SPE
Society of Petroleum Engineers

SPE 22919

Gas Reserve Growth Analysis of Fluvial-Deltaic Reservoirs in the Frio and Vicksburg Formations Located in the Stratton Field, Onshore Texas Gulf Coast

M.A. Sippel, Research & Engineering Consultants Inc., and R.A. Levey, Bureau of Economic Geology, U. of Texas
SPE Members

This paper was prepared for presentation at the 66th Annual Technical Conference and Exhibition of the Society of Petroleum Engineers held in Dallas, TX, October 6-9, 1991.

ABSTRACT

The reserve growth in a mature gas field is analyzed using a historical review over the past 20 years. The Stratton field is presented as an example of the significant additional gas reserves which are available through conventional drilling and completion methods using existing technology. The reserve growth is quantified and categorized by reservoir architecture, well density and depth.

INTRODUCTION

The Stratton field is located primarily in Kleberg and Nueces counties, Texas. It is part of a very large and mature exploration play. The analysis of historical reserve growth of natural gas in this field provides insight into the advanced stages of a mature producing province which is representative of other mature producing provinces of the United States. The field is one of twenty-nine multi-reservoir fields classified as part of the Frio Formation fluvial-deltaic play associated with the Vicksburg fault zone along the Texas Gulf Coast Basin [Kosters et al.[1]]. The multiple-stacked gas reservoirs at Stratton field are dominated by both fluvial and deltaic structures of the Frio and Vicksburg Formations. A significant portion of the gas production is from the middle Oligocene section deposited during the Catahoula-Frio depositional episode [Galloway[2]]. The Oligocene-age Frio Formation of the Gulf Coast Basin is volumetrically the greatest onshore gas-producing interval, having produced almost 41 Tcf of gas as of December 31, 1986 [Kosters et al.[1]].

Analysis of the oil and gas resource base of the United States has shown a positive correlation of oil reserve growth from drilling within existing fields [Fisher[3]]. An assessment of the natural gas resource base of the United States indicated that the potential for significant gas reserve growth of current non-associated gas reservoirs may be strongly related to reservoir heterogeneity. That analysis estimated infield reserve growth potential in non-associated gas reservoirs at 105 Tcf as of 1987 [Finley et al.[4]].

References and illustrations at end of paper.

To put this reserve growth potential in perspective related to existing proved natural gas reserve estimates, recently announced resource estimates by the Energy Information Administration indicate that recoverable natural gas resources are 168 Tcf in proved reserves for the total United States as of December 31, 1988. Proved reserves are defined as estimated quantities that analysis of geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions [EIA[5]].

This study of a portion of the Stratton field demonstrates the effect of reservoir heterogeneity in a field with fluvial-dominated reservoir architecture on historical and potential natural gas reserve growth. Stratton Field is an excellent candidate for detailed analysis because it has a long development and production history exceeding 50 years. During the 1970's and 1980's, an aggressive infield drilling and recompletion program provided a basis for using a historical approach to resource growth assessment. Until the late 1980's, producing intervals had been limited primarily to discrete sandstone units. There has been a trend for downhole commingling of several thin reservoirs and depleted reservoirs in the past few years. The analysis of reserve growth at Stratton during the past twenty years provides an opportunity to evaluate reserve growth attributable to discrete sandstone units which will not be possible in the future as more reservoirs become commingled and consolidated.

FIELD HISTORY

The Stratton field is primarily located in Kleberg and Nueces Counties of southeast Texas and approximately 30 miles southwest from Corpus Christi as shown in Figure 1. The field extends 14 miles along the Vicksburg fault with an average width of 4.5 miles and encompasses more than 120,000 acres. The major producing reservoirs are in the Frio and upper Vicksburg formations and are found at depths from approximately 4,500 ft to 9,000 ft subsea.

The field was discovered in 1937. The period from 1950 through 1968 is considered the primary development of middle Frio fluvial reservoirs. During this time period, gas recycling was performed in several reservoirs to provide pressure support to maximize production from associated oil completions along the flank of the field. During the time frame from 1968 to 1973, gas production peaked at more than 90 Bcf/year primarily as the result of depletion of the recycled reservoirs. Until the late 1980's, producing intervals had been primarily limited to discrete sandstone units. There has been a trend for downhole commingling of several reservoirs in the past few years. These commingled reservoirs have been designated as Stratton Consolidated. Reserve additions in the past two decades have effectively kept pace with production.

