Supplementary Material

Ceres—No further organic-rich sites: Implications for its evolution

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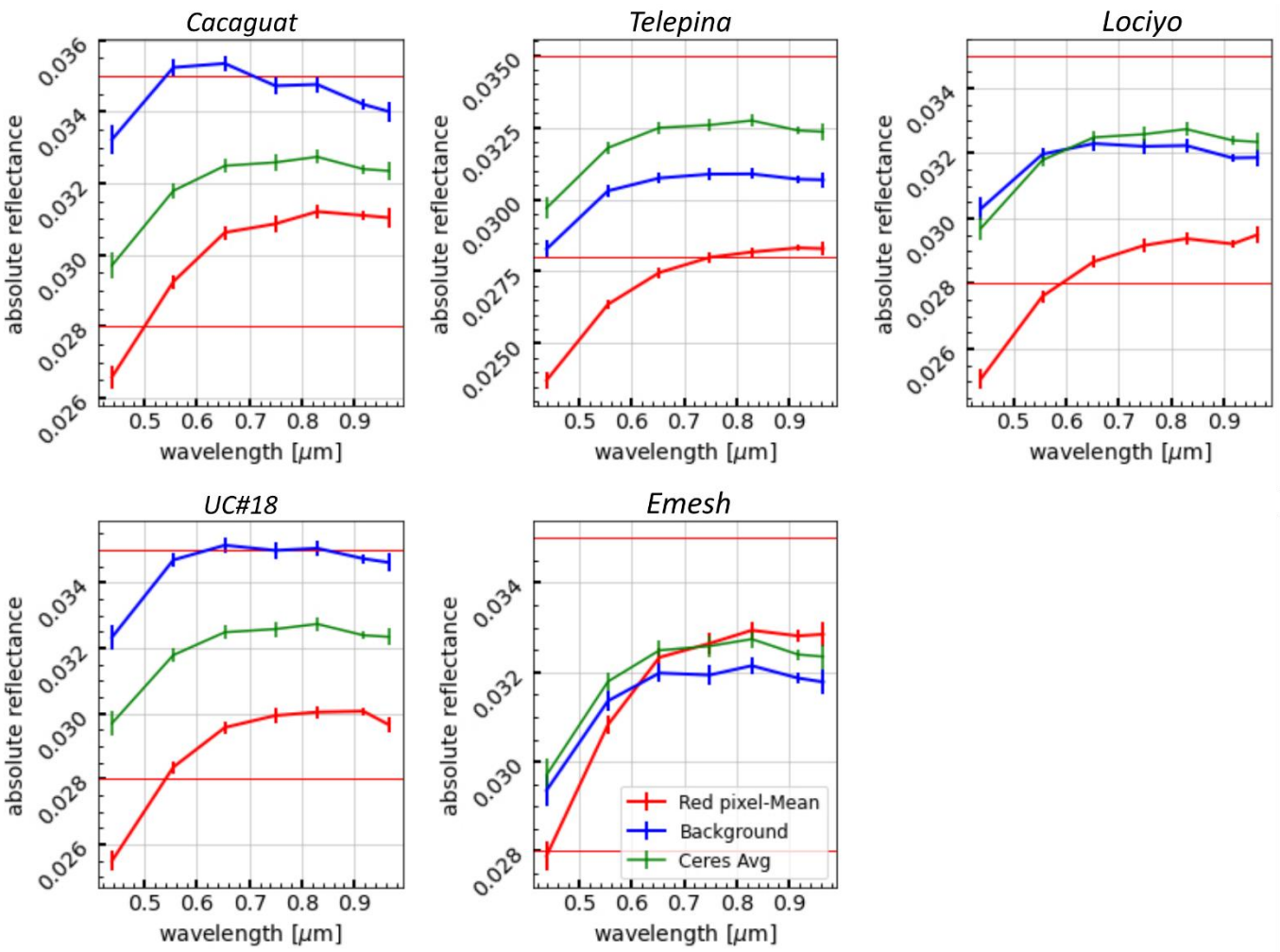
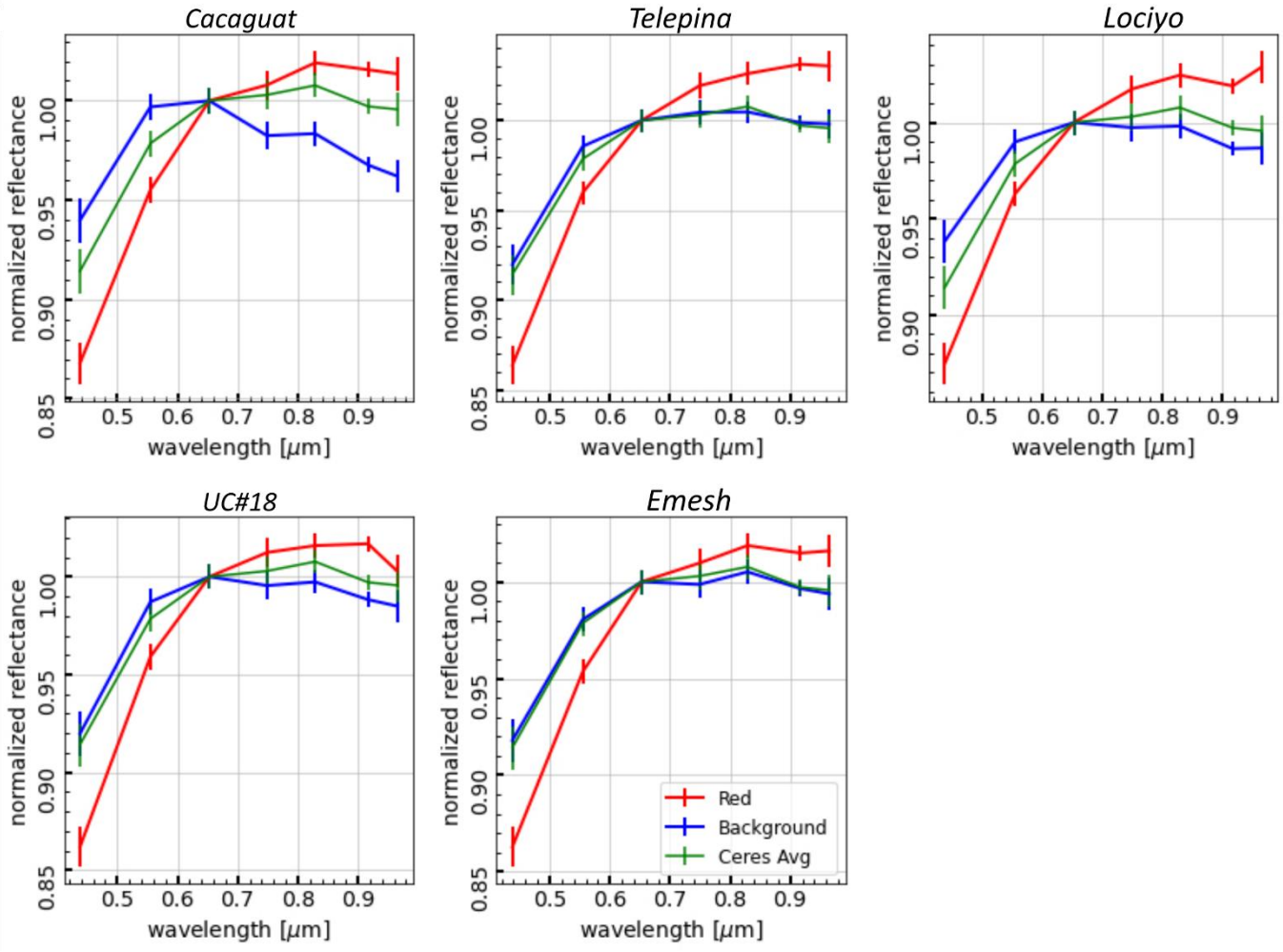
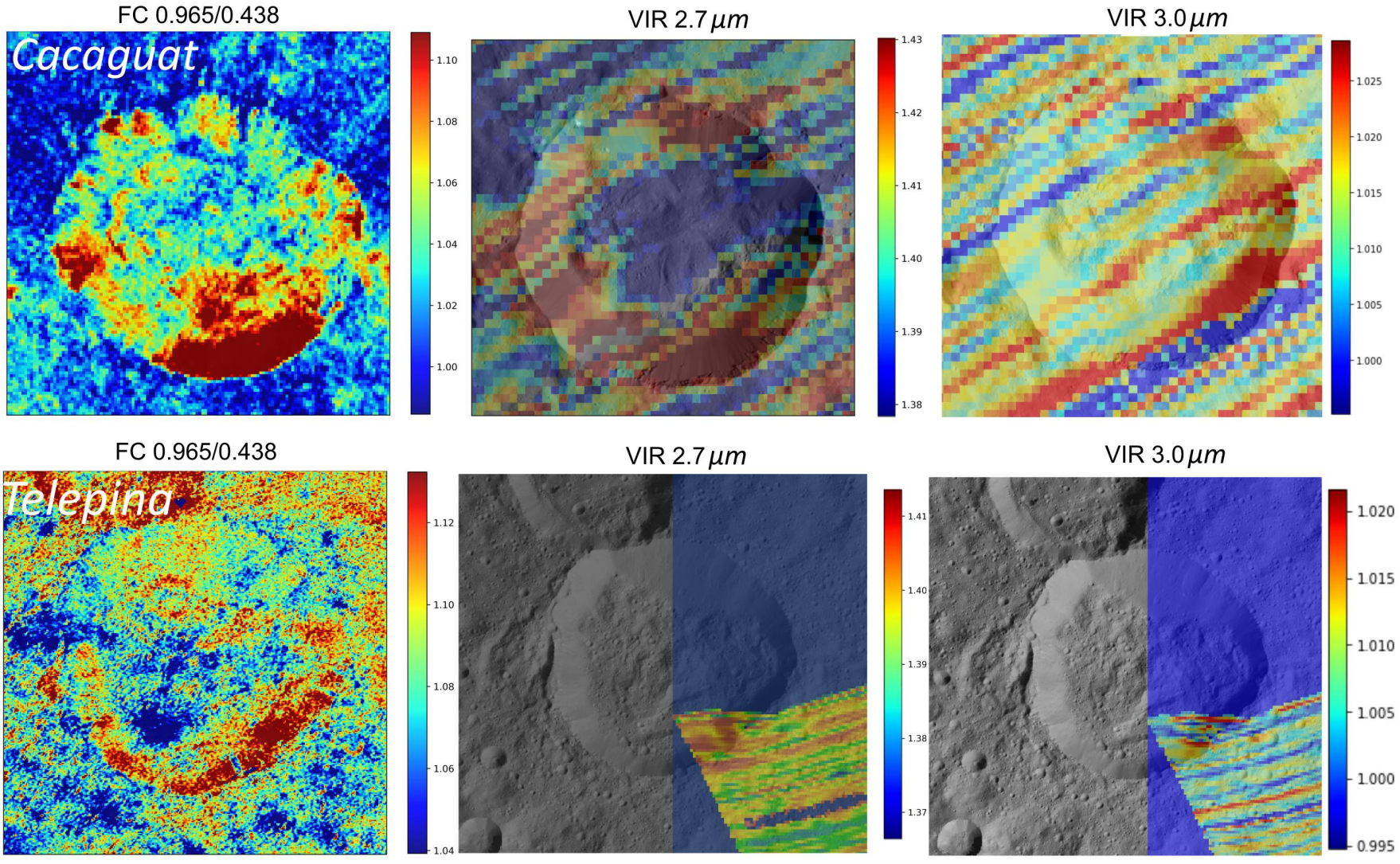


