

# The Importance of Geodetically Controlled Data Sets: THEMIS Controlled Mosaics of Mars, A Case Study

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Astrogeology Science Center

Planetary Science Informatics and Data Analytics International Conference

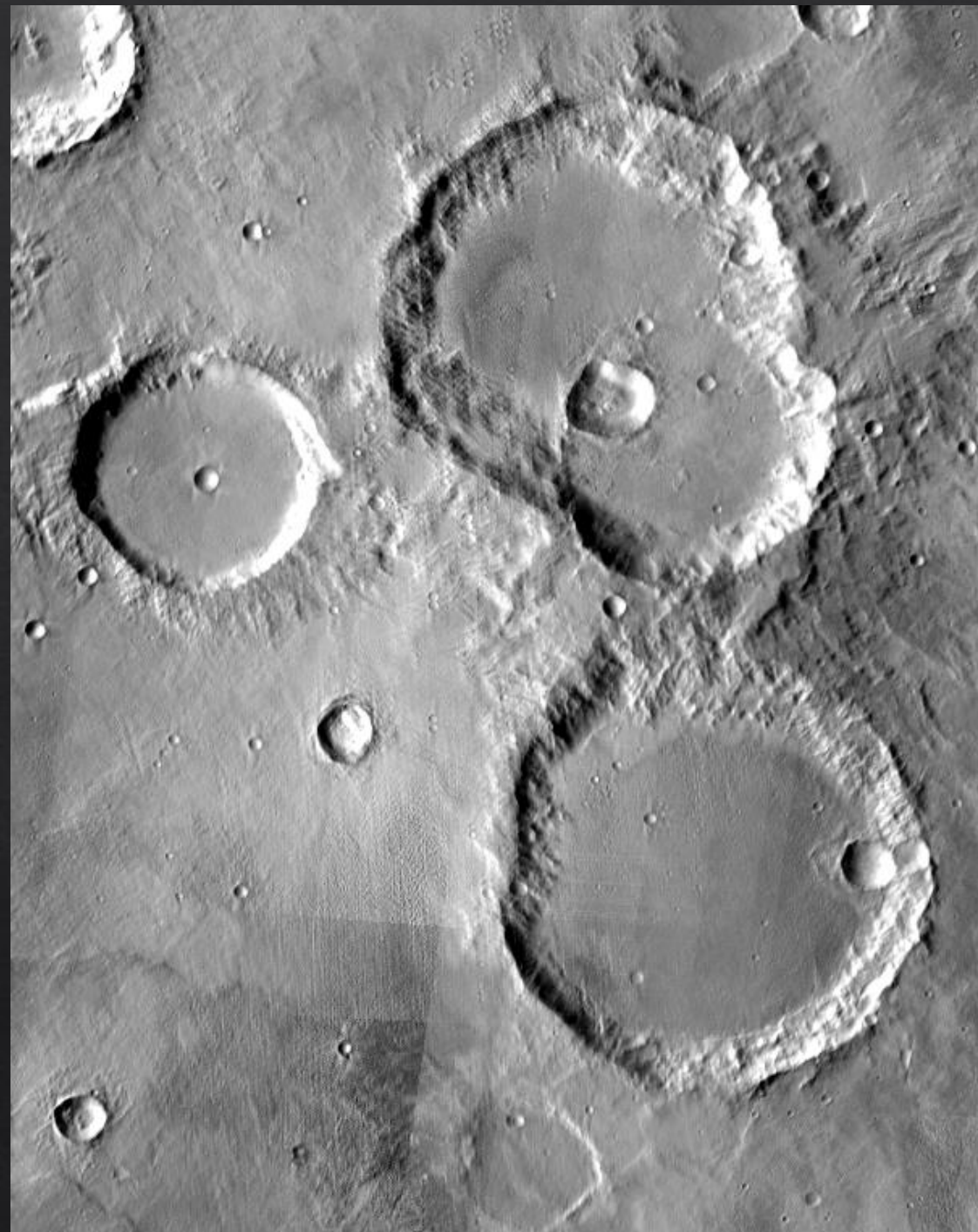
April 26, 2018

# Why Control?

- ◇ Geodetically controlled products are foundational data products.
  - ◇ Errors / uncertainties are quantified at local scales.
  - ◇ Tied to a legitimate base map.
  - ◇ Updated kernels are generated
- ◇ When do you want to use a controlled product?
  - ◇ Geologic mapping
  - ◇ Entry, landing, and descent evaluations for lander mission
  - ◇ Mission planning and coordination
  - ◇ Change detection studies
  - ◇ Fusion of multiple data sets

