

FUNDED: NASA Habitable Worlds Proposal.  
Timeline: February 2020 through January 2023.

### Title: Habitability of saponite-rich hydrothermal systems of early Mars.

Of all the potential sites in the solar system that may harbor life, those with hydrothermal vents have perhaps the greatest potential for creating environments conducive for life's origin and continued habitability. Energy production and availability is key: The disequilibria generated during water-rock reactions and the mixing of vent fluids with the overlying water column provides an energy-rich environment for chemosynthetic life to thrive. Studies of different types of hydrothermal vents on Earth have revolutionized our understanding of how life on Earth might have emerged, and how and where life might exist. But, modern Earth analogs for ancient Mars systems are uncommon.

Iceland rocks are similar to those found on Mars, and many authors have compared Iceland hydrothermal vents with putative vents thought to have once existed on early Mars. Environments where Iceland's iron-rich rocks are being altered by hot springs were suggested to reflect conditions on Mars more than three billion years ago. This makes Iceland a valuable analog site for upcoming missions to Mars, including that of the Mars 2020 rover. Set to launch in 2020, this mission will, among other things, search for evidence of extraterrestrial life, and will target environments that were similar to those found in Iceland.

Our target analog site, the Strytan Hydrothermal Field (SHF), is an exceptional terrestrial analog for past hydrothermal systems on Mars because of its basaltic setting and associated water-rock chemistry. The SHF is one of the only places on Earth where massive, hydrothermal saponite is being deposited in an anoxic, alkaline environment, making it an ideal locality for investigating the habitability of similar clay-rich deposits on Mars. Our overarching goal for this proposed work is to evaluate how, and to what extent, energy generated by ancient, saponite-rich, alkaline hydrothermal settings on Mars could have supported biological processes. Our focused objectives are to: 1) model the bioenergetics of SHF and compare to similar putative habitable sites on early Mars; 2) evaluate the electrical energy generated by Strytan vents and laboratory simulated vents that could support habitability via direct electron transfer from precipitates; 3) evaluate the amount of trapped organic matter in natural and synthetically generated laboratory vent precipitates and relate the results to the energy available for heterotrophic metabolisms.

The information gained by this project can be applied directly to the primary goals of the Habitable Worlds program: 1) to search for contemporary habitable environments relevant to exploring the possibility of extant life beyond Earth, and 2) to contribute to our understanding of the characteristics and the distribution of potentially habitable environments in the Solar System and beyond. It will use "field experiments that improve scientific understanding of how in situ measurements at analog sites can or will improve our understanding of the potential for the environment to support life"; it will investigate "sources of energy for life, using Mars as a target body"; and it will evaluate "the astrobiological potential of past or present environments on or in the Martian surface or subsurface." The proposed work is not relevant to Exobiology because it is not an evaluation of "biosignatures" and does not evaluate "phylogeny, physiology, or adaptations of extant terrestrial organisms to extreme environments", or PSTAR, as it is not designed to "develop technical or scientific basis to conduct planetary research".

We will use knowledge gained from characterizing diverse hydrothermal vent systems in Iceland as a guide for determining the processes and conditions that create and maintain habitable environments in hydrothermal systems broadly. This will provide significant insights into understanding the habitability of ancient hydrothermal systems on Mars.

