TECHNICAL PROGRESS REPORT

DOE/BC/14959--20

Title:

REVITALIZING A MATURE OIL PLAY: STRATEGIES FOR FINDING AND PRODUCING UNRECOVERED OIL IN FRIO FLUVIAL-DELTAIC RESERVOIRS OF SOUTH TEXAS

Cooperative Agreement No.:   DE-FC22-93BC14959

Institution: Bureau of Economic Geology
The University of Texas at Austin
University Station, Box X
Austin, Texas 78713-8924

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Technical Project Officer: Chandra Nautiyal

Reporting Period: April 1, 1996 – June 30, 1996

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OBJECTIVES

Advanced reservoir characterization techniques have been applied to selected reservoirs in the Frio Fluvial-Deltaic Sandstone (Vicksburg Fault Zone) trend of South Texas (Fig. 1) in order to maximize the economic producibility of resources in this mature oil play. More than half of the reservoirs in this depositionally complex play have already been abandoned, and large volumes of oil may remain unproduced unless advanced characterization techniques are applied to define untapped, incompletely drained, and new pool reservoirs as suitable targets for near-term recovery methods. This project has developed interwell-scale geological facies models and has assessed engineering attributes of Frio fluvial-deltaic reservoirs in selected fields in order to characterize reservoir architecture, flow unit boundaries, and the controls that these characteristics exert on the location and volume of unrecovered mobile and residual oil. Results of these studies led to the identification of specific opportunities to exploit these heterogeneous reservoirs for incremental recovery by recompletion and strategic infill drilling.

Project objectives are divided into three major phases. Phase I, reservoir selection and initial framework characterization, consisted of the initial tasks of (1) screening fields within the play to select representative reservoirs that have a large remaining oil resource and are in danger of premature abandonment and (2) performing initial characterization studies on selected reservoirs to identify the potential in untapped, incompletely drained, and new pool reservoirs. Phase II involved advanced characterization of selected reservoirs to delineate the incremental resource. Subtasks here included volumetric assessments of untapped and incompletely drained oil, along with an analysis of specific targets for recompletion and strategic infill drilling. The third (III) and final phase of the project consists of a series of tasks associated with documentation of Phase II results, technology transfer, and the extrapolation of specific results from reservoirs in this study to other heterogeneous fluvial-deltaic reservoirs within and beyond the Frio play in South Texas.

Goals of the Industrial Associates program (the source of industry cofunding to this project) are to (1) develop an understanding of sandstone architecture and permeability structure in a spectrum of fluvial-deltaic reservoirs deposited in high- to low-accommodation settings and (2) translate this understanding into improved, geologically constrained reservoir models to maximize recovery of hydrocarbons.

SUMMARY OF TECHNICAL PROGRESS

Project work during the second quarter of 1996 consisted of Phase III tasks related to the transfer of technologies to industry. The two primary vehicles for transferring technologies evaluated in the Frio Fluvial-Deltaic Sandstone play (Vicksburg Fault Zone) are a series of short courses and a microcomputer-based geologic advisor software program. During the second quarter, the last of the two short courses was given and a quantitative methodology for prioritizing reservoirs in terms of their reserve-growth potential was incorporated into the software program. In addition, an article that underscored the importance of integrated multidisciplinary reservoir characterization was prepared for the DOE publication *The Class Act*. Finally, a draft of the final report for the project has been prepared and submitted for review.

Short Courses

Short courses and workshops provide an opportunity to meet and train operators who are interested in applying integrated characterization methods to their reservoirs. This forum assists in the transfer of detailed information and allows extensive question and answer sessions. This ensures a deeper understanding of the steps required in identifying remaining resources and increases the confidence of operators in applying these steps, thereby improving the likelihood of increasing near-term production. Original project goals included two short courses. The first was held in San Antonio, Texas, during April 1996, and the second on June 6, 1996, in Houston.

