Paleoseismology Study in the Cache River Valley, Southern Illinois

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Annual Project Summary

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Investigations Undertaken

This paleoseismology investigation of the Cache River Valley (CRV) of southern Illinois is a collaboration between J. Chester (TAMU) and M. Tuttle (M. Tuttle & Associates) with contributions by J. Sims (USGS) and B. Noonan (M.S. student at TAMU). The main goals of the project are to (1) study and describe in detail liquefaction and post-Cretaceous fault features identified during our 1997 reconnaissance, (2) conduct a systematic search for additional earthquake-related features along the Cache River and several of its tributaries to provide information for estimating the timing and magnitudes of prehistoric earthquakes, (3) study the relations between faults, regional structures and seismicity, and (4) evaluate the relations between the size distribution of liquefaction features and possible earthquake sources in the CRV, New Madrid seismic zone, and Wabash Valley seismic zone.

The CRV is located along the northern margin of the Mississippian embayment, immediately northeast of the New Madrid seismic zone and southwest of the Wabash Valley seismic zone. Small to moderate earthquakes are common in this region, though less frequent than in the surrounding seismic zones. The CRV is located between several major fault systems including the Fluorospar Area fault complex to the east, Commerce fault system to the west, and Ste. Genevieve/Iron Mountain fault system to the northwest. Some significant post-Cretaceous faulting has occurred in these regions (e.g., Harrison and Schultz, 1994; Nelson, 1995, Nelson et al., 1997; Hoffman et al., 1996). The areas of focus for this project include the Cache River, Big Creek, Cypress Creek, Mill Creek, Columbia Ditch, Main Ditch, and Post Creek Cutoff.

During our 1997 reconnaissance in the CRV, we identified Holocene liquefaction features and a possible Quaternary fault (Tuttle et. al., 1996; Obermeier et al., 1996; Munson et al., 1996). Nine sand dikes and two possible sand blows were found during reconnaissance along a 3-km section of the Cache River and a possible Quaternary-age fault was found along a 5-km section of the Post Creek Cutoff (Tuttle et al., 1996a). Weathering characteristics of many of the liquefaction features indicate that they are prehistoric in age. Radiocarbon dating of the host sediments indicates that the features formed during the past 5,000 yr. The small to moderate size of the liquefaction features suggests that they formed as a result of ground shaking of modified Mercalli intensity VIII-IX. However, the number, timing, and magnitude of the Holocene earthquake(s) need to be better resolved. The northwest-oriented deformation zone found along the Post Creek Cutoff is 30 m wide and may be related to faulting. The zone is characterized by concentrated shear displacement involving a brown chert gravel deposit, probably the Pliocene-Pleistocene Mounds Gravel. The deformation zone includes many steeply dipping, polished surfaces that juxtapose different sedimentary units. The zone of deformation parallels a set of northwest-oriented lineaments in the area. Similar deformation structures, located about 3 km to the southeast, were interpreted as resulting from solution collapse during deposition of the Mounds Gravel along a northeast trending regional joint set (Kolata et al., 1981). The stratigraphic relations, however, do not rule out the possibility that both of the deformation zones resulted from faulting.

Results

We have spent several weeks in the field during the summer and fall of 1998 searching an additional 30 km of river and ditch cutbanks and numerous quarry and terrace exposures in the CRV for earthquake-related features (Figure 1). We also have trenched and logged one liquefaction feature in detail (Figure 2). Due to heavy rainfall this past summer and early fall, water levels often were above normal and therefore complete cutbank exposures were limited. We will continue our river and ditch cutbank studies to address our goals through the summer and fall of 1999 when hopefully there are more optimum water levels and vegetation conditions.

Stream sections investigated include Dutchman Creek south of Vienna, Cypress Creek east of Perks, Big Creek near the gauging station, Cache River near Cache Chapel on the Cypress Quad, and south of Ullin, Mill Creek west of Ullin and northeast of Tamms, Jackson Creek, New Columbia Ditch and Bear Creek Ditch on the Mermet Quad (Figure 1). High water, thick vegetation, and low banks characterized the tributaries north of the Cache River. Those that hold promise for cutbank studies will be revisited in the fall of 1999. Water levels were lower south of the Cache in Boar Creek and Hodges Creek, and others adjacent to the Ohio River, but Tertiary and older rocks are exposed in these creeks, making the possibility of finding liquefiable sediments in these drainages improbable. Searches in these latter drainages will focus on evidence for post-Cretaceous faulting.

