



Warwick Furnace: Lost & Found Using UAS- Magnetometer and 3D Electromagnetics

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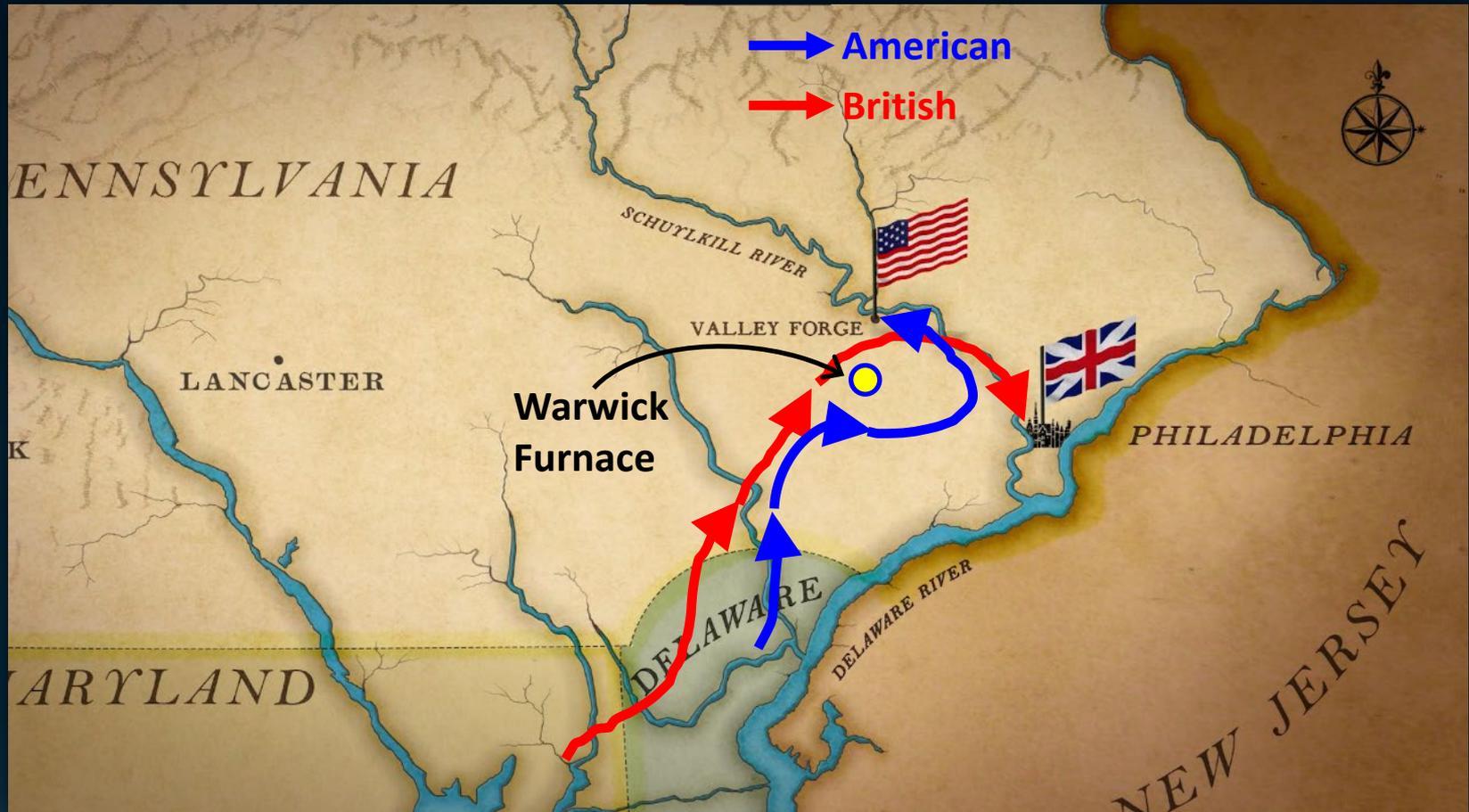
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**white river
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American Revolution: Fall of 1777

