Undeveloped Petroleum Potential of the Westernmost Santa Barbara Channel, Offshore California*

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Abstract

Offshore seismic surveys (now in the public domain) led to the discovery of several potential oil fields in the western-most Santa Barbara Channel. The surveys and wells also help to better understand this tectonically and stratigraphically complex area. It is at the western edge of the Transverse Ranges tectonic block, where the overall rotation may have created compressional structures, and it includes a portion of the transition zone from the Santa Barbara Channel to the Santa Maria Basin to the northwest. Offshore wells and seismic lines extend the control provided by onshore data, with unconformities, volcanics, and local depocenters documenting the opening of the Santa Maria Basin (from the Upper Oligocene). The exploratory wells in the area also discovered ten accumulations of heavy oil in the Miocene Monterey Formation. Only one of the two largest structural highs was developed, Point Arguello Field (200 MMBO), with much political opposition. The second large (undeveloped) structure is known as Sword. These structures illustrate aspects of the inter-basin transition zone, with very different structural orientations and ages. Sword is part of a persistent pre-Monterey structural high, whereas Point Arguello is a post-Monterey inversion structure typical of the Santa Maria Basin. Both Sword wells encountered oil in quartz-phase chert and dolomite in the Monterey. These zones have high matrix porosities, but fractures provide most of the permeability. Both wells tested 8 to 10 degree API oil at potentially economic rates (2000 to 3000 BOPD) on artificial lift. Conservative estimates for the undeveloped fields (226 MMBO) indicate a very large resource technically within reach of facilities at Point Arguello, but low oil prices and politics suggest they will be waiting many more years.

References Cited

Ballard, J.H., 1988, Sword Field, Offshore California: Challenges in Making This Giant Oil Field Commercial (Abs.): American Association of Petroleum Geologists Bulletin, v. 72/3, p. 374.

BOEM, 2008, Field Reserve Estimate Summary as of December 2008: Resource Evaluation Program-Pacific Region, Oil and Gas Energy Programs, Bureau of Ocean Energy Management, 6 p. https://www.boem.gov/Reserves-Inventory-Pacific-OCS-Region/ Website accessed December 2016.

Crain, W.E., W.E. Mero, and D. Paterson, 1985, Geology of the Point Arguello Discovery: American Association of Petroleum Geologists Bulletin, v. 69/4, p. 537-545.

Crouch, J.K., and J. Suppe, 1993, Late Cenozoic Tectonic Evolution of the Los Angeles Basin and California Borderland: A Model for Core Complex-Like Crustal Extension: Geological Society of America Bulletin, v 105, p. 1415-1434.

Dibblee, T.W., 1950, Geology of Southwestern Santa Barbara County, California, Point Arguello, Lompoc, Point Conception, Los Olivos, and Gaviota Quadrangles: California Division of Mines Bulletin 150, 95 p.

Fischer, P.J., 1998, Structure and Tectonics of the Northwestern Santa Barbara Basin: in Structure and Petroleum Geology, Santa Barbara Channel, California, Pacific Section AAPG and Coast Geological Society Miscellaneous Publication 46, p. 79-96.

Luyendyk, B.P., M.J. Kamerling, and R. Terres, 1980, Geometric Model for Neogene Crustal Rotations in Southern California: Geological Society of America Bulletin, Part I, v. 91, p. 211-217.

Zoback, M.D., M.L. Zoback, V.S. Mount J. Suppe, J.P. Eaton, J.H. Healy, D. Oppenheimer, P. Reasenberg, L. Jones, C.B. Raleigh, I.G. Wong, O. Scotti, and C. Wentworth, 1987, New Evidence on the State of Stress of the San Andreas Fault System, Science, 238/4830, p. 1105-1111.

322 #1 (check shot survey!)

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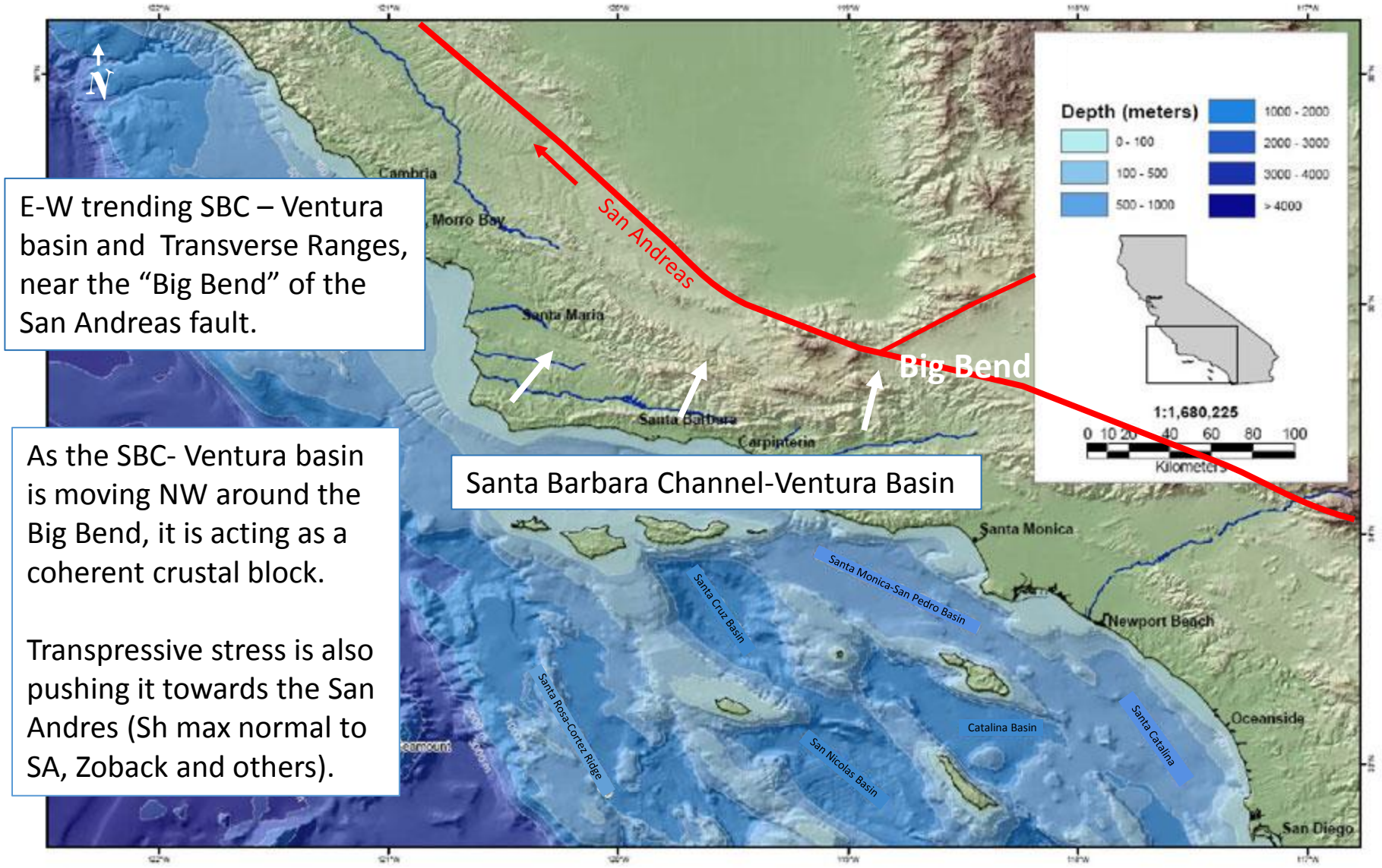
AAPG Pacific and Rocky Mountain Sections
October 3, 2016
Las Vegas, Nevada

