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A Large Area Geophysical Survey at Waremme-*Longchamps* A Fortified Linienbandkeramik Site in Liege Province, Belgium

Russell S. QUICK, Dominique BOSQUET, Lawrence H. KEELEY, Ivan JADIN & Mark L. GOLITKO

Abstract

From 1987-1989, the southeastern part of the fortified *LBK* village of Waremme-*Longchamps* was excavated by a team led by D. Cahen and L. Keeley. A large area geophysical survey of the site was begun in 2002. This report presents the results of a Caesium Vapour Gradiometer survey conducted in 2004-2005, which are compared with the findings of a ground truthing excavation (see also: Keeley *et al.*, 2005, this volume).

Keywords: *Linienbandkeramic* (*LBK*), geophysical survey, Ground Penetrating Radar, Proton Precession Gradiometer, Caesium Vapour Gradiometer, enclosure, ditch, pits.

1. Introduction

Waremme-*Longchamps* (WLP) is a fortified *Linienbandkeramik* (*LBK*) village located along the Upper Geer river in the Hesbaye Region of Liege Province, Belgium. First located by G. Destexhe in 1968 (Jadin, 2003: 72), it has been radiocarbon dated to approximately 4350 BC (*ibid*: 674), making it one of the earliest and most western Neolithic sites in this region. A large area geophysical survey of Waremme-*Longchamps* was begun in 2002. Over the last three years, a variety of geophysical methods have been employed to examine different parts of the site. This report presents results from Ground Penetrating Radar and Proton Precession Gradiometer surveys conducted from 2002 to 2004, but is primarily concerned with the results of a Caesium Vapour Gradiometer survey conducted in 2004-2005. It includes a description of potentially important anomalies and a comparison with the findings of ground-truthing excavations conducted in August 2005 (Keeley *et al.*, 2005, this volume).

1.1. Previous work at Waremme-Longchamps

From 1987-1989, excavations were carried out under the direction of Dr. Daniel Cahen of the *Institut Royal des Sciences Naturelles de Belgique* (*IRSNB*) and Dr. Lawrence H. Keeley of the University of Illinois at Chicago. These excavations were concentrated in the southeastern part of the site (fig. 1), where numerous *LBK* features and two longhouses were discovered. The pasture was left untouched, but a concerted effort was made to trace the line of the enclosure ditch through the northeastern field (not pictured in fig. 1) using both electrical resistivity and - when that proved unsuccessful - test trenches (Cahen *et al.*, 1990).

In the summer of 2002, experiments were begun to determine the utility of various near-surface sensing methods to locate and resolve the fortification ditches and domestic pits of early Neolithic sites. Previous excavations at *Longchamps* and other *LBK* sites in the region indicated that enclosure ditches were of two types: very deep (1.6 m below plowzone, 1.5 m wide) V-shaped ditches and more shallow (c. 1 m deep and wide) U-shaped ditches. The domestic pits invariably found alongside *LBK* houses were approximately 0.75 m to 1.4 m deep (below plowzone) and from 0.5 m to 1.5 m in width. Typically, both domestic pits and fortification ditches were filled in with household refuse. The team was therefore optimistic that these types of buried features could be rapidly located and mapped using a combination of Ground Penetrating Radar and magnetometry. Austrian archaeologists using similar techniques at the *LBK* site of Schletz-Asparn near Vienna readily and very accurately (as determined by 'ground truthing' excavations) detected such ditches and daub pits in loessic soils similar to those of the Upper Geer (Windl, 1999). However, some experts suggested that the chemical properties of Upper Geer soils (which contain high concentrations of clay particles and carbonates) would attenuate radar signals, and interfere with magnetic readings, thereby preventing the localization of archaeological features. The earlier work at Waremme-*Longchamps* made it possible to use the site as a "pre-ground-truthed" geophysical exercise area. The line of the buried, unexcavated ditch was known in the northeastern

field as was the location where it left the southeastern field and entered the pasture. Current geophysical survey results could therefore be directly compared to the locations of known buried archaeological features.

