Basement-Driven Deformation of the Sedimentary Sequences, North-Central Oklahoma

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BACKGROUND AND MOTIVATION

- Structures rooted in the crystalline basement may control deformation of the overlying sedimentary sequences.
- Such basement-sedimentary structural coupling has important implications for fluid migration and drilling hazard avoidance, which impact the emplacement and exploitation of oil & gas resources.
- Due to the thick sedimentary cover and limited Precambrian outcrops in Oklahoma (Fig. 1A), the tectonic fabric and structures of the igneous basement are poorly understood.
- To optimize safe exploitation of oil & gas in the Anadarko Basin, OK, there is need to decipher the basement-related sedimentary deformation.

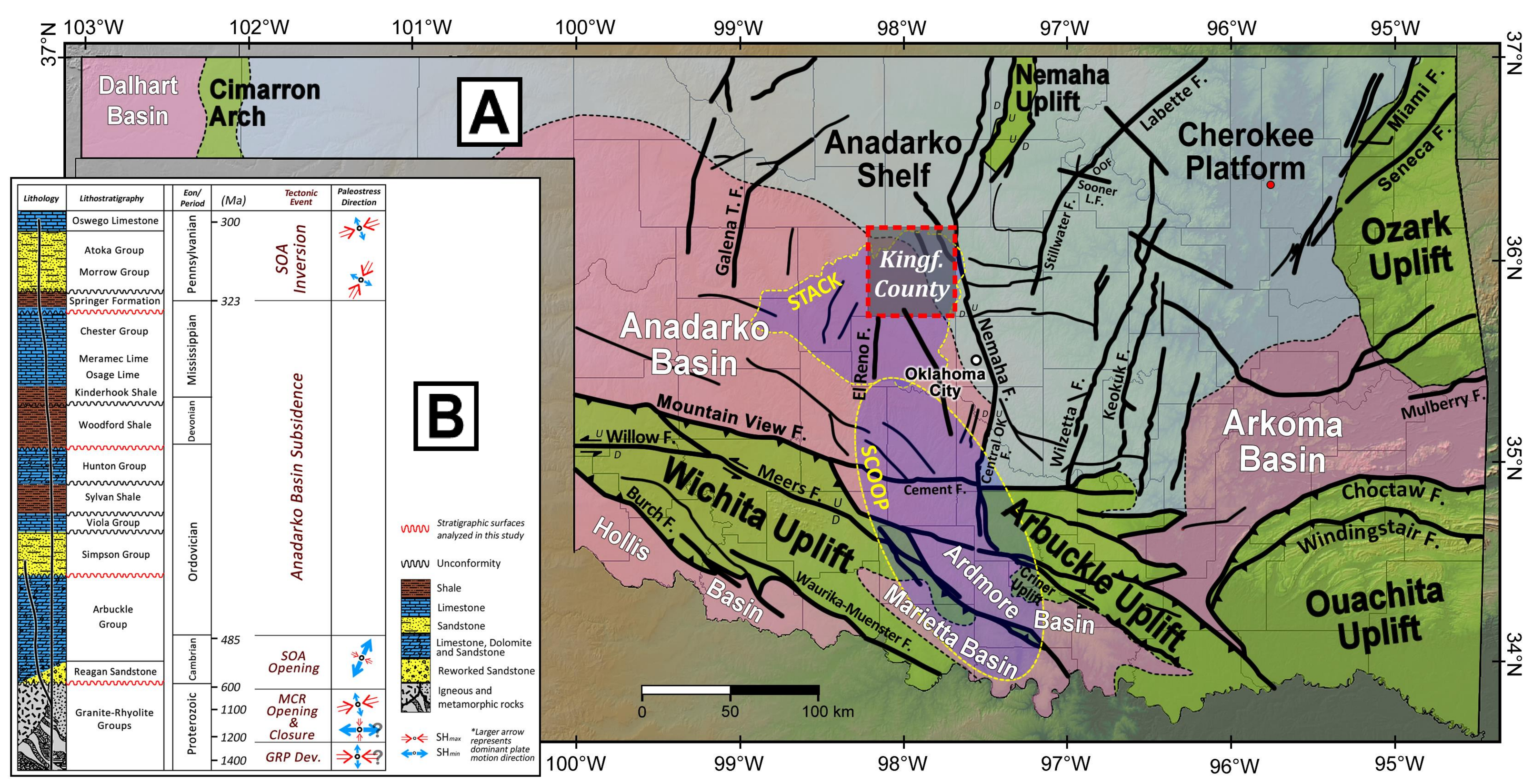


Figure 1: A) Map of Oklahoma showing the main geological provinces (after Northcutt and Campbell, 1995) and faults (after Marsh & Holland, 2016). **B)** Stratigraphic column of the Anadarko Basin, Oklahoma (after Elebiju et al., 2011).

Questions:

1.) What are the structures that define the intrabasement deformation in the Anadarko Shelf?

2.) How is this basement deformation propagated up into the overlying sedimentary sequences?

Approach:

Focus on the Kingfisher County part of the STACK Play (Fig. 1A) and use 3-D seismic data to analyze the subsurface structures.

DATA AND METHODOLOGY

3-D Seismic Reflection Data and Geometric Seismic Attributes

- 824 km² 3-D post-stack time-migrated seismic reflection data in Kingfisher Co., *red box in Fig. 1A* (courtesy: TGS).
- 3-D seismic attributes (curvature and coherence) to resolve structures.

3D Distribution of Deformation along Through-Going Faults:

- Spatial distribution of vertical separation (Vsep) of 5 selected stratigraphy along the faults.
- Plotting Vsep (and its cumulative) vs distance along-strike of the faults (Vsep-D).
- Plotting of Vsep versus depth along the large faults (Vsep-Z).

