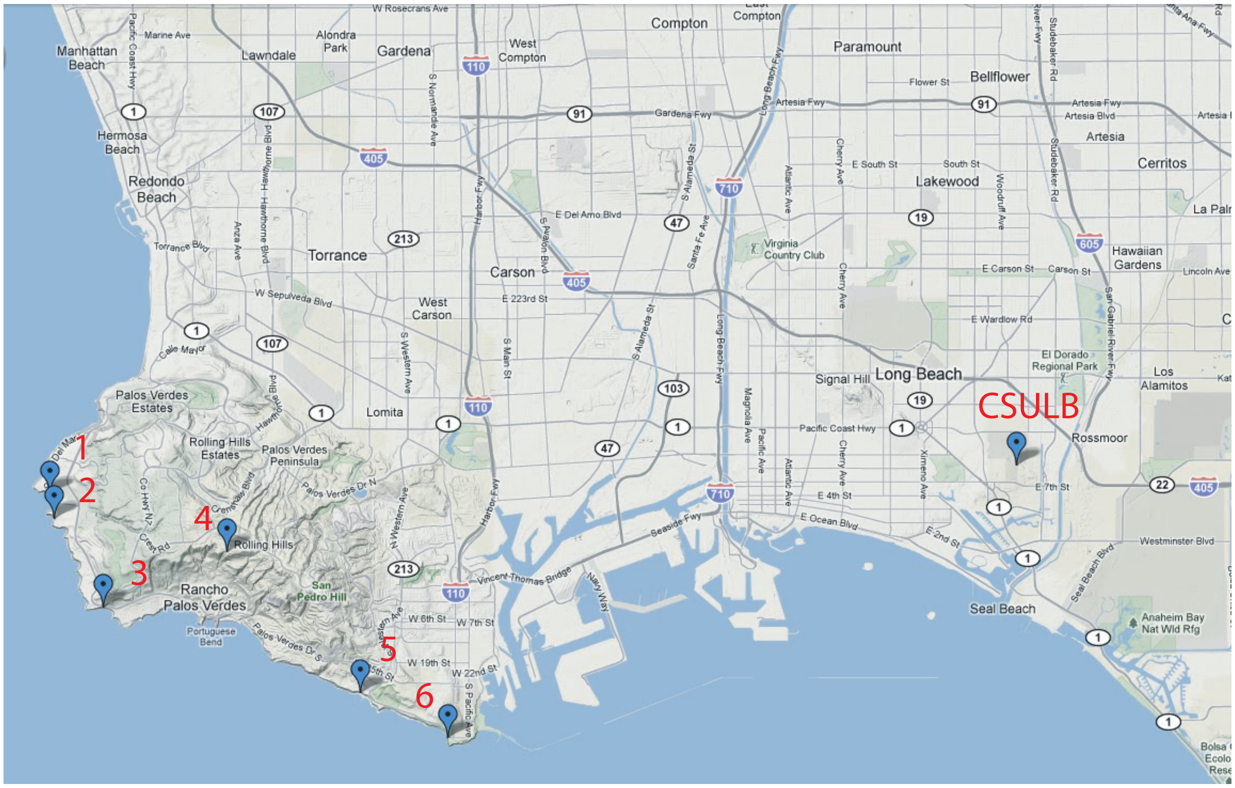
First Annual MARS Project Meeting Field Trip
Monterey Lithofacies of the Palos Verdes Hills

