Evaluating Mobile Device Hardware Differences, in MagMapper Surveys, for Locating Orphan Wells

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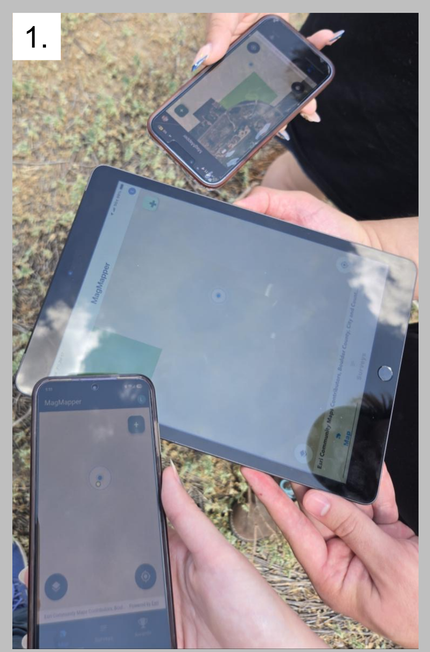
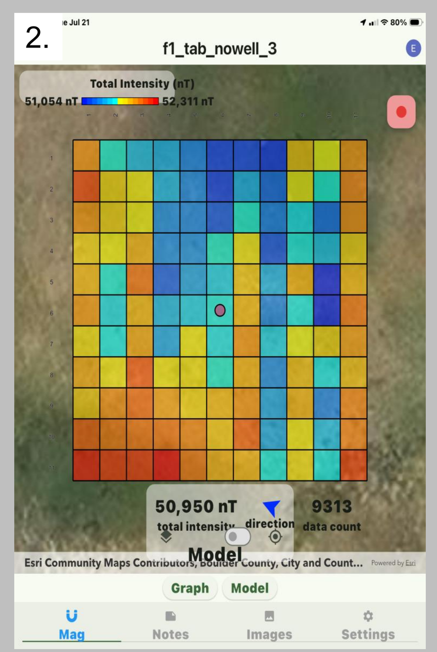
BACKGROUND

Ground-based magnetic surveys can locate buried **orphan wells** by detecting the strong magnetic anomalies produced by their steel casings. While professional backpack and drone **magnetometers** are highly effective, they are expensive and cumbersome in challenging terrain. **Crowdsourcing** surveys with consumer smartphones via apps like **MagMapper** offers a low-cost alternative for **citizen scientists** (everyday community members participating in data collection). Smartphones, however, were not built for geophysics. Variations in magnetometer hardware, internal shielding, GPS precision, and operating system architectures (Android vs. iOS) introduce unknown levels of **"noise"** and **spatial distortion**.

- **Research Question:** How do smartphone OS and hardware differences affect background noise and spatial accuracy in magnetic surveys?
- **Objective:** Quantify platform trade-offs to establish the calibration data needed to integrate citizen science surveys into federal orphan well models

METHODS





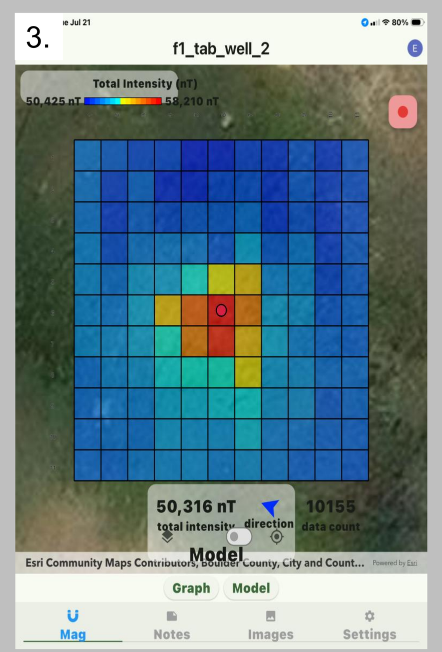


Figure 1 (Mobile Hardware): Tested three distinct mobile device classes running the MagMapper app:
iOS Smartphone: Apple iPhone (Cassandra, Top)
iOS Tablet: Apple iPad (Daniel, Middle)
Android Smartphone: Samsung Galaxy series (Lexy, Bottom)
Figure 2 (Well Grid Control Example): Survey 3 of MagMapper 11 X 11 grid heatmap recorded at the magnetically quiet Flagg Park control site (iPad).
Figure 3 (Well Grid Example): Survey 2 of MagMapper 11 X 11 grid heatmap recorded over the target orphan well site (iPad).

