Human Mars Mission Contamination Tracking

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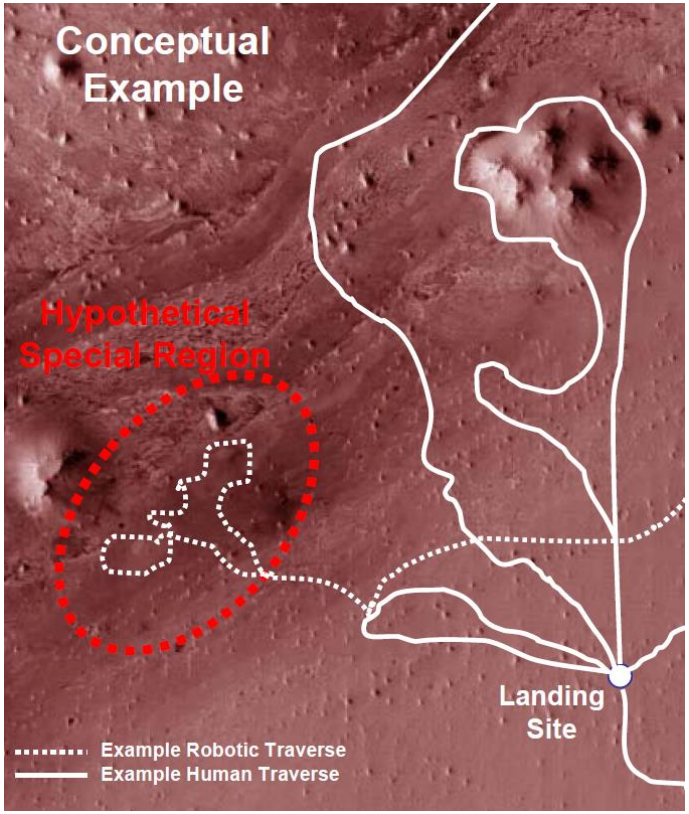
Österreichisches Weltraum Forum / Austrian Space Forum

THE CHALLENGE…



- **Dilemma:** keeping humans out vs. dispatching the most effective „system“ for exploration
- **Hard data:** very rare, hardly no field tests in the context of high-fidelity simulations
- → PolAres programme

- Groemer, G, et al., 2007, *AustroMars - a simulated high-fidelity human Mars analogue mission*, in: Mars2030, AustroMars Science Workshop. Published by Austrian Space Forum, pp4-12.
- Groemer, G et al., 2009, *Permafrost Drilling in a Simulated Spaceflight Environment*, Project report to the Tyrolean Science Fonds, pp1-15.

AustroMars 2006 / Track & Trace Experiment

Position on space suit	EVA A	B	C	D	E	G
Number of bacteria [CFU /cm^2]						
1 chest	72	n.e.	27	16	95	**91**
2 belly	35	18	n.e.	57	116	**97**
3 right arm	17	n.e.	56	62	127	**108**
4 left arm	65	103	102	105	103	**430**
5 Right waist	105	n.e.	92	217	317	**n.e.**
6 left waist	127	n.e.	109	119	431	**256**
7 right leg	n.e.	n.e.	272	395	n.e.	**397**
8 left leg	430	195	303	n.e.	695	**n.e.**
Remarks		losses due to wind			extremely dusty	extremely dusty

Overview of bacteria counts on Extra-Vehicular Suits

(n.e. not evaluated either due to loss by heavy wind during EVA or due to crushing of the filter)

Sattler, B. et al, 2007,„**New Insights about Cross-Contamination Procedures for Analogue Missions in Space Exploration**", Mars2030 - AustroMars Science Workshop, Procs. Of, September, 2006. Edited by G. Groemer. Published by Austrian Space Forum, 2007., p.13-17

Analog field tests, e.g….

- Northern Sahara/Morocco: large distance & sands
- Rio Tinto/Spain: early-wet Mars
- Kaunertal Glacier/Austria: periglacial environment
- Dachstein Ice Caves/Austria: subsurface ices

- Based upon NASA DRM 5.0 & Aurora
- NASA Human-System Standard STD-3000 & MIL-STD-882c

- <45 kg, unpressurized, Hard-Upper Torso, custom-built OBDH and advanced human-machine-interface

