YOWLUMNE OIL FIELD

Randall T. Metz
Tenneco Oil Company
10000 Ming Avenue
Bakersfield, CA 93389

John L. Whitworth
Tenneco Oil Company
10000 Ming Avenue
Bakersfield, CA 93389

INTRODUCTION

The Yowlumne Field, Kern County, is located approximately 24 miles south-southwest of Bakersfield near the southern border of the San Joaquin Valley (Figure 1). The field trends southeast-northwest and is narrow south of the Maricopa Highway, broadening out to its widest east-west dimension near the California Aquaduct two miles to the north. The field is located on the distal portions of the coalescing fanglomerates of the Pleito Hills, and elevations range from 750 to 450 feet above sea level with decreasing elevations toward the center of the basin.

The discovery well was drilled on a major anticline known as the San Emidio Nose which originates on the west side of the valley and plunges to the east into the Maricopa subbasin (Figure 2). Commencing in 1935, 27 dry holes were drilled on the structure; 23 of which penetrated Miocene sediments. In 1935 the Ohio Oil Company drilled an exploratory well in Section 11, T.11N.-R.22W., which was redrilled by Texaco in 1936 and Conoco in 1947. At that time, it was widely believed that porosity in the Upper Miocene Stevens Sands would be destroyed by compaction and recrystallization of the arkosic sand grains below 10,000 feet and no commercial oil would be found. Swelling clay problems were encountered around 10,000 feet, and drilling was halted before the Miocene section was penetrated. The Conoco redrill stopped 654 feet short of the Upper Stevens productive interval now informally known as the Yowlumne Sand.

In 1973 Texaco drilled an intended Eocene test, "San Emidio #1" to a total depth of 20,704 feet in the northeast corner of Section 14, T.11N.-R.22W., MDB&M. Numerous shows in Lower and Middle Miocene zones were tested in the lower portion of the well, and it was completed in the Upper Miocene Yowlumne sands. The "San Emidio #1" had an initial production of 428 barrels of 33.1°oil, 263 MCF of gas and 31 barrels of water which cleaned up to over 800 barrels of oil per day after thirty days of production. Operation of this well was subsequently assumed by Tenneco Oil Company.

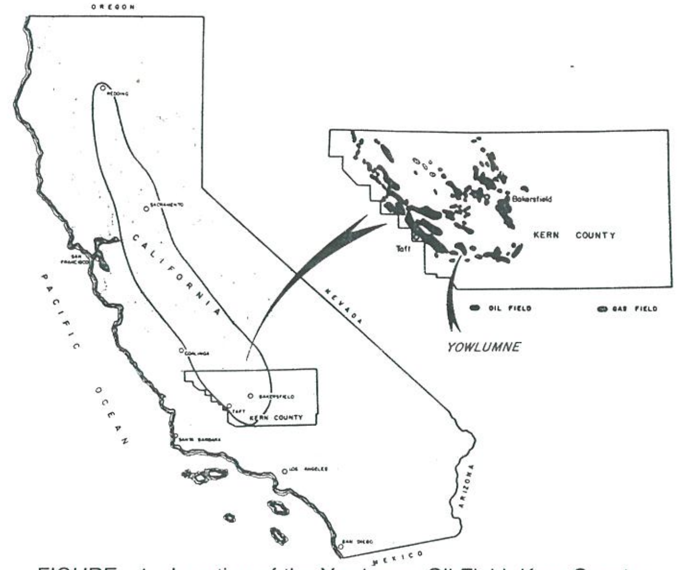

FIGURE 1 Location of the Yowlumne Oil Field, Kern County, California.

As development has continued through September of 1982, a total of 105 wells have been drilled; 90 completed in the Yowlumne Sand interval, eight completed in smaller pools, and seven dry holes. Wells currently productive in smaller pools include two from the Basal Pliocene zone 800-900 feet shallower, and five wells productive from the 10-4 Sand 600 feet deeper than the Yowlumne zone. One well, #88-10, produces from fractured "P" Chert below the Yowlumne Sand. Figure 3 is a type log showing the productive zones and major markers in the field.

For more efficient development the field has been unitized into southern and northern units (Unit A and Unit B, respectively), both of which are currently operated by Tenneco Oil Exploration and Production (Figure 4).

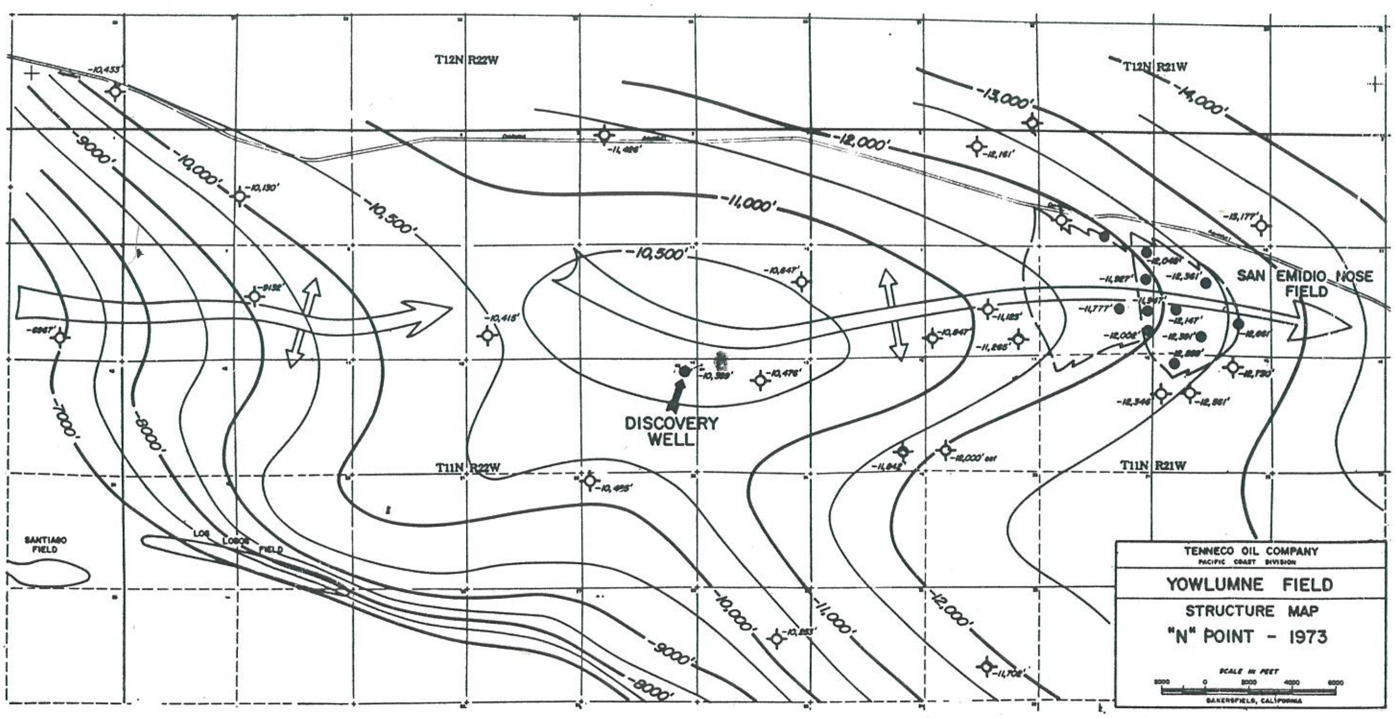

FIGURE 2 Location of the discovery well on San Emidio Nose as it was mapped in 1973. Structure contours are on the "N" chert marker.

