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Palaeoenvironmental dataset from the northern Apuo-Versilian coastal plain (NW Italy): a key tool for scientific and management applications

SUPPLEMENTARY MATERIAL

Suppl. Tab. 1 - Available drilling points topographic positioning.

Core code	X	Y	Ellipsoidal elevation (m) Accuracy ± 0.05 m	Orthometric elevation* (m) Accuracy ± 0.2 m
LUN_1	580982,962	4878909,473	NA	1.6
LUN_2	581388,63	4879181,869	53.228	1.0
LUN_3	581055,035	4878327,121	52.914	1.1
LUN_4	580972,391	4879570,168	53.105	0.9
LUN_5	580896,524	4879422,047	48.169	0.8
LUN_6	580149,042	4878685,183	51.898	1.0
LUN6_A	580110,403	4878725,453	same as LUN_6	same as LUN_6
LUN_7	581870,211	4879281,323	49.770	3.4
LUN_8	581785,376	4879242,475	48.730	3.6
LUN_9	581107,784	4877875,714	48.773	1.0
LUN_10	581491,264	4879656,874	46.7463	3.6
LUN_11	581533,976	4879732,63	47.557	3.5
LUN_12	580472,259	4879041,796	46.274	1.5
LUN_13	581392,541	4879480,431	48.088	4.0
LUN_14	582549,519	4878150,277	48.0862	1.8
LUN_15	582403,309	4878636,874	48.0875	1.4
LUN_16	579508,361	4879049,454	48.082	1.3
LUN_17	581812,446	4879234,554	46.809	3.1
LUN_18	578832,943	4878783,502	47.893	1.6
LUN_19	581055,455	4878293,021	46.935	0.3
LUN_20	579647,649	4878448,577	47.534	1.5
LUN_21	NA	NA	47.628	NA
LUN_22	581258,324	4879164,162	47.642	4.0
LUN_23	582221,75	4878796,053	NA	NA

Datum WGS84 UTM zone 32N

* Measured by means of ground leveling, referred to the official Italian geodetic network point "0031#_###_053P S.S. 1 "AURELIA" KM 388.680 (Stabilimento GMP - Granito Marmi e Pietre (<https://www.igmi.org/it/geoprodotto/punti-geodetici/capitaldi-livellazione/caposaldo-1541576426.25>))
NA = not available

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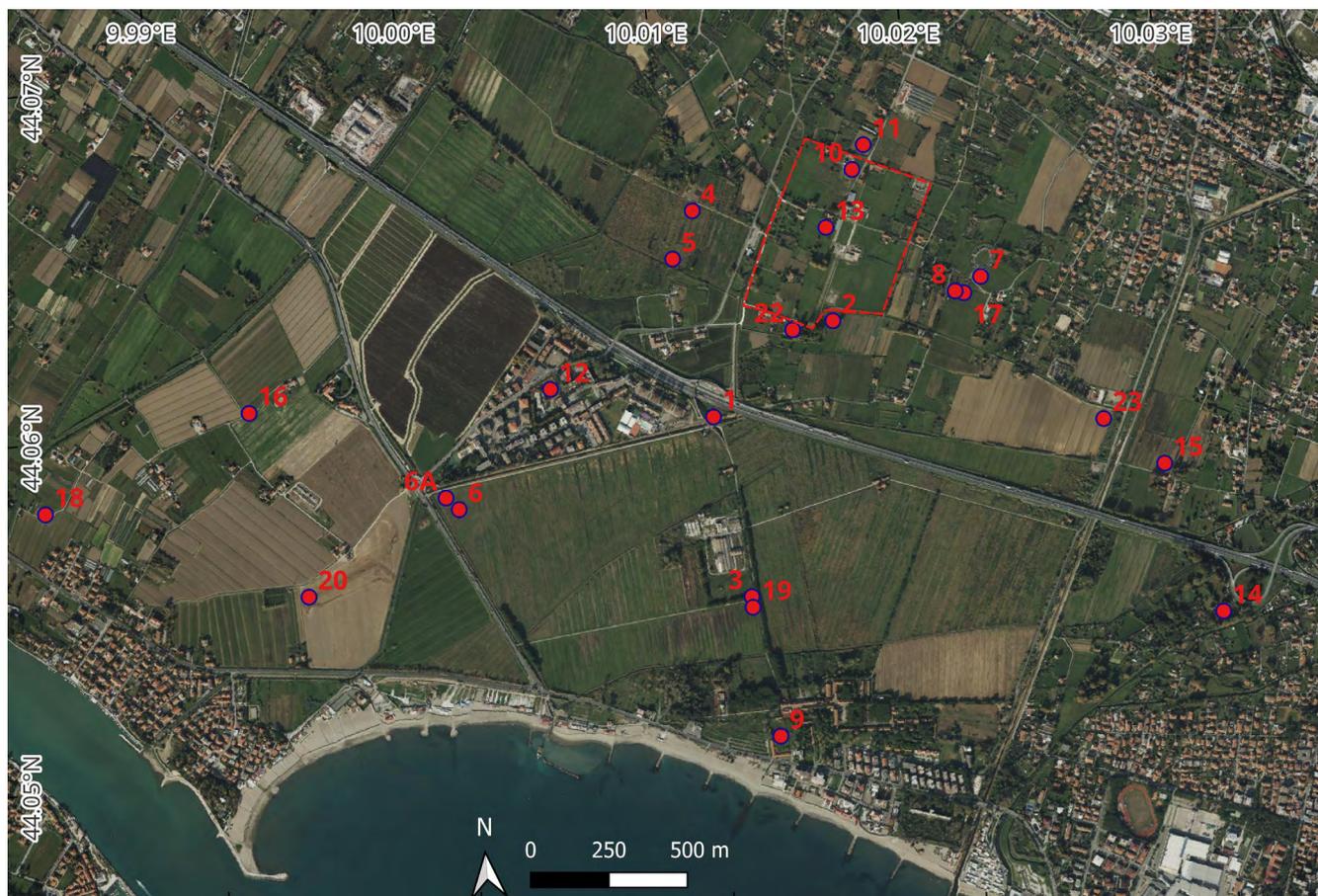
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This contribution was presented on the occasion of 25th anniversary of AIGeo, the Italian Association of Physical Geography and Geomorphology, under the guest editorship of Pappalardo M., Rotigliano E., Ferrando A.

Suppl. Tab. 2 - Radiocarbon ages, including uncalibrated data and the results of a new calibration performed for this work. Depths are reported below ground level measured from the drilling point.

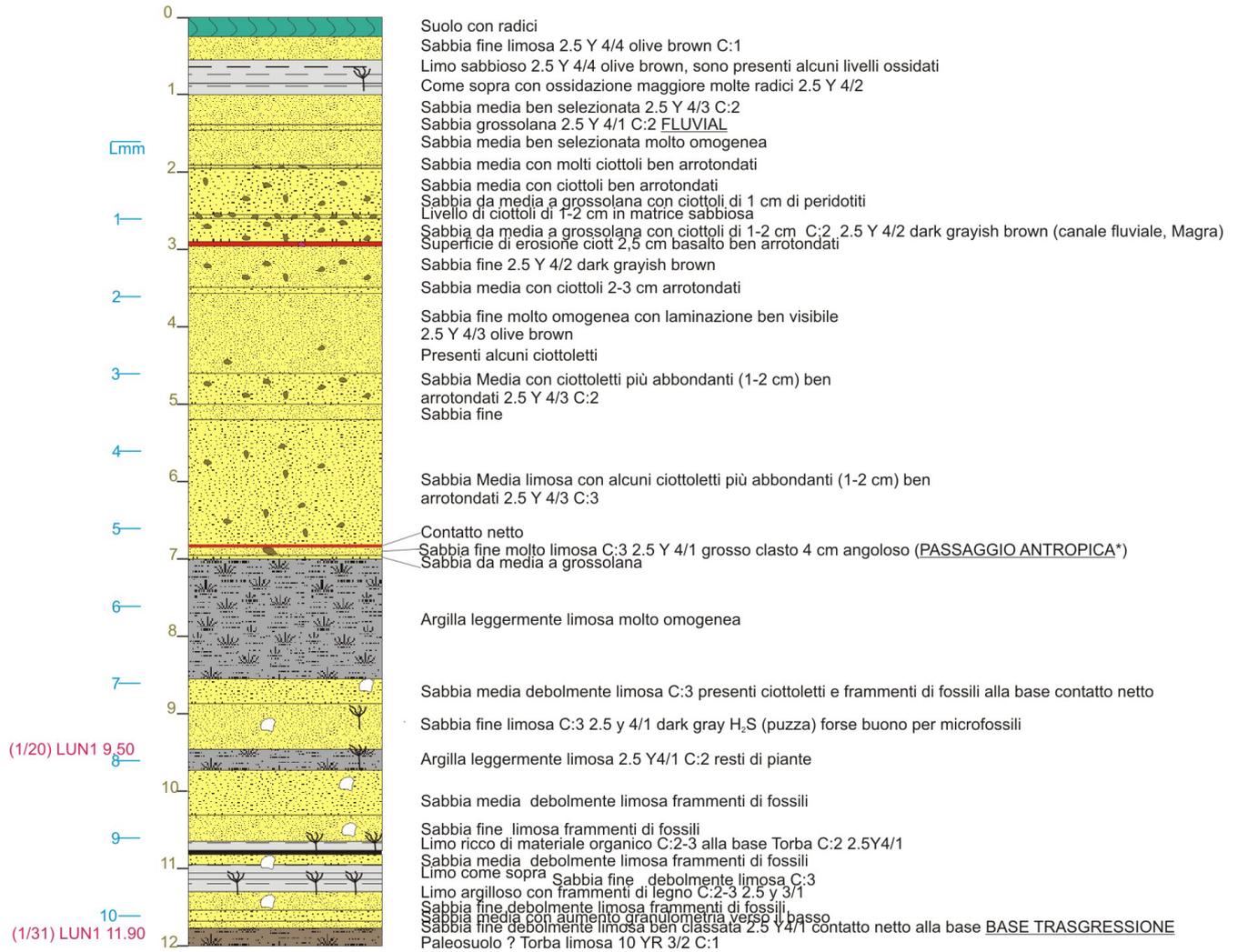
Core number	Sample code	Lab (code)	Depth (m bgl ± 0.01)	Conventional Age (yr BP)	δ13C	Calibrated age, 2σ (cal AD)	Material
1	LUNI1/20	Beta (255400)	9.50	3440±40	-26.0‰	1879-1627 BC	peat
1	LUNI1/31	Beta (255401)	11.90	5390±40	-24.0‰	4339-4059 BC	wood
3	LUNI3/14	Beta (255396)	4.85	4370±40	-25.1‰	3257-2898 BC	organic sediment
3	LUNI3/65	Beta (255402)	7.65	1150±40	-26.9‰	774-992 AD	wood
4	LUNI4/4	Beta (255403)	1.30	280±40	-25.4‰	1483-1946 AD	plant material
5	LUNI5/9	Beta (255399)	4.15	2680±40	NA	908-793 BC	plant material
5	LUNI5/15	Beta (255397)	6.80	4630±40	-25.8‰	3590-3347 BC	wood
5	LUNI5/21	Beta (255398)	8.10	5840±50	-29.3‰	4828-4550 BC	peat
6	LUN6_16H	CIRCE (DSH3613)	4.34-4.39	1035±27	-18±1‰	900-1113 AD	plant material
6	LUN6_36H	CIRCE (DSH3612)	8.60-8.75	1829±34	-34±2‰	126-325 AD	plant material
6A	LUN_6A_165-174	INNOVA ScaRL (DSH9302_PE)	1.65-1.75	910±22	-31±2‰	1042-1213 AD	plant material
6A	LUN_6A_340-353	INNOVA ScaRL (DSH9303_PE)	3.40-3.50	918±32	-39±2‰	1036-1211 AD	plant material
16	LUN16_6H	CIRCE (DSH3589)	3.85-3.90	1281±28	-31±2‰	663-818 AD	charcoal
16	LUN16_9HK	CIRCE (DSH3615)	4.65	1876±45	-31±3‰	28-306 AD	charcoal
16	LUN16_13H	CIRCE (DSH3611)	4.84	2524±29	-27±2‰	790-544 BC	plant material
22	LUN_22_5h	CIRCE (DSH3746)	2.65	1283±28	-31±2‰	662-817 AD	plant material

Suppl. Mat. 1 - Drilling point locations LUN_1-20 and LUN_22-23, projected on Bing Satellite basemap (WMS service, accessed 09/2025) via Quantum GIS software.