Leader: Rick Behl, CSU Long Beach



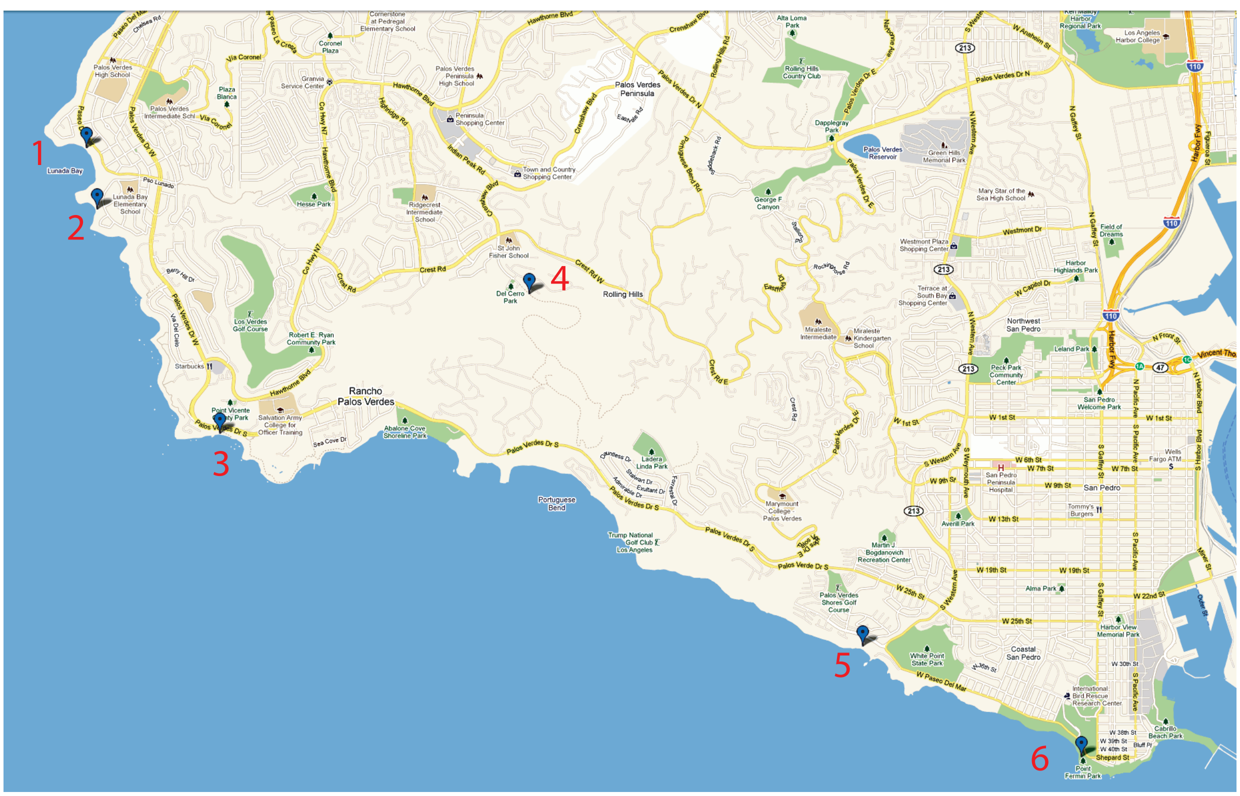


Figure A. Location map for field trip sites on Palos Verdes Penninsula.

July 18-19, 2011

2011 First Annual MARS Meeting Field Trip, July 19
Leader: Rick Behl, CSULB

Field Trip to the Monterey Formation in the Palos Verdes Peninsula

Depart CSULB at 7AM to take advantage of low tide in morning

Stop #1: Lunada Bay: Phosphatic lithofacies

Stop #2: Lunada Bay (south cove): Cherty lithofacies

Stop #3: Point Vicente (Fisherman's Access): Contact of basalt with Monterey tuffaceous lithofacies

Lunch

Stop #4: Crenshaw Extension: Valmonte Diatomite, Phosphatic, Cherty, and Tuffaceous lithofacies of the Altamira Sahle (Monterey Formation

Stop #5: White Point/Royal Palms Beach: tuffaceous lithofacies, synsedimentary folding

Stop # 6: Point Fermin Park: Point Fermin sandstone intercalated with phosphatic and cherty lithofacies. Exhumed petroleum reservoir in submarine fan channel.

Return to CSULB.

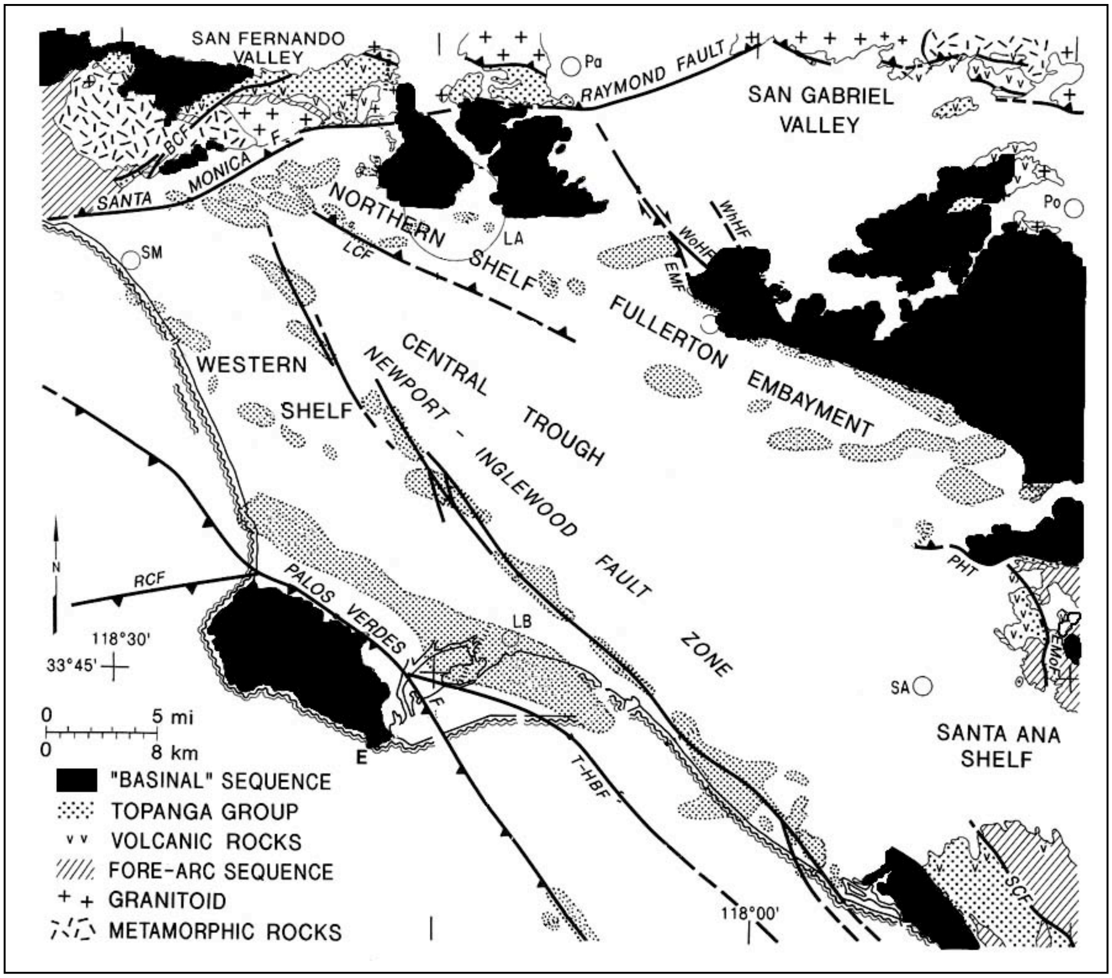


Figure B. Map of the Los Angeles basin, showing major faults, oil fields, and bedrock of the uplifted margins. “Basinal Sequence” includes the Monterey, Puente, and Modelo formations. Modified from Wright (1991).

