SURFACE FAULTING AND POSSIBLE KINEMATICS OF THE EAST TENNESSEE SEISMIC ZONE

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Abstract:

The East Tennessee seismic zone (ETSZ) trends NE-SW through the Appalachians from SE KY through East Tennessee into NE Georgia and NE Alabama. It is the second most active zone in the eastern U.S. after the New Madrid seismic zone (NMSZ). Previous fieldwork recently identified the first known ETSZ surface coseismic faulting near Dandridge, TN in a Pleistocene alluvial terrace along the French Broad River: a 055/SE-dipping fault that thrusts Ordovician shale (containing 035/vertical fissures filled with 15 ka alluvium) 1 m NW over French Broad River terrace alluvium.

Our new fieldwork identified surface faulting in an alluvial terrace along the Little Tennessee River near Vonore, TN: a NE-striking/SE-dipping normal fault with ≥2 m throw. Pleistocene alluvium is faulted against Cambrian Nolichucky Shale and drag folded into a SE-dipping structural terrace near the fault. A prominent NW-striking set of sub-vertical joints occurs in the alluvium. An OSL age of ~17 ka was obtained from the alluvium, but previous terrace mapping suggests it may be a higher, older terrace.

Faulting at Vonore is within the zone of highest concentration of ETSZ epicenters that trends 060 and projects to the thrust faulting along the French Broad River. These young faults and earthquakes may define a principal corridor of ETSZ tectonism with characteristics similar to the NMSZ. For example, the Reelfoot thrust and the Crittenden County fault in the NMSZ are contractional faults that caused parallel bending-moment extensional faulting and fracturing at shallow depths, like the French Broad River fissuring and Vonore faulting. This NE-trending corridor of ETSZ tectonism (≥130 km long) may be part of a NE-trending, SE-dipping strike-slip system with thrust and normal fault stepovers that is compatible with the modern stress field and first-motion studies of the ETSZ.

IMPETUS:

Electric power in East Tennessee runs on hydroelectric and nuclear energy. Several nuclear reactors operate in the area and more are scheduled to come online in the future. These power plants are located near the ETSZ. The purpose of this research is to map Quaternary faults in an attempt to interpret the ages, magnitudes, and locations of Quaternary paleo-earthquakes for incorporation into hazard assessment.

