Dynamics of subglacial lakes

Goal. The goal of the project is to predict the dominant large-scale circulation of water as well as the resulting distribution of particulates (sediments, microorganisms) in Antarctic and Greenland subglacial lakes (Fig. 1) based on the overlaying ice-sheet thickness, lake geometry and water depth.

Context. Subglacial lakes are pockets of water trapped between the polar ice sheets and continental bedrocks.[1] These bodies of water are buried under 2 km of ice on average and can be as large as Lake Michigan in the United States. To date, we have detected 400 subglacial lakes in Antarctica and 50 in Greenland. Subglacial lakes offer an exciting opportunity for scientists to probe whether microorganisms can strive in cold-temperature high-pressure water environments. An expedition to subglacial lake CECs in West Antarctica is planned for 2021-2022, which might unravel the first signs of a biome in an environment similar to subsurface oceans on icy moons.[2]

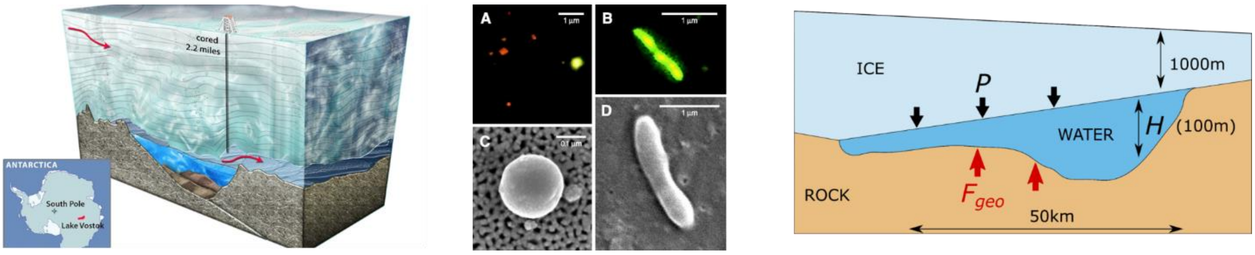

Figure 1: Schematic of lake Vostok (left), microorganisms in accreted ice above lake Vostok (middle), and idealized schematic of subglacial lakes of interest to this project (right).

Proposed work. The two key flow features expected in subglacial lakes are (i) a horizontal flow adjacent to the ice ceiling that depends on the ice-water interface slope, and (ii) a vertical circulation of water driven by geothermal heating.[3] The goal of this PhD project is to predict the type of circulation that may be obtained in subglacial lakes in general and in subglacial lake CECs[4] in particular. The project will first consider idealized lake geometry to draw the phase diagram of the fluid dynamics over a broad range of parameters (ice slope, geothermal flux) with and without rotation, before considering realistic lake geometries. The distribution of particulates resulting from the large-scale circulation will be studied last. We will use a state-of-the-art open-source code (Nek5000, which uses a spectral element method; nek5000.mcs.anl.gov), to numerically solve for fluid motions and heat transfers. Supplemental work related to the effect of salinity on lake hydrodynamics or long-term melting of the overlaying ice sheet will be possible based on interest.

Impact. The project will make fundamental progress on the fluid dynamics resulting from the competition between horizontal and vertical convection, with and without rotation, and the resulting particulate distribution. The applications of the results to real subglacial lakes in Antarctica and Greenland will provide guidelines for future expeditions (e.g., CECs, which may lead to collaborations with the British Antarctic Survey) and attract interest from the astrobiology community.

References.
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