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Seismic Stratigraphy of the post-Paleozoic Sedimentary Section in the Main Pass area, Northern Gulf of Mexico

멕시코만 Main Pass 해역의 중생대-신생대 퇴적층의 탄성파층서

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Abstract : Multichannel deep seismic reflection data in the Main Pass area of the northern Gulf of Mexico are interpreted in this study for the stratigraphy and the depositional history. Structural analysis of deep seismic reflection data provides new information on the locations of paleo-shelf margins and the basement. The basement occurs at about 7.5 km depth at the northern end of seismic line LSU-1 in the Mississippi shelf. The Jurassic and early Cretaceous shelf margins occupy approximately the same position, whereas the Oligocene shelf margin occurs about 28 km farther landward. Ten major seismic stratigraphic sequences are identified for the Mesozoic and Cenozoic sedimentary section. Correlation of sequence boundaries defined in this study with those in other areas of the circum-Gulf region indicates that major regional unconformities formed at the mid-Miocene (10.5 Ma), mid-Oligocene (30 Ma), mid-Cretaceous (97 Ma), and top-Jurassic (131 Ma). Three distinct periods are recognized in the depositional history of the Main Pass area of the northern Gulf of Mexico: (1) shallow marine deposition during the period from the opening of the Gulf to the mid-Cretaceous, (2) deep marine deposition in the Cretaceous to the mid-Oligocene, and (3) shallow marine deposition prevailed since the mid-Oligocene to present. A comparison of depositional rates between the Main Pass area and the Destin Dome area indicates that the northern Gulf of Mexico continental margin was initiated as a terrigenous sediment wedge province in the late Cretaceous.

Key Words: Main Pass area, Gulf of Mexico, Seismic stratigraphy, Seismic facies, Burial history, Unconformity

요 약

미국 멕시코만 Main Pass 해역의 심부 다중탄성파단면도를 해석하여 이 지역의 층서와 퇴적사에 대한 연구를 수행하였다. 탄성파단면을 이용한 구조해석을 통하여 기반암과 과거의 대륙붕단 위치에 대한 새로운 정보를 밝힐 수 있었다. 기반암은 미시시피 대륙붕의 탄성파 측선 LSU-1 북단에서 7.5 Km 깊이에 존재함이 밝혀졌다. 또한, 쥬라기-백악기 초기에는 대륙붕단이 거의 같은 지점에 위치하였으나 신생대 올리고세에는 그보다 약 28 Km 대륙쪽에 위치함이 밝혀 졌다. 중생대-신생대 퇴적층은 10개의 탄성파층서단위 (seismic stratigraphic sequence)로 구분되며, 멕시코만 주변의 다른 해역과 비교해볼 때 주된 광역부정합면은 중기 마이오세 (10.5 Ma), 중기올리고세 (30 Ma), 중기 백악기 (97 Ma)와 쥬라기말 (131 Ma)에 형성되었음을 알 수 있다. 연구해역은 퇴적사로 볼 때 3개의 현저한 시기로 나눌 수 있는바; (1) 멕시코만 열림-중기 백악기 사이의 천해퇴적환경; (2) 중기 백악기-중기 올리고세 사이의 심해퇴적환경; (3) 중기 올리고세 이후의 천해퇴적환경으로 구분된다. 멕시코만 북부해역에 위치하는 Main Pass해역과 동북부 해역에 위치하는 Destin Dome 지역에서 시추된 시추자료와 탄성파자료를 종합하여 해석한 결과 멕시코만 북부 퇴적분지가 후기백악기부터 육성기원의 쐐기 (wedge) 형태로 발달되기 시작하였음을 알 수 있다.

INTRODUCTION

Seismic reflection data have long been used for interpreting and modeling stratigraphy, sedimentary facies, and geologic history. Seismic stratigraphic studies consist of seismic sequence analysis, seismic facies analysis, and integrated interpretation of geological and geophysical data (Mitchum *et al.*, 1977; Bubb and Hatlelid, 1977; Cross, 1988). Seismic sections with a complete record of coastal onlap, little structural and tectonic deformation and well control are best suited for seismic stratigraphic purposes. In that sense, the continental shelf off Alabama and Mississippi (Fig. 1) is an ideal area for seismic stratigraphic study.

The northeastern region of the Gulf of Mexico is an area of transition between the thick terrigenous sedimentary wedges of the northern and western Gulf and the massive carbonate platforms of the West Florida bank to the east

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(Martin, 1972). The buried lower Cretaceous carbonate margin in the study area connects the southeastern extension of the Stuart City reef trend in Texas and Louisiana with the Florida Escarpment. Extensive seismic stratigraphic studies of the carbonate platform provinces in the eastern and southern Gulf and the deep marine region of the central and southern Gulf have been completed in recent years (Mitchum, 1978; Worzel and Burk, 1979; Addy and Buffler, 1984; Shaub *et al.*, 1984; Angstadt *et al.*, 1985; Mullins *et al.*, 1988). There is, however, less published information on the seismic stratigraphy of the thick terrigenous wedge province of the northern and western Gulf. Two earlier studies have been conducted in the Mississippi-Alabama shelf (Reed, 1983; Greenlee, 1988). These identified seven post-MCU (mid-Cretaceous unconformity) stratigraphic boundaries based on seismic reflection data and a deep well data.

Recent acquisition of a long, 16-second multichannel profile provides the opportunity for more complete analysis of the seismic stratigraphy of the continental shelf in the Main Pass area (Fig. 1) for the Mesozoic and Cenozoic sedimentary section.

DATA ACQUISITION AND PROCESSING

350 km of multichannel two-dimensional deep seismic reflection data were acquired in 1988 across the continental shelf, continental slope, and the Mississippi fan along the 88°35'W meridian by the GECO M/V Sea Sercher under contract to Louisiana State University (Fig. 1). Shots were fired every 50 m at water depths of 7 to 8 m using a tuned array of 48 air guns with a minimum total volume of 7000 cubic inches (about 123,300 cm^3) at about 2000 psi (6900 N/m^2). The resulting seismic signals were recorded for 16 seconds at 4 ms sampling rate with a 4.5 km-long, 180 channel marine seismic cable.

