Holocene Lower Mississippi River Avulsions: Autogenic Versus Allogenic Forcing*

Eric Prokocki[1,2]

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[1,2]Geology, University of Illinois (Champaign-Urbana), Urbana, IL; Geology, Louisiana State University, Baton Rouge, LA (ewaschle@yahoo.com)

Abstract

Optically stimulated luminescence (OSL) dates coupled with paleohydrological estimations conducted on lower Mississippi River (LMR) meander belts provide new insight into the Holocene avulsion history of the LMR. At least four avulsions of the LMR occurred within the Yazoo Basin, MS, and lower St. Francis Basin, AR, between ca. 9.19 ka to the present; these are inferred to have initiated at: (i) ca. 8.6 ka, (ii) ca. 7.6 ka, (iii) ca. 5.0 ka, and (iv) after ca. 4.21 ka. These avulsions created four distinct abandoned meander belts presently preserved within the Yazoo Basin (referred to as Stage 4 - Stage 1 LMR meander belts). The avulsion nodes (point of channel bifurcation) are all located between ~ 200 to 400 kilometers north of Baton Rouge, LA. Therefore, these avulsions are spatially far removed from the immediate effects of rapid rates of sea-level rise occurring from ~ 9.19 to 5.0 ka. Two of the four avulsions were initiated after the rate of sea-level rise began slowing at ca. 5.0 ka, thus suggesting these avulsions are unlikely to be primarily driven by sea-level rise forcing vertical aggradation of alluvial ridges via channel backfilling beyond suggested geomorphic threshold values. Climatic evidence supported by paleohydrological estimations suggests that all four identified avulsions initiated during inferred periods of increased precipitation throughout the lower Mississippi River drainage basin, causing more frequent overbank flooding events. Thus, allogenic controls on sediment supply and discharge have played a more important role in driving avulsions of the LMR during the Holocene than initially theorized.

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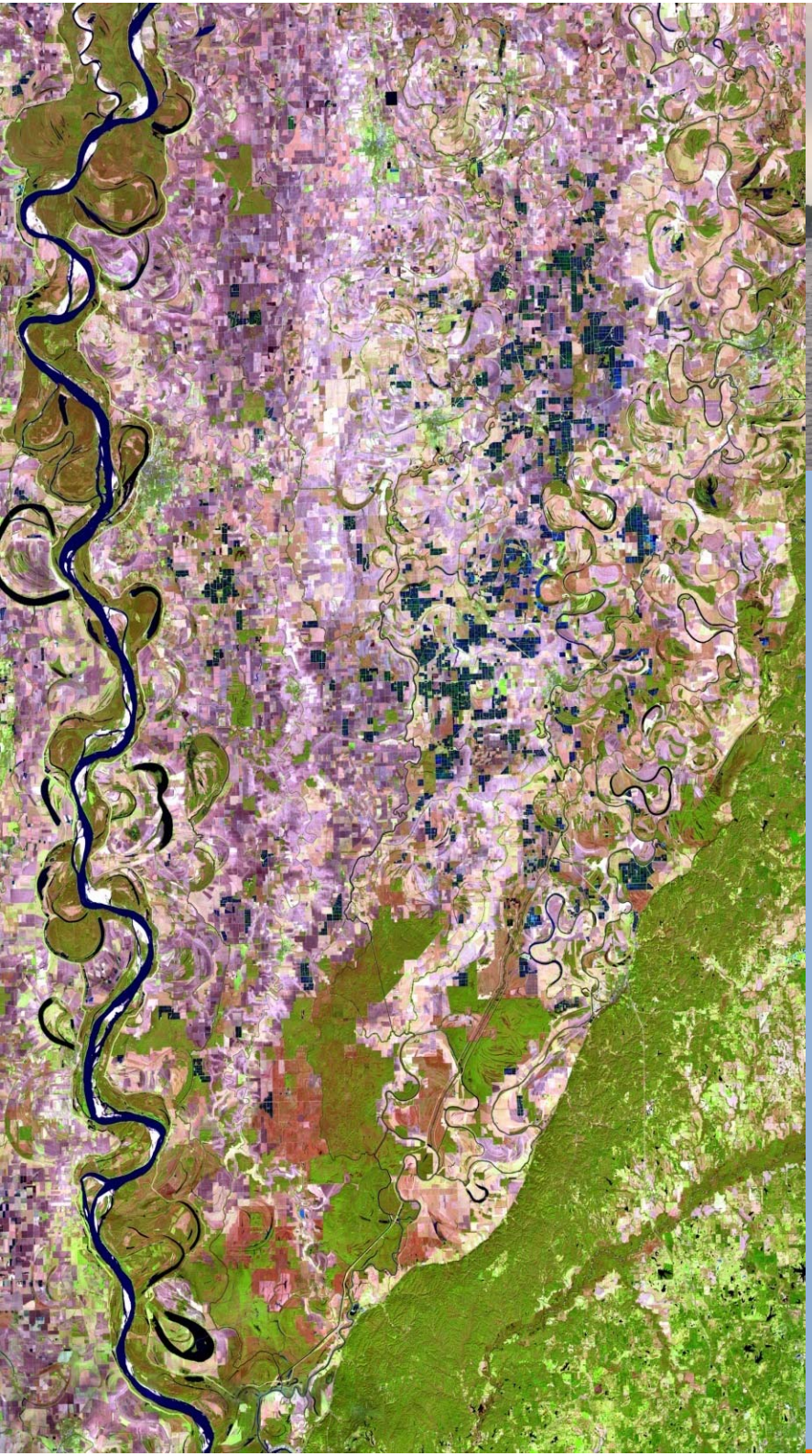
Holocene Lower Mississippi River Avulsions: Autogenic vs. Allogenic Forcing

Eric Prokocki[1,2]

1. University of Illinois (Champaign-Urbana) - Department of Geology
2. Louisiana State University - Department of Geology



Objectives

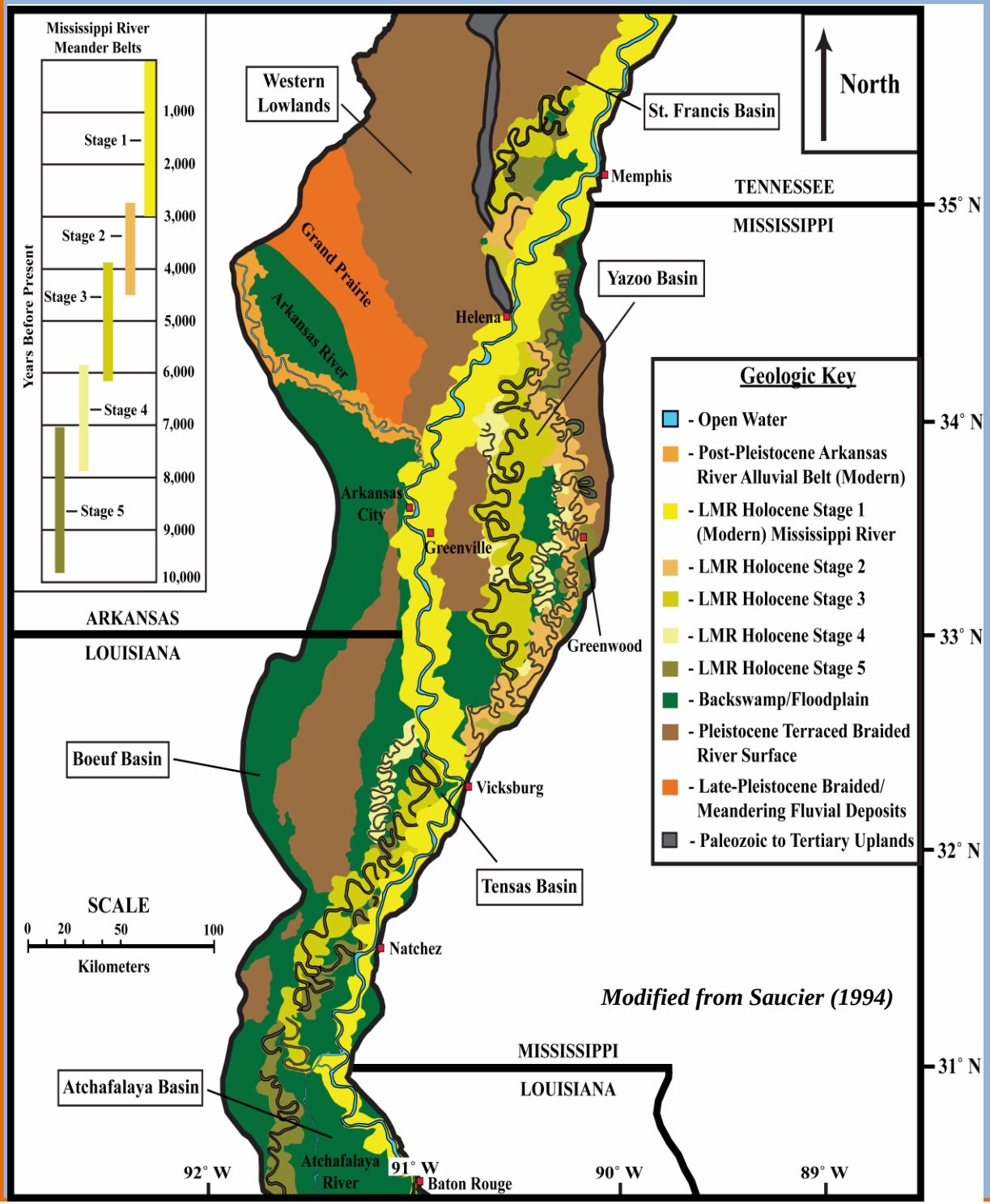
1) **Determine the Timing of Activity of Holocene LMR Alluvial Belts (Yazoo Basin, MS)**

