AN ALTERNATIVE HYPOTHESIS FOR THE ORIGIN AND EVOLUTION OF HEBES CHASMA, MARS. *M.A. de Pablo*. Área de Geología. Escuela Superior de Ciencias Experimentales y Tecnología. Universidad Rey Juan Carlos. 28933 Móstoles, Madrid. Spain. (depablo@geo.ucm.es).

Introduction. Hebes Chasma is an small martian canyon located at the North Candor Chasma, of the Valles Marineris canyon system, and near to the North limit of the Tharsis topographic dome. The origin and evolution of that canyon, like happend with the other martian canyons, are very disccused, but this is a particular case because Hebes Chasma is an enterely enclosed canyon. In the classic bibliografy of Mars is excluded to this canyon like a source for water on account of its closed shape and to its interior topography. Here is proposed a preliminar alternative hypothesis about the origin and evolution of Hebes Chasma based on the groundwater circulation and elaborated from the analysis of MOC/MGS images and MOLA/MGS topographic data.

General description. Hebes Chasma (76.1ºW, 1.1ºS) is a enclosed canyon elongated in a East-West direction, parallel to the Valles Marineris System. It has 8 km on deep, 300 km in length and 80 km in its width. There is a mesa into the canyon whose interior layered deposits were interpreted like an acumulation of phreatomagmatic deposits [1]. Some walls of Hebes Chasma shows the scars of landslides whose deposits fill the floor of the canyon around the central mesa [2] and whose origin and relation with the existence of water are very discused [2]. In relationship to the elongation of this canyon, approximately collinear and parallel to other canyons and regional fracture systems, it has been suggested that its primary origin has an important structural control [2,3]. The materials in those which is excavated Hebes Chasma seem to be of different types on account of the difference of competence observed [2], but in those which the volcanic materials have a great importance such indicate the accomplished interpretations of the spectrometric data [4]. The evolution of this canyon is related with differents geological processes like tectonic [5], volcanism [5,6,7], eolic erosion, and mass wasting [2].

The role of the water. Some authors discard that Hebes Chasma like a water source as well as to the water as an important geological modeler agent of this canyon on account of its thoroughly closed contour and the not existence of a height gradient toward the places where are located the outflow channels [2]. Furthermore it is very discussed the role of the water in the formation of the existing landslices in the walls of Hebes Chasma [2], having been suggested its formation on dryness conditions, like dry-rocks avalanches [2]. The MOLA/MGS topographic data show that exists a height gradient from East to West, in the surface of the volcanic flatness in the one which is excavated Hebes Chasma, as well as in the floor of this canyon. This solves one of the problems that were preventing to suppose that Hebes Chasma served as source for water for some outflow channel (Kasei Vallis). At the other hand, the disccusion about the kind of the martian canyons landslices implies that it is not possible to discard the water presence as an important geological agent implicating in the origin and evolution of this and other martian canyons, together with other causes like: 'oversteepening of the canyon walls by tectonic or erosional processes, a reduction of cohesion through weatering or hydrothermal alteration, or a reduction of slear strength through the effects of hydraulic pore pressures in the presence of an active groundwater system' [2]. Moreover, there is some papers where it is described that interior layer deposits of Hebes Chasma mesa could be a pyroclastic deposit of some phreatomagmatic eruptions [1] that reveal the existence of groundwater or ice. In any way, it is necessary to analyze in a detailed way the MOC/MGS images of the landslides to study the geomorphology in order to determinate the kind of the landslides, but there was suggested that the landslices were wet-debris flows [8] and even subaqueous landslices that collapsing into lakes [9], like the one which would have occupied part of the floor of Hebes Chasma, the same as has been suggested for other martian canyons [2].

The environment of Hebes Chasma. To understand better which could be the origin and evolution of this canyon is necessary to observe its environment, for what have been employed Viking and MOC/MGS images, and it has been studied the MOLA/MGS topographic data.

