Unraveling Late Holocene Dust Dynamics and Climatic in the High Arctic: Insights from loess in Adventdalen, Svalbard

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Holocene dust activity in the Arctic and its connection to climatic changes remain subjects of significant uncertainty. One approach to address this uncertainty is to investigate loess deposits, terrestrial records of atmospheric mineral dust in the past. Loess in Svalbard forms source-proximal archives of dust deposition and dust dynamics spanning the late Holocene. A loess-permafrost core extracted from Adventdalen provides a unique opportunity to investigate dust-climate relationships in the high Arctic in unprecedented detail.

Here we present a fully independent age model for this loess core, employing 136 quartz luminescence ages at a 2-cm-resolution together with Bayesian age modeling (Rasmussen et al., 2023). This approach makes it the most detailed luminescence chronology of a sedimentary archive to date. By complementing the high-resolution dating by grain size analyses, cryostratigraphic investigations, mineral magnetic analyses, anisotropy of magnetic susceptibilitly (AMS), and stratigraphic examination of an adjacent exposed profile, we gain insights into changes in loess accumulation rates, dust transport dynamics and reworking, and permafrost development over the past 3000 years.

Our findings reveal a noteworthy variability in loess mass accumulation rates during the late Holocene of Svalbard. Strikingly, exceptionally high rates of loess deposition, reaching up to 0.35 cm per year, coincide with coarse silt deposition and potential warm phases. This suggests a crucial link between the availability of sediments, driven by temperature-related processes in glaciofluvial source areas, and the dust levels in Adventdalen. Source-proximal transport of dust along Adventdalen is further supported by our results from AMS measurements, which indicate a dominantly aeolian mode of transport along the main axis of the valley, with episodical reworking by other surface processes.

If the observed deposition rates mirror broader trends across the valleys of Svalbard, it implies that the archipelago may be a more significant high-latitude dust source than previously recognized, and highly sensitive to temperature fluctuations. To further investigate the relationship between dust dynamics and warm phases, we test the reconstruction of paleo-temperatures utilizing glycerol dialkyl glycerol tetraether lipids (GDGTs). By combining advanced dating techniques, sediment analysis, and temperature reconstructions based on GDGTs, we aim to unravel the significance of temperature-driven processes in influencing dust activity in the High Arctic.

References

Rasmussen, C.F., Christiansen, H.H., Buylaert, J.-P., Cunningham, A., Schneider, R., Knudsen, M.F. & Stevens, T., 2023: High-resolution OSL dating of loess in Adventdalen, Svalbard: Late Holocene dust activity and permafrost development. *Quaternary Science Reviews 310*, 108137.