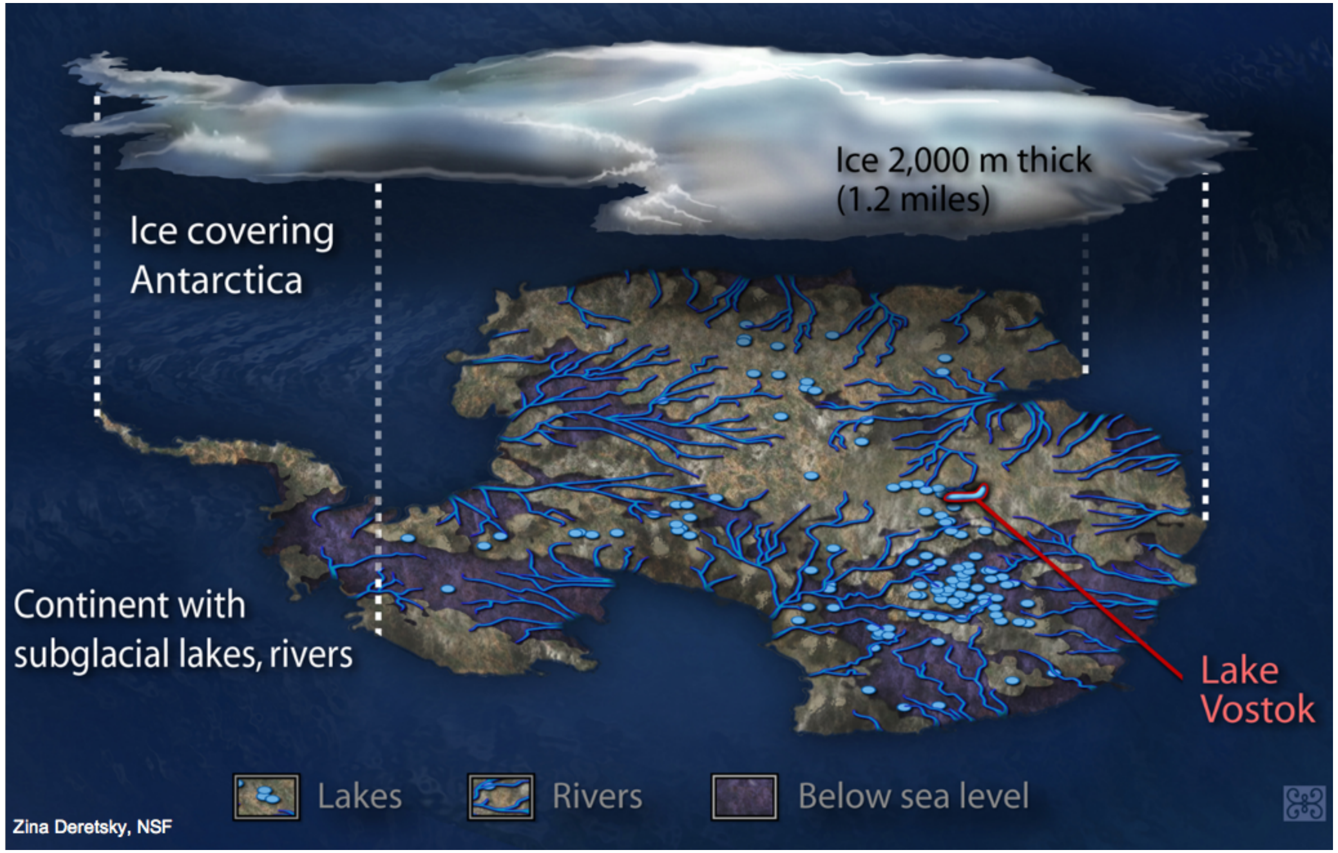
Direct access to subglacial aquatic environments: ecosystem perspectives