- Outer layer optimized for planetary protection

- Broadband telemetry, ca 60 parameters

AOUDA.X SPACESUIT SIMULATOR PROTOTYPE

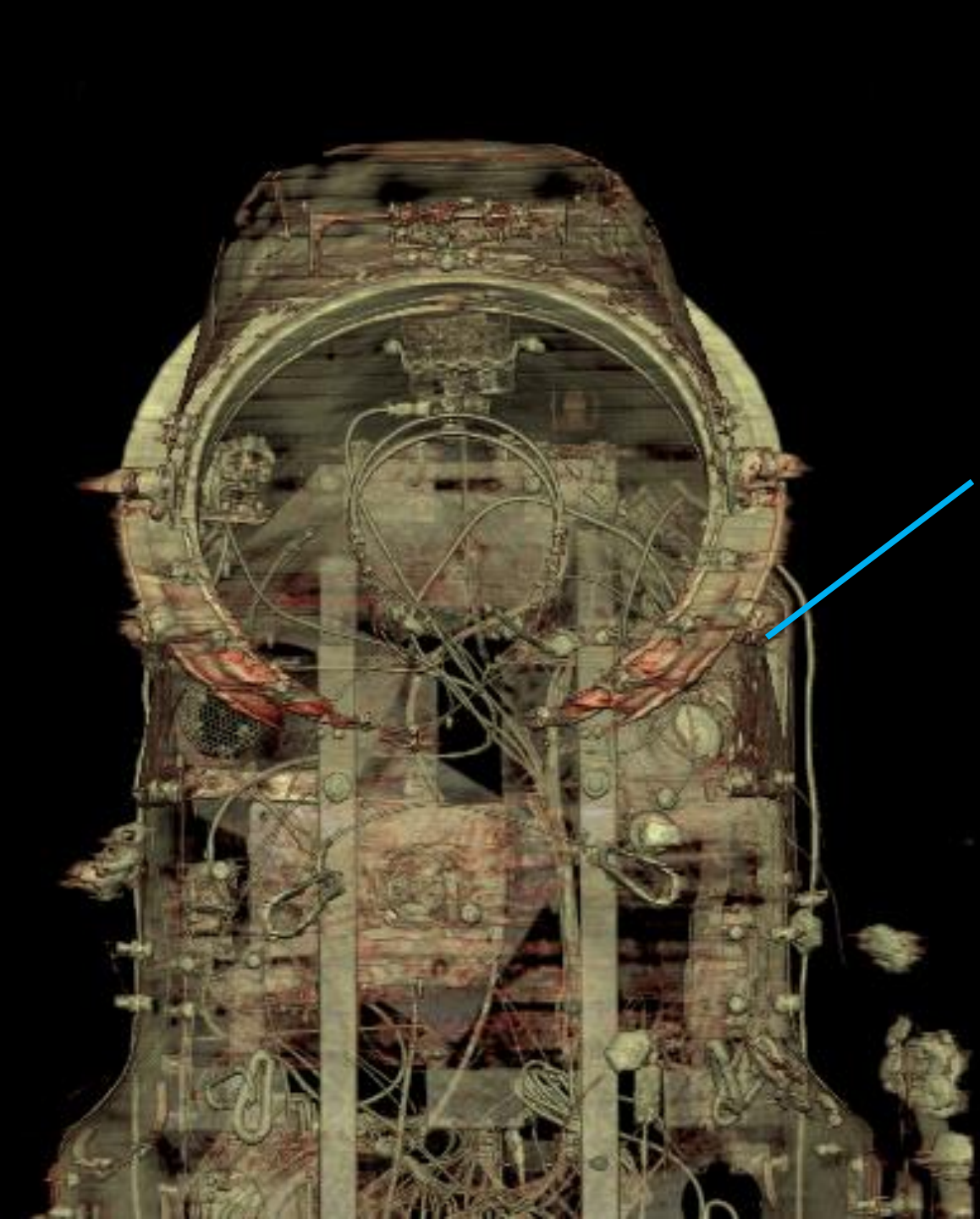
Groemer et al., 2012, *The Aouda.X space suit simulator and its applications Astrobiology. February 2012, 12(2): 125-134.*

Tissue sample of Inventex®
after abrasive tests at -80°C.

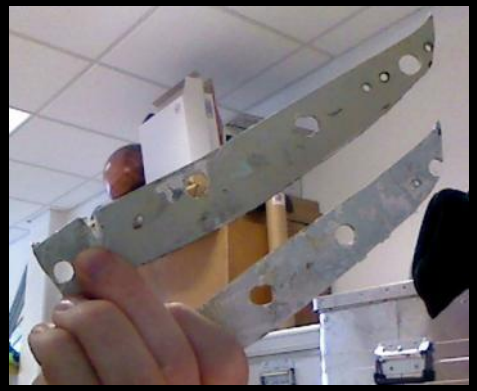
Cryo-chamber test @ -110°C

Vibrational tests at 156 Hz for 1 min showed, that only 5-10% or the granular material with sizes <90 µm was adhering to the outer layer textile.

