Shallow seismic reflection investigations of the Big Creek Fault Zone and its extension into the Memphis, Tennessee, Area: Collaborative with Millsaps College, Jackson, MS.

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Investigations

The Big Creek Fault Zone (BCFZ) is a poorly characterized southern component of the of the New Madrid Seismic Zone (NMSZ). The BCFZ was first proposed by Harold Fisk in his classic 1944 publication on the Mississippi River flood plain. Fisk's analysis was based largely on geomorphic and aerial photograph interpretations. Later Krinitzsky (1950) added additional detail regarding the BCFZ based on well logs drilled by the U.S. Army Corps of Engineers. Saucier (1994) expressed some skepticism as to the validity of the Fisk (1944) and Krinitzsky (1950) fault zones. This conclusion was based on his analysis of the geomorphology of the lower Mississippi River valley and the lack of subsurface data to verify the many lineaments proposed by Fisk and Krinitzsky. More recently, Spitz and Schumm (1997) summarized many of the known faults in the southern end of the NMSZ and recognized the major structural features proposed by Fisk (1944). All of these authors, with the exception of Saucier (1994), include generalized maps of the fault trends, including the BCFZ, and all closely resemble the original trends proposed by Fisk (1944). There has, surprisingly, been little detailed work to determine a more precise geographic location of these fault zones, width of the fault zones, style of faulting or to verify the published projection of the faults. Without data such as these, the job of earthquake hazard evaluation and more importantly, mitigation, is hampered. This lack of data is particularly acute regarding the BCFZ as its published orientation trends toward Memphis, Tennessee, the largest metropolitan area within the southern NMSZ.

The purpose of this investigation is to begin the task of verifying the trend of the BCFZ using both land- and water-based seismic methods. Dr. James Harris, of Millsaps College in Jackson, Mississippi, is responsible for the acquisition and interpretation of the land-based seismic profiles along the geomorphic scarp associated with the BCFZ in Phillips County, Arkansas, and along the fault trend in Mississippi. The water-based seismic investigation, described here, is the responsibility of the Mississippi Mineral Resources Institute (MMRI) and will be conducted within the Mississippi River. The ultimate goal of the water-based

investigation is to identify the BCFZ as it crosses the Mississippi River and thereby refine the trend the BCFZ assumes east of Crowleys Ridge. A secondary goal was to conduct seismic investigations in the Wolf River with the purpose of identifying any "along trend" fault zones.

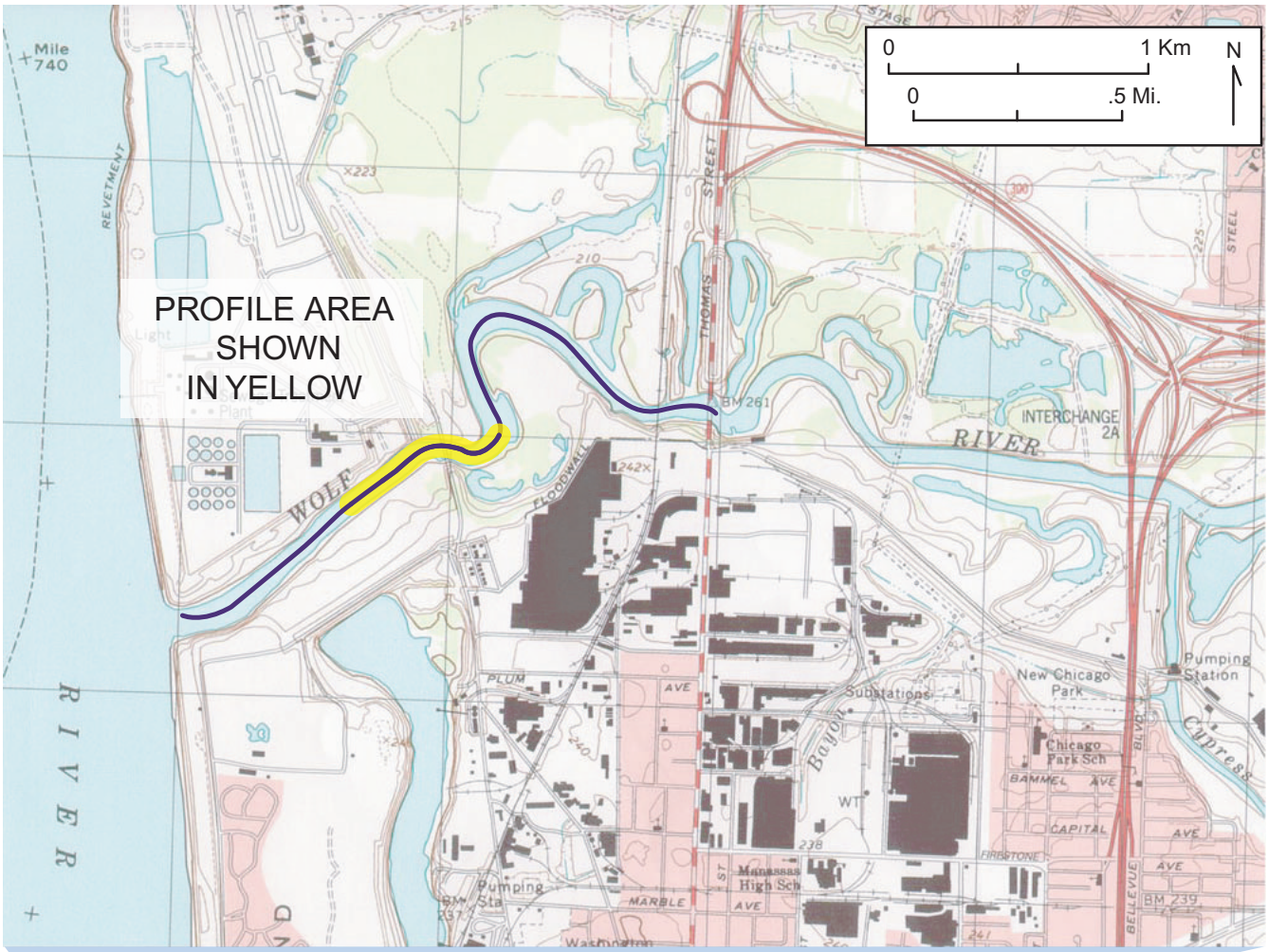
The preferred seismic imaging system is the I.K.B. Seistec high-resolution profiling system. The Seistec system consists of a line in cone receiver, which is simply a conventional hydrophone array, placed in a vertical position in a cone shaped housing located to the rear of the self contained unit. Located directly in front of the receiver is a conventional boomer plate which is used as the acoustic source. The boomer plate is powered by a E,G,& G power supply, which is configured to fire at 100 joules. The records were acquired at 200,000 samples per second and 32,000 samples per trace. Firing rate was once per second, with vessel speeds of 2 -3 knots per hour.