The short courses were held to present (1) an overview of Frio play characteristics, (2) details of the integrated multidisciplinary reservoir characterization methodology, (3) examples of methodology application within the Frio play, (4) strategies for identifying reservoirs that are prospective for detailed characterization studies, and (5) an overview of the Reservoir Characterization Advisor—Fluvial-Deltaic (RCA—FD) software. In addition, core material from Frio fluvial-deltaic reservoirs in Rincon field was available for viewing and discussion and the RCA—FD was demonstrated during breaks.

The second short course was held during this quarter, on June 6, in Houston at the Exxon Auditorium, and was hosted by the Houston Geological Society. The minimal cost of $50 (at-the-door and nonmember fees were higher) included a complete course notebook. Paid attendance was 75. Responses to a questionnaire passed out at the end of the meeting provided substantial encouragement that many operators intended to apply the methodology in mature Gulf Coast reservoirs. Nearly all of the questionnaire respondents were geologists, engineers, or geophysicists working for independent oil companies or consulting firms, with responsibilities for reservoirs on the Texas Gulf Coast. Evaluations of course content were overwhelmingly positive, with some opposing opinions regarding the ratio of time spent on methodology versus examples. The presentation of how to do 3-D geocellular modeling received all positive comments, as did the overall reservoir characterization methodology.

Reservoir Prioritization

The RCA–FD illustrates the integrated reservoir characterization process for operators and provides guidance in revitalizing mature fields. One portion of this software, Quicklook, provides an operator the ability to quantitatively rank reservoirs in terms of their reserve growth potential so that they can focus characterization efforts first on those reservoirs most likely to yield incremental oil.

Quicklook Evaluation Factors

On the basis of experience gained during this investigation, six factors are used to help determine the potential for reserve growth from untapped and incompletely drained compartments in mature reservoirs. Four of these factors, (1) relative reservoir size, (2) past completion density, (3) reservoir heterogeneity, and (4) hydrocarbon mobility, address the likelihood that unrecovered hydrocarbons exist in the reservoir. The two remaining factors, (5) reservoir depth and (6) operator gas/oil preference, provide indications of economic efficiency and practical company strategy.

Larger **relative reservoir size** indicates a greater potential for unrecovered oil because if two reservoirs with equal past recovery efficiency (percentage) are evaluated, the larger reservoir will contain a greater volume of oil still remaining. For example, although two reservoirs have similar characteristics, one contained 10 MMbbl and one contained 1 MMbbl of mobile oil originally. If 30 percent of the oil is

recovered from each reservoir, the larger reservoir will still contain 7 MMbbl of mobile oil to be recovered by recompletions and infill drilling, whereas the smaller reservoir contains only 0.7 MMbbl. It is more likely that the cost of the reservoir characterization study will be recouped in the course of increased production from the larger reservoir, and the risk of the smaller reservoir not paying out will be higher. Relative reservoir size can be evaluated from volumetric data (for example, OOIP), if available, or can be estimated by comparing cumulative production for the reservoirs being ranked. The latter approach assumes the reservoirs have had similarly thorough development and are at a similar stage of maturity.

If **past completion density** in a reservoir is low (well spacing is large), its potential for reserve growth may be high because there is a greater chance that untapped reservoir compartments exist between well penetrations (Fig. 2). In addition, heterogeneity within compartments may limit the size of the effective drainage area, leaving substantial portions of compartments incompletely drained. The greater the past completion density (closer well spacing), the less chance there is that substantial areas of the reservoir remain undrained, given that other variables remain unchanged.

The higher the **reservoir heterogeneity**, the greater the chance that areas exist in the reservoir that are not in good communication with current well penetrations. Reservoir heterogeneity is a function of (1) structural complexity, which creates fault-bounded compartments, (2) stratigraphic architecture complexity, which results in many small stratigraphically isolated compartments (for example, channel belts), and (3) intercompartment heterogeneity, in which lithologic contrasts within an architectural unit inhibit fluid flow through a compartment (for example, low-permeability channel-on-channel contacts). Structural heterogeneity can be qualitatively deduced from existing structure maps, general structural setting, or seismic sections or volumes. Both types of stratigraphic heterogeneity can be deduced from well log correlatability or knowledge of facies and position within a depositional cycle. For example, poor lateral continuity of log patterns in a reservoir interval indicates complex reservoir architecture, and the internal complexity of the deposits of a given facies will vary from the progradational portion of a depositional cycle through the aggradational and retrogradational phases of the cycle. Table 1 provides a summary of potential architectural and internal heterogeneity for Gulf Coast fluvial-deltaic reservoirs.

