THE RESURRECTION
OF THE
HALF MOON BAY OIL FIELD
SAN MATEO COUNTY, CALIFORNIA

by

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PRESENTED AT THE 58th ANNUAL MEETING

OF THE

PACIFIC SECTION, AAPG

MAY 19, 1983

SACRAMENTO, CALIFORNIA

ABSTRACT

The history and development of the Half Moon Bay Oil Field, one of the oldest in California, is reviewed. The importance of understanding the micro-geology of the area (structural, stratigraphic, and lithological) is emphasized to provide optimum well location and well completion procedures.

The author suggests that right lateral fault movement is critical to a determination of structural entrapment of commercial quantities of oil and gas in the Pliocene (Purisima), Miocene and Eocene rocks underlying the Oil Field. It is suggested that two important faults in the Field are branches of the San Gregorio Fault and related to the tectonics of the San Andreas and Pilarcitos Fault.

Previous well completions did not consider adequately the clays in the potentially productive zones and have, therefore, failed to prove the commercial viability of the known oil accumulations.

The return of old wells (originally drilled ca. 1910) to commercial production from very thin Pliocene intervals indicates that considerable potential remains that requires re-evaluation.

The hindrance of current San Mateo County regulations to proceed with proper evaluation is reviewed.

THE RESURRECTION OF THE HALF MOON BAY OIL FIELD

HISTORY

The Half Moon Bay Oil Field is one of the oldest oil fields in California. The discovery was made at "Lane's Well" in Section 15, T6S, R5W, MDB&M, in 1882-1884. The area was known for some time prior to that as being a source of oil seeps, and Lane's Well was drilled immediately adjacent to an oil seep in Purisima Creek. J. B. Trask, on a trip by stagecoach from Southern California to Northern California, (see references) reported in 1854 to the California Legislature that

> "on streams (in the area) are to be found several bituminous springs, which discharge large quantities of the fluid bitumen...".

He indicated that these springs led to the belief, with which he disagreed, that bituminous coal existed in the section. He further indicated that the origin of bituminous springs is but little understood and "alone are not reliable evidences of the existence of coal, except when found among the carboniferous rocks." This was some five years before the drilling of the Drake well on Oil Creek in Pennsylvania.

The next recorded study of the Half Moon Bay Area specifically took place in 1888 by W. A. Goodyear on a trip from San Mateo to Spanishtown (now Half Moon Bay) and then down the coast (approximately present Highway #1) including a stop at Purisima, a village near the mouth of Purisima Creek. During this visit, he describes "Lane's Well" and the seepage of oil along the (Purisima) Creek in the vicinity of the well. He indicates that the Lane's Well had been "sunk" to a depth of 772' with 5-5/8" casing. The first oil had been struck at 240' and then the well was sunk to 570' "at which depth it remained for awhile". Then later it was sunk 200' deeper. His records indicate that the well was begun in April, 1884, (although other records indicate 1882) but was standing idle in October, 1885. The oil was reported to be "dark green, with gravity of 49° or 50° B.". Goodyear further indicated that

> "the rocks do not show on the surface... they consist of shales of varying hardness though generally rather soft, and that they dip to the south east or south..."

Goodyear describes other wells and oil seepages (no asphaltum) in the nearby areas of Tunitas Creek and Lobitos.

The Purisima Creek Area (Lane's Well) and the Verde Area of the Half Moon Bay Oil Field (Figure 1) have seen several sporadic exploration and development periods to exploit the obvious oil productivity already established by seeps and producing oil wells. In spite of heroic efforts by the California Division of Oil and Gas, the available records of several of these periods are poor, although state regulations in 1916 required the approval for the drilling of wells and the reporting of production. It appears that drilling along or adjacent to Purisima Creek took place in the following periods: 1890-1910, 1920-1928, 1946-1952, 1956-1961, and 1975-1979. Most of these periods can be directly attributable as a follow-up to the established production in the Field by earlier drilling, but the drilling after 1955 was spurred by the Richfield discovery at Oil Creek and the Union Oil-Neaves discovery and development at nearby La Honda North. Since these discoveries, and particularly since the development by Neaves Petroleum (Now Kriti Pacific Resources) as a follow-up to the original Shell Butts and Wilshire Cowell development in the Verde Area, environmental regulations of San Mateo County have posed great difficulty or prevented by law further drilling in the two Areas of the Half Moon Bay Oil Field.

STRATIGRAPHY

The stratigraphic column penetrated by wells in the Purisima Creek and Verde Areas extends from the Middle Purisima (Pliocene), Pomponio member, as described in Bulletin 181 (Figure 2), through the Butano (?) sandstone of Eocene age. It is believed that the younger members of the Purisima Formation (i.e. Tunitas, Lobitos, and San Gregorio) have been stripped off by normal erosional processes. Although considerable surface examination and identification of the Purisima Formation by other investigators has been done both north and south of the area of interest, the fossil and foraminiferal information from wells drilled in the Half Moon Bay Oil Field is sadly lacking. Only two wells have any record of carefully recorded paleontological information; and there is some doubt in the recorded information in view of the origin of the Purisima Formation sedimentation. In the Purisima Creek Area (near the discovery well, Lane's Well), several wells have penetrated the Miocene, Mindego member (Saucesian) upon which the Purisima obviously rests unconformably. Underlying the Mindego, the Butano Sandstone of Eocene age (Narizian) is generally found, although some Vaqueros/San Lorenzo intervals appear to be present. Also, in several wells, a common conglomeratic sandstone appears

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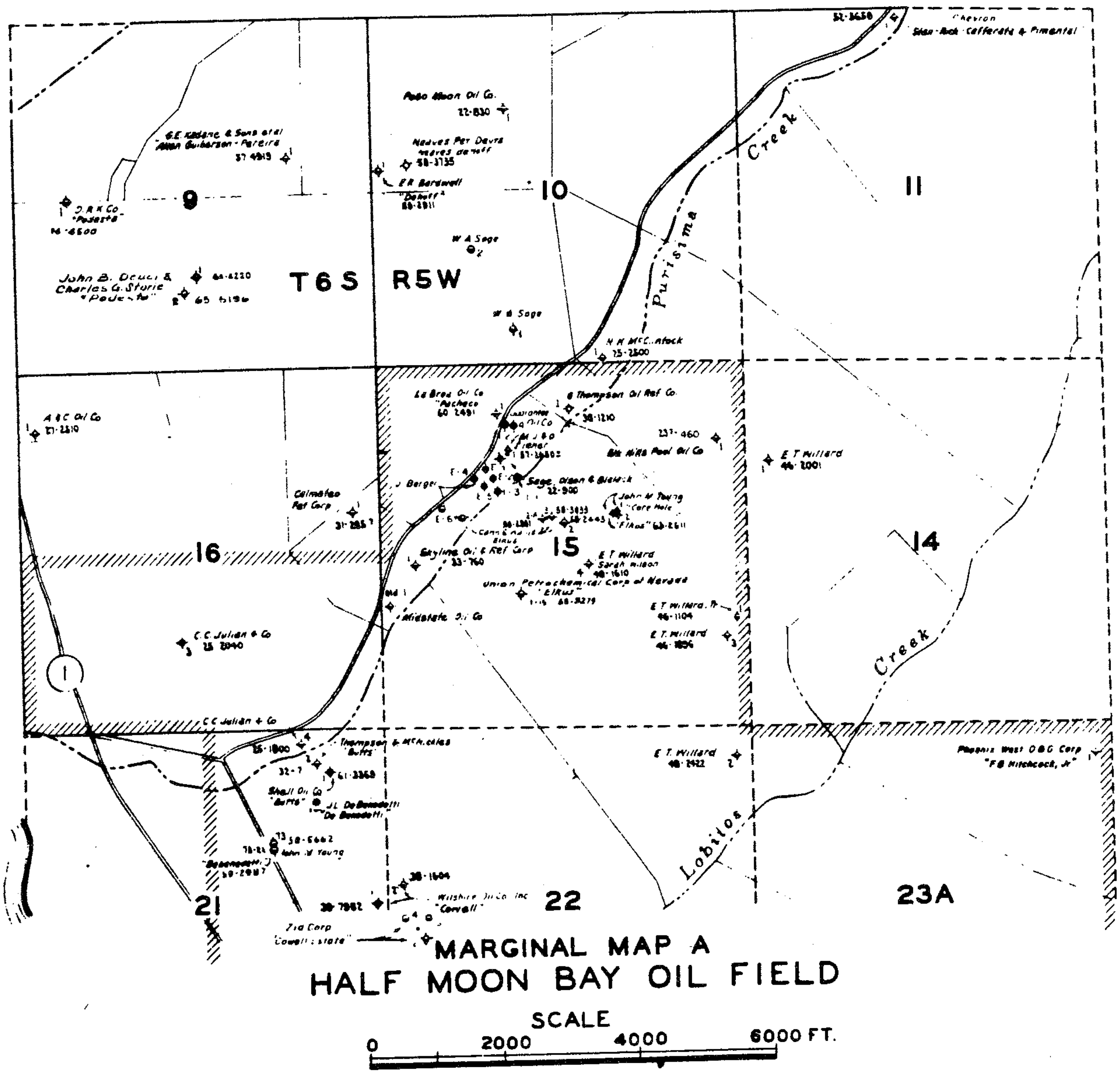


