34 Brisbane Street, Perth, WA 6000
PO Box 167, Northbridge, WA 6865
Ph: (08) 9289 9100 Fax: (08) 9328 5889
Email: info@respot.com.au

**SUMMARY REPORT**

**To** : Wayne Taylor – Energy Metals Limited
**From** : Matt Owers – Resource Potentials Pty Ltd
**CC** : Jayson Meyers and Nigel Cantwell – Resource Potentials Pty Ltd
**Subject :** Ngalia Basin high-resolution magnetic survey planning, QC, processing and imaging.
**Date** : 11 March 2015

## Executive Summary


- Four non-contiguous high-resolution airborne magnetic, radiometric and DEM surveys were flown in the Ngalia Basin for Energy Metals. A total of 7,915 line km were flown in November to December 2014 by Daishsat Ltd. The survey areas are mainly prospective for uranium mineralisation. Resource Potentials was commissioned to help plan, budget and monitor the surveys, QC the survey data and then process and image the final data received from Daishsat after completion of the survey.

- Uranium deposits were discovered in the 1970's along the northern central margin of the Ngalia Basin, e.g. the Bigrlyi uranium deposit. The deposits typically occur as tabular carnotite/uraninite deposits hosted within the lower parts of the late Devonian-Carboniferous Mount Eclipse Sandstone. More uranium deposits have since been discovered in other places where the Mount Eclipse Sandstone outcrops. Energy Metals have completed the airborne magnetic and radiometric surveys to better understand the rocks and associated structures hosting the uranium mineralisation.

- The data processing carried out by Resource Potentials included generating a standard suite of magnetic, radiometric and DEM images plus an assortment of specialised filters to enhance shallow and deep structures.

- The final processed magnetic and radiometric grids were merged with open file company and government gridded data, and closed file survey data, to produce regional grids covering all of Energy Metals tenements in the Ngalia Basin. Furthermore, the same set of specialised filters was applied to these regional grids and the subsequent images produced were all incorporated into a GIS package and delivered to Energy Metals.

- Recommended future work includes:

    - Carry out an interpretation of the new geophysical data and reassess existing geological models
    - Obtain open file seismic line data and incorporate into the interpretation
    - Carry out modelling and inversion of magnetic data over selected prospects
    - Plan future high-resolution aeromagnetic surveys

# 1 INTRODUCTION

Energy Metals' Ngalia Basin projects are located about 200 km northwest of Alice Springs in the Northern Territory. Four high-resolution airborne magnetic and radiometric survey areas were flown for Energy Metals by Daishsat Pty Ltd using an R44 helicopter at the Ngalia Basin during November and December 2014. The four aeromagnetic survey areas were named: Coonega, Dingo's Rest, Malawiri and Walbiri. The survey areas and the location of Energy Metals tenements are shown in Figure 1.

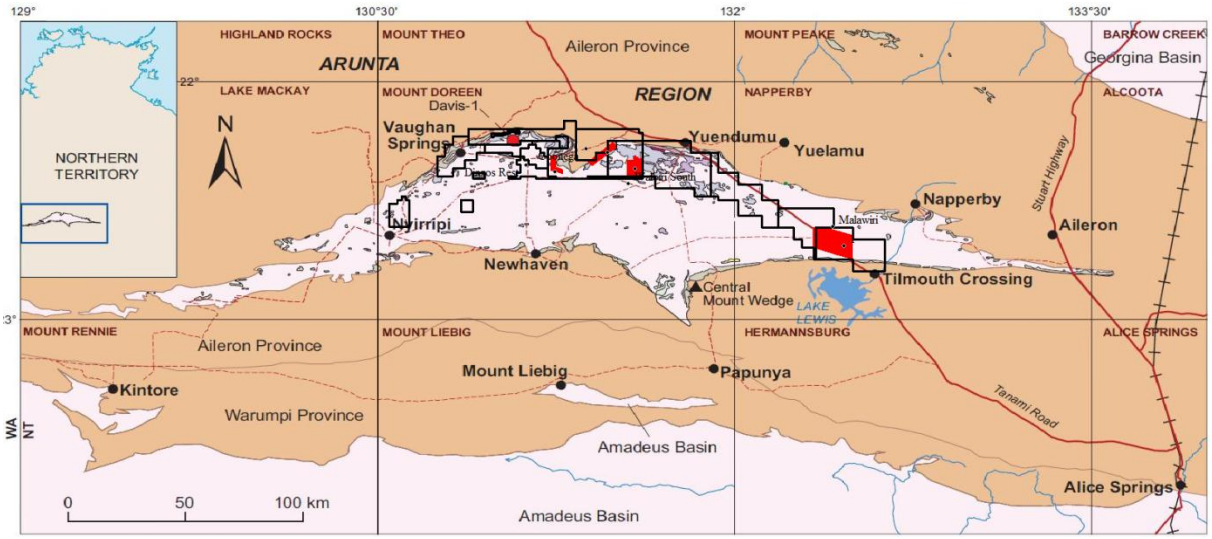


**Figure 1:** Energy Metals' Ngalia Basin tenement outlines (black) with airborne survey outlines (red) over a simplified geology map (image reproduced from Edgoose, 2013).

The geology of the Ngalia Basin consists of Neoproterozoic to Carboniferous sedimentary rocks up to 5 km thick, overlying the Paleoproterozoic basement Aileron Province of the Arunta Region. The Ngalia Basin sequence consists of shallow marine and fluvial sediments overlain by glacial clastics and then carbonates. Outcrop within the project areas is quite limited, due to extensive cover by Cainozoic sediments which can be up to 250 m thick.

Uranium exploration has occurred in the Ngalia Basin since the 1970's, with the focus being on roll-front style uranium mineralisation in the Mount Eclipse Sandstone, and carnotite mineralisation hosted in recent calcretes. Significant discoveries in the basin include the Bigrlyi, Walbiri and Cappers uranium deposits. The recent high-resolution aeromagnetic surveys flown for Energy Metals were designed to highlight the bedrock and regolith features associated with uranium mineralisation in the four areas of interest but also to be merged with existing open-file and company data to provide the best regional coverage. The merged regional datasets can be then interpreted to help identify other prospective uranium targets.

