Prospectus

Title: *Inspecting Mars Geomorphology with Implications of Yardangs/Lineaments using GIS and Python*
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Project Repository: *N/A*
Google Drive Link: *N/A*
Time Spent: 8 hours

Abstract

The basis of this project is to find geological implications from the fluvial and yardang influences that shape the surface of the Maritain surface. These findings will be to further confirm whether the drainage and fluvial processes of are geologically significant or implicate the geomorphology of Mars and how they are related to that of Earth qualitatively. The data used will be from many years of Mars missions that orbited around the red planet from Viking, Mars Global Surveyor, and to that of Context Camera and HiRISE and CRISM. Each of which have variable spatial resolutions and vast parts of the electromagnetic spectrum to depict geological features and phenomena. The systematic plan will derive a computational framework and develop a fluvial model from digitization of lineaments and yardangs, which result from abrasions, erosion, and wind inflicting on the landscape and alter/bend topological features. The expectations are to ultimately see if the extra variable of yardangs and lineaments can influence geomorphology and have a significant influence and will use extra quantitative methods to see so as well.

Problem Statement

In synopsis, a continuation of undergraduate work, that builds on lineament lines of geological origin that were ultimately supposed to confirm that drainage networks implicate the geomorphology of Mars (predominately in the Tharsis Volcanic region). Added variables to be included to the project are: 1. Yardangs, like that of lineaments which are eroded linear geological lines that eroded by wind through abrasions and have parallel troughs/ridges which depict the direction of where the direction is going. 2. Deeper Fluvial influence/modeling, create a model like that from the previous study, except factoring in the variables of erosion, abrasion, and wind that dictate Yardangs affect on subsurface phenomena and lineaments with slope, aspect, and hillshade DEMs. 3. Find evidence that geology (faulting and fractures) influences the Yardangs and lineaments of Mars and juxtaposed to Earth. (All to be processed with ArcGIS Pro and Arcpy (mosaicking, fluvial modeling and tabulating Juypter Notebooks of three image products for study area).

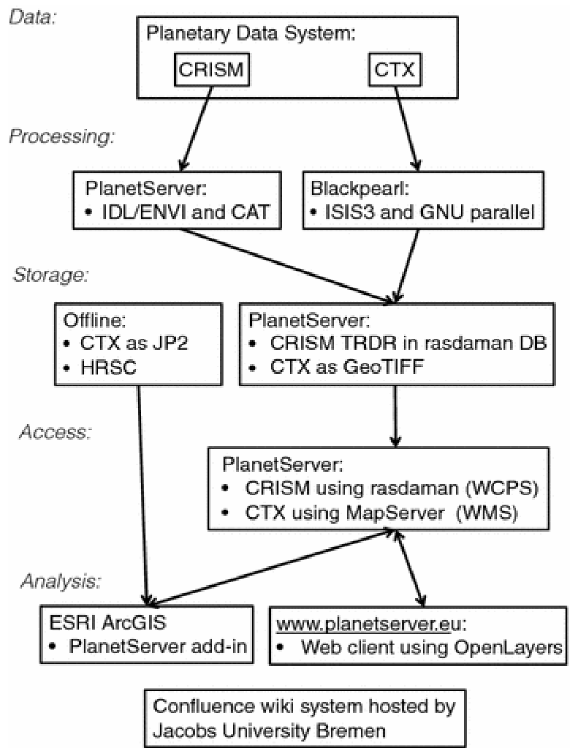

Figure 1. (Oosthoek and Rossi) A rough conceptual context map/model for the workflow of the project (with different semantics implemented based on problem statement).

