# HIGH-RESOLUTION GEOPHYSICAL AND GEOLOGICAL INVESTIGATION OF LOWER WABASH VALLEY FAULT SYSTEM NEOTECTONICS

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## INVESTIGATIONS UNDERTAKEN

We are further investigating the spatial and temporal characteristics (including fault segmentation) of recently discovered neotectonic deformation along the Hovey Lake fault (HLF), as well as, performing an initial assessment of the Caborn fault (CF) that is near the epicenter of the 18June2002 **M**5 earthquake. Both structures are located in the southern Wabash Valley Fault System (WVFS), near the northern New Madrid seismic zone (NMSZ) boundary suggested by Wheeler (1997) (Fig. 1). Field investigations are integrating reconnaissance and near-surface seismic reflection/refraction profiling, ground-penetrating-radar imaging and correlative drilling/14C dating. The work is an extension of earlier investigations, ~14 km to the southwest, wherein neotectonic deformation extending above the Pennsylvanian bedrock into late Quaternary-aged sediment was found (Woolery, 2005). Our target locations are based on mapped Paleozoic faults derived from the numerous drilling logs in the area. In addition, the test sites are also located in areas where bedrock is overlain by late Quaternary sediment. The well-constrained locations of the mapped faults generally limit the lengths of the reconnaissance reflection surveys to approximately1km.

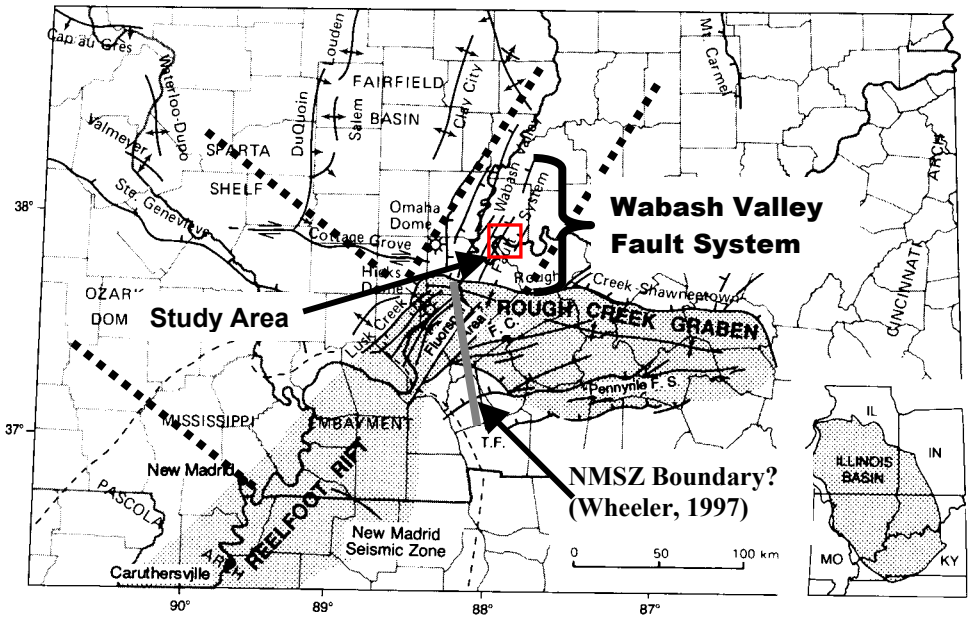


**Figure 1. Regional structural features in the central U.S. (modified from Kolata and Hildebrand, 1997) and inferred quadruple junction (heavy dashed line) from Braile et al. (1986). The general study area is bounded by the red rectangle in the lower part of the Wabash Valley.**

During the summer of 2005, an approximately 1km-long, reconnaissance reflection survey was acquired across a segment of the northern HLF (Fig. 2). Site conditions required us to reduce the spatial sampling (group interval) of the seismic-reflection reconnaissance survey from the originally anticipated 4 meters to 2 meters, a significant increase in field time. The seismic-reflection data were collected the SH-wave method in order to improve overall resolution (see Woolery, 2005).

