Lower Middle Miocene Retrogradational (MM4 R1) Play

Gyroidina "K" through *Amphistegina* "B" biozones

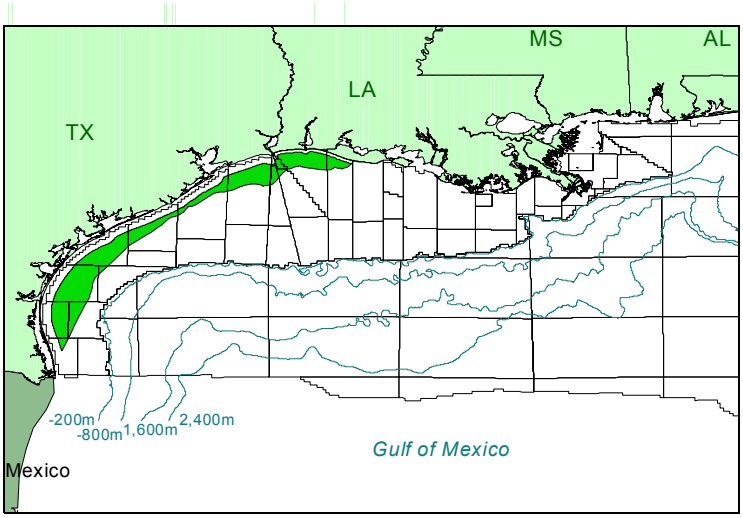

Figure 1. Play location.

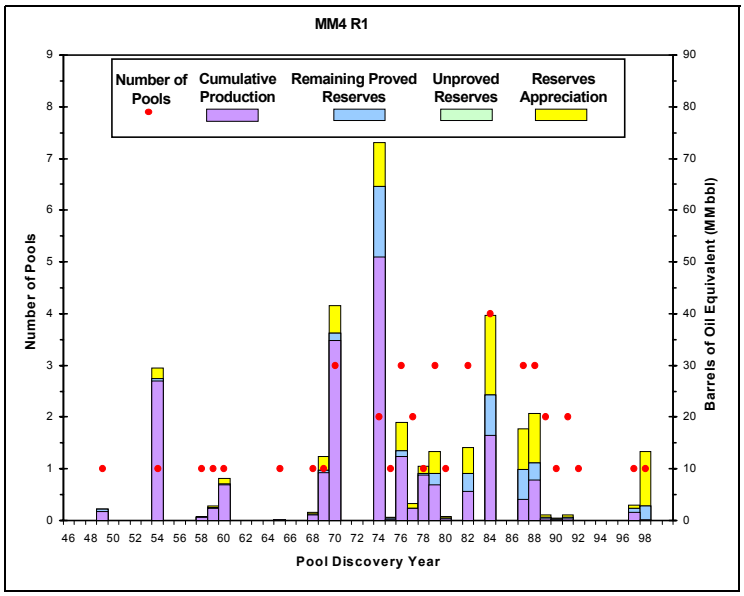

Figure 2. Exploration history graph showing reserves addition and number of pool discoveries by year.

MM4 R1 Play 45 Pools 90 Sands	Minimum	Mean	Maximum
Water depth (feet)	31	74	190
Subsea depth (feet)	3835	6967	13187
Number of sands per pool	1	2	7
Porosity	24%	28%	33%
Water saturation	17%	31%	55%

Table 1. Pool attributes. Values are volume-weighted averages of individual reservoir attributes.

Play Description

The established Lower Middle Miocene Retrogradational (MM4 R1) play occurs within the *Gyroidina* "K," *Cristellaria* 54/*Eponides* 14, *Robulus* 43, and *Amphistegina* "B" biozones. This play extends from the South Padre Island Area offshore Texas through the East Cameron Area offshore Louisiana (figure 1).

Updip, the play continues onshore into Texas and Louisiana. To the east, west, and downdip, the play grades either into the sediments of the Lower Middle Miocene Progradational (MM4 P1) play or the Lower Middle Miocene Aggradational (MM4 A1) play.