2) **Examine the Role of Allogenic and Autogenic Forcing of Upstream Holocene Avulsions**

3) **Investigate the Possible Importance between Antecedent Pleistocene LMR Deposits and Locations of LMR Holocene Avulsions**

4) **Future Goals/Research Initiatives**

Timing of Activity: LMR Alluvial Belts



- Timing of Holocene Meander Belts from Saucier (1994) According to ^{14}C Dating

Active Belt - **Stage 1**
Stage 2
Stage 3
Stage 4

Oldest Belt - **Stage 5**

Problems Concerning Dates:

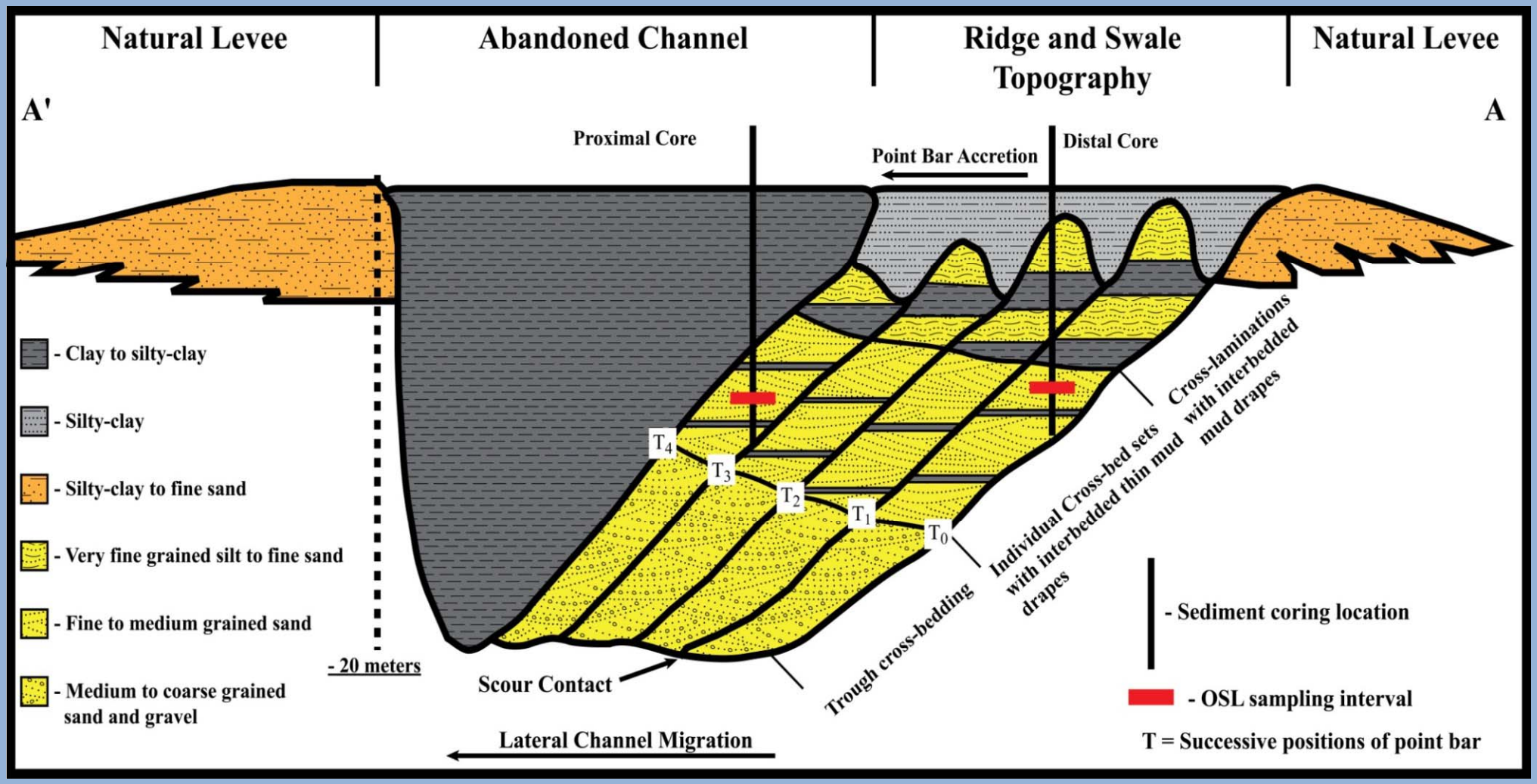
a) Few Acceptable Dates!!

b) Samples Suffer from Contamination of Lignite and Pleistocene Organic Material

c) Organics Derived from Anywhere in Drainage Basin (not in situ)

Problems Drive the Necessity of Secondary Dating Method!

