GEOMORPHOLOGICAL STUDY OF GULLIES IN PENTICTON CRATER, MARS: EVIDENCE FOR LATE AMAZONIAN LATITUDE DEPENDENT MANTLE. Varsha Natarajan[1,2], Kusuma K N[1], D Lekshmi Nandana[1], [1]Department of Earth Sciences, Pondicherry University, India, [2] Department of Systems Innovation, University of Tokyo, Tokyo, Japan (varsha.natarajan2014@gmail.com).

Introduction: Gullies were first discovered on Mars from the images by Mars Global Surveyor (MGS) [1]. The crater chronology and the law of superposition indicate that they are comparatively young features on the surface of Mars [2]. They typically consist of an upper theatre-shaped dendritic alcove that tapers downslope to converge on a channel, that extends further downslope to terminate in a debris fan apron [1]. Martian gullies are seen in the mid-latitudes of both the hemispheres, more prominently in the southern hemisphere (30° to 45° S) poleward-facing slopes [3].

The Penticton crater (38.35° S, 263.35° W) is a crater of diameter 8 km located in the Centauri Montes region of the Hellas quadrangle in Mars. This southern hemisphere mid-latitude crater is covered with flows that are typical examples of the martian gullies that resemble the terrestrial gullies on Earth. The gullies are present in the north, northeast, and southeast crater walls. We studied the gullies present in the Penticton crater, classified them, and tried to interpret their origin using a remote sensing approach.

Methodology: Regional geomorphology was investigated using CTX images and HRSC-MOLA blended DEM. Detailed geomorphological study and classification of the gullies is conducted using a combination of HiRISE images and HiRISE DTM [4]. The gullies are classified based on their morphological components [5]. To monitor the gully activity, the morphometric parameters like length, orientation, alcove and apron width of the gullies are measured for all the four martian seasons. In addition, mineral spectra analysis of the region is carried out using CRISM MTRDR data to look for the presence of water ice or dry ice [4]. The age of the study area is estimated using crater counting method.

Results and Discussions: The study area evidently shows the glacial landforms typical of martian Viscous flow features (VFF). We observe features like Lobate debris apron (LDA), Lineated valley fill (LVF), and Concentric crater fill (CCF) surrounding the crater (Figure 1c) [6]. Other terrain features like polygonised terrain, pasted-on terrain , mound and tail terrain, and

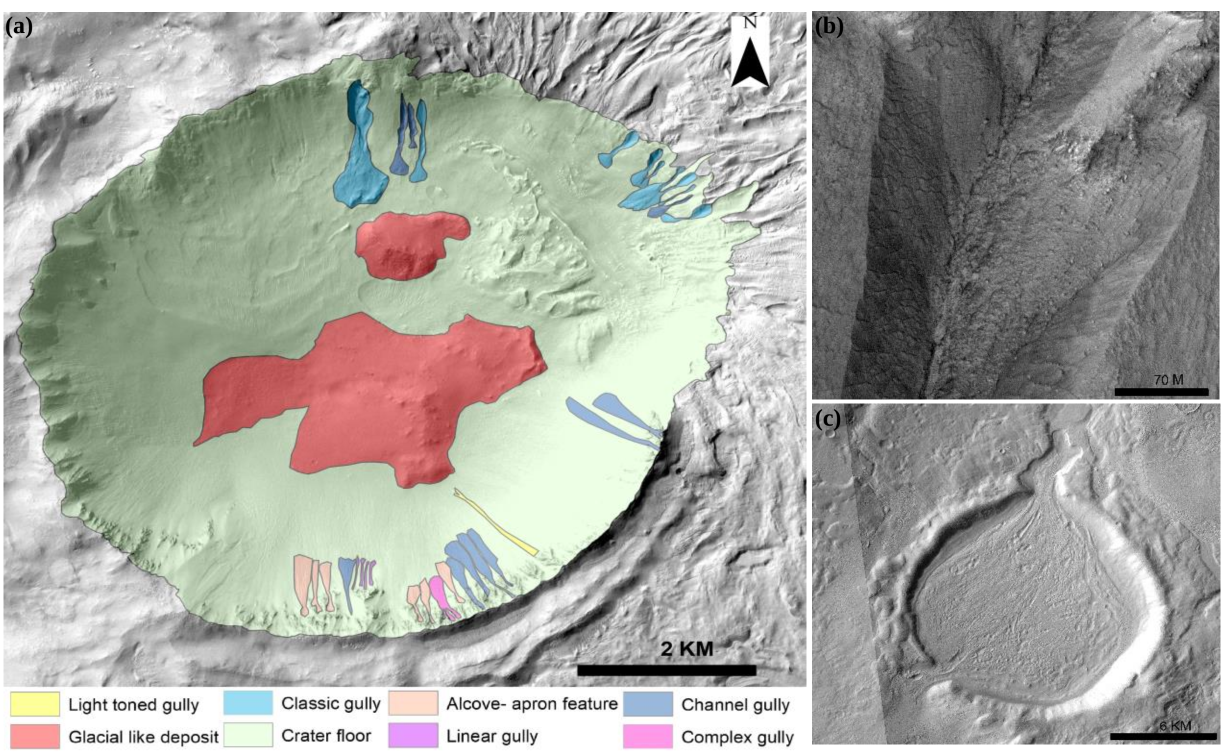

Figure 1. (a) Geomorphological map of classification of gullies over CTX image (b) Polygonised terrain in the alcove of the gully inside the crater (c) Concentric crater fill (CCF) at a crater near the Penticton crater

