

BACKGROUND AND MOTIVATION

- Due to the thick sedimentary cover and limited outcrops in Oklahoma, the pattern, properties and structural styles of basement-rooted faults in Oklahoma are practically unknown

Why Should We Care?

- Presence of basement-rooted faults in the sedimentary cover can directly impact drilling cost through 1.) Lost circulation into open/permeable faults 2.) Seismogenic fault reactivation
- Basement-related sedimentary deformation can form structural traps and fracture clusters in reservoirs
- Occurrence of basement-sourced hydrothermal fluid alteration within producing reservoirs of the Mississippi Lime, Oklahoma
- Knowledge of basement structure is required for basin modelling, especially in frontier basins

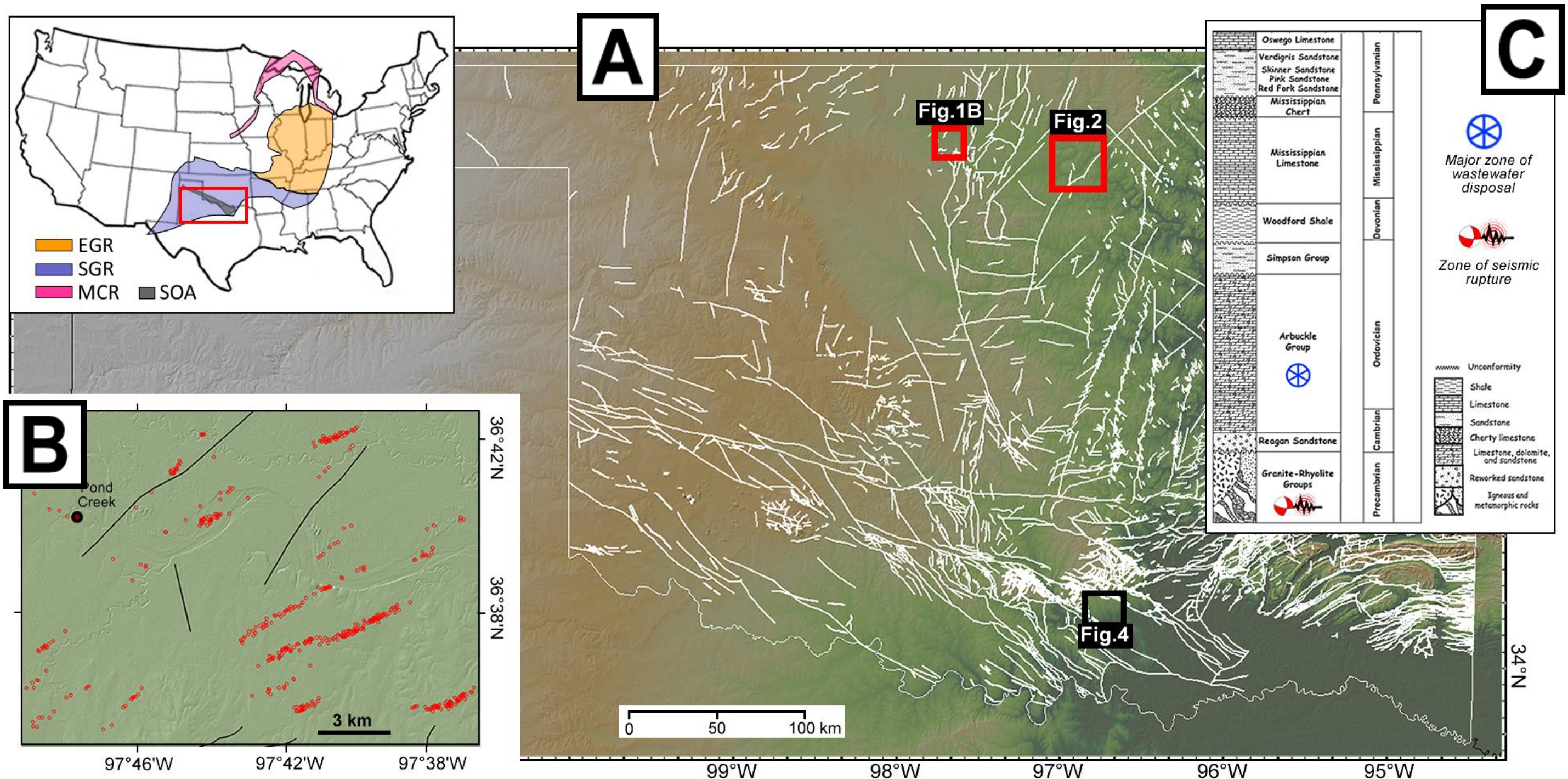


Figure 1: A) Fault map of Oklahoma overlaid with earthquakes (source: Oklahoma Geological Survey). *Inset:* Map of Precambrian Terranes in the US (after Bickford et al., 2015). B) Map shows recently active faults (red circles). C) Stratigraphic column for north-central Oklahoma (after Elebiju et al., 2011).

