ALTOMAXX
CASE STUDY

COMPANIES	DRONE & SENSORS	LOCATION	APPLICATION
Northrop Grumman Altomaxx	DJI M350 RTK Zond Aero 500 GPR MagDrone R3	Jemez Mountains, New Mexico United States	Archeology Mapping

The Mimbres Culture Heritage Site is an important archaeological landmark tied to the Mimbres people, an ancient Native American community who settled the site more than a millennium ago, known for its distinctive pottery and settlement structures. Despite its historical significance and two periods of professional excavation, much of the site remains unexplored. The Mimbres Culture Heritage Site is owned and protected by the Imogen F. Wilson Education Foundation, a 501(c)3 not-for-profit organization, and all archaeological exploration rights are held by Archaeology Southwest.

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NORTHROP GRUMMAN   Measur

Northrop Grumman, is a leading global aerospace and defense technology company. As a trusted technology innovator, it pioneers solutions to equip customers with the capability to connect and protect the world and push the boundaries of human exploration across the universe. Since 2016, as part of its Technology for Conservation (T4C) initiative, Northrop Grumman has leveraged innovative and cost-effective technologies to address critical environmental conservation challenges, evolving partnerships with conservation organizations and providing new opportunities for employees. In 2023, the T4C initiative launched the Cultural Scans for an Interactive 3D Experience (SITEs) effort to scan and preserve important historical sites. In partnership with the New Mexico Humanities Council (NMHC), Northrop Grumman has scanned five key locations across New Mexico, with the Mimbres Culture Heritage Site being the fourth.

The Mimbres Culture Heritage Site, situated in the Mimbres River Valley in Grant County, New Mexico, was selected due to its need for preservation and its potential for further discovery as the only publicly accessible interpreted Mimbres archeological site. Another factor in the selection was the isolated location, which creates financial challenges for researchers looking to uncover buried structures or artifacts crucial to understanding the Mimbres people and the site's history.

Focused on uncovering subsurface features, Northrop Grumman conducted initial research and identified ground-penetrating radar (GPR), magnetometers, and unmanned aerial vehicles (UAV), as the most effective non-invasive tools to leverage in this process.

As Northrop Grumman looked into solutions and potential technology partners for this work, Measur stood out as a leading name in drone technology. Measur then connected the Northrop Grumman team with its partner, Altomaxx, a provider of advanced drone-based services. Altomaxx, was excited by the project and brought technical expertise and advanced equipment to the collaboration.

"This use of the drone-based magnetometry and GPR for the purpose of Southwest Archaeology is quite unique; this project can conceivably provide useful benchmarks for its use in the future."

- Bill Hudson, President and Tour Guide Historian at Mimbres Culture Heritage Site

PROJECT OVERVIEW

The field scans took place over three days (November 12-14, 2024), emphasizing regions that previous excavations had not fully explored.

Altomaxx deployed the MagDrone R3 Magnetometer and Zond Aero 500 GPR, mounted on a DJI M350 RTK. Data were collected continuously, with precise georeferencing from the SkyHub onboard computer and real-time GPS corrections from a DJI RTK-2 GNSS station.

"Heritage projects are nothing new to Altomaxx, as we have done projects on multiple continents around the globe capturing data sets that can help unearth history. So the opportunity to collaborate with Northrop Grumman and Measur on this project was a natural fit, and one we were glad to utilize our experience to obtain optimal results."

- Jared Seufert, Senior Manager of Operations at Altomaxx

For data collection, the survey area was divided into ten sections. To ensure thorough spatial coverage of the entire area, each section was flown in two perpendicular directions, north-south and east-west. The GPR survey lines were spaced one meter apart, while the magnetometer lines were spaced two meters apart.

WHY THE MAGDRONE R3 & ZOND AERO 500 GPR ON DJI M350 RTK?

These advanced geophysical sensors were chosen for their complementary capabilities in collecting detailed subsurface data.

The Zond Aero 500 GPR, with a 500MHz center frequency, provided up to 13 feet of penetration in average soil, allowing for subsurface imaging.

The SENSYS MagDrone R3 Fluxgate Magnetometer, with a measurement range of +/- 75,000 nanoteslas (nTs) and a three-axis sensor, ensured precise magnetic data.

To navigate the dense vegetation in the survey area, the payloads were operated using manual flight patterns. The GPR was flown at an average speed of 1 m/s, while the Magnetometer was flown at 2 m/s. Both sensors continuously collected data throughout the flights and were flown as close to the ground as safely possible to maximize data quality, and flight parameters were tailored to each sensor's requirements.