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Table 1. Potential Effects on Reservoir Architecture of Position within 4th- and 5th-Order Cycles

STAGE	U. DELTA PLAIN	L. DELTA PLAIN	DELTA FRONT
LANDWARD STEPPING	Thick, broad, heterogeneous channel belts	Fewer but thicker heterogeneous distributaries	Fewer, thicker channel and mouth bar deposits with common wave-reworked tops
VERTICALLY STACKED	Broad, moderately thick and heterogeneous channel belts	A greater number of thick heterogeneous distributaries	Fewer, thicker channels, possibly subordinate to mouth bar and delta front bodies
SEAWARD STEPPING	Narrow, possibly thin and incised, isolated channels	Many broad shallow sandy channel belts?	Many long narrow sandy channel and mouth bar deposits

The greater the **hydrocarbon mobility**, the poorer the chances of a reservoir containing abundant undrained reserves, all other factors being equal between two reservoirs. Hydrocarbon mobility is a function of reservoir fluid viscosity and reservoir permeability, wherein the relationship can be expressed as

$$\text{Mobility} = \frac{\mu}{\log\ (k)} \tag{1}$$

in which μ is the average viscosity of the reservoir fluid (in cp) and k represents the geometric mean permeability in md (average permeability can be substituted, as long as that substitution is done for all reservoirs being compared). Because the average viscosity of reservoir fluid is not something readily available, it can be approximated by weighted averaging of the separate gas and oil phases in the reservoir by the following means:

$$\mu = \frac{\frac{12}{API}(100 - G) + 0.02G}{100} \tag{2}$$

where API is the average gravity of the oil leg and G is the volume percent of the reservoir containing gas. The expression 12/API yields oil viscosity (in cp) on the basis of a cross plot of oil gravity versus viscosity for the Frio play, and 0.02 is a mean value for gas viscosity (in cp) from the Frio play.

Reservoir depth is included as a criterion to compare economic viability of infill drilling that would occur during the recovery of any identified resources. For a given volume of expected reserves for an infill location, shallower wells are more economic than deeper wells because of the lower drilling costs. For

example, a 10,000-bbl opportunity would be an economic target at a depth of 2,000 ft but would be clearly uneconomic at 8,000 ft.

Operator gas/oil preference is included in a Quicklook evaluation because a given operator at a given time may be seeking to expand gas production more than oil production, or vice versa. This preference may occur because of commodity prices, infrastructure constraints, or contracted delivery goals.

The Formula

An equation has been established that incorporates readily available data from the above factors into a quantitative ranking of reservoirs in terms of their reserve growth potential. Because this formula is intended to yield a quick estimation of potential, it has several limitations, which are enumerated in the following section. The formula is as follows, with higher rank being equated to higher potential for economically recoverable reserves:

$$\text{RANK} = \frac{C\ (SUH)\ (SAH)\ V\ M\ G'}{D} \tag{3}$$

where

C = current well spacing (acres),

SUH = structural heterogeneity, from 1 (low) through 10 (high),

SAH = stratigraphic heterogeneity, from 1 (low) through 10 (high),

V = relative volumetric importance, ranked from 1 (smallest) to 100 (largest),

M = mobility, represented by $\dfrac{\mu}{\log(k)}$,

G' = Gas/oil bias (gas preference, G' = G (% gas in reservoir), oil preference, G' = 100-G),

$D = \dfrac{Depth}{6000}$ (economic risk factor - higher drilling costs for deeper reservoirs), and

k = geometric mean or estimated average permeability in md and

μ = average viscosity of reservoir fluid, as given by the following equation:

$$\frac{(\frac{12}{API}(100 - G) + 0.02G)}{100} \tag{4}$$

where API = reservoir oil gravity in API units.

