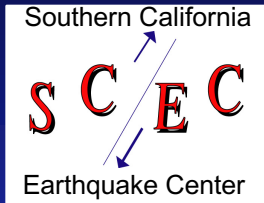


# 3D Fault Geometry & Slip History of the North Channel-Pitas Point-Red Mountain Fault System



**Craig Nicholson**

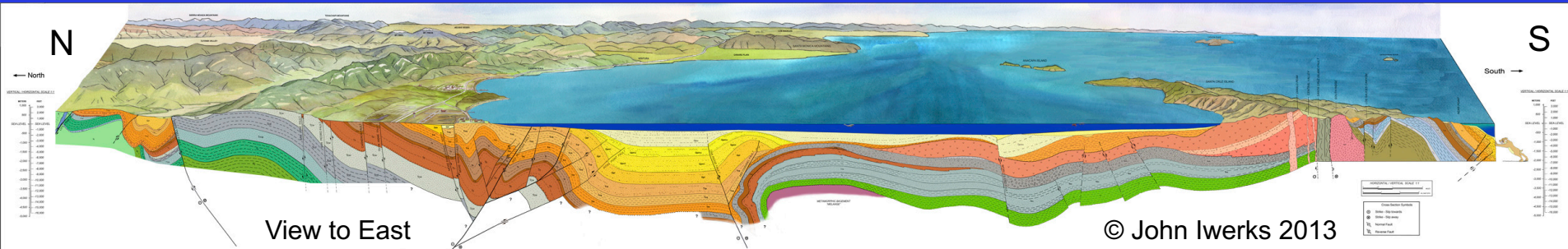
*Marine Science Institute, UC Santa Barbara*



With Major Contributions From

**Chris Sorlien, Marc Kamerling, Tom Hopps and Sam Johnson**

SCEC Ventura Special Fault Study Area Workshop, Palm Springs, 2016

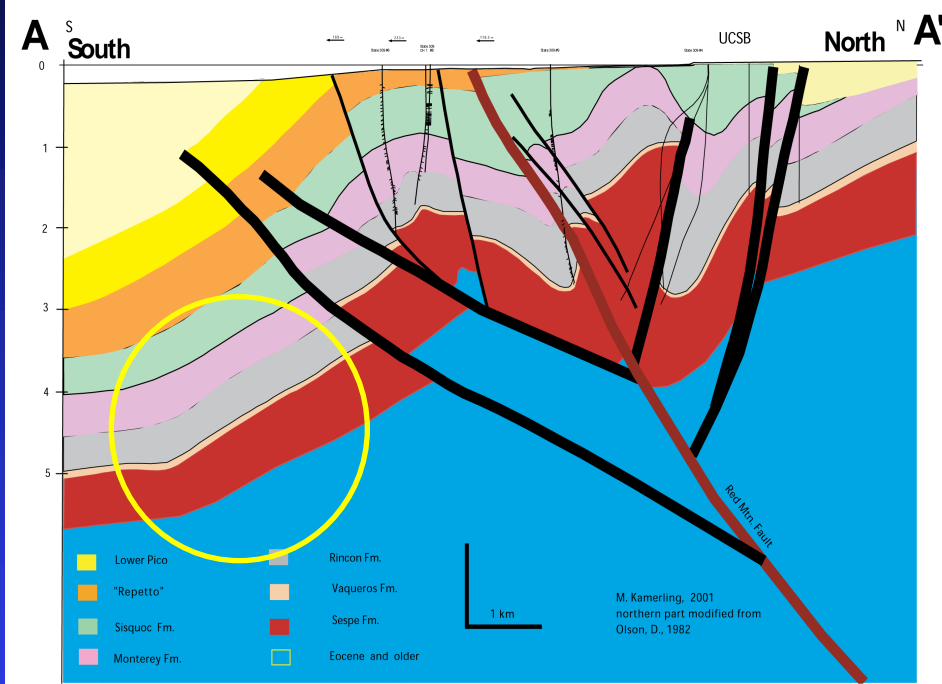
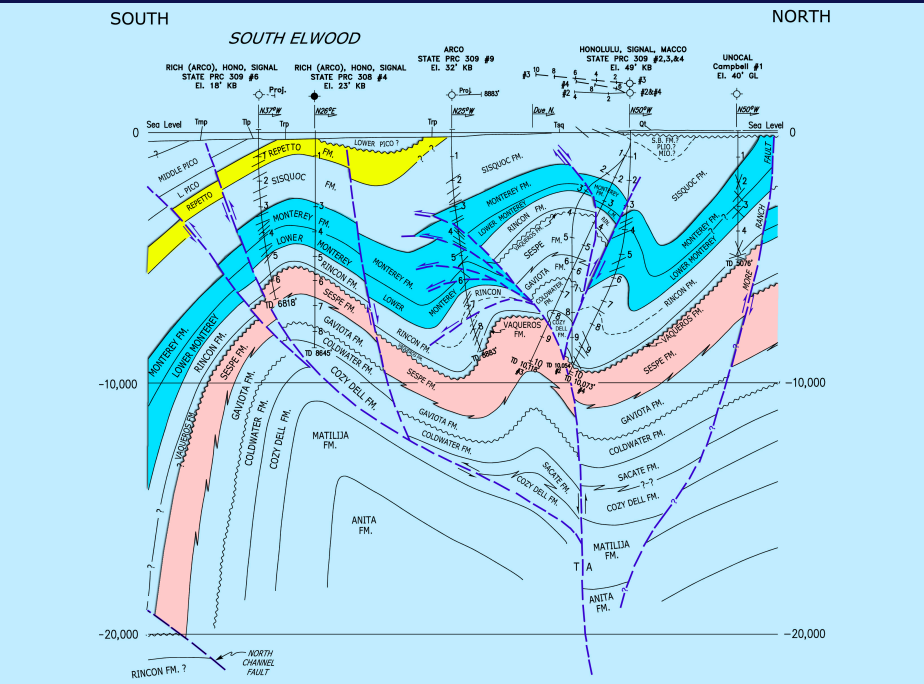


Perspective view looking east and geologic cross section across the Santa Barbara Channel - 23-ft wall mural at UCSB

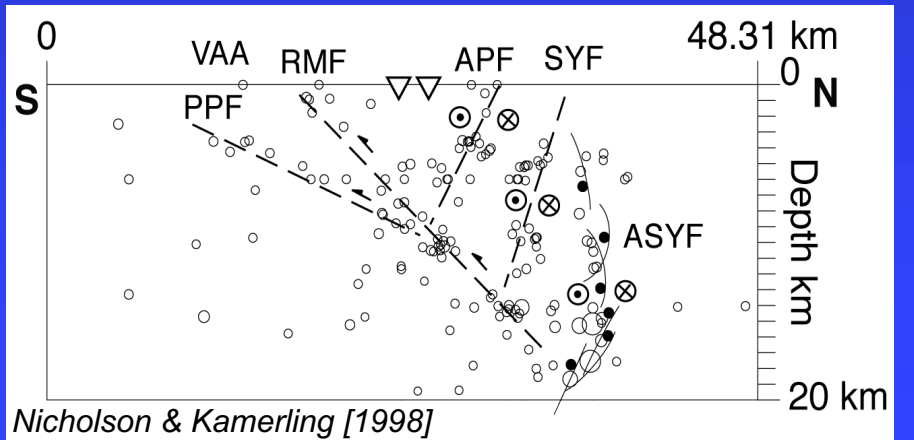
# Correlated Cross Sections from Industry Well Data Looking West at UCSB Across North Channel-Pitas Point-Red Mountain Fault System