The sensors were mounted on the DJI M350 RTK drone, chosen for its advanced capabilities, including long flight endurance and real-time GPS corrections. This combination ensured stable flights and precise georeferencing.

DATA PROCESSING WORKFLOW

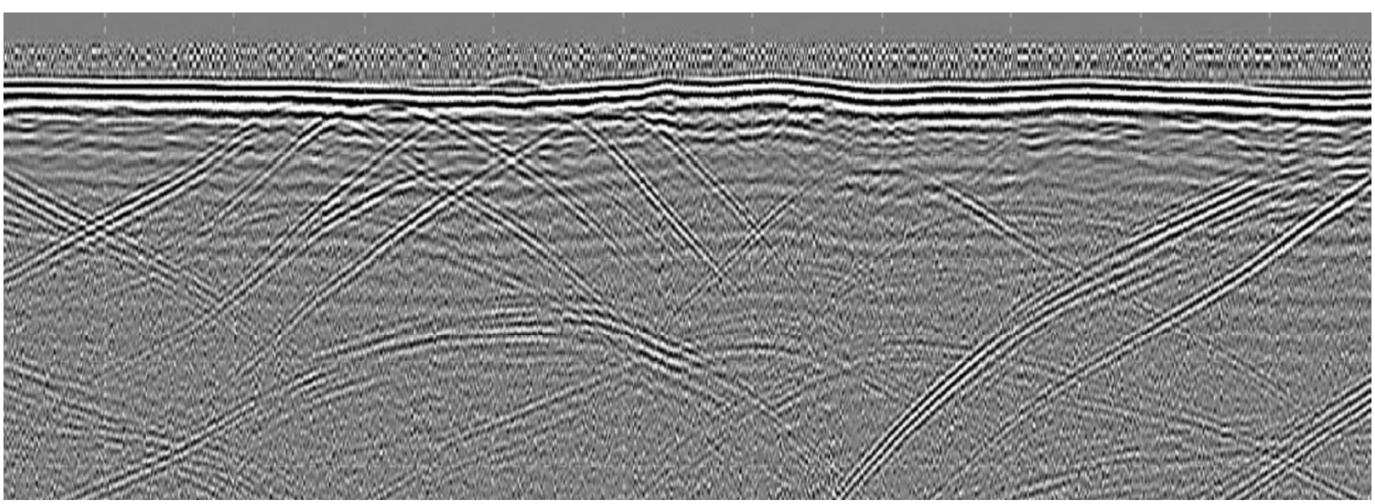
Ground Penetrating Radar (GPR)

Raw GPR data collected during the survey were imported into Geohammer for initial processing. This stage involved removing flight path segments associated with takeoff, landing, and turning maneuvers at the survey area's edges to ensure that only relevant data remained.

The cleaned dataset was then processed using Prism2.70, where a series of filters were applied and adjustments made to enhance data quality, including:

- Background removal filter to eliminate linear noise
- Gain adjustment to improve data visibility
- High-pass sharpening filter to reduce low-frequency noise and suppress horizontal banding caused by system artifacts
- Band-pass filter to retain mid-range frequencies and eliminate high- and low-frequency noise
- Final gain adjustment to optimize data for interpretation

Interpretation of the GPR data was complicated by dense vegetation, including trees, yucca, and cholla plants. The vegetation introduced air-wave reflections (i.e., signals bounced off nearby surfaces before reaching the receiver), contributing noise to the dataset (as shown in the image below). Anomalies identified during processing were tagged in Geohammer for further review, which led to identifying locations that may hold buried artifacts. Final results were exported in KML format to support additional spatial analysis.



