Tranquillon Ridge Prospect

Volume I

Drainage from the Tranquillon Ridge Prospect

by

Well A28 (Tranquillon Ridge Unit)

Prepared for:

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Important Note

Opinions expressed in this report are based on the data furnished to NAFT Consulting by various reliable sources. Except for production data, most raw data submitted is of confidential nature. Every effort has been made to preserve the confidential nature of such data in this public document.

Nomenclature:

bbl and Bbl =barrel

CUM= cumulative

BSCF= billion standard cubic feet

GOR= gas oil ratio in SCF/STB

IP= initial productivity, Bbls/well/day

MSCF = 1000 standard cubic feet

NGL= Natural gas liquids (Heavier gaseous hydrocarbons: ethane, propane normal butane, isobutane, pentanes and higher molecular weight hydrocarbons.)

SCF= standard cubic feet

STB = stock tank barrel

WOR= water oil ratio, dimensionless

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Executive Summary

This report summarizes a study on the oil and gas reserves of the Tranquillon Ridge resource area, its potential drainage by the operations of well A28 in the Tranquillon Ridge Unit and plausible mechanisms for such drainage. Furthermore, estimates have been made of expected future production for the development of The Tranquillon Ridge area as proposed by Plains Exploration and Production Company ("PXP"). Relying on information from other Monterey production in the area and from the analysis of geological data, mud logs, performance histories, well completion and an independent analysis of seismic data, we have reached several important conclusions:

1-Well A28 has drained and is continuing to drain about 27000 MSCF per year natural gas and the associated natural gas liquids from the Saddle part of the State-owned Tranquillon Ridge resource area. Amount of oil drained from the Saddle cannot be quantified at this stage. Well A28 is also wasting excessive stored water drive energy that is needed to improve ultimate recovery from the Tranquillon Ridge structure. Our estimation is that as of December 2007, the productivity of 1.4 million barrels of oil from the Tranquillon Ridge may have been jeopardized.

2- The maximum recoverable oil from the entire Tranquillon Resource area could amount to 170-180 million STB of oil and associated natural gas and natural gas liquids. Discounting for potential depletion of natural water drive energy, and the potentially lower quality rocks, the estimated recoverable may be a lower range of 40-150 million STB of oil. Information from initial delineation wells can be used later to revise the above estimates.

3- For the PXP limited 14 year scenario with 14 proposed wells, our estimation of recoverable oil ranges from 40-90 million STB.

4-In case of unitized operations between State and Federal lands, the division of reserves based on a volumetric calculation alone, a ratio of Fed 1.19 %/ State 98.8% applies. But, the dynamics of fluid movement across the structure can alter this ratio. A more accurate estimation of a split factor between the Federal and the State parts of the Tranquillon area will require the results of initial wells drilled and an assessment of pressure regimes.

Introduction

Following a Lease Line Well Agreement between the MMS and the California State Lands Commission dated February 13, 1997, Torch, as Operator for Nuevo, who at that time held the Federal lease, drilled Well A28 on Federal Lease OCS P-0441 from Platform Irene to a bottom hole location approximately fifty (50) feet from the seaward boundary of the State of California. This well drilling resulted in the discovery of a hydrocarbon-bearing Saddle connecting the Point Pedernales oilfield and the Tranquillon Ridge structure. Recent 3-D seismic data and existing 2-D seismic data, along with geologic interpretation developed by using the Point Pedernales Field as an analog, indicate that this structure continues and potentially increases in size into the lands under State waters, Fig. 1.

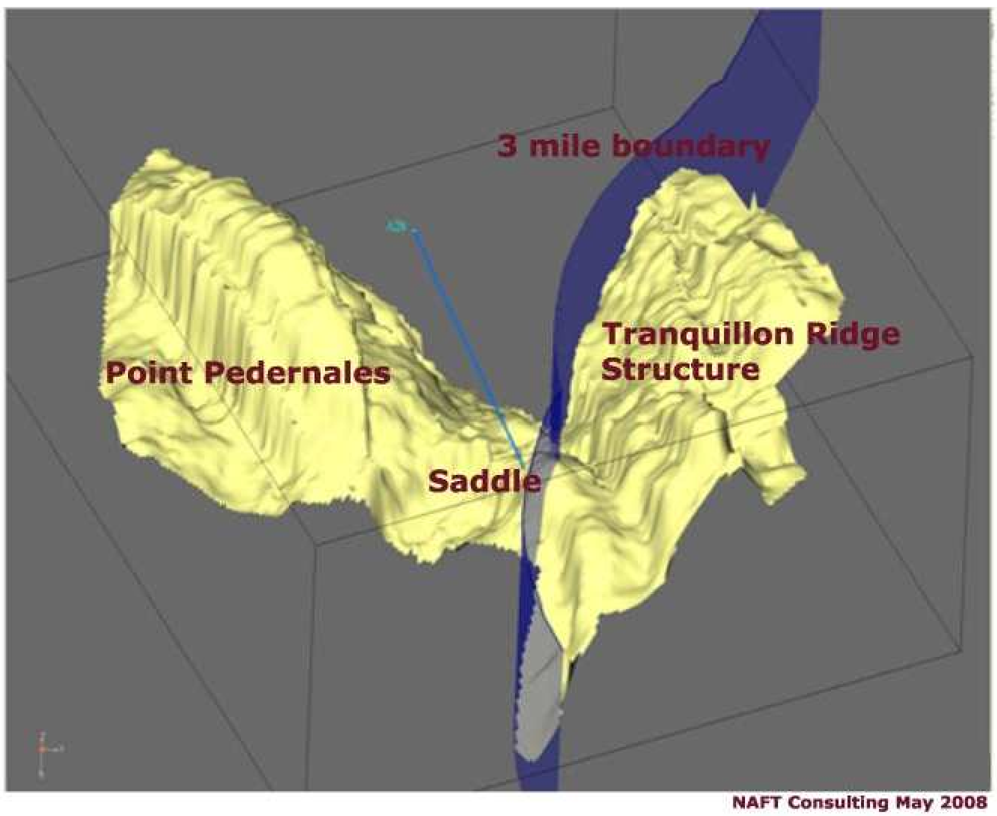

Fig. 1: Structural Continuity between the Point Pedernales and the Tranquillon Ridge (NAFT Interpretation).

For development of the State oil and gas reserves in the "Tranquillon Ridge" area, California State Lands Commission (CSLC) has received a proposal from Plains Exploration and Production Company ("PXP"), the current operator of the Point Pedernales oilfield.

PXP is requesting California State Lands Commission to issue two offshore leases in the area adjacent to their Federal leases. In its application PXP proposes to drill up to 14 new extended reach wells (and any required replacement or re-drilled wells) into the State leases from Federal Platform Irene, Fig. 2. Based on the applicant's data, the proposed project is planned around a 14 year life, with all operations to cease on or before December 31, 2022. Under the PXP proposal, the produced oil and gas from the Tranquillon Ridge operations will be measured and then commingled with the Point Pedernales oil and gas on Platform Irene, and will be sent, via an existing pipeline, to the Lompoc Oil and Gas Plant located just north of Lompoc, Fig. 3.

