VISIBLE AND NIR SPECTRAL CHARACTERISTICS OF ANDESITE AND SALINE MUD FIELD SAMPLES FROM LAKE ABERT, OREGON AND IMPLICATIONS FOR COMPOSITIONAL INVESTIGATIONS OF MARTIAN EVAPORITES.

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Introduction: Lake Abert in Lake County, Oregon, United States, is a large, shallow, alkali lake. The basin is endorheic, and the climate is semi-arid. The only sources of fresh water input to Lake Abert are from the Chewaucan River flowing from the south, from a small amount of runoff due to summer thunderstorms from the Abert Rim on the east side, and direct precipitation. The lake has a high concentration of alkali salts, including sodium carbonates. No vertebrates live in Lake Abert due to the high salinity and alkali concentrations. However, brine shrimp are abundant.

Saline lacustrine sediments often have more silica and various other cations relative to alumina in smectites. Lake Abert contains a range of silicate materials including smectites, such as montmorillonite, $(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2{\cdot}nH_2O$, and smectite-chlorite interstratifications. The primary source rocks are volcanic exposures of Miocene and Pliocene age that are mostly of an intermediate composition, including andesite [1].

Deposits from Lake Abert may be representative of similar materials present on the surface of Mars, if alkaline conditions were present in Mars's distant past. Smectite clay minerals have been identified on Mars, with CRISM reflectance spectra indicating Fe/Mg smectite, Al smectite, and hydrated silica [2, 3, 4]. Absorption bands near 2.2 µm (microns) and 2.3 µm have been used to differentiate minerals in these spectra, and to specifically identify phyllosilicates [5].

Spectral characteristics of samples from Lake Abert were investigated in the visible and near-infrared range (0.35–12 µm). Samples included organic saline mud and vesicular or trachy andesite from the east shore of the Abert Rim. Our analysis focuses on the alkaline hydrothermal-evaporitic-volcanic system and explores its applicability as an analog to martian geochemistry. The alkaline conditions at Lake Abert do not present a direct analog for surface conditions on Mars, but rather the conditions present a geologic environment, physical conditions, mineral assemblages and brines that may be analogous to the upper crust of Mars in rifted volcanic landscapes and impact craters.

Methods: Spectra of the andesite sample were collected for (i) an unprocessed sample, and (ii) a sample that was crushed and sieved to a fine-grained powder (< 100 µm). Spectra of the saline mud was collected for (i) an unprocessed sample, and (ii) a sample that was dried (>24 hours under dry nitrogen stream), crushed and sieved to a fine-grained powder.

The experiments were carried out at the Planetary Ice Characterization Laboratory (PICL) at the Jet Propulsion Laboratory (JPL). The PICL is a state of the art facility for spectrally characterizing ices, salts, and minerals under controlled temperature and pressure. The measurements performed for these results were performed at atmospheric pressure and room temperature. The samples were first illuminated with a Sciencetech, Inc.® 650W quartz-tungsten-halogen (QTH) lamp with low-OH silica fiber optics and spectra were collected using an Analytical Spectral Devices (ASD), Inc.® FieldSpec 3 (0.35-2.5 µm spectral range, 3 nm resolution <1 µm, and 10 nm resolution >1.0 µm). The sample was then illuminated with a globar from a Thermo Scientific® Nicolet 6700 Fourier transform infrared (FT-IR) spectrometer and spectra were collected using a Thermo Scientific® mercury cadmium telluride (MCTB) detector (0.85-25 µm spectral range, 2 cm^{-1} resolution). The spectra were ratioed against diffuse reflectance spectral standards (Spectralon® for the Vis/NIR region and diffuse gold for the NIR/mid-infrared (MIR) region). Corresponding spectral segments from the ASD spectrometer and from the MCTB detector were merged at 2.20 µm and normalized to create a continuous spectrum from 0.50-12 µm (characteristics past 12 µm are not discussed here due to low signal-to-noise ratio).

Results: In Fig. 1 we report the spectra of the field samples, andesite and the saline mud. The spectra are presented as relative reflectance of the samples with respect to wavelengths in microns. The specific wavelength region of 0.4 – 3.0 µm is ideal for identification of clay minerals due to the stretching and bending combination bands and overtones of OH and H_2O [6]. We present a more detailed analysis of this region in Fig. 2 below, showing spectra for the dried and processed fine-grained mud and andesite.

The spectra for the processed and unprocessed andesite sample are similar, with variation owing only to a grain size effect. With smaller grain size there are more scattering sites, resulting in higher reflectance.