Important Questions:

- What is the seismic-scale geometry & structure of Oklahoma's basement faults, and connection with the sedimentary cover?
- What is the outcrop/small-scale geometry & structure of these basement faults?

DATA AND METHODOLOGY

Subsurface Faults in North-Central Oklahoma:

- 3-D seismic reflection data in Osage County (*courtesy: SpyGlass Energy*) (see Rectangle "Fig.2" in Fig.1A for location)
- Used structure oriented seismic attributes to resolve structural features, computed in AASPI software application

Active Faults in North-Central Oklahoma:

- This was done by tracing lineaments described by clusters of relocated 10,879 Mw \geq 1 epicenters (e.g., Fig. 1B)

Surface Basement Fault/Fracture Systems:

- Characterized satellite- and outcrop-scale fault/fracture systems in Precambrian basement outcrops ("Fig.4" in Fig.1A)

RESULTS AND DISCUSSION

Subsurface Faults in North-Central Oklahoma

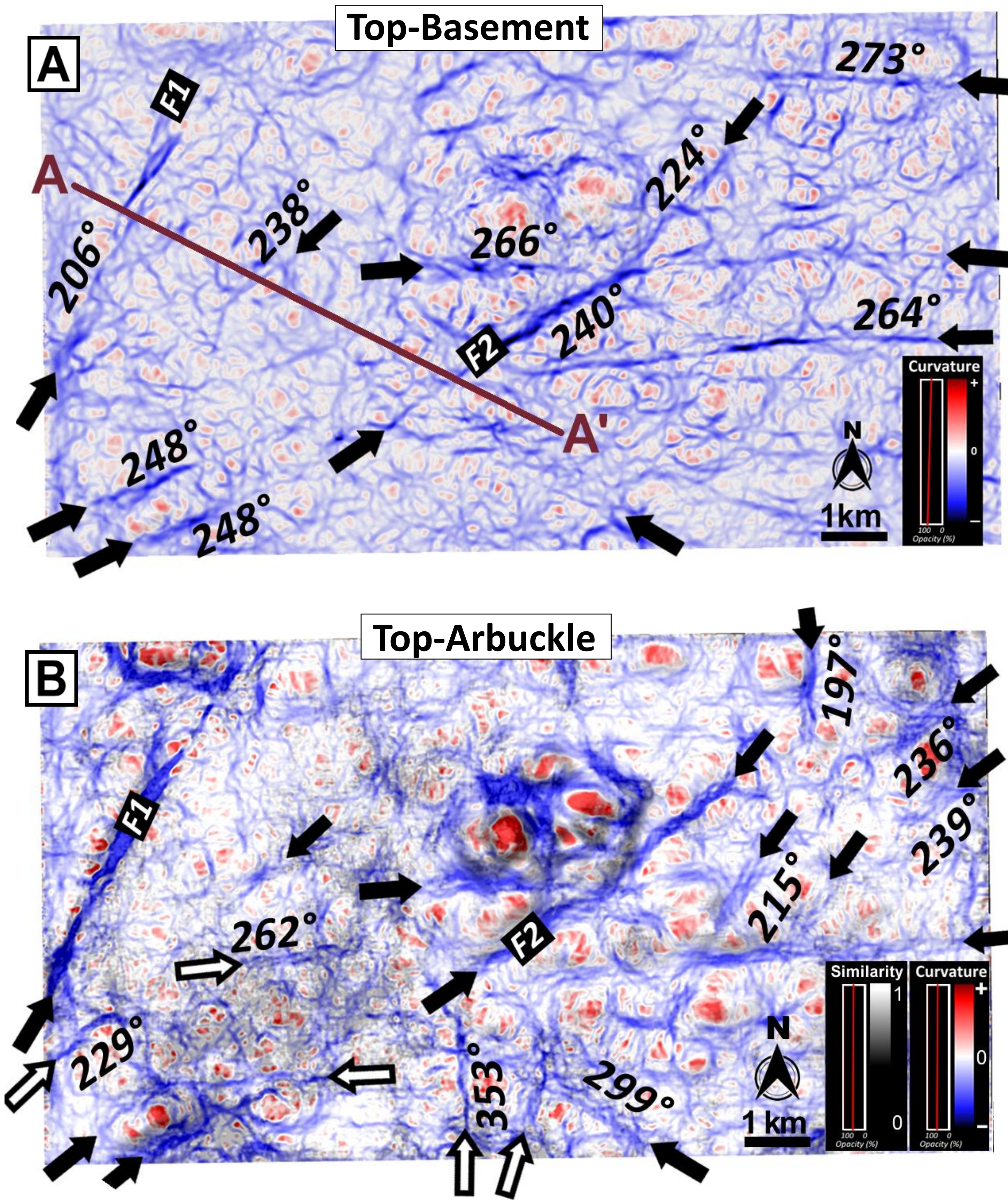


Figure 2: A) Top-Basement structure map co-rendered with most +ve and most -ve curvature attributes. B) Top-Arbuckle structure map co-rendered with most +ve, most -ve curvatures and Energy Ratio Sim. attributes. *Black arrows* = lineaments on both 2A and 2B, interpreted as faults. *White arrows* = lineaments only on 2B.

