Soil micromorphology, geochemistry and microbiology at two sites on James Ross Island, Maritime Antarctica

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1. Introduction

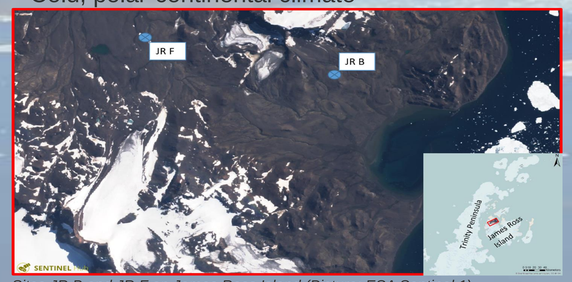
Referring to the fundamental question in ecosystem research, how biotic and abiotic processes interact, only few studies exist for polar environments that integrate microbial and pedogenic research. Antarctica offers the exceptional chance to study the impact of microbial processes on soil formation in a pristine „laboratory“, without higher plants or digging animals.

Since the effect of climate change on microbial community structure/functions and on soil formation in Antarctica is largely unknown, the knowledge about the state of microbial communities and soil formation is crucial for the evaluation of possible changes due to climate change. Integrated results of soil physical, pedochemical micromorphological and microbial analyses are presented.

2. Materials and Methods

Study area

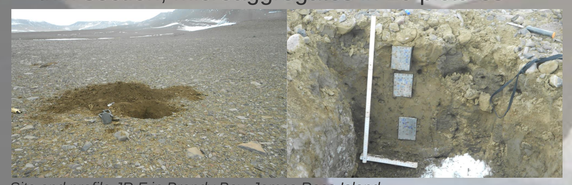
- Ulu-Peninsula, James Ross Island, Maritime Antarctica
- Cold, polar-continental climate



Sites JR B and JR F on James Ross Island (Picture: ESA Sentinel 1).

Field and lab work

- Soil sampling (2 profiles, representing lee- and windward location, 5 depth increments)
- Micromorphology, C, N, pH, grain size distribution, pedogenic oxides, DNA content and microbial abundances
- macroaggregates were counted for the whole thin section, microaggregates in 10 pictures



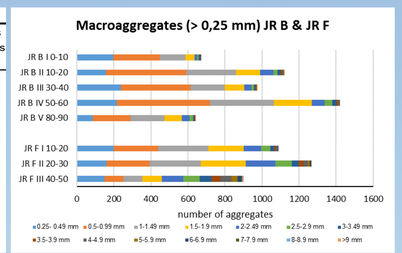
Site and profile JR F in Brandy Bay, James Ross Island.

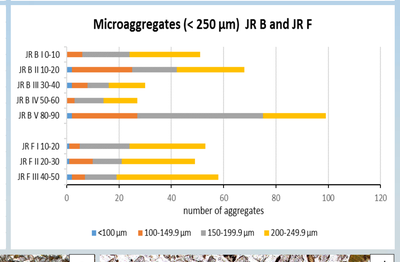
3. Results

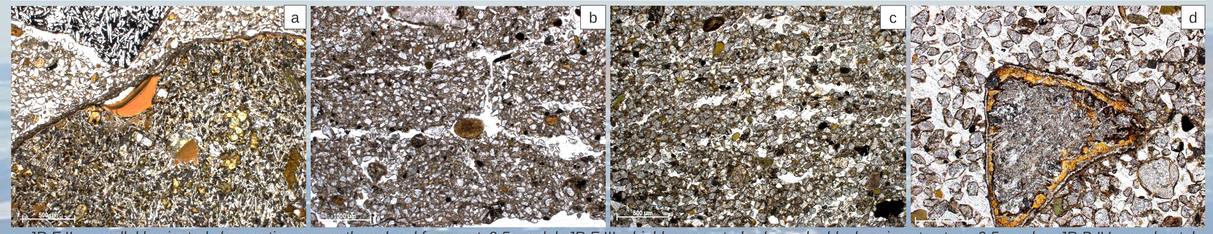
Slice	Depth	Aggregation			Voids			Micros *	Groundmass								Pedofeatures								
		Pedality							c/f- R. Distr.					Micromass			Redoximorphic features			Translocation features				
														colour	b-Fabric		nodules		HP	coatings			infillings	
	[cm]	wp	mp	hp	ds	spv	xpv	pl	vu	cm	cg	oee	ssee	chi	ce	u	gs	t	a	ro	li	cap	pen	tc	ld
JR B (St.Martha)																									
JR B I	0-10	x			w	(x)	x	(x)	fis / sgm	x	(x)			(x)		gb	x	x	x	(x)	(x)	(x)			
JR B II	10-20		x		w		x	(x)	pgm	(x)	x			x		gb	x		x		x				
JR B III	30-40		(x)		w/m		x	x	wsl	x	x			x	(x)	db	x	x		x			x		x
JR B IV	50-60		x		m/w		x	x	(x) msl (hssb)	x	x	x				db	x	x			x			x	x
JR B V	80-90	x			w		x	(x)	(fis) pgm	x	(x)			x	x	db	x	(x)			x			x	
JR F (Brandy Bay)																									
JR F I	10-20			(x)	m		x	x	(x) h-m ssb	(x)	x		x	(x)		gb	x	(x)	x			(x)		(x)	x
JR F II	20-30			x	m		x	x	x w-m ssb (msl)	(x)	x		x			gb	x	x		(x)	x		x	x	x
JR F III	40-50		x		m/h		x	x	(x) h-m ssb (msl)		x	x		x		gb	x	x	x	x		x			x

The micromorphological property is shown by the presence (cross) or absence (no cross). (x) = partly occurring
* microstructures separated by "/": two different microstructures were found. Microstructures separated by "()": one ms shows partly features of another ms

