CURRENT AND FUTURE EUROPEAN HARDWARE CONTRIBUTIONS TO MARS POLAR SCIENCE.

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Introduction: The ExoMars Trace Gas Orbiter (TGO) was launched on 14 March 2016 and entered Mars orbit on 19 October 2016. The spacecraft reached its primary science orbit (360 km x 420 km; inclination = 74°) on 9 April 2018. TGO carries a high-resolution colour and stereo camera system: the Colour and Stereo Surface Imaging System (CaSSIS) [1]. The objectives of CaSSIS are to (1) characterise sites on the Martian surface which have been identified as potential sources of trace gases, (2) investigate dynamic surface processes (e.g. sublimation, erosional processes, volcanism) that may help to constrain the atmospheric gas inventory, and (3) certify potential future landing sites by characterising local slopes (down to ~10 m).

The instrument capabilities include acquisition of images (1) at scales of ~4.5 m/px, (2) in 4 broad-band colours optimised for Mars photometry, (3) with swathes up to 9.5 km in width, and (4) with quasi-simultaneous stereo pairs over the full swath width for high res. digital terrain models. A full instrument description is provided in [2], and details about the ground calibration in [3]. Spectral-image simulations to assess the colour and spatial capabilities of CaSSIS are in [4], with recommended colour display combinations given in [5]. Photometric correction of instrument data is presented in [6].

Although the spacecraft orbit inclination is only 74 deg, this still allows observations of seasonal processes as well as layered terrains in, for example, the Ultima Lingula formation. CaSSIS observations at high latitudes will be discussed.

The European Space Agency has recently issued a call for “White Papers” for future mission concepts and ideas across the science community. Martian climate studies featured significantly in the responses to this call. The options for ESA (including the possibilities for collaboration with NASA) will be discussed.

We include additional details on these two aspects.

Current Polar Imaging with CaSSIS: CaSSIS has acquired over 8123 images of Mars through to 12 October 2019 (roughly 70% of the prime mission). Over 750 of these have been acquired southward of 66° S and just over 400 have been acquired northward of 66° N. 372 of these are images of South Polar Layered Deposits (SPLD), or other buried layered deposits that have been identified as ice [7] (Figure 1). Hence, these images form a significant additional resource for studying Mars polar terrains.

A recent example from the northern hemisphere is shown in Figure 2, which shows polar dunes exhibiting evidence of small scale geyser activity. What is particularly interesting is that the substrate shows a set of linear, quasi-parallel ridges that may be related to aeolian features such as longitudinal dunes with large particles sizes.

An example from the southern hemisphere (Sisyphi Cavi) is shown in Figures 3 and 4 where we see residual ices evident at the base of a south-facing cliff, and an outcrop of the SPLD exposed in the margin of Ultima Lingula. The image in Figure 3 (taken at Ls =287.9°) was acquired at 18:00 LST and illustrates that additional information may come from CaSSIS as a consequence of the non-Sun synchronous orbit.

Future European Contributions to Mars Polar Science: The situation in Europe is one in which the Human and Robotic Exploration directorate is now leading an optional Mars programme, and should ExoMars be successful, ESA (through HRE) will seek to participate in Mars Sample Return as a joint international mission with NASA (and possibly other agencies). This mission could be a precursor to the manned exploration of Mars, which would be consistent with the perceived aims of the HRE directorate.

The case has been made to the Science Programme of ESA, that missions and instruments such as TGO/CaSSIS and Mars Express/MARSIS could be followed up by exploration of the poles and specifically the polar layered deposits within a joint programme with NASA. (see www.cosmos.esa.int/web/voyage-2050/white-papers). ESA could contribute by evaluating possibilities for:

- deep drilling systems,
- rovers,
- near-surface flight (drones),
- surface networks, and/or
- orbital reconnaissance

Although financial limitations will restrict what could actually be implemented so that it is unlikely that ESA could lead such an endeavour.

There are various ways in which NASA-ESA collaborations can occur and we shall present how this could be achieved with specific application to the Mars Polar Layered terrains.