RESULTS AND DISCUSSION

Intrabasement Reflector and Associated Faulting

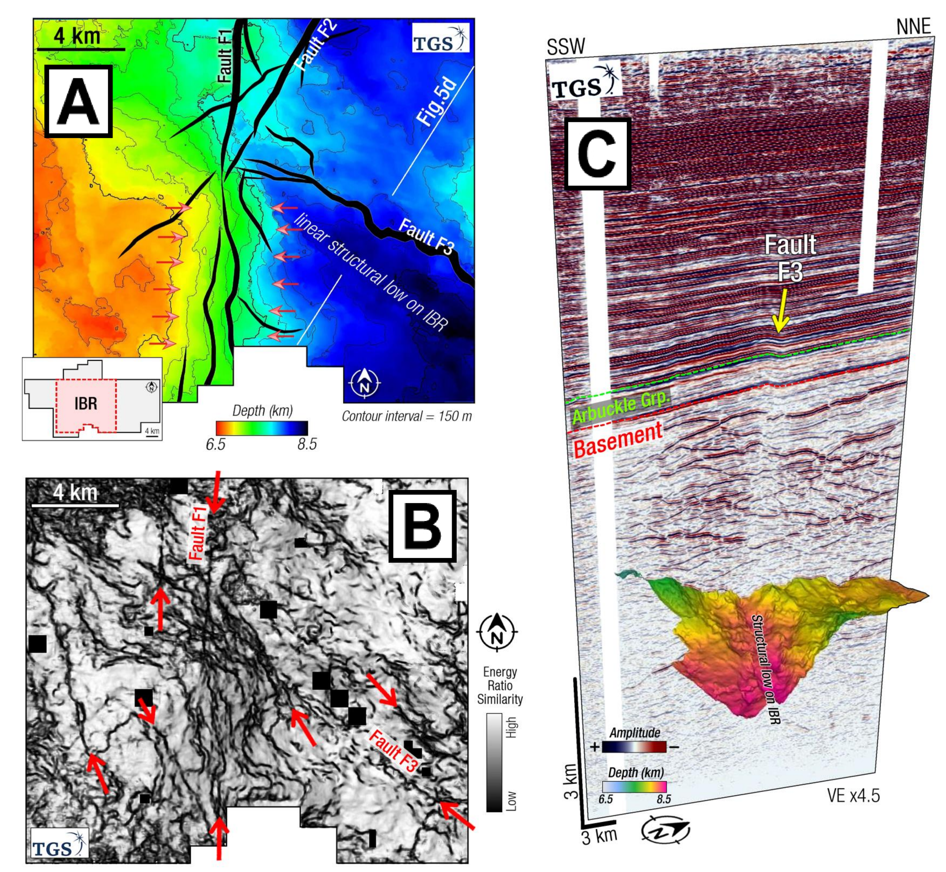


Figure 2: A) Structure map of a mapped extensive intrabasement reflector (IBR) in the seismic volume, overlaid with major Top-Basement faults. Red arrows = major N-S topographic gradient on IBR which coincide with Fault F1. **B)** Coherence attribute extracted on IBR. Red arrows = major faults. **C)** Seismic section across the volume with IBR structure map. ******Wireline and geochemical data suggest the IBRs are mafic sills (Kolawole et al., 2019; AAPG Expl).*

