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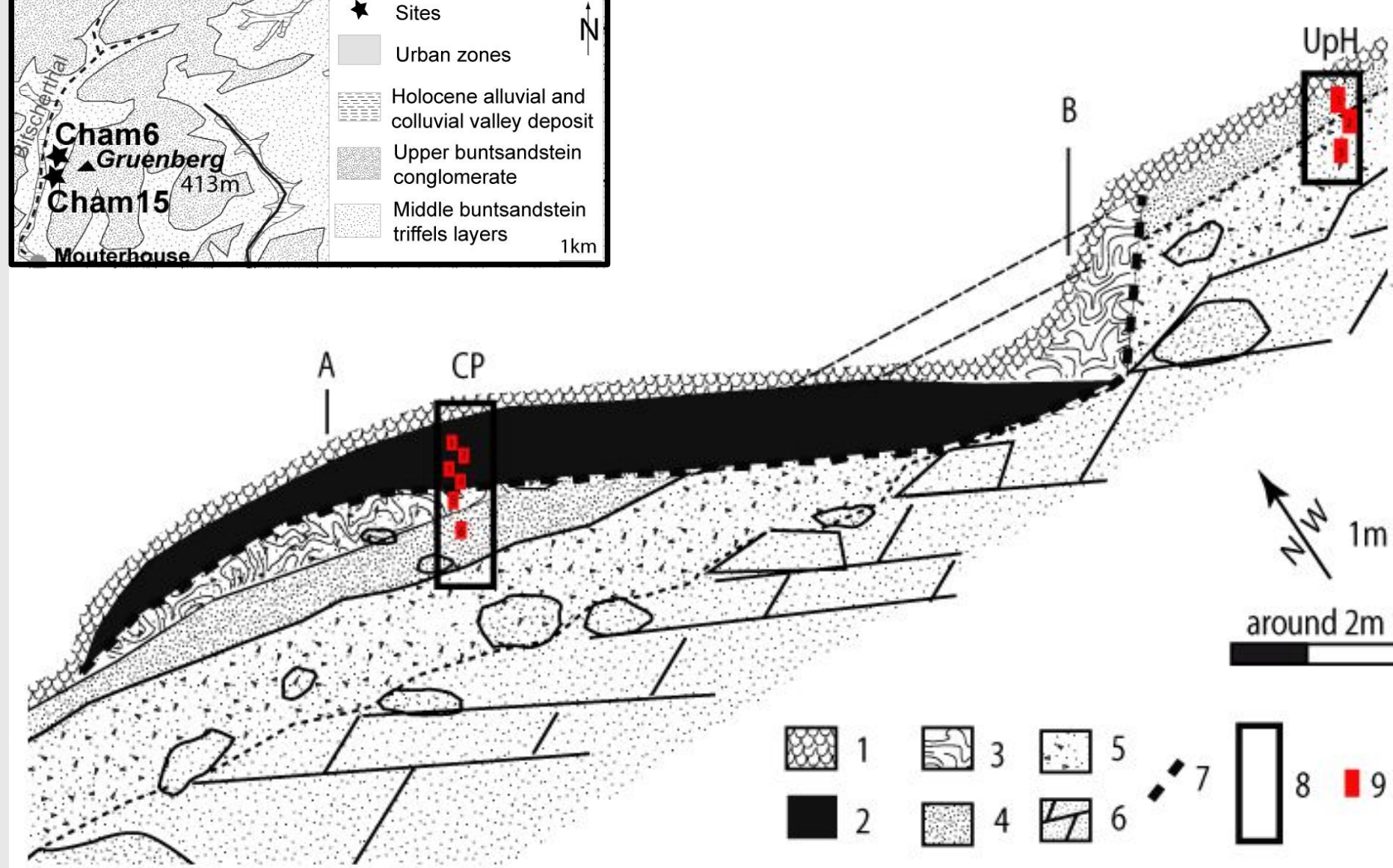
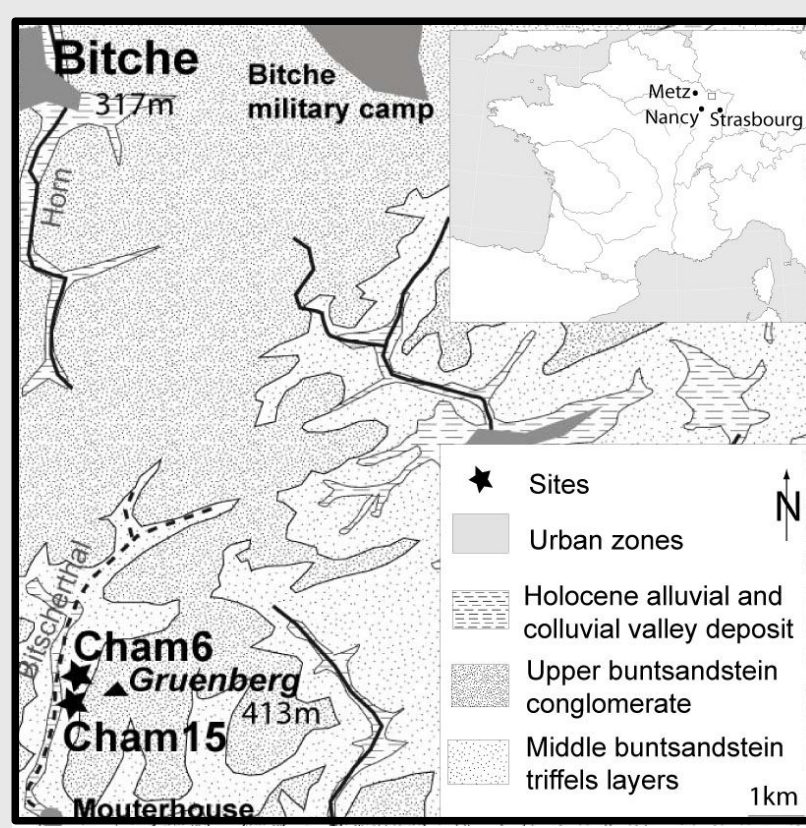
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# PALAEO-ENVIRONMENTAL STUDY OF TWO CHARCOAL-HEARTH SOIL SEQUENCES IN THE NORTHERN VOSGES MOUNTAINS (BITCHE, FRANCE)

