Using CrowdMag to Catalog Magnetic Anomalies from Urban Infrastructure and Geological Features

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Introduction

Geomagnetism:
Study of the Earth's magnetic field. We depend on the magnetic field for navigation, for example when using a compass.

CrowdMag:
A smartphone app that accesses the phone's built-in magnetometer, used to crowd-source local magnetic field data.

Magnetic Anomaly:
A deviation (interference) from the normal (background) reading of the magnetic field.

Project Goal:
Collecting geomagnetic data on urban infrastructure and geological anomalies in and around the Boulder area. Then analyzing and plotting different models to show similarities or differences.

Project Question:
What are the general characteristics of the urban infrastructure anomalies as observed and modeled using CrowdMag and Excel? Would these characteristics be useful for magnetic navigation?

Measurements

- Downloaded CrowdMag app
- 12 separate locations surveyed: 11 urban infrastructure features and 1 geological feature
- Surveying at least 3m on each side of feature
- Display data and forward models

Photo Credit: NOAA Geomagnetism Team

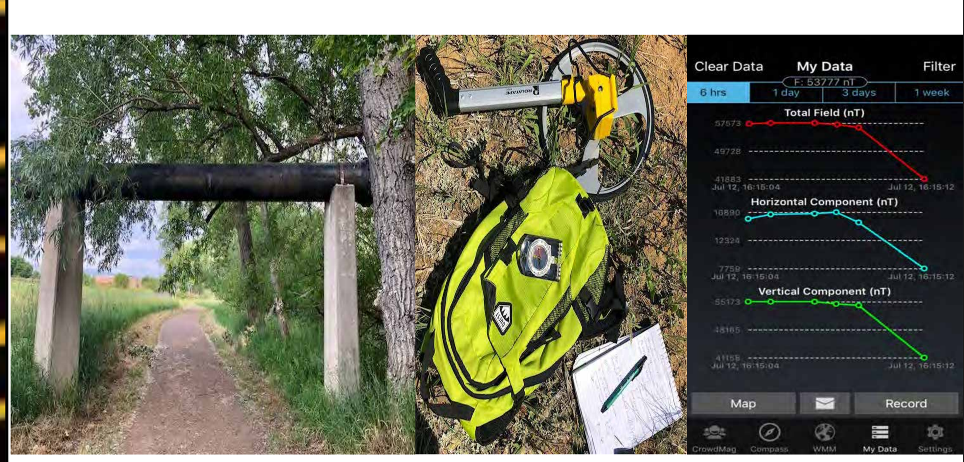

Figure 1. Iron pipe anomaly (left), measuring wheel (middle), CrowdMag app (right)

Results

We measured and modeled a number of high-amplitude magnetic anomalies over a variety of urban features (Table 1) . One experiment recorded from the nine CrowdMag users; it showed similar magnetic amplitudes for the same feature (Figure 2). For the individual features, we show our spherical equivalent-source interpretations of the observed anomalies (Figs 3-14). We identified the depths of each magnetic source with certainty but our models include trade-offs in modeling size (diameter) and intensity. Our catalog showed that the bridges, pipelines, and sidewalks profiled all had unique characteristics that might serve as magnetic landmarks for alternative navigation.

For our one geologic feature, Iron Dike, we were able to use the magnetic anomaly pattern to identify its exact location underground which was further west of the area we originally thought.

