Combining High-Resolution Climate Studies and Tectonics: Imaging Complex Folding in 4-Dimensions Above Active Blind Faults

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Understanding the regional geometry and slip of active faults and folds is crucial to proper seismic hazard evaluation. This knowledge is used to model earthquake sources, recurrence and effects, as well as to understand the distribution of plate boundary motion. Folding is important as it is critically linked to the slip on blind faults, as well as to bends and terminations of strike-slip faults, and absorbs finite strain that is not otherwise observable as near-surface fault offset. A quantitative measure of the finite strain absorbed by folding and fault slip is the cumulative deformation defined by mapped stratigraphic reference horizons and paleo-sealevel markers.

As part of a detailed global climate study in Santa Barbara Basin, grids of high-resolution single-channel and multichannel seismic (MCS) reflection data were used to correlate and map various stratigraphic reference horizons from ODP Site 893 (and other wells) across the basin to the Mid-Channel Trend. This trend is a complex fold structure growing above (and between) the high-angle oblique-reverse Oak Ridge fault and an associated back thrust. Fold growth has caused sediments deposited in the deep paleo-bathymetric basin to be uplifted and partially eroded so that strata as old as ~700 ka are exposed at the seafloor where they are now accessible to piston coring. In August 2005, over 30 piston cores—together with deep-towed chirp data—were taken using the *R/V Melville* to sample and survey these horizons and their intervening stratigraphic sequences (**Figure 1**). Preliminary core analyses confirm that most glacial and interglacial intervals between about 150 ka and 500 ka were sampled. The core results, together with the chirp data and interpreted grids of high-quality industry MCS data thus provide a dated high-resolution seismic stratigraphy to image and document the nature, geometry and evolution of the Mid-Channel anticline and the Oak Ridge fault system in 3D.

Our sequence of multiple mapped reference horizons documents a fairly complicated process of how slip on the deep fault system is transformed at shallow levels into fold growth as different strands, splays and back thrusts became active. The result is that much of the active offshore Oak Ridge fault is blind, despite the fault locally offsetting the unconformity created during the Last Glacial Maximum in the eastern Santa Barbara Channel. In addition, stratal thinning across faults and on to folds indicates the onset of fold growth and an alternation in fault activity between the north-verging Oak Ridge fault and the south-verging back thrust. Modeling the fold structure and stratigraphy in 3D also confirms propagation of the Mid-Channel Trend from east to west as previously proposed. South of Santa Barbara harbor, folding on the anticline began about 1 Ma, while 10 km farther west, folding began after ~500 ka.

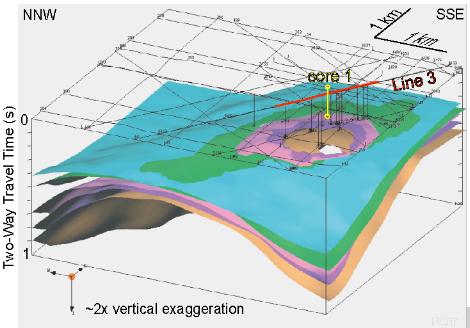

Figure 1. High-resolution USGS-Melville chirp line 3 over western culmination of Mid-Channel Trend showing dipping outcrop strata of late-Quaternary age, mapped stratigraphic reference horizons (green, pink, violet, orange) and core locations along line with approximate core penetration depths converted to equivalent two-way travel time (seconds). (inset) Oblique cut-away view looking ENE across western culmination of Mid-Channel Trend showing grid of high-resolution seismic reflection lines (black) at sea surface, five stratigraphic reference horizons used to define 3D structure and outcrop stratigraphy, and locations of Line 3 (red) and Core 1 (yellow). Depth scale of volume is also in two-way travel time (seconds).