

**Summary Report on Archaeological Geophysical Surveys
for the Wall Project at Site MA3
July 28 - August 15, 2023**



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[Full Report is forthcoming and raw data from surveys are on file at the University of Pittsburgh, Department of Anthropology, Pittsburgh, PA, USA]

1. RESEARCH OBJECTIVES

This initial report provides a brief summary of geophysical survey activities conducted in support of the Wall Project at MA3 in southeastern Mongolia. Survey work was carried out from July 28th – August 16th 2023. A more detailed report of the survey results will be forthcoming.

Geophysical survey was conducted by Emily Eklund and Aspen Greaves (University of Pittsburgh), Dr. William Honeychurch (Yale University), with additional assistance from “Kaho” Carola Franzen (University of Hawaii) from July 28th—August 15th on the Wall Project Fortification Site MA3 and associated long wall section. This report constitutes preliminary results. The objectives of the survey were as follows:

- A. Support geophysical survey conducted in 2022 by Drs. Bryan Hanks and Marx Bermann (University of Pittsburgh) in conjunction with the report authors on Wall Project Site Complex #23. Following those results, we implemented three methods:
 - a. Fluxgate Gradiometry - Bartington Grad 601 single probe fluxgate gradiometer
 - i. The 2022 survey used a Bartington Grad 601-2 double probe fluxgate gradiometer. Due to external processes regarding probe calibration, a single probe instrument was employed to conduct a more detailed gradiometry survey during the 2023 field season.
 - b. Soil Magnetic Susceptibility – Bartington MS2 meter with MS2D surface scanning probe and MS2K surface sensor
 - c. Ground Penetrating Radar (GPR)—Noggin GPR 250 Smarttow with handle
 - d. GPS points were taken on grid corner points and magnetic susceptibility test points with a Trimble Geo 7 series handheld. Accuracy was typically between 3-4 meters; however post-processing will be occurring to create an even smaller error range. Grid corner points were also recorded with a RTK system by Or Fenigstein (Hebrew University of Jerusalem) for greater accuracy.
- B. Geophysical surveys were structured to provide real time data and guide auguring and test excavations by the Wall Project team.
- C. Areas targeted includes:
 - a. Potential “gap” in the Long Wall between MA3 and MA2. Upon pedestrian survey, this gap could not be located, and so no survey was conducted at this point.
 - b. Across the Long Wall, due north of the square MA3 feature and east of the excavation unit across the Long Wall. This survey involved fluxgate gradiometry magnetic susceptibility, both surface scanning and surface sensor, and GPR along and on either side of the wall.
 - c. Within and surrounding the enclosed area of the MA3 square fortification feature. Fluxgate gradiometry was employed across the entire approximate 40x40 meter fortification, extending 20 meters beyond the feature on all sides.

Magnetic susceptibility, both surface scanning and surface sensor, was also employed utilizing the same 20x20m grid organization as the fluxgate gradiometry survey. GPR was employed on the southern portion of the feature, over the gate to the fortification.

- d. Magnetic susceptibility transverse in the area between MA3 and the Long Wall.

2. METHODS

Multiple geophysical methods were employed during the 2023 season, as it has been shown that different methods will respond to different dimensions of surface and subsurface soil properties and can therefore assist in the identification and interpretation of geophysical anomalies (Kvamme et al. 2006). In the sections below, a brief summary of the methods is provided.

2.1 Fluxgate Gradiometry

Magnetometry is one of the most productive and commonly used methods for geophysical prospection in archaeology (Aspinall et al. 2008; Gaffney & Gater 2002). The Bartington Grad 601, which is a fluxgate gradiometer, can be utilized to detect minute variations in the earth's magnetic field due to archaeological and geophysical subsurface features (parameters set at +/- 0.01 to 100 nT). This method is highly useful for identifying infilled subsurface pits, ditches or trenches, and fired or burnt features such as hearths, kilns and ovens. It offers a rapid method for quickly assessing archaeological sites for magnetic responses. Parallel transects were walked with this instrument using rope lines for path alignment. Measurements were taken with transects spaced every 0.5m, with 160 measurements collected along each 20 meter transect (data point every 12.5 cm). Data were downloaded to a laptop computer and processed with Terrasurveyor, a dedicated processing software for geophysical instruments.

2.2 Soil Magnetic Susceptibility Method (SMSM)

We also employed a SMSM survey of surface and near-surface through the use of transects either placed on archaeological features or that bisected them. The instrument used to collect these data was a Bartington MS2 meter combined with a MS2D Surface Scanning Probe and MS2K Surface Sensor.

