The Past and Future of the Gulf of Mexico OCS Shelf

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Abstract

The recent past of the Gulf of Mexico OCS Shelf provides the best indicator of its future. This paper examines that past in detail to provide strategic directions for the future exploration and development of the federal shelf.

From 1991 to 1998, reserve additions on the federal shelf totaled an impressive 6.66 billion barrels oil equivalent, nearly 70% of which was natural gas. These additions came predominantly from reserve growth (essentially extensions and new pool discoveries) in older fields, not from new field discoveries. Recent (1989-1998) discoveries accounted for less than 16% of total reserve additions on the shelf. Reserve growth from older fields was so predominant that average absolute growth in older fields was more than 25% larger than the average size of recent discoveries. Moreover, reserve growth by field was often substantial. Nearly 10% of the older fields on the shelf (65 of 681) had recent reserve additions greater than 25 million barrels oil equivalent.

Further insight into future possibilities is provided by an examination of recent shelf reserve additions by broad groups of lease areas, by geologic age, and by play type (combinations of reservoirs by chronostratigraphic age and depositional style). This analysis highlights the most likely possibilities for successful future exploration and development.

Introduction

The common view today is that any survey of the past and future of the Gulf of Mexico OCS shelf must be highly asymmetric. On the one hand, there is a glorious past to recount. During the past half-century, exploration and development on the shelf has not only proved up one of the major petroleum provinces of the world. It has also been the lead force behind many major developments in both offshore technology and geological thinking. On the other hand, the view of an increasing number of companies and individuals is that there is no future to the shelf, at least no future that merits their participation. At best, any survey of the future of the shelf can only be a tiny pamphlet.

This paper contests this common view. Its theme explicitly combines the theme of this year's GCACS convention: "Remember the Past - Visualize the Future". Rather than implying two distinct, separate activities, this survey of the past and future of the Gulf of Mexico OCS shelf argues for an integrated, seamless perspective: "Remember the Past to Visualize the Future". More specifically, it is only through a careful and extensive analysis of the shelf's past, including both what happened and what did not happen, that we can have a realistic basis for understanding what is likely to occur in its future.

In analyzing the past and envisioning the future of the Gulf of Mexico OCS shelf, this paper focuses on reserve additions, their rates, composition, and distribution. Reserve additions are the primary focus because they encompass many other traditional variables of upstream analyses. They are the goal and measure of success of drilling activity. When coupled with historic production data, they provide replacement rate data and thus the ability to forecast realistically future production. Aggregated over time, they add up to known petroleum resources.

The source of data on reserve additions used in this paper is the Significant Oil and Gas Fields of the Gulf of Mexico Database, a subset of NRG Associates' Significant Oil and Gas Fields of the United States Database. This database not only provides production and size histories by field and major reservoir from 1982 to 1998; it also combines these data with a variety of field and reservoir characteristics, thereby permitting a broad range of analyses. Aggregated, the recent reserve additions in this database by field and reservoir are within 0.5% of the reserve additions for the Gulf of Mexico OCS reported by the Energy Information Administration between 1991 and 1998.

The Past

Recent reserve additions on the Gulf of Mexico OCS Shelf are impressive (Table 1). From 1991 to 1998, reserve additions on the shelf were 6.57 billion BOE. These reserve additions were predominantly natural gas (69%), with crude oil (20%) and natural gas liquids (11%) providing relatively minor proportions of the total.

Table 1. Recent reserve additions and ultimate recovery by product on the Gulf of Mexico OCS Shelf.

	Crude Oil (million bbls)	NGL (million bbls)	Natural Gas (Bcf)	BOE (million bbls)
1983-1990 Reserve Additions	1,886	664	30,982	7,713
1990-1998 Reserve Additions	1,307[a]	721	27,232	6,567
Est. Ultimate Recovery, 12-31-1998	9,723	3,244	146,103	37,317

a. Source: NRG Associates, The Significant Oil and Gas Fields of the Gulf of Mexico Database

The impressive level of reserve additions on the OCS shelf is best illustrated by a comparison between them and reserve additions in the U.S. as a whole. By the end of 1998, ultimate recovery on the shelf was a healthy 9.1% of ultimate recovery in the United States (37.3 out of 409.8 billion BOE). Drilling on the shelf has proved up 5.1% of the ultimate recoverable resources of U.S. crude oil, 13.6% of U.S. natural gas, and 8.2% of U.S. NGL. From 1991 to 1998, the shelf outdid itself, providing 15.4% of total U.S. reserve additions of 42.6 billion BOE. This superior performance was demonstrated in every product. The shelf accounted for 10.2% of national crude oil additions, 19.4% of natural gas additions, and 11.3% of NGL additions.