Redin et al. [1998] CS 35-N

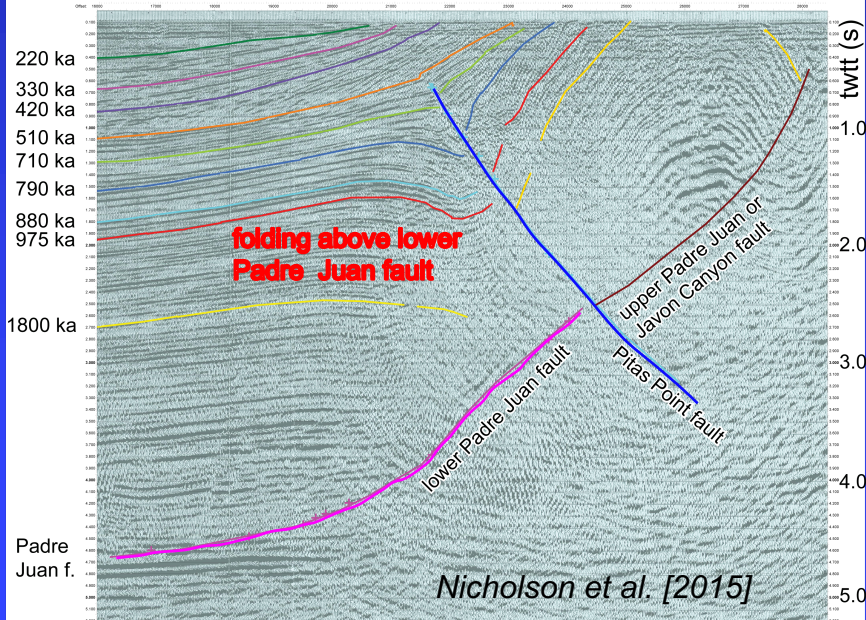
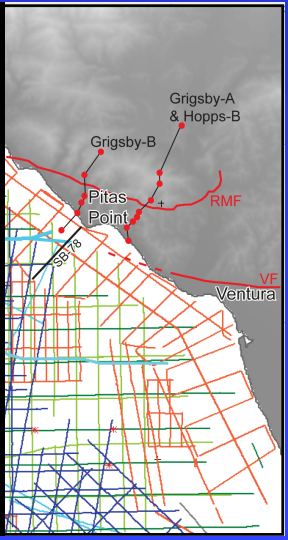
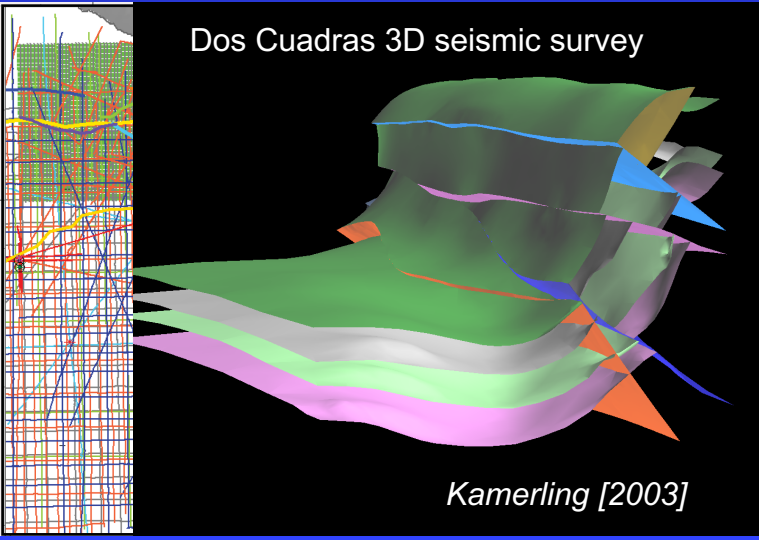
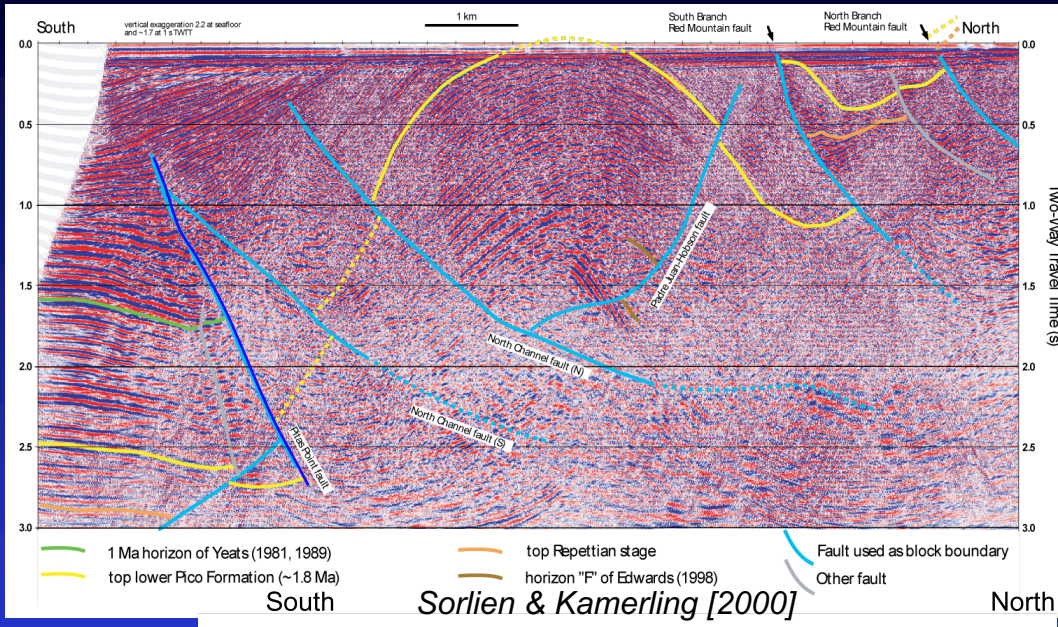
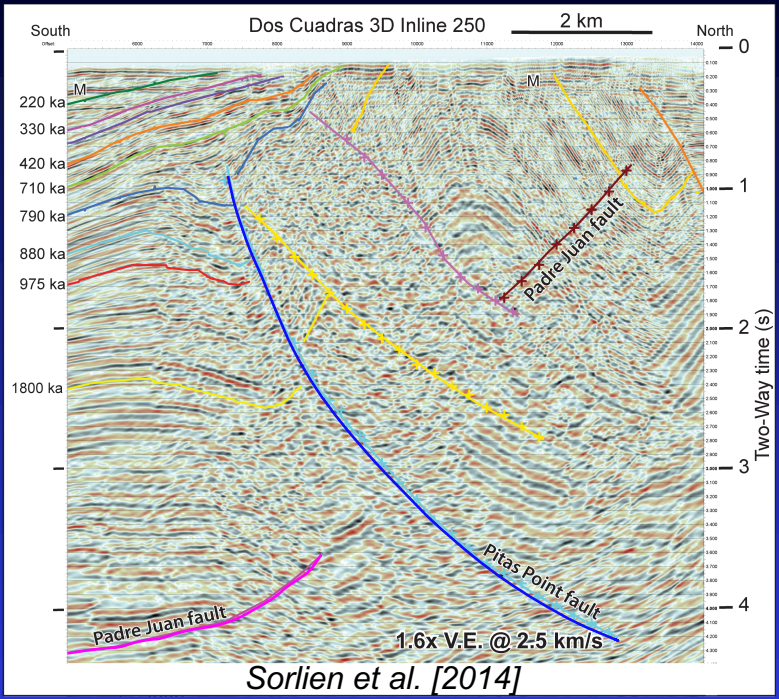
Kamerling et al. [2003]



