EuroGeoMoonMars:

Validation of Instruments, Robotics, EVAs and Human Research from Field Campaign in Utah

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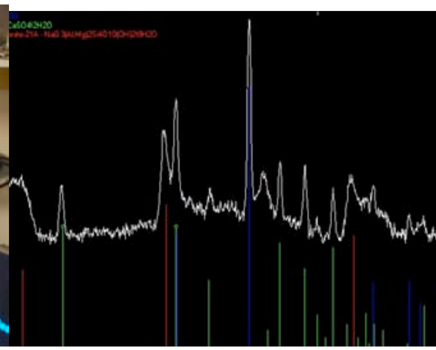
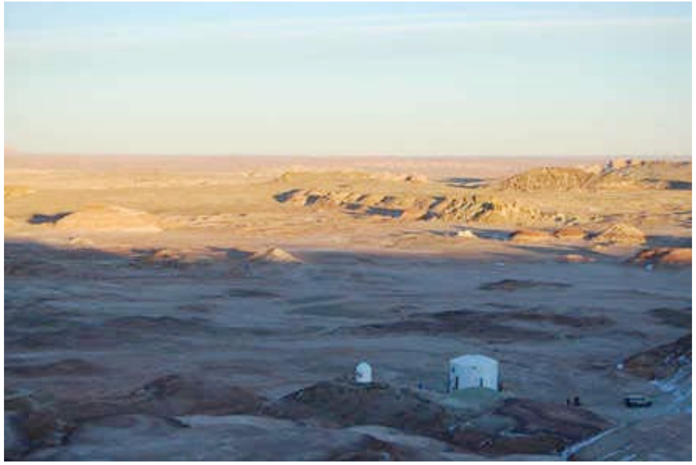
- *1ESTEC/SRE-S Postbus 299, 2200 AG Noordwijk, NL, 2ESTEC HSF Human Spaceflight, 3NASA Ames, 4ESTEC TEC Technology Dir., 5Delft TU Geology and Civil Engineering , 6VU Amsterdam, 7ESTEC Education Office, 8FU Berlin, , 9Delft TU Aerospace, 10Goettingen, 11Bristol U, 12Cranfield U, 13George Washington U, 14 Astrobiology Lab, Leiden U. , * EuroGeoMars crew*

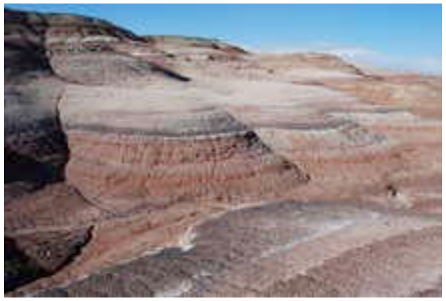



ExoGeoLab/ExoHab Field Tests: Goals EuroGeoMars MDRS 24 Jan-28 Feb 2009

- Instrument Technology Field demonstration
- Research supporting science and exploration
  - Geology
  - Geochemistry
  - Astrobiology
  - Biology
- Human aspects studies (supported HSF)
  - Crew operations
  - Simulations and EVAs
- Outreach and education

The geological scene, Utah





EuroGeoMars MDRS Crew 77
Feb. 15, 2009 - Feb. 28, 2009

- **Bernard Foing,** Commander / Instrumentation / Researcher (Mars-Moon-Earth science and exploration)
- **Pascale Ehrenfreund,** Executive Officer / Crew Scientist / Researcher (astrobiology, planetary, astronomy) / Health Safety
- **Ludivine Boche-Sauvan,** Crew Engineer / Logistics Coordinator/ Database manager / Researcher (human base aspects) / Food study
- **Cora Thiel,** Crew Scientist / Researcher (biologist)
- **Christoph Gross,** Crew Scientist / Researcher (geochemistry, XRD, Raman)
- **Lorenz Wendt,** Crew Scientist / Researcher (geophysics, drilling, robotics)

- **Guest crew:** Jeanette, Zoot, Jhony Zavaleta and co
- **Remote support:** Enguerran Petit-Fils, Pooja Mahapatra

14 Instrument Technology Field demonstrations at MDRS

- X-Ray Diffractometer/ X-Ray Fluorescence
- Visible-Infrared reflectance*
- Raman spectroscopy*
- PCR Polymerase Chain Reaction*
- Microscopy*
- Integration of research laboratory*
- Multiple camera system and data acquisition*
- Sample acquisition/ documentation*
- Soil analysis kit*
- Ground Penetrating Radar*
- Drilling core samples
- Remote control Field rover, cameras and instruments*
- Optical Positioning/Navigation experiment *
- Cyborg Astrobiologist

(*ExoGeoLab or equivalent)

Crew 77 sampling and analysis

Frozen pond canyon

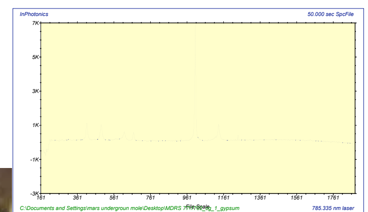
Sampling brigade reaching for the right tuff