The reflectance spectrum for the unprocessed ‘wet’ saline mud proves difficult to analyze due to low reflectance at all wavelengths, reducing spectral contrast. However, the processed (dried) sample contained more readily identifiable characteristics. Most notable are the characteristics in the 1.9 – 2.4 µm region, with absorption peaks centered near 0.86 µm, 1.9 µm, 2.2 µm, and 2.3 µm. More subdued but distinct features in the saline mud sample include absorption bands centered near 0.78 µm, 1.52 µm, 2.05 µm, and 2.50 µm.

Conclusions: Different rock-forming mineral groups have unique and distinguishable reflectance spectra, allowing for identification via reflectance spectroscopy. Further categorization within these groups is assisted when some species have distinguishing spectral features; other species, however, are more ambiguous. The spectrum for the saline mud presents characteristics of the feldspar group, primarily owing to (i) the absence of a distinct absorption band near 1.4 µm (a feature of either the H_2O combination stretching and bending fundamental modes, or the structural OH overtone), which is strong and narrow in most other groups; (ii) the fairly sharp absorption band near 1.9 µm due to combination of stretching and bending fundamental modes for H_2O (this band position can vary slightly near 1.9 µm based on strength of the H-bonding unique to each individual subcategory of mineral), which presents flatter and broader for most other groups; and (iii) a weak 0.86 µm absorption band, due to ionic interactions of Fe^{3+}, indicating the sample can be further characterized as a K-feldspar mineral, whereas the Plagioclase minerals show an absorption band near 1.2 µm due to Fe^{2+} ion, which is not present in the saline mud spectrum [7]. The weak absorption bands near 2.2 µm and 2.3 µm, which are OH overtones, are present in the spectrum; however, these OH overtones are also characteristic of other rock-forming mineral groups and are not used herein for classification.

More work is warranted to identify and classify field samples from Lake Abert, OR. The spectra from these samples will provide insight into the chemical processes occurring in an alkali lake. We will show how these chemical processes have implications to remote sensing and surface geology on Mars with emphasis on high pH environments that have been insufficiently investigated.

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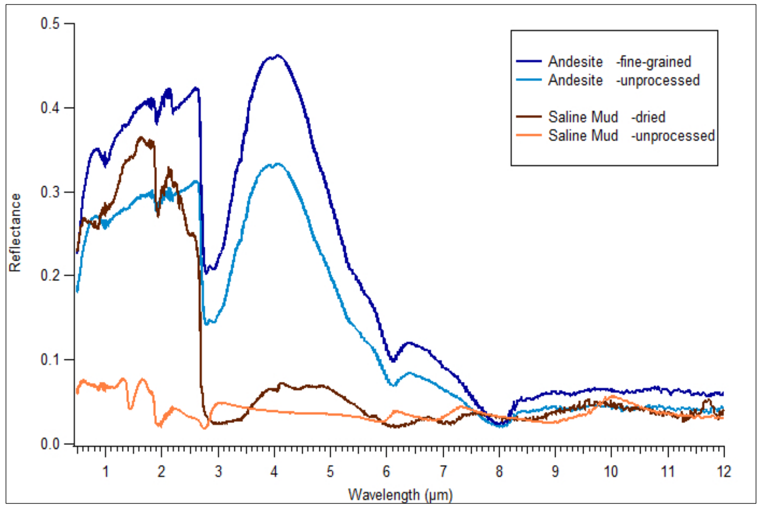

Figure 1. Reflectance spectra field samples from Lake Abert, OR for spectral range of 0.5 – 12.0 µm. Andesite, in blue, Saline Mud in orange.

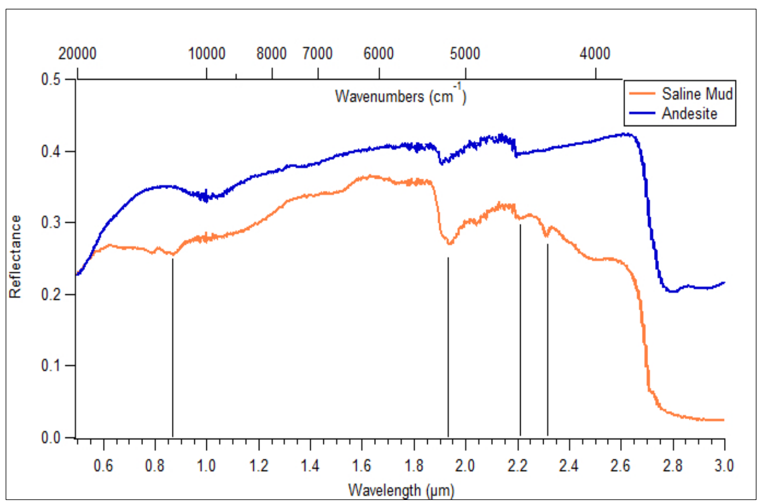

Figure 2. Reflectance spectra in range of 0.5 – 3.0 µm for Andesite and the Saline Mud, processed, dried, and sieved into fine-grained powders.