

AKUTAN ISLAND, ALASKA: A SUB-GLACIAL HYDROTHERMAL SYSTEM AS A TERRESTRIAL ANALOG FOR HABITABLE ENVIRONMENTS ON MARS. Pete Stelling¹, Kathleen Craft², Sally Potter-McIntyre³ and Amy J. Williams⁴, ¹Western Washington University, Bellingham, WA 98225-9080, pete.stelling@wwu.edu, ²The Johns Hopkins University Applied Physics Lab, Kate.Craft@jhuapl.edu, ³Southern Illinois University-Carbondale, Parkinson Lab, Carbondale, IL 62901, pottermcintyre@siu.edu, ⁴University of Maryland Baltimore County/NASA Goddard Space Flight Center, Greenbelt, MD 20771, amy.j.williams@nasa.gov.

Introduction: Terrestrial hydrothermal systems have long been identified as analogs for habitable environments on Mars [1]. Magmatic intrusions into frozen regions have been suggested to explain some Martian surface morphologies [2-6]. This scenario would also concentrate habitable environments into a narrow band surrounding the intrusion by providing an ideal combination of water, heat and chemical energy throughout certain temperature regimes. In order to take advantage of this concentration of the biosphere, it is critical to identify biosignatures endemic to these environments on Earth. The challenge is to find an appropriate terrestrial site that is accessible, contains evidence of hydrothermal-ice mixing and preserves ancient and sub-modern physical and chemical biosignatures.

Akutan Island - A Sub-Glacial Hydrothermal System And Excellent Terrestrial Analog:

The Hot Springs Bay Valley (HSBV) on Akutan Island in the eastern Aleutian Islands has been highlighted for geothermal exploration since the 1980's [7] and the focus of rigorous exploration since 2009. Soil, soil gas, fluid and fumarole chemistry has been collected, geophysical surveys have been conducted and 754 meters of drill core has been recovered from two wells [8]. These data show substantial evidence that the Akutan hydrothermal system formed while glaciers were present at the surface. This confluence of hot hydrothermal waters and frozen sub-glacial terrain make an excellent terrestrial analog for ancient and extant martian hydrothermal systems.

The strongest evidence for subglacial hydrothermal development appears in the alteration and secondary mineral assemblages exposed in the core. The highest temperature secondary minerals (epidote, prehnite, adularia and wairakite) all have minimum temperatures of formation (200 °C – 220 °C) that are higher than modern down-hole temperatures. At Akutan, these minerals also occur at depths too shallow (60 m below the surface) for 200 °C water to remain liquid. Because these minerals crystallize from liquid brine, the depth of formation must be >200 m deeper than they were found [8]. These temperatures of formation are used to identify environments that would have been within the temperature range for extremophile life (< 120 °C).

Why Not Glacial Erosion? Glacial erosion estimates for even the largest glacial periods range from

only 34 to 90 m, assuming glacial conditions lasting for 500,000 years [9,10]. The presence of a glacier > ~650 m thick, however, would generate the same pressures afforded by 200 m of basalt, allowing these minerals to form close to the rock-ice interface. This interpretation is consistent with geophysical surveys that indicate Akutan has many of the hallmarks of a mature geothermal system but at unusually shallow levels with the upper portions of the system intersecting the ground surface.

Potential Astrobiological Implications from the Akutan System: Life on Earth may have arisen in similar hydrothermal systems during the Archean [12], so understanding the interactions and preservation of biosignatures in the Akutan system will inform both the search for ancient biosignatures on Earth as well as potential biosignatures that may be preserved in similar martian systems such as Aromatum Chaos. Given the lack of plate tectonics on Mars and long-lived volcanism at individual volcanoes these hydrothermal sites could have been one of the longest duration habitable environments through time [13]. In addition to the parent rock lithology and environmental parameters exerting control on the alteration mineralogy, it has been well-documented that biology can control geochemical pathways and secondary mineral formation [14]. Chemotrophs can also push systems toward disequilibrium if it is energetically favorable, leading to precipitation of secondary minerals not expected in abiotic systems. Additionally, the microbes themselves or their diagnostic physical and chemical biosignatures may be preserved in these environments. These can serve as life detection targets for future robotic missions to Mars.

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