Limitations

The Quicklook prioritization equation (Eq. 3) is designed to utilize input that should be readily available to an operator for almost all reservoirs. Such an evaluation should not require significant additional research or data gathering. In establishing such a relationship, many assumptions have been made. The influence of drive mechanism on recovery has been neglected, as has the variable efficacy of past reservoir management practices. Additionally, sandstones that have not been produced in the past but that may contain future potential are not considered.

Drive mechanism is known to affect recovery efficiency.[1, 2] However, these effects are difficult to quantify and can change throughout the life of the reservoir, depending on initial gas saturation and reservoir management practices. In decreasing order of efficiency, common drive mechanisms are (1) water drive, (2) gas cap expansion, and (3) solution gas drive. However, recovery from solution gas drive reservoirs can be altered during their life by gas injection programs, which approximate gas expansion drives with variable success.

Another assumption inherent in Eq. 3 is that all reservoirs have undergone a similar degree of development and reservoir management. Not all reservoirs, however, have been given the same level of attention by past operators in terms of looking for recompletion/infill opportunities or identifying production anomalies that would indicate compartmentalization. In addition, past mismanagement of water or gas injection programs can affect reserve growth potential, and this history can be difficult to discern in a Quicklook evaluation. For example, injection of water into downdip wells that are in direct communication with updip wells through narrow high-permeability channel facies can result in large volumes of unswept oil in lateral facies between the channels.

Another possibility that is not considered in the Quicklook evaluation is the potential for reserve growth in sandstones that have not previously been economically produced. Possible scenarios include (1) unrecognized low-resistivity pay zones, caused either by anomalous mineralogy or a thinly bedded nature, (2) zones that have exhibited flow rates that were lower than desired during more prolific periods of field development, and (3) zones that have been misdiagnosed as unproductive because of unrecognized formation damage or unrecognized potential to produce when stimulated. Each of these

situations would not be recognized by the above Quicklook evaluation because of the lack of high relative reservoir volume (they are not considered reservoirs or have a low cumulative production volume).

Other Technology Transfer Activities

In addition to the presentation of the short course and the development of the prioritization formula, a manuscript[3] was completed for publication in the September issue of *The Class Act*, a newsletter distributed by the DOE to operators of fluvial-deltaic reservoirs. This article is intended to communicate to operators the importance of (1) properly identifying reservoir architecture through high-frequency genetic stratigraphic analysis and stratigraphic analysis of 3-D seismic data, (2) accurate numerical description of reservoir properties through facies-based petrophysical analysis and the construction of a 3-D geocellular model, and (3) prioritization of reservoirs in terms of their reserve-growth potential, which focuses characterization efforts on those reservoirs most likely to yield successful recompletion and infill drilling programs.

Finally, a draft version of a final report was prepared and submitted to DOE for review. This draft final report summarizes (1) the studies done to evaluate playwide reservoir characteristics and resource volumetrics, (2) appropriate reservoir characterization methodology, (3) examples of detailed studies demonstrating the effectiveness of characterization techniques, (4) guidelines for reservoir prioritization, and (5) efforts to transfer this information to operators of fluvial-deltaic reservoirs in Texas and throughout the United States.

Characterization of Heterogeneity Style and Permeability Structure in a Sequence Stratigraphic Framework in Fluvial-Deltaic Reservoirs (Matching Funds Source)

Because of the worldwide importance of resources in fluvial-deltaic reservoirs, a consortium of oil companies is funding research by the Bureau of Economic Geology, The University of Texas at Austin, aimed at reservoir characterization of fluvial-deltaic depositional systems. The goals of this program are to develop an understanding of sandstone architecture and permeability structure in a spectrum of fluvial-deltaic reservoirs and to translate this understanding into more realistic, geologically constrained reservoir models. Our approach is to quantify the interrelationships among sequence stratigraphy, depositional architecture, diagenesis, and permeability structure through detailed outcrop characterization. This Industrial Associates program is the source of the 50-percent cofunding for the Bureau's Class I Oil Project.