The airborne magnetic and radiometric survey data were assessed by Resource Potentials upon completion of acquisition to ensure data quality. The airborne survey parameters are summarised in Table 1. The processed airborne data and survey report were provided to Resource Potentials by Daishsat in December 2014. Quality control products of the survey data were generated by Resource Potentials and delivered to Energy Metals immediately after the survey was completed. Additional processing was completed by Resource Potentials and a suite of image products were generated.

These final processed data and images, and this report, were delivered on DVD, and a meeting was held to review the survey results. Figure 2 shows an image of the merged regional DEM with respect to the survey areas and tenements. More merged regional images are presented in Appendix 2.

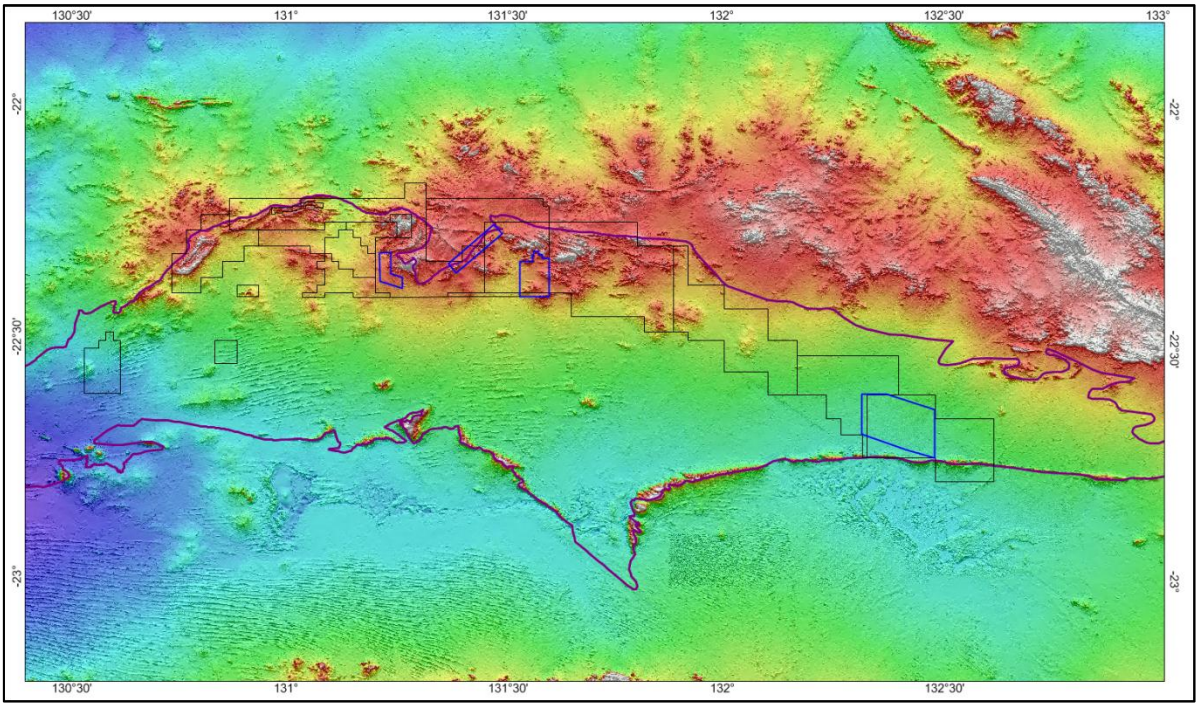


**Figure 2:** Image of merged regional SRTM and survey DEM data with sun-angle shading from the north. Airborne survey areas are outlined in blue, the Ngalia Basin is outlined in purple, and Energy Metals tenements are outlined in grey.

## 2 SCOPE OF WORK

The scope of the work undertaken by Resource Potentials for this project included:

- Airborne magnetic and radiometric survey planning, budgeting and contract review.
- Airborne magnetic and radiometric survey data QA/QC and provision of relevant products.
- Generation of preliminary and final data products, including georeferenced images.
- Obtain all available open-file regional and company geophysical data (including magnetic, radiometric and SRTM topographic data) and merge with new and other survey data.
- Recommendations for follow up work.
- Meeting and regular updates.
- This report and final data products handover.

## 3 AIRBORNE SURVEY SPECIFICATIONS

The Ngalia Basin airborne survey was flown from 25th November to 4th December 2014 using Daishsat's Robinson R44 helicopter system. A total of 7,915 line kilometres were flown with a line spacing of 50 m, as summarised in Table 2.

**Table 1:** Specifications for the airborne survey blocks flown in the Ngalia Basin for Energy Metals.

| | |
|---|---|
| Date of Survey | 25 Nov – 4 Dec 2014 |
| Areas Surveyed | Coonega, Dingos Rest, Malawiri, Walbiri |
| Survey Type | Airborne magnetics, radiometrics and digital elevation |
| Survey Height | 30 m |
| Line Spacing | 50 m |
| Line Direction | 140-320 (Coonega), 000-180 (other areas) |
| Tie Line Spacing | 500 m |
| Total Line Kilometres | 7,915 km |
| Datum | Geocentric Datum of Australia (GDA94) |
| Aircraft Type | Robinson R44 Helicopter (VH-DTZ) |
| System Set-up | Boom (stinger) mounted magnetometer, crystal pack in cockpit |
| Magnetometer | Geometrics Cs vapour magnetometer assembly, G823B |
| | with precision Kroum KMAG4 counter |
| | Billingsley TFM100G2 vector magnetometer |
| Base Magnetometer | Two Geometrics portable proton precession base magnetometers |
| Spectrometer | Model RSX-4 16L integrated gamma detector & spectrometer |
| Radar Altimeter | Model PT200 allied signal (Bendix-King) KRA-405B radar altimeter |
| Climatic Observations | Vaisala barometric and temperature/humidity module |
| Positional Information | Novatel OEMV-1G, 32 channel GPS & GLONASS Receiver |
| On-board Computers | ZDAS Acquisition and navigational control module |

A report detailing the airborne survey system specifications and data acquisition and processing carried out by Daishsat accompanies this report as Appendix 3.

