STRATIGRAPHICAL EVIDENCE OF ELYSIUM SEA ICE FROM HiRISE IMAGES.

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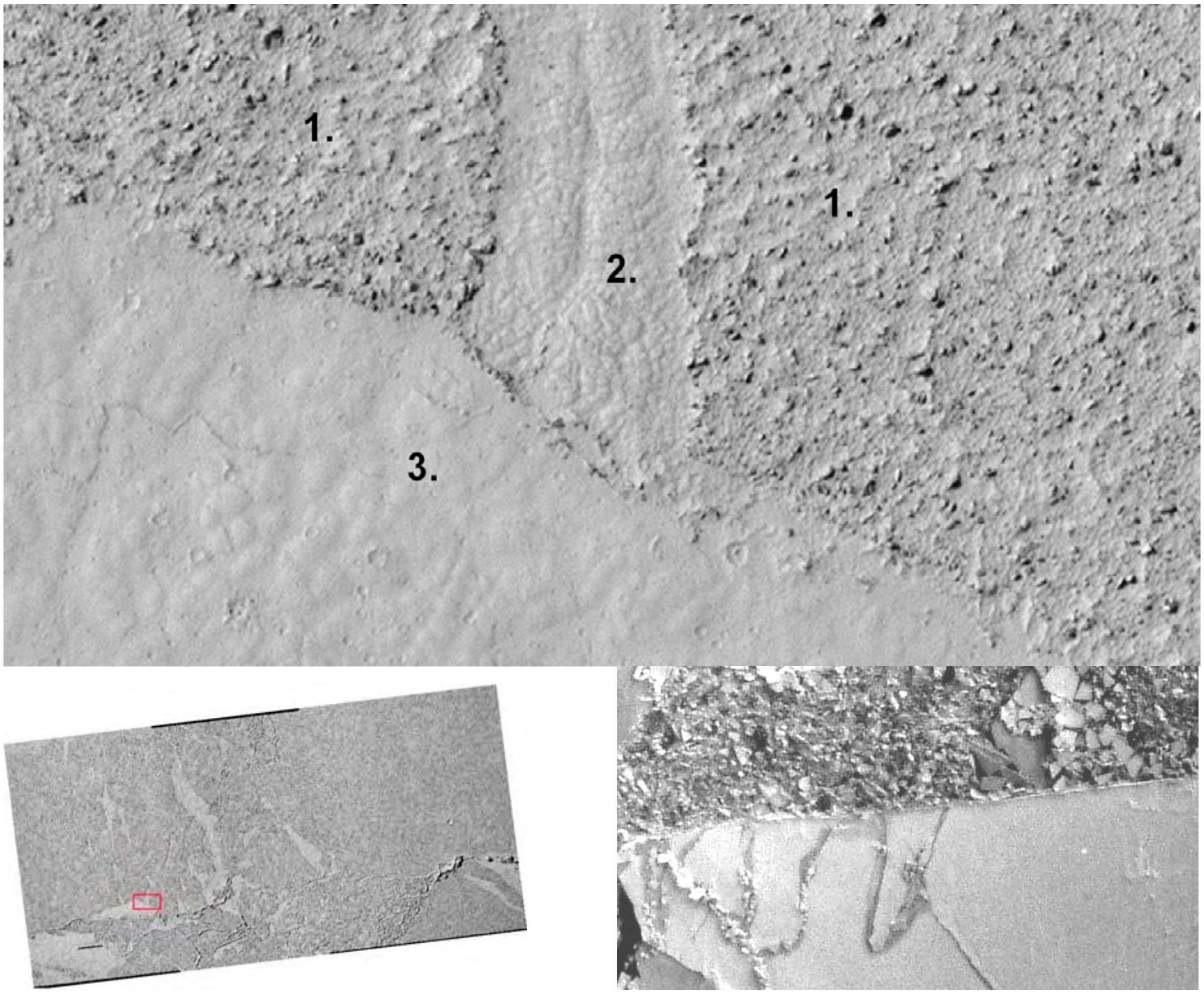

Fig. 1. (top) Enlargement of an area 300m left-right from HiRISE image TRA 000854 1855 showing the 3 terrain units described in the text. **Lower left** shows the full image & the location of the enlargement. **Lower right** shows pack-ice in the Canadian Beaufort sea at about the same scale (150m left-right), with a clear division between older broken & re-frozen pack ice at the top and new smoother ice with sinuous ridging below. *Courtesy T.J.O.Sanderson*

Introduction. The surface features of Elysium Planitia (Mars) include fractured, drifted and rotated rafts up to tens of kilometers across, which clearly demonstrate that a fluid emanating from the Cerberus Fossae, 200 km to the northeast, has flooded an area at least 800 km long, and solidified. This has lead to the interpretation of a frozen sea [1, 2] or a flood basalt lava [3], [4]. Whichever hypothesis is correct, there is no doubt that the age of the Elysium surface is very young – of the order of a few million years, and both explanations have important consequences for Mars' present geological activity and the possibility of life on Mars. The first HiRISE images of this area have resolutions of 0.3m, and show details that favour the frozen sea idea.

