GIS on Mars

Final Project

SCI 225

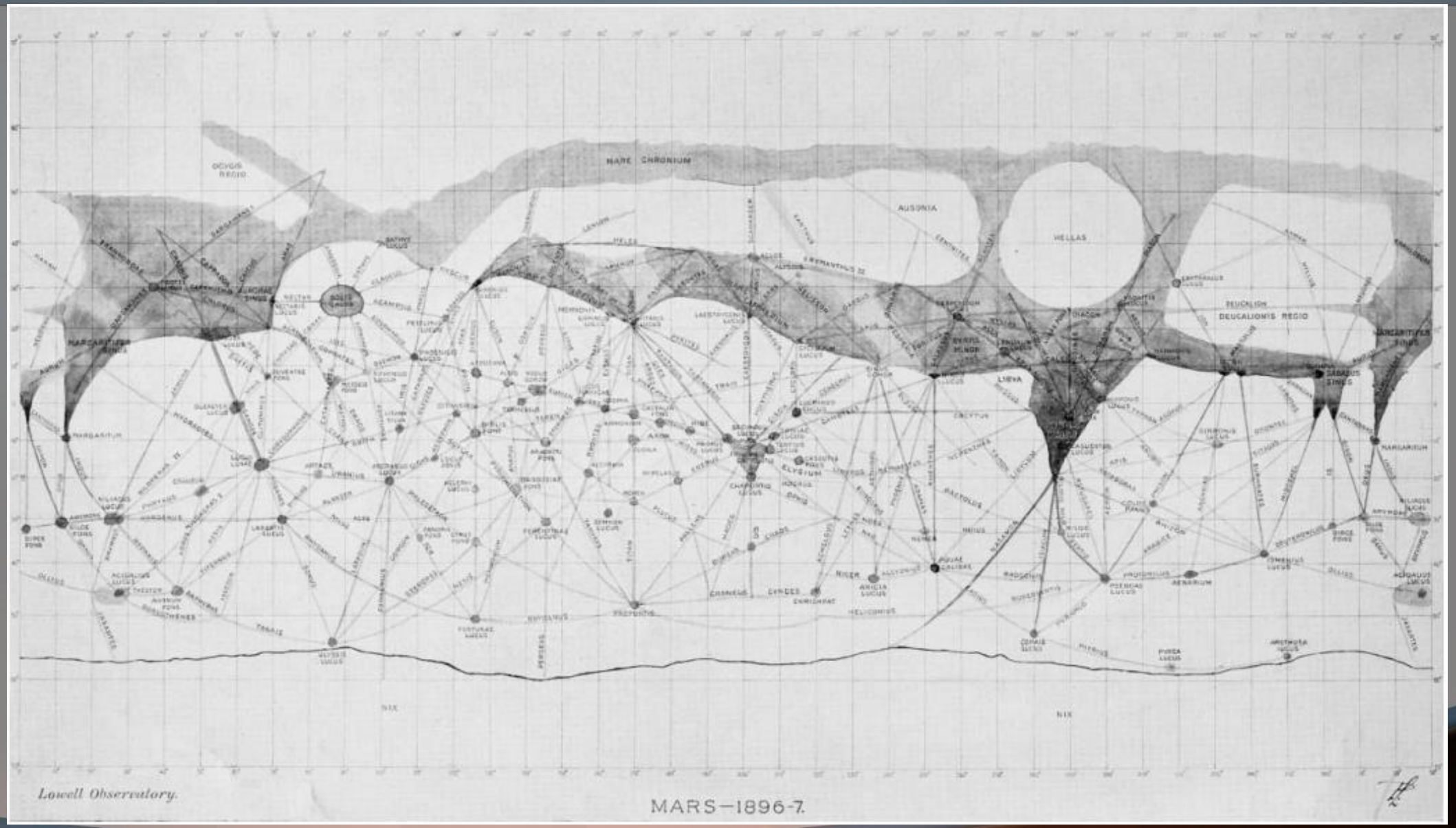
Betsy McCall

GIS on Mars

History

Cartography of Mars in History

- Mars has fascinated humans throughout history
- Early telescope views suggested to humans features that didn't really exist
- *Canali* (channels) became canals, which implied intelligent civilization
- A century of speculation was dashed by the first Mariner spacecraft to arrive at Mars (Library of Congress, n.d.)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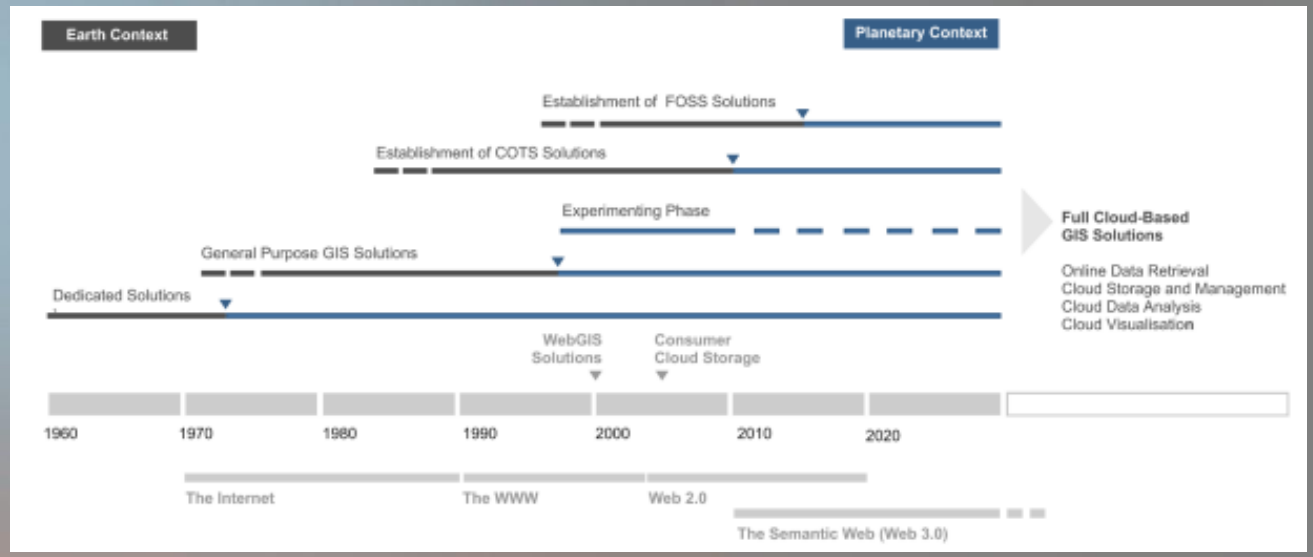
Lowell Observatory.
MARS—1896-7.

Evolution of Martian Cartography

- Mars had its first spacecraft flyby in 1965
- It has received regular mapping missions since then (Howell & Stein, 2022)
- Mars and the Moon are the most visited objects in the Solar System except for the Earth
- Mars mission failures are also rather common
- Resolution of orbital missions increases steadily

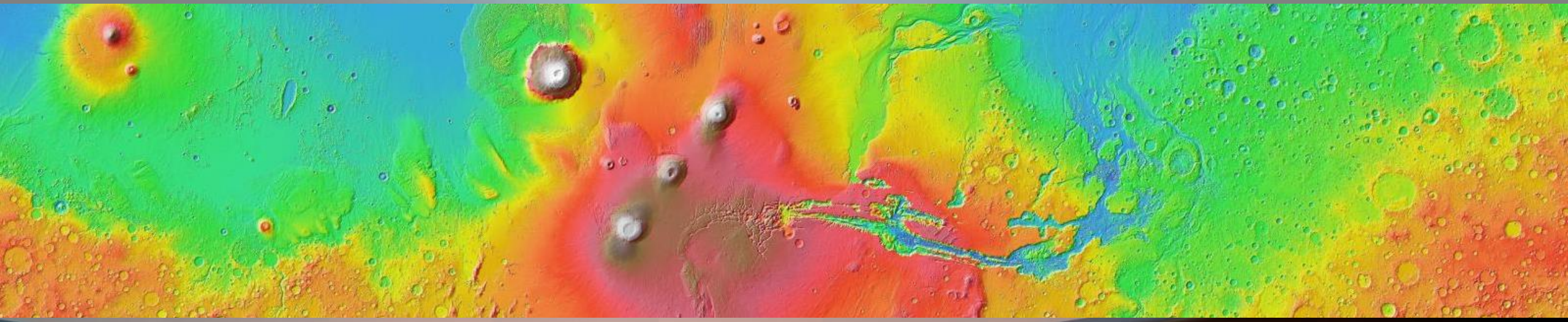
Planetary Information Systems

- Applying GIS technologies to planetary study got off to a slow start
- It is considered to be roughly 10-15 years behind Earth-based GIS
- Planetary GIS began to gain popularity to help manage data sets from the various Mars missions (Gasselt & Nass, 2021)
- There is a lack of a critical mass of users to push the process along



Google Mars

- Digital Elevation maps have taken us beyond 2D photographs
- It’s now possible to generate 3D movies skimming the surface of Mars
- Maps can make a place more real even when we’ve never been there (Messeri, 2017)



Maps of the Surface Drive Exploration

Landers

- Where can we safely put a stationary lander on Mars where it can land and still do good science?

Rovers

- Where can we land a rover that is safe to land, but is close to interesting geology?

