20 Years of Terrestrial Research in the Siberian Arctic

The History of the LENA Expeditions

Excerpt from:

20 Years of Terrestrial Research in the Siberian Arctic

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Organic Matter Matters – Quantifying the Amount of Carbon in Northern Siberia

The Lena River Delta is underlain by permafrost. Thus, it is highly vulnerable to climate warming and may degrade in different ways, by shoreline erosion (figure 1), land surface subsidence, deepening of the seasonal thawing front, and development of rapid thaw features such as lakes, gullies and landslides.

Permafrost thaw could cause a strong feedback with global implications, because high amounts of organic matter are stored in sediments and soils of the Lena River Delta. This organic matter, consisting of ancient dead plant and animal remnants, was freeze-locked for millennia due to the permanently frozen ground. In this way, it was kept away from the active carbon cycle. Now, thawing permafrost sets this organic matter free for mobilization and microbial activity. Thus, it is available in the active carbon cycle again where microbial decomposition processes result in the production of the greenhouse gases carbon dioxide and methane, which accelerate atmospheric warming. This, in turn, induces more permafrost thaw and carbon release – a feedback cycle that becomes stronger and stronger. Better understanding of how much and how fast carbon is vulnerable

Figure 1: Sediment layers rich in organic carbon including peat blocks sticking out of a Yedoma cliff on Sobo-Sise Island, Lena Delta, in 2014. (Photo: M. Fuchs)

to thaw and mobilization is therefore a critical need to predict the consequences of permafrost thaw in the Arctic. Our research in the joint Lena expeditions therefore put a spotlight on understanding the characteristics, origins, distribution, amount and vulnerability of carbon in the North Siberian Arctic.

Until the late 90's it was assumed that cold Arctic climate, causing low vegetation productivity, only allows a small input of organic matter into the Arctic soils. A low soil carbon pools was therefore assumed for this region. With increasing understanding that permafrost soils actually may feature characteristics such as low temperatures and water logging that slow or prevent organic matter degradation, and processes the enhance carbon burial, such as cryoturbation and long-term sedimentation under periglacial environmental conditions, this view changed in the late 2000's. Within the framework of the Lena Expeditions and based on numerous field surveys we were able to establish new insights into deep permafrost carbon storage in North Siberia. We sampled organic carbon in ancient permafrost sediments deeper than 50 metre, in the periodically unfrozen top layer, in summer and winter, in ice wedges and even in methane bubbles trapped in lake and ocean ice (figure 3). We found impressive witnesses of the last ice ages mega fauna, like mammoth tusks and skulls, woolly rhino bones and even the hair of a mammoth fur. One of the challenges during summer fieldwork for sampling organic carbon is to keep the carbon frozen to avoid decomposition after sampling. This sometimes results in a situation like bringing a freezer in a helicopter and run a freezer on permafrost.

Figure 2: Landing with an MI-8 helicopter in a remote site in the Lena Delta and starting a multi-week expedition to decipher the Delta's organic carbon characteristic. (Photo: J. Strauss, 2014)

Using the unique opportunities of the Lena expeditions and analysing the samples in our laboratories we were able to revise calculations specifically for the Lena Delta area (and contributed important datasets for circumarctic permafrost zone soil carbon estimates). We now know that freezing of organic matter over a period of thousands of years stored and freeze-locked large amounts of carbon in the Lena River Delta, 240,000,000,000 kg down to 1 m depth. In other words, this huge carbon inventory in the first meter of the Lena Delta equals the amount 29 million times the mass of the huge MI-8 helicopter (see figure 2) often used to bring us to the remote places where we want to study carbon and other interesting topics in the Lena River Delta.

However, even beyond the upper meter of soil abundant organic matter is preserved today but vulnerable to thaw in a future warming Arctic.

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Figure 3: Sampling for methane in ice on Bykovsky Peninsula. (Photo: H. Zimmermann, 2017)

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