YOWLUMNE TYPE LOG

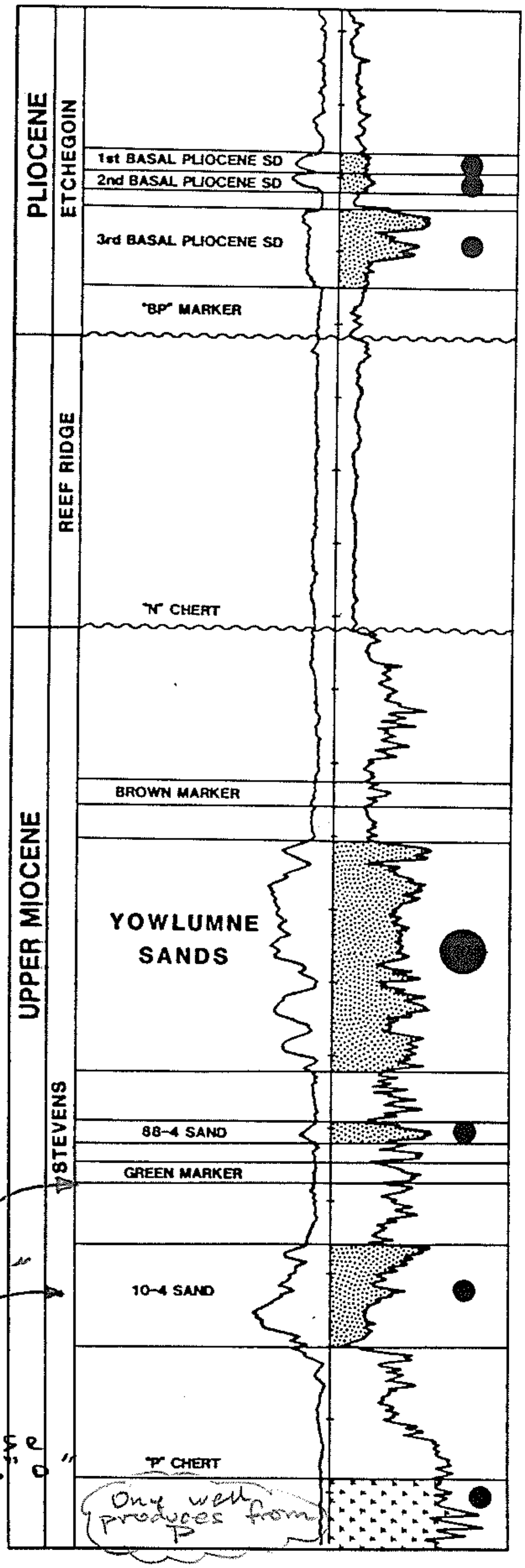

FIGURE 3 The type log for the Yowlumne Field identifying the productive zones with dots to the right of the electric log. Also shown are the "N" and "P" chert markers.

REGIONAL GEOLOGY

The Miocene sediments of the Great Valley sequence were deposited in the restricted marine San Joaquin Basin which had a depth in excess of 6,000 feet during lower Miocene (Bandy and Arnal, 1969). Subsequent sedimentation led to the shoaling of the basin to neritic depths in latest Miocene and Pliocene, and a southerly translation of the depocenter (Webb, 1981). Basin filling was accelerated by density current deposition of coarse clastic sediments shedding from local basement complexes: the Sierra Nevada to the east, the San Emigdio Mountains to the south, and Salinia to the west (McPherson, 1977).

Marine sand and mud deposition persisted through Upper Miocene and Pliocene time along the southern margin of the basin, and structural folding of the sediments probably did not begin until early Pliocene when the shallow water Etchegoin sands and shales were deposited.

STRUCTURE

The Yowlumne Sands lie obliquely across the axis of the east-west trending San Emidio Nose which forms the structural trap for the Yowlumne reservoir. Chert beds which accumulated during periods of low energy deposition provide excellent subsurface log correlation markers in the Upper Miocene strata. A stratigraphic cross-section hung on the "N" point marker in the chert immediately above the Yowlumne Sand and showing the "P" marker below the sand reveals that the markers "spread" to accommodate the intervening sand bodies indicating the absence of downcutting or major erosion during deposition of the lowermost sand bodies (Figure 5).

The folding of the San Emidio Nose structure post-dates the deposition of the Upper Miocene sediments and probably occurred subsequent to the deposition of the Pliocene sands. The Yowlumne sand deposits trend obliquely across the axis of the San Emidio Nose, and there is no indication of significant downcutting. In the Yowlumne field the basal Pliocene sands are thickest on the crest of the anticline.

No faults have been recognized as a result of drilling in the Yowlumne Field. Seismic events which had previously been attributed to faulting now appear to be a function of the Miocene stratigraphy.

STRATIGRAPHY

The Upper Stevens equivalent sands in the Yowlumne field consist of many individual sandstone beds which are separated by thin mudstones or shales, and of relatively thick-bedded, amalgamated, channelized sandstone intervals. These beds are interpreted to have been deposited by various types of sediment gravity flows including turbidity currents, grain flows, and fluidized sediment flow.

The sediments, informally known as the Yowlumne Sand, were deposited conformably on top of pelagic deposits containing the "P" chert marker bed. Later deposition resulted in the regional "N" chert marker bed. The 10-4 Sand is stratigraphically below the main Yowlumne Sand interval and is separated by relatively thick layers of mudstone and pelagic shale.

Unconformably overlying the Upper Miocene chert is the sandy brown siltstone and shale of the Reef Ridge Formation of Upper Miocene age. The second major unconformity occurs at the top of the Reef Ridge at the base of the Pliocene Etchegoin Formation. The productive basal Pliocene sands are transgressive, shallow marine deposits which thin to the north and west.

Approximately eleven wells have been cored in and around the Yowlumne field. Descriptions of these cores and subsurface log shapes are the basis for the following descriptions. Also helpful were environmental interpretations prepared for Tenneco Oil by Dr. Robert Berg of Texas A&M University.

