National Aeronautics and Space Administration

Exploring abiotic constraints on microbial habitability in subsurface hypersaline brines

Principal Investigator: Scott Perl (397); Co-Investigators: T.C. Onstott (Princeton University), Devan Nisson (Princeton University)

Program: FY21 SURP **Strategic Focus Area: Habitable Worlds**

Objectives & Background:

Our proposal focuses on brines from the Moab Khotsong gold and uranium mine in South Africa.

-Brines that are accessible via three boreholes utilized in this work are being investigated for microbial life under hypersaline and high temperature conditions (Fig. 1).

-These brines are contained within the 2.9-3.1 Ga West Rand quartzites and shales of the Witwatersrand basin, and noble gas isotopic signatures estimate their subsurface residence times between 1-2 Ga.

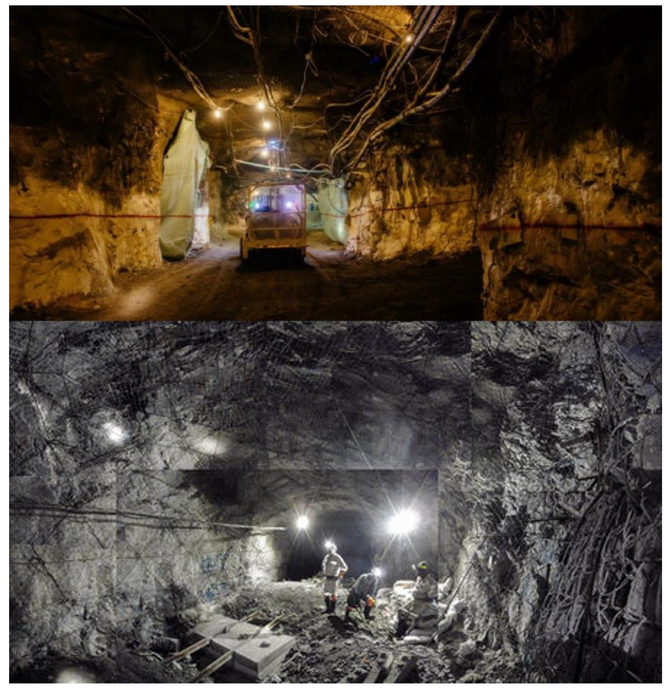

Fig. 1: West Rand quartzites and shales within the Witwatersrand basin that are uniform section of our planetary analogue field site.

Scientific & Technical

1) Delineate bioenergetic support for chemolithotrophic metabolisms in deep subsurface brines, including methanogenesis, through identification and quantification of energy sources, TOC substrates (organic & inorganic), nitrogen and phosphorous substrates, and selective enrichments simulating available soluble and mineral pools.

2) Characterize the taxonomy and expression activity of potential microbial inhabitants (Fig. 2) in rock-hosted deep subsurface brines, through fluorescent molecular probing and “omics”-based approaches (Fig. 3) to help reconstruct an in situ metabolite cycling trophic structure.

Approach and Results

-Selected results have shown extant microbial communities preserved in mineral-brine inclusion, significant biomass present in fluid mediums that can be traced back to the initial Operational Taxonomic Units (OTUs), and lessons for low biomass life detection methods that can be used in planetary frozen and fluid environments.

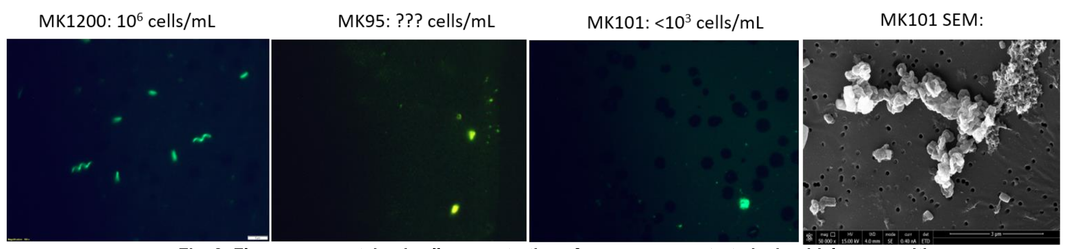

Fig. 2: Fluorescence stained cell concentrations from pre-concentrated microbial communities.

Strategic Significance / Benefits to JPL and NASA

Long-term goals of this proposal and collaboration include associating vibrational spectroscopic and fluorescence microscopy organic detections to microbial communities within subsurface brines and precipitated mineralogy for preservation and (simulated) UV-C protection studies. We will simulate Mars RSL and Europa temperatures from collected *in situ* brines using cryostage showing depressed freezing points and potential changes to organic structures after modern Mars temperatures are reached.Work between JPL and Princeton University to develop optimized protocols for nucleic acid extractions and organic carbon analysis in highly saline and low biomass samples.

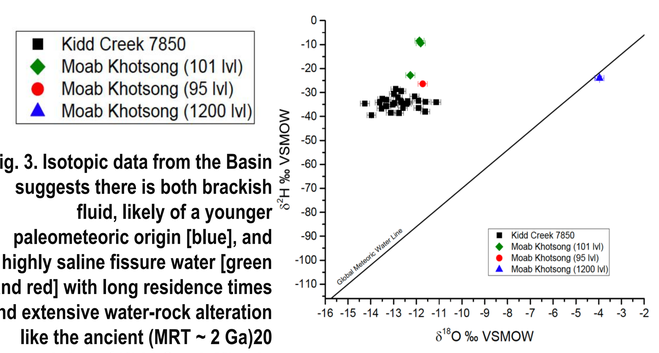

Fig. 3. Isotopic data from the Basin suggests there is both brackish fluid, likely of a younger paleometeoric origin [blue], and highly saline fissure water [green and red] with long residence times and extensive water-rock alteration like the ancient (MRT ~ 2 Ga)20 brine of Kidd Creek Mine in Ontario, Canada.

Publications

Perl, S.M. Celestian, A.J., Cockell, C.S., Corsetti, F.A., Barge, L.M., Bottjer, D., Filiberto, J., Baxter, B.K., Kanik, I., Potter-McIntyre, S., Weber, J.M., Rodriguez, L.E., Daswani, M.M. (2021) A Proposed Geobiology-Driven Nomenclature for Astrobiological *In Situ* Observations and Sample Analyses. Volume 21, Number 7, 2021. Mary Ann Liebert, Inc. DOI: 10.1089/ast.2020.2318

Perl, S.M., Adeli, S., Basu, C., Baxter, B.K., Bowman, J. Boyd, E., Cable, M., Celestian, A.J., Cockell, C.S., Corsetti, F.A., Craft, K.L., Engelhart, A., Fairen, A.G., Potter-McIntyre, S., Lynch, K., Schneegurt, M., Schwenzer, S., Shkolyar, S., Theiling, B., Wade, B., Zaloumis, J. (2020) Salty Environments: The importance of evaporites and brine environments as habitats and preservers of biosignatures. *National Academy of Sciences, Planetary Science & Astrobiology Decadal Survey 2023-2032.*

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

PI/Task Mgr Contact
Email: Scott.M.Perl@jpl.nasa.gov

Clearance Number:
RPC/JPL Task Number: SP21006