MESA-FORMING UNITS OVERLYING EROSIONALLY-RESISTANT PLAINS IN NOACHIAN TERRAIN: INSIGHTS INTO BASIN FILL PROCESSES. J.C Cowart and A.D Rogers, Department of Geosciences, Stony Brook University, Stony Brook, NY (justin.cowart@stonybrook.edu)

Introduction: The geologic record of Noachian Mars has been heavily reworked by >3 billion years of erosional processes. Noachian geologic units that are extant today likely reflect formation modes and/or diagenetic events that provide some resistance to erosion. This survivorship bias is illustrated by the heavily pitted surface morphology typically found in large-scale Noachian bedrock exposures [1]. The prevalence of these resistant units may lead to skewed interpretations of the types of surface processes operating during the Noachian (i.e., a lava flow is more likely to survive exposure to weathering than an ash fall). Recognizing the survivorship bias raises the questions: did less erosionally resistant Noachian units exist? If so, are there any remnant outcrops left to be found, and what processes do they record?

We report the finding of mesa-forming units that are often closely associated with infilled craters and ghost craters located within Noachian intercrater plains. The units have a scattered but widespread occurrence throughout the Noachis Terra, Tyrrhena Terra and Terra Cimmeria regions. The mesas appear to be less resistant to erosion relative to the surrounding terrain, and are often embayed by or appear to conformably overlie resistant units that are Noachian in age. We suggest that the mesas represent erosional remnants of poorly consolidated, Noachian basin fill material that has since largely been eroded from the surface.

Context and Morphology: The mesa-forming units typically outcrop as clusters of mesas and/or mosaic colles surfaces (**Figure 1**). In a few outcrop locations, a gradation occurs between the two, suggesting that the colles may be mesas in an advanced state of erosion (**Figure 1a**). Mesa clusters are relatively limited in size, with more than 50% of mapped occurrences (n=100) covering an area of < 200 km^2, and all but five covering areas < 1000 km^2. Individual mesas generally measure less than 5 km across. Mars Global Surveyor MOLA profiles across mesa clusters indicate that the tallest mesas rise approximately 200m above the surrounding plains or crater floor.

The mesa-forming units appear to be composed of poorly consolidated material. Larger craters within the mesas have softened rims and are heavily eroded, while few small craters are retained (**Figure 1b**). This observation is also supported by Mars Odyssey THEMIS nighttime IR radiance, in which the mesas usually appear darker than their surroundings, suggesting a low thermal inertia and lack of consolidation.

Despite these shared morphological features, there is substantial variation at finer scales. Mars Reconnaissance Orbiter CTX images show a wide range of tone and surface morphology. Some mesa locales are smooth mounds of light-toned, unstratified material (**Figure 1c**). Others have a mottled tone, rougher surface, and hints of stratification (**Figure 1d**).

In some degraded craters, the mesas have a clear stratigraphic relationship with crater fill. In most cases, the mesa material appears to be the stratigraphically highest remaining material within the crater (**Figure 1e**); in fewer examples, the mesas appear to be embayed by higher thermal inertia material, similar to the stratigraphic relationship between the Gusev plains and the Columbia Hills (**Figure 1f**). Where mesa-forming material is located within infilled craters, it does not appear to exceed the height of the crater rim.

The mesa clusters are found in various locations relative to the center of the basin, with the exception of mesa clusters in the northern Tyrrhena Terra region, which most commonly occur along the northwestern floors of ghost craters. The highly specific locations of these mesa clusters support a preferential removal mechanism, and is likely attributable to wind or paleowind vectors.

Implications for Noachian Mars: Most of the mesa-forming units are likely to be erosional remnants of much more extensive Noachian units. Their presence indicates substantial removal of crater infill from degraded craters and Noachian intercrater plains. This missing material may explain several observations about modern exposures of Noachian bedrock, described below.

Infilled craters in Noachis and Tyrrhena Terra have flat, high thermal inertia floors. This is suggestive of either sedimentary infilling and lithification processes [e.g. 2,3] or lava flooding [e.g. 2,4]. Explaining lithification in craters where the modern surface appears to be the sedimentary fill level is difficult. The presence of stratigraphically higher basin fill material in some craters could have helped to facilitate burial compaction and placed now-exposed units within the depth range of groundwater systems, which may have aided in diagenetic processes.

