MEMORANDUM

ANGLOGOLDASHANTI

To: Phil Newton, Phil Larson

CC: Rex Brommecker, Paul Bartos, Cees Swager

From: Keith Martin

Date: 7th March 2016

Subject: **Minnesota Area of Interest - Airborne Geophysical Data**

Summary

- Location of historical airborne geophysics obtained
- Extensive airborne data acquired including magnetic and TEM implying higher level of maturity than previously thought.
- Previous airborne geophysical data only available in hardcopy.
- Previous magnetic data considered low quality and low resolution, best is ~200m spaced lines.
- Recommend acquiring detailed 100m spaced gradient magnetic data to invert in 3D, defining bedrock geometry and structural controls not observed in either drilling, outcrop or till sampling. Prioritising exploration efforts early within the AOI.

Introduction

The following brief note summarises historical airborne geophysics over the AGA Minnesota area of interest (AOI). The details were obtained from both Val Chandler (chand004@umn.edu, Minnesota Geological Survey) and David Dahl (dave.dahl@state.mn.us, Minnesota Department of Natural Resources).

Acquiring 100m line spaced gradient magnetic data would facilitate detailed 3D magnetic inversion modelling to define geometries and structural controls not previously seen in either historical magnetic data, outcrop, till sampling or drilling. Detailed magnetic data can help prioritise compilation of historical data and focus exploration efforts early in the exploration program.

Historical Airborne Geophysical Data

Historical survey locations are presented in figure 1 and 2, summarised as;

- Red outlines the AGA AOI.
- White hatch area is Meridian Lands and Minerals 1/8 mile (~200m) line spacing AIRMAG and AEM (old INPUT VI or V time domain TEM).
- Yellow outlines are Hanna flight areas ¼ mile (~400m) line spacing AIRMAG and AEM.
- Black outlines are US Steel flight areas, similar vintage and line spacing as for Hanna (~400m).
- Blue outlines are recently donated Polaris Joint Venture (eastern blue outline may be geochemical coverage). The Polaris Joint Venture collection as pdf documents is scheduled to go online in conjunction with PDAC 2016. The Aerodat helicopter-borne work from that project, which followed up on Input AEM anomalies, was conducted at ~150 feet terrain clearance and a line spacing of ~125 meters.

David Dahl suspects that the Milestone Joint Venture (Selco) flight areas also reach into the vicinity but doesn't have a shapefile for those areas.

Discussion

The historical data was acquired from the 1960's through 1980's and is only available in hard copy form (maps, sections and profiles) which should be scanned and georeferenced. While 9-track tapes exist for the Meridian data David outsourced tapes to CGG (formally Fugro) for recovery without success, nothing could be recovered.

Even if we had access to historical digital magnetic data the quality of single sensor acquisition and large 200m line spacing is not considered sufficient resolution for modern exploration. We should review the historical AEM INPUT data but again, at best we're likely to only generate and use digitised contours knowing that the effectiveness is limited compared to modern AEM systems. Previous use of INPUT data elsewhere in Australia has added considerable value when compiled with all other datasets in an integrated common earth model environment.

Historical radiometric data is limited to the National Uranium Resource Evaluation (NURE) survey which was an airborne geophysical survey to assist evaluation of uranium sources across the US. The NURE survey covers the AGA AOI as shown in figure 3, though is limited to EW lines spaced 9 km and NS lines spaced ZZZ km. The flying height of 130m combined with broad line spacing is not considered an adequate test of the radiometric method. However Phil Larson suggests and Google Earth images show, minor lakes and likely transported cover for the AOI implying there is limited value in acquiring radiometric data. Though the cost to acquire radiometric data while collecting detailed magnetic data is minor and should proceed to assist defining areas more likely to contain outcrop.

Recommendations and Conclusions

The regional area of interest would benefit from building a 3D integrated model using modern potential field inversion techniques constrained by lithology and structural controls.

I recommend we acquire 100m spaced gradient airborne magnetic and radiometric data over the AOI to build a better understanding of bedrock geology, structure and geometry to assist geochemical sampling and shallow drill priorities. The acquisition of detailed magnetic data will facilitate 3D magnetic inversion modelling to integrate with previous drilling, geochemistry, geophysics and geology interpretations. Gradiometer magnetic acquisition will facilitate building a better total magnetic field understanding to commence the inversion process. Single sensor acquisition is not recommended as sources off the flight line cannot be positioned correctly, reducing our ability to build the best possible 3D magnetic inversion model for interpretation.

