LANDSLIDE OIL FIELD, KERN COUNTY, CALIFORNIA - A SUCCESS STORY
AN EXPLORATION/DEVELOPMENT CASE HISTORY

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ABSTRACT

The Landslide Oil Field, located in Kern County, has been a highly publicized field discovery due to its high initial flow rates (2000 BOPD), and thick pays (150'-300'). The field, located southeast of its predecessor the Yowlumne Field, is a combination stratigraphic structural trap with its own common field oil/water contact. The field reservoir, the Miocene Stevens sands, occur in a northwest-southeast oriented fan-channel system which originated from a southerly source. The trap at Landslide is formed by an updip Stevens sand pinchout into the Antelope shale as the channel crosses the east plunging Pioneer Nose. The Antelope-Stevens interval is a deep-water sequence with excellent reservoir characteristics in the thick channel facies, and a hydrocarbon sourcing from the Antelope and older stratigraphic units. A 3D seismic survey was conducted early in the life of the field and assisted in defining the channel system and locating development wells. A timely waterflood program was commenced early in the life of the field to enhance recovery. All aspects of the Landslide Field development, from early exploration through the drilling and production phases, has been a success story.

INTRODUCTION

Location

Landslide Oil Field is located in the southwestern corner of Kern County, approximately 25 miles south-southwest of Bakersfield. (Figure 1) Landslide Field trends northwest-southeast, on trend and about 2 miles southeast of the southern limit of its predecessor, the Yowlumne Field. Two miles to the southeast of Landslide lies White Wolf Field, trending west to east at a right angle to the Yowlumne-Landslide trend. Landslide Field is located upon the geomorphic feature known as the San Emidio fan emanating from San Emidio Canyon and at an elevation of approximately 1050' above sea level.

Regional Setting

Landslide Field is located on the boundary between the relatively simple structures of the Maricopa sub-basin and the complex structuring common along the White Wolf Fault and San Emidio Range. Less than a mile south of Landslide, the San Emidio Range rises quickly from the San Emidio fan to elevations over 2000' above sea level near the White Wolf Field. The steep north flank of the San Emidio Range is held up by west striking, vertical to overturned beds of Pliocene-Pleistocene age. At the base of the north flank of the range, where it meets the low relief valley floor, is concealed a major overthrust that underlies production in the White Wolf Field. Along the north flank of the range are numerous landslide deposits with an extensive landslide reaching the southern edge of the Landslide Field, hence the field name. While the area south of Landslide exhibits considerable structural complexity, the sequence penetrated at Landslide Field proper is normal and the structure fairly simple.

Play Concept and History

Exploration for Landslide Field was set up and commenced after the discovery of Yowlumne Field in 1974, an accumulation in a northwest-southeast trending Miocene deep-marine Stevens channel. The Stevens

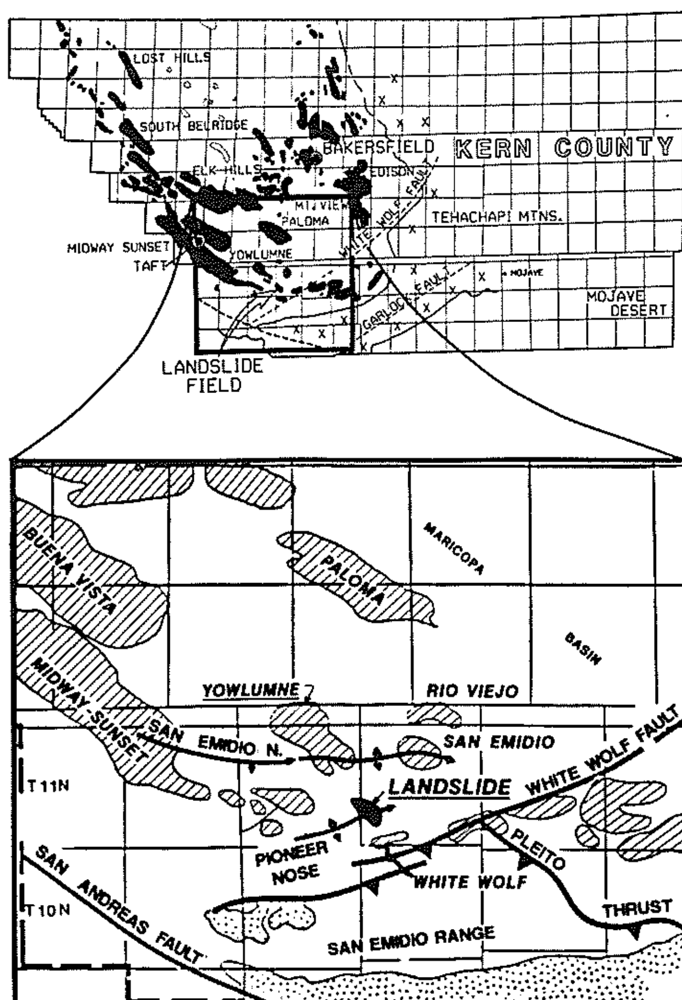


FIGURE 1 Index Map of the Southern San Joaquin Valley and location of Landslide Oil Field, Kern County, California

* PRIMARY CONTRIBUTOR AND PRESENTER

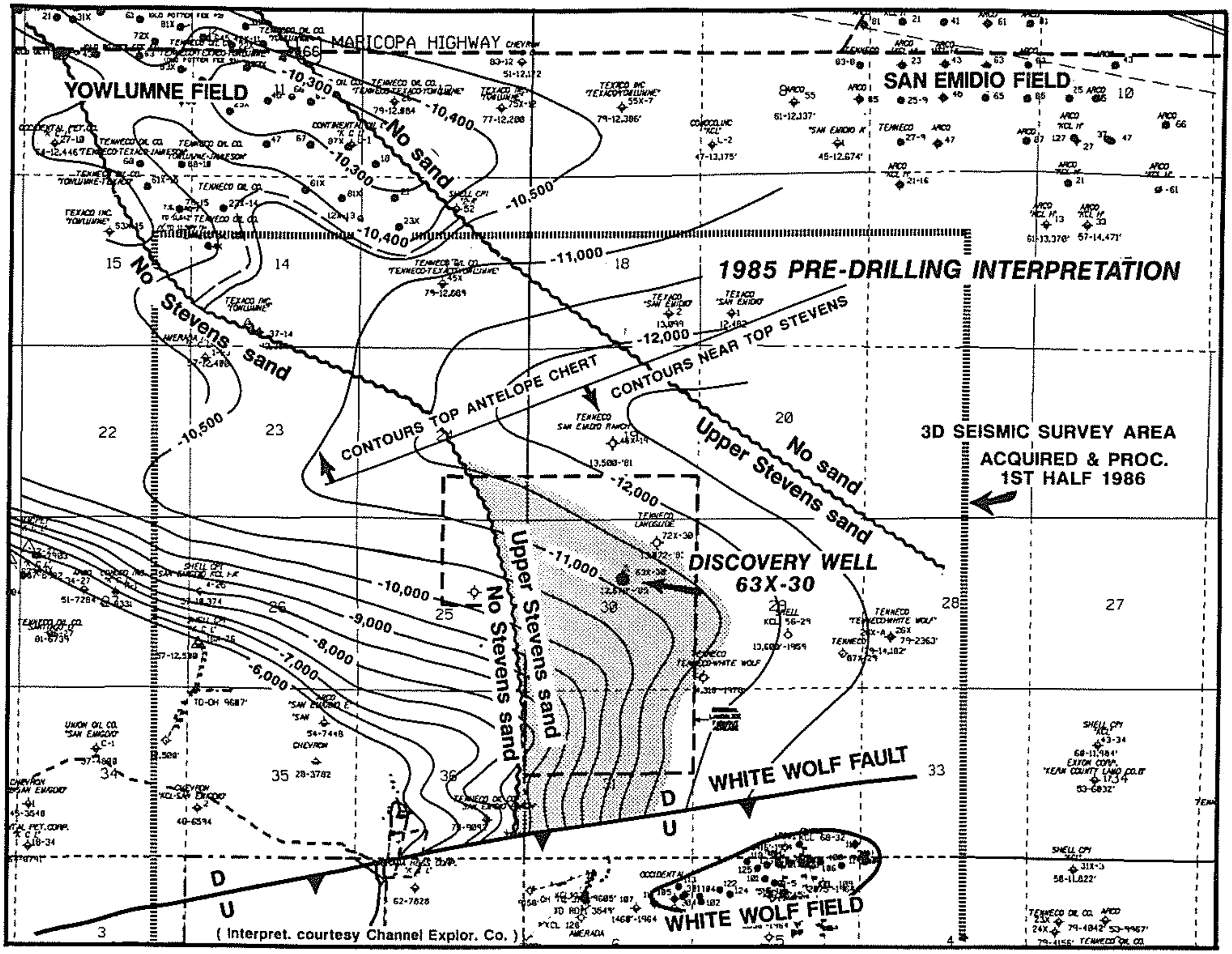


FIGURE 2 Pre-drilling interpretation of the Landslide Prospect on the 'N' Chert/Near Top Stevens Horizon early 1985

channel' had an origin south of Yowlumne and the exploration potential for thick reservoir sands with excellent reservoir quality and producing rates. By 1985, Yowlumne had produced 52.4 million barrels of oil (CCCOP, 1985), with an ultimate recovery near 100 million barrels oil, and offered excellent target to follow up on.

