Tectonic Geomorphic Analysis of the Eastern Lowlands of Upper Mississippi Embayment Using Recently Collected LiDAR Dataset

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ABSTRACT

The Quaternary glacial and interglacial cycle controlled the drainage system in the Northern Mississippi Embayment by draining the melt-water from retreating Laurentide ice sheet through midcontinent. The Mississippi River changed from the braided system during the initial glacial cycle to the meandering system during the Holocene. The advance and retreat of the ice sheet caused the avulsion of Mississippi River for a couple of times and created Pleistocene river terraces both in Western and Eastern Lowlands. These Pleistocene terraces of Eastern Lowland were used as a geomorphic marker for the evaluation of Pleistocene and Holocene deformation. The topography of this area is mostly flat. High-resolution LiDAR imagery of the terrace surfaces was analyzed to collect elevation data, and high order polynomial surface was constructed to look for subtle deformation on top of the terraces. From the third-order polynomial surface of Sikeston, the tectonic bulge of Lake County uplift can clearly be identified.

INTRODUCTION

- Exhibits intraplate seismicity (New Madrid Seismic Zone)
- No recognized significant surface expression of tectonics except Reelfoot fault scarp.
- Thick alluvial sediments covering the area.
- Seismic energy release recorded since 1811-1812 series of earthquakes.
- High resolution LiDAR dataset from USGS (1m and 10m).

BACKGROUND

Location
- West of the axis of Mississippi Embayment
- Situated north-eastern Arkansas, south-eastern Missouri, and north-western Tennessee, south-eastern Kentucky, West of Mississippi
- East of the Crowley's Ridge

Tectonic Setting
- Reelfoot Rift , a failed rift graben lies in Eastern Lowland
- Bounded by Eastern Reelfoot Rift Margin to the east, Western Reelfoot Rift Margin to the west

Surface and subsurface faults
- New Madrid Seismic Zone
  - New Madrid North
  - New Madrid West
  - Reelfoot thrust (Lake County uplift)
  - Reelfoot south
  - Axial fault (Blythville Arch)
- Crittenden County Fault Zone

Pleistocene Terraces
- Formed throughout last glacial cycle
- Due to meltwater discharge fluctuation and route diversion (Rittenour, 2013)
- Ages range from 64 ± 5 to 11 ± 1 ka