Subsurface interpretation of reservoirs is hindered by the fact that data are derived primarily from wells that sample small volumes of the reservoir at widely separated locations. In relatively homogeneous reservoirs, the continuity of reservoir units between wells may be relatively easy to determine. In more complex fluvial-deltaic reservoirs, continuity of sandstone bodies may be much less than the average well spacing. A fundamental problem in characterizing complex subsurface reservoirs is the determination of the three-dimensional architecture of depositional and diagenetic facies and their relationship to the spatial distribution of reservoir properties that control fluid flow.

The investigation of this general set of reservoir description and modeling problems continued during the reporting period. The goal was to test the hypothesis that stratigraphic heterogeneity can be predicted from a knowledge of the position within a stratigraphic cycle and used to estimate reserve growth potential in mature reservoirs. Outcrops of the Ferron Sandstone were selected for study because they were extremely well exposed, they display a number of similarities to Gulf Coast fluvial-deltaic reservoirs, and nearby borehole and production data are readily available. The hypothesis was also tested

on two subsurface examples: an upper-delta-plain fluvial reservoir within the T-C-B field, South Texas, and a shallow-marine reservoir within the Ferron gas field, Utah. Production characteristics and borehole data from the subsurface analogs were compared and contrasted with borehole signatures from those analyzed for the Ferron architectural models. The methodology illustrates how outcrop observations integrated with detailed mapping of reservoir parameters can be used to identify areas of bypassed and unswept gas reserves.

Outcrop observations from the Ferron Sandstone support the theory that changes in stratal architecture can be related to sequence stratigraphic factors such as changes in accommodation and sediment supply. From the perspective of petroleum reservoirs, extremely different styles of reservoir heterogeneity are represented.

During periods of low accommodation, valley fills are few and are preserved as narrow, isolated, internally homogeneous sandstone bodies encased in floodplain mudstones. Volumetrically, they are a minor component but may play an important role in terms of fluid flow by acting as conduits connecting isolated delta lobes. Coeval shallow-marine strata are preserved as thin, heterolithic successions that display a high degree of lithologic diversity and a low degree of lateral continuity. These deposits are likely to be highly compartmentalized at multiple scales.

During periods of high accommodation, valley fills are large but internally heterogeneous. Deposits are composed of a complex network of vertically and laterally stacked sandstone bodies separated by low-permeability mudstones and clay-clast conglomerates. Coeval shallow-marine strata are preserved as relatively thick, sandstone-rich successions that display a low degree of lithologic diversity and a high degree of lateral continuity. These deposits are best developed near the landward and seaward extents of the deltaic cycle. These deposits would be expected to make up the largest reservoir units that displayed very good reservoir properties.

Subdivision of a stratigraphic succession through identification and correlation of unconformities and flooding surfaces is a critical step in defining stratal architecture. Criteria necessary for differentiating key bounding surfaces and vertical stratal successions were extracted from borehole data calibrated to

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exposures of the Ferron Sandstone. The approach recommended is first to identify major flooding surfaces that are typically the easiest to recognize and correlate. Flooding surfaces display a distinctive gamma-ray response and are widespread in distribution. Once the stratigraphic succession has been subdivided in this fashion, the most likely candidate unconformities can then be identified or inferred on the basis of changes in parasequence stacking pattern, fluvial incision, truncation, and a basinward shift in facies.

Data from upper-delta-plain and shallow-marine reservoirs from the T-C-B field, Frio Formation, South Texas, and the Ferron gas field, Ferron Sandstone, Utah, respectively, support the theory that reservoir heterogeneity and reserve growth potential are related to the position within a depositional cycle. Upper-delta-plain channel-belt reservoirs deposited during periods of low accommodation are not effectively contacted by rigid well patterns but can drain large reservoir volumes through individual completions. Because they are commonly isolated within floodplain mudstones, they are favorable for stratigraphically trapped accumulations away from the structural crest. In contrast, upper-delta-plain channel belts deposited during periods of high accommodation may appear laterally continuous but are not effectively drained because they are extensively segmented by high volumes of low-permeability siltstones and shales, as well as mud-clast-rich lag deposits that drape channel boundaries and limit fluid flow at channel-on-channel contacts. All factors being equal, these channel-belt types possess the greatest amount of bypassed and unswept oil because past completions have contacted only small reservoir volumes.

