Roy Van Arsdale
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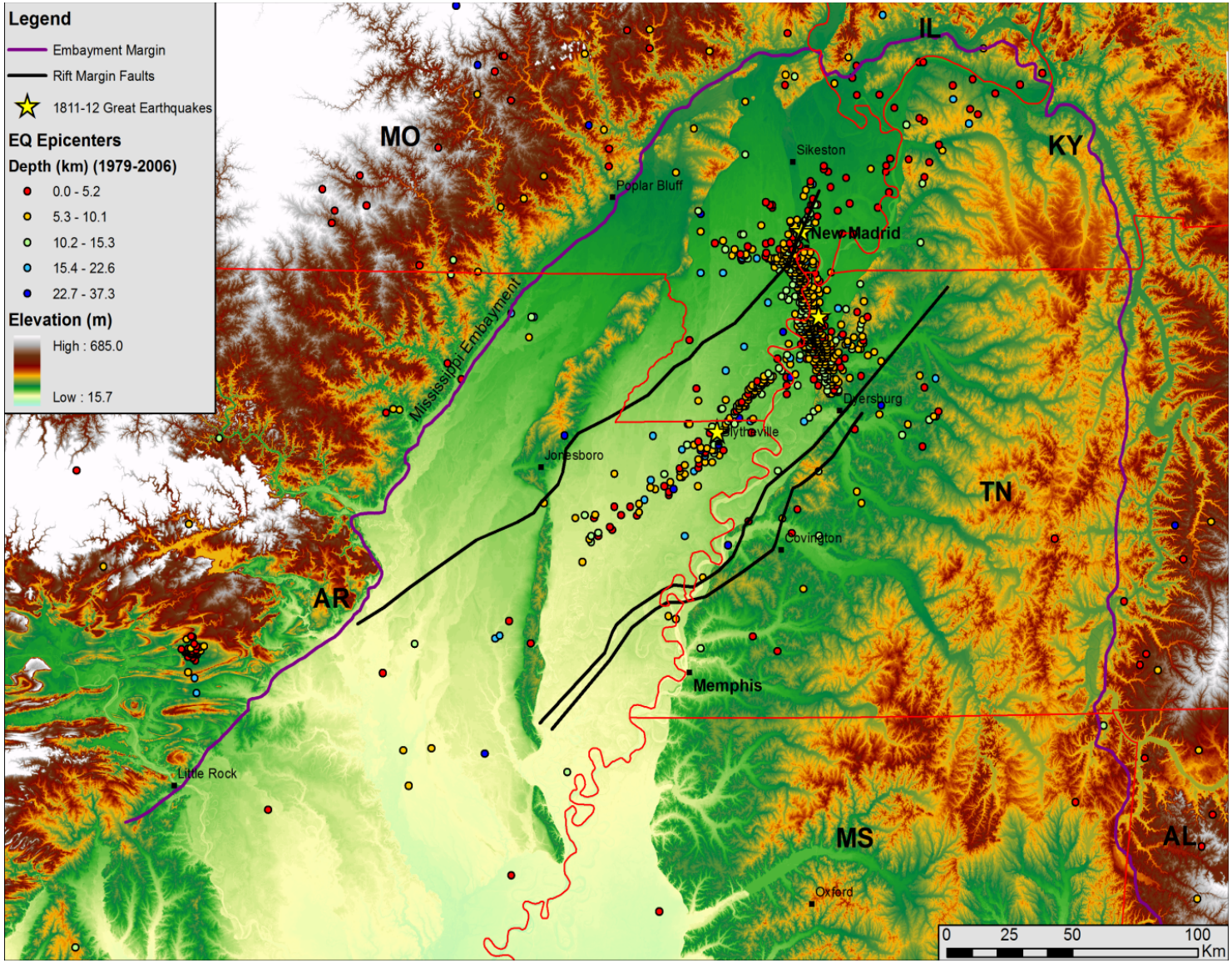
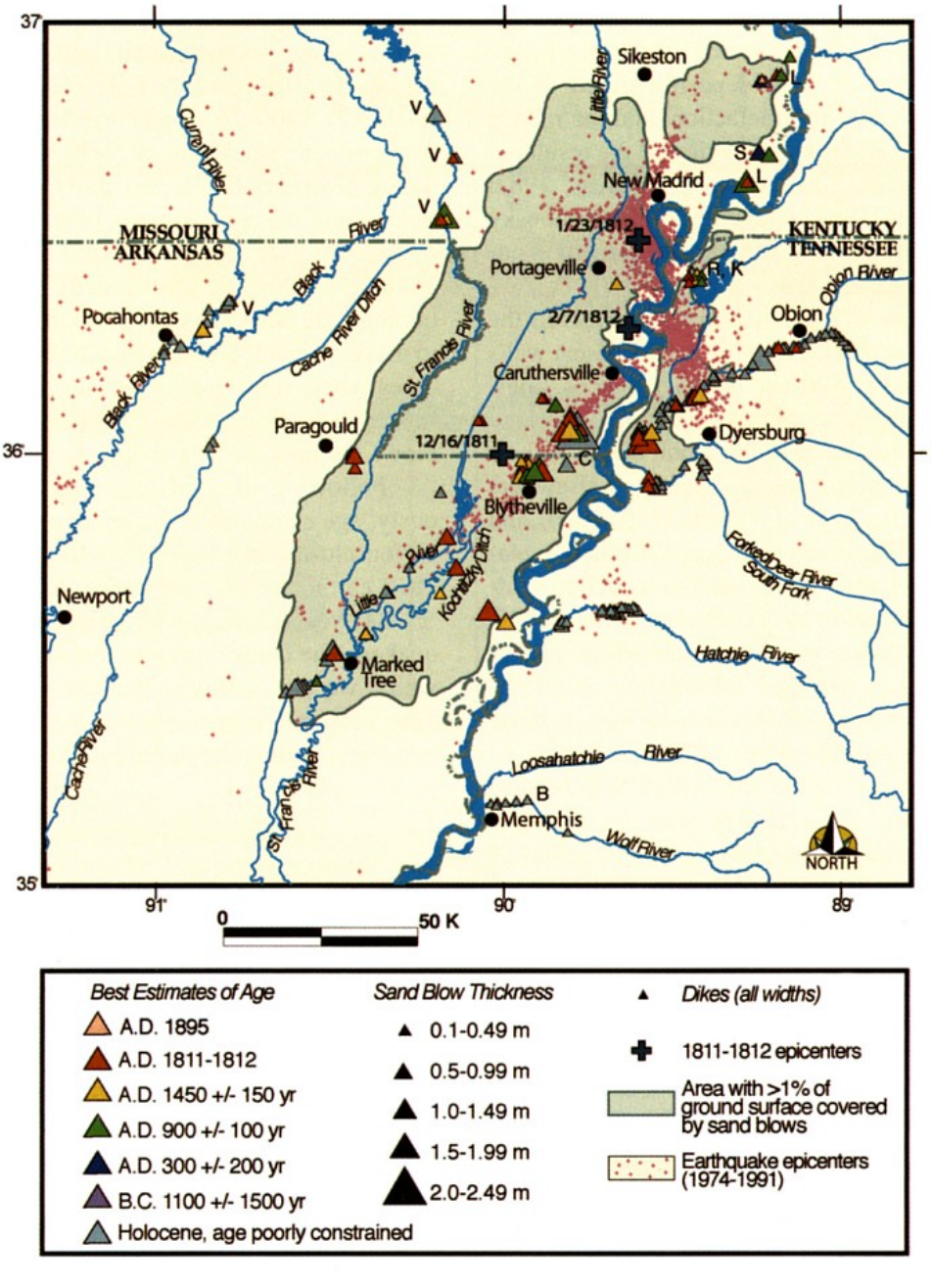
University of Memphis

USGS Seismic Hazards Workshop for CEUS Sources

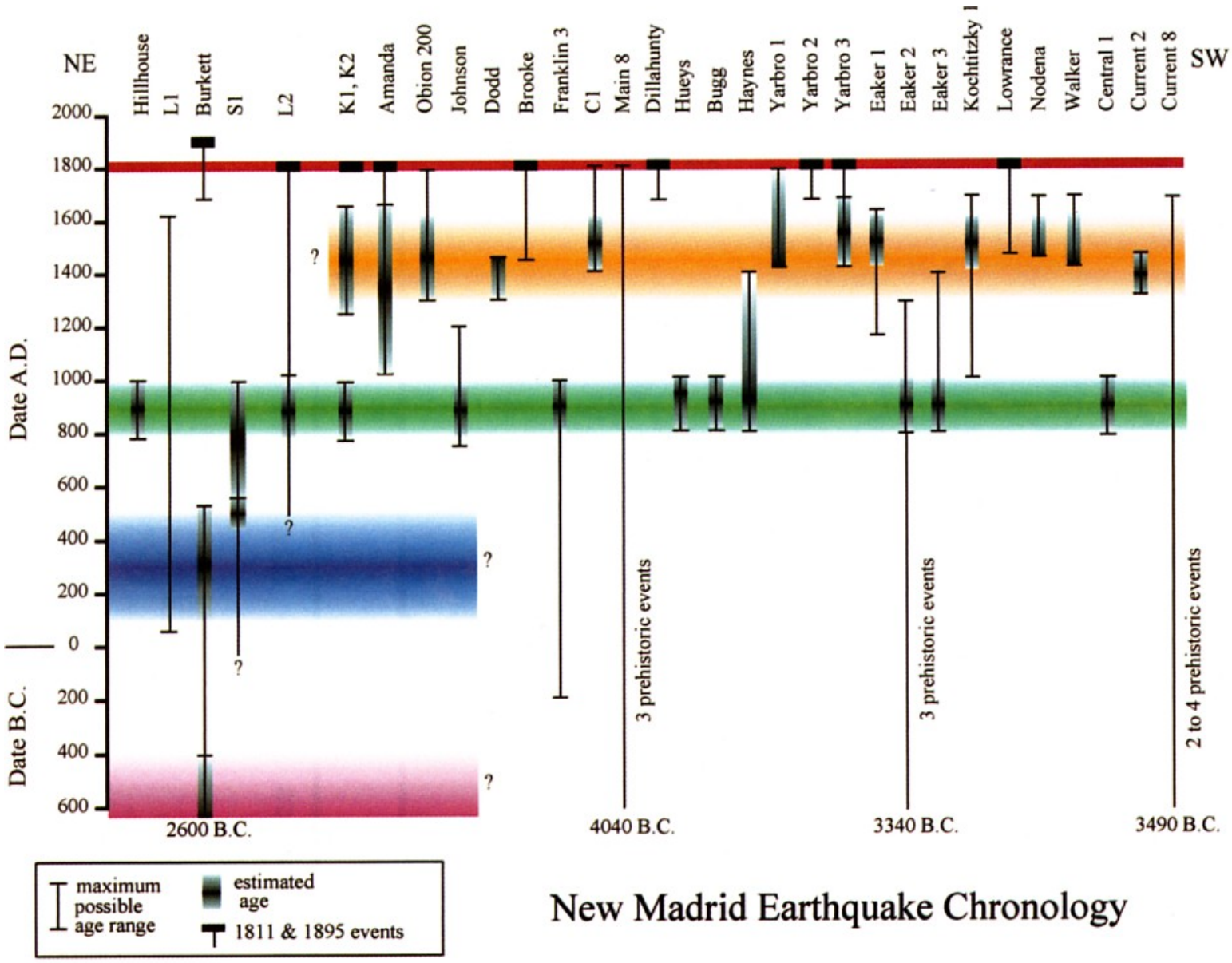
February 22-23, 2012



New Madrid seismic zone in northern Mississippi embayment . Stars are large earthquakes of 1811–1812 (from Csontos and Van Arsdale, 2008).

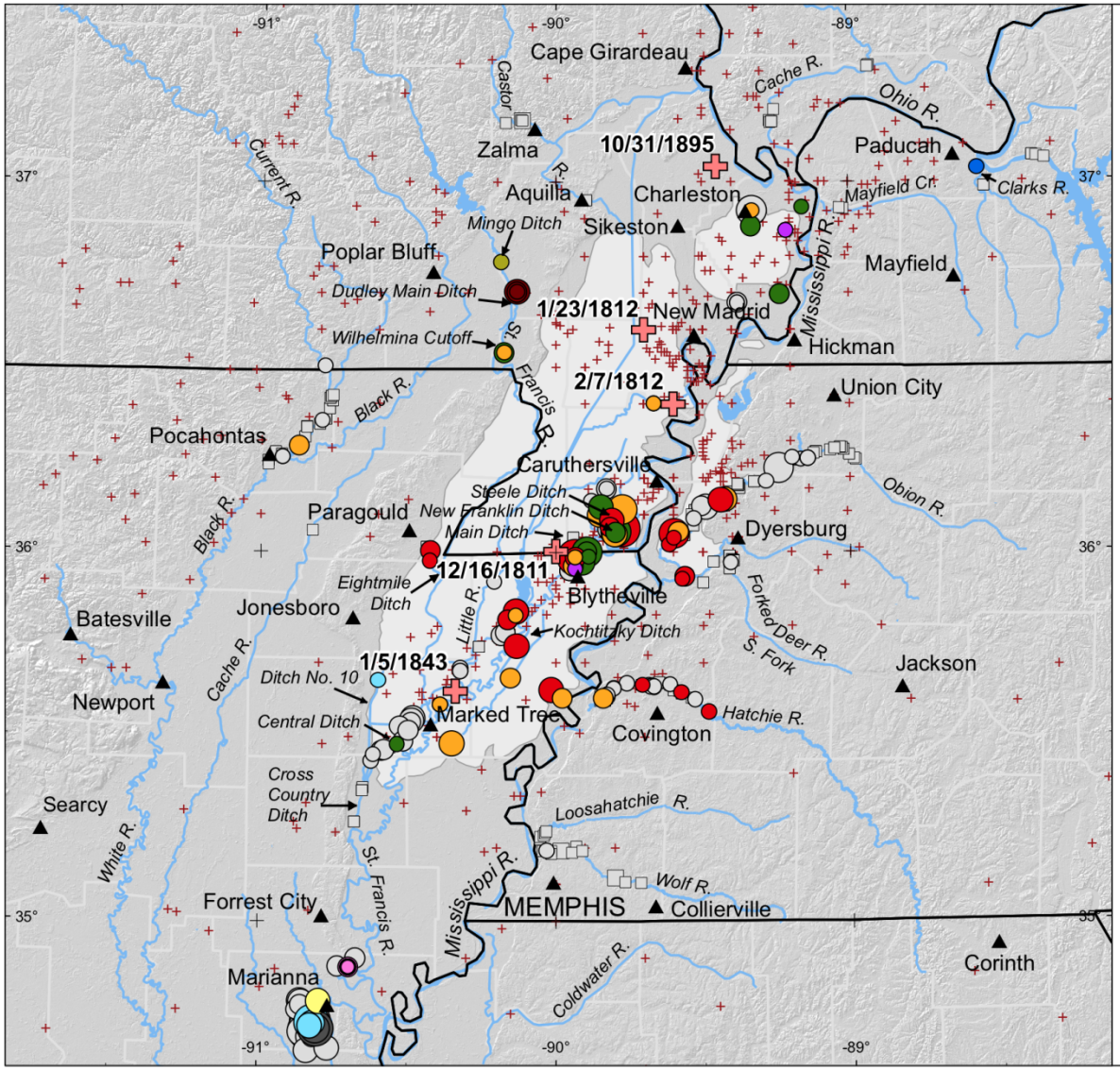


New Madrid seismic zone liquefaction. Map from Tuttle et al. (2002) and aerial photograph from Stewart and Knox (1993).



