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In-situ Geotechnical Investigation of Arctic Nearshore Zone Sediments, Herschel Island, Yukon

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INTRODUCTION: The Arctic is currently undergoing rapid changes with regard to sea ice extent, permafrost thaw and coastal erosion (Fig. 1b,c) (Radosavljevic et al. 2015). In addition to hydrodynamic processes, the sediments in the Arctic nearshore zone are affected by freeze-thaw cycles, as well as an increase of abundant suspended sediment introduced by permafrost-induced mass movements, such as retrogressive thaw slumps (Fig. 2), and increased river discharge (Lantuit and Pollard 2008).

The goals of the presented study were:
- assessment of free-fall penetrometer performance in Arctic coastal environments,
- investigation of geotechnical characteristics and sediment stratification,
- correlation to geological, and morphological conditions.

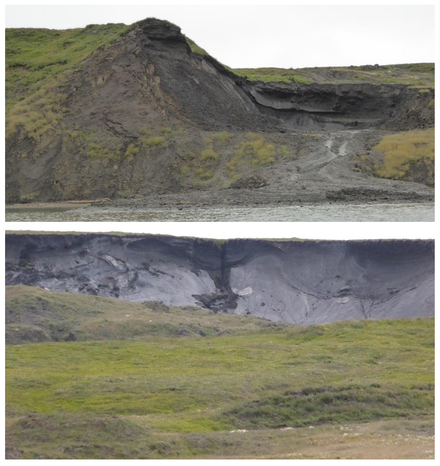

Fig. 2: Photos of thaw slumps.

Fig. 3: Survey vessel “Christine”.

METHODS: The portable free-fall penetrometer *BlueDrop* was used for geotechnical in-situ testing. The data analysis followed the approach by Stark et al. (2012). Sediment grab samples and short gravity cores were collected, and sediments were analyzed for grain size distribution. A phase measuring bathymetric sonar was utilized to display seabed topography and estimate sediment type distribution.

Fig. 4a,b: Deployments of the *BlueDrop.*

Fig.1: a) Google Earth Image indicating the location of Herschel Island in the Southern Beaufort Sea and showing a zoom of Herschel Island. b) Aerial photo of the surveyor camp. c) Shoreline positions of Simpson Point, Pauline Cove and Collinson Head from 1952-2011.

RESULTS:

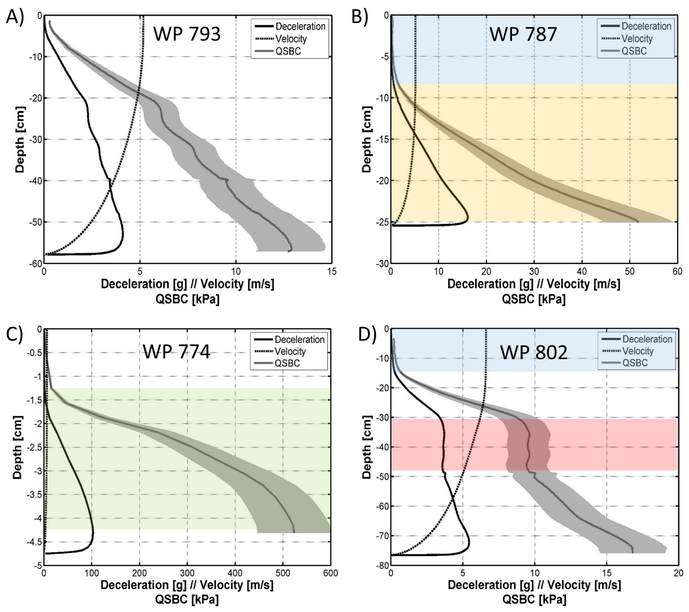

Fig. 5: *BlueDrop* penetrometer signatures from four exemplary locations. Different shadings indicated different geotechnical responses and sediment resistances to the penetration of the probe (Stark et al. subm.)

