PALEOSEISMOLOGY OF THE SOUTHEASTERN MARGIN OF THE REELFOOT RIFT IN THE VICINITY OF MEMPHIS, TENNESEE

ANNUAL PROJECT SUMMARY 2002

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INVESTIGATIONS UNDERTAKEN: An alignment of earthquake epicenters follows the zone of faulting along the southeastern margin of the Reelfoot rift in western Tennessee (Braile et al., 1997; Chiu et al., 1997). In western Tennessee, a prominent scarp and topographic lineament may be the surface expression of the eastern rift margin fault zone (Fig. 1)(Fisk, 1944; O'Leary and Simpson, 1977; Wyatt and Stearns, 1988; Cox et al., 2001a). The southern 60% of this lineament is the bluff line scarp of the Mississippi River Valley. We have recently completed an analysis of drainage basin asymmetry along the Reelfoot rift margin in western Tennessee and Kentucky that suggests this fault zone was active over an extended period during Quaternary stream incision (Cox et al., 2001b).

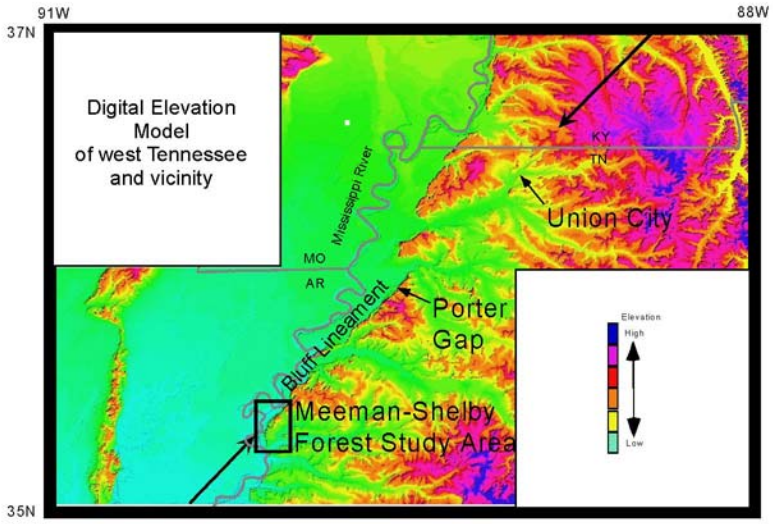

FIGURE 1

Two areas of the topographic lineament associated with the rift margin were investigated for evidence of paleoseismicity in the first phase of the study: the northern end at Union City, TN; and Porter Gap, Tennessee (Fig. 1). During 1999-2000 NEHRP-funded investigations we identified two sites along this rift margin that show strong topographic signatures of Quaternary surface fault rupture. We investigated these sites for near-surface faulting using a truck-mounted auger, by conducting shallow shear-wave seismic refection surveys, and by trench excavation at one site (Porter Gap, Tennessee). Our results show at least two Holocene events on this fault system. (Results of this NEHRP-funded work are published in Geology, Cox et al. 2001a).

In the 2002 phase, we have begun investigations at the southern end approximately 20km north of the Memphis metropolitan area in the vicinity of Meeman-Shelby Forest State Park and are continuing efforts at Porter Gap. For 2002, we acquired shear-wave reflection profiles, conducted electrical conductivity surveys, and drilled a core-hole transect to target excavation sites along the southeastern margin of the Reelfoot rift at Meeman-Shelby Forest State Park near

Memphis, Tennessee (15 to 25km north of the city) and at Porter Gap, Tennessee. We opened three trenches so far in 2002, one at Meeman-Shelby Forest and two at Porter Gap. We plan to open another trench north of Meeman-Shelby Forest State Park in early December 2002. Our goal is to document the sense and degree of slip and the chronology of fault movements. Trench walls were logged and photographed, and datable materials collected.

RESULTS: January 1 to October 1, 2002 we collected two shallow S-wave seismic reflection profiles in the Meeman-Shelby Forest area near Memphis (Fig. 2). These profiles show faulting beneath the topographic lineament, possibly extending to the surface. At the Boat-ramp Road site, a down-to-the-northwest monoclinal flexure (showing 20 to 30 m structural relief) marks the base of the bluff lineament, and there is a gentle anticline to the northwest adjacent to the monocline (Fig. 3). This shallow structure is consistent with deeper structure imaged on a published P-wave reflection profile coincident with part of this line (Williams et al. 2001). These folds are cut by several small-displacement (4 to 6 m) high-angle faults showing both normal and reverse separations (one fault changes down-dip from normal to reverse separation). The faulting style observed in this profile in consistent with strike-slip deformation and the associated juxtaposing