1.2. The Geophysical Survey Area

The *LBK* site of Waremme-*Longchamps* is located on the *Ferme de Froidebise*, owned by Mr. Andre Hanlet (fig. 4, 5 for an overview of the entire site). The geophysical survey at *Longchamps* encompasses 5.8 hectares in two fields: a cultivated one in the north and a pasture in the southwest. The area excavated in the 1980s - the southeastern portion of the farm - was not included, although every effort was made to survey as close to the boundaries of the old work as possible. The surveys were conducted by Russell S. Quick with the assistance of colleagues from UIC and the IRSNB (see acknowledgements). Surveys in the pasture area were hampered by the levelling of that field (to create a football pitch) during the Second World War, and the large number of metal objects (posts, fencing, buildings, farm equipment, etc) in that area. These obstructions were mercifully absent in the portion of the farm currently under cultivation, where the only limiting factor was time.

2. *Geophysical Methods*

2.1.Ground Penetrating Radar (GPR)

In order to test the utility of GPR for locating and mapping *LBK* fortifications in the loessic soils of the Belgian Hesbaye, the authors conducted a three-day trial at *Longchamps* in August 2002. This survey was conducted in the pasture which abuts the southwestern edge of the previously excavations. The fortification ditches discovered during the 1980s were expected to curve across this pasture to rejoin the known portions of the ditch to the north (see arrows, fig. 1). The pasture was therefore a ready-made test-bed for the GPR. A series of overlapping plots that began 6 m from the 1989 excavation limits were surveyed with the GPR so as to intercept the continuation of the fortification ditch. On this series of GPR profiles, a linear feature was detected, running diagonally across the pasture, exactly in line with where the ditch should be located (fig. 1). An auger sample was taken from the center of this linear anomaly. Beginning half a meter below the surface, this core contained material consistent with the fill of an *LBK* ditch: darker loess with small particles of charcoal. Based on these initial results, we believe that the GPR *was* successful in locating the continuation of the *LBK* fortification ditch and possibly the line of the inner palisade (fig. 2).

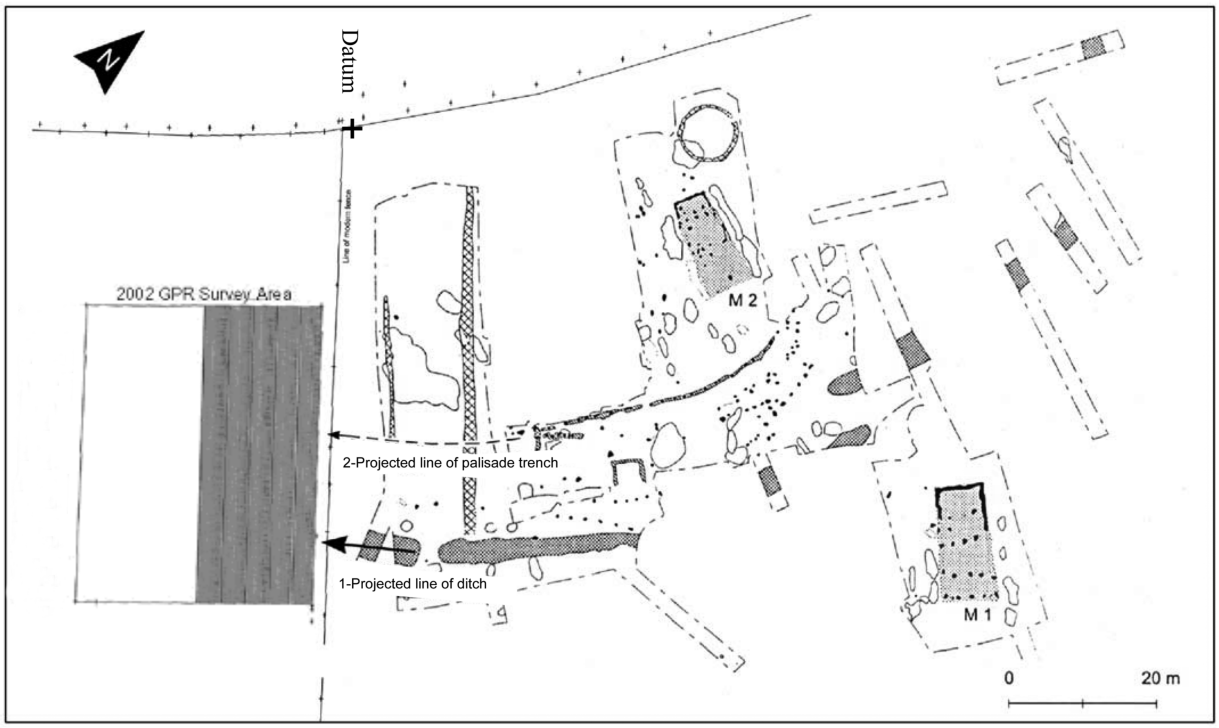

Fig. 1 — Waremme-*Longchamps*.
Previous excavations and the location of the summer 2002 Geophysical survey showing the GPR anomalies.

