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PRESIDENT'S MESSAGE

Well the year is moving quickly and as you read this, we're entering winter. Also moving quickly are the plans for the 1995 convention in San Francisco. Final plans are being made and lots of people are burning the midnight oil getting their abstracts into shape for submittal. Don't you be left out. Set aside a few days in early May and plan to attend. As an added incentive, everyone registering early will get a free copy of the "History of the PS–AAPG" volume added to their registration package. If any extra copies remain, they'll be given out on a first come, first served at the registration desk.

The PPG newsletter is increasing to a 5 issues per year schedule with publication planned for every 2 months and a hiatus in the summer. The more frequent publication will permit better and more timely news reporting (especially for local society activities). If finances continue to improve, we may go back to the 6 issues per year format sometime in the future. Newsletter editor Larry Knauer, PS–AAPG's renaissance man, continues his efforts to reduce the newsletter printing and mailing costs while also increasing advertising revenues. Another improvement we have to look forward to is the inclusion of a date on the mailing label indicating when your membership dues are expiring. This will help forgetful people like myself who are always unsure if they have mailed in their current years dues statement.

The PS–AAPG Executive Committee has a new committee member. We're pleased to welcome Jim Weddle as the new Finance Chair. Jim has previously served the PS–AAPG in a variety of positions including President back in 1983-84. His sage advice and business savvy are needed to help PS–AAPG through these difficult and changing times. Since change is a constant theme these days, it is not surprising that my phone number has changed. Starting November 1, I can be reached at [805] 633-4508 and my fax number is 633-4345. I'm still working for Chevron so my address remains the same. Please continue to call with your suggestions on how PS–AAPG can improve and be of greater value to you.

— *Robert Countryman*

DUES NOTICE

About one half of you have recently received post cards reminding you that your dues for 1994-95 have not been paid. Please take this opportunity to send them in now. A new AAPG/SEPM/SEG Pacific Section Directory will be published soon! If your dues are not paid at the time of publication, you will not be included in the new directory.

Placerita Oilfield - A Case Study of Steamflooding a Complexly Stratified Reservoir

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Background

Placerita field is located at the eastern edge of the Ventura basin in Los Angeles County, California approximately two miles from the town of Newhall. The field produces heavy oil (12° API) through cyclic steaming and steamflood injection support. Current oil production is approximately 3300 BOPD. In order to optimize steamflood recovery, ARCO has completed a detailed geological analysis and reservoir description of the main producing interval, the Pliocene lower Kraft zone. This discussion presents an overview of the field geology and addresses how completion and steam management strategies in the field were adjusted to fit the complex stratigraphy of the lower Kraft reservoir.

Geologic Summary of Field

Structure

A structure contour map on the top of the lower Kraft (Figure 1), shows a relatively simple structural configuration within the field. Placerita field is a gently folded homocline, striking northeast-southwest and dipping approximately 20° to the northwest. The field is bounded on two sides by faults.

The field is bounded on the north by the right-lateral San Gabriel fault, which trends N70°W in the area of the field. The north-dipping San Gabriel fault is actually a complex zone of faulting formed by multiple episodes of deformation. In the proximity of Placerita field, the most recent movement appears to be in a reverse sense. Several strands of the San Gabriel fault cut the Plio-Pleistocene upper Kraft and Saugus Formation in wells along the northern margin of the field.

The Whitney Canyon fault bounds the field on the east. This fault is interpreted as a west-dipping reverse fault. Throw along the fault ranges from approximately 150 feet in the south part of Placerita to only a few feet near its intersection with the San Gabriel Fault in the north. This fault possibly represents a leaky trap, as oil-stained cores and seeps have been noted east of the fault.

Pre-Pliocene rocks at Placerita are slightly more deformed than the Pliocene and Pleistocene section, a result of Miocene movement along the San Gabriel fault. The Placerita anticline, located in the southern part of the field (Figure 1), is a result of this deformation. This feature existed as a high during the Pliocene and consequently restricted lower Kraft deposition to the area north of the structure.

The west edge of the field is defined by a very irregular oil/water contact (Figure 1). The oil-water contact at Placerita differs by 600 feet in the space of 1 mile, from -350' in the south, to -940' in the north. This creates the situation that sands which are at equivalent structural levels may be productive in the north but wet in the south part of the field. Very few wells within the Placerita field penetrate the oil-water contact. The field is an edge-water drive, with a handful of wells in the southwest and northwest corners of the field drilled into the wedge zone.