Cross section looking west of seismicity in the eastern Santa Barbara Channel

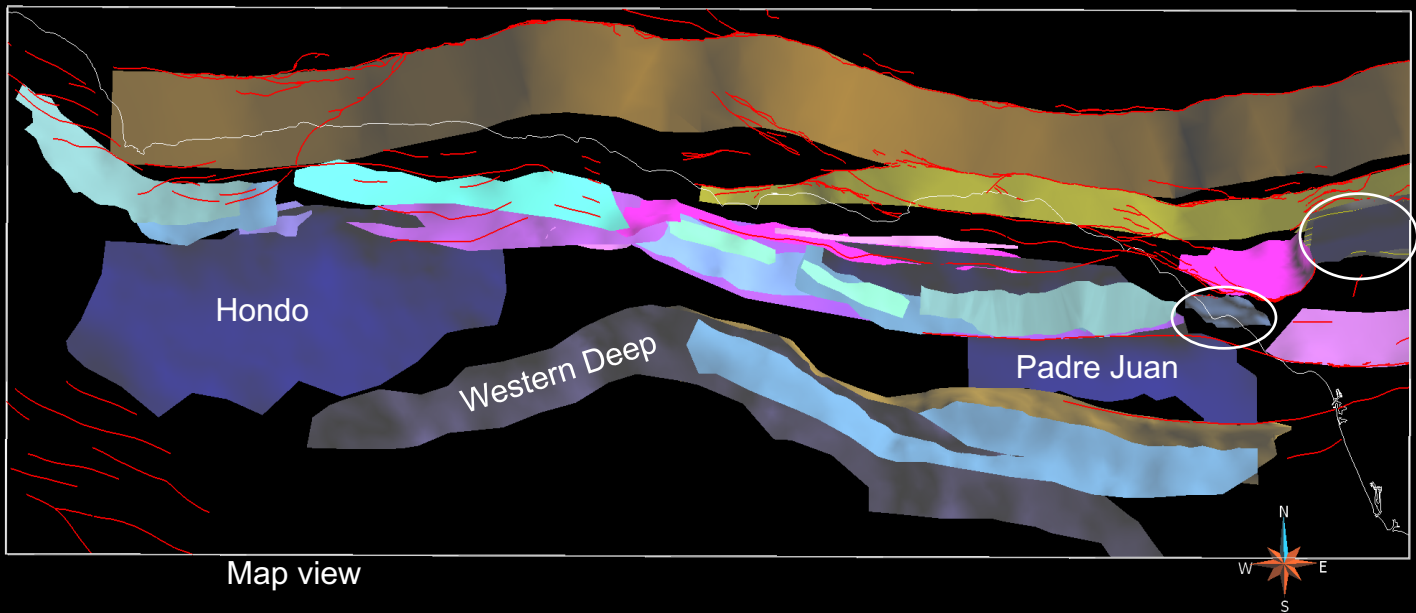
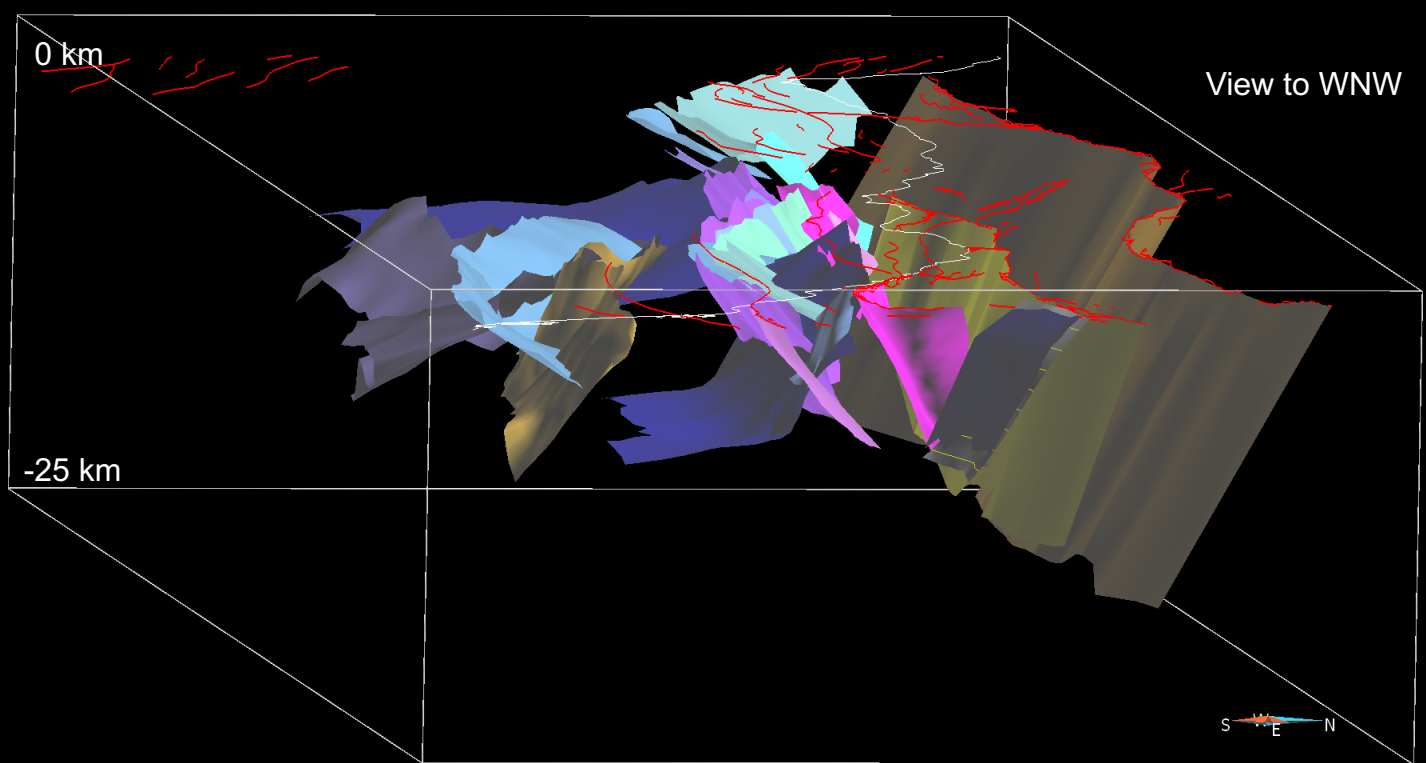


# Examples of Deep-Penetration Industry Seismic Reflection Data Looking West Across North Channel-Pitas Point-Red Mountain Fault System



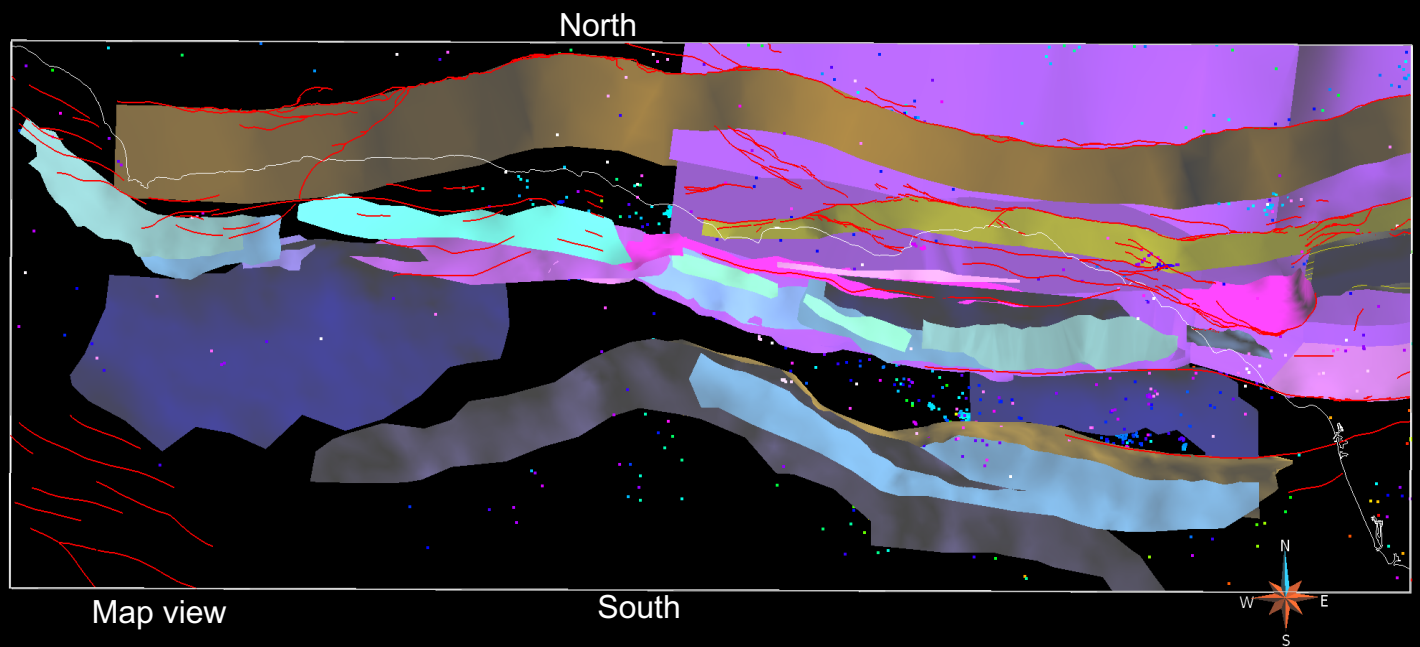
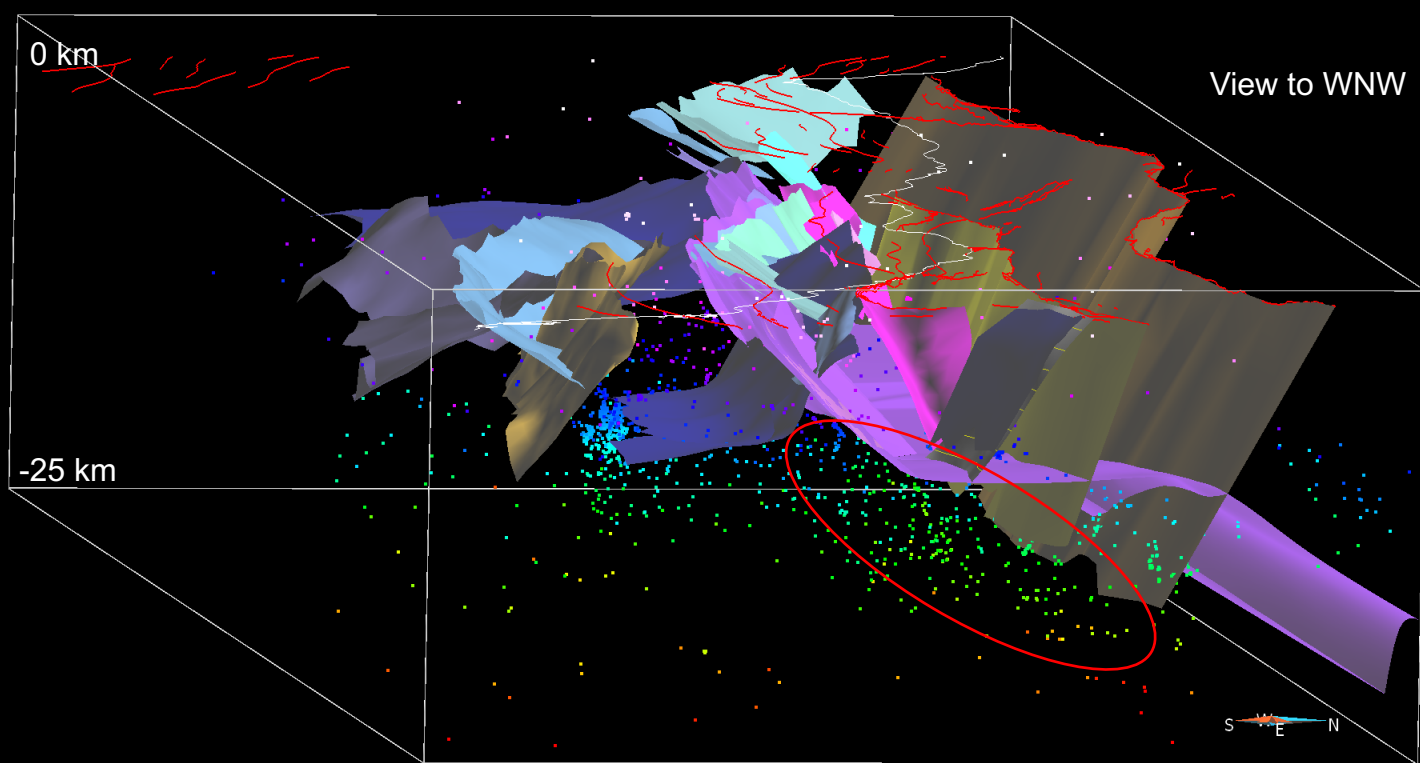
Faults shown in map and  
3D oblique view:

- S-dip Santa Ynez
- S-dip Mission Ridge**
- N-dip Red Mountain**
- N-dip Pitas Point-Ventura**
- N-dip North Channel**
- S-dip Oak Ridge
- N-dip Mid-Channel
- S-dip Hondo detachment
- S-dip Western Deep
- S-dip Upper Padre Juan
- S-dip Lower Padre Juan
- S-dip Javon Canyon
- S-dip Lion Canyon**
- S-dip Sisar fault

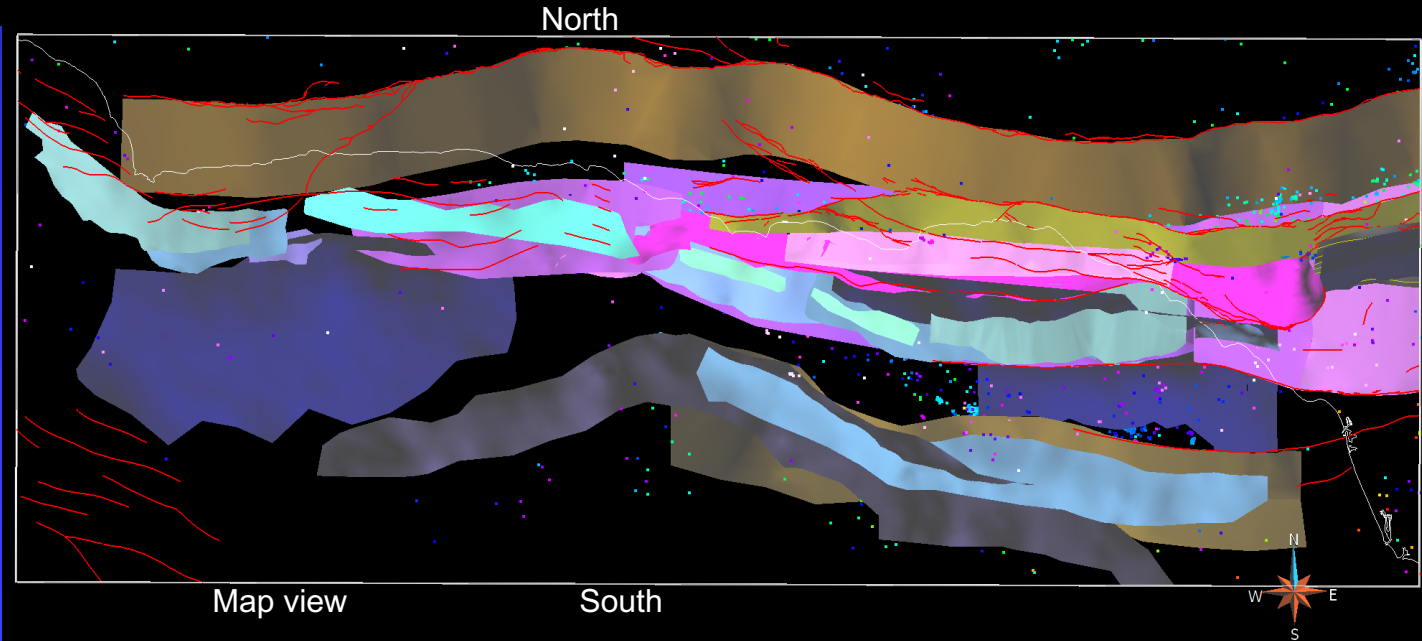
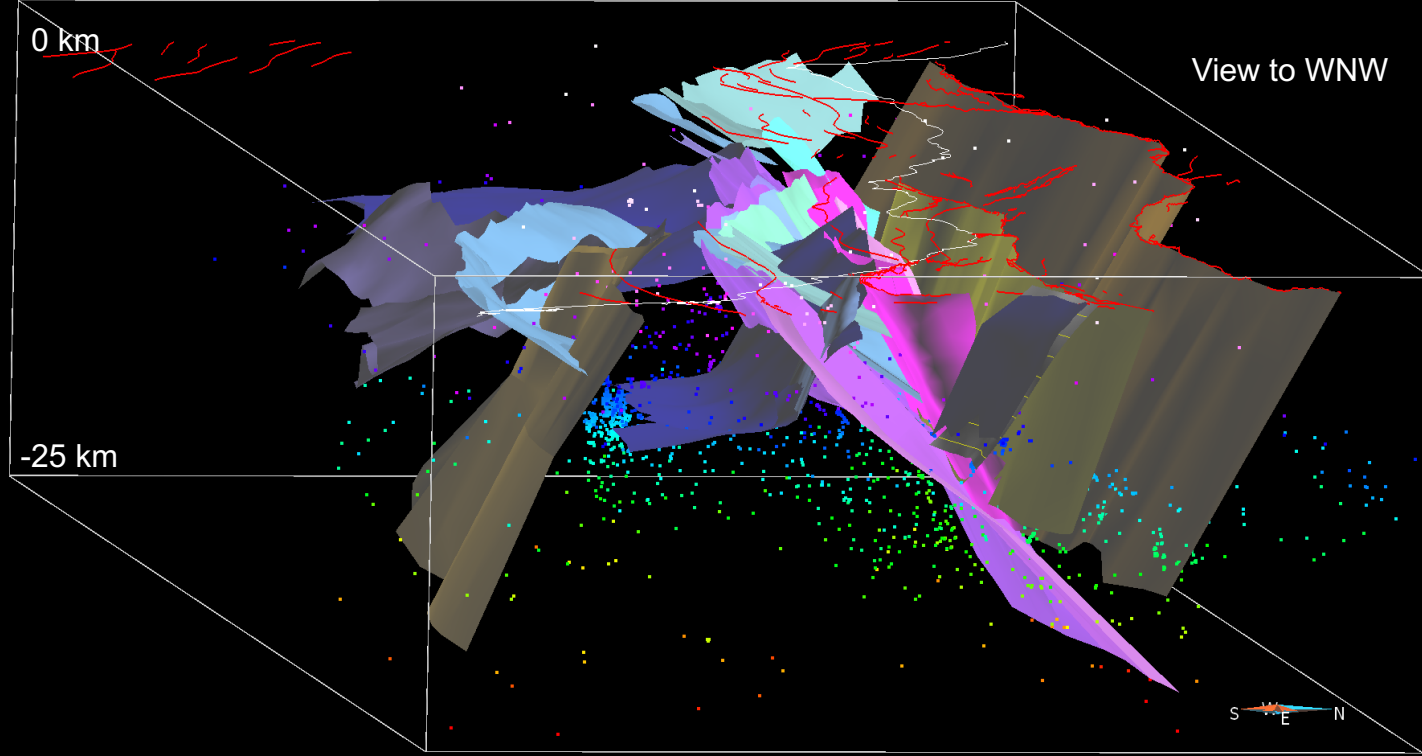


