The microbiome of ancient ice wedges in the Muostakh 'disappearing island'

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Climate change-driven thermal erosion makes Muostakh Island in the southern Laptev Sea (70°35´ N, 130° 0´ E) a very fragile ecosystem of the Arctic. Thus, understanding its biodiversity, the changes and loss in response to climate is a timely and pressing scientific objective. Here, we characterize the microbiome associated with several ice wedges covering the past ~45,000 years of climate/ecosystem history.

Ice wedges are a specific feature in the northern permafrost landscapes. They develop seasonally by spring-melting of snow that runs through permafrost contraction cracks, accumulates and creates ice formations in the wintertime through congelifraction. Such environment offers ideal conditions for the preservation of microbial cells and DNA over geological time.

Our work tackles four main research aspects, requiring an interdisciplinary approach with synergies between microbial ecology, geo- and paleo-sciences. First, we characterize the ice wedge mineral composition as an environmental micro-niche. Second, we analyze the biodiversity of the microbial communities via shotgun metagenomics of the ancient DNA (aDNA) extracted from the ice wedges. Third, we investigate the biomass content by recovering and enumerating microbial cells present in the ice wedges. In addition, we apply infrared spectroscopy to obtain cellular fingerprints that can serve as biomarkers. Finally, we assess the physiological state of microorganisms using stable isotope probing (SIP) experiments in microcosms that reproduce the environmental conditions (subzero temperature and anoxic conditions).

By integrating microbial biodiversity with activity and environmental context, this study will provide valuable new insights into Muostakh's ice wedge microbiome and the dynamics underlying its changes over time and climatic conditions.