THE NATURE AND MOBILITY OF BRIGHT PATCHES IN THE NORTH RESIDUAL ICE CAP FROM MARCI, CTX, OMEGA AND CRISM. W. M. Calvin[1] , J. M. Pocock[1], and P. B. James[2], S. W. Lee[3], P. C. Thomas[4], S. L. Murchie[5], F. Seelos[5], Y. Langevin[6], T. N. Titus[7], and P. McGuire[8], [1]Dept. Geological Sciences and Engineering, University of Nevada, Reno, NV 89557 (wcalvin@unr.edu), [2]Space Science Institute, Boulder, CO, [3]Denver Museum of Nature & Science, Denver, CO, [4]Cornell University, Ithaca NY, [5]Applied Physics Laboratory, Laurel, MD, [6]Institute d'Astrophysi-que Spatial (IAS), Orsay, France, [7]U. S. Geological Survey, Flagstaff, AZ, [8]Dept. Earth and Planetary Sciences, Washington University, St. Louis, MO

Introduction: Calvin and Titus [1] identified large-scale variations in the north residual ice cap using binned TES albedo data (Figure 1). The cap undergoes a period of defrosting up to Ls ~100 to 105, followed by frost migration and transport. These results are consistent with observations reported by Langevin et al. [2], of high northern latitudes by the Mars Express OMEGA imaging spectrometer from Ls 93 to 110. They attributed a decrease in albedo and the change in shape of absorption bands of the central cap in early summer to sublimation of fine-grained water ice frosts in the central cap. The increasing albedo and ice band strengths in outliers was attributed to a decrease in surface dust contamination and aerosol thickness.

While large scale patterns remain the same, interannual variability in both the persistence and location of the highest albedo deposits was noted [1]. In particular, sustained cold bright anomalies were found in two locations, one on the Titania lobe, near the end of Chasma Boreale and one near the northward limit of MGS coverage (Figure 1). The latter location was dubbed "CABA" by Kieffer and Titus [3]. Additional sustained bright spots were found by Langevin et al. [2] who studied a small area (Region A) that maintained a fine-grained ice signature and they suggested the persistence indicated thick fine ice deposits, akin to snow drifts.

The new Mars Reconnaissance Orbiter cameras, MARCI and CTX, coupled with the imaging spectrometer CRISM, afford both synoptic and detailed spectral views of these persistent locations and other evolutions of frost grain size and mobility in the north residual ice cap. These combined data sets can shed light on local accumulation and ablation zones. The factors controlling the location and persistence of cold and bright patches is the subject of a companion abstract [4] at this conference.

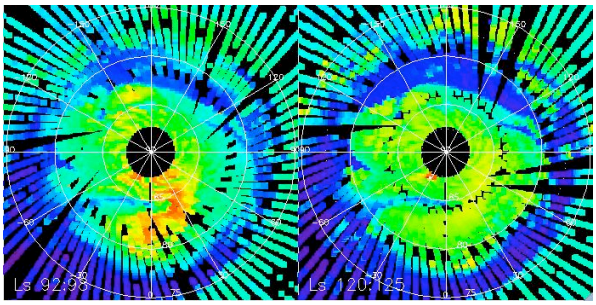

Figure 1: Albedo of the north ice cap at summer solstice (left) and at mid-summer (right). Bright regions (warmer colors) retreat to small patches on the Titania lobe and near the MGS observation limit.

MARCI Data: MRO began transition phase observations at the end of September, 2006. This corresponded to an Ls ~ 113, or after the residual cap has nearly retreated to its nominal summer state of coarse exposed ice. Once in mapping orbit, MARCI acquires roughly 10 images a day, the vast majority covering the polar regions allowing for high time fidelity synoptic coverage of the varying albedo deposits. An example of a map-projected image that has been photometrically corrected using a simple Lambertian function is shown in Figure 2. Time series shows numerous persistent small bright patches throughout the north residual cap and a sustained high albedo deposit along the ridgeline west of the Chasma Boreale. This deposit is above the Chasma in typical polar stereo projections with a central longitude of 0. This bright ridgeline was also observed in OMEGA data at similar Ls, as will be discussed later. These spots show up best in mosaics that limit the viewing geometry and account for the changing lighting conditions seen on the individual orbits. In addition to the Chasma ridgeline numerous small spots are observed and tend to be located near the lower latitude margins of permanent ice. Detailed examination of their mobility and change with Ls is underway.

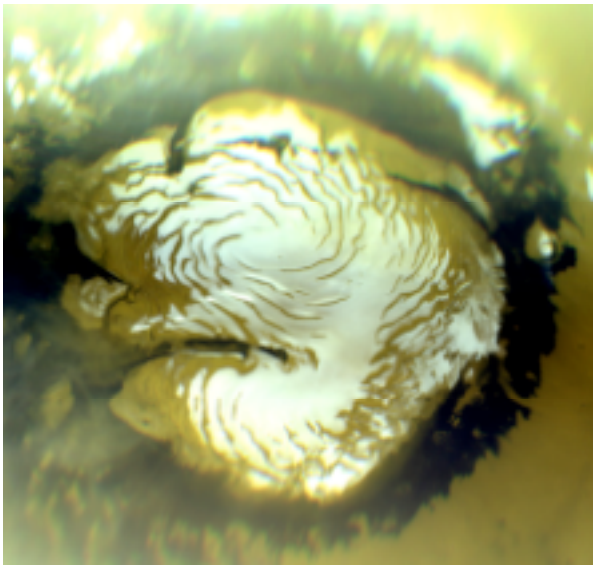

Figure 2: MARCI image from T01, 9/30/2006. Bright regions above the Chasma Boreale correspond well with sustained bright areas seen by TES and OMEGA.

