

THE ROLE OF BOTTOMFAST ICE IN CONTROLLING NEARSHORE PROCESSES AND ENGINEERING CONDITIONS AT THE MOUTH OF THE MACKENZIE RIVER DELTA, BEAUFORT SEA, CANADA

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Environmentally sound development of hydrocarbon resources in the Mackenzie Delta region will require an understanding of the processes that govern coastal stability, nearshore morphology and sediment properties. This region is characterized by extensive shallow water. During the winter months sea ice forms and thickens until it contacts the seabed (i.e. becomes "bottomfast"). Bottom-fast ice (BFI) exposes the seabed to the very cold air temperatures and heat is conducted rapidly out of the sediments, permitting the formation of seasonal frost and, in some cases, permafrost aggradation. Very subtle variations in water depth can therefore have profound effects on sediment properties on length scales of 10s of metres. Since water depths are so shallow and the tidal range is small (<0.5 m), conventional acoustic methods for collecting data have limited utility. In this study we apply new methods, including synthetic aperture radar (SAR) for mapping the distribution of BFI and ground penetrating radar (GPR) for investigating the subsurface. The success of both of these techniques is attributable to the freshness of the waters off the delta front.

The use of SAR to map BFI was developed for lake ice in Alaska (Jeffries et al. 1996). Data from several field surveys along the Beaufort coast have shown that this technique is valid for the inshore areas off the Mackenzie Delta in water depths of less than 2 m. These data reveal that extensive shoals covering areas of 30 km² or more are present at the mouths of channels where fine details of distributary mouth bars are visible (Figure 1). Imagery from several years has been used to track changes in the morphology and position of shoals. In one case, 1.35 km of shoreward migration was measured over a period of 11 years. Rapid changes are not surprising in a deltaic environment, but have not been documented in this region prior to the application of the SAR mapping technique. Thermistor cables installed in boreholes along a transect from shallow to deeper water show the impacts of differences in the duration that the seabed is affected by BFI. Sedimentary history (e.g. erosion and deposition) therefore plays a significant role in the distribution of sub-seabed temperatures and associated physical properties (i.e. the degree of ice-bonding).

In order to better understand the sedimentology and cryo-stratigraphy of shallow nearshore sediments GPR has been acquired along transects over some of

the large shoals in the region. The GPR is used to assist in the validation of the SAR interpretations and has proven to be very useful in mapping sub-bottom reflections where the ice is bottom-fast. Pseudo-3D surveys reveal very complex distributions of frozen and unfrozen sediments within transition zones between floating and bottom-fast ice. In well ice-bonded silts and sands, evidence of progradation in the form of foreset bedding is common.

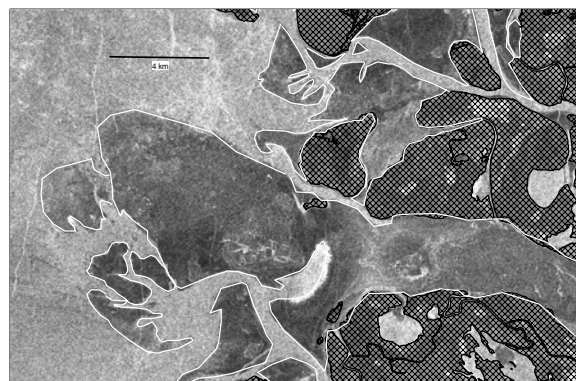


Figure 1 - ERS1 Synthetic Aperture Radar at the mouth of the Mackenzie River acquired on April 27, 1993. Black hatched areas are land; white-outlined regions are interpreted as bottomfast ice that highlights shoals and distributary mouth bars.

Rapid changes in sediment physical properties will accompany the observed variation in the distribution of BFI. These changes between frozen and unfrozen materials will affect the design of pipelines installed to transport gas and/or oil across the wide Mackenzie Delta front. Pumping warm fluids through frozen ground may lead to thaw subsidence; cold fluids piped through unfrozen sediment can cause heave. High spatial variability of sediment properties will affect the choice of installation methods. A sampling program is currently underway to develop a more complete understanding of the distribution of physical properties in delta-front deposits.

REFERENCES

Jeffries, M. O., K. Morris and G. E. Liston. 1996. A method to determine lake depth and water availability on the North Slope of Alaska with spaceborne imaging radar and numerical ice growth modelling. *Arctic*, 49(4), 367-374.