Magnetic imaging of a late Bronze Age tumulus in France before and during excavation

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Geophysical surveying is taking place in the Chatillon-sur-Seine area in France to examine and map prehistoric settlements and the structure of tumuli (gravemounds which originally reached a height of up to 5 m but which are now almost level). The magnetic survey discussed here was conducted to detect archaeological structures within a late La Tène (100-50 BCE) necropolis, in particular the preexcavation recording of a late Bronze Age round barrow. During the excavation, additional surveys were carried out to analyze the influence of immediate subsurface soil layers on the magnetic anomalies originating from the deeper archaeological features.

Additional radar surveys made use of a 500 MHz antenna and a SIR-2 system from GSSI which clearly showed the archaeological structures, but the results presented here will focus on the magnetic data.

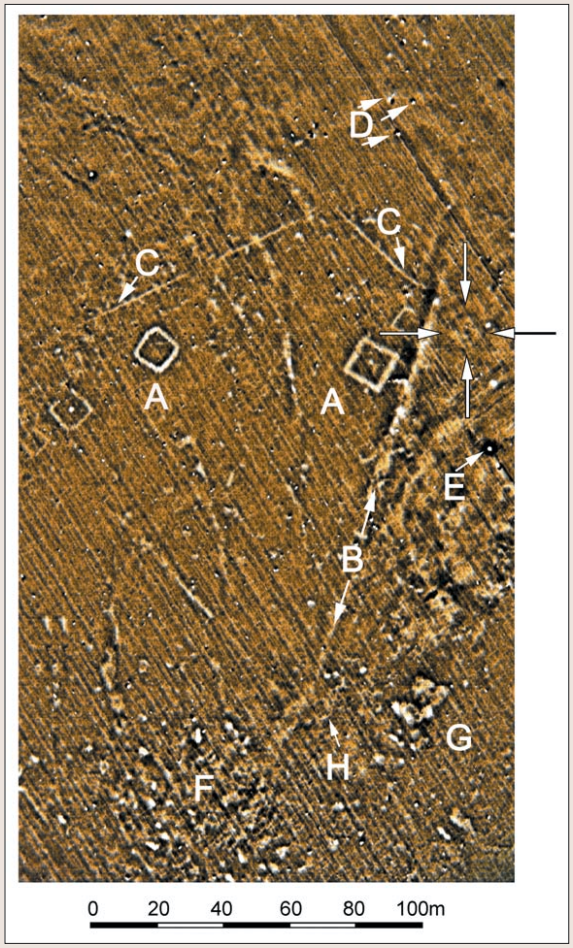

Figure 1. Magnetic map of the necropolis. (Arrows mark the examined tumulus).

Discoveries by magnetic imaging. Two family graves within a larger late La Tène necropolis dating to between 300 and 75 BCE were archaeologically examined in 1967. The objective of the present geomagnetic survey was to find more graves and record the structure of the whole necropolis. A Geoscan FM36 gradiometer was used, the upper probe being at a distance of 0.9 m from the surface, the lower probe at 0.4 m. The use of a gradiometer is preferable in order to reduce or cancel the effects of background noise and of metallic objects near the area of investigation. Most archaeological anomalies hardly achieve a value of more than 10 nanotesla (nT); therefore, sample and traverse intervals of 0.25 m were chosen to record small anomalies at a high resolution.

Figure 1 shows the strongest anomalies (6 nT) at point A (the two family graves excavated in 1967). It is known from the excavations that the central light anomaly is the position of a standing stone or small obelisk. The linear structure B, known from aerial photographs, was thought to be the boundary of the necropolis, but the magnetic survey proved it to be a geologic feature. The survey also suggests that the trenches marked C are the northern boundary of the necropolis. The discrete dipole fields (D) are caused by metal debris (mainly screws and parts of tractors) close to the surface. The discrete anomalies F and G are of archaeological interest—typical of pits and hut foundations. Although their chronology is not clear, they are likely to be a part of the necropolis.

A circular structure with a central anomaly (marked with four arrows in Figure 1) was found in the immediate vicinity of two grave fields. Anomaly H also appears to be circular. However, if we compare it with the structure marked by four arrows, differences in magnetic readings are evident, suggesting that the two circular images are not the same, given the fact that different soil types can yield varying magnetic properties. GPR data showed that the structure marked by arrows is likely to be a tumulus and the more promising site. Excavation work revealed a round borrow, consisting of stone kerbs 13 m in diameter with one or two central burials at a depth of only 0.40 m below the surface. Because the site lies in intensively farmed agricultural land, its preservation was acutely endangered.

Excavation while mapping. Removal of 0.30 m of clay topsoil revealed the uppermost surface of the limestone circle. Before proceeding with the excavation, GPR and the gradiometer surveys were conducted. For the geomagnetic survey, a sample interval of 0.125 m was used and the survey lines were spaced at 0.125 m intervals. The results are shown in Figure 2, with the magnetic map of the same area excerpted from Figure 1.