#	Requirement	Defined As	(Spatial) Data	Attribute Data	Dataset	Preparation
1	Mars Orbiter Laser Altimeter (MOLA) instrument dataset (apart of Mars Global Surveyor)	Shaded relief derived from altimetry.	Raster/Imagery	Pixel/Cells	Mars	None/Geoprocessing for Yardings and justifications for fluvial processes in geological evidence in that of Earths
2	Viking Merged Color Mosaic	Viking Color Mosaic sharped with MDIM 1.0.	Raster/Imagery	Pixel/Cells	Mars	None/Geoprocessing for Yardings and justifications for fluvial processes in geological evidence in that of Earths
3	Context Camera (CTX)	CTX (Context Camera) makes observations simultaneously with high-resolution images collected by HiRISE and data collected by the mineral-finding CRISM spectrometer.	Raster/Imagery	Pixel/Cells	NASA	Lengthy process of acquiring/pre-processing data and must be mosaiced together (see Github reference. HiRISE data comes in JP2 format, so must be converted to GeoTIFF in programming cycle.
4	CRISM (Compact Reconnaissance Imaging Spectrometer for Mars)	To study active surface processes and landscape evolution.	Raster/Imagery	Pixel/Cells	NASA	Same processes as those of CTXs, must be performed for CRISM imagery.

Table 1. List of Mars Data sources that serve as a precursor to setting up a model for processing 1. ArcGIS Pro and ArcPy: with mosaicking of CTX and CRISM image datasets for analysis of possible Yardang sites and imagery (if not deciphered from MOLA imagery). 2. Fluvial construction: Using the same tools from ArcGIS Pro and ArcPy to make a Fluvial model and possibly simulate the factors of wind, abrasion, and erosion for Yardangs (or separate one). 3. Juypter Notebooks: Use three imagery tools (slope, aspect, and hillshade) to be created and digitize Yardangs and lineaments in Tharsis regions.

Input Data

In comparing all the spectral resolution of each satellite, the VIKING would be the most poor and inadequate, but is still reputable and a good general reference for viewing at small scale or the general world of Mars itself. Viking paved the way for higher spectral, radiometric and magnet telescopes, and satellite technology such as the Mars Orbiter Laser, which lasted almost a decade in space, which will be used as the main dataset in thus study if CTX and CRISM cannot be pre-processed effectively. MOLA prior also had the ability to read wide gamut of the electromagnetic spectrums such as infrared/gamma from THEMIS (Thermal Emission Imaging System) and TES (Thermal Emission Spectrometer. These aren't necessarily needed for the analysis because the lineaments and yardangs are decipherable in the visible spectrum, and the other geoprocessing products are adequate to able to see them as well. CTX and CRISM products are more modern satellite and higher resolution data products up to almost six pixels per inch or 1 meter and would be more effective in deciphering those less prominent or microscopic features.

#	Title	Purpose in Analysis	Link to Source
1	Mars Orbiter Laser Altimeter (MOLA) dataset	Back-up general spectral imagery for deciphering lineaments and yardangs in the Martian surface.	MARS Global Data Sets
2	Viking Merged Color Mosaic	Back-up general spectral imagery for deciphering lineaments and yardangs in the Martian surface.	MARS Global Data Sets
3	Context Camera (CTX)	Higher-resolution imagery which will be attempted to be utilized for the project to decipher lineaments and yardangs.	https://ode.rsl.wustl.edu/mars/
4	CRISM (Compact Reconnaissance Imaging Spectrometer for Mars)	Higher-resolution imagery which will be attempted to be utilized for the project to decipher lineaments and yardangs. (with different application and processes used)	http://crism-map.jhuapl.edu/

Table 2. Data listing as each data source builds on each other from previous satellite launches to Mars from NASA missions from the Mars Global Surveyor to Mars Orbiter Mission. From technological innovations to resolution enhancement in each iteration of telescopes, sensor and gamut of sending and receiving data.