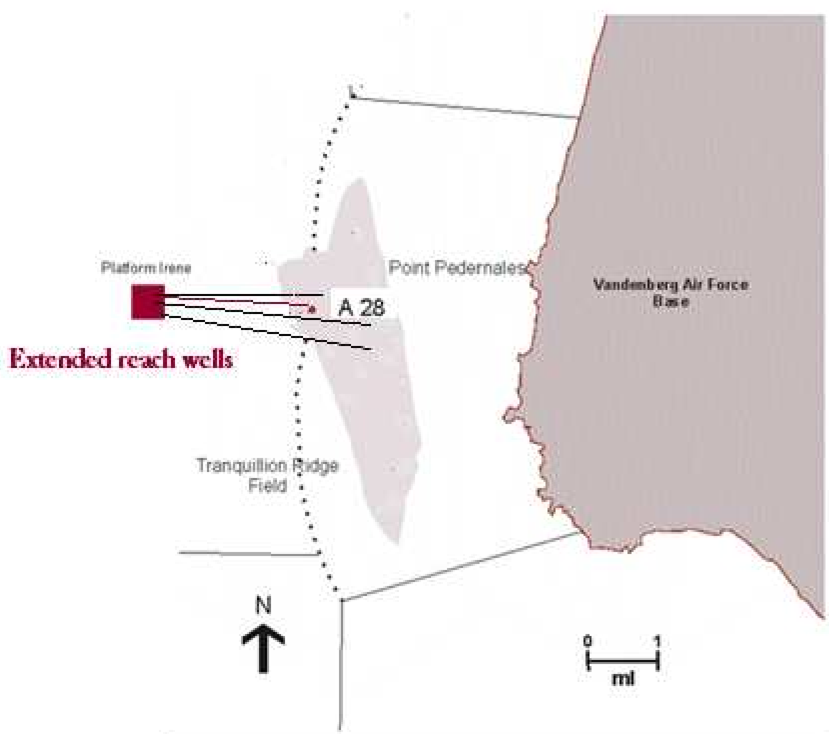

Fig. 2: Using Extended Reach Wells from Platform Irene.

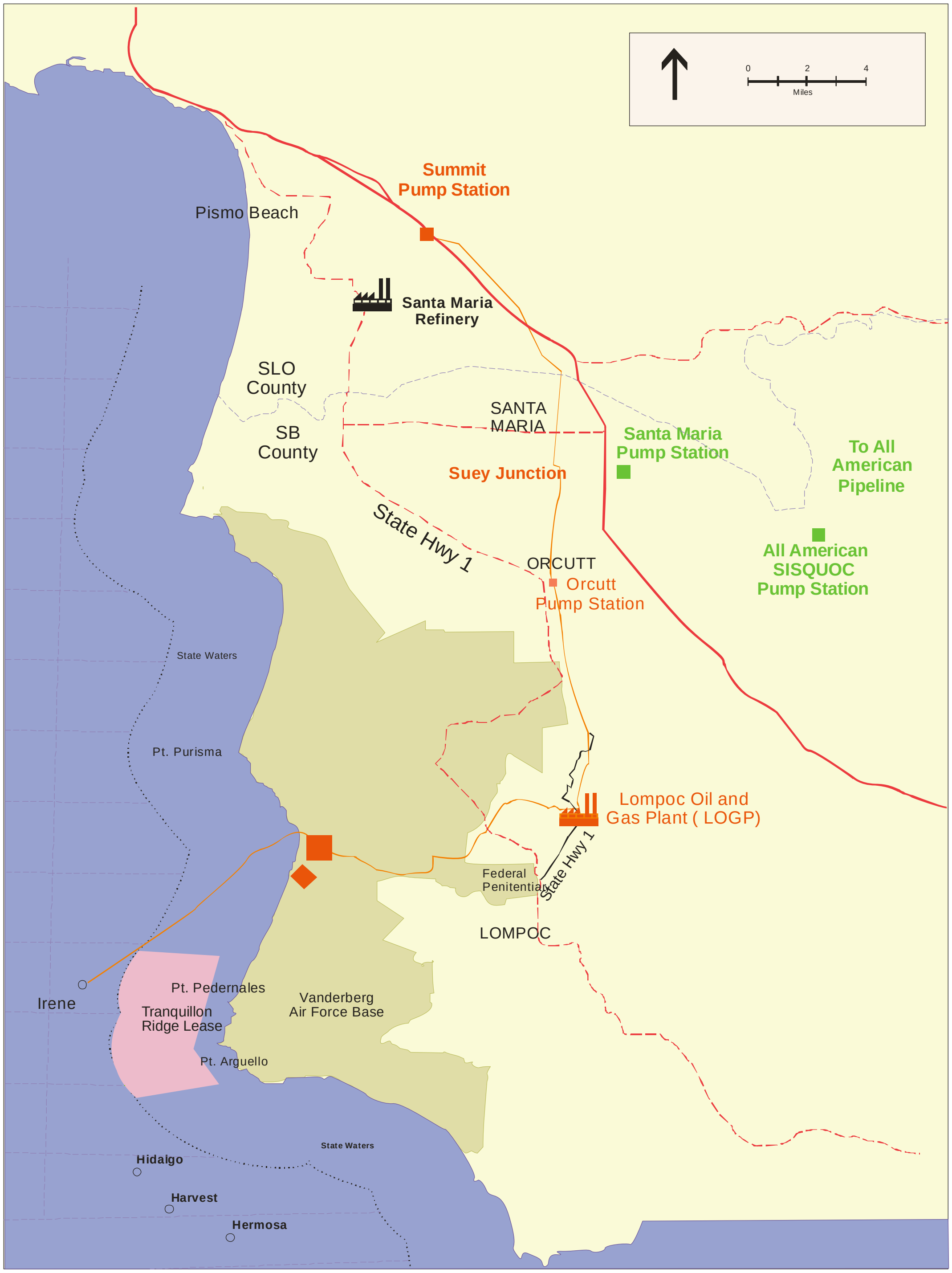

Fig. 3: The Treatment Facility in Lompoc CA (Courtesy PXP).

Regulatory Matters

The pending applications for State oil and gas leases pertain to the lands currently included in the California Coastal Sanctuary Act of 1994 that permanently prohibits the extraction of oil and gas in State waters. However according to Public Resources Code 6244:

> "*The commission may enter into any lease for the extraction of oil or gas from state-owned tide and submerged lands in the California Coastal Sanctuary if the commission determines that those oil or gas deposits are being drained by means of producing wells upon adjacent Federal lands and the lease is in the best interests of the state.*"

Under the PXP proposal, the development of the Tranquillon Ridge structure will not require the placement of an additional offshore platform in the area. California State Lands Commission Staff requires sufficient information and an expert opinion of the area under consideration for leasing to make a reasonably well founded recommendation to the Commission as to the mechanism and magnitude of drainage, if any, by the adjacent Federal oil and gas operations.

The main purpose of this study is to: determine if drainage from the Tranquillon Ridge structure is occurring because of production by well A28; explain the mechanism for such drainage, if occurring; and, provide engineering estimates of the potential oil and gas reserves of the reservoir in State waters which are being, or could be, drained.

The Point Pedernales Oilfield

Point Pedernales is an offshore field in the Federal Waters 4.7 miles off the Coast of Santa Barbara. Under the supervision of the Minerals Management Service, U. S. Department of Interior, The Point Pedernales Unit (OCS p-0441) has been operating since 1987. Total production (Dec. 2007) has been more than 80 million STB of oil, 27 BSCF of gas and 262 million barrels of water. Platform Irene is the only platform in the field and has 72 well slots. Produced fluid and sour gas are transported via separate lines to Lompoc Oil & Gas Processing Facility.

Production in this field is from the fractured Monterey Formation. Geophysical surveys show an extension of the field under the State waters. This extension is referred in this report as the Tranquillon Ridge Resource area. For the purpose of discussions in this report, we refer to the small structure connecting the Point Pedernales and the Tranquillon Ridge main structure as the "Saddle" that extends from Federal to State waters, Fig. 4.