Lower Kraft Stratigraphy - Impact on Steamflooding

The oil field has reservoir characteristics that are comparable to other fields in Kern County, California, such as Midway Sunset and Kern River, where steamflooding has been extremely successful. Thermal operations work by lowering the viscosity of oil to make it mobile. The viscosity of Placerita oil can be lowered from approximately 10,000cp at a temperature of 90°F to 13cp by steam heating the reservoir to a temperature of 300°F. Steamfloods in heavy oil reservoirs are often necessary to maximize ultimate recovery.

The original geological interpretation of the field described the lower Kraft as a single sand with a few interbedded shales, ideal for steamflooding due to good reservoir continuity. The current view after continued drilling is that these sands represent independent packages which may or may not be connected at some point in the field.

Lithofacies at Placerita fall into four classes. These include: 1) pebbly to cobbly very coarse-grained sandstone and medium to very coarse-grained sandstone; 2) fine-grained sandstone to argillaceous siltstone; 3) calcareous units; and 4) shale.

The most common lithofacies and best reservoir rock in the cores in terms of visible oil-staining is the medium-grained to pebbly sandstone. Excellent exposures of lower Kraft rocks crop out approximately 1 mile south of the field in roadcuts off Sierra Highway near the Tunnel area of Newhall field, and in old roadcuts and cliff exposures east of Highway 14 via the gated Remson Street underpass.

The Sierra Highway locality contains spectacular exposures of lower Kraft large-scale channel facies in roadcuts and cliffs hundreds of feet high. Notches in the roadcuts allow a three-dimensional view of these channels.

In the subsurface, we have subdivided the Lower Kraft reservoir into 4 main sand bodies each with separate subzones (Figure 2). These sands form linear to lobate features that are up to 150 feet thick separated from each other by discontinuous shale beds. The type log shows a very complicated lower Kraft reservoir, consisting of numerous amalgamated channels, sudden facies changes, and interbedded sand-shale sequences. Also shown on the type log is the onlap of these Pliocene sands against an Eocene paleohigh (Placerita anticline) located to the south.

Although intrafield correlations are difficult, they are solvable by integrating all available geological, engineering and production data. Understanding these geologic relationships is critical to the economic success of the steamflood.

Figures 3 and 4 are representative sand and shale isochore maps of portions of the Lower Kraft (see Figure 2). "Sand 2" appears to be a linear "channel-like" feature that trends across the field from the northeast, and bifurcates into discrete subchannels also oriented roughly northeast-southwest. It is evident that individual channelized sandstone bodies in the Lower Kraft are of limited lateral extent. The "Sand 2" channel is approximately 600 feet wide in the center of the field.

Stratigraphic cross section A-A' (Figure 5) shows a series of nested channel-like features, many with abrupt lateral terminations. In the beginning stages of the project, it was difficult to envision how this reservoir would be steamflooded. Fortunately, we have been able to capitalize on our understanding of reservoir geometry in portions of the field. For example, by injecting steam into sands bodies which pinchout updip, we have built-up effective steamchests in the reservoir and enhanced gravity drainage in downdip producing wells. Wells have been recompleted in unswept zones as our understanding of the reservoir continues to improve.

The "B shale" is a representative Placerita shale body stratigraphically in the middle of the lower Kraft. Comparison of the sand and shale isochores (Figures 3 and 4) shows that the shales are less continuous than the sands. These shales record interchannel levee and overbank fine-grained deposition, which were sometimes eroded by the next channel system. Temperature logs indicate that these shales form effective seals and baffles for confining steam. In a single 5 spot steamflood pattern, it is often necessary to complete surrounding injectors in different zones to achieve flooding of all perforated zones in corresponding producers. In some injection wells, dual zone injection is used to simultaneously heat multiple zones.

Depositional Environment

This style of deposition has been described by Lyons (1991), for nested channels and lobe facies of the Miocene Puente Formation in the Los Angeles basin, which he interpreted as forming at the shelf-edge and cut into the slope. The Lower Kraft member was deposited in middle to outer neritic water depths by rapid turbidite deposition. This interpretation is made collectively on the basis of fossil (mainly foraminiferal) data, lithology, regional geology, and stratigraphic position. Microfossils recovered from core and ditch samples from the lower Kraft zone are indicative of the "middle Pico" member of the Pico Formation of late Pliocene age (Dumont, 1990a, 1990b).