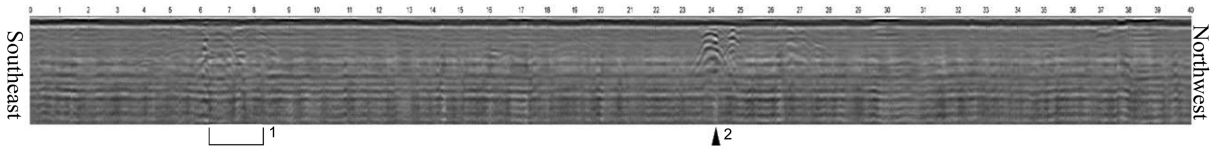

Fig. 2 — Waremme-*Longchamps*. Transect 3 from Summer 2002 Geophysical Survey. The position of bracket 1 corresponds to the projected location of the enclosure ditch. The position of arrow 2 corresponds to the projected location of the palisade trench.

Overall, however, the results of the survey were disappointing. Collecting the data in tall pasture grass was difficult and time-consuming and post-processing the data was tedious. In addition, no obvious *LBK* features were discernable within the enclosure ditch and the ditch itself was often difficult to see in the radar profiles. On the other hand, the radar had no problems penetrating the loessic soils, its problems were caused by the levelling of the field with a layer of fill.

2.2. Proton Precession Gradiometry (PPG)

In 2003 and 2004, further surveys were conducted in the pasture utilizing a GemSys 19TGW Proton Precession Gradiometer. The results of these surveys were even more promising. The fortification ditch and several hitherto unknown domestic pits were detected utilizing both walking and station modes. The walking data collection method was fairly rapid - over ½ hectare per day - but the results were noisy and difficult to interpret without "the eye of faith". In order to achieve optimum results with the PPG, six second readings were required, which meant that only about ¼ hectare per day could be completed with readings taken at 1 m station intervals (fig. 3)! Despite the apparent slowness of this method of data collection, it represents a considerable savings in terms of both time and money when compared with decapage excavation.

The results of these proton precession surveys agreed with both the GPR results and the information gained from the 1980s excavations. Utilizing gradiometry, we were able to expand upon the GPR survey and map out the a large portion of the fortified area in the southwestern part of the site, thus giving a more complete picture than was possible with GPR alone. The PPG