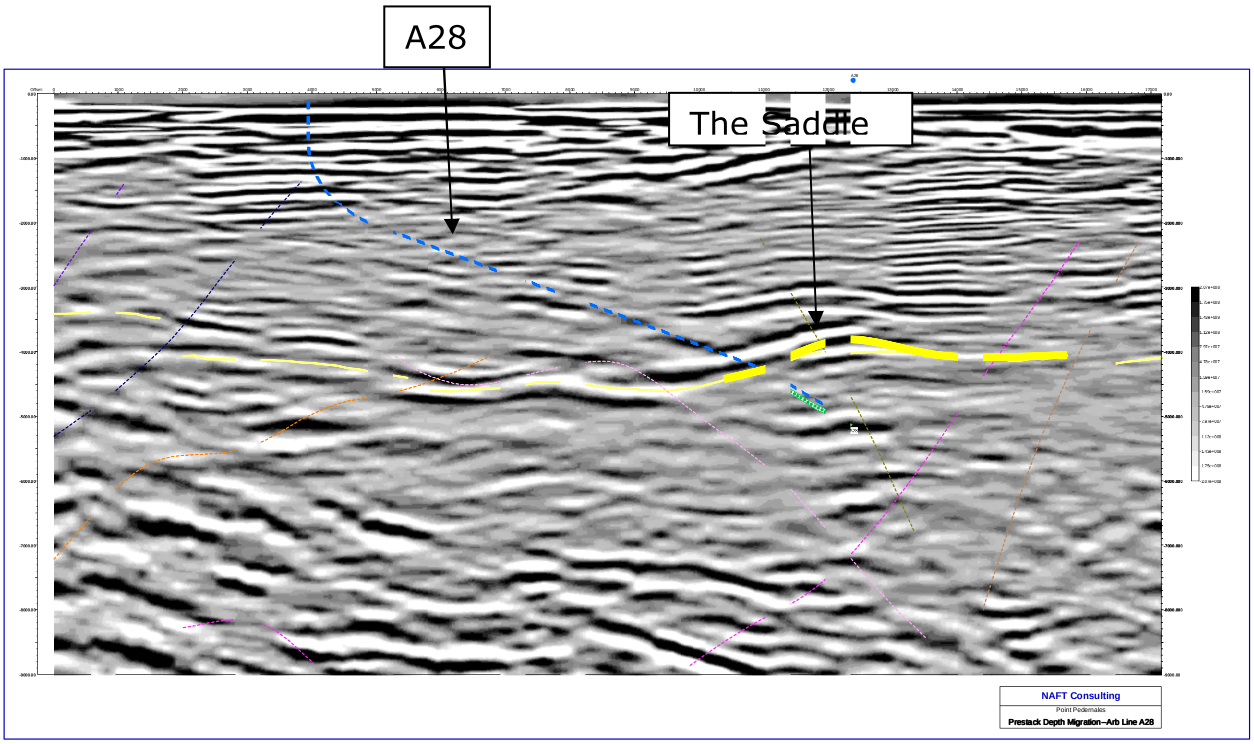

Fig. 4 Location of the Well A28 in the Saddle Area (top Monterey highlighted).

Data Sources

We gathered information from various sources. These included updated performance data on Point Pedernales wells, mud logs, completion data, seismic data, water chemistry data, performance on analog fields, published reports on outcrop studies and confidential reports on fracture orientation.

Performance data on Point Pedernales wells and well histories were collected from the archives of the Minerals Management Service in Camarillo, CA. Included in the information we received from State Lands were confidential reports by PXP and a previous study by Spivak Engineering.

Work Processes

The following is a summary of the work processes for developing an engineering opinion about the pending questions:

1-We reviewed available studies by PXP and the study by Spivak Engineering.

2-We collected seismic data and conducted independent 3D analysis of Point Pedernales field and the Tranquillon structure to assess the structural continuity. We used the 3D seismic data to compute the gross volumes of the Tranquillon Saddle under the Federal and State sides.

3-We studied the available geological data about the prospect under consideration by focusing on mud logs from the Point Pedernales Field and by examining previous studies of the Monterey Rock outcropping along the shoreline. We also reviewed various geological reports related to the analysis of fracture patterns, core analysis as well as observations made on the outcrops of reservoir rocks similar to those encountered in the Point Pedernales field.

4-We requested and received new water chemistry data from PXP on certain producing wells as well as that of sea water to ascertain the nature of the aquifer water in comparison to the sea water.

5- We examined performance histories of well A28 and others to scrutinize reservoir drive mechanisms.

7-We collected performance data from MMS on wells from analog fields (Point Arguello, Hondo, Sacate, Pescado) producing from the Monterey Formation.

8-We projected future production given the development plan by PXP and examined the determination of production split between State and Federal in case of a unitized operation.

Based on the above studies, we have developed various projections of the expected productivity from the proposed operation. In this Volume I of our Public Report, the focus is on well A28.

Observations:

1-There seems to be no discontinuities between the bottomhole location of A28 and the rest of the Saddle into which A28 has been drilled. The Point Pedernales field - the open hole completion of Well A28 drilled from Platform Irene - and the Tranquillon Ridge Saddle are on geologic structures connected to the undrilled Tranquillon Ridge structure under the State waters.

2- Produced water chemistry data indicates similarities among water composition from several producing wells pointing to the existence of a common aquifer. New data obtained from recent chemical analysis of produced water from several wells and analysis of sea water further confirm that understanding and demonstrate that sea water is not in communication with the aquifer water.

3-The mud log based lithological characteristics and the low oil recoveries from the formation around A28 indicate limited presence of high quality, highly fractured chert. The rocks seem to be mainly porcellanites and dolostones. As depicted on the 2D seismic image in Fig. 5, seismic data indicate that the bottomhole location of A28 is on the western side of the Saddle (Federal). The State area of the Saddle comprises more than ¾ of the volume of the Saddle.

3- At the start of A28 production, there was strong evidence of free gas in the Saddle suggesting prior depletion of reservoir energy. As shown in Fig. 6, in 1997, when well A28 was drilled, Point Pedernales had begun experiencing reservoir pressure losses as evident from its GOR history.

One potential cause of free gas is depletion of aquifer energy in the Saddle by prior operations at the Point Pedernales Field. As of December 2007, well A28 had produced a total of 201,657 STB oil and 443,547 MSCF of gas. The amount of gas produced from A28 was 393,000 MSCF more than the solution gas attributed to the total oil production of 201,000 STB. Fig. 8 shows a plot of cumulative gas oil ratio for well A28. From the start, Cum GOR values are above the solution gas oil ratio of 250+/- SCF/STB.

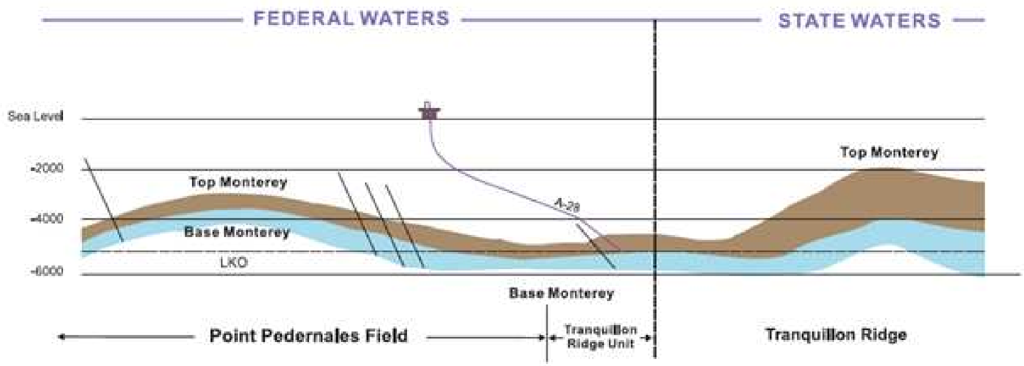

Fig. 5: Bottomhole Location of well A28 in the Saddle Area and the boundaries of the Saddle.

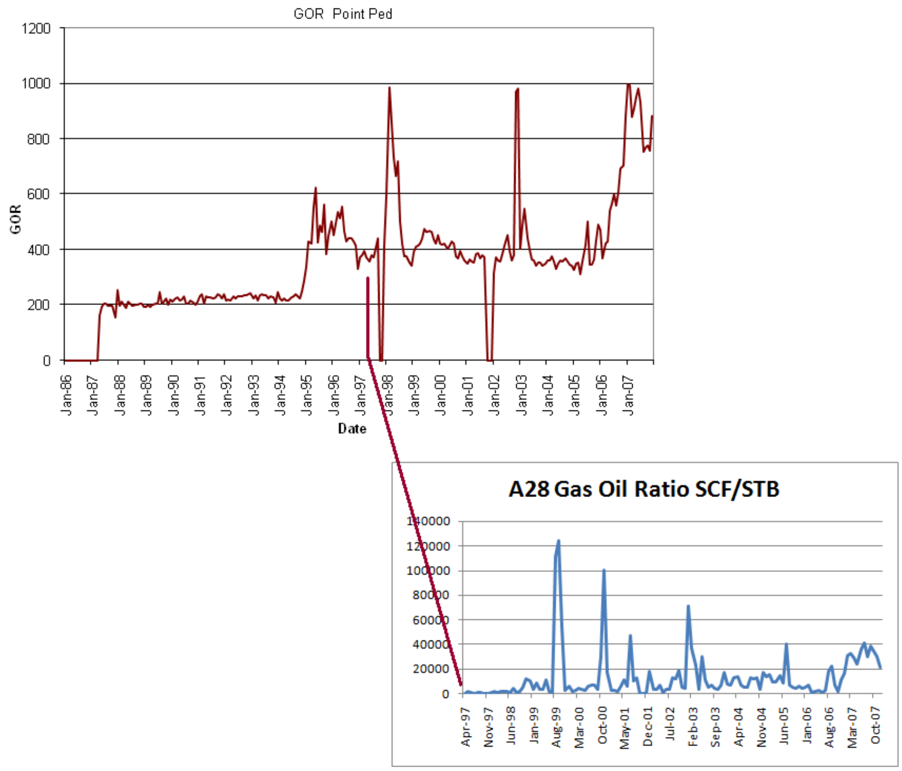

Fig. 6: GOR history of Point Pedernales field and the Start of well A28.

