The Harpeth River Fault Zone, Central Tennessee: Preliminary Results

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Abstract

Minor normal faults and structural relief on the contact between the Ordovician Carters and Hermitage Formations suggest the presence of two east-side-down normal fault zones in the subsurface 35 km south of Nashville. The Harpeth River Fault zone includes two principal structures: the Arno Fault zone on the west and the McDaniel Fault zone on the east. These two fault zones are separated by 2.5-4.3 km. Structural relief across the Arno Fault zone peaks at approximately 27 m, and structural relief across the McDaniel Fault zone peaks at approximately 24 m. The Arno and McDaniel Faults are approximately 13.2 km long and 11.6 km long, respectively, and strike approximately 340° and 350°, respectively. The Harpeth River Fault zone is likely a Precambrian basement structure which reactivated during the Paleozoic and accommodated extension during uplift of the Nashville Dome.

Introduction

The Nashville Dome (Fig. 1) likely formed in large part through flexure of the lithosphere during the growth of the Appalachian Mountains (Beaumont et al., 1988; Holland and Patzkowsky, 1997). As the lithosphere flexed, it may have extended in some areas, leading to the formation of normal faults. These hypothetical normal faults would likely strike approximately 050°, paralleling the axis of the elongate dome.

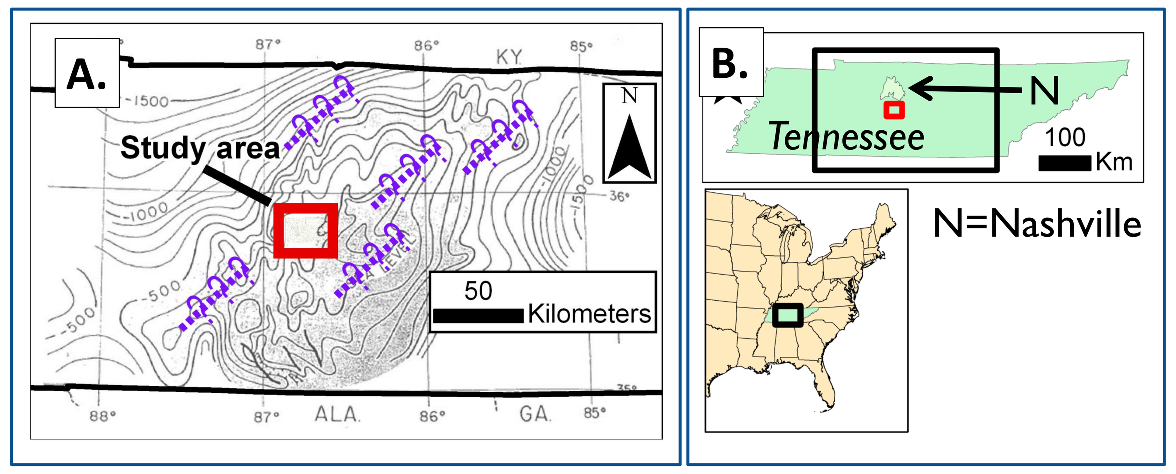

Figure 1. A. *Location of the study area on the Nashville dome. Strike of hypothetical normal faults in purple. Structure contours are the elevation of the top of the Cambrian-Ordovician Knox Dolomite (in feet relative to mean sea level) from Wilson and Stearns (1963).* **B.** *Location of the Nashville Dome (black box) in Tennessee (top) and the eastern U.S. (bottom).*

Although published geologic maps (Miller and McCary, 1963; Wilson et al., 1963) do not depict normal faults within the study area, the subsequent construction of TN-840 revealed minor normal faults and folds at two locations. In many other places, minor normal faults and folds formed in response to the propagation of subsurface normal faults (Fig. 2), and, consequently, the researchers hypothesized that minor normal faults and folds in central Tennessee formed in that way too.