10-4 Sand

The 10-4 Sand is the designation for a group of sands below the "Green" marker and above the "P" chert. The maximum

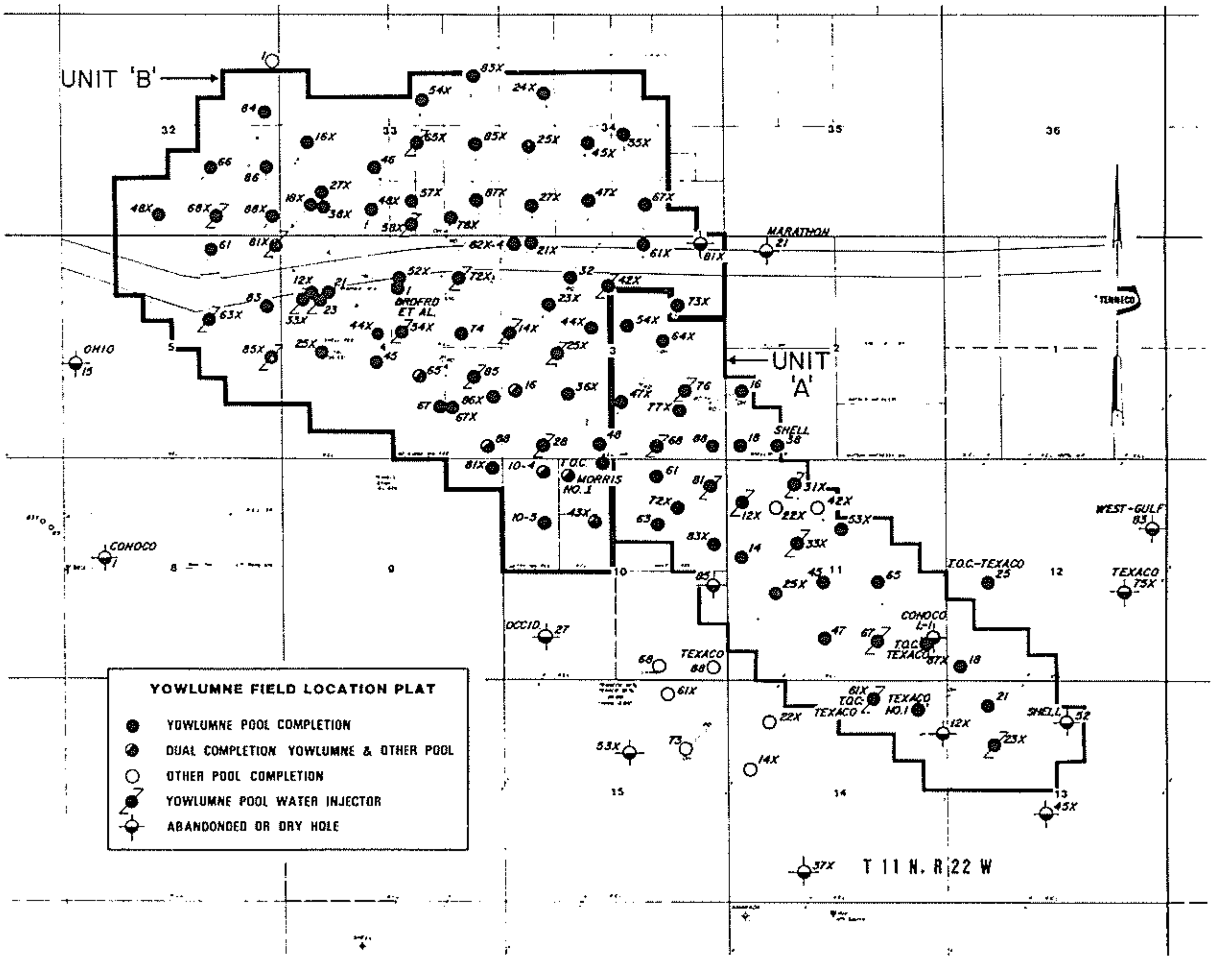

FIGURE 4 The Yowlumne Field, Kern County, California.

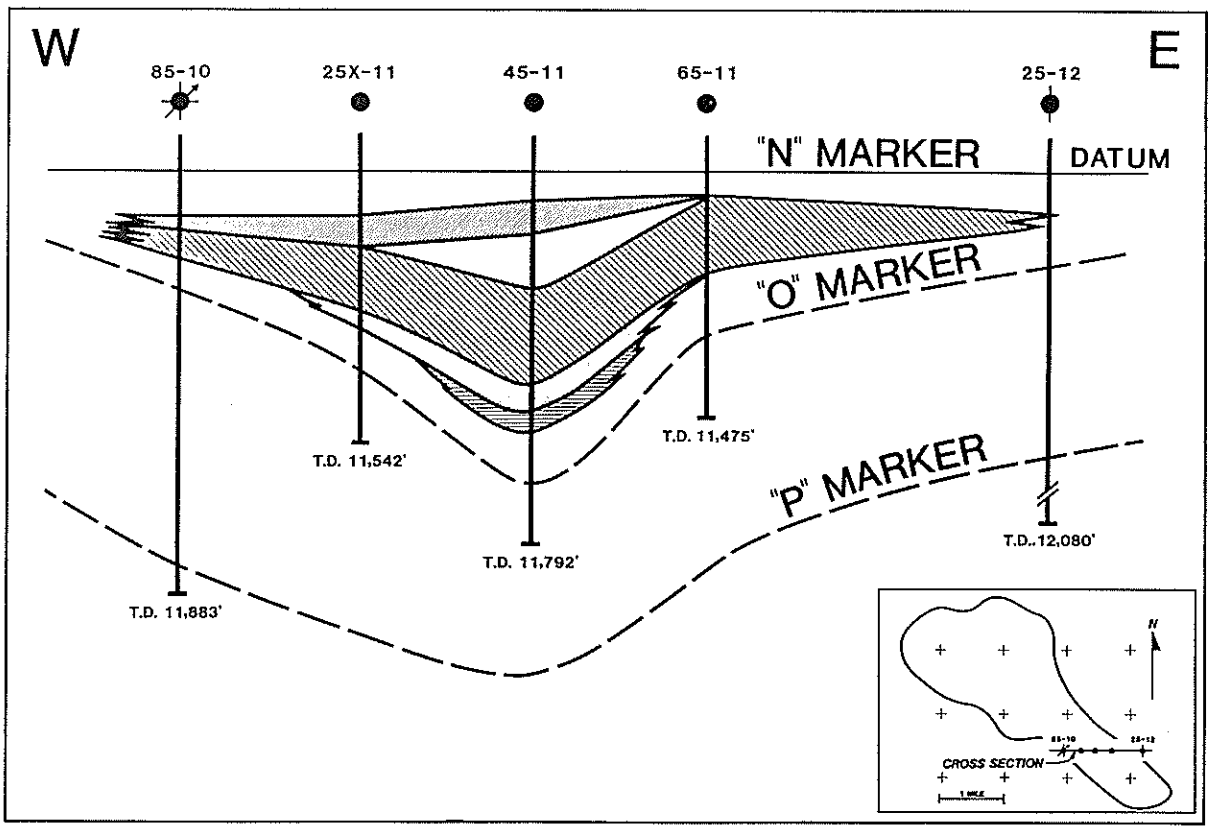

FIGURE 5 Stratigraphic cross-section. Datum is "N" point chert marker. The underlying "P" chert marker spreads downward indicating the absence of erosion by the channelized sandstones. Sand megasequences are differentiated by pressure and production contrasts as well as lithologic markers.

