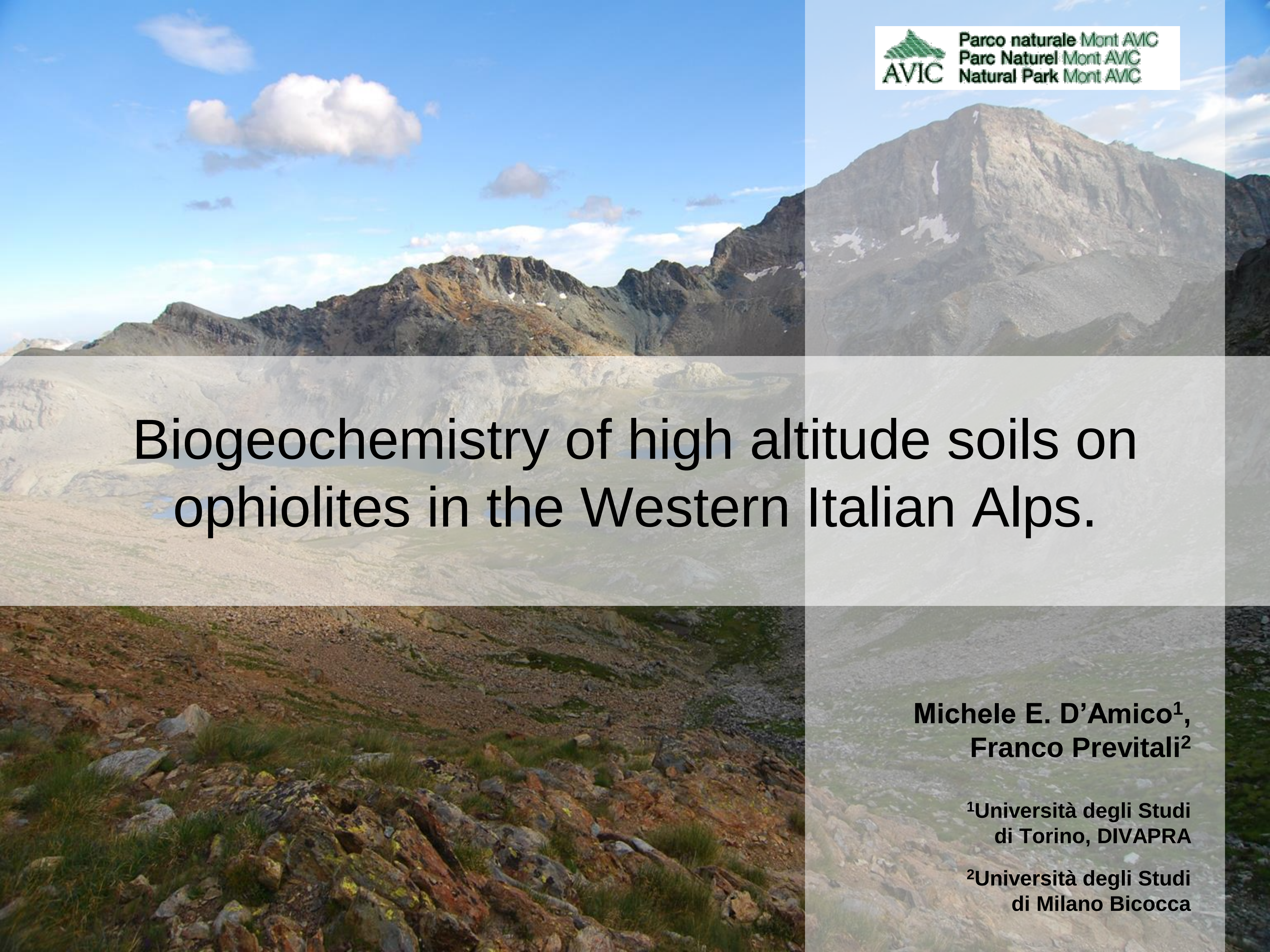

Biogeochemistry of high altitude soils on ophiolites in the Western Italian Alps.

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Aims

In alpine/arctic habitats, mobility and bioavailability of metals may increase because of:

- **acidifying vegetation**
- **the high humidity and waterlogging.**
- **And only few studies deal with biogeochemistry of alpine/arctic serp. Soils.**

- **Description of the main pedogenic processes, and their relationships with geomorphology and vegetation, above present-day timberline.**

- **Characterization of mobility and bioavailability of trace metals (Ni, Cr, Co, Mn), through “speciation” of their chemical forms.**

- **Analysis of the correlations between edaphic and biological parameters, and vegetation.**

↓

- <u>Are there toxicity symptoms?</u>

Methods

1 - 97 pits: standard analysis and vegetation survey: soil-vegetation rel.

Standard chemical analysis (pH, texture, TOC, N, CEC, bases).

2 - 20 typical profiles chosen between the 97: similar processes but diffrerent parent materials

Ni, Cr, Co, Mn speciation (selective sequential extraction)

BSQ: Biological Soil Quality index (0-6), based on microarthropodal communities;

- **Soil-dwelling adaptative body morphology;**
- **Biological diversity.**

Extractant	Vol.	T	Temp.	
H_2O	20 ml	1 h	25°C	Soluble
CH_3COONH_4 (1M)	20 ml	45’	25°C	Exchangeable
NH_2OH-HCl (0.1M)	20 ml	30’	25°C	Mn Oxy-hydroxides
Oxalate (1M)	20 ml	4 h	25°C	Fe Oxy-hydroxides
H_2O_2 (30%) +CH_3COONH_4 (0.1M)	20 ml 20 ml	10 h 30’	65°C 25°C	oxydable (organic matter, sulfur)
DCB	40 ml	14 h	25°C	Pedogenic oxydes
Aqua regia	10 ml	90’	MW owen	Residual

Microbial activity:

- **Microbal biomass;**
- **Base respiration.**

Stress indicators:

Metabolic quotient;

TOC/Cmic;