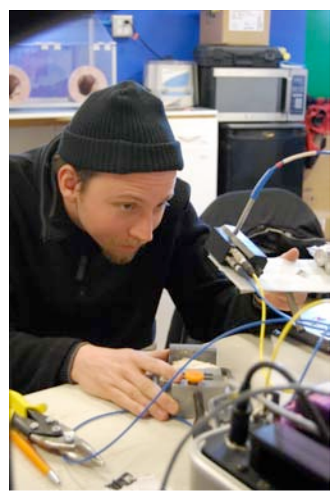
Risotto Morrison, inspired by back ridge layered clay and sandstone

Biologists with soil kit analysis: who has more phosphor?

Geochemistry sample measurements

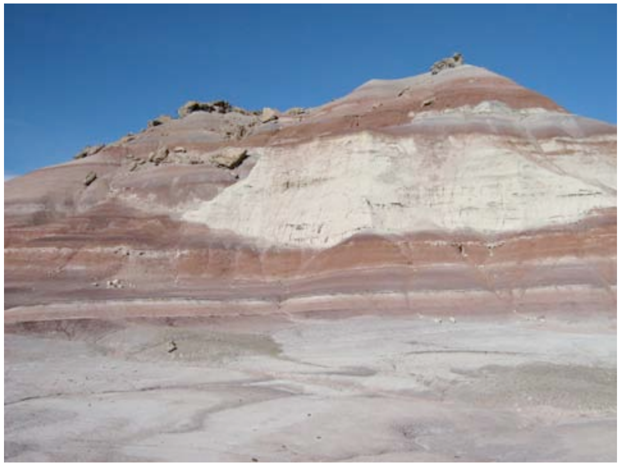
- X-Ray Diffractometer/ X-Ray Fluorescence
- Visible-Infrared reflectance*
- Raman spectroscopy*
- Microscopy*

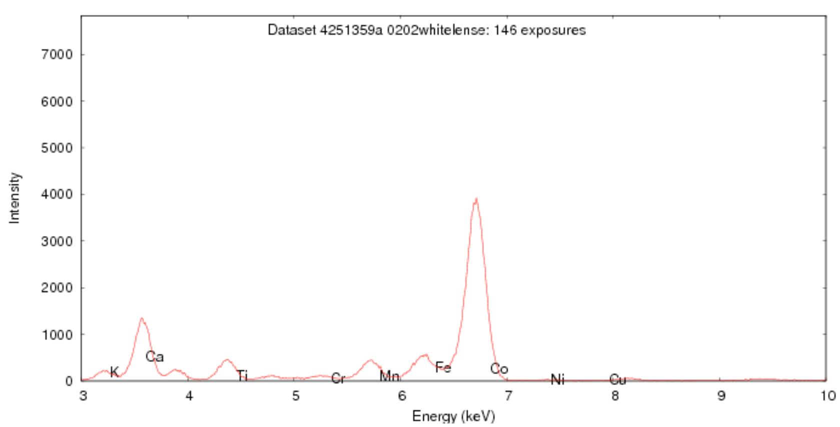




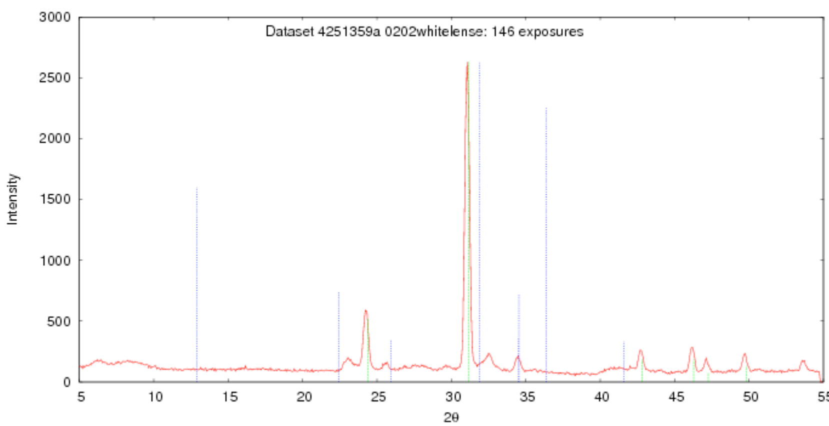
12_S_0518689_4251359a_0202whitelense

White, well sorted sandstone (microscopic)
part of a white channel-fill like lense in the Brushy basin member (Morrison formation).
This lense contains crossbedding structures.
Composition: Quartz Ca peak, Ti and Mn, low Fe.