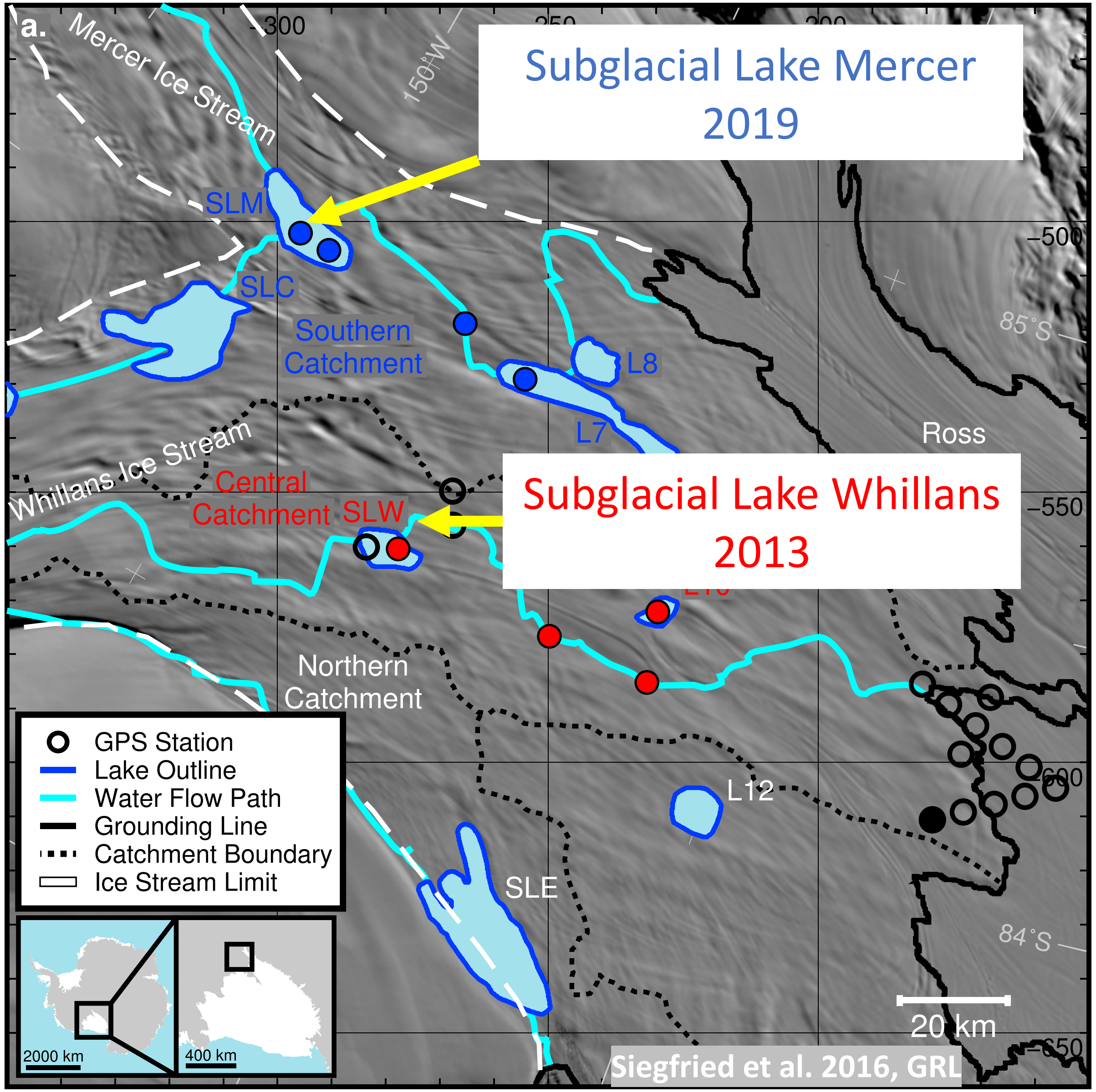


Compiled by Trista J. Vick-Majors on behalf of the SALSA Science Team