Recent shelf reserve additions are a predominant proportion of ultimate recovery on the shelf. In 52 years of exploration and development, 37.3 billion BOE were added on the shelf to U.S. petroleum reserves (Table 1). Recent additions account for 17.6% of this amount. The proportion of ultimate recovery provided by recent additions varies substantially by product. Only 13.6% of shelf crude oil ultimate recovery was added recently, but 18.6% of natural gas and 22.2% of natural gas liquids were added from 1991 to 1998. The recent rate of reserve additions (821 million BOE per year) was 17.5% higher than the average 699 million BOE added per year from 1947 through 1990, the result of higher rates of additions for both natural gas and natural gas liquids

Recent booked reserve additions on the OCS shelf were considerably greater than recent booked reserve additions on the OCS slope (those areas beyond a 200m water depth). Total shelf additions were nearly 80% greater than the 3.68 billion BOE booked on the slope. Once likely unbooked additions from recent discoveries are figured into the comparison, the two areas are much more equal, each exceeding seven billion BOE. The composition of additions by product between the two areas are vastly dissimilar. Recent slope additions are predominantly liquids (nearly 55% being crude oil). Natural gas accounts for only a third of recent slope additions.

Recent reserve additions on the shelf do not compare as well with the immediately prior rate of reserve additions. Recent reserve additions were 15% less than the reserve additions of 7.71 billion BOE from 1983 through 1990. This overall decline was primarily the result of a sharp drop (31%) in crude oil reserve additions from the previous period. By comparison, gas additions dropped only modestly (down 12%) while natural gas liquids additions actually increased (up 9%). The total trend is disquieting because 3-D seismic only began to be widely used on the shelf after 1990. Its availability plus an improved natural gas market were not enough to stem the gradual depletion of new possibilities.

Recent reserve additions on the shelf were also a relatively smaller proportion of national reserve additions. From 1983 to 1990, reserve additions on the shelf provided 17.5% of national reserve additions, compared with 15.4% from 1991 to 1998. Because natural gas reserve additions were particularly low onshore from 1983 to 1990, shelf additions were nearly one-third (31.2%) of the national total. As gas additions nearly doubled onshore in 1991-1998, the proportion of the national total from the shelf dropped dramatically. Despite this small proportional decline, the shelf has been a consistent growth area. Since 1982, its share of ultimate recovery nationwide has grown from 7.1% to 9.1%.

Recent reserve additions differ substantially by broad area across the OCS shelf. To simplify the analysis, the OCS shelf was divided into six areas: South Texas (South Padre Island to Brazos), North Texas (Galveston and High Island), West Louisiana (West Cameron to Vermilion), Central Louisiana (South Marsh Island to South Timbalier), East Louisiana (Grand Isle to Chandeleu), and MAFLA (Destin Dome, Mobile, Pensacola, and northern Viosca Knoll) (Table 2). In terms of absolute additions, the most important of these areas historically (the three

Table 2. Recent reserve additions and ultimate recovery by area on the Gulf of Mexico OCS Shelf.

	1983-1990 Reserve Adds (million BOE)	1991-1998 Reserve Adds (million BOE)[a]	Ult. Recovery 12-31-1998 (million BOE)
South Texas	947	611	1,918
North Texas	938	685	3,192
West Louisiana	1619	1137	8,792
Central Louisiana	2604	2471	14,848
East Louisiana	1443	1353	8,096
MAFLA	163	309	472
Total	7713	6567	37,317

a. Source: NRG Associates, The Significant Oil and Gas Fields of the Gulf of Mexico Database

Louisiana areas) were also the most important recently, with more than 75% of all 1991-1998 additions. Proportionately, the three smaller areas (South Texas, North Texas, and MAFLA) increased the most. (Nearly 85% of the estimated ultimate recovery in South Texas and MAFLA has been added to reserves since 1982.)

