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Deep structure of the eastern Malita Graben and adjacent areas in the Timor and western Arafura Seas:

Survey 118 operational report

by

P J Hill, D C Ramsay and
Survey 118 Shipboard Party

RECORD 1993/47

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Marine Geoscience and Petroleum Geology Program

Project 121.39

AGSO Record 1993/47

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EXECUTIVE SUMMARY

The objectives of Survey 118 were twofold. The primary objective was the acquisition of high quality deep seismic data and other geophysical data over the eastern Malita Graben region (including the Calder Graben and western part of the Goulburn Graben) in the northern Timor and western Arafura Seas (Project 121.39). The secondary objective was to collect deep seismic data on several long regional traverses in the Petrel Sub-basin - Londonderry Arch - NE Browse Basin region. The cruise was part of a continuing major program by AGSO designed to establish the structural architecture of the northwest Australian continental margin, examine reactivation histories and develop models for basin evolution in the region. The program aims to assist petroleum exploration and development of offshore resources.

The *Rig Seismic* left Darwin at 1700 hrs (local time) on Friday 30 April 1993 and transited to the Malita Graben survey area to the northwest. Seismic acquisition began at 0800 hrs on Monday 3 May. The survey progressed well and without major interruption. Survey operations were suspended on two occasions due to bad weather; total time lost was about one day. Seismic cable inspection and maintenance, including replacement of batteries in depth controllers, also resulted in some down-time. The survey ended in the NE Browse Basin at 0300 hrs Saturday 29 May. The ship transited back to Darwin, arriving at 0815 hrs on Monday 31 May.

There was no significant damage to the streamer, and apart from 3 Norwegian buoys (from the gun arrays), there was no loss of equipment. When the seismic cable was retrieved at the end of the survey, it was found to be in very good condition and no sections had to be replaced. Breakdown of the ship's shaft generator and failure of the UPS (Uninterruptible Power Supply) early in the survey had little impact on productivity, apart from the loss of 6 hours survey time incurred in looping back on line. A total of 5 gun maintenance loops were required during the cruise; an additional loop was needed to free a tangle on one array between towing chain and gun bundle.

Both the seismic and non-seismic (DAS) acquisition systems ran without problems and there were no system crashes. The onboard, real-time monitoring systems gave good QC on the data as they were collected. Navigational data were of very good quality, with differential GPS positioning being available at least 95% of the time.

Data collected on Survey 118 comprised:-

- Deep seismic reflection data, 48-fold, 16 second record-length. These were acquired with a 4800 m active length streamer and dual tuned airgun arrays (20 sleeve-guns of 50 litres total capacity).
- Gravity data on all lines, i.e. on all seismic lines and all transit lines.
- Magnetic data on ~90% of seismic lines and most transits.
- Bathymetry data on all lines.

A total of 17 seismic lines were shot in the Malita - Goulburn Graben region, and 4 lines were shot in the Petrel Sub-basin - NE Browse Basin area. The lines were tied to 7 exploration wells. The total seismic production was 3602 line-km. Of this, 2858 km were collected in the Malita - Goulburn Graben region and the rest (744 km) were collected on the 4 regional lines in the Petrel Sub-basin - NE Browse Basin area.

Survey 118 was a very successful operation with all lines in the planned core seismic program completed and a further two lines (on the Sahul Platform and across the western Goulburn Graben) added.

INTRODUCTION

The Australian Geological Survey Organisation (AGSO) conducted a deep crustal seismic survey, AGSO Survey 118, in the Timor and western Arafura Sea area (Figures 1 and 2) in May 1993. The survey was the data acquisition phase of Project 121.39 'Deep structure of the eastern Malita Graben region' (Pigram, 1992a). The survey vessel, RV *Rig Seismic* (Appendices 1 and 2), left Darwin on 30 April and returned to the same port at the end of the cruise on 31 May 1993. The shipboard personnel comprised 15 AGSO scientists and technicians, a university student and 14 Australian Maritime Safety Authority (AMSA) crew (Appendix 3).

The primary purpose of the Survey 118 data acquisition program was to collect new deep seismic and other geophysical data that would: -

(1) establish the regional structural framework of the eastern Timor Sea region by examining the boundaries between the major structural elements along a series of transects,
(2) provide modern regional seismic tie lines through the wells in the region to facilitate province-wide correlations,
(3) determine the deep crustal structure of the Malita and Calder Grabens,
(4) examine the effects of the deep crustal structure and its reactivation on the location of the known petroleum accumulations.

Data were collected on 17 lines in the eastern Malita Graben / Calder Graben / western Goulburn Graben region. This part of the survey area extends west to the Australia / Indonesia Zone of Co-operation and north to the Indonesian border. In addition, data were acquired on 4 regional lines in the Petrel Sub-basin / Londonderry Arch area north of the Kimberley coast. The extent of the survey coverage and precise locations of the survey lines are shown in the accompanying time-annotated track maps (Enclosures 1 and 2) and seismic shot-point maps (Enclosures 3 and 4). The seismic lines were tied to 7 exploration wells (Appendix 4).

The data collected comprise, (i) 16 second record-length, 48-fold seismic (shot using a 4800 m streamer and 50 litre dual airgun array), (ii) bathymetry, (iii) gravity and (iv) magnetics.

This Record is a post-cruise operational report on Survey 118.

BACKGROUND TO PROJECT AND SEISMIC PROGRAM

In 1990 the Marine Geoscience and Petroleum Geology Program (MGPG) of AGSO began a program of deep seismic acquisition (record length to 16 seconds) along the northwestern continental margin of Australia. The aim was to have a complete regional data set that covered the region from North West Cape to the western Arafura Sea by 1994. This sector of the Australian margin was seen to be the most prospective region outside of the Bass Strait basins, and the likely source of Australia's future hydrocarbon supplies. Portions of this margin have been explored in detail since the 1960's, but there has been little recent analysis of the regional structural framework using either modern extensional tectonic concepts for the formation of the margin (eg. Lister et al., 1991) or modern collisional tectonic concepts (eg. Beaumont, 1980; Allen and Homewood, 1986) for the deformation of parts of this margin.

The MGPG program on the northwest margin of Australia is designed to establish the gross architecture of the margin by imaging the margin forming structures and examining their reactivation histories through time. This information will be critical in developing new exploration strategies, and will assist future basin framework and resource studies of the region.

A number of cruises under this MGPG program, designed to address the margin structural framework problems of this region, have already taken place and several others are planned for the period mid-1993 to late 1994. Those planned include Browse Basin, offshore Canning Basin and Scott Plateau - Roti Basin. Cruises that have already taken place are:

i) Vulcan Graben - 1900 km of deep seismic data - acquisition completed December 1990 (O'Brien and Williamson, 1990),
ii) Bonaparte Basin (Petrel Sub-basin) - 2200 km of deep seismic data - acquisition completed May 1991 (Willcox and Ramsay, 1991),
iii) North Carnarvon Basin I - 1654 km of deep seismic data - acquisition completed June 1991 (Stagg et al., 1991),
iv) North Carnarvon Basin II - 2868 km of deep seismic data - acquisition completed July 1992 (Stagg et al.,1992).

In addition, AGSO recently completed a deep seismic survey (Survey 116) in the Australia / Indonesia Zone of Co-operation (ZOC) and adjacent areas (Pigram, 1992b). This survey, conducted in association with Nopec Australia Pty Ltd, took place between 22 January and 8 March 1993 and resulted in the acquisition of 3768 km of seismic data (Enclosure 4). Of this, 1020 km were collected to the east of the Zone of Co-operation - on lines of the proposed East Malita Graben program (Pigram, 1992a). These data were acquired earlier than originally planned because shooting of proposed lines across ZOC Area C and the Timor Trough in Indonesian waters could not proceed as a result of delays in finalisation of the requisite agreement between AGSO and PERTAMINA.

It was hoped that the agreement would be in place by the scheduled start of Survey 118, or at least early in this cruise, so that the proposed survey work in Indonesian waters could be undertaken as part of the cruise. This was not to be, however. Modifications to the Survey 118 program were made to compensate for this.

Immediately pre-cruise, with the assumption that the Indonesian work would not go ahead, the Survey 118 program was as follows:-

- Completion of the eastern Malita seismic program as proposed by Pigram (1992a).
- Enlargement of the above program, involving (a) addition of lines MA17 and MA18 in the Calder / Goulburn Graben area (tying to the Tuatara-1 well and AGSO Survey 106 grid in the Arafura Basin (Enclosure 4; Moore and Ramsay, 1992)), and (b) lengthening of lines MA05, MA08, MA14 and MA15.
- Collection of deep seismic data on regional lines in the Petrel Sub-basin - NE Browse Basin area. These lines comprised, (a) a NE-oriented dip line (PSB) across the Petrel Sub-basin through the Fishburn-1 well-site (this line would fill a major gap in AGSO Survey 100 coverage of the Sub-basin), (b) a WNW-oriented line (GRA) at the

western margin of the Petrel Sub-basin that would investigate a major gravity low in this area, and (c) a line to tie the Survey 116 network to the Londonderry-1 well in the NE Browse Basin (and thus to the proposed AGSO deep seismic survey in the Browse Basin).

GEOLOGICAL SETTING OF THE MALITA GRABEN AREA
(modified after Pigram, 1992a)

STRUCTURE

The Malita Graben region lies within that part of the northwestern margin of Australia that now forms the foreland to the Timor collision zone. It is bounded on its northern side by the Timor Trough (Figure 4). The Timor Trough generally trends northeasterly adjacent to Timor, but changes to an ENE trend at the eastern end of Timor adjacent to the Sunrise - Troubadour (Figure 3) region. This change in trend is clear in the 200 m bathymetric contour (Figure 3). The southern edge of the trough again swings around to a NE trend at about 130° 20'E. These marked changes in trend suggest an underlying structural control inherited from the structuring associated with formation of the margin.

The eastern Malita Graben region is regarded as the northeasterly part of the Bonaparte Basin. McLennan et al. (1990) place the boundary between the Bonaparte and Money Shoal Basin along the NNE-SSW Lynedoch Bank Fault system (Figure 4), which is assumed to be a reactivated offshore extension of the Proterozoic Tom Turner Fault Zone (McLennan et al., 1990). The principal depocentre in the region is the Malita Graben which trends in a ENE-WSW direction except on its northern end where it swings around to a more NE trend, which is referred to as the Calder Graben. The Malita Graben is asymmetric, with bounding structures of the northwest margin of the graben dipping southeasterly (Northern Territory Geological Survey, 1990; West et al., 1992).