Washington's Retreat: Brandywine to Valley Forge



American Revolution: Fall 1777

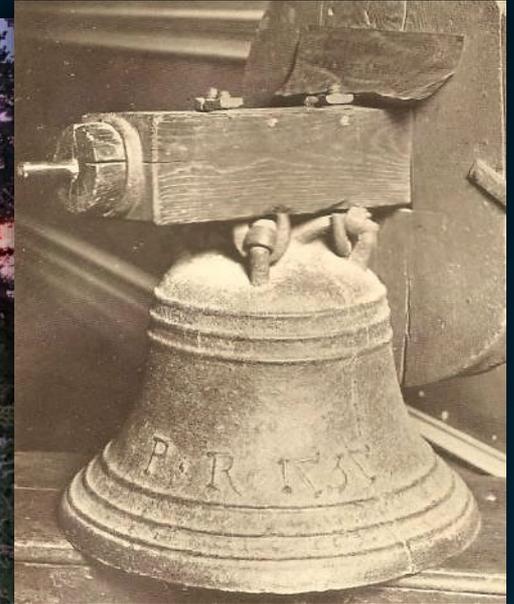
Warwick Furnace: Forging & Proving Cannon



American Revolution: Fall 1777

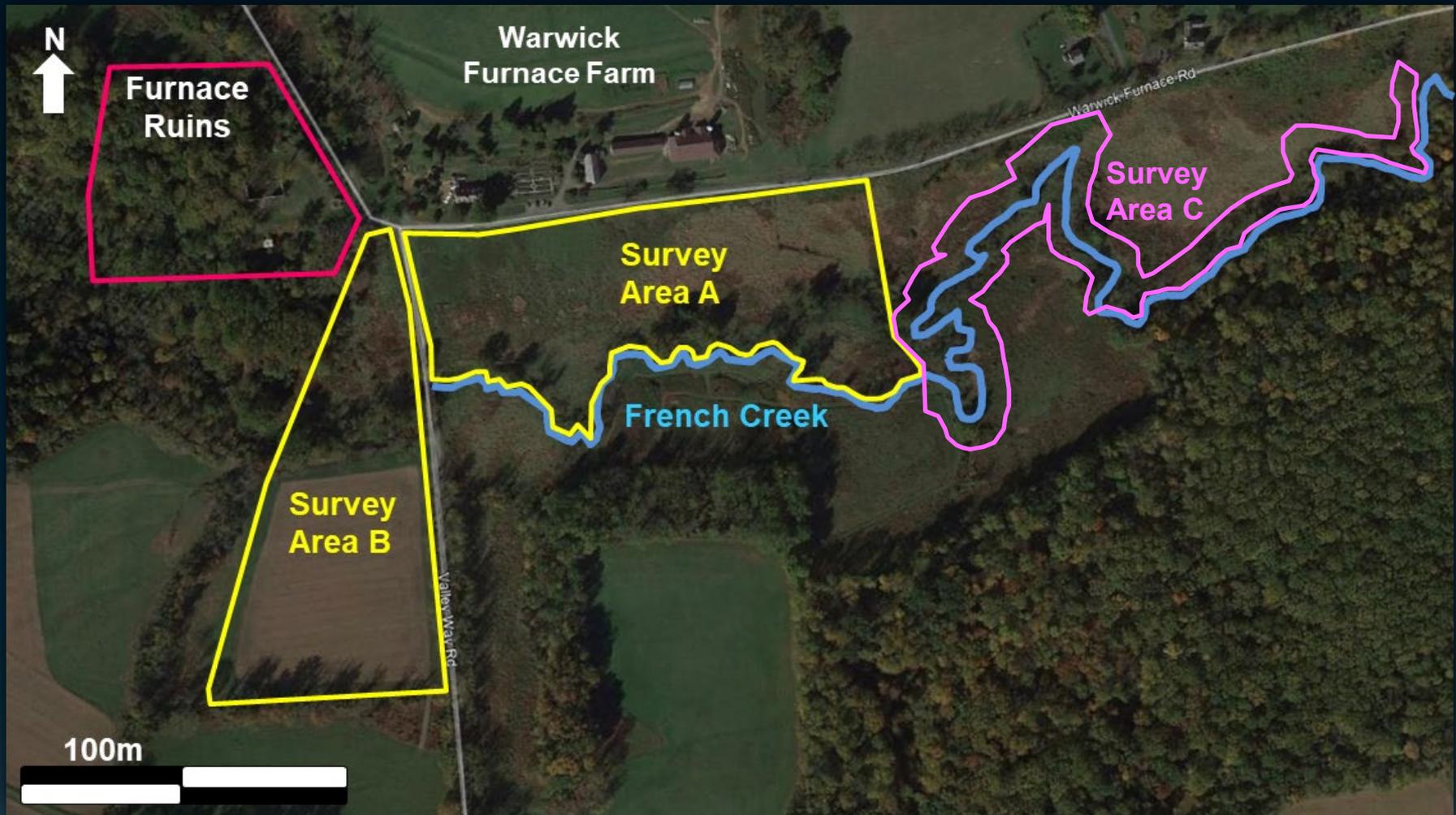
Bury All Cannons at Warwick Furnace:

when the Hessians were passing through the town, the bell was rung to summon the citizens to bury the cannons cast at the furnace that were awaiting delivery to the Continental Army.