Timing of Activity: OSL Dating of LMR Alluvial Belts



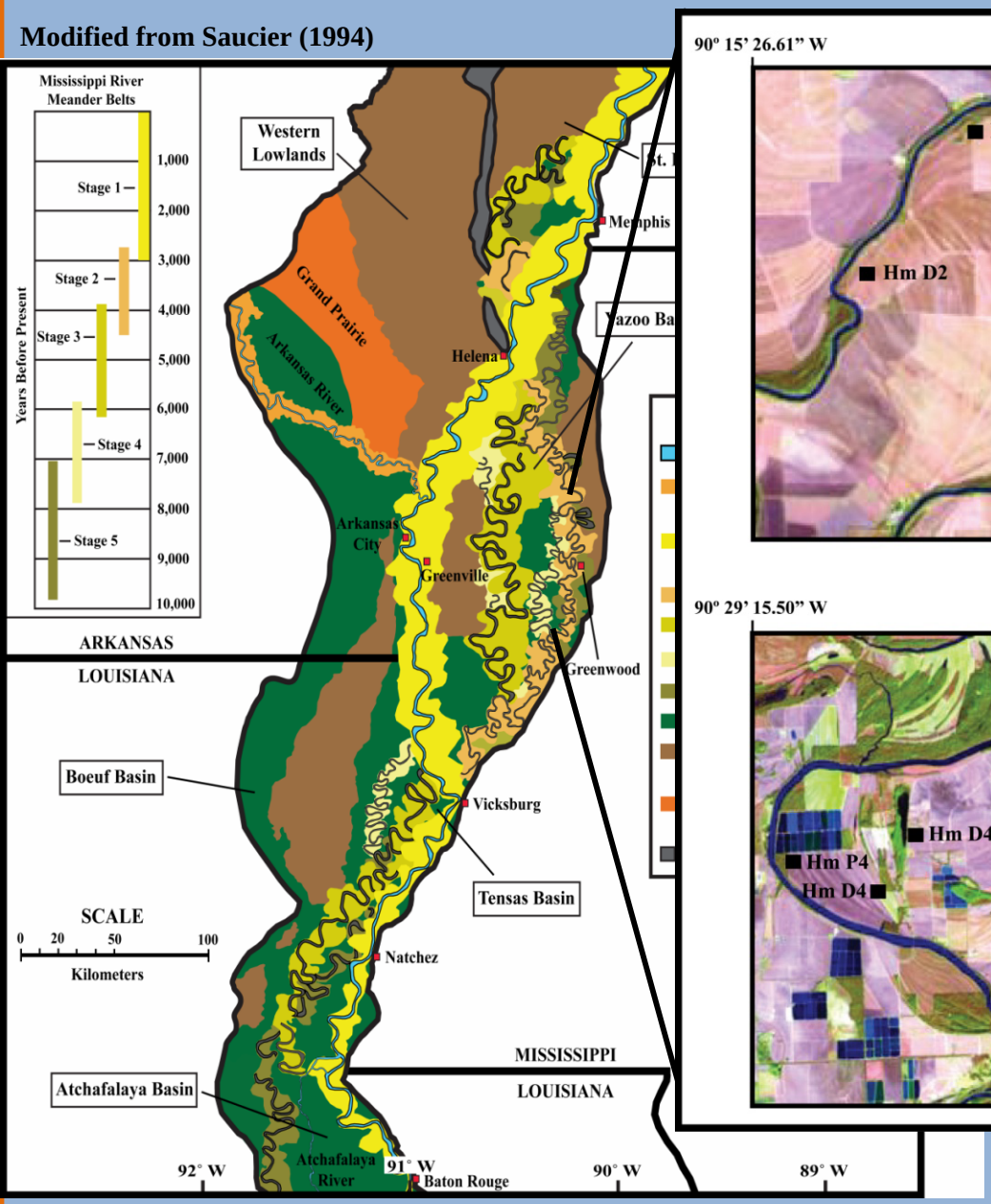
Modified from Saucier (1994), and Gagliano and van Beek (1970)

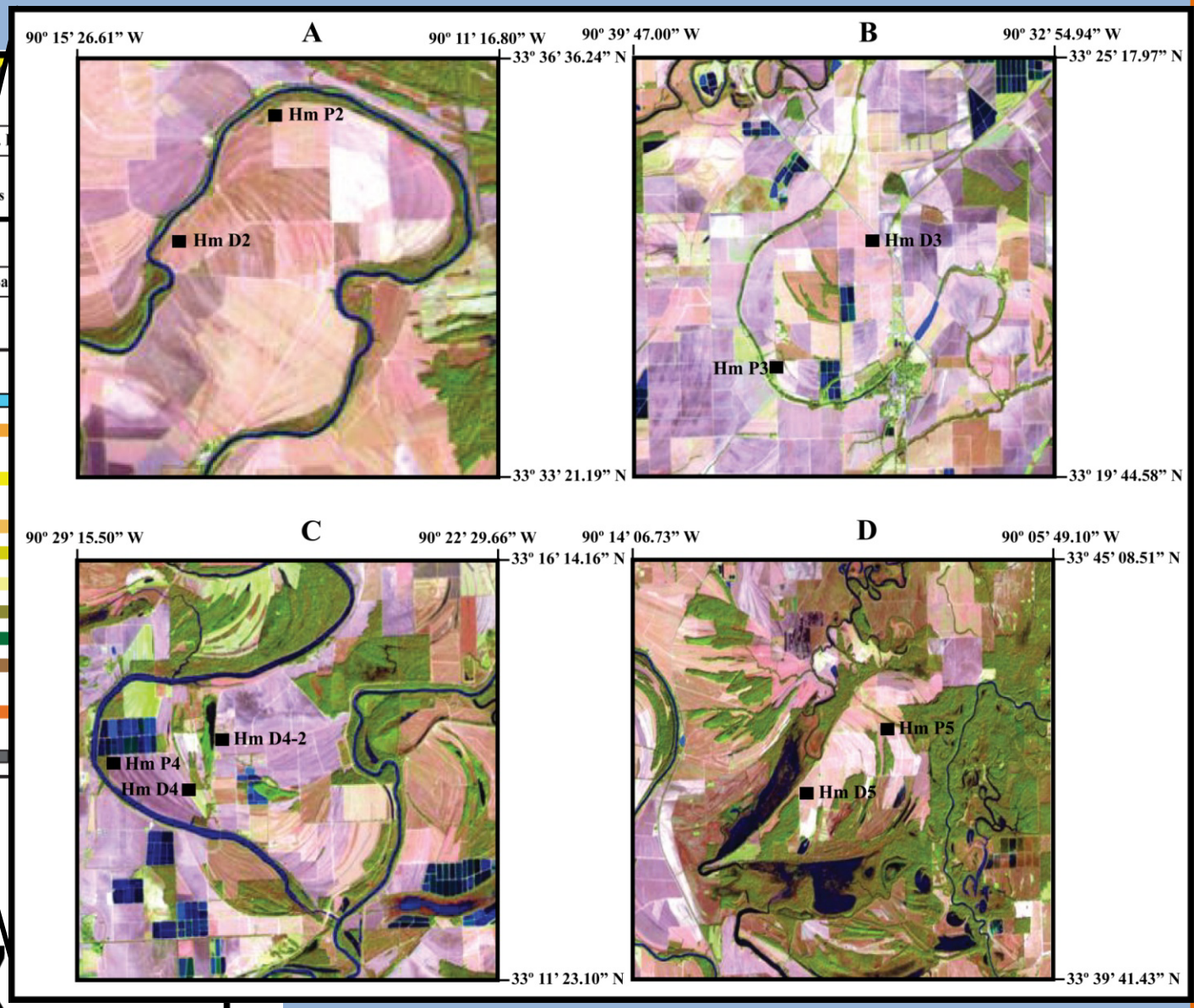
- Determine the Onset of Scroll Bar Deposition (T_0), and Subsequent Termination of Activity/Deposition (T_4)

- Sample from Youngest Cross-Bed Sets Determined from Core Analysis

Timing of Activity: OSL Dating of LMR Alluvial Belts

Modified from Saucier (1994)

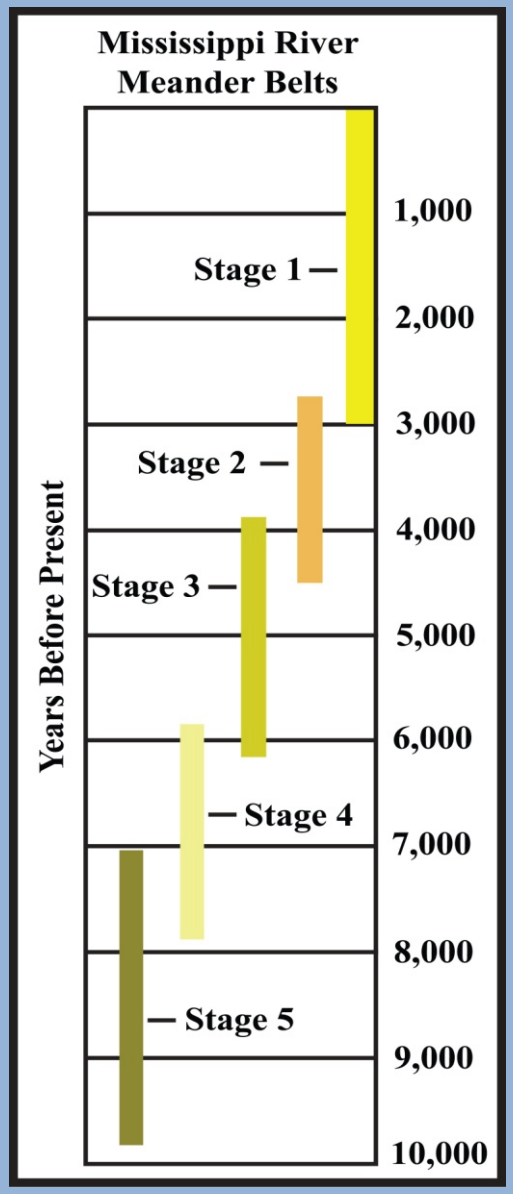




- **Specific Locations of OSL Sampling: (a) Stage 2 Belt , (b) Stage 3 Belt , (c) Stage 4 Belt , (d) Stage 5 Belt**

