

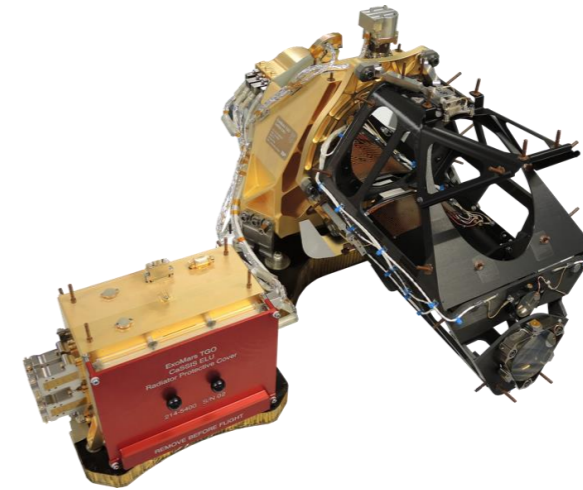
# Imaging of the Martian surface by the Colour and Stereo Surface Imaging System (CaSSIS) of ExoMars Trace Gas Orbiter.

u<sup>b</sup>

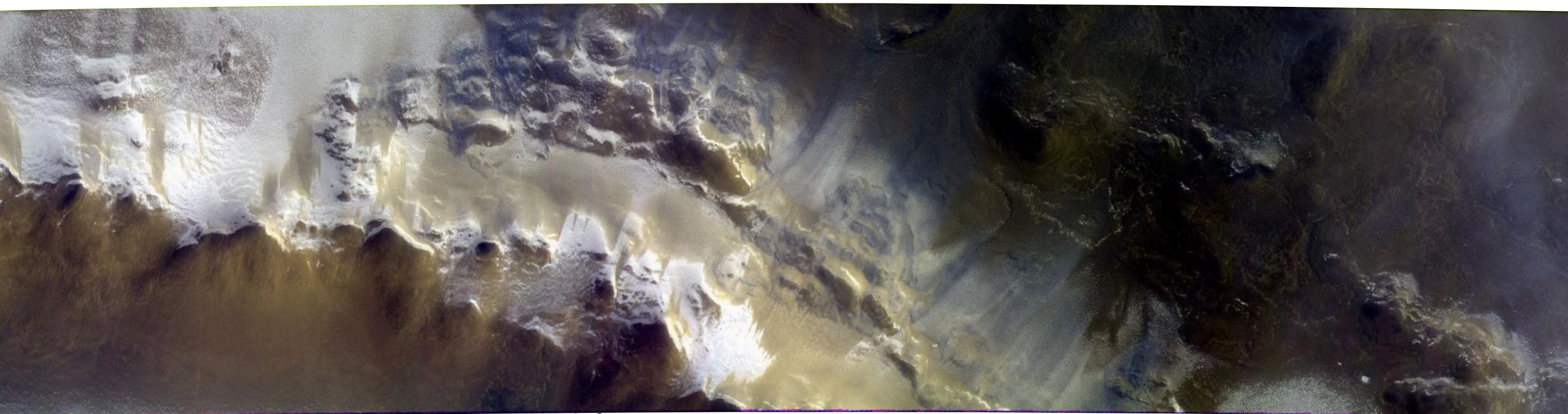
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A. Pommerol<sup>1</sup>, N. Thomas<sup>1</sup> and the  
CaSSIS Science and Operations team



<sup>1</sup>Physikalisches Institut / NCCR PlanetS - University of Bern - [antoine.pommerol@space.unibe.ch](mailto:antoine.pommerol@space.unibe.ch)



CAS-M00-2018-04-15T09.32.50.318 - MY34\_001751\_093\_0

# Mission and instrument objectives

Both scientific and technologic

u<sup>b</sup>

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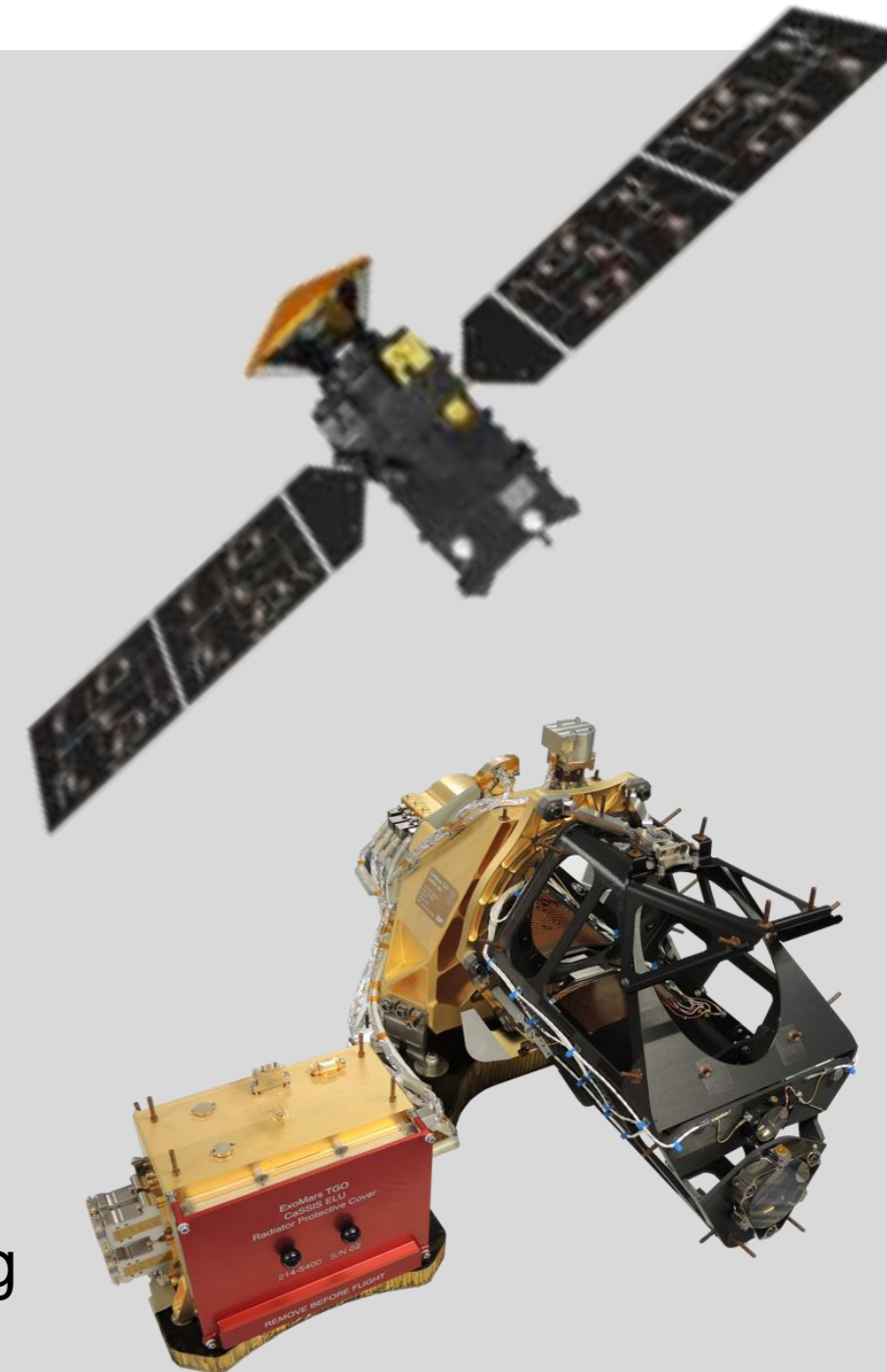


## Exomars Trace Gas Orbiter (EM16-TGO):

- To search for evidence of methane and other trace atmospheric gases that could be signatures of active biological or geological processes
- To test key technologies in preparation for ESA's contribution to subsequent missions to Mars.

## CaSSIS:

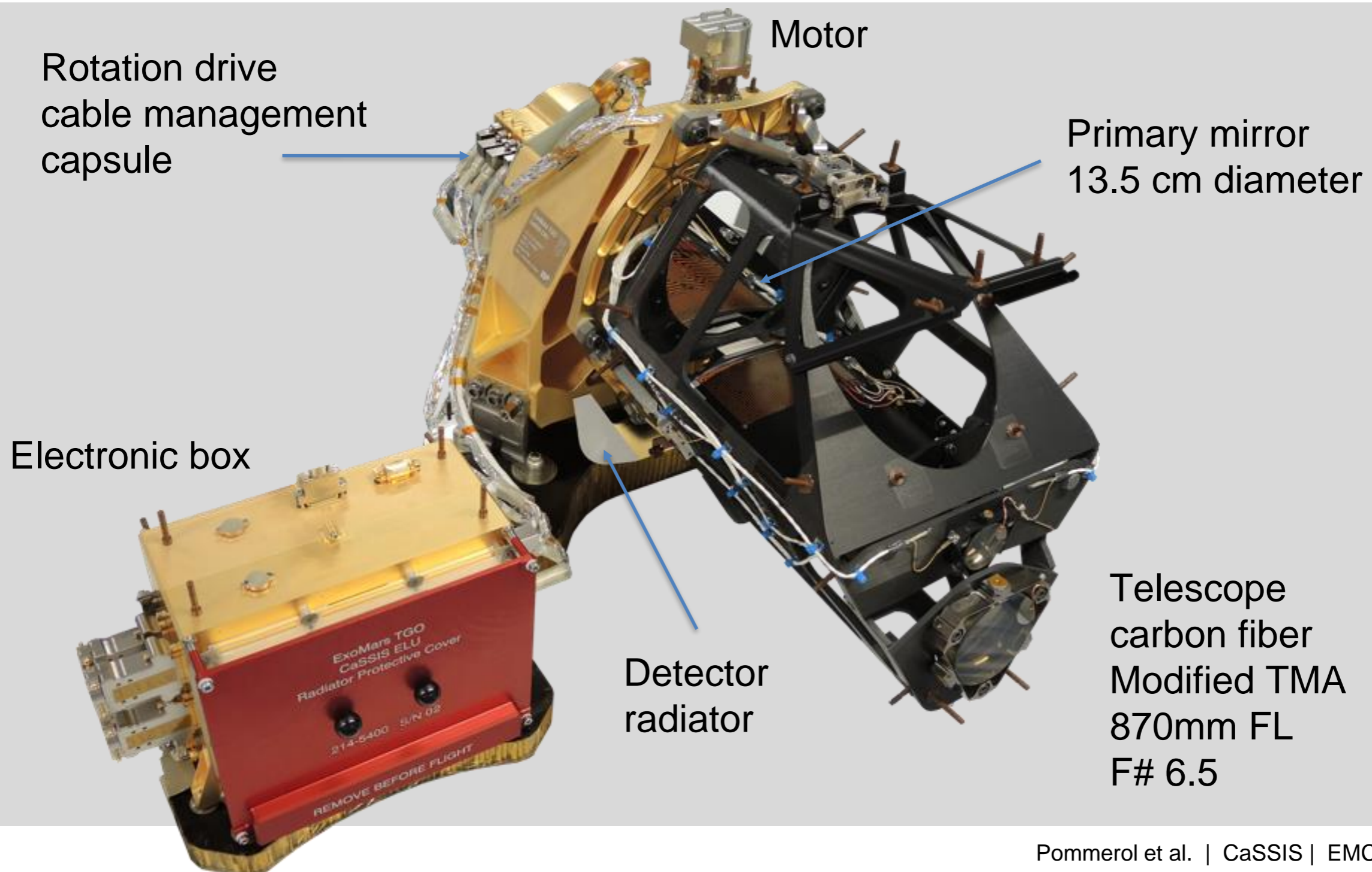
- To characterize sites which have been identified as potential sources of trace gases
- To investigate dynamic surface processes (e.g. sublimation, erosional processes, volcanism) which may contribute to the atmospheric gas inventory
- To certify potential future landing sites by characterizing local slopes, rocks, and other potential hazards.





