PINGO FIELDS IN THE UTOPIA BASIN, MARS: GEOLOGICAL AND CLIMATIC IMPLICATIONS. M.A. de Pablo[1,2] and G. Komatsu[2]. [1]Dpto. de Geología. Universidad de Alcalá. 28871 Madrid, Spain. (miguelangel.depablo@uah.es), [2]International Research School of Planetary Sciences. Università d'Annunzio. 65127 Pescara, Italy.

Introduction: On Mars, the presence of pingos has been hypothesized since soon after the Viking mission (e.g., [1]). A diverse range of pingo-like features has been found at various martian sites [2][3]. Some of these areas and described pingos are related to the proposed presence of permafrost and groundwater [4], and iced lakes in different martian regions such as Utopia Planitia [5, 6]. Athabasca Valles, Cerberus Plains and Elysium Planitia are the main areas where extensive fields of possible pingos have been described [7, 8, 9], and they are related to flood flows and groundwater from the Cerberus Fossae system. However, these features were previously described as rootless cones [10], indicating the complexity of interpreting these features from remote sensing [11].

With the objective of identifying pingos in the Utopia Basin (15-55ºN, 210-260ºE), we analyzed more than 2100 MOC-na images (AB1-S04 releases) in addition to Viking, THEMIS, and HRSC images. Some MOLA-derived DEMs, and regional/local geological maps were incorporated into a GIS platform in order to complement the image information of the study area.

Geologic setting: The Utopia Basin is located to the northwest of the Elysium volcanic region in the martian northern lowlands. The inner areas of the Utopia Basin are characterized by volcanic and fluvial deposits formed by lava flows and water flows [12], possible lahars [13], originating from other volcanic areas. The northern part of this basin is covered by ice-cemented dust [13].

Domes, Cones and Rings: Our detailed analysis of the images in this region showed a number of domes, cones and rings (Fig. 1). We note that there is not a clear distinction between dome and cone morphologies, but there is a gradual transition between them. The domes and the cones occur in groups composed of a few to tens of these features. The rings occur alone or in small groups. Complex groups of coalescing rings also exist. Moreover, mixtures of different features in the same group are observed frequently.

Our statistical analysis of diameters provides diameter ranges for those features. The domes are between 20 and 200 meters (mean value: 90 meters) in diameter. The cones are between 10 and 800 meters (mean value: 85 meters) in diameter. The rings are between 30 and 850 meters (mean value: 150 meters) in diameter. Plots of normal statistical distribution of their diameters are showing similar minimum sizes. The maximum diameters are greater for the cones and the rings than for the domes.

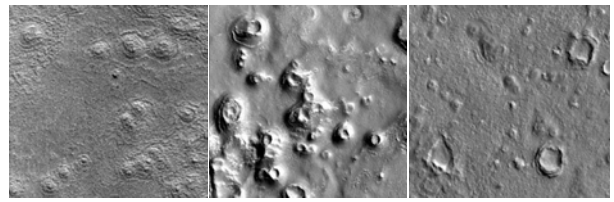

Fig. 1: MOC-na frames showing examples of domes (left), cones (center), and rings (right). Each frame is about one kilometer in width.

The spatial distribution of those features, and their combinations (Fig. 2) are related mainly to the proposed megalahars units [13], and especially to etched and rough lobate units.

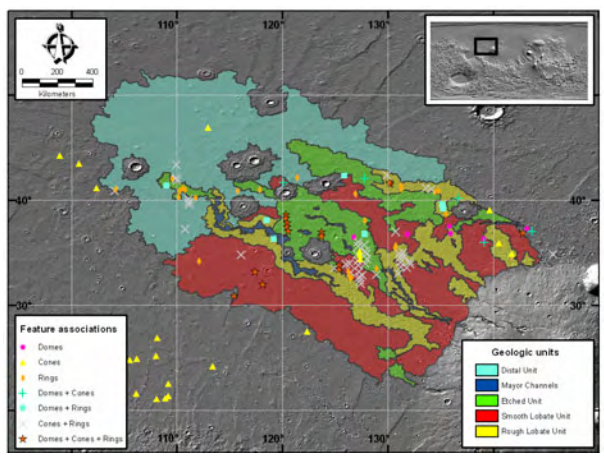

Fig. 2: Spatial distributions of domes, cones and rings, their associations in groups, and their relations with mapped geologic units [13].

