Large Area Magnetic Gradient Survey
In Lee County, Iowa
By Heartland Research Group

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By
Richard D. Moats, Archaeologist HRG
Calvin J. Hamilton, GIS, Computer, & Image Specialist

Prepared for:
Heartland Research Group
John Lefgrin, Ph. D., CEO, HRG

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Summary:

This report is the results of large-area magnetic gradient surveys from multiple areas scanned in Lee County Iowa. Over 225 acres were scanned from November 8, 2020 to November 20, 2020. The survey was conducted by the Heartland Research Group using a Sensys MV X3,16-foot-wide, 16 sensor, fluxgate gradiometer. This is a revolutionary array which was designed to scan large areas at a rate of approximately 8 miles per hour depending on terrain surface conditions and provide high resolution plot maps of the area in terms of magnetic variations.

Thousands of magnetic anomalies of archaeological interest were detected and georeferenced. Among the anomalies are fire pits, storage pits, cultural activity clusters, and possible round house structures believed to be from the middle to late Woodland cultures. One feature appears to be a destroyed mound or circular earthwork. C-14 carbon recovery and testing will be conducted to determine the age of the cultural activities. Modern activities such as farming and areas with ferrous metal will be eliminated to focus only on pre-Columbian cultures.

The data only reveals locations of magnetic anomalies and provides a range of probabilities for their cause by measuring the values of each anomaly in nanotesla, (nT). Magnetometry cannot provide definitive causation for every signature. Ground-truthing will be performed with C14 samples, minimal excavation, as well as historic and multi-spectral imagery.

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Introduction:

This report details the results of large-area magnetic survey done in 15 different fields in Lee County, Iowa. It is prepared for Mr. John Lefgrin, Ph. D., CEO of Heartland Research Group. One objective was to demonstrate the capabilities of the MV X3 array from SENSYS of Germany. In only 7 days, 223.451 acres of land were successfully scanned, and the data recorded in high resolution. The other objective was to search for Native American occupation sites in the area along the Mississippi River North of the town of Montrose, Iowa. This area is known to have been occupied by all native American cultures to include the Woodland cultures of the Adena and Hopewell. There is evidence that suggests there was a large population in the area between 1000 BC to 600 AD but the location of a large village site is yet to be identified.

A GPS responder attached to the MV X3 array provides precise recording of the coordinates of each sensor. With this system, any location can be identified to within 25cm for the purpose of core sampling, surface, and sub-surface investigation. (Figure 1).

Figure 1. The 16-sensor array with the GPS responder atop the array.

The SENSYS 16 probe array was pulled over the terrain with an ATV at an average rate of 8 mph. That is faster than most men can run. But, because of the unique design of the MV X3, vibration from rolling over bumpy terrain at relatively high speed is dampened by shock absorbers so the data is minimally compromised. (Figure 2).

Figure 2. The shock absorption system of the device minimizes vertical oscillations.

The data is recorded in the on-board computer sitting on the front of the ATV. It is downloaded and sent wirelessly to a GIS technician for processing. After filtering and enhancements, the data is then sent to an interpreter. The result is a geospatially registered image of the variations in the magnetic field of the ground. The goal of the geophysical survey is to cover large areas of terrain and locate sites of ancient human occupation which are not known.

The Magnetic Gradient Survey

Dr. Jarrod Burks, one of the leading scholars in geophysical research, gives the following description and function of the magnetic gradient survey.

"Magnetometers are extremely sensitive to ferromagnetic materials, that is, materials such as artifacts, rocks, and sediment that contain iron. Iron objects, such as large nails, farm machinery parts, and other structural and mechanical components, have extraordinarily strong, unmistakable magnetic signatures. In addition to their ability to detect iron objects, magnetometers also can detect changes in the soil related to iron oxides, especially variability in the thickness of topsoil or archaeological midden. The relative magnetic quality of the topsoil, in contrast to the clay subsoil, is often expressed in the visibility of plow scars on sites that have been plowed. In those areas where the topsoil is not as magnetic (i.e., has low magnetic susceptibility) plow scars tend to be hard to see in magnetic data. Conversely, topsoil that is magnetically enhanced tends to produce distinctive plow scars, especially when surface/subsurface ridges and furrows are present (Burks 2013)."

"Most magnetometers react to two kinds of magnetization in archaeological sediments: thermoremanent magnetization and magnetic. When sediments and rocks are heated above a certain temperature, known as the ferromagnetic Curie temperature (ca. 500-700 °C), their magnetic orientation is realigned to the local magnetic field, which produces a permanent remanent magnetization. Campfires and trash burning can produce more than enough heat to reach the Curie point. Upon cooling, magnetic iron oxides in the soil, such as magnetite and hematite, recrystallize and are fixed with a common orientation toward magnetic north. Intense heating can make an otherwise magnetically neutral (i.e., random) patch of ground highly magnetic by transforming less magnetic iron oxides (e.g., hematite) into a more magnetic iron oxide (e.g., magnetite and maghemite), and by producing magnetic ash. Even sediments that have been disturbed, such as by sweeping, raking, plowing, or other kinds of earth moving, can maintain at least some of their permanent magnetization, which is not reset until the sediments are once again heated up to a point above the Curie temperature. Objects and sediments that are permanently magnetic do not require an outside magnetic field to be magnetic, like those materials that are susceptible to magnetic fields (Burks 2013)."

"Soils and ferromagnetic substances that have high magnetic susceptibility react when they are in the presence of a magnetic field, which on archaeological sites is the earth's own magnetic field. Certain soil horizons and components of soil, such as organic rich topsoil is generally more susceptible to induced magnetic fields than other soil horizons, such as Bt horizons. If a hole dug a few feet into the ground is backfilled with mixed up sediments, the backfilled hole will likely have a different magnetic susceptibility than the surrounding, intact soils—especially if the hole is entirely filled with topsoil. Furthermore, human occupation of an area is known to enhance a soil's magnetic susceptibility. While the mechanisms behind soil susceptibility enhancement

are complex and not totally understood, bacteria that use and produce small magnetic particles are known to contribute to the process, as well as burning and the amount of certain iron oxides present in the soil." (Burks 2013)."

The 16 SENSYS fluxgate gradiometers are passive instruments that detect the local magnetic field without creating any magnetic field of their own. Each of the sensor tubes consist of two fluxgate sensors separated by 25 cm, one on top of the other. The top detector measures the earth's background magnetic field which is approximately 50,000-55,000 nanotesla (nT). The bottom detector measures the earth's background magnetic field and the changes caused by the soil and objects in the soil. By taking the difference between the two sensors, the earth's background magnetic field is eliminated leaving the magnetic field of the soil and objects in the soils. "Fired earth in prehistoric hearths and organic-rich soil in buried pits or ditches tend to concentrate the earth's magnetic field in measurable amounts of approximately 2-30 nT, while large iron objects or brick-filled features can measure in the hundreds or thousands of nanoteslas. Sandy soils or deep, highly organic soils can reduce the range of more subtle features to 1.5-5 nT." (Burks 2013)."

The SENSYS MV X3 Flux Gate Gradiometer

The SENSYS MV X3 Flux Gate Gradiometer was designed to be pulled over the terrain at a much higher speed than has ever been done by older technology. Its original application was to search for un-exploded munitions in Germany and adjoining countries from World Wars 1 and 2. For this application, the machine performs exceedingly well.

It was soon realized that the technology works very well in detecting anomalies in the magnetic field of the earth caused by human activity both modern and prehistoric. Many unknown sites have been discovered in Europe, Great Britton, France, Portugal, Spain, and Italy. Unknown earthworks were discovered around and near Stonehenge. Roman Villas have been discovered in Germany, and Heartland Research Group, (HRG), discovered multiple Round House signatures dating as far back as 2000 BC constructed by early woodland people named the Adena in Ohio using the MV X3.

Dr. Jerrod Burks is a Geophysical Archaeologist in Ohio. Using similar technology at a much slower scan rate has discovered many unknown Native American features on known Hopewell sites in Ohio. His work has often been referenced by HRG for testing the capabilities of the MV X3.

The image below shows the 16 sensors in place on the array carriage. The top of each tube measures the magnetic field about 4 feet above ground surface. The bottom of each tube measures the magnetic field in the ground up to a depth of 3 to 5 feet depending on soil types. Any difference between the two field is recorded by the onboard computer mounted on the front of the ATV. (Figure 3).

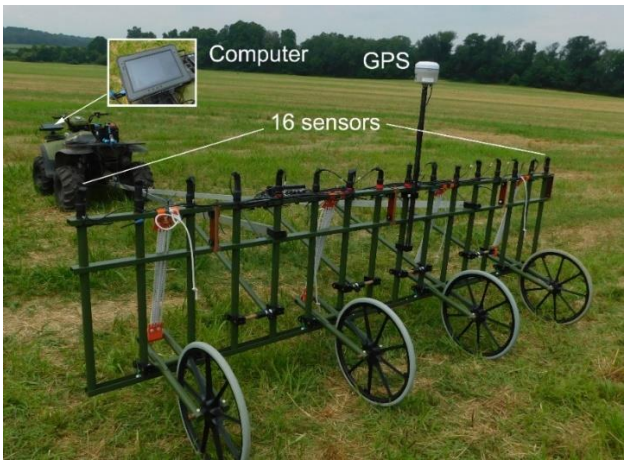


Figure 3. The SENSYS MV X3 Magnetometer array.

Signatures of human activity can be separated from naturally caused signatures. In most cases, the signatures left by human activity can be identified as to their cause such as fire, sub-surface intrusion, post-molds, and ditches. Remnants of soil deposited on top of pre-existing soil such as mounds, and geometric earthworks can also be detected. Modern activity can be separated from ancient activity by the presence of ferrous metals.

"To prepare the magnetometer data for analysis, the magnetic responses generated by the sensors are averaged together and then gridded and converted into an image where each pixel value represents the average magnetic response from the nearest sensor. Because the sensors are extremely sensitive, the data is noisy so averaging helps to produce a better overall magnetic reading. To visualize the image for analysis, the floating-point values in the image are converted to a gray scale image with +6 nT assigned to black and -6 nT to white with other values in that range taking on some grayscale value. Because values outside of +-6nT often indicate pits, fire pits, trenches, or iron implements, colors were assigned to represent these different ranges. The magnetic signatures in Iowa seem to be slightly less than in Ohio. The soil in South Eastern Iowa is very sandy compared to Ohio. In sandy soils, magnetic signatures can be reduced by 1nT to 5nT. If there is an extremely high sand ratio or an area is pure sand, magnetic signatures may only be detectable if they are recent. When visualizing the magnetometry data in Ohio, it was scaled +- 8 nT. A chart was created to increase the probability of selecting targets for core sampling based on the nT values of a given anomaly". (Figure 4). (2020 Hamilton).

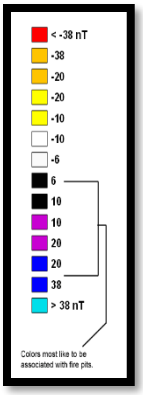


Figure 4. Reference legend for nT value ranges based on color.

Another legend was created to associate cause with color combinations of nT values. The causes are listed with the highest probability first followed by ever decreasing cause probabilities. Hence, anomalies which are black with a purple center or black with purple and a blue center are more likely to be a manmade pit, subsurface intrusion, small fire, or small ferrous metal object. Anomalies which are black, purple, blue, and turquoise are more likely to be a ferrous metal object. If there is any association with yellow, orange, or red, the feature is most likely to be ferrous. (Figure 5).

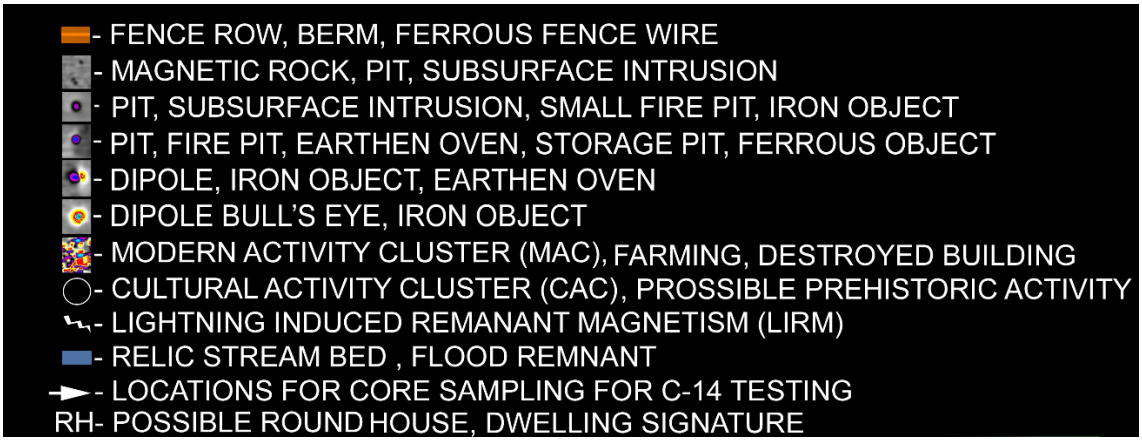


Figure 5. Legend for causes of anomalies based on color combinations which indicate nT values.

