THE ROLE OF WATER ON THE EVOLUTION OF THE NEPENTHES MENSAE REGION OF MARS.
A. Valenciano[1] , M.A. de Pablo[2,3], and A. Pacifici[3], [1]Facultad de Biología. Universidad de Alcalá. 28871 Madrid, Spain; [2]Dpto. de Geología. Universidad de Alcalá. 28871 Madrid, Spain. (miguelangel.depablo@uah.es); [3]IRSPS. Università d'Annunzio. 65127 Pescara, Italy.

Introduction: The recent observations about different water- and ice-related features on Nepenthes region of Mars [1] [2] [3], and the evidence of changes on the Oceanus Borealis' water level on this region [4] [5] inspired the work here presented. What are exactly the water-related landforms (glacial, periglacial, fluvial, etc) existing in this region of Mars? How are they spatially distributed? What was the role of water (liquid or frozen) on the evolution of this region? Try to reply to all these questions were the objective of a pre-graduate research whose first preliminary results we present here.

Data and Methods: In order to search and to locate possible landforms related to water (liquid or frozen) in Nepenthes Mensae we analyzed more than 500 THEMIS-Visible images (about 18 meters per pixel in resolution) from October 2002 to October 2008 releases. We selected all those images because their spatial coverage/spatial resolution ratio appears optimal for our investigation.

We analyzed each THEMIS-Vis image and classified each observed landform in a extense table what include aeolian, tectonic, glacial, periglacial, fluvial, volcanic, slopes-related landforms among others. We paid a special attention to the water-related landforms. In table 1 we show the most commond landforms that we recognized on the images.

Fluvial: Channels,Terrace, Dendritical fluvial net, Inundation plains, Alluvial fan, Delta, Meanders
Glacial: Glacier, Glacier valley, Glacial circus, Terminus, Grooves, Drumlins, Esker
Periglacial:Pingos, Poligonal terrain, thermokarst
Slopes: gullies, landslides
Littoral: Shorelines
Impacts: lobated and rampart ejecta deposits

Table 1:.List of water- and ice-related landforms searched in Nepenthes Mensae.

Nepenthes Mensae: The studied area extends between 4.8ºS-7.2ºN, and 119.7º-137.6ºE, including the eastern sector of the Nepenthes Mensae region. This region is part of the highlands-lowlands boundary of Mars, characterized by a scarp of about 3,000 meters, and a knobby and degraded terrain marked by the presence of mesas, hills and mounds. This landscape is probably related to the erosion and degradation of materials forming the Martian highlands in northern Terra Cimmeria. The scarp of Nepenthes Mensae appears as a linear feature (SE-NW oriented) like most of the faults and morphological alignments in this area. This sector of Nepenthes Mensae was part of the Oceanus Borealis Martian ocean, as seems to indicate the possible paleo-shorelines widely discussed in bibliography [5]. Debouching of different channels in this region seems to confirm this hypothesis as well as the presence of deltas formed by accumulation of sediments coming from these channels in the shore of the possible ancient ocean [1] [4] [5]. In other regions of Mars possible frozen ocean and lakes were also described [6] [7], some of these also at equatorial latitudes, such as southern Elysium Planitia, not far away from Nepenthes Mensae.

For all that reason, water –liquid and frozen– appears to have been widely related to the evolution of Nepenthe Mensae. Now we show some of the most important landforms that seems to confirm and to support this idea, whose detailed analyses could provide a more detailed idea of the evolution of this region of Mars.

Water-related landforms: There are different landforms in Nepenthes Mensae revealing the existence of liquid water along the history of Mars. The most important landforms are:

Channels: coming from the highlands in Terra Cimmeria, these channels terminate on the highlands-lowlands boundary, in some cases, excavating deep valleys. In general, these channels are narrow and shallow. Dendritical patterns of the channels are not well developed. In some cases, the channels cross flat-bed impact craters, possibly marking the existence of small crater lakes (such as those widely proposed to exist on Mars [8] [9] [10]). Inside the channels is also possible to recognize possible terraces. Some of the channels terminate with alluvial-fans and deltas.

Alluvial-fans and deltas: sediments transported by the water along the channels formed alluvial fans and deltas in the highlands-lowlands-boundary. Meanwhile the alluvial-fans form typically on dry landscapes and when water arise a thin water body, deltas are typical

of deep water bodies such as lakes and seas, when there is an important contrast between velocities, salinity and sediments contained in the water of the channel and the water body. The presence of both landforms in this region of Mars are indicative of the changing environmental conditions existing there.