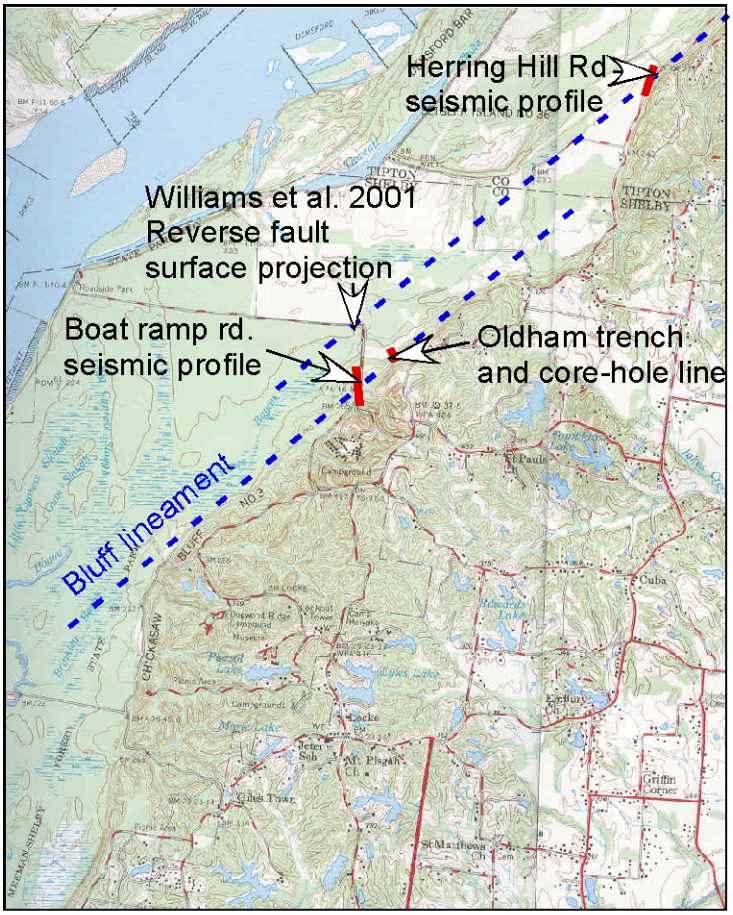

Figure 2. 2002 investigation sites in the vicinity of Meeman-Shelby Forest State Park.

of differing stratigraphic thicknesses. Due to excessive ground roll, we failed to image stratigraphy with a 120 m S-wave survey ~0.5 km southwest of the Boat-ramp Road site.

We collected push-cores along a transect across the topographic lineament at the Oldham site, near the Boat-ramp Road seismic profile. These cores revealed a tapering wedge of clay within an alluvial fan that suggests down-to-the-northwest displacement across two faults (~1 m separation on each) within 2 m of the surface (Fig. 4). We excavated a 42 m trench adjacent to the core-hole line exposing the eastern of these faults and flexures possibly associated with the western fault (Fig 5). The northeast-striking fault exposed in the trench displaces sediments with ^{14}C ages of ~4 ka, and organic-rich sediment from the base of a graben depression over the fault

