I5 : Batten Trough Deep Seismic Reflection Traverses

Project Summary

This is a collaborative project between the Northern Territory of Australia, represented by the Department of Business, Industry and Resource Development - Northern Territory Geological Survey (NTGS), Geoscience Australia (GA) and the predictive mineral discovery Cooperative Research Centre (pmd*CRC).

Projects Visionary Goal

Reflection seismic data has the potential to make the most significant impact on our understanding of the giant McArthur deposit. Seismic data will enable the basin geometry and sediment architectures to be reconstructed, on both a local scale and a regional scale, permitting ideas to be tested concerning the migration of metal bearing basinal fluids from their aquifer sandstones, along suitable fault planes to the reductant shales to form the deposits.

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Background Statement

Palaeoproterozoic rocks of the southern McArthur region contain an unmetamorphosed, relatively undeformed succession of carbonate, siliciclastic and volcanic rocks that host the McArthur River Pb-Zn-Ag deposit. Since its discovery in the late 1950's the deposit and surrounding rocks of the southern McArthur have been the subject of intensive stratigraphic, structural, mineral paragenesis and geochemical research, much at the local, deposit scale. The long-term objective of this research involved the generation of new exploration concepts and targets in the southern McArthur and elsewhere in the Carpentaria Zinc Province of northern Australia. From a research perspective the McArthur deposit occupies the pre-eminent position as the best-preserved deposit in the Carpentaria Zinc Belt. Coincident SHRIMP zircon depositional ages for host sediments to the deposit and Pb/Pb model ages for galena in the deposit constrain the time of ore body formation to ~1640Ma. A prominent hairpin bend on the Apparent Polar Wander Path provides evidence for changes in plate motion and coincident variations in the intraplate stress regime, the likely driver of fluid flow at this time.

Over the past five years the deposit has also been the subject of preliminary fluid flow modelling studies aimed at testing and constraining the range of conditions that led to its formation. These studies are dependent on our ability to reconstruct basin geometry and sediment architecture at the time(s) of fluid migration. At present, the weakest link in this research concerns the lack of suitable datasets to constrain the basin geometry and sediment architecture at the time(s) of fluid flow. The Geoscience Australia NABRE project erected a chronostratigraphic framework for northern Australia. In the McArthur region surfaces of chronostratigraphic significance have

been identified, but lack of regional thickness information have limited our ability to reconstruct basin geometries. Fluid flow modelling studies of the McArthur deposit at CODES are based on a simple 2D transect model in which the stratigraphic architecture and structure require testing.

The single dataset with the potential to make the most significant impact on our understanding of this giant deposit is reflection seismic data. Seismic data will enable basin geometry and sediment architectures to be reconstructed, on both a local scale and a regional scale, permitting ideas to be tested concerning the migration of metal bearing basinal fluids from their aquifer sandstones, up faults to the reductant shales to form the deposits.

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Objectives & Aims of Project

The seismic survey will examine the fundamental basin architecture of the Batten Trough, McArthur Basin and nature of the underlying basement. Geological field work by the NABRE project allowed the interpretation of the Proterozoic basin in terms of sequence stratigraphic and structural models which have been developed largely in much younger basins prospective for petroleum. Much of the seismic program is designed to test geometric models for the McArthur Basin, specifically to examine the sequence stratigraphy of the Palaeo- and Mesoproterozoic basins, their bounding faults and relevant basement structures. The results will have wider applicability in that the basin is an undeformed analogue of the Western Succession of the Mt Isa Province.