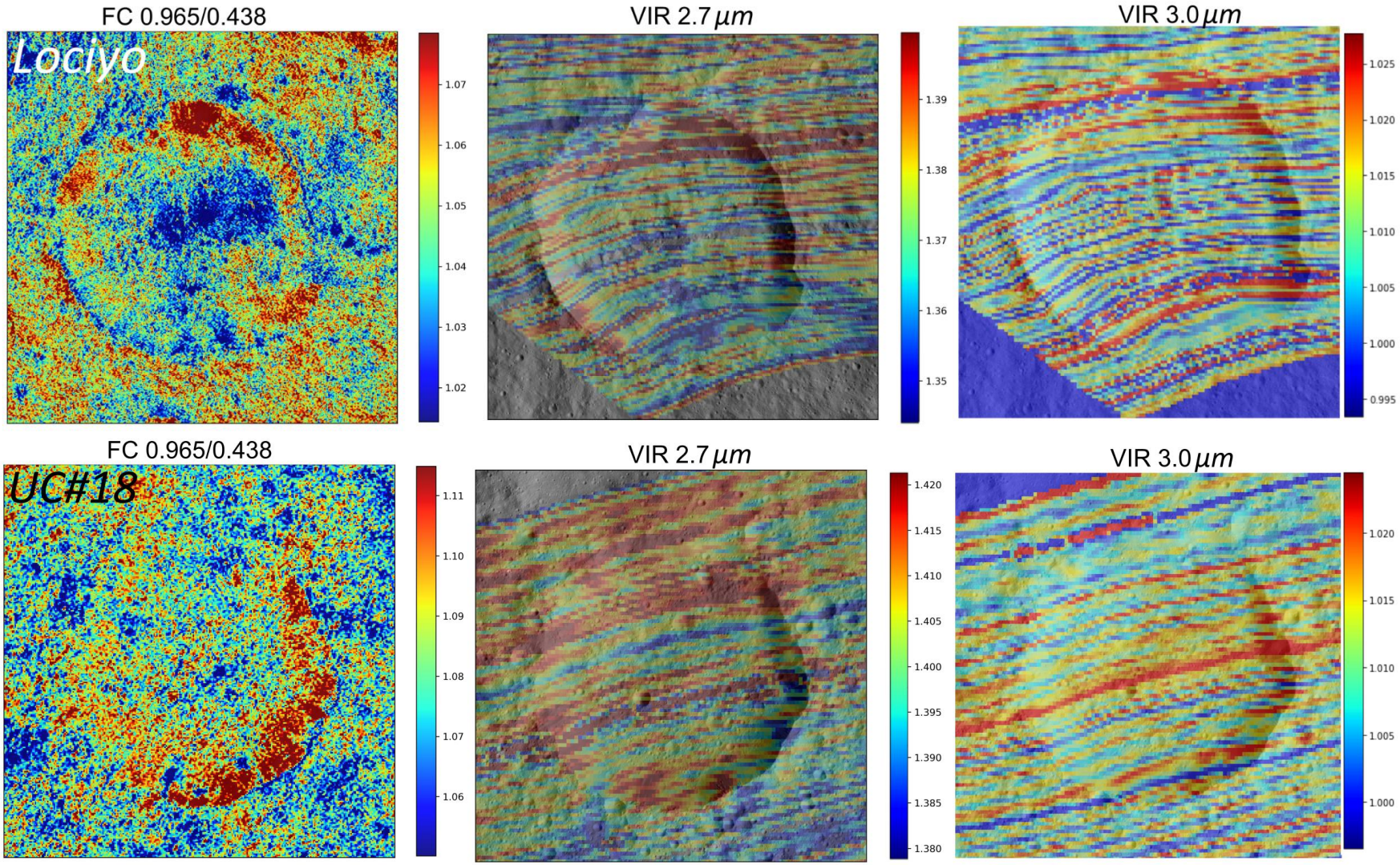
Supplementary Figure 1. Absolute spectra of craters showing Juling-type redness. *The corresponding crater names are provided at the top of each plot. The two horizontal lines indicate the boundaries between bright, intermediate, and dark materials on Ceres according to Thangjam et al. 2018, with the upper one at 0.035 (for bright materials) and the lower one at 0.028 (for dark materials), in between are the intermediate brightness values. The Cerean average spectrum, derived from the HAMO global mosaic, is provided for reference. The 'Red pixel-Mean' spectrum is derived as the mean of the red-pixels identified by the NN; the 'Background' spectrum is the mean of a surrounding area with a smooth surface and lying on a flat topography but devoid of any identified red-pixels. Vertical lines are filter-specific error bars explained in the Methods.*