Luni 1 12.09.07

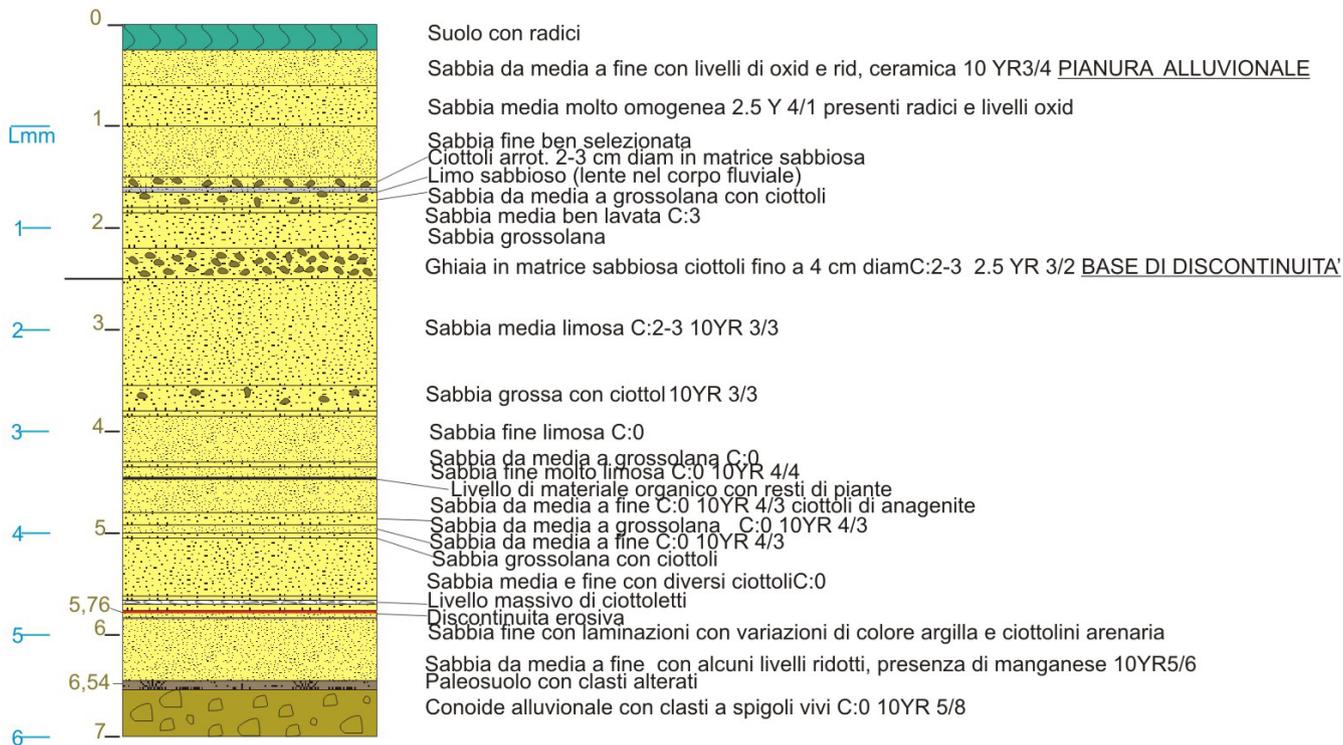
1,6 m pdc
depuratore



Luni 2 14.09.07

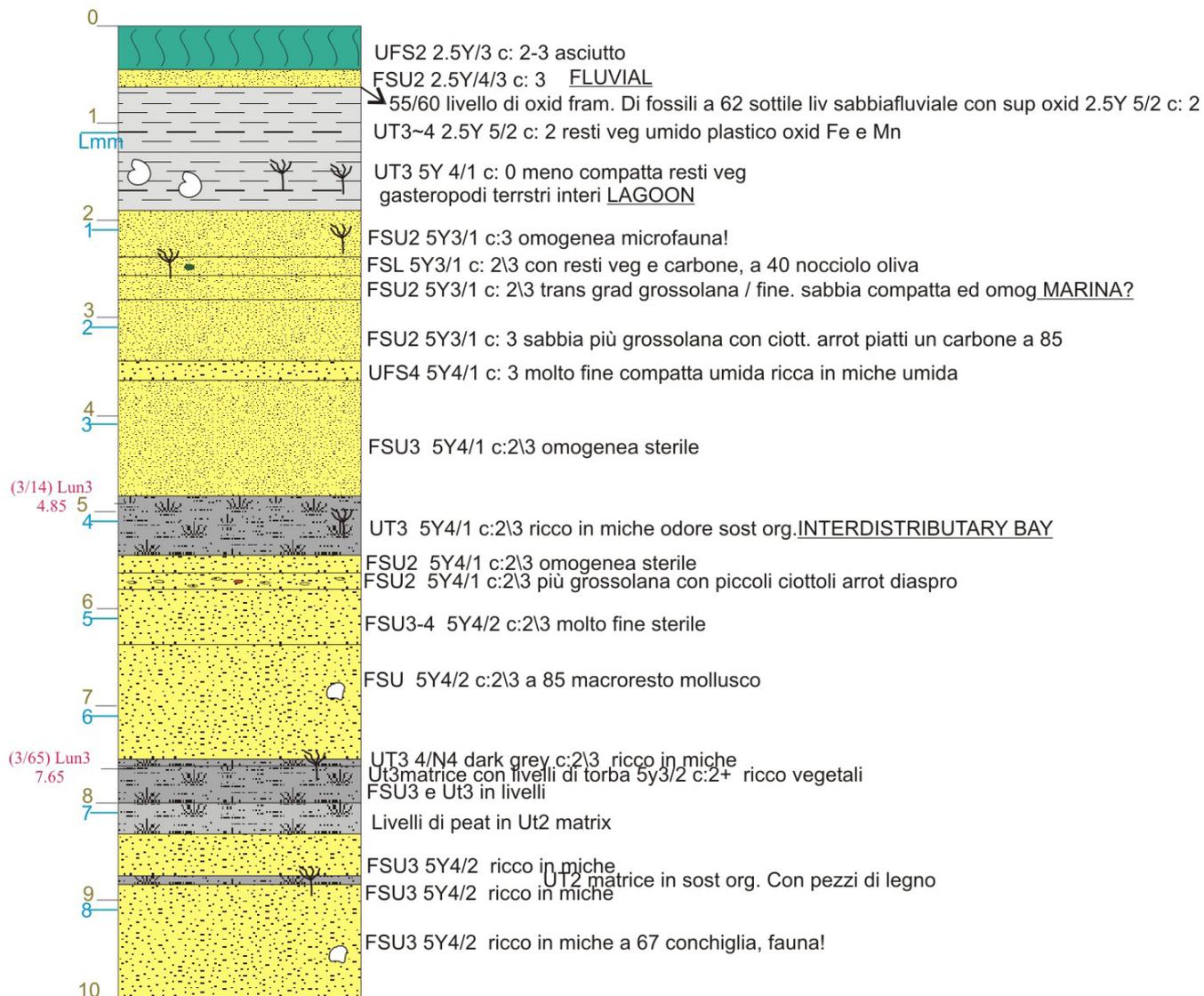
44° 03' 41"

10° 00' 58.6' E pdc 1 m falda 1,68 m

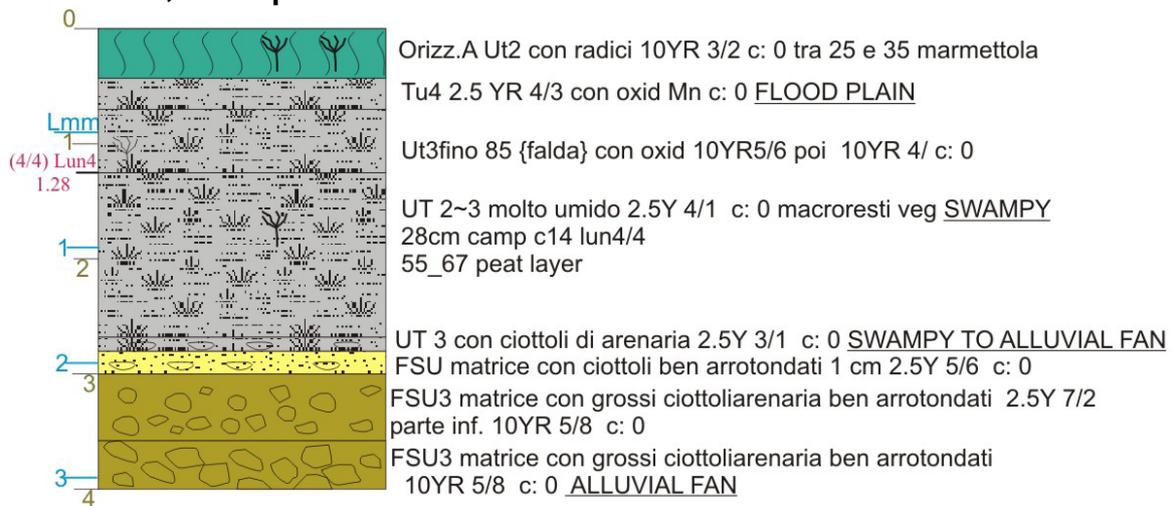


Luni 3 14.09.07

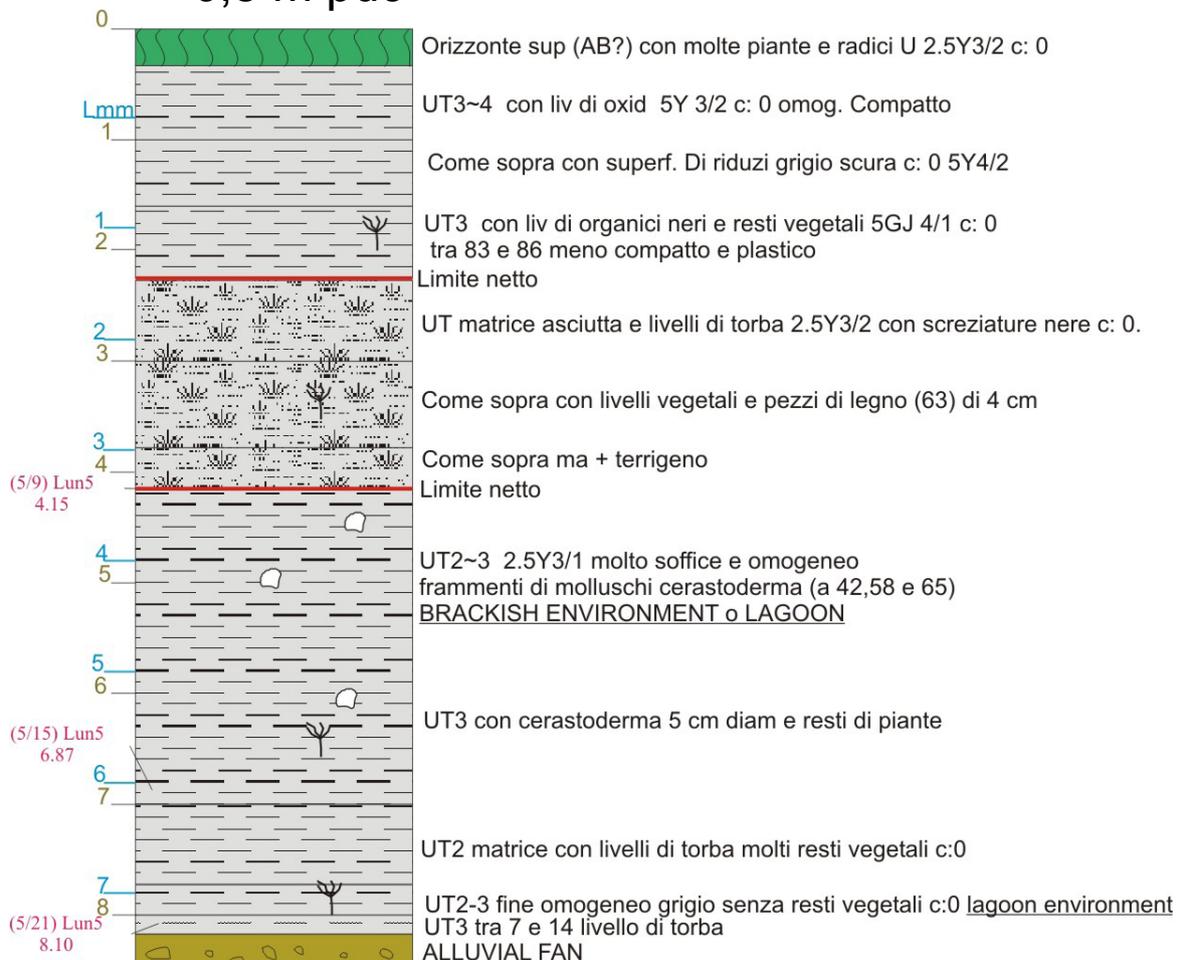
1,1 m pdc



Luni 4 0,9 m pdc



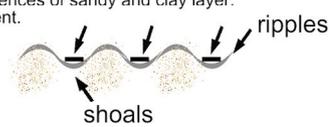
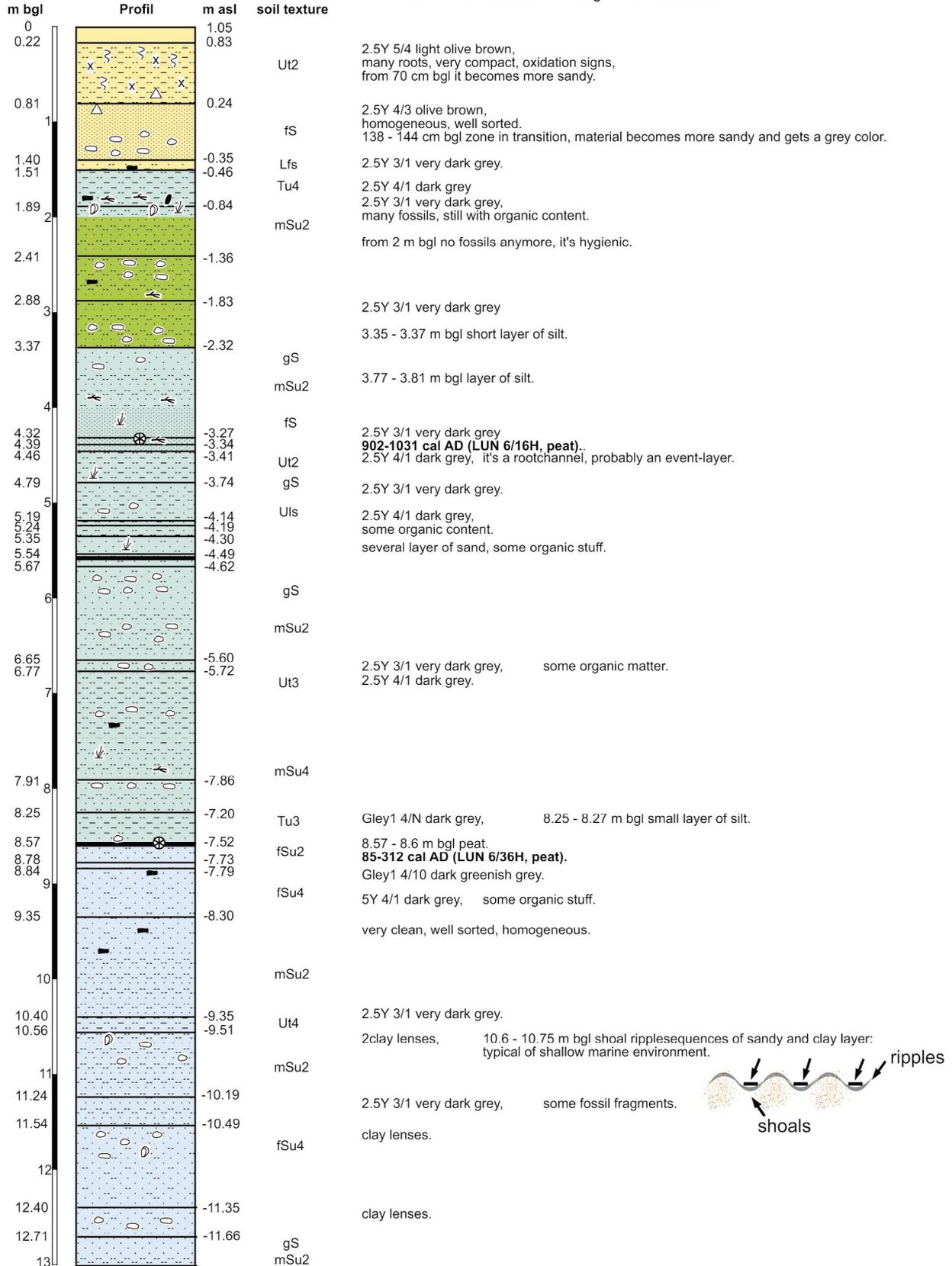
Luni 5 0,8 m pdc