A major question regarding these remnant units of crater infill is explaining where this overlying material went. For a small 10 km diameter infilled crater, the removal of 100 m of overburden would remove 8 km^3 of material. We suggest that the likely fine-grained

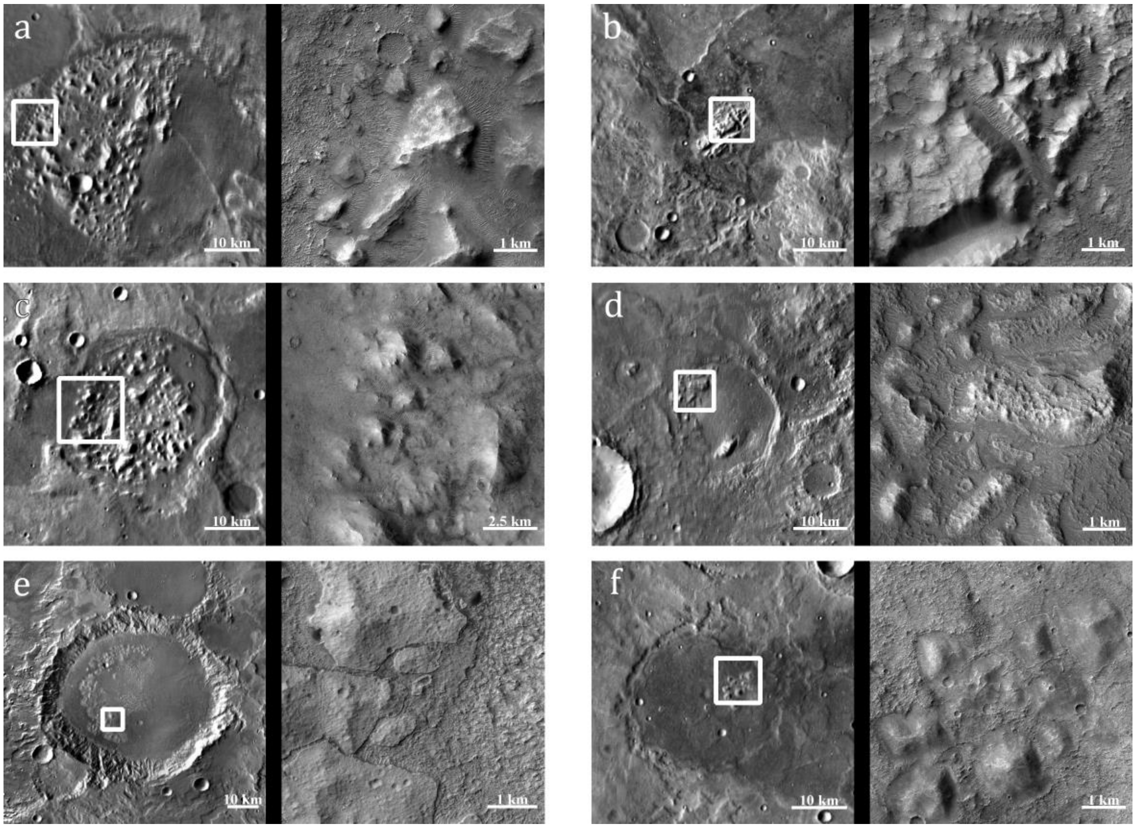

Figure 1 Morphologies of various mesa-forming units within the Martian southern hemisphere. Images on the left side of each pair are from the THEMIS Day IR global mosaic. Images on the right side of each pair are from individual CTX frames.

nature and poor consolidation of the mesa-forming material could have allowed eroded material to more quickly become part of the global dust unit. The original overburden might have also contained a significant volatile component [e.g. 5], which would have been easily removed.

In plains deposits, the morphology of some mesa clusters is reminiscent of the fractured plains and mosaic colles textures found in chaos terrains (e.g. Aram Chaos) in the circum-Chryse region (**e.g. Figures 1a; 1f**). These terrains have long been associated with catastrophic releases of groundwater during the Hesperian [6]. Could the processes responsible for chaos formation been operating outside this region? Some mesa clusters are located near incised channels, but do not show a clear relationship to the channels. Others are located in heavily degraded, partially open craters, but do not show any trace of outflow channels. In these cases, the mesa clusters are towards the center of the crater and trend into mosaic colles towards the rim gap, similar to trends seen in chaos terrains.

An alternative explanation may be that the mesa-forming units may be related to knob fields observed in the Eridania paleolake basin [7]. While superficially similar to chaos terrain in the circum-Chryse region, the knob fields in the Eridania basin are not associated with outflow channels. The knob fields were interpreted by [7] to be airfall deposits within a paleolake basin which have been extensively eroded by wind action.

Future work: Although the mesa-forming units described here have general morphological similarities, the diversity in fine-scale morphologies and settings suggests these units may record a variety of formation modes or depositional environments. Better morphological classification is needed. Compositional research (aided by THEMIS or Mars Reconnaissance Orbiter CRISM data) should provide insight into formation processes. The higher spatial resolution of CTX DTMs, where available, will help constrain the amount of material that may have been removed by erosion.

References: [1] Cowart, J.C and Rogers, A.D., this meeting [2] McDowell, M.L. and Hamilton, V.E. (2007), *JGR, 112,* E12001 [3] Forsberg-Taylor, N.K. et al. (2004), *JGR, 109,* E05002 [4] Edwards, C.S. (2014), *Icarus, 228,* 149-166 [5] Head, J.W. et al. (2006), *Geology, 34,* 285-288 [6] Carr, M.H. (2006) *The Surface of Mars* [7] Wendt, L. et al. (2013), *Icarus, 225,* 200-215