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DEEP-SEA FURROWS: PHYSICAL CHARACTERISTICS, MECHANISMS OF FORMATION AND ASSOCIATED ENVIRONMENTAL PROCESSES

FINAL REPORT

(August 2003 – September 2004)

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13. ABSTRACT (Maximum 200 words) Texas A&M University put together a Joint Industry Project (JIP) to study the mega-furrows in the Gulf of Mexico for two important scientific and practical reasons: 1) from a scientific standpoint, linking the bedform morphology to the overlying bottom water flow will allow regional geology to be used as a long term record of and proxy for the dominant flow at the base of the Sigsbee Escarpment, and 2) from a practical standpoint it is critical to understand the nature of the deepwater flow and the morphology of the mega-furrows to properly and safely engineer deepwater facilities. This first year of the JIP, in which RPSEA participated, focused on preparation and completion of a high-resolution seismic survey using the Texas A&M University Deep Tow system in the Green Knoll area of the Gulf of Mexico. Additionally, 2 long piston cores were collected from 2 key sites in the study area. As the entire project is actually a 3-year study, the complete results are proprietary and available only to the JIP participants for a period of 1 year following the end of the project. This final public distribution of the report for RPSEA summarizes the activities and results of the first year of the JIP. Additional, detailed proprietary data are available in a non-public distribution to current and future JIP participants as a separate set of Appendices.
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RPSEA FINAL REPORT

Project:

Deep-Sea Furrows: Physical Characteristics, Mechanisms of Formation and Associated Environmental Processes

A Joint Industry Project from:

Texas A&M University -
Department of Oceanography and
Offshore Technology Research Center

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Abstract:

Based on recent current meter measurements, 3-D seismic data, and high-resolution seismic data, it is now known that significant contour currents (up to 2 knots) sweep along the base of the Sigsbee Escarpment in the Gulf of Mexico. The geological evidence is in the form of fields of mega-furrows as well as other contour current bedforms. Texas A&M University Department of Oceanography and Offshore Technology Research Center put together a Joint Industry Project (JIP) to study the mega-furrows in the Gulf of Mexico for two important scientific and practical reasons: 1) from a scientific standpoint, linking the bedform morphology to the overlying bottom water flow will allow regional geology to be used as a long term record of and proxy for the dominant flow at the base of the Sigsbee Escarpment, and 2) from a practical standpoint it is critical to understand the nature of the deepwater flow and the morphology of the mega-furrows to properly and safely engineer deepwater facilities. Participation by RPSEA in the first year of this 3-year JIP provided critical funds to perform the initial seismic survey and leverage additional government and industrial participation for the full term of the JIP. This first year of the JIP focused on preparation and completion of a high-resolution seismic survey using the Texas A&M University Deep Tow system in the Green Knoll area of the Gulf of Mexico. Additionally, 2 long piston cores were collected from 2 key sites in the study area based on both the 3-D and high-resolution seismic data. Data interpretation is still in the early stages; however, the seismic data and core data have already provided valuable insights: 1) evidence for secondary flow structures within furrows, 2) evidence for currently active furrow erosion, 3) at least 2 regionally persistent subbottom reflectors, 4) outcrops of key reflectors for future coring and dating, 5) evidence for both depositional and erosional areas within the contour current zone, 6) indication of mobile surface sediments, and 7) existence of paleo-furrow horizons. As the entire project is actually a 3-year study, the complete results are proprietary and available only to the JIP participants for a period of 1 year following the end of the project. This final public distribution of the report for RPSEA summarizes the activities and results of the first year of the JIP. Additional, detailed proprietary data are available in a non-public distribution to current and future JIP participants as a separate set of Appendices.

Executive Summary:

The largest and most recent hydrocarbon finds in the Gulf of Mexico have been discovered along the continental rise at the base of the Sigsbee Escarpment in the Northwest Gulf of Mexico. Drilling on the continental rise south of the Sigsbee Escarpment allows for the recovery of hydrocarbons in Eocene and older deposits without drilling through the thick salt nappe that constitutes the base of the escarpment. Drilling on the continental rise at the base of the escarpment has its advantages as well as some serious difficulties that are related to the contour currents that sweep along the base of the escarpment as a result of topographic Rossby waves derived from the action of the loop current within the Gulf of Mexico. The recent discovery of mega-furrows on the continental rise at the base of the escarpment indicates that the bottom currents (contour currents) responsible for the furrow formations range up to 100 cm/sec and more. In addition to topographic Rossby waves, density currents associated with the leaching of exposed salt along the escarpment have added an additional parameter to the complex current conditions along the continental rise.