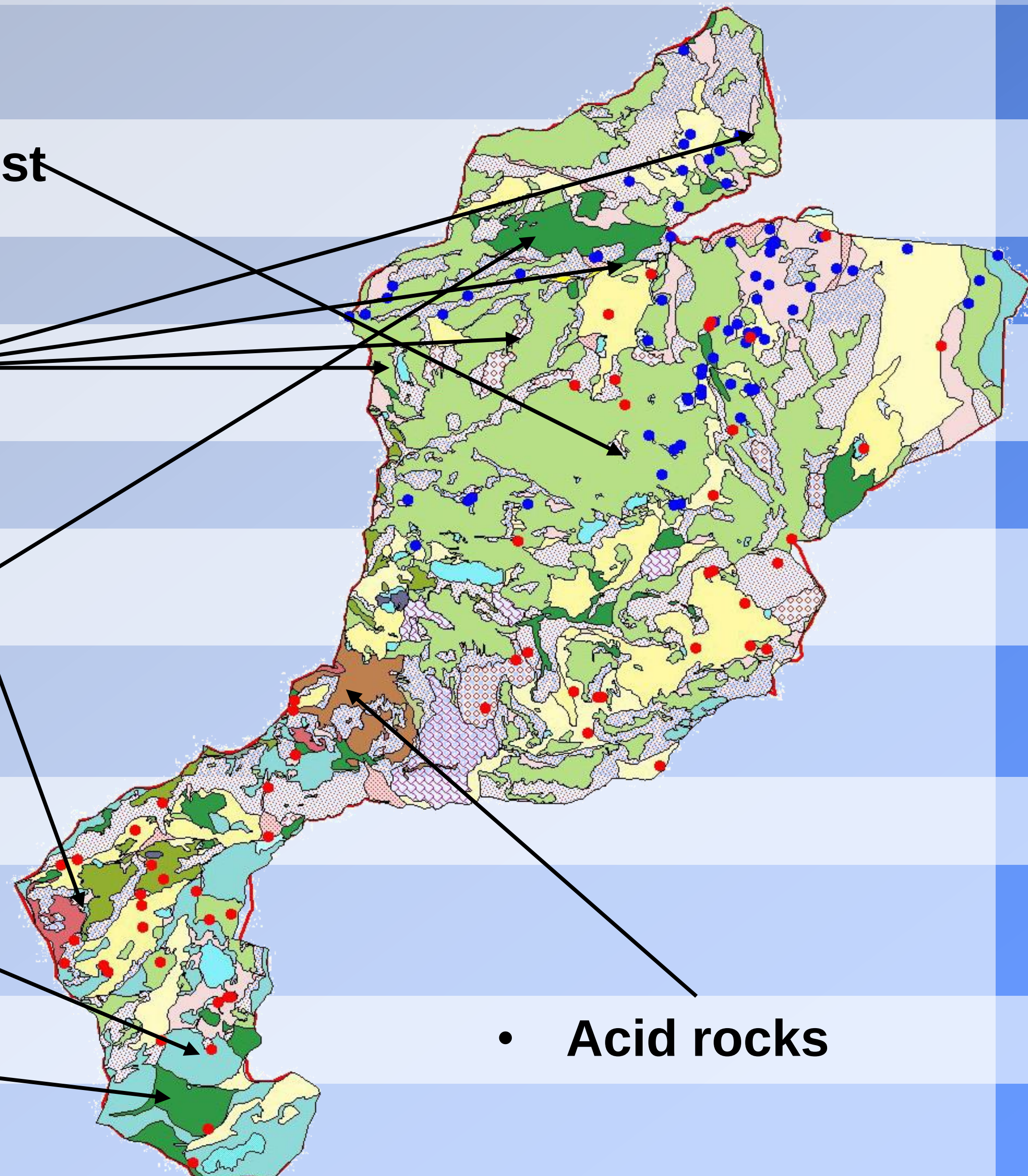
Clab/Cmic

Metabolic quotient (qCO2):

Base respiration / biomass: if it is high, it means that there is an excessive energy consumption for purposes other than growth: stress indicator. Used for comparison.

Geology

- **Serpentinite / chlorite-schist**
- **Mines**
- **Metagabbros**
- **Calcschists**
- **Meta-basalt**



- **Acid rocks**

Metals and parent material

	Serpentinite	*Metagabbro*	*Prasinite*	*Amph*	*Calcschist*	*Chloriteschist*
Fe_2O_3 (%)	5,9 (±2)	4,3	10,6 (±3)	7,8	5.4	6,5
Cr (μg/g)	3700 (±2000)	2654	506 (±200)	860	4.85	2242 (±1500)
Ni (μg/g)	1400 (±800)	310	284	1390	27	2373 (±300)
Co (μg/g)	10,7 (±7)	11,2 (±7)	12,3	5,6	2.5	3,4
Mn (%)	0,10	0,06	0,21 (±0,1)	0,09	0.21	0,12
SiO_2	42,5	46,1	42,4	36,2	31,5	61.2
Al_2O_3	0,3	15.7	10.6	11.8	14.0	15.4
MgO	42.0	15.6	18.2	31.0	32.1	3.4
CaO	0.05	10.5	7.6	7.8	2.1	14.2