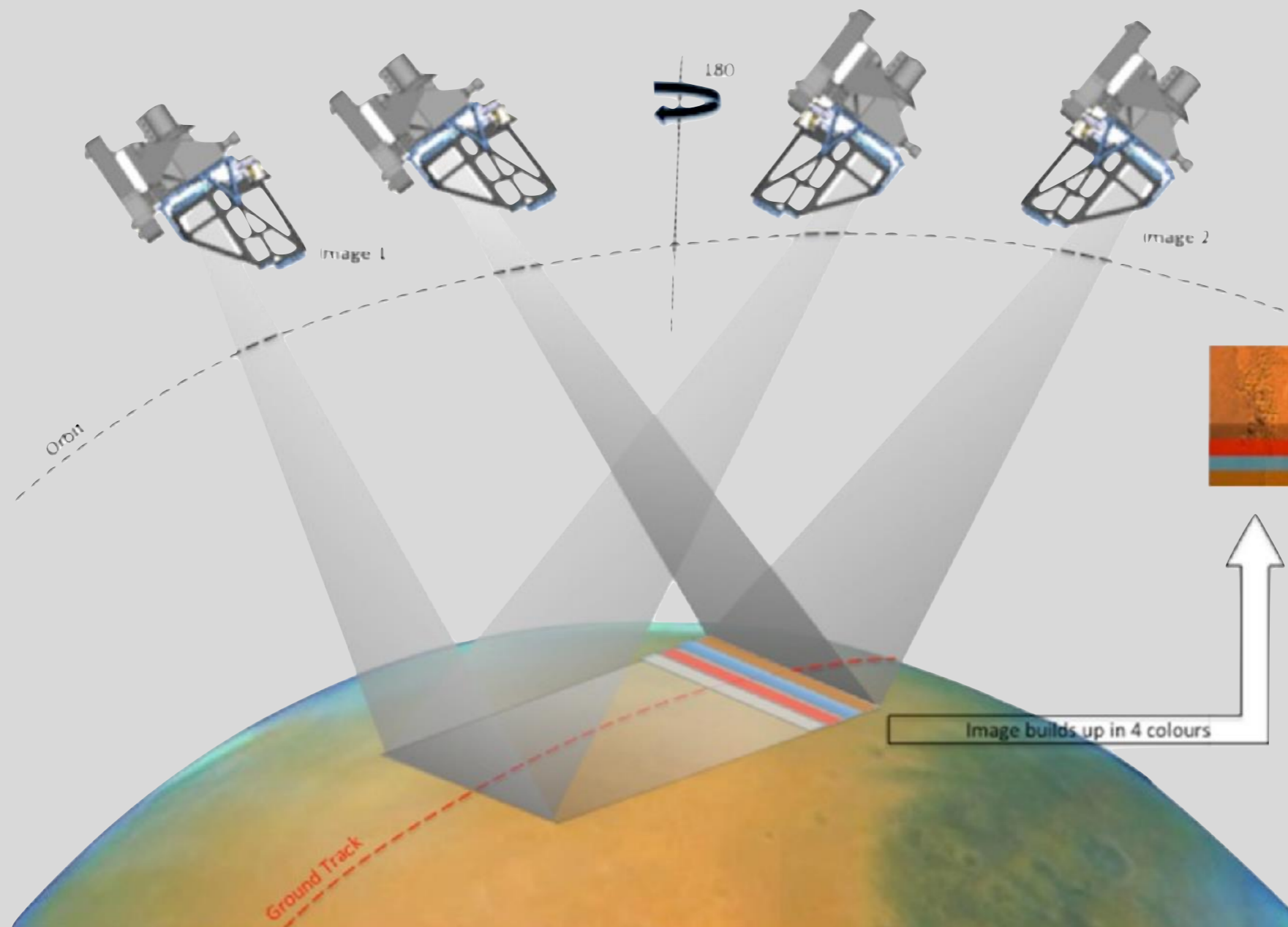
# The instrument

Mass: 18 kg, Average power: 17 W, Focal length: 870 mm



# Imaging principle - stereo

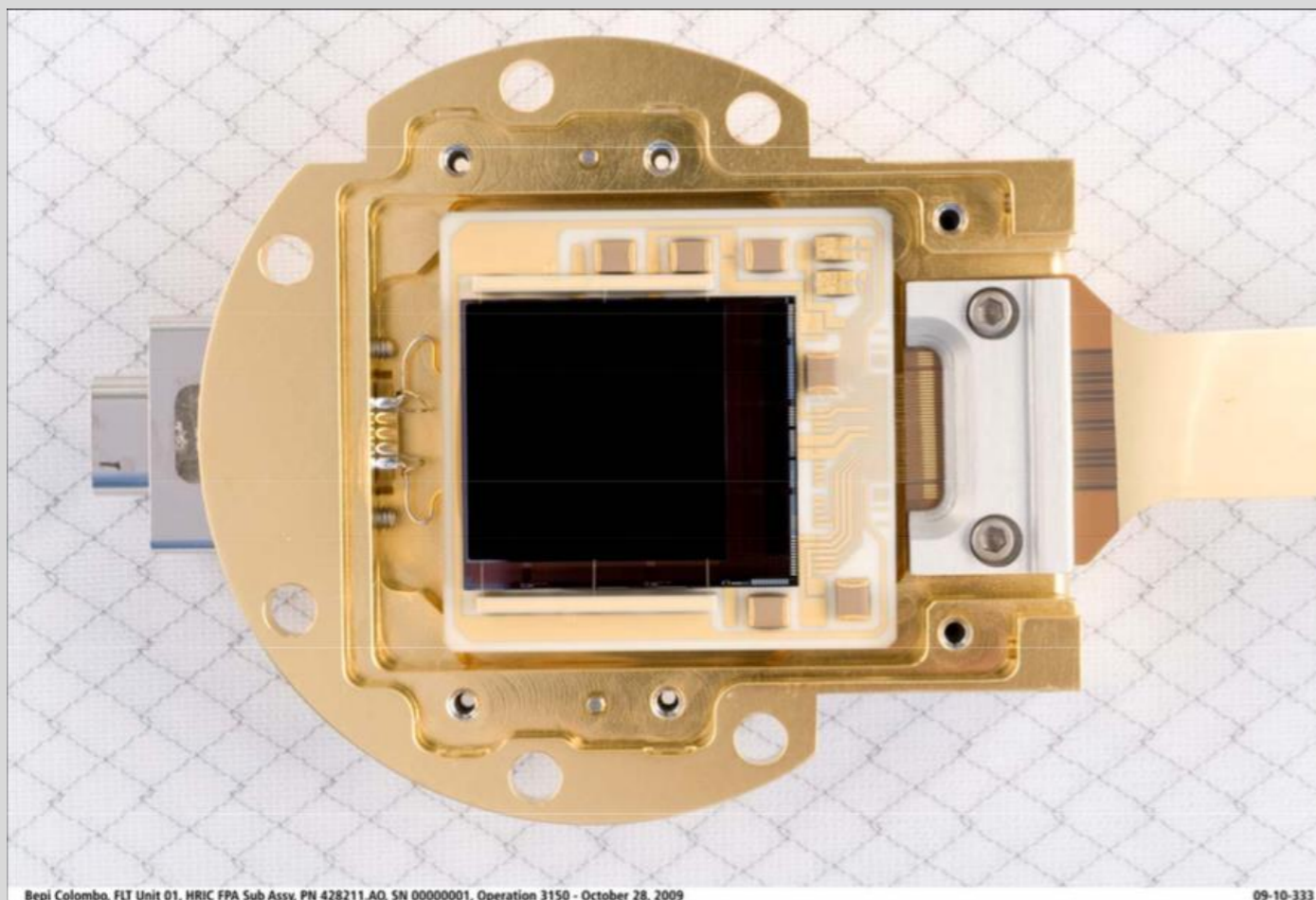
Nearly-simultaneous stereo using the rotation mechanism





# Imaging principle - colour imaging

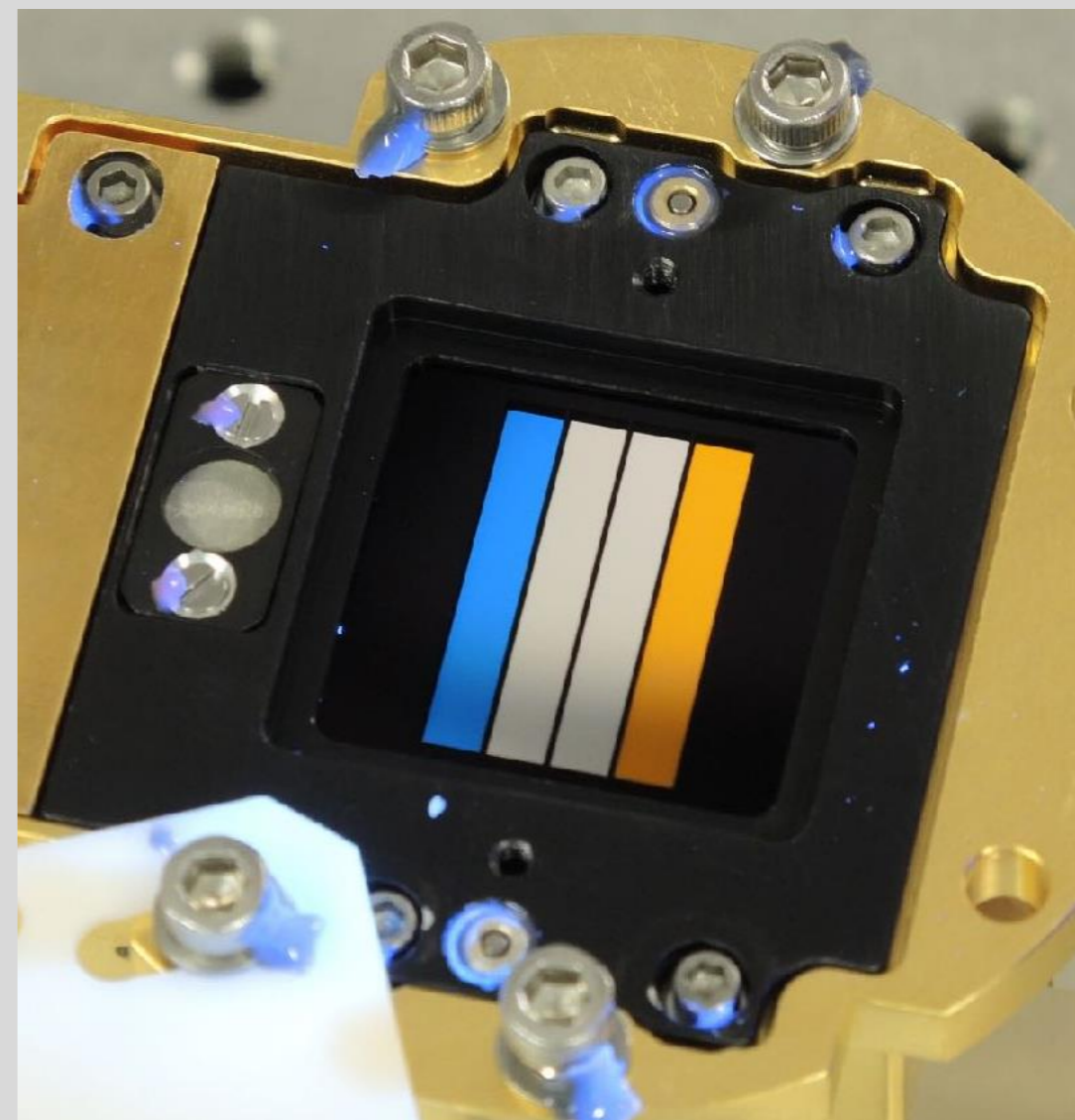
4-colour imaging with a push-frame approach



Raytheon 2k x 2k CMOS  
Flight-spare of SYMBIOSIS  
(Bepi-Colombo)

BLU: 400-550nm  
PAN: 550-800nm  
RED: 800-900nm  
NIR: 850-1100nm

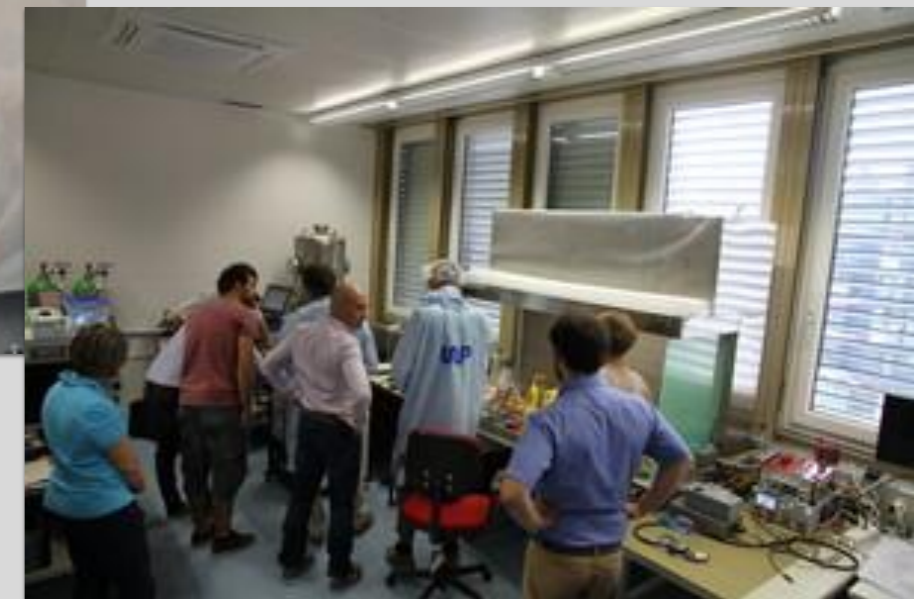
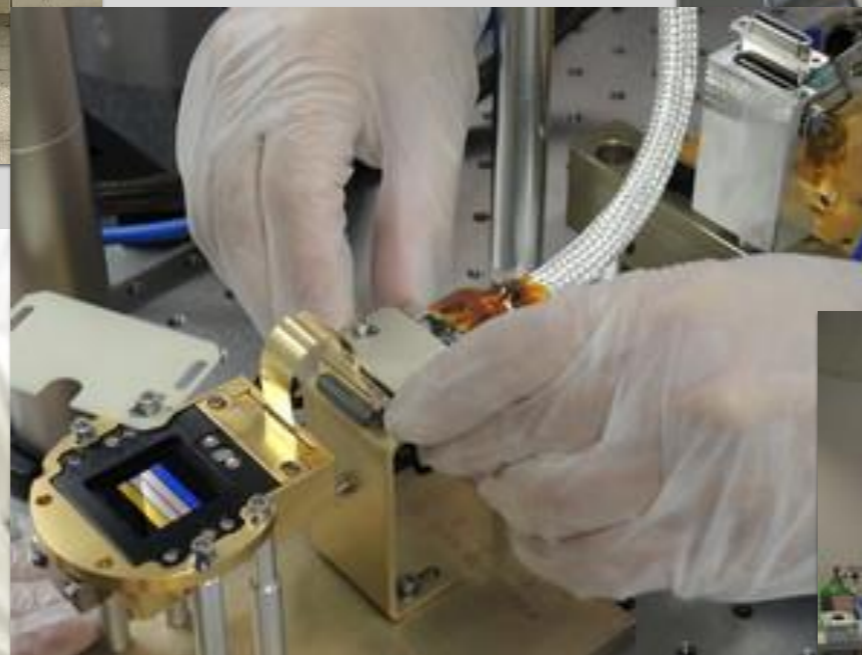
Colour filters (Balzers)





