

# DEEP SEISMIC REFLECTION PROFILING IN THE NORTHERN TERRITORY: PAST WORK AND FUTURE DIRECTIONS

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## Introduction

Current geological mapping by the Northern Territory Geological Survey is leading to a much better understanding of the surface geology of the Territory. Less well understood is the geometry of the Northern Territory in the third dimension, although this has been predicted by the construction of cross sections (e.g. on recent 1:250 000 geological maps). At shallow depths, the cross sections can be constrained by drilling results, if available, but deeper levels can only be examined by geophysical techniques such as seismic reflection or magnetotelluric profiling, or by modelling of potential field data.

Deep seismic reflection profiling has been used for many years by Geoscience Australia (formerly AGSO), often in conjunction with a state government, research and industry partners, to provide images of the continental crust of parts of Australia in the third (depth) dimension. Here, we discuss aspects of previous deep seismic surveys that have been conducted in the Northern Territory (Figure 1), briefly examine the results and interpretation of recent reprocessing of some of the deep seismic

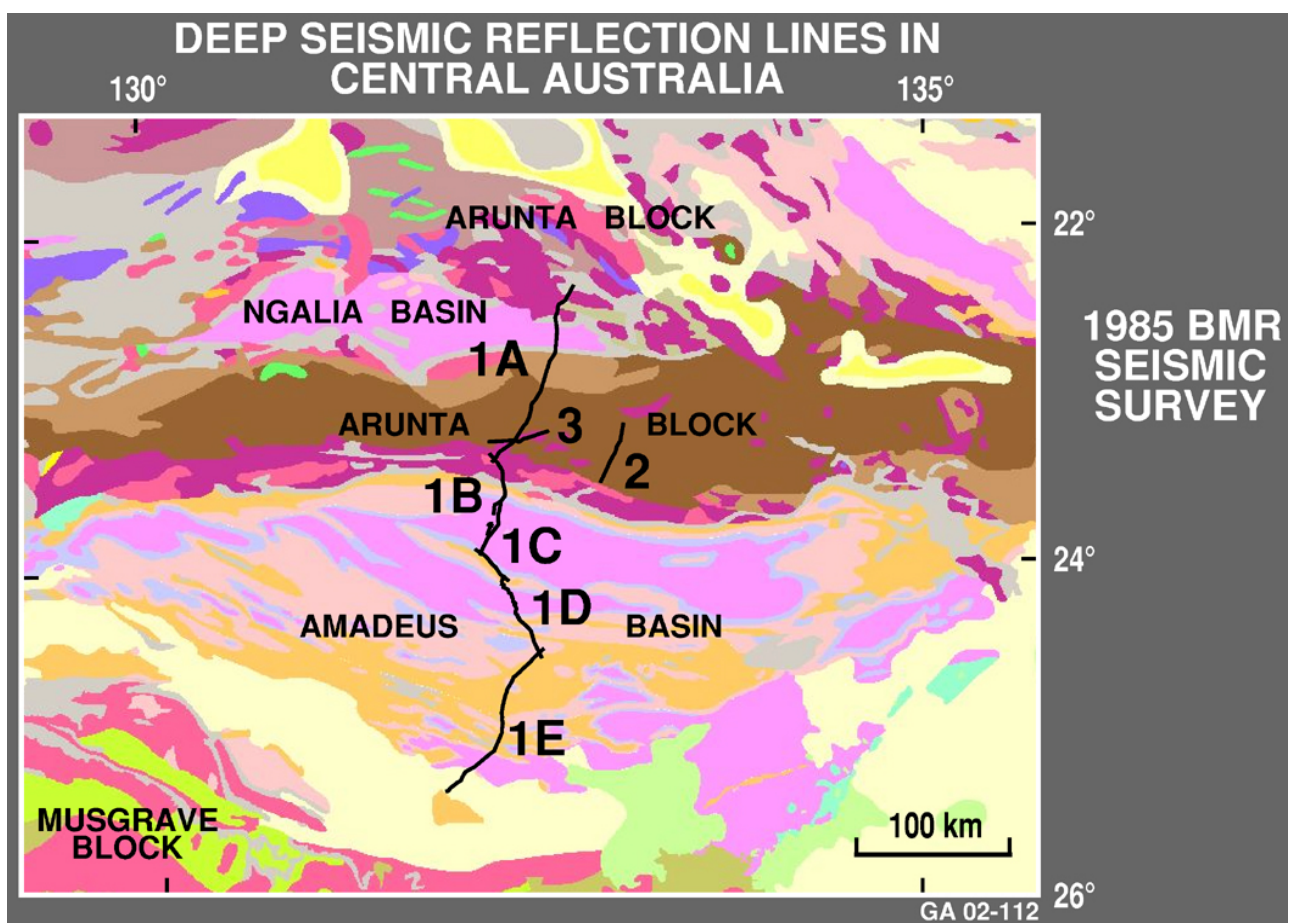


Figure 1: Location of the 1985 deep seismic lines in central Australia. Line 1 is subdivided into 5 segments, 1A through 1E. Line 1A crossed the Arunta Block and is the first line to be reprocessed. Geoscience Australia's 1:5m geology of region is used for the background.

reflection data from the Arunta Block, and present proposals for future deep seismic transects in the Northern Territory.

### **Previous Deep Seismic Surveys in the Northern Territory**

A very limited amount of deep seismic reflection profiling has been conducted in the Northern Territory to date, with one extensive survey in 1985 to examine the geometry of the Amadeus Basin and part of the Arunta Block (Goleby et al., 1988; Wright et al., 1990). This survey collected 486 km of 20 s two-way travel time (TWT) (approximately 60 km depth) data along four traverses (Figure 1) using explosive sources. In addition, a wide-angle refraction survey was conducted in the Arunta Block at the same time, and a second wide-angle survey was conducted in the Amadeus Basin in 1988.

The reflection profiling indicated that the dominant feature of the Arunta Block crust is a series of planar structures that dip about 40° to the north, and that these penetrate to depths of greater than 20 km (Goleby et al., 1989; Shaw et al., 1992).