**Focussing on XVII<sup>th</sup> century charcoal platform soil sequences, this multi-disciplinary study deciphers ecological legacy of historical charcoal production on vosgian acid sandy soils.**

## Site presentation

**Site context:** tabular low mountains (300/400m), steep slopes, wet valleys, red ferruginous sandstone (Buntsandstein), oceanic current climate with well marked seasons, deciduous mixed woodland (beech, oak, ashes, maple, pine, spruce), well drained acid siliceous soils (podzols(40%) and entic podzols (10%), ancient glassworkshop, iron melting activities, forges, charcoal production.



### Schematic organisation of the charcoal platform :

1. organic layers, 2. charcoal residues, 3. man-made platform,
  4. ancient organic horizons, 5. sandstone slope deposit,
  6. triassic sandstone, 7. limit of the charcoal platform surface,
  8. profiles location, 9. undisturbed bloc samples location.
- A-B. downslope longitudinal section.



### CHARCOAL PLATFORMS (CP):

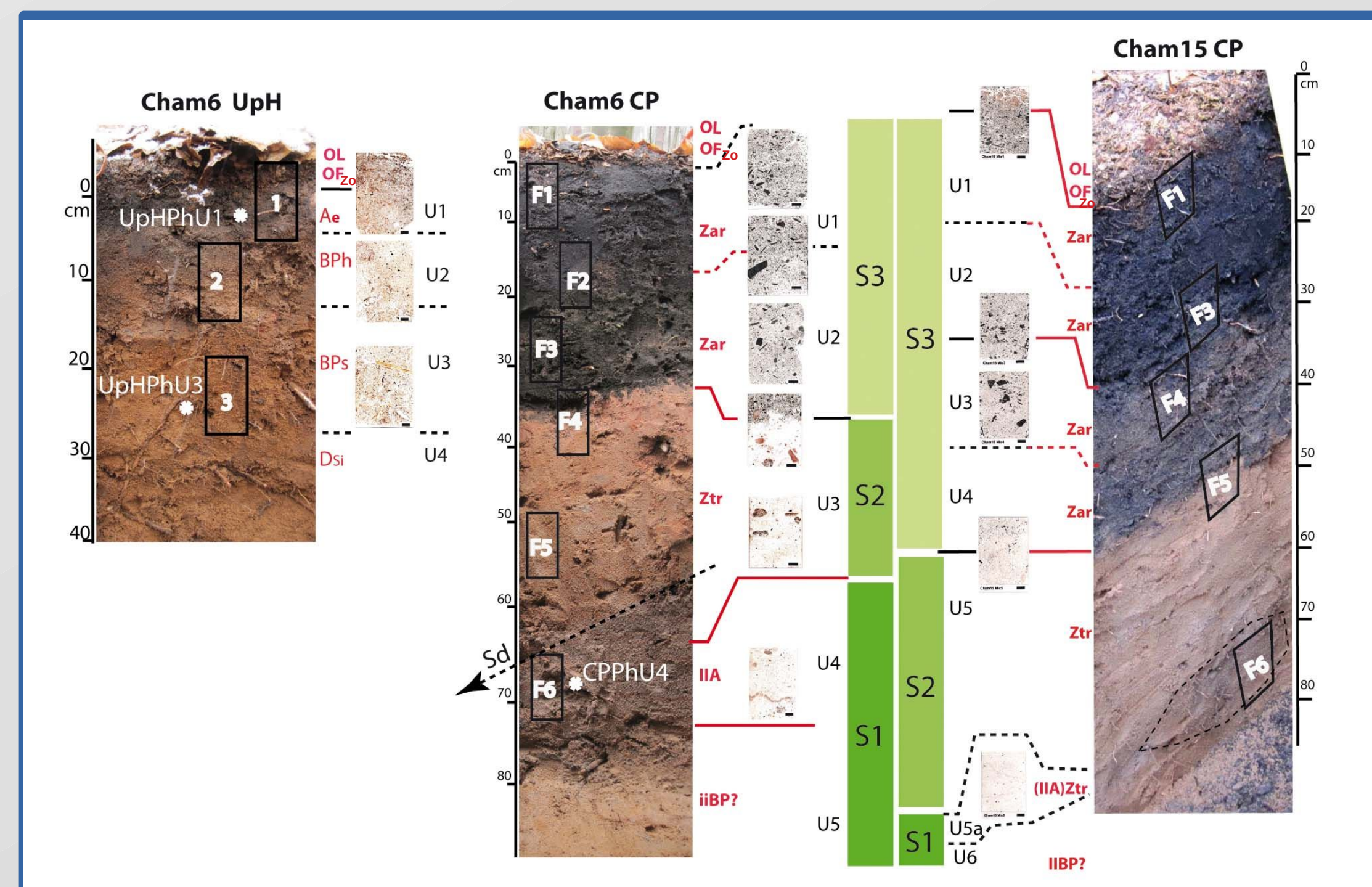
**Anthroposol archéologique artificiel (RP)**  
 OL/OFzo: Hemimoder humus type,  
 U1-U2/Cham6, U1-U2-U3-U4/Cham15: Zar  
 archaeological material (ar) of human origin (Z),  
 U3/Cham6, U5/Cham15) : Ztr  
 geological material (tr) of human origin (Z),  
 U4/Cham6: II A undisturbed buried organic horizon,  
 U5a/Cham15: (II A) Ztr clumps of organic horizon,  
 U5/Cham6, U6/Cham15: II BP? probable spodic horizon  
 <=> **Technosol** (World Reference Base, WRB)

### CURRENT UPHILL REFERENCE (UpH):

**Podzsol ocrique** (French soil referencial, RP)

OL/OFzo: "hemimoder" humus type,  
 U1: A<sub>e</sub> eluvial horizon,  
 U2: B<sub>p</sub> ] podzolic/spodic horizons,  
 U3: B<sub>p</sub> ]  
 U4: D<sub>si</sub> sandy slope deposit.

<=> **Entic podzol** (World Reference Base)  
 characterized by a spodic horizon without  
 clear upper eluvial horizon (albic, WRB) on top.

