MONITORING SEASONAL BEHAVIOR OF ICES IN THE CRATERS IN THE MARTIAN NORTHERN POLAR REGION WITH CTX AND HIRISE. M. Hajigholi[1], S. A. M. Bertilsson[2], A. J. Brown[3], C. P. McKay[4] and S. Fredriksson[5] [1]Department of Physics, Luleå University of Technology, 971 87 Luleå, Sweden, mitra.hajigholi@gmail.com, [2]Department of Physics, Luleå University of Technology. [3]SETI Institute, [4]NASA Ames Research Center, [5] Department of Physics, Luleå University of Technology.

Introduction: To better understand the behavior of ice in craters on Mars, seven Martian craters in the Northern Polar Region (NPR) have been monitored over a range of latitudes (60-90°). Each crater has been examined during varying solar longitude, during which the amount of ice has shown both expected and unexpected seasonal variations.

CTX and HiRISE: The Context Camera (CTX) on the Mars Reconnaissance Orbiter (MRO) (orbiting Mars since 2006) is a camera providing black and white context images of the Martian surface. These CTX images are used as a complement for the High spatial Resolution Imaging Science Experiment (HiRISE) camera. CTX has a spatial resolution of 6 m/pixel [1] and HiRISE 0.25 to 1.3 m/pixel [2].

The crater images we investigated from CTX and HiRISE were downloaded from the public internet web site provided by Arizona State University [3].

Crater mapping: We are creating a database called Information on Craters in the Martian Northern Polar Region. 75 Craters are monitored over, using images acquired between 2006 and 2008. The craters monitored are located poleward of 60° in latitude, with the help of CTX and HiRISE images and Google Earth (a tool we used for locating the craters on Mars and to measure the crater diameter).

Every crater has a set of images with data, such as image ID, image location, acquisition date, solar longitude and website the image can be downloaded from which are recorded in the database. In addition to image observation, the crater rim status (clear, diffuse or none), the amount of ice (None, less than 50 %, more than 50 % and full), unusual features, crater diameter, location and a description of the area are recorded.

Criteria used for crater selection: Our first analysis using the database included seven craters chosen throughout the Martian NPR, creating better data coverage. We have chosen to focus on craters with diameters ≥ 10 km. The crater should be covered by images from at least two different seasons. In all studied images, the crater should be clearly visible and easily identifiable i.e. no clouds or dust storms should obscure the crater area.

Analysis: A way of determining ice coverage in craters is by comparing images from different seasons. In the case of a fully covered crater it is quite easy to see, as the inner crater wall is white with frost. As ice coverage disperses we see darker spots emerge and the underlying Martian surface becomes more prominent. When dunes are present in the crater, they become visible when ice sublimes from their immediate vicinity. In order to categorize the craters we have divided the coverage into four levels; full, >50%, <50% and empty.

