EVOLUTION OF SEASONAL ICE IN REYNOLDS CRATER AND PROMETHEI RUPES FROM CTX AND CRISM. W. M. Calvin[1], K. D. Seelos[2], [1]Dept. of Geological Sciences and Engineering, University of Nevada, Reno, 1664 N. Virginia St., MS 172, Reno, NV 89557 (wcalvin@unr.edu), [2]Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723, (kim.seelos@jhuapl.edu).

Introduction: The "cryptic region" is a large area in the retreating southern seasonal cap of Mars that develops a low albedo, but retains the cold temperature of CO_2 ice in equilibrium with the atmosphere [1]. Calvin et al. [2] observed the seasonal retreat in four Mars Years (MY 28 to 31) using MARCI and found the large-scale boundary of this area was similar in all MY, with many small scale variations from year to year. Why the cryptic area occurs where it does and not throughout the retreating seasonal cap remains puzzling and not easily explained by elevation, deposition, or topography and may depend on subsurface or surface properties.

While there have been a number of coordinated campaigns by MRO imaging and spectral instruments to observed small, localized regions as they evolve with season [3-8], we noticed several regional scale phenomena in MARCI mosaics at ~2 km/pixel that we wished to explore at higher spatial resolution using CTX (~6 m/pix) and CRISM (up to 18 m/pix). The hemisphere opposite the cryptic region ("anti-cryptic") develops redder-hued material as compared to the classic low albedo cryptic region. Near the margins of the cryptic area there is a complex interplay of dark (presumably sand), red (dust), and retreating frost. MARCI data show clear defrosting of crater rims well within the seasonal cap boundary over Reynolds Crater (Figure 1).

Observations: Based on the MARCI seasonal views, new CTX and CRISM acquisitions were requested for Reynolds and a second nearby crater (Figure 2; 74ºS, 160ºW and 73ºS 156ºW), Main crater (75ºS, 312ºW), the boundary of Promethei Rupes (79ºS, 304ºW), and regions in Dorsa Argentea over the "anti-cryptic" area that retains seasonal frost very late. CTX observations of these 6 regions were acquired in MY 34 approximately every 5° of Ls from 180º to 280º, followed by every 10° to 20° of Ls up to 360º in order to monitor seasonal changes in color, albedo and terrain evolution. These observations for Reynolds crater are summarized in Table 1. CRISM color observations were made at the same time, primarily multi-spectral visible data (MSV; 90 channels at ~ 90 m/pix) to relate color evolution to changes seen in CTX. In addition to MSV data acquired in coordination with the CTX images in Table 1, there are an additional 20 observations in both MSV and FRS (full spectral resolution ~ 18 m/pixel) modes.

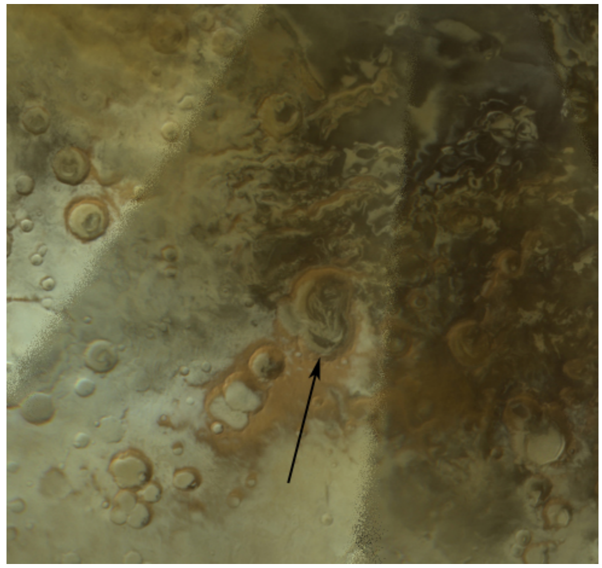

Figure 1: Close up of a MARCI mosaic at Ls 208º. The arrow points to Reynolds crater. Note the difference in color from the crater rim and areas below the crater to interior deposits and terrain above and right that has the characteristic low albedo associated with the "cryptic" terrain. Seasonal ice is also apparent throughout the scene and the region is well within the seasonal cap boundary.

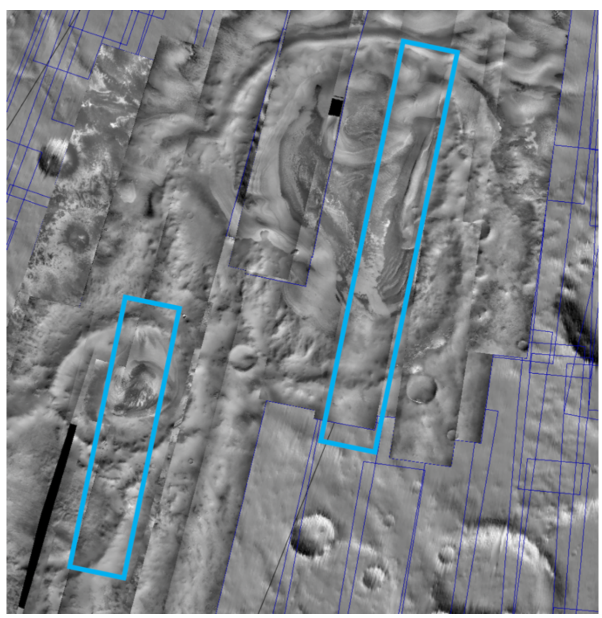

Figure 2: Approximate CTX footprints selected for seasonal repeat coverage over Reynolds and an adjacent crater at 74ºS 160ºW and 73ºS 156ºW.

