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Proposed Research

Reconstruction of paleo-sea ice in the Arctic Ocean is critical for evaluating sea-ice retreat under modern, climate warming conditions. This retreat is especially prominent in the western Arctic Ocean, adjacent to the Pacific (Fig. 1). The Northwind Ridge (NR), longitudinally stretched north of Alaskan margin, provides a strategically located seafloor structure for investigating the history of sedimentary and related climatic environments in the Pacific sector of the Arctic Ocean. Initial investigation indicates that sediments in cores recovered from the NR contain more calcareous microfossils (primarily foraminifers) than in many other areas of the Arctic Ocean, which makes these cores more valuable for paleo-proxy studies. More specifically, core P1-93ARP23 (Fig. 2) contains foraminifers in bottom sections of the core estimated to extend beyond Marine Isotope Stage (MIS) 16 (-650 ka). This is significant, as these foraminifers are preserved below the level of usual calcite undersaturation in other Arctic cores and contain assemblages and extinct species found in no other core. Overall, foraminiferal data indicate lower sea-ice conditions in the early Quaternary, preceding the growth of a supersized Laurentide ice-sheet. Links between sea-ice, as determined by foraminifers and stable isotopes, and glacial development will be an integral part of the proposed study.

Very low sedimentation rates and biological production, as well as poor preservation of microfossils and distortion of the paleomagnetic record, have typically made stratigraphy of Arctic Ocean sediment challenging (Polyak et al., 2009). This problem is compounded by glacial erosion, which creates widely varying sedimentation rates through time, making the interpretation of glacial and interglacial periods significantly more difficult. While there is some argument on appropriate age models of the sediment layers themselves, patterns within the sedimentological record of Arctic Ocean cores, such as foraminiferal abundances and isotope patterns, still provide valuable paleoceanographic information.

Foraminifera, the most common fossils in Arctic Ocean sediment cores, are useful in paleoenvironmental interpretation as sea ice cover and biologic activity characterize their assemblages and abundances through time. Typically, they are abundant in interglacial/interstadial units and rare or absent in glacial units. These cyclic patterns of abundance can be combined with other analogs of marine paleoenvironmental change, such as stable oxygen and carbon isotopes (8180 and 813C), to construct a record which can be used to correlate other cores throughout the Arctic Ocean. 8180 and 613C within foraminiferal tests have commonly been used to constrain and sometimes correlate the stratigraphy and paleoenvironments of the Arctic Ocean (Aksu and Mudie, 1985; Morris, 1998; Volkman and Mensch, 2001; Polyak et al., 2004; Hillaire-Marcel et al., 2004; Norgaard-Pedersen et al., 2007; Adler et al., 2009). Arctic paleo-5180 records cannot easily be correlated with global 5180 records, but they prove invaluable in correlating cores within the Arctic itself as well as identifying glacial/interglacial cycles (Spielhagen et al., 2004; Polyak et al., 2004; Adler et al., 2009). They are especially useful in the western Arctic, where 5180 values are highly variable and directly relate to deglacial meltwater pulses (depleted 5180 values) and warmer, interglacial, or major interstadial periods (enriched 5180 values). These dramatic changes in oxygen isotope ratios are similarly seen in 513C values, where cyclic shifts in depletion and enrichment of 513C have been as large as 2%o (Polyak et al., 2004; Adler et al., 2009). Changes in 513C values could be caused by changes in ocean ventilation and/or changes in productivity (Bauch et al., 2000; Volkmann and Mensch, 2001; Polyak et al., 2004). However, it has been demonstrated that 513C values co-vary with foraminiferal abundances (and other low-ice condition proxies), suggesting that biologic productivity is likely the most significant factor.

Preliminary 5180 and 513C profiles have been constructed for two cores collected from the Northwind Ridge (Fig. 2). Continuous sampling of foraminiferal species Neogloboquadrina pachyderma (sinistral [Nps]; a planktonic species) and Cassidulina teretis (benthic species) has been performed to characterize the surface and bottom water environments, respectively. A long 5180 and 513C profile of both species has been constructed for core P1-93AR-P23, but only a profile of Nps has been constructed for core P1-92AR-P39 (Fig. 2). The previously collected 5180 and 513C values in continuous Nps samples from P1-92AR-P39 reveal two minima at 450 and 400 cm depth, followed by a rise in values up to a maximum value at approximately 350 cm, followed by an overall decrease. This pattern of 5180 and 513C values is unique, differing from values recorded in other western Arctic cores which display significantly more erratic, high-amplitude variability (Polyak et al., 2004; Adler et al., 2009).