Different sampling strategies were utilized based upon which sensor was being employed. For sample collection with the MS2D Surface Scanning probe, the sensor was placed flat on the ground surface, ensuring the instrument was flush for optimal measurement readings. For the MS2K Surface sensor, a small shovel probe (STP) (approximately 20 cm in diameter) was utilized at each sampling location. Soils between 10-15cm below the surface were targeted, as this depth correlated with cultural activity as viewed in the excavation profiles. Three readings were taken at each location. Data were downloaded to a laptop computer and a mean value was calculated for each sampled location. Data were then plotted using Golden Software Surfer 13 software. Magnetic susceptibility of the near surface soils was completed as an exploratory

method to see whether enhanced areas could be identified spatially across the horizontal plane of the site through analysis of near surface soils only. It was expected that these data could represent enhanced soils associated with subsurface archaeological features and activity zones due to vertical movement of soils through forms of bioturbation (Dalan 2006). Association of surface magnetic susceptibility with subsurface features would also provide a comparative framework for better understanding how artifacts collected through the pedestrian survey may relate spatially to subsurface archaeological features.

2.3 Ground Penetrating Radar (GPR)

GPR has been used successfully in archaeological/forensic field research since the early 1970s and has been used on a wide variety of prehistoric and historic sites (Conyers & Goodman 1997; Conyers 2013). GPR is an active method that is typically employed using parallel survey traverses within a grid either starting all traverses from the same grid edge or using a zig-zag pattern. GPR antennas transmit electromagnetic pulses into the ground as the instrument is pushed along the traverse and then measures the time from when these pulses are emitted until they are reflected back to the unit receivers. Individual wave reflections (waveforms) of subsurface objects and features are plotted and digitized into two-dimensional reflection traces that produce profile/line views of the transects and depths and amplitude of the reflections. These data can be further processed to produce amplitude depth slices that yield plan views of the areas surveyed and anomalies associated with specific depths from the ground surface level. GPR data processed in these two ways have the potential to provide both spatial location and characterization of subsurface anomalies. Data were downloaded to a laptop computer and processed with Sensors and Software's Ekko Project, a dedicated processing software for ground penetrating radar. The Noggin GPR 250 Smartow employed in 2023 belongs to Yale University (Dr. William Honeychurch), unlike the other instruments in this report, which are owned by the University of Pittsburgh.

3. RESULTS

Currently, data collected from the GPR and Magnetic Susceptibility transects and auguring samples is being further analyzed and more will be available in the full report. Initial observation of the data during collection with these methods in the field indicated that substantial variability in geophysical anomalies were identifiable and plotting of this data, in conjunction with the results of drone survey, auguring, test trenches, and surface collection has a high probability of success. Based on this preliminary assessment, it is reasonable to state in this initial report that all geophysical methods employed during the 2023 season are of value in future studies at these site types. In the full report, it will be possible to provide a more detailed assessment of each individual method for future consideration.

In this report, we have provided grayscale plots of the fluxgate gradiometer data collected from the MA3 square feature (Figs 6 & 8) and for the linear wall feature north of the square fortification running parallel with the modern two-track dirt road (Figs 7 & 12). Numerous positive, negative, and dipolar (positive-negative) anomalies were identifiable at the MA3 square feature, including the recovered human burial in the inner northeastern corner of the feature. Additional likely infilled pits and ditch/trench features were also identifiable both within the square feature and surrounding it (Figs 6 & 8). Furthermore, the GPR survey conducted at the MA3 square feature (Figs 9, 10, & 11) suggested that there were positive anomalies related to the proposed southern gate feature along the southern wall of the square feature. Finally, the magnetic susceptibility survey (Fig. 5) conducted at the square feature suggests that MS 32 and MS 49 both suggest areas of high magnetic susceptibility that could be related to high areas of human activity in the center of the square feature and along the northern wall.

The fluxgate gradiometry survey conducted at the linear wall feature (Figs 7 & 12) did not produce easily identifiable anomalies like those found in the MA square feature gradiometry survey. A GPR survey was conducted at the linear wall feature, running perpendicular to the linear feature (Fig. 13) for comparison with the fluxgate gradiometry data. The GPR data does suggest that there might have been areas of human activity on either side of the linear wall feature in both Grids 8 and 7. These anomalies would require further ground truthing (shovel test probes, augering, or test unit excavations). The magnetic susceptibility survey suggests MS 98, which is located within the gap in the linear feature where there is evidence for an older, no longer frequently used two-track dirt road, may show evidence for higher human activity. Furthermore, it was noted when we conducting the survey that the shovel test probe at MS 98 had very dark brown, loamy soil suggesting it is highly organic compared to the sandier soil found around the wall feature and at the MA3 square feature.

Finally, a small magnetic susceptibility survey was conducted between the linear wall feature and the MA3 square fortification to test to see if there were any areas of high human activity occurring between the two earthen work features. However, the preliminary analysis of this data does not suggest that any evidence for this.

4. CONCLUSION

This initial report has provided a general overview of the surveys conducted, instruments used, and prominent anomalies detected through fluxgate gradiometry, magnetic susceptibility, and GPR surveys. More detailed results from these methods will provide a rich set of data from the multi-instrument approach to be discussed more fully.