Iapygia  
14.8 S, 72.9 E

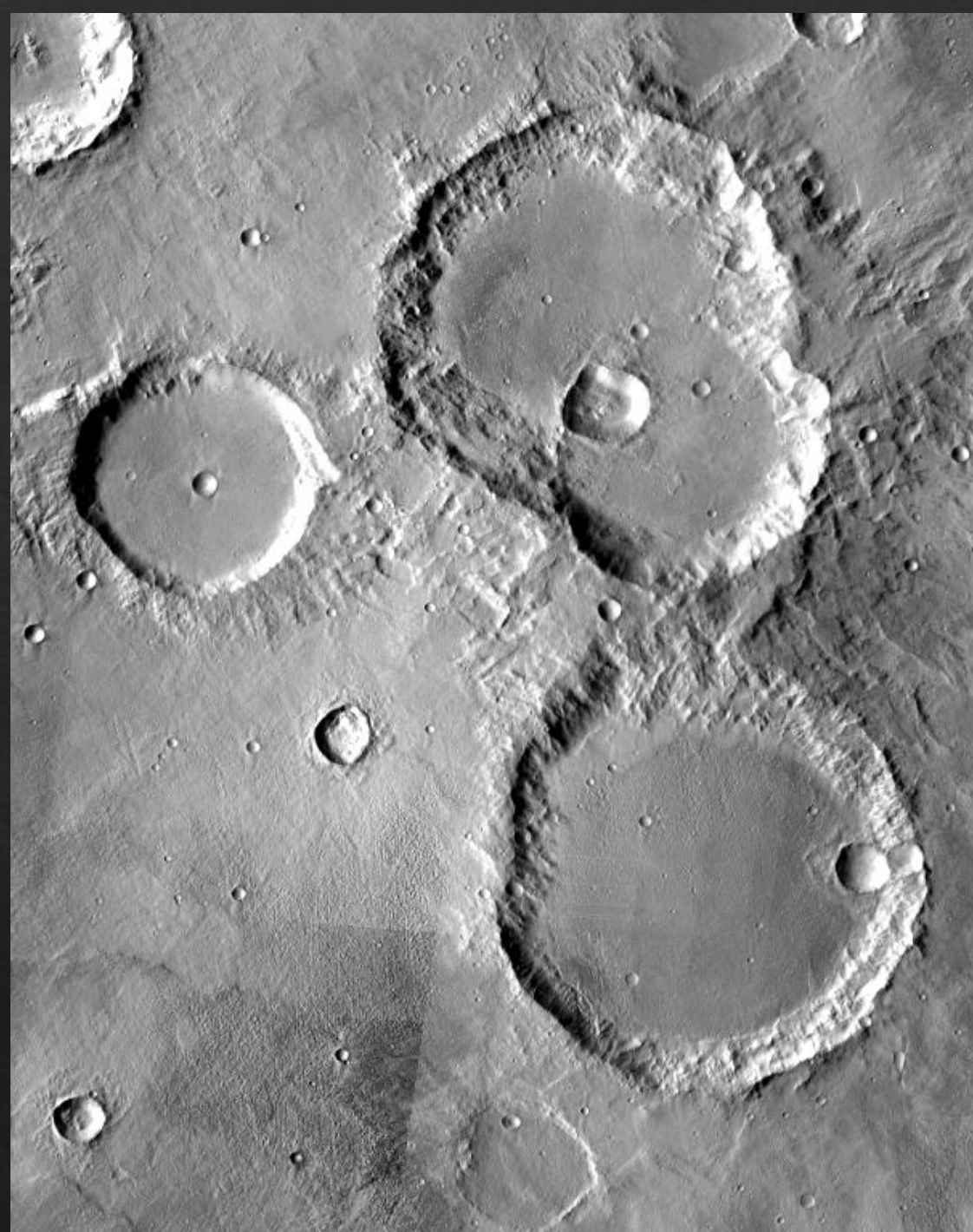
10 pixel (~1  
km) shift



30 km

Iapygia  
14.8 S, 72.9 E

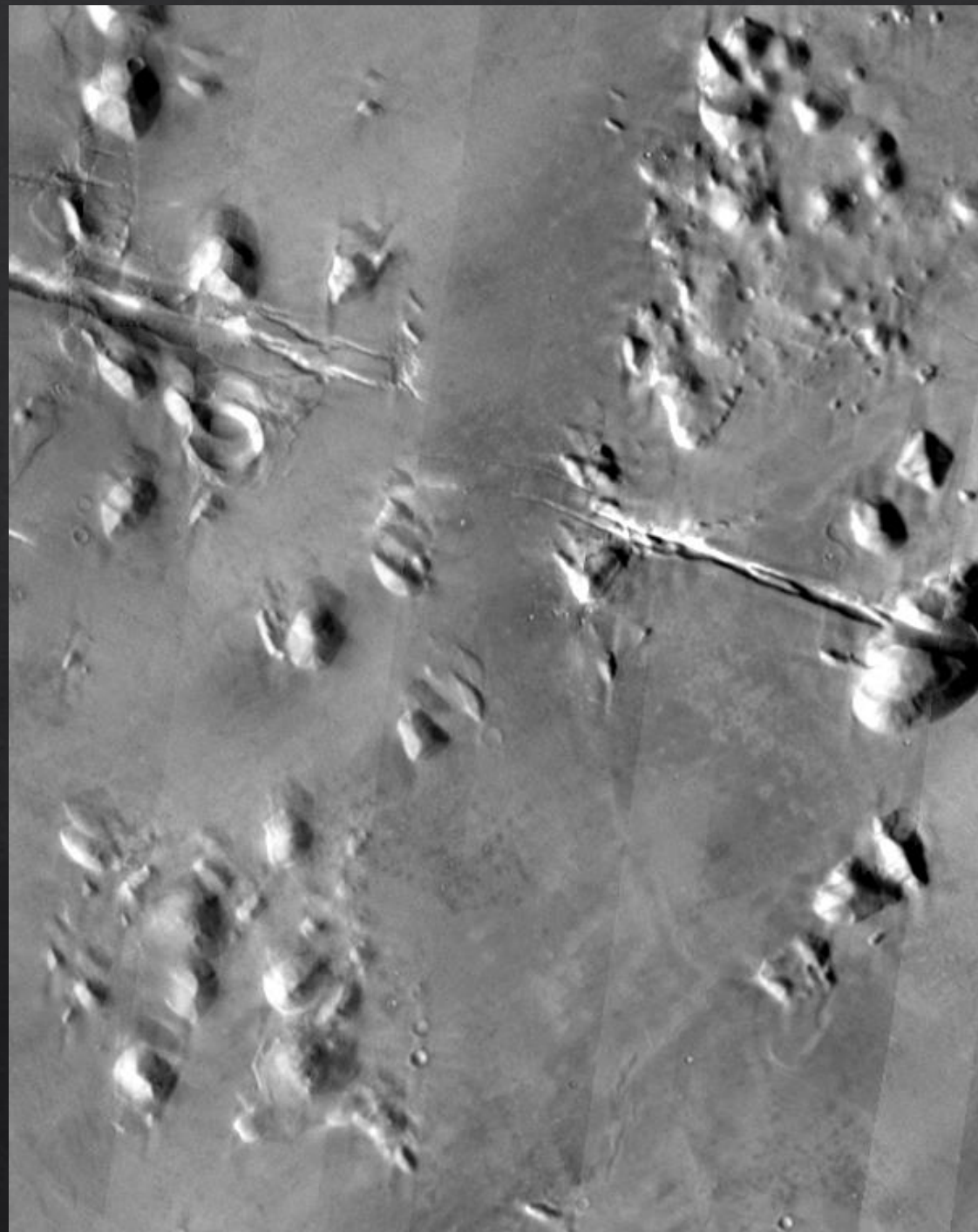
10 pixel (~1  
km) shift



30 km

Elysium  
15.4 N, 162.4 E

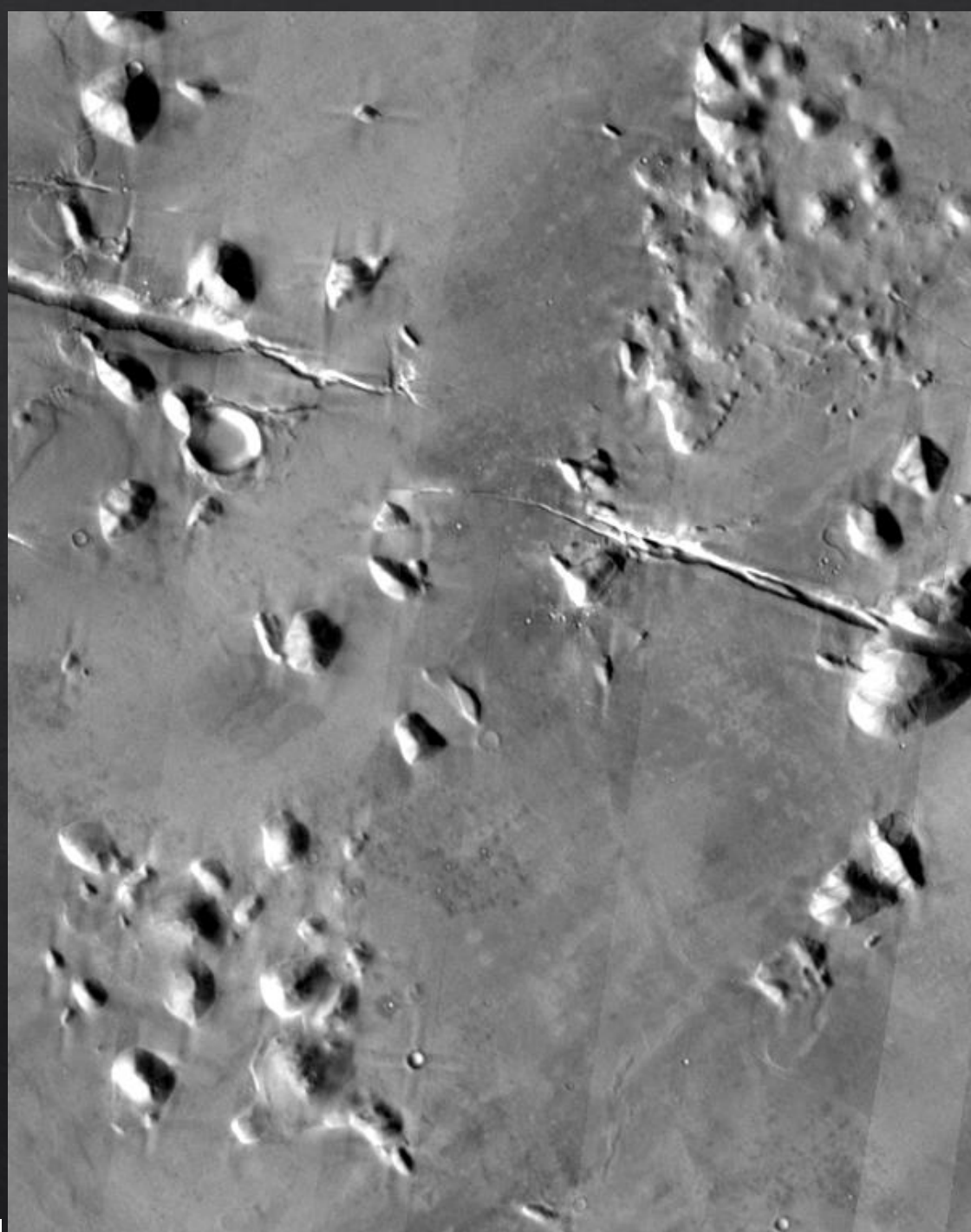
16-20 pixel  
(~1.6 to 2.0  
km) shift



10 km

Elysium  
15.4 N, 162.4 E

16-20 pixel  
(~1.6 to 2.0  
km) shift



10 km

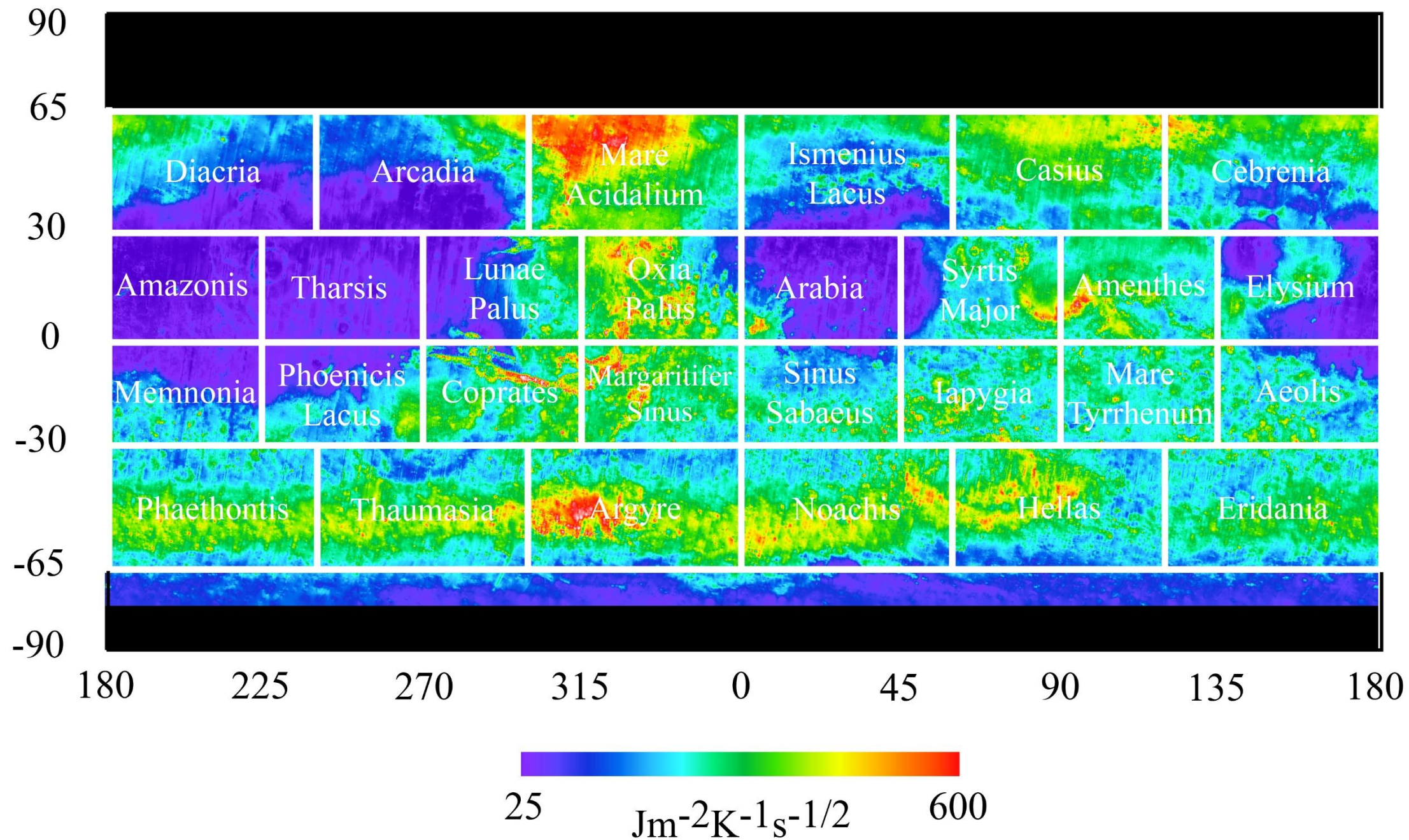
# THEMIS Instrument

- ◆ Spatial scale of 100 m per pixel
- ◆ Sensor type = Line-scan imager
- ◆ Mapping priority was to obtain global coverage, not with the intention of generating a controlled product.
- ◆ Images were acquired both during the day and at night.