The data were processed using standard marine seismic data processing sequences: deleting bad traces, sorting into common midpoint (CMP) gathers, semblance velocity analysis, normal moveout (NMO) correction, muting, band pass filtering, and stacking using the DISCO seismic processing package (registered trademark of the Cogniseis Development) on the SX-2 (NEC) supercomputer of the Houston Area Research Center. Velocity analysis was undertaken every 50 shot points (2.5 km) and the interval velocities calculated from the RMS velocities were compared to available refraction data obtained near the seismic line LSU-1. Because the RMS velocities had large error ranges for deeper parts of the seismic section, the refraction velocities determined by previous velocity studies (summerized by Locker and Chatterjee, 1984) were converted into stacking velocities using Dix's (1955) formula. The NMO-corrected traces were summed to produce 45-fold coverage and four

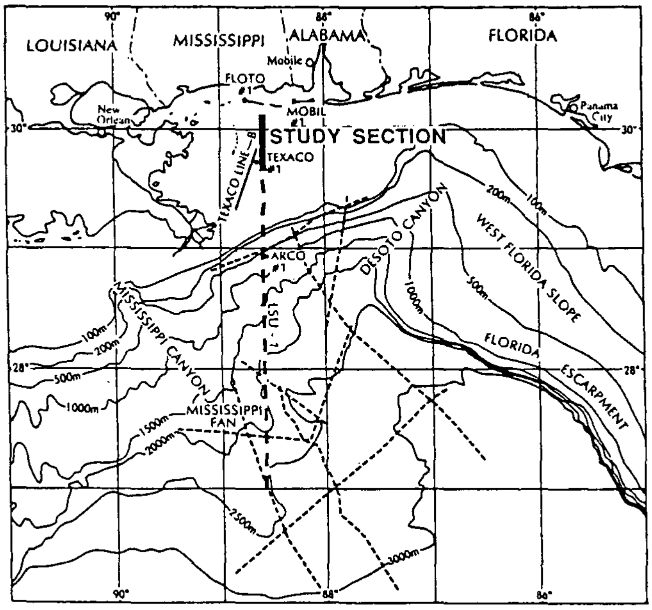

Fig. 1. Location map of the study area, seismic line LSU-1, and correlated wells.

stacked traces were summed onto one trace for display (Fig. 2a).

After completed structural and seismic sequence analysis of the northern 50 km of the line, the interpreted sequence boundaries were digitized and migrated using a ray path time migration scheme (Michaels, 1977) with a velocity funtion of $V=1.42+0.83Z$, where V is velocity (km/sec) and Z is depth (km) below sea level. The migrated sequence boundaries were then converted into a depth section for correlation with well data.

STRUCTURAL ANALYSIS

Overall stratification of the studied section is well preserved. Structural deformation is limited to the southern end of the section where two distinct growth faults occur (Fig. 2b). The growth faults have a typical listric geometry, decreasing in dip to the south, with a rollover structure in the downthrown block near the Early Cretaceous shelf edge. The major growth faults are located in a region of abrupt thickening of Late Cretaceous and Cenozoic sediments.

A shelf break is recognized in the middle of the seismic section and is interpreted to be a mid-Oligocene shelf edge formed by vertical build-up of a carbonate reef (Fig. 2b). The lower Cretaceous (Albian) carbonate shelf edge is inferred to be located just beneath the landward growth fault. It is inferred that the Albian shelf margin is a non-bedded carbonate reef because of an overall change in dip of reflectors and the absence of coherent reflectors. This reef provided a hinge for extensive seaward thickening of the younger sediemntary section (Fig. 2b). The Jurassic shelf

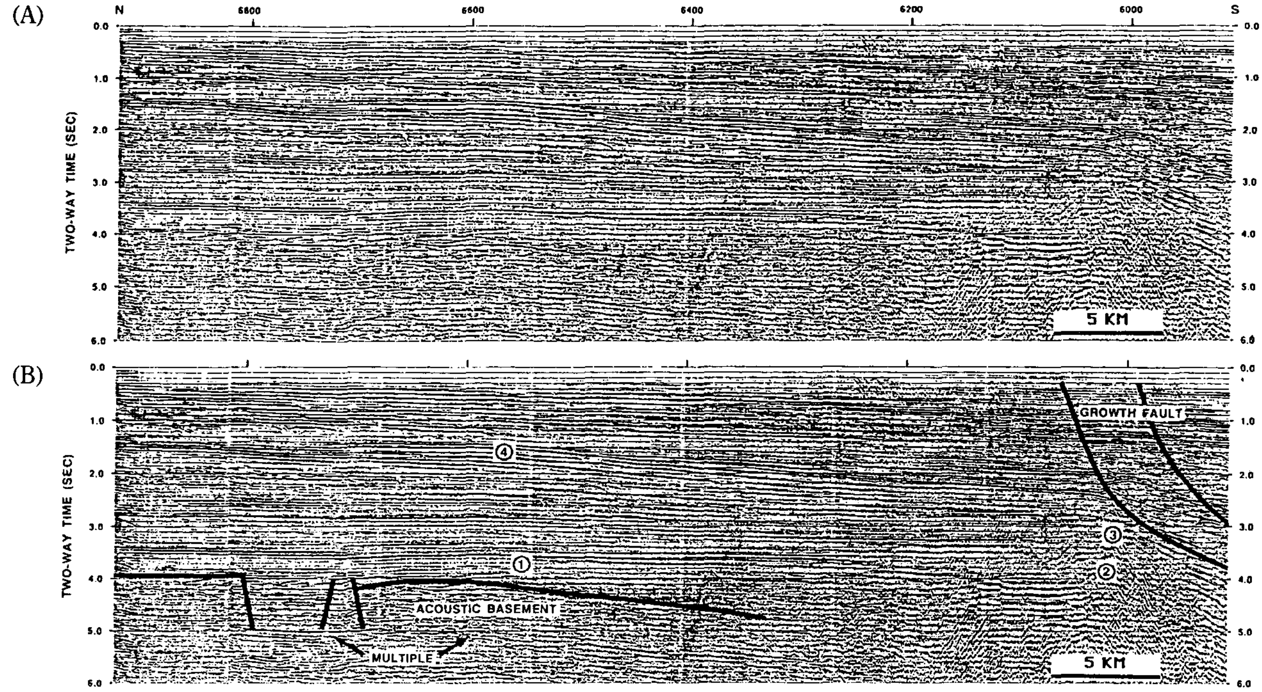

Fig. 2. A) Seismic section studied in this paper, B) Structural interpretation of the seismic section shown in Fig. 2a. Numbered features are; ① a possible carbonate reef in the Jurassic, ② Jurassic shelf margin, ③ Early Cretaceous carbonate shelf margin, and ④ mid-Oligocene shelf margin. Ages are based on sequence stratigraphic analysis of the section shown in Fig. 3.

margin is seen directly below the early Cretaceous carbonate shelf margin as in the form of subtle changes in the dip of reflectors obscured by the younger growth fault (Fig. 2b).

