INVESTIGATION OF SEISMICALLY-INDUCED LIQUEFACTION IN THE SOUTHERN MISSISSIPPI EMBAYMENT

ANNUAL PROJECT SUMMARY 2001

Award Number 01HQGR0052

Principal Investigator: Randel Tom Cox

Institute of award
Department of Geological Sciences
University of Memphis
Memphis, TN 38152

Telephone: 901-678-4361
Fax: 901-678-2178
E-mail: randycox@memphis.edu

Program Element: CU II

Key Words: Paleoliquefaction, Paleoseismicity, Neotectonics, Trench investigations

INVESTIGATIONS UNDERTAKEN: Strong ground shaking is indicated by a 12 km-long liquefaction field in the southern Mississippi Embayment in Ashley County, Arkansas (Fig. 1). The liquefaction field is comprised of circular and elliptical sand blows, ~1 m thick and ~10 to 15 m across, overlying overbank clays and silts of a late Holocene alluvial terrace with a shallow water table (Cox et al., 2000a). Sand dikes extend upward through the underlying clay and silt to the surficial sand blows. These liquefaction features are well outside the known region of liquefaction associated with the New Madrid seismic zone (NMSZ) in the northern embayment. If these sand bodies were vented in response to large New Madrid seismic events (300 km to 400 km to the northeast), then the area of induced liquefaction (and strong ground motion) recognized for the NMSZ is greatly underestimated. Alternatively, the liquefaction in Ashley County may be associated with a local seismic source, for example, the Saline River fault (Cox, 1994; Cox et al., 2000b).

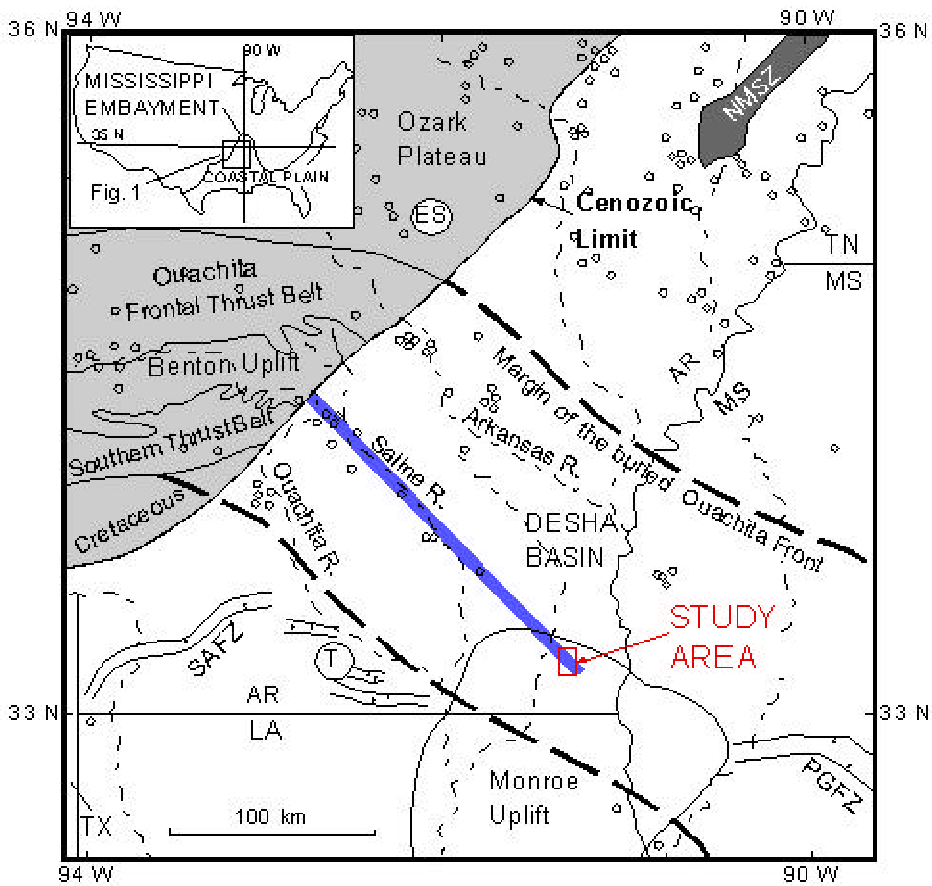

Figure 1. Regional tectonic elements of the southwestern Mississippi Embayment. Open circles are historic and instrumental epicenters (from Center for Earthquake Research and Information catalog, Memphis, TN); NMSZ = New Madrid seismic zone; SAFZ = South Arkansas fault zone; PGFZ = Pickens-Gilberttown fault zone; ES = Enola Swarm cluster of epicenters; T = cluster of epicenters of seismicity triggered by underground fluid injection. Ball on surface faults shows down-thrown block. Broad blue line shows approximate position of Saline River fault zone (after Cox, 1994; Cox et al., 2000b). Thin dashed lines are rivers. Red box is location of the liquefaction field under investigation in this study.