Objective: Find The Cannon

250 Years After Hasty Burial, Rediscover Warwick Cannon



Drone Magnetometer Surveys

UAS-based Magnetic Sensor Payload

- Combines Mini-Atomic MAGs, RTK-GPS, IMU, Radar Altimeter, Telemetry, Processing
- Heavy-lift UAS (1-10 kg payloads)
- Automated airframe & survey control



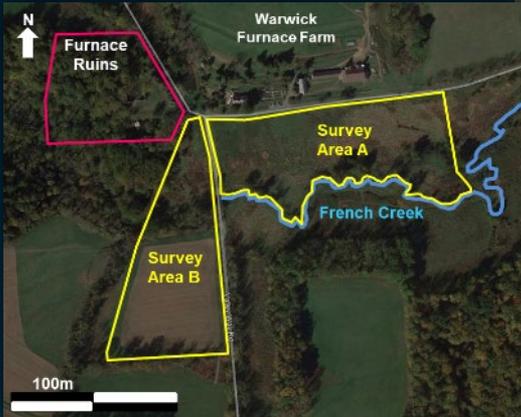
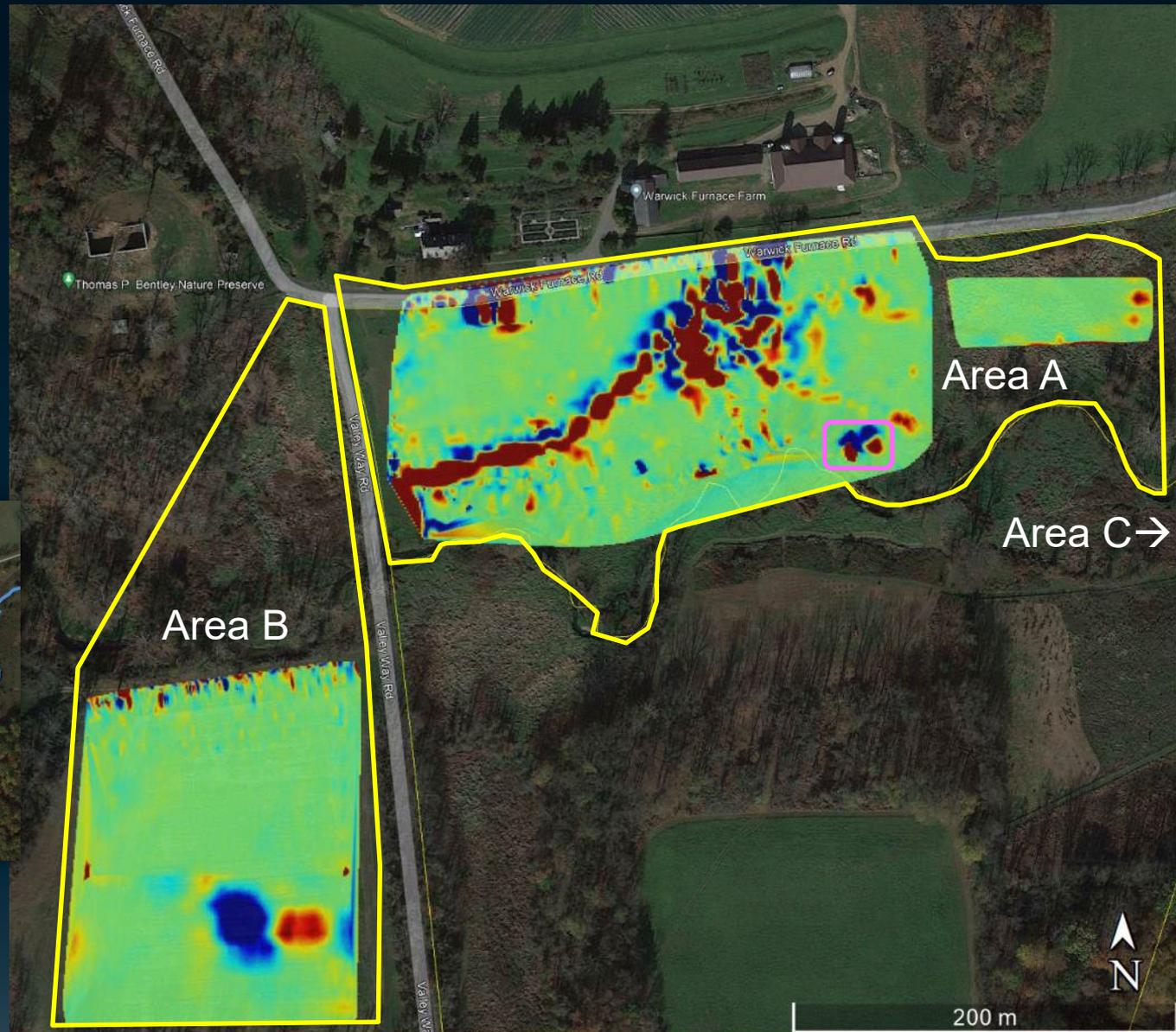
Field Data Collection (video)



