

Exploring the Limits of Material Discrimination with ExoMars TGO CaSSIS Multiband Imaging

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Introduction

Visible-to-near-infrared imaging is an efficient way to explore a planet, but the material diversity of a scene is not always expressed in the standard browse products of a multiband imager.

We are developing a new method, *Supervised Spectral Parameter Learning* (SSPL), that seeks optimal ways of stretching and combining multispectral bands to enhance contrast between pre-selected material groups [1, 2].

Here we report on empirical developments of the method through application to the *Jezero Crater* region, the landing sight of the Mars 2020 *Perseverance* rover, as explored pre-landing by *Horgan et al* [3] (fig. 1).

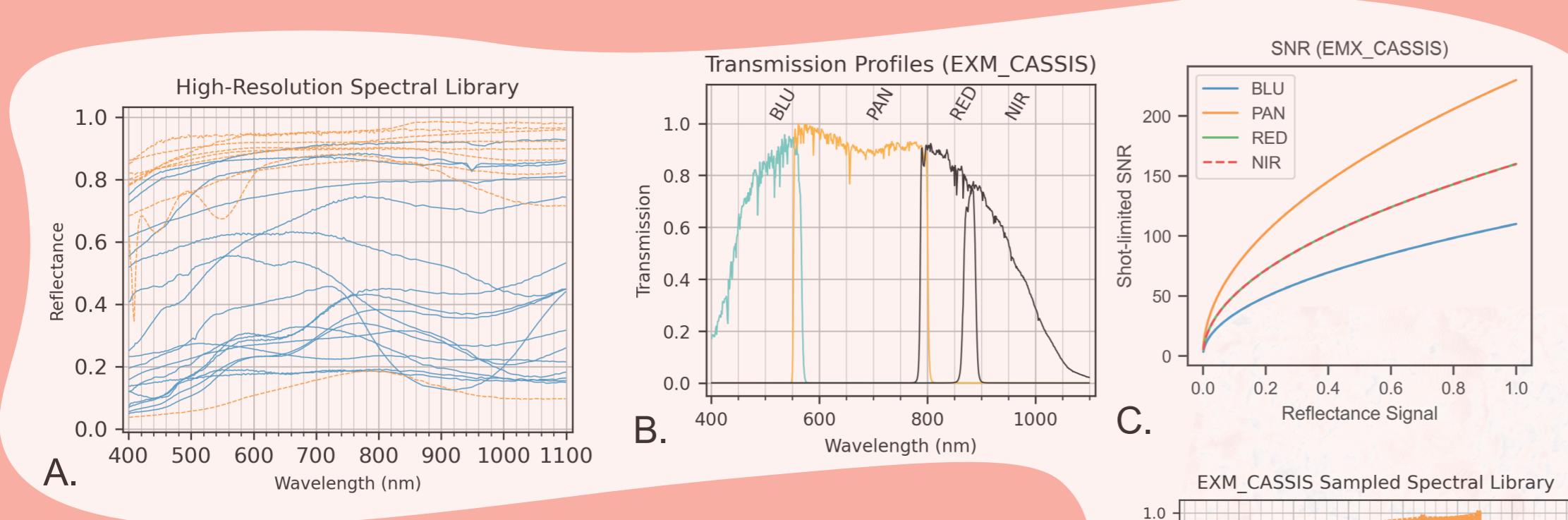


Figure 2. Sampling of (A) high-resolution spectral library identified by *Horgan et al* [3] with the (B) spectral profiles and (C) shot-limited noise of CaSSIS [4]. (D) We perform 200 repeat samples of each entry with added shot-noise according to (C), and (E) compute all permutations of ratio, slope, band-depth and shoulder height spectral parameters on (E).

Supervised Spectral Parameter Learning (SSPL)

We use the publicly available end-member profiles of the composition identified by [3] to investigate how the associated spectral diversity is sampled by the 4 spectral channels of the ESA Trace gas Orbiter CaSSIS imager (fig. 2) [4].

