Tectonic Characterization of the THUMS-Huntington Beach Fault, Offshore Southern California*

Sergey Ishutov[1]

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Abstract

This project is aimed at detailed mapping of the THUMS-Huntington Beach Fault based on the integration of high resolution 2D and 3D seismic data with wireline log data acquired offshore Southern California. Correlation of the seismic and well data provides a basis for tectonic characterization of the THUMS-Huntington Beach Fault and estimation of its structural relation to neighboring faults and petroleum traps by developing a 3D geological model.

The THUMS-Huntington Beach Fault branches from the Palos Verdes Fault Zone and from that point south forms the southwestern border of the Wilmington Anticline, where the 2 billion barrel Wilmington Field is located. The timing and trapping mechanisms in this field are closely related to the evolution of the continental margin from subduction to transform tectonics. The Inner Borderland, where the faults and oil field are located, is a rift zone between the main continental block and small detached, rotated blocks such as the Western Transverse Ranges, with probable changes in stress fields affecting fault motion. Newly acquired 2D images and existing 2D and 3D data will make it possible to more accurately map the THUMS-Huntington Beach Fault and shed light on the character of fault separation. This project's results will provide insights on the true nature of the THUMS-Huntington Beach Fault, including precise determination of dip and strike orientations and displacement components, and reveal important implications on the Palos Verdes Fault Zone and tectonic history of the California Continental Borderland.

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TECTONIC CHARACTERIZATION OF THE THUMS–HUNTINGTON BEACH FAULT, OFFSHORE SOUTHERN CALIFORNIA

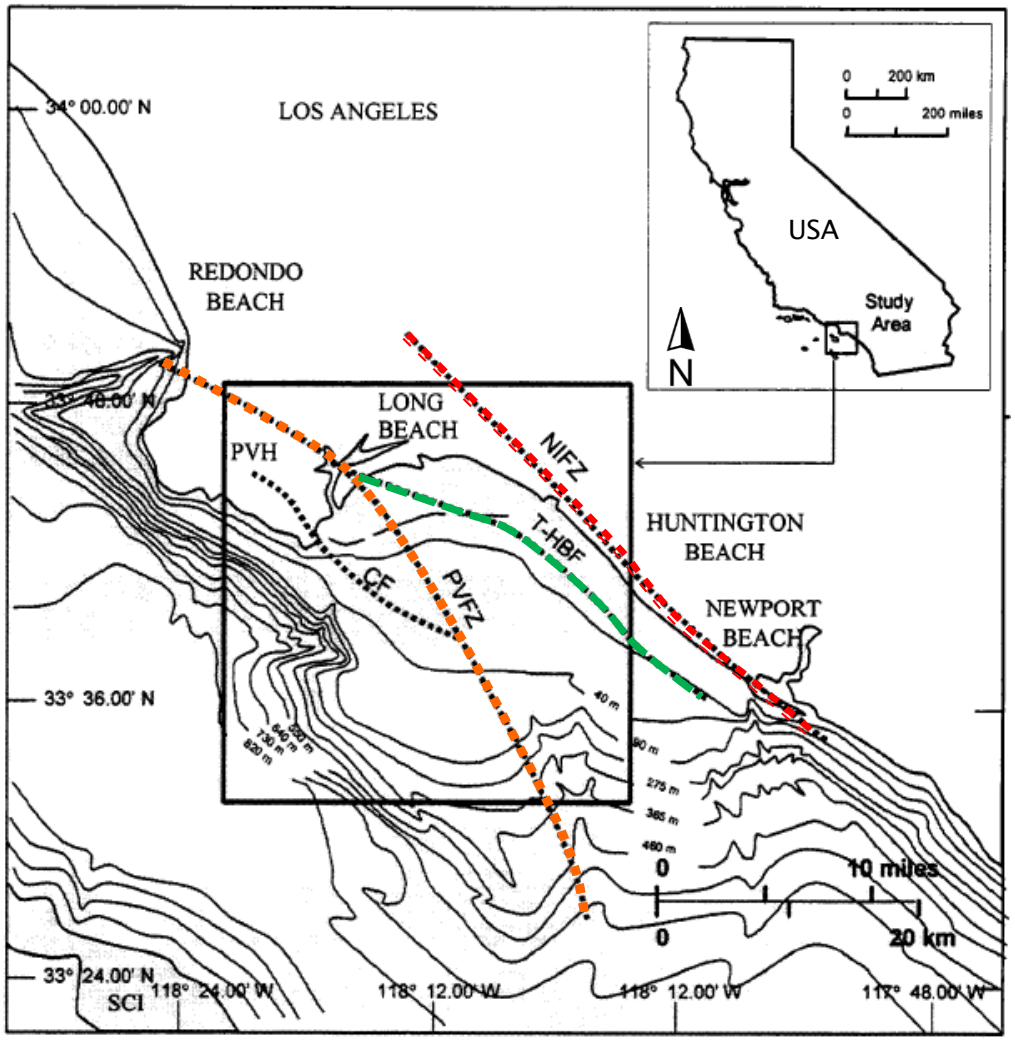
SERGEY ISHUTOV

SPE Western Regional/Pacific Section AAPG Conference
April 23, 2013

OUTLINE

- Introduction
- Significance and objectives
- Regional context
- Previous investigations
- Methods and techniques
- Models of T-HBF
- Future research

INTRODUCTION

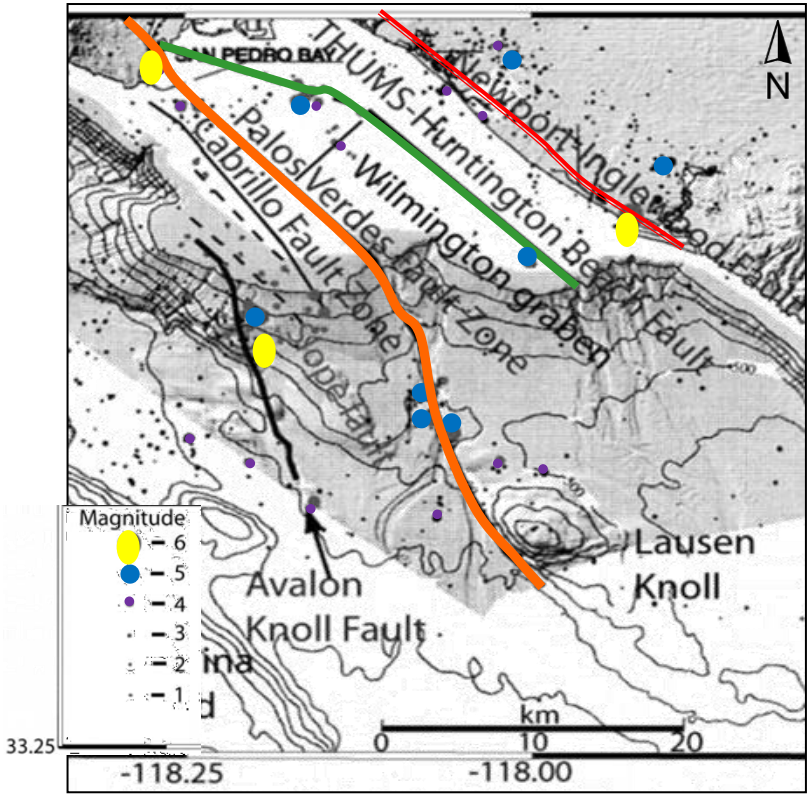


Schwiebert (2004)

The THUMS-Huntington Beach fault (T-HBF):

- discovered in 1969 by Oil City survey as a SE-striking fault;
- extends offshore from the PVFZ along the SW flank of the Wilmington Anticline;
- parallel to NIFZ and steps (?) towards Newport Beach;
- 10-15 miles long but discontinuous;
- poorly expressed and based on limited and sparse data.

SIGNIFICANCE



Baher et al. (2005)

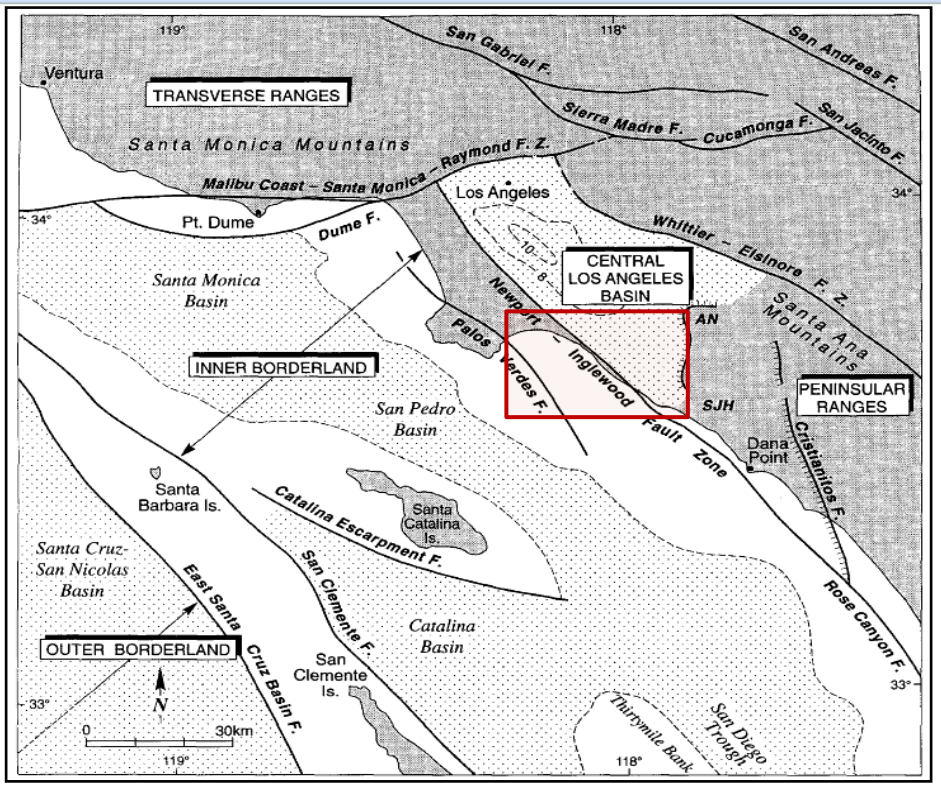
- **California Continental Borderland**: T-HBF tectonic history and implications on the PVFZ and NIFZ.
- **Earthquakes**: active faults within large restraining bends may pose potential hazards.
- **HC exploration**: timing and trapping mechanisms along T-HBF.

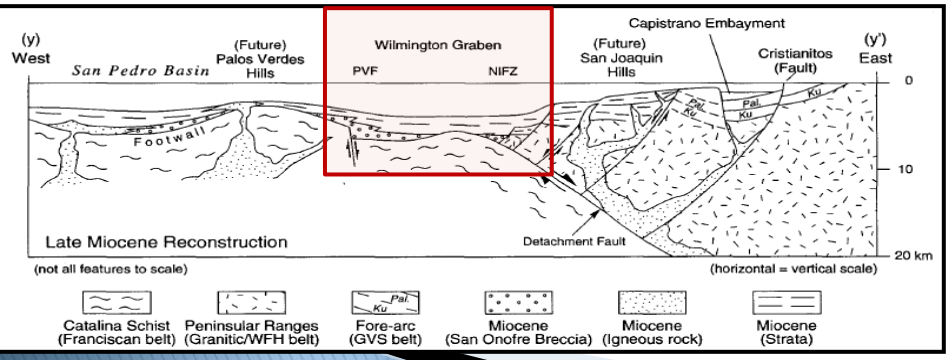
www.priweb.org

OBJECTIVES

- Detailed mapping of the THUMS-Huntington Beach Fault using 2D and 3D seismic and well data.
- Reconstruction of the T-HBF tectonic history.
- Estimation of the structural relation to neighboring faults (PVFZ and NIFZ).

REGIONAL CONTEXT





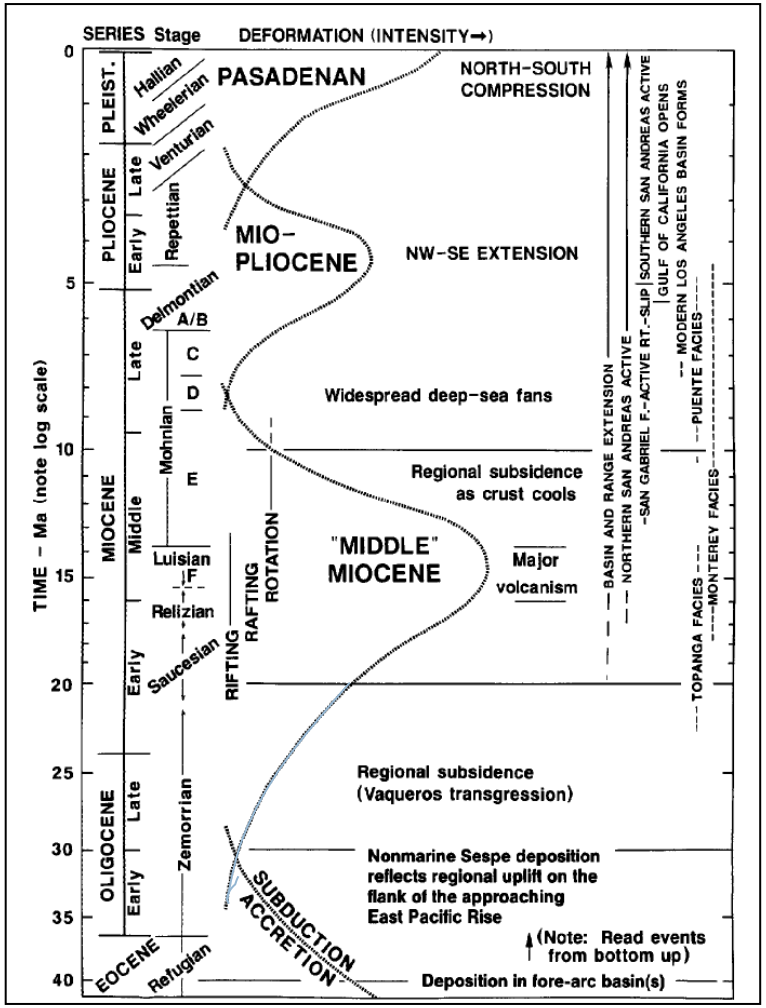
California Inner Borderland (CIB):

- series of N-NW-trending ridges and basins;
- unconformity between Catalina schist and Miocene strata;
- PVFZ, T-HBF, and NIFZ;
- San Pedro shelf;
- Wilmington Graben;
- Wilmington Anticline;
- Huntington Beach anticline.