Helicopters

- The latest mission has a helicopter making terrain less of an issue

- New techniques are developed for combining overhead camera information with on-ground camera information
- Local landmark mapping is essential for remote navigation of rovers and helicopters
- Lag time to Earth communication prohibits live navigation
- (McClelland, Campbell, & Estlin, 2014)

Geospatial Revolution

Google Mars is just one example of the geospatial revolution in action

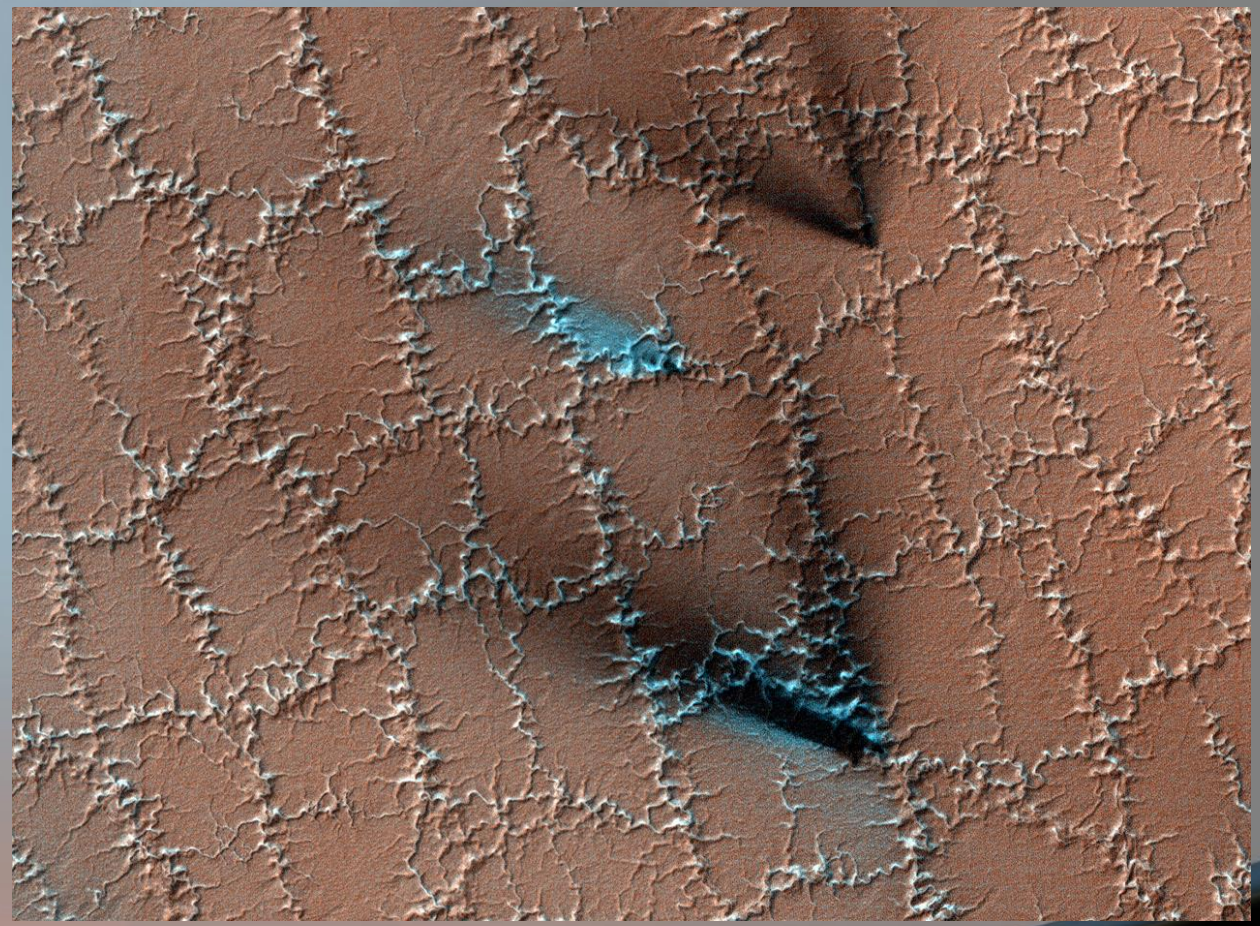
Data from Mars exploration is no longer just sitting in a vault at NASA somewhere, accessible to only a few people

While we don’t use Google Mars every day, we can use it to educate the public and inspire the imagination. (Benzinga Staff, 2010)

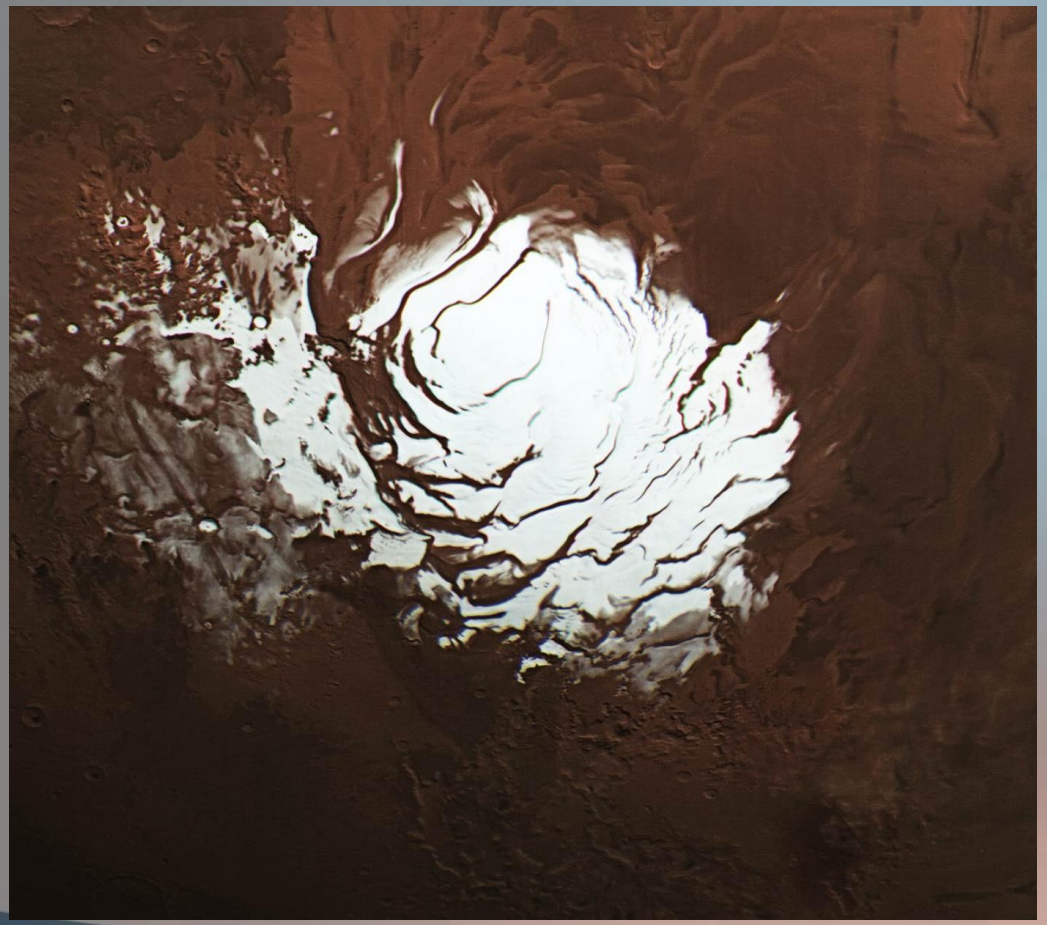
Machine Learning

- GIS can facilitate modeling data from Mars
- It can detect changes in the terrain over time
- It can facilitate new knowledge (Momennasab, 2021)

Class		
Atmosphere	Weather Analysis	Methane
Geology	Impact Craters	Layered Terrain
Path Planning	Landslides	Dust Devils