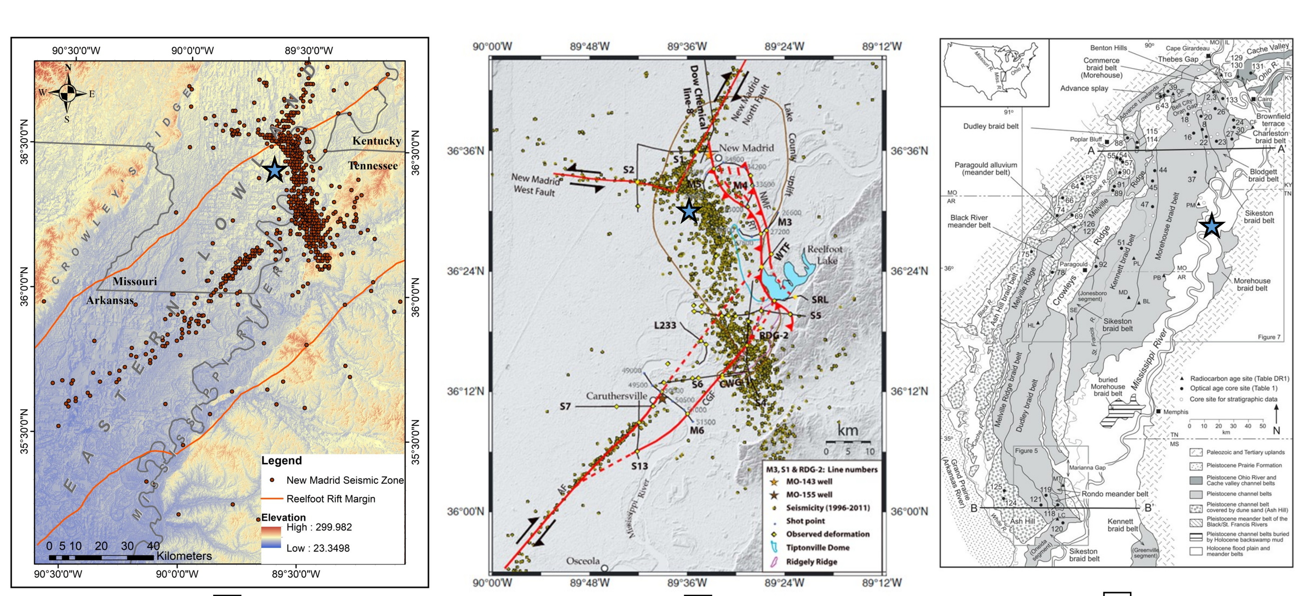


Figure 1: a. Location map, b. fault map (Lei et al., 2014) and c. river terraces map (Rittenour et al., 2007) of the Eastern Lowlands
★ Study area (South part of the Sikeston terrace)

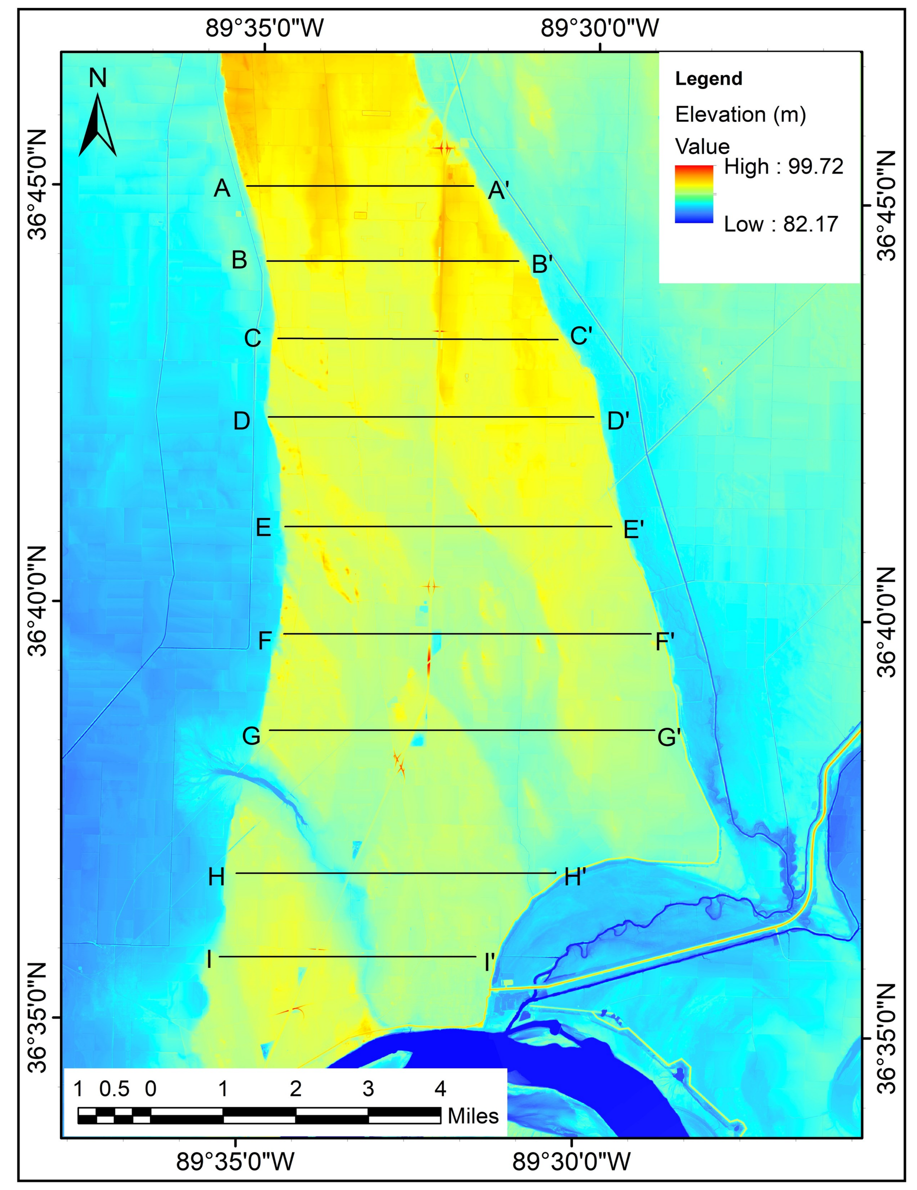


Figure 2: Data Elevation Model (DEM) of the southern part of the Sikeston terrace.