This Joint Industry Project (JIP) addresses the question of the nature the currents and the formation of furrows along the base of the Sigsbee Escarpment. Understanding the formation of furrows and associated contour-current bedforms will allow for the broad interpretation of current conditions over vast areas that are prime locations for hydrocarbon production. Seabed furrows have been subsequently found on the continental rise off Africa, Brazil and the East

Coast of the United States. Furrows are most likely ubiquitous features to be found along all passive continental rises. In addition to the basic understanding of formation of seabed furrows, the study of furrowing is a study in the basic nature of fine-grained sediment erosion and transport in shallow as well as ultra-deep waters; a point that has not been apparent but was suggested by J.R. Allen and R. Flood over 30 years ago.

The nature of this deepwater flow and the associated seafloor features need to be understood for several scientific and very practical reasons. Scientifically, the flow and associated seafloor features reflect primary sedimentary processes that form and maintain continental rises and lower continental slopes throughout the world's oceans. These features also provide a modern analog for previously unexplained long, linear subsurface structures identified on seismic profiles of slopes and rises. Establishing a link between modern contour current bedforms and the overlying bottom water flow will enable a better understanding a paleo-oceanograpic conditions based on geological evidence. The seafloor currents are temporally variable and have velocities of up to 2 knots, and the seabed features have very abrupt changes in relief on the scale of tens of meters. Such variability has significant implications for the development of deepwater oil reserves. We need to understand the nature of the deepwater flow, the morphology of the furrows, and the related environmental parameters to properly engineer deepwater facilities.

There are many implications of the effects of currents and furrows on the production of deepwater hydrocarbons. A few are: 1) Extreme topographic relief and strong flow affects the pattern that cuttings and drilling mud might be deposited on the seafloor. 2) Topographic relief and strong flow complicates the design and installation of pipelines. 3) Erosional scour affects stability of pipelines, foundation piles, and seafloor installations. 4) Slope undercutting by erosional scour potentially leads to hazardous slumps and slides. 5) Strong bottom-water flow may produce vortex-induced vibrations that cause fatigue and failure of riser strings, platform tension legs, and anchor cables. 6) In several recent instances, strong currents prevented the use of industrial type remotely operated vehicles (ROVs) intended to assess geohazards and inspect seafloor installations. 7) Observational data derived from study of the furrows and associated strong bottom water flow will provide valuable data for calibration and validation of numerical models used to predict trajectories of pollutant plumes. 8) Current flow against man-made structures could enhance corrosion of metallic components.

With the above considerations in mind, this JIP aims to characterize the extent and morphology of the furrows, measure the sediment properties, and assess the depositional history of the sediments using age-dating and seismic stratigraphic techniques. The study is designed to examine the local and regional flow of water associated with the furrow field, and relate it to the mechanisms of furrow formation and the climatology of deepwater currents. The overall JIP is scheduled to last three years and was put forward by Texas A&M University Department of Oceanography and Offshore Technology Research Center. RPSEA's participation was limited to the first year of the study. Two main benefits of involving RPSEA were to provide funding for the first year of research and the necessary leverage to bring in additional participants thereby making this important research possible. In fact, the money put forward by RPSEA did leverage the participation of both industry (BHP and BP) and government (MMS). Because of the generous contribution of RPSEA the first year of the JIP was a tremendous success, and the additional participants will be able to fund the remaining two years of the project. This report discusses the progress made during the time period of the participation of RPSEA and the contribution of this phase to the overall plan.

The major accomplishment during the first year of the JIP was the preparation and successful completion of a high-resolution seismic survey in the Green Knoll area, by means of TAMU's upgraded deep-tow seismic system. The cruise track for the seismic data collection (Figure 1) was designed to provide detailed information on a number of seafloor features, such as accelerated flow around an obstruction, junctions of furrows and abrupt changes in bedform morphologies. Interpretation of these data in conjunction with existing 3-D seismic data will address the characterization of furrow bedform types, morphologies, spatial distribution, and relations between bedforms and flow patterns. Additionally, the seismic data were used to select sites for coring and current meter placement during subsequent JIP operations. Following the high-resolution seismic survey, the data were extensively processed to correct and/or eliminate bad data, allowing the data to be formatted suitably for seismic interpretation software. Ultimately, a side-scan sonar mosaic was compiled and overlaid on the 3-D bathymetry. The integration of these seismic data sets with sediment samples provided by TDI Brooks will provide the geologic background and details necessary to establish a link between contour current bedforms and the overlying bottom water flow that will be analyzed in the remaining 2 years of the JIP.

