PLANETARY TERRESTRIAL ANALOGUES LIBRARY

PTAL Webinar (short version)

Online,10 November 2021

The **Planetary Terrestrial Analogue Library (PTAL)**, which is a research project funded by the European Commission through the H2020- COMPET-2015 programme (grant 687302).

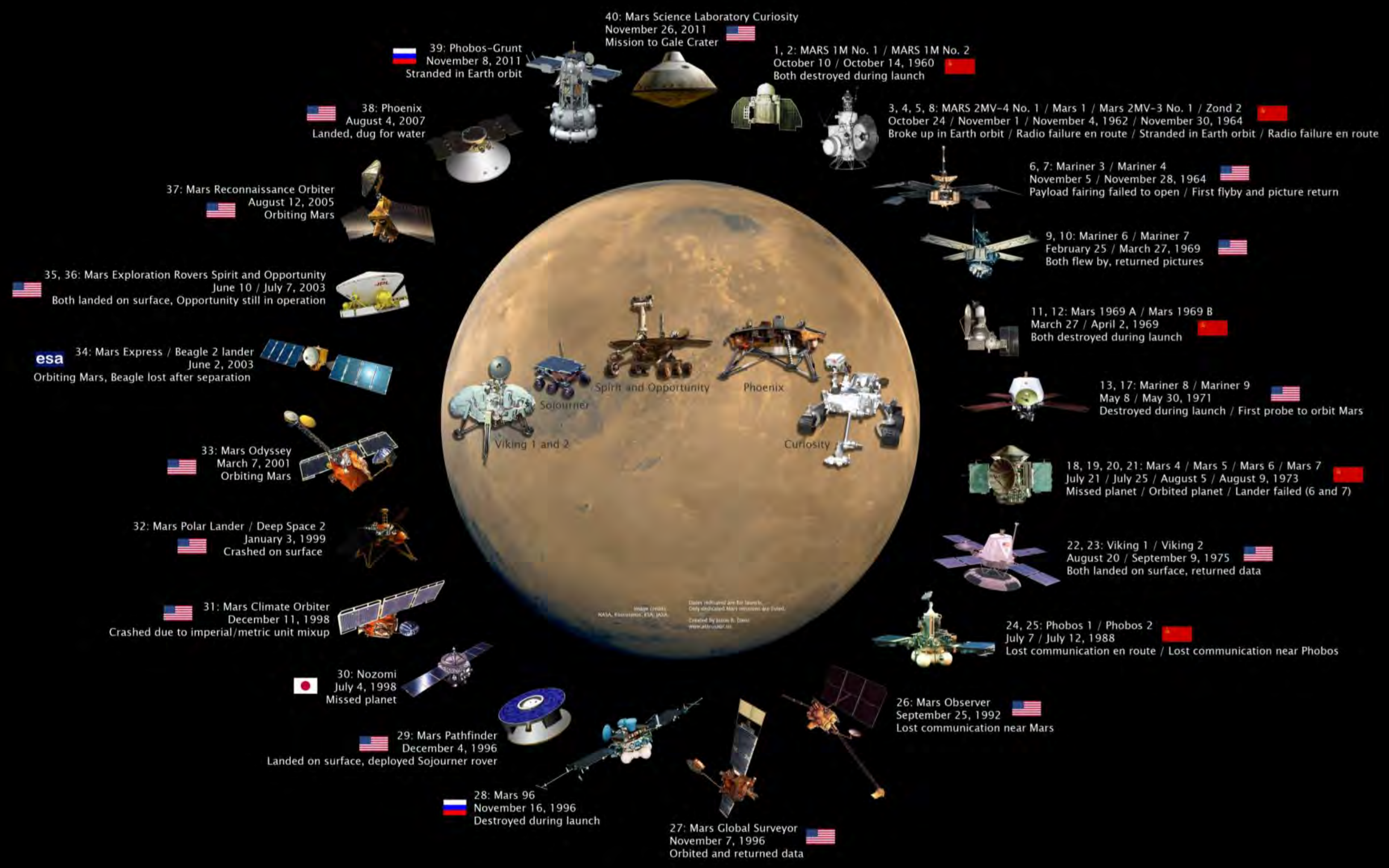
<u>The meeting is organized in three sections:</u>

- **Section 1:** General information about current and forthcoming missions to Mars.
- **Section 2: The** PTAL project, a multi-analytical database to support planetary exploration.
- **Section 3:** Insights on PTAL terrestrial analogue materials and related studies.

Section 1

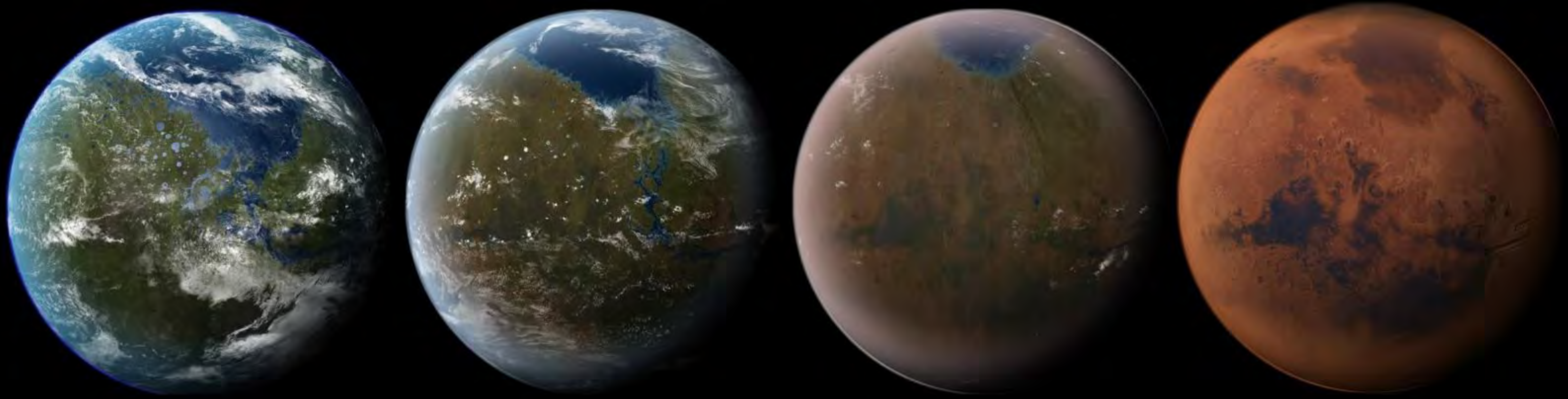
General information about current and forthcoming missions to Mars