# Development and assembly at UniBE

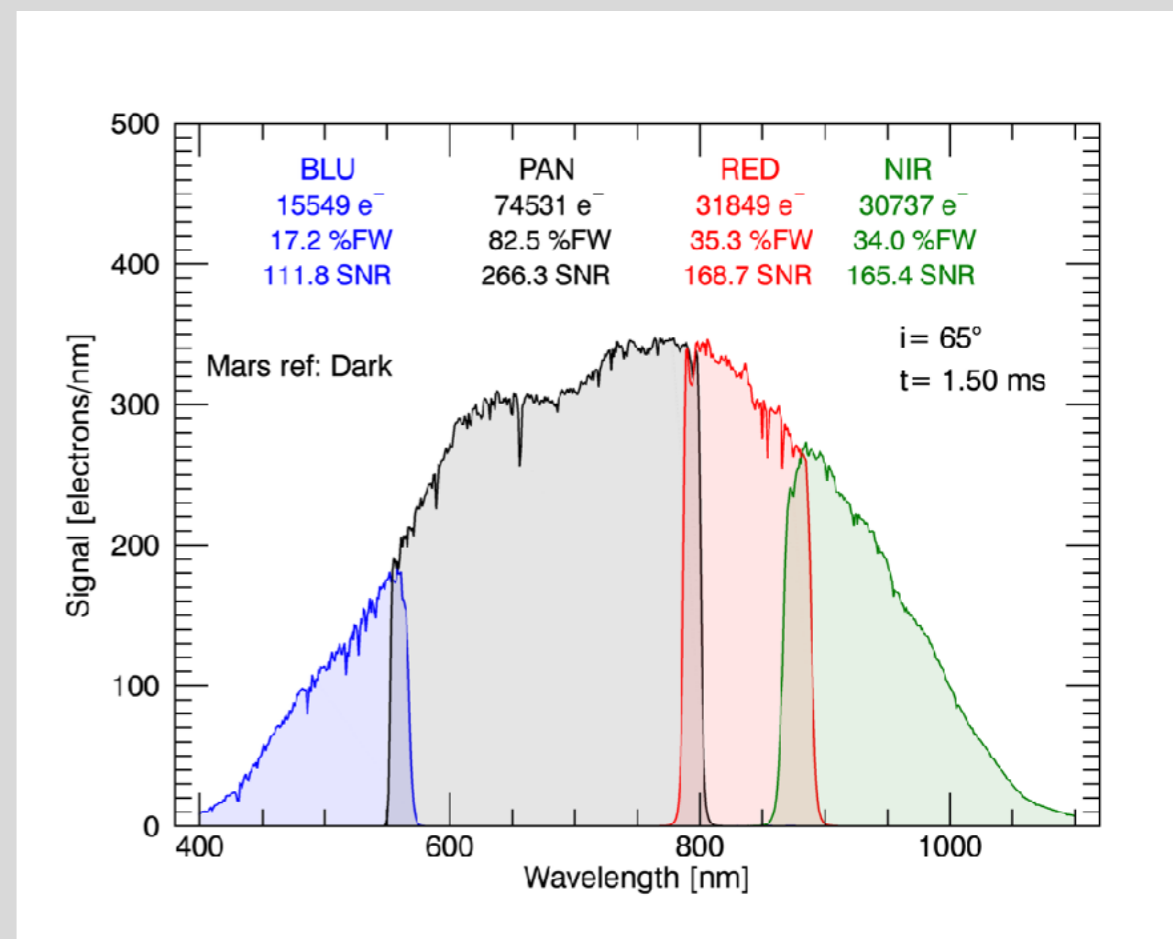
Very fast assembly and testing!



# Key points

The surface of Mars is imaged in:

- ⊙ 4 Colours (BLU: 400-550nm, PAN: 550-800nm, RED: 800-900nm, NIR: 850-1100nm)
- ⊙ Near-Simultaneous stereo on a single pass ~3% global coverage /Mars year
- ⊙ 1 stereo + 1 to 2 single observation per orbit
- ⊙ 9.4 km wide swath. 40 km long
- ⊙ 4.6 m/pixel-resolution
- ⊙ Variable local time
- ⊙ High S/N ratio





# Launch from Baikonur

Proton-M rocket - 14.03.2016

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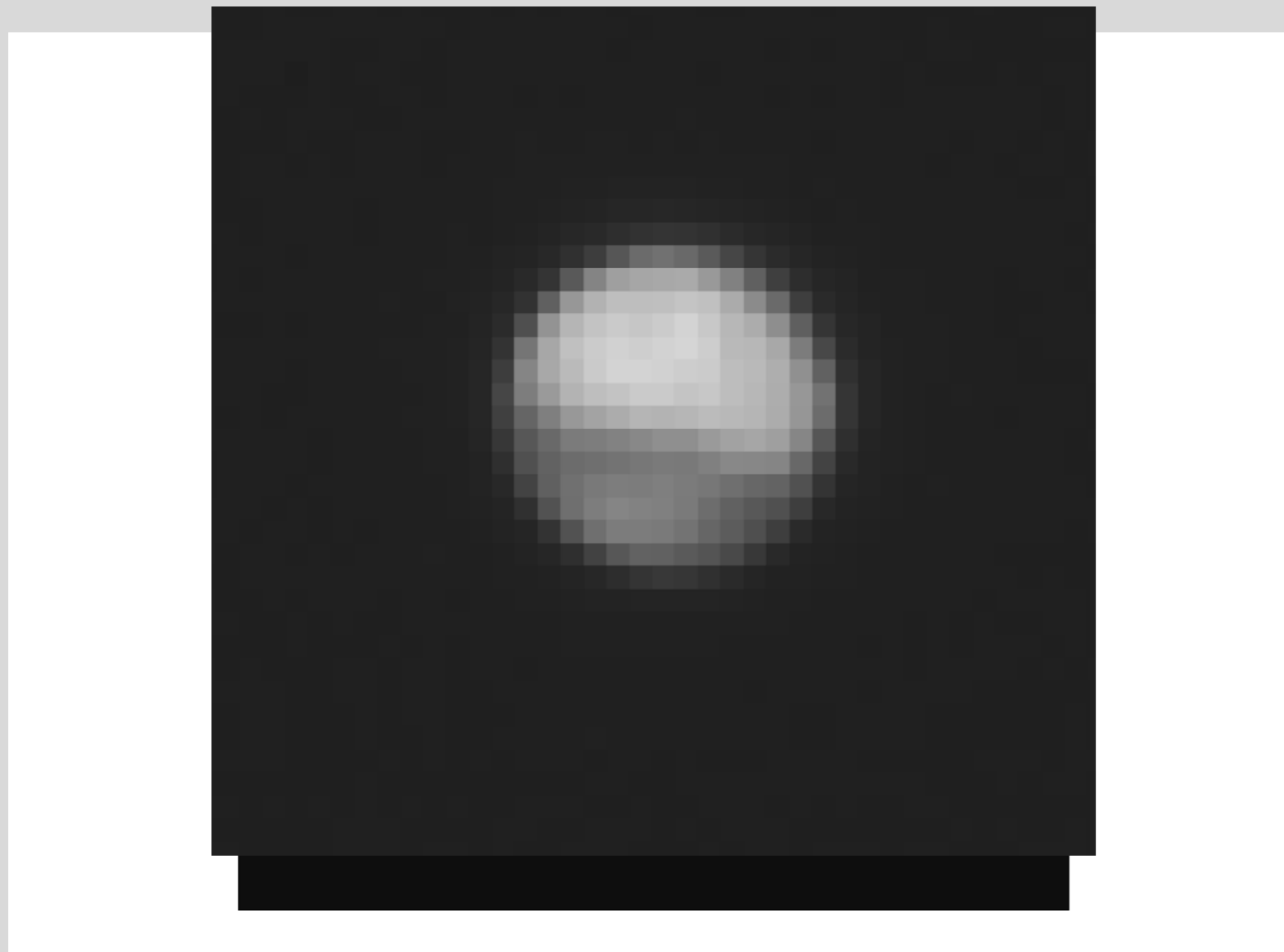


# Mid-cruise checkout

Mars in view - 13.06.2016

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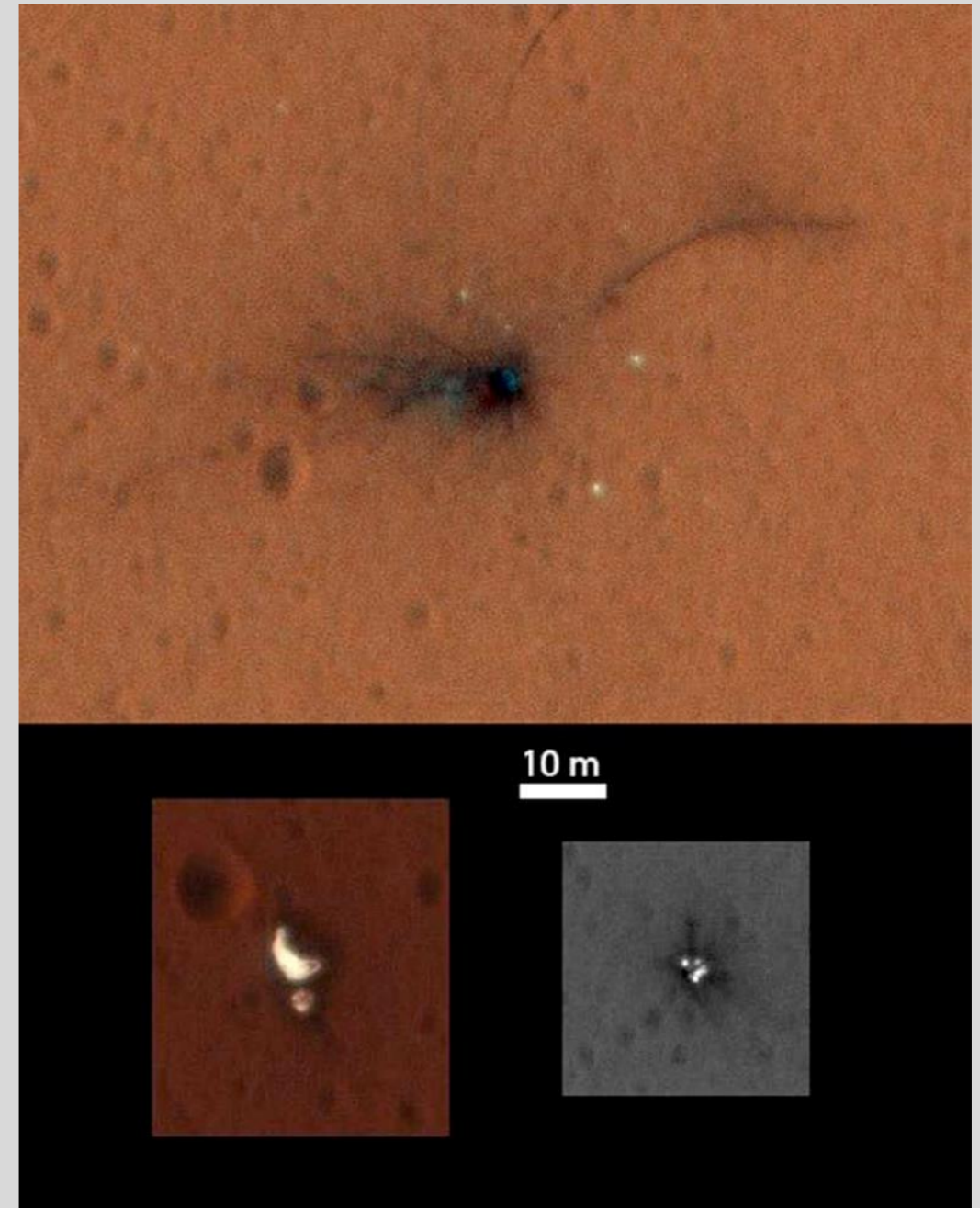
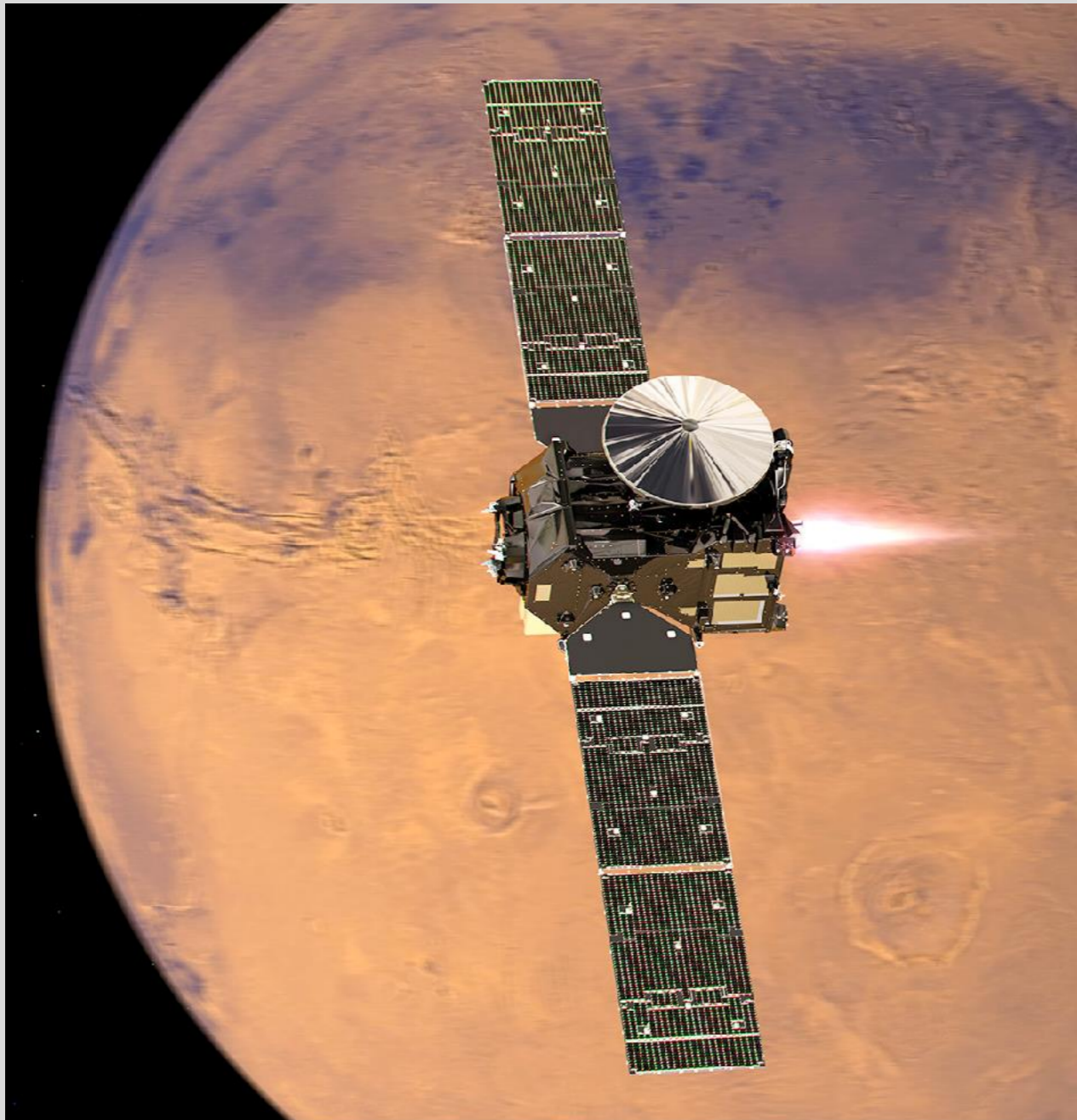


