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ANALOG STUDIES ON ICELAND FOR SUPPORT OF THE MEDA INSTRUMENT OF THE FUTURE MARS 2020 NASA MISSION.

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1. Introduction

The Mars Environmental Dynamics Analyzer (MEDA) instrument is the suite of environmental sensors of NASA's Mars 2020 mission, which development is led by the CAB (Madrid) [1]. MEDA will characterize the weather, radiation, and dust environment of Mars at present and will help to infer martian potential habitability by studying the interaction between atmosphere and substrate, in synergy with other instruments of the mission. Water-related minerals produced by weathering and hydrothermal processes are indicators of potential habitability. Indeed, hydration/dehydration of these mineral assemblages might affect the actual water cycle on Mars, e.g., phase change by absorption /release of water (deliquescence/efflorescence). The Iceland analog is used here to produce unique and valuable data for science and technology teams of MEDA, by characterizing the mineral changes due to substrate-atmosphere interaction, and thermal properties of hydrothermal mineral assemblages.

2. Field survey

We visited two main geothermal areas and some small geothermal patches during the Iceland field campaign in 2017, which shows characteristics significant for comparisons to Mars. The study sites have been selected because of the presence of high-Fe basalts and extensive sulfate and phyllosilicates-rich deposits from basalt weathering, but also according to the acid-sulfate alteration and oxidation conditions of the hydrothermal fluids:

- Krýsuvik + Seltúm area is located in the center of the Reykjanes peninsula, which is characterized by extensive post-glacial lava fields, ridges of pillow lavas, pillow breccias, and hyaloclastite, all basaltic in composition [2]. Alteration mineralogy at the surface is included in the smectite-zeolite zone. We sampled different materials (clays, sulfates, and amorphous silica. See figure 1).

- Hengill-Hveragerði area is located in the extinct Hveragerði volcano region, which connects with the active Hengill volcano by fissures swarms [3]. Rocks are subglacially formed hyaloclastite and interglacial basaltic lava flows. Montmorillonite is referred as the dominant clay at shallow depths. Calcite and zeolites are predicted.

- Small single areas. We also sampled one site close to the Reykjanes coast (Gunnuhver), and others in the way to Hveragerði (Hveradalir to the south of Henhill, and around Nesjavellir to the north).

We sampled active and extinct geothermal sites displaying different colors, textures, and humidity. They represent fresh bedrock, secondary hydrothermal minerals, and fluids from hot springs and mud pools.

Figure 1. Example of a sampling site in Krysuvik

In order to control substrate properties, we used a portable Raman spectrometer (similar to the Mars 2020's SuperCam in its characteristics), which allows replicating synergies of the mission. Few multiparametric physical-chemical sensors and a soil pH-meter helped to constrain the samples' properties. During sampling, MEDA's meteorological observations were simulated using comparable sensors (radiation, temperature, atmospheric pressure, winds).

3. Laboratory analysis

We are doing an analytical study with different settings: 1) Characterize the mineral phases at terrestrial environment (in the field, and at room laboratory conditions); 2) Simulate temperature /pressure /humidity martian cycles to determine the effect on the natural mineral substrate and, ultimately, on the habitability of the surface. The PASC simulation chamber will be used to replicate Mars planetary conditions [4]. This second goal is not the subject of this presentation.

Raman and NIR+MIR spectroscopy were performed before and after sample lyophilization (-70º C, 0.495 mbar). XRD analysis of the samples was used to confirm the mineralogy. After the characterization of the hydrothermal alteration mineralogy, heat capacity (Cp) and thermal conductivity (k) measurements of natural assemblages were done by differential scanning calorimetry. These parameters will help to interpret TIRS (Thermal Infrared Sensor)/MEDA observations from the Mars surface [5].

4. Results

Interesting samples comprise mixtures of several minerals such as Al-clays, opal, alunite, anatase, calcite, and iron oxides. Some assemblages have phases with different crystallinity and thermal behavior.

We use the semi-quantitative analysis of XRD and spectroscopy to determine the mineral ratio for calculations in the calorimetric analysis. Resulting measurements have been compared with particular mineral data [e.g., 6, 7]. Figure 2 shows an example of the temperature dependence of the specific heat capacity of two samples from Krýsuvik. The mineral analysis determines that main compositions are kaolinite, natroalunite, and opal in the case of sample KC_20171029_002; and kaolinite, hematite and opal in sample KA_20171026_001.

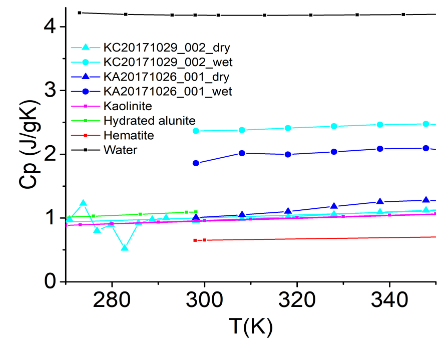

Figure 2. Specific heat of two natural samples from Krýsuvik compared to reference materials [6, 7].

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