Shallow-marine strata deposited during periods of high accommodation may contain large reservoir volumes that are effectively contacted and drained by conventional well patterns. Favorable sites for stratigraphic entrapment away from the structural crest may occur near the landward and seaward pinch-outs of shoreline sandstones into lagoonal and marine shales, respectively. In contrast, shallow-marine strata deposited during periods of low accommodation are extensively compartmentalized by marine and marginal-marine mudstones that separate offlapping sandstone successions. Past completions have contacted only small reservoir volumes. All factors being equal, these types of shallow-marine deposits possess the greatest amount of bypassed and unswept hydrocarbons.

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PLANNED ACTIVITIES

The project will reach completion during the third quarter, on August 31, 1996. Activities during this final period will focus on revision of the final report in response to DOE comments and completion of the reservoir characterization advisor software. Meetings will be held with operators of the characterized reservoirs to transfer study results.

REFERENCES

[1]American Petroleum Institute (API), 1967, A statistical study of recovery efficiency: API Bulletin D 14.

[2]Tyler, Noel, 1994, Tectono-stratigraphic controls on deltaic reservoir architecture and recovery response in foreland basins: *in* Perez de Mejia, Daisy, ed., Exploración Petrolera en las Cuencas Subandinas, V Simposio Bolivariano, Puerto La Cruz, March 13–16, 1994, Memoria, p. 578–588.

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[4]Galloway, W. E., Ewing, T. E., Garrett, C. M., Tyler, Noel, and Bebout, D. G., 1983, Atlas of major Texas oil reservoirs: The University of Texas at Austin, Bureau of Economic Geology, 139 p.

[5]Kosters, E. C., Bebout, D. G., Seni, S. J., Garrett, C. M., Jr., Brown, L. F., Hamlin, H. S., Dutton, S. P., Ruppel, S. C., Finley, R. J., and Tyler, Noel, 1989, Atlas of major Texas gas reservoirs: The University of Texas at Austin, Bureau of Economic Geology Special Publication, 161 p.
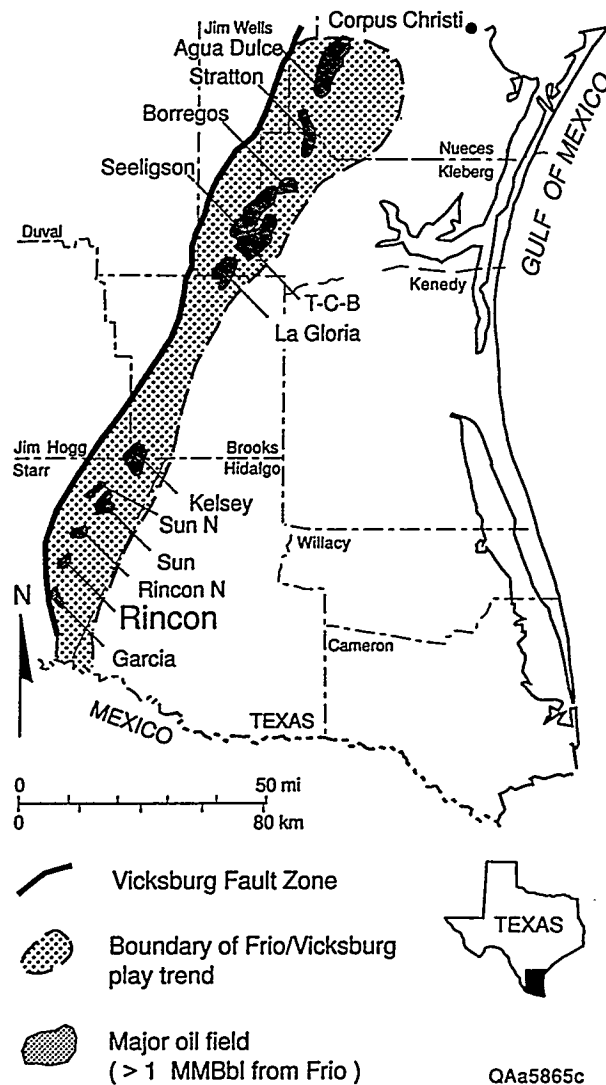
Fig. 1. Map of South Texas showing location of fields within the Frio Fluvial-Deltaic Sandstone play along the Vicksburg Fault Zone. This project included detailed studies of Rincon and T-C-B fields, located in the southern and northern parts of the play, respectively. (Modified from Galloway and others,[4] and Kosters and others.[5])

