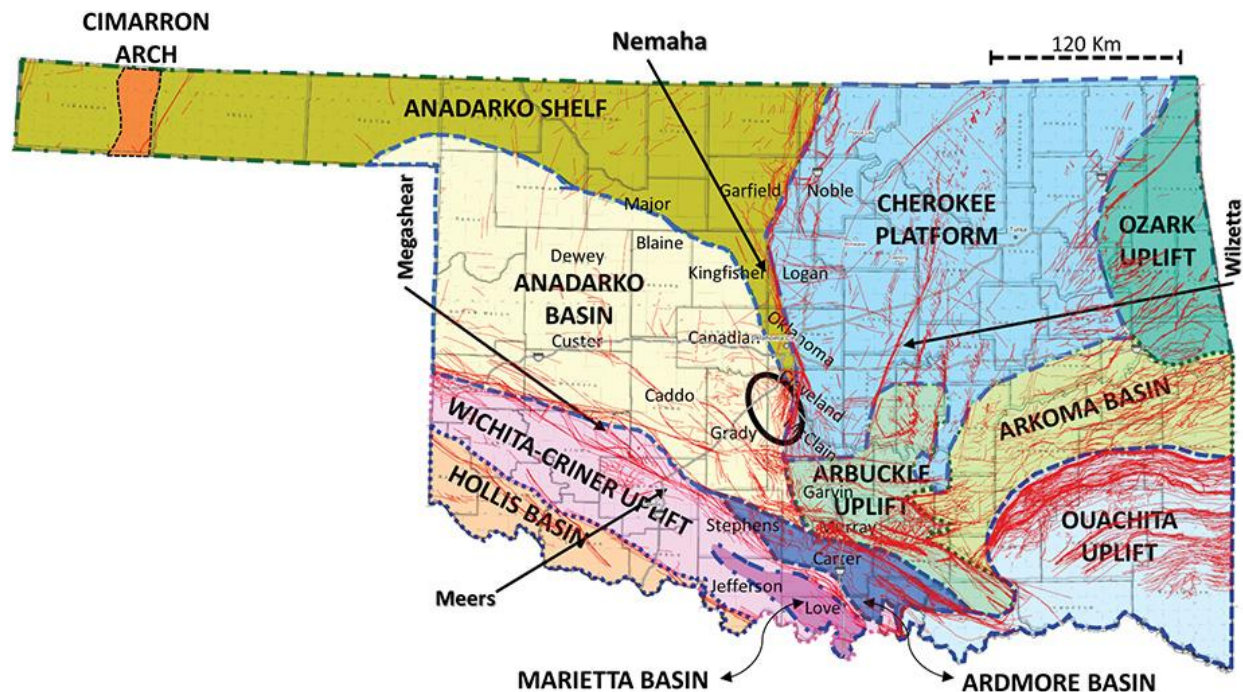




Nemaha Strike-Slip Fault Expression on 3-D Seismic Data in SCOOP Trend

June 2018 | Satinder Chopra , Kurt Marfurt , Folarin Kolawole , Brett M. Carpenter

Fault interpretation is an important step in seismic structural interpretation and has a bearing on the quantitative interpretation that may eventually be carried out. This requires the meaningful recognition of the faults within the proper geological context of the area. In Oklahoma, we see wrench faulting with strike-slip faults and other associated features.

In the case of a strike-slip fault, the maximum and minimum principal stress directions are horizontal, and the intermediate stress is vertical. Large strike-slip faults are also called “wrench faults.” In many cases, branches and step overs might form with two or more through-going faults instead of one, and offset one another. This results in complicated fault patterns.

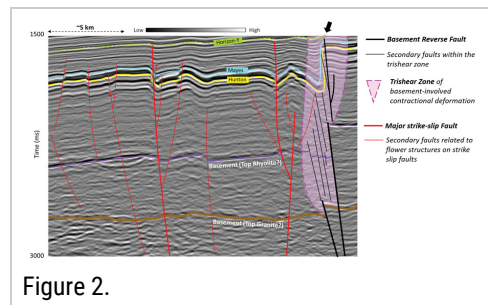


Figure 2.

