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TECHNOGENIC SOILS IN CLUJ-NAPOCA

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Cluj-Napoca is the second most populous city in Romania after the national capital Bucharest, and is the seat of Cluj County located in the northwestern part of the country (Fig. 1). The city is situated in the Someșul Mic River valley, and is considered to be an unofficial capital of the historical province of Transylvania. The Cluj-Napoca metropolitan area has a population of 411 379 people and 324 576 inhabitants live within the city limits (2011). The boundaries of the municipality contain an area of 179.52 square kilometres.

Today, Cluj-Napoca is one of the most important academic, cultural, industrial and business centres in Romania. At the site of the present-day city, there was a pre-Roman settlement called Napoca. After the Roman conquest of the area in 106 AD, the place was known as Municipium Aelium Hadrianum Napoca (Dragos et al. 2007).

Cluj-Napoca is located within the Someșul Mic corridor at the intersection of three major geographical units: the Transylvanian Plain, the Someș Plateau and the Apuseni Mountains, at an average altitude of 360 m and is intersected by the parallel of 46°46' north latitude and the meridian of 23°36' east longitude. It extends over the valleys of Someșul Mic and Nadăș. The southern part of the city covers the upper terrace of the northern slope of Feleac Hill, and is surrounded along three sides by hills or mountains with an altitude between 500 m and 700 m. The Someș plateau is situated to the east, while the northern part of the city includes Dealurile Clujului ('the Hills of Cluj'), with

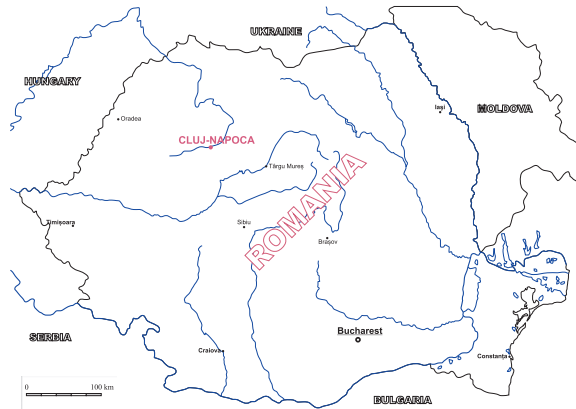


Fig. 1. Location of Cluj-Napoca

the following peaks: Lombului (684 m), Dealul Melcului (617 m), Techintău (633 m), Hoia (506 m) and Gârbău (570 m). Other hills are located in the western districts, and the hills of Calvaria and Cetățuia (Belvedere) are located near the centre of the city.

The natural dominant soils in the surroundings of the city are Eutric Cambisols, Haplic Luvisols and most fertile Haplic Phaeozems. In the river valleys, Eutric Gleyic Fluvisols predominate (Soil Atlas of Europe 2005).

The research on the urban soil cover was carried out in the city. Information on the lead contamination in Cluj-Napoca soils can be found in the paper by Rusu and Bartok (2002). The soils in the industrial zone Somes-Nord of Cluj-Napoca were described by Micle et al. (2005). The effects of a waste platform on soil pollution near the city of Cluj-Napoca was investigated by Cacovean et al. (2007). Studies of bacterial communities and enzymatic activities in the polluted soils of the traffic, industrial and household waste dumping ground in Cluj-Napoca was carried out by Simule and Bularda (2009a, b). Ekranosols in the Cluj-Napoca city centre was investigated by Charzyński et al. (2011a).

Acknowledgments

We are grateful to Marcin Chmurzyński and Jolanta Błaszczkiewicz for support in the field and laboratory.

Site 1 – Ekranic Technosol (Calcaric, Skeletic)**Location:**

Tipografieii 10 st.,
Cluj-Napoca, Romania

Coordinates:

46°46'39.7" N 23°35'40.4" E

Altitude:

341 m a.s.l.

