IDENTIFICATION OF SURFACE MORPHOLOGY BASED TECTONIC DEFORMATIONS: EVIDENCE OF RECENT SEISMIC ACTIVITY WITHIN THE CRUSTAL DICHOTOMY OF MARS

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Introduction: Crustal deformation on planetary bodies is identified by the distribution of extensional and compressional features depicting surface expressions of underlying tectonic activity [1]. Lobate scarps are typical compressional deformation features morphologically occurring as one sided, linear or arcuate segments within en èchelon step-like scarp fragments [2,3]. They, at times transition to wrinkle ridges on the Moon and Mars, e.g., at the dichotomous boundary on Mars [4].

Study Area: The Oxia Palus quadrangle on Mars is unique as it falls within the geographic transition zone between the southern highlands and northern lowlands. The diversity in terms of landforms depict the active geologic processes and remnants of paleo-climatic effects which make this region one of the most studied parts of the Martian surface [5]. One of the lobate scarps identified in this study area lies within the Ares Vallis region of Oxia Palus quadrangle, located south west of Taytay crater falling along a stretch marked by 6°47’43.02”N, 18°53” 48.96”W to 6°5’9.76”N, 18°56’ 45.23”W approximately (Fig. 1).

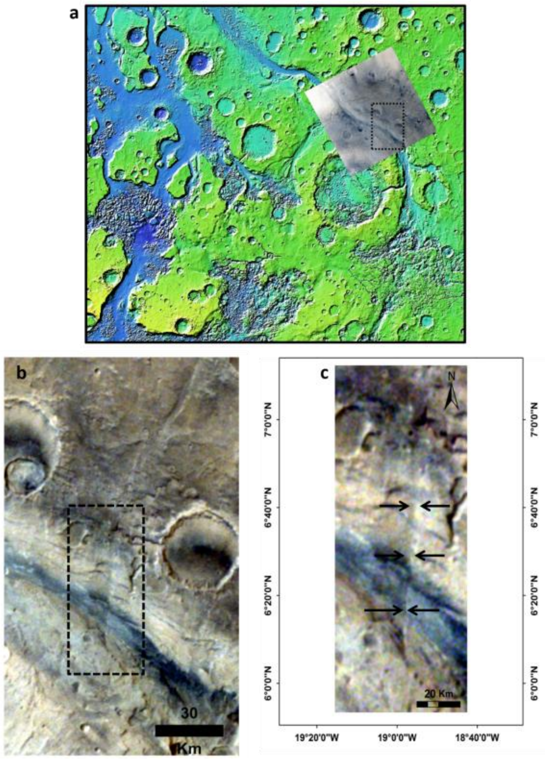

Fig. 1a. *MOLA-HRSC blended DEM with MCC image overlay showing the study area in **b** and **c**.*

The lobate scarp traverses vertically across the central part of the Ares Vallis region oriented perpendicular to the Martian dichotomous boundary. The length of the scarp within the valley region is estimated to be ~ 40 km.

Material and Methods: Mars Color Camera (MCC) images from the Mars Orbiter Mission (MOM) were used to identify the unique scarp initially. To analyze and map the extent and complex nature of the inferred lobate scarp, high resolution Context camera (CTX) (~6 m/pixel resolution) images from Mars Reconnaissance Orbiter (MRO), were used. The elevation profiles were drawn by deriving the digital elevation model across the scarp face through the IMARS web software which uses the AMES stereo pipeline images for DEM generation.

To estimate the absolute model age (AMA) of the identified scarp, the Crater Size-Frequency Distribution (CSFD) plot was generated using Buffered Crater Counting (BCC) method using production function derived by [6] and the chronology function (CF) from [7]. The craters used for deriving the CSFD plot were marked using the three point draw function of cratertools on ArgGIS platform.

Results: Elevation profile of a segment of the scarp falling within the Ares Vallis valley portion was generated by using the TIN image. Profile curves along this segment indicate that the approximate height of the scarp ranges from ~60 to 100m. Slope of the region of the scarp segment ranges from 0 to 81° (Fig. 2).