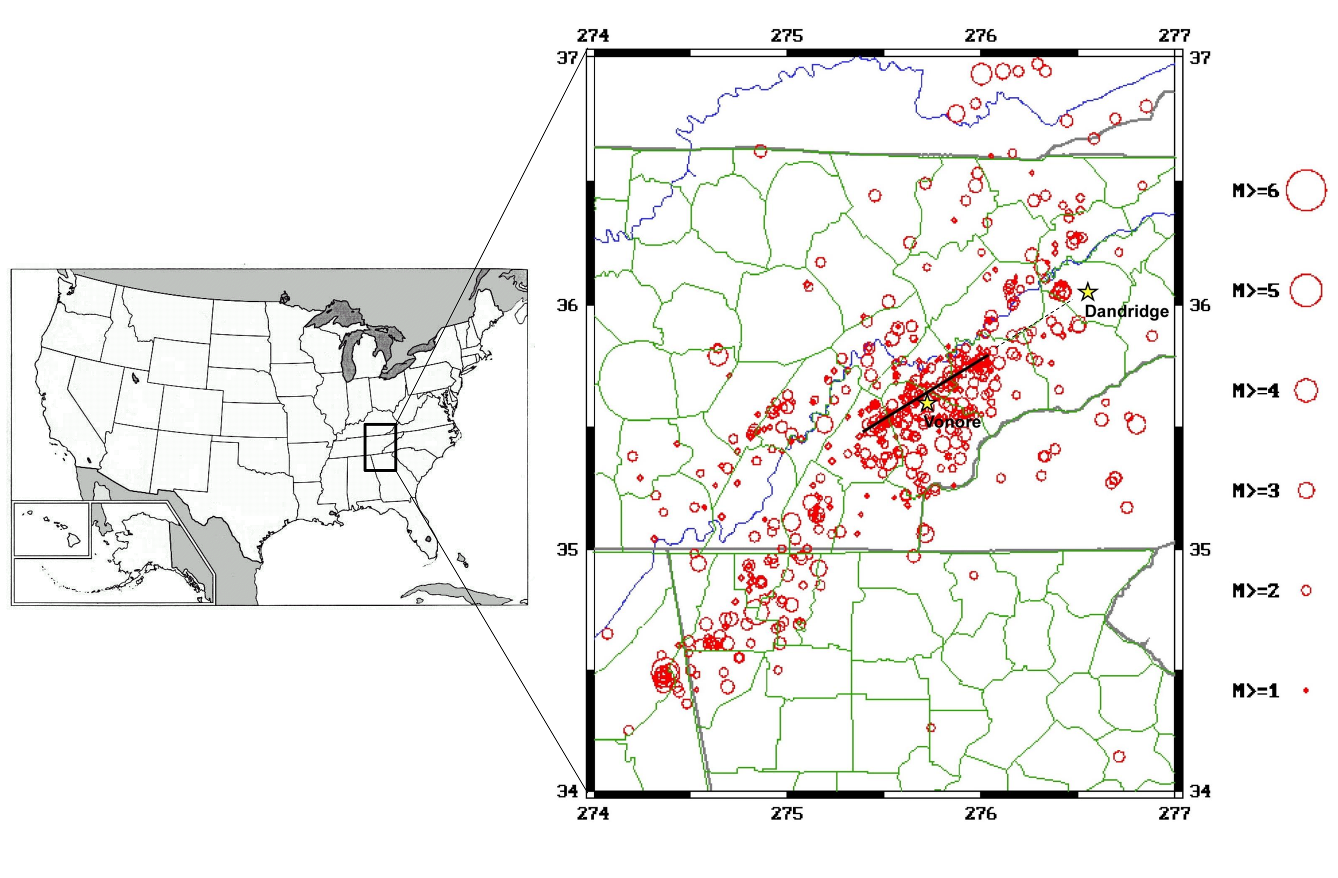

Fig. 1. Epicenters of the East Tennessee seismic zone and the relationship of alignment of seismicity concentration and fault exposures at Vonore and Dandridge, TN.