Historical hardcopy data should be scanned and georeferenced. The AEM INPUT contour data should be digitised and integrated into a common earth model.

Historical gravity data should be sourced and the value of airborne gradient gravity considered.

Where possible petrophysical properties should be sourced from historical documents and/or acquired on available drill core to facilitate constrained potential field inversions.

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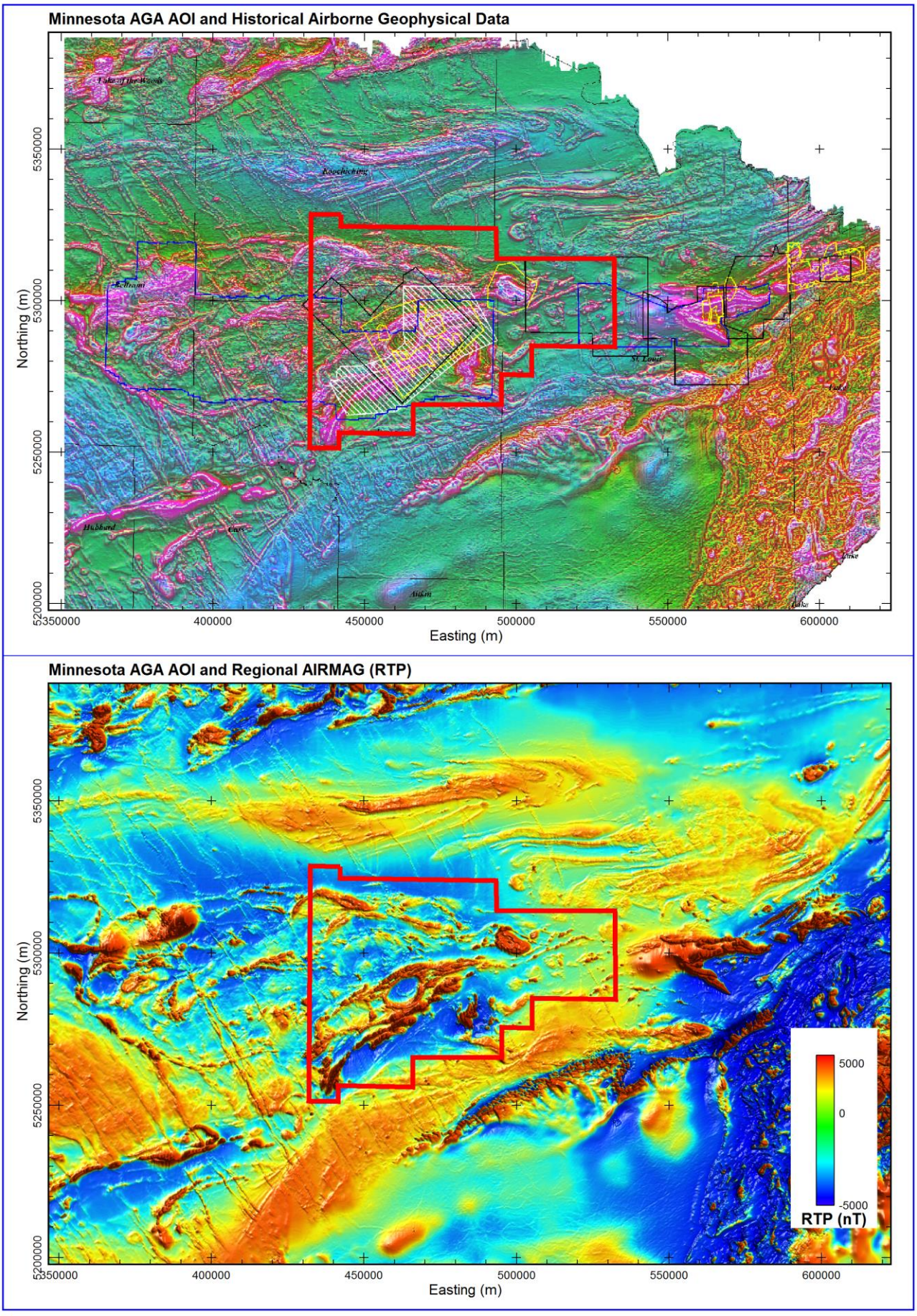

Figure 1, Red - AGA AOI, White - Meridian Lands and Minerals (AIRMAG and AEM), Yellow – Hanna (AIRMAG and AEM), Black - US Steel (AIRMAG) and Blue - recently donated Polaris Joint Venture data.

