AN INTEGRATED GEOPHYSICAL ASSESSMENT OF LATE QUATERNARY NEOTECTONICS ALONG THE NORTHERN MISSISSIPPI EMBAYMENT EXTENSION OF THE FLUORSPAR AREA FAULT COMPLEX

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INVESTIGATIONS UNDERTAKEN (Year 2)

The northeast–southwest-oriented Fluorspar Area fault complex (FAFC), exposed in parts of southern Illinois, is believed to continue southwest beneath the sedimentary cover of the northern Mississippi embayment, where it appears to form the northwest margin of the Reelfoot rift [Kolata and Nelson, 1991] (Fig. 1). In addition, strands of the FAFC in the area of McCracken County and Ballard County, Kentucky, are coincident with, and near the terminals of, two diffuse northeast zones of seismicity that Wheeler [1997] called Trends 1 and 2 (Fig. 1).

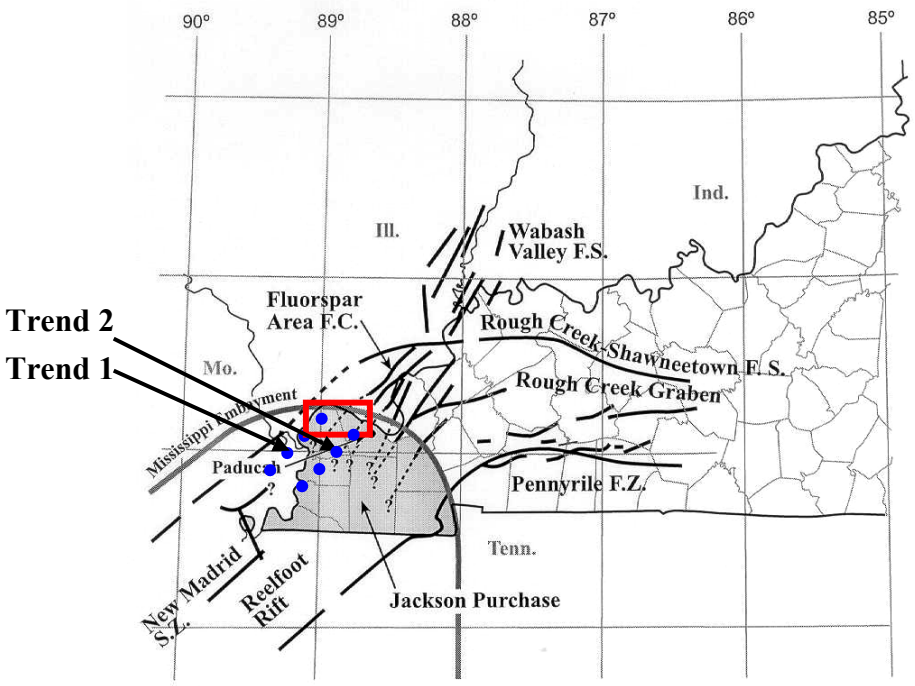

Figure 1. Major structural features in the central Mississippi Valley (modified from Kolata and Nelson, 1991). The blue-filled circles represent the diffuse trends of seimicity. The red box is the area of study.

We are using integrated geophysical techniques to consider the seismogenic potential of selected FAFC structures in the vicinity of these northeast trends of seismicity. The tasks for the overall investigation are to: (1) perform reconnaissance P-wave reflection surveys to identify locations exhibiting potential Post-Paleozoic tectonic deformation, (2) collect high-resolution SH-wave reflection profiles to further assess the style, geometry, and timing of the neotectonic structure, and (3) identify/evaluate additional targets amenable to very high-resolution, near-surface, ground-penetrating-radar (GPR) methods.

