ACCESS NUMBER: MU9-10

STUDY TITLE: Geologic Studies of the Northern Gulf of Mexico and the Mississippi River Delta

REPORT TITLE: Subaqueous Sediment Instabilities in the Offshore Mississippi River Delta

CONTRACT NUMBER: BLM: MU9-10

SPONSORING OCS REGION: Gulf of Mexico

APPLICABLE PLANNING AREAS: Central Gulf of Mexico; Western Gulf of Mexico

FISCAL YEAR OF PROJECT FUNDING: 1979

COMPLETION DATE OF REPORT: 1980

COST: FY 1979: $612,585

CUMULATIVE PROJECT COST: $612,585

PROJECT MANAGER: L. Garrison

AFFILIATION: U.S. Department of the Interior, U.S. Geological Survey

ADDRESS: P.O. Box 6732, Corpus Christi, Texas 78411

PRINCIPAL INVESTIGATORS*: J. Coleman, L. Garrison, D. Prior

KEY WORDS: Central Gulf; Western Gulf; Mississippi River; hazards; geology; distribution; submarine features; sediment; sonar; shelf; slope; geohazards

BACKGROUND: The Mississippi River Delta is known to be an unstable geomorphic feature characterized by mass movements and sediment failures. These characteristics represent hazards for oil and gas structures erected on the Outer Continental Shelf (OCS) off the Mississippi Delta. Combined efforts of the U.S. Department of the Interior, Louisiana State University, and Texas A&M University were directed toward assessing the cause, frequency, and location of sedimentary irregularities on the Mississippi River Delta OCS. Maps were developed from geophysical studies of the region to delineate particular sedimentary features.

OBJECTIVES: (1) To establish the regional geologic framework of the delta; (2) to map the distribution and describe the variety of types of submarine instabilities; (3) to characterize the soil properties and their behavior under various stresses; and (4) to determine the mechanisms responsible for submarine sediment failures.

DESCRIPTION: Maps of near-surface marine geology of the Delta were prepared from high resolution geophysical and side-scan sonar data collected during October 1977 to March 1978. Geophysical surveys utilized a depth recorder (110 kHz), a subbottom profiler (3.5 to 12 kHz), and a low frequency sparker or boomer unit (50 to 100 kHz). A

two-way travel time of 5,000 ft s^{-1} (1,524 m s^{-1}) was used for all conversions of velocity to depth. Several side-scan sonar systems, with range settings of 150 to 200 m on a side, were employed to detect surficial irregularities. Trackline spacing for all surveys ranged from 256 to 366 m. Any side-scan data distorted by ship speed and slant range were corrected manually before mapping of bottom features. Original side-scan data were recorded at scales of 1:1,500 to 1:2,000 and photographically reduced to the map scale of 1:48,000. Navigation using Loran-C, transponder ranging systems, and auto-tape produced negligible errors at 1:12,000 scale. Approximately 17,506 km of data were collected, interpreted, and mapped covering a 2,005 km^2 area and 98 oil and gas lease blocks.

SIGNIFICANT CONCLUSIONS: Many sediment instabilities were found on the shelf near the periphery of the delta that vary in magnitude, frequency of occurrence, and causative mechanisms. Additional sediment failures were observed in deepwater areas at the shelf margin and on the upper slope, despite incomplete survey coverage of these areas. Deformational features disclosed by side-scan sonar included collapse depressions, bottleneck slides, rotational slides, mud flow gullies, mud flow lobes, erosional furrows, and reefs. Subsurface irregularities detected by profilers were methane gas, sediment disturbances, faults, folds, shelf-edge separation scars, and diapirs. The final maps allow accurate evaluation of geological hazards within individual lease blocks of the region.

STUDY RESULTS: Bathymetric maps produced from data gathered in 1874, 1940, and 1977 to 1979 revealed that considerable mass sediment movements had occurred on the OCS off the Mississippi River Delta. Large amounts of sediment have accumulated in depths of 91 to 152 m, some deposits 30 m thick were the result of mass movement episodes. Historical comparisons show the shelf edge has prograded approximately 2,438 m during the 100-year time span with most accumulation occurring on northeastern and western margins of the study area. Examination of a series of gullies and ridges revealed the dynamic nature and frequency of mass-movement events. Sediment failure of a gulley or ridge usually followed a major flood on the river. Rapid movements result in increased pore pressure, hence decreased stability of these sediments. In general, historic maps described sediment accumulation, frequency of mass movement events, causative mechanisms, and predictions of down slope movement of sediments.

Seafloor morphology and irregularities were mapped from the side-scan sonar data. In shallow waters 9 to 15 m, collapse depressions and bottleneck slides were most common. These features were 36 to 152 m in diameter, bounded by escarpments as much as 3 m high. Peripheral rotational slides were found on the upper delta front slope, near the distributary mouths of the river. Mud flow gullies extended radially seaward from each distributary in water depths of 6 to 91 m. Gullies were the most common type of sediment instability fronting the Delta. At the seaward extent of most mudflow gullies exists a fan or lobe of overlapping discharged debris and mud. Around the peripheral edge of these mud flow lobes were convective pressure ridges and many small slumps, vents, and mud volcanoes. In two deep-water (122 to 396 m) regions, erosional furrows were detected that were 9 to 24 m wide with depths of 1 to 3 m.

Along the southeast margin of the salt dome in the South Pass OCS area (Blocks 60 to 67), an extensive cemented reefal system exists. The reef was reported to be dead but does provide considerable topographic relief. A separate map (1:12,000) of South Pass disclosed large mud flow gullies, collapsed depressions, bottle neck slides, and large mud flow lobes. A similar map (1:12,000) of South Pass East depicted narrow mud flow gullies with bifurcations preceding mud flow lobes. Side-scan sonar mosaic and isopach maps (1:12,000; 1:48,000) were also prepared showing surface deformational areas. In addition to surface instabilities, shallow subsurface irregularities recorded with subbottom profilers were also mapped (1:48,000). Biochemically produced methane gas was detected in several areas, but actual measurements of bubble density or thickness of gas charged sediments were not made. A variety of contemporaneous slumps and faults were found in deeper waters of the OCS. Most of these faults were formed during late Pleistocene times, and movement along the fault plane has been continuous to the present. Scarps associated with these faults were 12 to 30 m high. Extensive mud flows cause rapid sediment accumulation across the scarp, thus maintaining sediment movement along the fault. Folding of sediments was observed in the vicinity of contemporaneous faults usually in the upper 152 m of the sedimentary column. Folds were believed to be the result of compressional forces. A large buried shelf-edge separation scar was detected off the central portion of the Delta, probably the result of a massive failure during late Pleistocene times. Shallow-seated diapiric structures or salt domes were found offshore of the modern Mississippi River Delta. One such salt structure was documented in the South Pass Blocks 60 to 67 region. Mud flow has surrounded and covered most diapirs; however, some exhibit topographic expression.

STUDY PRODUCTS: Coleman, J. M., D. B. Prior, and L. E. Garrison. 1980. Subaqueous Sediment Instabilities in the Offshore Mississippi River Delta. A final report by Louisiana State University and the U.S. Department of the Interior, U.S. Geological Survey for the U.S. Department of the Interior, Bureau of Land Management Gulf of Mexico OCS Office, New Orleans, LA. NTIS No. PB80-224629. BLM Open File Report 80-01. Contract No. AA551-MU9-10. 60 pp.

*P.I.'s affiliation may be different than that listed for Project Manager.