SPECTRAL ANALYSIS OF DARK DUNES IN KA'U DESERT (HAWAI'I): INITIALLY ALTERED TERRESTRIAL ANALOGS TO DARK DUNES ON MARS.

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Introduction: Unlike on Earth, dark basaltic dunes represent the majority of Martian eolian bedforms. There are only few places where basaltic dunes can be found on Earth, including New Zealand, Iceland, the western USA, Peru, and Hawai'i [1]. Is has been suggested that the Marian dunes sands are volcanic in origin because their mineralogical composition consists of pyroxene and olivine [e.g. 2, 3, 4]. The dark dunes in Ka'u Desert on the Big Island of Hawaii are located on the western flank of Kilauea volcano. The dark sands are derived from volcanic ash and reworked pyroclastic material [e.g. 1, 5, 6]. Thus, the Hawaiian dark sand dunes are an adequate analog to Martian dunes, particularly for testing the hypothesis of volcanic origin and to determine basic spectral characteristics that may be associated with differences in grain size and chemistry indicative of maturity and transport distances.

Methods: Samples of different dark dunes in Ka'u Desert were collected during a field trip in summer 2009. Several samples were taken from a large, dark vegetated parabolic dune (Fig. 1, sample 6), a falling dune (Fig. 2, sample 1), and a large dark climbing dune (Fig. 3, sample 2). The sand samples have a dark grayish color and are of fine- to coarse-grained sand sizes. We measured the samples with an ASD field spectrometer [7] in a laboratory. For each sample, we took 10 reflection spectra from 0.5 to 2.5 µm each consisting of 50 single measurements and created an average spectrum, which best reflects the mineralogical composition. We compared the terrestrial spectra with typical OMEGA [8] near-infrared spectra of different Martian dark dune fields.

Results and Discussion: Fig. 4 presents a comparison between spectra of Martian and terrestrial dark dunes and library spectra. The Martian OMEGA spectrum (black curve) reflects the basaltic composition of the dark dunes as it is typical for Martian dunes [cf. 10]. The spectrum shows a deep broad absorption band at 1 µm (slightly shifted to shorter wavelengths due to the mineral mixture) and a broad shallower band around 2 µm. Both bands result from Fe^{2+} in the minerals and are indicative of a mixture of olivine and pyroxene. The terrestrial spectra (sample 1, 2, 6) strongly reflect the olivine content of the dark sands as indicated by the deep broad absorption band at 1 µm. A pyroxene absorption around 2 µm is less obvious in sample 1 and 6 and seems to be overlapped by other features, although it still exists. The increase of the spectra to higher wavelengths, results from the alteration of these silica materials. Sample 2 strongly exhibits a narrow 2.2 µm-band, probably related to bending metal-OH-bounds, and a further absorption at 1.9 µm, which is generated by molecular H_2O in the minerals. Thus, a beginning aqueous alteration is obvious in the spectral shape of sample 2. The coarser grain size (1-3 mm) of this sample results in the decrease of the reflectance intensity and an increase of the absorption band depths [e.g. 11, 12]. We compared our sample spectra with library spectra (USGS and RELAB spectral database) of olivine, pyroxene, and iddingsite. The latter is a common alteration product of olivine on Earth, comprising phyllosilicates, iron oxides, quartz and calcite [13, 14]. However this library spectrum represents a sample which is in its initial alteration phase, as indicated by the lack of the 1.4 µm band and the weakness of the 1.9 µm water associated absorption band [14]. However it represents a good intermediate stage between unaltered and altered olivine-rich material.

Conclusions: The overall spectral shape of the terrestrial spectra reflects a basaltic composition of the sands similar to that of Martian dunes. The rock-forming minerals olivine and pyroxene form as the lava cools, and are commonly found in basaltic volcanic ash. The correlation in mineralogical composition of terrestrial and Martian dunes hints to a similar origin of the dark sands on Mars and Earth. The sources of the Ka'u Desert dune sands are ashes erupted from the volcanoes in the vicinity and lava disintegration particles [e.g. 1, 5, 6]. A similar volcanic ash origin for Martian dunes has been suggested by [4], who found dark layers of fine-grained materials exposed in impact craters and a material transport to the dark intra-crater dune fields. Based on the mineralogical similarities and the morphological evidence, the sources of the dark material on Mars are probably layers of volcanic ash [4]. Our initial analyses of the Ka'u Desert's dark dune sands support these findings. Since the terrestrial spectra show a beginning aqueous alteration of the dark sands these samples could be used to analyse alteration features of Martian dark dunes.