DESCRIPTION OF STUDY AREA

A large portion of contiguous acreage from the south portion of Stratton field was selected for detailed analysis as shown in Figure 2. The approach to evaluating incremental reserve growth was to perform an assessment of the historical changes in producing gas reserves for a portion of this large lease referred to as the study area. The study area is a contiguous block of the Wardner lease which comprises approximately 7,400 acres. It is operated by Union Pacific Resources. This acreage was separated from the whole Wardner lease because it is on the east side of the major Vicksburg fault. Figure 2 shows a map of the limits of the study area in the Wardner lease and the structural relief of the reservoirs using a consistent shale marker approximately in the middle of the middle Frio Formation. This structure map shows there is about 200 ft of relief from the crest to the depth of the outer limits of the study area boundary. This structural relief of 200 ft also approximates the maximum height of the gas cap above the oil rim that is part of certain reservoirs. Most of the completions in the Wardner lease study area have been above the gas-oil contact of these reservoirs.

NUMBER OF RESERVOIRS COMPLETED

Analysis of the Texas Railroad Commission gas well production records from the 1989 annual report, indicate that between 1937 and 1990, more than 340 regulatory reservoirs have been designated within the greater Stratton field of Kleberg, Nueces and Jim Wells counties. The Texas Railroad Commission annual production reports indicate that newly discovery reservoirs at depths shallower than 7,000 ft have occurred more frequently than at deeper depths. The Wardner lease area within Kleberg and Nueces Counties contains 99 distinct regulatory reservoirs. A total of 49 of these reservoirs can be assigned to the middle Frio. Detailed stratigraphic correlations, based on all existing well control across large parts of Stratton Field, indicate this number of reservoirs is slightly inflated due to variations in reporting practices related to new reservoir designations. Stratigraphic analyses based on well log correlations indicate that these 49 regulatory reservoirs can be grouped into 37 unique operational reservoirs. These reservoirs are bounded by field-wide stratigraphic markers that are identifiable as resistivity or conductivity markers on conventional electric logs. A total of 34 of these 37 middle Frio reservoirs have been developed in the Wardner lease study area as of January 1, 1990. Table 1 compares the number of middle and lower Frio reservoirs with the Vicksburg reservoirs which have been developed over time. The number of middle Frio reservoirs has increased from 26 in 1970 to 34 in 1990 while the number of lower Frio and Vicksburg reservoirs increased from 10 to 31 in the same time frame.

GEOLOGY OF PRODUCING RESERVOIRS

The Oligocene-age middle Frio Formation, within the Wardner lease at Stratton field, lies approximately at a depth between 4,500 to 7,000 ft subsea. Regional stratigraphic analysis of well logs from south Texas [Galloway et al.[2]] and inter-field correlations of Stratton [Kerr[6]], indicate that the middle Frio at Stratton field consists of non-marine deposits of the Gueydan fluvial system. Reference to a type log of the Union Pacific Producing Co. Driscoll No. 7A well as shown in Figure 3, indicates that the middle Frio contains multiple sandstone packages within a series of multiple stacked reservoirs referred to as B, C, D, E, and F series reservoirs (descending stratigraphic order) at Stratton field. Reservoir lithofacies identified from core and borehole images, calibrated to well logs, support the interpretation of fluvial deposits comprised of both single, and multiple, amalgamated channel-fill and splay sandstones as the dominant reservoir facies for the middle Frio producing reservoir units. Channel-fill deposits range from 10 to 30 ft in thickness, and typically have a bell-shaped spontaneous potential log profile which suggests an upward-fining of grain size distribution. Lateral splay deposits often range from less than 5 ft to as much as 20 ft in thickness. The character of the spontaneous potential profile on electric logs within splay deposits have an inverted-funnel shape, indicative of an upward-coarsening textural profile.

The lower Frio Formation in the Wardner lease area occurs at depths between approximately 7,000 to 7,400 ft subsea. These sandstones range from 5 to 15 ft in thickness and show an inverted-funnel shape on the spontaneous potential log profile. These lower frio Formation sandstone packages were interpreted as lower coastal plain deposits to inner shelf deposits [Kerr[6]] and are probably related to the Norias wave-dominated delta system [Galloway[2]]. Correlation of field-wide resistivity and conductivity markers across Stratton field, to the Union Producing Co. Driscoll No. 7A well as shown in Figure 3 indicate these sandstone packages are referred to as the G series reservoirs.

Sandstones in the upper Vicksburg Formation are often greater than 20 ft in thickness (up to 80 ft) and show a distinctive inverted-funnel shaped spontaneous potential log profile. These upper Vicksburg sandstones in the Stratton field are interpreted as deltaic deposits.

