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# Multi-Method Geophysical Survey of Caesar's Military System at the Battle of Gergovie

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## Highlights:

- We used different geophysical technics to map Caesar's military system.
- Low frequency electromagnetic system allowed to reduce disturbances induced by basaltic blocks.
- Old archaeological hypothesis were verified and corrected based on the new geophysical results.

**Keywords:** magnetic, low frequency electromagnetic, basaltic rocks, gallic war, Iron Age.

A research project dedicated to the enhancement of the cultural heritage of the Gergovie site, launched in 2018 with the support of the Puy-de-Dôme Council, has provided a key opportunity to study one of the most iconic battle fields of the Gallic Wars. In the spring of 52 BC, Caesar's legions settled just below the Gallic city of Gergovie, in the heart of the Arverni territory, with a view to besiege the stronghold where Vercingetorix was born. But none of Caesar's strategies succeeded in destroying the defensive lines of the fortress and he suffered there one of the very rare defeats that the Romans met with during the conquest of Gaul.

As mentioned in Caesar's *De Bello Gallico*, the offensive facilities built for that purpose were meant to accommodate 35,000 soldiers and followed the classic rules of poliorcetics. The military works link together the main entrenchment set up in the plain ("the big camp"), an advanced position on a

hill (the 'small camp') and a line of fortifications connecting the two cantonments.

However, the building techniques and the organisation of these military structures are not commented upon, and there is no information either regarding the surface area, the mapping and internal structuring of the camps, the overall number of access doors, the presence of watch towers and other defensive obstacles similar to those that were described around Alesia (*cippi*, wolf pit) or the type of building materials that were used.

In the 1860s, under the Second Empire, the detailed structure of the Roman siege set up in front of the Gergovie *oppidum* was identified for the first time, thanks to extensive and ground-breaking research initiated by Napoleon III, thereby filling in some of the gaps from Caesar's narrative. In more recent times, excavation programmes were able to

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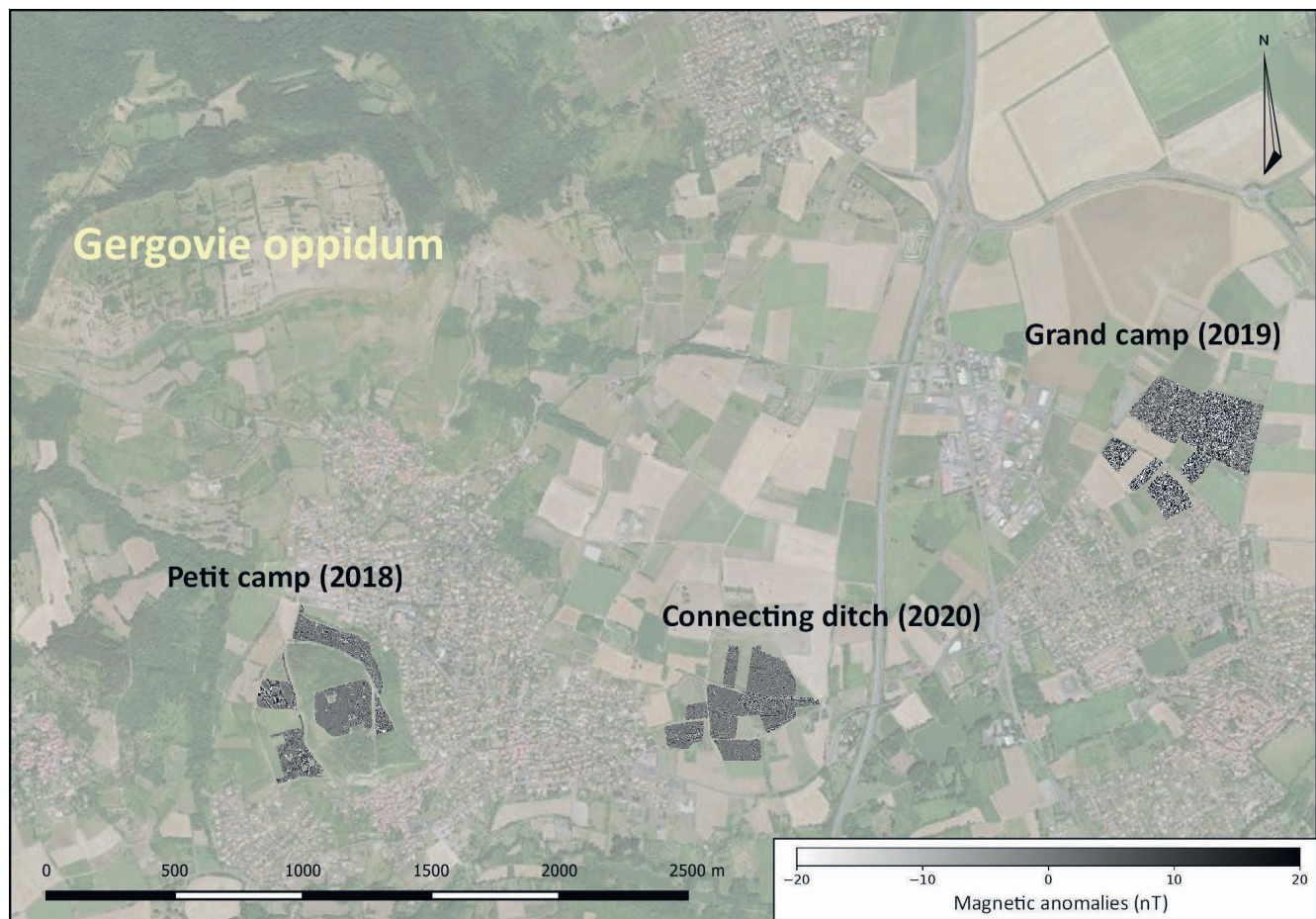