Preliminary work included logging of a partially exposed sand blow in a drainage ditch and additional logging of this blow in a pit we excavated. The project funds became available in February 2001, and work accomplished so far in 2001 includes taking three Giddings rig push cores (two within the liquefaction field and one just outside it) to characterize the shallow stratigraphy, logging a sand blow partially exposed in a drainage ditch, logging this blow more completely in a trench we excavated adjacent to the drainage ditch, and reconnoitering addition trenching sites using aerial photography, field inspections and electrical conductivity surveys (with a Geonics EM-31). Walls of the trench were logged in detail to establish the stratigraphic relationships of vented liquefaction deposits to alluvial deposits and soil horizons (Fig. 2). From this trench we obtained ^{14}C charcoal and bulk sediment carbon ages (Beta Analytic Inc.) for four stratigraphic units and are presently awaiting two thermoluminescence ages of silt horizons buried by vented sand (analyses being conducted by Steve Forman, Univ. of Illinois at Chicago).

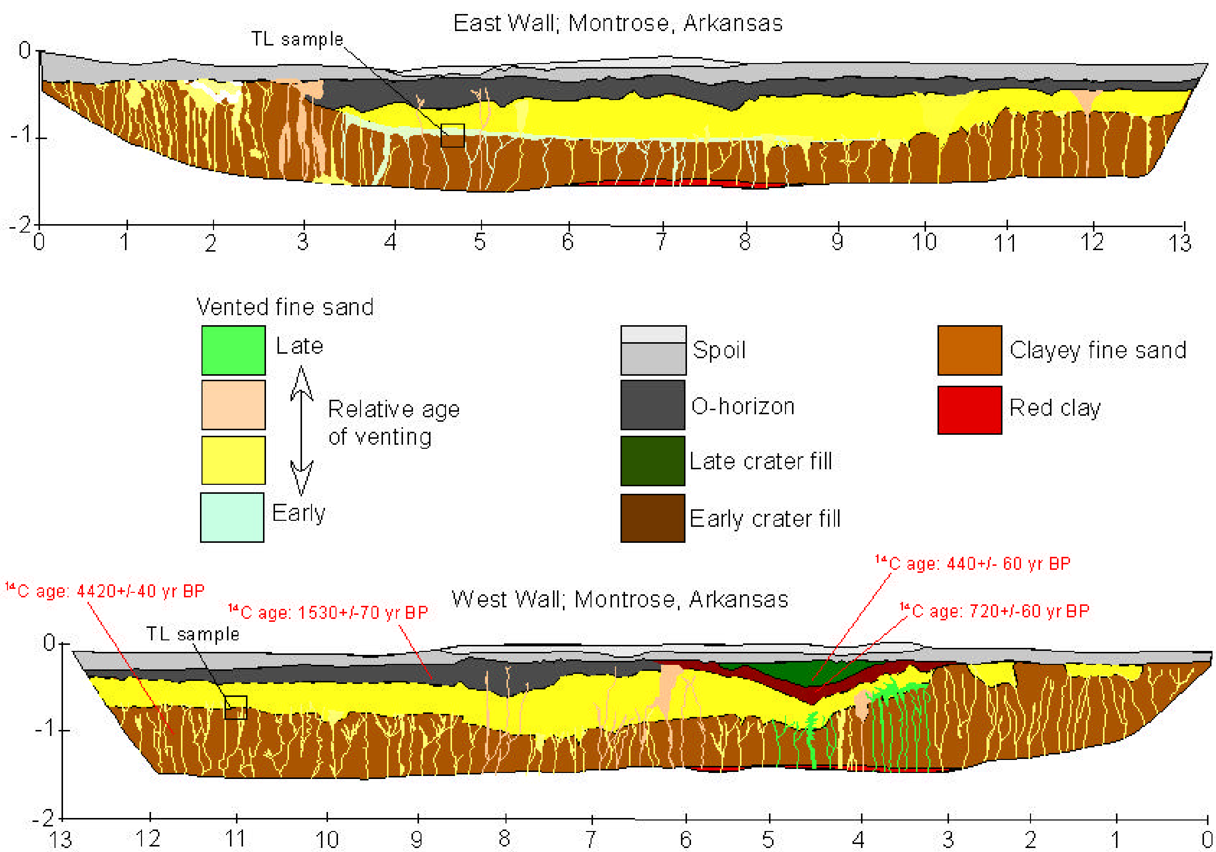

FIGURE 2

Log of walls of trench through a sand blow in the study area.

RESULTS: Our trench was located in the region of the liquefaction field having the densest concentration of sand blows. The principal vented sand deposit in the trench was ~0.75 m thick, and 10 m of this blow were exposed laterally (Fig. 2). A large number of small vents (<10 cm wide) feed this sand blow, and a large number of clasts (~1 cm diameter) of the alluvium substrate have been entrained by the vented sand and moved up into the sand blow deposit. A bulk sediment ^{14}C age of 1530+/-70 yr BP was obtained from the base of the O soil horizon developed on this blow, and a charcoal age of 4420+/-40 yr BP was obtained from the alluvium covered by the blow. In addition, thermoluminescence age analysis is currently being conducted on the alluvium immediately below this vented sand (see Fig. 2 for location of samples for age control). We interpret this venting episode as the strongest paleoseismic event recorded in the liquefaction field.

In a portion of the trench, this blow buries a thinner vented sand deposit (Fig. 2, East wall, meter 3.5 to 9.5) fed by several small vents. This older blow is <10 cm thick, but it may have been eroded substantially before the overlying venting episode. Thermoluminescence age analysis is currently being conducted on the alluvium immediately below this older blow (see Fig. 2).