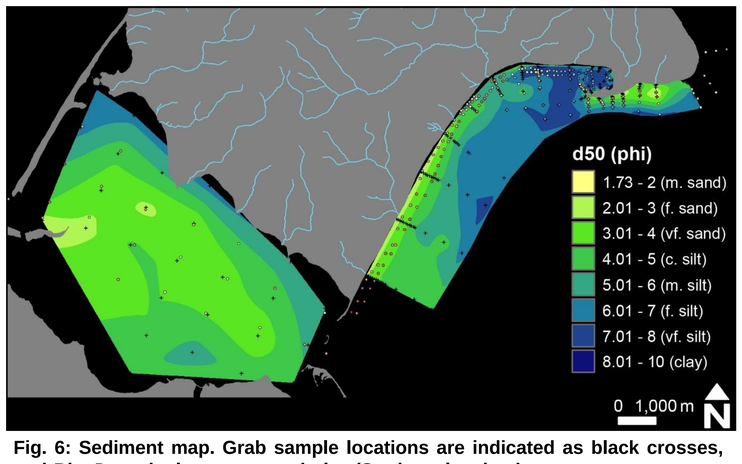

Fig. 6: Sediment map. Grab sample locations are indicated as black crosses, and *BlueDrop* deployments as circles (Stark et al. subm.)

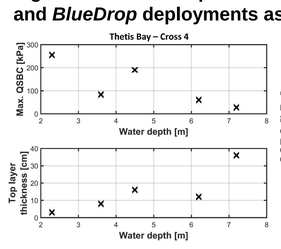

Fig. 7: Max. qsbc and top layer thickness (Stark et al. subm.).

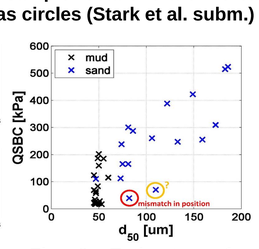

Fig. 8: Estimates of max. quasi-static bearing capacity (qsbc) vs. d_{50} (Stark et al. subm.)

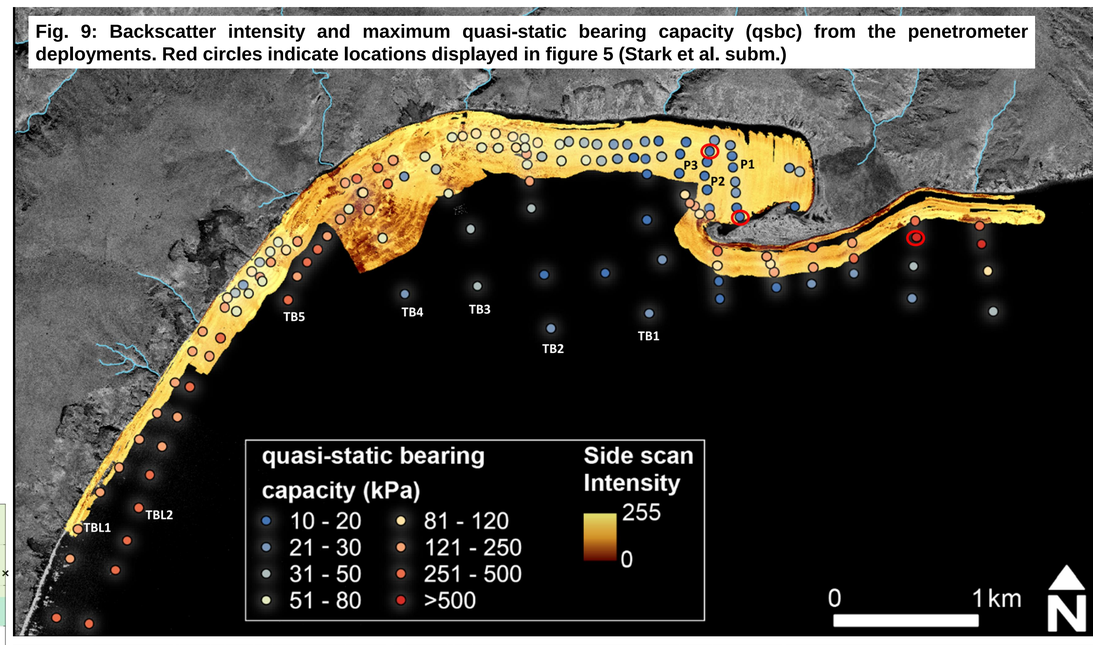

Fig. 9: Backscatter intensity and maximum quasi-static bearing capacity (qsbc) from the penetrometer deployments. Red circles indicate locations displayed in figure 5 (Stark et al. subm.)

