Bureau of Mineral Resources, Geology & Geophysics

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R E C O R D

EAST ARAFURA SEA - SEISMIC RECONNAISSANCE (PROJECT 121.31)

- RESEARCH CRUISE PROPOSAL -

by

A. MOORE

BMR
GEOLOGY AND
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SUMMARY

The eastern part of the Arafura Sea in Australian waters is virtually unknown geologically, with seismic coverage being limited to widely separated traverses, some of which have poor sub-seabed penetration.
Cruise 94 in 1990 demonstrated that the area outside the Goulburn Graben is not as unprospective as previously assumed. Preliminary results indicate a very thick sedimentary sequence north of the Graben, with a variety of hydrocarbon plays in what had been dismissed as an unstructured basin.
It is proposed that the Rig Seismic be used for one month in late 1991 to carry out reconnaissance of the eastern Arafura Basin. A maximum of nearly 2900 kilometres of seismic multifold coverage will be acquired, together with magnetic and gravity data. The aims will be to complete the framework of essential seismic reconnaissance in the sparsely-explored and little-known eastern part of the Arafura Basin, to investigate the Wessel Rise and possible northern extensions of the Walker Fault Zone, and to clarify the relationship of the Arafura Basin to the eastern McArthur Basin and the Carpentaria Basin.

INTRODUCTION

The Arafura Basin (Figure 1) is the most extensive of the basins underlying the shallow Arafura Sea, and contains sediments of Cambrian to Permo-Triassic age. The west-northwest-trending Goulburn Graben (Bradshaw et al., 1990) within it contains up to 10 kilometres of Palaeozoic sediments. Exploration by a number of oil companies since 1971 (McLennan et al., 1990) has led to partial delineation of the basin sediments and structure, which has been recently reviewed (Petroconsultants, 1989). The eight exploration wells in the basin (Figure 2) have all been sited on structural targets in the Goulburn Graben (Figure 3), and most of the modern seismic coverage is within it. The majority of the Cambrian and Permo-Triassic sequences remain untested and extensive areas of the basin outside the graben are virtually unexplored.
In a recent study (Bradshaw et al., 1990), extensive redating of the Cambrian to Devonian sequences and analysis of the regional geology highlighted several new concepts. These have implications for the understanding of basin architecture and the tectonic history of Northern Australia, and for petroleum exploration in the area and beyond. Important features that have been recognised include, late restructuring in the Goulburn Graben and variations in style along its length, Lower Palaeozoic stratigraphic intervals that are of equivalent age to the oil source rocks in the Amadeus and Canning basins, the continuance of the Palaeozoic north of the graben to the Australian - Indonesian border, the existence of the lower Palaeozoic sequence to the northeast of the Wessel Islands, and the prevalence of relatively low geothermal gradients, thus raising the petroleum potential of the older sequences.
The first results from Cruise 94 of the BMR's vessel RV Rig

Seismic (Napier et al., 1991, in prep., Bradshaw and Moore, 1991) indicated a thick succession in the northern and eastern parts of the basin (Bradshaw et al., 1991). Later stacked profiles indicate structuring in the shallower part of the seismic succession in the east of the basin, and apparent detachment of this shallow structuring from the deeper layers of the basin. Because of this, and the widespread occurrence of poor data zones on the sparse existing seismic west of the Wessel Islands, which might be caused in part by poor spatial sampling, the planned seismic traverses will use a shorter group-interval and a higher fold of stacking than Cruise 94.

GEOLOGICAL SETTING

The Arafura Basin is a broad platform sequence situated on the northern margin of Australia mostly beneath the shallow waters of the Arafura Sea. Structurally it consists of a northern and a southern 'platform' separated by a mid-basin graben, the Goulburn Graben, perhaps analogous to the Fitzroy Graben in the Canning Basin. The Cambrian to Permo-Triassic Arafura Basin sequence is unconformably overlain by the mid-Jurassic to Recent Money Shoal Basin sequence and is underlain by Proterozoic sediments of the McArthur Basin (Figure 4). In the Goulburn Graben (formerly called Arafura Graben or Money Shoal Graben or Pre-Mesozoic Graben) there is a Palaeozoic sequence over 10 km in thickness, whilst on the northern and southern 'platforms' there are respectively at least 5 and 3 km of those sediments preserved.