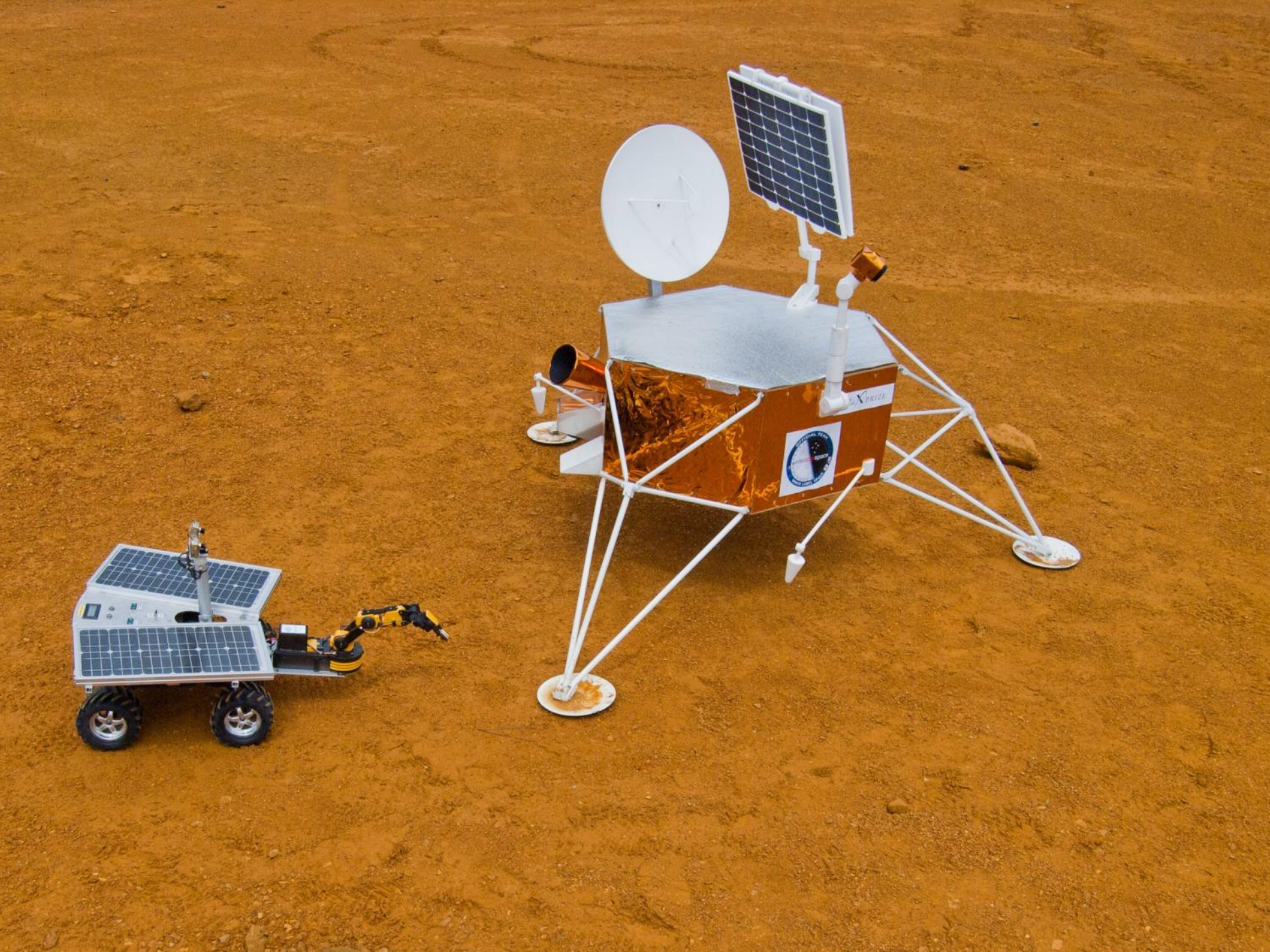
AOUDA.X STRUCTURAL TESTS/CT



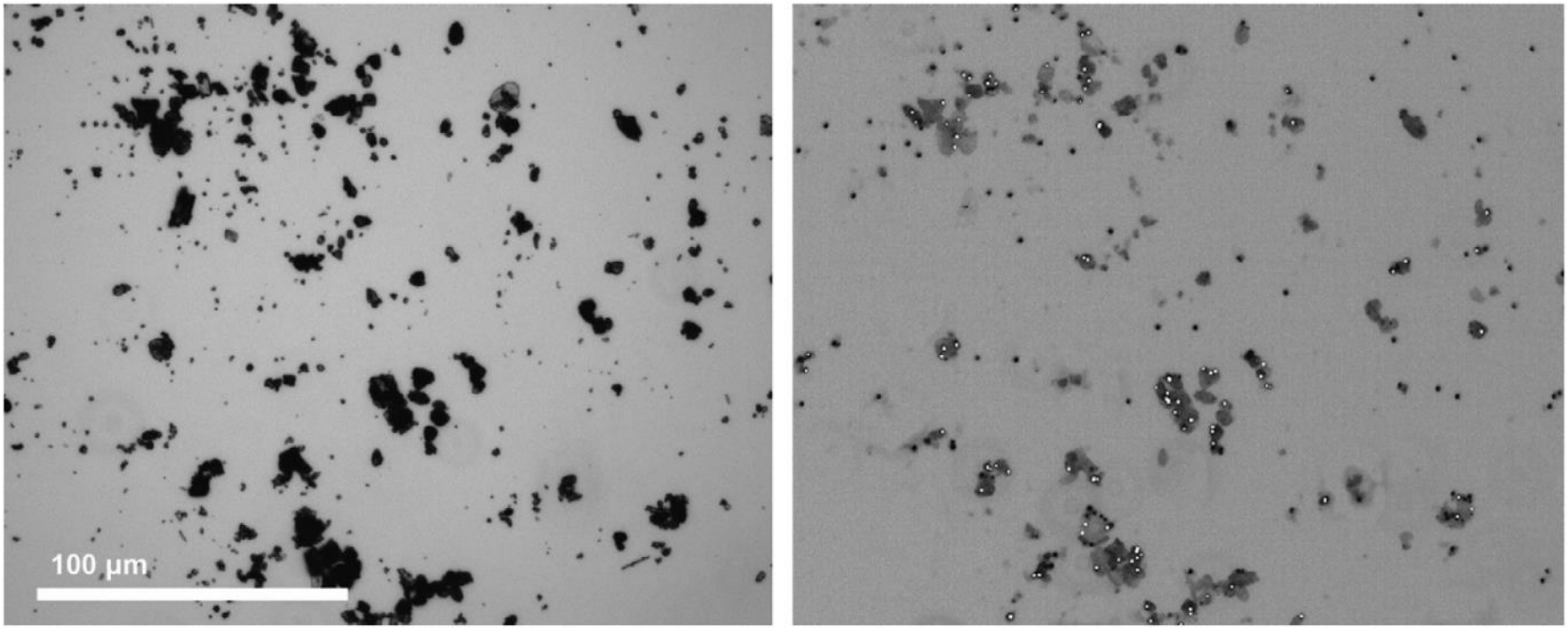
Structural damage




ThalesAlenia
gtmv
esa
LEFT




Contamination Vector Experiment
Microspherules



Direct optical imaging of a soil sample of palagonitic tephra (left, grain size <90 µm), and the