Identification of Landslides Along Crowley's Ridge in the Upper Mississippi Embayment Using Topographic Algorithms

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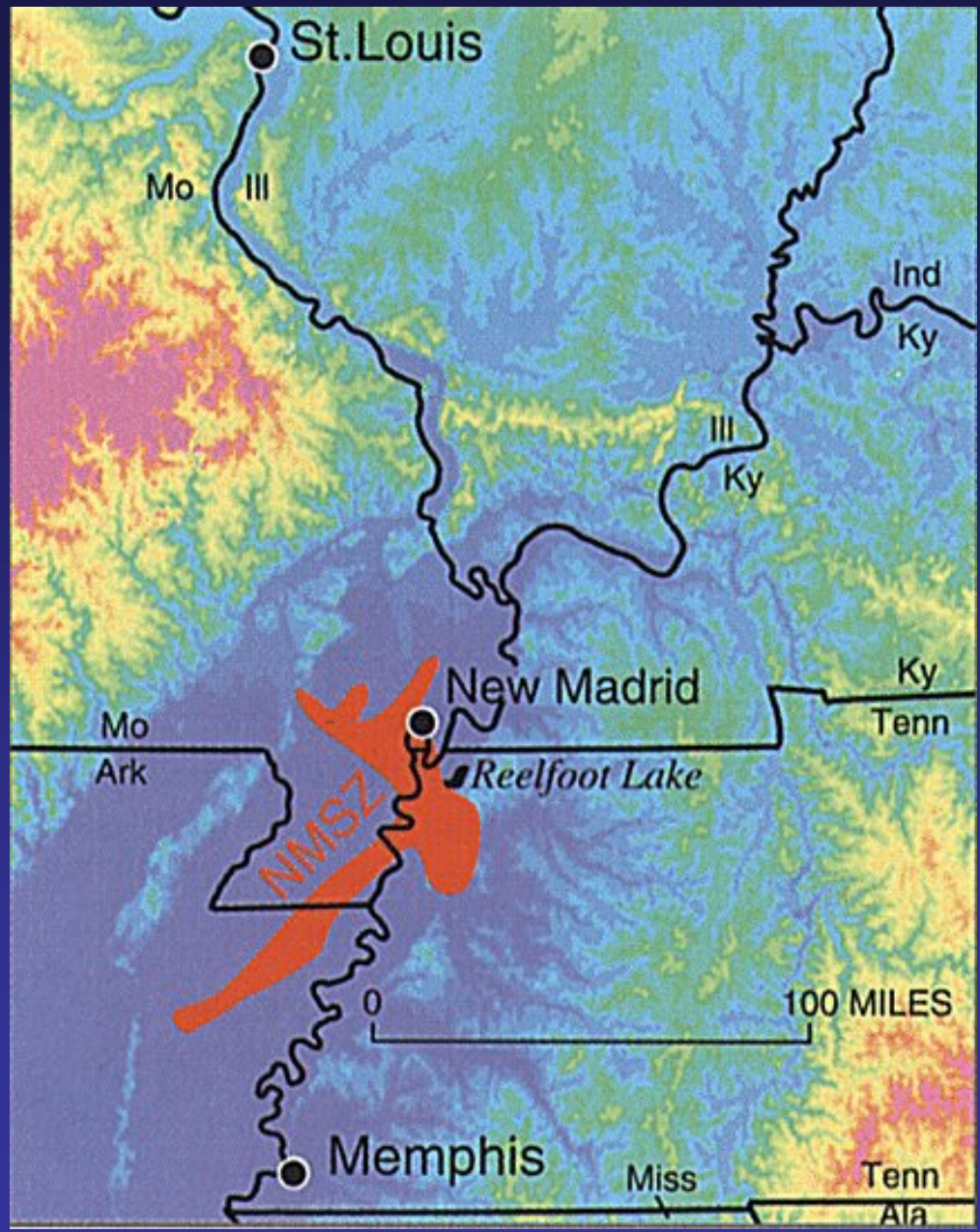
Objective of Research

- Determine the feasibility of identifying and categorizing seismically-induced landslides and lateral spreads using **topographic pattern recognition**

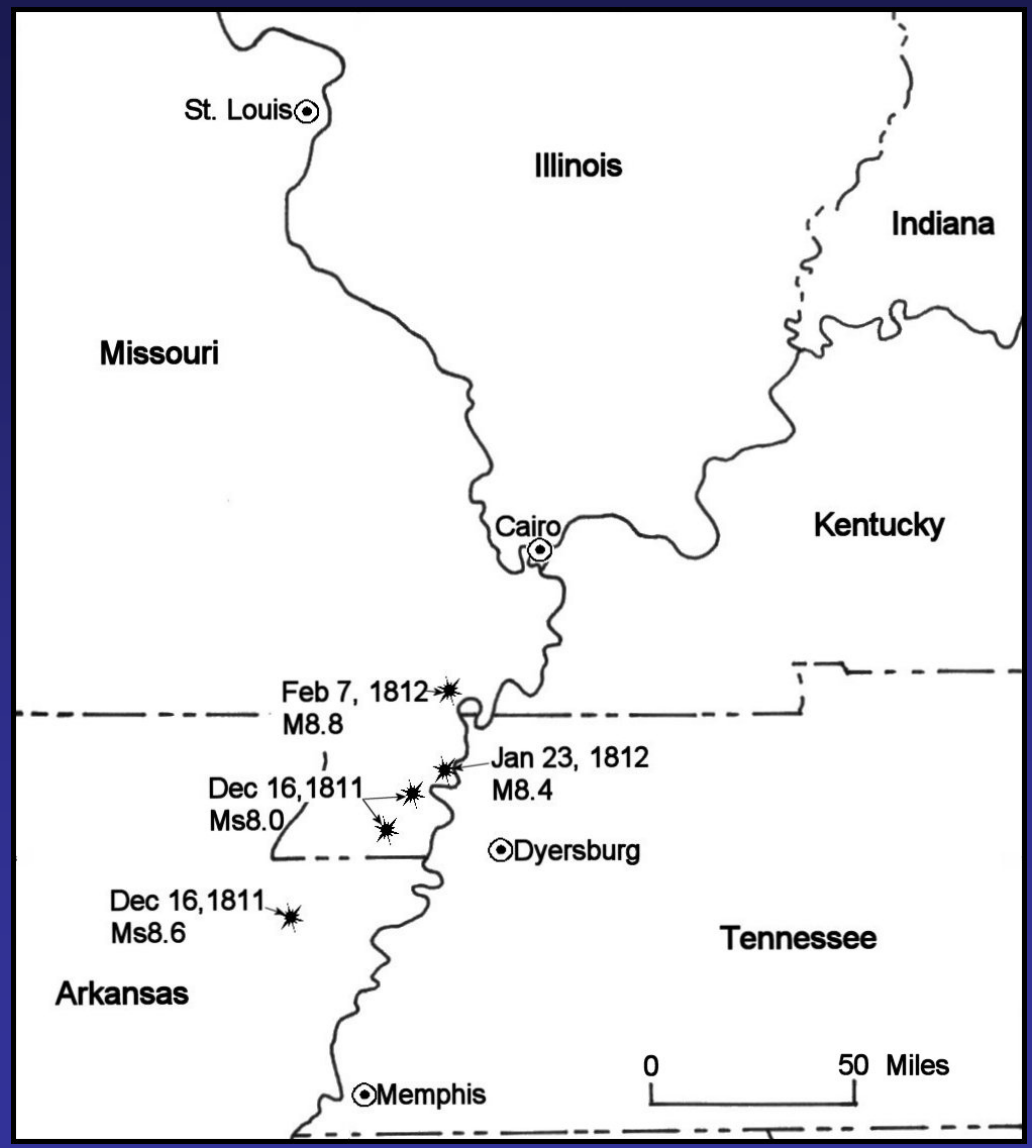
New Madrid Seismic Zone (NMSZ)

- Most seismically active area east of Rocky Mts.
  - Located within Upper Mississippi Embayment