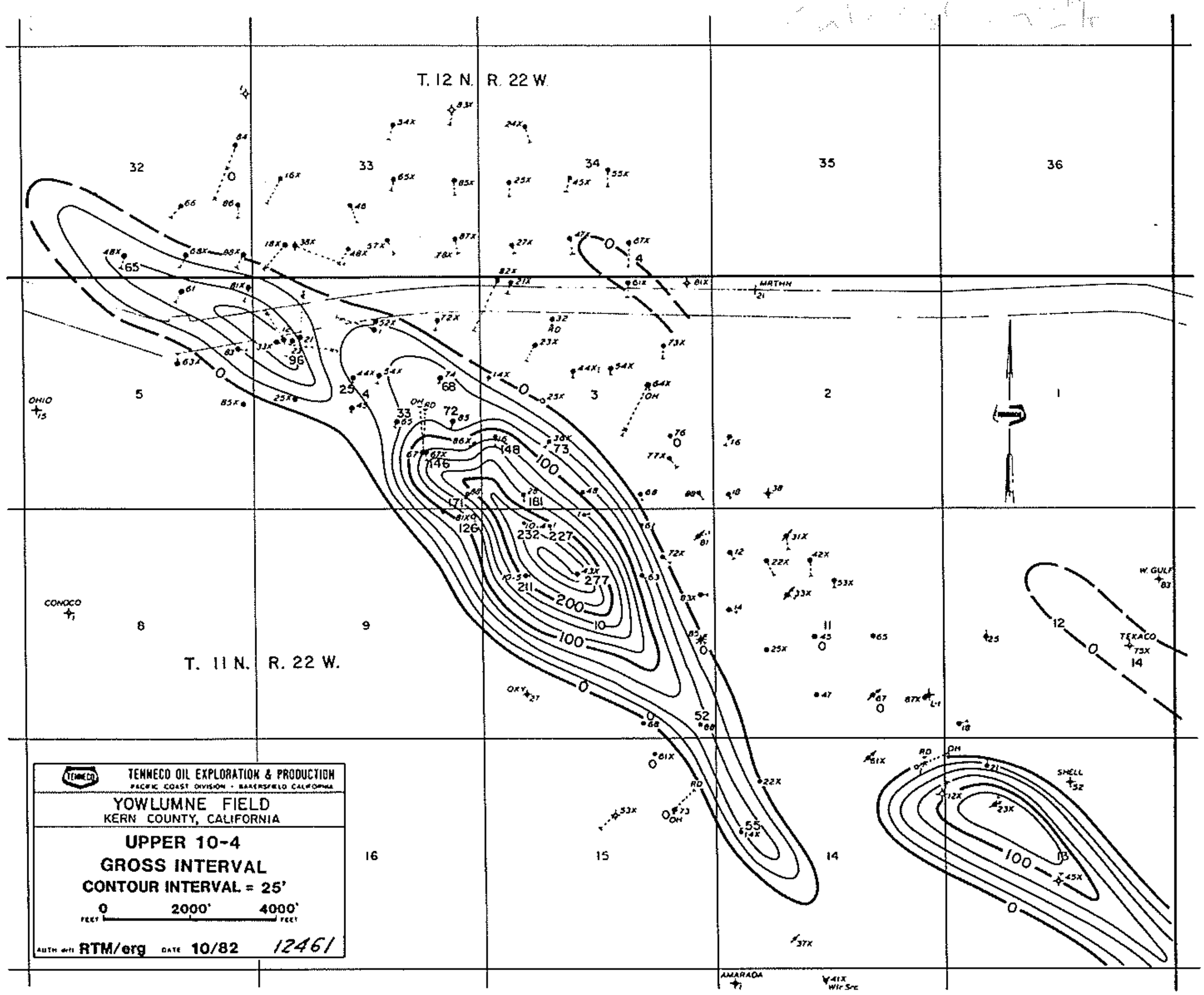

FIGURE 6 Upper 10-4 sand gross interval isopach map. Contour interval is 25 feet.

thickness is just over 200 feet in the northwest quarter of Section 10, (Figure 6) and the average depth is 11,600 feet.

Named for the Getty "Hay Fee" 10-4 well in which it was first penetrated, the 10-4 Sand is a medium- to coarse-grained, moderately well sorted, arkosic sand. Average composition of the cored sandstone is found on Table 1. Rock fragments are mainly from granodiorite intrusive rocks with rare, fine-grained metamorphic fragments. Unlike the Upper Stevens sands in other parts of the San Joaquin Valley, muscovite is rare and volcanic glass is found only in trace amounts. The predominance of soda-rich plagioclase in the 10-4 Sand also contrasts with the potash feldspar of the stratigraphically higher Yowlumne Sand.

The sandstone sequences commonly include the Bouma (1962) *a* divisions overlain characteristically by thin *e* or *b* divisions. More complete *abcd* sequences are rare, and some contorted bedding has been formed by slumping. Sand bed thicknesses measured in cores are as great as 4½ feet and shale beds are no thicker than two feet. Thinly bedded sands and shales are also present. Insufficient cores have been cut in the 10-4 Sand to permit estimates of sand/shale ratios with certainty, but subsurface logs indicate thick, amalgamated, channelized sand comprises the majority of the sandstone beds.

These sands are restricted to a narrow, northwest-southwest trending body in Sections 3, 4, 9 and 10 which is slightly offset to the west of the narrow portions of the younger Yowlumne Sand.

Yowlumne Sand

The Yowlumne Sand is the main producing horizon and is composed of sand sequences found below the "N" chert marker and above the "Green" marker (Figure 3) at a depth of 11,000 feet at the top of the structure plunging to over 13,200 feet off structure to the north. As many as sixty individual bed sets separated by thin shale laminae or amalgamated together can be found in a typical well. The average thickness of 252 measured sandstone beds is 2.8 feet with a range from 0.3 to 14.0 feet.

The grains composing the moderately sorted arkosic sand are generally subangular to subrounded, and the matrix material consists of alteration products from the plagioclase feldspars. Most of the rock fragments are from a crystalline igneous terrane with lesser amounts of metamorphic and volcanic rocks. Muscovite flakes are common, but comprise less than one percent of the total mineralogy.

Sandstone constitutes more than ninety percent of the interval between the top of the first sand and the base of the lowest sand. The sand/shale ratio is predominantly 20 to 1 but it can be much lower locally and as high as 110 to 1 in Section 3. These sandstone beds are arranged in sequences which commonly fine and thin upward and more rarely in sequences which coarsen and thicken upward. Individual beds are laterally discontinuous, and are usually either elongate or lobate in shape. The sandstone beds commonly include the Bouma (1962) *a* divi-

TABLE 1

Producing Unit	Quartz Size (mm)[1].			Detrital Composition					
	Mean	Max.		Qtz	Feld.	Rx	Other	Matrix	F-spar
Basal Pliocene (Well 12X-11)	0.50	1.57	0.32	41	43	8	1	7	Orthoclase & Microcline
	(Moderately well sorted)								
Yowlumne	0.33	1.20	0.26	54	34	3	1	8	Orthoclase
	(Moderately sorted)								
10-4 Sand	0.29	0.90	0.18	46	32	2	1	19	Plagioclase (75%) Orthoclase
	(Moderately well sorted)								

1. Long axis measurements.

Table 1. Average quartz grain size and detrital composition by producing unit.
Values taken from conventional cores and measured by R. Berg and T. Tieh of Texas A & M University.

sion overlain by *b* or *e* divisions. Bouma *c* divisions are relatively rare. Other sedimentary features include dish structure, water escape features, ripple marks, slump structures and rip-up clasts.

