NEW OBSERVATIONS OF CO_2 AND H_2O ICE BY OMEGA/MEX IN THE SOUTH POLAR REGION OF MARS DURiNG LATE SUMMER (NOVEMBER / DECEMBER 2005)

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Introduction: Observations of Mars by The OMEGA VIS-near IR imaging spectrometer on board Mars Express have been initiated in January 2004, during the very first elliptical orbits after insertion. The early pericenters were close to the equator. Due to precession, the pericenter moved south, and it was possible in late January 2004 to observe the South pole shortly before the local fall equinox (two orbits at Ls 337.8° and Ls 341.3°). TES observations over several M-years show that this period corresponds to the minimum extent of the South polar cap [1]. At that time, the altitude over the cap ranged from 1600 km to 1900 km, so that the pixel size of OMEGA varied from 2 km to 2.4 km. These observations made it possible to identify small patches of water ice at the boundary of the CO_2 ice cap [2]. They also allowed to estimate the relative abundances and grain sizes of CO2, H2O and dust for the different icy terrains [3]. Shortly after these observations, the Southern polar cap moved into the polar night and could not be observed by OMEGA. Later observations of the northern seasonal cap [4] and permanent cap [5] confirmed that OMEGA can unambigously identify both CO_2 ice and water ice in the wavelength range 1 to 2.7 µm. Strong constraints can be obtained on the mean path length of photons in ices, which is linked to grain size and dust contramination.

The motion of the pericenter of the elliptical orbit of Mars Express was adjusted so as to provide a seasonal drift of regions observed at high latitudes. In November and December 2005, it was possible to observe South polar regions with OMEGA at values of Ls ranging from 326° to 350°, one full martian year after the initial observations. In this abstract, we compare these new observations with the observations in early 2004, in particular for the small regions, which were observed to be covered by water ice. The altitude of the pericenter at high latitudes ranged from 800 km to less than 400 km, with an rapidly decreasing dwell time. After mid December 2005, the dwell time was only compatible with the narrowest, highest resolution mode of OMEGA (16-pixel track). Therefore, in this contribution, we focus on a period from Ls 326° to Ls 335°, when broader tracks (32 and 64 pixels wide) could be imaged, to compare the late 2005 observations and the early 2004 observations of the South polar cap by OMEGA over significant fractions of the cap.

Observations: Nine tracks were obtained with pixel size ranging from 0.5 to 0.8 km, a resolution 3 to 5 times higher than that obtained in early 2004. It is first important to check whether the recess of the CO_2 seasonal cap is complete, to minimize the possible impact of the small discrepancy in Ls (326° to 335° in 2005, to be compared with 339° to 341° in early 2004). Figure 1 shows the late 2005 observations of the 1.425 µm feature of CO_2 ice superimposed as dark framed rectangles on the two swaths obtained in early 2004 with a consistent color scheme. The positioning and pointing information of Mars Express is not accurate to the few 100 msec level which is required at such scales. HR tracks and low resolution tracks have therefore been slightly shifted so as to provide the best match between regions covered by CO_2 ice observed by OMEGA and bright areas observed by Viking and MGS/MOC [6]. As the incidence angle ranged from 73° to 84° over regions with a significant CO_2 signature, even small variations in aerosol content could have had a significant impact on band strength. However, the only significant mismatch between the two sets of OMEGA observations is observed for the outlying patches of CO_2 frost close to 86°N and 340°E, which have not yet fully sublimated in 2005 at Ls 325°. At these longitudes, the recess of the seasonal CO_2 cap lags systematically behind regions at longitudes from 60 to 210°, which correspond to the cryptic region in early summer. All around the central cap, the boundaries observed in early 2004 and 2005 match within a few km, possibly better as this corresponds to the pixel size of observations in 2004.