MagPi Anomaly Map

UAS-MAG

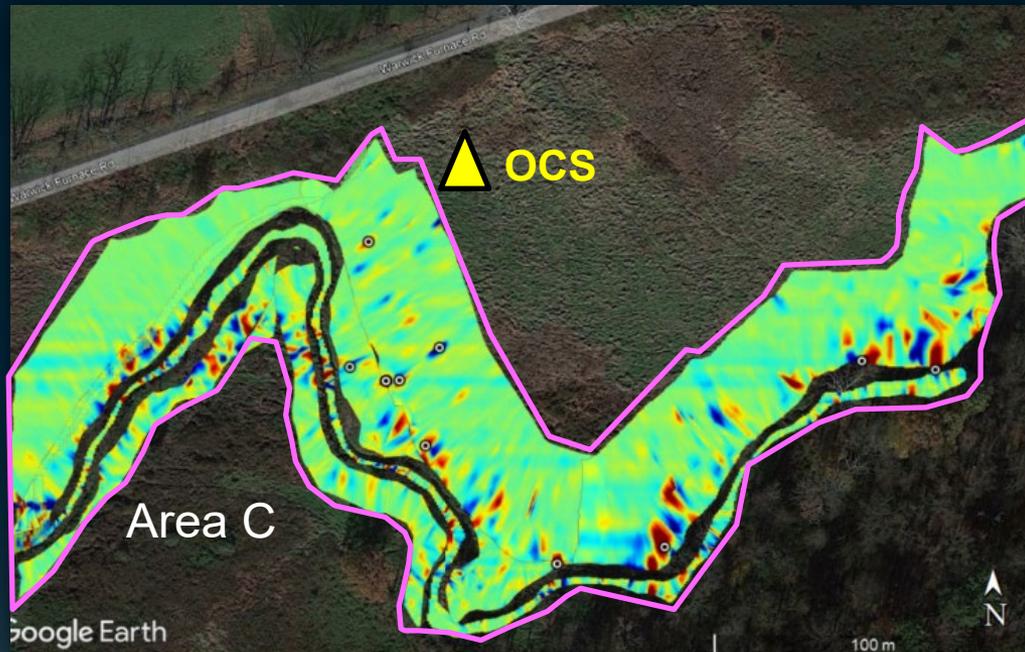
- 3 Primary Areas
- Full Coverage
- 68,800 m²
- ~17 acres