The play concept for Landslide Prospect was a southerly continuation of the Stevens channel crossing the next structural nose south of the San Emidio Nose. (Figure 2) Three miles south, and roughly paralleling the San Emidio Nose, lies the east-plunging Pioneer Nose. Several wells in the Landslide area were drilled in 1959 to 1960 with some encouragement, but no commercial success. The Texaco Pleito Creek #1, drilled in Section 25, T11N, R22W, penetrated the stratigraphic section into the Antelope 'P' chert, but encountered no Upper Stevens sands. This well became the limiting well for a major accumulation on the updip side. In the late 1970's and early 1980's, Tenneco Oil drilled several other exploratory wells in the southwest corner of T11N, R21W. Each of the wells penetrated either a lower Yowlumne sand equivalent (the 10-4), herein called the 18X sand after the Tenneco 18X-29, or an Upper Yowlumne sand equivalent, however none were commercial discoveries. A key well setting up the Landslide Field was the Tenneco Landslide 72X-30 in Section 30, T11N, R21W. It was drilled in 1983 to 13,072' and encountered a 120'+ Upper Yowlumne sand equivalent, heavily oil stained and with excellent reservoir qualities averaging 19% porosity and 150 to 180 millidarcies permeability. The zone was clearly wet by testing but suggested it was located at or near an oil/water contact.

A farmout was obtained from Tenneco on Channel's Landslide Prospect with the discovery well being drilled by partners Channel Exploration, Merlin Petroleum and Transco Exploration Company. The Landslide discovery well, the Channel Tenneco-San Emidio 63X-30, was drilled 1200' southwest of the 72X-30 to a depth of 12,670'. The 63X-30 penetrated a Stevens section three times thicker than the 72X-30, and all in the oil column. Production commenced August 1, 1985, at a stabilized flow rate of 2064 BOPD, 28.4° API oil, 405 Mcfg/d through a 28/64" choke. Payout for the discovery well, with an investment for the completed well cost of approximately 1.6 million dollars, was close to 75 days. Contractually, Tenneco had the right to take over as operator, and Tenneco exercised this right effective September 1985. Lease provisions provided for a 90 day period between wells for the entire field development. In practice, the field was developed essentially continuously, utilizing one rig, Marlin Drilling Rig 13, through the last water-flood well. (Figure 3)

As a follow-up to the discovery well, the 65X-30 location was drilled, being 1200' south or the next 40 acre location south of the 63X-30. With the euphoria associated with the discovery well's flow rates, it was interesting to note how jaded one's outlook can be to anything less productive. The 65X-30 encountered a thin, 165 foot Stevens 'bundle' from 12,168' to 12,333' and went on production for a 'disappointing' 700 BOPD initial rate. The rapid rate of thinning from the 63X to the 65X gave early and justifiable concern for any locations near the southern pinchout. Within a week following the penetration of the 65X-30 sand, a 3D seismic survey was being contemplated to assist in further field development. Action on the 3D survey moved ahead rapidly, but actual data was not available until about the commencement of the seventh field well. (See outline on Figure 2 for survey size.)

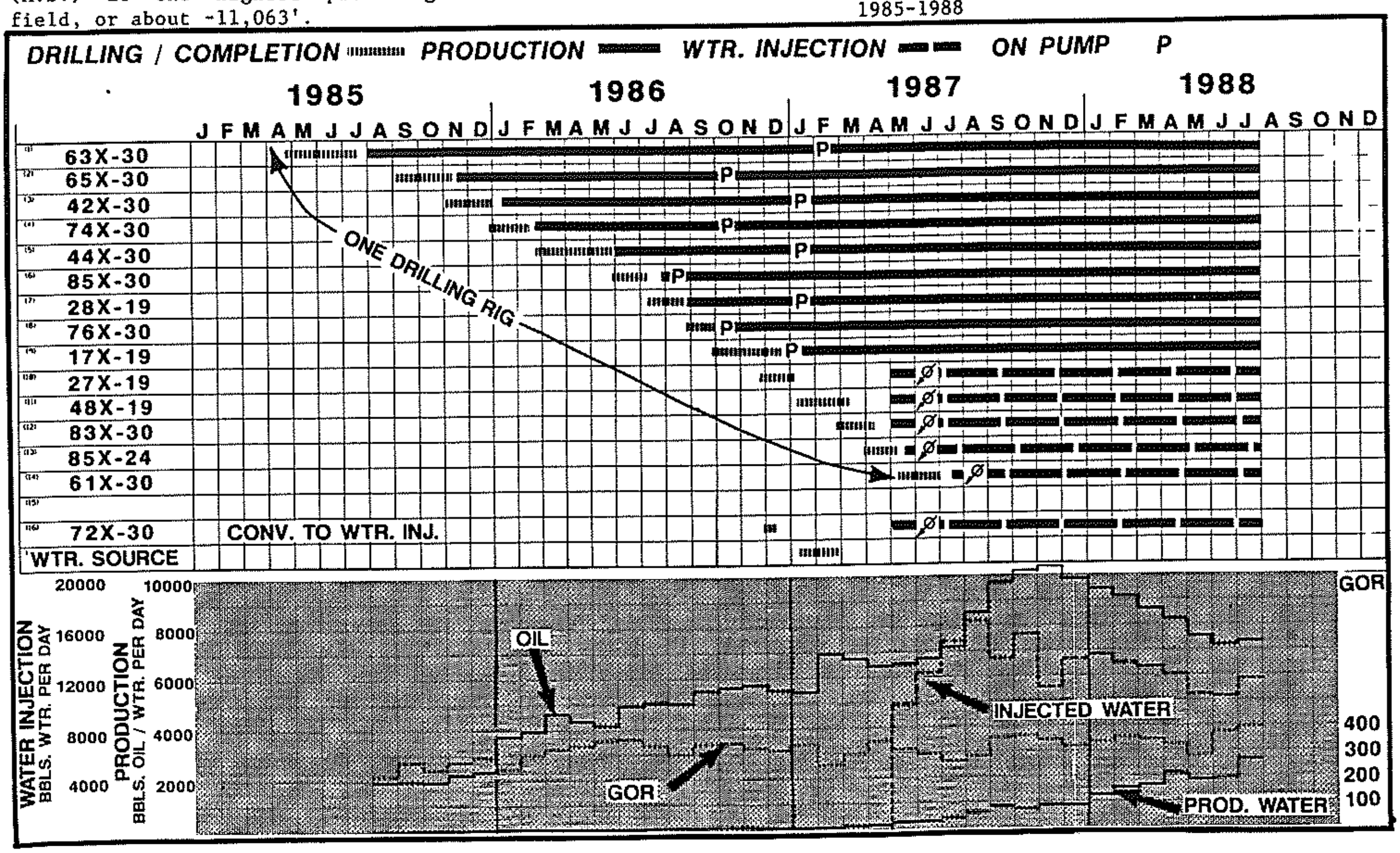
The third well, the 42X-30, was drilled on location west of the 63X and penetrated the maximum gross 'Landslide' sand thickness of about 350 feet, netting about 240' of pay. The 42X commenced flowing at 1530 BOPD and, to date, represents the field well with the highest cumulative production. The fifth field well, the 44X-30, is worthy of discussion. It was drilled one location south of the 42X and prior to the utilization of the 3D data. This well hit the edge of the channel, encountering a section with less than 50' or less of gross sand and very little effective pay. A 3-Arm offset VSP was run, and the northeast oriented arm clearly recorded the abrupt south edge and thinning of the reservoir. (Figure 6) The 44X was sidetracked to penetrate the Stevens about 750' northeast of the original hole. The sidetrack drilled into a 300' section (M.D.) at the highest producing location in the field, or about -11,063'.

Subsequent to the 44X, four other wells were drilled and completed for a total of nine producing wells. Five water injection wells were drilled and the 72X-30 exploratory well converted for a total of six injector wells. A 2000' water source well for the water-flood was drilled just north of the 65X-30. Upon testing, it was determined this single source well would produce the volumes needed for the flood. The water-flood was initiated in the spring of 1987 to reverse the rapidly declining reservoir pressure well prior to reaching the reservoir's bubble point. By August 1988, three years after the discovery, the field had produced 6.7 MMBO and 2.2 Bcf and was averaging above 7,300 BOPD production.

GENERAL STRATIGRAPHY

Stratigraphic units penetrated in Landslide Field proper include units down to the Antelope Shale 'P' Chert, with the majority of the wells reaching total depth in the 'P' Chert. Below the 'P' Chert, the shales of Lower Mohnian through Middle Miocene age were penetrated by the Tenneco 18X-29, on the southeast edge of the field, and the Tenneco 36-1, some 2 miles south of the field. For purposes of stratigraphic correlation and facies reconstruction, it is often advantageous to tie to the surface outcrops of the same stratigraphic horizon. It is unfortunate, but interesting to note, that the whole Antelope Shale through the 'P' Chert seen in the field wells is missing in the San Emidio Range just south of the field, due to the Upper Miocene or Lower Pliocene erosion. It is a testament to the structural dynamics of the area to realize the Antelope stratigraphic package, found at about subsea 11,000' in the field, is located at about 2000' above sea level 2 miles south of the field - a structural difference of at least 13,000'.