Climate:

Average annual temperature: 8.3°C

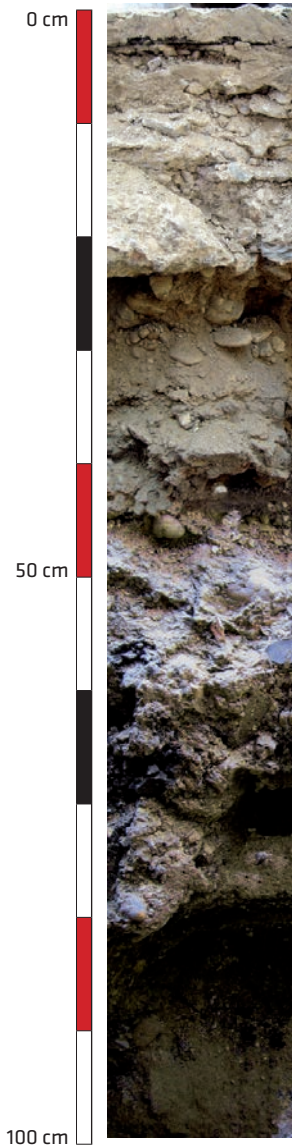
Average annual precipitation:
594 mm

Land-use: side-street

Vegetation: none



Site 1 – Ekranic Technosol (Calcaric, Skeletic)



Morphology:

0–20 cm: *technic hard rock* (asphalt).

Bu1 – 20–73 cm: sand, white, granular structure, dry, few artefacts (tile fragment; about 5%), clear boundary.

Bu2 – 73–97 cm: sandy loam, very pale brown, granular structure, slightly moist, few artefacts (grout; 5%).

Site 1 – Ekranic Technosol (Calcaric, Skeletic)

Selected soil properties

HORIZON		Bu1	Bu2
DEPTH [cm]		20–73	73–97
PARTICLE SIZE DISTRIBUTION			
ø [mm]		[%]	
>2.0		40	6
2.0–1.0		24	1
1.0–0.5		26	1
0.5–0.25		22	2
0.25–0.1		15	23
0.1–0.05		4	37
0.05–0.02		2	23
0.02–0.002		5	6
<0.002		2	8
TEXTURE CLASS (USDA)		sand	sandy loam
SOIL MATRIX COLOUR	dry	10YR 8/1	10YR 8/2
	wet	10YR 5/1	10YR 7/3
OC [%]		0.22	0.16
N _t [%]		0.006	0.008
C:N		37	20
P _t [mg·kg ⁻¹]		268	331
pH	H ₂ O	8.0	9.3
	1M KCl	7.4	8.0
CaCO ₃ [%]		3.1	1.6

Site 2 – Linic Technosol (Paracalcaric, Parahumic)



Location:

Cardinal Luliu Hossu 37 st.,
Cluj-Napoca, Romania

Coordinates:

46°46'11.8" N 23°34'15.0" E

Altitude:

343 m a.s.l.

Climate:

Average annual temperature: 8.3°C

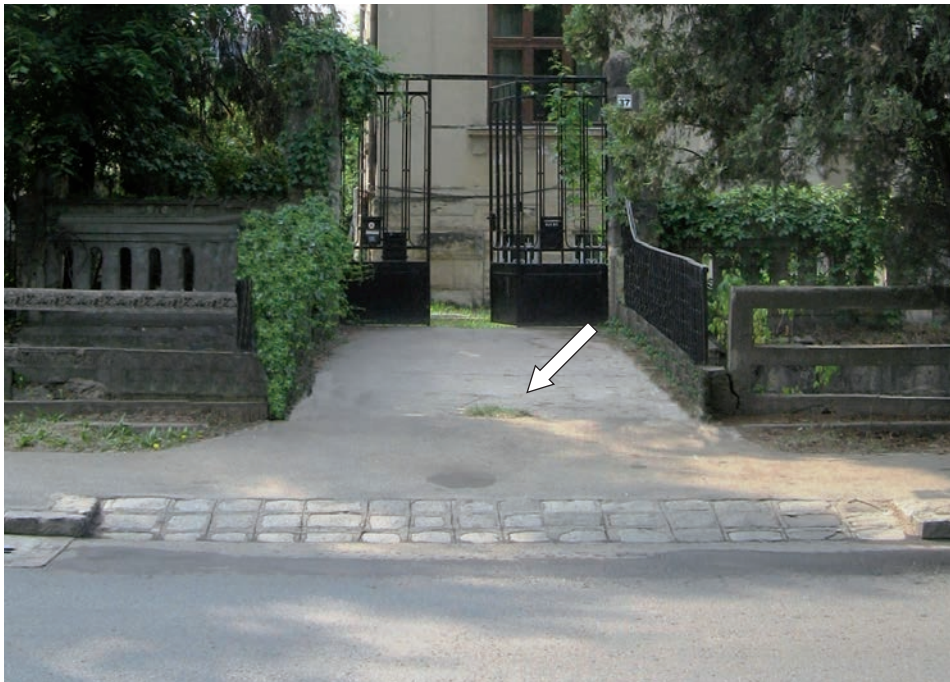
Average annual precipitation:
594 mm

Position:

bridge over rain channel

Vegetation:

grass (*Poaceae* sp.)