Figure 1

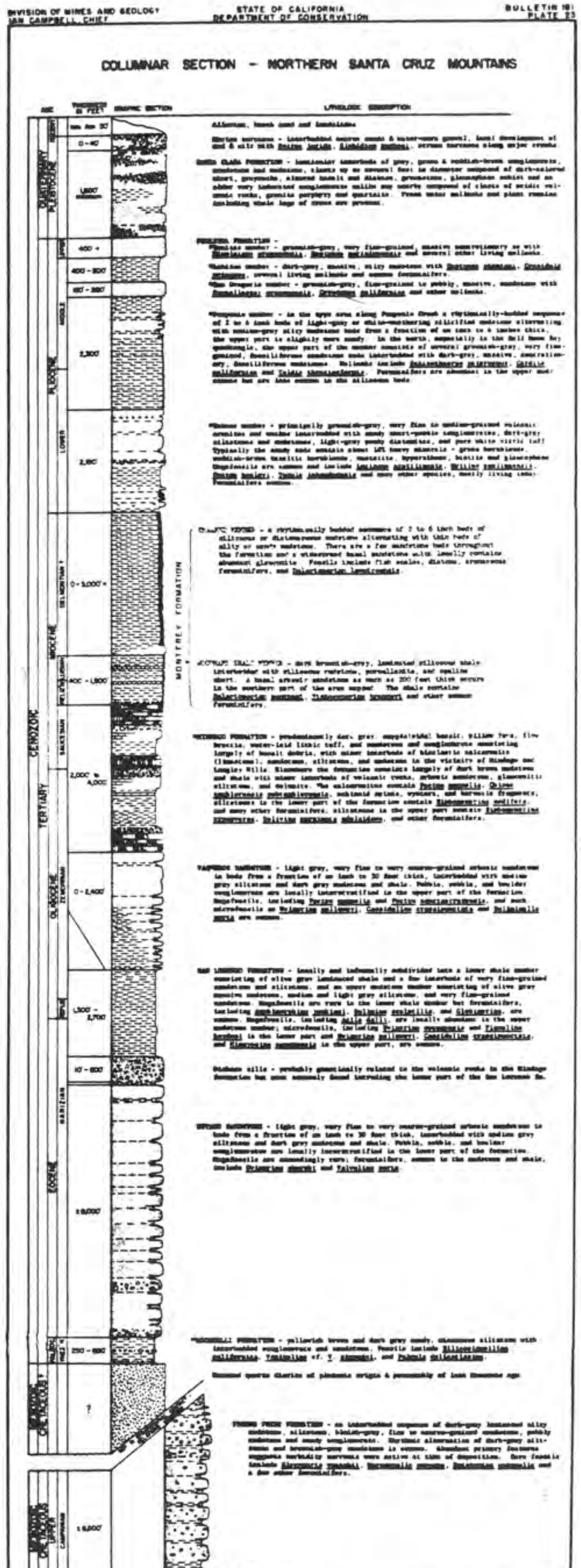


Figure 2

STRATIGRAPHIC COLUMN

to be present at the unconformity which may be related to the Santa Margarita Transition Zone, more usually associated with the Pliocene-Miocene contact in the San Joaquin Valley. A part of the Lower Purisima Formation in deeper wells, particularly toward the Verde Area and into the offshore, may grade into the Monterey Formation (Delmontian/Mohnian). Cross-sections of the area are shown in Figures 6, 7, 8, and 9.

LITHOLOGY

Since the lack of good paleontological information cannot assist in accurate identification of the geologic section penetrated by the many wells in this Field, considerable reliance has been placed on electrical logging characteristics (where the few logs are available) and excellent core descriptions by Elmo Adams and Charles Cross. In addition, particular attention has been given to the lithologic descriptions of surface samples by several investigators in the area (Cummings, et. al., Classen, and Brabb). This is not an accurate method of determining the age of the several petroliferous intervals in the geologic column, but, in the absence of other information, this method may suffice to satisfy part of the theory of the oil accumulation in the Field; and, more importantly, the potential available for further exploration and development.

From the several core descriptions, it is believed that the Monterey Shale plays an important part in the analysis of the oil generation and accumulation. For example, the Wilshire Cowell #1 in Section 21 cored most of the section below the presently established oil productive interval of the Purisima in the Verde Area. Correlation of the core descriptions and comparison with the logs from the Shell offshore wells (and generally accepted descriptions of the Monterey) indicate that a gradation of the Purisima (Tahana Member) into the Monterey is a distinct possibility. It is reported that the Wilshire well bottomed in Eocene at 7982' but no evidence exists in the public domain for such a conclusion. On the other hand, the analysis of the Standard Cafferata and Pimentel #1 well in Section 11 indicates that the Pliocene rests directly on the Butano sandstone of Eocene age.

In the vicinity of the original discovery in the Purisima Creek Area of the Half Moon Bay Field, later drilling indicates that the Purisima (Tahana?) rests unconformably on the Mindego member of the Miocene, with possibly a Transition Zone (Santa Margarita) being present. The lithology of the rocks penetrated by the wells, together with a knowledge of the origin of the sediments, is very critical in understanding the structural vagaries that exist, in determining the most likely areas of additional oil accumulation, and in determining the proper well completion procedure. Accordingly, three structural contour maps have been prepared,

