Compositional Variation of the Icy Units of the South Residual Polar Cap of Mars Using CRISM. W. M. Calvin[1] and K. D. Seelos[2], [1]University of Nevada – Reno, 1664 N. Virginia St., MS 172, Reno, NV 89557 (wcalvin@unr.edu), [2]JHU Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723 (kim.seelos@jhuapl.edu).

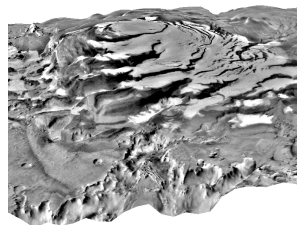
Introduction: The south polar residual ice dome (SPRID) rises nearly 4 km above the more extensive, flat, and low-relief plateau known as the south polar layered deposits (SPLD) (Figure 1). The highest albedo deposits on the planet sit on these highest southern elevations and are observed to be made of carbon dioxide (CO_2) ice [1]. Recent observations have demonstrated that the SPRID and SPLD are composed primarily of water ice with a meter to tens of meter veneer of carbon dioxide at the highest elevations [e.g. 2-4]. The uppermost CO_2 ice unit has a wide array of surface textures and erosional morphologies [e.g. 5].

Water ice has been observed along the margins of the bright CO_2 residual ice cap, most prominently in a large, lower elevation outlier occurring from 82 to 84S and 315 E to 5E [6-9, Figures 1, 2]. However numerous small water ice exposures also occur at the margins of the residual CO_2 ice (Figure 2). These exposures of water ice are inferred to be the uppermost unit that dominates the interior of the SPRID; however others have interpreted them as an annealed layer of seasonal water ice, rather than an intrinsic layer or substrate within the SPRID. As described below, water ice has variable geomorphic expression in different locations. Water ice appears both in steep scarps and in more diffuse and extensive regions at the margins of residual CO_2 ice. Water appears to underlay CO_2 in many locations and is an important and variable constituent of the dark erosional surfaces within the upper CO_2 ice.

Limited high resolution compositional studies or mapping have been performed to date on these units of residual ice in the south.

CRISM Targeted Data: The CRISM instrument is a hyperspectral imaging spectrometer with 544 bands in the visible/near infrared wavelength range from 0.362 to 3.92 µm [10]. To date CRISM has acquired over 240 targeted (20-40 m/pix) observations of south polar residual ice units with the criteria of having data from the L (or IR) detector (1 to 3.9 µm), at temperatures less than -145C and between Ls 300 to 360 (Figure 2). These are Ls values when seasonal frost should be largely absent [e.g. 11] We have explored selected targeted observations of the varying morphologic units of the residual CO_2 ice, water ice exposures at the margins of the residual CO_2 ice, and select examples of seasonal retreat.

Previous Work: Thomas et al. [5], found variable CO_2 ice grain size, amount of non-ice material, and abundance and grain size of water ice in debris ramps and downwasted material surrounding the CO_2 erosional pits and mesas. That study also noted variation in the expression of water ice, appearing both as a contiguous layer directly underlying the upper CO_2 ice surface, and as a patina of cold trapped material on slopes away from the sun. Seelos et al. [12] examined a small subset of CRISM targeted imagery that has been acquired over the Aa3 geologic unit that is associated with buried CO_2 ice [13]. That study found weak carbon dioxide signatures in the walls of a sublimation pit in Aa3 terrain, and found variable amounts of water ice in troughs where Aa3 material is exposed.



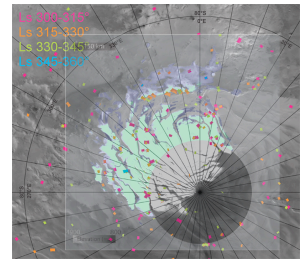


Figure 1 (left): *Perspective view of MOC albedo image draped over MOLA topography showing residual ice confined to high elevations of the SPLD. The largest water ice exposure is the lighter material to the left and at the base of the steep dome scarp.* ***Figure 2 (right):*** *CRISM targeted observations color coded by Ls. Data overlain on a MOC albedo image with semi-transparent water ice locations (blue) and CO_2 ice (green) mapped by THEMIS [9].*

Initial Results: We have examined several additional targeted scenes as well as those first examined in [5]. **CO_2 Ice Surfaces:** Figure 3 shows true and false color composites and Figure 4A illustrates spectra from the upper most CO_2 ice surface at locations that are separated by over 200 km (FRT 8517 acquired at Ls 333.75, and FRT 8744, Ls 337.5, both acquired in 2007). These surfaces are characteristic of large grained CO_2 ice (narrow absorptions at 1.43, 2.28, 2.34, 3.1, 3.3, and 3.7 µm) and overall differences are primarily due to apparent albedo caused by local slope variations creating brighter surfaces that are more oriented toward the sun. To date, we have not observed wide variation in the grain size or spectral properties of the residual CO_2 ices in scenes we have examined.

