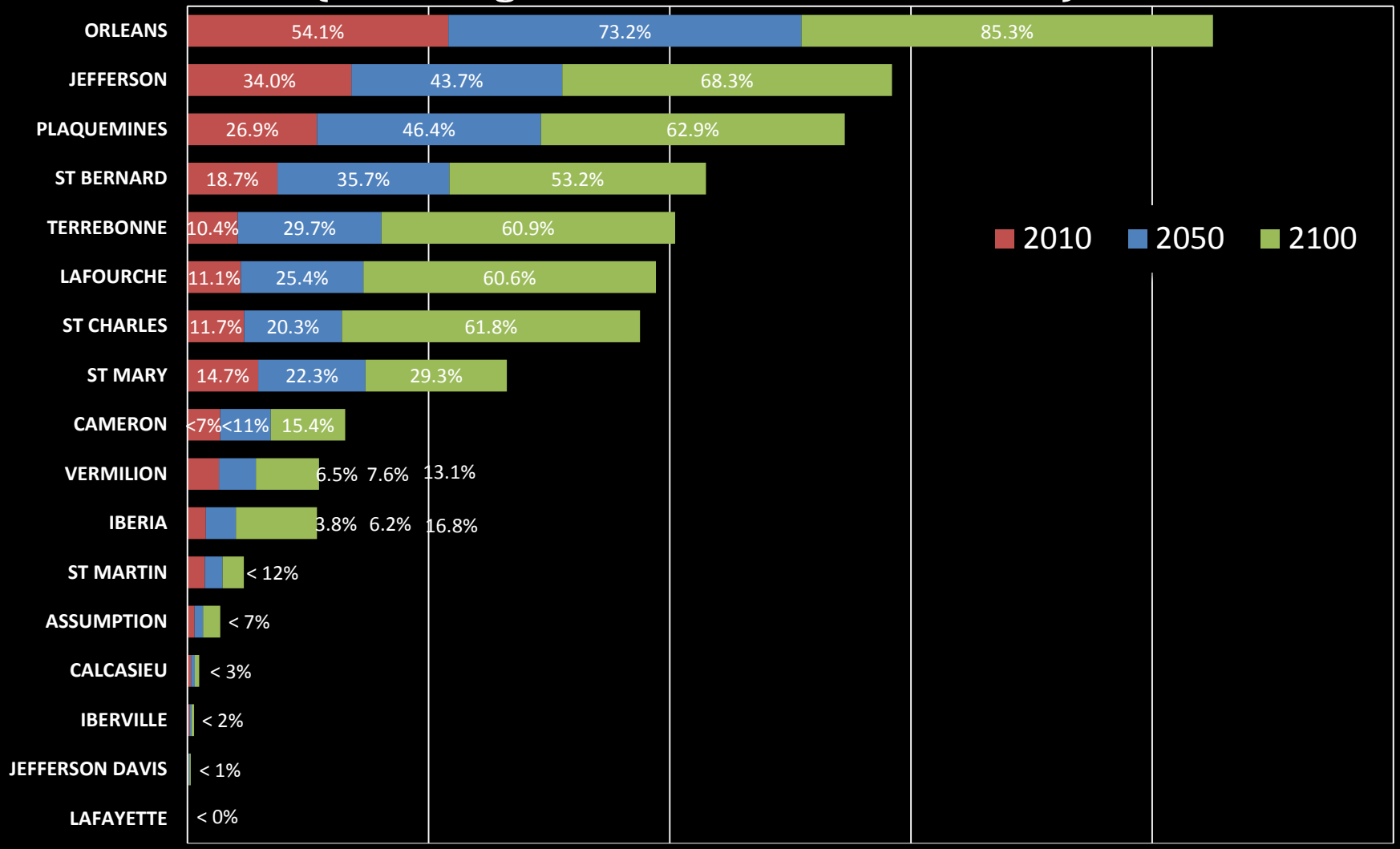
LA-1 Expressway

Gulf of Mexico

Port Fourchon

GILL, 2013

Percent Land Below Sea Level by Parish Through 2100 (assuming no increase in sea level rise)



Did Land Loss Start in 1932?

