Geoarchaeology and Geophysics at Feltus

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Part B: Geophysics (by Byan S. Haley and Jay K. Johnson) [Slide B-1]

In February 2006, Jay Johnson, John Peukert, and I were invited to Natchez, Mississippi to perform a trial geophysical survey at the Feltus site. This offered us a chance to evaluate geophysical techniques on a Coles Creek site in the Loess Hills, a time period and physiographic zone where we had yet to apply the technique.

We brought our usual suite of instruments to the site [Slide B-2]: magnetic gradiometer, electromagnetic induction, electrical resistivity, and ground penetrating radar. The resistivity produced essentially the same results as conductivity, which will be discussed later, and the GPR did not produce good results due to the fine grained soils at the site. The primary focus was therefore on two magnetic gradient system that we were able to bring to the site: a Geoscan FM36 owned by the University of Mississippi and a dual Bartington 601 brought by John Peukert, then with the Army Corps of Engineers office in Vicksburg, Mississippi.

The magnetic gradiometer has been proven over and over as an effective technique for locating prehistoric features, especially burned houses and midden pits [Slide B-3]. In the right circumstances, burned features are ideal for magnetic survey because heating causes a realignment of electrons to the Earth's magnetic field. This results in remnant or permanent magnetism and some of our geophysical "greatest hits."

Midden pits are visible in magnetic gradiometer data for a different reason: certain organic processes cause a subtle enhancement of the magnetic susceptibility (or the induced magnetism) in these features [Slide B-4]. These are typically less dramatic signatures than is produced by burned features, usually in the 2 to 4 nT range compared to the 10 to 100 nT range for a typical burned Mississippian structure. Nonetheless, the magnetic anomaly produced by these features can be quite clear.

Our initial surveys were limited by the vegetation in the plaza and so the results are small snapshots of what might be found there [Slide B-5]. Three areas were surveyed with magnetic gradient, in addition to one resistivity area and several GPR transects on the top of mounds A and C [Slide B-6]. The results were encouraging and included several anomalies we interpreted as pits [Slide B-7]. These are small, magnetic highs located in survey areas 2 and 3. Although it is not the goal of this paper to compare the two brands of instruments, it is apparent from survey area 2, which was surveyed with both magnetic gradiometers, that the Bartington 601 produced cleaner data than the Geoscan FM36.

The most exciting anomalies were found in the data set from Area 1 on the south side of the plaza [Slide B-8]. These are two magnetic highs that we interpreted as burned structures, primarily based on their size and shape. The strength of the anomaly (at about 6 nT) was a little less than might be expected of a burned structure, but since magnetism drops off with depth, this could have been a buried structure.

However, our interpretation turned out to be incorrect [Slide B-9]. Excavation revealed a large Coles Creek midden pit. This was a valuable lesson for us. Simply using shape and size can lead to incorrect interpretations and we began to think of how we might improve our accuracy in identfying this type of feature. One approach is data fusion, where the results of data derived from multiple instruments are combined or compared to yield more information than can be derived from any single instrument.

Another instrument used at Feltus was a Geonics EM38B electromagnetic induction (or EMI) meter, an instrument well known for its ability to collect conductivity data, but also able to collect magnetic susceptibility data [Slide B-10]. The model used at Feltus simultaneously records both types of data. Although this instrument is relatively commonplace in archaeological geophysics, the ability of the instrument to collect magnetic susceptibility data has often been overlooked.

The utility of magnetic susceptibility was apparent on a number of contact period Chickasaw sites that we have surveyed [Slide B-11]. The resulting anomaly is often even more distinct than it is in gradiometer derived imagery.

One approach to data fusion begins with the assumption that burned and midden features should exhibit different ratios of remnant and induced magnetism [Slide B-12]. Magnetic gradiometers provide a way to measure remnant and induced magnetism, although it is impossible to differentiate them. EMI provides a way to measure magnetic susceptibility only. To test our assumption, ratio plots were created from some previous data sets. The results suggest that the two types of features have distinct ratio plot patterns.

A visual inspection of the pit in the data reveals that an anomaly is visible in the magnetic susceptibility, although it is not as well defined as in the magnetic gradient data [Slide B-13].

When the data for the anomaly is plotted on a scattergram, the result is more similar to the midden than the burned house, suggesting it is a pit [Slide B-14]. Had we performed this operation ahead of time, our interpretation would have been correct.