Yowlumne Sand — Discussion

The Yowlumne Sand is made up of distinct stratigraphic units: (1) a thick sequence of superimposed channelized bodies of thick bedded sandstone, (2) alternating sequences of channelized and splay-type sandstone bodies and siltstone-shale, and (3) blanket deposits of finer-grained sandstone.

In terms of the turbidite classification scheme of Mutti and Ricci Lucchi summarized by Nilsen (1977), the channelized sequences are interpreted to be confined-channel deposits of the Middle Fan Sub-association which are indicated by fining and thinning upward megasequences, the assocition of facies A, B and F, the abundance of tractive features, and the lack of bioturbation. Eighty percent of the beds described in Yowlumne cores are found in channelized sequences.

The less common alternating sequences are interpreted to be mid-fan channels, crevasse-splays, surprafan deposits (Normark, 1970), and interchannel deposits as indicated by coarsening and thickening upward cycles containing facies B, C, F and occasionally A; a lower sand/shale ratio; and the occurrence of interbedded facies D sandstone and siltstone.

The blanket sands are interpreted to be infilling channel deposits during the last stage of clastic deposition. These sediments are found at the top of the Yowlumne sands, they form thinner beds and have greater amounts of interbedded shale.

Yowlumne Sand — Sedimentology

The Yowlumne Sand is a mid-fan assemblage which currently lies in a structurally advantageous position for oil accumulation. The associated outer-fan facies lies below the oil/water contact and in the depths of the Maricopa sub-basin. The inner-fan and slope facies to the south have not been identified in outcrop and are probably nowhere preserved due to tectonic activity around the southern margin of the basin.

The Yowlumne Sand is interpreted to be a series of rapidly deposited, channelized, sand-rich sequences in a deep marine basin northerly of the point source input of sediments. The channelized sandstone deposits are laterally equivalent and contemporaneous with the finer grained levee and interchannel deposits.

Following a period of chert and shale deposition in the relatively quite basin, sand was transported in a northwesterly direction across Section 13 toward Section 3 where the main direction of flow veered in a more northerly direction across section 34 (Figure 7). The initial turbidity currents must have been influenced by subtle topography on the gently dipping basin floor. Non-erosion of the pelagic sediments is evidence for the depositional nature of the channels (Nelson and Kulm, 1973), and levees were constructed on either side by overbank deposits.

The western levee was breached one or more times in Section 3 and 10, and crevasse-splays and lesser channelized sequences were deposited to the northwest. The lobate sands in this portion of the field thin continuously to the north and west and are generally siltier and finer grained than the sediments to the east. The youngest sediments were infilling channel deposits representing the final stages of deposition before the cutoff of sediment supply.

Basal Pliocene

The basal Pliocene sands in the lower portion of the Etchegoin Formation thin to the north and west and reach a maximum thickness of 200 feet east of the field. The first basal sands are penetrated around 10,200 feet in the center of the field, and the upper sands are areally widespread. The lower basal Pliocene sand bodies appear to have only limited areal extent.

The basal Pliocene sands are medium- to coarse-grained, moderately well sorted, arkoses. Calcite is present as cementing material and as localized nodules — probably remnants of fossil material.

The sandstone beds are typically massive or show indistinct tangential foreset bedding. Biotubation exceeded the rate of deposition, and bedding features are disturbed in many of the sands and completely destroyed in others. Large (3 cm) burrow tubes preserved in cores were probably formed by relatively large, nearshore molluscs or crustacea normally found in relatively shallow water. The sandstone beds are characteristically composed of coarsening and thickening upward sequences.

The textural and structural features of these sands indicate fluvial deposition into a shallow marine environment and subsequent reworking by benthonic organisms.

DRILLING AND COMPLETION PRACTICES

All wells in the field have been drilled using conventional rotary drilling techniques. Current drilling and completion practices are as follows. To provide anchorage for blowout prevention equipment and to protect the fresh waters from contamination, 2,500 feet of 10¾-inch casing is cemented to surface. Drilling continues with a 9⅞-inch hole, and at 7,000 feet the drilling fluid is changed over from a gel- to potassium-lignite-type. Several of the early wells were drilled using lignosulfonate base drilling fluid. Mud weight of between 10 and 13 pounds per gallon is used, with the higher weights being necessary to control uphole sloughing shale problems.

Upon reaching total depth, 7-inch or 7⅝-inch casing is cemented, and the integrity of the cement job is evaluated through a cement bond log. Pay zones are selectively jet perforated with four holes per foot.