FIGURE 3 Development time-chart and display of production and injection volumes, years 1985-1988



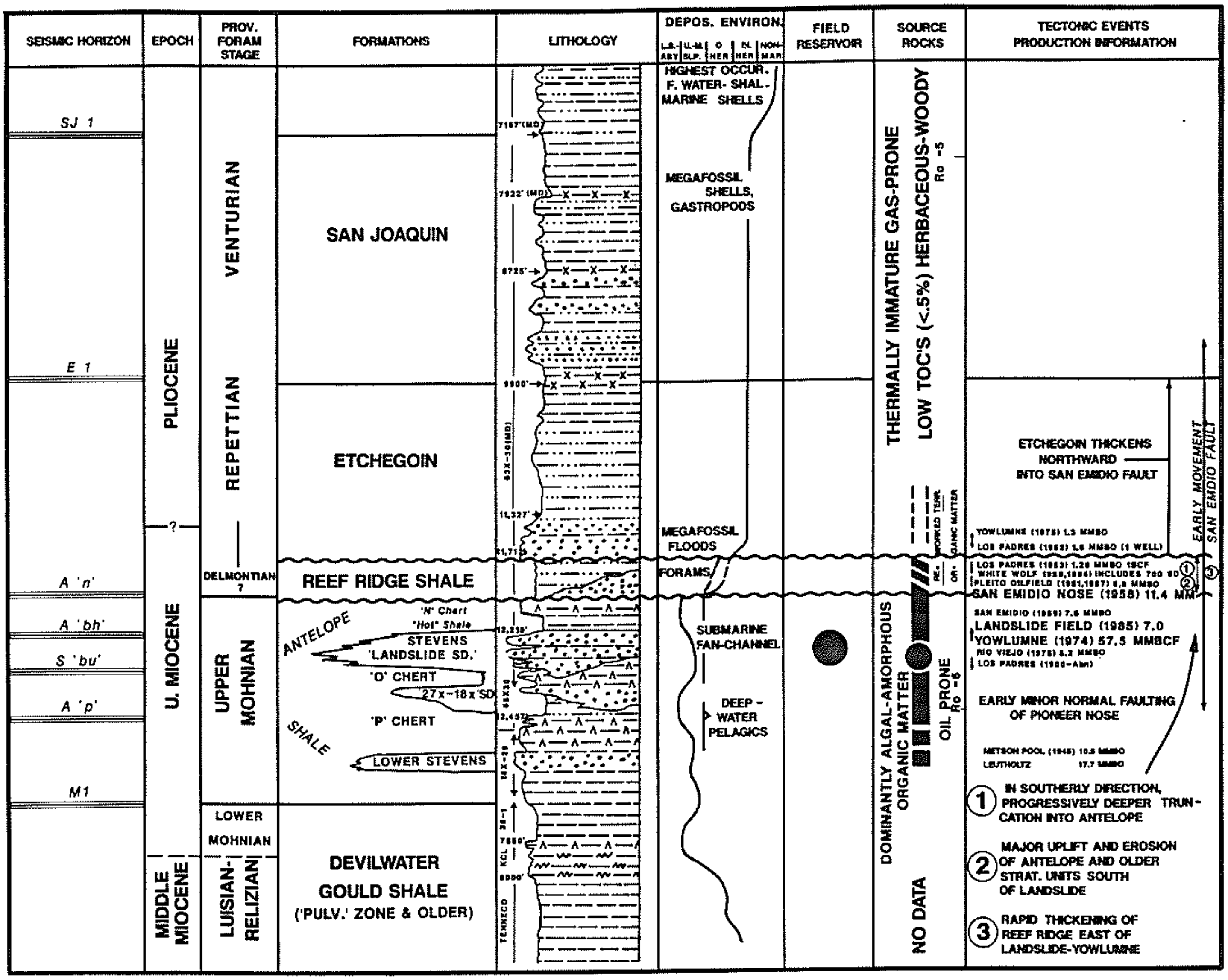


FIGURE 4 - Stratigraphic Column of the Landslide Field depicting related depositional environment, geochemical, production and tectonic information.

Illustrated in Figure 4 are all the stratigraphic units penetrated below about 7000' in the Landslide area proper, which happens to be the start of the marine sequence. Above 7000', the section is entirely non-marine and increases in a shallowing direction, in sand percentage, grain size, and depositional energy. At the surface are the fanglomerates of the San Emidio Fan, which can be coarse with very large boulders. Substantial velocity anomalies in the time to depth seismic conversion occur at Landslide-Yowlumne area and appear to all be tied to near surface (1000' and less) velocity differences.

Antelope Shale/Stevens Sands

The Antelope Shale consists dominantly of shale facies (inclusive of cherty, silicious and carbonate components) and a sandy facies, where present, called the Stevens sandstone. The shales of the Antelope are informally divided into an upper 'N' chert, middle 'O' chert and lower 'P' chert sections. (zonation credited to Don Sprouse, retired Tenneco geologist). The overall package at Landslide from the top 'N' chert to the top of the 'P' chert ranges from 475' near the southern edge of the field (Figure 9), to 600' in the core of the field (Figure 8), to 600-850' in the water injector wells along the north flank of the field. The thickest area is at the northwest side of the field. The increased thickness is largely due to the addition of Stevens sand section within the 'O' chert package. The additive nature of the sands to the top 'N' chert to top 'P' chert interval provides a geological/geophysical technique for mapping the Stevens sand thick's (Don Sprouse, pers. comm.).

The 'P' chert is a complex of interbedded silicious shales, glassy cherts and dolomites, the most massive of the three chert units. It is recognized on log character by an unusual alternating of 'hot' shales and normal shales on the Gamma Ray curves in its upper 100' of section (Figure 7). It is almost always overlain by a conductive shale/siltstone of the basal 'O' chert package.

The 'O' chert is somewhat of a misnomer because very little chert exists. Instead the 'O' chert usually consists of silicious shale, shale, limestone and dolomite. Within the overall 'O' chert package are the additive Stevens 'Landslide' sands.

Metz and Whitworth, (1984a) documented well the Stevens model at Yowlumne Field. The Landslide sands fit this same model but are closer to the source and appear very similar to the "Confinement" model proposed by Scott & Tillman (p. 130). The Stevens package at Landslide appears to be prograding down a topographic low, with sands getting progressively younger to the northwest. (see interval zonation to landslide sands in Figure 8) The continuity of the Stevens channel between Landslide Field and Yowlumne Field is not in doubt. The combination of well data and 3D seismic clearly demonstrates the continuity. The U. Yowlumne sands are likely, however, slightly younger than those at Landslide.

Following the massive upper sands seen in Landslide-Yowlumne are the quiet, deeper water shales and chert of the Antelope 'N' chert. The 'N' chert section is uniform with an average thickness of 150-200'. At least in the field area, no sands occur in the 'N' chert and not shale package. It seems likely that the basal 'hot' shale of the 'N' chert represents a major environmental shift with the Stevens source area cut off. To the east and northeast of Landslide, sands do occur in the 'N' chert interval, so it may be that the Landslide-Yowlumne channel was by-passed or cut-off from sediments at this time.

Reef Ridge Shale

Following the Antelope shales is a clastic and shale sequence called the Reef Ridge shale that reflects major ongoing basinal changes. Truncation on the 'N' chert occurs regionally in the southern San Joaquin Valley and significantly cuts down into the Antelope in the southerly direction of the San Emidio Range. While this truncation is almost unnoticeable at Landslide, a mile south the truncation becomes increasing severe as the Reef Ridge is seen overlying the 'P' chert to 'Pulv' shale sequences.

Documenting this major erosional period and indeed truncation probably far deeper than Mid-Miocene shales is evidence from geochemistry. Vitrinite reflectance data from the Reef Ridge in the 63X-30 well, clearly shows a well developed bi-model distribution of vitrinite in the Reef Ridge and Lower Etchegoin. The in-place Reef Ridge shales have Ro values in the .5-.55 range and grade uniformly with respect to Ro values into the Antelope shale. The other prominent peak is in the vicinity of Ro=1.0. The source of the high Ro values are derived from rock units that were high in terrigenous organic matter (versus the algal-amorphous of the Antelope). These values likely reflects the unroofing of an older stratigraphic sequence, buried deeper than anything the Antelope has experienced and probably out of the early San Emidio Range.

At the base of the Reef Ridge, thick clastic sequences develop in an easterly direction both on the San Emidio Nose and east of Landslide. The Reef Ridge averages 280-350' thick at Landslide with almost no basal Reef Ridge sand. This section expands to over 800' thick a mile east of Landslide. While paleo evidence is not available from any of the field wells, environmental evidence gleamed from mud logs would suggest the Reef Ridge - etchegoin units to be in a rapidly shallowing depositional sequence.

Overlying the Reef Ridge shales, are the clastics and claystones of the Etchegoin, averaging 1800' thick near Landslide Field. This Etchegoin interval thickens towards Yowlumne, and probably reflects early development of the San Emidio fault along the southern flank of the San Emidio nose. The top of the Etchegoin is in the vicinity of 9900' M.D. in the field, and is mapped geophysically at the base of a prominent 100' bentonitic shale.

The overlying San Joaquin is some 2700' thick and of a shallow marine to marginal marine environment. Numerous bentonitic shales generate lots of mappable horizons on seismic.

From about 7000' M.D. to the ground level are all non-marine clastics.

GEOPHYSICAL EFFORTS

Early in the life of the field a 3D seismic survey was conducted that covered about 20 square miles(figure 2). The purpose was to help determine the southerly Stevens pinchout, assist in the placement of development locations and thirdly,look for new plays in the area. In all areas, the utilization of the survey exceeded all expectations.

The amount of data is somewhat overwhelming. The final trace or shot point spacing of the survey is 110'x165' which meant in a north to south direction,the (cross) lines are 110' apart, with about 210 such lines. The east to west lines (inlines) were 165' apart, with 140 such lines. Manually, the sheer effort of tying all the data is enormous. The interpretation of the survey for both Tenneco and Transco was conducted on Geoquest 3D workstations. The geophysical techniques and tools available on this workstation or others like it offer evaluation capabilities and speed far exceeding anything that can be done manually.Some of the particularly valuable tools are described below.

