Continental slope sediment distribution and characterization and implications to hydrocarbon prospectivity: case studies from the Scotian margin

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ABSTRACT
Numerous unsuccessful deep water exploration wells indicate a global need to recognize and understand continental shelf-to-slope and slope sedimentary systems. This study addresses this issue through study of analogues on the Scotian margin using 3D seismic volumes and an extensive network of 2D seismic data. Results indicate the need for regional comprehension of the margin that includes ties to global paleoceanographic events in order to establish the stratigraphic framework and predict lithologic facies.

KEYWORDS: continental margin, sedimentation, deposits, petroleum potential.

1. Introduction
The Scotian margin endured a number of unsuccessful hydrocarbon exploration attempts in large part because of insufficient understanding of continental shelf-to-slope and slope geologic processes. These poor results highlight a global need to recognize and understand continental shelf-to-slope and slope sedimentary processes and depositional systems. This study addresses this issue through study of analogues on the Scotian margin, which have had a complex geologic
history with canyon incision, salt tectonism and glacial influences.

2. Methods
Five 3D seismic volumes distributed across the Scotian margin and an extensive grid of 2D seismic data were interpreted for this study (Figure 1). Data were interpreted on seismic workstations, including application of modern practices of seismic stratigraphy, sequence stratigraphy, seismic geomorphology and attribute analysis.

Results and Discussion
For the Scotian margin, application of conventional seismic sequence stratigraphic methods has proven difficult to apply because of the dominance of erosive processes. Such processes include numerous episodes of canyon cut and fill coupled with slope bypass, mass transport reworking and re-deposition, and along-slope sediment erosion and transport by deepwater contour currents (contourites). These processes dominate over sediment input and sea level controls and greatly impact the preserved stratigraphic record with significant spatial and temporal variation.

The modern seafloor of the eastern Scotian Slope is heavily incised by canyons and valleys, providing recognizable conduits for off-shelf sediment transport, slope by-pass and deposition on the continental rise and abyssal plain (Fig. 1). Canyon incision appears to have been episodic throughout the Cenozoic, involving multiple phases of cut-and-fill with new systems often re-occupying old (Fig. 2). This episodic canyon incision indicates a limited residence period of sediments on the shelf and slope, having implications for potential reservoir distribution.

Mass transport processes are a fundamental aspect of continental slope construction (Fig. 3), yet their significance in sediment delivery in terms of processes and quantities, to deep water remains poorly understood. As a result, their impact on oil and gas exploration has yet to be fully understood. The magnitude of sediment redistribution by contour-currents was only recently understood.
recognized along the Scotian margin (Fig. 4). This process leads to difficulty in predicting sediment distribution patterns and ultimate prospectivity for hydrocarbons.

Little is known of the ultra-deep water region of the base-of-slope. It appears to be a region dominated by mass transport and turbidite deposits (e.g. Fig. 5). It may well represent a sediment catchment zone, but it is important to understand sediment deposition patterns in time and space in order to understand its prospectivity for hydrocarbons.

Despite these complexities and differences in sedimentary processes, there are consistencies in depositional patterns across and amongst continental margins. Atlantic-wide paleoceanographic events permit establishment of a broad stratigraphic framework. For example, a major Eocene canyon cutting period and a mid-Miocene bottom current intensification period provide stratigraphic markers throughout the western Atlantic, despite having varying depositional signatures across different margins. These results indicate the need for regional and in fact global comprehension of the margins that include ties to global paleoceanographic events.

3. Conclusions

- Along the Scotian margin, canyons and mass-transport processes provided mechanisms for slope bypass and delivery to the rise and abyssal plane.
- Mass transport processes resulted in removal of stratigraphic section and transport of significant amounts of sediment downslope.
- Significant deep water margin erosion occurred at certain periods, apparently related to development of strong along-slope bottom currents. These currents were responsible for removal and redistribution of vast amounts of material.

The processes indicated above indicate that reservoir-grade sediments can be reworked, relocated and transported to great water depths and offer significant challenges to reservoir detection along the Scotian margin. A thorough understanding of the interplay and complexity of these processes is necessary to develop and apply exploration models.
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