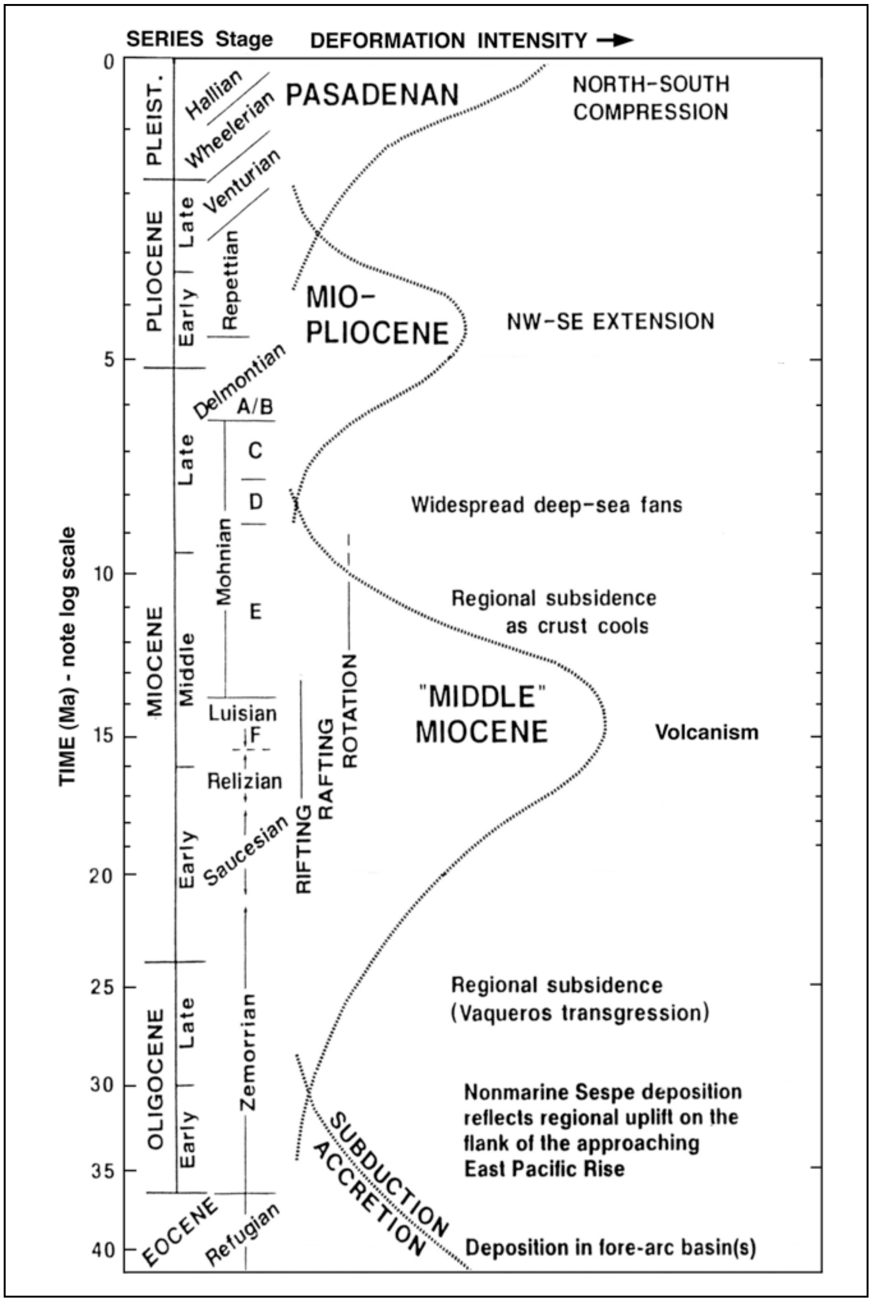


Figure C. Timing of major Cenozoic events in the Los Angeles basin. Dotted curve shows the intensity of tectonic deformation. Includes the provincial benthic foraminiferal stages of Kleinpell (1980) and Natland (1952). Modified from Wright (1991)

