

Iron dynamics upon thermokarst formation in the Yedoma domain

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Ice-rich permafrost is subject to abrupt thaw, during past and present global warming. Ice-rich domains encompass Yedoma Ice Complex deposits that have never thawed since deposition and Alas deposits that have undergone previous thermokarst processes during the Late glacial and Holocene warming periods. Upon thaw of these deep ice-rich deposits, organic carbon (OC) and minerals are unlocked and OC is exposed to mineralization. A portion of this OC is associated with iron (Fe), that provides physico-chemical protection of OC or drives the mineralization of OC by redox processes. We hypothesize that post-depositional thaw processes induce changes in redox conditions in Alas deposits and so affect the role that Fe plays in mediating present day OC mineralization.

To test this hypothesis, we quantify the vertical distribution of Fe concentrations and Fe mineralogy in unthawed Yedoma and previously thawed Alas deposits from the Yedoma domain (Alaska, the Kolyma region, the Indigirka region, the New Siberian Archipelago, the Laptev Sea coastal region, and Central Yakutia). Portable XRF-measured concentrations trueness were calibrated from alkaline fusion and inductively coupled plasma optical emission spectrometry (ICP-OES) measurement method on a subset of 144 samples ($R^2 = 0.95$). Iron extractions of unthawed and previously thawed deposits show that, ~25% of the total iron is a reactive species, composed of crystalline or amorphous oxides, or complexed with OC, with no significant difference between Yedoma and Alas deposits. We observe a consistent total Fe concentration in Yedoma deposits, but a depletion or accumulation of total Fe in Alas deposits, which experienced previous thaw and/or flooding events. These results suggest that redox driven processes during the Lateglacial and Holocene thermokarst formation impact the present-day distribution of reactive Fe and its association with OC in ice-rich permafrost.