# Mars capture orbit

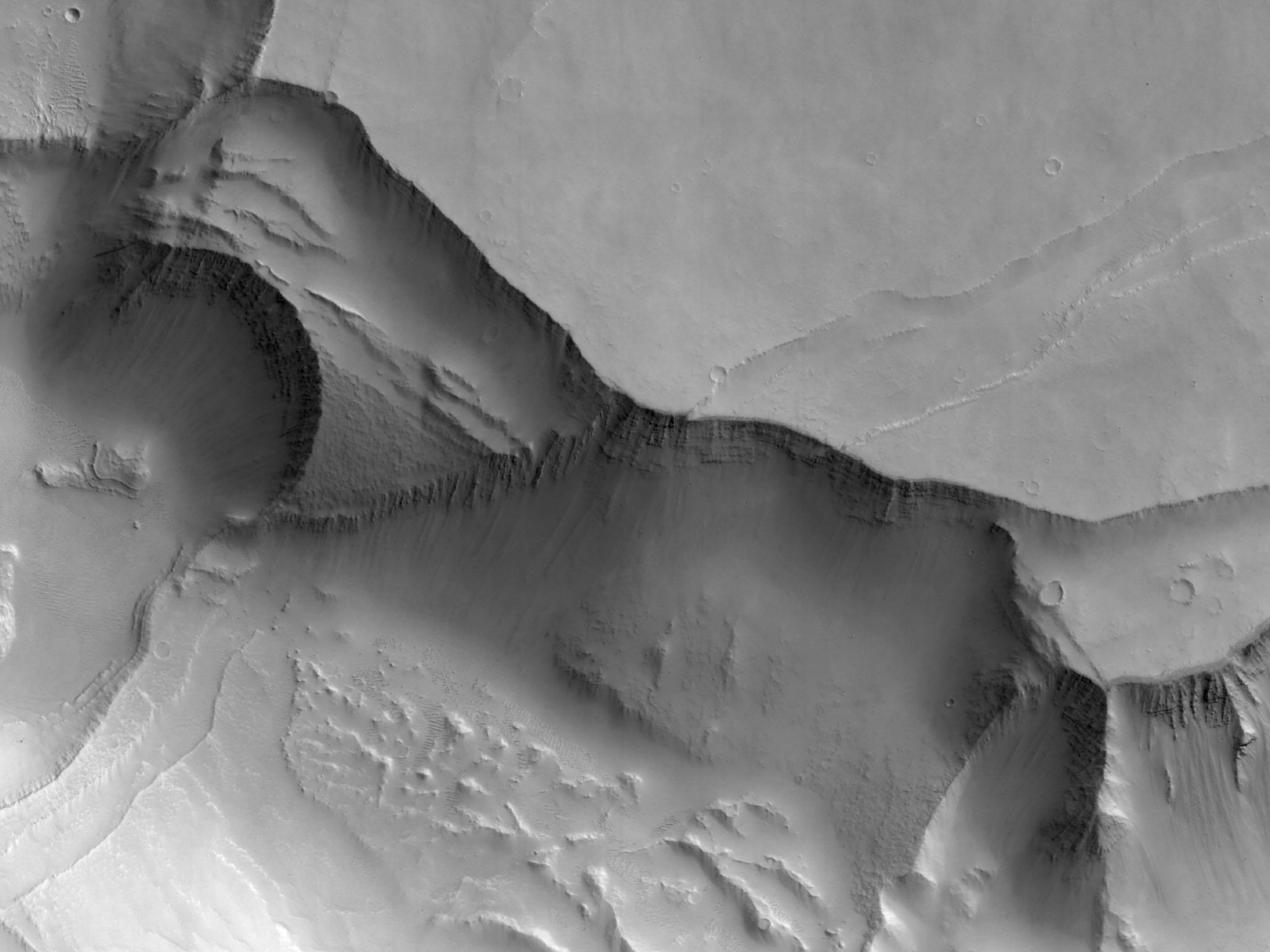
Successful MOI of TGO - 19.10.2016

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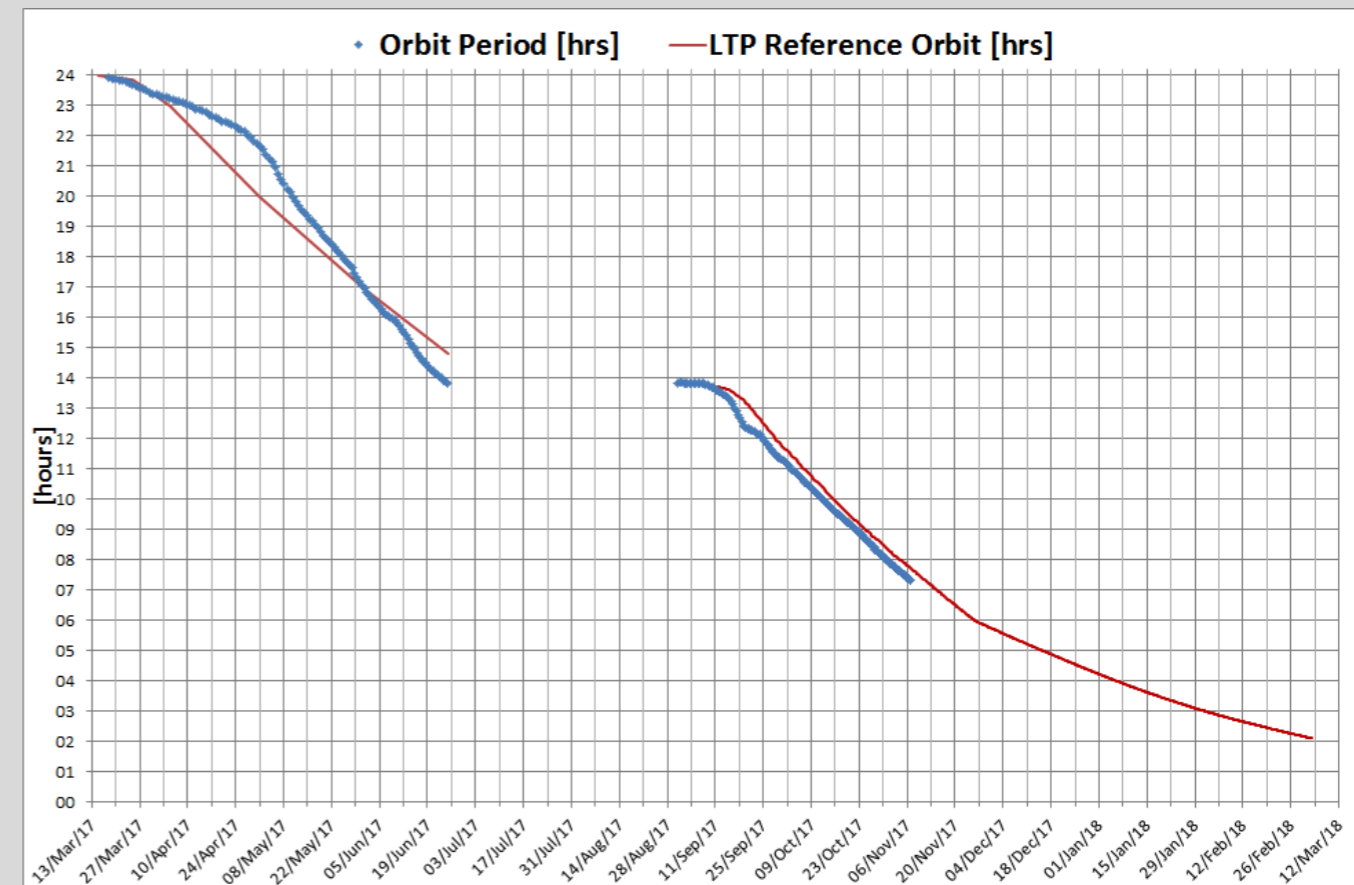
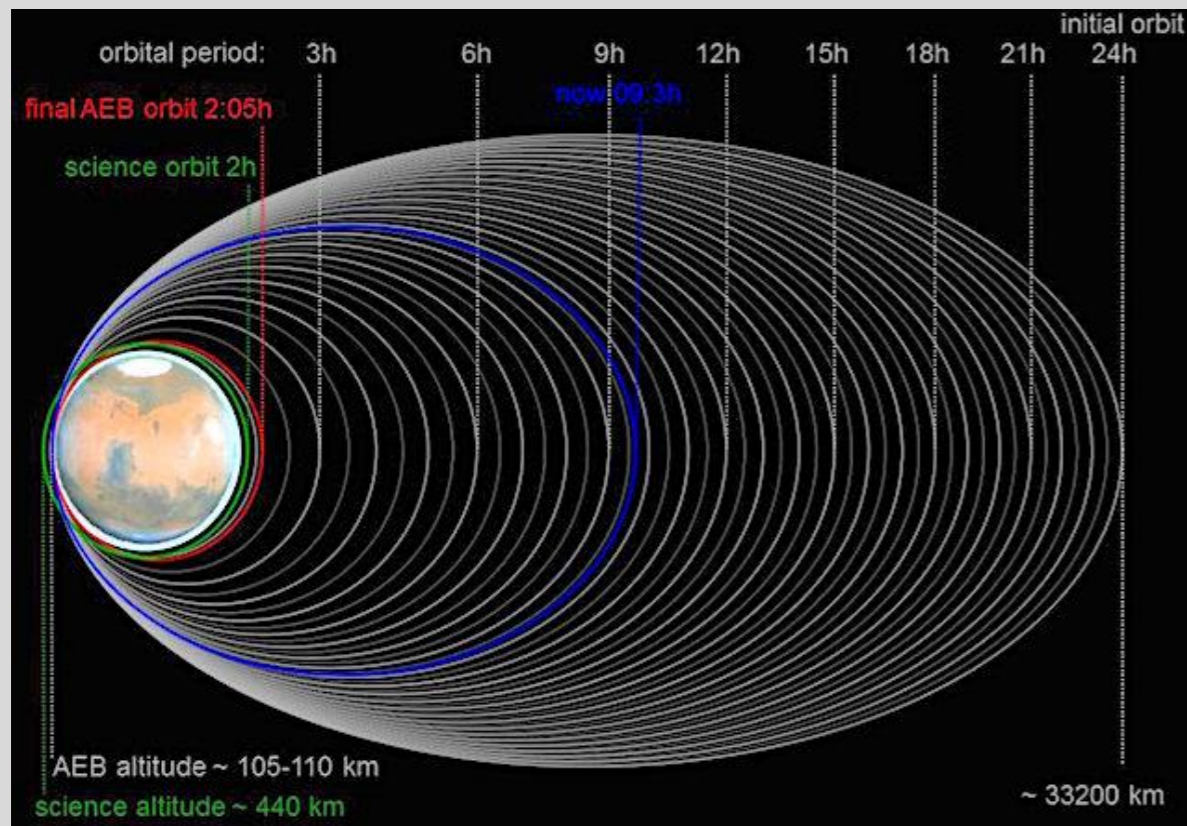
t = 0 s





# Aerobraking

March 2017 - March 2018, interrupted by Solar conjunction



No science ops  
during this time!  
:-(

# Seven months in the primary science phase

## Introductory remarks

- Focused on improving the operations and the data validation/calibration
- Fixed bugs
- Tested various colour modes
- Regular improvements of the darks, flatfield and straylight removal algorithms
- Started doing a little bit of science
- Good data for half of this time only because of the dust