Foraminiferal checklists from Dumont were compared with published lists (Winterer and Durham, 1962) from the Pico Canyon area 7 miles to the west. The Pico Canyon section was chosen for comparison because of excellent and widely recognized exposures of "type" Pico deepwater sediments. The Pico Canyon section shows the traditional Pico faunal succession which indicates prograding up section from water depths of 2,000-3,000 feet in the lower part of the section, to a depth of 600-1,600 feet during deposition of the upper part. The shallowing-upward Pico records a regional regression in the Ventura Basin.

Although many of the forms collected at Pico Canyon by Winterer and Durham (1962) are also present at Placerita, there are significant differences. Specifically, foraminera from the lower Pico Canyon section are characteristic of water depths which are significantly deeper than the range of depths for forms at Placerita.

Lower Kraft sands at Placerita are approximately the same thickness as sands cropping out in Pico Canyon and penetrated in the Newhall Potrero subsurface. This is in contrast with the gross thickness of the Pico which decreases from nearly 5,000 feet thick in the Newhall-Potrero field (7 miles west of Placerita) to several hundred feet at Placerita. Almost all of the decrease in gross thickness of the Pico takes place in the upper part of the formation. Winterer and Durham (1962) were able to show this by tracing persistent units of conglomerate and sandstone eastward from the Newhall-Potrero oil field. They demonstrated that the contact between the Pico and the overlying beds of the Saugus occurs at lower and lower stratigraphic levels eastward beyond Pico Canyon. This implies that Pico sands at Placerita and those in Pico Canyon may be depositionally contiguous and time transgressive.

Physiographic Setting

Pulses of coarse clastic sediment into the basin resulted from ongoing tectonism. Periods of uplift along the basin margins probably coincided with continued subsidence in deeper parts of the basin. This subsidence resulted from sediment loading, as well as structural warping and faulting along the basin edges. As the sea withdrew from the basin edge, fan deltas prograded across the exposed shelf and sourced turbidite complexes at the distal toes of the deltas. Compressional folding and reverse faulting in the east Ventura basin had initiated during the Pliocene. (Yeats et al., 1994). Pulses of movement on several faults, in particular the San Gabriel Fault at Placerita, must have caused debris to be shed into the depocenter off topographic highs.

The Lower Kraft was likely deposited in a relatively proximal position, probably abutting a fan-delta staging area (Figure 6). This complex of nested channel-fill deposits may indicate deposition seaward of a narrow shelf in an embayment at the eastern margin of the basin. Lower Kraft channelized turbidites at Placerita may represent the transport fairways for correlative sand-rich turbidites and deep-marine submarine fan deposits that make up other major hydrocarbon reservoirs further west in the basin.

REFERENCES

Dumont, M.P., 1990a. Biostratigraphic Report for the ARCO Orwig #11-7, Sec. 31, T4N, R15W, Placerita Field, Los Angeles County, California. ARCO Oil & Gas Co., Geological Resources, Geoscience Operations, Plano, Texas. Report B90-146.

Dumont, M.P., 1990b. Biostratigraphic Report for the ARCO Kraft #6-19, Sec. 31, T4N, R15W, Placerita Field, Los Angeles County, California. ARCO Oil & Gas Co., Geological Resources, Geoscience Operations, Plano, Texas. Report B90-148.

Lyons, K.T., 1991, Sequence Stratigraphy of the Miocene Puente Formation, Chino Hills, California (unpub. M.S. thesis): Southern Methodist University, Dallas, Texas. 215 p.

May, J.A., 1982, Basin-margin sedimentation: Eocene La Jolla Group. San Diego County, California (unpub. Ph.D. dissert.): Rice University., Houston, Texas. 402 p.

Winterer, E.L., and Durham, D.L., 1962. Geology of Southeastern Ventura Basin, Los Angeles County, California, USGS Professional Paper 334-H.

Yeats, R.S., Huftile, G.J., and Stitt, L.T., 1994. Late Cenozoic Tectonics of the East Ventura Basin, Transverse Ranges, California: AAPG Bulletin, V. 78. p. 1040-1075.