The high GOR's can best be seen on a magnified scale as shown in Fig. 7.

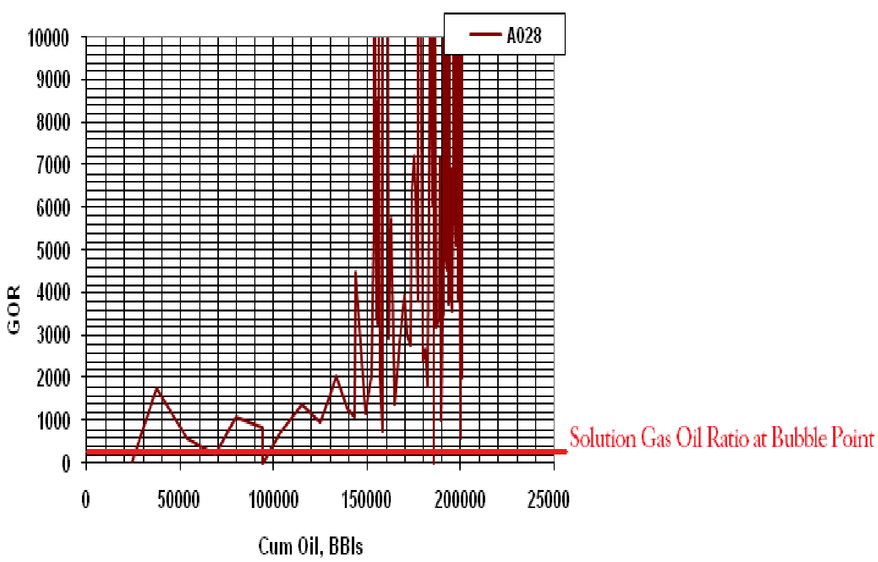

Fig. 7: Producing Gas Oil Ratio History of Well A28.

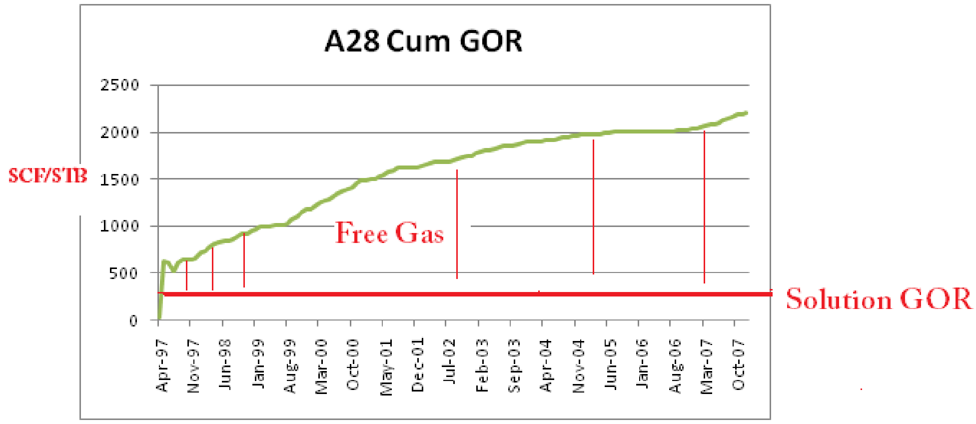

Fig. 8: Cumulative GOR for well A28, Tranquillon Ridge Unit.

Production of 393,000 MSCF free gas, corresponds to volumetric expansion of at least 1.5 million barrels of oil just below the bubble point in the Saddle area prior to the drilling of A28. Because of higher mobility and lower density, free gas tends to migrate to the higher structural positions. In the case of the Saddle, that would have been in the segment under State side. As such, the opening of A28 had probably resulted in the production of the free gas and associated liquids that had accumulated under the State side as depicted in Fig. 9.

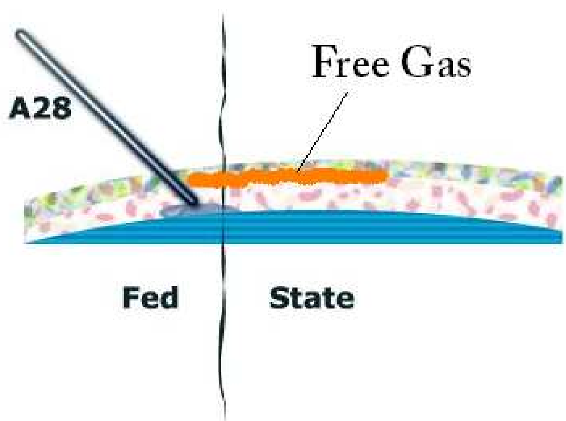

Fig. 9: Schematic of the proposed mechanism for free gas migration from State side of the Saddle.

Meanwhile, well A28 has been draining natural water drive energy from the Tranquillon Ridge structure as evident by its high cumulative water oil ratio, shown in Fig. 10.

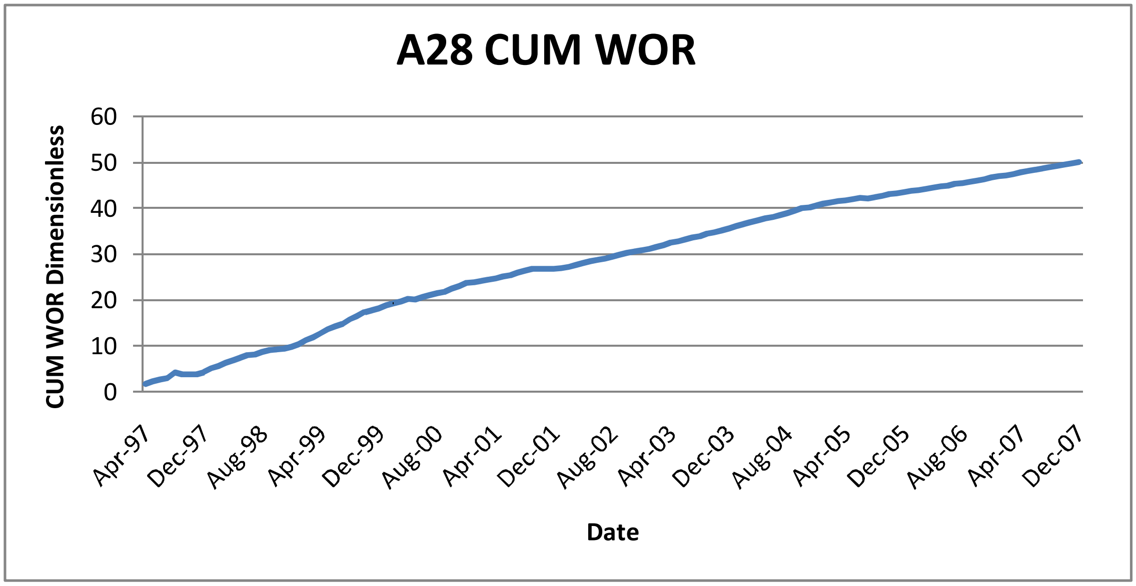

Fig. 10: CUM WOR History of Well A-28.