Coastal Land Area Change since 1932

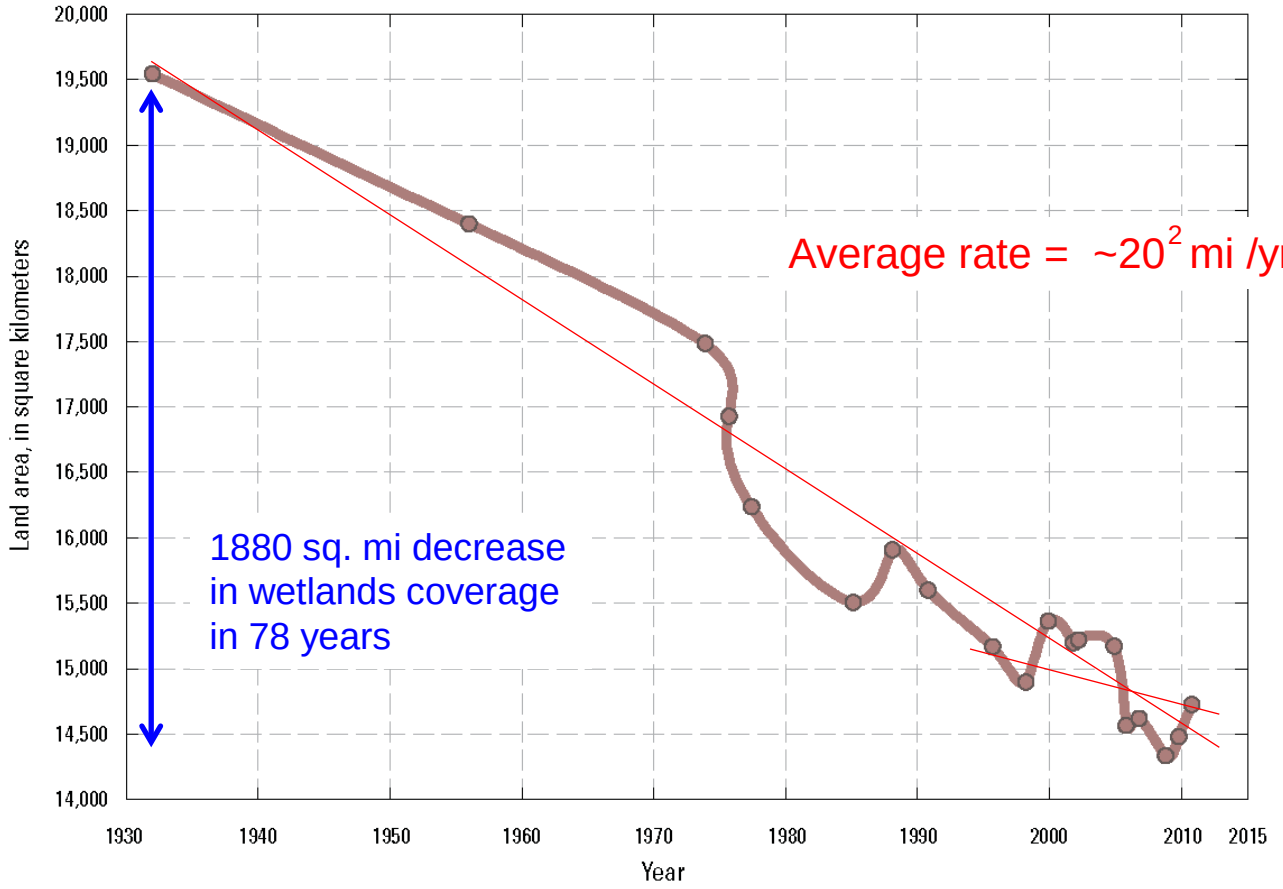