We fitted Linear Discriminants that optimally (by Fisher Ratio) separate carbonates against phyllosilicates and mafic silicates for all paired combinations of spectral parameters (465), and measured classification accuracy over 500 repeat trials with 80/20 train/test splitting, to rank all spectral parameter combinations (SPCs).

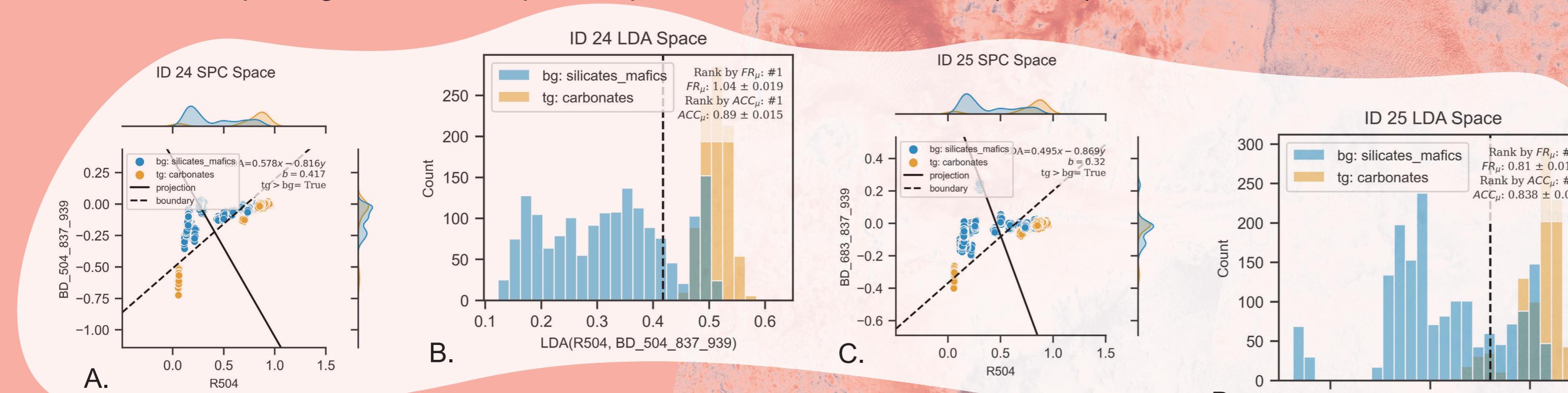


Figure 4. CASSIS-resampled mineral endmembers in paired spectral parameter scatterplots (A, C) and projected onto linear discriminants (B, C), for two top-ranking SPCs, of 465 combinations.

Application to CaSSIS I/F Products

We applied the top ranking SPCs to the I/F calibrated MY37 027246 019 CaSSIS observation (fig.1, fig. 3). Carbonates are not distinctive in the 400 - 1100 nm range, so we expect limited performance for this trial study. We find that combining the BLU (~500 nm) channel with the RED (~840 nm) Band Depth can achieve sorting, but with a maximum of ~90% accuracy (fig. 4).

We find that changing the shortwave limb of the RED Band Depth significantly changes the LDA product contrast (fig. 5), with the right LDA product identifying a distinct signal, otherwise subtle in the NPB CaSSIS product (fig.3).