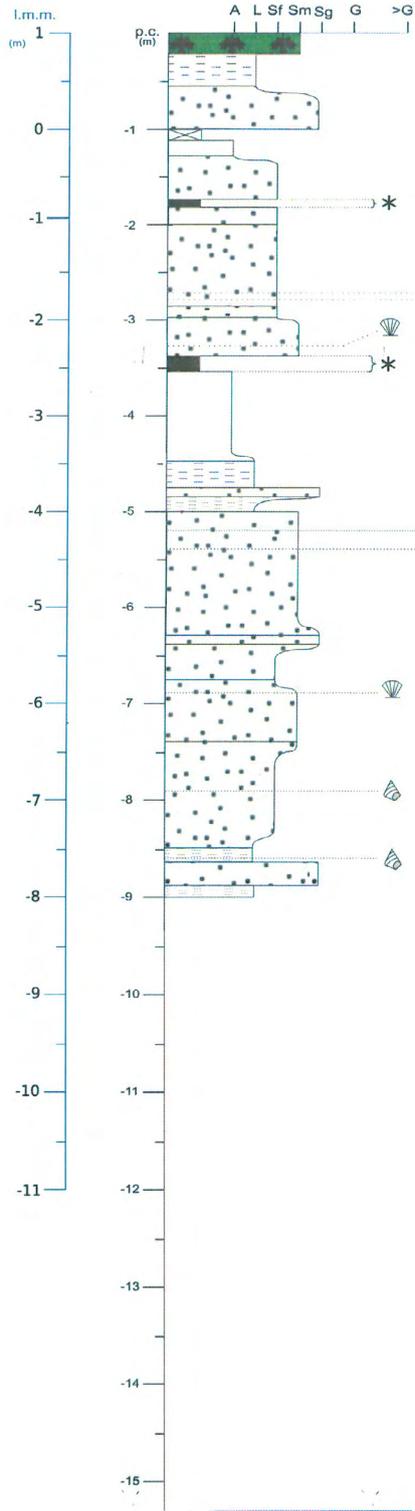


LUN 6

Drilling log close to Luni Mare

lat. 44° 03' 26.5328" N / long. 9° 59' 58.8592' E





Sigla	LUN6 A
Località	LUNI
Coordinate	1 m
Quote piano campagna (l.m.m.)	12/6/2018
Data	DST
Esecutori	

Legenda

	Terreno vegetale		Argilla		Limo
	Sabbia		Ghiaia		Mancato recupero/ carota disturbata
	Torba				

	forma	litologia		
Clasti		arrotondati		calcarei
		angolosi		crist. e metam. massivi
		sub_arrotondati		scistosi
		appiattiti		arenacei

	Carboni e ceneri		Catrame
	Malta		Laterizi
	Intonaco		Ceramica
	Termotrasformazione		Metallo
	Vetro		Scorie
	Ossa		Tessera di mosaico
	Bivalve s.l.		
	Frammenti di bivalve		
	Gastropodi salmastro/marino		Gastropodi dulcicoli
	Frammenti di gastropodi		
	Frammenti di coralli		
	Lag conchigliare		
	Frammenti di molluschi		
	Sostanza organica decomposta		
	Frammenti di legno e/o carboni		
	Resti di radici e piante		
	Mud clasts		
	Concrezioni carbonatiche		
	Ossidi		
	Livello consolidato		
	Sedimenti plastici		
	Superficie di erosione		
	Materiale databile		

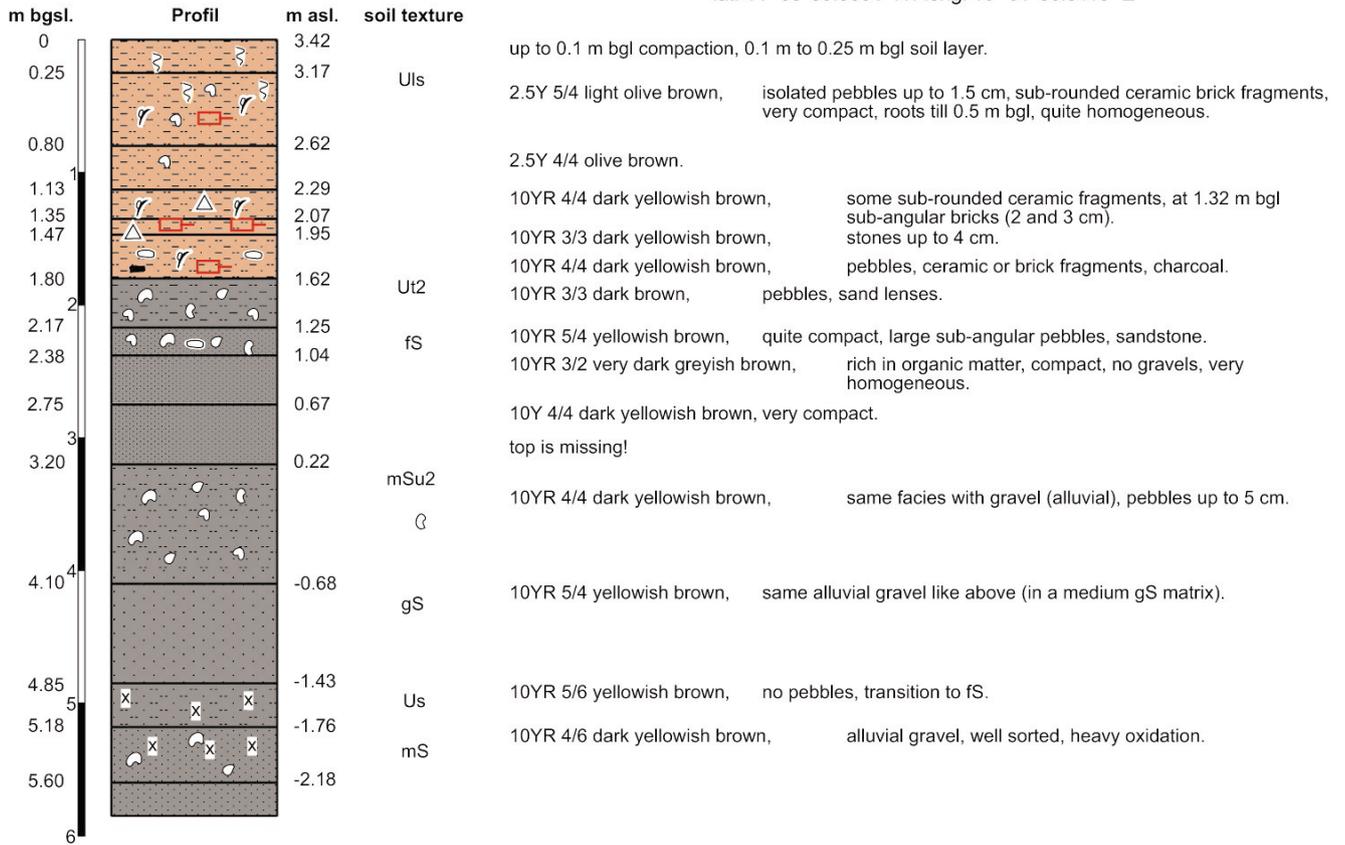
Agenti morfogenetici

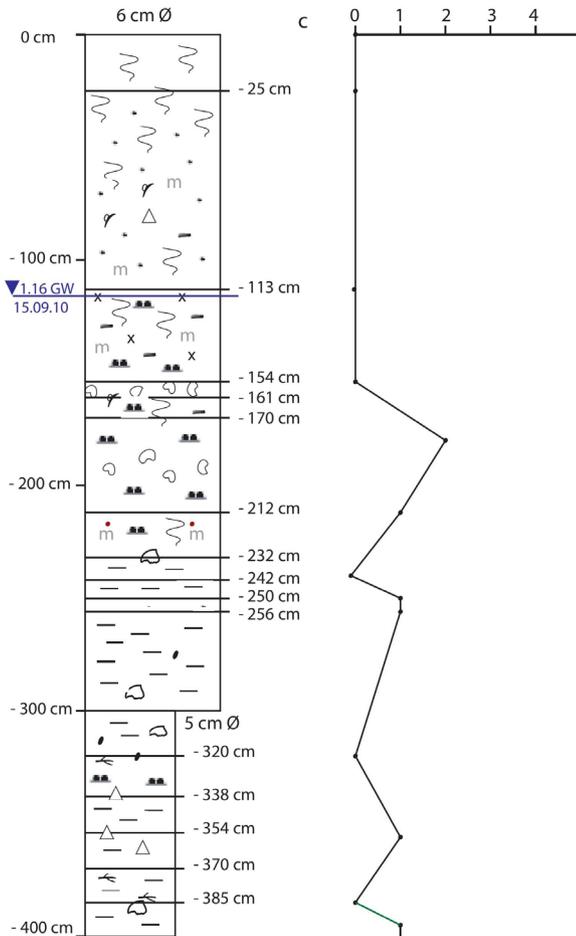
	Antropico
	Fluviale
	Marino/transizionale

LUN 7

Drilling log east of the ancient *Luna* at the entrance of the amphitheater

lat. 44° 03' 39.6664" N / long. 10° 01' 00.5113" E





LUN 8 (0 - 4 m) 12.09.2010
 Coring at the mausoleum towards the sea "Wölbäcker"

soil layer, organic, roots, dry, 10YR 4/4 dark yellowish brown.

fSu2, 10YR 5/4 yellowish brown,
 more compaction, roots, homogeneous, manganese slightly mottled,
 sparkling, mica, from 70 cm down it's getting more silty,
 from 90 cm down it's no fs in it, angular stone (shist).

Ut2, 10YR 4/4 dark yellowish brown,
 oxidation mottled, some manganese, roots, homogeneous, compact, organic,
 mottling.

gSu2, 10YR 4/4 dark yellowish brown, organic mottling, weathered shist.
 Ums2, 10YR 4/4 dark yellowish brown, organic mottled, at 168cm root (3cm),
 no more pebbles.

Ums2, 10YR 4/4 dark yellowish brown,
 sparkling, organic mottled, from 180 cm Ufs3 + small pebbles, from 195 cm more fs.

Ut2, 2.5Y 5/3 light olive brown, iron, manganese, small roots, compact, sparkling
 mudstone.

Zone in transition, more clay!

Tu4, 5Y 4/1 dark grey.

fSu3, Gley1 4/10Y dark greenish grey.

Tu4, 5Y 4/1 dark grey,
 very homogeneous, isolated pieces of strongly weathered stones.

Ut4, 7.5YR 3/1 very dark grey.

Tu4, 5Y 2.5/2 black.

Tu4, 5Y 3/1 very dark grey, 356-360 cm: lense fSu3

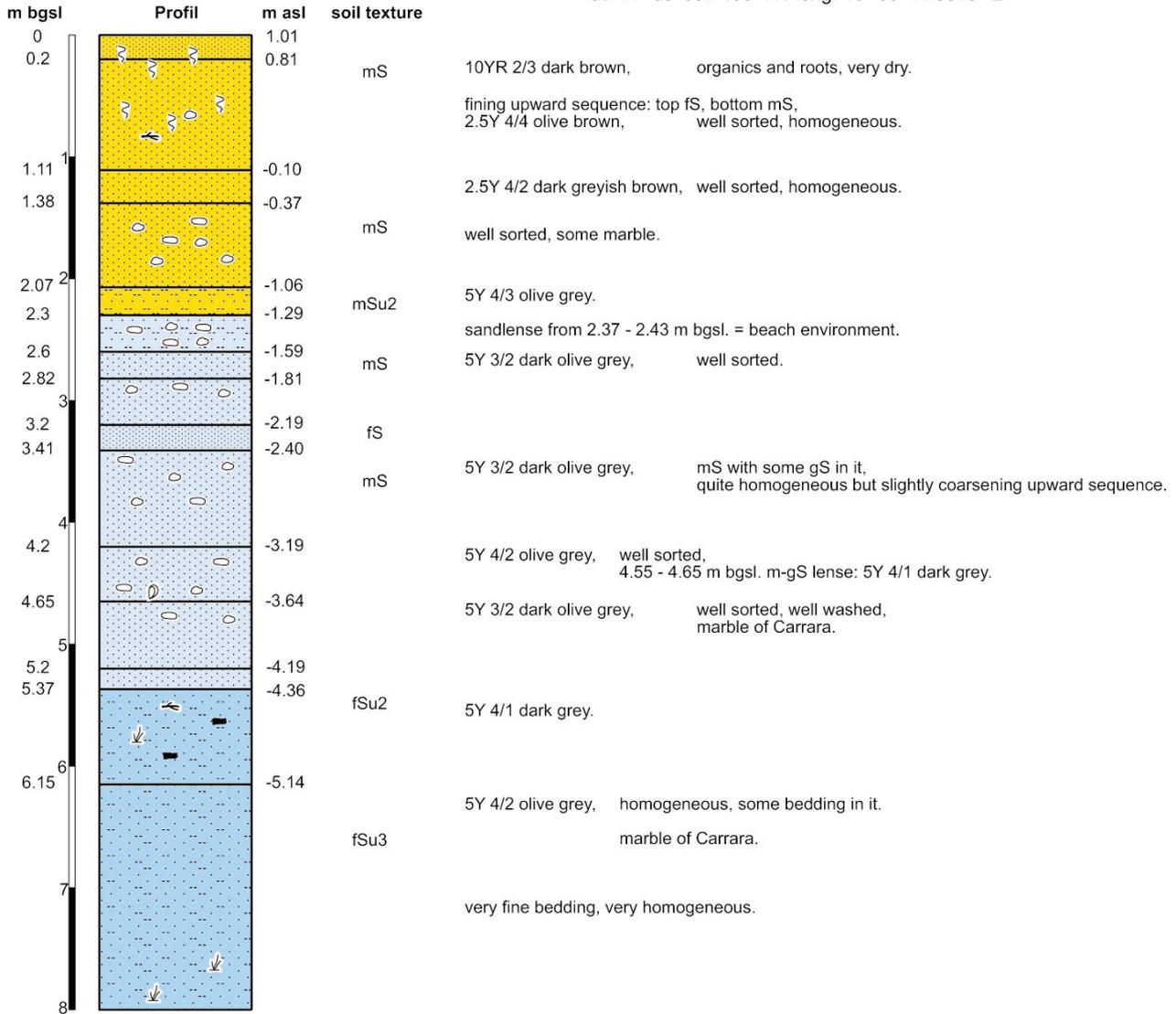
Tu3, homogeneous, organic.