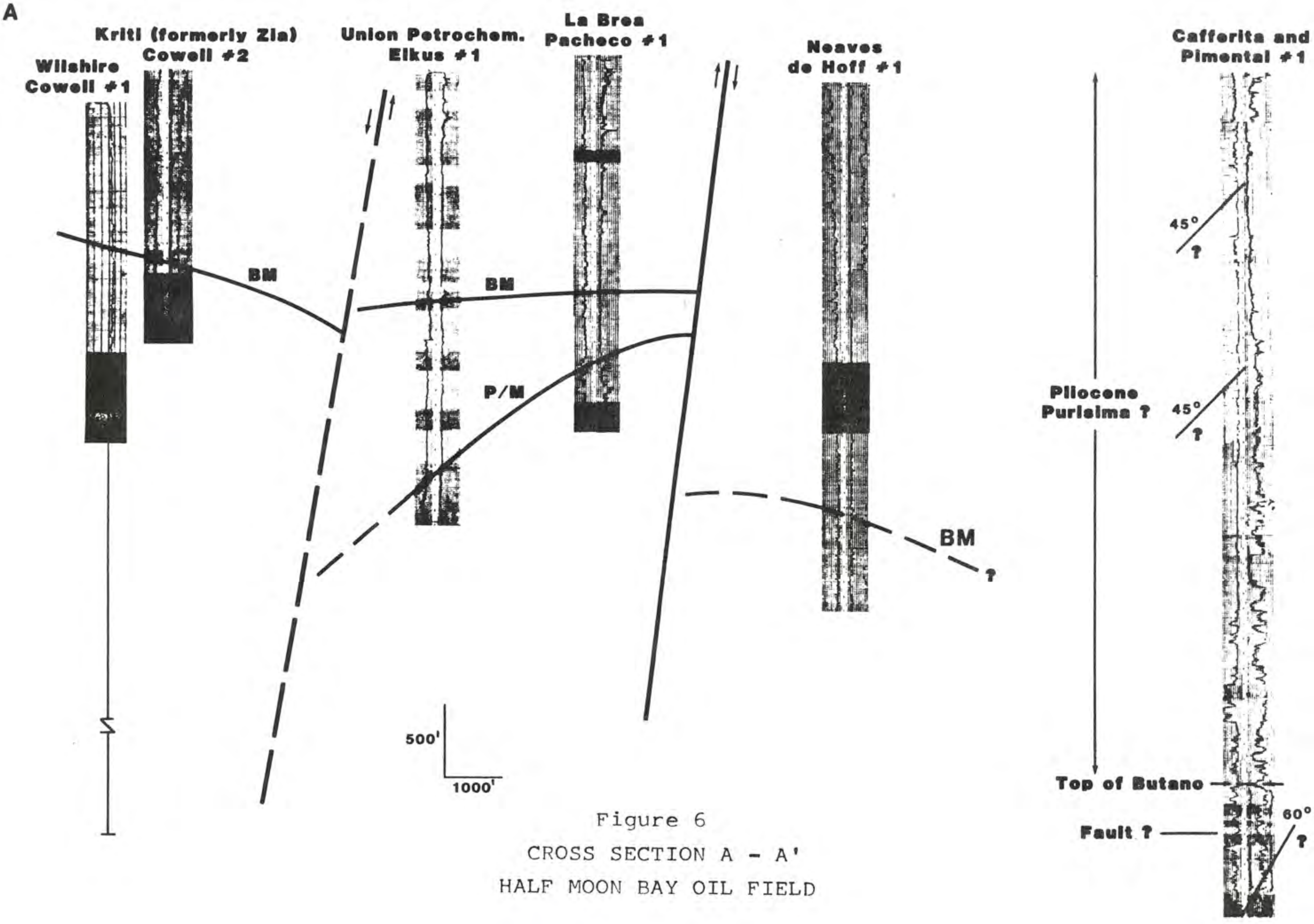


Figure 6
CROSS SECTION A - A'
HALF MOON BAY OIL FIELD

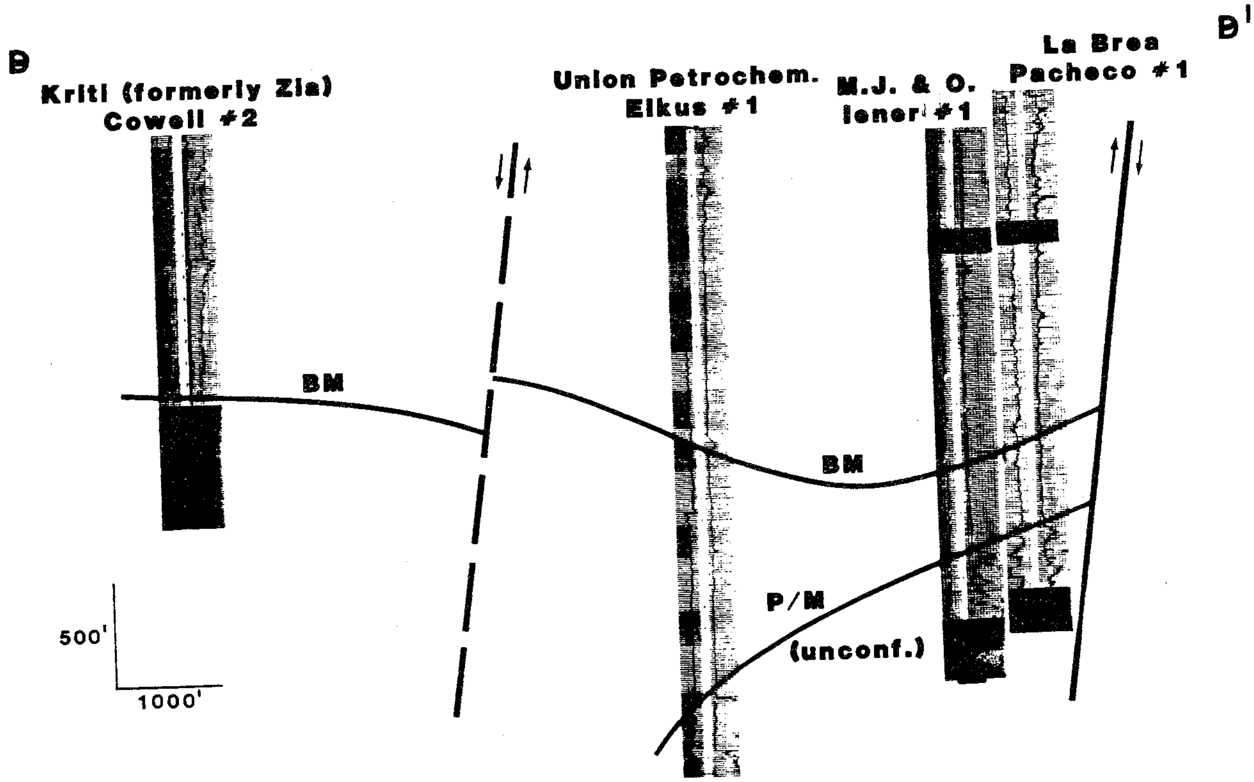


Figure 7

CROSS SECTION B - B'

