Quantitative Structural Analysis of Newly Acquired Data from Mexican Ridges Fold Belt, Western Gulf of Mexico

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Modern broadband long-offset seismic datasets provide significantly improved resolution of complex structural geometries compared to legacy datasets but understanding the geologic implications of the imaged structures is still a challenge for interpreters. Here, we show that the most effective way to define and understand the structural complexity imaged in modern seismic datasets is to apply multiple quantitative structural interpretation techniques, namely kinematic forward models and area-depth-strain (ADS) analyses.

In the Mexican Ridges Fold Belt (MRFB) in the western Gulf of Mexico, new broadband long-offset regional seismic data was recently acquired and processed by TGS. The MRFB is a gravitationally driven deformation system that detaches on overpressured shale. Extension at the continental shelf (Quetzalcoatl extensional system) is taken up downslope by a series of contractional fault related folds that comprise the MRFB. Compared with legacy data available for the region, the new regional seismic lines provide significantly clearer images of the normal faults within the Quetzalcoatl system, the regional detachment, and the folds within the MRFB. To develop robust interpretations of the extensional and contractional structures, we apply kinematic forward modeling in conjunction with a recently developed ADS technique that can estimate fault trajectories directly from observed fold areas (referred to as fault trajectory ADS analysis). Structural modeling and ADS analysis independently estimate displacement, horizon strain and fault trajectory for each structure. The kinematic models for the extensional Quetzalcoatl faults and the contractional MRFB folds are then linked together to form a regional model that shows the development of the entire gravitationally driven system.

We also compare structural analysis results of the legacy data to analyses performed on the higher quality dataset. While the legacy data provides a decent image of the general fold geometry, the fold cores are not well resolved. In contrast, the newer broadband and long-offset data shows that the MFRB folds are actually cored by complex imbricate structures. Fault trajectory ADS analyses and forward models constrained by the lower-quality legacy data predict fault paths that are consistent with the imbrication imaged in the broadband dataset. This demonstrates that results provided by these methods can reliably guide structural interpretations in under-constrained settings.