Proportionately high rates of recent additions to ultimate recovery are not an unambiguous indicator of future potential. Two of the areas with the highest proportional increase (South Texas and North Texas) were also two of the areas with the largest decrease in reserve additions from 1983-1990 to 1991-1998. In the three western areas, reserve additions dropped nearly 31% from the prior eight years to the most recent eight years. In sharp contrast, reserve additions in the three eastern areas fell only 2%.

The reason for this difference becomes clearer if we examine changes in reserve additions by type of addition. The basic distinction used will be that between additions from new field discoveries and additions from older fields. On the Gulf of Mexico shelf, the latter includes better drainage from known recoveries, discoveries of new fault blocks in known sand bodies, discoveries of new sand bodies, and discoveries of new reservoirs of exploratory significance. Table 3 shows recent reserve additions by type and by area for two eight-year periods: 1983 to 1990 and 1991 to 1998. For the former period, additions from new field discoveries are from all fields discovered between 1981 and 1990. For the latter period, additions from new field discoveries are from all fields discovered between 1989 and 1998. The two additional years added before each period allows for most of the usual lags between discovery and development on the shelf.

Between 1983 and 1990, new field discoveries accounted for 30% of all reserve additions on the shelf. By 1991 to 1998, new field discoveries had dropped to less than 16% of all additions. From the former to the latter period, additions from new field discoveries plummeted 55%. In sharp contrast, despite decades of prior development, reserve additions from older fields increased 29%.

These changes in reserve additions by type were not uniform across all areas. In five of the six areas, reserve additions from new field discoveries sank by 60 to 70%. In the East Louisiana lease areas, reserve additions from new field discoveries increased by 42% thanks to a number of substantial discoveries in the Main Pass area. In the three western areas, reserve additions from older fields dropped by 9%. In the three eastern areas, they increased by 10%. The greater geological complexity of the eastern and central Louisiana lease areas appears to have offered greater opportunity there for reserve additions in older fields.

Examining average additions by field (Table 4) helps clarify why reserve additions in older fields are becoming increasingly important on the shelf. In both 1983-1990, and 1991-1998 average reserve additions per field from older fields were 27% larger than the average size of new field discoveries. This margin occurred despite a large and growing proportion of older fields with negative revisions. In 1983-1990, 21% of older fields shrunk in size; by 1991-1998, 26% of all older fields on the shelf shrunk. Without these underperformers, older fields would have had a 75% margin over new discoveries in terms of average additions per field by 1991-1998. The shelf offers a clear demonstration of the maxim that it is easier to find new reserves in known fields than in new discoveries.

Table 3. Recent reserve additions by type and area on the Gulf of Mexico OCS Shelf (million BOE).

	1983-1990 Reserve Adds		1991-1998 Reserve Adds	
	New Fields	Older Fields	New Fields	Older Fields
South Texas	400	547	137	475
North Texas	362	576	143	543[a]
West Louisiana	552	1067	168	969
Central Louisiana	607	1997	217	2254
East Louisiana	219	1223	312	1041
MAFLA	163	0	58	251
Total	2303	5410	1034	5533

a. Source: NRG Associates, The Significant Oil and Gas Fields of the Gulf of Mexico Database

Table 4. Average recent reserve additions by field, type and area on the Gulf of Mexico OCS Shelf (million BOE).

	1983-1990		1991-1998	
	New Fields	Older Fields	New Fields	Older Fields
South Texas	10.5	17.1	4.9	7.1
North Texas	7.5	8.1	3.9	4.6
West Louisiana	9.4	8.1	[a]5.6	5.1
Central Louisiana	11.2	15.0	7.0	11.9
East Louisiana	7.8	20.4	15.6	11.1
MAFLA	54.3	0.0	3.9	12.0
Total	10.0	12.7	6.4	8.1

a. Source: NRG Associates, The Significant Oil and Gas Fields of the Gulf of Mexico Database

New field discoveries suffered from a double whammy in 1991-1998. Not only was the average size of new field discoveries down 36% from its 1983-1990 average; the number of new field discoveries also dropped 30%. Although the average size of reserve additions in older fields was down 31%, the number of older fields was 60% higher than it was in 1983-1990, permitting an overall increase in reserve additions from older fields.

