



2017 Ground Magnetic Survey

Cleveland Project, Tasmania

Operations and logistics report prepared by Modern Mag ground magnetic surveys.



ModernMag

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1. General Information

1.1 Introduction

In December 2016, Modern Mag was awarded the contract to conduct a ground magnetic survey for Elementos Limited over the Cleveland Project in Tasmania. This report summarises the survey details, procedures and equipment used by Modern Mag in the acquisition, verification and processing of the magnetic data. Below is a summary of the survey details.

Client	Elementos Limited
Modern Mag project number	1048
Survey Area	~1km south of Luina, Tasmania
Field base	Waratah
Mobilisation	Monday, 9 th January, 2017.
Production	Tuesday 10 th – Monday 16 th January, 2017.
Demobilisation	Monday 16 th – Tuesday 17 th January, 2017

Table 1. Survey details

1.2 Mobilisation and Demobilisation

On the morning of Monday 9th January the survey crew mobilised from Horsham to the field base at Waratah. The Modern Mag 4WD, equipment and personnel was transported on the Spirit of Tasmania ferry. The survey was conducted between the 10th of January and the 16th of January. The crew returned to Horsham on the 17th January. They flew and took a bus on the 17th. Nathan returned to Tasmania a week later to collect the vehicle which was stranded in Devonport due to a lack of available space on the Spirit of Tasmania Ferry until that time.

Preliminary data checks were performed in the field. Data acquisition was monitored during the survey and digital data was sent each day to the Modern Mag office in Melbourne.

1.3 Survey Personnel

The following Modern Mag personnel were involved with this project:

Title	Name
Project Manager	Justin Ward
Field Manager	Nathan Ward
Operator	Troy Jolley

Table 2. Survey personnel

1.4 Survey Equipment and Specifications

The survey equipment used was as follows:

Roving magnetometer	GEM GSMP-35. Potassium magnetometer.
Base magnetometer	GEM GSM-19 overhauser (Sampled at 10 second intervals)
Station spacing	<1m (1Hz sampling)

Table 3. Survey equipment and specifications

All data was surveyed and acquired in GDA94, MGA 55.

1.5 Survey Grid Specifications

The survey grid specifications were as follows:

Grid	Line Spacing	Line Direction	Line-km
Cleveland	30m	140°	~32 l-km

Table 4. Survey grid specifications

A total of 32 l-km was surveyed. Lines had been cut through the thick forest by a line cutting crew.

1.6 Survey location

The location of the grid is shown in figure 1 on the next page.