Methods

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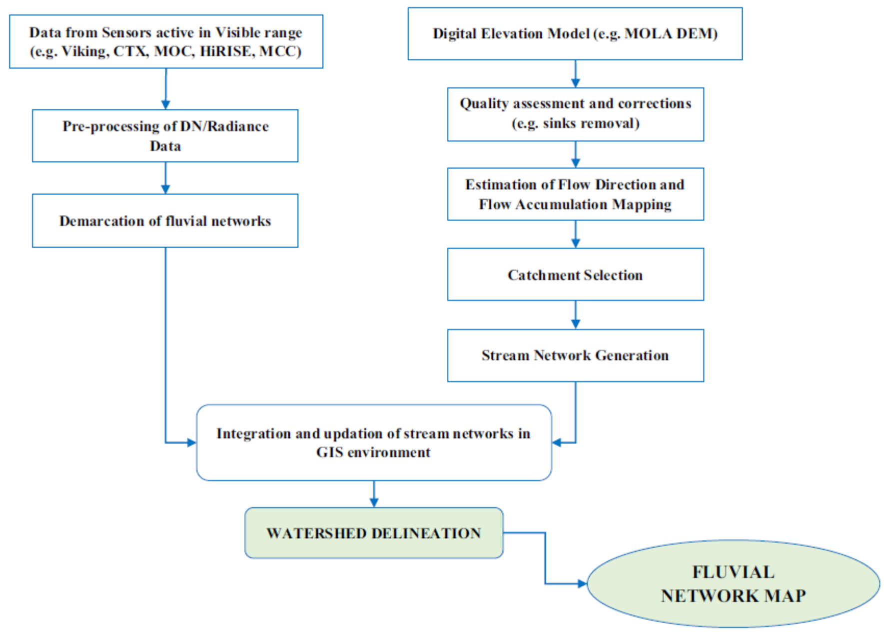

Fig. 3 Methodology for mapping of Martian fluvial networks

Figure 2. (Rangarajan, et. al) A conceptual model depicting steps taken for the supposed model of drainage networks and fluvial processes.

1. Pre-Process Context Camera with Github.com steps and convert CRISM JP2 to Geo TIFFs for analysis
2. Create initial study boundary that has supplemental lineaments and yardangs for comparison (Tharsis Volcanic area already good pre-defined area based on recent study).
3. Replicate follow steps from study using ArcGIS Pro, ArcPy, and Jupyter Notebooks for geological influences and conformation.

- **Extraction of the drainage networks using ArcGIS Pro + ArcPy**
  - *Flow direction*
  - *Flow accumulation*
  - *Flow Area*
    - *Times by Cell Size*
    - *Log10*
  - *Reclassification*
  - *Raster to line*
  - *Stream Order*
  - *Strahler*

- **Mapping lineaments (expression of fractures and faults on the three digital products in Jupyter Notebooks)**
  - *Slope*
  - *Hillshade*
  - *Aspect*