Faulting at Top-Basement and Top-Arbuckle

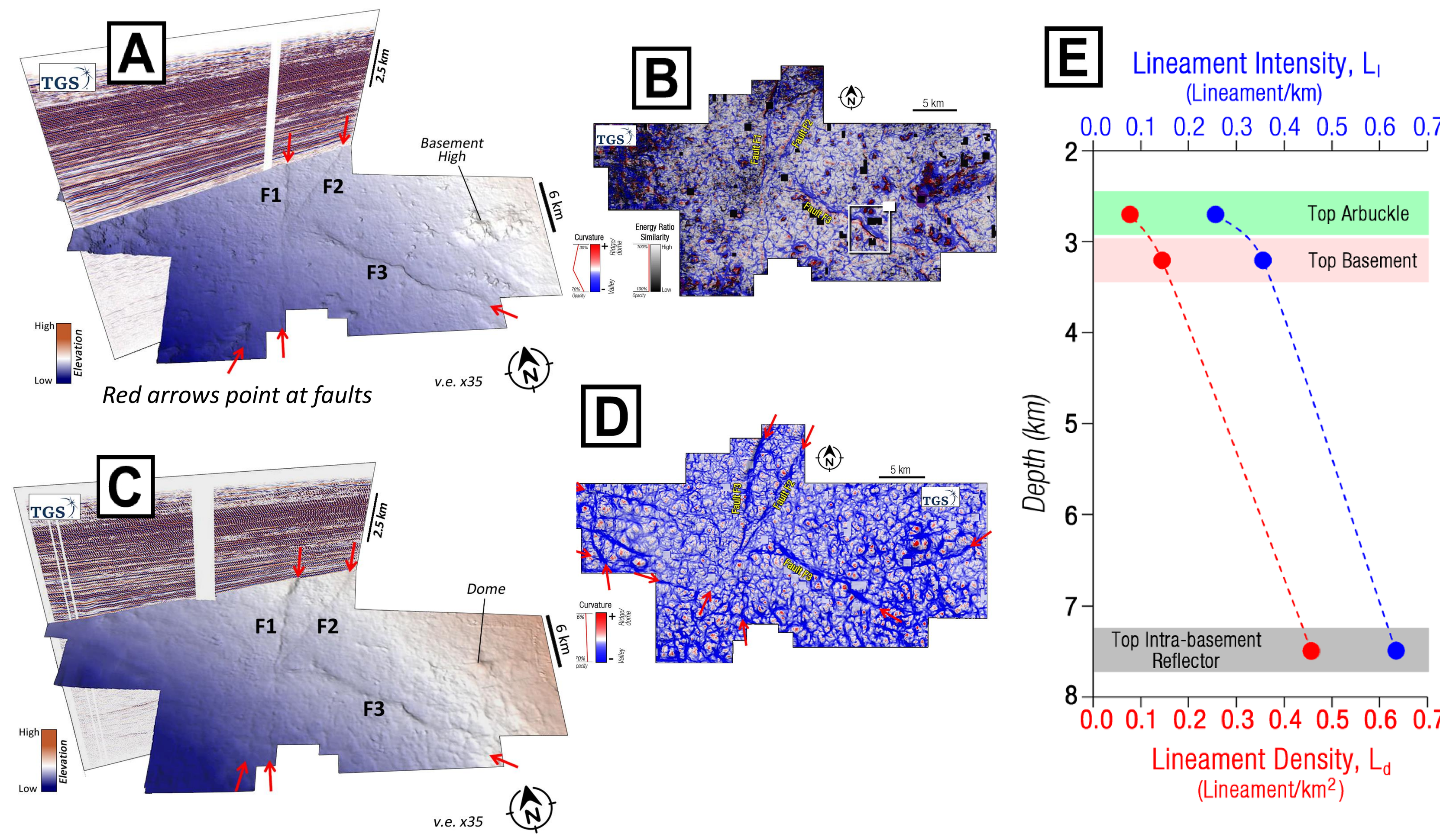


Figure 3: A) Top-Basement surface map showing the major (>10 km-long) faults F1, F2, & F3. **B)** Co-rendering of Fig. 3A with coherence and curvature attributes. **C)** Top-Arbuckle surface map showing faults F1, F2 & F3. **D)** Co-rendering of Fig. 3C with curvature attributes. **E)** Distribution of discontinuity lineaments at the Top-Arbuckle, Top-Basement and Top-Intrabasement Reflector surfaces.