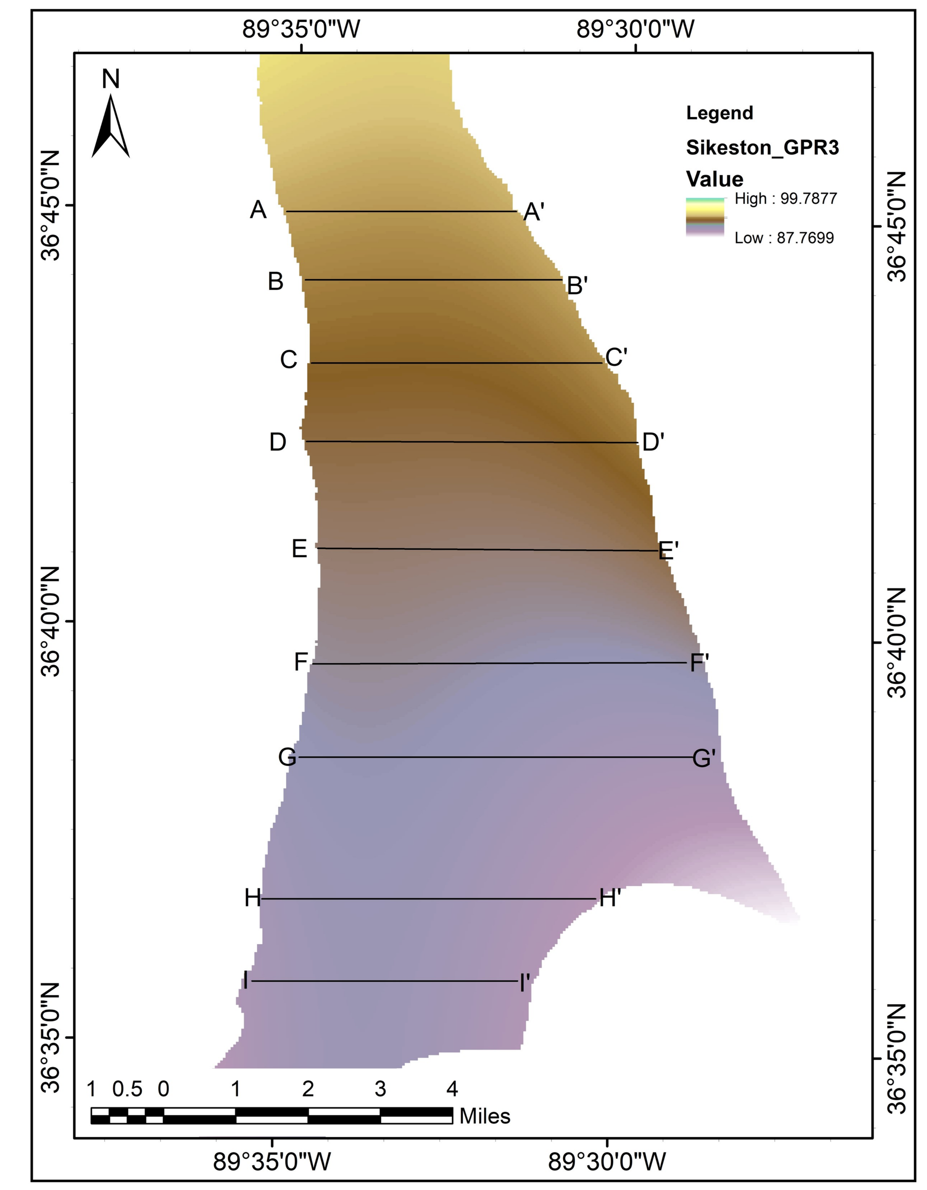


Figure 3: Third order polynomial surface of the southern part of the Sikeston terrace.