Results

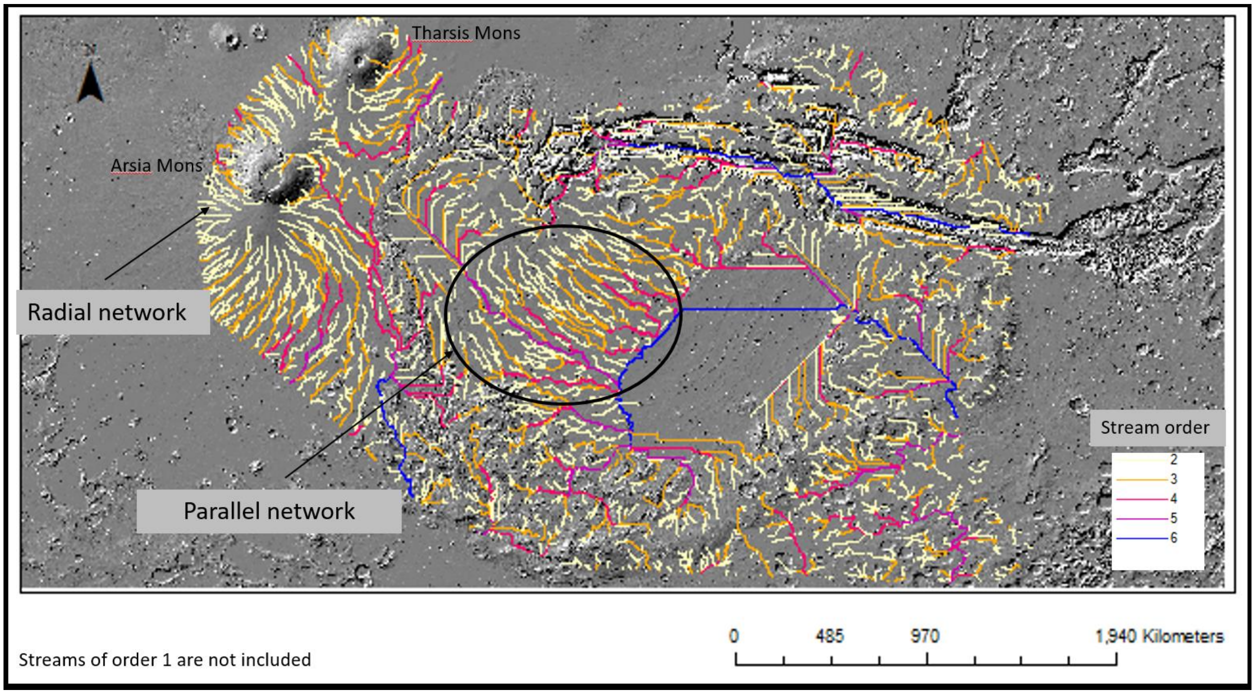

Figure 3. (Danielson, et. al) Drainage networks and stream orders used for outlining flow direction, accumulation, area and then being reclassified. Sinuosity of streams (how they bend relative to valley) factor into how geology influenced the landscape.

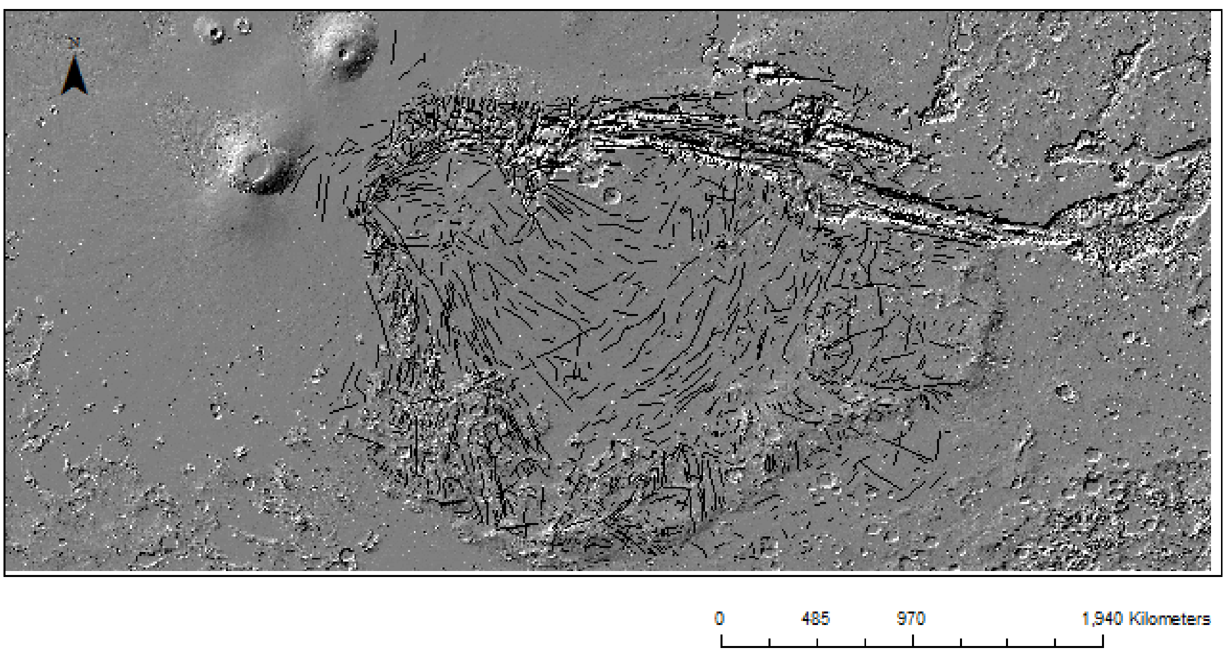

Figure 4. (Danielson, et. al) Slope and Aspect lineaments digitized on the surface of Mars (shown on MOLA imagery).