Echus Chasma, a canyon located immediately to the West of Hebes Chasma, and opened in its North side, it is separated of Hebes Chasma by about10 km. Its 'smooth floor suggests that it is filled by a deposit' [1], that could be formed under a water layer of a possible lake. The age of this deposit is relatively recent (there is very few impact craters). At the other hand, Kasei Vallis, an outflow channel, has its head cut in the North side of Echus Chasma, that is consider its source of water. With these observations is difficult not to think that Hebes Chasma could be a source for water while Echus Chasma, located only at 10 km of distance, it will be capable to provided the great quantity of necessary water for the formation of Kasei Vallis. Moreover, the existence of two fracture families (SW-NE and WNW-ESE), observed in the images, implies the existence of a preferential circulation zone for the groundwater that could exist in the region. The elevated topographic situation of Hebes Chasma, with respect to Echus Chasma, implies that, if the groundwater circulation was produced, it would be made from East (Hebes Chasma) toward West (Echus Chasma). In the Southwest and East extremes of Hebes Chasma and some hundred of kilometers to the East (70ºW, 2.5ºS) it has been observed subsidence zones (pits) aligned with the regional fractures. About the origin and configuration of that pits and pit chains there are some differents hypothesis that relate it with dikes intrusion [10], magmatic or ice withdrawal [11], or carbonates dissolution [12,13,14]. Perhaps the hypothesis that more is approached the reality observed in the images is the proposal by some authors [15, 16] than relate the pits with the ice withdrew along faults planes. It is possible that the origin of the pits was the collapse of the surface due to drag of materials like a consecuence of the groundwater circulation throughout of the fracture plans.

Hebes Chasma origin and evolution. In relation with the morphology, phisiography, and stratigraphy observed in the

MOC/MGS images, with the topographic MOLA/MGS data, and with the previous bibliography, about Hebes Chasma and its environment, it could be possible to describe a preliminar hypothesis about the Hebes Chasma origin and evolution. The geological history of Hebes Chasma could be simplified in the following stages:

1st stage: partial subsidence of the surface to depart of the existing previous fractures in the region, giving cause for pits and pit chains. The origin of these would be must to the undergroundwater circulation by such fractures. An example of this evolution stage can be observed in the collapse zones located in the East and Southwest Hebes Chasma extremes and in the coordenates 70ºW, 2.5ºS.

2nd stage: collapse of the surface in the zones where is produced the pits coalescence of throughout fracture zones. The materials is being dragged by the groundwater in favor of those toward smaller topographic levels. An example of this stage is found in the coordinates 65ºW, 4ºS.

3rd stage: opening of a canyon favored by the tectonic processes and the landslices caused to the water existence in the subsoil and to the groundwater circulation. This would be the stage in the one which would be found Hebes Chasma (76.1ºW, 1.1ºS).

4th stage: ocasionally these canyons could be opened originating outflow channels, as would happen in Echus (79.1ºW, 0.5ºS) and Juventae Chasmata (61.8ºW, 1.9ºS). In the interior of these closed canyons could be formed lakes, that could explain the smooth floor of Echus Chasma.

The presence of mesas in their interior has relationship to the volcanic processes existence, independently of the evolution stage in the one which is found the canyon, like the landslices observed in the canyons walls. All this described process could be developed between the late Noechian and the late Hesperian or the early Amazonian, between the beginning of the martian canyons system formation [2], and the last volcanic events described in these canyons, included Hebes Chasma [7]. This age for the origin of Hebes Chasma as a consecuence of the water circulation also it could coincide with the second or the thrid episodes of water stability in Mars proposal by some authors [17] that was produced during the Early Hesperian (the second episode) and during Late Hesperian to Amazonian. That proposed hypothesis about the origin and evolution of Hebes Chasma is complatible with the previously described history for the interior layered deposits [1] and with the hypothesis about the origin and evolution of the martian canyons [2].

Conclusions. The phisiographic, geomorphologic and topographic features observed in the MOC/MGS images and in the MOLA/MGS data, as well as with some of the previous geological interpretations permit to deduce that the origin of Hebes Chasma is due to the groundwater circulation from the highest topographic zones of the North zone of Valles Marineris, toward the most decrease zones throughout of the existing regional fractures. The groundwater circulation of produce the drag of materials and the collapse of the surface in fracture zones, generating pits, pit chains, closed canyons and opened canyons with the consequent formation of outflow channels. This opening process of the canyons would be supported by the tectonic opening and the landslices in the canyon walls. Central mesas presence would be related with the phreatomagmatic volcanic processes existence for the interaction of the magma and the groundwater and even of the possible lakes that they could exist in the interior of some canyons. This evolution and origing process of Hebes Chasma would have occurred in the Early Hesperian or during the Late Hesperian to Amazonian.

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