5. ACKNOWLEDGEMENTS

The team from the University of Pittsburgh were grateful for the opportunity to continue to assist with geophysical survey as part of the Wall Project research project. We appreciate the valuable assistance we received from other team members, particularly those who participated in geophysical survey, took RTK points, and provided drone and other images. We look forward to continuing collaboration in the presentation of full results of this work.

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FIGURES



Figure 1. Upper left – image showing survey conducted with the single probe fluxgate gradiometer; upper right – Image showing layout of grid traverse lines for fluxgate gradiometry; lower left – image showing GPR survey; lower right - image showing GPR survey of the MA3 gate (photo credits - Aspen Greaves & Emily Eklund)

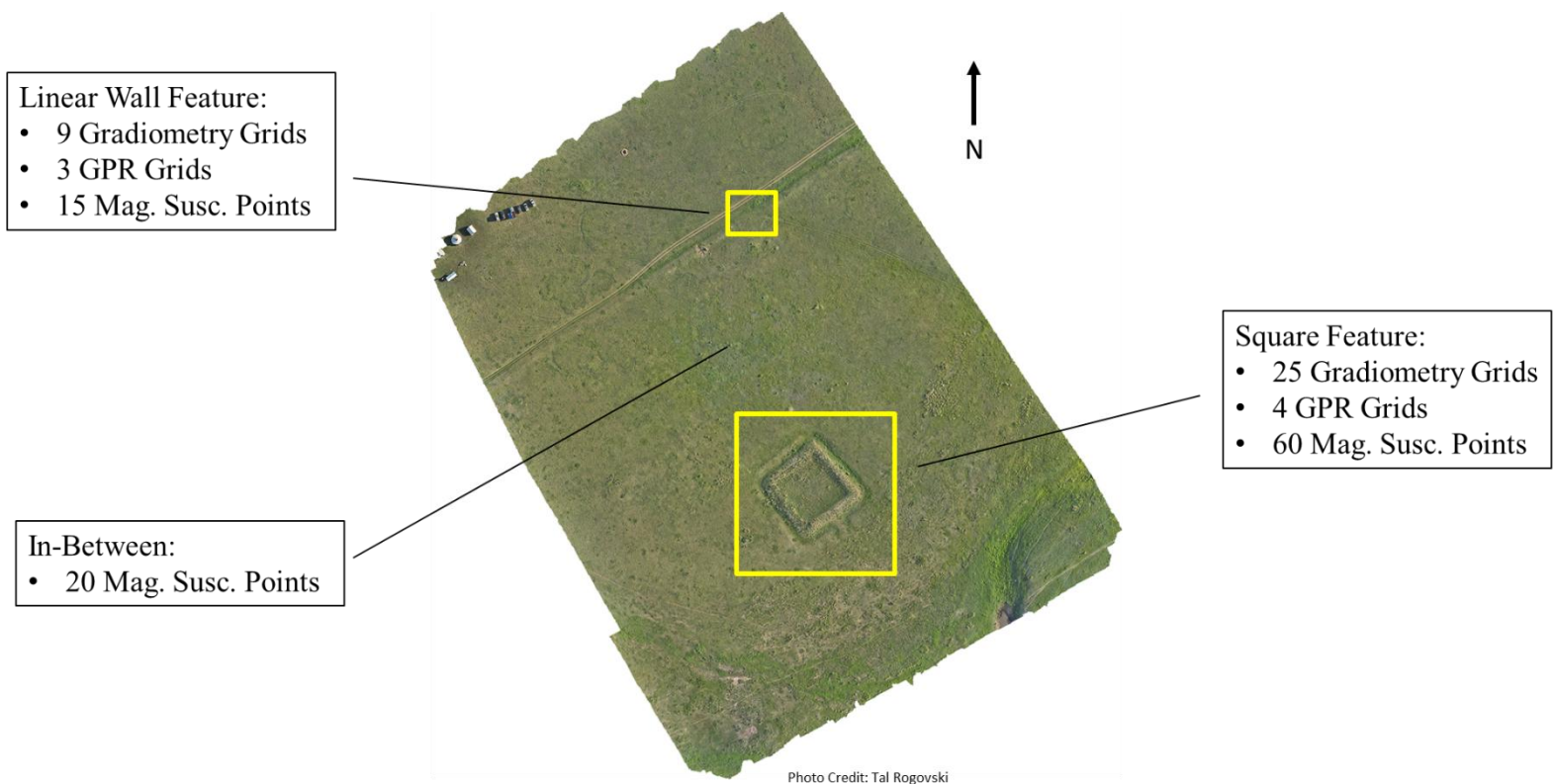


Figure 2. Drone image which demonstrates where different geophysical method surveys were conducting, including: (a) Linear wall feature where 9 gradiometry 20 x 20 grids and 3 GPR 20 x 20 grids were surveyed, along with 15 magnetic susceptibility points; (b) In-between the linear wall feature and the square feature where 20 magnetic survey points were collected; (c) the square feature where 25 gradiometry 20 x 20 grids and 4 GPR grids were surveyed, along with 60 magnetic susceptibility points.