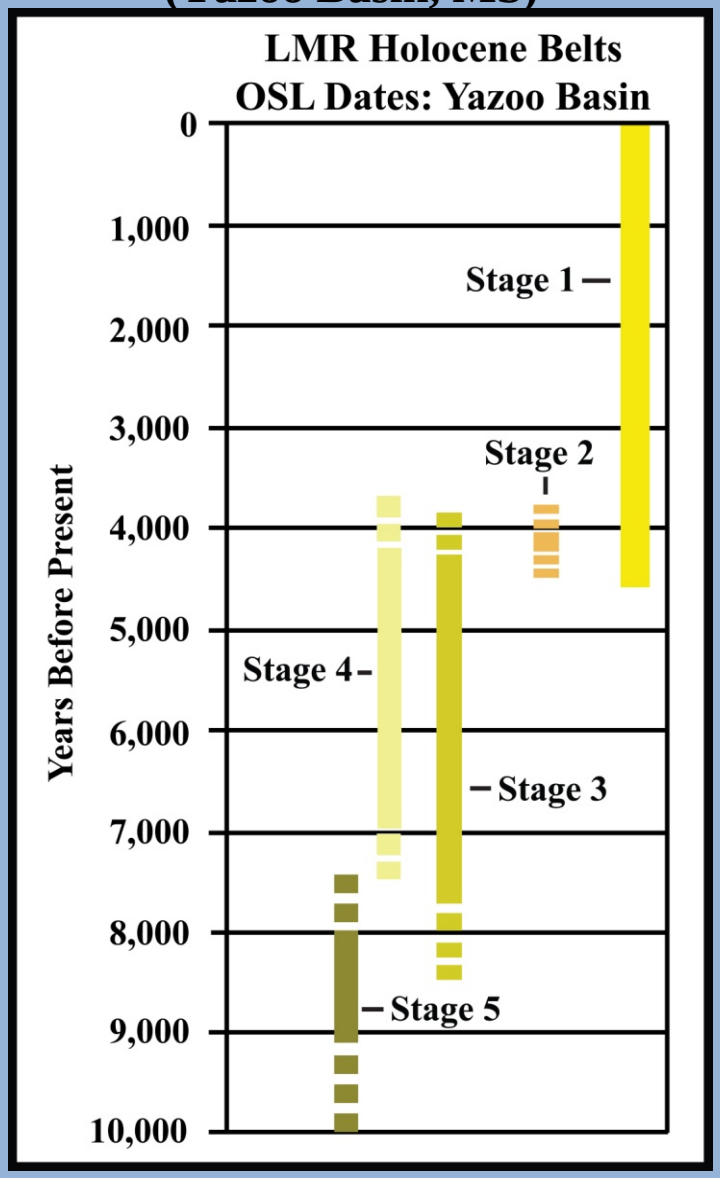
Timing of Activity: OSL Dating of LMR Alluvial Belts

Saucier (1994) - ^{14}C Dates (Yazoo Basin, MS)



Modified from Saucier (1994)

Prokocki (2010) - OSL Dates (Yazoo Basin, MS)



Results: OSL Dates

Stage 1 (Modern) MB: <= 4.21 ka

Stage 2 MB: < 4.21 ka

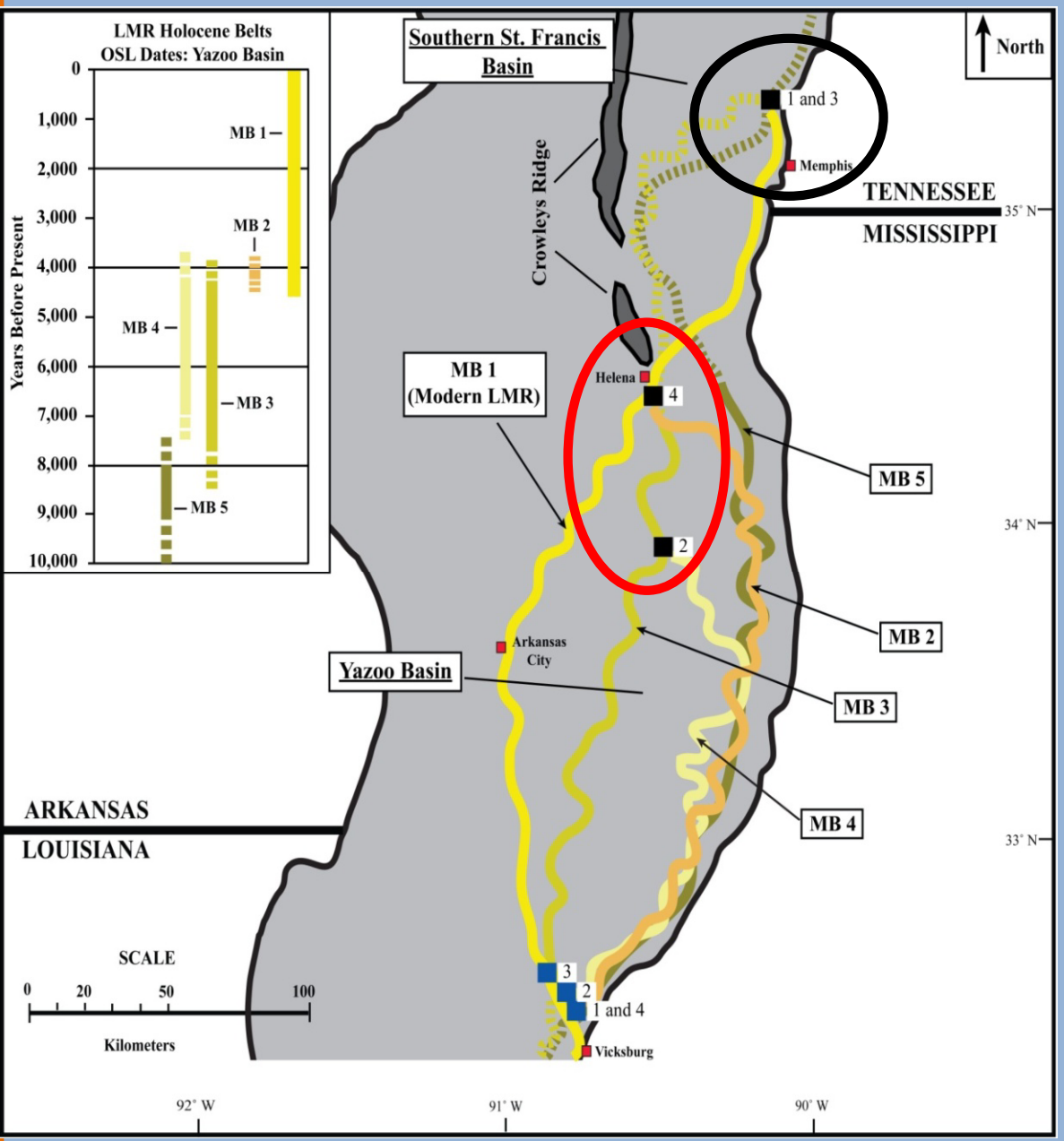
Stage 3 MB: ~ 7.85 to 4.32 ka

Stage 4 MB: ~ 6.96 to 4.21 ka

Stage 5 MB: ~ 9.19 to 8.07 ka

Now We Can Take the First Attempt at Determining the Timing of Upstream Avulsions…