Year 2 investigations focus on the GPR profiling identified in task 3. In addition, and as per the recommendation of the review panel, we have communicated with investigators performing related research in the area. Consequently, we have coordinated efforts with the Illinois State Geological Survey (ISGS) to obtain targets in areas of common interest. This inter-group communication has resulted in the University of Kentucky (UK) GPR surveys being concentrated in the vicinity of the Trend 1 seismicity in Ballard County, Kentucky. There are four primary reasons for this decision: 1) the ISGS are performing trench studies of targets coincident with Trend 2 seismicity, 2) potential Trend 2 structural targets identified by UK seismic-reflection surveys do not have stratigraphic units later than Pleistocene, 3) UK targets identified in the vicinity of Trend 1 are located in the active Ohio River flood plain that have Holocene-aged sediment, and 4) ISGS seismic reflection profiles in Ballard County identified two excellent target areas for GPR imaging. We appreciate the cooperation and assistance from the ISGS.

Approximately 0.5 kilometers of the anticipated 1.5 km of GPR profiling have been acquired. The remaining target areas lie inside the boundaries of the Ballard Wildlife Management Area; officials have granted UK permission to conduct the GPR profiles, but have requested that data acquisition not begin until the end of the November hunting season.

RESULTS (Year 2)

High-resolution reflection profiles have indicated that Paleozoic bedrock in the McCracken and Ballard counties area of western Kentucky is overlain by an approximately 100-m sequence of unlithified Cretaceous, Tertiary, and Quaternary sediments. Moreover, both ISGS P-wave and UK SH-wave surveys in the active floodplain deposits of Ballard County, Kentucky image evidence of fault and apparent fold propagation into the near-surface Quaternary units (Fig. 2). The seismic profiles also exhibit evidence of various structural styles associated with episodic movement. The GPR surveys are concentrated coincident with these targets. Preliminary GPR data interpretation indicate that the deformation characteristics imaged by seismic reflection extend to within 2 meters of the ground surface; nearby Corps of Engineers interpreted borehole data also suggest that these materials are Holocene-aged deposits.

The GPR data are being acquired with a Sensors and Software PulseEkko 100 system. Field trials have identified the 50 MHz bi-static antennae with 1-m separation and a 0.5-m group interval as the optimal configuration for data quality and field efficiency. The near-surface silty sands and gravels have an estimated velocity of 0.1 nanoseconds per meter. We hope to confirm the age of the sediment unit corresponding to the very near-surface reflecting horizon with

additional soil sampling. Both ISGS (John Nelson) and the Missouri Geological Survey (Dave Hoffman) have been contacted for equipment availability. Although not a required task under this contract, we believe that the implications of the interpretation warrant and justify the additional effort.

NONTECHNICAL SUMMARY

Subsurface images of deformed sediments within the northern Mississippi embayment are providing direct physical evidence of relatively recent tectonic activity. The seismic and ground penetrating radar images are enabling us to estimate the time of movement, as well as, to understand the style and geometry of the deformation. GPR results have thus far shown that deformation extends to within at least 2 meters of the ground surface. Preliminary age estimates suggest that the movement occurred within Holocene time.

There are limitations to the resolving power of each geophysical technique being used; consequently, the exact timing of the latest tectonic episode at some locations will be uncertain. In such instances, we hope to coordinate with, and provide target information to, researchers specializing in trenching/paleoseismology.

PUBLICATIONS

Woolery, E., J. Schaefer, and Z. Wang. Geotechnical and geophysical indicators for local anomalous stress in the unlithified sediment of the northern Mississippi Embayment, central United States. *Tectonophysics (in review)*.

Woolery, E., J. Schaefer, and Z. Wang (2002). SH-Wave Seismic-Reflection Evidence for a Tectonic Origin of Anomalous Stress in Near-Surface Unlithified Sediment, Midcontinent, United States. *Eos Trans. AGU, 83*(47), Fall Meet. Suppl., Abstract T22B-1155

Woolery, E., and R. Street (2002). Quaternary fault reactivation in the Fluorspar Area fault complex of western Kentucky–Evidence from shallow SH-wave reflection profiles. *Seismological Research Letters (accepted)*.

Woolery, E., Z. Wang, and R. Street (2001). Neotectonic deformation in the Fluorspar Area fault complex of western Kentucky–Evidence from shallow SH-wave reflection profiles. *Geological Society of America Annual Meeting*, Abstracts with Program, Boston, MA. T63.