Earthquake chronology for NMSZ from dating and correlation of liquefaction and trench features at sites (listed at top) along NE-SW transect across region. Earthquake recurrence interval is ~500 yrs (from Tuttle et al., 2002).

Paleoliquefaction Record



Explanation

Estimated sand blow age in years BP, relative to 1950 AD (1)

- 1-238 (1811-1812 AD)
- 350-650
- 900-1200
- 2600-2900
- 4150-4450
- 4650-4950
- 5350-5650
- 6650-6950
- 9550-10150
- 11100-11500
- 12400-12800
- 22100-23400
- Poorly constrained

Sand blow thickness (cm) (1)

- 1-49
- 50-99
- 100-149
- 150-199
- 200-249

Sand dike width (cm) (1)

- 1-49
- 50-99

- Historical earthquake epicenter (2)
- CEUS dependent catalog, M>2 (3)
- >1% of surface area covered by sand blows (4)

Sources: 1. CEUS SSC paleoliquefaction database; 2. Hough (2004); 3.CEUS SSC earthquake catalog; 4. Saucier, 1977 and Obermeier, 1989. Basemap: SRTM Shaded Relief, USGS (2005)

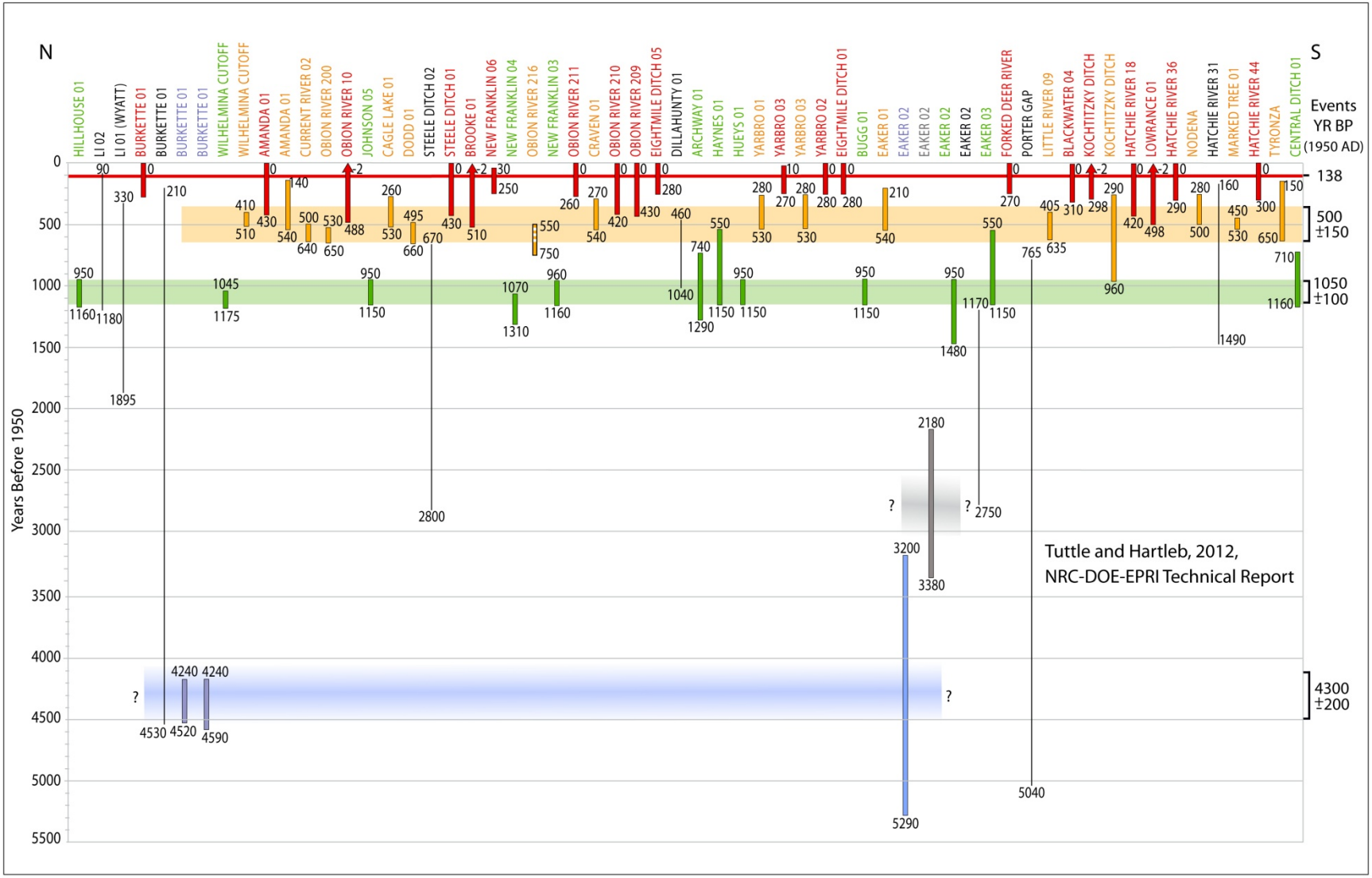
N

0 40 mi

0 40 km

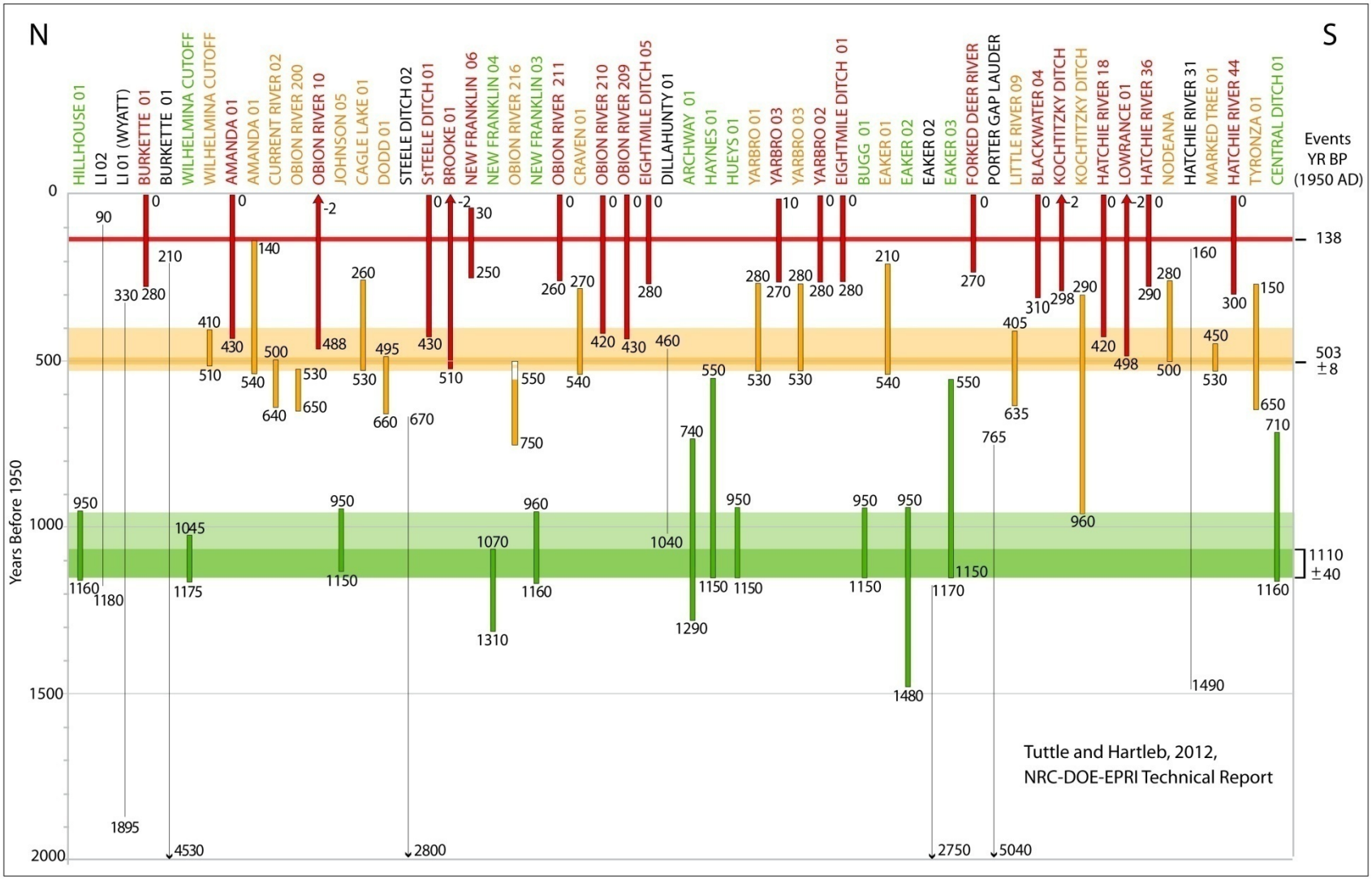
Tuttle and Hartleb, 2012,
NRC-DOE-EPRI Technical Report

New Madrid Paleoearthquake Chronology

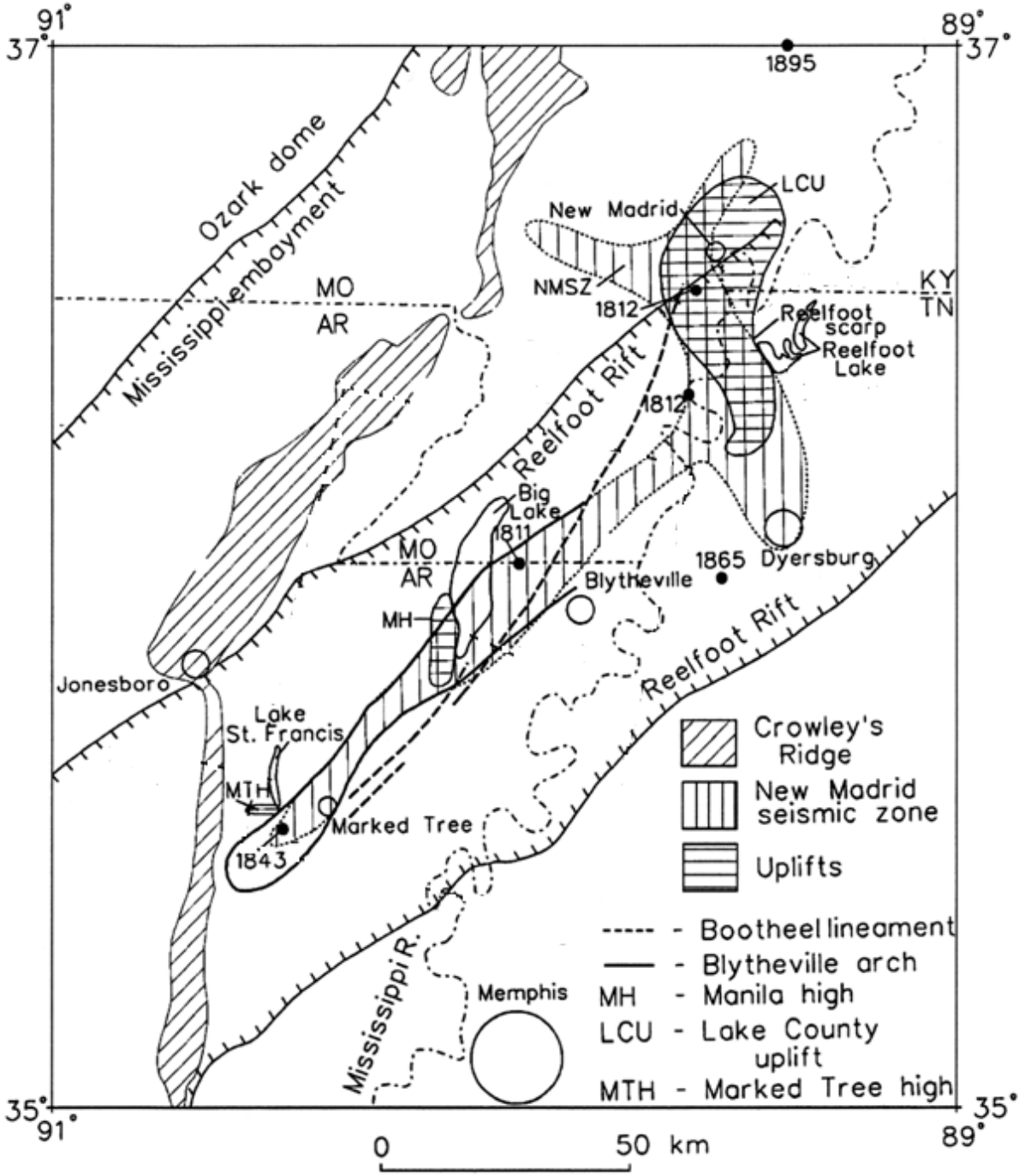


Larger uncertainty ranges: 500 yr BP (1450 C.E.) +/- 150 yr,
1050 yr BP (900 C.E.) +/- 100 yr, and 4300 (2350 B.C.E.) +/- 200 yr