Vertical Propagation Styles of the Basement-Rooted Faults

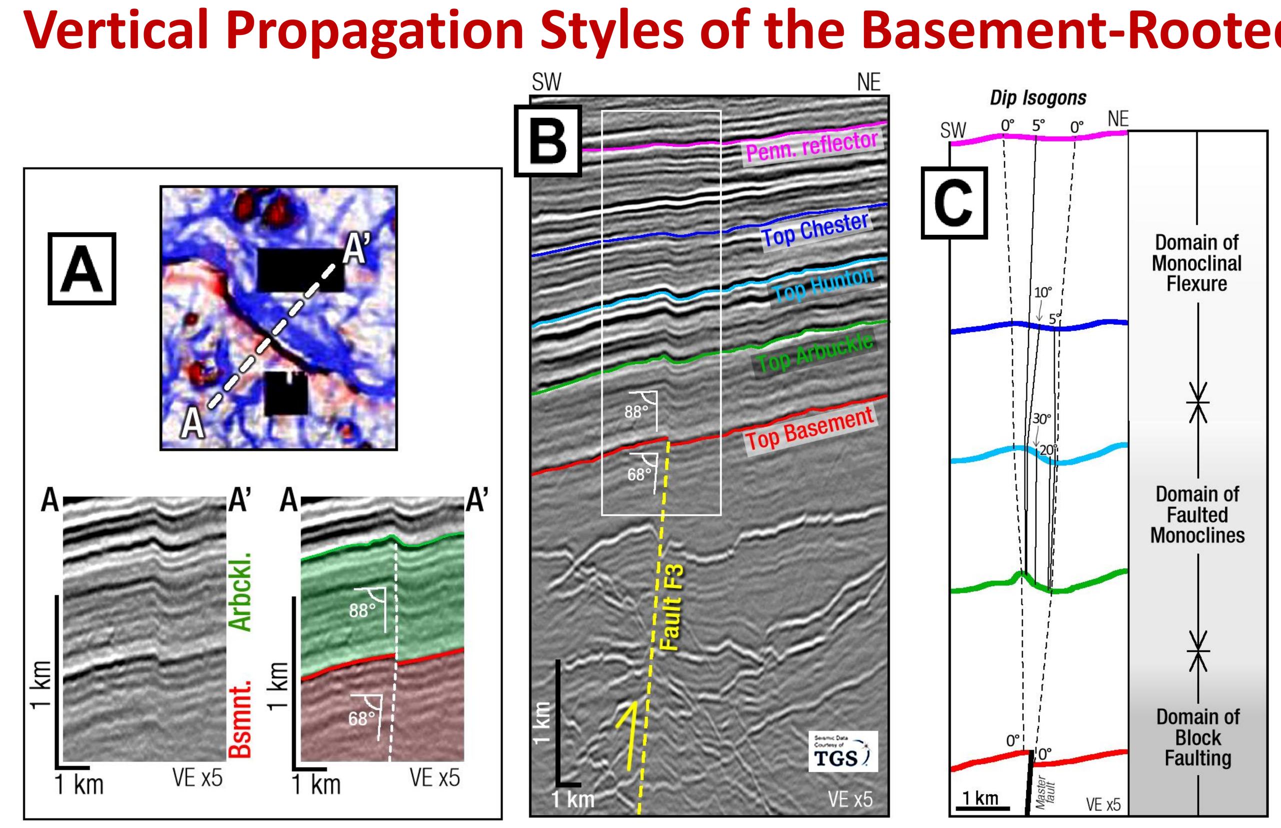
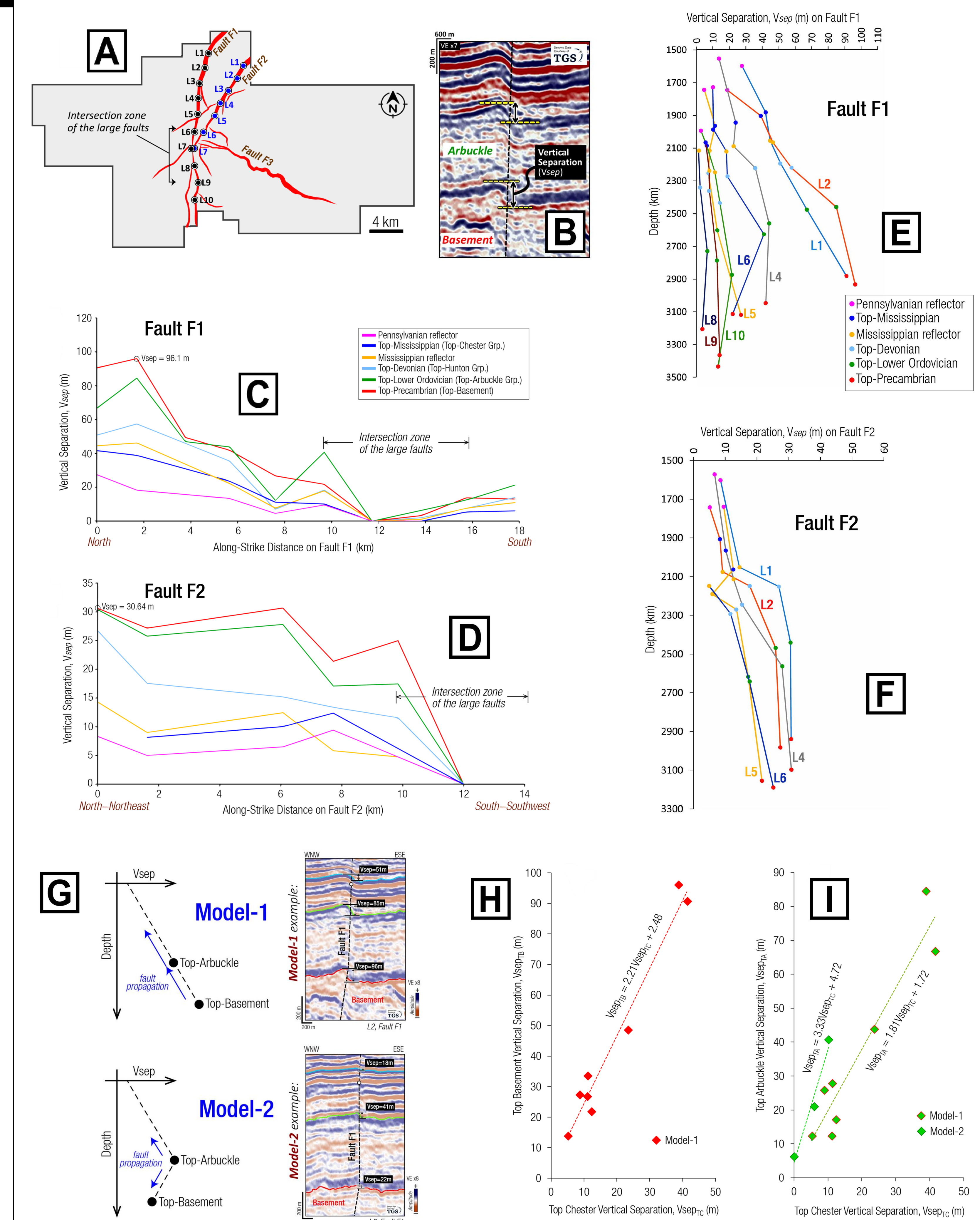