LMR Avulsions: Locations and Styles



Interpreted Timing of Avulsions

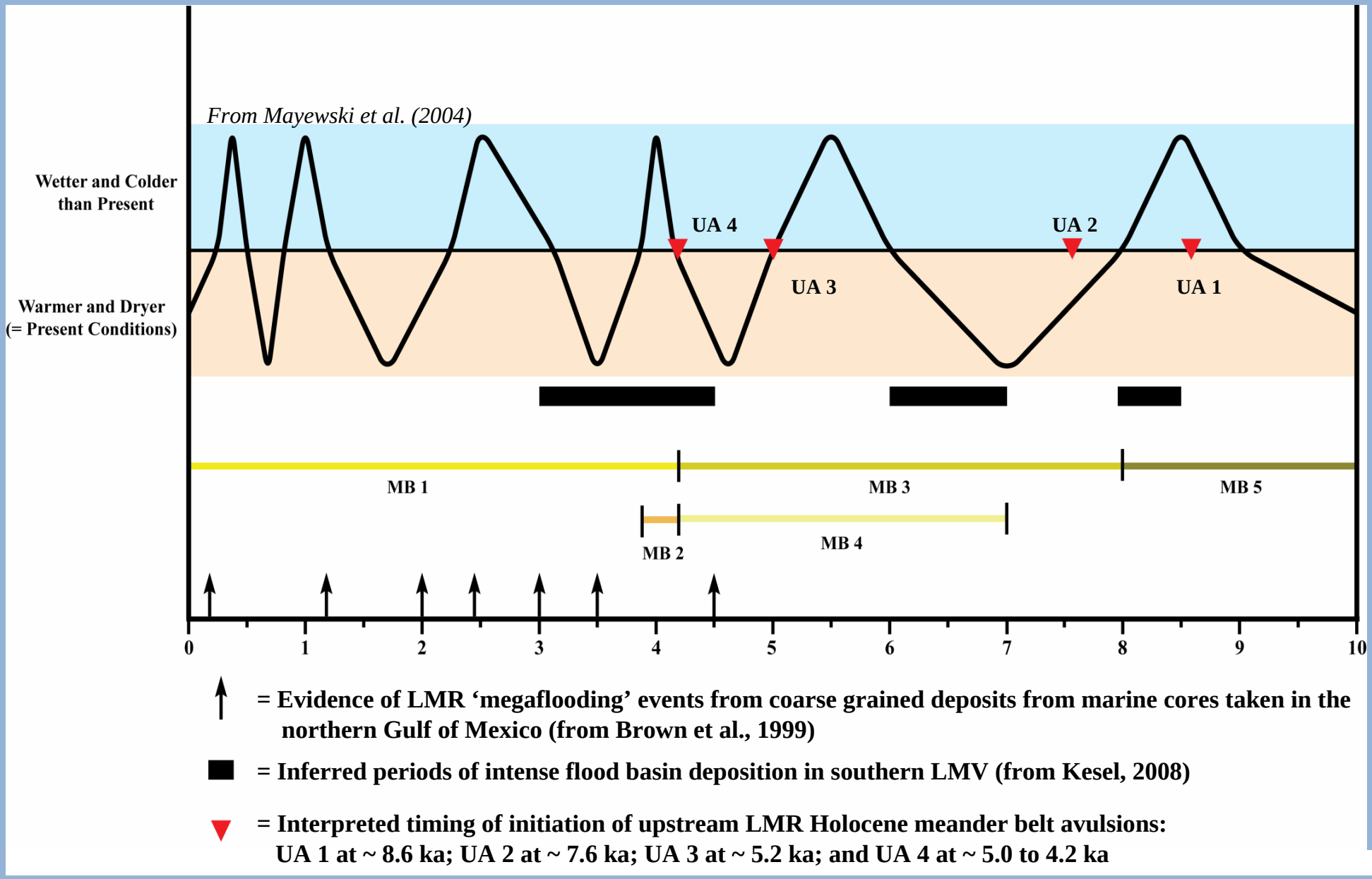
- 1 = Interpreted avulsion node position for the MB 5 to MB 3 local avulsion at ~ ca. 8.65 ka (Upstream Avulsion 1 - UA 1)
- 2 = Interpreted avulsion node position for the MB 3 to MB 4 local avulsion at ~ ca. 7.6 ka (Upstream Avulsion 2 - UA 2)
- 3 = Inferred avulsion node position for the MB 3 to MB 1 local avulsion at ~ ca. 5.2 ka (Upstream Avulsion 3 - UA 3)
- 4 = Inferred avulsion node position for the MB 1 to MB 2 local avulsion at ~ ca. 5.0-4.5 ka (Ustream Avulsion 4 - UA 4)

- 1 = Inferred Point of reconnection of MB 3 with MB 5
- 2 = Inferred Point of reconnection of MB 4 with MB 3
- 3 = Inferred Point of reconnection of MB 1 with MB 3
- 4 = Inferred Point of reconnection of MB 2 with MB 1

Unique Pattern: Northernmost avulsions in St. Francis Basin followed by secondary downstream avulsions in Yazoo Basin

- Contrary to Predictions of Numerical Model by Mackey and Bridge (1995) and Holocene Avulsion History of the Rhine-Meuse System According to Stouthamer and Berendsen (2007)

LMR Avulsions: Autogenic vs. Allogenic Forcing



= Evidence of LMR 'megaflooding' events from coarse grained deposits from marine cores taken in the northern Gulf of Mexico (from Brown et al., 1999)

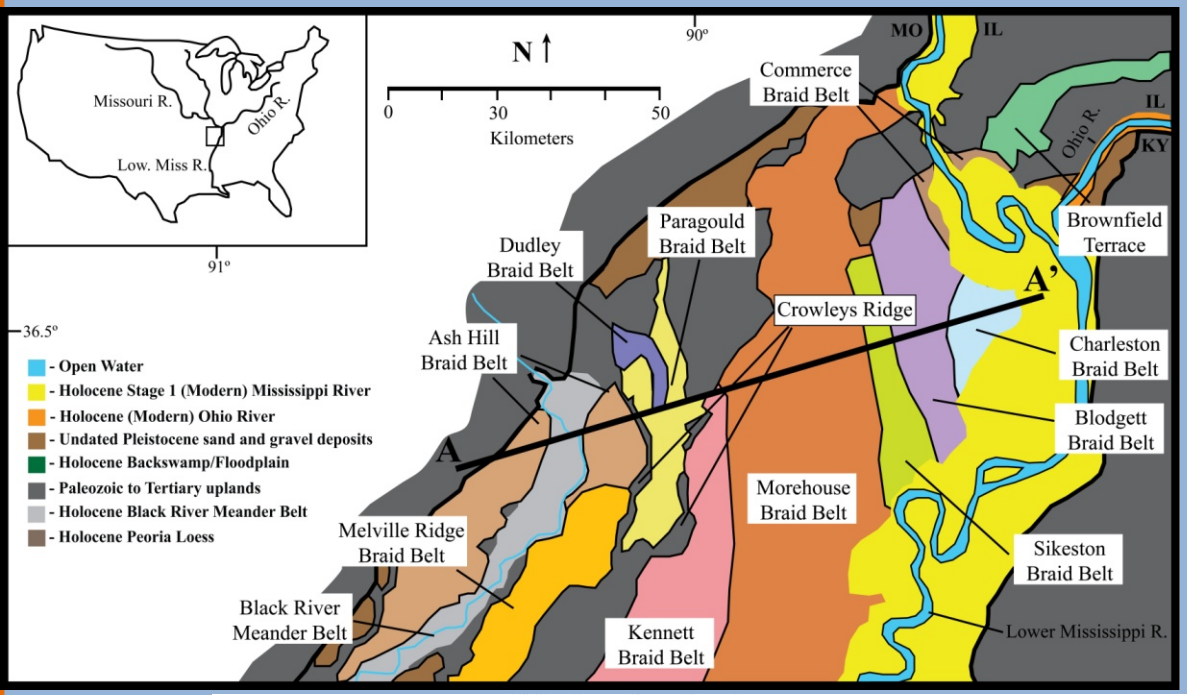
= Inferred periods of intense flood basin deposition in southern LMV (from Kesel, 2008)