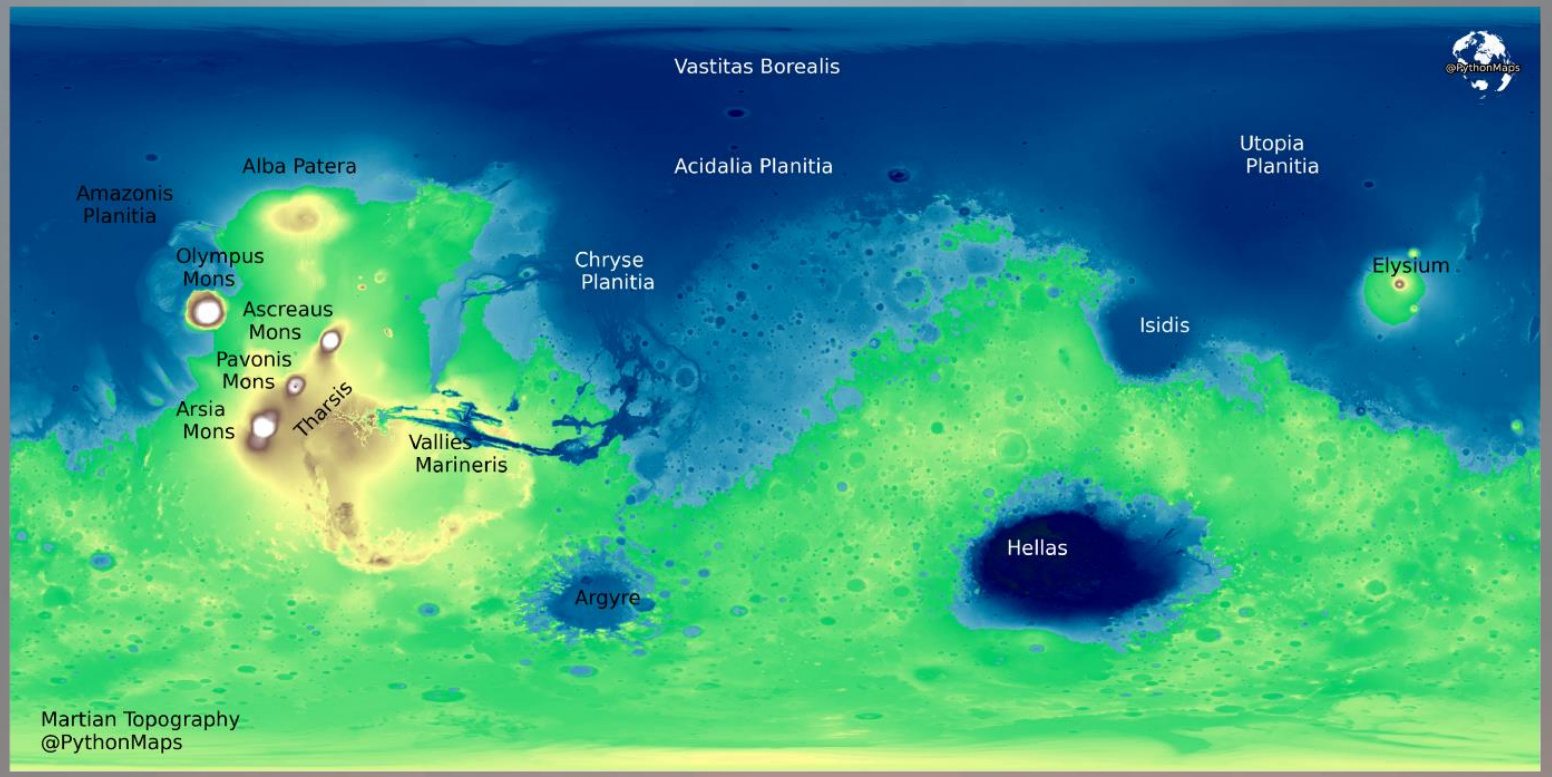


Future of Mars Study with GIS



- Mars oxygen and methane detection
- Mars cloud formation
- Mars valley network mapping
- Mars weather analysis
- Mapping polar deposits and seasonal changes
- Organic molecule analyzer (Momennasab, 2021)

Terraforming Mars

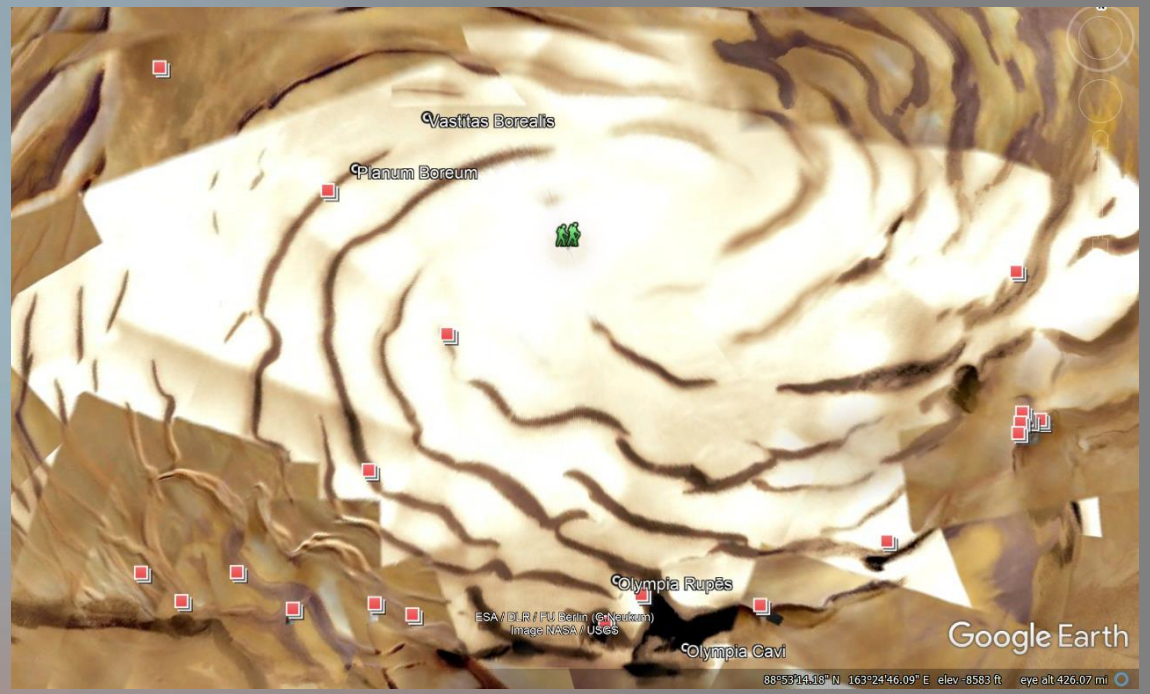


GIS on Mars

Tools and Technology

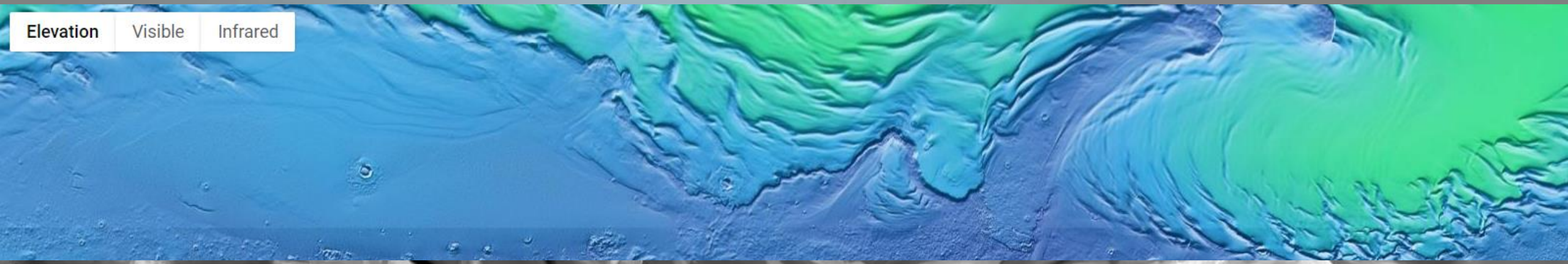
Types of GIS Tools Available for Use

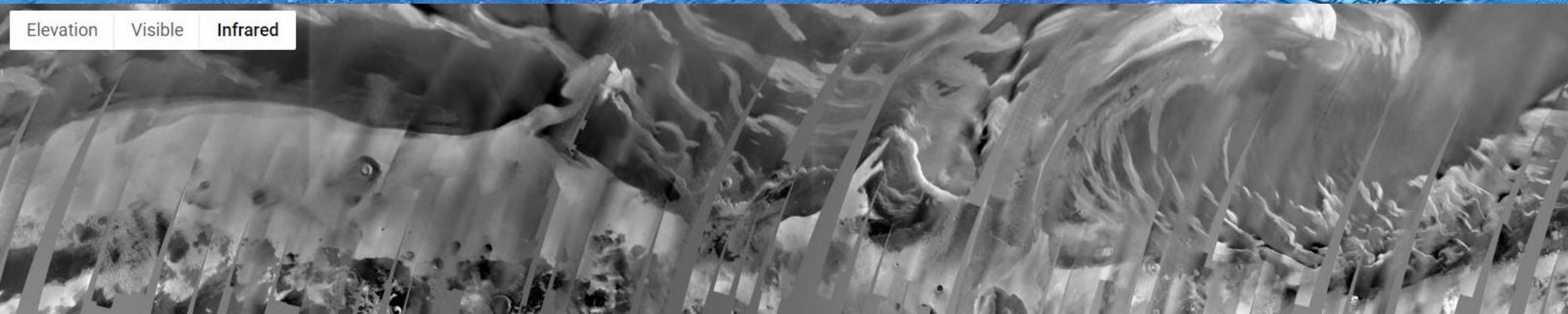
- Google Tools:
  - Google Mars https://www.google.com/mars/
  - Mars on Google Earth Pro https://www.google.com/earth/about/versions/
- Processing Data with Coding Tools
  - R https://www.r-project.org/
  - Python https://www.python.org/



Google Mars

- Digital Elevation maps have taken us beyond 2D photographs
- Google Mars online interface provides digital elevation maps, and both visible and infrared data





Mars In Situ Tomography System (MISTS) Development for Characterizing the Stratigraphy of Polar Layered Deposits