Shorelines: action of waves near the coast (erosion, mobilization, and deposition of sediments) produce the formation of terrace-like shores. Depending on the site and the geological characteristics of the terrain (materials, degradation stage, availability of sediments, etc), shorelines could not exist all around the water body. Altitude of terraces-like features observed on Nepenthes Mensae is approximately constants (at the resolution of the MOLA-derived topographic maps), what support the hypothesis of water-related origin of these features in this region [4].

Gullies: they are not easy to recognize at the THEMIS-Vis spatial resolution, but some gullies have been observed in the slopes of mesas and hills. These could suggest existence of fluids (possibly liquid water) in the sediments on the flanks of hills or such as groundwater [11] [12]. Although they could be related to recent cold climatic conditions, their existence suggests the presence of a small amount of liquid water in recent times.

Lobate ejecta deposits: Lobate ejecta deposits are thought to be related to the existence of permafrost melted during the impact or to water-rich sediments in the target surface [13]. They were observed in the lowlands. To date all those features require a detailed impact crater counting what could provide an important information about the sequence of occurrence of each feature, and the history of this region.

Ice-related landforms: There are different landforms in Nepenthes Mensae revealing the existence of frozen water under the surface in the most recent history of Mars. In addiction to the described discussed gullies and lobated ejecta deposits, the most important landforms are:

Pingo: located in both highlands and lowlands, possible pingos were recognized, but in all cases, near the boundary. They appear both isolated and forming groups. In the lowlands they appear in the valleys between the mesas and hills in areas covered by smooth materials.

Glaciers: although it is not possible to discard other origins, in the lowlands near the boundary there are some features filling valleys between mesas and hills with morphologies similar to other glaciers observed on Eath and possibly on Mars. Sometimes "terminus" scarps were recognized. Most of these possible glaciers are related to some of the valleys coming from highlands. Moreover, other previous works described in this area other glacier-related landforms [2].

Water and the evolution of Nepenthes Mensae: The here presented features are in agreement with the general idea about the evolution of water-history on Mars [14] [5]. The overall morphology of the Nepenthes Mensae is due to tectonic processes [15], but water seems to had an important role on its evolution, forming the shorelines of Oceanus Borealis, excavating the channels in the highlands that transported sediments to the lowlands, forming later the alluvial-fan and deltas. Changes on the water level of this ocean was already proposed [14] [5] [4], and these changes could be also responsible of some of the described shorelines. Later, once the ocean disappeared, part of this water could form water- and/or ice-rich sediments, as reveals the lobate ejecta deposits. On the other hand, probably due to a new change on the climatic conditions [16] and the existence of water under the surface or near it, possible glaciers and pingoes were formed in this area, increasing the erosion and degradation of the landscape in Nepenthes Mensae.

Conclusions: Here we summarized the most important features suggesting the existence of water and/or ice in Nepenthes Mensae, and revealing the important role that they have in the evolution of the landscape in this region. Once the existence of the diverse and numerous landforms related to water and ice has been confirmed by higher-resolution images, next works will include a cartography of the area, and the geographical location of each landform observed in order to deduce the complete history of the water in Nepenthes Mensae.

References: [1] Irwin et al., 2005. *JGR*, 110. doi:10.1029/2005JE002460. [2] de Pablo and Pacifici, 2007. *Geophys. Res. Abstracts*, 9. 01765 [3] de Pablo and Pacifici, 2007. *Geophys. Res. Abstracts*, 9. 02266 [4] de Pablo and Pacifici, 2008. *Icarus*, 196. 667-671 [5] Fairén et al., 2003. *Icarus*, 165. 53-67 [6] Chapman, 1994. *Icarus*, 109. 393-406. [7] Murray et al., 2005. *Nature*, 434. 352-355. [8] Cabrol and Grin, 1999. *Icarus*, 142. 160-172. [9] Irwin et al., 2002. *Science*, 297. 2209-2212. [10] Scott et al., 1005. *USGS*. Map I-2461. [11] Mustard et al., 2001. *Nature*, 412. 411-414. [12] Márquez et al., 2005. *Icarus*, 179. 398-414. [13] Melosh. 1989. *Oxford Univ.Press*. 253 pp. [14] Baker et al., 1991. *Nature*, 352. 589-594. [15] Martín-González et al., 2007. *Geophys. Res. Abstracts*, 9. 007796. [16] Laskar et al., 2004. *Icarus*, 140. 343-364.