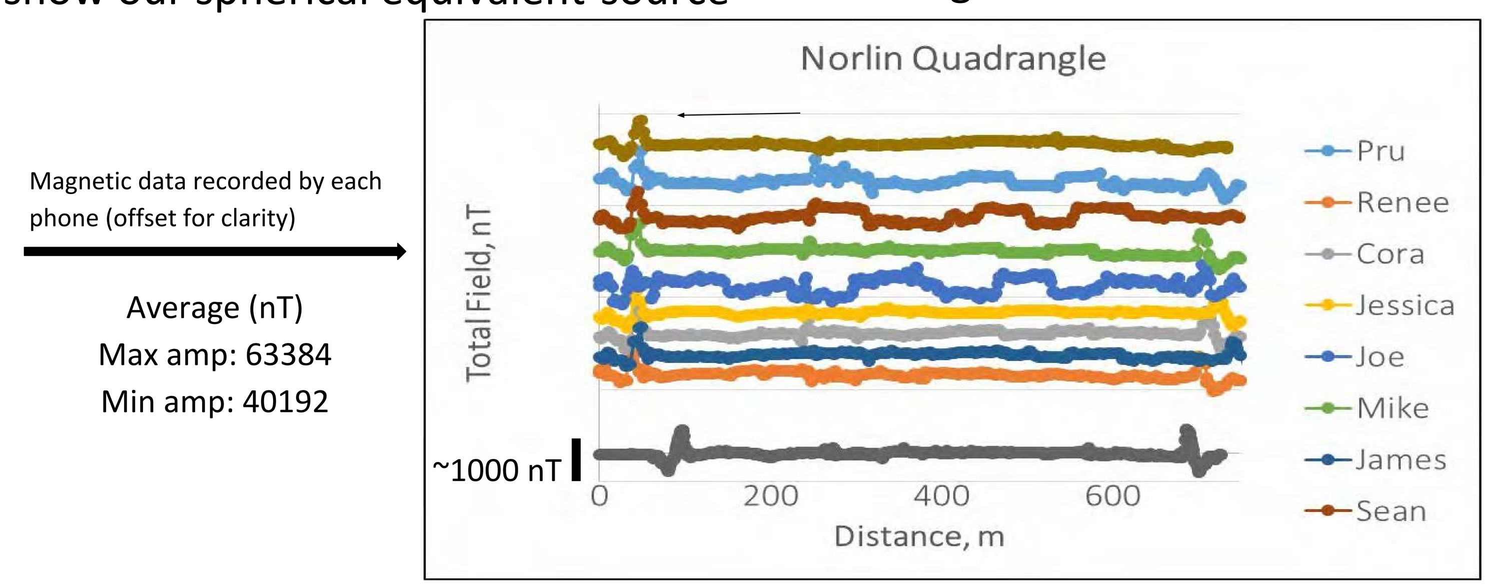

Fig. 2. Nine CrowdMag users surveyed one urban location (Norlin Quad) to compare noise source of traverse.

Anomaly Features	Mean (nT)	Minimum (nT)	Maximum (nT)	Range (nT)
Iron Pipe	49846	49335	50457	1122
Natural Gas Pipe	53077	52853	53974	1121
Cable Bridge	53395	39661	68144	28483
Bear Creek Bridge	57535	40995	76091	35096
NOAA East sidewalk	55540	53619	57573	3954
NOAA South sidewalk	52063	47981	55979	7998
Powerline	51651	51166	52285	1119
Railroad Track	49766	45546	52728	7182
Bear Creek Solar Panel	50915	48371	52131	3760
Bear Creek Overpass	53331	40787	72525	31738
Iron Dike	56080	55137	58792	3655

Table 1. The minimum, maximum, mean, and range of the magnetic intensity (nT) for 12 anomaly features in Boulder, CO

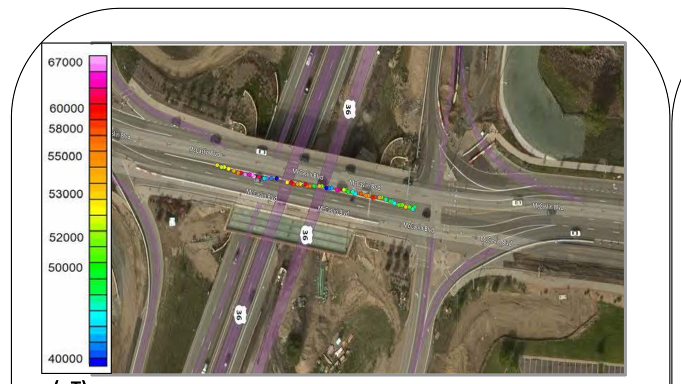

Fig. 3. Aerial view of Cable Bridge. (Bing Maps, 2018)