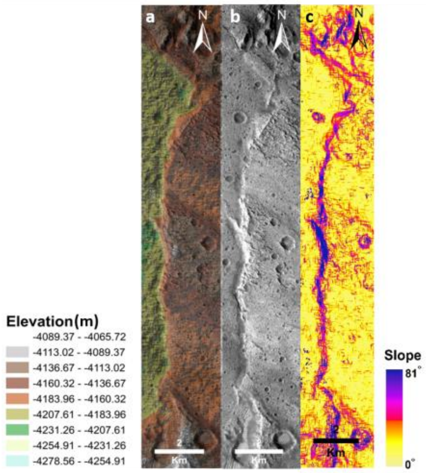

Fig.2. *CTX image in **(b)** overlaid on the derived digital elevation model (DEM) image of the lobate scarp **(a)** **(c)** Slope derived from the CTX DEM*

The CSFD plot of the identified scarp helped to estimate the absolute model age (AMA) of the scarp. The segment used to delineate the buffer region along with the craters used to derive the CSFD plot is shown in Fig. 3

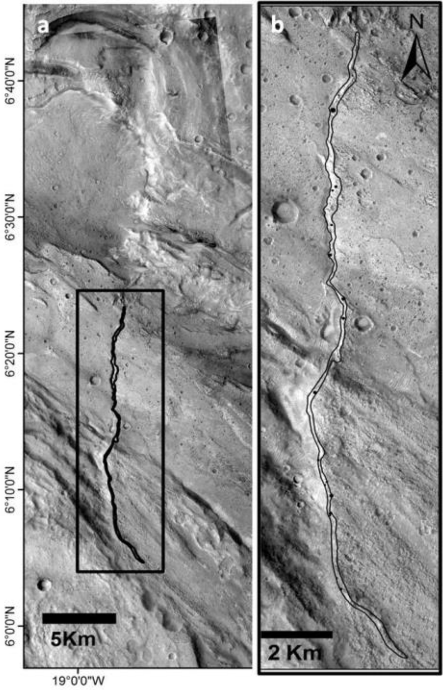

Fig. 3. a. *Scarp segment used for AMA determination.* ***b.*** *Buffer boundary along the scarp segment (black line) and the craters marked with solid black circles*

The CSFD plot estimating the AMA of the scarp is shown in Fig. 4.

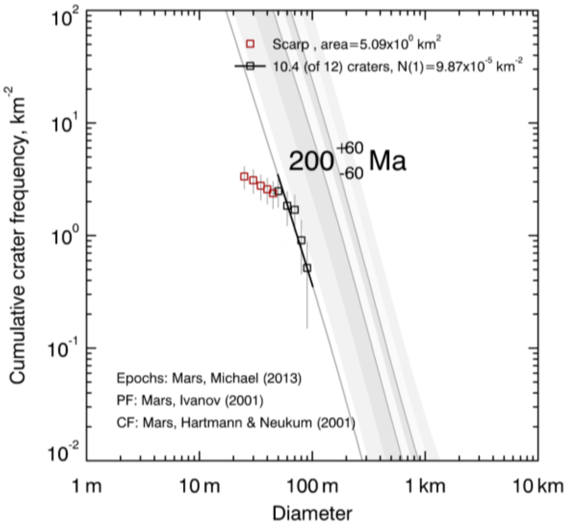

Fig. 4 *CSFD plot for the age determination of scarp*

Discussion: The CSFD plot suggests that the absolute model age of the identified scarp is 200 ± 60 million years. This age estimate suggests that the scarp is relatively young and could be indicating recent tectonic activity along the underlying thrust fault. Since the scarp segment used for age estimation lies in the valley portion which is a region that seems to have relatively low surface weathering, the estimated age is inferred to be accurate. The InSight lander data recorded over a four year period suggests that most of the significant high frequency seismic waves originate from a region known as Cerberus Fossae, a region filled with fissures due to movement along the underlying faults. This region falls close to the volcanic complex of Elysium Mons, suggesting that the seismic activity is largely attributed to the inferred volcanic magma movement in the underlying mantle of the region, however, other parts of the Martian surface lying farther away from this volcanic region within the transition zone might still be containing surface deformations which could elucidate the inferred geologically active nature of the underlying fault system on Mars within the dichotomous boundary.

These observations are important when geophysical data obtained from the InSight lander containing high frequency seismic wave recordings will be interpreted to gain better understanding of the geodynamics of Mars. Furthermore, such studies are helpful in decision making process for appropriate landing site selection for future manned and unmanned exploration missions.

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References: [1] Watters T.R. et al. (2010) *Science, 329*, 936–940. [2] Watters T.R. (1993) *JGR., 98*, 17049–17060. [3] Mukherjee S. and Singh P. (2015) *Plan. & Sp. Sci., 112*, 46-52. [4] Watters T.R. and Robinson M.S. (1999) *JGR: Planets, 104(8)*, 18981-18990. [5] Pacifici A. et al. (2009) *Icarus, 202 (1)*, 60. [6] Ivanov B.A. (2001) *Space Science Reviews, 96 (1*), 87e104. [7] Michael G.G. and Neukum G. (2010) *EPSL, 294(3)*, 223-229.