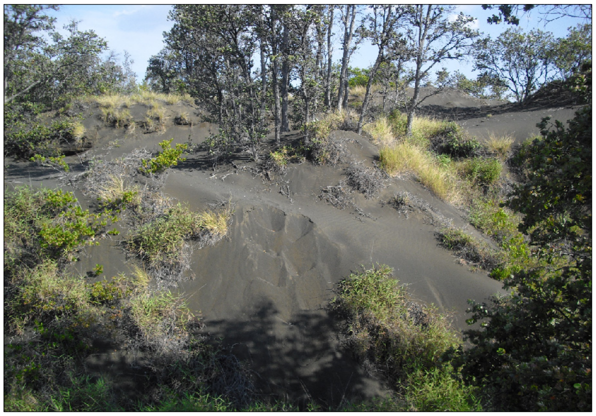

Fig. 1: Dark parabolic dune located off the Footprints trail at 19°21'17.52"N, 155°21'51.59"W (sample 6).

Fig. 2: Dark falling dune located off the Ka'u Desert trail at 19°19'29"N, 155°21'51.15"W (sample 1).

Fig. 3: Dark climbing dune located at the base of a small pali along the Mauna Iki trail at 19°20'39.43"N, 155°18'26.56"W (sample 2), (see also [9]).

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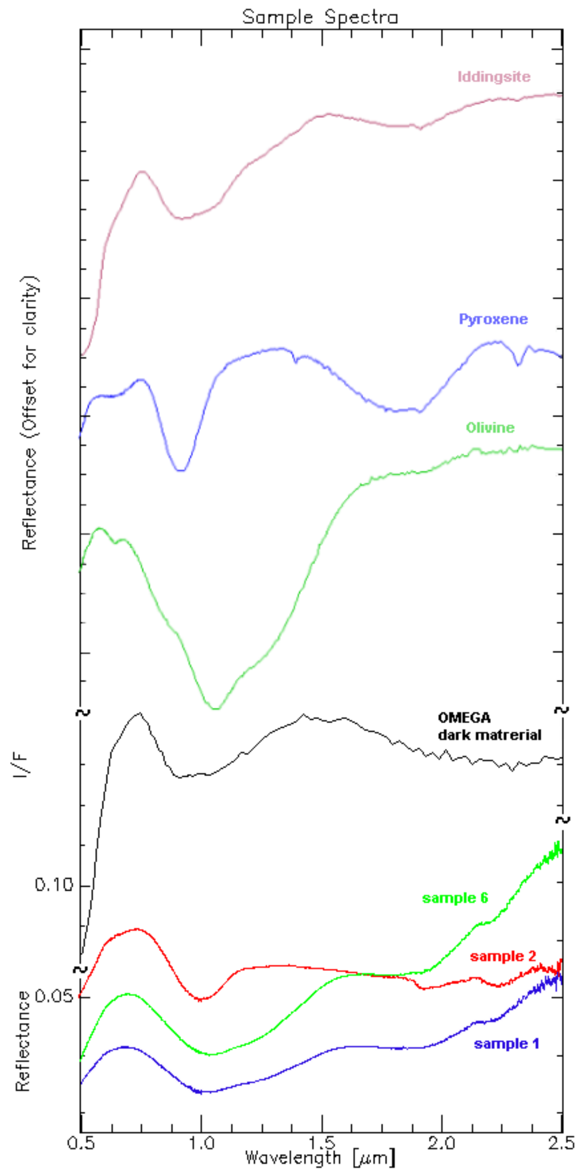

Fig. 4: Comparison of library, Martian and terrestrial spectra.

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