The Graben is surrounded by platforms comprising relatively shallow basement with thin Mesozoic and Cainozoic cover. The Sahul Platform occurs to the north, the Darwin Platform/Shelf (and adjoining Bathurst Terrace) to the south and the Money Shoal Platform to the east (Figure 4). The Money Shoal Platform separates the Malita/Calder Graben from the Goulburn Graben to the east (Figure 4).

The Malita Graben is thought to be either a Late Paleozoic or Mesozoic structure. The timing of the initiation of the Malita Graben is controversial with Botten and Wulff (1990) and Northern Territory Geological Survey (1990) suggesting that it was initiated during the Jurassic, whereas McLennan et al. (1990) favour a late Permian initiation. The total sediment thickness is not known. It may be up to 10 km thick (Northern Territory Geological Survey, 1990; West et al., 1992). The basin-forming structures are not imaged on conventional 5 or 6 second seismic records. It may also have a Paleozoic structural and depositional precursor, as does the Petrel Sub-basin to the south. The graben is thought to be the kitchen for hydrocarbon generation is this region.

STRATIGRAPHY

The stratigraphy of the region is poorly known due to the sparsity of wells, and the nomenclature used is usually that applied to the Bonaparte Basin. The thickness and age of sedimentary packages vary with structural provinces. The Darwin Shelf has a thin cover of Jurassic to Cainozoic sediments overlying basement (Northern Territory Geological Survey, 1990; Mory, 1991). The Sahul Platform has less than 5000 m of late Permian to Recent section and the Money Shoal Platform is thought to be covered by a Mesozoic and younger section (Mory, 1991; McLennan et al., 1990). The middle of the Malita Graben has only been drilled at Heron-1, which bottomed at 4208 m depth in mid Jurassic sediments.

The major sediment groups encountered during drilling in the eastern Malita region are: (i) the Permian Kinmore Group, (ii) the Triassic to Jurassic Troughton Group, (iii) the Jurassic Flamingo Group, (iv) the Cretaceous Bathurst Island Group (BIG) and (v) Cainozoic carbonate and siliciclastic sediments (Figures 5 and 6). The oldest sediments encountered by drilling so far are late Permian carbonate sediments in Troubadour-1. The Troughton Group was intersected in the Troubadour-1 and Shearwater-1 wells. The Troughton and Flamingo Groups are separated by a Callovian unconformity, which is attributed to a major tectonic event associated with the breakup of the margin (Mory, 1991). The Flamingo Group varies from 867 m of mainly grey silty pyritic claystone in Heron-1 to 25 m of mainly siltstone in Evans Shoal-1. The Flamingo Group pinches out laterally on the Darwin Shelf and the Sahul Platform. It is less than 8 m thick in Troubadour-1 and consists of coarse sand. The Flamingo Group is separated from the overlying Bathurst Island Group by a Valanginian unconformity. Elsewhere in the region the basal Bathurst Island Group consists of a greensand-rich condensed section. The Bathurst Island Group in the Malita Graben consists of over 2000 m of section (Botten and Wulff, 1990).

The Cainozoic sediments consist of basal sandy units that grade up into shallow-water carbonate sediments. There is a major hiatus in the Oligocene and probably also in the Miocene, but the section has not been well sampled.

PETROLEUM EXPLORATION OF THE MALITA GRABEN AREA
(modified after Pigram, 1992a)

Exploration began in the eastern Malita Graben region during the 1960's when Shell collected regional seismic data and aeromagnetics in the eastern part of the region and Woodside and Arco led consortia collected regional seismic data in the western part. Woodside and Arco collected over 9000 km of regional data from 1969 to 1974. This led to the drilling of several wells. In 1971 Arco drilled Heron-1 just north of the middle of the Malita Graben. The well had gas shows at several levels (including Lower Cretaceous limestone and claystone, and in Jurassic sandstone), but was not tested. In 1973, Shell drilled Lynedoch-1 also on the northern flank of the graben. It was plugged and abandoned after recording gas shows. Arco drilled a dry hole at Shearwater-1 in 1974 and a Woodside-led consortium made gas and condensate discoveries at Sunrise-1 and Troubadour-1 located on the Sahul Platform. These hydrocarbons are reservoired in the middle Jurassic Plover Formation. Troubadour flowed 279 000 m^3 of gas and 38.8 kL of condensate per day (Northern Territory Geological Survey, 1990; Mory 1991).

During the mid 1980's, Western Mining Corporation (WMC) collected 2500 km of seismic data (Durrant and Young, 1988). This led to the drilling of Evans Shoal-1 by BHP Petroleum (BHPP) in 1988. Evans Shoal discovered gas in Mesozoic sands. During the late 1980's, BHPP collected regional aeromagnetics and seismic data in permit NT/P41 and further east. In 1990 BHPP drilled Tuatara-1 in the western part of the area and Beluga-1 on the southern flank of the graben in 1991. Beluga had gas shows but Tuatara was dry.

In early 1992 the British Institutions Reflection Profiling Syndicate (BIRPS), in conjunction with Marine Geoscience Institute of Indonesia (MGI), conducted a deep crustal survey (20 second records) across the Banda Arc to the east of Timor (Enclosure 4). These lines finished on the outer shelf just within Australian waters.

PETROLEUM GEOLOGY OF ADJACENT AREAS - WESTERN GOULBURN GRABEN AND PETREL SUB-BASIN

GOULBURN GRABEN AREA

Recent accounts of the petroleum geology of the western Arafura Sea area are provided by Northern Territory Geological Survey (1989), Bradshaw et al. (1990), McLennan et al. (1990) and Labutis et al. (1992). This area is underlain by the Arafura Basin, which contains a thick Cambrian to Permo-Triassic sedimentary sequence. The Goulburn Graben (Figure 4) is a deep northwest-trending structure within the basin. It has over 10 km of faulted and folded Paleozoic section. The Arafura Basin is overlain by relatively flat-lying, mid-Jurassic to Cainozoic sediments of the Money Shoal Basin.

The Arafura Basin was a stable platform dominated by carbonate deposition during the Cambrian and Ordovician (Bradshaw et al., 1990). Marine and non-marine clastics, with minor carbonates, were deposited during Late Devonian and Late Carboniferous. Movement on bounding faults of the Goulburn Graben first took place in the early Carboniferous (Bradshaw et al., 1990) or early to middle Devonian (Labutis et al., 1992). However, major graben development and deformation did not occur until the Permo-Triassic. Westward tilting accompanied this structural development. Uplift produced large-scale erosion in the Late Triassic to Early Jurassic.

Eight exploration wells have been drilled in the Goulburn Graben. All were sited on structural targets and most recorded oil shows. Good quality source rocks occur at Cambrian, Carboniferous and Middle Jurassic to Lower Cretaceous levels (McLennan, 1990).

PETREL SUB-BASIN

The geology and hydrocarbon potential of the Bonaparte Basin, and specifically the Petrel Sub-basin, are described by Lee and Gunn (1988), Northern Territory Geological Survey (1990), Mory (1991), and O'Brien et al. (1993). The Late Carboniferous to Cainozoic stratigraphy is shown in Figure 7.

The northwest-trending Petrel Sub-basin developed by rifting in the Late Devonian to Early Carboniferous. The rift system was compartmentalised by northeast-trending accommodation (transfer fault) zones. Part of this rift system (particularly the northwest) was overprinted in the Late Carboniferous to Early Permian by the Westralian Super-basin rift system, which developed on a northeast trend. Thermal subsidence continued until Late Triassic, resulting in deposition of 10-14 km of relatively unstructured sediments.

There followed 3 important, but low magnitude, reactivation events (O'Brien et al., 1993): (i) compression in Late Triassic to Early Jurassic (expressed as uplift and folding eg. Tern structure -see below), (ii) extension in late Middle to early Late Jurassic (associated with continental rifting and breakup), and (iii) compression in Late Jurassic / Early Cretaceous (which slowed or stopped seafloor spreading in the Argo Abyssal Plain).

Sedimentation during the Mesozoic rift and margin sag phase resulted in deposition of a mix of terrestrial and marine facies. Northwesterly tilting of the basin in the late Cretaceous and Tertiary led to deposition of thick, fine-grained siliciclastic and prograding carbonate wedges.

A significant thickness of evaporites is believed to lie in the basal (? Siliurian) section of the basin. Seismic data show salt diapiric penetration of the late Paleozoic to Tertiary section at several locations in the sub-basin.

Large gas-condensate fields, Petrel and Tern, were discovered in the central Petrel Sub-basin in 1969 and 1971, respectively. The hydrocarbon reservoirs of both fields occur in sands of the Late Permian Hyland Bay Formation (Figure 7).

PROJECT OBJECTIVES IN THE MALITA GRABEN AREA
(after Pigram, 1992a)

The major objectives of the Malita Graben project are to:-

1) determine the regional structural framework of the eastern Timor Sea region by examining the boundaries between the major structural elements along a series of transects;
2) provide modern regional seismic tie lines through the wells in the region to facilitate province wide correlations;
3) determine the deep crustal structure of the Malita and Calder Grabens;
4) examine the effects of the deep crustal structure and their various phases of reactivation on the known petroleum accumulations.

More specifically, the project has been designed to:-

- examine the structural relationship of the Malita and Calder Grabens to their surrounding platforms
- examine the structural development of the Darwin, Sahul and Money Shoal Platforms
- determine the timing and style of reactivation of the major structures
- examine the age and nature of the movement on the bounding structures of the Malita Graben. In particular, determine the nature of the northern bounding fault system. On conventional industry data sets the graben-forming structures are not evident and several ages have been suggested for the formation of the graben.

- determine the extent and nature of any Paleozoic underpinning, and its influence on both the structural and depositional history of the graben
- attempt to determine the distribution and stratigraphic level of evaporites in the Malita and Calder Grabens and their role, if any, in the structural history of the basin
- determine the nature and movement history of the Lynedoch Bank Fault Zone. This structure appears to be the eastern boundary to the Bonaparte Basin and the eastern boundary to the Mesozoic passive margin.
- determine the pre-collisional nature of this segment of the margin in terms of its upper or lower plate affinities as described in detachment models for margin formation (Lister et al., 1990). Determining the pre-collisional nature of the margin may be essential for predicting the nature of the collision-induced reactivation of the margin-forming structures.

EXECUTION OF SEISMIC PROGRAM

After leaving Darwin and reaching the Malita Graben survey area, the seismic cable was deployed, tested and adjusted to achieve correct balance. Seismic acquisition commenced at 0800 hrs on Monday 3 May. The survey progressed well and without major interruption, though acquisition conditions were often marginal due to rough seas. The last line was completed in the NE Browse Basin at 0300 hrs Saturday 29 May.