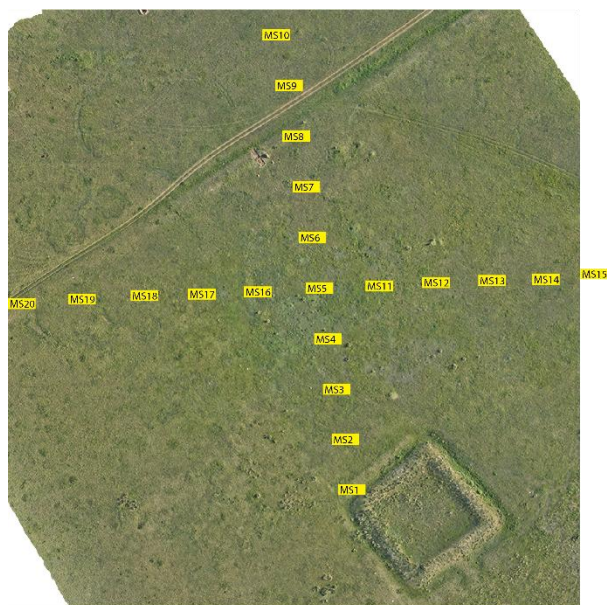


Figure 3. Image showing the location of the Magnetic Susceptibility survey between the long wall feature and the square feature. (Drone Photo: Tal Rogovski; Image credit: Aspen Greaves)



Figure 4. Image showing the location of the Magnetic Susceptibility survey along the long wall feature (running parallel to the modern two-track dirt road). (Drone Photo: Tal Rogovski; Image credit: Aspen Greaves)

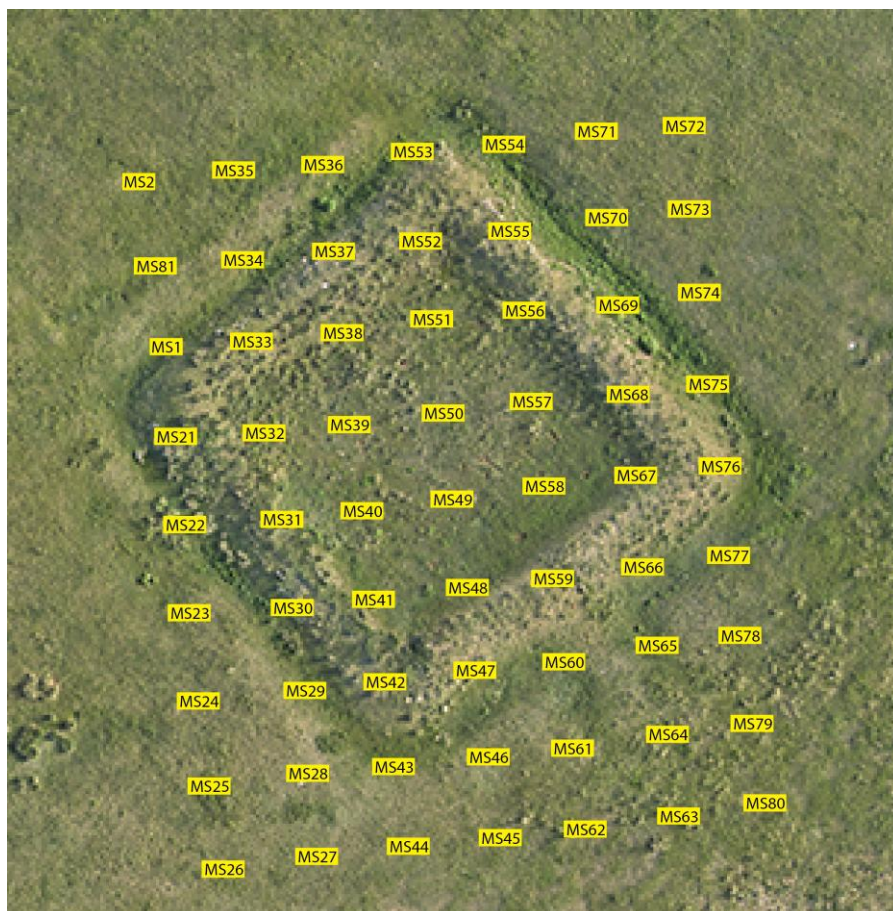


Figure 5. Image showing the location of the Magnetic Susceptibility survey conducted in and around the square feature. Along with the Magnetic Susceptibility surveys shown in Fig. 3 and 4, measurements are approximately every 20 meters. The location of the measurements in both Fig. 4 and 5 occurred within the 20 by 20 meter grids used for the fluxgate gradiometry survey. (Drone Photo: Tal Rogovski; Image credit: Aspen Greaves)

