Analysis of craters on Mars

Maddalena Faletti   -   40th Cycle
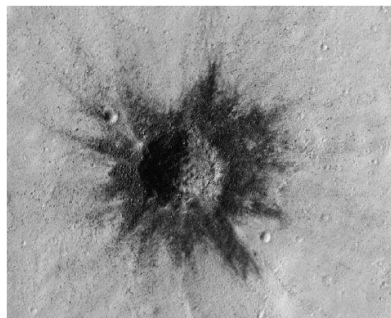
Admission to the first year - 13/11/2024

Morphological analysis

– Craters reveal surface properties and layering of the soil.

– Morphology provides insights into terrain structure.

A simple crater
Mars

NASA/JPL/MSSS

A small rayed impact crater
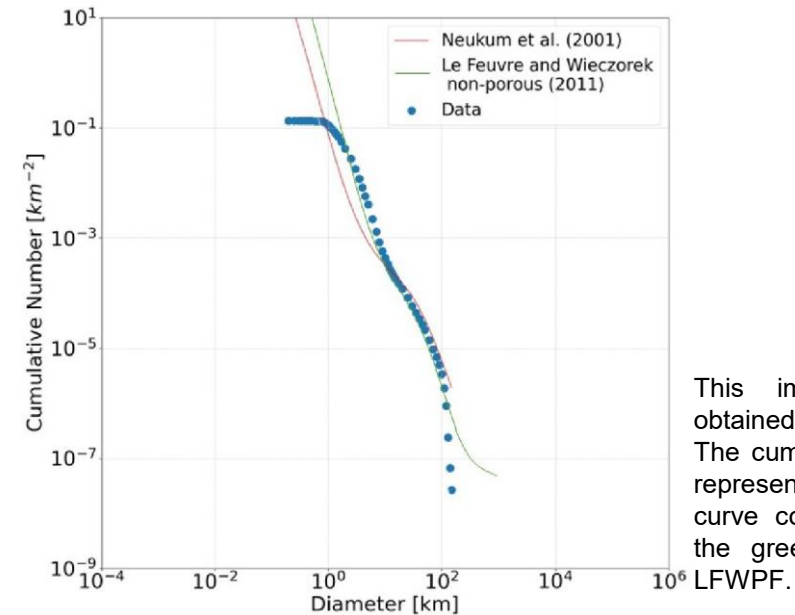Tharsis region

NASA/JPL/University of Arizona

Crater in an icy surface
43.833˚ N, 206.168˚ E

NASA/JPL-Caltech/UArizona

Statistical analysis

– By analyzing the crater population, we can estimate the crater density.

– Crater density and chronological models allow dating of geological events.