**u<sup>b</sup>**

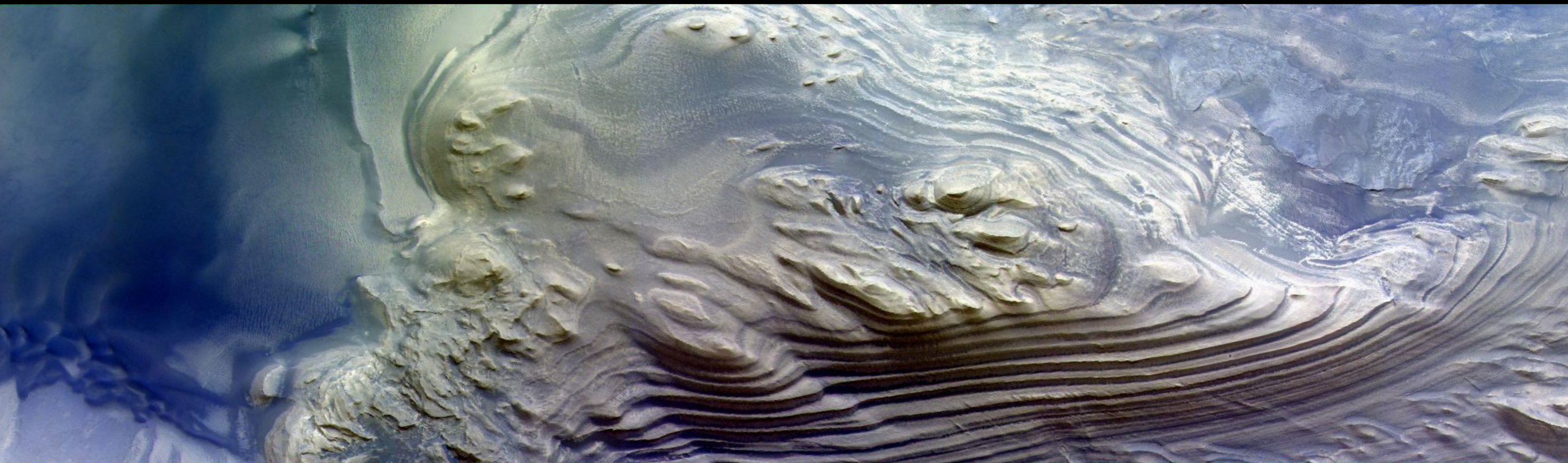
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CAS-M02-2018-06-07T09.29.21.224  
MY34\_002398\_304\_2



# Layered mound in Juventae Chasma



**Folder: 180929\_stp024\_boot3**

**Observation #: 24**

**Start time: 2018-10-02T16.19.17.702**

**Stop time: 2018-10-02T16.19.27.910**

**Resolution [m/pixel]: 4.60000**

**Min latitude [°]: -4.7078942**

**Max latitude [°]: -4.0637669**

**Min longitude [°]: 297.55019**

**Max longitude [°]: 297.83636**

**Incidence angle [°]: 49.2860**

**Phase angle [°]: 45.6050**

**Local solar time: 08:52:43**

**Compression ratio: 0.996000**

**Exposure time [ms]: 1.5360000**

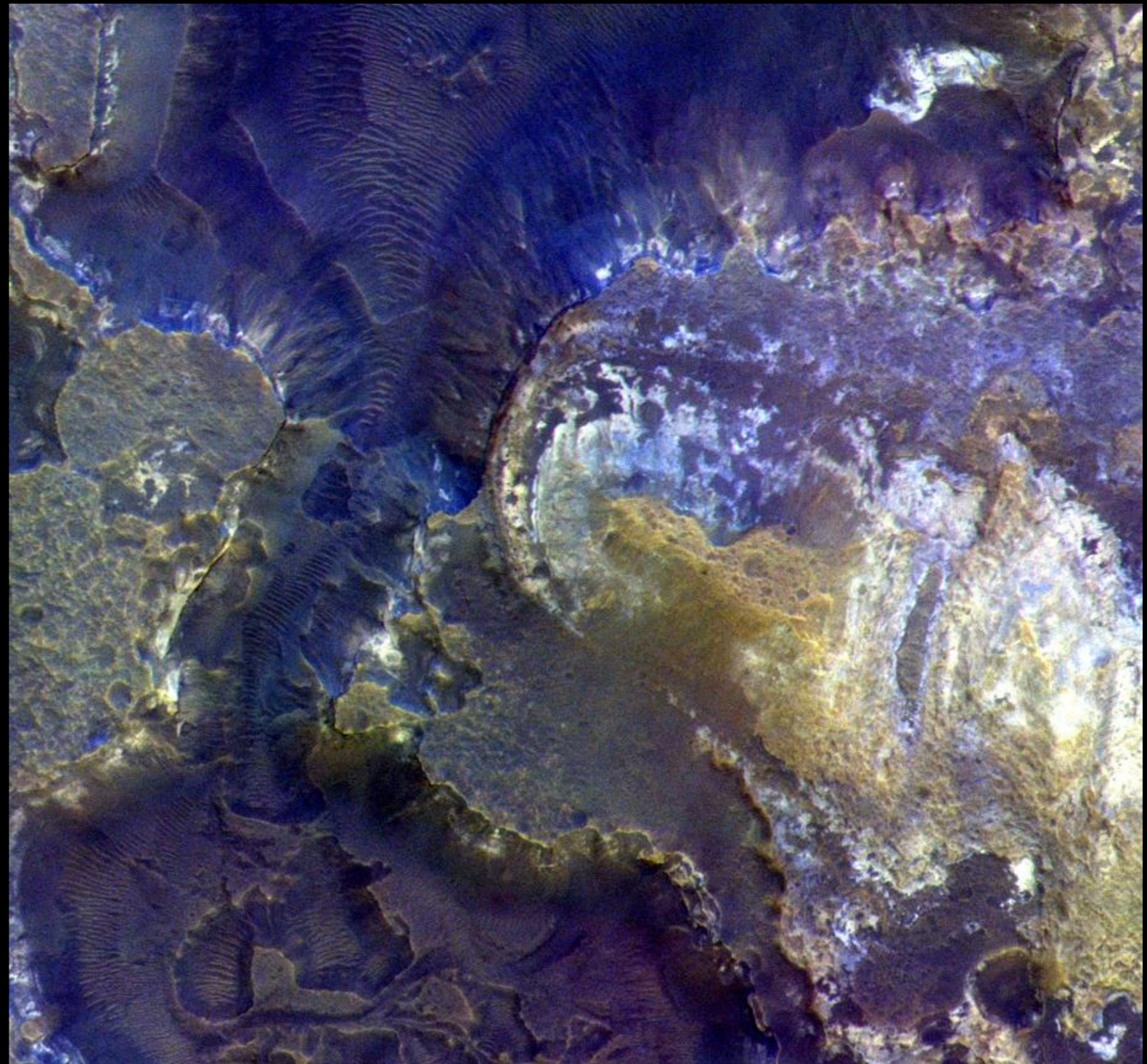
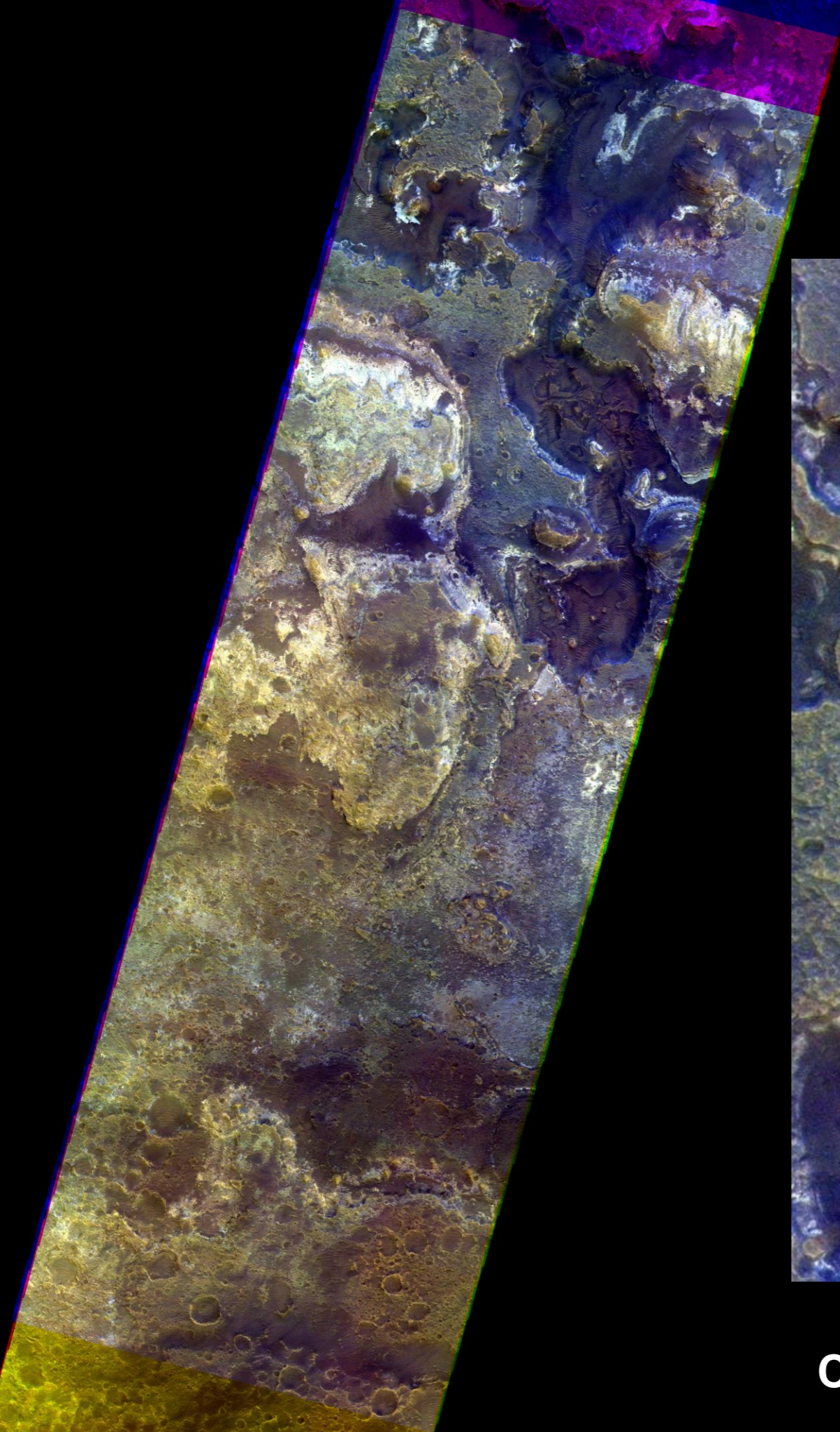
**Filters: PAN, NIR, BLU**

**Binning: 0, 0, 0**

**Exposures: 30**



Hadriacus Palus - 78°E, 27°S  
Northeast of Hellas basin



CAS-M02-2018-06-09T06.48.42.790-RED-PAN-BLU



# Korolev crater

Early-morning observation of the northern rim

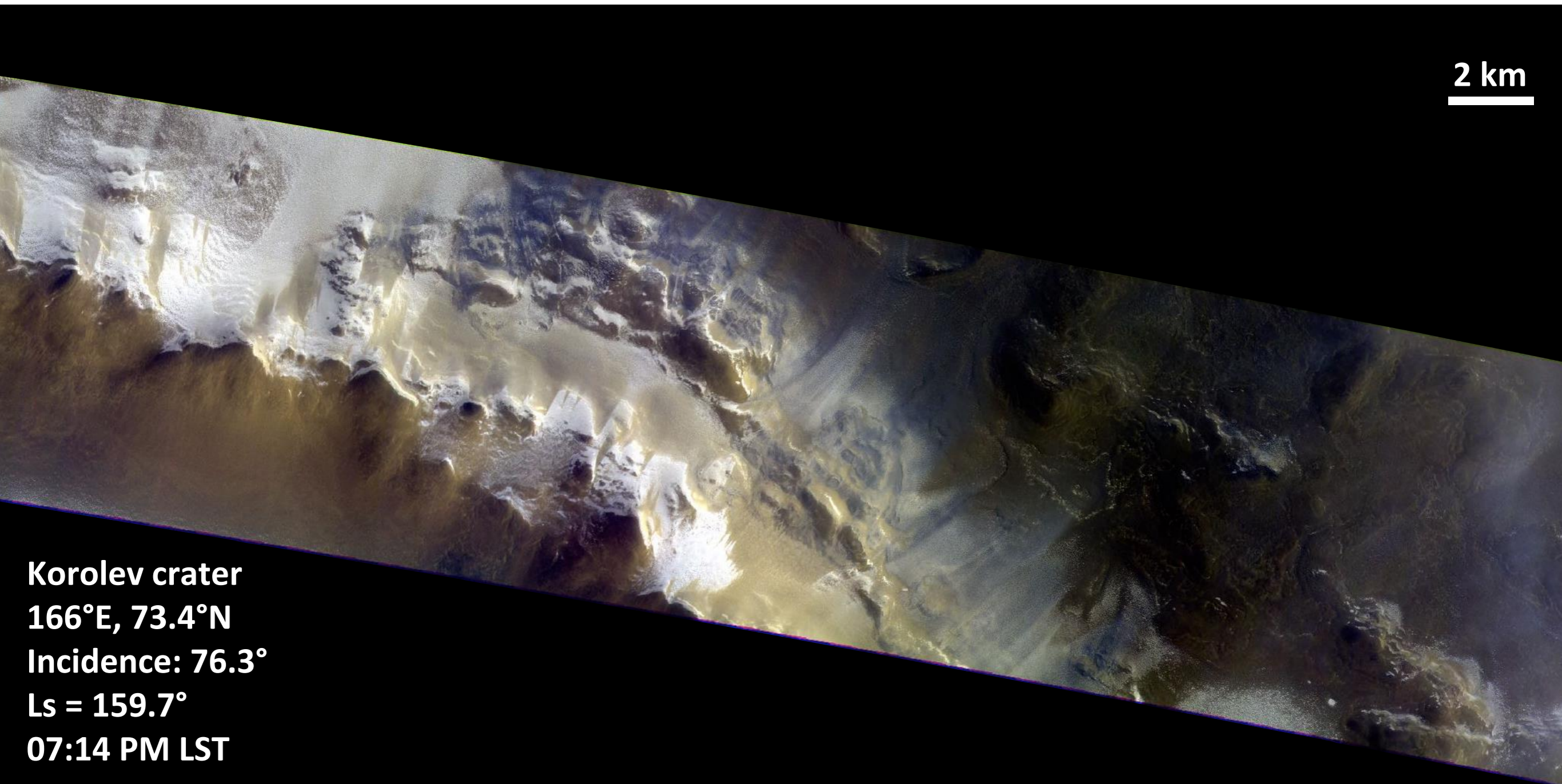
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**u<sup>b</sup>**

