Mega-Furrows, Contour Currents and Density Flows of the Northwest Gulf of Mexico Continental Slope and Rise

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Abstract A geophysical survey of the northern Gulf of Mexico Continental Slope and Rise around Bryant Canyon in the spring of 1999, collecting deep-tow data, which consisted of a 3.5 kHz subbottom profiler and a 100 kHz side-scan-sonar, surveyed a series of longitudinal mega-bed-forms in ~3000 m of water along strike and at the base of the Sigsbee Escarpment. The mega-bed-forms surveyed included a field of sedimentary mega-furrows ~10 m deep and ~30 m wide, spaced ~100 m apart in a field 10-25 km wide south of the Sigsbee Escarpment. Further investigations have reviled that the furrow system extend the full length of the Sigsbee Escarpment a distance of over 700 kilometers. The furrows are the results of high-velocity bottom currents associated with contour currents generated by topographic Rossby waves and density flows.

An extensive field of mega-furrows has been discovered on the seafloor at the base of the Sigsbee Escarpment in the northwestern Gulf of Mexico (Bryant et al., 2000). High-resolution geophysical deep-tow surveys conducted in 1997 observed sedimentary furrows proximal to the escarpment north and south of Green Knoll in water depths ranging from 1400m to 1900m and on the slopes of Vaca Basin. Sedimentary furrows are longitudinal bed-forms that occur in fine-grained sediment, and have been observed in a wide variety of settings ranging from the deep ocean, to deep lakes to the Hudson River. The existence of furrows in deep sea settings suggest that unidirectional bottom currents exist in the range of 1 to 100 cm/sec and higher. Such currents may be continuous or highly episodic, and the furrows are inferred to be formed due to helical secondary circulation. Sedimentary furrows were first produced in the labortory by Allen (1969). Allen found a hierarchy of bed-forms ranging from uniform furrows at low flow conditions, to meandering furrows and flute casts, at the highest flow conditions he found sheet flow.

All the conditions described by Allen are present in the area due south of Bryant Canyon on the continental rise. The significance of these features is the high water velocities necessary for their formation and the large amount of erosion occurring at the base of the Sigsbee Escarpment. Indications are that the erosional processes are active during high-sea stands and depositional and infilling of the furrows are active during low-sea stands.

The impact of these features and the currents on pipeline and platform activities may be significant. Data obtained by Texas A&M deep-tow surveys and 3-D seismic data supplied by WesternGeco show that the scale of this field far exceeds anything previously observed in the world's oceans. These data allow the furrows to be resolved in unprecedented detail. The size of the furrows, variations in their morphology, and their orientation relative to large topographic features all suggest that the furrows are produced by strong deep water flows. Individual furrows can be traced continuously for at least 50 km on 3-D surface renderings. They are among the longest continuous individual sedimentary bed forms on the surface of the Earth. Data from a near-bottom current meter confirms that strong, previously unknown, currents do exist at the base of the Sigsbee Escarpment (Hamilton and Lugo-Fernandez, 2001). The furrows and associated environmental processes are dominant features of the northwestern Gulf of Mexico and similar features will probably be found to exist in many other areas of the world's oceans.

Existing seismic data is limited, but initial analysis indicates that mega-furrows are long, relatively narrow depressions in the seafloor that are generally oriented parallel to the escarpment. Individual mega-furrows are ~1 to 10 m deep and ~5 to 50 m wide with ~20 to 200 m between individual furrows. An example of the furrow field south of Bryant Canyon is Illustrated in Figure 1. Figure 2 illustrates the extent of know and possible furrow field along the Sigebee Escarpment.The whole field of furrows appears to cover an area in excess of 18,000 km^2. Extremely limited current velocity measurements in the furrows show that near bottom currents can exceed 2 knots (100 cm/sec). The spatial variations of furrow topography have not been characterized and the spatial and temporal variations of the bottom water flow field are also unknown. Knowledge of the spatial and temporal variations of furrows is necessary to understand the processes forming furrows and to predict the variations of sediment properties with depth below the seafloor. It will also provide important insight into the geological development of the continental rise.

