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1400 years of man-environment interactions and soil evolution in the Saint-Mont mountain (Remiremont, Vosges)

Poszwa A.^a, Grzesznik A.^d, Gebhardt A.^{a,c}, Agat A.^a, Even P.^b, Ngo P.^b, Cartier D.^a, Robin V.^a, Delangre C.^a, Occhietti S.^f, De Junet A.^a, Harmand D.^h, Kraemer C.ⁱ, Chenal T.^d, Bartier J.^d

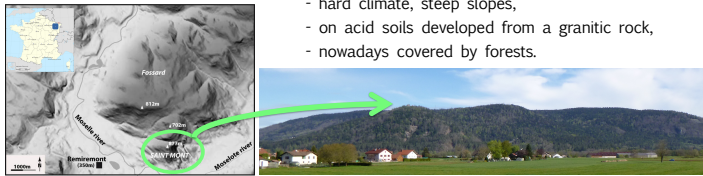
(a) Univ. Lorraine, CNRS, UMR 7360 LIEC (Anne.Poszwa@univ-lorraine.fr); (b) Univ. Lorraine UMR7503 - LORIA; (c) INRAP Grand Est; (d) Univ. Bourgogne UMR 6298 - ARTEHIS; (e) Centre de Géologie Terrae Genesis; (f) Univ. Québec, département de géographie; (g) indépendant botaniste; (h) Univ. Lorraine LOTERR EA 7304; (i) Univ. Lorraine HISCANT-MA EA 1132; (j) Univ. Lorraine UMR 7359 GeoRessources.

Context of the study

The Saint-Mont site

A relatively inhospitable mountain:

- hard climate, steep slopes,
- on acid soils developed from a granitic rock,
- nowadays covered by forests.



Remains suggest human presence for at least 1400 years

- At the top, the monasterium Habendum (from the 7th century to the French Revolution) and a late antique occupation (Chenal 2016),



- Monumental enclosure dry-stones walls of unknown age (Grzesznik, 2019).



- The « Pont des Fées »
An enigmatic structure

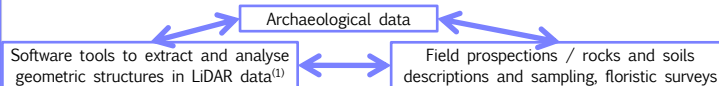
Objectives

To investigate traces of ancient anthropic activities in soils and landscapes, on areas where archaeological structures have not yet been detected

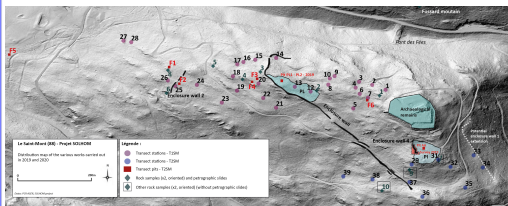
Material and methods

Joint work involving soil scientists, archaeologists, geographers, geologists and computer scientists

Approaches from the landscape to the microscopic scales.



Studies along gradients from highly to poorly human impacted areas.



LiDAR image to locate (i) platforms connected to archaeological structures and (ii) all our sampling stations: subsurface soils, pits and rock outcrops.

stations chosen on flat areas, supposedly more favourable to ancient human occupation.

Analysis in the lab.

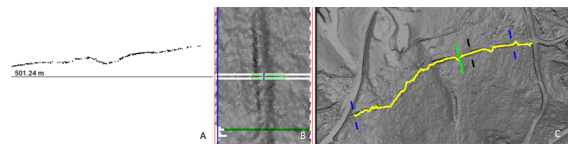
Rocks: petrography
Soils: physico-chemistry, micromorphology, organic matter content,
Charcoals: dating

Results

Interactive extraction of linear structures from LiDAR raw data

Development of new algorithms based on digital geometry tools to directly process 3D ground points and get rid of digital terrain model approximations in forested areas (Even and Ngo, 2020).

Immediate visualization of extracted structure, cross and longitudinal profiles and of geometric estimations (height or depth, width, volume, ...).



A: example of ground point profile used to detect a linear structure, here a holloway.
B: processed adjacent profile aligned on the tracked structure center line.
C: detected structure superimposed to the digital terrain model (in green, the manual initial scan; in black, the currently analysed profile; in blue, selected bound profiles for volume estimation)

Time and precision performance evaluated on well controlled structures: forest roads (Even and Ngo, 2021).

