OBSERVATIONS OF WATER ICE HALOS AND BRIGHT CORES WITHIN DARK DUNE SPOTS: IMPLICATION FOR A SOLID GREEN-HOUSE EFFECT. Jimin Peng1,2,3 (jimin.peng@ustc.edu.cn), Lu Pan1, Alice Luechetti2, Gabriele Cremonese2, 1School of Earth and Space Sciences, University of Science and Technology of China, Hefei, China, 2INAF, Osservatorio Astronomico di Padova, Padova, Italy, 3Department of Physics and Astronomy “G. Galilei”, University of Padova, Padova, Italy

Introduction: Dark Dune Spots (DDS) are common and ephemeral low albedo features observed on frost-covered sand dunes in Martian polar regions. In general, DDS have an ice-free dark central region, a surrounding gray water ice annuli, and an outer bright dry ice halo [1]. Diffuse fan-shaped streaks are emanated from a select group of DDS, suggesting that CO₂ jets are formed under the translucent ice slab during the formation of DDS [2]. DDS are circular on flat territories and elliptical on mild slopes, with dark streaks emanating from the center on steeper slopes, suggesting the role of gravity on their morphogenesis [3]. Dark materials seem to flow within DDS’ streaks [4].

The formation of DDS was explained by different physical processes. As an example, DDS were interpreted as dry materials outflow resulted by CO₂ jets [2]. An interfacial water layer was also proposed to explain the seasonal lengthening flow-like streaks emanating from some DDS [4-6]. Horvath [3] speculated that some kind of biological activity may exist within DDS. Until now, there is a lack of strong observational evidence, especially with regards to the activity of underlying material within DDS, to support or disprove these hypotheses. In this work, we report a set of new morphological characteristics of DDS observed by HiRISE in an unnamed crater located at 71.9 °S, 143.7 °E. These new observations and related analysis may provide clues to the formation of DDS.

Observations: HiRISE data taken from the unnamed crater and Richardson crater, and recently released CRISM MTRDR data obtained from Richardson crater are analyzed to explain the formation mechanism of DDS.

HiRISE observation. The seasonal changes of dark dune spots in the unnamed crater and Richardson crater are established (Fig. 1). DDS show a dichotomous characteristic during their evolution within the unnamed crater: dark central deposits and bright cores are observed within the DDS that do not generate streaks (Column 1 in Fig. 1). The dark central deposits and bright cores are absent within the DDS that emanate dark streaks (Column 2 in Fig. 1). We find that the DDS in both craters have similar seasonal changes by comparing the Column 1 and Column 3 in Fig. 1. However, a larger area of dark central deposits appears in the DDS in the unnamed crater compared with that in the Richardson crater, as shown in a5 and c5 of Fig. 1, and bright cores only exist within the DDS that do

![Figure 1: Seasonal changes of dark dune spots in an unnamed crater (Column 1, 2) and Richardson crater (Column 3). The subset image size is 200m×200m.](image)

not emanate streaks in the unnamed crater (a6 in Fig. 1). Bright halos are formed around the DDS in both
craters (a4, b4, c5 in Fig. 1). Bright cores are exposed when the dark central deposits seem to be removed by winds (Fig. 2b). We also note that the bright cores appear after the disappearance of the bright halos, as shown in Fig. 2b and 2e. Finally, the surface seems to be cleared in the subsequent seasons (Fig. 2c and Fig. 2f).

CRISM observations. CRISM data provides coverage in southern late spring (Ls = 252°) for the observation over the bright halos in Richardson crater, hence the compositions of the bright halos were analyzed in this work. The bright halos exhibit both a stronger 1.43 \mu m and 1.5 \mu m band compared to the outer surrounding plains and inner spot area (Fig. 3b,c). The spectrum taken from the bright halo show broad absorption bands at 1.5 and 1.9 – 2 \mu m, suggesting the halo is mainly composed by water ice, in contrast to the surrounding plains. A sharp absorption feature at 1.43 \mu m and a possible triplet around 2 \mu m buried in the broad water band absorption suggest possibly minor contributions of CO₂, also observed in the spectrum of surrounding area (Fig. 3d).

Discussion: In the HiRISE observations, a large area of dark grains is accumulated within DDS in the unnamed crater during their formation. Bright halos are formed around the dark spots after the sublimation of ices on the surrounding terrain. Subsurface bright materials within DDS that do not emanate dark streaks, are exposed due to the removal of dark grains after the disappearance of bright halos. CRISM data analysis indicate that the main composition of the bright halos is water ice. As the dark dune spot forms, dark grains may be collected from the surrounding terrain, resulting in a colder underlayer where the dark grains are removed, and therefore facilitating the bright water ice halo to be deposited. The combination of HiRISE and CRISM observations point to the fact that the bright core was immediately exposed after the sublimation of bright water ice halos, suggesting that the main component of bright cores could be water ice. Two possible scenarios may explain the formation of the bright water ice cores depending on how the dark grains are collected. Either gas flow under the ice slab may move the dark grains to cover the seasonal ice deposits, or water ice melt may lubricate dark grains to move to the center of DDS. In the second scenario, liquid water accumulate under the dark grains and freeze to form the bright core. Both scenarios require a warmer environment under the seasonal ice slab, implying a solid greenhouse within the regolith and ice slab.

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