Average reserve additions from older fields declined sharply in the three western areas; by comparison, in the three eastern areas average reserve additions declined only moderately. Moreover, average reserve additions per field from older fields in the three eastern areas were more than double average reserve additions per field in the three western areas. The decline in the average size of new discoveries was nearly universal across all areas. The East Louisiana area (which had five of the seven largest new field discoveries on the shelf in 1991-1998, all in the Main Pass lease area) was the only exception to this trend, the average size of new discoveries actually doubling there.

The distribution of reserve additions by amount added per field further clarifies why older fields have become so important (Table 5). In both recent time periods, the largest reserve additions were disproportionately in older fields. From 1983 to 1990, older fields were 77% of the fields with more than 25 million BOE of reserve additions. By 1991-1998, they accounted for 88% of the fields with this level of additions. The number of new field discoveries at least this size dropped 57% from the former to the latter period; the number of older fields with this level of reserve additions dropped only 7%.

The same trend holds true for fields in the mid-range of size additions (5-25 million BOE). In 1983 to 1990, older fields provided accounted for 60% of the fields with this range of additions. By 1991 to 1998, they provided 82% of the fields with this level of additions. The number of new discoveries this size dropped 52% from the former to the latter period; the number of older fields with this level of additions increased 46%.

The most surprising aspect of the concentration of recent reserve growth in older fields is that it was **not** primarily a case of the big fields getting bigger. As of the end of 1998, there were 103 national class giant fields (100 million BOE or more ultimate recovery) on the Gulf of Mexico OCS shelf. Only 17 of these fields became giant fields because of 1991-1998 reserve additions. These fields provide the dominant share of ultimate recovery on the Gulf of Mexico shelf (23.28 out of 37.32 billion BOE or 62.4%). However, they provided a much lesser share of 1991-1998 reserve additions (3.00 out of 6.57 billion BOE or 45.7%). The great majority (nearly 90%) of giant fields on the shelf grew in the 1990s, but they tended to grow by only modest amounts proportionately. From 1990 to 1998, the average growth in ultimate recovery in these giant fields was only 14.8%. On reflection, the lack of dominance in giant fields in recent reserve additions seems to be a reflection of their discovery and development histories. Most of these giant fields were discovered in the 1950s and 1960s. Because most were recognized early as major fields, they were treated throughout their history as core assets by their operators. Thus by the 1990s, they had already experienced several cycles of reevaluation and reexploration, leaving in most relatively few reserves still to be added.

By comparison, ultimate recovery in the older non-giant fields on the shelf increased 24.2% from 10.47 to 13.00 billion BOE during 1991-1998. This was primarily the result of spectacular percentage growth in about 20% of these fields. Of the 260 older fields with at least 5 million BOE recent reserve additions, 120 grew at least 50% and 77 grew more than 100% from their 1990 size. Recent

Table 5. Distribution of recent reserve additions by amount added and type on the Gulf of Mexico OCS Shelf.

Amount of Reserve Adds (million BOE)	1983-1990		1991-1998	
	New Fields	Older Fields	New Fields	Older Fields
>100	2	5	0	4
50-100	6	23	3	18
25-50	13	42	6	43
10-25	46	80	19	121
5-10	43	54	24	74
1-5	96	141[a]	80	152
0-1	24	44	29	93
Negative				
Total # Fields	230	427	161	681

a. Source: NRG Associates, The Significant Oil and Gas Fields of the Gulf of Mexico Database

large reserve additions in older fields were thus disproportionately concentrated in previously small and medium - sized fields, advancing them to larger size categories. In the late 1990s, one interesting sidelight of this phenomenon has been the revitalization of previously abandoned small fields through substantial new pool discoveries.