Sea conditions were generally not as favourable as one would have wished for the type of seismic work undertaken. Calm seas would have been a bonus in shooting the long record-length data. As it was, seas were moderate or calmer on fewer than about 6 days. Rough seas, driven by persistent 20-30 knot east or southeast trade winds, were frequently experienced. The strong winds were caused by reinforcement of the easterly trades by a succession of high pressure systems located over southern Australia. Modifications to the acquisition program were made when high streamer noise levels or potential damage to outboard gear were a possibility due to very rough seas and large swell. Survey operations were suspended on two occasions due to bad weather. Total time lost while waiting for weather conditions to improve was about 1 day.

During times of rough seas and short, steep swell, it was our experience that noise levels were lowest when heading across the prevailing seas, and at their highest when heading directly into the seas. The difference was quite significant. Following seas were only marginally better than oncoming seas. The higher noise levels encountered when heading into, or running with the seas, are attributed to heavy tugging on the tow leader as the ship pitches in the swell. On some lines where streamer noise was a potential problem, it was reduced to a satisfactory level by increasing the depth of the streamer from 10 m to 12 m and slowing the ship to about 4.4 knots.

MODIFICATIONS TO PRE-CRUISE PROGRAM

The seismic acquisition program was executed as planned, except for the following additions and changes.

1. Line 118/0401 (MAX1) was added. This line runs in a NNE direction from the vicinity of the Troubadour-1 and Sunrise-1 wells (NE Sahul Platform) to the border with Indonesia (Enclosure 3). It ties the northern ends of several AGSO deep seismic lines (Survey 116 and 118) and also ties the BIRPS-D line into the AGSO regional network for the first time. It allowed useful data to be collected on what would otherwise have been a long transit between the end of 118/0301 and the start of 118/0501.

2. Line 118/1401 (MAX2) was added. This line runs SSW across the Goulburn Graben just west of Kulka-1. It is the first deep crustal (16 second) seismic line to be shot across the Goulburn Graben. It was shot when sea conditions were too rough to commence the only Survey 118 line (MA14 - 118/1501) left to do in the area. Noise levels during shooting of 118/1401 were relatively low since the line was oriented across the prevailing wind and swell direction (ESE).

3. Line 118/2001 (MAX3) was added to replace a westward continuation of 118/1901. This 'dog-leg' in the original line GRA significantly reduced transit time to the start of the final line (118/2101), allowing just enough time to tie to the Londonderry-1 well and complete the full seismic program before returning to Darwin.

Way points used for navigation during Survey 118 are given in Appendix 5.

CRUISE NARRATIVE

A chronology of the main events during Survey 118 is provided below. Times indicated are local, i.e. Central Australian Time. 0000 UTC(GMT) ≡ 0930 hrs local.

Friday 30 April

Rig Seismic left Darwin at 1700 hrs and steamed northwest at ~9.7 knots towards first seismic line (MA13N) to be shot in Malita Graben. Pre-survey and safety meeting was conducted at 1830 hrs.

Saturday 1 May

The tailbuoy went over the side at 0745 hrs; the seismic cable was deployed progressively throughout the day. Fire drill / muster was held at 1230 hrs. Standard pre-survey calibrations and tests carried out. Seas rough with easterly wind to 30 knots.

Sunday 2 May

Seismic cable fully deployed by 0400 hrs. Two sections found to be 'heavy' during preceding Trials (S117) were replaced during deployment. Cable performance was monitored while running at different angles to prevailing seas.
Began retrieving front end of cable at 1200 hrs in order to improve balance by adding and redistributing lead. Damaged stretch section was replaced. On redeployment, cable balance

still not satisfactory at front end. Problem was traced to faulty DT in depth controller (bird #2). Bird was replaced; subsequently cable ran well and within depth specifications.
Proceeded to the start of line MA13N. Had to loop back because of minor gun problems.

Monday 3 May

The last group on one gun array was still inoperative so a second loop was necessary. Seismic acquisition began at 0805 hrs in moderate sea state. Finished the first line (118/0001) at 1657 hrs.
Started line MA12 (118/0002) at 2353 hrs.

Tuesday 4 May

Magnetometer was deployed and operating at ~0900 hrs.
Completed line MA12 (118/0002) at 1924 hrs.

Wednesday 5 May

Started line MA10A (118/0301) at 0148 hrs and completed the line at 2238 hrs.

Thursday 6 May

Began shooting line MAX1 (118/0401) at 0457 hrs, starting at the NE end of line 116/0902. Encountered a group of 3 Indonesian long-line fishing boats about 10 km from the start of line. Their movements were erratic and unpredictable, so had to deviate off the planned line. The line was relocated (2 new way points - 09° 40.663' 128° 16.974' and 09° 27.000' 129° 00.000') and shooting continued. Seas were moderate, but streamer was run at 12 m depth to reduce noise. MAX1 was completed at 1622 hrs.

At the start of line MA05 (118/0501), a number of the starboard array guns failed to fire correctly. The problem was fixed soon after (at 2258 hrs). By this time, however, the first 5.6 km of line had been missed. Because this small segment of the line was not critical to the program, it was decided not to do a re-run - which would have meant a 6-hour loop. The guns were fully operational in time for a full-fold tie to line MAX1 (118/0401).

Friday 7 May

Shooting MA05 (118/0501). At ~ 0900 hrs two fishing boats were close to the tailbuoy - managed to make contact by radio just in time and warn them to stay clear.

Saturday 8 May

Line MA05 (118/0501) was completed at 0050 hrs. Line MA06 (118/0601) was started at 0710 hrs. The magnetometer output had become increasingly noisy. Consequently the sensor fish was recovered at 1245 hrs for inspection. The fish had a 2 cm tear in the diaphragm and some salt-water was found in the fluid (white spirit). The diaphragm was replaced, the sensor re-filled and redeployed at 1610 hrs. The noise level returned to a low 1-2 nT.

Sunday 9 May

Finished line MA06 (118/0601) at 0001 hrs. Started MA15 (118/0701) at 0508 hrs.
Operations came to a temporary halt at 1256 hrs when the ship's shaft generator broke down. Power went off in the Instrument Room. Because of a fault the UPS (Uninterruptible Power Supply) did not take over immediately. Power was restored using the ship's emergency and auxiliary generators. The acquisition systems were rebooted and shooting recommenced after looping back on the line. The new segment of line MA15 (118/0702) was started at 1848 hrs.

Monday 10 May

Shooting of this segment ended at 0810 hrs when gun maintenance was required. The ship was back on line and shooting the third segment of MA15 (118/0703) at 1428 hrs It was completed at 2239 hrs.

Tuesday 11 May

Shooting of line MA10B (118/0801) started at 0450 hrs.

Wednesday 12 May

The line was completed at 0915 hrs.
The seas, which had been moderate-rough since the start of the survey, finally calmed down.
It was an opportune time to inspect the streamer and tailbuoy and to exchange 4 birds (cable levellers) whose batteries were getting low. This work was done in the early afternoon (1200-1430 hrs) after the streamer had been surfaced, using the ship's Zodiac (rubber dinghy).
The streamer was seen to be in good condition; a piece of old netting was removed from the tailbuoy.
Because of some gun timing problems experienced on the previous line, the solenoids were re-built as per pre-Trials (i.e. ZOCA S116 etc). This work was done while in transit to the start of the next line MA07 (118/0901). This line was begun at 2019 hrs.

Thursday 13 May

Shooting of MA07 had to be interrupted mid-line at 0639 hrs for gun maintenance. The second segment of the line (118/0902) was begun at 1307 hrs, and completed by 2313 hrs.

Friday 14 May

Line MA11 (118/1001) was started at 0717 hrs and completed at 1837 hrs.

Saturday 15 May

Line MA08 (118/1101) was begun at 0040 hrs. Acquisition was terminated at 0935 hrs because several air leaks had developed, dropping the air pressure below 1600 psi. Shooting of the line (segment 118/1102) was resumed at 1533 hrs after gun repair.
The weather had been deteriorating - seas were rough with a large swell; the southeasterly winds had risen to 25-30 knots. To reduce streamer noise, the streamer was driven to 12 m depth and ship's speed was reduced to 4.4 knots. Despite this, noise levels remained high (often in the order of 5 microbars mean RMS) due to cable tug as the ship pitched in the head-on seas.

Sunday 16 May

MA08 was completed at 0321 hrs.
Seismic acquisition began on line MA17 (118/1201) at 0914 hrs. Seas continued to be rough with a short, steep swell. Winds were east to southeast at 25-30 knots. Streamer noise levels were reasonable (2-3 microbars) since the line was oriented across, rather than in, the direction of the prevailing seas. Ship's speed was initially reduced to 4.4 knots and the streamer run at 12 m depth to reduce noise. In the late afternoon the wind eased and speed was increased to about 5.0 - 5.2 knots.
A magnetic anomaly of ~15 nT was recorded over the Tuatara-1 well site; as seen on the earlier crossing, the anomaly in the area is of low amplitude and unexpectedly broad.

Monday 17 May

In the early hours of the morning there were rain squalls and seas were very rough.
Line MA17 was finished at 0428 hrs.
The seismic cable was partly retrieved (while steaming WNW, i.e. with seas from behind) to replace batteries on birds # 1 and 2.
The seas were still rough as the ship headed to the start of MA18 (118/1301). Shooting commenced at 1325 hrs. As expected, noise levels were high because of the oncoming seas and the short, steep swell (similar conditions to those encountered on line MA08). The line was completed at 2154 hrs.

Tuesday 18 May

To allow time for the weather to moderate before shooting the next important line, MA14, it was decided to shoot a new line, MAX2, across the western Goulburn Graben. The streamer (and tailbuoy) would then be retrieved for general inspection and maintenance, but

especially to renew batteries on all the birds. The bird batteries had run down more quickly than usual because the birds had to 'work' harder in the rough seas.
Line MAX2 (118/1401) was begun at 0211 hrs, and completed at 1354 hrs. Cable noise levels were satisfactory at 2-3 microbars despite rough seas and 20 knot easterly winds
Recovery of the streamer commenced at 1800 hrs. It was done with the ship slowly steaming downwind, i.e. with following seas, to reduce the strain on the streamer. Balance of the streamer was fine-tuned by adding and taking off lead as it came aboard.

