Europlanet TA Scientific Report

PROJECT LEADER

Project number: 20-EPN2-112
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TA Facility visited: Planetary Environment Facility (DK) -- Aarhus Mars chamber (AWTSII)

Project Title: **Aeolian saltation at Martian pressures and below**

Scientific Report Summary.
(plain text, no figures, maximum 250 words, to be included in database and published)

Understanding the conditions required for initiating and sustaining sand motion on Mars is important for determining wind strengths required for mobilizing widespread ripples and dunes. Our previous experimental campaign in the planetary laboratory facility of Aarhus has provided evidence for a lower than expected transport threshold and for the emergence of impact ripples at Martian-like pressures. This time, we have made use of a new grain injector set-up at the entrance of the bed, which allowed us to trigger saltation with grains impacting with the granular surface, and therefore to mimic an effective longer bed. Even with a relatively low injection rate, we were able to reach a saturated sediment flux at the bed outlet, characterised by a neutral bed (no erosion nor deposition), whereas a purely erosive regime is always observed at vanishing injection. We could measure this saturated flux varying wind velocity in Martian conditions and found that transport can be sustained at even lower values than previously reported. With the analysis of the erosion profile along the bed, we shall furthermore be able to extract the saturation length. Finally, we recorded movies of grain motion close to the bed with a high-speed camera, which will allow us to study the properties of grain trajectories in the saturated state.

Full Scientific Report on the outcome of your TNA visit

A question left open by the study of Andreotti et al. (2021) is the behavior of the saturation length upon decreasing the pressure. This length L_{sat} is the characteristic scale of the spatial relaxation of the sediment flux in inhomogeneous conditions. L_{sat} has been shown to be of prime importance in the emergence of dunes from an instability mechanism (Durán et al., 2011; Charru et al., 2013). Wind tunnel experiments in ambient conditions (Andreotti et al., 2010; Selmani et al., 2018) have measured a meter-scale saturation length, which one expects to increase when decreasing the pressure. The measurement of L_{sat} as a function of pressure P is an experimental challenge, which requires a good control of sediment entry conditions at the upwind side of the bed.

During this experimental campaign, we have made use of a new grain injector at the entrance of the bed. This set-up, located close to the ceiling of the tunnel section, allowed us to trigger saltation with grains falling and impacting with the granular surface, and therefore to mimic an effective longer bed. Even with a relatively low injection rate, we were able to reach a saturated sediment flux at the bed outlet, characterised by a neutral bed (no erosion nor deposition in the most downwind part of the working section), whereas a purely overall erosive regime is always observed at vanishing injection. We could measure this saturated flux as a function of the wind velocity, in Martian conditions (P=14 mbars). This measurement was performed in two independent ways: after a run of given time (10 min.), we weighted (i) the amount of particles collected in all part of the wind tunnel, coming from the erosion of the bed, and (ii) the amount of particles needed to prepare a new flat bed for the next run. The difference of these two quantities nicely balances (within ~10 %) with the injected mass by the grain feeder. These measurements are displayed in figure 1. A quadratic law with a threshold is observed, in agreement with the saltation transport law at ambient pressures (Iversen & Rasmussen 1999, Durán et al., 2011). However, interestingly and unexpectedly, we found that transport can be sustained at even lower values than previously reported, in fact suggesting a threshold close to the value observed at ambient pressure.

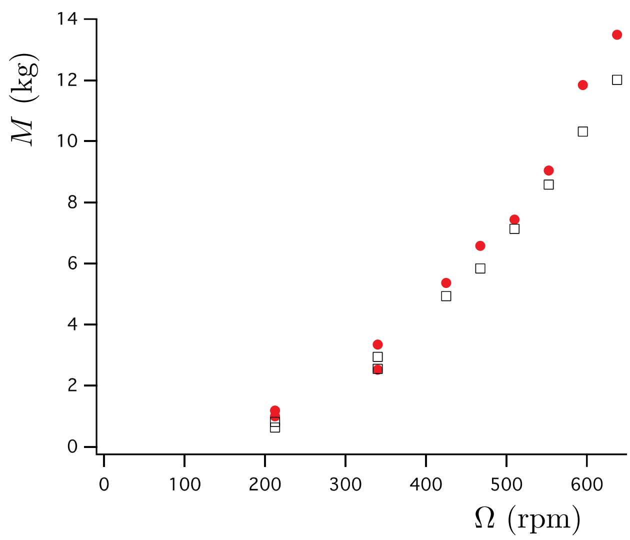

Figure 1: Mass of sand collected after each 10-min run (black squares) and brought to prepare a new flat bed (red dots), once the mass of grains injected by the feeder has been added, for various values of the fan rotation velocity. Extrapolation of these data for a vanishing mass gives a threshold around 100 rpm, i.e. not so different to the value at ambient pressure, whereas all these runs were performed at P=14 mbars.

Inclined laser sheets, whose traces on the bed were recorded by four cameras on the ceiling of the tunnel and distributed along the working section, also allowed us to measure the profile of the bed erosion rate from the entrance to the outlet of the bed. By the virtue of mass conservation, it relates to the space variation of the flux. Analysing these profiles, we shall then be able to deduce the saturation length, i.e. the scale over which the flux relaxes towards its saturated value, which we did observe at the outlet of the bed. This measurement is a key value for the calibration of sediment transport model to be applied on Mars.

Finally, we came to Aarhus with a high-speed camera. It was mounted to look at grains close to the bed, focused on a vertical laser sheet at the center of the section, close to the outlet of the bed. The analysis of these movies will allow us to study the grain trajectories in the saturated state, for various values of the wind speed. The investigation of the microscopic aspects of grain motion in low-pressure conditions is also of prime importance for the models, as well as for numerical simulations of saltation.

In conclusion, this experimental campaign was a success (measurement of saturated flux, data to extract saturation length and grain trajectories) as well as a source of surprise (an even lower threshold than measured last time). The excellent work of the grain feeder set-up, which remarkably allowed us to reach flux saturation, made us focus on runs for the flux measure and flux relaxation, thus putting aside the initial (more conservative) plan of changing grain type and size to duplicate our previous measurements (Andreotti et al., 2021). These new data now need to be carefully analysed, and will also be complemented by additional ambient pressure runs, in order to produce a publication.

References

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- Give details of any publications arising/planned (include conference abstracts etc)

A paper will be submitted next year to an international journal. These results will be also presented in various forthcoming meetings, including the next Europlanet Science Congress and the next International Conference on Aeolian Research.

- Host confirmation

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Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: 28-05-2022 Arrived: 28-05-2022	30-05-2022	[0]	5	[0]	03-06-2022	Departed: 04-06-2022 Arrived: 04-06-2022

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name	**Jon Merrison**
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Date	**14/06/2022**

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Project Leader Name	Philippe Claudin
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