RESERVOIR PERFORMANCE AND PRODUCTION CHARACTERISTICS

The effective permeabilities to gas in the majority of middle Frio reservoirs have been found to be on the order of between 10 md and 100 md by analysis of pressure transient and deliverability tests. Some of the reservoirs in the D series and E series have much lower effective permeabilities to gas, these being on the order of 1 md to 10 md. Some of these lower permeability reservoirs have been stimulated by hydraulic fracture treatment during completion operations. The original pressure gradient is about 0.46 psi/ft. The operational abandonment reservoir pressure of the major producing middle Frio reservoirs is about 200 psi. The temperature gradient is about 16 °F per 1000 ft. The produced gas has an average specific gravity of about 0.65, relative to air. Some condensate and water are generally produced with the gas from wells with completions at crestal positions in the field.

METHOD OF RESERVE ASSESSMENT

Incremental gas reserves as of January 1970 were determined instead of ultimate recovery since discovery because several reservoirs were being recycled until the late 1960's. Public-domain production records available from computer-based systems were used for determination of remaining reserves. Remaining producing reserves were determined from extrapolation of the decline of production rates with time for each completion in the study area. A best-fit exponential decline was made to an arbitrary, but realistic, ending rate of 1,000 mcf per month. The pressure data were not used for reserve determinations because these are infrequently reported in the depleted stages of most reservoirs. Only the producing completions were evaluated on the time frames of January 1, 1970, 1979 and 1990. These evaluations did not consider behind-pipe or other undeveloped reserves. The determination of proved producing remaining reserves on January 1, 1970 was made by ignoring any production after that date. The remaining reserves of producing completions were then redetermined with all production data through December 31, 1978 and again through December 31, 1989. The reserves for each depth group and the total are the summation of the appropriate individual completions. The production from January 1970 through December 1978 was then added to the remaining reserves determined for January 1, 1979 to make a direct comparison to the remaining reserves determined for January 1, 1970. In similar fashion, the production from January 1970 through December 1989 was then added to the remaining reserves determined for January 1, 1990 to make a direct comparison to the remaining reserves determined for January 1, 1970. The difference between these two reserve re-determinations and the base-reserve determination for January 1, 1970 are the reserve growths realized on 1979 and 1990 for the study area.

Table 2 summarizes the base reserves as of January 1, 1970 and the reserve revisions of 1979 and 1990. The table shows a reserve growth from 87.3 Bcf in 1970 to 220.5 Bcf by 1990. The majority of the reserve growth occurred in the middle Frio at depths less than 7,000 ft.

The reported reservoir pressure at completion was also investigated as an indicator for reserve growth. It was found that 43% of the completions in reservoirs shallower than 7,000 ft from 1970 through 1978 had initial pressures greater than 80% of the original pressure adjusted for depth. This statistic was re-evaluated from 1979 through 1989, where it is observed that 46% of shallower completions had initial pressures of 80% or more of the original pressure. Table 3 summarizes the frequency of high completion pressure by depth groups.

RESERVE GROWTH ANALYSIS

There are three possible sources for reserve additions: 1) reservoirs previously untapped by current well spacing, 2) reservoirs already contacted in existing wellbores but not effectively drained by current completion spacing, and 3) new reservoirs that are deeper pools than the current production. Analyzing the reserve growth for the study area by depth, reservoir and spacing has allowed this study to arrive at conclusions as to the probable source of future incremental reserves for fields similar to Stratton.

Since the gas production peak in 1973, reserve additions in the past two decades have effectively kept pace with production. Figure 4 shows the average daily gas producing rate, determined from annual production, for completions in the Wardner lease study area. The production data are divided into separate curves which reflect the contributions from completions made in three time frames. The lowest curve represents the production from completions made prior to 1970. This is the base case for reserve growth assessment. The middle curve exhibits the production from completions made in the period from 1970 through 1978. An increase in rate and reserve additions is noted at about 1977-1978 which was the result of several successful discoveries in deeper pool reservoirs. The upper curve represents the summation of production from all completions. The areas between the curves shows the relative reserve additions which are attributable to the 1970-1978 and post 1978 completions. The production graph shows that the decline of producing rate and depletion of reserves has been dramatically slowed by continued drilling and completion activity.

Analysis of where these reserve additions occurred is shown by Figure 4. This is a graph of reserve additions with time as a function of depth. The depth division for this comparison is 7,000 ft. This is the approximate depth for the transition from middle Frio to lower Frio reservoirs. The graph combines the reserve additions that have occurred since 1970 from the 1970-1978 and post-1978 completions for these depth intervals so that a cumulative reserve growth is depicted. Notice that reservoirs deeper than 7,000 ft had essentially no remaining reserves from completions made prior to 1970. The graph shows the dominance of the middle Frio reservoirs for reserves and reserve additions. The next step in evaluating the reserve growth is to identify which group, or series of reservoirs, in the middle Frio have accounted for the most significant contributions.