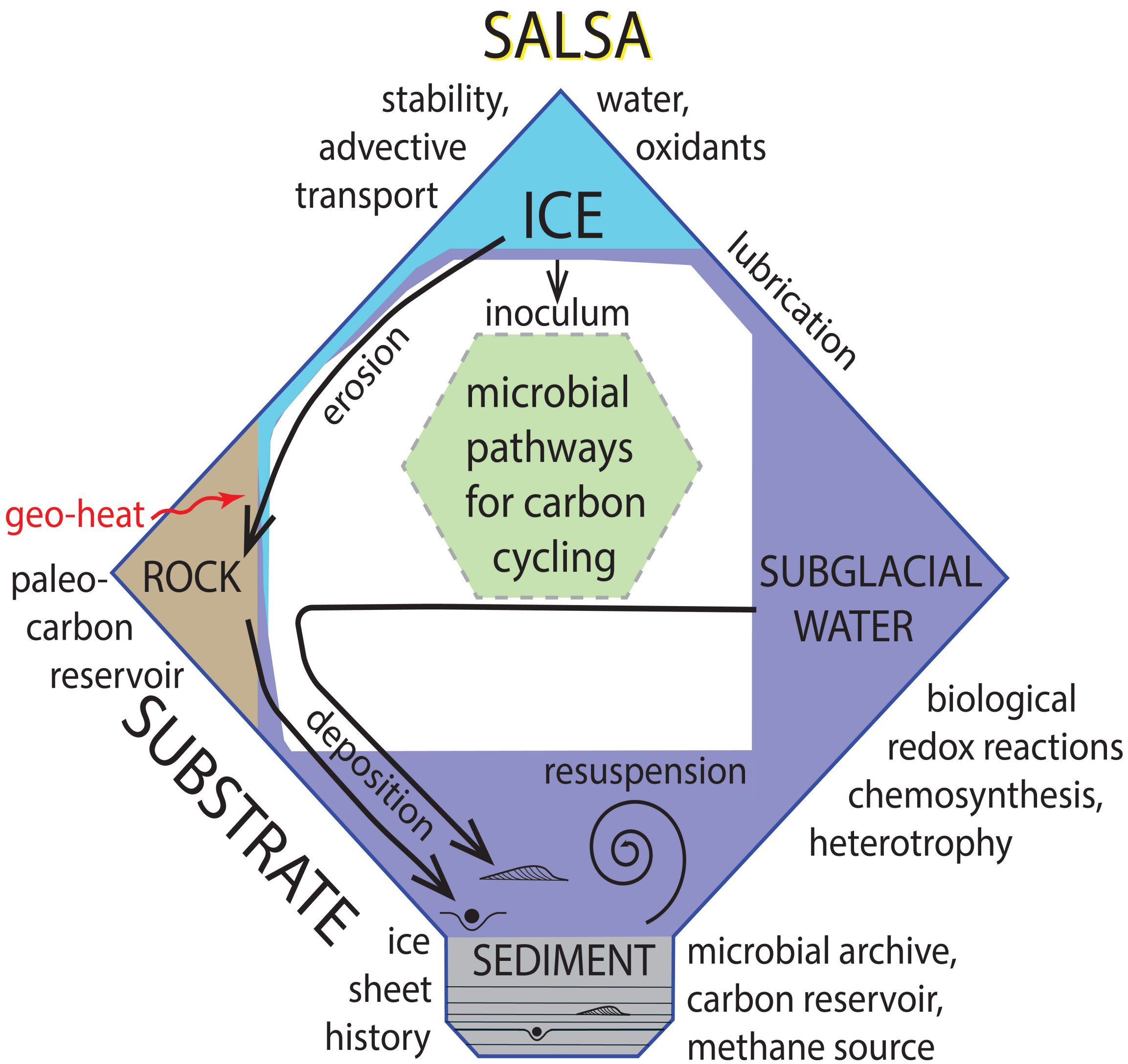
For the IDP SAB Meeting – SAWG Update

18 March 2021

Direct access to subglacial lakes: where are we now?

