Is Thawing Permafrost as a Result of Global Warming a Significant Source of Organic Matter for Microbiota Residing *in situ* and in Arctic Rivers?

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Significant atmospheric and terrestrial changes have occurred in the Arctic over the past several decades. Surface air temperatures have risen over northern land areas more than elsewhere in the world. Northern high-latitude ecosystems contain about half of Earth's soil carbon, most of which is stored in permanently frozen soil (permafrost). Global warming through the 21st century is expected to induce permafrost thaw, including thickening of the top layer of permafrost that freezes in winter and thaws in summer. Thickening of this layer will increase microbial decomposition of organic matter and release large amounts of the greenhouse gasses methane and carbon dioxide into the atmosphere. In addition, Arctic rivers are a globally important source of terrestrial organic carbon to the ocean, and further permafrost melting will impact surface runoff, directly affecting groundwater storage and river discharge. It remains largely unknown to what extent the ancient organic matter stored in newly thawing permafrost can be consumed by microbes *in situ* or by microbes residing in Arctic rivers; and, moreover, we know little about which microbes are capable of degrading permafrost organic matter.

In August of 2008 and with support from the Clark Arctic Research Initiative, WHOI summer student fellow Liz Zhu, Research Assistant Nan Trowbridge, and I conducted field work at the Toolik Lake Arctic Long Term Ecological Research (LTER) field station in northern Alaska. We collected water and surface sediment samples from the Kuparuk River, which flows northward across the Arctic Coastal Plain to the Arctic Ocean, as well as soil cores of moist acidic tundra spanning the permafrost located near the river (Figure 1, below, and Figure 2, next page).

Figure 1: Location of the Kuparuk River at the Toolik Lake field station in Northern Alaska. Permafrost cores were obtained in the summer of 2008 from moist acidic tundra located near the river.

Figure 2: Summer Student Fellow Liz Zhu and Principal Investigator Coolen obtaining a permafrost core underlying moist acidic tundra near the Kuparuk River.

At Toolik, the samples of thawed permafrost, river water, and river surface sediments were incubated for up to 11 days, and time-series experiments were performed on the samples to study the quantity and diversity of viable *in situ* microbial populations and their enzymatic activities. We took core samples of the permafrost down to 110 centimeters below the top layer and analyzed the initial microbial enzymatic activity on the particulate organic matter stored in the permafrost. Our analysis showed that one enzyme that breaks down organic matter into phosphate remained fairly constant throughout the permafrost and was only one order of magnitude lower than in the top layer. This finding was important, because phosphate can cause oxygen deprivation of lakes and rivers via ground water discharge. Similar results were found for an enzyme that fuels bacteria to produce carbon dioxide, which, in return, could be converted to the stronger greenhouse gas methane.

In a second set of time series experiments, river water and river surface sediments were incubated with sterilized organic matter from the permafrost soils so that the samples contained both microbes from the river and organic matter stemming from the sterilized soils. These experiments were performed to study the activity of the river microbes after having been exposed to thawed permafrost organic matter. Our analysis showed that the enzymatic activity greatly increased when the river and sediment samples were incubated with soils from the oldest permafrost soils and from the youngest top layer. These results indicated that river water and surface sediment bacteria were able to break down the organic material present in the Arctic permafrost in the event that eroding permafrost enters the Arctic rivers.

We have determined that organic matter from eroding permafrost can be degraded by microbes both *in situ* and in Arctic rivers. We are now turning our attention to identifying the microbes that are present. We are grateful to the Clark Arctic Research Initiative for making this important research possible.