Undeveloped Petroleum Potential of the Offshore Santa Maria Basin, California*

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Abstract

Offshore seismic surveys (now in the public domain) and exploration drilling led to the discovery of several potential oil fields in the offshore Santa Maria basin, California. The seismic and well data also help to better understand this tectonically complex area. The current transpressional stress regime has created thrusted anticlinal trends extending from onshore, with a long history of oil production, to the offshore discoveries. The anticlinal trends change orientation offshore and merge into the Hosgri fault system. The Hosgri has strike-slip displacement, but the structures are dominantly compressional with strikes sub-parallel to the San Andreas. The offshore wells discovered heavy oil in the Miocene Monterey formation, eight fields north of Point Arguello. Only one of these was developed, Point Pedernales field (106 MMBO). The others were unitized under the federal OCS statutes but became the focus of state political opposition. The wells encountered oil in fractured siliceous rocks and carbonates in the Monterey. These zones have high matrix porosities, but fractures provide most of the permeability. Many of the wells tested relatively low gravity oil (< 15 deg API) at potentially economic rates (100's to 1000's BOPD). Producing this oil offshore has unique challenges. Conservative estimates for the undeveloped fields total 974 MMBO, technically recoverable. They are now on “open acreage”. Politics, and low oil prices, will keep them from being produced for many more years. Note: this is a companion paper to “Undeveloped petroleum potential of the western-most Santa Barbara Channel, offshore California” presented at the PCS and RMS AAPG Joint Meeting in 2016.

References Cited


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Note, this is a companion paper to “Undeveloped petroleum potential of the western-most Santa Barbara Channel, offshore California” presented last year in Las Vegas (PS and RMS AAPG Joint Meeting).
NW trending Santa Maria Basin extends offshore to the Santa Lucia Bank. WD’s shown. Onshore hills are uplifts, result of current transpressive stress (de-coupled). NE – SW compression and strike slip at the San Andreas.
Earlier transtensional stress allowed opening of the basin by block rotation. The crustal blocks can be outlined based on pre-SA, Early Tertiary and Cretaceous formations. Originally a linear subduction complex (undo the “Z”).
Onshore Santa Maria geologic mapping by Dibblee, most compiled by Jennings.

Units of interest in the stratigraphic column; Franciscan, Great Valley (S), Mio. to L Plio. – volcanics (N and S areas), Monterey and Sisquoc.

Anticlinal trends (red) extend offshore where there is a change in direction, a merger into the Hosgri Fault Zone. HFZ has strike slip motion, e.g. Graham and Dickenson, sub-parallel to the San Andreas. Right lateral slip equal to shortening of folds/thrust faults (ocean side not buttressed).

Note location of cross-section for next slide.
Pre-Miocene unconformity, no Great Valley forearc, Jurassic subduction complex, Monterey and other units thickening to the basin center (transtension created space) and late thrusted anticlines (transpression).

In the Santa Maria Basin, just about every high is an oil field, mostly in fractured Monterey “shale”, also sands above and below. EUR’s and API oil gravities shown.

Lompoc Field
50 MMBO; 15-24

Orcutt Field
180 MMBO; 16,23

Santa Maria Valley
230 MMBO; 12-17
Offshore there are P&A’d wells and 2D seismic data (more than shown) also OCS block outlines in Federal Waters. The well locations were based on the 2D seismic grid (late 70’s to 80’s), nearly all are oil discoveries or step-outs in the Monterey.

Data available from the USGS National Archive of Marine Seismic Surveys, walrus.wr.usgs.gov
Generalized Monterey Structure from the seismic and well data. Anticlines (green to closing 1000’ contours, not total field limits) strike parallel to HFZ, local strain partitioning sub-parallel to San Andreas. Not wrench structures.

Area between the coast and HFZ very structurally complex, certainly prospective but poorly imaged on seismic, see USGS Bulletin 1995.

Dark green producing oil (Pt Pedernales field IP 2950 BOPD/well 22 wells ’92 16 deg API), medium green have listed reserves.

Note locations of B-B’ and C-C’
Constructed from the 2D seismic and wells. Note recent displacements of the seafloor. Stratigraphy very similar to onshore A – A’. Changing formation thicknesses suggest strike slip on HFZ (there is a nearby well east of the fault). Most of the obvious places drilled, San Miguel a major discovery (256 MMBO). Deepwater wells were not Unitized, probably less economically attractive.
Three recognized fields, Purisima Pt another major discovery. HFZ offsets seafloor again, traceable for many miles. Compressional, thrust-related anticlines (de-coupled transpression), SW and NE vergent (towards over-steepened limbs), faults flatten at some depth below section shown.
There are tops from these wells on intersecting lines. Note how shallow thrust faults go is interpretive on this vintage data (limited offsets, “steep” dips not imaged).
435 #1

Type well, a discovery...

TD 6740’ WD 243’

1250’ Top Miocene/L. Sisquoc
shale, siliceous siltstone

4550’ Top Monterey
quartz-phase porcelanite/chert
dark organic-rich zones
carbonate/dolomite
oil-filled (resistive)

6300’ Base Monterey
clastic-rich

6500’ Franciscan Basement
subduction complex
The main reservoir is the bioclastic Monterey porcelanite and chert, also carbonates. Matrix porosities can be very good (20-30%). Matrix permeability is low (.1 md), high flow rates depend on fractures.

Low oil gravities are due to the thermal maturation of the Monterey source rock (and low Ro generation). The map shows the oil gravity distribution; higher gravity near where the Monterey is more deeply buried.
Most discoveries Unitized in the 1980’s (blue), downturn in 1986 (like 2015) made an impact, but environmental studies and development plans continued.

North of Pt Arguello, only platform Irene, Pt Pedernales field, made it through to approval (platform Julius, San Miguel field, got close) Then in the “Seaweed Rebellion” of the 1990’s, all others were lost (CCC, local elections, court cases).
Top Monterey Structure Map
C.I. 1000 Ft SS

*BOEM lumps these 3 fields into “B”
974 MMBO outside Pt Pedernales
Fields farther south discussed previously.

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

1 A 98 MMBO
2 San Miguel* 256 MMBO
3 Pt Sal* 210 MMBO
4 Purisima Pt* 230 MMBO
5 Santa Maria 25 MMBO
6 435 92 MMBO
7 Pt Pedernales 106 MMBO
8 443 14 MMBO
9 Bonito 49 MMBO

Only Pt Pedernales field has production (EUR). Reserves must be economic, politically feasible, the others are only technically recoverable now.

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974 MMBO outside Pt Pedernales
Fields farther south discussed previously.
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Low-gravity oil offshore California, pour points can be problematic, as they are onshore.

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