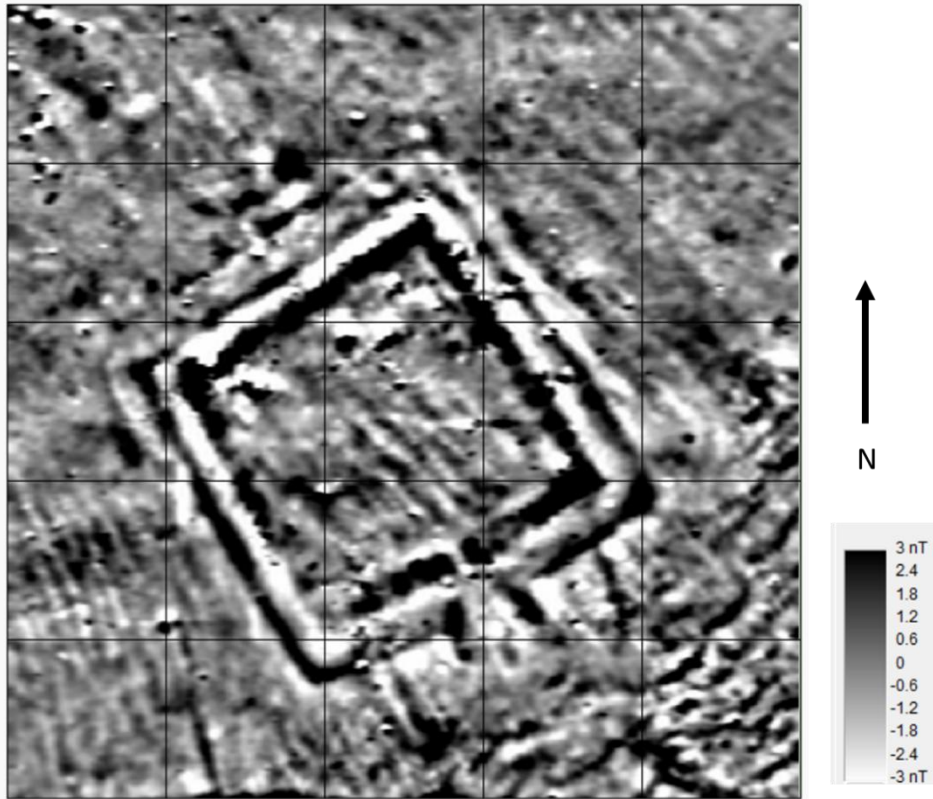


Figure 6. Grayscale image of the 25 (20 x 20 m) grids that were used to survey the square feature at MA3 with the Bartington Grad-601 single probe fluxgate gradiometer at half meter spacing. The fluxgate gradiometry survey was processed with Terrasurveyor software.

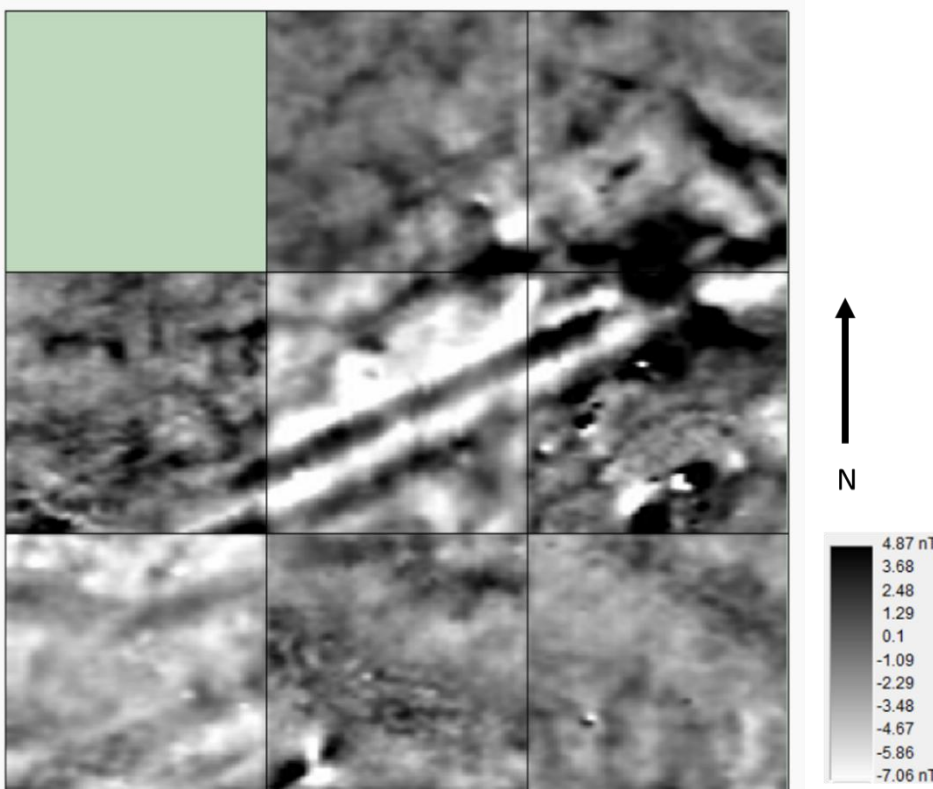


Figure 7. Grayscale image of the 8 (20 x 20 m) grids that were used to survey the linear wall feature at MA3 with the Bartington Grad-601 single probe fluxgate gradiometer at half meter spacing. The fluxgate gradiometry survey was processed with Terrasurveyor software.