Point Conception



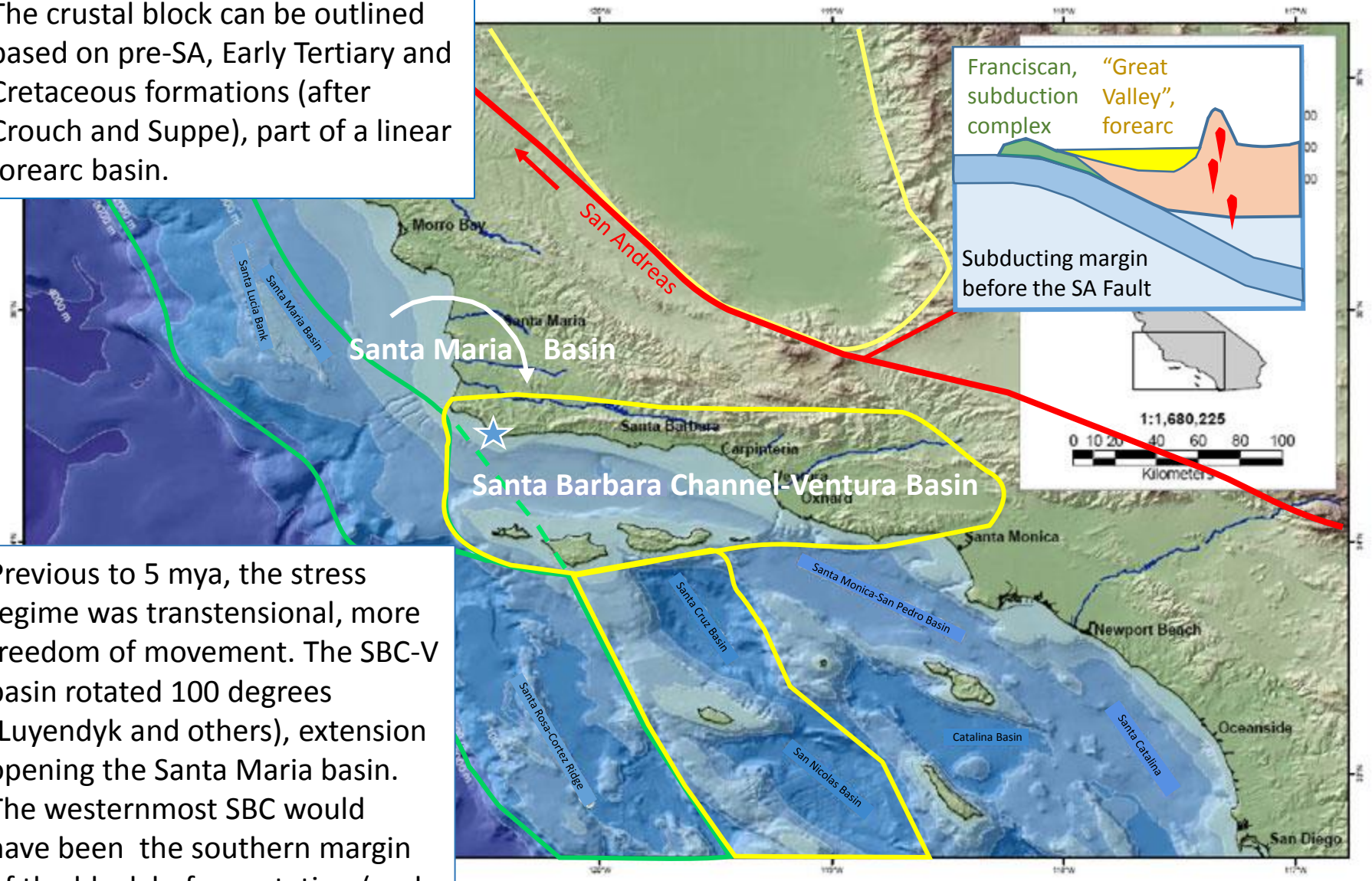
E-W trending SBC – Ventura basin and Transverse Ranges, near the "Big Bend" of the San Andreas fault.

As the SBC- Ventura basin is moving NW around the Big Bend, it is acting as a coherent crustal block.

Transpressive stress is also pushing it towards the San Andres (Sh max normal to SA, Zoback and others).

