Morphological study of landforms on The Norther Polar Region of Mars.

Marina Sánchez-Bayton[1] , Erwan Tréguier[2], Miguel Herraiz [1,3], Patrick Martin[4,] Akos Kereszturi[5,, 6], Beatriz Sánchez-Cano[6.]

[1] Department of Physics of the Earth and Astrophysics, Universidad Complutense de Madrid (UCM), Madrid, Spain
[2] Formerly at ESAC (European Space Astronomy Centre), Villanueva de la Cañada, Spain
[3] Instituto de Matemática Interdisciplinar (IMI), Madrid, Spain
[4] ESAC (European Space Astronomy Centre), Villanueva de la Cañada, Spain
[5] Research Centre for Astronomy and Earth Sciences, Konkoly Thege Miklos Astronomical Institute, Hungary
[6] Radio and Space Plasma Physics Group, School of Physics and Astronomy, University of Leicester, University Road, Leicester LE1 7RH, UK.
[7] European Astrobiology Institute

Abstract

This study focuses on the characteristics and possible origin of different geologic features located in Scandia Cavi and Olympia Undae. These are two regions close to the northern polar cap of Mars that spans between 64 72-80º N and 150-230º E. They have an especial interest, because they can cast light on the geological evolution of the area, the existence of volcanism and the gypsum formation.

We use images from Mars Express and Mars Reconnaissance Orbiter, and topographic information from Mars Global Surveyor that have allowed determine the location and evaluate the morphometric parameters of 201 landforms that were classified into 6 groups: cratered cones CC, impact craters IC, ambiguous craters AC, simple and peaked domes SD, PD, and irregular structures SD.

Sanchez-Bayton et al., under review at JGR Planets

Context of the research

Olympia Undae is the largest continuous dune field on Mars with an average elevation of 4,250 m below the reference ellipsoid. It lacks well-defined geological positive topographic features and contains the largest to date gypsum deposit on Mars.
By contrast, Scandia Cavi is composed of two rugged mountainous terrains and includes irregularly shaped deep depressions (also called "cavi") surrounded by tens- to hundreds-of-meters-high rough terrain. This area is probably older than the smoother Olympia Undae.

Since the formation of gypsum (hydrated Ca sulphate, $CaSO_4{\cdot}2H_2O$) requires liquid water, its presence in our study area sets out new questions about the aqueous history and the geologic evolution of the entire region. Several theories have been considered so far to explain the origin of the gypsum in the northern polar region. They include interaction of Ca-rich minerals with water containing sulphuric acid of volcanic origin (Langevin et al., 2005, Fishbaugh et al., 2006), ice cap melting during warm periods (Langevin et al., 2005), or evaporation of saline waters (Szynkiewick et al., 2010).

A more exhaustive study of the positive topographic features could contribute to significantly improve our understanding of the area, as well as of the role played by volcanism in the origin and evolution of gypsum in these areas. Moreover, it can help to identify possible heat sources that are so far unknown

