DEGANA CRATER, MARS: EVIDENCE FOR FLUVIAL AND GLACIAL LANDFORMS ON A VOLCANIC DOME. Harish[1], Vijayan S[1], and Nicholas Mangold[2]. [1]Physical Research Laboratory, Ahmedabad, India, [2]CNRS/Université de Nantes, 44322 Nantes, France. [1]harish@prl.res.in, [1]vijayan@prl.res.in, [2]nicolas.mangold@univ-nantes.fr

Introduction: Impact craters on Mars have exposed the earlier crust in the form of mafic minerals, retained the record of ancient environments and climatic transitions in the form of alluvial fans and glacial like features [1-7]. Records of these volcanic, fluvial and glacial activities within the same location is rare on Mars. Though, fluvial and glacial landforms are widely reported on Mars [1-7], however, no evidence is yet reported for both of these activities within impact craters formed within a volcano.

We present the first report of both the fluvial and glacial landforms formed within the Degana crater [Fig 1], which is formed over a Noachian shield volcano [1]. An elevation profile across the shield volcano display convex up shape [Fig 1d]. Degana is a ~50 km diameter impact crater [Fig 1b], located on top this dome [Figure 1a]located in Coprates quadrangle, southern highlands of Mars. This crater is superposed by another impact crater of ~22 km diameter called here as Degana-A [Fig 1b]. The present study aims to understand the geomorphological, mineralogical and chronological context of the Degana crater that has implication for early volcanic crust and climatic transitions underwent on Mars.

Data and Method: In this study, MRO-CTX and -HiRISE images were used for geomorphological analysis and CRISM S and L, FRT TRDR spectral datasets were used for mineralogical analysis. Spectral summary products were generated for IR processed data. MAF browse product was generated using the band combinations OLINDEX3, LCPINDEX2 and HCPINDEX2 as described by [8] for analysing qualitative mineralogical abundances of major rock forming mafic minerals. For topographical analysis we used MOLA DEM, MOLA-HRSC blended DEM, along with the available CTX and HiRISE DEM.

Results and Discussion: Fig.1c shows the geomorphic map of the Degana crater with alluvial fans, channels and ridges.

Depositional fans: Degana-A crater floor is entirely covered by four large depositions, whereas the Degana crater eastern and southern walls are mantled by depositions with associated channels. These depositions show typical fan shape, erosional valleys upstream, inverted channels/distributaries on the fan [Fig 1c,e]. These patterns being similar to alluvial fan deposits on Mars, we interpret these landforms as alluvial fans. Alluvial fans generally formed by the deposition of water transported material in low relief regions and

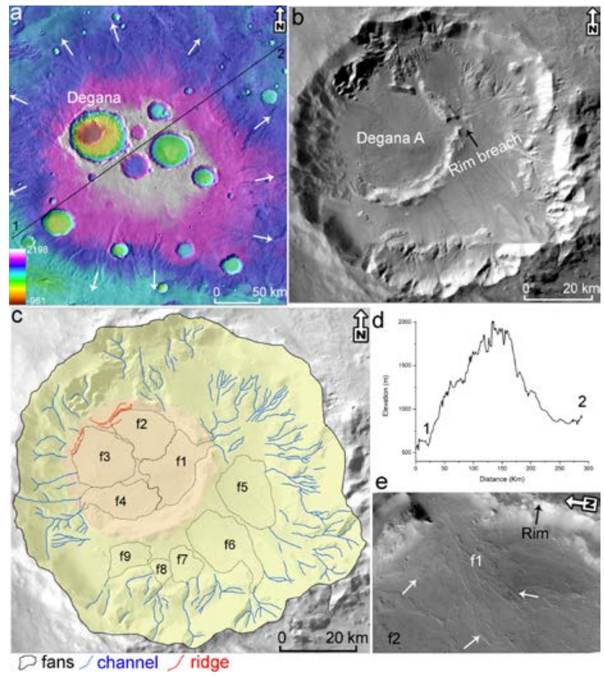

Figure 1: a) MOLA topographic map of the Degana crater and elevated dome region, b) CTX mosaic of Degana and Degana-A crater on the volcanic dome, with notable rim breach, c) Geomorphic map of the Degana crater, d) Profile across the ancient shield volcano shows dome shape e) Fan f1 within Degana-A.

fed by controlled catchments [2,9]. Interestingly, fans within Degana-A converging towards each-other and coalescing of fans suggest formation of fan bajadas within the Degana. The fan f1 formed by breaching the eastern rim of Degana-A crater. For this fan f1, we quantitatively measure the flow velocity and discharge rate. Following [3] we determined the flow velocity as ~2 m/s and discharge rate as ~2.25 mm/hr.

Moraine-like ridges: There are very few studies [4,10,11] that have suggested potential glacial like features in the craters located in the lower latitudes (~5° to 30°). We identified moraine-like ridges [Fig 2] superposed over the alluvial fans within Degana-A. These ridges are U-shaped and display convex up geometry, being generally thicker in the center [Fig 2]. These features are interpreted as terminal moraines and are direct marker of glacial activity within the Degana crater. We determined the average thickness of these moraine-like ridges as ~22 m and following [6] the ratio of basal stress to density was estimated as ~4 m^2/s^2 that plausibly suggests occurrence of nearly pure-ice glacier within Degana-A.

