Imaging and Mapping Active 3D Fault Geometry in the California Continental Borderland

Catherine Sarah Schindler[1], Craig Nicholson[2], Christopher Sorlien[2]

[1]California State University Bakersfield, Bakersfield, CA 93311; [2]Marine Science Institute and Department of Earth Science, University of California, Santa Barbara, CA 93106

The Continental Borderland offshore southern California has had a complex tectonic history. This area experienced late Cenozoic subduction and Miocene oblique extension, as well as components of large-scale tectonic rotation that continue to the present. The northern part of the Continental Borderland was the locus of Pacific-North American plate motion for more than 70% of its displacement history, and recent GPS data suggest that as much as 20% of current plate motion is still located offshore. Much of this plate motion in the Continental Borderland appears to occur on NW-striking right-transpressive faults and folds that terminate against the predominantly E-W-striking left-transpressive structures of the rotating Western Transverse Ranges province. How this crustal deformation is accommodated in 3D, and the interaction between rotated and non-rotated domains is little understood. These active offshore structures also represent a largely as yet unknown seismic and tsunami hazard to many California coastal communities, and provide important analogs to active buried (less-accessible) onshore California structures that are likely to produce large, damaging earthquakes in the adjacent Los Angeles basin.

As part of a collaborative, multidisciplinary approach, extensive grids of existing high-quality industry multichannel seismic (MCS) and high-resolution multibeam data are being used to image and map active 3D fault surfaces, stratigraphic reference horizons, and seafloor morphology in this offshore area. These digital surfaces help to define the geometry and evolution of active subsurface faults and folds, and to better quantify the finite strain field with time. Initial results suggest a complex pattern of faults and folds that interact to partition oblique strain on systems of intersecting high- and low-angle structures. For example, the near-vertical Malibu Coast fault accommodates predominantly left-slip above a set of stacked north-dipping low-angle thrust faults. At greater depth, these high- and low-angle faults may merge to form oblique-reverse faults that reactivate inherited Miocene normal-separation faults associated with the initial rifting and rotation of the Western Transverse Ranges province, and which now drive the uplift and folding of the Santa Monica Mountains and northern Channel Islands.

This system of interacting faults, folds and crustal block rotations is comparable to similar fault systems around the world, including the North Anatolia fault system in the Marmara Sea, where combinations of low-angle faults beneath long-wavelength folds and adjacent high-angle faults also appear to accommodate distributed continental plate motion and inferred block rotation.