INVESTIGATIONS OF MARS POLAR PROCESSES BY OMEGA/MEX OVER 3 MARTIAN YEARS.

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Introduction: The seasonal and perennial polar caps of Mars play a major role in the polar energy balance as well as the CO_2 and H_2O cycles. Until 2004, the main results on the extent and evolution of the caps were obtained in the visible (bright regions being associated with ices) by orbiting cameras (from the very first Mariner missions to Viking, then MGS/MOC) then in the thermal IR (MGS/TES and Odyssey Themis). Ices could then be detected from their characteristic equilibrium temperatures. Since January 2004, the OMEGA Vis-NIR imaging spectrometer on board Mars Express has provided a powerful new tool for investigating ices on Mars. Both CO_2 and H_2O ices present strong characteristic absorption bands in the near-IR (Fig. 1). The relative strength of these bands provides information on grain size while the albedo is controlled by dust contamination within the ice or at the surface.

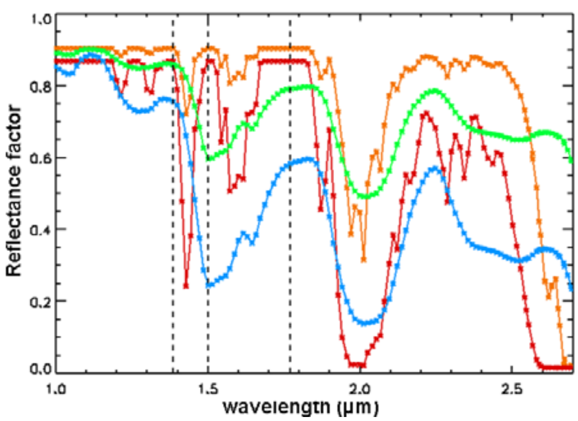

Fig. 1: spectral signatures of CO2 ice (orange: 1 mm size; red: 5 cm size) and H2O ice (green: 10 µm size; blue: 100 µm size)

Observations started in January 2004 at Ls 331°. They now cover nearly 3 full martian years (20/07/2009: Ls 306°). The precession of the pericenter of the elliptical orbit of Mars Express (300 km x 10400 km, 6.7 h) and the combination of the precession of the orbit plane with the orbital motion of the planet generate a wide range of observation conditions of high latitude regions in terms of altitude and local time. As an example, for observations at Ls 90° in 2004 (Fig. 2a), the orbit was close to the terminator with an altitude over the north pole of 4000 km while it was at a local time of 2 AM – 2 PM with an altitude of 500 km over the north pole in 2006 (Fig. 2h).

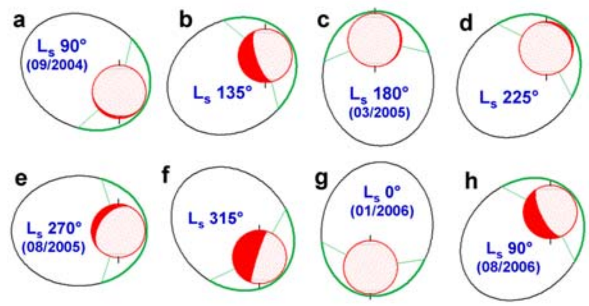

Fig. 2: Evolution of the orbit of Mars Express during one martian year (Ls 90° to Ls 90°)

Main results: Observations of southern polar regions after one month in orbit yielded a first important result, with the detection of the spectral signature of H_2O ice in well defined areas (dark blue in Fig. 3) at the edge of the southern perennial cap [1]. Spectral modeling provided constraints on H_2O ice grain size both in these regions and as contamination of CO_2 ice over the perennial cap [2].These regions have an albedo similar to dust covered terrains, hence they could not be identified in imaging data.

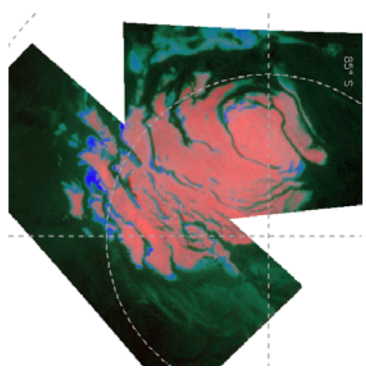

Fig. 3: Signatures of CO_2 ice (pink) and H_2O ice (blue) near the South pole observed by OMEGA at L_s 335° in early 2004.

