# COMPARISON OF VIKING- AND THEMIS/MOLA-BASED GEOLOGIC MAPPING.

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**Introduction:** How much of an improvement over Viking-based geologic mapping is there using THEMIS [1] and MOLA [2] data at regional to local scales? For example, quantitatively, how much change is there in the geologic unit designations (including total number of units), geologic unit areas, fault, fault-length, channel, and channel-length densities per stage of major geologic activity. Do the overall mapping-based hypotheses change when the mapper uses recently acquired data sets such as THEMIS and MOLA? Here, 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 part of the Claritas rise and nearby regions (referred to below as CR; see Fig. 1).

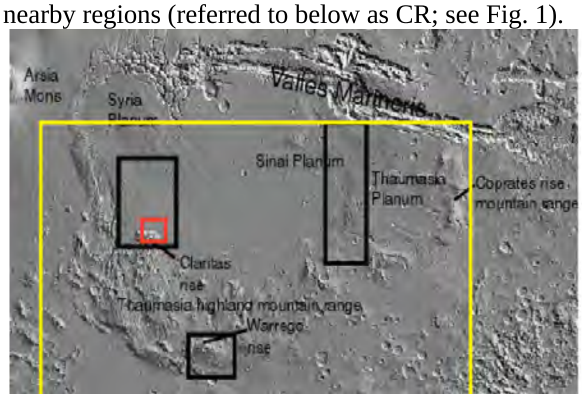


Fig. 1. Example area of the detailed mapping of the CR regions using THEMIS and MOLA for comparison with the published Viking-based geologic map data of [3] (red box). The CR region is 1 of 3 regions (black boxes) under re-evaluation. Also shown is a large part of the Thaumasia region that was mapped using Viking data (yellow outline).

**Approach:** Geologic units and tectonic structures (faults and complex rift systems) have been identified and mapped on the THEMIS IR map base using GIS software. 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.

Similar to [3], the materials of the CR region have been divided into 5 geologic units based on stratigraphic relations and morphologic characteristics, including basement complex (unit Nb), older fractured material (unit Nf), younger fractured material (unit Hf), and older flows of lower member ($Hsl_1$) and younger flows of lower member of the Syria Planum Formation ($Hsl_2$). In addition, 3 types of contacts delineating the map units have been used: (1) certain, (2) approximate, and (3) gradational (Fig.2).

Using the approach of [3], we have also mapped and determined the relative ages of tectonic structures in the CR region based stratigraphic and cross-cutting relations. [3] mapped thousands of tectonic structures, which included faults and grabens, mare-type wrinkle ridges, and broad and narrow ridges. Stratigraphic and crosscutting relations among the rock units permitted [3] to construct a map of the tectonic structures as they prevailed during five successive stages. The five stages are defined by major periods of geologic activity, which are recorded in sets of geologic units of the Thaumasia region (each rock unit was assigned a stage based on crater densities and stratigraphic and structural relations [3]), and their stratigraphic positions are correlative with the stratigraphic series defined by [5]. Based on uncertainties in the unit age ranges, [3] conservatively showed slight overlaps between the stages.

The stage assignments of structures on the map shown in Fig. 2 follow the same guidelines used by [3]: (1) structures of younger age may extend across boundaries of older rock units, (2) structures of intermediate age may extend into older units but not into younger rocks, and (3) stage 1 structures occur only in Noachian rocks. Mostly Stage 1 (Noachian) and Stage 3 (Early Hesperian) tectonic structures were mapped in the CR region.

GIS-based evaluation allows us to quantitatively assess whether there is a change in the geologic unit designations (including total number of units), unit areas, fault, fault-length, channel, and channel-length densities per stage of major geologic activity, and to test working hypotheses. We performed GIS-based comparative analysis among the published Viking-based map information [3] and the information obtained from this investigation.

**Results:** We have determined the areal extent of each map unit type and the fault-length densities for the CR region using the same method as [3]. Fault-length density is defined as the total fault length (sum of all faults of a given Stage) divided by the total area of geological units that pertain to a specific Stage. The faults that intersect the stage-assigned polygons were identified and the total feature length for each stage was tallied. For example, all faults that intersect polygons of Stage 3 materials were assigned a Stage 3 designation, since the youngest material a fault cuts conservatively represents its maximum stratigraphic age. All Stage 3 faults were then counted and their lengths totaled similar to what was done in the [3]. In the case of Stage 1, all Stage 1 geologic units were selected and any feature that was fully contained was identified. This information then forms the basis for performing a comparative analysis among the Viking-based published information of [3] (Tables 1-2 and Fig. 3).