Method

The array is pulled over the terrain at a speed up to 8 MPH depending on the smoothness of the field. The pattern of scanning is like mowing the grass but with a 16-foot-wide mower. A GPS transponder communicates with a base receiver to georeference the data. A map of the track of the array is displayed on the screen so the operator can cover all the field. The computer combines the many tracks to complete a map of the area scanned by the trillions of data anomalies in the magnetic field. The data is stored in the computer and can be downloaded into a laptop for processing in programs designed to filter the data and produce the magnetic map of the field. Figure 6 is a picture of the field from the

air. Figure 7 is the same field made by the variations in the magnetic field of the soil over laid and georeferenced with the aerial image.

Figure 6. Standard aerial photo of a field.

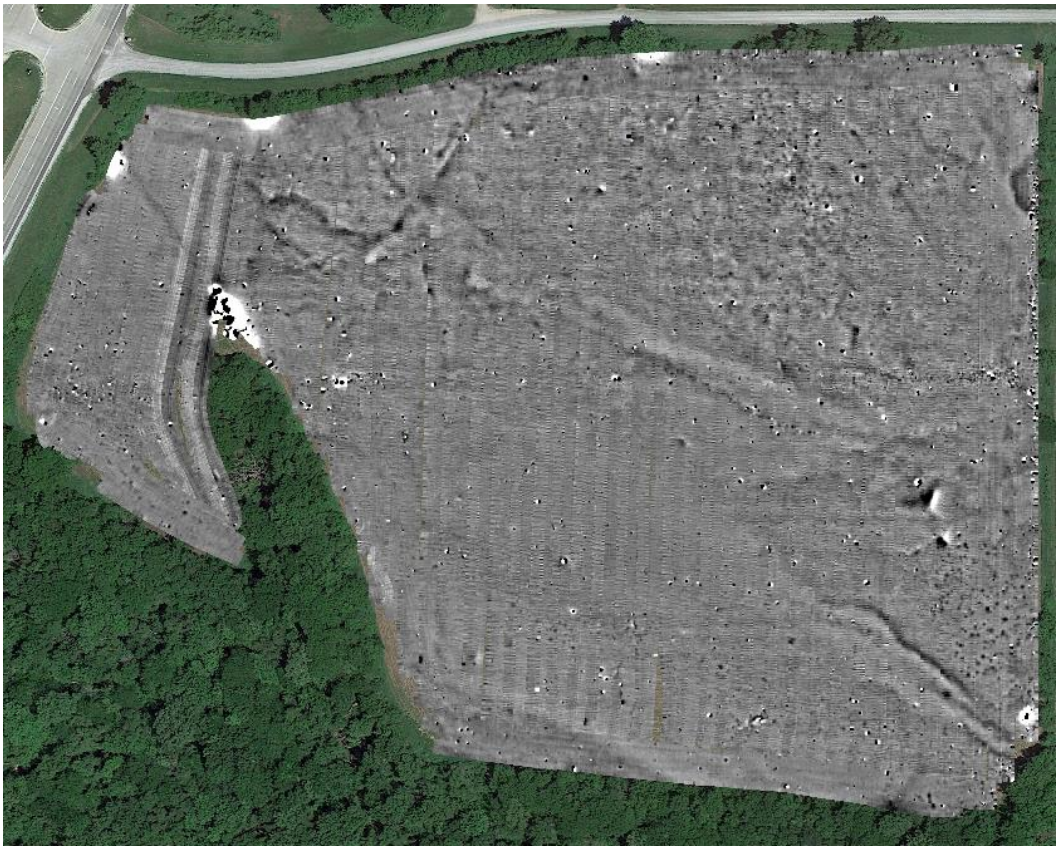


Figure 7. The field by magnetic deviation.

Interpreting Survey Results

Interpretation of a magnetometry results is determining the cause of every deviation in the magnetic field of the earth. It is much easier to say than to perform. Archaeologist have been using magnetometry for several years. Interpretation of magnetometric data from the perspective of an archaeologist requires an understanding of various practices of the cultures. This is particularly so with the Adena and Hopewell cultures in the woodland period. The Adena constructed circular dwellings called round houses. The have been dated as far back as 2000 BC and varied in size from 10 feet up 90 feet in diameter. They were constructed by placing posts in the earth about 2 feet apart in a circular pattern and then weaving lighter branches between the posts. Up to 4 large posts were set in the middle of the structure to support a conical roof made of tree bark shingles. (Figure 8).

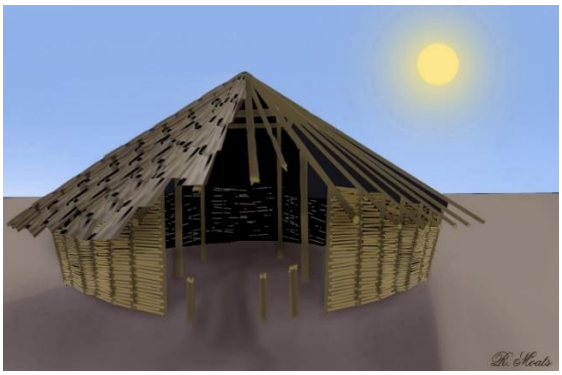


Figure 8. Artist concept of a Woodland Culture round house.

The walls were likely covered with mud to keep out the winter wind. The perimeter of a round house can sometimes be detected by a curvilinear line linking the post molds together. The round house tradition is also seen in the later Hopewell culture. They are discerned in the magnetic data by a ring of black dots in a circular formation and up to four larger black spots in the middle. These black dots are the signatures of the posts. (Figure 9).

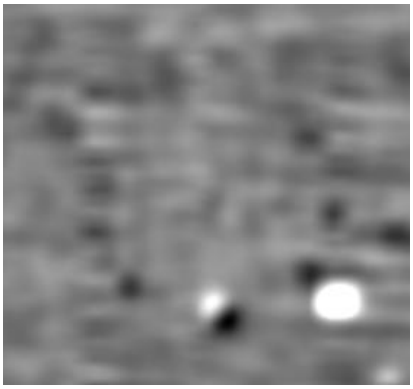


Figure 9. Signature of a round house in the magnetometry Data

Other features such as fire pits, storage pits, ditches, earthworks, walls, roadways, post molds, crematory pits, destroyed mounds, and general cultural related activities can also be seen in the magnetometric data, (MD). Prehistoric activity which causes an area of

anomalies is termed Cultural Activity Clusters, (CAC). Historical to modern activity is termed Modern Activity Clusters, (MAC). If the cause and age of anomalies is not know the applicable term is Activity Cluster, (CA).

Not all black areas be they circular spots or irregularly shaped are cultural activity. Magnetized stones make up the great majority of irregularities in the magnetic data. They generally have no detectable negative polarity. Either the negative pole is too far away from the sensor or the intensity of the negative pole is too weak to be detected. If a black area has an elevated nT value at its center, there is an increased probability the cause was fire or an ancient sub-surface intrusion. Small ferrous metal objects can cause the nT value to elevate at the center of a positively poled area. Therefore, only coring can objectively determine the actual cause for any given anomaly. The pattern of a cluster of anomalies such as a circular arrangement can be very definitive as to cause such as the pattern of a round house, "medicine wheel", destroyed fence line, building corners, and other geometric arrangements.

Results of the SE Iowa Survey

Fifteen fields were scanned in South East Iowa North West of the city of Montrose on the Western shore of the upper Mississippi River. The fields are addressed by the order in which they were scanned. The names of each landowner have been omitted to protect their privacy. Below is an aerial view of the area with the scans georeferenced and numbered. (Figure 10).

Figure 10. Fields scanned by number.

The full resolution scans are too large to print in this paper. The scans are at 300 ppi, (pixels/inch), and range in dimensions depending on the size of the field. Each field is scaled to fit the page dimensions at 72 ppi. Areas of interest in selected fields are printed at 300ppi. The original full resolution images are maintained by HRG.

Field 1 Magnetometry Survey

Historical aerial imagery of this field shows a large rectangular area inside the margins of this field caused by what appears to be a differential in foliage growth. (Figure 11).

Figure 11. Google Earth image 2020.

To determine the cause of the differences in foliage growth, an excavation of the area was conducted by the landowner Wayne May. A circular excavation was conducted and can be seen at the top middle marked with the number 15. (Figure 12).

Figure 12. The pure sand in the excavation areas.

The magnetic signature left by excavation 15, with the spoils replaced, is visible and is marked “Recent Intrusion”. (Figure 13). This proves extremely sandy soils can hold a magnetic signature. The length of time that soils with high sand to biomass ratios may hold a magnetic signature caused by human activity is not known. Logically, constant movement of the sand caused by wind and natural process would not hold a signature for a long period. The many floods evidenced in the data also suggest the oldest signatures may have been erased. This area of the county is known for the sandy soils to be wind-blown to the point where the farmers say they “trade farms” with every windstorm.

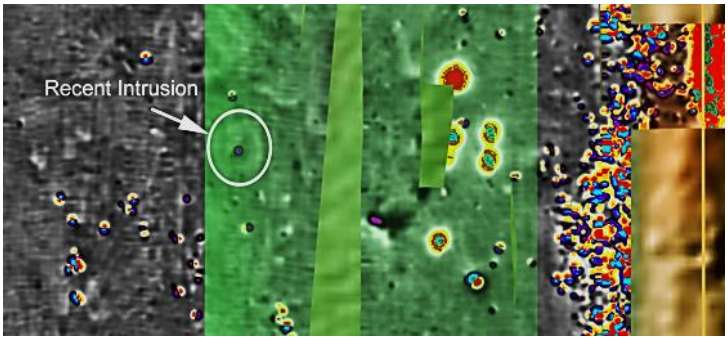


Figure 13. The area marked “Recent Intrusion” is location 15 as seen in figure 16.

The presence of recent activity detected by the magnetometer inside the archaeological area proves the array was working properly and signatures outside of the green area may have older signatures of human activity. Therefore, field 1 as well as fields 1, 2, 3, 4, and 15 may have reduced or undetectable magnetic signatures caused by activities of prehistoric cultures. The magnetic data from these 5 fields cannot be definitive as to the presence or absence of early cultures. (Moats 2020).

The question of sandy soil’s ability to maintain a magnetic signature over time where natural processes are in play was proposed to Gorden Konieczek, Applications Engineer for SENSYS. He states: *“That certainly depends on the features and properties of the sand. If this is your observation in that area, this is certainly a point. But it is not a general rule. I would think that the properties of the soil is the feature, not holding it. A pit for example is more magnetic than the surrounding soil. If the spot gets modified or the soil gets removed or mixed, the feature is gone and may become invisible because the magnetic contrast compared to the adjacent soil is too small. The spot does not get magnetized by the pit”.* (Konieczek 2020).

Constant moving of the soils is the likely cause of virtually all the fence rows in the area to have an elevation to as high as 10 feet above the flat areas of a field. This strongly suggests that the fields in this area are constantly being reduced and/or elevated. The LiDAR image of the area easily shows the naturally elevated fence rows. (Figure 14). (Moats 2020).

Figure 14. LiDAR of the area of naturally elevated fence rows.

Some remnants of fence rows that have been removed are visible in the LiDAR image. Generally, foliated fence rows cause the windblown sand to accumulate by acting in the same way as a snow-fence causes drift at the fence and not in the road. Notice the East West fence rows are not as prominent as the North South rows. This difference in fencerow elevations based on orientation is likely caused by the highest average winds in the area coming from the West, North West, and North. Winds running perpendicular to a fence row would gather more deposits than winds the run more parallel with the rows.

The next page is the magnetometry scan of field 1. The resolution has been reduced to fit the 8.5 x 11-inch page. (Figure 15).

