# Deep-water Gulf of Mexico Basin: An Overview of Its Petroleum Exploration

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The Gulf of Mexico Basin is one of the most prolific petroleum provinces in the world. The present-day deepwater portion of the Gulf of Mexico has been explored since mid 1970's. Exploration and development activities have increased significantly during the last couples of years. Since then, over 600 wildcat wells have been drilled in the various deep-water plays in the basin, and industry has leased in excess of 4300 lease blocks covering a cumulative area of more than 38,700 square miles. This activity has been caused by several factors including significant discoveries in deep-water, outstanding reservoir performance in some these discoveries, innovative production techniques, and new Federal royalty relief (Weimer et al, 1998a).

There have been 121 discoveries made in the province during the period from 1975 to the end of 1998 with the mean size of these discoveries is 96.5 MMBOE (Cossey, 1999) and the largest field found to date is Mars (720 MMBOE). Despite the abundance of drilling and leasing in the basin, some deepwater Gulf of Mexico plays are still in the unproven stage.

## *Exploration Focus*

The center of attention for hydrocarbon exploration has been in the present-day slope where water depth ranging approximately from 200 to 2000 meters.

This area mostly lies within the tabular salt and minibasin province of Diegel et al (1995). Interplay of salt tectonics and sedimentation dominates the geology, reflected in the formation and filling of slat-withdrawal intraslope basins. As the consequences, these sub-basins have pronounced paloetopographic relifes, massive salt walls, and circular to elliptical mapview. External factors dictated the volume and type of systemwide clastic input. Regional factors, such as nearby salt structures and the position of the feeder deltas, controlled the dispersal of clastics. Local factors, such as the thickness of underlying salt, influenced minibasin specific evolution.

Neogene turbidite systems are major reservoirs and exploration targets in the Gulf of Mexico (Figure 2). In some areas the key defining element of the play is the absence of an allochthonous salt layer between the Pre-Tertiary source rock interval and the Neogene reservoir succession, which is deposited in local lower slope salt basins. In this kind of prospects, access to charge is not impeded by an intervening salt layer, and charge timing is not dependent on welding of a salt layer to allow passage of hydrocarbons into the prospective section. Trap style is most commonly structural (4-way dip or 3-way dip against a fault or salt), although lateral trap boundaries are sometimes stratigraphic.

In general, the target is sand-prone section deposited in a depositional basin center or basin flank position that was subsequently structurally inverted due to local salt movement.

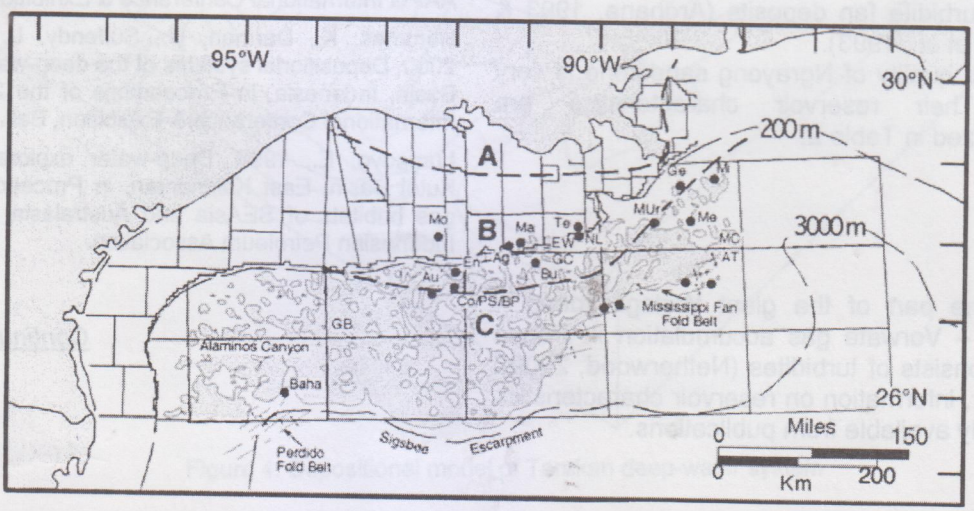



Figure 1: Gulf of Mexico Basin in relation to central southern portion of northern America (after Weimer et al, 1998a)