= Interpreted timing of initiation of upstream LMR Holocene meander belt avulsions: UA 1 at ~ 8.6 ka; UA 2 at ~ 7.6 ka; UA 3 at ~ 5.2 ka; and UA 4 at ~ 5.0 to 4.2 ka

- **Autogenic Forcing : Inter-avulsion Period Not Constant!!**

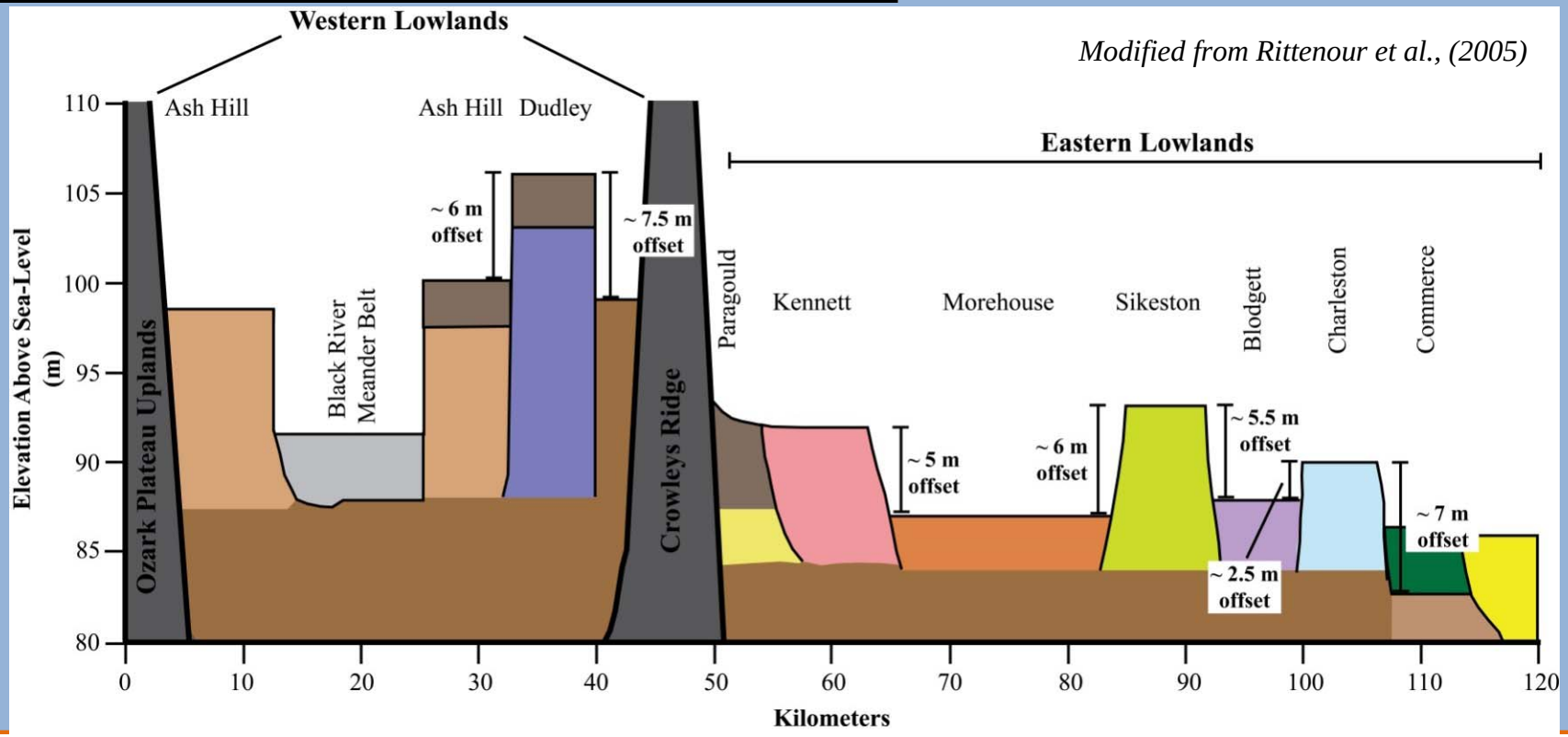
- **Allogenic Forcing (Climate Induced): Avulsions Do Not Correlate with Climate Change!!**

LMR Avulsions: Role of Pleistocene Deposits



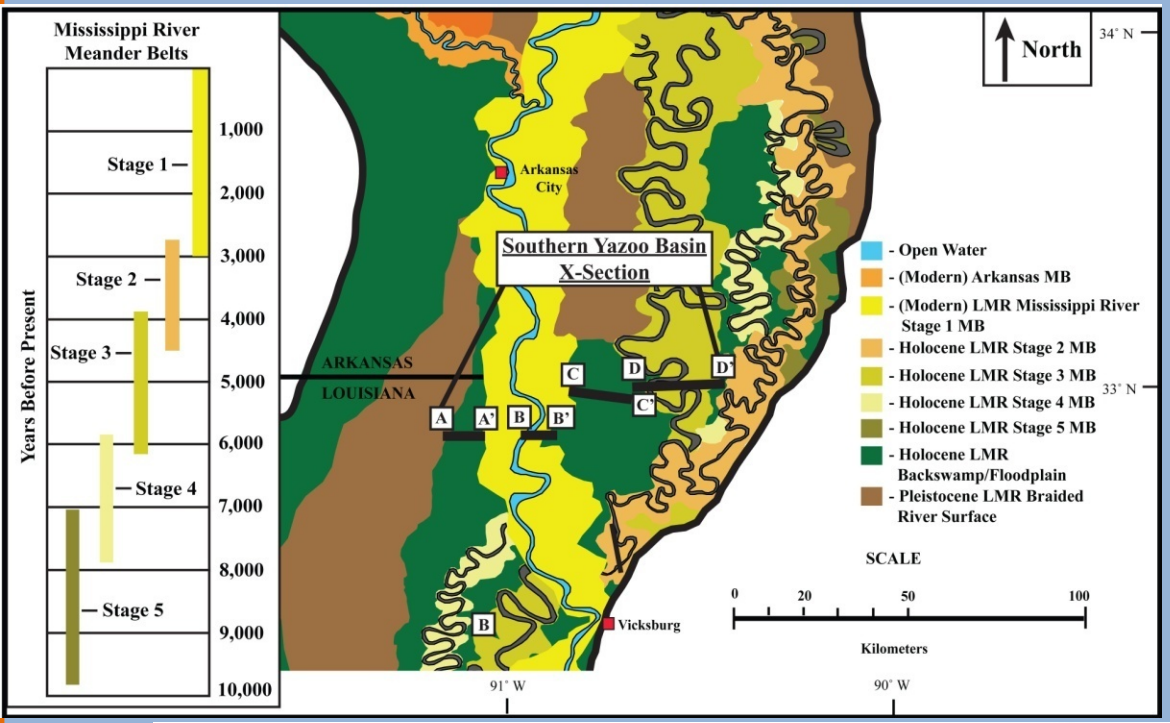
- Significant Vertical Offset Exists Between LMR late-Pleistocene Sand and Gravel Deposits (~ 2 to 7 m) Near Ohio River Confluence

- Do the Offsets Maintain their Integrity Downvalley??



