

## Evolution of subglacial weathering based on multiple isotopic systems

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Multiple isotope systems with distinct and specific applications provide a comprehensive overview of the evolution of subglacial hydrologic pathways, and thus weathering processes, at the Athabasca Glacier, Canada. Synthesizing traditional stable isotopic analysis of  $\delta^{18}\text{O}$  and  $\delta\text{D}$ , traditional radiogenic analysis of  $^{87}\text{Sr}/^{86}\text{Sr}$  and  $\epsilon_{\text{Nd}}$ , with a non-traditional application of uranium-series isotopes, allows us to quantify seasonal subglacial evolution and the impacts on weathering processes.

We apply the hydrologic tracers  $\delta^{18}\text{O}$  and  $\delta\text{D}$  to estimate volumes and fractions of water sources to glacial discharge originating as ice, snow, and precipitation. We coupled a  $\delta^{18}\text{O}$  and  $\delta\text{D}$  isotope-mixing model and a Bayesian Monte Carlo estimation scheme to infer the evolving water mass contributions from these three sources. We assess the extent of these water mass interactions and melt pathways with bedrock via heavy isotopes.

The length of time that subglacial water is in contact with underlying bedrock affects hydrological pathways and the magnitude of chemical interactions. Excess  $^{234}\text{U}$  and  $^{222}\text{Rn}$  from alpha decay depends on this residence time via their radioactive decay. Based on our newly established techniques, we find that the residence time varies by a factor of two through the melt season and is correlated with weathering fluxes. The spatial scale of weathering processes is investigated using radiogenic Sr and Nd isotopes; the age of the bedrock exposed to subglacial weathering varies systematically. The spatial variability in weathering location is revealed by the large variation in  $^{87}\text{Sr}/^{86}\text{Sr}$  and  $\epsilon_{\text{Nd}}$  (0.712-0.716 and 16-35, respectively). By combining these four isotope systems, we provide a quantifiable evaluation of the meltwater evolution in a polythermal glacier.

## Diagnosing petroleum fractionation processes in surface and subsurface environments using GCxGC

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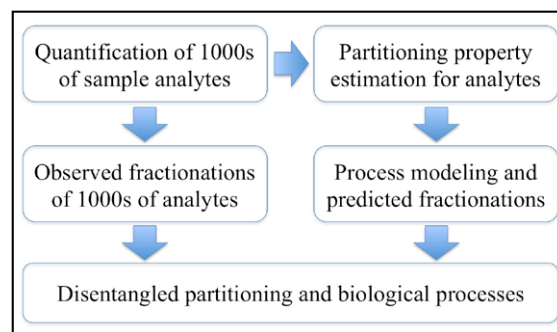
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Petroleum mixtures undergo significant compositional changes when exposed to air or water. This arises when oil is spilled on the sea surface, when deposited on the sea floor, or when extracted using enhanced recovery methods.

Using GCxGC, or Comprehensive Two-Dimensional Gas Chromatography, we can quantify thousands of individual hydrocarbon constituents in oil, including many biomarkers and structural isomers. Further, GCxGC instrument retention times convey information about the phase partitioning properties of each analyzed solute, indicating its tendency to dissolve into water, volatilize into air, or remain in oil phase. Applying GCxGC together with models of environmental behavior, we can differentiate physical fractionation and biotransformation processes acting on thousands of hydrocarbon constituents in diverse surface and subsurface environments.

In this talk, I will describe diverse examples in which GCxGC allows us to disentangle volatilization, dissolution, and biodegradation processes acting on petroleum mixtures. Case studies include: oil evaporation and dissolution on the open sea; oil weathering on contaminated coastlines; fractionation of oil deposited on the deep ocean floor; and anaerobic oil biodegradation in a subsurface reservoir. An outlook into anticipated future developments is also given.



**Figure 1:** Elucidating fractionation processes using GCxGC.