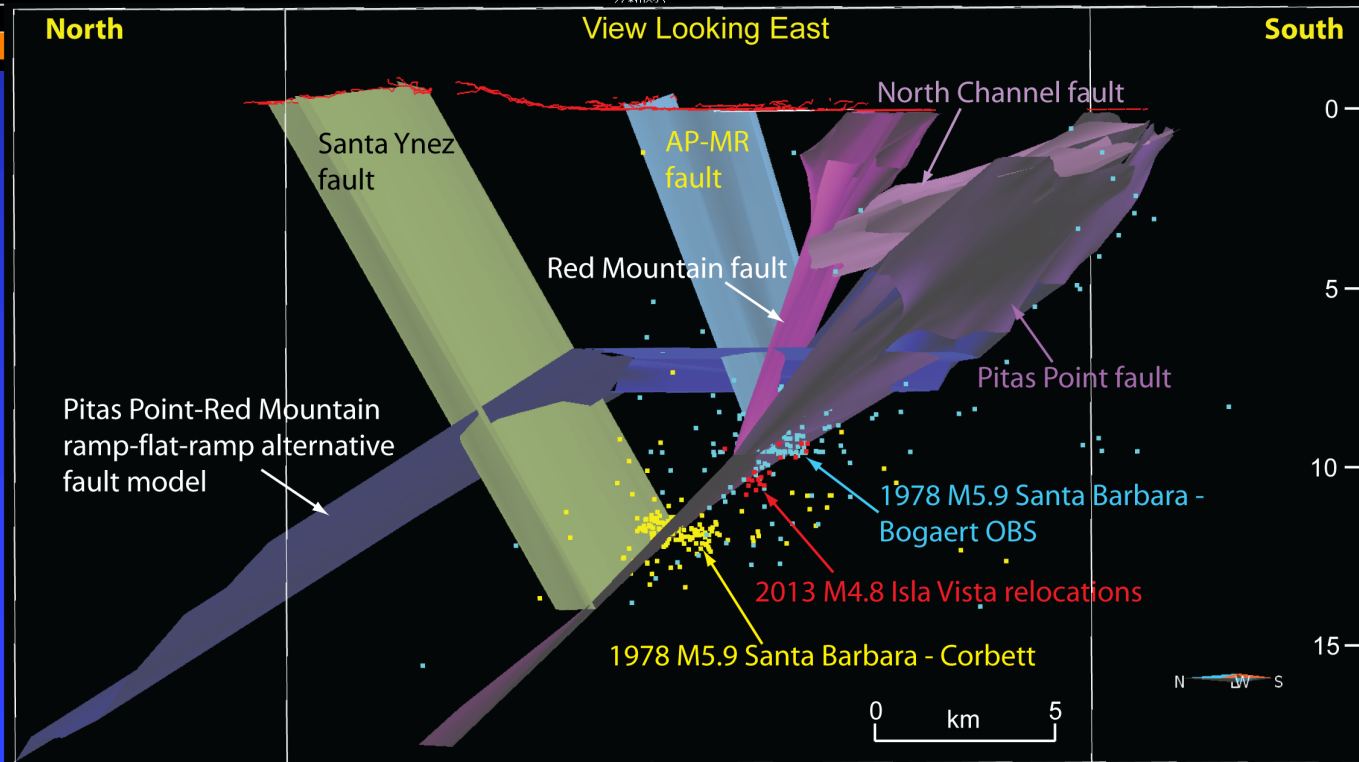
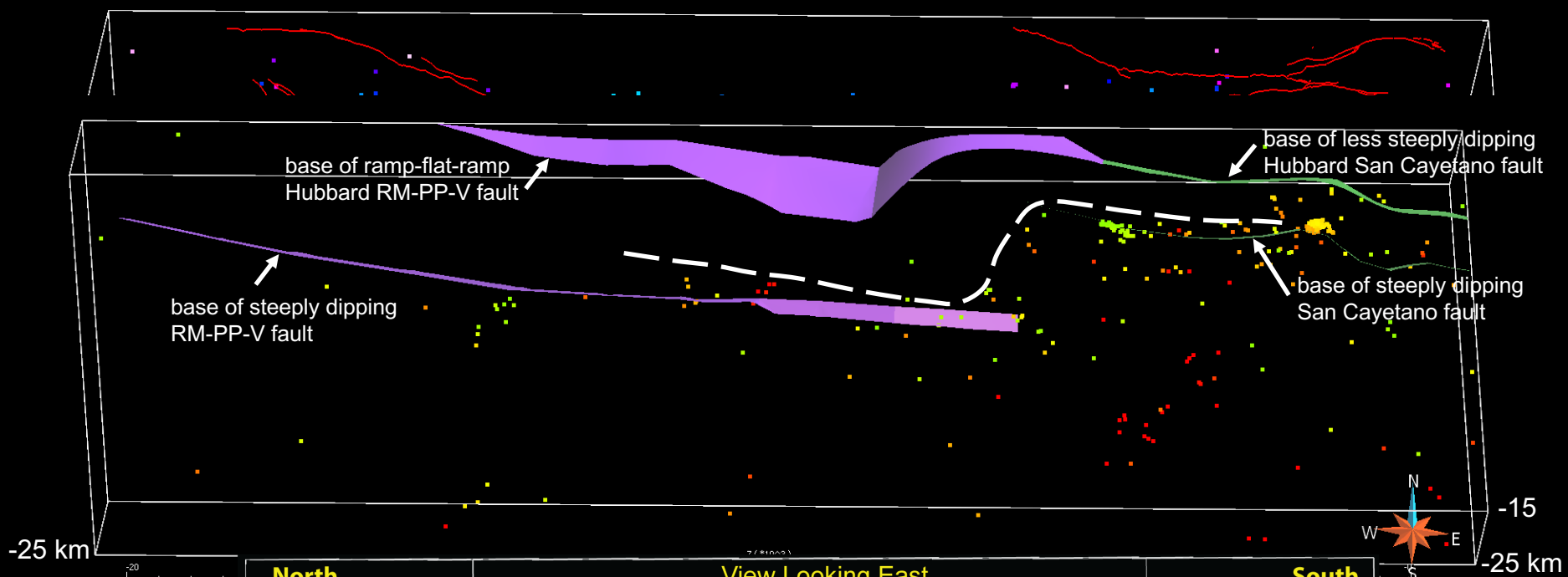
Faults shown in map and  
3D oblique view:

- S-dip Santa Ynez
- S-dip Mission Ridge
- N-dip Red Mountain
- N-dip Pitas Point-Ventura
- N-dip North Channel
- S-dip Oak Ridge
- N-dip Mid-Channel
- S-dip Hondo detachment
- S-dip Western Deep
- S-dip Upper Padre Juan
- S-dip Lower Padre Juan
- S-dip Javon Canyon
- S-dip Lion Canyon
- S-dip Sisar fault
- N-dip Hubbard PP-VF