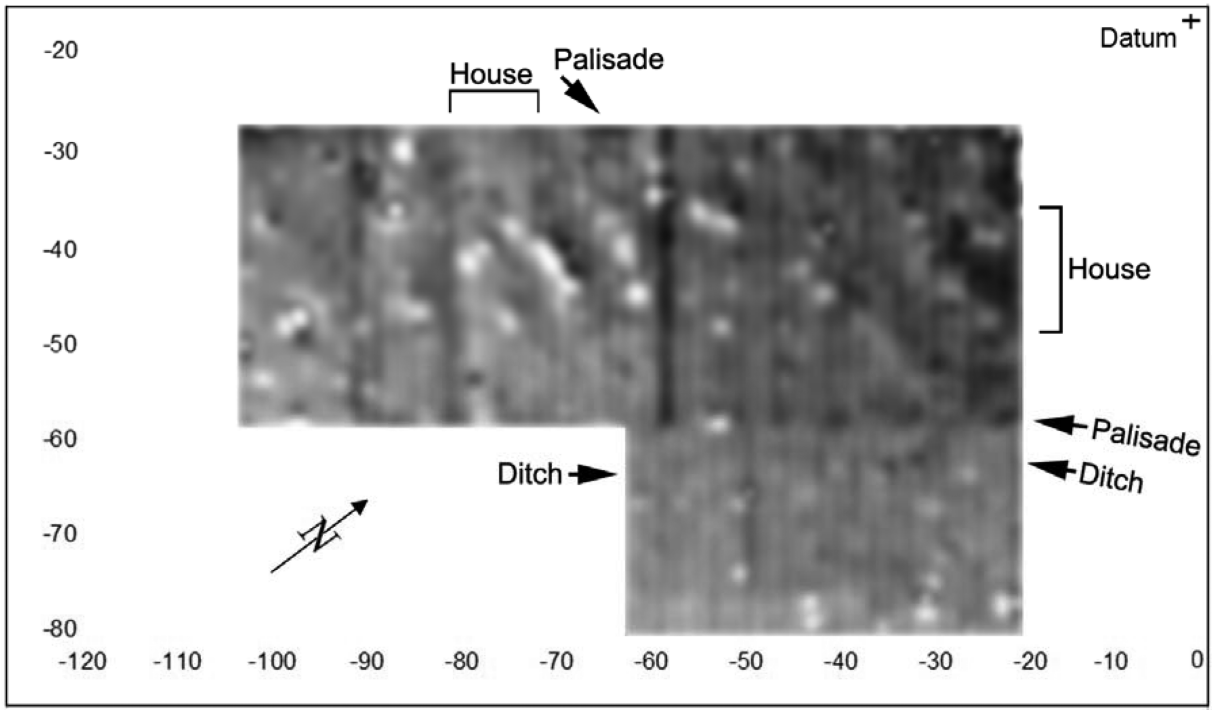

Fig. 3 — Waremme-*Longchamps*. Proton precession Gradiometry Results from the Northeast Corner of the Pasture (compare with same area surveyed by Caesium-Vapour Gradiometer, fig. 4 near "A2").

surveys further validated the use of geophysical methods in this region of Belgium.

2.3. Caesium-Vapour Gradiometry (CVG)

The 2004-2005 magnetic field gradient survey was conducted using a Geometrics G-858 Caesium Vapour gradiometer. The survey was conducted in a patchwork fashion because the site is a working farm with crops in the fields and numerous large metal objects (farm machinery) moving about. Transects were spaced approximately 1 m apart and 10 data values per meter were collected walking roughly SE-NW. The survey was designed to trace the full extent of the enclosure ditch by collecting data over the maximum area rather than attempting to detect small and/or low-contrast anomalies such as post-holes. The survey located numerous anomalies (fig. 4), the majority of which were prehistoric in origin. What follows is an overview of the important anomalies and their properties.

2.3.1. Caesium-Vapour Gradiometry Results

A. This curvilinear dipole anomaly is associated with the *LBK* fortification ditch traced during the 1980s excavations (fig. 4). "A1" is a newly discovered section of the ditch in the northwest field, and "A2" is a new section in the pasture. Because some of the ditch segments excavated during the 1980s were filled with large quantities of household waste (ceramics, lithics, and hearth cleanings), it was hoped that this anomaly would show up well on a magnetograph. Following the 1980s excavations,