The pre-Mesozoic basement lies beneath a relatively strong reflector which is onlapped by beds of the early rift stage and broken by a sediment-filled graben indicative of an extensional tectonic regime in pre-Early Jurassic time. The basement shallows to 7.5 km depth at the northern end of the section and is interpreted to represent part of the southern flank of the Wiggins arch. Depth to the basement increases to the south and the surface becomes unrecognizable as a distinct reflector beneath the outer continental shelf (Fig. 2b).

SEISMIC STRATIGRAPHIC SEQUENCE ANALYSIS

Seismic sequence boundaries are defined as surfaces of stoped lap-out according to the scheme of Vail *et al.* (1977). Some small sequences were combined into major sequences on the basis of regional continuity and consistency of unconformities. Geological ages of the sequence boundaries were inferred from correlation of the section with biostratigraphic data from Texaco #1 well (Chandeleur Area Block 24) and Getty #1 well (Chandeleur Area Block 33) and with published data (Reed, 1983; Greenlee, 1988) for the post-middle Cretaceous unconformity (MCU). Paleontologic data from Mobil #1 (Mississippi Sound Block 72) and Floto #1 (west coast of Horn island) wells were also used to confirm the ages for sequence boundaries at the northern end of the section. The absolute time scale used in this study is the one constructed by Haq *et al.* (1987) in which both high- and low- temperature radiometric dates were used.

A complete seismic stratigraphic framework from the time of opening of the Gulf of Mexico to the present was established for the continental shelf off Mississippi. Ten major seismic depositional sequences were ideentified and named, from oldest, I, to youngest, X (Fig. 3).

The oldest depositional sequence (sequence I) occurs at a depth of 6.3 km below sea level at the northern end of the section (Fig. 3 and Fig. 4). Its base is recognized by reflectors onlapping the pre-Mesozoic basement and the top is characterized by truncation of reflectors (Fig. 3). Truncation of reflectors implies the existence of a widespread, regional erosion surface. The age of both sequence boundaries at top and base of the sequence is uncertain because wells do not penetrate this deep. However, Salvador (1987) reports the existence of a conspicuous subaerial erosion surface of Early Jurassic age along the Gulf margin. The position of sequence boundary I below the top of the Jurassic, and the similarity in lap-out pattern to that reported elsewhere for the Early Jurassic unconformity, suggest that SB (sequence boundary) 1 in our section does represent the Early Jurassic circum-Gulf unconformity. The boundary between Triassic

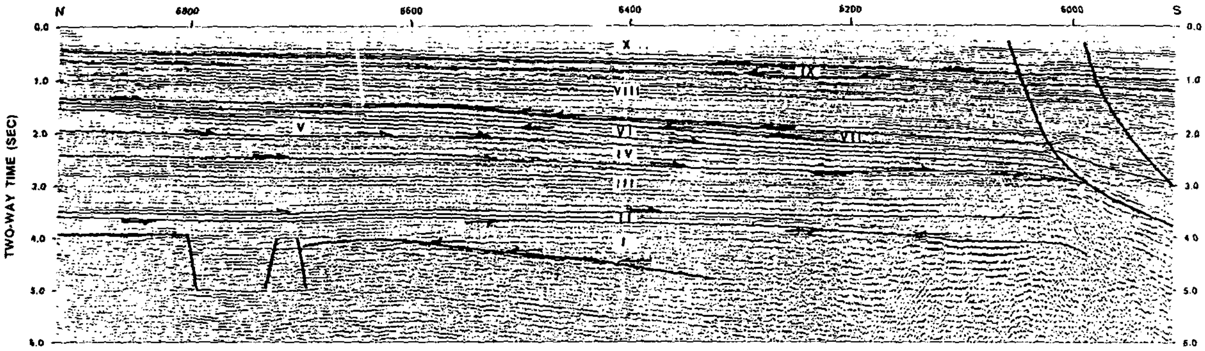

Fig. 3. Seismic stratigraphic sequences and sequence boundaries with some marks of reflector terminations.

and Jurassic strata of South Texas and offshore West Africa (Todd and Mitchum, 1977) and the significant hiatus in the early Jurassic period reported in the North Louisiana Salt basin (Scardina, 1982) are tentatively correlated with the erosional unconformity at the top of the depositional sequence I.

The top of seismic sequence II (SB 2) is a downlap surface (Fig. 3). Downlap surface, representing a condensed section, is used as sequence boundary in this case because of non-existence of onlap terminations below the downlap surface in the seismic section. The transgressive sequences will not be resolved in seismic section if their thicknesses are less than vertical resolution. SB 2 occurs at a depth of approximately 6 km at the northern end of the section and it is interpreted as the top of Jurassic according to similar depth to the top Jurassic (about 6 km) near the northern end of the seismic line LSU-1 (Locker, 1984). The top of the upper Jurassic Haynesville formation lies at a depth of 5.2 km at the Mobil #1 well (Fig. 4).

Sequence boundary 3 at the top of sequence III (SB3) is recognized by truncation of reflectors below (near the shelf margin) and several distinct downlap above (Fig. 3). This is inferred to be the Mid-Cretaceous unconformity (MCU), the most distinct unconformity in both shallow and deep water regions of the Gulf of Mexico. The top of lower Cretaceous rocks lies at 2.92 km and 2.73 km at Floto #1 and Mobil #1 wells respectively (Rogers, 1988). The landward projection of SB 3 to the line linking Mobil #1 well and Floto #1 well corresponds with the top of the Early Cretaceous rocks at a depth of 2.86 km at a point about 15 km north of the northern end of the section (Fig. 4).

For sequence boundaries at the top of units IV, V, and VI, their ages are determined as the top of the Late Cretaceous (66.5 Ma), late Paleocene (58.5 Ma), and middle Eocene (39.5 Ma), respectively, based on paleontologic data from Texaco #1 well and correlation of seismic section LSU-1 with Texaco Line B (Reed, 1983) and Exxon Line 7 (Greenlee, 1988). The projection of SB 4, the Cretaceous-Tertiary boundary, correlates with well data from th Mobil

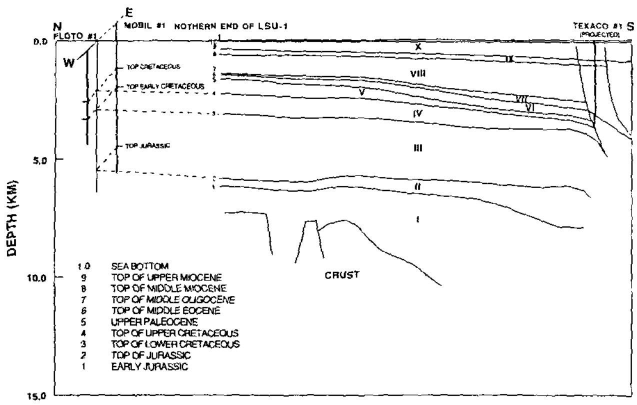

Fig. 4. Depth section of the seismic sequence boundaries shown in Fig. 3 and the correlation of the sequence boundaries with well data. Sequence boundaries were migrated and converted into depths.

