DARK ROCK COATINGS OBSERVED AT ZHURONG LANDING SITE. Q. Zhang¹,², J. Carter²,³, M. Vincent², F. Poulet², M. Pineau³, L. Guo¹, D.W. Liu¹, J.-P. Bibring², J.J. Liu¹, C.L. Li¹. ¹Key Laboratory of Lunar and Deep Space Exploration, National Astronomical Observatories, Chinese Academy of Sciences, China (zhangq@nao.cas.cn). ²Institut d’Astrophysique Spatiale, CNRS, Paris-Saclay University, France. ³Laboratoire d’Astrophysique de Marseille, CNRS, Aix-Marseille University, France.

Introduction: The Zhurong rover conducted in-situ spectral investigations of southern Utopia Planitia, where orbital observations revealed the presence of spectrally featureless dust [1]. However, in-situ reflectance spectra collected by the Short Wave Infrared (SWIR) spectrometer on the Zhurong rover exhibit hydrated features for all the surfaces including soils, rocks and dunes [2,3]. SWIR is a point spectrometer with a wide FOV of 36.5 mrad and can acquire spectra in the 850-2400 nm range [4]. The multispectral camera (MSCam) has acquired images ranging from 480 nm to 1000 nm to constrain the mineralogy and crystallinity of iron-bearing minerals [5]. These images reveal that a few rock surfaces show dark blue tones in the false color composites, which are distinct from the nearby red hued materials. These darker materials may represent less dust-coated surfaces, providing a window into the underlying bedrocks. In this study, we use the MSCam multispectral images and SWIR data to characterize the spectral features of these dark-hued patches and to investigate the potential alteration processes at the landing site.

Morphological feature: The dark hued materials are commonly observed on the rock surfaces and these rocks are characterized with ventifacts [6] (Fig. 1a, c). These dark surfaces show smooth and dull patches, and their grain size cannot be resolved from micro-imager (MI) images (~20 µm/pixel, Fig. 1b). The MI images taken after LIBS shooting show some surfaces became darker and smoother (Fig. 1d, red arrows). The LIBS shock wave may clean the superficial dust layer, exposing the underlying dark patches. Besides, the dark patches exposed at the surface can be easily interrupted by the shock wave (Fig. 1d, yellow arrows), which indicate that these patches retain the loosely bound structure, consistent with surface coatings instead of pristine rock surfaces.

Spectral characterization: The surface targets are classified into five types: soil, dark rock surface (also called dark patch), red rock surface, bright dune and dark dune, according to the MSCam false color and morphological variations. Most of the surfaces exhibit red tones in color composites and are characterized with strong slopes from blue to red bands, deep absorptions at 525 nm and are spectrally featureless in the NIR, demonstrating the presence of nanophase ferric oxides [7]. However, dark patches are spectrally different from the other surface materials (Fig. 2a): they exhibit weak absorptions at 525 nm, relatively flat slopes from blue to red bands and negative slopes after 800 nm. Multispectral data suggest that most of surfaces are consistent with the presence of dust whereas the dark patches are compositionally distinct.

Fig 1. (a) and (c) MSCam false color composites (R:650 nm; G:525 nm; B:480 nm) observed on Sol 256 and 79. Blue and red circles indicate the FOV of MI and SWIR, respectively. The enlarged images correspond to the FOV of MI. (b) and (d) MI images before and after LIBS shooting acquired on Sol 256 and 79, respectively. The blue dashed lines outline dark patches. The red arrows indicate the newly exposed dark patches and the yellow arrows show the break dark patches.
The SWIR data can be used to further constrain the surface compositions. It is important to note that the observed SWIR spectra are usually mixtures of different surface types identified with MSCam. Principle Component Analysis (PCA) of the SWIR dataset shows that a few surface targets are spectrally different from others. These surface targets show blue slopes in the NIR and are typically associated with either dust clean regions cleared by the engine plume during landing, or targets where there are more dark patches in the FOV, illustrating that the blue slope feature may be due to the presence of these dark patches. Thanks to the co-observation between MSCam and SWIR, the proportion of each surface type in the FOV of SWIR can be estimated from the co-observational MSCam and then a linear unmixing was performed for SWIR to derive the endmember spectrum of the dark patch. The dark patch endmember spectrum exhibits a strong blue slope without 1900 and 2200 nm hydration absorptions or broad mafic signatures at 1000 and 2000 nm (Fig. 2b).

Discussion: Factors like atmospheric aerosol, photometric effect, deposited dust on the calibration target and surface context may modify the spectral slope. However, we did not find the correlations between slope in the NIR and atmospheric opacity or phase angle or time or surface type variation. Thus, it is reasonable to believe that the blue slope feature is caused by the specific composition of these dark patches.

In-situ MSCam and SWIR observations reveal that the dark patches are characterized with weak absorptions at 525 nm, strong blue slopes from 850 nm to 2400 nm, lack of apparent basaltic signatures and H2O absorption at 1900 nm. This spectral behavior has been previously attributed to the coatings on a dark substrate [8,9]. The penetrating depth of solar light is usually increasing with increasing wavelength, resulting in more absorptions at longer wavelength by the underlying substrate and thus decreasing reflectance with increasing wavelength [9]. Silica coatings exhibit a blue slope but also significant H2O band at 1900 nm and Si-OH vibration band at 2200 nm [10], which could not explain the observed features. If these dark patches are in the form of oxides coatings like ferric and manganese, this could exhibit a blue slope without H2O absorption band. But the ferric oxides should have a deep absorption at 525 nm due to ferric absorptions [11], and the manganese oxides should be characterized with a red slope in MSCam wavelengths [12]. Therefore, ferric and manganese oxides are not consistent with the in-situ spectra. A possible origin can be associated with silica-rich leached rinds on glass with precipitated Fe2+ [13], that exhibit a strong linear blue slope without other features, consistent with the observations. This coatings can be explained by acidic weathering of basaltic glass [14].

The strong blue slope features in the NIR are also broadly observed from the northern low albedo regions [8,9], suggesting that these unique features may be more widespread in the northern plains but obscured by the ubiquitous dust. The presence of small-scaled dark patches at Zhurong landing site is always associated with abraded rocks. Wind erosion can clean some superficial dust and abrade the rock surfaces to reveal the dark patches.