When reserves and reserve additions are further divided into reservoir groups, such as B-series, C-Series, D-series and so on, reserve growth is more narrowly defined. Figure 5 shows the reserve additions that have been realized by a more restrictive grouping. The most significant reserve growth is shown to have occurred in the E-series and F-series reservoirs. Closer examination by specific reservoir, shows that the reservoirs in the lower F-series have realized the most reserve growth. These reservoirs had been drilled through and producing since the 1950's. Stratigraphic and structural cross-sections were prepared over the Wardner lease study area. These cross-sections show that stratigraphic variation is the mechanism for the reserve growth which was realized from 1970 to 1990. Structural complexity caused by faulting appears to be minor at depths above 7,500 ft across the Wardner lease study area.
Analysis shows that the majority of reserve growth has occurred from reservoirs previously contacted in existing wellbores but ineffectively drained by the existing completion spacing. New, and previously untapped, reservoirs are judged to be less significant because of the relatively few completions in new reservoirs in the middle Frio. There were a total of 8 new reservoirs added to the existing 26 producing reservoirs in the Wardner lease study area from 1970 to 1990. The lesser importance of the deeper pool contributions in the Wardner lease study area is demonstrated by the statistic that only 23.6% of the reserve additions from 1970 to 1990 are attributable to completions made at depths greater than 7,000 ft.

COMPLETION ACTIVITY AND SPACING

The level of effort required to produce these reserve additions, in terms of the number of completions and the spacing of these completions, is shown in Figure 7. Figure 7 shows the addition of successful completions by reservoir groups. This graph shows the relative success of completions in middle Frio reservoirs compared to deeper pool reservoirs.

The level of effort is also depicted by Figure 8 which shows the active completions for the time-segregated completion groups. An active completion was determined from the annual producing rates. A completion producing less than an average of 5 mcfd for a calendar year was determined to be inactive. The figure shows that the active completion count was nearly constant over time until 1987, when there was a sharp rise in completion activity.

To evaluate the impact of well spacing on reserve additions, completion and well density were determined from the digitized locations of wells in the study area. The relative x-y coordinates were used in a computer program to perform the tedious calculation of the distance to the nearest well. The completions were sorted by reservoir to make spacing calculations at each of the reservoir levels. The allocated area for each completion, or well, was assigned as the square of the distance to its nearest neighbor at the appropriate completion or reservoir level. The mean spacing between all wellbores has decreased from 48 acres in 1970 to 27 acres in 1990. The statistics on well and completion density provide an important perspective of the development that has occurred at Stratton field. Furthermore, these provide a means of comparison to other fields. Table 5 shows the effective spacing of completions at a reservoir level for the Wardner study area. The table shows that completion spacing has been reduced by half since 1970, from 170 acres per completion to 89 acres per completion.

APPLICATION OF RESULTS

The reserve growth realized from the shallower, middle Frio completions has been superior to that realized by the lower Frio and Vicksburg completions in the study area, both on a total volume basis and on a per completion basis. The variation in incremental reserve growth between the two depth groups is believed to reflect the major change in depositional setting associated with the fluvial reservoirs of the middle Frio Formation and the deltaic dominated reservoirs in the lower Frio and Vicksburg formation.

The average incremental reserve growth from middle Frio completions made during the time from 1970 through 1989 is determined to be about 821,000 mcf per completion using the data from Tables 2 and 4. Using a statistical approach this incremental reserve growth can be described as a recovery factor using the average reservoir properties and completion spacing for the middle Frio completions.The original gas-in-place (G) can be computed volumetrically using

$$G = 43.56\ A\ h\ \phi\ (1-S_w)\ (B_{gi}),\ \text{mcf.}$$

The incremental recovery factor (RF) is defined as

$$RF = G_p/G \times 100\%$$

where G_p is the incremental recovery.

Using the average reservoir and completion data of the middle Frio Formation at the Stratton field found in Table 6, a recovery factor which relates the incremental recovery realized to the change in average completion spacing can be statistically derived. This incremental recovery factor is 31% based on decreasing the mean completion spacing from 165 acres to 91 acres per completion. This incremental recovery factor appears to be substantiated by the number of relatively high initial completion pressures reported since 1970. Table 1 shows that 46% of the new completions made from 1979 through 1989 in the middle Frio reported initial reservoir pressures of 80% of original pressure, or greater.