Air-wave reflections from nearby vegetation

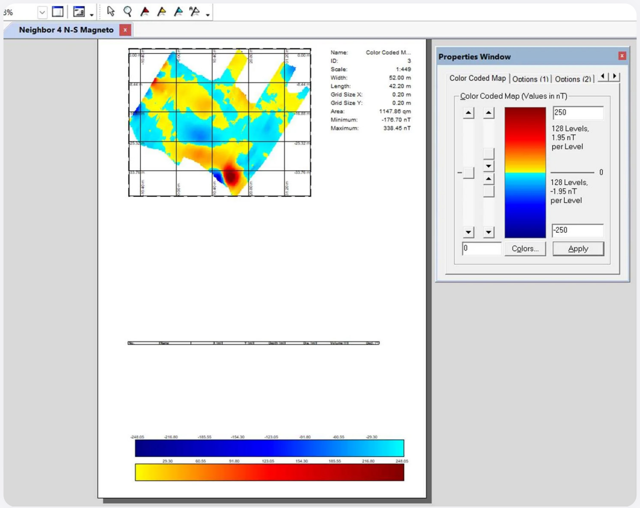
Magnetometry

Magnetometer data, recorded in MDD format, was initially imported into the MagDrone Data Tool for preliminary processing. Non-essential flight segments, such as takeoff, landing, and short turns along the survey grid's perimeter were removed to isolate the core dataset. The refined data was then exported in UXO64 format for further processing.

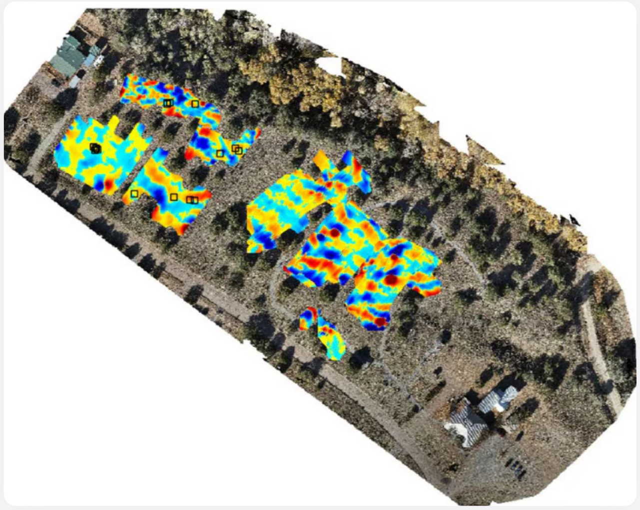
Subsequent analysis was conducted using Magneto software. Magnetic anomalies were evaluated based on their strength, measured in nanoteslas (nTs). The data scale was adjusted to detect more subtle magnetic variations, enabling the identification of smaller anomalies. For larger or more distinct features, the "Object Search Total Field" tool was used to estimate the depth and size.

Upon completion of this analysis, a magnetic anomaly map was generated and exported in TIF format. This file was then imported into QGIS for spatial visualization and integration.

All GPR survey lines and magnetometer heat maps were ultimately exported as TIF files and overlaid onto an ortho-mosaic map created from aerial imagery captured on the final day of the scan (November 14). Using QGIS, these layers were accurately aligned to visualize the surveyed areas and the precise locations of identified anomalies. This geospatial integration enabled a more comprehensive interpretation of the data within the physical landscape of the site than would have been possible using any of the components individually.