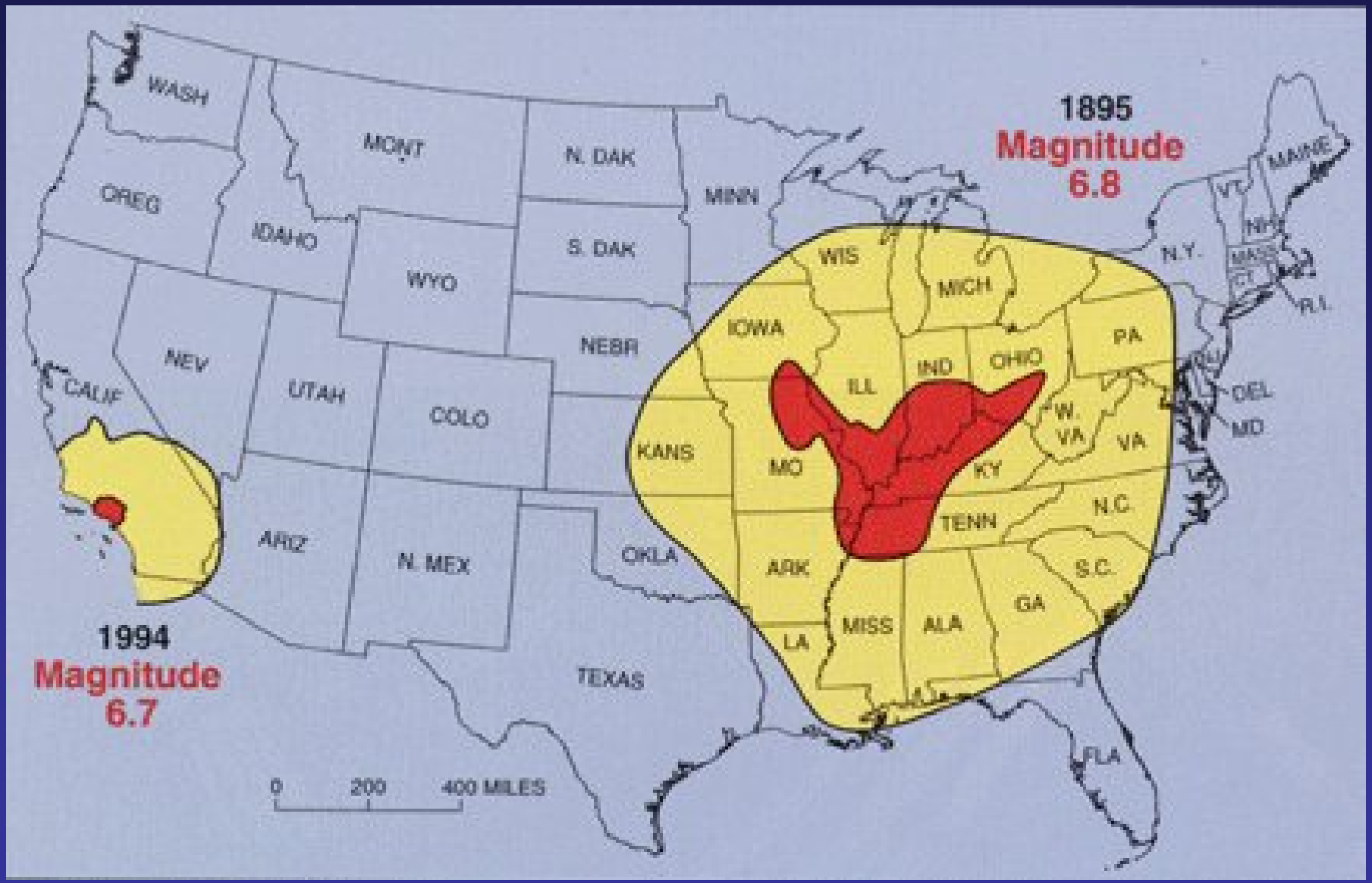


1811-1812 New Madrid earthquakes

- Over 2000 felt earthquakes in 4 month period
  - 5 quakes with $M_s \geq 8.0$
  - Felt over an area of 5 million km^2
- Damage estimates for similar quakes
  - $10 -$20 billion in Central U.S. (1994)



Area effected by a M_s 6.8 Earthquake

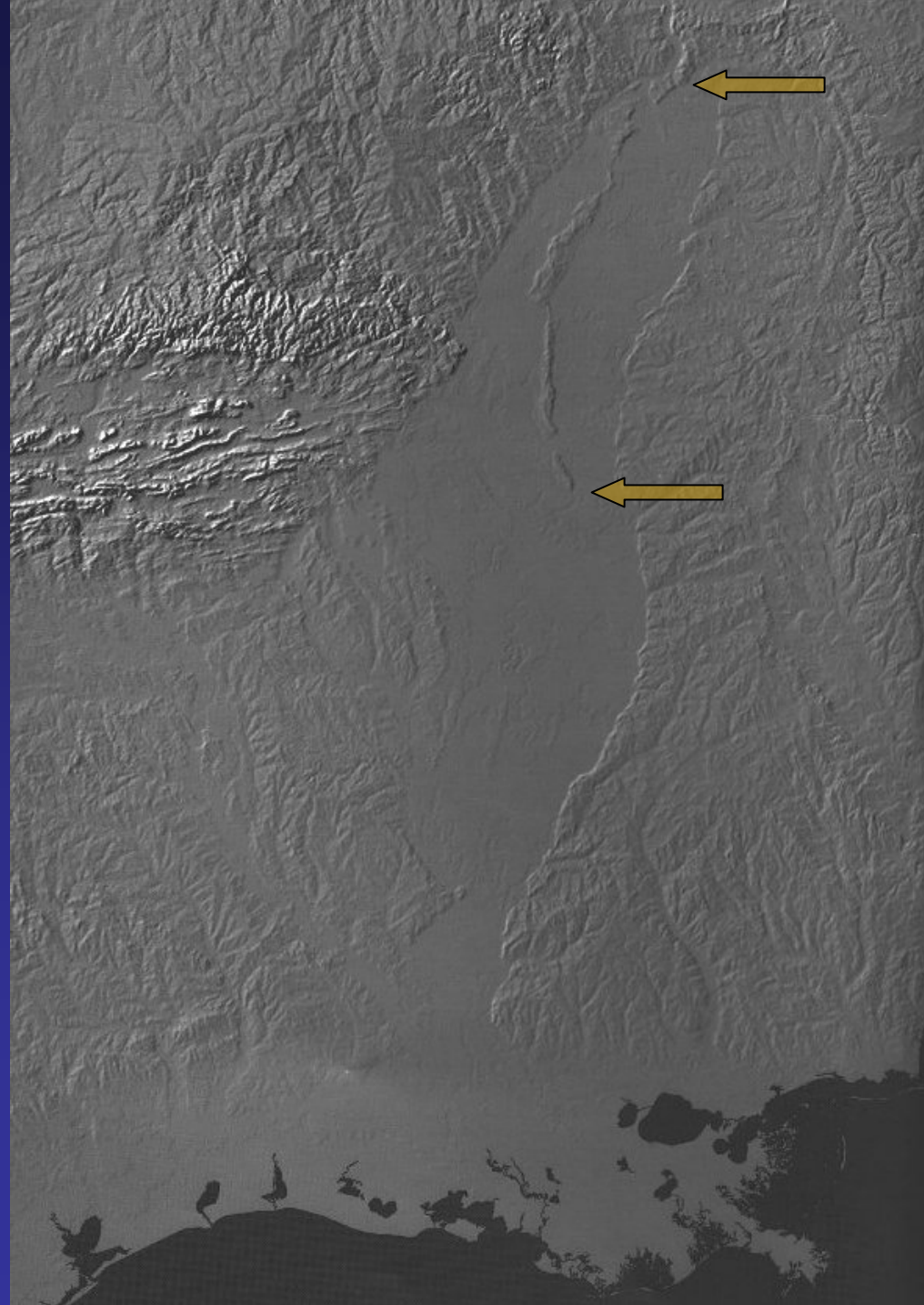


Previous Landslide Work in the NMSZ

- Eastern NMSZ
  - Myron Fuller (1912)
  - Jibson (1985); Jibson and Keefer (1988,1994)
    - Identified over 200 landslides along the Chickasaw Bluffs (KY and TN)
- Western NMSZ
  - Ding (1991)
    - Mapped at 1:100,000 scale
    - Did not map individual slides
  - McFarland (1992)
    - Mapped only historical slides
  - This Study
    - Over 900 slides mapped on the 5 quadrangles studied.
    - Individual slides mapped at 1:24,000 scale (initial reconnaissance mapping) and 1:5000 scale (detailed mapping)

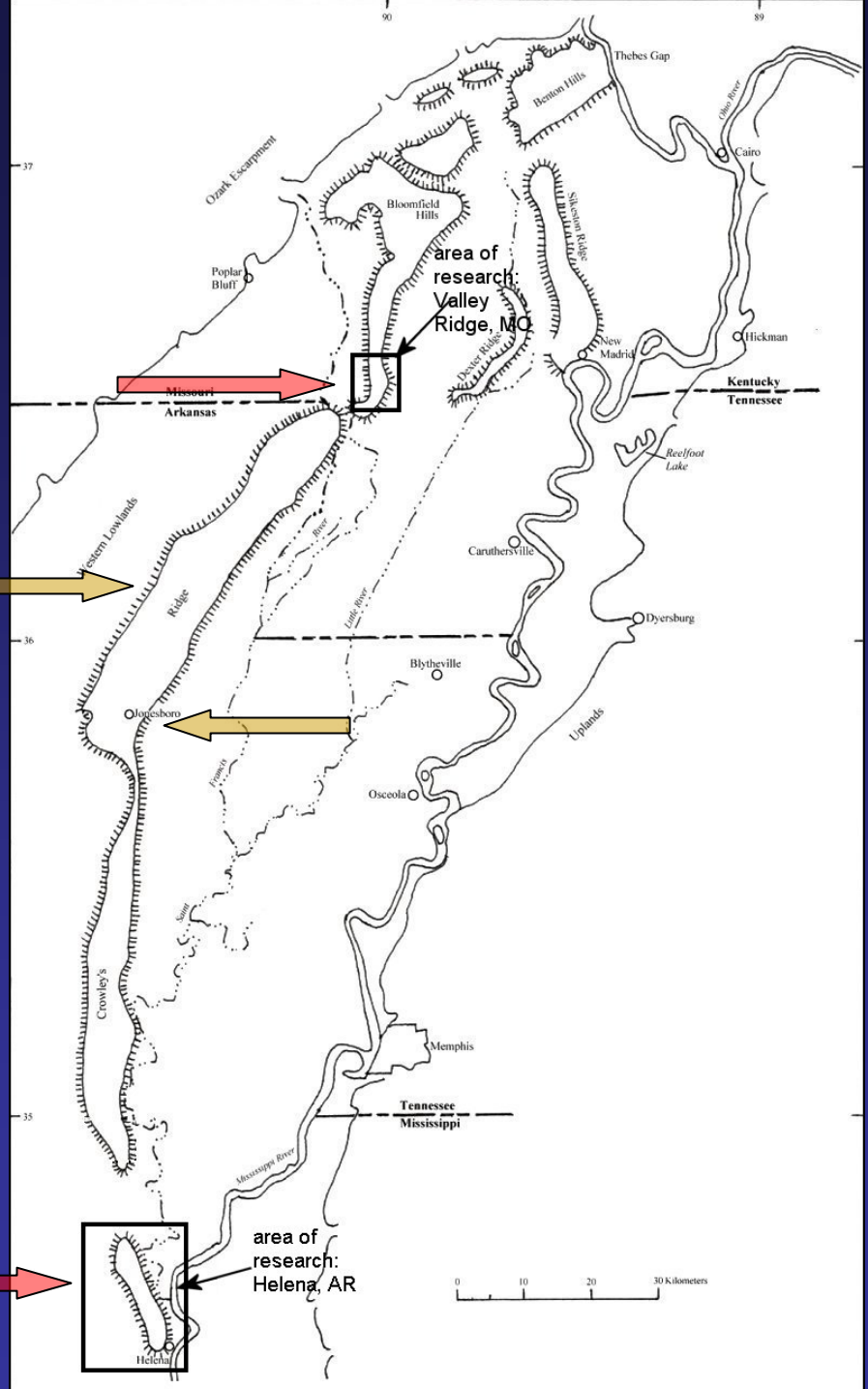
Crowley's Ridge

- Elevated upland within the Mississippi River Embayment and near the NMSZ
- Over 380 km long
- 32 km wide at widest point
- Over 90 m of relief in areas