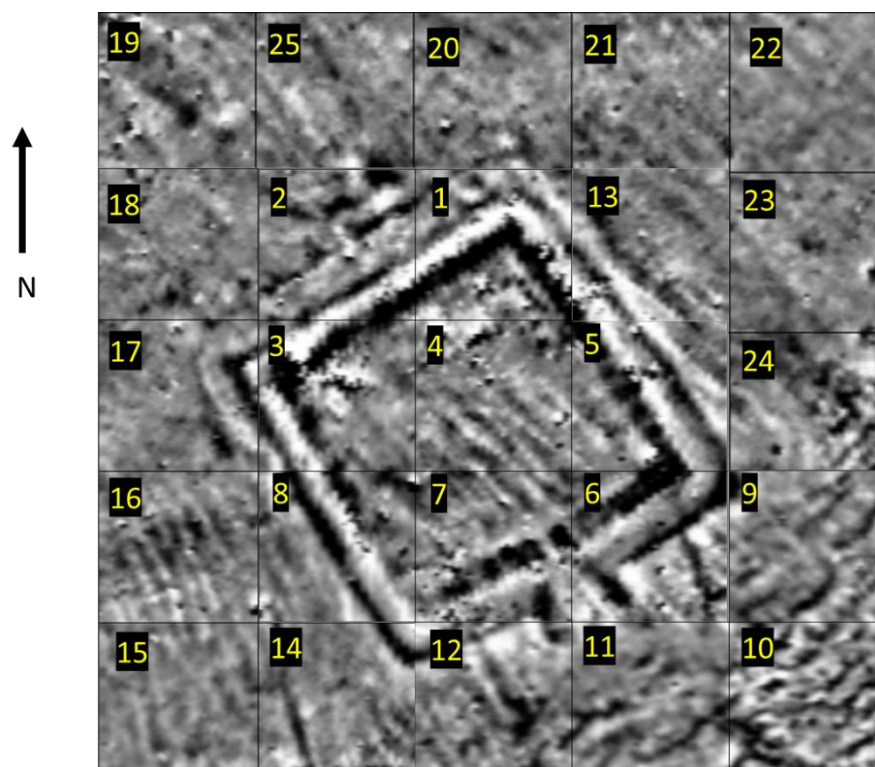


Figure 8. Grayscale image of the fluxgate gradiometry survey (20 x 20 meter grids) conducted on the square feature of MA3 with each grid numbered.

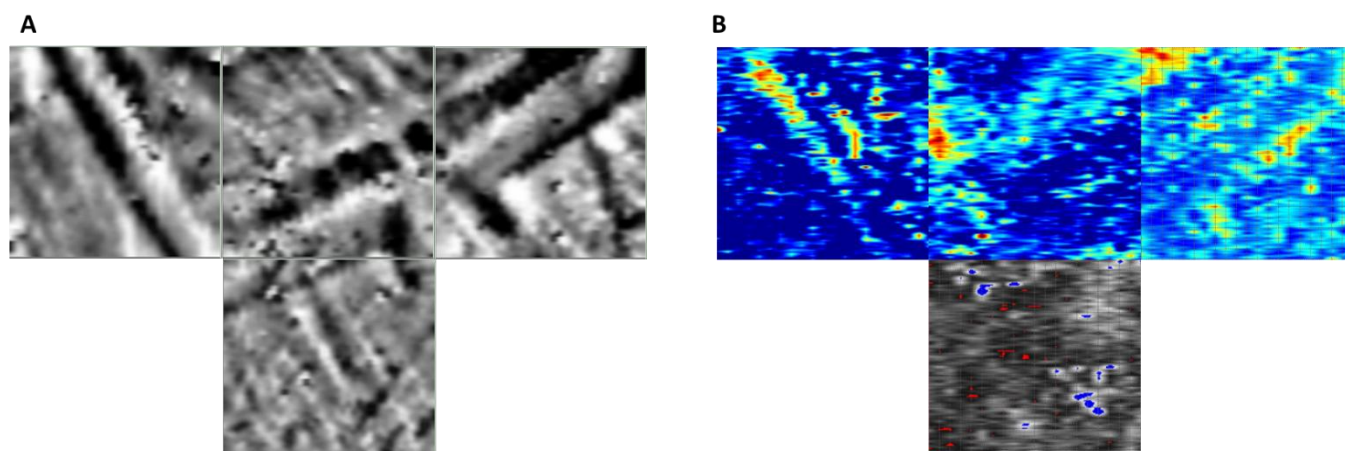
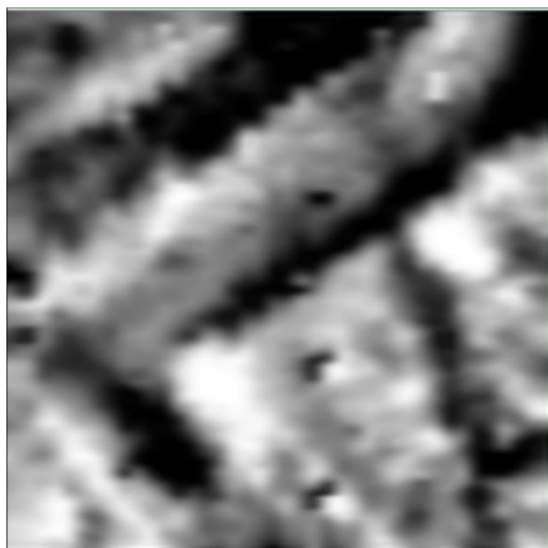


