Observed degradation stages of ring-mold craters (RMC): Geomorphic evidence for modification of ice-rich deposits in the transition zone between Elysium and Utopia Basin, Mars G. B. M. Pedersen[1], [1]Dept. of Earth Sciences, Aarhus University, Denmark, gro.birkefeldt@geo.au.dk.

Summary: Characteristic deposits with pits, depressions and RMCs observed north of Elysium rise are interpreted as degraded mixtures of ice and clastic material. The deposits originated from concentric crater fill (CCF), lineated valley fill (LVF) and lobate debris aprons (LDA), and have experienced deflation and sublimation, creating a patchy distribution of material around mesas, in valleys and in craters. These observations provide a plausible link between pristine examples of LDA and the former LDAs observed as circumferential depressions [1]. Moreover, degradation stages of RMCs provide an important tool for mapping dusty, deflated ice-rich units.

Background and Geologic Setting : LDAs, LVFs and CCFs are distinctive landforms showing possible evidence for ice-rich material [2,3,4]. RMCs have been reported as abundant morphologies in LDAs and LVFs and they have been proposed as an instrument to assess the presence of ancient ice-rich deposits by [5,6]. In this study RMC-morphologies have been used to map degraded ice-rich deposits in the transition zone between Elysium and Utopia. Except [7], who suggested ice-rich deposits in the flank depression of Hecates Tholus, no observations observations of LDA, LVF or CCFs have been reported in the area. CTX-images has been the primary data source for this study and a few THEMIS-VIS images in good very good quality have also been used.

Morphology and Distribution: A range of RMC-morphologies has been observed in the transition zone between Elysium rise and Utopia Basin. Fig. 1 shows the variety and the frequency of each type. Variants with bluish and greenish signatures display typical RMC morphologies as described by [2], whereas craters with light red, orange, pink and purple signatures are proposed to be degraded RMCs. An illustration of this relationship is displayed in fig. 2 where RMC 1 and 2 are possible degraded versions of RMC 3, a ring-mold crater with a central plateau. As deflation and sublimation of the ice-rich deposit progress, the depression around RMC 3 grows, leaving a circular plateau producing a degraded RMC like RMC 2. Further degradation of plateau sides would create a concentric spallation pattern displaying a multiple-ringed plateau, as RMC 3. The distribution of observed RMC morphologies and their relationship to geologic units in the study area are shown on fig. 3, where degraded CCFs, LVFs and LDAs have all been marked as white units, while crater ejecta have been shown in yellow. 93 RMCs has been observed outside these units.

LDA: The degraded LDA deposits represent the largest unit of modified ice-rich material with an area of ca. 15700 km^2; 484 observations of RMCs have been made in this unit. The deposits are pitted with a lobate to irregular outline; a herring-bone texture is observed around some blocks. The thickness varies; in some places the deposits display a convex-upward profile, whereas thinner deposits appear to represent a thin veneer. Likewise, the albedo varies from significantly lighter than the surroundings to dark and dusty pitted regions with RMCs.

CCF: Degraded CCFs are widespread and deposits have been observed in an area 31.2° N – 40° N, 138° E - 150° E and within the elevation range -4250m to 4575m. The deposits cover an area of c. 1600 km^2 with variable thickness, ranging from a thin, uneven surfaced deposit in the bottom of craters to very thick deposits with equipotential surfaces that almost fill some craters. The deposits are pitted and commonly have either concentric or radial lineations; a few observations of a chaotic pattern of raised rim folds have been observed. 37 RMCs have been mapped, primarily with typical RMC morphology [2].

LVF: Degraded LVF deposits have only been observed in Hrad Vallis and Galaxias Fossae where they cover a total area of ca. 1400 km^2. Only 7 RMCs have been observed, most of which are classified as degraded RMCs. The deposits are pitted with lineations parallel to the valley walls; the thickness varies. Observations are complicated by shadowing from the side walls as well as dune migration, which may be an explanation for the scarcity of RMC observations.

Ejecta: A significant amount of RMCs were observed within crater ejecta, and ejecta were therefore included in the mapped geologic units, though ejecta do not represent a degraded ice-rich deposit. The ejecta unit comprises an area of 24600 km^2 and contribute with 234 of 855 RMC observations, of which RMCs with light red and dark blue signatures prevail. This may partly be explained by the fact that these RMCs resemble infill of small, degraded, secondary craters. However, more than 80 RMCs with different morphologies have been observed, indicating that some ejecta deposits may consist of mixtures of ice and clastic material.

Discussion: The evidence for degraded ice-rich morphologies in the study area suggests that ice-rich material has played a significant role in the transition zone between Elysium and Utopia Basin. Since the deposits are found in all latitudes and within an

elevation span from -4250m to 4575m the degradation process seems to be very slow. Moreover, the significant amount of RMCs outside the degraded ice-rich deposits suggests that the ice-rich deposits have had a greater extent.

References: [1] Hauber, E. et al. (2008) *JGR 113: E02007, doi:10.1029/2007JE002897* [2] Squyres, S. W. (1979) *JGR 84 B14,* 8087-8096 [3] Mangold, N. (2003) *JGR 108, 8021, doi:10.1029/2002JE001885* [4] Holt, J. W. et al. (2008) *Science 322 1235-1238* [5] Kress, A. and J. W. Head (2008) *GRL 35(L23206): doi:10.1029/2008GL035501*. [6] Ostrach, L. R., J. W. Head, et al. (2008) *LPSC XXXIX*, 2422, Leage City, Texas, USA [7] Hauber, E. et al. (2005) *Nature 434: 356-361*.