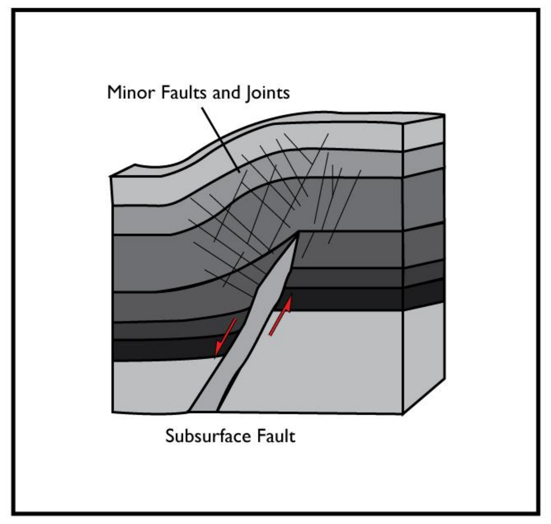

Figure 2. Relationship between folds and minor normal faults at the surface and a larger normal fault in the subsurface (Berg and Skar, 2005).

Methods

To test the hypothesis that subsurface normal faults strike approximately 050°, the undergraduate research team observed folds and faults in road cuts and along the Harpeth River, and the team used published geologic maps to examine structural relief on the contact between the Ordovician Carters and Hermitage formations.

Field observations. The undergraduate researchers used a Brunton pocket transit to measure the strike and dip of faults, non-vertical joints, and fold axes. To measure the orientation of gently dipping bedding planes, the researchers placed a flat aluminum sheet or clipboard on top of a bedding plane. Then the researchers used a Macklanburg-Duncan SmartTool 24 inch digital level or a Brunton to find the strike line. Having found the strike line, the researchers measured the strike with the Brunton, and they measured the dip with the digital level.

Structural relief. The undergraduate researchers used scanned, georeferenced geologic maps to digitize the elevation of the Carters-Hermitage contact at 4,133 locations within the study area.

Results

The researchers collected surface observations at road cuts and at 84 stream bank sites along a 13.3 km canoe traverse (Fig. 3). Structural relief on the Carters-Hermitage contact and surface geologic observations indicate two principal east-side-down subsurface normal faults: the Arno fault zone in the west and the McDaniel fault zone in the east (Fig. 3). Field observations and previous mapping (Miller and McCary, 1963) revealed a syncline interpreted as the surface expression of the subsurface Rudderville fault, and field observations also indicate the presence of another subsurface fault, the McCrory fault. However, the lack of structural relief shows that the Rudderville and McCrory faults are lesser structures.