As shown in Fig. 11, the cumulative wor's of 259 wells in Monterey producing fields range from 0.026 to 6.25 with a mean of 0.929. For well A 28, the cum wor, as of December 2007, was 50.1. Taking the highest and assuming the worst case scenario of 6.25 was applicable to A28, the production of 10 million barrels of water from A28 has resulted in the production of (50.1-6.25)*201,000=8.7 million barrels of excess water. This excess production corresponds to a similar shortfall in availability of invading water from the common aquifer. It can potentially cause the loss of about 1.4 million barrels of ultimate recoverable oil in future development of the Tranquillon Ridge.

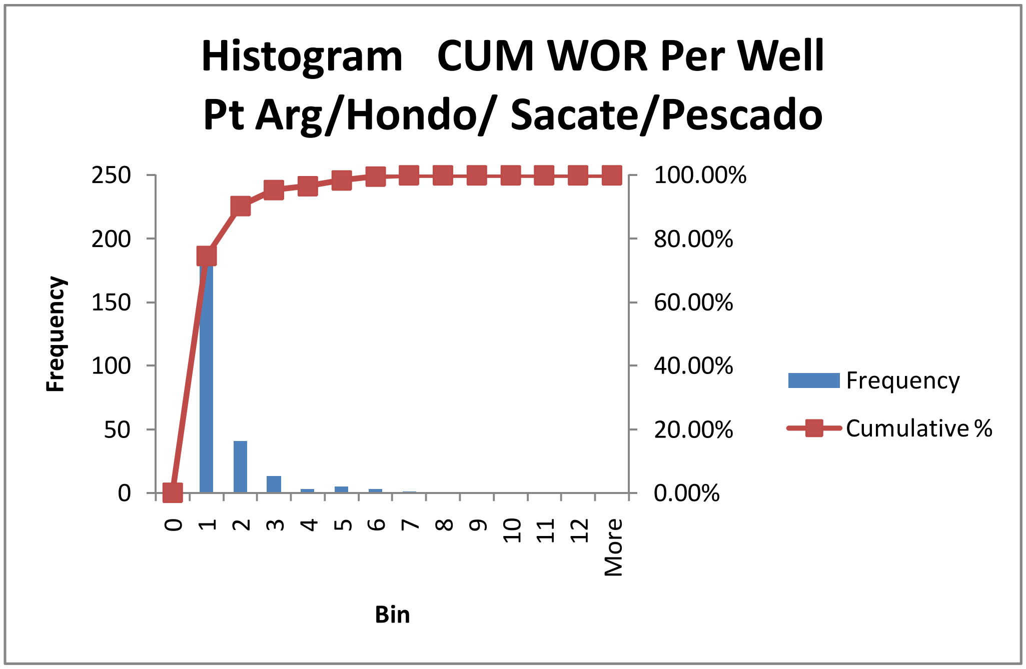

Fig. 11: Histogram of CUM WOR's for 259 wells Producing from the Monterey Formation.

Taking the worst case scenario to apply to the annual production, during 2007, the excess water production of more than 739,000 bbls from A28, corresponds to a loss of reservoir energy that can affect the ultimate recovery of more than 118,000. STB of oil or 323 STB of oil per day from the Tranquillon structure.

4-As shown in Fig. 12, substantial analog data of neighboring oilfields, producing from the Monterey Formation, shows that cumulative production from typical wells over a lifespan of 15-25 years has averaged 3- 5 million. barrels of oil. We use these estimates as the basis for projecting the recoverable reserves for the PXP proposed number of wells.

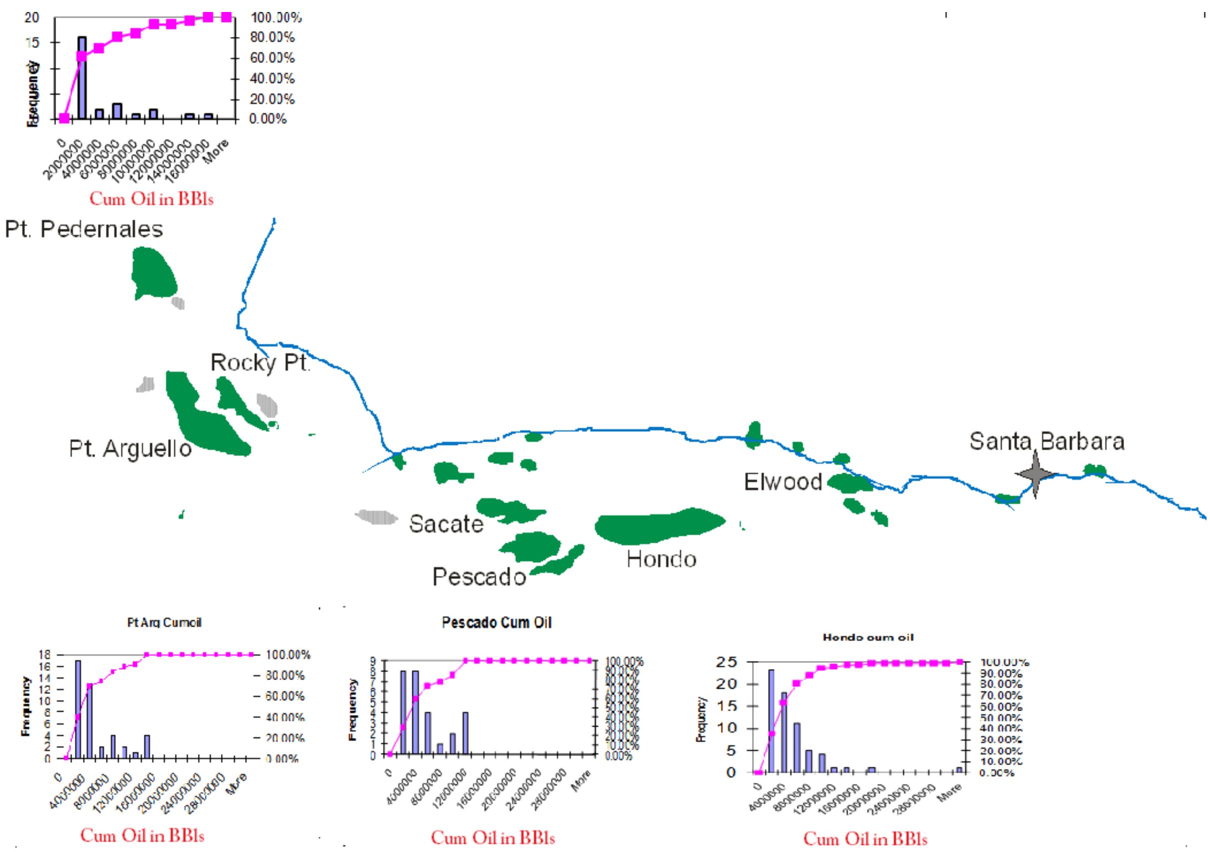

Fig. 12: Histograms of Per Well Cum Oil Production from Analog Monterey Fields.

Summary and Conclusions

We now present the results of this study in a format that responds to the questions posed under objectives of the study

Q1: Is drainage of oil and gas from State lands occurring by virtue of production from the A-28 well completed in Tranquillon Ridge structure? Identify potential drainage mechanisms if applicable.

Answer: Well A28 has been and is continuing to drain natural gas and associated natural gas liquids from the Saddle part as well as water drive energy, critical for recovering oil, from the Tranquillon Ridge State Resource. Table I shows the year 2007 production history of A28.

Date	Days	Oil	Gas	Water
Jan-07	31	105	1,713	73,964
Feb-07	27	63	1,948	37,546
Mar-07	31	89	2,866	51,013
Apr-07	30	125	3,678	74,946
May-07	29	113	2,722	78,489
Jun-07	28	92	3,292	56,165
Jul-07	30	107	4,371	63,093
Aug-07	30	101	3,047	62,963
Sep-07	30	139	5,409	66,390
Oct-07	30	133	4,576	55,732
Nov-07	30	79	2,387	53,523
Dec-07	31	83	1,800	65,771
Annual		1,229	37,809	739,595

Table I- Performance History of Well A28 in 2007.