Site 2 – Linc Technosol (Paracalcaric, Parahumic)



Selected soil properties

HORIZON		AuCu
DEPTH [cm]		0–(1–3)
PARTICLE SIZE DISTRIBUTION		
ø [mm]		[%]
>2.0		4
2.0–1.0		7
1.0–0.5		13
0.5–0.25		18
0.25–0.1		16
0.1–0.05		30
0.05–0.02		9
0.02–0.002		7
<0.002		0
TEXTURE CLASS (USDA)		loamy sand
SOIL MATRIX	dry	10YR 5/3
COLOUR	wet	10YR 5/1
OC [%]		7.03
N_t [%]		0.281
C:N		25
pH	H ₂ O	7.3
	1M KCl	7.1
CaCO₃ [%]		3.2
P_{ca} [mg·kg⁻¹]		198
HEAVY METALS EXTRACTED IN MIXTURE OF ACIDS HF AND HClO₃		
Pb		<16
Zn		297
Cu	[mg·kg ⁻¹]	84
Cd		<5

Site 3 – Linic Technosol (Paracalcaric, Parahumic)



Location:

Cardinal Luliu Hossu 37 st.,
Cluj-Napoca, Romania

Coordinates:

46°46'11.8" N 23°34'15.0" E

Altitude:

343 m a.s.l.

Climate:

Average annual temperature: 8.3°C

Average annual precipitation:

594 mm

Position:

bridge over rain channel

Vegetation:

ruderal species (e.g. *Plantago* sp.,
Taraxacum sp., *Poaceae* sp.)



Site 3 – Linc Technosol (Paracalcaric, Parahumic)



Selected soil properties

HORIZON		AuCu
DEPTH [cm]		0–(1–4)
PARTICLE SIZE DISTRIBUTION		
ø [mm]		[%]
>2.0		6
2.0–1.0		12
1.0–0.5		20
0.5–0.25		26
0.25–0.1		15
0.1–0.05		11
0.05–0.02		11
0.02–0.002		4
<0.002		1
TEXTURE CLASS (USDA)		loamy sand
SOIL MATRIX	dry	10YR 4/2
COLOUR	wet	10YR 2/2
OC [%]		4.84
N_t [%]		0.279
C:N		17
pH	H ₂ O	7.4
	1M KCl	7.2
CaCO₃ [%]		3.2
P_{ca} [mg·kg⁻¹]		210
HEAVY METALS EXTRACTED IN MIXTURE OF ACIDS HF AND HClO₃		
Pb		365
Zn		569
Cu	[mg·kg ⁻¹]	48
Cd		<5

Site 4 – Linic Technosol (Paracalcaric, Parahumic)



Location:

Prahovei 5 st.,
Cluj-Napoca, Romania

Coordinates:

46°46'10.6" N 23°35'25.6" E

Altitude:

350 m a.s.l.

Climate:

Average annual temperature: 8.3°C

Average annual precipitation:
594 mm

Position:

Top of brick wall at a height of 2.5 m

Vegetation:

Chelidonium maius L.



Site 4 – Linic Technosol (Paracalcaric, Parahumic)



Selected soil properties

HORIZON		AuCu
DEPTH [cm]		0–(2–3)
PARTICLE SIZE DISTRIBUTION		
ø [mm]		[%]
>2.0		13
2.0–1.0		9
1.0–0.5		21
0.5–0.25		31
0.25–0.1		22
0.1–0.05		5
0.05–0.02		5
0.02–0.002		5
<0.002		2
TEXTURE CLASS (USDA)		sand
SOIL MATRIX	dry	10YR 8/1
COLOUR	wet	10YR 7/2
OC [%]		10.4
N_t [%]		0.068
C:N		152
pH	H ₂ O	8.2
	1M KCl	8.0
CaCO₃ [%]		9.5
P_{ca} [mg·kg⁻¹]		161
HEAVY METALS EXTRACTED IN MIXTURE OF ACIDS HF AND HClO₃		
Pb		<16
Zn		87
Cu	[mg·kg ⁻¹]	91
Cd		<5

Site 5 – Linc Technosol (Paracalcaric)



Location:

Prahovei 5 st., Cluj-Napoca,
Romania

Coordinates:

46°46'10.6" N 23°35'25.6" E

Altitude:

350 m a.s.l.

