UNUSUAL AND POSSIBLE GLACIAL DEPOSITS IN NEREIDUM MONTES, MARS: INSIGHTS FROM VEIKI MORAINES IN NORTHERN SWEDEN. A. Johnsson[1], D. Reiss[2], S.J., Conway[3], E. Hauber[4], H. Hiesinger[2], M.D. Johnson[1], M. Olvmo[1]. [1]Department of Earth Sciences, University of Gothenburg, Gothenburg, Sweden (andreasj@gvc.gu.se). [2]Institut für Planetologie, Westfälische Wilhelms-Universität, Münster, Germany. [3]Laboratoire de Planétologie et Géodynamique, Nantes, France. [4]Institut für Planetenforschung, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Berlin, Germany

Introduction: Numerous studies have reported on glacier-like landforms on Mars such as viscous flow features (VFF's), liniated valley fill (LVF's), concentric crater fill (CCF's) and lobate debris aprons (LDA's) where water-ice is believed to be present under insulating debris cover [e.g., 1]. This notion was confirmed by SHARAD measurements [2]. However, very little is known about glacially deposited landforms in which water is an important factor [3]. Most studies have focused on moraine-like ridges that are associated to gully systems in crater environments [4], glacier landforms at the equatorial volcanic province [5] and drop-moraines from CO_2 glaciers [6]. Here we report on unusual irregular ring-shaped landforms within a mountain complex in Nereidum Montes, Mars. These landforms are well preserved and may suggest ablation of a debris-covered glacier. These martian ring-shaped landforms show a striking resemblance to Veiki moraine complexes in northern Sweden. Veiki moraines are believed to have formed at the lobate margins of a stagnant ice sheet during the first Weichselian glaciation [7]. The Veiki moraine complex sharply ends to the east in several large lobate shaped features that marks the maximum extent of this former ice sheet. The Veiki moraine is characterized by highly irregular to more or less circular plateaus that are surrounded by a rim ridge 10-20 m high. The newly acquired national LiDAR data over Sweden enable us studying these landforms in unprecedented detail. They also enable us exploring geomorphological similarities between Earth and Mars in large spatial contexts. This study aims to increase our understanding of glacial landforms on Mars by comparison to terrestrial analogues. Questions addressed are: (1) How morphological similar are the Martian landforms to the Veiki moraine of Sweden? (2) Do the ring-shaped landforms indicate the maximum extent of former ice sheets on Mars? (4) Was any meltwater involved and what can we learn about the glacial dynamics at this location on Mars? Our work aim to constrain the formative processes for the enigmatic martian irregular ring-shaped landforms and test different hypotheses including (1) a subglacial origin [e.g. 8], (2) a supraglacial origin [e.g. 7], englacial debris or (3) solid-state convection (diapirism) [9].

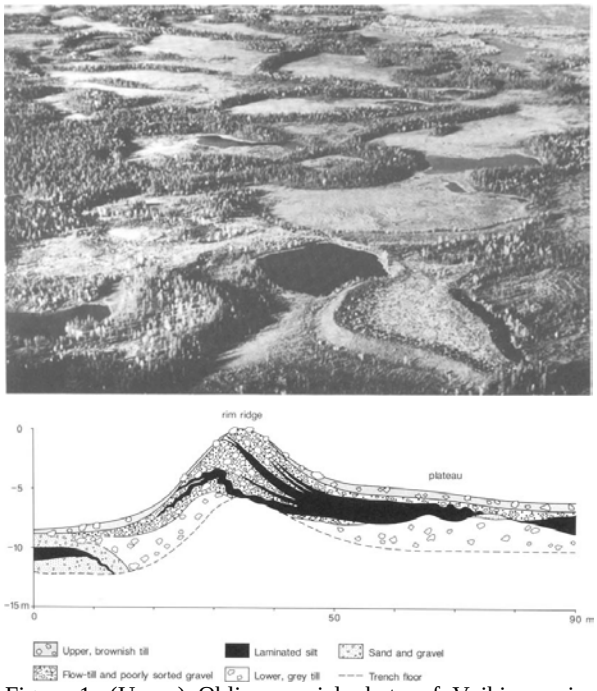

Figure 1. (Upper) Oblique aerial photo of Veiki moraine northwest of Nattavaar in northern Sweden (Photo credit: R. Lagerbäck [1980]). (Lower) Cross-section through parts of a Veiki moraine plateau with rim ridge (from Lagerbäck [1988]).

Data and Methods: For our study we use HiRISE (25 cm/pxl) including a HiRISE DTM, CTX (6 m/pxl), MOLA topography and point data. CTX images have been processed using ISIS 3.0. The terrestrial analogues are covered by LiDAR. The LiDAR data have a point density between 0.5 to 1.0 points/m^2, with a footprint of 0.5 m and a scan angle of 20°. Accuracy of the z-axis is typically better than 0.1 m on flat surfaces.

Observations and results: The rings-shaped landforms are located in close spatial proximity to other landforms of possibly glacial origin such as pronival rampart-like glaciers and remnant cirque glaciers. The topography around the rings-shaped landforms shows features that may be interpreted as bergschrunds (crevasses at the head of a glacier), arêtes, cols (saddle-like narrow depression formed by two head-ward eroding cirques that reduce an arête) and cirques (Fig. 2). If these interpretations are correct it shows an area with clear evidence of possibly ancient and current presence

of glacier ice. The floor of the valley, adjacent to the ring-shaped landforms shows a number of exhumed impact craters which probably represent the pre-glacial surface. The very few fresh-looking impact craters point to a relatively young surface age post glacial recession.