Magneto example with Nanotesla scale

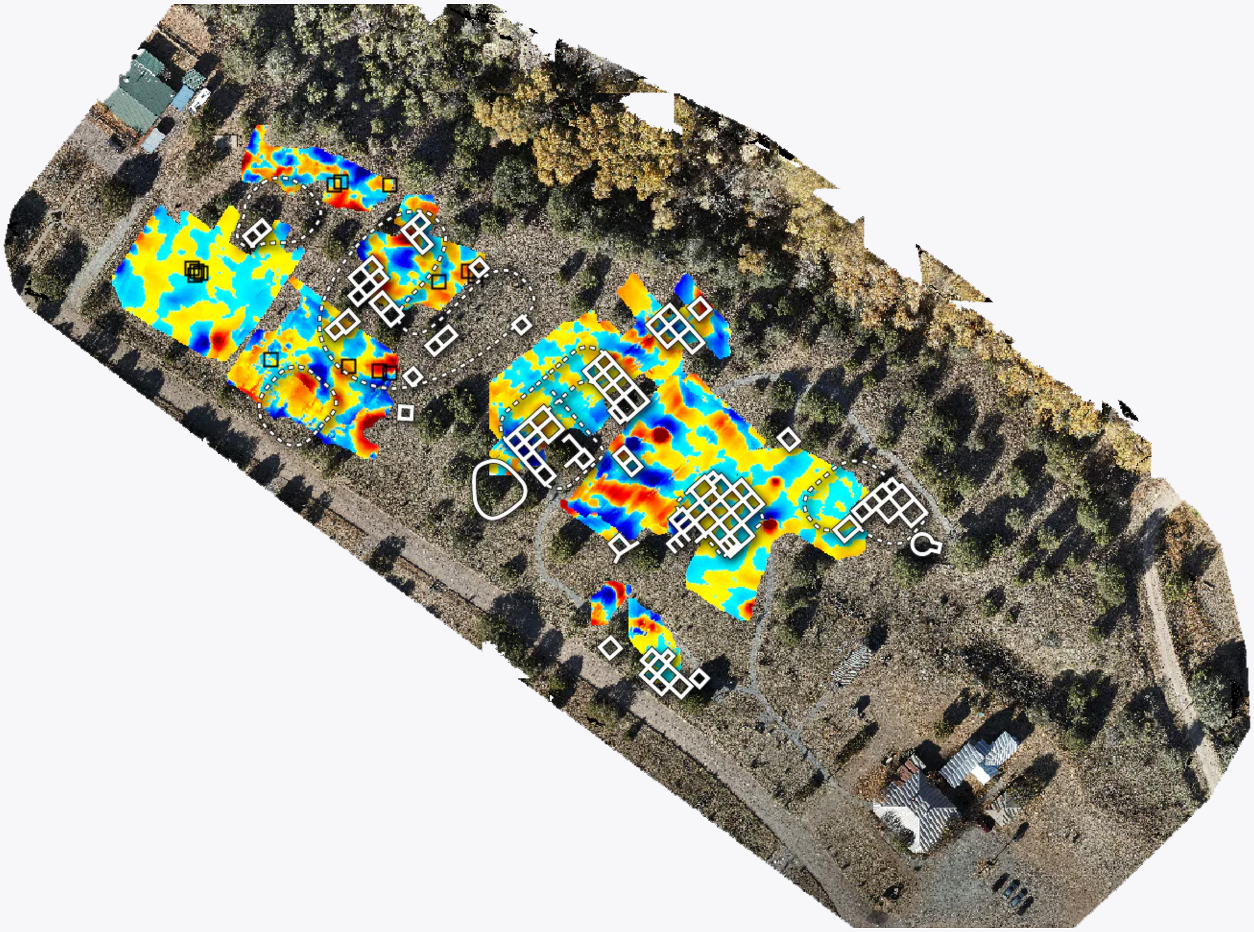


Magneto example with Nanotesla scale

FINDINGS

Altomaxx's analysis derived several key insights and actionable recommendations from the geophysical survey. Interpretation of ground penetrating radar (GPR) data was made more difficult by dense vegetation, which introduced signal noise and air-wave reflections. Despite this, the refined GPR data provided invaluable information on the location of buried objects. Meanwhile, magnetometer data proved highly effective, detecting metallic objects and identifying magnetic anomalies potentially associated with human activity, likely influenced by the volcanic composition of construction materials.

To address the limitations posed by vegetation and to further enhance surface feature detection, the use of aerial LiDAR (Light Detection and Ranging) is recommended. This technology offers the ability to penetrate forest canopy and capture subtle topographic variations, supporting a more nuanced understanding of site layout and archaeological potential.



Anomalies detected by GPR and magnetometry scans, mapped to known subsurface structures

"The use of aerial LiDAR (Light Detection and Ranging) technology could help mitigate the effects of vegetation by providing a more detailed view of the surface topography. LiDAR could reveal subtle mounds, dips, or other surface features that may not be visible to the naked eye, further enhancing the overall understanding of the site".

- Jared Seufert, Senior Manager of Operations at Altomaxx

As part of the research, Altomaxx produced the following deliverables:

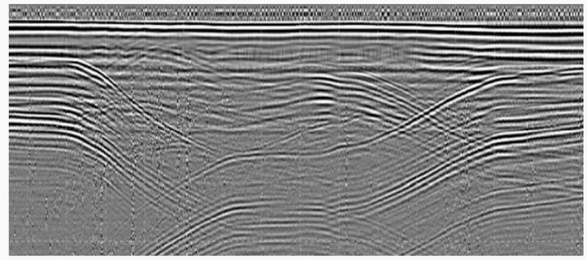
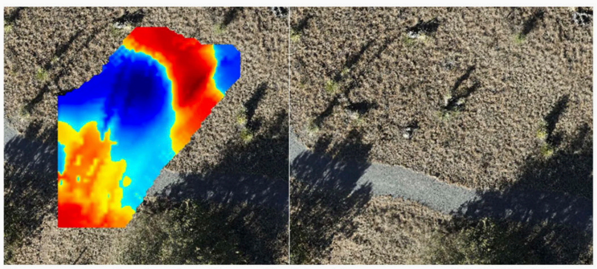
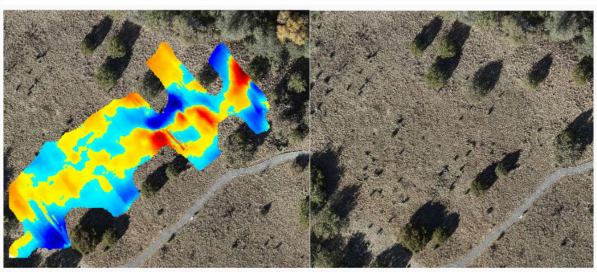
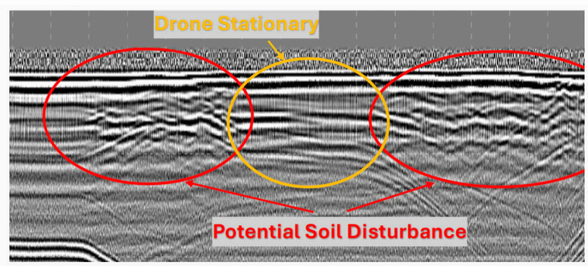
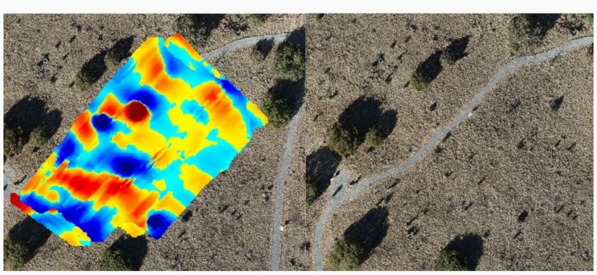
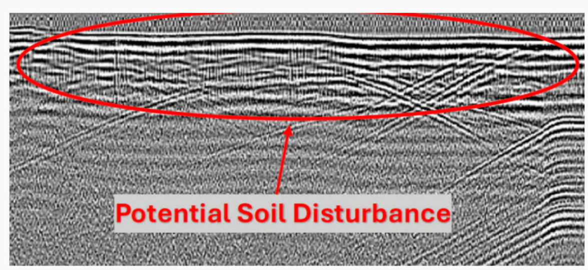
Comprehensive Magnetometry and GPR Survey Results:
Provided across key locations.

Detailed Magnetometry Maps
Provided for each survey area, highlighting significant magnetic anomalies and zones of interference and including anomalies contextualized against both natural elements (e.g., vegetation, trees) and cultural features (e.g., pathways, signage, fences).

Targeted (GPR) Data
Collected in areas where vegetation and terrain permitted; note: Though many readings were affected by surface-level interference, some indicated possible subsurface disturbances of archaeological interest.

Anomaly Interpretation and Object Detection Analysis
Analyzed both magnetometry and GPR data to look for any signal differences that stood out from the background, such as differences in magnetic field strength and ground permittivity.

DATA SAMPLES

Survey Area	Magnetometry Findings	GPR Findings
400 Room Block	 Strong NW signal (-675 to 2321 nT); cross patterns in South/SE possibly from flight lines	 Heavy vegetation interference; GPR largely inconclusive
410 Pit House	 Strong magnetic signal on the north side of the scan area (-150/150nT) could indicate a pathway or an anomaly beneath the nearby yucca plants, some magnetic strength noted along the south end, likely caused by the fence line	Not collected due to dense vegetation
Great Kiva & 200 Room Block	 Strong central, NE, SE signals; possible object ~4.32m deep, 2814L, 1.75m diameter	 Disturbed soil N line; possible anomalies unrelated to vegetation
Central Plaza (Priority 3)	 Strong East/SE anomalies (-1912/6967 nT); structural remnants in South possible	 SE corner soil disturbance; vegetation interference elsewhere

CONCLUSION

The Mimbres Culture Heritage Site remains a crucial yet underexplored archaeological gem. The collaboration between Northrop Grumman, the NMHC, Measur and Altomaxx has proven invaluable in advancing the understanding of this site through non-invasive technologies such as GPR and magnetometry.

Even with challenges such as dense vegetation, the data collection results highlight the site's rich potential for further discovery. The integration of advanced technologies used for this effort not only enhances knowledge of the ancient Mimbres people but also sets a precedent for future archaeological efforts.