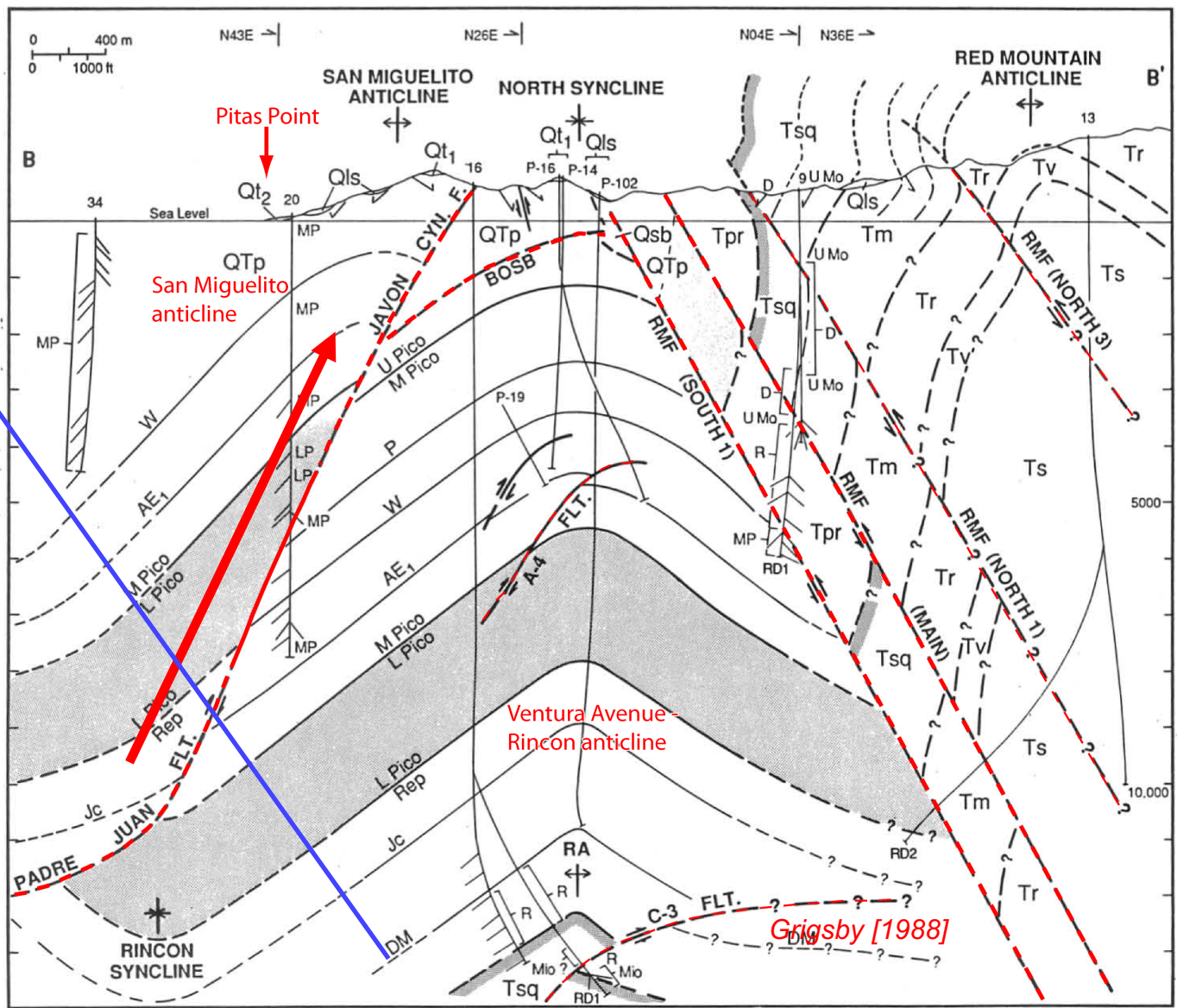
- Faults shown in map and 3D oblique view:
- S-dip Santa Ynez
  - S-dip Mission Ridge
  - N-dip Red Mountain
  - N-dip Pitas Point-Ventura
  - N-dip North Channel
  - S-dip Oak Ridge
  - N-dip Mid-Channel
  - S-dip Hondo detachment
  - S-dip Western Deep
  - S-dip Upper Padre Juan
  - S-dip Lower Padre Juan
  - S-dip Javon Canyon
  - S-dip Lion Canyon
  - S-dip Sisar fault
  - N-dip steep PP-VF
  - N-dip deep Red Mountain
  - N-dip deep N. Channel
  - S-dip steep Oak Ridge
  - S-dip Padre Juan onshore
  - S-dip deep Javon Canyon





# Subsurface Fault & Fold Structure from Industry Wells 1-km West of Pitas Point

CFM 3D Ventura fault location



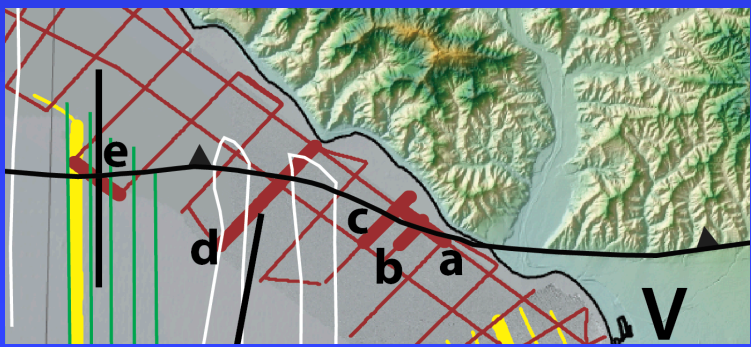
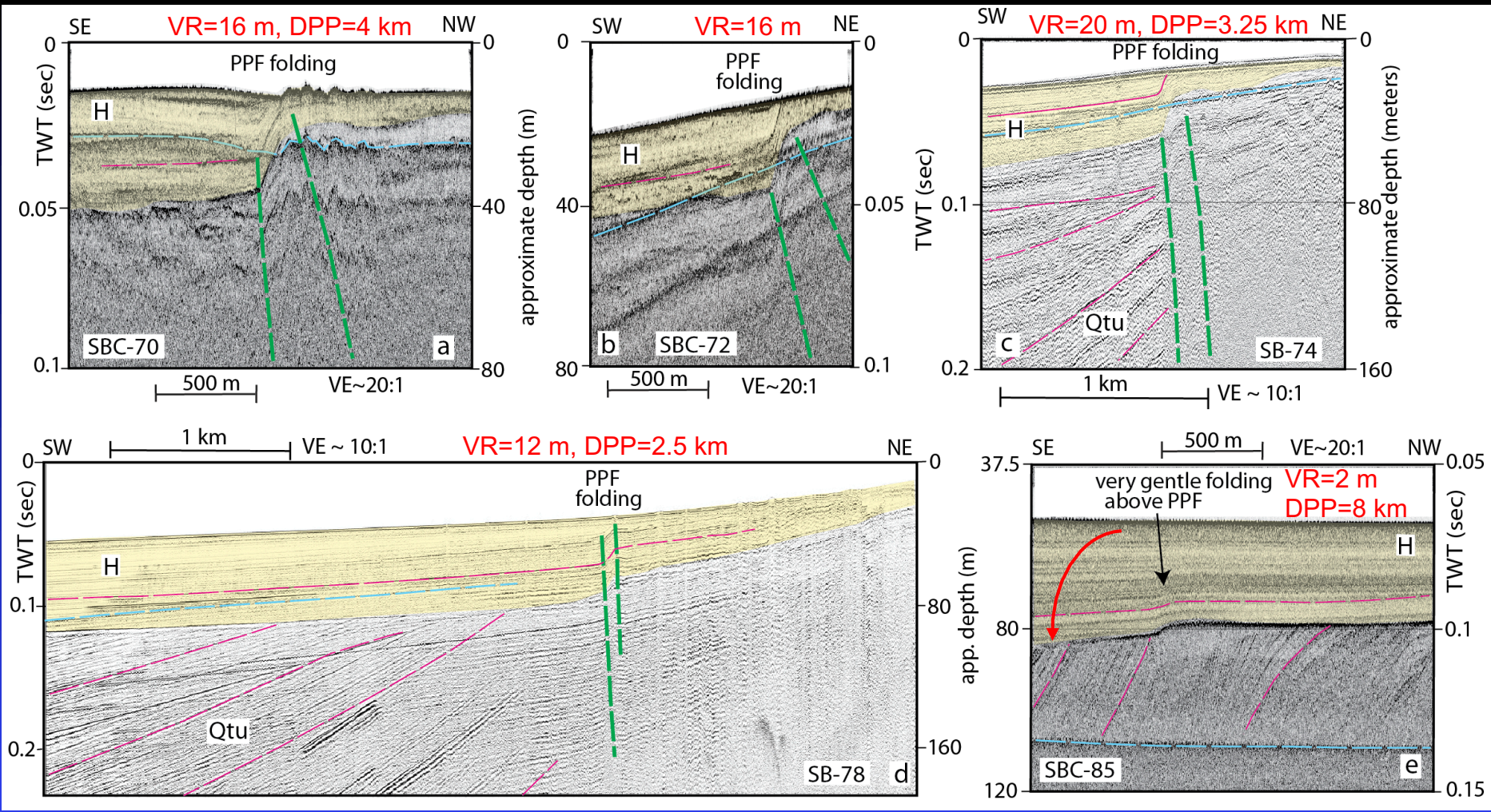
0 km