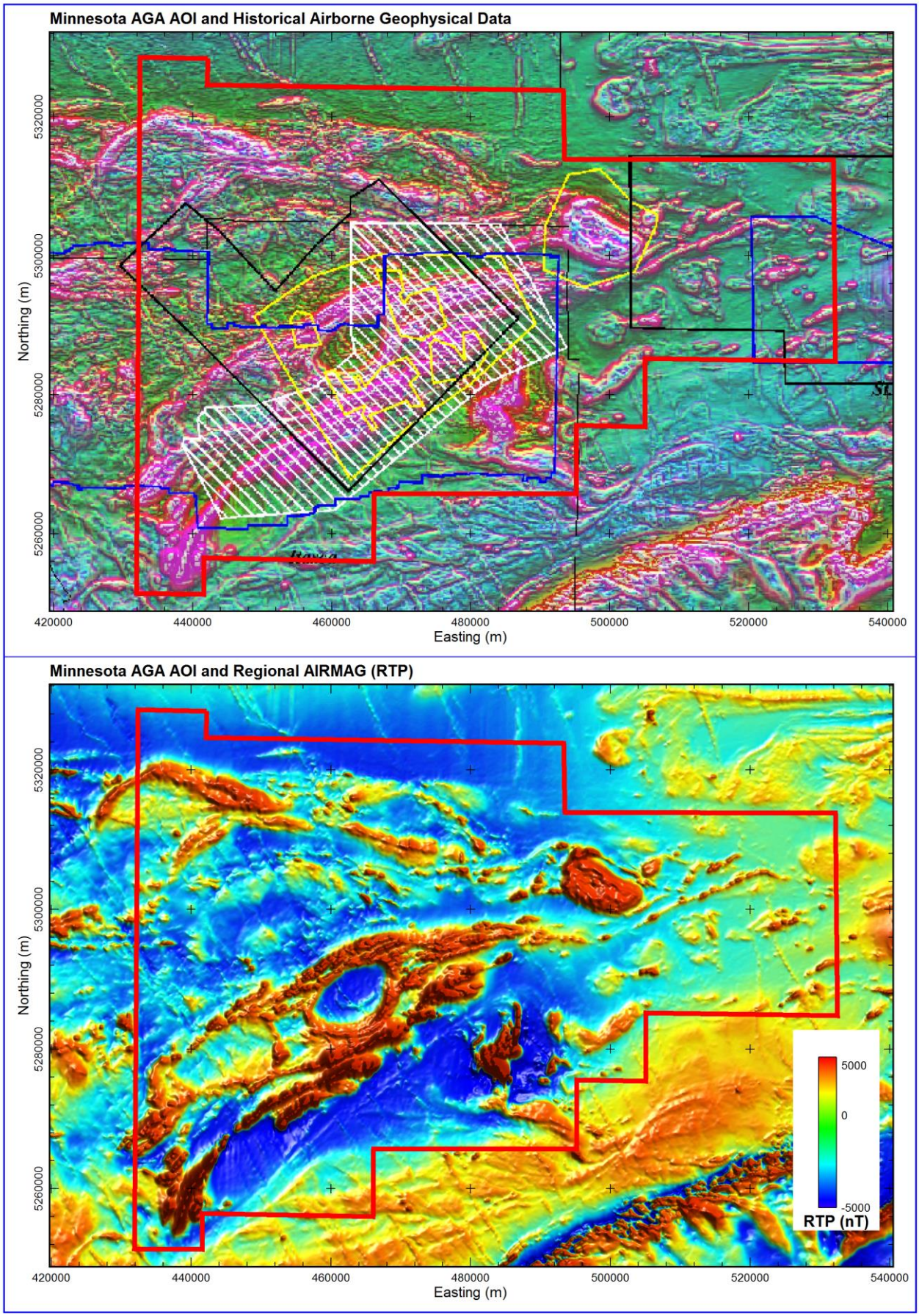

Figure 2, Red - AGA AOI, White - Meridian Lands and Minerals (AIRMAG and AEM), Yellow – Hanna (AIRMAG and AEM), Black - US Steel (AIRMAG) and Blue - recently donated Polaris Joint Venture data.

