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Deltaic and Fully Marine Settings Interpreted From Conventional Core, Offshore Labrador, Canada

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Introduction

Previous work in the Labrador Sea has led to development of the Labrador Sea Atlas (Bell, 1989), as well as lithostratigraphic, paleoenvironmental, and seismic interpretations involving the Saglek and Hopedale basins (e.g., Miller and D'Eon, 1987; Dickie et al., 2011; Jauer et al., in press). Dickie et al. (2011) revised the stratigraphic framework for the Labrador margin with a focus on seismic and biostratigraphic identification of unconformities. Despite these detailed studies, the work thus far has not assessed the data from a rigorous sequence stratigraphic approach. A sequence stratigraphic framework can provide an understanding of the nature of horizons, stratal packages and provide a predictive framework for understanding the stratigraphic succession. Our initial work on a sequence stratigraphic framework that can be used as an analogue to understand the succession in Baffin Bay involves the assessment of sedimentary cores from offshore Labrador to better understand the paleoenvironments of deposition.

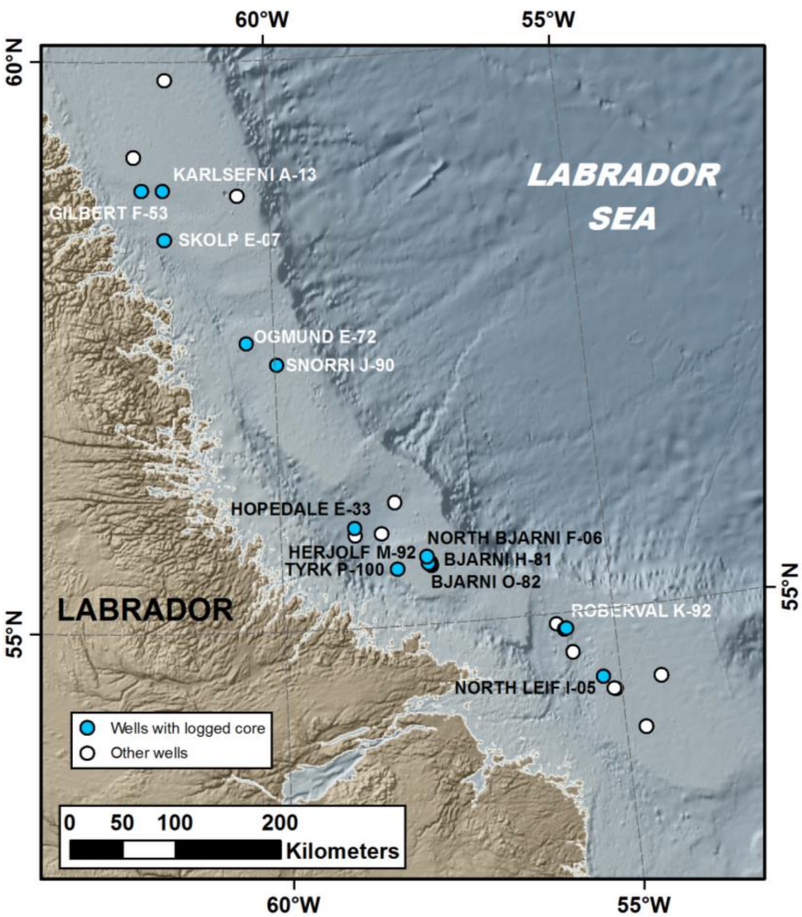

Figure 1: Study area, offshore Labrador showing the location of wells with sedimentary cores that were logged and sampled (blue) and other remaining wells (white).

Methods

Available sedimentary Mesozoic and Cenozoic conventional cores from wells offshore Labrador (Fig. 1) were analyzed in terms of lithology, sedimentary structures, degree of bioturbation, trace fossil suites and presence of fossil material. These data were used to interpret depositional environments in samples from the Bjarni, Markland and Gudrid formations. As fossil material was extremely rare within the core materials, sedimentological and trace fossil observations were primarily used to assess depositional settings. Samples were collected for palynological analysis to provide additional biostratigraphic ages and to augment the paleoenvironmental interpretations. While core materials are limited, they provide ground truth to depositional environments that can be extrapolated vertically in the wells and tied to seismic facies.