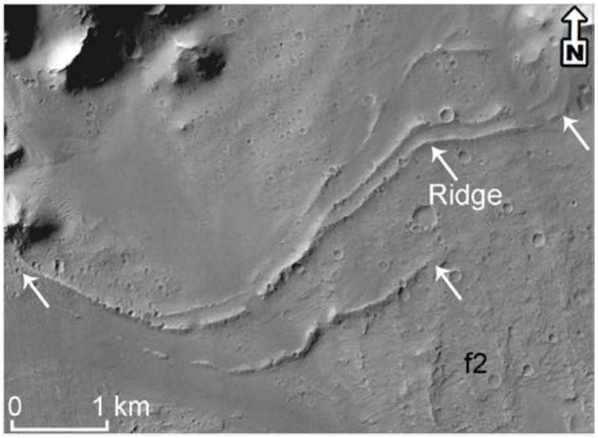

Figure 2: *Moraine-like ridges superposed over the fan f2 within Degana-A.*

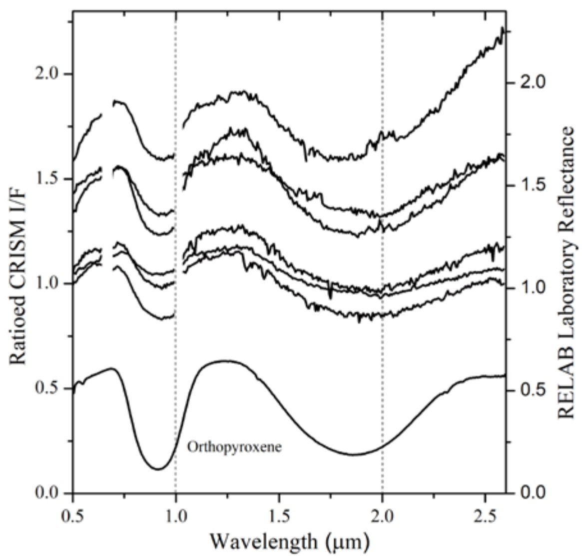

Figure 3: LCP spectrum observed within the north-eastern wall of Degana-A crater.

Mafic minerals: CRISM derived spectral signatures from Degana crater show absorptions at 1 and/or 2 μm wavelengths (Fig 3-4). Spectra from the northeast rim of Degana-A is characterized by broad absorptions around 1 μm and 2 μm [12,13], which are spectrally attributed to pyroxene [Fig 3]. All the spectrum display absorption features between 0.8-1.0 μm [14], which indicate presence of exposed low-calcium pyroxene (LCP). Whereas, few locations over the southeast rim of Degana-A is characterized by absorptions around 1 μm and a lack of absorption around 2 μm [Fig 4], which is interpreted as olivine [15]. As the spectra shown in fig 4 do not display absorption feature between 1.2-1.4 μm, therefore we report the presence of exposed Mg-rich olivine [14].

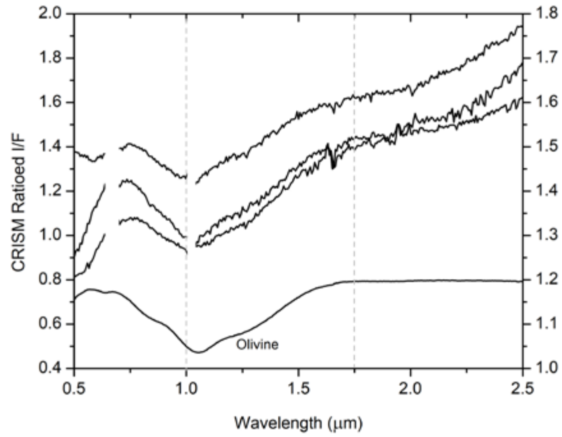

Figure 4: *Olivine spectrums observed over the south-eastern wall of Degana-A*

Crater chronology: The age of the volcanic dome is ~4.0 Ga[1] or Mid-to-Late Noachian. The crater size frequency distribution for the Degana crater suggests an age of ~3.8 Ga (late Noachian) using the Neukum-Ivanov system [16,17]. We interpret that the depositional fans are relatively younger than the Degana-A crater and the ridges are further younger than the fan deposits.

Conclusions: We carried out a detailed study of Degana crater region, which revealed: 1) pristine exposures of interior of a mid-Noachian aged volcanic dome, which is mafic in nature (olivine and LCP), 2) the possible source for the fan deposits are the local precipitation of snow/ice deposits related runoff over the dome, 3) alluvial fans from the pole facing walls are superposed by moraine-like ridges, which indicates the last stage glacial activity in the region during mid-Amazonian. Thus, this region is one of the locations on Mars, which recorded diagnostic evidences for volcanic, fluvial as well as glacial activities over the same location. The exposure of pristine mid-Noachian crust and non-coeval fluvial and glacial activities suggests that this region witnessed wide geologic and climatic transitions on Mars.

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