1. Field Collection

Location: Field surveys conducted at Flagg Park over a known orphan well casing (test site) and an adjacent clear zone (control site).
Grid Setup: Established uniform 2m X 2m grid paths (11 X 11 matrix) over target survey zones.

2. Field Data Collection Protocol

Trial Surveys: Conducted 5 survey trials per device category at the orphan well site and 5 trials at the control site (30 total surveys compiled across hardware types).
Synchronized Execution: To control for atmospheric and environmental variables, team members recorded surveys at the same times.
Data Streams Captured: Recorded continuous magnetic intensity (nT), 3D tri-axial vector components (X, Y, Z), GPS coordinates (latitude, longitude), and sampling frequencies.

3. Data Processing & Spatial Pipeline

Custom Python Architecture: Developed a standardized processing pipeline (pandas, matplotlib, seaborn) to parse raw MagMapper exports across varying OS column structures.

RESULTS

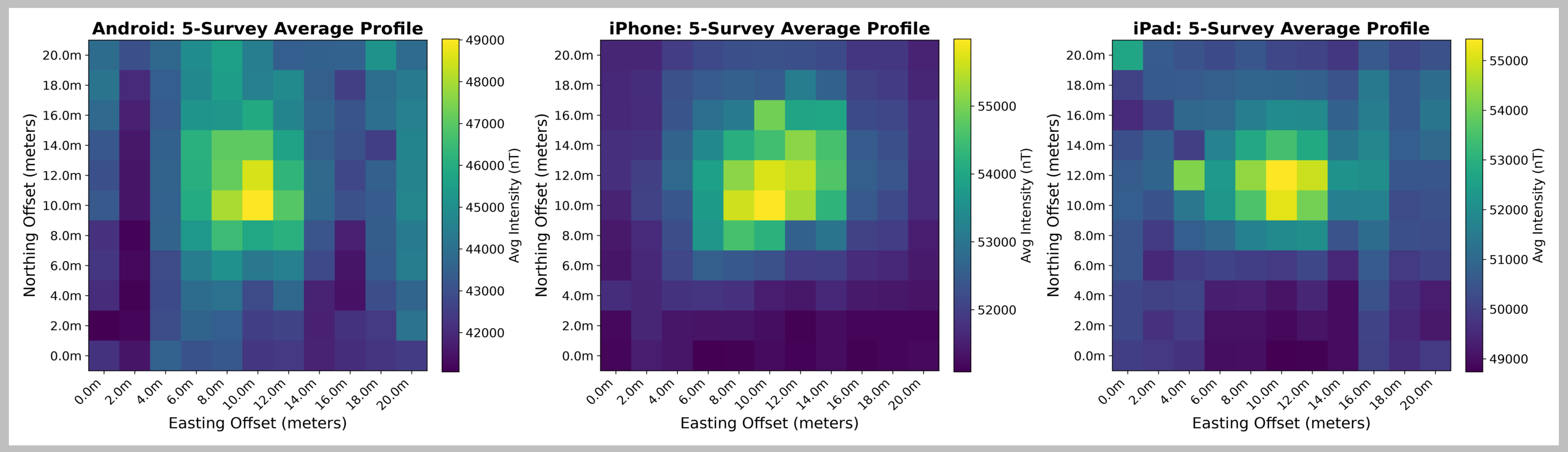


Figure 4 (Platform Anomaly Heatmaps): Multi-trial average heatmaps showing relative field intensity (nT) across the grid. Despite absolute baseline shifts, all three hardware types identify the strong, localized magnetic anomaly directly over the well casing.