DATA AVAILABILITY

GPR reflection data acquired in the study are being organized by site, and will be archived at the Kentucky Geological Survey as raw and processed files. In addition, there will be information as to the location of the site, recording parameters, and other pertinent information. The data will be stored in standard SEG-Y format at the completion of the study, and available upon request. Requests for information should be directed to the PI.

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Kolata, D.R., and W.J. Nelson (1991). Tectonic history of the Illinois Basin, *in* Leighton, M.W., and D.R. Kolata, D.F. Oltz, and J.J. Eidel, eds., *Am. Assoc. Petroleum Geologists Memoir* 51. 263–292.

Wheeler, R.L. (1997). Boundary separating the seismically active Reelfoot rift from the sparely seismic Rough Creek graben, Kentucky and Illinois. *Seism. Res. Letters*. 66. 586–598.

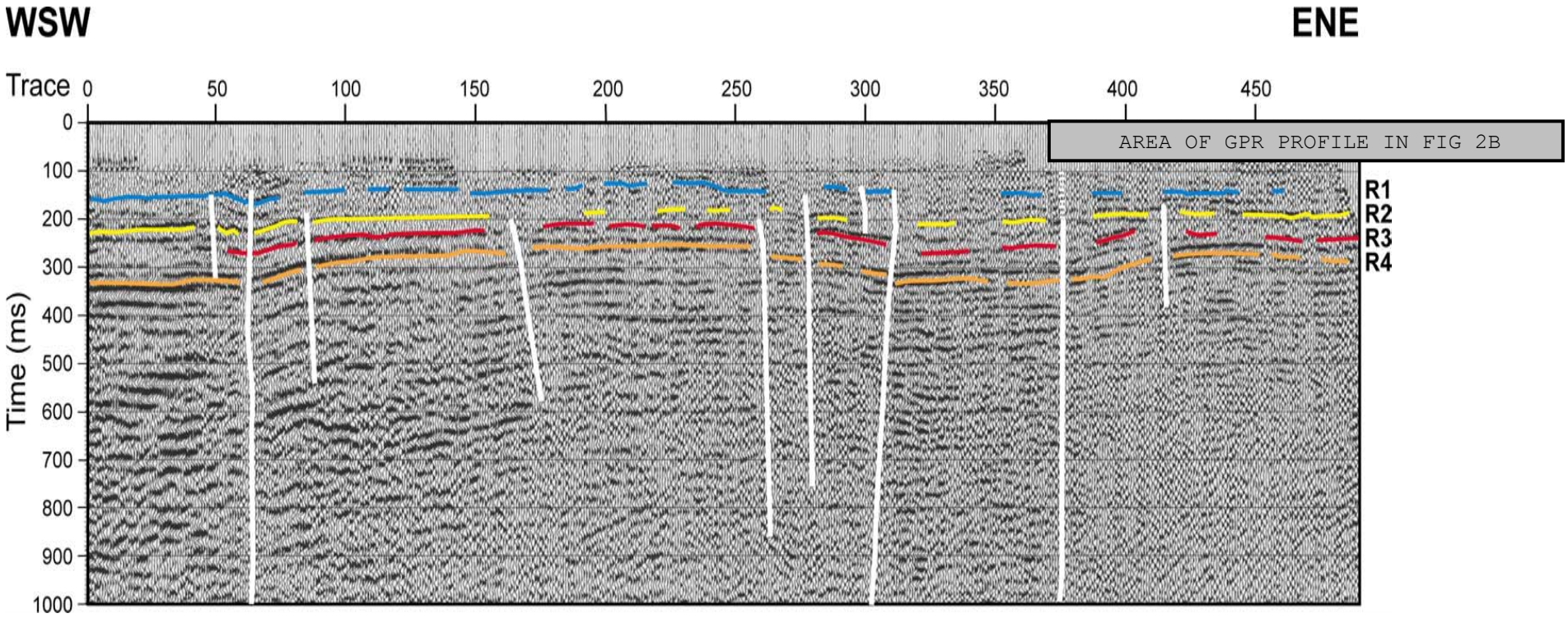

Figure 2a. Example of a Ballard County seismic-reflection profile acquired during Year 1 of the study, and used to site high-resolution, very near-surface GPR surveys.