There is an anomaly to the southeast of the previous feature [Slide B-15] . It is not visible at all in the magnetic susceptibility data at all, suggesting that the anomaly is the result of burning. However, the excavation showed this to be another midden pit [Slide B-16]. There were some differences between this feature and the previous one – it was actually two superimposed pits (a shallow Coles Creek midden overlying a Baytown feature). At this point, we do not fully understand why the method is not effective on this anomaly, although it is not accounting for differences in prospection depth between the two instruments.

We eventually expanded the survey to include most of the plaza area [Slide B-17]. The magnetic gradient results show some additional anomalies of interest, although they have not been tested yet [Slide B-18]. Just to the west of the first midden pit, there is another large feature that is probably also midden. There are also a number of smaller magnetic highs throughout the plaza that might also be pits. There is a large square anomaly in the southeastern corner of the survey. There is a large arc-shaped anomaly visible in the southeastern part of the survey area.

We would like to perform our magnetic ratioing on these features to help us interpret them. Unfortunately, we have had some problems getting a clean version of magnetic susceptibility data for plaza at the site. Compared to conductivity data, magnetic susceptibility is much more subject to drift. While processing techniques can sometimes be used to correct this, the drift can be so extreme that the data cannot be salvaged. More frequent zeroing of the instrument in the field and collecting larger sized grids can help alleviate this problem. At this point, there are relatively few examples of EMI magnetic susceptibility data collected for archaeological applications and, as a result, there is not much guidance available. As more work is done, we should have a better protocol for collecting consistent, high-quality magnetic susceptibility data.

Although we have focused on the magnetic techniques, the conductivity data was also productive [Slide B-19]. The broad arc visible in the magnetic gradient data is even clearer in this data set. There is a no topographic change related to this feature and, according to John O'Hear, it is not related to vehicles driving across the area. Another large-scale anomaly is a conductivity low near the center of the plaza. Although it has not been investigated, O'Hear suggests that this could be related to the natural topography of the plaza and that it was filled in around the edges to make it level.

Another task that we were hoping to address with geophysics was determining the location of Mound D [Slide B-20]. However, the most recent projection of its location from the historic maps indicates that its center was located in the woods, just south of our survey area.

Despite some successes, we did miss at least one feature that has been excavated [Slide B-21]. This is a pit, or possibly a post mold, that contained a bear skull and long bone. This feature was relatively small, which might explain the failure of the geophysics to find it since a profile separation of 1 meter was used.

Although we've had a good start with the geophysical survey at Feltus, there are several things that could we could still add or improve. We need to expand the gradiometer survey outside the 2007 survey area to include mound D and more of the plaza, perhaps with a higher sampling rate and with a Bartington 601 instrument. It should be possible to map smaller post features that have been encountered there. Most importantly, we need to collect a complete magnetic susceptibility data set so that we can use data fusion analysis on the magnetic and magnetic susceptibility data to enhance our interpretation of the anomalies in these data sets.