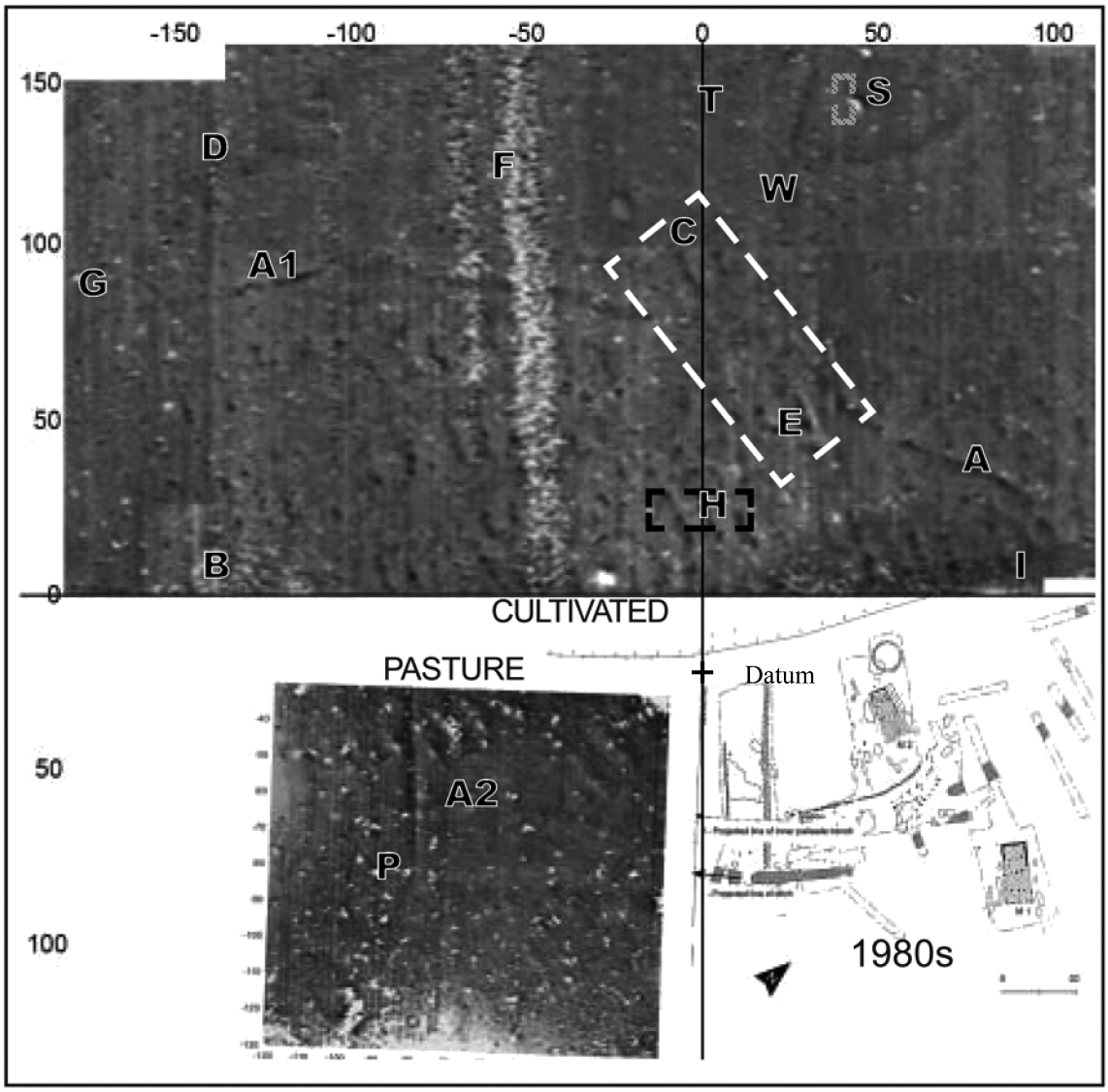

Fig. 4 — Waremme-*Longchamps*. Caesium Vapour Anomalies.

the ditch was believed to be approximately 150 m wide by 200 m in length. However, the CVG survey shows that the ditch is at least 170 m across and over 300 m (up to 350 m) on its long axis. Although somewhat larger than expected, the circumference of the ditch at WLP is "average" for fortified *LBK* sites in this region. Some magnetographs show a consistent line of "point" anomalies just inside the ditch, suggesting the presence of palisade post-moulds.

B. This area of clutter was caused by magnetic disturbance from a backhoe, which was unfortunately parked on this corner of the site during the last day of the survey. A large metal electrified fence post exacerbated the problem.

C. These two parallel positive anomalies generated a lot of interest because they appeared to define the limits of a house *outside* the fortification ditch. Up to this point, only one house has been discovered outside the fortifications and it is the earliest type of *LBK* house on the site, possibly predating the construction of the fortification (Cahen *et al.*, 1990).

D. This area of weakly positive magnetic clutter may be related to the location of a buried stream channel believed to run past the northwest edge of the site down to a modern drainage canal.

E. This strong dipole anomaly also appeared to be another set of house pits. What is particularly interesting about this house is that the enclosure ditch seems to go around it, suggesting that the house pre-dated the ditch. A second possibility for this anomaly is that it was part of the gate system itself.