Results

Offshore Labrador conventional cores sampled the Bjarni, Markland (Freydis), and Gudrid formations with the Gudrid Formation sampled in southern Saglek Basin and the Markland and Bjarni formations sampled across the Hopedale Basin and into the southern Saglek Basin.

In the Bjarni Formation, massive to cross-bedded sandstones and conglomerates are present in Skolp E-07 (core 6), Ogmund E-72 (core 3) and North Bjarni F-06 (core 1) and are interpreted as alluvial to fluvial successions. In addition to these coarse-grained facies, heterolithic sandstone and shales and shale-dominated facies preserve sedimentological and trace fossil evidence of marine deposition. Early Bjarni sediments in both the Herjolf M-92 (core 2) and Hopedale E-33 (core 1) wells are characterized by dark grey shales with a low abundance and diversity trace fossil suite including grazing traces primarily observed from within sideritized intervals (*Phycosiphon*, *Helminthopsis*, *Chondrites* and *Schaubcylindrichnus*). Coal fragments are also present. The fine-grained nature of the sediment, presence of coaly material and trace fossil suite predominated by grazing traces suggests deposition in a restricted bay setting with poor oxygenation and little coarse clastic input. Heterolithic sandstones and shales are prevalent in Ogmund E-72 (core 2), Herjolf M-92 (core 1), Bjarni H-81 (core 1), Roberval K-92 (core 2), and North Leif (cores 1 and 2). These deposits are characterized by: cross bedding; planar lamination; soft-sediment deformation; thick mudstone beds of likely hypopycnal origin; unbioturbated, carbonaceous mudstone beds; microfaulting; organic detritus; coal fragments; and common sideritized intervals. The trace fossil suites comprise a generally low abundance and diversity of trace fossils with grazing traces most common. There is also evidence of opportunistic colonization, and overall the deposits are characterized by a stressed *Cruziana* ichnofacies. Based on the sedimentological and ichnological evidence, these sediments were deposited in delta front (possibly distributary channels) and prodeltaic settings. Differences in the nature of the sediments suggest that some core intervals represent river-dominated deltaic deposition while others reflect wave-influenced deposition.