Section 1
History of Mars exploration

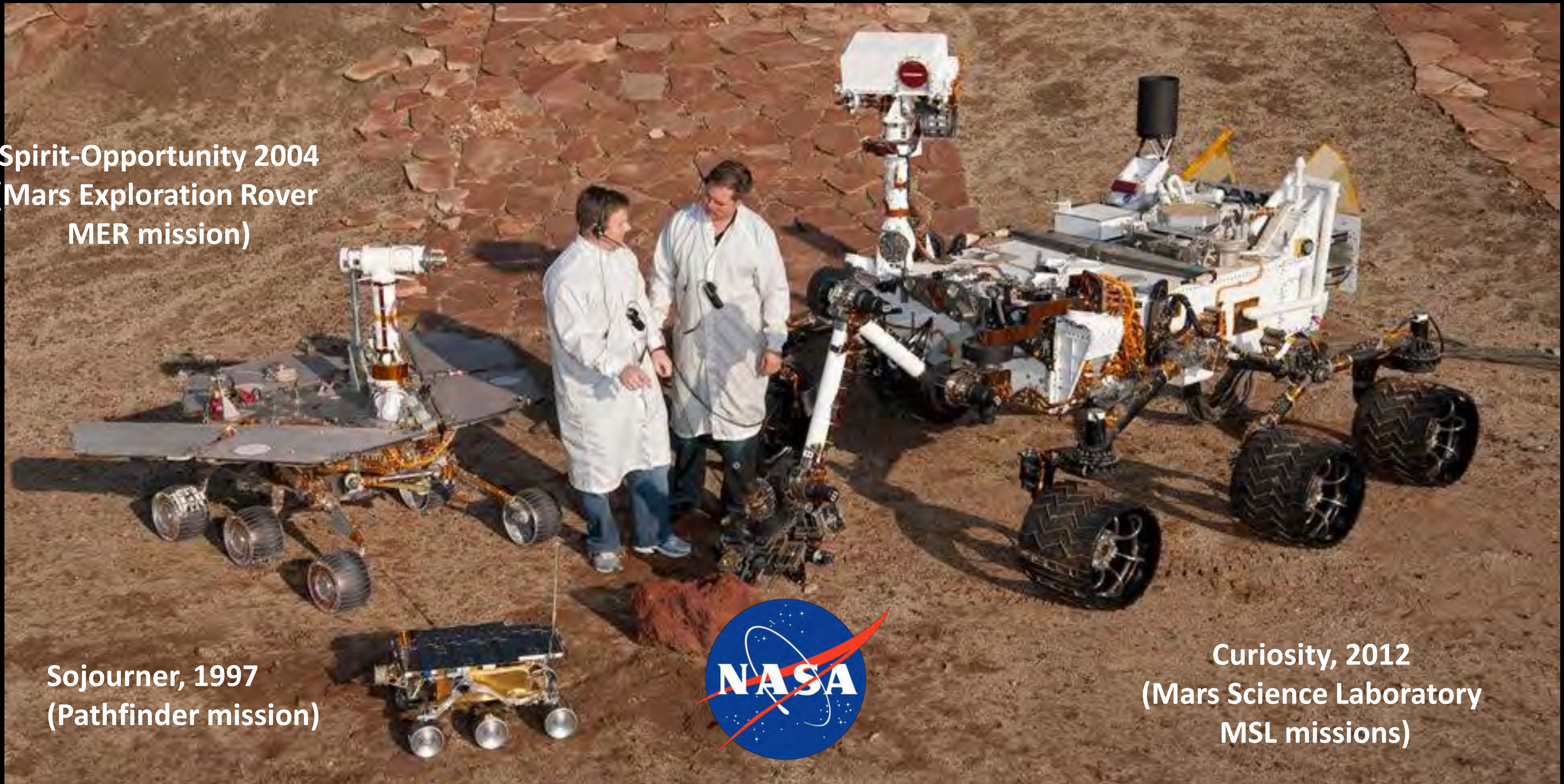


Section 1
Past and present of Mars


Section 1
Past and present of Mars

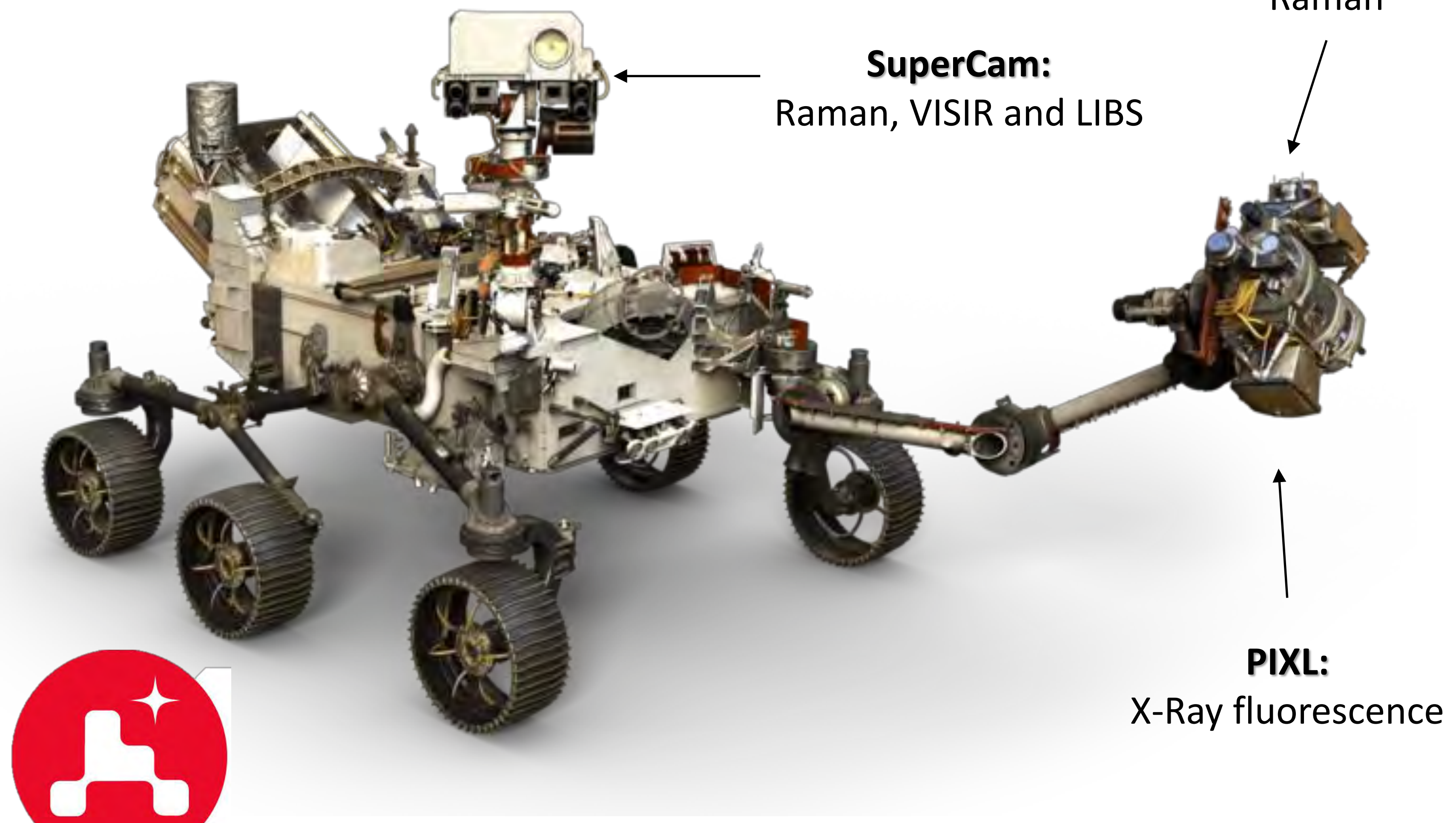


Section 1
Past rover missions to Mars



Section 1
Current rover missions to Mars

Mars 2020 Perseverance rover



Launched:
July 31st, 2020

Landed:
February 18th, 2021

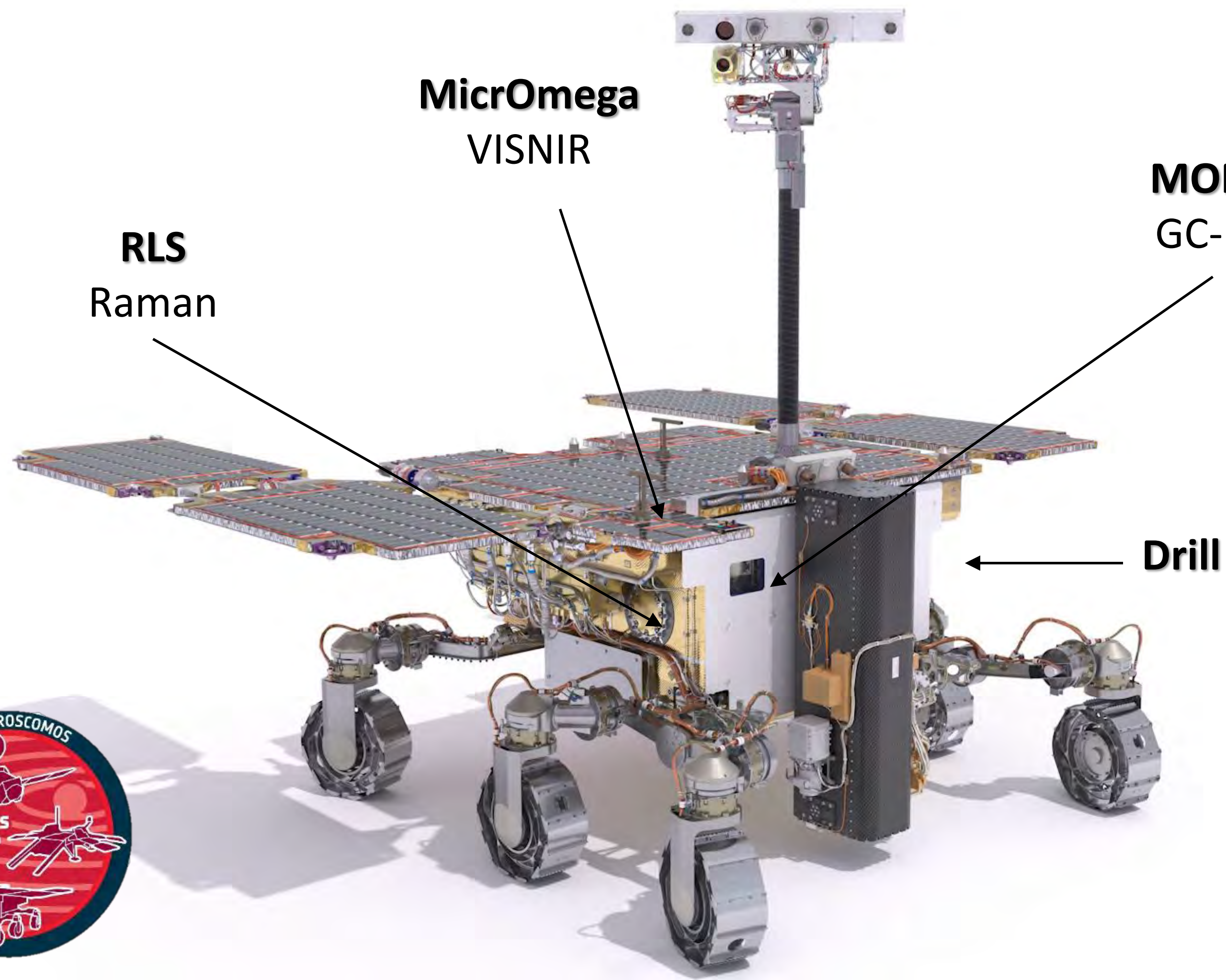
Site:
Jezero Crater

Weight:
1025 Kg

Main objectives:

- Characterize the composition of Martian rocks and soils
- Select and store the optimal samples for the future Sample Return Mission

ExoMars 2022 Rosalind Franklin rover



Planned launch:
September 20th, 2022

Planned landing:
June 10^{th}, 2023

Site:
Oxia Planum

Weight:
310 Kg

Main objectives:

- Investigate the composition of Martian sub-soil
- In-situ identification of potential biomarkers preserved within the mineralogical matrix of sub-soil samples

Section 2

The PTAL project, a multi-analytical database to support planetary exploration

Section 2
Terrestrial analogues

Section 2
PTAL terrestrial analogues sites

Section 2
PTAL terrestrial analogues samples

The original list of terrestrial analogues included a total of 94 samples, which were organized in 12 different groups:

Group 1: Impact melt rocks (4 samples)

Impact melt rocks	Sample place #	Sample #	Sampled by	Site	Coordinates	Weight
Gardnos	GN	GN16-0001	E.Kalleson	Dokkelva		100 g
Vredefort	VR	VR16-0021	H.Dypvik	Leeukop Qu		130 g
Chesapeake Bay	WH	WH16-0005	Wright Horton	Eyreville B core		19,8 g
		WH16-0014	Wright Horton	Eyreville B core		21,4 g

Group 2: Canary Islands-Tenerife (9 samples)

Tenerife	Sample place #	Sample #	Sampled by	Site	Coordinates	Weight
Mna. Reventada	MR	MR16-0001	**DHS**	Mna. Reventada	N28.16.20.7 W016.43.43.4	652 g
Mna. Reventada	MR	MR16-0002	DHS	Mna. Reventada	N28.16.20.7 W016.43.43.4	450 g
Adeje	AD	AD16-0001	**DHS**	Adeje	N28.06.50.7 W016.44.00.1	438 g
Mna. Amarilla	AM	AM16-0001	DHS	Mna. Amarilla	N28.00.34.4 W016.38.14.4	155 g
Mna. Amarilla	AM	AM16-0002	**DHS**	Mna. Amarilla	N28.00.34.4 W016.38.14.4	490 g
Los Azulejos	TF	TF16 -0002	**FT**	Los Azulejos	N28 13 07.67, W 16.37.40.39	61 g
Los Azulejos	TF	TF16 -0028	**FT**	Los Azulejos	N28 13 07.67, W 16.37.40.39	173 g
Los Azulejos	TF	TF16-0059	**FT**	Los Azulejos	N28 13 07.67, W 16.37.40.39	167 g
Los Azulejos	TF	TF16-0066	**FT**	Los Azulejos	N28 13 07.67, W 16.37.40.39	66 g

Group 3: Scotland (1 sample)

Scotland			Sampled by	Site	Coordinates	Weight
Rum	RU	RU16-0001	Dougal Jerram			158g

Group 4: Antarctica (1 sample)

Antartica			Sampled by	Site	Coordinates	Weight
Dry Vallies	DV	DV16-0001	Dougal Jerram			358g

Group 5: Canary Islands - Grand Canary (9 samples)

Grand Canary	Sample place #	Sample #	Sampled by	Site	Coordinates	Weight
Agaete	AG	AG16-0001	**DHST**	Agaete	N28.05.50.4 W015.41.50.9	764 g
Punta Camello	TO	TO16-0001	**DHST**	Arucas	N28.09.08.1 W 015.31.31.9	350 g
Bc.Tamaraceite	BT	BT16-0001	**DHST**		N28.07.14.0 W 015.27.30.0	130 g
Bc.Tamaraceite	BT	BT16-0002	**DHST**		N28.07.14.0 W 015.27.30.0	120 g
Pica Bandama	CB	CB16-0001	**DHST**	Bandama	N28.02.30.0 W015. 27.45.0	110 g
Fuente de Az.	FA	FA16-0001	**DHST**	Azulejos	N27.55.26.1 W 015.43.40.8	180 g
Fuente de Az.	FA	FA16-0002	**DHST**	Azulejos	N27.55.26.1 W 015.43.40.8	283 g
Fuente de Az.	FA	FA16-0003	**DHST**	Azulejos	N27.55.26.1 W 015.43.40.8	265 g
Roque Nublo	RN	RN16-0001	**VT**	Roque Nublo	N 27.54.02.7 W015.28.12.3	389g

Group 6: Spain mainland – Jaroso Ravine (3 samples)

Jaroso Ravine		Sample #	Sampled by	Site	Coordinates	Weight
Jaroso Ravine	JA	JA08-501	**CR**		N37.18.11.4 W 1.45.19.3	17g
Jaroso Ravine	JA	JA08-502	**CR**		N37.18.17.6 W 1.45.36.6	28g
Jaroso Ravine	JA	JA08-503	**CR**		N37.18.05.4 W1.45.09.6	48g

Section 2
PTAL terrestrial analogues samples

Group 7: Spain mainland – Rio Tinto (3 samples)

Rio Tinto		Sample #	Sampled by	Site	Coordinates	Weight
Rio Tinto	RT	RT03-501	**CR**		N37.43.32.4 W6.33.19.0	136g
Rio Tinto	RT	RT03-502	**CR**		N37.43.19.5 W6.33.04.5	13g
Rio Tinto	RT	RT03-503	**CR**		N37.43.30.5 W 6.33.29.7	26g

Group 8: Norway – Oslo Rift (3 samples)

Oslo Rift		Sample #	Sampled by	Site	Coordinates	Weight
Ullernåsen	UL	UL16-0001	**D**	Gregers Gramsvei	N59.56.13.7 E010.38.47.9	866 g
Brattåsen	BR	BR16-0001	**D**	Brattåsen,Vestby	N59.35.44.3 E010.40.41.9	1022g
Brattåsen	BR	BR16-0002	**D**	Brattåsen,Vestby	N59.35.44.6 E010.40.57.8	1282g

Group 9: Norway – Leka (17 samples)

Leka		Sample #	Sampled by	Site	Coordinates	Weight
Leka	LA	LE16-0001	**DV**	Lauvhatten	N65.06.16.3 E011.41.44.9	446g
Leka	LA	LE16-0002	**DV**	Lauvhatten	N65.06.20.4 E011.41.18.7	962g
Leka	LA	LE16-0003	**DV**	Lauvhatten	N65.06.20.4 E011.41.18.7	478g
Leka	SK	LE16-0004	**DV**	At Skråen road	N65.06.35.5 E011.40.18.6	764g
Leka	ST	LE16-0005	**DV**	At Steinfjellet	N65.06.16.0 E011.36.29.0	550g
Leka	ST	LE16-0006	**DV**	At Steinfjellet	N65.06.16.0 E011.36.29.0	493g
Leka	ST	LE16-0007	**DV**	At Steinfjellet	N65.06.16.0 E011.36.29.0	84g
Leka	PV	LE16-0008	**DV**	At Pavillion	N65.06.17.5 E011.37.17.6	415g
Leka	AU	LE16-0009	**DV**	Aunkollen	N65.05.07.8 E011.35.05.8	548g
Leka	AU	LE16-0010	**DV**	Aunkollen	N65.05.07.8 E011.35.05.8	495g
Leka	AU	LE16-0011	**DV**	Aunkollen	N65.05.07.8 E011.35.05.8	371g
Leka	KV	LE16-0012	**DV**	Kvaløy	N65.06.58.2 E011.39.24.2	411g
Leka	MA	LE16-0013	**DV**	Madsøy	N65.02.32.6 E011.40.33.1	496g
Leka	SO	LE16-0014	**DV**	Solsem	N65.02.46.4 E011.32.58.2	314g+227g
Leka	SO	LE16-0015	**DV**	Solsemhola	N65.03.37.2 E011.34.11.7	168g
Leka	MO	LE16-0016	**DV**	Moho	N65.05.53.5 E011.39.54.0	890g
Leka	MO	LE16-0017	**DV**	Moho	N65.05.53.5 E011.39.54.0	876g