PLAYS AND FIELDS WITH SIMILAR GEOLOGIC CHARACTERISTICS

The multiple-stacked gas reservoirs at Stratton field are dominated by both fluvial and deltaic reservoirs of the Frio and Vicksburg Formations. It is part of the geologic play known as the Frio Fluvial/Deltaic Sandstone along the Vicksburg Fault Zone (FR-4) which has produced a cumulative 11.8 Tcf of gas and is the volumetrically most significant of the 10 plays in the Frio Formation. Other Frio Formation plays with fluvial deposits include the Updip Frio Fluvial Sandstone in the Rio Grande Embayment (FR-5) and the Frio Fluvial/Coastal-Plain Sandstone on the San Marcos Arch (FR-8). Other Gulf Coast Basin plays containing either fluvial or fluvial-deltaic reservoirs are present among major gas reservoirs within the state of Texas. These plays include the Eocene, Yegua Fluvial/Deltaic Sandstone in the Houston Embayment (EO-3) and the Miocene, Fluvial Sandstone in the Rio Grande Embayment (MC-2). Play nomenclature and designations are from Reference 1.

CONCLUSIONS

Reserve growth of producing reservoirs has occurred in the Wardner lease study area of the Stratton field over the last two decades as the result of infield drilling and recompletion activity. The number of wells and completions has resulted in decreasing the mean spacing of completions at a reservoir level to nearly half, from 170 acres to 89 acres between completions. The projected and produced recoverable reserves as of January 1, 1970 increased from 87.3 Bcf to 220.5 Bcf. Analysis of these reserve additions shows that 76.4% of the growth occurred in the middle Frio at depths less than 7,000 ft while 50.6% of the infield wells drilled in that period were initially completed in deeper pool objectives of the lower Frio and Vicksburg Formations. It is concluded from this field example that incremental reserves have been developed by decreased spacing to nearly 80 acres and that reserve development in the deeper-pool objectives of the lower Frio and Vicksburg Formations has not been as successful as that from the infield development of the middle Frio.

A statistical estimate of the ineffective, or poorly drained, volume of the fluvial reservoirs in the middle Frio at Stratton field is 31% of the original gas-in-place. This is based on development spacing of 165 acres per completion at the beginning of the study time frame. This incremental recovery appears to be supported by the high fraction of completions (46% in the middle Frio) which had initial completion pressures of 80%, or greater, of the original reservoir pressure, adjusted for depth.

Additional studies of similar fields will be necessary to determine if these statistics or similarly derived statistics, can be confidently applied throughout the play. It would be a further benefit to determine this recovery factor from different completion spacings, such as from 640 to 320 acres and 320 to 160 acres. The results of these and similar studies should benefit companies in planning field development strategies. Extended studies like this could assist government agencies make accurate predictions for infield reserve growth in the future.

NOMENCLATURE

A = reservoir or drainage area, acres (43,560 ft^2/acre)
Bcf = billion ft^3
B_{gi} = gas volume factor at initial conditions, scf/cf
G = gas volume, mcf
G_p = gas produced, mcf
cf = ft^3
mcf = thousand ft^3
h = formation thickness, ft
s_{cf} = volume at standard conditions, ft^3
S_w = water saturation, fraction
Tcf = trillion ft^3
ϕ = total porosity, fraction

SI metric Conversion Factors

acres x 4.046873 x 10^3	= m^2
ft x 3.048 x 10^{-1}	= m
ft^3 x 2.831685 x 10^{-2}	= m^3
°F(deg F-32)/1.8	= °C
miles x 1.609344	= km
psi x 6.894757	= kPa

ACKNOWLEDGEMENTS

The study and results presented are part of an ongoing research program titled "Secondary Natural Gas Recovery: Targeted Technology Applications for Infield Reserve Growth." This research program is co-sponsored by the Gas Research Institute, the U.S. Department of Energy and the State of Texas. Acknowledgment and thanks are given to Union Pacific Resources for cooperative discussions.

REFERENCES

1 Kosters, E.C., Bebout, D.G., Seni, S.J., 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.

2 Galloway, W.E., Hobday, D.K., and Margarine, K.: "Frio Formation of the Texas Gulf Coast Basin-Depositional Systems, Structural Framework, and Hydrocarbon Origin, Migration, Distribution, and Exploration Potential," The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations No. 122, (1982) 78 p.

3 Fisher, W.L.: "Can the U.S. Oil and Gas Resource Base Support Sustained Production?," *Science* Vol. 236, 1631-1636 (1987).