MagPi Ground Surveys

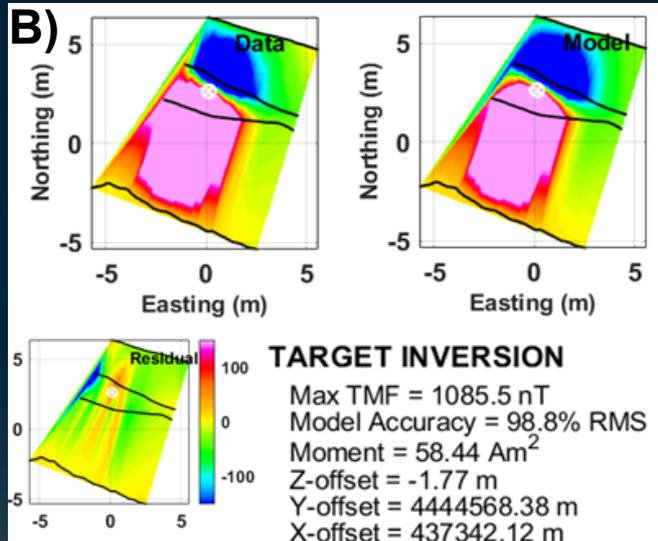
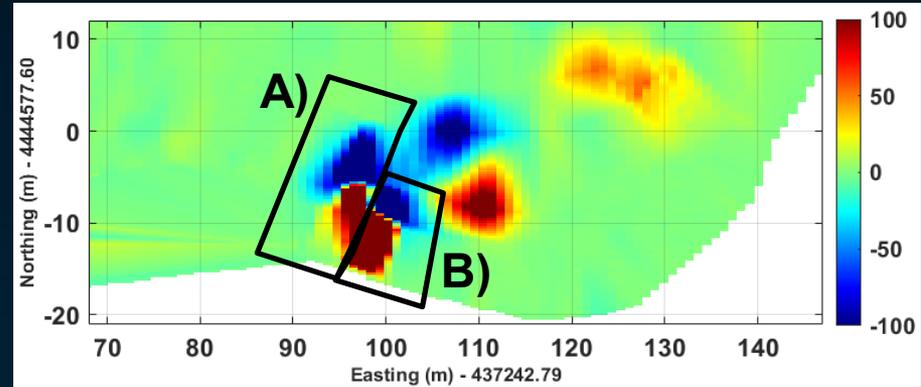
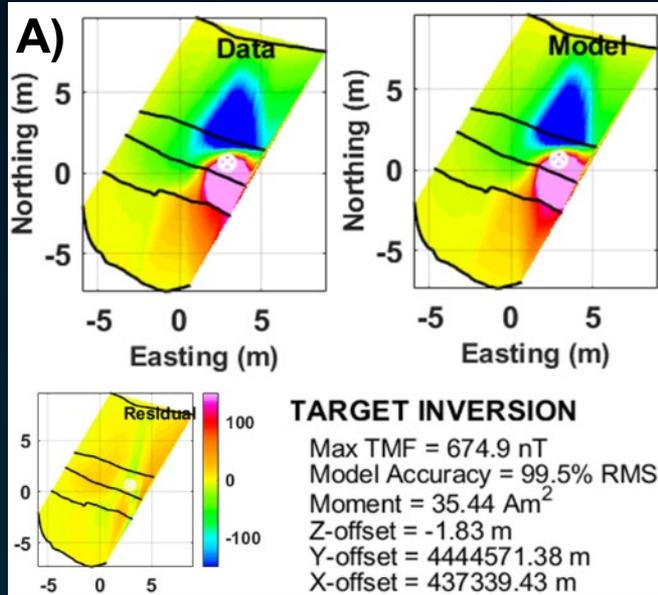
Areas Inaccessible to UAS

- Hand-carried in & along banks of French Creek (Area C)
- Simultaneous real-time telemetry from multiple units to OCS