Geophysics at Feltus

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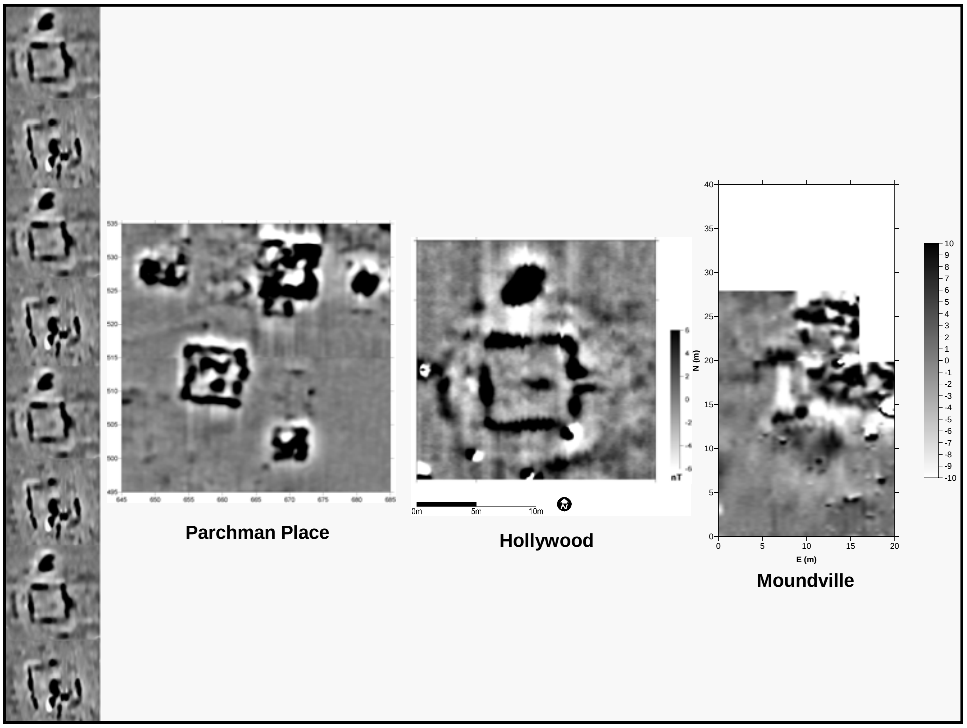
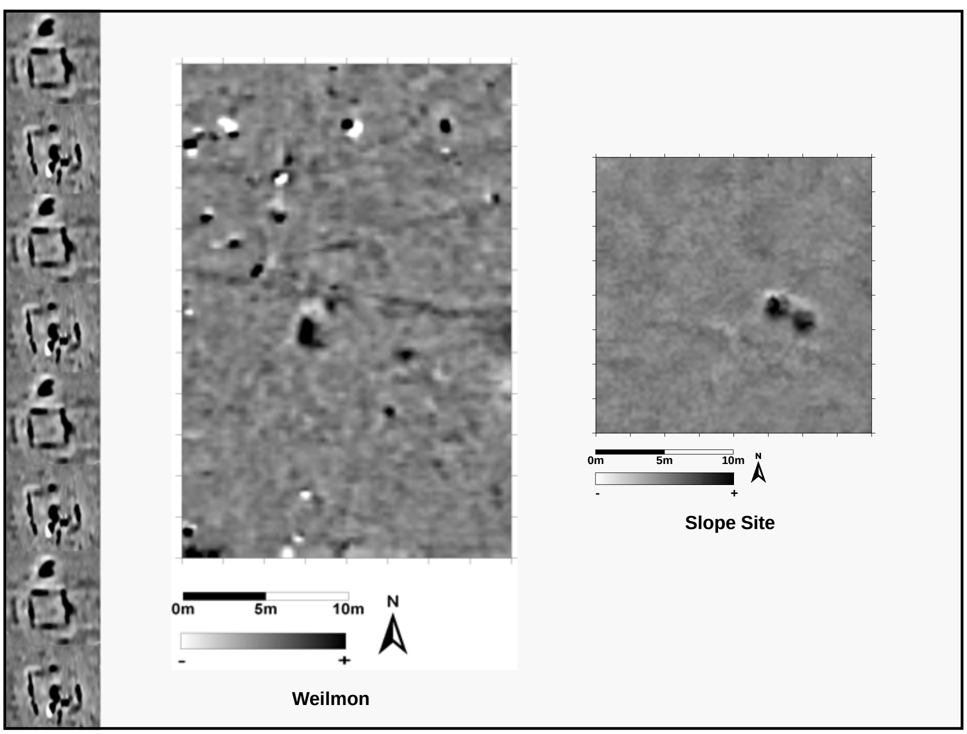
[Slide B-1]

[Slide B-2]



[Slide B-3]



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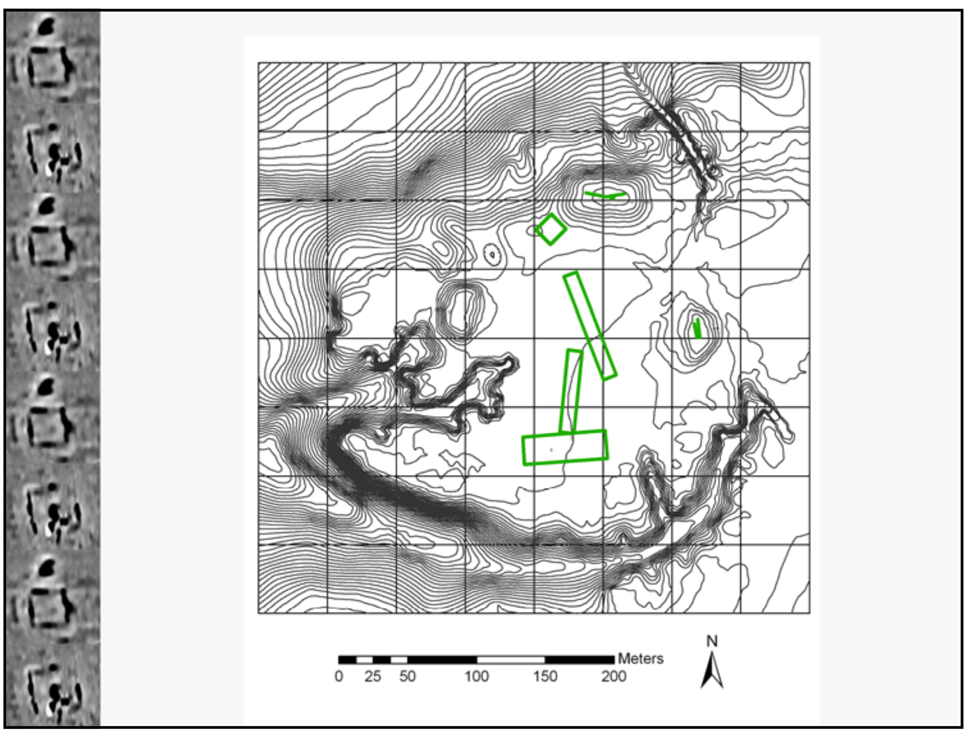
[Slide B-5]