Play Characteristics

Retrogradational sediments are characterized by the reworking of shelf sands during relative sea level rises. Thin, reworked MM4 R1 sands exhibit an upward-fining, back-stepping log signature and are overlain by a thick shale sequence associated with one of the *Gyroidina* "K," *Cristellaria* 54/*Eponides* 14, *Robulus* 43, or *Amphistegina* "B" flooding events. The MM4 retrogradational interval varies from approximately 100 feet to more than 2,600 feet in thickness, with net sand thicknesses as much as 300 feet. Individual MM4 R1 sands are, at the most, a few tens of feet thick and are interbedded with shales of the same thickness. The overlying shales associated with the *Amphistegina* "B" flooding event are over 1,000 feet thick and mark the transition to the younger middle middle Miocene (MM7) deposits.

Productive MM4 R1 sequences are associated with three distinct marine transgressions. They are, from oldest to youngest, the *Cristellaria* 54/*Eponides* 14, which occurs in the Brazos and Galveston Areas; the *Robulus* 43, which occurs from the Mustang Island to West Cameron

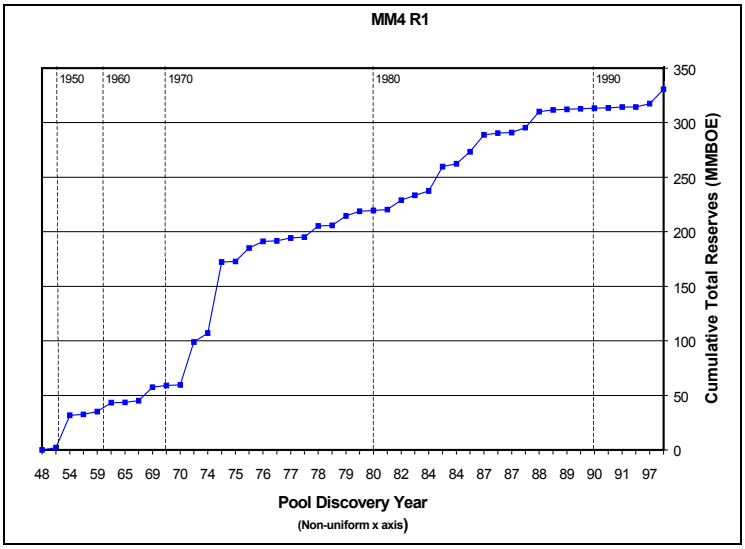

Figure 3. Plot of pools showing cumulative reserves by discovery order. Note the non-uniform x axis.

MM4 R1 Play Marginal Probability = 1.00	Number of Pools	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)
Reserves				
Original proved	45	0.036	1.192	0.248
Cumulative production	–	0.030	0.967	0.202
Remaining proved	–	0.006	0.225	0.046
Unproved	0	0.000	0.000	0.000
Appreciation (P & U)	–	0.007	0.428	0.083
Undiscovered Conventionally Recoverable Resources				
95th percentile	–	0.003	0.148	0.032
Mean	11	0.008	0.201	0.044
5th percentile	–	0.016	0.269	0.060
Total Endowment				
95th percentile	–	0.045	1.768	0.363
Mean	56	0.050	1.821	0.375
5th percentile	–	0.058	1.889	0.391

Table 2. Assessment results for reserves, undiscovered conventionally recoverable resources, and total endowment.

Area; and the *Amphistegina* "B," which occurs from the North Padre Island to East Cameron Area. The lateral expansion of these sequences through MM4 time reflects not only the magnitude of the marine transgressions but also the increased sand influx from delta systems located in the Louisiana area.

The majority of fields in MM4 R1 are structurally associated with normal faults and simple anticlines. Other less common structures are associated with growth fault anticlines, and salt or shale diapirs with traps on the flanks of the diapir or in sediment drape over the diapir. Seals are provided by the juxtaposition of reservoir sands with shales and salt, either structurally (e.g., faulting, diapirism) or stratigraphically (e.g., lateral shale-outs, overlying shales).

Discoveries

The MM4 R1 gas play contains total reserves of 0.042 Bbo and 1.620 Tcfg (0.331 BBOE), of which 0.030 Bbo and 0.967 Tcfg (0.202 BBOE) have been produced. The play contains 90 producible sands in 45 pools (table 1; refer to the Methodology section for a discussion of reservoirs, sands, and pools). The first reserves in the play were discovered in the West Cameron 45 field in 1949 (figure 2). The maximum yearly total reserves of 73 MMBOE were added in 1974 when two pools were discovered, including the largest pool in the play in the West Cameron 66 field. The West Cameron 66 field has 65 MMBOE in total reserves. Ninety-nine percent of the play's cumulative production and 95 percent of the play's total reserves have come from pools discovered before 1990. The most recent discovery, prior to this study's cutoff date of January 1, 1999, occurred in 1998.