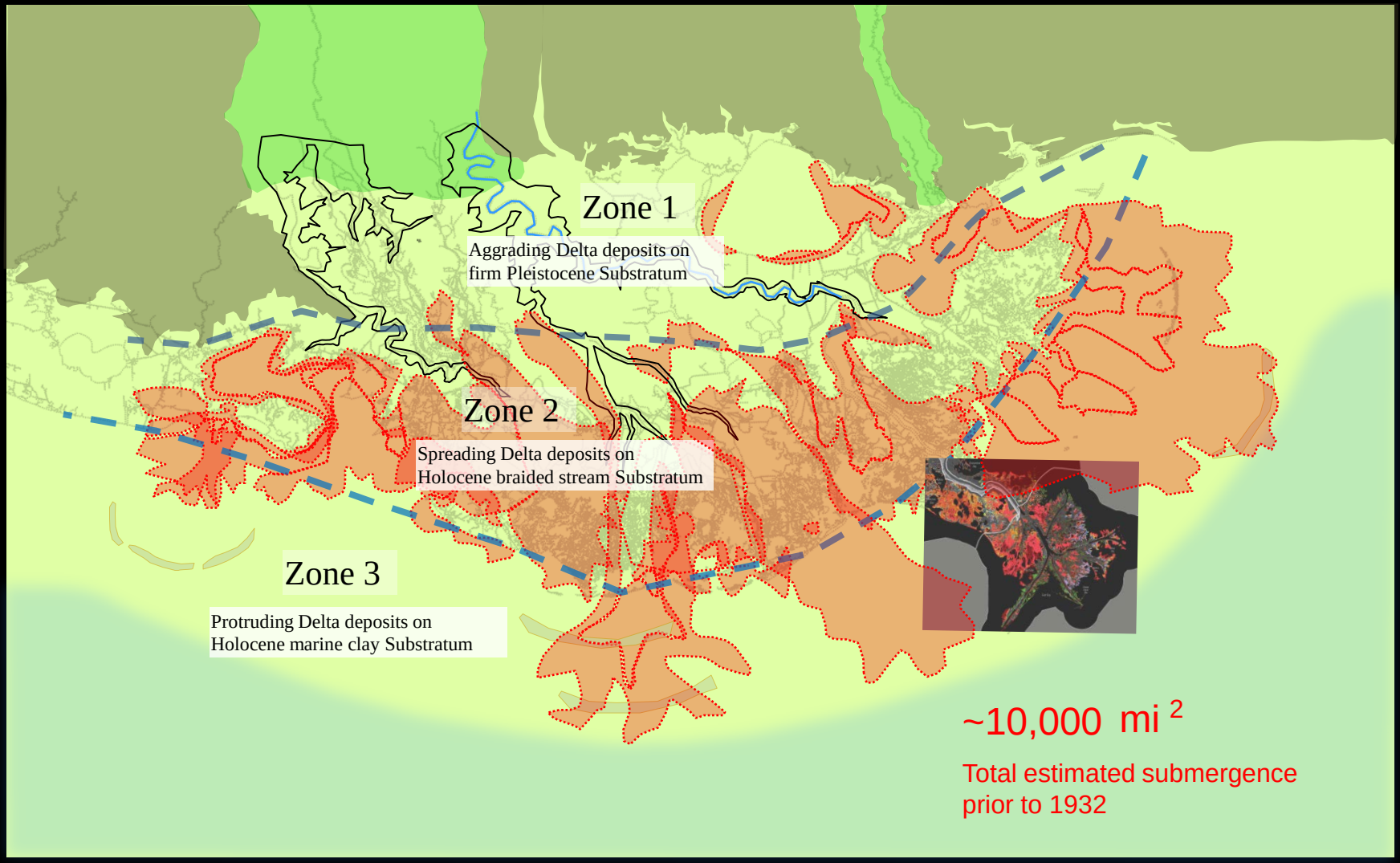