*Image credit: ASU/Christensen et al., 2004*

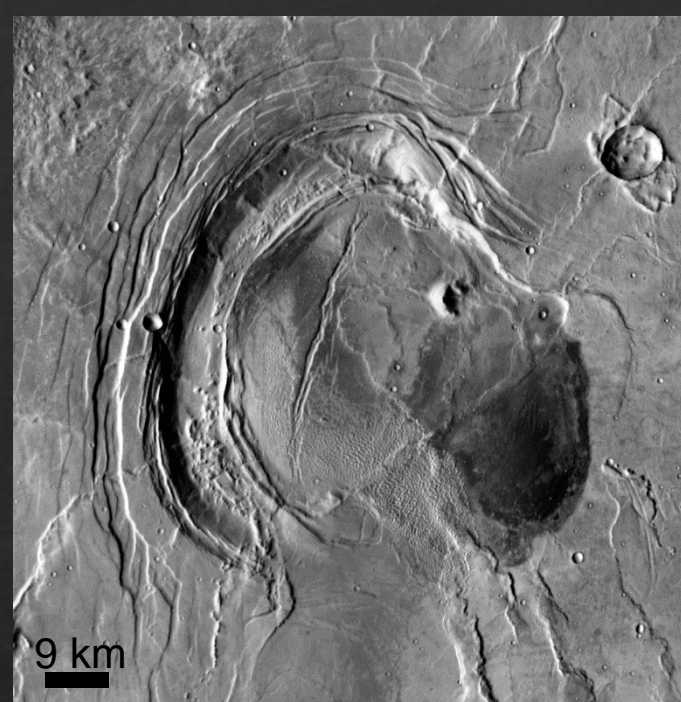
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# Methods and Data

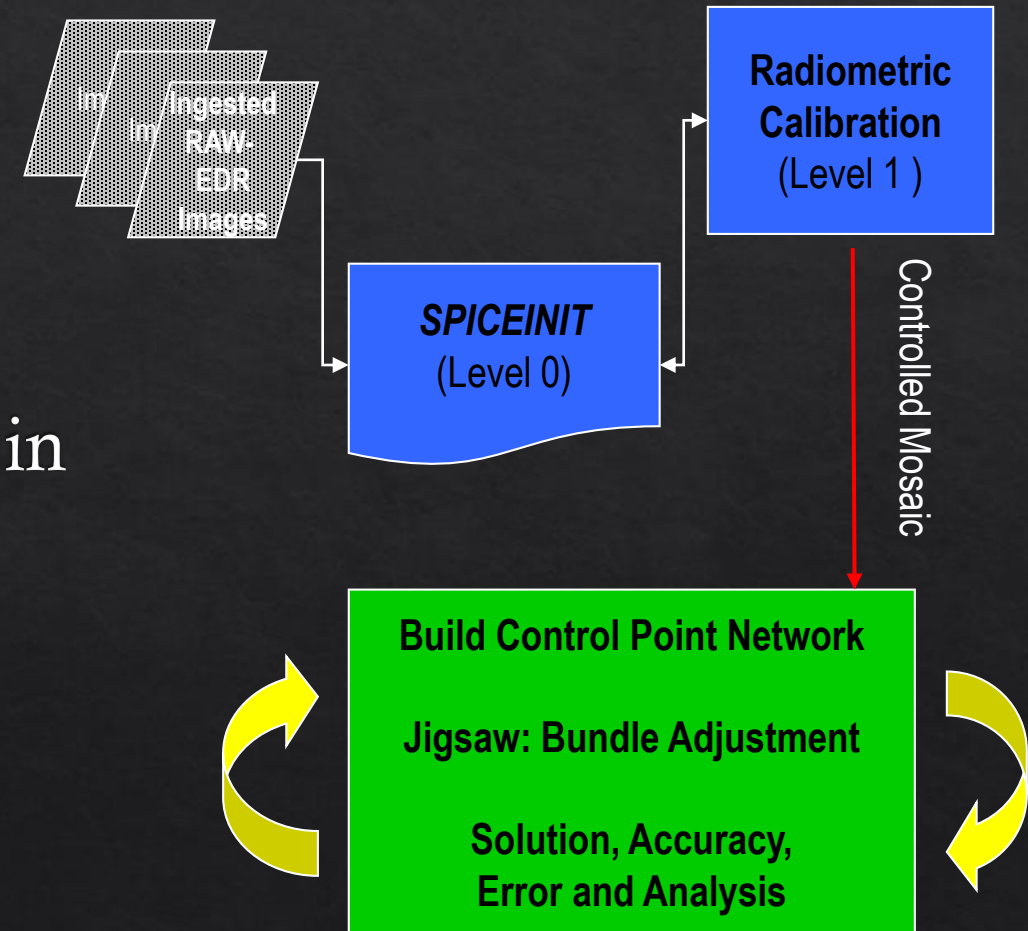
- ◆ This is one of the first global controlled products made with ISIS3
- ◆ Software
  - ◆ Jmars to identify and constrain THEMIS image list.
  - ◆ ISIS3 to generate the control network.
  - ◆ Davinci to process THEMIS data and generate the controlled mosaics.
  - ◆ ArcGIS to visually inspect each mosaic.
- ◆ Ground Control
  - ◆ Current accepted ground data source for Mars is the MOLA DEM.
  - ◆ Tied to the Viking MDIM network, which is tied to the MOLA DEM.