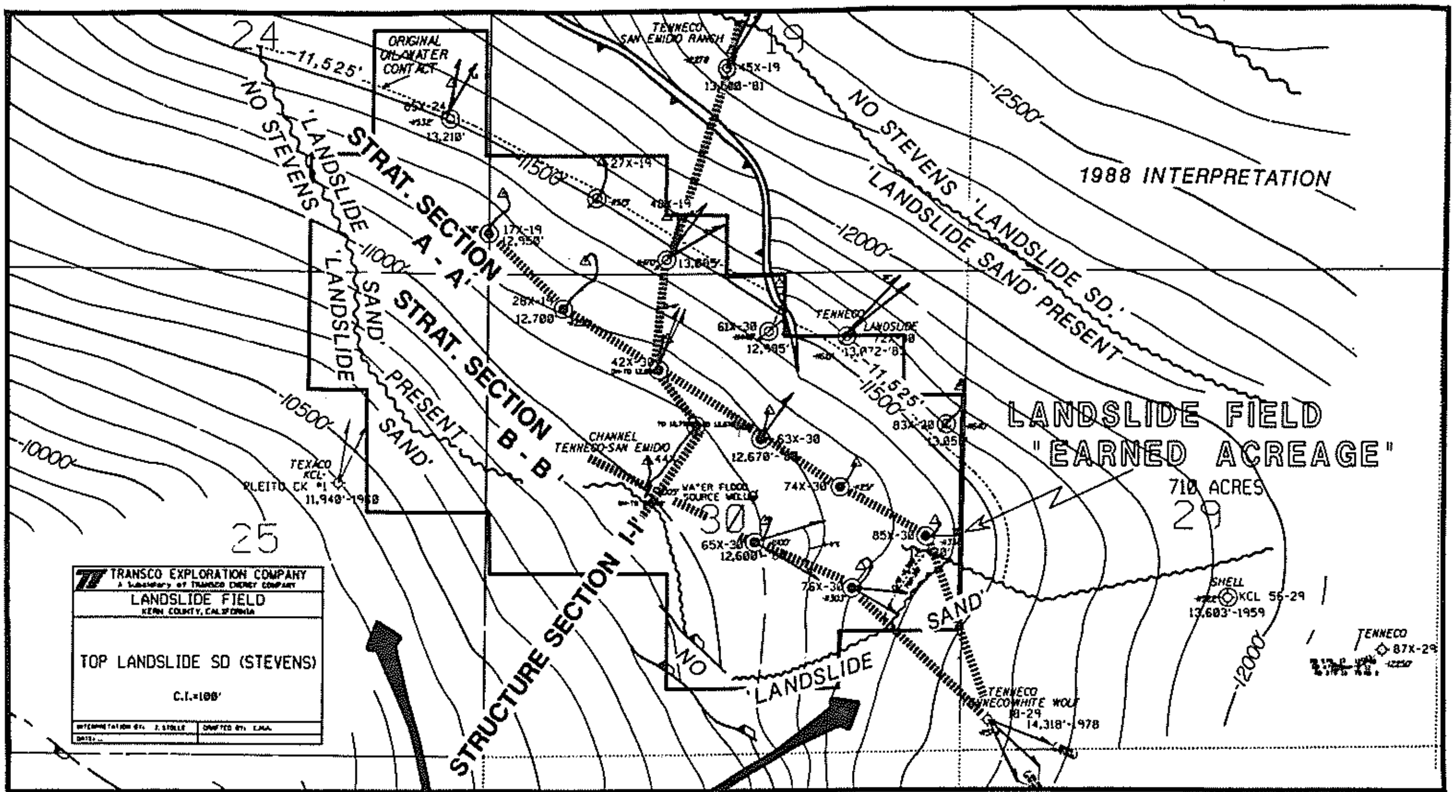
The ability to geophysically tie the geology to seismic sections and know what really represents the Stevens is made possible through the use and easy generation of synthetic seismograms. Combine this with the ability to easily extract seismic wavelets and generate synthetics that actually match the data was a great step forward. In all about twenty-five synthetics were generated over the 3D area that provided a good control grid.(a good part of these were provided by continued drilling.)

Secondly, generating seismic lines in any direction to connect wells on a single line is an easy step (reconstruction cuts) and it certainly aids in the recognition of common seismic character as related to lithologic units.Examples of reconstruction cuts are shown in figures 6 and 13.

A third tool that was particularly helpful was the ability to flatten a seismic section thus removing the structural dip component. In many areas of stratigraphic complexity, like in the Antelope sequence, the flattening technique helped resolve stratigraphic problems and helped to see new areas with potential for other Stevens reservoirs.

Other tools that are useful and helped speed the process were the character 'snapping' techniques for the proper timing of an event.Seismic modeling procedures were of great value in understanding the tuning effects of thin versus thicker Stevens bundles.Other mapping tools provide the capability to generate fast structural maps, create isochron/isopach maps and in the difficult time to depth conversions of maps, the intensive manual procedure became quite easy.

The original cost of the 3D survey in 1986 was about $600,000 in its entirety, acquired and processed.It was originally justified in terms of trying to avoid a dry hole by missing the channel. It was certainly worth the cost for that purpose.



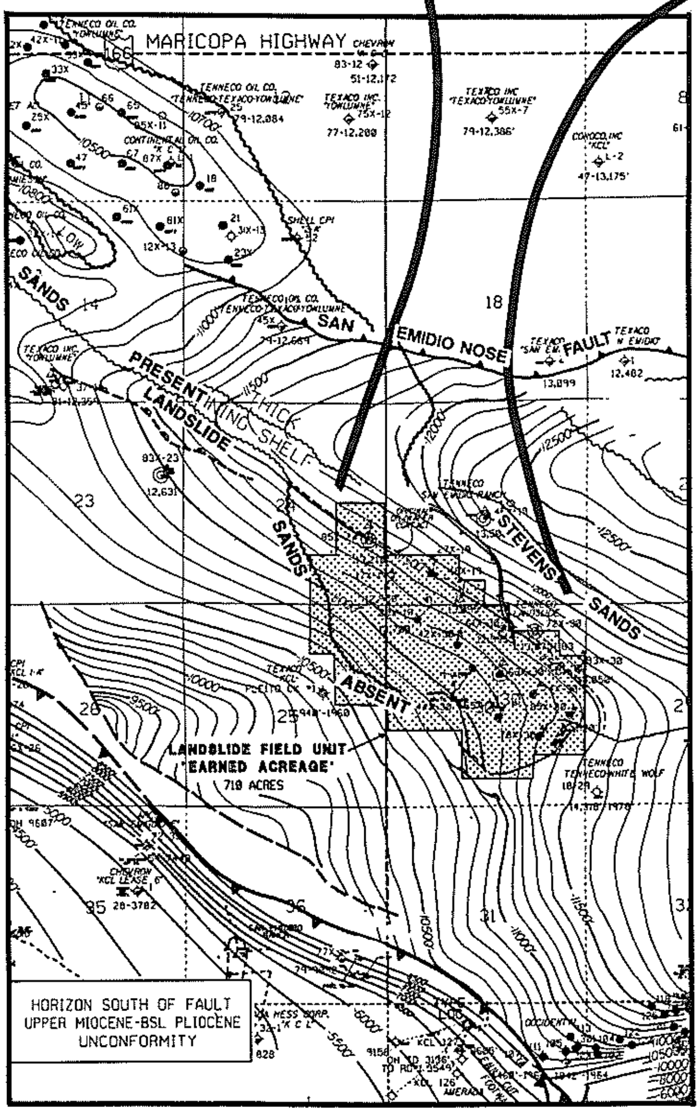


FIGURE 5 Structure map of the Landslide Field area on Top Landslide Sand/Base 'Hot' Shale

STRUCTURE

The two maps on Figure 5 demonstrates the overall structural setting at Landslide Field. The east to northeast plunging nose is clearly seen, with Tenneco's 18X-29 well providing evidence of the southeast dip to the feature. Dips average 10-12° north over much of the field steepening to 20-22° in the water injectors. The east plunge is about 5°-10° as reflected by the 65X and 85X field wells. The updip Stevens pinchout forming the trap is also shown. (Figure 6)

One fault east of the 61X-30 within the field is noteworthy as it cuts the producing horizon. It is a high angle reverse fault, up or the west side, and may have controlled some water injection flow. The area north of the field, in the vicinity of the 45X-19 is simplistic and probably has more faulting than shown. The only other faults in the field are deeper seated faults, active prior to Stevens deposition. There are several faults, each appearing to be oriented N-NW to S-SE that may cause depositional thicks in their downthrown blocks. These faults don't generally break the top Antelope 'N' chert horizon. One such fault is located on the west side of the 17X-19 well.

Regionally, several other significant faults occur. The San Emidio Nose fault (herein named) is a high angle reverse fault, up on the north side. Interpretation of 3D seismic data would suggest early movement as early as Reef Ridge or Stevens time, with major reverse movement in the Pleistocene. South of Landslide is a major high angle reverse fault extending from Los Lobos Area and trending to the southeast.

