HOW MUCH OF AN IMPROVEMENT IN PALEOTECTONIC DETAIL IS THERE WHEN THEMIS AND MOLA DATA ARE COUPLED WITH VIKING INFORMATION?

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Introduction: Quantitatively, how much of an improvement in paleotectonic detail is there when Thermal Emission Imaging System (THEMIS) [1] and Mars Orbiter Laser Altimeter (MOLA) [2] data are coupled with Viking information [3]? This is a significant question, as there have been numerous Viking-based efforts to unfold the paleotectonic history of Mars, which is recorded in the distribution and relative age of extensional and compressional features (graben and ridges, respectively) [e.g., 4]. We report preliminary findings on the re-evaluation of the Viking-based, published geologic map information of the Thaumasia region [3] through detailed investigation of the western margin of Thaumasia Planum (Fig. 1). Thaumasia Planum (referred to hereafter as TP) is a geologic province that records significant geologic information on the evolution of the Tharsis magmatic complex [3-7], which includes the development of Valles Marineris (also see Dohm et al., this issue, and Tanaka et al., this issue).

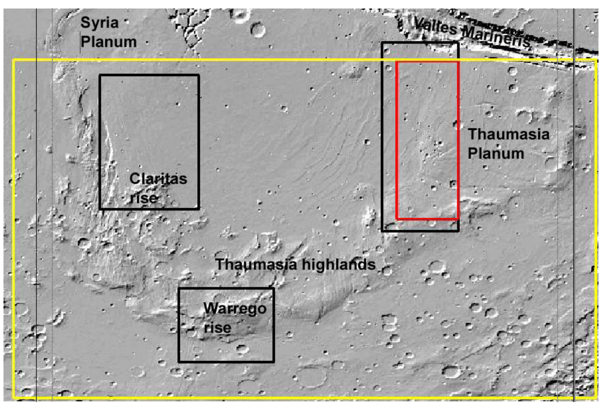

Fig. 1. Detailed mapping of the western margin of Thaumasia Planum using THEMIS and MOLA (red box) for comparison with the published Viking-based geologic map data of [3]. The highlighted region is 1 of 3 regions (black boxes) under re-evaluation (also see [5] which details comparison results of the geologic information of Claritas rise). Also shown is the Thaumasia region that was mapped using Viking data (yellow outline) based on [3].

Approach: Tectonic structures (faults and wrinkle ridges) have been identified and mapped using THEMIS (both daytime and nighttime), Viking Mars Digital Image Mosaic (MDIM 2.1), and MOLA data compiled using GIS software (Fig. 2). This contrasts with the Viking-based geologic map units and structures that were identified and mapped on individual, digitally enhanced Viking images and 1:2,000,000-scale photomosaic bases and compiled on the 1:5,000,000-scale digital photomosaic map base using pen and mylar (Fig. 2). THEMIS IR resolution for the Thaumasia region is 100m/pixel. Supportive mapping information included THEMIS VIS images with an approximate resolution of 18m/p and gridded MOLA topography at 463m/p.

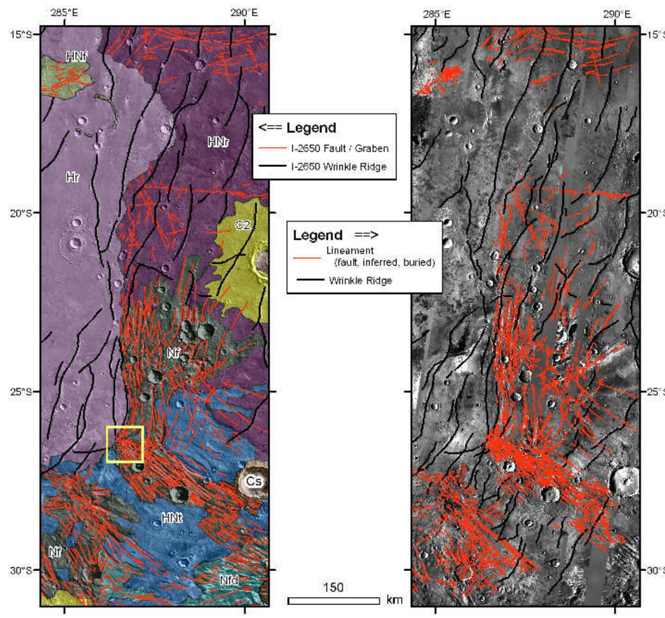

Fig. 2. Viking-based geologic information on Viking base (left; map information based from [3], including contacts that delineate geologic map units and wrinkle ridges (black lines) and faults (red lines)) and THEMIS/Viking/MOLA-based tectonic information on THEMIS day-time mosaic (right; wrinkle ridges (black lines) and faults (red lines)) for comparative analysis using GIS to quantify improvement in geologic detail. Yellow box shows location of Fig. 4.

GIS-based evaluation allows us to quantitatively assess whether there is a change in the geologic detail when THEMIS and MOLA data are coupled with Viking information. Here, for example, detailed tectonic information newly compiled for the TP region using the three data types can be compared to Viking-based information [3] of the same region. This includes total number of faults and wrinkle ridges, total length of faults and wrinkle ridges, and fault-length and wrinkle ridge-length densities (sum of all feature types divided by the total area of Viking-based geological units mapped by [3] that pertain to a specific stage of major geologic activity of Tharsis; see [3] and [5] for further explanation and Fig. 3 and Tables 1 and 2).

Fault stage	Total area of map units per Stage (km^2)	Fault Total (Viking; Reevaluated)	Total fault length (km)	Density ($km/10^2km^2$)
1	79403.9	553; 1069	9635.5;11861.4	12.1/14.9
2	156652.9	275; 683	5453.5; 8434.4	3.5/5.4
3	95342.7	0; 0	0; 0	0/0
5	1689.5	0; 0	0; 0	0/0

Table 1. Comparison between the Viking- [3] and newly mapped VIKING/THEMIS/MOLA-based fault information.