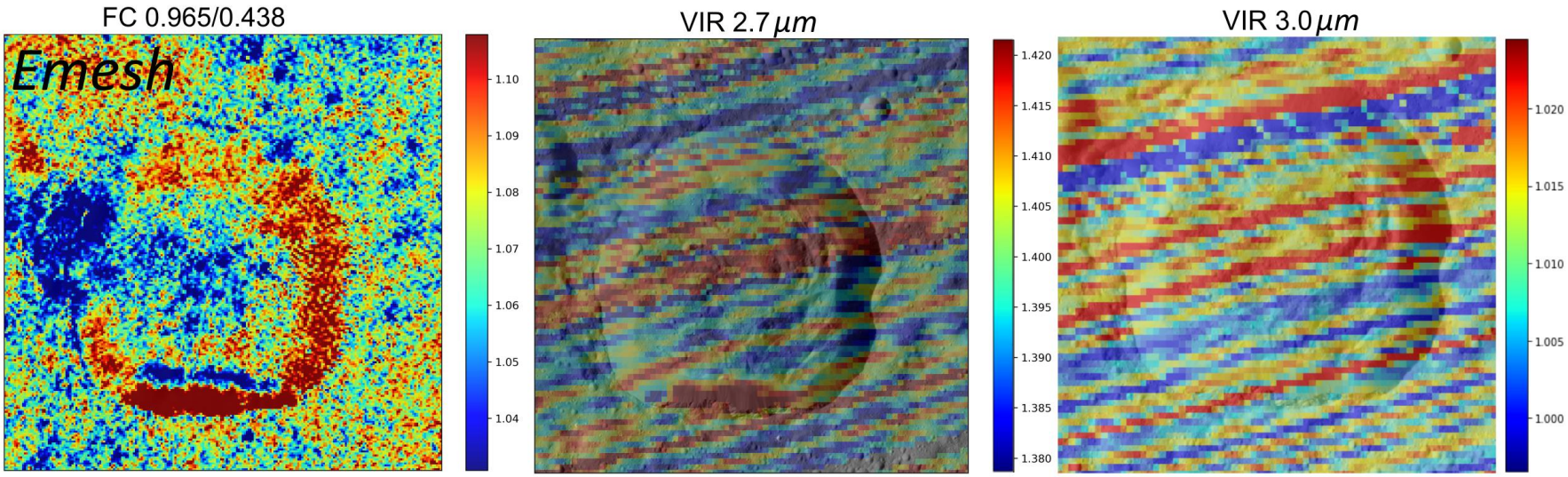
Supplementary Figure 2. Normalized reflectance spectra of the craters showing Juling-type redness. *The corresponding crater names are provided at the top of each plot. The Cerean average spectrum, derived from the HAMO global mosaic, is provided for reference. The 'Red pixel-Mean' spectrum is derived as the mean of the red-pixels identified by the NN; the 'Background' spectrum is the mean of a surrounding area with a smooth surface and lying on a flat topography but devoid of any identified red-pixels. Vertical lines are filter-specific error bars explained in the Methods.*