Study area

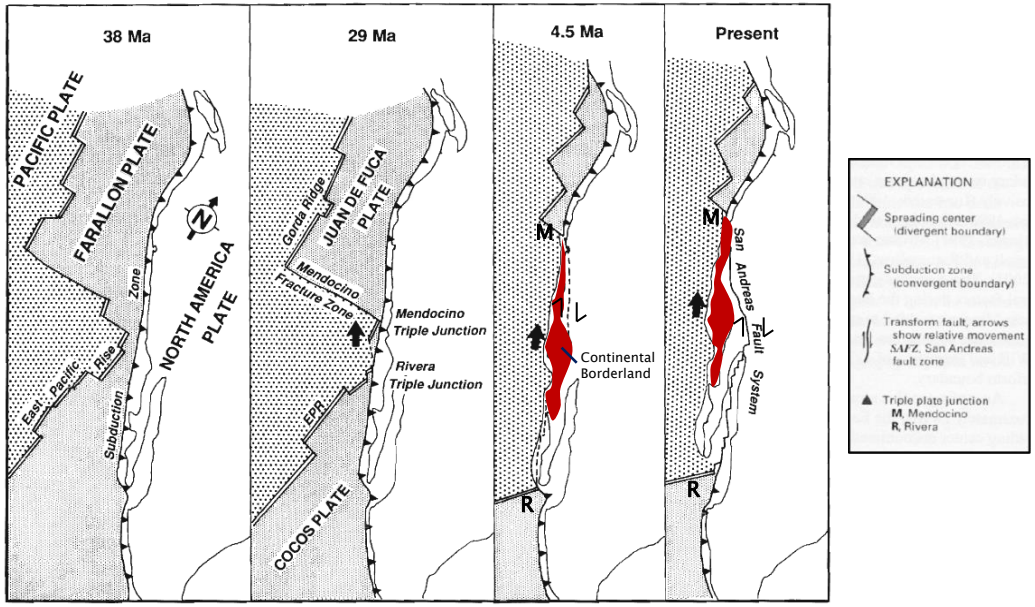
Crouch and Suppe (1993)

REGIONAL CONTEXT



Wright (1991)

- **Middle Oligocene**: subduction-transform, uplift, regression
- **Early Miocene**: rifting and rafting
- **Middle Miocene**: transrotation, major volcanism and subsidence
- **Mio-Pliocene**: transtension
- **Late Pliocene**: transpression

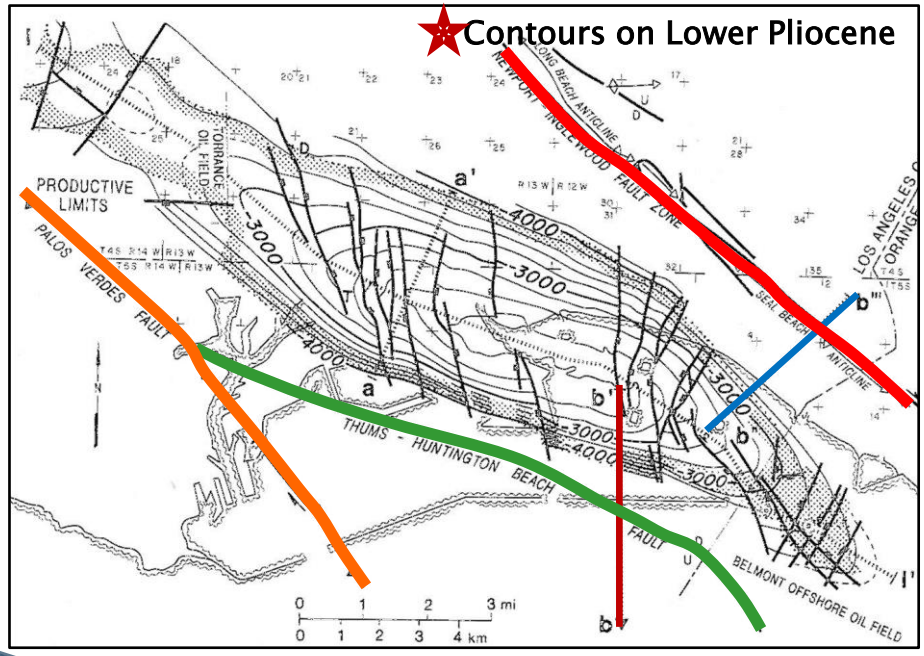


Legg (1991)

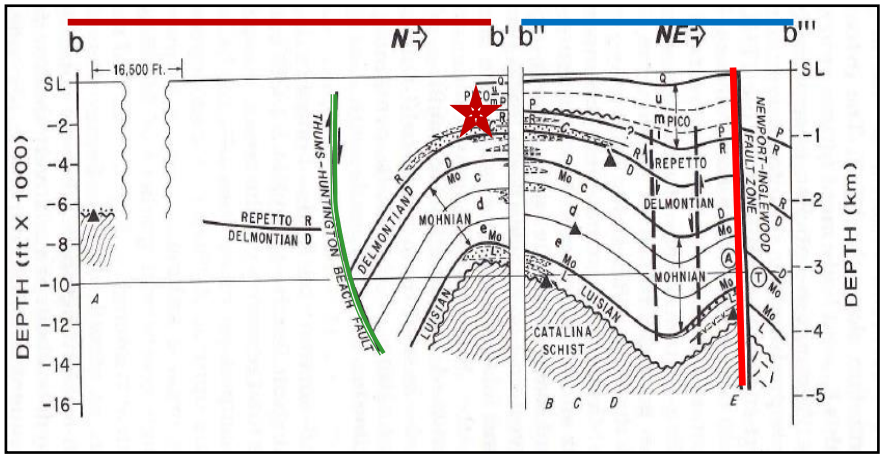
PREVIOUS INVESTIGATIONS

Truex (1974) and Wright (1991):

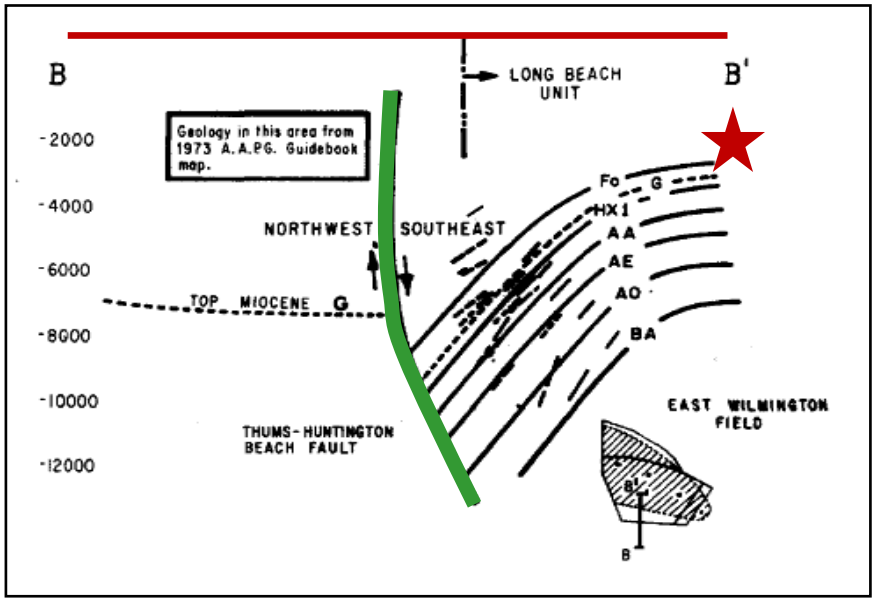
- a high-angle normal fault;
- dips NE into the Wilmington Anticline;
- T-HBF converges with NIFZ (south of Huntington Beach)?



Wright (1991)

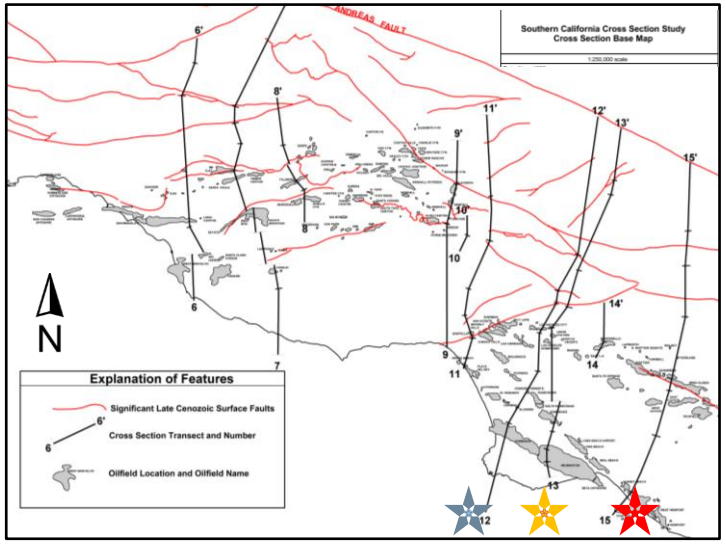


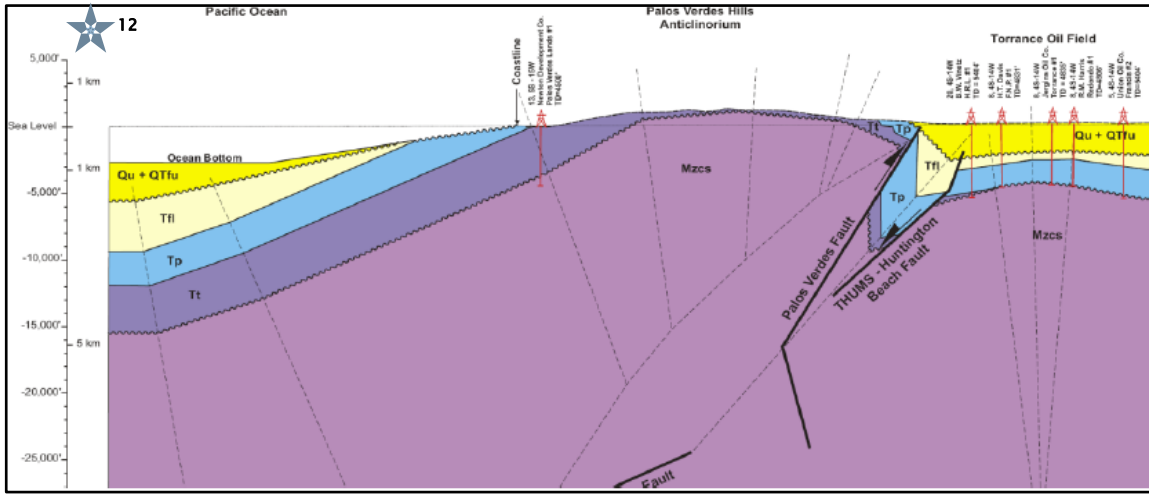
Wright (1991)

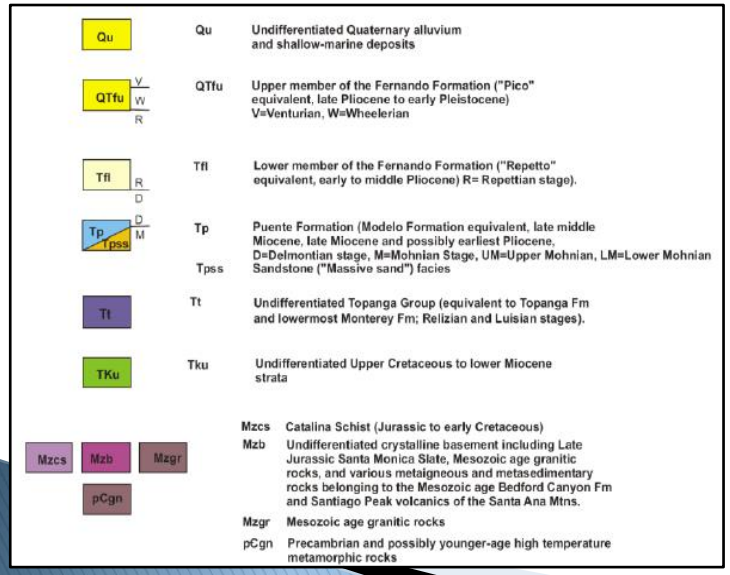


Truex (1974)

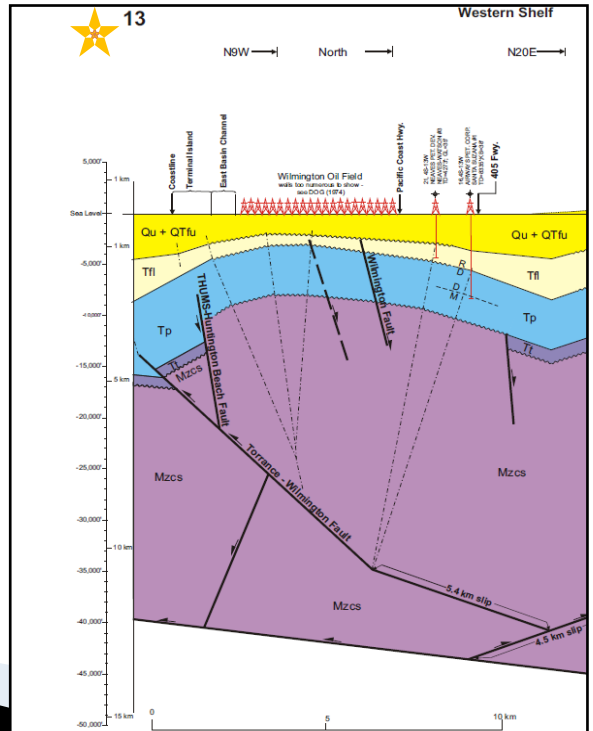
PREVIOUS INVESTIGATIONS

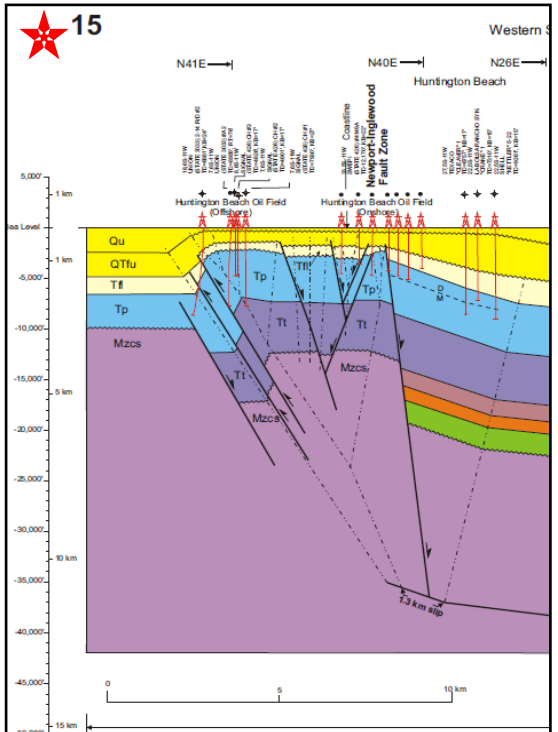






Davis and Namson (1998)