Figure 9. Image comparing (A) the fluxgate gradiometry data from Grids 6, 7, 8, and 12 which were surveyed in the square feature at MA3, along the southeastern section of the feature which included the southern gate along the compacted earthen work walls; and (B) the GPR grids 0, 1, 2, and 3 which correspond with the gradiometry grids. The GPR amplitude slices were processed with Sensor and Software's Ekko Project.

Gradiometry Grid 6



GPR Grid 0

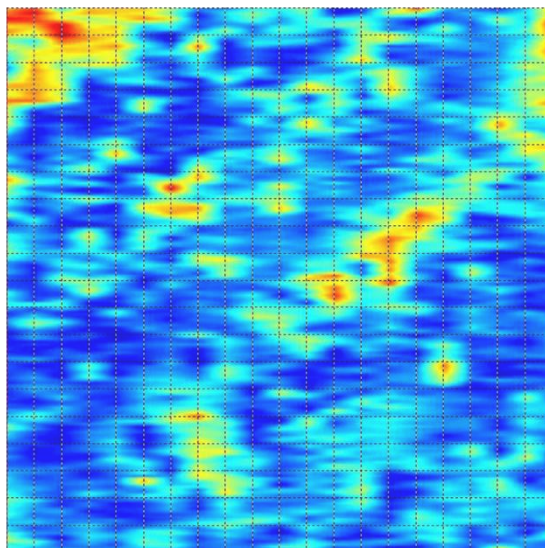
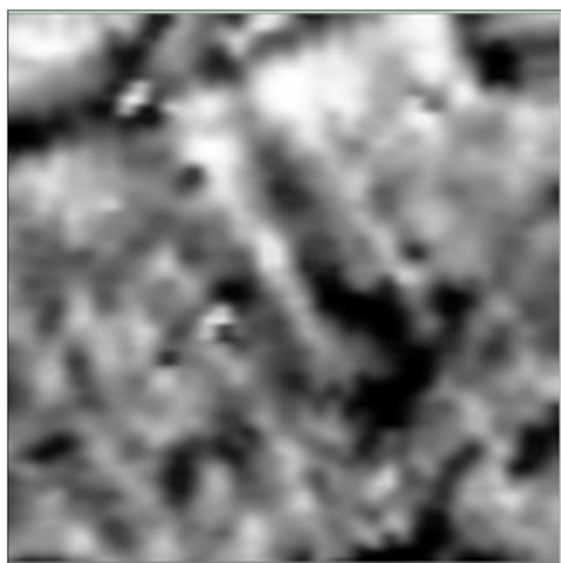


Figure 10. Image compares fluxgate gradiometry Grid 6 and GPR grid 0. The GPR amplitude slice was processed with Sensor and Software's Ekko Project, 20-40 cm slice, Frequency: 250 MHz.

Gradiometry Grid 12



GPR Grid 1

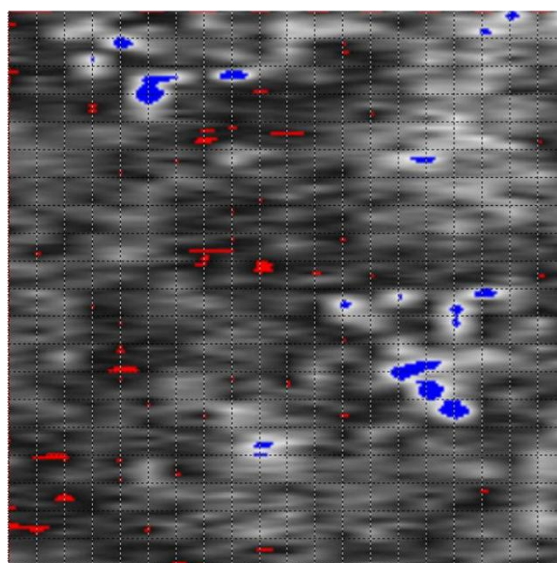


Figure 11. Image compares fluxgate gradiometry Grid 12 and GPR grid 1. The GPR amplitude slice was processed with Sensor and Software's Ekko Project, 20-30 cm slice, Frequency: 250 MHz.