### **Reprocessing of 1985 data**

As part of the NGA North Australia Project Mineral Promotion, Geoscience Australia has reprocessed the northern part of the 1985 regional traverse that was completely within the Arunta Block (line BMR85-1A; Figure 1) to investigate if it was possible to improve the quality of the section and hence improve on the original interpretation of this line.

Improvements in processing algorithms, particularly signal enhancement and pre-stack migration techniques, have greatly enhanced the final quality of the seismic section. The recent reprocessing concentrated on three main areas of processing; static corrections, signal enhancement and migration. First breaks were picked for all shots and an improved refraction statics model was calculated, resulting in better definition of the near surface. Signal enhancement methods focused on increasing the signal to noise levels within the recorded data and improving in continuity of reflecting events. The main improvement to the quality of the section came from the application of time based pre-stack migration. The pre-stack migration resolves details in many of the smaller structures and sharpens up the final section. The results of this reprocessing are an improvement in the quality of the final section through improved clarity (Figure 2), leading to a better understanding of the geodynamic history of the region. The remainder of the 1985 seismic data will now be scheduled for reprocessing.

### **Interpretation of the reprocessed data**

The reprocessing of the reflection data (Figure 2), and in particular the migration of the upper 10 s TWT (approximately 30 km) of the data, has enabled us to refine the published interpretations (see references above). The new sections confirm the existence of the north-dipping faults. In addition, the increased clarity shows the presence of several large hanging wall anticlines, indicating that the faults are thrusts. Hence massive crustal shortening has occurred in this part of central Australia.

Some of the planar faults have a stronger seismic response than others. For example, an unnamed fault about 8 km to the north of the Desert Bore Fault has a much stronger seismic response than the Desert Bore and Harry Creek faults.

Based on the crustal reflectivity patterns, we are able to partition the crust into several fault-bounded packages. The key faults forming the boundaries to the packages are the Ormiston Thrust

Zone, the Redbank Thrust Zone, the Desert Bore Thrust, the unnamed fault about 8 km to the north of the Desert Bore Fault and the Patty Hill Thrust.

