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

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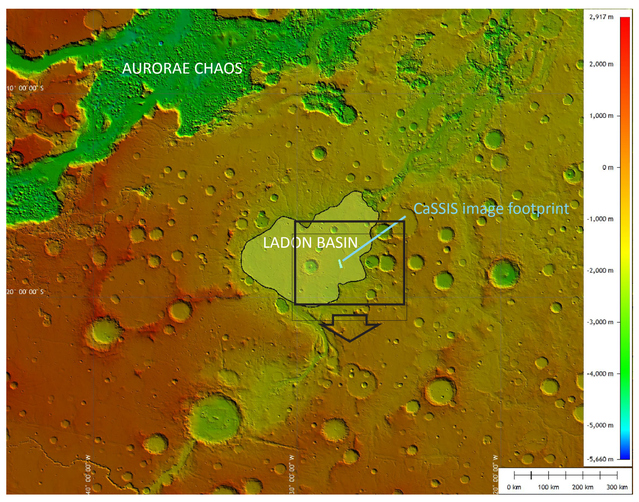
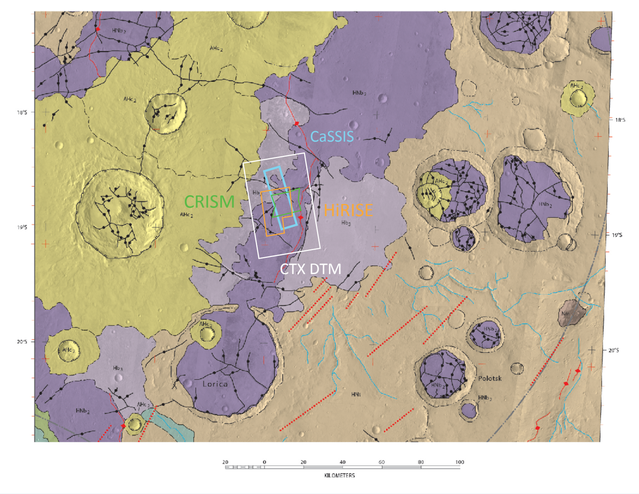
A Geologic context

Large volumes of sediments were deposited in the Ladon basin during late Noachian and Hesperian [2], transported from the surrounding Noachian terrains through a vast and multiphase drainage system. Groundwater flow is thought to play an important role in the evolution of the region, in connection with the formation of the several nearby chaos. The basin undergone later widespread extensional fracturing and more sparsely, contractional deformation [3]. Some of the fractures are radial or concentric about filled craters, others are consistently NNW-dipping.



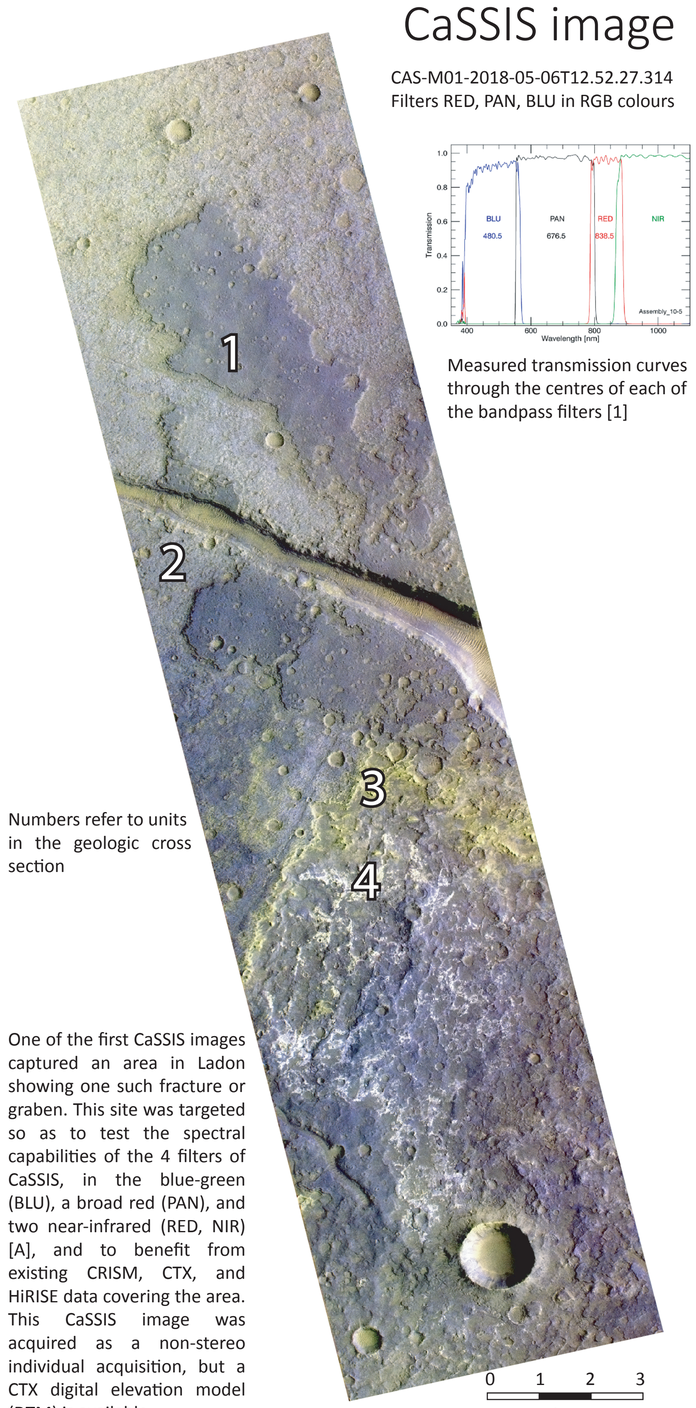
MOLA context of the Ladon basin and the studied CaSSIS image.