Considering the gas production during year 2007, a quantitative estimate of gas drained from the State side of the Saddle is about 27000 MSCF of gas per year and the associated NGL. This is about 75% 0f the total gas produced. The exact amount of liquid oil cannot be quantified based on available data.

Q2: What are the potential reserves of the entire Tranquillon Ridge State resource area proposed to be developed using performance history and analogue of other Monterey production in the area?

Answer: Potential Reserves of the Tranquillon Structures can be as high as 170-180 million STB. This is based on the volumetric and recovery/ acre feet of analogs. The actual recoverable, however, will depend on the long term recovery losses caused by drainage of natural water drive energy, rock quality and other factors such as the economics, number of wells drilled and duration of development operations. Based on the PXP proposed operations, depending on the productivities observed on the newly drilled wells, the estimated reserves may range between 40-90 million STB.

Q3: What is the split between State and Federal reserves?

Answer: This is a question that cannot be accurately answered at this time. On the bulk volumetric basis, one may argue that the Federal side of the Saddle is roughly 1.19 percent of the total Tranquillon Ridge resource area.

But only after initial development drilling, can an assessment be made as to the nature of drainage of the Saddle by the operations on the State side.

Q3: What is the estimated production forecast based on the applicant's proposed development plan, using an analogue of other Monterey producers in the area?

Answer: Computations using the statistical averages attributed to other Monterey Producing fields show mean values in the range of 3-5 million barrels per well. According to the schedule of drilling proposed by PXP, as wells are added, a plateau attributed to the period of aquifer support develops followed by a decline period reflecting typical declines seen in other wells. The integrated forecast including the associated natural gas and natural gas liquids is shown below. Fig. 13-14 show the projected recoveries under various scenarios of IP.

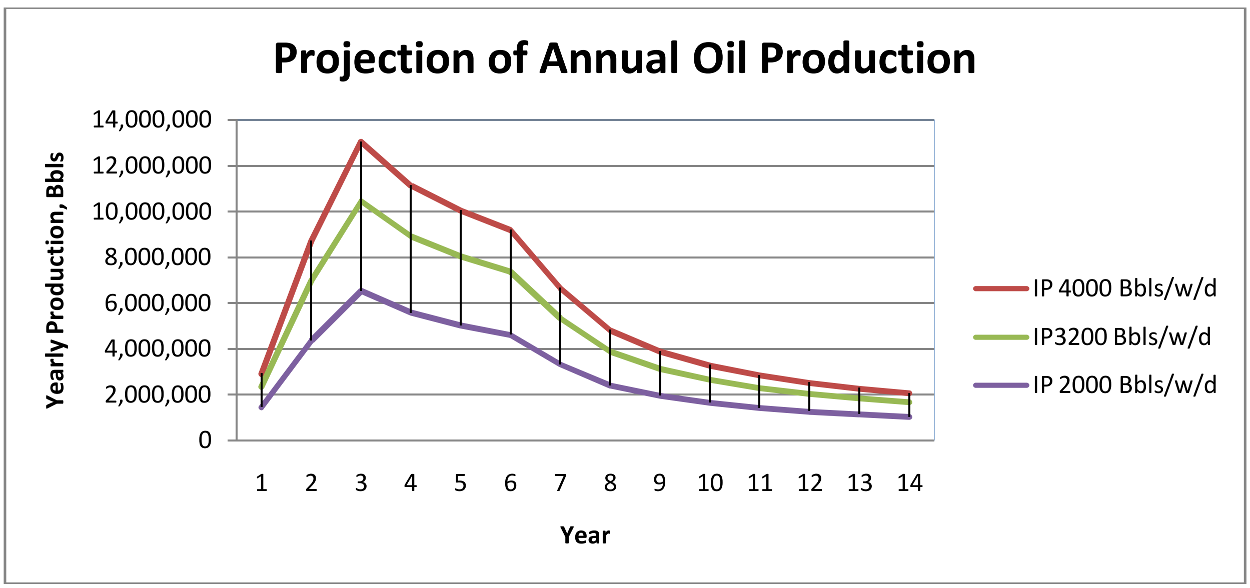

Fig. 13: Projection of annual production based on PXP proposed operations.

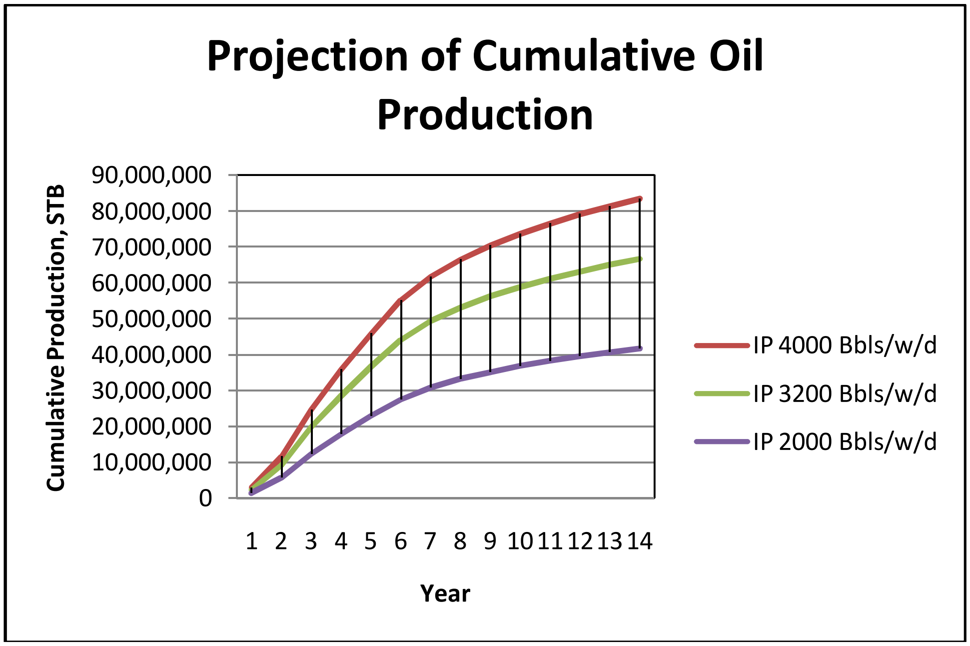

Fig. 14: Projection of cumulative oil production.

Appendix A: Geological Observations

The Tranquillon Ridge is located in a complicated structural area in the offshore Santa Maria basin. The area is in the transition zone between offshore north-south structures north of Point Arguello and east-west structures to the south and east. North of Point Arguello, numerous onshore east-west faults end at the Hosgri fault zone. The structural features in this region are the result of Miocene basin development during transpression-extension and block rotation followed by a Pliocene and later period of compression, in which pre-existing Miocene normal faults were reactivated as thrust faults. A major fault zone, the Hosgri fault zone, forms the east side of the Santa Maria offshore basin and is believed to terminate in the area of the Tranquillon Ridge.

The stratigraphy of the Monterey Formation in the region appears to be relatively uniform, although the offshore sections are generally thinner than the onshore section. The characteristic succession of rock types appears to be represented throughout the area. The development of fractures is key to Monterey hydrocarbon production and the dolomite and quartz-grade chert-rich parts of the Monterey section are where the most productive fractures are found. Quartz chert forms from opal (diatoms), primarily as a result of elevated temperature during burial. Fracture orientations vary due to the complicated tectonic history of the area. The result of this analysis, based on available studies, is that the productive open extension fractures are largely normal to fold axes.

1. Stratigraphy of the Monterey Formation at Tranquillon Ridge
   The closest outcrops of the Monterey Formation to the offshore 'Tranquillon Ridge' are about two miles due east on the coast at Point Pedernales and south of Point Arguello at the Rodeo Canyon Boathouse section (described and measured by Grivetti, 1982). The most complete section is exposed at Point Pedernales. Here, about 3200 feet of the Monterey Formation is exposed, including an upper section of 500 to 800 feet of clayey diatomaceous rock. If this clayey section at the top is excluded as reservoir rock, the thickness of the Monterey Formation is about 2400 to 2700 feet, depending on how the top of the formation is defined. The Point Pedernales section appears to be a complete section and is similar in thickness and represented rock types to that reported both inland and in the subsurface of the Santa Maria basin (Woodring and Bramlette, 1950; Mackinnon, 1989).