Group 10: Brazil (4 samples)

Brazil			Sampled by	Site	Coordinates	Weight
Vista Allegre	VA	VA16-0001	Alvaro Crosta			134,45g
Vargeao Dome	VD	VO16-0001	Alvaro Crosta			140,45g
Vargeao Dome	VD	VO16-0002	Alvaro Crosta			133,10g
Vargeao Dome	VD	VO16-0003	Alvaro Crosta			257,0g

Group 11: USA (26 samples)

USA			Sampled by	Site	Coordinates	Weight
John Day Valley	FO	JD16-0001	D	Foree	N44.65.07.70 W119.63.79.27	260,89g
John Day Valley	FO	JD16-0002	D	Foree	N44.65.07.70 W119.63.79.27	209,58g
John Day Valley	PG	JD16-0003	D	Picture Gorge	N44.53.05.70 W119.63.50.80	233,18g
John Day Valley	PG	JD16-0004	D	Picture Gorge	N44.53.05.70 W119.63.50.80	294,95g
John Day Valley	PG	JD16-0005	D	Picture Gorge	N44.53.05.70 W119.63.50.80	358,20g
John Day Valley	PG	JD16-0006	D	Picture Gorge	N44.51.20.65 W119.62.35.95	195,53g
John Day Valley	PG	JD16-0007	D	Picture Gorge	N44.51.20.65 W119.62.35.95	276,72g
John Day Valley	MB	JD16-0008	D	Mascall Basin	N44.50.30.3 W119.62.49.8	130,27g
John Day Valley	MB	JD16-0009	D	Mascall Basin	N44.50.30.3 W119.62.49.8	251,07g
Painted Hills	BG	JD16-0010	D	Painted Hills	N44.65.32.2 W120.28.37.3	194,31g
Painted Hills	BG	JD16-0011	D	Painted Hills	N44.65.32.2 W120.28.37.3	603,53g
Painted Hills	BG	JD16-0012	D	Painted Hills	N44.65.03.24 W120.28.40.14	144,69g
Painted Hills	BG	JD16.0013	D	Painted Hills	1102016	244,64g
Painted Hills	BG	JD16-0014	D	Painted Hills	N44.65.27.81 W120.28.43.38	297,48g
Painted Hills	BG	JD16-0015	D	Painted Hills	N44.65.27.81 W120.28.43.38	154,92g
Clarno	HS	JD16-0016	D	Hancock Station	N44.92.21.7 W120.43.32.4	212,14g
Clarno	HS	JD16-0017	D	Hancock Station	N44.92.21.7 W120.43.32.4	206,63g
Clarno	HS	JD16-0018	D	Hancock Station	N44.92.23.6 W120.43.34.7	320,01g
Clarno	HS	JD16-0019	D	Hancock Station	N44.92.23.6 W120.43.34.7	349,90g
Painted Hills	PH r	JD16-0020	D	Painted Hills	N44.38.00.9 W120.13.10.6(WGS84)	332,44g
Painted Hills	PH r	JD16-0021	D	Painted Hills	N44.38.00.9 W120.13.10.6(WGS84)	423,27g
Painted Hills	PH l	JD16-0022	D	Painted Hills	N44.38.22.8 W120.16.51.4(WGS84)	206,07g
Painted Hills	PH l	JD16-0023	D	Painted Hills	N44.38.22.8 W120.16.51.4(WGS84)	213,62g
Painted Hills	PH l	JD16-0024	D	Painted Hills	N44.38.22.8 W120.16.51.4(WGS84)	325,61g

Section 2
PTAL terrestrial analogues samples

Group 12: Iceland (16 samples)

Iceland			Sampled by	Site	Coordinates	Weight
Reykjanes	HB	IS16-0001	DV	Haleyjabunga	N63 49 01.7 W22 39 03.1	355,77g
Reykjanes	HB	IS16-0002	DV	Haleyjabunga	N63 49 01.7 W22 39 03.1	472,77g
Near Stapafell	LF	IS16-0003	DV	Lagafell	N63 53 05.2 W22 32 10.8	251,81g
Near Stapafell	LF	IS16-0004	DV	Lagafell	N63 52 56.4 W22 32 32.3	618,04g
Near Stapafell	LF	IS16-0005	DV	Lagafell	N63 52 50.0 W22 32 24.6	647,80g
Stapafell	SF	IS16-0006	DV	Stapafell	N63 54 19.9 W22 31 58.0	415,23g
Stapafell	SF	IS16-0007	DV	Stapafell	N63 54 19.9 W22 31 58.0	331,42g
Stapafell	SF	IS16-0008	DV	Stapafell	N63 54 19.9 W22 31 58.0	163,31g
Stapafell	SF	IS16-0009	DV	Stapafell	N63 54 15.5 W22 31 52.0	345,86g
Krysuvik	SE	IS16-0010	DV	Seltun	N63 53 44.9 W22 03 09.2	77,18g
Krysuvik	SE	IS16-0011	DV	Seltun	N63 53 44.9 W22 03 09.2	218,79g
Krysuvik	SE	IS16-0012	DV	Seltun	N63 53 44.9 W22 03 09.2	288,43g
Reykjanes	HB	IS16-0013	DV	Haleyjabunga	N63 48 58.3 W22 39 38.8	318,22g
Reykjanes	RE	IS16-0014	DV	Reykjanes	N63 49 09.1 W22 40 55.9	187,59g
Grindavik	VH	IS16-0015	DV	Vatnsheidi	N63 51 48.5 W22 24 11.7	276,05g
Grindavik	VH	IS16-0016	DV	Vatnsheidi	N63 51 43.9 W22 24 22.6	296,80g

Samples added in 2020:

Group 13: Otago (5 samples)

Otago			Sampled by	Site	Coordinates	Weight
Otago	OT	OT-001	Agata	Blue Spur conglomerate	169° 40.60821’E,45° 52.66415’S	520 g
Otago	OT	OT-002	Agata	Blue Spur conglomerate	169° 40.60821’E,45° 52.66415’S	260 g
Otago	OT	OT-003	Agata	Blue Spur conglomerate	169° 40.60821’E,45° 52.66415’S	310 g
Otago	OT	OT-004	Agata	Blue Spur conglomerate	169° 40.60821’E,45° 52.66415’S	330 g
Otago	OT	OT-005	Agata	Blue Spur conglomerate	169° 40.60821’E,45° 52.66415’S	230 g

Group 14: Lonar crater (3 samples)

Lonar Crater			Sampled by	Site	Coordinates	Weight
India	OT	OT-001	Agata	Lonar Crater	76°30.30'E,19°59'N	330 g
India	OT	OT-002	Agata	Lonar Crater	76°30.30'E,19°59'N	200 g
India	OT	OT-003	Agata	Lonar Crater	76°30.30'E,19°59'N	54 g

Group 15: Granby shists (4 samples)

Detailed information about the selected terrestrial analogue site, the collected samples, and their relevance for Mars-related science will be provided in a dedicated manuscript:

H. Dypvik et al., *The Planetary Terrestrial Analogues Library (PTAL) - An Exclusive Lithological Selection of Possible Martian Earth Analogues. Planetary and Space Science, 208 (2021) 105339* https://doi.org/10.1016/j.pss.2021.105339

Section 2
Terrestrial analogues of Oxia Planum

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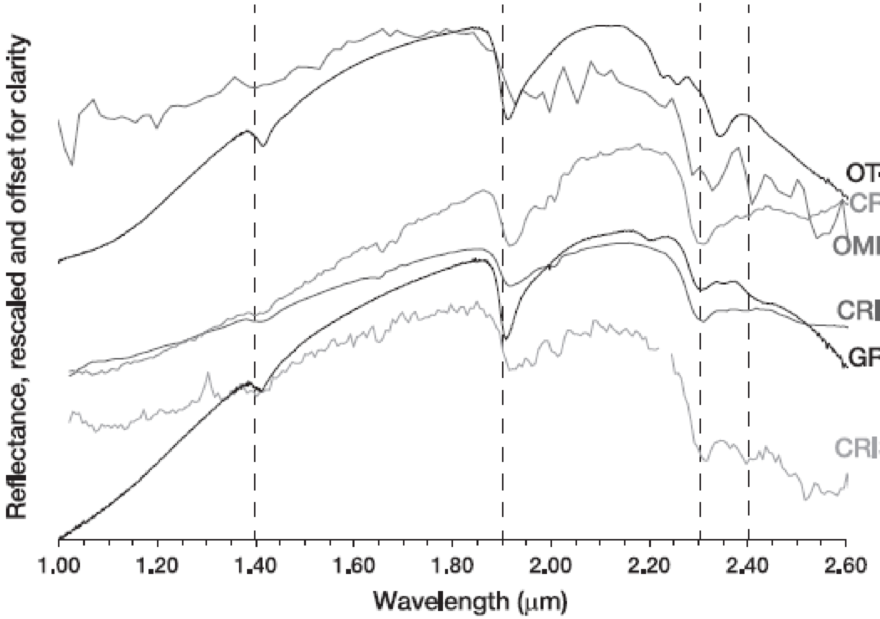
Research Article

DOI: 10.1089/ast.2020.2410

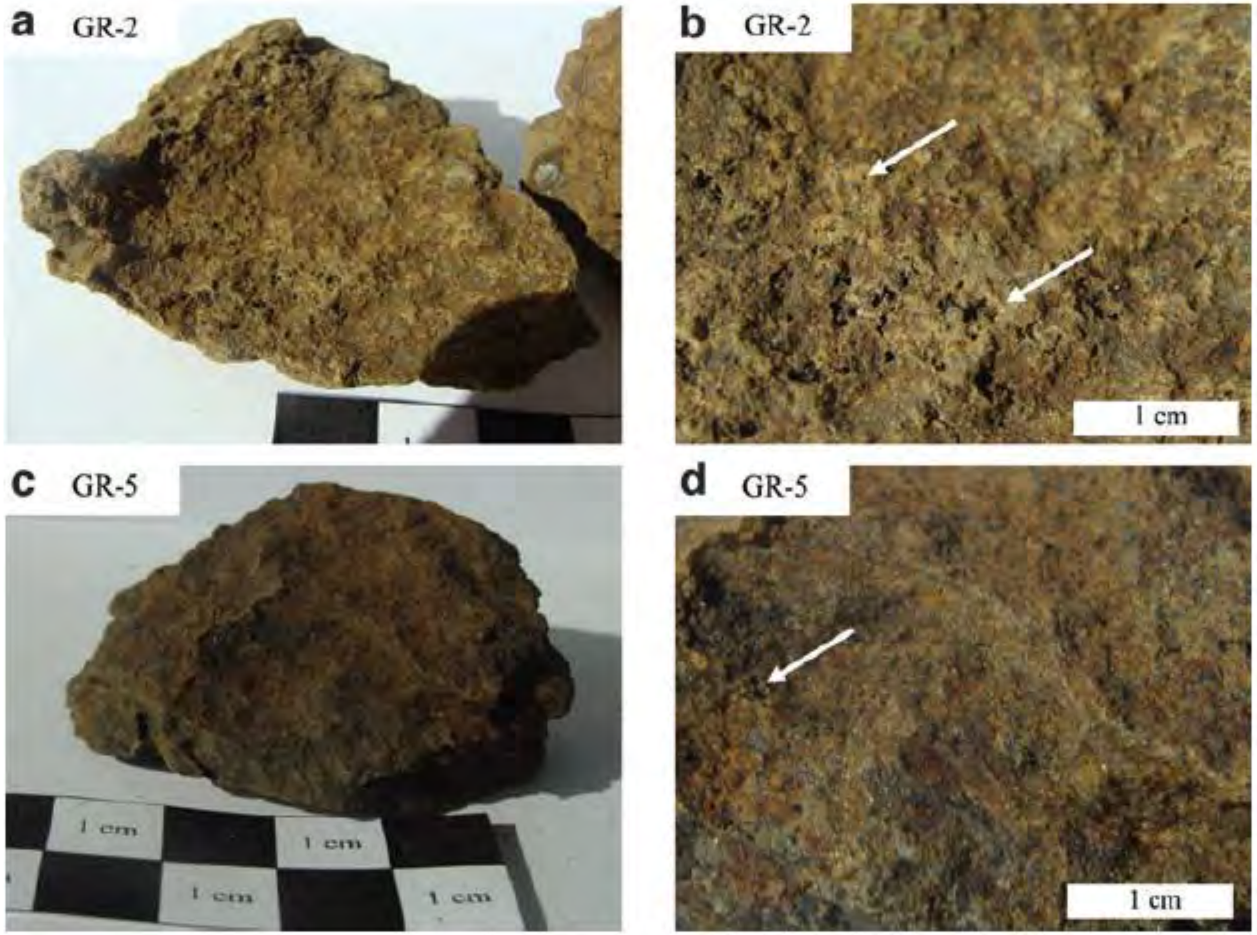
Mineralogical and Spectral (Near-Infrared) Characterization of Fe-Rich Vermiculite-Bearing Terrestrial Deposits and Constraints for Mineralogy of Oxia Planum, ExoMars 2022 Landing Site

Agata M. Krzesińska,[1] Benjamin Bultel,[1] Damien Loizeau,[2] David Craw,[3] Richard April,[4]
François Poulet,[2] and Stephanie C. Werner[1]

NIR spectra of Oxia Planum vs GR-2 sample



Terrestrial analogue materials collected from Granby basaltic tuff formation (New Zealand)



Section 2
PTAL artificial analogues

Artificial samples altered under controlled environmental conditions

AGU PUBLICATIONS JGR

Journal of Geophysical Research: Planets

RESEARCH ARTICLE
10.1002/2017JE005343

Key Points:
- Experiments and geochemical modeling to investigate the effect of CO_2 content on mineral formation on early Mars
- Dioctahedral phyllosilicates versus zeolites and carbonates versus zeolites formation as a proxy to determining aqueous alteration history

Dioctahedral Phyllosilicates Versus Zeolites and Carbonates Versus Zeolites Competitions as Constraints to Understanding Early Mars Alteration Conditions

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The Meteoritical Society

Meteoritics & Planetary Science 1–22 (2018)
doi: 10.1111/maps.13214

Experimental hydrothermal alteration of basaltic glass with relevance to Mars

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Section 2
PTAL workflow

Samples / XRD analysis

NIR analysis

LIBS analysis

Raman analysis

The spectroscopic analysis of PTAL samples is carried out by combining the use of commercial systems with instruments derived from present and forthcoming space missions to Mars.