F. These bands of highly magnetic clutter often appear along the margins of cultivated fields in Belgium. The bands seem to be areas where farmers have pushed most of the debris extracted from their fields by plowing (they are always parallel to the

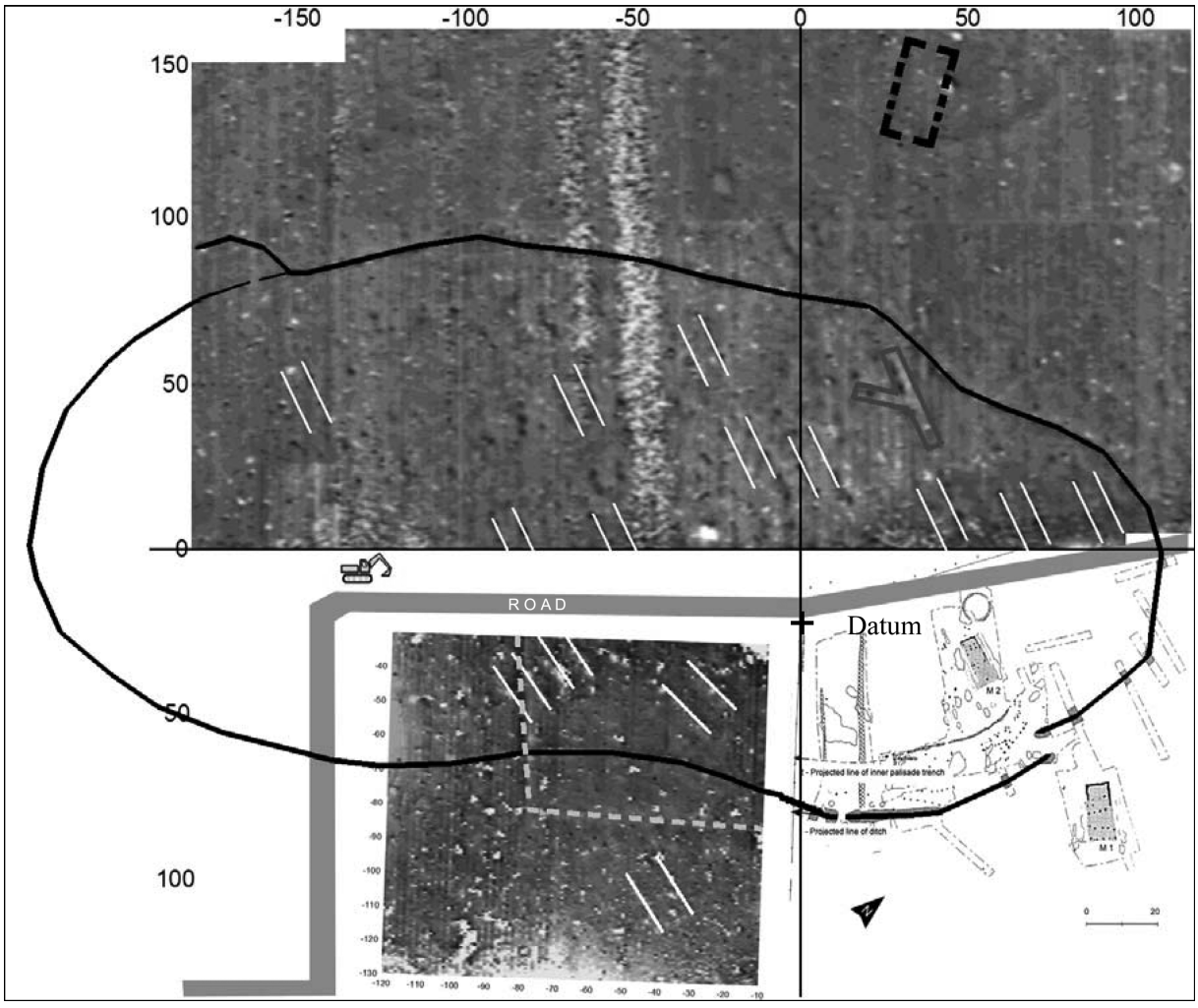

Fig. 5 — Waremme-*Longchamps*. Interpretation of Caesium Vapour Gradiometry Results.

primary direction of plowing). This line was mapped as a field boundary during the 1980s. Some of these bands could be related to Medieval field systems. Another much wider band (ca. 20 m) exists on the eastern side of the site, and accounts for the omission of that data from this report.