HALF MOON BAY OIL FIELD

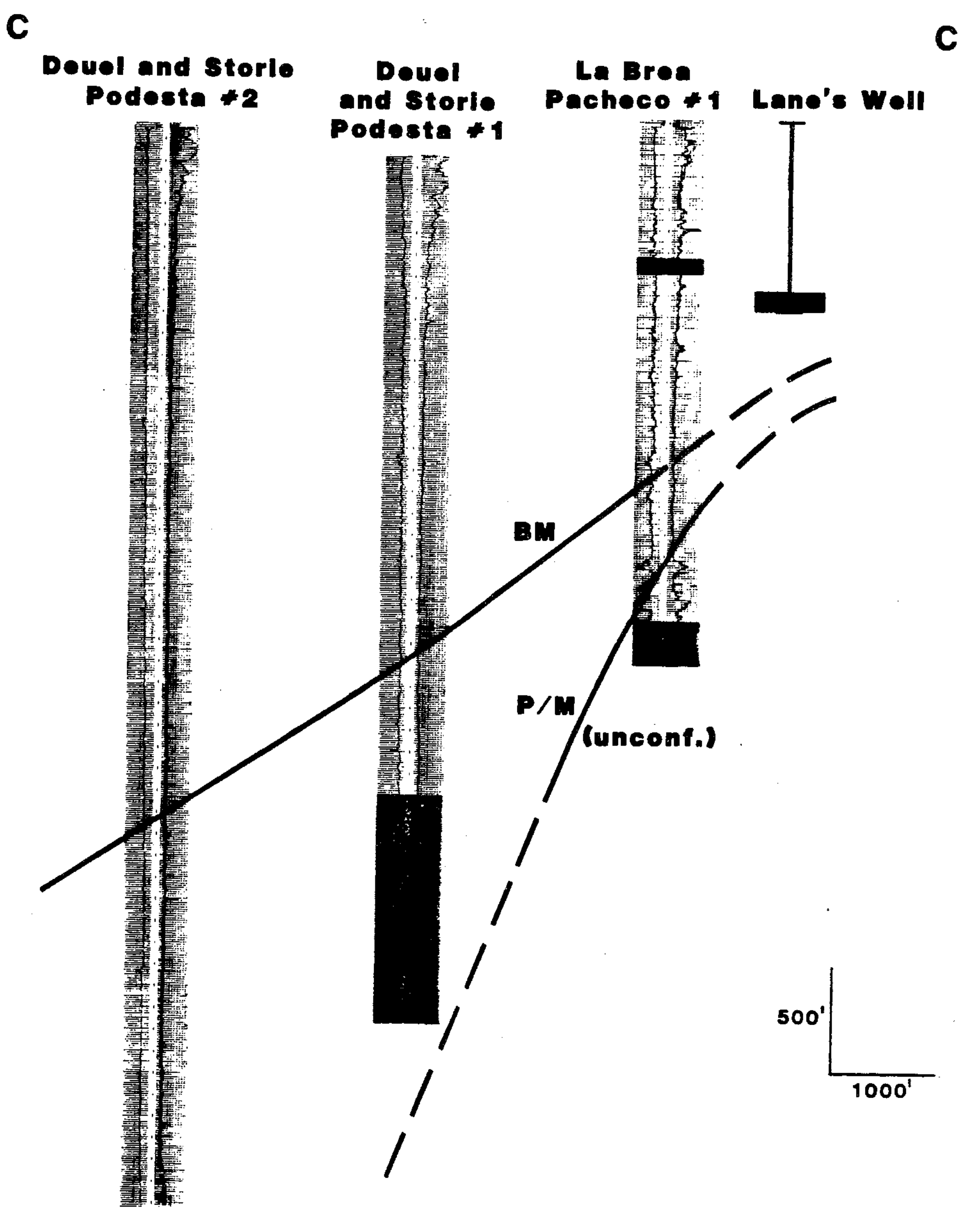


Figure 8
CROSS SECTION C - C'
PURISIMA CREEK AREA
HALF MOON BAY OIL FIELD

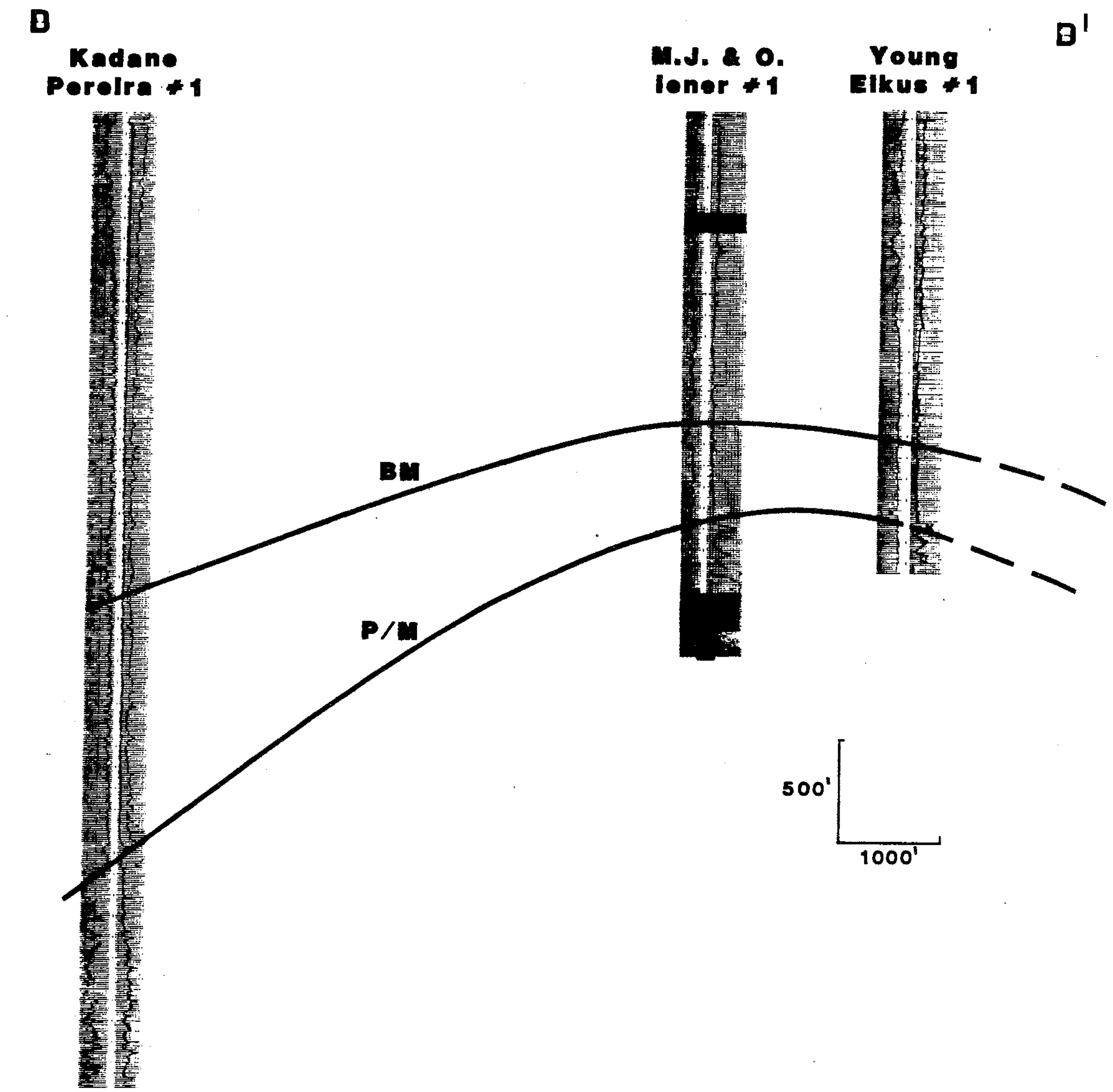


Figure 9
CROSS SECTION D - D'
PURISIMA CREEK AREA
HALF MOON BAY OIL FIELD

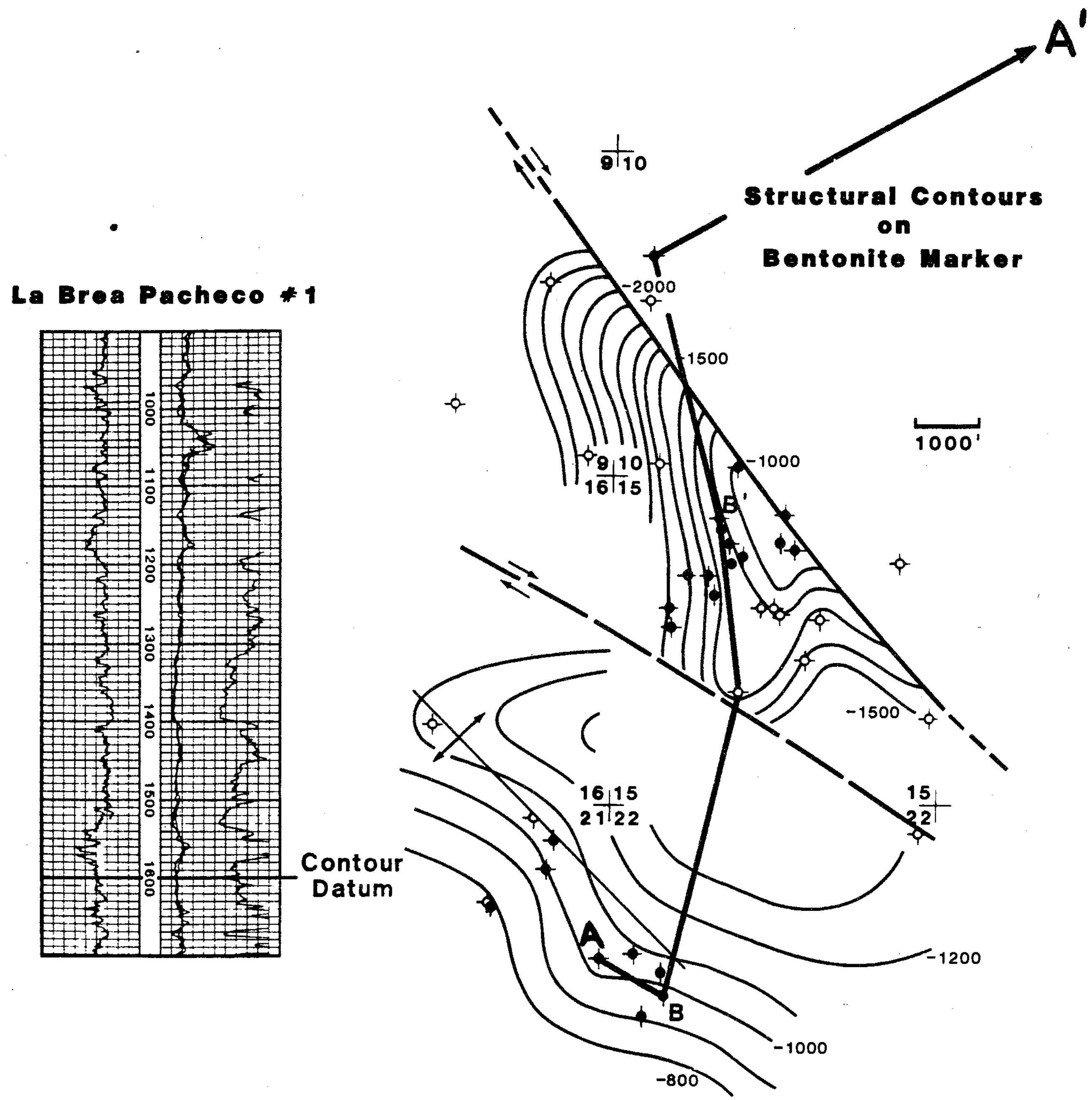


Figure 4
PURISIMA CREEK & VERDE AREAS
HALF MOON BAY OIL FIELD

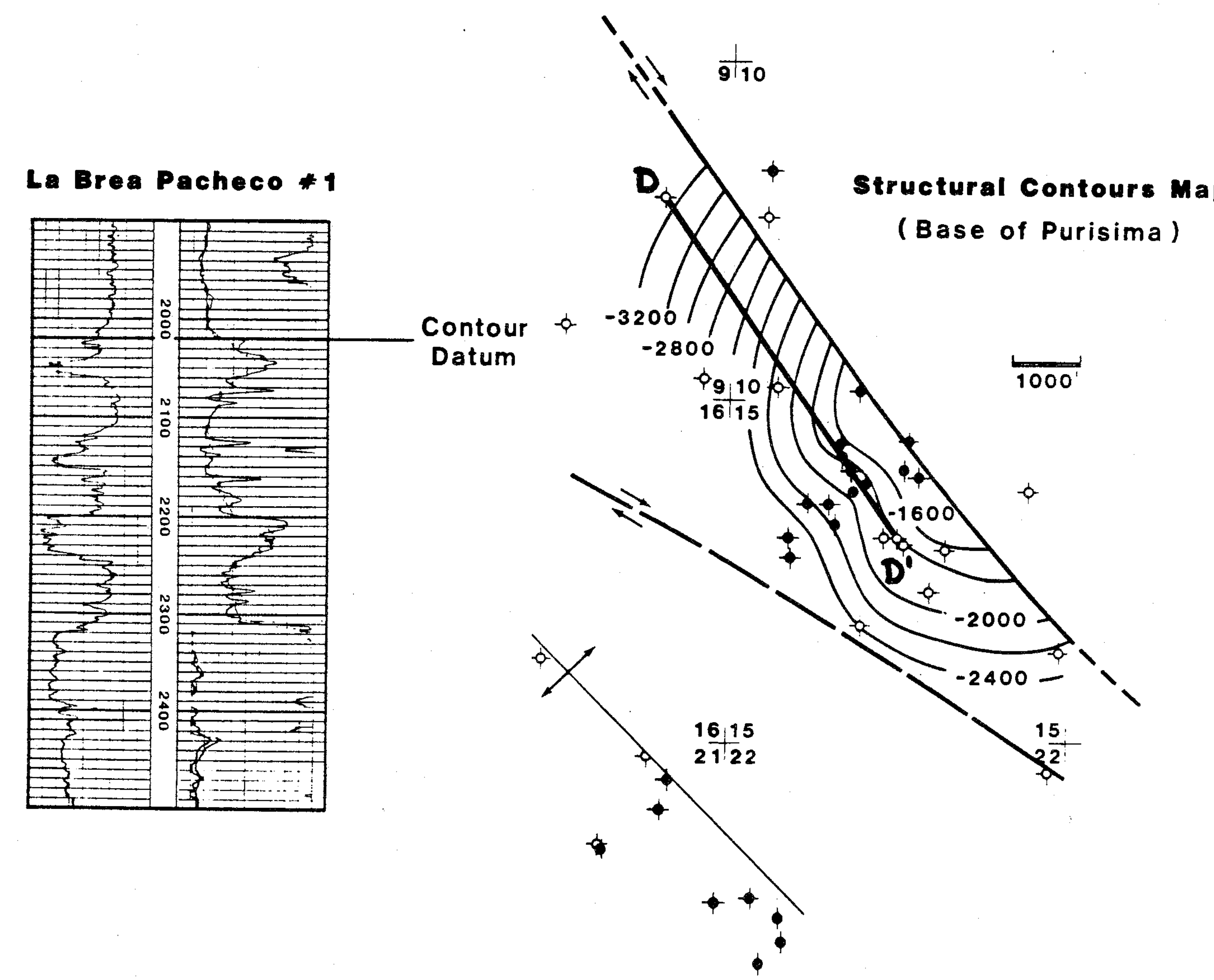


Figure 5
PURISIMA CREEK AREA
HALF MOON BAY OIL FIELD

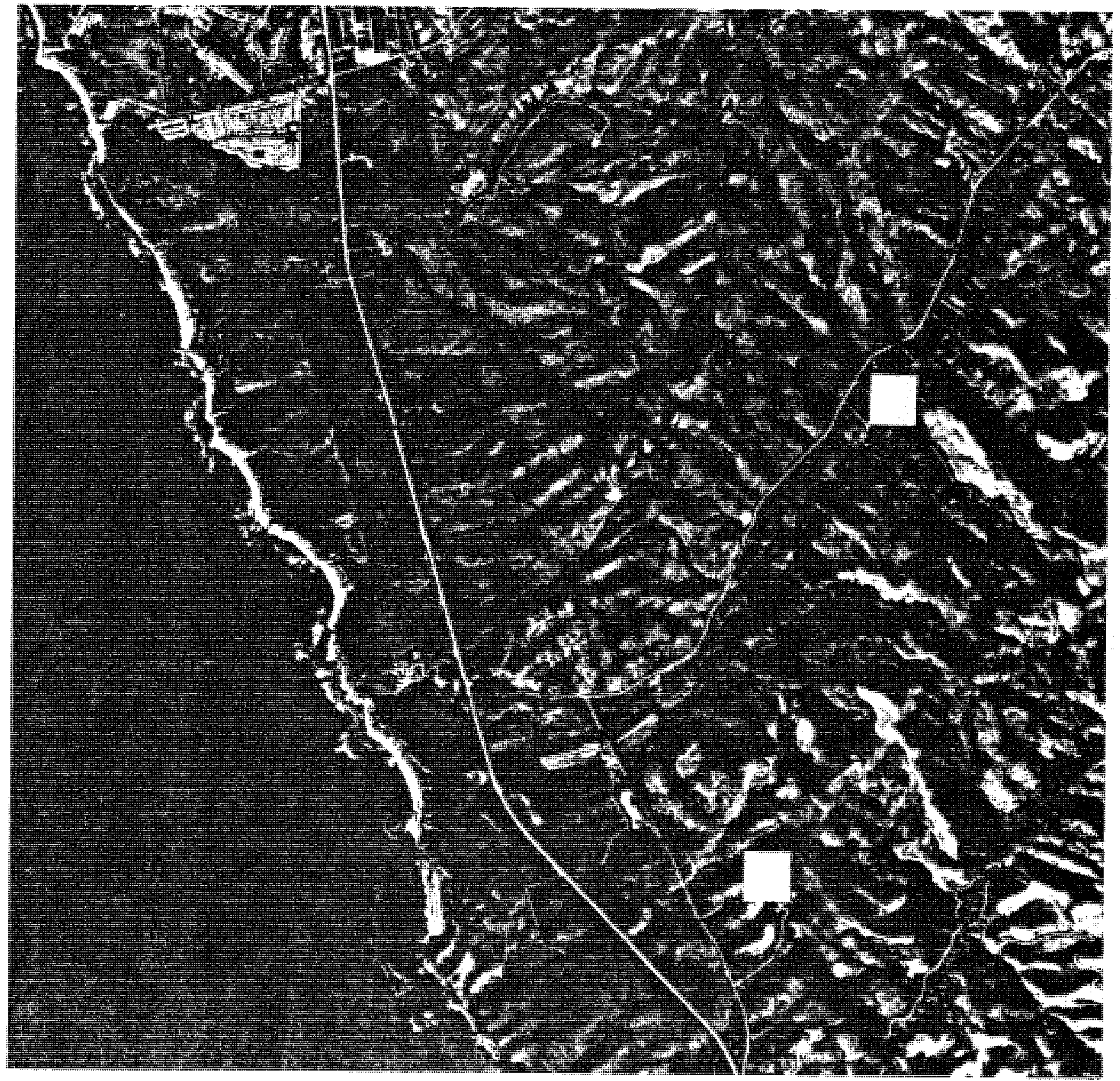


Figure 10

AERIAL VIEW OF PURISIMA CREEK AND VERDE AREAS

HALF MOON BAY OIL FIELD

Verde (?) Fault may be considered as either a normal or thrust type fault. But the establishment of the right lateral movement and the apparent nearly vertical hade of the fault makes such a consideration merely academic. The significant right lateral movement of other faults (e.g. 115 km along the San Gregorio Fault) suggests that the several branches of these faults would also have locally significant lateral displacement. Lack of subsurface information does not permit an accurate determination of the lateral movement but it is conceivable to hypothesize a five to ten km movement. The determination of a more exact figure is critical in determining the more likely position of Miocene-Eocene productive potential on the northerly side of the Canada Verde (?) fault as shown on the Pliocene-Miocene Unconformity Structural Contour map. As Nur has pointed out, with right lateral faults, "pull apart basins" become wider as they grow longer. Thus, the continual shear along the fault zone would result in several fault blocks at differing distances from the main lateral fault. Then the thickness of deposition of overlying sediments (and the position of older sediments) could vary considerably with time.

In addition to establishing oil production in the Mindego and Butano sand (although apparently non-commercial because of operational difficulties) in the La Brea Pacheco #1 and in the M.J.& O. Iener #1 in Section 15, drilling north of the fault indicated a considerably thicker section of the Purisima. Because of the right lateral movement probably taking place throughout the Lower Pliocene time, a graben type situation provided for continual sinking of the northerly block(s) during Purisima time deposition. It is therefore possible that better reservoir rock characteristics would be found in portions of the Pliocene basin north of the Canada Verde (?) fault, as indicated in the electric log of the Standard Cafferata & Pimentel #1 well in Section 11.

Presuming that the Canada Verde Fault controls both shallow Purisima and deeper Mindego-Butano oil accumulation in the Purisima Creek Area, subsurface well correlations have been made in the Verde Area of the Field on the previously recognized Purisima Anticline. It does not appear possible to logically correlate the "monocline" of the Purisima Creek Area with this established anticline to the south within the Pliocene Purisima without providing for a significant structural discontinuity. Previous investigators for many years have mapped the "Purisima Syncline" north of the surface anticline. Subsurface well control in Sections 15, 21, and 22, indicate that the axial plane of the anticline dips to the southwest, such that the crest of the anticline at the Bentonite Marker bed is shifted offshore (Figure 4). The result of the subsurface well correlations indicate that the "Purisima Syncline" should in fact be regarded as the surface expression of a significant, and again right lateral, fault. This fault, together with stratigraphic anomalies in the Purisima Formation, probably provides the trapping mechanism for the established oil production in the Verde Area of the Field.