Federal

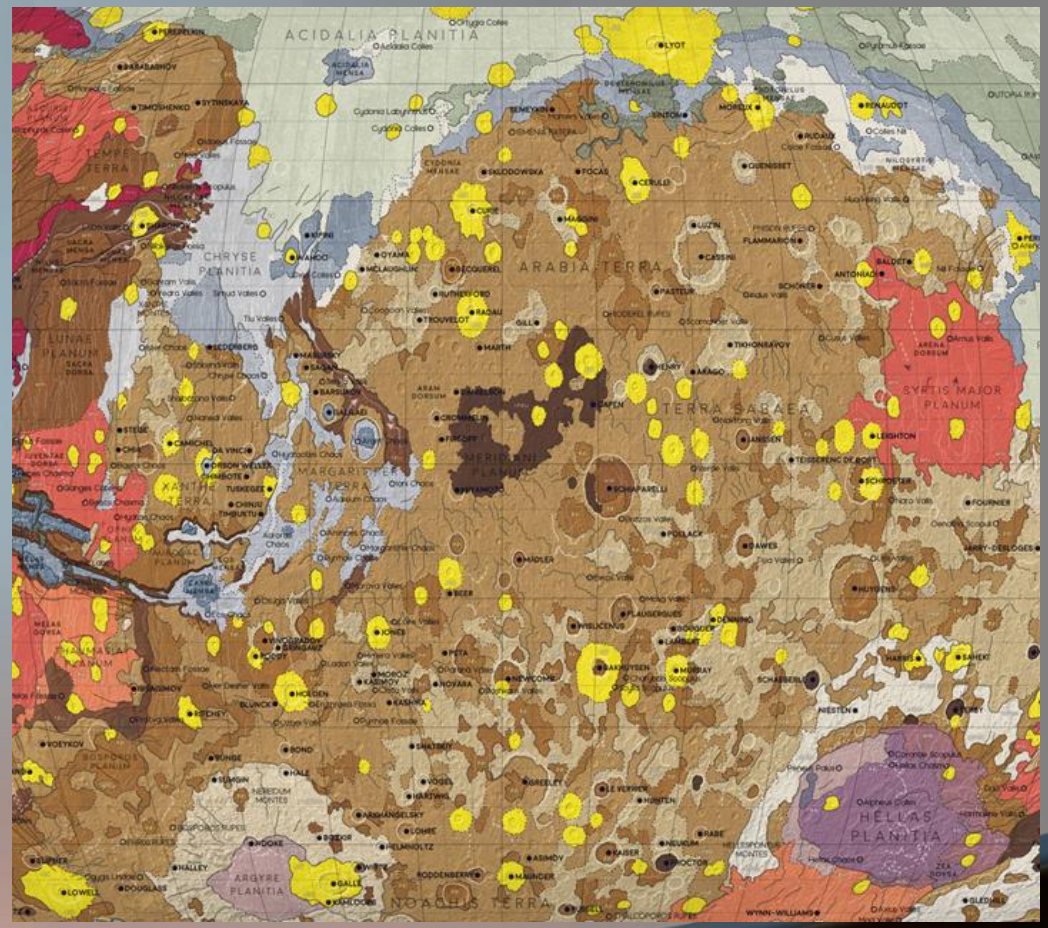
National Aeronautics and Space Administration —We propose to miniaturize an X-ray microcomputed tomography (microCT) system for in situ analysis of layered martian ice. The Micro In Situ Tomography System (MISTS)...

HTML HTML HTML HTML

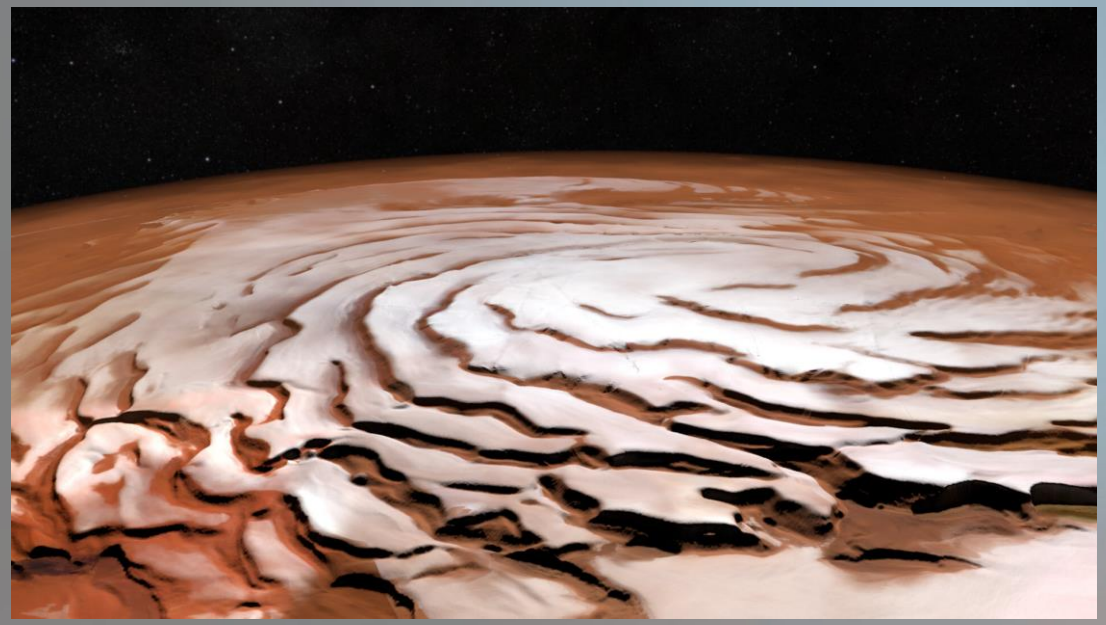
- Raw data sets are also available for a variety of Mars missions.
- Thus, we can go beyond just what other people have done for us, and analyze the data ourselves
- R and Python both have geospatial processing tools to visualizing data and performing analyses.

Coding up Maps of Mars

- Python and R can both create maps from data
- A geological map can tell you about the history of place
- Looking for cratering history tells you the age of the surface
- Chemical composition will differ from deposit history: is it from water? Is it volcanic? Something else?



Plan a Future Mission to the Polar Caps

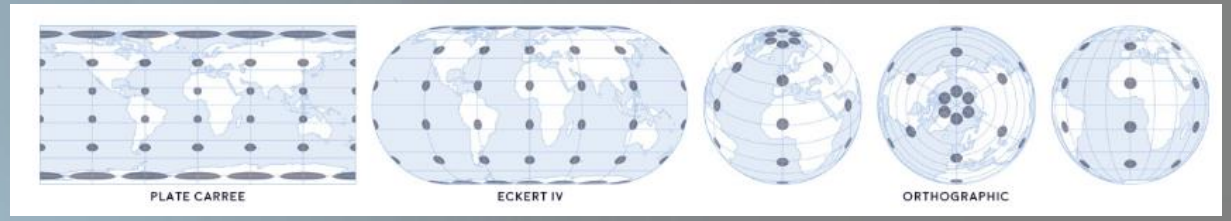


- Suppose you want to plan a lander for the Martian polar cap
- GIS can help us plan and answer questions
  - Why go? What is there to learn that we can't learn from satellites?
  - Where can we land safely?
  - How do the caps change? How will that effect the mission?
  - What are the opportunities for mobility?

