Old permafrost carbon released

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Eurasian arctic rivers transport carbon into the Polar Sea. Analyzes show that carbon is released from the permafrost. Credit: Jorien Vonk

Using indicator molecules, a team of researchers headed by ETH Zurich demonstrates that carbon stored in the Arctic permafrost is being mobilised in Eurasian river basins.

Arctic permafrost soils store vast amounts of carbon in the form of dead

but not decomposed plant debris. Around half of the global soil carbon reservoir is stored in these permanently frozen Arctic soils. Through global warming, however, the permafrost is thawing to increasing depths, which may mobilise the carbon stored within. The amount of water drainage from rivers such as the Yenisey and the Ob in Siberia or the Kalixälven in Northern Sweden, which drain vast land areas, has also changed. Due, among other things, to a changing precipitation regime, these rivers are conducting more water away into the seas than a few decades ago, also transporting the carbon from their basins towards the sea. The main concern for scientists is that the activity of microbes or other organisms that live off organic matter and exhale CO2 could cause carbon that has been stored for thousands of years to get back into the atmosphere – and in a big way.

Age of tracer molecules determined using carbon dating

Consequently, researchers from ETH Zurich and the University of Stockholm set about finding out whether "old" carbon from permafrost areas of Arctic Eurasia is being mobilised and transported through large river basins, ranging from Northern Sweden to Eastern Siberia, to the sea. They took sediment samples from near the mouths of these rivers and isolated three types of carbon compounds, the sources of which could clearly be identified. These so-called tracer compounds include organic molecules derived from lignin, a rigidifying biopolymer in higher plants, plant waxes that form a protective coating on leaf surfaces, and a group of compounds abundant in mosses. The researchers were able to determine the age of these molecules using radiocarbon dating.

First concrete evidence of mobilisation

Based on this age diagnosis, the research team headed by Timothy

Eglinton, a professor of biogeoscience at the Department of Earth Sciences, were for the first time able to assess contributions of old carbon from permafrost soils to riverine carbon. Furthermore, the scientists were able to demonstrate that permafrost soils where the frozen areas are interspersed with gaps release more old carbon than those where the permafrost is uninterrupted. This coincides with the different permafrost profiles that Eurasia exhibits from west to east. "In Far Eastern Siberia, the majority of the mobilised carbon comes from the surface layers," says Eglinton. In the European part of Eurasia and Western Siberia, however, water can penetrate the soil between the frozen permafrost areas more effectively, release the carbon previously stored for thousands of years, and carry it to the sea.

Using carbon dating, the geoscientists were able to measure age differences of up to 13,000 years between young and old terrestrial components. "The age difference between the various carbon sources is particularly great in the Arctic due to the release of old permafrost carbon," says Xiaojuan Feng, a postdoc under Eglinton and first author on the study just published in *PNAS*. This leads the researchers to the conclusion that lignin represents a tracer of surface carbon sources and plants waxes reflect old permafrost.

Carbon thousands of years old released

Based on documented changes in river discharge and on relationships of radiocarbon age of lignin tracer molecules with water run-off from the river basins, the researchers calculated that the proportion of carbon from permafrost has increased by five per cent in the last twenty years. "While masked by changes in other carbon sources, mobilisation of the carbon from the once deep-frozen soils appears well underway," says Eglinton. This proportion of this carbon is still fairly modest, and how it will change in the future remains unclear. "Nevertheless, our new results go a long way towards helping us to understand and assess the links

between climate warming and the behaviour of different carbon sources in the Arctic more effectively," stresses Eglinton. It will now be interesting to extend the molecule-specific carbon dating analyses to other sediment archives in order to examine the release of carbon from Arctic permafrost soils and the past climate more effectively.

More information: Feng X, et al. Differential mobilization of terrestrial carbon pools in Eurasian Arctic river basins. *PNAS Early Edition*, published online 12 August 2013. DOI: 10.1073/pnas.1307031110

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