An examination of the Pliocene-Miocene unconformity Structural Contour map (Figure 5) shows that the most southerly well, Union Petrochemical Elkus #1, may actually be in the Verde fault block, southerly from the herein defined "Purisima Fault".

Other investigators have named a fault to the northeast and beyond the area of study as the Purisima Fault but, based on the work of Graham and others, it appears that this major feature should be more properly designated the Pilarcitos Fault. Again, the position of the herein newly named Purisima Fault, suggests that it (and the Canada Verde Fault) are major branches of the San Gregorio Fault which has been projected to lie just offshore along the coast near the mouth of Purisima Creek. If in fact the Union Petrochemical Elkus #1 well in Section 15 is determined to be in the Purisima Anticline fault block, this leads to interesting speculation as to the position of the Miocene-Eocene intervals in a geologic environment of right lateral movement along the Purisima Fault.

Considerable time was spent in attempting to determine if the few wells with subsurface electric logs have, in fact, penetrated either the Canada Verde or Purisima Fault zones, but only vague and non-conclusive results were obtained. The interbedding of the Pomponio and Tahana members of the Purisima Formation provided little clue as to possible missing or repeated sections. In addition, it appears that the critical faults in the area of study are essentially vertical, and the obvious right lateral movement precludes the establishment of conclusive evidence of fault zone penetration, position, or hade.

STRUCTURE

It can be clearly established in the Purisima Creek Area of the Field that the oil accumulation in the Purisima interval, initially established by Lane's Well, is a result of faulting to the northeast of this discovery well. A well drilled later about 400' north of Lane's Well and across apparent surface evidence of the Canada Verde Fault produced small but significant volumes of 19° API oil. This is a distinct contrast to the 45° - 50° API oil produced by Lane's Well and still being produced in the Purisima Creek Area by two resurrected wells to the southwest of the fault. In addition, the Neaves DeHoff #1 well in Section 10 to the northeast of the Canada Verde Fault also produced oil on pump test from a part of the Purisima but again with a significant gravity anomaly. As shown on the Structural Contour map (Figure 3), the present oil accumulation in the Purisima Creek Area of the Field is depicted as a fault controlled "half dome" to the southwest of this major fault.

With the discoveries by Richfield at Oil Creek and Union-Neaves at La Honda North, renewed interest in the deeper possibilities in the Purisima Creek area was evidenced by the drilling of several wells deeper along the Canada Verde Fault trend. Most of the wells found some oil shows in the Miocene-Eocene section, when the section was encountered. Two wells in Section 15, La Brea Pacheco #1 and M.J. & O. Iener #1, established significant but low volume oil production of 37°API from the Butano sandstone. Further discussion of the reasons for lack of commercial production from these wells is noted in the OPERATIONS section of this study. Again, the available well control indicates that this potentially productive interval is a half dome lying southwest of the controlling Canada Verde Fault as shown in Figure 5. The establishment of production from these sands urges further study of the amount of right lateral movement along the fault and the potential for the "other half" of the Purisima Creek Area Miocene-Eocene oil accumulation.