Figure 25. Time series of land-area changes in coastal wetlands of Louisiana, 1932 to 2010 (modified from Couvillion and others, 2011).

USGS, ALEXANDER, et.al., 2012

Land Lost before 1932

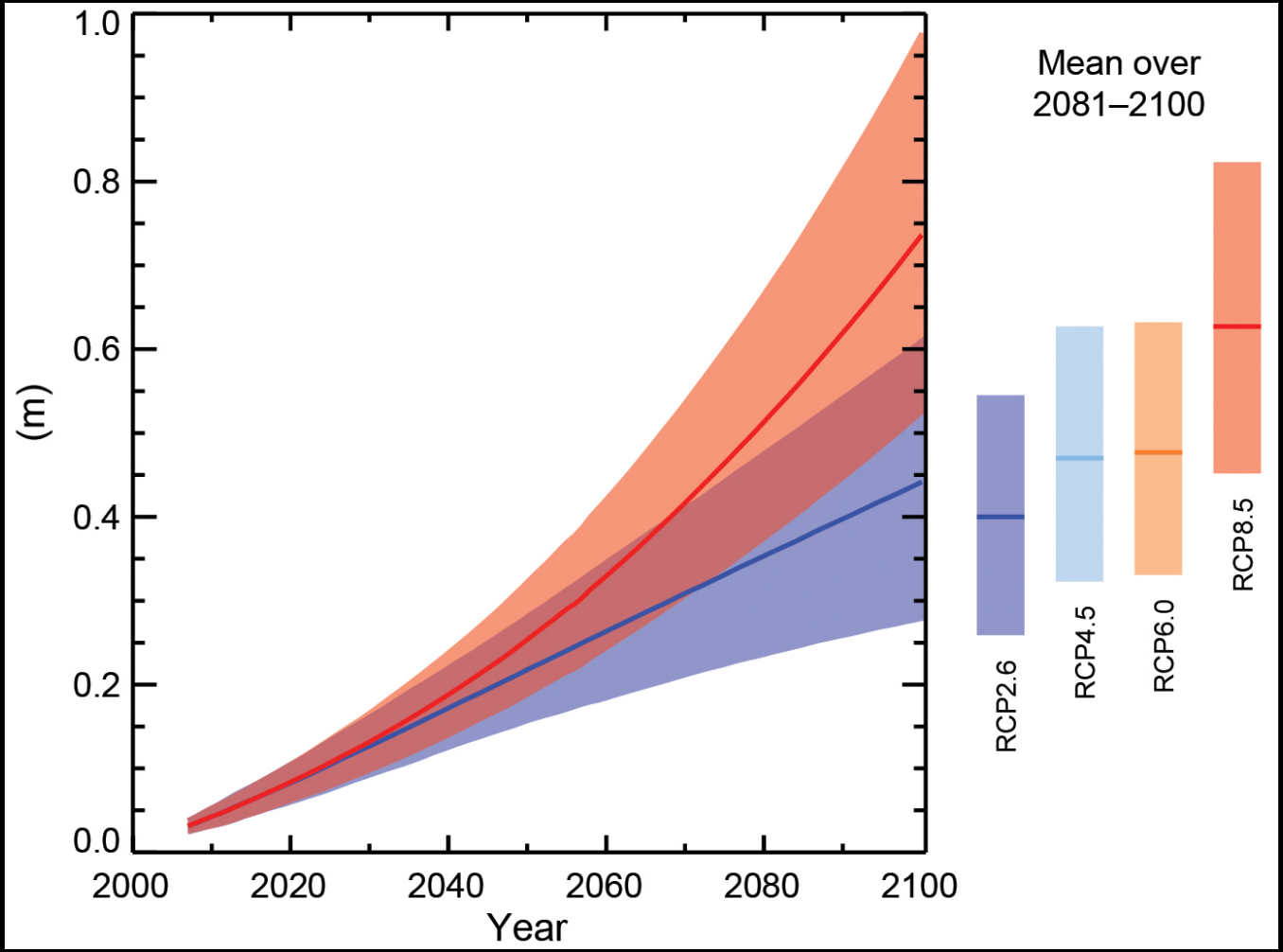


This land was lost without human intervention

The Effect of Global Warming

As Sea Level Rises Faster, the Coast Must Retreat.