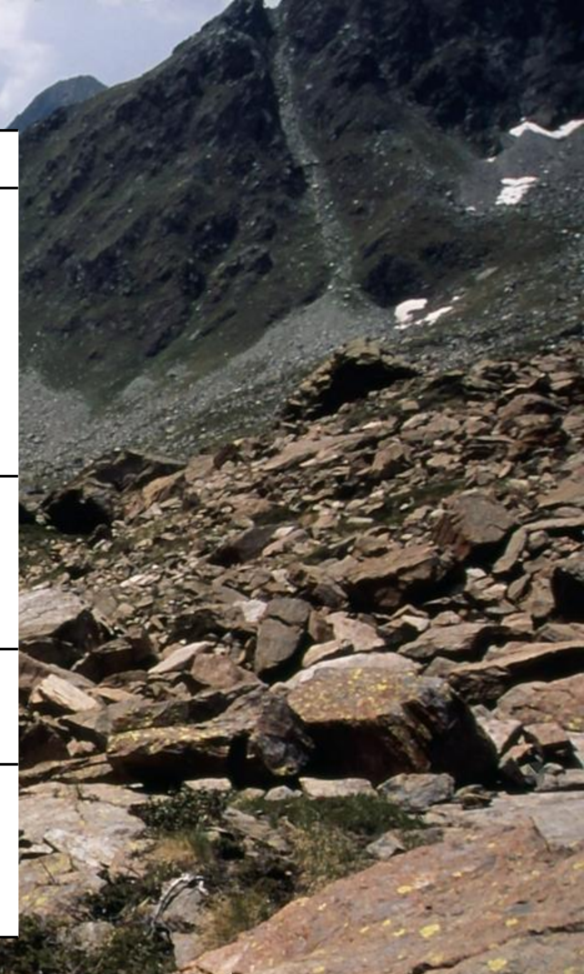
Serpentinite and associated chloriteschists are rich in Ni and Cr, followed by amphibolites.

Cr high in metagabbros: Cr-rich Chlorite?

Mn in prasinite and calcschists.

Example: stable soils

		pH	Ca/Mg	Ni_{aq}	Ni_{ex}	Ni_{mn}	Ni_{ox}	Ni_{org}	Ni_{d}	Ni_{tot}
A		5.7	21	0	0.89	4.69	1.21	19.63	23.21	171.21
AE		5.5	28	0	0.04	3.91	0.87	15.44	12.67	154.67
Bw	**P56**	5.6	89	0	0.13	21.43	9.34	13.21	65.38	221.45
CB		5.1	25	0	0.43	89.67	16.38	26.29	83.11	256.45
C		4.7	26	0	0.34	25.54	13.73	36.86	6.12	241.21
A		4.8	0.3	0.21	16.87	104.81	160.89	100.63	35.82	1864.21
Bw	**P138**	5.6	0.2	1.88	22.9	193.32	285.89	120.52	50.44	2356.57
C		5.7	0.1	1.55	14.4	120.82	184.93	123.92	24.74	1992.09
A	**P10**	3.7	2.3	0.21	4.97	7.35	10.39	52.79	11.34	221.34
Bw		4.0	2.3	0	4.42	3.88	17.39	41.7	15.61	415.61
Ah		4.0	3.3	0	0	4.37	2.89	9.91	1.86	1.86
AE	**P41**	3.9	3.4	0	0	0.72	4.95	0.72	1.03	1.03
Bhs		4.4	3.2	0	0.07	1.21	12.21	5.56	3.78	3.78

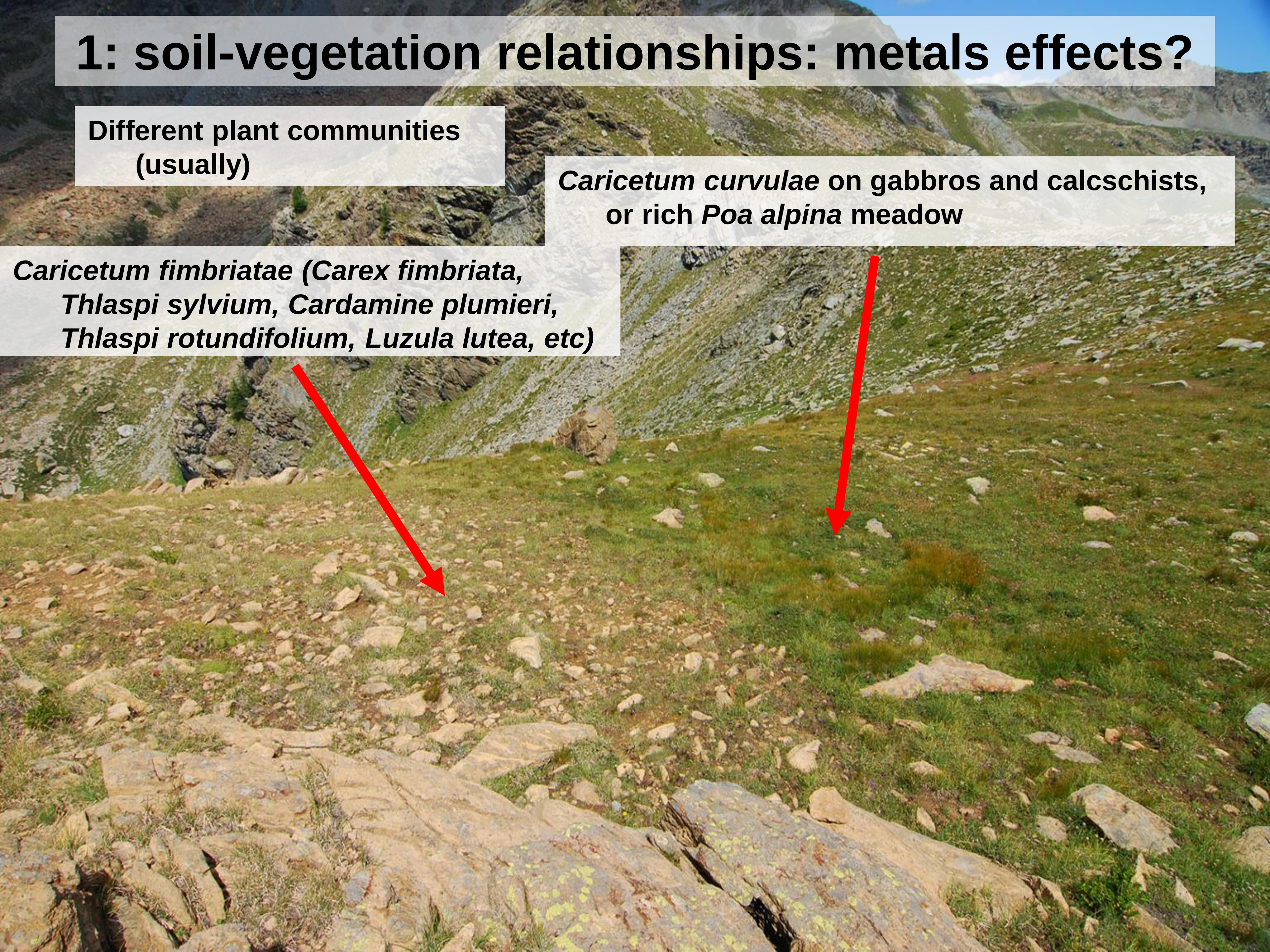


Strong acidification.