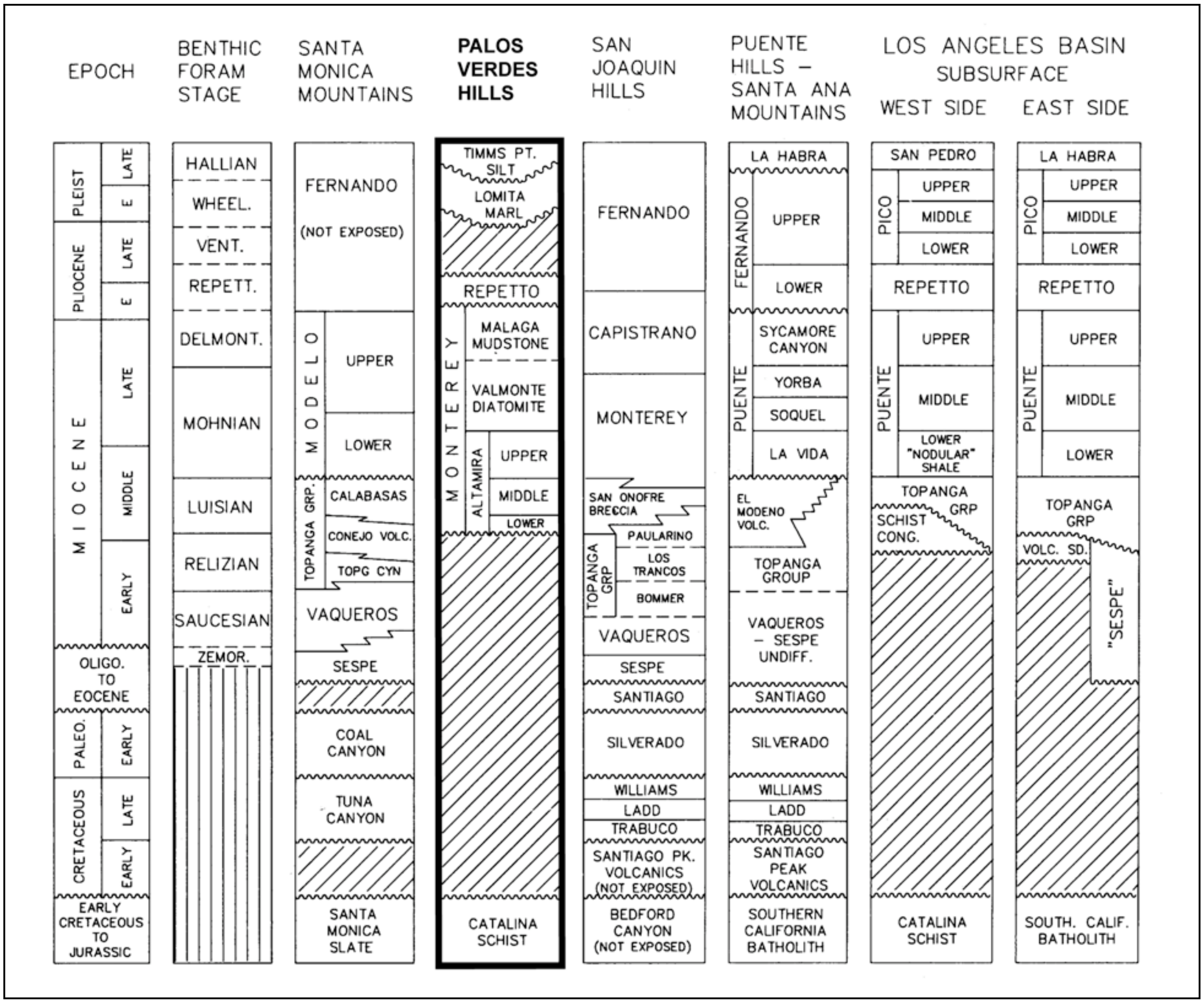


Figure D. Generalized stratigraphic chart for the Los Angeles basin and uplifted margins of the region, including benthic foraminiferal stages of Kleinpell (1980) and Natland (1952). Modified from Blake (1991).

Monterey Formation Lithostratigraphy and Chronostratigraphy

Crenshaw Extension section, with comments on other parts of the Palos Verdes Hills

Malaga Mudstone (6.9 to 3.5 Ma)

Radiolarian and diatomaceous mudstone

Valmonte Diatomite (13.0 to 6.9 Ma)

Diatomite , and diatomaceous mudstone & shale.

Lowest 8m exposed of 50m local total thickness (125m in Malaga Cove)

Base of the Valmonte Diatomite placed at a laminated 0.9m-thick dolostone bed

Altamira Shale (Altamira Canyon) (15.5 to 13 Ma)

Phosphatic lithofacies (14.2 to 13.0 Ma)

Truly gradational contact with Valmonte Diatomite

25m thick here at type section (~75m? in Lunada Bay)

Phosphatic lithofacies at the Crenshaw extension contains 25 m of soft phosphatic and diatomaceous siltstone and shale (visible diatoms on partings) with thin fine-grained sandstone beds and laminations. ~5% porcelanite lenses.Diatomaceous shale is most abundant in the upper 2/3 of the section.

2 1m-thick dolostone beds, ~6 m apart near middle of section. Many more at Lunada Bay.

Two samples from the section were analyzed and found to contain greater than 25 ppm uranium

Cherty lithofacies (14.5 to 14.2 Ma)

16 m of porcelanite and chert with minor dolostone and siliceous shale

Red to black Fe-oxide stains on most siliceous porcelanites and chert

Chert spheroids 40% from top of section.

Top defined by 15-cm thick sandstone bed between 2 ~1m-thick dolostone beds

Base at 2cm thick orange bentonitic tuff , 66cm above underlying tuff bed.

Tuffaceous lithofacies (15.5 to 14.5 Ma)

Upper 87m out of 275m total thickness

Tuff and tuffaceous sedimentary rocks comprise 10 to 20 percent of the total volume of the tuffaceous lithofacies. Silty shale dominates in the lower part of the type section porcelanite dominates the upper part. Sandy shale, tuff, tuffaceous siltstone, dolostone, and dolomitic siltstone are also common in the type section. Six samples contain less than 3 ppm uranium

Miraleste Tuff = 0-2m thick unaltered lapilli tuff, overlain by 11m of contorted strata. (elsewhere is a debris flow deposit)

Portuguese Tuff 14.9 ± 1.1 Ma (composite gravity flow and turbidites 20m thick)