Wednesday 19 May

The streamer and tailbuoy were onboard by 0300 hrs. Electronics maintenance work was done on the tailbuoy and its dGPS as the ship proceeded towards the start of the next line, MA14.
Weather conditions remained bad, with strong winds, rough seas and a large breaking swell. Consequently, re-deployment of the streamer was delayed until some improvement in the weather was evident. Weather conditions eased about mid-day, and at 1300 hrs the re-deployment began - with the ship slowly steaming up-wind.
During the deployment, 5 active sections (# 47, 40, 39, 28 & 5) had minor damage and were replaced. After deployment, bird #2 was found to be defective. The front of the streamer was pulled in and the bird replaced.

Thursday 20 May

Seismic acquisition recommenced at 1010 hrs on line MA14 (118/1501). The seas and swell had moderated. The mean RMS noise on the seismic cable was typically 3-4 microbars along the first part of the line, later decreasing.
A sharp 25 nT magnetic anomaly was recorded over Kulka-1.

Friday 21 May

Line MA14 (118/1501) was completed at 1119 hrs.
Shooting of line MA09 (118/1601) started at 1946 hrs. Seas were moderate with easterly winds of 10-15 knots; the weather was showing signs of improvement. Streamer noise was down to ~ 2.2 microbars.

Saturday 22 May

The gun bundle and main towing chain of the port array were seen to be wrapped around each other. The guns were shut down and brought aboard - there was no significant visible damage. The line segment was terminated at 0121 hrs and the ship looped back to recontinue the line. The second segment (118/1602) was started at 0611 hrs.
After several hours of shooting, 4 of the 5 guns of the second group of the port array had problems (1 o/c solenoid, 1 air leak & 2 with timing problems). The line was terminated for maintenance (last good shot at 1000 hrs). Having looped back on line, the third segment of the line (118/1603) was commenced at 1617 hrs.

Sunday 23 May

The line (MA09) was completed at 0710 hrs in moderate-rough seas on a moderate swell. Shooting of line MA16N (118/1701) began at 1432 hrs in similar sea state and fine weather conditions.

Monday 24 May

Line MA16N (118/1701), the final line of the Malita Graben seismic program, was completed at 0138 hrs.
Line PSB, the first of the regional lines to be shot in the Petrel Sub-basin / Londonderry Arch area, was begun at 1013 hrs. Acquisition conditions were good - slight to moderate seas on a low swell.
Auto-firing of a gun on the port array about quarter way down line PSB meant that it was necessary to stop acquisition (at 1530 hrs) and loop back on the line. The auto-fires were due to the combination of 2 faults - a leaking gun and a u/s Hoke valve. About 7 hours survey time were lost.
Line PSB was restarted at 2158 hrs as line segment 118/1802.

Tuesday 25 May

A 1.05 nautical mile deviation had to be made in 118/1802 in the early hours of the morning (~0330 hrs) to avoid an anchored RAN warship. Two submarines were also in the area. The vessels were part of a naval fleet on exercise in the Timor Sea.
By mid-day, seas were moderate to rough. Streamer noise levels were 1.9 - 2.4 microbars.
The ship crossed over the Fishburn-1 well site at 1743 hrs (S.P. 6197) - a distinct 45 nT magnetic anomaly was registered.
Towards the end of line, noise levels were down to 1.9 microbars; the tailbuoy feather angle was up to 15° to starboard because of strong tidal currents.

Wednesday 26 May

Line PSB (118/1802) was finished at 0233 hrs.
During the transit to the next line (GRA) the weather deteriorated, with the seas rising to very rough on a short, steep swell; winds were 30 knots. The start of shooting on GRA (118/1901) was delayed by about 5 hours until there was an improvement in the sea state. Streamer noise levels and shortage of gun spares were factors in deciding to hold back on shooting.
The line was started at 1632 hrs in following seas. Streamer noise was about 2.5 microbars mean RMS with the streamer at 12 m depth.

Thursday 27 May

Moderate seas with 15-20 knot winds; there was little ship movement (pitching/rolling) in the following seas.
Ship's speed ranged from 4.4 to 5.5 knots, depending upon direction and strength of tidal flow.
Line GRA (118/1901) was terminated at 1400 hrs to allow maintenance to be done on the gun arrays.
To allow enough time to complete the tie to the Londonderry-1 well, it was decided to shoot a new line (MAX3, 118/2001) direct from the gun maintenance point to the start of the next (and last) line LON. The start of LON corresponds (i.e. ties) to the end of line 116/0702.
Shooting of MAX3 (118/2001) began at 2231 hrs.

Friday 28 May

MAX3 was finished at 0512 hrs.
Acquisition on line LON (118/2101) commenced at 0932 hrs.
An air leak developed at the U-tube at the base of the starboard array Xmas tree. In an attempt to fix the problem, the starboard array was briefly shut down at 1603 hrs and the U-tube replaced by a high-pressure hose. 11 shots on the starboard array were missed. The leak proved to be in the fitting. To replace the fitting would have taken some time, and meant a time-consuming loop to resume the line. Since the leak had no significant effect on the air pressure to the guns, it was decided to keep shooting to the end of the line.
Moderate seas with 15-18 knot ESE wind.

Saturday 29 May

Soon after the tie to the Londonderry-1 well was made, an air leak also developed at the port array Xmas tree. The line was terminated at 0236 hrs about 1.9 nm past the well site. No pronounced magnetic anomaly was registered over the well site.
Recovery of the seismic cable began at 0330 hrs and was completed by 0815 hrs. The cable was in very good condition and no sections needed replacing.
The transit back to Darwin began as soon as the gear was aboard.

Sunday 30 May

Transit to Darwin across northern Joseph Bonaparte Gulf.

Monday 31 May

Rig Seismic berthed at Stokes Hill Wharf, Darwin, at 0815 hrs. This marked the successful completion of Survey 118.

DATA ACQUIRED AND SURVEY PARAMETERS

Data collected on Survey 118 comprised:-

1. Deep seismic reflection data, 48-fold, 16 second record length. These were acquired with a 4800 m active length streamer and dual tuned airgun arrays (20 sleeve-guns of 50 litres total capacity).
2. Gravity data on all lines, i.e. on all seismic lines and all transit lines (Figure 1 and Enclosures 1 and 2).
3. Magnetic data on ~90% of seismic lines and most transits.
4. Bathymetry data on all lines.

Survey equipment details are given in Appendix 2.

A total of 17 seismic lines were shot in the Malita - Goulburn Graben region, and 4 lines were shot in the Petrel Sub-basin - NE Browse Basin area (Enclosure 3). The lines were tied to 7 exploration wells (Appendix 4). Total seismic production was 3602 line-km, with 2858 km collected in the Malita - Goulburn Graben region and 744 km in the Petrel Sub-basin - NE Browse Basin area. Seismic line information is summarised in Appendix 6.

The total magnetic profile data collected (on seismic lines plus transits and loops) amounted to approximately 4800 km (Appendix 12). The total gravity and bathymetric profile data acquired was in the order of 5500 km.

SEISMIC ACQUISITION DETAILS

The seismic acquisition parameters are shown in Appendix 7, and the acquisition geometry (streamer / source configuration) in Appendix 8.

Streamer depth data and tow leader length data (for calculation of offsets) for the entire survey are provided in Appendix 9. Appendix 9 also shows maximum deviations in tailbuoy feather angle for each line, as well as the mean RMS streamer noise for each line. Streamer noise was 2.4 microbars or less on all lines except 118/1101, 1102, 1301 and 1501. Noise levels on these lines, located in the western Arafura Sea, were higher due to the combination of rough seas and unfavourable line orientation (i.e. WNW-ESE, in the direction of prevailing wind and swell). When sea conditions were good (slight to moderate seas), the streamer performed very well in terms of noise levels (Figure 8). Under such conditions, noise on most channels at the front end of the streamer was 1.5 microbars or less, and less than about 1.0 microbar towards the rear. Channels at birds (depth controllers) had higher noise levels because of the additional turbulance generated at these locations.

Water depths at the start and end of all the seismic lines are shown in Appendix 10. Tape numbers, together with first and last shot points, are listed for all lines in Appendix 11.

NON-SEISMIC ACQUISITION DETAILS

The locations on the ship of GPS aerials and echo-sounder transducers are indicated in Appendix 13. This information will allow precise positioning corrections to be made to the data.

A list of channel allocations for the non-seismic data is provided in Appendix 14.

Magnetic data acquisition details are tabled in Appendix 12. Shown are start and stop times of acquisition, the distance the sensor was towed behind the ship during these periods, and also the approximate profile coverage. Magnetic anomalies (?due to steel casing, well head and drilling junk) were recorded over Tuatara-1, Kulka-1 and Fishburn-1 well-sites. The fact that no significant anomalies were registered over some of the other well-sites may be because of deeper water at these locations.

Gravity ties were made to gravity base stations in Darwin immediately before and after the survey. The pre-survey and post-survey gravity tie data and reductions are presented in Appendices 15 and 16, respectively.

SYSTEMS AND EQUIPMENT PERFORMANCE

NAVIGATION / GEOPHYSICAL (NON-SEISMIC) DATA ACQUISITION SYSTEM (DAS)

(Condensed and edited version of report by Richard Mleczko)

There was only one interruption to the operation of the DAS, that was the power black-out associated with failure of the ship's shaft generator on 9 May. There were no problems with the printers, the Roland plotter or the EPC recorders. The tape writing was switched from Unit 1 to Unit 0 because of a few bad blocks encountered on Unit 1. On one occasion Unit 0 went down and was then brought up again. No data were lost. The system console for the HP failed and was replaced with a spare VT220. At the beginning of the cruise the GED clocks were synchronised with the clock on the Trimble receiver. By the end of the cruise the clocks were 0.5 seconds out as compared with the Trimble.

Navigation

Differential GPS positioning was available most of the time. There was only one lengthy period (58 minutes) when there was no such coverage. On another occasion differential GPS was lost for 14 minutes. Figure 9 shows the percentage of navigation modes in use for each day and for each line.

GPS/dGPS (Racal Systems)

The two Racal systems had only minor problems. The operation of the software on the two Compaq computers, the operation of the two Trimble receivers and the two demodulators was without incident.

The antenna control unit (ACU) of the Racal dome did lose track on about ten occasions during turns and was re-aligned on the manual setting. Every day at the same time the HDOP on Racal #1 became greater than 3 and the navigation switched to Racal #2. This period was between 1400 and 1600 GMT.

Dead Reckoning

Dead reckoning was used for very brief periods (less than ten minutes) when the HDOP on both Racal #1 and #2 was high.

Sonar Dopplers
The Magnavox sonar doppler operated without incident; the Raytheon DSN-450 continued to have a minor instability problem.

Gyro-compasses
There were no problems with the gyros.