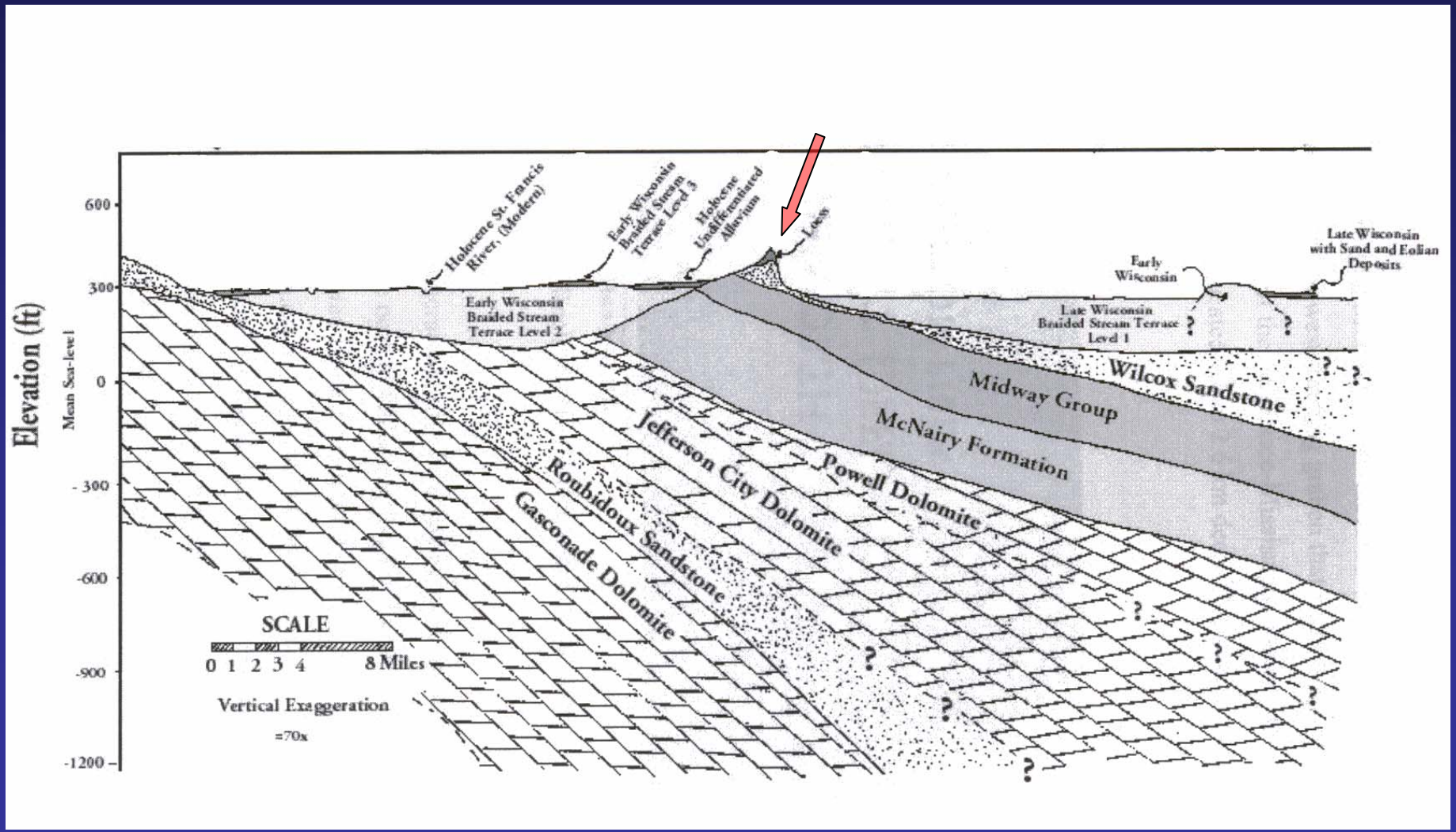


Crowley's Ridge

- Likely formed by:
  - erosive processes
  - tectonic processes
    - related to the NMSZ, Reelfoot Rift, and CGL
- Demonstration Quadrangles
  - LaGrange, Helena, West Helena, and Stubbs Island, AR
  - Valley Ridge, MO



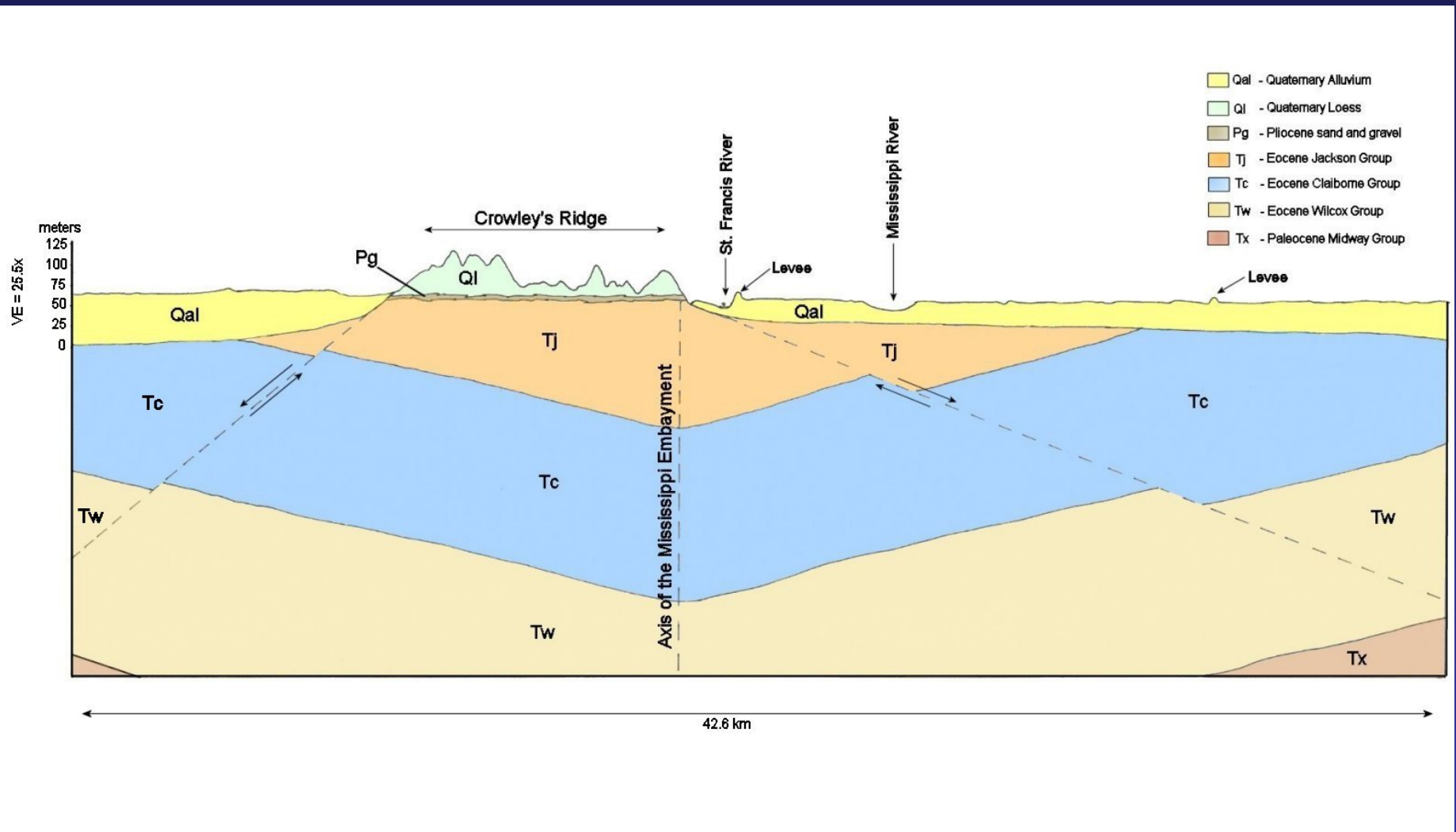
Geology of northern Crowley's Ridge (VE=70x)



From: Santi, P.M. and Neuner, E.J., 2002

Geology of southern Crowley's Ridge

(VE=25.5x)

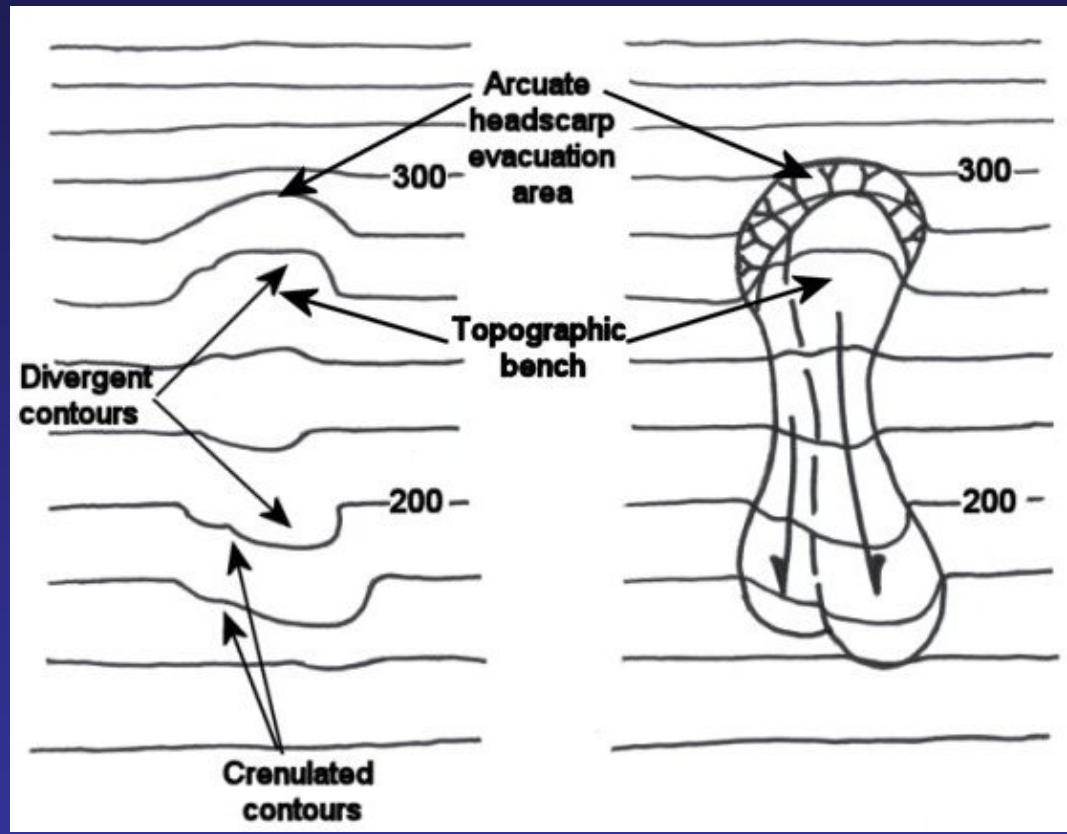


Topographic Patterns

- Useful for **rapid overviews** of large areas
- May be used in conjunction with aerial photographic methods
- Following initial identification, detailed **field mapping and analyses** are used to determine if anomalous topographic features are seismically-induced landslippage