CONCLUSION: There is no significant stratigraphic difference between the Monterey Formation in the Santa Maria Basin and the coastal outcrops.

2. Stratigraphy/Thickness of the Monterey Formation at Tranquillon Ridge
The boundary between the Monterey Formation and overlying Sisquoc Formation is gradational and defined differently by various groups (Dunham, 1983). Dunham shows that the offshore contact is marked by a decrease in pure silica and a substantial increase in detrital clay in the shale at the transition of the Monterey and Sisquoc Formation. Thus, depending on how "clay-rich" is defined, the section in the Point Arguello field might include anywhere from 660 feet of Monterey Formation to as much as 900 feet, depending on how much of the clayey siliceous member is assigned to the Monterey Formation. A similar problem occurs with defining the top of the Monterey Formation in outcrops (see Grivetti's Point Pedernales section). Thus, some of the differences in thicknesses reported for the Monterey, aside from faulting issues, may be the result of how the top is picked. This may be important in interpreting the thickness of the Monterey Formation. Clearly, there may be some room for interpretation with regard to the thickness of the Monterey Formation at the Tranquillon Ridge.

The Point Pedernales outcrop section contains about 330 feet of lower calcareous rock, 1050 feet of organic-phosphatic rock, 2200 feet of siliceous rock (including 330 feet of a lower calcareous section). The top of the section grades upward into the relatively clay-rich Sisquoc Formation. Grivetti reports that "no tar is found in fractured dolomites at Point Pedernales." Tar-filled fractures and breccias are common in other coastal and inland outcrops of Monterey dolomites. Grivetti (1982) reports that the diagenetic grade of the Monterey Formation in the Point Pedernales section contains all grades of silica, including cristobalite, whereas the Lions Head and Rodeo Canyon outcrops are of higher grade and contain mostly quartz chert.

Offshore, the Monterey section is reported to be 1000 feet (300 m) thick in the Phillips P-0406 #1 well, 40 km NW of Purisima Point or about 30 km due west of Point Sal (Clark et al., 1991). This is considerably offshore and north from the Tranquillon Ridge site, in the approximate middle of the offshore Santa Maria basin (between the Santa Lucia fault zone to the west and the Hosgri fault to the east).

In the Point Arguello field, 10 miles SSE of the Point Pedernales field, the Monterey Formation is about 900 feet thick (Sadler, 1990). From the base up, the formation consists of 75 feet of calcareous siliceous facies, 80 feet of a phosphatic facies, 500 feet of calcareous siliceous facies, and 260 feet of a clayey siliceous member.

In the Point Pedernales field, Dunham (1982) describes about 700 to 800 feet of Monterey Formation in the Union OCS P 0441 #2 well (directly beneath the field platform), which is comparable to the thickness reported for the Monterey Formation in the Point Arguello field. Spivak Engineering reports that the Monterey Formation is 742 feet thick in the thickest section directly beneath Platform Irene (UNOCAL A-1 well), but much thinner over a paleo high in the eastern half of the OCS P 0440 block (northwestern part of the field) where it is only 225 feet thick. The UNOCAL A-12 well has only 112’ of Monterey section that is interpreted to be thinned over a paleo high in the B-B’cross section in the Point Pedernales field. Spivak Engineering also interprets, based on seismic cross sections, the Monterey units to thin over a paleo high in the northwestern part of the field, indicating that the structures were growing during Monterey deposition.

The A-13 well in the Point Pedernales field is reported by Yvarra (1992) to have at least 1072 feet of Monterey section (uncorrected log depths), of which the best chert-rich section occurs from 8030’ to 8205’ (UNOCAL Zone 3). An additional fractured chert section occurs in the upper part of a sequence from 8258’ to 8472’ (UNOCAL Zone 5). UNOCAL Zones 3 and 5 are generally believed to the best producers in the field (see Spivak Engineering report).

The ARCO OCS P-0444 No.1, south and east of the Platform Irene in the northeast corner of OCS P-044, has 1680 feet of Monterey Formation. Of significance here is that this well is the closest to the Tranquillon Ridge area and has a considerably thicker section than the wells in the Point Pedernales field.

CONCLUSION: The offshore Monterey Formation is about 1000 feet thick, about 1/3 to 1/2 the thickness of the onshore outcrops. Based on available data, the thickness at the Tranquillon Ridge is probably the same or greater than in the currently developed Pedernales offshore oil field and Point Arguello fields. The PXP interpretation shows the Monterey Formation to be 2000 feet thick on the top of the Tranquillon Ridge structure. We consider this to be an optimistic estimate. Two key variables are whether the Tranquillon Ridge was an active growing structure during Monterey deposition and how the boundary between the Monterey Formation and the Sisquoc Formation is picked. The Monterey Formation at the Tranquillon Ridge could be considerably thinner than this estimate.

The Monterey rock types present within the Tranquillon Ridge are probably similar to surrounding sections to the east (Point Pedernales coastal), the northwest (Point Pedernales field), and south (Point Arguello field). There is no indication from present data that suitable reservoir rock (i.e. the productive siliceous chert section) is missing from this area.

3. Fracture intensity of the Monterey Formation at Tranquillon Ridge
   The fracture intensity in the Monterey Formation is widely accepted to be a function of rock-type. Dolomites and quartz chert are relatively brittle and are the most intensely fractured. Dolomites form during early diagenesis of these rocks (essentially within meters of the sediment-water interface), therefore dolomite occurrence is largely independent of burial history. Quartz cherts, however, develop from opal (diatoms) that are crystallized to cristobalite (opal-CT) then to quartz as the rocks are progressively buried. These reactions occur mainly as the result of increased temperature during burial. Clay content also tends to enhance the reaction at a given temperature. The transition temperatures from opal to cristobalite and cristobalite to quartz, are approximately 40-60°C and 80-110°C, respectively (Murata and Larsen, 1975; Isaacs, 1982).

   Structure maps of the Monterey Formation at Tranquillon Ridge indicate that the top of the formation is approximately 1000 feet shallower than in the Point Pedernales field. Thus, depending on burial and uplift history and thermal gradients, the diagenetic grade of the siliceous section at Tranquillon Ridge may be lower and less fractured than the siliceous part of the Monterey Formation in the Point Pedernales field. If the shallower depths are a result of less burial, the section at Tranquillion Ridge may have been subjected from 10 to 20°C lower burial temperatures. Alternatively, the section at Tranquillon Ridge may have been subsequently uplifted more than the Monterey Formation in the Point Pedernales field, and the fracture intensity may be similar. PXP interprets the shallow Monterey Formation as being due to uplift.

   CONCLUSION: If the diagenetic grade of the Monterey Formation at Tranquillon Ridge is lower than in the Point Pedernales field, the siliceous part of the Monterey Formation may be less fractured.

4. Fracture orientations in the Monterey Formation at Tranquillon Ridge
   The best study of fracture orientations in coastal Monterey outcrops is by Hickman (1984; 1992). This internal UNOCAL report (later published in Hickman, 1992) describes fracture orientations from outcrop measurements between the Honda fault and Point Conception. Hickman’s study clearly shows that the major fractures are oriented NE-SW, roughly perpendicular to the fold axes, which trend NW-SE in the northwest part of this area and WNW-ESE in the southeast part of this area, forming a gentle curve subparallel to the coastline.

   Grivetti (1982) reports extensive joints and fractures with ‘random’ orientations in the Monterey Formation south of the Honda fault, which he attributes to proximity of the section to the fault. Chert fold axes in the Point Pedernales coastal section trend NW-SE and plunge 20-35° SE.

Bedding in this area, south of the Tranquillon volcanic outcrops, strikes approximately E-W and dips 30° S. Faults in this area generally strike E-W (including the major Honda fault).

At the Rodeo Canyon section, where about 1300 feet of the lower part of the Monterey Formation is exposed, bedding strikes NW-SE and is parallel to the axes of at least three anticlines and synclines. Fold axes within the deformed chert beds are parallel to those of the anticline-syncline structures. Similar fold axes orientations occur at Lions Head. Bedding in the Rodeo Canyon section dips 20-40° to the south.