20 Acres   Area drained
                                  70 %

40 Acres   Area drained
                                  33 %

0   3500 ft

0   500   1000 m

▦ Channelbelt reservoir   ◟ Oil/water contact
   compartment

▧ Non-reservoir facies   ⊙ Completion location
                                     and area drained

⊹ Plugged and abandoned
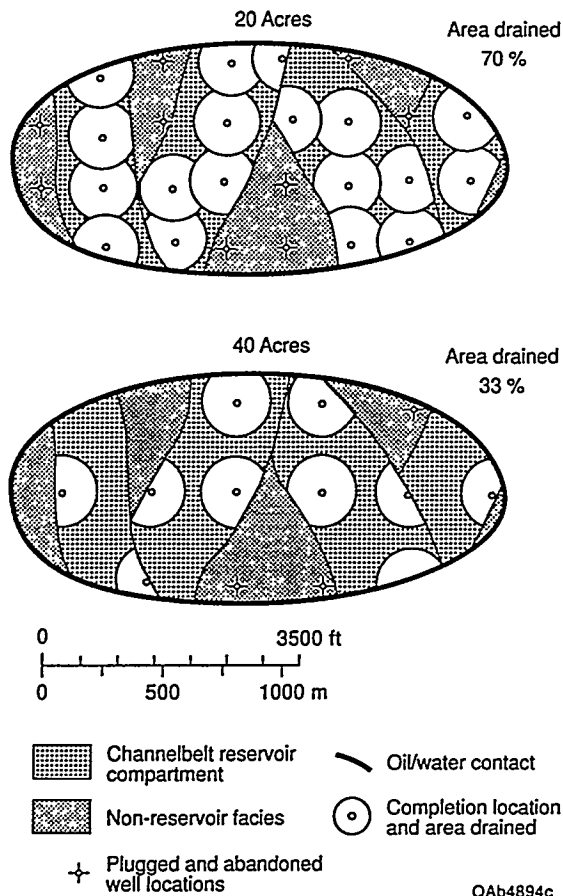   well locations   QAb4894c

Fig. 2. The effect of past completion density on reserve growth potential. Two identical reservoirs composed of fluvial channel bodies draped across a simple anticlinal structure are shown, and effective drainage radius is assumed to be approximately 400 ft. If developed on 20-acre grid spacing, 70 percent of the reservoir area would be drained. Opportunities for targeted infill drilling would contain few or significantly smaller reserves than did previous completions. However, if developed on 40-acre grid spacing, only 33 percent would be drained, leaving many opportunities for reserve growth through targeted infill drilling.

U. S. DEPARTMENT OF ENERGY
MILESTONE LOG

ELEMENT CODE	DESCRIPTION	PLANNED COMPLETION DATE	ACTUAL COMPLETION DATE	COMMENTS
I	Reservoir selection and initial framework characterization			
1	Screen play for suitable fields	2/28/93	2/26/93	100% complete
2	Identify potential for untapped reservoirs	10/21/93	10/21/93	100% complete
3	Identify potential for incompletely drained/compartmentalized reservoirs	10/21/93	10/21/93	100% complete
4	Identify potential for new pool reservoirs	12/31/93	12/22/93	100% complete
II	Delineation of incremental recovery opportunities: targeting the advanced recovery resource			
1	Delineate untapped reservoirs and assess volumetrics	12/31/94	12/31/94	100% complete
2	Delineate incompletely drained/compartmentalized reservoirs and assess volumetrics	12/31/94	12/31/94	100% complete
3	Evaluate potential for new pool reservoirs	12/31/94	12/31/94	100% complete
III	Technology transfer and definition of extrapolation potential			
1	Document distribution of untapped reservoirs for technology transfer	7/31/95	7/31/95	100% complete
2	Document distribution of incompletely drained/compartmentalized reservoirs for technology transfer	7/31/95	7/31/95	100% complete
3	Document distribution of new pool reservoirs for technology transfer	7/31/95	7/31/95	100% complete
4	Conduct technology transfer activities and extrapolate results within and between plays	6/30/96	6/30/96	*100%* 81% complete
5	Develop computer-based advisor for recompletion and infill drilling and transfer to industry	8/31/96		*89* 82% complete