PLACERITA LOWER KRAFT TYPE LOG

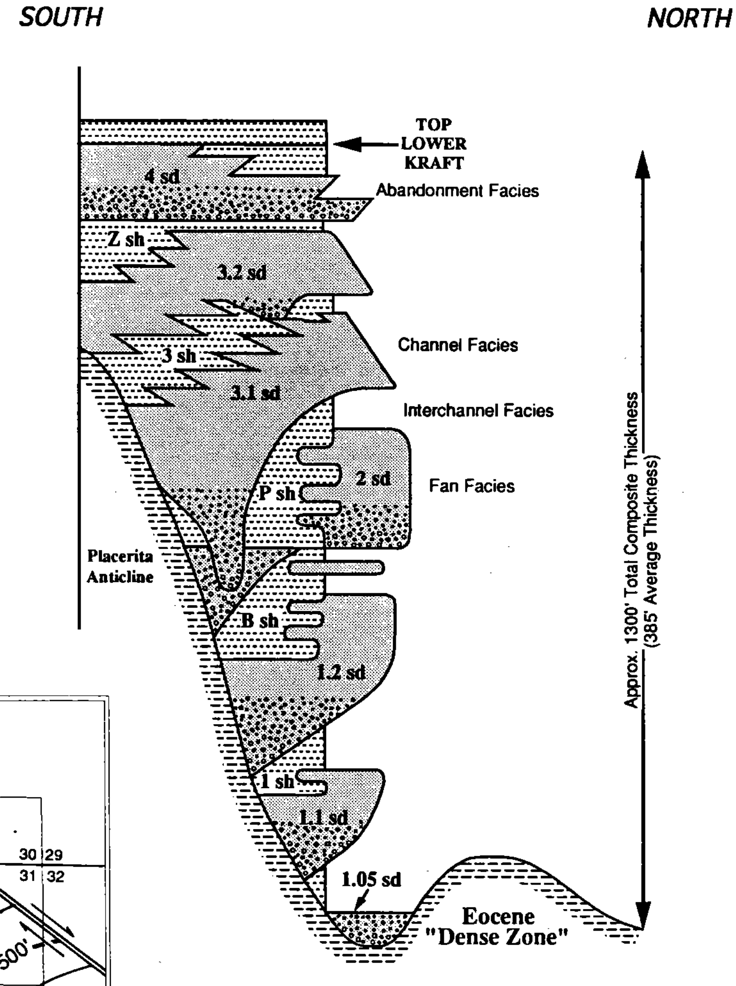
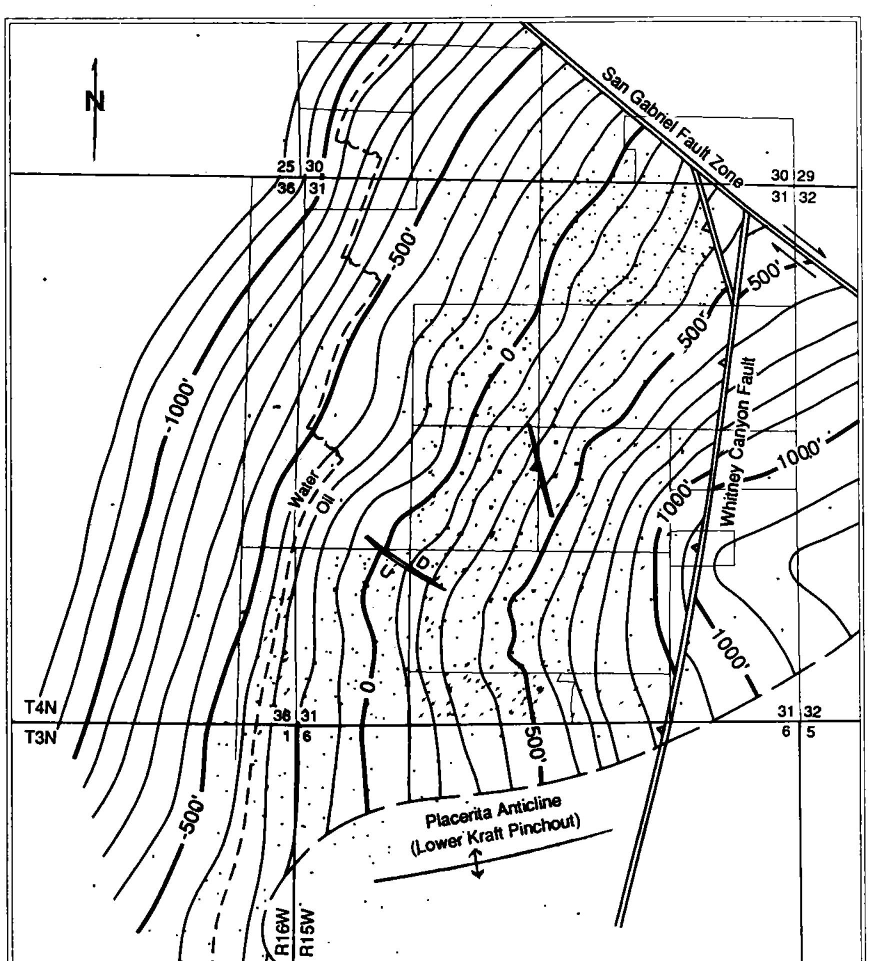