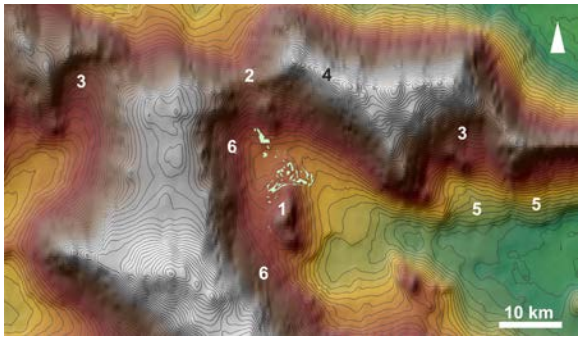

Figure 2. MOLA topographic map with 100 m contour lines and locations of possible glacial morphologies. Area located at the western part of Nereidum Montes. MLL's outlined in green dots (center). 1) Roche moutonnées. 2) Col. 3) Cirques. 4) Arête. 5) Pronival rampart. 6) Bergschrunds.

The martian rings-shaped landforms are located at the upper end of a valley that are open in the eastward direction. In planform the overall morphology of the landform complex has a distinct lobe shape and covers an area of approximately 80 km^2 . Individual landforms form irregular open and enclosed ridges and tend to be more elongated towards the lobe margin. The ridges are approx. 10-15 m in height. Ridges show a higher concentration of clasts and boulders than the surrounding terrain. The outer lobe perimeter is mainly made up of aligned fractured mounds. The Veiki moraines in northern Sweden show a similar irregularity of landforms forming ridged plateaus and enclosed depressions (Fig. 3). In some areas Veiki moraines also show elongation parallel to the lobe margin. Other similarities include the raised intra-ridge floor and more gently sloping plateau margins. Morphometry show that the landforms are of similar scale in area and height (Fig. 3).

Summary: We have identified an area in the Nereidum Montes region that shows clear evidence of glaciation, including possibly preserved glacial ice and glacial landforms. We have also found unusual landforms that are strikingly similar to the Veiki moraines of northern Sweden. A better understanding of these features may provide important insight into Martian geologic and climatic history. This project is on-going and a multiple working hypothesis including several known formation mechanisms on Earth will be stested.

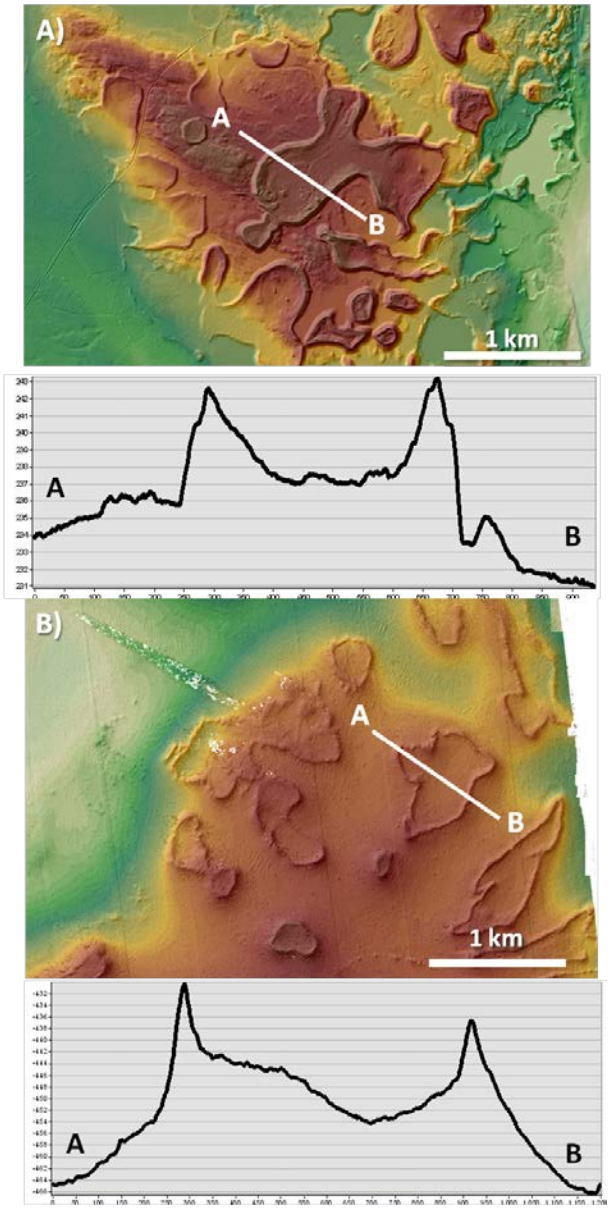

Figure 3. Comparison of topographic expressions of individual landforms on Earth and Mars. A) Veiki moraine in northern Sweden. Rim 6-10 m high. Center floor elevated above ground. B) Mars irregular ring-shaped landform. Rim 12-20 m high. Center floor elevated above ground. Note that both assemblages are located on topographic highs.

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