A new assessment of the depositional record at Kimberley (Gale crater, Mars) using Virtual Reality
Gwénaël Caravaca, Nicolas Mangold, Stéphane Le Mouélic, Laetitia Le Deit, Marion Massé

To cite this version:
Gwénaël Caravaca, Nicolas Mangold, Stéphane Le Mouélic, Laetitia Le Deit, Marion Massé. A new assessment of the depositional record at Kimberley (Gale crater, Mars) using Virtual Reality. 34th IAS International Meeting of Sedimentology, Sep 2019, Rome, Italy. 10.13140/RG.2.2.14403.35367 . hal-02882315

HAL Id: hal-02882315
https://hal.science/hal-02882315
Submitted on 26 Jun 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
A new assessment of the depositional record at Kimberley (Gale crater, Mars) using Virtual Reality

Gwénaël Caravaca1, Nicolas Mangold1, Stéphanie Le Mouël1, Laetitia Le Deit1, Marion Mass1
1Laboratoire de Planétologie et Géodynamique, UMR 6112 CNRS, Université de Nantes, Université d’Angers, 2 Rue de la Houssinière, 44322 Nantes Cedex 3, France

Introduction:
Reconstruction of highly-resolved Digital Outcrop Models (DOM) using Structure-from-Motion (SfM) photogrammetry from ground-based photos taken by Martian rovers such as Mars Science Laboratory’s Curiosity is a low-cost yet powerful and efficient method to obtain accurate and realistic 3D depictions of remote planetary outcrops. Their integration into a Virtual Reality (VR) environment and the use of purposely-developed tools offers an unique opportunity to assess the poorly constrained stratigraphy of the Kimberley outcrop. This new edge technique allows to observe in 3D and at real scale the lateral variations in the sedimentary record of Kimberley that are usually hardly observable using traditional observation methods.

Context:
The Kimberley outcrop was traversed by Curiosity between sols 603 and 630 [1, 2]. This area presents poorly constrained stratigraphic relations though they are critical to the signification of the local unusually high potassic accumulations [2, 3].

Therefore, the integration of the Kimberley DOM into VR allows: a new and more accurate geological “in situ” analysis of the outcrop, aiming to new understandings of the local to regional paleoenvironments.

Reconstruction of the DOM and integration within a Virtual Reality environment

Using Agisoft Metashape SfM photogrammetry software, a high-resolution DOM of the Kimberley outcrop (covering a surface ~1670 m²) and a micro-DOM of the Windjana drill hole [4] were reconstructed using Curiosity imagery available on the POS [5]. These DOM were then integrated into a Virtual Reality environment, allowing one or several networked users:
- Visualization and exploration of the model at real-scale and without deformation
- Contextualization of the sampling targets (e.g. Windjana drill)
- Accurate characterization, description and mapping of the geological features and stratigraphic relations at Kimberley.

In situ characterization of the Kimberley outcrop sedimentology

The Kimberley formation studied here displays 4 distinct members [1 - 3]: Square Top, Dillinger, Mt. Remarkable and Beagle (from bottom to top). They are composed by siliciclastic rocks ranging from fine sandstones to pebble conglomerates.

Outcropping conditions makes it difficult to characterize whether the intraformational contacts are conformable or not (hence the use of new VR techniques). Our observations however seems to corroborate the idea of a conformable and continuous contact between Dillinger and Mt. Remarkable members.

Further down the section, the conformability of the continuous contact between Square Top and Dillinger members cannot be ascertained. Moreover, the surface of this contact is seemingly presents a dip around 3° southwestward. This contact is also mapped lower on the section than previous observations [3].

We observe a lateral variation of the thickness of the Dillinger member. Between the lower Square Top/Dillinger contact and the reference bed in the upper half of the member (defined as the continuous bed on which the Windjana drill as been made), thicknesses vary between 55 cm at the northern end of Mount Remarkable and ~ 85 cm toward the drill site and southern part of the butte. This southward thickening trend may result from a deposition of the Dillinger onto a slight paleotopography made by the top of the Square Top member and illustrated by the ~3° southwestward dip of the Square Top/Dillinger contact.

We also observe lateral variations in the sedimentary structures of the Dillinger. In the northern part, several sets of well-preserved dm-scale cross-stratifications (plausible trough cross-stratifications, a and b) are present. Towards the South, the size of these cross-stratifications gradually decrease down to a few cm (c and d). Together with this decrease, we can note the apparition around the middle of the butte of dm-scale gullies that could be still active today (dry flow?).

Both the distribution of these structures and the thickening might result from a lateral variation of the local hydrodynamism. This variation may be the consequence of an increase in accommodation space due to the local paleotopography. These results are in agreement with previous interpretations of the Kimberley as a fluvial paleoenvironment, but bring new ideas in favor of a much more dynamic and laterally-evolving pattern.

The DOM also allows to observe much more recent features, such as the presence of dm-scale gullies that may have been formed very recently and could be still active today (dry flow?).

Conclusion:
At Kimberley, use of a reliable photorealistic DOM within a VR environment made possible to observe up-dose previously underrated lateral variations in thickness and in both size and abundance of key sedimentary structures of the Dillinger member, as well as reevaluating the position of the intraformational contacts, or estimating the dip of the latter.

These information bring new insights towards the understanding of the laterally-evolving and dynamic fluvial environment that led to the deposition of these series.

Acknowledgments:
This work is part of a project that has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement 876276 (PLANMAP)

References:

MT. REMARKABLE

PLANMAP

Laboratoire de Planétologie et Géodynamique, UMR 6112 CNRS, Université de Nantes, Université d’Angers, 2 Rue de la Houssinière, 44322 Nantes Cedex 3, France