Night-Time Thermal Infrared Data Interpretation

Part 1

Deep Yellow Limited
Exploration Licences 23655, 23888, 23991, 23923 and 23924

Reynolds Range Project, N.T.

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Executive Summary

This report addresses the application and findings of Night-time Thermal Infra-Red (NTIR) data over the Reynolds Range Project area comprising of granted ELs 23655, 23888, 23991, 23923 and 23924.

Three types of landforms were recognised using NTIR. These included concealed palaeochannels, alluvial fans and regions of accumulated transported sediment. Cooler thermal responses appear dark on NTIR data. Channels and fans showed characteristic dendritic distribution of cool thermal sediments and dark zones of irregular polydons were noted in areas of sediment accumulation. No direct surface expressions of buried palaeochannels were apparent.

Zones of greater sediment accumulation identified may act as potential trapsites for sediment hosted uranium mineralization. They may reflect the palaeovalley architecture or may represent a similar scenario to the Beverley Prospect in the Frome Basin in South Australia. Further investigation is required during the drilling phase of the exploration program.

The main lithologies outcropping in the Reynolds Range Project are granites and sediments of Palaeozoic age. These occur parallel and trend in a NW to SE orientation. Elevation data was integrated into this NTIR data interpretation. Further processing of the elevation data revealed an orthogonal series of trendlines which seem to have truncated or acted as some sort of bounding control of the surface lithologies and provided a preferred orientation for present day drainage. Evidence of structural controls from both NTIR data and elevation data has implications on the transport of uraniferous groundwater.

NTIR data is another geophysical tool for mineral exploration which provides indirect information about concealed palaeomorphologies. Depending on the source data resolution can vary but it is inexpensive an excellent first pass to establishing areas of focus for uranium targeting.
# CONTENTS

1. Introduction ................................................. 5  
2. Reynolds Range Project ................................... 6  
   • Location ................................................. 6  
   • Geological Explanation ............................... 6  
2. Remotely Sensed Data ..................................... 6  
   • 2.1 ASTER ............................................... 6  
   • 2.2 NOAA-AVHRR ...................................... 7  
   • 2.3 Elevation Model ................................... 8  
3. Discussion ................................................ 9  
4. Conclusions ............................................... 11  
5. Recommendations ....................................... 11  
6. References ............................................... 12  
7. Appendix ............................................... 13  

# Figures

Figure 1: Location map of the Reynolds Range Project area 5  
Figure 2: ASTER NTIR coverage over central Australia 6  
Figure 3: ASTER NTIR scene over Reynolds Range Project area 7  
Figure 4: Full scene of NOAA NTIR over Australia 7  
Figure 5: Enlarged area of NOAA NTIR over Reynolds Ranges 8  
Figure 6: Elevation model of Project area with current drainage 9  
Figure 7: Interpreted channels draped over the U channel from the airborne radiometrics 10

# Appendices

- **Appendix 1** Raw NOAA data images  
- **Appendix 2** ASTER NTIR from Lake Frome showing Beverley and Beverley Four Mile  
- **Appendix 3** ASTER NTIR image from Reynold Ranges  
- **Appendix 4** LANDSAT™ image with current drainage  
- **Appendix 5** Palaeochannel interpretation draped over Elevation model integrated with airborne radiometrics  
- **Appendix 6** Interpretation of EL 23888 draped over ASTER integrated with airborne radiometrics and DEM
1. INTRODUCTION.

Night-time Thermal Infra-Red (NTIR) data from the NOAA satellites have been acquired over Deep Yellow Limited’s (DYL) Reynolds Range Uranium Project area. Exploration licences include EL 23655, 23888, 23991, 23923 and 23924 located on the boundary of the MT PEAKE and NAPPERBY 1:250 000 mapsheets in the Northern Territory (Fig 1). Higher resolution NTIR data from the ASTER satellite were used where available.