4 Finley, R.J., Fisher, W.L., Seni, S.J., Ruppel, S.C., White, G., Ayers, A.B., Dutton S.P., Jackson, M.L., and Banta, N.: "An Assessment of the Natural Gas Resource Base of the United States," The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations No. 179 (1988) 69 p.

5. "The Domestic Oil and Gas Recoverable Resource Base: Supporting Analysis for the National Energy Strategy," SR/NES/90-05, EIA (1990) 56 p.

6 Kerr, D.R.: "Reservoir Heterogeneity in the Middle Frio Formation: Case Studies in Stratton and Agua Dulce Fields, Nueces County, Texas," Gulf Coast Association of Geological Societies Transactions, V. 40 (1990) 363-373.

TABLE 1 - NUMBER OF PRODUCING RESERVOIRS

	Number of Reservoirs		
Evaluation Date	1970	1979	1990
Middle Frio	26	29	34
Lower Frio	7	7	10
Vicksburg	3	9	21

TABLE 2 - DEVELOPED PRODUCING RESERVES AS OF 1970

Evaluation Date	1970	1979	1990	1979	1990
	Bcf	Bcf	Bcf	% of growth	
< 7,000 ft	87.3	162.5	189.1	80.5%	66.8%
> 7,000 ft	0.0	18.2	31.4	19.5%	33.2%
All completions	87.3	180.7	220.5	100.0%	100.0%

TABLE 3 - NEW COMPLETION PRESSURES GREATER THAN 80% OF ORIGINAL

Evaluation Date	1970-78	1979-89
< 7,000 ft	43%	46%
> 7,000 ft	0%	55%

TABLE 4 - WELL AND COMPLETION COUNT

	Number Wells			Number Completions		
Evaluation Date	1970	1979	1990	1970	1979	1990
< 7,000 ft	59	67	118	105	138	229
> 7,000 ft	8	19	48	9	23	81
All Completions	62	78	141	114	161	310

The well counts of shallow and deep wells do not add because a well may have both shallow and deep completions.

TABLE 5 - AVERAGE COMPLETION SPACING

Evaluation Date	1970	1979	1990
	Acres	Acres	Acres
< 7,000 ft	165	143	91
> 7,000 ft	192	101	85
All Completions	170	132	89

TABLE 6 - AVERAGE MIDDLE FRIO RESERVOIR STATISTICS, COMPLETIONS MADE BETWEEN 1970 AND 1990

Average Incremental Recovery(G_p)	821,000 mcf/new completion
Completion Spacing 1970 (A)	165 acres
Average depth	6,300 ft
Net Thickness (h)	20 ft
Porosity (ϕ)	20 %
Water Saturation (S_w)	50 %
Original Pressure	2850 psi
Initial Gas Volume Factor (B_{gi})	184.5 scf/cf

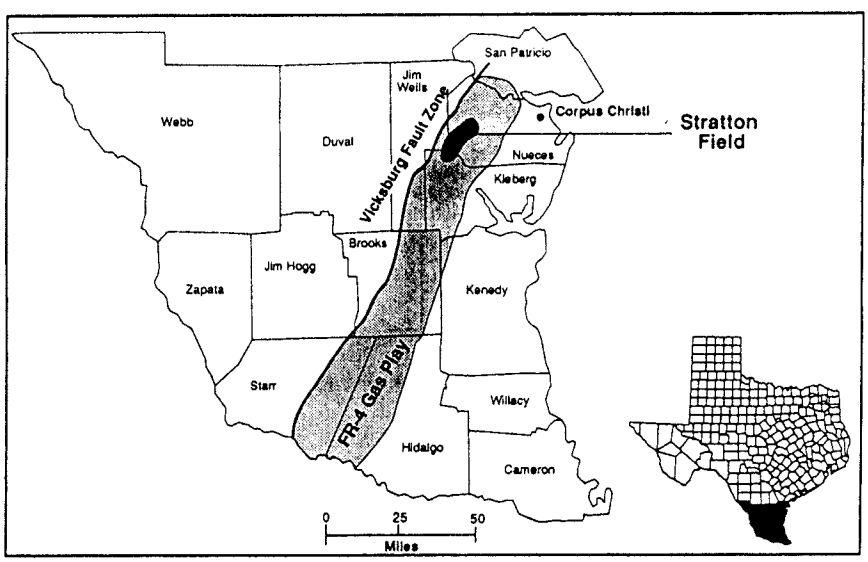

Fig. 1—Location of Stratton Field and FR-4 gas play.

