EGU23-15566, updated on 25 Feb 2024
https://doi.org/10.5194/egusphere-egu23-15566
EGU General Assembly 2023

Does vertical mobility of eDNA in old soils affect the reconstruction of past environments?

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Environmental DNA (eDNA) in sediments (soils, lake and marine sediments) can – in principle - be used to reconstruct past environments, provided the DNA is readily preserved and is relatively immobile within the sedimentary sequence (to allow accurate dating). Concerns over the mobility of DNA in soils have meant that these sediments have not been considered a reliable source of eDNA for palaeo-reconstruction. However, eDNA in soils could be preserved and immobilized through adsorption to secondary minerals (predominantly clays) in sediments. The potential of clay minerals to immobilize DNA is poorly understood; to address this knowledge gap, we conducted an experiment to evaluate the vertical mobility of eDNA between soil layers.

Our experiment involved the application of spiked (non-indigenous) DNA to an experimental plot in eastern Greenland over a period of two years. During this period, we took soil samples at different depths below the plot and sequenced the samples to detect the spiked DNA. In addition to our experiment, we analyzed plant DNA from sequences of paleosols at a site in west Greenland and a site in south Iceland, to attempt to reconstruct long-term changes in vegetation cover.

Our Greenland experiment indicated that faint traces of alien DNA can be transported to deep (thus old) soil horizons by percolating rainwater and can remain intact for at least two years. We suspect this occurred in Greenland because a) rainfall is high and b) the soils are skeletal and exceptionally porous. Despite this result, we observed changes in plant DNA with depth at our other two sites; these changes seemed to track century-scale environmental changes. We could not date the changes in the Greenlandic record due to the scarcity of macrofossils for radiocarbon dating. However, macroscopic tephra layers at the site in Iceland provided isochrons (time parallel marker beds) that allowed us to assign approximate dates using tephrochronology.

Our results indicate that most of the spiked eDNA was either retained at the surface or degraded in the soil profile: only very tiny quantities leached to deep soil horizons. Therefore, we propose that eDNA in paleosols, especially those on tephra beds, possesses great potential in palaeo-reconstruction, especially when other archives (fossils, lake sediments) are not available. However, we recommend that more studies are required to examine how mineralogy and soil types govern eDNA mobility and longevity in soils.