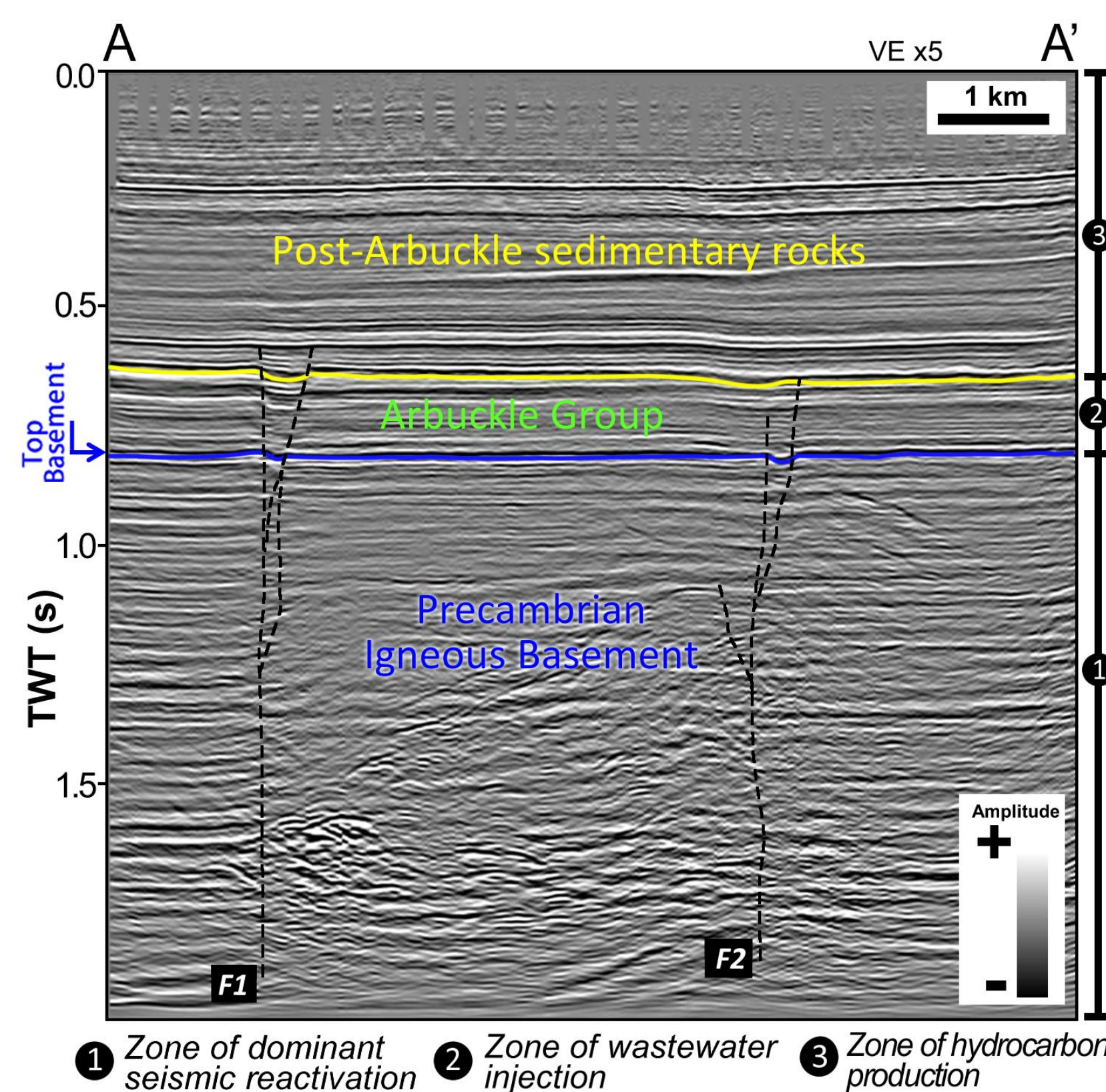
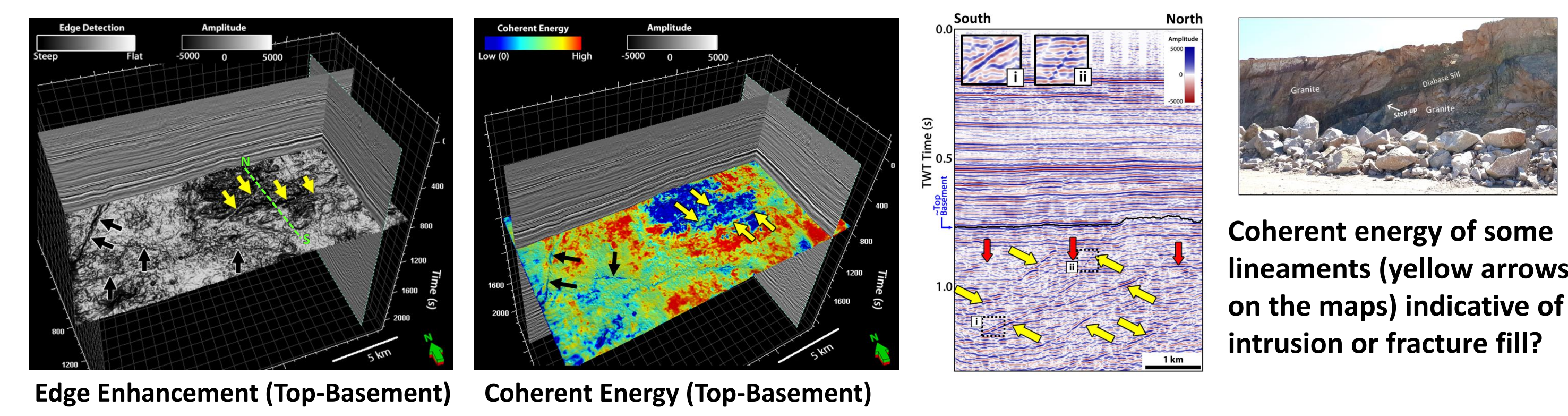


Figure 3: Cross-section A-A' (in 2A) overlaid with interpretations. F1 and F2 are sub-vertical through-going faults with flower structures. The faults cut Top-Basement, Top-Arbuckle and shallower sedimentary units.