Figure 4: A) Map & sections showing a change in reflector geometry from the Top-Basement into the cover. **B-C)** Section and dip isogons showing vertical changes in the fault propagation style.

Models of Fault Propagation along the Basement-Rooted Faults



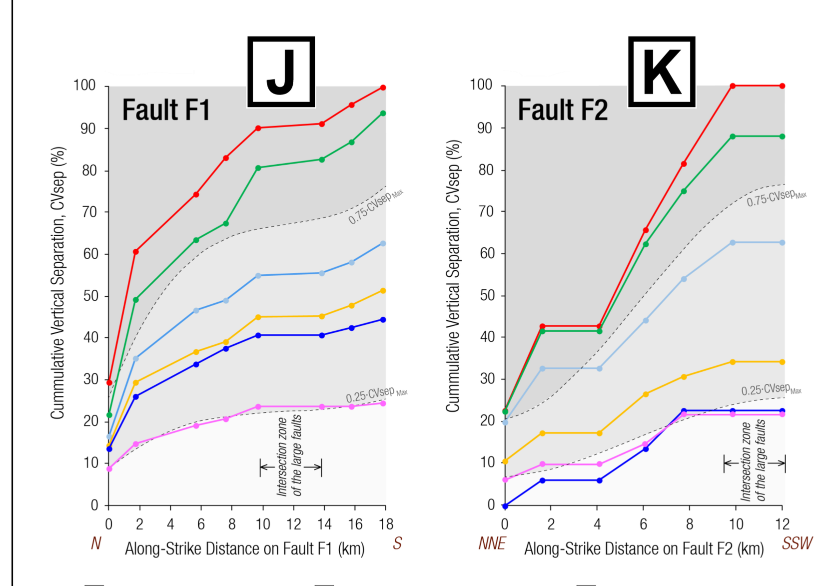


Figure 5: A) Measurement locations of Vsep, and **B)** Example of measurements. **C-D)** Vsep-D and **E-F)** Vsep-Z along F1 and F2. **G)** Observed models of Vsep-Z in Figs. 5E-F. **H-I)** Plots describing the relative efficiency of the models in propagating deformation up-section of the faults. **J-K)** Cumulative Vsep-D (CVsep-D) trends along the faults showing variation with offset accrual on the faults.

SUMMARY

- Faults and mafic sills define intrabasement deformation beneath the Anadarko Basin
- Basement fault deformation is propagated up over 3 structural styles: 1) ***basal faulted-block*** 2) ***middle faulted-monocline*** 3) ***upper monoclinal flexure***
- Basement driven fault propagation (**Model-1**) is more efficient than the intrasedimentary-driven fault nucleation and propagation (**Model-2**)
- Distribution of CVsep-D curves is useful for comparable analysis of contractional faults.