linear terrain that are commonly called as Glacier – like forms (GLF) are dominant inside the Penticton crater (Figure 1b) [7]. The asymmetry in the crater profile graph indicates the presence of a latitude dependent mantle (LDM) [8]. The pole facing crater wall is found to have a thicker LDM compared to the equator facing slope.

The Penticton crater shows the presence of almost all types of gullies, which makes it unique. From the geomorphological study, it is found that the north and north-eastern crater walls are dominated by classic gullies (Figure 1a). Few channel gullies are also observed. On the other hand, southern crater wall is dominated by channel gullies and alcove-apron features. Four linear gullies that originate from the middle of the crater wall are observed on the southern side. The morphometric parameters did not show any seasonal variations in their magnitude. The alcove and apron width showed a maximum relative standard deviation of 3%. The gully length also did not show any changes and a maximum of 5% relative standard deviation was observed. Gullies in the northern and north-eastern walls of the crater are found to have a slope less than 20°. The gullies on the equator facing slopes had an average slope between 20° and 34°. The light toned gully in the southern wall also did not show any seasonal changes in the parameters. Diurnal or seasonal variations might have happened in the past but as of now the gullies are found to be stagnant with almost constant average slopes. The orientation of the gullies did not show affinity towards any direction (Figure 2a). The mineral spectra analysis confirmed the absence of water ice and dry ice. The Penticton crater region is found to be 5.5 Ma old and hence belongs to the recent period of Amazonian (Figure 2b).

Conclusions: The study area is covered by glacial features including the interior of the Penticton crater. It is observed that the gullies do not dominate on a specific crater wall as commonly seen in other mid-latitude craters. Even though this study clearly proved that there is no presence of dry ice or water ice in the region at present, the geomorphological evidence points out that the region was covered by glaciers in the past. However, the gullies are not active now as there is no seasonal variations in the morphometric parameters. As the region is very young, the glacial depositions might have occurred during the periods of high obliquity [9]. The gullies maintained a slope of less than 34°, which is the angle of repose for dry granular sand during all the seasons [10]. Therefore, the gullies seem to have formed by dry granular material sliding triggered by the sublimation of the LDM during the recent shift of Mars to low obliquity [11].

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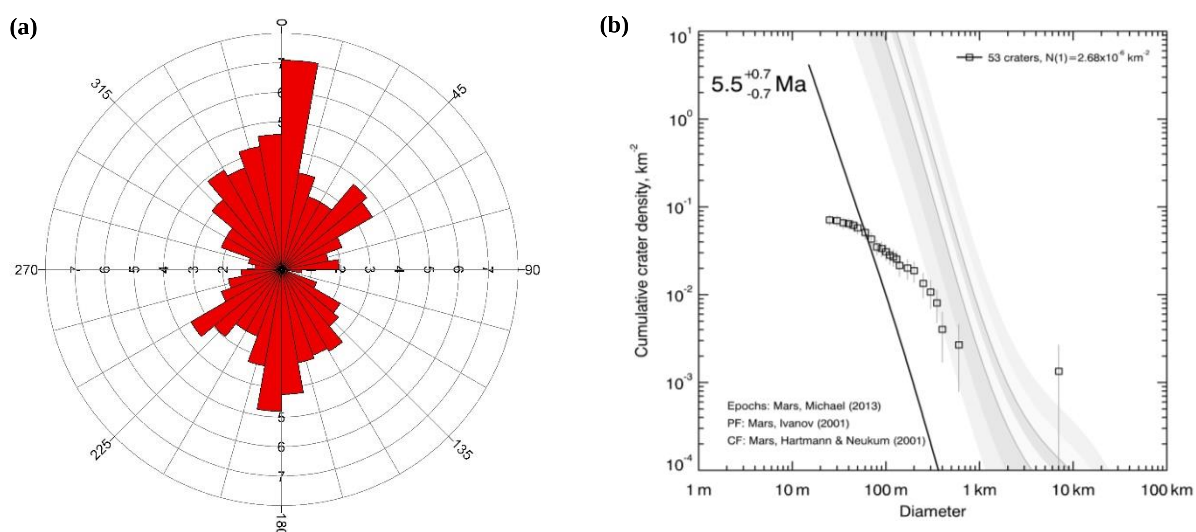

Figure 2. (a) Rose diagram indicating the orientation of gullies (b) Age of the region around Penticton crater