After [3]. Units HNb2 and Hb3 are interpreted as sedimentary basin fill units of age Late Noachian-Late Hesperian, HNt are smooth to rolling, cratered, and variably dissected surfaces between degraded impact craters (AHc2).

CaSSIS image

CAS-M01-2018-05-06T12.52.27.314
Filters RED, PAN, BLU in RGB colours



Numbers refer to units in the geologic cross section

Measured transmission curves through the centres of each of the bandpass filters [1]

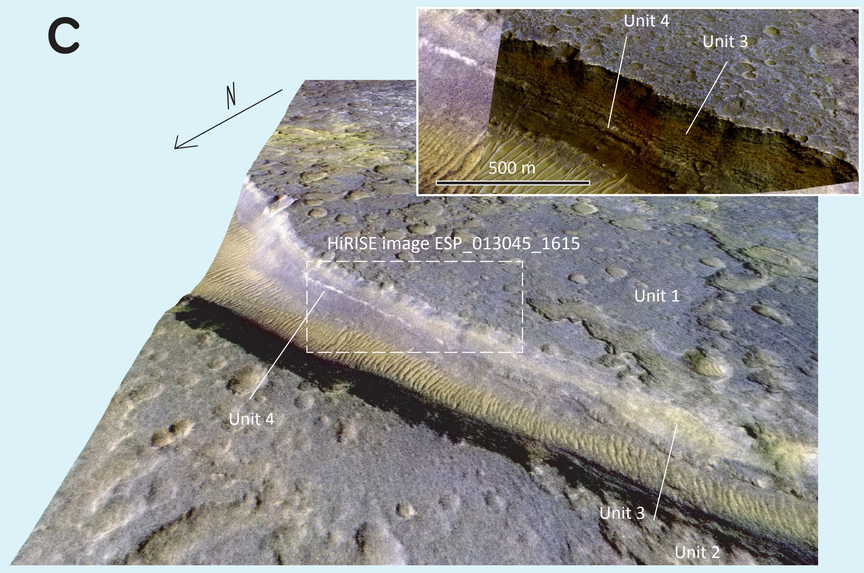
One of the first CaSSIS images captured an area in Ladon showing one such fracture or graben. This site was targeted so as to test the spectral capabilities of the 4 filters of CaSSIS, in the blue-green (BLU), a broad red (PAN), and two near-infrared (RED, NIR) [A], and to benefit from existing CRISM, CTX, and HiRISE data covering the area. This CaSSIS image was acquired as a non-stereo individual acquisition, but a CTX digital elevation model (DTM) is available.