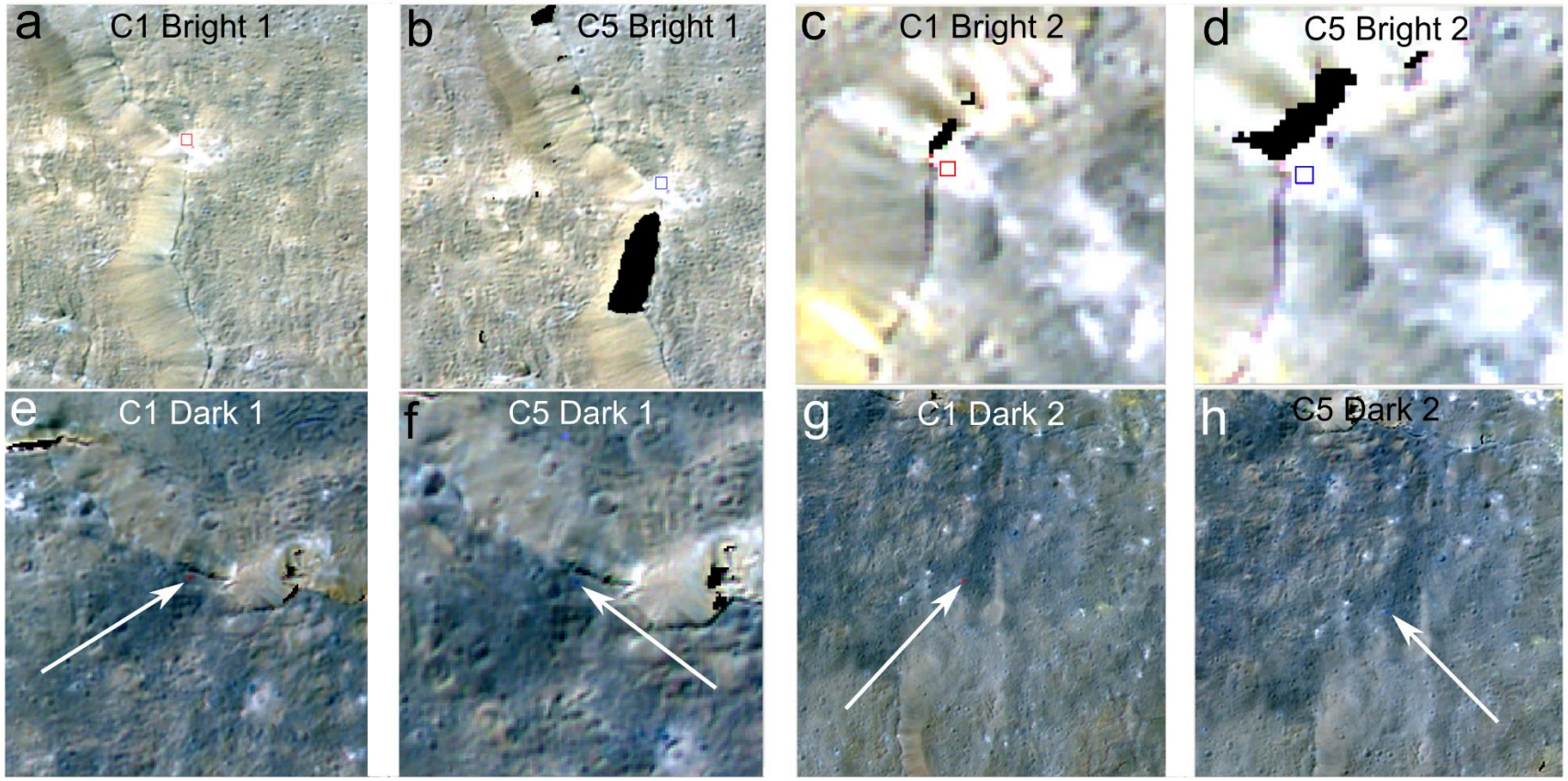
Supplementary Figure 3 (continues on the next page...)