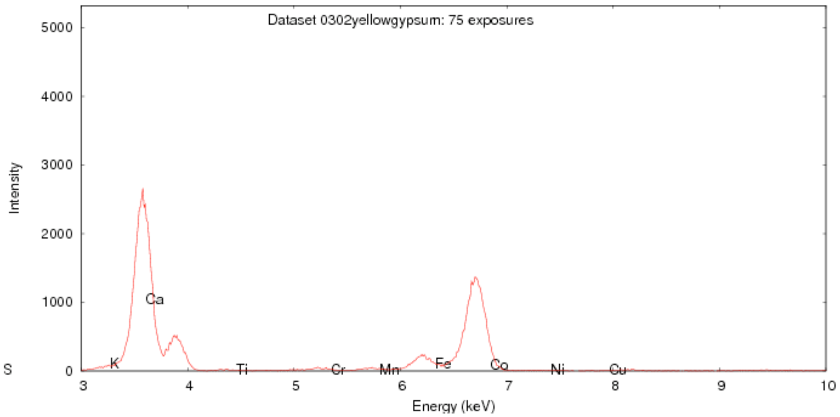


X-Ray Fluorescence (elements)

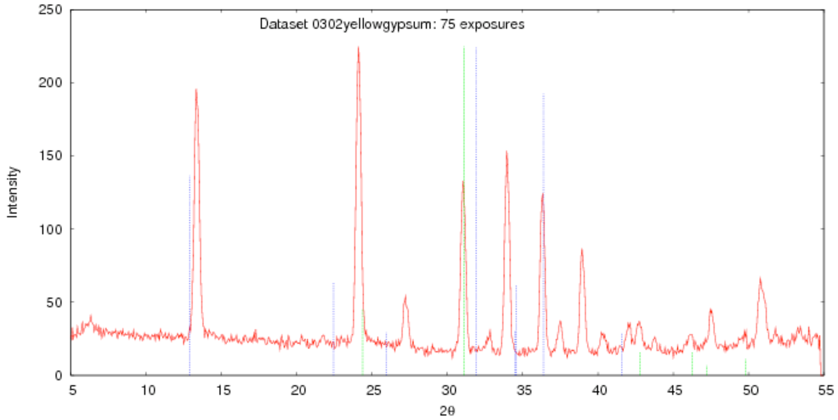


X-Ray Diffractometer (Mineralogy)