**Table 2:** Survey line numbers and final line kilometres for the Ngalia Basin aeromagnetic surveys.

| SURVEY AREA | Line Direction | | Line Kilometres | | Line Numbers | |
|---|---|---|---|---|---|---|
| | Traverses | Ties | Traverses | Ties | Traverses | Ties |
| **Coonega** | 140-320 | 050-230 | 1016.7 | 99.2 | 300010-302930 | 390010-390070 |
| **Dingo's Rest** | 000-180 | 090-270 | 636.5 | 65.9 | 400010-401150 | 490010-490180 |
| **Malawiri** | 000-180 | 090-270 | 4107.3 | 412.5 | 100010-103500 | 190010-190320 |
| **Walbiri** | 000-180 | 090-270 | 1430.0 | 147.0 | 200010-201490 | 290010-290220 |
| | | **Sub-totals** | 7190.5 | 724.6 | | |
| | | **Total** | **7915.1** | | | |

## 4 QUALITY CONTROL OF DATA

The airborne system comprised a low noise, high-sensitivity magnetometer and a 16 L sodium-iodide crystal pack. The magnetometer was mounted in a boom which projects forward from the helicopter and the crystal pack sits inside the cockpit, behind the pilot.

While operating, the magnetometer acquires data at 20 Hz which equates to sampling approximately every 2 m. The boom used to place the magnetic sensor far away from likely sources of magnetic interference generated by the helicopter is effective at reducing noise, but small sources of directional magnetic noise still perturb the magnetic data. Some of these effects are reduced by filter and magnetic compensation, which further improves the signal to noise. Post-flight compensation was performed on these survey data.

The radiometric spectrometer acquires data at 1 Hz which equates to a sample spacing of approximately 48 m. More crystal packs would improve the spectrometer the signal to noise ratio. However, crystal packs are rather large and heavy, so only one can fit in the small confines of the R44 helicopter. This means that the radiometric data will be noisy despite the advantage gained by the low flying height of 30 m.

The final survey data were received from Daishsat in December 2014. These data were downloaded and imported into a Geosoft database. The flight lines were plotted on a map to verify their location and adherence to the survey specifications. Important data channels were quickly gridded and imaged to verify that they were correctly named and visually appeared to be in good order. The radar altimeter channel was reviewed to ascertain possible areas where topographic effects may cause problems in the magnetics or radiometrics. Noise analysis was performed on the magnetics by applying a $4^{th}$ difference filter and reviewing the results in profile. Furthermore, statistics were computed and collated for all data channels and verified for compliance with the survey contract. The data were found to be within acceptable noise limits although the magnetic data was considered a little noisier than seen in the past from this contractor. The statistics and flight line profiles were delivered to Energy Metals to validate quality assurance.

## 5 DELIVERABLE PRODUCTS

Flying at a low altitude and at a tight line spacing of 50 m with a high rate of acquisition, means that the magnetometer will better detect subtle magnetic responses caused by high frequency and low amplitude anomalies from shallow sources, and other features in the underlying rocks. Subsequent image processing helped to highlight these features, as well as filter out the shallow responses in order to see the response from deeper sources.

Prior to imaging, the magnetic data were reduced to the pole (RTP). This transformation is common practice to effectively place the magnetic anomaly directly over the magnetic source. All subsequent imaging of the magnetics is performed on the RTP grid for each survey area apart, from the analytic signal filter.

The standard Resource Potentials suite of images typically provides reasonable visual coverage of the data. However, further imaging was performed to enhance the fine detail contained in the high-pass

filtered images, and the broad feature anomalies in the low-pass filtered images. Consequently, some new imaging techniques were trialled, such as the Goussev filter and two new in-house edge-detecting filters. Deep features were highlighted by applying a tuned low-pass filter to the gridded magnetic data. The resulting images were provided on disc and are listed in Appendix 1.

Additional geophysical data images also have been provided. Regional open-file magnetic and radiometric data, and 1-second SRTM (Shuttle Radar Topography Mission) data, were obtained and merged with the following datasets to produce higher quality regional images:

B119 "Crystal Creek" high-resolution airborne survey
EL24566 "Ngalia Thrust" airborne magnetic and radiometric survey
EL2296 "Vaughn Springs" airborne magnetic and radiometric survey
EL24451 "Resupply" airborne magnetic and radiometric survey

These surveys are shown in Figures 7-9, and provided in Appendix 2.

The procedure used to merge the regional and survey grids achieves high quality by retaining the high- resolution data in the merged output. The final merged regional images were designed to cover a large portion of the Ngalia Basin to assist in the interpretation of the current areas of interest and for further uranium exploration work. A selection of images of the merged regional datasets is provided in Appendix 2.

All geophysical data images have been provided as georeferenced ECW images suitable for use in MapInfo or ArcGIS. The regional merged images and images of the individual Coonega, Dingo's Rest and Walbiri survey areas are provided in GDA94/MGA zone 52 coordinates. Images for the Malawiri survey area are provided in MGA zone 53 to better suit its location. However, it was also reprojected into MGA zone 52 in order to merge with the regional datasets, therefore an additional set of images for this are provided in MGA zone 52 for convenience. A list of all the images and other data products supplied is provided in Appendix 1.

## 6 DISCUSSION

The high-resolution magnetic and radiometric airborne survey data was intended to enhance the subtle magnetic responses in the regolith associated with essentially non-magnetic sediments, and highlight possible structures and other features not previously apparent in the geology and other available geophysical data. The outcome of these new surveys is improved interpretability and the provision for better targeting of potential uranium mineralisation. In this regard, the airborne survey has been successful at the four survey areas.

At the survey block scale, there is clear evidence of folding of the sedimentary sequence across all four survey areas, and probable evidence of depositional unconformities and thrust faulting in places. Also apparent, is the overprint of more recent drainage which has remobilised the near-surface magnetic material and thereby disrupted the magnetic response caused by bedding and other underlying features, which are of prime interest for uranium exploration. Figures 3 to 6 display examples of these features in the Walbiri, Coonega, Dingo's Rest and Malawiri survey areas, respectively.

The regional magnetic grids have been merged from standard open-file data yet have retained the higher resolution of the smaller tenement-scale airborne surveys. The regional images, therefore, offer a wider perspective which, when reviewed in tandem with the individual high-resolution survey areas, provides a very useful suite of images from which bedding, structure, and other features can be traced more confidently across the basin. This encourages a more holistic interpretation and raises the possibility of discovering new uranium deposits under an expanded exploration program. Some regional images have been included in Appendix 2.