Wrench faults are usually characterized by near vertical fault planes, along which the strike-slip motion takes place, and might produce positive and negative flower structures, in response to compressional and extensional driving forces respectively. Evidence of strike-slip movement along the fault plane usually manifests in additional fault and fracture patterns. A continental-scale zone of deformation produced by strike-slip movement is sometimes referred to as a megashear fault.

In the central and eastern United States, such faults typically root into igneous basement (about 1.5 billion years ago in Oklahoma). Displacement within the basement produces characteristic fault structures in the sediments above. Strike-slip movement and relatively low strains result in Riedel (R) faults as well as faults in the R' and, P orientations. Riedel fault segments will commonly get linked to P fault segments. Such combinations can give rise to an echelon fault patterns in the direct vicinity of the main fault or a zone of intense strike-slip deformation with complicated vertical offsets, i.e. positive and negative flower-type structures. Three prominent faults in Oklahoma are marked in figure 1. The Nemaha Fault, striking nearly north-south through the state is a wrench fault rooted in the deep crust (past the basement).

There are two thoughts on its formation, one is that it is related to the deep-rooted tip of the mid-continent rift; the other is that it could have formed due to a gentle counter-clockwise rotation of an intra-continental block lying between two bounding, left-lateral megashears, namely the Oklahoma megashear to the south (figure 1) and the Central Plains Megashear in Nebraska. It is perpendicular to the regional maximum horizontal principal stress (SHmax) orientation, which is a consistent 80-degree north/90-degree east orientation through much of Oklahoma, except in the southern part, where it deviates to approximately 50 degrees northeast. The Meers Fault is steeply dipping oblique-slip fault, which formed as part of the Wichita Uplift system. Finally, there is the Wilzetta fault, a long north-northeast trending strike-slip fault.

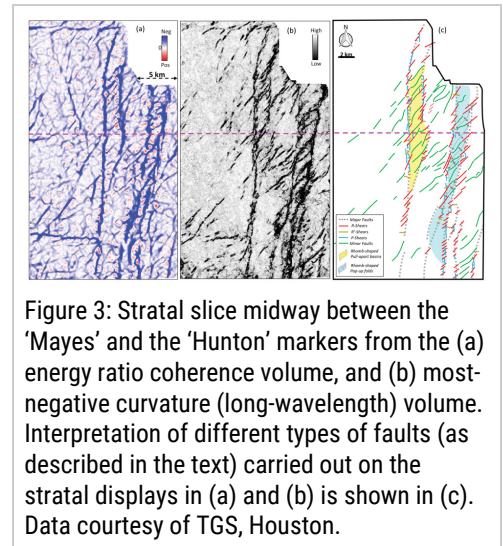


Figure 3: Stratal slice midway between the 'Mayes' and the 'Hunton' markers from the (a) energy ratio coherence volume, and (b) most-negative curvature (long-wavelength) volume. Interpretation of different types of faults (as described in the text) carried out on the stratal displays in (a) and (b) is shown in (c). Data courtesy of TGS, Houston.

Nemaha Fault Zone

The 400-mile-long Nemaha fault zone extends from southeastern Nebraska through northeastern Kansas and across Kansas and Oklahoma and terminates in central Oklahoma.

As wrench faults form because of a horizontal shear couple, which in this case is likely basement rooted, compressional and tensional forces are generated in the overlying sediments. Such forces may provide additional signatures, such as en echelon faults and fractures that could be utilized as a means of interpreting them.

We study the seismic expressions of such faults and fractures and try to interpret them on a 3-D seismic volume from the SCOOP area of Oklahoma, and its location is shown in figure 1. The quality of the seismic data seems to be very good as seen on a segment of a seismic section from the 3-D seismic volume shown in figure 2. Notice the basement reflection tracked in purple. The Nemaha fault marked on the section penetrates beyond the top of the basement. In fact, it is the Nemaha fault zone that can be seen there, and its spatial disposition is seen clearly on the stratal slices in figure 3 between the Mayes and the Hunton markers from the coherence and most-negative curvature attribute volumes. The fault lineaments are seen better defined on the curvature than the coherence. The Nemaha fault appears to be in the form of a zone rather than a single fault, as indicated by the two black arrows. Another fault zone is also seen to the left of the Nemaha fault zone as indicated with the cyan arrows.