#1 and Floto #1 wells at a depth of 2.1 km at a point about 15 km north of the northern end of the section (Fig. 4). Sequence IV and V are characterized by prominent downlapping terminations of prograding reflectors at their base.

Sequence boundary 7, at the top of sequence VII, is defined by a series of onlaps and dated as the top of middle Oligocene (30 Ma) based on the correlation of the section to the Texaco Line B (Reed, 1983). Sequence boundaries at the top of sequence VIII and IX are both defined by onlaps and are dated as top of middle Miocene (10.5 Ma) and top of upper Miocene (5.5 Ma), respectively, based on paleontologic data of Texaco #1 and Getty #1 wells.

CORRELATION OF SEISMIC SEQUENCES

Seismic sequence boundaries defined in the study area are correlated with the published eustatic sea level curve of Haq *et al.* (1987) and the sequence boundaries defined in the Destin dome area (Addy and Buffler, 1984), west Florida slope (Mitchum, 1978), west Florida bank (Mullins *et al.*, 1988), deep Gulf of Mexico (Shaub *et al.*, 1984), and east Texas basin (Todd and Mitchum, 1977)

The sequence boundary between depositional sequences

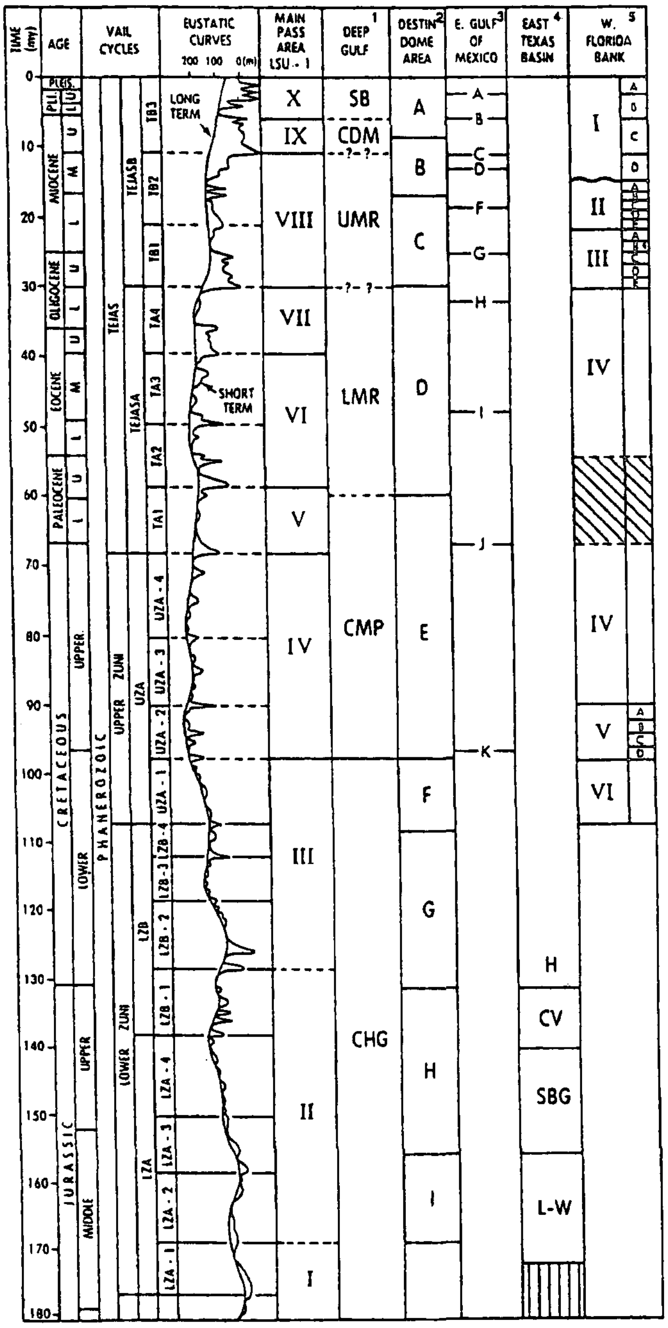

Fig. 5. Correlation of the seismic sequence boundaries defined from this study with the eustatic sea level curve and those seismic sequence boundaries defined in other areas: (1) from Shaub *et al.* (1984), (2) from Addy and Buffler (1984), (3) from Mitchum (1978), (4) from Todd and Mitchum (1977), and (5) from Mullins *et al.* (1988).

X and IX is the Miocen-Pliocene boundary and is correlated with boundary B of the west Florida slope, the boundary between unit I-B and unit I-C of the west Florida bank, and to the boudary between Vail's third order cycles 3.3 and 3.4 within TEJAS B3.

The mid-Miocene/upper-Miocene boundary (10.5 Ma) at the top of depositional unit VIII is correlated with boudary C of the west Florida slope (Mitchum, 1978), with the boundary between sequences I-C and I-D of the west Florida bank (Mullins *et al.*, 1988), and to the TB2/TB3 boundary of Vail's Tejas-B super cycle (Fig. 5). Given the fact that the unconformity between unit A and unit B of Destin dome area has the error range between boudary B and boudary C of west Florida slope (Addy and Buffler, 1984), this mid-Miocene unconformity is interpreted as a distinctive unconformity formed at the time of lowest sea level stand ever since the opening of the Gulf of Mexico. This sequence boundary is recognized in both offshore Alabama and New Jersey as the most pronounced downward shift in coastal onlap in the Neogene (Greenlee, 1988).

There are two other distinctive boundaries in each area: mid-Cretaceous (97 Ma) and mid-Oligocene unconformities (30 Ma). The unconformity between depositional sequences III and IV (MCU) coincides well in its age all around the eastern Gulf of Mexico and deep Gulf of Mexico (Fig. 5). The unconformity at the top of depositional unit VII is correlated with the sequence boudary between unit C and D of the Destin dome area (Addy and Buffler, 1984), to the boundary between unit III and IV of the west Florida bank (Mullins *et al.*, 1988), and to the TEJAS A/TEJAS B sequence boundary of Vail's super cycle (Fig. 5). The mid-Oligocene downward shift in onlap followed by progressive landward onlap in the offshore of both Alabama and New Jersey (Greenlee, 1988) is also found in this study area. Uncomformity H of Mitchum (1978) might also be correlative with the mid-Oligocene unconfomity in the study area. The presence of a mid-Oligocene sequence boundary in deep water of the West Folorida basin (Lord, 1987) suggests that this is a major regional unconformity. It probably formed at 30 Ma (Haq *et al.*, 1987).