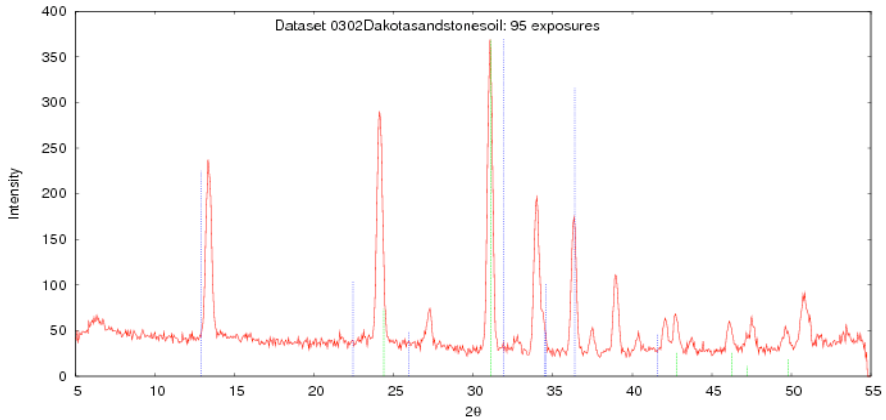
12_S_0518689_4251359b_0202greenlayers

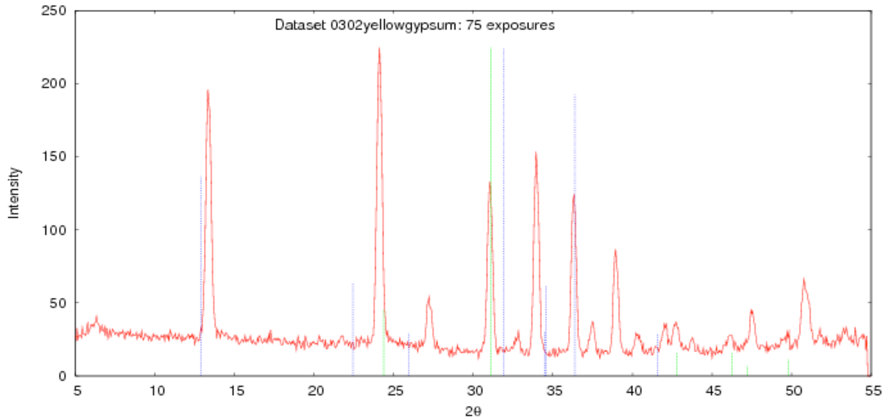


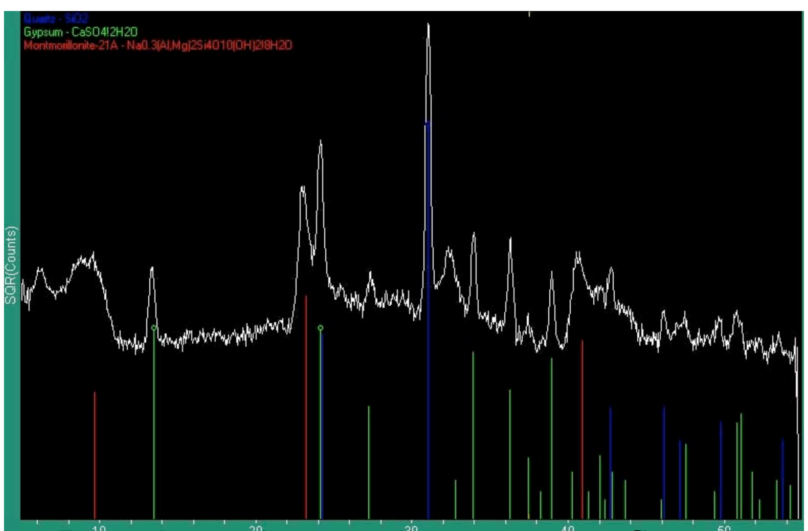
X-Ray Fluorescence (elements)



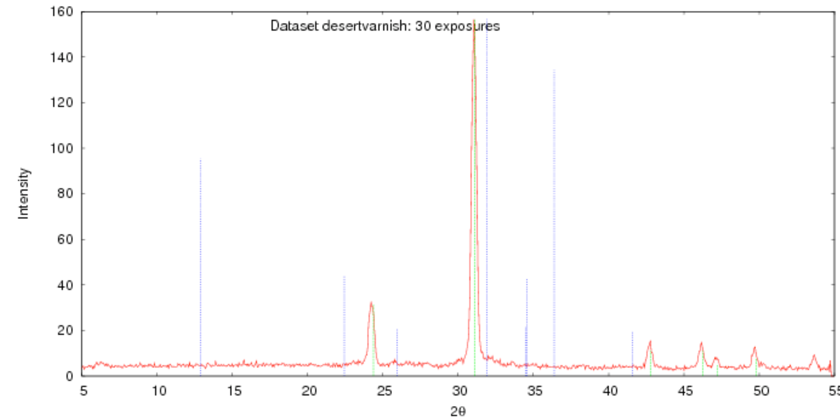
X-Ray Diffractometer (Mineralogy)