same region under laser excitation (right). Field size: 0,2 mm

JSC1A + MICROSPHERULES @ 520/540 NM

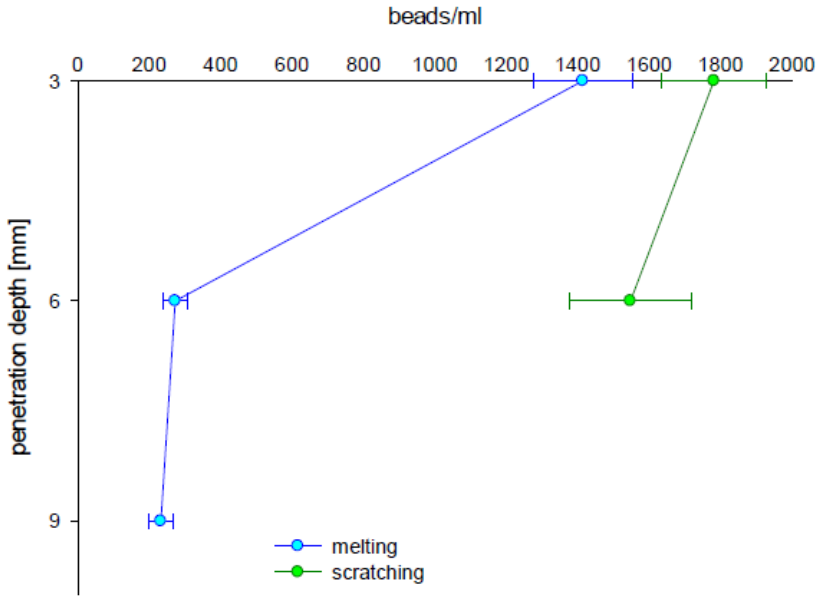
Groemer et al. 2011, *Reducing biological contamination by a space suited astronaut: Laboratory and field test results from Aouda.X*, Acta Astronautica, **68**, pp218–225