Note:

All reports, data, and project details can be found at: http://deeptow.tamu.edu/jip_private/. These data are proprietary and available only to JIP participants until 1 year after the end of the project in 2006. To become a participant and have immediate access to all current and future data, please contact Dr. William Bryant or Dr. Niall Slowey at the following locations:

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The cost of participation is $60K per year for a total of 3 years. If you are already a JIP participant and need to request a username and password, please email your request to: dabean@ocean.tamu.edu.

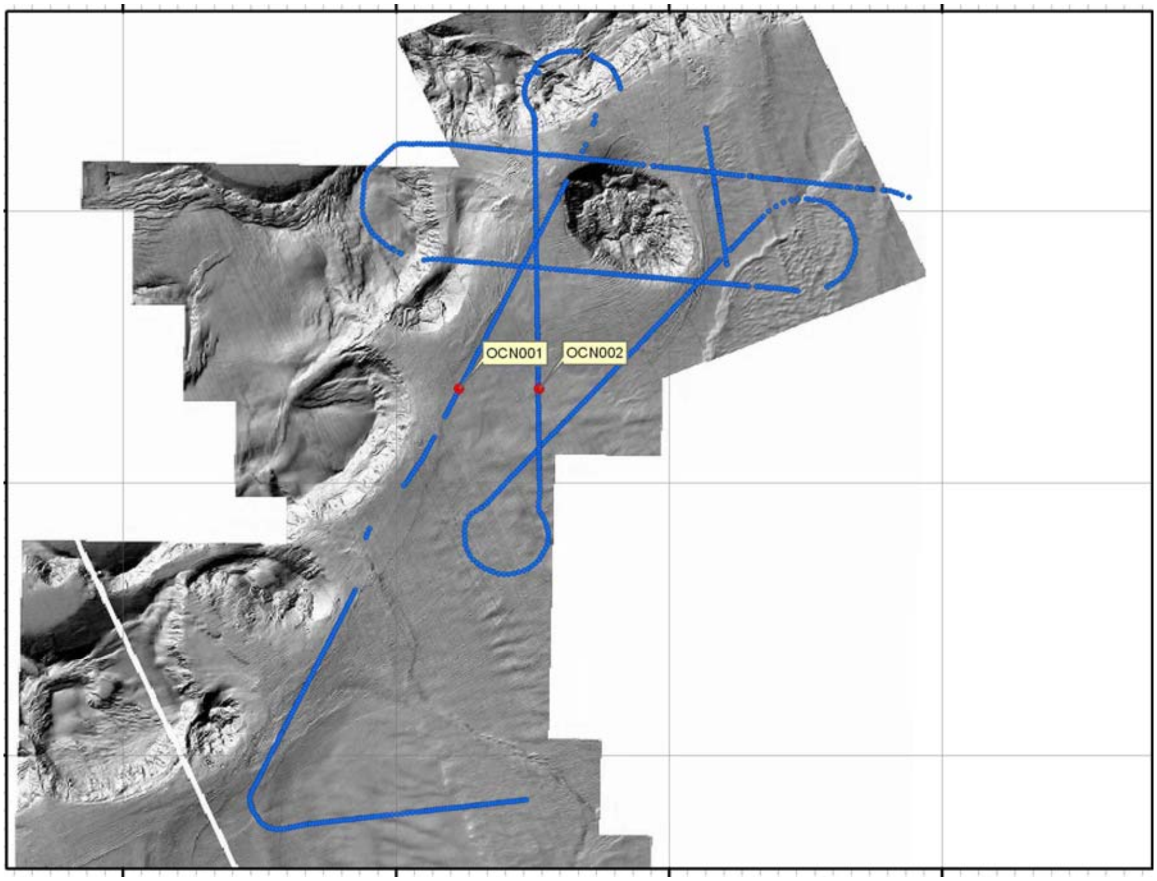

Figure 1. Survey cruise track and selected location of the jumbo piston cores, collected by TDI-Brooks International Inc. The seismic and core data will provide the necessary geological details necessary to understand the morphology and development of furrows and other contour current bedforms along with critical information for planning the remaining aspects of the JIP.