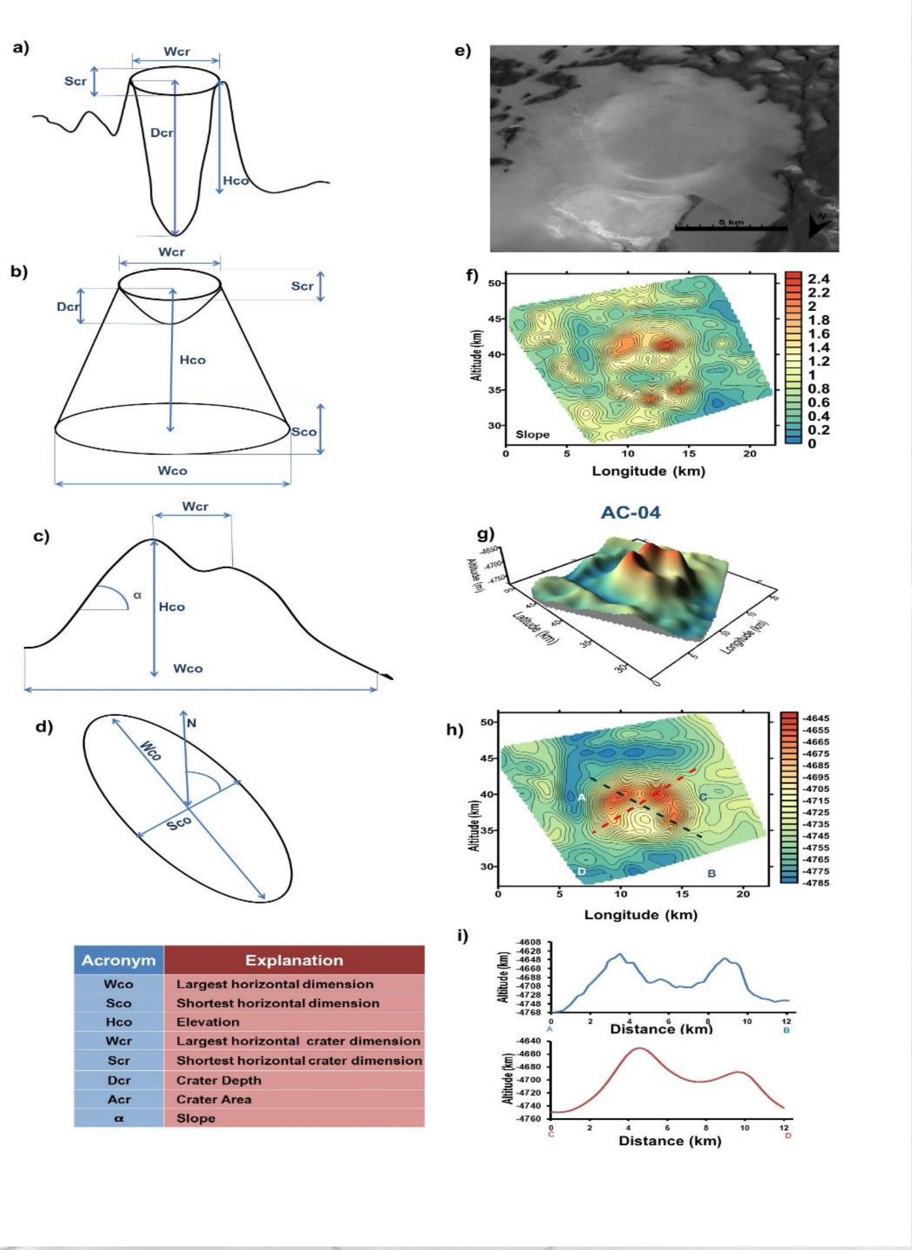
Sanchez-Bayton et al., under review at JGR Planets

Methodology

Focusing on those edifices that have preferably small features, and for which assessment there are enough images and topographic profiles with good quality. Considering these criteria, an initial set of 201 positive topographic landforms is collected. They include 23 structures in Olympia Undae, and 178 in Scandia Cavi.

The data analysis is performed with the help of the JMARS (Java Mission-planning and 160 Analysis for Remote Sensing) software.

Geomorphological data such as the depth of the crater, areas, slopes, basal lengths. etc (see Figure) have been analyzed, making comparisons with respect to the surrounding areas.



Acronym	Explanation
Wco	Largest horizontal dimension
Sco	Shortest horizontal dimension
Hco	Elevation
Wcr	Largest horizontal crater dimension
Scr	Shortest horizontal crater dimension
Dcr	Crater Depth
Acr	Crater Area
α	Slope

Sanchez-Bayton et al., under review at JGR Planets

Results

The 201 landforms selected have been classified into three principal groups:

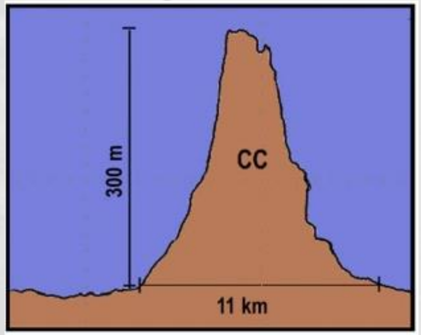
***1-Cratered Edifices:** Cratered Cones (CC), Impact Craters (IC), Ambiguous Craters (AC).*
***2-Domes:** Simple and Peaked Domes (SD, PD).*
3- Irregular Structures (IS).

The following slides show their main characteristics and Figure 2 displays an example of each category

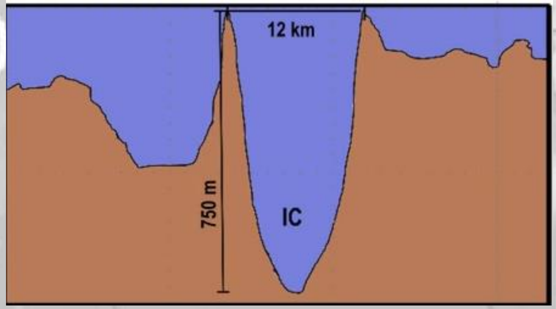
Sanchez-Bayton et al., under review at JGR Planets