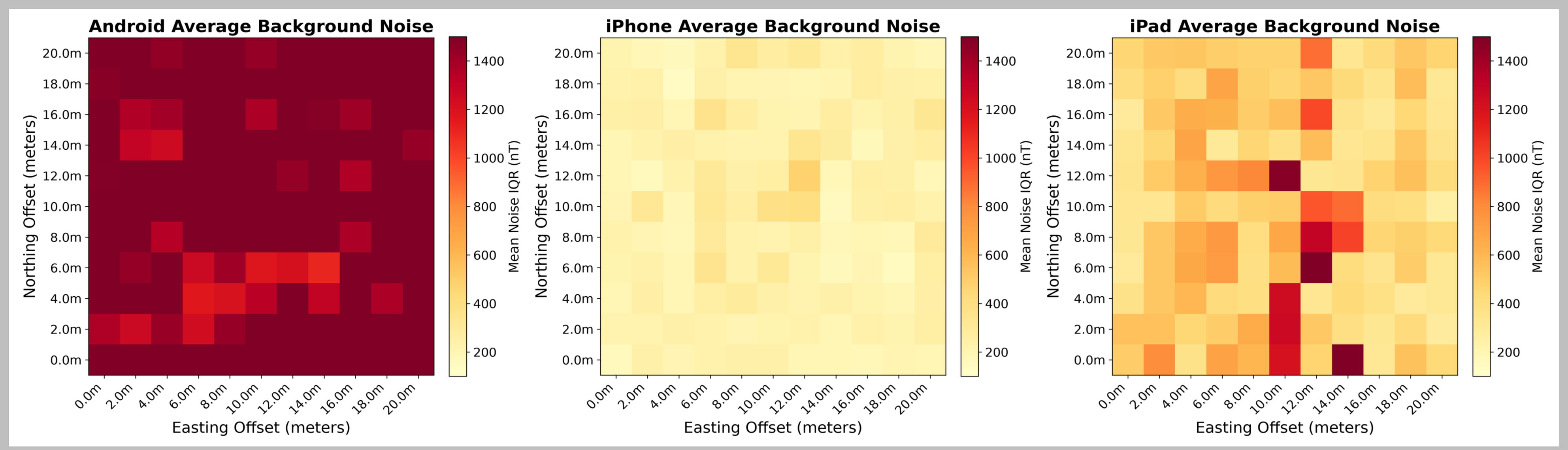


Figure 5 (Hardware Interquartile Range (IQR) Noise): iPhone displays ultra-low internal noise (< 200 nT IQR). iPad exhibits moderate noise with localized spikes (≥1,400 nT) from turning/heading artifacts. Android shows high systemic noise (1,200 to 1,500+ nT) across the entire grid.

