Mafic Aeolian Systems on Earth as Analogues for Mars

E. M. LUND[1,2] | R. C. EWING[2]

[1]Department of Geology, Lund University, Sölvegatan 12, 223 62 Lund, Sweden. martin.lund@geol.lu.se, [2]Department of Geology & Geophysics, Texas A&M University, 108 Halbouty Building, 3115 TAMU, College Station, Texas 77843-3115, USA.

Conclusions

- More than 20 dune fields and regions with dunes have been identified
- Few identified dune fields are purely volcaniclastic and instead are some mixture of quartzose sands and volcaniclastic sands
- Studies measuring the relative amount of, for example, basalt and quartz in dunes in a specific dune field are largely absent
- The locations of the dune fields range from coastal to continental, with a wide range in temperature and precipitation
- Due to the lack of mineralogical data for most sites, the level of suitability as an analogue site for Mars remains to be determined

Introduction

Recent studies of martian aeolian systems focus on dune and ripple activity, unique bedform morphologies, and spatial variations in mineral composition of martian dunes based on their spectral variability [1, 2, 3, 4, 5, 6]. The uniqueness and ubiquity of the mafic aeolian landscape on Mars, the abundance of yet answered questions about the morphology and mineralogy of these landscapes, and a need for a robust method for constraining age in mafic sediments highlights a need for a comprehensive examination of mafic aeolian landscapes on Earth as an analogue to the martian environment.

Edgett and Lancaster [7] published in 1993 an excellent review paper concerning volcaniclastic aeolian dunes on Earth. However, since then, the planetary aeolian community has taken large leaps forward in understanding these systems, and our knowledge of Mars has increased greatly. This, taken together with the data and tools available to us now, such as the HiRISE camera [8], hyperspectral images, LiDAR and UAVs, present unprecedented opportunities to investigate volcaniclastic aeolian systems on both Earth and Mars. Here we expand on the work of Edgett and Lancaster and provide an updated review of volcaniclastic aeolian systems on Earth and discuss the implication for Mars and future terrestrial analogue studies.

World map with red dots marking volcaniclastic aeolian sites. (Map background sources: Esri, HERE, Garmin, NOAA USGS, © OpenStreetMap contributors, and the GIS User Community)

References and Funding Agencies

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Method

The work so far has mostly consisted of a literature review of published peer reviewed journals, Master and PhD theses, reports from geological surveys and other state and governmental reports. Google Earth has been used to examine how some of these dune fields look at the present day, but also to identify new potential sites.

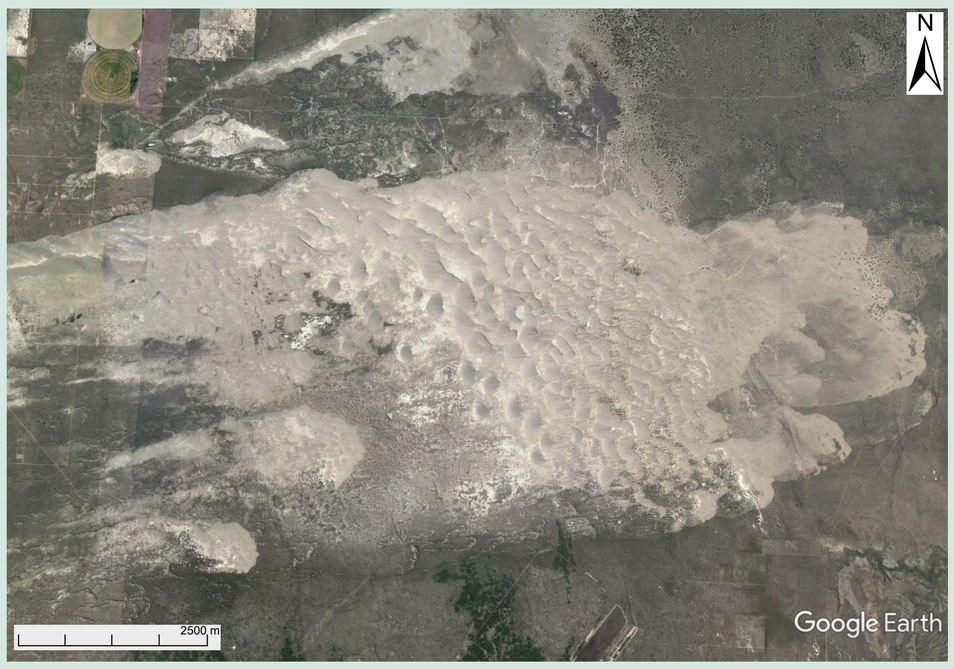

Image of the Christmas Lake Valley Dunes, a.k.a. The Shifting Sand Dunes, Oregon, USA. Dole [9] showed that the Shifting Sand Dunes contain close to 50% plagioclase and 10-30% volcanic glass.

Initial findings

More than 20 dune fields and regions with dunes have been identified, with some regions containing multiple dune fields.

Few identified dune fields are purely volcaniclastic and instead are some mixture of quartzose sands and volcaniclastic sands. However, studies measuring the relative amount of, for example, basalt and quartz in dunes in a specific dune field are largely absent.

The locations of the dune fields range from coastal to continental, with a wide range in temperature and precipitation. Many dune fields are proximal to mafic volcanoes, which are associated with subduction zones, rifts, or hotspots.

At this stage, we have a fairly good idea of where on Earth these potential analogue sites are, but due to the lack of mineralogical data for most sites, the level of suitability as an analogue site for Mars remains to be determined.

Using criteria such as morphology, geographic setting, tectonic setting, and mineralogy we will rate the suitability for Mars analogues for different scientific purposes.

We plan to visit some of these potential sites, utilizing state-of-the-art hyperspectral sensors mounted on UAVs, as well as luminescence dating and more traditional sedimentologic and stratigraphic techniques to build more detailed knowledge of some of these sites.

Image of the Sigatoka Dune Site, Viti Levu, Fiji. The sand is mineralogically complex with a dominance of volcaniclastic minerals [10].