Climate:

Average annual temperature: 8.3°C

Average annual precipitation:

594 mm

Position:

Foundation of partly ruined
building at a height of 0.4 m

Vegetation:

grass (*Poaceae* sp.)



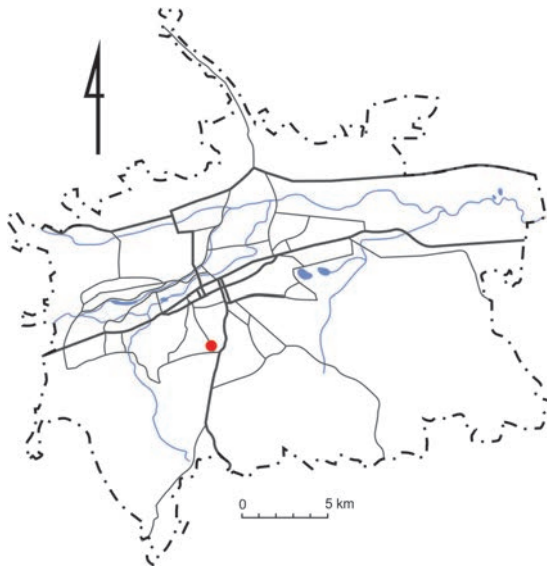
Site 5 – Linc Technosol (Paracalcaric)



Selected soil properties

HORIZON		AuCu
DEPTH [cm]		0-(3-5)
PARTICLE SIZE DISTRIBUTION		
ø [mm]		[%]
>2.0		12
2.0-1.0		8
1.0-0.5		17
0.5-0.25		25
0.25-0.1		24
0.1-0.05		5
0.05-0.02		6
0.02-0.002		9
<0.002		6
TEXTURE CLASS (USDA)		loamy sand
SOIL MATRIX	dry	7.5YR 8/1
COLOUR	wet	7.5YR 4/4
OC [%]		0.45
N_t [%]		0.187
C:N		2
pH	H ₂ O	7.8
	1M KCl	7.7
CaCO₃ [%]		8.3
P_{ca} [mg·kg⁻¹]		216
HEAVY METALS EXTRACTED IN MIXTURE OF ACIDS HF AND HClO₃		
Pb		<16
Zn		70
Cu	[mg·kg ⁻¹]	17
Cd		<5

Site 6 – Linic Technosol (Paracalcic, Parahumic)



Location:

Avram Iancu 23 st.,
Cluj-Napoca, Romania

Coordinates:

46°46'00.2" N 23°35'33.5" E

Altitude:

354 m a.s.l.

Climate:

Average annual temperature: 8.3°C

Average annual precipitation:

594 mm

Position:

Top of the wall at a height of 3.0 m

Vegetation:

Chelidonium maius L.,

Chenopodium bonus-henricus L.



Site 6 – Linic Technosol (Paracalcaric, Parahumic)



Selected soil properties

HORIZON		AuCu
DEPTH [cm]		0-(3-7)
PARTICLE SIZE DISTRIBUTION		
ø [mm]		[%]
>2.0		10
2.0-1.0		5
1.0-0.5		8
0.5-0.25		12
0.25-0.1		17
0.1-0.05		12
0.05-0.02		10
0.02-0.002		21
<0.002		15
TEXTURE CLASS (USDA)		sandy loam
SOIL MATRIX	dry	7.5YR 8/1
COLOUR	wet	7.5YR 4/4
OC [%]		1.88
N_t [%]		0.178
C:N		11
pH	H ₂ O	8.3
	1M KCl	7.4
CaCO₃ [%]		8.3
P_{ca} [mg·kg⁻¹]		78,2
HEAVY METALS EXTRACTED IN MIXTURE OF ACIDS HF AND HClO₃		
Pb		256
Zn		96
Cu	[mg·kg ⁻¹]	60
Cr		<5

Site 7 – Protofolic Linic Technosol



Location:

Avram Iancu 23 st.,
Cluj-Napoca, Romania

Coordinates:

46°46'00.8" N 23°35'37.1" E

Altitude:

354 m a.s.l.

