First field trial of an airborne magnetic survey using ergodic sampling

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ABSTRACT

We present the results from the first field-trial survey applying ergodic sampling for efficient airborne magnetic data acquisition. Using two independently flown airborne surveys over the same area, we demonstrate that an ergodic survey using 50% of the lines spaced in an optimized irregular pattern acquires the data with the comparable quality as those acquired from dense regularly spaced lines commonly used in the mineral exploration. The study provides the first supporting evidence from direct surveys, instead of numerically sampling existing data sets, that modern survey design theory derived from applied mathematics and signal processing can significantly reduce the cost of airborne magnetic surveys or increase the data resolution.

Airborne magnetic surveys are flown nearly exclusively along parallel lines spaced equally apart, with tie lines. The line spacing is commonly determined considering factors such as the spectral content of the expected magnetic anomaly and the narrowest anomalies one wishes to resolve in the data. Ultimately, the equal-spaced line design is rooted in the Nyquist sampling strategy and the spectral decay of the magnetic anomaly produced by the shallowest sources to be investigated. Such a survey strategy is sufficient when evaluated using Fourier transform-based signal reconstruction. Using modern criteria established in compressive sensing theory (Donoho, 2006), it is now understood that such a survey strategy oversamples the data unnecessarily.

The newly developed ergodic sampling (Zhang and Li, 2023) coupled with compressive sensing reconstruction enable the acquisition of nearly the same information but uses only a fraction of the survey lines if they are spaced irregularly in an optimized pattern. The optimized line-based ergodic sampling for airborne surveys is obtained by simultaneously optimizing four information sampling ability (ISA) criteria, including interval distribution, angle distribution, sample density distribution, and spectral resolution function (SRF), subject to the constraint that all observation points must be located along different flight lines (Zhang and Li, 2023).

We have carried out a field trial consisting of two independent airborne surveys. The first is a standard aeromagnetic survey using equally spaced flight lines at a 50-m line spacing. This survey is a small portion of a much larger survey for an active exploration project. The second is flown in the same area but uses an ergodic design that has half of the lines that are spaced in an irregular pattern derived from the ergodic design.

Figure 1 shows the lien patterns of the two surveys as they were flown and the comparison of the interpolated TMI data from the equal-spaced traditional survey and the reconstructed TMI data from the ergodic survey. The two final data sets are of the comparable quality.

In the presentation, we will present the design parameters of the original survey, the ergodic design criteria, and their relationship. We will also present detailed analyses to compare the two final data sets.

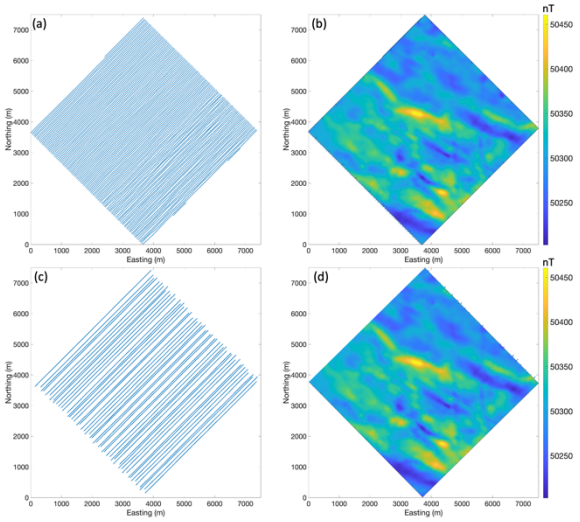

Figure 1. Comparison of a standard aeromagnetic survey using 100 lines evenly spaced 50 m apart (a) and corresponding TMI data with an ergodic aeromagnetic survey using 50 lines in an optimized irregular pattern (c) and reconstructed TMI data (d).

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