BRIEF EXPLORATION HISTORY

The existence of a large Palaeozoic basin to the north of Australia was suspected for many years from the outcropping Cambrian sequence on Elcho Island (Wade, 1924; Plumb, 1965; Plumb et al., 1976) and aeromagnetic surveys (Balke & Burt, 1976). Oil exploration began in the early 1920s with the drilling of several shallow holes (<100 m) on Elcho Island in response to bitumen occurrences (Plumb, 1965). Offshore, Shell drilled Money Shoal 1 in 1971, which primarily tested a Mesozoic sequence. Tests of the Palaeozoic sequence of the Arafura Basin occurred between 1983 and 1986 with the drilling of Tasman 1, Torres 1, Arafura 1, Kulka 1 and Goulburn 1. All of these wells were sited offshore in the southern part of the basin along the Goulburn Graben. There were oil shows in most wells, and four source rock intervals were intersected. Arafura 1 was the most encouraging, encountering oil shows over a gross interval of 425 m in the Devonian and Ordovician and recording total organic carbon (TOC) values of up to 8.65% in the Middle Cambrian.

Seismic surveys of regional significance and with good subsurface penetration on at least some lines include:

Wessel Marine Seismic Survey 1972, shot by Western Geophysical for Beaver Exploration, Line ID - WM and W.

M81A Seismic Survey 1981, by GSI for Esso, Line ID - M81.
Arafura Sea S81 Survey 1981, by GSI for Sion Resources, Line ID - S81.
AM81 Survey 1981, by GSI for Mincorp, Line ID AM81.
DS81 Survey 1981, by Western Geophysical for Diamond Shamrock, Line ID DS-81.
DS84 Survey 1984, by Western Geophysical for Diamond Shamrock, Line ID DS-84.
Recent seismic surveys in the area include -
HA88A Seismic Survey by Halliburton for BHP, Line ID HA88A, PSLA ID 88/43
HA88B Seismic Survey by Halliburton for BHP, Line ID HA88B, PSLA ID 89/1
HA89A and HA89B, 1989, by Halliburton for BHP, Line ID HA89A and HA89B,
BMR Survey 94, 1990, by RV Rig Seismic. Line ID BMR94

CRUISE OBJECTIVES

The objectives of the cruise are as follows:-
*to fill gaps in the seismic coverage of the eastern part of the Arafura Basin and to tie it to seismic traverses in the central part of the basin.
*to investigate the relationship of the Arafura Basin to the Carpentaria Basin and the McArthur Basin.
*to investigate the Wessel Rise and the offshore extension of the Walker Fault Zone.

CRUISE PLAN

The cruise is scheduled for a 31-day period in November/December 1991, commencing in Cairns, beginning operations in the Arafura Sea on 19 November, and finishing in Darwin on 16 December. Eleven lines of multifold seismic traverse will be recorded, a total of 2879 kilometres. The traverses are shown on Figure 5 as lines A to L (there is no line I). The figures are line lengths in kilometres. Arrows on ends indicate that the traverse will join end-on to an existing or intended future line. The co-ordinates of the waypoints of the lines are listed in Appendix 1. These are according to the Australian Map Grid (AMG co-ordinates). Lines will be recorded in the order most convenient at the time, and they will be numbered in the order of acquisition. The geophysical equipment that will be used is shown in Appendix 2. The parameters of data collection are detailed in Appendix 3.
Magnetic, bathymetric and gravity data will be collected simultaneously with the seismic.

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ILLUSTRATIONS

APPENDIX 1

CO-ORDINATES OF SEISMIC LINES - WAY POINTS
LINE LENGTH in KM
DECIMAL LATITUDES (SOUTHERN HEMISPHERE IS NEGATIVE)
AND LONGITUDES (EASTERN HEMISPHERE IS POSITIVE)

APPENDIX 2: List of Geophysical Equipment

Seismic System

Streamer - Fjord Instruments transformerless analogue streamer configured as up to 288 x 6.25m groups. Syntron RCL3 cable levellers.

Source Array - 32-element tuned HGS sleeve-gun array available; 20 elements (3000 cubic inches/49 litres) configured as two strings of 10 in use at any one time.