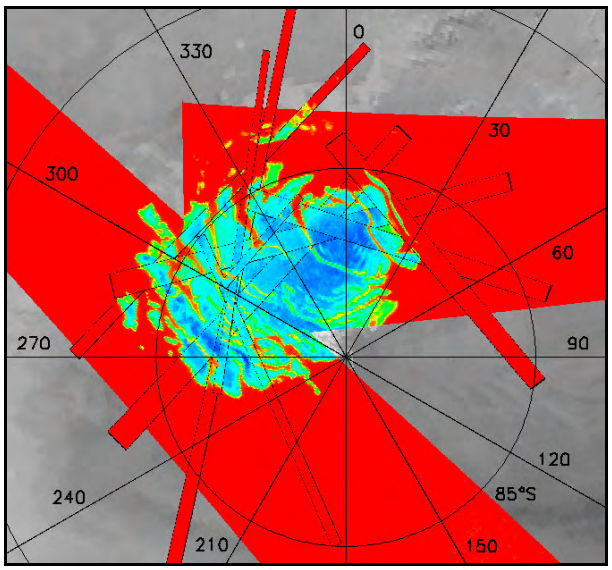

Fig. 1 : *nine observations of a specific absorption feature of CO2 ice at 1.425 µm over the South polar cap at high resolution by OMEGA in late 2005. These observations correspond to the dark framed elongated rectangles. They are superimposed on the two wide tracks obtained in January 2004. The rainbow color code ranges from 0% (red) to 50% (very dark blue).*

In [2], Bibring et al. concluded that the surface water ice patches observed in January 2004 were linked to permanent subsurface reservoirs. This interpretation required that water ice patches would be observed in the same locations in late 2005, as we have shown that seasonal CO_2 frost, which hides underlying features at such high southern latitudes for most of the summer, had recessed to the minimum of the seasonal cycle. The results on water ice signatures in 2005 indeed show a remarkable consistency in terms of location with previous observations. A global map is provided in Fig. 2. HR observations in late 2005 show significantly weaker signatures (30 to 35% maximum band strength) than in early 2004 (38% to 40% band strength) over the same

regions. This will be shown to be linked with the discrepancy in Ls. Band strengths of 40% are observed in late 2005 in an outlying region at longitudes 340° to 0°, ~ 83.5° S that was just missed in early 2004. The color scale of HR observations was adjusted to be able to compare relative variations in water ice band strength over the two periods. All regions of intermediate albedo beyond the edge of the CO_2 cap where surface water ice was observed in early 2004 also exhibit the strongest water ice signatures in late 2005.

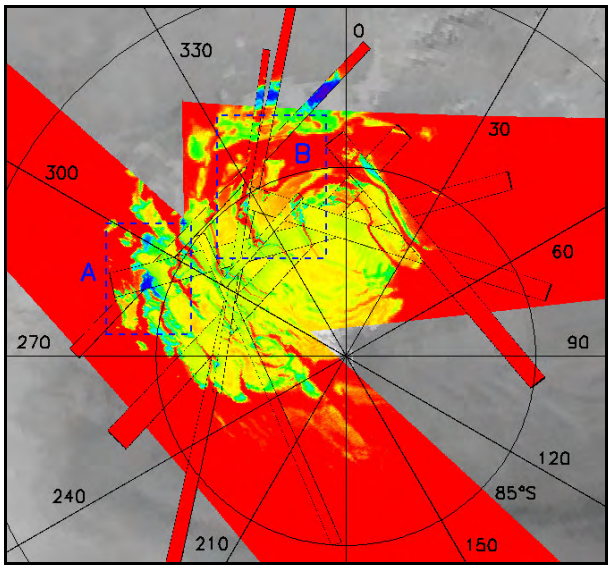

Fig. 2 : *nine observations of the 1.5 µm water ice absorption band over the South polar cap at high resolution by OMEGA in late 2005 (dark-framed elongated rectangles) are superimposed on the two wide tracks obtained in January 2004. The rainbow color code ranges from 0% (red) to 38% (very dark blue) for the two wide tracks. The color scale for HR observations has been adjusted. Two regions of interest (ROI A and ROI B) have been identified.*