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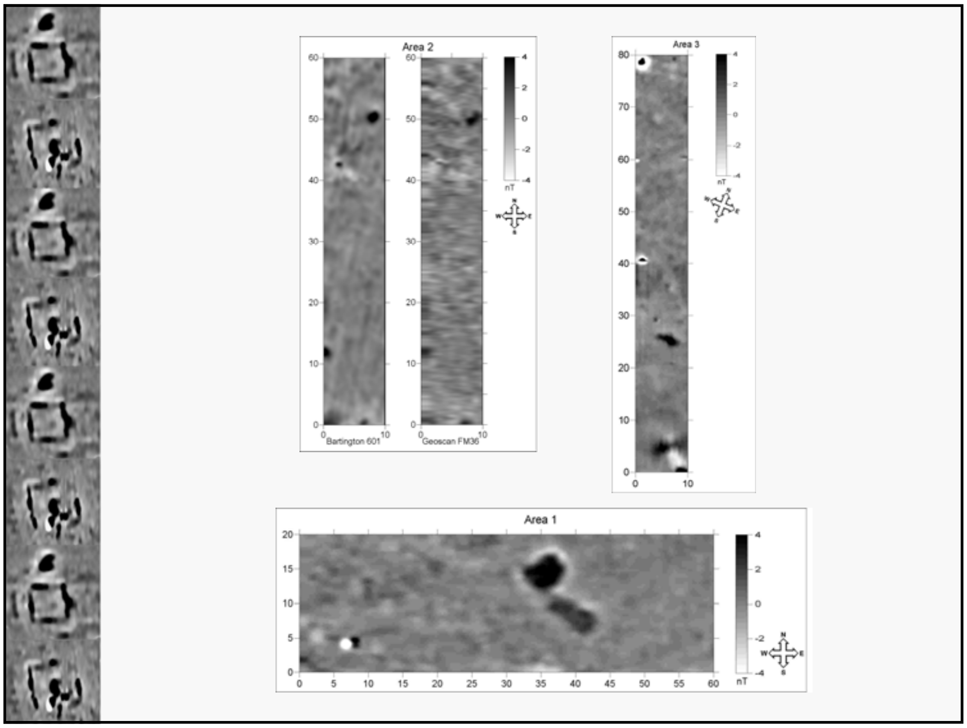