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**2 km**



**Korolev crater**  
**166°E, 73.4°N**  
**Incidence: 76.3°**  
**Ls = 159.7°**  
**07:14 PM LST**



# Imaging the surface in low-light conditions

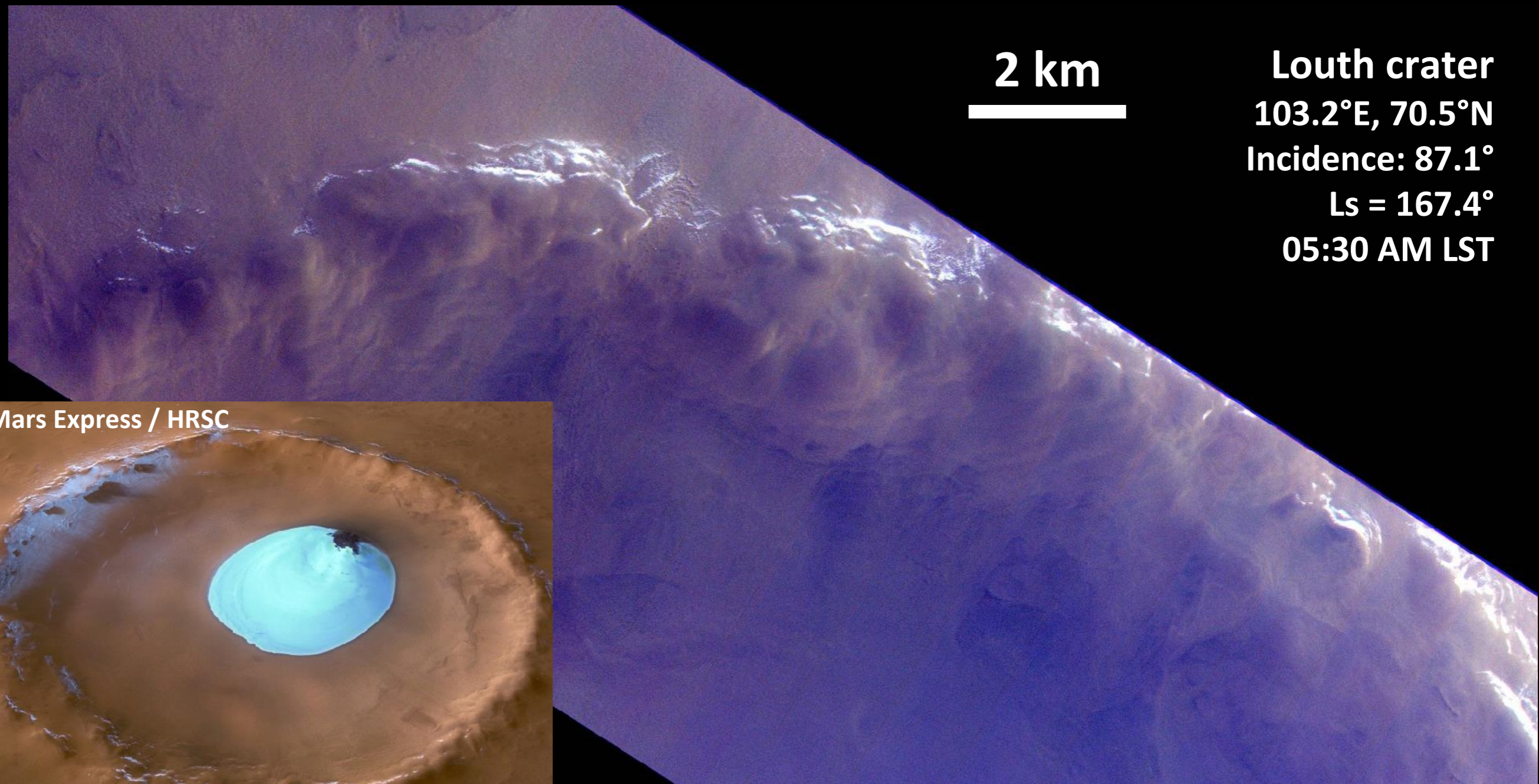
*u<sup>b</sup>*

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## Ice on the northern rim of Louth crater

CAS-M01-2018-04-29T21.14.20.928 - MY34\_001928\_101\_0



2 km

**Louth crater**  
**103.2°E, 70.5°N**  
**Incidence: 87.1°**  
**Ls = 167.4°**  
**05:30 AM LST**

Mars Express / HRSC

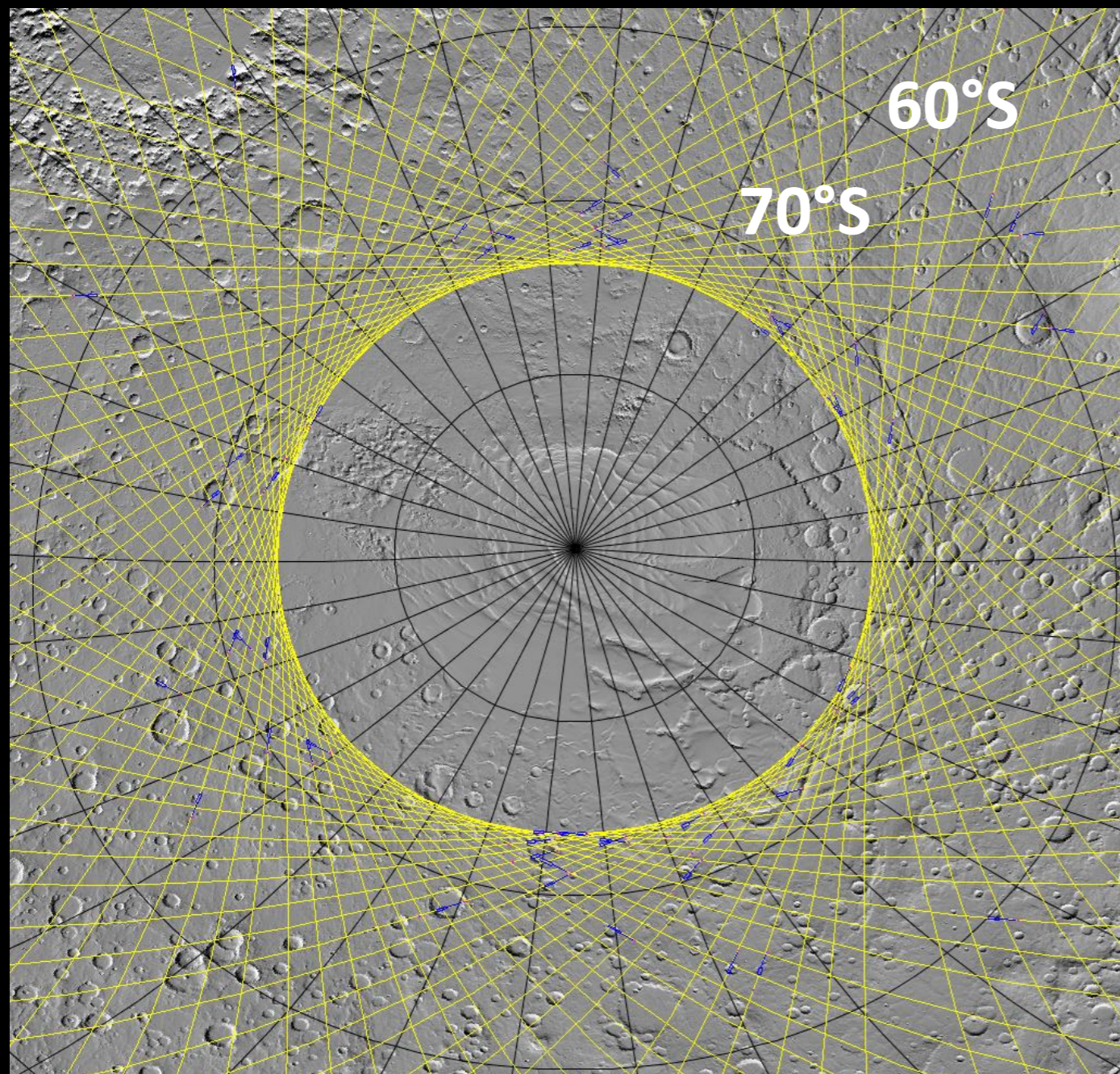


ESA/DLR/FU Berlin (G. Neukum)



# Circum-polar observations

74°-inclination orbit - stp020 at high southern latitudes



Screenshot from our PLAN-C planning tool.