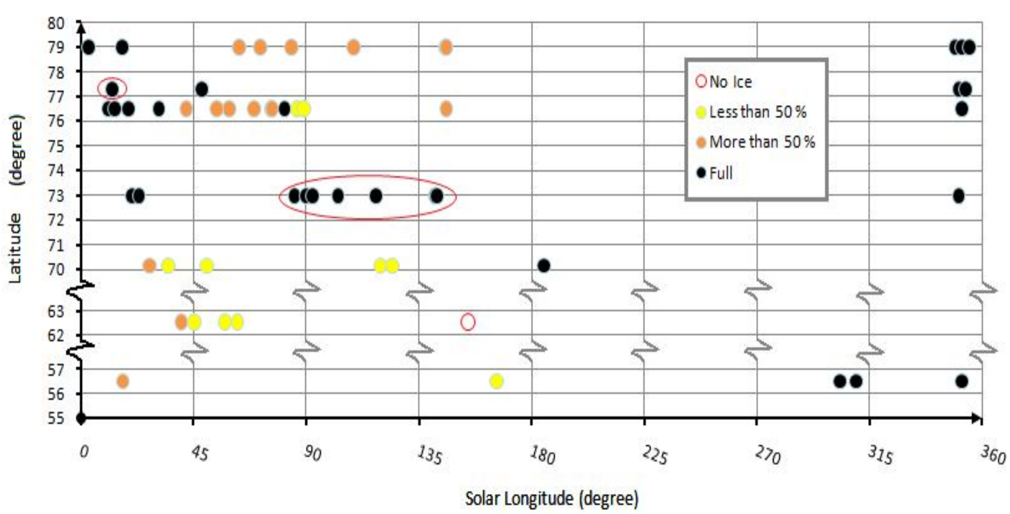

Figure 1. The ice coverage of the craters on the Martian northern polar region over different latitude as a function of solar longitude. The red markings indicate when defrosting patterns are visible for Korolev and Dokka, which are completely covered by the seasonal ice cap during a Marsian Year.

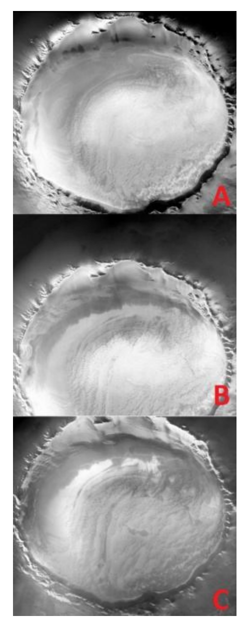

Figure 2. The 34 km Crater C, in solar longitude sequence. A: L_S =76.42, B: L_S =81.37 and C: L_S =86.32. We can see the behavior in the amount of ice coverage during the spring season going from (A) more than 50 % to (B) full to (C) less than 50 %.