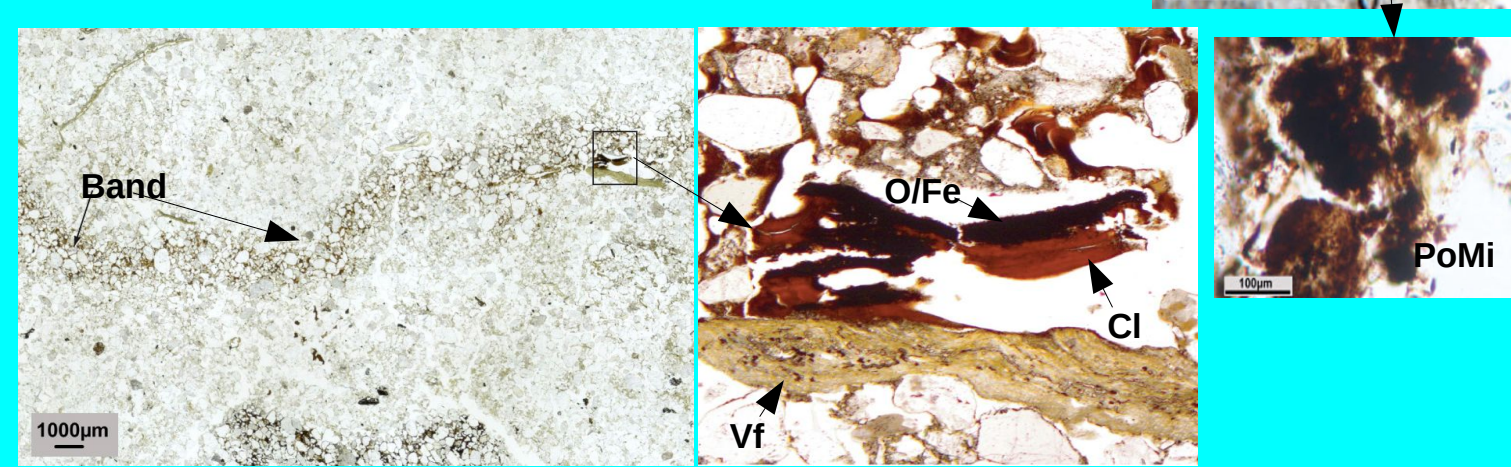


## Results

### Soil analysis

	Hz	Al µg/g Tamm	Fe µg/g	pH water	C <sub>tot</sub> %	N <sub>tot</sub> %	C <sub>ex</sub> <sup>+</sup> exchangeable cmol(+)/kg
UpH	U1	A <sub>e</sub>	668.5	856.1	4.5	3.39	0.13
	U2	B <sub>p</sub>	1507.3	1439.2	4.2	1.78	0.05
	U3	B <sub>p</sub>	3434.2	1872.9	4.9	1.32	0.04
	U4	D <sub>si</sub>	/	/	4.9	0.97	0.03
CP Cham6	U1	Zar	1303.2	1198.1	4.24	6.21	0.19
	U2	Zar	1306.7	922.7	5.36	2.98	0.07
	U3	Zar	720.2	498.8	5.87	0.37	0.006
	U4	II A	287.2	291.6	5.92	0.65	0.002
	U5	II BP?	/	/	6.21	0.44	0.005

Main chemical characteristics of UpH et CP.  
 Cham15 is similar to Cham6.