The 45 discovered pools pools contain 183 reservoirs, of which 161 are nonassociated gas, 9 are undersaturated oil, and 13 are saturated oil. Cumulative production has consisted of 85 percent gas and

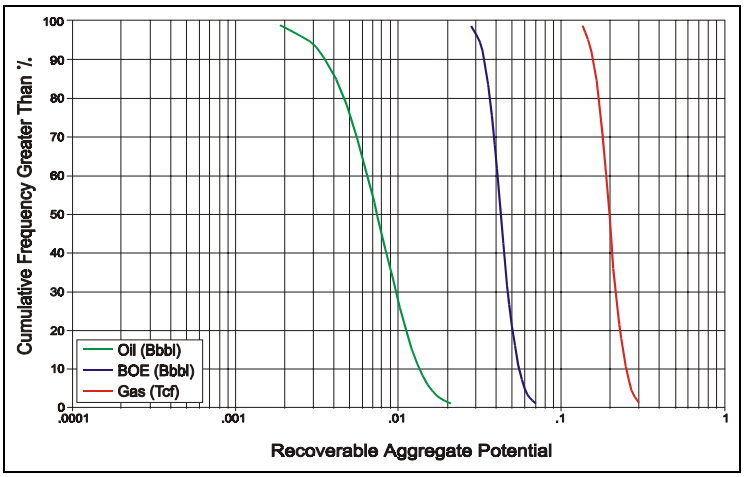

Figure 4. Cumulative probability distribution for undiscovered conventionally recoverable resources.

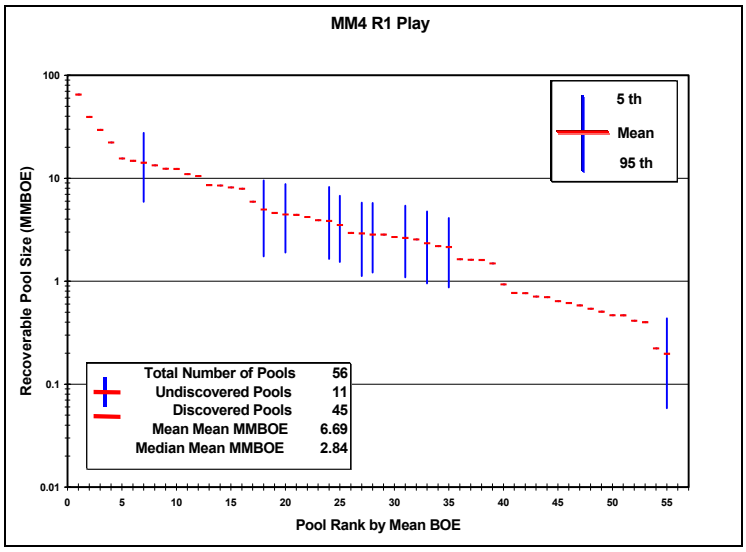

Figure 5. Pool rank plot showing the number of discovered pools (red lines) and the number of pools forecast as remaining to be discovered (blue bars).

15 percent oil.

Assessment Results

The marginal probability of hydrocarbons for the MM4 R1 play is 1.00. The play contains a mean total endowment of 0.050 Bbo and 1.821 Tcfg (0.375 BBOE) (table 2). Fifty-four percent of this BOE mean total endowment has been produced.

Assessment results indicate that undiscovered conventionally recoverable resources (UCRR) have a range of 0.003 to 0.016 Bbo and 0.148 to 0.269 Tcfg at the 95th and 5th percentiles, respectively (figure 3). Mean UCRR are estimated at 0.008 Bbo and 0.201 Tcfg (0.044 BBOE). Of the four retrogradational plays, the MM4 R1 play contains the most UCRR. These undiscovered resources might occur in as many as 11 pools. The largest undiscovered pool, with a mean size of 14 MMBOE, is forecast as the seventh largest pool in the play (figure 4). The next four largest undiscovered pools are forecast to occupy positions 18, 20, 24, and 25 on the pool rank plot. For all the undiscovered pools in the MM4 A play, the mean mean size is 4 MMBOE compared with the 7 MMBOE mean size of the discovered pools. The mean mean size for all pools, including both discovered and undiscovered, is 7 MMBOE.

BOE mean UCRR contribute 12 percent to the play's mean total endowment.