Possible interpretations: In order to find possible interpretations and a common origin for those features (domes, cones and rings), we examined several geological processes, and their consequent landfoms. Separately, each analyzed feature could have its own origin different from others. However, we attempt to find a common origin that could explain all features, all groups, and their locations. This is because these features seem to be closely related to each other spatially. We examined the following hypotheses; (1)

rootless cones, (2) rampart craters, (3) volcanoes, (4) mud volcanoes, and (5) pingos. We compared the identified features in the Utopia Basin with other geologic landforms on Mars and Earth. Some features, especially those located at the southern part of the Utopia Basin, outside of the megalahar units [13], show morphology similar to that of volcanoes. But for others, the pingo hypothesis is the most feasible origin because it could explain the existence of domes, cones and rings as different stages of their evolution [14]. Furthermore, pingos are possible in geologic units that are related to water-rich flows (i.e., megalahars). This is because some remnant water could have been still present in these units. Domes represent the younger stage of a pingo growing to form a cone in its mature stage. When the cone collapses, a ring is the relict relief.

Rootless cones could be another strong hypothesis. However, we did not find clear evidence for volcanic materials in the area where domes, cones and rings occur, as was discussed by other authors [13].

Geologic and climatic implications: If those features are truly pingos, their presence in this area, and its relation with surface materials have important geologic and climatic implications. The presence of groups where those features occur together implies that the period of the formation lasted long, or the formation occurred in different episodes.

The existence of pingos indicates a presence of liquid water under the surface. The geologic units where those features occur could have water ice as permafrost. However, the localized nature of pingo-like landform occurrence implies that climatic change was not the primary cause of their formation. In present climatic conditions: where does the liquid water come from? Here, we present a possible geologic explanation for this enigma (Fig. 3). Liquid water could be a result of (1) melting of water ice forming the permafrost, (2) hydrothermal water flows, or (3) both of them. In all these cases, an internal heat source is necessary, and we propose the geologically recent presence of a magmatic chamber under the surface in the Utopia Basin. It could have provided heat for the local melting of the permafrost, or hydrothermal water flowing through faults and unit contacts, melting partially the permafrost. We think that the magmatic chamber is not near the surface. This is because in this case more extensive fields of pingos and/or outflow features should exist. However, only small fields of probable pingos exist in the Utopia Basin, and the outflow features are related to the volcanic activity in the Elysium volcanic region. For those reasons, we think that the magmatic chamber is relatively deep, and the hydrothermal water coming from this chamber is the responsible for the permafrost melting in different places of the Utopia Basin where remnant water of the megalahars may have existed.

Other geologic features could support our hypothesis: (1) the proximity of the Elysium volcanic region [12], (2) the abundance of tectonic faults crossing this basin, (3) existence of volcanic cones and ridges [5] inside the basin, and abundance of magma-water interactions surrounding the Elysium volcanic region (e.g. [15]).

Conclusions: groups of domes, cones and rings are located in the Utopia Basin. We analyzed the morphology of those features, and examined multiple formation hypotheses. We found that most of them could be explained as pingos at different evolutionary stages. In order to explain the presence of pingos and their evolutionary stages, their associations, and their spatial distributions, we propose the geologically recent presence of a magmatic chamber under the Utopia Basin. Hydrothermal water coming from this camber could have melted locally the permafrost, and allowed formation of pingos under present climatic conditions.

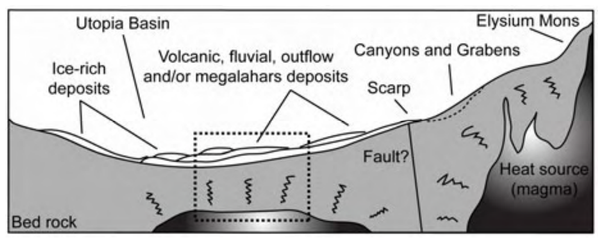

Fig. 3: A proposed model for the existence of possible pingos in different evolution stages (forming domes, cones and rings) in the Utopia Basin. Under the surface, a possible magma-camber may have existed.

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