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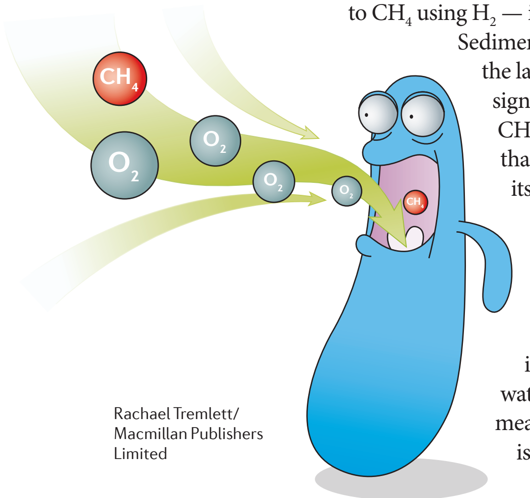
BIOGEOCHEMISTRY

A subglacial microbial methane sink

Antarctic subglacial lakes are largely unexplored frontiers that play host to dynamic microbial ecosystems. Among the organisms present are several that either produce or consume CH_4 as an important energy vector. New research explores subglacial biogeochemical cycling by analysing CH_4 isotopologues and bacterial genes and species from Subglacial Lake Whillans (SLW), which sits beneath the West Antarctic Ice Sheet (WAIS). A team led by Alexander Michaud reports its findings in *Nature Geoscience*, revealing that a microbial community beneath SLW acts as a CH_4 sink that might mitigate large-scale release of this greenhouse gas as ice sheets retreat.

Mapping the biogeochemical CH_4 cycle required Michaud and colleagues to probe below SLW. “We had never drilled through 800 m of ice before,” stresses Priscu, the Chief Scientist for SLW sampling efforts. “Once we had determined that there was life, it was time to address how microbial processes beneath large ice sheets participate in biogeochemical cycles,” adds Michaud. In the anoxic sediments beneath SLW, they found that hydrogenotrophic methanogenesis — the reduction of CO_2 to CH_4 using H_2 — is prevalent. Sediment 39 cm below the lake contains significantly more CH_4 (300 μM) than does the lake itself (0.024 μM), such that 6.8 ± 1.8 mmol CH_4 m^{-2} yr^{-1} pass upward through the sediments to the lake water. The authors measured the relative isotopic abundances in SLW sedimentary CH_4, and the natural variations provided a ‘fingerprint’ that revealed clues regarding its origin. The CH_4 concentrations, as well as $\delta^{13}C$–CH_4 and $\delta^{2}H$–CH_4 values (the extent to which the quotients $^{13}C/^{12}C$ and $^{2}H/^{1}H$ in CH_4, respectively, depart from standard values), provide evidence for hydrogenotrophic methanogenesis. The resulting CH_4 diffuses upwards and is oxidized by bacteria at the sediment/water interface.



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Michaud and colleagues calculate that >99% of sub-ice-sheet CH_4 is oxidized at the sediment/water interface, a finding supported by a large positive shift in $\delta^{13}C$–CH_4. Their results challenge earlier models that emphasized the significance of a possible subglacial CH_4 flux into the atmosphere. The authors attribute CH_4 consumption to oxidation by aerobic methanotrophs in surficial sediment, with O_2 sourced from basal melting of the WAIS. These active SLW methanotrophs may be a globally important CH_4 sink; conversion of sedimentary CH_4 efflux into CO_2 and biomass may act as a ‘buffer’ and lessen the warming potential of subglacial gases that escape as ice sheets retreat.

Having established the flow of CH_4, the team sought to find out which organisms were trading this currency. “Molecular microbiological data complement the geochemical analyses,” says Michaud. “Together, these methods allow us to say that methane is being consumed by known methane-oxidizing bacteria.” *pmoA* genes, which encode particulate methane monooxygenases (enzymes that enable methanotrophy in the O_2-rich SLW regions), were found in the SLW sediment. Chemical affinity calculations also implicate aerobic CH_4 oxidation as the most energetically favourable process for sustaining microorganisms in SLW surficial sediment (whereas the oxidation of both FeS_2 and NH_4^+ is more favorable in the SLW water column). The *pmoA* sequences and community analysis of 16S rRNA genes indicated that SLW, particularly in surficial sediments, is home to *Methylobacter tundripaludum* and other methanotrophs. *M. tundripaludum* is an aerobic cold-adapted bacterium that oxidizes CH_4 to eventually produce CO_2 and biomass, with the product ratio being dependent on O_2 supply and energy requirements.

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Given the role of CH_4 in climate forcing, understanding its sources, sinks and feedbacks is paramount. Priscu is now leading a second project (SALSA) — one that will involve drilling beneath Subglacial Lake Mercer, a deeper and larger system that may reveal more about biogeochemical cycling beneath the Antarctic ice sheet. “I was not surprised that we found life in Subglacial Lake Whillans. I was surprised, however, by the diversity of life we found and the biogeochemical transformations associated with this life,” says Priscu.

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ORIGINAL ARTICLE Michaud, A. B. *et al.* Microbial oxidation as a methane sink beneath the West Antarctic Ice Sheet. *Nat. Geosci.* http://dx.doi.org/10.1038/NGEO2992 (2017)

WEB SITES

Whillans Ice Stream Subglacial Access Research Drilling (WISSARD) project: http://www.wissard.org/

Subglacial Antarctic Lakes Scientific Access (SALSA) project: https://salsa-antarctica.org/