The analysis of reserve additions benefits from the use of more than one perspective. The prior analysis used aggregations of field level data. The following analysis uses aggregations of reservoir level data. The reservoir level data is aggregated primarily by broad geologic age. These aggregations are either by system in the Mesozoic (Jurassic and Cretaceous) or by series in the Cenozoic (Oligocene, Miocene, Pliocene, and Pleistocene). In identifying reservoirs by geologic age, this analysis employs the internationally recognized Plio-Pleistocene boundary (1.6 million years b.p.) instead of the traditional boundary used by many Gulf Coast geologists. Specifically, the Upper Pliocene used in this analysis is equivalent to the Lower Pleistocene as defined by the MMS.

Historically, Miocene, Pliocene, and Pleistocene reservoirs have monopolized discoveries on the shelf. As of the end of 1998, reservoirs of these three series contained 99% of shelf ultimate recovery (Table 6). Miocene reservoirs are predominant, with 15.48 billion barrels BOE, 41.5% of the total. Pliocene reservoirs are right behind with 14.99 billion barrels BOE, 40.2% of the total. Pleistocene reservoirs, with 6.47 billion barrels BOE, provide 17.3% of the total. Older reservoirs - Oligocene, Cretaceous, and Jurassic - currently have only 0.38 billion BOE ultimate recovery.

Recent reserve additions have changed the dominance of younger reservoirs only slightly. Miocene, Pliocene, and Pleistocene reservoirs provided 96.5% or 6.33 billion BOE of recent additions. The Pliocene dominated with 44.2% of the total, narrowing the gap between it and the Miocene for overall leadership. The Miocene was still substantial, having 36.3% of all additions. The Pleistocene also slipped slightly, having only 15.9% of all additions. Nearly 60% of all Jurassic ultimate recovery was added to reserves from 1991 to 1998, while both the Oligocene and the Cretaceous first became measurable objectives only during the 1990's.

Like reserve additions on the field level, reserve additions from new reservoir discoveries can be divided into additions from new reservoir discoveries and additions from older reservoirs. Table 7 shows the composition of recent reserve additions by both type of addition and geologic age. New reservoir discoveries include both all reservoirs in new fields discoveries and all new reservoirs of exploratory significance in older fields. New reservoirs of exploratory significance are those in which the combination of the specific chronostraphic age and the depositional type of the reservoir are different from all previous discoveries within a field. Recent new reservoir discoveries refer to all reservoirs discovered between 1989-1998.

Like reserve additions on the field level, recent reserve additions on the reservoir level are dominated by additions to older reservoirs, not by new reservoir discoveries. Additions in older reservoirs accounted for 4.80 billion BOE, 73.1% of all recent additions. New reservoir discoveries were only 1.77 billion barrels, only 26.9% of the total. Of these, 1.03 billion barrels BOE came from new reservoirs in new fields while 0.74 billion barrels BOE came from new reservoirs in older fields.

Surprisingly, given that the earliest exploration on the shelf was predominantly for Miocene objectives, of the three dominant reservoir ages, new reservoir discoveries were most important in the Miocene. Nearly half of all recent additions from new reservoirs were in Miocene reservoirs. By comparison, new reservoir discoveries in the Pliocene added relatively little to Pliocene reserves.

The MMS has identified all major reservoirs (= MMS pools) in the Gulf of Mexico OCS by both chronostratigraphic age and depositional type. This combination provides their primary criteria for defining plays in the Gulf of Mexico. Their depositional types and the resulting plays can be characterized by two broad categories; *paleo-shelf* plays (aggradational, progradational, and retrogradational) and *paleo-slope* plays (submarine fan). These two categories provide a useful tool for examining recent reserve additions. (For convenience, the non-marine Jurassic Norphlet is included with the paleo-shelf plays.)

Paleo-shelf plays (including the non-marine Jurassic) dominate recent reserve additions on the shelf, accounting for 69.5% of all recent additions. This dominance reflects an even greater dominance in ultimate recovery. As of the end of 1998, paleo-shelf plays accounted for 83.5% of shelf ultimate recovery. Paleo-shelf plays may be dominant, but paleo-slope plays are emerging as a significant exploration and development objective on the shelf. Reserve additions from paleo-slope plays between 1991 and 1998 added 48.2% to paleo-slope ultimate recovery as of the end of 1990. By comparison, recent reserve additions from paleo-shelf plays added only 17.1% to paleo-shelf ultimate recovery (Table 8).