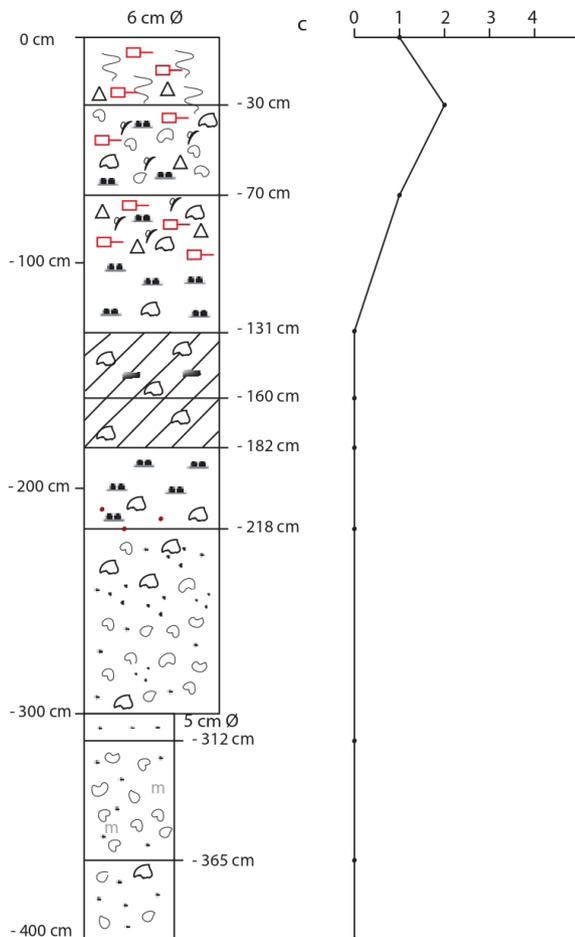
385-395 cm maybe shist fills out the core, 395-396cm sand lense, 396-400 cm Tu3.

LUN 9

Drilling log in the village of Marinella

lat. 44° 03' 00.7400" N / long. 10° 00' 44.3319" E





LUN 10 (0 - 4m) 14.09.2010
 Inside the walls of Luni, east of the great temple. It was never excavated.

Ap, mixed material, Ufs2, 10YR 3/2 very dark greyish brown, many pieces of bricks.

Ufs2, 10YR 3/2 very dark greyish brown, sharp boundary, two pieces of marble, sandstone, chert, shist, mortar.

Ufs2, color like above, sharp boundary, totally weathered sandstone, marble fragments, mortar, shist.

Lu + fS, flat loam, 10YR 3/6 dark yellowish brown, sharp boundary, shist.

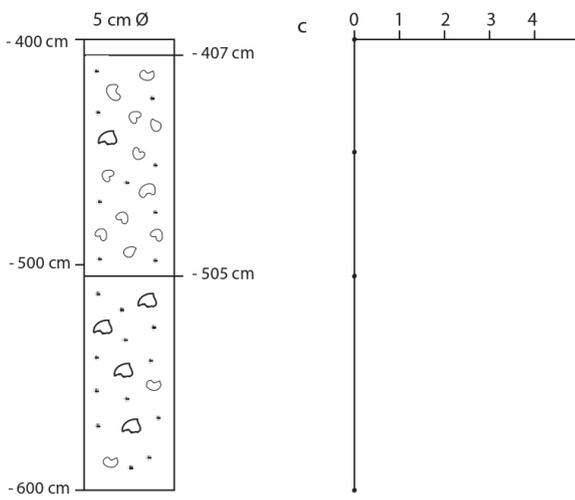
Lu + fS, 10YR 4/6 dark yellowish brown, weathered sandstones.

Ufs2 with some gS, 10YR 5/6 yellowish brown, fragments of sandstone, marble, quartz, no organic material, 207-218 cm Us, 7.5 YR 5/8 strong brown, iron rich!

f-mSu2, 10YR 6/6 brownish yellow, sharp boundary, many pebbles, weathered sandstone, small marble grains, no ceramic, no organic.

fSu2, 10YR 5/6 yellowish brown, sharp boundary, very compact, no organic, no anthropogenics, manganese.

fSu2, 10YR 5/6 yellowish brown, no organics, no ceramics.



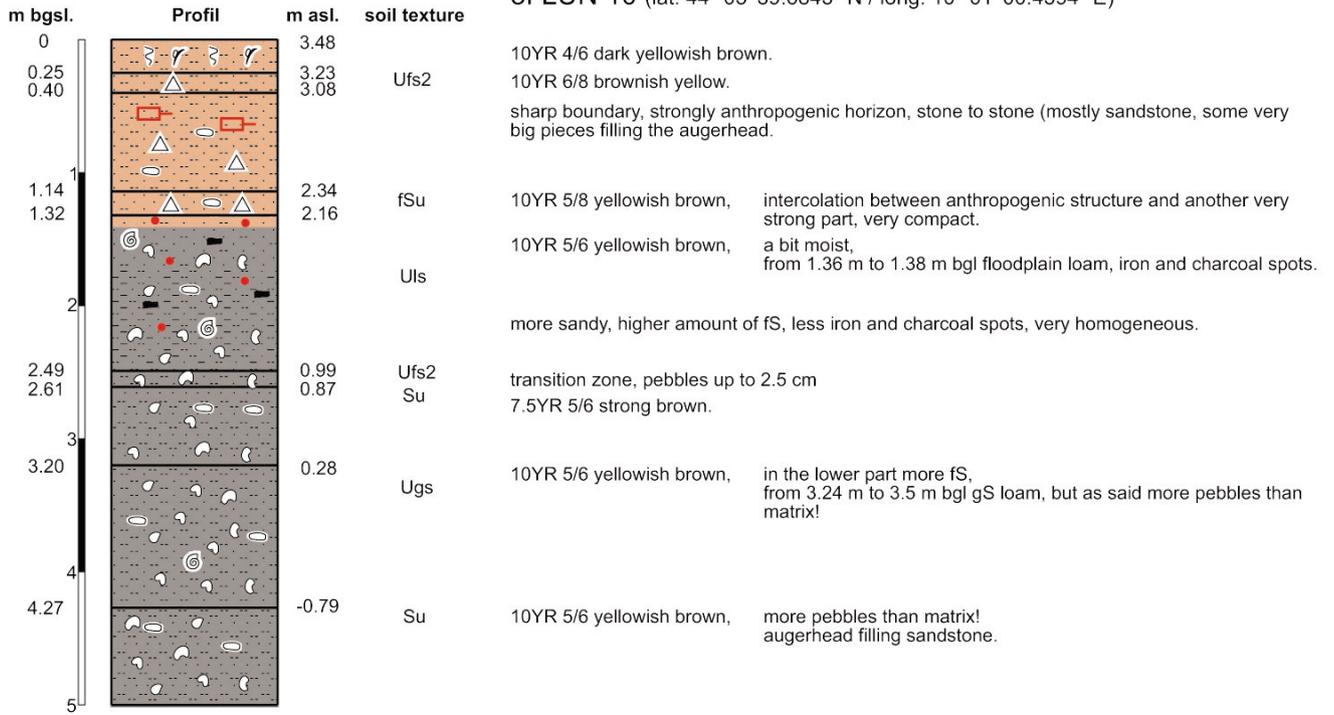
LUN 10 (4 - 6m) 14.09.2010

fSu2, 10YR 5/6 yellowish brown, red sandstone pebble.

fSu2, 10YR 5/6 yellowish brown, sandstones, augerhead filling!

LUN 11

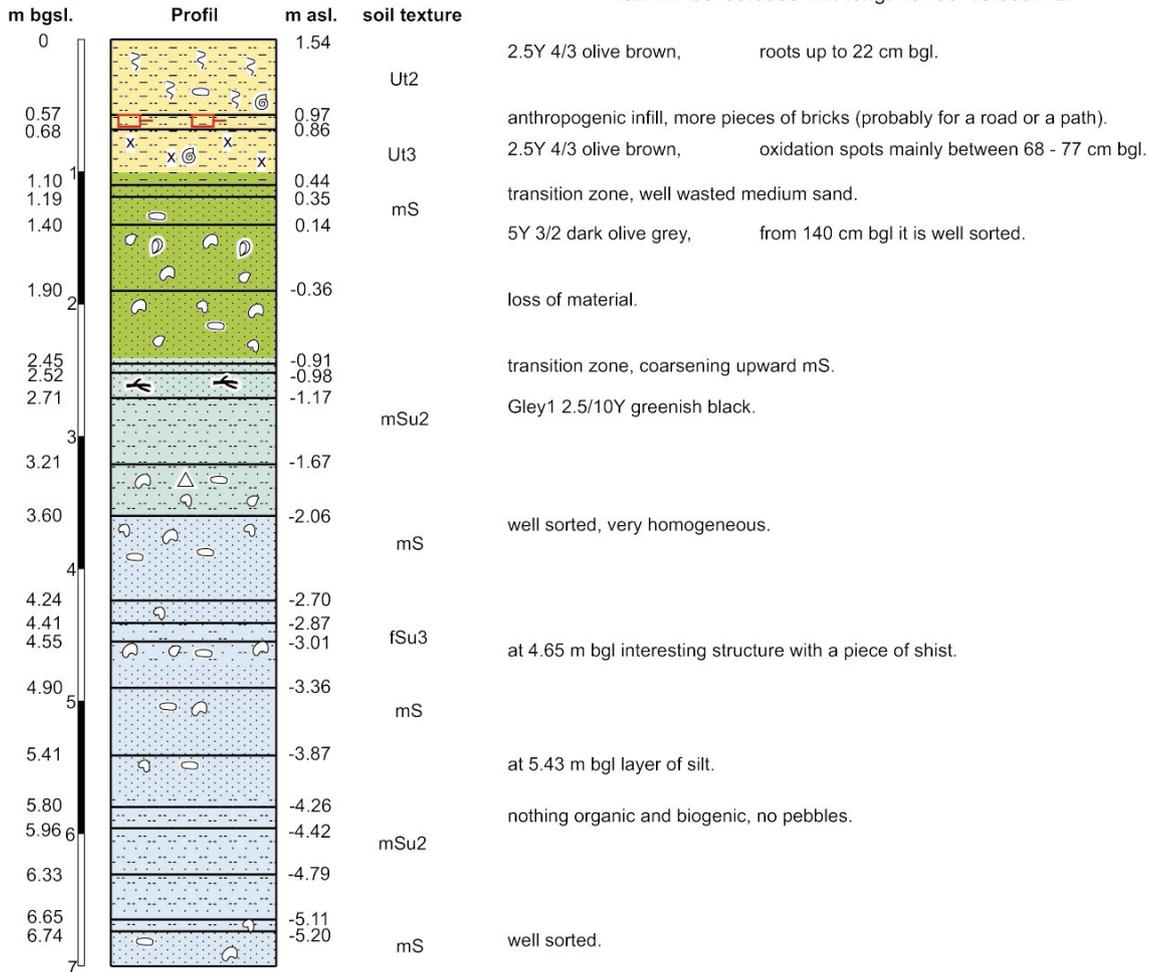
Drilling log north of the historic city of *Luna*, outside the ancient city on extensively cultivated meadow, and 80 m north of LUN 10 (lat. 44° 03' 39.6843" N / long. 10° 01' 00.4594" E)

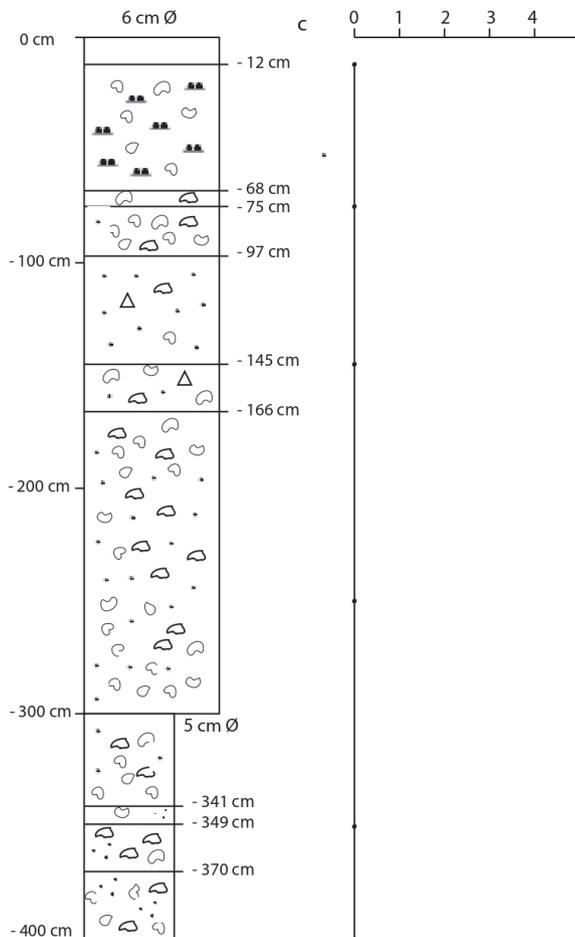


LUN 12

Drilling log in the local kindergarden of Luni Mare

lat. 44° 03' 35.9088" N / long. 10° 00' 18.6607" E





LUN 13 (0 - 4m) 15.09.2010
 Am Forum der römischen Stadt.

Ufs2, 7.5YR 3/4 dark brown, some gravels (< 1cm).

sharp boundary, augerhead filling sandstone.

f-mSu3, 10YR 4/6 dark yellowish brown, poorly sorted, many pebbles.

fSu2, 10YR 5/6 yellowish brown, homogeneous.

f-mSu2, 10YR 5/4 yellowish brown.

fSu2, 10YR 4/6 dark yellowish brown.

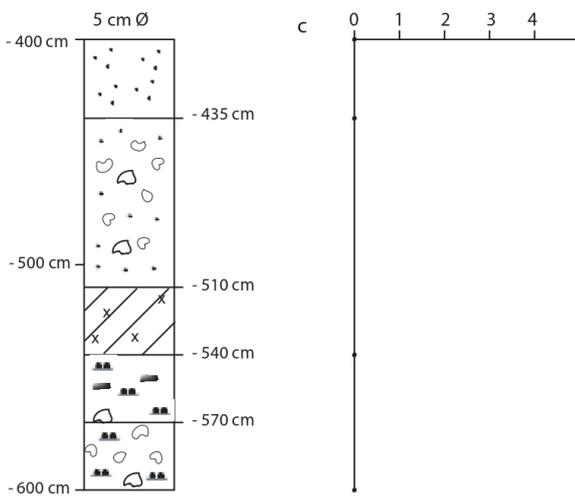
like above, augerhead filling stones, mainly sandstones.

fSu2, 10YR 5/6 yellowish brown, very compact, many pebbles.

mSu2, 10YR 4/6 dark yellowish brown.

mSu2, color like above, homogeneous, compact, well sorted.

mSu2, 10YR 5/4 yellowish brown, many pebbles, mostly sandstones, more compact from 380-400 cm.



LUN 13 (4 - 6m) 15.09.2010

fSu2, 10YR 4/6 dark yellowish brown, organic lamination, 482-487 cm coarser matrix.