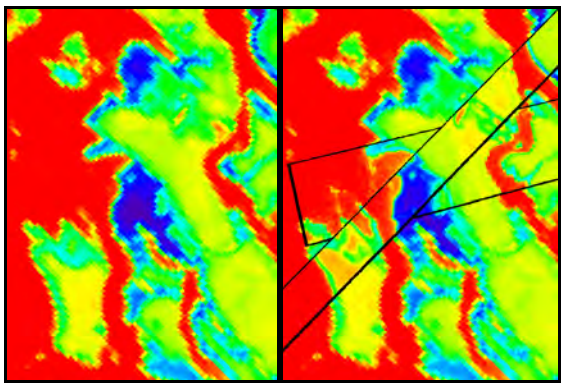

Fig. 3: *ROI A includes the largest water ice patch observed at low resolution in 2004 (left). Two superimposed HR tracks are displayed on the right.*

The largest water ice patch observed in 2004 lies at the center of ROI A (fig. 3). High resolution observations in 2005 (right) are remarkably consistent with low resolution observations in 2004 (left) which shows that this feature persists over two successive martian years. Spectra of surface water ice are markedly different in the South when compared to the North permanent cap. The albedo is lower (35 - 40% compared to 60 – 70%) and the 2 µm band is not saturated. These two characteristics can be attributed to a significant level of dust contamination.

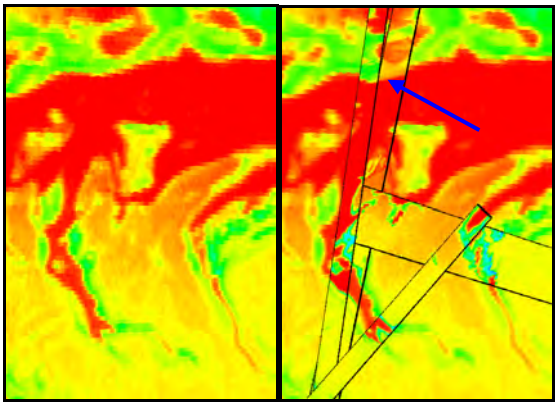

Fig. 4 : *ROI B includes 4 HR tracks (right) superimposed on a LR track (left). HR observations in 2005 are very consistent at the km level.*

In Fig. 4 (ROI B), the region with a lower water ice band strength (blue arrow) corresponds to an HR track obtained at Ls 326.3°, when some residual CO_2 frost is observed in the same region (see Fig. 1). This CO_2 frost with a minor H_2O contamination has disappeared at Ls 335° (overlying, narrower track on the left), and band strength is now similar to that observed at Ls ~ 340° in 2004.

H_2O band strengths increase in 2005 from Ls 325° to 335°. This trend continues in later observations, with a close match to 2004 results. This trend could be linked either to bidirectional reflectance effects at high incidence or to ice-rich aerosols with significant optical thicknesses close to equinox. As an example, the low intensity signatures observed in 2004 at Ls 341° around 180° of longitude (Fig. 3) could be linked to water ice rich aerosols.

Conclusion:

The distribution of CO2 ice observed by OMEGA on the south polar cap is very similar in late summer over two Martian years. These observations at a resolution of 0.5 to 1 km per pixel confirm the existence of water ice patches close to the boundaries of the southern CO_2 cap at its minimum extension, which are strongly correlated with geological features such as scarps. The water ice patches are remarkably stable in extent over two Martian years. Therefore, the recent observations of OMEGA support the conclusion of Bibring et al. [2] that surface water ice patches close to the edge of the southern CO_2 cap are linked to extended subsurface reservoirs.

References:

[1] Titus, T.N, (2005) *Lunar Planet. Sci* **36**, 1993. [2] Bibring J-P. et al. (2004), *Nature* **428**, 627. [3] Douté et al. (2006), submitted, [4] Schmitt B. et al. (2005) *LPS* **36**, 2326. [5] Langevin Y. et al. (2005) *Science* **307**, 1581. [6] Thomas P.C. et al. (2005), *Icarus* **174**, 535