Geomorphological mapping and investigation of a mountain glacier in the Argyre Region, Mars. Nisha Gor[1], [1]University College London (UCL), London UK.

Introduction: MRO data has shown that the equatorial and mid-latitudinal regions on Mars contain hundreds of viscous flow features. Geomorphological studies interpret these features to be similar to dust-covered glaciers [1]. Radar studies have also confirmed their interiors are composed of nearly pure water ice [2]. These features are known as glacier-like-forms (GLFs) because they are visually like terrestrial valley glaciers seen on Earth and have numerous similarities in their ice-rich landforms [3]. However, despite this observation, there are many differences and concepts which are still unknown. Very little is known about the fundamental glaciology and geological aspects of Martian GLFs. The study of non-polar ice is essential for determining an accurate geological and climatic evolution of Mars particularly during the Amazonian, a Martian epoch which has received less attention than older terrains.

Glaciers are known to be effective recorders of climate change. Investigating them can help us understand mechanisms or parameters which may have affected atmospheric and surface changes during the Amazonian. Many clusters of GLFs are concentrated around the latitudinal range between ~20-60º N and S [3]. Within this range lies the Argyre Basin which hosts one of the largest viscous flow features and several GLFs, particularly in northern Argyre. The region is one of the best-preserved basins revealing many features of flowing water in the past [4]. This paper aims to explore the geomorphology and present the results of a mapping investigation of a debris-covered mountain glacier in Argyre.

Aims and Objective: This project aims to utilize existing high-resolution images a mountain glacier located in Argyre. By creating a geomorphological map and characterizing the glacier system in more detail, further interpretations can be made about the formation and evolution of non-polar ice on Mars particularly during periods of high obliquity. Observations and interpretations can either support the knowledge already known about non-polar or challenge it. Another objective of this paper is to derive surface ages for different parts of the glacier using crater counting. This will help gain a better understanding of its long-term stability and timing of formation.

Methodology: For this mapping investigation, Context Camera (CTX) data from NASA's Mars Reconnaissance Orbiter (MRO) was mosaiced together for the Region of Interest (ROI). The mosaiced CTX file covers approximately 10,400km² over the region of interest. The file is georeferenced to a High-Resolution Stereo Camera (HRSC) Digital Terrain Model (DTM). The HRSC is an instrument on board the ESA's Mars Express. Combining CTX and HRSC data provides a powerful 3D tool because we can extract morphometric information of the flow directions of the glaciers and its influence on the surrounding topography. Furthermore, High Resolution Imaging Science Experiment (HiRISE) images of the glacier was laid on top of this data. The spatial resolution of the data is 0.25–0.5cm/pixel which is useful for identifying surface features in more detail

Geological Setting of ROI: The study region is located 326ºE, 47ºS on the eastern rim of Argyre Basin. SE of the region lies the Galle crater, commonly known as the 'happy face crater'. Since the location of the ROI is on the rim of the Argyre and outside the rim of Galle, we can infer that the mountain hosting the glacial system is possibly made up with rim material from the time of impact or erosional material from the uplifted mountain during the time of impact.

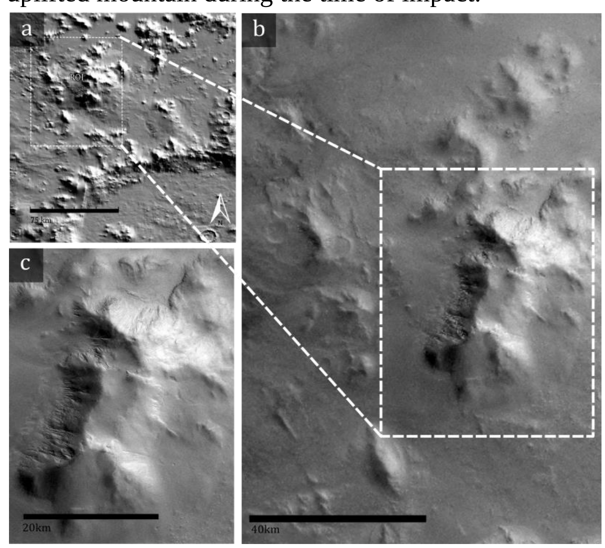

Figure 1:HiRISE images of heavily cratered surface SW of the study region, mid-Noachian in Age.

Observations: The host mountain is the most significant feature in the study region located slightly to the east as shown in Fig. 1. Using MOLA elevation data from JMARS, it topographic height is ~3013 m south of the mountain and ~3408 m NE where the mountain displays a cirque-like feature. The overall shape of the mountain displays a rectangular mesa-like mound with a flat top as displayed in Fig. 1. The size of the mountain is approximately 40x30 km with a flat top of ~20x5 km. The relationship between the mountain and the surrounding fretted terrain is difficult to establish because of the extensive flows from the mountain and regolith covering the margins of the mountains. The lithology of the mountain is likely to be erosional remnant from the impact rather than a continuous unit from older terrains. The sides of the mesa-like mountain, particularly north and west of the mountain have prominent sets of what is interpreted to be gullies fed by 2 prominent cirques striking NE-SW and NW-SE (Fig.2). These gullies seem to have created very deep depressions on the northern and western sides of the mountain. It can be suggested that these 2 prominent cirques are the source of flows from the mountain.