Magnetics

The magnetometer was deployed for most of the survey. On a few occasions it was retrieved due to shallow water and shoals.

The sensor was flushed with white spirit at the start of the survey because noisy signal had been reported the last time the magnetometer was used (Survey 116).

The magnetometer worked well initially, but noise levels gradually increased after a few days. The sensor was retrieved, dismantled and closely examined. The diaphragm was found to have a small tear, which allowed entry of a small amount of saltwater. The diaphragm was replaced and the sensor re-filled. Noise levels were very low for the remainder of the cruise.

Gravity

The gyro in the gravity meter was replaced just before leaving Darwin. There was no problem with the gravity meter for the entire survey.

Bathymetry

Both the 3.5 and 12 kHz echo sounders worked well. At the end of the trials (Survey 117) a card in the 3.5 kHz correllator was replaced and this unit gave no further trouble. Water depths of 20 to 500 m were encountered. In rough weather the 3.5 kHz was turned off due to the continual loss of tracking.

SEISMIC ACQUISITION SYSTEM
(Condensed and edited version of report by Ed Chudyk)

The seismic acquisition system ran throughout the survey without problems, other than that caused by the shaft generator/UPS failure. During the survey the minimum shot rate for 16 second record was just over 17 seconds which is a tribute to the Vax system.

Phoenix A-D Converter

IFP number 009, sample and hold number 002, C19/2 and C18/3 were used throughout the survey. The offset of the first 8 IFP stages and the overall offset P2 were set before the start of the survey, as was the offset of the sample and hold card. As the survey progressed the sample and hold offset was adjusted, if necessary, at the start of each line and line part. A dynamic range test was run between lines.

On 13 May the dynamic range test showed the maximum mean signal DC offset to be approximately 400 µV. P2 was adjusted and the DRT re-run; the maximum offset was measured at less than 100 µV at 36.9 °C. There was no further need to adjust P2 during the cruise.

Amplifiers

The usual tests were run on the amplifiers before the start of the cruise. A couple of groups of channels were observed to have low output on the high-cut filter test. These channels were within specification, but gave the appearance of a systematic fault. To remove the problem, channels 34-50 were changed with channels 130-146 and 174-180 were swapped with 148,158,160 and 156. A check was made to ensure that the DC offset of the swapped channels was not upset. The amplifier tests were re-run and checked and a normalization parameter file created.

3480 Tape Drives

The tape drives worked nearly flawlessly all cruise. There was one very minor tape jam on rewind, which was cleared without a problem. Several tapes gave bad block errors; two of these were read without mishap. After the frequency of drive cleaning was increased to three times per shift (day shift), few errors were noted. Several short tapes were discovered; however, these did not adversely affect data acquisition.

Syntron Controller and Depth Controllers (Birds)

The Syntron controller ran very well for the entire cruise. On the other hand, the depth controllers gave some problems. Five birds were changed out by rubber boat when they prematurely flattened their batteries. Later in the survey, the front two birds were changed by partially retrieving the cable. Several days later the entire cable was retrieved and all the birds changed. All the birds, but number 23, worked well until the end of the survey. Bird 23 suffered from intermittent communication problems.

Depth Controller Wing Angles and Cable Lead

A total 5000 wing angles were averaged to produce the graph in Figure 10. As can be seen, the angles were generally negative. Birds 6, 8, 12 and 19 had positive wing angles while birds 9 and 23 had very small negative wing angles. The situation would be better if there was lead on all the sections. However, as the cable lead graph (Figure 10) shows, this is not the case. No lead is present on the cable at birds 6, 8, 9, 12 and 19. Two kilos could be removed near bird number 23.

Gun Array Depth Detectors

Two types of depth detectors, analogue and digital, were used during the cruise. There appeared to be little difference between the two types of detector. The analogue detectors tended to show larger errors at times, but both types drifted.

Gun Controller

During the survey a digital storage CRO was used extensively to investigate apparent bad gun timing, when it occurred. Bad timing was generally found to be due to poor sleeve sensor signals (resulting from damage to the sensor lines or pigtails), worn-out guns or worn-out solenoids. The gun controller itself behaved very well.

The gun trigger times were closely observed once the guns had settled down on line. Trigger times varied between 38.5 ms and 49.0 ms. To compensate for very slow firing guns, the trigger target and window were changed to 45.0 ms and 7.5 ms, respectively. A narrower window of say 7.0 and a target of 44.5 would probably work slightly better. At no time did the modified window and target cause any problems with gun timing.

Source Sensors

The source sensors worked well at the start, but lost sensitivity as the cruise progressed. Spurious signals were occasionally seen on the sensor traces. All the guns in the group were observed with the digital CRO and none could be found auto-firing. It was concluded that the apparent auto fires were in fact some form of cross-feed in the bundle.

ELECTRONIC ENGINEERING REPORT

(Condensed and edited version of report by Martin Callaway)

Instrument Room and DAS

Phoenix A-D Converter

FPC assembly FPC008/B1, originally operational after trials 117, was adjustable well within the 300 μV DC mean offset specifications, but performed badly in terms of linearity (up to 1.8% spread on dynamic range test). This figure could not be improved upon, due partly to last stage offset adjustment (R36) coming to full adjustment before offset null, but also due to the 5th stage offset adjustment (R20) being noisy and unstable. The card was replaced by card FPC009/B3, brought from Canberra. It required only minimal adjustment to achieve overall DC mean offset < 87 μV with linearity of 0.31% over the full dynamic range.

Only a small drift (DC mean offset to <190 μV at 0.37%) occurred throughout the first two weeks during which time the temperature of the unit ranged from 35.2 to 38.0°C.

The unit was re-tuned for overall mean DC offset on 13 May due to an extended air-conditioning failure resulting in a drift of 368 μV, well outside specifications.

Gravity Meter

As indicated in an earlier section, the gyro was replaced before the survey. The meter operated without problem for the entire survey.

Depth Transducers

The Teledyne reader showed improved performance; a more stable display was the result of longer transducer signal integration periods.

A newer set of digital DTs was fitted to the bundle for evaluation. They seemed to be easier to tune.

Magnetometer
As reported in an earlier section, the sensor was flushed twice - before initial deployment and again during the survey after the signal had become noisy. The rupture in the diaphragm discovered during the second opening/inspection may have been present pre Survey 118. The damage may have resulted from numerous deployment / retrieval cycles past the arrays whilst the guns were firing.

Cable length measurements (Appendix 17) were made early in the survey. The available cable allows towing of the sensor up to 265 m astern.

Echo Sounders
Both the 3.5 and 12 kHz echo sounders worked well. At the end of the trials (Survey 117), a card in the 3.5 kHz correlator was replaced and no further trouble was experienced.

<u>Uninterruptible Power Supply (UPS)</u>

The ship's shaft generator failed on 9 May, resulting in a total power outage.

At the time of the power outage, i.e. between shaft generator failure and auxiliary generator coming on line, the recently installed UPS system failed to provide backup to the Instrument Room for about 8 seconds. Once general power had been restored the UPS performed well in terms of converting a crudely regulated 60 Hz diesel backup supply to a clean, reliable 240 volt, 50 Hz supply to the Instrument Room. It is not clear why the UPS failed to provide backup power during the critical 8 seconds power outage. A number of over-voltage protection devices (varisters) within the UPS had been ruptured during the final stages of the sea trials (Survey 117), apparently as a result of some power switching activities at that time. This may have caused the UPS malfunction.

<u>Rear Deck</u>

Seismic Cable
Only one channel, #111, was dead. Three channels were reversed within the cable (channels 1, 69 and 105). These reversals were rectified at the Zip plugs at the rear of the amplifiers. This is normally a temporary measure which is usually returned to pre-cruise status at the end of the survey. However, it was decided to leave these reversals so that the next survey (Browse Basin) could go ahead without further action.

Active Tailbuoy
The prototype tailbuoy equipment and GPS performed well for about the first three days. Transmissions from the tailbuoy after this period became intermittent, particularly during periods of higher sea states. The tailbuoy electronic equipment failed to function reliably for any appreciable length of time during the remainder of the cruise. Wiring problems and poor electrical connections appear to be the cause.

Depth Controllers (Birds)
Four birds were rejected for various reasons during initial cable deployment. When checked later, two were found to be okay and returned to service as spares.

During final cable retrieval, all bird DTs were read by the Syntron at zero and 10 metres pressure to check transducer accuracy. The results appear below:-

Bird	Zero	10 metres	Bird	Zero	10 metres
1	0	10.1	14	0	10.2
2	0	9.9	15	0	9.4
3	0	10.0	16	0	10.0
4	0	9.9	17	0	10.0
5	0	9.6	18	0	9.9
6	0	10.2	19	0	10.2
7	0	9.9	20	0	9.8
8	0	10.0	21	0	10.0
9	0	10.0	22	0	9.7
10	0	9.9	23	0	10.0
11	0	9.6	24	0.4	10.4
12	0	10.3	25	0	10.3
13	0	9.7			

Bundle

The insulation resistance of up to 25% of all lines were at 40 kΩ (some approaching 10 kΩ) by the end of the third seismic line, despite recent bundle refurbishment.

It is considered that this may be as a result of either:-
(a) Poor quality heatshrink splices (Sucofit is brittle; also not snug shrinking i.e. internal voids remain),
(b) The previous lines not being cut back far enough thus inheriting an already leaky bundle.

As many as 10 pigtails were changed at one time in response to bad timing. While this did increase overall bundle insulation resistance, some lines remained much the same throughout the remainder of the survey.

To increase bundle life, it is recommended that future bundle refurbishment incorporate a final loop around the bundle before leading off to the pigtail splice. This would have two positive effects:-
1. The final lead out would not exit the bundle at right angles, thus avoiding rapid fatigue and development of open circuits, and
2. More length of rhino between bundle and pigtail would be available for future re-splicing.

Pigtails used:

Solenoids	23
Sensors	16

MECHANICAL EQUIPMENT
(Condensed and edited version of report by Mark James)

Gun Arrays

The gun arrays were towed from the magnetometer booms at a distance of ~45 m. These arrays consisted of thirty-two 150 cubic inch sleeve guns. Twenty-three of these were rebuilt during the survey.

Prior to the cruise both the port and starboard arrays were fitted with bottom plates. These allow the bottom of the sleeve guns to be joined together via chains. The biggest advantage of this configuration is that the base of the sleeve guns suffer minimal damage due to guns hitting each other while being towed. Sympathetic firing is increased, however.