LIBS → **Curiosity / ChemCam FS**

NIR → **ExoMars / MicrOmega FS**

Raman → **ExoMars / RLS-Sim**
Mars 2020 / Simulcam

Section 2
Raman data overview

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RESEARCH ARTICLE

WILEY Journal of RAMAN SPECTROSCOPY

Planetary Terrestrial Analogues Library (PTAL) project: Raman data overview

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Abstract
The multianalytical study of terrestrial analogues is a useful strategy to deepen the knowledge about the geological and environmental evolution of Mars and other extraterrestrial bodies. In spite of the increasing importance that laser-induced breakdown spectroscopy (LIBS), near-infrared spectroscopy (NIR), and Raman techniques are acquiring in the field of space exploration, there is a lack Web-based platform providing free access to a wide multispectral database of terrestrial analogue materials. The Planetary Terrestrial Analogues Library (PTAL) project aims at responding to this critical need by developing and providing free Web accessibility to LIBS, NIR, and Raman data from more than 94 terrestrial analogues selected according to their congruence with Martian geological contexts. In this framework, the present manuscript provides the scientific community with a complete overview of the over 4,500 Raman spectra collected to feed the PTAL database. Raman data, obtained through the complementary use of laboratory and spacecraft-simulator systems, confirmed the effectiveness of this spectroscopic technique for the detection of major and minor mineralogical phases of the samples, the latter being of critical importance for the recognition of geological processes that could have occurred on Mars and other planets. In light of the forthcoming missions to Mars, the results obtained through the Raman Laser Spectrometer (RLS) ExoMars Simulator offer a valuable insight on the scientific outcome that could derive from the RLS spectrometer that will soon land on Mars as part of the ExoMars rover payload.

TABLE 1 Overview of Raman results from Jaroso Ravine and Rio Tinto samples

Sample details												
ID code	Sampling site	Quartz	Hematite	Goethite	Jarosite	Pyrite	Biotite	Anatase	Rutile	Calcite	Carbon	Barite
JA08-501	Jaroso Ravine				Both			RLS				
JA08-502	Jaroso Ravine	Both		microRaman				RLS	microRaman		microRaman	
JA08-503	Jaroso Ravine	Both	Both	microRaman			microRaman	microRaman		RLS	Both	Both
RT03-501	Rio Tinto	Both	Both	Both								RLS
RT03-502	Rio Tinto		microRaman			microRaman						
RT03-503	Rio Tinto	Both				Both						

Both microRaman and RLS simulator | *RLS simulator* | *microRaman*

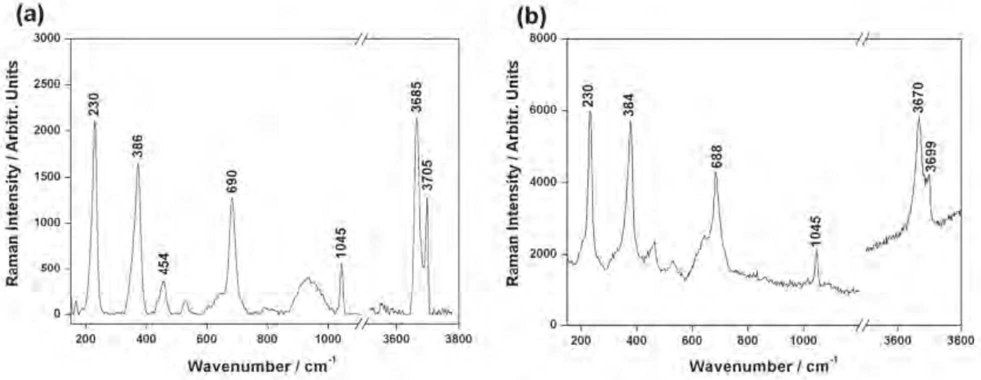
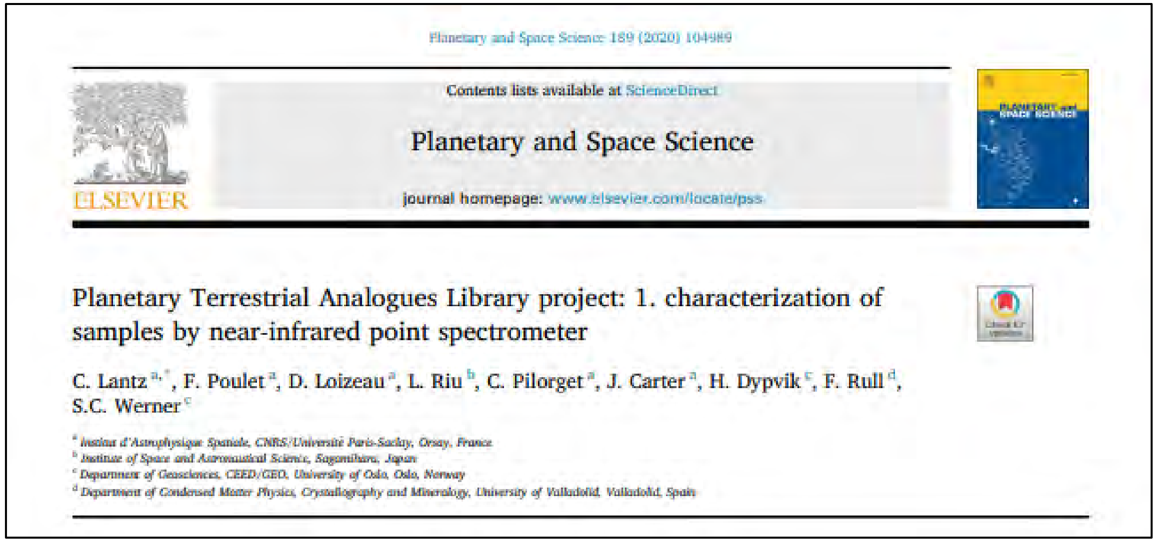


FIGURE 7 Serpentine spectra collected from sample LE16-0004 by means of both microRaman system (a) and RLS ExoMars Simulator (b)

Section 2
NIR data overview

https://doi.org/10.1016/j.pss.2020.104989



Planetary and Space Science 189 (2020) 104989

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journal homepage: www.elsevier.com/locate/pss

Planetary Terrestrial Analogues Library project: 1. characterization of samples by near-infrared point spectrometer

C. Lantz [a,*], F. Poulet [a], D. Loizeau [a], L. Riu [b], C. Pilorget [a], J. Carter [a], H. Dypvik [c], F. Rull [d], S.C. Werner [c]

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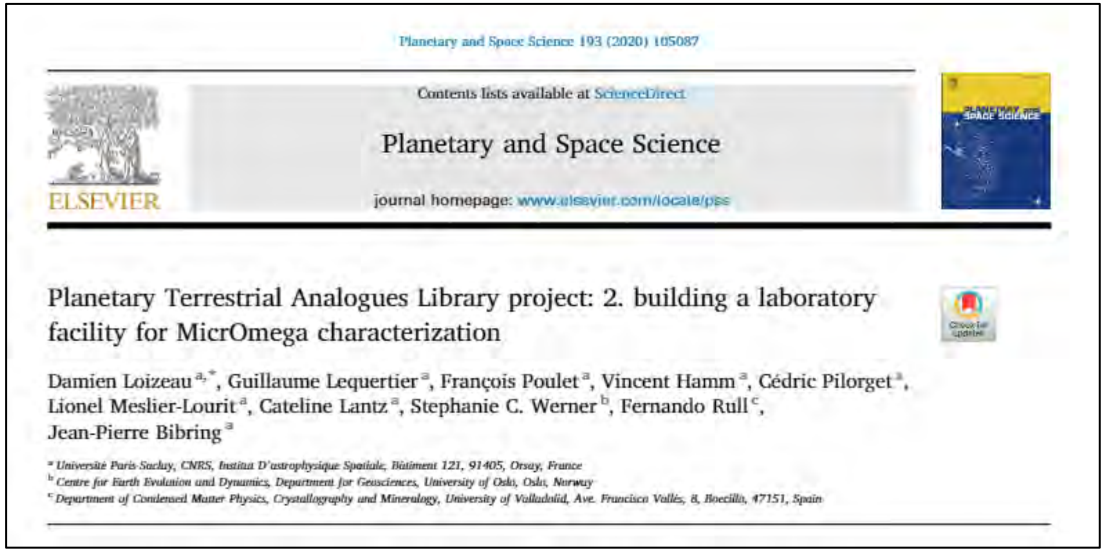
https://doi.org/10.1016/j.pss.2020.105087



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Planetary Terrestrial Analogues Library project: 2. building a laboratory facility for MicrOmega characterization