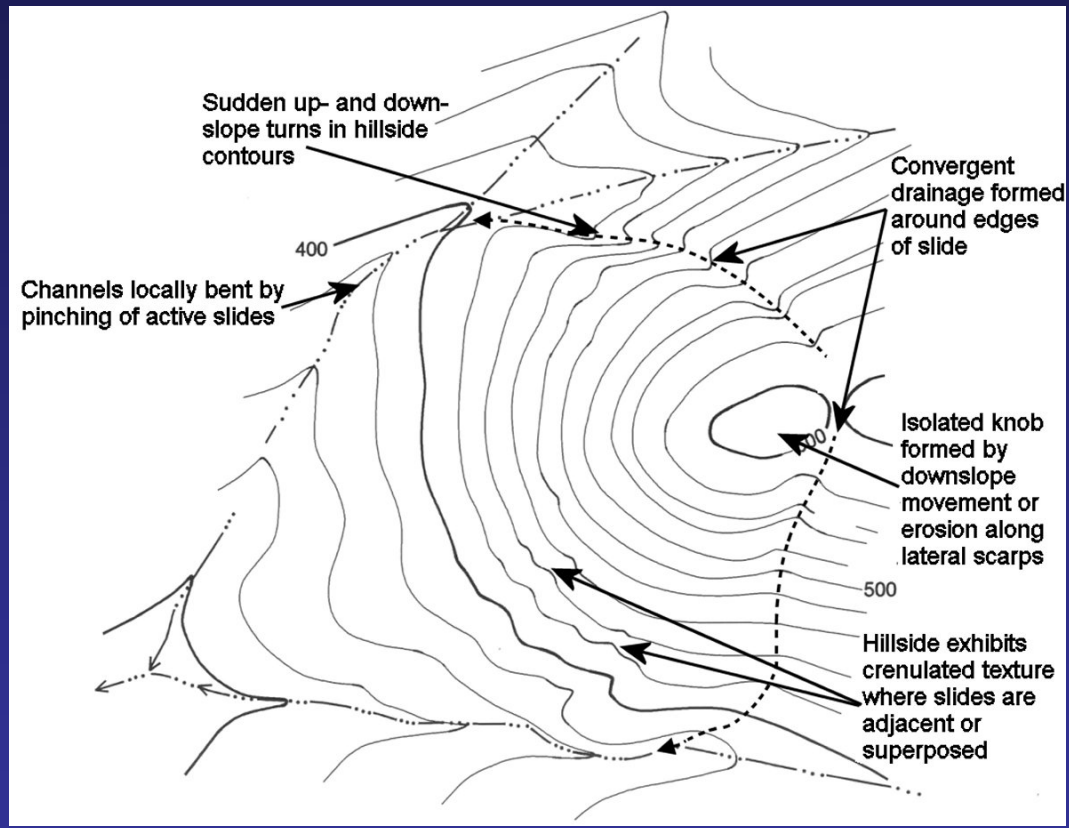
Topographic Patterns

- Use drainage and topographic keys to recognize anomalous site characteristics typical of landslides
  - Divergent contours
  - Crenulated contours
  - Arcuate headscarp evacuation areas
  - Isolated topographic benches



Topographic Patterns

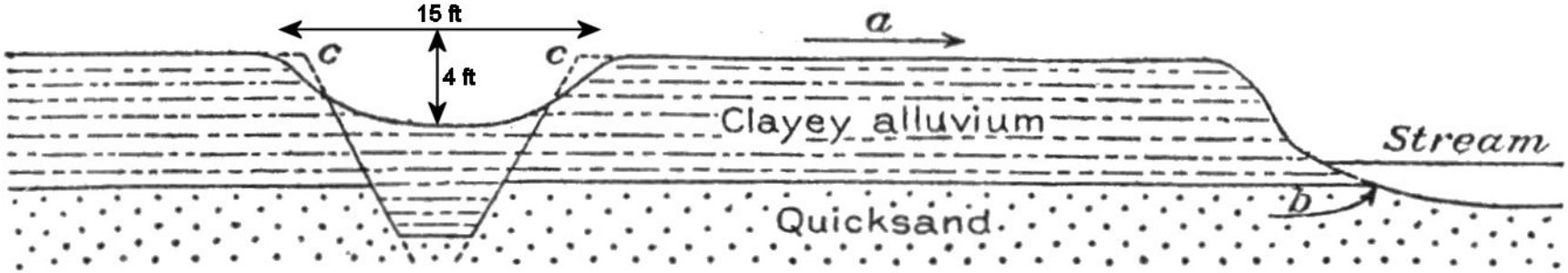
- Use drainage and topographic keys to recognize anomalous site characteristics typical of landslides
  - Extended ridges or isolated knobs
  - Sudden turns in hillside contours
  - Convergent drainage



Common Landslide Types Along Crowley's Ridge

- Lateral Spreads
- Earthflows
- Translational Block Slides
- Slumps and Retrogressive Slump Complexes