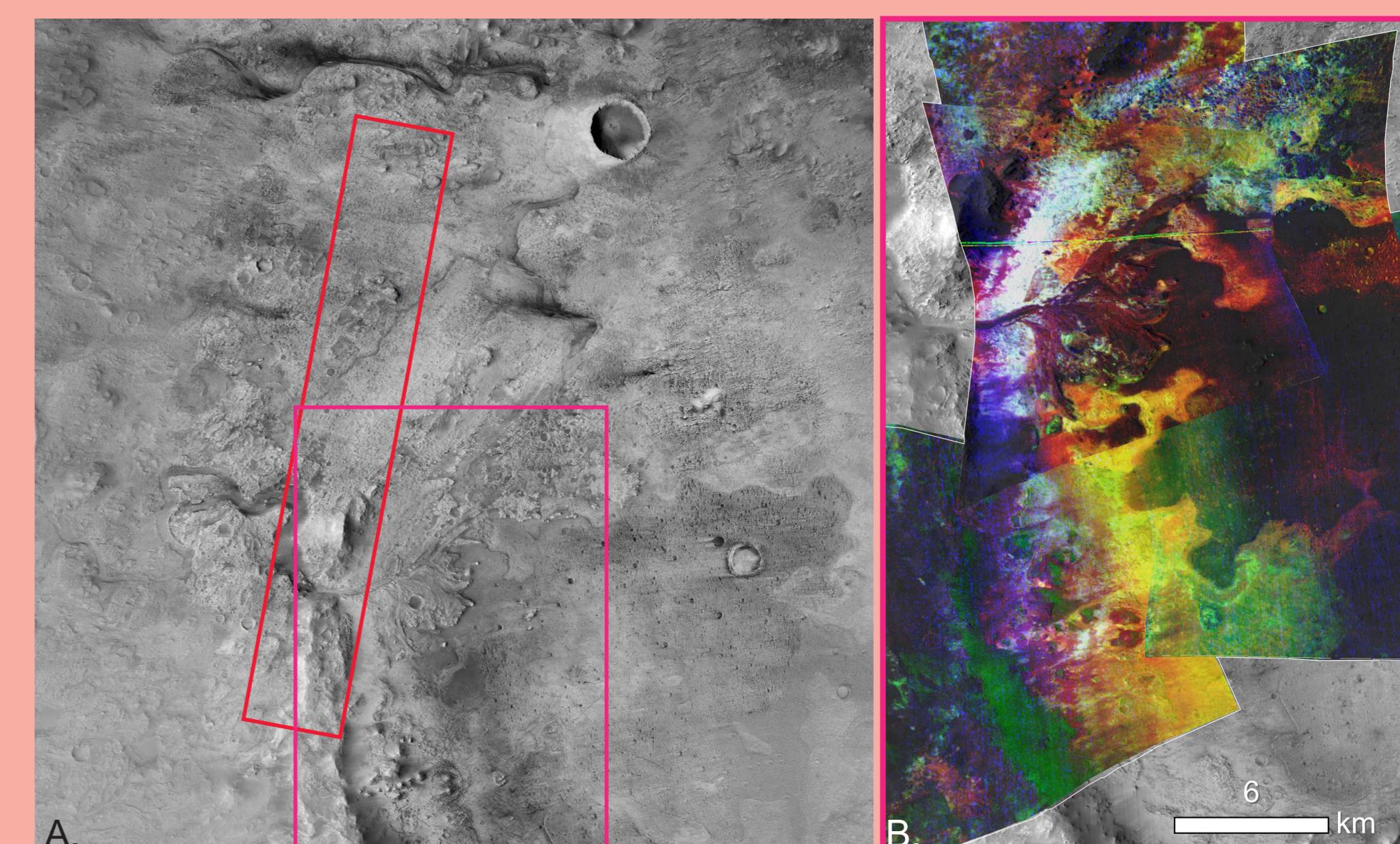


Figure 1. (A) The Jezero Crater study area context showing the CaSSIS MY37_027246_019 footprint, and the footprint and (B) Short-Wave Infrared spectral diversity of Jezero Crater, revealed by MRO CRISM spectral summary products, as studied by *Horgan et al.* [3, Fig. 3].

