INVESTIGATION OF SURFACE FAULTING ALONG THE SOUTHEASTERN MARGIN OF THE REELFOOT RIFT, WESTERN TENNESSEE AND KENTUCKY

ANNUAL PROJECT SUMMARY 2000

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INVESTIGATIONS UNDERTAKEN: A linear topographic scarp (trend 043°) follows the southeastern margin of the RFR basement fault system for 150 km. From Oct. 1, 1999 to June 30, 2000 we continued investigations of this scarp from near Memphis to the Tennessee/Kentucky line for evidence of late Quaternary surface faulting. In follow-up of our 1999 reconnaissance and seismic profiling, we acquired a shallow S-wave reflection profile, auger data, trench log data, sedimentological data, and radiometric ages that reveal late Wisconsin/early Holocene surface faulting and late Holocene liquefaction associated with this fault-line scarp at Porter Gap, TN. We also conducted addition field reconnaissance and an electrical conductivity survey across the scarp near Union City, TN and found evidence of surface faulting consistent with our 1999 seismic profile. Variation in sense of throw along strike and flower-structure geometry suggests this is a strike-slip system. The proximity of this fault to Memphis makes it a primary concern for hazard mitigation, and continued research is crucial to assessment of its seismic potential. Our proposed second year project plan entails trenching three or more additional sites (including near Memphis in northern Shelby County) in order to collect sufficient data for estimations of paleomagnitudes and recurrence interval.

RESULTS: South of the Forked Deer River, the scarp is the west-facing bluff line formed by late Quaternary Mississippi River incision and loess deposition (Fig. 1a). North of the Forked Deer River (Fig. 1b) this scarp displaces fluvial terraces of the Obion River valley and alternates facing east and west (Wyatt and Stearns, 1988; Saucier, 1987). Quantitative analysis of drainage-basin asymmetry in the eastern ME (Cox and others, in press) delineates a principal boundary between geomorphic domains that is coincident with the northern portion of the scarp. We suggest this scarp follows the rift-margin fault system, and we concluded it has experienced late Quaternary surface fault displacements. In 1999 and 2000 we reconnoitered eight sites along this scarp from near Memphis to the Tennessee/Kentucky state line. Two of these sites (Porter Gap, TN, 89°30'W 35°55'N, and at Union City, TN, 89°00'W 36°22'N) were chosen for our initial investigations of Quaternary faulting based on accessibility and topographic suggestion of near-surface faulting. Our experience gained at these sites (e.g., recognition of landslide features, knowledge of surficial geologic units on and in front of the scarp, expectations of datable materials…) is of great value with respect to the siting of other detailed investigations along the scarp.

Porter gap: In 1999 at Porter Gap, where the linear scarp is the bluff line of the Mississippi Valley, we acquired a shallow s-wave reflection profile across the base of the scarp. Eocene reflectors at 50m to 120m depth dip west beneath the bluff face, and a high-angle fault showing 25 m to 30 m reverse separation underlies the base of the bluff (Fig. 2a). A second shorter, near-surface (1m geophone spacing) s-wave reflection line acquired in 2000 across the high-angle reverse fault shows it to extend up-dip to the surface (Fig. 2a). Our documentation that a fault zone underlies the bluff line at this site is in agreement with previous studies suggesting fault control of the Mississippi Valley margin (Fisk, 1944; Wyatt and Stearns, 1988; Van Arsdale and others, 1998). Interestingly, structural relief at Porter Gap is higher on the east (consistent with topography), but separation on the fault is up-to-the-west. Thus, structure has been inverted during late Tertiary or Quaternary time, and along the Mississippi Valley bluffs the scarp is a fault-line scarp rather than a surface displacement of the most recent stage of fault activity. The fault splays up-section (Fig. 2a), and we interpret it as a transpressive flower structure. Considering the east-west compressive contemporary stress field, we assume there is a significant right-lateral component to active slip.

In 2000 we drilled an 5m-deep auger line at Porter Gap (Fig. 3) and we ran an additional shallow s-wave reflection profile (1m geophone spacing; Fig. 2c) that suggested a surficial fault, and we excavated a trench across this fault (Fig. 2a). The trench revealed ≥3 m of up-to-the-west reverse and vertical separation of late Quaternary Peoria loess (21.05±0.17ka and 18.04±0.07ka ^{14}C ages) and Quaternary alluvium distributed across several fault splays. Down-to-the-west shear planes and folds associated with landsliding of the bluff were also revealed in the trench, and mutually crosscutting relationships of these features and the fault splays show the landsliding to have been co-seismic. Saucier (1994) maps this site as Holocene alluvium of the Forked Deer River (FDR, Fig. 1b). For sediments exposed in the trench, radiometric ages could be determined only for the uppermost Holocene alluvial units and Peoria loess. Based on texture, x-ray diffraction, heavy mineral suites, and degree of oxidation and consolidation of sediments, we interpret lower faulted alluvial units as late Wisconsin/early Holocene Forked Deer River alluvium and early/middle Pleistocene Mississippi/Ohio River alluvium. Marine Eocene clay of the Jackson Formation was present in the bottom of part of the trench. Surficial Holocene colluvial and alluvial units in the trench (9.68±0.04ka, 4.41±0.04ka, and 4.30±0.05ka ^{14}C ages) post-date the principal faulting event and have been deformed by minor liquefaction. Recent alluvium (0.97±0.04ka ^{14}C age) post-dates this liquefaction.