New Madrid Paleoearthquake Chronology



Smaller of two possible uncertainty ranges derived during CEUS SSC Project: 503 yr BP (1447 C.E.) +/- 8 yr and 1110 yr BP (840 C.E.) +/- 40 yr

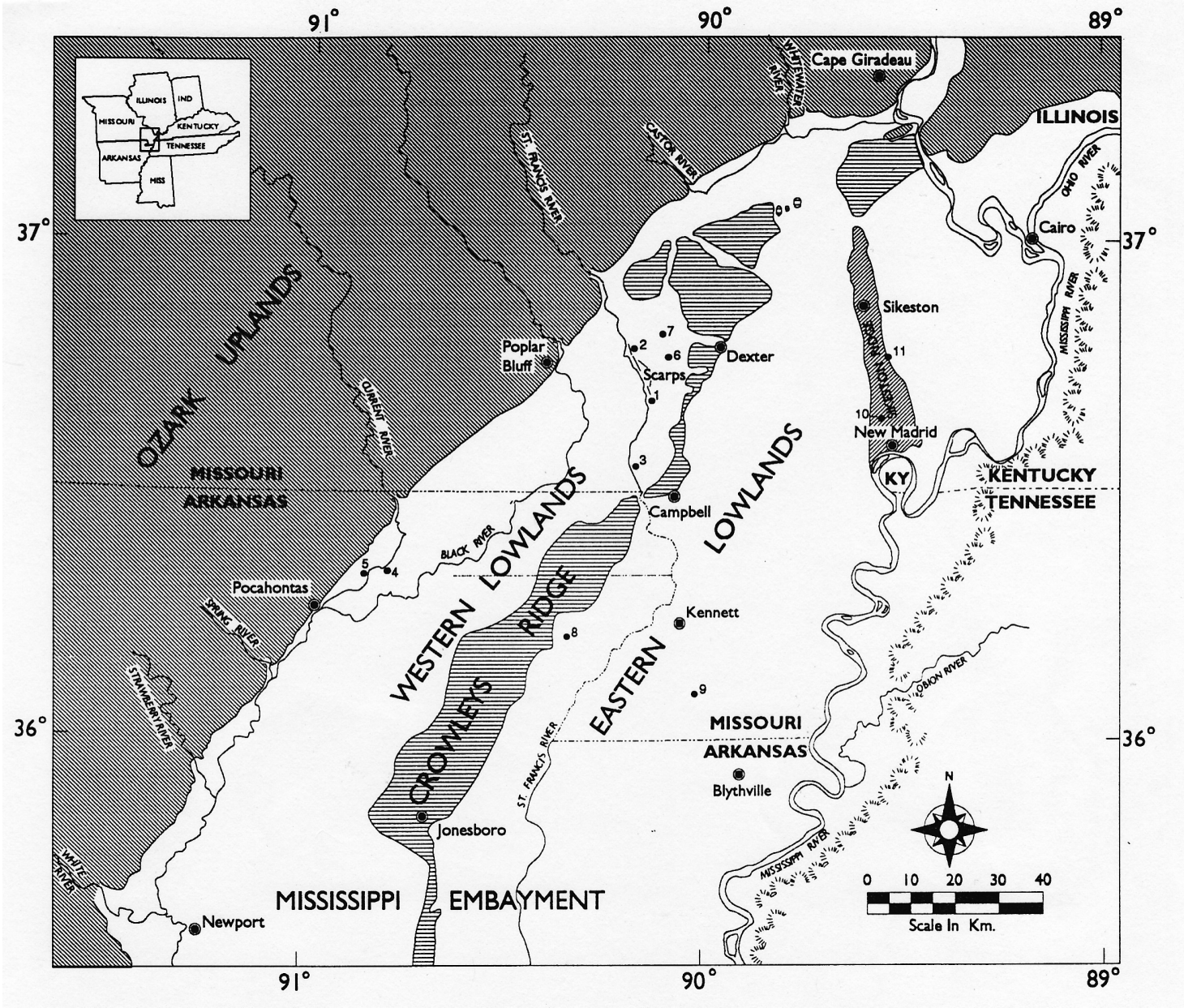


The Marked Tree high and Manila high along the Blytheville arch and the Bootheel fault (modified from Guccione, 2005).

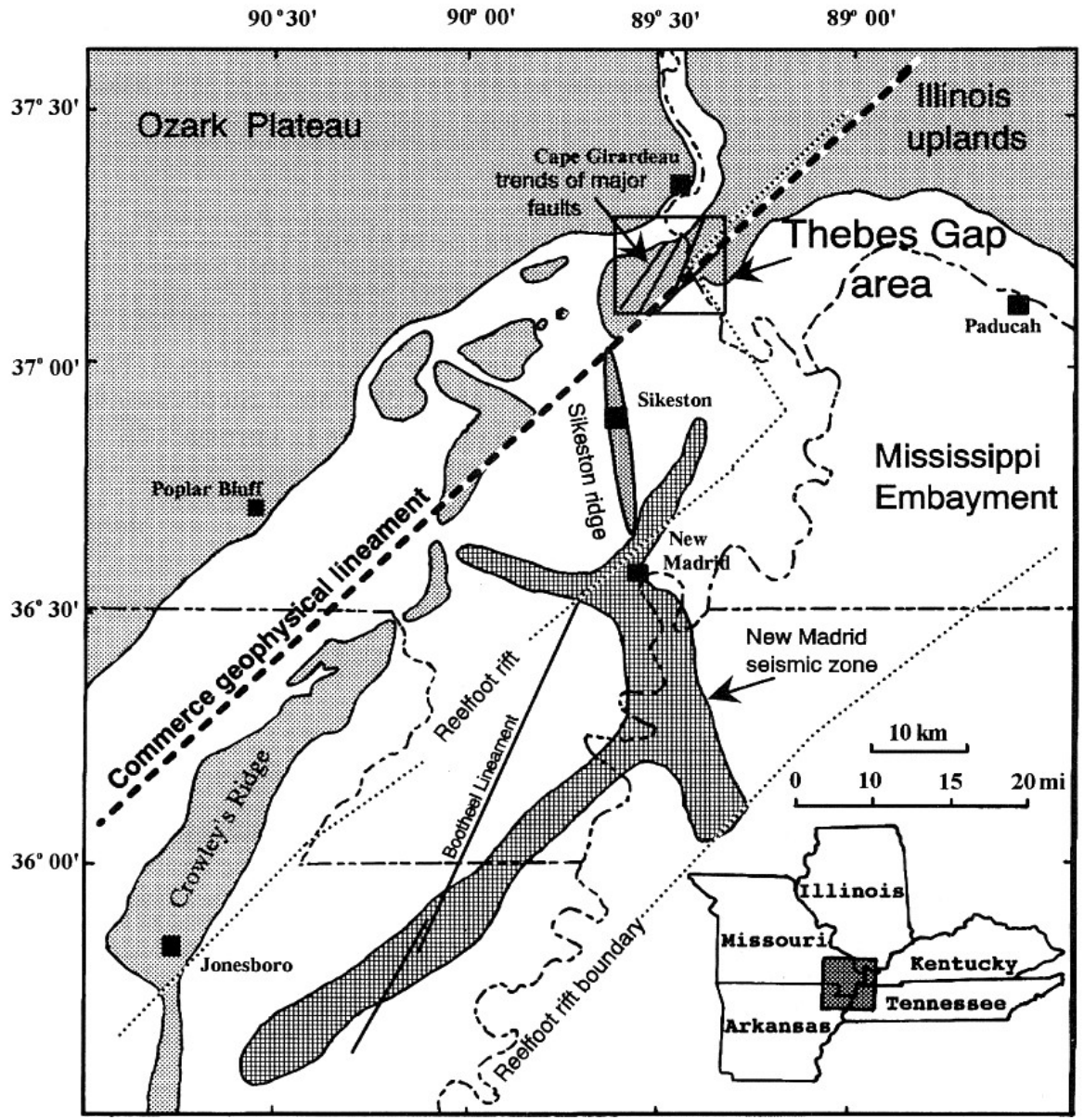
Bootheel fault has >13 m of Quat. right-lateral strike-slip offset and ~3 m of up-to-the-east displacement
~12,100-10,200 BP

Manila High uplift at 16,600-5400 BP
and at
90 B.C - A.D. 1640

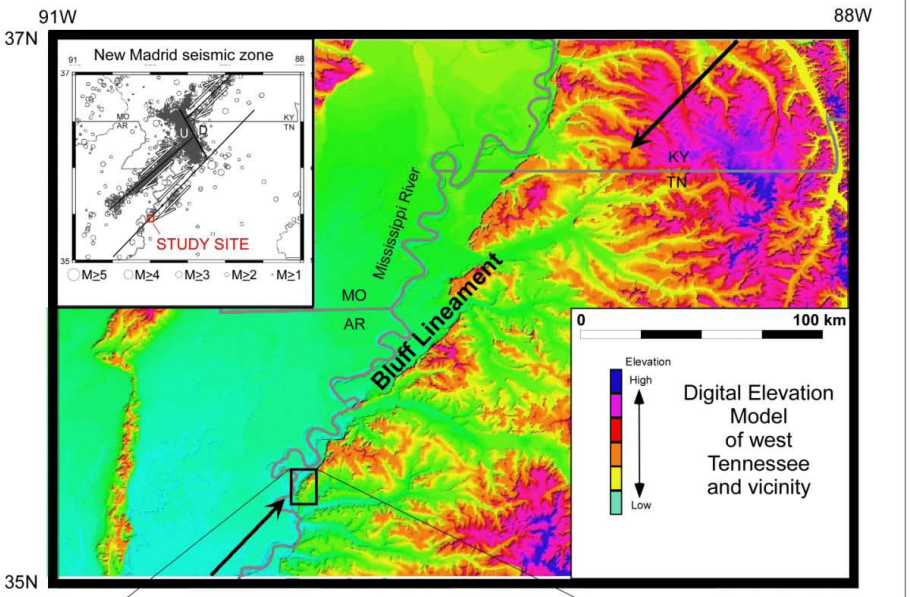
Marked Tree high uplift 4400-3050 BP.

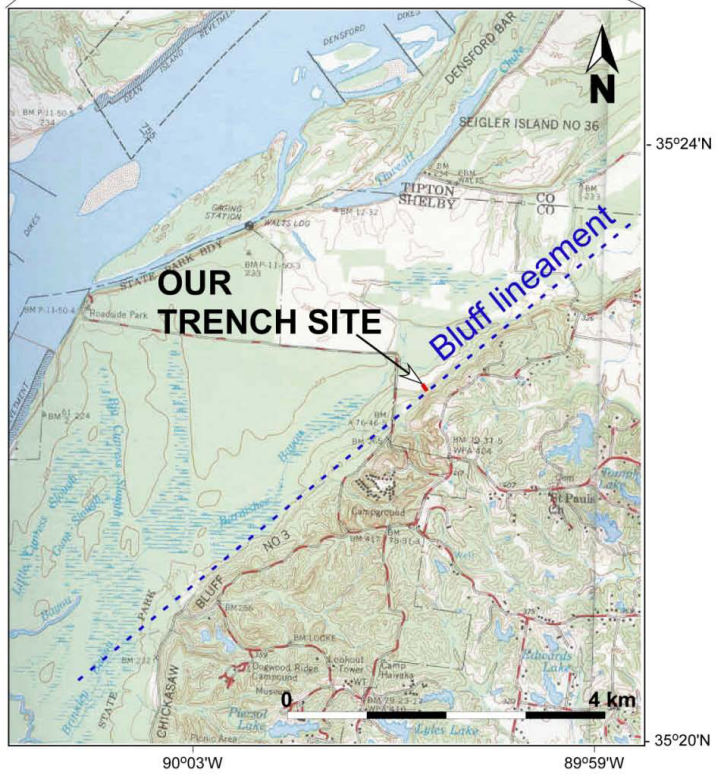


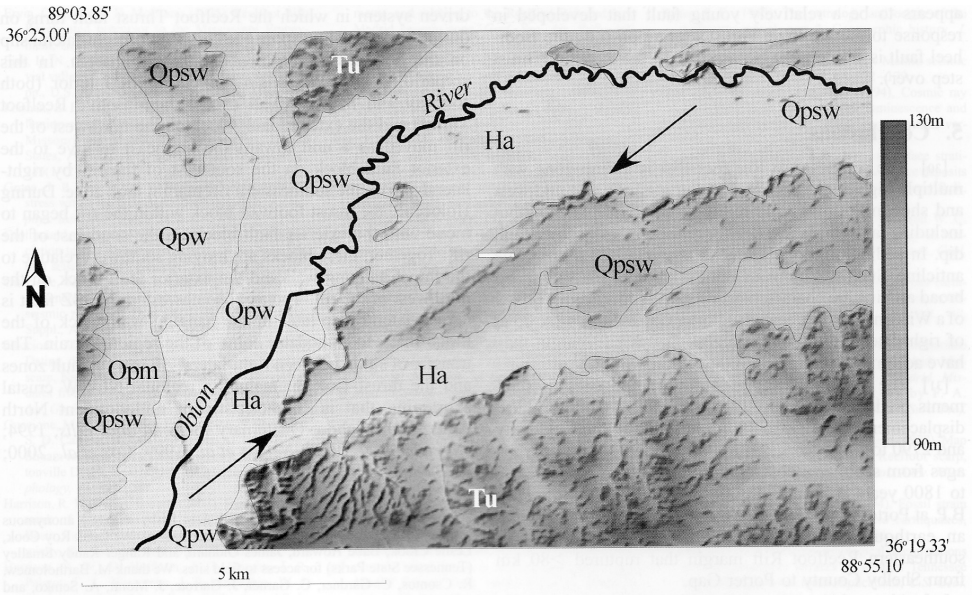
Earthquake paleoliquefaction deposits near Dexter, MO dated at 23,000–17,000 yr BP, 13,430–9,000 yr BP, A.D. 240–1020, and A.D. 1440–1540 may be due to faulting beneath the St. Francis River (from Vaughn, 1994).



