MARS MISSION CONCEPT: MARS ICE CONDENSATION AND DENSITY ORBITER. T. N. Titus[1], A.J. Brown[2], S. Byrne[3], A. Colaprete[4], T. H. Prettyman[5], [1]USGS Astrogeology Science Center, 2255 North Gemini Dr., Flagstaff, AZ 86001 (ttitus@usgs.gov), [2]Plancius Research, Severna Park, MD 21146. [3]University of Arizona, Tucson, AZ 85721 [4]NASA Ames Research Center, [5]Planetary Science Institute.

Introduction: Over the last two decades, our understanding of Mars has changed. Missions such as Mars Global Surveyor (MGS), Mars 2001 Odyssey (M01), Mars Express (MEx) and Mars Reconnaissance Orbiter (MRO) have shown modern Mars to have an active and dynamic surface, dominated by surface-atmosphere interactions. The Phoenix lander has provided ground-truth for the presence of extensive subsurface deposits of water ice at high latitudes; however, no other landed mission has probed the Martian high latitudes and polar regions.

This abstract will focus on polar processes and describes a set of investigations that will be crucial to fully unravel the exchange of volatiles between the surface and the atmosphere.

The Mars Polar Night: Much of Mars polar processes occur during dark periods (seasonal and diurnal). The majority of the seasonal polar cap forms in darkness through direct condensation and snowfall. Thermal instruments, such as MGS Thermal Emission Spectrometer (TES), M01 Thermal Emission Imaging System (THEMIS), and MRO Mars Climate Sounder (MCS), observed surface temperatures and spectral features, enabling CO_2 ice grain size and H_2O ice and dust contamination to be constrained. Surface compositional information has been gleaned from visible, near infrared, and short –wave infrared imaging and spectroscopy. However, these instruments depend on reflected solar light and are accordingly useless during periods of darkness. MGS Mars Observer Laser Altimeter (MOLA) was the only instrument to view the polar cap in the polar night at 1-µm. The primary mission was to map elevation, not measure the reflectance of the polar ice. Most of the polar night reflectance data were therefore saturated.

The exchange of polar ice from one pole to the other is sufficient to affect the gravity field of Mars. These shifts in the gravity field, when combined with MOLA altimetry, can be used to constrain the seasonal cap bulk density, but not local variations related to accumulation modes or temporal changes in density, porosity, and grain size [1-3].

Neutron and gamma ray observations have provided another method to determine the cap mass and distribution of CO_2 on broad spatial scales (of a few hundred square kilometers) [4].

Composition, Density, & Condensation Modes: The CO_2 ice that forms in the polar night is mostly CO_2 ice with small amounts of dust and H_2O. It is possible that a layer of H_2O ice may exist as a bottom layer since the surface will reach the freezing temperature of H_2O before it reaches that of CO_2. The seasonal CO_2 may also have density gradient as the two accumulation modes, direct condensation and snowfall, are superimposed. Additionally, the sintering process may cause surface ice-grain sizes to increase [5-7].

CO_2 Accumulation Modes: What is the nature of CO_2 deposition (e.g., snow or direct frosting, continuous or sporadic) in space and time?

Investigation: Measure and monitor clouds in the polar night, ground fogs, and CO_2 precipitation (snow).

Investigation: Measure and monitor surface ice composition and grain size.

CO_2 Ice Density: What are the densities, column abundances and areal coverage of the CO_2 ice composing the seasonal and residual polar caps?

Investigation: Measure the spatial and temporal evolution (thickness) of the seasonal polar caps with centimeter-scale vertical resolution, sampled at approximately every 10º of L_s.

Investigation: Measure the column mass abundance of the CO_2 ice in the seasonal polar caps with accuracy of 50 kg/m^2 sampled at approximately every 10º of L_s.

Mission Concept: The key instrument to these investigations, which has yet to fly to Mars, is an imaging LIDAR system that is sensitive to (and can differentiate between) CO_2 and H_2O ice [8]. This instrument could determine accumulation modes and monitor changes in compositions and grain sizes of surface ices within the polar night. This instrument could also monitor changes in ice thickness. Interferometric synthetic-aperture radar could also monitor ice thickness and possible changes in ice properties. A thermal neutron imaging system could directly monitor ice column abundance. A thermal emission spectrometer or bolometer could indirectly derive column abundance and grain sizes.

The key to further understanding Mars polar processes is to peel back the veil of darkness from the polar night!

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