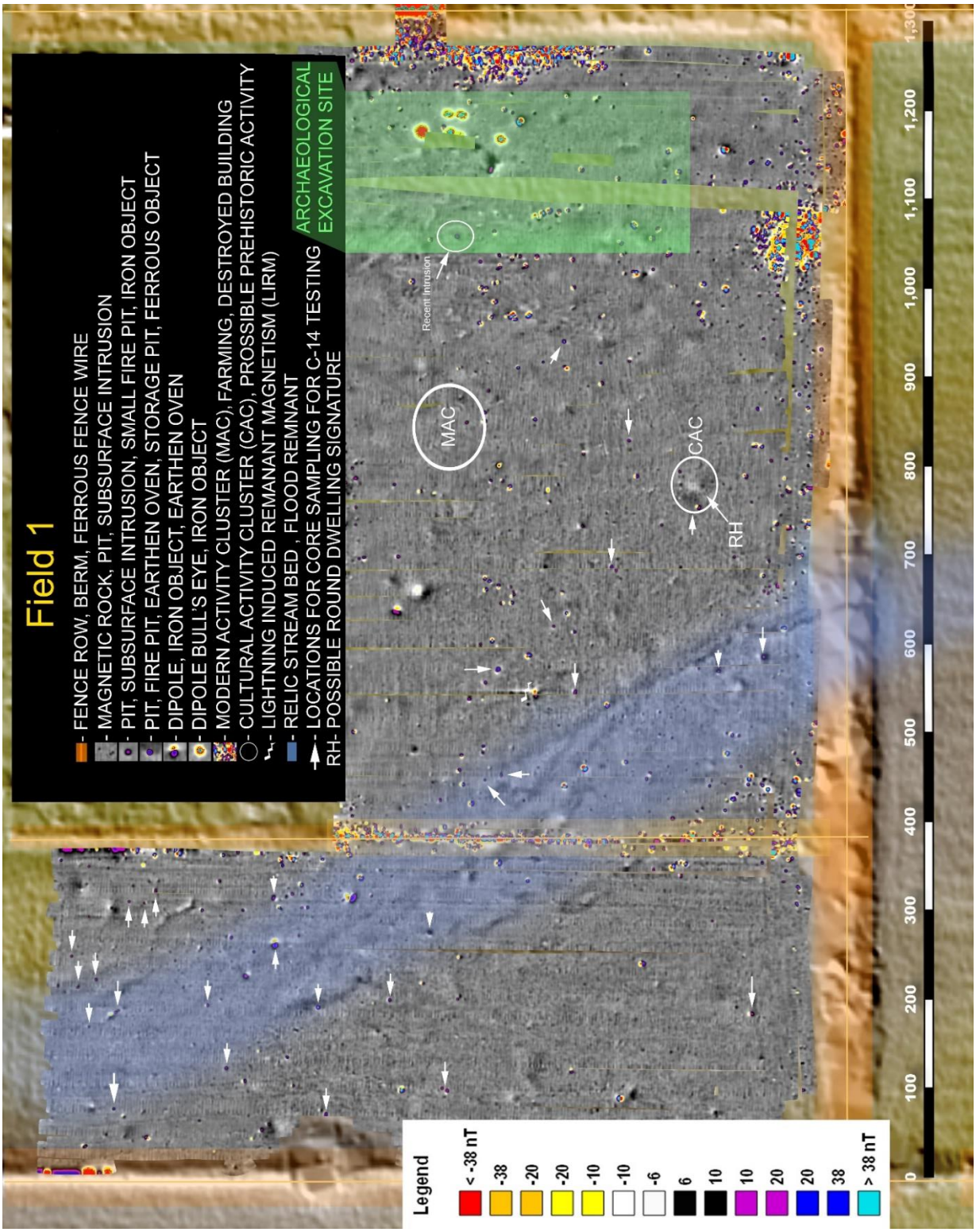


Figure 15. The analyzed and notated magnetometry plot of field 1.

The raw magnetic data was processed by the application QGIS (qgis.org) to filter and measure the data. The program assigned colors to represent nT values. The signatures of possible fire pits are indicated by a black spot with a purple center. This nT value is +6 to +20. These could also be naturally magnetic rocks. Black spots with a purple center and a dark blue in the purple, "target like", have nT values of +6 to +38. These signatures are most likely to be fire pits, earthen ovens, or sub-surface intrusions by early Americans. The only way to positively identify the later as ancient fires, food storage pits, or possibly burials is to take core samples and find datable material such as carbonized wood, (charcoal), or decayed plant material in a deep context such as a fragment of corn cob.

Summary of Field 1 Analysis:

"The large rectangle formed by variations in foliage growth and farming practices is likely caused by a program called the USDA Conservation Reserve Program, (CRP). CRP practices are used to conserve soil and water. CRP systems include conservation tillage practices such as zero-till, reduced till, bed planting, and other practices that provide sufficient residue cover to protect the soil surface from the erosive effects of wind and rain. The program took some of the land out of production to reduce the production of some crops so there was not an overabundance of crops that reduce crop prices. It created wildlife habitat, preserved some native plant species, protected some soils from wind and water erosion." (Price 2020).

*"This site has multiple native grass species growing on it including Big and Little Bluestem, Switch Grass, Indian Grass, Buffalo grass and others. Most of these grasses do not grow well on sandy soils ("Big Bluestem grows best in full sun and slightly moist soil. It can take dry conditions but may not be as tall and vigorous. It is quite versatile in that it can grow in almost any soil type, from clay to loam, and even slightly sandy. Plants are strong indicators of soil conditions, and since the grasses listed above as a native grass association are growing in field 1 in abundance, this suggests to me that the depth of the sand in the field is not usually deep, except where (*a building*) plot (*is believe*) to be located at the east end of the field and was excavated to over 20 feet of pure unsorted sand. Other places in the field do have sand deposits, and there I found sand dropseed and sandburs growing. The plant Spotted Beebalm also grows very well on sand and it grows on the site".* (Price 2020).

The area where a rectangular plot was excavated, (foreground in figure 12), could not be scanned because the plot was open and not backfilled. Therefore, there is no magnetometry data to prove or disprove the presence of a rectangular signature.

What appear to be fire pits, and sub-surface intrusions created by early Native Americans are scattered over this field. The area circled and labeled MAC is likely modern activity. The area at the center bottom of the scan labeled CAC is what appears to be a cultural activity cluster of anomalies. The area labeled RH appears to be the signature of a Woodland Culture Round House or dwelling. I suspect the older a culturally caused anomaly in the magnetic field the higher the probability it has been erased by natural erosion process in this and adjacent fields.

Field 2 Magnetometry Survey

Field 2 is South and adjacent to field 1. Below is the magnetometry scan of field 2. (Figure 16).

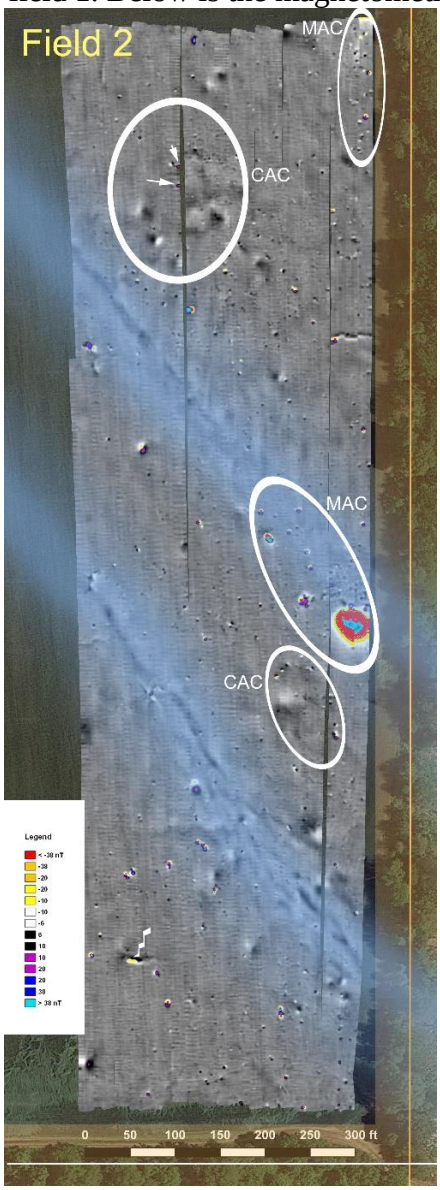


Figure 16. Field 2 Survey.

Summary of Field 2 Analysis:

Field 2 is relatively unremarkable. Remnants of a creek or flood movement are visible and highlighted in light blue. There are two areas of MAC in which we have no interest. There are two areas of what appear to be CAC. These areas have 1 or more elevated nT values which suggest locations of ancient fire. These areas of CAC should be investigated and cored to determine their cause and age.

Field 3 Magnetometry Survey

Field 3 is West and adjacent to field 1. Below is the magnetometry scan of field 3. (Figure 17).

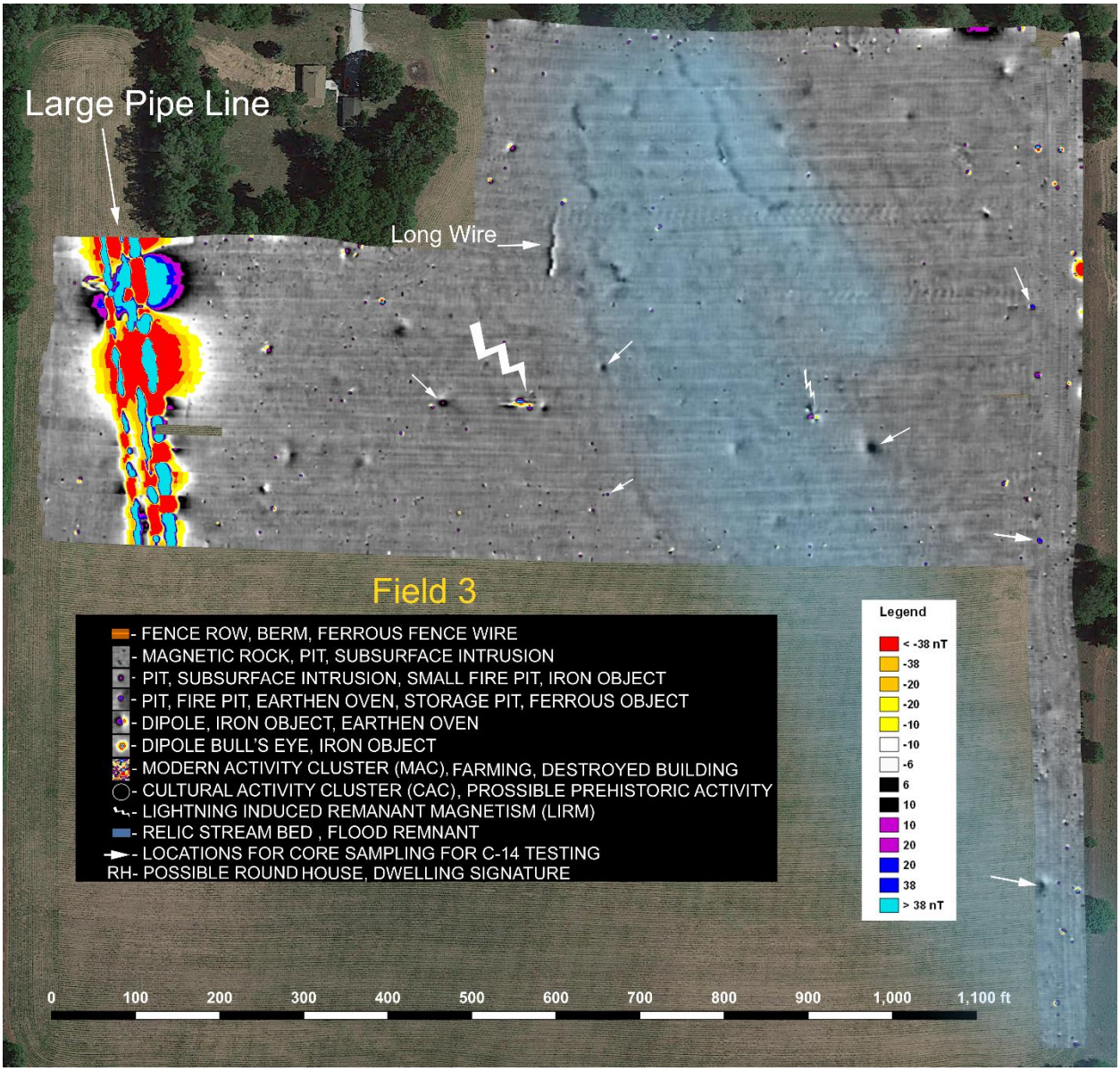


Figure 17. Field 3 magnetometry survey.

Summary of Field 3 Analysis:

Field three contains multiple locations indicated by arrows which could be features caused by cultural activity. The obvious Large Pipe Line is of no interest nor is the LIRM in the center of the field. There are no geometric patterns which would suggest a building, of dwelling. The locations marked with arrows should be cored for the purpose of determining cause and age.