Nili Patera - Daytime IR (upper) and nighttime IR (lower); 8.9 N, 67.2 E

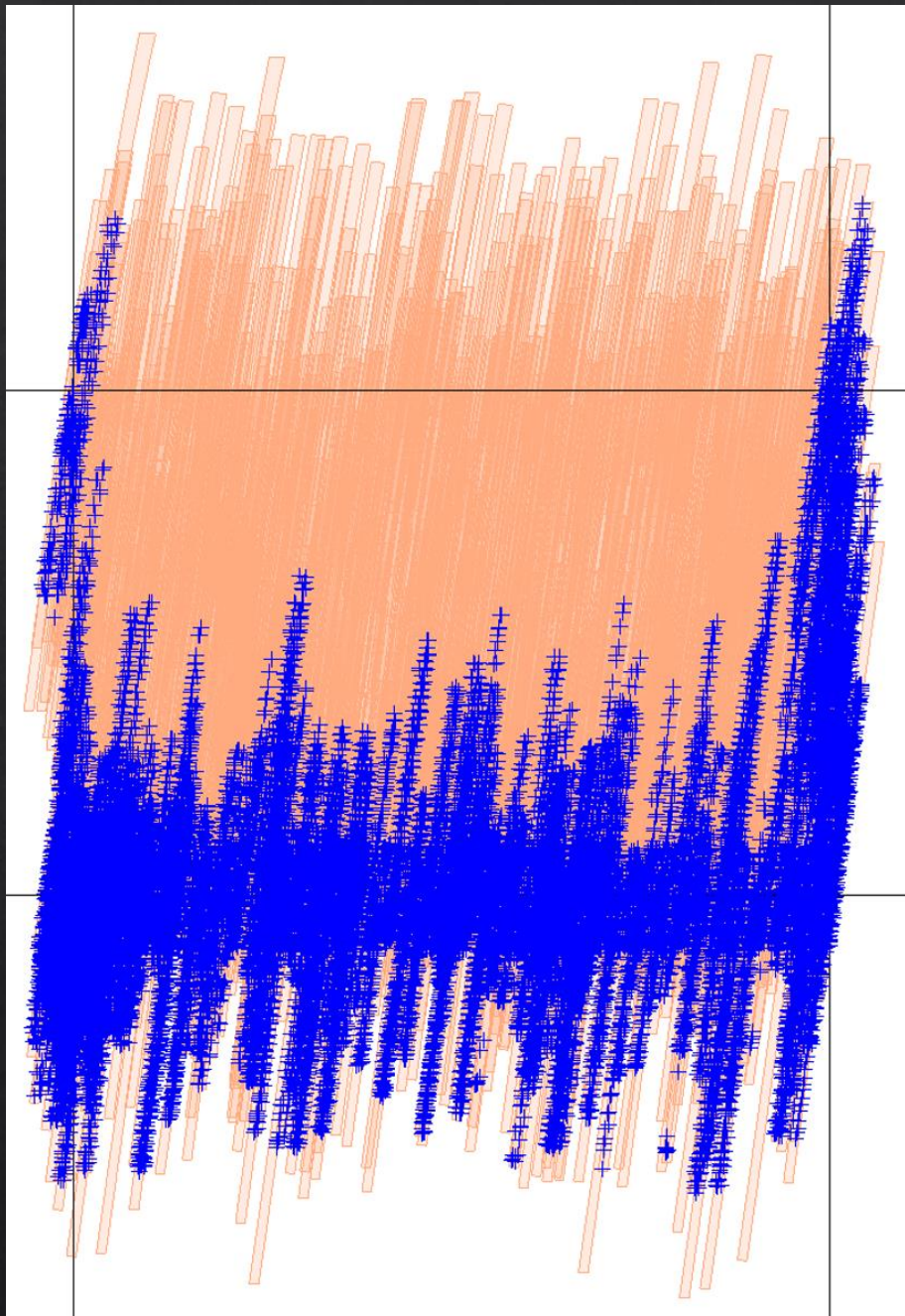
# Workflow Overview

- ◆ Identify suitable images by constraining on various parameters (Jmars)
- ◆ THEMIS image processing (ISIS3/Davinci)
- ◆ Assemble the control network (ISIS3)
- ◆ Run bundle adjustment (iterative process in ISIS3)
- ◆ Tie to ground (ISIS3)
- ◆ Write out updated image and spacecraft kernels (ISIS3)
- ◆ Generate controlled mosaics (davinci)