Figure 1. Location of the three areas mapped by magnetometry and location of the besieged oppidum.

validate, one at a time, the 19<sup>th</sup> century working hypotheses, whilst providing further insights into the dating

of the works and everyday life within the cantonments (Deberge *et al.*, 2015). However, those investigations were very often based on limited surface areas (a few hundred square metres at most) and were therefore only applied to a very small percentage of Caesar's military set-up.

Over the last three years, a research program between the Inrap (Direction Scientifique et Technique et Centre archéologique de Clermont-Ferrand) and the Maison des Sciences de l'Homme (Université Clermont Auvergne/ CNRS – UAR 3550) has therefore prioritized remote-sensing techniques on large areas. By targeting either areas that have not been investigated for close to one hundred years or less established parts of the Roman set-up, these new investigations provide key insights into the architectural features of the military infrastructures.

Three distinct areas were studied, the “Petit camp de César” in 2018 at the foot of the Gergovie plateau, the

“Grand camp” located in the plain and the double connecting ditch linking the two previous sites. While they are located near the Gergovie plateau, the geological and soil characteristics of these three areas are very different. The first site is located on a limestone hillock covered with a silty-clay soil, the second on an ancient alluvial terrace composed of basaltic gravels, the third site is marked by alternating silty-clay soils and basaltic rock deposits.

Both the “Petit camp” and the “Grand camp” have been used to test different geophysical methods in 2018 and 2019: magnetometry, but also frequency domain electromagnetic method, GPR and electrical resistivity. With these first tests, it was decided to focus on the magnetic and electromagnetic method, because the latter, easier to implement on large areas as long as they are associated with a towed system, showed the most relevant results (Fig. 1).