G. This small curvilinear anomaly may represent a baffled or screened gate. Excavations at the fortified *LBK* site of Darion-*Colia*, 2.5 km to the southwest, revealed a gate that was similar in structure to this one (almost, but not quite, a "crab claw" type; Bosquet, 1993).

H. As stated, the 1980s excavations located two complete *LBK* longhouses. The "longhouse" anomalies visible on the magnetometer plot are not caused by post-holes, but rather by domestic pits which lie along the outer edge of the house walls. These generally positive anomalies appear as parallel lines of dark grey on the magnetic plot (parallel white lines, fig. 5). The geophysical survey results reveal that there are possibly as many as 15 longhouses remaining to be explored. Further, they suggest that there is at least one of the older house types in the northeast corner of the pasture, as the domestic pits are slightly farther apart in the older houses. At least one house discovered in the pasture by CVG was also located by the Proton-Precession gradiometer, although considerably more data "scrubbing" was required.

I. This linear band of generally positive magnetic readings is caused by the disturbance from a concrete road and an irrigation system that parallels it.

P. The "L" shaped, positive disturbance enclosing the entire northeast corner of the pasture is caused by "fill" material brought in to construct a reasonably level football pitch sometime around the Second World War. This also accounts for the noisiness of this survey area compared to the cultivated field. This anomaly was also visible on the Proton-Precession gradiometer plots. The GPR survey intentionally avoided this area.

The strong negative values on the west and south edges of the pasture were caused by farm buildings and equipment.

S. This magnetic dipole anomaly initially raised some concerns. Because of the extremely strong (ca. -2900 nT) readings obtained, it was not-so-jokingly nicknamed the "Bomb Surprise." Mr. Hanlet's father informed the team that there had been World War II era munitions dumps in the immediate area suggesting this anomaly might represent some kind of unexploded ordinance (UXO).

T. However, further examination of the magnetic plot showed that there was a large (ca. 45 m in diameter) Semi-Circular Anomaly enclosing the "Surprise" and a copse of trees on the northeast edge of the site. When tests demonstrated that a relatively small bar of iron produced a - 2900nT anomaly, it seemed less likely that anomaly "S" was a UXO and more likely that it was either a lost piece of farm equipment or a burned area within a circular enclosure - such as a cremation pit, kiln or furnace - from a period following the Neolithic. (There is a Bronze Age site ca. 500 m to the east).

W. This interpretation is reinforced by the presence of a positive linear anomaly that extends from the outside anomaly "T" towards its center, passing anomaly "S" on its northwestern side.

3. Ground Truthing Excavations

Based upon these results, ground-truthing excavations at WLP were scheduled for August 2005 (see also: Keeley *et al.*, 2005, this volume). Mr. Hanlet kindly set aside the three weeks between harvest and replanting for our use. A 25 m x 75 m area was selected for excavation (dashed white box, fig. 4). It encompassed a number of anomalies in the north field, including a segment of the ditch at "A", the presumed house at "C", and the anomaly at "E". Unfortunately, the weather during August was close to drought conditions, making it very difficult to spot small anomalies (like post-holes) that exhibit little contrast from the surrounding loess.

A. As expected, the curvilinear anomaly that begins in the eastern corner of the north field is associated with the enclosure ditch. It is approximately 1.5 m wide at the surface, and is in some places over 2 m in depth. With approximately 50 to 60 cm of erosion to account for, that means the original dimensions must have been something on the order of 2 m wide at the surface and over 2.5 m in depth. Definitive attribution of the ditch to the *LBK* culture was provided by a large portion of an *LBK* coarse ware vessel lying on its side in the middle of the ditch at "A". Its form is similar to two *LBK* cooking vessels recovered during the 1980s excavations. Samples of this vessel were selected for residue analysis. All other material recovered seem to be attributable to the *LBK* as well. Preliminary analysis of lithic and ceramic material from the enclosure dicth suggests that the recovered artefacts were domestic waste comparable to those from the pits.