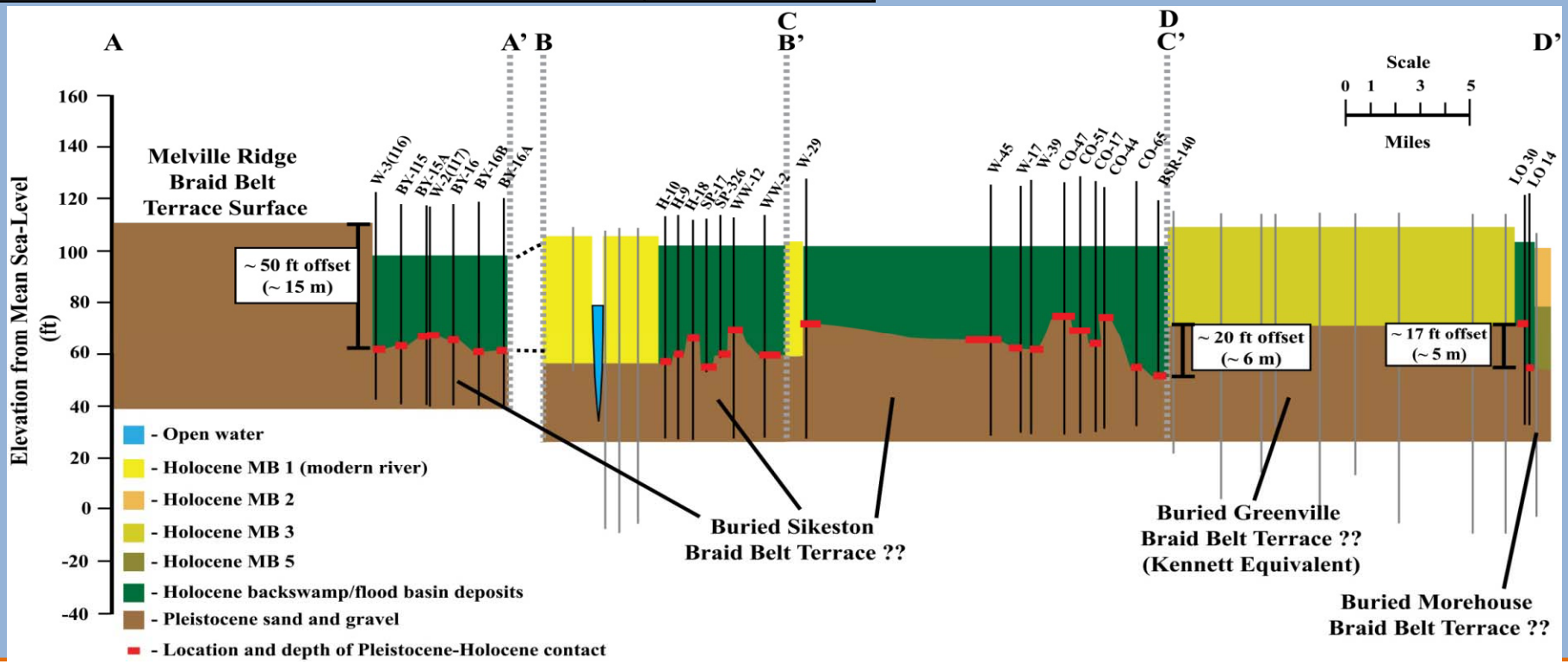
Modified from Rittenour et al., (2005)

LMR Avulsions: Role of Pleistocene Deposits



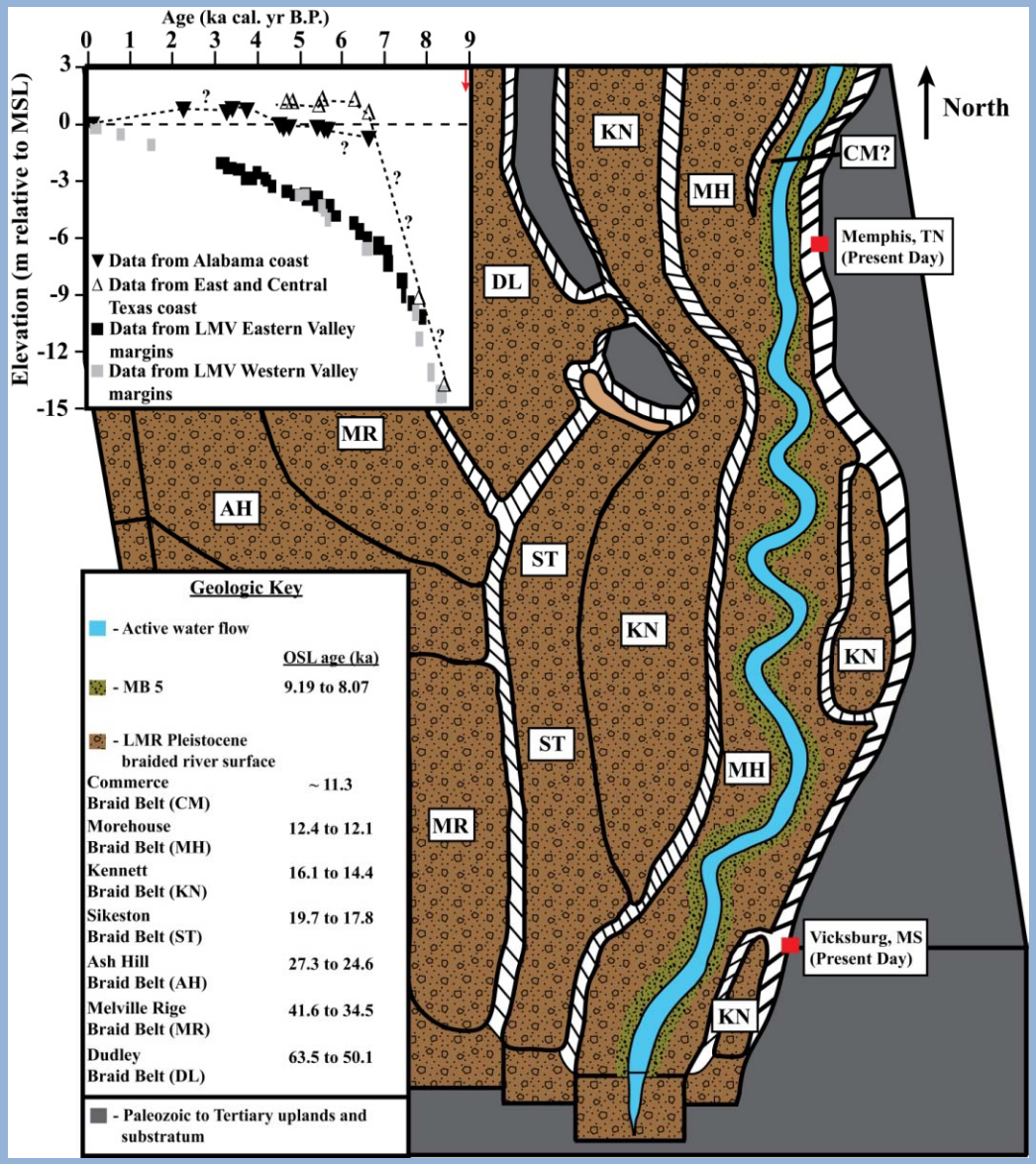
- Potentially, Offsets between late-Pleistocene Surfaces Maintain Their Integrity beneath Holocene Sediment Downvalley

- How Does This Affect Overall Holocene LMR Avulsion Story??