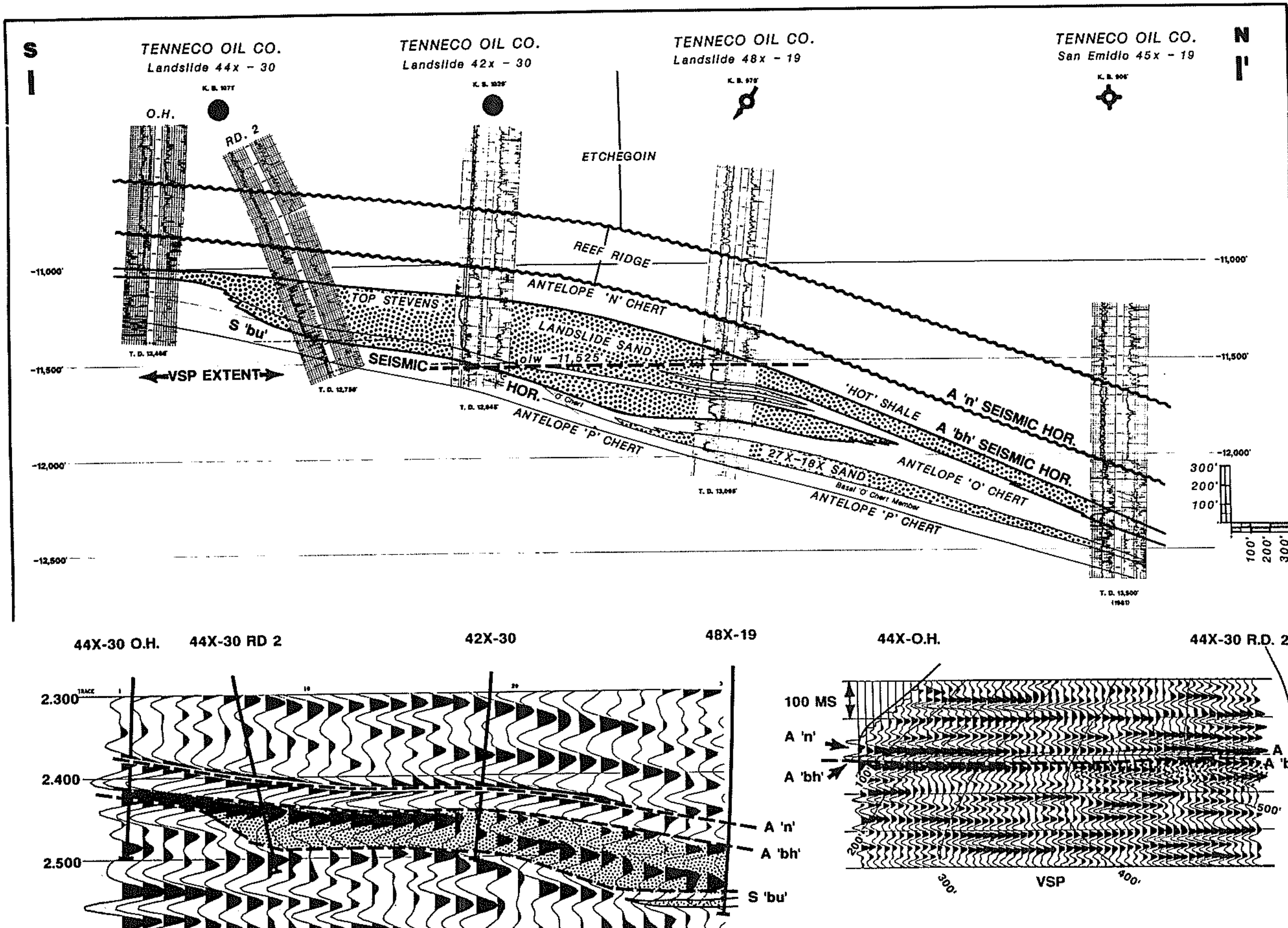
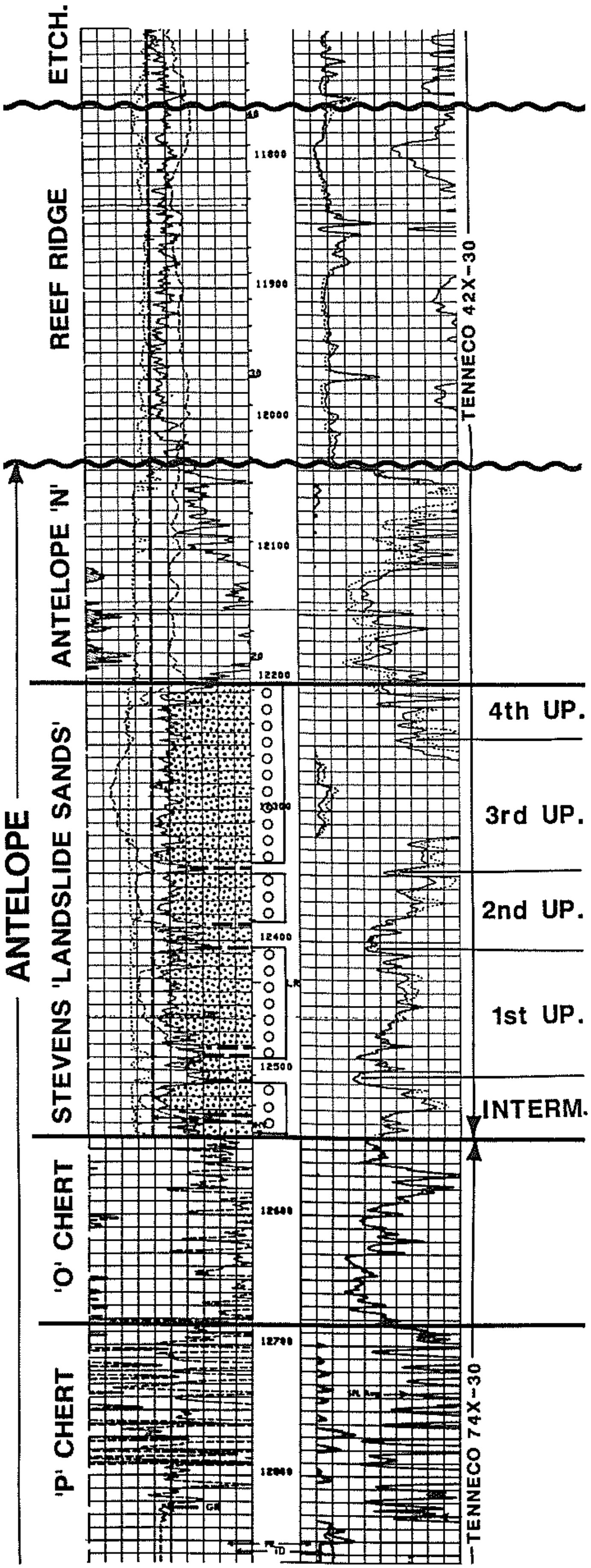


FIGURE 6 Structural cross-section I-I' with coinciding 3D reconstruction cut and VSP

FIGURE 7 Composite type log with the zonation of the producing reservoir



The generation of regional and field depth maps from seismic requires care in the time to depth conversion. Because of significant shallow velocity anomalies, average velocity maps for each horizon were generated to convert from time to depth.

RESERVOIR DISCUSSION

The Landslide reservoir is complicated, and interval correlations have not always been clear. Correlations tend to evolve as more and more reservoir information becomes available. The current interpretation breaks the Landslide sand 'tank' into 6 zones (Figure 7 & 8) with the bulk of the reserves in the 1st to 4th upper zones.

The overall volume of the reservoir in 560 acres is estimated to contain 44,400,000 barrels oil in place, with about 16,000,000 barrels recoverable. This is based upon a primary and secondary recovery of 38% or 275 barrels/acre-feet recovery (760 barrels acre-foot oil in place). Tables 1 and 2 provides the various reservoir and fluid properties at Landslide. Landslide, like Yowlumne, has been developed on a 40 acre spacing.

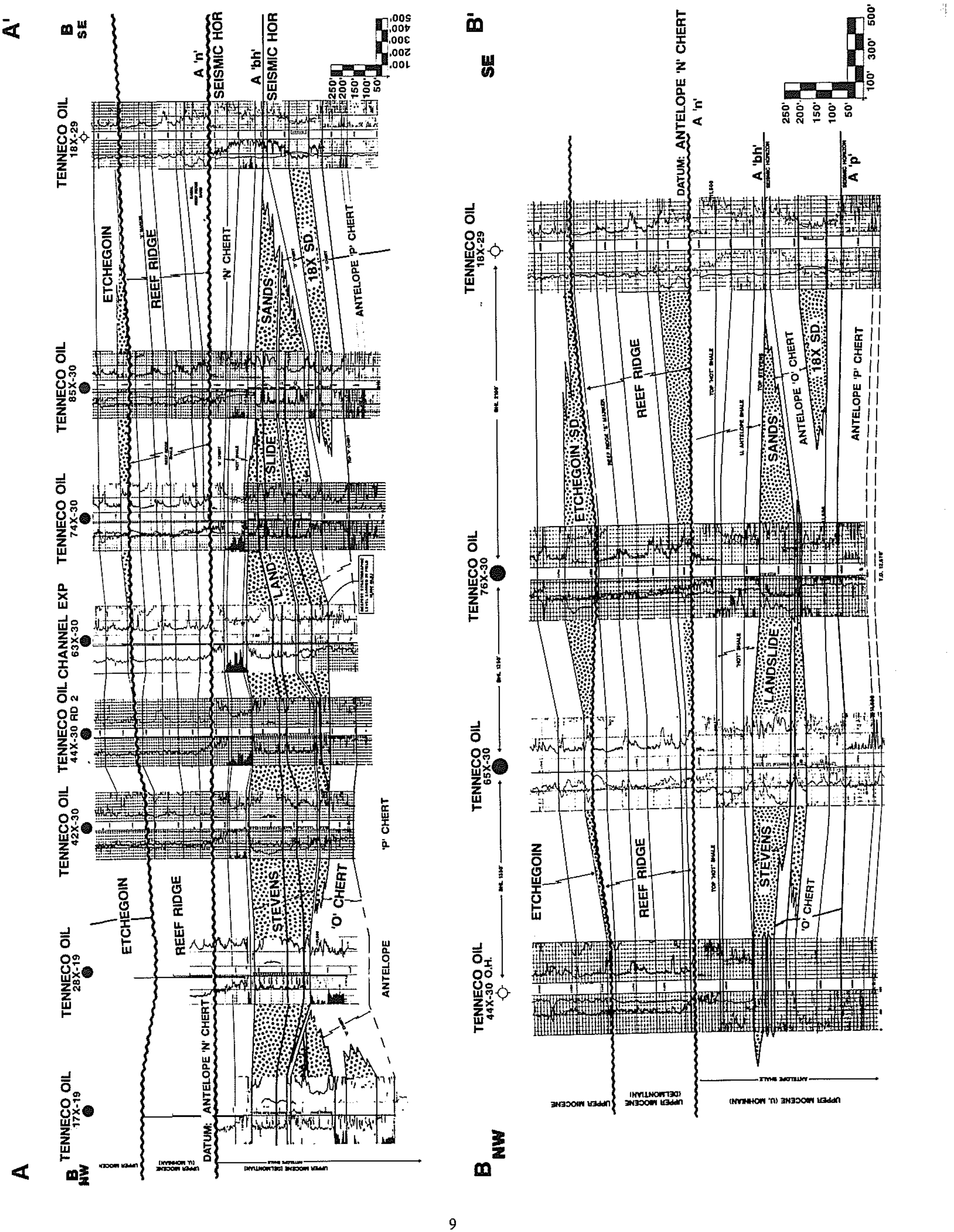
Currently, the waterflood front is progressing into the core of the producers, with the wells on the east side of the field now producing at high water cuts. The westerly two wells are still largely water free as are the more southerly wells. The encroachment of the injected waters has cut the daily oil produced from a high of 10,000 B.O.P.D. to current rates (as of August 1, 1988) near 7300 B.O.P.D. (Figure 3)

The Landslide reservoir is compositional similar to that of Yowlumne (Figure 10). The characteristics of the reservoir are highlighted on page 11 and in plates 1 through 5. While the reservoir rocks have several factors (primaryly clay growths on the grains and in the pore-spaces) that can detract from the flow and producing capabilities, careful management by the operator of drilling and completion fluids and practices has largely prevented any serious long-term reservoir damage.

