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BASAL MARINE TUSCALOOSA PETROLIFEROUS ZONE

The Basal Marine Tuscaloosa is presently believed capable of producing oil at rates ranging from 40 to 200 barrels per day at any location within a 1,000,000 acre area straddling the Miss.-East Louisiana state boundary. This area can be described as an elongated lens shaped area commencing west of Tylertown, Mississippi and extending westward past Woodville, Mississippi. It is estimated that the oil in place under this area ranges from 50-75 billion barrels. Successful recovery of a small fraction of these potential reserves would be of national consequence.

As early as 1962, sufficient data was available to suggest that the Marine Tuscaloosa might be capable of producing oil within this general area. However, no actual production testing was planned and attempted until late 1971, and then not again until 1974-75. These three wildcats were not conclusive, due to human error in the earlier wildcat, and unforeseen mechanical problems in the latter two wildcats. Data from these three wildcats, when collated with available older data, makes possible this detailed report and its recommendations as to production testing procedures.

It must be stressed that a massive hydraulic sand fracturing treatment (properly executed) will be necessary to induce the Basal Marine Tuscaloosa to produce at the abovementioned daily rates in any well drilled within this large area.

This report is based on all available subsurface data drawn from the well histories of over 400 scattered Lower Tuscaloosa test wells. The individual well data is often limited to at what depth at which the drilling mud became heavily oil cut, and the Induction Log. Fortunately, there is considerable log, mud log, diamond core, drillstem test, and limited production test data from more than 30 widely separated test wells drilled throughout most of the possibly productive area. Therefore, considerable quantitative data is available on which to base this report.

GEOLOGY

The Marine Tuscaloosa Formation was deposited throughout the Mississippi and North Louisiana Salt Basins, and is typically a barren shale, grey to black, usually fissile, and varying from 300' to 500' in thickness under most of Southern Mississippi. However, in this particular area, the Basal Marine Tuscaloosa is entirely oil saturated and the lithology is considerably different from the typical "Marine Shale". This rock may be described as: grey to black, slightly to considerably calcareous shale with a primary porosity range of 6%-10% and permeability of less than 0.2 millidarcies. In addition, this shale is almost always interspersed with thin to wafer-thin siltstones, marly shales, and sometimes dolomitic marly shales. These variegated stringer zones are usually elaborately cross-bedded with fracture planes and planes of weakness. Diamond cores have good live oil shows in the fractures and most bedding planes. Frequency of these shows varies directly with the number of fracture planes, planes of weakness, and bedding planes in each length of core. The diamond core data from 5 widely separated wildcats was carefully correlated with the Induction logs and an accurate relationship between resistivity and saturated shale and barren shale was established. Even more important, it was noted that within the petroliferous interval itself, there seems to be a clear relationship between a certain resistivity range and the greatest incidence of cross bedding (with its numerous fracture planes and planes of weakness). Then, all the available Induction Logs were used to construct an isopach of this saturated Basal Marine Tuscaloosa Zone. Using the Justiss-Mears #1 Thompson (33-T1N-R7E) as a reference point, the saturated zone is over 200 feet thick and thinning slowly in a Northerly, Easterly, and Southerly direction, but consistently thick in a westerly direction. In this well, and within this interval, the cross-bedded fracture zone is approximately 80 feet thick (from diamond cores). This cross-bedded zone does vary somewhat in thickness, being thickest at the abovementioned location. This entire petroliferous shaley interval is overlain, and also gradually replaced laterally, by the barren Marine Tuscaloosa Shale common to the region.

Detailed subsurface studies provide an explanation for the lithology and saturation of this lens shaped deposit. It was clearly caused by an elongated topographic ridge which constituted at least a partial sill in this region during early Marine Tuscaloosa Time. These studies also show that pronounced compressive stresses occurred locallyduring Sparta-Cook Mountain and Cockfield time when there was 6000'-7000' of overburden on the Marine Tuscaloosa. These compressive folds had an E-W strike which coincided to that of the Basal Marine Tuscaloosa petroliferous interval, and could be expected to induce extensive fracturing in the variegated brittle, saturated interval.