Aggregation : hp = highly developed pedality, mp = moderately developed pedality, wp = weakly developed pedality
ds = degree of separation; h = highly separated, m = moderately separated, w = weakly separated
Voids : spv = simple packing voids, xpv = complex packing voids, pl = planes, vu = vughs
Microstructure (Micros) : fis = fissure, sgm = single grain ms, pgm = pellicular grain ms, wsl = weakly separated lenticular ms, hssb = highly separated subangular blocky ms, mssb = moderately separated subangular blocky ms, wssb = weakly separated subangular blocky ms, msl: moderaltely separated lenticular ms
Groundmass
c/f - Related Distripution (c/f - R. Distr.) : cm = coarse monic, cg = chito-gefuric,oee = open equal enaulic ,ssee = single spaced equal enaulic, chi = chitonic, ce = close enaulic
colour : gb = greyish brown, db = dark brown
b - Fabric : u = undifferentiated, gs = granostriated
Pedofeatures
nodules : t = typic, a = aggregate
HP (hypocoatings) : FM = iron and manganese; ro = redoximorphic hypocoatings
coatings : li = link cappings, cap = cappings, pen = pendent, tc = typic coating
infillings : ld = loose discontinuous

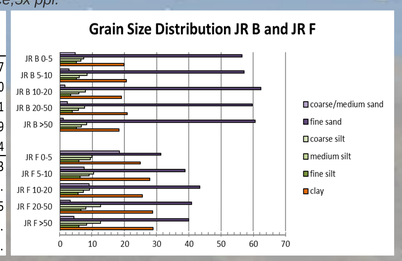


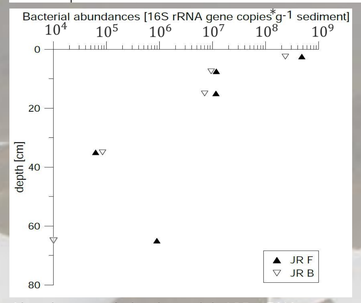




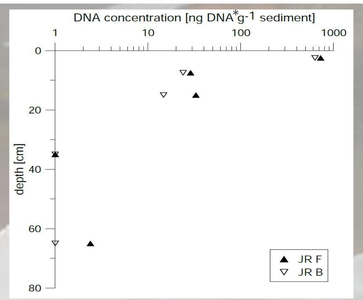
a: JR F II – parallel laminated clay coating on weathered rockfragment, 2,5x, ppl b:JR F III – highly separated subangular blocky microstructure, 2,5x, ppl; c: JR B IV – moderately separated lenticular microstructure, 2,5x, ppl; d: JR B I – weathered rockfragment showing strong alteration at its surface,5x ppl.

sample	pH_{H2O}	EC[µS*cm^{-1}]	Fe_T [mg*g^{-1}]	Fe_{ox} [mg*g^{-1}]	Fe_D [mg*g^{-1}]	Fe_{Ox}/Fe_D	Fe_D/Fe_T	N [mg*g^{-1}]	C_T[mg*g^{-1}]	C_{org}[mg*g^{-1}]	C/N
JR B 0-5	7.73	53.5	47.03	4.49	6.93	0.65	0.147	0.36	1.08	1.06	2.97
JR B 5-10	7.98	35.7	34.57	3.40	6.96	0.49	0.201	0.35	1	0.98	2.80
JR B 10-20	7.90	33.4	43.54	3.07	6.53	0.47	0.150	0.40	1.2	1.03	2.61
JR B 20-50	7.96	34.7	43.88	3.66	5.49	0.67	0.125	0.37	0.96	0.92	2.49
JR B > 50	8.14	68.4	45.41	9.17	4.38	2.09	0.096	0.42	1.12	0.97	2.34
JR F 0-5	8.58	943	51.22	6.48	7.83	0.83	0.153	0.36	2.8	1.72	4.83
JR F 5-10	8.05	557	42.32	6.09	8.51	0.72	0.201	0.38	3.36	n.a.	n.a.
JR F 10-20	7.74	380	37.94	5.58	7.48	0.75	0.197	0.34	2.68	2.30	6.75
JR F 20-50	7.58	500	36.12	6.02	7.07	0.85	0.196	0.37	4.45	n.a.	n.a.
JR F > 50	7.42	956	34.51	5.40	6.84	0.79	0.198	0.35	3.56	n.a.	n.a.





Abundances of the bacterial 16S rRNA genes revealed by quantitative PCR in the investigated soils from James Ross Island, Antarctica. The shown data represents mean values from triplicates.



DNA content of soils from both sites across a depth profile determined by Qubit® Fluorometric Quantitation.

4. Conclusion

(1) Both soil profiles show little to no development of soil horizons. Cryoturbation is the main pedogenic process. Both soils are classified as Protic Cryosols (eutric, loamic) after WRB 2014.

(2) Windward position of profile JR F is responsible for much higer pH values (>7) because of soluble salt input from sea spray. The depth function of the pH is opposing in both profiles with decreasing trend in JR F and an increasing trend in JR B indicating solution processes in the latter and additional input of bases in JR F.

(3) Fe_D/Fe_T ratio indicates weathering and soil formation in 5 – 10 cm of both profiles. At JR B soil formation is limited to that depth, while JR F shows constant rations throughout the profile. Low ratios at the surface are caused by freshly deposited material.

(4) Both soil profiles show similar trends in DNA content and bacterial 16S rRNA gene abundances. DNA content and bacterial 16S rRNA copy numbers decrease substantially with depth, indicating worse conditions for microbial life compared to the topmost layers.

(5) The results indicate that microbial “hot spots” do not depend on weathering.

Acknowledgements

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Further Reading

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