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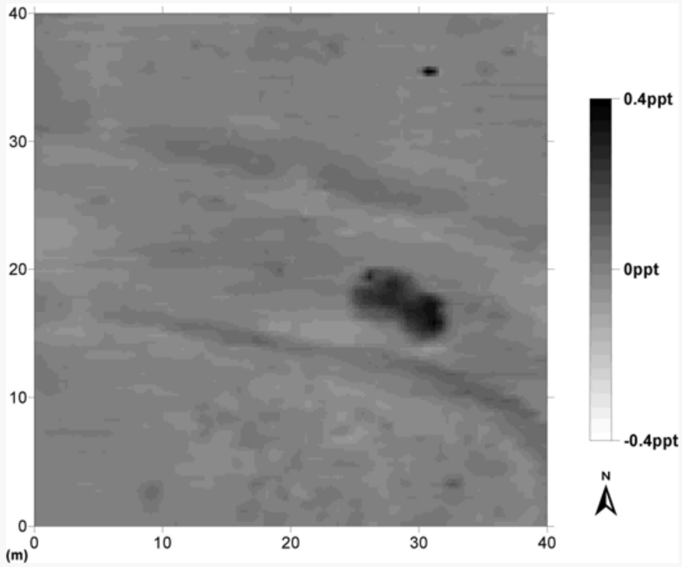
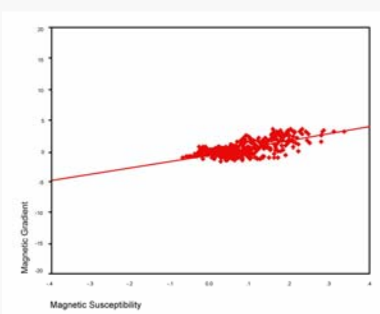
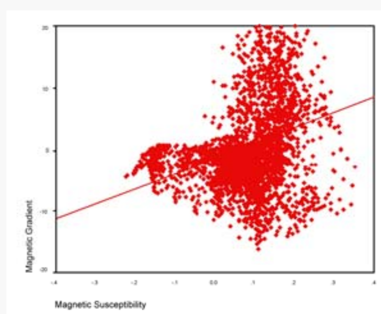


[Slide B-11]