Specific characteristics of the NOAA NTIR data are its 1.1 km spatial resolution, the frequency of overpass, and the low cost of the data. Although the spatial resolution is coarse it is sufficient to delineate larger anomalous zones of contrasting temperature variation between the sediments and the outcropping granites and Lander Beds. Cloud cover and wind-shear affect the quality of the data however for interpretive work numerous scenes can be acquired due to the frequent overpass of the satellite and the value of the data. Images used were acquired early morning flight paths between 16/9/2008 – 28/9/2008. ASTER data was valuable in identifying the fine framework of the palaeochannels.

Results of NTIR data applied to this region demonstrate suitability of these data for palaeochannel interpretation. Subsurface regions with cooler thermal responses interpreted as variations in the palaeovalley architecture require follow up investigations. The integration of elevation data from the shuttle radar highlighted structural trends showing no surface expression. Understanding the effect these structures may have had on the distribution and deposition of sediments during the Tertiary will compliment findings from this study.

![Figure 1 Location map of the Reynolds Range Project area](image-url)
2 REYNOLDS RANGE PROJECT

Location

The project area lies approximately 170 Km NNW of Alice Springs. It is accessed by the main Alice Springs to Darwin Highway and numerous access tracks. There is sparse vegetation cover, mainly low-lying mallee and the landuse is mainly cattle farming.

Geological Explanation

Deep Yellow’s Reynolds Range Project area captures the valleys that flank the Reynolds, Anmanjira and Yundurbulu Ranges. Reynolds Range is a belt of north-west to south-east trending metasedimentary rocks of generally low metamorphic grade. To the north, trending in the same direction are the Anmanjira and Yundurbulu Ranges rounded batholithic granites and small masses of moderate to high grade metamorphic rocks which occupy the spaces between the batholiths. A series of faults trending orthogonal to the outcropping units have been interpreted from elevation data.

Regional airborne radiometrics show these metasediments to have low values of U emissivity which is a contrast to higher levels display by the granites bounding the tenement to the north-east and the south-west.

Stewart (1982) described the sequence of uplift and weathering and depositional events during the Cainozoic which have contributed to the present landscape. Ferricrete surfaces developed on two occasions, during the Late Cretaceous (or Early Tertiary) and Mid Tertiary. Lithification of colluvium to fanglomerate was another event during the Mid-Tertiary which has the potential of influencing NTIR thermal response, as the solid impervious nature of these sedimentary units may mask or mottle the true extent of Tertiary palaeovalleys presently occupied partially by the Lander River.

2. REMOTELY SENSED DATA

The main remotely sensed datasets used in this interpretation are elevation data, NOAA and ASTER NTIR data, Landsat 7™ and the U channel of regional scale airborne radiometrics. Standard geological mapsheets and explanatory notes were referred to for geological units

2.1 ASTER

The ASTER satellite has 5 bands acquiring data in the thermal infrared. The concept of identifying temperature variations is similar to NOAA, the key difference between the 2 satellites is the higher spatial resolution of the ASTER data (90 m). The disadvantage of using ASTER is the lack of continuity. (Fig 2) Each scene covers an area of 60km x 60km. The scene used for this study was acquired in spring 16/10/2008 (Fig 3).

Figure 2 ASTER NTIR coverage over central Australia
2.2 NOAA- AVHRR

The Advanced Very High Resolution Radiometer (AVHRR) carried on board the National Oceanic and Atmospheric Administration (NOAA) satellite provides global coverage of radiance data. An example of one NOAA image full scene is shown in Figure 4.

Each pass of the satellite provides a 2399km wide swath. The satellite orbits the Earth 14 times a day from a height of 833km. The ground resolution from this height is 1.1 k. Data is gathered from 5 channels, however only channels 4 and 5 are relevant to this work. Numerous images were downloaded but the best results were derived from almost cloud free data in central Australia acquired in late winter 2008..(25/9/2008) (Fig 5).
2.3 Elevation Model

The elevation model used in this work is a subset from the shuttle radar (SRTM) data. It provides a spatial resolution of 90 meters. Integrating elevation data with other remotely sensed data to locate concealed palaeochannels has been successfully used in studies of the Yilgarn Craton W.A., the Eromanga Basin S.A. and Queensland and the Gawler Craton in SA. A close correlation exists between the transported regolith regions identified from the elevation model and the occurrence of the thermal responses of NTIR data.