Analysis of diamond cores recovered during 1971 and 1975 affords critical data:

A. The saturated country rock has extremely low permeability, and this is due to grain size and matrix material. Essentially the oil is contained in a sort of microporosity as well as macroporosity. This means that when subjected to severe hydraulic differentials (Drawdowns) the rock almost stops giving up any oil at all. Also, fresh water mud filtrate will tend to impair permeability in the immediate vicinity of the borehole. Any fluid used in mechanical fracture treatments should be KCl water and/or gelled crude oil.

B. The oil in place is calculated at approximatley 500 barrels per acre foot in the country rock, and recoverable oil (primary) is estimated at 30-50 barrels per acre foot (SUN LAB).

C. The porosity in the thin siltstones, marly shales, and dolomitic marls ranges from 3%-12%, and the permeability varies between 0.1 - 2.0 millidarcies. It is considered too difficult to estimate oil in place or recoverable oil in these stringers. Their reserves are simply included in the abovementioned country rock reserve estimates.

D. Obviously, there is secondary porosity and permeability in the natural fracture planes and planes of weakness. Incidence of these planes will vary from well to well and it seems impossible to attempt to measure secondary porosity and permeability from diamond cores. Estimated recoverable oil reserves from this secondary porosity vary from 10-30 barrels per acre foot, varying with the incidence of cross-bedding.

E. The reservoir temperature is approximately 275° Fahrenheit. Laboratory retorting of the saturated country rock recovered most of the oil when the cores were subjected to 160°-300° F. temperature range. Saturations of cores from wells employing water base mud were slightly lower than cores from a well employing oil based drilling fluid.

F. Therefore, it is certain that the country rock can and will feed the natural fractures plus the much more extensive induced mechanical fractures (sand-propped).

Although it is believed that at least one well in Gillsburg Field, plus another in McComb Field, have produced considerable volumes of oil from the Basal Marine Tuscaloosa, their data is not featured in this study. This is because rates and volumes could not be measured due to the fact that Lower Tuscaloosa perforations were also contributing to the production. Both wells had suspected channels in their cement up into the Basal Marine Tuscaloosa, and were treated with massive acid and/or fracture treatments. Their production rates were remarkably better after stimulation than the Lower Tuscaloosa's past production, sand development, or stage of depletion would seem to justify. Also, several other Lower Tuscaloosa wells were subjected to fracture treatments (in Pike and Amite Counties) with no significant increase in production. These wells had one noteworthy common characteristic - good apparent cement bonding above and below the Lower Tuscaloosa perforations or, if not, remedial block squeeze operations were performed prior to treatments. The Gillsburg well was junked and plugged during 1971 due to collapsed casing. The McComb well is presently producing 60 barrels of oil plus 150 barrels of water per day, although all four offset wells were watered out prior to 1973.

LIMITED PRODUCTION TESTING

The three production tests drilled during 1971, 1974, and 1975, did not conclusively evaluate the Basal Marine Tuscaloosa. All three wildcats did establish that this zone can flow 36°-38° oil at rates of 2-4 barrels per day (natural flow). Not one of the three had an executed massive sand fracture treatment. A brief history of the three wildcats is very instructive:

Sun #1 Spinks (7-T2N-R7E, Pike County, Mississippi)
October, 1971-February, 1972. This well was cored 40 feet into the Lower Tuscaloosa (T.D. 11,069'). DAP mud was used and 5½" casing was run to total depth and cemented, using high pressure (turbulent flow) technique. The 300 foot continuous diamond coring program provides the most comprehensive Marine Tuscaloosa core data available at any single location. Further details :

1. Three sets of perforations were made:
   11,011-11,029 (Basal Marine Tuscaloosa)
   11,038-11,040 (Lower Tuscaloosa)
   11,042-11,044 (Lower Tuscaloosa)
   Top of Lower Tuscaloosa is 11,030 feet.