Base and metal leaching depend on snow cover, humidity and parent material (P138 vs P10)

High content of labile / pedogenic metal fractions on Cs in depth: solute input?

1: soil-vegetation relationships: metals effects?

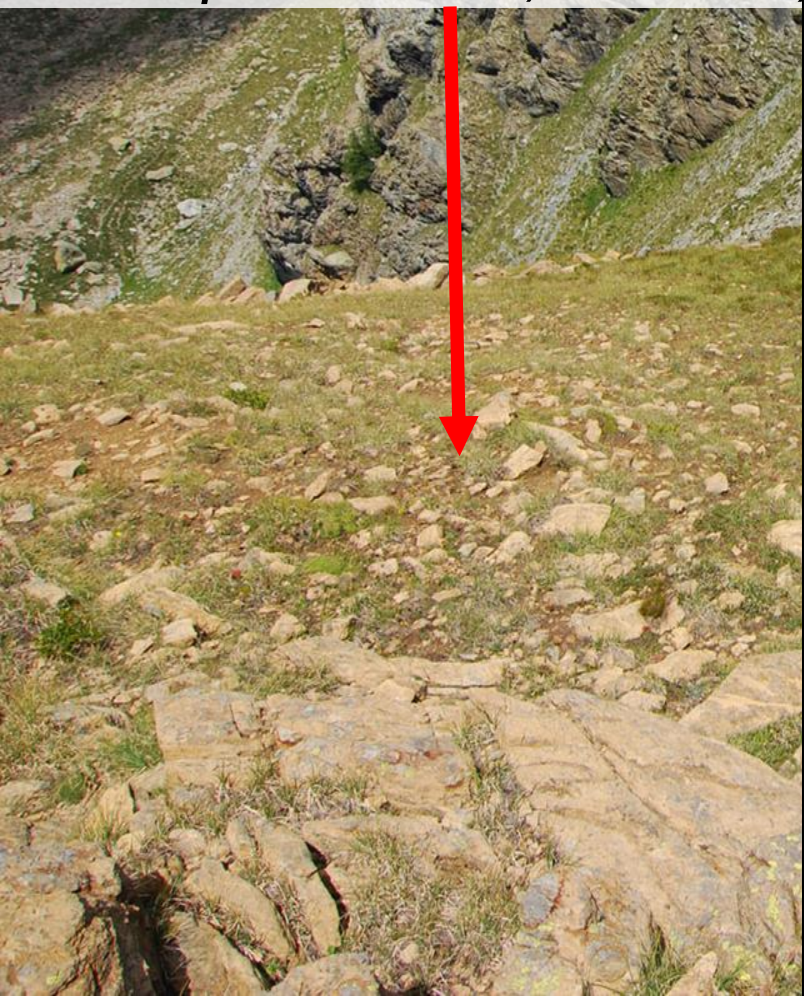


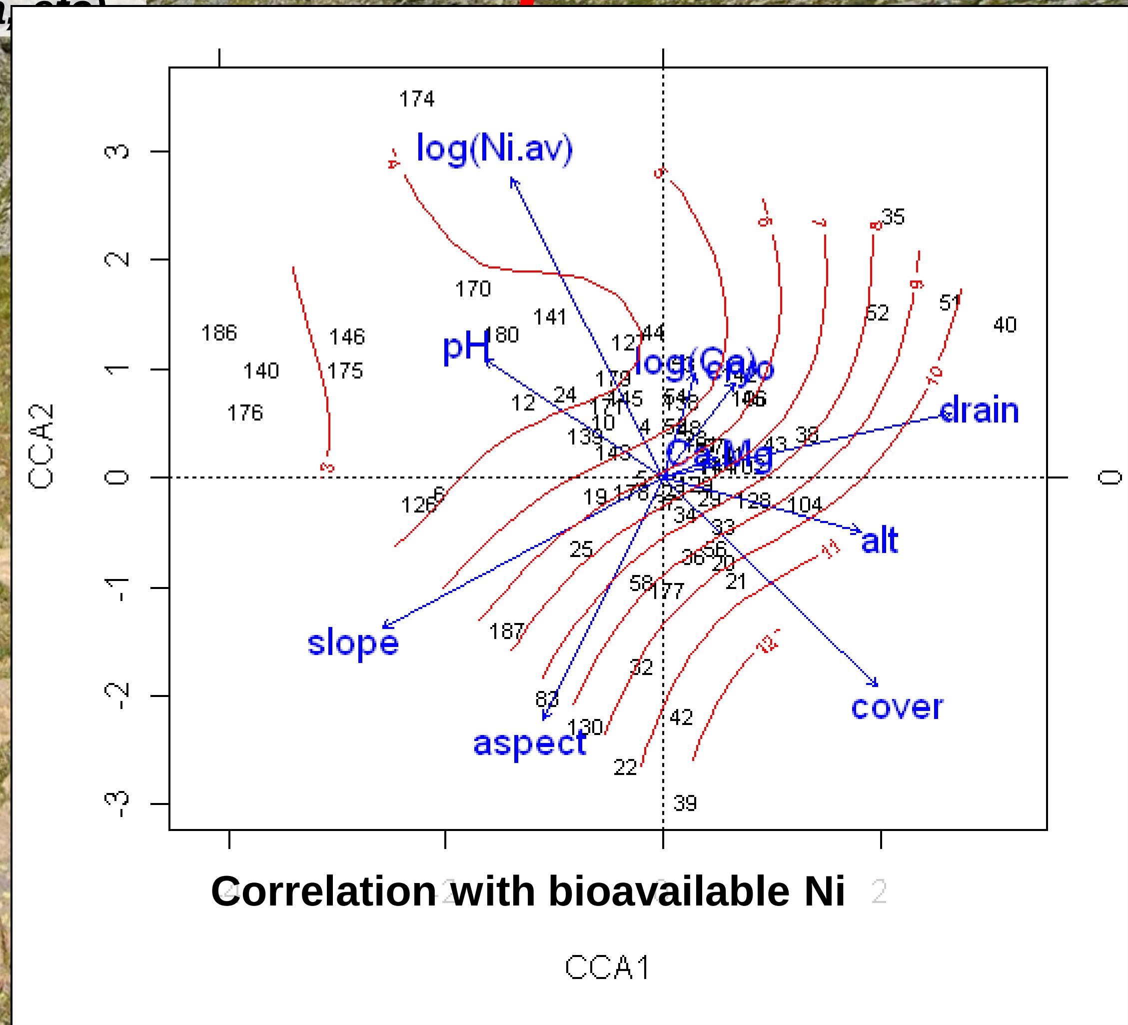
1: soil-vegetation relationships: metals effects?