stp020: 01-08 Sept. 2018

180 images

1/3 circum-polar targets

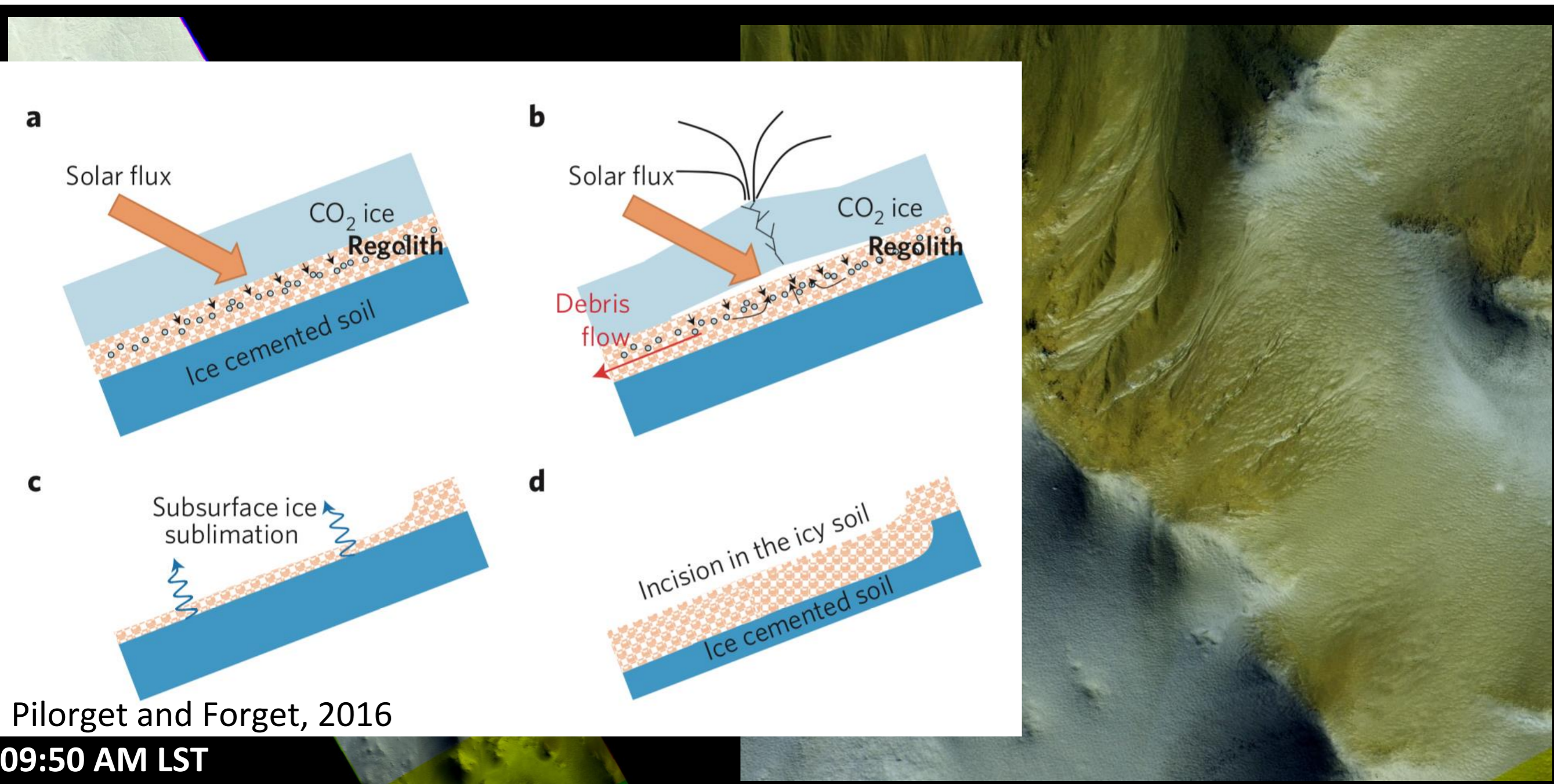
early to late morning LST



# Defrosting of equator-facing slopes

Downslope flows on icy slopes - frosted gullies on the other side

CAS-M01-2018-05-05T19.25.42.020 - MY34\_002000\_243\_0



Pilorget and Forget, 2016

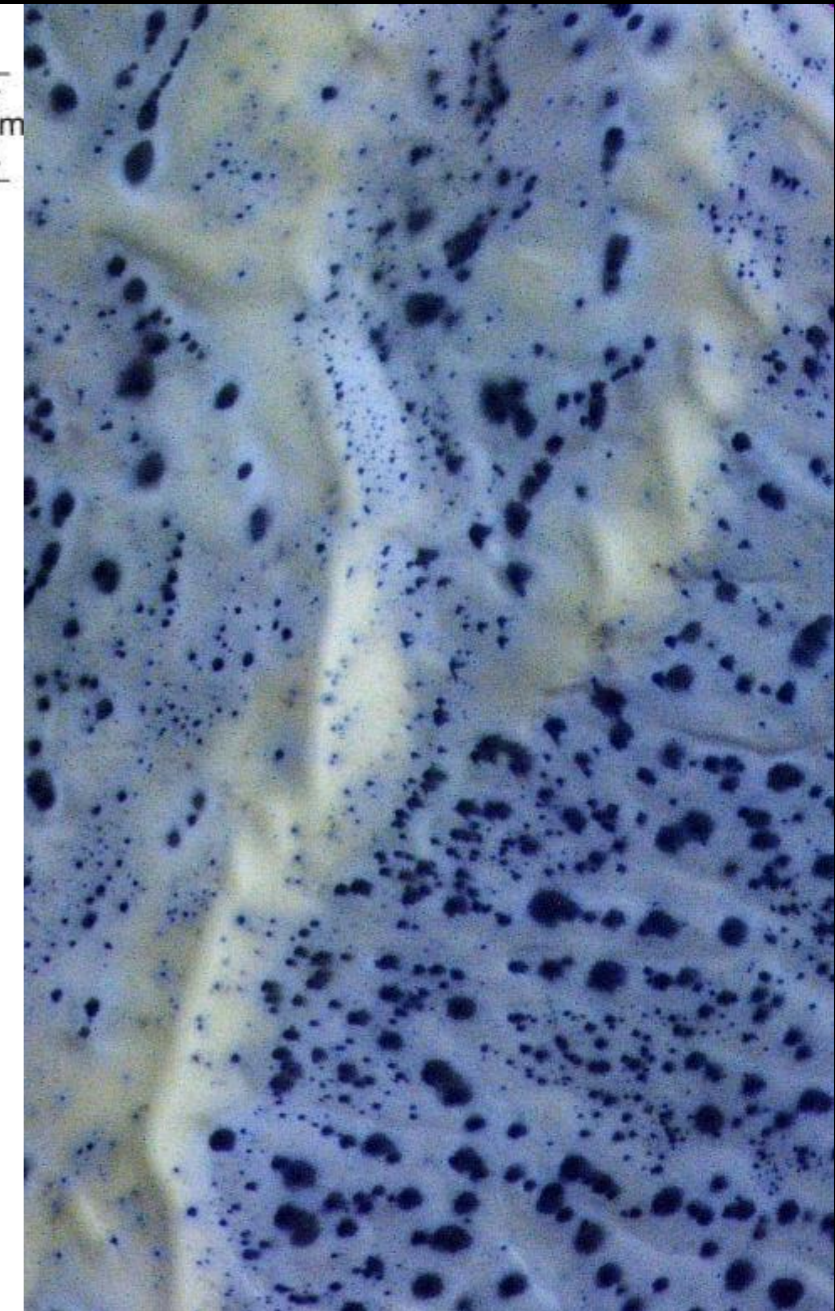
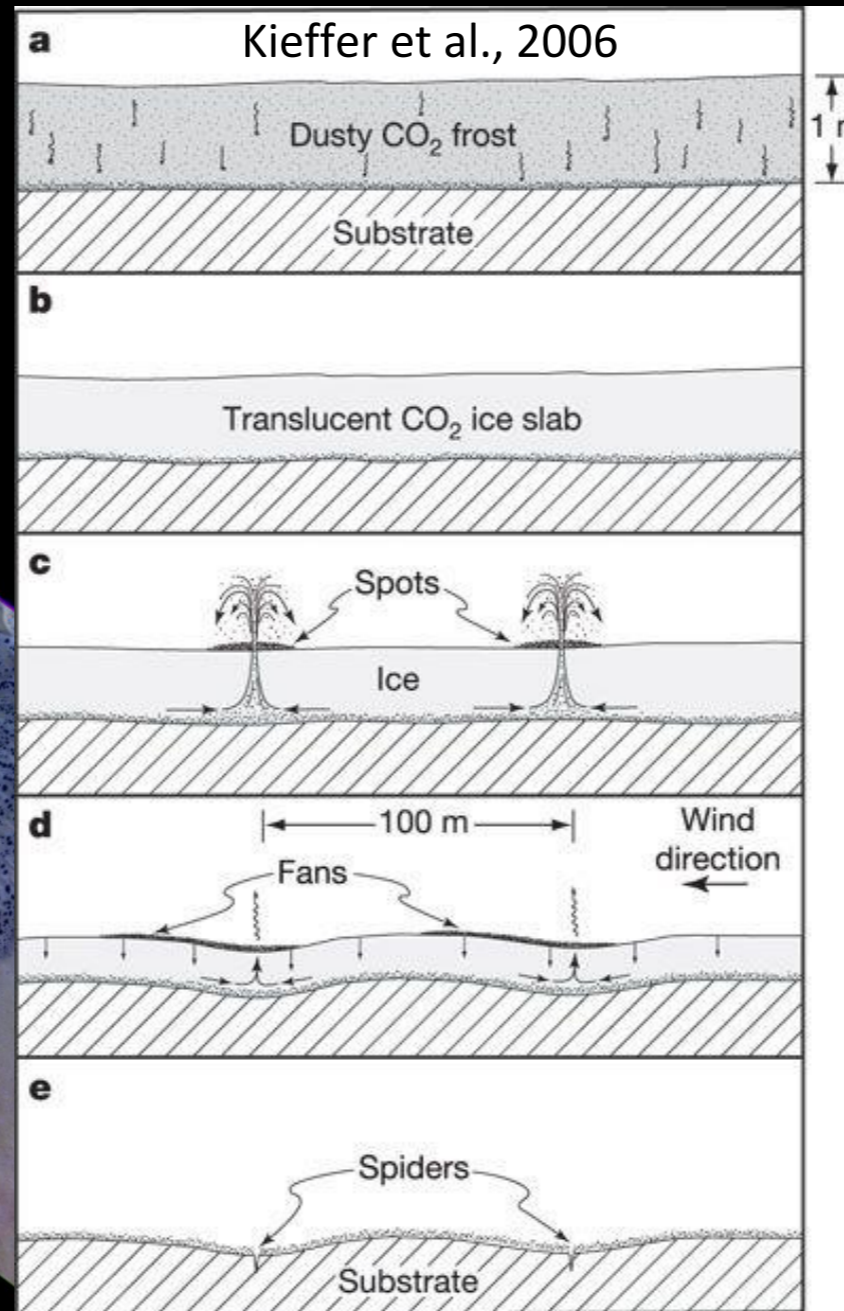
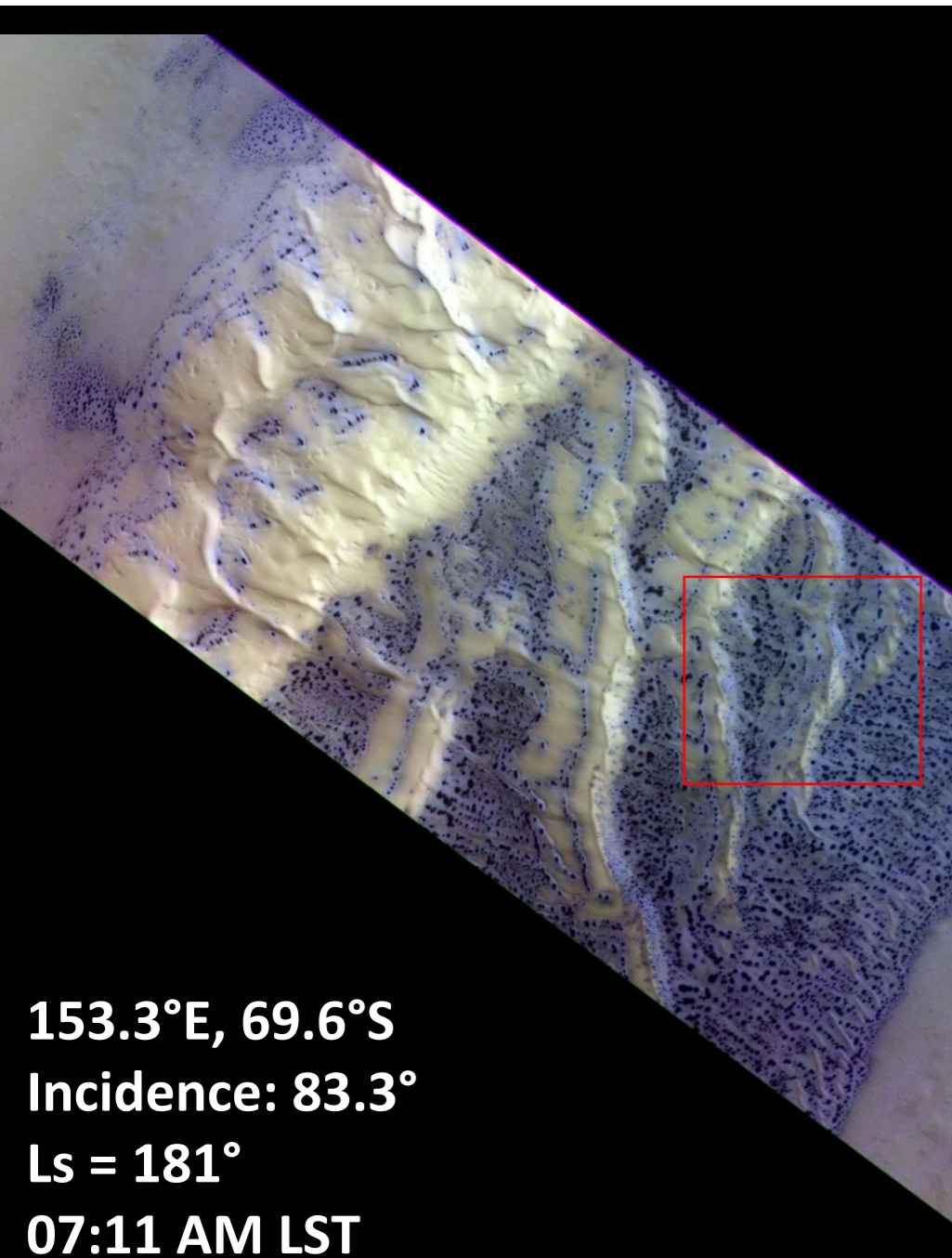
09:50 AM LST



# Dark spots and blue haloes

Peculiar activity in early spring - Kieffer model

CAS-M02-2018-05-24T11.19.48.406 - MY34\_002228\_258\_1



153.3°E, 69.6°S  
Incidence: 83.3°  
Ls = 181°  
07:11 AM LST



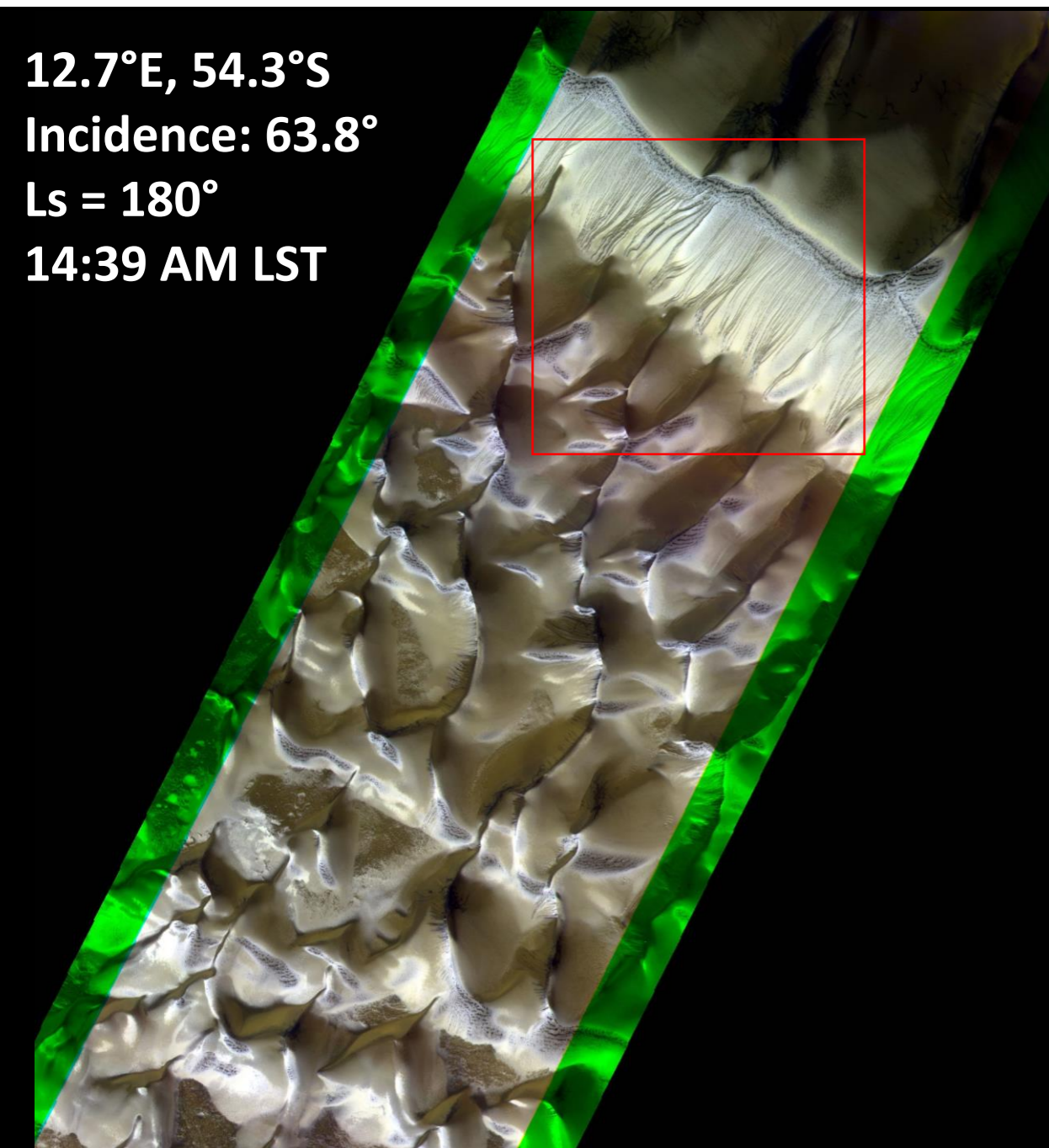
# The dunes of Russel crater

Groups of dark spots - linear gullies

CAS-M02-2018-05-22T02.36.30.858 - MY34\_002199\_302\_1

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**12.7°E, 54.3°S**  
**Incidence: 63.8°**  
**Ls = 180°**  
**14:39 AM LST**





