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Digital outcrop model reconstruction and virtual reality integration of the Kimberley outcrop (Gale Crater, Mars) for geological “in situ” analysis

Gwénaël Caravaca, Stéphane Le Mouélic, Nicolas Mangold, Jonas L’Haridon, Laetitia Le Deit, and Marion Massé

UMR 6112 CNRS Laboratoire de Planétologie et Géodynamique Nantes, Nantes, France (gwenael.caravaca@univ-nantes.fr)

Structure-from-Motion (SfM) photogrammetry is an efficient, low-cost and powerful method to reconstruct Digital Outcrop Models (DOM) only from a set of overlapping photos. Apparent displacement of similar points across the set are used to determine the position of these points within a 3D space, and therefore recreate the tri-dimensional geometry (3D mesh) of the photographed objects. This method has recently been explored for remote planetary exploration such as that of the Gale Crater, Mars, thanks to the extensive imagery data from the Mars Science Laboratory (MSL) rover Curiosity.

Here, we reconstructed a DOM of the Kimberley outcrop, traversed by Curiosity between sols 603 and 630, based on a comprehensive set of multi-scale photos gathered by 3 different imaging instruments aboard Curiosity, namely the navigational cameras (NavCam, 530 photos), mast cameras (MastCam, 1443 photos) and the Mars Hand Lens Imager (MAHLI, 32 photos).

Despite the difference in resolution, colorization (greyscale vs full color), coverage and overlap parameters across these three different image data, we were able to compute a highly resolved full color DOM of the Kimberley outcrop using Agisoft PhotoScan software. Moreover, use of PhotoScan’s embedded advanced geospatial features allowed us to obtain a geographically constrained DOM and a direct and proper scaling of the model (validated using the rover’s tracks on the model).

As the Kimberley outcrop presents a sedimentary succession with unusually high potassic content (Le Deit et al., JGR-Planets, 2016), the stratigraphic relations within this series and with its immediate to local surroundings are critical to understand the extent of these potassic accumulations and their signification from a paleoenvironmental point of view. We therefore integrated this high-resolution DOM into a collaborative Virtual Reality (VR) environment. VR lets one or several users observe at real scale the various sedimentary series and structures of the outcrop. This way, precise and accurate description, quantification and mapping of the outcrop is possible, allowing for more precise characterization and interpretation, as well as enabling contextualization within the local geological setting of the various data gathered by Curiosity (e.g. ChemCam Laser-Induced Breakdown Spectrometer and Remote Micro-Imager data).

Collaborative VR exploration and characterization of photogrammetrically reconstructed reliable DOM is paving the way for remote geological exploration of Martian outcrops and other planetary bodies in near future.

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