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# Dreaming of Perfect Soil: Interactions between Soil and Geophysical Measurements for Archaeological Detection

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# Dreaming of Perfect Soil : Interactions between Soil and Geophysical Measurements

Michel Dabas<sup>1</sup>, Armin Schmidt<sup>2</sup>, Apostolos Sarris<sup>3</sup>

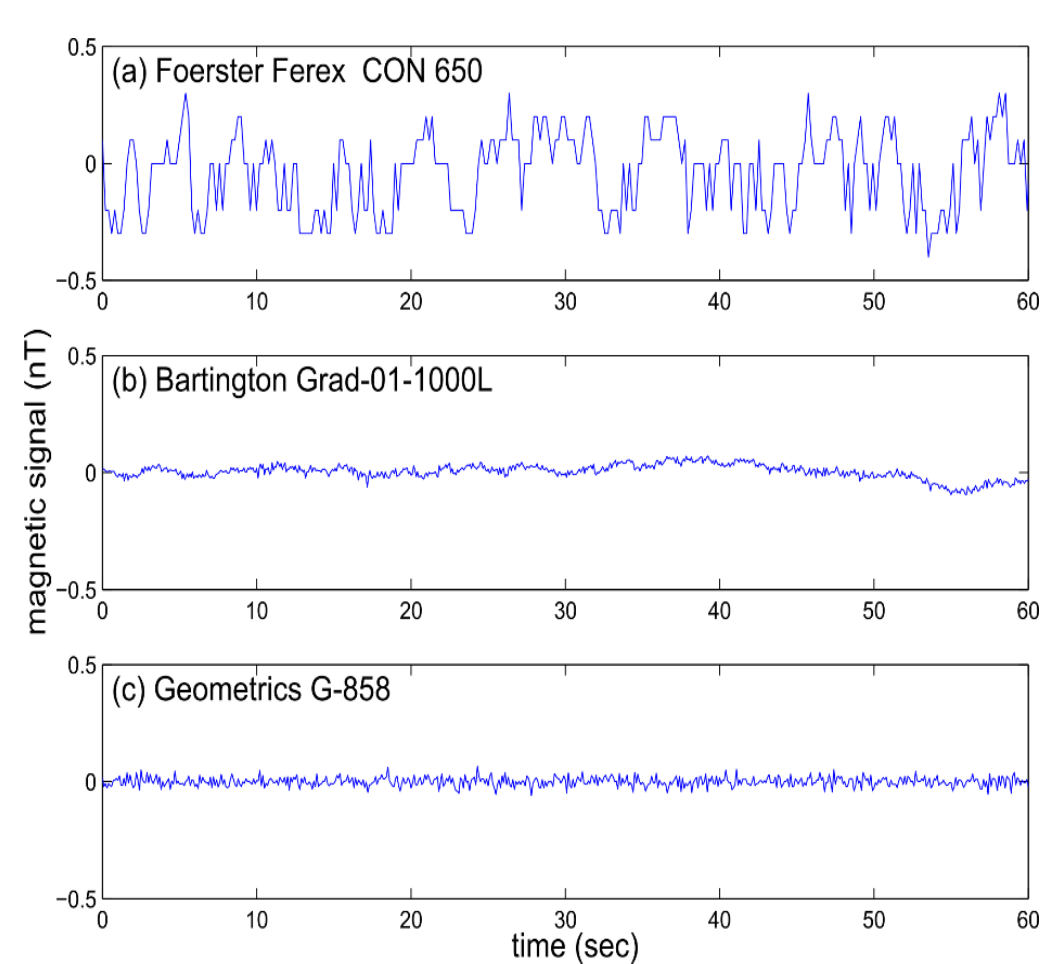
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## Abstract

For the interpretation of archaeological geophysical data as archaeological features, it is essential that the recorded anomalies can be clearly delineated and analyzed, and therefore, care must be taken to obtain the best possible data. However, as with all measurements, data are degraded by unwanted components, or noise. This poster clarifies the terminology, discusses the three major sources of noise (instrument, use of instrument, external). But soil has to be considered also as the origin of another type of noise rarely described: for archaeological structures to be detectable, archaeo-geophysicists know that there must be one or more contrasts in physical properties between the soil and the structures. But much more rarely are considered two other factors: the spatial structure of the soil and/or its surface condition. However, these intrinsic factors greatly influence the detection of buried heritage. These factors will not have the same consequences depending on the types of geophysical methods used and even depending on the type of device used.