## 7 RECOMMENDATIONS

The most obvious recommendation is to re-assess the existing geological models based on an interpretation of the new geophysical data. Therefore, Resource Potentials offers to carry out an interpretation with a focus on structural setting based on the open-file seismic line data as well as the final suite of products produced as part of this survey work.

Another recommendation would be to plan out the location of future high-resolution airborne surveys to complement Energy Metals revised exploration program. Resource Potentials would include this in any subsequent work for Energy Metals.

Resource Potentials also recommends that modelling and inversion of magnetic data be carried out over selected prospects. Modelling better defines the depth and orientation of target bodies for drill testing.

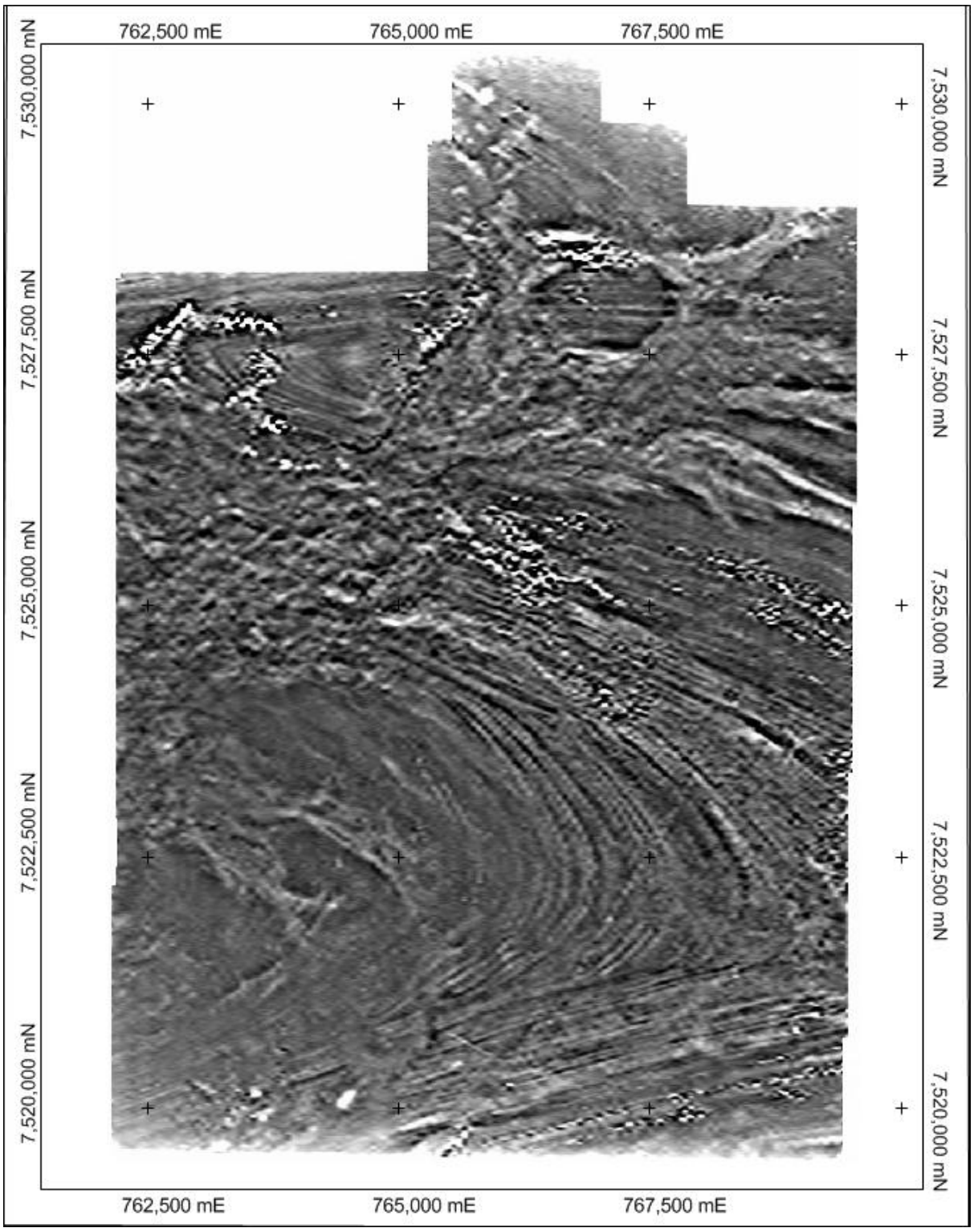


**Figure 3:** First vertical derivative of the TMI RTP of the Walbiri survey area. Depositional unconformities and subsequent folding in the sedimentary bedding can be clearly seen in the centre of the image. However, in the northern half of the image, the folded bedding is obscured by recent drainage, which has redistributed the magnetic material into paleodrainage systems.