Figure 2: Lower Kraft Log



PLACERITA FIELD
TOP LOWER KRAFT STRUCTURE
C.I. - 100'
1000'

Figure 1

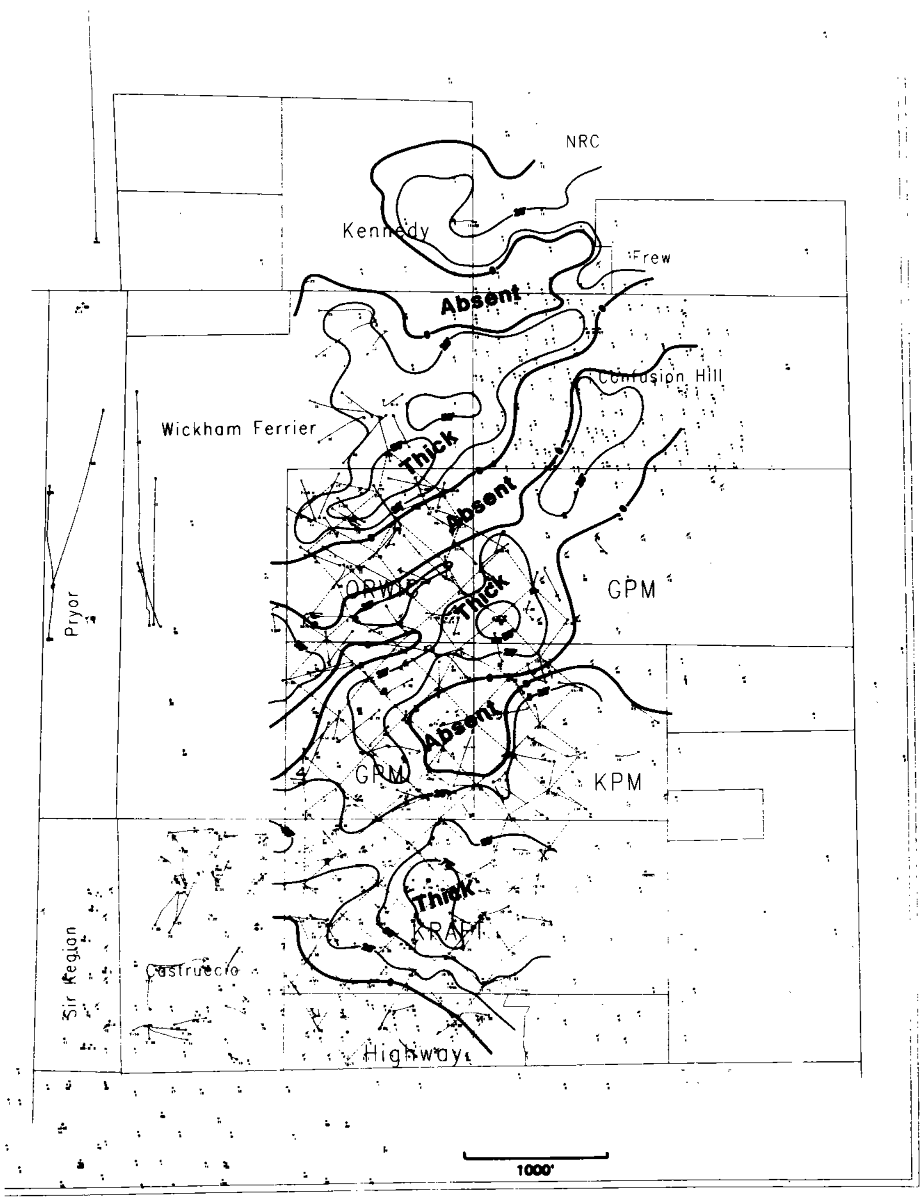


Figure 4: B shale isochore