IPCC Sea Level Projections



The Impact of Global Warming on Coastal Restoration

- Without sea level rise, it would be technically, if not politically, possible to increase sediment and slow the delta loss in some places.
  - This would require removing the levees and dams, flooding every river city and ending navigation.
- With increasing sea level rise, the coast will retreat inland, no matter what is done.

Conclusion
Restoration Schemes are not Sustainable

- Looking back at the geologic and paleoclimate data shows that the Mississippi Delta must recede with the rising sea level that is already baked into current levels of GHGs.
- Coastal restoration schemes and attempts to shift the blame for land loss to localized actors deny the long term reality of climate change on the Mississippi Delta.

Extra Slides for Discussion

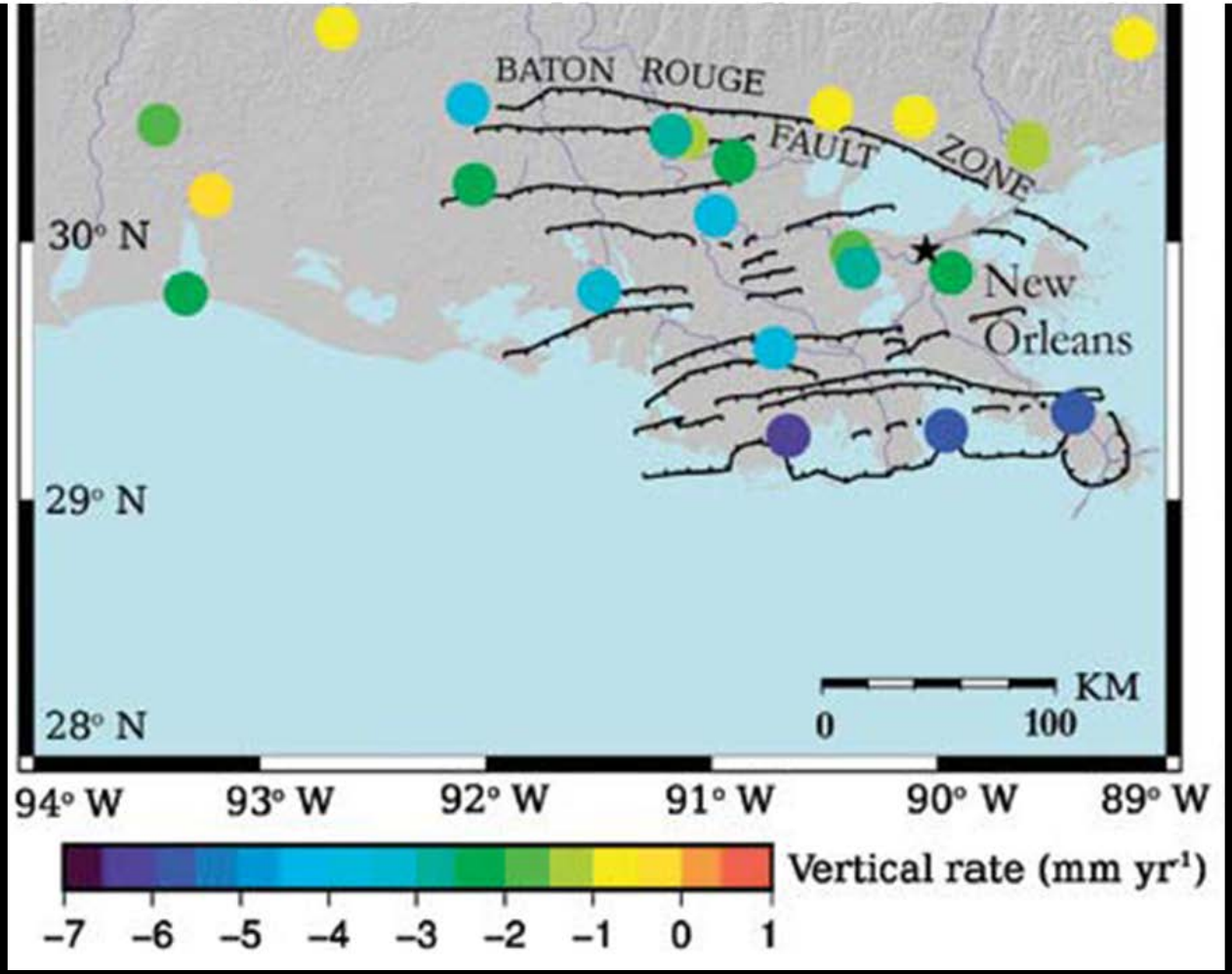
MRGO


Bayou Sauvage National Wildlife Refuge
90
10
Lake Borgne
610
Metairie
New Orleans
Meraux
Biloxi State Wildlife Management Area
Chandeleur Sound
Marrero
90
Violet
Timberlane
St Bernard
Woodmere
Jean Lafitte
onal Historical...
Gulf of Mexico
Black Bay
Little Lake

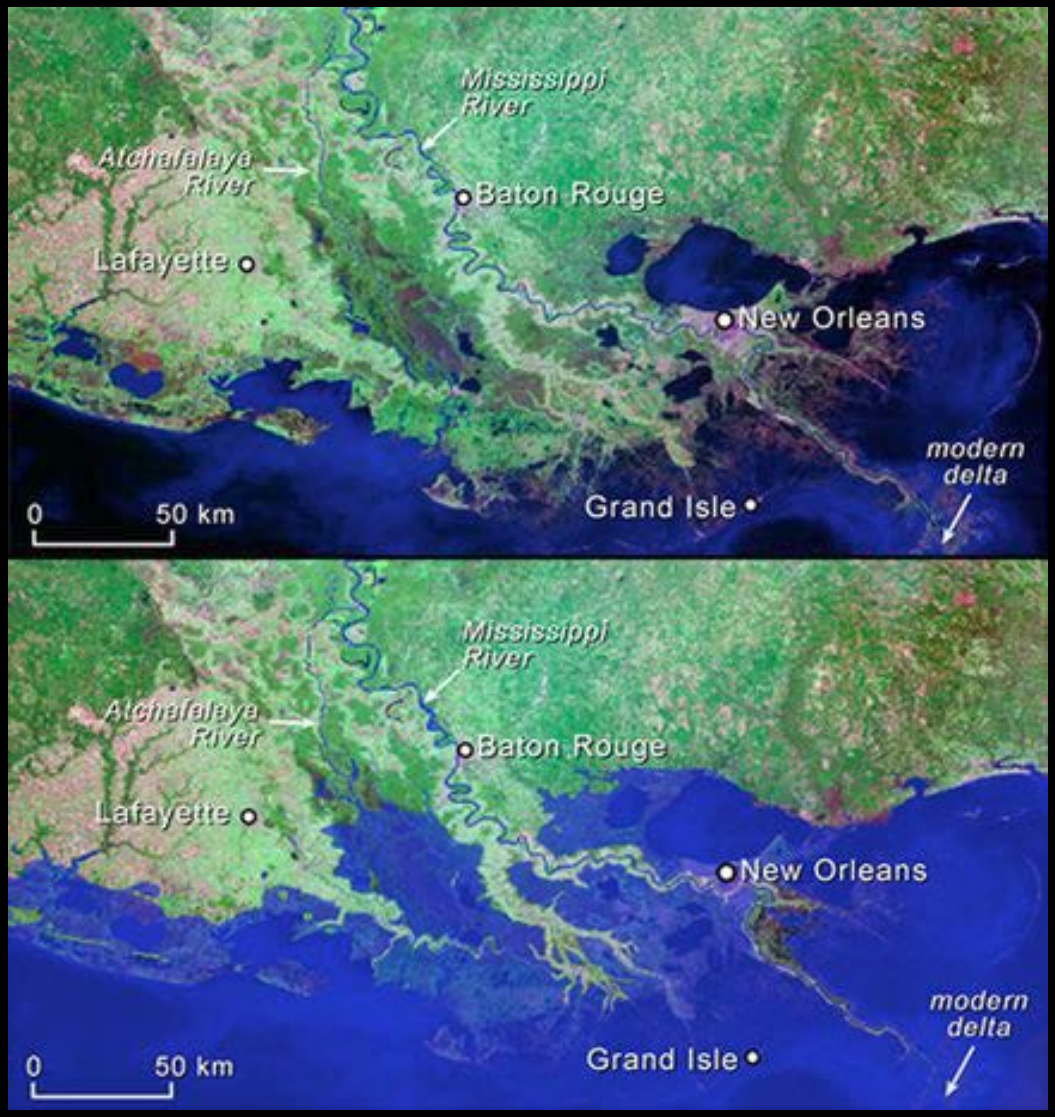
Geology, published online on 27 April 2015 as doi:10.1130/G36598.1