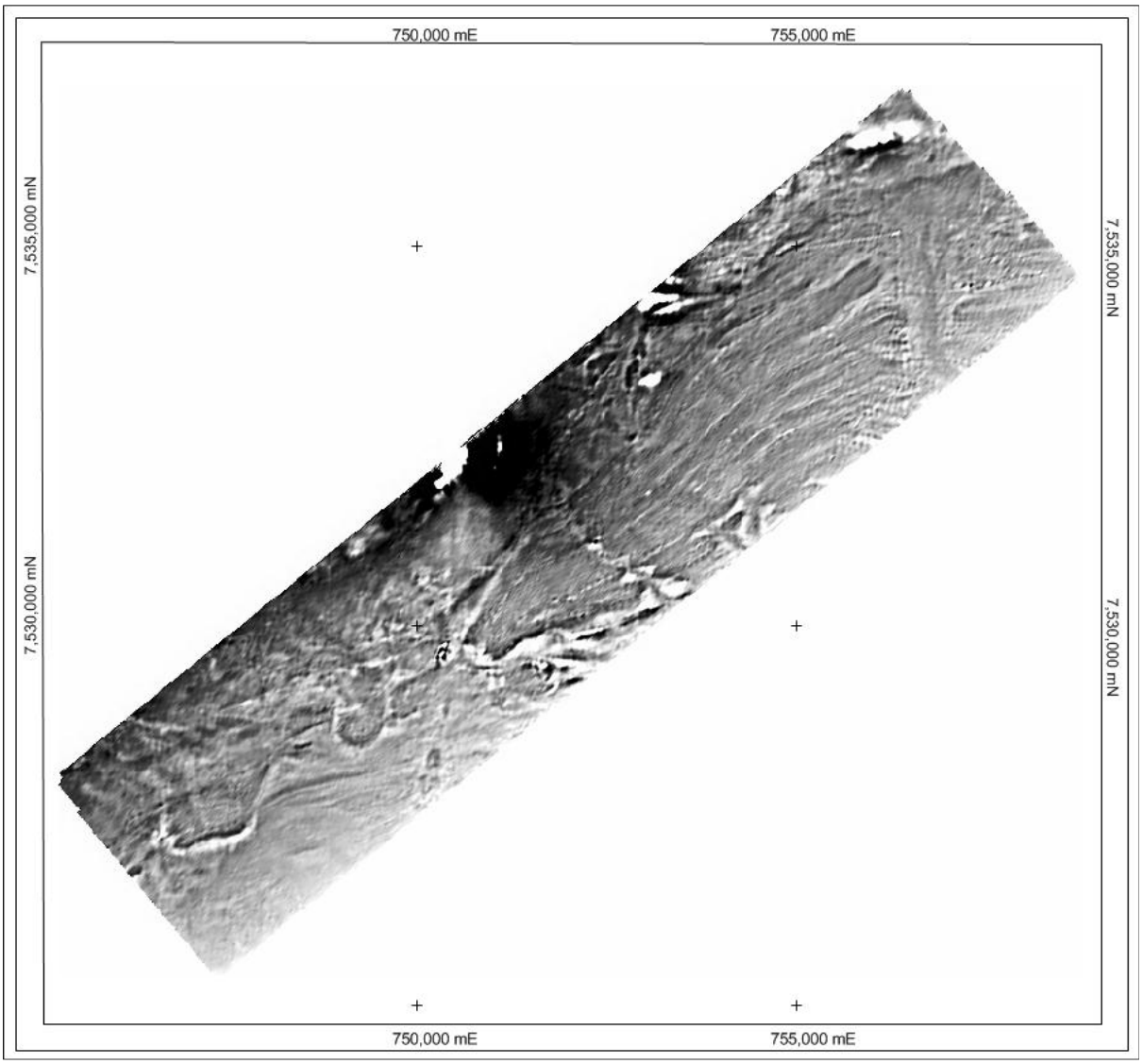


**Figure 4:** First vertical derivative of the TMI RTP of the Coonega survey area. Sedimentary bedding is apparent and strikes to the NE-SW. However, in the north-eastern corner of the image, recent drainage has redistributed the magnetic material.

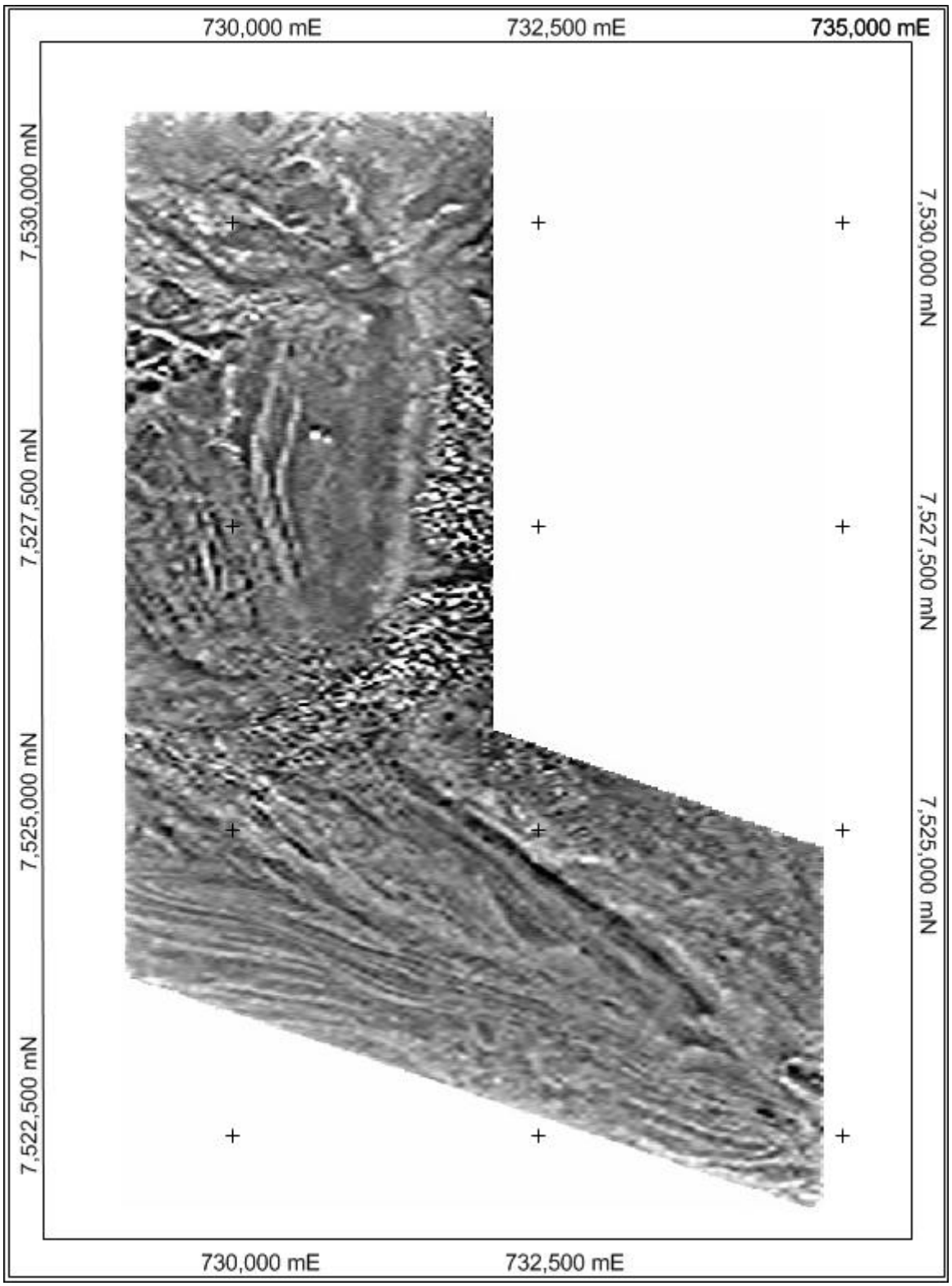


**Figure 5:** First vertical derivative of the TMI RTP of the Dingo's Rest survey area. Sedimentary bedding can be seen striking N-S in the upper half of the image, and striking NW-SE in the lower half of the image. Tight folding is also apparent in the southern part of the survey area. Recent drainage has overprinted the magnetic material where a mottled or dendritic pattern is observed.