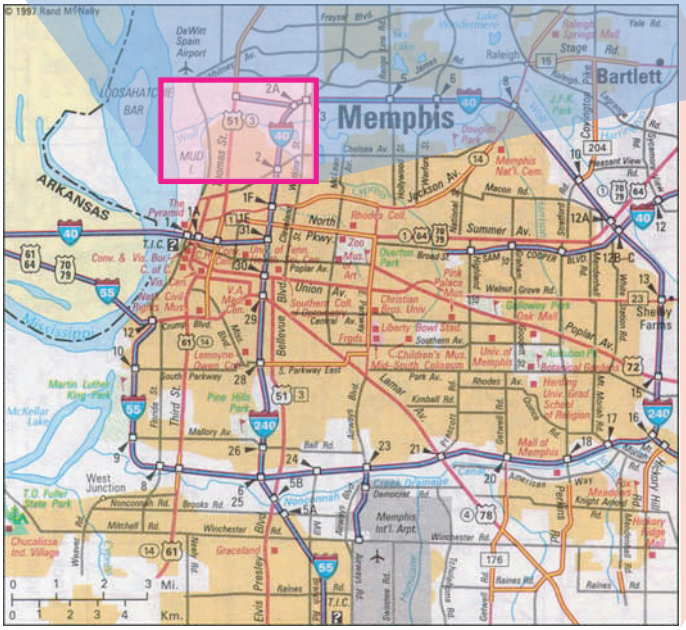
The configuration for deeper penetration consists of an in-house built hydrophone array. The array consists of two sections contained in one unit. The front section contains six phones, spaced two inches apart. The second section also contains six phones, but are spaced one foot apart. The closely spaced section will serve two purposes. The first is to act as a break-phone for the acquisition. In other words, this section will act as the trigger for the system. The second purpose is to provide a detailed profile of the shallow sub-bottom stratigraphy in the survey areas. The section with the longer space phones will be used to acquire detailed records with more penetration. This acoustic source will consist of a Seismic Systems Inc., fifteen cubic inch water gun. The gun is powered by a bank of oxygen cylinders which will be pre-charged to 3,000 p.s.i..

Two high priority areas were identified in the Mississippi River that appeared to represent the best locations where faulting was likely to be imaged. The first area was near the confluence of the St. Francis River and the Mississippi River. This area represented a projection of the BCFZ using the orientation of the geomorphic scarp marking the fault zone near Barton, Arkansas, as a guide to project the structure northeast across Crowleys Ridge to the Mississippi River. The second high priority area included a reach of the Mississippi River south of Helena, Arkansas, where Krinitzsky (1950) documented faulting from well data. Profiles across this reach of the Mississippi would be valuable in evaluating the potential of including this faulting in the BCFZ or perhaps as part of another as-yet-to-be-described structural feature. The Wolf River profile was designed to cross any potential extending into the Memphis area. The original concept was to run a profile starting its mouth on the Mississippi River and extend as far east as possible within the course of the river.