Results

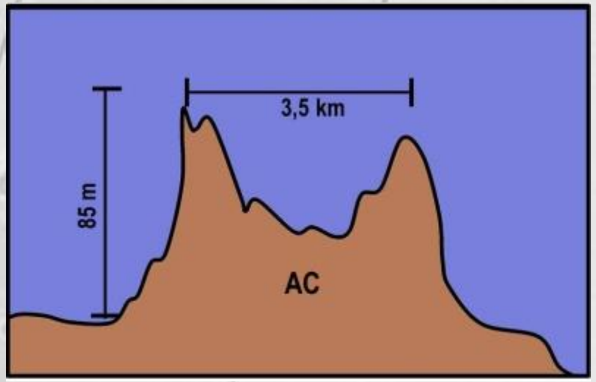
1-Cratered Edifices



Cratered Cones (CC): *This subgroup includes 87 landforms, all of them in Scandia Cavi, with a well-defined cone together with a crater that have a large variability of slope and size parameters. All the structures have shallow craters ranging between 15 and 100 m and they are located above the level of the surrounding terrain. The height of the landform is notably larger than the depth of the crater.*



Impact Craters (IC): *This subgroup is made up of 30 edifices. Two of them are located in Olympia Undae and 28 in Scandia Cavi. ICs frequently have a deep central depression surrounded by a notable elevated wall encircled by well-defined ejecta*

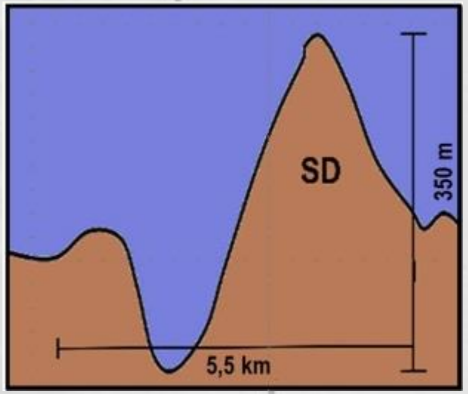


Ambiguous Craters (AC): *This subgroup is formed by 13 edifices that share characteristics of both ICs and CCs. After a careful study, their classification as ICs or CCs is not clear as they show intermediate characteristics of both of them.*

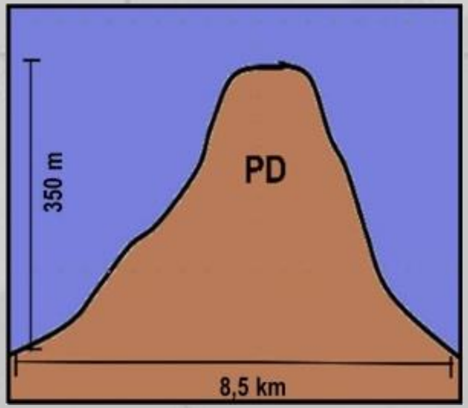
Sanchez-Bayton et al., under review at JGR Planets

Results

2-Domes: *The group of landforms without evidence of a crater-like feature included in the structure is composed of 46 topographic structures and is named by the generic term Domes.*

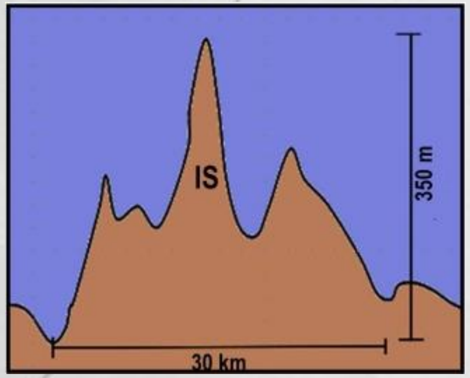


Simple Domes (SD): *This subgroup is composed of 6 landforms that follow a longitudinal alignment near 80º latitude. They are small and have a characteristic asymmetry with a lower rim toward the southwest, opposite to the higher rim in the northeast at all cross sectional profiles. All of them are located in Olympia Undae. They have a predominant circular shape*



Peaked Domes (PD): *This subgroup is composed of 40 positive topographic features located in Scandia Cavi They are undulated landforms with at least a defined peak that constitutes its characteristic feature. They present also a steep wall and lack of a central summit depression. In general, this is the group that most resembles to a conical*

3- Irregular Structures (IS): *This category encompasses the remaining identified landforms, 25 landforms. All of them show a large complexity because they are composed of both cratered and non-cratered structures having most probable mixed origin .*