Results Continued

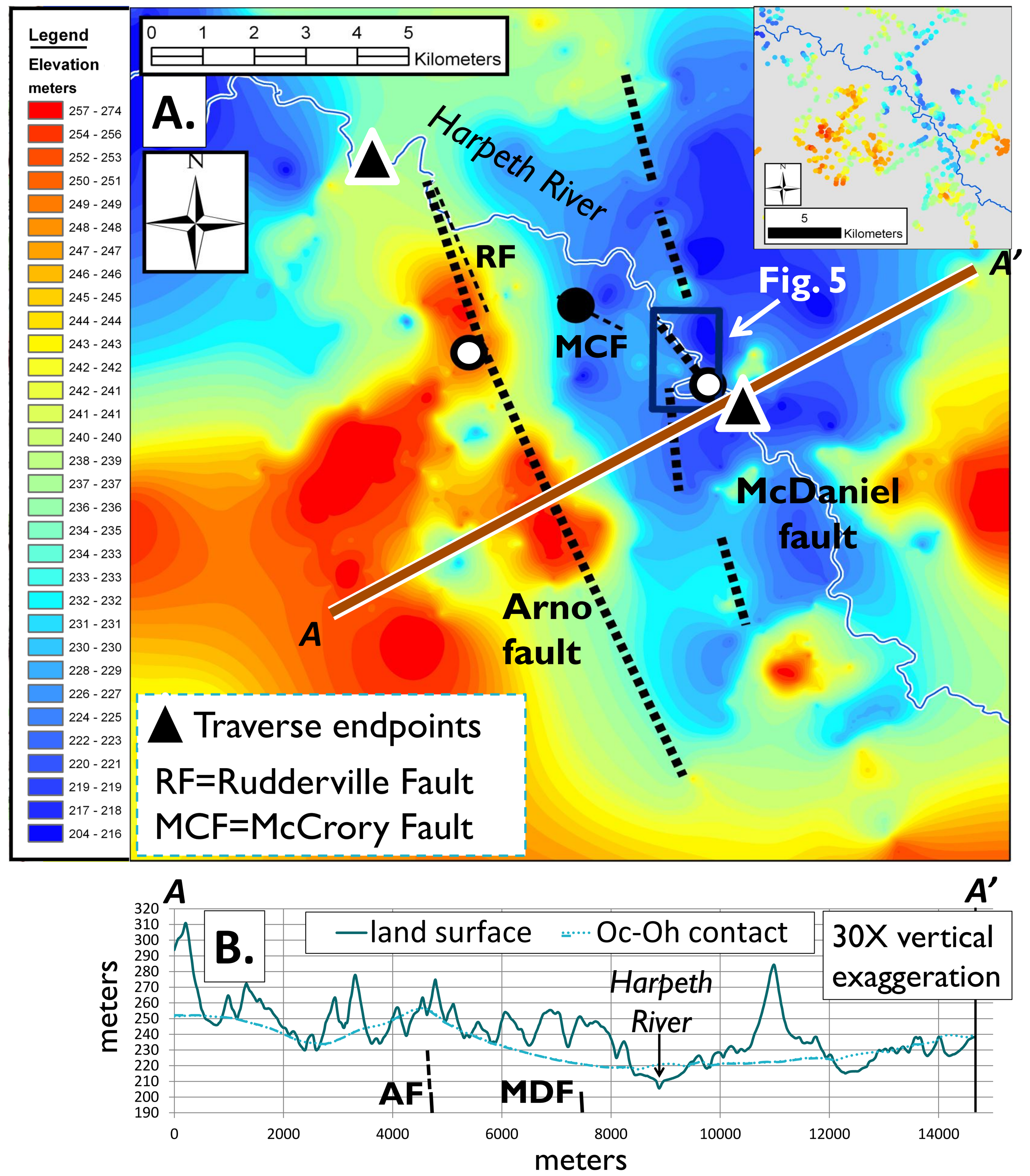

Figure 3 with inset map. A. *Surface fitted to the elevation of the Carters-Hermitage contact. Black lines indicate inferred subsurface northeast-side-down normal fault zones. Lesser faults depicted by thin lines. Dots indicate locations where minor faults were observed at the surface. Triangles indicate the start and end points of the canoe traverse. The inset map shows all of the locations where the researchers digitized the elevation of the contact..* **B.** *Profile of the Carters-Hermitage contact along A-A'. AF=Arno fault zone, MDF=McDaniel fault zone.*

Minor Faults and Folds in the Arno Fault Zone

Minor faults and folds are exposed at one location within the Arno fault zone. The principal structures within the 50 m wide zone are an east-side-down normal fault (Figure 4) and four synclines, interpreted as fault-propagation folds.