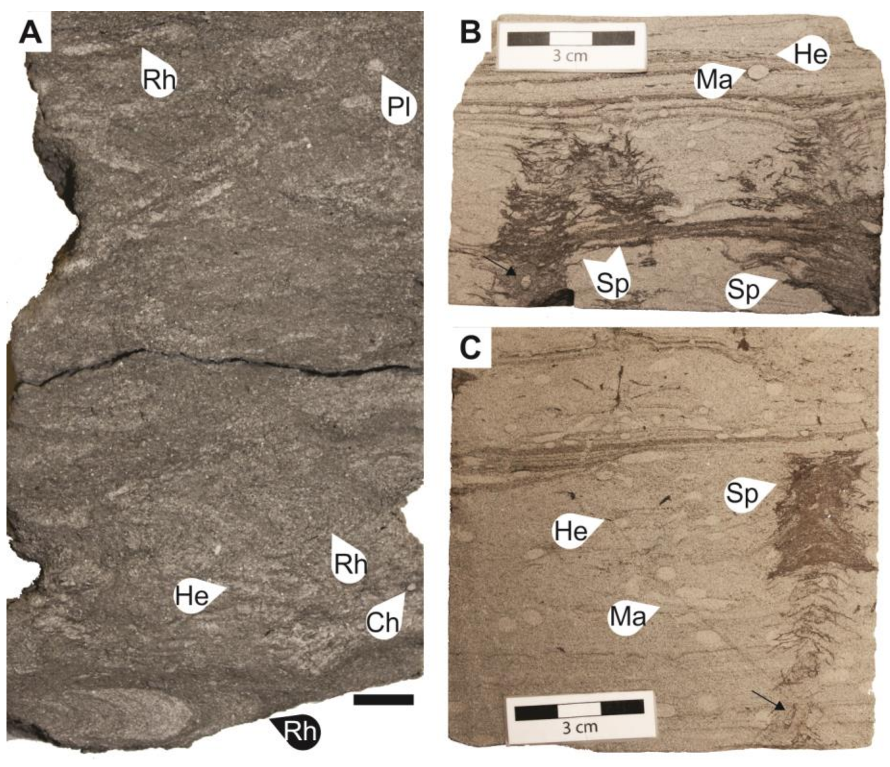

Figure 2: A) Bioturbated shelfal shales from core 3 of Skolp E-07. B-C) Muddy deltaic sandstones of core 1 from Snorri J-90. Trace fossils include: Chondrites (Ch), Helminthopsis (He), Rhizocorallium (Rh), Macaronichnus (Ma), Planolites (Pl), and Spirophyton (Sp).

The Markland Formation is characterized by shaly successions and sandstone-dominated intervals

(Freydis Member). Dark grey, laminated shales in Roberval K-92 (core 1) are devoid of trace fossils, but green mineralizations suggest possible reduced conditions and a likely distal marine (bathyal) setting during early Markland deposition. Significant thicknesses of shales, sandy mudstones and muddy sandstones characterize cores 1-5 of the Skolp E-07 well (Fig. 2A). Here, intense bioturbation and trace fossil suites of the *Cruziana* ichnofacies indicate alternating deposition in lower shoreface to outer shelf successions in the early Markland. Similar to successions from the Bjarni Formation, heterolithic sandstone and shales in Gilbert F-53 (core 1) show massive to cross-bedded units with scattered trace fossils including: *Phycosiphon*, *Helminthopsis*, *Rhizocorallium*, *Ophiomorpha*, *Planolites* and *Chondrites* suggestive of a stressed *Cruziana* ichnofacies. This core interval is interpreted as a river-dominated deltaic succession of the Freydis Member.

The late Gudrid Formation is only sampled by two conventional core intervals from the southern Saglek Basin reflecting two different depositional settings. Core 1 of Snorri J-90 consists of fine-grained, cross-bedded sandstones with coal fragments, wave ripples and mudstone rip-up clasts show varying degrees of bioturbation from 0 to 80% (Fig. 2B, C). The trace fossil succession is dominated by grazing traces (*Helminthopsis*) and deposit-feeding structures including intense burrowing by *Macaronichnus* and *Spirophyton* trace-makers. This weakly stressed *Cruziana* ichnofacies suggests deposition within a wave or storm-dominated delta front. In the Karlsefni A-13 well (core 1), sandy, wave-rippled mudstones are highly bioturbated, but some beds of carbonaceous shale and sandstone remain unburrowed or show opportunistic colonization. The trace fossil suite is predominated by *Phycosiphon* and *Helminthopsis* with *Chrondrites*, *Planolites*, *Rhizocorallium*, *Diplocraterion*, *Skolithos* and *Schaubcylindrichnus* also common. Here, the deposits are interpreted to reflect a deltaic-influenced proximal inner shelf to prodelta setting.

Conclusions

While non-marine deposition in the Bjarni Formation is well known, indications from a number of core intervals show shallow marine deposition in deltaic and restricted marine settings across the Labrador shelf as early as the Aptian. Trace fossil occurrences suggest the presence of both wave-influenced and river-dominated successions which suggest varying degrees of marine and fluvial influence. Marine deposits in the Markland Formation are expected; however, the presence of bathyal shales above the Bjarni Formation in Roberval K-92 suggests a major flooding event. The thickness of fluctuating inner and outer shelf deposits in Skolp E-07 indicates that sedimentation rates kept pace with subsidence at that time. Finally, the late Gudrid Formation appears to be influenced by deltaic deposition in the southern Saglek Basin, which contrasts significantly with previous interpretations of bathyal deposition in the case of the Karlsefni A-13 well (Miller and D'Eon, 1987). This assessment of the core materials from the Labrador margin has refined the paleoenvironmental interpretations and allows us to extrapolate this understanding within the wells and to the seismic data.

Acknowledgements

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