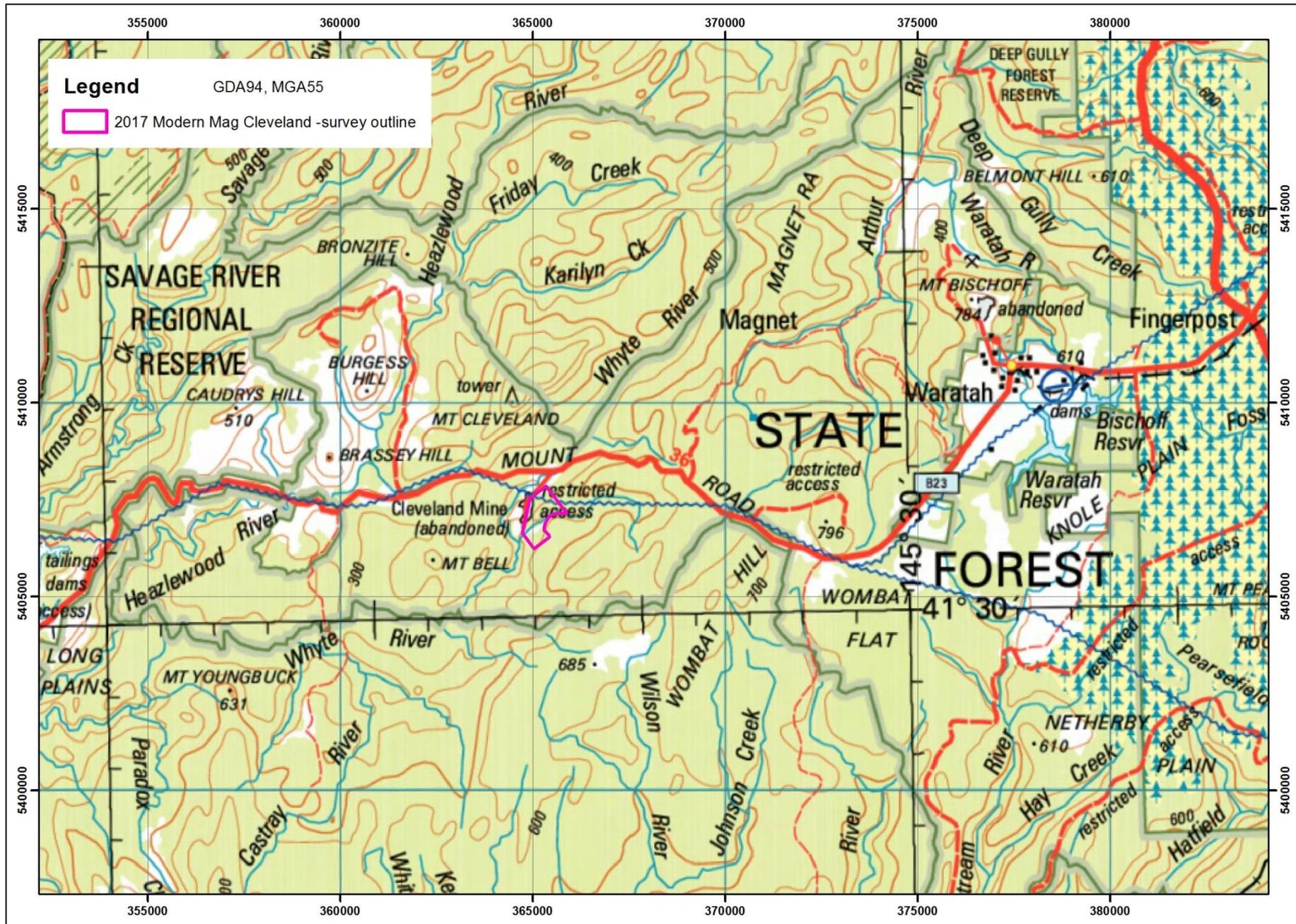


Figure 1. Survey location

2. Production Report

This survey was conducted on a dollar per 1-km rate so the daily production rates are not itemised in this section.

There were 1.5 days lost due to bad weather. The close proximity of the house in Waratah to the grid allowed the crew to frequently assess the condition of the grid after rain.

There were no environmental or health and safety accidents/incidents. There were significant obstacles in the grid. The crew had to survey up to cliff faces and across man-made pits before back tracking to the base line and going around to the other side. This added significant time to the survey.

While the line cutting was done very well, there was 450m of elevation in the grid. The severe slopes and wet slippery footing slowed the survey.

The thick forest canopy and deep gullies blocked GPS satellite signal. On most surveys the high end Novatel GPS units Modern Mag uses track 10-12 satellites. However the average for this grid was just 4. The crew estimate they spent 2 days standing still waiting to regain GPS lock or moving to a different location to regain GPS lock.

To avert this problem in the future, Modern Mag is upgrading all of our GPS units to GPS + Glonass for greater satellite visibility in thick vegetation and mountainous terrain.

3. Final magnetic data processing

The following processes were performed on the data:

3.1 Diurnal processing

The raw diurnal data was checked and corrected for spikes. This has not degraded the data at all since the base station was sampled at 0.1Hz. Two base stations were used for this survey. The original base station locations were found to be noisy, so the base stations were moved on day 3. A 200nT base shift was used to compensate for the difference between base station locations.

3.2 Diurnal correction to the magnetic data

The synchronized digital diurnal data collected by the base station was first subtracted from the corresponding raw ground magnetic readings. The diurnally corrected channel is *Mag_corr*. The median value for the grid was as follows:

Grid	Median grid values
Cleveland	61,401.197 nT

Table 5. Median magnetic value for the grid

The *Mag_corr* channel has been adjusted so as to have the median value in table 5 above.

3.3 Data editing. No filtering applied to line data.

The *Mag_corr* channel has been edited to remove signal dropouts and values where the sensor lost lock. These values have been dummied using the *Mag_lock* channel as the mask. An extra reading on either side of an unlock event has also been removed since the mag unlock parameter seems to miss these values in some instances.

No other filtering of the line data has been applied. However a non-linear filter with a width of 2 and a 5 point (~5m) low pass filter could be applied to the data with good effect.

3.4 Gridding

The grid has been interpolated with a cell spacing equivalent to $1/4^{\text{th}}$ of the narrowest line spacing. In this case the cell size is 8m.