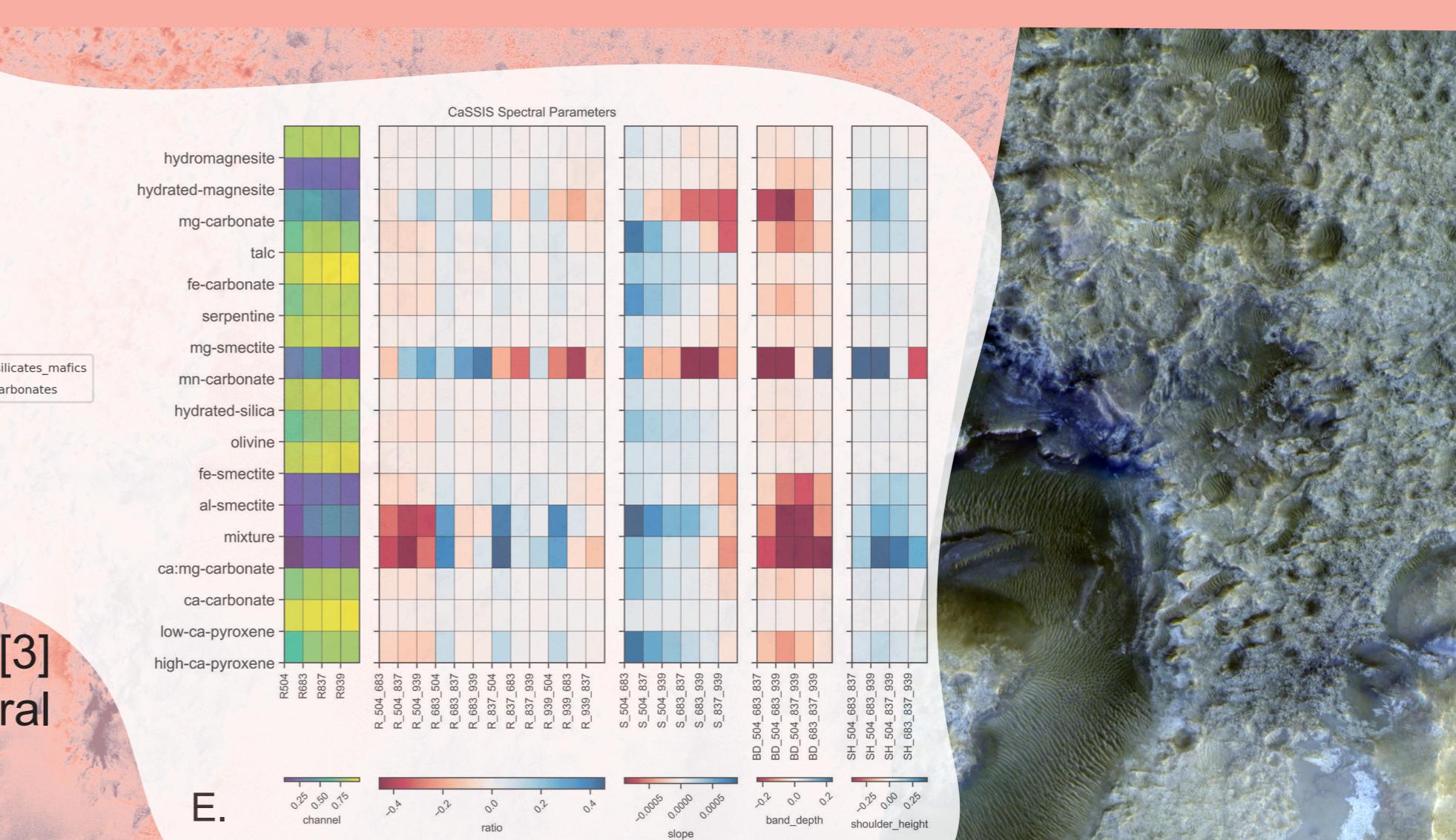


Figure 3. CaSSIS NPB (NIR, RED, BLU) browse product, MY37_027246_019.

