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Recent findings from a European Planetary Simulation Facility

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Abstract

This unique and recently improved planetary simulation facility is capable of re-creating extreme terrestrial, Martian and other planetary environments. It is supported by EU activities including **Europlanet 2020 RI** here the latest research and networking activities will be presented. This facility is also used as a test facility by ESA for the forthcoming ExoMars 2020 mission. Specifically it is capable of recreating the key physical parameters such as temperature, pressure (gas composition), wind flow and importantly the suspension/transport of dust, sand or ice particulates. This facility is available both to the scientific and Industrial communities.

1. Europlanet Transnational Access

This environmental simulator facility is utilized for a broad range of research programs including; the study of other planets (such as Mars), for recreating extreme terrestrial environments, or in specific investigations involving aerosols and other forms of Aeolian particulate transport. The facility is also involved in the Europlanet 2020 Research Infrastructure through which a trans-national access program is allowing numerous research groups access to this facility. Some selected recent projects are listed below;

- Polar CO_2 ice on Mars (Bern CH) [5]
- LIBS system on Mars2020 (ISAE France) [3]
- Sand transport and ripples on Mars (P. Claudin, B. Andreotti, et al. 2019)
- Dust aerosols at low pressure. INGV, I [6]
- MarsTEM sensor simulations in Martian dust environment. INAF, I [4]
- In-situ utilization on Mars2020 and dust loading. Imperial College UK [7]
- Passive acoustic wind sensor on Mars (R. Lorenz, John Hopkins University USA)

Other activities include the development, testing and calibration of sensor and planetary lander systems, both for ESA and NASA. Currently testing for missions ExoMars 2020 and Mars 2020 are being carried out.

Figure 1 The main Planetary Simulation Facility 2019 preparing for the final Europlanet2020 funded experiments (for ExoMars 2020 instrumentation).

2. Design and operation

The simulator consists of a 38m^3 environmental (thermal-vacuum) chamber within which a re-circulating wind tunnel is housed [1,2]. The wind is generated by a set of two fans which draw flow down the 2m×1m tunnel section and return it above and below. Wind speeds in the range 1-40 m/s have been demonstrated. Cooling is achieved by a novel liquid nitrogen flow system which has achieved temperatures below -160ºC. The inner chamber is thermally isolated from the vacuum chamber.
Improved functionalities of this facility (funded by Europlanet 2020RI) include the implementation of;
An atmospheric (gas) cooling system allowing independent control of the air temperature (tested to -50°C) and a particle image velocimetry (PIV) system consisting of high speed imaging and laser illumination.

3. Ices, sand and dust on Mars

With control of wind flow at low pressure and temperature this facility is well suited for recreating the environment at the surfaces of terrestrial type planets such as Mars, Earth and Titan. The interaction of wind and the planetary surface, specifically the transport of sand and dust is fundamental to understanding the evolution of the planets' surface and atmosphere. Laboratory studies of the entrainment, flow, deposition and erosion are scarce and empirical in nature. The effects of low atmospheric pressure, composition, temperature can now be studied in detail.

Recently Martian Aeolian ripples have been recreated in experiments to investigate the behaviour of wind-driven sand transport under decreasing pressures, from the ambient (1 bar) towards Martian atmospheric conditions, and even to lower pressures than on Mars (2 mbar). In comparison to terrestrial conditions, sand transport at Martian pressures is significantly modified by viscous effects. However, centimeter-scale ripples nevertheless emerge (fig. 2), which match recent observations made by NASA's rover Opportunity on the surface of Martian dunes. These experiments will provide valuable insights for understanding the formation of wind-driven features on Mars.

Fig. 2 Ripples created at low pressure (P. Claudin, B. Andreotti, et al.).

The cryogenic capabilities of this facility have allowed pioneering experiments involving the creation of a translucent/transparent phase of CO_2 ice (slab ice), see fig. 3.

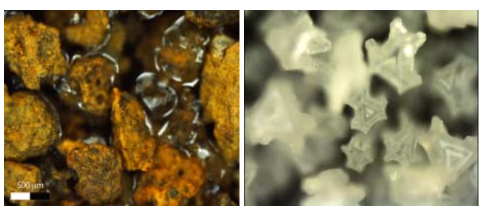

Figure 3 Translucent CO_2 ice encapsulating Mars analogue sand grins (left) and at lower temperature crystalline CO_2 (as yet unknown structure) [5].

More recently and ongoing is a study of the transport of water (and CO_2) ice by wind in which the entrainment threshold is being measured and effects of sintering and sublimation are being studied.

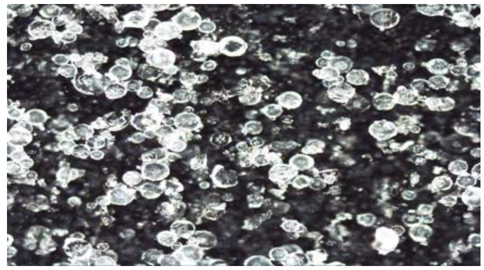

Figure 4 Sand sized water ice particles prior to wind removal (C. Herny, et al. 2019).

5. Conclusion

This planetary simulation facility has many unique and recently improved features which make it well suited for both planetary research applications and the development/testing of instrumentation. Details of some of the most recent collaborative research activities will be summarized. For information on access to this facility please contact the author.

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