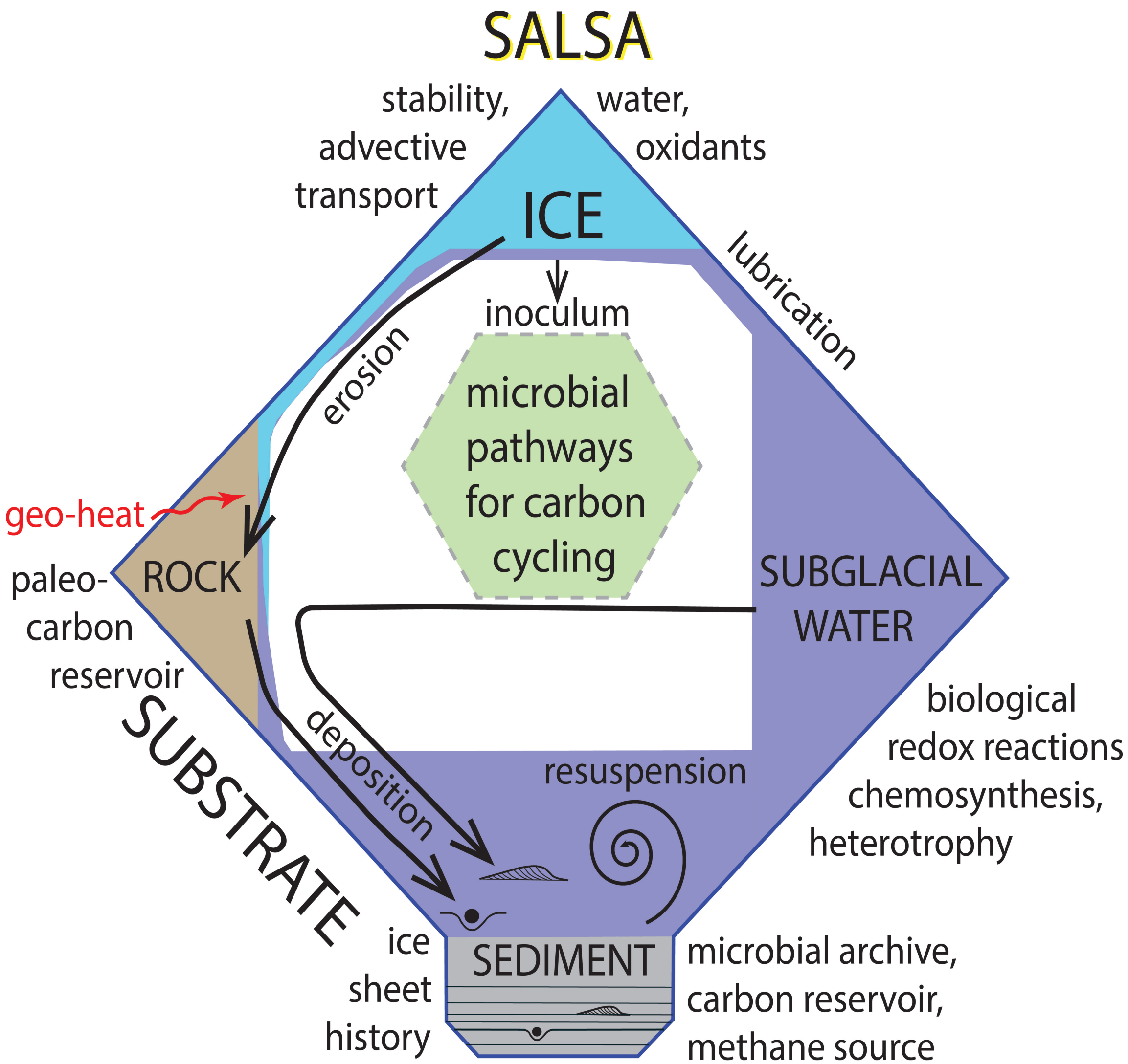


- Two active lakes (and two marine sites) have been accessed using hot water drilling with clean access
- Samples for water and sediment chemistry and microbiology
- Integration of geophysical and biogeochemical research to understand active subglacial aquatic environments



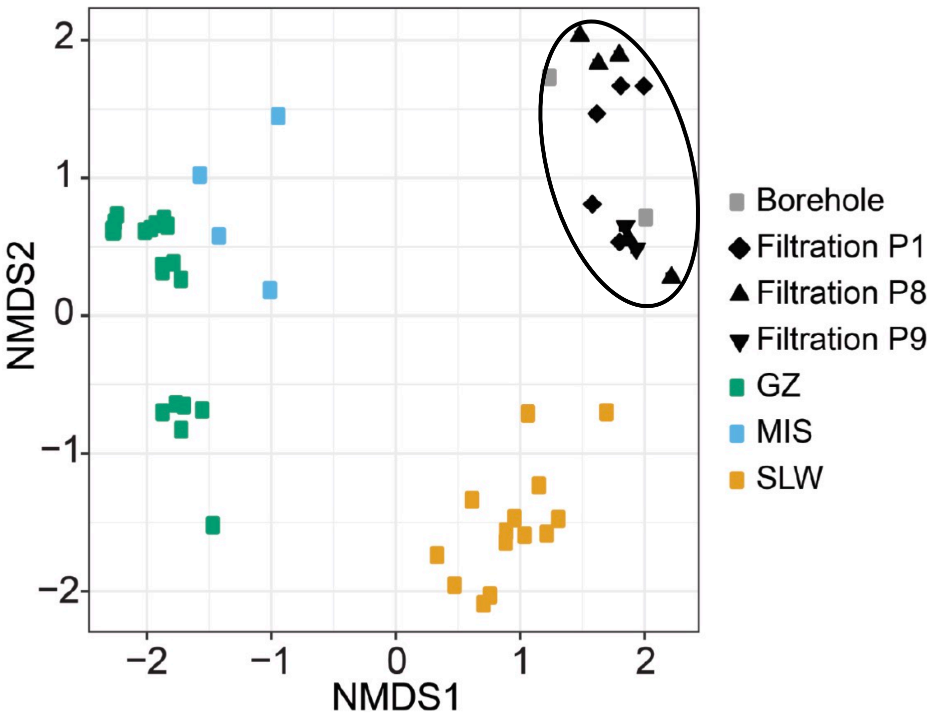
SALSA hypothesis:

"subglacial hydrology and relict deposits of marine organic carbon regulate microbial ecosystem processes in active subglacial environments"



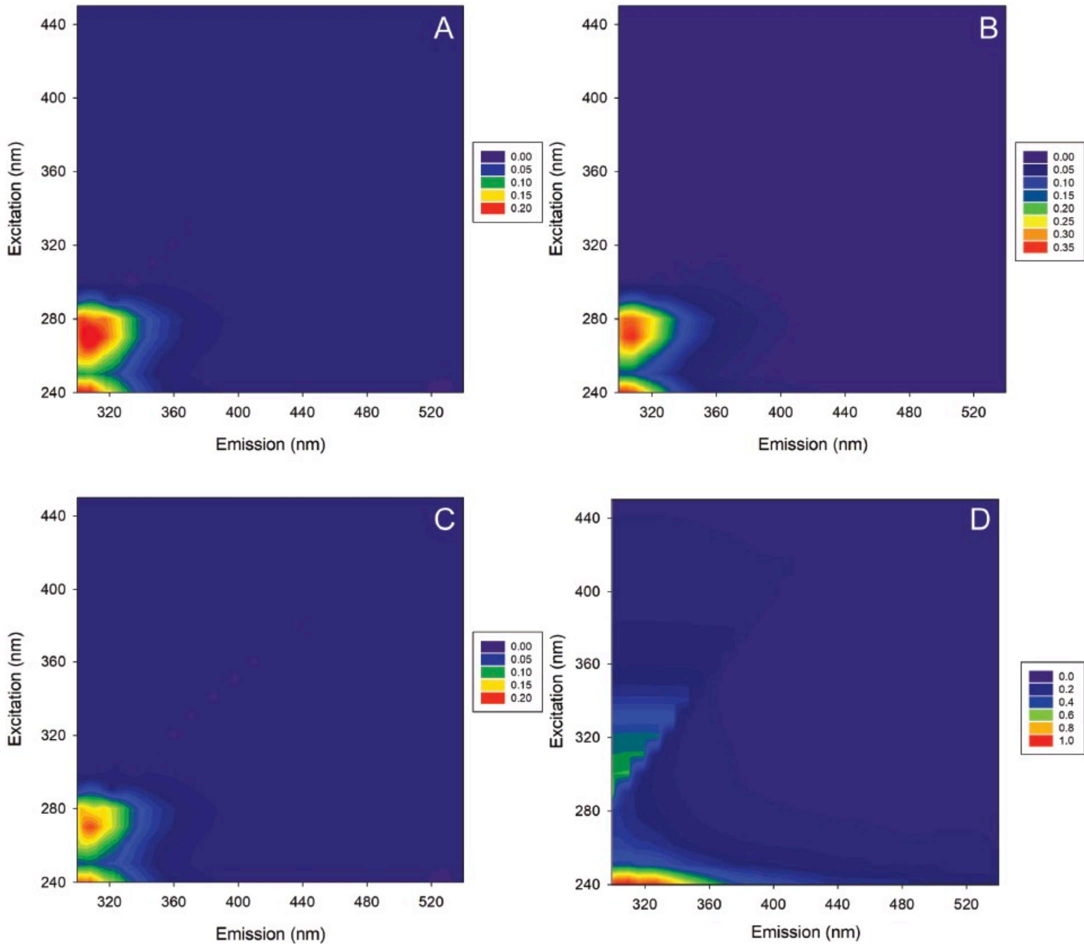
- Successes and lessons learned
  - The importance and success of subglacial clean access
  - Successful collaborative research (radiocarbon)
- Science
  - Physicochemical diversity of subglacial lakes
  - Biological diversity in subglacial environments
  - Sediment organic matter
  - Subglacial contributions to global biogeochemical processes
- What's next? What do we need to move forward?

Clean drilling technologies **work** for subglacial clean access



Closer clustering = more similar microbial communities.