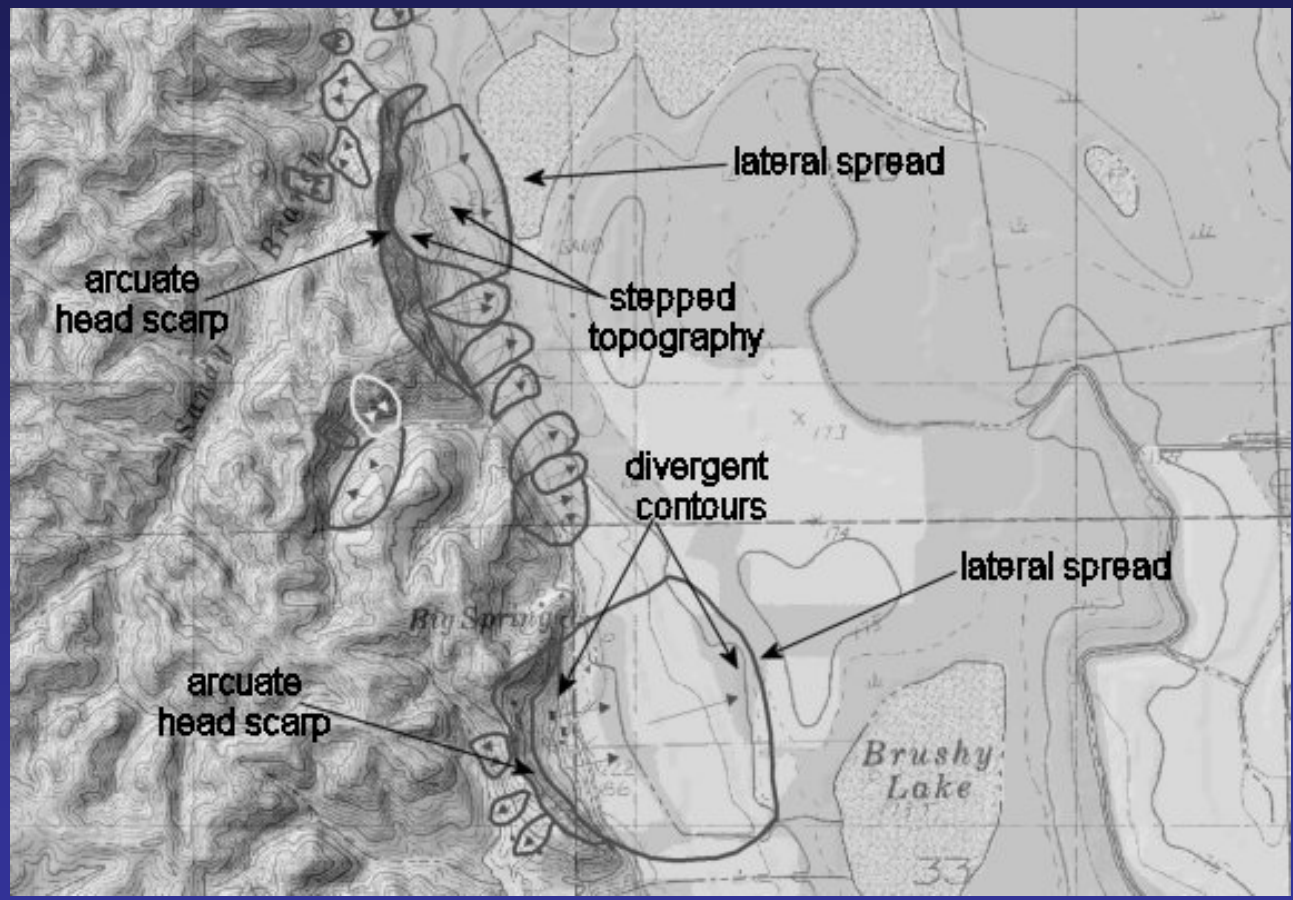
Lateral Spreading in the NMSZ



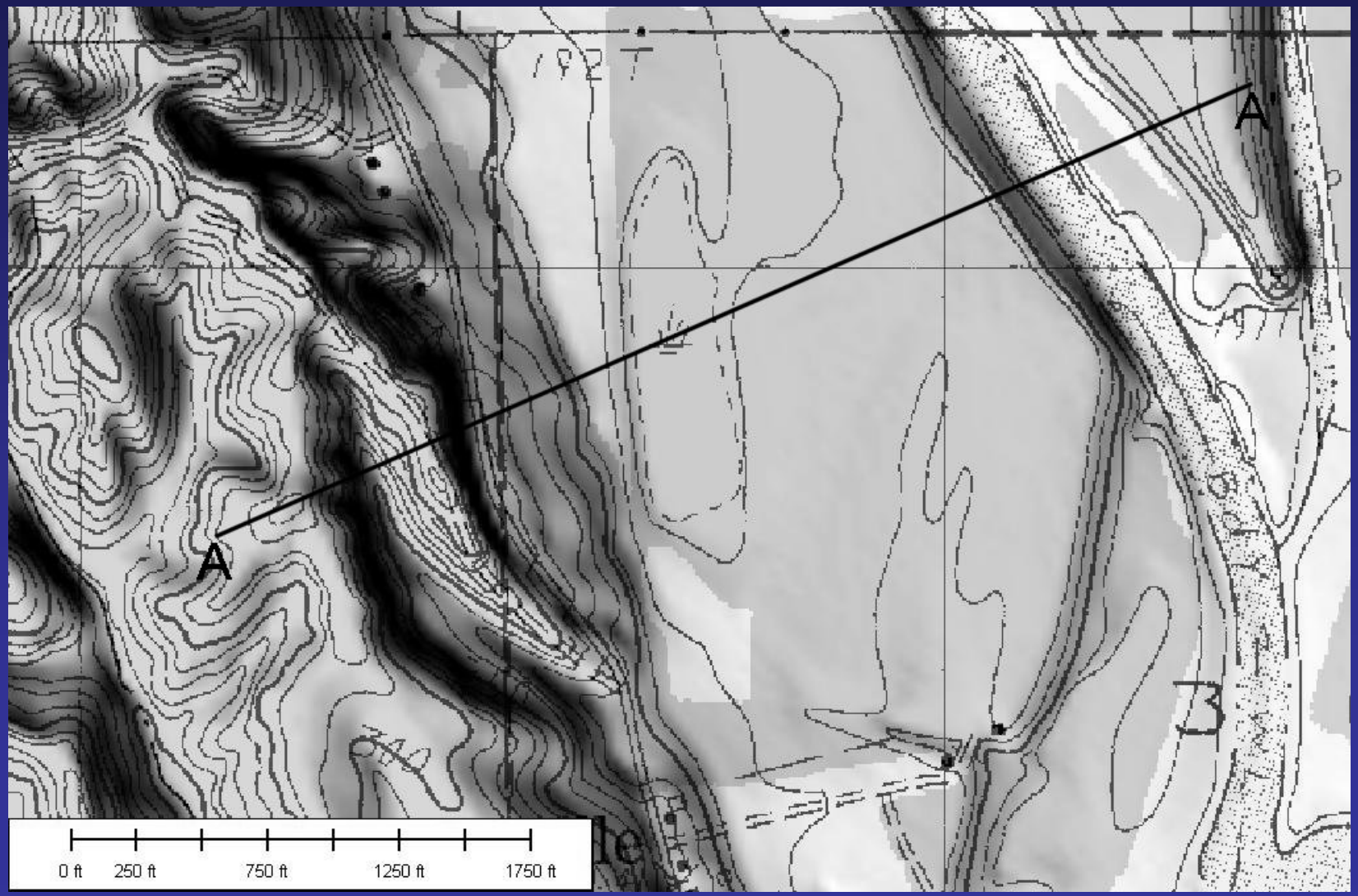
- Cross-sectional sketch by Myron Fuller (1912) suggesting a likely mode of formation for large “fissure” features Fuller found in the NMSZ. The mode of formation is the same as in lateral spreading.

Topographic Expression of Lateral Spreads

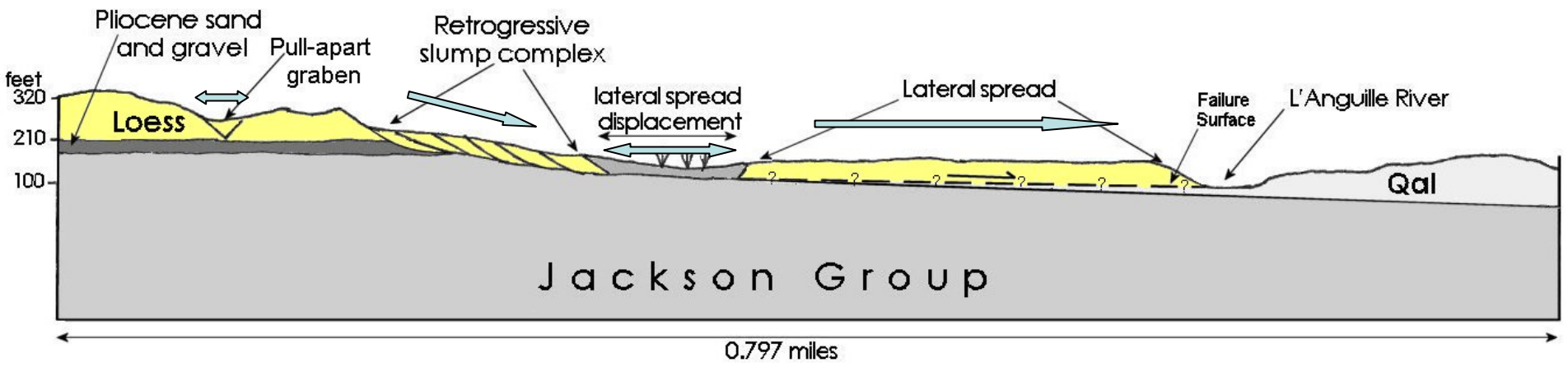
- Divergent contours
- Stepped topography
- Headscarp evacuation grabens
- Arcuate headscarps



Shaded relief map showing Jeffersonville lateral spread



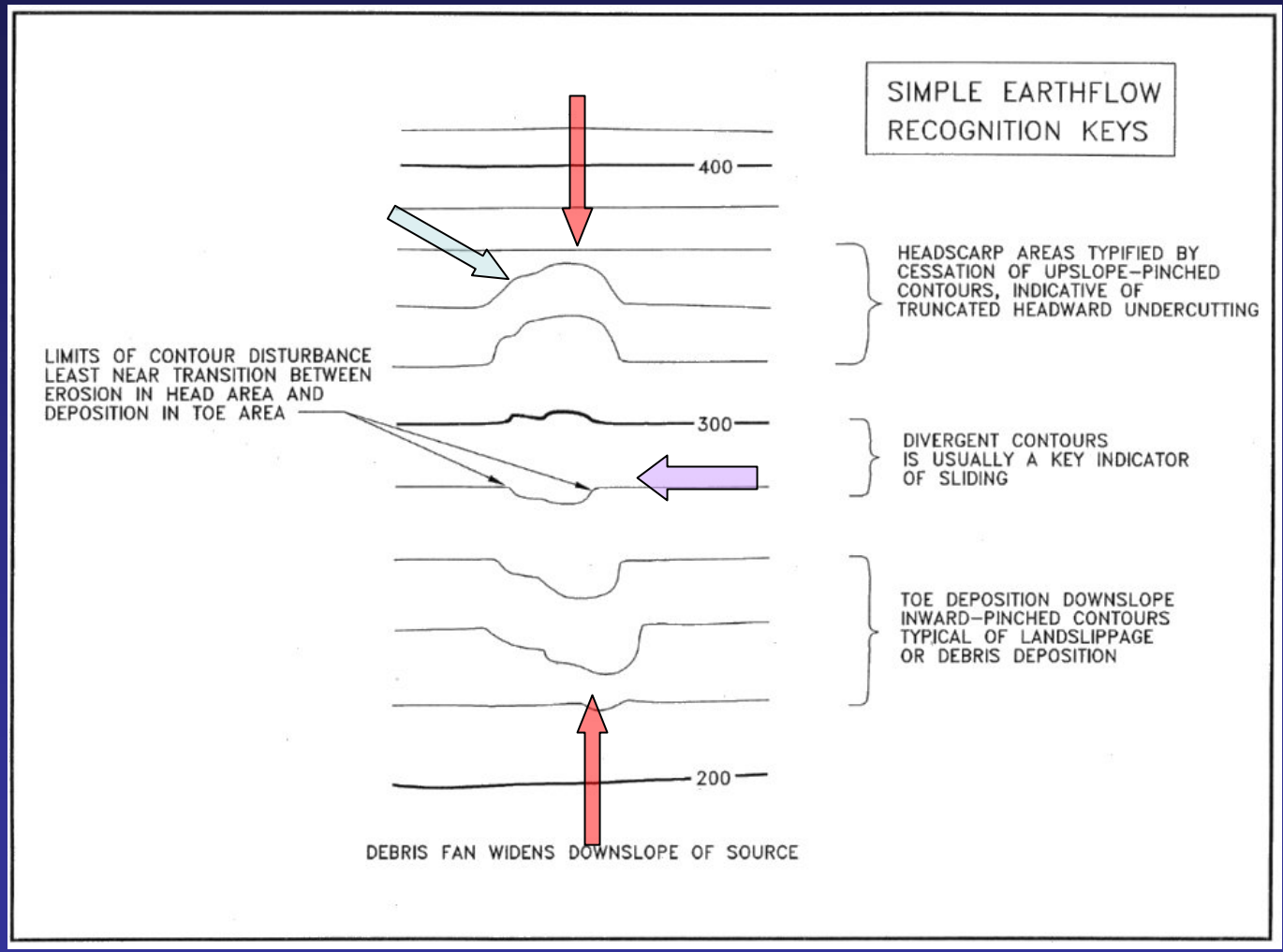
Cross-section of Jeffersonville lateral spread