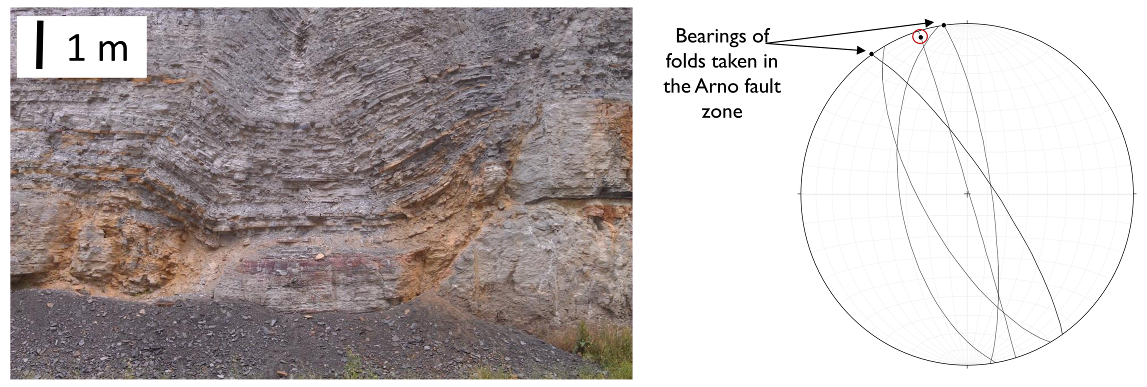

Figure 4. A. Minor east-side-down normal fault striking 350° and exhibiting approximately 3.1 m of dip slip. Note syncline in hanging wall. **B.** Strike of minor faults and non-vertical joints, bearing of syncline hinges, and mean intersection of bedding plane attitudes suggest that the Arno fault zone strikes approximately 325-350° near its northern end.

Minor Faults in the McDaniel Fault Zone

Surface geologic observations revealed four steeply-dipping minor normal faults (see circle on Fig. 5). Three are east-side-down, east dipping, and strike 300-326°, and one is west-side down, west dipping, and strikes 315°. They dip 74-85°. The faults are interpreted as the southern terminus of one segment of the fault zone.

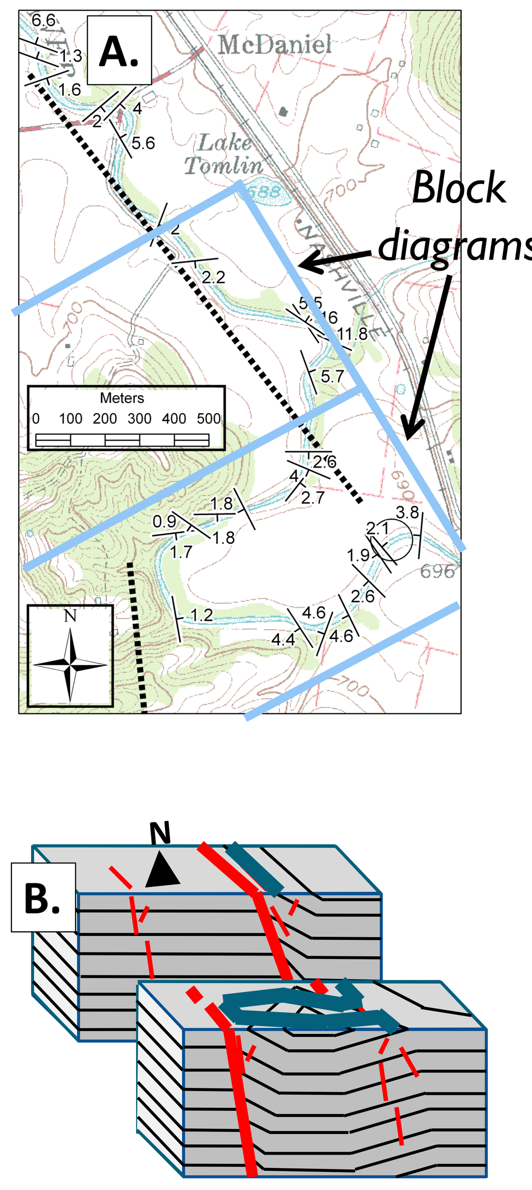

Figure 5. A. *Measurements taken while canoeing a section of the Harpeth River in the study area. Faults are inferred where strata dip NE, E, or SE. The small circle indicates the location of the four minor faults.* **B.** *Block diagrams depicting the inferred stepover in the McDaniel fault zone.*

Discussion and Conclusion

Almost all folds and faults within the Arno, McDaniel, Rudderville, and McCrory fault zones strike 320° – 350°, suggesting that they did not form in response to extension perpendicular to the axis of the Nashville dome. Rather, these faults have an orientation similar to that of a geophysical lineament 200 km to the southwest in northern Mississippi (Sims et al., 2008). Consequently, these faults may be Precambrian basement structures which reactivated during the Paleozoic, accommodating some extension across the Nashville dome.

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