Microbial communities in drill water filtration system samples are different from the microbial communities found in the subglacial habitats.



This figure shows the signatures of fluorescent dissolved organic matter sampled from the clean access system (A, B) and the borehole before breakthrough to Whillans Subglacial Lake (C) and Whillans Subglacial Lake (D).

Successes and lessons learned: Environmentally clean access to Antarctic subglacial aquatic environments

Michaud et al., 2020, *Antarctic Science*

SALSA scientific goals included the measurement of natural level radiocarbon AND the use of radiocarbon-enriched tracers, **typically thought to be incompatible activities**

Challenges

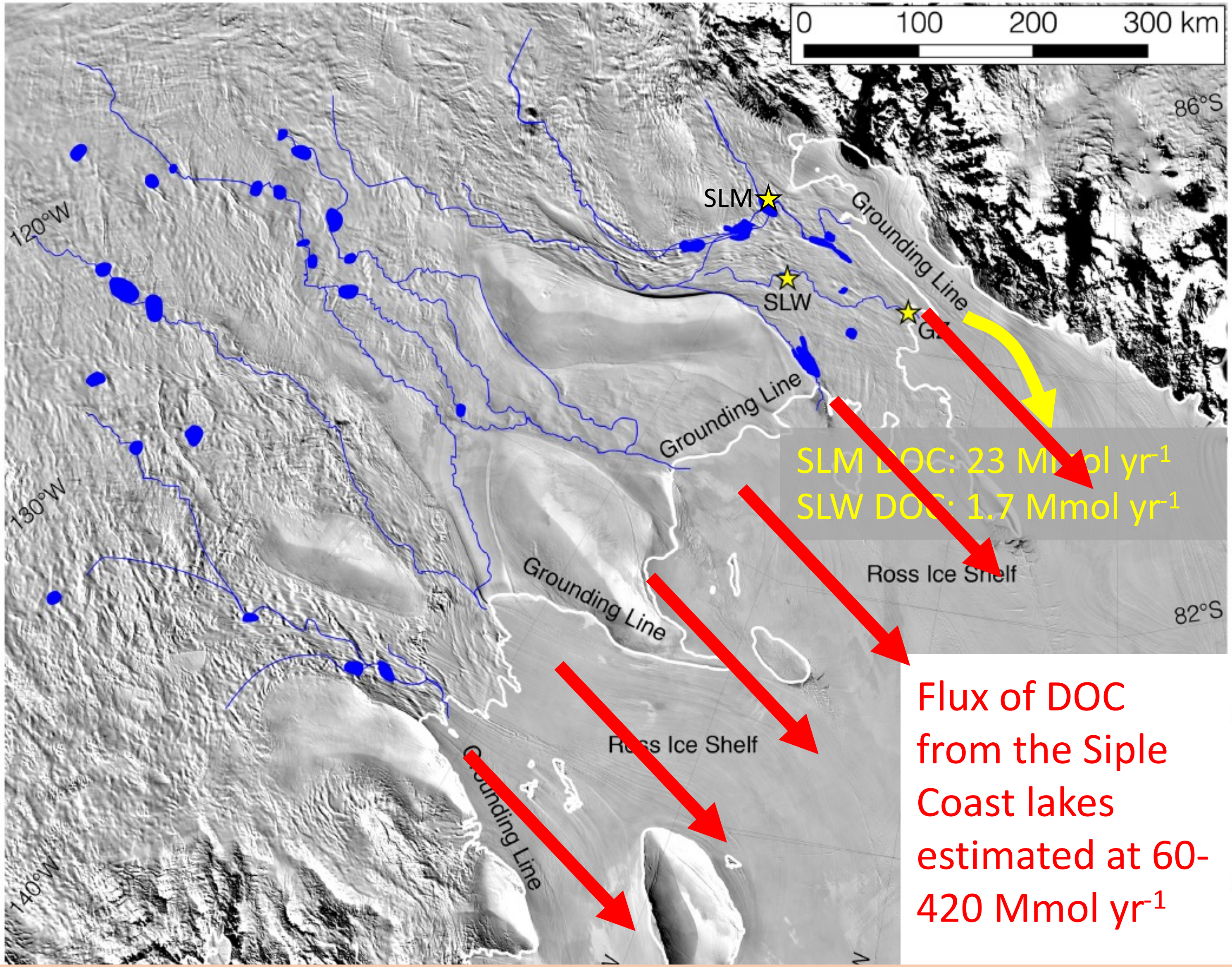
1. Contaminated space for natural level work a concern
2. Speaking different radiocarbon language
3. One researcher's analyte is another researcher's contaminant

Successes

1. Successful decontamination of laboratory space
2. Developed an understanding between natural-level and tracer working groups
3. Managed not to contaminate natural-level work!