In particular the seismic program will:

- Determine the thickness, detailed stratigraphy, and structure of the Tawallah, McArthur and Nathan Groups within the Batten Trough and on the Bauhinia Shelf to the west and the Wearyan Shelf to the east of the trough.
- Determine the direction of extension that formed the Batten Trough, and the direction of compression that inverted the trough. Can we constrain the timing of these events?
- Investigate the nature of the Emu Fault and its relationship to the Batten Trough. Is this a strike slip fault and does it have a decollement at some level within the upper crust?
- Possibly investigate the relationship of the Mallapunyah Fault to the Batten Trough. Is there a major crustal structure controlling the Mallapunyah-Calvert-Termite Range fault system.
- The McArthur Group has a projected thickness of over 4000 m east of the Broadmere Syncline, but surface geology indicates that it has wedged out to the west of the Broadmere Syncline. Does this western edge of the McArthur Group represent the edge of the depositional basin, or a postdepositional structure?
- Where is the eastern edge of the McArthur Group? What influence did the Emu Fault have on deposition of this succession?

- The RTP magnetic image indicates the presence of small rotational blocks (sub basins?) east of the Emu Fault. Has transtensional movement on this fault formed these structures, and what is their influence on the mineralisation in this region?
- What is the nature of the Tawallah Fault, and what is its association with the Emu and Mallapunyah faults.

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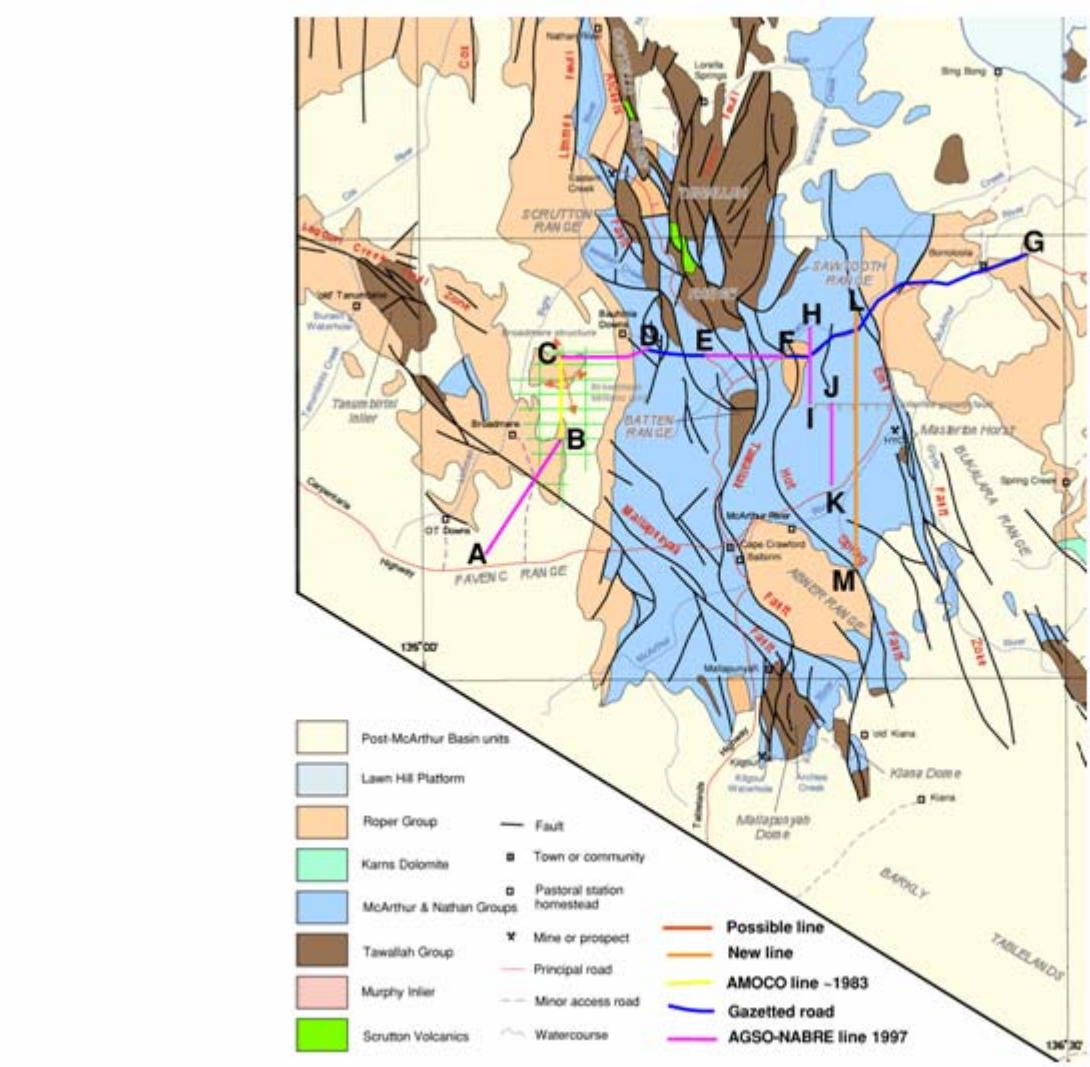
Research Strategy & Methodology