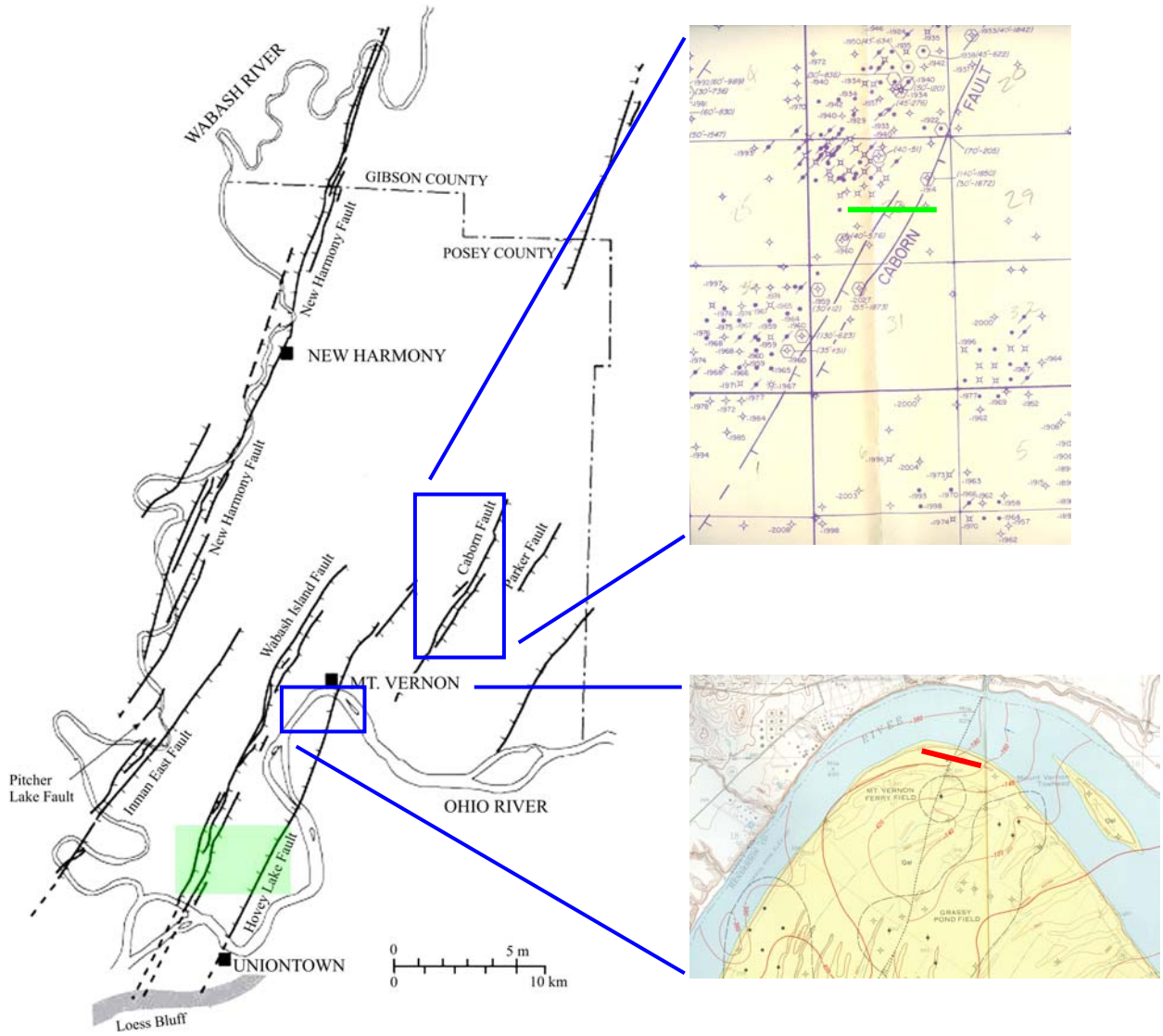


**Figure 2. Map showing locations of current and past geophysical/geological surveys. The green-shaded box is the location of the prior NEHRP study, and the light gray-shaded rectangles indicate the current investigations. The red line on the lower inset represents HL-C reconnaissance reflection survey collected acquired at a 2-m group interval. The green line in the upper inset identifies the location of the future reconnaissance survey. The base maps for both insets show some of the wells used in the subsurface mapping of the HLF and CF.**