YOWLUMNE DEPOSITIONAL MODEL

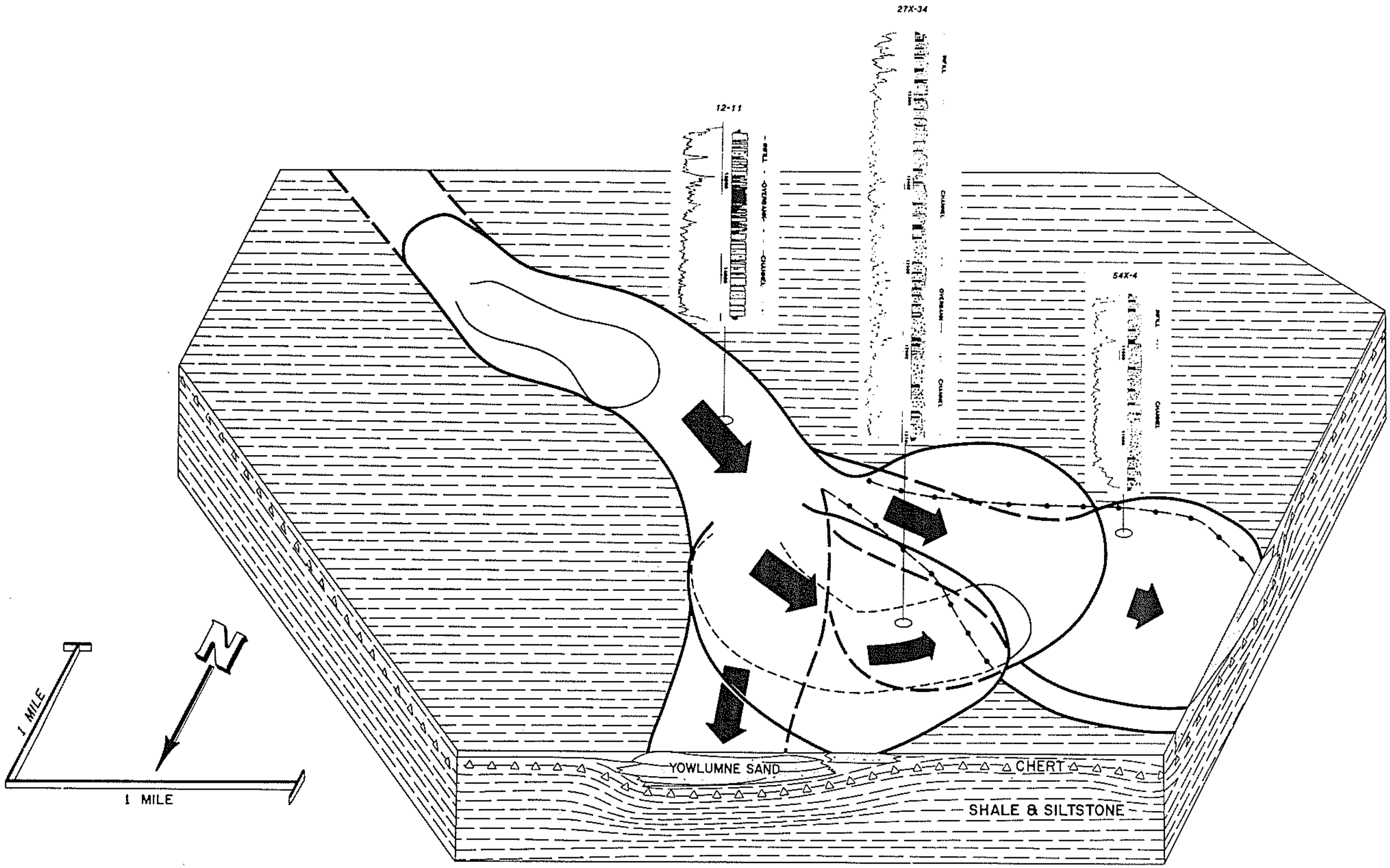

FIGURE 7 Conceptual reconstruction of deposition of Yowlumne turbidite sands. Arrows indicate paleocurrent flow directions.

TABLE 2
SUMMARY OF RESERVOIR ROCK AND FLUID PROPERTIES

Reservoir Property	Basal Pliocene Sd.	Yowlumne Sd.	10-4 Sd.
Average porosity	17%	18-20%	14%
Average permeability, to air	250 md	50-100 md	3 md
Depth	10,600'	11,200' to 13,300'	11,700'
Reservoir temperature	195°F	240-280°F	250°F
Irreducible water saturation	40%	35%	50%
Original reservoir pressure	4,400 psia @ -10,000'	5,660 psia @ -10,500'	5,800 psia @ -11,000'
Bubble point pressure	1,800 psia	2,400-2,800 psia	4,600 psia
Oil gravity	32°API	29-34° API	35° API
Gas gravity (air = 1.0)	.75	.85	.84
Oil viscosity	.61 cps	.52 cps	.50 cps
Initial solution GOR	350	400-800	1,100
Residual oil saturation, to water	—	30%	—
Rw at 25°C	.53 ohm-m	.39-.45 ohm-m	.29 ohm-m
Drive Mechanism	water	fluid expansion	fluid expansion

TABLE 3
HYDROCARBON ANALYSIS*

COMPONENT	YOWLUMNE Oil	YOWLUMNE Gas 67 psig, 74°F	BASAL PLIOCENE Oil	BASAL PLIOCENE Gas 100 psig, 75°F
Hydrogen Sulfide	Nil	Nil	Nil	Nil
Carbon Dioxide	1.16	2.29	0.19	0.19
Nitrogen	0.21	0.49	0.10	0.34
Methane	35.72	67.64	29.52	79.65
Ethane	6.89	12.71	3.34	6.78
Propane	7.77	10.63	6.67	8.09
iso-Butane	1.43	1.50	2.26	1.49
n-Butane	4.37	2.99	4.84	2.21
iso-Pentane	1.55	0.65	2.22	0.49
n-Pentane	1.39	0.54	2.50	0.31
Hexanes	2.46	0.32	3.96	0.19
Heptanes plus	37.05	0.33	44.40	0.26

*Values in mole percent

TABLE 4
YOWLUMNE PRODUCTION ALL ZONES

Year	Oil (MBO)	Water (MBW)	Gas (MMCF)
1974	488.3	49.0	267.4
1975	2,106.6	33.7	1,524.1
1976	4,061.0	100.9	4,231.2
1977	5,986.7	217.4	7,421.0
1978	8,710.1	413.7	13,521.0
1979	7,291.6	390.9	14,619.3
1980	5,703.0	897.1	9,187.3
1981	4,534.7	1,093.3	6,542.9
1982*	3,653.8	817.0	4,930.8
TOTAL	42,535.8	4,013.0	62,245.0

*estimated

The majority of wells were originally completed flowing, with wells producing from more than one interval being dually completed with packers. As wells cease to flow, they are placed on pump. In dually completed wells, production from the second zone is either commingled or squeezed off prior to putting the Yowlumne interval on pump. Rod and hydraulic pumps are the primary artificial lift mechanism; however, several high volume wells are produced with jet pumps.

FORMATION EVALUATION

Productive intervals are identified through evaluation of dual induction and acoustic velocity logs. Yowlumne sand intervals having calculated values of Sw <55%, Ø sonic > 14%, and a gamma ray reading of less than 90 API units have been defined as pay. These cutoff values were determined from core studies and production histories of wells in the field. Log calculations are based on:

1. Archie's (1942 modified) equation,
   $$Sw = \left(\frac{Rw}{Ø^m \text{ sonic } Rt}\right)^{1/n}$$
2. Pickett (1966) crossplots to determine m values.
3. n values from special core analysis.
4. Rw's measured from produced waters and Pickett (1966) crossplots.
5. Shell (Geertsma, 1961 modified) equation,
   $$Ø\text{sonic} = \frac{\Delta t - \Delta tm}{B}$$
   with B determined from Øcore vs Δt crossplots.

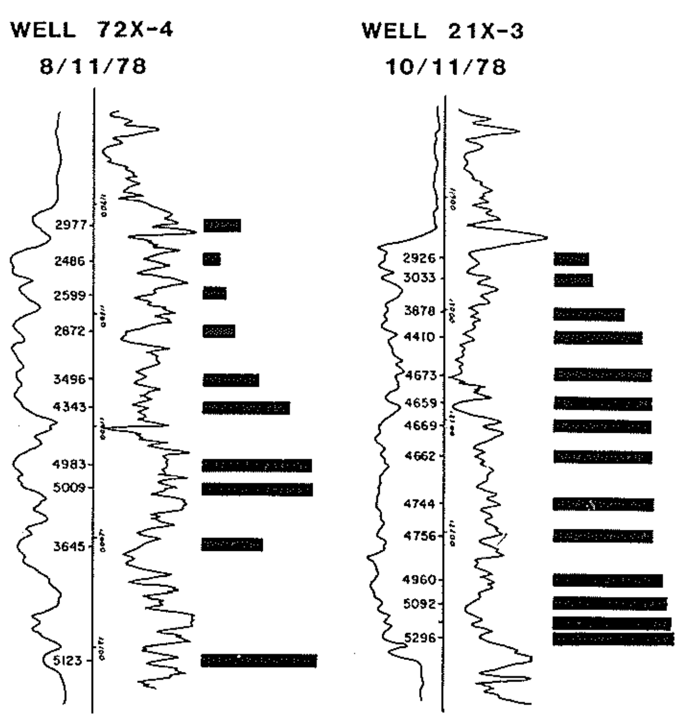

FIGURE 9 Pressures recorded by repeat formation pressure tests in adjacent wells reveal pressure reversal in Well 72X-4. Bars indicate pressure magnitude increasing to the right. These data were used to delineate isolated reservoirs within the Yowlumne sand.