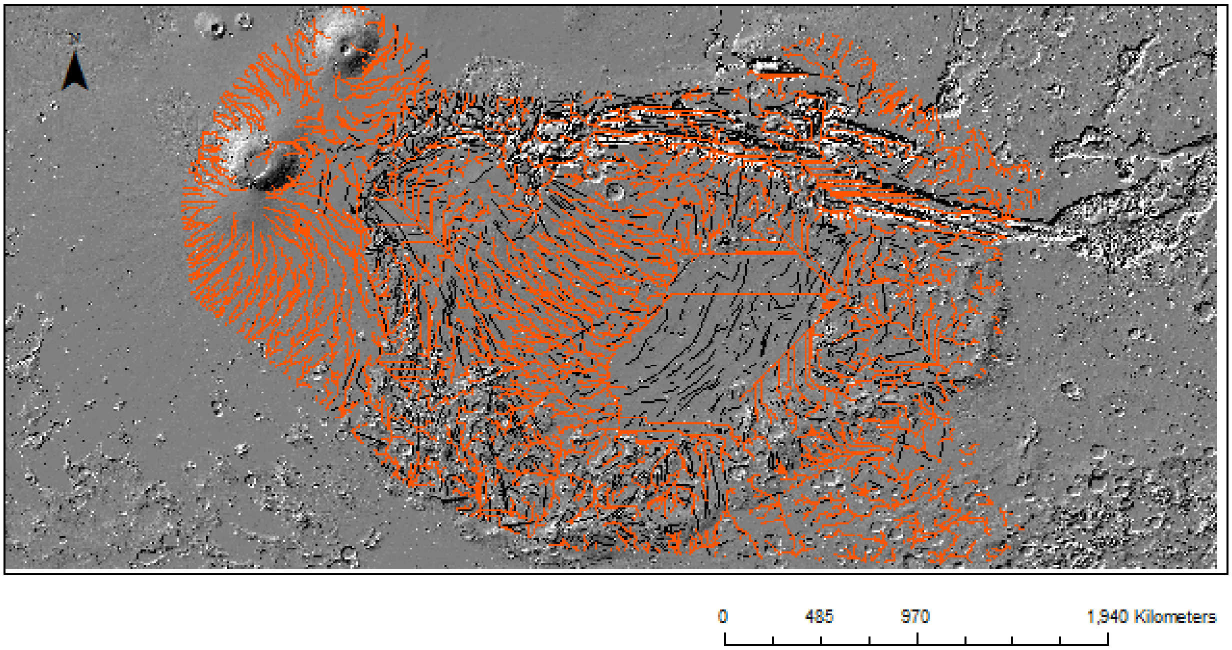

Figure 5. (Danielson, et. al) Hillshade Lineaments digitized on the surface of Mars (shown on MOLA imagery)