Future data acquisition will include an additional 1 to 3 km of seismic-reflection data (SH), and ~1 km of GPR profiles over more prominent reflection anomalies. It is anticipated that 0.5 to 0.75 km of the remaining reflection work will include re-imaging the near-surface sediment above prominent bedrock anomalies identified in the reconnaissance reflection surveys. The spatial sampling for these near-surface geophysical surveys will most likely range between 0.25 m and 1.0 m. We also plan to drill and collect core samples over selected anomalies for stratigraphic control, including potential carbon dating.

## RESULTS

Reconnaissance line HL-C is an approximate 1 km-long, east–west-oriented, SH-wave reflection profile collected across the northern part of the Hovey Lake fault (HLF) in the southern WVFS of southern Indiana. The primary objective of this initial survey was to identify the top-of-rock expression of the HLF; consequently, the line was centered across the fault's inferred surface projection. The sediment-bedrock impedance boundary is defined on the profile by the large amplitude reflection arriving between 300 ms and 350 ms TWTT. The HLF top-of-rock deformation zone is interpreted between CDP numbers 250 and 750. The most severe distortion occurs at approximately CDP #425 which is within 50 meters of the fault's mapped projection. This location also appears as a hinge point on a bedrock-high. Specifically, there is apparent westerward bedrock "dip" west of CDP #425. East of this point the bedrock reflector appears sub-horizontal; however, two distinct east-downthrow offsets are exhibited at CDP numbers 510 and 740. Compared with the reflection profiles HL-A and HL-B across central part of the HLF, approximately 14 km to the southwest, the HL-C profile exhibits much lower s-wave velocities and more subtle top-of-bedrock structural relief (Figure 4). These observations are likely the result of being located in the active part of the Ohio River fluvial system. The smaller geophone group interval also resulted in the imaging of two relatively continuous and coherent "intra-alluvial"(?) reflections at approximately 175ms and 250 ms TWTT. These horizons appear distorted directly above the more prominent bedrock anomalies. The overburden anomalies will be targeted and further evaluated by the near-surface reflection, GPR and drilling surveys.

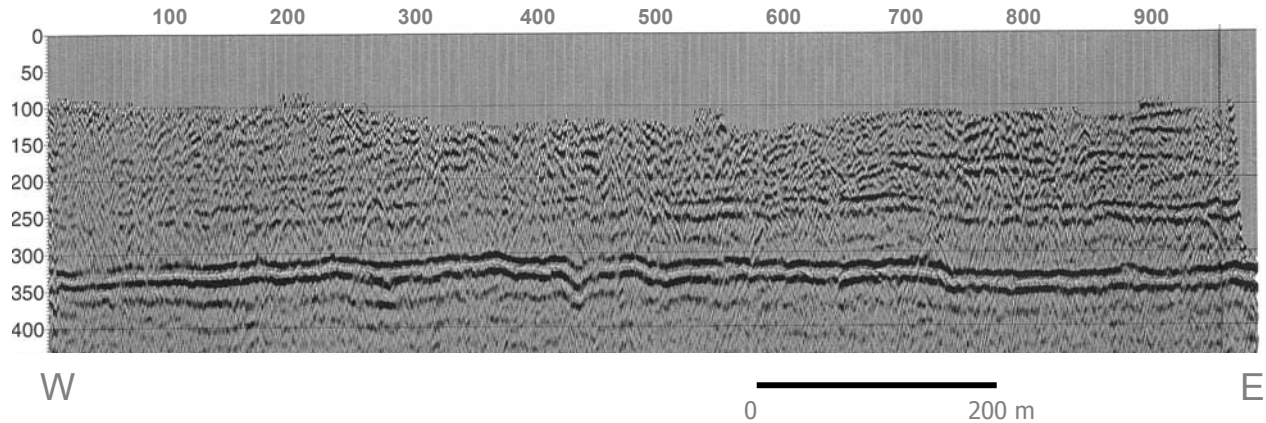


**Figure 3. Brute-stacked reconnaissance profile HL-C (12-fold) collected across a northern part of the Hovey Lake fault. HL-C was collected at a reduced group interval in order to ensure an effective 12-fold horizontal stack. The profile indicates a relatively broad deformation zone, but the interpreted location of the primary fault is at approximately CDP 425; this correlates to within 30 m of the fault's mapped projection.**