Elevation models highlight surface textures which are related to geomorphic landscapes such as incised valleys, sand dunes, river deltas and flood plains. What has become evident from the elevation data in this study is the NE-SW orientation of present day drainage. However more significant it has been modelled to depict the terrain prior to the formation of the fanglomerates and silcrete units which flank the Reynolds and Anmanturra Ranges. The Lander River valley during the Late Cretaceous appears to have been greater than 10 kms in width.

A grey elevation model from SRTM data enhanced to show the highest outcrops of the Reynolds Range Project is used in the background of present day drainage and the outline of the project area in red. (Figure 6)
Figure 6: Elevation model of Project area with current drainage

3 DISCUSSION

Sediments in palaeochannels are recognised as host units for uranium in “roll front” style deposits through which U-rich groundwater can travel. Palaeochannels comprising of sediments of a porous permeable nature act as ideal conduits for the transportation of groundwater. However the recent discovery by Heathgate Resources at Beverley Four Mile in the Frome Region of South Australia was identified within an alluvial fan system demonstrating that conduits are not confined to palaeochannels but extended to include alluvial fans and in the case of Kazakhstan style uranium mineralization, sheet sands. Reynold Ranges project area comprises both palaeochannels and alluvial fans adjacent to and incising granitic source rocks with observed elevated uranium levels from airborne radiometric surveys.

Subsurface moisture such as groundwater trapped in sediments of palaeolandforms contributes to their ability to cool down and heat up at a different rate to that of surrounding bedrock. It is this feature of sediments which responds well to thermal analysis. Thermal bands from imaging systems such as NOAA and ASTER supply information which can be used to calculate variations in temperature from surface and near surface lithologies. The optimal time for these measurements is early morning and late evening when the temperature contrast will be the greatest. Data for the Reynolds Range was acquired in the morning. Cooler temperatures on greyscale images generated from these data are dark grey to black. No surface water or claypans are indicative of these subsurface river systems but moisture rich sediments create dendritic drainage patterns which can infer the presence of palaeosystems.

Interpretation of palaeosystems from NTIR data in the Reynolds Range project (Fig 7) was based on principals of remote sensing, sedimentology and geomorphology. Thermal responses which may be relevant to uranium exploration in the region fall into one of three categories, palaeochannels, palaeo-alluvial fans and zones of congestion such as creek intersections and creek truncations due to structural controls.
Palaeochannel centrelines with strong thermal contrasts have been delineated from the integration of ASTER and NOAA NTIR. In some cases these follow present day drainage. In the Yilgarn and Gawler Cratons these palaeovalleys comprise of sediments of different ages suggesting a stacked channel environment. The Lander River is located in a wide valley and has an associated dendritic thermal response which may also relate to deeper Tertiary sediments.

Tectonism appears to have influenced stream directions with numerous faults trending NE – SW inferred from the elevation model. Zones of strong thermal response along a paleosystem which has been interrupted by neotectinism indicate similarities to the Beverley deposit which is structurally controlled by a fault system trending NE and parallel to the Paralanna Fault. The thermal response at Beverley is more of a polygon, a zone of darker thermal response and less of a sinuous channel feature. In this text the polygon shaped thermal features have been referred to as “ponding”. Ponding features are also seen to occur at creek intersections. They are also more evident in NOAA data and in some instances may be a product of the poorer spatial resolution of the data.

The last of the three landforms identified are fan lobes. NOAA data does not clearly discriminate these lobes. Again this may be related to data resolution or may be a seasonal effect during acquisition time. ASTER data has highlighted a series of fans draining from granites with elevated U levels. These trend NE across EL 23924. Satellite imagery from Landsat TM and Google Earth show the present day distribution of sediments from the Reynolds Range via fan systems. NTIR ASTER highlights the displacement, preferred channels and extent of the palaeo-fan lobes. Thermal responses in the lobes vary, showing sinuous dendritic channels and dark polygons of “ponding” where sediments have accumulated. These fans extend up to 5km from the ranges. And are mapped as ..........in a region of low relief on the plains north of Reynolds Range. Beverley Four Mile (Appendix 2) is located on the plains east of the Mt Painter Province (MPP) (Stamoulis, V. 2007).