Sanchez-Bayton et al., under review at JGR Planets

Examples of the 6 categories

Crater Cone

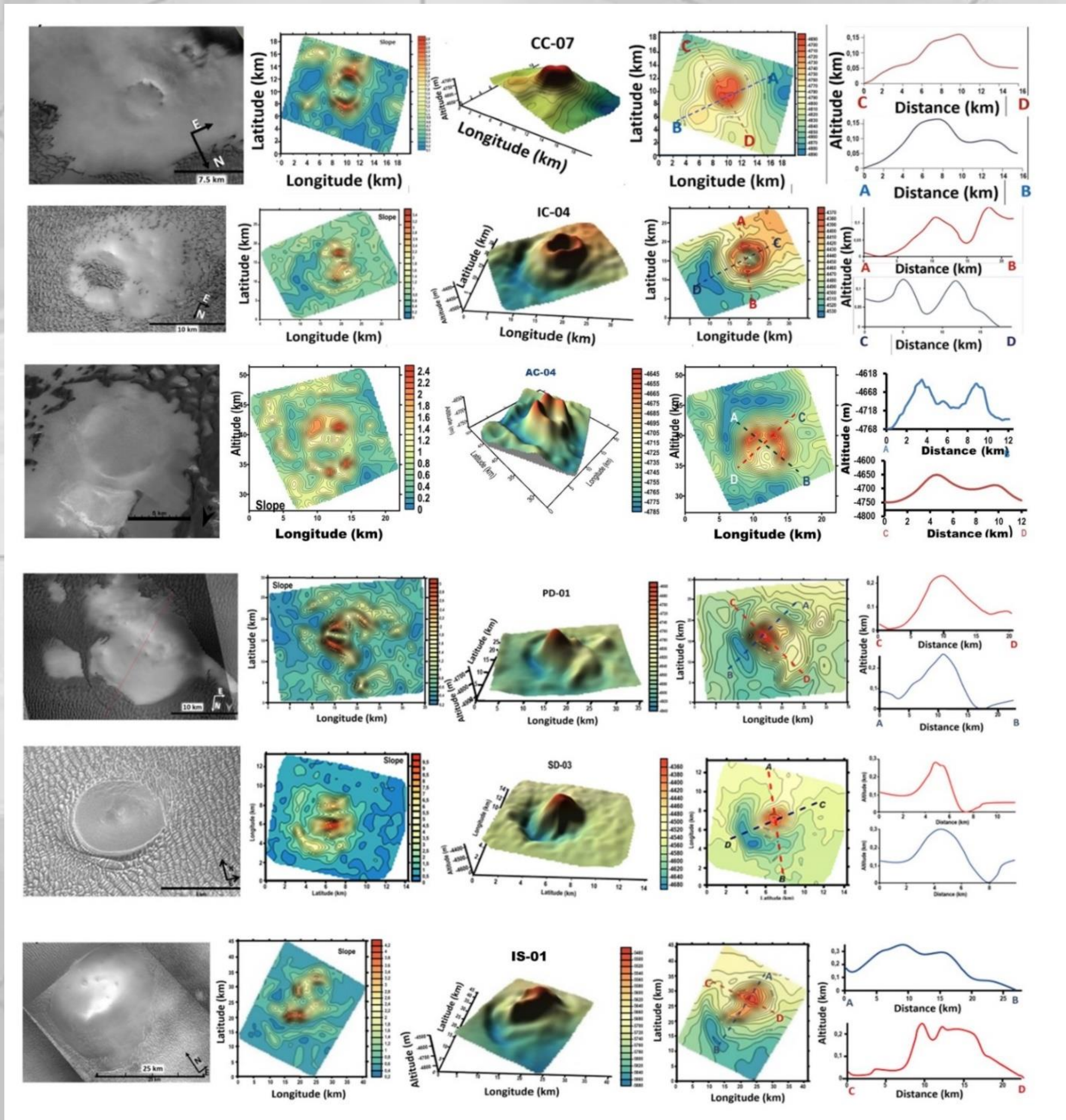
Impact crater

Ambiguous crater

Peak dome

Simple dome

Irregular Structure



Impact and prospects

This study can contribute to differentiate the landforms located on the studied areas of the North Pole of Mars, compare them with other studies carried out in those areas and helping us to know and clarify their possible nature.

The study of small structures can be very complex on Mars. Currently, we only have information from orbital images, DTMS models and radars observations (such as MARSIS and SHARAD). This limited amount of observations makes sometimes extremely difficult to differentiate structures.

Focusing on images and DTMS models, we have found that CC structures are probably volcanic in nature, and this could give us new views to understand the formation process of Olympia Undae gypsum dunes.

The IC structures are in many cases very similar in size to other structures that do not have an impact nature. In this study we have found that these small impact structures are often present at these latitudes, and we have found a way to differentiate them from structures formed by internal processes.

The next step of this study is to analyse radar observations in order to get a more comprehensive view of the morphology of the Northern Polar cap of Mars.

Sanchez-Bayton et al., under review at JGR Planets