noaa.gov

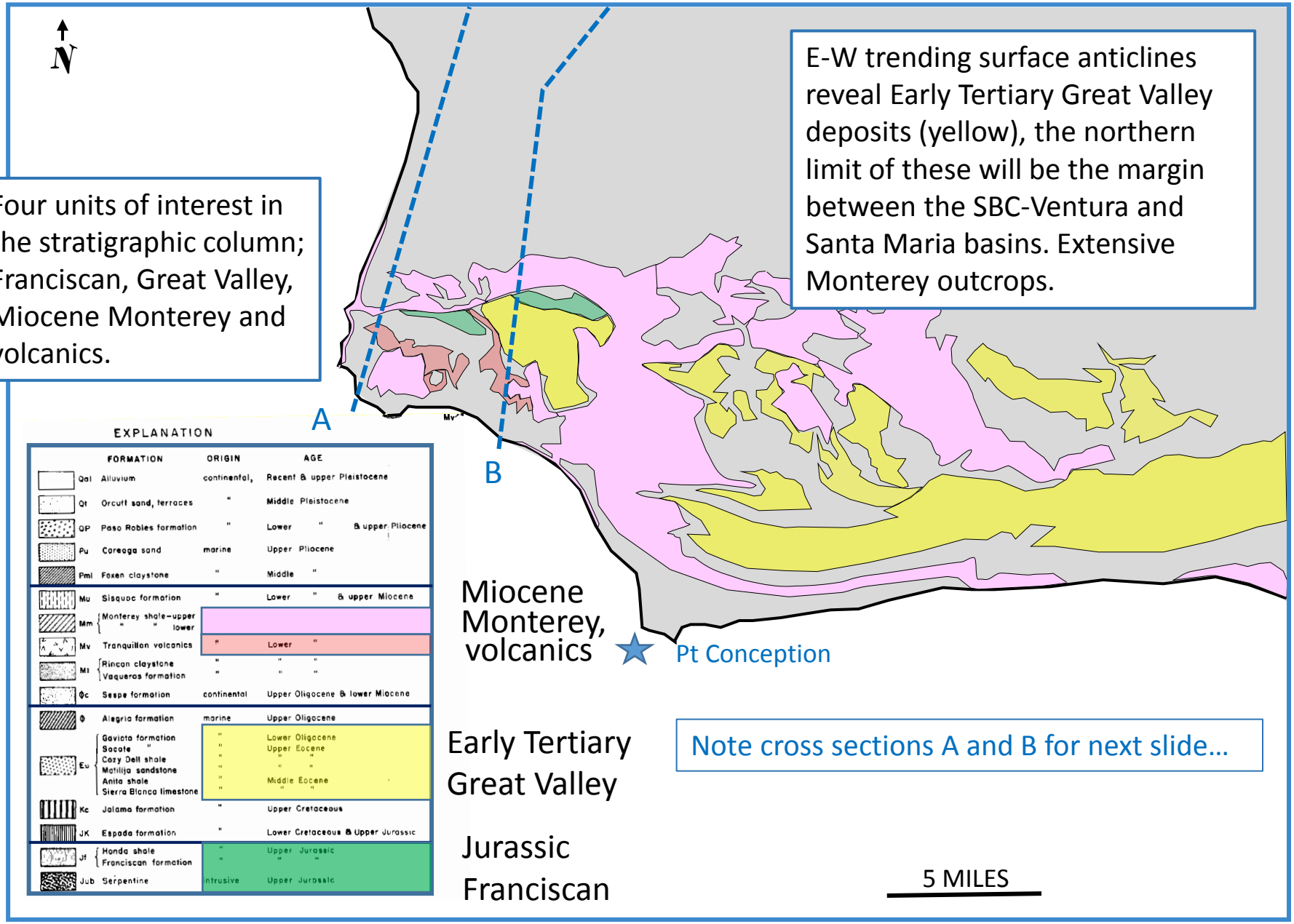
The crustal block can be outlined based on pre-SA, Early Tertiary and Cretaceous formations (after Crouch and Suppe), part of a linear forearc basin.



Previous to 5 mya, the stress regime was transtensional, more freedom of movement. The SBC-V basin rotated 100 degrees (Luyendyk and others), extension opening the Santa Maria basin. The westernmost SBC would have been the southern margin of the block before rotation (undo the "Z").

★ Point Conception, location of next slide…

Onshore geologic mapping by Tom Dibblee (CA DNR Bulletin 150)



Four units of interest in the stratigraphic column; Franciscan, Great Valley, Miocene Monterey and volcanics.

E-W trending surface anticlines reveal Early Tertiary Great Valley deposits (yellow), the northern limit of these will be the margin between the SBC-Ventura and Santa Maria basins. Extensive Monterey outcrops.

EXPLANATION

	FORMATION	ORIGIN	AGE
Qal	Alluvium	continental,	Recent & upper Pleistocene
Qt	Orcutt sand, terraces	"	Middle Pleistocene
QP	Paso Robles formation	"	Lower " & upper Pliocene
Pu	Careaga sand	marine	Upper Pliocene
Pml	Foxen claystone	"	Middle "
Mu	Sisquoc formation	"	Lower " & upper Miocene
Mm	Monterey shale–upper " " lower		
Mv	Tranquillon volcanics	"	Lower "
Ml	Rincon claystone / Vaqueros formation	"	" "
Φc	Sespe formation	continental	Upper Oligocene & lower Miocene
Φ	Alegria formation	marine	Upper Oligocene
Eu	Gaviota formation	"	Lower Oligocene
	Sacate "	"	Upper Eocene
	Cozy Dell shale	"	" "
	Matilija sandstone	"	" "
	Anita shale	"	" "
	Sierra Blanca limestone	"	Middle Eocene
Kc	Jalama formation	"	Upper Cretaceous
JK	Espada formation	"	Lower Cretaceous & Upper Jurassic
Jf	Honda shale	"	Upper Jurassic
	Franciscan formation	"	" "
Jub	Serpentine	intrusive	Upper Jurassic