Magnetic Ratioing

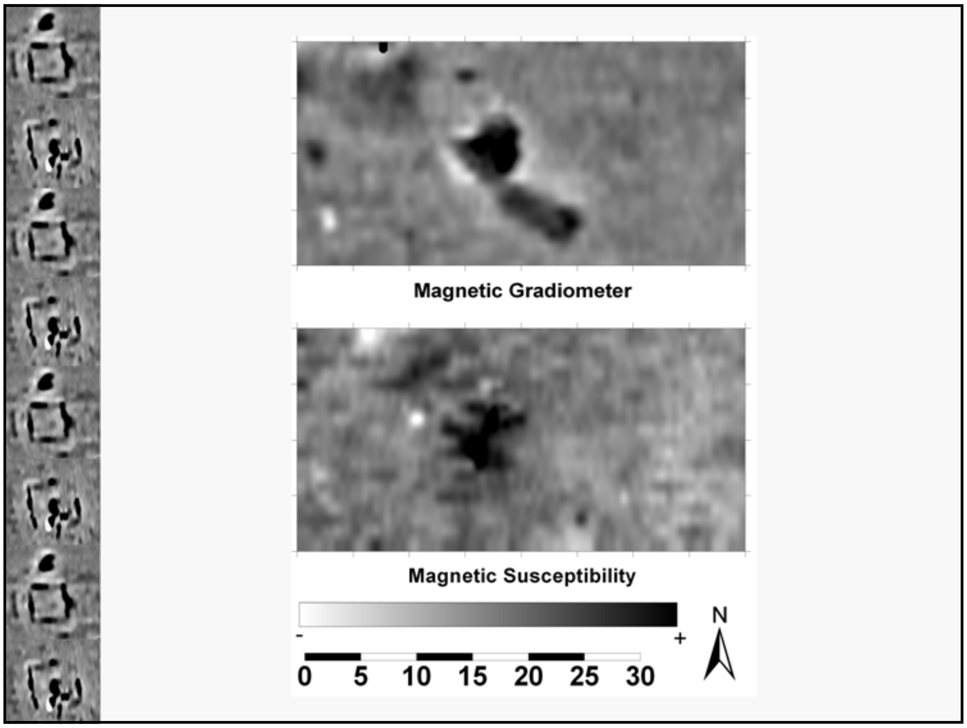


Midden Pit

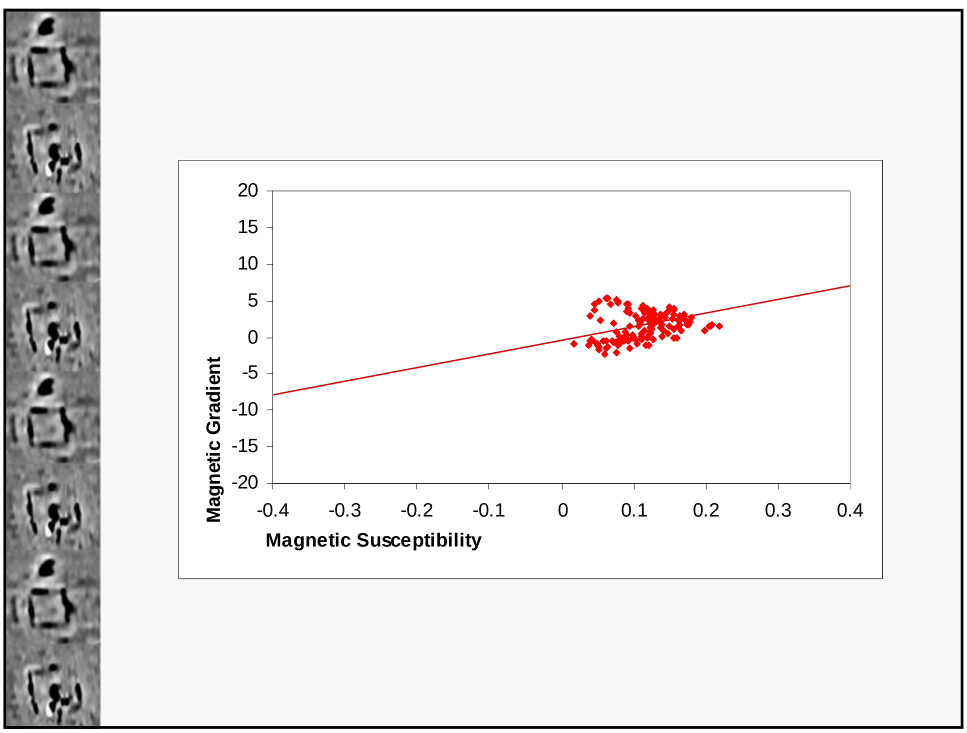


Burned House

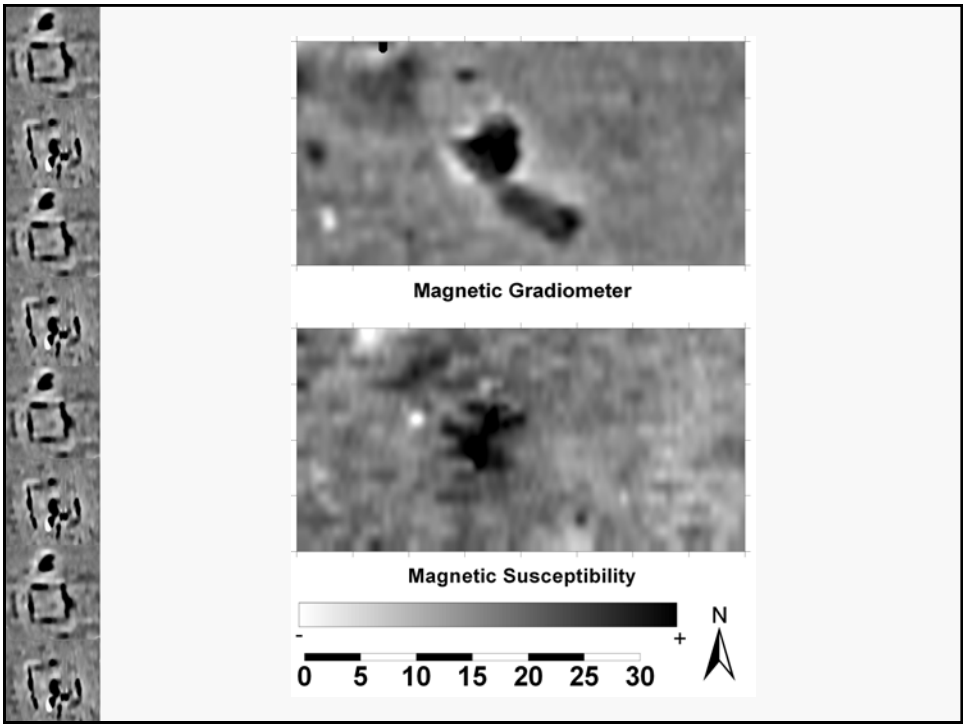
[Slide B-12]



[Slide B-13]