Field 4 Magnetometry Survey

Field four is East and adjacent to field 1. Two test scans were performed in this field. One on the North side and one on the South side. (Figure 18 N & 18 S).

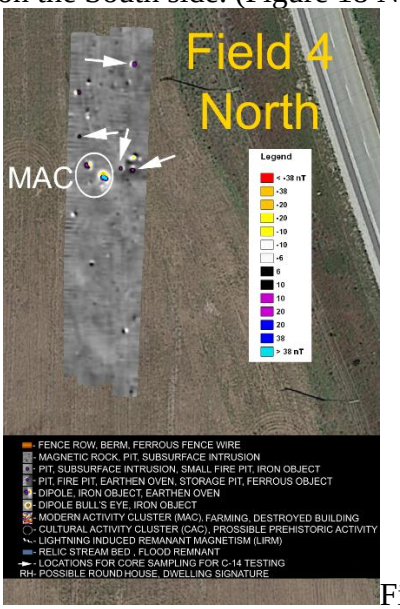


Figure 18 N.

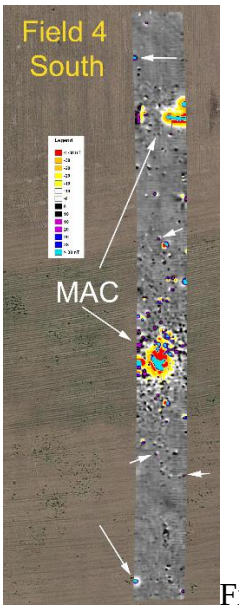


Figure 18 S.

Summary of Field 4 Analysis

Field 4 has no geometric or CACs. Areas of MAC can be ignored. Locations marked by arrows could be sub-surface intrusions such as a fire pit. This field presents no obvious areas for investigation. The terrain is sloped down toward the East and is not conducive to long term ancient occupation such as dwellings or large areas of CAC.

Field 5 Magnetometry Survey

Field 5 presents many potential locations which appear to be of cultural interest. (Figure 19).

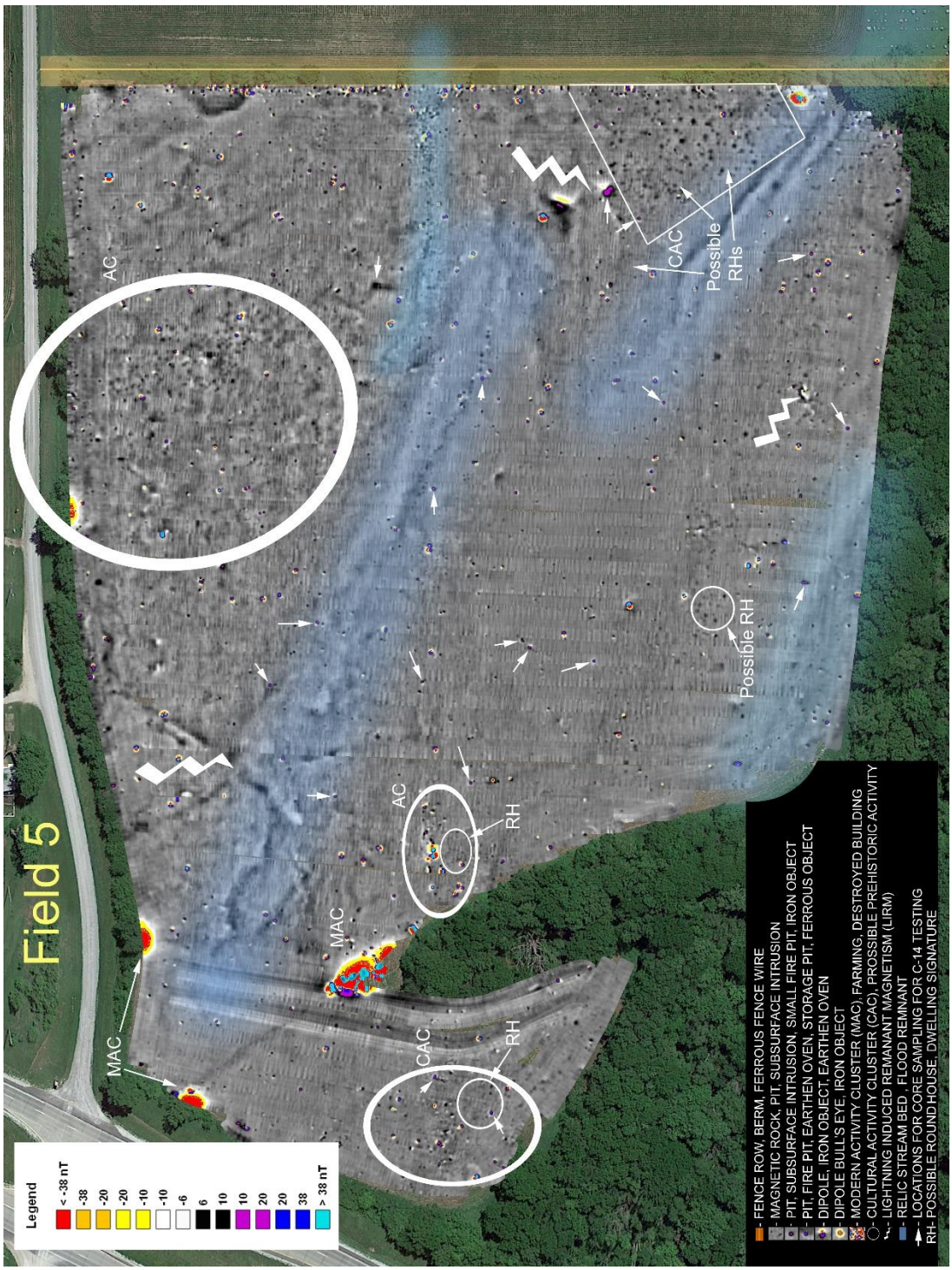
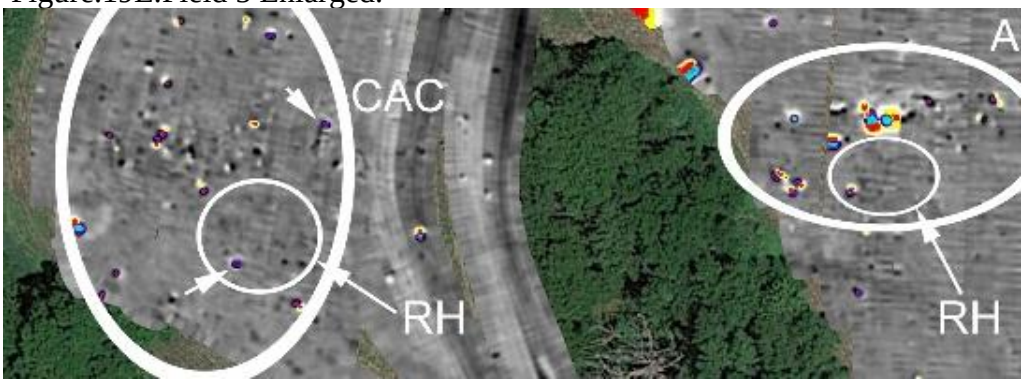


Figure 19. Field 5 magnetometry scan.

Figure.19E.Field 5 Enlarged.



The large area in field five is marked as AC, meaning an activity cluster which could be modern or culturally ancient. The uncertainty is due to the absence of metal, or elevated nT returns. The large number of dark spots are likely magnetized rocks. The modeling of the soil in the area suggests human activity.

The CAC on the West side of the ravine with the possible round house configuration is a strong indication of ancient activity as well as the AC on the East side of the ravine. The presence of a round houses here would be typical for ravine starts having early Native American activity.

The presence of two other possible round houses in this field suggests the area was occupied by at least four family units and associated activity in this field. Samples for coring here as well as all other fields, should be spread out over the widest possible area. By taking multiple core samples over a wide area reduces the possibility of pseudo replication. Spreading the samplings over a wide area provides the best spatial correlation.

Summary of Field 5 Analysis

Field 5 is far to the South and East of fields 1 through 4. Field 1 through 4 are in a location where the soil has a high sand to biomass ratio. The soil composition in the region of fields 5 through 15 is more conducive to holding the signatures of early human activity as opposed to the sandy soils farther North. This could be the reason for what appears to be a generalized increase in ancient activity in this region as opposed to the Northern fields. An increase in early population density and activity in the region could also be the cause of increased signatures per square meter as opposed to the more Northern fields.

Population density based on an increased number of CACs, fire pits, storage pits, and round houses per cubic meter is valid. However, it is dependent upon ground truthing by excavation, coring, and C14 dating.

Note the increased number of low nT value black spots clustered along the flow of creek and flood water. This is typical of the clustering of magnetic stone by the flow of water and is not necessarily related to human activity.

Field 6 Magnetometry Survey

Field six is greatly deficient in CA. Two areas are labeled as AC could be modern or cultural. Disturbances in the magnetic field caused by recent activity are obvious. The area running East/West was suspected as CA but with the use of historic imagery it was determined it was the remnant of an old farm lane. (Figure 20).

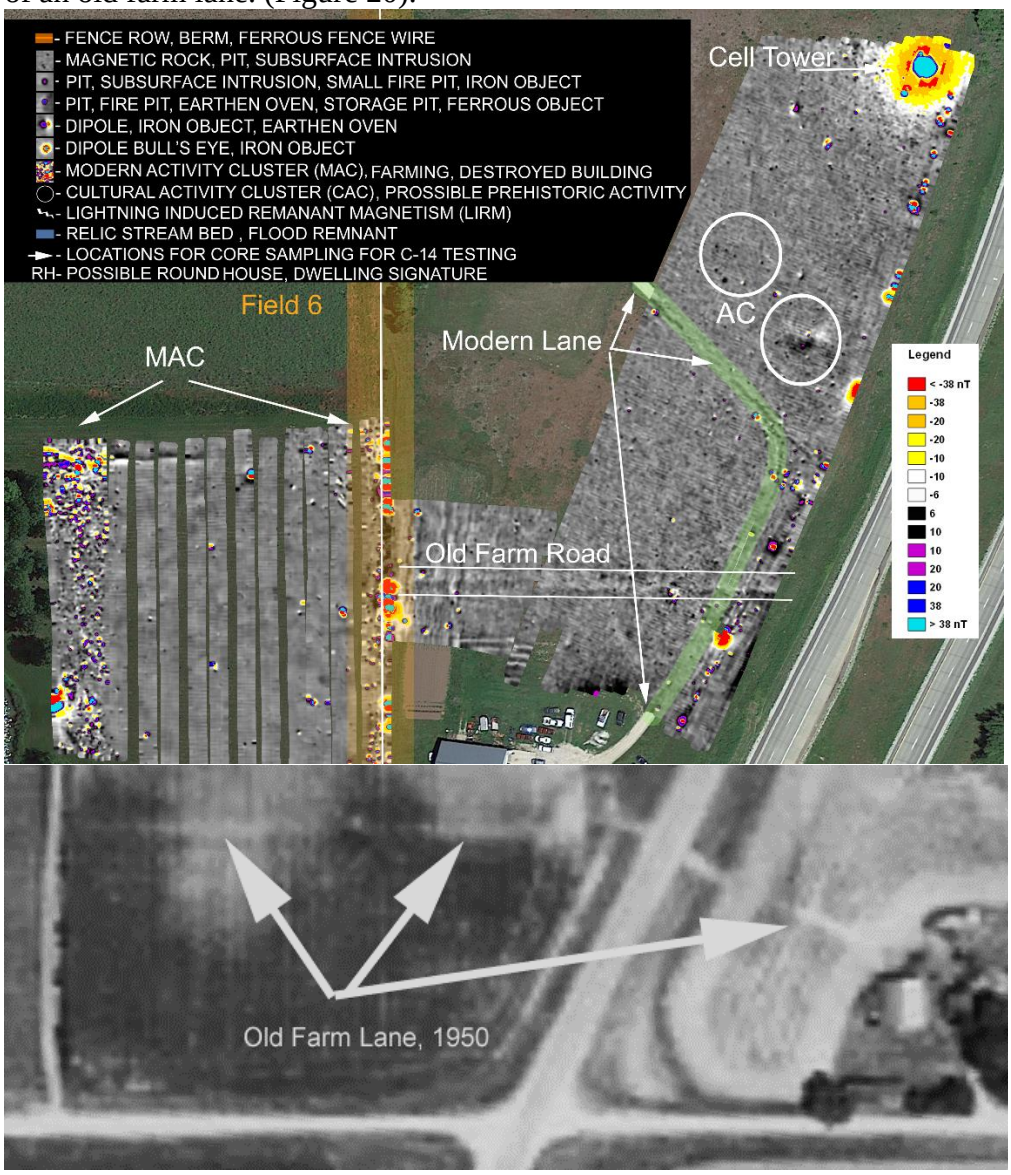


Figure 20 Field 6 showing old farm road or lane.

