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CaSSIS colour imaging of late lava flows and hydrothermal alteration in Ladon Basin, Mars

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Abstract

The CaSSIS colour stereo camera of ExoMars/TGO views the surface of Mars with 4 filters in the range 0.4-1.2 µm and pixel size 4.6 m. Its colour capabilities for geological interpretations are explored in the Ladon impact basin, where it reveals a surprising diversity of terrains, that CRISM, CTX, and HiRISE data help interpret further. Most likely, the surface is capped by a rather fresh thin mafic or ultramafic flow, dated middle Amazonian, underlain by a serpentinised flow of similar composition. These results indicate that a long time after formation, the Ladon basin had undergoing volcanic and hydrothermal activity, and reveals the exceptional potential of CaSSIS for geologic mapping.

1. Introduction

Large volumes of sediments were deposited in the Ladon basin during late Noachian to early Hesperian [1], transported from the surrounding Noachian terrain. Some NNW-trending fractures and grabens can be traced in places up to the Valles Marineris main chasmata and with the same direction ([2] and Figure 1b). One of the first CaSSIS images captured an area in Ladon showing such a feature (Figure 1a). This site was targeted so as to test the spectral capabilities of the 4 filters of CaSSIS, in the blue-green (BLU), a broad red (PAN), and two near-infrared (RED, NIR) [3], and to benefit from existing CRISM, CTX, and HiRISE data covering the area. This CaSSIS image was acquired as an non-stereo individual acquisition, but a CTX digital elevation model (DTM) is available.

2. Terrain units revealed by CaSSIS

The CaSSIS image (Figure 1b) shows 4 main colour units outside the walls of the fracture. The fracture floor itself is covered by dunes. Unit 1 is a dark blue-violet, smooth capping unit restricted to the fracture surroundings, a feature also observed in the basin. Its front is lobate, consistent with a flow origin, whether lava or mud [4]. Unit 2, a lighter-toned, rougher unit, underlies Unit 1. Its eroded surface reveals widespread yellowish and whitish patches (Units 3 and 4). Units 3 and 4 are also observed in cross section along the fracture walls. The yellowish unit displays linear positive topographic highs, which from the HiRISE image are interpreted as dykes. Similar features are also observed on an adjacent HiRISE image, where they are highlighted as dune sand traps.

3. Age and Composition

Composition is determined using combined VNIR and IR CRISM spectra, by absorption analysis of individual spectra and representative regions of interest, spectral indexes, and spectral unmixing using multiple endmember spectral mixture analysis [5]. Age is determined by crater counting [6]. Unit 1 is spectrally close to Mg-olivine, with absorptions suggesting pyroxenes of pigeonite-augite, and is dated middle Amazonian, 1.9±0.5 to 1.6±0.2 Ga. Unit 2, dated 2.2±0.3 Ga, is spectrally similar to Unit 1. Unit 3 has the diagnostic absorption features of serpentine [7] in the range 1.0-2.6 µm. Olivine associated with a small amount of chromite (5%, [8]) well matches spectra in the range 0.4-1.4 µm. Clinochlore and minerals of hydrothermal origin have also been identified. The mineralogy of Unit

4 is weakly defined but might include illite-muscovite or copiapite. As expected, its age is similar to the age of Unit 2, 2.5±0.3 Ga. In addition, the HiRISE image suggests the presence of rare chloride deposits, from comparison with documented chloride deposits on Mars.

4. Stratigraphy and structure

A CTX DTM was generated by photogrammetry, and improved by photoclinometry [9] to a vertical precision of ~1 m. It reveals that the thickness of units 1 and 2 is 10-20 m. Unit 3 and Unit 4 have highly variable thickness and do not follow stratigraphy, confirming that they are alteration levels (Figure 1c).

