

REMNANT ICE ON PRESENT DAY IN THE FLOOR OF THE NESTED DEPRESSIONS AT THE NW FLANK OF THE HECATES THOLUS VOLCANO ON MARS? A DISCUSSION. M.A. de Pablo. Unidad de Geología. Departamento de Geología, Geografía y Medio Ambiente. Universidad de Alcalá. 28871 Alcalá de Henares, Madrid. Spain. (miguelangel.depablo@uah.es).

Introduction: Hecates Tholus volcano is the unique edifice of the Elysium volcanic province on Mars where glacial-related features has been described, e.g. [1,2,3,4], and detailed mapped [5]. Geomorphological and morphometric analyses we also made [6] corroborating the glacial origin of the landforms observed in the NW flank of the volcano and the 2 nested depressions that characterice it. The geomorphology [5,7] and the observed analogues between the covered glaciers on Deception Island (Antarctica) and Hecates Tholus volcano [8,9] let us attempt to understand the environmental and geological conditions of the Martian site. Here we analyse some of those geomorphological evidences in order to discuss the possible existence of buried ice lenses at the floor of the nested depressions on the flank of the volcano.

Surficial materials: the materials covering the area could be any combination of the following cases: (1) debris deposits from slope processes (including solifluction and rockfalls, among others) at the base of the high walls forming the nested depressions on the flank of the volcano, as well as the valleys dissecting their walls; (2) pyroclastic deposits (from cinder to bomb-size particles) from eruptive events, such as occurs on Deception Island, taking into account the volcanic origin of this region –in fact, some authors proposed a possible eruption on the flank of the volcano about 350 Ma ago, e.g., [1,2]; and (3) dust deposits caused by the periodic Martian storms responsible of cover the surface of the planet with a very fine-grained material, e.g., [10,11]. Other type of materials are not discarded, such as impact ejecta deposits. Whatever is the origin of these materials, glacial reworking is a possibility.

Lobate features: The distribution of ridges and possible moraines mapped in the area [5], reveal a maximum glacial phase followed by a retreat of the glaciers from NW to SE (Fig. 2) [12]. At the maximum glacial extension in the area, the glaciers covered all the surface of the nested depressions, and also overflowed their NW edge. When the glaciers started their retreat, could leave a rough deposit on the floor of the western sector of the main depression. These materials could be exposed on basal moraines or sublimation-fusion till deposits. The remnant glaciers should be then located at the eastern part of the main depression and filling most of the smaller one, which are the areas where the ridges are distributed.

Crevasses and bergschrunds: crevasses and bergschrunds on the floor of the nested depressions were

also mapped and described [13]. This fracture-like features are 1) curved in shape, 2) their pattern follow the scarp general morphology, 3) they do not have other morphological expression outside the area where they appear, and 4) they do not follow regional fractures patterns. Then, those fractures should be produced by adjustment on the terrain materials, probably ice due to all the other glacial features described in the area. They also occurs on the floor of the main valleys dissecting the main depression, where those fractures have been also observed, but not in the area of possible moraine deposits, such as observed on the available CTX and HiRISE images. Finally, the presence of downslope and upslope curved fractures in the bottom of a valley due to compressive and extensive stress due to the downslope movement of the glaciers corroborates the glacial origin of those fractures.

Crevasses and bergschrunds are certainly linked to active glaciers –in Deception Island they are only visible on the area where glaciers exist, including covered-glaciers. In addition, crevasses and bergschrunds are very frail forms, easy to destroy, and subjects to be buried and concealed by any pyroclastic event (we should remind that terrestrial bergschrunds are covered every winter by snow). Those glaciers are located on the eastern sector of the main depression, filling the main valleys dissecting it, as well as on the floor of smaller depression, but not at the western part of the main one, were moraines remnants of a more extensive glacial episode [12] are located.