The shackles used on the bottom plates will need to be upgraded on the first two groups of each array. Parts of the arrays have been fitted with higher grade chain and this results in breakage of the 2.5 tonne bow shackles - at an average rate of 2-3 shackles per array each time the arrays are retrieved.

The new upper clamping plates on the sleeve guns have been very successful, with six more being fitted to the guns on this cruise. The thickness of any additional plates that are manufactured and fitted in the future should be upgraded to 19 mm to prevent dishing.

During the cruise, three A6 polyform (Norwegian) buoys were lost from the arrays. This was due to the buoy ropes tangling and abrading through. One other A6 buoy was punctured. After the third A6 buoy was lost approximately half-way through the survey, it was decided to only use five buoys on each array. This did not alter the gun depths greatly and provided more spares for backup.

The bundle clamps and hooks are significantly worn and will need replacing in the near future. The hooks and chains are still responsible for bundle damage. A change in design could ease this problem.

Solenoids

At the start of the survey all the sleeve guns were fitted with the modified solenoids. They had been shown to reduce timing errors during the preceding sea trials (Survey 117). However, their reliability after the first week of shooting on Survey 118 was found to be questionable. While shooting line 118/0801, the system developed an unusually high number of "no fire" and "bad timing " signals. When inspected, it appeared that the modified solenoid components were partly responsible for these conditions.

To eliminate possible errors it was decided to rebuild all of the SV-2 solenoids to standard specifications, to test them and refit them to the arrays. While doing this, it was found that four of the solenoid coils had leaked water into the windings. The coils were tested, dried out and reused. They need to be replaced, however, to ensure reliable performance.

Compressor Units

Compressor #1
This unit was found to be in regular need of clutch adjustment during the first half of the survey. This condition is thought to have contributed to the failure of the low stage crankshaft. When the crankshaft broke one piston and connecting rod were badly damaged. The crankshaft was replaced and the unit brought back into service. A new clutch assembly was fitted.

Piston damage in the 3rd stage meant it had to be rebuilt - it was fitted with new rings, piston and wrist pin.

Compressor #2
The auto-drain valves on the second stage were replaced and a new actuator supply line fitted.

The fourth stage inlet valve seat was found to be leaking, causing the third stage relief valve to blow off. A new cylinder head was fitted, the cylinder honed and new rings fitted.

Compressor #3
The auto-drain was not operating on all stages. When checked, the electric solenoid was found to have burnt out. It was replaced.

Compressor #4
No problems.

Compressor #5
The diesel had burnt-out exhaust valves in cylinders 3 and 5. The cylinder head was reconditioned.

Compressor #6
The fourth stage booster piston picked up on the cylinder. The unit was shut down before any major damage occurred. The cylinder was removed and was found to be scored in the centre of the stroke and the ring lands worn on the booster piston. The cylinder was honed and fitted with a new piston and rings.

All of the compressor units had regular preventive maintenance for the duration of the cruise. This included clutch adjustment, greasing of PTO and couplings, cleaning of heat exchangers, oils and filter replacement.

High Pressure Air System

Three of the flexible high pressure supply lines from the receivers to the supply manifold were replaced. This was done because one of the hydraulic fittings was found to be cracked and corroded. The steel fittings currently used cannot cope with prolonged high velocity and high volumes of compressed air. Stainless steel fitting are needed.

Two of the supply lines to the Xmas tree also require new fittings. On the last day of shooting a large air leak developed on the starboard Xmas tree. When the system was aired down, the mild steel jic fitting was found to be severely corroded. Such fittings need to be replaced, preferably with stainless steel.

Thirty Hoke valve kits were used during the survey. These valves need to be replaced as soon as possible since they cannot handle the large volumes of air used.

Gun Bundles

The bundles were refurbished during the preceding sea trials (Survey 117). There was no evidence of significant problems until after the first week of shooting. When problems did occur, many were related to faulty electrical components such as leaking wire splices, pigtails and solenoid coils. Only 50% of rebuilt sleeve guns developed mechanical faults.

Down-time during surveys could be reduced by concentrating fault-finding efforts on the bundles rather than the guns.

Seismic Reels

Early in the survey, some minor trouble with the Danfoss proportional control valves was experienced. The remote control unit does not allow speed control, therefore reels should be operated manually until further technical information for rectifying the problem is available.

PRELIMINARY RESULTS

The shipboard seismic monitor records provide some insight into the sub-bottom geology. Seismic sections are displayed on line-printer as single trace (channel 2 on this survey) records. Being unprocessed, there is no suppression of multiples or reverberation in the data. Any definitive seismic interpretation will have to wait until the field data are properly processed. Nevertheless, some examples of monitor sections and corresponding preliminary interpretations are presented below. The sections demonstrate aspects of the basin geology in the region and give some indication of what the final processed data will reveal. All the monitor sections presented show only the first 3 seconds of the 16 second data collected.

(a) Part of strike line 118/1501 through Kulka-1 well, Money Shoal Basin / Goulburn Graben (Figure 11).
About 2 seconds (twt) of mainly Mesozoic section of the Money Shoal Basin overlies the Paleozoic Goulburn Graben of the Arafura Basin. The Money Shoal Basin thickens along the line to the northwest, i.e. towards the Calder Graben; the sediments are relatively flat-lying. The Arafura Basin section beneath the prominent base Jurassic unconformity shows major faulting. The fault blocks have undergone appreciable relative movement, as seen by contrasting dips (often relatively steep) in adjacent blocks.

(b) Part of line 118/0002 through Beluga-1 well, eastern Malita Graben (Figure 12).
This profile is located across the south-east margin of the eastern Malita Graben. The Mesozoic section extends down to a time-depth of at least 2 seconds (twt) in the south, and deepens to more than 3 seconds (twt) in the north.

(c) Part of line 118/1001 through Lynedoch-1 well, eastern Malita / Calder Graben (Figure 13).
At least 2.5 seconds (twt) of gently-dipping Jurassic and younger section is seen in this S-N profile in the middle of the Calder Graben. The upper part of the sedimentary section comprises a relatively thick, 1.0 second (twt), succession of Cainozoic carbonates.

(d) Part of line 118/0901 across the Sahul Platform and southern flank of the Timor Trough (Figure 14).
The profile shows intense Tertiary high-angle, ?extensional faulting on the southern flank of the Trough. Water depth here is up to 500 m. The sedimentary section, consisting of Cretaceous and younger sediments, is more than 2.5 seconds (twt) thick. Most of the faults terminate at a prominent late Tertiary (?Middle Miocene - Apthorpe (1988)) angular unconformity. Some minor faulting appears to extend into the overlying prograding beds, almost to the seafloor. The faulting is attributed to tectonics associated with convergence of the Eurasian and Australian plates.

(e) Part of dip line 118/1802 across the NE margin of the Petrel Sub-basin (Figure 15).
The great thickness of late Phanerozoic sedimentary deposits contained in the Sub-Basin is illustrated by this profile. A faulted Permian section underlies a prominent unconformity, and dips relatively steeply basinward (SW) to a time-depth of more than 3 seconds (twt).

(f) Part of dip line 118/1802 through Fishburn-1 well, western Petrel Sub-basin (Figure 16).
As on the NE margin of the Petrel Sub-basin, at least 3 seconds (twt) of Phanerozoic section is evident in this profile. The strata dip NE towards the central axis of the basin.
The Tertiary section thins significantly at the basin margin. Faulting extends upward at least as far as the Valanginian unconformity.

(g) Part of line 118/2101 through Londonderry-1 well, NE Browse Basin (Figure 17).
Basement (Proterozoic rhyodacite) is relatively shallow at ~1150 m depth (~1.0 second twt). The overlying sediments are flat-lying and Cretaceous to Cainozoic in age.

ACKNOWLEDGEMENTS

The Master, Bob Hardinge, and AMSA crew of the RV *Rig Seismic* are thanked for their help and close co-operation during the execution of Survey 118. Their expert skills and demonstrated professionalism made a vital contribution to the successful completion of the scientific program.

