Much more than carbon: Element stocks in ice-rich permafrost of the Yedoma domain

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Abstract

Soils of the permafrost zone store globally relevant reservoirs of frozen matter, such as organic matter, mineral elements as well as other biogeochemical relevant compounds like contaminants. Besides the well-studied organic carbon (OC), other compounds can become available in active biological and hydrological element cycling as global climate change is warming northern permafrost regions nearly four times faster than the global average. Current heating in Siberia is unprecedented during the past seven millennia, triggering widespread permafrost degradation and collapse. This is especially relevant for our study region, the Yedoma domain. In this region, a large amount of belowground ice is present and the ground can become unstable with warming, allowing the mobilisation of previously frozen sediments with their geochemical element contents. With this presentation, we synthesise recent studies, which have improved the understanding of various frozen stocks. Here, we estimated that the Yedoma domain contains 41.2 Gt of nitrogen (N), which increases the previous estimate for the circumpolar permafrost zone by ~46 %. The highest element stock within the Yedoma domain is estimated for Si (2739 Gt), followed by Al, Fe, K, Ca, Ti, Mn, Zr, Sr, and Zn. The stocks of Al and Fe (598 and 288 Gt, respectively) are in the same order of magnitude as OC (327-466 Gt). Concerning contaminants, we focused on mercury. Using the ratio of mercury to OC (R(HgC), value based on own measurements: 2.57 µg Hg g C−1) and the OC levels from various studies for a first rough estimation of the Hg reservoir, we estimate the Yedoma mercury pool to be ~542,000 tons. In conclusion, we find that deep thaw of the Yedoma permafrost domain and its degradation will bear the potential to change the availability of various elements in active biogeochemical and hydrological cycles in northern regions, which will have the potential to change crucial ecosystem variables and services.