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Seasonal climate signals from ground ice and pollen since the Middle Pleistocene as recorded in the ancient permafrost exposed in the Batagay megaslump (East Siberia)

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The Batagay megaslump (67.58°N, 134.77°E) in East Siberia is the largest known retrogressive thaw slump on Earth. Its approximately 55 m high headwall exposes discontinuously ancient permafrost that dates back to at least 650 ka. The permafrost preserves several paleoclimate and paleoecological proxies with distinct seasonality, e.g., ground ice and pollen.

In this study, we constrain the cryostratigraphy and chronology of the exposed permafrost based on field observations, newly obtained post-infrared infrared stimulated luminescence ages and systematic radiocarbon dating of the upper part of the sequence. To obtain seasonal climate signals, we reconstructed temperatures and precipitation from pollen and analyzed the stable isotope composition of ice wedges and composite wedges as well as pore ice from all exposed stratigraphic units.

A strongly continental climate with strong seasonal contrasts is characteristic for this region throughout glacial and interglacial periods of the Quaternary. The Lower Ice Complex with large syngenetic ice wedges (3-7 m thick, dated MIS 17/16 to MIS 13/12) indicates rather moist, cold winters and variable summers. Above an erosional unconformity, the Lower Sand unit (≤20 m) is characterized by narrow composite (i.e. ice-sand) wedges and formed under cold and dry conditions during late MIS 7 and MIS 6. Substantial warming during the Last Interglacial, i.e., MIS 5e was accompanied by permafrost degradation and the development of taiga forest, as evidenced by a woody debris layer (≤3m). The formation of the overlying Upper Ice Complex (20-25 m thick, local Yedoma Ice Complex equivalent) with huge syngenetic ice wedges started already during MIS 5, probably in MIS 5d, and ended towards the end of MIS 3. A rather cold and dry MIS 4 was followed by the coldest but moist winters of the record and variable but warmer and dry summers in MIS 3. The Upper Sand unit (≤20 m, MIS 3-2) with narrow composite wedges represents a dry climate with less cold winters than in MIS 3 and relatively warm summers. Above an erosional unconformity, the Holocene cover (≤3m) reflects the warmest and rather dry climate of the entire record. The comprehensive permafrost record of the Batagay megaslump delineates Late Quaternary seasonality variability and provides thus far-reaching paleoclimate baseline data

for the East Siberian terrestrial Arctic that deserves further proxy-based and model-based validation.