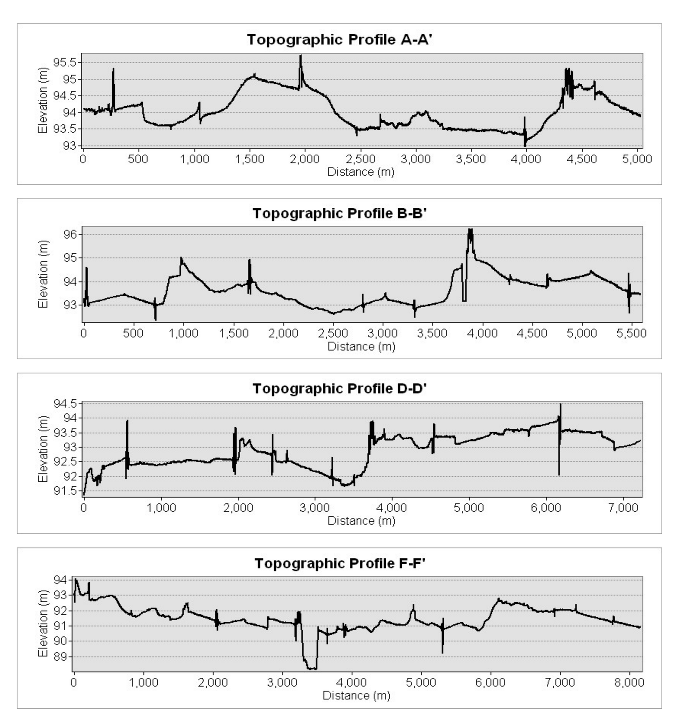
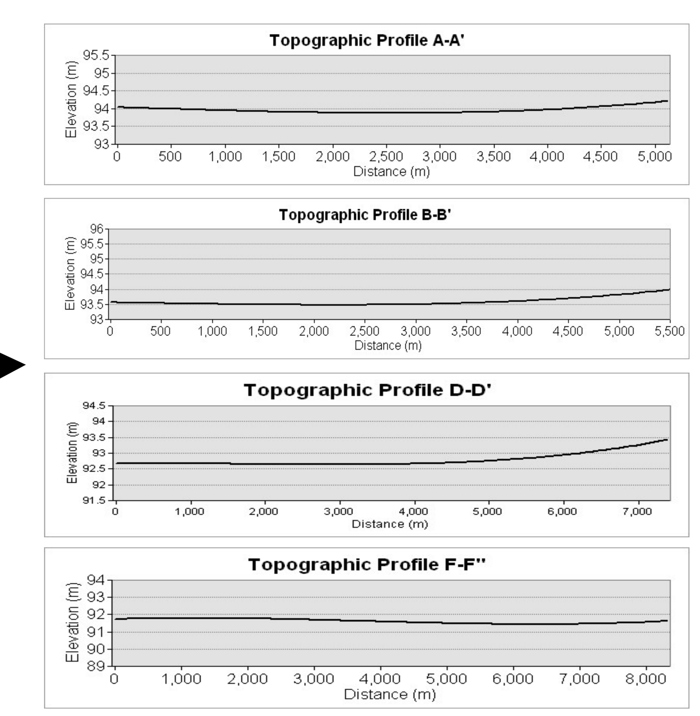


Figure 4: Topographic profile of the Sikeston terrace along lines A-A', B-B', D-D' and F-F' (Figure 2). These profiles are showing an abandoned braided river channel on the terrace surface.

Figure 5: Polynomial surface profile of the Sikeston terrace along lines A-A', B-B', D-D' and F-F' (Figure 3). These profiles are showing the general trend of the terrace surface from west to east.