Several areas exist updip from the current producing wells for future development wells with good confidence in the presence of the reservoir. Figure 6 clearly showed the rapid pinchout of the reservoir in a southerly direction near the 44X-30 original hole. Early on, this created extreme caution in the placement of southerly wells. The 3D seismic grid has allowed for the mapping of the reservoir volume in the thinner areas, with a confidence for further development locations. Figure 11 demonstrates some of the limitations of the seismic data. In the Landslide 3D grid, the minimum resolution is somewhere around 125', where both top and base of a reservoir can be resolved. Resolution is possible to probably half of this thickness on short extensions from control wells. (One offset location) through careful seismic modeling of possible stratigraphic situations..

FIGURE 8 Stratigraphic section A-A' oriented north-west-southeast through producers in core of the field

FIGURE 9 Stratigraphic section B-B' oriented north-west-southeast along southern 'shelf' close to southerly pinchout.



A
A'
B NW
B SE
B NW
B' SE
TENNECO OIL 17X-19
TENNECO OIL 28X-19
TENNECO OIL 42X-30
TENNECO OIL 44X-30 RD 2
TENNECO OIL CHANNEL EXP 63X-30
TENNECO OIL 74X-30
TENNECO OIL 85X-30
TENNECO OIL 18X-29
DATUM: ANTELOPE 'N' CHERT
A 'n' SEISMIC HOR
A 'bh' SEISMIC HOR
ETCHEGOIN
REEF RIDGE
'N' CHERT
STEVENS
LAND SLIDE SANDS
18X SD.
'O' CHERT
'P' CHERT
ANTELOPE
ANTELOPE 'P' CHERT
250' 200' 150' 100' 50'
100' 200' 300' 400' 500'
TENNECO OIL 44X-30 O.H.
TENNECO OIL 65X-30
TENNECO OIL 76X-30
TENNECO OIL 18X-29
DATUM: ANTELOPE 'N' CHERT
A 'n'
A 'bh'
A 'p'
ETCHEGOIN SD
ANTELOPE 'O' CHERT
ANTELOPE 'P' CHERT
250' 200' 150' 100' 50'
100' 300' 500'

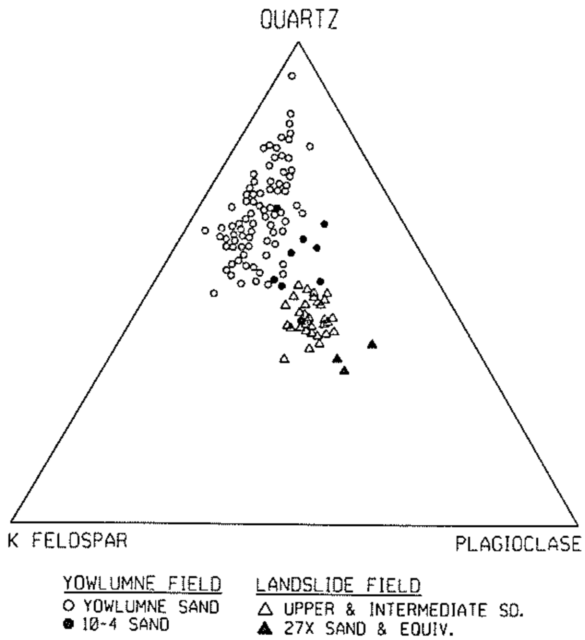


FIGURE 10 Ternary diagram of sand composition of Upper and Intermediate Landslide sands versus the lower 27X-18X. A comparison versus Yowlumne sand and 10-4 sand zones

TABLE 1 RESERVOIR ROCK / FLUID PROPERTIES

Reservoir Property	Landslide Sand
Average Porosity	19%
Permeability - Avg.	130
(to air) - Range	50 - 400
Depth (SS)	11,000'-11,525'
Reservoir temperature	245°F
Irreducible water saturation	32%
Original reservoir pressure	5570 @ -11,400'
Bubble point pressure	2195 psi
Oil gravity	28° API
Gas gravity (air = 1.0)	.692 (262 PSI @ 130°F)
Oil viscosity (init.)	1.05 cps
Initial solution GOR	470
R_w at 25°C	.57 - .6 ohm-m
Drive mechanism	fluid expansion
Oil FVF (orig.)	1.312
Oil FVF (B.P.)	1.357

TABLE 2 HYDROCARBON ANALYSIS

values in mole percent

	Oil	Gas 67 psig. 74°F
Hydrogen Sulfide	0.00	0.00
Carbon Dioxide	0.71	2.41
Nitrogen	0.23	0.27
Methane	32.35	75.78
Ethane	2.35	7.98
Propane	3.78	7.72
iso-Butane	1.68	1.88
n-Butane	3.19	2.45
iso-Pentane	0.94	0.69
n-Pentane	1.72	0.37
Hexanes	3.05	0.21
Heptanes plus	50.00	0.24
	100.00	100.00

Plate 1 65X-30 12,261-262'

A generally porous, moderately to poorly sorted, medium-grained sandstone. Potassium feldspar (A6, E11, E-F4-5), plagioclase feldspar (B9-10, C3), and quartz (D-E9, F-G5, J7) make up most of the framework grains. Matrix materials are sparse. Clays (grain-coating, mixed-layer illite/smectite and pore-filling kaolinite) are the dominant authigenic minerals. (50X)

Plate 2 74X-30 12,451'

Massive to vaguely laminated, moderately sorted sandstone. Note the size of the perthitic feldspar grain at E-12 relative to other potassium feldspar grains AT D5-6, B6, and H-J9-10. In addition to the feldspars, the framework-grain fraction also includes quartz (B11-12, H-J11-12, B4-5) and lithic fragments. Although the pore network appears poorly interconnected, most of the porosity, chiefly intergranular, remains unobstructed the minor amounts of matrix and authigenic cements. (51X)

Plate 3 65X-30 12,261-262

This photomicrograph is an enlarged view of the central area in Plate 1 (F7). The crenulated clay on the surface of quartz grains (B6, E2, D8, F8, H13) is authigenic mixed-layer illite/smectite. Secondary quartz overgrowths occur at (G-H5-6, J5, K8). (750X)

Plate 4 74X-30 12,451'

The web-like morphology of authigenic smectite and the vermicular habit of kaolinite are well displayed in this closeup view of a small intergranular pore. Both of these authigenic clays may reduce reservoir quality if improperly treated. (1400X)

Plate 5 74X-30 12,451'

Rhombohedral ferroan calcite (F7) partially plugs an intergranular pore in this enhanced image of the sample. Smectite-coated quartz grains can be observed at H4, B11-12, and H11. Note that smectite does not coat ferroan calcite, a textural feature which suggests that ferroan calcite postdates smectite. (850X)

(SEM descriptions by Core Laboratories, Inc.)

LANDSLIDE SS. RESERVOIR

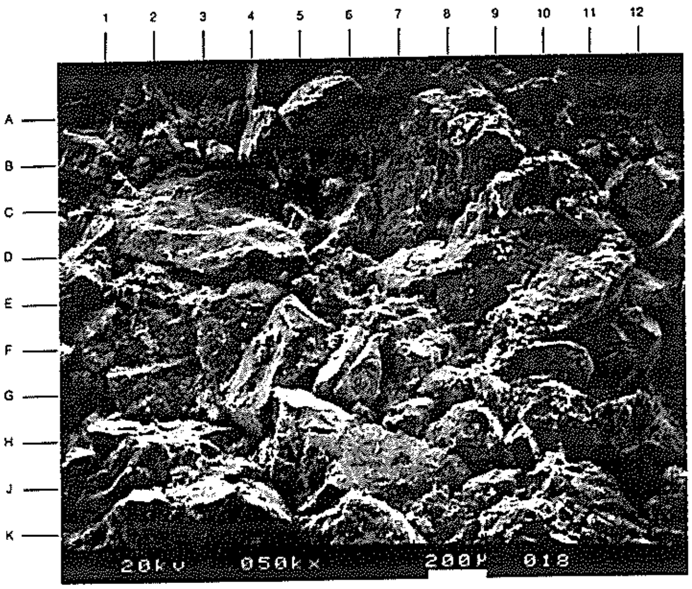
MODERATE TO GOOD POROSITY (19% ±)
- PRIMARY INTERGRANULAR
- SECONDARY INTRAGRANULAR : FELDSPAR DISSOL.
- MICROPOROSITY DUE TO AUTHIGENIC CLAYS