MagPi Inversions

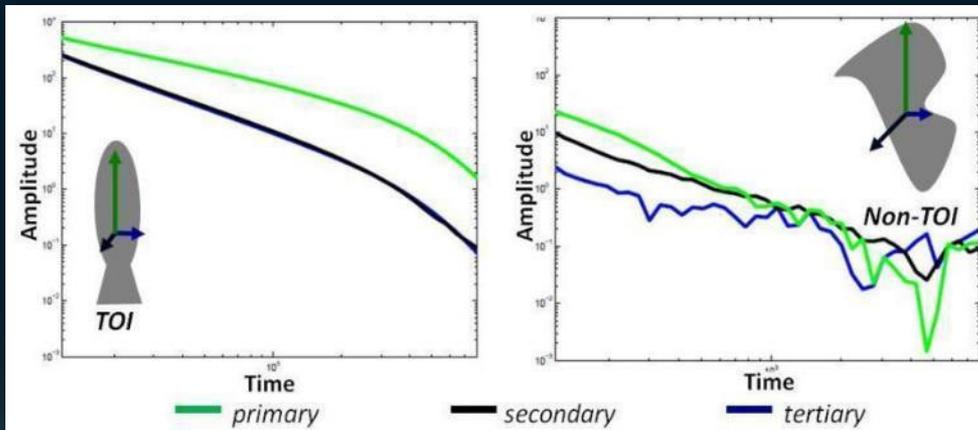
Inverted MAG Anomalies



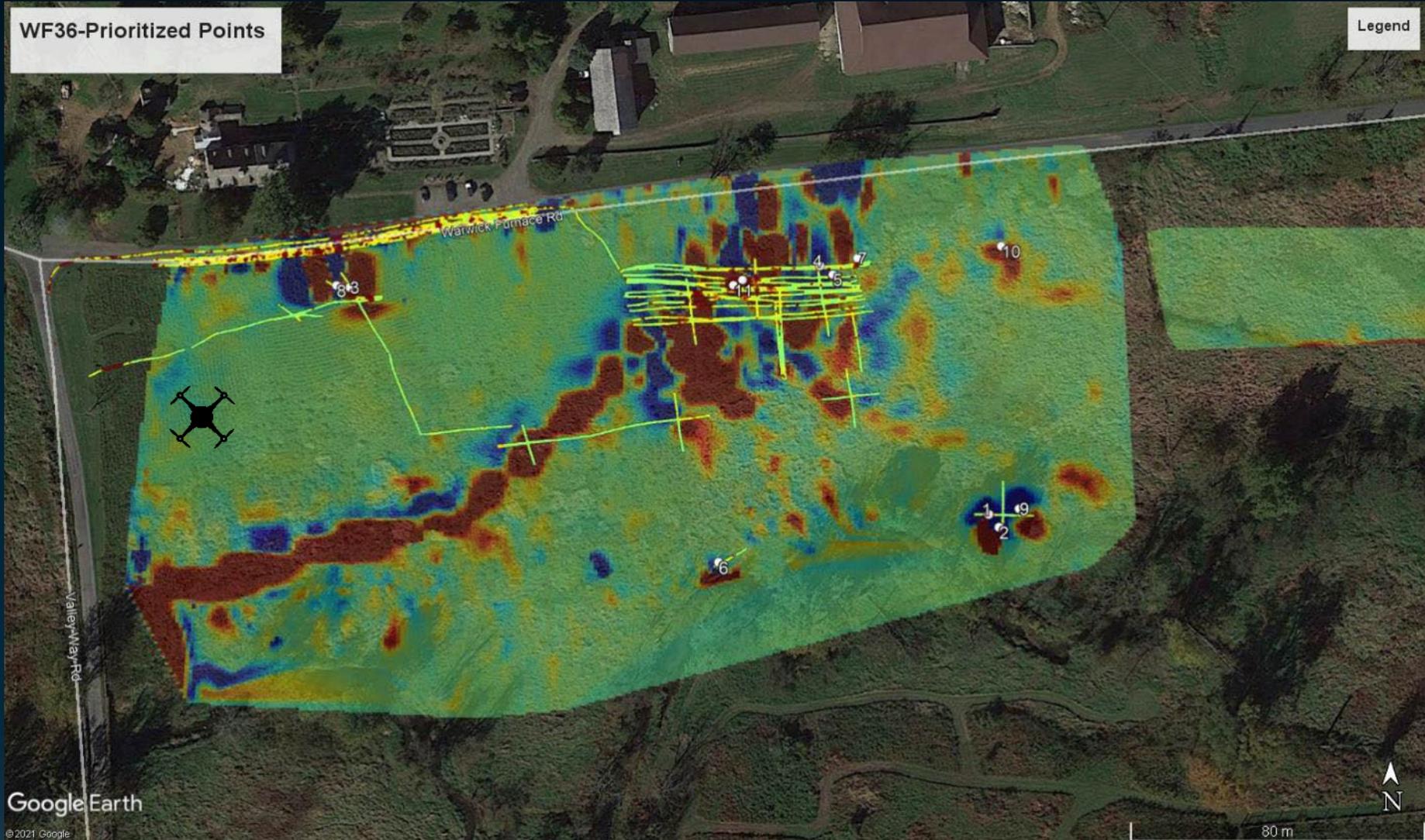
APEX 3DEM: Object Classification

Controlled Source 3D Cart Unit

- Triaxial EM Transmitters
- Array of Multi-axis Receivers
- Dynamic Classification Analyses
- Inverted Parameters Unique
- Yield Intrinsic Features: *size, shape, composition, metal thickness*