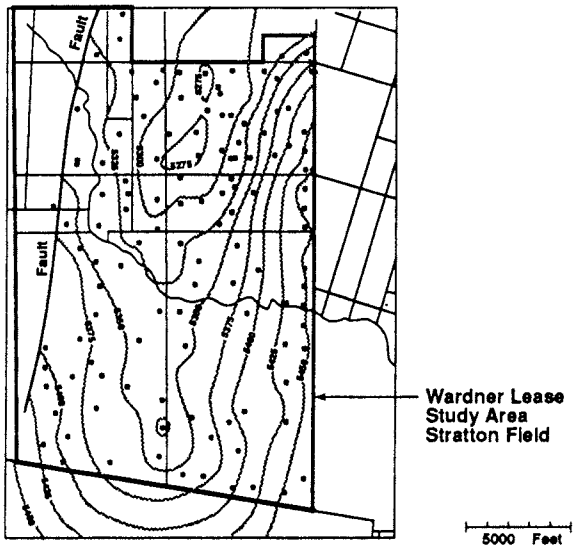

Fig. 2—Map showing Wardner lease study area with well locations and structure of the middle Frio.

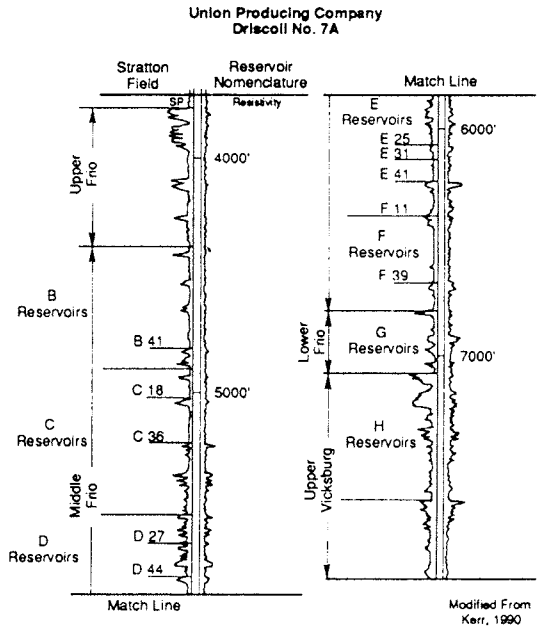

Fig. 3—Type log of the upper, middle and lower Frio and upper Vicksburg reservoirs in the study area with local reservoir nomenclature.

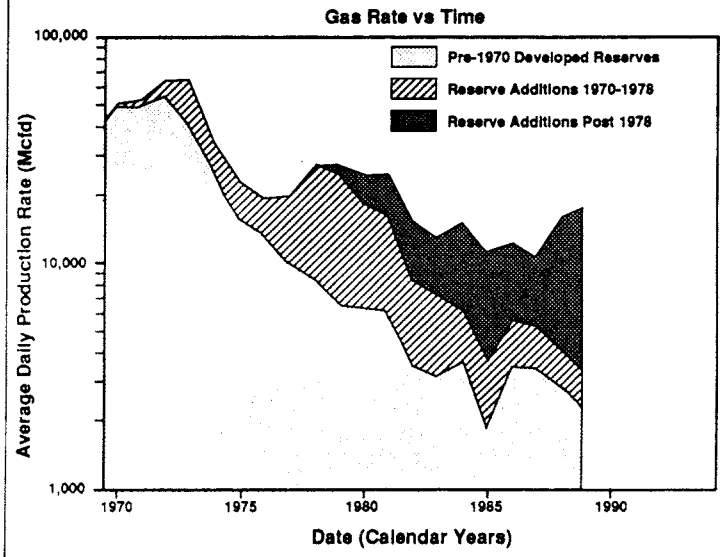

Fig. 4—Gas production rate with time.

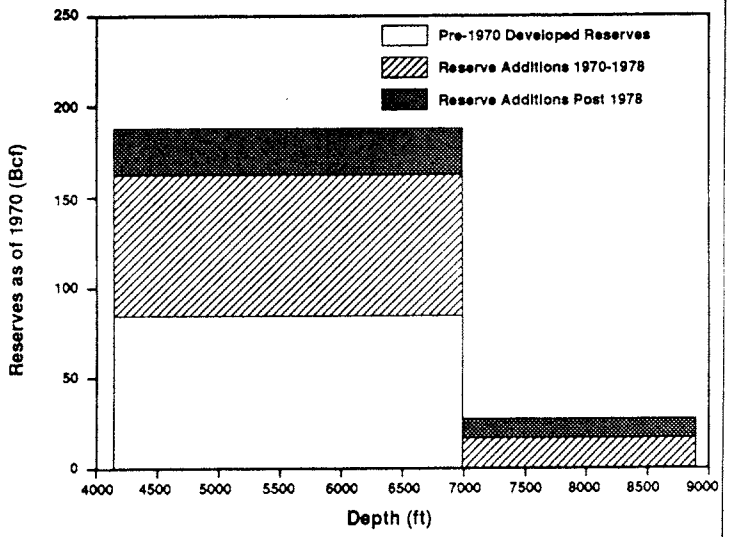

Fig. 5—Reserve additions for reservoirs above and below 7,000 ft.

