Latest Quaternary Regional Sedimentation Processes in the U.S. Gulf of Mexico Exclusive Economic Zone (EEZ)*

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Abstract

Interpretation of very high-resolution (3.5 kHz) seismic facies reveals that turbidity-current, mass-transport (MTD), and bottom-current depositional processes have all contributed to the regional sediment distribution throughout the U.S. Exclusive Economic Zone (EEZ) in the northern Gulf of Mexico. Piston cores from these deposits confirm the interpretations of these processes and show that most were deposited during the Last Glacial sea-level lowstand. The eastern half of the EEZ is dominated by the Mississippi Submarine Fan, which is composed of mud-rich channel-levee complexes on the upper and middle fan, and sandy lobes on the lower fan. Although MTDs were previously mapped from the east side of the fan, our 3.5 kHz data reveals the total distribution of MTDs across the western side. The 3.5 kHz data also shows seismic facies consistent with very sandy deposits throughout the lower fan. In contrast, the western EEZ is dominated by intraslope mini-basin systems, and turbidity currents have deposited large volumes of sands into these basins canyons.

Although most of these systems do not traverse the entire intraslope area, the extensive Bryant Canyon system allows turbidity currents to bypass through all the mini-basins via fill-and-spill processes and form the large Bryant Submarine Fan, which extends hundreds of km seaward from the Sigsbee Escarpment. In contrast, the smaller Rio Grande Submarine Fan was deposited in an intraslope plateau. The 3.5 kHz seismic facies and piston cores indicate a sand-rich fan with numerous small, un-leveed channels that appear to show a braided channel system. MTDs are ubiquitous throughout the mini-basins, along the upper continental slope and at the eastern base of the Sigsbee Escarpment. Cores confirm that the majority of MTDs are mostly muddy debris flows with mud clasts of variegated colors, but sandy debris flows also occur in some mini-basins. Deformation, folds and faults in some cores indicate slump or slide deposits. The East Breaks Slide Complex is the largest MTD complex of slump/slide blocks and debris flows and extends from the shelf edge downslope for >100 km. Most MTDs were deposited during the Last Glacial (MIS 2) lowstand. Three large regions of migrating sediment waves occur on the Sigsbee Abyssal Plain and were formed by bottom current circulation of the Loop Current. Sediment waves also occur locally along the base of the Sigsbee Escarpment in conjunction with previously reported erosional furrows.
Abstract

Late Quaternary Regional Sedimentation Processes in the U.S. Gulf of Mexico Submarine Canyons and Basins: A Case Study

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Abstract

(A-C) Air-gun seismic profiles across the Bryant Fan (locations on echo character map in center panel). Note modern channel on fan surface. Also note high-amplitude reflections (HARs), which are indicative of mass-transport deposits. The upper part of the section shows an area affected by bottom-current activity. Locations of cores shown on map in central panel in areas of Type 4 echoes.

Biostratigraphy of Piston Cores

Globorotalia menardii index curves show a distinct change in the zonal distribution of this species across the Bryant Fan. This change is correlated with changes in the sedimentary environment, suggesting a link between sedimentation and paleoclimatic conditions.

Bryant Submarine Fan

(A) Examples of piston cores from the Trinity-Brazos mini-basin turbidite system showing Globorotalia menardii index curves for hemipelagic cores that penetrate the Z and Y zones. Note that a calcium-carbonate curve (%) is used for these cores, while other cores show only the Z and Y zones. Core locations shown in Group 1 in the location map above.

Rio Grande Submarine Fan

B (A) 3.5 kHz profiles across Rio Grande Fan (location in Box B on echo character map in central panel). Note the small, high-amplitude reflections (HARs), which are indicative of mass-transport deposits. The upper part of the section shows an area affected by bottom-current activity. Locations of cores shown in Box B, central panel and Group 4 on map to left in this panel.

Relationship of Late Quaternary climatic zones (glacial and interglacial cycles) as determined from oxygen-isotope stratigraphy for the past 150,000 years (e.g., Imbrie, 1985) to biostratigraphic zonation of piston cores based on Globorotalia menardii zonation (Z, Y, etc.) developed by Ericson and Wollin (1968), and on fluctuations of calcium-carbonate and coarse-fraction content downcore. Examples of these fluctuations compared with marine isotope stages (MIS 1-5) and the Globorotalia menardii, Globorotalia ungulata, Globorotalia inflata, and Globorotalia menardii flexuosa. Estimated sea-level based on the oxygen-isotope curve is also from Imbrie (1985).

Trinity-Brazos Turbidite System

Examples of piston cores from the Trinity-Brazos mini-basin turbidite system showing Globorotalia menardii index curves for hemipelagic cores that penetrate the Z and Y zones. Note that a calcium-carbonate curve (%) is used for these cores, while other cores show only the Z and Y zones. Core locations shown in Group 1 in the location map above.

Bottom-Current Deposits

(A) Close-up photos of piston cores showing examples of sediments interpreted as bottom-current deposits. The sediments have a distinctive layering and are typically rich in fine-grained material. Locations of cores shown on map in central panel in areas of Type 4 echoes.