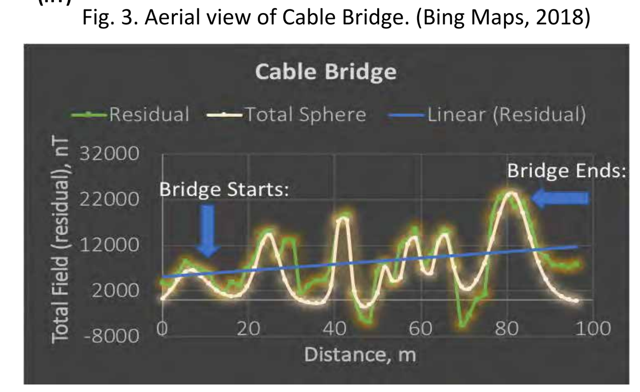

Fig. 4. Comparison of observed data and forward model calculation:

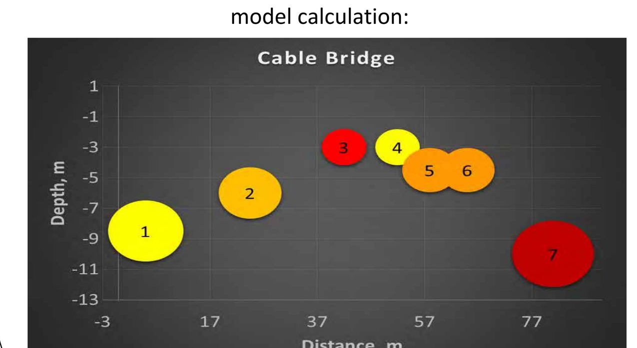

Fig. 5. Diagram of spherical equivalent source bodies:

Fig. 6. Aerial view of Bear Creek Bridge. (Bing Maps, 2018)

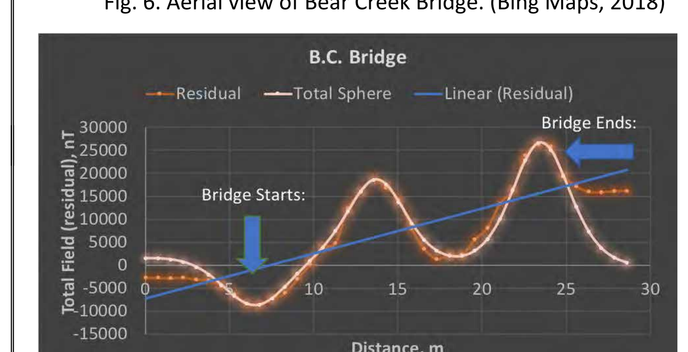

Fig. 7. Comparison of observed data and forward model calculation:

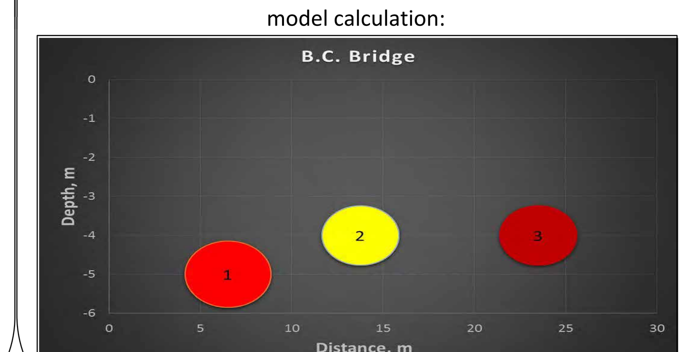

Fig. 8. Diagram of spherical equivalent source bodies:

Fig. 9. Aerial view of Iron Pipe. (Bing Maps, 2018)

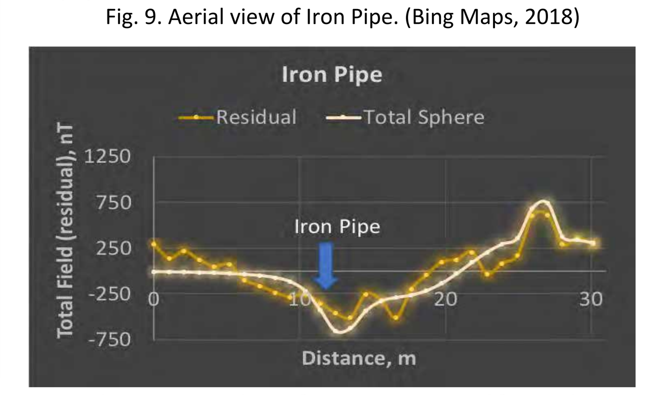

Fig. 10. Comparison of observed data and forward model calculation:

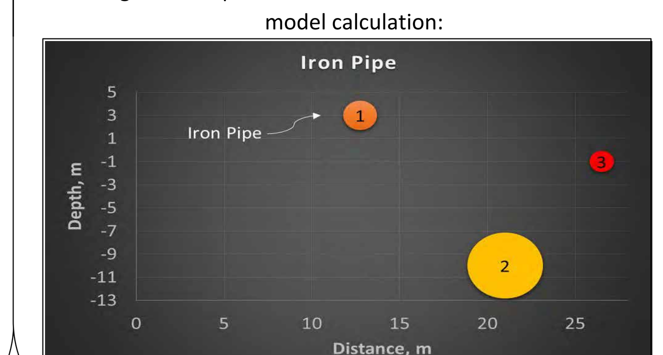

Figure 11. Diagram of spherical equivalent source bodies:

Fig. 12. Aerial view of Gas Pipeline. (Bing Maps, 2018)

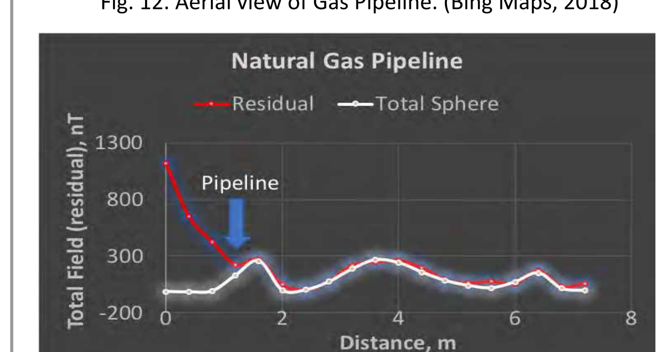

Fig. 13. Comparison of observed data and forward model calculation:

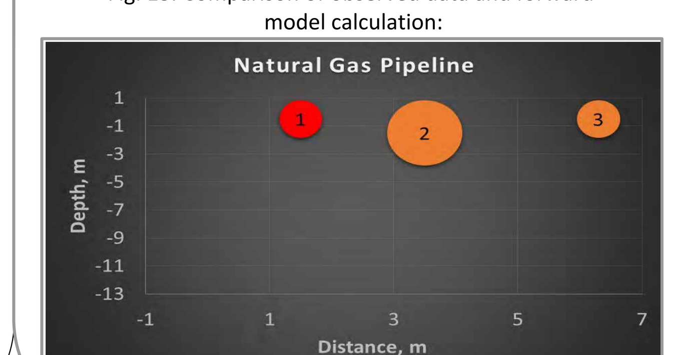

Figure 14. Diagram of spherical equivalent source bodies:

Discussion

Our results showed: (1) that there does appear to be significant magnetic effects from urban infrastructure features (Table 1); (2) source models of these features helped us to identify the depths and strengths for each urban features (Fig. 5.). Magnetic measurements using the phone sensors can be noisy, but we did find general consistency among data from different users (Fig. 2.). If the study was continued, we would make multiple traverses to further determine noise characteristics. Variables to consider would be different types of metals used for infrastructures and features, as susceptibility of different metals affect Earth's magnetic field differently.

Typically when geologic studies of magnetic anomalies are conducted, urban infrastructure anomalies are considered to be noise and are avoided or edited out of the data collected. Groups, like Google, are exploring the use of magnetic tracking for alternative navigation, and our approach that uses crowd-sourced magnetic data to identify these anomalies could assist in these efforts.

Conclusions

- CrowdMag was successfully able to map magnetic anomalies of both urban and geologic structures.
- We confidently identified the depths of each magnetic source, with trade-offs in modeling between size and intensity/volume of the equivalent-source models (sets of magnetic spheres).
- Future data collection can aid in alternate navigation (e.g. indoor navigation being researched by Google)(Indoor Maps), and may use these signatures as magnetic "mile markers."

References

Bing Maps - Directions, trip planning, traffic cameras; more. https://www.bing.com/maps (Accessed July 25, 2018).

Indoor Maps – About – Google Maps. (n.d.). Retrieved July 25, 2018, from https://www.google.com/maps/about/partners/indoormaps/

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