Maps of the Surface Drive Exploration

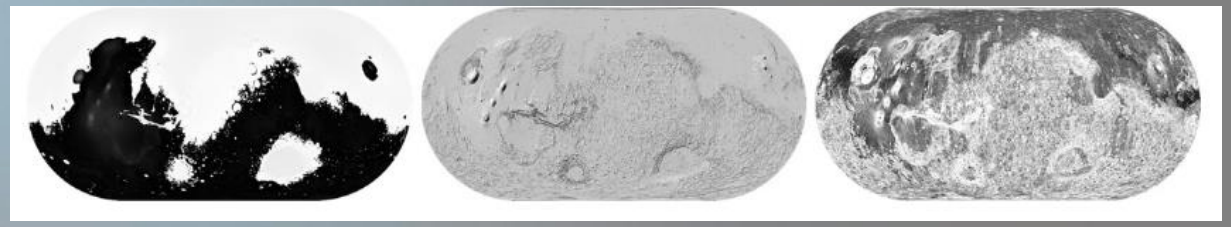
Map Projections

- Python lets us display maps in a variety of map projections



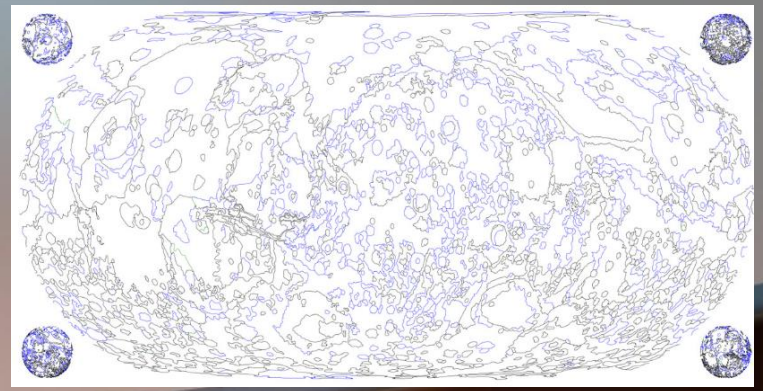
Slopes

- From elevation DEMs we can derive surface slopes



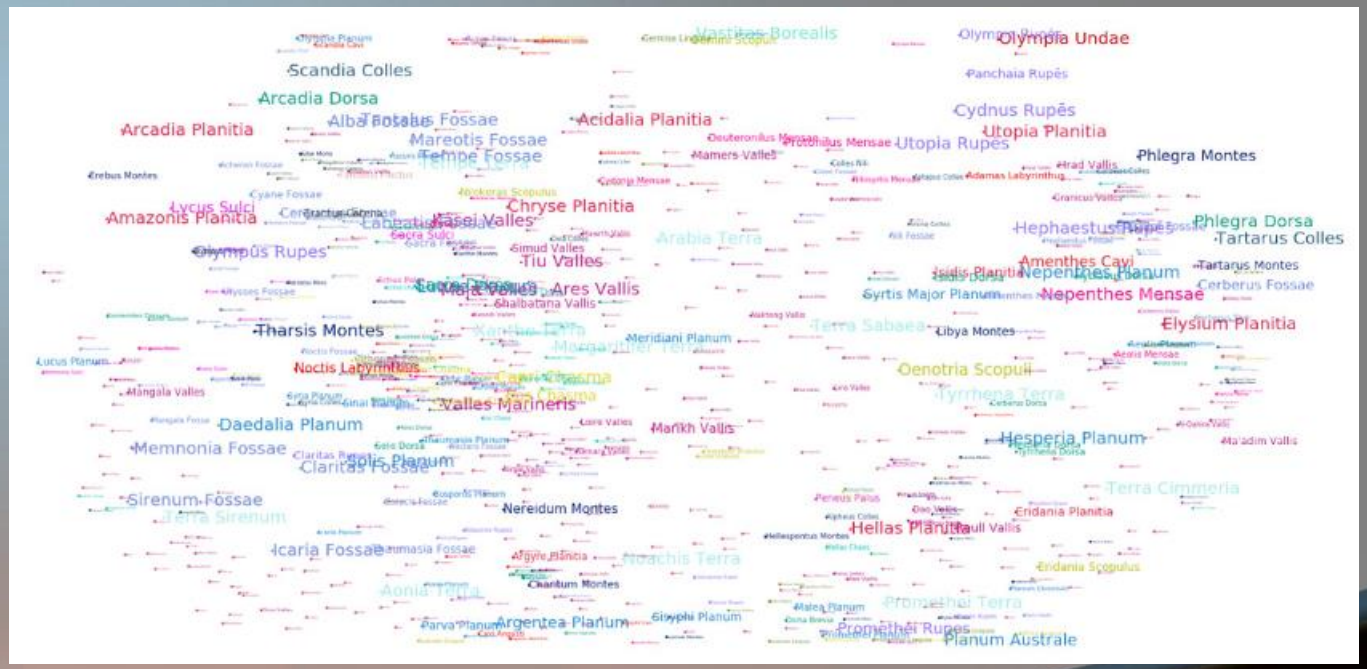
Geologic Boundaries

- We can plot derived geologic boundaries

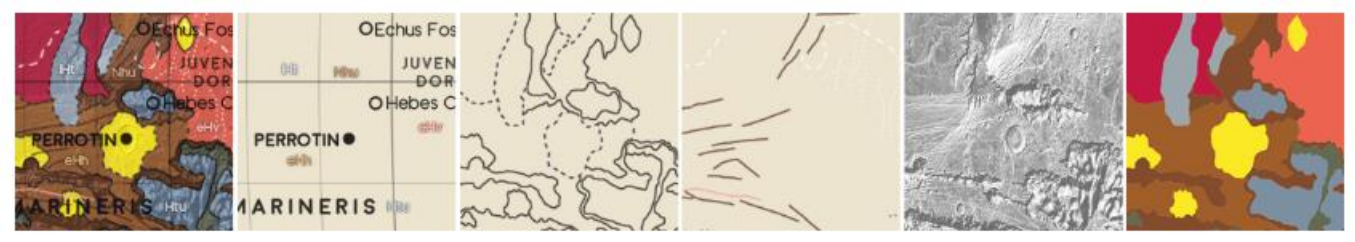


Nomenclature and Location names

- The International Astronomical Union approves place names on objects in space.
- We can plot those place names along with previous lander sites



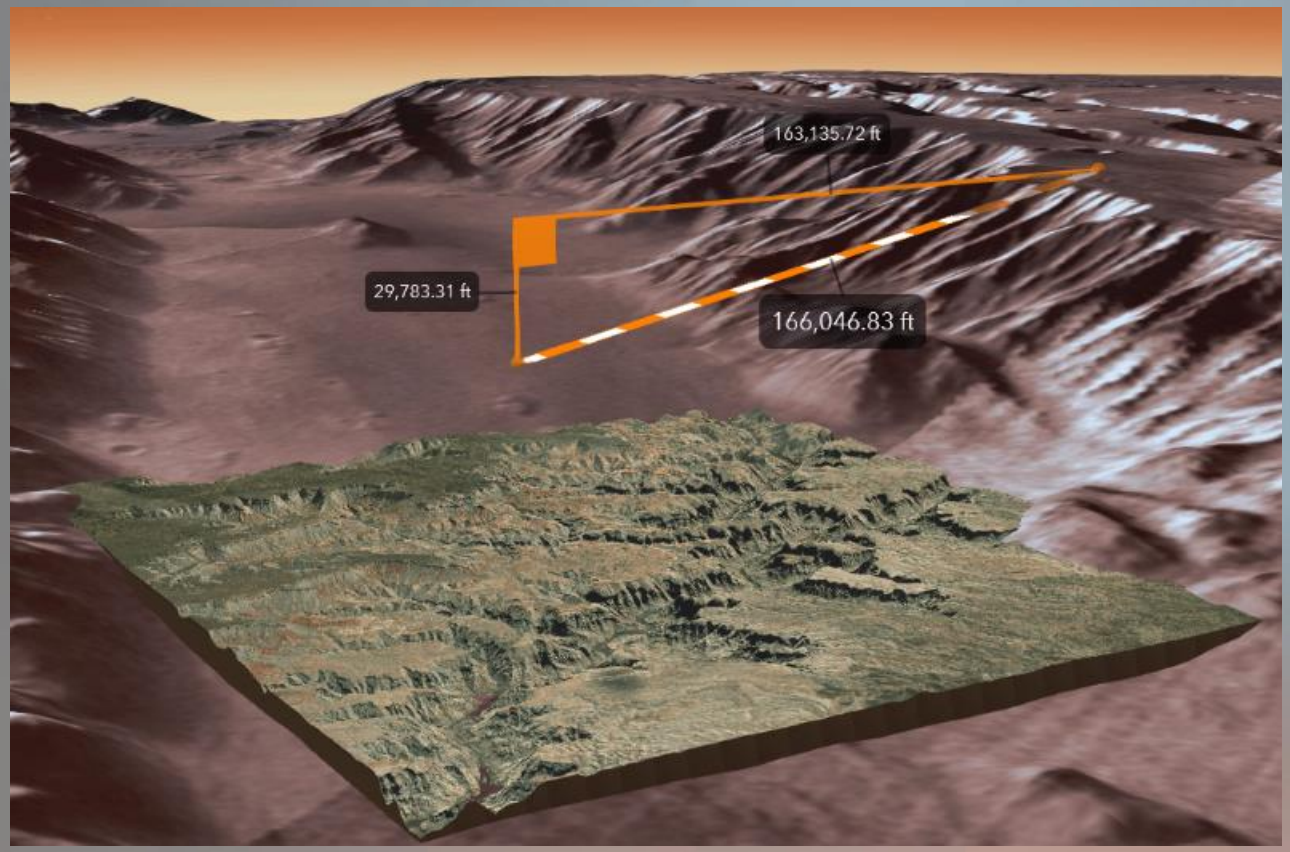
Machine Learning



Class		
Atmosphere	Weather Analysis	Methane
Geology	Impact Craters	Layered Terrain
Path Planning	Landslides	Dust Devils

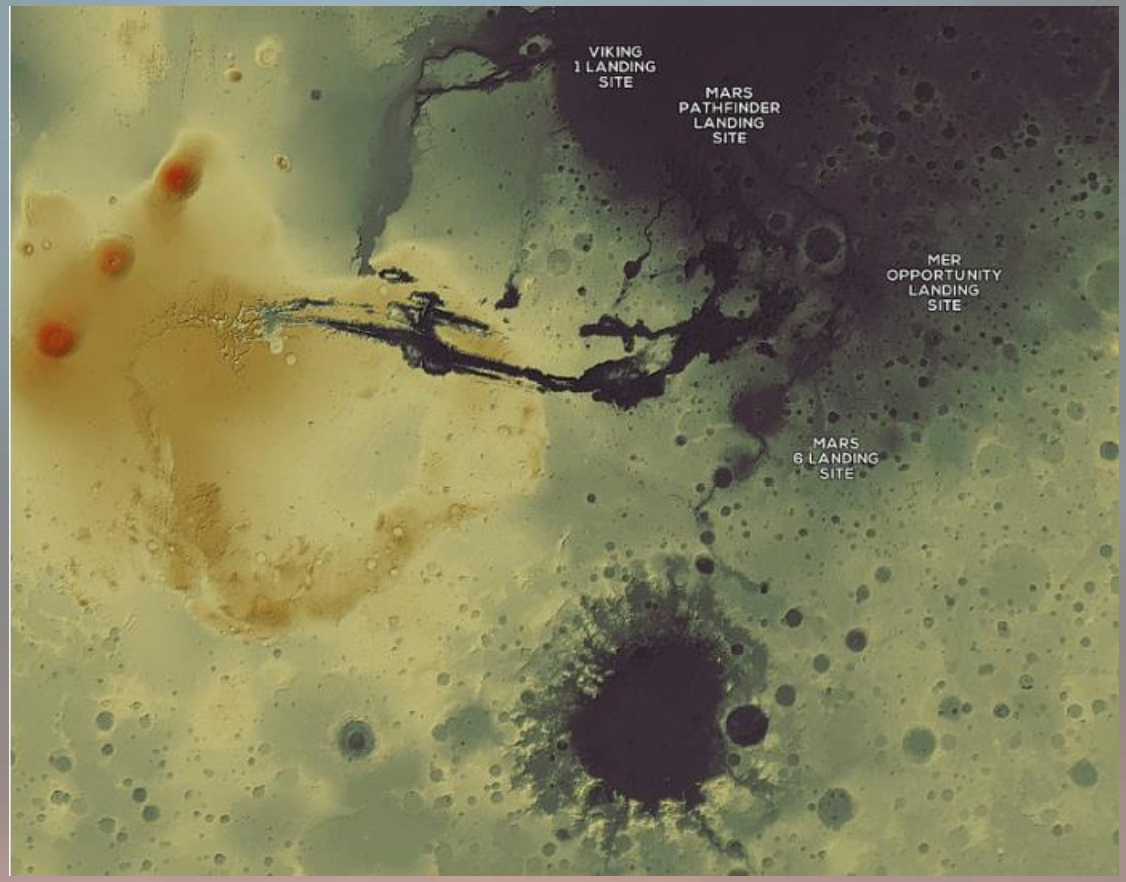
- Python has a lot of tools for performing machine learning, including those not available in a dedicated GIS software.
- It can facilitate new knowledge (Momennasab, 2021)

ArcGIS on Mars



- ArcGIS also has tools to study Mars.
- The data for Mars is comparatively advanced because there is so much of it relative to other bodies, so there are more options.
- If you want to study less commonly studied objects, Python or R are the best options since they don’t depend on a major software supporting them.