It is recommended that any magnetic modelling or inversions be applied to the line data as this provides more accurate results.

The *mag_corr* product has been gridded and presented as a *TMI grid. The sun shading inclination is 45° and the declination is 45° . The minimum curvature algorithm was used to interpolate the data.

4. Special notes on this survey

This survey was the most difficult survey Modern Mag has ever encountered and the second most difficult survey the director of the company has encountered in his 20 year career. Only a survey in the mountains of Kyrgyzstan was more difficult.

While the line cutting was done very well, man made and natural obstacles in the survey path could not be walked around due to the thick vegetation. Instead, the crew had to backtrack to the base line and separate lines into sections.

Man-made objects were not always visible until standing on top of them. The forest growth made them difficult to see. Thus some man-made (cultural) features are recorded in this survey. Ground truthing of these features would allow a geophysicist to remove these features before any interpretation or inversion is attempted.

Ten to twelve satellites are usually tracked by the sub metre accurate Novatel GPS Modern Mag uses. However on this survey an average of 4 satellites were tracked. Losing GPS lock added 2 days to the survey time. The operators had to wait for lock or move to a location with more sky visible to recover lock. Given the cut lines are straight, some easting and northing filtering of the coordinates would improve the positioning and inversion/interpretation results.

The steep, slippery and rough terrain caused the GMSP-35 magnetometer to lose lock quite a lot. This has had little effect on the gridded data, since the grid is still oversampled. The crew was walking very slowly and would stop if the sensor lost lock.

A more severe condition, which we rarely see, is the GSMP-35 locks onto the secondary potassium spectral line. This often occurs after the sensor has suffered a blow on a tree or rock. This condition is visible in the raw data and was manually flagged using the *Shift* channel in the database. All mag readings with *Shift* = 1 have 134nT added to them.

One magnetometer operator had the sample rate set to 20Hz on the first day. This data has been decimated to 1Hz, consistent with the rest of the survey and other magnetometer. The first day only covered the one easternmost line. This line was surveyed twice, once by each magnetometer.

The digital terrain model looks quite good considering only 4 satellites were tracked. This is mostly due to the large dynamic range of the survey (>450m). It is strongly suggested that any and all interpretations/inversions incorporate elevation data. No flat earth assumptions should be made.

Gaps in the data are due to man-made objects, a large open pit that was not traversable, impassable cliff faces, or impassable (thickly forested) gullies.

Normally Modern Mag would produce line data in an ordered, neat and consistent database. However the requirement to survey lines in a piecemeal fashion to get around obstacles and the difficulty obtaining GPS lock, meant that the crew would at times survey almost in discrete mode, standing in one location until lock was gained, walking until lock was lost and standing still again. In some locations lock could not be gained

at all, so there are short gaps in the lines. The result is that the line data and numbering is not as neat as usual. In contrast, there are some lines that are very consistent and coherent. It is these lines that should be sought out and used for any 2.5D (manual) inversion and modelling.

Some additional filtering of the data may be required before applying 3D inversions. Consider:

1. Non-linear filter on *mag_cor*
2. Non-linear filter on *easting* and *northing*.
3. Low pass filter on *easting* and *northing*
4. Low pass filter on *mag_cor* OR upward continuation by 5-10m of the *mag_cor* data.

If future ground magnetic surveys are required in this area it is recommended the following conditions are met:

- Summer survey
- Cut lines
- Overhauser magnetometers (Modern Mag also operates these)
- GPS + Glonass signals will need to be tracked to reduce GPS unlocks.
- Allow twice the amount of time for the survey due to the severe terrain.

Despite these difficulties, Modern Mag has acquired quality data that clearly shows significant geological features.

Any airborne survey would have had a minimum 100m terrain clearance due to the tall forest. A grid of the data upward continued 100m approximates an airborne survey and shows no detail compared to the ground magnetic data.

5. Deliverables

The data has been provided in the following formats:

Point data:

- Grid corner points have been delivered as *.ply text files.

Line data:

- Geosoft database
- Ascii *.xyz file with file header and line numbers. This is a valid Geosoft XYZ file.
- ASEG-GDF2 data suitable for government submission.
- Grid outlines have been delivered as ArcMap shape, Mapinfo TAB and DXF files.
- Survey path has been delivered as ArcMap shape, Mapinfo TAB and DXF files.