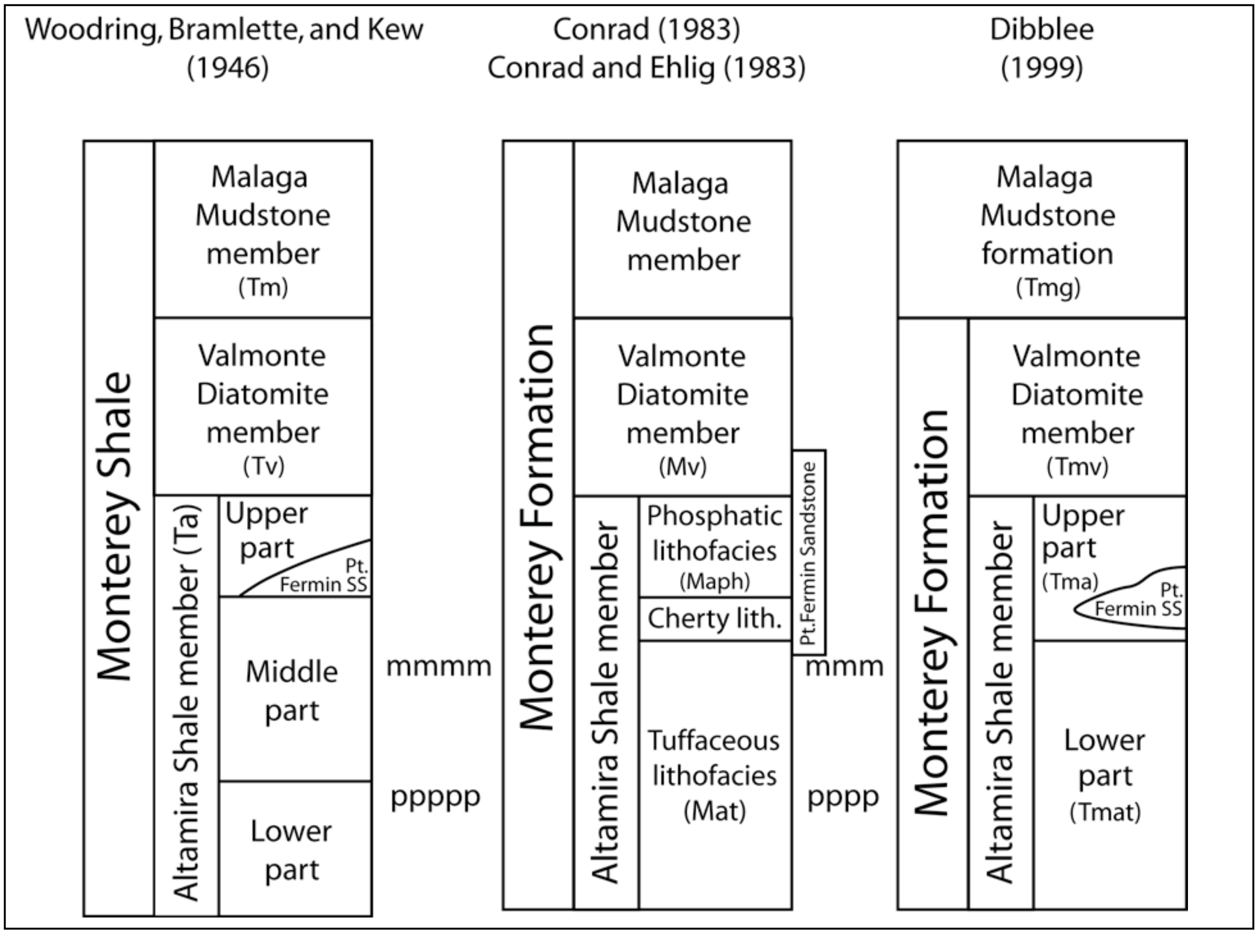


Figure E. Lithostratigraphic divisions of the Monterey Formation developed by Woodring et al. (1946), Conrad and Ehlig (1983), and Dibblee (1999) for the Palos Verdes Hills. "ppp" = Portuguese Tuff. "mmm" = Miraleste Tuff. Abbreviations are those used in the different workers' maps. From Behl and Morita (2007).

Figure F. Lunada Bay. Cliff exposures of the phosphatic lithofacies of the Altamira Shale (Monterey). Cliffs show weather phosphatic, carbonaceous shale, with spaced dolomite beds and localized occurences of pink "burnt shale". Sparse, fresh exposures of black, phosphatic shale in intertidal zone.

Figure G. Lunada Bay, south cove. Cliff exposures of the cherty lithofacies of the Altamira Shale (Monterey). Cliffs display interbedded porcelanite, siliceous shale, some chert and dolostone.

Figure H. Point Vicente. Access via Fisherman's trail or view from Interpretive Center. Cliff exposures contact of the tuffaceous lithofacies with Miocene basalt, related to syntectonic extension and vulcanism.