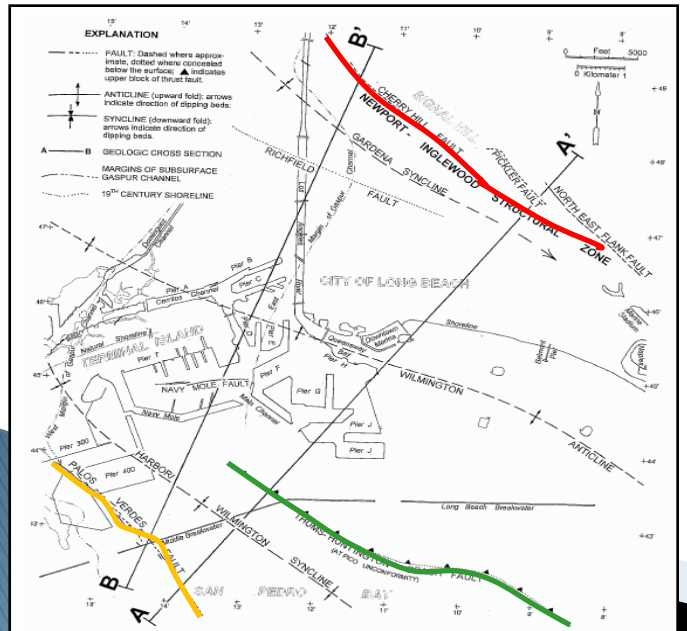


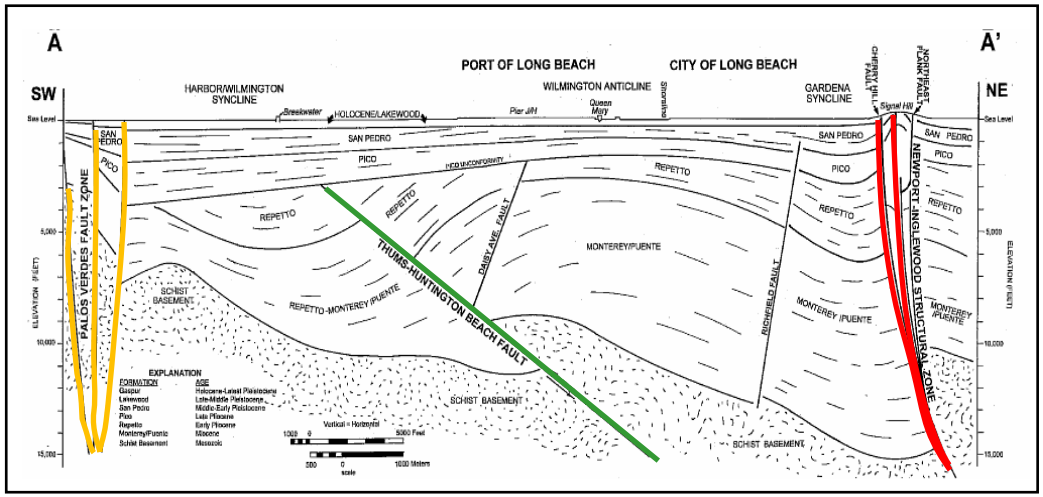


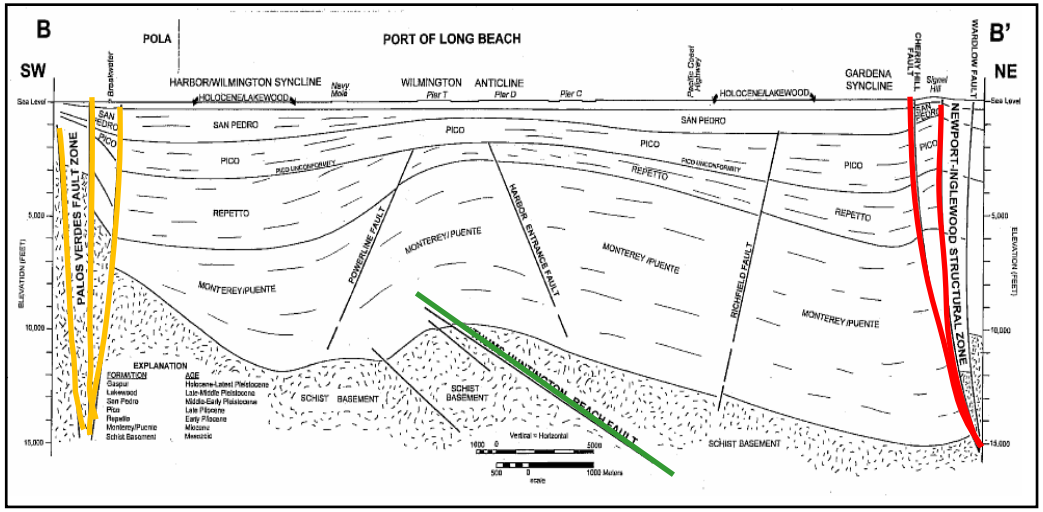
PREVIOUS INVESTIGATIONS

Earth Mechanics Report:

- T-HBF: a low-angle thrust fault;
- Displacement of Catalina schist basement (A-A');
- Displacement decreases to NW and T-HBF dies out in the western area of the Long Beach Harbor, with no basement offset (B-B');
- No evidence for convergence with PVFZ and/or NIFZ.



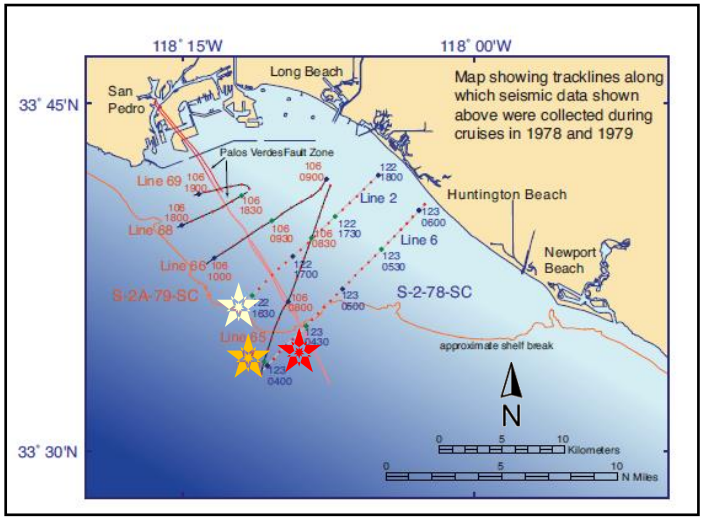


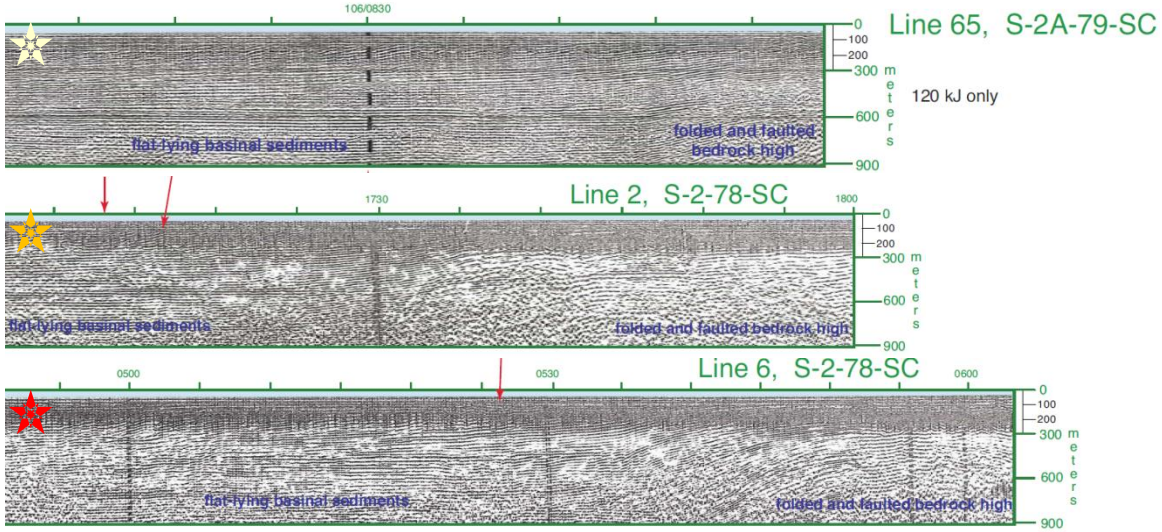


Earth Mechanics Inc. report (2006)

PREVIOUS INVESTIGATIONS

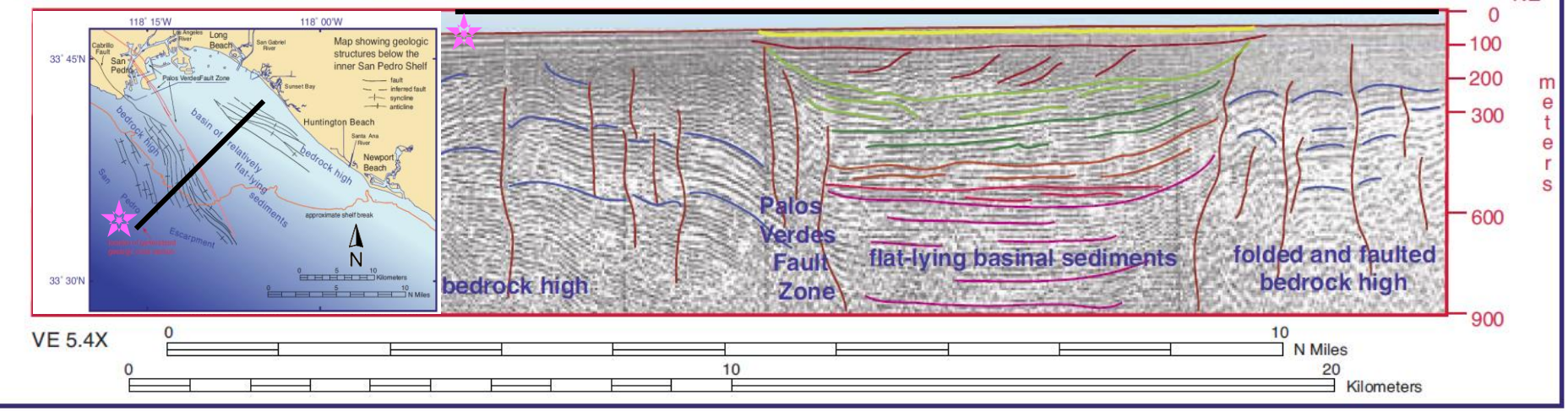
USGS Geologic and bathymetric reconnaissance overview of the San Pedro shelf region





Wolf et al (2004)

Representative northeast/southwest seismic/geologic cross-section showing bedrock highs near- and offshore separated by a basin filled with multiple sequences of sedimentary deposits which are generally flat-lying. A thin veneer of unconsolidated(?) sediment (yellow) overlies the basin fill.



METHODS AND TECHNIQUES

2D and 3D seismic interpretation

+

New 2D seismic data collection

+

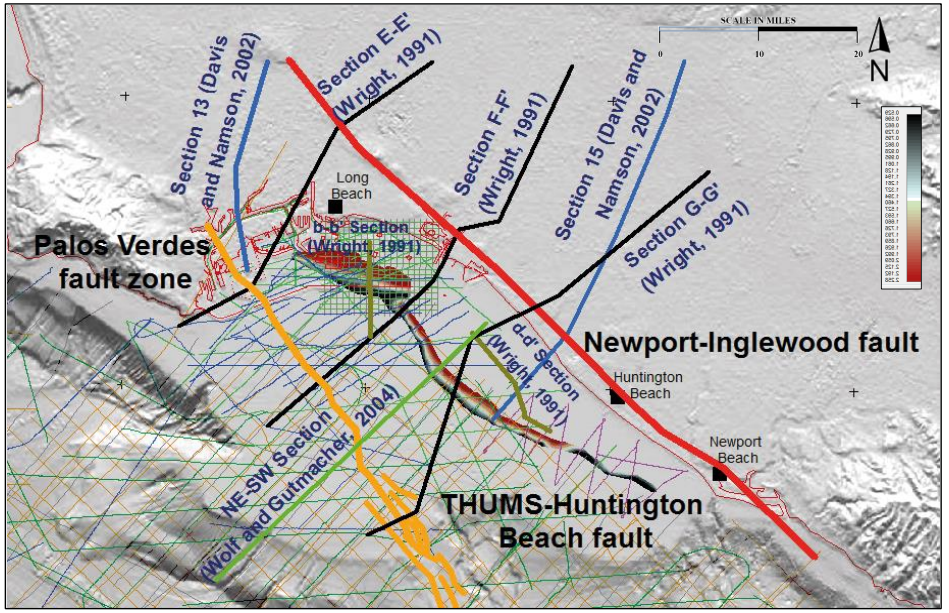
Well logs correlation (DOGGR)

+

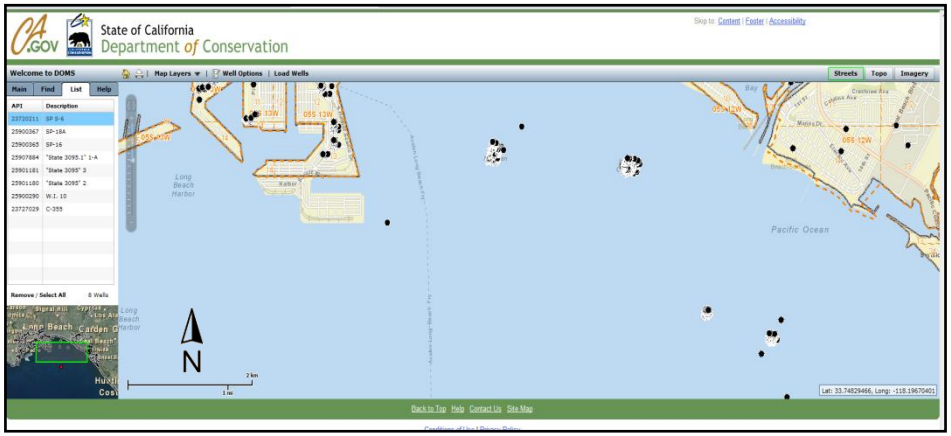
Seismic and well tie

↓

Structural and tectonic framework



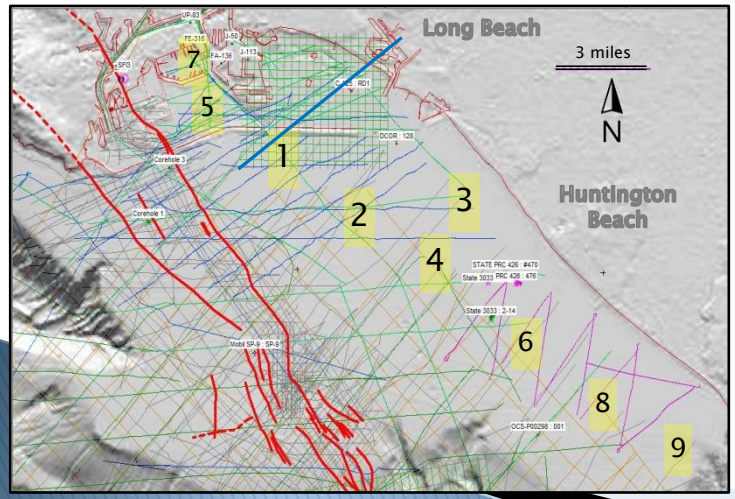
Base map from Kingdom project



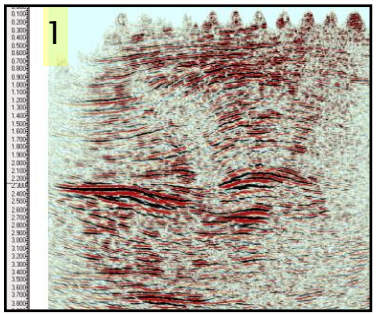
www.conservation.ca.gov/dog

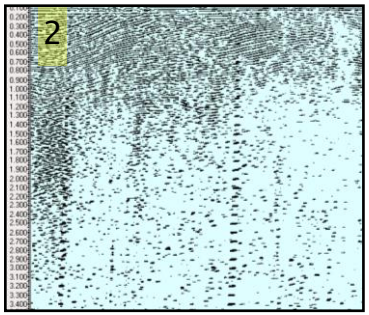
SEISMIC DATA

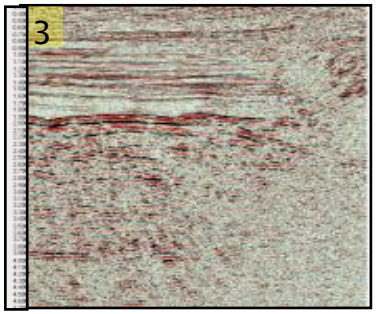
#	Survey details	Source, receiver	Year	Data type
1	THUMS 3D	4 patches (1232-1372 receivers)	1995	digital, SEGY
2	USGS Oil City (O-1-69 SC)	30-100 kJ sparker, single channel	1969	paper
3	CSULB	2kJ sparker, 16 channels	2009	digital, SEGY
4	WesternGeco (W-30-81-SC)	Airgun, 96 channels	1982	digital, SEGY
5	USGS (E-1-01 SC)	airgun, 24 channels	2001	digital, SEGY
6	CSULB	2kJ sparker, 16 channels	2012	digital, SEGY
7	USGS (A-1-00 SC)	1.5kJ minisparker, 24 channels	2000	digital, SEGY
8	WesternGeco (W-5-82-SC)	Airgun, 120 channels	1982	digital, SEGY
9	USGS Kelez (K-2-73 SC)	Airgun, uniboom, single channel	1973	paper