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AGSO SURVEY 118

MALITA GRABEN

100 km

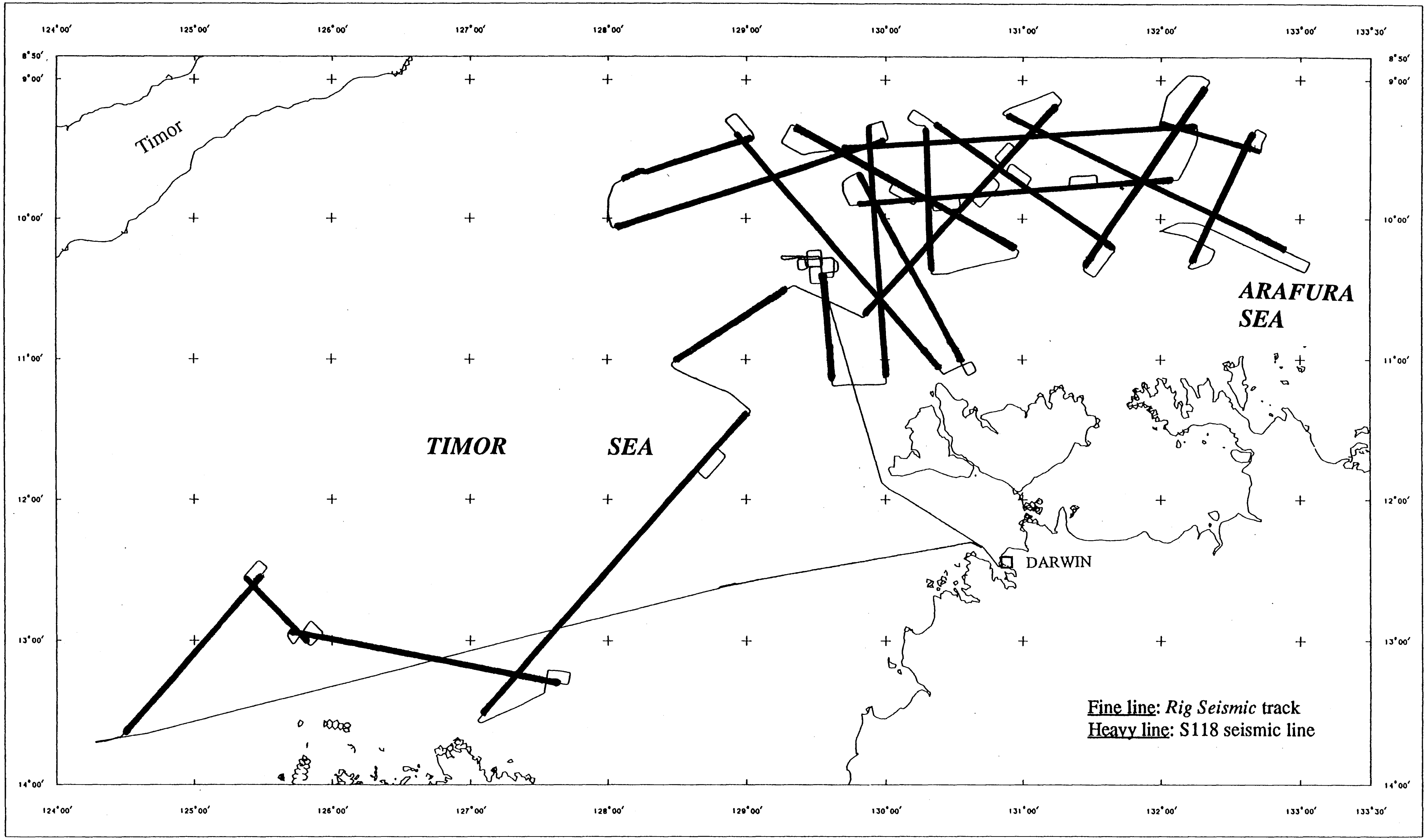


FIGURE 1. Survey 118 ship's track and seismic lines

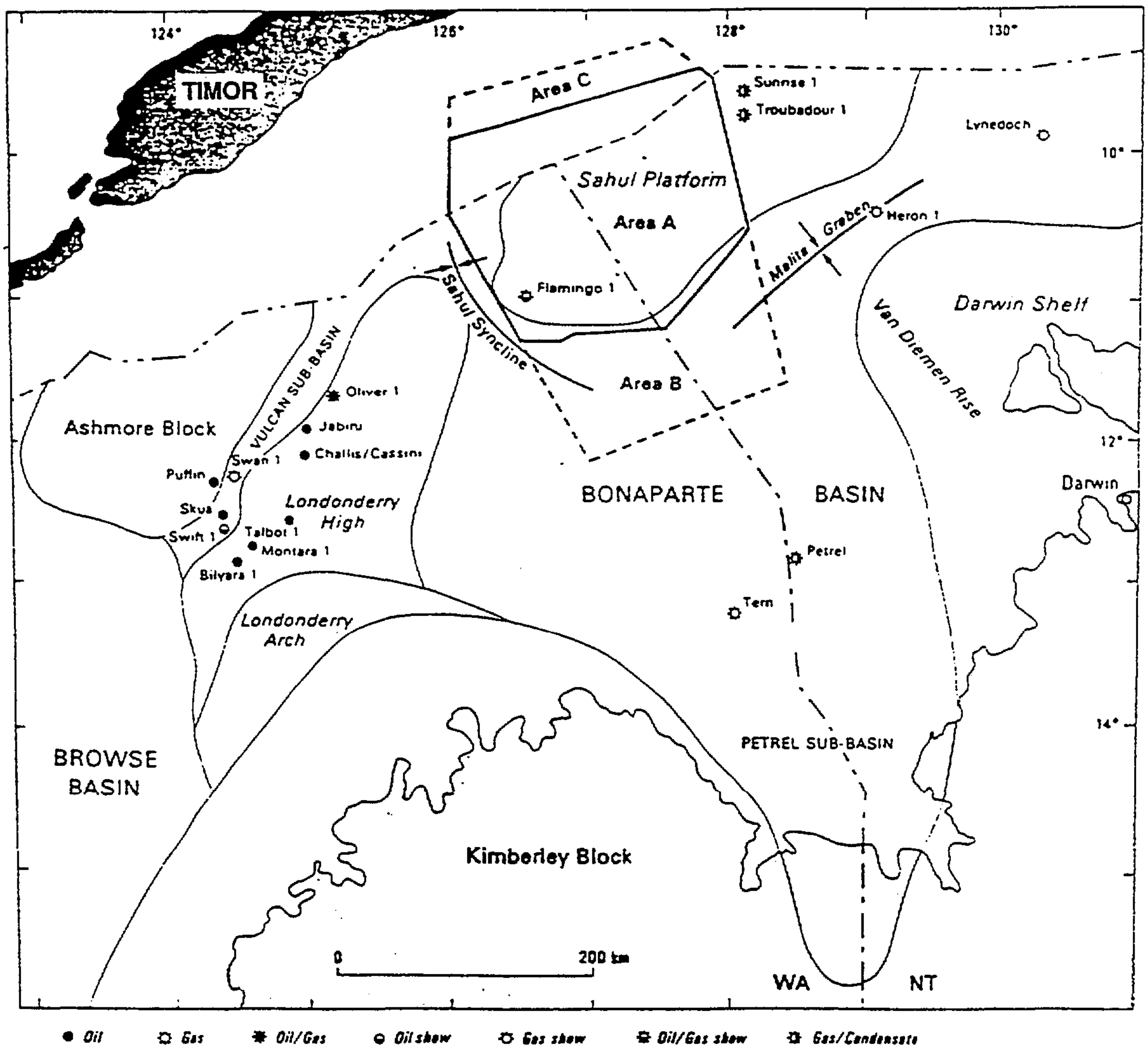


FIGURE 2. Map of the Timor Sea region showing the main structural elements, petroleum accumulations and the Australia / Indonesia Zone of Co-operation (after Williamson and Lavering, 1990).

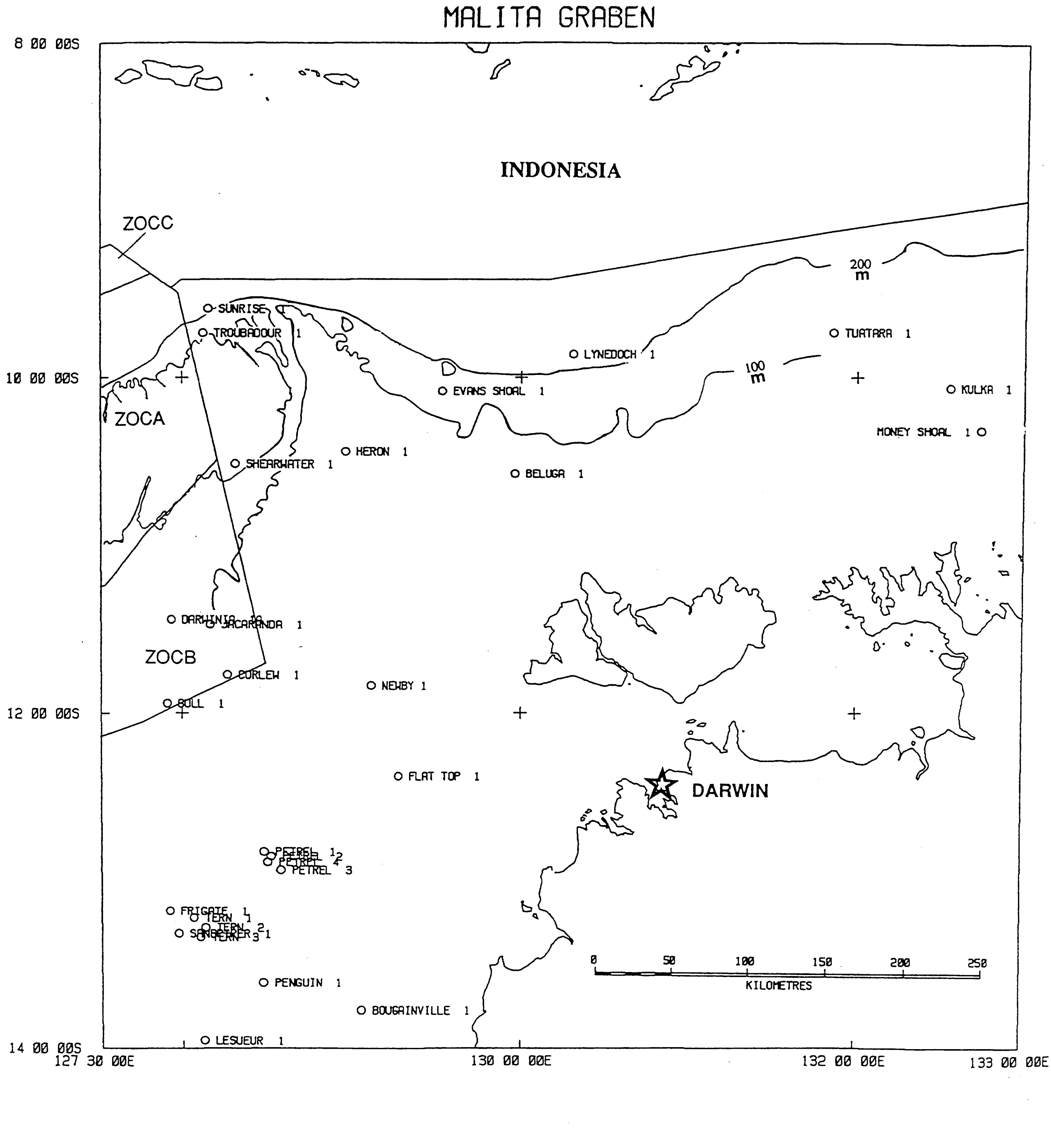


FIGURE 3. Eastern Malita Graben survey area, exploration well locations and 100 / 200 m bathymetry contours.