A three-dimensional surface velocity field for the Mississippi Delta: Implications for coastal restoration and flood potential

Makan A. Karegar, Timothy H. Dixon, and Rocco Malservisi



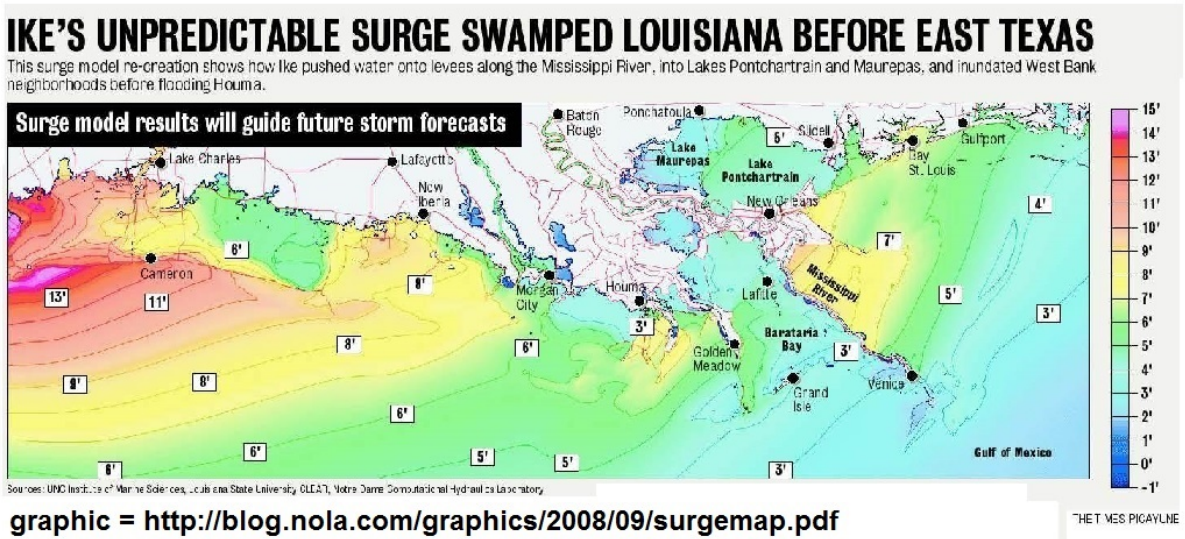
2100 – Minimum Sea Level Rise + Subsidence (subsidence + sea level rise = 1 meter)



Ike Compared to 2100

Blum & Roberts 2009 prediction of the coast of La in 2100; sea level rise plus sediment deficit

Figure 3b in *Nature Geoscience* 2, 488 - 491 (2009); online: 28 June 2009 | doi:10.1038/ngeo553