2. Pumped in @2850# and then broke down @ 5600# and treated with 30,000 gallons of gelled diesel oil plus 30,000# of 20-40 mesh sand plus 3,000# of walnut shells with maximum pressure of 6200# and average 5800#. Pumping rates range from 11-14 barrels per minute.

3. After cleaning up, the well pumped at rates of 1-2 barrels per day

(pump setting was 10,000 feet). When rods and pump were pulled, and tubing and casing filled, the well would flow 2-3 barrels per day.

4. During February, 1972 a wireline bridge plug was set at 11,035', closing off the Lower Tuscaloosa perforations. Then, it required 5200# to pump into the 11,011-29' Marine Tuscaloosa perforations. Rate was 1-2 barrels per minute (with packer at 10,500').

5. Well was pumped intermittently (10,000' setting) with packer set at 10,500' during March-April, 1972 averaging 1-2 barrels per day. During April, rods and pump were pulled and well was shut in. During late May, it was opened up and it flowed at average rate of 3 barrels per day for several weeks.

6. Well was shut in during August and pulled and plugged during Sept. 1972. Bottom hole pressure was calculated to be 6100#, using shut in tubing pressure. No water was ever used or produced during these tests (therefore the tubing was assumed to be full of oil).

Conclusions: The writer is convinced that the modest sand fracture treatment went entirely into the Lower Tuscaloosa perforations. Result is that we learned, for the first time, that the Basal Marine Tuscaloosa could flow 3 barrels per day (38^{o}) without stimulation.

In all fairness, it must be stated that the old Sun Oil Company management had planned to perforate only in the Basal Marine Tuscaloosa. The new management team which replaced the old team, just prior to the diamond coring operations, altered the "game plan". It was also their decision to give up, without fraccing the 11,011-29' perforations. The responsibility for failure to conclusively evaluate rests entirely with them.

Callon #1 Cutrer (37-T1S-R7E, Tangipahoa Parish, Louisiana)
October, 1974-March, 1976. This well was drilled to 11,222' and 7" casing was run and cemented in barren shale. Using gelled salt water as drilling fluid, petroliferous shale was cut between 11,500' (by mud log) and 11,635' (T.D.). An uncemented 5" liner was run to 11,600'. No fracture treatment was attempted due to a loss circulation zone at 11,300'-350' and junk in the open hole. The well flowed at an average rate of 2 barrels per day for almost a year. It was observed on several occasions that when fluid level was swabbed below 6,500', the rate of entry was drastically reduced.

Callon #2 Cutrer (37-T1S-R7E, Tangipahoa Parish, La.)
March, 1975-March, 1976. This well was drilled to 11,544 feet and 5½" casing was run and cemented. This casing was landed in the very top of the petroliferous Basal Marine Tuscaloosa (mud log). Using gelled oil as drilling fluid, continuous diamond cores were cut 11,550'-11,670' (T.D.). An uncemented 4" liner was run to T.D. and perforated 11,584'-644' with 1 jet per 2 feet and the following operations performed:

1. Untreated perforations flowed 37^{o} oil at rate of 2-3 barrels per day during late April and early May.
2. Bottom hole shut in pressure was measured to be 6200#.
3. When swabbed below 6500', entry would almost cease.
4. A fracture treatment was attempted in May, 1975, but had to be suspended because well head equipment and tubing were inadequate. The pump-in pressure was 5200# and breakdown could not be achieved at 7800# pump pressure.

