Identifying active tectonics in the New Madrid Seismic Zone using LiDAR and geologic data

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The New Madrid Seismic Zone (NMSZ) is located in the central U.S. and includes parts of west Tennessee, eastern Arkansas, and eastern Missouri. This earthquake zone is considered the most seismically active area east of the Rocky Mountains, though most of the earthquakes are small and not always felt by humans (magnitudes < 3). In 1811-1812, however, three major earthquake sequences occurred with estimated magnitudes up to M 7.8. Earthquakes of that magnitude today would cause massive damage to cities and towns along the Mississippi River valley, including Memphis and St. Louis. Studies suggest an earthquake recurrence interval of approximately 500 years during the last 1200-year period.

The purpose of this project was to analyze recently available Light Detection and Ranging (LiDAR) data for portions of the NMSZ to identify surface deformation that is possibly related to active faults in the region. Most faults in the central U.S. are hidden by a thick covering of alluvial sediment; thus, researchers have to rely on subtle changes in surface topography and remote sensing of subsurface structures for evidence of deeply buried active faults.

For this project, we compiled a comprehensive database of geologic and geophysical information for the study area using Geographical Information Systems. This database consists of Digital Elevation Models (DEMs), mapped locations of known or suspected basement faults, geologic maps and cross-sections, and information on earthquake locations and magnitude. The new LiDAR data was added to the database and provided the highest resolution topography available for the area. By combining features identified in the LiDAR data with earthquake locations and magnetic field anomalies, potentially active faults can be identified. Aeromagnetic data were downloaded and processed using wavelength separation methods. A literature search was conducted to collect articles describing magnetic anomalies and subsurface geology that could be related to regional seismic activity and surface features observed in the LiDAR models.

The LiDAR data collected show prominent earthquake-induced soil liquefaction deposits aligned in a northeast-southwest orientation that match the orientation of faults in the area. The LiDAR data also show linear ridges that align sub-parallel to the liquefaction deposits and that may suggest deformation from buried faults. Analysis of the magnetic data shows anomalies that share the northeast orientation and that could be related to seismic activity in the area. It also shows the presence of igneous plutons that may concentrate tectonic stress, which may explain some of the observed seismicity. These hypotheses may be further explored in future work.

Statement of Research Advisor:

Caleb's work on compiling data sets related to seismicity in the NMSZ represents a solid contribution to earthquake research in intraplate areas. Unlike that seen at tectonic plate margins, evidence of active faulting and deformation in the mid-continent is subtle and often not visible. Through his analysis of newly acquired, high-resolution topography, Caleb has identified surface features that suggest the presence of active, but hidden faults.

—Lorraine Wolf, Geosciences