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Characterization of near-surface bedrock occurrences along the Scotian Shelf: a framework for offshore wind development

Lynn T. Dafoe[1], Mark E. Deptuck[2], Jordan B.R. Eamer[1], D. Calvin Campbell[1], Pierre-Arnaud Desiage[1], Laura Broom[1], Vânia Correia[1], and Robert A. Fensome[1]

[1]Geological Survey of Canada, Natural Resources Canada

[2]Canada-Nova Scotia Offshore Petroleum Board

Summary

Bedrock occurrences at or near the seabed play a critical role in assessing the feasibility of offshore wind turbine installations and determining suitable foundation types. In tens of metres of water depth, monopiles are the most commonly used foundation for wind turbines; however, their installation requires loose, unconsolidated sediment (Fugro, 2017). Consequently, surface and near-surface bedrock can present challenges for offshore wind development in these regions. On the Scotian Shelf, offshore Nova Scotia (Fig. 1), several shallow-water banks provide regions potentially suitable for offshore wind development (Philibert et al., in press), with ongoing regional assessment leading up to an expected 2025 call for bids (Daborn et al., 2024). In these settings, post-glacial sediment typically overlies glacigenic deposits that sit unconformably above bedrock (e.g., Piper et al., 1990). In nearshore settings, the sediment cover may be thin with underlying bedrock comprising partially exposed basement terranes (e.g., Eamer et al., 2020). Basinward (middle to outer shelf), a post-Triassic passive margin succession composed mainly of carbonates and siliciclastics accumulated during rifting of Pangea and the subsequent opening of the North Atlantic (Wade and MacLean, 1990; Sibuet et al. 2012), separating Paleozoic basement rocks from post-Pliocene glaciogenic sediments. To support future offshore wind development on the Scotian Shelf, this study undertakes a two-fold investigation of bedrock character and distribution to develop a preliminary subcrop map: 1) bedrock occurrences at or near the seabed from direct sampling; and 2) the nature and distribution of subcropping bedrock units below Quaternary sedimentary cover.

Methods

The character and distribution of bedrock exposed at or near the seabed was assessed through a combination of ongoing studies and the compilation of archived and recently acquired Geological Survey of Canada dredge, drill core, piston core, and grab samples (Fig. 1). The samples were characterized in terms of their gross lithology, depositional paleoenvironments, potential lithostratigraphic assignment, and age, building on existing published studies. Where possible, these samples were placed in context of multibeam bathymetry, seabed photography, and shallow seismic data.

Wells and seismic data are abundant across the middle to outer Scotian Shelf and were used to produce a map of Quaternary sediment thickness at the resolution of industry seismic data. Well analysis allowed for mapping of the distribution of formations (Fig. 1), as well as their age and thickness, with consideration of casing depths. Preliminary seismic interpretation involved

mapping of key markers and clinothem units comprising mainly the Wyandot and Banquereau formations, the uppermost units along the Scotian Shelf of Coniacian to Pliocene age (Wade and MacLean, 1990; Fensome et al., 2008). Cuttings samples from key wells were analyzed for their lithology and sedimentary features to interpret depositional paleoenvironments. These results were incorporated with available age data and seismic interpretation to develop a preliminary framework for post-Coniacian strata and more detailed understanding of key subcrop units that are variably buried by glaciogenic sediments.