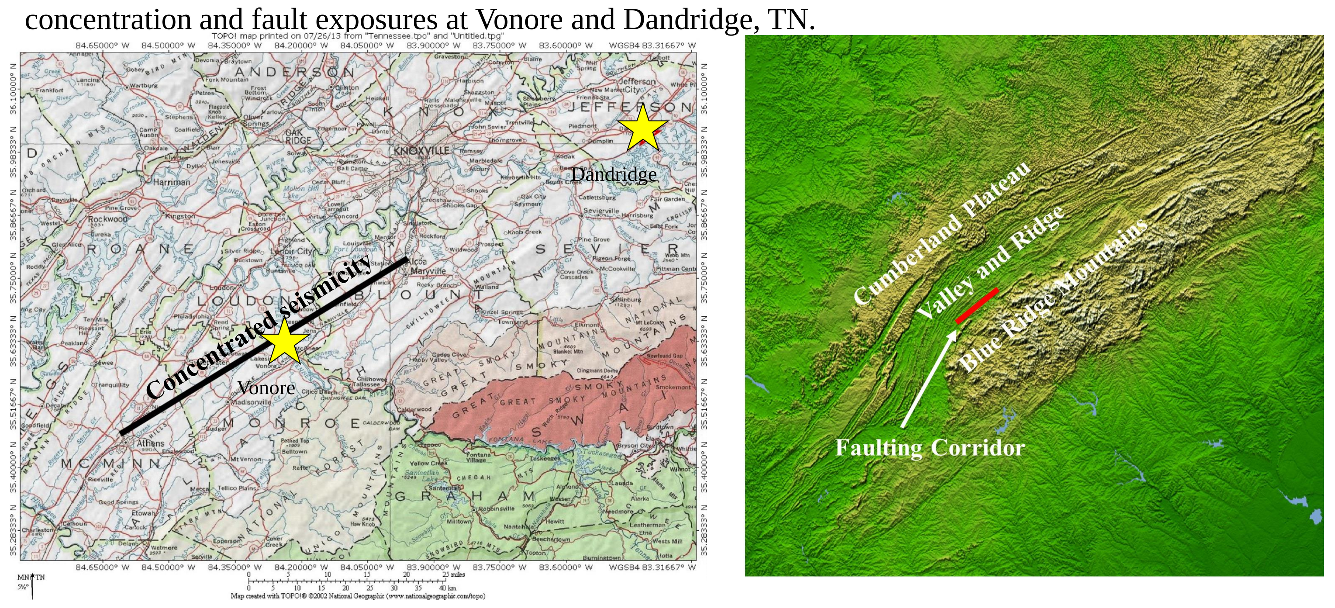

Fig. 2. Political and shaded relief maps showing locations of fault exposures at Vonore and Dandridge, TN and seismicity concentration alignment (faulting corridor?). Note that the "faulting corridor" separates the high Blue Ridge (Smoky Mountains) from the anomalously low part of the Valley & Ridge Province.

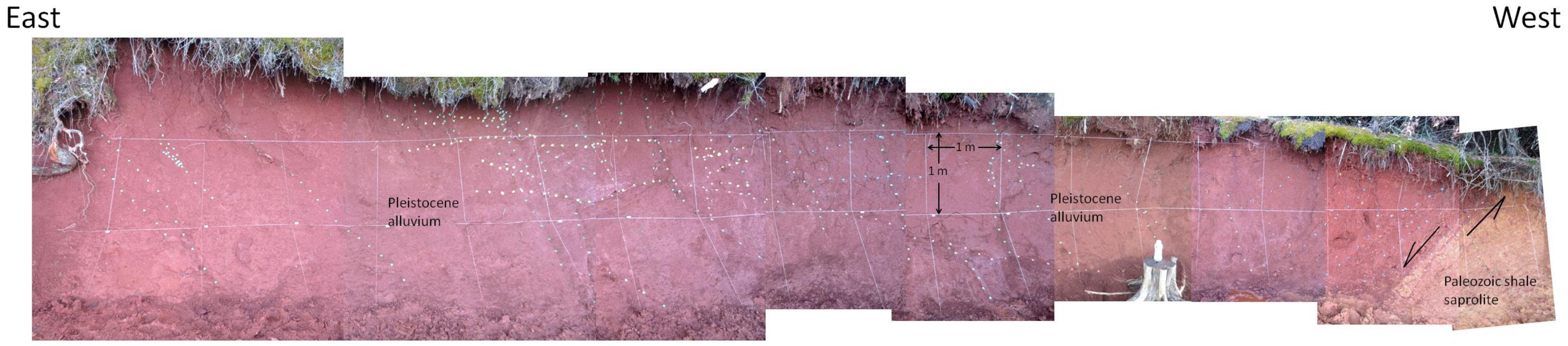

Fig. 3: Normal fault exposed during winter drawdown of Tellico Reservoir. Location of photo indicated by the yellow star "Vonore" in Figs. 1, 2 and 5. White lines are part of a one-meter string grid. Colored flags denote fractures and bedding.