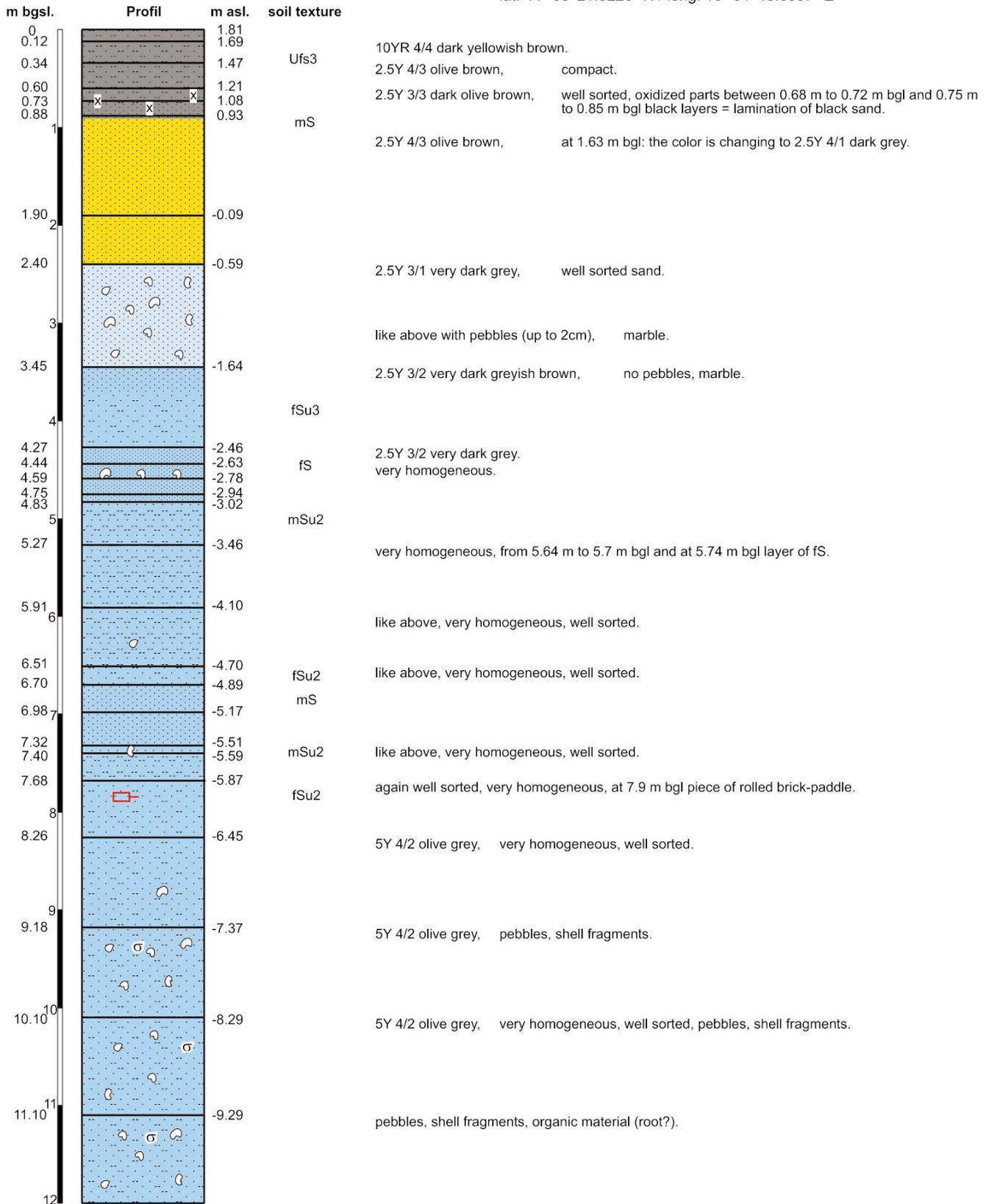
loam, organic lamination, very compact, no pebbles, oxidation mottle.

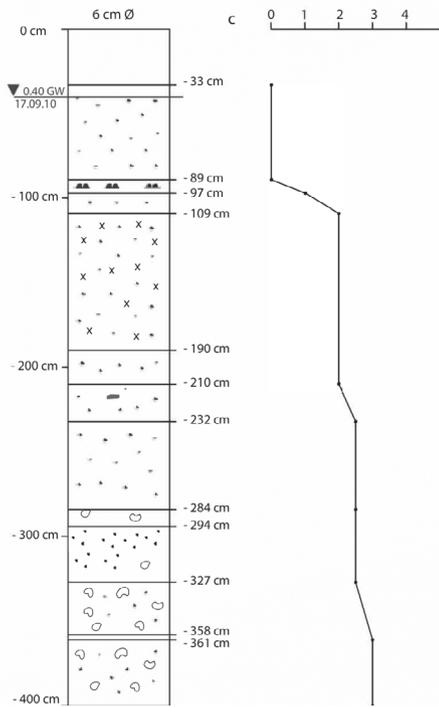
Ufs2, 10YR 3/6 dark yellowish brown.

sharp boundary, matrix like above with more pebbles, augerhead filling sandstone at 600 cm.

LUN 14

Drilling log in Tuscany, in the northernmost part of the Versilia Plain, east of the present day course of the Parmignola Stream
lat. 44° 03' 21.5223" N / long. 10° 01' 43.6597" E





LUN 15 (0 - 4m) 16.09.2010
 Battilana house (Agriturismo), near the highway. Im 10ten m
 Paläosol.

Fliesenbruchstück (modern) at 33 cm!
 fsu2-3, more silt in lower part,
 2.5Y 4/4 olive brown - upper part,
 2.5Y 4/2 dark greyish brown - lower part.

Ut2, Gley1 4/10Y dark greenish grey, homogeneous.
 fsu2, 2.5Y 4/4 olive brown.

fs, A: 2.5Y 4/3 olive brown (109-157cm oxidation character),
 B: Gley1 3/10GY very dark greenish grey (157-190cm reduced conditions),
 no pebbles! homogeneous and well sorted! Dune?

void.

fs-fsu2, Gley1 3/10GY very dark greenish grey, well sorted and homogeneous.

fs, Gley1 3/5GY very dark greenish grey.

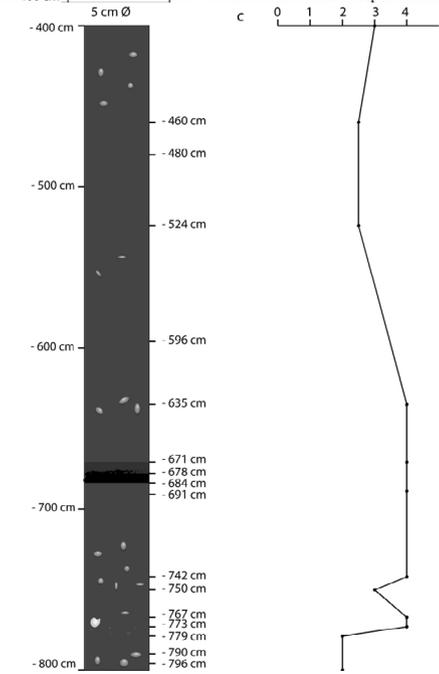
mS-fG, Gley1 3/5GY very dark greenish grey.
 void.

like above.

fs, Gley1 3/5GY very dark greenish grey, pebble (2cm), well rounded.

sharp boundary! pebbles up to 4cm.

fsu3, Gley1 3/5GY very dark greenish grey.



LUN 15 (4 - 8m) 16.09.2010

like above (fsu3, Gley1 3/5GY very dark greenish grey),
 no organic, no biogenic! well sorted.

fs, Gley1 3/5GY very dark greenish grey.

like above, very homogeneous.

void.

like above.

fsu3, Gley1 4/5GY dark greenish grey,
 no organics, no biogene, homogeneous.

fsu4, Gley2 2.5/5B bluish black, H2S after limecontent test.
 678-684 cm peat!
 sharp boundary! fsu4, Gley1 3/5GY very dark greenish grey.

like above.

mS, color like above.

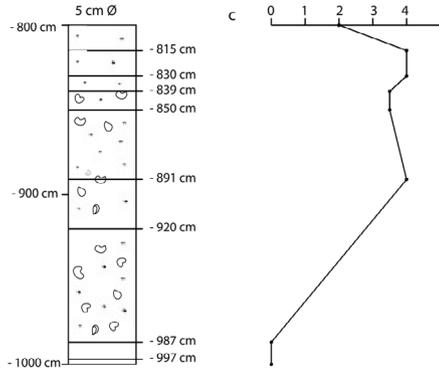
fs, some gS, color like above.

mS, color like above, shell fragment.

sharp boundary, -776cm: Ufs2, Gley2 3/5BG, -779cm: fsu3, color like above.

Tu4/Ut4, color like above.

fsu2, color like above.



LUN 15 (8 - 10m) 16.09.2010

fs, Gley2 3/5BG very dark greenish grey, shell fragment, H2S.

fs, color like above, only few gravel, H2S, sharp boundary.
 Two layers - 1: fsu4, 2: U, color like above, H2S.

fsu2, color like above, many shell fragments.

gS in fs matrix, color like above, H2S.

like above, lot of pebbles, C.g.

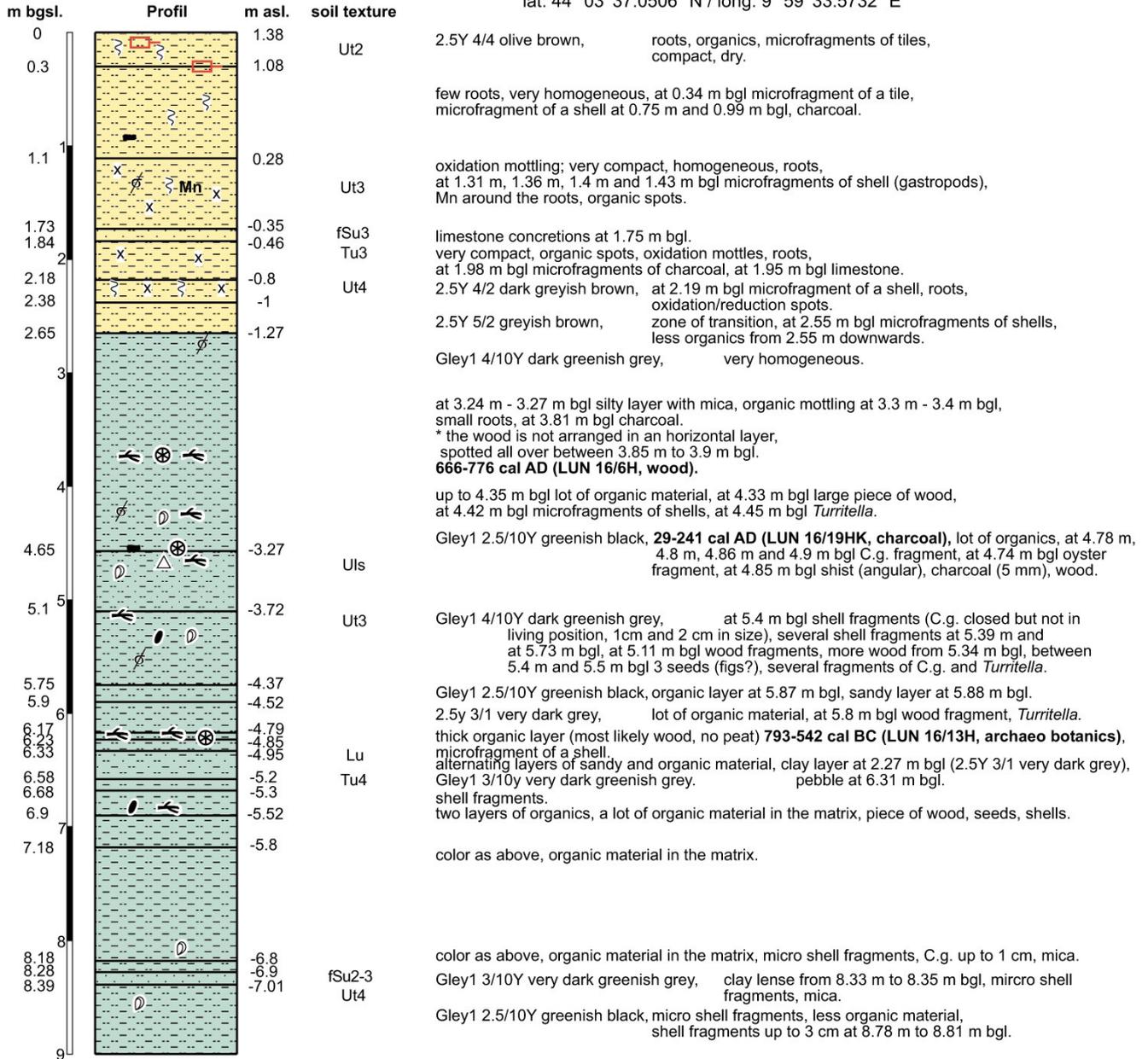
mS, dark greyish brown.

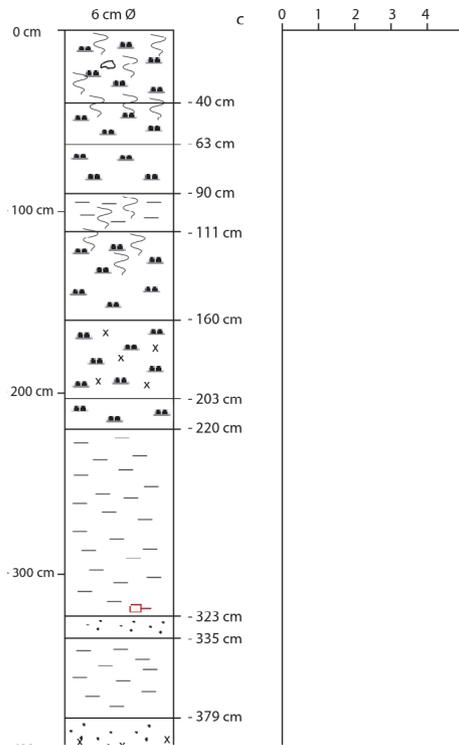
Paläoboden (?)

LUN 16

Drilling log near the mouth of Magra River at the intersection Via Pretura/Via Luni in a basil field.