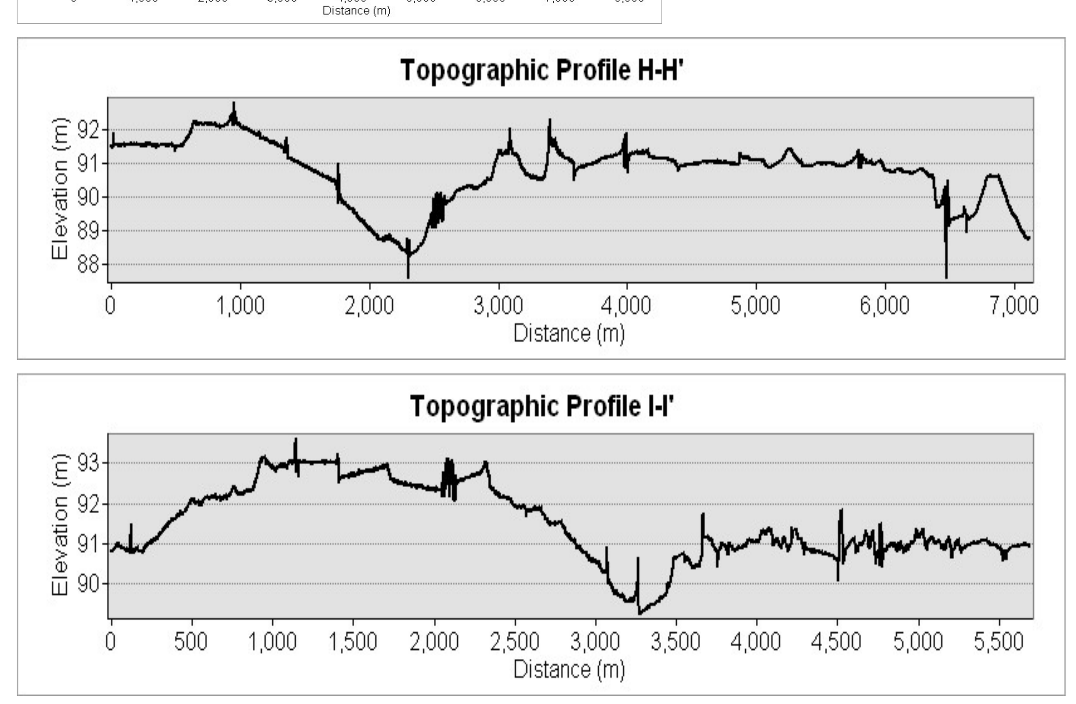


Figure 6: Topographic profile of the Sikeston terrace along lines H-H' and I-I' (Figure 2). The anticline-like bulge is the probable surface expression of the northwestern part of Lake County Uplift.

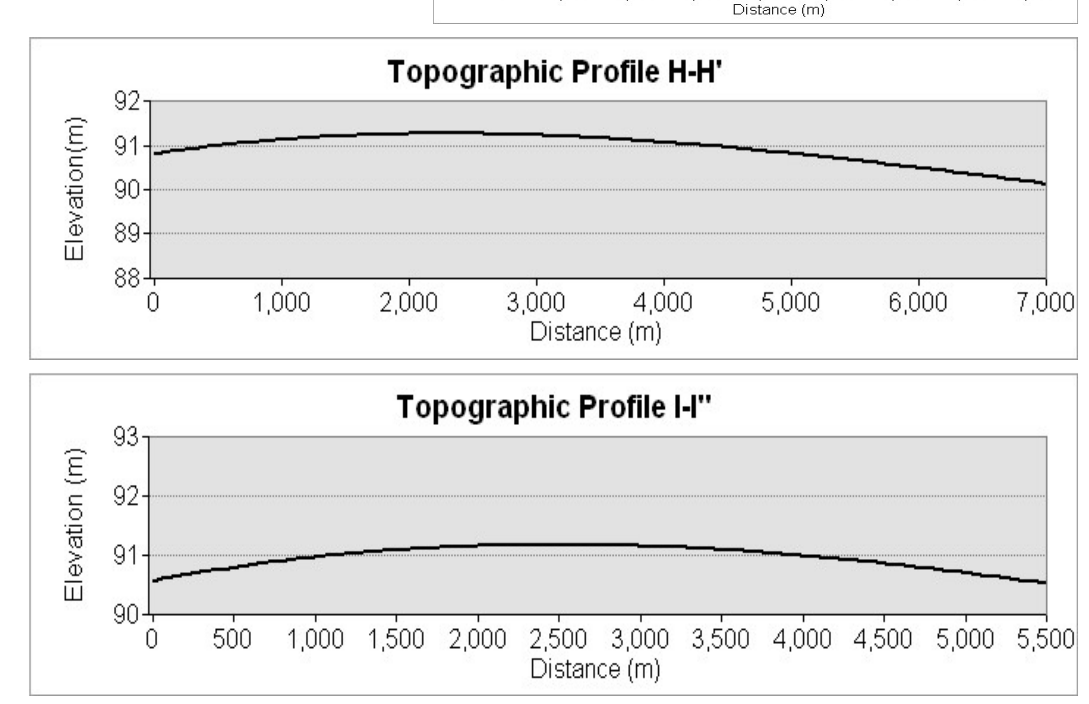


Figure 7: Polynomial surface profile of the Sikeston terrace along lines H-H' and I-I' (Figure 3). These profiles are showing the general trend of the terrace surface from west to east.

RESEARCH STATEMENT

- H_0 – Terraces are not deformed and contoured to their expected down valley slope.
- H_1- Terraces deviate from expected non-tectonic geomorphology (concave upward) due to tectonics.
- H_2- Terraces deviate from expected non-tectonic geomorphology (concave upward) due to glacial sedimentary processes.