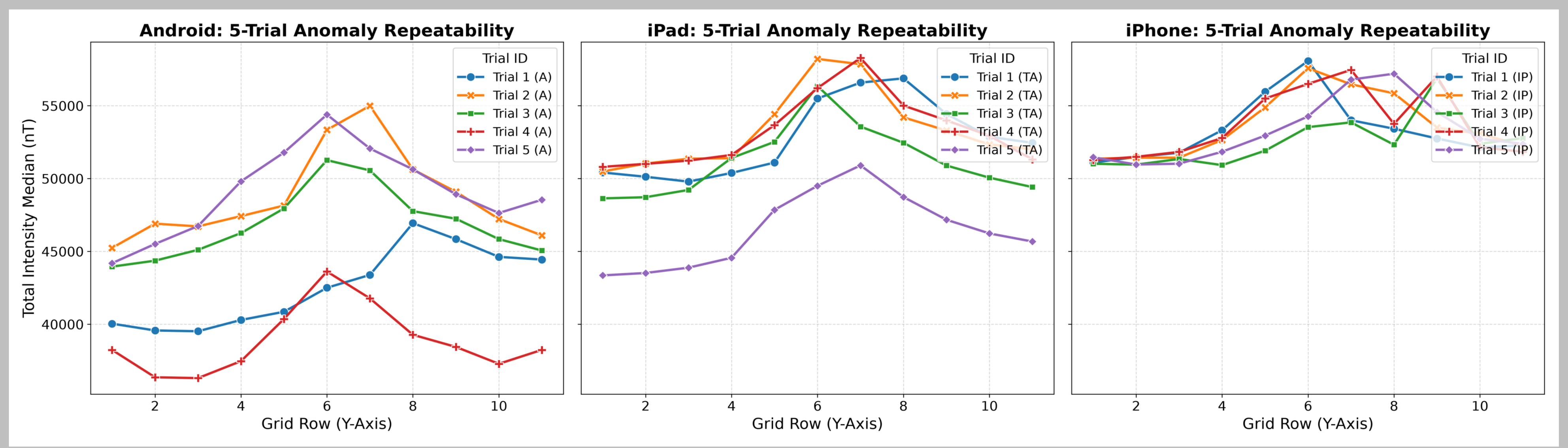


Figure 6 (Trial-by-Trial Repeatability & Baseline Drift): Individual 5-walk line profiles (sliced along Column 6) reveal platform stability differences. While iPhone exhibits tight, overlapping repeatability across all trials (±250 nT), Android experiences significant walk-to-walk baseline drift (8,000 nT vertical spread). Crucially, every individual trial across all devices successfully recovers the peak anomaly at Grid Rows 6–7.

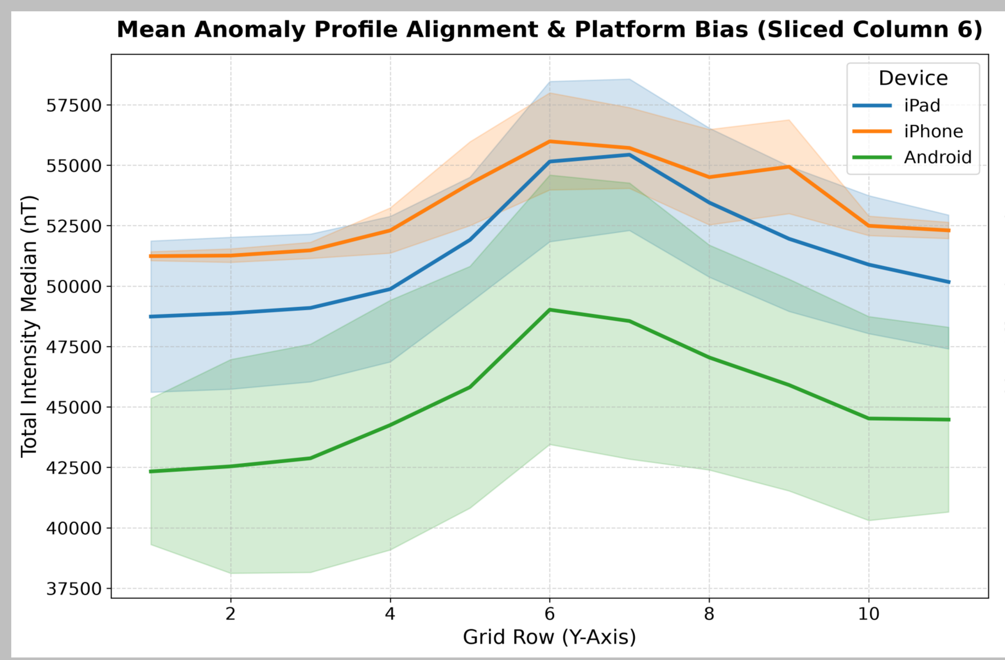


Figure 7 (Anomaly Profile & OS Baseline Shift): All three platforms cleanly capture the anomaly peak at Grid Row 6 (sliced along Column 6 over the well casing). Android demonstrates a systematic 8,000 nT DC offset lower than iOS devices (43,000 nT vs. 51,000 nT), highlighting the need for baseline normalization.