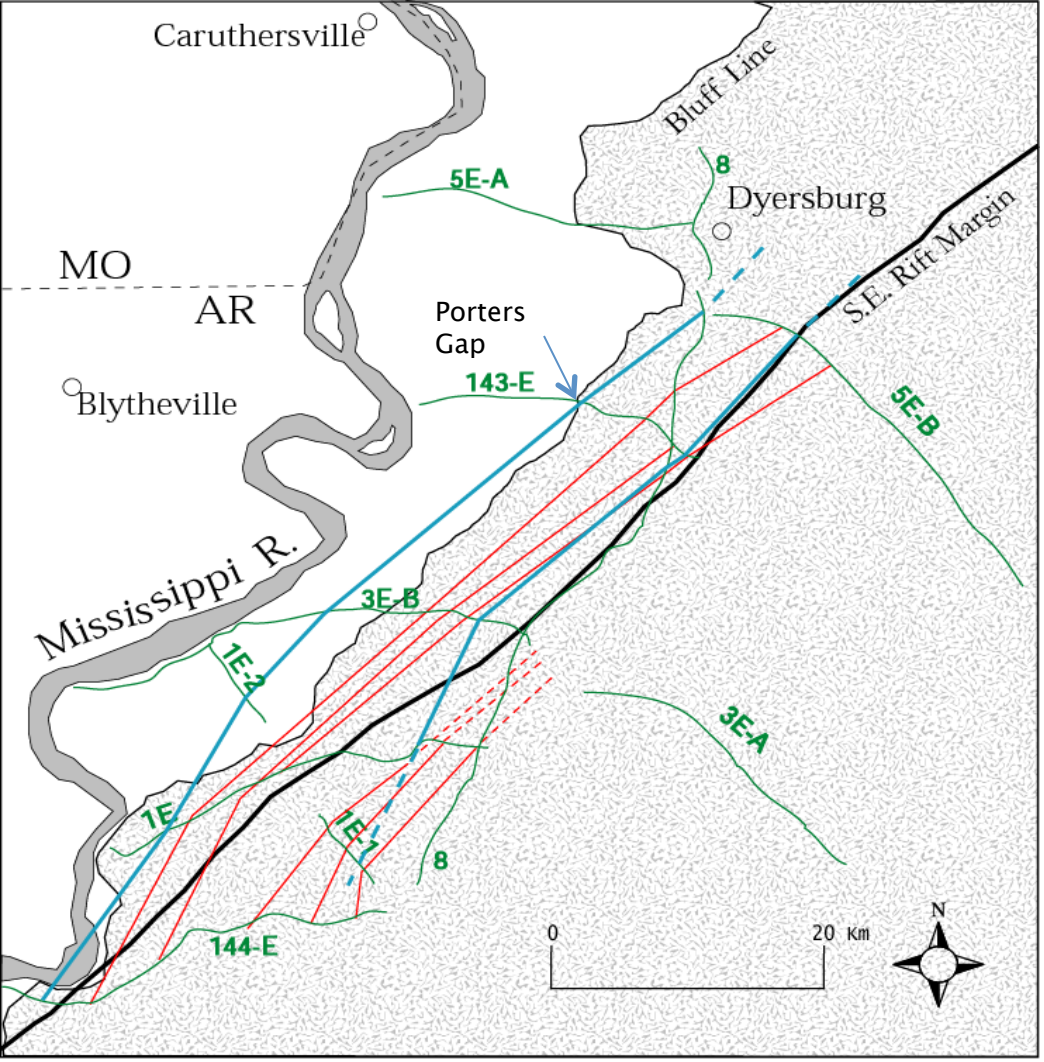
Commerce fault Eqs. ~60–50 ka, ~35–25 ka, 5 ka $\pm$ 400 yr, 3660 $\pm$ 290, 1811–1812
(from Harrison et al. 1999).





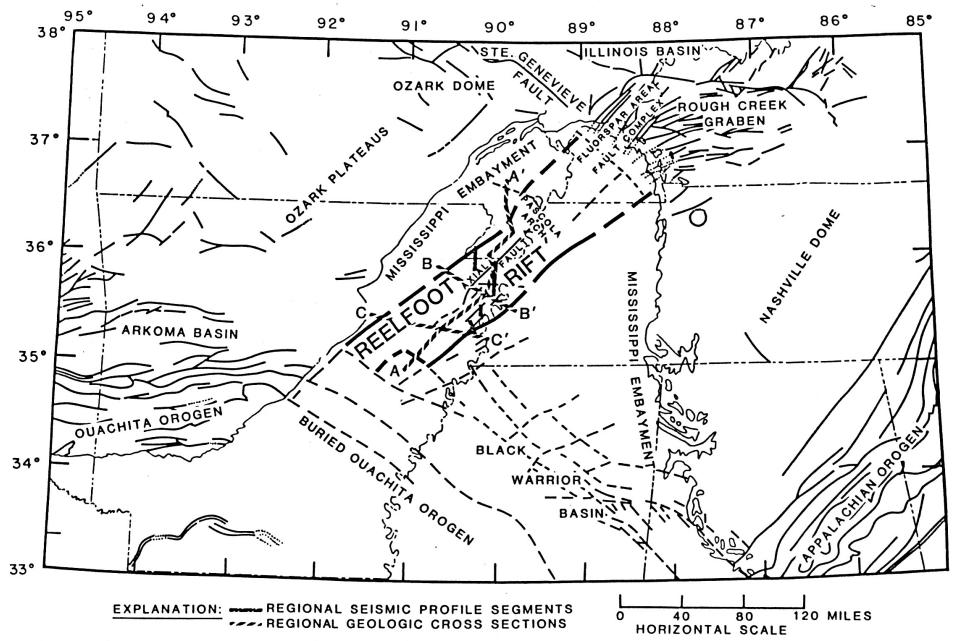


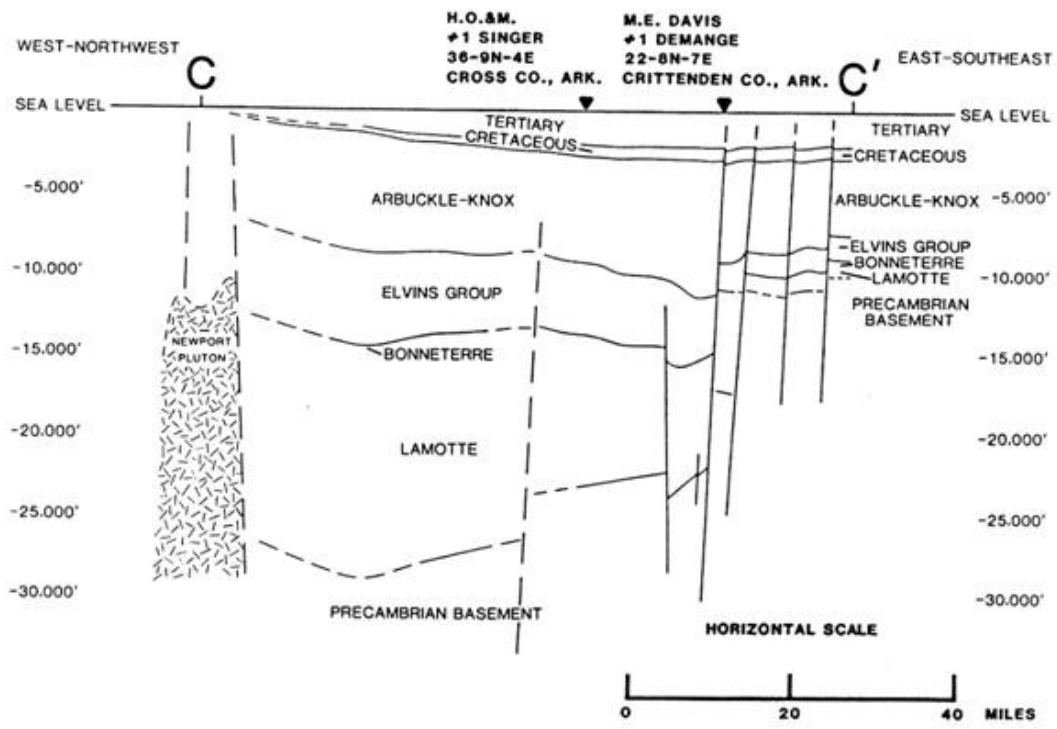
Southeastern margin of the Reelfoot Rift Quaternary faulting.
Wisconsin faulting at Union City, TN (from Cox et al., 2005; Van Arsdale et al., 2011).



Porter's Gap is on seismic line 143-E at bluff line (from Parrish and Van Arsdale, 2004).

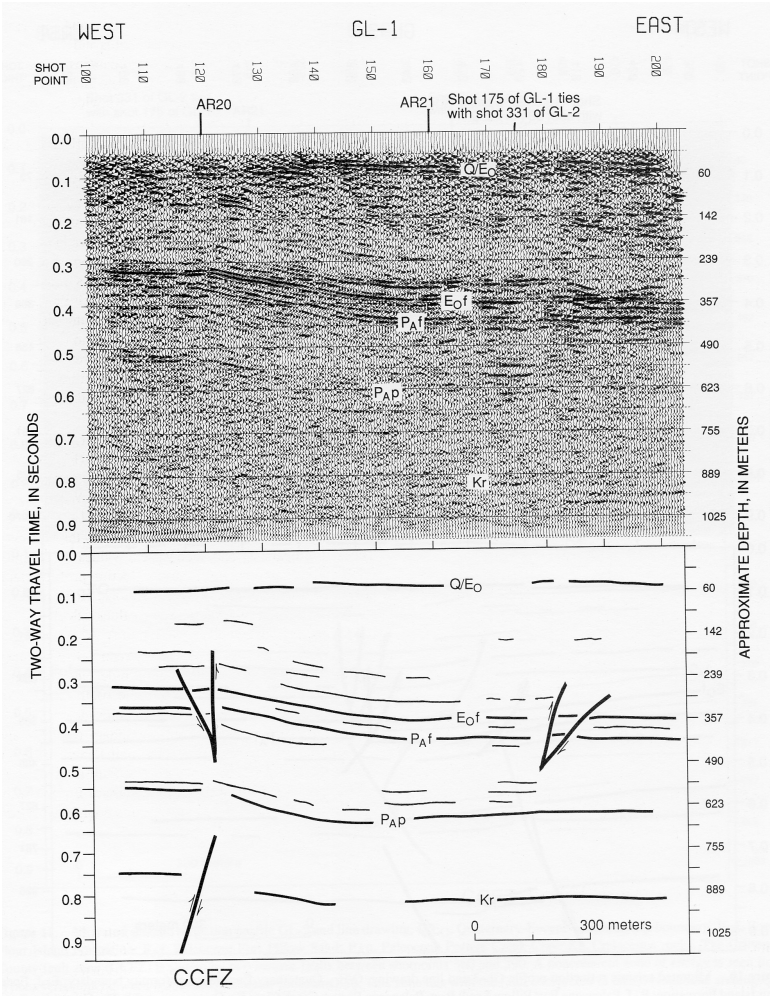
10 m of post 20,000 yr right lateral strike slip faulting at Porter's Gap (from Cox et al., 2006).