Different plant communities (usually)

Caricetum fimbriatae (Carex fimbriata, Thlaspi sylvium, Cardamine plumieri, Thlaspi rotundifolium, Luzula lutea, etc)

Caricetum curvulae on gabbros and calcschists, or rich _Poa alpina_ meadow





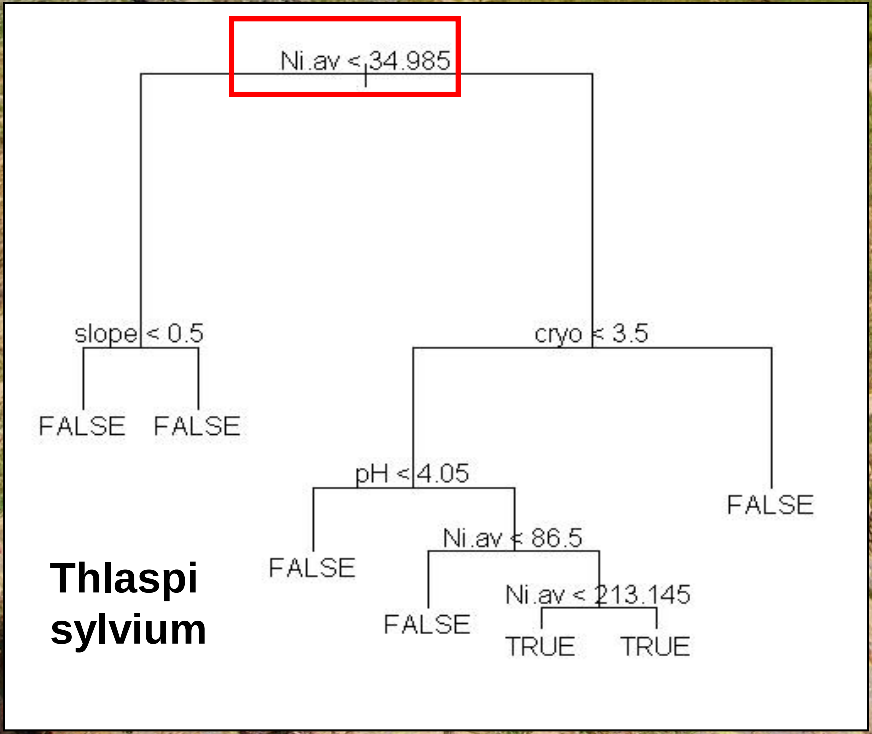
Correlation with bioavailable Ni

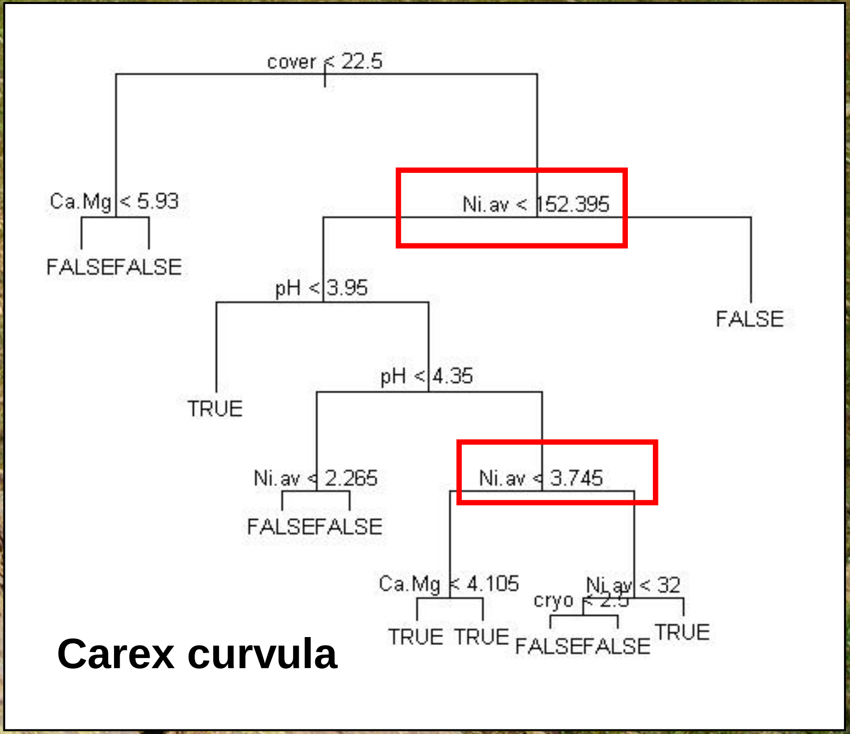
1: soil-vegetation relationships: metals effects?