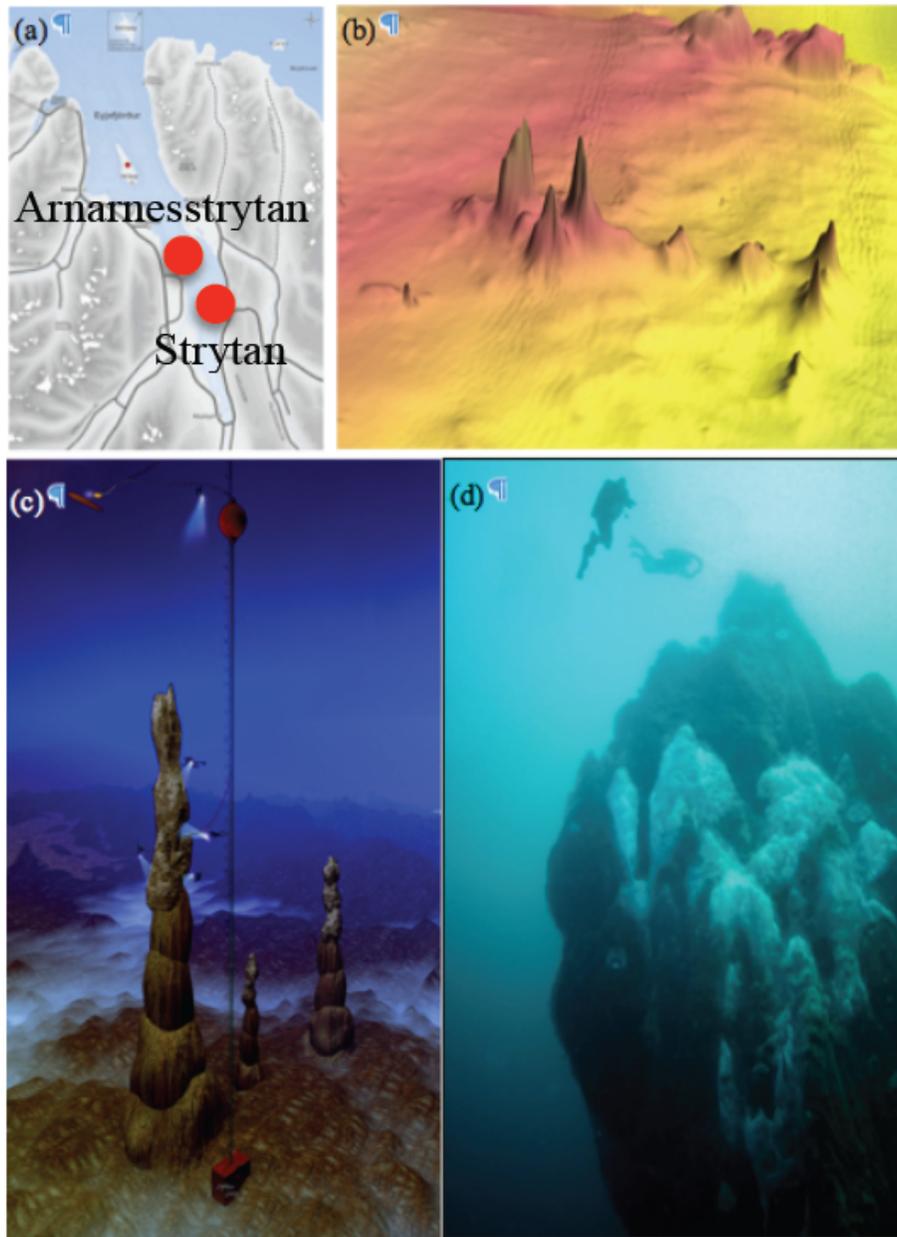


Fig 1. Strytan Hydrothermal Field, Iceland (a) Location of vents as red dots. (b) Bathymetry of abundant, large saponite cones. (c) Schematic of Strytan cones with divers as scale (d) Photo of active venting (white = fresh saponite).

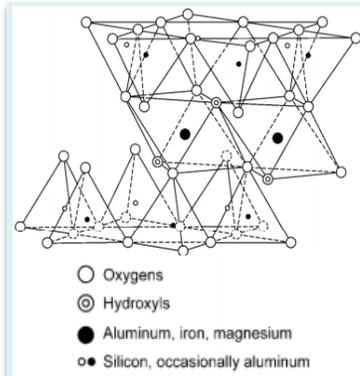


Fig 2. Smectites are layered silicate minerals with either divalent or trivalent cations. When trivalent cations occupy the space between layers (e.g.,  $\text{Al}^{3+}$ ,  $\text{Fe}^{3+}$ ), they are dioctahedral smectites, including nontronites ( $\text{Fe}^{3+}$ -rich). Trioctahedral **saponites** have divalent cations, e.g.,  $\text{Mg}^{2+}$  or  $\text{Fe}^{2+}$ .

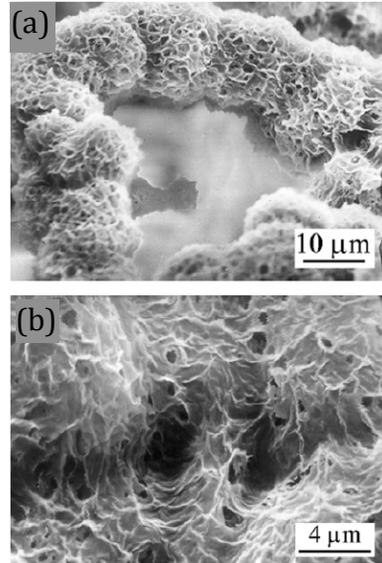


Fig 3. SHF microstructures (a) Filamentous chain of globules with numerous pores. (b) Surface of globular chain displaying abundant pores.

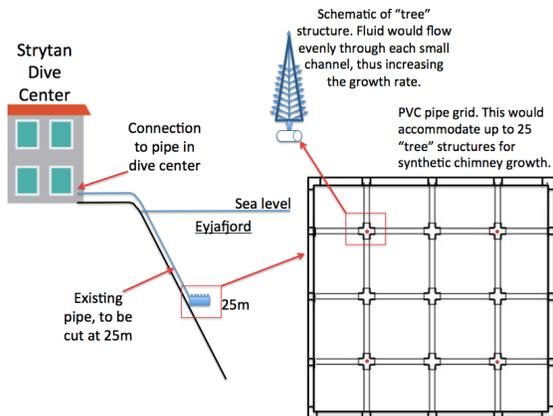


Fig 4. Design for growing synthetic chimneys in Eyjafjord.

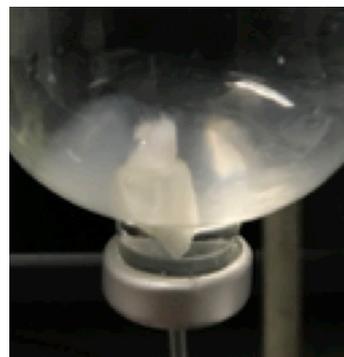


Fig 5. Lab-grown Mg-silicate (saponite) chimney using Strytan-like chemistry.