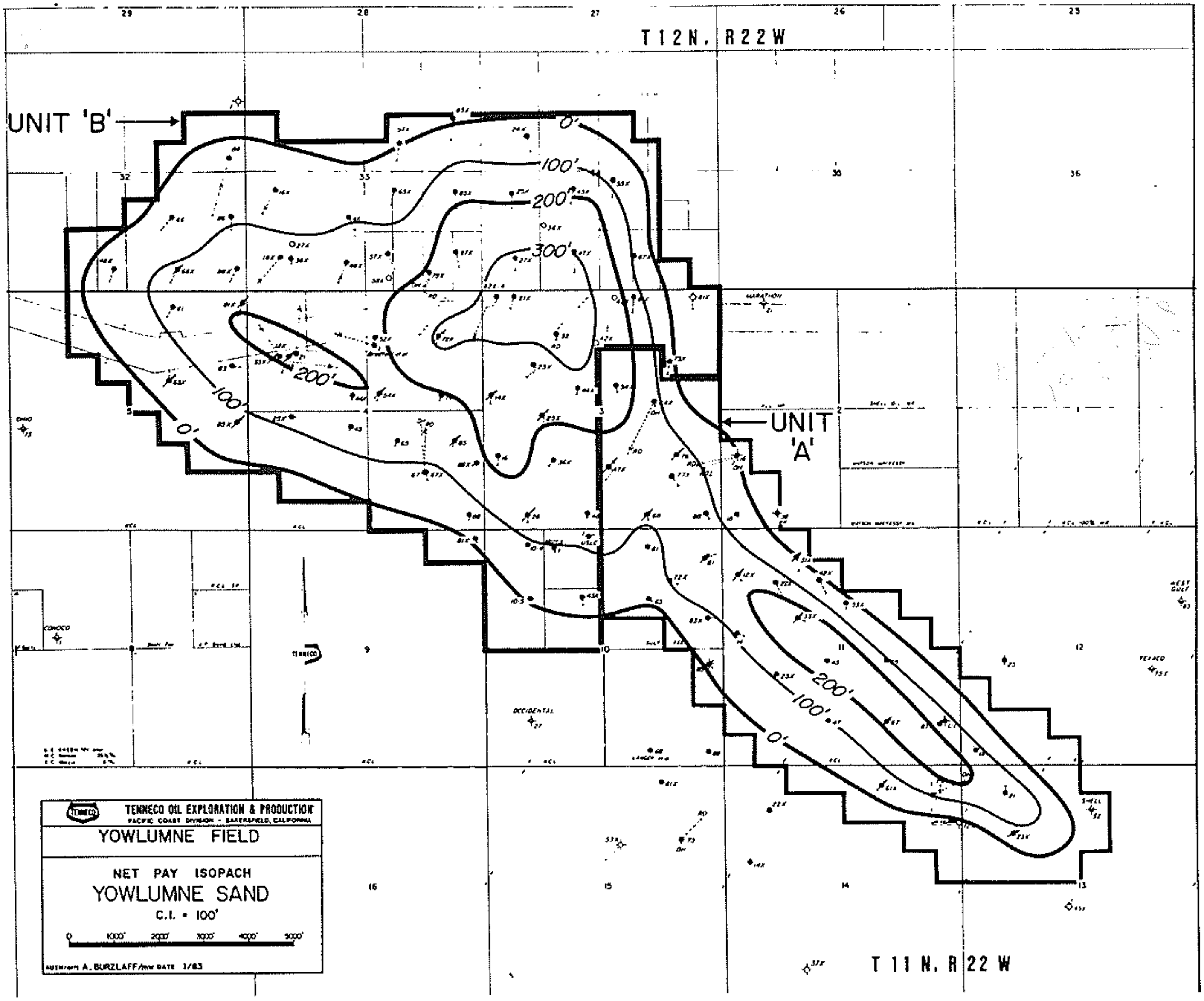

FIGURE 8 The areal extent of major sands map outlines the seventeen individual reservoirs. This map is being constantly modified as more production data become available.

Tenneco Oil Exploration and Production, operator of both Yowlumne units, employs a computerized log analysis program known as LOGCALC. Prior to evaluation, LOGCALC is used to normalize log data to curves defined as field standards. Ideally, logs run in similar subsurface conditions should appear the same. Normalization removes differences due to the effects of differing logging tools, logging companies, and borehole conditions. Calculations from normalized log data have identified a number of intervals which calculated as non-pay on the raw log data as being potentially oil productive.

Approximately one third of the wells in the field have both density-neutron and acoustic logs run through the Yowlumne Sand. Little difference was found between porosities calculated from density-neutron logging combinations and sonic logs when the acoustic values were used in conjunction with normalized gamma ray values.

RESERVOIR DISCUSSION

The Yowlumne field is estimated to contain 275 MMBO STOOIP of which 76.7 MMBO is estimated as recoverable from combined primary and secondary recovery methods currently being employed. Tables 2 and 3 summarize various reservoir and fluid properties. The field has been developed on 40-acre spacing. The average net pay is 150-200 feet per well and average initial production is 500 to 1000 BOPD with zero percent water cut after cleanup. Total production to date is summarized on Table 4, and the net pay for the field is illustrated by Figure 8.

The Yowlumne reservoir is not one but a series of stacked reservoirs each consisting of one or a group of turbidite sand sequences. Figure 9 shows the results of RFT pressure measurements through the Yowlumne interval. Variations in pressure dictate dual completions in some wells or initial completions in higher pressure intervals with lower pressure intervals opened as reservoir pressure declined. Currently the Yowlumne sands are broken into 15 sand groups or reservoirs (Figure 10) based on pressure contrasts, stratigraphic position, production characteristics, and log correlations.

The Yowlumne field is bound on the east and west by sand pinchouts and on the north and south by oil-water contacts with northerly contacts 1500 feet structurally low to those at the south end of the field. This asymmetry is due primarily to the vertical and horizontal heterogeneity of the Yowlumne sands. Permeability of the sands is largely controlled by the