The boundary at the top of the middle Eocene sequence (SB#6) has not previously been reported in the Gulf. This unconformity matches the TA3/TA4 sequence boundary of Vail's super cycle, which has an age of 39.5 m.y. (Fig. 5). The unconformity between depositional sequences VI and V is probably of late Paleocene age (58.5 m.y.) and is correlated with the unconformity between depositional units D and E of the Destin dome area and a hiatus spaning most of the Paleocene in the West Florida Bank (Mullins, 1988).

Depositional sequence IV encompasses Vail's super cycles UZA2 (Upper Zuni A2), UZA3, and UZA4, and its top and bottom boundaries are correlated to boundaries J and K of Mitchum (1978) respectively. Depositional sequence III, which is bounded by the top Jurrassic unconformity at its base and the MCU at its top, encompasses units F and G of the Destin dome area. The base of Sequence III is correlated to the unconformity between Hosston Group and the Cotton Valley Group of the East Texas basin (Todd and Mitchum, 1977) and to the sequence boundary between the units G and H of the Destin dome area. The unconformity at the base of the depositional unit II is tentatively correlated to the base of the Louann-Werner Group of the East Texas basin on the basis of chraracteristics of reflector terminations which indicate a subaerial erosional surface (Fig. 5).

SEISMIC FACIES INTERPRETATION

Seismic facies are defined in this study using reflection characters: geometry, continuity, and amplitude. The seismic section generally contains reflector with a parallel (P) or a basinward convergent geometry (C). Reflectors may be continuous (C) or discontinous (D). Finally, seismic facies may have high (H) or low (L) amplitudes or they are reflection free (RF). A PCH seismic facies, for example, is one that has parallel and continuous reflectors with high amplitude. Seismic facies are interpreted in terms of depositional environments, processes, and lithology only after they are tied to well logs.

JURASSIC AND LOWER CRETACEOUS SEQUENCES

Sequences I, II and III were deposited during the period of generally rising 1st order global sea level (Fig. 5). Depositional sequence I consists of parallel and discontinuous seismic reflections of very low amplitude (PDL seismic facies; Fig. 3). This pattern is consistent with a fluvial environment, although no well data is available. The relatively strong but discontinuous reflectors may represent sand bodies. Velocity analysis of the seismic reflection data indicates that this sequence has velocities less than 4.0 km/s (Suh, 1989) consistent with the suggestion that it consists of clastic sedimentary rocks. This sequence also indicates a graben fill (Fig. 3) of nonmarine red beds and volcanics primarily related to the rifting of the continental crust (Klitgord *et al.*, 1984). As discussed above, the overlying sequence boundary (SB1, Fig. 3) is suggestive of subaerial erosion.

Depositional sequences I and II include a mound-like structure whose top has a very high amplitude reflector near the shot point #6600 (Fig. 2 and Fig. 3). This mound-like structure may be a vertical build-up of shallow marine carbonates. The reduced reflector amplitudes in the central part of the mound is consistent with the evidence of a poorly bedded reef facies. A dolostone facies of shallow marine or restricted lagoonal origin has been described from the upper Jurassic Buckner Formation in southwestern Alabama, at depths of about 6 km (Lowenstein, 1987). Perhaps the mound in Sequences I and II represent an offshore continuation of such a facies.

Depositional sequence III shows parallel and continuous reflectors with relatively high amplitude (PCH seismic facies) in the lower and upper parts, and parallel, discontinuous low amplitude reflections (PDL seismic facies) in the middle (Fig. 3). The velocity analysis of this sequence yields typical velocities in the range of 5.0 to 5.5 km/s suggesting that the entire sequence is made up of carbonate rocks (Suh, 1989).

POST-MCU SEQUENCES

Depositional sequence IV, which consists mainly of prograding clinoforms with very low angle downlaps at their base, corresponds to UZA-2, UZA-3, and UZA-4 of Vail's second order super cycles (Fig. 5). The unit was deposited during the Late Cretaceous in a period of generally high sea level stand with intermittent falls. This sequence is characterized by convergence of reflectors and variability both in reflector amplitude and continuity (CDL seismic facies: Fig. 3). The well logs for Mobil #1 and Floto #1 indicate that the lower half of this unit consists mainly of shale (Tuscaloosa) as inferred by relatively low values of gamma ray and resistivity (Suh, 1989). The upper half consists mainly of chalk (Seluca chalk) indicated by relative high values in gamma ray and resistivity. These lithologies suggest that the lower half of depositional sequence IV was deposited in a prodelta setting and the upper half was deposited as a marine carbonate during sea level highstand. The absence of coherent reflectors just landward of shot point 6000 indicates the presence of reef facies (Fig. 2 and Fig. 3). Abrupt kicks in spontaneous potential (SP), resistivity, and gamma ray logs in well logs for Texaco #1 well indicate the existence of carbonate rocks at the top of the Cretaceous senquence (Suh, 1989). The downlap surface at the Cretaceous-Tertiary boundary is interpreted as indicating a rapid rise in sea level during latest Maastrichtian and earliest Paleocene time.

Sequence V consists predominantly of prograding clinoforms with low angle downlaps onto the top of depositional sequence IV. Internal reflections are discontinuous and have relatively low amplitudes (CDL seismic facies: Fig. 3). Well data from Mobil #1 and Floto #1 wells indicate that this sequence is shale of the Paleocene Midway Group, which was apparently deposited in a prodelta setting.

Data from Mobil #1, Floto #1, and Texaco #1 wells indicate that depositional sequence VI consists predominantly of shale. This shale was deposited in a prodelta setting during the Eocene sea level high stand and forms the distal portion of the Wilcox and Claiborne groups. Onlap and downlap onto the top of sequence V in front of the paleo-break at SB5 near shot point 6400 suggests the presence of a eustatic lowstand fan system (Fig. 3 and Fig. 6). During the sea level