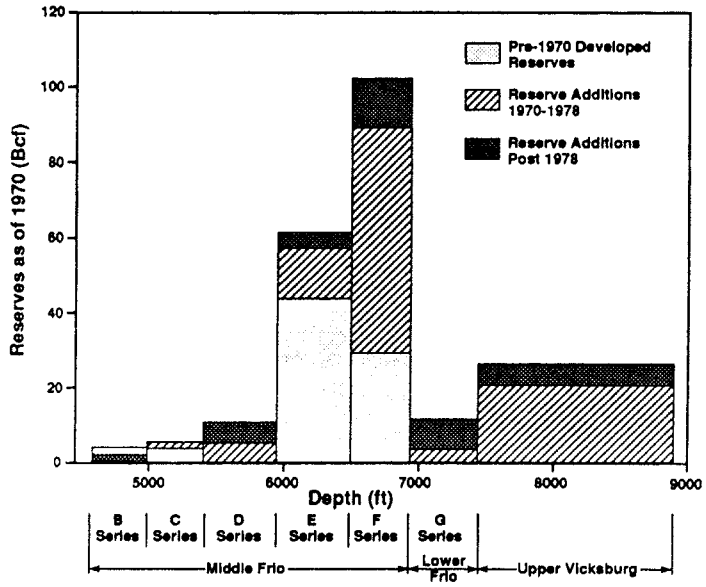

Fig. 6—Reserve additions for reservoirs grouped by series.

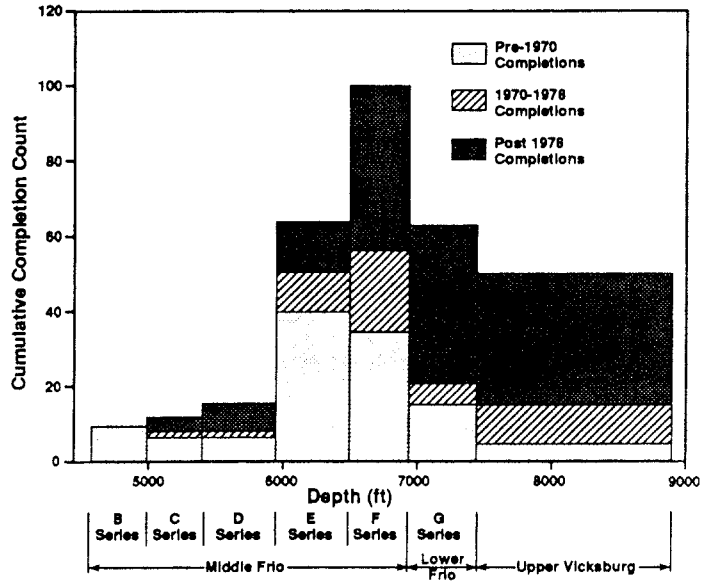

Fig. 7—Cumulative completions grouped by reservoir series.

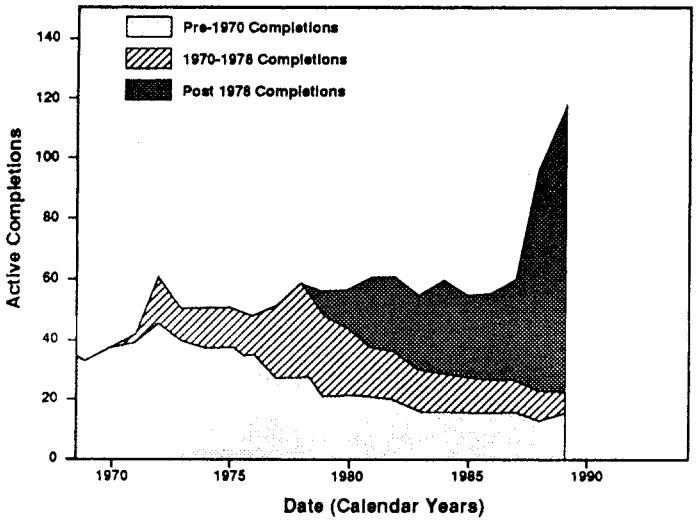

Fig. 8—Active completions with time.