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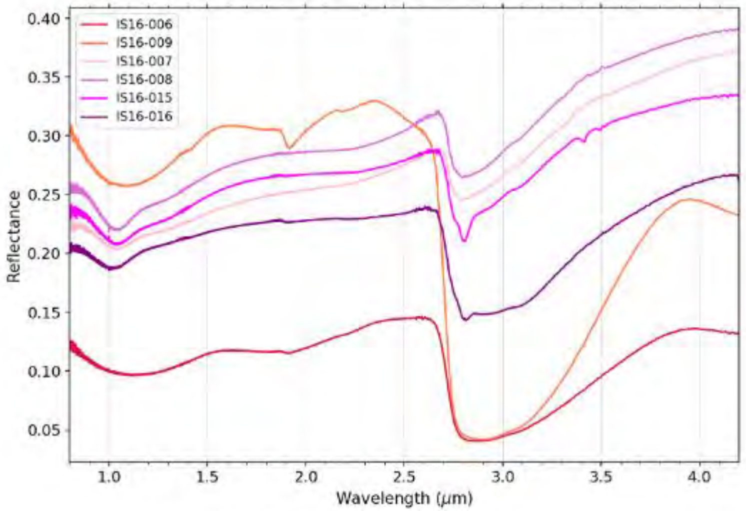
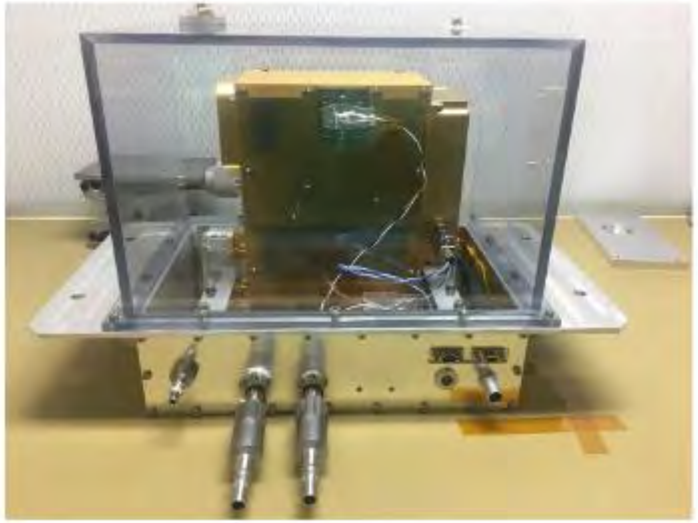
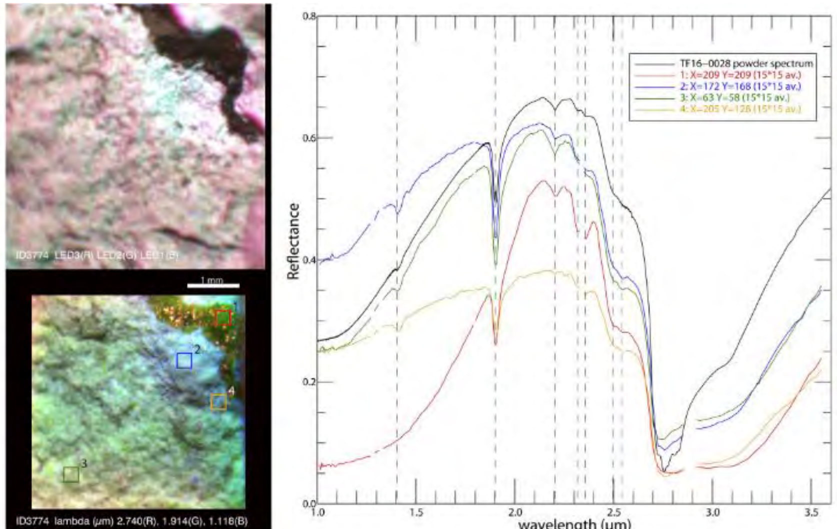
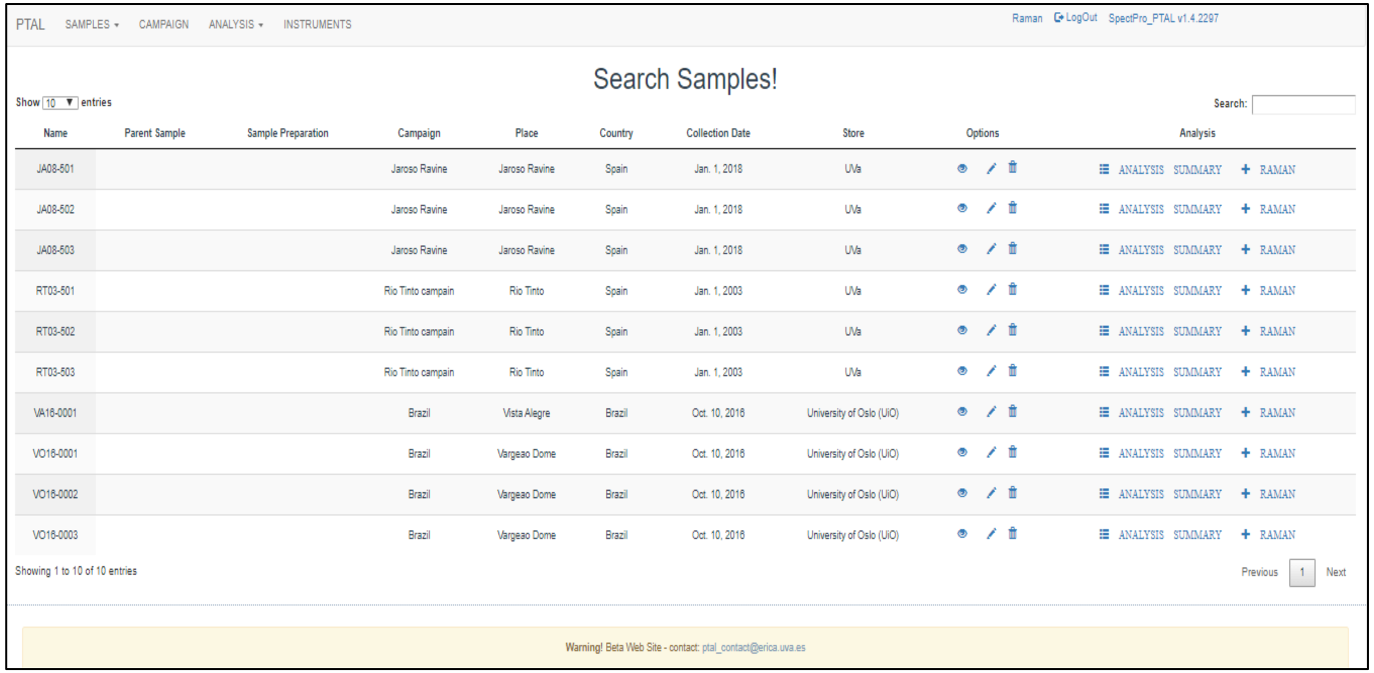






Section 2
The PTAL platform

http://erica.uva.es/PTAL/



PTAL SAMPLES CAMPAIGN ANALYSIS INSTRUMENTS Raman LogOut SpectPro_PTAL v1.4.2297

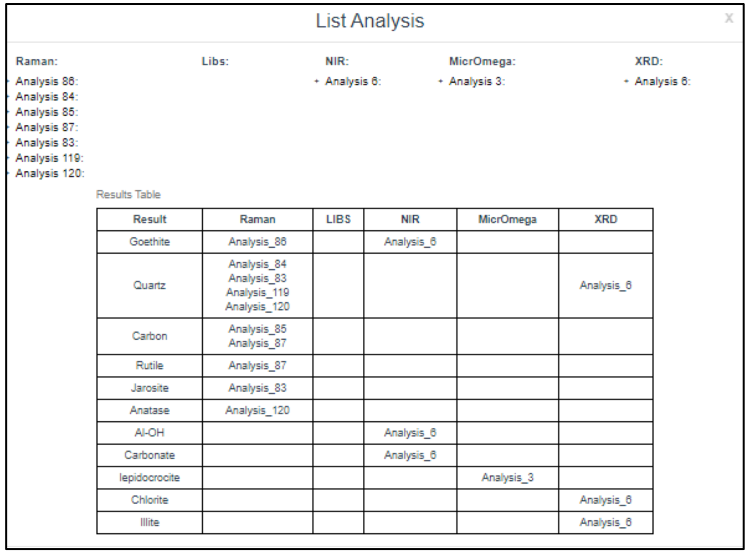
Search Samples!

Show 10 entries Search:

Name	Parent Sample	Sample Preparation	Campaign	Place	Country	Collection Date	Store	Options	Analysis
JA08-501			Jaroso Ravine	Jaroso Ravine	Spain	Jan. 1, 2018	UVa		ANALYSIS SUMMARY + RAMAN
JA08-502			Jaroso Ravine	Jaroso Ravine	Spain	Jan. 1, 2018	UVa		ANALYSIS SUMMARY + RAMAN
JA08-503			Jaroso Ravine	Jaroso Ravine	Spain	Jan. 1, 2018	UVa		ANALYSIS SUMMARY + RAMAN
RT03-501			Rio Tinto campain	Rio Tinto	Spain	Jan. 1, 2003	UVa		ANALYSIS SUMMARY + RAMAN
RT03-502			Rio Tinto campain	Rio Tinto	Spain	Jan. 1, 2003	UVa		ANALYSIS SUMMARY + RAMAN
RT03-503			Rio Tinto campain	Rio Tinto	Spain	Jan. 1, 2003	UVa		ANALYSIS SUMMARY + RAMAN
VA16-0001			Brazil	Vista Alegre	Brazil	Oct. 10, 2016	University of Oslo (UiO)		ANALYSIS SUMMARY + RAMAN
VO16-0001			Brazil	Vargeao Dome	Brazil	Oct. 10, 2016	University of Oslo (UiO)		ANALYSIS SUMMARY + RAMAN
VO16-0002			Brazil	Vargeao Dome	Brazil	Oct. 10, 2016	University of Oslo (UiO)		ANALYSIS SUMMARY + RAMAN
VO16-0003			Brazil	Vargeao Dome	Brazil	Oct. 10, 2016	University of Oslo (UiO)		ANALYSIS SUMMARY + RAMAN

Showing 1 to 10 of 10 entries Previous 1 Next

Warning! Beta Web Site - contact: ptal_contact@erica.uva.es



List Analysis

Raman:
- Analysis 86:
- Analysis 84:
- Analysis 85:
- Analysis 87:
- Analysis 83:
- Analysis 119:
- Analysis 120:

Libs:

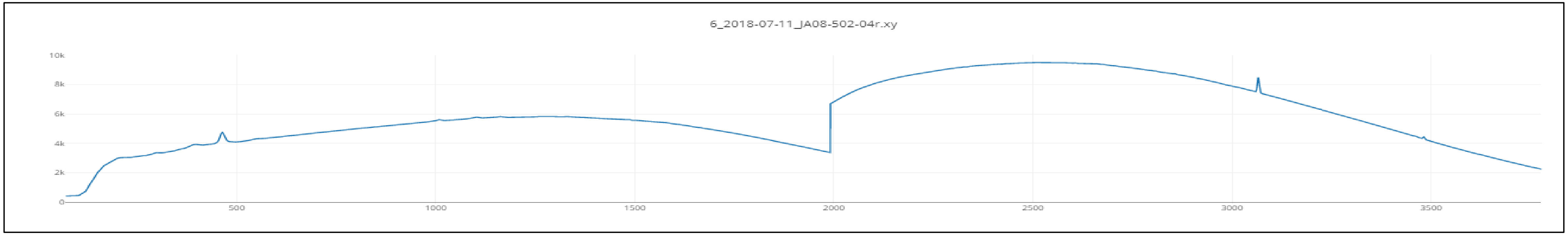
NIR:
- Analysis 6:

MicrOmega:
- Analysis 3:

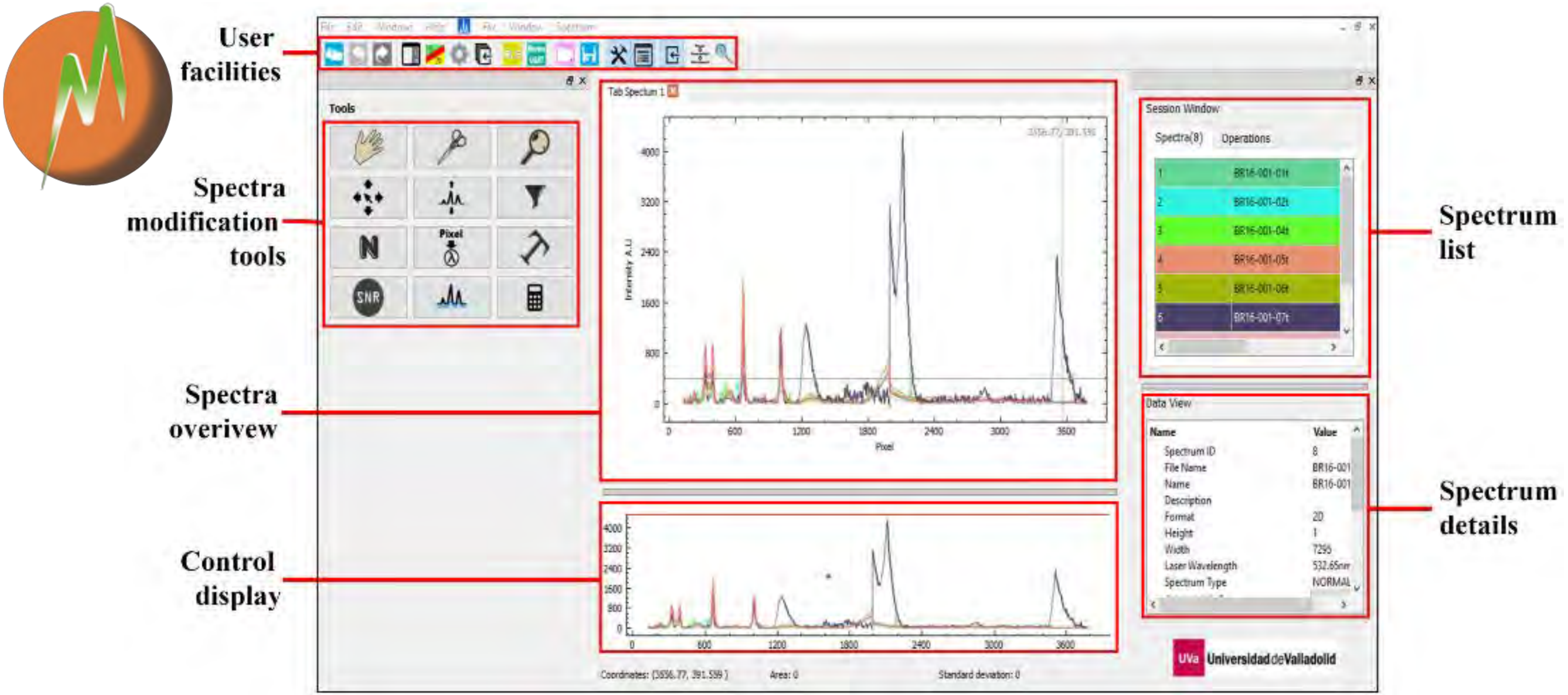
XRD:
- Analysis 6:

Results Table

Result	Raman	LIBS	NIR	MicrOmega	XRD
Goethite	Analysis_86		Analysis_6		
Quartz	Analysis_84 Analysis_83 Analysis_119 Analysis_120				Analysis_6
Carbon	Analysis_85 Analysis_87				
Rutile	Analysis_87				
Jarosite	Analysis_83				
Anatase	Analysis_120				
Al-OH			Analysis_6		
Carbonate			Analysis_6		
lepidocrocite				Analysis_3	
Chlorite					Analysis_6
Illite					Analysis_6