Table 6. Recent reserve additions and ultimate recovery by geologic age on the Gulf of Mexico OCS Shelf.

Geologic Age	1991-1998 Reserve Additions (million BOE)[a]	Est. Ultimate Recovery 12-31-1998 (million BOE)
Pleistocene	1,044	6,467
Pliocene	2,903	14,990
Miocene	2,387	15,477
Oligocene	6	6
Cretaceous	4	4
Jurassic	223	373
Total	6,567	37,317

a. Source: NRG Associates, The Significant Oil and Gas Fields of the Gulf of Mexico Database

Table 7. Composition of recent reserve additions by type of addition and geologic age on the Gulf of Mexico OCS Shelf.

Geologic Age	New Reservoir Discoveries (million BOE)	Additions to Older Reservoirs (million BOE)	Total 1991-1998 Additions (million BOE)
Pleistocene	290	754	1044
Pliocene	591	2312	2903
Miocene	819	1568	2387
Oligocene	6	0	6
Cretaceous	4	0	4
Jurassic	60[a]	163	223
Total	1770	4797	6567

a. Source: NRG Associates, The Significant Oil and Gas Fields of the Gulf of Mexico Database

The rapid recent growth rate in paleo-slope ultimate recovery occurred in Miocene, Pliocene, and Pleistocene reservoirs, each increasing from 47 to 57%. Paleo-slope plays in the Pliocene accounted for nearly 40% of recent Pliocene reserve additions, primarily because Pliocene paleo-slope reservoirs can be found across a large area of the shelf and are not too deep. By comparison, because the Pleistocene shelf edges are close to the current shelf edge, the area in which Pleistocene paleo-slope reservoirs can be found on the current shelf is highly limited. Miocene paleo-slope reservoirs tend to be deeper than Pliocene paleo-slope reservoirs and thus have not yet been as extensively explored.

Because paleo-slope reservoirs are a relatively new exploratory and development objective on the shelf, reserve additions in them are considerably more likely to come from new reservoir discoveries. Of the 2.01 billion BOE recent reserve additions from paleo-slope reservoirs, 38.3% came from new reservoir discoveries (49.6% of the Miocene additions, 28.1% of the Pliocene additions, and 62.8% of the Pleistocene additions). By contrast, only 22.0% of recent reserve additions from paleo-shelf reservoirs came from new reservoir discoveries.

Table 8. Composition of recent reserve additions by paleo-depositional environment and geologic age on the Gulf of Mexico OCS Shelf.

Geologic Age	Paleo-Shelf Plays (million BOE)	Paleo-Slope Plays (million BOE)	Total 1991-1998 Additions
Pleistocene	896	148	1044
Pliocene	1757	1146	2903
Miocene	1675	712	2387
Oligocene	6[a]	0	6
Cretaceous	4	0	4
Jurassic	223	0	223
Total	4561	2006	6567

a. Source: NRG Associates, The Significant Oil and Gas Fields of the Gulf of Mexico Database

The Future

The ultimate recoverable petroleum resources of the Gulf of Mexico OCS shelf are likely to be between 45 and 54 billion BOE. In other words, there is a high probability that at least 8 billion BOE still remains to be added to shelf reserves and a low probability that future reserve additions will exceed 17 billion BOE. The recent continuing high rates of reserve additions through growth in existing fields, the relative lack of exploration and development for deep objectives, and the subsalt potential on the shelf strongly support the lower range of this estimate. The recent declines in both the number and size of new field discoveries, the large proportion of lease blocks already assigned to fields, and the growth to date in reservoirs less than 12,000 feet deep in existing fields together make it highly unlikely that the upper range of this estimate will be exceeded.

Given the number of companies currently emphasizing shelf reexploration as an essential component of either a growth or cash flow strategy and given favorable natural gas prices, annual rates of reserve additions on the shelf are likely to average 700 to 800 million BOE for the next several years. If future reserve additions only prove to be at the lower end of the preceding estimate, this rate of reserve additions will be declining by 2005. If reserve additions are closer to the higher end of the preceding estimate, this rate of reserve additions could be extended beyond 2010.