In spite of the high-water conditions, one previously discovered sand dike was exposed along the Main Ditch (MD-1; Figures 1 and 2). Brian Noonan (Texas A & M University) and John Sims (USGS) excavated and logged this feature in detail. The sand dike cuts an alluvial sequence of interbedded sand, silt and clay in the northern bank of Main Ditch, approximately 20 meters upstream from the intersection of Main Ditch and Post Creek Cutoff. An exposure, approximately 8 meters long and 1.5 meters high, consisting of two main benches, was excavated parallel to the existing walls of the Main Ditch to reveal the cross-cutting relations between the dike and surrounding strata. A gray and yellow mottled silty clay, overlain by a sequence of red, weakly cemented sands, gray, organic rich clays, and organic mats with intact leaves and logs were exposed along the lower bench. The sand dike cut all of these units. The upper portion of the clay/sand sequence was also exposed on the lower portion of the upper bench where it was overlain by a 70 centimeter thick mottled silt displaying some areas of significant iron staining and iron nodule development. The sand dike is oriented subparallel to the Main Ditch wall and therefore additional exposures were created to allow observation of the dike perpendicular to its

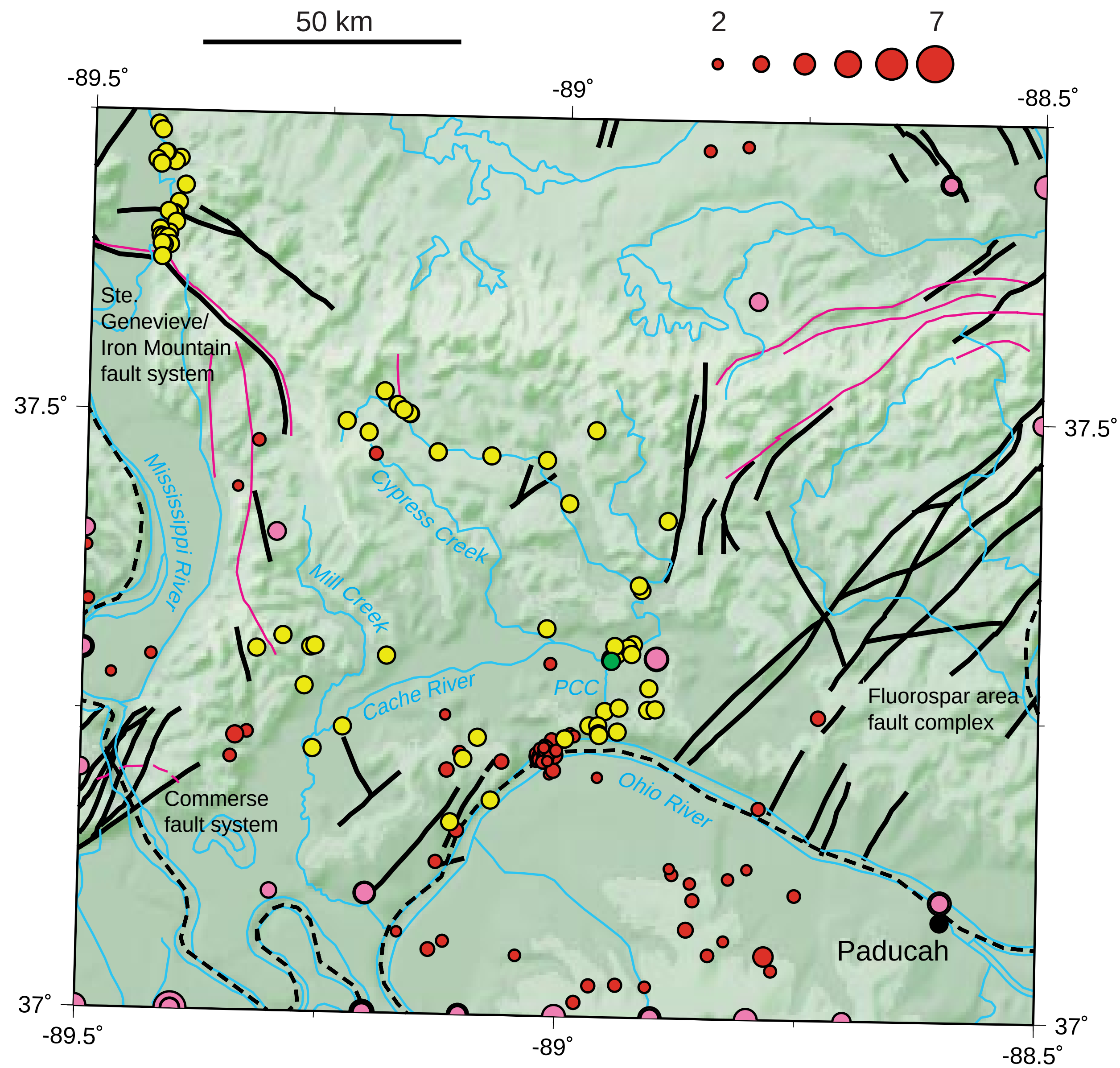

Figure 1. Study locations, seismicity and structural features on a topographic-hydrographic base map of the Cache River Valley region. Yellow circles show the study locations; the green circle shows the location of site MD-1 where the exposure log in Figure 2 was made. Red circles show the epicenters of all earthquakes of magnitude 2.0 or greater recorded by the Central Mississippi Valley Seismic Network between 1972 to present. Pink circles show the epicenters of historical earthquakes of magnitude 2.0 or greater prior to 1972 (Nuttli and Brill, 1981). Symbol size increases with earthquake magnitude as shown above the figure. The surface traces of faults and fold axes are shown with heavy black and thin magenta lines, respectively. The topographic base map is a shaded relief map where green and yellow shades represent lower and higher elevations, respectively. Shading, as if illuminated from the northwest, is used to accentuate shorter scale changes in topography. The topography is based on the 1-Degree USGS Digital Elevation Model sampled at a 9 arc-second interval. Smaller rivers, streams and other waterways and the outlines of major rivers, lakes and reservoirs are shown by cyan lines. Hydrography is based on the USGS Digital Line Graph of the 1:2,000,000-scale sectional maps of the National Atlas of the USA. Base map is a Lambert Conic Conformal projection.

