Small Scale Topographical Characterization of Jezero Crater Region, Mars. S. Douté[1], S. Conway[2], M. Massé[2] [1]IPAG, Université Grenoble Alpes, Bât OSUG A CS 40700 38058 Grenoble Cedex 9 France (sylvain.doute@univ-grenoble-alpes.fr), [2]Université de Nantes, Nantes, France.

Introduction: Jezero crater paleolake basin and its associated fluvial sedimentary deposits will be the site of rover exploration in 2020. Detailed studies have been dedicated to the region in order to determine the stratigraphic architecture and mineralogy of the deltas using high-resolution orbital images and near-infrared mineralogic signatures extracted from CRISM hyperspectral images [1-3]. We perform the topographical characterization of the Jezero region at metric to hectometric horizontal scales by generating improved high-resolution digital elevation models (DEMs). In this work we focus on slope statistics that are useful to constrain past and present geological processes and to prepare the future traverse of the rover.

Methods: A new method combining photogrammetry and photoclinometry [4] is used in order to produce high quality, large Digital Elevation Models (DEMs) from panchromatic images of Jezero crater region acquired by the Context Camera (CTX) and the High Resolution Imaging Science Experiment (HiRISE) of the Mars Reconnaissance Orbiter. The method integrates an intensity model of the image based on a novel radiative transfer scheme with a two component slope vector and a realistic bidirectional reflectance distribution function (BRDF) of the surface as its main parameters. Two carefully crafted regularization terms are also introduced ensuring the smoothness of the solution and the consistence with photogrammetric information at large scales. The regularized inversion of the model is based on an efficient numerical optimization scheme and means that the method can generate the height field with details missing or distorted in the DEMs generated by photometry, maps of absolute slope, and of intrinsic albedo. The method ensures a spatial resolution that is comparable to that of the imagery and allows the measurements of heights with a relative precision of 1 m with CTX imagery and down to 15 centimeters with HiRISE imagery. The refined DEMs are validated, then carefully characterized by conducting a multi-scale analysis with the Isotropic Undecimated Wavelet Transform of the DEMs. For that purpose we use the IUWT algorithm proposed by [5] which is adapted to discrete 2D fields. Furthermore the reconstruction of the signal is straightforward and is written as the sum:

$$\boldsymbol{c_J} = \boldsymbol{c_0} + \sum_{j=1}^{J} \boldsymbol{d_j}$$

where c_0 represents the smoothest version of the signal that is considered and d_j the details of the signal at decreasing spatial scales j. The J scales follow a dyadic behavior as the spatial resolution of the j[th] scale is $r_j = 2^{J-j} r_J$, r_J being the initial resolution of the signal (6m for CTX, 1m for HiRISE).

Data and products: Tables 1 and 2 describe the radiometric acquisition conditions of the CTX and HiRISE images as well as the extent of the processing.

Table 1: CTX Image information for Jezero.

	Left image	Right image
Image ID	F04_037396_1985	D15_033216_1989
Sun elevation	34.69°	51.°
Sensor elevation	81.26°	73.68°
Sun azimuth angle	272°	261°
Phase angle	46.58°	22.92°
Used Region	Upper-left, N lat: 18.92°, E lon: 77.13°; Lower-right, N lat: 17.98°, E lon: 77.68°.	

Table 2: HiRISE Image information for Jezero.

	Left image	Right image
Image ID	ESP_045994_1985	ESP_046060_1985
Sun elevation	42.42°	40°
Sensor elevation	86.23°	70.2°
Sun azimuth angle	267°	267°
Phase angle	51.31°	30.1°
Used Region	Upper-left, N lat: 18.55°, E lon: 77.38°; Lower-right, N lat: 18.30°, E lon: 77.50°.	

Fig.1 compares the relief shaded version of a DEM generated from CTX images by photogrammetry (top) with our refined DEM (bottom) for a region of interest (ROI) centered on the western fan deposit of the paleolake. The defects initially present in the DEM are removed while increasing the level of details as shown by the improved sharpness of the lower shaded image.

Figure 1

Fig.2 is a false color composition of a reduced portion of the Jezero region indicative of the roughness of the scene at three consecutive spatial scales (Red: 2m, Green: 8m, Blue: 32m). The composition is superposed with transparency on the HiRISE orthorectified image and draped onto a 3D rendering of the DEM. Reddish colors correspond to ripples affecting sand deposits and dune systems inside big craters or in troughs revealing sedimentary deposits. These areas turn to yellow as the ripple amplitude increases. Green colors indicate dissected portions of the paleolake deposits and eroded portions of the volcanic floors. Bluish colors correspond to the largest topographical features such as crater ramparts and fan deposit fronts. Finally we extract multi-scale slope statistics for different terrain units of the scene as defined by [1]: fluvial fans, volcanic floor, inlet channel bottom, etc. Two examples are provided in Fig. 3 for an eroded sedimentary deposit (large yellowish depressed area in the center of Fig.2) and for an ancient lava flow.

Figure 2

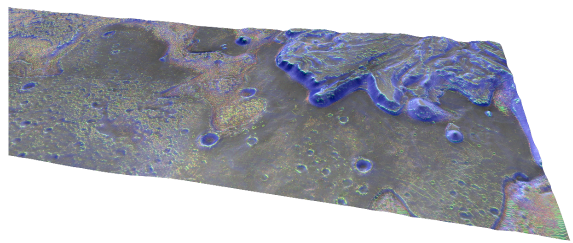
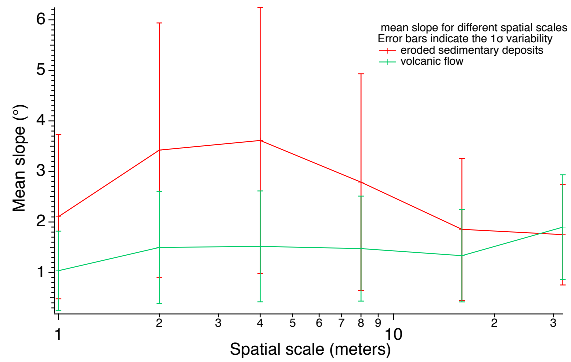


Figure 3



Discussion: The processing of a series of CTX and HiRISE images of Jezero crater paleolake with our new DEM generation method provides an extremely detailed view of the region's geomorphology at different spatial scales allowing quantitative investigations of stratigraphy, paleohydrology, present aeolian processes and slope statistics. In addition, thermophysical characterization and mineral mapping of Jezero will greatly benefit from improved DEMs and maps of intrinsic albedo. Radiative balance calculations and non linear spectral unmixing are based on these products. Finally the dataset for detailed topographical characterization of Jezero will soon be completed with stereo pair acquisitions by the CaSSIS imager of the Trace Gas Orbiter (ESA) providing color images et 4 m.pixel-1 over the entire region.

References:

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