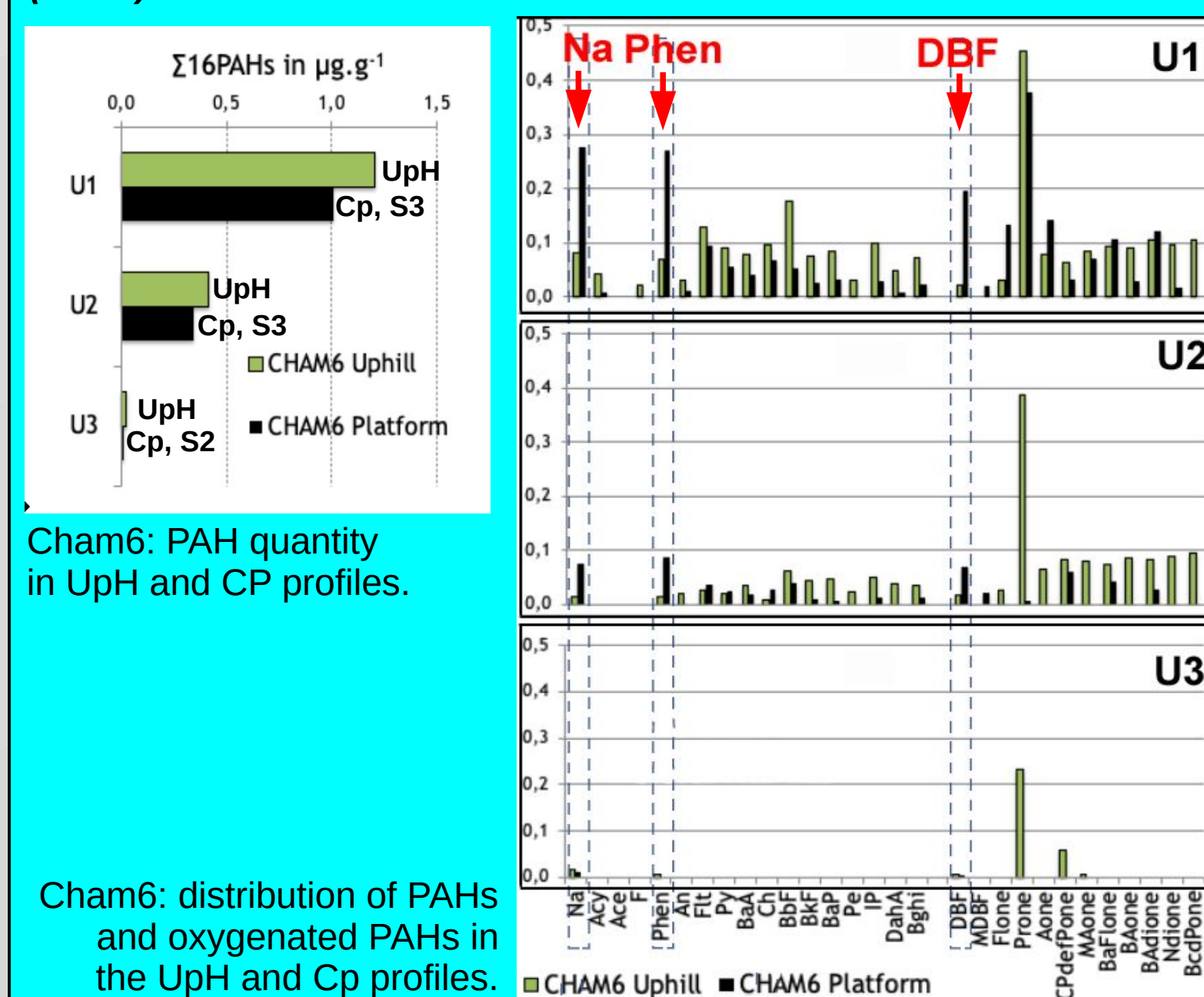
### Main characteristics of the UpH reference :

- acid soil inducing low biological activity,
- polymorphic microfabric in the BP (PoMi),
- silt coating around grains and charcoals (Scoa) in all units.

### Specific observation of the Cps :

- low alcalinization in the charcoal remains,
- quite fresh undisturbed plant residues (Vf) in the upper palaeosol (S1),
- iron/organic (O/Fe) + clay (Cl) bands in the upper palaeosol and the dump material units.