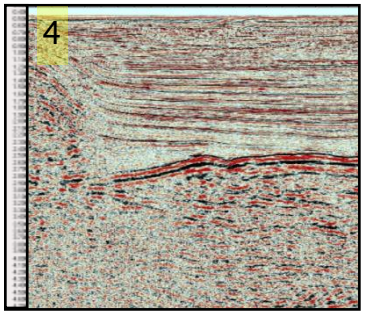


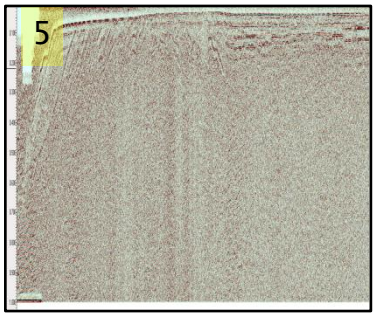
Base map from Kingdom project

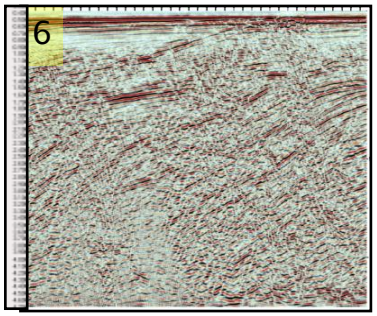


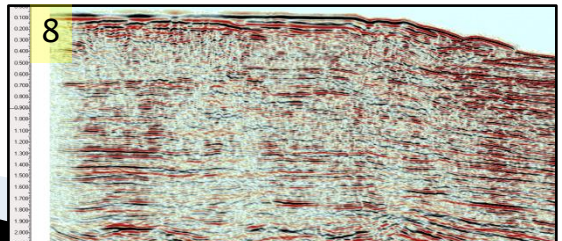


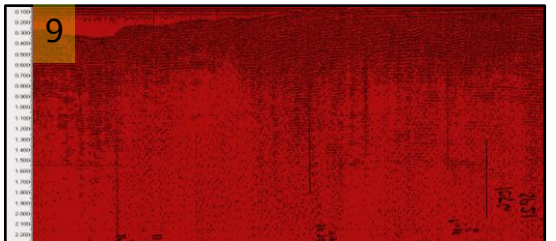




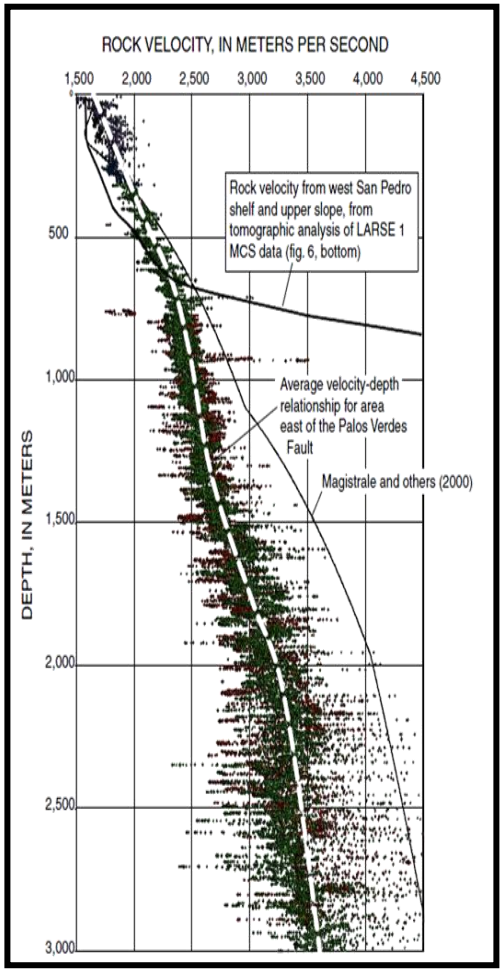




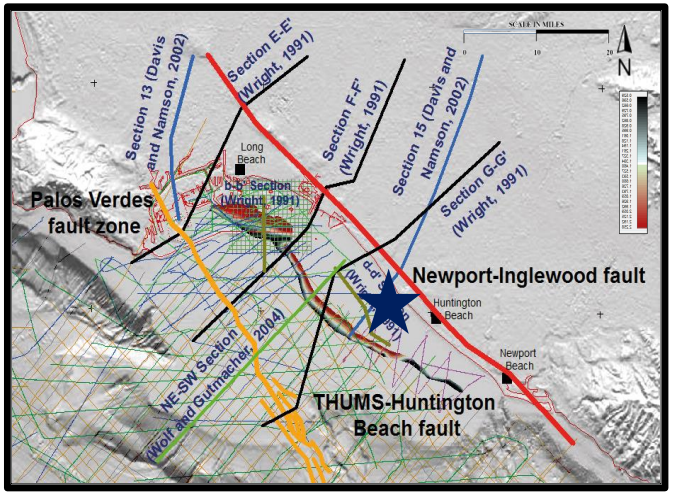


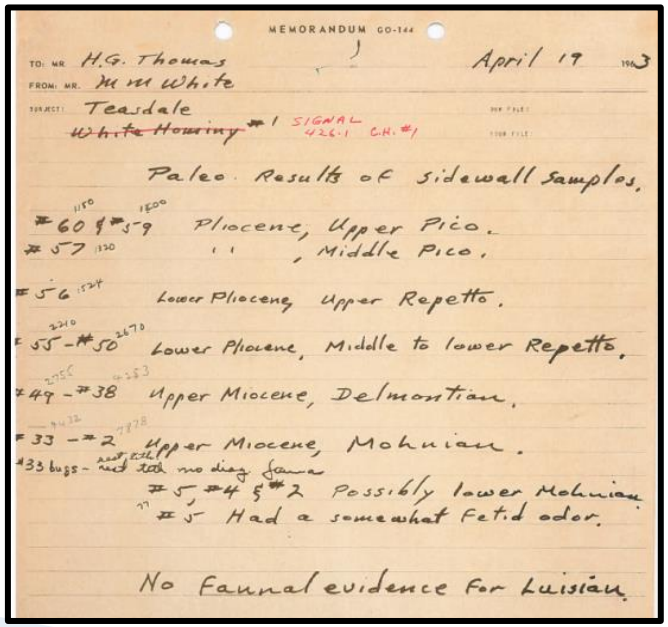


WELL CORRELATION



Fisher et al. (2004)



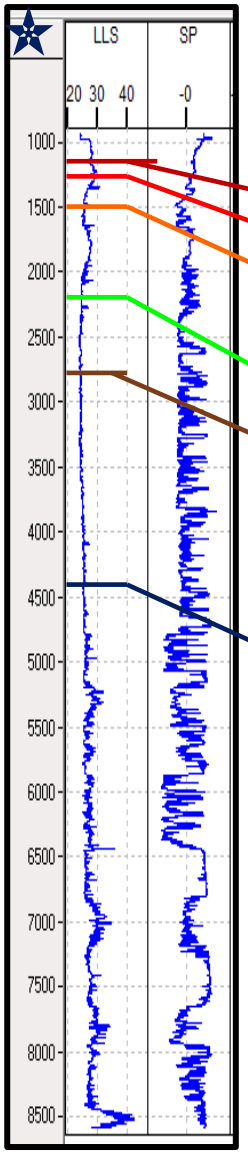

MEMORANDUM GO-744

TO: MR. H.G. Thomas
FROM: MR. M M White
SUBJECT: Teasdale
~~White Houring~~ #1 SIGNAL 426-1 C.H. #1
April 19 1963

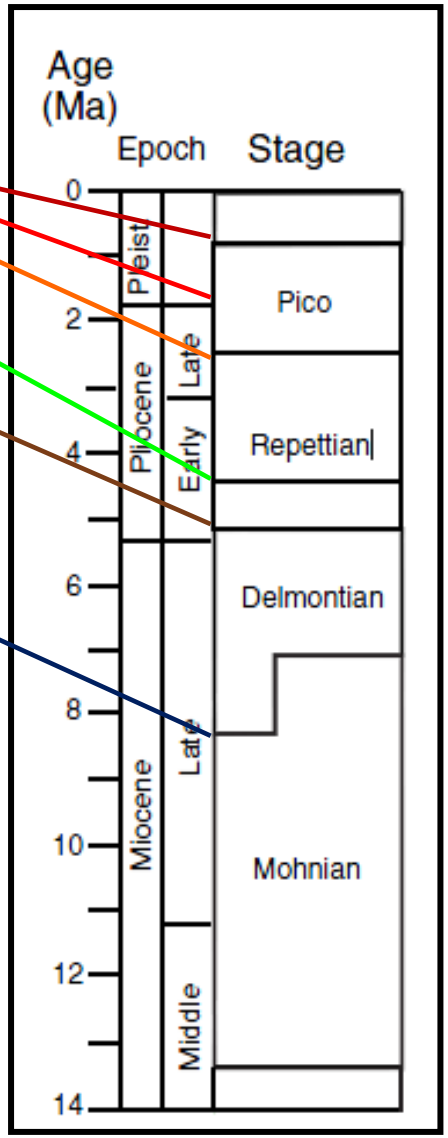
Paleo Results of sidewall samples,

#60 (1150) & #59 (1500) Pliocene, Upper Pico.
#57 (1330) " , Middle Pico.
#56 (1524) Lower Pliocene, Upper Repetto.
#55 (2210) - #50 (2470) Lower Pliocene, Middle to lower Repetto.
#49 (2750) - #38 (3253) Upper Miocene, Delmontian.
#33 (3432) - #2 (7778) Upper Miocene, Mohnian.
#33 bugs - not tab no diag fauna
#5, #4 & #2 Possibly lower Mohnian.
#5 Had a somewhat fetid odor.

No Faunal evidence for Luisian.

