THE CURIOUS CASE OF MISSING DRILL CORE: AN INVESTIGATION ON SUPERCAM DERIVED IR AND LIBS SPECTRA FROM THE FIRST DRILL SITE OF MARS 2020 PERSEVERANCE ROVER MISSION.

Subham Sarkar[1,2] (subhamrajsarkar@gmail.com), Narayan Bose[3] (narayan.bghs@gmail.com), Satadru Bhattacharya[1,3] and Subhash Bhandari[2]. [1]Space Applications Centre (ISRO), Ahmedabad - 380015, India; [2]Dept. of Earth and Environment Science, KSKV Kachchh University, Bhuj - 370001, India; [3]Dept. of Geology and Geophysics, Indian Institute of Technology Kharagpur, West Bengal - 721302, India.

Introduction: The first-ever sub-surface spectral data from Mars has been obtained by the SuperCam suite onboard the Perseverance rover of Mars 2020 mission. The very first drilling on Mars was conducted at the 'Roubion' target located on the Jezero crater's Volcanic Floor Unit [1], commonly referred to as 'Crater Floor Fracture Rough' [2] or 'paver stone' [3]. The presence of mafic silicates, carbonates, and opaline silica in this oldest (Noachian-Hesperian, > 3 Ga) part of the Jezero crater floor makes it a suitable location to execute the mission objectives, i.e., search for ancient life and sample caching for Earth return [1-3]. On sol 164, the first-ever drilling on the martian surface was attempted at the 'Roubion' target, but unexpectedly no core could be retrieved from the 7 cm drilling. However, during sol 166-168, near-infrared reflectance spectroscopy (IR) and laser-induced breakdown spectroscopy (LIBS) data were captured from the drill cuttings and borehole wall. This data provides the first opportunity to study the sub-surface (fresh and devoid of atmospheric exposure) spectra for better prediction of the martian crust's mineralogical/chemical properties. Moreover, the missing drill core indulges our curiosity by asking why the mechanical property of the target sample did not match our expectations.

Methodology: SuperCam Bundle's Calibrated Data Records (CDRs) were used for IR analysis and Derived Data Records (DDRs) for LIBS data and Remote Micro Imager (RMI) images.

Observations: The SuperCam suite obtained the following data from 'Roubion' target (Fig. 1A): sol-166 - five IR data from drill cutting pile; sol-167 - IR and LIBS data from 10 spots (spots 1-8 from dill hole and 9, 10 from cuttings); sol-168 - five LIBS data from the borehole.

1. IR spectra (Fig. 1B): For all the sol-166 IR spectra, the 1.9-μm absorption is centred at ~1.93 μm with left and right shoulders at ~1.86- and ~2.01 μm, respectively. Another broad absorption occurs near 2.45 μm, but its exact band minimum is not properly identifiable. Spectra from spots 3 and 5 shows a doublet feature having shorter- and longer wavelength minima at ~2.27- and ~2.32 μm, respectively. Interestingly for sol-167 IR spectra, the data collected from the deepest part of the drill hole (i.e. spots 7 and 8 in Fig. 1A) show similar features with the data collected from the cutting pile on the surface (spots 9 and 10 in Fig. 1A). These four spectra are visually identical to those collected on sol-166 and show prominent 1.9-μm absorption features with shoulders ~1.86- and ~1.99 μm along with a weak absorption near 2.4 μm. Although the spectra from spots 1-6 of sol-167 show overall similar trends, their absorption features are relatively flat compared to the rest. Here, the 1.9-μm absorption is centred at 1.93 μm with shoulders at ~1.85 and ~2.08 μm respectively, while the 2.4-μm absorption is almost non-existent.

2. LIBS data (Table 1): The five sol-167 and four sol-168 LIBS DDRs show somewhat comparable variations of the major oxide weight percentages. Along with the most abundant SiO_2 and FeO_T, the prominent presence of CaO and Al_2O_3 is observed. Note the high standard deviation in all the K_2O and MgO values as well as in the values for sol-167 spots 7, 8.

