Subtle faults interpretation in the Mississippian lime

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The Mississippian lime is a carbonate formation, which has high light oil production, extending from northern Oklahoma into Southern Kansas. Identification of major and subtle faults are critical to both identifying potential drilling hazards and to understanding orientation and intensity of natural fractures in unconventional resource production. For large datasets, hand-picking faults can be very time-consuming, such that any means to accelerate or facilitate the process can be quite attractive. While major faults can be easily seen and picked by experienced interpreters in areas of this seismic volume exhibiting relatively good signal-to-noise ratio, in other areas, more subtle faults are masked by noise.

Improving the efficiency, accuracy, and completeness of subtle fault mapping in noisy data helps identify the location and intensity of fracture zones and predict mobility of hydrocarbon fluids. Our workflow includes several steps. First, we apply principal component structure-oriented filtering to reject random noise and sharpen fault edges. We then apply spectral balancing to further improve the vertical resolution of small-offset faults. Next, we compute eigenstructure coherence, which delineates both stratigraphic and tectonic discontinuities. We then apply three iterations of a Laplacian of a Gaussian filter that sharpens steeply dipping faults and attenuates stratigraphic features parallel to the seismic reflectors. Finally, skeletonizing the fault features along the fault dip azimuth and dip magnitude, result in a clear fault image within different scale fault features. These faults can be displayed color-coded by their orientation, or as a suite of independent, azimuthally limited volumes, providing the interpreter a means of isolated fault sets that are either problematic or especially productive.

Our workflow accelerates to map multi-scale faults and highlight subtle faults from incoherent noises and stratigraphic discontinuities. The skeletonized fault result rejected noise, and enhanced faults imaging in the vertical and lateral direction. Co-rendered with the fault azimuth and the fault dip magnitude can exhibit both strength of the discontinuities and their orientation.