Union city: Near Union City, 70km northeast of Porter Gap, the scarp is 9m high and cuts across Sangamon/early Wisconsin river terraces of the Obion River (OR, Fig.1b) (Saucier, 1987; Rodbell, 1996). Regionally, this terrace is mantled with early Wisconsin Roxana loess (~60ka to 35ka) and late Wisconsin Peoria loess (~24ka to 12ka) (Rodbell, 1996; Rodbell and others, 1997). A p-wave reflection profile across this scarp segment shows a subsurface fault (Luzietti and Harding, 1991). In 1999 we acquired an s-wave reflection profile and auger hole data across the scarp to determine if surficial units are faulted (Fig. 2b). Our seismic profile reveals west-dipping reflectors beneath the scarp face that appear truncated on the west near the base of the scarp by an eastward-dipping fault. Our auger data suggest that an up-to-the-east fault may have propagated near the surface below the scarp face prior to deposition of units A, B, and C (Peoria? Loess) (Fig.2b). This faulting event offset or warped units D, E (Roxana? loess), and F (Sangamon/early Wisconsin Obion River alluvium) up-to-the-east. Faulting was followed by erosion of the scarp (thinned unit D) and colluviation at the base of the scarp (thickened unit D). An electrical conductivity survey we conducted in 2000 at this site (using a Geonics EM31) suggests the fault comes within 4m of the surface. The change in sense of vertical movement on the fault between Porter Gap and Union City (from up-to-the-west to up-to-the-east) is characteristic of variations in vertical slip along a strike-slip system.

