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

Hassan H. Hassan

GEDCO

1200, 815 - 8th Avenue SW, Calgary, Alberta, CANADA T2P 3P2

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 into a regional grid, which is available free over the Internet. Much of the same prospective area 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.

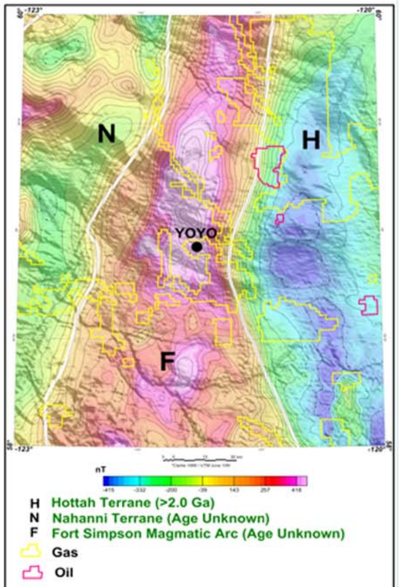


Fig. 2. HRAM total magnetic field draped on shaded topography showing structural terrane boundary and oil and gas prospects.

Introduction

For many explorationists the total magnetic field image from the Geological Survey of Canada (GSC) data and from the HRAM data appear to be nearly identical and therefore they believe that the end results of interpreting their prospects using either kind of data will be the same. However, those who have worked in detail with both the HRAM 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 poster 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 tectono-magnetic terranes based on their magnetic pattern. Three of these terranes are present in the area (Figure 2). Sharp magnetic gradients are identified at the boundaries of these terranes reflecting faults that extend deep into the crystalline basement.

The GSC data is a synthesis of many vintages of aeromagnetic surveys which have been merged together at the grid level. In general, these surveys are flown at relatively high altitudes (e.g. 300 m barometric above the highest topography in the area) without GPS navigation and with relatively wide line spacings (typically 1 x 3 miles). The merged data have been gridded using a 2 km cell size.

The newer GSC surveys, flown since 1992, have used GPS navigation and tighter line spacings, and often they have been flown at lower elevations. For the most part these newer surveys are in southern Alberta, southwest Saskatchewan, and in the Mackenzie Valley and Mackenzie Delta. The comparisons in this poster are not valid for these newer surveys, which are, in fact, HRAM surveys flown by the GSC, and available in line format at very low cost.

HRAM data refers to data flown at 800 m line spacing or closer, navigated with GPS, and generally flown close to the ground in drape mode (e.g., 100-150 m above topography, within aircraft safety limitations). Some HRAM data available for licensing has been edited to remove manmade cultural effects such as pipelines and well heads.The HRAM and the GSC total magnetic field maps (Figures 3.1 and 4.1) show in general the same gross features. Notably, the patterns of major magnetic anomalies are similar; the large positive anomalies are related to large bodies of mafic rocks in the basement. In addition to the large positive and negative anomalies, the maps show a suite of NE-trending short wavelength, linear anomalies which have been emphasized in the horizontal gradient maps (Figures 3.3 and 4.3). The linear anomalies are associated with mafic dikes intersecting the Hottah Terrane.

The area has high potential for gas discoveries within Devonian carbonate reservoirs.