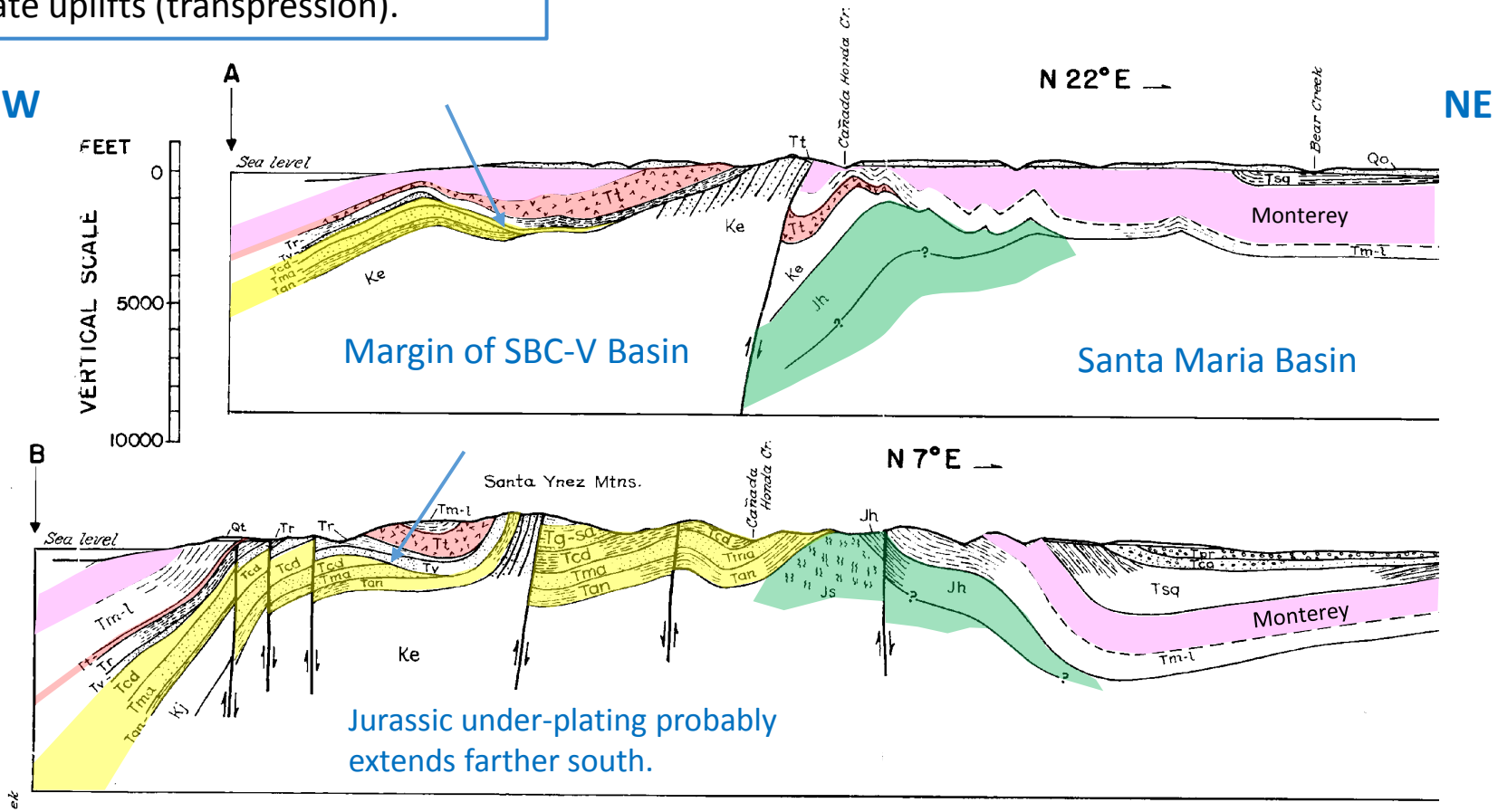
Note cross sections A and B for next slide…

GEOLOGIC STRUCTURE SECTIONS ACROSS SOUTHWESTERN SANTA BARBARA COUNTY CALIFORNIA

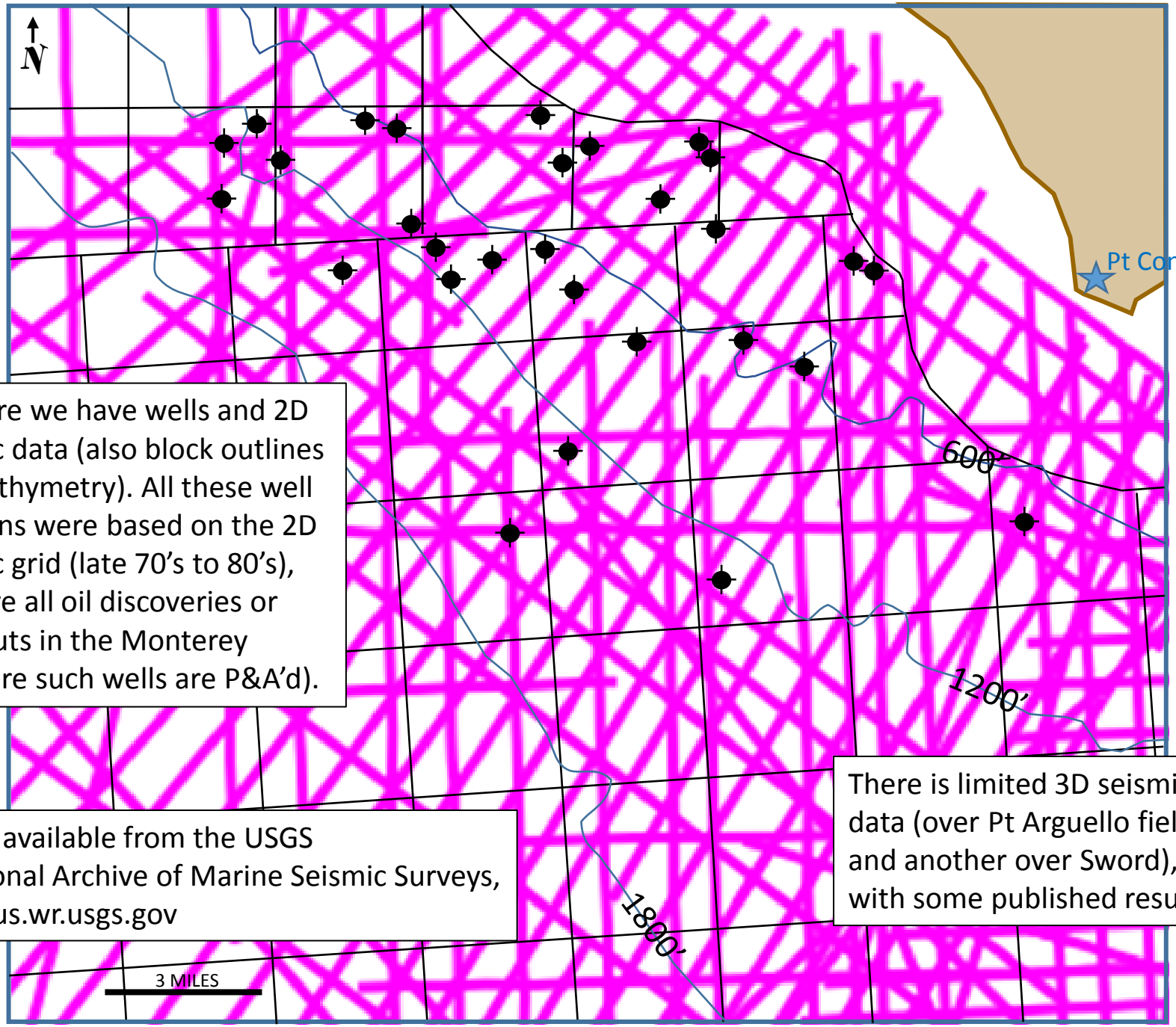
by

T.W. DIBBLEE JR.

Early or Pre-Miocene unconformity (truncating the Great Valley), local rhyolite/tuff, Monterey thickening to the north (transtension creating space) and late uplifts (transpression).