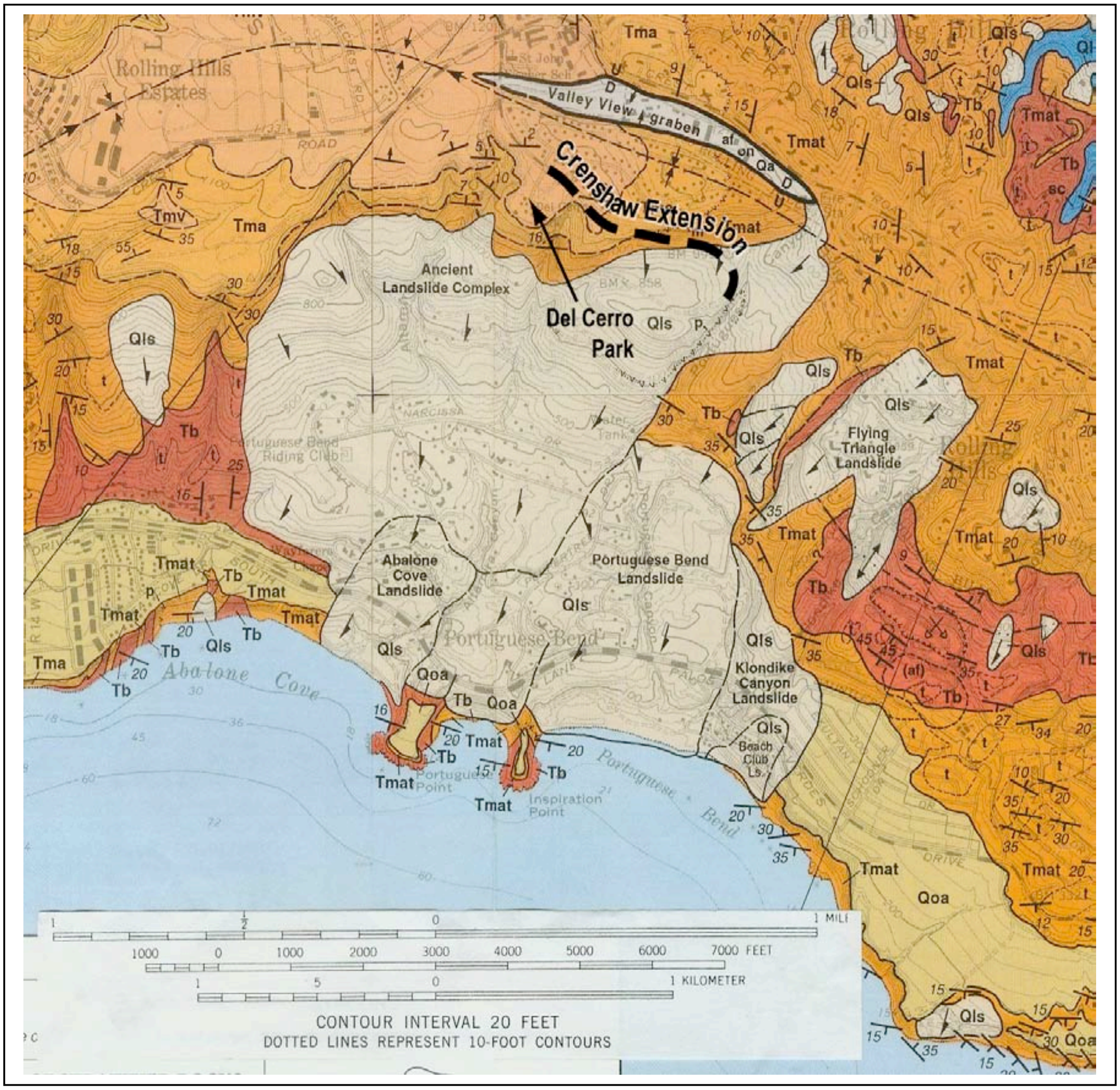


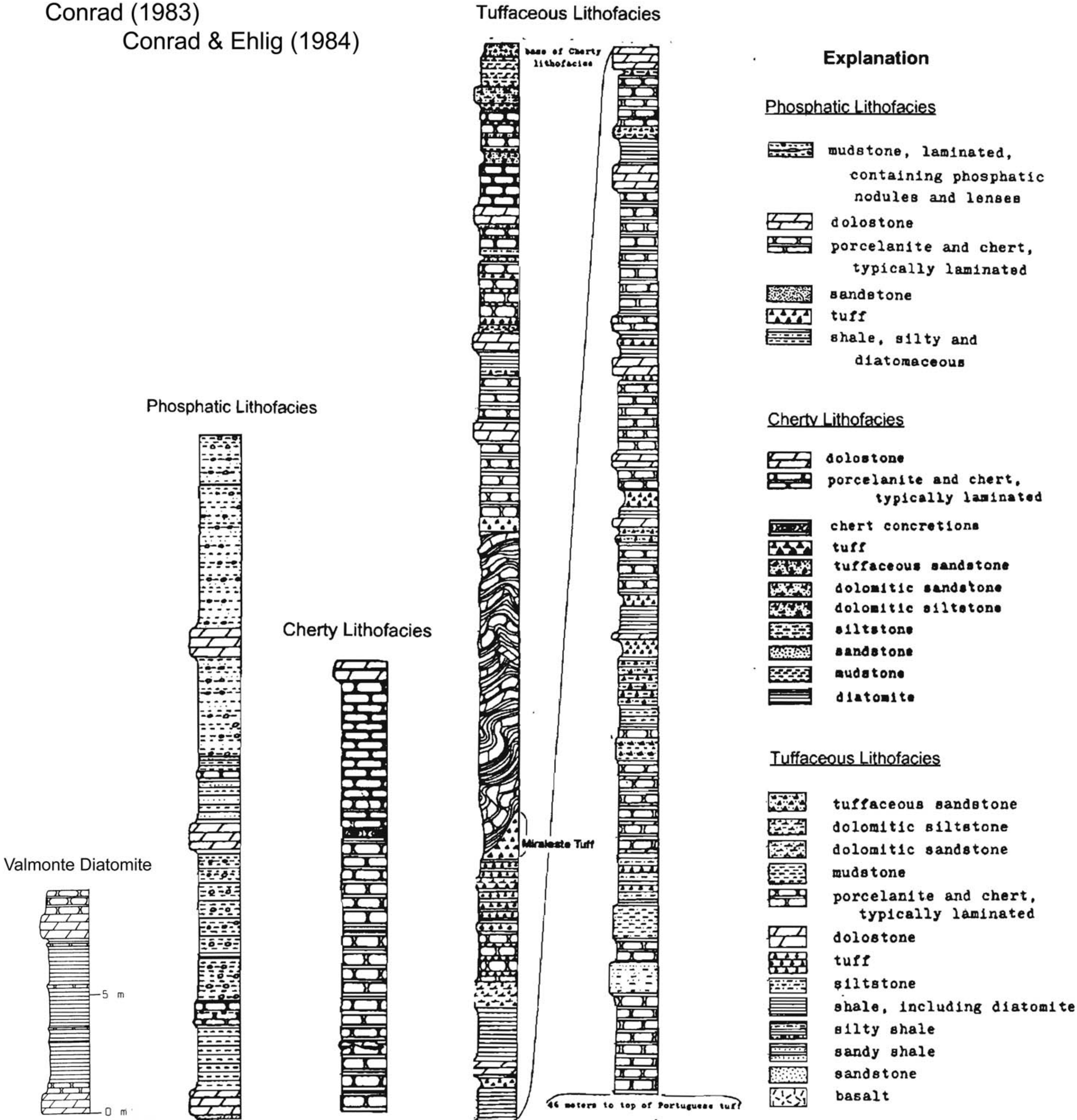
Figure I. Del Cerro Park and Crenshaw Extension . Here we can overlook the massive Portuguese Bend landslide complex and examine the most complete section of the Monterey Formation in the Palos Verdes Hills. Modified from Dibblee (1999).