5. During July, 1975 another fracture treatment was attempted but had to be aborted due to the mechanical failures of Halliburton equipment. This resulted in a screen-out which burst the tubing at 10,925-30'. This treatment was attempted with the packer at 11,414' inside the 5½" casing. The fluid was gelled crude oil and 70,000# of 20-40 mesh sand was actually displaced. Breakdown pressure was 12,500# @ 14 barrels per minute. The pumping rates (with sand) were 10-13 barrels per minute with pressure range of 10,500# to 14,500#. Two things should be noted:
   a. Halliburton's static test was only 13,500# prior to commencing.
   b. Just prior to the screen-out, Halliburton had to shut down twice due to equipment failure. After the second shut-down a pumping rate of 10 barrels per minute was laboriously achieved. Then, very suddenly, tubing pressure rose past 15,500# and casing pressure in-increased from 6000# to 8000#. After cleaning up, the well settled into an average flow rate of 3-5 barrels per day (Oct.1975-March 1976). The tubing has not been pulled, nor has any remedial work been attempted. Wire line survey established the depth of the tubing rupture and that the perforations down to 11,600' were clear.

CONCLUSIONS

1. It is believed that the formation is not blocked due to the uncemented liner being only partially filled by the 20-40 mesh sand.

2. The after-treatment flow rate is much the same as the natural flow rate measured in April and May, 1975 and similar to the two other wildcats.

3. Based on the abovementioned factors, it seems almost certain that an effective mechanical fracture was never achieved or, if one was, it is not presently connected to the well bore due to the sequence of two sudden shut-downs, followed by the abrupt screen-out.

It is regrettable that the three abovementioned wildcats failed to achieve a definite evaluation of the true productive capability of this huge oil reservoir. Using the Justin-Mears #1 Thompson (33-T1N-R7E, Pike County, Miss.) and its Induction Log as a reference, a simpler (and less expensive) drilling and testing plan is submitted:

A. Drill a 7 7/8-8 1/4 inch hole to a point approximately 30' into the Lower Tuscaloosa (11,730'T.D.). A regular drilling mud (less than 6 cc water loss) can be used. Addition of DAP (Di-ammonium Phosphate) is recommended in order to minimize hole enlargement in the Marine Tuscaloosa shales between 11,200' and 11,500'.

B. Run and cement 5½" (N-80 grade) casing at T.D., using less than 500 sacks of cement engineered to sustain high stresses. High pump pressures that might induce turbulent flow should be avoided.

C. Check bonding in the 11,300'-11,730' interval and if there is doubt as to bonding in the 11,500-570' interval, perform a precautionary squeeze (staged) in that interval in order to isolate the 11,570'-11,685' interval.

D. Perforate at selected intervals within the 11,615'-85' interval. Halliburton or Dowell engineers should be consulted on the number and placement of the specific perforations.

E. Clear Perforations using acid and ball sealers. Employ pressures up to 6500# if necessary. If possible, KCl water should be used.

F. Well head equipment should be capable of sustaining 20,000# and tubing should be tested to at least 10,000#.

G. The service company must be required to static test its equipment to 16,000# before commencement of the fracturing treatment. This is due to the expectancy that the breakdown pressure and treating pressures will be within the 10,000-15,000# pressure range.

H. At least 150,000# and perhaps as much as 200,000# of sand should be displaced and in a continuous pumping operation, once sand is going into the formation.

In view of "lessons learned", the writer believes that the above described plan has a far better prospectof being fully and conclusively executed than the essentially experimental earlier plans.

All interested parties should keep in mind the staggering potential of this Basal Marine Tuscaloosa saturated reservoir. For perspective:

1. It underlies in excess of one million acres.
2. Its thickness of saturated country rock averages 125 feet.
3. This computes to 125 million acre feet and, using 500 barrels per acre foot of oil in place, this computes to over 60 billion barrels of oil in place (or over 60,000 barrels per acre).

4. It is estimated that a fully equipped development well would cost between $450,000-$500,000 (including fracture treatment).

5. If 160 acre spacing is employed, recovery of 1,000 barrels per acre @ $11 per barrel would constitute favorable economics.

6. This 1,000 barrel per acre recovery computes to 1.6% of the calculated oil in place. The writer believes and hopes that at least 5% of the oil in place can be recovered by present and available technology.