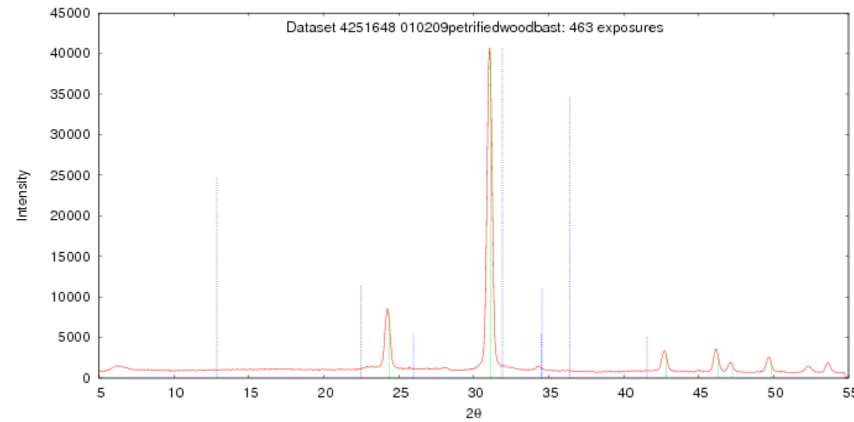


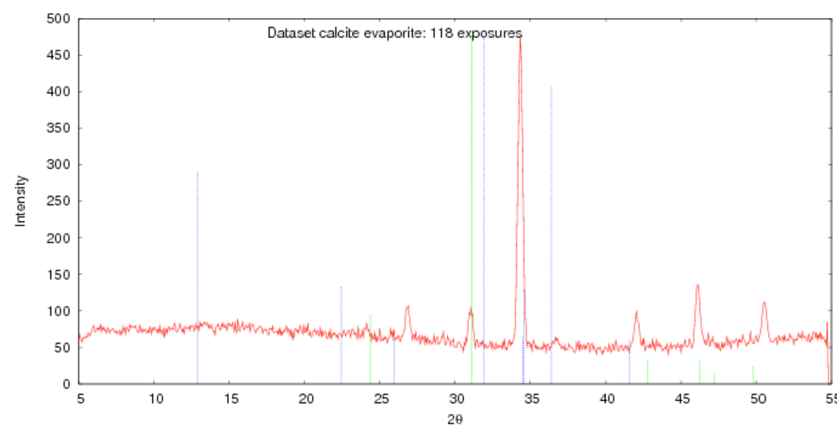




Borehole1-core4-claylevel-film-3

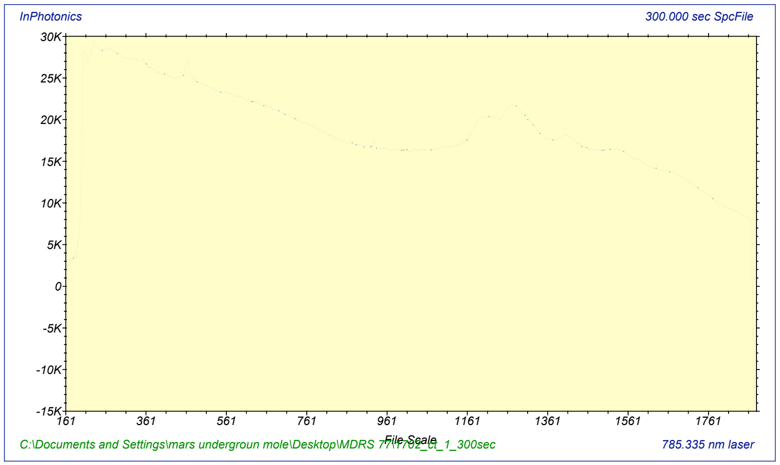


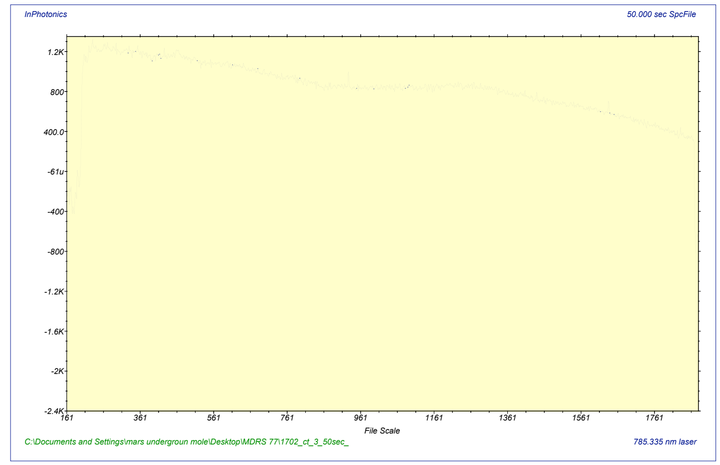


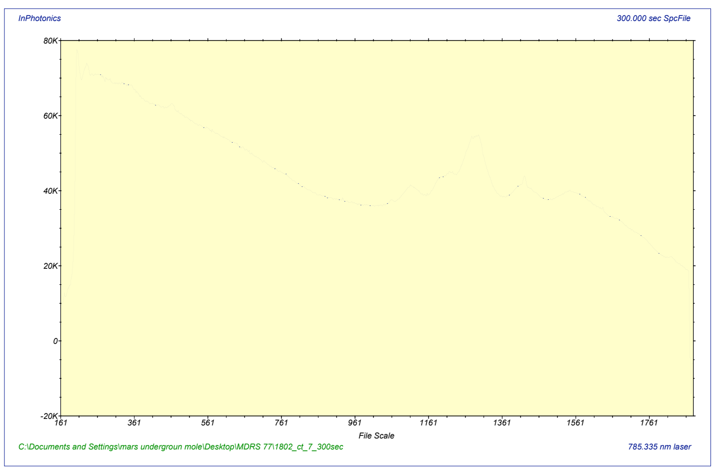


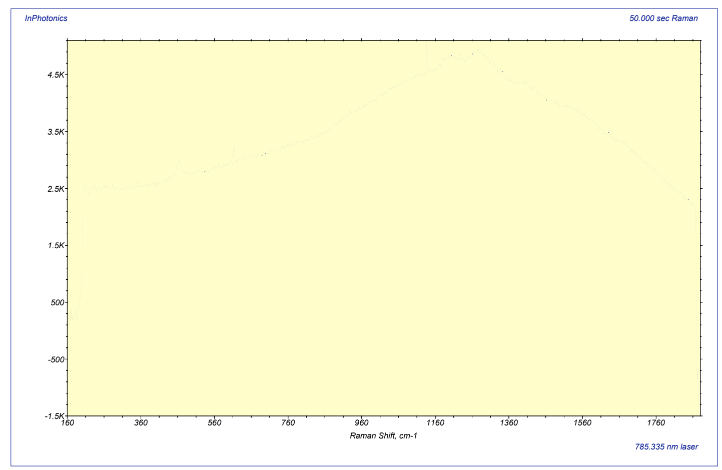
XRD: mineral composition

1702_ct_1_300sec_full, 1702_ct_3_50sec_full, 1802_ct_7_300sec_full (green), 2002_ct_16_50sec_full