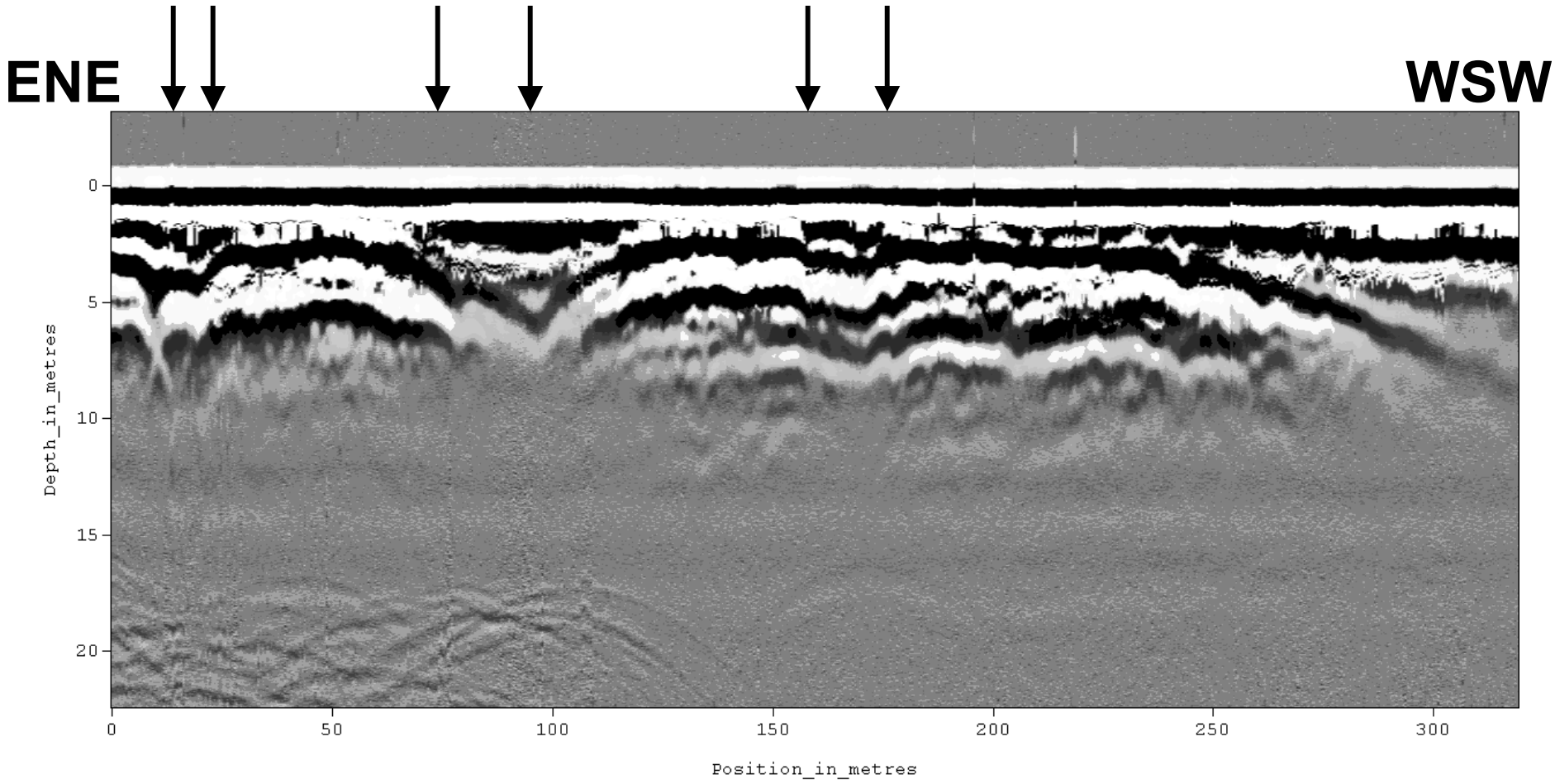

Figure 2b. Partial GPR profile coincident with a target identified by the seismic-reflection survey shown in figure 2a. Arrows indicate locations of interpreted faults.