CRISM OBSERVATIONS OF FRESH ICY CRATERS IN MID- TO HIGH-LATITUDES ON MARS .

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Introduction: Byrne et al. (2009) [1] reported exposed ground ice in five new mid-latitude impact craters that had formed between High-Resolution Imaging Science Experiment (HiRISE) observations taken a few months to a few years apart. Dundas et al. (2010) [2] reported an additional eight fresh icy impact craters in the northern mid-latitudes. Each of these craters has been targeted by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), and several of them are large enough to be resolved with CRISM's Full-Resolution Targeted (FRT) mode, which covers 16-18 m/pixel [3]. Here, we report on analyses of CRISM observations taken over these 13 fresh craters.

CRISM Observations: Water ice is identified in CRISM data using the 1.2, 1.5, and 2.0 μm absorption bands. To date, CRISM observations of five fresh impact craters show evidence of water ice exposed within the craters or their ejecta, including one observation from the original reporting (FRT0000D2F7) and four new observations (Table 1). At the other sites, it is likely that ice cannot be identified in CRISM observations due to small exposure areas.

Table 1

CRISM Observation	Lat (N)	Long (E)
FRT0001719F	44.2	164.2
FRT00018C3b	53.3	46.3
FRT00018E24	63.9	44.9
FRT00018F7E	50.5	265.2
FRT0000D2F7	55.6	150.6

For each of these craters, CRISM shows a dark central ejecta zone, where surface dust has been blown off, surrounded by a brightened ejecta zone, presumably where the blown-off dust settles (*Figures 1 and 3*). Pixels with water ice signatures are seen exclusively within the central darkened zone, consistent with HiRISE observations that show ice within the newly-formed craters and in the immediate area around the craters [2].

The water ice absorptions range in strength from 1 to 20% relative to undistributed areas (*Figure 2*), and are usually restricted to 1-2 pixels.

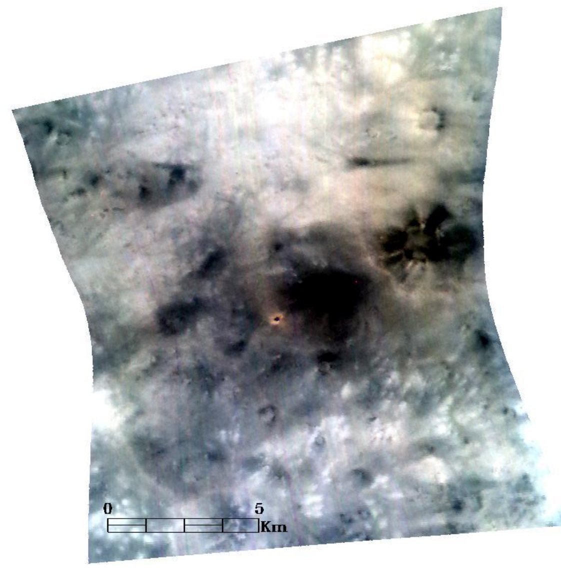

Figure 1 – CRISM FRT00018E24 (centered 63.9N, 44.9E). The fresh crater is the dark spot in the center, with a bright reddish ring. A strong water ice signature (Figure 2) can be seen in the darkened center portion of the crater. The bright ejecta ring is ice-free.

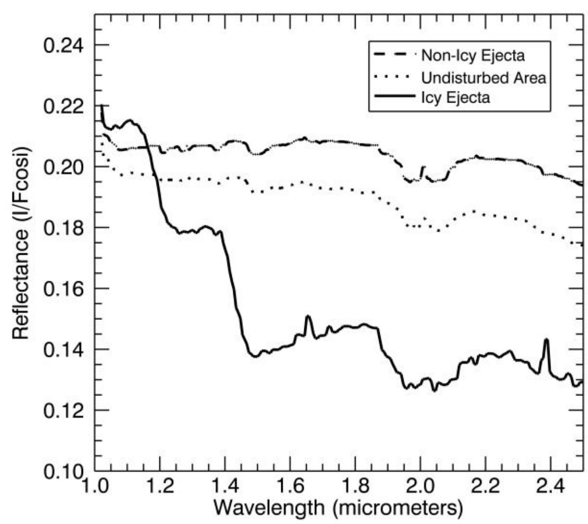

Figure 2 – CRISM spectra of icy pixels in FRT000018E24, compared to non-icy ejecta pixels and undisturbed areas.

Even the pixels with the strongest water ice signature show strong ferric “red edges” in the <1 μm region, indicating that the pixel is covering both icy areas and dusty areas.

