Periglacially Reworked Craters within Utopia Planitia and Noachis Terra: Implication for Widespread Ice Interactions and the Climate History of Mars. C. Pan, C. S. Edwards, M. R. Salvatore Dept. of Physics and Astronomy, Northern Arizona Univ., Flagstaff, AZ 86011 (cong.pan@nau.edu)

**Introduction:** The preservation and properties of ground ice and periglacial landscapes on Mars are sensitive abiotic indicators of climate change. Periglacially modified regions of Earth are characterized by patterned surfaces resulting from cyclic seasonal freezing and thawing [e.g. 1]. The distinct morphological patterns of periglacially re-worked landforms on the Martian surface record a range of environmental conditions from both during and after their formation. Impact craters may be ideal targets to study the periglacially re-worked landforms. First, as sinks for ice, the physical properties of impact craters are more likely to be dominated by ice than in the surrounding landscape, where larger deposits are more likely to survive through sublimation potentially. The crater floors with high thermal inertia from our preliminary study indicate relatively consolidated materials, rather than mobile regolith.

Periglacially reworked landforms have been identified on Mars and investigated through high resolution visible images (CTX, MOC and HiRISE) [e.g. 2]. Previous studies of periglacially reworked craters focused on the Utopia Planitia and Argyre regions, Noachis Terra [e.g. 3, 4, 5]. There are latitudinal variations in the occurrence of patterns of surface morphology within northern plains that young craters are located at the higher latitudes and the older craters are at lower-latitude regions [6]. However whether there are distinct mineralogies associated with the periglacially reworked landforms remains unclear. The study constrains the mineralogy and geological setting of periglacially re-worked landforms within impact craters in the Utopia Planitia and Noachis Terra to investigate whether there is distinct compositions and morphologies in northern and southern hemispheres. We will also test the hypothesis that there are hydrated mineral phases at the lowest latitudes where we observe periglacial landforms by investigation of the distribution of mineralogy and their associated morphology.

**Data and Methods:** In this work, we first used High Resolution Imaging Science Experiment (HiRISE) images to identify the periglacially reworked landforms within impact craters in the study area. We used Thermal Emission Imaging System (THEMIS) and Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) images to examine mineral compositions. 220 impact craters were selected for spectral analysis based on the periglacially reworked landforms identified using HiRISE images (Figure 1). In order to determine thermal inertia, we will use a thermal model (KRC) [7] to model temperatures from THEMIS nighttime data. The THEMIS thermal inertia will be derived on a pixel by pixel base with an improved method that will significantly reduce the uncertainties related to albedo, slope, azimuth and elevation by taking the advantage of spatially registered data at the same scale as the THEMIS infrared data [8].

**Results:** Our preliminary results of morphologies using HiRISE of Utopia Planitia and Noachis Terra suggest latitudinal variations of morphologies in both hemispheres (Figure 1). Small scale polygons within impact craters are only found at the high latitudes (~50° S and N and higher) within these regions. With the lower latitude regions (~35°-50° S and N), other periglacially-reworked landforms are most common, such as rubble piles, scalloped depressions and grainy surface.

**Figure 2** is an example of periglacially modified terrain in a crater located in Noachis Terra. There is a dark dune field within the crater floor, and the light-toned materials exhibit rubble pile textures, indicating periglacial reworking (Figure 2.B). There are no significant spectral variations between the THEMIS DCS magenta and yellow colors and the surrounding terrains (Figure 2.C and 2.D). A CRISM targeted image covers the THEMIS DCS magenta and yellow (sand dune) units. The CRISM spectrum of the sand dune materials is consistent with mixture of low and high Ca pyroxene (diopside and enstatite). Within Utopia Planitia, there are polygonal landforms and sulfate mineral in one example crater (Figure 3) The polygonally patterned ground is indicator of periglacial reworking based on the high latitude and previous studies of this region [9] (Figure 3.B). CRISM spectra suggest the crater floor hosts sulfate minerals (Figure 3.C).

**Discussion:** Our preliminary results suggest there may be distinct compositions and morphologies in northern and southern hemispheres. There may be latitude dependent periglacial processes causing the variation of morphology and composition, which are related to the distinct surface alteration processes in the distinct areas.


Figure 1. Periglacially-reworked craters within Utopia Planitia and Noachis Terra. A. Distribution of the 220 identified craters. We conducted detailed spectral analyze of CRISM data to the craters within the area in white rectangle and sulfates were detected in two of the craters. B–E. HiRISE image shows the polygon morphologies of the crater within Utopia Planitia (111.36°E, 50.47°N, ESP_034810_2305), (101.53°E, 53.2°N, ESP_028613_2335) and shows the polygon morphologies of the crater within Noachis Terra (111.36°E, 50.47°N, ESP_012951_1120), (111.36°E, 50.47°N, ESP_016103_1435).

Figure 2. An example of periglacially reworked crater (38.8°E, 45.4°S) within Noachis Terra with mafic mineral. A. CTX image shows the morphologies of the crater. White polygon indicates close up view of floor with periglacially reworked landforms in B. B. Close up view of rubble pile textures (HiRISE ESP_024462_1340). C. THEMIS (I16974002) DCS mosaic of the crater and its surrounding terrain. The mosaic image indicates part of the crater floor and wall are olivine rich (magenta tones) and the surrounding terrain is olivine poor. D. THEMIS spectra of DCS magenta unit and surrounding terrain from the crater, indicating the DCS magenta units may be slight olivine rich, while the surrounding terrain is olivine poor. Spectra of TES Surface Type1 and Type 2 converted to THEMIS spectral resolution and laboratory olivine spectrum are plotted for comparison. E. CRISM spectra of sand dune unit of the crater (gray polygon in C) and comparison with near infrared of Low and high Ca pyroxene (diopside and enstatite) laboratory spectra. All spectra are offset for clarity.

Figure 3. Example of one periglacially reworked craters (95.77°E, 57.0°S) within Utopia Planitia with sulfate mineral. A. CTX image shows the morphologies of the craters. B. Polygonally patterned-ground (HiRISE ESP_17563_2375). C. CRISM (HRL00018499) spectrum of the bright deposits and comparison with near infrared of sulfate spectra from MRO CRISM type spectral library (MICA) [10]. All spectra are offset for clarity.