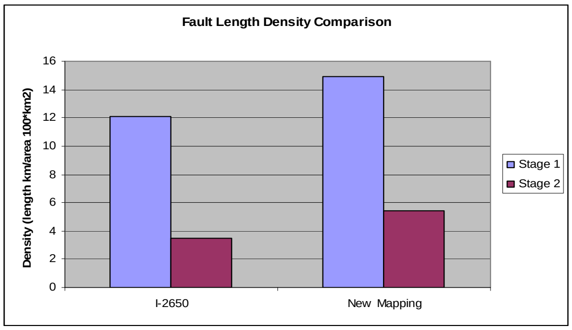

Figure 3. Histograms comparing Viking- [3] and newly mapped VIKING/THEMIS/MOLA-based Stage 1 and 2 fault-length densities.

Total Area (km^2)	Wrinkle Ridge Total (Viking; Reevaluated)	Total wrinkle ridge length (km)	Density ($km/10^2km^2$)
333089.1	61; 105	4405.7; 6382.1	1.3/1.9

Table 2. Comparison between the Viking- and Viking/THEMIS/MOLA-based wrinkle ridge count and density.

Results and Implications: Preliminary highlights include: (1) an increase in the total number and total length of faults and wrinkle ridges; (2) an increase in fault-length and wrinkle ridge-length densities, (3) in several cases, Viking-mapped tectonic structures were revised; this includes improved differentiation of fault segments and fault scarps of complex rift systems; (4) THEMIS and MOLA resulted in enhanced structural detail, which includes improved assessment of stratigraphic and cross-cutting relations among map units and tectonic structures; (5) multiple data types allow for greater geologic perspective and thus greater accuracy in geologic mapping and related interpretation based largely on factors such as scale, structural orientation, look direction of the acquired image, sun angle, atmospheric conditions, etc. (Fig. 4); (6) geologic mapping using GIS software is advantageous over ink mapping and physical transferal of map information (error accompanies old practices, yet the geologic interpretation has mostly remained the same thus far).

Results from the ongoing investigation will have a direct bearing on the geologic evolution of Mars, since the Thaumasia region records geologic features and materials that span the recorded geologic history of Mars. For example, a newly identified large vent structure (> 50 km in diameter) is consistent with other geologic information that collectively point to magmatic-driven activity as a major contributor to the development of Valles Marineris (Fig. 5).

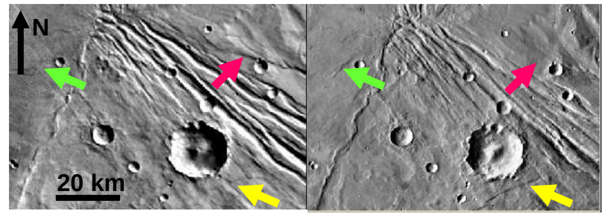

Figure. 4. Comparison between Viking MDIM (left) and THEMIS-IR daytime (right) information. Importantly, both data sets are necessary for greater geologic perspective and thus greater accuracy in geologic mapping and related interpretation. For example, note that (1) a fault is visible on THEMIS but not on MDIM (yellow arrow), (2) a fault is visible on MDIM but not on THEMIS (red arrow), and (3) a wrinkle ridge is more distinct using THEMIS when compared to the MDIM perspective (green arrow). Factors such as feature alignment, sun angle, etc., influence the mappers' perspective, and thus geologic detective work should be based on all existing information.

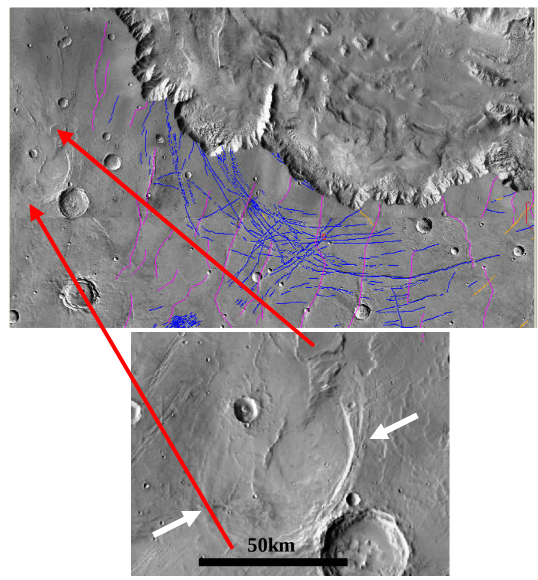

Figure 5. THEMIS day time mosaic (top; ASU) with faults radial and concentric about Melas Chasma (blue lines) and wrinkle ridges (violet lines) with red arrows pointing to newly identified vent structure (bottom; white arrows) (also see Dohm et al., this issue).

References: [1] Christensen, P.R. et al., 2003, *Science*, 300, 2056-2061. [2] Smith, D.E. et al., 1998, *Science*, 279, 1686–1692. [3] Dohm, J.M. et al., 2001a, *USGS Misc. Inv. Ser. Map I-2650*, scale 1:5,000,000. [4] Anderson R.C., et al., 2001, *J. Geophys. Res.*, 106, 20,563-20,585. [5] Dohm, J.M., and Hare, T.M., 2007, *LPSC 38, Abstract #1403*. [6] Dohm, J.M., et al., 2001b, *J. Geophys. Res.*, 106, 32 943-32 958. [7] Dohm, J.M., et al., 2007, *In Superplumes: beyond plate tectonics.* D.A Yuen, S. Maruyama, S-I Karato, and B.F. Windley (eds.). Springer, pgs. 523-537.