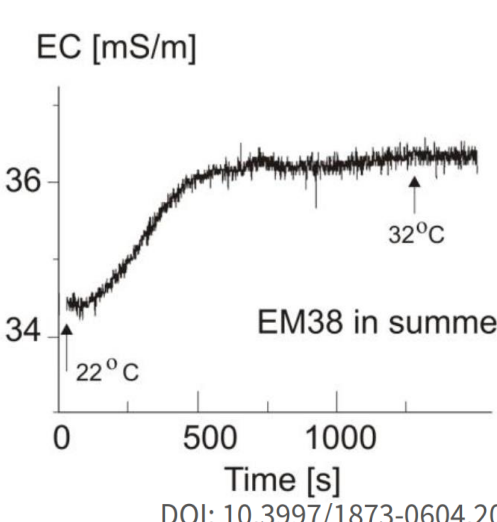
## Instrument noise : ask the manufacturer!

- Random variations => Characterized by RMS error, function of frequency
- Can be lowered by high frequency/ Data rate measurements (BUT only if Random noise) ⇔ only possible if high bandwidth systems (noise  $\approx \sqrt{N}$ )
- Higher frequencies/denser sampling => better separation between small real variations ("soil noise") and the random noise.



Instrument/Sensor	RMS (nT)
Geoscan FM36	0.29
Ferex CON 650	0.21
Bartington Grad 601	0.06
Geometrics G-858	0.02
Scintrex SM4s	0.01

Comparison of RMS errors for magnetometers (stationary mode)



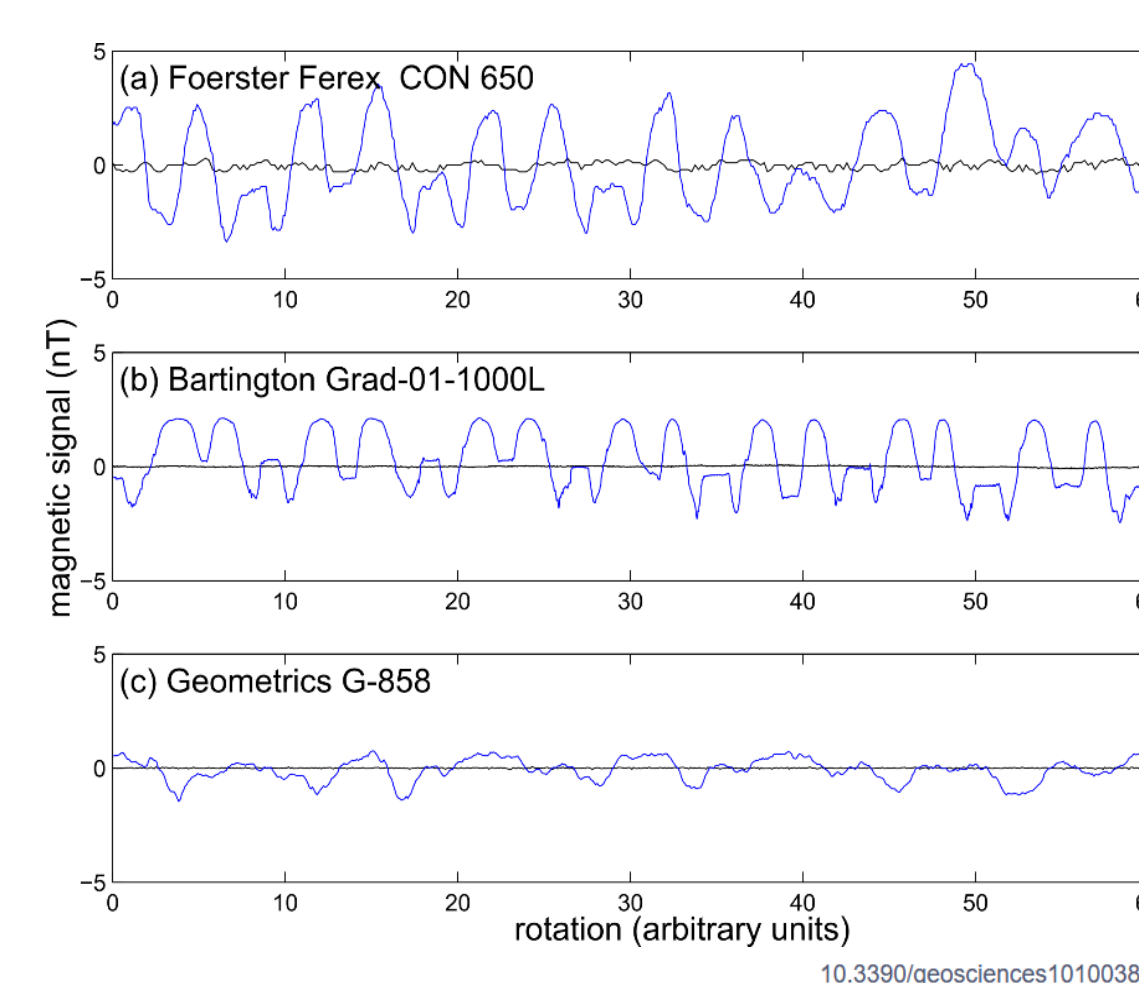
Variation of conductivity In EMI surveys due to a temperature change (stationary mode)