This proposal seeks funding to complete the 5180 and 513C profiles of P1-92AR-P39 by continuously sampling the core for C. teretis which could reassess the trends found in this core for Nps. Additional 5180 and 513C measurements of both foraminiferal taxa could also be performed on another NR core, P1-92AR-P25, to complete a transect along the ridge. Data from this transect could then be used to interpret an extended downcore stratigraphy present in P1-93AR-P23.

Preliminary results show a good potential of the NR cores for reconstructing Quaternary sea-ice and related paleoenvironments on various time scales. Foraminiferal assemblages will be investigated in detail in various size fractions (Hillaire-Marcel et al., 2004). This data will be combined with other proxies such as stable/radiogenic isotopes and sedimentology. Our constructed stratigraphy will be used in conjunction with other data such as paleomagnetic, amino-acid racemization, beryllium isotopes, and trans-basin (and possibly inter-oceanic) correlations to better understand patterns of past sea-ice distribution.

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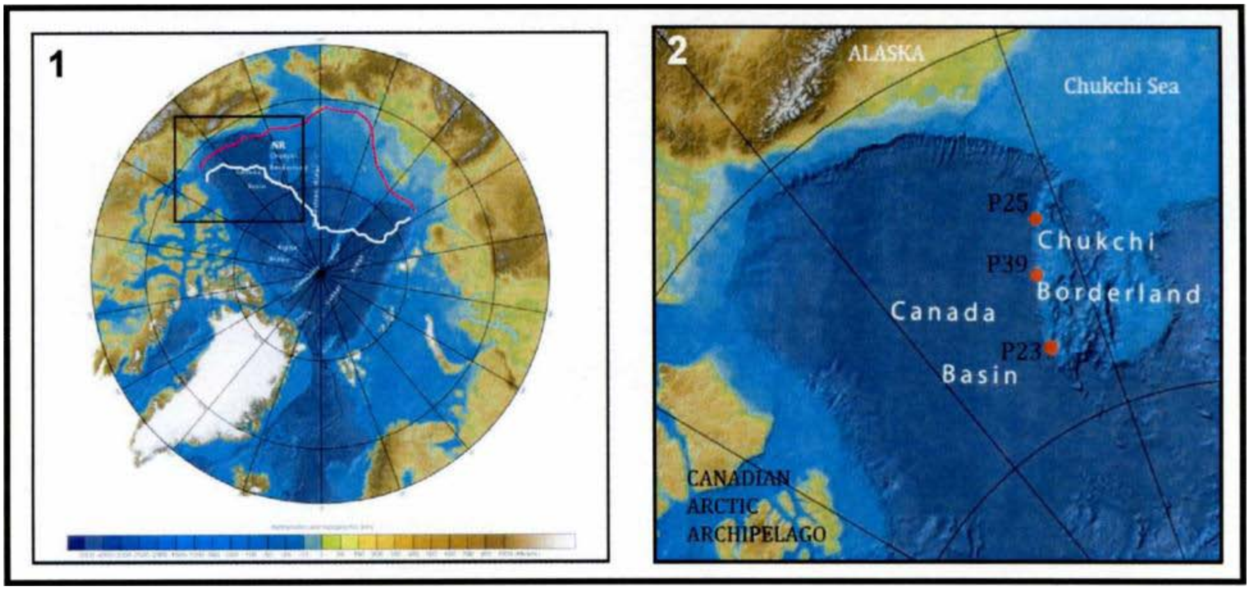

Figure 1. (Left) Bathymetric map of the Arctic Ocean (IBCAO-2) with major seafloor features labeled. Black box indicates inset map. NR - Northwind Ridge. Western Arctic summer sea-ice limits are shown for the 2007 historical minimum (white line) and multi-year average (purple line) (data courtesy NSIDC).

Figure 2 (Right). Location of sediment cores P1-92AR-P25, P1-92AR-P39, and P1-93AR-P23 along the Northwind Ridge.