Kluibenschedl, A 2011, *Contamination vectors an issue in the human exploration of extraterrestrial planets examined during the PolAres Project,* Bachelor thesis, University of Innsbruck

*Figure 5: A) Aplication of the 5.4*10⁷ microspheres solution. B) Sampling ice core wearing exoskeleton and gloves above. c) Retrieving sample and preparation for further steps.*

ICE CORE SAMPLING / SCRATCH-MELTING

CVE.04 Laboratory													
Sample nr.	**depth [mm]**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**AVRG**	**Sigma**
1.1.	0-3	1713	2086	2055	1687	1673	1767	1730	1704	1667	1735	1782	147
1.2.	3-6	1573	1265	1419	1676	1556	1864	1641	1402	1385	1693	1547	171
1.3.	0-3	1226	1428	1192	1299	1456	1407	1612	1386	1610	1524	1414	138
1.4.	3-6	312	230	308	274	277	211	288	244	271	315	273	34
1.5.	6-9	270	245	236	257	230	297	189	182	239	187	233	36



Scratch-melting is causing deep penetration of beads and cross-contamination.

microEVA

(NASA/JPL-OeWF)

Quantifying contamination vectors
for planetary protection

*G. Groemer, et al. (2012) "**The Aouda.X Space Suit Simulator and Its Applications to Astrobiology**", ASTROBIOLOGY, 12:2*

- 25 g packages of JSC1A soil simulant, mixed with 3 ml suspension of e.g. 5,4x10^7/ml @2 µm carboxylate modified polystyrene MS

	Excitation (nm)	Emission (nm)
Blue	360	420
Orange	520	540
Red	575	610
Yellow-green	470	505

- **"sterile" inoculation on cores & A.X.& sci h/w**
  - Touching: 1000 g vertical pressure
  - Grazing: 250 g vertical & lateral pressure
  - "Aeolian transport": fan @ 15 cm & ≈50 m/s

→**Sample processung**

→Adhesive sampling with Scotch Crystal 6-1925R1

→ epiflourescent microscopy & recording

→>25 fields/sample & t-test

→Repeated blind tests & blank samples in lab environment (negative below significance)

CVE METHOD

Material 1	Material 2	Contact method	Avg. Transfer probability	$\sigma_{transfer}$	t-value
Inventex	Inventex	Touching	**11,2 %**	8,4 %	0,42
Inventex	Inventex	Grazing	**30,5 %**	7,6 %	0,98
Inventex	Aluminum	Touching	**24,1 %**	31,2 %	0,76
Inventex	Aluminum	Grazing	**41,0 %**	25,8 %	0,87
Inventex	Leather	Touching	**8,4 %**	6,9 %	0,73
Inventex	Leather	Grazing	**41,5 %**	18,5 %	0,95
Inventex	PMMA	Touching	**21,0 %**	1,9 %	0,94
Inventex	PMMA	Grazing	**38,6 %**	18,0 %	0,76
Aluminum	Leather	Touching	**6,17 %**	3,9 %	0,50
Aluminum	Leather	Grazing	**6,99 %**	4,0 %	0,43
Leather	Leather	Touching	**18,68 %**	25,3 %	0,63
Leather	Leather	Grazing	**50,48 %**	15,0 %	0,39
Leather	PMMA	Touching	**61,90 %**	42,7 %	0,12
Leather	PMMA	Grazing	**69,32 %**	41,8 %	0,14

(1-p) of coincidentally having the same source distribution

TRANSFER PROBABILITIES

Conclusion

- Aouda.X is currently the most advanced suit simulator for contamination vector tracking
- Contamination vector asessement method using micro-sperules is reliable and reproducable with high sensitivity and specifity.
- Drilling has yet to be demonstrated.

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