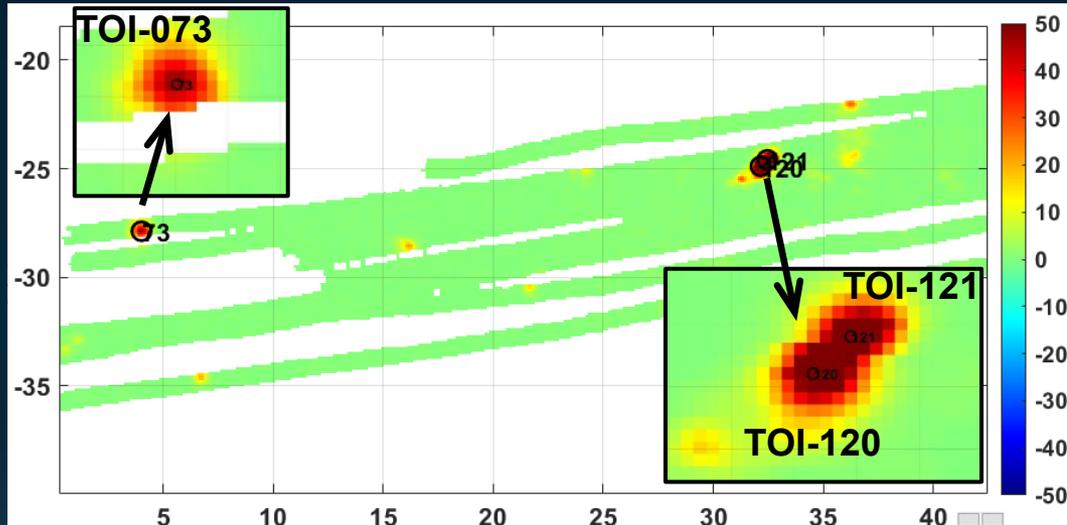
MagPi + APEX Combined



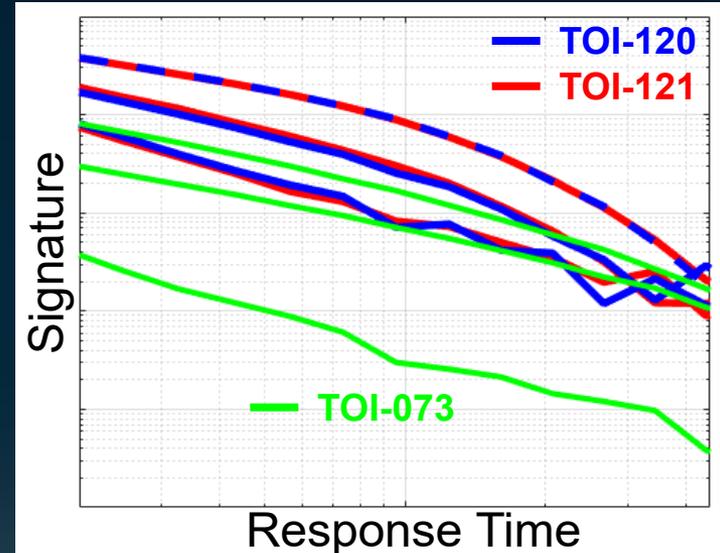
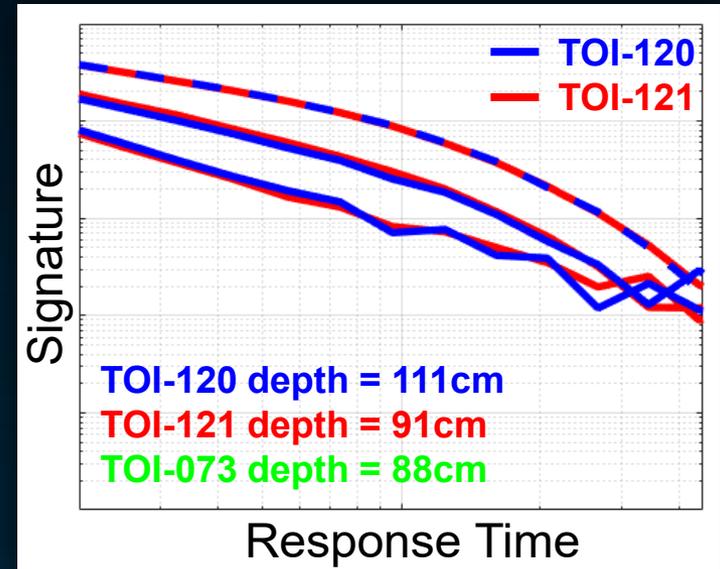
APEX 3DEM Inversions

Inverted Target-of-Interest Signatures

- Same Signatures for TOIs 120 & 121
- Likely large iron-rich cylinders
- Smaller Irregular TOI-073
- Listed as highest priority items to dig first



