EFFECTS OF SOLAR RADIATION ON THE GLACIAL DEPOSITS DISTRIBUTED AT NORTHERN LOW TO MID-LATITUDES OF MARS. T. Ruj[1], P-A. Tesson[2], H. Okuda[3,4], T. Usui[1], G. Komatsu[5], G. W. Schmidt[6], and S. Mihira[1,4]. [1]Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA), 3-1-1 Yoshinodai, Sagamihara, Kanagawa 252–5210, Japan, (trishitruj@gmail.com), [2]Centrum Badan Kosmicznych Polskiej Akademii Nauk (CBK PAN), Bartycka 18A, 00-716 Warsaw, Poland, Poland, [3]Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, University of Tokyo, Kashiwanoha 5-1-5, Kashiwa, Chiba 277-8564, Japan, [4]Department of Earth and Planetary Science, Graduate school of Science, University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo, Japan, [5]International Research School of Planetary Sciences, Università d'Annunzio, Viale Pindaro 42, 65127, Pescara, Italy, [6]Department of Science, Università degli studi Roma Tre, Rome, Italy.

Introduction: Martian geomorphology and their terrestrial analogs suggest the presence of volatile-rich zones as a possible reservoir for water ice at an accessible subsurface depth [1, 2, 3]. In the recent past, with high orbital obliquity, the nonpolar ice accumulation shifted even towards the low to mid-latitude region [4, 5, 6], and due to the episodic glaciation/deglaciation, lobate debris aprons LDA, concentric crater fill (CCF), and lineated valley fill (LVF) like landforms were formed even at the low to mid-latitudes [3]. Morphologically, these landforms resemble pits and buttes formed by viscous deformation by the flow of rock and ice [2, 7]. Hence, exploration of these ice-related geomorphic features could potentially be the target locations for future missions focused on the exploration of Martian ice.

In this research, we focused on the craters within the 25ºN–40ºN latitudes of the Arabia Terra region. Geologically, the region belongs to the middle Noachian highland unit of 3.87–3.97 Ga [8, 9] that has been resurfaced later [10]. The region is important because future Mars missions are targeted to explore water ice deposits from the low to mid-latitude regions that receive enough solar energy to power the lander/rover.

We have investigated craters with diameters >2 km for evidence of water ice-related morphologies and have encountered CCF deposits from over 700 craters. Typically, CCF deposits are found in regions with abundant LVF and/or associated with LDA deposits as a crater interior unit of multiple crater wall concentric lineations and are significant components of Amazonian aged (~60–300 Ma) glacial landforms [2, 11, 12]. Several hypotheses have been proposed to explain the origin of these deposits and they include “ice-enhanced regolith creep” [13], debris derived from bedrock recession along scarps due to sublimation of ground ice or the emergence of groundwater [14], mobilization and seasonal flow of talus by diffusional emplaced pore ice [12], and debris-covered glacier [2, 15]. On Earth, similar landforms are formed due to the advancements of debris-covered glaciers in response to climate, driven by obliquity changes and their effect on the ice mass balance [1].

Methodology and datasets: This research has two components, a geomorphological investigation of the water ice-related landforms and a modeling to understand the variation of insolation at the different parts of the crater [16]. We primarily identified the glacial landforms using the Thermal Emission Imaging System (THEMIS)–InfraRed (IR) daytime [17] coupled with a high-resolution Stereo Camera (HRSC)-MOLA blended Digital Terrain Models (DEM) (200 m/pixel) in ArcGIS platform. Then, we used Context (CTX) camera (6 m/pixel) [18] and a High-Resolution Imaging Science Experiment (HiRISE) [19] images for detailed morphometric observation. For the solar radiation model, we have computed the daily mean solar insolation for a model crater at 30ºN latitude. To this end, we have used a publicly available high-resolution HiRISE DTM of pristine 3-km wide impact crater resampled at 50 m and calculated direct insolation for each pixel at every sol between solar longitude (Ls) 280–290 [16].

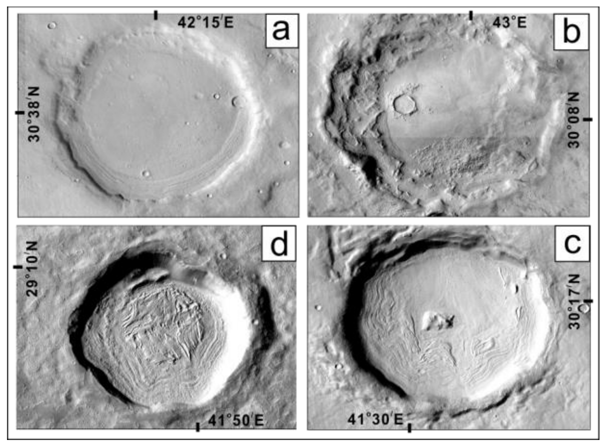

Fig. 1: Craters with concentric fills. Impact crater in this image (a, 21 km; b, 49 km; c, 18; d, 4 km diameter) show incremental growth of the deposit from low definition CCF to high definition CCF deposit in a clockwise manner. It should be noted that are at similar latitudes.

Results and observations: Our observation suggests that a significant number of craters above the 25º N latitude have CCF deposits on their floors (Fig. 1). Floors are partially (low definition; Fig. 1a) to completely filled (high definition; Fig. 1d) depending on the crater depth. We have also noticed that the fresh-looking craters with preserved ejecta tend to have high definition CCF deposits, and larger craters with eroded ejecta have low definition CCF deposits. A detailed look at the morphology of the deposits indicates three distinct morphologies namely brain terrain at the crater floor, mound and tail terrain, and linear terrains with polygonal cracks (Fig. 2) in areas transitioning from floor to wall. We have also noticed that the CCF deposits in average thicker at the southern part (south-southwest to be more precise) of the crater floor.