5000

10,000

Grigsby [1988]



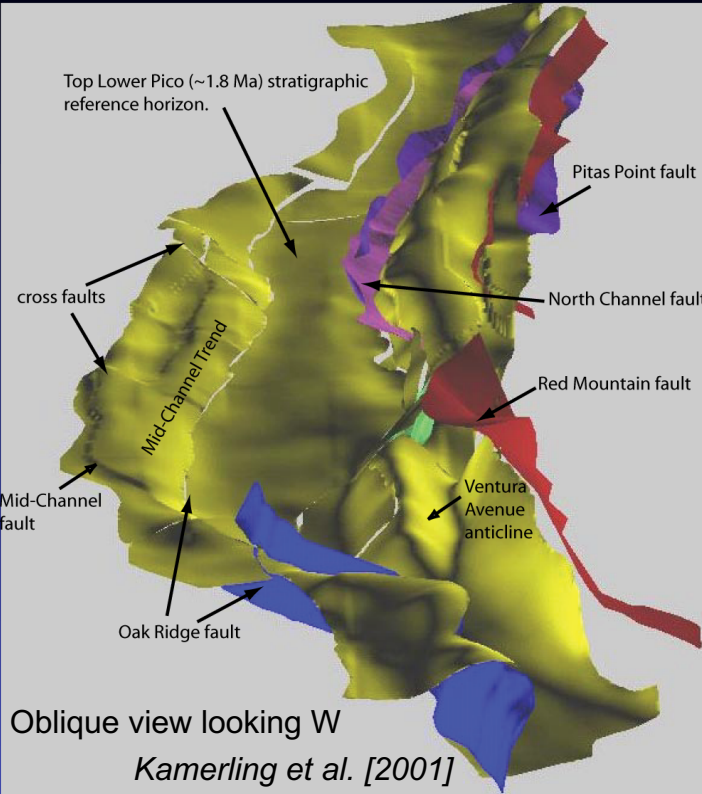


High-resolution USGS chirp (a, b, e) and minisparker (c, d) seismic-reflection profiles showing monoclinical-fold deformation above Pitav Point-Ventura fault, eastern Santa Barbara Channel (Johnson et al., in review). Green lines are fold axes – not faults. Yellow shaded sediments are Holocene deposits above the Last Glacial Maximum (LGM) unconformity dated at ~10-12 ka. VR = vertical relief; DPP = distance to Pitav Point

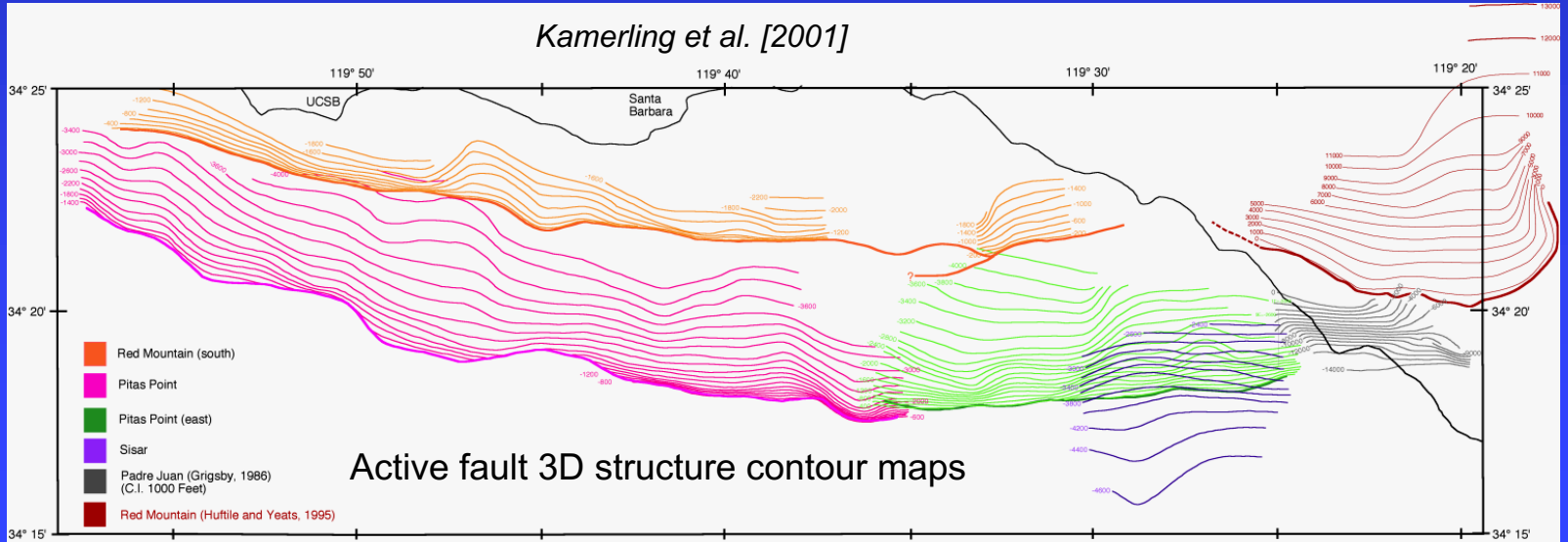
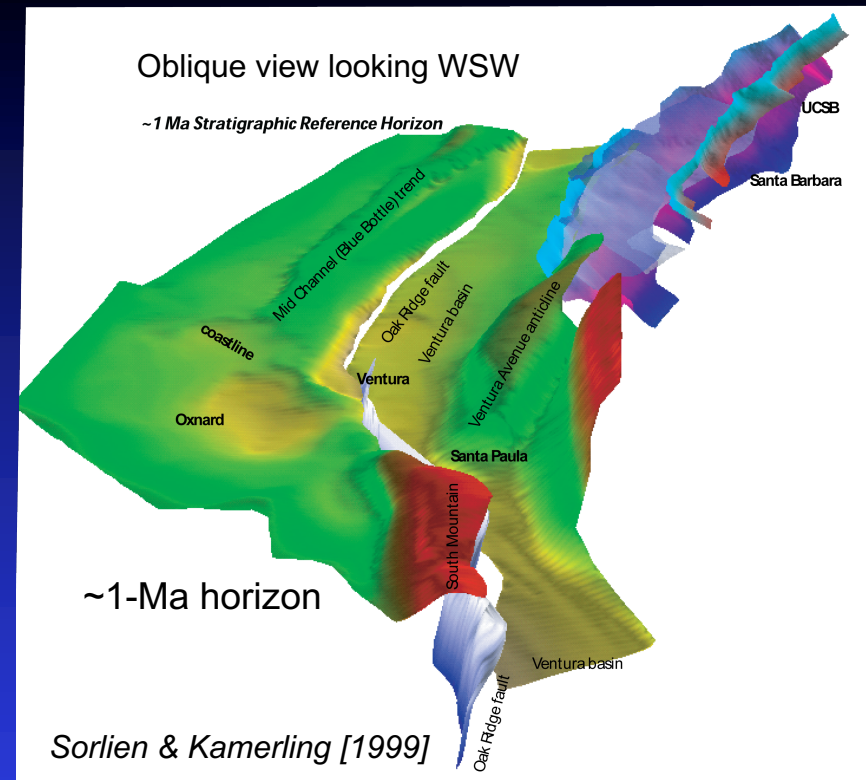
# Conclusions