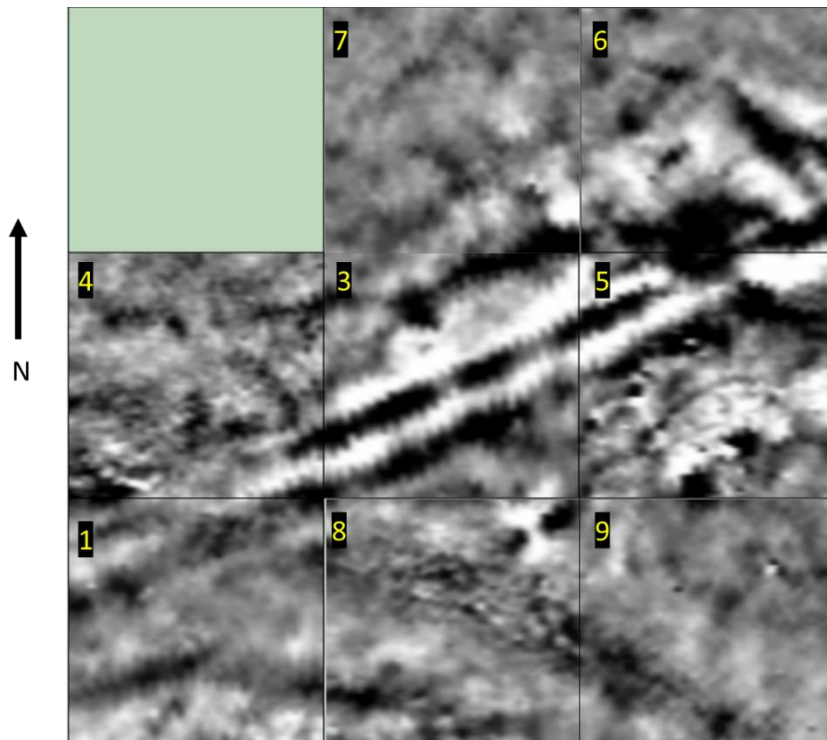


Figure 12. Grayscale image of the fluxgate gradiometry survey (20 x 20 meter grids) conducted on the linear wall feature of MA3 with each grid numbered.

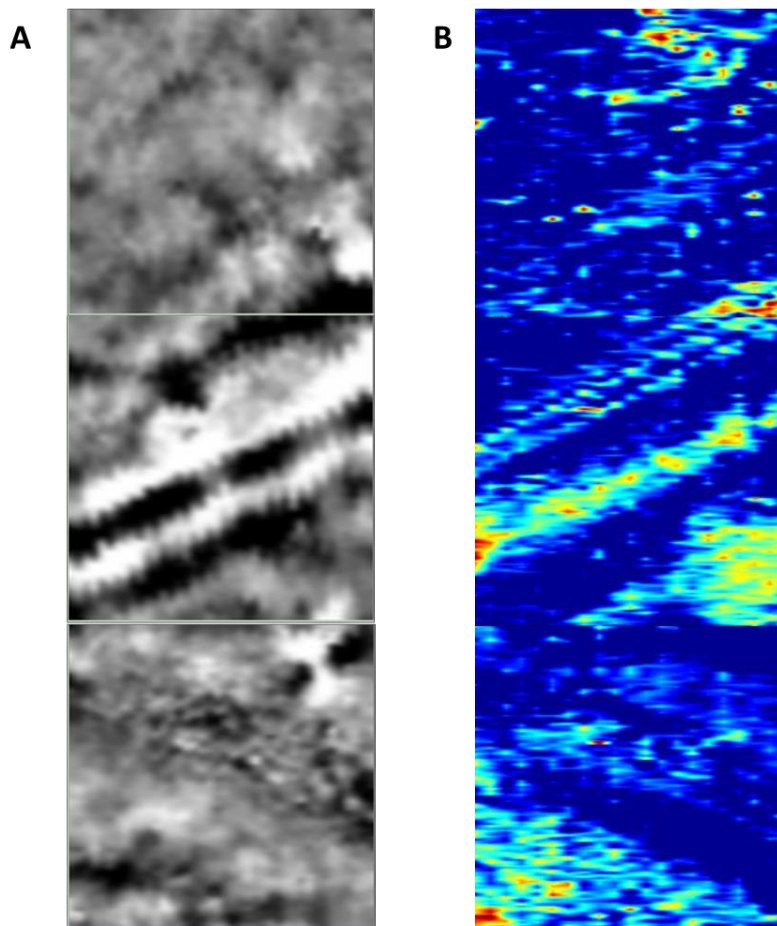


Figure 13. Image comparing (A) the fluxgate gradiometry data from Grids 8, 3, and 7 which were surveyed at the Linear Wall Feature north of MA3; and (B) the GPR grids 4, 5, and 6 which correspond with the gradiometry grids. The GPR amplitude slices were processed with Sensor and Software's Ekko Project.