(C) Examples of piston cores from the Trinity-Brazos mini-basin turbidite system showing Globorotalia menardii index curves for hemipelagic cores that penetrate only the Z and Y zones. Core locations shown in Group 1 in the location map above.

(D) Examples of piston cores from the Trinity-Brazos mini-basin turbidite system showing Globorotalia menardii index curves for hemipelagic cores that penetrate only the Z and Y zones. Core locations shown in Group 1 in the location map above.
Latest Quaternary Regional Sedimentation Processes in the U.S. Gulf of Mexico Exclusive Economic Zone (EEZ)

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\(3.5\) kHz ECHO TYPES (SEISMIC FACIES)

**Type 1A**
- Sharp Bottom Echoes with Continuous Parallel (Conformable) Sub-bottom Reflections Recorded from Flat to Gently Rolling Sea Floor.
- Pelagic and Hemipelagic Sediment, Turbidites.

**Type 1B**
- Sharp Bottom Echoes with Sub-parallel or Disconformable to Convergent Sub-bottom Reflections which Appear to be Migrating Wave Forms.
- Bottom-Current and Contourite Deposits, Mud with Thin Silt/Fine Sand Lamine and Beds.

**Type 2**
- Semi-prolonged Bottom Echoes with Discontinuous, Parallel Sub-bottom Reflections.
- Moderately Sandy Sediments, Possible Interbedded MTDs.

**Type 3**
- Complex Bottom Echoes with Varying Vertex Elevations; Sub-bottom Reflections Are Absent to Very Rare.
- MTDs, Mainly Slumps and Slide Blocks.

**Type 4**
- Prolonged Bottom Echoes Generally with No Sub-bottom Reflections or Single Discontinuous Sub-bottoms.
- Very Sandy Sediments, Turbidites & MTDs

**Type 5**
- Large, Single Irregular Hyperbolic Bottom Echoes with Widely Varying Vertex Elevations; Sub-bottoms Absent.
- Modestly Rugged Seafloor Topography, Steep Seamounts, Continental Slope, Diapirs; No Sedimentary Information.

**Type 6**
- Semi-prolonged Bottom Echoes with Transparent or Non-Reflective Internal Character (No Sub-bottoms) Commonly Contained in External Forms that Display Irregular Wedge, Mound, Fill or Lens Shapes.
- Muddy Debris Flows, but also Can Be Very Sandy.

**Type 7**
- Lightweight Echoes with Transparent Internal Character (No Sub-bottoms) Commonly Contained in External Forms that Display Irregular Wedge, Mound, Fill or Lens Shapes.
- Muddy Debris Flows, but also Can Be Very Sandy.

**Type 8**
- Modern Channels Levee Crests Fan Edges

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Close-up photographs of cores from DSDP Hole 616 which were taken in the large Eastern Debris Flow deposits of the ... large debris flows as shown by the echo character map at left where most of this region returns sharp-to-prolonged bottom echoes (Type 5 below) with transparent internal character (no sub-bottoms) consistent with debris flows. Common external forms are irregular wedge, mound, or fill shapes. The deformed sediments and mudclasts in the cores above confirm the echo character interpretation. The examples below show the downslope western edge of the large debris flow. Scale bar on cores = 5 cm.

On the lower portion of the Mississippi Fan (location at left). The sediments from the lower fan are mainly thick sands ... to the sections shown below. Prolonged echoes are generally returned from very sandy sediments. Scale bar = 5 cm.

3.5 kHz profiles across the East Breaks Slide Complex. Location of profiles are shown in map at left. Dip profile AB down the middle of the western portion of the complex shows the head of the mass-transport deposit (MTD). Note the echo character is predominantly Type 6 echoes, which is indicative of deposits with large slump and slide blocks. Strike profile CD across the entire upper portion of ... of deposits with large slump and slide blocks. Note the abrupt edge of the buried MTD beneath the channel in profile IJ.

Mass-Transport Deposits in Intraslope Basins

The occurrence of very large mass-transport deposits on Mississippi Fan was first suggested by Walker and Massingill (1970). Based on a few widely spaced regional lines they interpreted the distribution of large eastern and western mass-transport deposits as shown in the map below.

Examples of piston cores from mini-basins showing silt and/or sand beds deposited by turbidity currents and related MTDs. (A) Debris-flow deposits with a thin layer of hemipelagic sediment or turbidite on top. The basins' north and south margins teem with organic material, but its origin is not clear. The north margin is interpreted as a slump deposit. (C) This basin shows multiple, thick MTDs. Location of core and profiles are in map on central panel.

Mass-Transport Deposits

Mass-Transport Deposits

Mississippi Fan

East Breaks Slide Complex

Mass-Transport Deposits in Intraslope Basins

Turbidity Currents

Additional piston cores showing examples of debris-flow deposits from the East Breaks Slide Complex. Note the deformed mud clasts in cores, which we interpret as a slump deposit. Locations of cores and profile are shown on map in center panel.