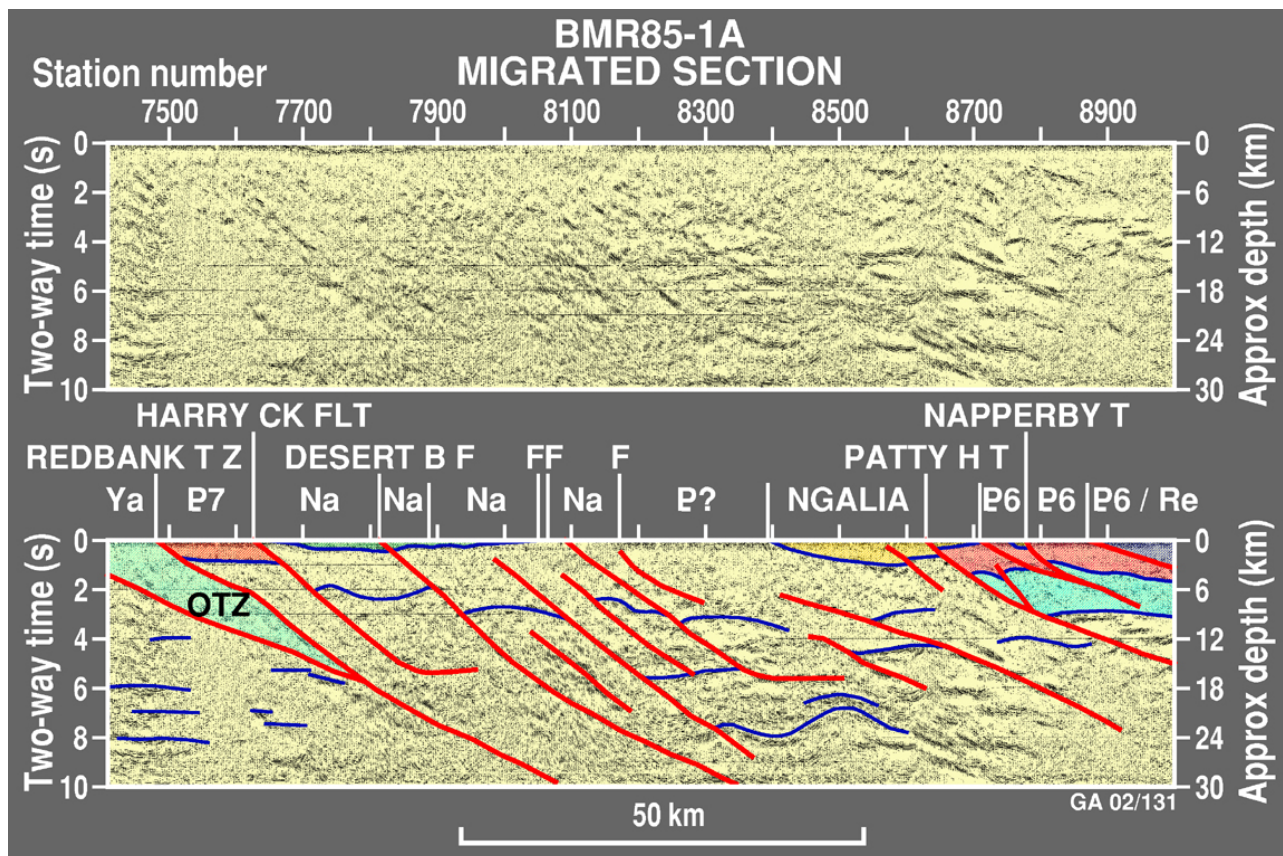


Figure 2: Reprocessed deep seismic reflection data from line BMR85-1A across the Arunta Block, central Australia. Top figure shown uninterpreted reprocessed section, bottom figure shows interpreted seismic section. Red lines show major faults or shear zones, blue lines indicate interpreted lithological markers. OTZ - Ormiston Thrust Zone, TZ - Thrust Zone, T- Thrust, F (or FLT) - Fault, B - Bore, Na - Narwietooma Terrane (>1820 Ma), Re - Reynolds Terrane (1810 - 1780 Ma), Ya - Yaya Terrane (1680-1640 Ma), P7 - 1640-1600 Ma granites, P6 - 1780 - 1760 Ma granites, P? - unknown aged granites.