This image shows the SFD obtained using Python code. The cumulative data distribution is represented by blue dots. The red curve corresponds to NPF, while the green curve corresponds to LFWPF.
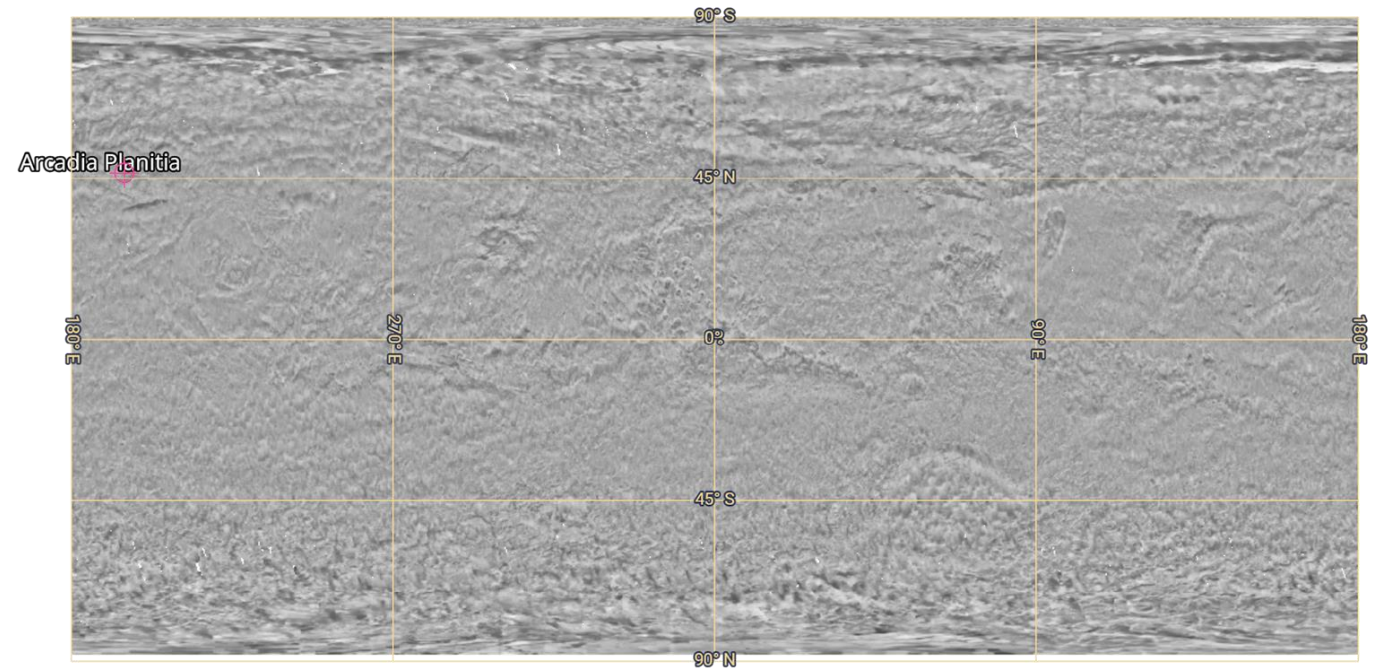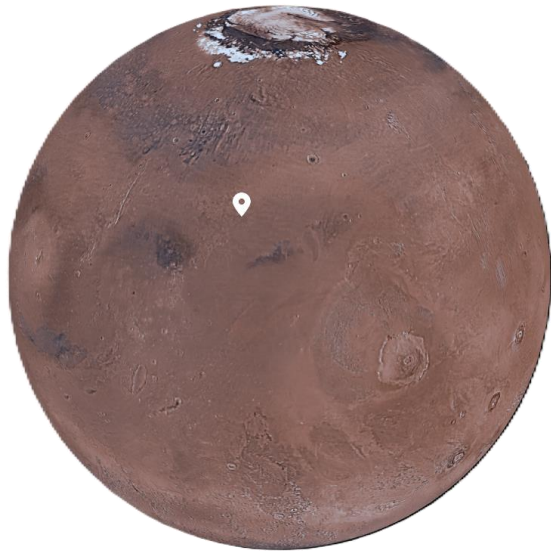
Terraced Craters

– Impacts into layered materials can create craters with terraced walls instead of a simple bowl shape.

– Radar measurements suggest that the near surface layers could be made of excess water ice.

500 m
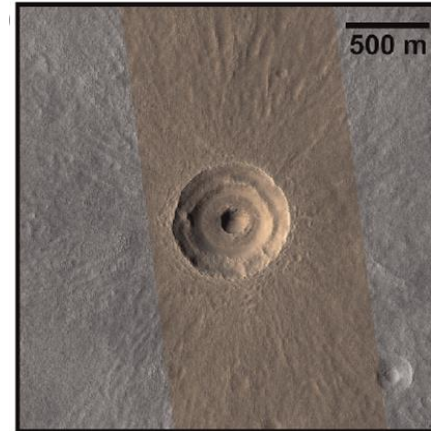
Terraced crater
46.58° N, 194.85° E