Spectral Modeling: Spectral modeling of the fresh ice exposed in these craters is complicated by the lack of knowledge about how much of each pixel is covered by the ice and how much by surrounding dust. Spatial coverage of the ice is estimated from HiRISE observations, and a checkerboard linear unmixing model run for a variety of spatial mixtures (*Figure 4*).

The resulting ice signature is then modeled using a modified Hapke method [4, 5]. The single-scattering albedo is calculated from known optical constants, using Mauna Kea palagonite as an analog for Mars dust. Mauna Kea palagonite has been shown to be a good spectral match for most Mars dusty areas [e.g. 5]

Dust grain sizes are assumed based on MER and Phoenix grain size measurements. Ice grain sizes and relative abundances are allowed to vary. Single-particle phase function is assumed to be isotropic, and the effects of surface roughness are ignored.

Preliminary spectral modeling results indicate a relatively pure water ice, with small amounts of dust mixed in to create the steep red edge at < 1 μm. This purity is consistent with than inferred from sublimation modeling [1, 6]. Additional modeling is required to constrain ice grain size, relative abundances, and ice volume.

High concetrations of ice at the impact-excavated depths are consistent with Phoenix-like light-toned ice [5] occurring in other areas of Mars at similar depths as Phoenix, and with estimates of ice concentration from ice sublimation models [6]. Confirmation of water ice at these geographic locations and latitudes is consistent with a myriad of ice stability models in the current and recent climate [e.g., 7] and GRS observations [e.g., 8]. Formation of such concentrations of subsurface ice remain puzzling for assorted reasons.

References: [1] Byrne et al. (2009) *Science* doi:10.1126/science.1175307. [2] Dundas et al. (2010) AGU abstract P23A-1694. [3] Murchie et al. (2007) J. Geophys. Res. doi:10.1029/2006JE002682. [4] Hapke (1993) Theory of Reflectance and Emittance Spectroscopy, Cambridge UP. [5] Cull et al. (2010) Geophys. Res. Lett. doi:10.1029/2010GL045372. [6] Dundas C. M. and Byrne S. (2010) *Icarus*, 206, 716-728. [7] Mellon, M. and B. Jakosky (1993) J. Geophys. Res., 98, 3345-3364. [8] Feldman, W. C., (2008) Cambridge U. Press, London, 125-148.

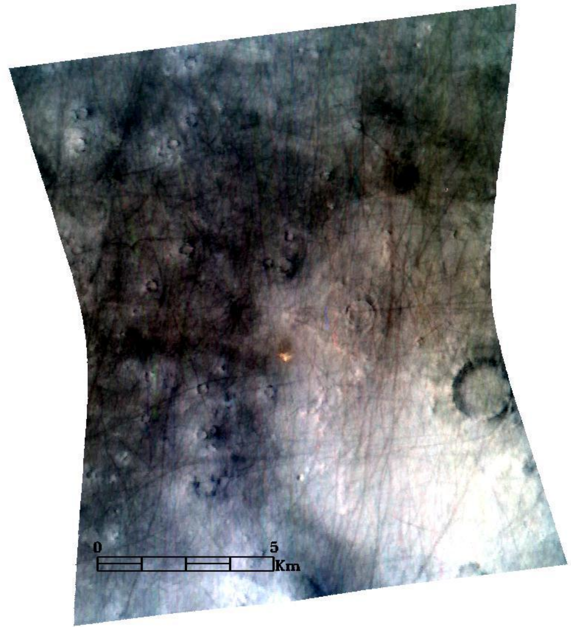

Figure 3 – CRISM FRT0000D2F7 (centered 55.6N, 150.6E). The fresh crater is the dark spot in the center, with a bright reddish ring. A weak water ice signature can be seen in the darkened center portion of the crater. The bright ejecta ring is ice-free.

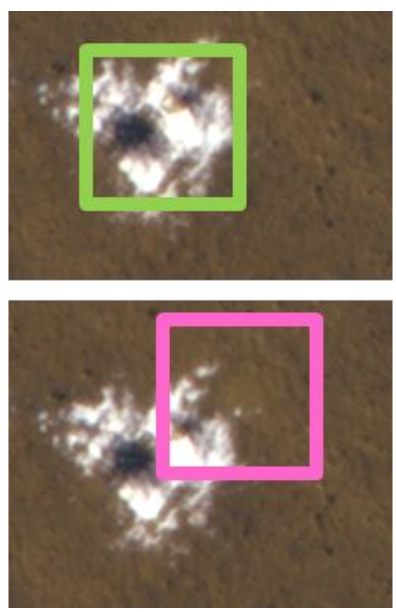

Figure 4 – Possible CRISM pixel orientations relative to the icy ejecta deposits.