CTX Imaging: Based on the low spatial resolution TES maps, repeat observations of the two sustained bright patches, dubbed McMurdo and Vostok (CABA) were planned in order to explore photometric changes over the summer season. The bright area nearest the pole (Vostok) was imaged 16 times and the area adjacent to Chasma Boreale (McMurdo) was imaged ~6 times. From the current imagery it is difficult to tell whether the bright areas are on the face of scarps or on higher elevation ridgelines. The photometry gives the impression of sunward facing slopes, but in all instances, the brightest areas appear regardless of sun direction and are often enhanced in forward scattering. This shows they must be on upper surfaces in order to remain illuminated regardless of solar incidence. Future work will integrate the MARCI and CTX images with MOLA topography to explore slope effects in detail [4].

OMEGA DATA: Many of the small bright patches seen in MARCI are observed in the later season mosaic of OMEGA data [2]. In order to explore Ls variation we wanted to work with individual data cubes for comparison to other data sets. Data up through July 2005 have been released via the PDS. Examination was made of image cubes acquired on orbit 1000, at the end of October 2004, at Ls 107. The third observation 1000_2 was selected due to good coverage of the Vostok (CABA) bright region. This image also covers the ridge just west of Chasma Boreale. Figure 3 shows color composites based on water ice grain size.

In Figure 3, the color composite on the left uses channels 190 (2.25μm), 137 (1.50 μm) and 125 (1.32 μm). This highlights fine ice (deeper ice absorption bands) in magenta colors. We next performed a band depth map on the 1.5 μm water ice band. This band depth is density sliced (even increments of increasing band strength) and color-coded . Both of these images highlight the ridgeline west of Chasma Boreale as a location of fine grained water ice also seen due to its high albedo in MARCI data. Figure 4 shows the average spectra associated with each of the band depth slices. The dark blue areas are consistent with finer water ice (blue spectrum) and other regions are either coarser or include more dusty, non-ice material. Regions in red have only a very weak ice feature and significant portions of the polar layered deposit (PLD) have no ice features at all.

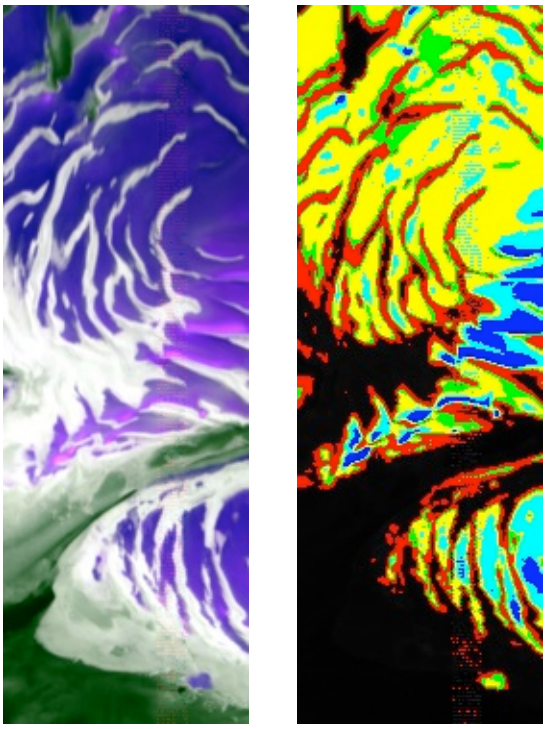

Figure 3: (left) All blue colors are water ice. Magenta tones highlight bright fine-grained ice. (right) A band depth map of the 1.5 μm water ice band has been density sliced and colorized. Band depth increases from red to blue colors.

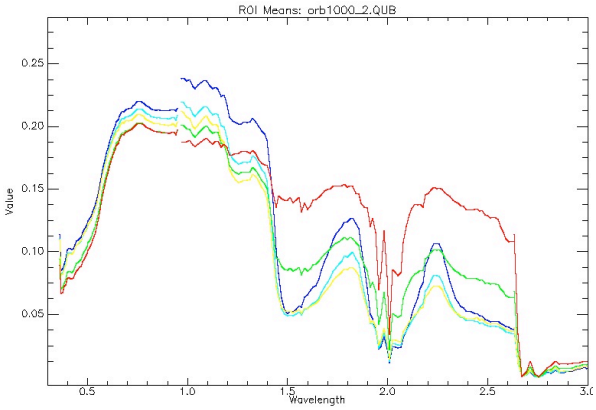

Figure 4: Average spectra of colored regions from Figure 3 (right). Colors are the same between the two Figures.

CRISM Imaging: Concurrent with CTX, CRISM acquired 12 multi-spectral window observations and 2 full resolution FRT observations of the Vostok (CABA) region. There are approximately 70, lower spatial resolution MSP observations as well. Data analysis and calibration for these images is underway and results synthesizing these with MARCI, CTX, and OMEGA will be presented at the meeting.

Summary: Significant mobility and spatial variation in high albedo patches are noted in the summer northern ice cap. These patches are shown to be fine-grained water frost and their motions may provide information on winds or local accumulation and ablation occurring in the permanent ice deposits. It is interesting to note that large fractions of the PLD shown to be transparent water ice by MARSIS and SHARAD have no spectral absorption features of water ice in OMEGA. Apparently, lag deposits are effective at masking underlying composition in many locations. Through further study we hope to illuminate the thickness of the ice veneer on top of the northern PLD and why both small bright patches and the persistant coarse-grained ice cap appear as they do.

References: [1] Calvin, W.M. and T.N Titus, Planet. Space Sci., in press. [2] Langevin, Y., et al. (2005), Science, 307, p. 1581. [3] Kieffer, H.H., and T.N. Titus (2001), Icarus, 154, p. 162. [4] Pocock, J.M. and W.M. Calvin, this conference.