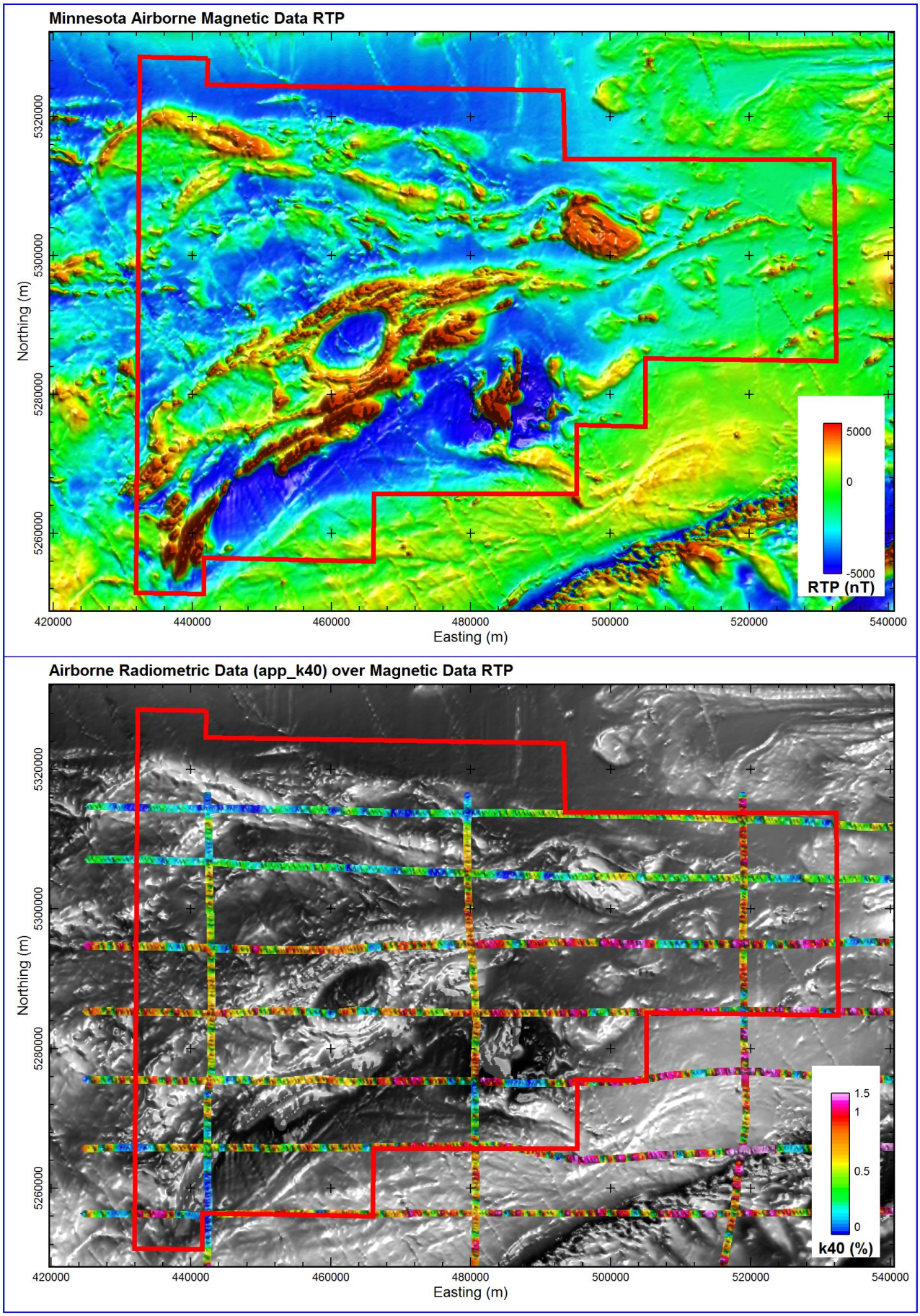

Figure 3, Regional RTP magnetic data (greyscale) with NSEC radiometric data lines (colour). Radiometric lines are broad spaced and not considered sufficiently adequate to have tested the radiometric method.