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Possible volcanic structures near Olympia Undae, North circumpolar area of Mars.

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1. Introduction

Although volcanism on Mars began to decline significantly a long time ago [1] (at least since the early Amazonian), recent orbital data suggest a relatively recent (localized and episodic) volcanic activity (until <100 My in the Tharsis region) in some areas on the Martian surface of Mars [2,3,4,5]. Some of these areas are located in the North circumpolar region of Mars [5]. The work presented here is a study of structures encountered in the area bordering the Olympia Undae dune sea (Fig. 1). Various structures have been observed in this area, such as cones and domes [6] (whose origin may be volcanic), impact craters, etc. These structures are particularly difficult to characterize because of their relatively small size and the occasional occurrence of a sediment cover. This study is mainly based on data from Mars Express (HRSC imagery) and Mars Global Surveyor (MOLA altimetry data).

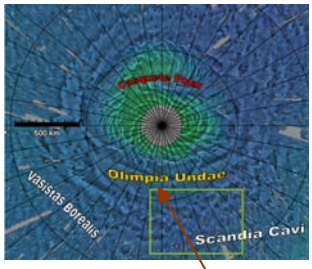


Figure 1: General map of the North Pole (THEMIS background)

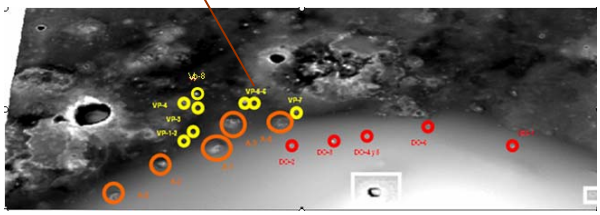


Figure 2. Detail of the area with the localization of the structures listed in Table 1: Red and orange circle = domes, Yellow circles = cratered structures (MOLA background).

2. Identification of structures.

We identified a certain number of structures in the area between Olympia Undae and Scandia Cavi units (Fig. 2). Table 1 presents some examples of encountered structures (some of them had also been mentioned in a previous preliminary study dedicated to the entire North polar area [6]). Tables 2 and 3 show the complete list of structures encountered in this study.

- Domes, possibly of volcanic origin (Do-3, Do-6, A-3, in Table 1) They do not present any crater at their summit. The shape of most of these edifices is asymmetric and elongated. They are located within Olympia Undae.

- Cratered edifices, also possibly of volcanic origin (VP1, VP2, in Table 1). They are located right at the border between Scandia Cavi and Olympia Undae.

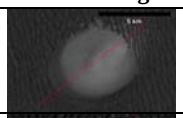
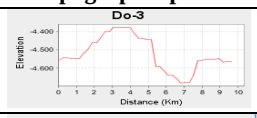
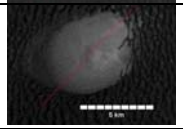
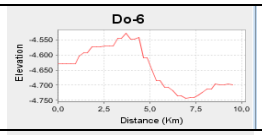
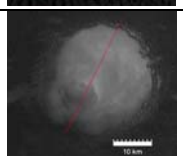
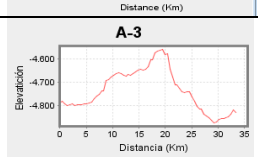
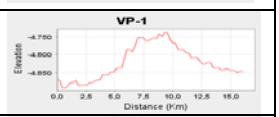
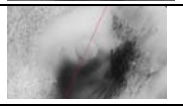
	HRSC Image	Topographic profile
Do3		
Do6		
A-3		
VP1		
VP2		

Table 1. Examples of encountered structures (topographic profiles were performed thanks to the JMARS software [10]).