Martellato E., et al. (2020)
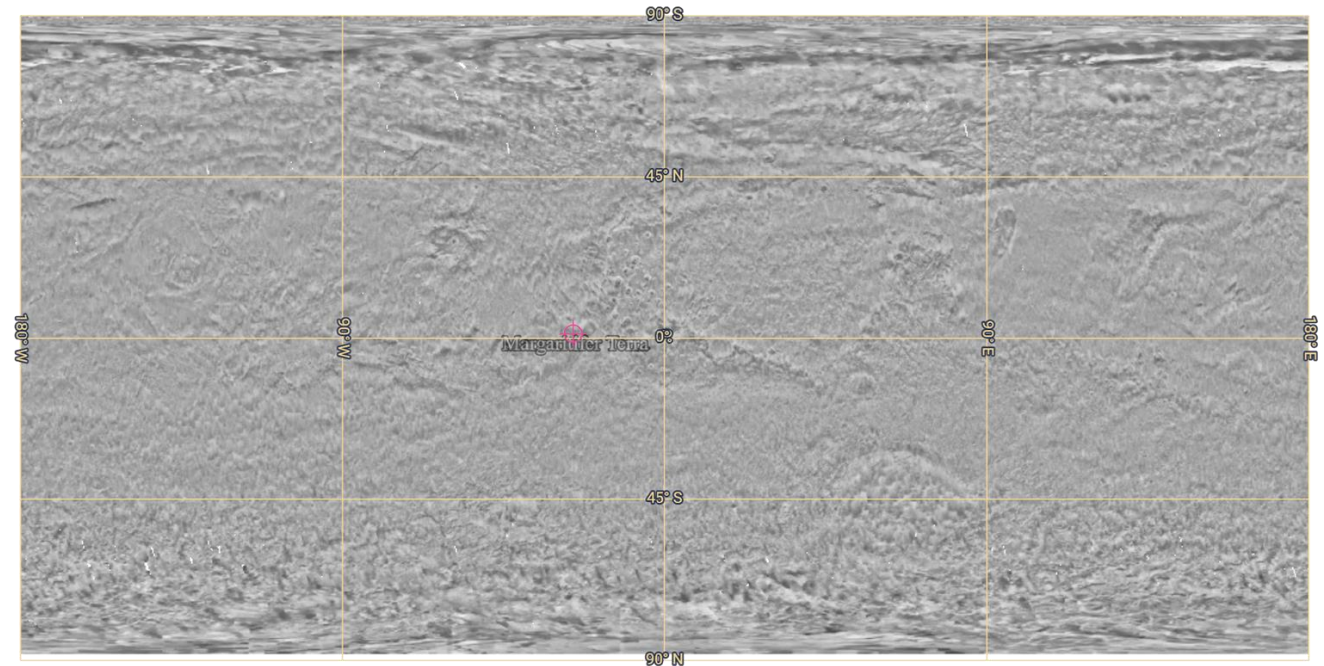

Arcadia Planitia

Floor Fractured Craters (FFCs)

– They are distinguished by the appearance of their floors, which have fractures, mesas, and knobs.

– The presence of water ice in Mars' subsurface may have played a significant role in the formation of fractures.
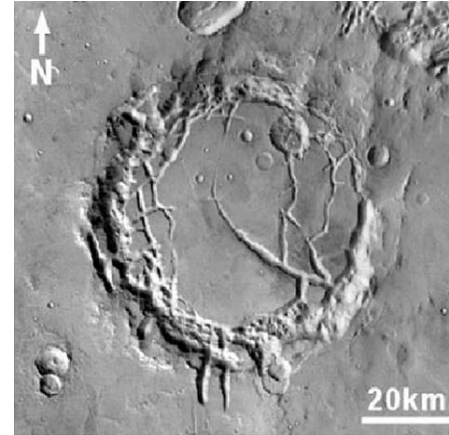
FFC crater
1.2° N, 334.4° E

Sato H., et al. (2009)

Statistical analysis

Age determination by means of crater density analysis and chronological models:

- available databases of manually or authomatically detected craters, both on a regional or global basis
- YOLOLens Martian catalog:
  o YOLOLens method combines the principles of super-resolution with YOLO, an AI algorithm based on Deep Learning, specifically for state-of-the-art object detection.
- Possible additional analysis: distribution of the depth-to-diameter ratio

Methods:

- Geological maps
- Multimodal data
- Standard plots to represent the crater distributions: SFD, R-plot
- Chronological models.