At least two venting episodes postdate the principal sand blow. Sand vents cross-cut the principal sand blow deposit at meter 2.7 to 3.5, 4.4, 4.9, and 11.9 on the east trench wall and at meter 3.2 to 4.8, 5.7 to 6.9, and 7.9 to 8.2 on the west wall (see Fig. 2). Vents at meter 4.0 to 4.2 cross-cut the vent at meter 4.3, indicating two venting episodes. Many of these relatively young vents are in the vicinity of a crater showing two periods of subsidence and filling with organic-rich sediment, and we interpret this crater as a subsidence feature related to these venting episodes. In the west trench wall, the lower crater fill extends from meter 2.9 to 6.3, and the upper crater fill extends from meter 3.8 to 5.7. A bulk sediment ^{14}C age of 720+/-60 yr BP was obtained from the lower crater fill, and an AMS ^{14}C age of 440+/- 60 yr BP was obtained from the upper crater fill (see Fig. 2). In our interpretation, the first venting episode to cross-cutting the principal blow pre-dates these ages, and the second cross-cutting venting episode is bracketed by these ages.

TENTATIVE CONCLUSIONS: The principal sand blow deposit in this trench represents the event that produced the presently observable liquefaction field at this site. Following Ambraseys (1988), the diameter of this field suggests a paleoseismic event of magnitude 5.5 to 6. The earlier, thinner sand blow deposit may have been more extensive before erosion, and indeed, it is fed by a 5 to 10 cm wide vent (Fig. 2, meter 3.8, east wall) comparable to the largest vents feeding the principal sand blow. The latest events were either related to paleoseismicity of much lower intensity than the principal event, or other factors reduced the venting volume. For example, a lower water table would reduce the liquefaction potential. Alternatively, previous shattering of the clay cap during the principal venting episode may have reduced the potential for elevated pore pressure in the liquefying horizon during ground shaking.

NON-TECHNICAL SUMMARY: Circular to elliptical sand bodies found on a low elevation river terrace in the lower Mississippi River Valley in southeastern Arkansas are similar in size, shape and spacing to eruptions of sand caused by earthquakes in the New Madrid seismic zone. Excavation of two of these sand bodies show the sand moved upward to the surface through fissures, and thus we interpret they were formed during ground shaking during prehistoric earthquakes. Based on ^{14}C age analyses, we find at least four earthquakes occurred between 2400 BC and 1560 AD.

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