**Figure 7** Interpreted channels draped over the U channel from the airborne radiometrics
Other observations relating to the palaeo-landforms include:

- Fans tend to be more pronounced on the northern side of the ranges.
- A number of tributaries within these fans trending in a specific direction indicate the main palaeosystem into which they flow and help identify slight elevations creating drainage divides.
- The uranium channel of the radiometrics shows present day drainage systems from the ranges have slightly elevated uranium levels. Buried channels and fans have no associated radiometric anomaly at the surface.
- Fractured and weathered near surface units may have similar thermal response which may contribute to palaeochannel thermal response.

Geological maps of the area show numerous small outcrops of basement, particularly in the Lander River Valley surrounded by Quaternary units. It can be assumed this cover sequence is shallow but it can also indicate intense fracturing resulting in severe weathering. Any event which generates porosity and permeability whether localised fracturing/jointing and weathering or on a larger scale such as shear zones, or sedimentary units themselves will produce a thermal response. As this interpretation is based only on NTIR data cold zones with thermal contrasts, some areas whether sedimentary in origin or weathered may fall into this category. Knowledge of the geology and its weathering ability needs to be incorporated into the prospective model of the region.

There is a marked difference in appearance of thermal responses between the two NTIR datasets however both showed changes in moisture intensity within a channel system. Moisture retained in sediment, the close proximity and volume of weathered bedrock and volume of sediment vary in channels so the thermal response seen in the NTIR data will also vary giving rise to the uneven thermal responses and pixel definition.

4 CONCLUSIONS

The aim of this study was to identify palaeochannels using NOAA and ASTER NTIR data. Integration of these data delineated main trunks and tributaries of possibly stacked channel sediments. The centerlines of these have been mapped (Figure 7) from the NOAA data (yellow linework) and the ASTER (magenta linework) The high resolution ASTER data highlighted finer details of fluvial morphology such as fan lobes and zones of more intent thermal response which was often poorly defined if at all evident in the NOAA data. Sediments retain moisture due to their porosity and permeability forming a direct contrasted against the impervious granites surrounding them. The dark dendritic patterns they form have no surface uranium signature but still indicate transport direction from the “hottest” granites.

Terrain and the quality of the data may impacts on thermal interpretation. Some of the Lander River Valley thermal responses may be due to shallow weathered in situ basement sparsely outcropping which has similar moisture retention abilities of transported sediments. Atmospheric effects resulting from cloud and wind moisture seen in both NTIR datasets may obscure thermal boundaries.

Overall the technology has provided exploration targets for uranium mineralization in sedimentary host rocks which have no surface expression.

5 RECOMMENDATIONS

Recommendations from this work include:

- Further investigations and drilling should be directed in regions identified with thermal responses and which drain directly from granites with high uranium radiometric response.
- It may also be of benefit to ratio the airborne radiometric data and investigate anomalous regions in relation to these thermal responses.
- Where possible further ASTER NTIR should be acquired over the tenements.
- Pockets of sediments which have been referred to as “ponding” may be deeper due to a structural constraints or reflect the valley architecture.
• Potential targets are concealed and may have no surface radiometric response and may now appear as topographic highs. Further investigation of these thermal responses is recommended.

6 REFERENCES


7 APPENDICES

1. Raw NOAA Files

28/9/2008 T16

25/9/2008
2. ASTER NTIR from Lake Frome showing Beverley and Beverley Four Mile
3. ASTER NTIR image from Reynolds Range
4. LANDSAT™ image with current drainage
5. Palaeochannel interpretation draped over Elevation model integrated with airborne radiometrics
6. Interpretation of EL 23888 draped over ASTER integrated with airborne radiometrics and DEM

Fanglomerates mapped on the northern side of the Reynolds Range give a mottled effect in the ASTER data. There are pockets of intense thermal responses which require further field investigation (A)