HiRISE images: HiRISE image TRA 000854 1855 is situated near the centre of the Elysium plains, encompassing a junction between an area of relatively static fluid to the north, and a channel in which rafts have drifted to the west (Fig. 1). Broadly speaking, three terrain units can be identified in the image:

Unit 1 consists of large (100m to 3 km) fractured rafts, which dominate most of the image, with a 10% cover of platy blocks 1-6m wide, interspersed with a honeycombed pattern of networked eolian ridges, with cells about 3m wide. There are few impact craters, and these are degraded, infilled & difficult to recognize.

Unit 2 lies between the rafts, particularly in the northern part of the image, and is topographically lower (from shadows) than unit 1 at contacts. It is smoother terrain of lower albedo, with prominent patterned ground comprising centrally-domed polygons 5m-10m wide. In places these polygons are aligned almost parallel and/or normal to the raft edges, and there are patterns of more pronounced valleys spaced about 30m apart, running longitudinally down each lane.

Unit 3 is found only in the southern part of the image, where the pale, smooth lanes between rafts are aligned more east-west. There are still traces of polygons, but these are much fainter and wider (20m - 40m wide), and are much more heavily cratered than the previous two terrain units.

Size-frequency crater distributions for sample areas of each of the terrain units show that terrain unit 3 is about an order of magnitude older than unit 2 (fig. 2).

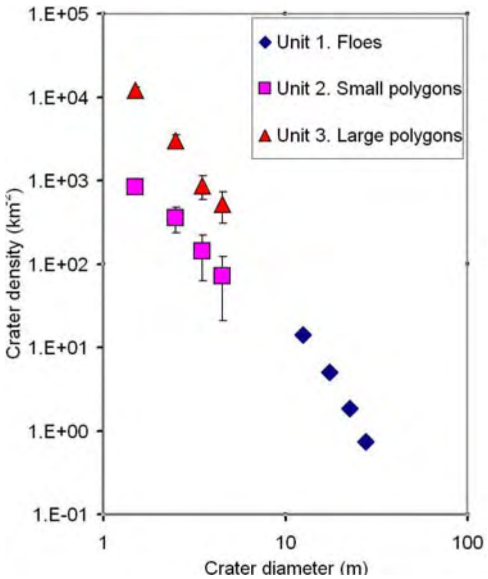

Fig 2. Impact crater size-frequency plot for units 1-3 described in the text.

Pressure ridges can be seen in all 3 terrain units. In the rafts (unit 1) they are prominent and 10m-30m broad, sometimes bordering the edges of the rafts to form rounded polygons 100m-300m in diameter, resembling large versions of terrestrial pancake-ice. In units 2 & 3 there are occasional sinuous or castellated ridges 3m-10m wide that run for a few hundreds of metres. These sinuous ridges are morphologically indistinguishable from finger-rafting and sinuous pressure ridges found in terrestrial sea-ice, and some overlie and partly obscure the impact craters in unit 3.

Interpretation: We interpret these observations as direct evidence of volatile loss at this site. The platy terrain of unit 1 is similar in metre-scale morphology to broken and re-frozen arctic pack-ice (fig. 1, lower right), except that finer, topographically lower features are obscured by wind-blown dust or sand. Unit 1 corresponds to the giant ice-floes of Murray et al. [2].

The small domed polygons of terrain unit 2 suggest shrinkage contraction, and are similar to polygonally-cracked ground on subliming ice in Antarctica [6]. We interpret this as subliming sea ice, now stabilized by surface dust and a sublimation till.

The larger scale (tens of m) patterned ground of unit 3 is closer in size to terrestrial ice wedge polygons, which have been used to map ground ice on Mars [5]. Shadows at contacts show this to be topographically lower than unit 2, and we believe it to represent the sea bed after the sea ice above has sublimed away. This interpretation is confirmed by the impact crater size-frequency distributions of the 3 terrain units, which show it to be much older than unit 2 that overlies it.

Conclusions: The crater counts in particular are strong evidence that the vast flood that covered the Elysium plains with the platy deposits cannot have been lava, since a lava eruption would have had no discernable age difference between solid rafts and fluid inter-raft areas. The HiRISE images indicate a very similar sequence of events to that postulated in ref [2]: firstly a catastrophic water flood from Cerberus Fossae, possibly including a simultaneous volcanic eruption with widespread pyroclastics, that cover the surface sea-ice with volcanic ash. Secondly, a lowering of the water level causing widespread break up of the initial surface ice to form giant ice floes with open water lanes between that also quickly freeze over. Thirdly, the entire sea freezes solid, and sublimation begins. The initial ice floes are protected by volcanic ash, and will contain much suspended sediment, so sublimation remains minimal. The open water lanes are composed of ice containing less suspended sediment, so will gradually sublime (unit 2), in some places disappearing away entirely to reveal the sea bottom (unit 3).

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