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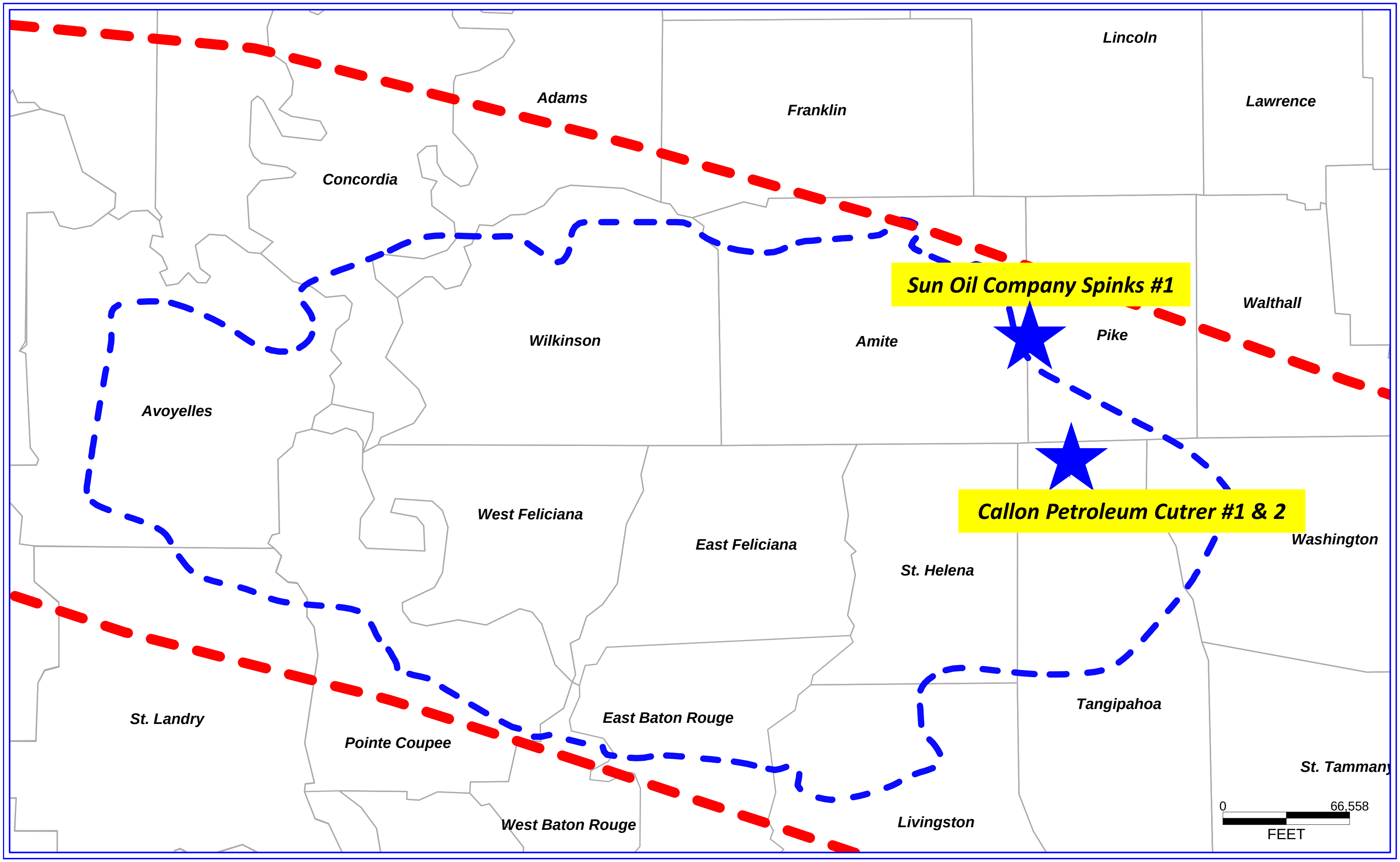