Conclusions: ***1. Smectites:*** The observed characteristic absorptions are attributable to the FeFe-OH combination band (1.9 μm) along with the combination of OH stretch with AlFe-OH (2.27 μm) and AlMg-OH bends (2.32 μm) [4, 5]. Additionally, the 2.45-μm absorption is the characteristic property of Fe-bearing smectite [5]. The LIBS data also confirms it. Our observations are in good agreement with the SuperCam [6, 7] as well as orbiter data [8] reporting the presence of Fe/Mg-smectites and Al-phyllosilicates from the surface of the current study area, which experienced aqueous alteration followed by a long dry spell [9].

2. Rheological and biological aspects: Basalt weathering on the Earth's crust produces mechanically 'soft' smectite-rich horizons [10]. This friable nature of smectites justifies the nonrecovery of the drill core at the 'Roubion' target. At the same time, the high porosity-permeability of smectite-rich layers makes them an excellent host of microbial life [11]. However, the preservation potential of the bio-signatures will ultimately govern the positive detection of extinct or extant life on the surface of the red planet.

Acknowledgments: Data acquired from PDS Geosciences Node: pds-geosciences.wustl.edu/m2020/urn-nasa-pds-mars2020_supercam/.

References: [1] Goudge, T. A. et al. (2015) *JG Planet, 120,* 775-808. [2] Farley, K. et al. (2021) *B. Am. Astron. Soc., 53,* #100.04. [3] Voosen, P. (2021) *Science, 373,* 477. [4] Bishop, J. et al. (2002) *Clay Miner., 37,* 607-616. [5] Bishop, J. et al. (1994) *Clay*

Miner., *42*, 702-716. [6] Mandon, L. et al. (2021) *EPSC Abstracts, 15*, EPSC2021-534. [7] Cousin, A. et al. (2021) EPSC *Abstracts, 15*, EPSC2021-644. [8] Bristow, T. F. et al. (2018) *Sci. Adv., 4*, eaar3330. [9] Greenberger, R. N. et al. (2012) *JGR Planet, 117*, E00J12. [10] Vrolijk, P. (1990) *Geology, 18*, 703-707. [11] Yamashita, S. et al. (2019) *Sci. Rep., 9*, 1-8.

