Flexures in the Anadarko Basin – Do they indicate faulting or folding?

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We would like to thank TGS for sharing with us the 3D survey

Location of data

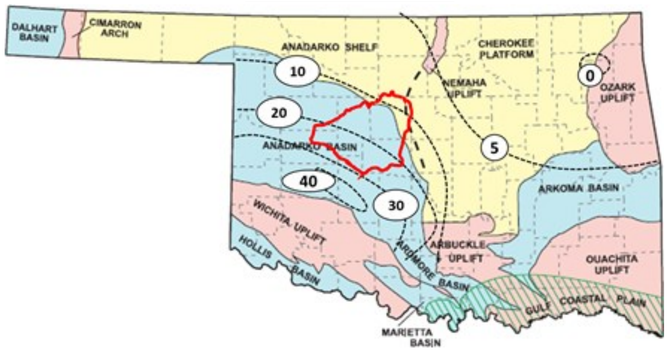


Figure 1. Map showing the location of the basins and structurally significant areas in Oklahoma. The contours shown by the black-dash line indicate the depth of the eroded top of the Precambrian and Cambrian Basement rocks in thousands of feet. The depth of the basement varies from ~1000 ft in the northeast to ~40,000 ft in the deepest part of the Anadarko Basin in the southwest. The red curve outlines the limits of the STACK play. (modified from Johnson, 2008).

Response on Coherence

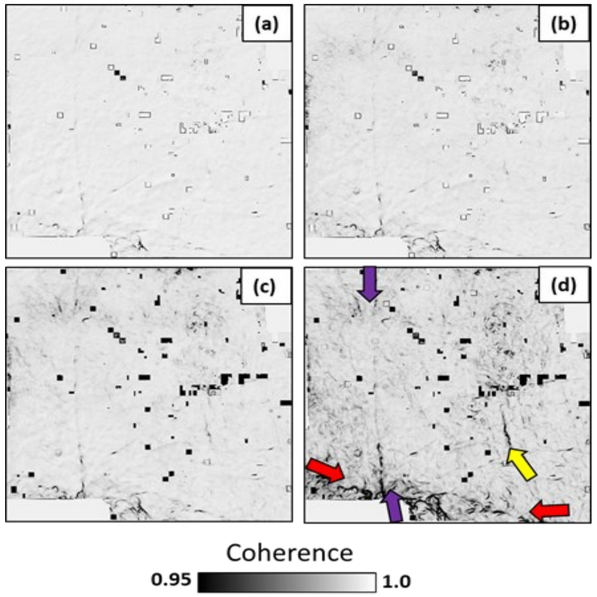


Figure 3. Horizon slices along the top Hunton through (a) broadband coherence volume computed on original seismic data volume, (b) broadband coherence volume computed on spectrally balanced data, (c) multispectral coherence volume computed on spectrally balanced data, and (d) multispectral coherence volume computed on spectrally balanced band pass data (30-55 Hz). Note that (d) provides better delineation of discontinuities than (c) and (b). Purple arrows indicate the El-Reno fault. Red arrows indicate east west trending faults and associated splays. Yellow arrow indicate strike slip fault.

Interpretation

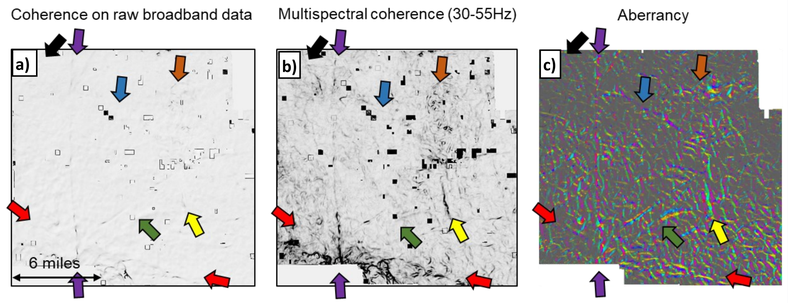
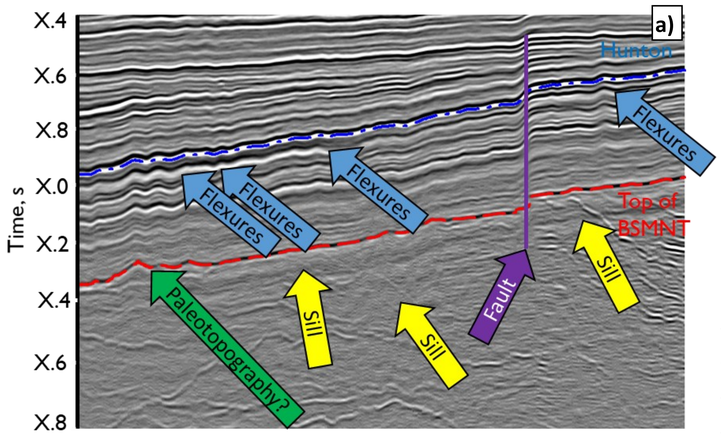


Figure 5. Proportional slice 40% above Hunton through a) broadband coherence, b) band limited (30-55Hz) multispectral coherence and, c) aberrancy. Broadband coherence do not delineate most of the structural features while, band limited multispectral coherence and aberrancy delineates NS El-Reno fault (purple arrows), E-W strike-slip fault with splays (red arrows), strike-slip fault (yellow arrows), structural lineaments (blue and green arrows), channel (black arrow) and, faulted oval structure (orange arrow).