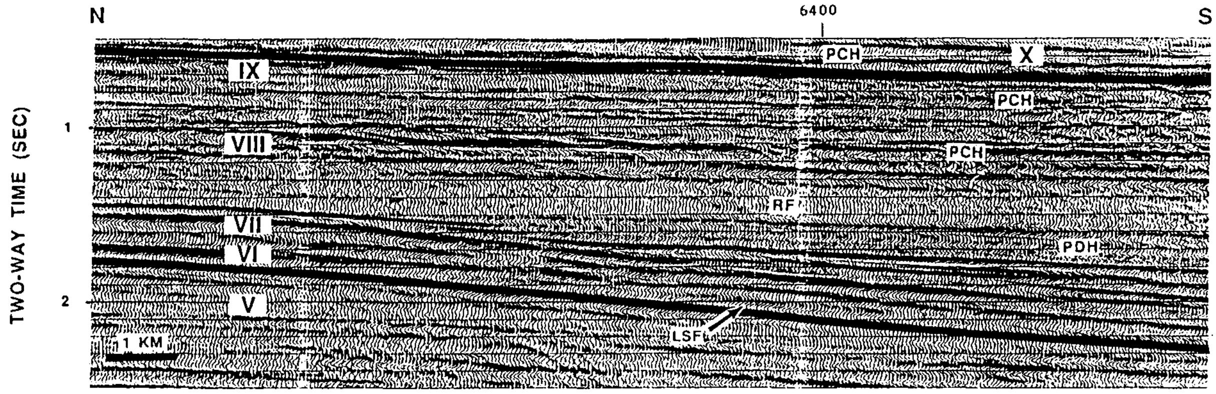

Fig. 6. Seismic section showing sequences VI, VII, VIII, and IX near the mid-Oligocene shelf margin. Sequence boundaries are not all drawn for better look of seismic reflectors (see Fig. 3 for sequence boundaries).

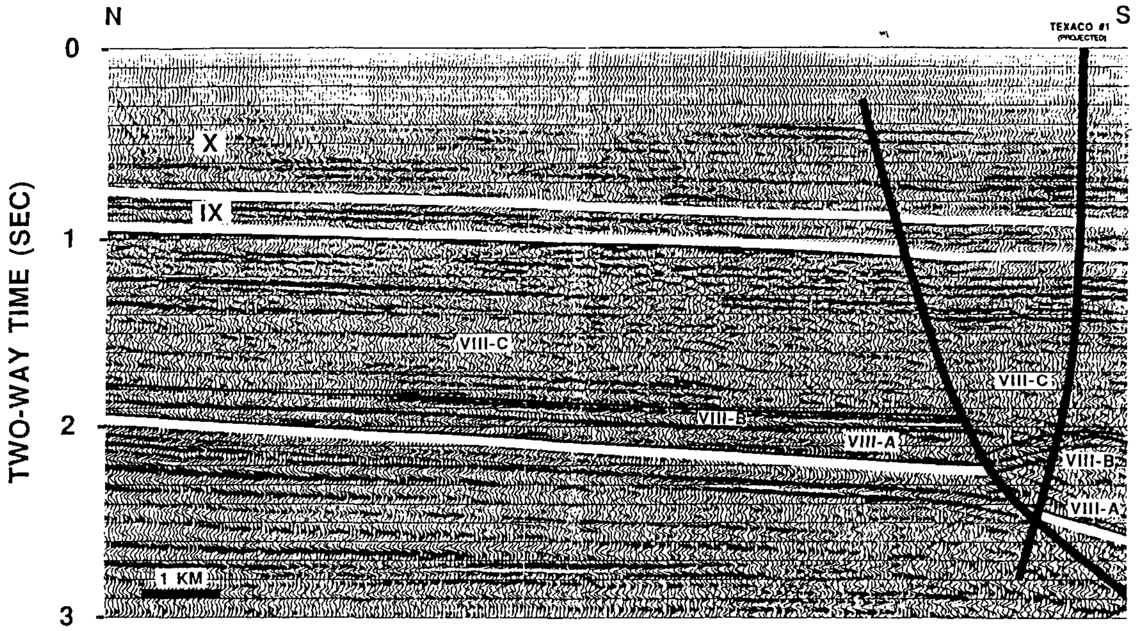

Fig. 7. Seismic section showing seismic facies of depositional sequence VIII. Sequence VIII includes three subsequences, VIII-A, VIII-B and VIII-C in decreasing age. Subsequences VIII-A and VIII-B and the lower part of the subsequence VIII-C represent a PDH seismic facies while the middle and upper parts of the subsequence VIII-C represent a PDL and PCH seismic facies, respectively.

lowstand most terrigenous sediment bypassed the continental shelf to form submarine fans at the base of the slope.

Depositional sequence VII is characterized by a parallel and discontinous reflection configration with low amplitude (PDL seismic facies) in the upper continental shelf. The top of this unit is concordant with the basal sequence bounding unconformity of sequence VIII and the base of the sequence onlaps the top of sequence VI. The eustatic sea level curve has two subdivisions in the depositional period represented by sequence VII; the first half (Late Eocene) is a period of rising of sea level; the second half (Early Oligocene) is one of sea level highstand (Fig. 5). The reflectors which onlap the top of sequence VI (Fig. 3) may represent a lowstand and transgressive systems tract. Well data from Mobil #1, Floto #1, and Texaco #1 wells indicate that deposional sequence VII consists mainly of limestone, chalk and shale in ascending order (Suh, 1989). The top of this unit shows a unique shelf break near shot point 6570 (Fig. 3). This domal structure has reflection free seismic facies indicating that it may represent a reefal structure on the seaward margin of an Early Oligocene carbonate platform. A coral reef penetrated offshore Alabama indicates that reef growth was terminated by a major downward shift in onlap at 21 Ma (Greenlee, 1988).

Depositional sequence VIII is subdivided into three subsequences by reflection geometry (Fig. 7). Subsequences VIII-A, VIII-B and the basal part of VIII-C consist of a parallel, discontinuous, high amplitude (PDH) seismic facies (Suh, 1989). The middle part of subsequence VIII-C consist of low amplitude to reflection free seismic clinoforms (RF se-