Climate:

Average annual temperature: 8.3°C

Average annual precipitation:

594 mm

Position:

roof of the outbuilding at a height
of 3.0 m

Vegetation:

Chelidonium maius L.



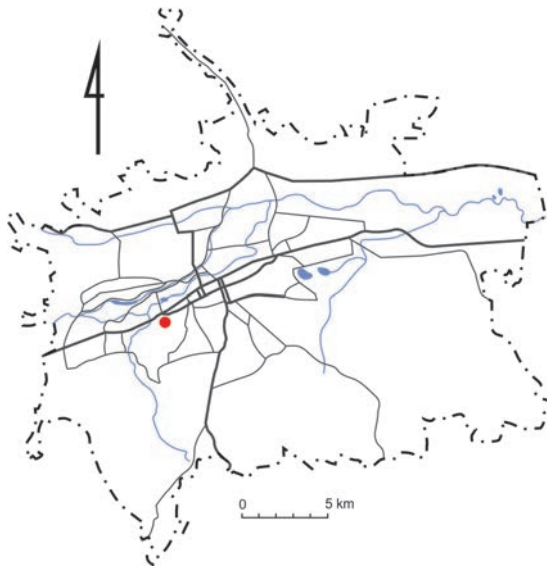
Site 7 – Protofolic Linic Technosol



Selected soil properties

HORIZON		Ou
DEPTH [cm]		0–(5–7)
SOIL MATRIX	dry	7.5YR 3/2
COLOUR	wet	7.5YR 3/1
OC [%]		25.8
N _t [%]		2.05
C:N		13
pH	H ₂ O	7.2
	1M KCl	6.8
CaCO ₃ [%]		–
P _{ca} [mg·kg ⁻¹]		267
HEAVY METALS EXTRACTED IN MIXTURE OF ACIDS HF AND HClO ₃		
Pb		67
Zn	[mg·kg ⁻¹]	124
Cu		17
Cr		<5

Site 8 – Linic Technosol (Paracalcaric, Parahumic, Paraskeletic)



Location:

Uzinei Electrica / Stadion,
Cluj-Napoca, Romania

Coordinates:

N 46°45'58.3" E 23°34'12.7"

Altitude:

343 m a.s.l.

Climate:

Average annual temperature: 8.3°C

Average annual precipitation:

594 mm

Position:

Roof of transformer substation at
a height of 5.0 m

Vegetation:

Acer negundo L.



Site 8 – Linic Technosol (Paracalcaric, Parahumic, Paraskeletic)

Selected soil properties

HORIZON		AuCu
DEPTH [cm]		0-(1-4)
PARTICLE SIZE DISTRIBUTION		
ø [mm]		[%]
>2.0		29
2.0-1.0		10
1.0-0.5		18
0.5-0.25		16
0.25-0.1		19
0.1-0.05		9
0.05-0.02		12
0.02-0.002		13
<0.002		3
TEXTURE CLASS (USDA)		sandy loam
SOIL MATRIX COLOUR	dry	10YR 8/1
	wet	10YR 5/2
OC [%]		1.52
N_t [%]		0.101
C:N		15
pH	H₂O	7.9
	1M KCl	7.6
CaCO₃ [%]		4.7
P_{ca} [mg·kg⁻¹]		1115
BASE CATIONS		
Ca²⁺		21.5
Mg²⁺	[cmol·kg⁻¹]	0.5
K⁺		0.6
Na⁺		0.3
HEAVY METALS EXTRACTED IN MIXTURE OF ACIDS HF AND HClO₃		
Pb		<16
Zn	[mg·kg⁻¹]	128
Cu		22
Cr		<5

Site 9 – Linic Technosol (Paracalcaric, Parahumic)



Location:

Uzinei Electric/Stadion,
Cluj-Napoca, Romania

Coordinates:

46°45'58.3" N 23°34'12.7" E

Altitude:

343 m a.s.l.

Climate:

Average annual temperature: 8.3°C

Average annual precipitation:
594 mm

Position:

Roof of transformer substation at
a height of 5.0 m

Vegetation:

Populus L.