Preliminary highlights resulting include: (1) map unit designations are consistent with [3]; (2) areal extents of the reevaluated map unit types are similar to those of [3] (Table 1); (3) in some cases, MOLA data aided in the differentiation among units Nb, Nf, and Hf; (4) the total number of mapped tectonic structures increased; (5) in several cases, Viking-mapped tectonic structures were revised (e.g., improved differentiation of fault segments and fault scarps of complex rift systems); (6) THEMIS and MOLA resulted in more structural trends and enhanced structural detail such as the large structures in the SE corner of the CR region (compare left and right maps of Fig. 2); (7) multiple data types allow for greater geologic perspective based largely on factors such as structural orientation, look direction of the acquired image, sun angle, atmospheric conditions, etc.; (8) 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).

Table 1. Comparison between the Viking- and THEMIS/MOLA-based map unit information.

| Unit symbol/Stage | Number of Polygons (Viking based; Reevaluated) | Total area |
|---|---|---|
| Nb/1 | 2; 2 | 4834.5; 4800.3 |
| Nf/1 | 2; 2 | 946.9; 1269.6 |
| Hf/3 | 1; 1 | 5651.1; 5683.4 |
| Hsl1/4 | 1;1 | 2554.1; 2184.6 |
| Hsl2/4 | 1;1 | 566.8; 614.0 |

Table 2. Comparison between the Viking- and THEMIS/MOLA-based paleotectonic information.

| Fault stage | Total area of map units per Stage ($km^2$) (Viking; Re-evaluated) | Fault total | Total fault length (km) | Density ($km/10^2km^2$) |
|---|---|---|---|---|
| 1 | 5798.2;6069.9 | 71;260 | 750.9; 1662.8 | 13.0/27.4 |
| 3 | 5651.1;5683.4 | 40;104 | 965.9; 880.7 | 17.1/15.5 |
| 4 | 3121.0;2798.6 | 0;1 | 0;6 | 0/0.2 |

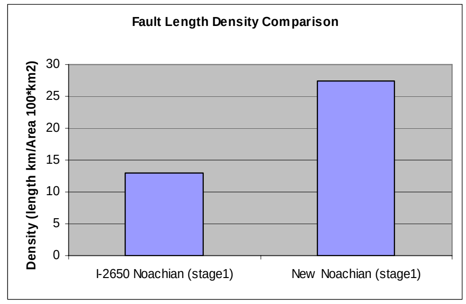


Figure 3. Histograms comparing- Viking and THEMIS/ MOLA-based Stage 1 fault-length densities.

**Implications:** 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. In addition, quantitative assessment of Viking- and THEMIS/MOLA-based mapping data will provide valuable information for both the planetary geologic mapping community and instrument science teams.

**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. (2001) *USGS Misc. Inv. Ser. Map I-2650*, scale 1:5,000,000. [4] Scott, D.H. and Carr, M.H. (1978) *USGS Misc. Inv. Ser. Map I-1083*, scale 1:25,000,000. [5] Tanaka, K.L. (1986) J. Geophys. Res., 91, E139-E158.

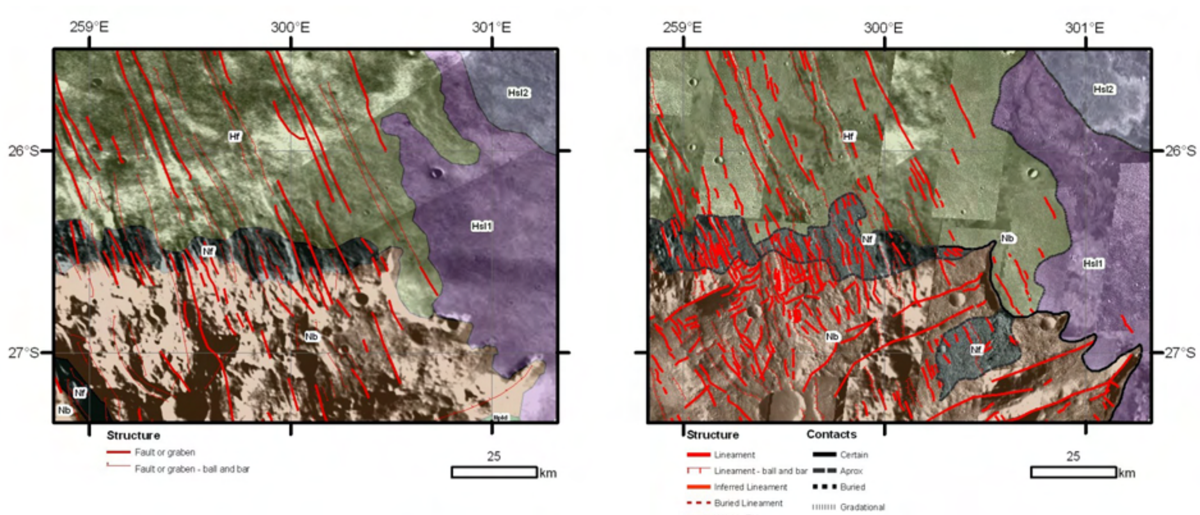


Figure 2. Comparison between the Viking- (left; map information on Viking base) and THEMIS/MOLA- (right; map information placed on THEMIS IR, VIS, and Viking to fill the gaps) based geologic information.