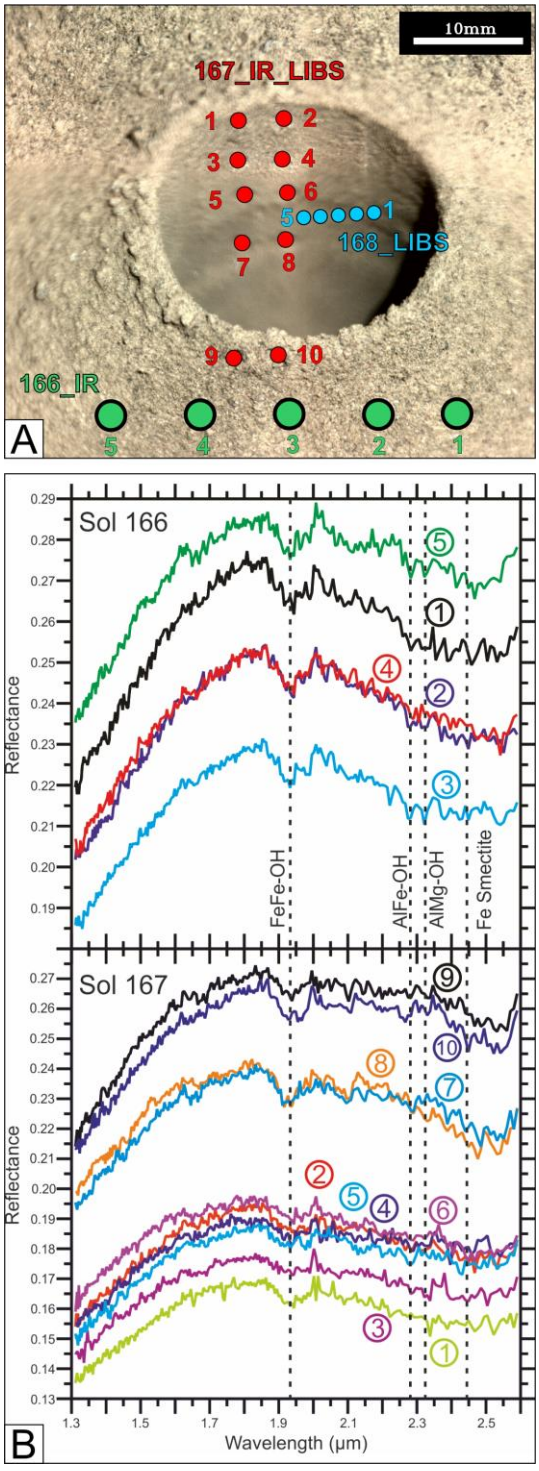

Fig. 1. A. The libs and IR data collection spots marked on SuperCam's RMI mosaic (ascam_sol0167_ scam02167_mos_fr08_fus_rgb_____roubion_cuttings_ 167_p01). **B.** Infra-Red (1.3 - 2.6 μm) reflectance spectra collected by the SuperCam instrument on sol-166 (above) and sol-167 (below). The dotted lines are drawn at ~1.93, ~2.27, ~2.32 and ~2.45 μm for visual reference.

Table 1. Weight percentages (wt%) of major elements (given as oxides) obtained from LIBS Derived Data Record (DDR) of the point marked in Fig. 1. A.

Oxide wt%	**Sol-167 spots**				
	1	**4**	**6**	**7**	**8**
SiO_2	45.35	45.16	46.32	12.5	47.1
SiO_2_stdev	4.34	3.6	4.49	11.8	7.48
TiO_2	0.73	0.76	0.72	0.17	0.7
TiO_2_stdev	0.29	0.1	0.33	0.28	0.17
Al_2O_3	4.35	4.38	6.01	3.64	9.27
Al_2O_3_stdev	1.57	1.76	1.48	1.76	2.72
FeO_T	40.78	43.64	45.09	71.3	29.6
FeO_T_stdev	7.17	5.39	7.3	15.3	11.2
MgO	1.44	1.16	0.94	0.6	1.3
MgO_stdev	1.49	1.07	1.69	1.05	0.71
CaO	5.41	5.26	5.63	1.24	4.5
CaO_stdev	1.02	0.72	0.79	1.51	1.41
Na_2O	1.58	2.51	1.85	1.19	3.4
Na_2O_stdev	0.38	0.55	0.48	0.71	0.73
K_2O	0.47	0	0.51	0.44	0.62
K_2O_stdev	0.52	0.31	0.46	0.61	0.46
Total	100.1	102.9	107.1	91.1	96.5

Oxide wt%	**Sol-168 spots**			
	1	**3**	**4**	**5**
SiO_2	45.73	40.61	43.26	41
SiO_2_stdev	3.76	5.73	2.32	3.73
TiO_2	0.74	0.78	0.76	0.72
TiO_2_stdev	0.07	0.1	0.18	0.12
Al_2O_3	5.55	5.65	6.21	6.72
Al_2O_3_stdev	0.84	1.13	1.27	1.12
FeO_T	38.07	36.13	36.14	32.9
FeO_T_stdev	4.96	5.83	4.83	9.19
MgO	1.02	1.21	1.16	1.8
MgO_stdev	1.07	1.1	0.75	1.39
CaO	5.38	6.4	4.95	4.43
CaO_stdev	0.93	1.36	0.66	1.18
Na_2O	1.42	2.57	3.43	3.32
Na_2O_stdev	0.39	0.57	0.42	0.48
K_2O	0.3	0.34	0.25	0.53
K_2O_stdev	0.51	0.32	0.33	0.42
Total	98.21	93.69	96.16	91.4