Site 9 – Linic Technosol (Paracalcaric, Parahumic)



Selected soil properties

HORIZON		AuCu
DEPTH [cm]		0-(3-5)
PARTICLE SIZE DISTRIBUTION		
ø [mm]		[%]
>2.0		30
2.0-1.0		11
1.0-0.5		31
0.5-0.25		28
0.25-0.1		14
0.1-0.05		4
0.05-0.02		3
0.02-0.002		5
<0.002		4
TEXTURE CLASS (USDA)		sand
SOIL MATRIX	dry	10YR 2/2
COLOUR	wet	10YR 2/1
OC [%]		9.58
N_t [%]		0.238
C:N		40
pH	H ₂ O	8.1
	1M KCl	7.7
CaCO₃	[%]	4.7
P_{ca} [mg·kg⁻¹]		151
HEAVY METALS EXTRACTED IN MIXTURE OF ACIDS HF AND HClO₃		
Pb		<16
Zn		143
Cu	[mg·kg ⁻¹]	110
Cr		<5

Site 10 – Urbic Ekranic Technosol (Calcaric)



Location:

Tipografiei 12 st.,
Cluj-Napoca, Romania

Coordinates:

46°46'39.7" N 23°35'40.6" E

Altitude:

341 m a.s.l.

Climate:

Average annual temperature: 8.3°C

Average annual precipitation:

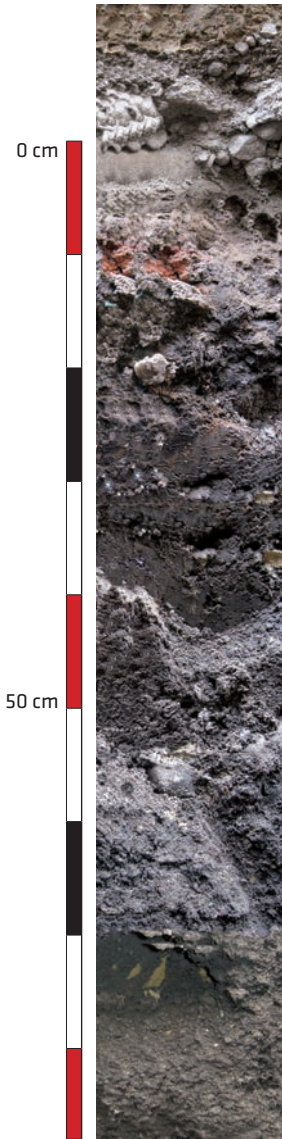
594 mm

Land-use: pavement

Vegetation: none



Site 10 – Urbic Ekranic Technosol (Calcaric)



Morphology:

0–5 cm: *technic hard rock* (asphalt).

Bu1 – 5–20 cm: sand, grey, granular structure, dry, clear boundary; common artefacts: (brick pieces, charcoals 30%).

Bu2 – 20–45 cm: loam, light grey, angular structure, slightly moist, common artefacts: (bones, charcoals, wood, metal elements; 10%), clear boundary.

Bu3 – 45–95 cm: loam, light brownish grey, angular structure, moist.

Site 10 – Urbic Ekranic Technosol (Calcaric)

Selected soil properties

HORIZON		Bu1	Bu2	Bu3
DEPTH [cm]		5–20	20–45	45–95
PARTICLE SIZE DISTRIBUTION				
ø [mm]		[%]		
>2.0		50	0	19
2.0–1.0		10	4	4
1.0–0.5		35	5	7
0.5–0.25		24	8	10
0.25–0.1		16	20	16
0.1–0.05		5	11	11
0.05–0.02		5	13	10
0.02–0.002		4	27	28
<0.002		1	12	14
TEXTURE CLASS (USDA)		sand	loam	loam
SOIL COLOUR MATRIX	dry	5Y 5/1	5Y 7/1	2.5Y 6/2
	wet	5Y 3/1	5Y 4/2	2.5Y 3/4
OC [%]		0.53	–	1.53
N_t [%]		0.012	0.119	0.138
C:N		44	–	11
P_t [mg·kg⁻¹]		519	2 559	636
pH	H ₂ O	9.3	8.6	8.3
	1M KCl	8.0	7.3	7.2
CaCO₃ [%]		10.4	21.4	6.8