Transformative work benefits from unusual integration across disciplines

Flux of organic matter and nutrients from Siple Coast subglacial lakes



Mean flux for DOC based on concentrations of 32 mM for SLM and 221 mM for SLW.

SLW DOC pool replenished in ~decade, which is similar timeframe for fill-drain cycle.

Water outflow estimates of 0.71 km3 yr-1 for SLW/SLM and 1.9 km3 yr-1 for Siple Coast.

DOC would supply 5,400% more than heterotrophic carbon demand in Siple coast embayments and 6.5% for the entire RIS cavity.

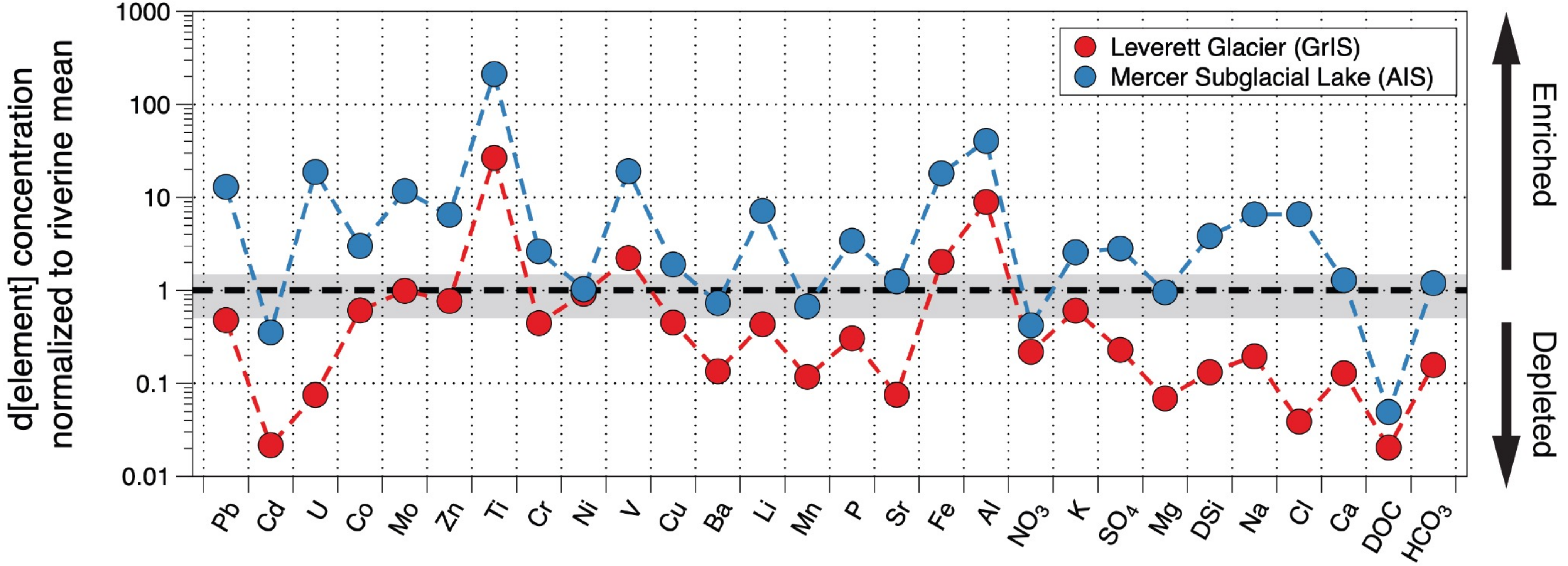
Using modeled basal rates to extrapolate to the AIS (65 km3 yr-1): 2,100 Mmol yr-1 (SLM data) to 14,000 Mmol yr-1 (SLW data).

High DOC flux estimate similar to the predicted contributions from Antarctic surface runoff.

