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Remobilization and degradation of Muostakh Island (Laptev Sea) as part of the collapsing Arctic coastal ice complex

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East Siberian´s permafrost is thought to contain about 400 GtC (Giga = 10^9) [1] in form of the so-called Yedoma or Ice Complex, a huge stock of carbon mainly as frozen loess deposits formed during the Last Glacial Maximum (∼40,000 years ago). The Pleistocene Ice Complex has not undergone much alteration by soil microorganisms since deposited, which makes it particularly sensitive to global warming effects on large-scale C dynamics. Accelerated coastal erosion of the Ice Complexes is brought on by a combination of thermal collapse, sea-level rise and enhanced wave fetch from loss of coastal sea-ice cover [2, 3]. Despite coastal erosion is estimated to deliver as much OC to the East Siberian Arctic Shelf (ESAS) as all the great Russian-Arctic rivers combined [3], the process is poorly understood, in particular with regard to the fate of the OM derived from coastal erosion. This study aims to alleviate the lack of information on the remobilization of OM from massive coastal erosion in the ESAS.

The erosion evolution of a significant example of this destructive geological process (Muostakh Island, SE Laptev Sea), has been observed over the past decade and it has been estimated a retreat rate up to 20 m during the summer months (from 2001 to 2009). In summer 2006, soil samples were collected from Muostakh at 11 different locations along four "erosion transects", spanning reliefs with ranges of approximately 25 m from the top plateau to the water boundary. On-site CO_2measurements were carried out on the surface along five different transects across the island. Quantification of the organic carbon (OC), bulk ^{14}C content and biomarker analysis (n-alkanes, n-alkanoic acids, n-alkanols, sterols) were performed to elucidate whether the old carbon forms eroded from Muostakh Island are subject to degradation.

Elemental and isotopic analyses showed a vertical trend of younger (∼modern) and C-enriched (OC∼38%) material toward the plateau of the island, in contrast to the older (∼35 000 y) and C-depleted (OC∼0.7%) components at the land-sea boundary. Different biomarker ratios, indicative of microbial degradation or loss of functional groups, suggested higher extent of degradation at the low part of the island. The on-site measurements of CO_2 registered the largest fluxes on the land-sea boundary, supporting a more intense degradation signal at the low locations of the sampling transects. The presence of older OC in the lower parts of the island, more exposed to wave impact and coastal erosion, suggests that nearly fossil C forms (>35,000 years) could be remobilized and are therewith bioavailable to be degraded to CO_2. The larger CO_2fluxes of Muostakh (∼5 μM m^{-2} sec^{-1}), compared to those measured on Sphagnum-dominated tundra at the continental coasts (0.1-1.1 μM m^{-2} sec^{-1}), manifest the more intense biodegradation undergone by the eroding Muostakh Island.

References

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