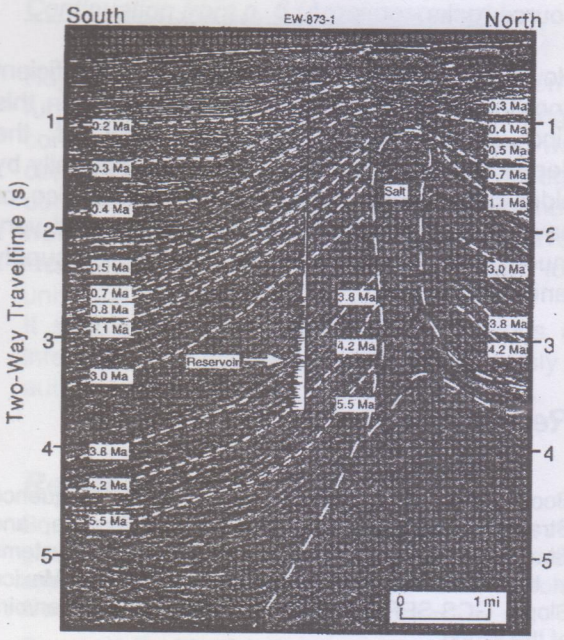



Figure 2: Typical seismic section of GoM showing characteristic play type of deep-water reservoirs against salt diapers (Weimer et al, 1998b)

The more challenging exploration areas are the abyssal play and the Perdido Foldbelt outboard of the allochthonous salt canopy/ the minibasin province.

In the abyssal area, reservoir quantity, trap definition and source rock presence are all critical risks for the play. The Miocene objectives are expected to have subtle or no amplitude support whereas the Pleistocene objectives are expected to have. Traps in both parts of the section are very subtle 4-way dip traps resulting from flexure and/or differential compaction over underlying structural or stratigraphic features. Trap definition is risky because trap presence and position can be affected by overlying laterally variant seismic velocities. Source rock presence has not been proven in this setting by well data, sea floor seep sampling, or observation of radar slicks.

The Perdido Foldbelt play has reservoir objectives of Late Paleocene through Oligocene distal turbidite sheet sands shed off of the South Texas continental shelf. A critical concern for the play is compartmentalization of the reservoir intervals by faulting related to the Oligocene compressional event.

## *Reservoir Type*

Few publications have described the stratigraphic variations or the three-dimensional geometries of these turbidite systems in the detail. In general, there are three major turbidite elements (Mutti & Normark, 1991) were chased as reservoir bodies, namely basin-floor fans - forming amalgamated depositional lobes (Figure 3), erosional and depositional channels (Figure 4), and overbank sediments (Figure 4).

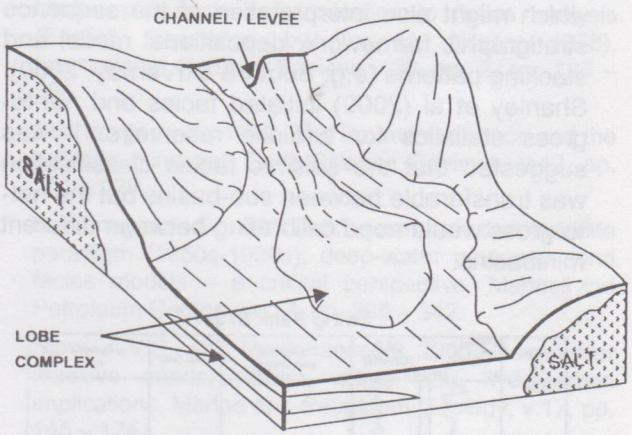



Figure 3: Schematic cartoon showing depositional lobe complex in relation with salt diapirs

The submarine fans usually have gradational lower contact and show coarsening- and thickening-upward stacking patterns. They form layered to amalgamated sheet architecture with excellent lateral continuity. Whereas the submarine channels have sharp or erosional lower contact and demonstrate thinning- and fining-upward successions (Figure 5). The overbank sediments usually have gradational lower contact and both coarsening-and thickening-upward and thinning- and fining-upward stacking patterns. Their net-to-gross varies depending on distance from channel axis.

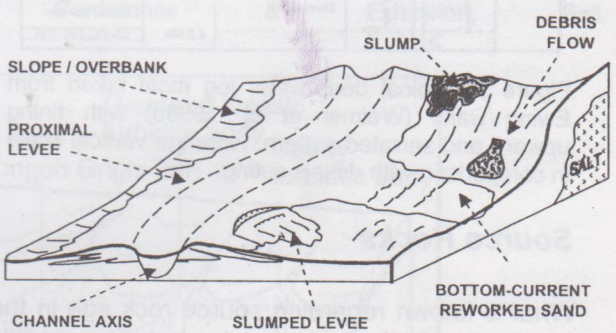



Figure 4: Various deep-water facies of submarine channel and levee complex.

Since reservoir quantity is generally a critical uncertainty for the deep-water plays, reservoir prediction is dependent on definition of sub-regional sand fairways and the position of prospects in their local depositional basin, which eventually rely much on the seismic. Hence, an

understanding of the seismic stratigraphic characteristics of the producing sands is important for deep-water exploration in the Gulf of Mexico as well as similar basins worldwide.
Attempts to make seismic facies classification of the ponded and slope systems from this area have been carried out (e.g. Prather et al, 1998) which might also interpretation of the sequence stratigraphic framework, depositional model and stacking patterns (e.g. Booth & DuVernay, 2000). Shanley et al (2000) initiated facies and net-to-gross statistics for turbidite reservoirs. It was suggested that the seismic facies classification was transferable between sub-basins but the net-to-gross would need calibrating between different minibasins.