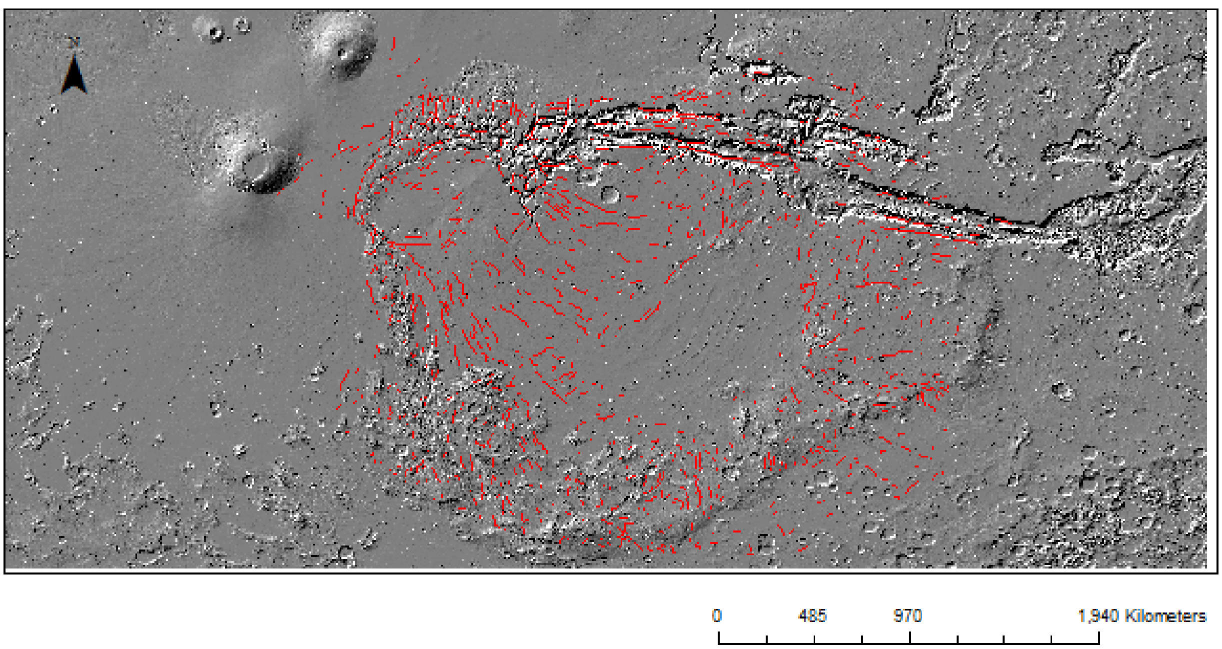

Figure 6. (Danielson, et. al) Intersection tool used for all lineaments and drainage network to conclude there was no substantial evidence of geological implications in the fluvial processes on Mars or drainage.

Results Verification

The results depicted are from previous work and are not yet fully developed for this next investigation but serve as precursor for the lineaments and how they can compare to Yardangs as another factor in configuring the geological implications of Mars and to that of Earth. Also, the fluvial and drainage networks are also a factor in implicating the fact that water once was on Mars and has similar biophysical and geomorphological processes to that Earth if looking at the historical past. The wind, abrasion, and erosion were paramount in shaping the faults, valleys, gullies, and faults of Mars and much of the plateaus we see on Earth, so another qualitative and deterministic analysis must be carried out with better information and computational frameworks. Quantitative analysis can be used to some extent with the stream orders and comparison of yardang/lineaments (i.e spatial autocorrelation or nearest neighbor). with each digital imagery product. Possible deep learning or machine learning could be implemented, but time management and budgeting needs to be factored into what can be achieved and what AOIs should be delved into.,

Discussion and Conclusion

As mentioned in the Results, tentatively this is building on the work done in a prior project, but with more robust analysis and computational frameworks. What needs to be done is to see if there can be an actual finding and geological significance with configurations of Yardangs in conformity with lineaments as they shape the drainage and fluival processes on Mars. This can be parallel to the formations on Earth such as the trellis riverbeds of Cairo to that in Mar's Tharsis region. Since yardangs from in approximately narrow corridors of soft bedrock, evidence can point to drainage and fluvial processes which these can house feldspar, quartz, and other sedimentary rocks in rivers which configured geological processes and shapes in forming rivers/outcroppings along the yardangs.

References

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(N.d.). Jhuapl.edu. Retrieved September 28, 2022, from http://crism-map.jhuapl.edu/

https://github.com/USGS-Astrogeology/ISIS3/wiki/Working_with_Mars_Reconnaissance_Orbiter_CTX_Data#Projecting-the-Image-

Self-score

Category	Description	Points Possible	Score
Structural Elements	All elements of a lab report are included **(2 points each)**: Title, Notice: Dr. Bryan Runck, Author, Project Repository, Date, Abstract, Problem Statement, Input Data w/ tables, Methods w/ Data, Flow Diagrams,	28	**28**

	Results, Results Verification, Discussion and Conclusion, References in common format, Self-score		
Clarity of Content	Each element above is executed at a professional level so that someone can understand the goal, data, methods, results, and their validity and implications in a 5 minute reading at a cursory-level, and in a 30 minute meeting at a deep level **(12 points)**. There is a clear connection from data to results to discussion and conclusion **(12 points)**.	24	**22**
Reproducibility	Results are completely reproducible by someone with basic GIS training. There is no ambiguity in data flow or rationale for data operations. Every step is documented and justified.	28	**28**
Verification	Results are correct in that they have been verified in comparison to some standard. The standard is clearly stated **(10 points)**, the method of comparison is clearly stated **(5 points)**, and the result of verification is clearly stated **(5 points)**.	20	**18**
		100	**96**