METHODOLOGY

The 1m USGS LiDAR Data Elevation Model (DEM) of the Eastern Lowlands has been used to crop out the luminescence-dated Sikeston terrace for analysis. Shapefiles of the terrace boundary were created from the terrace map from Rittenour (2007). The cropped terrace raster contains spatial references as well as the elevation data of the terrace surface. The converting tool was used to convert the raster files to ASCII files in ArcMap. ASCII files created earlier have been transformed into Comma-Separated Values (CSV) format using MATLAB script to construct a polynomial surface (Figure 8). The polynomial surface of the terrace is used to analyze the general trend, and subtle deformation of the Sikeston terrace was identified by comparing the topographic profiles with polynomial surface profiles.

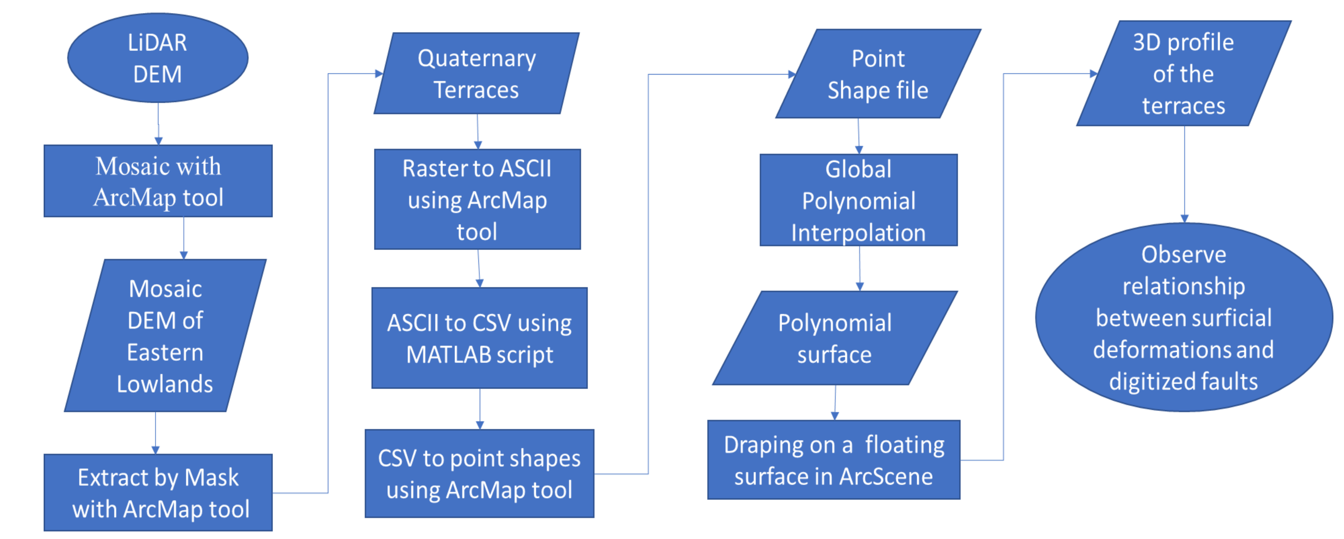
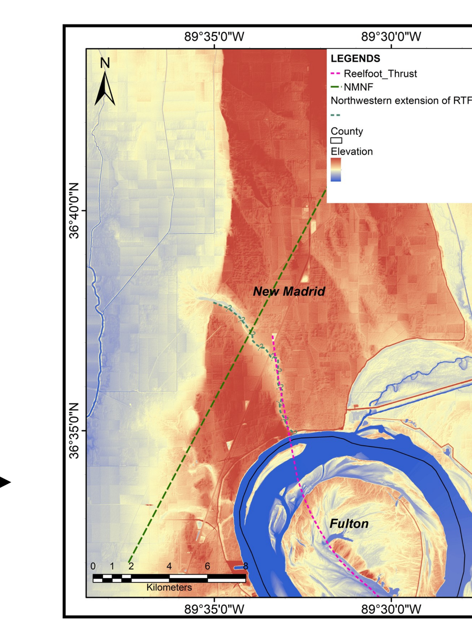


Figure 8: Polynomial surface construction process

RESULTS

- New Madrid North fault (NMNF) does not show deformed surface on Sikeston Ridge.
- Reelfoot North thrust probably deforms Sikeston at its southwestern corner.

Figure 4: South part of the Sikeston terrace



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