### Polycyclic Aromatic Hydrocarbons (PAH)

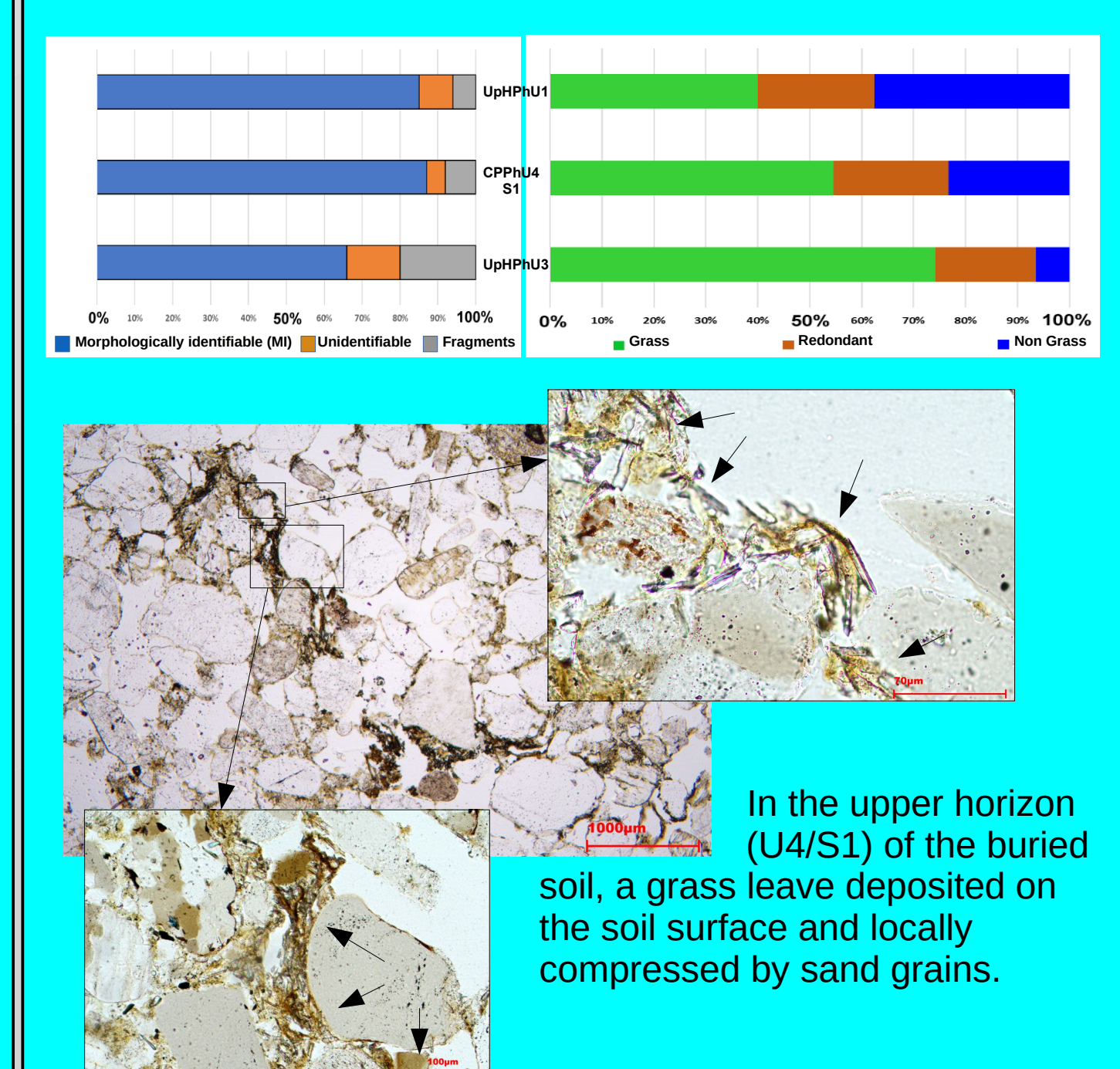


Cham6: PAH quantity in UpH and CP profiles.

Cham6: distribution of PAHs and oxygenated PAHs in the UpH and Cp profiles.