Results

The I.K.B. Seistec system was used for the Wolf River profiles. The seismic profile along the Wolf River was, unfortunately, limited in extent by a sand bar across the river resulting in water too shallow for the boat with the seismic gear to cross. The lack of landings to launch the boat further up stream precluded launching the boat and gear upstream from the obstruction. The geographic location of the Wolf River and the extent of the seismic line is illustrated in Figure 1 and a portion of the seismic record is included as Figure 2. Of particular interest is a zone of apparent offset of shallow beds near the center of the Figure 2 profile. There is also an adjacent area where continuous reflections are present only near the surface and deeper





Location of Memphis, Tennessee
in the Southeast U. S.

Figure 1 - The geographic location of the Wolf River and the seismic line are indicated above. The area shaded in yellow represents the profile reproduced in Figure 2.

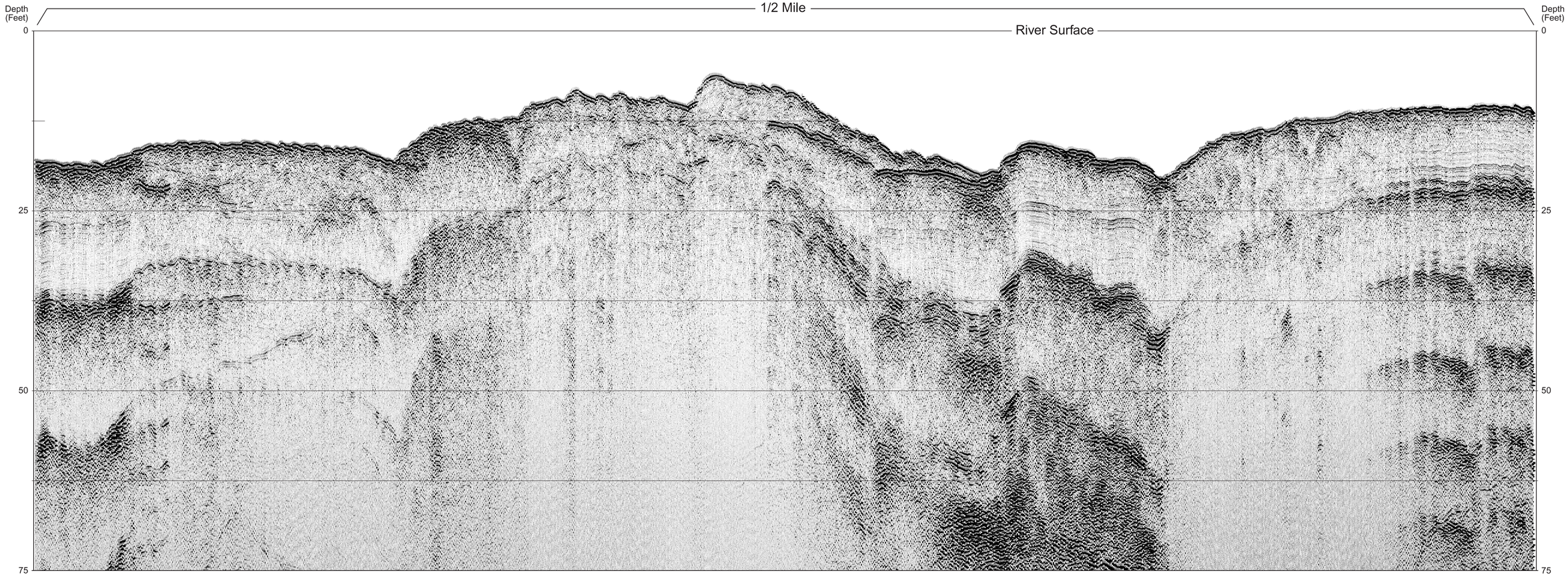


Figure 2 -This profile is across an area of disturbed bedding that may be indicative of faulting. Note the apparent small-scale offset of beds and the unusual zone without continuous reflections.

reflections are very discontinuous. These areas could be interpreted as a fault zone with displacement along small, multiple faults.

The seismic lines and priority areas in the Mississippi River are illustrated in Figure 3. This work has been problematic. Two efforts were made to obtain useful high revolution seismic data with the Seistec system and neither resulted in suitable data. The acoustic source is, apparently, insufficient to adequately penetrate the bottom sediments. Penetration was generally poor and seldom could enough resolution could be obtained to identify any offset of beds. At present, a third effort is underway on the Mississippi River to obtain useful data using the more robust fifteen cubic inch water gun and the array described above.