Comparison of stationary measurements collected with three different magnetometer sensors over one minute.

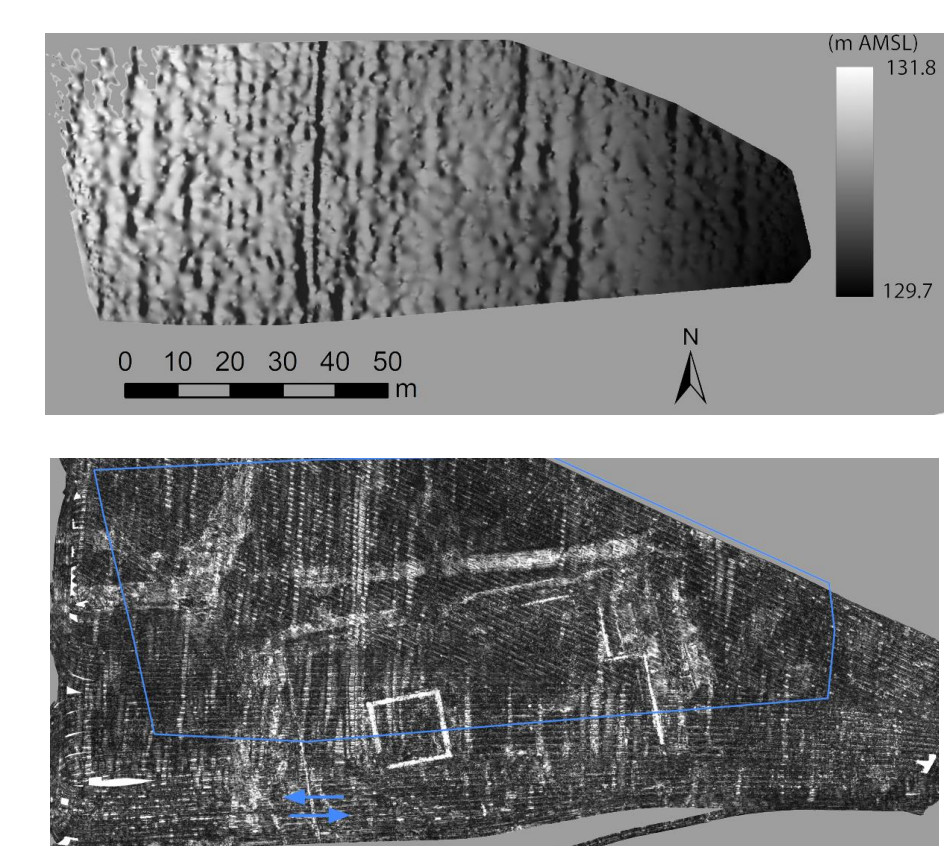
- If not random noise : DRIFT : cannot be taken into account except if the drift variations is known and subtracted.