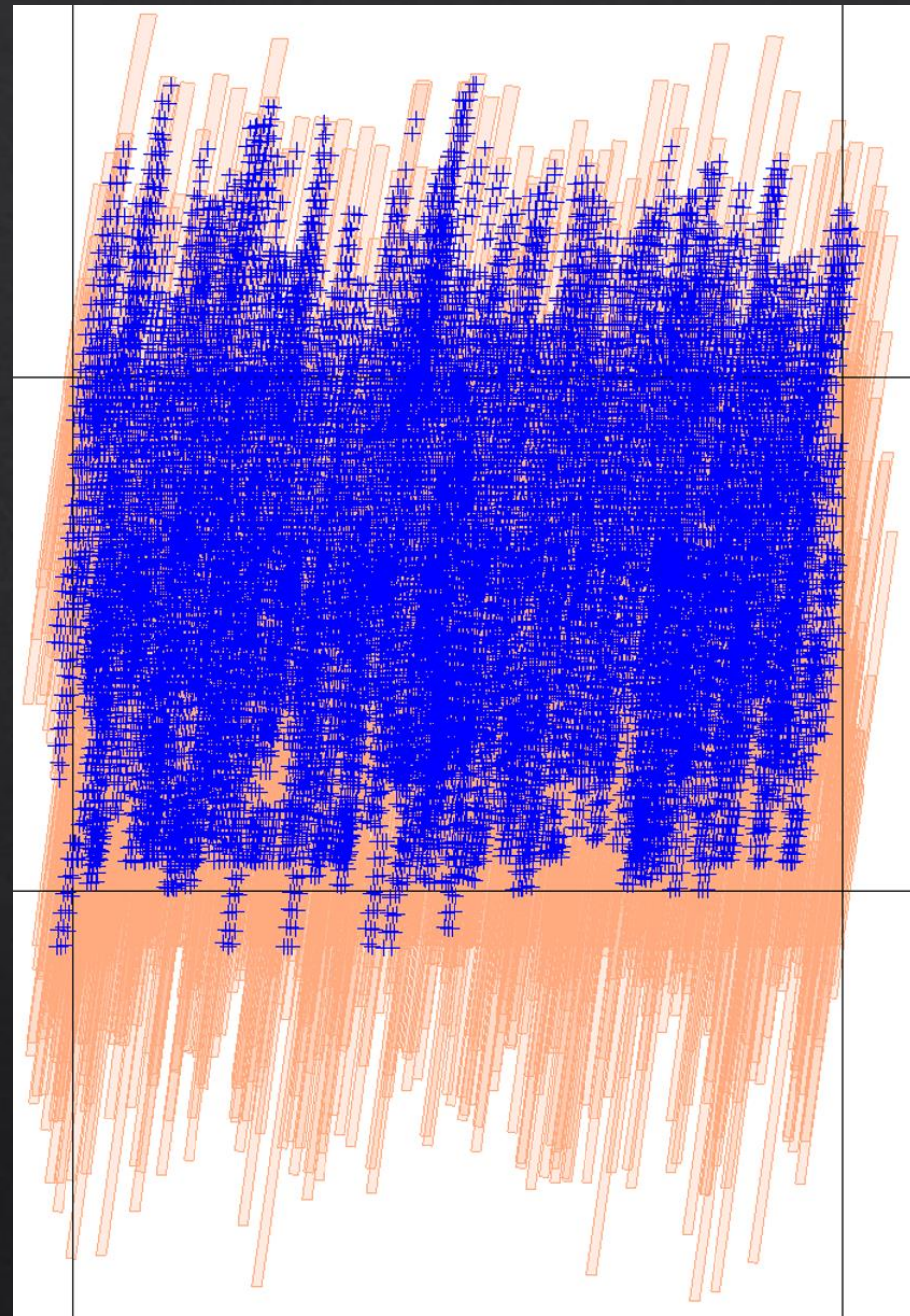


# Workflow: Control Network Assembly

- ◆ Two processes were used to generate the control networks:
  - ◆ Utilizing existing points in the merged network
  - ◆ Creating new points and measures
- ◆ Merge these two networks into a single, cohesive network that we pass to the bundle adjustment program.



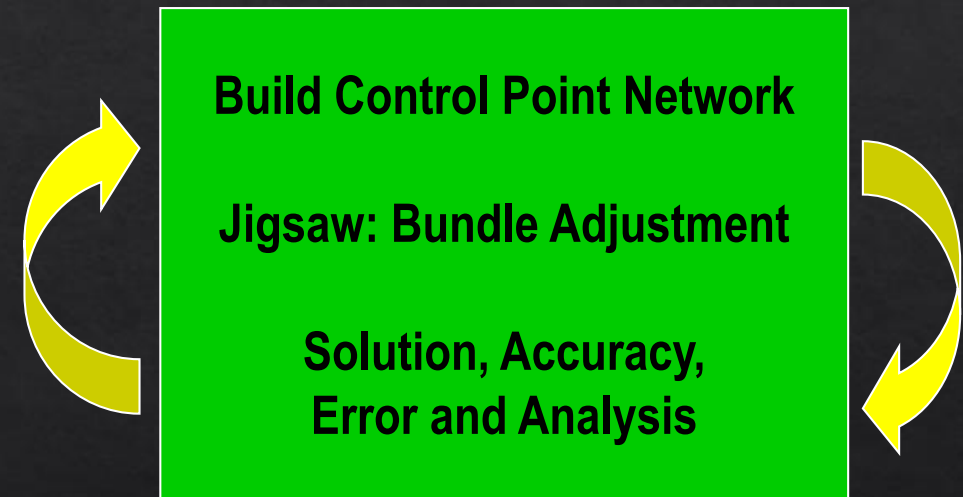
Utilizing Existing Points from the Merged Network

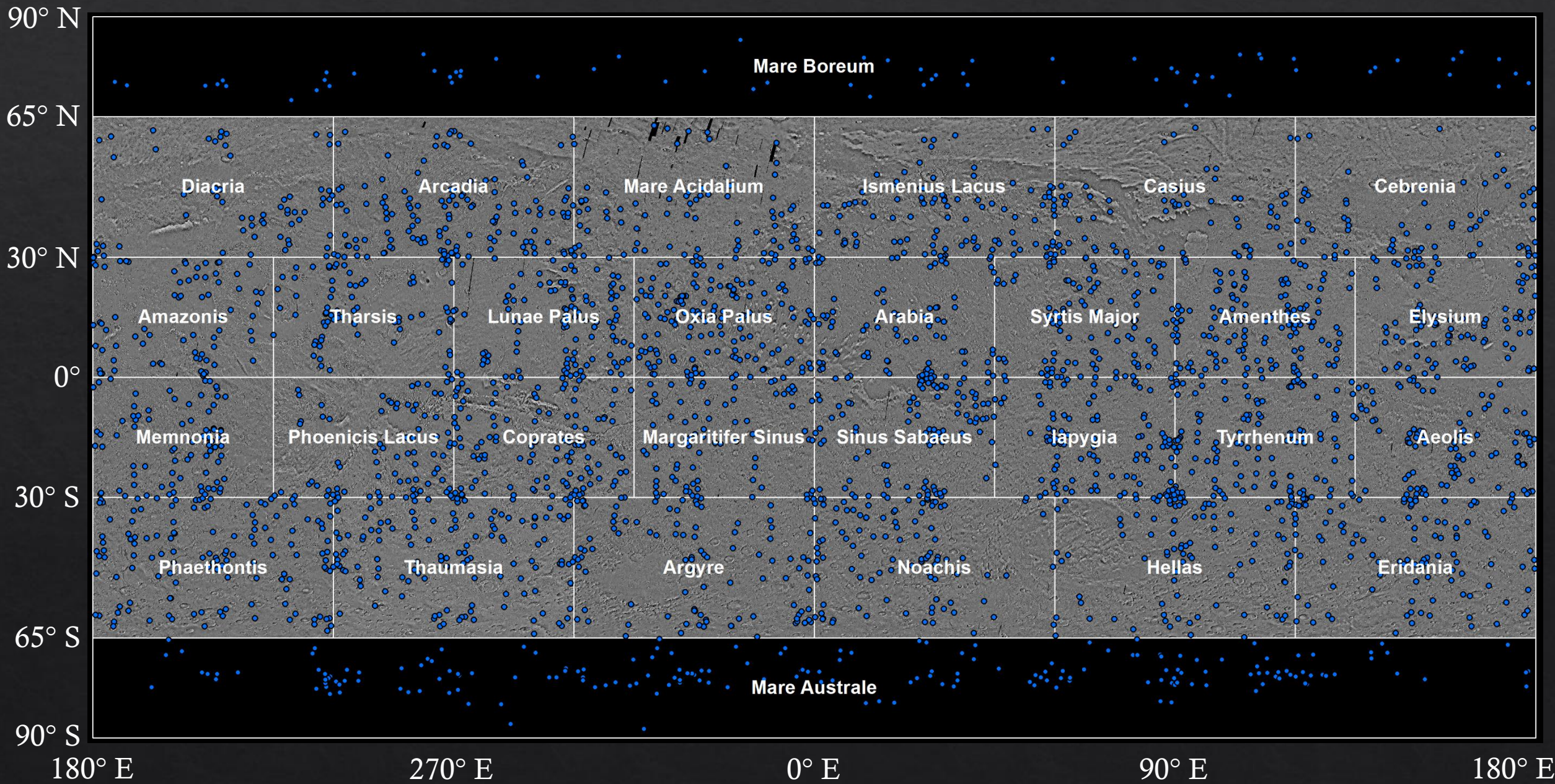


Creating New Points and Measures

# Workflow: Bundle Adjustment

- ◆ Evaluate the health of the network
  - ◆ Identify images with zero or few points
  - ◆ Identify islands
- ◆ Run bundle adjustment
  - ◆ Evaluate the results
  - ◆ Remove high residual measures
  - ◆ Re-evaluate the health of the network
  - ◆ Re-run bundle adjustment
- ◆ We tie the network to the Viking MDIM, which is tied to MOLA.