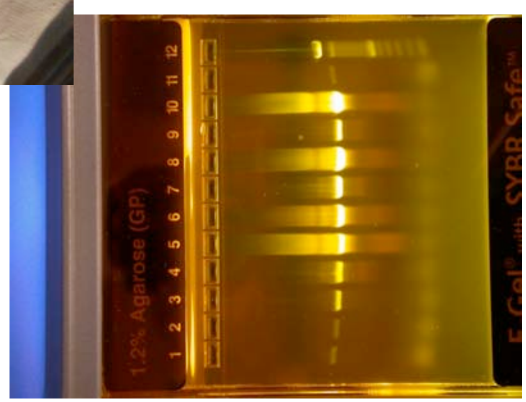




Raman spectra of various clays

Life sensors

- Sample acquisition/ documentation*
- Soil analysis kit*
- Microchip Oxidation Sensor
  (ExoMars MOI)
- PCR Polymerase Chain Reaction*
- Integration of research biology laboratory*



EuroGeoMoon

- Instruments technology demonstration
- Habitat studies
- 7-15 days duration similar to lunar sorties
- Human operations
- EVAs
- Sampling igneous rocks at Mt Henry
- Sampling in Moon-like illumination and soil conditions

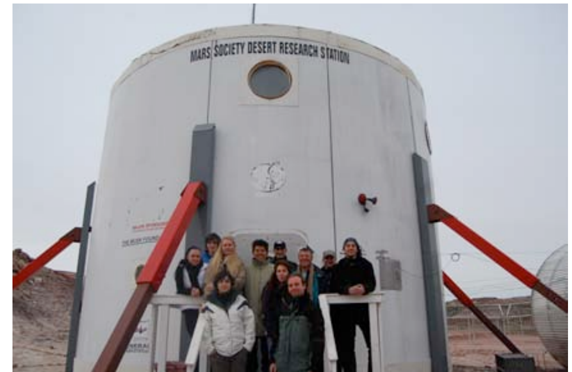
EuroGeoMoon

EVAs /Outside field instruments

- Multiple camera system and data acquisition*
- Ground Penetrating Radar*
- Drilling core samples
- Remote control Field rover, cameras and instruments*
- Optical Positioning/Navigation experiment *