# Defrosting of patterned ground in late Spring

Shallow surface features highlighted by the remaining ice

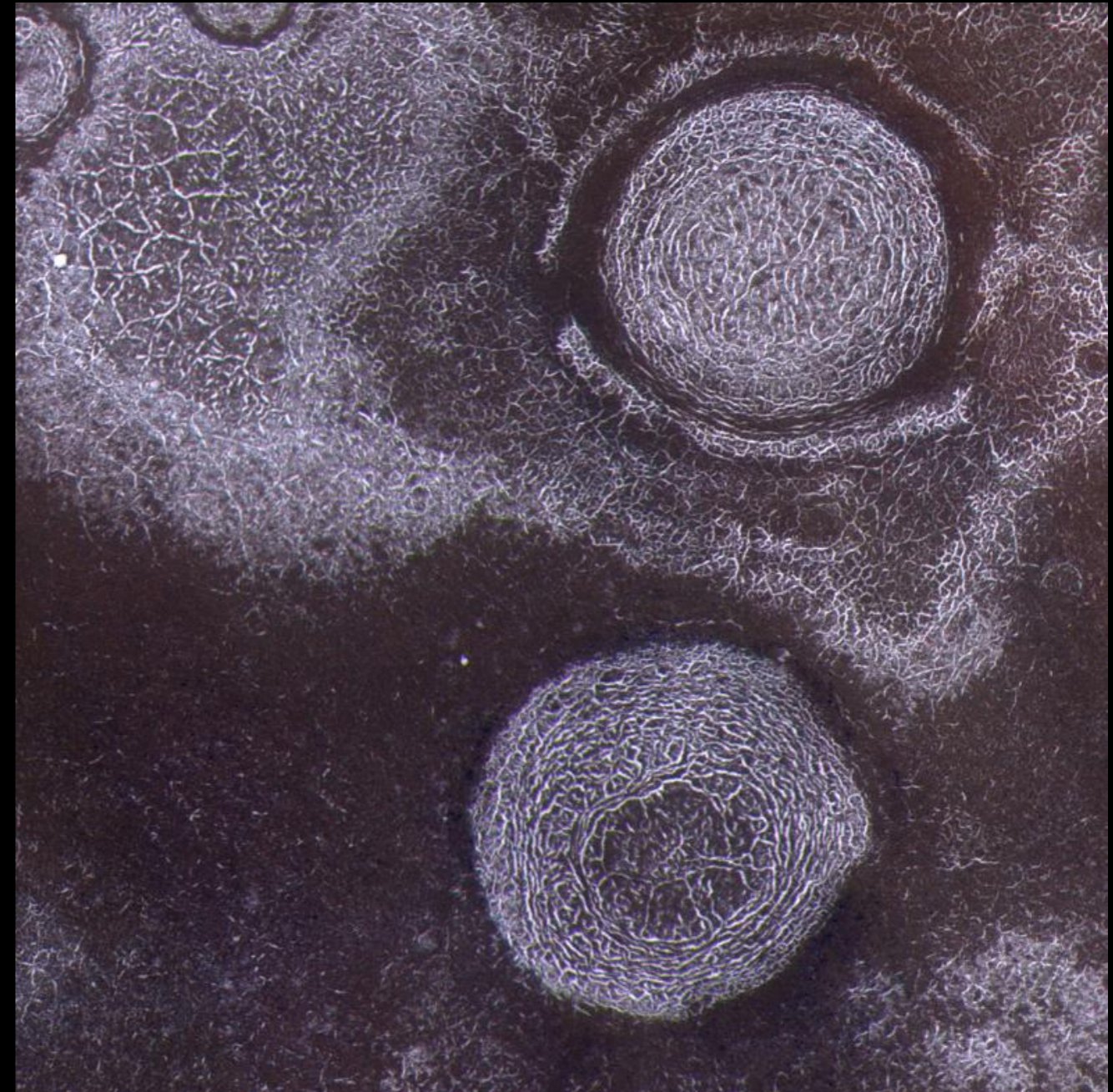
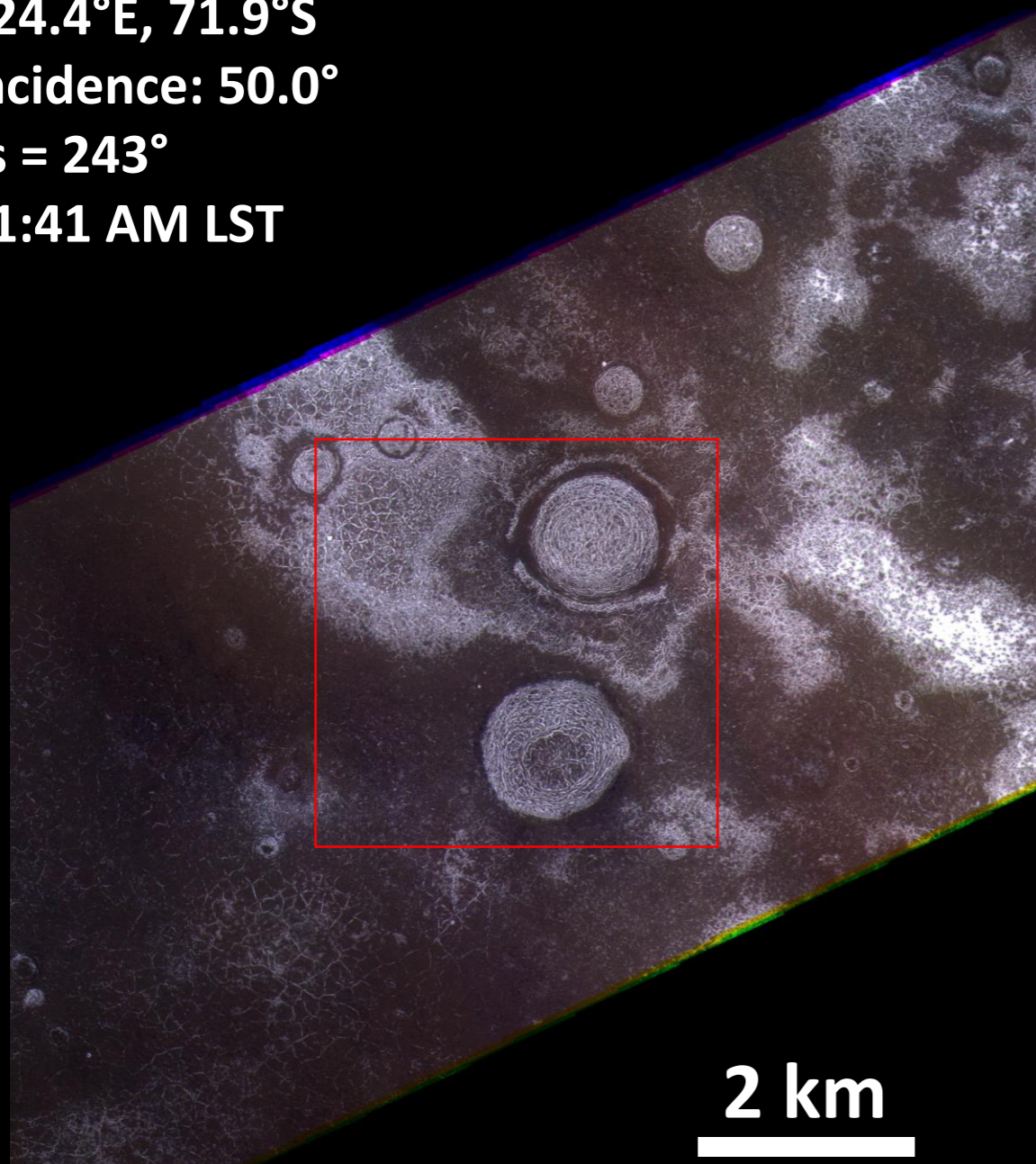
CAS-M05-2018-09-03T04.48.55.341 - MY34\_003471\_278\_0

**u<sup>b</sup>**

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**224.4°E, 71.9°S**  
**Incidence: 50.0°**  
**Ls = 243°**  
**11:41 AM LST**





# Gullies and seasonal ice

## Frosted gullies in a polar pit

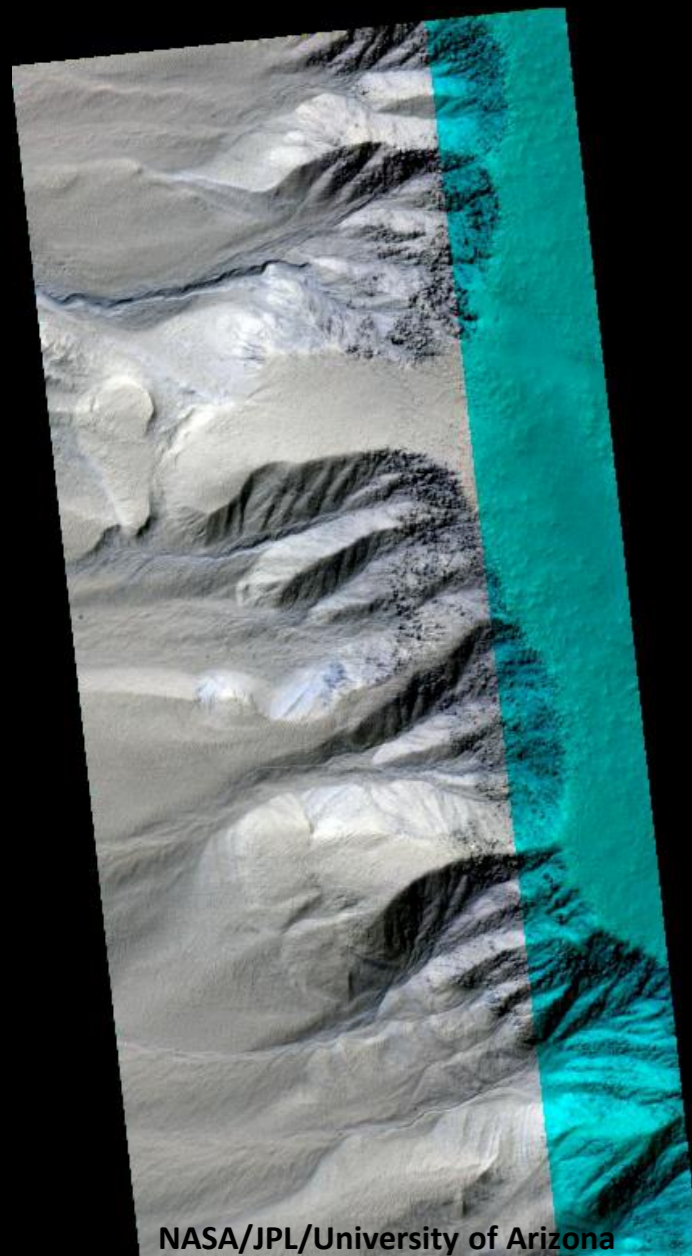
CAS-M02-2018-09-02T14.57.42.304 - MY34\_003464\_256\_2

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ESP\_031927\_1115\_UNFILTERED\_COLOR



NASA/JPL/University of Arizona



ESA Image of the week - 17.09.2018



# Conclusions and perspectives

Very good data already. But the best is yet to come!

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- Unique dataset: colour at high-resolution with variable local time
- Excellent quality of many colour images, also in difficult conditions
- Instrument operations now quite smooth; lots of images acquired
- Calibration already good but we are still working on it
  
- Stereo capability - DTMs from stereo images coming soon
- Comparison with lab results for colour interpretation
- Transition from nadir-only to targeted images -> greater flexibility, more possibilities for repeated observations of a target
  
- Ready to look for INSIGHT at the surface!