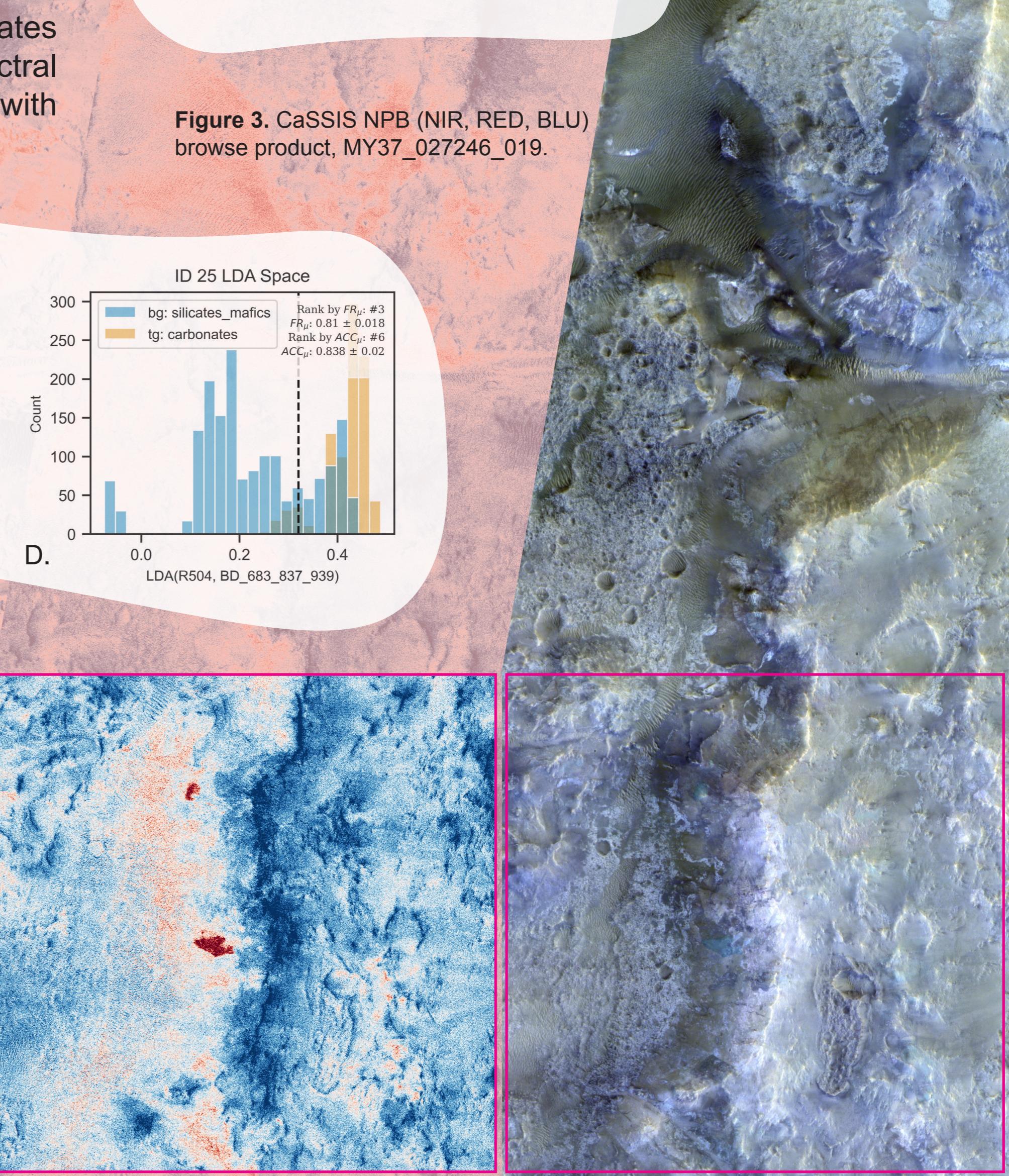


Figure 5. Scene contrast revealed by the two different spectral parameter combinations of figure 4, showing the significant change in scene contrast from substitution of the shortwave limb of the Band Depth spectral parameter, from BLU (~500 nm, left) to PAN (~680 nm, centre), compared to the standard NIR/PAN/BLU CaSSIS false-colour browse product (right).