TOI 120 & 121 Are Same Object Type



Prioritized Dig List

12 Dig Locations Recommended

- Based on MagPi & APEX Inversions
- First 5 Dig Locations Resulted in Discoveries
- 4 Cannons Were Discovered
- Cannonball and Other Artifacts Were Also Found



Dig Site #1

First Dig Site Uncovered a Cannon (and Cannonball)



DISCOVERY: Dig Sites

Warwick Cannon (4500-4800 lbs each)



Synopsis

- Washington's cannon suspected to be hidden at Warwick Furnace in Fall of 1777 (246 years ago)
 - Little known of MAG or EM signatures
 - Efficient combination of unmanned airborne MAG, limited ground MAG, and high-resolution APEX 3D-EM deployed
 - Unique characterizations from “advanced geophysical classification” inversions using APEX 3D-EM
 - Prioritized dig-list resulted in discovery of cannon and artifacts at first 5 locations
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Acknowledgments: GES, F&P CCT, Moose Meadows Properties

Ray Bentley & Jim Moore

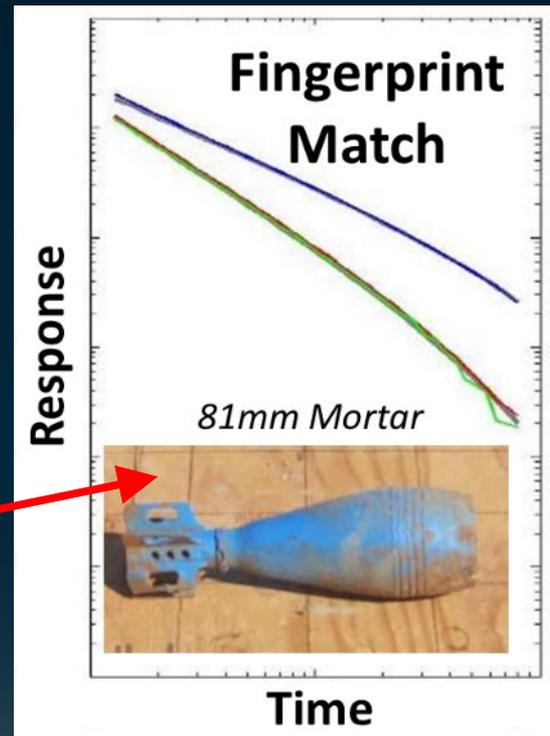
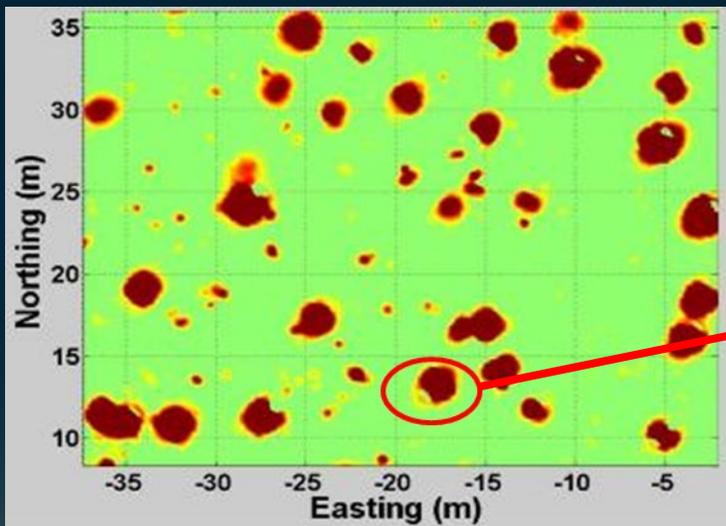


Steph Grillo (GES)

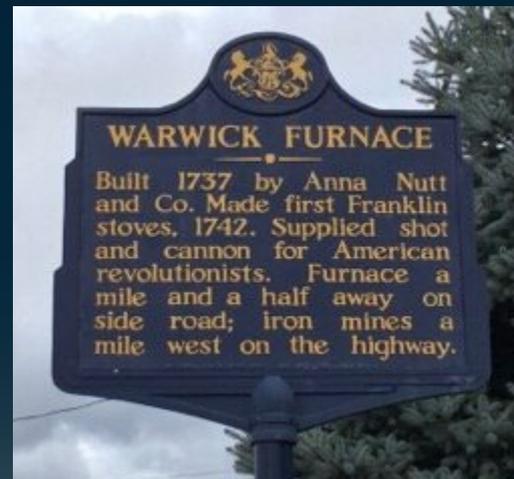


APPENDIX

APEX 3DEM



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