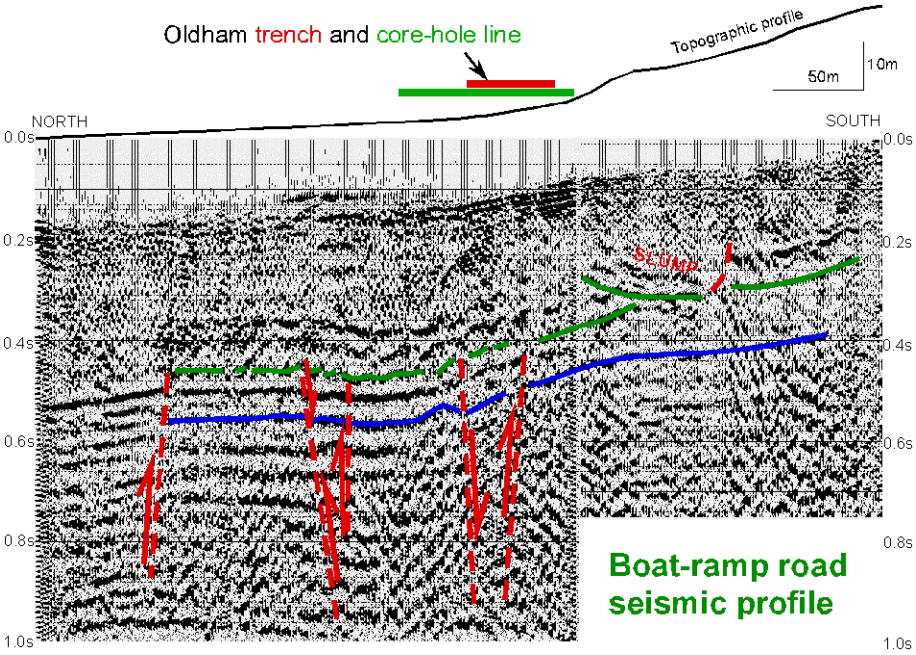

FIGURE 3

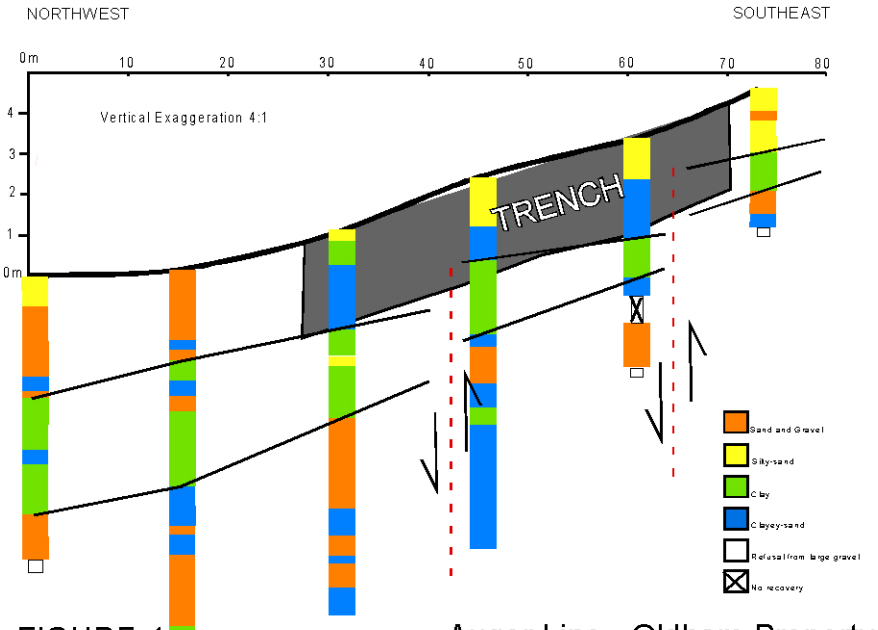

FIGURE 4 Auger Line - Oldham Property

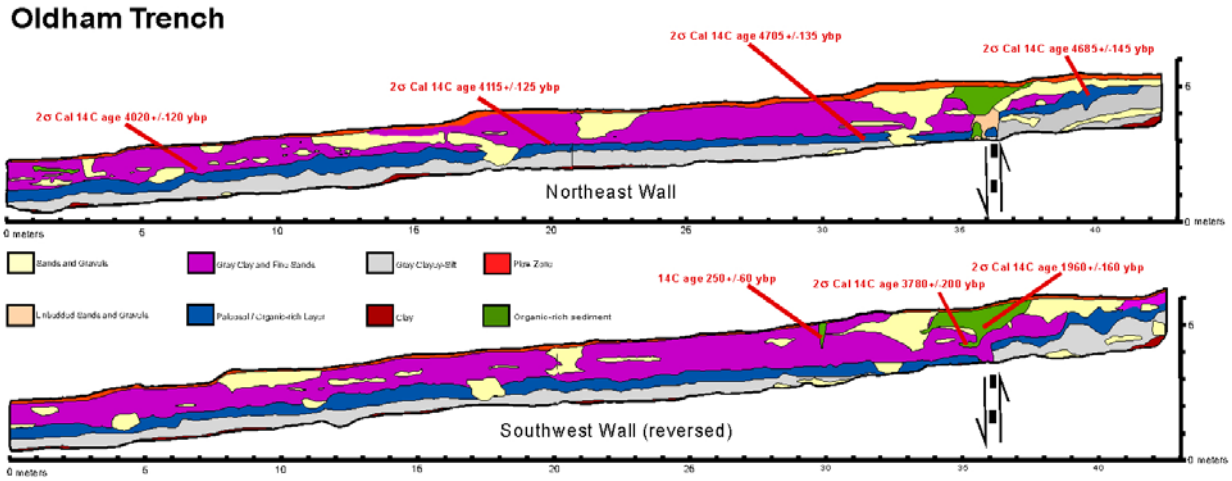

FIGURE 5

has a ^{14}C age of ~2 ka. We interpret this faulting event to have been slightly before 2 ka. Based on our core-hole data, we interpret this fault to be the surface expression of a fault revealed in the Boat-ramp Road profile, rather than a surficial landslide.