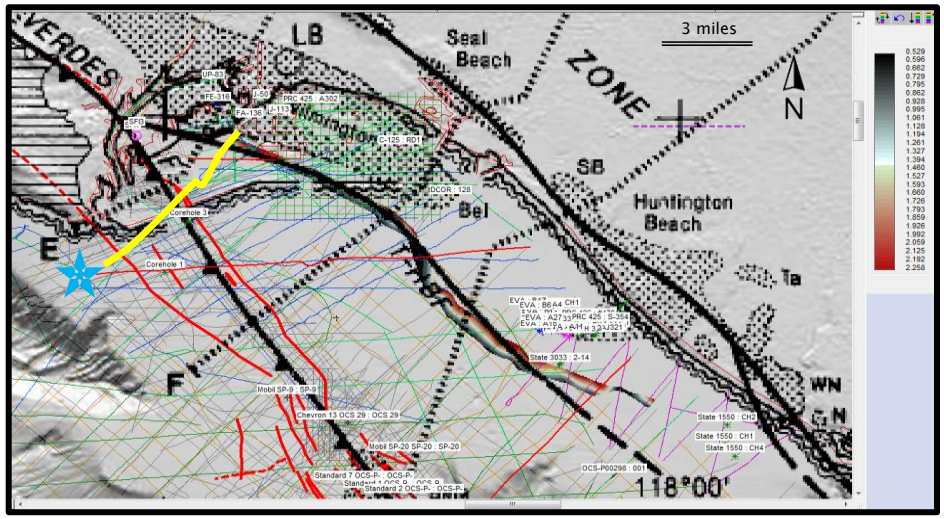


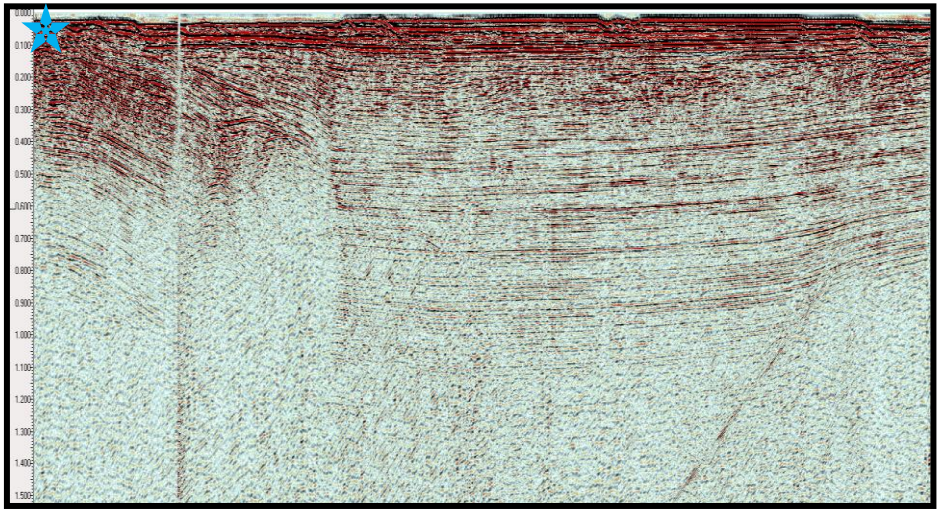
PRC 426 CH1

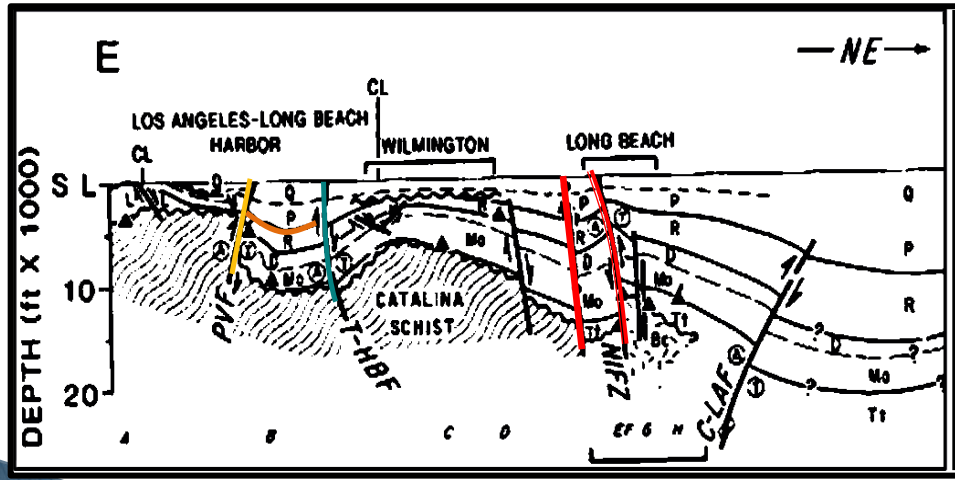


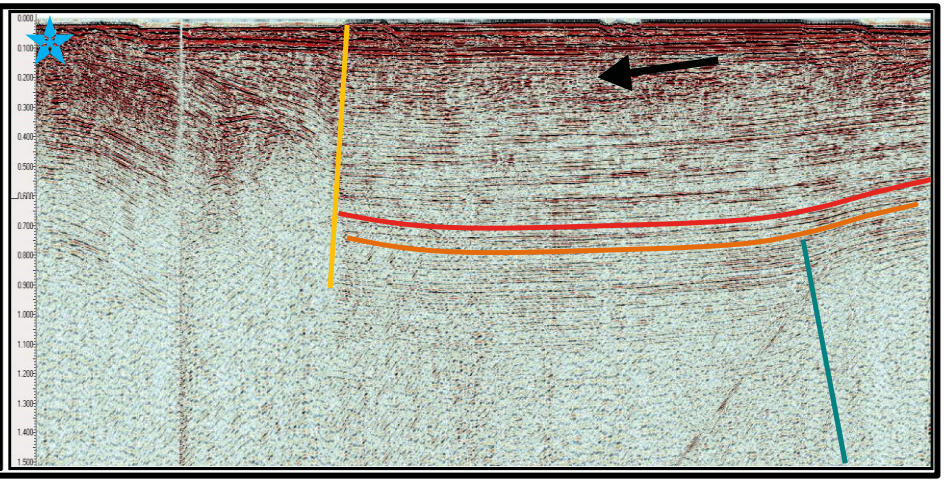
Fisher et al. (2004)

SEISMIC INTERPRETATION







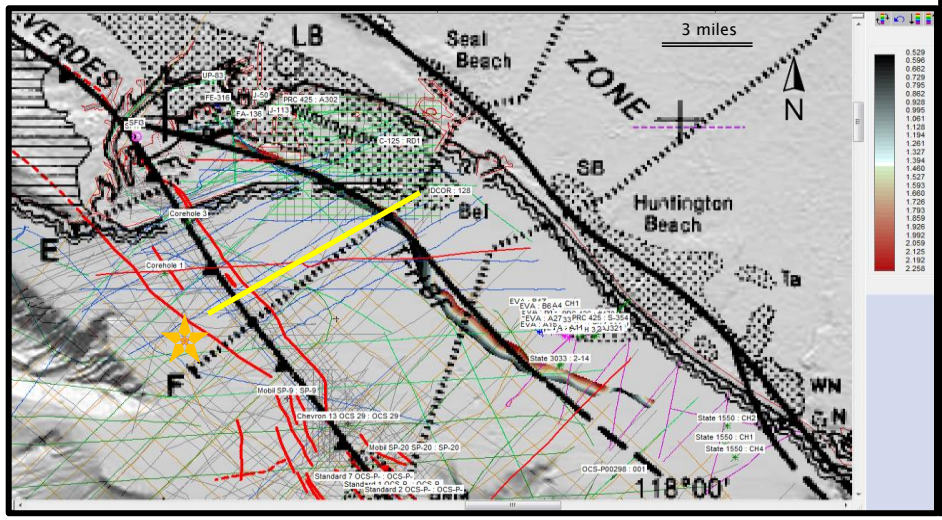


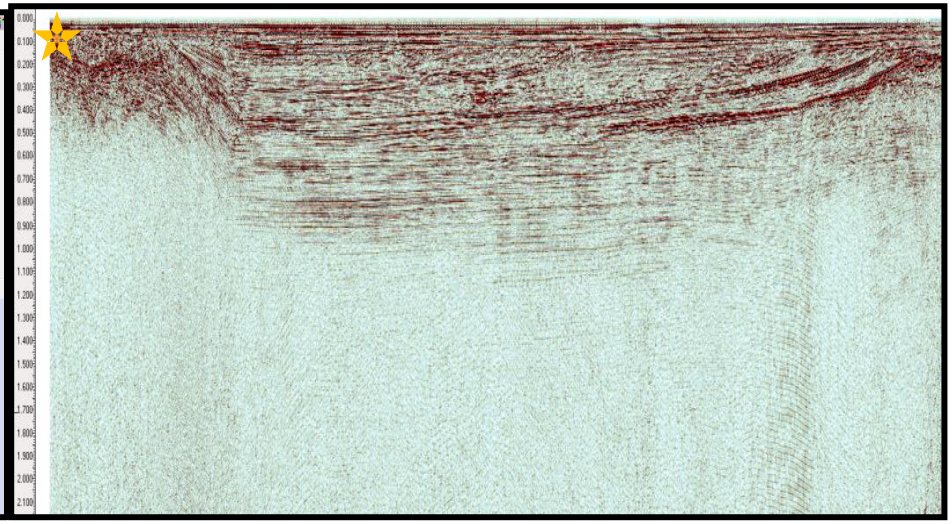
Wright (1991)

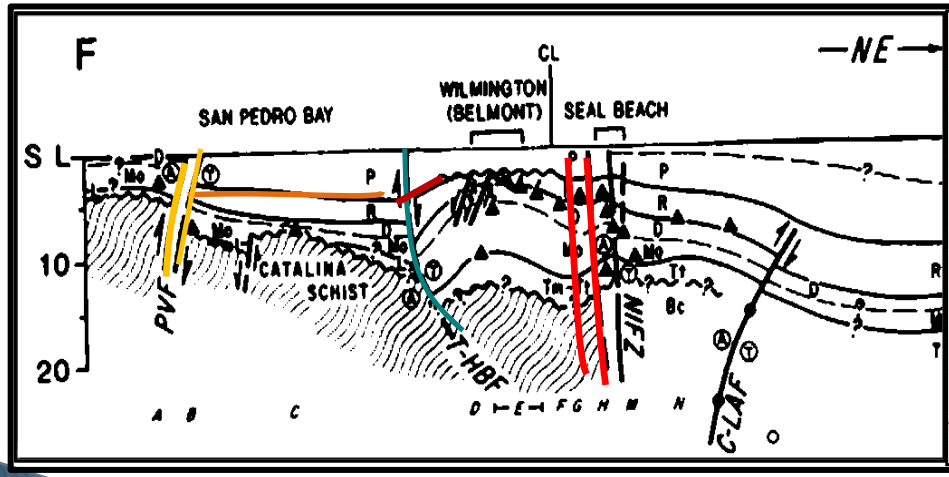
- Pico Formation
- Repetto Formation

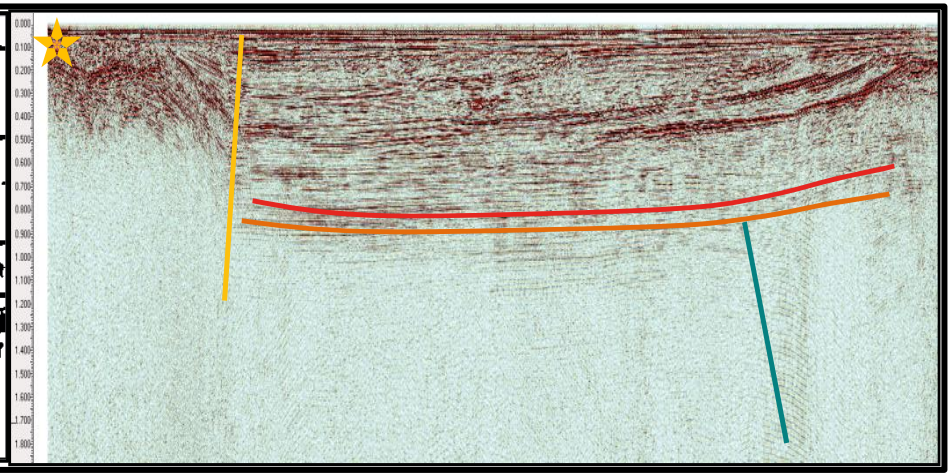
- PVF
- T-HBF
- NIFZ

SEISMIC INTERPRETATION









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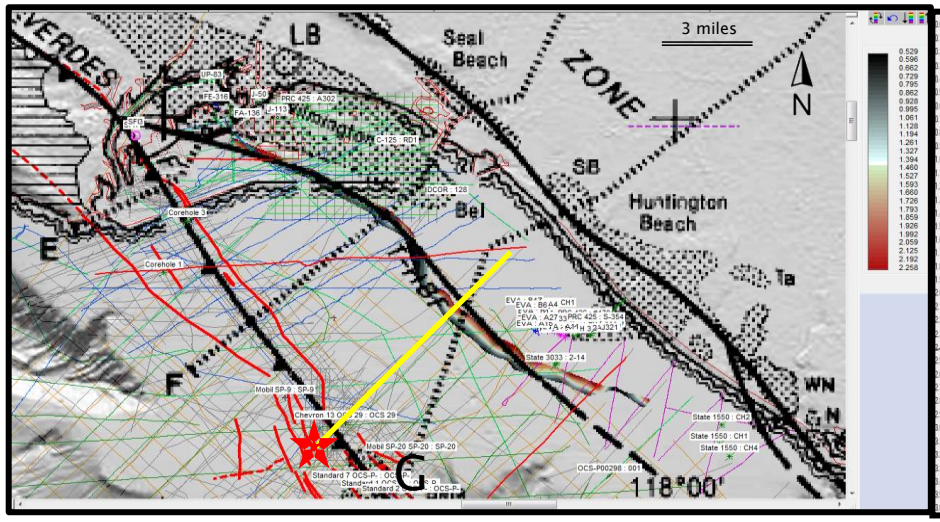
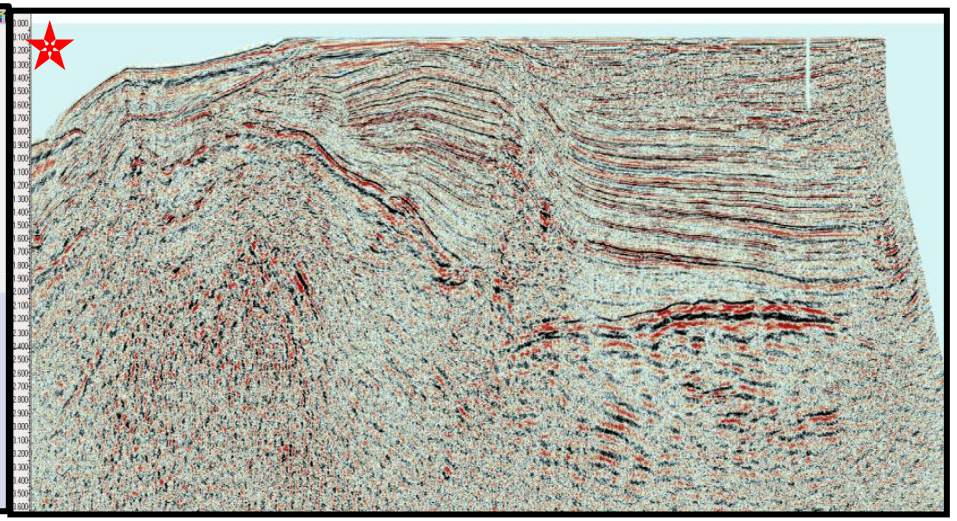
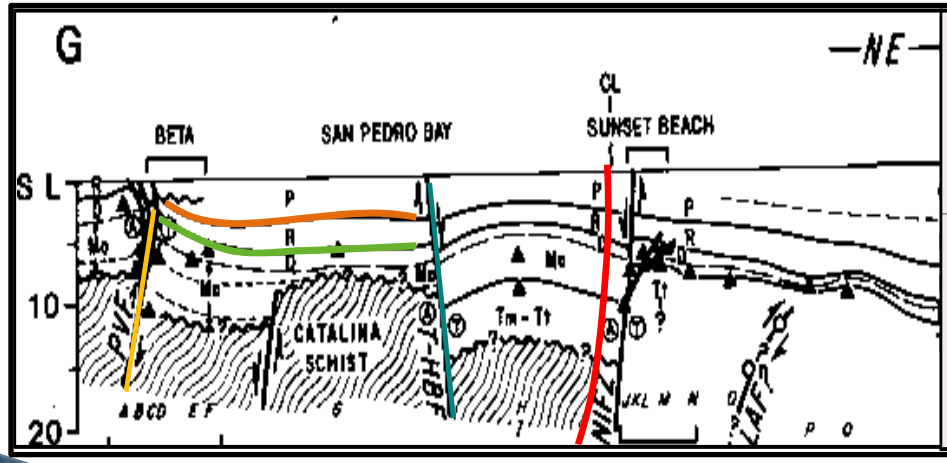
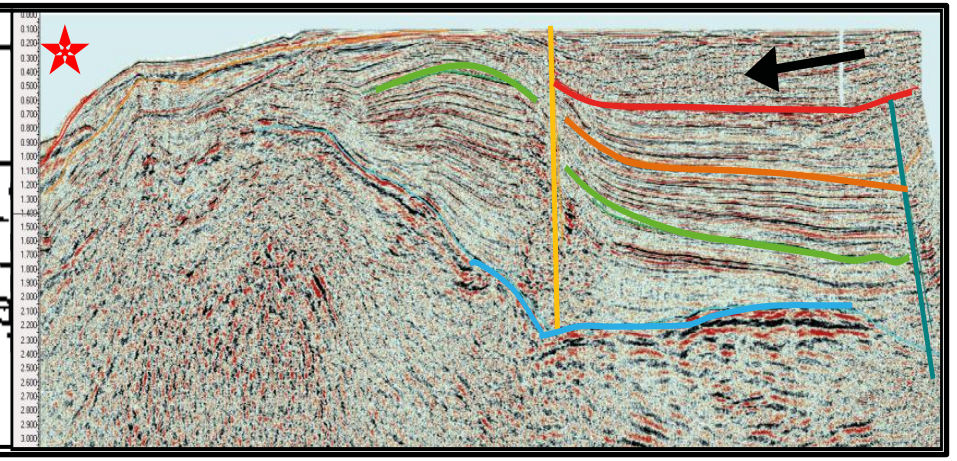
SEISMIC INTERPRETATION