C. Regrettably, not all of the anomalies at WLP are (clearly) anthropogenic in origin. The possible lines of domestic pits outside the northern edge of the enclosure turned out to be two rows of "chablis" pits, so-called because of their resemblance to the cross-section of a wine glass. They are the pits

created by uprooted trees, into which decayed roots and other materials have fallen. Typically, they are defined by their amorphous edges, a migration of clay and manganese - which may account for the difference between their magnetic signature and that of the background soil - and mottled grey organic fill caused by the decomposition of the exposed roots of the tree.

E. The dipole anomaly "E" was another disappointment. As noted earlier, a series of test trenches was excavated during the 1980s to try to locate the enclosure ditch. Unfortunately, not all of these were reproduced on the published excavation maps. This anomaly turned out to be one of those. After the initial *decapage*, a 2 m wide area of disturbed soil with straight edges was clearly visible (Y-shaped, medium grey area, fig. 5).

The plow zone above the ditch was machined away by backhoe, but in view of the nature of anomalies "C" and "E", plans to strip more soil from these areas were terminated. To examine a different set of "longhouse-like" anomalies, a 5 m x 30 m area (dashed black box, fig. 4) was opened over three rows of parallel lines just to the southwest of the original survey area.

H. The dry conditions and the erosion made it impossible to locate any post-holes in this part of the field. However, the three parallel lines of anomalies on the magnetometer survey did correspond with three parallel lines of pits, several of which conformed to the size and shape of the domestic pits which surround the perimeter of *LBK* longhouses. One pit contained a lens of carbonized seeds that were collected for analysis.

Two others appear to contain only "organic rich fill". Few artifacts were found in them and it has been suggested that they may be latrine pits.

These lines of pits suggest that there may, in fact, be houses in this location (see Keeley *et al.*, 2005, this volume). Lines of domestic pits are often found beyond the actual sides of longhouses. However, the poor soil conditions and time constraints made this impossible to confirm by excavation. The possibility exists that this opening was made too far south, and as such missed much of the longhouses in this area.

S. In order to identify the source of this extremely strong anomaly, a 2 m x 10 m test trench (hatched box, fig. 4) was excavated using the backhoe. Although two very small pieces of metal were found in the plow zone, the trench was continued to a depth of approximately 1 m, where an area of lighter fill material was uncovered. This feature had straight, well-defined edges, and was comprised of white, fine-grained fill, almost the consistency of lime-plaster. However, no artifacts were found below the plow zone, and nothing about the feature could account for the strong anomaly. This feature, along with anomaly "W", is now believed to be the foundation trench for a structure (black dashed box, fig. 5). Anomaly "S" was mapped, photographed, and then reburied. Interestingly, a subsequent magnetometer test showed that the anomaly had moved approximately 1 m, suggesting that something was overlooked in the back-dirt, a surprise remaining to be discovered.

4. Conclusion

In general, the geophysical survey techniques employed at WLP were remarkably successful in locating buried archaeological features, particularly those from *LBK* contexts. As demonstrated by the 2005 ground-truthing excavations, however, the interpretation of near-surface sensing results is not an exact science. Even anomalies that appear to be the correct shape, size and spacing for expected archaeological features (*eg.* anomalies "C" and "E") can be misinterpreted. On a more positive note, *every* anomaly that was localized with the magnetometer turned out to be *something*, even if that something was not anthropogenic in origin. This enabled the team to target excavations - which are far more costly than geophysical surveys - to specific areas of interest within the larger site. Based on the information from the surveys conducted thus far, much remains to be done at *Longchamps*. In the near future, the geophysical surveys will be extended into the southeastern and western portions of the field, right down to the edge of the Upper Geer. Future excavations will be targeted at anomaly "G", the supposed gate area, or anomalies of interest located by the next round of surveys.

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Russell S. Quick
Lawrence H. Keeley
Mark Golitko
Department of Anthropology (M/C027)
College of Liberal Arts and Sciences
University of Illinois at Chicago Circle, 1007
West Harrison Street
Chicago, Illinois 60607-7139 (USA)
LKeeley@uic.edu
RQuick2@uic.edu
Russ@archaeologist.com
MGoliko@yahoo.com

Dominique Bosquet
Ivan Jadin
Institut Royal des Sciences Naturelles de Belgique
Section d'Anthropologie et de Préhistgoire
29, rue Vautier
BE - 1000 Bruxelles
Dominique.Bosquet@naturalsciences.be
Ivan.Jadin@naturalsciences.be