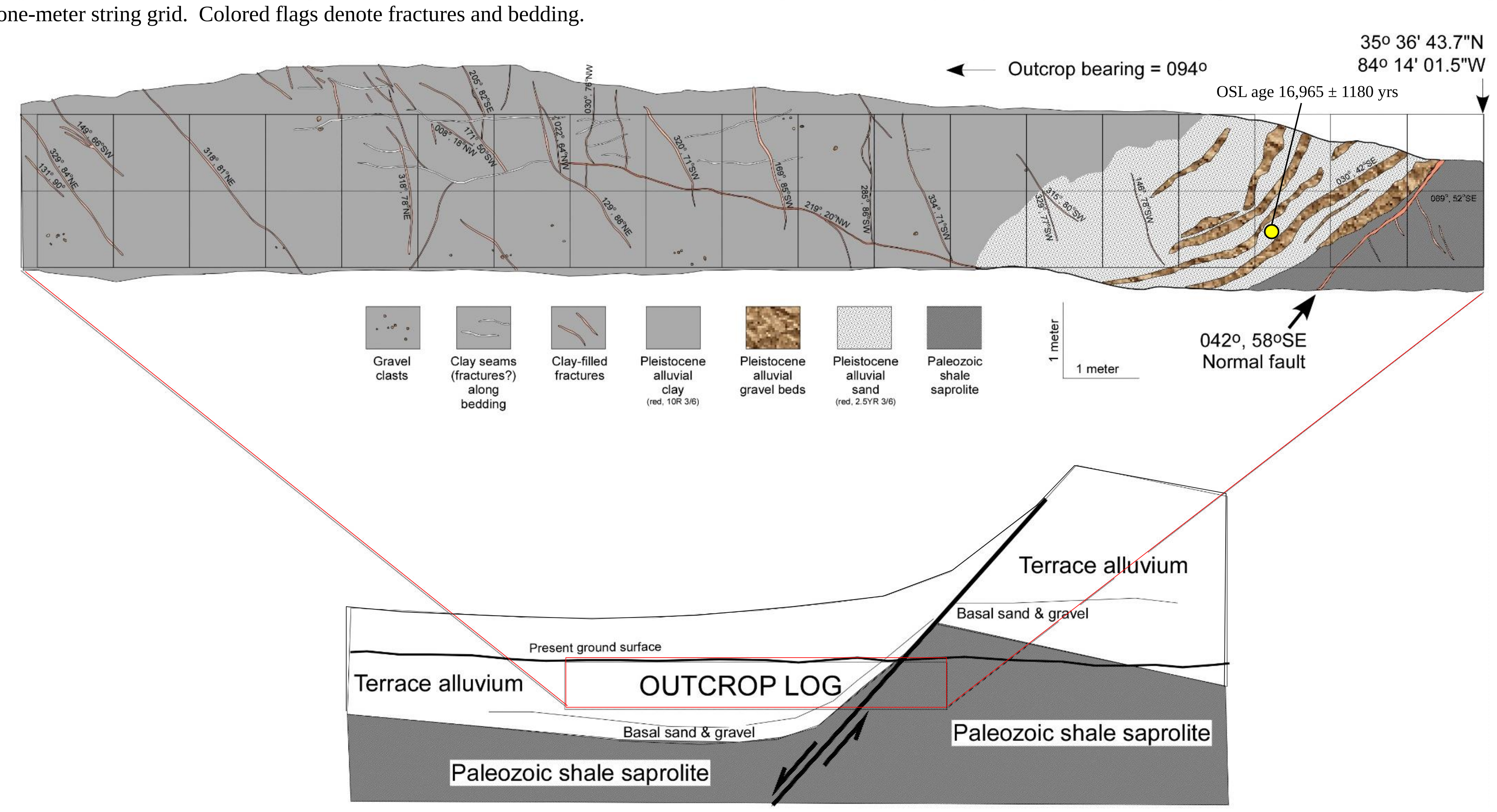

Fig. 4. Outcrop log of Fig 4 showing sketch of drag folding within a Pleistocene alluvial terrace where it is faulted against Paleozoic shale saprolite. Normal fault striking NE and dipping SE. WGS84 GPS coordinates of fault shown in upper right.