Gutierrez-Alanso and Gross (1997) report joints at Purisima Point (approx 10 miles north of Point Pedernales) that are normal to the hinge line of folds (i.e. fold axis trend E-W and joints strike NNE-SSW). This confirms earlier outcrop studies and the relationship of fractures to fold axes. Their study recognizes small inversion faults within the section, which indicates that small scale compressional deformation occurs east of the major N-S Hosgri fault zone.

The Point Arguello field, 10 miles SSE of the Point Pedernales field, has a doubly plunging anticline that trends NW-SE. Extension fractures have developed in this structure that are oriented within +/- 15° of the fold axes (Sadler, 1990) and these fractures were recognized in all of the wells studied in the field. Fracture identification is from core and FMS image logs. The best developed open fractures are in the purest chert facies, which are believed to be the most important type of fractures for hydrocarbon production. Sadler (1990) also reported shear fractures and longitudinal fractures, oblique and parallel, respectively, to the fold axes. Shear fractures are not consistently oriented across the fold structures and longitudinal fractures are not always present.

Wells drilled from Platform Hidalgo, which produces in the northern part of the Point Arguello field, penetrate a NNW to NW trending anticlinal structure and confirm the presence of extension fractures perpendicular to the fold axes. This part of the field is approximately four miles due south of the offshore Tranquillon Ridge structure, and is therefore one of the spatially closest analog as to what might be encountered in the Tranquillon Ridge area. Based on offshore Quaternary fault trends, which extend from the Tranquillon Ridge structure around Point Arguello to the Point Arguello field (McLaren and Savage, 2001, Fig. 3) and recalling that the compression is mainly a late Pliocene to Recent event, the structural history of the Tranquillon Ridge would appear to be analogous to the structural development in the Point Arguello field.

A pilot fracture study of the A-13 well in the Point Pedernales field indicates average fracture orientations of 035 with dips either to the east or west of about 74° (Yvarra, 1994). This orientation is about 70° from the 325 trend of the main fold axis in the field. As expected, the best fractures are developed in the siliceous and dolomite facies. Preliminary studies of fracture orientations at Point Pedernales indicate that fractures are approximately normal to the fold axes. Large faults may increase the fractures intensity, but there is no data to quantify this relationship.

There are no studies of the relationship of fractures to the numerous cross faults orthogonal to the fold axes in any of the offshore studies. So the effect of these cross faults on fracturing is uncertain.

CONCLUSION: Joints develop perpendicular to the fold axes of both major folds and small folds within chert beds of the Monterey Formation. Joints in the coastal outcrops closest to the offshore Tranquillon Ridge (i.e Point Pedernales and Rodeo Canyon coastal outcrops) strike NE-SW. Based on previous studies, the north-south Tranquillon Ridge would be expected to have E-W extension fractures. Based on Sadler's 1990 study at Point Arguello field, fractures oriented oblique and/or parallel to folds are not important for hydrocarbon production. Grivetti's 1982 study indicates that fractures and breccias are more common in the Point Pedernales coastal section, which he attributed to proximity of the E-W trending Honda fault. The NW-SE thrust faults in the Point Pedernales field would presumably generate relatively closed fractures parallel to the thrust plane. Some faults might form perpendicular to the thrust direction, which in the case of the Point Pedernales field would be parallel to the extension fractures.

5. Fault orientations in the Monterey Formation at Tranquillon Ridge
The major fault closest to the offshore Tranquillon Ridge is the N-S trending Hosgri fault zone (HFZ). This fault, north of Point Arguello, largely separates onshore from offshore structures. Offshore north of Point Arguello, thrust faults strike N-S to NW-SE. These thrust faults are believed to have reactivated pre-existing Miocene normal faults during Quaternary (late Pliocene?) age compression. At and north of Point Pedernales, the thrust faults truncate major E-W trending onshore faults such as the Lion's Head, Santa Ynez River, and Honda faults (see Clark et al., 1991; and Lettis et al. 1995). The HFZ fault is upthrown on the east side and is interpreted to have 3.5 km of right-lateral offset (Sorlein et al., 1999).

The offshore thrust faults strike slightly more E-W south of Point Arguello (e.g. see Point Arguello field-see Sadler,1990), but the difference between the structural grain in the Point Arguello field and that in the Point Pedernales field is not that great (see Hickman, 1983, Fig. 3; 1992). This suggests that the HFZ is not a major structural boundary in the area of the Tranquillon Ridge.

Maps of the Hosgri fault zone (HFZ) based on published seismic lines (1979-1985 data) show that both the Tranquillon Ridge structure and the Point Arguello field structures are west of this major boundary (Streitz and Luyendyk, 1994). The HFZ is interpreted as an oblique right-slip fault that has been upthrown on the east side. Pliocene drag folds indicate right-slip motion in Pliocene and later time. No piercing points were identified by Streitz and Luyendyk (1994) to determine strike separation. A more recent study based on 3D block reconstructions indicates that the southern part of the HFZ has 3.5 km of post-Miocene right-lateral slip, with little if any vertical offset (Sorlien and others, 1999).

A different interpretation of the southern end of the HFZ is given by Cummings and Johnson (Fig. 1, 1994: compare to Fig. 2 of Streitz and Luyendyk, 1994) based on 1986 shallow (upper 1600') offshore seismic data between Point Sal and Point Arguello. They interpret the southern termination as a series of splays that bend to an east–west orientation. In their scenario, these splays extend into the Honda Fault and the Santa Ynez river fault as well as several other E-W trending faults in the area. They report that these splays do not cut a Pleistocene erosion surface, indicating mainly Pliocene and older fault activity. Note that McLaren and Savage (2001) show numerous Quaternary faults in the offshore area indicating relatively recent deformation.

Regardless of the structural interpretation of the HFZ, the Tranquillon Ridge structure would appear to be west or south of the HFZ. The Cummings and Johnson (1994) interpretation of the termination of the HFZ is a better match to the structural map of Hickman (1983), the latter which shows the gentle curvature of the structures around the Point Arguello area.

Overall, the structural location of the Tranquillon Ridge area is complicated by the transition from NW-SE structures to E-W structures and the termination of the Hosgri fault zone. Because of the apparent poor quality of the offshore seismic in this area (Spivak engineering report) there is a lot of room for interpretation. Hickman's (1983) field study of Monterey fracture orientations is a compelling documentation of the development of extension fractures roughly perpendicular to fold axes. Furthermore, his map shows that folds south of Point Pedernales to Point Conception are oriented roughly NW-SE, hence extension fractures are NE-SW. This also corresponds to data from the Point Arguello field (Sadler, 1990). So in spite of the proximity to the termination of the Hosgri fault zone, there appears to be a fairly good correspondence between coastal and offshore folds, thrust faults and fractures in this area.

Structure maps of the Monterey Formation in the Point Pedernales and Point Arguello fields show small cross faults orthogonal to the main thrust faults. The affect of small cross faults (normal to main thrust faults) on fracture intensity and orientation has not been studied.

CONCLUSION: In spite of the structural complexity of the area (transition from N-S to E-W structural grain), available data show similar fracture orientations for the offshore oil field and the coastal outcrops in the vicinity of Point Conception. The Point Arguello field may be a good analog for the Tranquillon Ridge. Faults at the Tranquillon Ridge would be expected to be oriented N-S to NNW-SSE with thrust offset.

OVERALL CONCLUSIONS:

1. The Monterey Formation at Tranquillon Ridge is probably similar or somewhat thicker than the Monterey Formation at Point Pedernales field with similar fracture patterns.

Caveats:

a. The Monterey section could be thinner if the Tranquillon structure was active during Monterey deposition.

b. The diagenetic grade of the chert could be lower (and the rock less fractured) if the relatively shallow depth of the Monterey Formation is due to shallow burial and not subsequent uplift.

2. Relatively open extension fractures should be oriented roughly E-W or normal to the Tranquillon Ridge fold axis.

3. The offshore thrust faults are oriented as expected for NE-SE compression. The NW-SE folds have resulted from this compression and extension fractures have developed normal to the fold axes. These spatial relationships correspond to the coastal outcrops in the vicinity of Point Arguello.

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