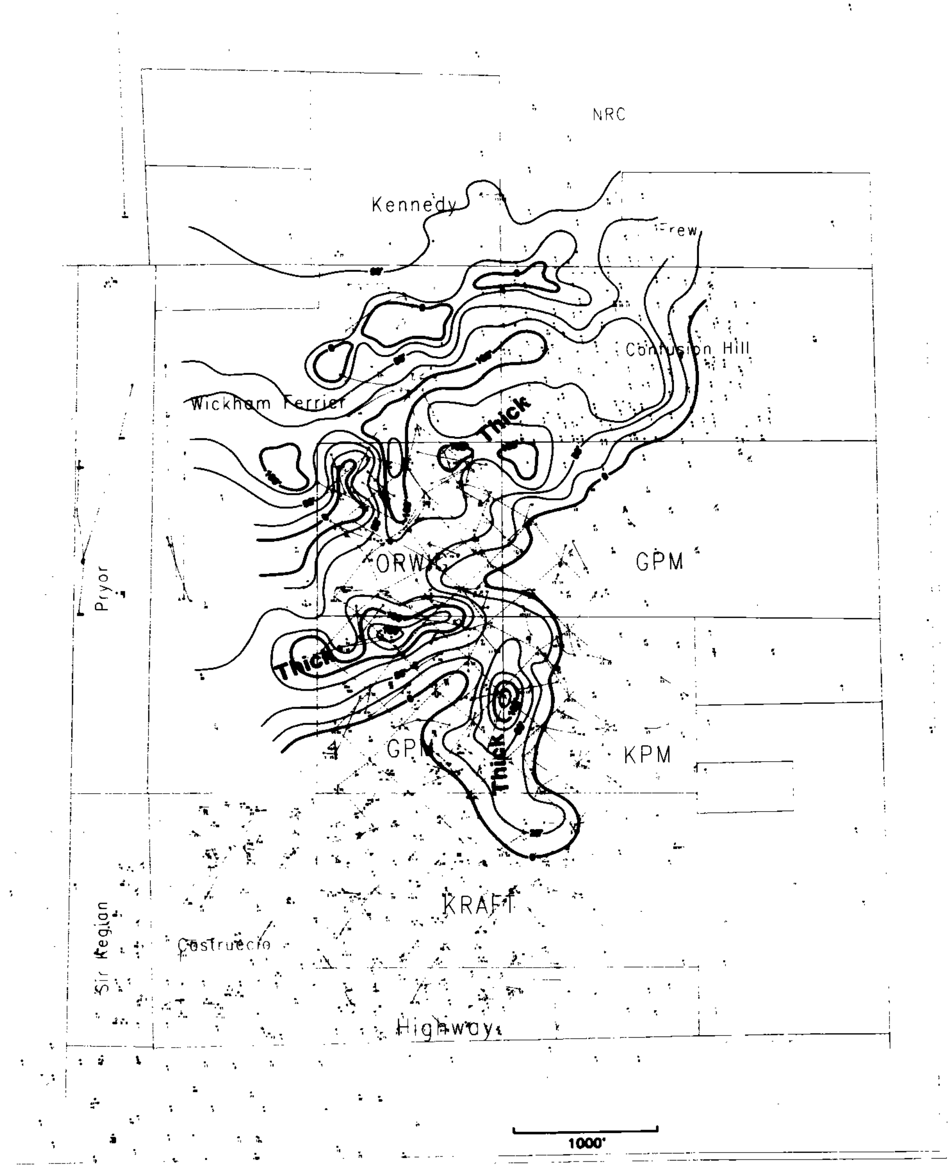


Figure 3: Sand 2 net sand isochore

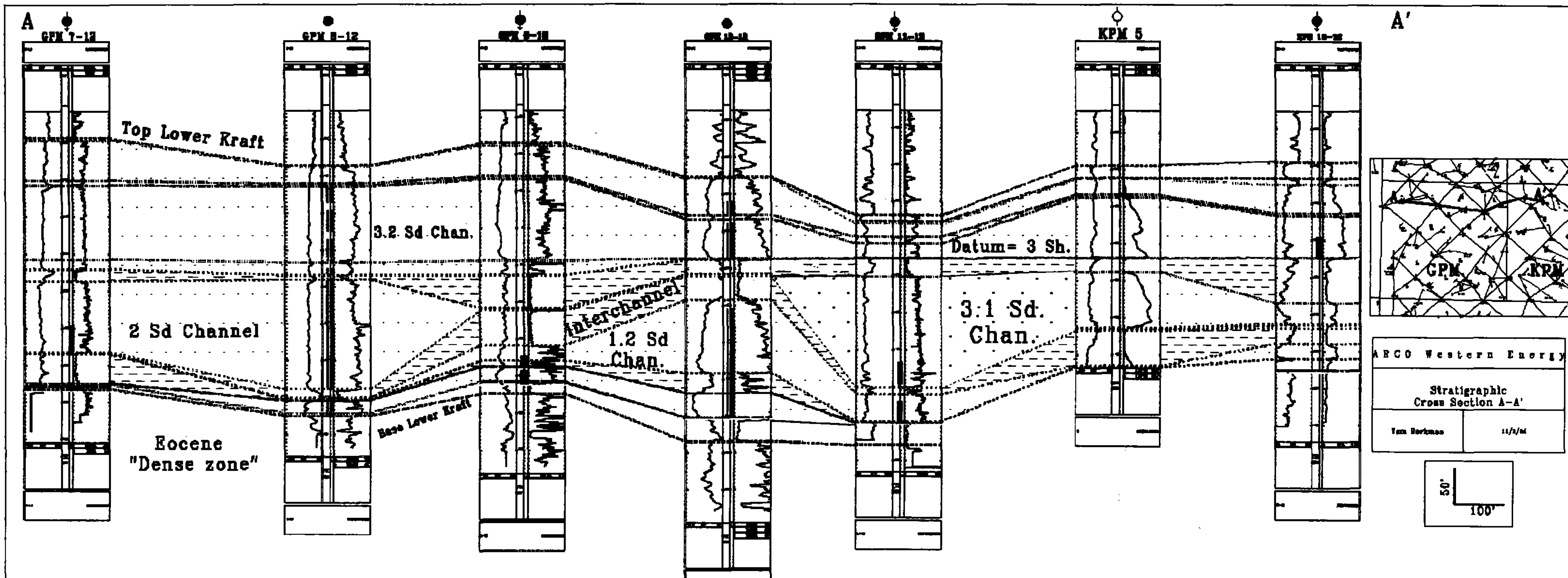
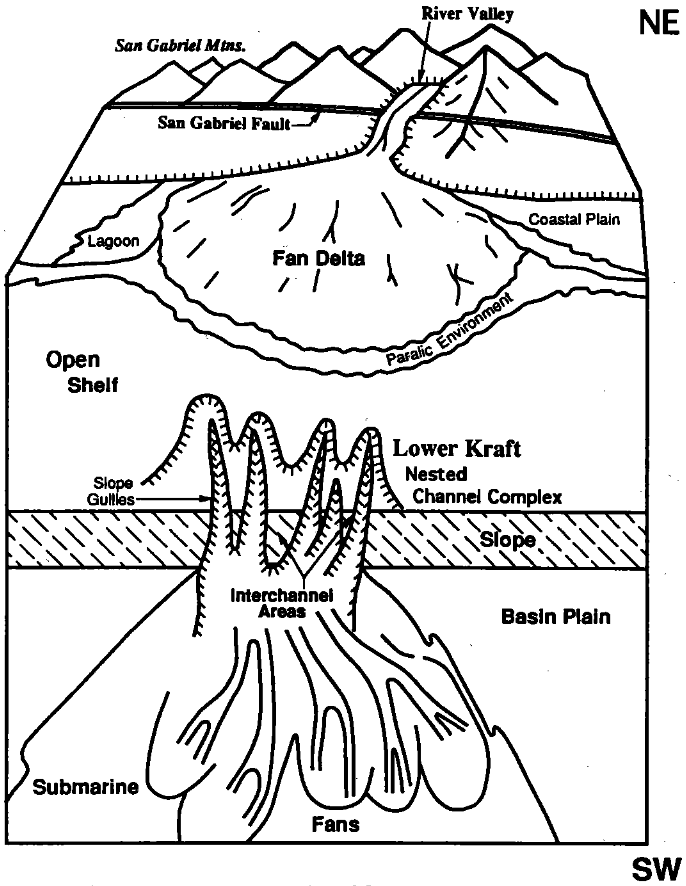


Figure 5: Stratigraphic Cross Section A-A'



Schematic Representation Of Lower Kraft Depositional Setting As Sea Gullies Incised Into Shelf Slope Break.

(No Scale Implied)
Modified From May, 1982

Figure 6