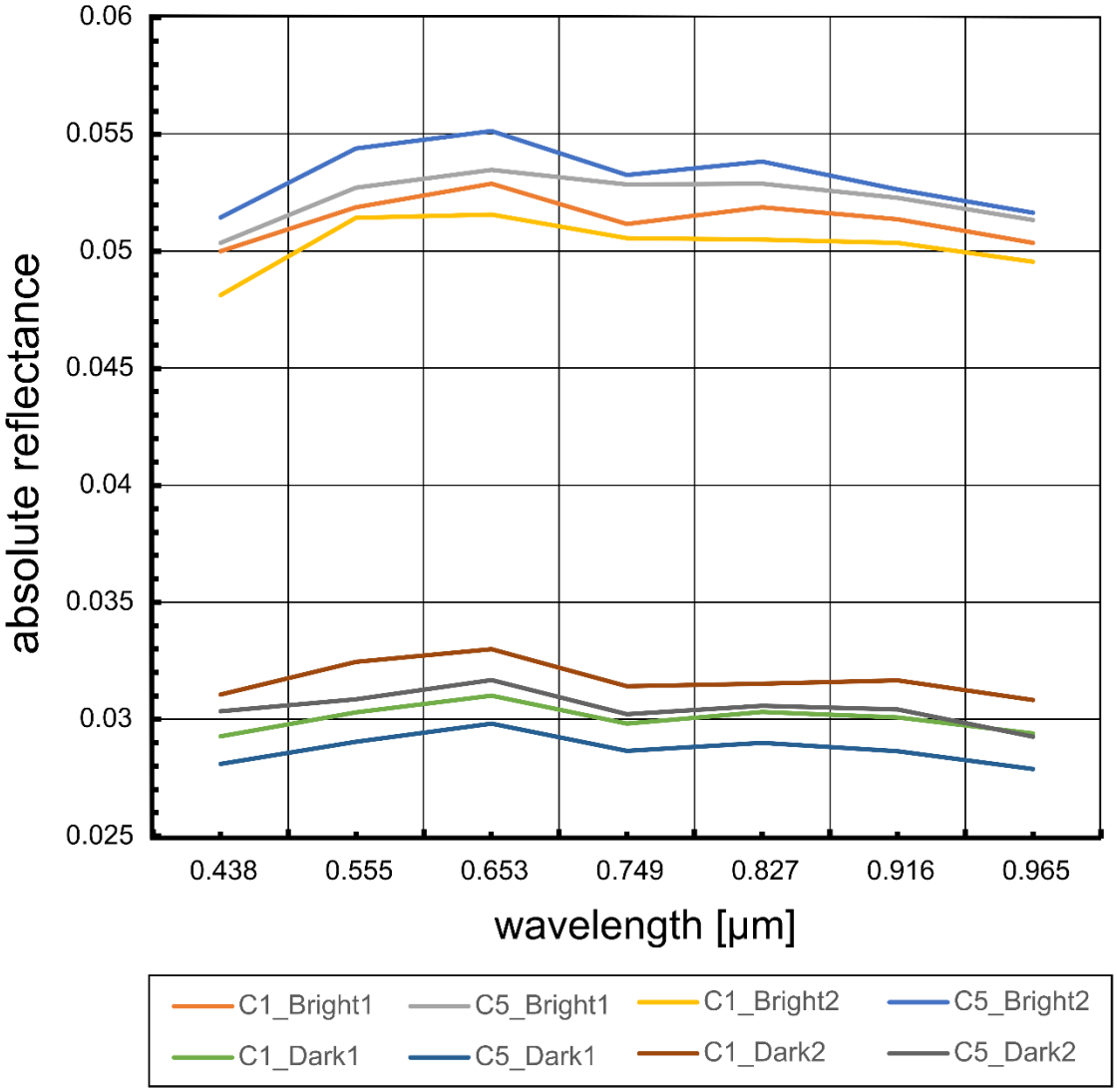
Supplementary Figure 3 (continues on the next page...)