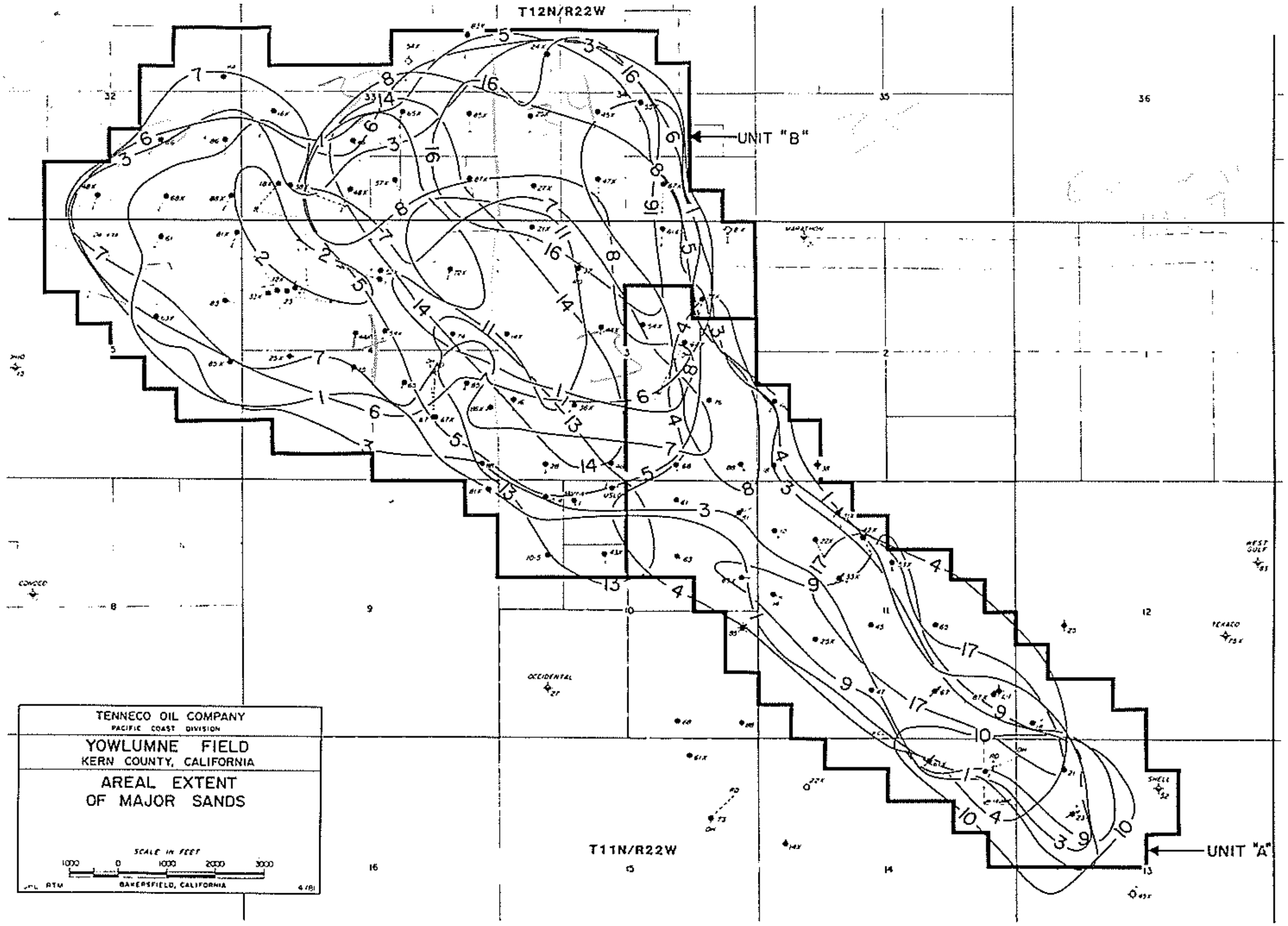

FIGURE 10 Net pay isopach map of Yowlumne sand: contour interval is 100 feet.

amount of clay present. Authigenic clays formed by chemical alteration of feldspar, a process which increases with depth of burial, control to a great extent the permeability of the sands. Thus a permeability barrier at the more deeply buried north end of the field may help preserve the asymmetry of the oil-water contacts.

ENHANCED RECOVERY

The Yowlumne sand waterflood project was initiated by Tenneco and Texaco in April, 1976 with the conversion of well 31X-11 to water injection; a second well, 61X-14, was converted to an injector in October, 1976. Upon the formation of Unit A, four additional wells were converted to water injection in late 1978. Approximately 19.9 MMBW has been injected into theYowlumne Unit A sands through June, 1982. The average reservoir pressure at the start of injection was 1,500 psi and has increased to 5,000 psi. It is at this pressure that the reservoir has been maintained and one reservoir barrel injected equals one reservoir barrel produced. An ultimate secondary recovery of 14-16 percent of the original oil in place is expected.

Currently the Unit A waterflood is being expanded to seven injectors (31X-11 and 61X-14 have been shut in), and with the formation of Unit B in May, 1982 the northern two thirds of the field should be under full flood by June, 1983. When completed, the field will contain 60 producers and 36 injectors.

Experience gained from the Unit A flood greatly aided the design of the Unit B waterflood. A line drive design was chosen because of its ability to maximize sweep efficiency in a heterogeneous reservoir while minimizing water breakthrough along directional permeability tends. These permeability trends are parallel to the direction of sediment deposition.

Polymer injection is currently being evaluated as a method of improving the waterflood sweep efficiency, and several tertiary methods are under study targeted at the 70 percent of the original oil in place that will remain after waterflooding.

REFERENCES

ARCHIE, G. E., 1942, *The electrical resistivity log as an aid in determining some reservoir characteristics:* Petroleum Technology, v. 5, p. 54-62.

BANDY, O. L., and Arnal, R. E., 1969, *Middle Tertiary Basin Development. San Joaquin Valley, California:* Geol. Soc. America Bull., v. 80, p. 783-820.

BOUMA, A. H., 1962, *Sedimentology of some Flysch Deposits:* Amsterdam, Elsevier, 196 p.

GEERTSMA, J., 1961, *Velocity-log interpretation: the effect of rock bulk compressibility:* Soc. Pet. Eng. Jour., December, p. 235-248.

McPHERSON, B. A., 1977, *Sedimentation and Trapping Mechanism in Upper Miocene Stevens and Older Turbidite Fans of the Southeastern San Joaquin Valley, California*, in *W. J. Bazeley, ed., Late Miocene Geology and New Oil Fields of the Southern San Joaquin Valley:* Am. Assoc. Petroleum Geol. Pacific Sec. Guidebook, p. 5-36.

NELSON, C. H., and Kulm, L. D., 1973, *Submarine Fans and Deep-sea Channels*, in *Middleton, G. V., and Bouma, A. H., Co-Chairmen, Turbidites and deep water sedimentation:* Soc. Econ. Paleontologists and Mineralogists, Lecture Notes for Short Course, Pacific Sect., Anaheim, California, p. 39-78.

NILSEN, T. H., 1977, *Turbidite Facies and Sedimentation Patterns*, in *Nilsen, T. H., ed., Late Mesozoic and Cenozoic Sedimentation and Tectonics in California:* San Joaquin Geol. Soc., Short Course, Bakersfield, California, p.39-52.

NORMARK, W. R., 1970, *Growth patterns of Deep-sea fans:* Am. Assoc. Petroleum Geologists Bull., v. 54, p. 2170-2195.

PICKETT, G. R., 1966, *A review of current techniques for determination of water saturation from logs:* Jour. Pet. Tech. v. 18, p. 1425-1433.

WEBB, G. W., 1981, *Stevens and Earlier Miocene Turbidite Sandstones, Southern San Joaquin Valley, California:* Am. Assoc. Petroleum Geologists Bull., v. 65, No. 3, p. 438-465.