Science Findings: Subglacial lakes are important sources of organic matter and nutrients to the ocean | Vick-Majors et al. 2020, *Global Biogeochemical Cycles*; Hawkings et al. 2020, *PNAS*

Subglacial environments should be components of regional biogeochemical cycles

Concentrations of many dissolved trace elements (<0.45 µm) are elevated in subglacial lakes compared to global riverine mean values



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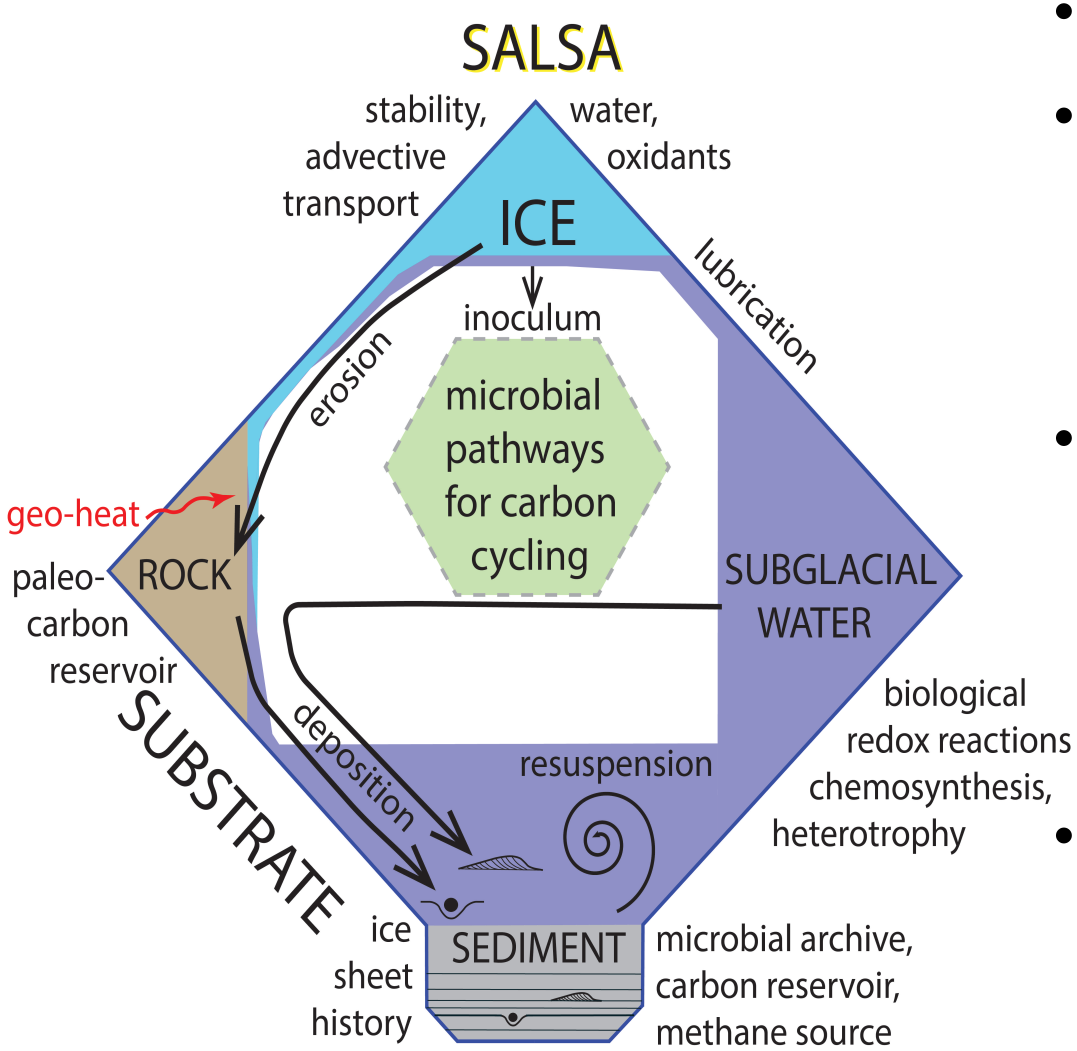
Direct access to subglacial lakes: what do we need to move forward?



- Basal ice! Wide agreement that this is a missing piece
- Future targets of interest include:
  1. Sites with thicker ice covers
  2. Higher resolution sampling of sites with thinner ice covers
- “1” requires a re-thinking of current drilling systems, which are not scalable for sites with ice thickness > ~1000 m.
  - Boreholes must be at least 30 cm in diameter and be maintained for at least 10 days.
- “2” requires a mobile, fast drill, capable of making a borehole transect across a lake of ice thickness up to ~1000 m
  - 5 boreholes, maintained for 5 days each.