

Quantifying glacial sediment thicknesses offshore Greenland: Using a neural network to extrapolate spatial data in remote areas

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Glacial erosion rates over a million-year time scale are relatively unconstrained for the Greenland Ice Sheet (e.g. Strunk et al., 2017). Yet these rates can give valuable insights into long-term landscape evolution and glacial dynamics. One approach to constrain the glacial erosion is to quantify glacial deposition volumes (Dowdeswell et al., 2010; Paxman et al., 2019; Pedersen et al., 2021). However, due to Greenland's remoteness and the challenging environmental conditions for seismic acquisition, spatial gaps in the seismic sediment record remain. Consequently, a quantification of glacial sediment volumes is difficult. To address this, we present a first compilation of available and newly interpreted Quaternary marine seismic data with age constraints where scientific boreholes are available. For areas with sparse data coverage, we employ a data-informed artificial neural network to predict Quaternary sediment thicknesses. The neural network is trained using the seismic-derived thicknesses, along with several parameters related to glacial and geomorphological features. This approach allows us to obtain a glacial sediment thickness map, thereby constraining the total volumes of deposition. The predicted sediment thicknesses reveal variations in glacial deposition volumes across different areas of Greenland's continental margin. The steeper southern and parts of the northern Greenlandic continental slope are covered by thinner Quaternary sediments, whereas in west and east Greenland, larger glacial sediment deposits advanced the shelf farther throughout the Quaternary, extending observations of regional seismic studies (e.g., Heirmann et al., 2019; Knutz et al., 2019; Nielsen et al., 2019; Pérez et al., 2018). These differences in glacial deposition highlight the diverse influence of paleoclimatic, oceanographic, and orographic processes on glacial dynamics and the source-to-sink sediment transport. Our results show that the application of machine learning to integrate available seismic records can provide new insights into the temporal and spatial variability of Quaternary glacial erosion and deposition processes in Greenland.

Dowdeswell, J. A. et al. (2010). Rates of sediment delivery from the Fennoscandian Ice Sheet through an ice age. *Geology*, 38(1), 3-6. <https://doi.org/10.1130/g25523.1>

Heirman, K. A., Nielsen, T., & Kuijpers, A. (2019). Impact of Tectonic, Glacial and Contour Current Processes on the Late Cenozoic Sedimentary Development of the Southeast Greenland Margin. *Geosciences*, 9(4), 157. <https://doi.org/10.3390/geosciences9040157>

Knutz, P. C., Newton, A. M., Hopper, J. R., Huuse, M., Gregersen, U., Sheldon, E., & Dybkjær, K. (2019). Eleven phases of Greenland Ice Sheet shelf-edge advance over the past 2.7 million years. *Nature Geoscience*, 12(5), 361-368. <https://doi.org/10.1038/s41561-019-0340-8>

Nielsen, T., Kuijpers, A., & Mørk, F. (2019). Sedimentary processes and seabed morphology of the Southwest Greenland margin. *arktos*, 5(2), 89-104. <https://doi.org/10.1007/s41063-019-00069-5>

Paxman, G. J., Jamieson, S. S., Hochmuth, K., Gohl, K., Bentley, M. J., Leitchenkov, G., & Ferraccioli, F. (2019). Reconstructions of Antarctic topography since the Eocene-Oligocene boundary. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 535, 109346. <https://doi.org/10.1016/j.palaeo.2019.109346>

Pedersen, V. K., Knutsen, Å. R., Pallisgaard-Olesen, G., Andersen, J. L., Moucha, R., & Huismans, R. S. (2021). Widespread glacial erosion on the Scandinavian passive margin. *Geology*, 49(8), 1004-1008. <https://doi.org/10.1130/G48836.1>

Pérez, L. F., Nielsen, T., Knutz, P. C., Kuijpers, A., & Damm, V. (2018). Large-scale evolution of the central-east Greenland margin: New insights to the North Atlantic glaciation history. *Global and Planetary Change*, 163, 141-157. <https://doi.org/10.1016/j.gloplacha.2017.12.010>

Strunk, A., Knudsen, M. F., Egholm, D. L., Jansen, J. D., Levy, L. B., Jacobsen, B. H., & Larsen, N. K. (2017). One million years of glaciation and denudation history in west Greenland. *Nature Communications*, 8(1), 14199. <https://doi.org/10.1038/ncomms14199>