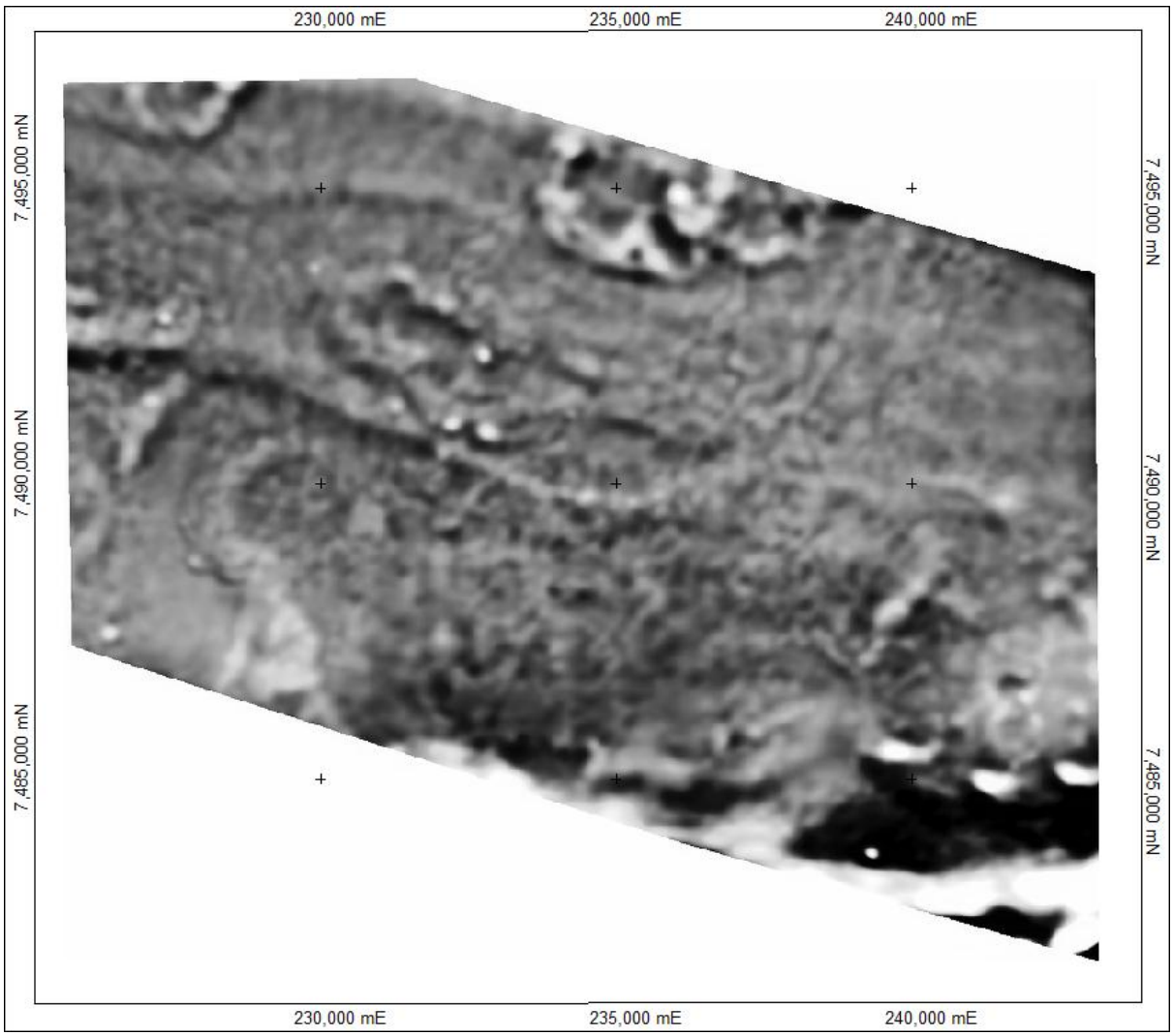


**Figure 6:** Low-pass filtered TMI RTP of the Malawiri survey area to enhance deeper magnetic features. The sedimentary bedding in this area shows much more complexity than apparent in previous low-resolution surveys, and may represent beds following thrust planes, and folded beds from underlying salt or shale diapirs, or carbonate reefs.

# 8 BIBLIOGRAPHY


- Daishsat Ltd, 2014, Aerosystems Survey Summary Report, Ngalia Basin Airborne Survey, Project 14050; for Energy Metals Limited, December 2014 (unpublished).

- Edgoose, C.J., 2013. Chapter 24: Ngalia Basin: in Ahmad M and Munson TJ (compilers). *'Geology and mineral resources of the Northern Territory'*. Northern Territory Geological Survey, Special Publication 5, p. 24:1-24.

## APPENDIX 1 - List of Supplied Geo-referenced Images and Vector Files

(See the Resource Potentials Filenaming Convention list also supplied)

| Airborne Survey Data Products | | |
|---|---|---|
| **MapInfo Registered ECW Images** | | |
| Magnetics | TMI RTP | greyscale, colour & sun-shaded colour |
| | TMI RTP over RTP 1VD | colour |
| | TMI RTP 1VD | greyscale, colour & sun-shaded colour |
| | TMI RTP 1VD AGC | greyscale |
| | TMI RTP 1VD over 2VD AGC | colour |
| | TMI RTP 2VD | greyscale |
| | TMI RTP 2VD AGC | greyscale |
| | TMI RTP Deep HP | greyscale |
| | TMI RTP Deep HP2 | greyscale |
| | TMI AS | colour |
| | TMI RTP EDGE{1, 2} | greyscale, colour & sun-shaded colour |
| | TMI RTP Goussev | greyscale, colour & sun-shaded colour |
| | TMI RTP Resid | greyscale |
| | TMI RTP TDR | greyscale, colour & sun-shaded colour |
| | | |
| DTM | DEM | greyscale, colour & sun-shaded colour |
| | DEM 1VD | greyscale |
| | | |
| Radiometric Data | Rad {TC, K, Th, U} | greyscale, colour & sun-shaded colour |
| | Rad ratio K over Th | colour |
| | Rad ratio U over Th | colour |
| | Rad ratio U*U over Th | colour |
| | Rad K-Th-U | ternary colour |
| | | |
| **Vector Files** | | |
| | Airborne survey line paths | MapInfo tab |
| | Airborne survey outlines | MapInfo tab |
| | Tenements | MapInfo tab |