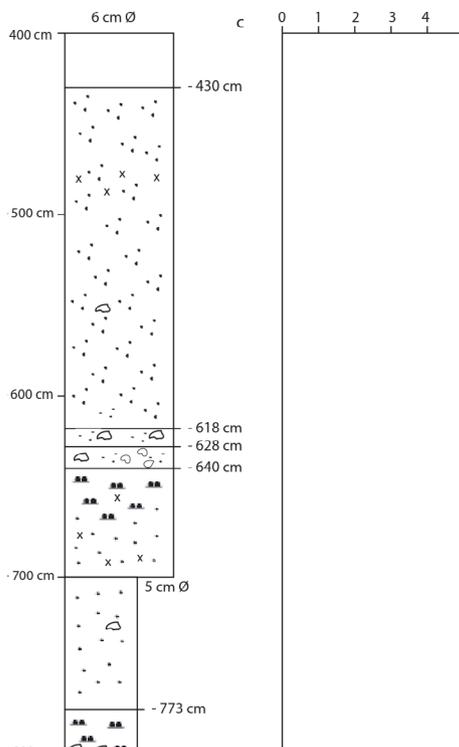
lat. 44° 03' 37.0506" N / long. 9° 59' 33.5732" E





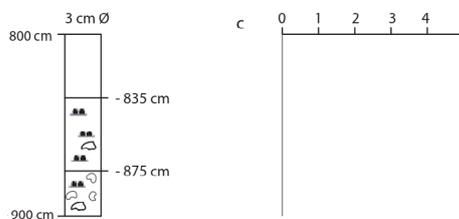
LUN 17 (0 - 4m) 22.08.2011
NEAR MAUSOLEUM (similar context to LUN 8 2010)

- Ufs2, 10YA 5/4 yellowish brown, farmland, up to 10 cm many roots, at 20 cm subangular stone (2,5 cm).
- U, 2.5Y 5/4 light olive brown, compact, in the top many roots, no stones, homogeneous, downwards it becomes more sandy.
- Ut2, 10YR 4/4 dark yellowish brown, rust stain.
- Tu2, 10YR 4/4 dark yellowish brown, homogeneous, compact, roots.
- Ut2, 10YR 5/4 yellowish brown, organic mottles, in the upper part many roots.
- Ufs2, 10YR 4/3 orange brown, oxidation signs/layer of oxidation, rust stain, at the bottom in becomes more sandy.
- U-Ufs2, 10YR 3/2 very dark greyish brown, transition zone, about 220 cm fSu2.
- Tu2, color like above, exhalation of H2S.
- like above, at 320 cm fragment of a brick (0,5 cm).
- mSu2, 2.5Y 4/1 dark grey.
- Tu2, color like above.
- mS, color like above, homogeneous, downwards oxidation mottles, from 387-388 cm clay lense.



LUN 17 (4 - 8m) 22.08.2010

- collapsed Material.
- mS, 2.5Y 3/2 very dark greyish brown, homogeneous, typical sand of a beach, from 465 cm 2.5Y 3/3 dark olive brown, oxidation mottles.
- mS, 2.5Y 3/3 dark olive brown, at 568 subangular stone (3 cm, quartz) from 585 to 600 less of material (cramp crushed).
- like above.
- mS, color like above, transition zone, 2 augerhead filling sandstones.
- sieved material: well rounded pebbles, gravel (chert, quartz), no organic, no plants, 2 rounded sandstones (3 and 4 cm).
- top: Ufs2, bottom: fSu2, 10YR 5/6 yellowish brown, oxidation mottles.
- fSu2, 2.5Y 3/3 dark olive brown, up to 723 cm homogeneous, from 742 cm gravels and 1 rounded sandstone (3 cm), sieved material (743-755cm): gravels (quartz, chert, marble, sandstones (1,5 cm), no organic.
- Ufs2, 10YR 4/6 dark yellowish brown, more compact, augerhead filling stones (sandstone, rounded), no organic.



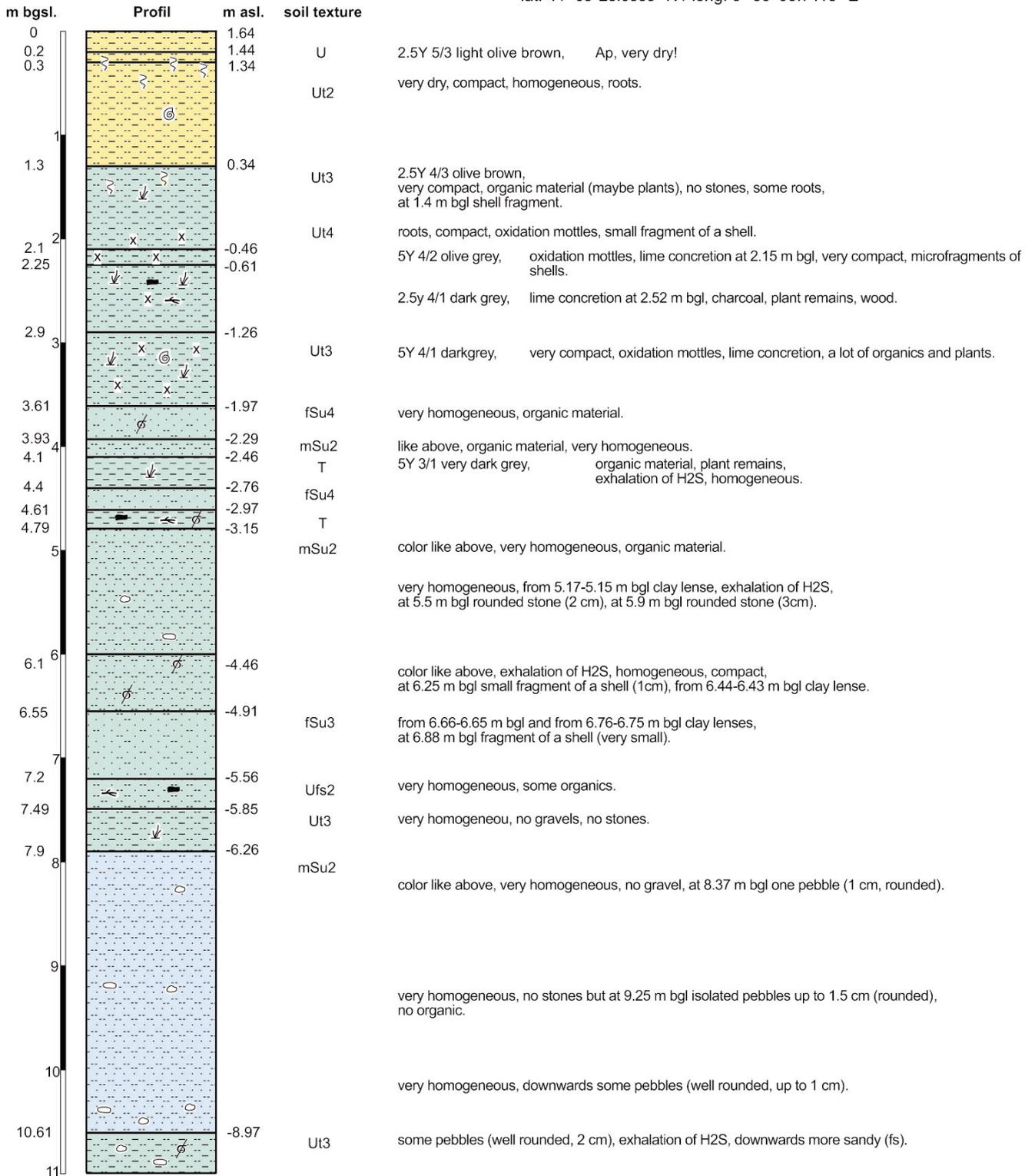
LUN 17 (8 - 9m) 22.08.2011

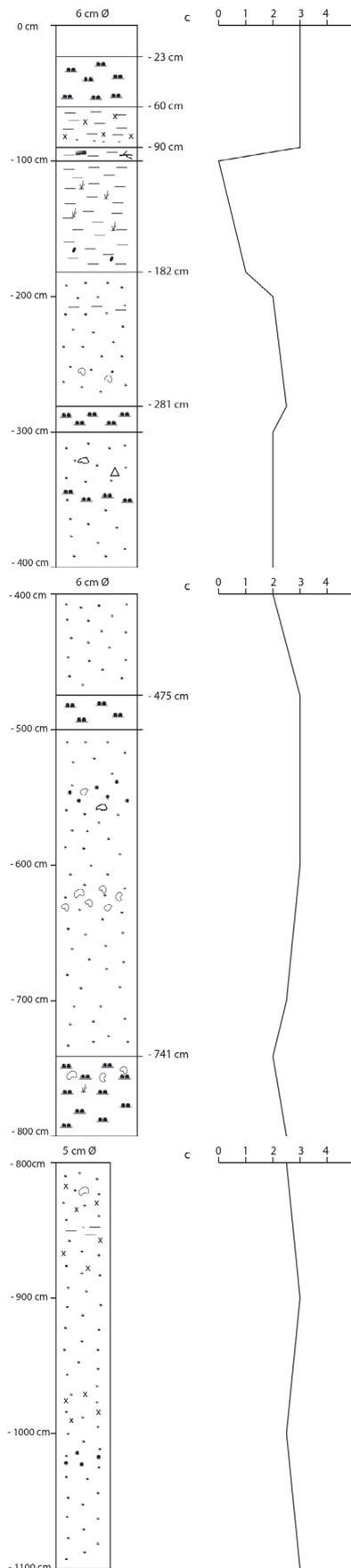
- collapsed material.
- Ufs2, 2.5Y 3/3 dark olive brown, more homogeneous, gravel (rounded), at 862 cm one stone (1cm).
- U, 10YR 4/6 dark yellowish brown, pebbles (rounded up to 2 cm), from 895-900 cm augerhead filling sandstone.

LUN 18

Drilling log west of at S. Maurizio site, southeast of Luni

lat. 44° 03' 28.0833" N / long. 9° 59' 03.7118" E





LUN 19 (0 - 4m) 24.08.2011
 Centro Zootechnico = Lun 3
 less material.

Ap: U, 2.5Y 5/3 light olive brown, very compact and very dry.

Tu3, 2.5Y 4/3 olive brown, very compact with oxidation mottles, limestone (very small), sandy layer at the boundary to 90cm.

T, Gley 1 4/10Y dark greenish grey, homogeneous.

T, Gley 1 4/N dark grey, very rich on organic matter (plant remains), at 170 cm seeds.

fsu3, 5Y 3/1 very dark grey, homogeneous, no organics, no plant remains, from 208-212 cm clay lense, very homogeneous, no organic.

from 230-236 cm organic layer, at 268 cm two small pebbles (well rounded, sandstone).

Ufs3, 5Y 3/2 dark olive grey, homogeneous, no organics.

fsu2, 5Y 3/1 very dark grey, downwards the color changes to 5Y 4/2 olive grey, from 345-360 cm Ufs2-lense, very homogeneous, no plants, no organics.

at 330 and 335 cm 2 pebbles (one well rounded, one angular).

LUN 16g (4 - 8m) 24.08.2011

fsu2, 5Y 4/2 olive grey, very homogeneous, no organics.

Ufs2, 5Y 3/1 very dark grey, organic material.

fsu2, color like above, from 520-527cm silty clay-lense, no organics, very homogeneous,

from 548-558 cm coarser insert: big stone, sandstone (well rounded, 6cm), at 549 cm pebble (well rounded),
 g5 in an fs-matrix = earthquake or tsunami?

fsu2, color like above, very homogeneous, from 630-635 cm well rounded pebbles up to 3cm (sandstone, basalt, limestone), no organics, no plants.

fsu3, 5Y 4/2 olive grey, very homogeneous, no organics, no plants.

Ufs2, 5Y 3/1 very dark grey, exhalation of H2S, plant remains, from 751-753 cm some well rounded pebbles up to 1 cm (chert, gabbro, limestone, sandstone), fragment of a shell, sieved material (740-750 cm): fragment of a shell (1cm), posedonia (seagrass)?, gravel.

LUN 19 (8 - 11m) 24.08.2011

fsu2, 5Y 4/2 olive grey, downwards it becomes more silty, oxidation mottles, from 835-845 cm clay lense, at 845 cm coarser fs-matrix, at 815 cm gabbro (well rounded, 1 cm), at 825 cm very small fragment of a shell, exhalation of H2S, at 880 cm very small chert (0,5 cm).

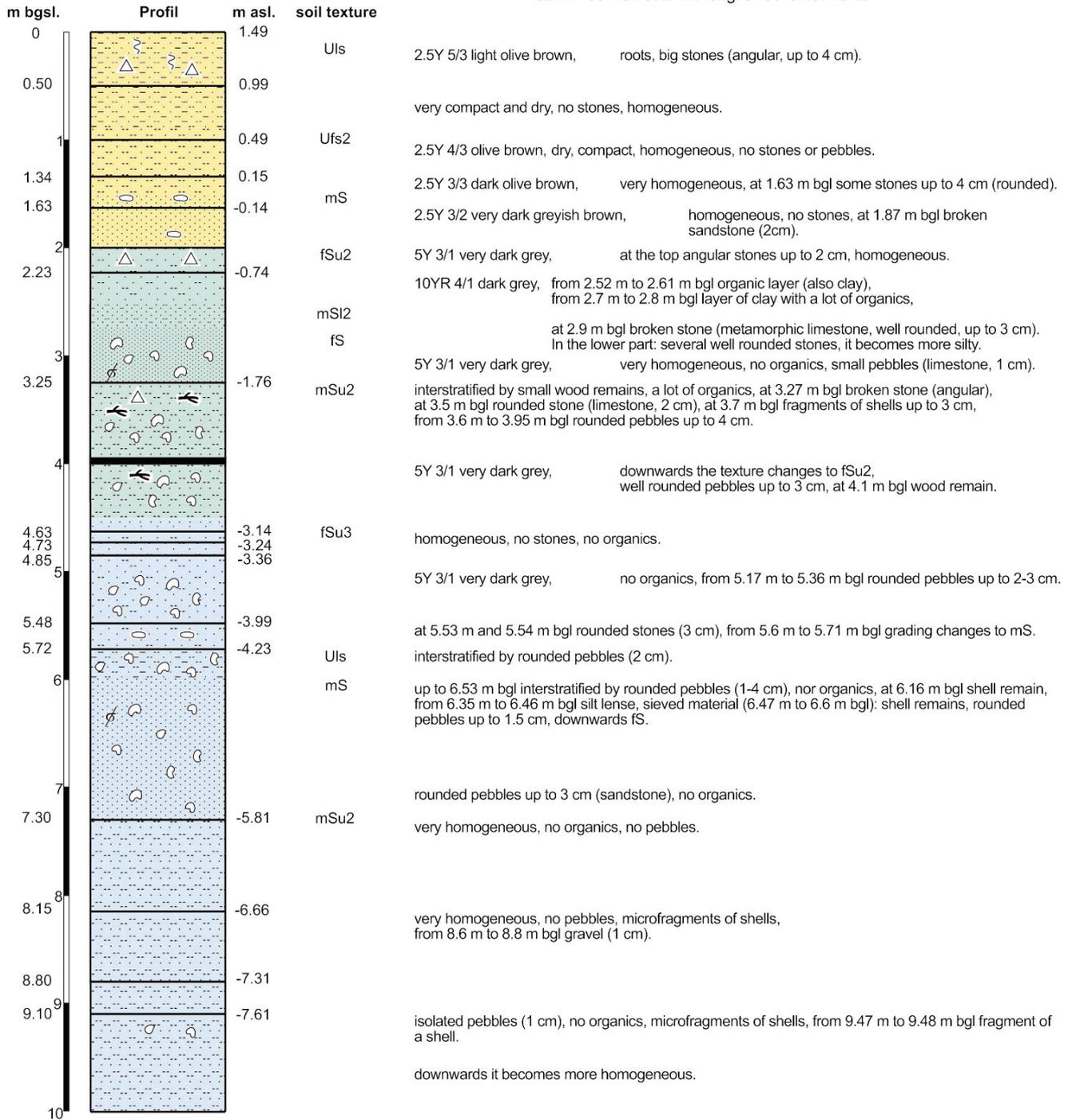
fsu3, color like above, oxidation mottles, from 920-925 cm fragments of shells (up to 1 cm), very homogeneous.