Non-Technical Summary

The work conducted to present has identified a potential fault in the Wolf River in Memphis, Tennessee. If additional geological work confirms the fault, it will obviously be a component of the NMSZ that will warrant additional study. The high resolution seismic work in the Mississippi River has not yielded useful information on subsurface conditions. Work continues on the Mississippi with a more powerful system that will, hopefully, yield the desired results.

Reports Published

No reports regarding this work have been published to date.

Statement of Availability & Contact Information

The seismic data is in digital form and can be made available in several formats. Inquiries regarding the project should be directed to Charles T. Swann, Mississippi Mineral Resources Institute, 220 Old Chemistry Building, University, Mississippi. 38677.

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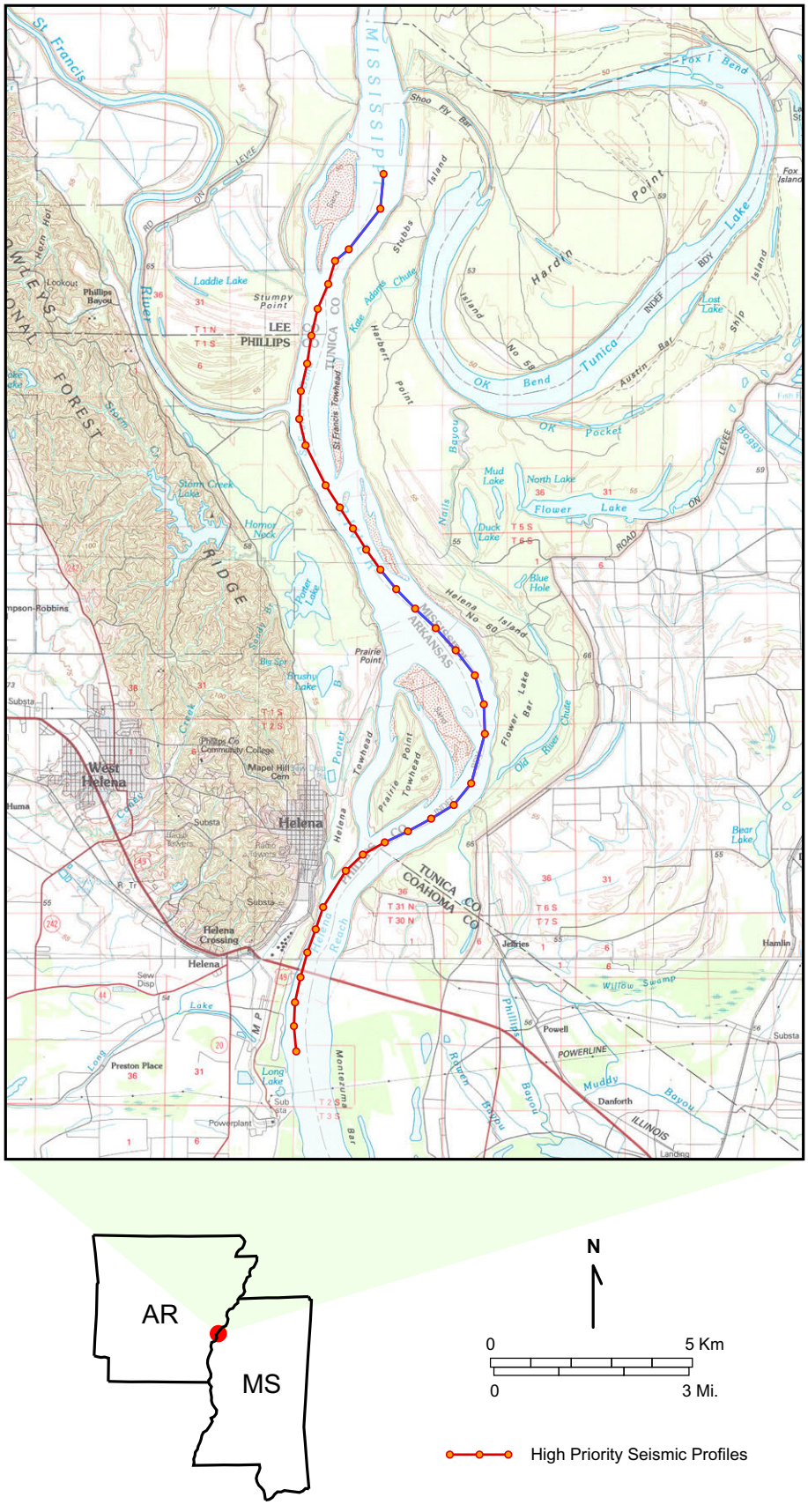

Figure 3 - The red and blue lines represent the location of the seismic profiles in the Mississippi River. Note that the red line segments are the high priority areas where faulting has been projected. The northern-most priority area is the projected crossing of the BCFZ.