In the early phases of the mission, observations near apoapsis were not authorized, hence the first comprehensive observations of the North high latitude regions were obtained shortly after the northern summer sulstice. The observations of the North perennial cap demonstrated that it is constituted of large grained H2O ice covered by small-grained H_2O frost until shortly after the summer solstice [3]. Part of the observed evolution of the albedo of ice covered surfaces results from a decrease of the aerosol optical thickness after summer solstice [4]

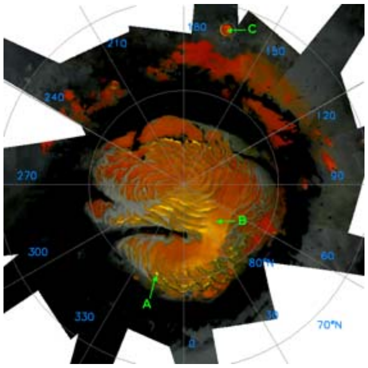

Fig. 4: large grained perennial H_2O ice (red) and residual seasonal frost (yellow) over the North cap at Ls 115° (from [3])

Low albedo areas with weak H2O ice signatures have been observed in NPLD. As these signatures correspond to large grained H2O ice (~ 1 mm), these areas correspond to ice-dust mixtures (permafrost).

A comprehensive set of observations on the retreat of the seasonal cap was obtained in 2005 [5], the swath width decreasing in step with the retreat of the cap as the altitude over the South pole decreased (Fig. 2c to 2f). These observations revealed a very complex role of CO2 ice, H2O ice and dust both on the ground and as aerosols for H2O ice and dust. The "cryptic region" (a dark, cold area within the cap which is prominent in mid-spring [6]) was of particular interest as its low albedo had been attributed to the underlying surface observed through clear CO_2 ice. OMEGA observations exhibited much weaker CO_2 ice signatures in this region, which demonstrated that its low albedo could be attributed to surface dust contamination [7].

In the South, H_2O frost is observed as aerosols close to the spring equinox. It sediments in well defined areas within the cap, which sublimate in late spring (Fig. 5). Contrary to the situation in the North, there is no evidence for a ring of H_2O frost lagging behind the retreat of CO_2 frost [5,8].

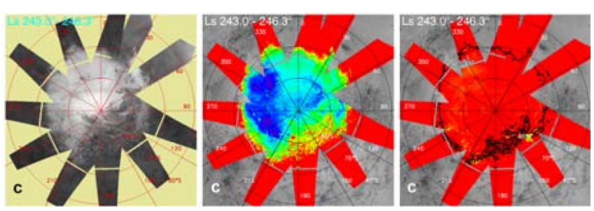

Fig. 5: albedo (left), CO_2 ice signatures (center) and H_2O ice signature (right) over the south seasonal cap in late spring; at this stage, only a few small patches of H_2O frost are observed along the sublimation front (from [5]).

Observations in the North in 2006 and 2008 revealed a completely different pattern: after mid-spring, H_2O ice signatures spectrally dominates over the seasonal cap, except from a few patches where CO_2 ice signatures are still observed, even when it is clear that the bulk of the cap is still constituted by CO_2 ice.

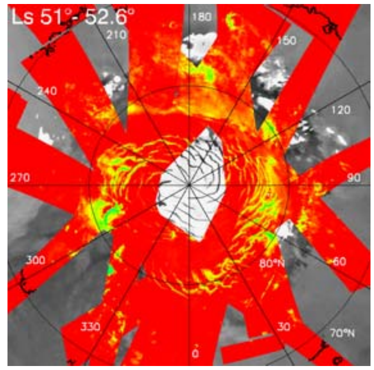

Fig. 4: signatures of CO2 ice (green) observed as patches within the limits (black) of the north seasonal cap in mid spring

The saturated bands of CO_2 ice provide a very powerful diagnostic tool for evaluating the optical thickness of aerosols over icy regions, as only photons scattered by airborne dust can be observed at these wavelengths. This made it possible to track dust clouds crossing the south seasonal cap and the evolution of dust loading at high latitudes [9], with clear similarities with time evolution patterns observed at low latitudes by the MER's confirm the global character

Conclusion and perspectives: Nearly 3 Martian years of spectral imaging observations by OMEGA/Mex at Vis-NIR wavelengths have provided major results on the role of CO_2 ice, H_2O ice and dust in the evolution of Martian seasonal and perennial caps. The focus of on-going and scheduled OMEGA observations of polar regions is on inter-annual variability and on multi-instrument investigations of regions of interest. Higher resolution IR observations are now provided by CRISM/MRO, which can be set within the wider context provided by OMEGA tracks. The results of a coordinated observation campaign of the cryptic region with OMEGA, CRISM, HIRISE and THEMIS are presented in a companion abstract.

References:

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