Different plant communities (usually)

Caricetum curvulae **on gabbros and calcschists, or rich** ***Poa alpina*** **meadow**

Caricetum fimbriatae (Carex fimbriata, Thlaspi sylvium, Cardamine plumieri, Thlaspi rotundifolium, Luzula lutea, etc)





2: biological activity and metal speciation

Great variability depending on substrate and topography/geomorphology:

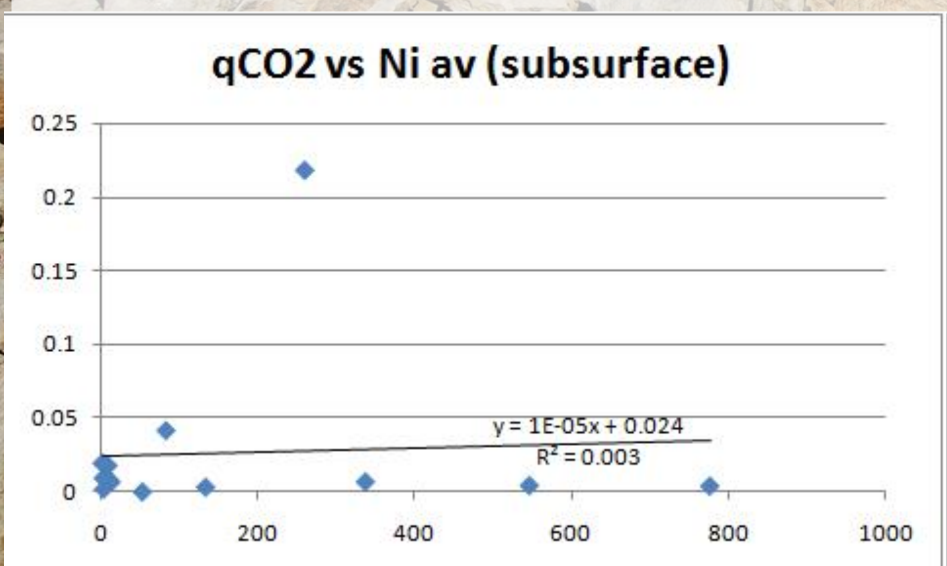
- serpentinite: acid soils, rich in heavy metals, Ca/Mg ratio between 0.1 and 10);

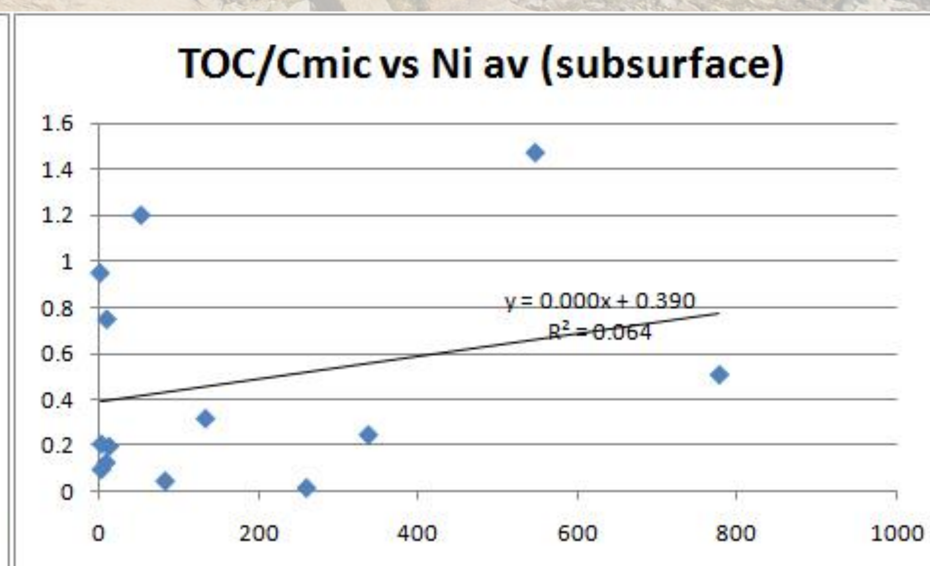
- calcschists: complete decarbonation, surface acidif., low metals, Ca/Mg>15;

- metagabbros/mafic: extremely acidic soils, podzols;

- cryoturbation and other disturbs increase labile metal content, because of surface input of “fresh”, easily weatherable materials.

Lack of correlation between biological activity (for example, metabolic quotient) and metal speciation / bioavailability (excessive variability): no comparison possible.