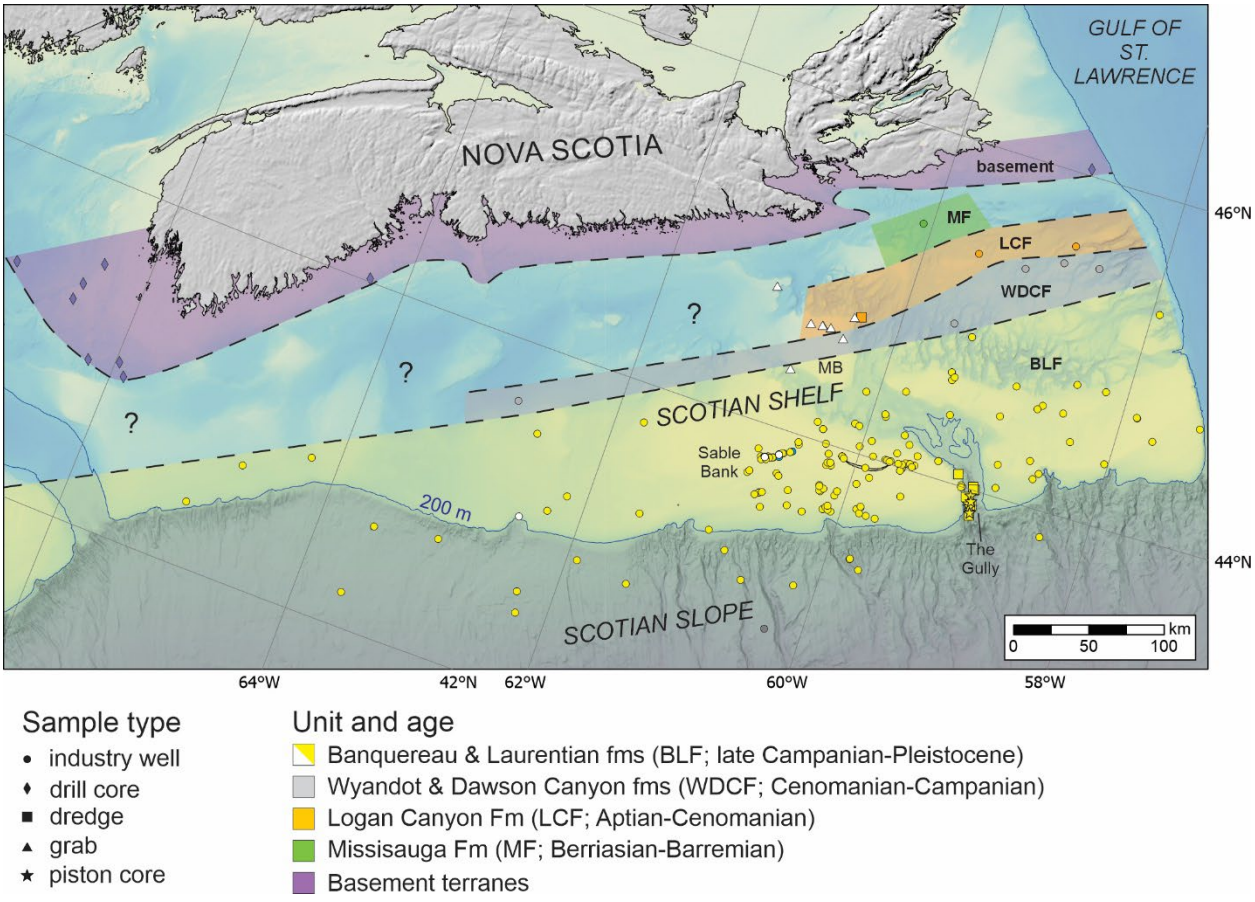

Figure 1: Map of offshore Nova Scotia showing preliminary subcrop units based on available sample data as shown. Rough seabed character is seen in the GEBCO bathymetry data extending from land up to about 100 m water depth and is used to define a zone of likely basement terrane at or near the sediment surface. Colours for sample types also correspond to the units. MB=Middle Bank.

Results

In the subsurface, the Scotian Shelf passive margin succession has been generally well studied from a petroleum perspective, but little attention has been given to its uppermost part, particularly the Banquereau Formation, as its shallow burial depth limits its exploration potential. Along the middle to outer shelf, this formation is documented at the top of several wells, with older units

locally exposed in the inner to middle shelf region (Fig. 1). The age of the uppermost Banquereau Formation strata varies along the margin, but is partly dependent on the depth of well casings and/or directional nature of the well. As seen in both well and seismic data, the thickness of this formation generally decreases from the shelf edge landward as the base Quaternary unconformity has truncated the passive margin succession. Corresponding ages, where sufficient biostratigraphic information exists, further illustrate the presence of older strata subcropping landward. Preliminary findings indicate that several clinothem units comprise the Banquereau Formation and are likely tied to changing shoreline positions during delta lobe switching through the latest Cretaceous and Cenozoic (Fensome et al., 2008). This framework provides key lithological considerations for bedrock lying below potential turbine foundations, with the Wyandot chalk and younger sandstone-dominated deltaic units being less competent than older siliciclastic deposits.

Existing seabed bedrock samples are limited and are located near Middle Bank, on Sable Bank, in the Gully and in nearshore areas (Fig. 1). Nearshore regions include offshore extensions of basement terranes composed of various igneous and metamorphic units. Outcropping bedrock within the bank areas appears to be limited as supported by localized multibeam bathymetry surveys showing mobile sediment features. Archive dredge samples, collected from regions with topographic expression, include Cretaceous and Cenozoic rocks. Additionally, recent grab samples recovered stiff clays of possible Quaternary age from the Middle Bank area. Future biostratigraphic study of both archived and recently collected material is expected to improve age control.

Conclusions

A preliminary subcrop map (Fig. 1) has been developed by integrating data from seabed samples and subsurface studies. Ongoing analyses and interpretations allow refinement of our understanding of bedrock occurrences at and near the seabed on the Scotian Shelf. These results shed light on the paleogeographic reconstructions from the Late Cretaceous through Cenozoic and potential challenges for future infrastructure development in the region.

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