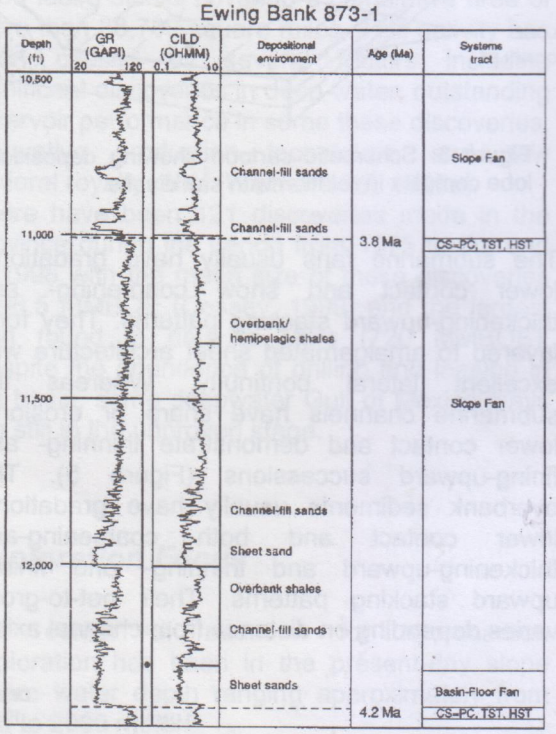



Figure 5: Typical deep-water log motif taken from Ewing Bank (Weimer et al, 1998b) with fining upward and serrated pattern. Note the vertical scale in comparison with deltaic seting.

## Source Rocks

What is known regarding source rock age in the deepwater Gulf of Mexico is derived primarily from the character of produced oils. Three main source rock-prone intervals are recognized: Paleogene and Upper Cretaceous shales, which generally produce high GOR sweet fluids, and Upper Jurassic carbonates & marls, which tend to produce a lower GOR sulfur-prone fluid (Weissenburger et al., 2000). The geographic distribution of oils derived from these sources is strongly influenced by maturity. In the shallower water areas, oils derived from the youngest source rocks predominate. Moving into deeper water, oils are derived from progressively older source rocks.

However, up to now, there is insufficient knowledge of intra-formation source rock in this kind of deep-water systems. Most of the deepwater discoveries are charged externally by older successions, such as the Gulf of Mexico, or have source rocks whose potential depend very much on carbonaceous material supply landward.

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Hopefully this short note could help implement further study and add interest to geological community in the country on deep-water depositions. There is no intention to disregard other opinions on how the Cinambo Formation was deposited. It is our responsibility to develop local models and opinions that might lead to be universal interpretation.
It should be noted here that all opinions and interpretations appear in this note are solely the author's responsibility.

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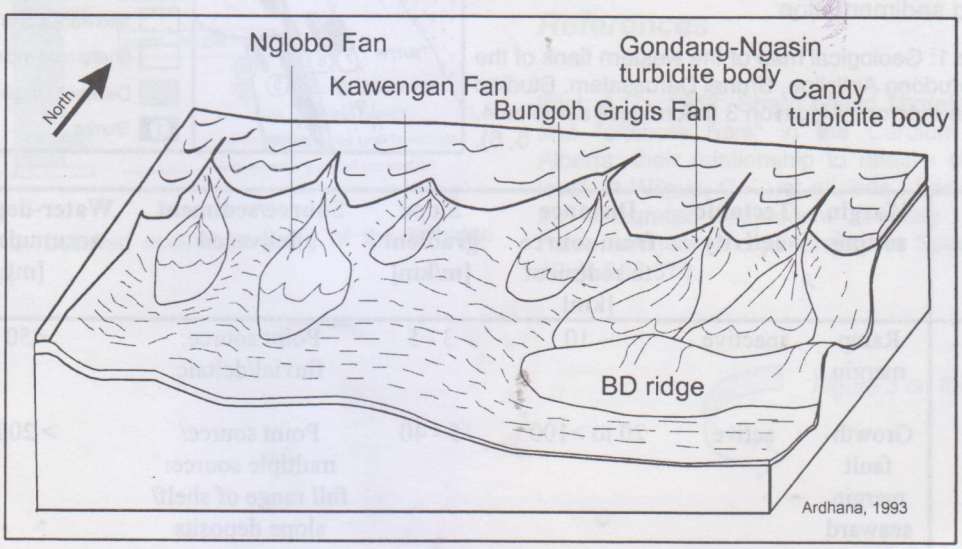




Figure 5: Depositional model of of lower Ngrayong Formation (Ardhana, 1993)