Archaeologically relevant anomalies are clearer due both to the removal of the topsoil, which had previously acted as a filter, and the fact that the probes are closer to the magnetic sources. This is especially clear in the case of the structure marked by three arrows. During the excavation it became clearer that anomaly A was induced by *fibulae* (metal clasps for fastening clothing). Anomaly B is another burial and C is the excavation balk leading to the center of the barrow. Excavation spoil was deposited to the north of anomaly B and therefore remains as a white area, unsurveyed. The dark

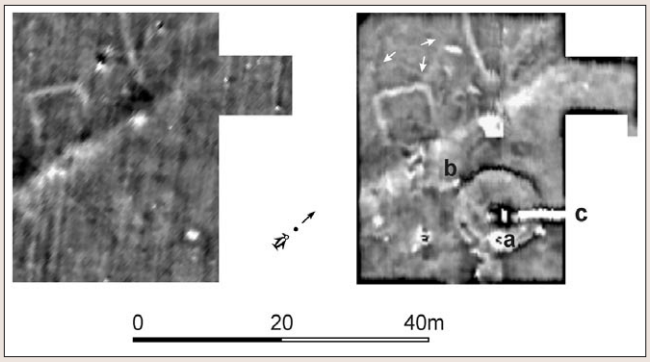

Figure 2. Results of the magnetic imaging after removal of 0.30 m of topsoil (right) in comparison with the same area from Figure 1 (left).

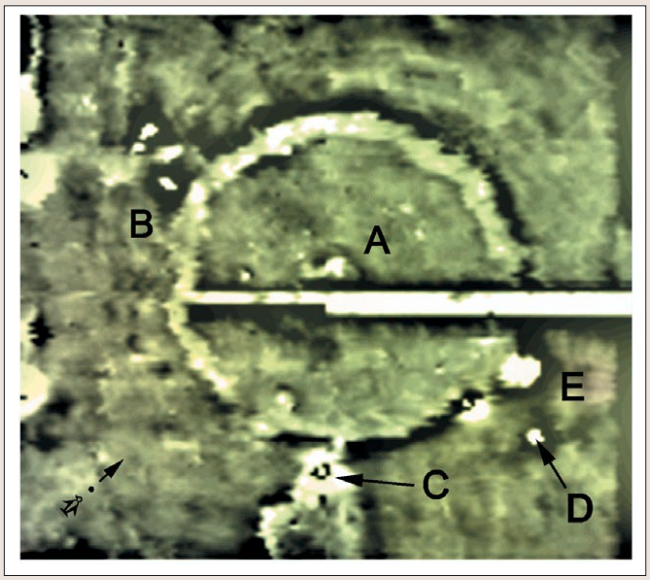

Figure 3. Magnetic map of the whole grave after the removal of 0.50 m of topsoil.

rim at the edge of the surveyed area is a "shadow" caused by the vertical earth surfaces of the excavation trench, which were between 30 and 50 cm high at the time of the survey.

Before the final excavation of the central burial, a last geomagnetic measurement was taken. At this point in time a further 0.20 m deep humus layer had been removed. Figure 3 includes much more detailed information about the magnetic heterogeneity of near-surface layers than Figure 1. The traverse intervals and the profile intervals measured 0.125 m. Much clearer at this point are the anomalies resulting from the central burial A as well as the anomalies originating from the secondary burial B (which is almost invisible in Figure 1). The *fibulae* are clearly indicated by their magnetic interference at location C. Location D is a modern nail marking the find spot of an archaeological object. Anomaly E, already present in Figure 1, could be traced to a modern metal fragment. The bowed structures mostly to the north and west of the barrow result from excavation activity.

Although the geophysical survey indicated that the burial was under the easternmost of the two central anomalies, excavation presented a more differentiated picture (Figures 4 and 5). According to the evidence, the burial chamber was constructed of wood and capped with limestone. The wooden walls eventually collapsed and the chamber caved in. The two central anomalies resulted from stone piles on each side of the burial chamber. The burial itself consisted

Figure 4. Excavated round barrow showing a stone kerb 13 m in diameter.

Figure 5. Central burial ground of the late Bronze Age tumulus.

of seven or eight vessels which could be radiocarbon dated to 902-801 BCE.

Conclusions. In this study, we linked geophysical surveys to site-excavation planning and activities. The removal of topsoil provided an increasingly detailed view of buried structures within the site. It was possible to confirm with upward continuation transformations that this was not only because of the decreased distance of the instrument to the magnetic sources, but also because of the influence of the topsoil with its nonnegligible magnetic properties based on the transformation of iron oxides to more magnetic minerals. The transformation was the result of fires and fermentation processes. The intensively and repeatedly plowed topsoil seems to work as a muffling filter.

Suggested reading. Although R. Joffroy did not publish the results of his 1967 excavation, they are presented in "Vix et son territoire à l´âge du Fer. Fouilles du mont Lassois et environnement du site princier" by Chaume (Montagnac: Librairie Archéologique, 2001). "Susceptibilité magnétique anormale du sol superficiel" by Le Borgne (*Annales de Géophysique*, 1955). "Influence du feu sur les propriétés magnétiques du sol et sur celles du schiste et du granite" by Le Borgne (*Annales de Géophysique*, 1960). TLE

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