It is also possible that the significant movement along this controlling fault may have provided a channel for the higher oil fractions of the underlying oil accumulation in the Miocene-Eocene section to have seeped upwards along the fault zone and to have been injected into the overlying Purisima beds. This is not regarded as very likely in view of

- the sharp difference of oil gravity (45° to 19° API) in the Purisima at shallow depths on both sides of the fault

- the essentially normal pressure gradient observed in tests of the Eocene interval in the two aforementioned wells, and

- the extensive oil accumulation established throughout the area, including the subsurface offshore, of numerous intervals within the Purisima Formation in the Purisima Creek Area and the Verde Area of the Field.

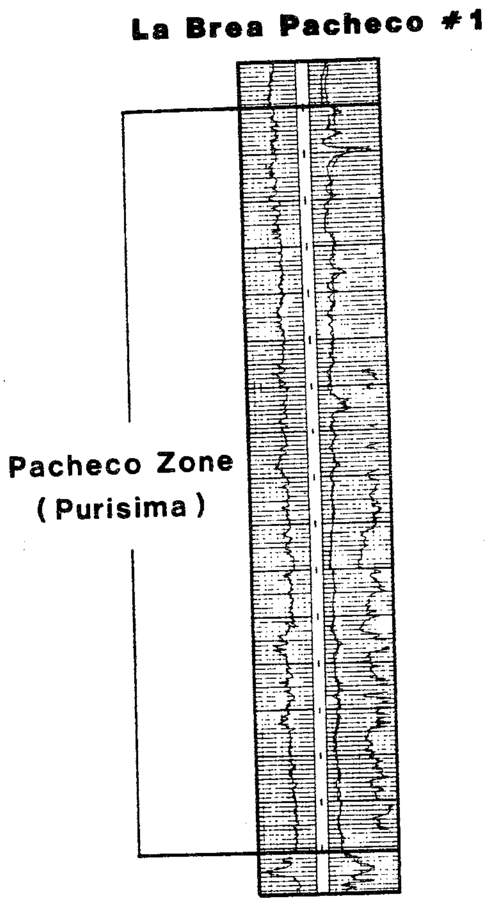
RESERVOIR CHARACTERISTICS

Close examinations of the few electric logs, core descriptions, and production characteristics of the numerous Purisima Formation completions in both Areas of the Field, indicate that the Pliocene accumulation occurs in the many thin (¼" to 6") sand lenses of the Pomponio and Tahana members of the Purisima. In addition, however, it is believed that there are numerous and significant fractures existing within the overall productive interval. The fractures, and their importance in acting as a reservoir rock, should be expected in view of the tectonic history of the entire area, and the tendency of many of the more competent shale intervals to exhibit bedding plane slippage and block fracturing. These characteristics have been observed in the surface outcrops and in a number of the core descriptions studied.

Accordingly, a study of the electric logs and core descriptions provided a basis, however tenuous, for an estimation of the reservoir volume of the Pliocene accumulation, as shown on the isopachous map of the "Pacheco Zone" (Figure 11). Using a combination of fractures and the many thin sands in the Pliocene section in the Purisima Creek Area and using the reservoir and oil characteristics as shown in Tables 1, 2 & 3, a calculation for a 130 acre parcel overlying the main accumulation has been made. The result of these calculations indicates that about 9,000,000 barrels of stock tank oil is in place in the Purisima Formation underlying the Purisima Creek Area. To date, however, less than 50,000 barrels (on the basis of very poor production records) have been produced from this shallow reservoir. For an explanation of the poor recovery and possible remedies to recover an economically significant portion of this large volume of oil in place, refer to the OPERATIONS section below.

OPERATIONS - COMPLETION AND PRODUCTION

Fortunately, the original drilling in the Half Moon Bay Oil Field was conducted by cable tool drilling methods during the period 1882-1884 to 1928, and even a well in 1959. This method undoubtedly provided for "automatic" mud logging methods. It has been established by several modern wells in the Field, and particularly the Verde Area, that some of the very thin sand layers in the Pliocene contain gas only, or the oil production is exhausted early and relative permeability characteristics of these sands provide for gas-only production. As such, it is easily conceivable that the early wells were completed as soon as apparently significant shows ("gushers"?) were encountered. It has been established



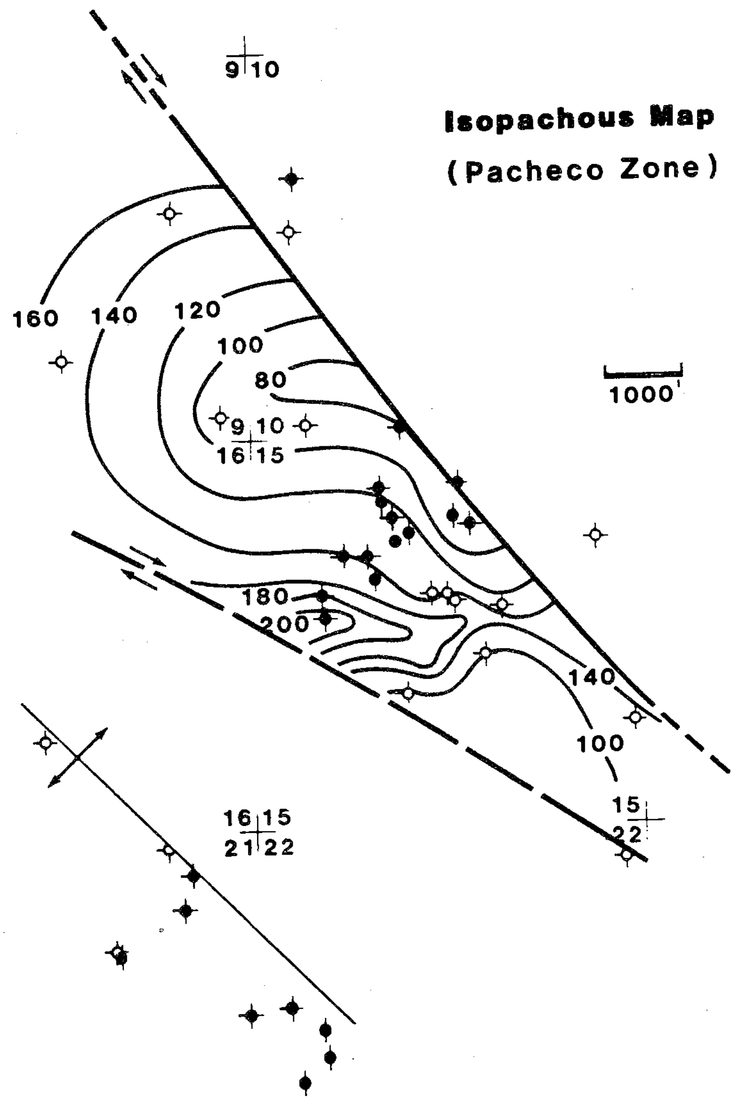


Figure 11
PURISIMA CREEK AREA
HALF MOON BAY OIL FIELD

by re-entry into some of the oldest wells (ca 1900-1920 completions) that only a very small section of the oil productive interval has been exposed for production. Yet a close examination of the many wells and the structural and known oil "shows" leads to the conclusion that over 1600' of the Pliocene (Purisima) formation is capable of yielding oil and gas production, in the range of 40^{o} - 50^{o} API. Although the production records are poor, particularly for the initial completions, eyewitness accounts (Miramontes) indicate that several wells had initial flowing oil production rates of up to 100 BOPD, although they declined (apparently rapidly, say, within a year) to about the four to ten BOPD level. As nearly as can be determined, none of the early wells exposed more than 30' to 60' of the oil productive portion of the Purisima.

During the period 1910 (prox.) to 1926, about five wells were pumped by a "jack-line" operation near the center of main shallow production area. The Division of Oil and Gas records indicate that up to 50 BOPD were obtained from these wells but the amount varied considerably, apparently because of the variation in the number of producing wells and the "jack-line" type of operation (Figure 12). Apparently, most of the wells "carried" the casing during the cable tool drilling and when significant shows were encountered, a short interval was penetrated. Exposure of the zone was done by a casing "ripper" or "pecker-punching" tool. Obviously, this completion method was successful in view of the lack of sand during production, thus giving further credence to the thin sands and fractured nature of the oil reservoir. There are several reports of the cable tools being "blown out" of the hole and, more recently with rotary drilling (1946-1979), attempted "blowouts" or strong "kicks" have been recorded while penetrating various sections of the Purisima Formation. Additionally, one cable tool drilled well, A & C Oil Co. #1 in the Verde Area of the Field, had to "add water" several times in order to provide sufficient fluid for bailing the cuttings from the hole, while reporting gas and oil shows from 340' to 1915'. This well was apparently near the Shell Oil Co. Butts #1 well, which is reported to have been the best producer in the Field, although production records are not available on this now abandoned well. The Shell Butts #1 well (and possibly others) supplied oil to another small refinery in the Verde Area, the remains of which can still be seen along Purisima Creek.

In 1926, the Purisima Creek Area of the Purisima production was shut in because of poor market conditions and poor economics and only returned to production when several of the wells were resurrected by the Layne Oil Co. A small refinery located near these wells was then abandoned when the wells were shut in in 1926. Meanwhile, in the Verde Area, the Shell Butts well was apparently producing from the Purisima at some depth above about 3000'. In addition, the Wilshire Oil Co. drilled two wells in 1938 on the Cowell lease in Section 21. Again, only a portion, but a longer portion, of the oil productive Purisima was exposed and these wells produced initially from intervals 1370' to 1730' and 2155' to 2724' (Cowell #1). Flowing production of up to 35 BOPD was obtained from both wells, but the production declined rapidly to 3 BOPD in about a year, at which time they were put on the pump and the production stabilized for a short time but then declined to about one BOPD, after which they were subsequently abandoned.