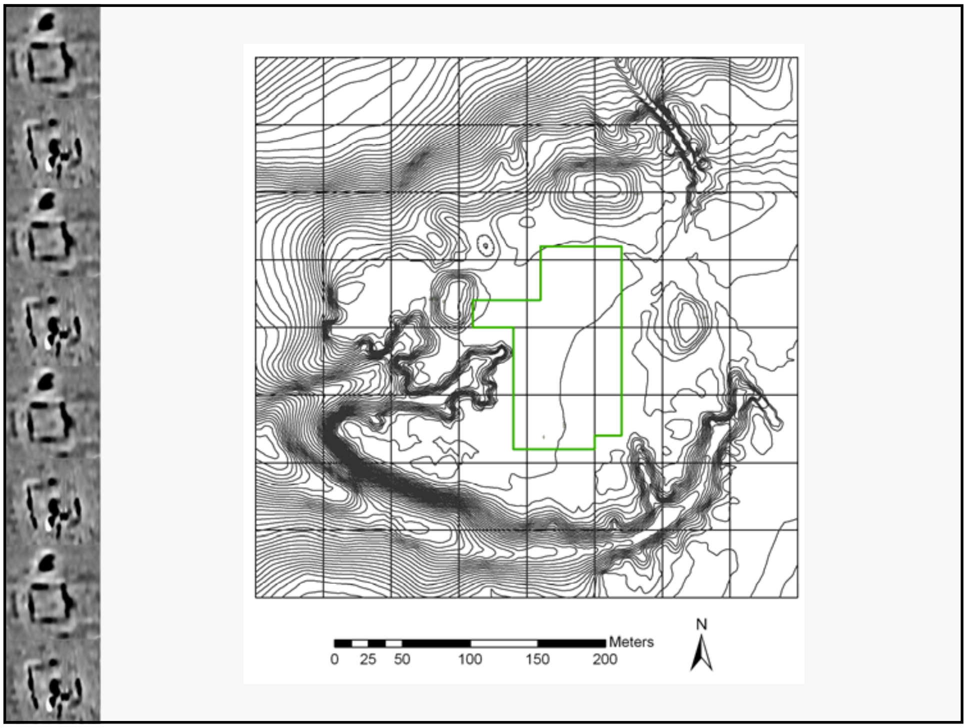


[Slide B-14]

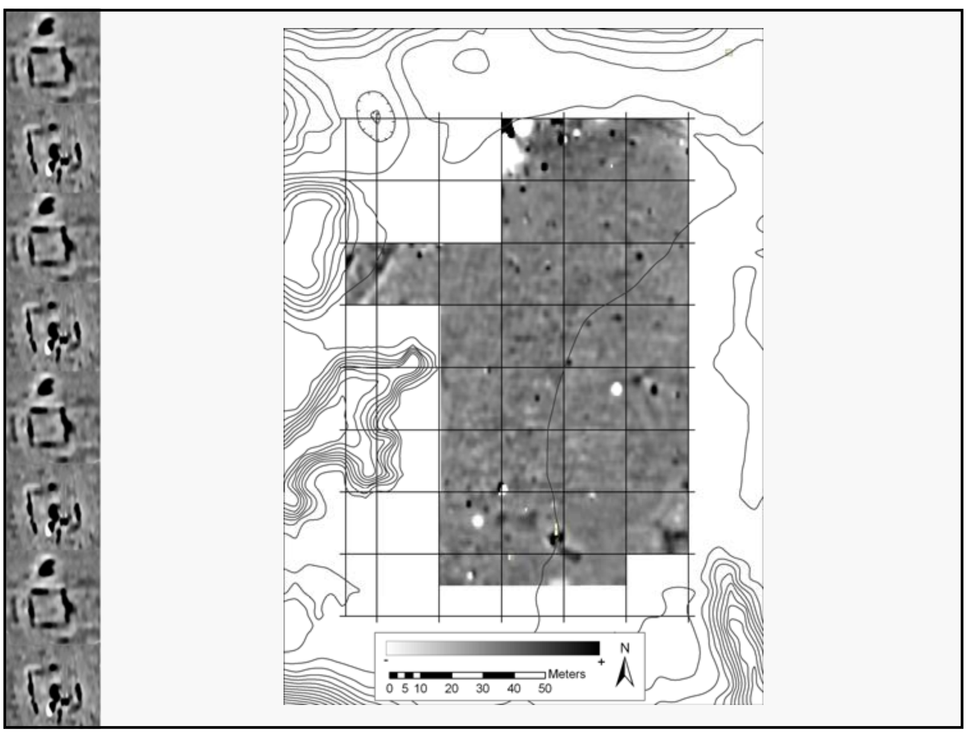


[Slide B-15]