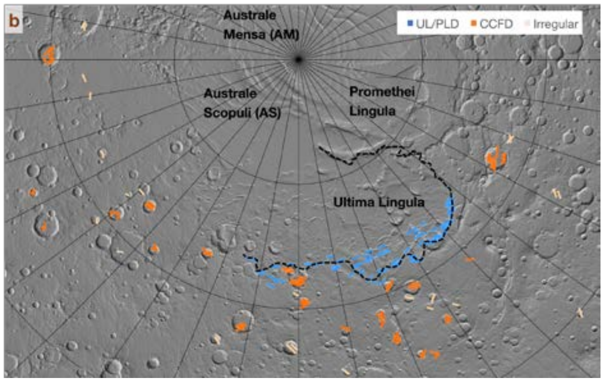

Figure 1. CaSSIS stamps of icy layered deposits in the SPLD, and within Circumpolar Crater Filling Deposits and Irregular deposits as defined by [7].

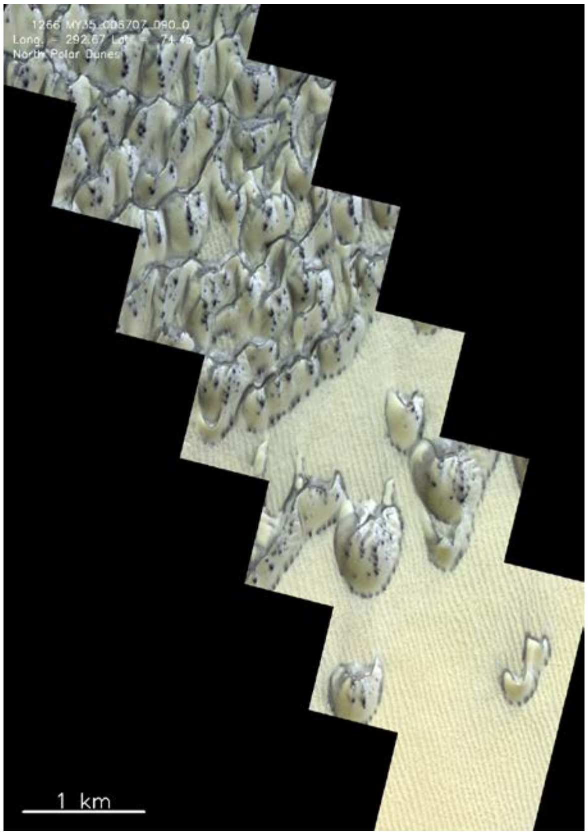

Figure 1 North polar dunes acquired at close to the maximum latitude observable with CaSSIS TGO. Note the linear, quasi-parallel ridges in the substrate that may be related to longitudinal dunes.

Figure 3 CaSSIS observation from Sisyphi Cavi showing residual ices at the base of south facing cliffs.

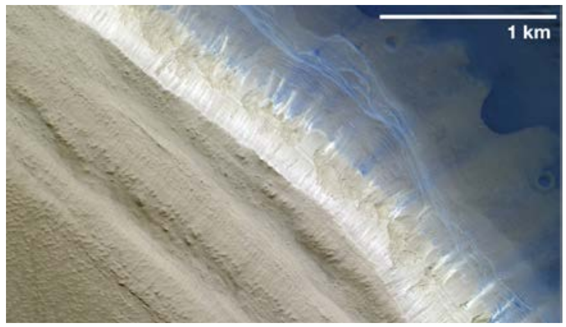

Figure 4. CaSSIS Image of SPLD marginal deposits in Ultima Lingula. The icier units of the SPLD can be distinguished from more silicate-rich basal deposits.

References:
[1] Vago, J., et al. (2015), Solar System Research, 49, 518-528. [2] Thomas, N. et al. (2017) Space Sci. Rev., 212, 1897. [3] Roloff, V. et al. (2017) Space Sci. Rev., 212, 1871. [4] Tornabene, L.L. et al. (2018) Space Sci. Rev., 214, 18. [5] Tornabene, L.L., et al. (2019) Mars 9 abstract. [6] Pommerol, A. et al. (2019) Mars 9 abstract. [7] Sori et al., (2019), *JGR*

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