The tests in the Purisima Creek Area in 1959-1960 for the Butano potential and recent tests of the Purisima in the Verde Area in 1979-1980 have been plagued by incomplete testing, improper completion methods, and regulatory delays. These wells cannot be considered authentic tests of the Miocene-Eocene oil potential in the Purisima Creek Area or the Purisima Formation oil productivity potential in the Verde Area. Studies are currently underway by Operators in both of these areas to re-examine the work already done and determine possible salvage, stimulation, and/or new well drilling to more properly test the known oil potential and improve the known oil productivity of the various intervals for economic viability.

THE RESURRECTION

In 1978, Mr. Donald Layne decided to reevaluate the oil production potential of property that he had recently acquired in Sections 10 and 15, consisting of a 272 acre parcel of the old Pacheco Ranch which occupied the main portion of the older producing wells, including the original Purisima Creek Area discovery, Lane's Well (no relation). After geological, petroleum engineering, and economic analyses of the shallow zone potential, the Layne Oil Company was formed. The initial purpose was to re-enter three old wells on the property and determine if they could be returned to economical operation. The wells had been idled "in place" and "as is" in 1926 with the exception of the removal of the prime mover for the "jack-line" operation. The wells that were resurrected had the jack-line unit or a closed-in well head with bent polish rods or a very simple Christmas tree (Figures 12 & 13).

The first well, Layne #2 (formerly Sage, Olson, & Blalock #1), that was re-entered in July, 1980, was chosen as it was in a flat pasture (Figure 14). Residents of the ranch house

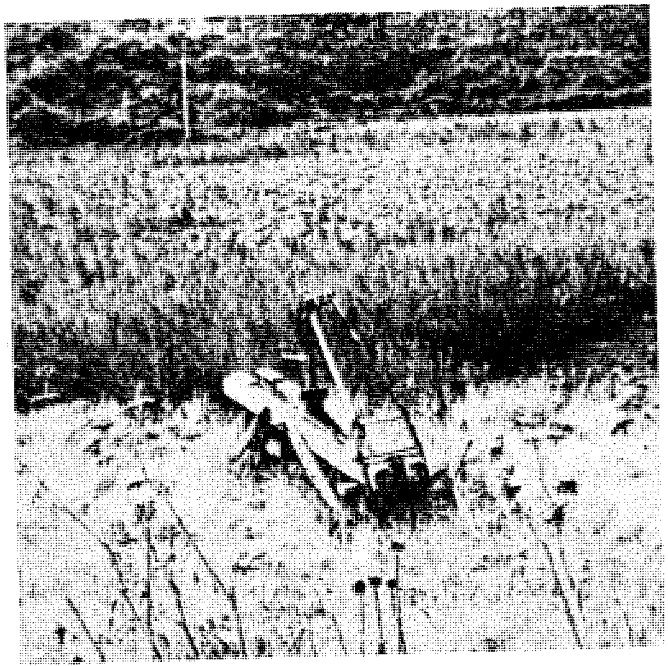


FIGURE 12: "Jack Line" Pumping Unit (ca. 1910)

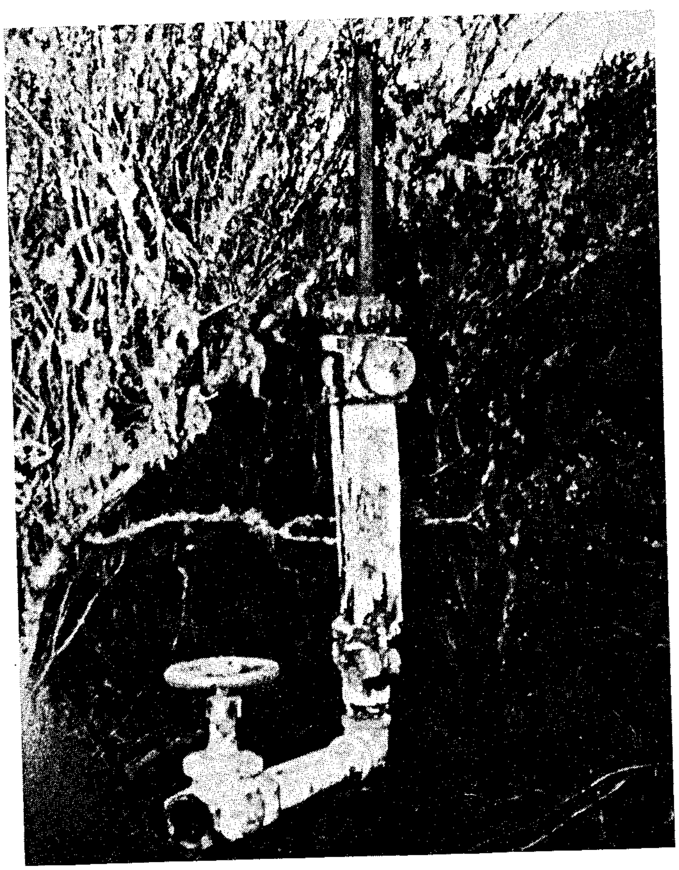


FIGURE 13: Old Well with Polish Rod (ca. 1920)

indicated that at one time, after 1926, the small amount of gas from the well was used for domestic purposes. A well pulling unit was moved in, the casing was cut below the well head, and the entire 600' of 2-½" tubing, 3/4" rods, and pump were removed without difficulty! Careful examination of the bottom 60' of the tubing indicated a very thin (2 mm) evenly deposited gray crystalline scale which readily dissolved in hydrochloric (and acetic) acid. A bailer was run several times to bottom, or effective depth of 710', but only a handful of very fine silt and some scale was obtained. New 2" tubing, 3/4" rods, and an insert pump were run and hung at 690'. By careful planning, a vertical hydraulic (Salentine)pumping unit was installed with a 3 HP electric motor and an environmentally pleasant and safe fence was erected around the location (Figure 15). When the pumping unit was started the initial production was 60 BOPD of 42° API oil! On part-time operation, in two succeeding months, the well averaged 20 to 25 BOPD with oil gravity increasing to 45.3° API (Table 1). The part-time operation has continued to the present time and the well has declined to 2 to 3 BOPD for about 10 days per month operating time.

The second well returned to production in September, 1980, was Layne #4 (formerly J. Berger L-2) indicated an initial production of 30 BOPD but rapidly declined to 2 BOPD, also on part-time operation. This well is now shut-in pending installation of a new flow line and additional tankage. The third well which was attempted to be resurrected, Layne #3 (formerly J. Berger L-1), encountered mechanical difficulty and is idle awaiting suitable fishing equipment.

It is obvious that the long idle period (1926-1980) provided time for a resaturation of the small interval exposed in these old wells and an equalization of the reservoir pressure near the well bore. The current low productivity from the short interval of the entire oil bearing Purisima Formation fits the petroleum engineering analysis derived from an abbreviated bailing test on one of the wells. It is significant that only minute amounts of water have been observed in the production from either of the currently producible wells

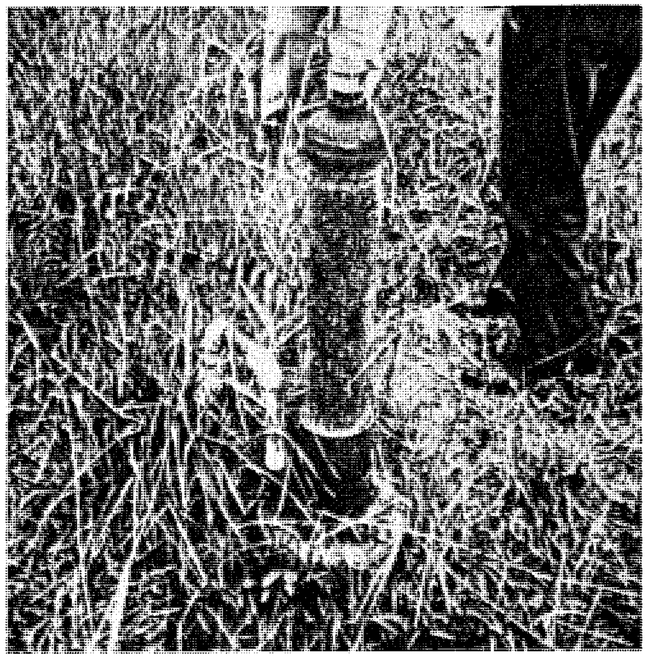


FIGURE 14: Layne #2 Before Re-entry

FIGURE 15: Layne 3 After Return to Production

THE FUTURE OF THE HALF MOON BAY OIL FIELD

PURISIMA FORMATION (PACHECO ZONE)

It is clearly evident from a careful study of well logs, core descriptions, electric logs, and production records that approximately 1500' of the 2000' of the Pomponio (and Tahana) member overlying the originally discovered Purisima Creek Area of the Field is oil productive. Further, with proper completion methods involving foam as a circulating fluid and a slotted liner, additional development drilling will be economically attractive. In the Verde Area, a possible 3000' of the Purisima Formation should prove to be economically attractive for additional development.

