Why is High Resolution AeroMagnetic (HRAM) data better for exploration purposes than the magnetic data available from the GSC?

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Summary
The Western Canada Sedimentary Basin (WCSB) and the Williston Basin are both covered by many aeromagnetic surveys of many different resolutions. Almost the entire WCSB and the Canadian portion of the Williston Basin are covered by regional aeromagnetic surveys flown by the Geological Survey of Canada (the GSC data) and compiled by the Geological Survey of Canada. The aeromagnetic data for the USA portion of the Williston Basin is also covered by High Resolution Aeromagnetic (HRAM) data which are licensed on a multi-client basis by service companies or as trade data by oil and mining companies.

What is the difference between these two sources of data when it comes to solving exploration problems? The difference is resolution. The GSC data, in gridded form, does not have adequate frequency content to solve structural problems, except on a very regional scale. HRAM data, on the other hand, can resolve faults in both the basement and the sedimentary section and allow one to map the depth to magnetic basement more accurately.

Introduction
For many explorations the total magnetic field image from the Geophysical Survey of Canada (GSC) data and from the HRAM data are very similar. However, it was believed by the authors that the results of interpreting their prospects using either kind of data will be the same. However, those who have worked in oil and gas exploration and the GSC data find an enormous difference between the two datasets, especially in terms of their power to resolve subtle geological features in the sedimentary section.

This paper compares in detail the HRAM data with the GSC gridded aeromagnetic data, using data from North Eastern British Columbia (NEBC) (Figures 1 and 2).

The Precambrian basement of the WCSB is subdivided into several tectonic-magnetic terrains based on their magnetic pattern. Three of these terrains are present in the area (Figure 2). Sharp magnetic gradients are identified at the boundaries of these terrains reflecting the change in the magnetic character of the basement.

The GSC data is a synthesis of many surveys of aeromagnetic surveys which have been merged together at the grid level. In general, these surveys are flown at relatively high altitudes (e.g., 100-300 m barometric) and over very large areas with relative wide line spacings (typically 1 x 3 miles). The merged data have been gridded using a 2 km grid size.

The newer GSC surveys, flown since 1992, have used GFS navigation and tighter line spacings (500 ft), and have been flown at lower elevations. For the most part these newer surveys are in southern Alberta, southeast Saskatchewan, and in the Mackenzie Valley and Mackenzie Delta. The comparisons in this paper are not valid for these newer surveys, which are, in fact, HRAM surveys flown by the GSC and available in the format at a very low cost.

Fig. 1. HRAM total magnetic field draped on shaded topography showing structural features below and gas prospects.

Hottah Terrane (10-20 Ga)
Nlahanni Terrane (Age Unknown)
Fort Simpson Magnetic Arc (Age Unknown)
Gas
Oil

NEDC Comparisons
The new resolution of the data sets demonstrates that the GSC data is unable to resolve geological features located at shallow depths (i.e., depth < 10 km) whereas the HRAM data is able to resolve geological features located at depths of 5 or 10 km (Figures 5 and 6).

Filling in of a way of separating signals of different wavelengths is enhanced because of the inherent limitations of different wavelengths. In order to illustrate this point further we have decomposed the total magnetic field into its constituent parts, each exhibiting different wavelengths, manifesting different geological features. These are: 1.2 - 4.8 km (shallow depths, 3.0 - 5.5 km medium depths, 4.8 - 9.0 km deeps and 9.0 - 25 km very deep, within the crust) (Figures 3.3 - 3.7 and 4.4 - 4.7). For a very crude translation from wavelength to depth, divide wavelength by two. So a wavelength of 3.0 - 5.0 km wavelength has most resolution in the range of 1.5 - 2.5 km; but signal from other depths will also be present.

Note that the GSC data becomes noisier as we move towards the high frequency short wavelength end of the spectrum (i.e., 1.2 - 4.8 km wavelength range) with radiometric, cloud and image quality and has reducing power throughout the entire spectrum.

Conclusions
This paper demonstrates that the HRAM data has better resolution than the GSC data because of its higher frequency content. The high-frequency signal carries information related to subtle and shallow features in the intra-sedimentary rocks such as faults, palaeochannels and hydrocarbons.

HRAM data can delineate the following geologic features more clearly than the GSC data:
(a) Magnetic lineations in the intra-sedimentary rocks. Magnetic lineations are associated with shear zones, faults and subcrop.
(b) Magnetic lineations (observed features) that indicate underlying rock types, using pattern recognition approaches.
(c) Remagnetized faults and features caused by migration of hydrocarbon brines as well as hydrothermal deaminizations.

Statistical correlation coefficients between the HRAM and the GSC data, calculated on profiles extracted from the bandpass filtered data show low correlation coefficients (p = 0.80 - 0.90) for the short-wavelength features (1.2 - 4.8 km) and high correlation coefficients (p = 0.95 - 0.99) for the very deep bandpass (9 - 24 km) (Figures 5).

These results indicate that the GSC data is good enough to map deep regional geological structures (i.e., geologic terranes), but they are not good enough to map shallow subtle features in the sedimentary basin. In contrast, the HRAM data has the frequency content to map subtle geological features in the sedimentary basin, as well as in the basement.