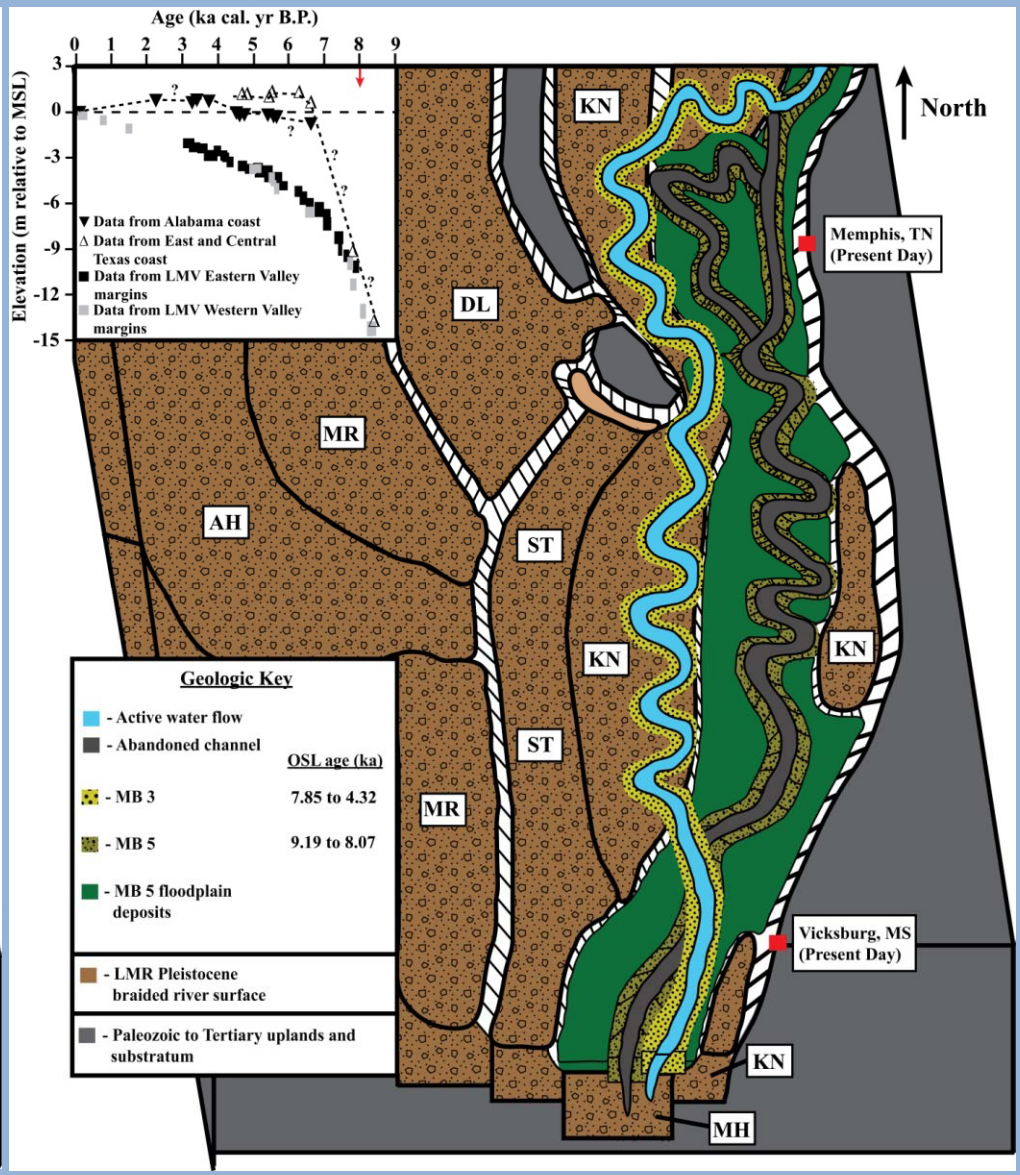


LMR Avulsions: Role of Pleistocene Deposits

Schematic Diagram of LMR at ca. 9.0 ka

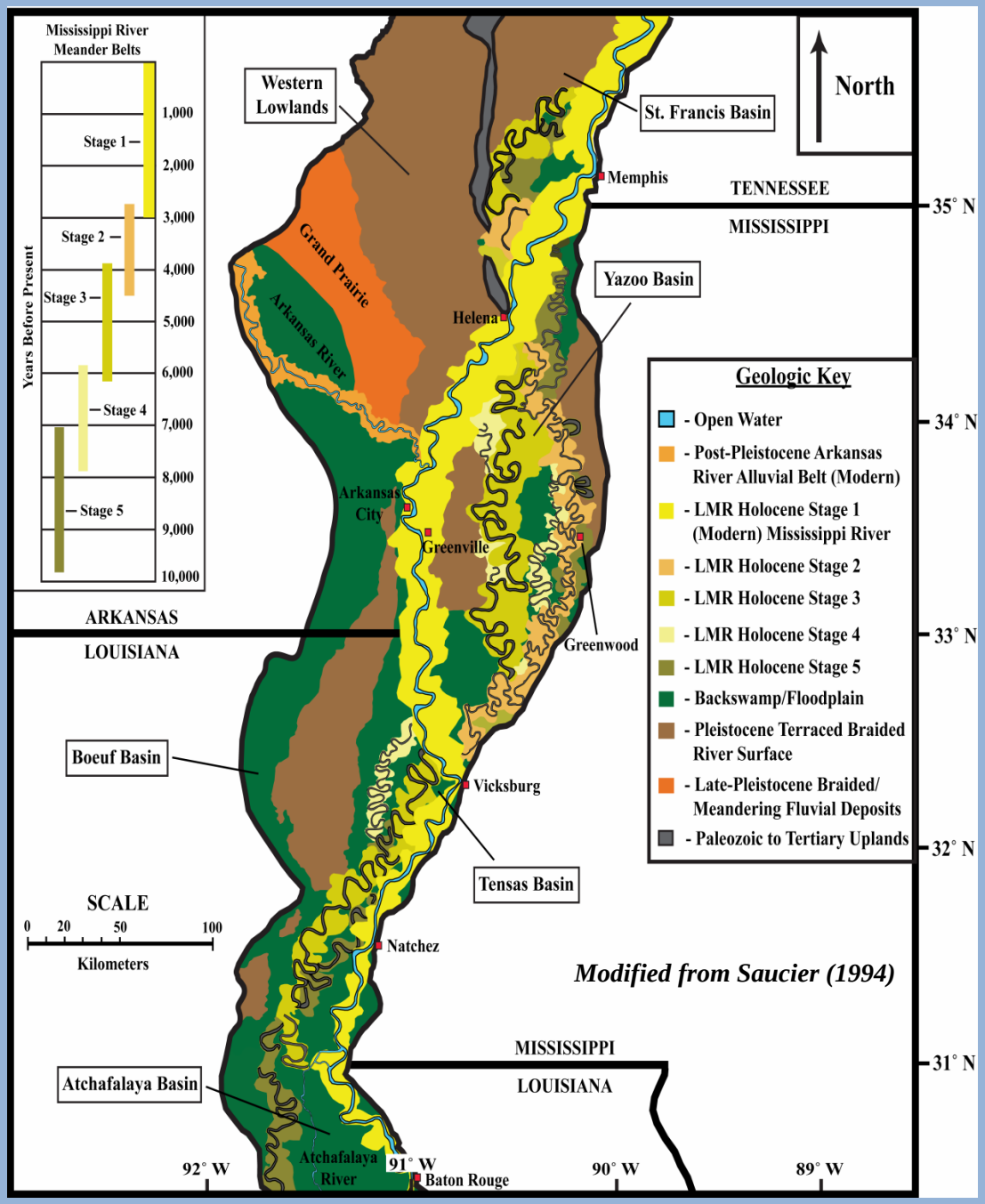


Schematic Diagram of LMR at ca. 8.0 ka



- Holocene LMR Channel Potentially Aggrades above the Elevation of Adjacent late-Pleistocene Sand and Gravel Surface…..Then Avulses….Local Control vs. Global Control

Summary/Future Research



1) Holocene LMR Avulsions Driven by Unique Combination of Autogenic and Allogenic Forcing??….Need Further OSL Dating to Constrain Timing of All Avulsions (St. Francis to Atchafalaya Basin)

2) How Much Channel Aggradation was Forced by Sea-Level Rise from ca. 10 to 4.5 ka??....Numerical Modeling with Gary Parker

3) Is It More Advantages for the LMR to Construct a New Channel via Avulsion within late-Pleistocene Sand and Gravel Deposits, or Holocene Fine-Grained Flood Basin Deposits??

4) What is the significance of Local vs. Global Controls on the Timing and Position of Avulsion During the


Thank You!!