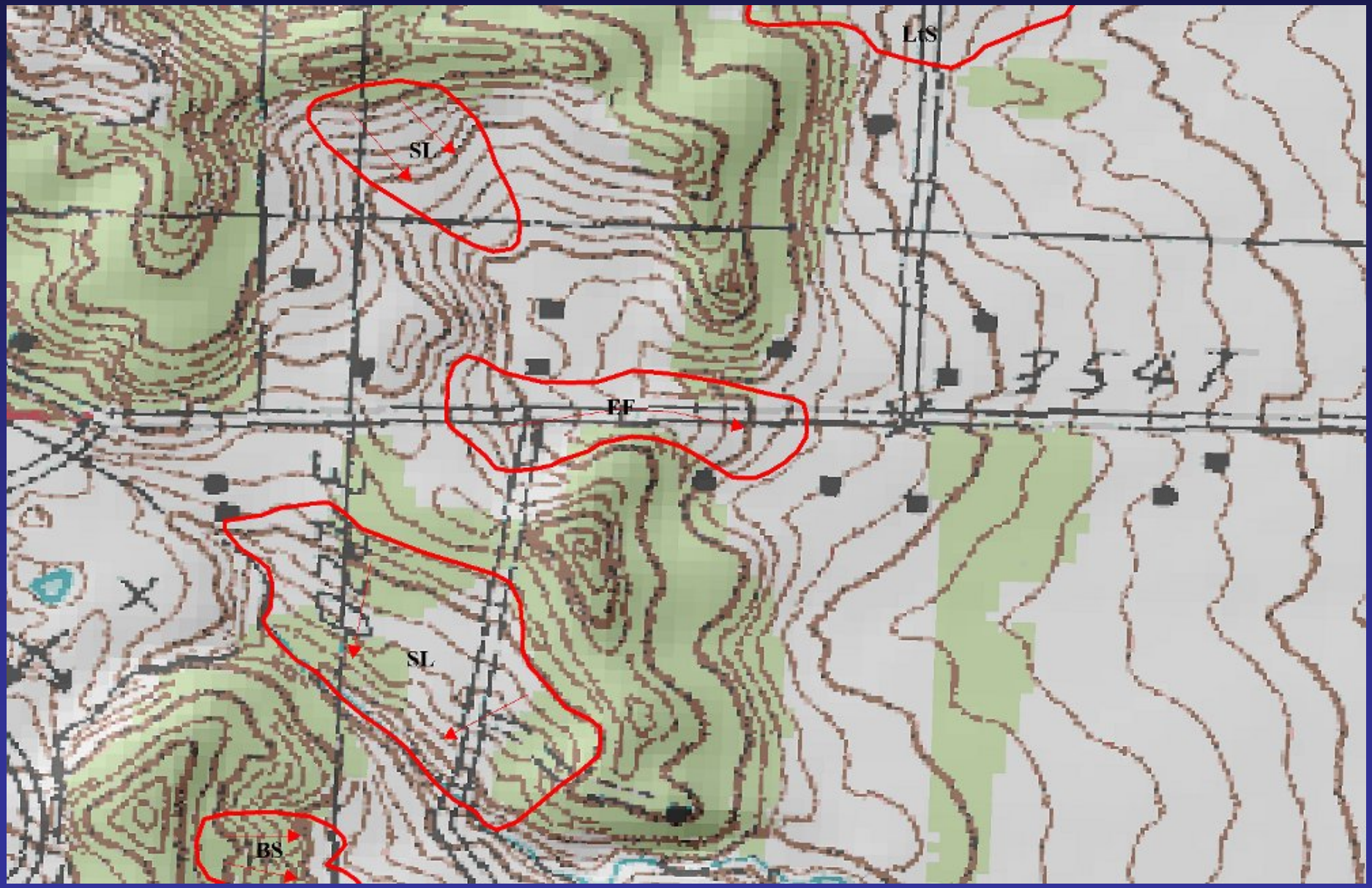
Topographic Expression of Earthflows

Topographic Expression of Earthflows

- Opposing contours
- Headscarp evacuation areas
- Necking down at transition between deflation/ inflation zones

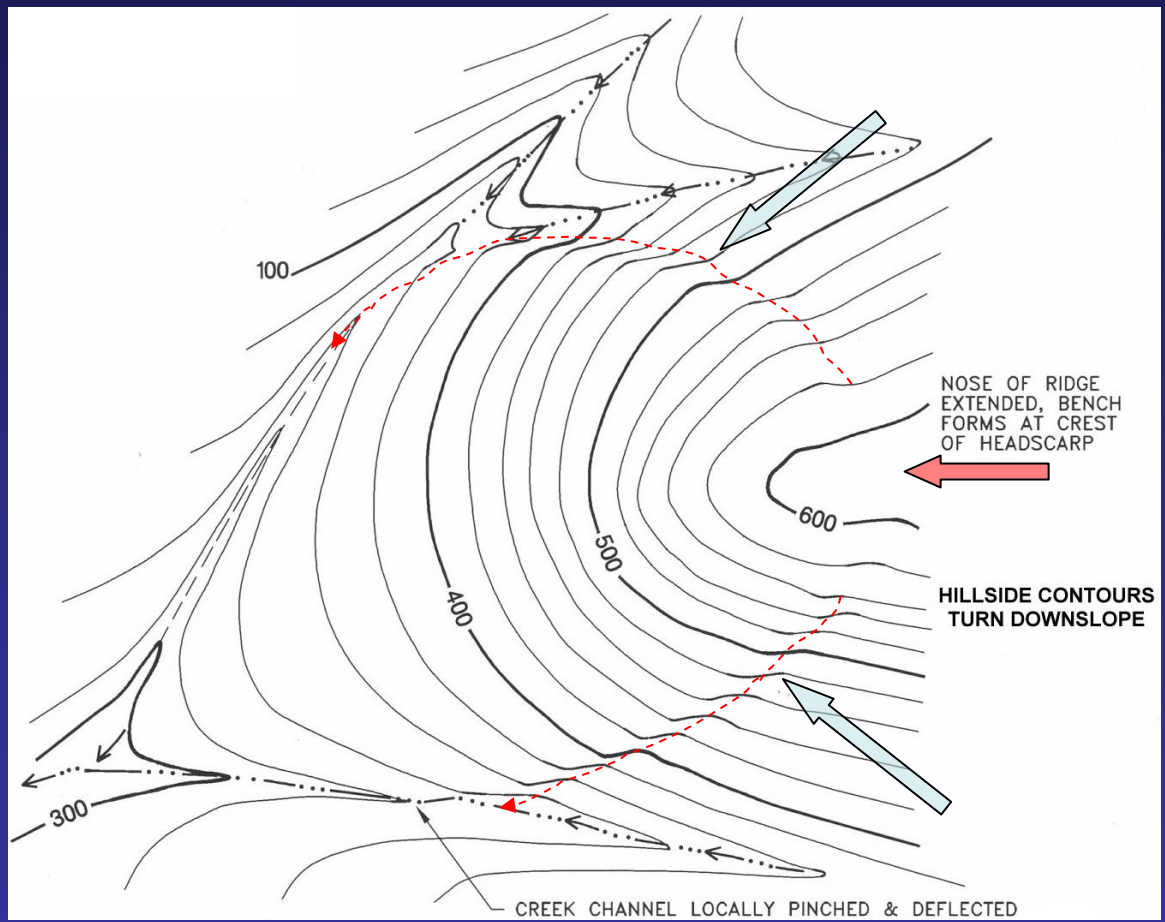


Crowley's Ridge Earthflows

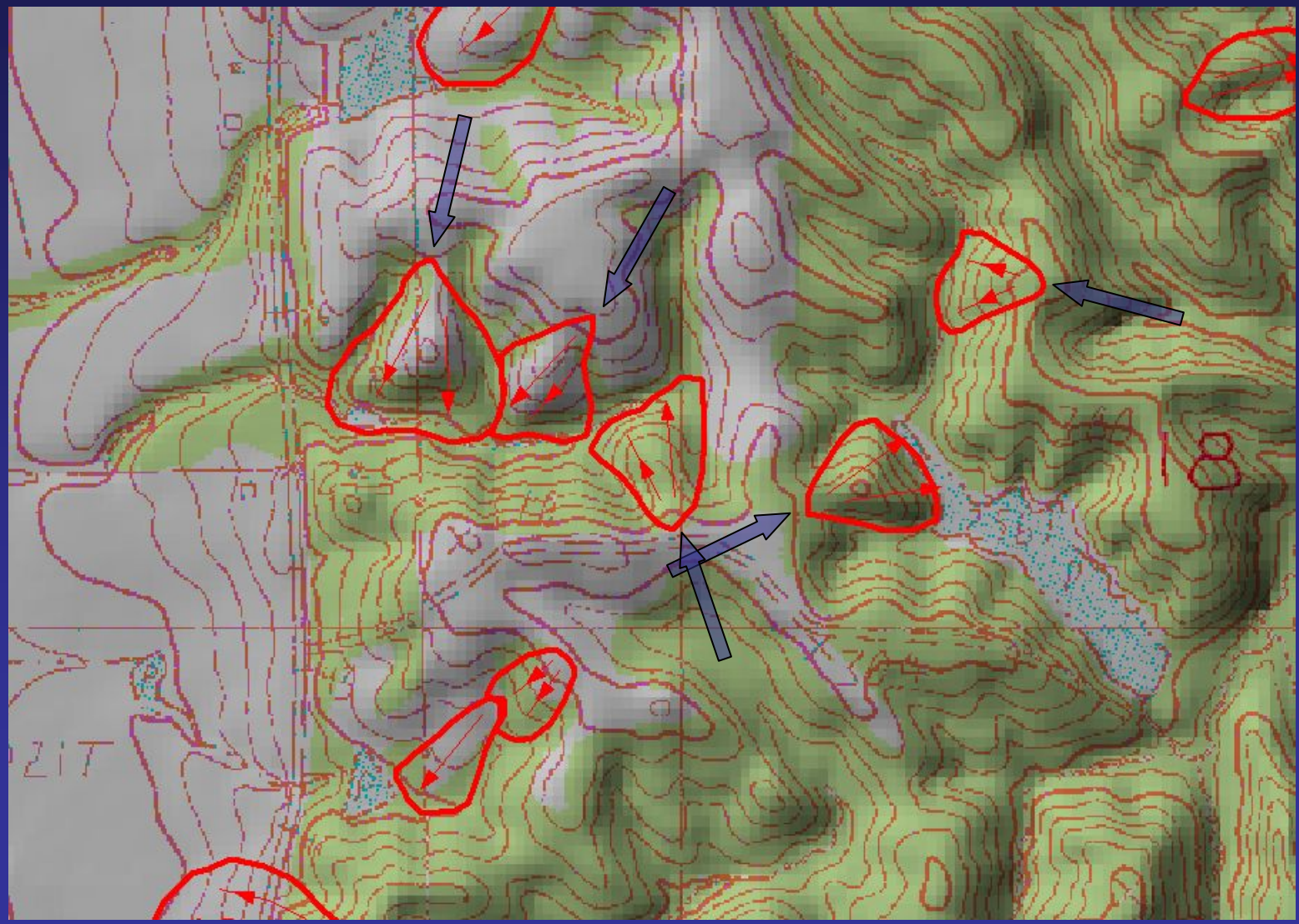


Topographic Expression of Translational Block Slides

- Extended ridges or topographic knobs
- Convergent drainage
- Sharp downslope turns in contour lines