Section 2
The SpectPro software



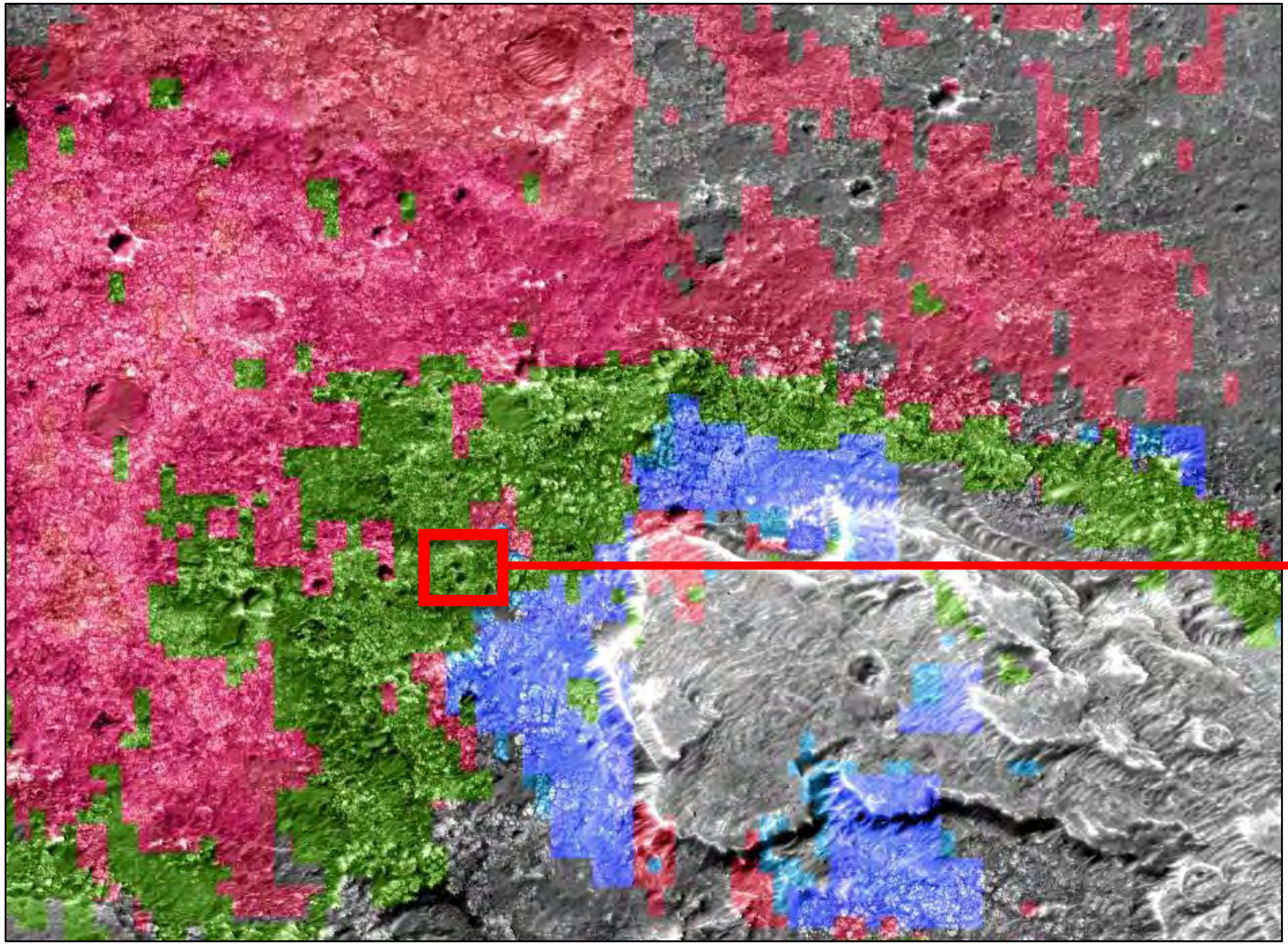
Section 2

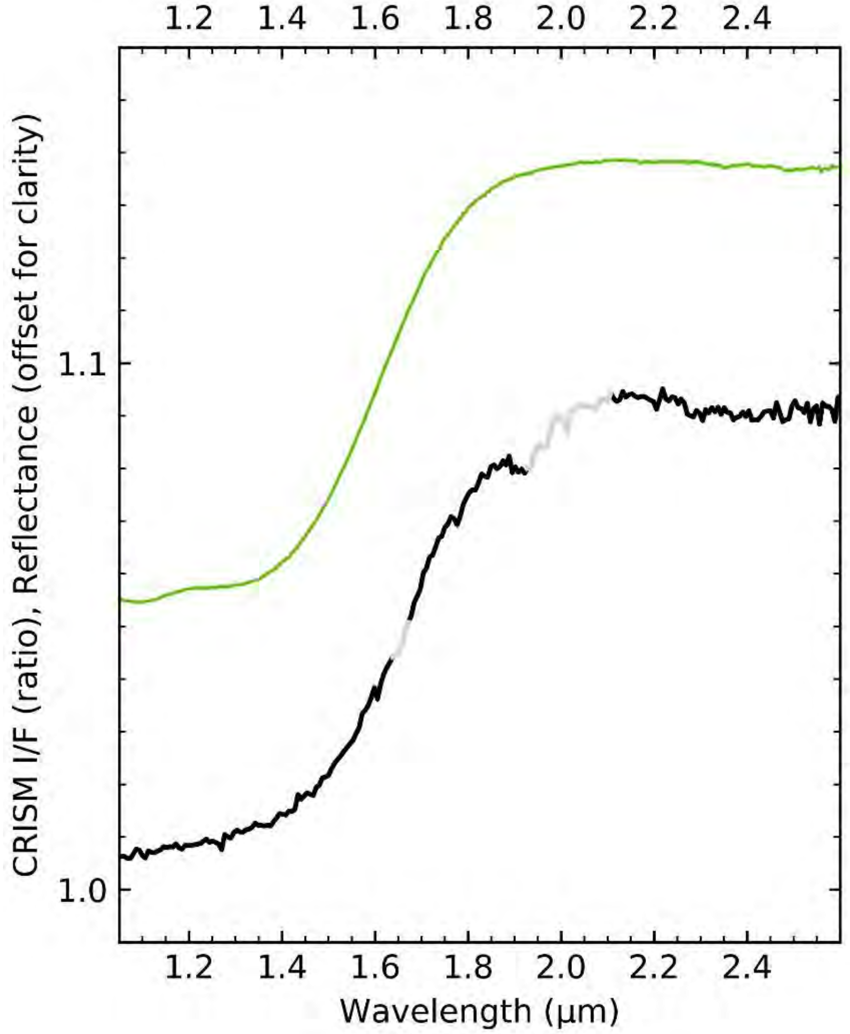
Physical access to the samples

Section 3

Insights on PTAL terrestrial analogue materials and related studies

Distribution map of olivine bearing rocks detected at Oxia Planum





Section 3
Multi-analytical study of olivine bearing rocks

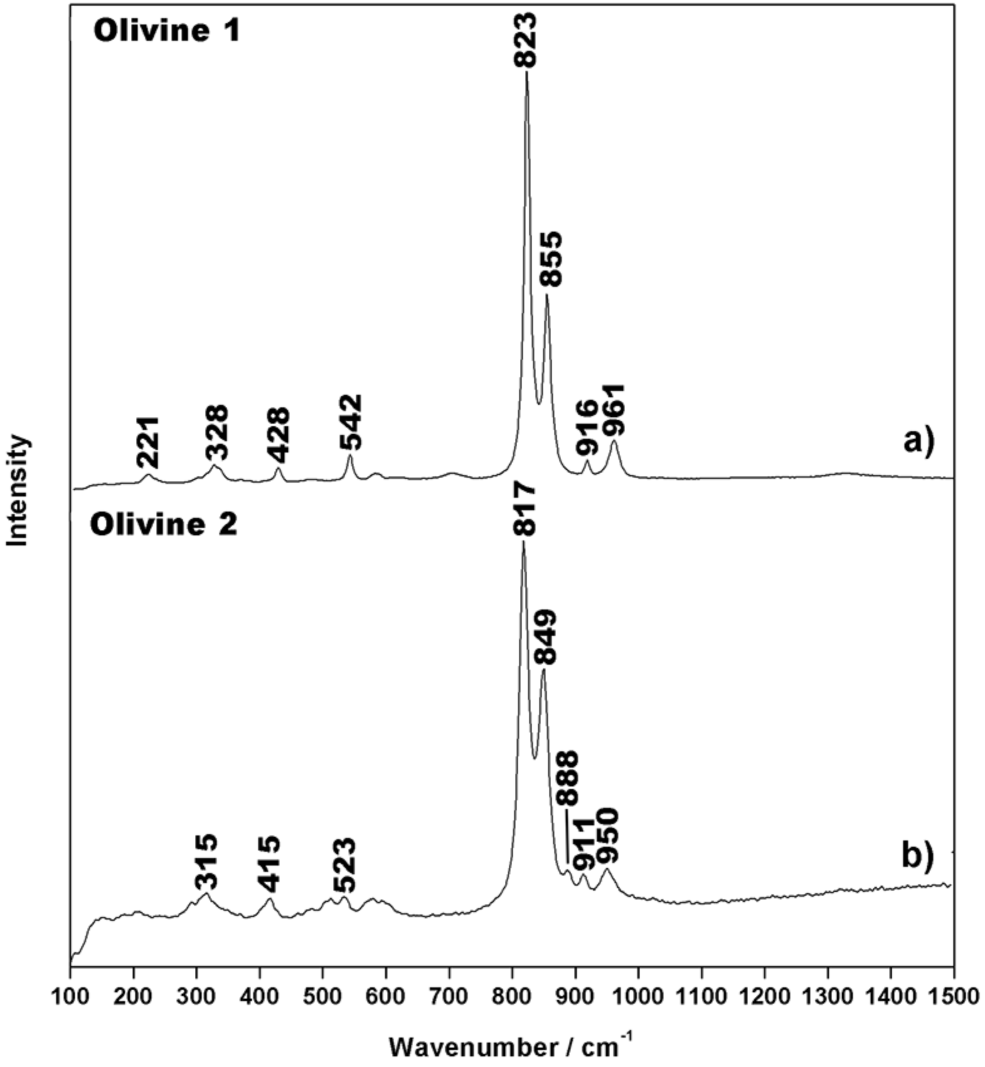
Comparing XRD, NIR and Raman data collected from olivine-bearing terretrial analogues (Iceland)

Table 1
mineralogical results comparison (the values included between parentheses represent the semi-quantitative estimation obtained by each technique).

Detected compounds		IS16-0001				IS16-0002				IS16-0013			
		Commercial instruments			RLS ExoMars Simulator	Commercial instruments			RLS ExoMars Simulator	Commercial instruments			RLS ExoMars Simulator
		XRD	NIR	Raman		XRD	NIR	Raman		XRD	NIR	Raman	
	Diopside		X (44%)	X	X		X (35%)	X	X			X	X
	Augite	X (35%)	X (9%)	X	X	X (48%)	X (33%)	X	X	X (50%)	X (78%)	X	X
Pyroxene	Pigeonite										X (6%)	X	
	Plagioclase	X (40%)	X (44%)	X	X	X (40%)	X (30%)	X		X (40%)	X (15%)	X	X
	Ternary											X	
Feldspar	Anorthite			X									
Olivine	Forsterite	X (25%)	X (<5%)	X	X	X (11%)	X (<5%)	X	X	X (3%)			X
	Ilmenite	X (<5%)	X (<1%)	X			X (2%)	X			X (<1%)		
	Anatase				X								
Ti/Fe-oxides	Hematite	X (<5%)		X				X				X	X
	Ankerite	X (<5%)				X (<5%)				X (<5%)			
Carbonates	Calcite	X (<5%)		x	X	X (<5%)				X (<5%)			
	Carbon			X				X					
Others	Apatite											X	X