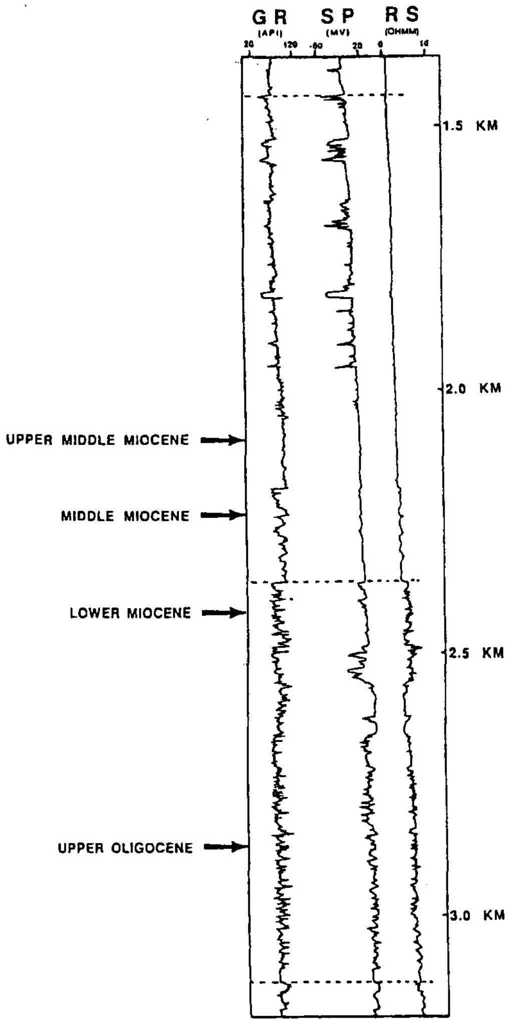

Fig. 8. Logs for the seismic sequence VIII in the Texaco #1 well (GR: Gamma ray, SP: Self-potential, RS: Resistivity). Well data represent a sand-dominated section in the upper Oligocene and lower Miocene, a shale dominated section in mid-Miocene, and a section of increasing clastics in the upper Miocene.

ismic facies). The top portion of subsequence VIII-C has a parallel, continuous high amplitude (PCH) seismic facies (Fig. 6 and Fig. 7). Well data from Texaco #1 demonstrate that sequence VIII is of Late Oligocene and Early Miocene age. Well-log lithological data (Fig. 8) and reflection geometry suggest that the PDH seismic facies represents coastal plain or nearshore deposits. The basal onlap on top of SB7 further implies a sea level rise as a transgressive systems tract. A major basinward shift of onlap in mid-Oligocene time, which made basal sequence boundary of sequence VIII, resulted in coastal sedimentation in the study area. Data from the Texaco #1 well indicate that the middle part of subsequence VIII-C, which is characterized by reflection free facies, consists dominantly of marine shale suggesting that the low amplitude seismic facies was deposited in a prodelta setting during sea level highstand. A downlap surface occurs within subsequence VIII-C between the RF seismic facies of deep marine shale and the PDH seismic facies of shallow marine sandstone sequences (Fig. 7). The PCH seismic facies of the upper part of subsequence VIII-C consists of sandstone, siltstone, and shale based on the integration of data of Texaco #1 (Fig. 8), Mobil #1, and Floto #1 wells. The eustatic sea level curve (Haq *et al.*, 1987) demonstrates major mid-Miocene sea level lowering. These observations indicate that the upper part of subsequence VIII-C of PCH seismic facies was deposited by rapid delta progradation during sea level lowering in late middle Miocene.

The Late Miocene depositional sequence IX has parallel, continuous high amplitude (PCH) seismic facies (Fig. 3 and Fig. 6). Lithologic data from Getty #1 well indicate that depositional sequence IX consists of alternating layers of poorly sorted sandstone and silty or calcareous shale (Suh, 1989). This type of interbedding probably represents high-frequency sea level changes; during sea level lowstands, terrigenous sediment was transported far basinward and deposited poorly to moderately sorted sandstone on the deltaic plain or delta front whereas shale was deposited on prodelta during sea level highstand. Good continuty and high amplitude of reflectors may be the result of this type of lithologic change, which can give sufficient acoustic impedance contrasts.

The youngest depositional sequence (X) is of Pliocene and Pleistocene age. This consists of very low amplitude or reflection free seismic facies except for a portion of the lower part of the sequence in which parallel and continuous reflections with relatively high amplitude are present (PCH seismic facies) (Fig. 3 and Fig. 6). The onlap at the base of this sequence certainly implies sea level rise after the Late Miocene (Messinian) fall. The continuous, high-amplitude reflectors at the base of sequence X, therefore, probably are lowstand and trangressive systems tract coastal plain strata. The apparent reflection free seismic facies is probably due to inappropriate recording and processing parameters for imaging shallow layers. The upper part of the sequence probably consists of unconsolidated sediments which can not produce enough acoustic impedance contrast to generate a distinctive reflection given the recording and processing parameters. Also, the increased frequency and intensity of glacial eustatic sea level fluctuations during the Plio-Pleistocene produced sedimentary layers in the continental shelf area too thin to be recorded given the low vertical resolution of this study. Minimum vertical resolution for the data set is approximately 8 m based on a velocity of 1.6 km/s for the upper part of this sequence.

DEPOSITIONAL HISTORY

The northern continental margin of the Gulf of Mexico, which extends from the De Soto canyon to northern Mexico,

Table 1. Depositional rates of each sequence in the Main Pass area and their comparison with those of Destin Dome area.

Depositional Sequance Unit	Depositional rate (cm/1000 yr)	Average Depositional Rate	
		Main Pass area	Destin Dome area
X	8.2		
IX	4.0	5.1	2.1
VII	4.3		
		MID-OLIGOCENE MAJOR BREAK	
VII	1.3		
VI	1.3	2.6	0.8
V	5.5		
IV	2.8		
		MID-CRETACEOUS MAJOR BREAK	
III	7.5	7.5	7.8
		TOP-JURASSIC MAJOR BREAK	

comprises a broad wedge of Mesozoic strata that accumulated from the Jurassic to the present (Martin, 1978). The entire stratigraphic section of the Destin dome area is divided into three main depositional settings; a shallow marine environment from the time of opening of the Gulf of Mexico to the mid Cretaceous, a deeper water setting (middle to outer neritic) from mid-Cretaceous to mid-Oligocene, and the shallow water conditions of late Tertiary and Quaternary age (Addy and Buffler, 1984). Seismic and lithostratigraphic data from wells of the study area indicate that the three main depositional environments are also present in the study area.

Average accumulation rates are estimated (Table 1) on the basis of the seismic depth section at 30°N latitude which is in a similar depositional setting to that of Exxon #3 well of Destin dome area (Addy and Buffler, 1984) (Fig. 9). Because the rates were computed on the basis of depth data converted from seismic data, there is a possibility of slight error due to the chosen velocity function. Accumulation rates are minima because they are not corrected for compaction, possible erosion, or nondeposition.

The average depositional rates of the Main Pass area and Destin dome area represent three main depositional periods: (a) the highest accumulation rate of pre-MCU, (b) low accumulation rate from mid-Cretaceous to mid-Oligocene, and (c) intermediate accumulation rate of post mid-Oligocene time (Table 1).