The proposed seismic program consists of two deep seismic lines within the Batten Trough, McArthur Basin. The main seismic line is a regional E-W line. A shorter N-S line located to the east of the Emu Fault crosses this regional line and extends southwards towards the HYC deposit. The location of these lines is Figure 1 below, along with a several additional lines and some existing seismic data.

- Location map of the Batten Trough regional deep seismic reflection traverse (section recorded was line C-D-E-F-to almost G, ~110 km) and the north-south seismic traverse (H-I, ~18 km). Note that traverse segments A-B-C and traverse J-K and L-M were not collected.



The regional E-W line is designed to acquire deep seismic data to provide a continuous profile of the crust through the Batten Trough. The regional E-W line recorded went from point **C** to some 20 km east of the Emu Fault or some 10 km west of point **G** near Borroloola. The N-S line recorded is line **H - I** as shown on Figure 1.

Line 1 - length 120 km

Main line across the Batten Trough from the eastern edge of the Amoco grid (Bauhinia Shelf) to Borroloola (Wearyan Shelf, see Figure 1). This line will test the overall structure and basin geometry of the Batten Fault Zone ('Batten Trough') and determine:

- Thickness and stratigraphy of the McArthur Basin succession and lateral variations thereof.
- Does the Batten Trough exist and what is its geometry? What stratigraphic changes occur at proposed trough margins? (ie, from Batten Trough onto Wearyan and Bauhinia Shelves). For example, does the McArthur Group wedge out on the Bauhinia Shelf or is it a structural remnant? (Plumb, 1979 vs Pietsch et al., 1991). Was this fault zone a 'rift'?

- Architecture of sub-basins in the middle McArthur Group currently implied from surface thickness variations and magnetic images (eg, Myrtle Sub-basin; CEC, 1972).
- Revisit the Broadmere structure (petroleum target based on old, poor quality, Amoco seismic data).
- Orientation, inter-relationship and form (strike-slip vs extensional) of major crustal features such as the Emu and Tawallah Faults. What influence did they have on deposition and when?
- Are there any stratigraphic or structural relationships with known mineralisation around HYC and can they be extrapolated to the rest of the Batten Trough to generate new SEDEX and MVT prospects?
- Basement-cover relationships. and
- Thickness variations and structure of the immediate basement, which may include thick piles of volcanic rocks (Leaman, 1998).

Line 2 - length approx 35 km

Short north-south line west of, and parallel to, the Emu Fault in the central Batten Trough. Designed to test the inferred presence of east-oriented growth-fault and sub-basin architectures in the middle McArthur Group near HYC (Hinman, 1996 and others). This line will address the questions:

- Do these architectures exist, and
- What is their style.

Key Deliverables

- Digital seismic data for traverse(s) in the Batten Trough.
- Seismic sections as final stack sections and migrated sections (in both paper and digital formats).
- Interpretations of the above seismic sections.
- Final report on acquisition and processing procedures.
- Scientific paper outlining geological interpretations and implications (post confidentiality period).