Make Custom Maps

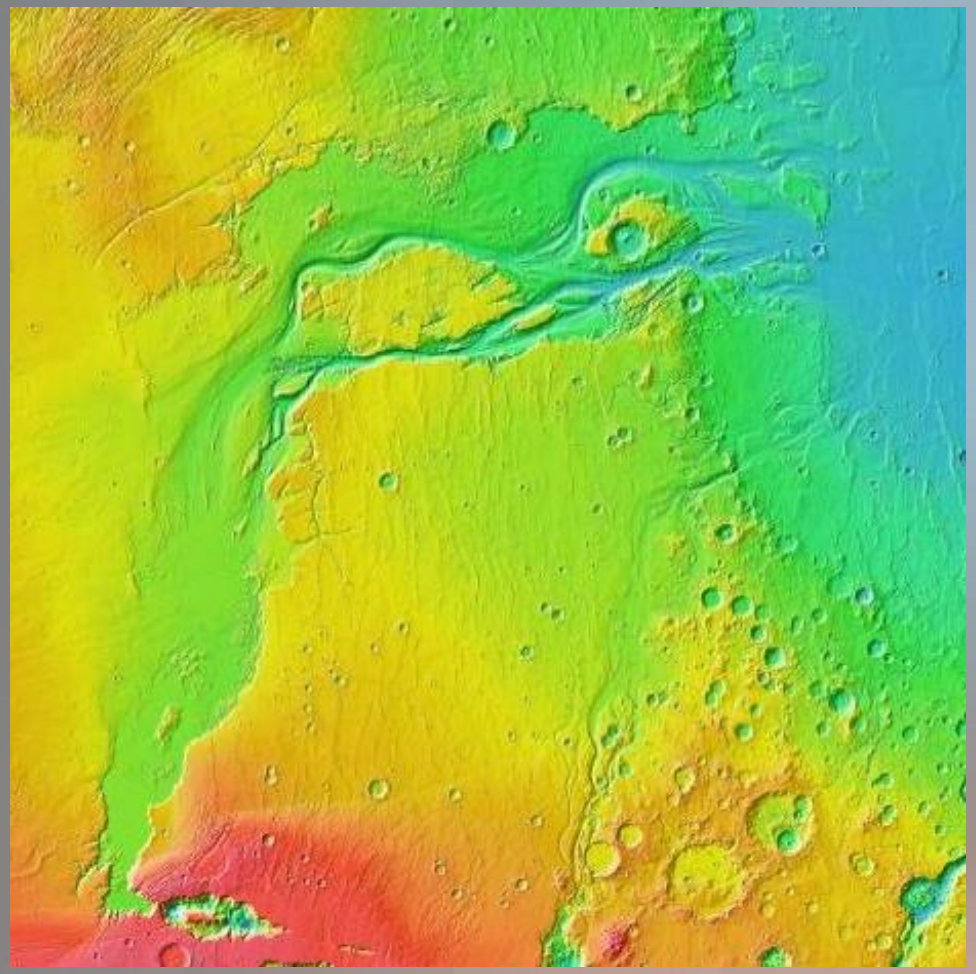


GIS on Mars

Maps

Betsy McCall

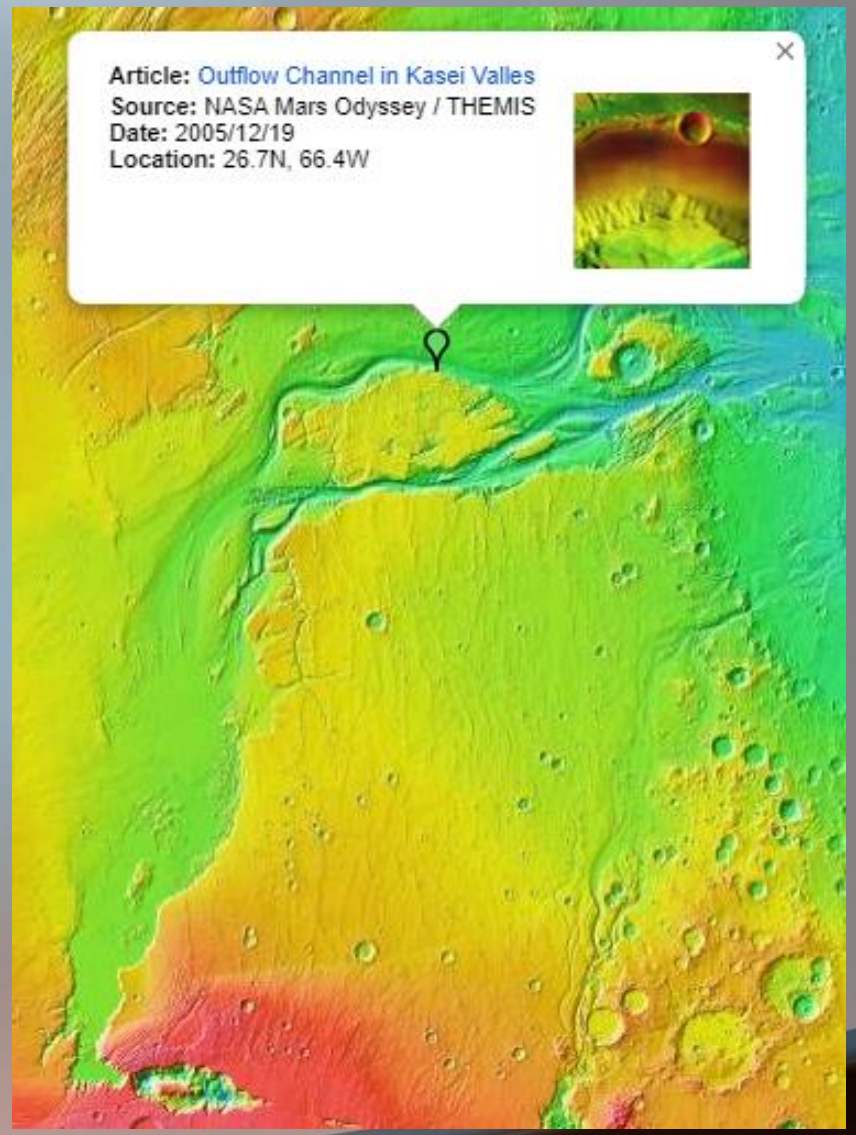
Where to Focus



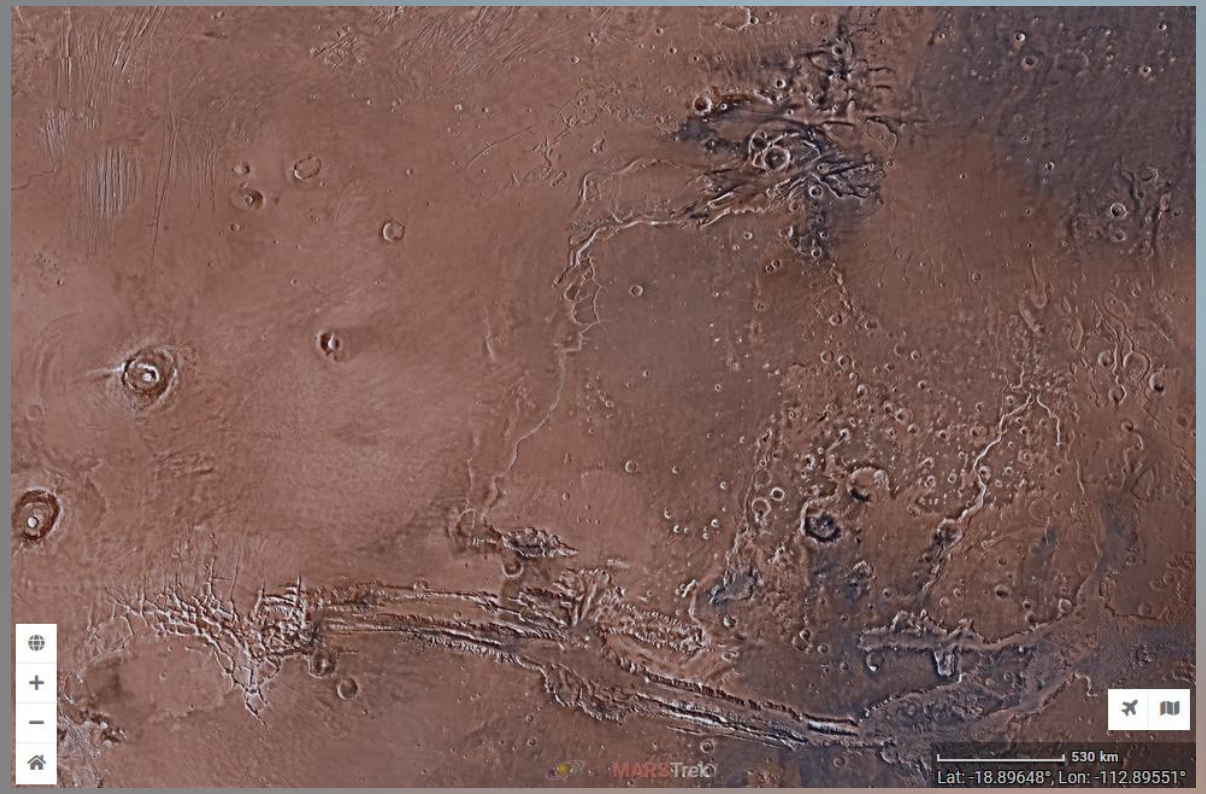
- To begin building a map, first choose a place to focus on
- This is an image of a water run-off channel north of Valles Marineris
- It appears to be a place where an underground reservoir of water was melted suddenly (from thermal heating or impact event) that melted catastrophically
- Notice the sharp elevation change

