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Organic chemistry of basal ice – presence of labile, low molecular weight compounds available for microbial metabolism

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Recent studies show that subglacial environments previously thought to be devoid of life contain a host of active microbial organisms. Presence of liquid water due to overburden pressure, the release of nutrients from chemical erosion of bedrock, and the potential carbon sources in overridden sediments facilitate life in this extreme environment. However, little is still known of concentrations and diversity of labile organic compounds essential for sustaining microbial metabolism in subglacial environments.

Three subglacial ecosystems that considerably differ in range and amount of available organic compounds were selected for this study 1-Engabreen, northern Norway, overlying high-grade metamorphic rocks with low organic carbon content; 2-Finsterwalderbreen, Svalbard, overriding ancient black shales with a relatively high carbon content yet recalcitrant to microbiological consumption; and 3-Russell Glacier in western Greenland with recently overridden quaternary organic rich paleosols. Basal and pressure ridge ice samples were collected and subsequently analysed for low molecular weight organic compounds, with the emphasis on volatile fatty acids, carbohydrates and amino acids.

The highest concentration of labile organic compounds in Greenland basal ice suggest that recently overridden paleosols have the greatest potential for sustaining microbial populations present within and underneath basal ice. The high concentration of “ancient” organic carbon in basal ice from Finsterwalderbreen, Svalbard, doesn’t correlate with the presence of labile organic compounds. This indicates the inability of microbes to digest recalcitrant kerogen carbon in cold temperatures. In all three investigated environments, concentrations of labile organic compounds are elevated in basal ice with a high debris content.

Until recently, most models of the global carbon cycle tend to neglect the pool of subglacial organic carbon as little is known about the range and concentrations of organic compounds as well as the composition of microbial communities and their ability to degrade and metabolize organic carbon at low temperatures. Recently overridden paleosols in western Greenland may serve as a biogeochemical model for vast pool of organic carbon from areas of boreal forest and tundra overridden during the Quaternary glacial cycles.