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Geologic mapping and stratigraphy of remote Martian outcrops using digital outcrop model and virtual reality: example of the Kimberley outcrop (Gale Crater, Mars)

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Reconstruction of highly-resolved Digital Outcrop Model (DOM) using Structure-from-Motion photogrammetry is a low-cost but very effective method to explore and study remote planetary outcrops. Extensive data gathered by Mars Science Laboratory (MSL) rover Curiosity can be used to produce models of specific outcrops visited by the rover in the Gale Crater, on Mars. Integration into a Virtual Reality (VR) environment of these DOM enables one or several users to experience a reliable and realistic depiction of the actual geometries of the geological features, which is usually prevented by classic viewing methods on computer screens. Also, use of a VR environment authorizes the observation at real scale of various sedimentary series, structures and objects present at an outcrop, the same way they would on a real field. Moreover, this practice allows for a very precise and accurate characterization, description and therefore mapping of the features, as well as the contextualization of the sampling and remote analyses underwent by the Curiosity rover within their geological setting (e.g. ChemCam Laser-Induced Breakdown Spectrometer and Remote Micro-Imager data).
Here, we focus on the Kimberley outcrop, traversed by Curiosity in 2014 between martian sols 603 and 630. This section presents a sedimentary succession with unusually high potassic content (Le Deit et al., JGR-Planets, 2016). However, poorly constrained stratigraphic relations between the series of the Kimberley Formation and its local to regional surroundings prevent further understanding of the exact extent of these accumulations and their significance within the broader Gale Crater paleoenvironmental scheme. Such questions highlight the need for a new finer mapping of, first, the outcrop itself to notably achieve precise characterization at the cm-scale of the Mount Remarkable butte; and then of the various structures present in the immediate vicinity of the outcrop. We therefore propose to use a custom true color highly resolved (up to the mm-scale) DOM of the Kimberley outcrop integrated into a VR environment to achieve precise and accurate mapping of the area and of the different geomorphological and sedimentological features (beds, structures and contacts alike). This represents a first step toward a better understanding of the intra- and inter-formational relations of the Kimberley series.
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