## Use of instrument : a perfect soil is a flat soil!

- Roughness of the ground => Variations of height between sensors and soil surface (and/or coupling) + vibrations for motorized systems



Heading error for three magnetometer sensors

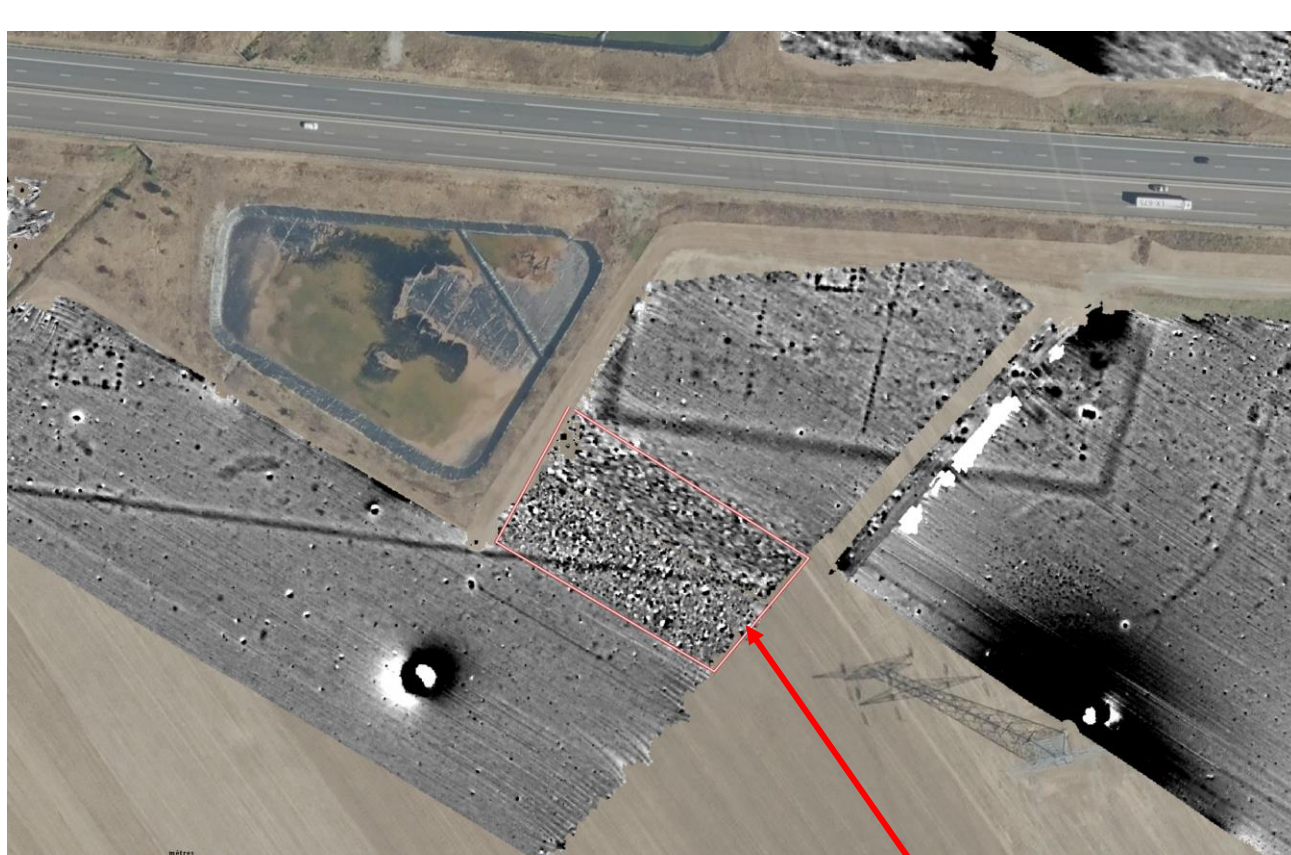


Height variations (DEM above) causing stripes in GPR time-slices

- Plough lines => Influence survey strategy => Sensitive to the azimuth response of the sensors.