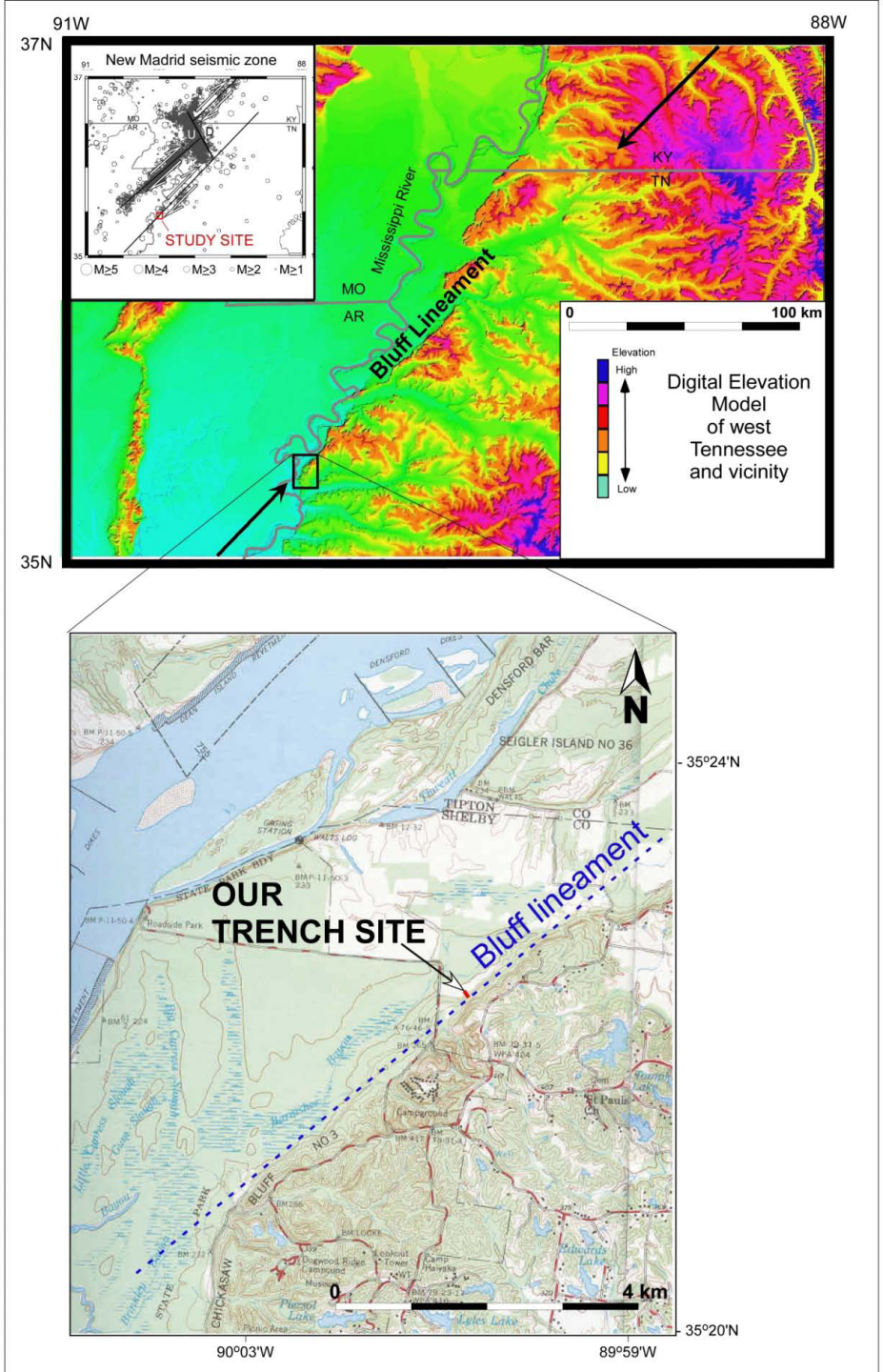


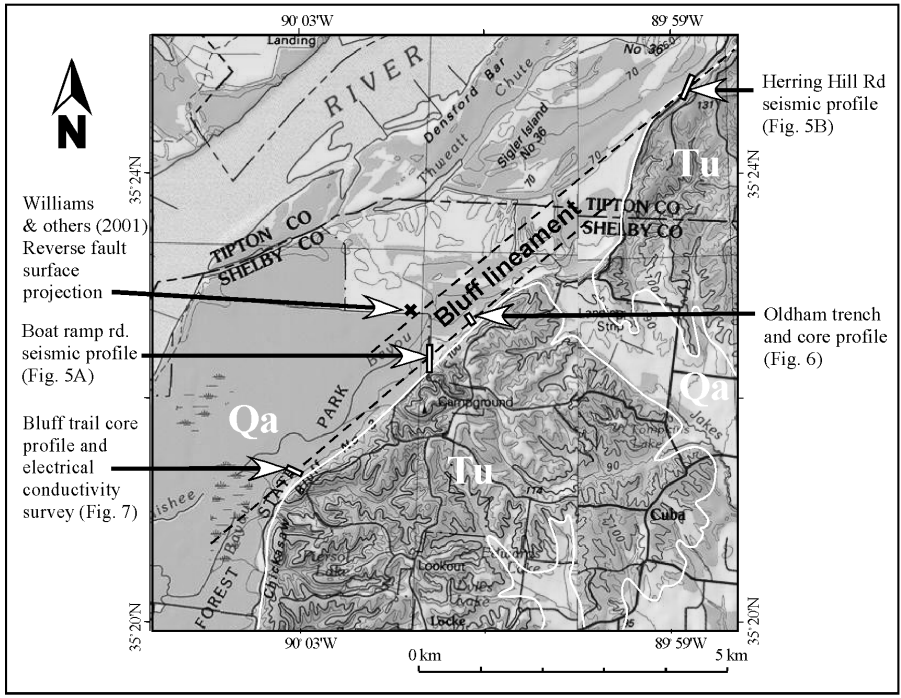


Reelfoot Rift and cross section C–C' extending east of rift margin to near Shelby County with outboard Tertiary inverted faults (from Howe, 1985).

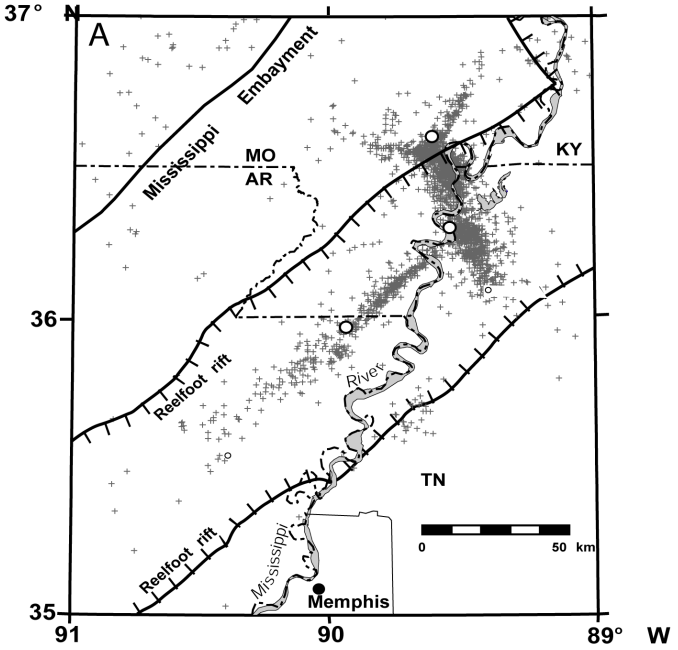
Crittenden County fault (from Luzietti et al., 1995).

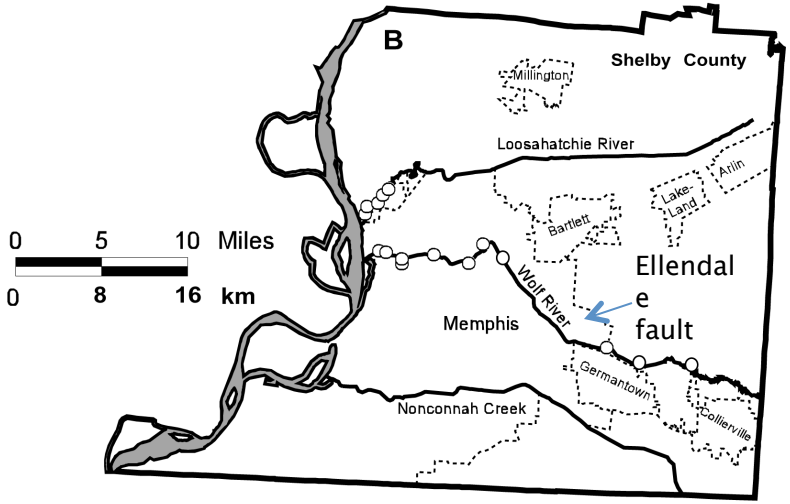


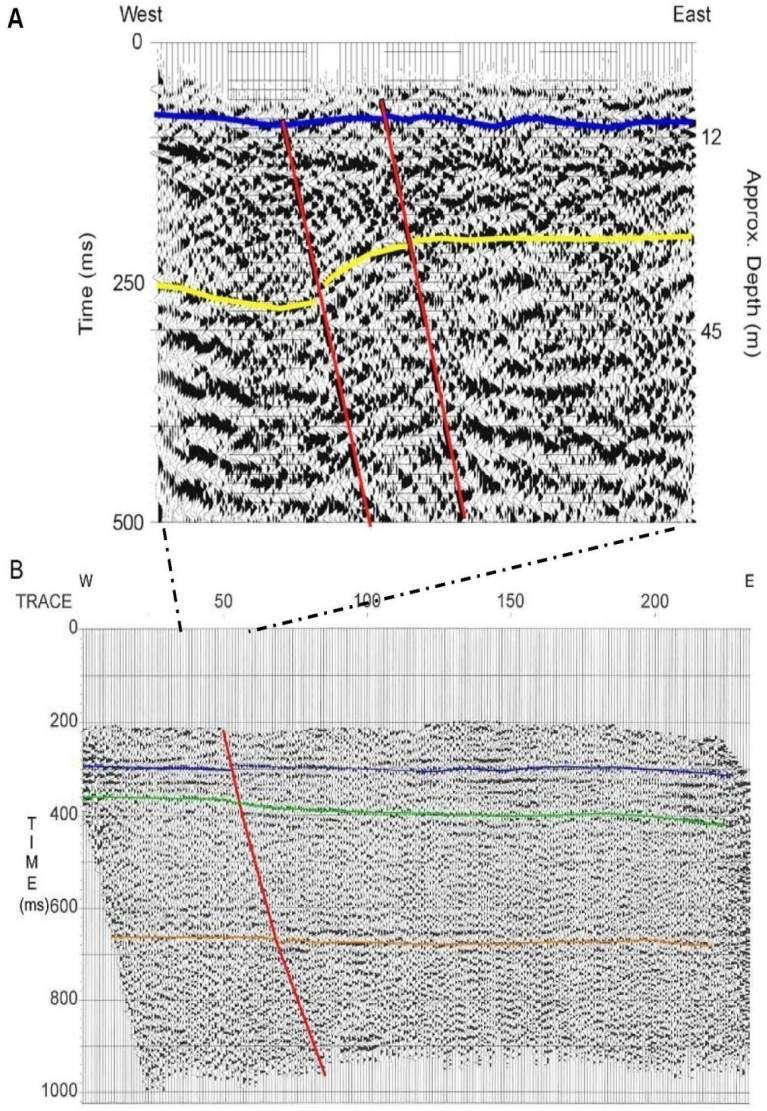




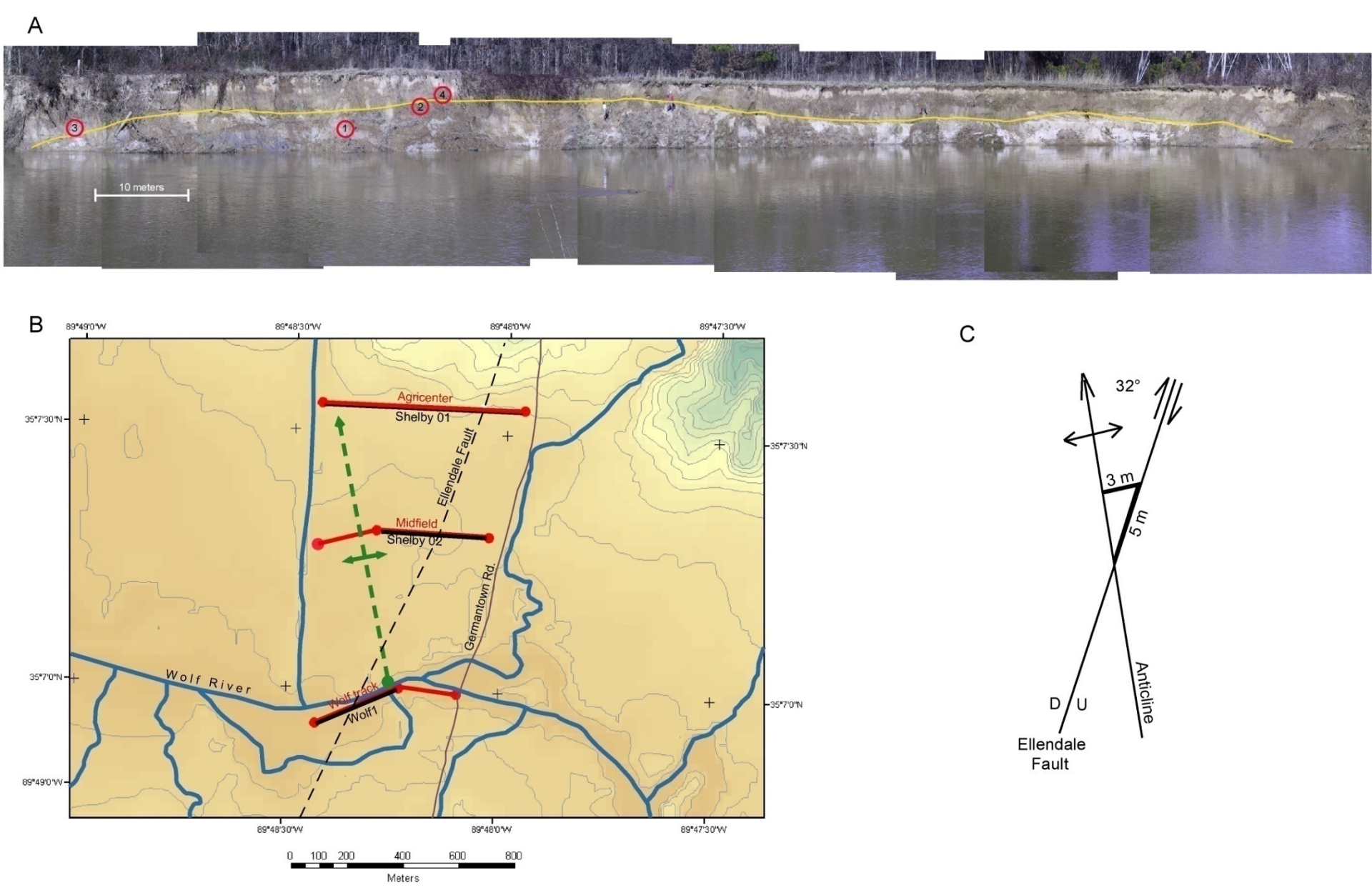
3 late Holocene eqs. identified in 2011 SSA-USGS trench (from Cox et al., 2006; Van Arsdale et al., 2011).







Inverted normal Ellendale fault and fold beneath central Shelby County
(from Van Arsdale et al., in press).



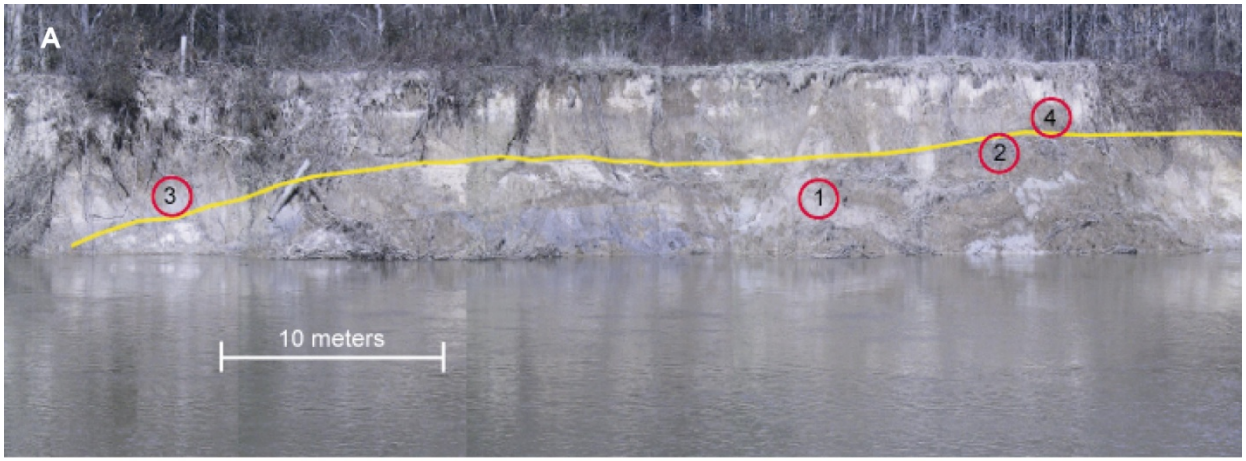
Anticline in northern bank of Wolf River in Shelby County. Anticline attributed to right lateral strike slip faulting (from Velasco et al., 2005).