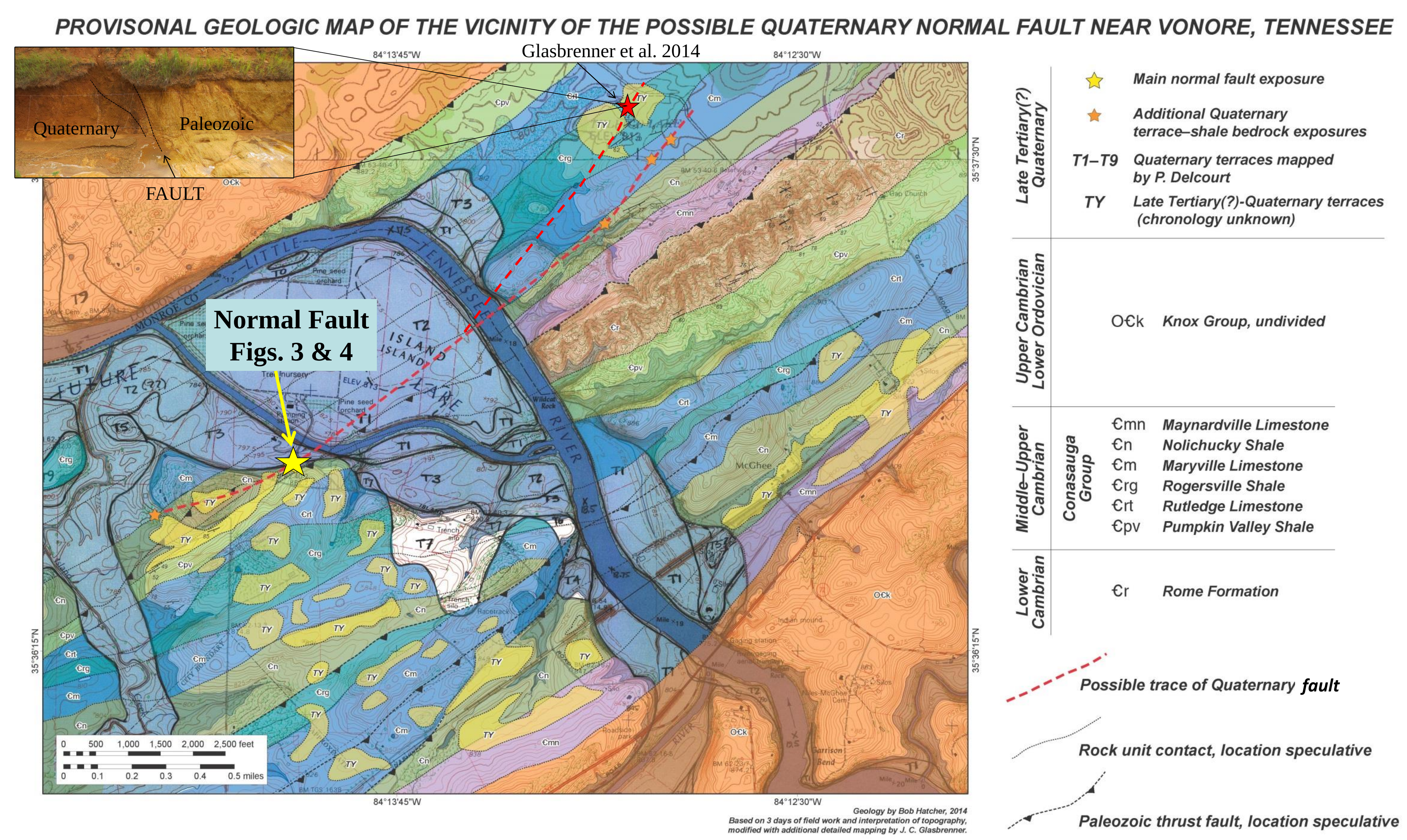

Figure 5. Provisional geologic map of the Vonore area. Geology by RDH from minimal amounts of field work, modified with additional detailed mapping by J. C. Glasbrenner.