## External noise : a perfect soil is a 'clean' soil!

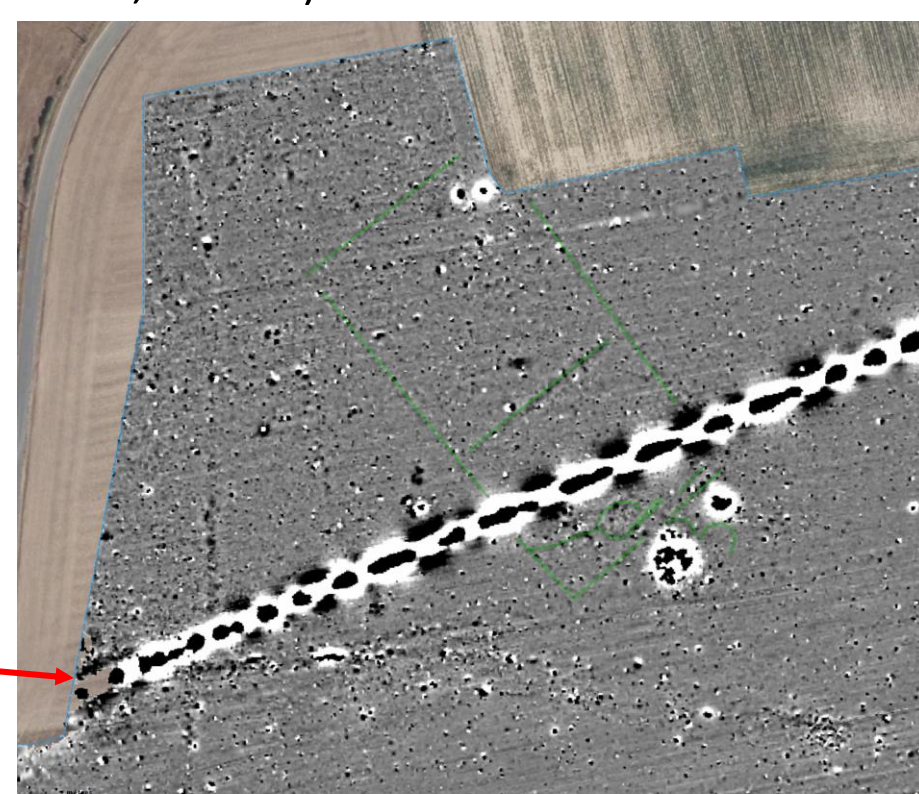
- Old manure / New types of 'green' waste
- Pipes, drainage ditches, lightning strikes, etc.



Example of (possible) old manure spreading: Magnetic map of the Iron Age Aristocratic Settlement of Batilly-en-Gâtinais (45340, France).



Example of drainage ditches Magnetic map of the Roman site of Roullée (72600, France).