The magnetic survey has been carried out on the three sites with the Sensys MXPDA system composed of 5 flux-gate probes and towed by a quad bike. The low frequency



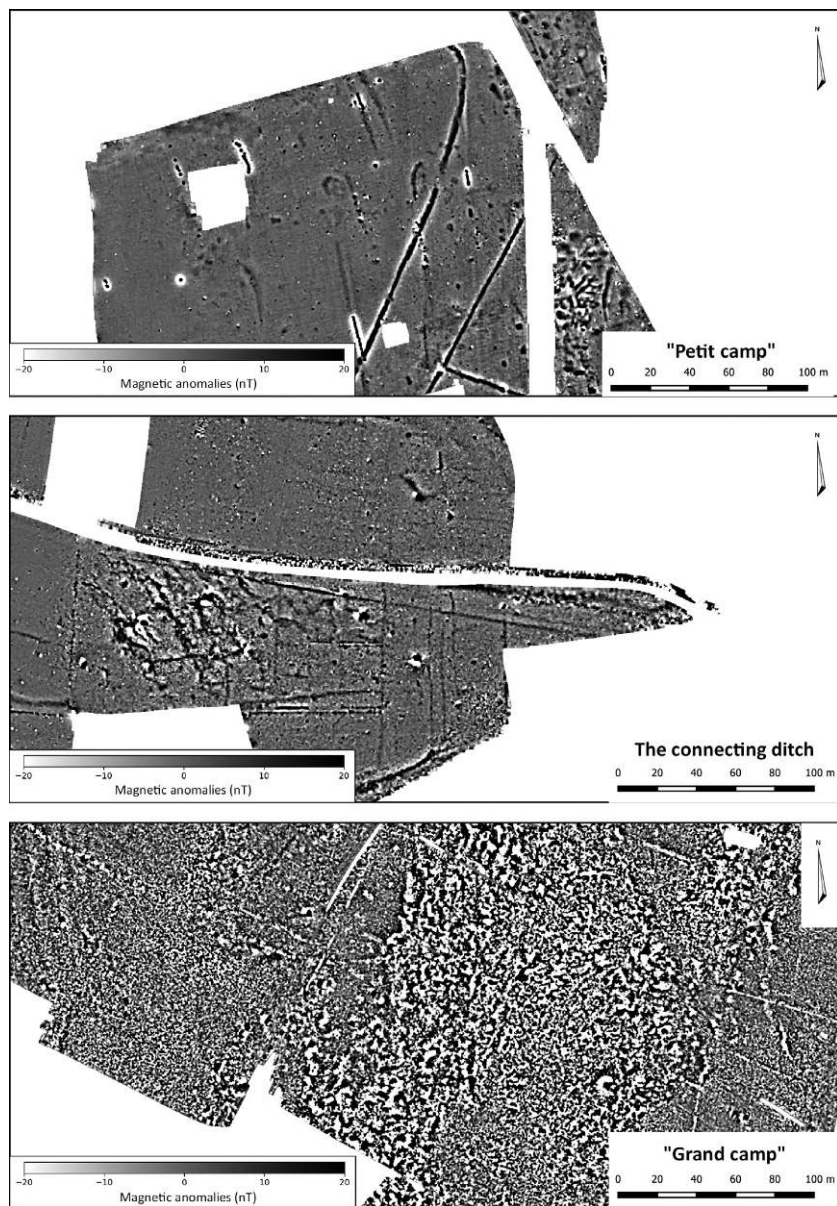


Figure 2. Results of the magnetic survey presenting a wide variety of magnetic noise resulting from different concentration of basaltic rocks.

electromagnetic method was also deployed on a sledge towed by a quad bike in order to reduce the acquisition noise to the movement of the device. The used sensor is the GEM2 of Geophex which provides a measurement at 5 frequencies (Won *et al.*, 1996). An EMP400 of GSSI has also been tested. The association of magnetic and electromagnetic methods was intended to map the magnetic susceptibility in order to refine the results observed with the magnetic method and to eliminate the effect of remanent magnetization associated with volcanic rocks (Benech *et al.*, 2002).

The combination of the magnetometry and low frequency electromagnetic method yielded conclusive results on all

three sites (Fig. 2). On the “Petit Camp”, the magnetic survey highlighted the layout of the ditches studied by Stoeffel's research team. This first campaign also revealed an interruption in the main ditch that can hypothetically be associated with an entrance system. Numerous pits were also detected outside the camp, but their function and chronology remain uncertain. Inside the camp, no specific archaeological feature is visible on either the magnetic or electromagnetic maps.