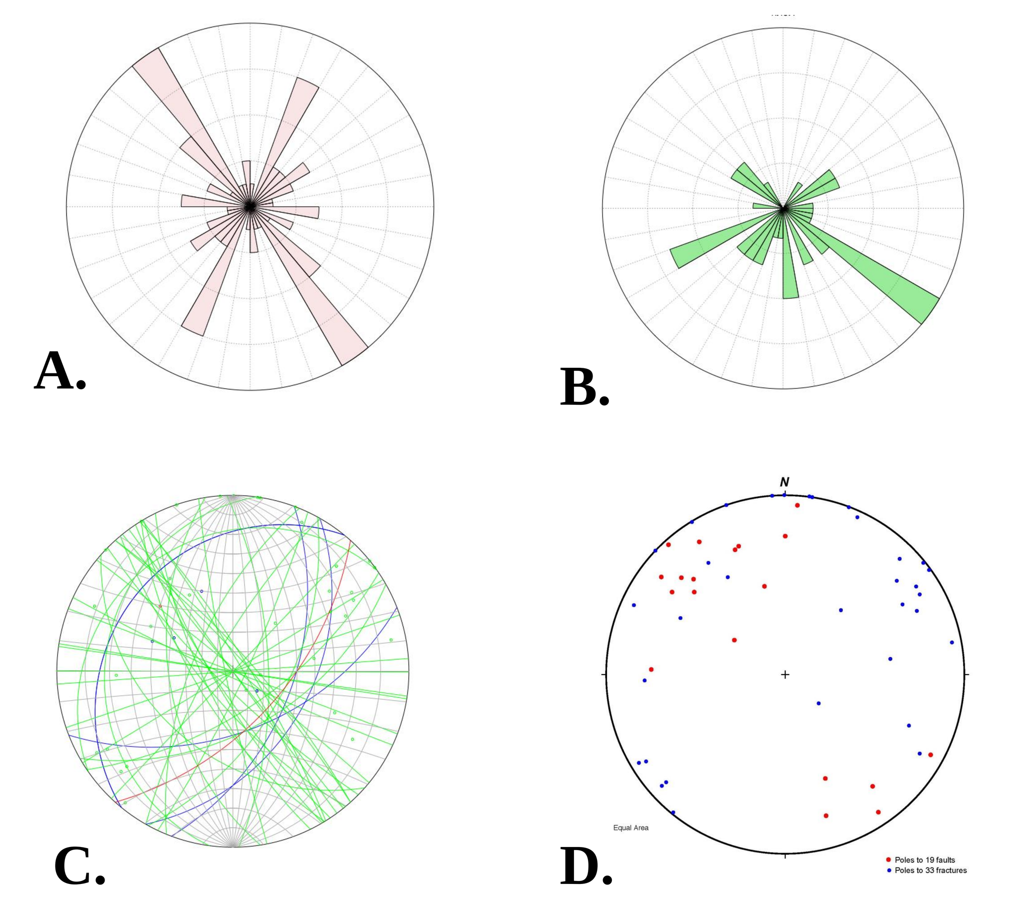

Fig. 6A Rose diagram showing distribution of fracture strike at the normal fault exposure.
B. Rose diagram showing distribution of fractures dip at the normal fault exposure.
C Stereo-net showing joints in green, normal fault in red, and bedding in blue
D. Plot of poles of faults in red and joints in blue in greater Vonore vicinity.