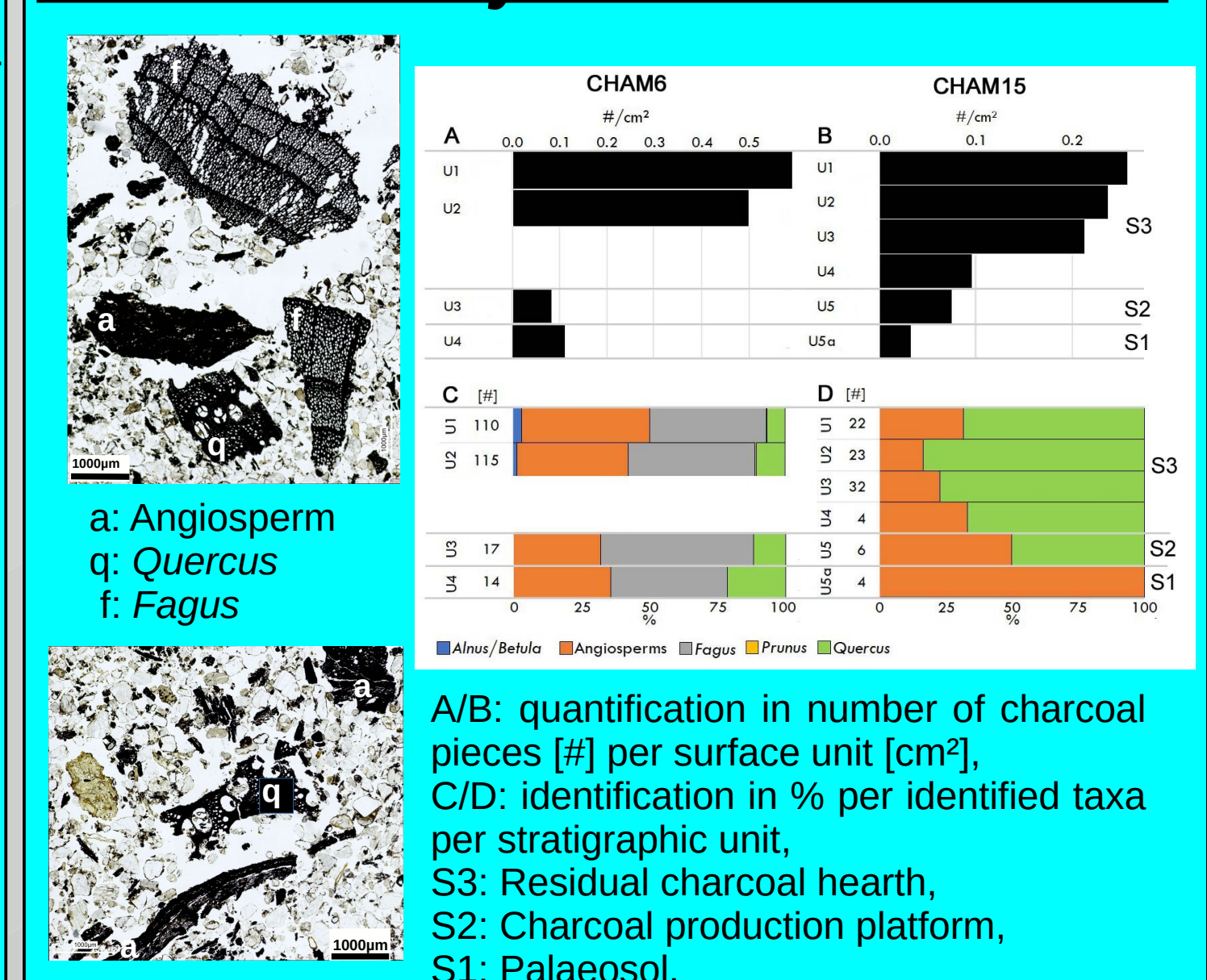
- PAH concentrations decrease downwards in UpH and CP profiles,
- no PAHs in the lower layer (S2),
- significant difference in distribution of PAH between UpH and CP profiles
- domination of Naphtalene (Na), Phenantrene (Phen) and Dibenzofuran (DBF) in the CP residual charcoal layers (U1/U2).

### Phytolith analysis on thin sections



- in the current UpHPhU1 horizon grass and trees phytoliths present in similar proportions,
- in the palaeosol CPPHU4 (S1):  
 - clear analogies with the phytolith record of the modern day vegetation but with a more marked record of grass phytoliths,  
 - a grass leave covering the sand grains,
- in UpHPhU3: fragmented phytoliths more abundant.

### Charcoal analysis on thin sections



- similar spectrum but lower taxonomical diversity observed in thin sections compared to classical analysis,
- charcoal more abundant in S3 than in S1/ S2,
- better preserved and identifiable charcoal in Cham6 than in Cham15,
- the perturbation of the palaeosol in Cham15 broke the charcoal and made them non identifiable,
- the charcoal assemblage of the the platforms and the palaeosol are similar.

## Conclusions

- **Low bioactivity** induced by soil acidity allows confident interpretation of the different palaeoecological data issued from the CP soil profile.
- Fragmented phytoliths, silt cover around sand grains and very all charcoal fragment reveal **significant slope movements during quaternary sedimentary processes.**
- **The CP construction** was conducted by scraping and dumping soil horizons on the slope forming an inverted profile, and buried well the palaeosol.
- **The thickness of the II A** horizon of the palaeosol can be related to this last process and/or to past pedogenetic and climatic conditions that prevent organic matter mineralization.
- **Compaction of the ancient buried soil by the charcoal platform construction** are shown by phytolith leave.
- **Degraded forest before the charcoal production activities**, revealed by higher grass phytoliths frequencies, can result from forestry mismanagement preceding later wood coppicing regulation.
- **Charcoal analysis on thin section confirms the forest heterogeneity before the charcoal production activities.**
- **Temporarily soil alcalinization by ash may favour migration of clay, iron and organic material** in the form of discontinuous bands in the palaeosol.
- Wood burning produced specific **PAHs in the charcoal and tar balls rich upper layers of the Cp**,
- **HAPs do not migrate deeper** in the profile in this acid low bioturbated soils.