Surface Basement Fault/Fracture Systems

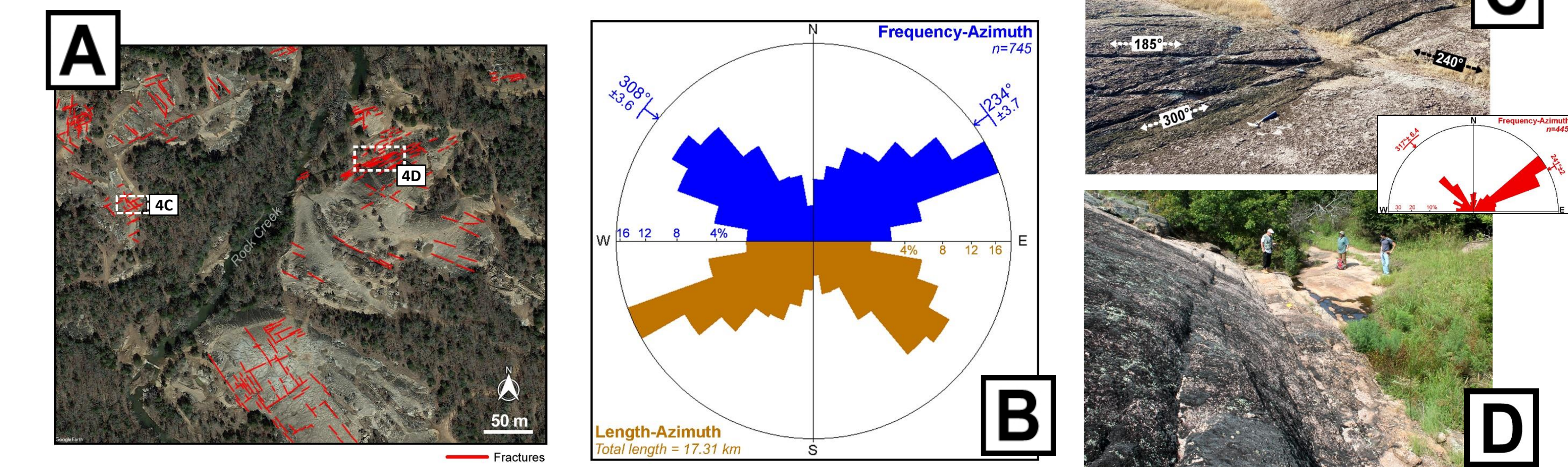


Figure 4: A) Satellite image of the exposed basement showing fractures (location in 1A). B) Rose diagram for the satellite-scale fractures. C) Intersections of the dominant fracture trends. *Inset:* Rose diagram of the outcrop fractures. D) 240° linear zone of fracture cluster, interpreted as strike-slip fault zone.