Summary Field 6 Analysis

Field 6 has two areas of possible cultural interest. Otherwise, this area is unremarkable.

Fields 7 & 8 Magnetometry Survey

The magnetometry scan of fields 7 & 8 are shown in figure 21.

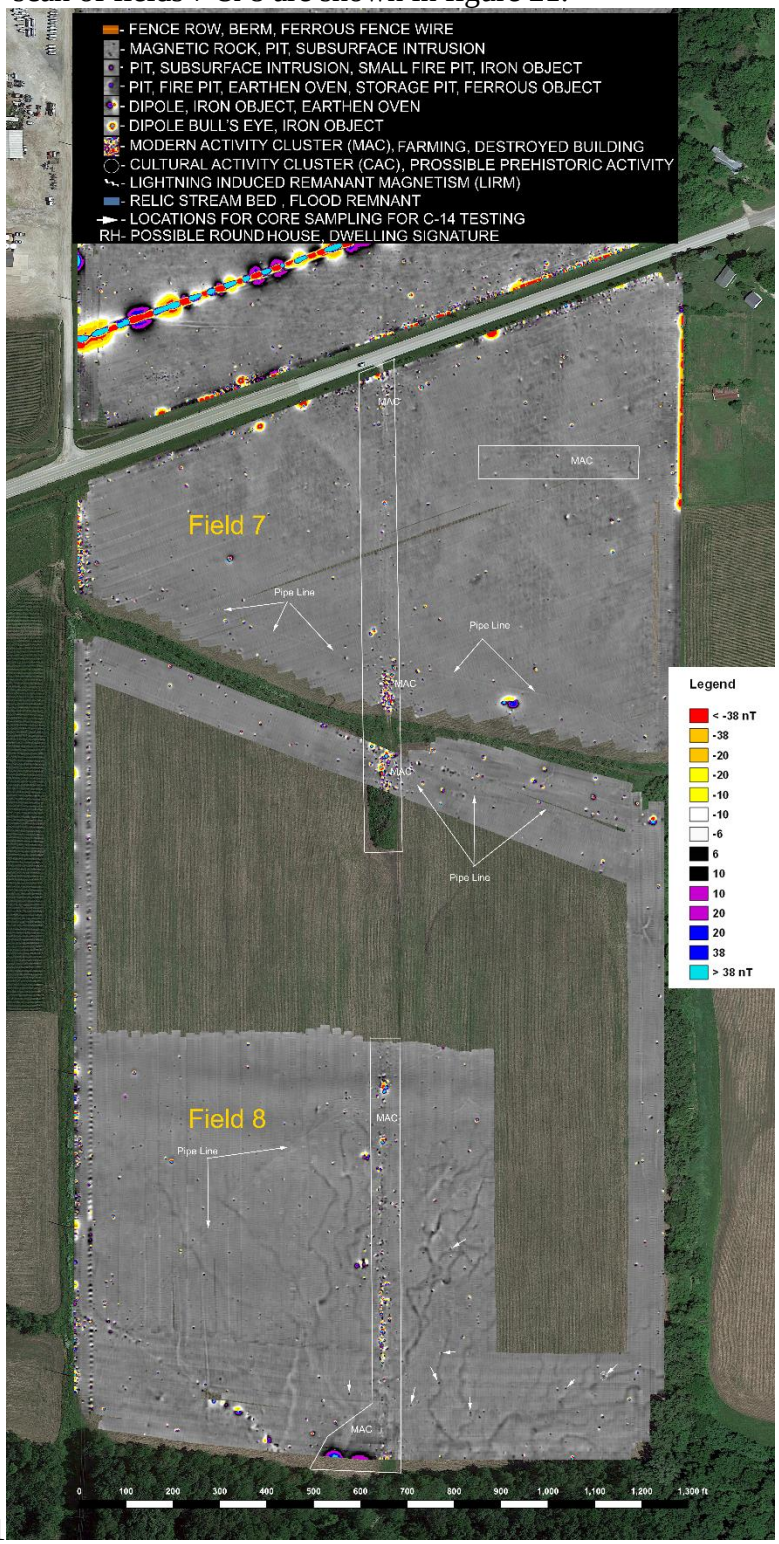


Figure 21

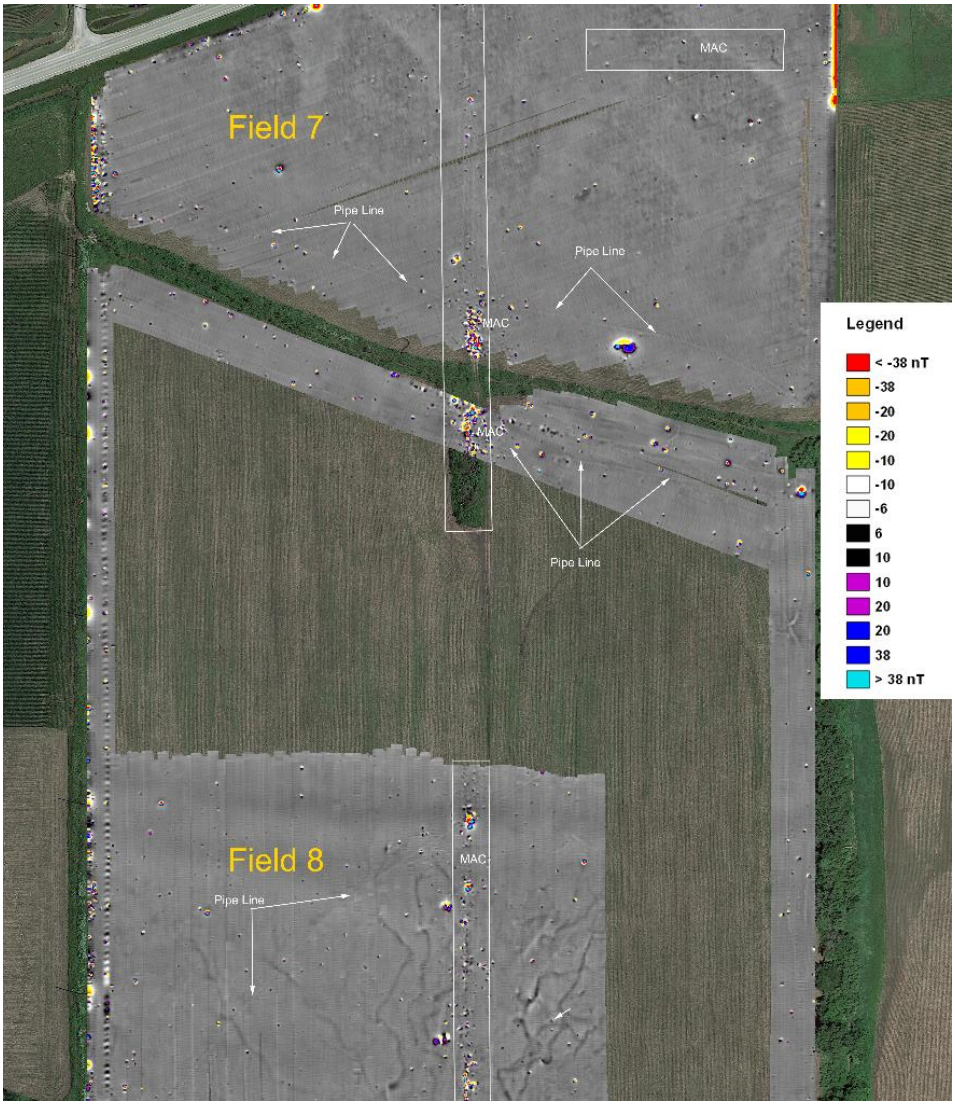


Figure 21E Fields 7 & 8 Enlarged.

Summary Fields 7 & 8 Analysis

Fields 7 & 8 have very minimal areas of interest. The area running North and South in the middle of the fields appears to be a remnant of a long lane or fence row. The MAC in the middle is the remnants of house. Fragments of brick are scattered along the entire pathway. The irregular dark areas are due to increased moisture causing slightly positive signatures.

The area of high nT value in the South East corner of field seven is probably a metal object. There are no locations in field seven which I would recommend for coring. There is an area in the South East corner of field 8 that could contain some CA. They are designated with arrows.

Overall, fields 7 &8 are of little interest except to demonstrate the arrays ability to detect a pipeline that is below the plow zone and likely made of tile or PVC pipe,

Field 9 Magnetometry Survey

Field 9 is to the North of field 7 & 8 and is seen on the next page. Notice the contrast in proliferation of possible CACs and signatures consistent with fire pits, sub-surface intrusions, and possible round houses, and what appears to be a destroyed mound or circular earth work. Figure 22.

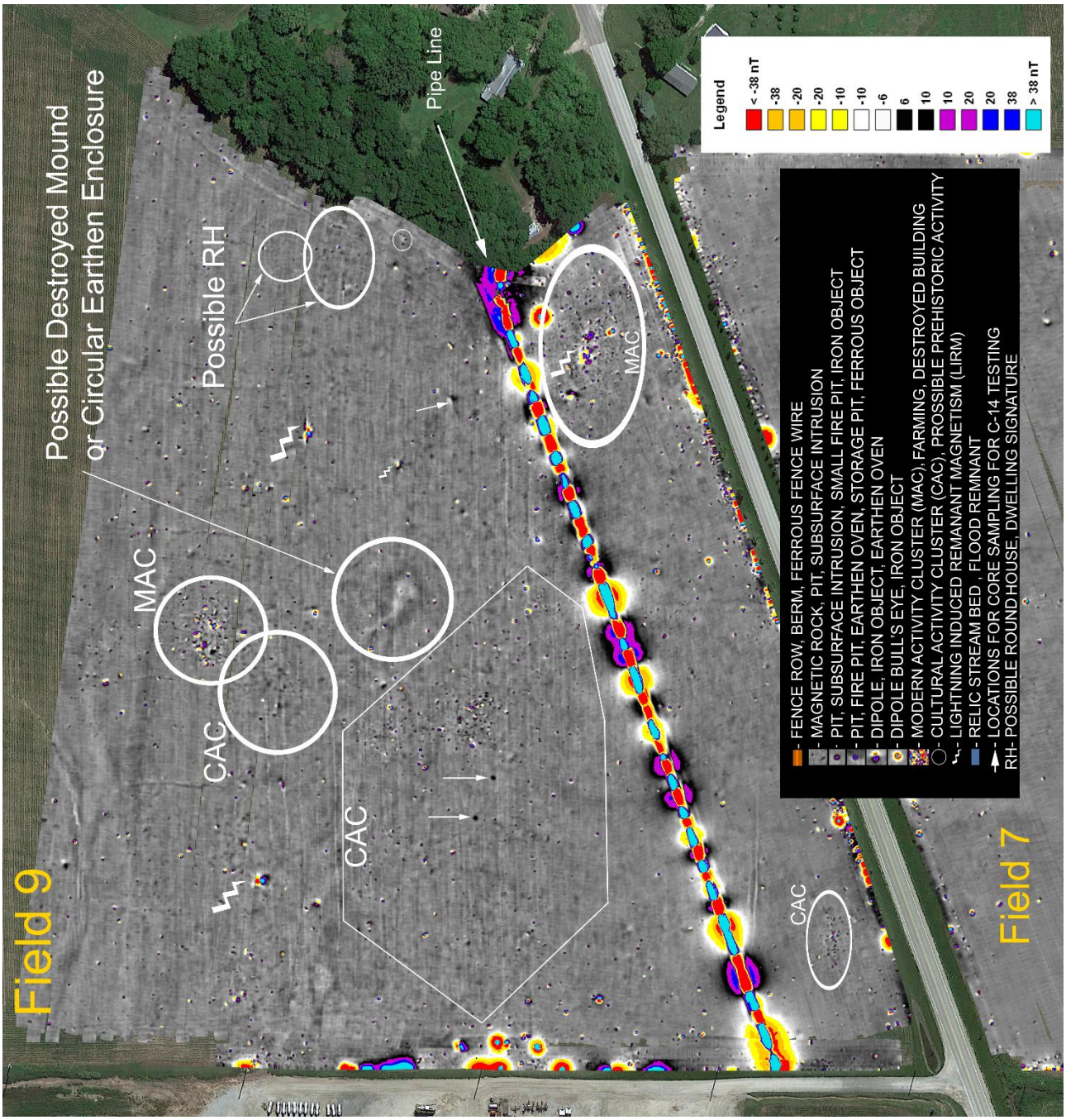


Figure 22. Field 9 with multiple locations of probable CA.

