THE QUATERNARY ENVIRONMENTAL EVOLUTION OF THE NORTHWEST-PASSAGE ("QUEEN")

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Final Report
List of publications

Fellow: Dr. Anna J. Pieńkowski
Scientist-in-Charge: Prof. James D. Scourse

QUEEN ("The Quaternary environmental evolution of the Northwest-Passage") aims to significantly advance our understanding of environmental change in the marine channels of Arctic Canada (the "Northwest Passage", NWP), from the last (Late Wisconsinan) deglaciation to present. The project centered on trigger weight & piston cores (TWC/PC), boxcores (BC), and surface sediments recovered during a 2011 expedition in collaboration of the fellow with the Geological Survey of Canada-Atlantic, for which a website was kept by the fellow for the general public (northwestpassage.bangor.ac.uk).

Period 1 focused on multiproxy analyses (litho- and biostratigraphy, micropalaeontology, biogeochemistry) and geochronology (radiocarbon dating) of TWC/PC which extend to deglaciation, providing a longterm perspective on late Quaternary environmental and oceanographic shifts. Two records were targeted for high-resolution analyses. Core 2011804-005 (Viscount Melville Sound) provides the first direct marine evidence and chronology for the existence and demise of an extensive deglacial ice-shelf analogous to those in modern-day Antarctica. Lithostratigraphy indicates basal ice-shelf rainout sediments, subsequent glaciomarine and postglacial environments. Lithology of ice-shelf deposit ice-rafted debris supports previous suggestions of a NW Laurentide Ice Sheet origin. Post-ice-shelf (early-mid Holocene) deposits contain abundant foraminifera (planktonics, benthics) suggestive of Arctic Intermediate Water inflow. Existing geochronology permits a maximum date of ice-shelf demise at 9,000 cal yrs BP (= calibrated years before present), consistent with, though younger than, terrestrial reconstructions, likely due to earlier establishment of a viable post-ice-shelf coastal ecosystem. Core 2011-010 (Lancaster Sound) comprises a ~3 m deglacial sequence, which allows an unprecedented high-resolution insight into glaciomarine conditions and biota re-colonization, simultaneously chronologically constraining marine-based deglaciation of the NE Laurentide Ice Sheet (~13,000 cal yrs BP). The missing postglacial sequence and geophysical data suggest submarine slope failure, with direct implications for geohazard assessments of this economically-important region.

The deglacial to mid-Holocene sequences of two PC (Barrow Strait: 2011804-007; Lancaster Sound/Baffin Bay: 2011804-012) analysed for micropalaeontology (foraminiferal assemblages, $\delta^{18}O$, $\delta^{13}C$) confirm the influx of abundant planktonic foraminifera immediately after deglaciation (early Holocene). Combined with the results from core 2011804-005 this suggests Atlantic-derived deep-water inflow, facilitated by higher deglacial, glacioisostatically-driven sea-levels, most likely via Baffin Bay. This invaluable regional biostratigraphic marker implies a different deglacial/early Holocene NWP oceanography (circulation, water masses), with implications for broader northern hemisphere heat exchange between Pacific, Arctic, and Atlantic oceans.

Period 2 focussed on BCs and seabed sediments. Providing robust and accurate BC geochronologies was a priority, to contextualize environmental changes and to test whether recent climatic episodes well documented from land are manifested in marine archives. Emerging geochronologies will elucidate potential age offsets between and within dating materials (molluscs vs. foraminifera); preliminary data

suggest decadal to centennial offsets. High-resolution biogeochemical analyses have proceeded on the BC samples, including biogenic silica (BioSil), total organic/inorganic carbon (TIC/TOC), and biomarkers (open-water algae biomarkers vs. sea-ice diatom biomarkers; PIP25). Preliminary results show TOC and BioSil decreases up-core in channels with severe sea-ice, conversely to those with less sea-ice. Biomarker analyses are underway. Pending geochronologies will allow inter- and intra-regional comparisons.

Surface sediments provide a modern microfossil distribution baseline (foraminifera, diatoms, dinocysts) and their relationships with environmental parameters essential for accurate palaeo-data interpretation. The modern NWP is characterized by abundant and diverse benthic foraminifera. Western channels exhibit abundant planktonic foraminifera along the inflow of Atlantic-derived waters. Whereas marine diatoms are sparse in the western NWP, abundances and species diversities (alongside preservation potential) increase farther east where BioSil and TOC are also elevated. Dinocyst assemblages are composed of opportunistic taxa tolerant of wide environmental fluctuations, showing minimal change. This work is currently being expanded within the scope of two newly funded research projects.

The marine micropalaeontology of Arctic Canada is complicated by the grouping of several morphologically close but environmentally distant foraminiferal taxa, hindering the confident application of microfossils as environmental proxies. Period 2 addressed these taxonomic complications in close collaboration with European micropalaeontologists. Period 2 also critically assessed the use of sea-ice proxies (micropalaeontological vs. biogeochemical methods). This high-resolution comparison has highlighted agreement of BioSil, PIP25, and qualitative dinocyst data. Conversely, quantitative dinocyst-based transfer function reconstructions showed little change in sea-surface temperatures, salinities, and sea-ice cover. Period 2 saw completion of geochronologies and most proxy analyses on palaeo-records (TWC/PC), though recent taxonomical work has prompted the re-assessment of TWC/PC foraminiferal data gathered during Period 1.

Given the spatial and temporal extent of NWP marine studies, QUEEN represents a significant effort to improve our current understanding of regional late Quaternary evolution via: a standardized multiproxy approach coupled with rigorous chronologies; the application of new proxies and an evaluation of their suitability; up-to-date microfossil taxonomy; and the integration of marine and terrestrial data. Emerging and forthcoming results have important implications for reconstructions of recent polar marine climate and Late Pleistocene deglaciation, formation and demise of ice-shelves analogous to those in Antarctica, and Pacific-Arctic-Atlantic ocean heat exchanges, aside from providing a springboard for future research into the dynamic environments of Arctic North America. The results of this project are of interest to the International scientific community, especially to researchers focusing on the Circumpolar North.