3. Results and discussion

Name	Latitude	Longitud	Perimeter (km)	Area (km²)	Width (km)	Length (km)	Height (m)	
							Max	Min
Do-1	170,09°E	80,05°N	38,9	116,48	13,23	10,8	-4502	-4681
Do-2	197,95°E	79,70°N	26,53	52,83	6,93	6,99	-4477	-4636
Do-3	193,09°E	79,88°N	18,4	25,13	5,75	5,26	-4348	-4684
Do-4	188,95°E	79,84°N	14	14,5	4,75	4,28	-4500	-4597
Do-5	189,16°E	79,78°N	15,08	13,8	3,1	4,38	-4498	-4613
Do-6	181,98°E	79,54°N	23	32	5,65	7,29	-4527	-4740
A-1	205,87°E	79,3°N	94,33	495,99	29,68	27,55	-4482	-4801
A-2	212°E	79,25°N	62,86	290,27	20,24	20,24	-4422	-4943
A-3	202,99°E	78,71°N	99,71	764,31	30,2	30,2	-4560	-4872
A-4	197,79°E	78,92°N	115,58	532,01	33,7	24,26	-4658	-4859
A-5	219,83°E	79,13°N	55	121,77	7,66	20	-4518	-4804

Table 2: Localization and characteristics for large (A) and small (Do) domes encountered in the study area.

Name	Latitude	Longitud	Perimeter (km)		Area (km2)		Width (km)		Length (km)		Height (m)	
			Crater	Total	Crater	Total	Crater	Total	Crater	Total	Max.	Min
VP-1	207,12° E	78,68° N	12,79	43	12,77	142,56	3,9	12,86	4,1	13	-4719	-4925
VP-2	208,24°E	78,75°N	9,24	51	6,62	189,96	3,56	17,33	3,10	15	-4738	-4896
VP-3	204,82°E	78,10°N	9,28	49	6,5	182,55	2,95	10,8	2,85	10,5	-4771	-4897
VP-4	204,39°E	77,53°N	10,1	47,5	7,1	174,12	32,43	16	3,62	14	-4771	-4897
VP-5	200,41°E	78,15°N	3,41 6,62 4,6	27,72	0,9 2,82 1,1		1 1,27 1,4	9,71	1,1 2,15 1,4	7,97	-4381	-4825
VP-6	198,75°E	77,93°N		26,35		50,74		6,78		8,4	-4487	-4792
VP-7	195,94°E	78,73°N		12,9		12,8		3,67		3,73	-4702	-4842
VP-8	205,98°E	77,12°N	3,28	6,7		3	2,16	1	2,23	1,06	-4673	-4965

Table 3: Localization and characteristics for cratered edifices (VP) encountered in the study area.

We evaluated the probable direction of the local winds, taking into account [7] the type of dunes (based on their shape) and the orientation of their crests (large barkhans in the case of Do-3 on Fig. 3).

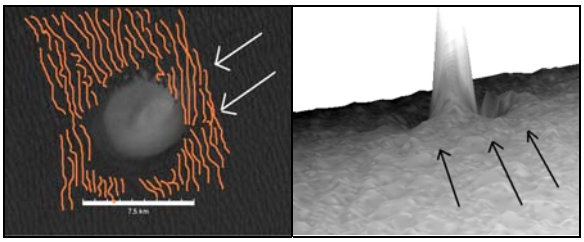


Figure 3: HRSC image (left) for Do3, with highlighted dune crests.3D view of Do-3 (right) based on MOLA topography (vertical exaggeration x 10) with the evaluated wind direction.

Strong similarities and geographic proximity of the encountered structures suggest a similar origin. Although a volcanic origin might appear to be the most probable at first glance, other geological processes can lead to the formation of similar structures (pingos, impact craters filled by ice, mud domes, spring mounds, etc.) which can be confused with volcanic structures.

South of these structures, in Olympia Undae, gypsum deposits have been detected thanks to the OMEGA instrument onboard Mars Express [8]. Although still uncertain, several hypotheses have been formulated as regards their origin [9]. A formation related to volcanic processes (e.g. hydrothermal vents), would be consistent with the presence of volcanic edifices close to this unit (Fig. 4).

As regards the elongation and/or asymmetry of the small domes, it appears to be consistent with the direction of the local winds, derived from the shape of the surrounding dunes. Whether winds shaped the edifices during of after the eruptive phase (in the probable case of a volcanic origin) remains to be investigated.

Figure 4: Area where gypsum has been detected within Olympia Undae [8] (inside the orange line), wind directions (white arrows) and structures encountered in our study (same symbols as Fig. 2).

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