Multiple areas of suspected CA can be seen in this field. Five areas stand out as being of great interest; the three CACs, the possible round house with associated AC, and the feature which is suspected of being the result of a destroyed mound or circular earthwork. These areas are enlarged for greater clarity. (Figures 22E).

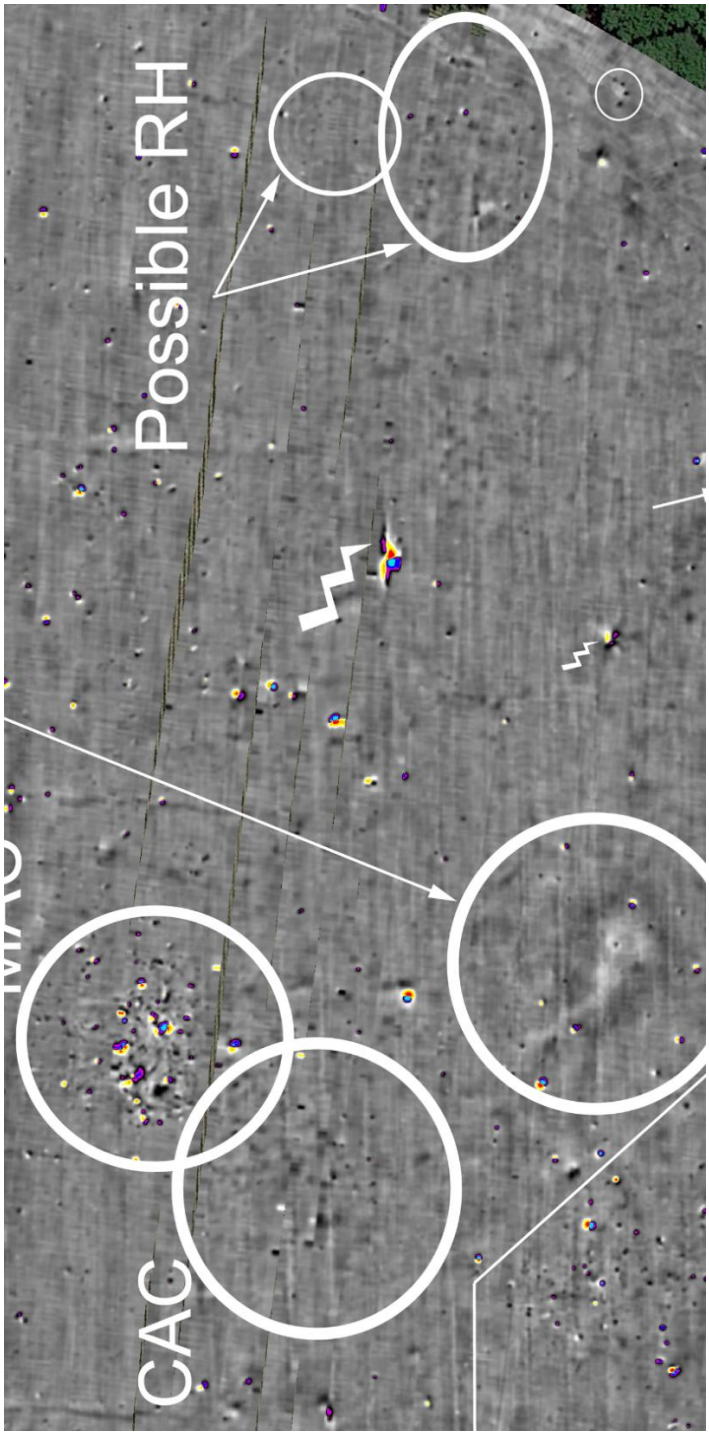


Figure 22E Field 9 Enlarged

Summary of Field 9 Analysis

Field 9 appears to have significantly more areas of CA than field 7 or 8. One explanation for this is this area of field 9 is on the edge of a small ridge. Elevated terraces above lowlands are known in the Midwest to generally have more Native American activity than other landforms. (Converse 2003). In terms of long-term occupation, Native Americans of the later Woodland period chose elevated areas above flood plains and lowlands for long-term living areas. The reasons are many but include the tendency toward farming as opposed to hunting and gathering.

Burial mounds of the Adena and the early Hopewell were generally small diameter and elevation above ground with sub-surface burials. These mounds are prominent found on ridges that have a distant view of the landscape. This location fits this pattern of behavior in that it is an elevated ridge with a view of many miles to the Northeast.

This field has three areas of probable CAC and the two areas of high interest. The area marked as a possible destroyed mound or earthwork should be investigated by coring and sub-surface excavation. If there is an absence of charcoal and distinct horizons below the plow zone, then the probability of the feature being caused by Native Americans increases. Multiple horizons would support the circular earthwork scenario. If a sub-surface burial is discovered, then the mound scenario is proven.

The area that is identified as hiving two or more possible round houses should also be thoroughly investigated. Long term occupation could be proven with conformation of round house dwellings. In general, this field has great potential for discovery of a large population in the area from some time in the Woodland period.

Field 10 Magnetic Survey

Field 10 is the North end of field 9. Field 9 is exceptionally large. Scans 9 and 10 are separated by nearly ½ of a mile. (Figure 23).

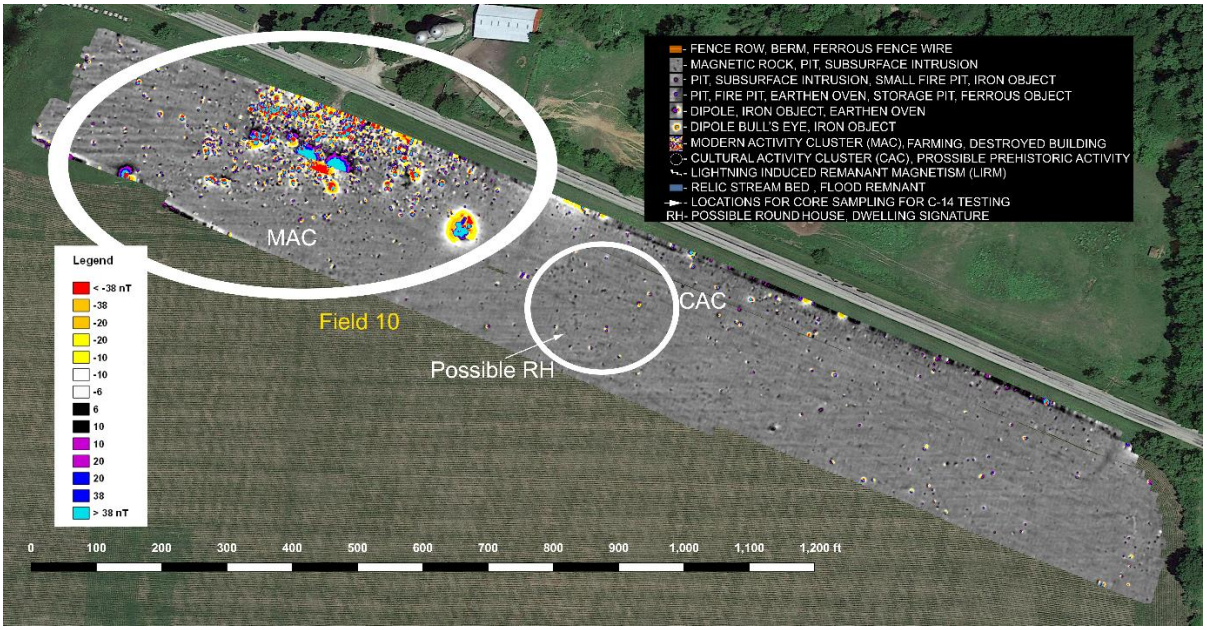


Figure 23. The North end of field 9.

Summary of Field 10 Analysis

The area of MAC is a destroyed barn. The profusion of small metallic objects, (in red), and range from the size of a nail to large pieces metal such as hinges, straps, latches, and pieces of farming equipment. The area of CAC contains the possible signature of a round house.

This portion of the field is also higher in elevation than the portion between this and the ridge of field 9. The view in the photograph below shows the separation. ***Because this area is so large and has evidence suggesting a population of Native Americans on the South and North sides of lower terrain, it should be scanned completely for evidence of a possible village.*** (Figure 24).

Figure 24. A wide-angle view of the entire field containing sites 9 & 10 respectively 10 on left, 9 on the right.

Field 11 Magnetometry Survey

Below is the scan of field 11. (Figure 24).

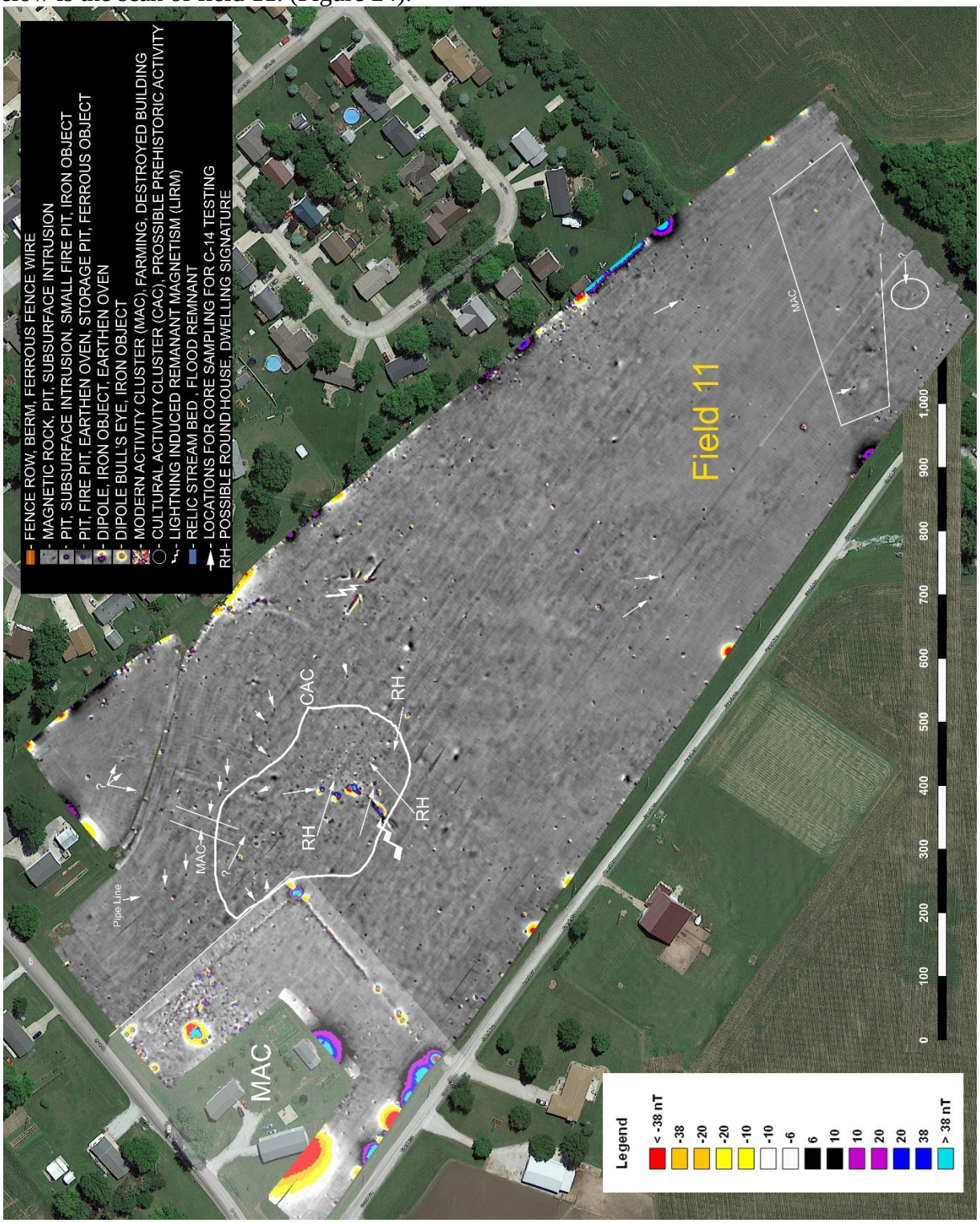


Figure 24. The magnetometry scan of field 10.

Below is an enlargement of the North end of the field. (Figure 24E).