- Teledyne gun signature phones, gun depth sensors
- 6x Price A-300 compressors, each rated at 300scfm @ 2000 psi

Recording - BMR designed and built seismic acquisition system based on DEC MICROVAX computer

- up to 320 channel digitally controlled preamp/filters
- bit accuracy
  - 16 bit floating point
- 6250 bpi Telex tape drives
- data written to tape in demultiplexed SEG-Y format
- 2 or 4 msec sampling
- streamer noise, leakage, and individual group QC
- source array timing QC
- recording oscillator and 4 seismic QC monitors

Bathymetric System

- Raytheon deep-sea echo-sounder; 2 kW output at 12 kHz
- " sub-bottom profiler; 2 kW " 3.5kHz

Gravity Meter

- Bodenseewerk Geosystem KSS - 31 marine gravity meter

Magnetometer

- Geometrics G801/803 magnetometer/gradiometer

Navigation Systems

GPS System - 2x Racal Skyfix in differential mode.
Backup - Magnavox T-Set GPS navigator
- Magnavox MX 1107RS and MX 1142 Transit satellite receivers
- Magnavox MX610D dual-axis sonar doppler speed log
- Sperry and Arma Brown gyro-compasses
- Ben paddle log
- Raytheon DSN450 dual-axis sonar doppler speed log

Non-seismic Data Acquisition System (DAS)

- acquisition system built around Hewlett-Packard 2117 F-Series minicomputer, with tape drives, disc drives, 12" and 36" plotters, line printers and interactive terminals

APPENDIX 3

ACQUISITION PARAMETERS

Source	2x1500 cubic inch sleeve air-gun arrays	
Shot Spacing	25m	50m
Shooting Interval	10 seconds	20sec
Ship Speed	4.5 - 5.0 knots	
Cable Length	3000m (subject to review)	
Group Interval	12.5m	
No. of Channels	240 (subject to review)	
Near Offset	approx. 200m	
Far Offset	approx. 3200m	
Cable Depth	10 - 12m	
Recording Fold	60 (subject to review)	30
Record Length	8 - 12 seconds	
Sample Rate	2 or 4 milliseconds	
Filter Settings	8 Hz Low cut; 125 or 62.5 Hz High cut	
Field Tape Output	6250 bpi	
Tape Format	SEG Y	

