DUST PRODUCTION FROM SALTATION OF AEOLIAN BASALT SANDS: ANALOGUE FOR MARS.

C.S. Bristow[1] and T. Moller[1], [1]Department of Earth and Planetary Sciences, Birkbeck College, University of London, Malet Street, London WC1E 7HX c.bristow@ucl.ac.uk

Introduction: Dust is almost ubiquitous on Mars covering much of the planet's surface having been spread around the planet by dust storms [1]. Analysis of dust by the Mars Exploration Rovers indicates a basaltic composition for the protolith [2]. In this paper we use samples of aeolian sands derived from basaltic hinterlands in an experiment to simulate dust production from basalt dune sands within a saltation chamber. In addition, we used samples from gypsum dunes because gypsum is found within dune fields on the northern plains of Mars. The results show that saltating basalt sands produce more dust than quartz sands, and some potential Mars analogue materials can potentially produce large amounts of dust.

The majority of the surface of Mars is covered by a layer of dust that gives the planet its characteristic reddish hue. The dust has been described as an assemblage of clay and fine silt sized particles (< 5 μm), that contains primary igneous minerals: olivine, pyroxene feldspar and magnetite, as well as sulphate bearing alteration/weathering products [3]. Dust covers large areas of Mars, especially the regions of Tharsis, Arabia and Elysium [4], with dust deposits reaching thicknesses of 20m or more in Arabia [5]. Given the cold and arid conditions that occur on the surface of Mars wind erosion, sediment transport and deposition are extremely important, and aeolian movement of sand on the surface of Mars is a potential source of fine grained sediment or dust. These arid conditions have apparently prevailed for around 3.7 Ga [6, 7]). On Mars there is evidence for aeolian activity from dust storms [1], dust devils [8], avalanches on dune slipfaces [9], wind ripple movement [10], sand dune migration [11], and abrasion from saltating sand is a likely cause of erosion on the surface of Mars [11]. However, it is suggested that most fine grained (dust) particles on Mars are probably produced from ancient volcanic, impact and fluvial processes [12], and that rates of primary dust production on Mars are very low and that the dust is more likely to be derived from extensive reworking of fine grained, silt and clay sized sediments and aggregates. In this paper we test a selection of Mars analogue dune sands in a saltation chamber to determine how much dust might be produced by saltating basalt sands.

Martian Dune sands: On Mars, sand dunes commonly appear to be darker than the surrounding soils and the low albedo are indicative of mafic minerals and a basaltic composition [13]. Spectral analysis of the dark dunes and sand sheets on Mars indicates that they nearly all have the same mafic composition and that they are most likely to be derived from volcanic rocks [13]. The North Polar dunes are basaltic with a hydrated mineral believed to be gypsum [14].

Earth Analogues: Basalt dune sands are found on Earth [15], and these relatively rare dunes are considered to be analogues for Martian dunes [13]. Basaltic dunes on Earth are rare, most likely due to a combination of chemical and physical weathering on Earth's surface. In contrast the surface of Mars is cold and dry with limited chemical weathering [16] and combined with a basaltic crust this has resulted in widespread dark (basaltic) dunes and dust on the planet's surface.

In our experiment we use samples from sand dunes on the Islands of Hawaii and Iceland as analogues for Martian sands. We selected these samples because the islands have a basaltic crust with little or no quartz sand and the volcanic activity is recent so that the sands have undergone only limited weathering and alteration. This is consistent with observations of dust on Mars where [2] conclude that Martian dust is formed from parent basaltic rocks by physical processes including: diurnal temperature cycles, comminution by meteoritic impacts, and wind abrasion. However, [2] also note that the dust particles cannot be exclusively unaltered 'small basaltic rocks' because the presence of ferric oxides indicates that some chemical alteration must have taken place.

Physical experiments on Mars analogue mafic minerals and basalt grans has been conducted by [17] and [16].. A Mars erosion devise (MED) constructed by [17] could operate at low pressure and simulate grain impacts under Mars atmospheric pressure. [17] used a modified Bond air mill to investigate the durability and rounding of mafic grains, volcanic glass and basalt rock fragments, as well as a mix of minerals, glass and basalt together. They found that olivine became rounded most rapidly and achieved a high sphericity within two hours, in contrast, augite and labradorite took slightly longer to become well rounded and retained a platy shape never achieving a high sphericity with the two and a half hour experiments. They found that the volcanic glass and basalt were the slowest to decrease in grainsize and took longer (7 hours) to become well rounded [17]. Our experiments run for 72 hours in a saltation chamber produce significant amounts of dust suggesting that saltation of basaltic sands is a viable source for dust on Mars.

References:

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