Discussion

- The 040º-trending ETSZ has a 060º-trending concentration of seismicity (Figs. 1-2).
- Hatcher et al. (2012) found thrust faulting in the Dandridge, TN area along this 060º trend (Figs. 1-2).
- Near the center of this 060º alignment we found a 042º-striking Quaternary normal fault with >2 m throw at Vonore, TN (Figs. 3-6), and ~3 km along strike to the NE, Glasbrenner et al. (this meeting) found a NE-striking fault with probable strike-slip movement and a thrust component (Fig. 5).
- Vonore and Dandridge, TN are the two areas of known Quaternary faulting within the ETSZ. Faults of both areas have NE strikes and are along the 060º seismicity alignment, suggesting a faulting corridor (Figs. 1-2).
- Thrusting at Dandridge may be related deep-seated strike-slip faults (Fig. 7A or B) driven by regional NE-SW compression (Heidbach et al., 2008). Normal faulting at Vonore may be due to a releasing bend on a larger strike-slip fault (Fig 7A) or due to folding in the hanging wall of an underlying thrust fault (Fig 7B). The 042º-strike of the Vonore normal fault is consistent with Fig. 7B, but more field data is needed to distinguish between the two models.

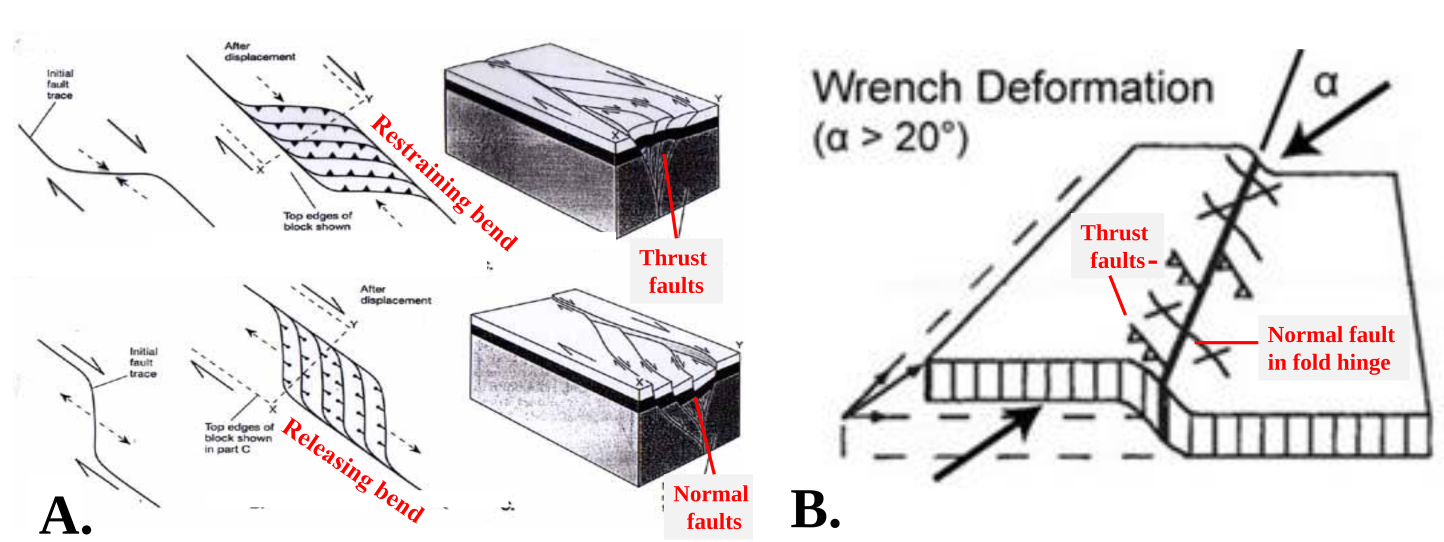

Fig. 7. Schematic of a right-lateral fault with: A) thrust faults at a restraining bend and normal faults at a releasing bend; and B) en echelon thrust faults and folds (with shallow normal faults in fold hinges).

Conclusion

ETSZ seismic source zones may be subsidiary thrusts, normal faults, and strike-slip faults along a right-lateral strike-slip system. Our working hypotheses include: 1) restraining bend thrusts and releasing bend normal faults localized along the strike-slip system; and/or 2) an overall transpressive system with *en echelon* thrust faults and folds (and shallow normal faults in fold hinges). More field data are needed to discriminate between these styles as an interpretation for ETSZ kinematics.

References:

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