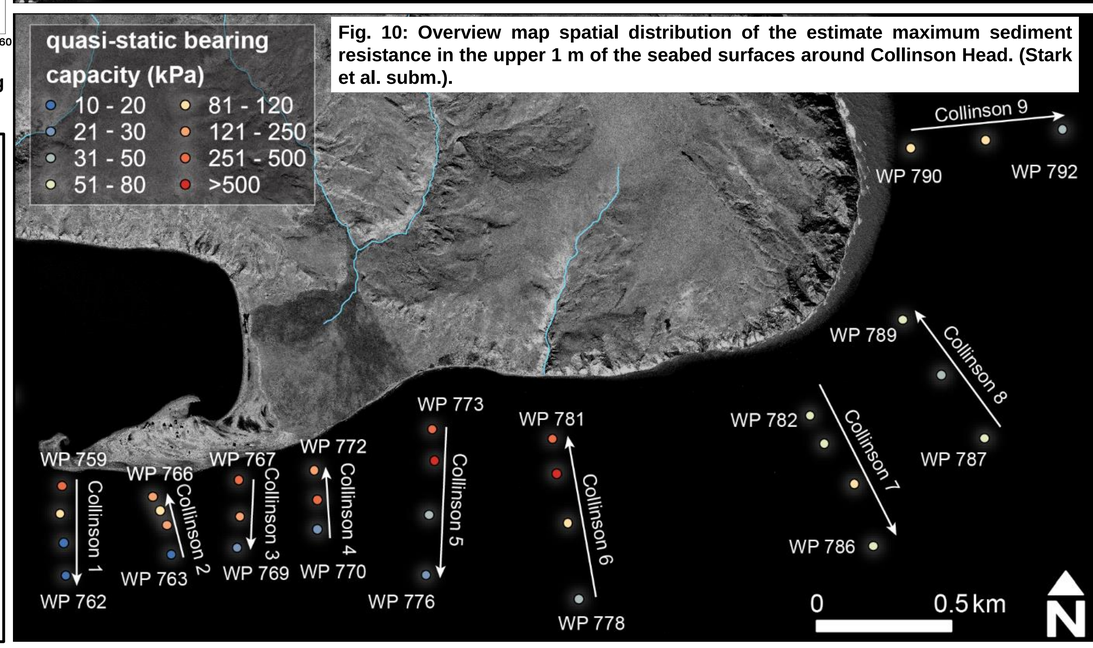

Fig. 10: Overview map spatial distribution of the estimate maximum sediment resistance in the upper 1 m of the seabed surfaces around Collinson Head. (Stark et al. subm.).

DISCUSSION & CONCLUSIONS:

- ***Penetrometer performance:*** A portable free-fall penetrometer proved a valuable tool giving insight into sediment type, stratification, and the qualitative state of consolidation. The advantage of this tool is its ease of transport and performance in harsh conditions.
- ***Sediment characterization & distribution:*** The results obtained indicated distinct separations of sediment types. Fine and soft sediment was deposited further offshore, and especially in Pauline Cove, a local sediment sink. Surprisingly little fine sediment deposits were identified in front of some of the larger retrogressive thaw slumps in Thetis Bay, indicating that sediments are rapidly washed away from these locations (Lintern et al. 2013).
- ***Sediment stratification:*** At some sites weak layers at a sediment depth of 30-50 cm were observed. While the cause of these weak layers cannot be confirmed here, their character may be explained by deposition of large sediment volumes in conjunction with a freeze-thaw history and/or gassy sediments (Kayen and Lee 1991; Lantuit and Pollard 2008; Aubert and Gasc-Barbier 2012; Stark et al. 2015).

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