Section 3
Multi-analytical study of olivine bearing rocks

Raman-based determinaton of olivines FoFa ratio



OLIVINE

Forsterite (Fo, Mg_2SiO_4) ⟷ **Fayalite (Fa, Fe_2SiO_4)**

$$\%Mg = -610.65 + 1.3981K_1 - 0.00079869K_1^2$$

$$\%Mg = -3715.8 + 8.9889K_2 - 0.0054348K_2^2$$

T. Mouri, M. Enami, *J. Mineral. Petrol. Sci.* 2008, **103**, 100

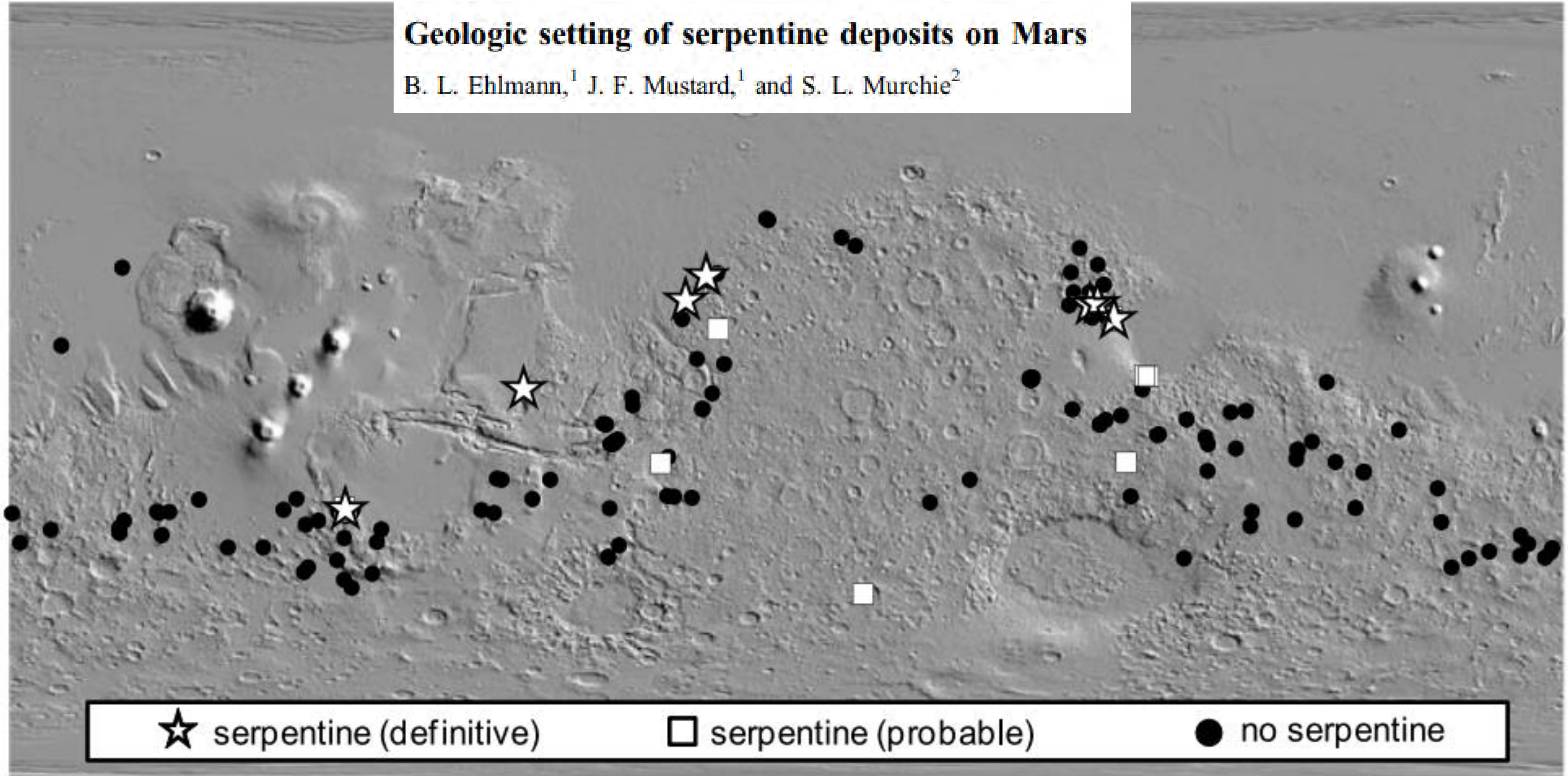
$$\%Mg = \frac{-38847.1256 + 86.9086K_1 - 0.048382K_1^2}{100}$$

$$\%Mg = \frac{-484679.0451 + 1172.7260K_2 - 0.70923K_2^2}{100}$$

K. E. Kuebler et al. *Geochim. Cosmochim. Acta* 2006, **70**, 6201

IS16-0001	**$Fo_{86}Fa_{14}$ ←→ $Fo_{64}Fa_{36}$**
IS16-0002	**$Fo_{86}Fa_{14}$ ←→ $Fo_{64}Fa_{36}$**
IS16-0013	**$Fo_{83}Fa_{17}$**

Section 3
Analysis of serpentinization degree of olivine bearing rocks

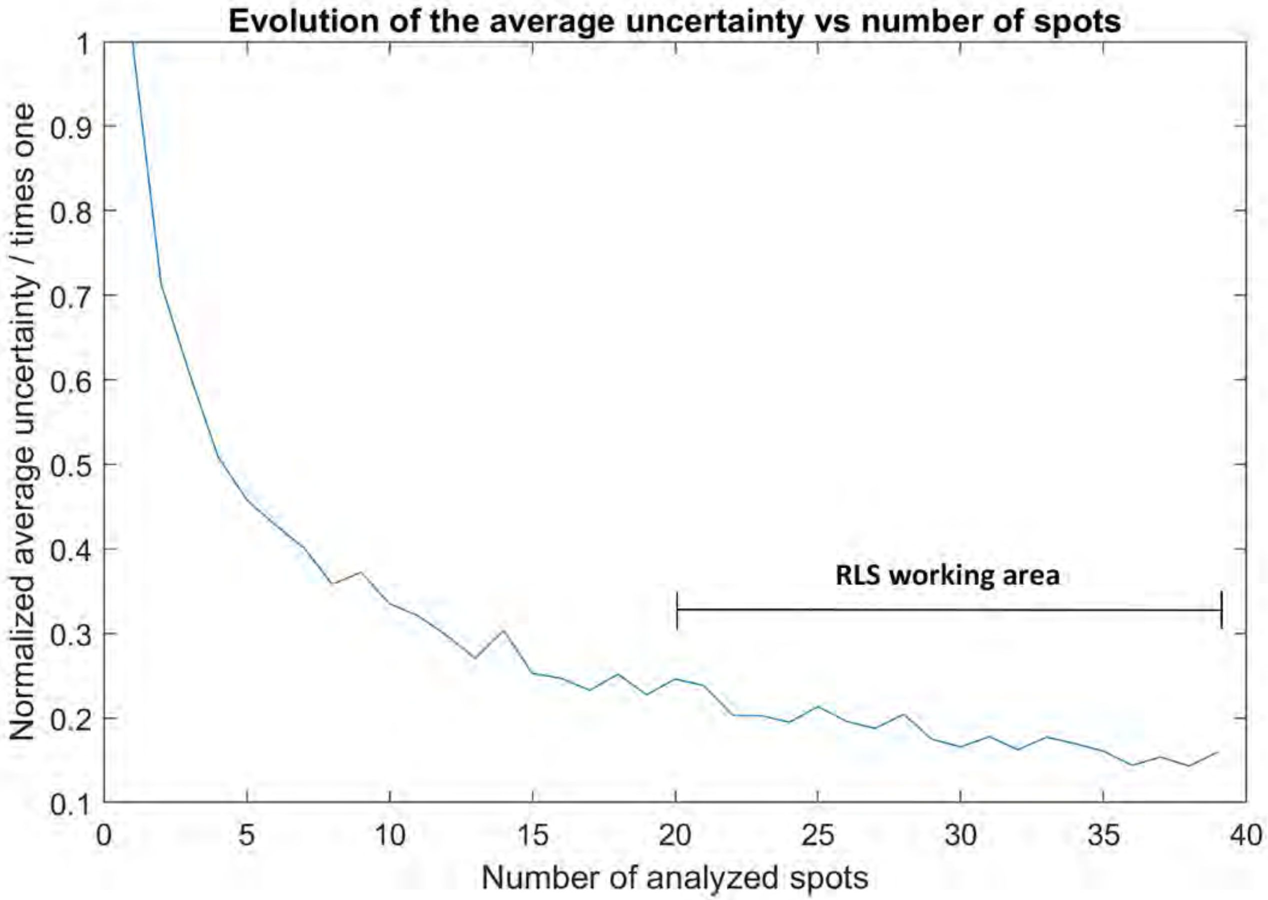


Section 3
Multi-analytical study of olivine bearing rocks

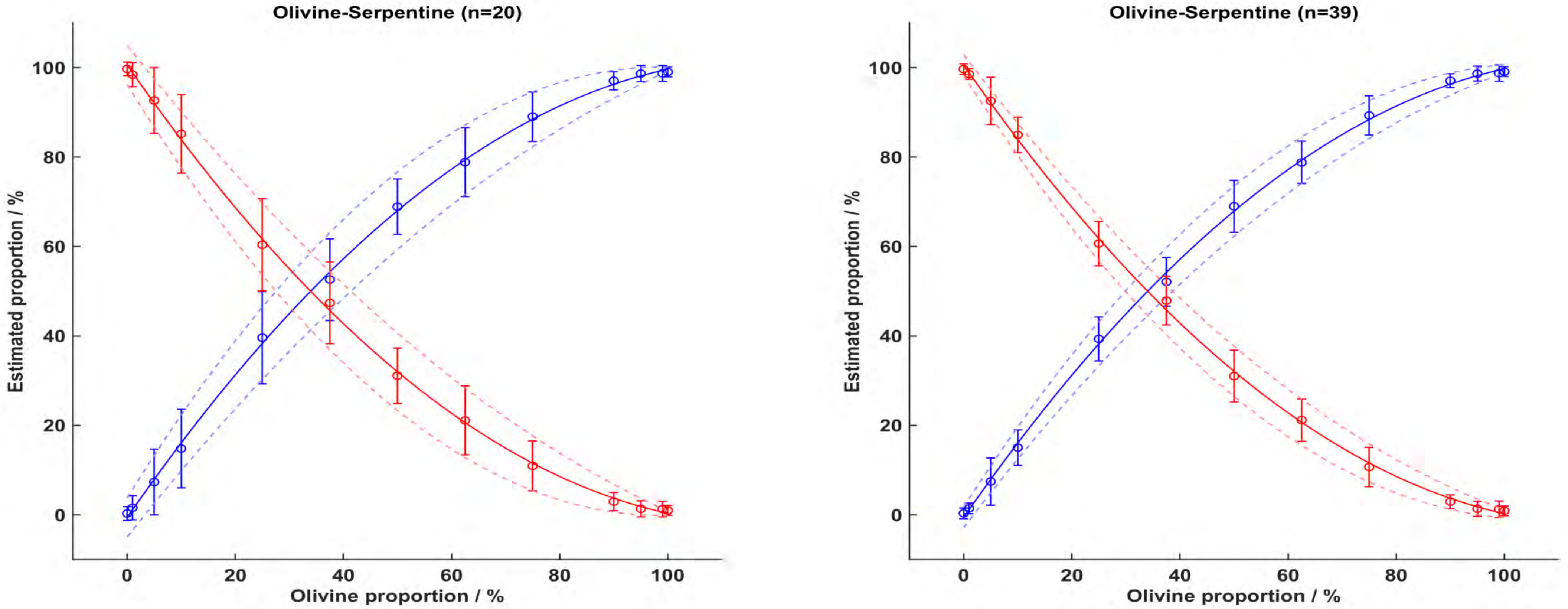
Sample ID	Olivine (wt%)	Serpentine (wt%)
M0	0.00	100.00
M1	1.10	98.90
M5	5.09	94.91
M10	9.99	90.01
M25	24.98	75.02
M37.5	37.45	62.55
M50	50.10	49.90
M62.5	63.34	37.66
M75	75.10	24.90
M90	89.94	10.06
M95	94.89	5.11
M99	98.90	1.10
M100	100.00	0.00

RLS ExoMars Simulator:

By increasing the numbers of analysis por line, the normalized avarage uncertainity decrease. Between 20 and 39 spectra (RLS working area), can be used to obtain reliable semiquantification estimations.