Figure J (next page). Stratigraphic column from Conrad & Ehlig (1983) for Crenshaw extension.

Figure K (on second page). Diagrams and scanning electron microscope (SEM) photomicrographs depicting steps in silica diagenesis. A. SEM image of mixed clay and diatom fragments (opal-A) in a muddy diatomite. B. SEM image of nearly pure opal-A diatomite (penate diatoms). C. SEM image of large centric diatom simultaneously being dissolved and infilled with opal-CT lepispheres. D. Close-up of opal-CT lepispheres ("spheres of blades"). E. Nearly completely cemented opal-CT chert showing lost intercrystalline microporosity and minor remaining moldic porosity. F. Silica phase diagram (Keller and Isaacs, 1985 as modified by Behl and Garrison, 1994) showing that the transition of opal-A to opal-CT and opal-Ct to quartz in most sediments is a function of both temperature and composition. Note that the purest cherts form at considerably lower temperature than the silica phase transitions in less-pure porcelanite and siliceous mudrocks. G. Sequence of diagenesis for the timing of formation of various siliceous rocks (Behl and Garrison, 1994).

Monterey Formation: Crenshaw Extension Section

Conrad (1983)
Conrad & Ehlig (1984)



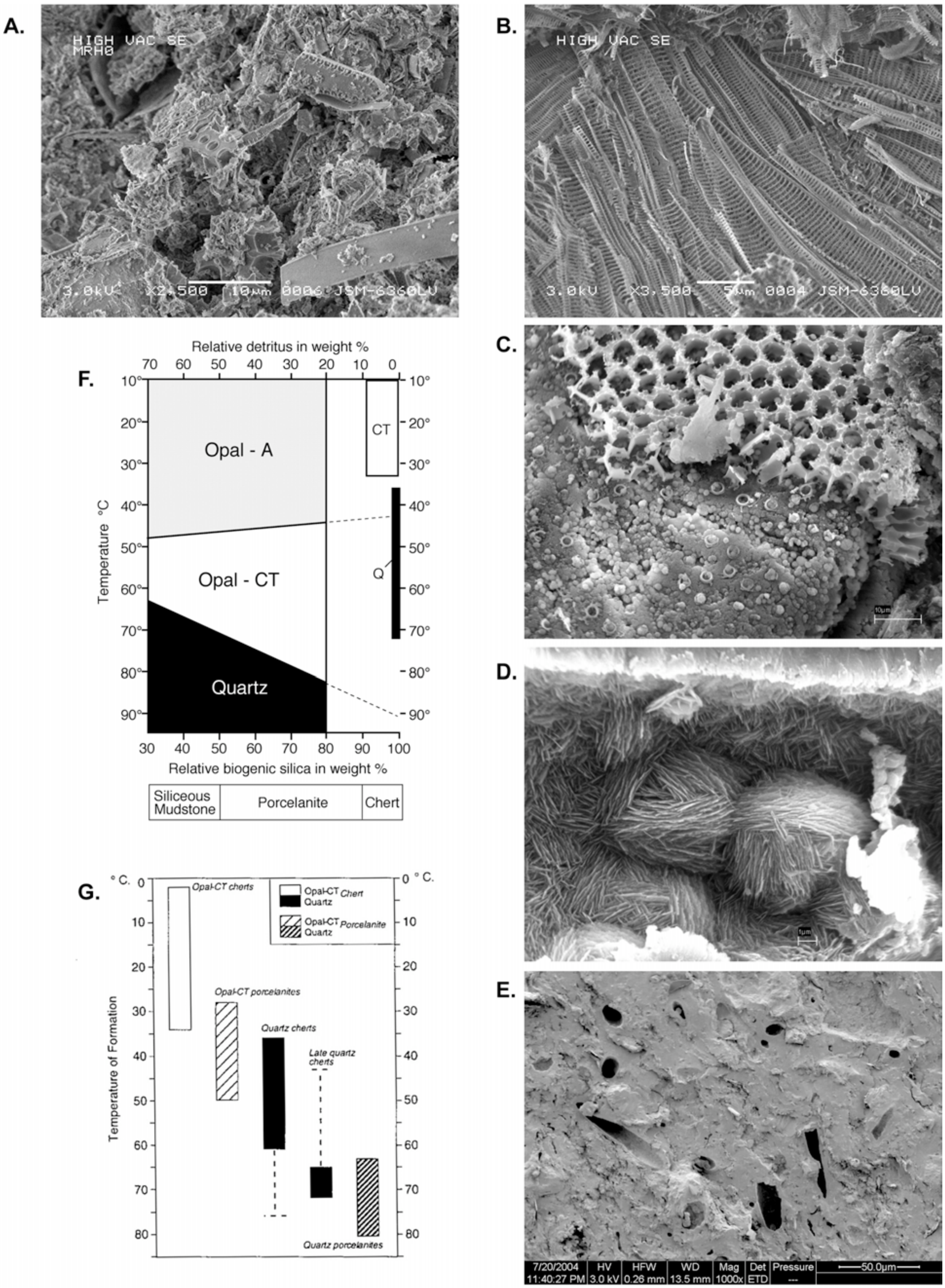

A.
HIGH VAC SE
MRH0