## Proposals for future seismic work in the NT

In terms of enhancing the mineral potential, we present four proposals for deep seismic reflection profiling within the Northern Territory (Figure 3). An accompanying program that would undertake a wide-angle refraction experiment and/or a lithospheric tomography experiment, such as has been conducted by the SKIPPY Australia-wide experiments, could strengthen the surveys.

### 1. Batten Trough, McArthur Basin

Key geological problems that could be addressed here are:

1. Geometry of McArthur Basin and contained sub-basins
2. Stratigraphy and thickness of basin succession
3. Nature of main faults (e.g. Emu, Tawallah, Mallapunyah, Calvert faults)
4. Possible east-west growth faults and sub-basin architecture near HYC

### 2. Western Arunta - Tanami

Key geological problems that could be addressed here are:

1. Geometry and character of Trans Tanami Fault Zone



2. Relationship of Proterozoic rocks to Archaean domes
3. Relationship of major gold deposits to major regional structures
4. Nature of boundaries between North Australia Craton and Central Australia domains, and between the Tanami region and the Arunta Block.

### 3. Northern Arunta – Tennant Creek Inlier

Key geological problems that could be addressed here are:

1. Comparison of tectonic style between Northern Arunta and Tennant Creek Inlier
2. Nature of boundaries between North Australia Craton and Central Australia domains, and between the Tennant Creek Inlier and the Arunta Block
3. Geometry of Wiso Basin, including Lander Trough and its margins
4. Controls on mineralisation in Tennant Creek Inlier

