GLACIER LANDFORMS IN THE NORTHEASTERN HELLAS BASIN. G. Komatsu¹, A.P. Rossi¹, J. Ormo¹ and J.S. Kargel², ¹International Research School of Planetary Sciences, Universita’ d’Annunzio, Viale Pindaro 42, 65127 Pescara, Italy, goro@sci.unich.it, ²Astrogeology Team, USGS, 2255 N. Gemini Drive, Flagstaff, AZ 86001, U.S.A., jkargel@flagmail.wr.usgs.gov.

Introduction: One of the most intriguing questions regarding Mars geology is in what climatic conditions landforms were produced. Important but controversial features are landforms that may be related to surface ice. Kargel and Strom [1] mapped in the Hellas and Argyre basins landforms with close resemblance to those formed by ice-sheets and alpine glaciers on Earth. Glacial landforms are of great importance as they require precipitation and, thus, have paleoclimatic implications.

Observations: The released MOC images cover areas along the presumed proglacial lake and the edge of the ice-sheet delineated by Kargel and Strom [1]. The images reveal areas with low topographic variation. The surface is, however, disturbed by a number of depressions as well as numerous dark narrow features. These narrow features are tightly spaced, some linear (Figure 1) and others are curvilinear (Figure 2) in their alignments. These features appear to be very shallow grooves although this observation is not always clear. The linear features are typically 1-5 km long and a few tens to one hundred meters wide. They have a preferred SW-NE direction. The curvilinear features are most common in the southern part of the area covered by MOC images. They have a more S-E trend. Their dimensions are about the same as the linear features. The majority of bending occurs with their concave side to the south. In some cases these features seem to be related to each other where two curvilinear features run parallel.

The depressions are semi-circular and generally less than 1 km wide (Figures 1 and 2). Their southwestern rims are often straight and steep-walled, and in many cases perpendicular to the general trend of the direction of the narrow features. The steep walls are more straight in the area dominated by the linear features than the curvilinear ones (Figure 1). In some cases a low, smooth, mound appears outside of the depression’s steep rim (Figure 2). The width of the mound is generally a few hundred meters to one kilometer.

Origin: The dark linear and curvilinear features do not appear to be volcanic or tectonic. Eolian landforms such as dust devil trails can not be ruled out at this point, but it would be difficult for them to explain the association with the depressions. The alternative hypotheses are either erosion by sub-glacial streams, direct scouring by the ice [2], or scouring by iceberg keels, so called “plowmarks”. Although the first alternative can not be ruled out, this hypothesis does not explain the depressions. The second alternative may explain the linear features and associated straight steep-walled depressions (Figure 1). These depressions can be interpreted as roches moutonées [2]. The orientations of depressions are consistent with the flow directions inferred from the linear features. The third alternative, iceberg plowmarks form when icebergs drift into areas with water depths less than the iceberg keel depth (Figures 3 and 4). On Earth the troughs that form in the seafloor are about 0.5-5 m (rarely 25 m) deep. They may be flanked by berms up to 2 meters high [3][4]. In the study by Vogt et al. [4] of the North Atlantic Yermak Plateau the plowmarks are usually a couple of hundred meters to some kilometers long but some can continue for tens of kilometers and be tens of hundreds of meters wide. These figures are consistent with the sizes of both the linear and curvilinear features seen in our study area. In connection to terrestrial plowmarks 30-150 m wide, semi-circular, flat-floored depressions may occur (Figure 4). These “iceberg craters” form when icebergs ground in shallow water. In places where the water is so shallow that the icebergs ground before they can cross, the icebergs suspend sediments that form a shoal inboard of a sharp knick-point [5]. In the view of the close resemblance between the dark narrow features and terrestrial iceberg plowmarks, we suggest that the shallow depressions and their adjacent mounds may have formed by grounding icebergs in a similar way as the terrestrial “iceberg craters” and shoals.

The origin of the linear and curvilinear features and the mound/depression morphology can be hypothesized in association with other landforms in the region. Viking data, although much lower resolutions, has revealed landforms interpreted to be glacier related [1]. The interpretation of the dark narrow features and depressions as formed by ice-sheet and/or icebergs would fit well with the glacial hypothesis [1]. The studied area is positioned at the proposed limit between the maximum extent of the ice-sheet and a large proglacial lake.

Implications: If our interpretation is correct, it supports the widespread glaciation in the Hellas basin. The importance of glaciers on the Martian surfaces is that they require snow precipitation and sources of water. The proposed northern plain ocean [6][7][8]
may have provided the water. Furthermore, if icebergs played roles in the formation of some landforms as suggested above, they provide evidence for the deglaciation processes. The deglaciation processes imply that the supply of snow was eventually shut off and the melting of ice occurred in a relatively warm atmosphere. These implications stand in sharp contrast to those implied by a possible eolian interpretation. Therefore, it is important to examine these and related features in more detail by further MOC imaging and other observations and analysis of those data.