graphic = http://blog.nola.com/graphics/2008/09/surgemap.pdf

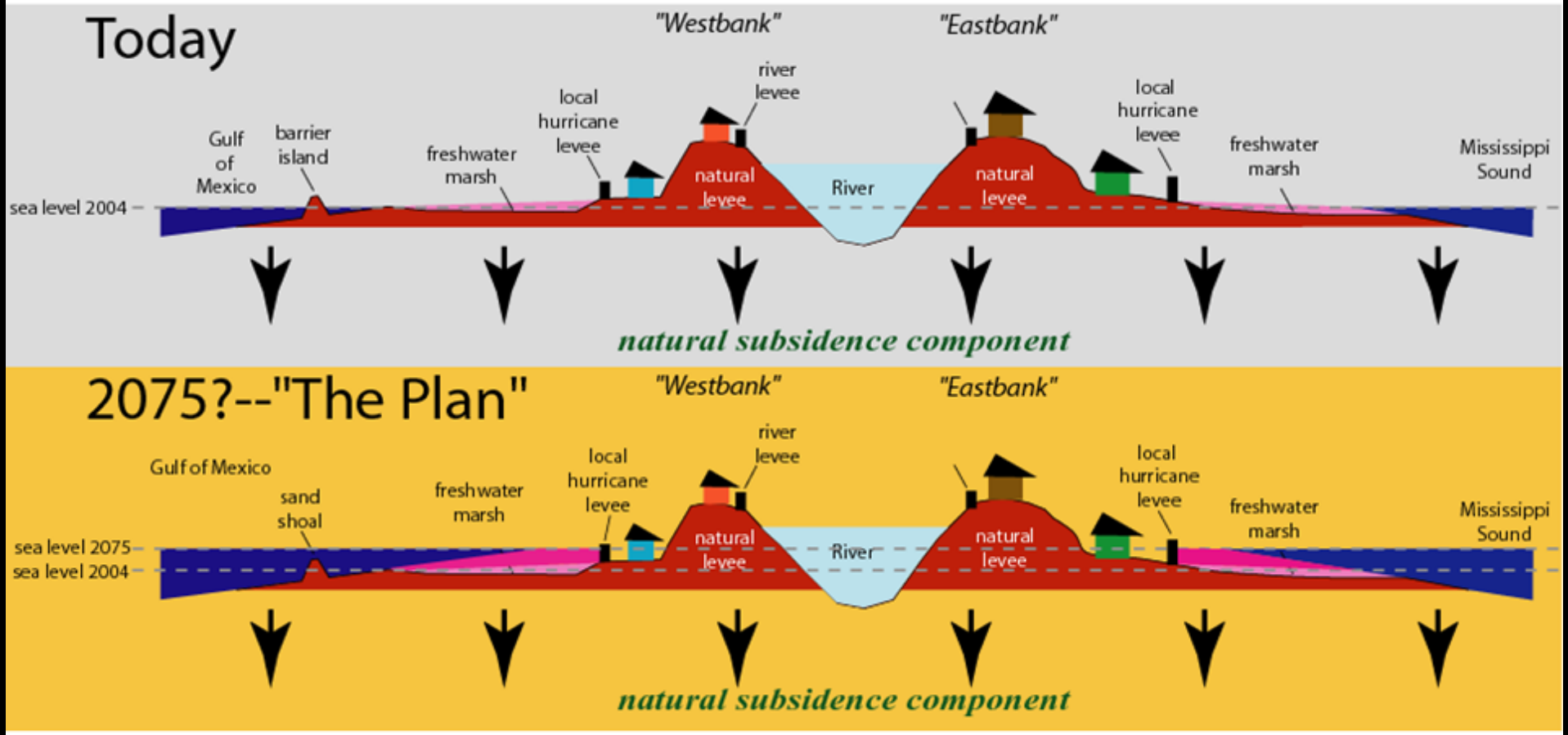
Ike tracked parallel to La coast; eye did not get within 225 miles of Ponchatoula, N shore of Lake P.

(Typo corrected by KMH on 27 Sep 08)

The Lesson of the Delta and Climate Cycles

- The land that is lost is just a thin veneer on the real delta.
- The loss of sediment from levees and dams has hastened the loss of land but delayed the clogging of the Mississippi main channel.
- This natural process cannot be reversed.
- Sea level rise will push the coast inland.

Current plans to save the Coast are focused on fixing the wetlands



Even if the wetlands could be restored, the coastal communities will continue to sink below sea level. Storms will ultimately make these communities uninhabitable.