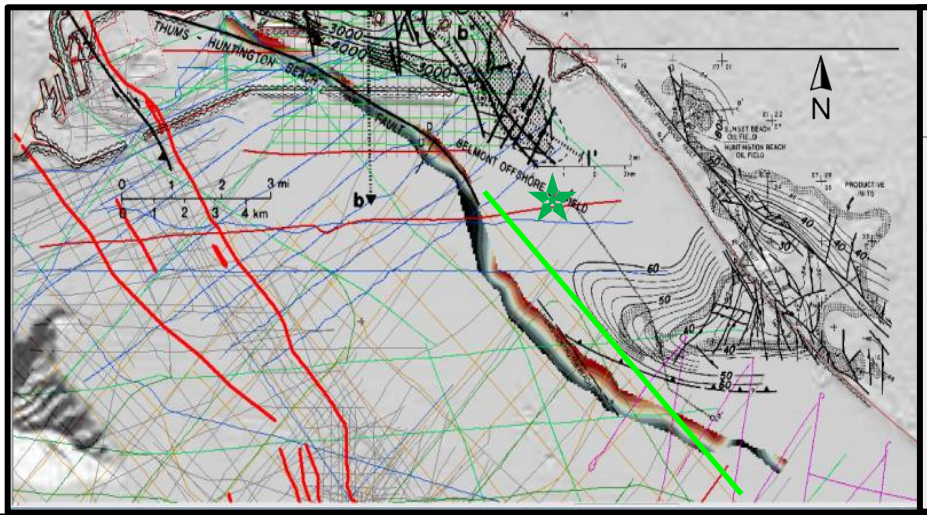


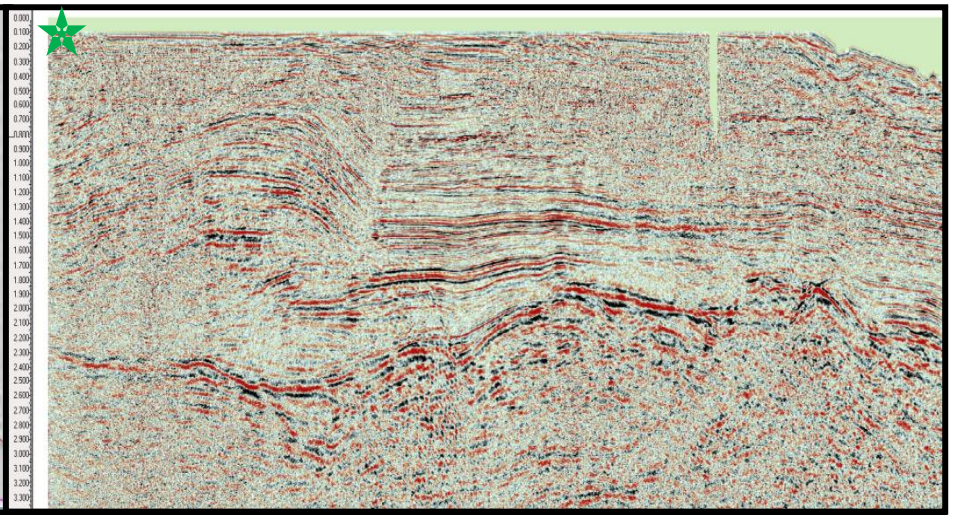


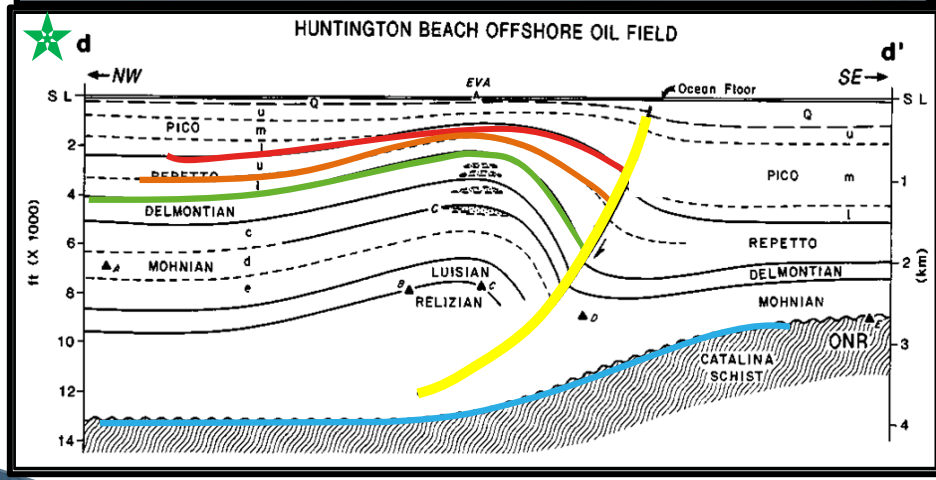
Wright (1991)

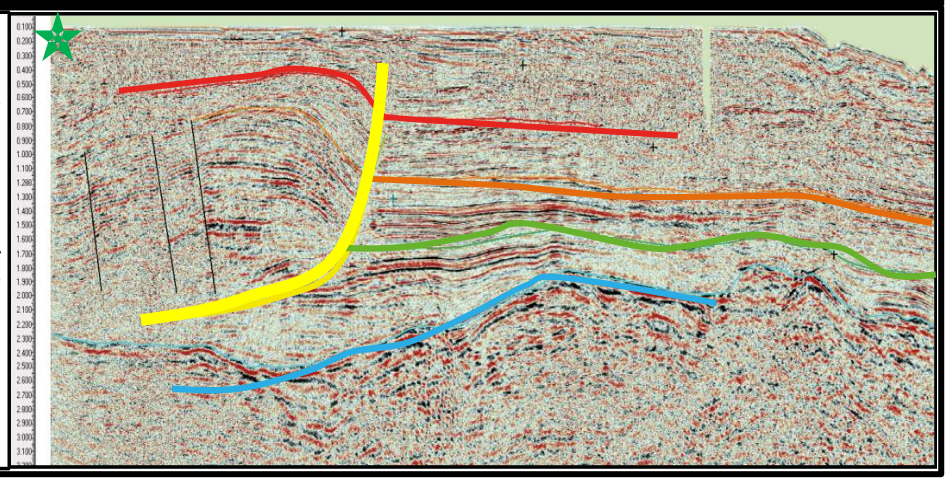
- Pico Formation
- Repetto Formation
- Catalina schist
- PVF
- T-HBF
- NIFZ

SEISMIC INTERPRETATION





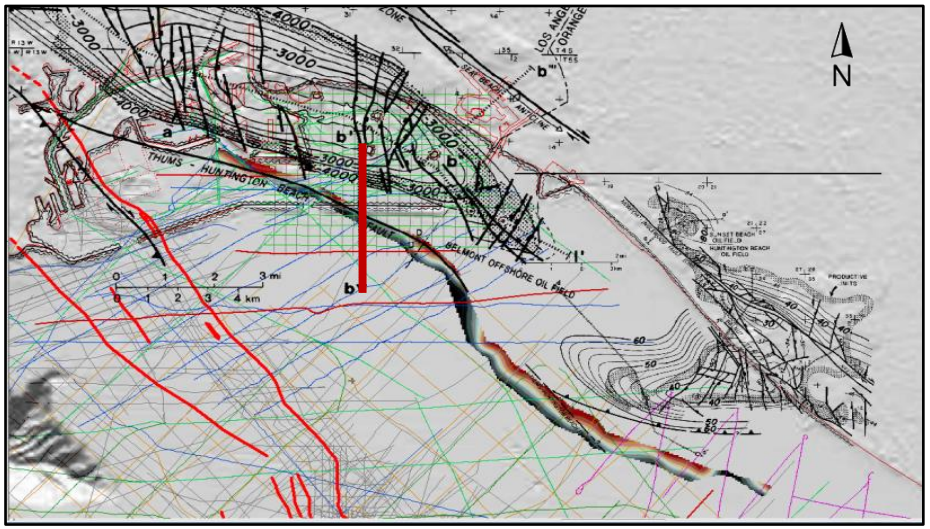


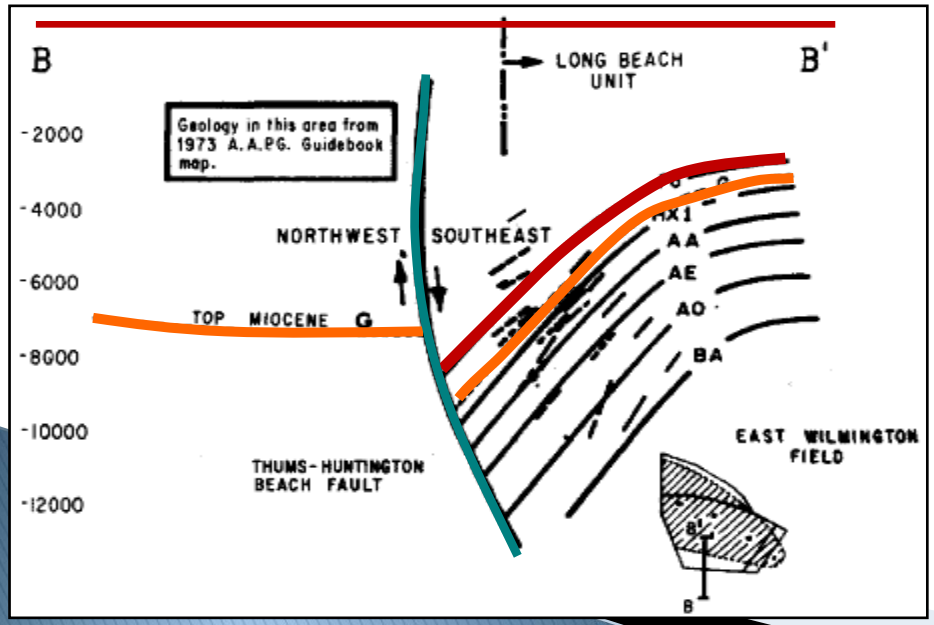


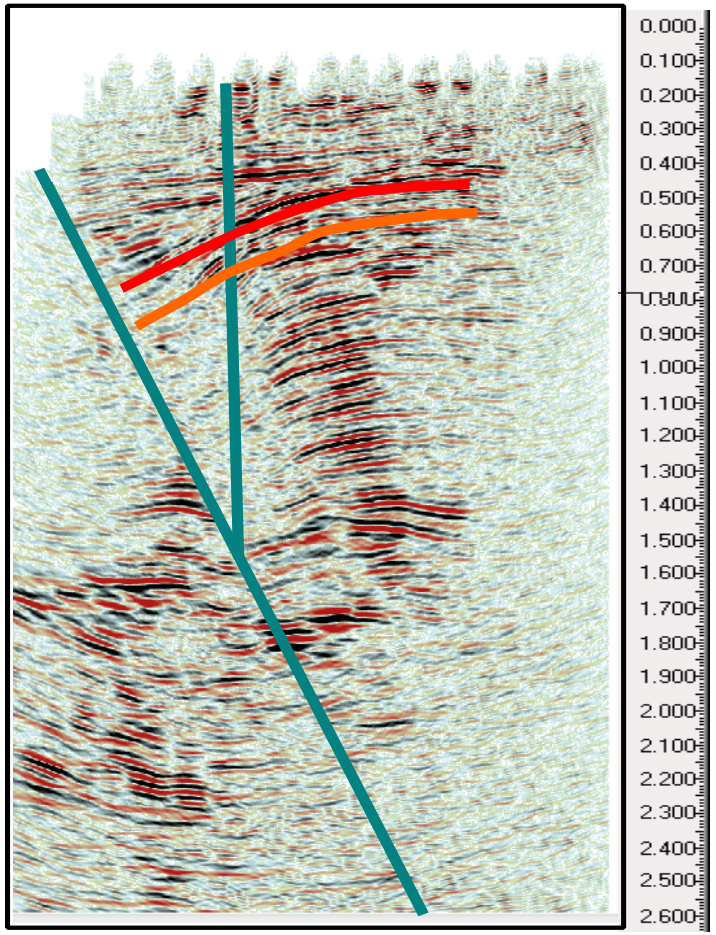
Wright (1991)

- Pico Formation
- Repetto Formation
- Catalina schist
- T-HBF splay

SEISMIC INTERPRETATION







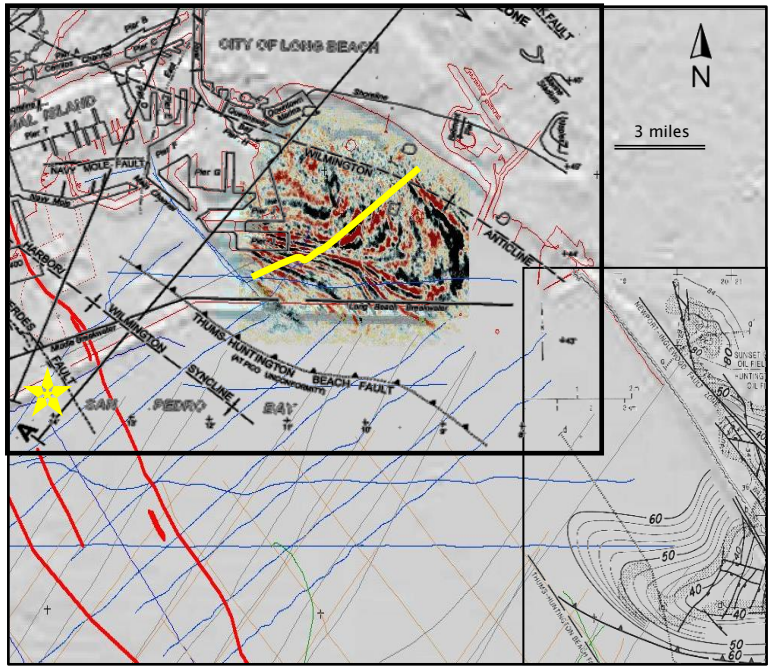
Truex (1974)