Buried ice: Then ice lenses are very likely to exist in Hecates Tholus. In most terrestrial deglaciated areas, these two elements coexist with glacier in the late stages of glacial recession, which seems to be the present state of those glaciers on Hecates Tholus [12]. Furthermore, if crevasses are visible in the images, it means that the materials covering them are not very thick to allow to recognize the glacial crevasses below it. Otherwise, the crevasse should be also completely filled and hided, and indistinguishable respect to the surrounding terrains. In fact, on Deception Island (as well as in any other glacier of the Earth), the snow precipitation each winter is enough to hide the fractures and crevasses. Then, the thickness of these mantle deposits should not be so thick and this could point to aeolian and dust deposits. The abundant wind streak deposits related to the erratic blocks observed on the floor of a valley at the lower NW flank of the Hecates Tholus volcano could support this interpretation. This

thin layer, that could partially fill the crevasses (or some of them) but allow to recognize most of them, it is compatible with the existence of ice 1–2 meters below the surface [14], and explain why we could not observe ice in this region, but the morphology derived from its glacial flow. On Deception Island, the thickness of the pyroclastic layer covering some parts of the glaciers reach 3 meters at located sites, but in general they are about 2 meters, and they also allow to recognize the morphology of the crevasses, but not the ice that forms the glacier.

Remnant ice lenses: Then, taking into account the observations on CTX and HiRISE images and their analogues in Deception Island, the geomorphological map of the area [5], and the evolutionary model of the glaciers in the area [12], and assuming these interpretations are correct, we propose a geological model of the present state of the floor of the nested depressions on the lower NW flank of the Hecates Tholus volcano (Fig. 1). This model proposes that main depression, the floor of the valleys dissecting it, as well as the floor of smaller one are filled by glaciers on present day. The ice of them is not visible on satellite images because they are covered by debris, pyroclastic and aeolian/dust deposits. Those glaciers are the remnants of extensive glaciers that filled completely those depression in the past [12] and probably other areas of the Hecates Tholus volcano. Here, the glaciers show central and lateral moraines (ridges), as well as erratic blocks and cre-

vasses and bergschrunds related to the recent flow. The western sector of three main depression is characterized by moraine deposits (basal moraines or meltout till deposits) during the retreatment of the glaciers. We could not discard the presence of small ice lenses in this sector of the depression, as would indicate the pingos in the area [5]. However, the presence of lobated and lineated landforms at the eastern sector of the main depression, the presence of knobby terrain at the western sector if that depression, and the topographic step at the limit between those sectors could be indicative of the presence of a covered glacier in the eastern sector nowadays, which terminus is marked by the topographic step respect the western sector probably formed by ancient basal moraine deposits. This model is in agreement with the remnant ice existence under the surface at present day [14]).

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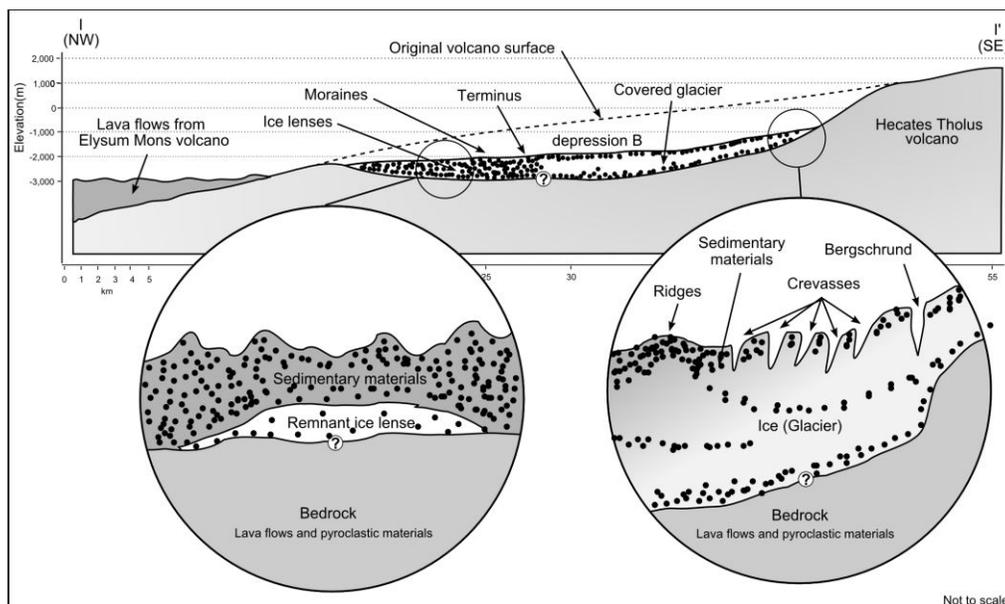


Figure 1: HRSC-derived topographic profile showing a schematic model of the possible glaciers distribution in the main depression at the NW flank of the Hecates Tholus volcano. Circles show details of the location of possible remnant ice lenses as well as covered glaciers with their crevasses.