At the Herring Hill Road site we acquired another S-wave seismic line across an en echelon segment of the topographic lineament that shows shallow (≤10 m depth) folding and faulting (Fig. 6). This deformation may be associated with the same fault imaged by Williams et al. (2001) 5 km to the southwest and showing reverse motion. We plan to collect push cores at this site to target a site for trenching in early December 2002. We are now analyzing data from two additional trenches we opened at Porter Gap in October.

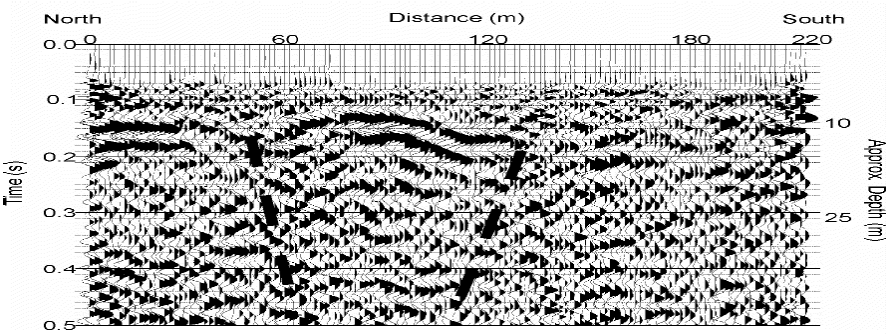

FIGURE 6 Herring Hill Road seismic profile

TENTATIVE CONCLUSIONS: Minor down-to-the-northwest surface faulting occurred on the bluff line lineament at ~2ka. There may have been a lateral component to the slip, but we could not discern any geomorphic signature of lateral slip. This movement at Meeman-Shelby Forest is more recent than pre-Mid-Holocene faulting we previously documented along the rift margin lineament at Porter Gap, thus a long rupture length is not suggested by our present data.

NON-TECHNICAL SUMMARY: Geophysical surveys, drilling, and excavations were undertaken along the Mississippi River bluff line near Memphis to look for evidence of faulting and prehistoric earthquakes. Evidence was found for one earthquake approximately 2000 years ago that was probably of moderate to low magnitude.

REPORTS PUBLISHED TO DATE:

Cox, R.T., Van Arsdale, R.B., Larsen, D., Harris, J.B., and Cherryhomes, J, 2002, Late Quaternary surface faulting in western Tennessee along the southeastern margin of the Reelfoot Rift: Geol. Soc. Am. Abstrts/Programs, 43(6):28.

DATA AVAILABILITY: Seismic data can be obtained from Dr. Jamie Harris, Department of Geology, Millsaps College, Jackson, MS 39210-0001; Ph. 601-974-1343; harrijb@okra.millsaps.edu.

REFERENCES:

Braile, L. W., Hinze, W. J., and Keller, G. R., 1997, New Madrid seismicity, gravity anomalies, and interpreted ancient rift structures: Seismological Research Letters, 68: 599-610.

Chiu, S. C., Chiu, J. M., and Johnston, A. C., 1997, Seismicity of the southeastern margin of Reelfoot rift, central United States: Seismological Research Letters, 68: 785-796.

Cox, R.T., VanArsdale, R.B., Harris, J. B., and Larsen, D., 2001a, Neotectonics of the southeastern Reelfoot rift zone margin, central United States, and implications for regional strain accommodation: Geology, 29:419-422.

Cox, R.T., VanArsdale, R.B., and Harris, J. B., 2001b, Identification of possible Quaternary deformation in the northeastern Mississippi Embayment using quantitative geomorphic analysis of drainage-basin symmetry: Geol. Soc. Am. Bull, 113: 615-624.

Fisk, H.N., 1944, Geologic investigation of the alluvial valley of the lower Mississippi River: U.S. Army Corps of Engineers, Vicksburg, MS, 78 p.

O'Leary, D. W., and Simpson, S. L., 1977, Remote sensor applications to tectonism and seismicity in the northern part of the Mississippi Embayment: Geophysics, 42: 542-548.

Williams, R., Stephenson, W., Odum, J., and Worley, D., 2001, Seismic-reflection imaging of Tertiary faulting and related post-Eocene deformation 20 km north of Memphis, Tennessee: Engineering Geology, 62: 79-90.

Wyatt, D. E., and Stearns, R. G., 1988, Possible active fault zones in west Tennessee interpreted from surface lineaments and magnetic and gravity anomalies: Southeastern Geology, 28: 191-210.