APPENDIX 4: Science Personnel

A.Moore	Co-chief scientist
D.Ramsay	Co-chief scientist

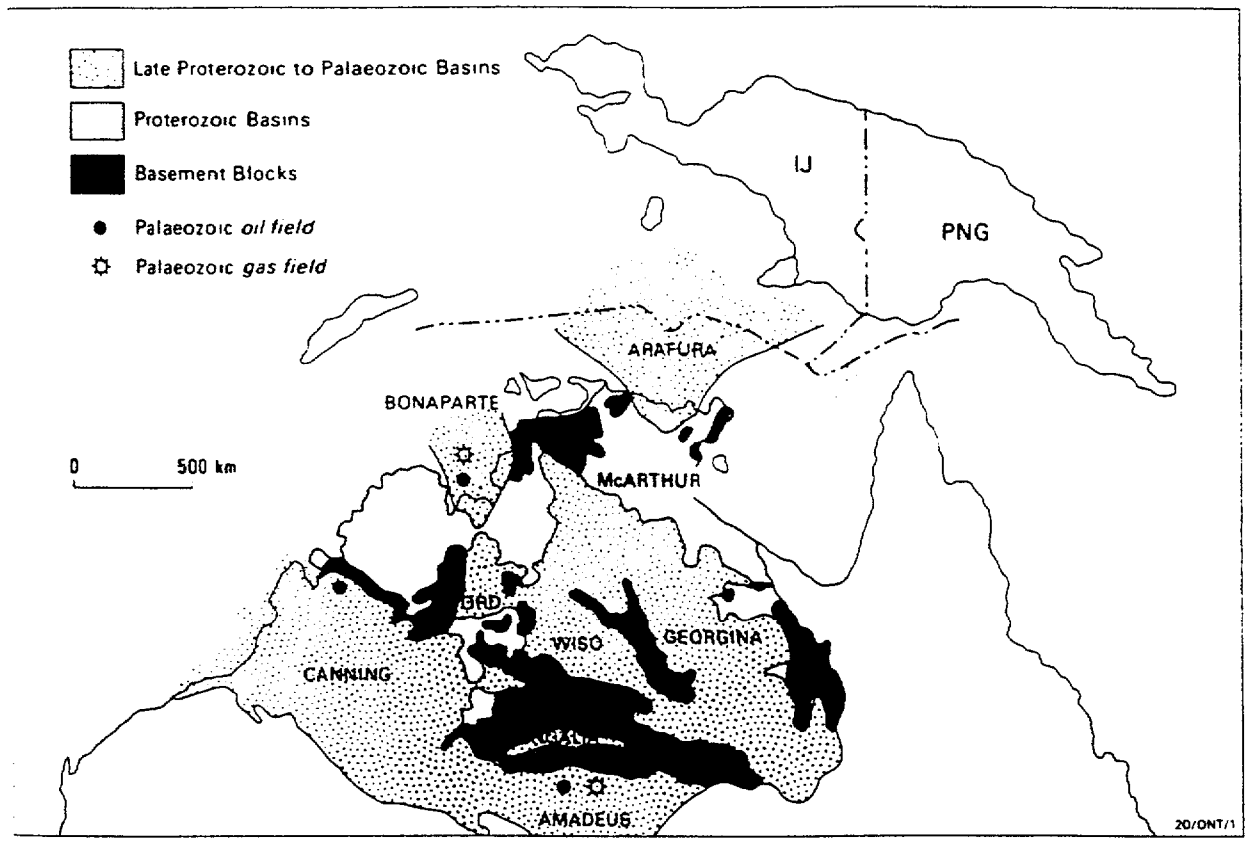


Figure 1 Northern Australia and New Guinea, showing Palaeozoic and Proterozoic basins.

(after Bradshaw et al, 1990)

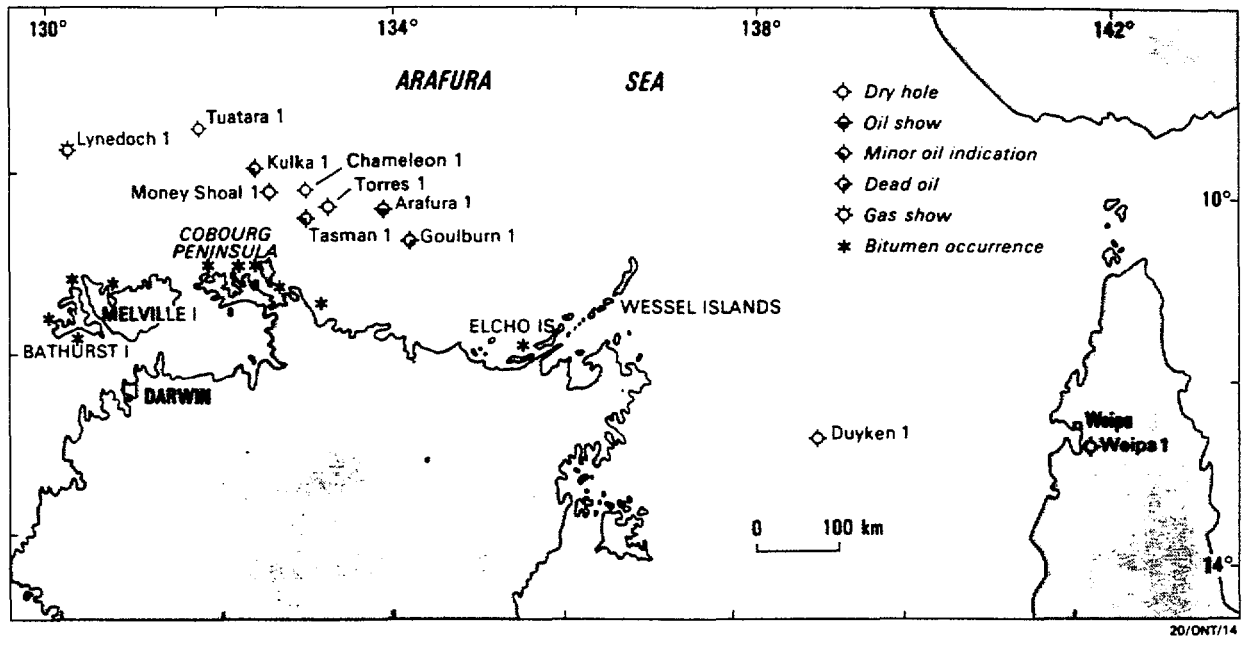


Figure 2 The Arafura Sea, showing oil exploration wells and hydrocarbon shows.