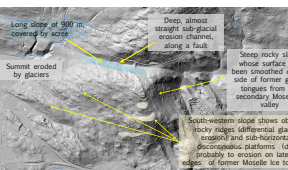
Usability assessed on archaeomorphological enclosure walls and old holloways (Even et al., 2021).

ILSD: Available open-source software for direct exploitation by soil scientists or future integration in geographical information systems (<https://github.com/EvenP/ILSD.git>).

Landscape and geological materials

A tectonic and glacial heritage

- 3 axes of fracturing highlighted from rock outcrops and preferential feldspar orientations in thin-sections measurements.



- Tectonic fracturing guided the action of the glaciers during the Quaternary. Both factors structure the massif and control its triangular shape.

Geological heritage The rock descriptions (macroscopically and in thin sections) confirm that most of the Saint-Mont is composed of Remiremont granite (Vincent, 1976).



- New informations, not noted on the geological map:

- * Longer vein of aplites (suggested by the presence of aplites fragments in our studied profiles)
- * At the bottom of pit 6, a lamprophyre vein (rock more basic than granite).

Soil covers

1. Soils not clearly disturbed

- Far from any known archaeological remains, two main types of soils develop on granite:

Humic allocrisols (RP^{2D})
Cambic Umbrisols (WRB^{3D})



Rankosols (RP)
Umbric Lentosols (WRB)



Acidic (pH_{water} < 4 in the organo-mineral horizon) and desaturated soils (S/T15%).

Strict acidiphyle vegetation

=> Reference soils not affected by ancient activities

- Undisturbed soils associated to ancient walls :

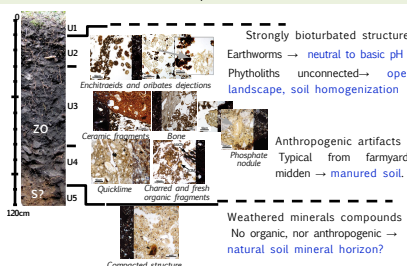


Physico-chemical characteristics close to those of « reference soils ».

=> low human activity?

2. Highly anthropised soils on platform Pi

Anthrosol (RP) « Transformed on a man made terrace »
Anthrosol with a pretic horizon (WRB)



Strongly bioturbated structure
Earthworms → neutral to basic pH
Phytoliths unconnected → open landscape, soil homogenization

Anthropogenic artifacts
Typical from farmyard midden → manured soil.

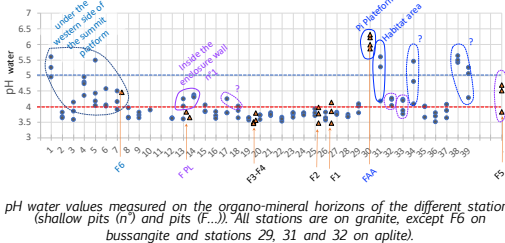
Weathered minerals compounds
No organic, nor anthropogenic → natural soil mineral horizon?

Black unit (>1m thick) very rich in organic matter. Almost neutral pH (pH_{water}=5.86 in the organo-mineral horizon) and saturated soils (S/T<95%).

Acidicline to neutrocline vegetation

=> Clues of long term tillage and regular manure inputs

3. Other evidence of ancient human influence on soils?



pH water values measured on the organo-mineral horizons of the different stations (shallow pits (n°) and pits (F...)). All stations are on granite, except F6 on bussangite and stations 29, 31 and 32 on aplites.

Detection of some « anomalies »:

- Light when pH is between 4 and 5
- More significant when pH is > 5
- Easily related to the long-lasting human occupation on the summit.
- More surprising on some western or southern platforms:

=> Leads for future archaeological studies?

Conclusion and perspectives

Our results confirm:

- A very strong imprint of historical human activities on soils close to the summit part of the massif.
- An heritage on the western slope mainly from natural glacial and pedogenetic processes.
- Possible other human activities on some western or southern platforms.

We hypothesize that the weak anomalies are due to older and/or different human activities than those that took place at the top of Saint-Mont (like breeding).

Other analyses are being acquired and interpreted on soils, rocks and LiDAR images.

¹ LiDAR data provided by the PCR AGER (Ch. Kraemer, dir.). ² RP: Référentiel pédologique ³ WRB: World reference base
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