In order to contemplate further development, it should be recognized that the oil bearing intervals contain only very thin sands and some fractures. As a consequence, it is essential that long gross intervals be exposed for production in order to obtain 30' to 50' of permeable sand and/or fractures. This is not a new concept for many oil fields in California, but it is sometimes difficult to prove, pending a properly designed test of the section. In addition, the sediments of the Purisima Formation, and particularly of the Pomponio and Tahana members, contain high percentages of water sensitive clays derived from the nearby extensive volcanics of the Miocene period. Unless the micro-geology of this potentially commercial reservoir is taken into account, further tests are doomed to failure. Faulting in the Purisima section is believed important but is not thought to be critical to the main accumulation. Further drilling will undoubtedly reveal several important cross faults, now not evident from surface study or the scattered subsurface well control.

MIOCENE AND EOCENE FORMATIONS

Several excellently located tests of the potentially oil productive sandstones underlying the Purisima have been made in the Purisima Creek Area of the Field, notably M.J.& O. Iener #1 and La Brea Pacheco #1 in Section 15. Both of these wells encountered producible oil in the Butano (?) sandstone of Eocene age. Unfortunately, these tests were marred by poor completion procedures, poor testing methods, and/or lack of money. The drilling was significant in providing an electric log in the immediate area of the original shallow discovery well, and in encountering several Miocene (?) intervals which were, unfortunately, not evaluated. Electric log evaluation now indicates that there is a definite possibility of producible oil existing in a Transition Zone (Santa Margarita?) at the Pliocene-Miocene contact and in several Miocene sands above the primary objective Eocene (Butano?) sands. The Layne Oil Company plans to re-enter these wells and evaluate the untested sands, subject to the problems next outlined below.

ENVIRONMENTAL REGULATIONS - SAN MATEO COUNTY

Unfortunately, new drilling operations are held up in the oil productive portion of the Purisima Creek Area of the Half Moon Bay Oil Field because of stringent regulations by San Mateo County. The permitting procedure is, in itself, onerous. But the main problem is that the County has designated certain portions of the area as "Prime Soil" (Figure 16). By definition, this land is to be saved for the "growing of broccoli, brussel sprouts, and artichokes" and an exception cannot be obtained, even if the Planning Commission was inclined to approve of the drilling in such an area. It appears inconsistent that when the United States of America is in such bad shape for domestic production to satisfy our domestic demand, such action on the part of poorly informed people can stop further investigation and development of one of the oldest oil fields in California, namely Half Moon Bay!

ACKNOWLEDGMENT

For permission to present this paper, gratitude is expressed to Donald Layne, Esq., Managing Partner, Layne Oil Company. Also thanks are given to Dr. H. J. Ramey, Jr. for time permitted to prepare the paper and to Ms. Terri Ramey for the exhibits preparation.

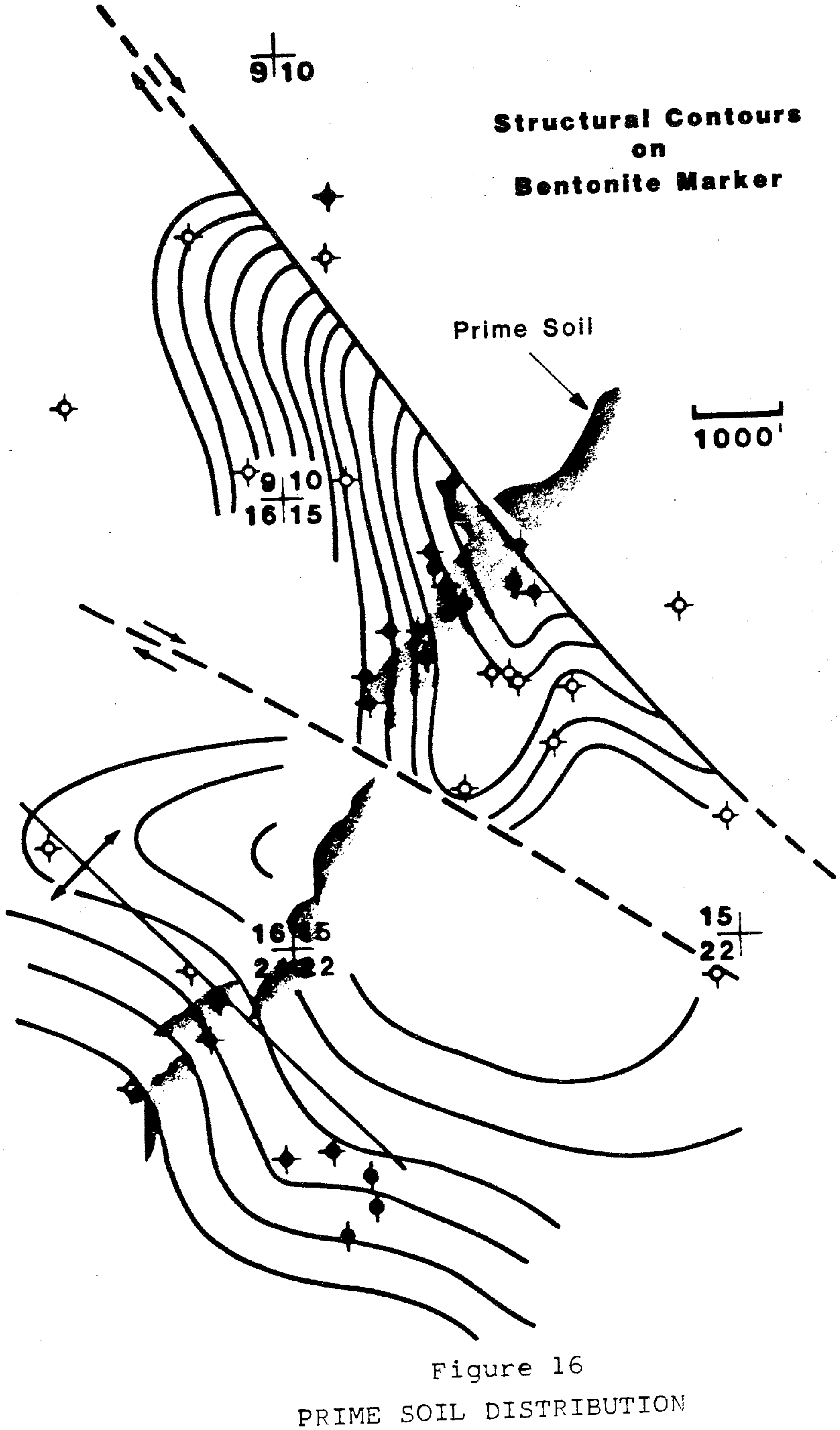


Figure 16

PRIME SOIL DISTRIBUTION

HALF MOON BAY OIL FIELD

TABLE 1

TEST OF CRUDE OIL

LAYNE OIL CO. #2

HALF MOON BAY OIL FIELD

A.P.I. @ 60°F	44.3
SULFUR, WT. %	0.19
TOTAL NITROGEN, ppm	649
ORGANIC CHLORIDES, ppm (70% OH @ 450°F)	20.7
DOCTOR ON 70% OH	H_2S
BS&W, VOL. %	0.1
PARAFFINS, VOL. %	79.0
OLEFINS, VOL. %	0
NAPHTHENES, VOL. %	15.1
AROMATICS, VOL. %	5.9
POUR POINT ON 450°F PLUS	-70°F

TABLE 2

WATER ANALYSIS

LAYNE OIL CO. #4

HALF MOON BAY OIL FIELD

pH:	5.00
Sp Gr:	1.03
Chlorides:	21000 ppm
Bicarbonates:	30 ppm
Magnesium:	540 ppm
Calcium:	1350 ppm
Iron:	30 ppm

TABLE 3

SIDEWALL CORE ANALYSIS

KRITI (FORMERLY ZIA) COWELL #3

HALF MOON BAY OIL FIELD

REC IN	DEPTH	PERM MD	POR %	OIL% PORE	WTR% PORE	O/W RATIO	SAMPLE WEIGHT
1.9	633.0	0.9	31.8	0.0	85.7	0.00	18.50
1.0	637.0	0.3	32.4	0.0	88.0	0.00	7.80
1.4	1070.0	1.4	33.0	5.2	80.2	0.06	13.14
2.0	1088.0	0.5	33.5	3.2	84.4	0.04	9.24
1.0	1095.0	1.9	32.4	1.9	76.3	0.03	12.40
1.5	1743.0	0.7	30.6	0.0	88.4	0.00	17.33
1.8	1745.5	0.3	30.0	0.0	82.4	0.00	18.00
0.9	1747.5	39.	30.7	2.6	68.7	0.04	15.73
1.6	1845.0	1.1	30.3	0.0	78.3	0.00	15.89
2.0	1868.0	0.6	30.3	1.0	88.9	0.01	14.60
2.0	1870.0	0.2	30.7	0.0	90.4	0.00	11.47
2.0	1927.0	0.3	29.0	1.6	80.4	0.02	18.80
2.0	1941.0	0.5	28.2	1.9	81.4	0.02	15.61
2.0	1952.0	12.	32.2	1.2	87.0	0.01	16.99
1.0	1984.0	52.	36.4	1.8	84.5	0.02	11.32
1.2	2093.0	1.4	30.6	0.0	88.4	0.00	12.14
1.3	2097.0	0.5	31.4	0.0	89.7	0.00	15.50
0.4	2151.0	10.	30.7	1.9	82.3	0.02	10.52
1.4	2205.0	0.2	30.8	0.0	94.7	0.00	11.48
2.0	2237.0	0.1	30.0	2.2	94.4	0.02	12.71

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