Methodology of Wind Tunnel Experiments Applied to Gravel Megaripple Formation on Earth and Mars

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1) Introduction

Background: Aeolian transport is the most active geomorphic agent on Mars today. Transverse Aeolian Ridges (TARs) are a landform that may be distinct from dunes and ripples on Earth [1, 2]. The origin and evolution of TARs have been debated in the literature [1-5], in large part because, until recently, suitable terrestrial analogs were lacking. However, recent work shows that gravel megaripples in the Argentine Puna have many morphologic similarities [6, 7], making the study of this region critical for understanding TARs.

Purpose and Scope: Part of this investigation is to quantify the wind speeds necessary to move the megaripple material. These gravel bedforms are built on a local substrate of ignimbrites and are composed of a bimodal association of dense lava and metamorphic clasts (>2 g/cm³) up to 2.5 cm in diameter (here called “lithics”) and pumice clasts (<1.5 g/cm³) up to 8 cm in diameter [6, 7].

2) Wind Tunnel Experiments

Wind Tunnel Experiments: Samples of megaripple materials were used in wind tunnel experiments at the Arizona State University Wind Tunnel (ASUWIT). The objective was to determine threshold wind velocities for movement of these clasts. Once threshold velocities are established, they can be applied to similar landforms on Earth and ultimately on Mars (TARs) by scaling to Martian gravitational and atmospheric density conditions [1].

Experiment Conditions: Several experiments were made, changing environmental conditions:

1) Fluid: The only lateral force was the wind.
2) Quartz Impact: Sand was dropped from the upwind hopper, simulating saltating sand.
3) Scoria Impact: Scoria material was dropped from the upwind hopper, simulating saltating pumice.

The experiments were recorded in oblique view to be able to see the type of movement of the clasts (e.g. saltation). The results of this work are also described in [7, 8]. The focus of this presentation is on a methodology to extract further information from video and photo documentation of the experiments.

3) Measurement Methods

In order to quantify the movement of clasts and the threshold velocities we used Kinovea software, which allows precise video measurements. The wind tunnel data were calibrated to get proper measurements of clast size, migration direction, and speed (Fig 2).

Considerations

- Accurate experiment floor reference measurements
- Oblique camera views requires camera angles and distances

Converting Pixel Measurements to Centimeters

- Clast diameter measured in pixels
  - Rounded
  - Elongated and/or angular – representative area circle
- Experiment flow width at clast center (at movement start)
- Conversion from pixels to cm using floor and clast measurements

Clast Characteristics

- Pumice or lithic
- Movement type – vibrating, sliding, rolling, saltating
- Location – patch or edge, and up- or down-wind

Fig 1. Perspective view of ASUWIT experiment floor showing one clast and tunnel width measurement.

4) Determination of Threshold Velocities

The same sets of measurements were completed for one of the experiment videos by two people separately and measurement sets were compared to each other. The coefficient of determination showed the regression line fit the data well and the comparison showed sufficient method reliability (Fig. 3).

5) Method Reliability

The research is by different people using the same experiment video.

6) Preliminary Results

A table was constructed with all of the computed values for each clast, providing a semi-quantitative analysis of the experiments. Preliminary results show a correlation between the clast diameter and saltation threshold wind velocity. Some dispersion is caused by clasts shapes and the fact that only one direction of the clast was measured. Nevertheless, this technique allows comparison of data between different experiments and even with field data. These data estimate wind threshold velocity for different types of grains. These data are the first (that we are aware of) of threshold speeds for large clasts that compose mega-ripples in the Puna, and possibly Mars. An abstract describing extended results is presented at the 2014 LPSC [8].

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