2: biological activity and metal speciation

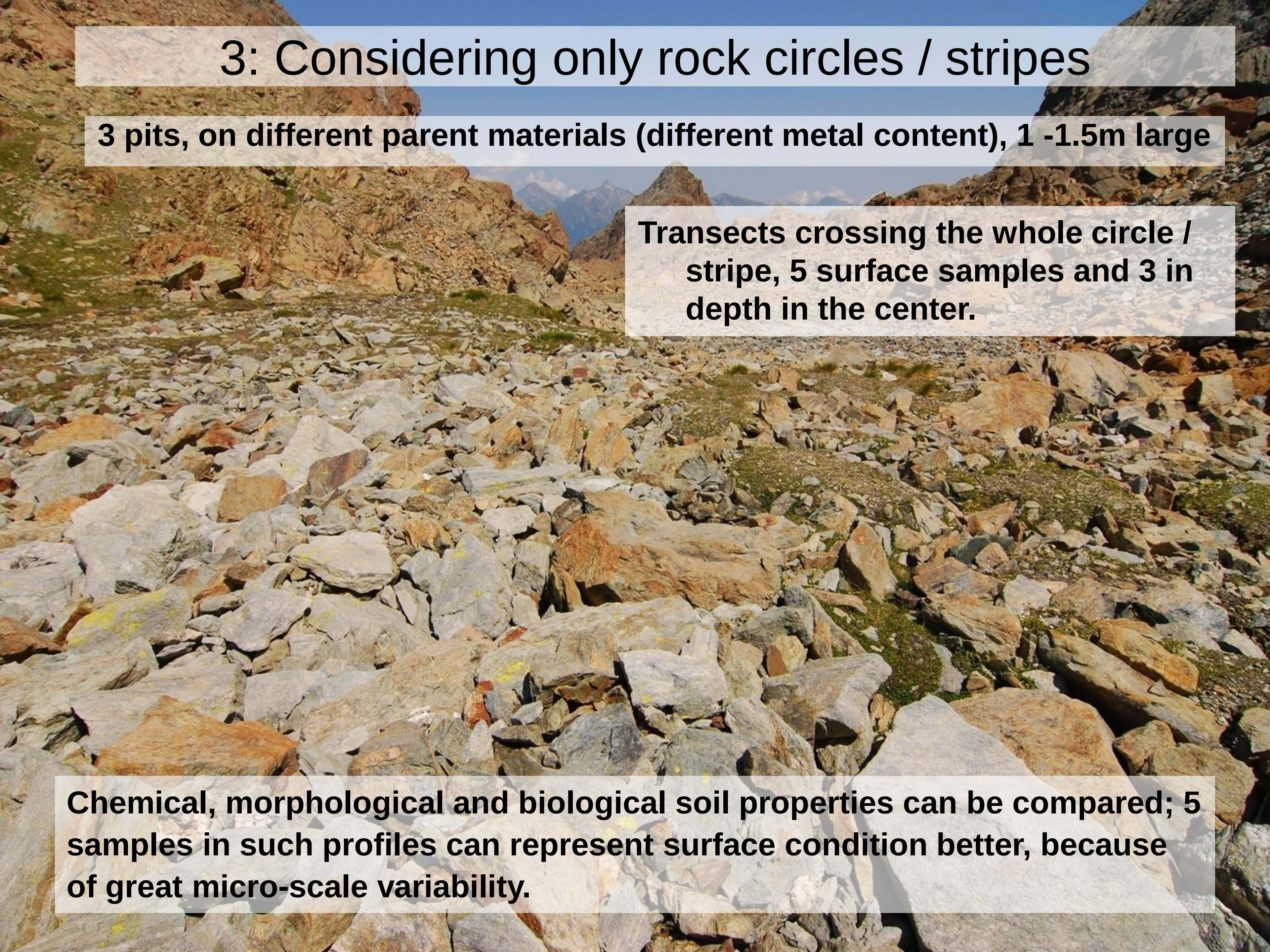
	Mn_{ass}.	Co $_{ass}$.	Ni $_{ass}$.	Ni_{av}	Ni_{mn}	Ni_{ox}	Ni_{org}
QBS	-0.11	0.21	0.50	-0.21	-0.16	-0.01	0.33
	Mn_{org}	Mn_{d}	Cr_{ox}	Cr_{org}	Cr_{d}	pH KCl	pH H2O
QBS	-0.26	-0.14	0.59	0.78	0.09	0.00	0.17
	Co_{org}	Co $_{tot}$.	Mn_{av}	Mn_{mn}	Mn_{ox}	Co_{mn}	Co_{ox}
QBS	-0.41	-0.20	-0.47	-0.11	-0.45	-0.13	0.23
	ac	TSB	Ca/Mg	umidità	Ca	Mg	Na
QBS	-0.31	0.12	-0.48	0.10	-0.40	0.37	0.38

BSQ decreases with Mn av, while it increases with Cr and Ni. No ecological significance.
BSQ higher in talus soils, low in fertile grassland soils. Why??

3: Considering only rock circles / stripes

3 pits, on different parent materials (different metal content), 1 -1.5m large

Transects crossing the whole circle / stripe, 5 surface samples and 3 in depth in the center.



Chemical, morphological and biological soil properties can be compared; 5 samples in such profiles can represent surface condition better, because of great micro-scale variability.

Eg.: Turbic Regosol (serpentinite)

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		Ni_{aq}	Ni_{ex}	Ni_{mn}	Ni_{ox}	Ni_{org}	Ni_{d}	Ni_{tot}
A		1.81	9.49	9.69	37.56	122.68	122.45	1275.79
AC	**P141**	0.27	7.21	49.88	57.88	149.85	220.14	1742
C		0.92	6.07	46.22	69.98	108.55	137.21	1649.02
		CrVI	Cr_{ex}	Cr_{mn}	Cr_{ox}	Cr_{org}	Cr_{d}	Cr_{tot}
A		11.43	2.1		43.96	79.92	4	2714
AC	**P141**	14.65	1.7		49.16	91.18	6.8	2550
C		9.63	1.2		41.75	75.55	10.7	2580
		pH	**Corg**	**C/N**	**Txt**	**Ca/Mg**		
A		4.7	0.6	14.1	FS	0.8		
CA	**P141**	5.2	0.5	8.2	FS	0.9		
C		5.3	0.2	11.4	FS	0.5		

Low Corg, but strong acidification.

High Cr(VI)

High metal mobility and potential availability

Low organic matter content (redistribution under the surface, cryoturbation) but high metals associated with it.

Cr not very mobile and exchangeable. Ni highly bioavailable.

Eg.: Turbic Regosol (serpentinite)

	1	2	3	4	5
pH	5.1	5.4	5.3	5.1	4.8
Mg	2.08	1.37	1.44	1.55	2.16
Ca/Mg	2.16	3.17	2.61	2.67	2.58
TOC	0.82	0.36	0.28	0.32	2.11
Ni_{aq}	4.23	5.27	5.26	4.2	5.15
Ni_{ex}	20.27	18.82	17.57	17.47	20.55
Mn_{ex}	2.11	1.83	0.82	1.3	3.04
Cr_{ex}	7.51	4.35	1.21	6.2	8.51
C_{lab} (mg/kg)	11.47	50.62	12.77	38.84	115.17

Great horizontal variability:

- TOC accumulates on the sides, and lowers pH;

- C_{lab} has no clear trend;

- Ni_{aq} shows no trend;

- Ni_{ex}, Cr_{ex} higher in TOC rich parts (because of CEC)

Eg.: Turbic Regosol (serpentinite)

	1	2	3	4	5
TOC	0.82	0.36	0.28	0.32	2.11
C_{lab}(mg/kg)	11.47	50.62	12.77	38.84	115.17
Resp (10°C)	6.52	7.18	6.93	9.32	10.10
C_{mic}	12.89	14.22	33.56	37.38	33.37
Qmet	0.51	0.51	0.21	0.25	0.07

Cmic and respiration are not related with TOC or Clab, unexplainable.