Add Layers

- We can add layers to the map.
- Here, this is location data
- The northern branch of the outflow channel is called Kasei Valles
- We can see from the thumbnail that if we zoom in we can see additional detail related to the depth of the channel locally and other features like craters that formed since the melt event



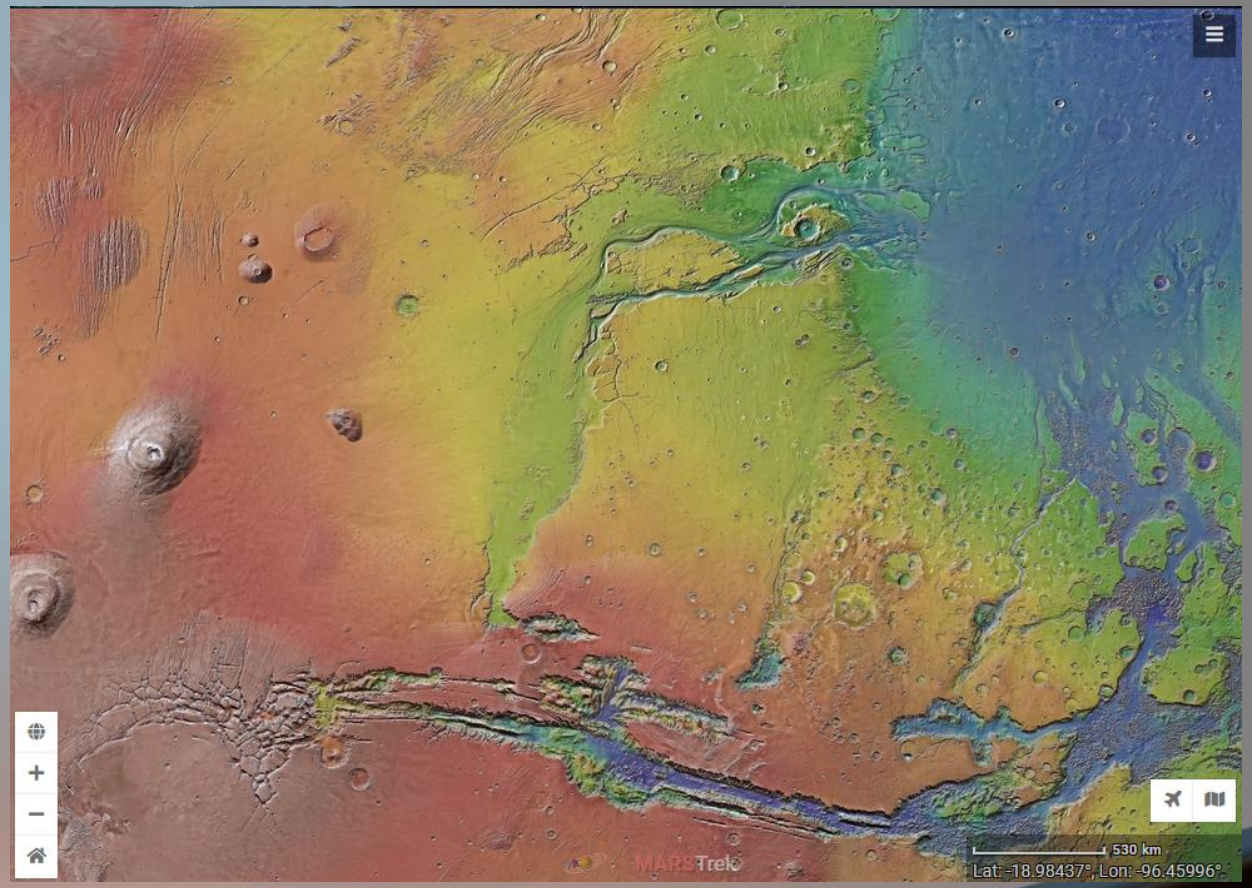
Adding Layers



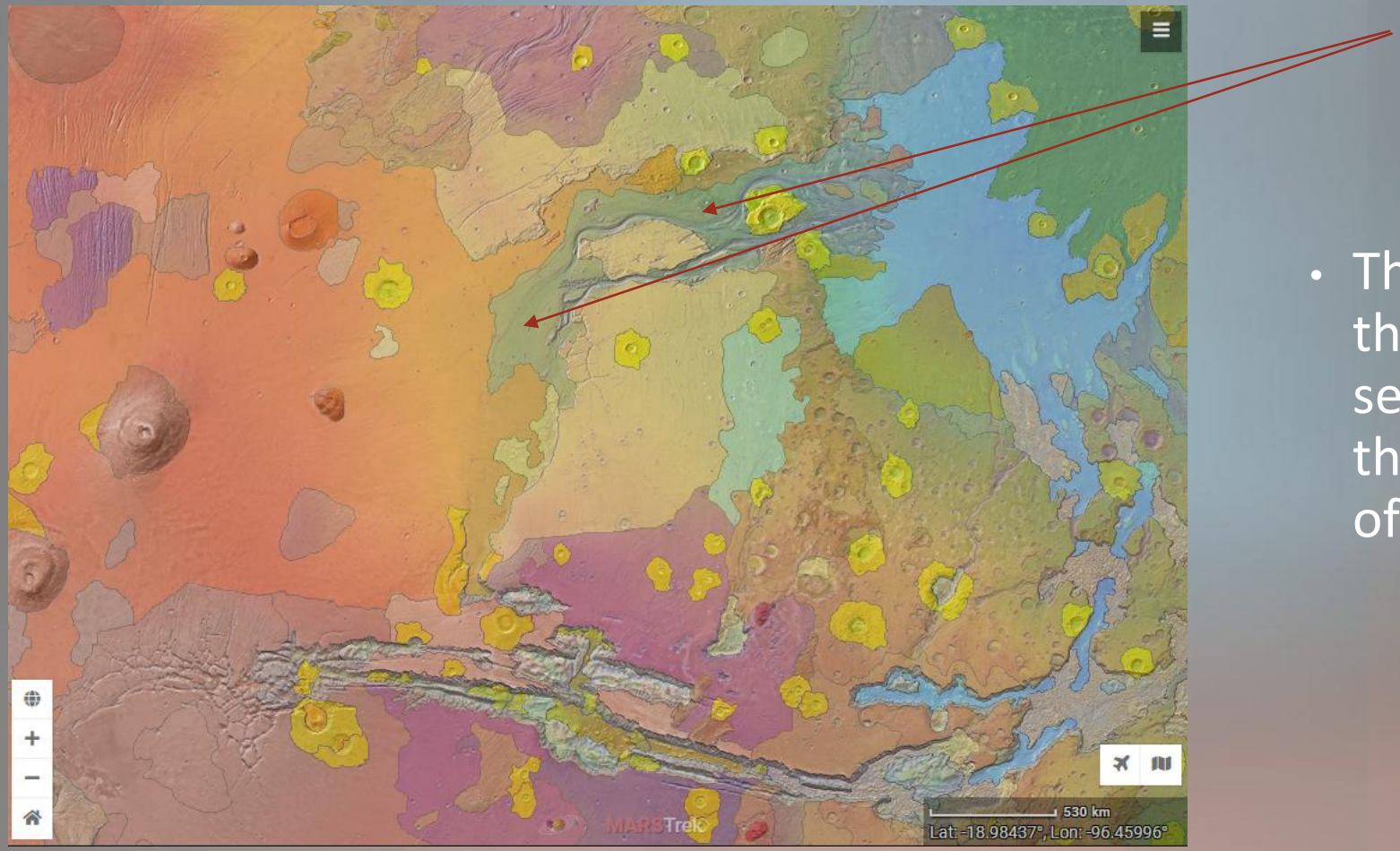
- I’m starting here with the visible layer of the same region around Kasei Valles

Adding Layers

- I’ve added on top (with 50% transparency) the elevation data from Google Mars images.



