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Microbial Characterization of Arctic Glacial Ice Cores with a Semiautomated Life Detection System

David Touchette,^{1–3} Catherine Maggiori,^{1,2} Ianina Altshuler,^{1,4} Alex Tettenborn,⁵
Louis-Jacques Bourdages,^{1,6} Elisse Magnuson,¹ Olivia Blenner-Hassett,^{1,2}
Isabelle Raymond-Bouchard,^{1,2} Alex Ellery,⁵ and Lyle G. Whyte^{1–2}

Abstract

The search for extant microbial life will be a major focus of future astrobiology missions; however, no direct extant life detection instrumentation is included in current missions to Mars. In this study, we developed the semiautomated MicroLife detection platform that collects and processes environmental samples, detects biosignatures, and characterizes microbial activity. This platform is composed of a drill for sample collection, a redox dye colorimetric system for microbial metabolic activity detection and assessment (μMAMA [microfluidics Microbial Activity MicroAssay]), and a MinION sequencer for biosignature detection and characterization of microbial communities. The MicroLife platform was field-tested on White Glacier on Axel Heiberg Island in the Canadian high Arctic, with two extracted ice cores. The μMAMA successfully detected microbial metabolism from the ice cores within 1 day of incubation. The MinION sequencing of the ice cores and the positive μMAMA card identified a microbial community consistent with cold and oligotrophic environments. Furthermore, isolation and identification of microbial isolates from the μMAMA card corroborated the MinION sequencing. Together, these analyses support the MicroLife platform's efficacy in identifying microbes natively present in cryoenvironments and detecting their metabolic activity. Given our MicroLife platform's size and low energy requirements, it could be incorporated into a future landed platform or rovers for life detection. **Key Words:** Life detection—Automation—Drilling—MinION—μMAMA—Glaciers—Cryoenvironments—Astrobiology. *Astrobiology* 23, xxx–xxx.

1. Introduction

THE SEARCH FOR SIGNS of ancient life is a primary objective of the Mars 2020 and ExoMars 2022 missions (Vago *et al.*, 2017; Farley *et al.*, 2020) and will certainly be a focus of future missions as evidence of ancient habitable environments continues to emerge; for example, recent modeling of Martian chloride salt deposits suggests surface waters persisted into the Amazonian period 2–2.5 Ga (Leask and

Ehlmann, 2022). The search for extant life will also likely be a key objective as more putatively habitable regions are uncovered. Life as we know it is dependent on water; recent discoveries of liquid water in the Martian subsurface, including subglacial lakes below Mars' southern ice cap (Orosi *et al.*, 2018; Lauro *et al.*, 2021) and recurring slope lineae potentially resulting from near-surface sulfate–chloride brines (Bishop *et al.*, 2021), raise the possibility that extant life could exist in the subsurface.

¹Department of Natural Resource Sciences, McGill University, Sainte-Anne-de-Bellevue, Canada.

²McGill Space Institute, Montréal, Canada.

³Environmental Engineering Institute, River Ecosystems Laboratory, School of Architecture, Civil and Environmental Engineering, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland.

⁴Environmental Engineering Institute, MACE Laboratory, School of Architecture, Civil and Environmental Engineering, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland.

⁵Department of Mechanical and Aerospace Engineering, Carleton University, Ottawa, Canada.

⁶Department of Mechanical Engineering, Faculty of Engineering, McGill University, Montréal, Canada.

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