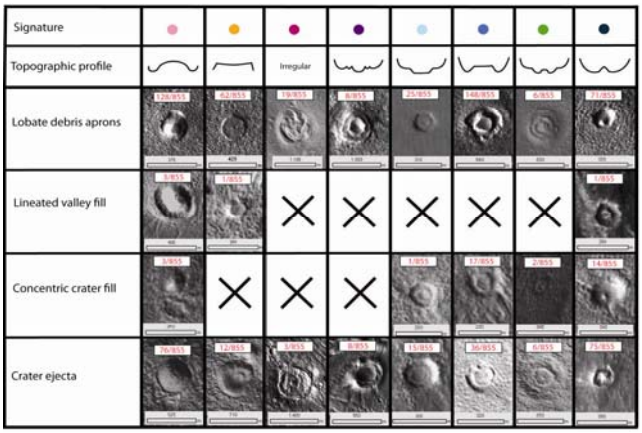

Fig. 1. Scheme of the variety of observed RMC morphologies and their distribution in different in degraded CCF-, LVF-, LDA- deposits as well as ejecta deposits. The colored signature refers to the map in fig. 3 and the fractions refer to the frequency of each type of RMC in each unit. The illumination is from the left.

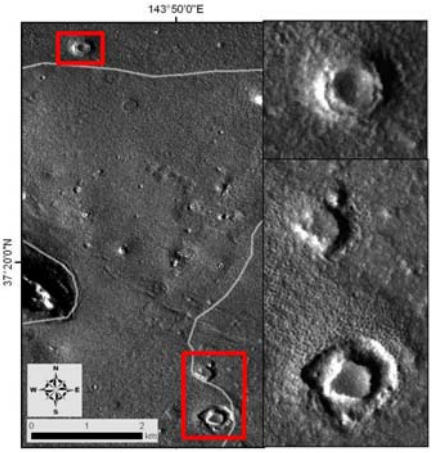

Fig. 2. Pitted deposits with characteristic RMC morphologies highlighted in red boxes and enlarged to the right. RMC 1 (Purple signature) and 2 (Orange signature) are suggested to be degraded examples of RMC.

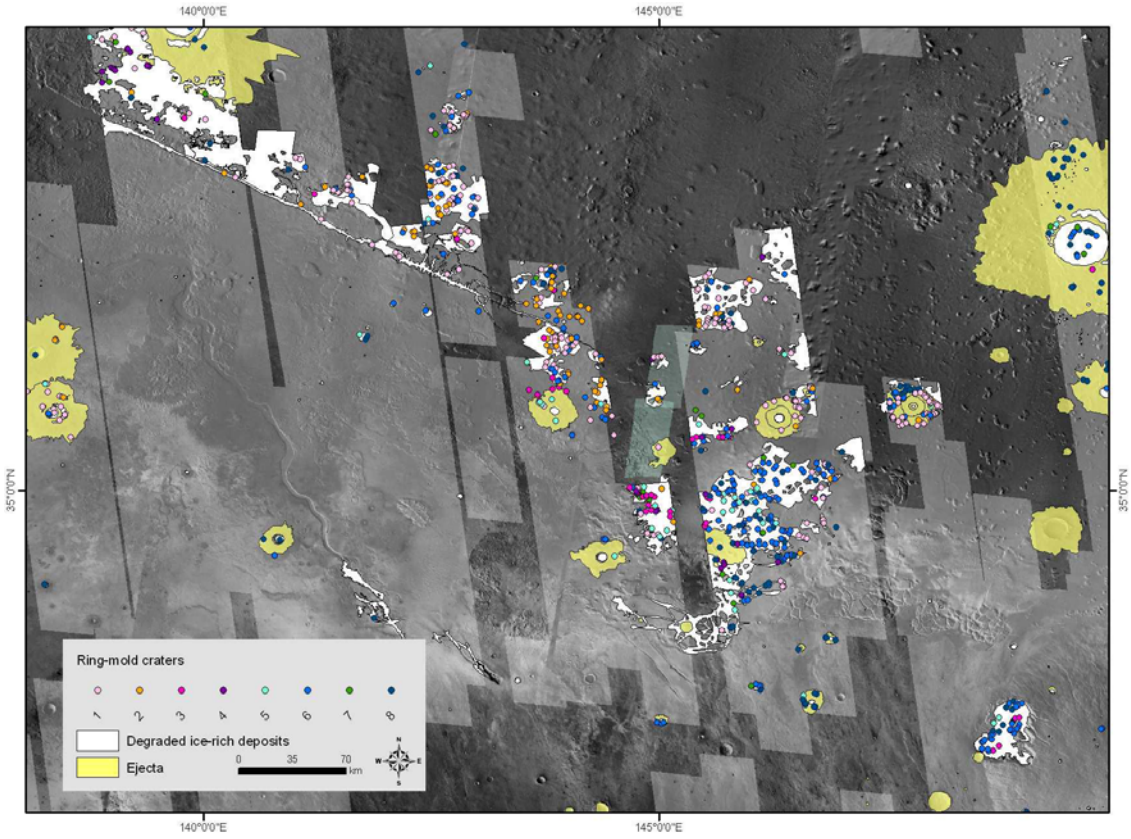

Fig. 3. Map of the distribution of observed RMC morphologies on ejecta and degraded ice-rich deposits (CCF, LVF and LDA). The transparent whitish and grenish rectangles show the distribution of CTX images and THEMIS images of sufficient quality for mapping. The colored signature of RMC's refers to fig. 1.