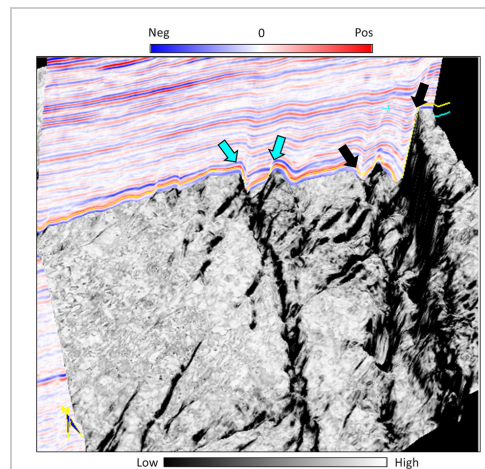


Figure 4: A chair display showing the energy ratio coherence stratal slice shown in figure 2 as the horizontal display and an inline from the seismic volume as the vertical display. Data courtesy of TGS, Houston.

In addition to these two fault zones, there is another fault lineament pattern in the northeast-southwest orientation that seems overlaid on the display. The observed basement fault patterns are consistent with the tectonic history of the mid-continent and may provide explanations for deformation observed in the shallower sediments. As the Precambrian basement of the mid-continent is only exposed in a few places and limited in aerial extent, studies using seismic attributes on robust 3-D volumes provide a critical tool for understanding how deep structures and deformation may influence the overlying sediments.

Explorer Geophysical Corner [\(Click to View Column Archives \)](#)

The Geophysical Corner is a regular column in the EXPLORER that features geophysical case studies, techniques and application to the petroleum industry. **R. Randy Ray**, consulting geophysicist/geologist in Lakewood, Colo., served as editor of Geophysical Corner from January 2001 until January 2006. **Bob A. Hardage**, senior research scientist at the Bureau of Economic Geology, the University of Texas at Austin was editor of Geophysical Corner

from January 2006 until 2012. **Satinder Chopra**, award-winning chief geophysicist (reservoir) at Arcis Seismic Solutions, Calgary, Canada, and a past AAPG-SEG Joint Distinguished Lecturer began serving as the editor of the Geophysical Corner column in 2012.



Satinder Chopra

Satinder Chopra, award-winning chief geophysicist (reservoir), at Arcis Seismic Solutions, Calgary, Canada, and a past AAPG-SEG Joint Distinguished Lecturer began serving as the editor of the Geophysical Corner column in 2012.



Kurt Marfurt

Kurt currently serves as the Frank and Henrietta Schultz Professor of Geophysics within the ConocoPhillips School of Geology and Geophysics. Marfurt also served as the EAGE/SEG Distinguished Short Course Instructor for 2006 (on seismic attributes).



Folarin Kolawole

Folarin Kolawole received a bachelor's in Geology from the Federal University of Technology Akure, Nigeria, and a master's in geology with a focus on structural geophysics from Oklahoma State University.



Brett M. Carpenter

Brett Carpenter received his bachelor's degree in earth and space science education and physics education from Mansfield University of Pennsylvania. He then received his master's and doctoral degrees in geosciences from the Pennsylvania State University.

Share this article:

Figure 1: Map of Oklahoma showing the major geologic provinces. (Modified from Oklahoma Geological Survey map by R. A. Northcutt and J. A. Campbell, 1998). Some counties have also been annotated as well as the location of the 3-D seismic survey under study. The comprehensive fault lineaments overlaid over the map have been taken from the document by March and Holland, 2016 accessed from www.ou.edu/content/ogs/data/fault.html. The three main faults, namely the Nemaha, Meers and the Wilzetta on this image, as well as the megashear trend are also indicated.