## NONTECHNICAL SUMMARY

Subsurface images of deformed sediments within the southern Wabash Valley are providing direct physical evidence of relatively recent tectonic activity. The images are enabling us to estimate the time of movement, as well as, to understand the deformation style, fault geometry, and potentially segmentation.

There are limitations to the resolving power of each geophysical and geological technique being used, and consequently limitations to the accuracy of the interpreted timing and style of the late tectonic episodes. In order to minimize the uncertainty, we hope to our data and interpretations will encourage further investigations by researchers specializing in higher resolution methodologies (i.e., paleoseismologic trenching, etc.).

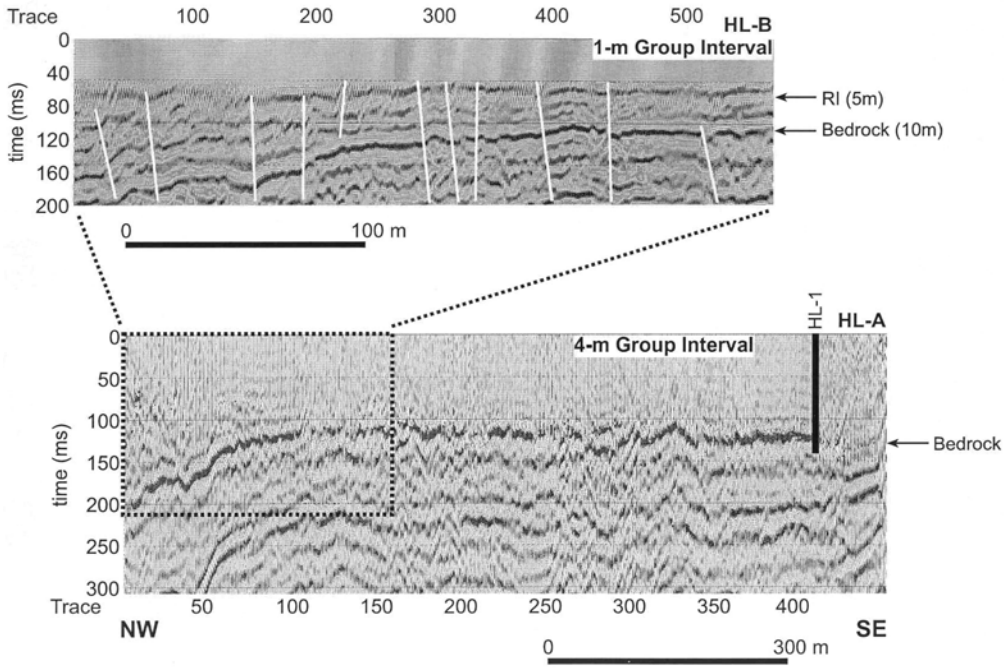


**Figure 4. Reconnaissance (6-fold) bedrock and near-surface (3-fold) soil profiles collected over the central part of the Hovey Lake fault. These data are approximately 14 km down strike (SW) of HL-C (see Figure 2).**

## PUBLICATIONS/PRESENTATIONS

N/A

## DATA AVAILABILITY

SH-wave seismic reflection/refraction and GPR data acquired in the study are being organized by site, and will be archived at the Kentucky Geological Survey as field and stacked files. There will also be information as to the location of the site, recording parameters, and other pertinent information. The seismic data will be stored in standard SEG-Y format at the completion of the study, and available upon request. Requests for information can be directed to the PI.

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