The Mississippi Fan Fold Belt / Green Canyon area of the Sigsbee Escarpment and portions of the western Sigsbee Escarpment is the primary area of ultra-deepwater oil and gas prospects in the United States. In this area and the rest of the 700 km long escarpment as well, an extremely large field of mega-furrows on the seafloor and associated strong bottom currents may have major affects on the enginerring of deep water platforms and other bottom instalations.

There are significant practical reasons to better understand the mega-furrows and associated strong currents along the base of the Sigsbee Escarpment and in other areas where strong currents erode muddy sediments. The following are several technical and environmental concerns associated with the furrows and the currents that generate such geological structures.:

- Extreme topographic relief and strong flow affects the pattern that cuttings and drilling mud might be deposited on the seafloor,
- Topographic relief and strong flow complicates the design and installation of pipelines,
- Erosional scour affects stability of pipelines, foundation piles, and seafloor installations,
- Slope undercutting by erosional scour potentially leads to hazardous slumps and slides,
- Strong bottom-water flow may produce vortex-induced vibrations that cause fatigue and failure of riser strings, platform tension legs, and anchor cables,
- In several recent instances, strong currents prevented the use of industrial type remotely operated vehicles (ROVs) intended to assess geohazards and inspect seafloor installations,
- 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,

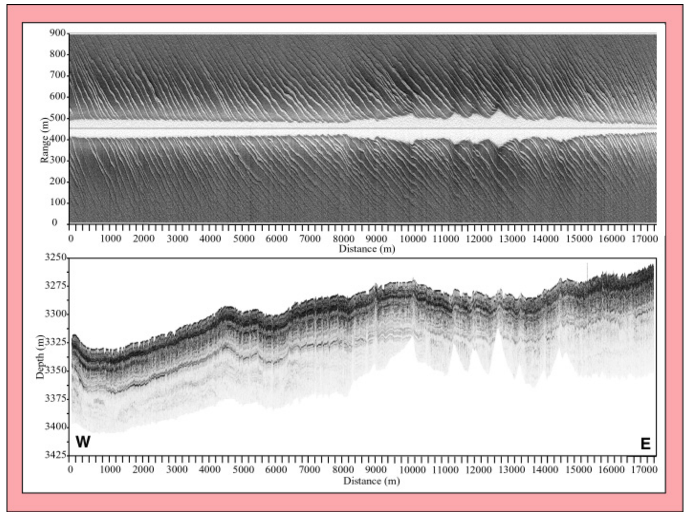

Figure 1 Side-scan and high-resolution subbottom profile of furrow field south of Bryant Canyon.

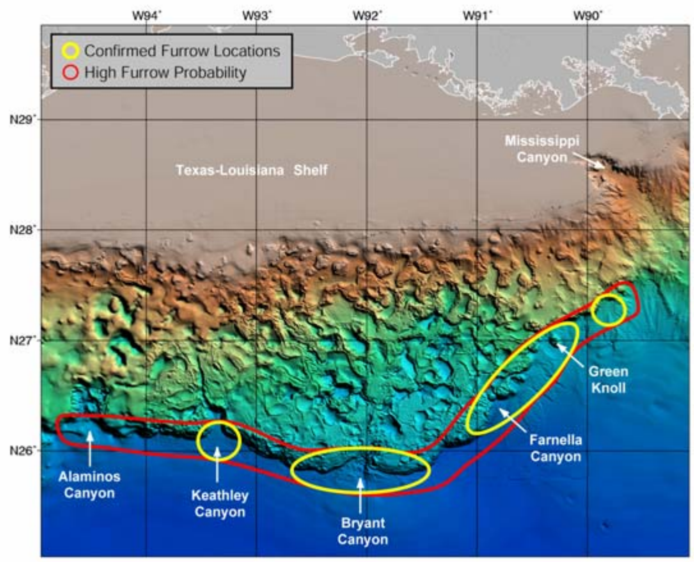

Figure 2 Location of mega-furrows in the Northwest Gulf of Mexico.

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