strike. The dike cuts the sands, clays and silts, appearing to terminate in the upper gray clay at the top of the lower bench. We believe that the far NW plan view exposure represents a portion of the dike termination. At this location, the dike splays into several smaller dikelets, and is spatially associated with a small sand sill in the terminal region. Our preliminary interpretation is that the pore pressure in the sand dike decreased sufficiently during formation of these features such that it could not intrude the overlying silts. Radiocarbon dating of two samples collected from the alluvial sequence during reconnaissance suggests that the dike formed since 2890 B.C. Several additional samples of charcoal and wood were collected to help constrain the age of this feature and the ages of the host deposits. As part of his M.S. thesis research at Texas A & M University, Brian Noonan is working on the trench log for the MD-1 site and is in the process of preparing samples from this site for age dating.

An additional site, where a liquefied source layer, sand dikes, and a possible sill were described during 1997 reconnaissance (PCC-8 and PC-8), was revisited for further study. Flagging marking the site was found at the edge of the adjacent levee. Unfortunately, it appears that this site has been severely undercut, slumped and eroded due to springs flowing out of the bank at the sand/clay interfaces. An exposure, several meters in length excavated at this site, displayed interbedded quartz sand and brown clay, of probable fluvial origin, overlain by an orange/gray mottled silt. The liquefaction features were no longer present.

To date, our findings indicate that a broader systematic search for liquefaction features, faults and other earthquake-related deformation is likely to yield new information relevant to the earthquake potential of the region. This project will contribute to the NEHRP Element I (Evaluating National and Regional Hazard and Risk) by providing new information about the timing and magnitudes of prehistoric earthquakes and their relations to structural elements in the region. The results of this project will contribute to our understanding of the earthquake potential of the New Madrid and Wabash Valley seismic zones, as well as the Cache River Valley area in between, and guide efforts to reduce the earthquake hazard in the central United States.