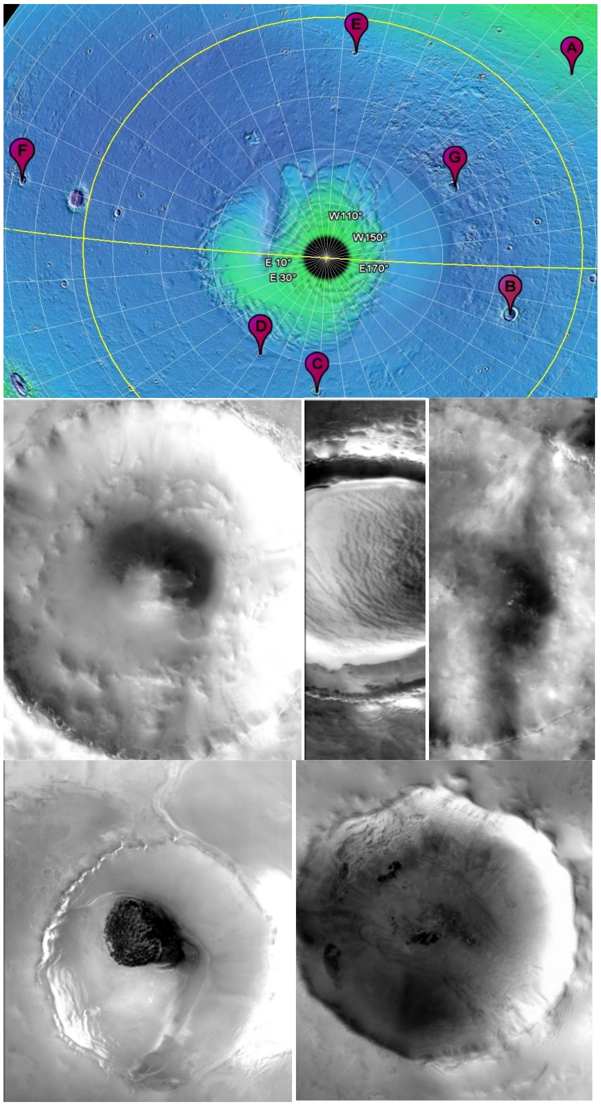

Figure 3. (Top) The Martian northern polar region (map from *Google Earth*) with the 7 monitored craters pointed out, with the locations as follows: **A**: 186.81°E- 62.53°N; **B**: Korolev, 164.5°E-73.0°N; **C**: 89°E-76.5°N; **D**: 62°E-79°N; **E**: 266.55°E-70.16°N; **F**: Kunowsky, 350.58°N-56.50°E and **G**: *Dokka (*not pictured), 214.46°E-77.10°N . Five CTX images below the map represents the craters A (L_S = 40.13 °) (P17_007512_2432_XN_63N173W), B (L_S = 55.67 °) (P18_007961_2529_XN_72N197W), F (L_S = 16.72 °), (P15_006860_2371_XN_57N009W), D (L_S = 84.1 °) (P20_008795_2592_XN_79N299W) and E (L_S = 27.4 °) (P16_007153_2505_XN_70N093W) from the same season, the Martian northern spring i.e. $0° \geq L_S \leq 90°$.

During winter, five of our seven craters are completely covered by the seasonal ice cap. The ~84 km in diameter Korolev crater on ~73° latitude is permanently covered by residual water ice [4]. This is also true for the ~45 km in diameter crater Dokka at ~77.16° latitude. Only one of the craters monitored had an image which could be classified as having absolutely no ice in the whole crater, which was during the Martian summer and at a quite low latitude (~62.5°).

All the craters have many images from the spring season, showing expected and unexpected results of the ice coverage over different latitude. An expected result is that the ice coverage in crater increases with latitude from solar longitude 135° to 360° and decreases from longitude 0° to 135°. This is true in figure 1 for crater F (Kunowsky), A, E and D located in figure 3. Seasonal ice coverage was variable for crater C, (Figure 2). During the late spring of Mars Year 29 [5] the ice in this crater accumulates, from containing more than 50 % ice to being fully covered and then the ice disperses to less than 50 %.

Conclusions: Anomalous seasonal behavior of ice in craters could be explained by the type of ice covering it. Latitudinal variations in insulation (which drives the atmospheric circulation of water, carbon dioxide and airborne dust [6]) affect the constituents of the ice, resulting in a mixture of water and carbon dioxide ice, perhaps with airborne dust which has settled on the ice after seasonal dust storms. When ice becomes dark due to dust it will absorb more sunlight, thereby warming relatively quickly and defrosting more rapidly [8].These factors in turn determines the stability characteristics of the ice [7].

Our observations suggest the ice in crater C experiences two periods of accumulation during the spring and winter season, in Mars Year 29 [5]. This could be due to unusual events but also may be a periodic behavior as the Martian season turns into summer and winter. At this stage we cannot verify either hypothesis however we will be looking at other craters at similar latitudes for similar accumulation periods. The likely factors controlling ice accumulation are the length of day and night, distance to the sun, the solar angle, latitude, altitude, clouds and seasonal dust storms.

Craters on lower latitude than Korolev crater and on higher latitude than Dokka crater do not show obvious evidence of ice accumulation. One conclusion we can draw from this is that over and under roughly 73° and 77° latitude, the ice coverage in craters is more stable. The craters on lower latitude contain less ice than those on higher latitude during a Martian year. We intend to look at craters similar to crater C in order to investigate whether ice coverage fluctuates during spring time as we are observing in crater C.

References: [1] Malin, M. C. et al. 2007. *JGR* **112** doi:10.1029/2006JE002808. [2] McEwen, A. S. et al. 2007. *JGR* **112** doi:10.1029/2005JE002605. [3] http://global-data.mars.asu.edu/. [4] Bertilsson S. A. M. et al. 2009. *LPSC XXXXI*, this meeting. [5] http://www.mars.lmd.jussieu.fr/mars/time/martian_time.html. [6] Jakosky B. M. and Haberle R. M. 1992. *SAO/NASA Astrophysics Data System*, 969-1016, doi:1992mars.book..969J. [7] Snyder Hale A. et al. 2005. *Icarus* **174** 502-512, doi:10.1016/j.icarus.2004.10.033. [8] Calvin W. M et al. 2008. *PSS* **56** 212-226.