Screws & Bolts

Human aspects

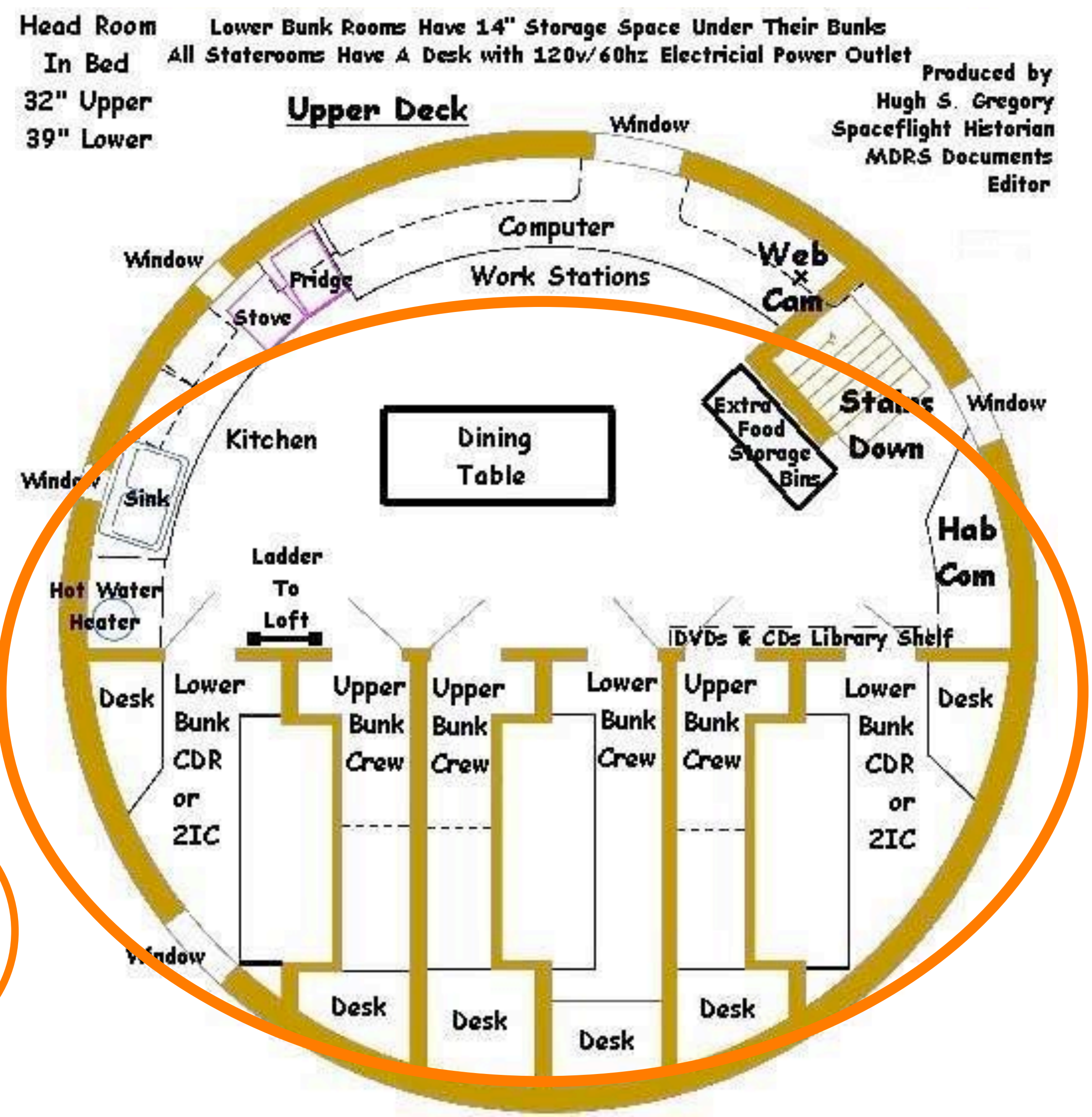


- Habitat technologies:
  - Hab structure and architecture
  - power,
  - grey water,
  - Greenhouse
  - Laboratory
- Human aspects
  - Time sheets
  - Performance
  - EVAs suits
  - Food study

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	26-Feb	Full sim + 14 EVA tasks + lab					Commander	Exec-O	Engineer	Scientist	Scientist 2	Bio		Film crew	
2	When	What	How	Where						Raman/XRD	GPR	PCR			
3															
4															
5					Who	Crew2	Bernard	Pascale	Ludivine	Christoph	Lorenz	Cora		Jhony	Amesx3
6	8:00									X				Zavaleta	
7								Cook		Email	Email	cook			
8	9:00	Breakfast		Hab			Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast			
9		Briefing					Briefing	Briefing	Briefing	Briefing	Briefing	Briefing			
10	10:00	Laboratory and data analysis						vehicle		XRD-XRF	EVA cams	gel electrophoresis			
11		EVA x2 and welcome of NASA Ames visitors					EVA	telecon	space suit	XRD-XRF	EVA cams	gel electropho		EVA	EVA cams
12	11:00	Ames visitors in hab					visit	telecon H/C	space suit	XRD-XRF		database			visit hab
13	11:30						visit	telecon H/C		XRD-XRF		Prep			visit hab
14	12:00	3 outreach /demos EVAs (including 16 yr young					EVA cam/comm		cook	XRD-XRF	cook				EVA
15	12:30						EVA cam/comm		cook	XRD-XRF	cook				EVA
16	13:00	Lunch					Lunch	Lunch	Lunch	Lunch	Lunch	Lunch		Lunch	Lunch
17							Lunch	Lunch	Lunch	Lunch	Lunch	Lunch		Lunch	Lunch
18	14:00	2 EVAs towards Skyline rim							kitchen	GreenHab					
19		3 EVAs for Ground Penetrating Radar operation					EVA cam/co	Prep	space suit	GPR	GPR				
20	15:00	Laboratory and data analysis					EVA cam/co	lab	radio	GPR	GPR			EVA GPR	EVA
21							EVA cam/co	lab	report	XRD data	EVA cam/comm			EVA shell	EVA
22	16:00	3 EVAs for Milwaukee drill operation at observato					EVA cam/co	lab	navigation	drill support	drill support			EVA drill	EVA
23							EVA cam/co	lab	navigation	drill support	drill support			EVA drill	EVA
24	17:00	4 ATV sorties near hab and 2 ATV far sorties to					analysis	ATV	close-up	inventory gre	Raman/VISI	ATV		EVA market	
25		DNA extraction for PCR and soil analysis, repor					analysis	lab	exploration			lab		ATV	ATV
26	18:00						analysis	lab	Enginr. Check/report		Enginr. Che	lab		ATV	ATV
27								analysis	Enginr. Re	XRD-XRF		lab			
28	19:00							analysis	cook	study	study	lab			
29							Cdr report	lab	cook	report	report	lab			
30	20:00	Dinner					Dinner	Dinner	Dinner	Dinner	Dinner	Dinner			
31		wrap-up					Dinner	Dinner	Dinner	Dinner	Dinner	Dinner			
32	21:00	Human aspects questions					analysis	pics/videos	kitchen	XRD XRF	Raman/VISI	analysis			
33							reports		data	XRD XRF	Raman/VISI	report			
34	22:00								X	XRD XRF	Raman/VISI	report			
35							study	study	interviews	study	study	study			
36	23:00							X	astro	X	X	interviews			
37															

HabitatLab

- 1 Context
  - 1.1 ExoHab
  - 1.2 Objectives
  - 1.3 Concept
- 2 A first Solution
  - 2.1 The first idea
  - 2.2 The specifications
  - 2.3 The choice
- **3 Comparison with an experienced simulated planetary habitat**