(after Bradshaw et al, 1990)

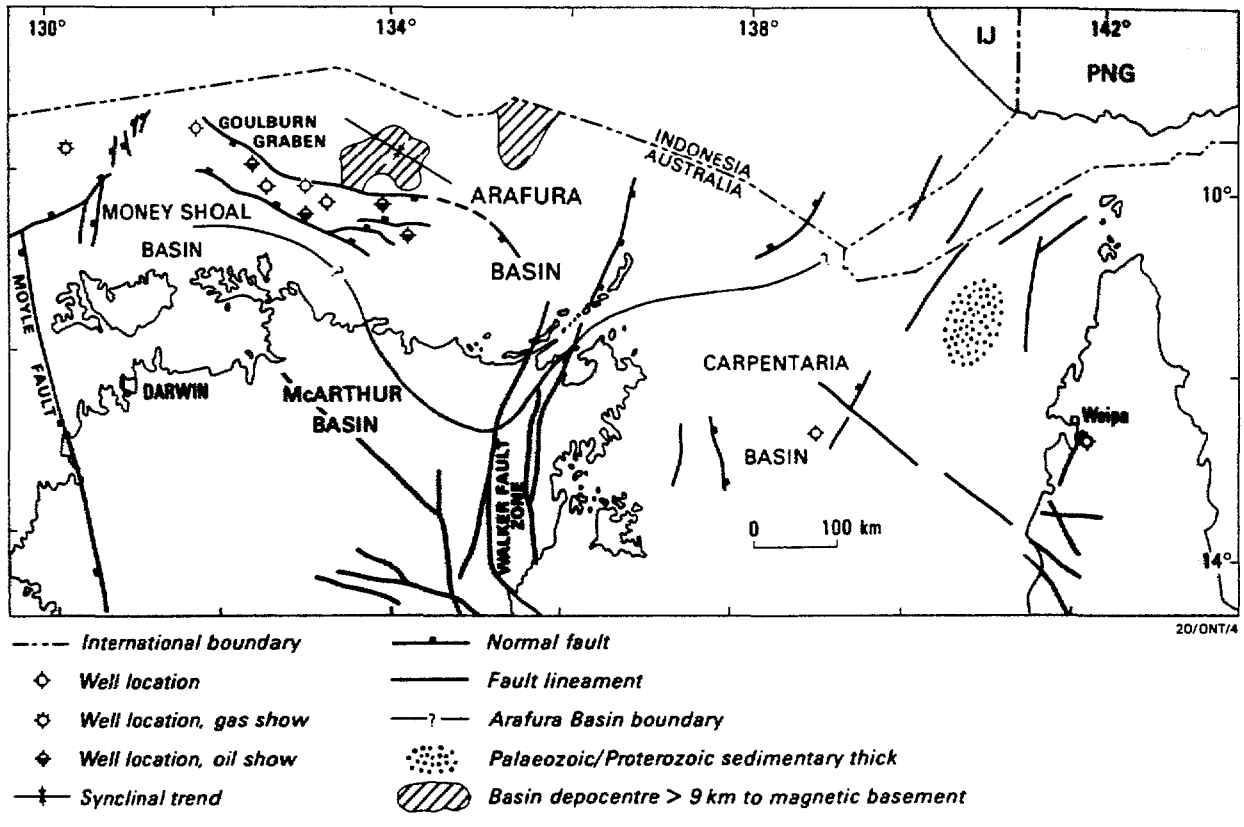


Figure 3 The Arafura Basin, showing major faults.