3. Synthesis

Mafic or ultramafic volcanic activity has occurred in the Ladon Basin during Early to mid-Amazonian, and appears to be associated with a fracture line that can be traced in places up to Valles Marineris, where other evidence of Amazonian volcanism was found [10]. Alteration of the upper flows reveals a fissure system through which hydrothermal activity serpentinised the lava pile. The groundwater table documented until the mid-Hesperian [1] may have persisted during the Amazonian and triggered this activity while lava outpouring occurred.

Acknowledgements

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Data used

CaSSIS: CAS-M01-2018-05-06T12.52.27.314 with filters BLU, PAN, RED and NIR
CRISM: FRT000128EA_J_TRR3
CTX: B09_013045_1614, F20_043532_1613
HiRISE: ESP_013045_1615, ESP_043532_1615

References

[1] Grant, J.A., and Parker T.J.: Journal of Geophysical Research-Planets, 107(E9), 5066, 2002. [2] Skinner, J.A., Jr, et al.: LPSC XXXVII, abstract #2331, 2006. [3] Thomas, N. et al.: Space Sci. Rev., doi:10.1007/s11214-017-0421-1, 2017. [4] Brož, P. et al.: 50th LPSC, Abstract #1511, 2019. [5] Dennison, P.E. and Roberts, D.A.: Remote Sensing Environ., 87, 123–135, 2003. [6] Kneissl, T.A. et al.: Planet. Space Sci., 59, 1243–1254, 2011. [7] Ehlmann, B.L., et al.: J. Geophys Res., 114, E00D08, 2009. [8] Cloutis, E.A., Sunshine, J.M., and Morris, R.V., Meteor. Planet. Sci., 39, 545–565, 2004. [9] Jiang, C., et al., ISPRS 2017, 130, 418–430, 2017. [10] Brož, P., et al., Earth Planet. Sci. Lett., 473, 122–130, 2017.

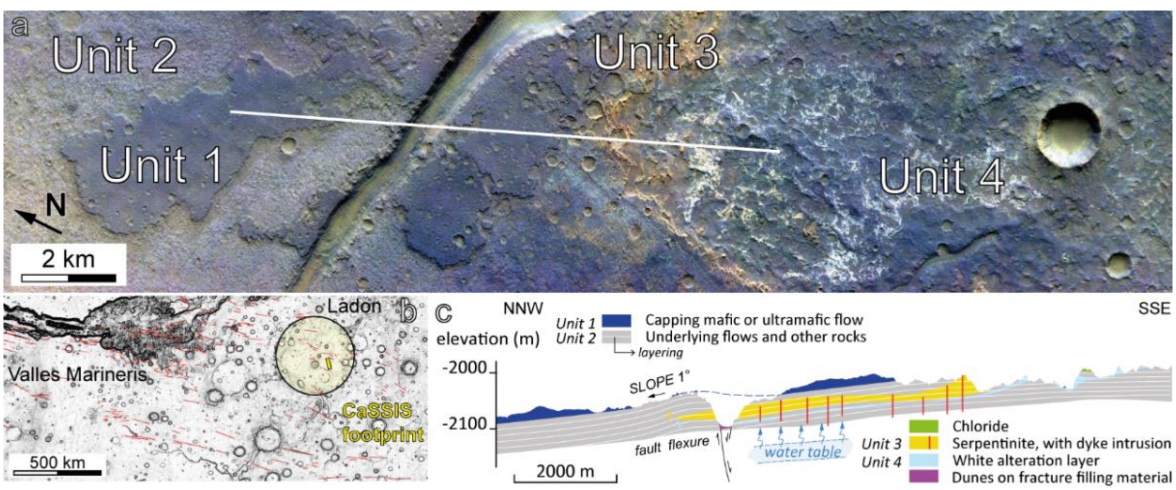

Figure 1: (a) Colour composite of the CaSSIS image (filters BLU-PAN-NIR, 6 x 25.6 km); (b) Regional WNW-trending fracturing (background MOLA slope map); (c) Geologic interpretation.