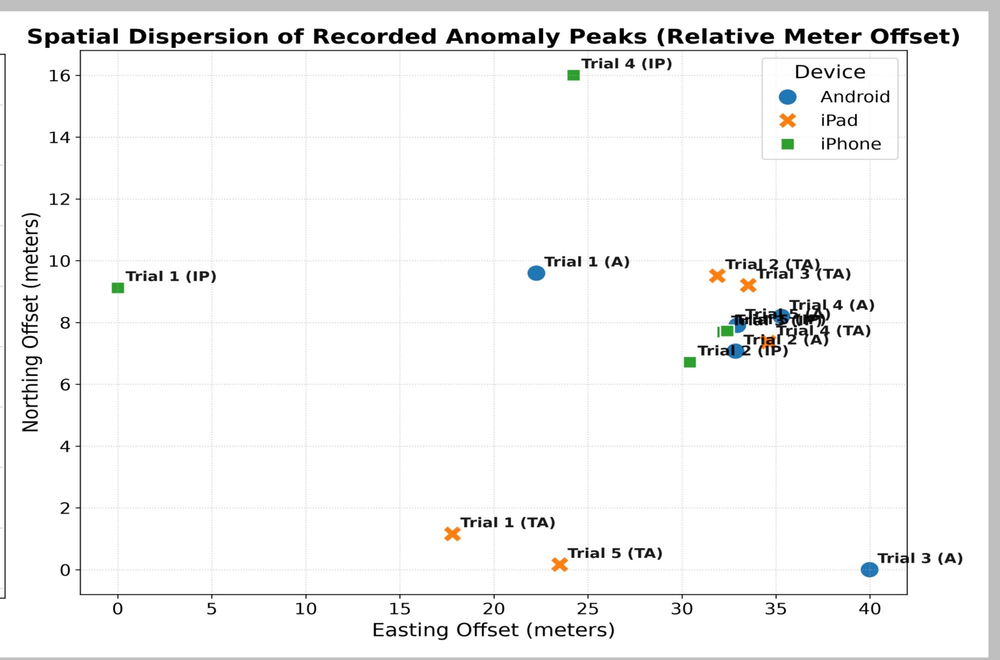


Figure 8 (Spatial Peak Scatter vs. Grid Locking): Coordinates of detected peak anomalies using unassisted mobile GPS show spatial scatter drifting up to 30m+ across trials. Pacing along physical 2m X 2m grid lines reliably locks the anomaly centroid, overcoming GPS instability.

DISCUSSION/CONCLUSION

- **Low-Cost Crowdsourced Detection:** Smartphones offer a reliable, cost-effective tool for citizen scientists to help locate hidden orphan well infrastructure.
- **Anomaly Detection Success:** All three mobile hardware platforms (Android, iPhone, iPad) successfully detected the orphan well's primary magnetic peak anomaly at Grid Rows 6–7.
- **Overcoming GPS Drift:** Unassisted mobile GPS points drifted up to 30m across trials, proving that phone GPS alone is insufficient for pinpointing well casings. However, using smartphone magnetometers in tandem with **physical grid pacing** successfully recovers true spatial anomaly geometry.
- **OS & Hardware Trade-Offs:** iOS platforms provide tighter internal filtering, resulting in cleaner, more consistent magnetic readings, whereas Android platforms offer an improved user experience and interface flexibility during survey recording.

FUTURE RESEARCH

- Determine differences in mobile devices for orphan well depth
- Compare peak magnetic reading anomalies with more sophisticated magnetic reading devices.
- Test more devices such as Android tablets and go more in depth with differences in device generations.
  - i.e. look at difference between iPhone 17 and iPhone 16
- Compare recently added metrics to MagMapper of device differences
  - Heading
  - Heading accuracy
  - Altitude accuracy

ACKNOWLEDGEMENTS

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Figure 9 (Field Researchers): Cassandra Barrientos (Left), Daniel Barrientos (Middle), Lexy Nissen (Right)

REFERENCES

ABSTRACT/EMAIL