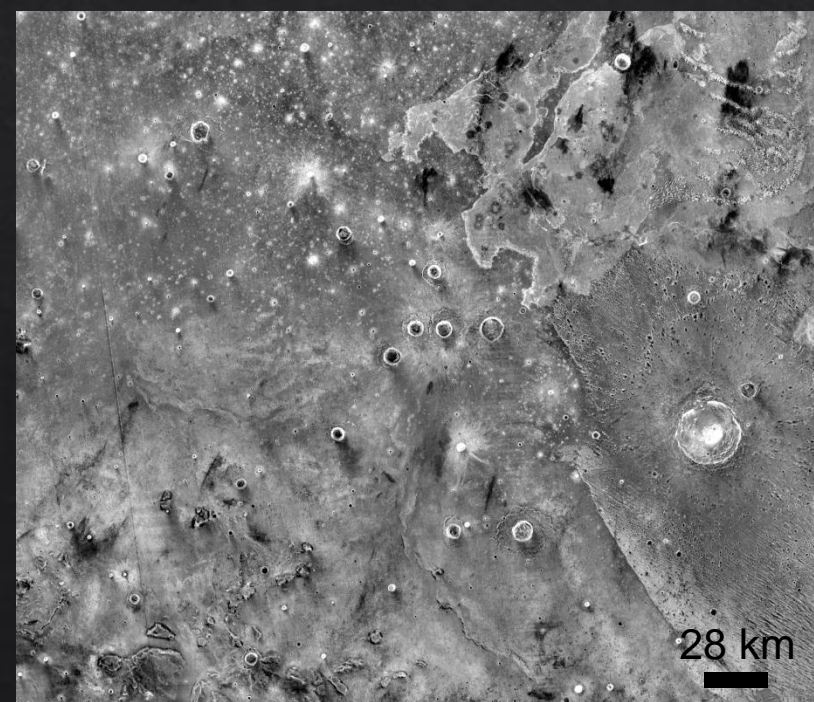




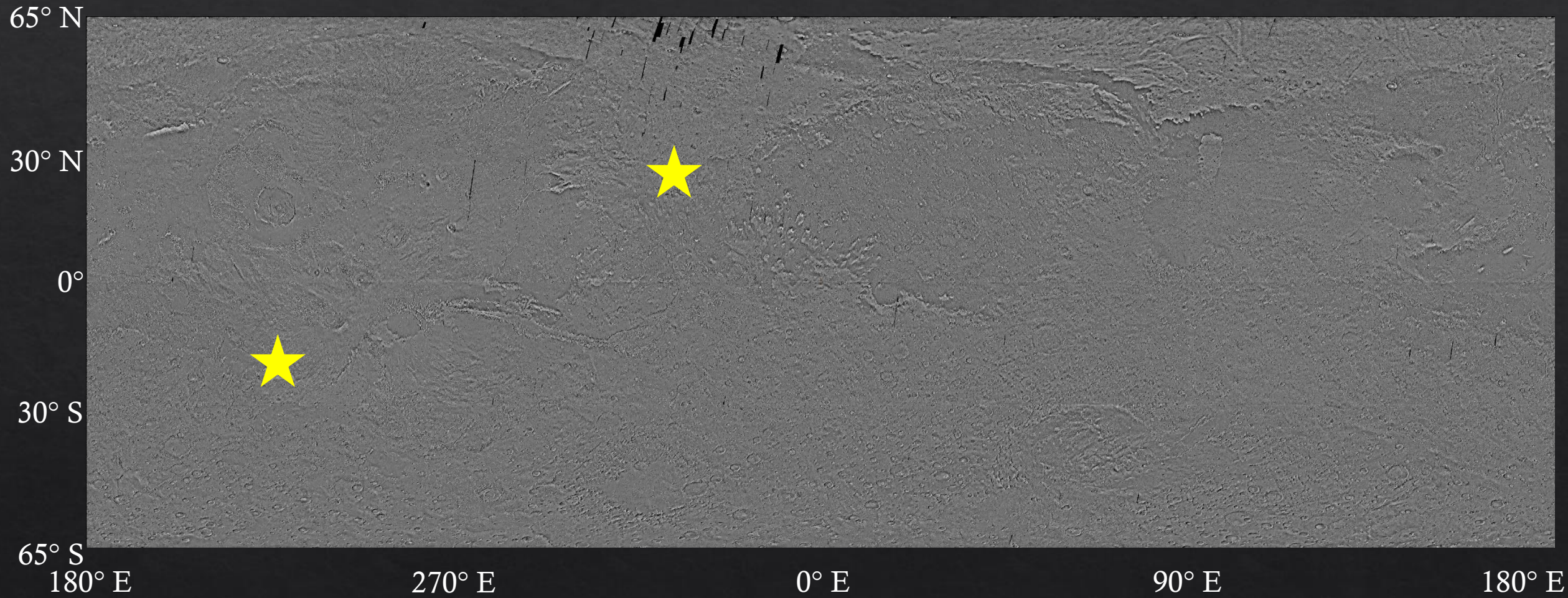
# Accuracy

- ❖ Horizontal accuracy is *60-390 meters*
- ❖ 0.6 to 3.9 pixels

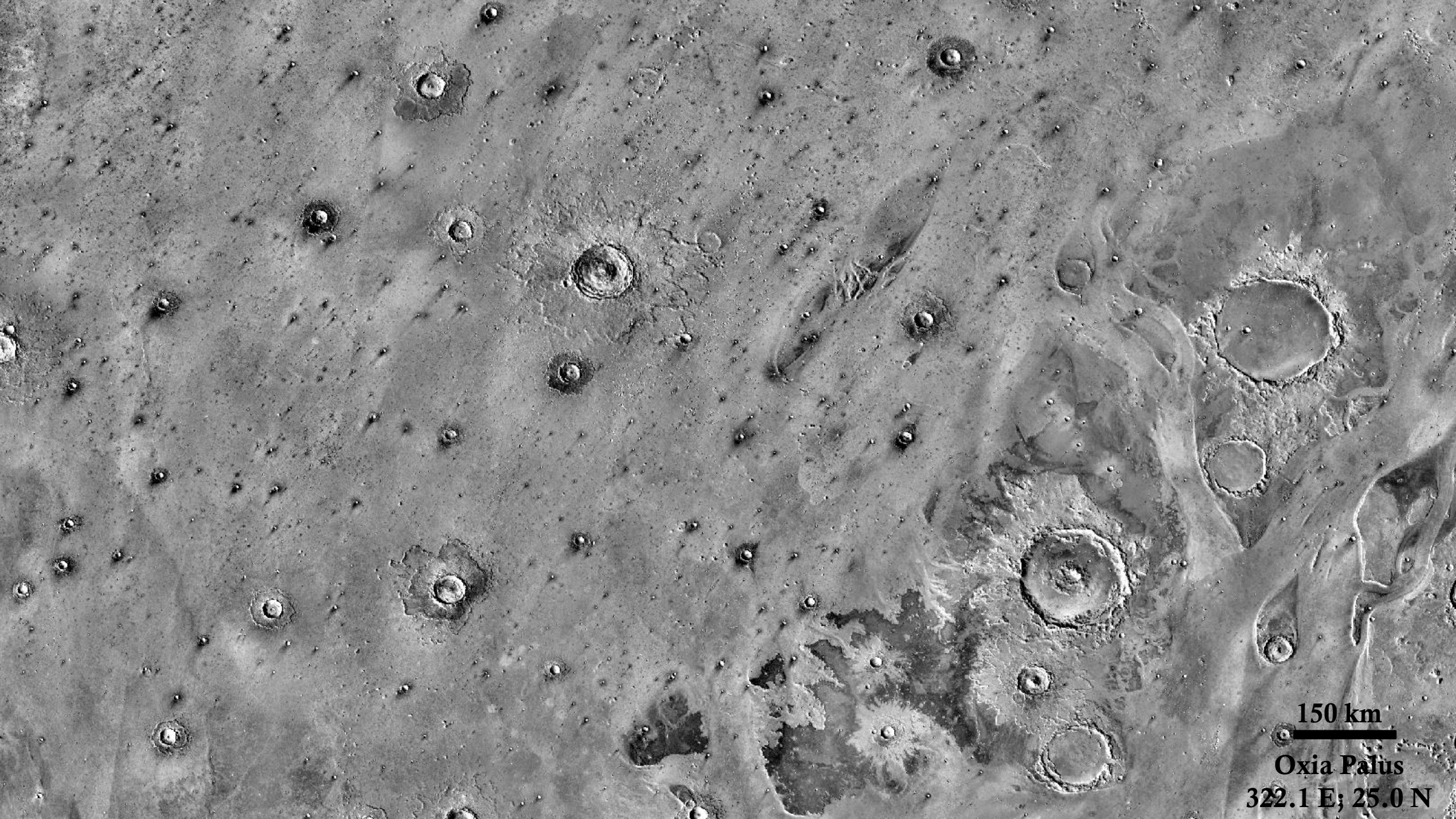
If you do not control your data, you have no idea about the accuracy of your product.