Eg.: Turbic Cryosol (calcshists)

Eg.: Turbic Cryosol (calcshists)

Instead of rock circles, vegetation circles-hummocks, because of stronger physical weatherability

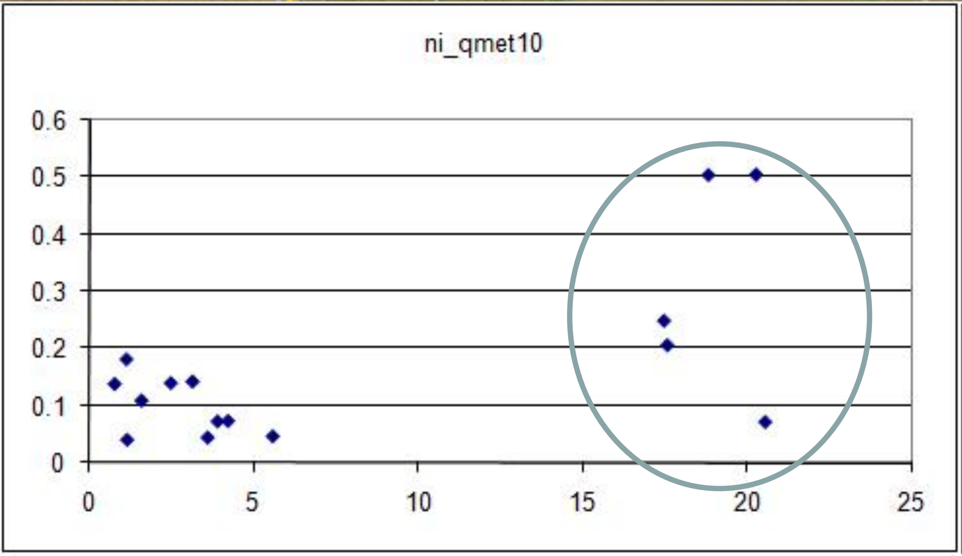
Strong surface acidification

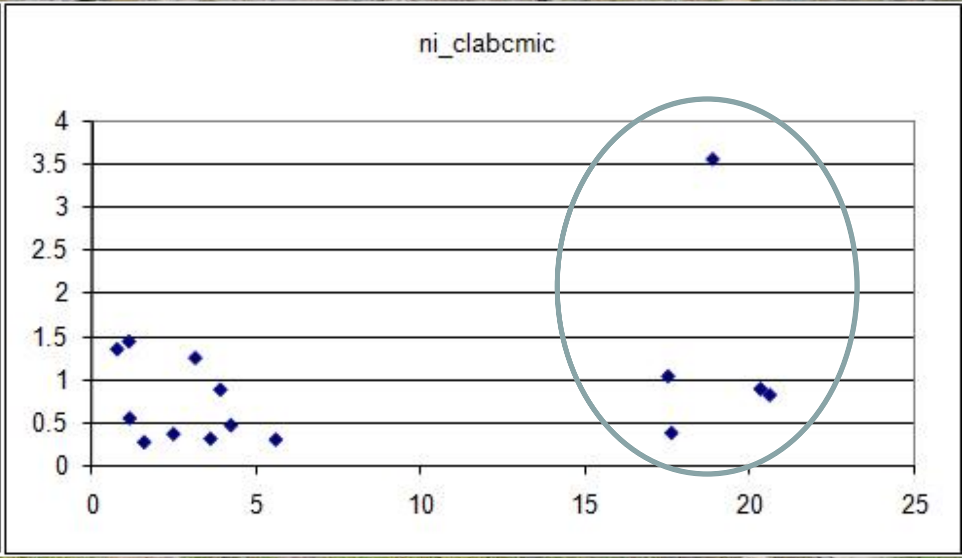
Large content in labile Ni and Cr (CrVI) fraction

Because of external input of soluble metals?

		Ni_{aq}	Ni_{ex}	Ni_{mn}	Ni_{ox}	Ni_{org}	Ni_{d}	Ni_{tot}
A		0.11	5.58	26.8	12.95	47.11	11.75	470
AC	**P52**	0.50	2.62	30.62	26.67	77.37	53.1	510
C		0.63	1.82	95.73	29.81	56.6	79.46	572
		CrVI	Cr_{ex}	Cr_{mn}	Cr_{ox}	Cr_{org}	Cr_{d}	Cr_{tot}
A		5.04			13.35	58.88	4.20	351.56
AC	**P52**	7.75			15.02	46.95	5.69	331.29
C		2.21			11.32	30.19	9.21	298.43
		pH	**Corg**	**C/N**	**Txt**	**Ca/Mg**		
A		4.9	1.3	11	FS	5.9		
AC	**P52**	5.1	0.8	9.2	FS	7.6		
C		4.7	0.7	13	FS	6.7		

Turbic Cryosols





Stress indicator correlated with Ni (qualitatively)

Conclusions

- **Heavy metals are always very high, particularly on serpentinite. Speciation evidences high mobility and bioavailability.**

- **Weathering processes increase the release from easily weatherable parent material, also in weakly developed parts of cryoturbated soils;**
- **The different pedogenic processes differentiate speciation and bioavailability in different alpine habitats:**
- **- in cryoturbated areas, cryogenic movements associated with weathering of "fresh" materials recently brought to the surface increase labile fraction content;**
- **- in stable areas, strong acidification and leaching.**

- **Biological activity and stress indicators show unclear trends and correlations in high altitude soils: excessive variability in microclimate and pedogenic processes?**

- **High metal mobility at high altitudes, shown by accumulation on deep horizons on metal-poor substrates: water contamination?**
- **How does mineral weathering work in cold alpine soils?**


Thank You!