## Colour and Stereo Surface Imaging System (CaSSIS)

- It is a high-resolution imaging system for Mars surface analysis.
- It complements data from other EMTGO instruments.
- It provides stereo pairs and then DTM of any feature observed.
- It enhances understanding of Martian surface features.
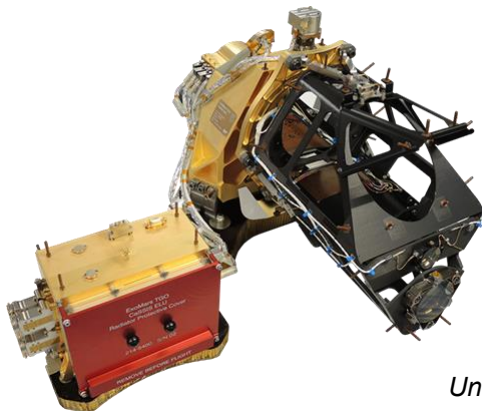
CaSSIS
Universität Bern – INAF-Padova

Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS)

- It is a radar on ESA's Mars Express mission for studying Mars' subsurface and ionosphere.
- It transmits medium-frequency pulses towards Mars, operating up to 1200 km in altitude.
- Reflected pulses from the surface and subsurface are analyzed to determine composition.
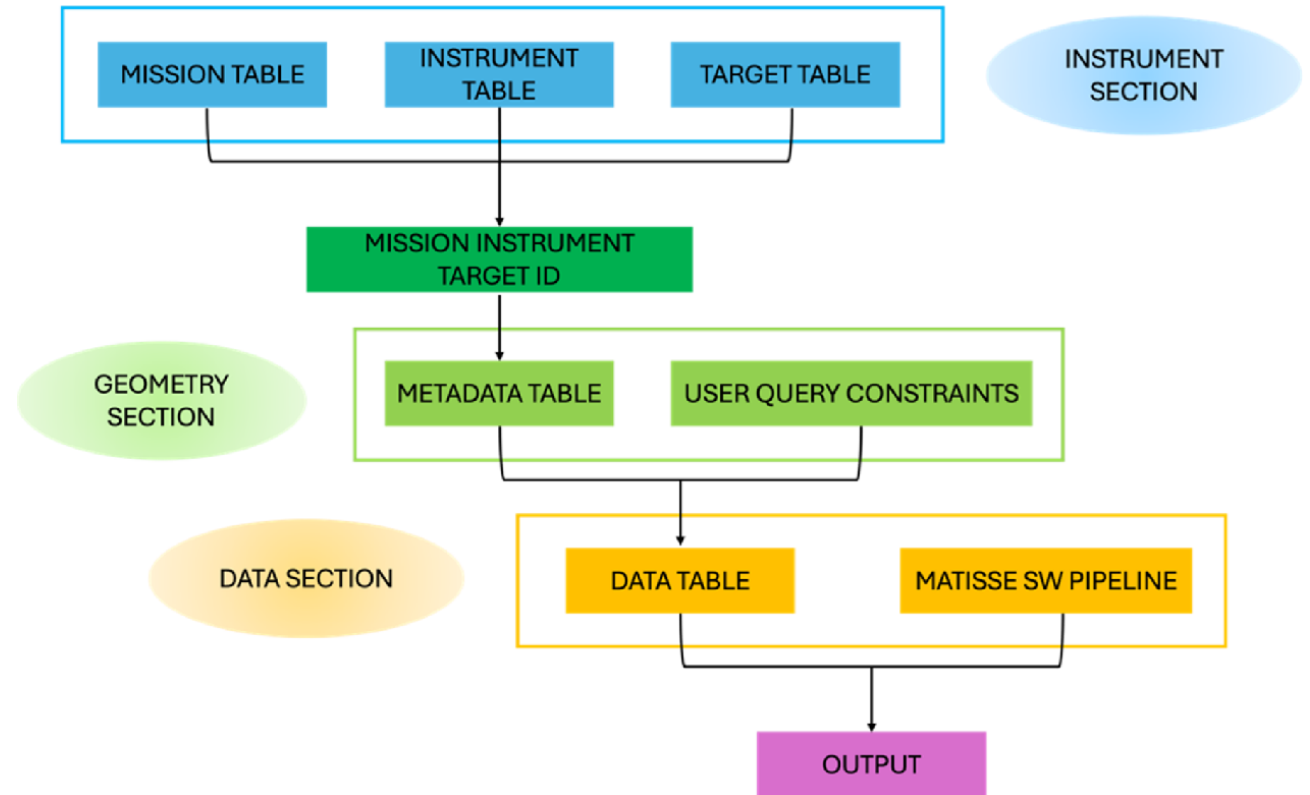- The 40-meter antenna enables pulse penetration several kilometers below the surface.
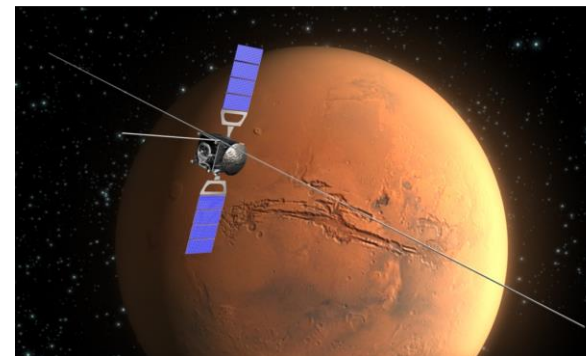
Mars Express' MARSIS Radar Deployed Over Mars
ESA -ASI (2016)