Elysium Planitia - Daytime IR (upper) and nighttime IR (lower); 3.7 N, 138.0 E



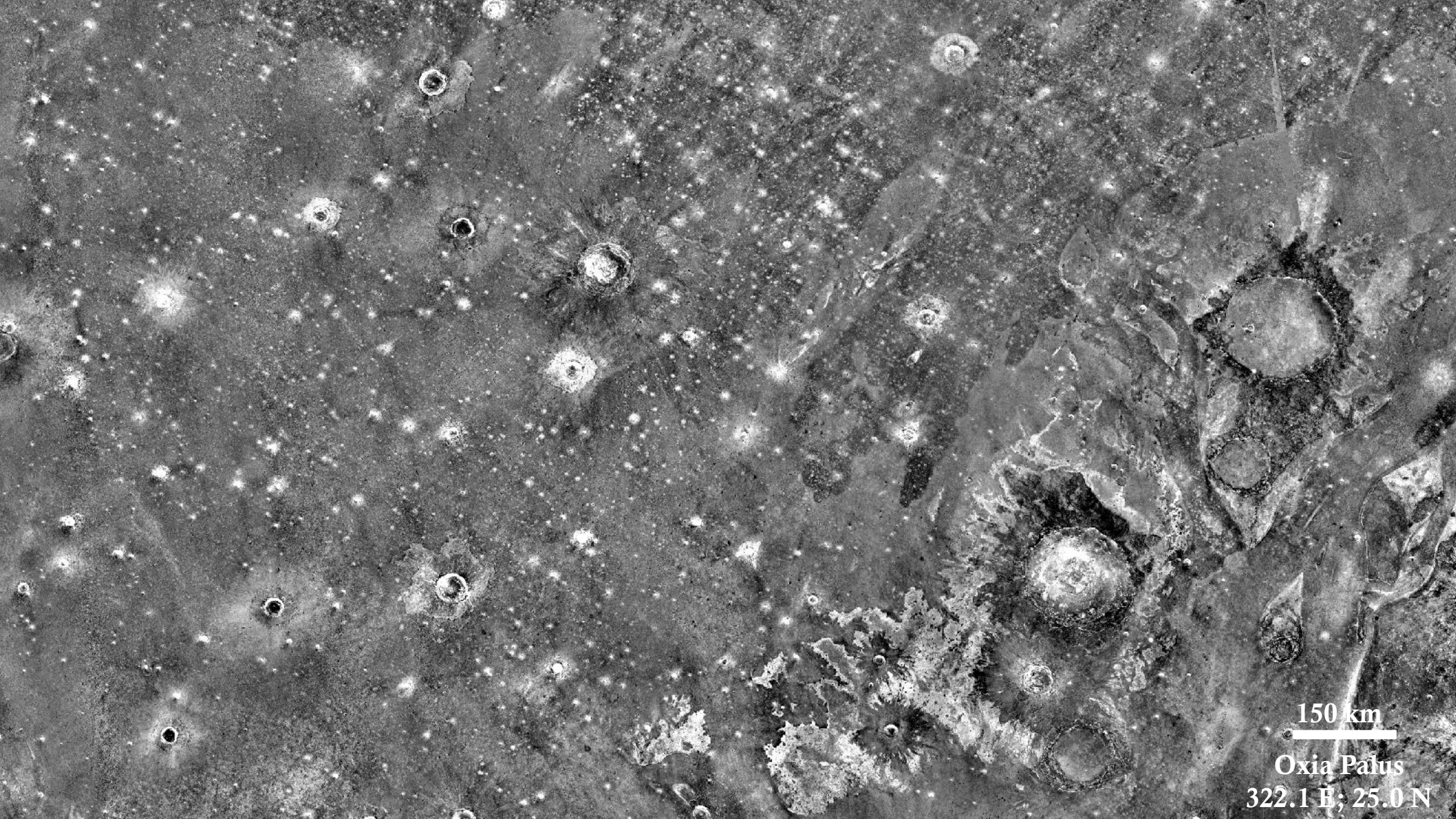




150 km

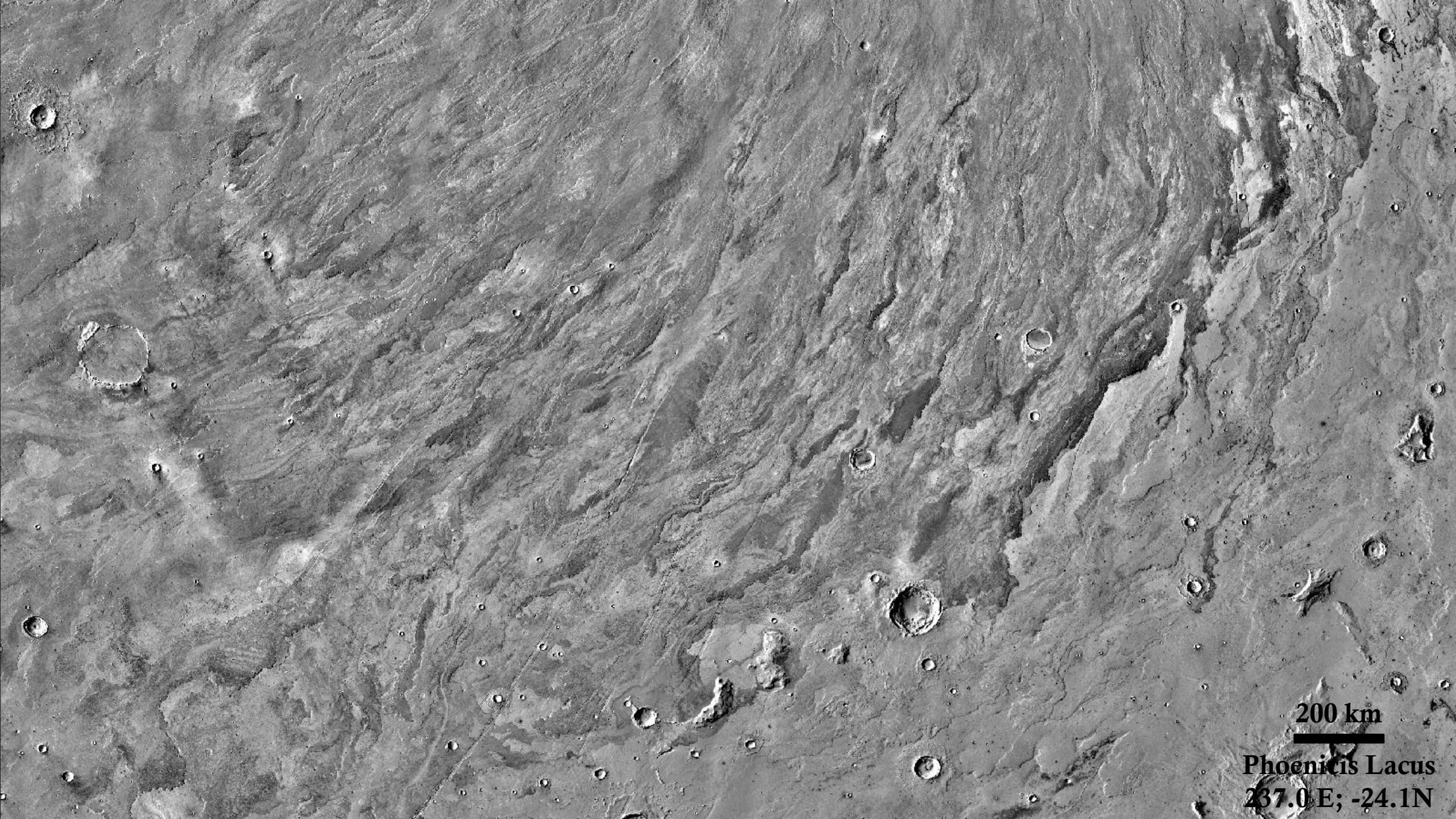
Oxia Palus

322.1 E; 25.0 N



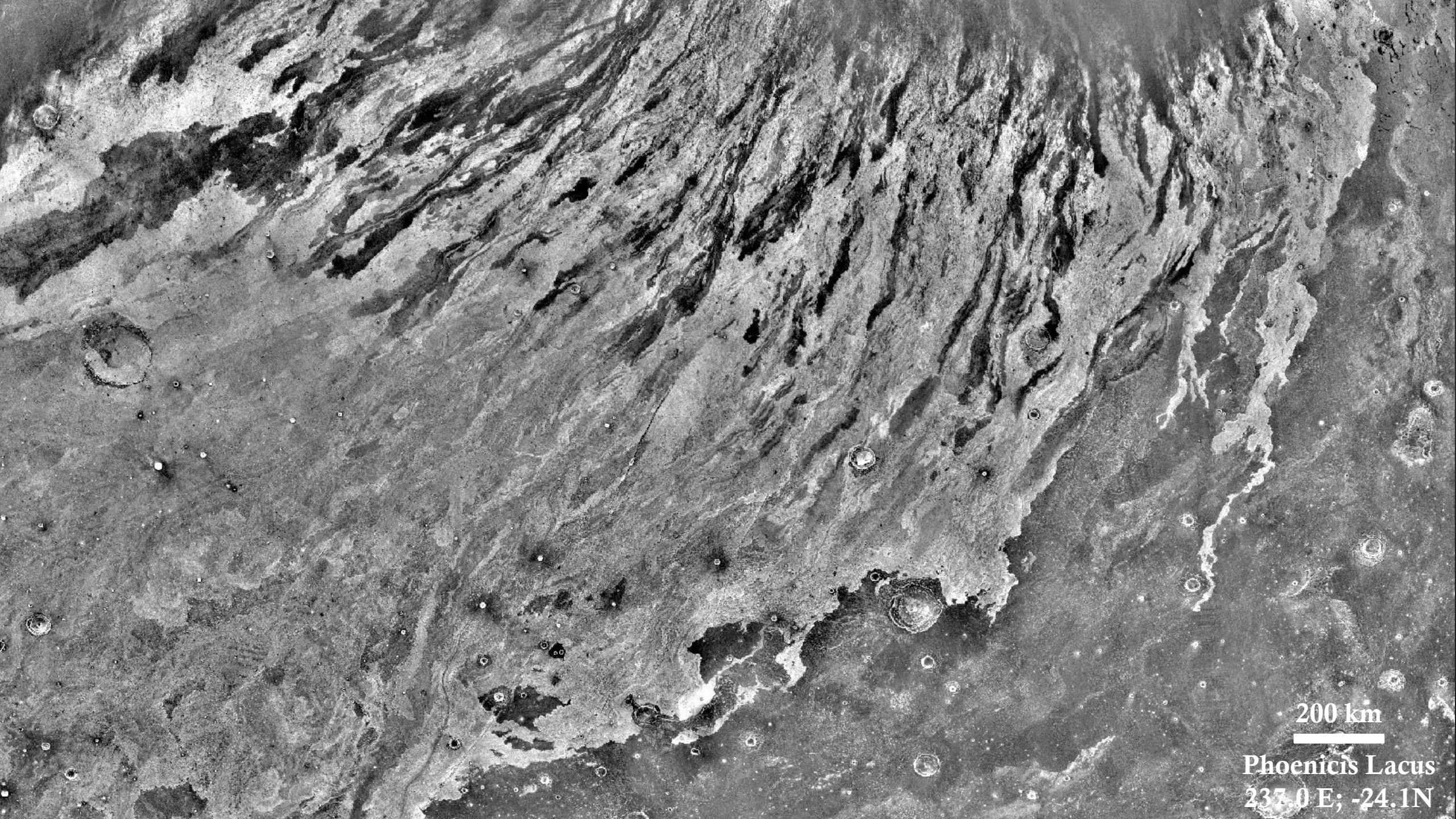
150 km

Oxia Palus  
322.1 E; 25.0 N



200 km

Phoenix Lacus  
237.0 E; -24.1 N



200 km



Phoenicis Lacus  
237.0 E; -24.1N

# Product Availability

- ◆ Products that are available from:
  - ◆ PDS Annex  
<http://astrogeology.usgs.gov/>
  - ◆ Custom layer in Jmars.
- ◆ Products:
  - ◆ Kernel files describing these improvements for each image in the control network.
  - ◆ Controlled, orthoprojected daytime IR and nighttime IR mosaics of Mars at 100 m/pixel scale for the  $\pm 65^\circ$  latitude region of Mars.
- ◆ Image mosaic formats:
  - ◆ GeoTiff format with available ISIS3 and PDS3 labels.
- ◆ Final mosaics will be available in September 2018.

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ASTROPEDIA Product Details

Annex NASA PDS and Derived Products

Download

- Maximum Size (jpg)
- Sample (jpg) 1024px wide
- Original (tif\*) (453 MB)

Back Mars THEMIS Day IR Controlled Mosaic Margaritifer Sinus 30S 315E 100 mpp

This product is an infrared image mosaic generated using Thermal Emission Imaging System (THEMIS) images from the 2001 Mars Odyssey orbiter mission. The mosaic is generated at the full resolution of the THEMIS infrared dataset, which is approximately 100 meters/pixel. The mosaic was registered horizontally to an improved Viking MDIM network that was developed by the USGS Astrogeology cartography group.

**Publisher:** USGS Astrogeology Science Center  
**Publication Date:** 31 January 2014  
**Author:** Robin Fergason  
**Originator:** USGS Astrogeology Science Center  
**Group:** PDS\*  
**Added to Astropedia:** 3 March 2014  
**Modified:** 27 November 2017

**General**

**Purpose:**  
This work is funded by the Planetary Geology and Geophysics (PGG) Cartography program to improve the registration of the THEMIS infrared dataset. These controlled mosaics and improved image pointing knowledge will positively impact both the work performed by the Astrogeology cartography group and a broad range of disciplines within the larger science community. Controlled THEMIS mosaics will benefit geologic mapping efforts (superior basemap\*), landed science operations (site characterization and traverse planning), and orbital observation