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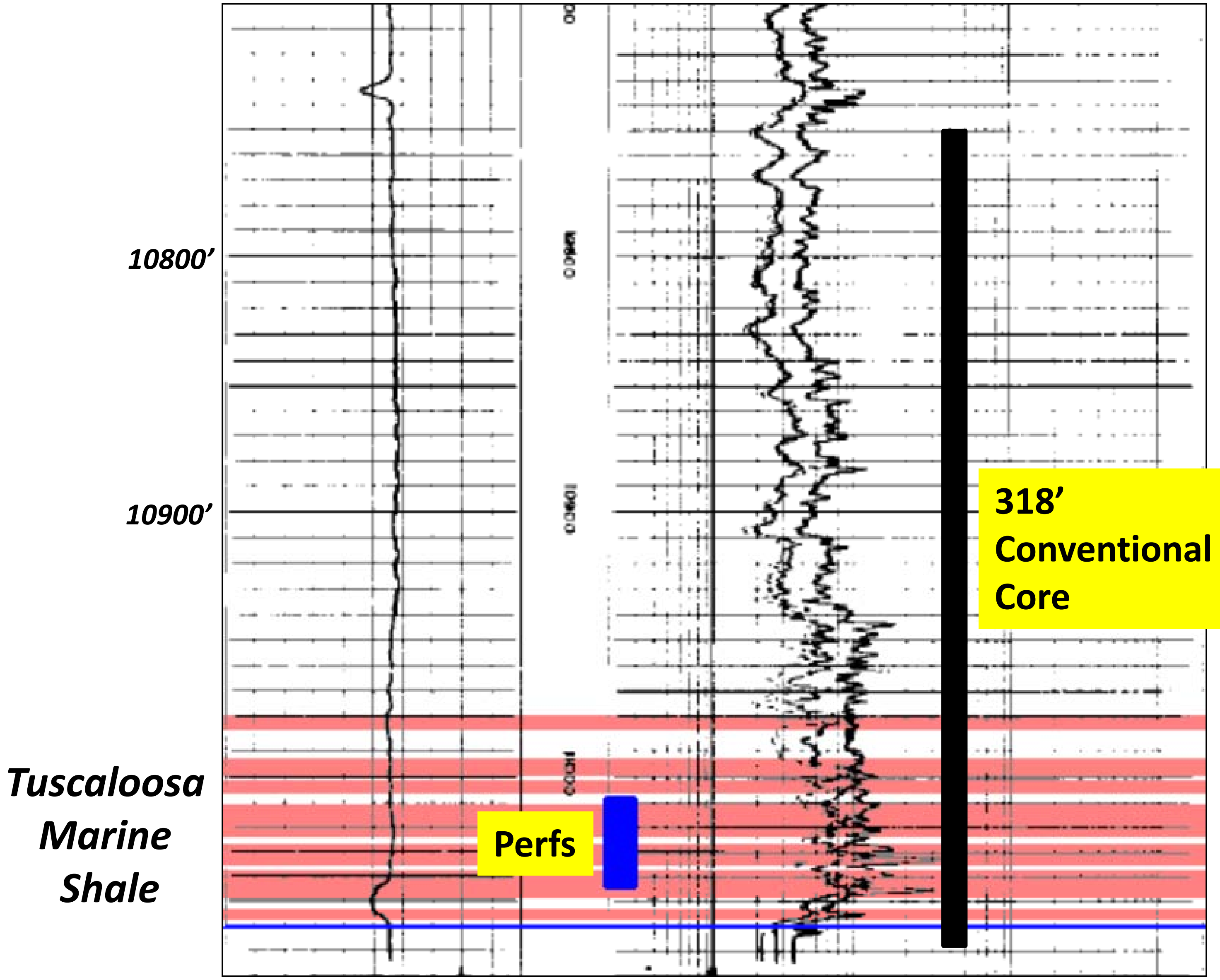
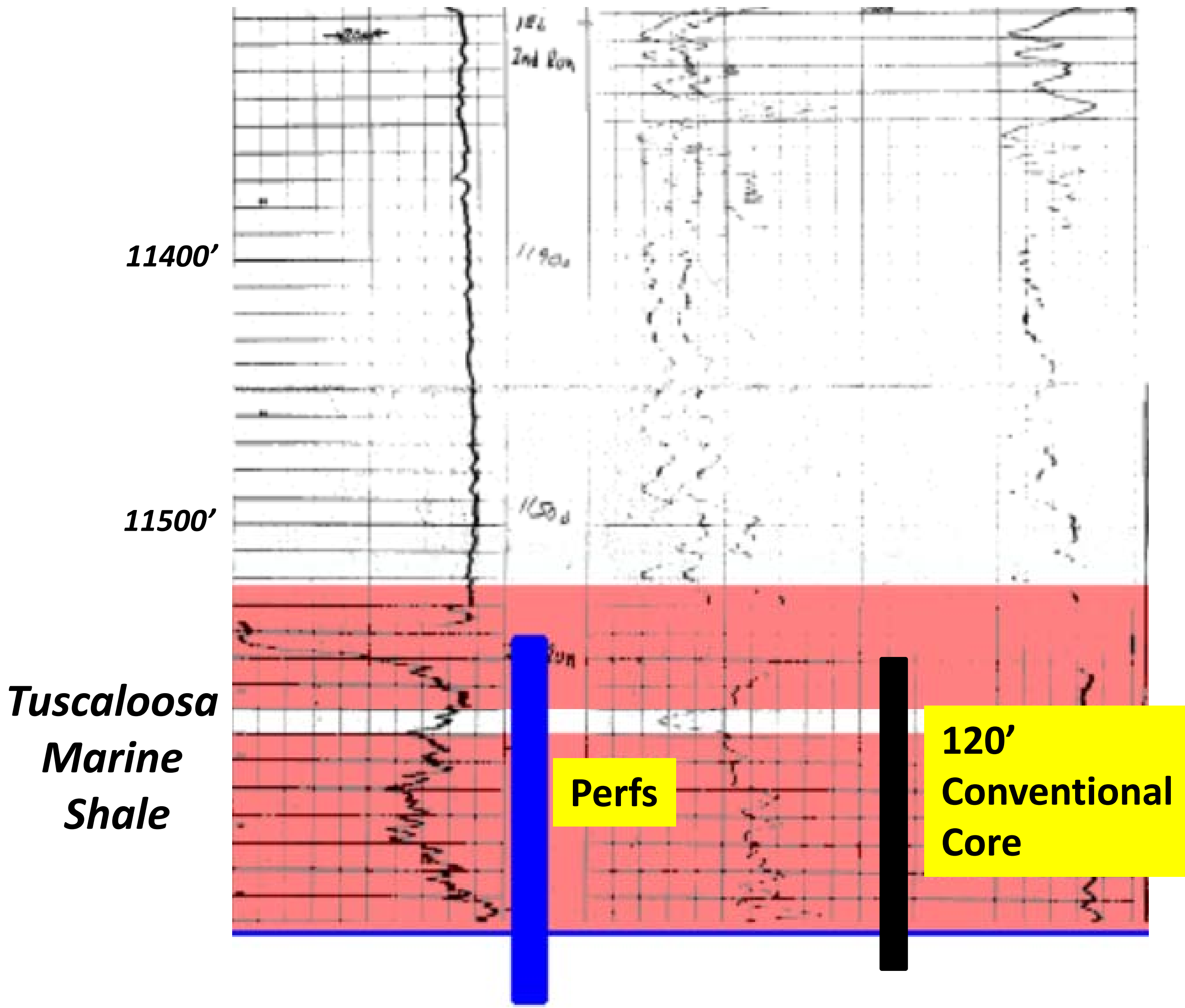
Sun Oil Company Spinks #1
Pike County, MS 7-2n-7e



Callon Petroleum Cutrer #2
Tangipahoa Parish, LA   55-1s-7e



Al Moore at the Callon Cutrer #2 (1975)

Clint Moore at the the Callon Cutrer #1 (1975)

Clint Moore at the the Callon Cutrer #2 (1975)