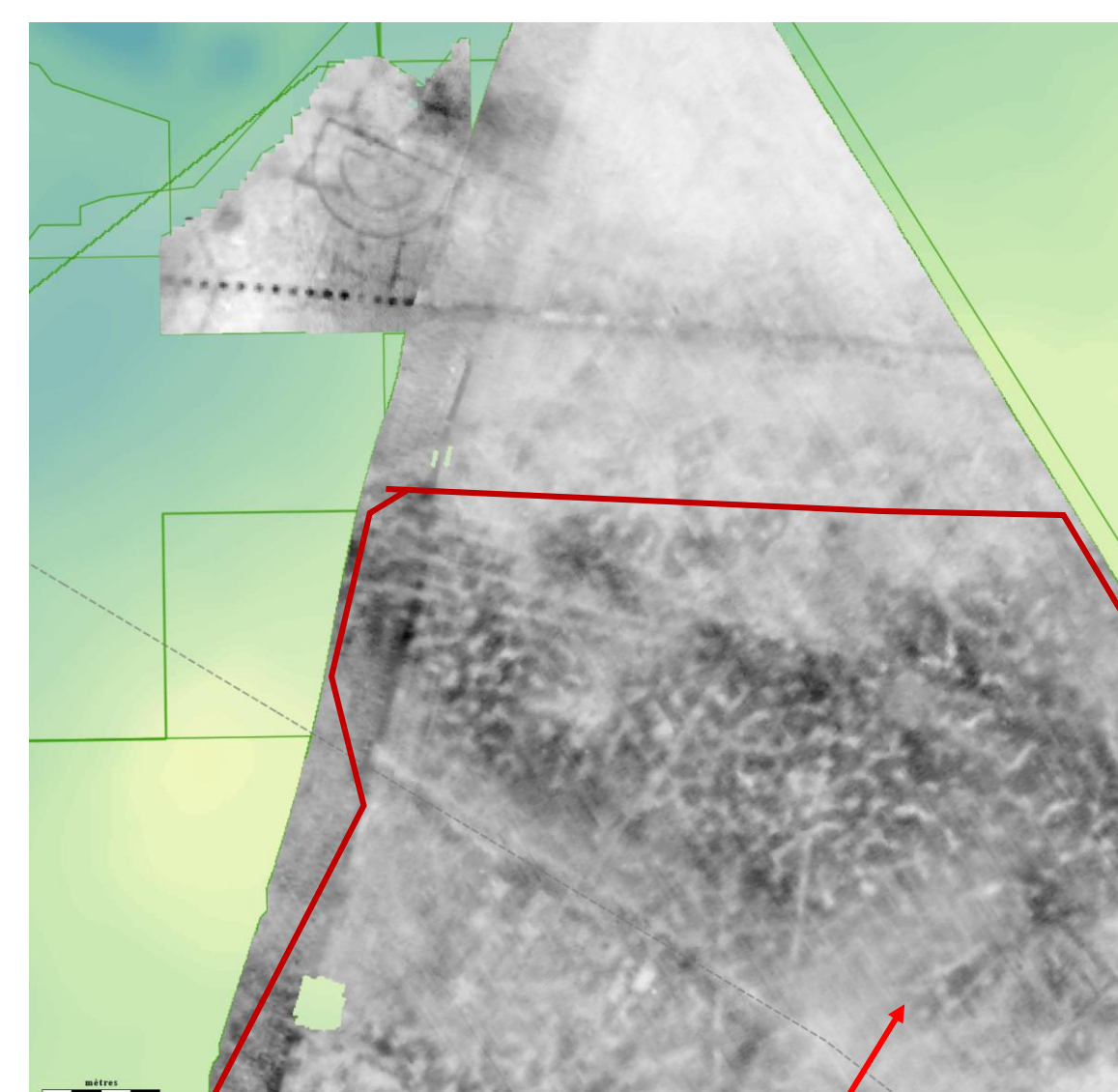


Example of pipe Magnetic map of the Celtic Enclosure of Grand Chêne (72700, France).