Phase III

U.S. DEPARTMENT OF ENERGY
MILESTONE SCHEDULE ☐ PLAN ☒ STATUS REPORT

| 1. TITLE | Revitalizing a Mature Oil Play: Strategies for Finding and Producing Unrecovered Oil in Frio Fluvial-Deltaic Reservoirs of South Texas | 2. REPORTING PERIOD January 1, to March 31, 1996 | 3. IDENTIFICATION NUMBER DE-FC22-93BC14959 |

4. PARTICIPANT NAME AND ADDRESS	Bureau of Economic Geology The University of Texas at Austin P.O. Box X, University Station Austin, Texas 78713

5. START DATE January 1, 1995

6. COMPLETION DATE August 31, 1996

7. ELEMENT CODE	8. REPORTING ELEMENT	9. DURATION FY95 / FY96	10. PERCENT COMPLETE	
		O N D J F M A M J J A S O N D J F M A M J J A	Plan	Actual
Phase III				
1	Document Untapped Reservoirs		100%	100%
2	Document Incompletely Drained Reservoirs		100%	100%
3	Document New Pool Potential		100%	100%
4	Conduct Technology Transfer		81% 100	81% 100
5	Develop Computer-based Advisor		62% 51	62% 87

11. SIGNATURE OF PARTICIPANTS PROJECT MANAGER AND DATE

R A L 30 Ap 96

R. A. Levey
4-30-96

Phase III

U.S. DEPARTMENT OF ENERGY

MILESTONE SCHEDULE ☐ PLAN ☒ STATUS REPORT

| 1. TITLE | Revitalizing a Mature Oil Play: Strategies for Finding and Producing Unrecovered Oil in Frio Fluvial-Deltaic Reservoirs of South Texas | 2. REPORTING PERIOD April 1, to June 30, 1996 | 3. IDENTIFICATION NUMBER DE-FC22-93BC14959 |

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7. ELEMENT CODE	8. REPORTING ELEMENT	9. DURATION																							10. PERCENT COMPLETE	
		FY95											FY96											FY	a. Plan	b. Actual
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A		
Phase III 1	Document Untapped Reservoirs																									100%	100%
2	Document Incompletely Drained Reservoirs																									100%	100%
3	Document New Pool Potential																									100%	100%
4	Conduct Technology Transfer																									100%	100%
5	Develop Computer-based Advisor																									89%	89%

11. SIGNATURE OF PARTICIPANT'S PROJECT MANAGER AND DATE

R. A. Levey
July 19, 1996

U. S. DEPARTMENT OF ENERGY
MILESTONE LOG

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I	Reservoir selection and initial framework characterization			
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2	Identify potential for untapped reservoirs	10/21/93	10/21/93	100% complete
3	Identify potential for incompletely drained/compartmentalized reservoirs	10/21/93	10/21/93	100% complete
4	Identify potential for new pool reservoirs	12/31/93	12/22/93	100% complete
II	Delineation of incremental recovery opportunities: targeting the advanced recovery resource			
1	Delineate untapped reservoirs and assess volumetrics	12/31/94	12/31/94	100% complete
2	Delineate incompletely drained/compartmentalized reservoirs and assess volumetrics	12/31/94	12/31/94	100% complete
3	Evaluate potential for new pool reservoirs	12/31/94	12/31/94	100% complete
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3	Document distribution of new pool reservoirs for technology transfer	7/31/95	7/31/95	100% complete
4	Conduct technology transfer activities and extrapolate results within and between plays	6/30/96	6/30/96	100% complete
5	Develop computer-based advisor for recompletion and infill drilling and transfer to industry	8/31/96		89% complete