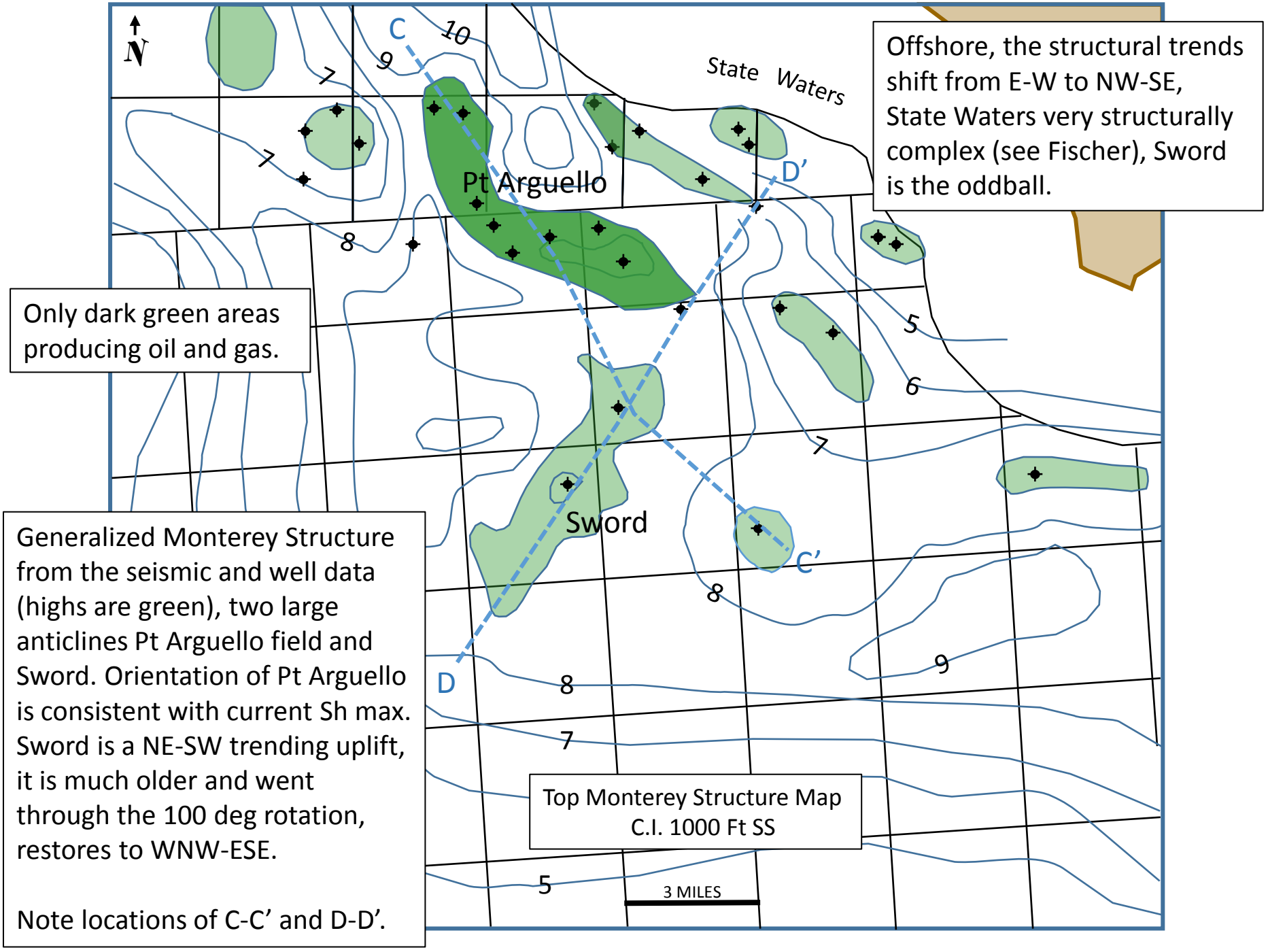
CA DNR Bulletin 150



Offshore we have wells and 2D seismic data (also block outlines and bathymetry). All these well locations were based on the 2D seismic grid (late 70's to 80's), they are all oil discoveries or step-outs in the Monterey (offshore such wells are P&A'd).

Data available from the USGS National Archive of Marine Seismic Surveys, walrus.wr.usgs.gov

There is limited 3D seismic data (over Pt Arguello field and another over Sword), with some published results.



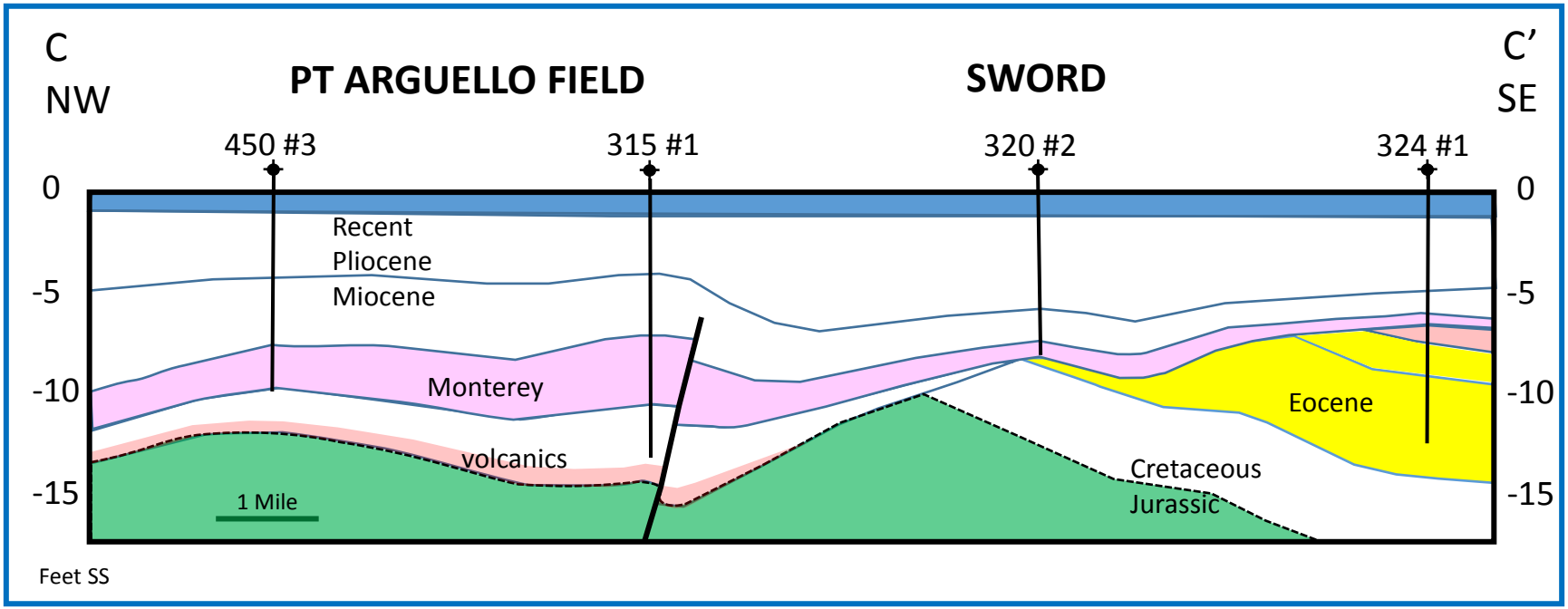
Offshore, the structural trends shift from E-W to NW-SE, State Waters very structurally complex (see Fischer), Sword is the oddball.