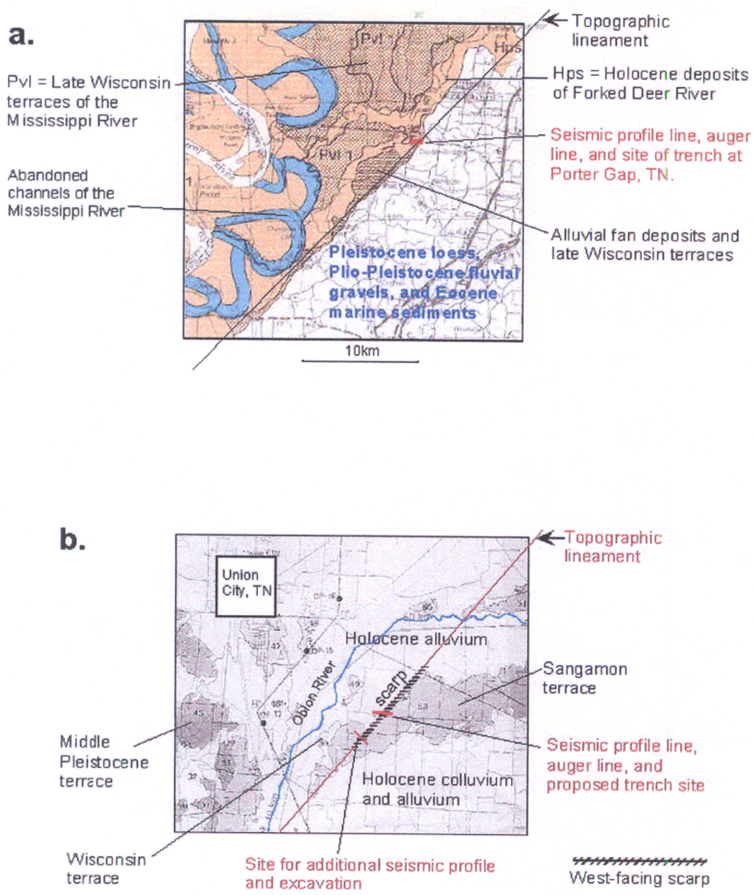
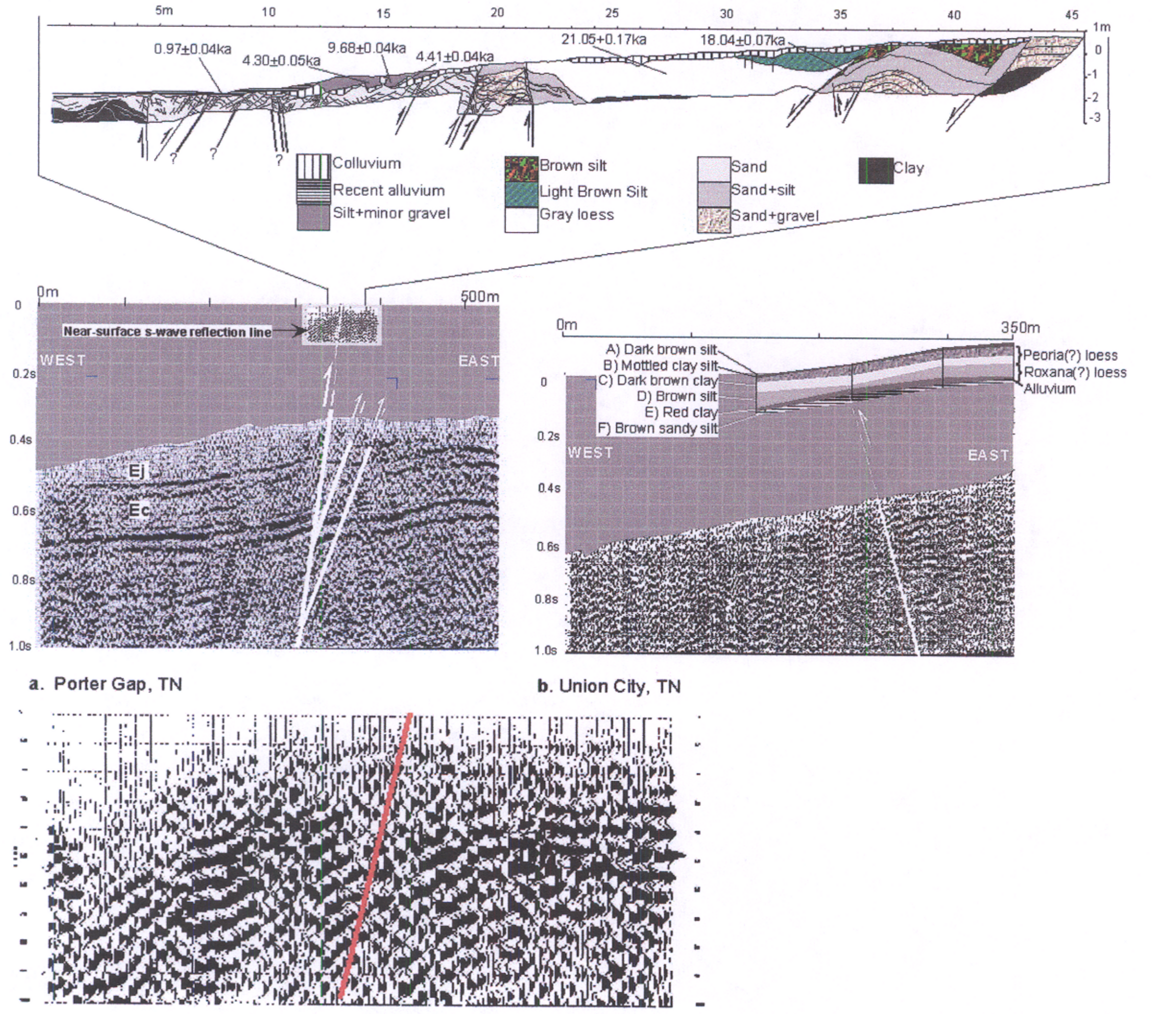


Figure 1. Quaternary geology of investigation sites: a) Porter Gap, Tennessee(after Saucier, 1994); b) Union City, Tennessee (after Rodbell, 1996).



c.

Figure 2. Data collected across the scarp associated with the southeastern Reelfoot rift margin. These data show near-surface faulting and folding of unconsolidated Eocene strata (see Fig. 1a for locations). Vertical scales are in two-way travel time (seconds). Wave velocities are uncertain, but depths at 1s are ~200 to 300m. a) Reflection profiles and trench log at Porter Gap, TN (the near-surface line was sited to target the principal fault revealed in the original line). Ej = Eocene Jackson Formation; Ec = Eocene Claiborne Formation. b) Reflection profile and auger line at Union City, TN (auger line is vertically exaggerated 5x). c) Detail of shallow reflection profile at Porter Gap.

CONCLUSIONS: The southeastern RFR-margin fault system is at least 150 km long and thus capable of producing earthquakes of M≥7 (Wells and Coppersmith, 1994). This fault system (part of the “Big Creek fault zone” of Fisk, 1944) may continue southwestward into Arkansas for a significant distance beneath the present meander belt of the Mississippi River. Memphis is closer to the southeastern RFR margin than to the southern arm of the NMFS, and thus it is critical to further assess the seismic risk posed by this fault system. Our proposed second year project plan entails trenching three or more additional sites in order to collect sufficient data for estimations of paleomagnitudes and recurrence interval.