Grid data:

- Geosoft grids
- ERMMapper grids
- Mapinfo Tiffs
- ArcMap Tiffs

Maps:

Geosoft maps are the recommended way to view the data from this survey. These maps can be opened with the free Geosoft viewer, or within ArcMap or Mapinfo using the free Geosoft plugins for these products. All these free Geosoft products were included in the deliverables. However these are older versions and it is recommended that new versions be downloaded from the Geosoft website. This now requires users to create an account.

Contractor information

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Grid Plot

A plot of the grid is included on the following page. Image show the Total Magnetic Intensity (TMI) data upward continued 10m

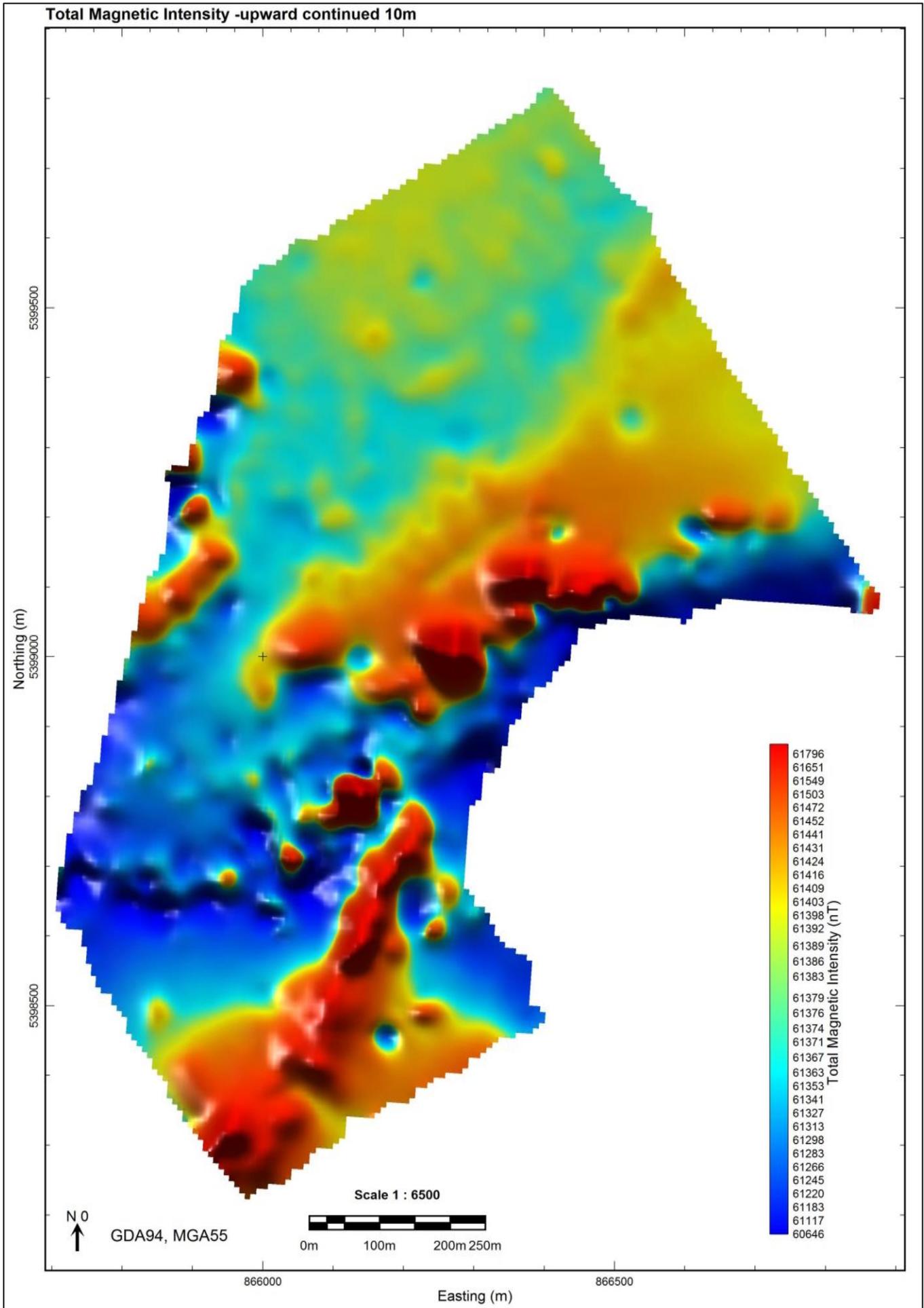


Figure 2. Total Magnetic Intensity Image of survey grid. Upward continued 10m