Only dark green areas producing oil and gas.

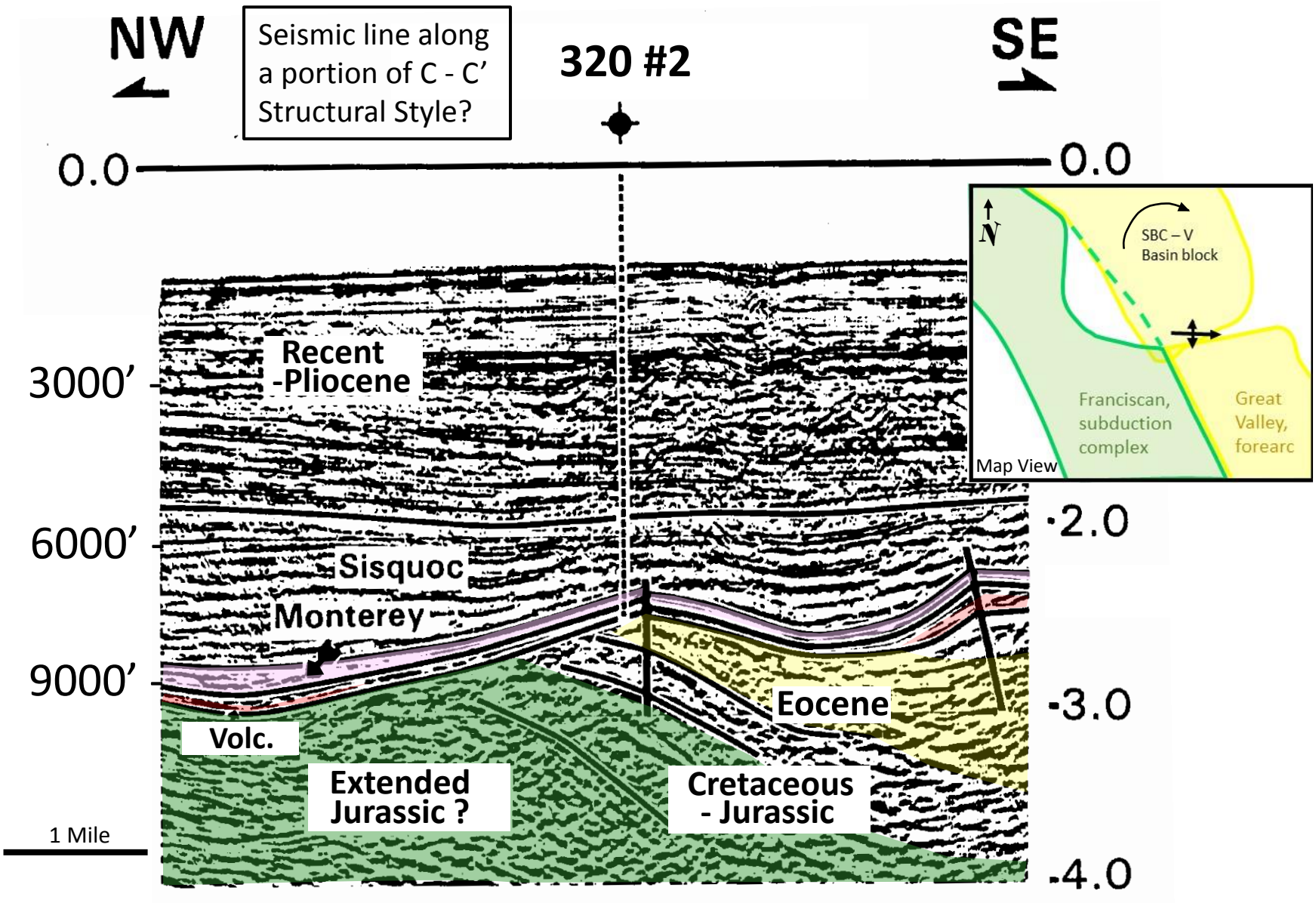
Generalized Monterey Structure from the seismic and well data (highs are green), two large anticlines Pt Arguello field and Sword. Orientation of Pt Arguello is consistent with current Sh max. Sword is a NE-SW trending uplift, it is much older and went through the 100 deg rotation, restores to WNW-ESE.

Note locations of C-C' and D-D'.

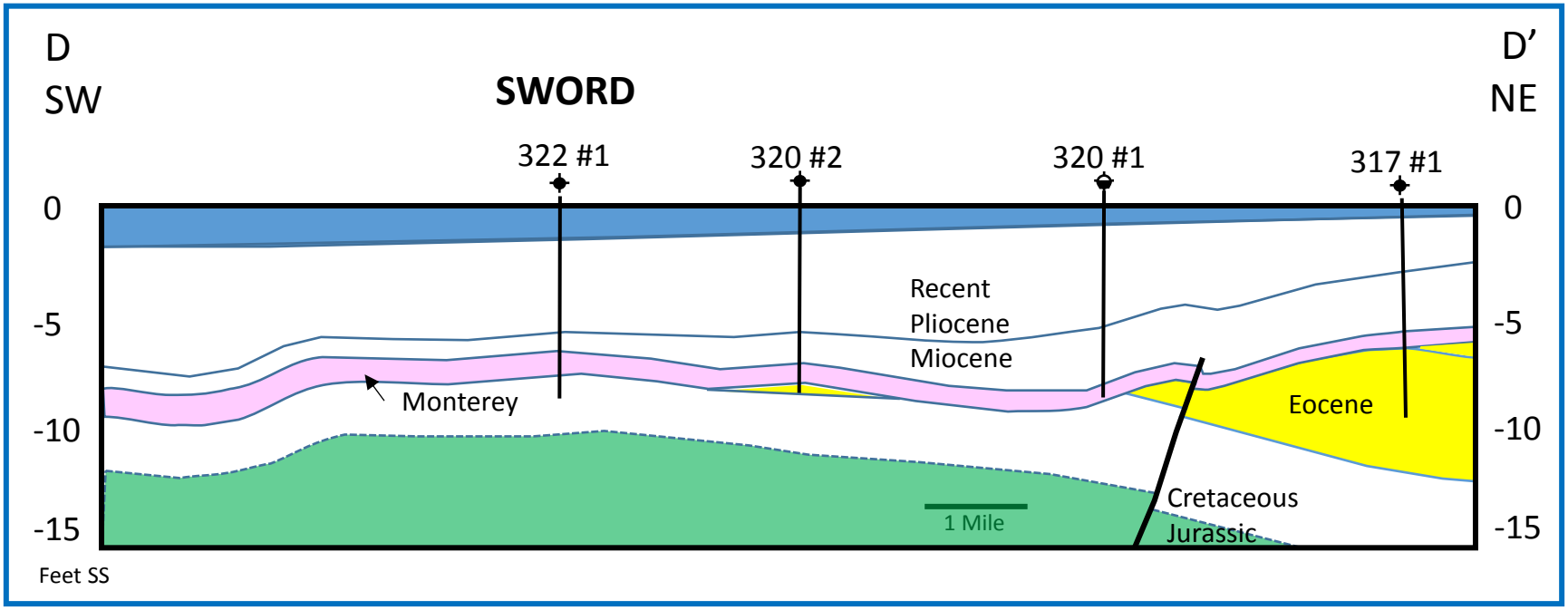
Top Monterey Structure Map
C.I. 1000 Ft SS