3.0kV X2,500 10μm 0006 JSM-6360LV
B.
HIGH VAC SE
3.0kV X3,500 5μm 0004 JSM-6360LV
C.
D.
E.
7/20/2004 11:40:27 PM
HV 3.0 kV
HFW 0.26 mm
WD 13.5 mm
Mag 1000x
Det ETD
Pressure ---
50.0μm
F.
Relative detritus in weight %
70 60 50 40 30 20 10 0
Opal - A
Opal - CT
Quartz
CT
Q
Temperature °C
10° 20° 30° 40° 50° 60° 70° 80° 90°
30 40 50 60 70 80 90 100
Relative biogenic silica in weight %
Siliceous Mudstone
Porcelanite
Chert
G.
° C.
0 10 20 30 40 50 60 70 80
Temperature of Formation
Opal-CT cherts
Opal-CT porcelanites
Quartz cherts
Late quartz cherts
Quartz porcelanites
Opal-CT Chert Quartz
Opal-CT Porcelanite Quartz

Figure L. White Point/Royal Palms exposures of the tuffaceous lithofacies of the Altamira Shale (Monterey).

Figure M. White Point/Royal Palms exposures of large recumbant fold, interpreted as forming by synsedimentary sliding by Fleisher (1971).

Figure N. Point Fermin. Point Fermin sandstone facies, submarine channel cutting down through the phosphatic and cherty facies into the tuffaceous facies. Oil-saturated blueschist sand with abundant phosphatic clasts.

Key References for The Monterey Formation of the Palos Verdes Hills

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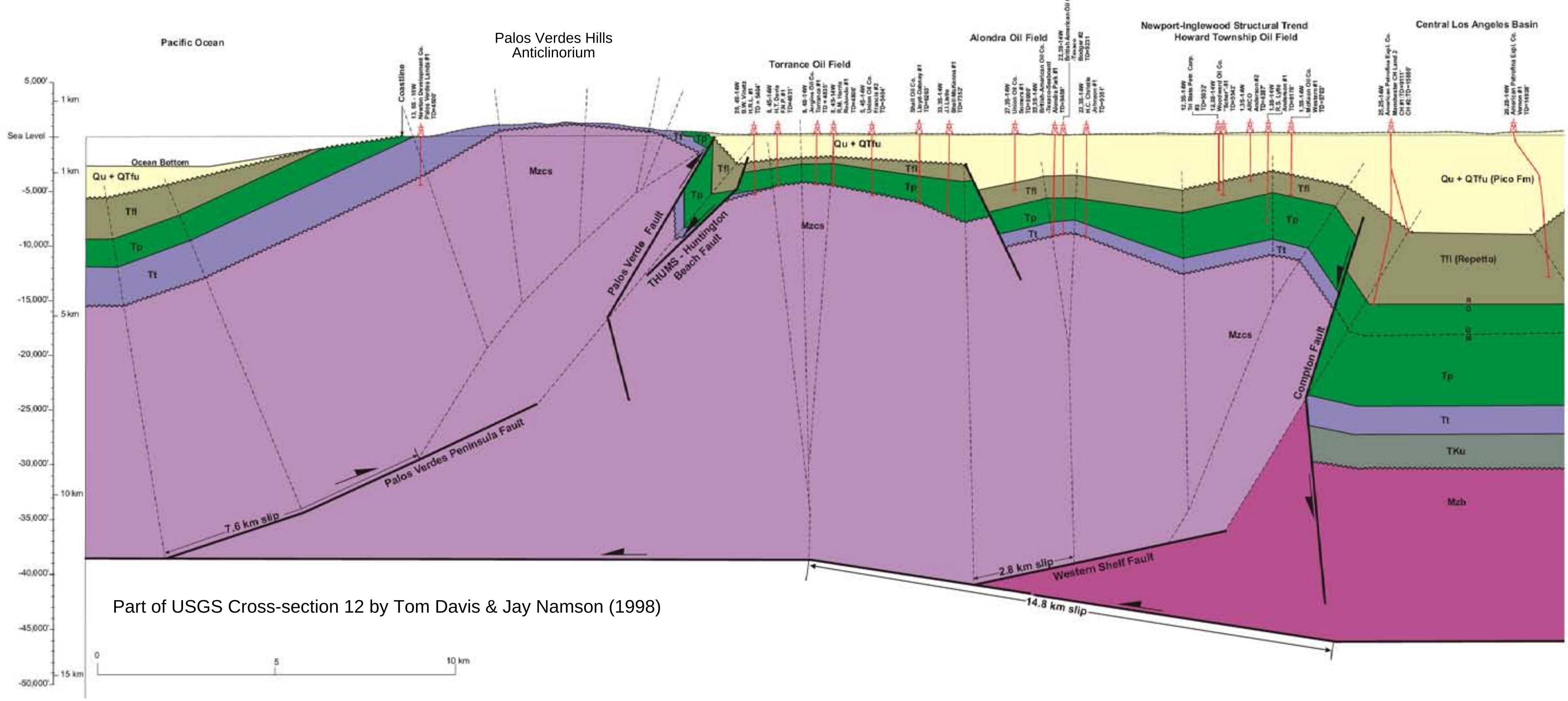

Part of USGS Cross-section 12 by Tom Davis & Jay Namson (1998)