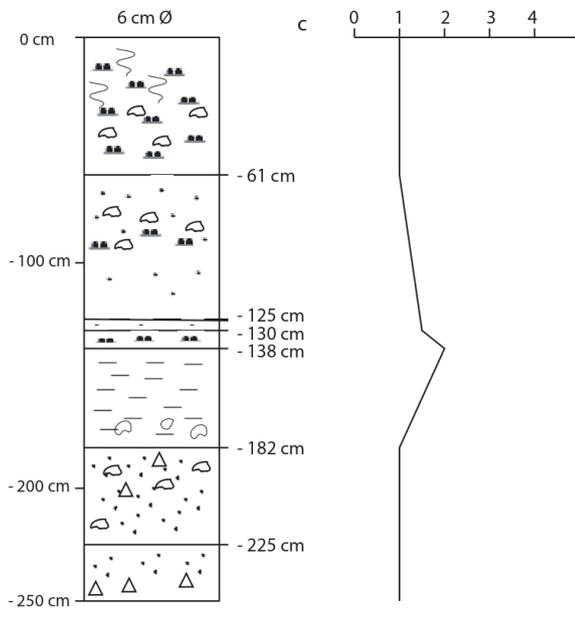
fsu2, 5Y 3/1 very dark grey, very homogeneous, no organic, from 1015-1030 cm g5 in a fs-matrix, at 1015 cm fragment of a shell (0,5 cm).

LUN 20

Drilling log between Marinella and Fiumaretta

lat. 44° 03' 18.7072" N / long. 9° 59' 37.5746" E





LUN 21 (0 - 2.50m) 26.08.2011
 BOCCA DI MAGRA

up to 16 cm less of material,
 U, 10YR 4/3 dark yellowish brown, roots, stones (rounded to subangular, broken, augerheadfilling), anthropogenic?

fS, downwards U, color like above, up to 75cm homogeneous sandy layer, from 75 cm to 100 cm stones, rounded (up to 2 cm).

collapsed material.

same like above, transition zone follows.
 Ufs2, 2.5Y 3/2 very dark greyish brown, no pebbles.

Tu2, 10YR 4/1 dark grey, sandy layers from 158-162cm and 174-180 cm, at 165 cm pebble (rounded), 170-173 cm pebble (rounded, 3cm).

mS, color like above, big stones (rounded and angular, augerheadfilling), transition zone (weathered bedrock), at the bottom (micashist, bedrock).

up to 210 cm collapsed material, mS, 2.5Y 4/4 olive brown, big stones.

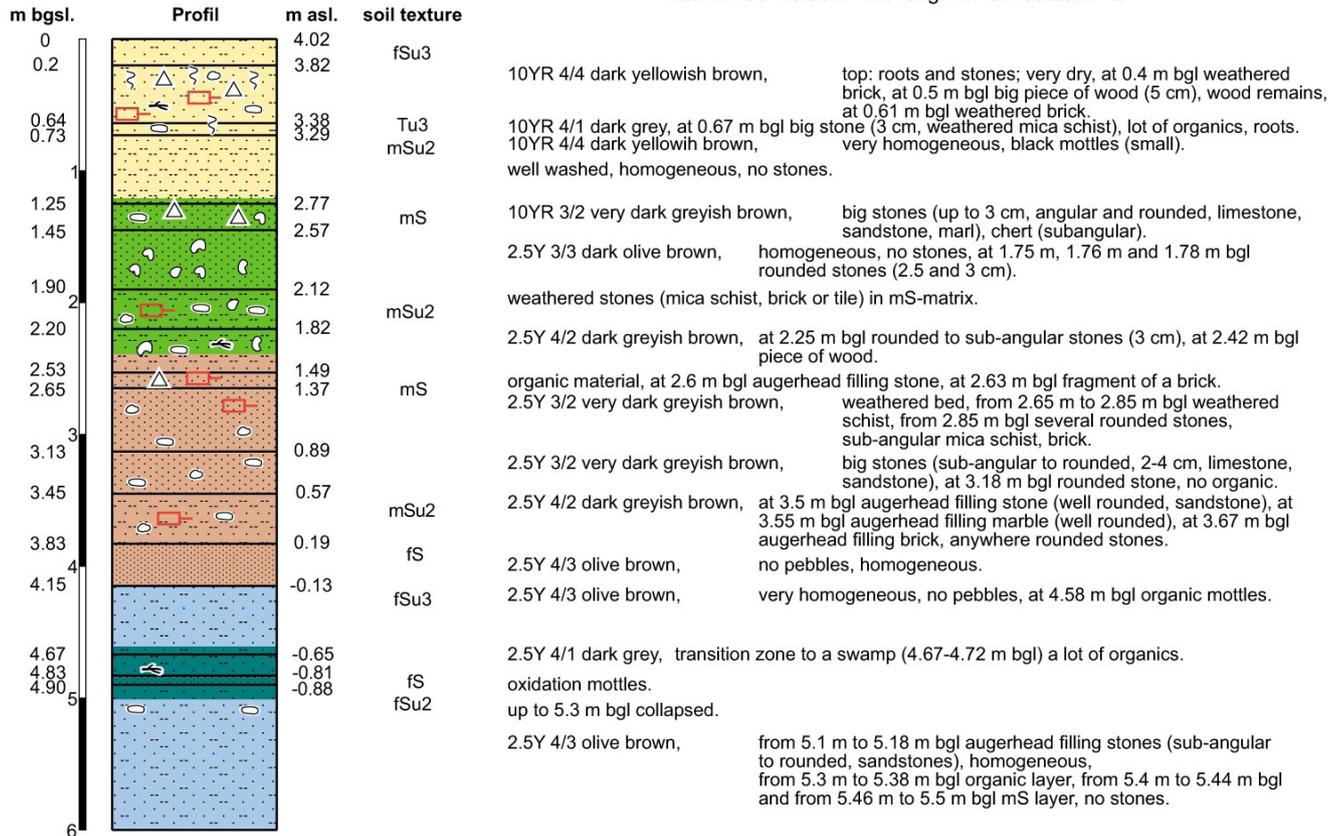
a lot of micashist (bedrock).

The Magra floodplain alluvium (alternation of sediments)?

LUN 22

Drilling log just outside the ancient Roman city in the southern perimeter and southeast of LUN 2

lat. 44° 03' 40.5047" N / long. 10° 01' 00.2684" E



Suppl. Mat. 3 - Photographs of the sediment cores taken in the field soon after extraction.