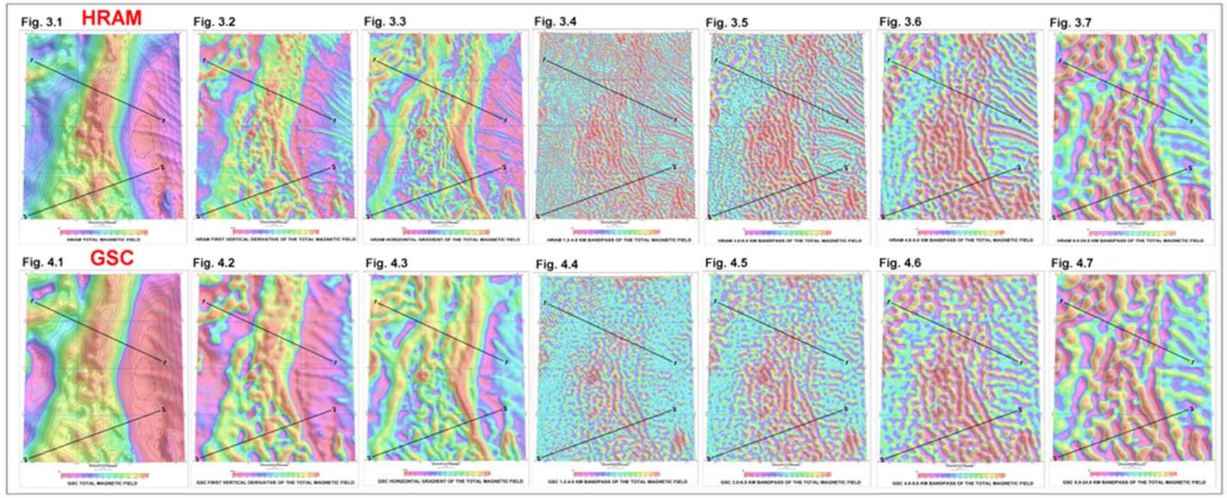
NEBC Comparisons

The radial power spectra of the two data sets demonstrate that the GSC data is unable to resolve geological features located at shallow depths (i.e., depth < 3.0 km) whereas the HRAM data is able to resolve geological features located as shallow as 400 m (Figures 5.1 and 5.2).

Filtering is a way of separating signals of different wavelength to enhance anomalous features with a certain wavelength.

In order to illustrate this point further we have decomposed the total magnetic field grids into four bandpass filters of varying wavelengths manifesting different geological depths. These are: 1.2 - 4.8 km (shallow depth), 3.0 - 6.0 km (medium depth), 4.8 - 9.6 km (deep) and 8.0 - 24 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 bandpass of 3.0 – 6.0 km wavelength has most resolution in the range of 1.5 – 3.0 km depth, 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 bandpass filter) (Figure 6). In contrast, the HRAM data maintains a coherent image quality and has resolving power throughout the entire spectrum.



Statistical correlation coefficients between the HRAM and the GSC data calculated on profiles extracted from the bandpass filters show low correlation coefficients (r = 0.37 - 0.51) for the shallow-depth bandpass (1.2 - 4.8 km) and high correlation coefficients (r = 0.95 - 0.96) for the very deep bandpass (8.0 - 24.0 km) (Figure 6).

These results indicate that the GSC data is good enough to map deep, regional geological structures (e.g., geological 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 the in the basement.

Conclusions

This comparison 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, paleochannels and kimberlites.

HRAM data can delineate the following geological features more clearly than the GSC data:

(**a**). Magnetic lineaments in the intra-sedimentary rocks. Magnetic lineaments are associated with shear zones, faults and subcrops.

(**b**). Magnetic textures (distinctive pattern) that indicate underlying rock types, using pattern recognition approaches.

(**c**). Remagnetized faults and fractures caused by migration of hydrocarbon brines as well as hydrothermal dolomitization.

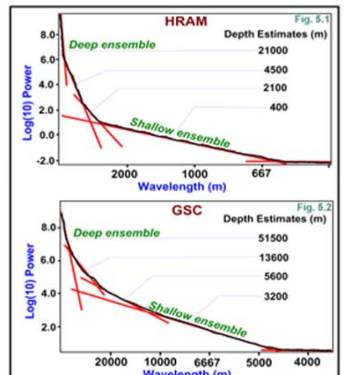


Fig. 5 Radially averaged power spectrum.Straight red line segments indicate an ensemble of sources at different depths. Note the 10:1 difference in scale between HRAM and GSC.

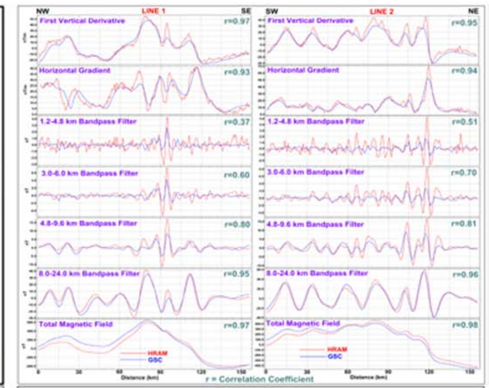


Fig. 6 Profiles of lines 1 and 2 extracted from Figures 3.1 - 3.7 and 4.1 - 4.7.