Summary

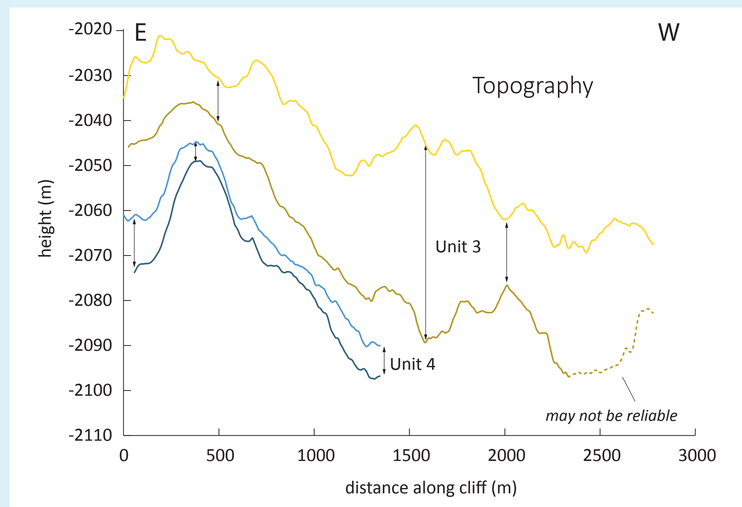
The CaSSIS colour stereo camera of ExoMars/TGO views the surface of Mars with 4 filters in the range 0.4-1.2 µm and pixel size 4.6 m. Its colour capabilities for geological interpretations are explored in the Ladon impact basin, where it reveals unexpected geology, that CRISM, CTX, and HiRISE data help interpret further. Most likely, the surface is capped by a thin mafic or ultramafic flow, dated early or middle Amazonian, underlain by a serpentinised flow. 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.

Evidence of intraformational alteration

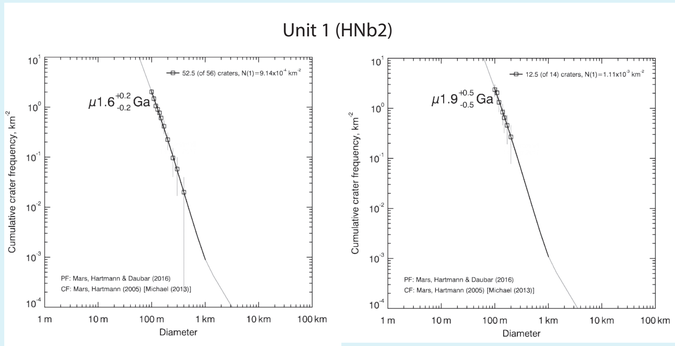
C



CaSSIS image draped over CTX DTM generated by fusion of photogrammetric and photoclinometric information [6], of vertical resolution 1 m.



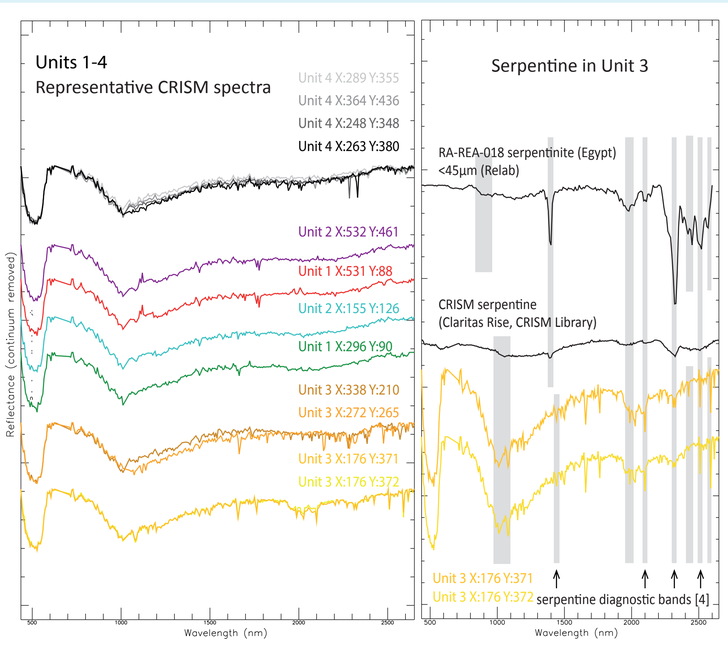
B New ages



New dating of the local units indicates that lava outpouring occurred later than expected (see A), during early or middle Amazonian.

