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Aquatic ecosystems beneath Antarctic Ice

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The first measurements on permanently ice-covered Antarctic lakes were made by R.F. Scott in 1903, when he gathered morphometric data from Lake Bonney, Taylor Valley. It was not until the late 1950's when research initiated as part of the International Geophysical Year led to systematic studies of Antarctic lakes. Most of these studies focused on coastal lakes along the Soya Coast, the Vestfold Hills, the Bungar Hills, the South Orkney Islands, and Southern Victoria Land. Lakes in Southern Victoria Land, the most southerly of these lakes, are the only that maintain permanent ice covers overlying deep water columns (~20 to 85m). Research in the Southern Victoria Land lakes over the past 60 years, particularly the climate integrated studies conducted in the Taylor Valley by the NSF-funded Long Term Ecological Research Program, have shown that most organisms in the lakes are not just "surviving the extremes" but are actively feeding, growing and reproducing. As such, they are ecosystems in which we can identify and begin to understand physiological and genomic adaptations in the context of one of the most extreme environments on our planet. Research in these coastal lakes led scientist to hypothesize that subglacial lakes, discovered more than 40 years ago beneath the Antarctic ice sheet, may also contain a diverse group of microorganisms that form functional ecosystems beneath the ice sheets. The first biological studies on subglacial lakes focused on Lake Vostok, a ~1 km deep lake lying ~4 km beneath the East Antarctic Ice Sheet. This research (published in 1999) revealed that a relatively diverse group of microorganisms were present in Lake Vostok at densities of $\sim 10^3$ cell ml⁻¹. Importantly, these first reports of life in Vostok were indirect, focusing on organisms found in accretion ice overlying the lake. It was not until 2012-2013 when three national programs began drilling programs to directly sample subglacial lakes. Russian drillers penetrated Lake Vostok in February 2012 allowing water to flood their borehole as hydraulic equilibrium was reached. Ice cores representing this water were collected the following season after the lake water in the borehole had refrozen. Unfortunately, these samples were badly contaminated by hydrocarbon-based drilling fluid leading to equivocal results of life in Lake Vostok. In December 2012, scientists from the United Kingdom attempted to access Subglacial Lake Ellsworth, West Antarctica, using a clean access hot-water drill. Their mission had to be cancelled owing to equipment and operational failures. One month later a US team, using a hot-water drill and clean protocols, successfully accessed and sampled water and sediment from Subglacial Lake Whillans, West Antarctica. The results from Whillans revealed a functional ecosystem containing a highly diverse group of microorganisms. Results from these three campaigns provided a wealth of new technological and scientific knowledge about subglacial lakes and pave the way for future Antarctic subglacial lake research.