Section 3
Multi-analytical study of olivine bearing rocks



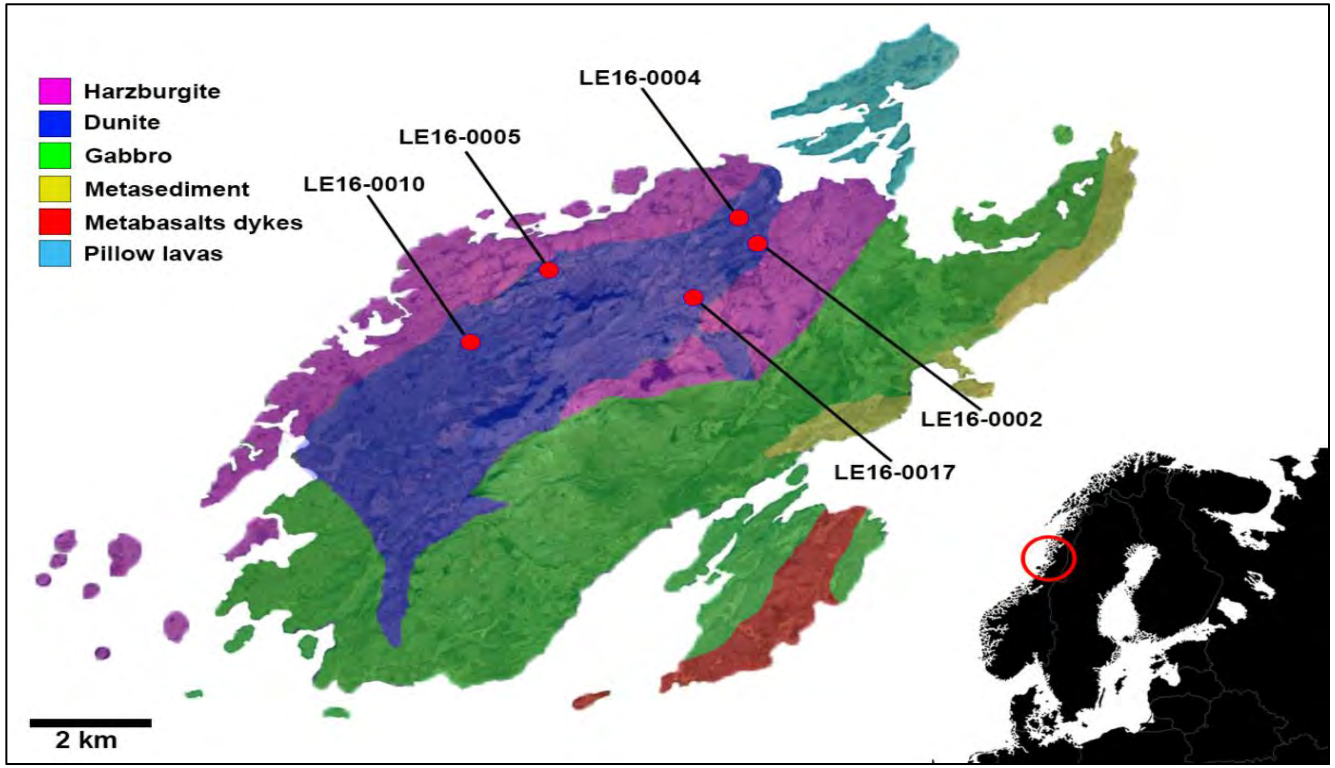
$proportion_{olivine}(20\ spots) = -0.007394 \cdot r_{oli}{}^2 + 1.742 \cdot r_{oli} - 0.5958;$ $R^2 = 0.9995$

$proportion_{serpentine}(20\ spots) = 0.007394 \cdot r_{serp}{}^2 - 1.742 \cdot r_{serp} + 100.6;$ $R^2 = 0.9993$

$proportion_{olivine}(39\ spots) = -0.007328 \cdot r_{oli}{}^2 + 1.736 \cdot r_{oli} - 0.5731;$ $R^2 = 0.9994$

$proportion_{serpentine}(39\ spots) = 0.007328 \cdot r_{serp}{}^2 - 1.736 \cdot r_{serp} + 100.6;$ $R^2 = 0.9994$

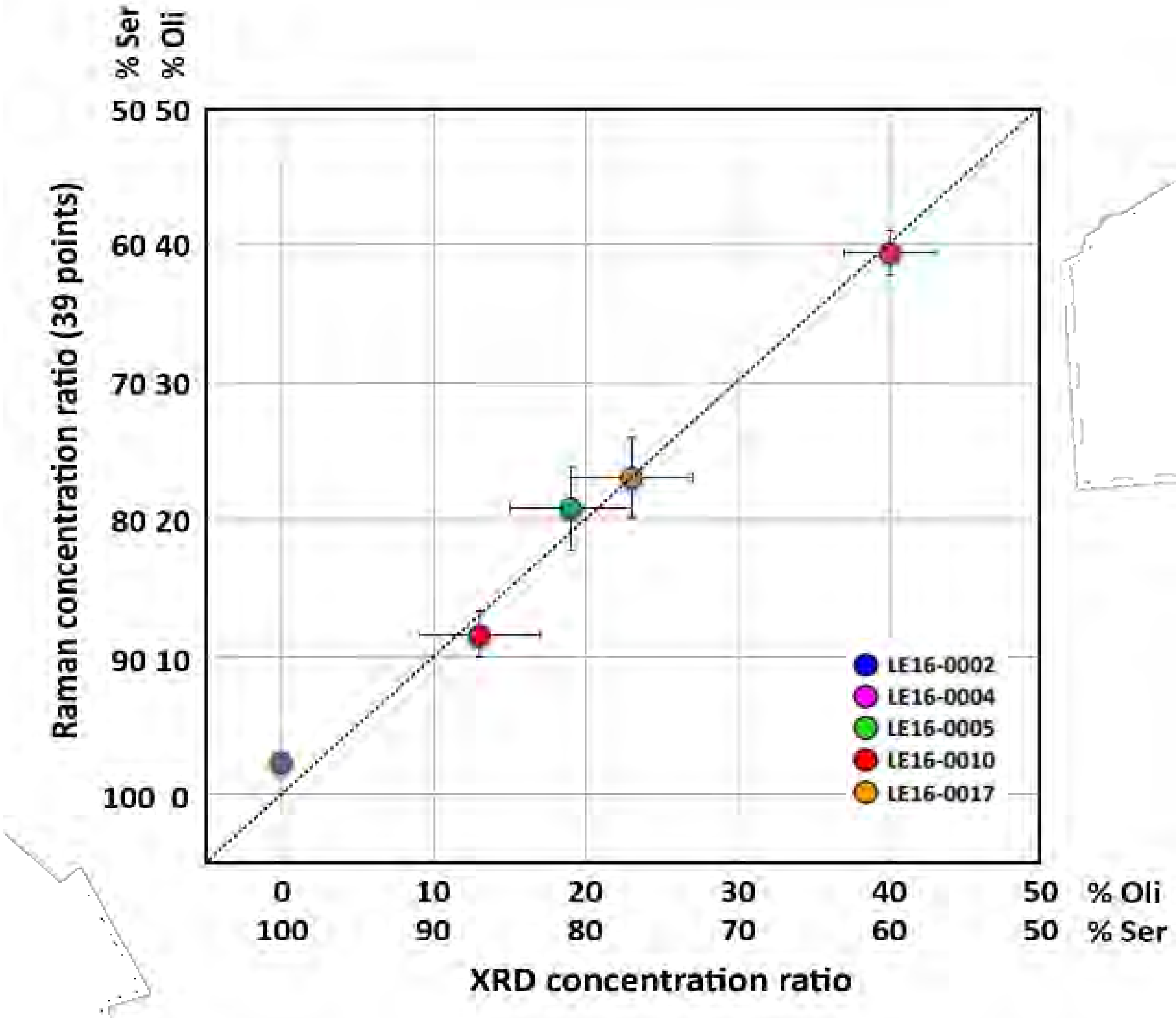
Section 3
Multi-analytical study of olivine bearing rocks



LE16-0002	LE16-0004	LE16-0005	LE16-0010	LE16-0017
Serpentine	Serpentine	Serpentine	Serpentine	Serpentine
Pyroxene	Olivine	Olivine	Olivine	Olivine
Fe-oxides	Pyroxene	Pyroxene	Mg-hydroxide	Fe-oxides
	Mg-hydroxide	Mg-hydroxide	Fe-oxides	Pyroxene
	Fe-oxides	Fe-oxides	Pyroxene	Calcite
		Ilmenite	Unknown phyllosilicate	

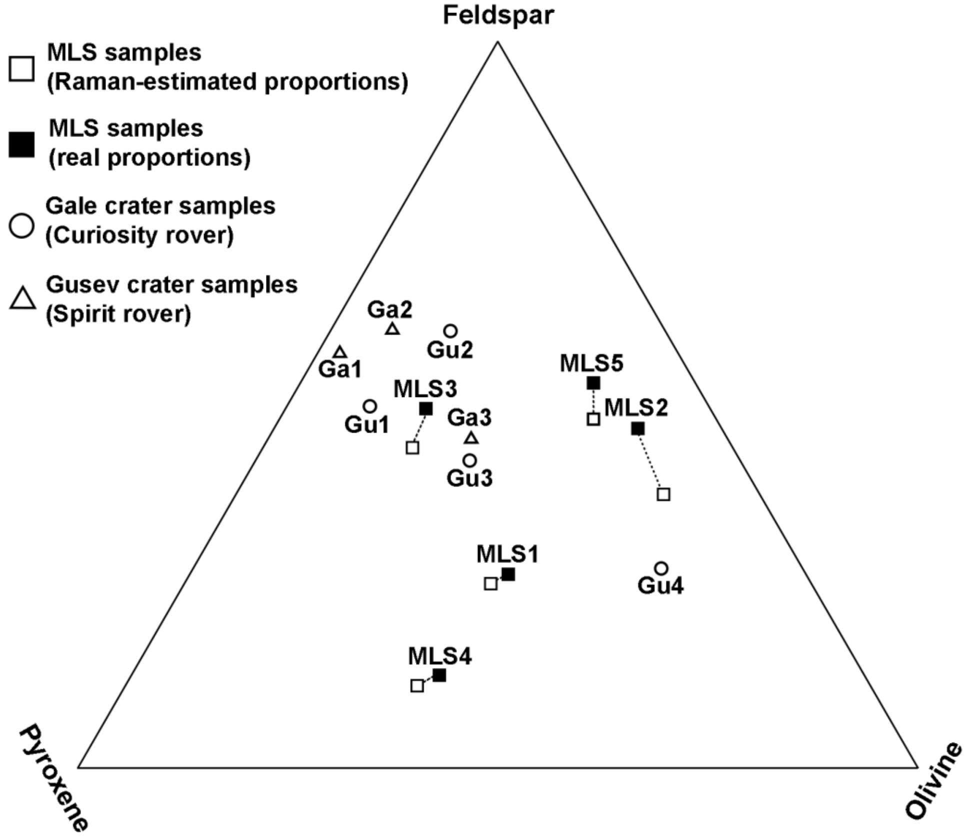
XRD
NIR
microRaman
RLS ExoMars Simulator

Raman determination of olivine, serpentine concentration ratio

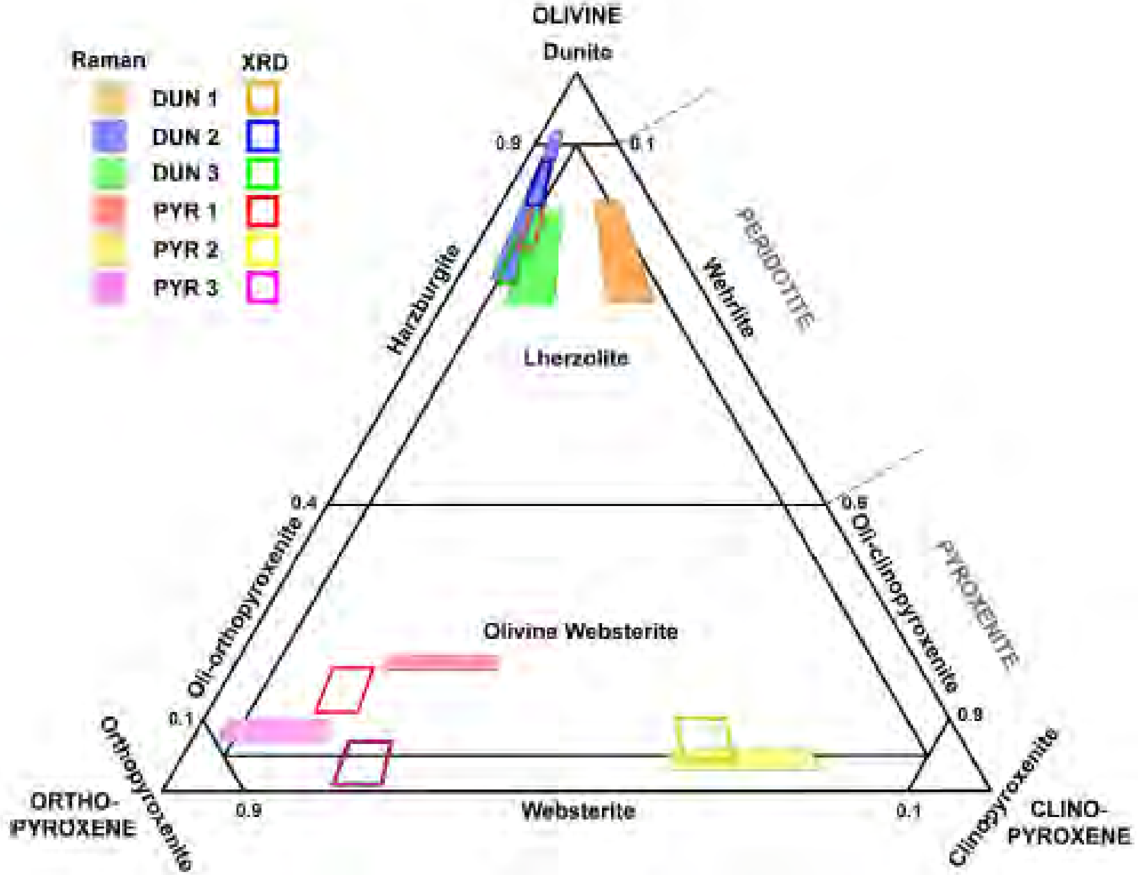


Section 3
Multi-analytical study of olivine bearing rocks

Raman-based classification of ultramafic igneous rocks on Mars – complex mixtures



XRD-Raman analysis of Martian basaltic analogues



XRD-Raman analysis of ultramafic terrestrial analogues (dunite-peridotite)

https://doi.org/10.1016/j.icarus.2021.114542

https://doi.org/10.1038/s41598-020-73846-y

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