
**Introduction:** Mars’ south polar residual cap (SPRC) is a 1–10 m-thick deposit of high-albedo CO₂ ice overlying a ~4 km-high dome of dusty water ice layers known as the south polar layered deposits (SPLD) [1]. Additional water ice-rich deposits have been detected around the periphery of the SPRC and in an extensive outlying deposit [2]; these exposures are distinct from the underlying SPLD, but their exact nature remains unclear [3, 4]. Because variable mixtures of CO₂ ice, H₂O ice, and dust within these deposits influence their interaction with solar insolation and atmospheric cycling, constraining compositional variation across the south polar region is a critical step in understanding the formation, evolution, and preservation of Mars climate records.

In previous work [5, 6], we used short-wave infrared (SWIR) data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [7] to identify and map a suite of 21 spectral endmembers across the SPRC and surrounding ice exposures. Specifically, this work leveraged CRISM “targeted” data, which provide high spatial and spectral resolution views of localized sites (18–36 m/pix, 438 SWIR channels). To map the distribution of compositional endmembers more completely across the region, we now turn to CRISM “mapping” data, which cover broader swaths of the surface at coarser resolutions (90–180 m/pix, 55 SWIR channels). Here we present the results of endmember classification in a mosaic of CRISM Multispectral Window (MSW) observations and discuss their implications for south polar ice composition.

**Methods:** Mosaic generation. To balance spatial coverage with a consistent view of seasonal state (i.e., degree of CO₂ frost cover), the mosaic was restricted to observations acquired between solar longitude (Ls) 310–360°. Most of the resulting mosaic (Fig. 1) captures the surface after Ls 330° when the majority of seasonal CO₂ ice cover is expected to have been removed. Unlike other observing modes that were gathered across multiple Mars Years (MYs), all south polar MSW data were acquired during MY 28 following a significant dust event [8, 9]. To produce the clearest possible view of surface spectral variation, each of the 89 MSW observations were passed through a series of standard corrections that address atmospheric gas absorption, photometric effects, and spectral smile [10]. The map-projected observations were then stacked according to the Ls of acquisition to create the final mosaic at 90 m/pix resolution.

![Figure 1. Spatial coverage and temporal sampling provided by a mosaic of 89 Multispectral Window (MSW) observations from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM).](Image)

Endmember classification. In the previous work with CRISM targeted data, we used iterative k-means clustering [11] to extract a set of spectral endmembers in common across a representative subset of high-quality observations. Those endmembers were then mapped across the entire dataset using a random forest classification model [12]. The latter process was also used to classify the MSW mosaic, but in this case, the random forest model was trained on spectra sourced from the targeted dataset and downsampled to the 55 mapping data wavelengths. This allowed each of the spectra in the MSW mosaic to be classified as one of the endmembers identified in targeted data analyses.

**Preliminary Results & Discussion:** Influence of seasonal CO₂ ice. A prominent characteristic of the classified MSW mosaic (Fig. 2A) is the presence of strip-to-strip variations in mapped endmembers within the SPRC. Broadly speaking, earlier observations (lower in the stacking order) are dominated by more CO₂ ice-rich endmembers associated with seasonal frost cover (reds of C1/C2) while later observations (top of the stacking order) show stronger H₂O ice signatures (yellows of C5/C6) consistent with the expected spectral expression of residual CO₂ ice. This endmember progression continues even after Ls 330°, suggesting that an unusually thick or long-lived seasonal cover was deposited following the large dust
event of MY 28. Although this strong spectral influence from seasonal frost complicates the characterization of residual ice, the results suggest that CRISM mapping data could be used to track the retreat of the seasonal cap over the SPRC, which is difficult to do with thermal or visible data [8, 9].

Water ice-rich exposures. Strong H$_2$O ice absorptions (blues and pinks of W/Cd/Cw endmembers) are mapped consistently in two important contexts. The first is in association with peripheral water ice deposits mapped by [2](Fig. 2C), but importantly, these exposures display a variety of apparent compositions that can include stronger contributions from dust (paler blues of Dw) and/or CO$_2$ ice (pinks of Dc/Cd). This variation could have important implications for how dust and CO$_2$ ice are introduced into SPLD climate records. The second context is along low-albedo slope faces within the SPRC (Fig. 2D), which display strong CO$_2$ and H$_2$O ice features (pinks of Dc/Cd). These slopes face the higher elevations of the south polar dome and could be linked to interactions with solar insolation that drive the development of topography in the SPRC.

Conclusions & Next Steps: The classified MSW mosaic expands our understanding of compositional variation across south polar ice exposures by showing that 1) seasonal CO$_2$ frost in MY 28 played a significant role in surface spectral expression throughout the summer and 2) water ice exposures in and around the SPRC may be linked to SPLD layer formation display unexpected variation in contributions from CO$_2$ ice and dust. Further analyses should focus on classifying individual observations to allow detailed tracking of seasonal ice retreat and on expanding classification to other CRISM mapping data to fill remaining gaps in coverage.