Supplementary Figure 3: Comparison of spectral redness with strength of absorption at ~2.7 μm and ~3.0 μm. *The crater names, Cacaguat, Telepina, Lociyo, UC#18, and Emesh, are mentioned in the left column of each row in the figure. Strength of the VIR ~2.7 μm and ~3.0 μm absorptions in Cacaguat, Telepina, Lociyo, UC#18, and Emesh are provided along the same rows. The processing of the VIR cubes is mentioned in the Methods.*



Supplementary Figure 4. Homogeneously bright and dark areas from the area surrounding Dantu crater for error estimation of FC filters. *The images from C1 cycles are shown in a, c, e, and g; C5 cycle is shown in b, d, f, and h. The 3x3 windows are shown by red boxes (HAMO C1 cycle) and blue boxes (HAMO C5 cycle). White arrows in e—h point to the location of the 3x3 pixel window.*



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49 ***Supplementary Figure 5. Eight spectra from the sites mentioned in Supplementary Figure 4 for error***

50 ***estimation of FC filters.*** *The data is provided in Supplementary Table 2.*

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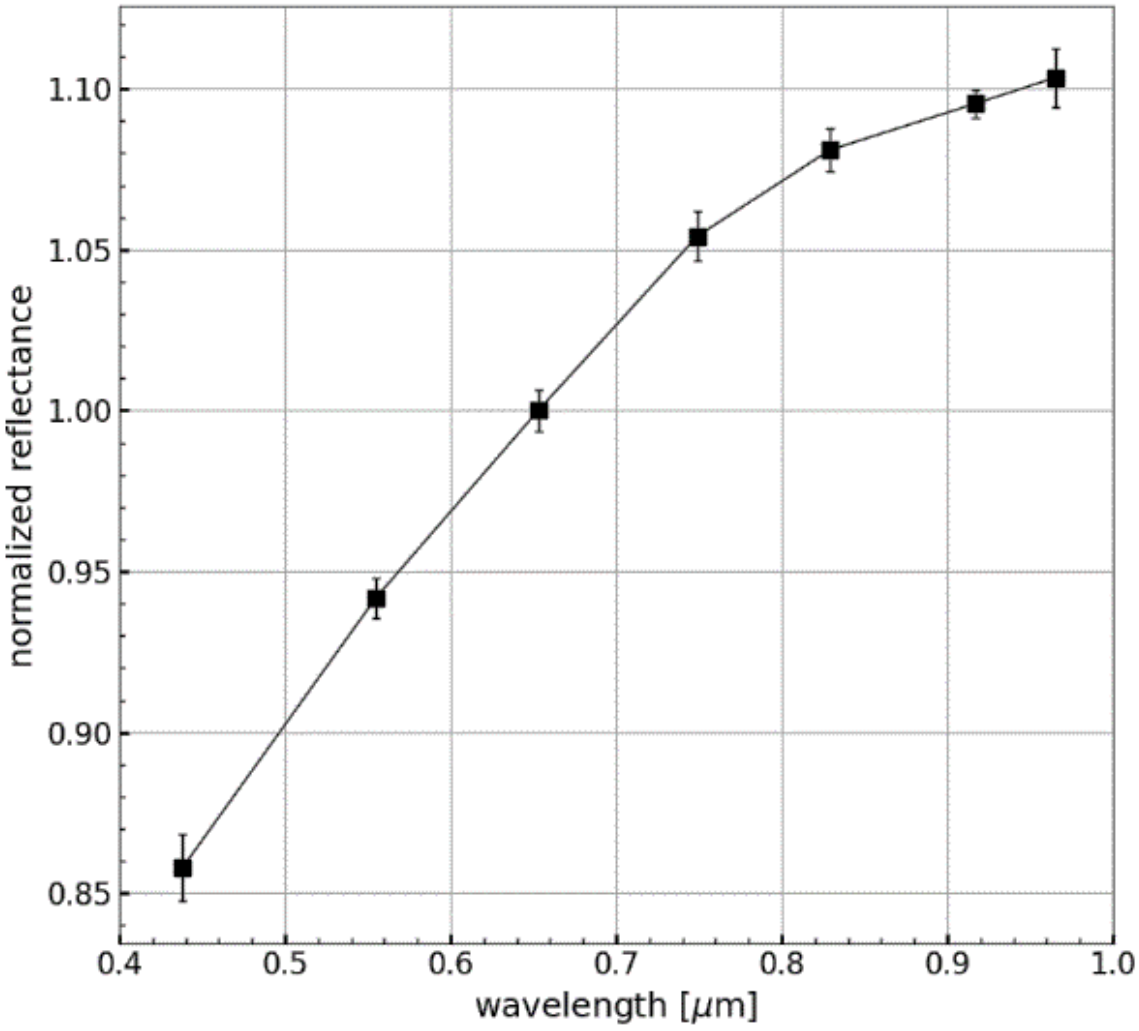

Supplementary Figure 6. Median red-sloped training spectrum. *Normalized median spectrum of manually selected red sloped pixels related to Ernutet crater used for training the neural network. Vertical lines are filter-specific error bars, explained in the Methods.*

Supplementary Table 1A: Locations of all twenty craters identified with red-sloped materials on the crater walls.