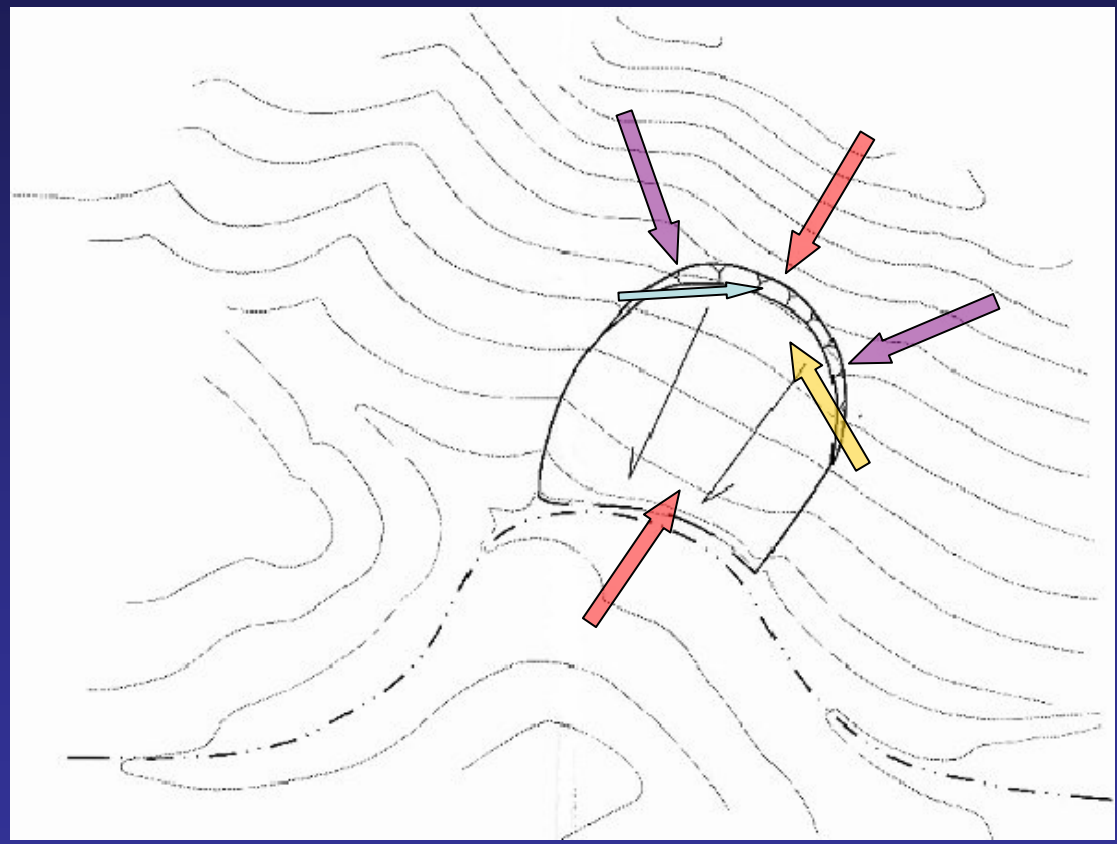


Crowley's Ridge Translational Block Slides

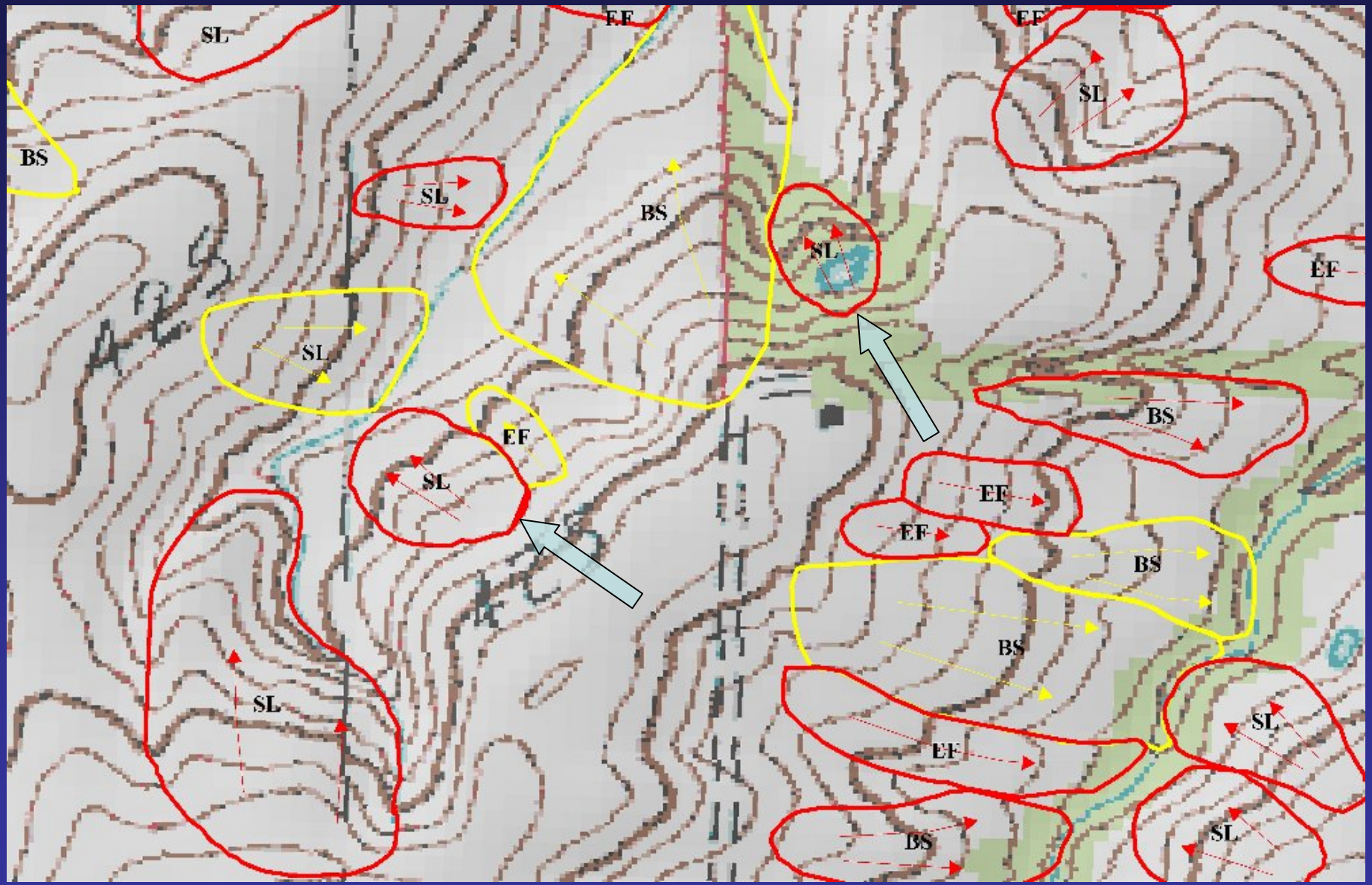


Topographic Expression of Slumps and Retrogressive Slump Complexes

- Asymmetric opposing contours
- Isolated breaks in contours
- Arcuate headscarps
- Back-rotated grabens and topographic benches



