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Microbial Life in Deep-Subsurface Environments: The Role of High Pressure in Biogeochemical Cycles

Cheyenne Brokaw
University of Nevada, Las Vegas, Brokac2@unlv.Nevada.edu

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Cheyenne Brokaw & Dr. Aude Picard
School of Life Sciences, University of Nevada Las Vegas

UNLV COLLEGE OF SCIENCES

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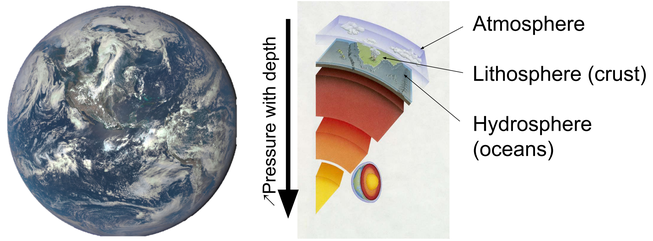
Introduction

Ocean World: An ocean world is considered any planet or moon currently with a liquid ocean.

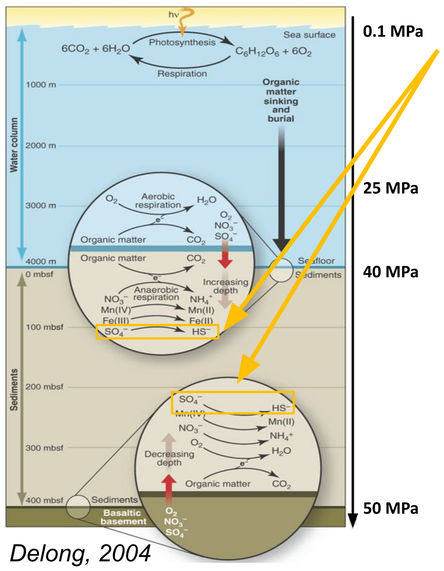


While the deepest part of the Ocean (Mariana Trench, 11,000 mbsl, 110 MPa) and the lithosphere host microbial life, it begs the question, **How**?

Research Question

What Are The Pressure Limits For Microbial Activity In Aquatic Environments?

We are investigating the role of hydrostatic pressure on the S and C biogeochemical cycles in the Earth's marine environment.



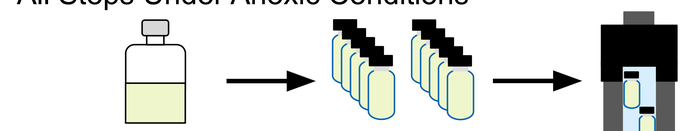
Delong, 2004

Microbial Sulfate Reduction: coupled to organic matter oxidation, as a model for microbial activity on Ocean Worlds

Model sulfate-reducing bacterium: *Desulfovibrio hydrothermalis (Dh)* AM13, isolated from the deep sea (*Alazard et al. 2003*)

Methods

High-Pressure (HP) incubation Set-up:
All Steps Under Anoxic Conditions



50 mL of anoxic marine medium (~22 mM sulfate, ~22 mM lactate) inoculated with a high cell concentration of *Dh* AM13; incubated from 1-2 weeks @ 35°C

Transfer inoculum into HP- compatible containers (5-ml Hungate Tubes)***

***5 tubes are put under pressure and 4-5 tubes are kept at atmospheric pressure in an incubator as control variables.

Loaded High Pressure (HP) Vessel with 5 inoculum filled Hungate tubes

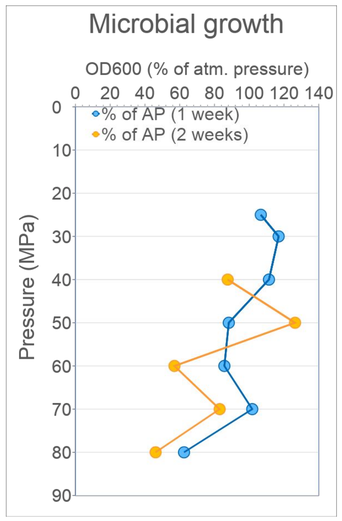
HP vessels pressurized with manual HP pump (0-80 MPa)

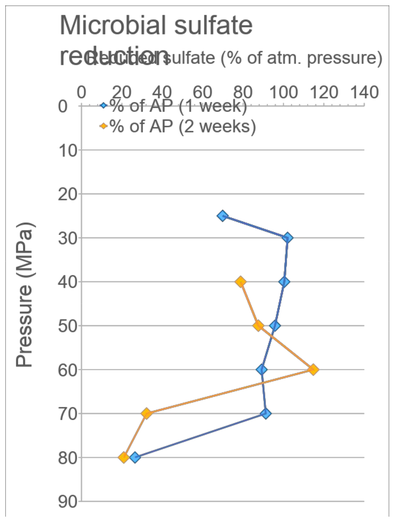
Microbial growth measured through optical density at 600 nm (OD_{600}): indicates the growth stage of the bacteria

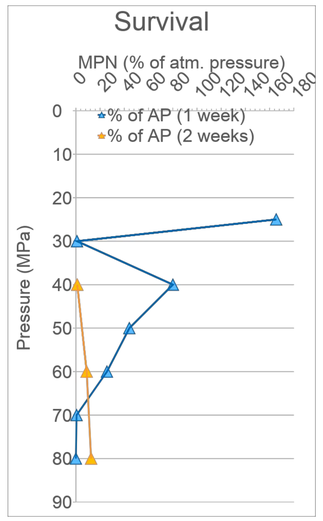
Microbial sulfate reduction monitored with sulfate concentrations in the medium: indicates the levels of the sulfate reduction cycle

Survival measured through the most probable number method (MPN): based on the principle of extinction dilution; estimates the number of viable bacteria in the cultures

Results and conclusions







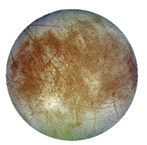
- At low cell density, *Dh* AM13 is active only up to 50 MPa (data not shown)
- At high cell density, *Dh* AM13 is active at least up to 80 MPa (this study)
- Resistance to pressure is higher under low energy availability
- Cell-to-cell communication (quorum sensing) promoted by high cell density might play a role in coping with pressure effects
- Pressure and/or high cell density seem to induce a change in microbial lifestyle, from planktonic to biofilm-like organization (ongoing work)

Discussion/Future Research

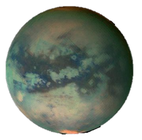
Is there any life on other ocean worlds?

Earth is the only known Ocean World with life, but there are ocean worlds in the outer solar system. These planetary bodies are believed to have larger/deep water depth. Can pressure-adapted microbes survive at these depths?

Example of Known Ocean Worlds (aka Icy Moons) and their estimate maximum pressures in oceans



Europa (200 MPa)



Titan (500 MPa)

Ganymede (1000 MPa)

Acknowledgements

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