Seismic sequences I, II, and III were deposited during the late Triassic to mid-Cretaceous in a shallow marine environment. It was difficult to estimate the accumulation rates for depositional sequences I and II because of the uncertain ages for sequence boundaries. The estimated depositional rate for sequence III is approximately 7.5 cm/1000yr, which is close to the average depositional rate of 7.79 cm/1000yr in the Destin dome area to the east (Addy and Buffler, 1984). This data indicates that depositional system between the two areas was similar in the early stage of

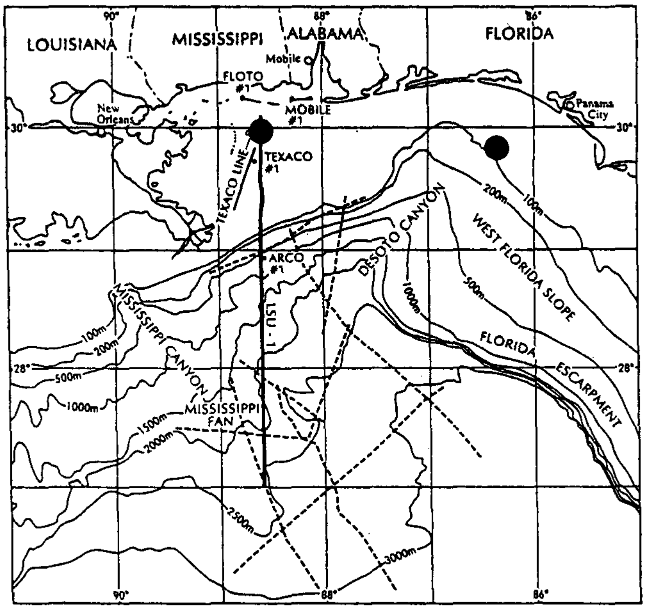

Fig. 9. Two locations where depositional rates were caculated. Rates are based on the seismic depth section in Main Pass area and drillhole data in the Destin dome area (Addy and Buffler, 1984).

the basin evolution.

During the period of deep water deposition which occurred from mid-Cretaceous to mid-Oligocene, which is represented by seismic sequences IV, V, VI, and VII, the average rate of deposition was 2.6 cm/1000yr in the study area. This sedimentation rate is more than three times higher than that of the Destin dome area (0.78 cm/1000yr). The large difference in the rate of deposition is probably due to a change in source area for the northwestern and north-central Gulf. It also indicates that the differentiation of the Gulf margin into two distinct depositional provinces of continental margin was initiated after the mid-Cretaceous. Depositional rates for sequences IV and V of late Cretaceous and Paleocene are even higher than those of sequence VI and VII of the Eocene and Oligocene, although the sea level in late Cretaceous and Paleocene time was higher (Table 1 and Fig. 10). These results suggest that the huge amounts of clastic sediment were introduced into the northern Gulf coast from the western interior as a result of the Cretaceous-Paleocene Laramide orogeny (Martin, 1978). Logs from Mobil #1, Floto #1, and Texaco #1 wells indicate that the period is represented mainly by limestone, chalk, and shale, indicating a middle to outer neritic depositional setting for the study area. This lithologic information may imply that the high accumulation rate in the late Cretaceous and Paleocene time is not the result of proximity of the study area to the shoreline but the result of high sediment influx into the Gulf basin.

Seismic sequences VIII, IX, and X were deposited in shal-

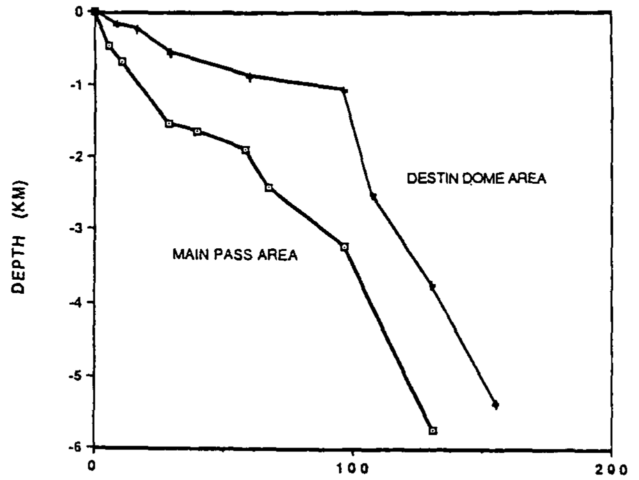

Fig. 10. Age-depth curves for two sites, where accumulation rates were calculated. Depths are measured below the sea bottom. Locations are shown in Fig. 9.

low water and their lithologic content is primarily shallow marine calcareous shale, sandstone, and siltstone, affected by frequent sea level oscillations. The average depositional rate was about 5 cm/1000yr, which is higher than those of the previous deep water environment as well as the nearby Destin dome area (2.1 cm/1000yr) (Table 1 and Fig. 10).

CONCLUSIONS

The interpretation of multichannel deep seismic reflection data in the Main Pass area provides a detailed seismic stratigraphic framework for the thick sedimentary section of the northern Gulf of Mexico. Structural analysis of the seismic section provides new information on paleo-shelf margin and the basement. The basement occurrs at a depth of about 8 km and includes a sediment filled graben. Three paleo-shelf margins are recognized in the seismic section: in the Jurassic, early Cretaceus, and Oligocene. The Oligocene shelf break occurs landward of the early Cretaceus carbonate shelf margin, corresponding to the major global sea level drop.

Ten major seismic sequences are defined in the study area since the opening of the Gulf of Mexico. These are labeled I through X in order of decreasing age. The correlation of seismic sequence boundaries defined in the study area with those of onshore Texas and Louisiana, west Frorida bank and slope, and southeastern Gulf of Mexico indicates that the unconformities at the top of the Jurassic (131 Ma), mid-Cretaceous (97 Ma), mid-Oligocene (30 Ma), and mid-Miocene (10.5 Ma) are major regional unconformities. The unconformity between depositional sequences I and II represents a severe subaerial erosional surface which formed in the early to middle Jurassic.

The results of the seismic facies analysis, correlation with the eustatic sea level curve, and the lithologic interpretation of well logs indicate that seismic facies characterized by a good continuity and high amplitude are generally composed of alternating sand and shale layers deposited during the period of frequent and intense sea level fluctuations. Seismic facies characterized by low continuity and low amplitude are mainly from sedimentary sequences dominated by shale or limestone that were deposited during sea level high stand.

Depositional history of the study area can be divided into three main stages: shallow marine deposition until mid-Cretaceous, deep water deposition from mid-Cretaceous to mid-Oligocene, and shallow marine deposition since mid-Oligocene time. The comparison of depositional rates of the study area with those of nearby Destin dome area indicates that an acceleraton of sediment accumulation in the northern Gulf continental margin began in the mid-Cretaceous. The relatively high deposition rates of late Cretaceus and Paleocene periods reflect the large amounts of clastic sediments introduced into the northern Gulf coast region from the continental interior as a result of the Laramide orogeny.

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