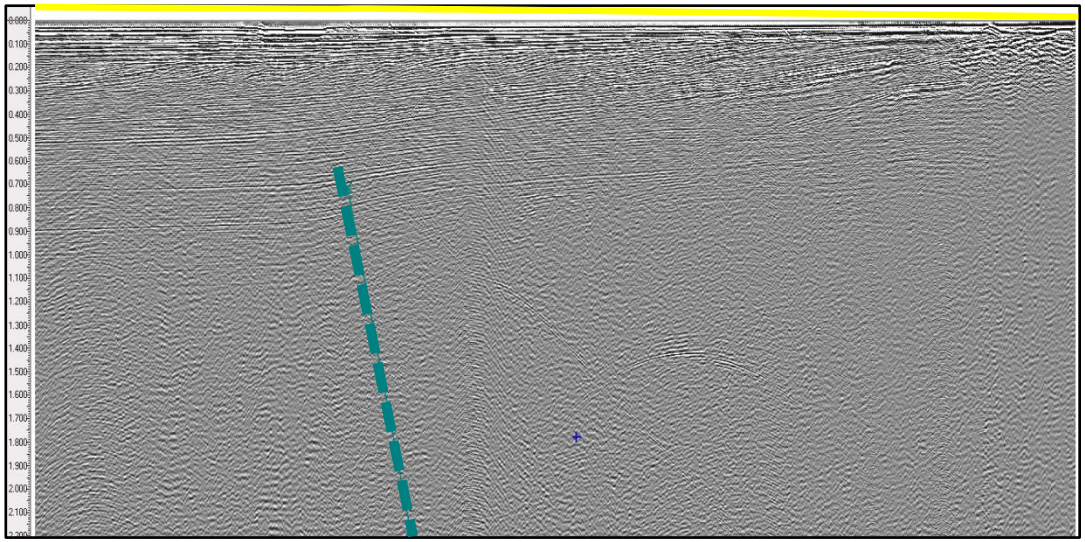
T-HBF

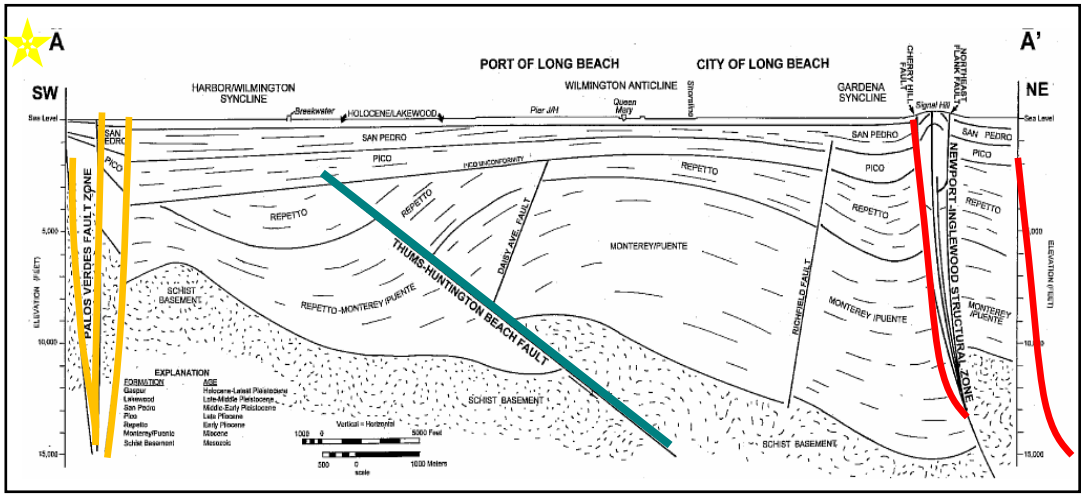
Pico Formation

Repetto Formation

SEISMIC INTERPRETATION







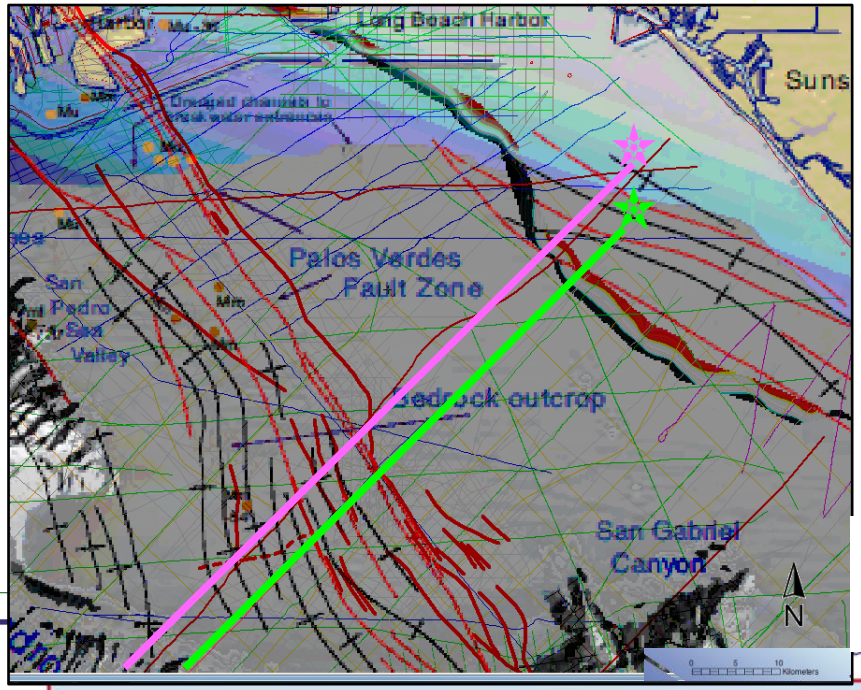
- Shallow penetration of seismic – problems with interpretation.
- The upper tip of T-HBF at Pico Formaton.
- Evidence for basement rocks offset.

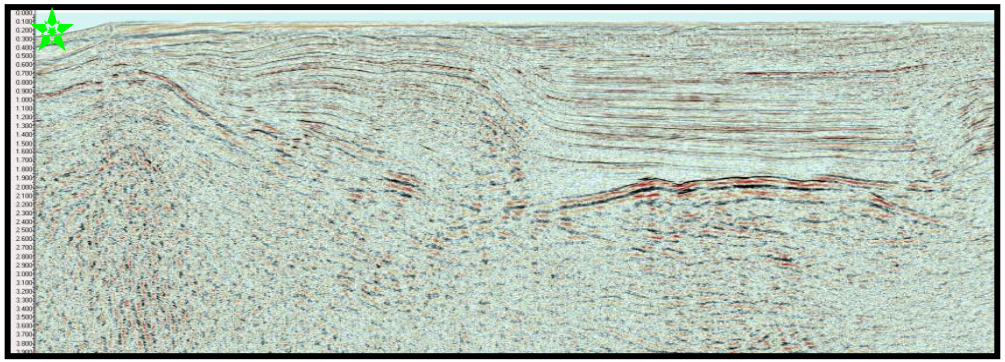
PVF
T-HBF
NIFZ

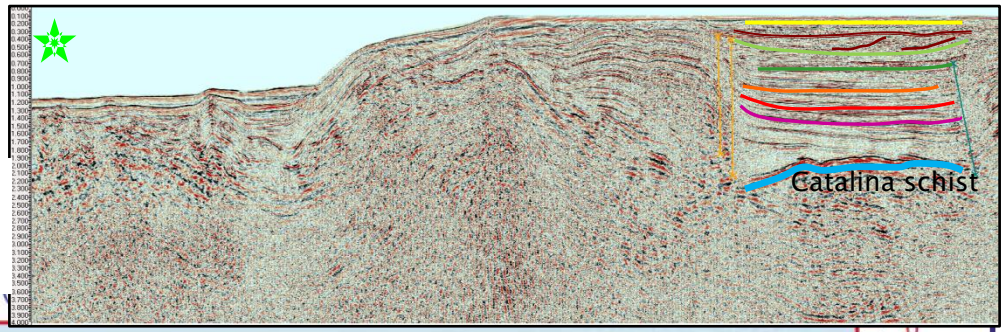
Earth Mechanics Inc. report (2006)

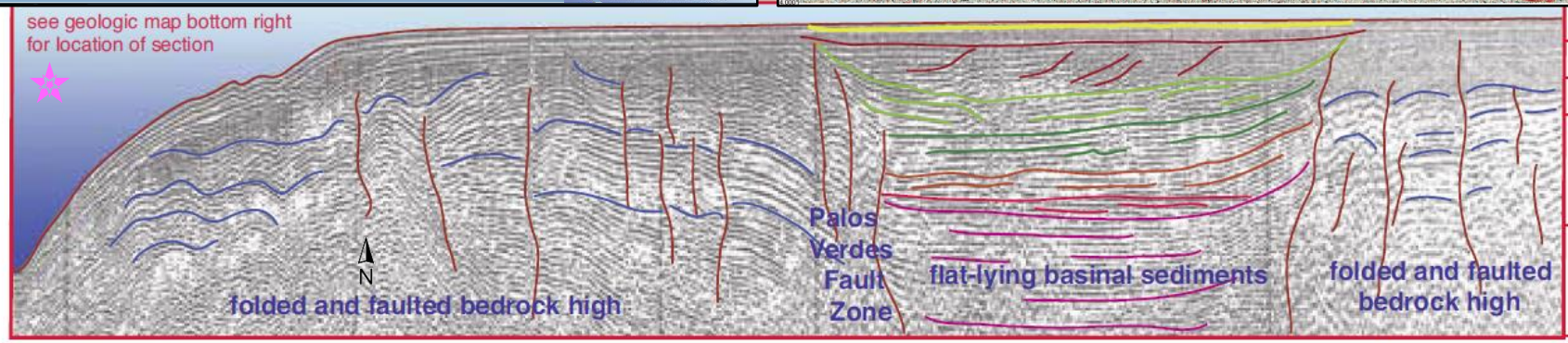
SEISMIC INTERPRETATION

USGS Geologic and bathymetric reconnaissance overview of the San Pedro shelf region



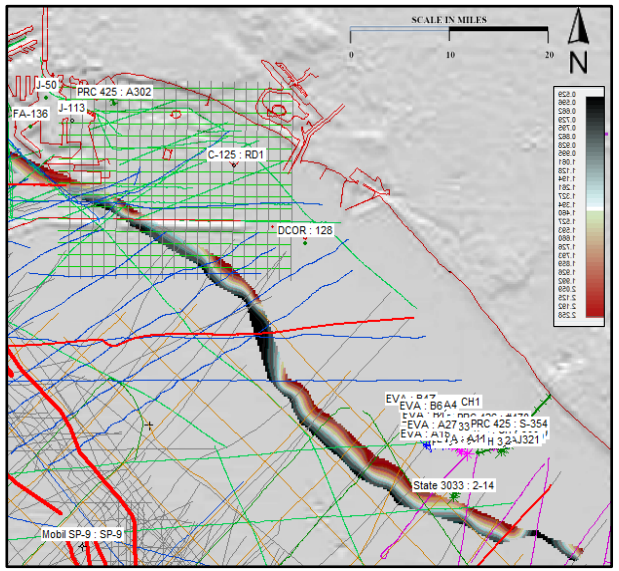


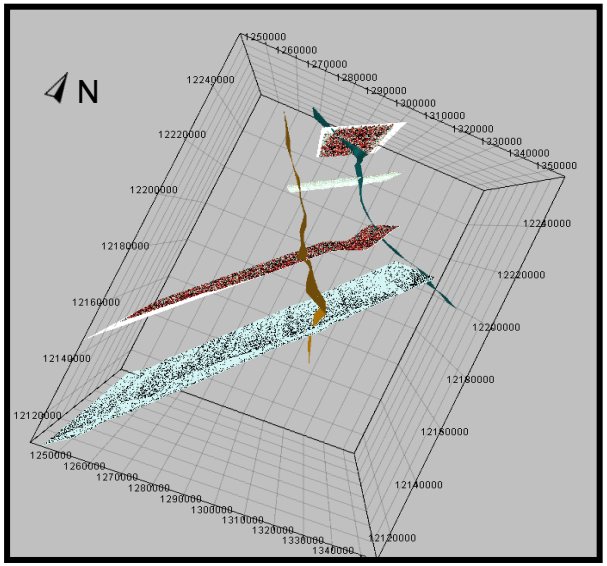


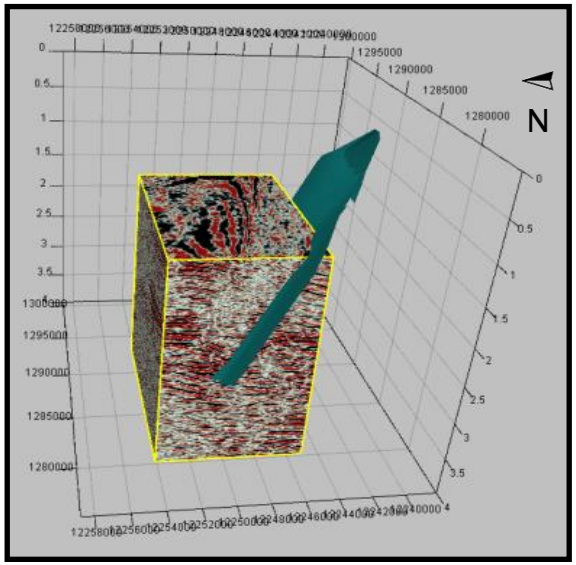


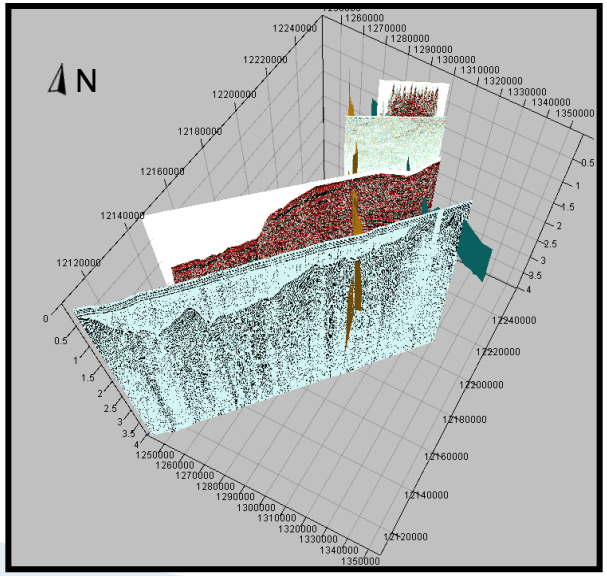
Wolf et al (2004)

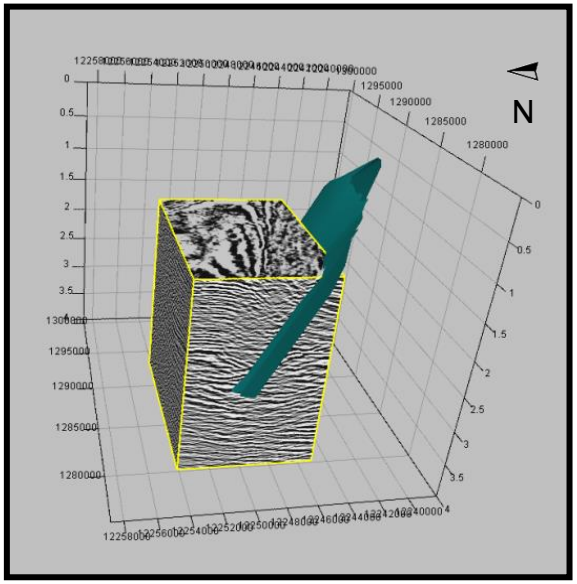
SEISMIC INTERPRETATION







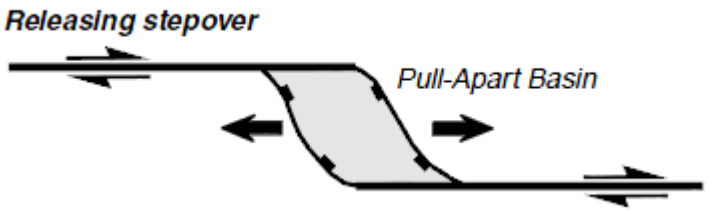




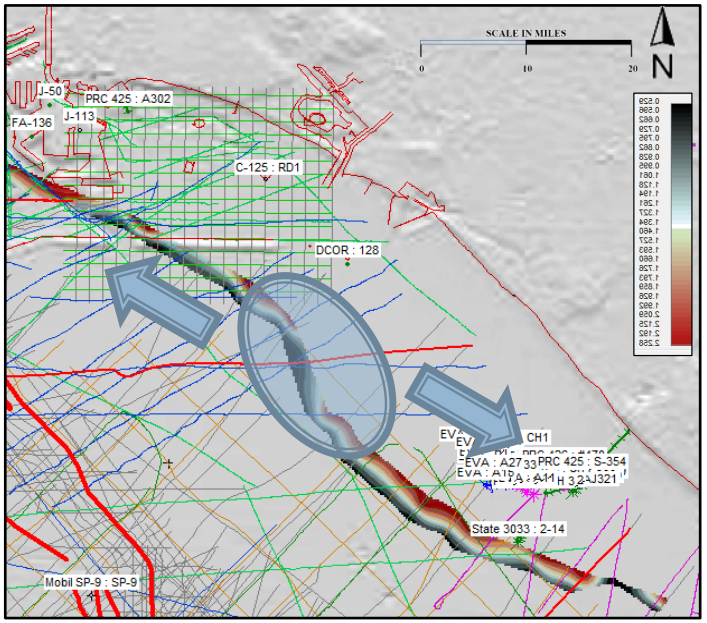
- Fault surfaces in 3D cube, Kingdom suite.