Multi-purpose Advanced Tool for Instruments for the Solar System Exploration (MATISSE)

– Online tool for space data collection and analysis developed by Italian Space Agency (ASI).

– I will use MATISSE for data collection and analysis.

– Since its first version in 2013 the tool has grown, improving its scientific capabilities and including new targets, missions and instruments.

– During data collection, I will apply FAIR data storage standards,

– These principles will enable cataloging the data at the Space Science Data Center (SSDC), ensuring they are preserved and accessible for future analysis and research.

MATISSE workflow

Camplone V., et al. (2024)

MATISSE

A new DBMS

The PostgreSQL + PostGIS solution allows to correctly manage spatial queries, improving spatial interpolation between

Integration with advanced scientific codes

HPC + Artificial Intelligence

A new version of the tool to overcome fundamental issues
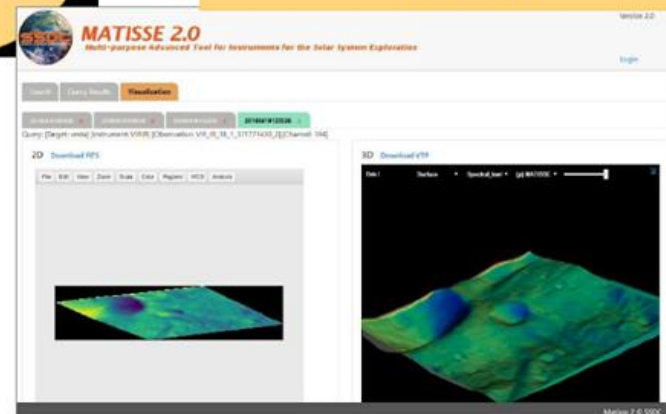
User-friendly interface

Planetary FITS and VTP files allow 2D/3D interactions on the web

It is possible to execute complex queries by command-line and not only by browser

Servlet based

Zinzi A.

Summary

Background

- Morphological analysis
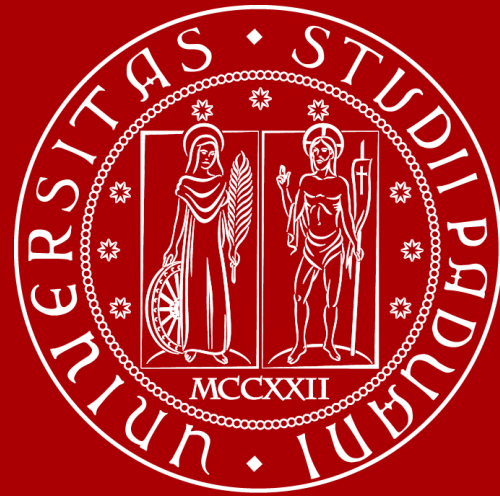- Statistical analysis

Topics

- Terraced craters
- Floor-fractured craters
- Age determination

Instruments and tools

- Colour and Stereo Surface Imaging System (CaSSIS)
- Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS)
- Multi-purpose Advanced Tool for Instruments for the Solar System Exploration (MATISSE)

Thanks for the attention

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