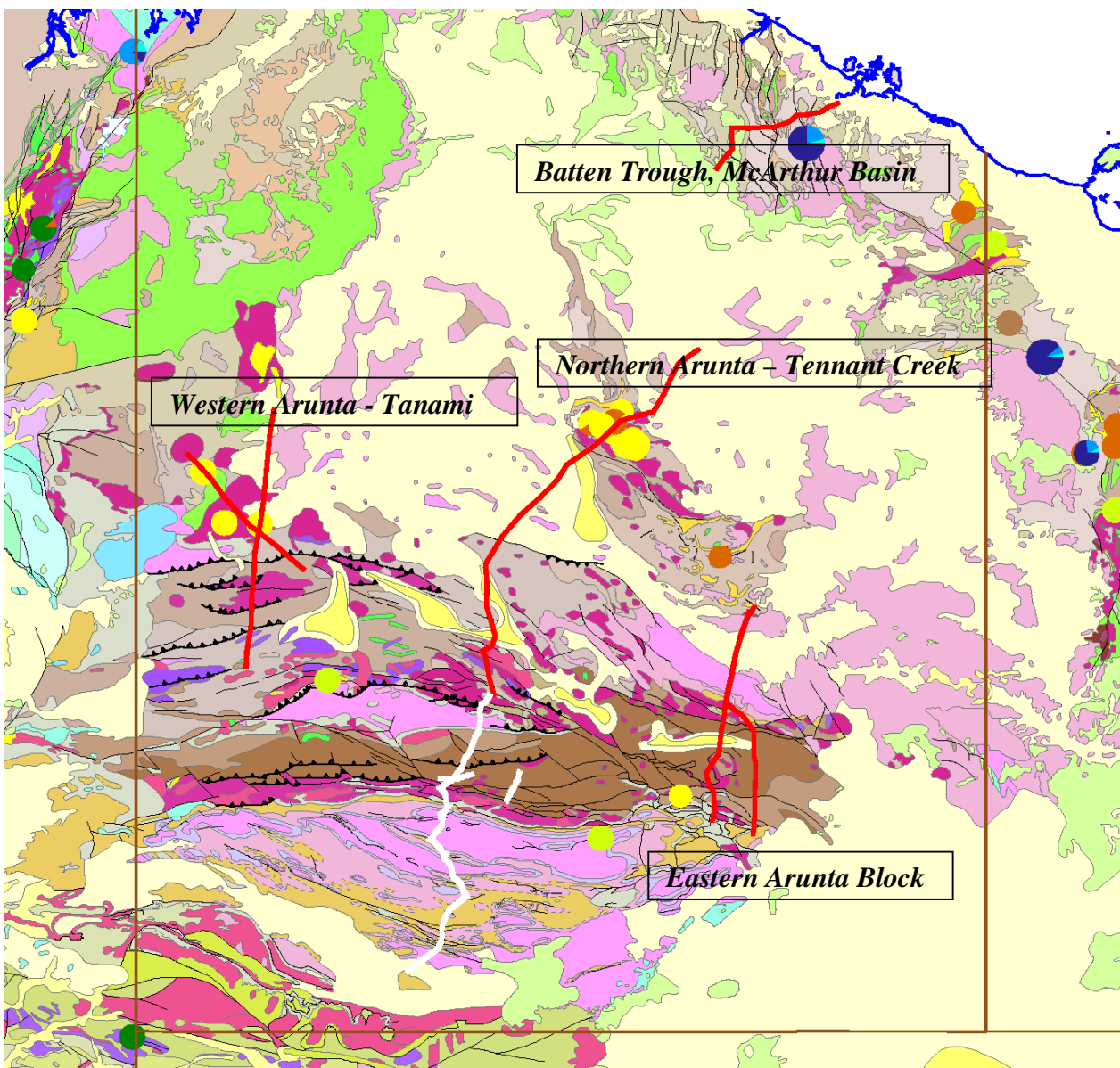


Figure 3: Geological map of the Northern Territory showing proposed deep seismic traverses. Coloured dots indicate major ore deposits. Gold - yellow, Lead/Zinc - blue/cyan.

### 4. Eastern Arunta Block

Key geological problems that could be addressed here are:

1. Geometry of southern Georgina Basin

2. internal sequence stratigraphy, structural geometry, potential petroleum traps
3. Geometry of structures and rock packages associated with Ordovician Larapinta Event
4. Crustal architecture across the doubly vergent intraplate Alice Springs Orogen
5. Nature of boundary between North Australia Craton and Central Australia domains

## Conclusions

Only a very limited amount of deep seismic reflection data has been collected in the Northern Territory. Reprocessing of part of these 1985 data has improved the section quality. Interpretation of the new sections confirms that the Central Australian crust is dominated by north dipping faults, and that large hanging wall anticlines show that these faults are thrusts. Also, based on reflectivity patterns, major crustal packages can be defined. Future seismic programs can address several key geological problems of importance to mineral exploration, with the potential for high impact.

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## References

- Goleby, B.R., Wright, C., Collins, C.D.N. and Kennett, B.L.N., 1988. Seismic reflection and refraction profiling across the Arunta Block and Ngalia and Amadeus basins. *Australian Journal of Earth Sciences*, 35, 275-294.
- Goleby, B.R., Shaw, R.D., Wright, C., Kennett, B.L.N. and Lamberk, K., 1989. Geophysical evidence for "thick-skinned" crustal deformation in central Australia. *Nature*, 337, 325-330.
- Shaw, R.D., Goleby, B.R., Korsch, R.J. and Wright, C., 1992. Basement and cover thrust tectonics in central Australia based on the Arunta-Amadeus seismic reflection profile. In: Rickard, M.J., Harrington, H.J., & Williams, P.R., (editors), *Basement Tectonics* 9, Kluwer Academic Publishers, Dordrecht, pp. 55-84.
- Wright, C., Goleby, B.R., Collins, C.D.N., Korsch, R.J., Barton, T., Sugiharto, S. and Greenhalgh, S.A., 1990. Deep seismic profiling in central Australia. *Tectonophysics*, 173, 247-256.