PVF
T-HBF

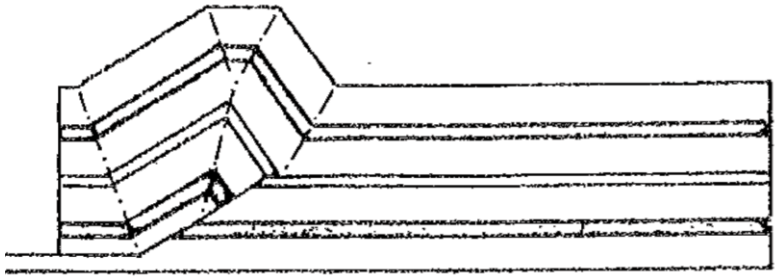
T-HBF MODELS



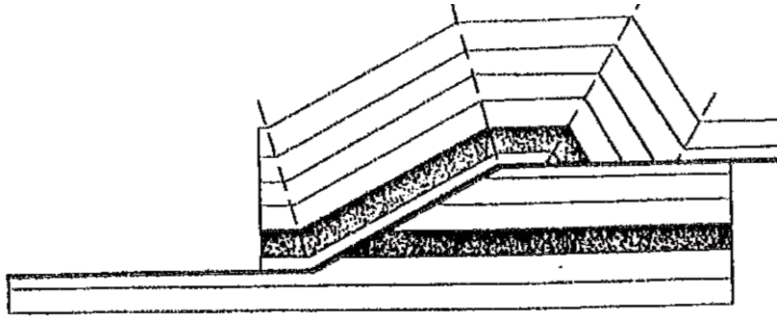
Right-stepping right-lateral strike-slip fault



McClay (2002)

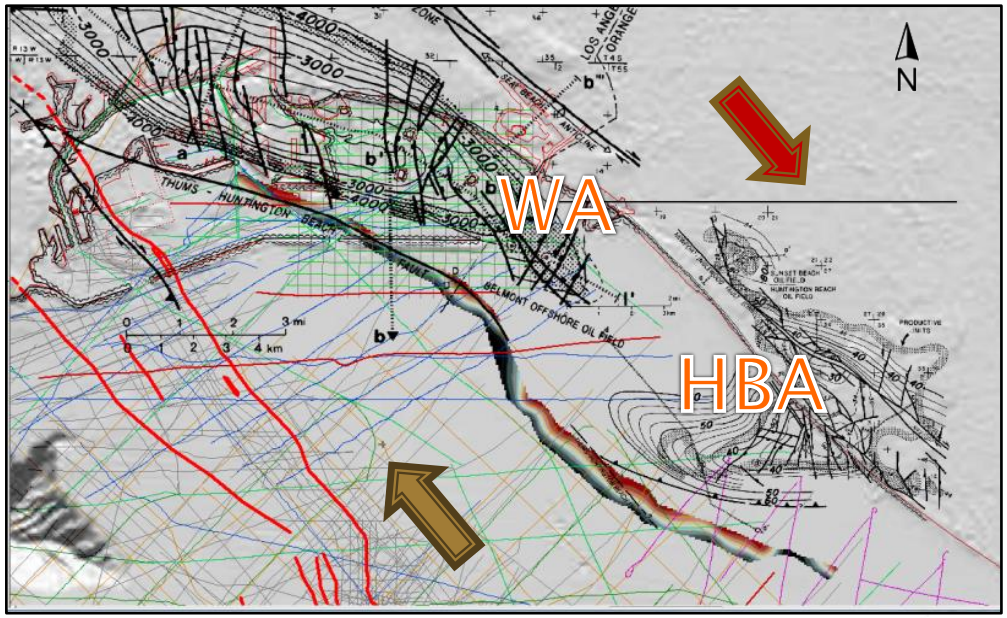


Fault propagation fold



Fault bend fold

T-HBF MODELS

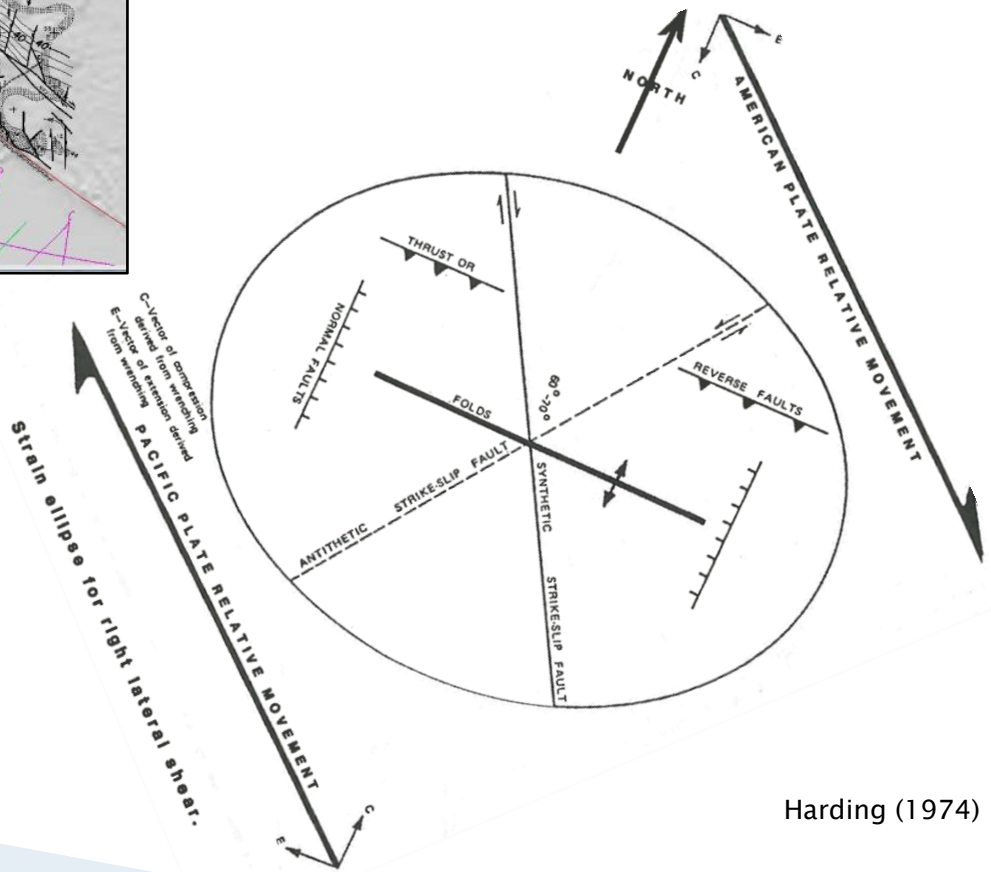


North American plate relative motion

Pacific plate relative motion

WA Wilmington Anticline

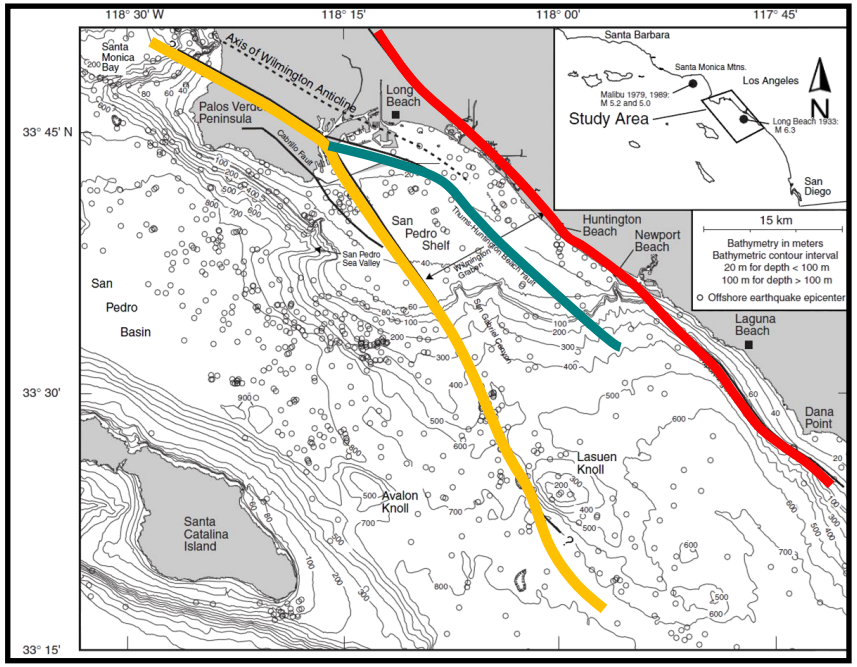
HBA Huntington Beach anticline



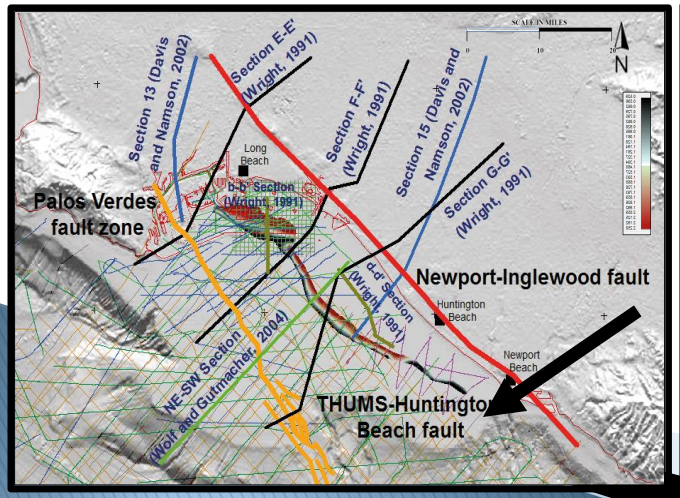
Harding (1974)

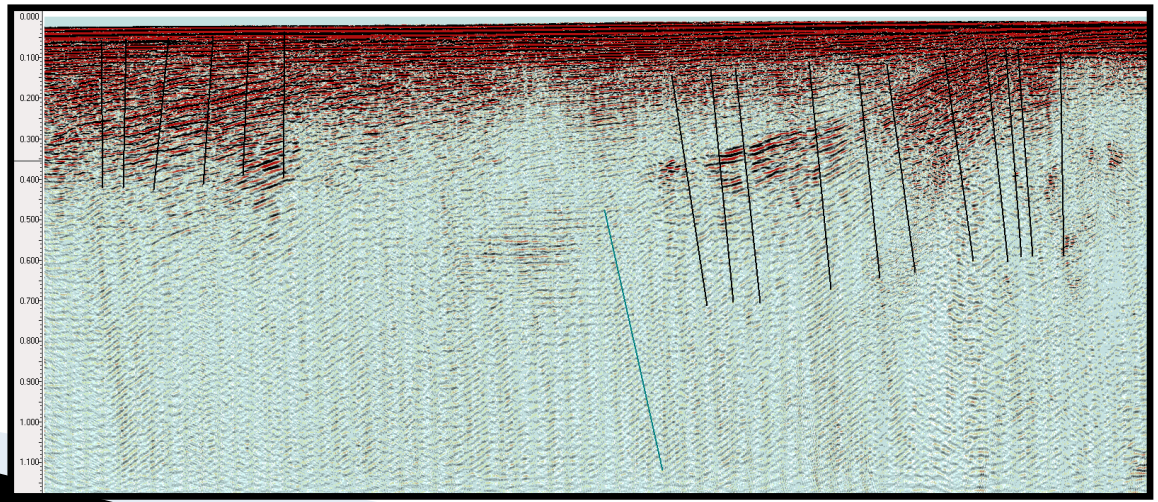
FUTURE RESEARCH

- Reprocessing of seismic data to attenuate noise.
- Acquiring more well and seismic data to refine deep stratigraphy and T-HBF offset.
- PVFZ, NIFZ, and THBF: timing and trapping mechanisms in the neighboring oil fields.
- Earthquakes studies.



Fisher et al. (2004)





THANK YOU!

QUESTIONS?

ACKNOWLEDGEMENTS

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Dr. R.D. Francis
Dr. M.R. Legg
M. Barth

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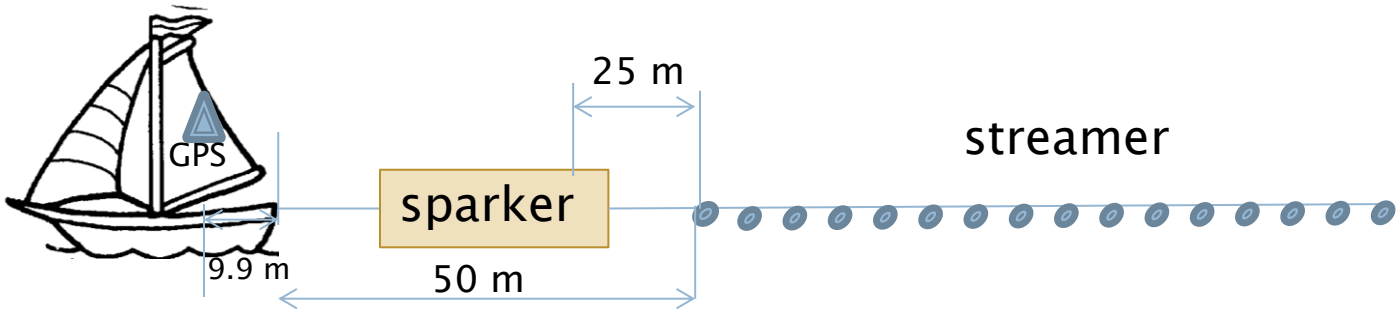
HB SURVEY



- Shot point interval – 3 sec.
- Receiver interval – 6.25 m
- # receivers in streamer – 16
- line length – 118.75 m
- Seismic length line – c.4.5 km
- Source – 2kj Sparker
- Acquisition – Oct. 31, 2012
- Data ownership – CSULB

Obtained through AAPG grant