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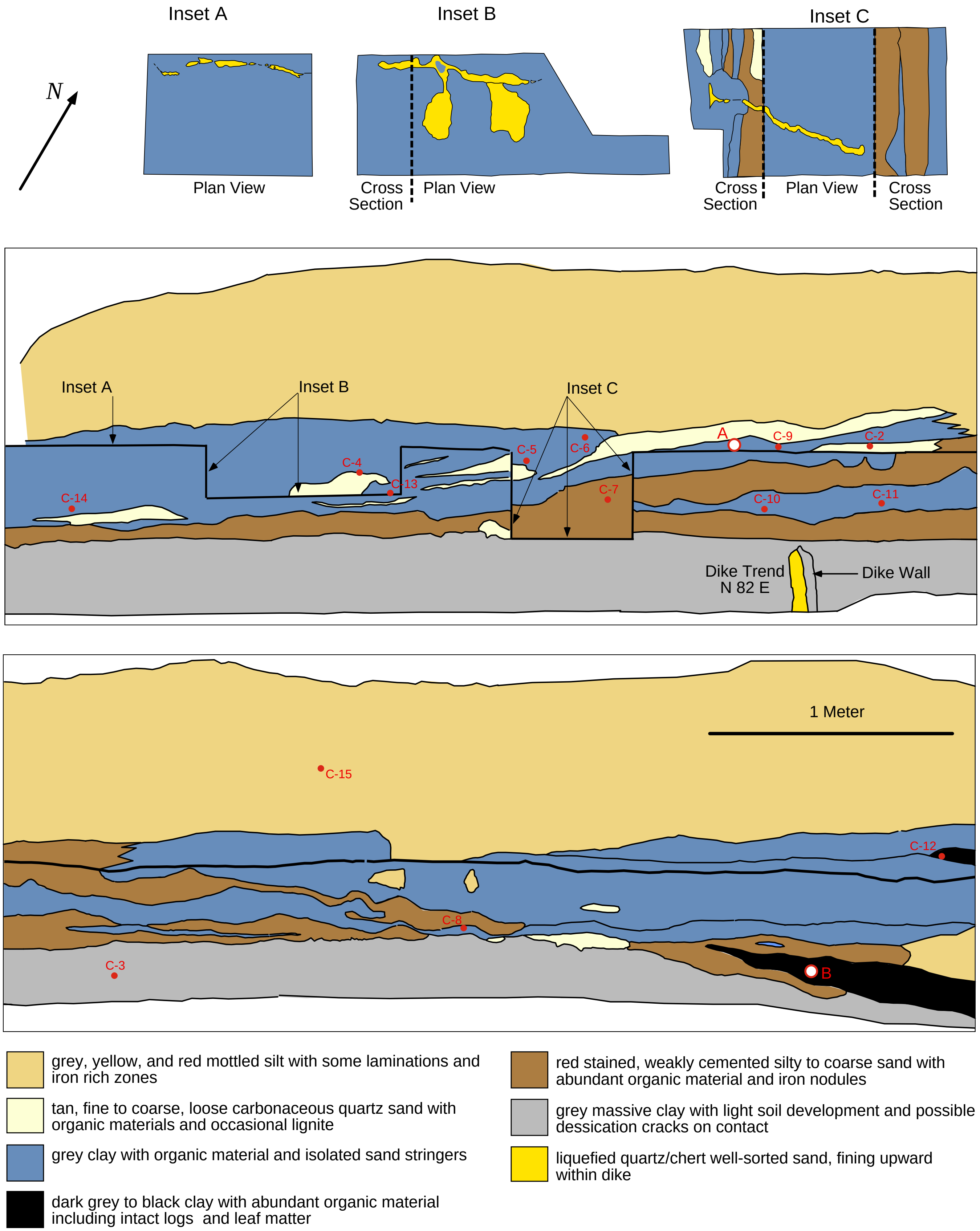

Figure 2. Log of paleoliquefaction site MD-1. Main Ditch, near Karnak, Illinois. Radiometric age determinations for location (A) B.C. 2885-2575 and (B) B.C. 3340-3025, B.C. 2970-2940. Logged by John Sims and Brian Noonan.

Non-Technical Summary

J. Chester (TAMU) and M. Tuttle (M. Tuttle & Associates) are performing a systematic search for and detailed study of earthquake-produced features in the Cache River Valley of southern Illinois to provide information about the timing and magnitudes of prehistoric earthquakes that occurred in this region, and to identify the possible earthquake sources for these events. To date, several earthquake-related features have been found in the Cache River Valley that are suggestive of ground shaking of modified Mercalli intensity of VIII-IX. Clearly, the number, ages and magnitudes of these ancient events need to be better resolved. This study will contribute to our understanding of the earthquake potential of the New Madrid and Wabash Valley seismic zones, as well as the Cache River Valley area in between, and guide future efforts to reduce the earthquake hazard in the central United States.

Reports Published

Tuttle, M., Chester, J. S., Lafferty, R., Dyer-Williams, K., Haynes, M., Cande, R., and Sierzchula, M., 1998, Liquefaction features in southwestern Illinois and southeastern Missouri and their implications for paleoseismicity, EOS Trans. AGU, 79, p. S342.