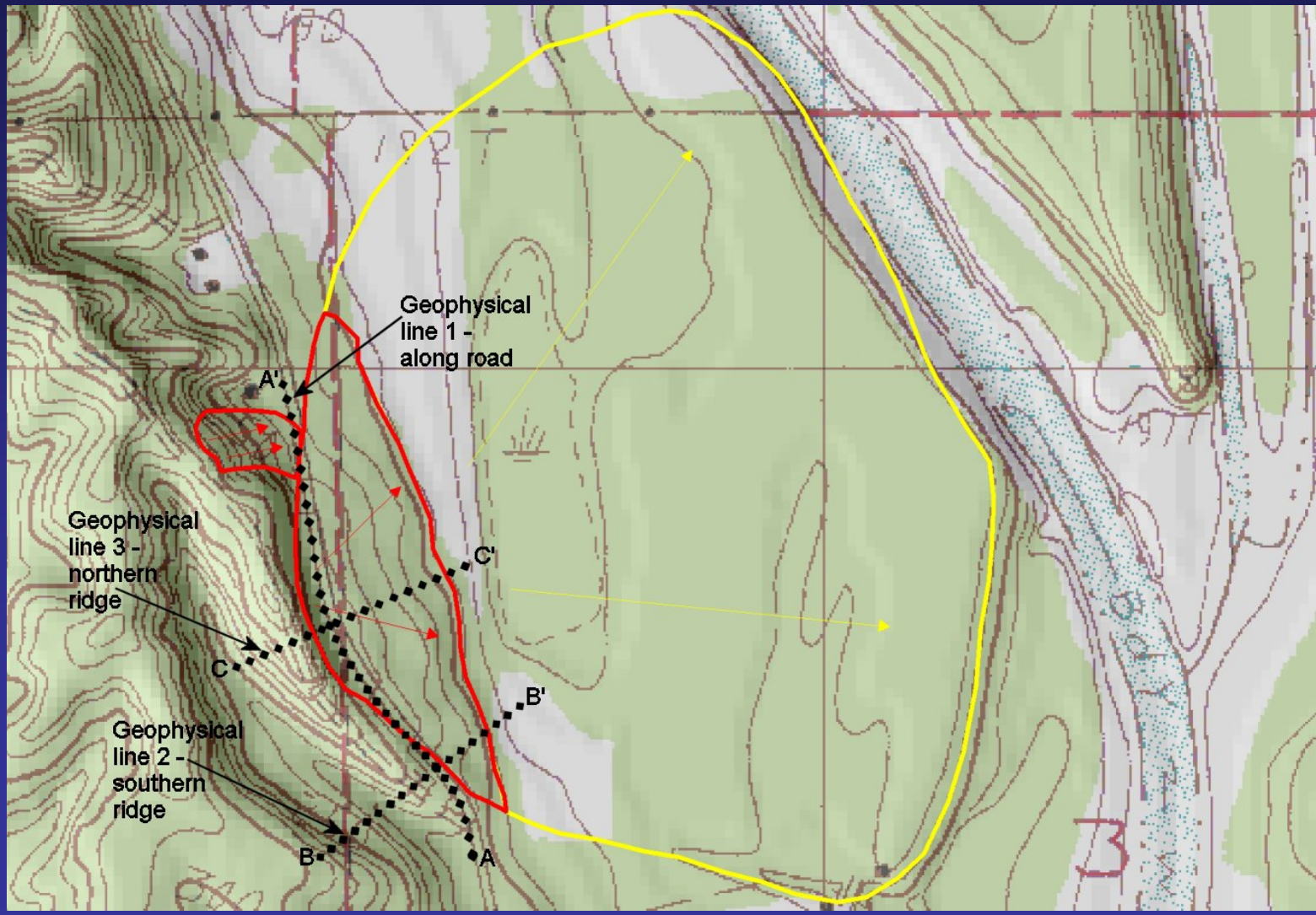
Crowley's Ridge Slumps



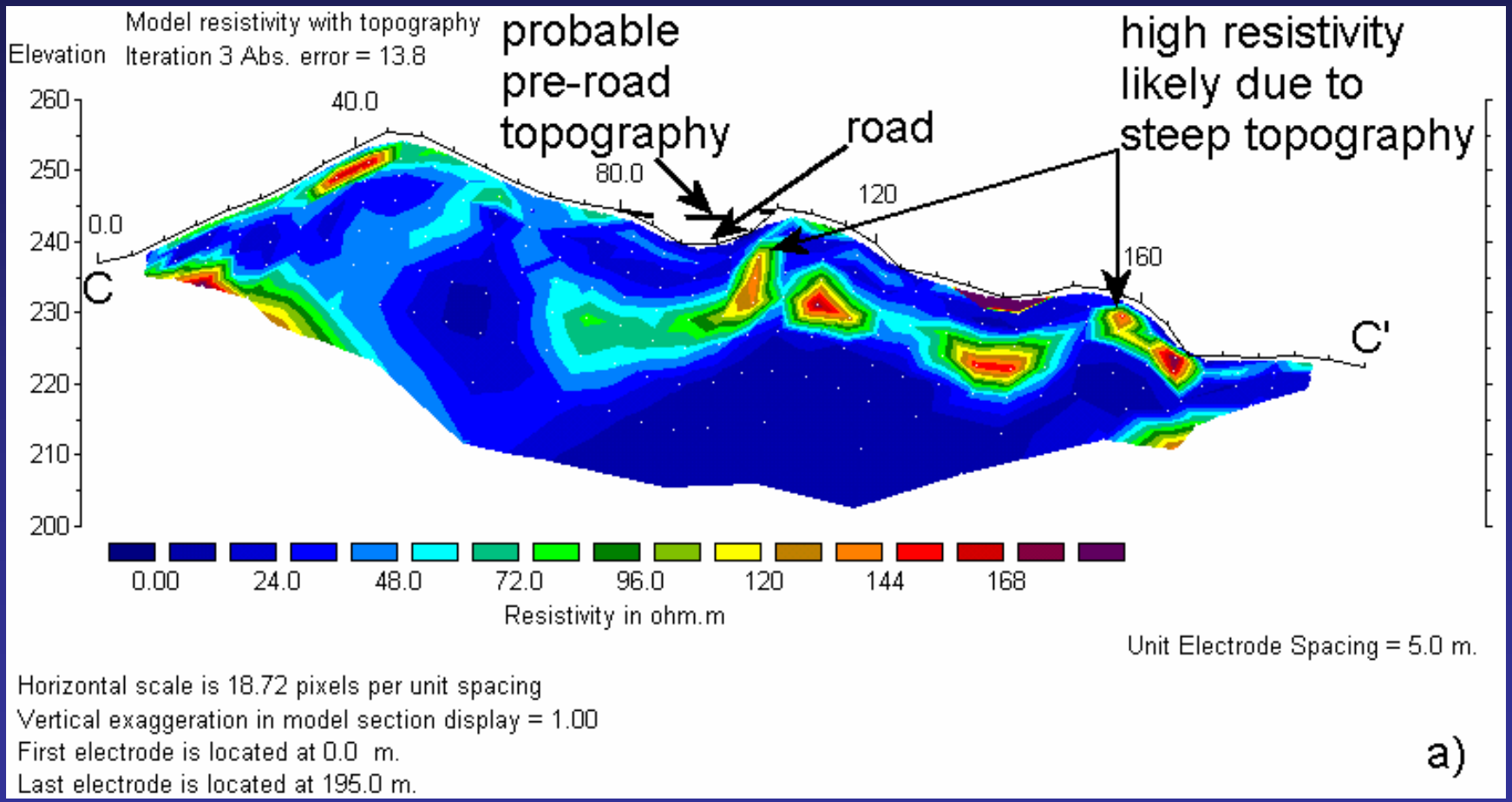
Field Work to Confirm Landslides

- Field reconnaissance
  - Hummocky topography
  - Head scarps
  - Deranged drainage
  - Graben structures
- Geophysics
  - Electrical Resistivity
  - Induced Polarization

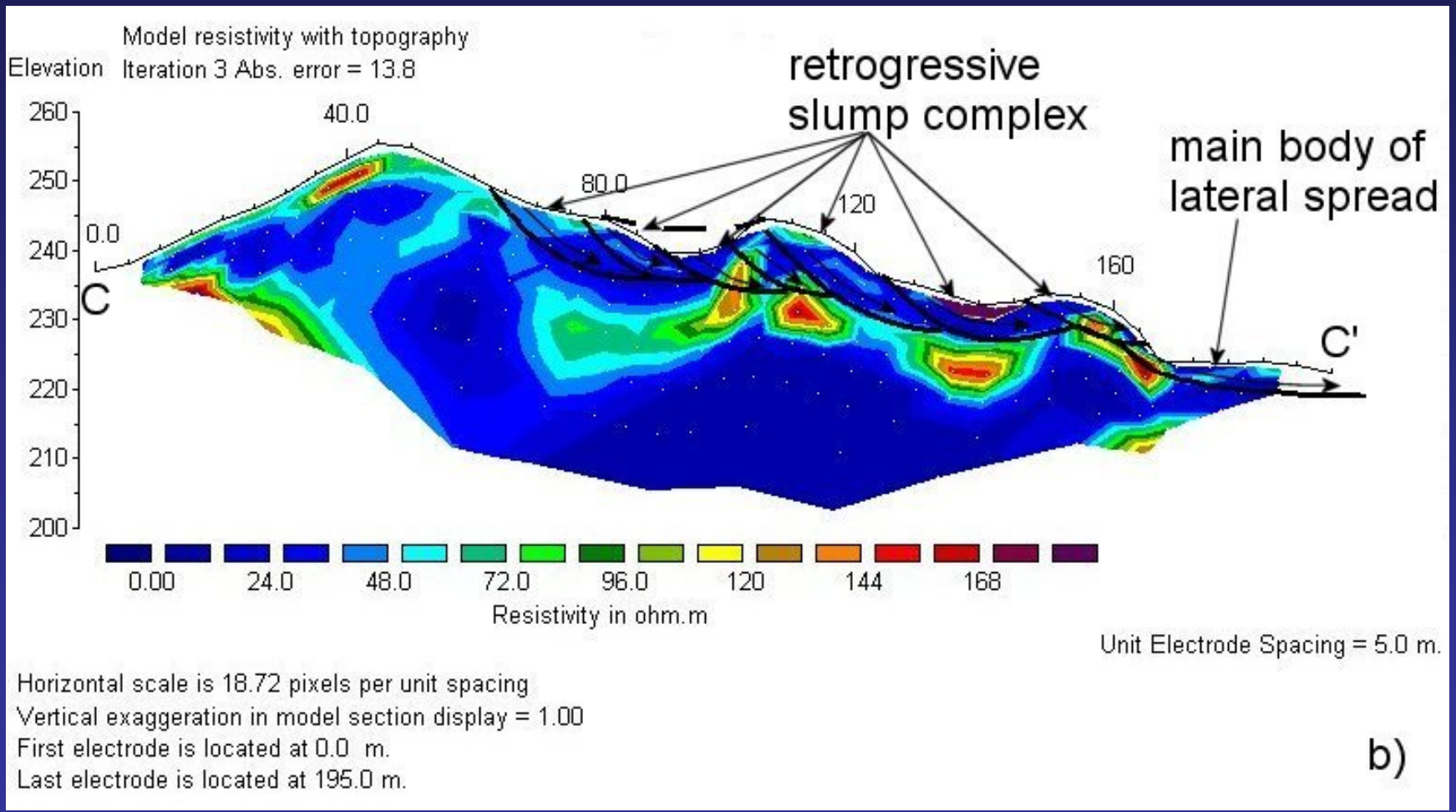
Geophysical Investigations



Geophysical investigations electrical resistivity



Geophysical investigations electrical resistivity



Conclusions

- Topographic patterns recognition has the potential to be useful for **rapid screening** of large areas.
- Most landslides found are likely related to the 1811-1812 New Madrid earthquakes.
- **Lateral spreads**, not previously mapped in the NMSZ, have the potential to cause disruption and damage to engineered structures over large areas.

Future Work

- Further geophysical investigations
  - Seismic reflection/refraction
  - Ground Penetrating Radar
- Computer-Based Topographic Algorithms
- “Bare-earth” mapping methods
  - LiDAR
  - INSAR (Band-C)
  - SAR (Band-P and Band-X)

Acknowledgements

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