Synthesis: Pattern of Oklahoma Basement Faults

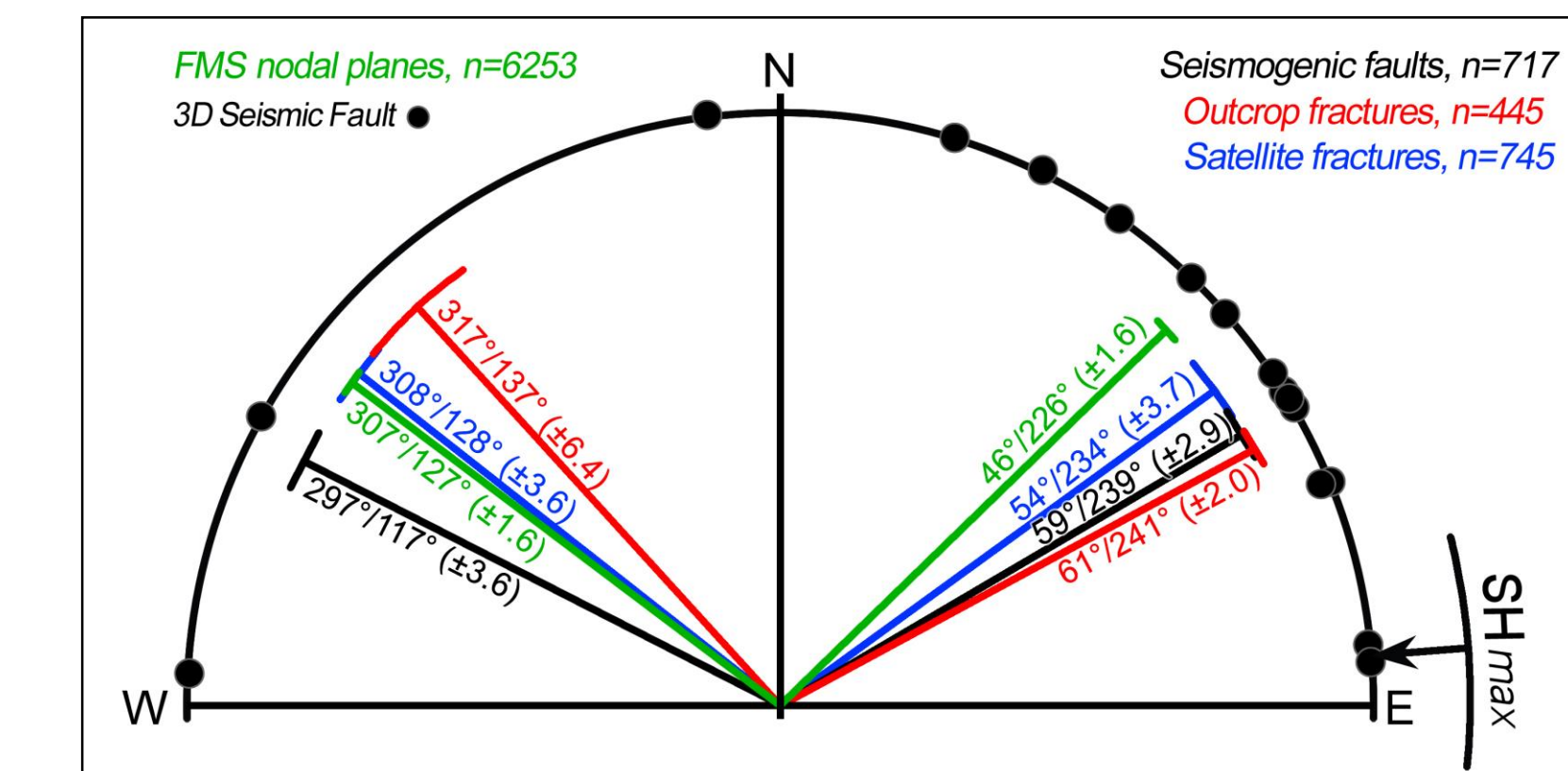


Figure 5: Overlays of structural trends of basement fractures/faults obtained through four independent methods, revealing a predominance of NW and NE structural fabric in the basement.

Outcrop/small-scale structure of the Basement Faults

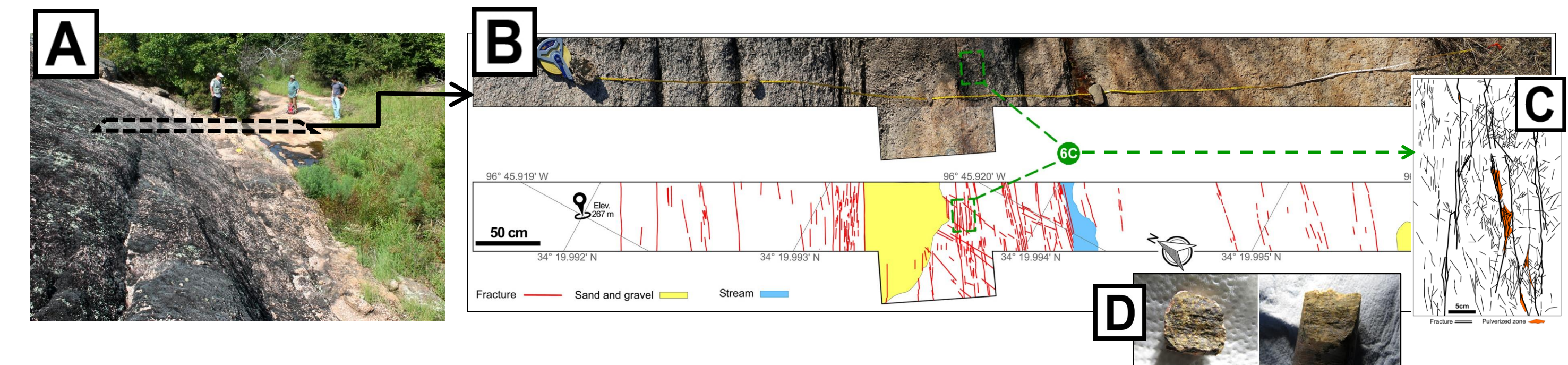


Figure 6: A) Precambrian basement outcrop in 4D, interpreted as strike-slip fault zone. B) Photograph of the fault zone with interpretations. C) Anastomosing fracture patterns with local zones of gouge-like structures at the core of the fault zone. D) Core samples of the fault zone showing horizontal slickenlines.

SUMMARY

- Basement-rooted faults in north-central OK are sub-vertical and connect with sedimentary sequences, defining potential pathways for vertical fluid migration
- Small-scale basement fault zone structure is characterized by linear fracture cluster with anastomosing pattern at the core
- Predominant NW and NE structural fabric in the OK basement

Future work: Analyses/characterization of the geophysical properties of basement fault damage zones (field experiments, 3D seismic attribute analyses etc.)