Crew time sheet analysis 26 Feb

26-Feb	Full sim + 14 EVA tasks + lab					Commander	Exec-O	Engineer	Scientist	Scientist 2	Bio		Film crew	
When	What	How	Where						Raman/XRD	GPR	PCR			
				Who	Crew2	Bernard	Pascale	Ludivine	Christoph	Lorenz	Cora		Jhony	Amesx3
08:00									X				Zavaleta	
							Cook		Email	Email	cook			
09:00	Breakfast		Hab			Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast			
	Briefing					Briefing	Briefing	Briefing	Briefing	Briefing	Briefing			
10:00	Laboratory and data analysis						vehicle		XRD-XRF	EVA cams	gel electrophoresis			
	EVA x2 and welcome of NASA Ames visitors					EVA	telecon	space suit	XRD-XRF	EVA cams	gel electropho		EVA	EVA cams
11:00	Ames visitors in hab					visit	telecon H/C	space suit	XRD-XRF		database			visit hab
11:30						visit	telecon H/C		XRD-XRF		Prep			visit hab
12:00	3 outreach /demos EVAs (including 16 yr young vis					EVA cam/comm		cook	XRD-XRF	cook				EVA
12:30						EVA cam/comm		cook	XRD-XRF	cook				EVA
13:00	Lunch					Lunch	Lunch	Lunch	Lunch	Lunch	Lunch		Lunch	Lunch
						Lunch	Lunch	Lunch	Lunch	Lunch	Lunch		Lunch	Lunch
14:00	2 EVAs towards Skyline rim							kitchen	GreenHab					
	3 EVAs for Ground Penetrating Radar operation on					EVA cam/cor	Prep	space suit	GPR	GPR				
15:00	Laboratory and data analysis					EVA cam/cor	lab	radio	GPR	GPR			EVA GPR	EVA
						EVA cam/cor	lab	report	XRD data	EVA cam/comm			EVA shell	EVA
16:00	3 EVAs for Milwaukee drill operation at observatory					EVA cam/cor	lab	navigation	drill support	drill support			EVA drill	EVA
						EVA cam/cor	lab	navigation	drill support	drill support			EVA drill	EVA
17:00	4 ATV sorties near hab and 2 ATV far sorties to gy					analysis	ATV	close-up	inventory gre	Raman/VISIF	ATV		EVA market	
	DNA extraction for PCR and soil analysis, reports					analysis	lab	exploration			lab		ATV	ATV
18:00						analysis	lab	Enginr. Check/report		Enginr. Chec	lab		ATV	ATV
							analysis	Enginr. Re	XRD-XRF		lab			
19:00							analysis	cook	study	study	lab			
						Cdr report	lab	cook	report	report	lab			
20:00	Dinner					Dinner	Dinner	Dinner	Dinner	Dinner	Dinner			
	wrap-up					Dinner	Dinner	Dinner	Dinner	Dinner	Dinner			
21:00	Human aspects questions					analysis	pics/videos	kitchen	XRD XRF	Raman/VISIF	analysis			
						reports		data	XRD XRF	Raman/VISIF	report			
22:00								X	XRD XRF	Raman/VISIF	report			
						study	study	interviews	study	study	study			
23:00							X	astro	X	X	interviews			

EuroGeoMoonMars campaign at Utah Desert Research Station

- Instrument Technology Field demonstration
- Research supporting science and exploration
  - Geology, Geochemistry, Astrobiology, Biology
- Human aspects studies (supported HSF)
  - Crew operations, Simulations and EVAs
- Outreach and education
- Related posters:

  I6) C. Stoker et al, DOMEX Drilling on Moon & Mars
  I5) B. Foing et al, EuroGeoMoonMars Outreach
  H9) L. Boche-Sauvan et al, Human aspects
  B2) P. Mahapatra et al, Raman & rover studies
  F5) B. Foing et al, ExoGeoLab rovers & instruments

reserve

EVAs

Esther, Drina , Chris EVA

EuroGeoMars science goals

- The goal of the mission (from 24 January to 1 March 2009) was to demonstrate and validate a procedure for Martian surface in-situ and return science. This chain begins with characterisation of the local surface and close sub-surface environment, before moving on to sample extraction and analysis. The characterisation stage involves a survey of a sample area in the vicinity of the MDRS site by our geologists and other team members. This utilises satellite and aerial photography to inform the overallmorphology and geological unit distribution, with the specific geological and geochemical context being provided through the use of imagers and spectrometers. Further reconnaissance is used to plan sample-extraction EVAs at sites of geochemical and astrobiological significance. Characterisation of larger-scale features is conducted in-situ (for example using ground penetrating radar to investigate the close sub-surface).

- Results from these sorties informed the choice and planning of sites for surface and sub-surface sampling.
- The sample extraction step – the nature of which is dependent on the identified areas of interest – involves standard geological tools such as rock drills, scoops with cameras and instruments support.
- These samples are returned to the MDRS for analysis using microscopes and other analysis techniques.
- These documented samples are afterwards taken to ESTEC and collaborators institutes for analysis by various techniques.

Outside field instruments

- Multiple camera system and data acquisition*
- Ground Penetrating Radar*
- Drilling core samples
- Remote control Field rover, cameras and instruments*
- Optical Positioning/Navigation experiment *