On the “Grand camp”, the basalt blocks constituting the alluvial terrace have totally disturbed the magnetic anomaly map and hide all archaeological information. The only relevant result in this sector comes from the low frequency

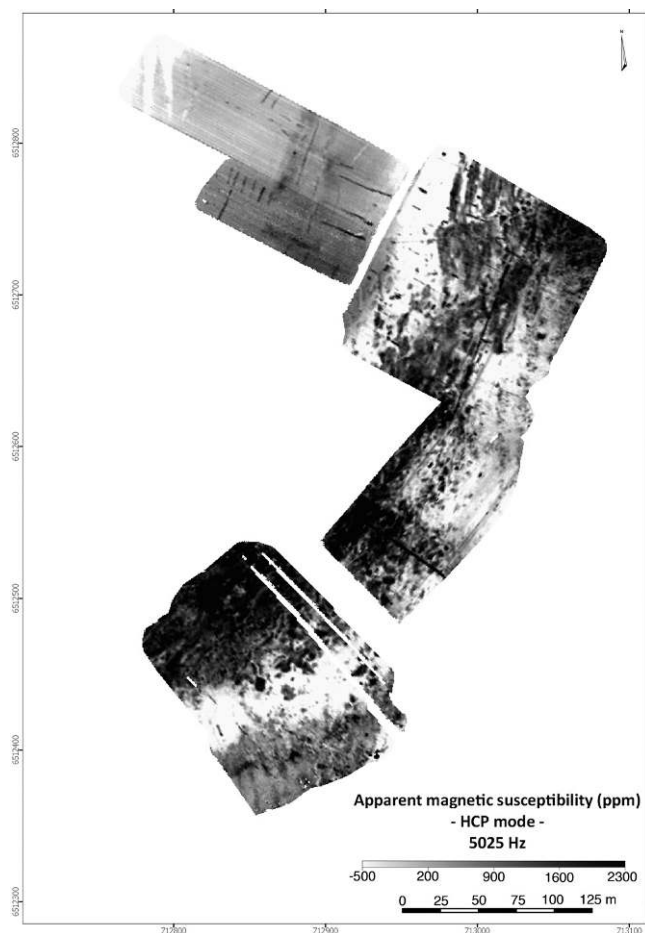


Figure 3. Results of the electromagnetic in-phase measurement acquired with the GEM2 in HCP mode: both ditch of the “Grand Camp” and basaltic blocks are visible in this area.

electromagnetic data which, by measuring the magnetic susceptibility, has revealed the layout of the ditch and has rectifying the hypothesis based on the old excavation campaigns (Fig. 3). Here again no indication of spatial structuring or occupation is visible inside the camp, while recent excavations shown the existence of small fireplaces associated with military camps. Anomalies that may be associated with ovens are not distinguishable from those related to the basalt block whatever is the used method.

The last studied area, corresponding to the double connecting ditch between both camps, mapped during the fall of 2020, lends itself to both magnetometry and low frequency electromagnetic methods. In this sector, the geophysical maps make it possible to better understand the ditches found during the archaeological surveys carried out in the 1990s. Nevertheless, no double ditch such as those mentioned by Stoeffel’s team can be clearly distinguished. Only tenuous clues suggest that it was preserved on the ridge line linking the two camps. In order to support these assumptions, electrical resistivity tomography and GPR profiles were carried out, but these do not allow us to decide on the assumptions initially made, given the nature of the filling.

The various geophysical studies carried out on the three sites provide elements of information about the presence and state of conservation of the military settlements made by Caesar’s army. They partially confirm the maps established by Stoeffel and make it possible to accurately relocate the implantation of the sites in the current landscape. Unfortunately, no evidence other than the ditches is perceptible despite the great variety of techniques and measurement protocols used. The heterogeneous volcanic context is thus here both an advantage, notably for the low frequency electromagnetic method, but also a strong constraint, notably for the detection of archaeological structures that are less spatially organized and that can easily be mistaken for basaltic elements.

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