## APPENDIX 2 – A selection of images and vector files that accompany this report

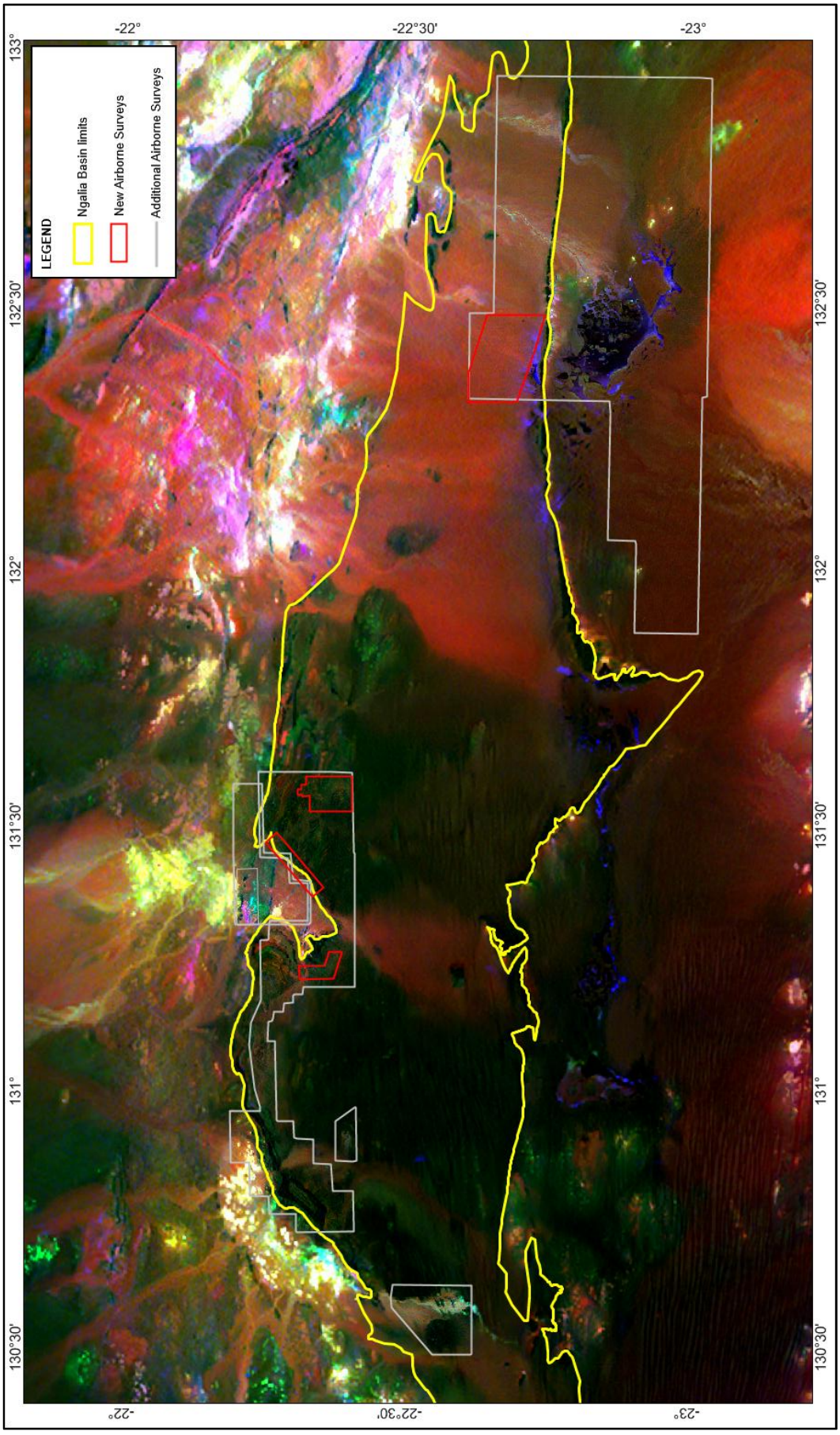


**Figure 7:** Ternary image of the merged regional radiometric data (red = potassium, green = thorium, blue = uranium).

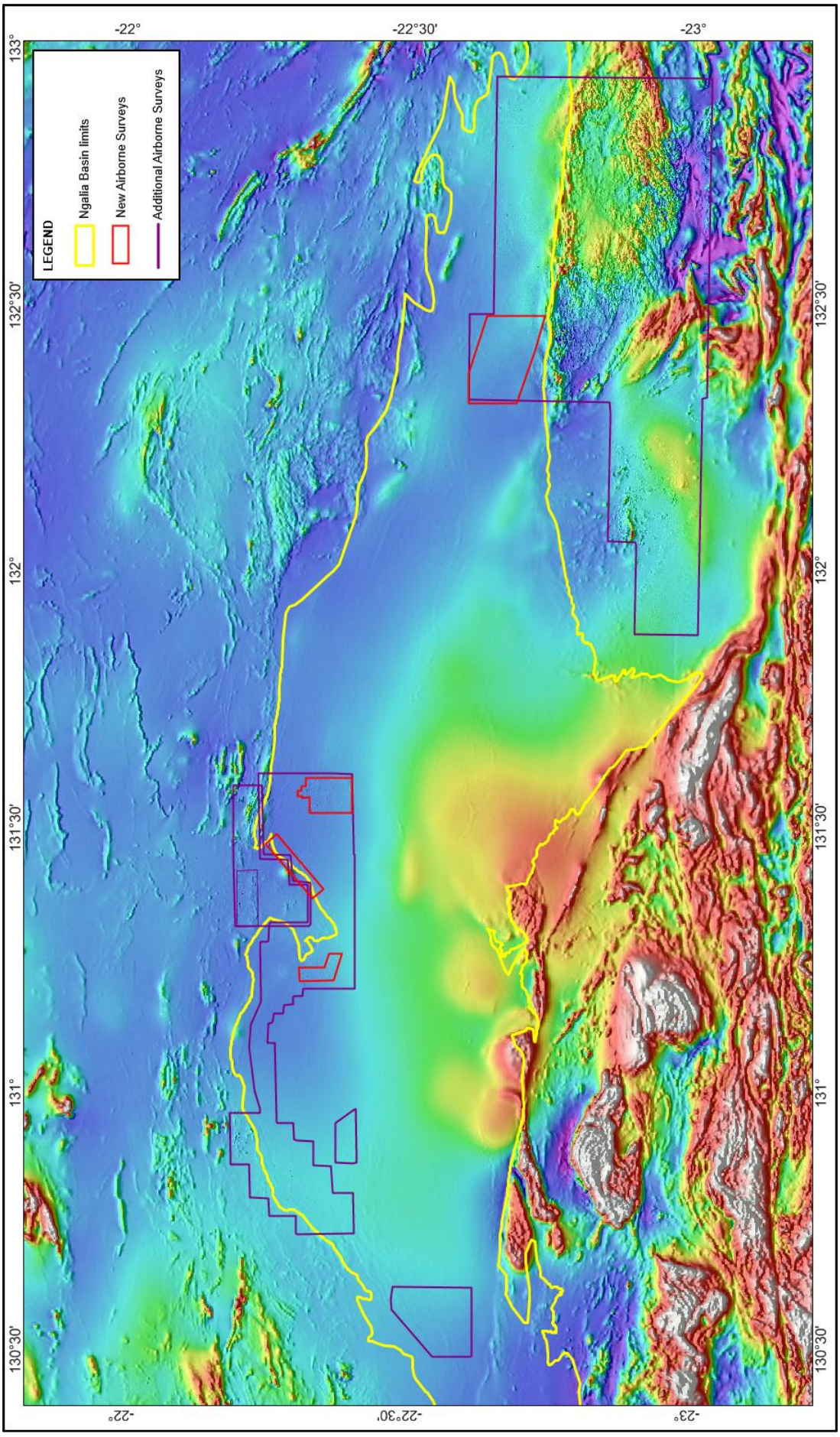


