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Mineralogical Analyses of Basaltic Dune Sands from Ka'u Desert (Hawaii) - Comparison with Martian Dark Dunes

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Abstract

Samples of tephra collected in Hawaii's Ka'u Desert are investigated by means of different laboratory methods in order to examine their detailed mineral assemblages and chemistries. The analyses involve spectral, microscopic, and microporobe investigations. Spectral analyses reveal similar mineral assemblages as Martian dark dunes pointing to a similar volcanic origin of the material.

1. Introduction

Dark basaltic dunes are the dominant of aeolian bedforms on Mars. On Earth basaltic dunes occur in the vicinity of volcanic regions such as Hawaii, Iceland, New Zealand, and the western United States [1]. Due to the correlation of volcanic processes and dune development, the terrestrial dark dunes are promising study objects as analogue for Martian dark dunes as the latter are supposed to consist of ancient volcanic ashes (e.g. [2]). We want to determine (i) if the dune sands originate from the stripping of Keanakakoi tephra or from local reworked tephra emplaced by larger phreatic eruptions, (ii) the change of grain size and composition with transport distance, and (iii) the material's transport mechanisms (i.e. fluvial and/or aeolian) [3]. The results will be used for an analogy studies between dark dune sands on Mars and Earth which aims to shed light on the sediment source, transport mechanism, and development of the dune material.

2. Methodology

Different tephra samples were collected during a field trip to Ka'u Desert in summer 2009. Dune sand samples were collected from 3 different dark dunes in Ka'u Desert: A large, dark vegetated parabolic dune (Fig. 1A, sample 6), a falling dune (Fig. 1B, sample 1), and a large dark climbing dune (Fig. 1C, sample 2). Airfall ashes (Fig.2) were collected over one year in several bins placed at different locations downwind of Kilauea caldera in summer 2008 in order to catch fresh tephra of the small phreatic eruption that started on March 19, 2008 (cf. [3]).

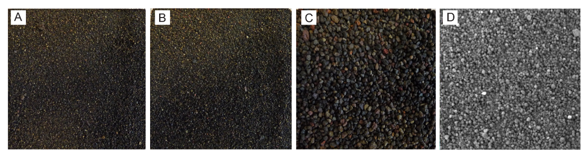

Figure 1: Comparison of terrestrial (A, B, C) and Martian (D) dark sands. Note different image width and grain sizes. A, B, C: Photographs of the sand samples collected in Ka'u Desert, Hawaii (A=sample 6, B=sample1, C=sample2, cf. Fig. 2, 3, 4, and 9). Grain size ranges between fine- to coarse-grained sand; image width is about 65 cm. D: View of Microscopic Imager (MI) onboard the Mars Exploration Rover "Spirit" of very fine dark sand on Mars; image width is about 15 mm (image from [4]).

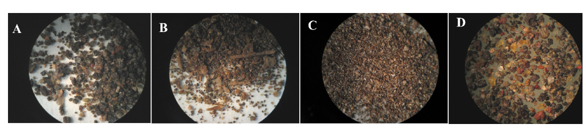

Figure 2: Microscopic view of airfall ash samples collected in sample bins downwind of Kilauea caldera (A,B,C), and a dune sand sample collected ~6.2 km from Kilauea caldera (D). Magnification is 20x, field of view 9.3 mm.

2.1. Spectral Analyses

Reflectance spectra of the airfall tephra and two dune sand samples were acquired at the Planetary Emissivity Laboratory (PEL) [5] of the DLR Institute of Planetary Research using a Bruker IFS 88 FTIR spectrometer for the VIS/NIR spectral range from 0.4 to 1.2 μm. The near-infrared measurements from 1.2 to 2.5 μm were obtained by means of a Bruker Vertex 80V FTIR spectrometer. Sample preparation involved the the comminution of the coarse-grained samples and the separation into four different grain size ranges. The reflectance spectra of further dune sand samples were acquired from 0.5 to 2.5 μm at the German Research Centre for Geosciences by using an Analytical Spectral Device (ASD) FieldSpec Pro spectrometer, which was installed in a laboratory. Here, we measured the samples in their original constitution, no special sample preparation has been performed. For each sample, we took average reflection spectra from 0.5 to 2.5 μm, which best reflect the mineralogical composition.

2.2. Laboratory Analyses

For these analyses, the samples have been prepared to thin-sections enabling to investigate the tephra on a grain scale. Microscope analyses will be accomplished to determine the individual minerals and for a characterization of grain size and shape. We will analyse how grain size changes with transport distance. The grain shape information will shed light on the transport mechanisms of the material. We suppose most of the material to be aeolian transported, which might be evidenced by a high amount of angular mineral grains. However, fluvial channels in Ka'u Desert also indicate the involvement of fluvial processes in that region. The amount of rounded mineral grains in the samples will indicate the proportion of this alternative transport mechanism. The microprobe analysis will be accomplished in order to determine the exact concentration of the individual elements of a mineral with high accuracy. The results will be used to cross-check the interpretation of the spectra and to determine the initiators of the individual absorption bands.

3. Preliminary Results

Spectral analyses reveal an initial aqueous alteration of the Hawaiian samples, probably related to hydrated amorphous silica (Fig. 3). Water absorptions might also be caused by molecular water in the glass fragments. The overall spectral shape of all samples indicates a mineralogical correlation between Martian and terrestrial dune sands pointing to a similar volcanic origin of the material.

First microscopic analyses revealed a high amount of volcanic glass fragments in the samples, followed by feldspars, olivine and pyroxene. Figure 4 provides an impression of the different proportions of rock fragments and glasse shards. For example, sand sample 2 (climbing dune) consists of a high amount of rock fragments. This may indicate that a considerable amount of this dune sand originates from reworked lava.

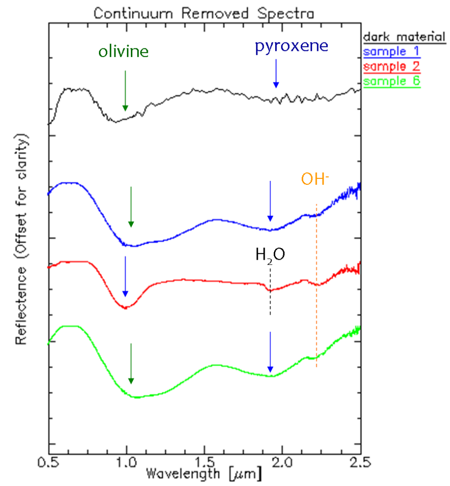

Figure 3: Comparison of Terrestrial (ASD) and Martian reflectance spectra of dark dune sands. Olivine and pyroxene are represented in all spectra by the 1 and ~2 μm bands. Aqueous alteration is indicated by the 1.9 and 2.2 μm bands.

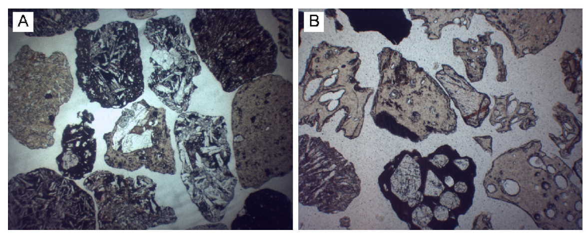

Figure 4: Microscopic view of thin sections of (A) a sample collected from a climbing dune dominated by rock fragments, and (B) a dark ripple dominated by volcanic glass fragments. Field of view is about ~3.5 mm.

Acknowledgments

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