Analysis: Unexpectedly, a large, planet-encircling dust storm began in early June, 2018, just at the beginning of this imaging campaign. This flattened contrast in CTX images, but most were clear enough to observe the evolution of seasonal frost patterns. As noted by [9], the dust storm did not cause enhanced or early retreat of the seasonal cap. Instead, as observed in CTX data, the MY 34 dust storm appears to have increased CO_2 deposition over Reynolds crater perhaps due to surface cooling from increased opacity that lead to deposition as frost sublimated from lower latitudes. We also observe that steep scarps or slopes retain seasonal frost the longest. Local equator-facing slopes initiate venting, and albedo feedback propagates seasonal frost retreat which allows dark covered material to sublimate faster, as also noted by Schmidt et al. [10]. Late season brightening is observed over Reynolds and Promethei Rupes, as also seen over other sites [7]. It has been suggested that solar heating will cause the surficial dust grains to sink into the remaining seasonal ice [6]; however removal of a surface layer of dust by local winds also seems likely, based on processes observed in the north [11].

Figure 3 illustrates albedo evolution in Reynolds crater from Ls 180º, before the dust storm, to Ls 307º, with no seasonal ice present. We have noted many large bright-dark boundaries and patterns are preserved and new jet events occur in the regions that were brightest at Ls 180º [12]. We will present the evolution of these regions and comparison to concurrent CRISM data. Through analysis of additional imagery we hope to better constrain local effects on seasonal cap sublimation and processes that contribute to development of the cryptic terrain in one location, rather than throughout the south seasonal cap.

References: [1] Kieffer et al. JGR-Planets, 105, p. 9653, 2000. [2] Calvin et al., Icarus, 292, p. 144, 2017. [3] Kieffer et al. Nature, 442, p. 793, 2006. [4] Hansen et al. Icarus, 205, p. 283, 2010. [5] Thomas et al. Icarus, 205, p. 296, 2010. [6] Portyankina Icarus, 205, p. 311, 2010. [7] Pommerol et al. JGR, 116, E08007, 2010JE003790, 2011. [8] Pilorget et al. JGR 118, p. 2520, 2013. [9] Calvin et al. AGU, P43J-3860, 2018. [10] Schmidt et al. Icarus, 200 p. 374, 2009. [[11] Calvin et al. 49th LPSC, #2455, 2018. [12] Calvin and Seelos, 50th LPSC, #2913, 2019.

Table 1: CTX Observations over Reynolds Crater

Cryptic terrain monitoring in Reynolds Crater	Ls
K05_055418_1054_XI_74S159W_180523	180
K05_055484_1054_XI_74S159W_180528	183
K06_055629_1054_XI_74S159W_180609	190
K06_055695_1054_XI_74S159W_180614	193
K06_055840_1047_XI_75S159W_180625	199
K06_055906_1066_XI_73S160W_180630	202
K07_055972_1042_XI_75S158W_180705	205
K07_056051_1054_XI_74S159W_180712	210
K07_056117_1065_XI_73S160W_180717	213
K08_056460_1066_XI_73S160W_180812	229
K08_056671_1057_XI_74S159W_180829	239
K09_056882_1064_XI_73S160W_180914	250
K09_057014_1054_XI_74S159W_180925	257
K10_057159_1054_XI_74S159W_181006	264
K11_057779_1054_XI_74S159W_181123	293
K12_058056_1052_XI_74S159W_181215	307
K13_058346_1054_XI_74S159W_190106	319

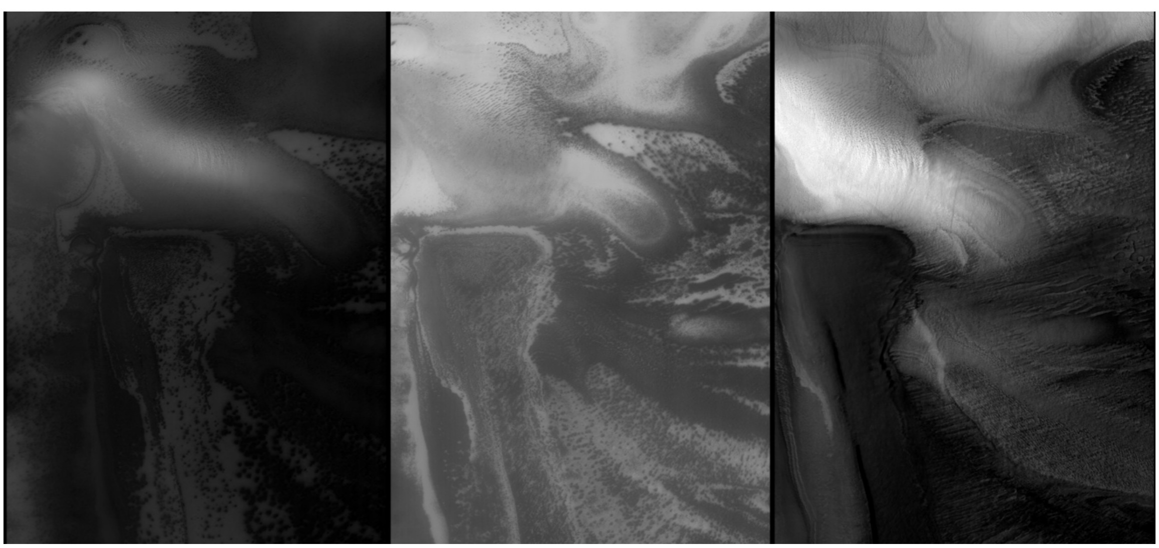

Figure 3: CTX images of albedo pattern evolution in Reynolds crater from Ls 180º, 205º, and 307º (left to right, portions of K05..180523, K07..180705, and K12..181215). Calibrated 8-bit data with a linear stretch on each. The right most panel is completely devoid of seasonal ice and shows relative topographic features associated with longer seasonal ice retention or earlier ice removal.