POOR TO MODERATE SORTING

ANGULAR TO SUB-ROUNDED GRAINS

LITHIC ARKOSES TO ARKOSIC LITHARENITES

PLATE 1



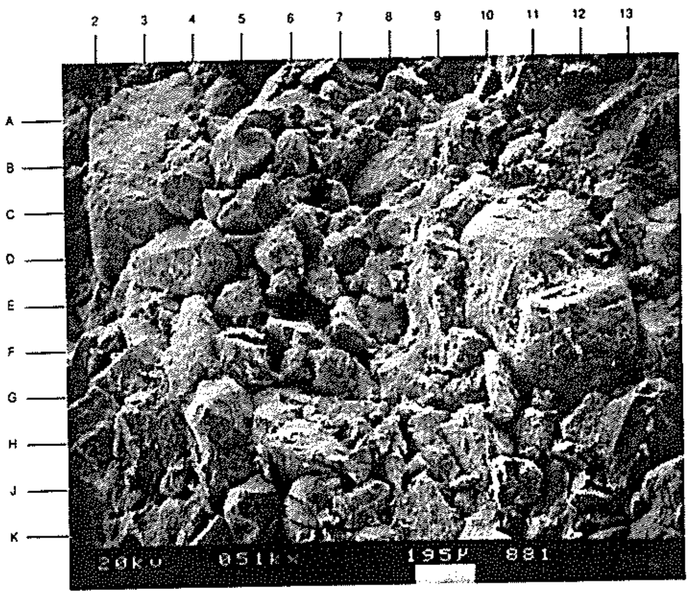


PLATE 2

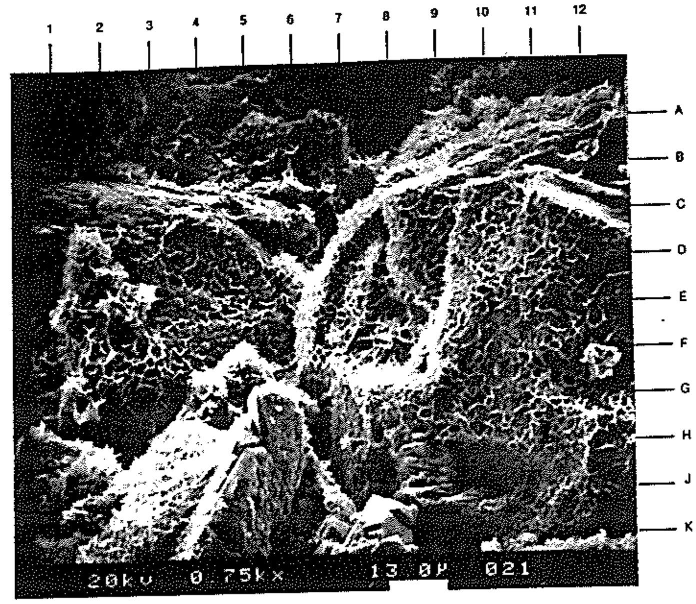


PLATE 3

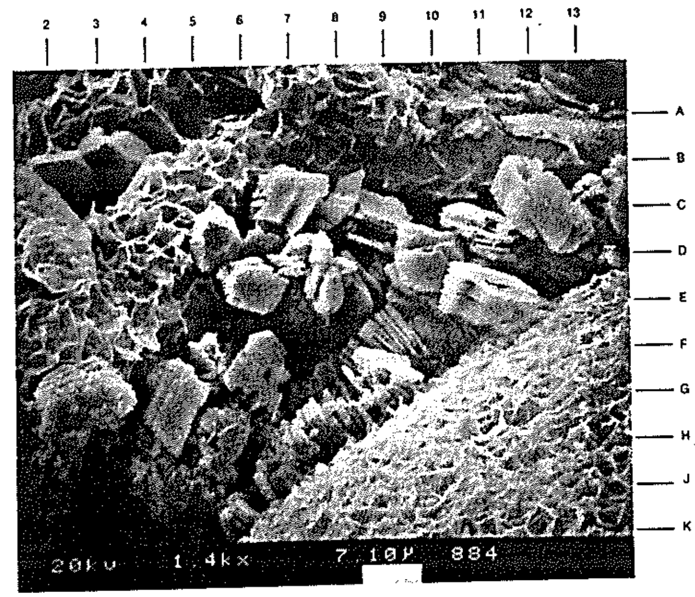


PLATE 4

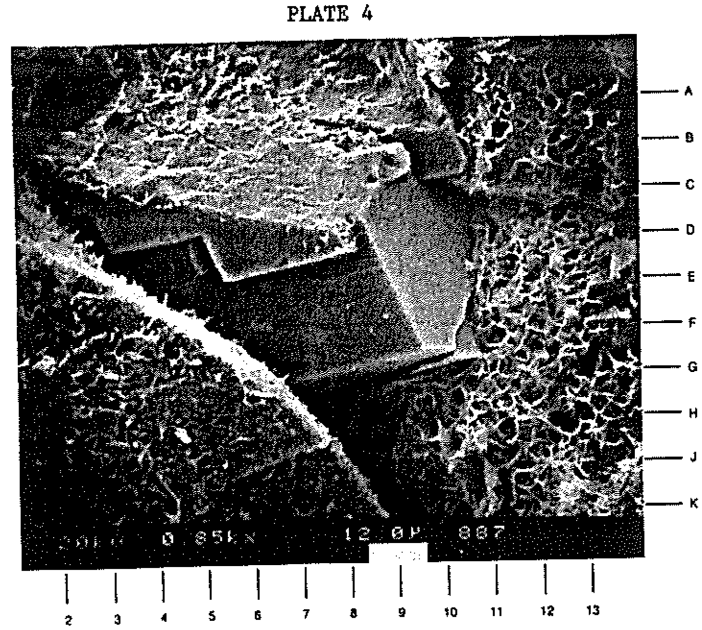


PLATE 5

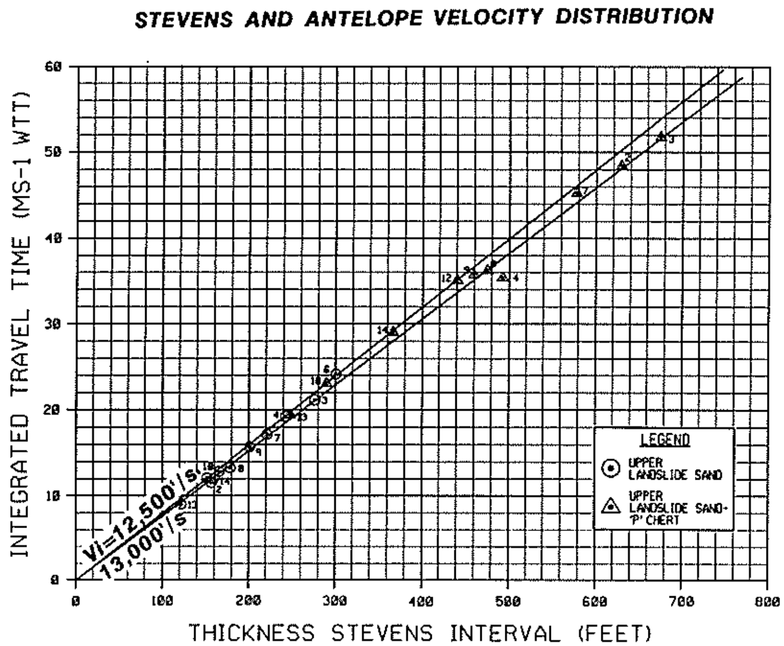
MAJOR RESERVOIR PROBLEMS

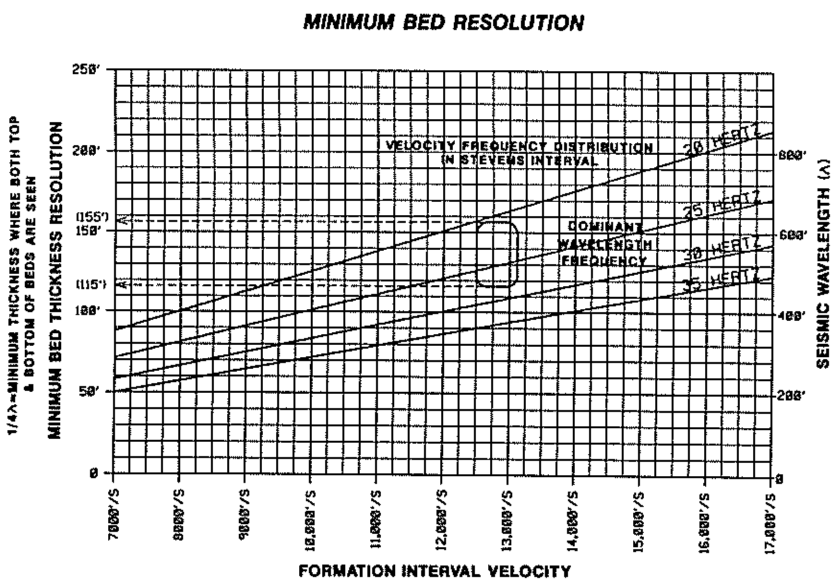
' THE PORE FILLERS '