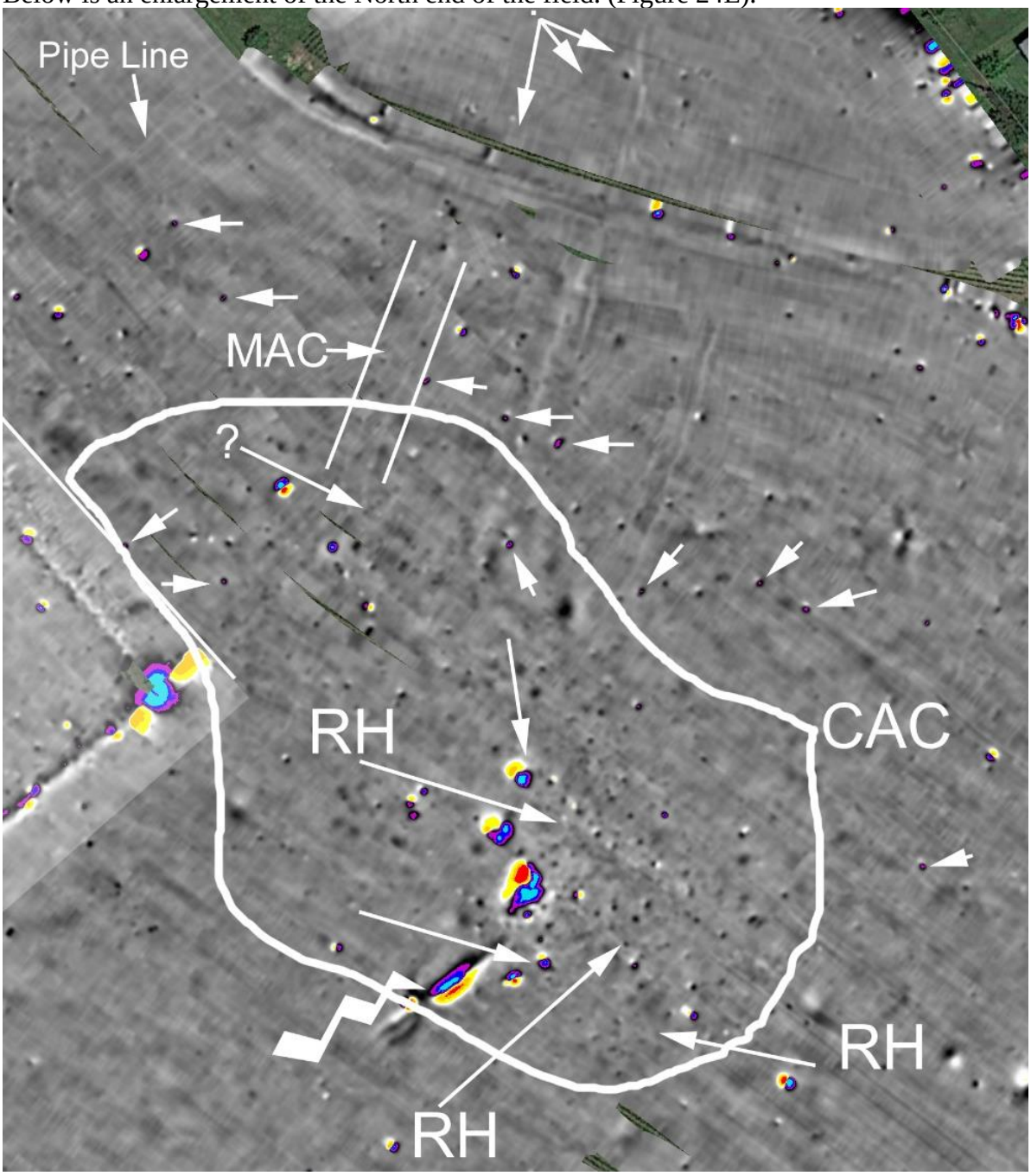


Figure 24E Enlarged North end of field 11.

This scan shows a large area of CAC with possible round houses embedded in the CACs. At the top middle is a dark line which could be an ancient pathway. There is a feature inside the CAC perimeter which cannot be identified but appears to be a row of post molds. Arrows point to features which could be fire pits or sub-surface intrusions.

Below is an enlarged view of the South end of field 11. (Figure 25S).

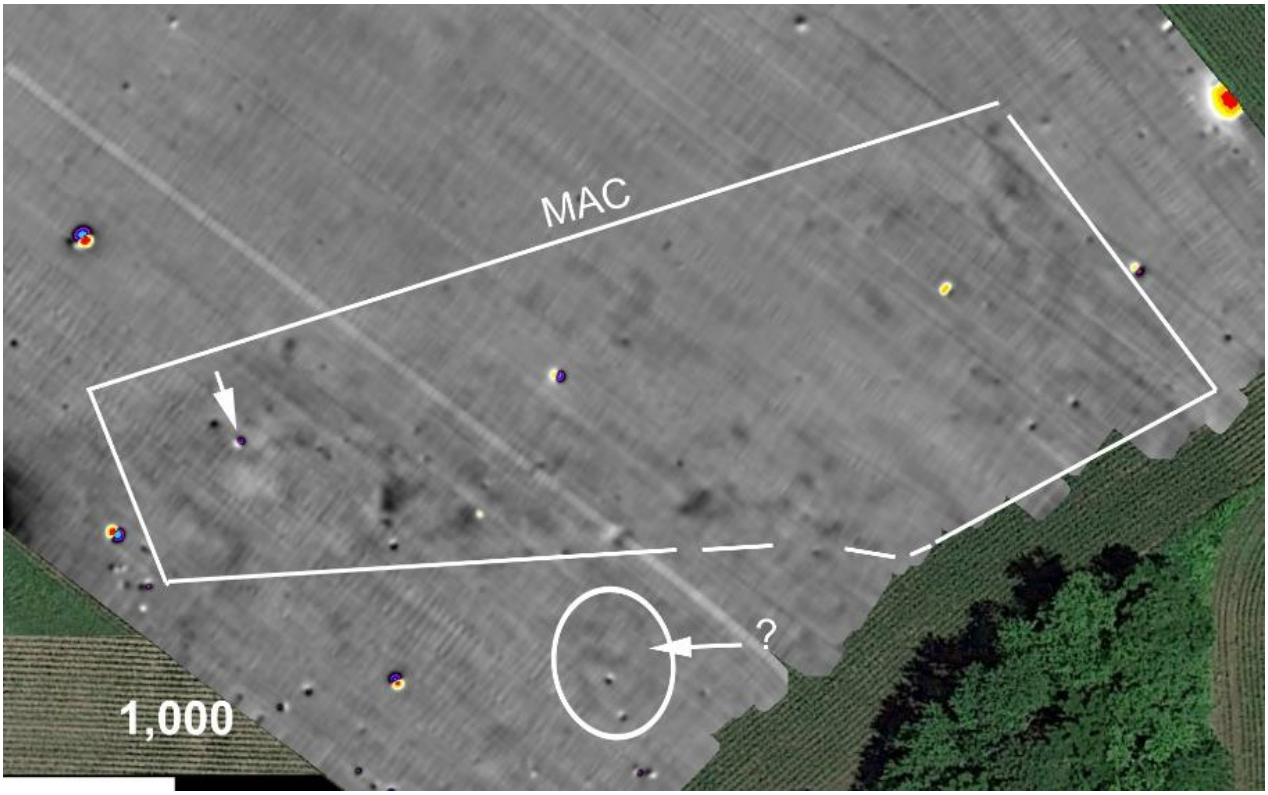


Figure 25S. The South end of field 11.

The features inside the area labeled MAC that are dark with some having straight edges and 90-degree corners is the result of farming. The feature circled and marked with a "?" appears to be a possible area of CA. The cause of the oval shaped anomaly is not known and should be investigated.

Summary of Field 11 Analysis

Field 11 contains multiple features which appear to be CA. CACs and the presence of two or more round house signatures suggests this area was used by Native Americans long before contamination and destruction by the encroachment of modern culture. The features marked with arrows, particularly those in or near round house signatures should be cored and investigated. It appears that as scanning moved toward the city of Montrose not only does the "junk" of society increase but so does the population of possible Native Americans and their activities.

Fields 12 & 13 Magnetometry Survey

Below is the magnetometry scan of fields 12 & 13. (Figure 26).