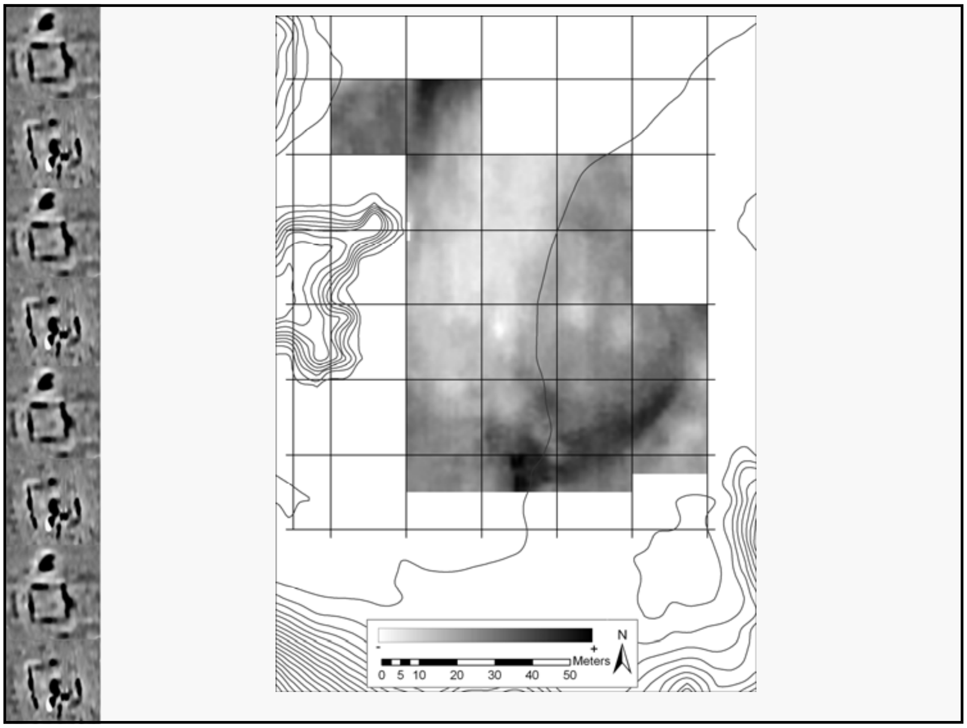
[Slide B-16]



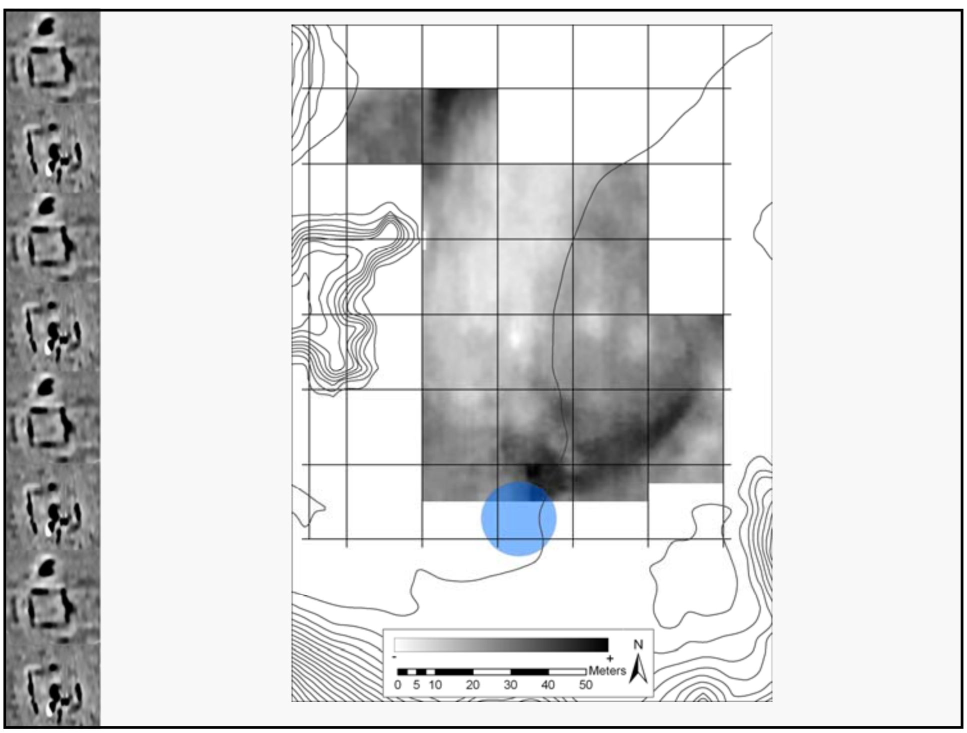
[Slide B-17]



[Slide B-18]



[Slide B-19]



[Slide B-20]

[Slide B-21]

Thanks!

[Slide B-22]