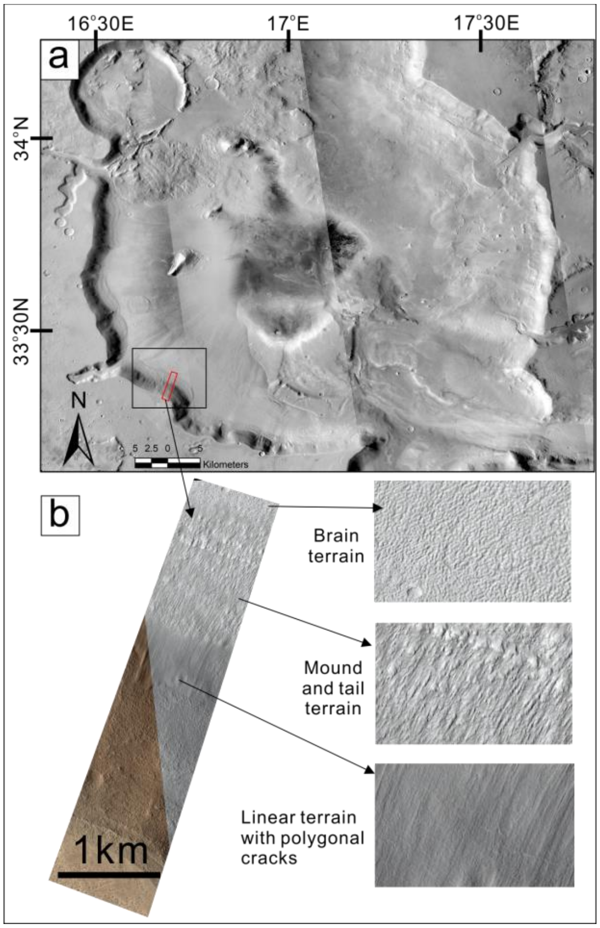

Fig. 2: a) Low-definition concentric crater fills. b) HiRISE image (ESP_017065_2135) shows three distinct parts of the deposit. Brain terrain at the crater floor, mound and tail terrain with ridges, and the top linear terrains with polygonal cracks from the crater floor to crater wall direction.

Therefore, we focused on answering two basic questions. 1. Why are the deposits concentrated on the southern inner wall of the crater? 2. How has the solar radiation contributed to the ice deposits in one part of the crater?

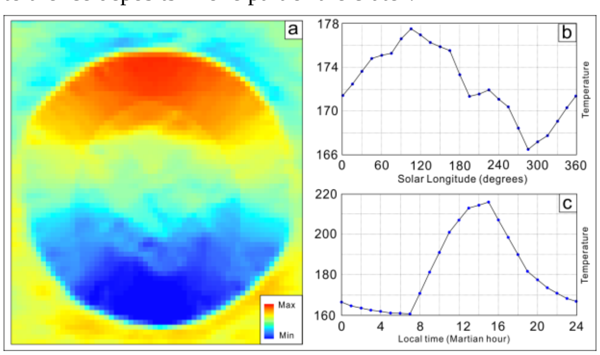

Fig. 3: a) Relative magnitude of solar insolation HiRISE DTM DTEEC_002118_1510_003608_1510_A01 placed at 30° N latitude. b) Yearly variation of minimum temperature at midnight. c) Daily variation of temperature Ls 285.

Direct insolation: Following the general circulation model, extracted from the Mars climate database [19], we observed that the minimum temperature at 30° N latitude is in between Ls 280–290 (i.e., early winter on the northern hemisphere) (Fig. 3b). The circulation model also suggests that in this time the accumulation of water ice is also highest. Our model indicates that the southern part of the inner crater wall receives less direct solar flux (as a proxy to surface temperature) than the northern part of the crater in the winter season (Fig. 3).

Discussion and Conclusion: The geomorphological observation suggests that the fresh-looking impact craters with a greater depth of excavation host high definition CCF deposits in the same latitude range (Fig. 1). If this is the case, then the supply of groundwater has played an important role in the ice formation in the region. However, polygonal cracks related to the CCF features (Fig. 2b) indicate its close relation with the shallow subsurface ice. Gullies [3], as well as the mound and tail terrain (Fig. 2b), indicate the transportation of water from the polygonal crack-dominated region to the brain terrain region (Fig. 2b). Therefore, these CCF are recent geological features possibly hosting water ice at an accessible depth. On the other hand, the direct insolation model (Fig. 3) suggests that at 30°N, in the winter, pole-facing slopes (i.e., the southern part of the inner crater wall) receive less sunlight than the equator-facing walls. This apparent trend in deposition could also be correlated with the hypothesis that ice on the southern part is preferentially melted whereas in the northern part it is mostly sublimated [11]. However, the daily difference in surface temperature in the morning and the evening can lead to the southwestern part of the inner crater wall being colder than the southeastern part. Consequently, we have observed the CCF deposits are thicker and wider in the south-southwest part of the crater. Future work could consist on using a surface temperature model as opposed to a direct insolation one to explain the observed south-southwest trend.

Therefore, CCF deposits concentrated on the south-southwestern part of the crater inner wall could also be a potential region for the future investigation of the ice deposits even in the low to mid-latitude region.

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