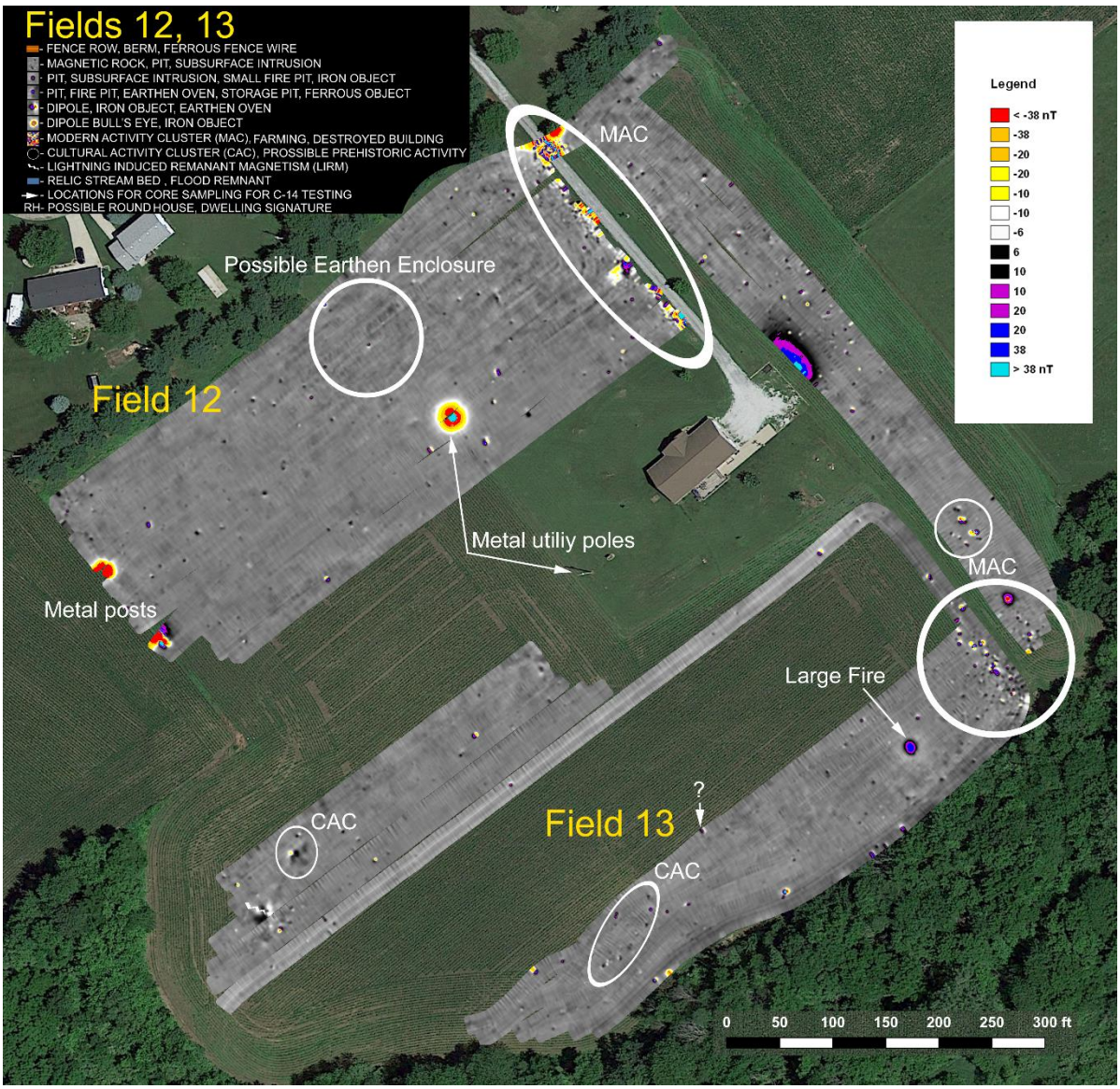


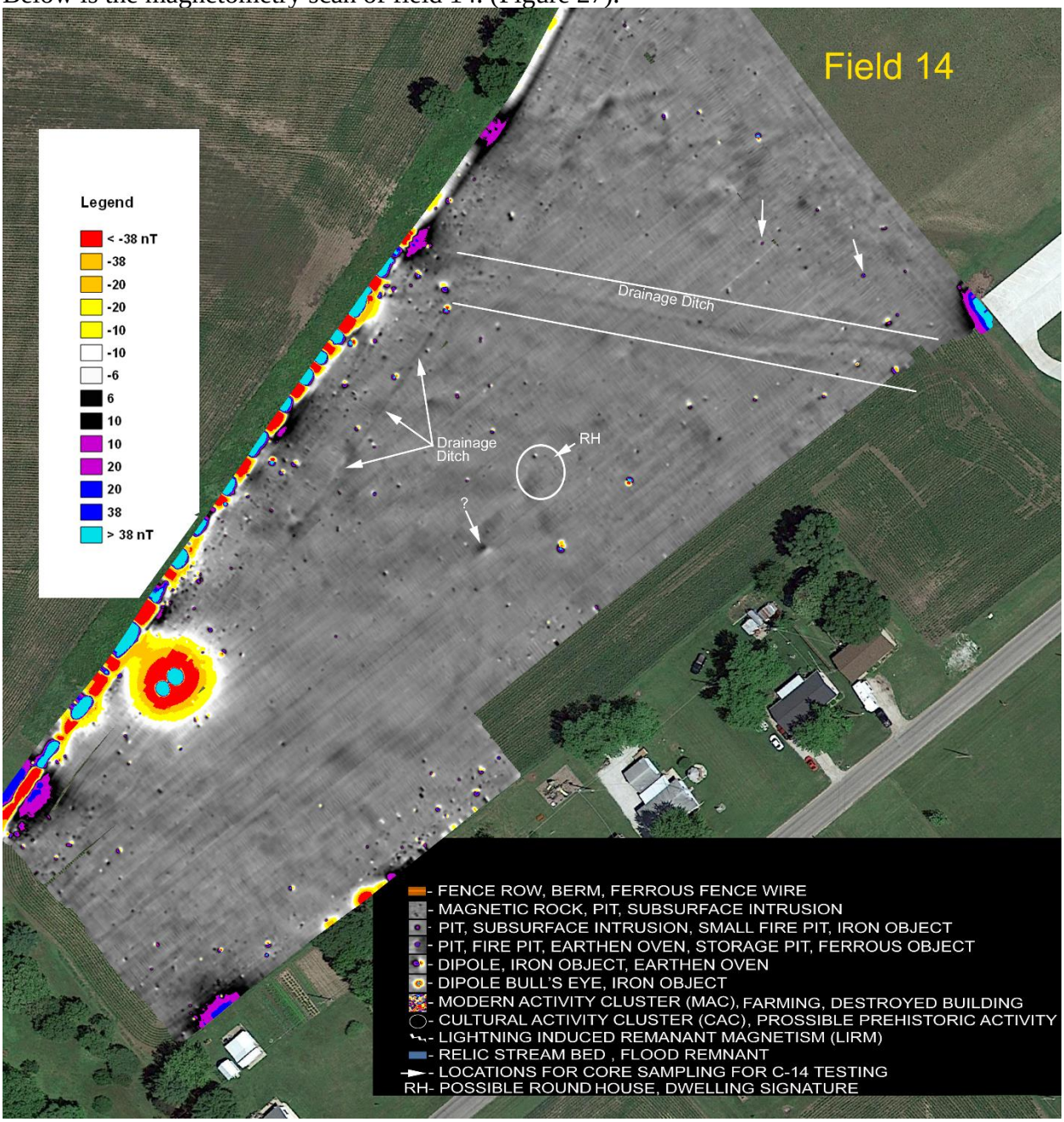
Figure 26. Fields 12 and 13.

Summary 12 &13 Analysis

There are two areas of possible CA and a possible remnant of a circular enclosure. The “Large Fire” area at the bottom right corner is a very probable fire pit. Coring should determine its age.

Field 14 Magnetometry Survey

Below is the magnetometry scan of field 14. (Figure 27).



Summary of field 14 Analysis

The feature marked RH should be investigated for cause. It is oval and not round. It is likely caused by farming. But it could be an "oval" shaped structure or earthwork like the one marked CAC in field 15. (Figure 28). The linear feature between the lines and the dark line pointed out by the arrows is a drainage ditch. The single feature marked with "?" appears to be cultural and should be investigated.

Field 15 Magnetometry Survey

Below is the magnetometry scan of field 15. (Figure 28).

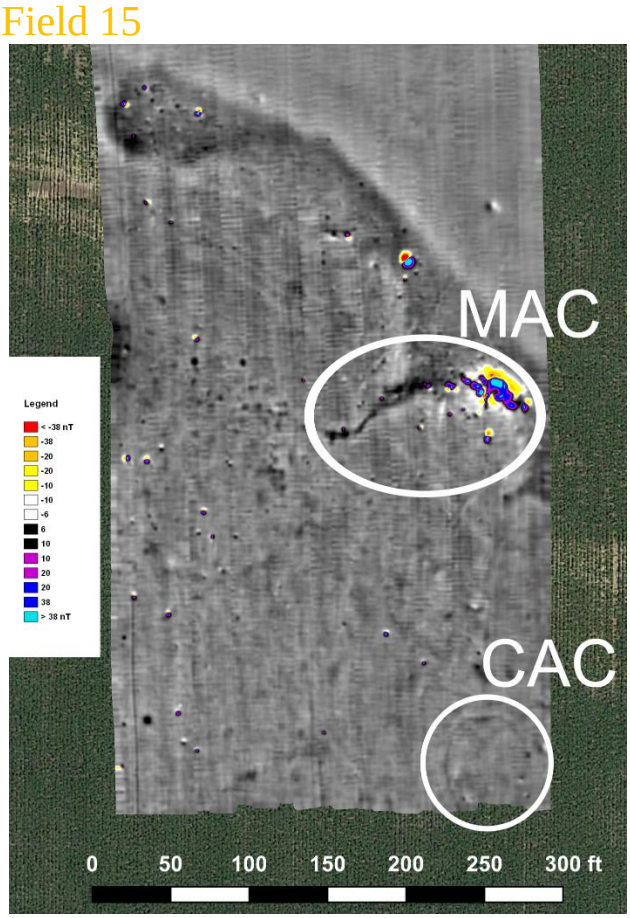


Figure 28. Magnetometry scan of field 15.

Summary of Field 15 Analysis

The area between the color legend and the circle labeled MAC could be cultural. The curvilinear dark area at the top of the image is a sandy ridge. The black area inside the MAC circle is a waterway. The colorful area is metal or a possible LIRM.

The only feature of interest in this field is the signature of an ovoid structure marked CAC. If this is an “oval house”, then it should have post molds in the perimeter. The absence of post molds in the perimeter and middle suggests this is not a “house” structure. The ovoid structure in field 14 has what appear to be post mold in the perimeter and internal roof supports consistent with RHs.

Field 15 is far to the North West of fields 9 through 14. See the field number image. (Figure 10).

The similarities between the two structures are obvious. (Figures 29 & 30). However, the feature in figure 29 is smaller than the feature in figure 30. The common cause of the two features could be the result of the movement of farm equipment. The differences suggest two different causes.

The feature in field 14, figure 29, appears to be an ovoid shaped "pole structure" with internal roof support. The feature in field 15 appears to be the remnant of an ovoid earthwork with an external ditch. The width of the external ring is 5.54 feet. This is narrow for large tractors. Adena round houses have been known to be as large as 90 feet. The largest diameter of both features is less than 70 feet.

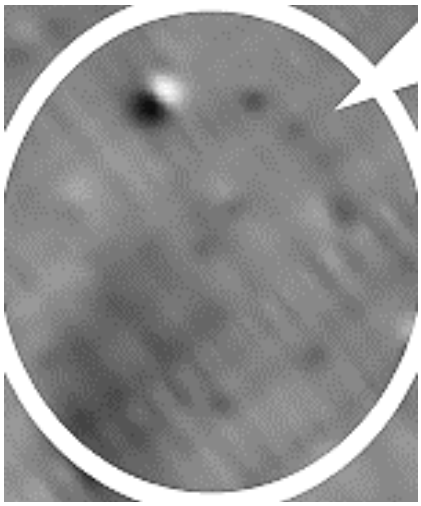


Figure 29. Ovoid feature field 14.

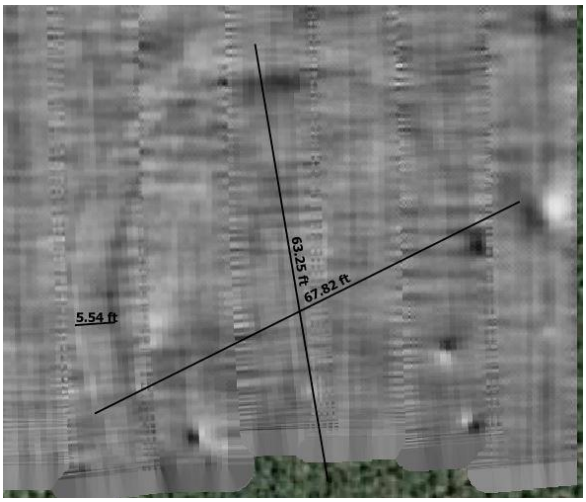


Figure 30. Ovoid feature field 15.

Both anomalies should be investigated. There is a possibility they are both "ovoid houses". Oval shaped structures in the late Woodland Period would be a unique discovery but not impossible. Many NA cultures which came after the Hopewell fluorescence constructed round, ovoid, square, and rectangular dwelling structures. The Algonquin people, found in the North East, particularly in New York State, built Long Houses. They were rectangular. These two structures, figures 29 and 30, could be a transition from round to ovoid. (Wickipedia).

Conclusions

The SENSYS magnetometry array and electronics is a cutting-edge system. It is capable of scanning exceptionally large areas of terrain in a fraction of the time of "walk behind arrays". The resulting magnetometry data is as good or better than the results of slow-moving arrays. It appears the sensitivity of the SENSYS array can detect magnetic anomalies at a greater depth than other technology.

The total number of acres scanned in the 7 “scan-days” is 223.451. See chart below.

#	Day	Hectors	Acres
1	Day 1	8.001	19.770
2	Day 1	3.841	9.490
3	Day 1	0.136	0.335
4	Day 3	8.677	21.440
5	Day 3	1.520	3.755
6	Day 4	6.224	15.379
7	Day 4	8.235	20.348
8	Day 5	1.343	3.319
9	Day 5	18.750	46.331
10	Day 8	11.196	27.665
11	Day 8	3.913	9.670
12	Day 9	1.618	3.998
0	Day 10	0.873	2.157
13	Day 10	2.730	6.745
14	Day 10	3.618	8.939
15	Day 10	9.757	24.110
	Total Scanned	90.429	223.451

Figure 31. Acreage Scanned.

The number of possible Native American, (NA), features discovered in this expedition appears to be greatest in the South East toward the Mississippi River and the city of Montrose. There were no large concentration of features suggesting a pre-historic village. Because the highest number of round houses were found closer to the city of Montrose suggests the modern city was constructed over the site/sites of a large NA concentration.

The fields available for scanning were determined by crop harvesting and permissions from landowners. The intent was to scan multiple fields in a wide pattern and follow the evidence for NA activity by evaluating the data on site within 12 hours of scanning. This was done by sending the data to Maryland for processing and filtering to remove noise and enhance the layered results. The data was then sent back to Iowa where it was analyzed and used to determine the following days scanning location. By spreading the scans over a wide area, the probability of locating a NA concentration in the region should be increased.

The total acreage scanned is a fraction of the possible locations for a large NA concentration. Scans 9 & 10 were on opposite sides of an exceptionally large field. This field should be completely scanned during a follow-up expedition because it is near the river and is close to areas where NA activity was located. Scanning inside the city limits of Montrose is not an option. It would be fruitless because of modern activity and the limited available open ground. However, there are outlying rural residences on the highest terrain in the area to the South and above the main part of Montrose proper. **The plots of open grass on top of the bluff would be ideal locations to search for a NA hilltop settlement.**

Summary:

This expedition was a success on several fronts. One, the SENSYS MV X3 magnetometry array functions very well in detecting variations in the magnetic field of the earth. The speed at which it can be moved over terrain is multiple times faster than other magnetometry systems available to archaeologists. This offers archaeologists and researchers the ability for high resolution magnetometry to be accomplished over large terrain areas to obtain high quality results in a fraction of time as opposed to older systems.

The discoveries of 2000 to 4000-year-old NA features in the SE of Iowa near the town of Montrose suggest there may be have been a high population center in the area. A future expedition applying this technology to other fields in this area could locate a high concentration of NA occupation. A large cluster of dwellings, pits, and CA in this area would be an important discovery. Here to for, the NA complex near Saint Louis, MO named Cahokia is thought to be the largest NA village in North America. The discovery of a comparable size NA population center in SE Iowa would be of great importance to North American archaeology and history.

Features Discovered:

Multiple signatures representing dwellings, pits, fire pits, storage pits, and circular earthworks. Conformation investigation and C-14 specimen collection is ongoing.

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