(after Bradshaw et al, 1990)

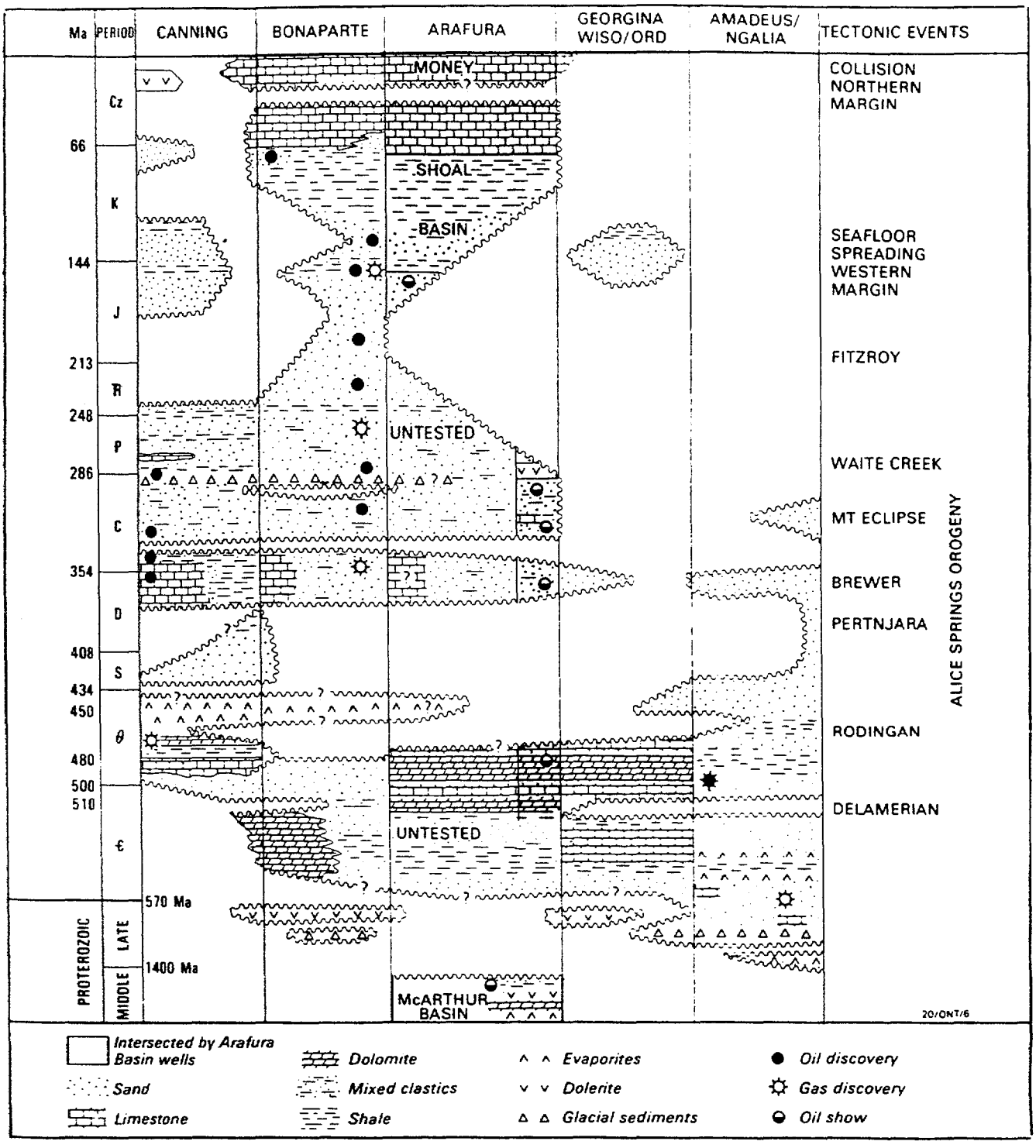
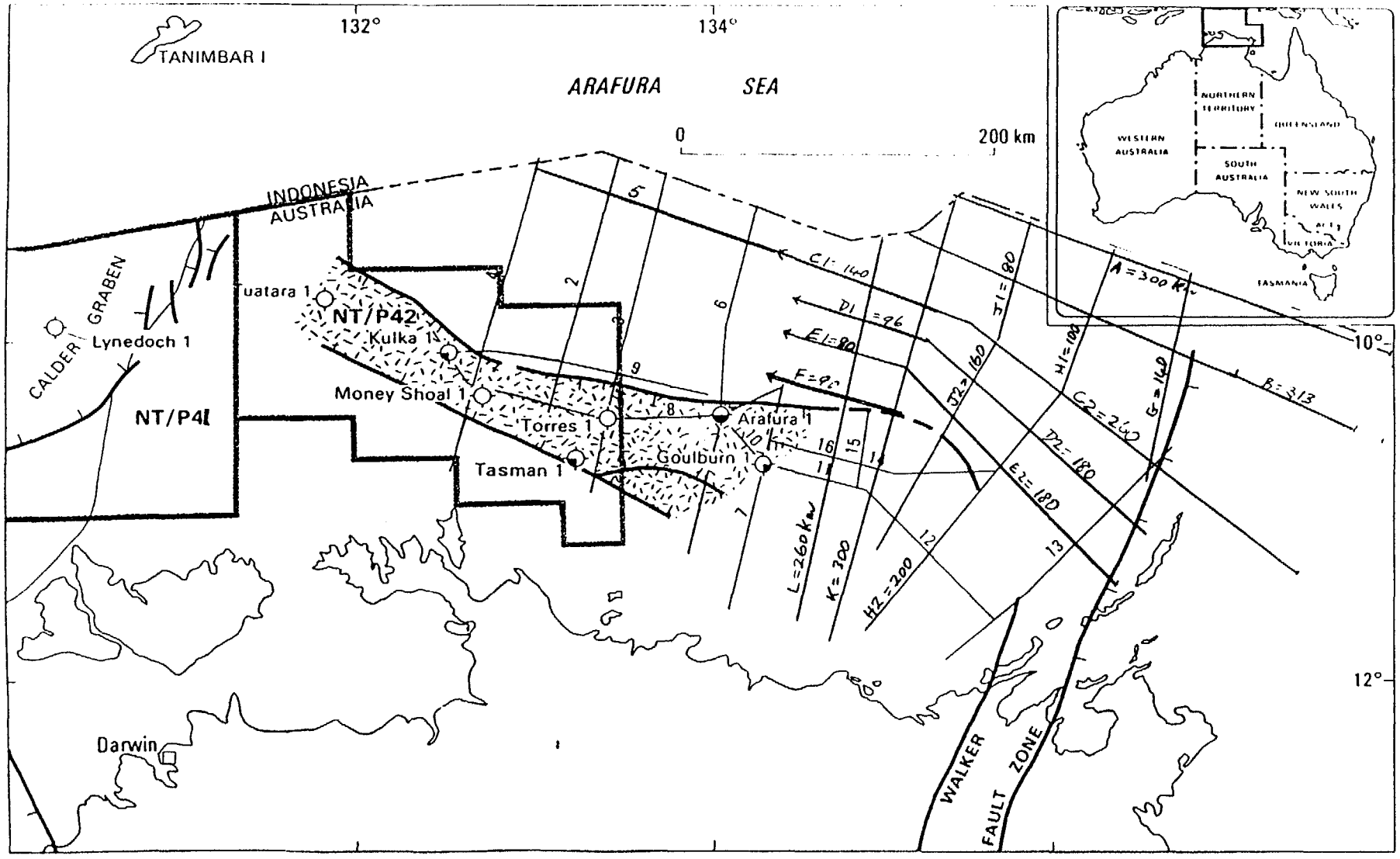


Figure 4 Northern Australian Basins, comparative stratigraphy.

(after Bradshaw et al, 1990)



LINE LENGTH KM

A	300
B	313
C1	140
C2	260
D1	96
D2	180
E1	80
E2	180
F	90
G	140
H1	100
H2	200
J1	80
J2	160
K	300
L	260
	2879

Fault

Normal fault

2 *BMR 1990 multichannel seismic and direct-hydrocarbon-detection lines*

Goulburn Graben

Dry hole

Oil show

Minor oil indication

Dead oil

D1=96 **BMR 1991 Survey 105 proposed lines. Line length in kilometres**

Figure 5

BMR Rig Seismic Research Cruise 105
Planned Seismic Traverses