planning (precision targeting). The control networks that result constitute a (potentially global) framework for the precision cartographic control of existing and future higher spatial resolution data products (e.g. CTX), and will allow the registration of historical data sets to be improved. In addition, the preliminary smoothed kernels will be very valuable to scientists and allow them to perform quantitative analyses with THEMIS images using improved pointing knowledge as well as the precision and accuracy of that knowledge.

**Geospatial Data Presentation Form:** [Raster Data](#), [Regional Mosaic](#)  
**Edition:** 1

**Online Linkage:**  
[https://planetarymaps.usgs.gov/mosaic/Mars/THEMIS\\_controlled\\_mosaics/MargaritiferSinus\\_DayIR\\_31Jan2014/THEMIS\\_DayIR\\_ControlledMosaic\\_MargaritiferSinus\\_30S315E\\_100mpp.tif](https://planetarymaps.usgs.gov/mosaic/Mars/THEMIS_controlled_mosaics/MargaritiferSinus_DayIR_31Jan2014/THEMIS_DayIR_ControlledMosaic_MargaritiferSinus_30S315E_100mpp.tif)

**Ancillary Products**

- CK Kernel (bc) 17 MB
- Metadata\* (xml) 15 kB
- Kernel File List (txt) 17 kB
- Kernel Summary (txt) 957 kB
- Mosaic File List (txt) 13 kB
- ISIS3 Label (lbl) 1 kB
- PDS3 Label (lbl) 2 kB

**Related Products**

- [THEMIS Day IR Controlled Mosaic Eridania 65S 120E 100 mpp](#)  
This product is an infrared image mosaic generated using Thermal...
- [THEMIS Day IR Controlled Mosaic Thaumasia 65S 240E 100 mpp](#)  
This product is an infrared image mosaic generated using Thermal...
- [THEMIS Day IR Controlled Mosaic Phaethontis 65S 180E 100 mpp](#)  
This product is an infrared image mosaic generated using Thermal...
- [THEMIS Day IR Controlled Mosaic Cebrenia 30N 120E 100 mpp](#)  
This product is an infrared image mosaic generated using Thermal...

# Acknowledgements

- ◆ Constructive proposal reviews from Frank Seelos (APL), Wes Patterson (APL), Ross Beyer (Ames), and others.
- ◆ Contributions early in the project from Ella Lee (USGS) and Orin Thomas (USGS), particularly with improvements to the Viking MDIM network.
- ◆ Helpful conversations with Jeff Anderson (USGS), Tammy Becker (USGS), Brent Archinal (USGS), Kenneth Edmundson (USGS), Kimberly Murray (ASU), and Christopher Edwards (NAU).
- ◆ Ingestion of the product into JMars by the Mars Space Flight Facility at ASU, and particularly Dale Noss and Scott Dickenshied.
- ◆ Funding from the NASA – USGS Interagency Agreement.