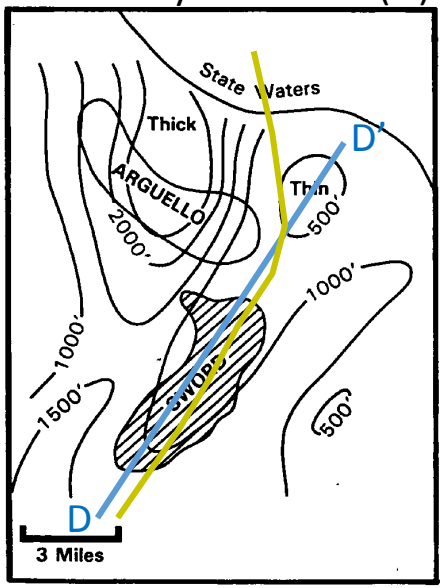
Constructed from the 2D seismic data and wells. Truncation of Great Valley as on A and B by Early or Pre-Miocene unconformity. Sword is part of SBC-V basin margin (pre-Monterey structure). Miocene depocenter to NW, Pt Arguello is a late inversion structure, (timing and orientation as in Santa Maria Basin).



Is the area normal faulted (extensional break-up)? Farther "East" relatively unstructured.
Or a compressional feature, left-lateral wrenching overriding Franciscan block during rotation?



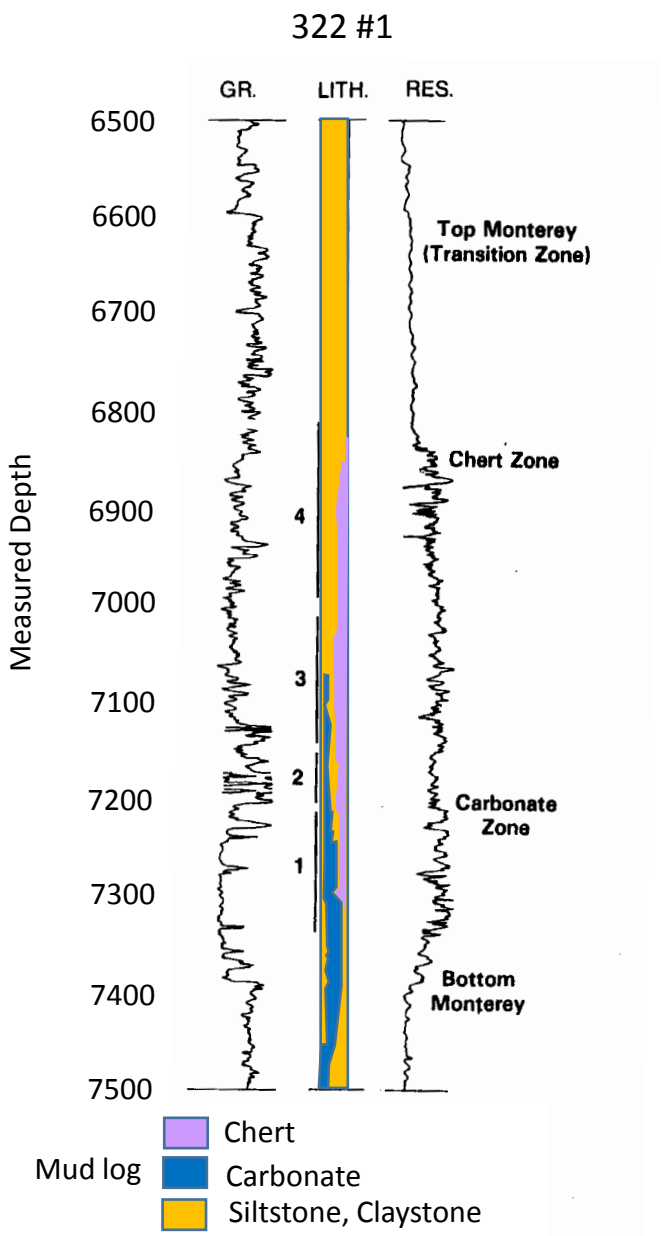
Monterey Thickness (ft)



JHB 1988

Truncation of Great Valley again. Thin Monterey section, strike view of the Sword/Amberjack paleo-high (Crain, Mero), delineated by Monterey Thickness on this map. Limit of Great Valley truncation shown as yellow line, connects to onshore limit as margin of SBC-V Basin.

A Monterey Thick is shown at Pt Arguello field.