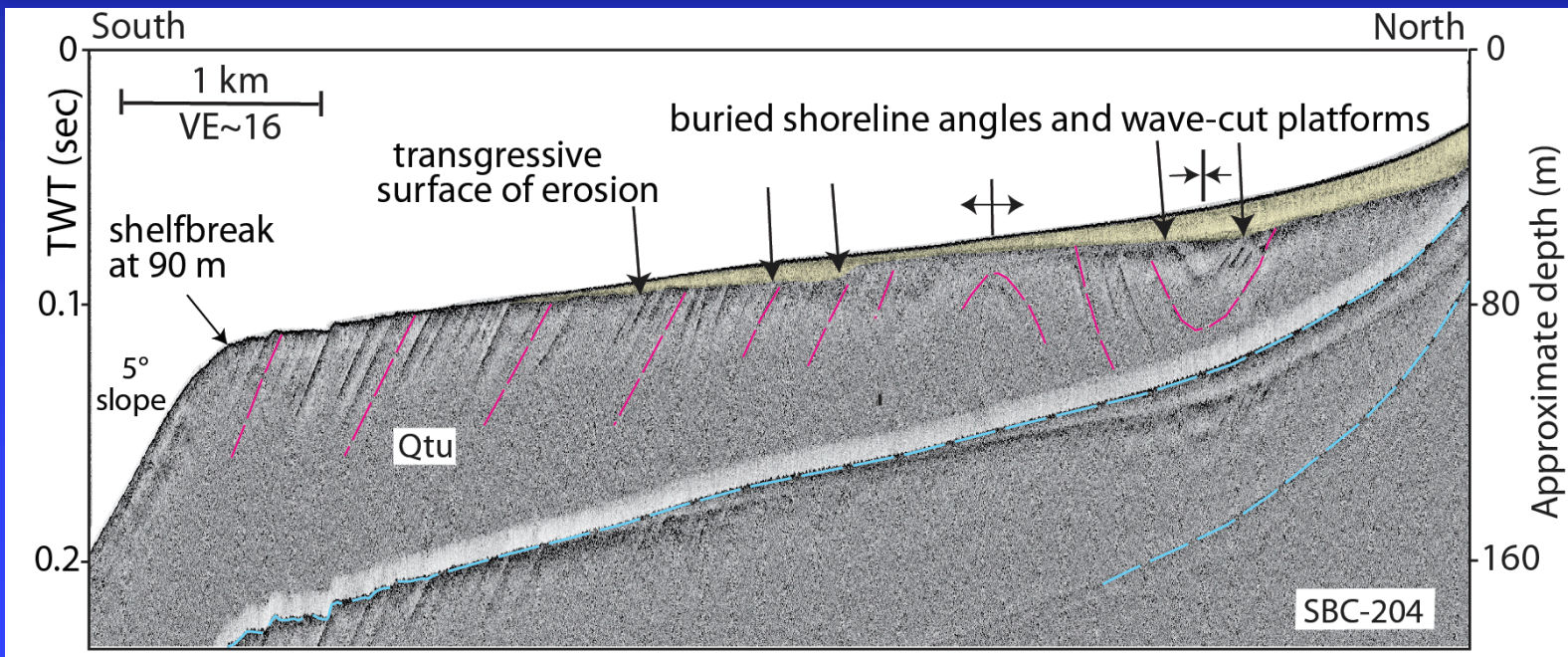
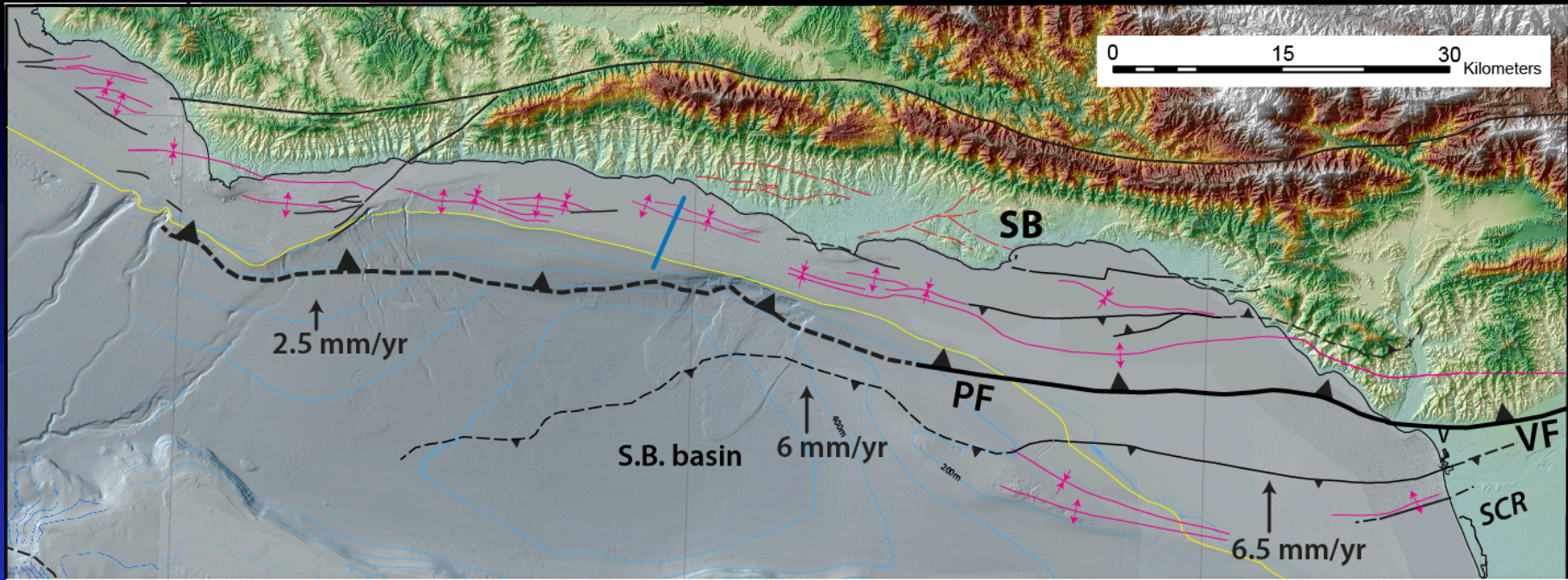
- Integrated datasets of seismic reflection, well and seismicity data define important 3D fault and fold geometry and can be used to map important dated reference horizons to resolve fault slip rates.
- The N-dipping North Channel-Pitas Point-Red Mountain fault system can be mapped from onshore Ventura to west of Pt. Conception, a distance of over 120 km. However, the fault geometry is highly complex, segmented, and based on seismicity, is steeply dipping to depths of 20 km.
- The Pitas Point-Ventura fault (PP-VF) is everywhere blind, with the depth of the fault tip increasing westwards from about 500 m depth in the eastern Channel to over 1 km south of Santa Barbara. In most places, there has been no near-seafloor fault rupture of the PP-VF in the last 500,000 years.
- Local vertical fold relief of the 10-12 ka LGM unconformity at the PP-VF decreases westwards with this increasing depth of the fault tip, but indicate a slip rate of ~2 mm/yr on the Pitas Point fault. Additional progressive limb rotation and tilting also occurs in the Pitas Point fault hanging wall.
- Seismic reflection and industry well data image and define a N-verging San Miguelito anticline and S-dipping, listric upper & lower Padre Juan fault. At Pitas Point, this fault exhibits 2.5 km of late Quaternary dip separation, which necessarily occurred as slip on an independent Padre Juan fault.
- High-resolution & deep-penetration seismic reflection data image continued late Quaternary folding and progressive limb rotation in the footwall of the Pitas Point fault likely related to the lower Padre Juan fault. As the LGM unconformity may also be tilted, the Padre Juan may be Holocene active.
- Regardless, neither the Pitas Point nor the Padre Juan faults exhibit uplift rates sufficient to produce the anomalous uplift rates inferred at Pitas Point, and neither fault exhibits Recent near-surface fault rupture. The ~8-10-m uplift events at Pitas Point suggest 10-12-m fault slip events at depth. Both faults are located about 2.5 km below Pitas Point. Globally, M8 earthquakes with 10-12-m slip events at 2.5 km depth always produce surface fault rupture, which neither fault exhibits.

# 3D Structure Maps of Dated Reference Horizons & Subsurface Faults



These 3D mapped horizons document a shortening rate of ~2-3 mm/yr across the North Channel-Pitas Point fault to the south branch of the Red Mountain fault





From Johnson et al. (in review)