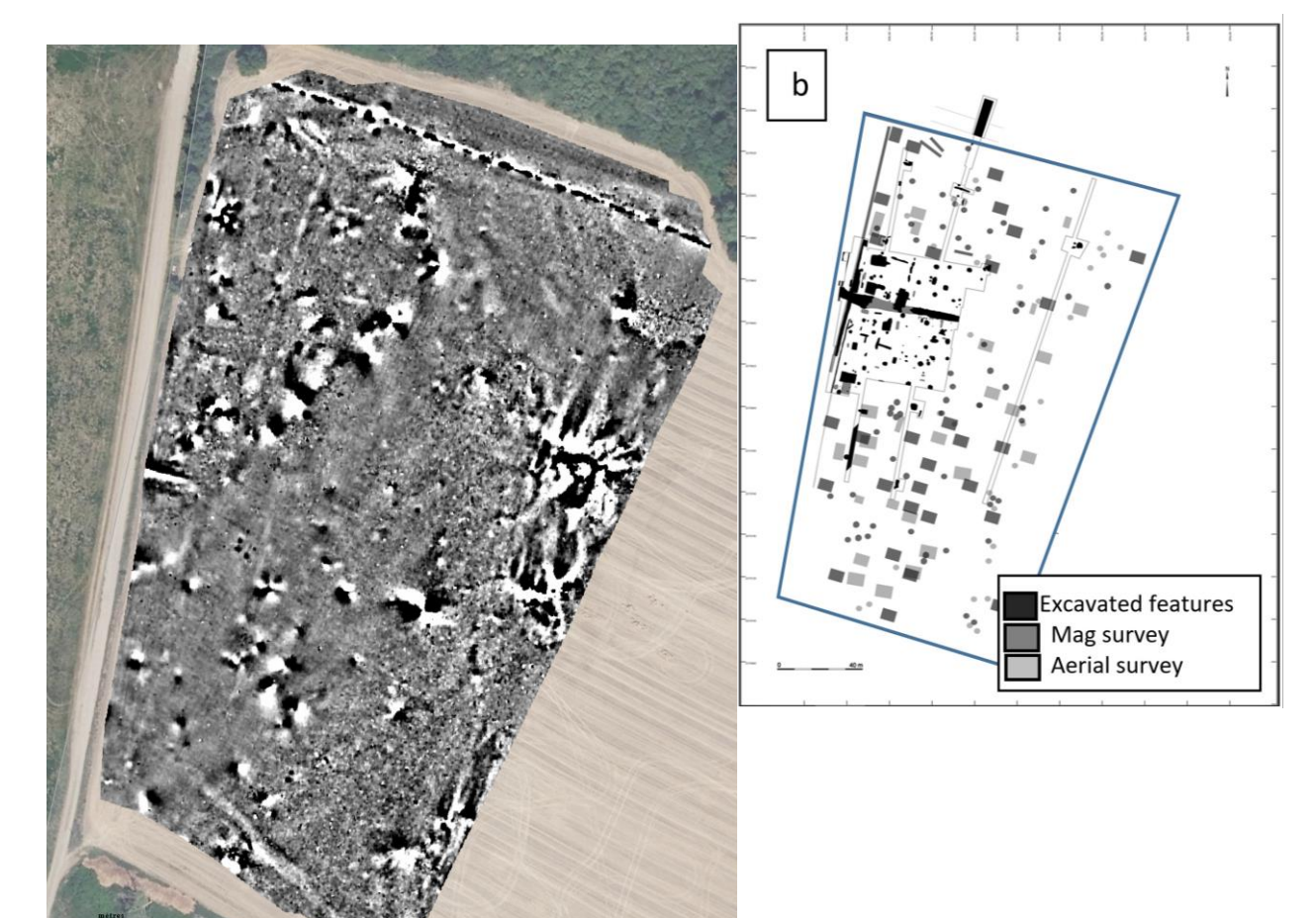
(All data from the web-GIS repository : [www.chronocarto.eu](http://www.chronocarto.eu) / CELTECOPHYS Project)

## Soil noise : a perfect soil is a soil where only archaeology shows up!

- Magnetically disturbed soils
- Specific cryoturbated soils



Example of cryoturbated soils Resistivity map of the Roman site of Vieil-Evreux (27930, France)



Example of alluvial soils polluted by magnetic pebbles Magnetic map of the Oppidum of Gondole (63670, France)



## References

Data courtesy of : Géocarta SAS, Paris, France, and ENS, Paris, France.

Schmidt, A., Dabas, M., Sarris, A., 2020. Dreaming of perfect data: characterizing Noise in Archaeo-geophysical Measurements. *Geosciences*, 10, (10): (382). <https://doi.org/10.3390/geosciences10100382>

(otherwise DOI below figures)