During the last 2-5 Ma, the Transverse Ranges (Southern California) have been subject to a N-S compression related to the formation of a regional restraining bend in the San Andreas Fault and resulting in the development of an E-W trending thrust-and-fold belt system. The westward striking Ventura basin and its offshore extension, which is filled by more than 5 km of Pleistocene sediment, cross the western Transverse Ranges. The analysis and inversion of GPS data reveal a north-south convergence at 7–10 mm/yr and fast contraction rates along the Ventura Basin. Although the different thrust and folds are fairly well known in the onshore areas of the western Transverse Ranges, there is still uncertainty about their continuation in the offshore. The analysis of new high-resolution CHIRP and reprocessed mini-sparker (USGS) data has allowed us to characterize better the active geostrophic structures in the offshore Ventura Basin. In the dataset, we have identified two different seismic stratigraphic units separated by a regional erosional unconformity, which corresponds to a transgressive surface (LQTS) after the Last Glacial Maximum. The LQTS developed over the Pleistocene units at 104-ka BP and since then it has been deformed mostly by blind thrust and backthrust faults. Below the LQTS, there are the Early to Late Pleistocene units, which are also faulted (anticlines and synclines). Above the LQTS, there is the Holocene unit, which exhibits an irregular distribution and thickness with less deformation (folding and faulting) than the LQTS and Pleistocene units. The dense grid of new and existing seismic reflection data has allowed us to correlate the offshore structures to the main fault systems identified onshore: the Pitas Point, the Red Mountain, the Mesa Rincon Creek faults, and the Ventura-Avenue anticline. Furthermore, we have indentified between 3 and 6 different Holocene deformation events (i.e., earthquakes) based on the different observed structures, such as anticline scarps, growth strata sequences, onlap unconformities and erosion surfaces in the Holocene unit.

2. Holocene active structures

3. Ventura Basin - Late Quaternary structural map

Based on the identification and correlation of faults and folds (anticlines and synclines) that deform the Pleistocene units and the LQTS along the margin, we have been able to correlate the observed offshore structures to the main fault systems identified onshore: the Pitas Point, the Red Mountain, and the Mesa Rincon Creek fault systems.

The CHIRP seismic data reveal that the Pitas Point fault clearly continues offshore. The fault is blind and shows a monocline geometry verging to the south. Nevertheless, towards the west this monocline becomes more subtle and just deforms deeper Holocene reflectors. This suggests either the fault does not extend far into the basin or that the sedimentary rate during the Holocene has been much higher than the folding rate, obscuring the deformation.

The Ventura-Avenue Anticline continues offshore as evidenced by the gentle folding of the sediments above LQTS. It appears that towards the west, however, it has become inactive during the Holocene and it does not deform the LQTS. Nevertheless, deformation associated with the Ventura-Avenue Anticline is clearly observed in the Pleistocene units. We suggest that the Red Mountain fault has been the main structure accommodating the deformation in the area because the lack of observed deformation in the Ventura-Avenue Anticline occurs in a region that is parallel, and in close proximity to the Red Mountain fault.

The Red Mountain fault is recorded by a high amplitude anticline and significant uplift of the LQTS between Rincon Point and Santa Barbara. The anticline changes trend from E-W on the western portion of the basin to NNE-SSW close to Rincon Point. This large anticline may be related to a main blind thrust dipping to the north and a shallow southwestward dipping blind backthrust. Even though these observations point to this anticline being a continuation of the deformation near Rincon Point is complex and more detailed structural analysis of the region is needed.

The Mesa Rincon Creek fault described in the onshore areas has been correlated with a deformation zone (faults and folds) observed in the offshore between Carpinteria and Santa Barbara. Associated with this system, we have identified an area where the LQTS dips markedly towards the north engendering accommodation for sediment accumulation. We suggest that this area may correspond to a subsidence zone related to folding and faulting along the Mesa-Rincon Creek thrust.