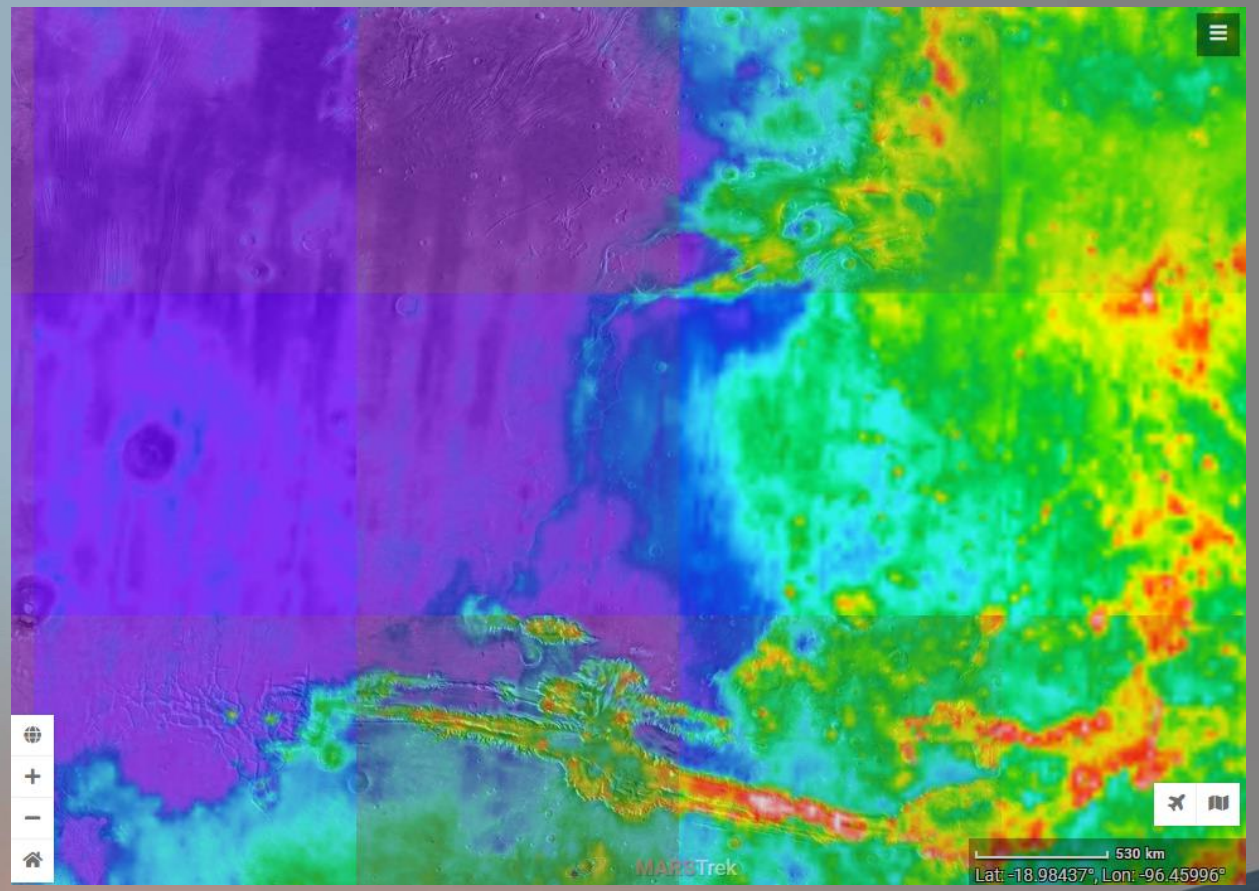
Adding Layers



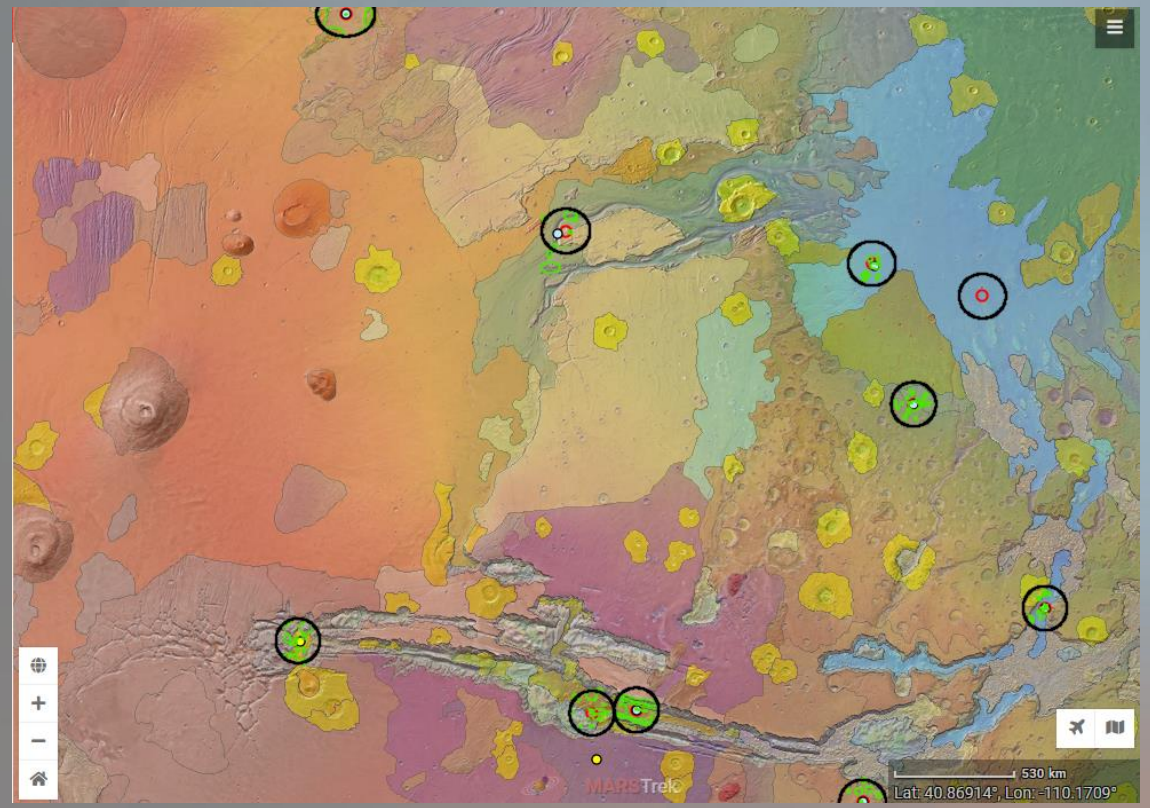
- The next layer I added was the geology layer. You can see how the lower part of the outflow channel are part of a common formation.

Adding Layers

- Alternatively, we can consider a thermal inertia map.
- Adding too many color layers can create interpretation problems.
- I'll leave this off the final map



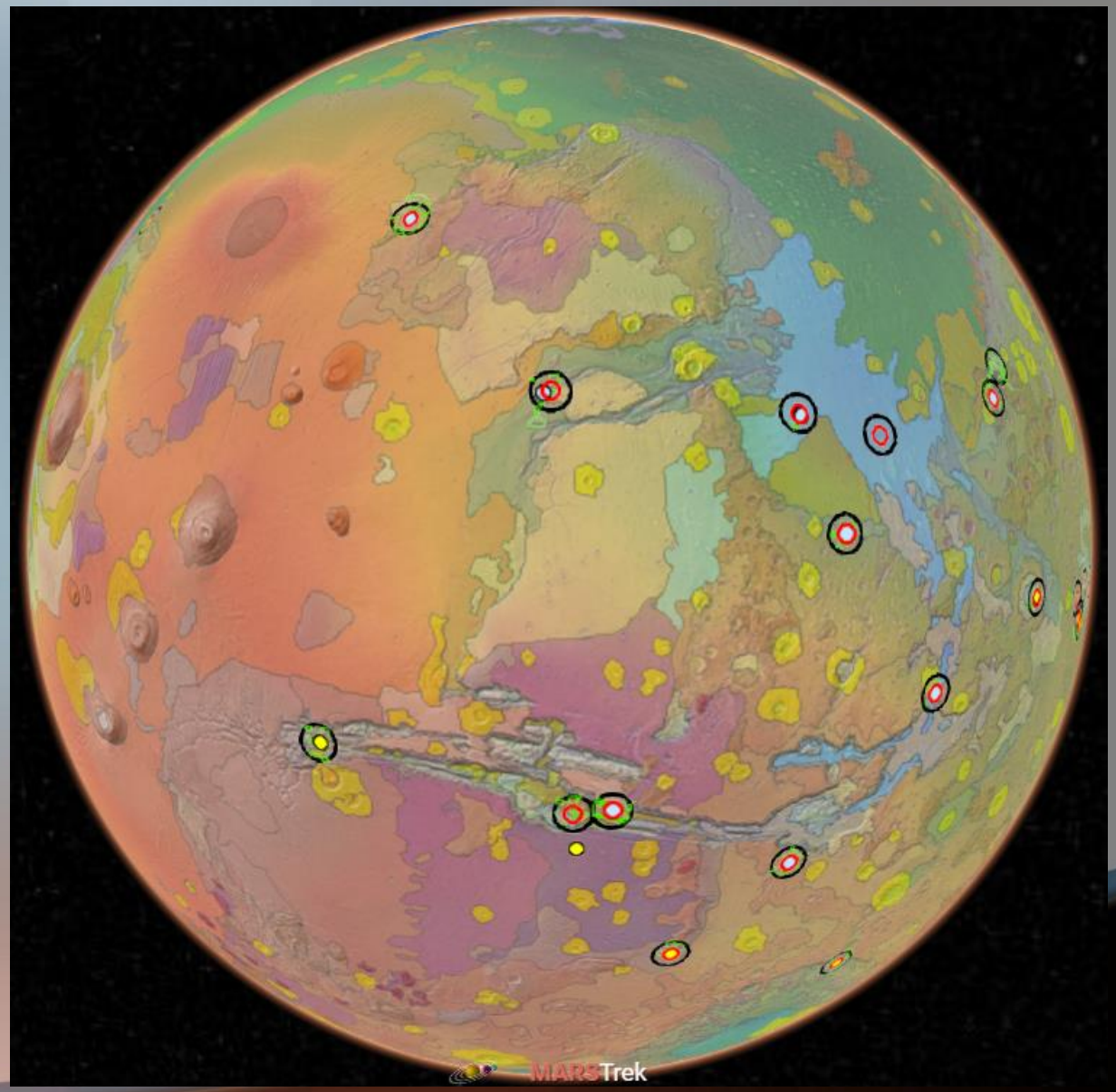
Final Map View



- Add exploration zones.
- The red circles are “exploration zones”
- Green are regions of interest
- Black is just a buffer region

Global View

- If we are worried about distortions from projection by looking at a global view.



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