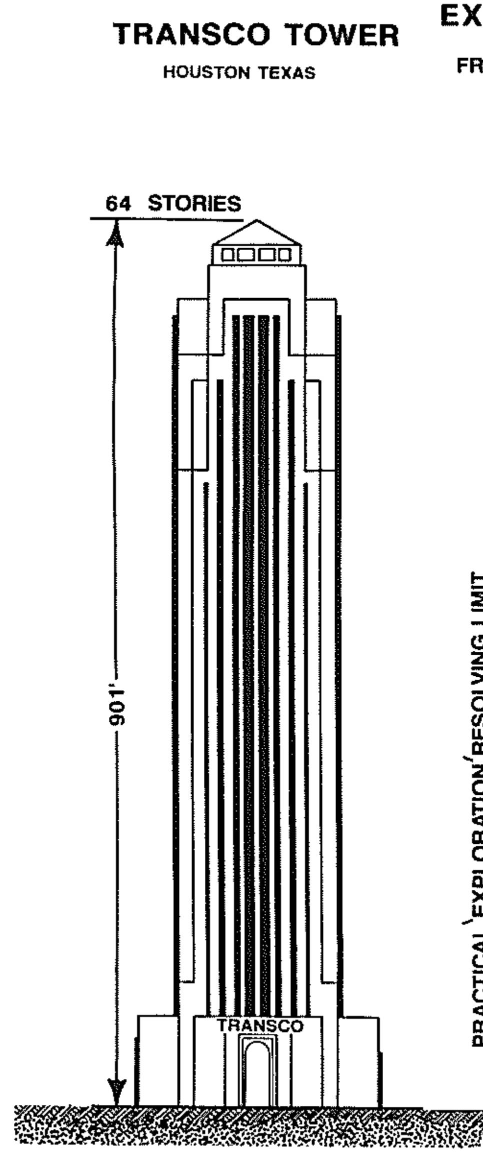
ILLITE / SMECTITE GRAIN COATING—COMMON

AUTHIGENIC PORE-FILLING KOALINITE

LATE ANKERITE / CARBONATE CEMENT—MINOR







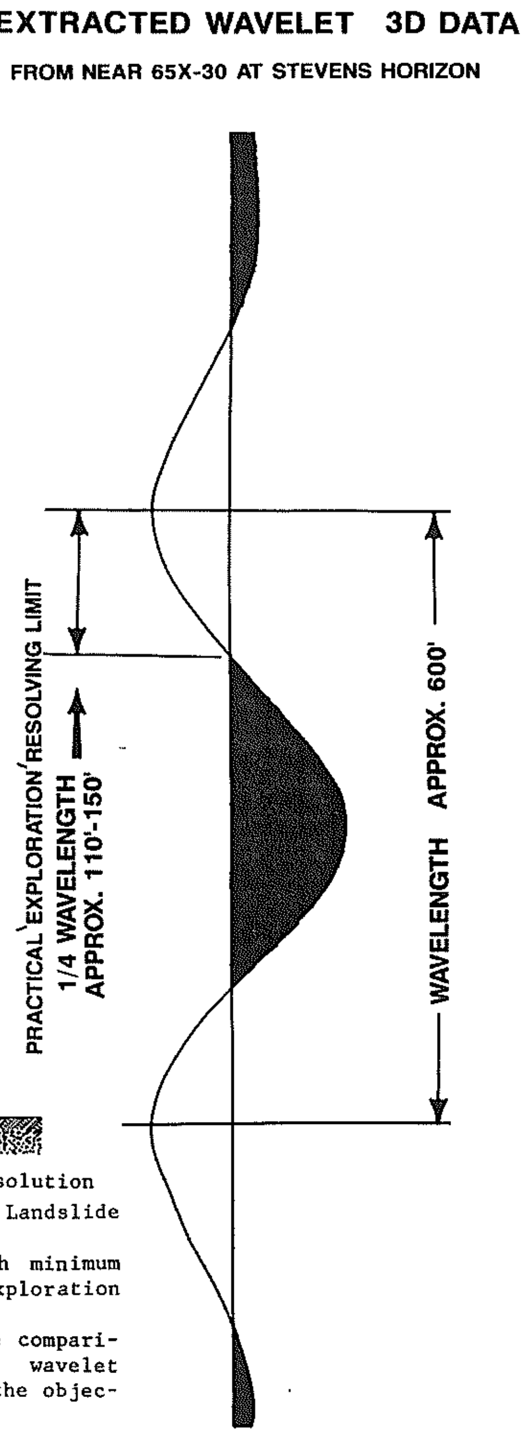


FIGURE 11 Landslide 3D seismic resolution
a) Plot of interval velocity of Landslide sand section for all wells
b) Quarter wavelength graph with minimum 'practical' resolution for exploration work
c) Transco Tower diagram for size comparison with extracted seismic wavelet from the 65X-30 loction near the objective Landslide sand horizon

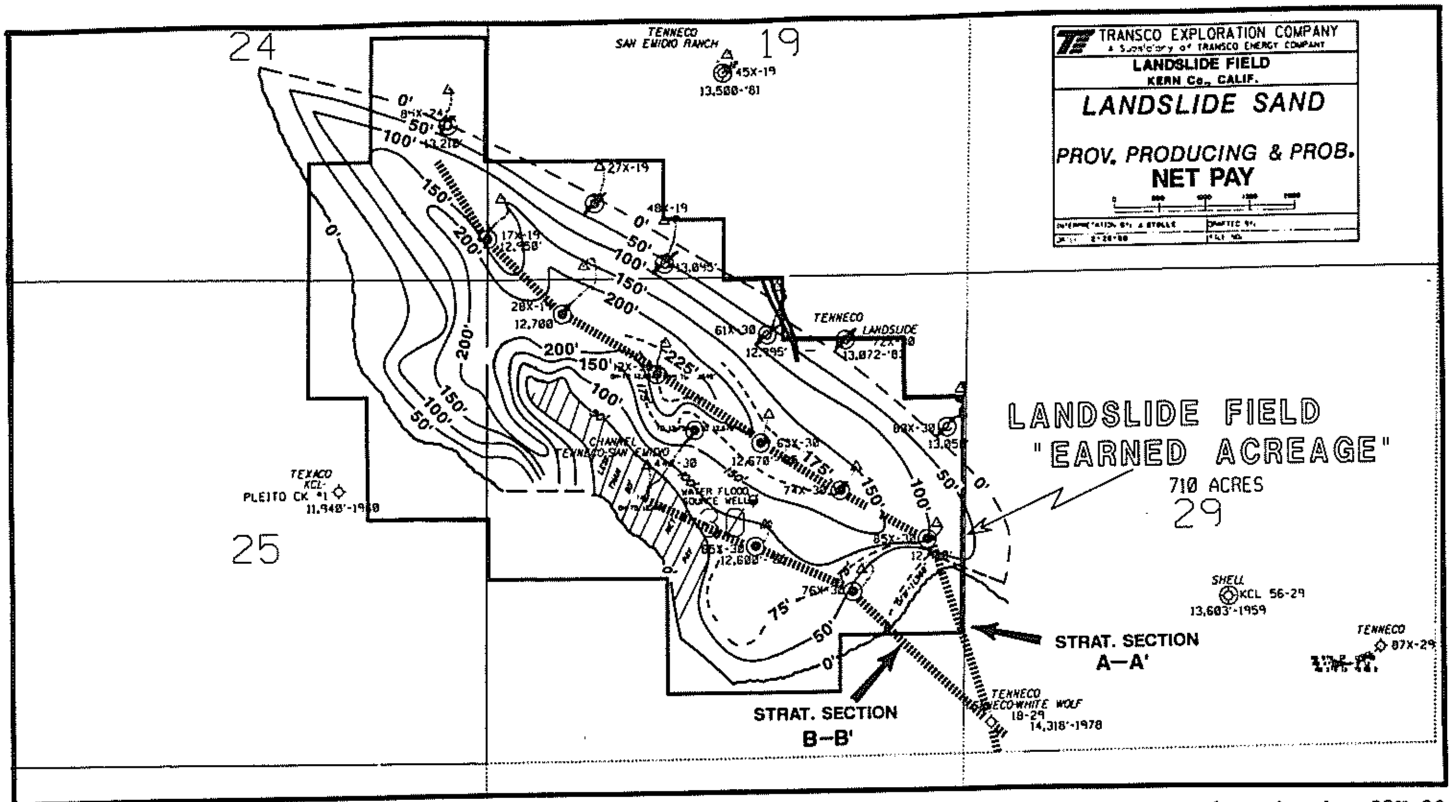
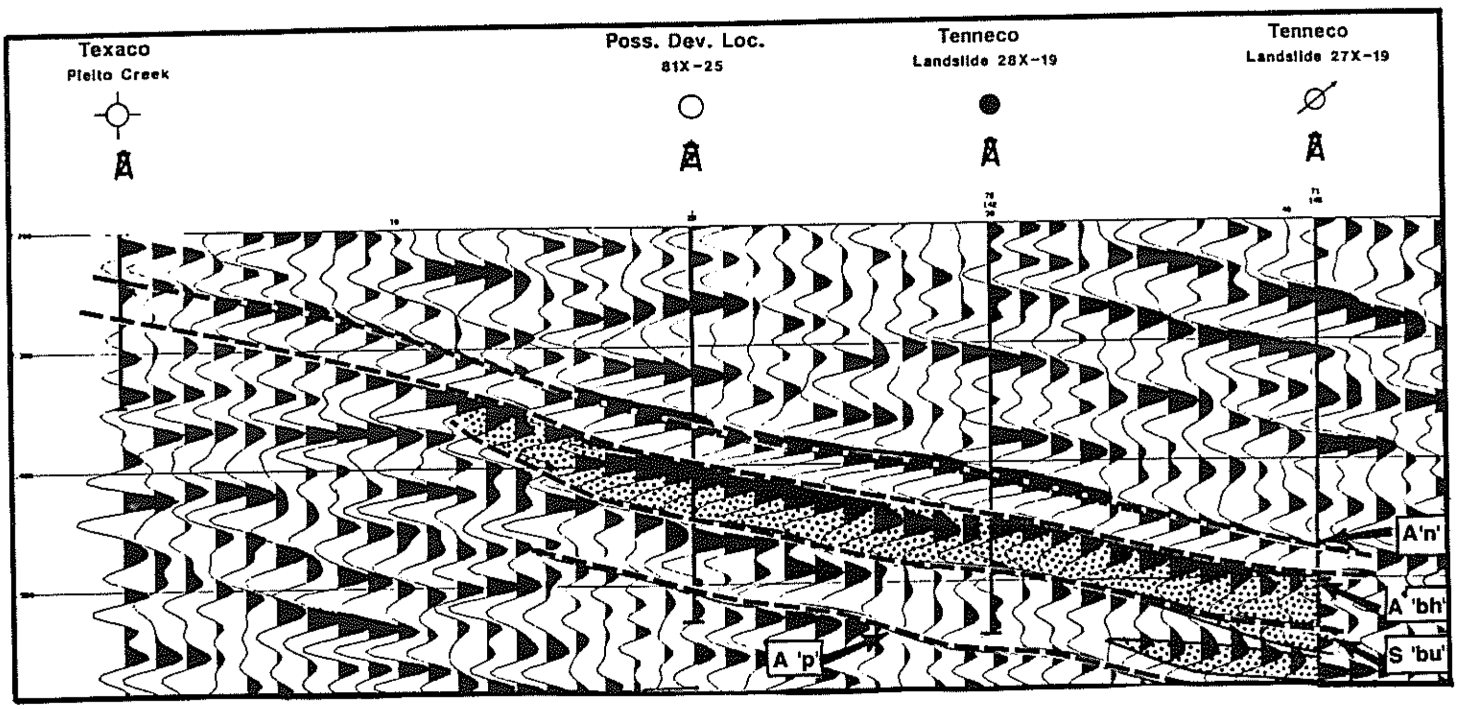


FIGURE 12 Isopach of total proven and probable net pay in the Landslide sands, excluding the 27X-18X sand

Figure 13 Reconstruction cut through the 28X-30 producer to the Texas Pleito Creek #1 showing an example of remaining updip locations.



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