**Figure 8:** Sun-shaded image of merged regional total magnetic intensity (TMI) reduced to the pole (RTP).

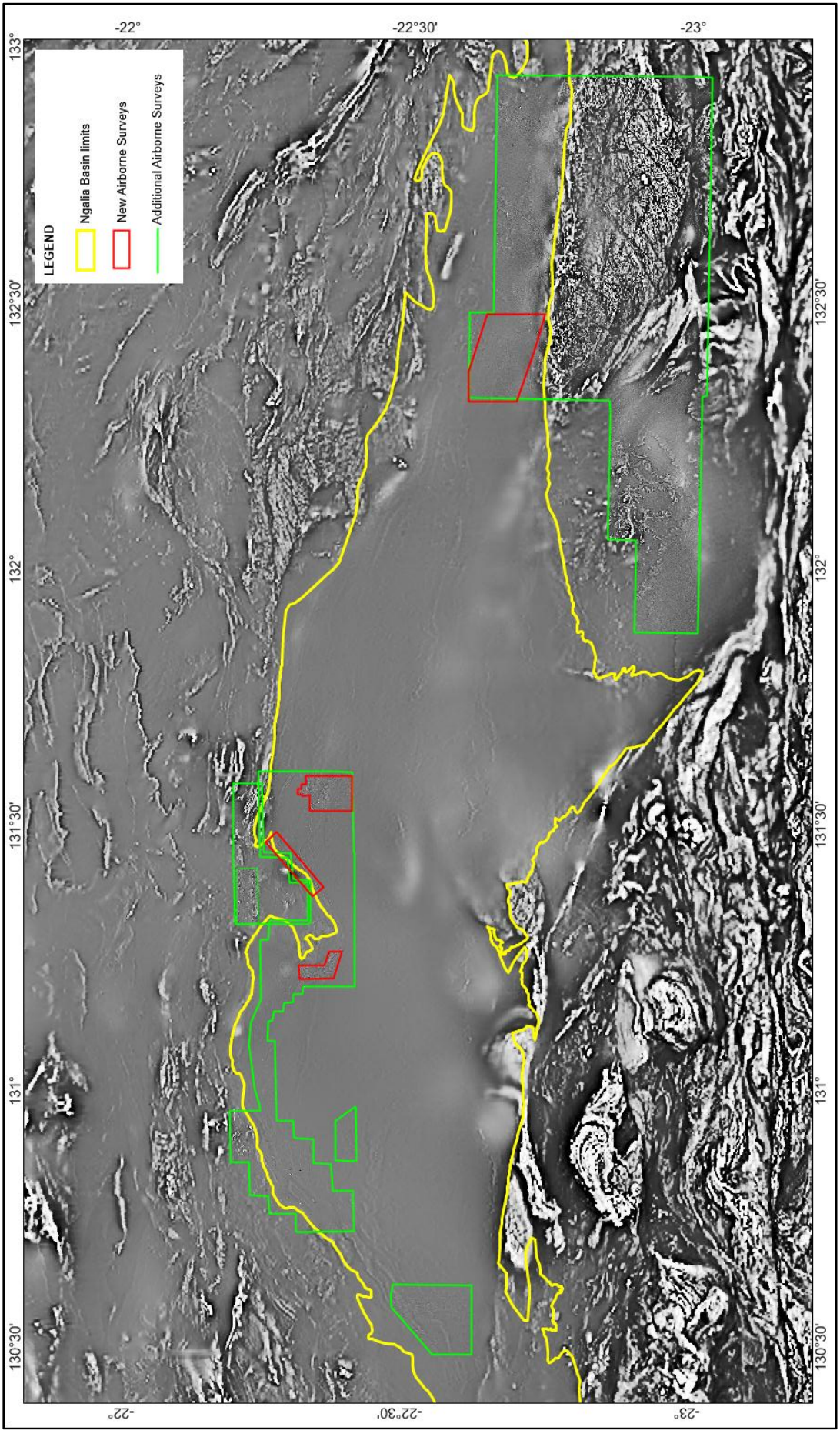


**Figure 9:** Image of the 1st vertical derivative (1VD) of merged regional magnetic intensity reduced to the pole (TMI RTP).