1 = 4000 ±60 BP

2 = 2130 ±50 BP

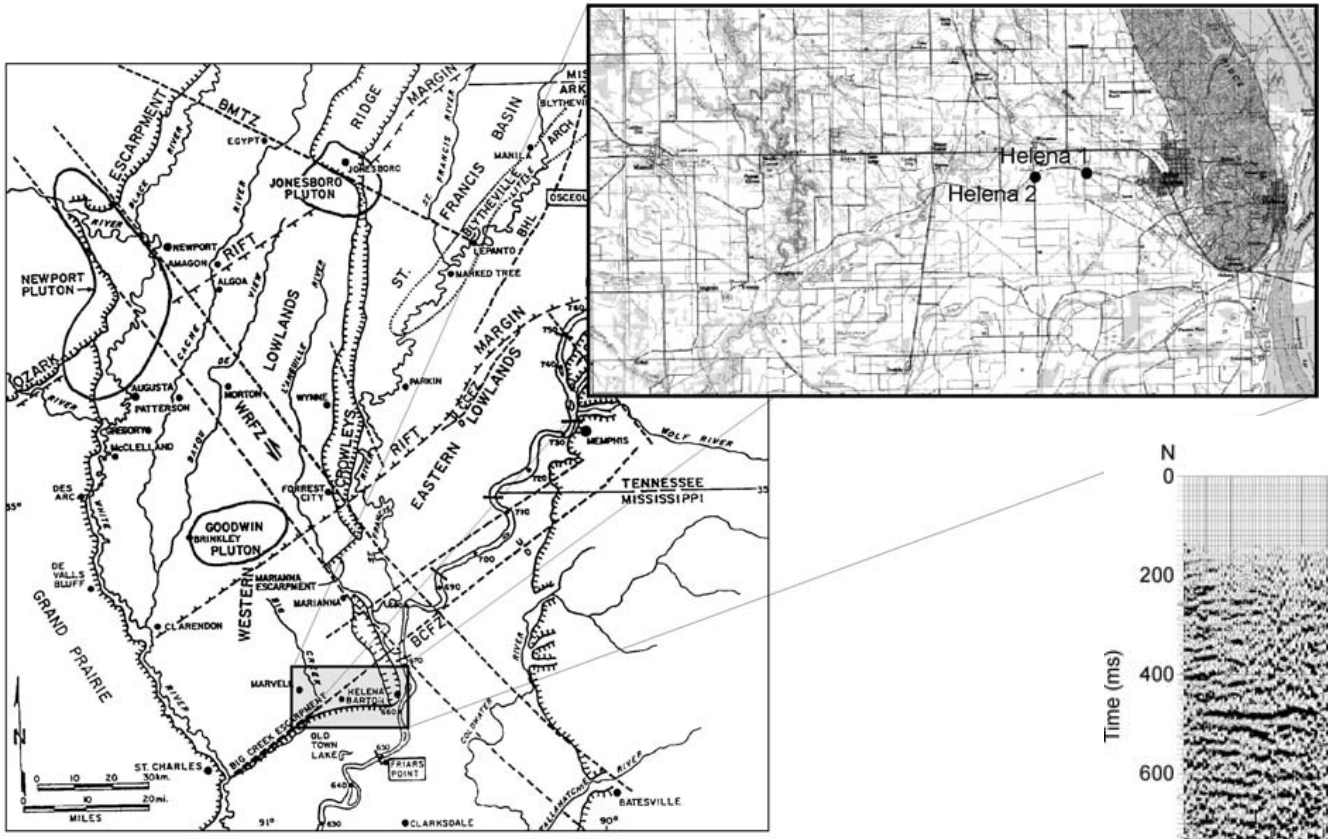
3 = 1610 ±60 BP

4 = 1550 ±40 BP



B

Unit 3 truncated by unit 4 indicates folding/ faulting occurred ~400 AD (from Velasco et al., 2005).



Big Creek Quaternary fault scarp west of Helena, AR (from Harris and Sorrells, 2006).

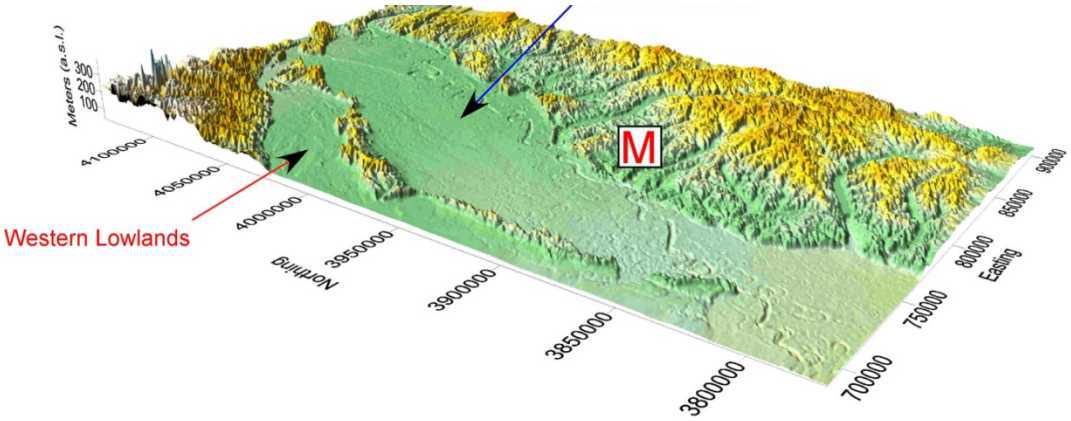
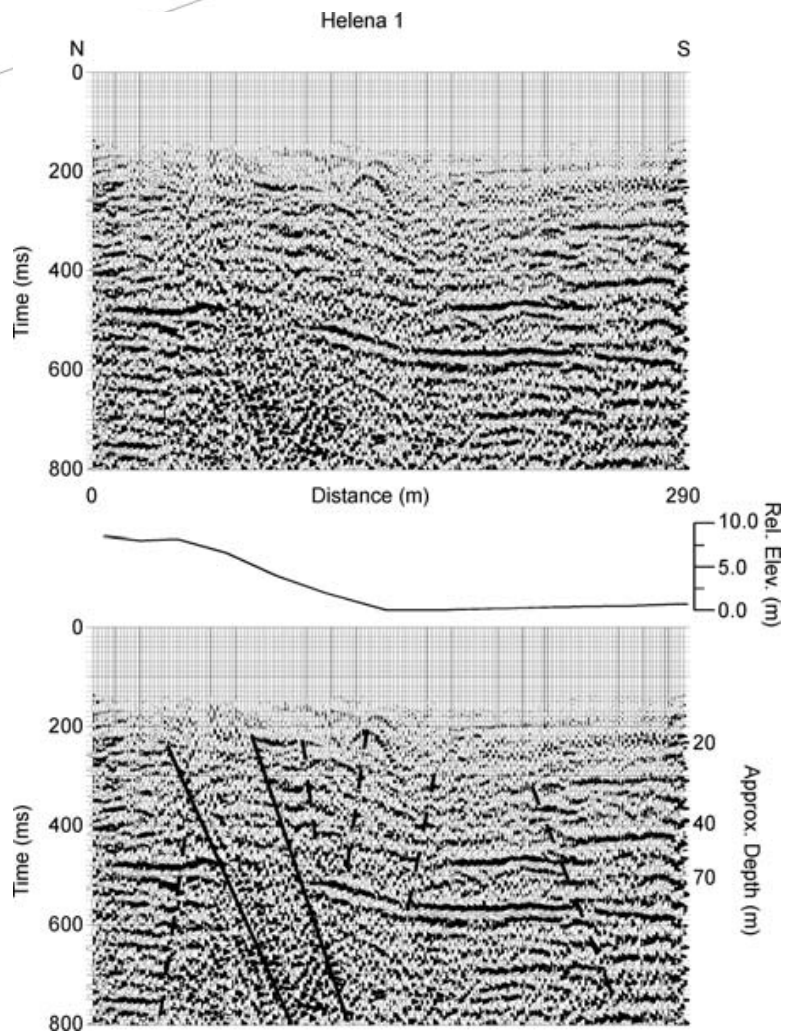
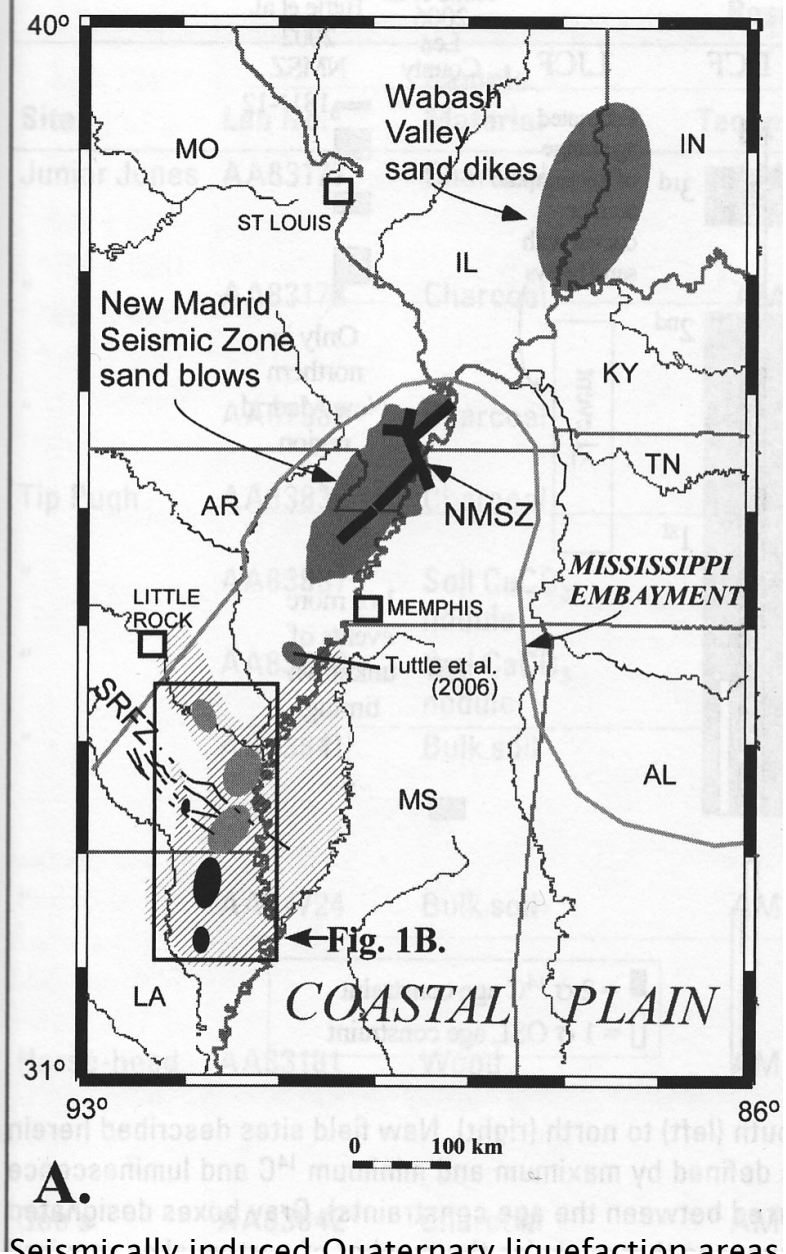
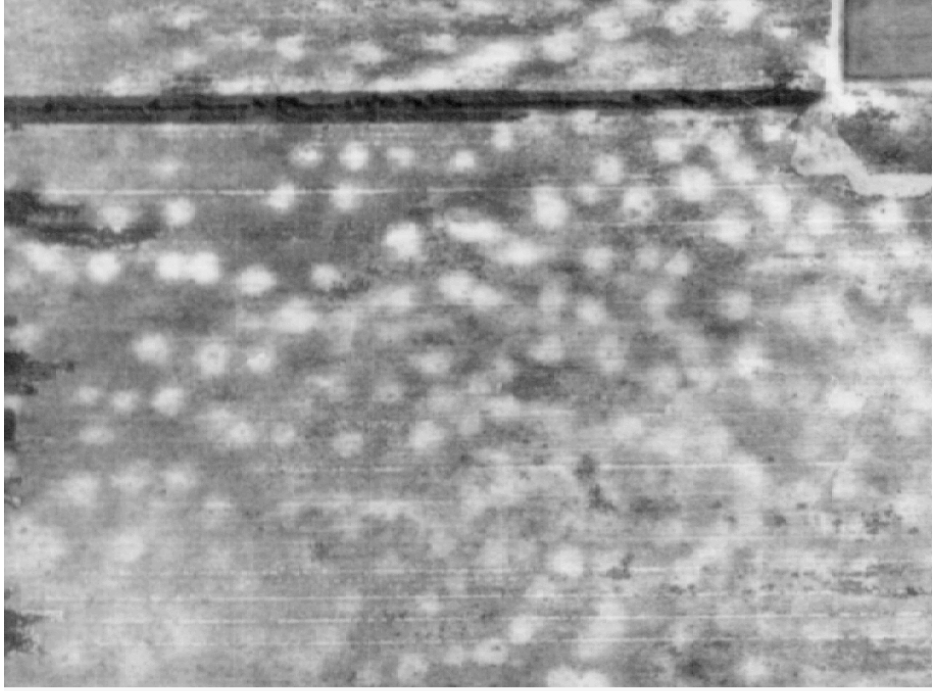