Type well from the paleo-high…

TD 9343’ WD 1544’
6600’ Top Monterey Transition Zone
laminated siliceous siltstone
6800’ to 7388’ Oil Shows
6850’ to 7130’ Chert Zone
quartz-phase chert
clastic-rich interval at base (little phosphate in this well)
7200’ to 7388’ Carbonate Zone
mostly dolomite in this well
7388’ Bottom Monterey
All above Oil/Water Contact

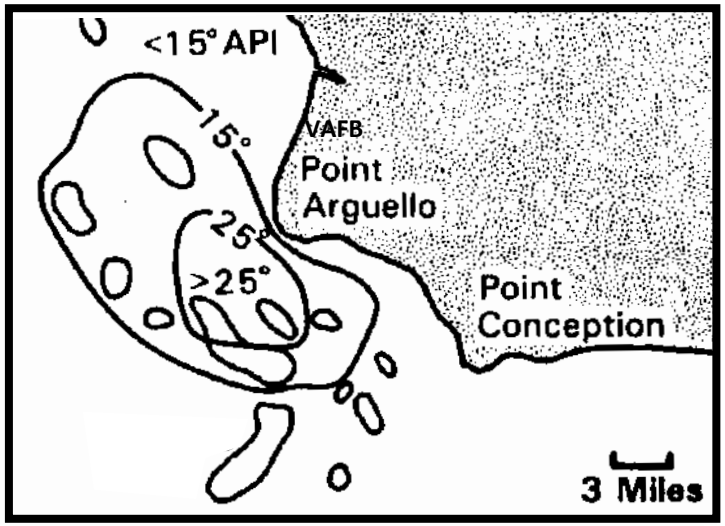
Four DST Intervals Shown;
relatively short duration (hours)
nitrogen lift, coiled tubing
total rate 2100 BOPD
oil gravity 8.5 to 10.5 API

Unfortunately low gravity oil…

Monterey coastal outcrop, Vandenberg AFB

archives.aapg.org

Tested Oil Gravities

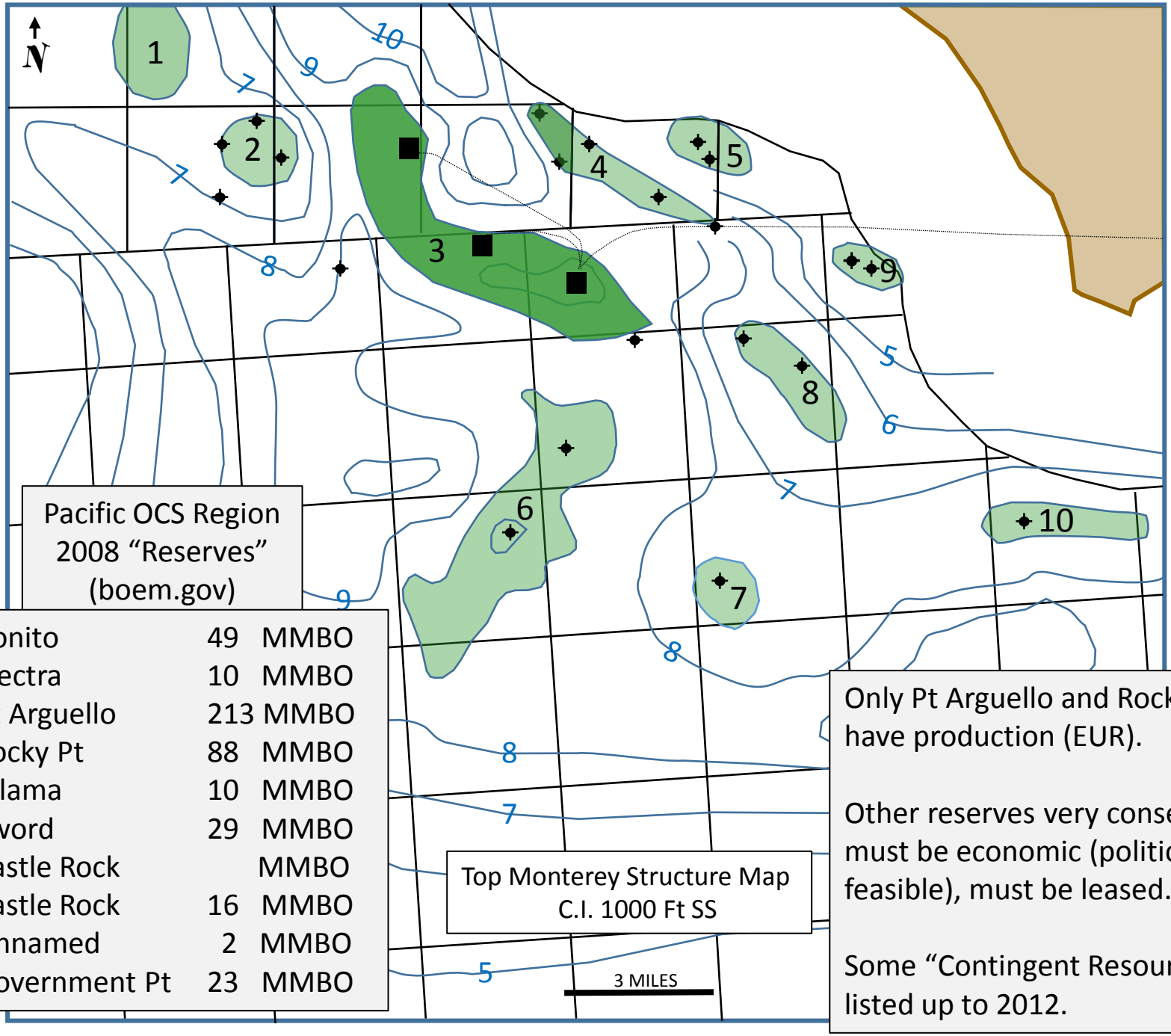


JHB 1988

The main reservoir is the glassy and porcelaneous bioclastic chert. Chert and Carbonate Zone matrix porosities can be very good (30%). Matrix permeability is low (.1 md); the high oil flow rates depend on fractures.

The low oil gravity is due to the thermal maturation of the Monterey source rock (and sulfur). The map above shows the oil gravity distribution; higher gravity in the area of thick Miocene sediments.

Low matrix permeability and low oil gravity result in low Recovery Factors, probably just a few percent of Oil in Place (onshore recovery would be much higher). Uncertainty in recovery factors and economics result in uncertain reserves.



Pacific OCS Region
2008 “Reserves”
(boem.gov)

1	Bonito	49	MMBO
2	Electra	10	MMBO
3	Pt Arguello	213	MMBO
4	Rocky Pt	88	MMBO
5	Jalama	10	MMBO
6	Sword	29	MMBO
7	Castle Rock		MMBO
8	Castle Rock	16	MMBO
9	Unnamed	2	MMBO
10	Government Pt	23	MMBO

Top Monterey Structure Map
C.I. 1000 Ft SS

Only Pt Arguello and Rocky Pt have production (EUR).

Other reserves very conservative, must be economic (politically feasible), must be leased.

Some “Contingent Resources” listed up to 2012.

8.5 degree API oil from 320 #2

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Oil/Water/Surfactant