S.no.	Crater name	Latitude	Longitude	Diam.
1	*Juling*	-35.9	168.48	20.0
2		-33.19	109.22	3.9
3		-32.96	137.55	4.7
4		-23.06	278.99	15.5
5	*Braciaca*	-22.78	84.37	8.0
6		-18.13	78.81	2.5
7		-17.99	162.05	8.5
8		-16.77	223.15	3.1
9		-11.46	199.12	15.6
10		-10.74	86.34	5.3
11		-10.33	211.42	2.5
12	*Lociyo*	-6.53	228.83	37.8
13	*Cacaguat*	-1.19	143.61	13.6
14	*Emesh*	11.1	158.2	20.0
15		11.48	177.12	5.6
16	*UC#18*	15.39	153.4	26.9
17	*UC#1*	20.54	7.64	9.9
18	*Telepina*	23.2	335.6	31.0
19		25.59	351.0	4.0
20		59.0	300.35	21.1

Supplementary Table 1B. Crater details and VIR dataset IDs of all craters showing Juling-type redness that were analyzed in this study.

Crater name	Diameter	VIR Cube ID	Boulders?	Redness in crater-free debris apron?	Brightness?	Floor deposits?
Juling	20.0	496088556	Yes	Yes, some	Bright	Yes
Braciaca	8.0	493712171	Yes	Yes, + in FD	Bright	Yes
UC#1	9.9	494797528	Yes	Yes, + some in FD	Dark	Yes
Cacaguat	13.6	494392549	Yes, plenty	Yes	Dark	Yes
Telepina	31.0	494863951	No	Yes	Dark	Yes
Lociyo	37.8	494188448	No	Yes	Dark	Yes
UC#18	26.9	495341623	No	Yes	Dark	No
Emesh	20.0	495341623	Few	Yes	Bright	Yes

Supplementary Table 2. The eight spectra from the surroundings of Dantu bright and dark areas, taken from the same location in HAMO C1 and C5 cycles. The final errors are mentioned under STDEV% column.

FC FILTER	C1_BRIGHT1	C5_BRIGHT1	C1_BRIGHT2	C5_BRIGHT2	C1_DARK1	C5_DARK1	C1_DARK2	C5_DARK2
0.438	0.04998564	0.05034769	0.048114443	0.05143548	0.029265674	0.028096996	0.031053971	0.030341669
0.555	0.05185839	0.0527044	0.051412353	0.05437171	0.030292739	0.029031012	0.032451252	0.030846544
0.653	0.05286842	0.05346753	0.051551829	0.05512615	0.031001568	0.029810738	0.032995494	0.031669462
0.749	0.0511543	0.05284778	0.050545207	0.05323803	0.02980558	0.028646161	0.031404401	0.03022083
0.827	0.05185651	0.05287625	0.050482036	0.05381667	0.030315541	0.028997123	0.031510652	0.030568486
0.916	0.05135444	0.05226829	0.050351124	0.0526291	0.030083373	0.028627152	0.031654833	0.030414222
0.965	0.05034276	0.05132514	0.049534022	0.05163365	0.029394807	0.027875134	0.030823109	0.029252815
AVERAGE	0.05134578	0.05226244	0.050284431	0.05317868	0.030022754	0.028726331	0.031699102	0.030473433

NORMALIZED

FC FILTER	C1_Bright1	C5_Bright1	C1_Bright2	C5_Bright2	C1_Dark1	C5_Dark1	C1_Dark2	C5_Dark2	Average	STDEV	STDEV%
0.438	0.97351017	0.96336278	0.956845745	0.96721981	0.974783104	0.978092075	0.979648304	0.99567611	0.973642	0.011782	1.21
0.555	1.0099835	1.0084565	1.02243085	1.02243434	1.008992671	1.01060634	1.02372782	1.012243833	1.014859	0.006735	0.66
0.653	1.02965465	1.02305842	1.025204587	1.0366212	1.032602376	1.037749577	1.040896802	1.039248264	1.033129	0.006632	0.64
0.749	0.99627074	1.01120004	1.005186028	1.00111594	0.992766342	0.997209194	0.990703191	0.991710738	0.99827	0.00716	0.72
0.827	1.00994688	1.01174479	1.003929751	1.01199704	1.009752144	1.009426615	0.994055042	1.003119229	1.006746	0.006108	0.61
0.916	1.00016865	1.00011194	1.001326315	0.9896653	1.002019071	0.996547448	0.998603459	0.99805698	0.998312	0.00392	0.39
0.965	0.98046541	0.98206553	0.985076724	0.97094637	0.979084291	0.97036875	0.972365383	0.959944847	0.97504	0.00819	0.84

70 *References*

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