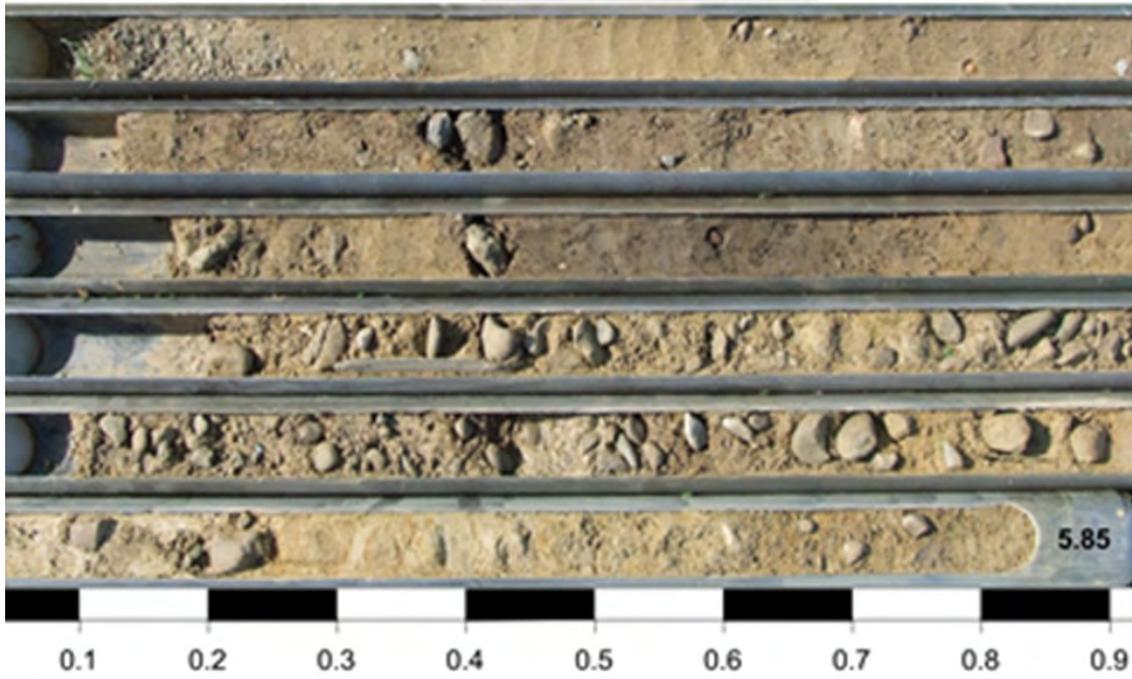
LUN 6
0-13 m (1.05 m asl)
11.09.2010



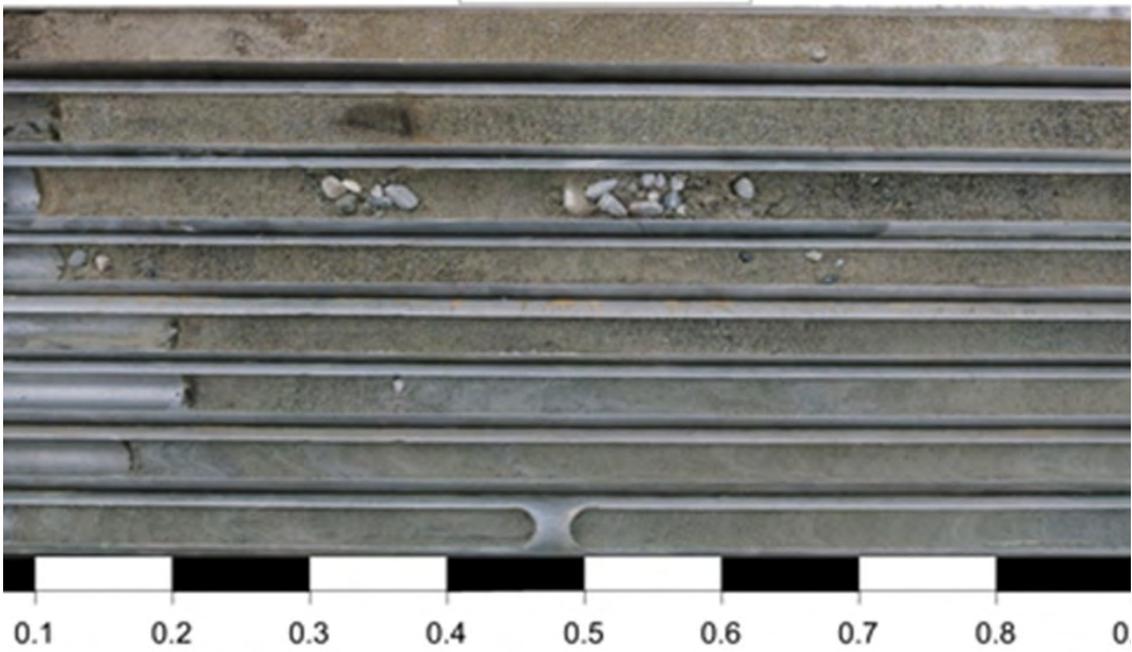
12-06-2018
LUNG_A



LUN 7
0-5.85 m (3.42 m asl)
12.09.2010

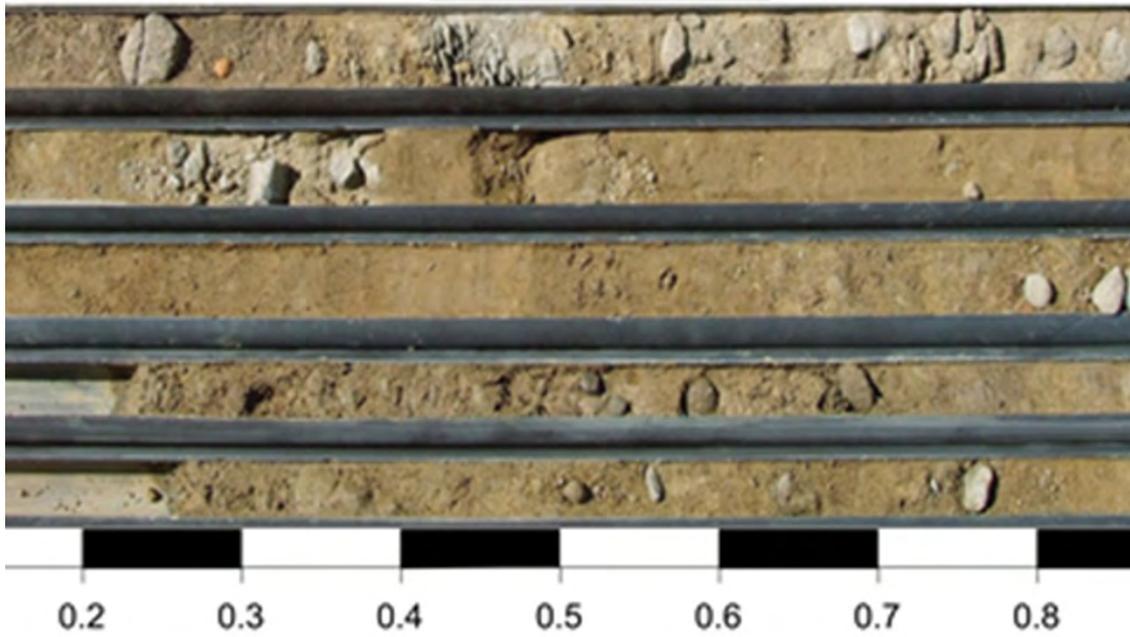


LUN 09
0-8 m (1.01 m asl)
13.09.2010

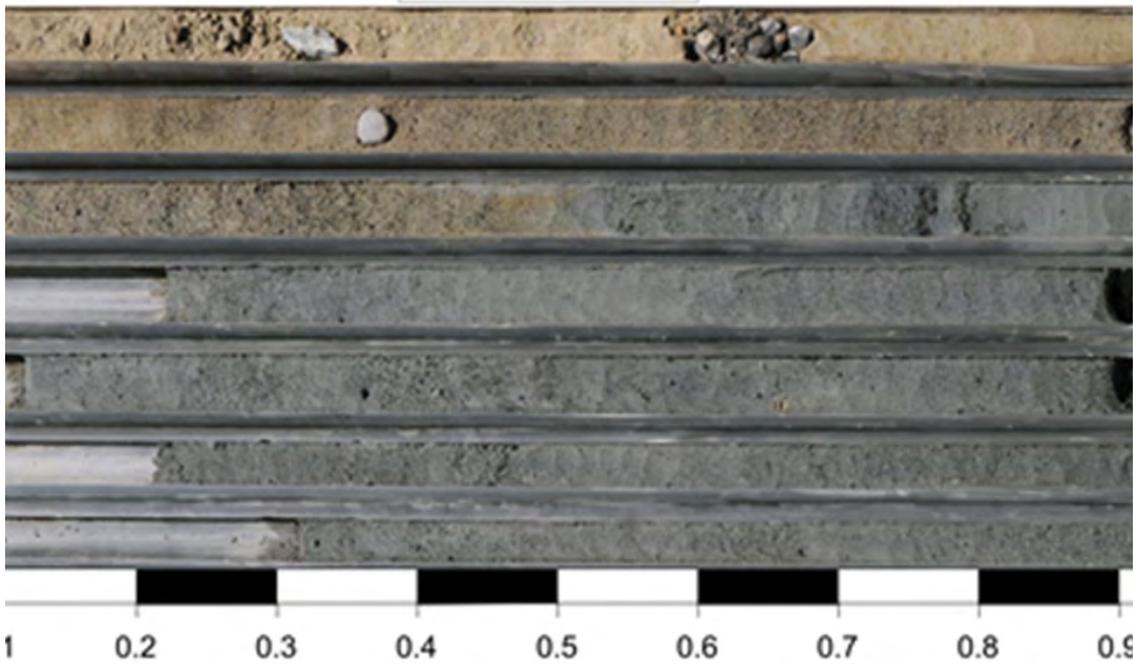




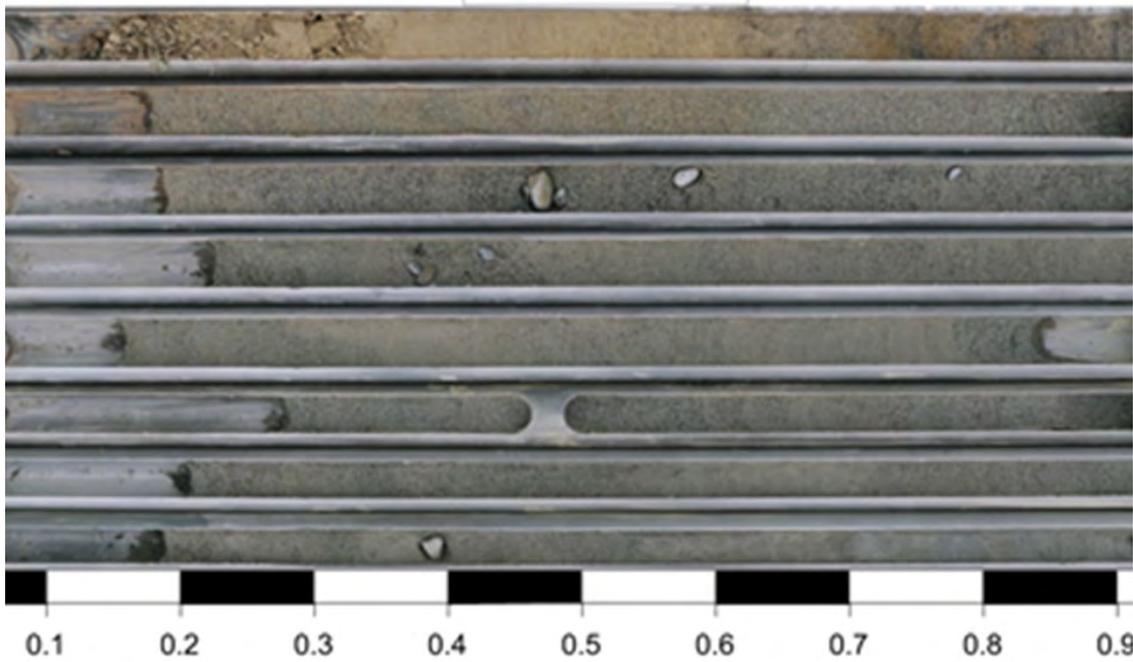
LUN 11
0-5 m (3.48 m asl)
14.09.2010



LUN 12
0-7 m (1.54 m asl)
15.09.2010

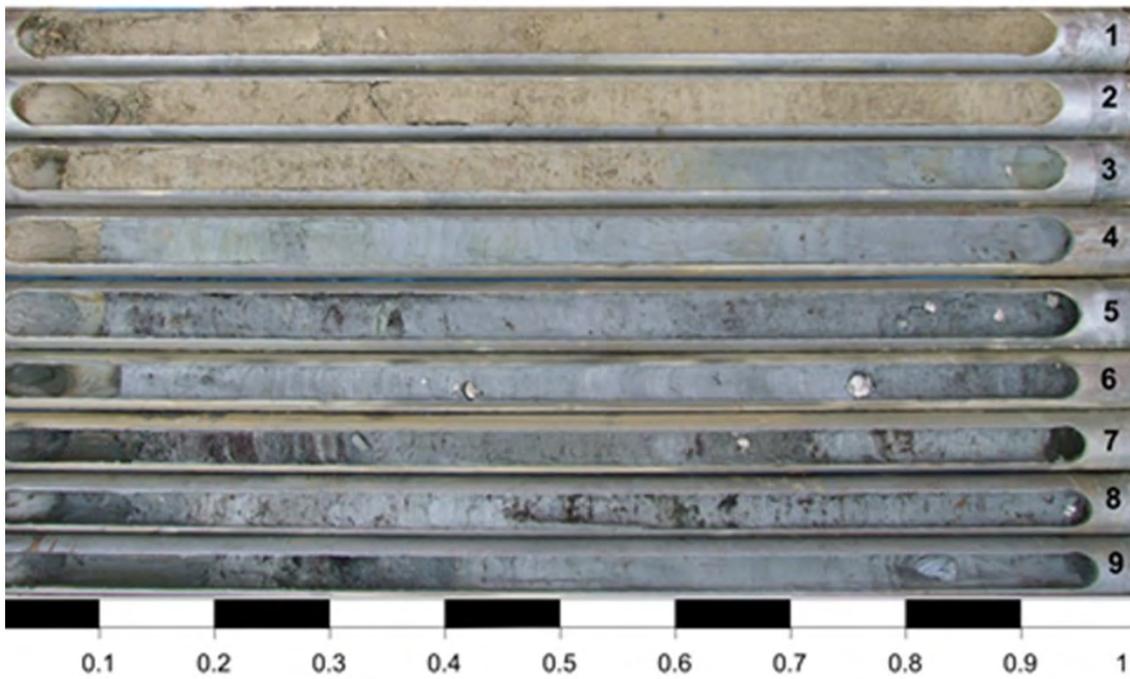


LUN 14
0-8 m (1.81 m asl)
16.09.2010

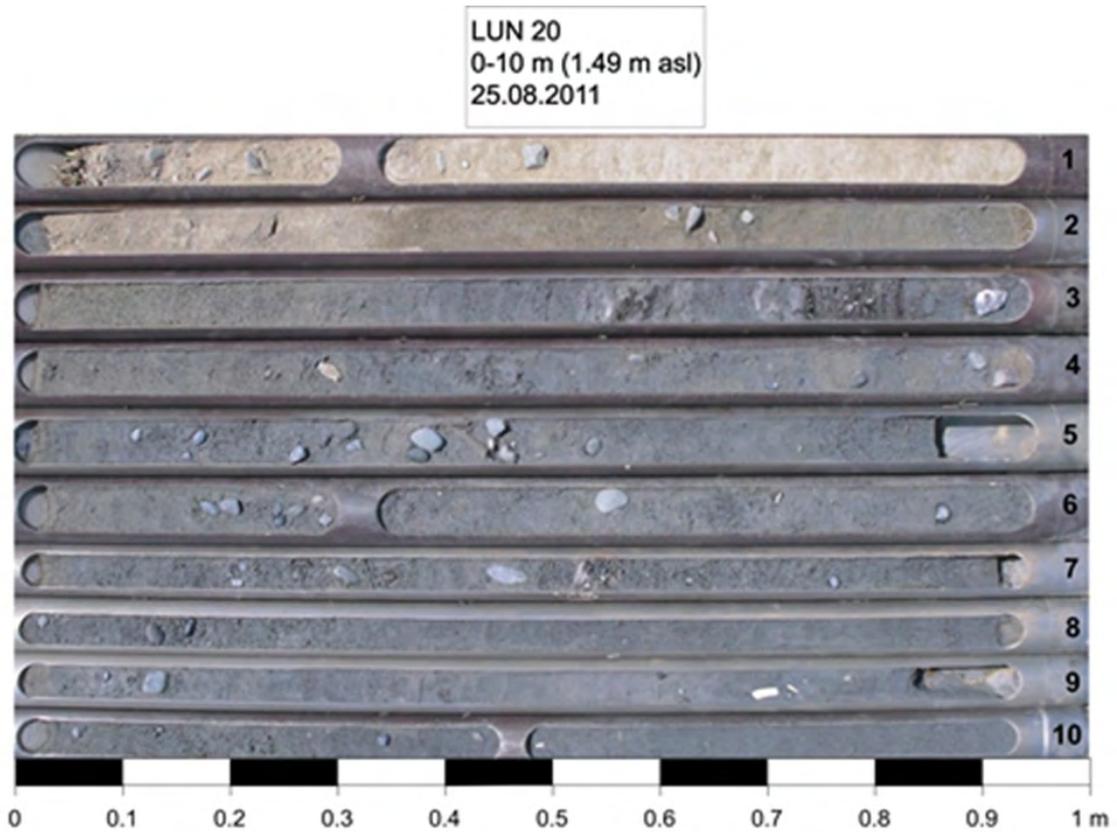


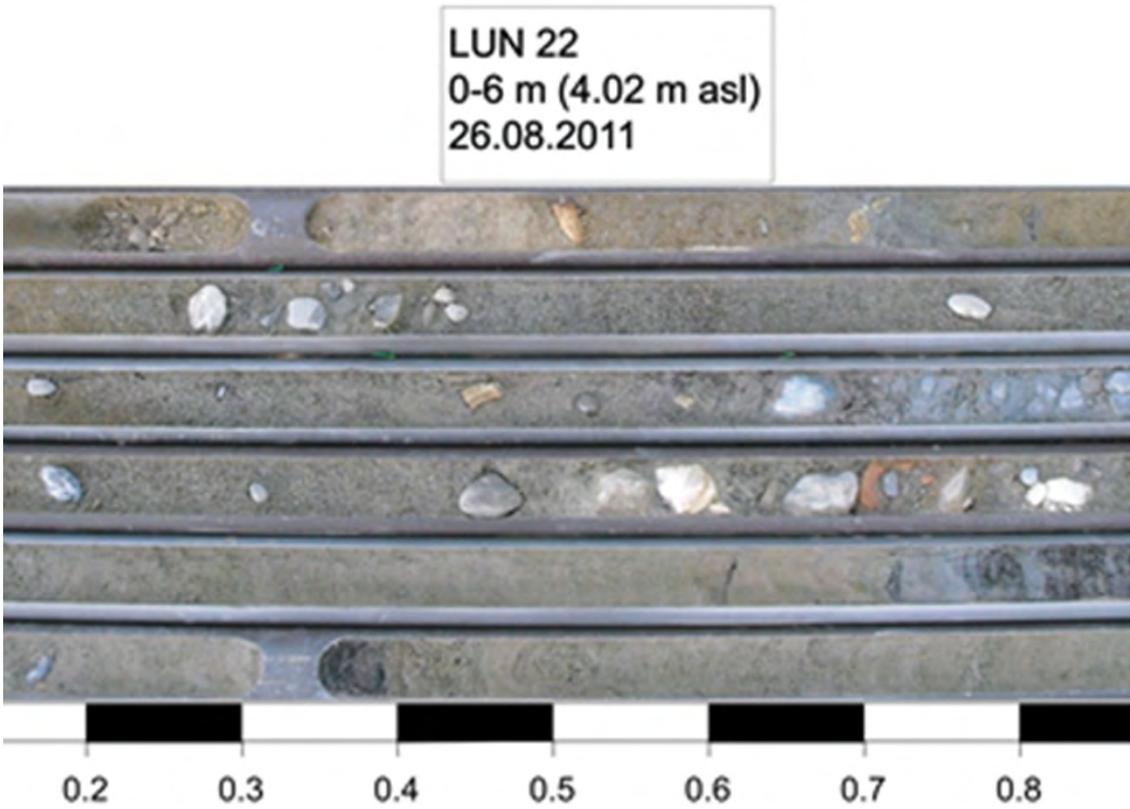


LUN 16
0-9 m (1.38 m asl)
18.09.2010











Suppl. Mat. 4 - Metadata associated to the logs: symbols used in Suppl.Mat. 2.

 coarse sand	 fine sand	 medium sand	 peat layer
 silty fine sand	 loamy sand	 loamy fine sand	
 sandy loam	 clayey sand	 loam	
 silt	 silty loam	 clayey loam	
 clayey silt	 loamy silt	 sandy silt	
 silty sand	 clay	 silty clay	
 plant remain	 (sub)rounded pebbles	 roots	 radiocarbon dating
 wood	 ceramic fragment	 oxidation/reduction signs	 tile/brick fragment
 charcoal	 <i>Cerastoderma glaucum (C.g.)</i>	 limnic/terrestrial fossils	 brackish fossils
 angular stone	 seed	 marine fossils	 manganese
 iron spot			

Facies:

 lagoonal	 fluvial	 alluvial
 littoral	 anthropogenic	 dune
 marine	 terrestrial	 swampy

Abbreviations used for granulometry:

(capital letter=dominant grain size, lowercase letters=subordinate grain size)

T = clay	mS = medium sand	2 = slightly	example: mSu2 slightly silty medium sand
U = silt	gS = coarse sand	3 = medium	
fS = fine sand	S = sand	4 = highly	