Motivation



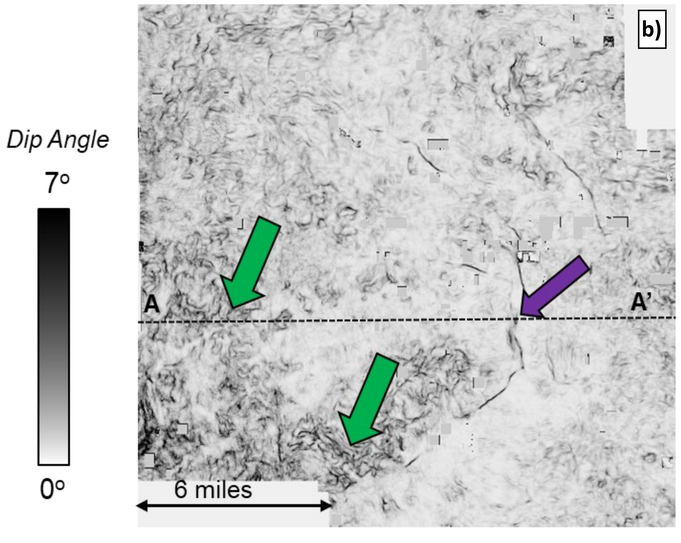


Figure 2. (a) Vertical section through the seismic amplitude volume showing sills (yellow arrows), fault (purple arrow), paleotopography (green arrow) and flexures (blue arrows). The sills and other basement structural features cause paleotopography on the top of the basement, which influences overlying sedimentary layers. Most of the faults cutting the top basement are strike slip faults which appear as flexure when they reach the Mississippian sedimentary layers. In the absence of well control, it is unclear if these flexures are folds or faults whose offset falls below seismic resolution. The top Hunton Limestone (HNTN) forms the base of the STACK play. (b) Dip magnitude computed from the top of the basement time-structure map. Purple arrows indicate faults that penetrate from basement into overlying sedimentary layers. Green arrows indicate paleotopography that gives rise to drape and differential compaction in the overlying layers. The faults, differential compaction and other folded features, all appear as flexures.

Aberrancy

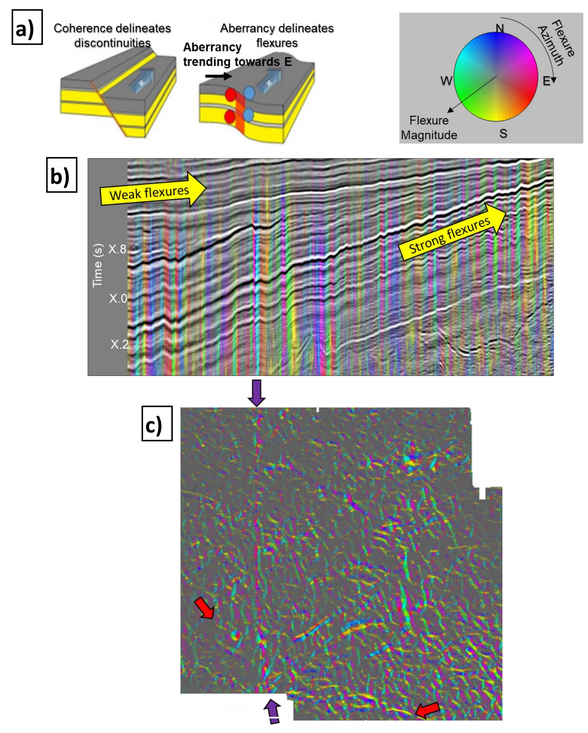


Figure 4. a) Cartoon showing difference between coherence, curvature and aberrancy. Coherence will image discontinuity in wavelet, curvature will image side lobes of the faults and aberrancy will image change in curvature whose maximum value will lie at the fault location. b) A amplitude cross section corendered with the magnitude and azimuth of aberrancy. Areas of strong flexures appear as bright colors while areas of weak flexures appear gray. c) Proportional slices through the magnitude and azimuth of aberrancy 40% above Hunton within Mississippian formation. Purple arrow indicate NS El-Reno fault and red arrows indicate east west trending faults and associated splays.

Earthquakes

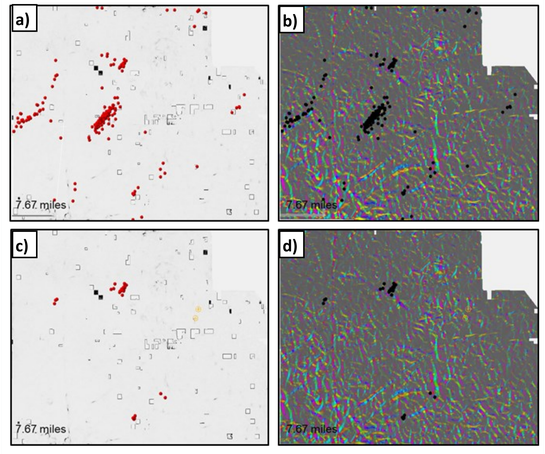


Figure 6. Proportional slice 40% above Hunton through a) and c) broadband coherence, b) and d) aberrancy. a) and b) shows that the earthquakes (red and black dots) occurred in Oklahoma are associated with structural lineaments delineated by aberrancy. c) and d) shows earthquakes caused by hydraulic fracturing .

Conclusion

Though there is significant offset of faults at the top basement and as shallow as the Hunton, by the time this deformation reaches the Mississippian, almost all these deeper faults appear as cross-cutting flexures. In mapping these discontinuities, bandlimited (30-55Hz) multispectral coherence provide better results than multispectral or conventional coherence. Aberrancy provides a means to map the intensity and orientations of these flexures. Earthquakes appears to occur near the flexures and faults delineated by aberrancy.