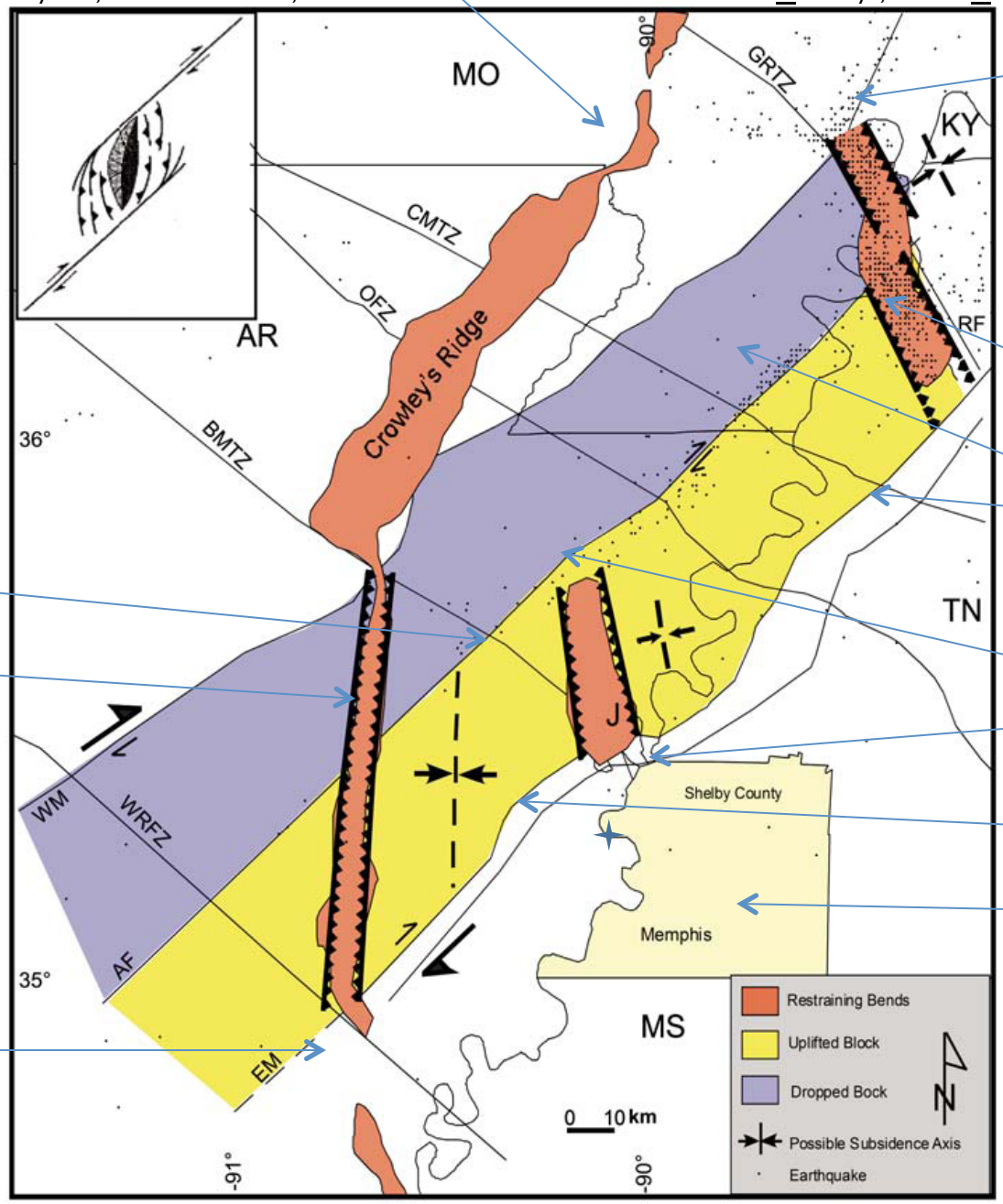
Figure 6. Three dimensional surface map of the upper Mississippi embayment with the position of the Eastern and Western Lowlands. M = Memphis.







Seismically induced Quaternary liquefaction areas in NMSZ, Marianna (Tuttle et al., 2006), and southeastern Arkansas and northeastern Louisiana. SRFZ–Saline River fault zone (from Cox et al., 2010).



Western Lowlands Eqs at 23,000–17,000 yr BP, 13,430–9,000 yr BP, A.D. 240–1020, and A.D. 1440–1540

Commerce fault Eqs. ~60–50 ka, ~35–25 ka, 5 ka ± 400 yr, 3660 ± 290 yr, 1811–1812

New Madrid North Quat. faulting

Wisconsin Union City scarp

Axial, Reelfoot, New Madrid North faults – 500 yr recurrence. A.D. 1811–1812, 1447 ± 8, 840 ± 40, 800 BC?, and 2350 B.C. ± 200 years

Bootheel faulting – 12,100–10,200 BP

Porters Gap – once <20 ka

Marked Tree high uplift 4440–3350 BP

Crowleys Ridge probable Wisconsin faulting

Manila High uplift 14,600–4200 BP and 90 B.C–A.D. 1640

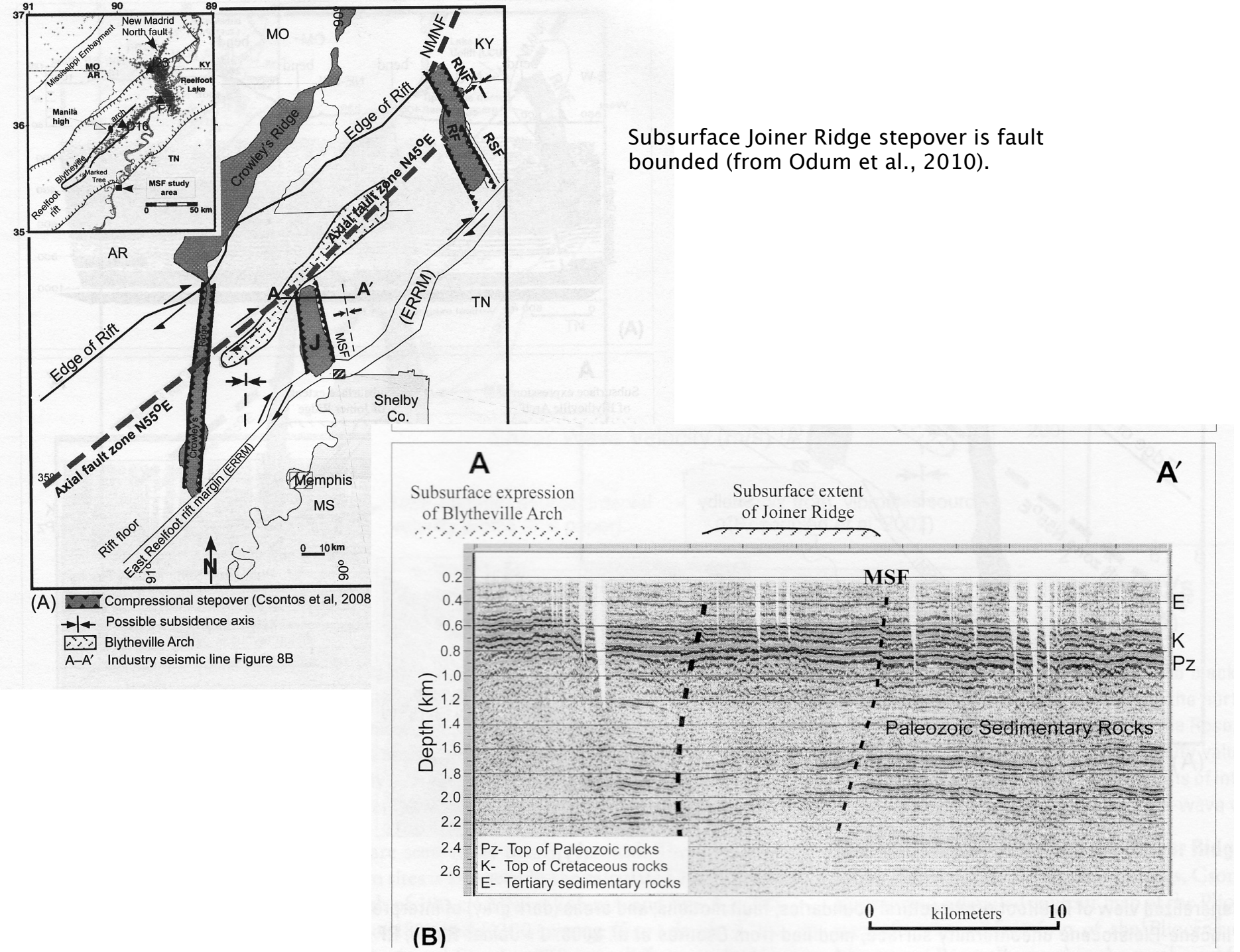
Shelby Forest – 2 Eqs. 4000 – 2000 B.P. and one at 2120–1800 B.P.

Crittenden County/Howe Quat. faulting

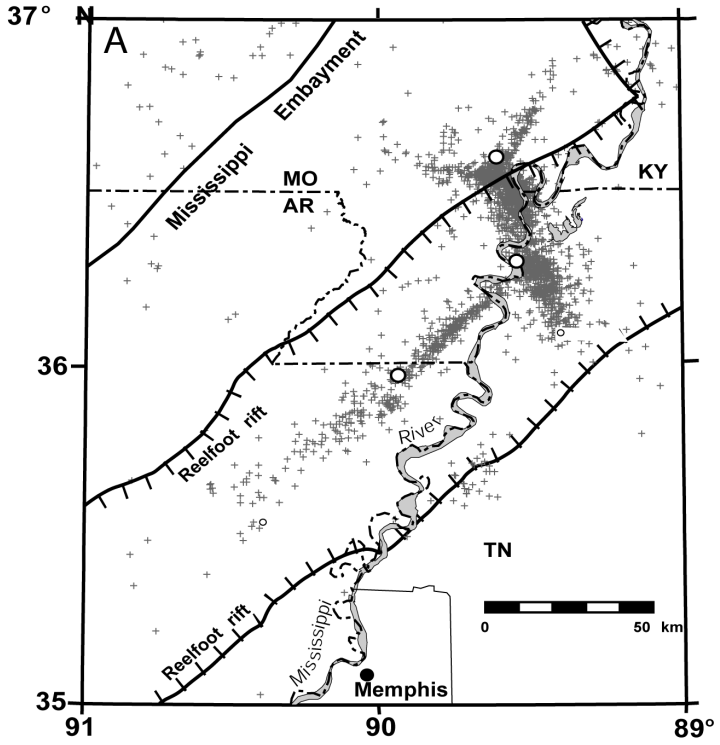
Ellendale faulting ~A.D. 400

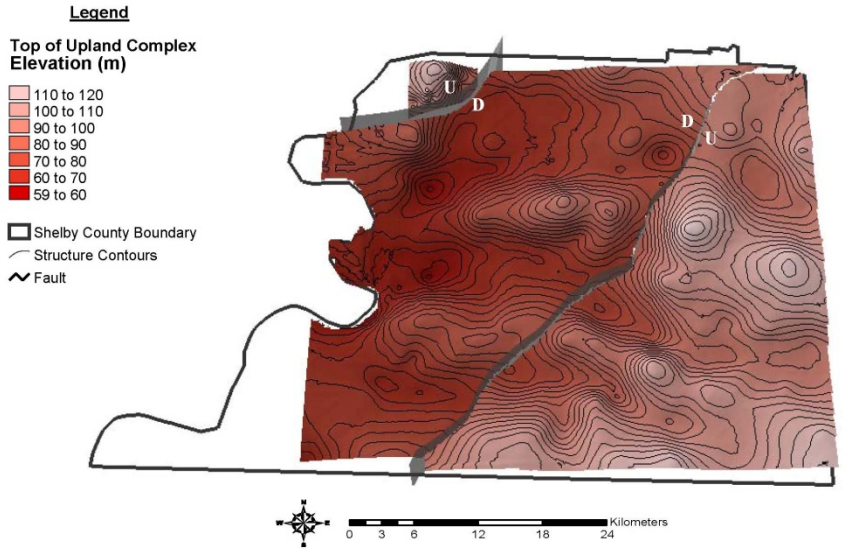
Marianna Eqs 7000–5000 BP

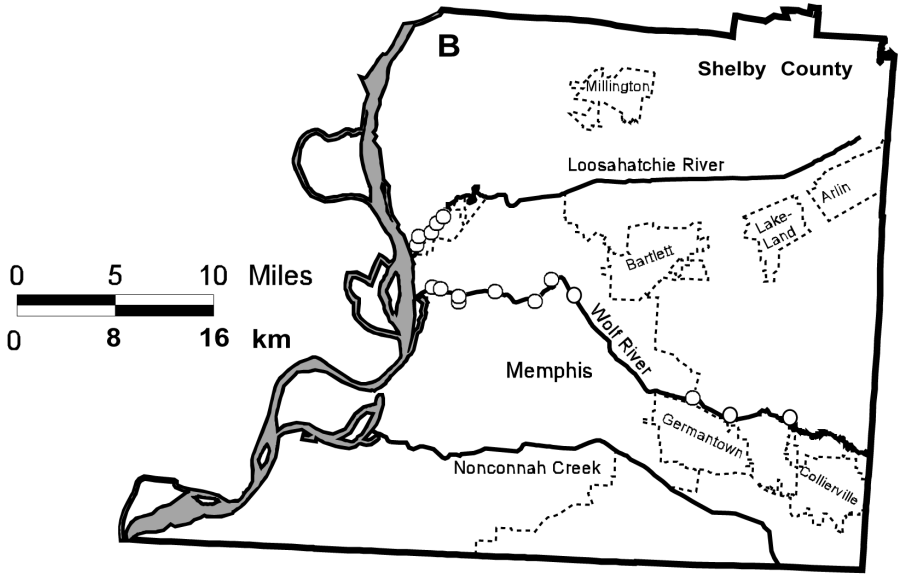
Big Creek Quat. faulting



Subsurface Joiner Ridge stepover is fault bounded (from Odum et al., 2010).