Unit 1 is spectrally close to Mg-olivine (forsterite), with absorptions also suggesting the presence of pyroxenes of pigeonite-augite composition. Unit 2 is spectrally similar to Unit 1. Unit 3 has the diagnostic absorption features of serpentine [4] in the range 1.0-2.6 µm. Olivine associated with a small amount of chromite (5%, [5]) 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. In addition, a HiRISE image suggests the presence of rare chloride deposits, from comparison with documented chloride deposits on Mars.

D Rock composition



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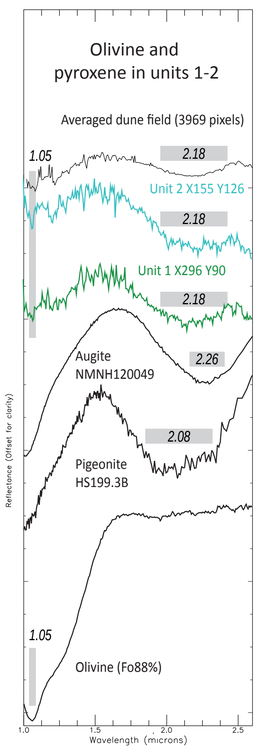


Conclusion

We illustrate the usefulness of CaSSIS imagery to unify earlier datasets in a coherent geological framework.

1. The layers studied here have been interpreted as sedimentary deposits, such as aqueous sediments, evaporites, or duricrust [3].

2. The CaSSIS image allows to follow the light-toned layers for a longer distance than on HiRISE imagery, making possible new interpretation.

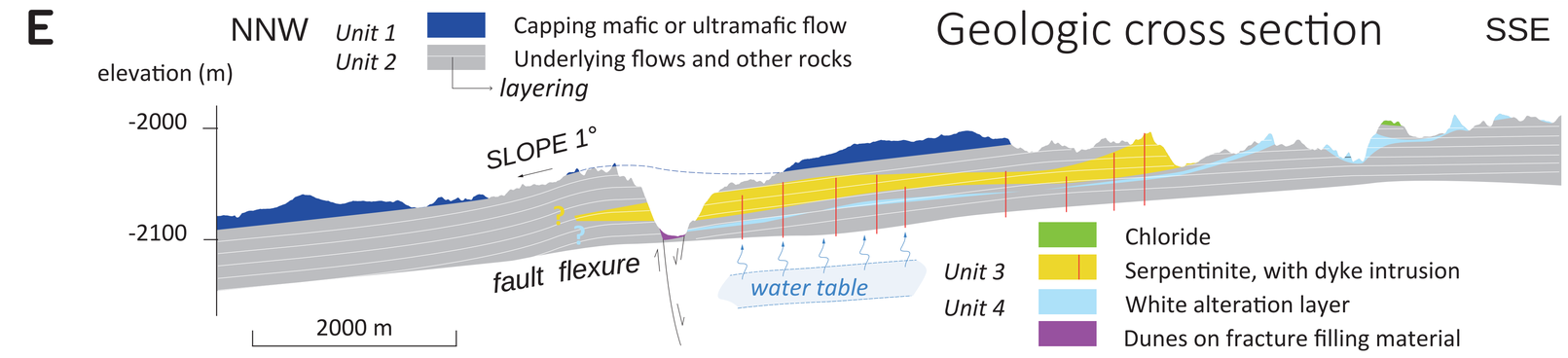
3. High-resolution DTM shows that these layers have variable thicknesses over very short distances, suggesting that they are alteration layers.

4. CRISM cube analysis suggests that the yellow layer probably includes serpentine.

5. Furthermore, CRISM data also indicates that the rocks exposed at the surface are of either mafic or ultramafic composition.

6. It follows that the simplest scenario for explaining the geology of this area is serpentinite alteration of ultramafic lava outpourings during Amazonian. The groundwater table documented until the mid-Hesperian [2] may have persisted during the Amazonian and be involved in these processes.

E Geologic cross section



References

[1] Thomas, N., et al., 2017, Space Sci. Rev. 10.1007/s11214-017-0421-1
[2] Grant, J.A., and Parker T.J., 2002, J. Geophys Res. 107(E9), 5066
[3] Irwin, R.P., III., and Grant, J.A., 2013, USGS Scientific Investigation Map 3209
[4] Ehlmann, B.L., et al., 2009, J. Geophys Res. 114, E00D08
[5] Cloutis, E.A., Sunshine, J.M., and Morris, R.V., 2004, Meteor. Planet. Sci. 39, 545–565
[6] Jiang et al., 2017, ISPRS 2017, 130, 418–430

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