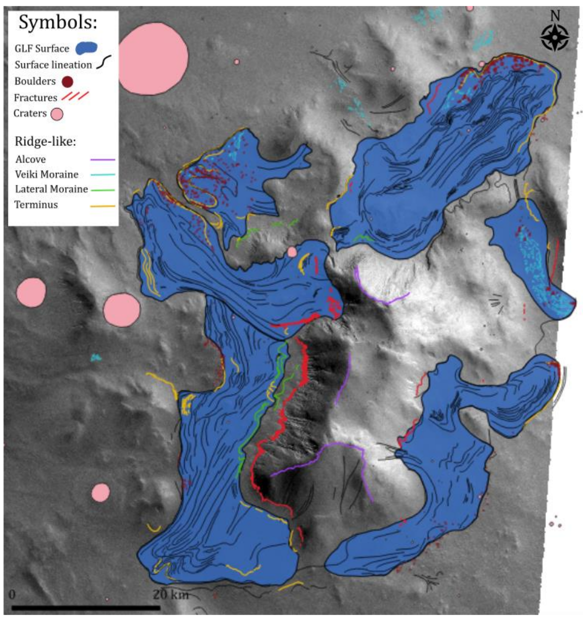

Figure 2:Geomorphological map and interpretation of glacial system around mountain.

Other than the ice mountain, the lobes around the mountain are a distinctive feature. A geomorphological map is presented in Fig. 2 of the lobes which flow outwards from the mountain. In total, 6 flow bodies were identified flowing in different directions trending NE, NW, and SW. 3 of these flows are prominent than others as they display features which characterize a GLFs. The other 3 flows trending SE are quite minor in comparison but still shows characteristics of debris apron flow. The source of the flows seems to be from the 2 NE and NW-facing prominent cirques. The 3 main lobes terminate around 20kms from the source mountain. The lobes terminate sharply without mixing with the lithology underneath. Near the terminus of the lobes are several boulders in the NE and NE facing lobes suggesting evidence for young glacial flow. The NW lobes has been displayed as two separate lobes as the northern most lobe seems to be cross cutting across the lower one. Similarly, the NW lobe is flowing over the SW lobe suggesting possibly different phases/cycles of melting or erosion. The SE debris apron displays no ridges suggesting they may have not yet terminated, and motion is still ongoing. Surface lineation's were clear to see on all lobes except. Several types of ridges were found as shown in Fig. 3. The source of gullies were the ridges seen above alcoves. Veiki moraines were also found in isolated places (Fig 3b). For example, in the west most part of the map a minor debris flow displays veiki moraines-like ridges. These are irregular enclosed ridges characteristic of glacial flows. The fresh surface with little to no craters could suggest that a relatively young surface post-glacial recession and a recent ablation of the glacier system. Lateral and terminal-like ridges have also been identified in the region. A well-preserved example of a lateral-like ridge is at the base of the NW-facing cirque (Fig. 3c). The NE trending lobes displays the terminus of the flow (Fig. 3d).

Several other geomorphological features found and interpretations will be presented and discussed in more detail during the meeting.

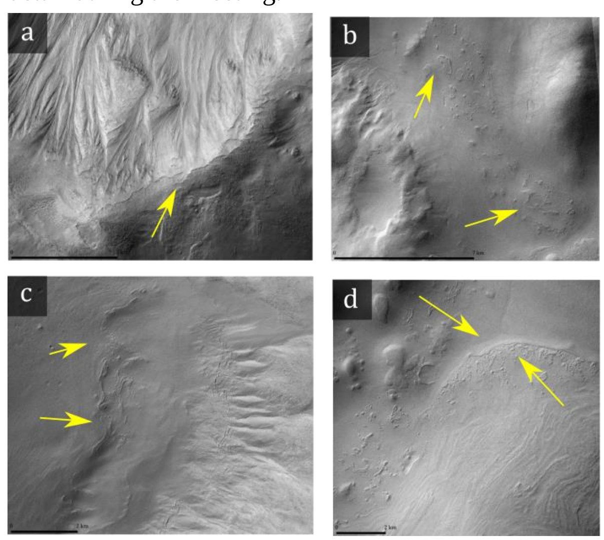

Figure 3: HiRISE images of observed ridges in the region. Ridges shown by yellow arrows. Fig. 3a- Alcove ridge. Fig. 3b- Veiki moraine-like ridge. Fig. 3c- Lateral ridges, sinuous in shape at the base of gulley system. Fig. 3d- Terminal moraine-like ridge where mixing has not occurred.

Acknowledgments: Data from NASA's Mars Reconnaissance Orbiter (MRO) and HRSC and DTM data from ESA's Mars Express mission has been utilized.

References: [1] Milliken et al., (2003), Geophys Res 108(E6):5057 [2] Plaut et al.,(2009), Geophys. Res. Lett., 36, L02203. [3] Souness et al., (2012). , Icarus, 217, 243–255. [4] Hubbard et al. (2014), The Cryosphere, 8, 2047–2061.