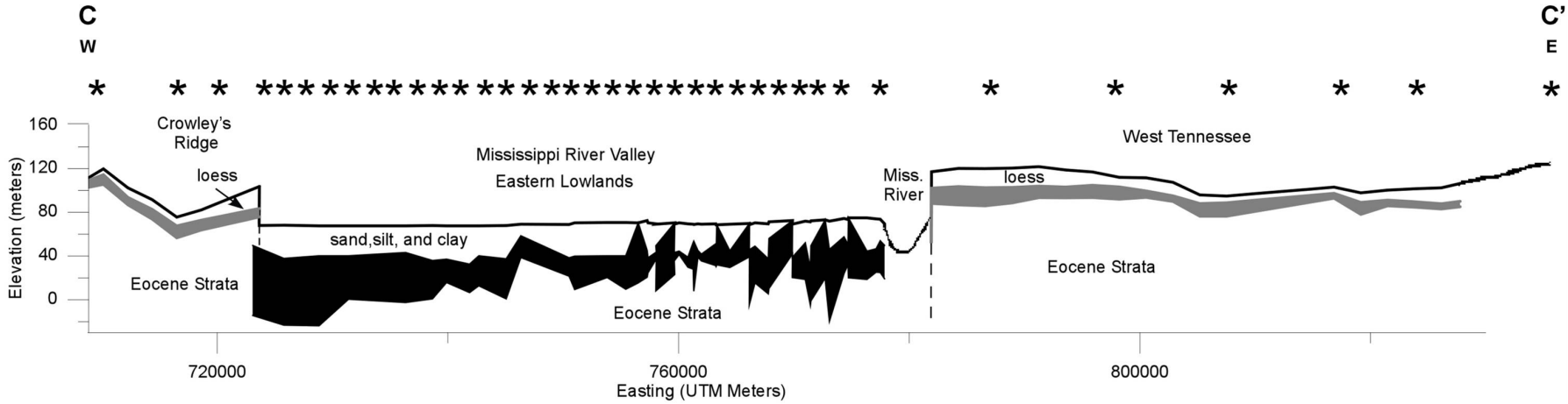




Commerce and Ellendale outboard faults

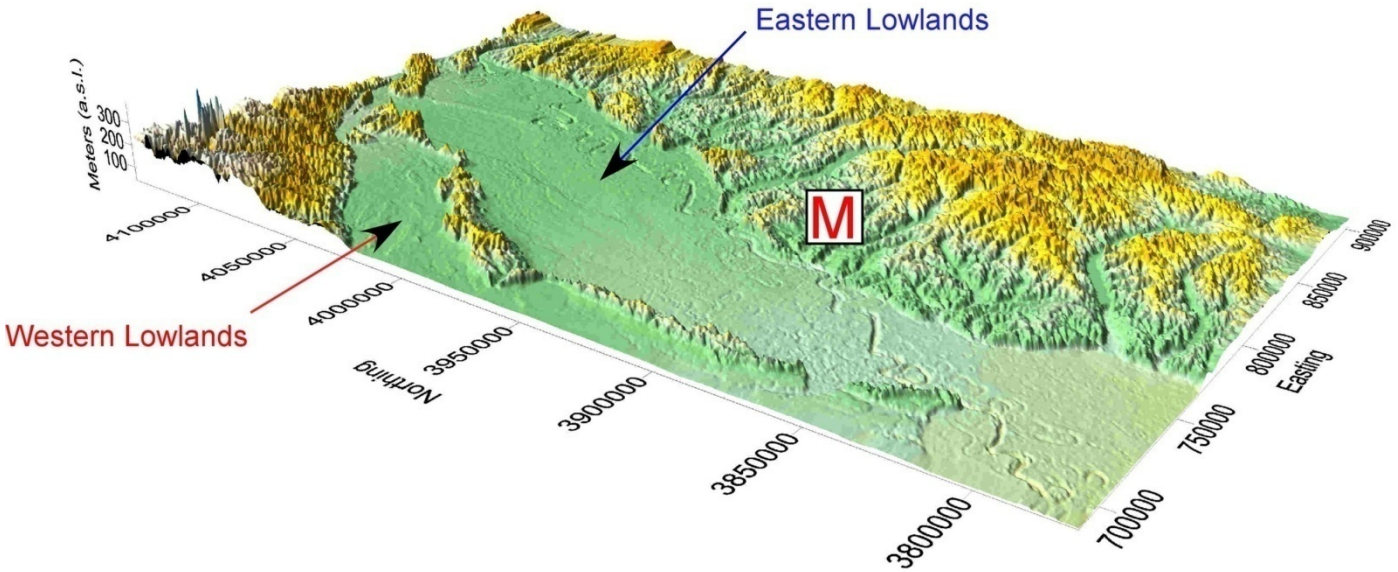
Animation

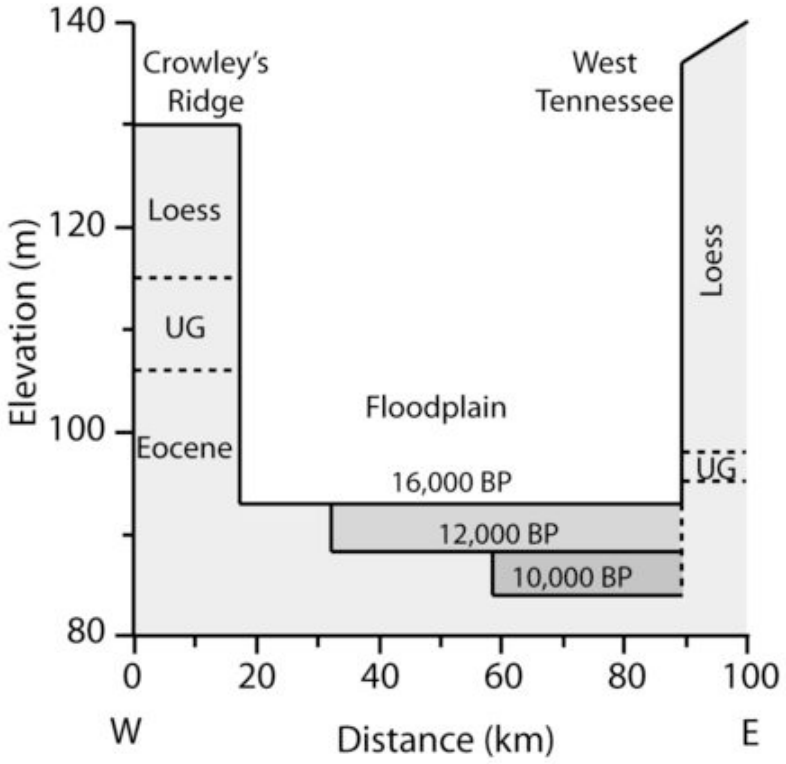
Cross section of Mississippi River Valley (Eastern Lowlands) just north of Memphis. Gray is remaining gravel facies of ancestral Mississippi River terrace. Mississippi River has entrenched to current elevation within last 5 Ma (from Van Arsdale et al., 2007).

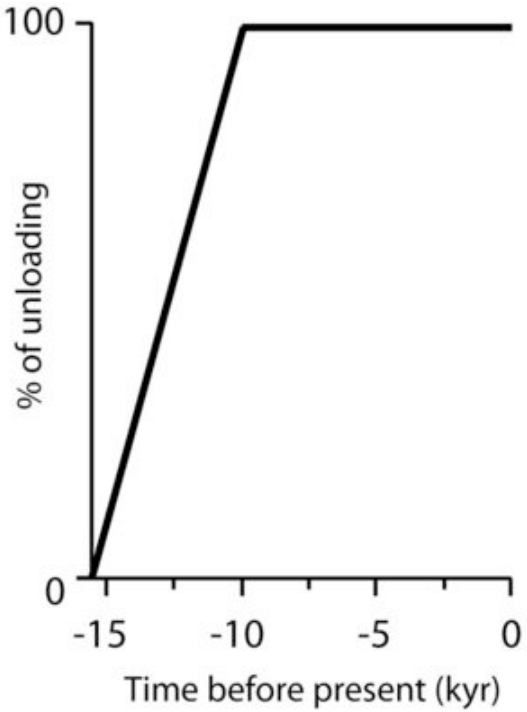


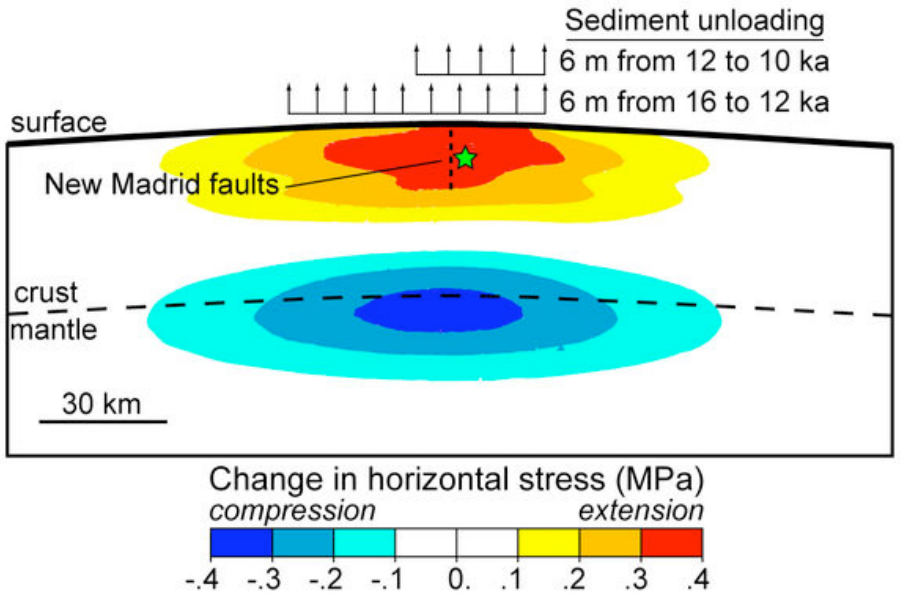
V.E. ~ 100

Black = Mississippi River Quaternary alluvial gravel
Gray = Upland gravel
* = Well position

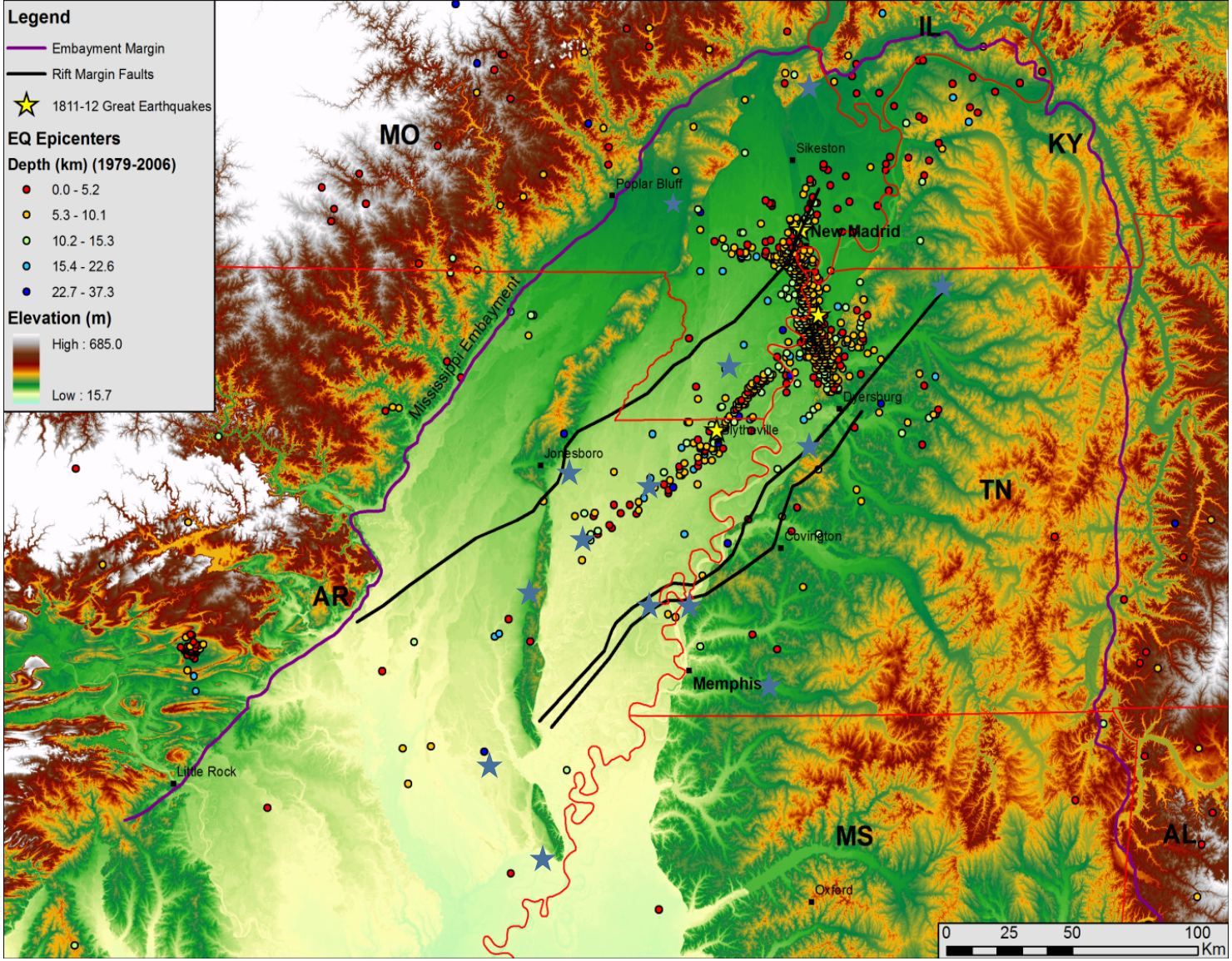








Mississippi River incision during the late Wisconsin reduced the horizontal compression across the NE trending Reelfoot Rift faults thereby activating them in the Holocene (from Calais et al., 2010).



1. Quaternary faulting extends beyond NMSZ seismicity pattern.
2. Quaternary faulting is confined within or along margins of Quaternary Mississippi River Valley.
3. Quaternary incision of the Mississippi River and its tributaries may be responsible for Quaternary faulting.