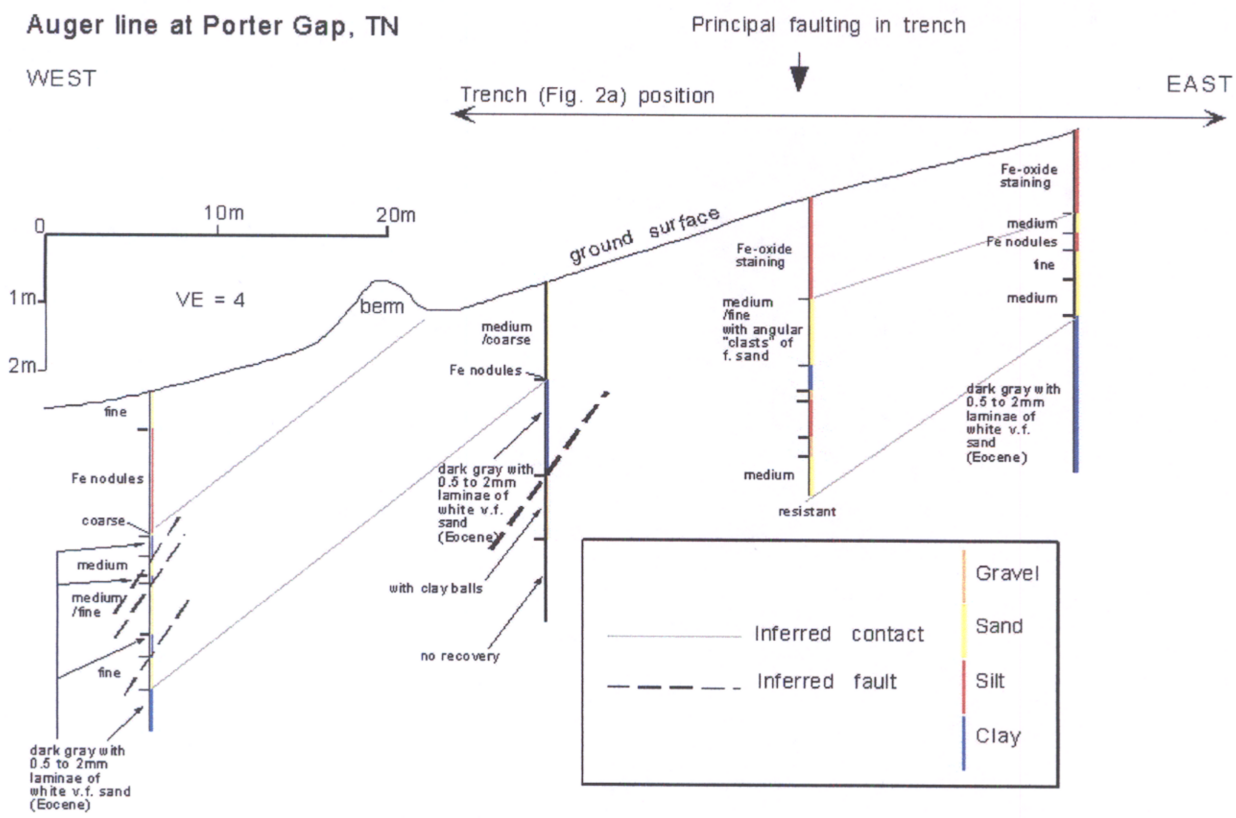


Figure 3. Auger data collected at Porter Gap, Tennessee.

Seismic data may be obtained from Dr. James Harris, Millsaps College, Geology Department, Jackson, MS 39210; (601)974-1343; harrijb@okra.millsaps.edu.
Trench log data and auger data may be obtained from Dr. Randel Cox, Geological Sciences, University of Memphis, Memphis, TN 38152; (901)678-4361; randycox@memphis.edu.

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NON-TECHNICAL SUMMARY

We continued investigations begun in early 1999 of a break in the landscape extending from near Memphis to the Tennessee/ Kentucky line. Straightness of this feature suggest it is a fault zone, and our goal is to determine if the feature is indeed fault controlled and if it is an earthquake hazard. Our 1999 drilling and seismic profiling showed fault planes extending from depth upward to near the surface. Building on these results, in 2000 we conducted additional field reconnaissance, drilling, and seismic profiling, and we conducted an electrical conductivity survey, excavated a trench across the expected fault line, and analyzed soils for age. We showed the fault planes come to the surface and documented prehistoric earthquakes before and after ~4400 years ago (but not after 970 years ago).

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