Which point within the estimated range proves to be correct will have major consequences for both U.S. gas production and jackup demand in the Gulf of Mexico. In 1998, the OCS shelf provided 4.0 Tcf (21%) of U.S. gas production. A substantial decline in OCS shelf production in the latter half of this decade would seriously impede efforts to increases domestic gas production. Declining opportunities on the shelf and the subsequent fall in drilling demand would make it unnecessary to replace the older portions of the jackup fleet as they reach the end of their economic lives during the next decade.

Like recent additions, future additions reserve additions on the shelf will be predominantly natural gas (70-75% or 34-76 Tcf). As operators continue to push their search toward deeper objectives, the share of oil in future additions (15-17.5% or 1.2-3.0 billion bbls) will continue to decline. Major oil additions are only likely from subsalt objectives. Natural gas liquids will continue to provide much the same proportion (10 - 12.5% or 0.8-2.1 billion barrels) of future additions as they have of recent additions.

Unless several major discoveries are made in both the subsalt and the currently unleased portions of the MAFLA lease areas, new field discoveries will provide only a small proportion (10-15% or 0.8-2.5 billion BOE) of future reserve additions. Even with several national-class giant discoveries from these two objectives, other potential new field objectives are becoming both too small and too few to provide really large additions to future reserves.

New reservoirs of exploratory significance in older fields will likely become even more important than new field discoveries for future reserve additions, particularly if deeper, paleo-slope reservoirs fulfill their promise. Thus reserve additions from older reservoirs in older fields will continue to dominate future reserve additions, just as they have dominated recent reserve additions. Overall, 50-75%

of future reserve additions will come from growth in existing major reservoirs of known producing fields.

Future reserve additions will be concentrated in the eastern and central lease areas of the Gulf of Mexico OCS. Except for parts of the High Island lease area, the Texas lease areas lack the geological complexity of the Louisiana lease areas and thus do not offer as many opportunities for future growth. This relative lack of potential is reflected in the pronounced declines in reserve additions in these areas from the 1980's to the 1990's. The Louisiana lease areas have substantial new field potential subsalt, new reservoir potential in deeper objectives, and many remaining new sand body and new fault block objectives in existing reservoirs. Because much of the MAFLA shelf is still unleased, it has the most potential for large relative growth. Nonetheless, it is still likely to have the least ultimate resources of any of the six shelf areas.

Stratigraphically, future reserve additions will be concentrated in Miocene and Pliocene objectives. These still provide the bulk of untested sediments. The Pleistocene, while still easily remaining the third most important objective, is likely to diminish in importance, primarily because of its limited area on the outer shelf and its comparatively shallow (and thus more thoroughly evaluated) depths. The Cretaceous will show the highest growth rates, primarily because it is starting from such a low level. Future Jurassic potential is concentrated within some of the unleased portions of the MAFLA lease areas.

The outlook for future reserve additions by broad paleo-depositional environment is mixed. The importance of paleo-slope reservoirs for Miocene additions is likely to increase as deep exploration becomes more widespread. In the Pliocene, future paleo-slope reserve additions will likely remain around 40% of all Pliocene additions. Similarly, Pleistocene paleo-shelf plays are likely to provide only 15-20% of future Pleistocene reserve additions.

Conclusion

The Gulf of Mexico OCS shelf must, in conventional terms, be considered a highly mature petroleum province. It has now been explored for more than fifty years. For more than the past thirty years, all of the shelf has been technically accessible. It has been a major focus of many companies' upstream strategies for decades. This has in turn generated intense competition for the opportunities it has presented to the industry.

Although the Gulf of Mexico OCS shelf is, in conventional terms, a highly mature petroleum province, it is nonetheless a highly mature province with a difference. Unlike most other mature provinces, the Gulf of Mexico OCS shelf has both an unusually thick sedimentary section with potentially productive reservoirs throughout that section and an unusual degree of structural complexity because of the extensive movement of the Jurassic salt. Thus, although the shelf is highly mature **extensively**, many opportunities remain for more **intensive** exploration. Despite the usual pessimists, there is a future for the shelf, both to be visualized and to be realized in the years ahead.

Notes