INVESTIGATING HYDROTHERMAL SAPONITE PRECIPITATES ON MARS USING AN ICELANDIC VENT ANALOGUE. A. M. Sanchez1, R. E. Price1, A. A. Fraeman2, M. T. Thorpe1, and L. M. Barge1, 1School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY, USA (arlaine.sanchez@stonybrook.edu), 2Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, 3NASA Johnson Space Center, Houston, TX, USA.

Introduction: Alkaline, hydrothermal systems on early Earth may have provided the necessary geochemical conditions for the onset of life. On Mars, hydrothermally-formed clay minerals found in the Eridania Basin has stirred speculation of an ancient, alkaline hydrothermal vent system that was once active during the Noachian 4.1-3.7 Ga [1]. The massive, mottled deposits in Eridania largely consist of ferromagnesian smectite clays, including saponite [1]. Geological context suggests these saponite-rich clay deposits may have formed through deep-water, hydrothermal processes when Eridania Basin was once a vast inland sea [1]. This presents an exciting target for Mars habitability research.

To better understand the potential geochemistry and habitability of the putative hydrothermal vent systems on Mars, the Strytan Hydrothermal vent Field (SHF), located in Eyjafjordur, Iceland has been used as a terrestrial analog. The SHF shares many geochemical similarities to the proposed setting in Eridania [2]. It is the only known mafic-hosted, shallow-sea system that discharges ~70°C alkaline fluids of meteoric origin into seawater [2]. Mixing between these fluids precipitates Mg-rich saponite chimneys as tall as 55 m [2]. Vent fluid composition reveal measurable concentrations of H₂ and CH₄, which are hypothesized to have been essential prebiotic energy sources for the emergence of life [2].

The objective of this research is to assess the viability of SHF as an analog for the ancient hydrothermal environment in Eridania Basin using data from instruments equivalent to the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) and Chemistry and Mineralogy (CheMin) on the Mars Reconnaissance Orbiter and Mars Science Laboratory Curiosity rover, respectively. Broadly, this work may provide important implications for the habitability of Eridania Basin and similar potential hydrothermal environments on Mars during the Noachian.

Mars-Relevant Instrumental Analyses:

Sampling of Natural and Artificial SHF Precipitates. To fulfill our objective, we collected samples of saponite-rich clay deposits from the vent chimney precipitates at SHF and characterized them with Mars-relevant instruments. Visible to shortwave infrared (VSWIR) spectra (362-3920 nm) for Eridania clay deposits were obtained through CRISM data sets, while VSWIR spectra (350-2500 nm) of the dried SHF precipitates were collected at the NASA Jet Propulsion Laboratory using an Analytical Spectral Devices (ASD) field spectrometer in ambient air conditions (Fig. 2). The precipitates were sampled in two different settings at SHF. Core samples collected from the 55 m tall Strytan chimney, referred to as Big Strytan, comprise the natural precipitates. Saponite-rich vent chimneys were also artificially grown and collected in a controlled environment. These artificial precipitates were formed in In-situ Growth Chambers (IGCs) constructed in a laboratory-like setting adjacent to the fjord (Fig. 1A) [3]. Briefly, the saponite-rich chimneys are precipitated by diverting geothermal groundwater through a custom-built apparatus that discharges the hot fluids into a large reservoir of flowing seawater. The IGC experiments essentially simulate the SHF on a smaller scale, which provides an alternative for long-term sampling [3]. Of the total precipitate samples analyzed, three are natural precipitates from Big Strytan (denoted as BS 1, BS 2, and BS 4) and one is an artificial precipitate (IGC 4).

Preliminary VSWIR & XRD Work

CRISM spectra of the clay deposits in Eridania were processed and compared with SHF spectra. Fig. 1C highlights outcrops with high Fe/Mg-phyllosilicate content in a region of Eridania Basin to aid in targeting saponite-rich deposits. VSWIR data from these outcrops reveal spectral features at ~1914 (HOH), 2317 (metal-OH) and 2395 (metal-OH) nm, which are diagnostic of trioctahedral, Mg-bearing smectites [4]. The SHF spectra also share strong absorptions at these wavelengths, with slight variation in the position of the 2300 nm spectral feature (Fig. 2). Within the natural SHF samples, the metal-OH absorption is positioned at slightly longer wavelengths (2316 nm), while the artificial precipitate exhibits an absorption at 2313 nm. This variation may be due to differences in the redox state of the precipitates [5]; however, further investigation is required. Spectral features in the short-wavelength range, 350-1000 nm, are attributed to Fe²⁺, Fe³⁺ crystal field effects and charge transfer [6]. For the SHF samples, consistent absorptions at ~667, 956, and 1160 nm are observed. Although the Eridania and SHF spectra do not share similar spectral features at shorter wavelengths, interpretation is made difficult due to the effects of Martian dust in this wavelength range.

Currently, X-ray Diffraction (XRD) data are not available for the deposits in Eridania Basin. Therefore, XRD analysis of a potential terrestrial analog will provide further mineralogical context, and aid in
interpreting the VSWIR spectra. The same suite of samples from SHF will be analyzed with state-of-the-art powder-XRD at the NASA Johnson Space Center. The addition of XRD data will also allow comparison with CheMin data of saponites found in Gale crater, which may provide interesting insights into the effects of varying environmental conditions on clay mineral formation.

**Figure 1.** A) Saponite vent chimneys grown in our IGC experiments and sampled for analyses. B) Example CRISM Map-Projected Targeted Reduced Data Record (MTRDR) map of Observation ID 8C90 in Eridania Basin. C) BD2300 spectral parameter map of 8C90 stretched from 0 to 0.015. Bright regions with strong 2300 nm absorptions indicate saponite-rich deposits.

**Implications of Spectral Data:** Similarities in the spectral patterns between the SHF samples and Eridania clay deposits further supports the hypothesis that the SHF is a terrestrial analog for the ancient hydrothermal system in the Eridania Basin. Thus, sustained chemical disequilibria under prolonged mineral-rich, aqueous periods may have occurred in ancient Eridania as it does in the SHF. The potential for a hydrothermal vent system on Mars makes Eridania a viable target for habitability research. Further investigation on the potential fluid chemistry of the Eridania hydrothermal system is underway, and will shed light on the dominant metabolic pathways that may have been present [7]. For more information, please see abstract #2547 “Habitability of Saponite-rich Hydrothermal Systems of Early Mars and a Modern Earth-based Analog in Iceland” from Roy et al., at this conference.

Additionally, the formation of Mg-rich saponite through hydrothermal vent precipitation would be unique relative to the typical formation pathways of smectites on Mars, including secondary weathering and subsurface aqueous alteration [8]. Thus, data collected from this work may be useful for current and future Mars missions in the identification of hydrothermal, alkaline environments hosted in mafic rock for astrobiological research.

**Figure 2.** I/F spectra of SHF samples compared to ratio CRISM spectra of saponite-rich deposits in Eridania Basin. A-D correspond to IGC 4, BS 4, BS 2, and BS 1, respectively. E-G correspond to Eridania clay minerals from CRISM Targeted Empirical Record (TER) Observation IDs 8D2D, 865F, and, 8C90, respectively. Diagnostic absorption features for trioctahedral, Mg-bearing saponite are indicated.


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