Water Ice: Water ice is clearly a constituent of erosional material surrounding the CO_2 mesas and plateaus (Figure 4B). The amount of water ice is spatially quite variable and may reflect that the erosional surfaces are providing a window into a water ice rich layer that directly underlies the upper CO_2 ice surface. This is inferred by the strong signature of water ice at the margins of CO_2 in trough walls and where the SPRID elevations begin to ramp down (Figure 4C). Water ice is also a constituent in the dark lanes that expose the interior of the SPRID, again with spatially quite variable signatures (Figure 4C).

Future Work: Detailed modeling of grain size and abundance of non-ice material of these varying units is planned. We will map spectral units across the SPRID in order to better understand the compositional stratigraphy. We will present highlights of the work to date at the meeting.

References: [1]Kieffer, *JGR*, **84**, 8263, 1979. [2]Seu et al. *Science*, **317**, 1715, 2007. [3]Plaut et al. *Science*, **316**, 92, 2007. [4]Zuber et al. *Science*, **317**, 1718, 2007. [5]Thomas et al. *Icarus*, **203**, 352, 2009. [6]Titus et al. *Science*, **299**, 1048, 2003. [7]Bibring et al. *Nature*, **428**, 627, 2004. [8]Douté et al. *PSS*, **55**, 113, 2007. [9]Piqueux et al. 2008. [10] Murchie et al. *JGR*, **112**, 2006je002682, 2007. [11]Calvin et al. submitted. [12] Seelos et al. *47th LPSC*, #1783, 2016. [13] Phillips et al. *Science*, **332**, 838, 2011.

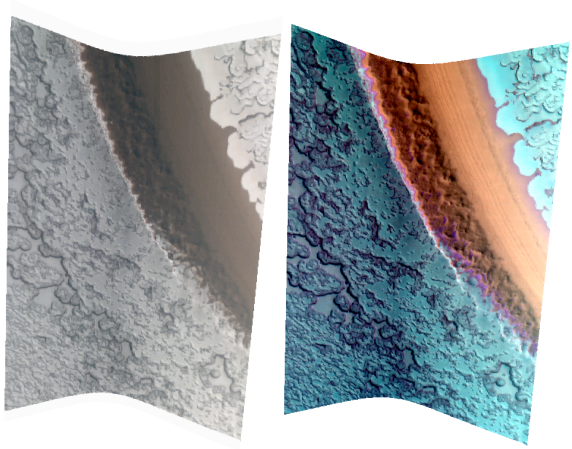


Figure 3: CRISM FRT 8744 visible color (left) and IR false color (right) that emphasizes CO_2 ice in cyan and water ice in blue/purple. As shown in Figure 4, CO_2 ice surfaces don't vary strongly while water ice is highly variable component in the troughs and erosional terrain.

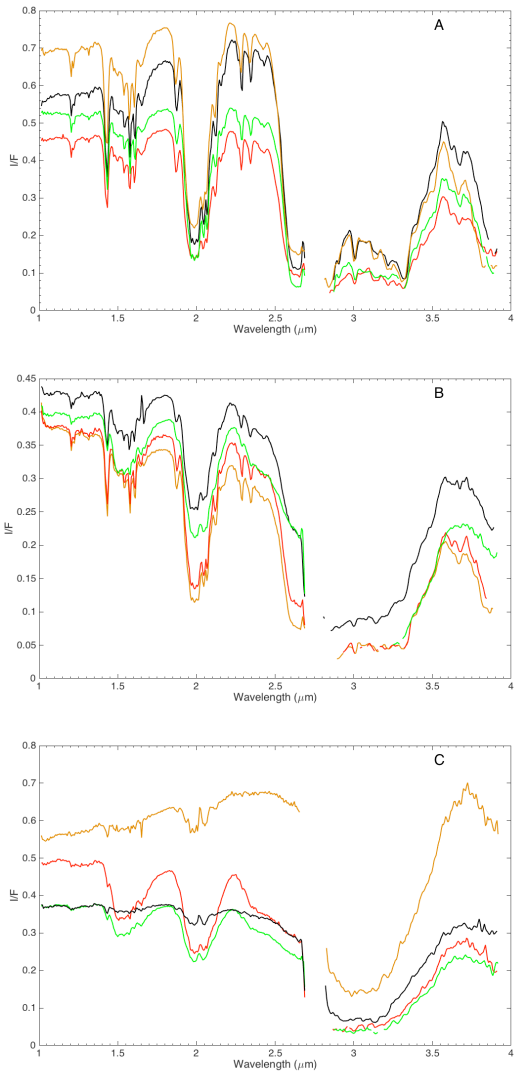


Figure 4: Spectral profiles from varying units. In all spectral plots black and green are from FRT 8517 and red and brown are from FRT 8744. Spectra of CO_2 surfaces (A) vary only in overall brightness due to local slope orientation. Spectra of dark units surrounding pits and mesas of CO_2 ice (B) show a wide range of water ice content and grain size. Spectra of dark units at the margin of CO_2 ice and in dark lanes (C) all show water ice features. Water ice is a strong constituent of dark material surrounding erosional terrain, a layer underlying the upper most CO_2 layer, and a varying constituent of the dark lanes.