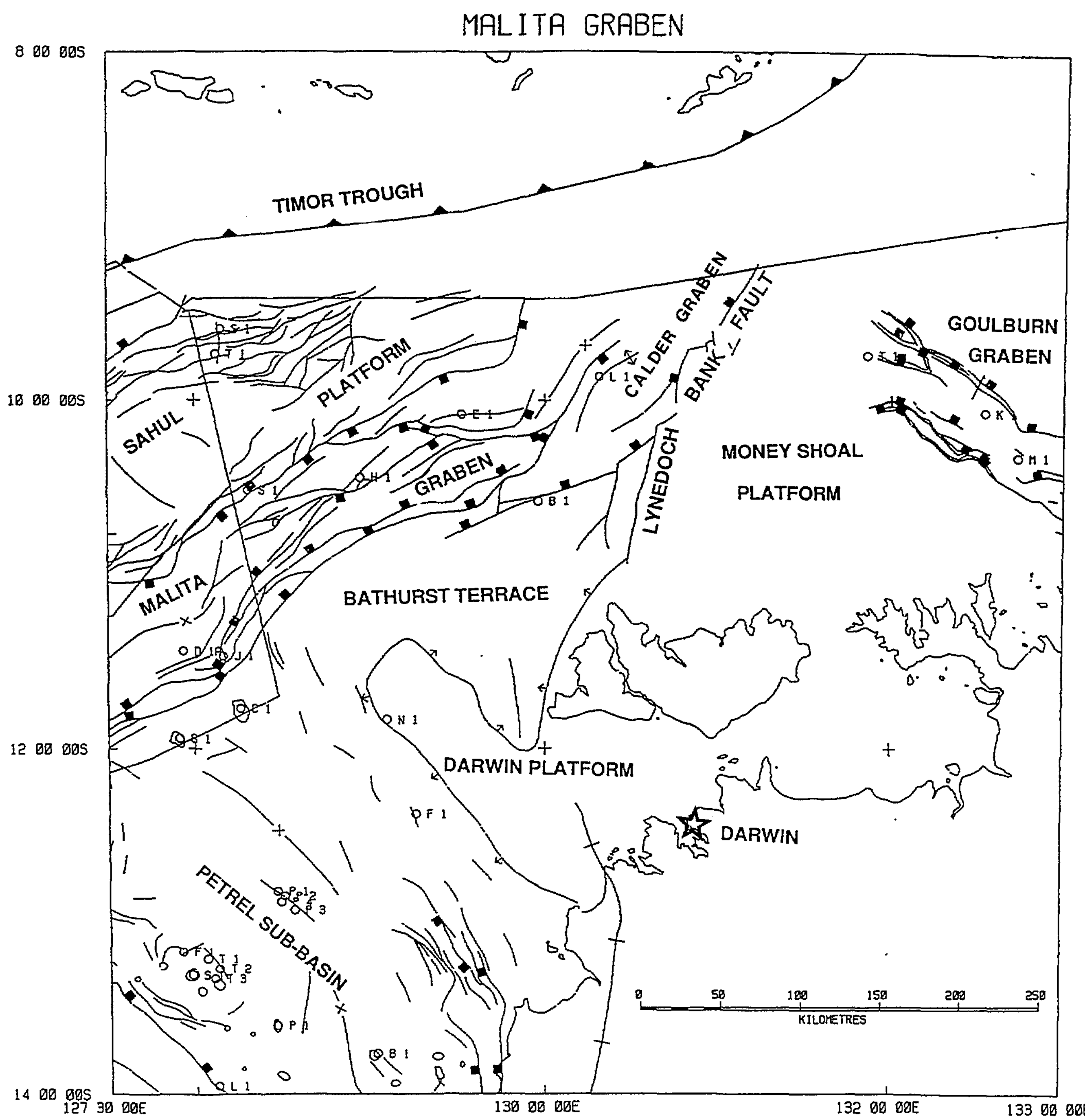


FIGURE 4. Structural framework of the eastern Malita Graben region (Northern Territory Geological Survey, 1989; 1990).

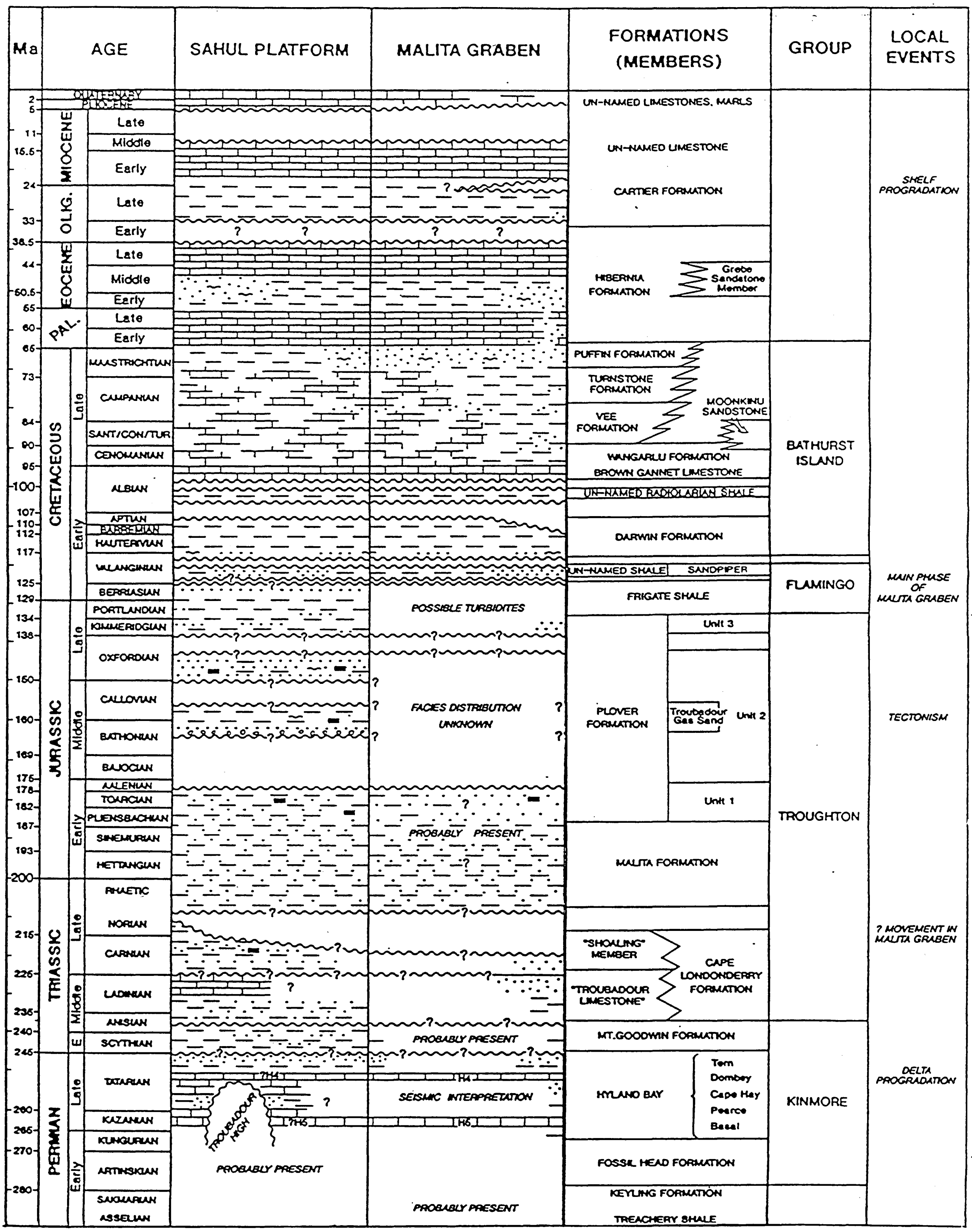


FIGURE 5. Stratigraphy of the eastern Malita Graben region (Northern Territory Geological Survey, 1990).

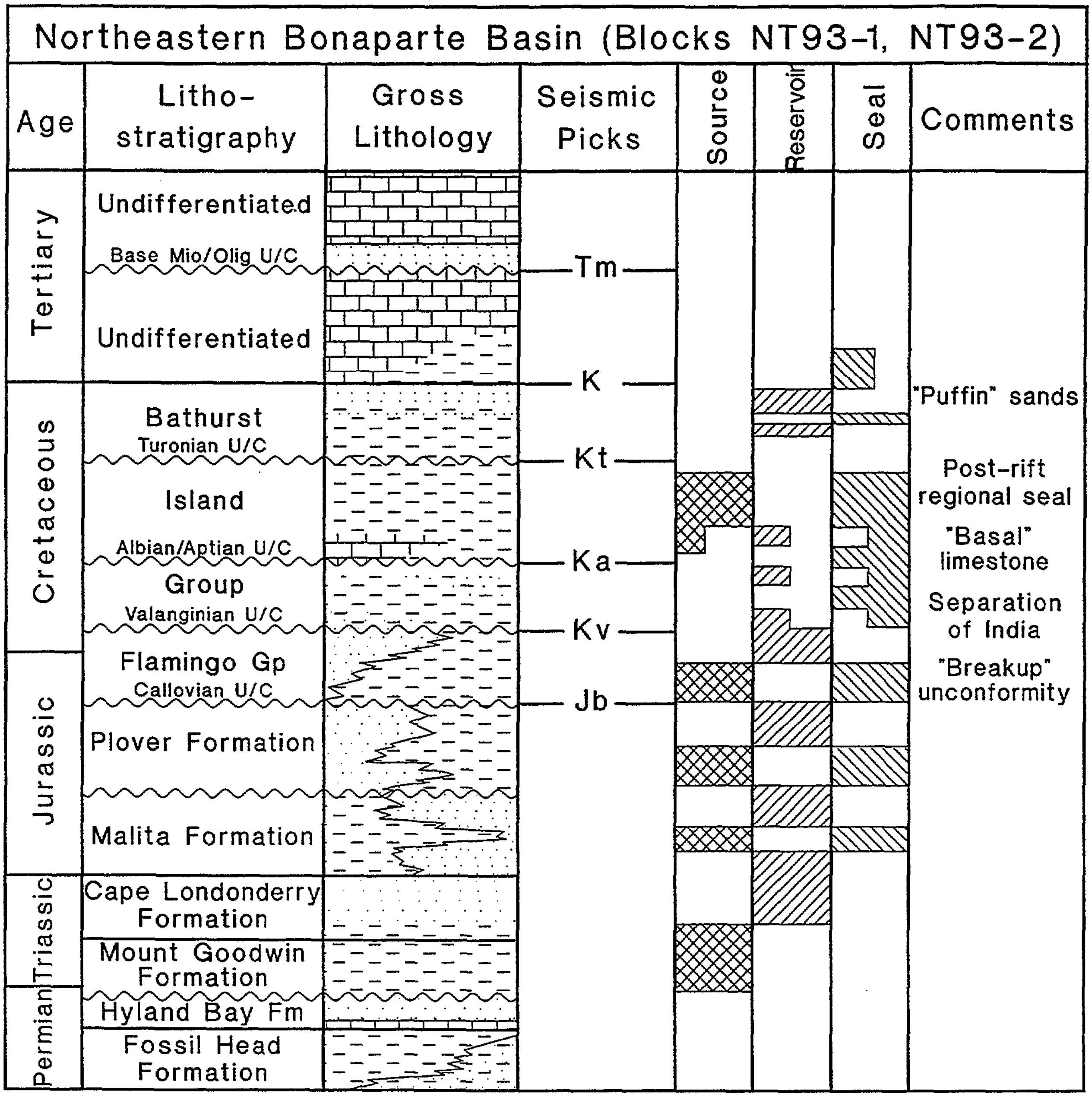


FIGURE 6. Generalised stratigraphy, main seismic horizons and source/reservoir/seal characteristics of the NE Bonaparte Basin (West and Passmore, 1993).

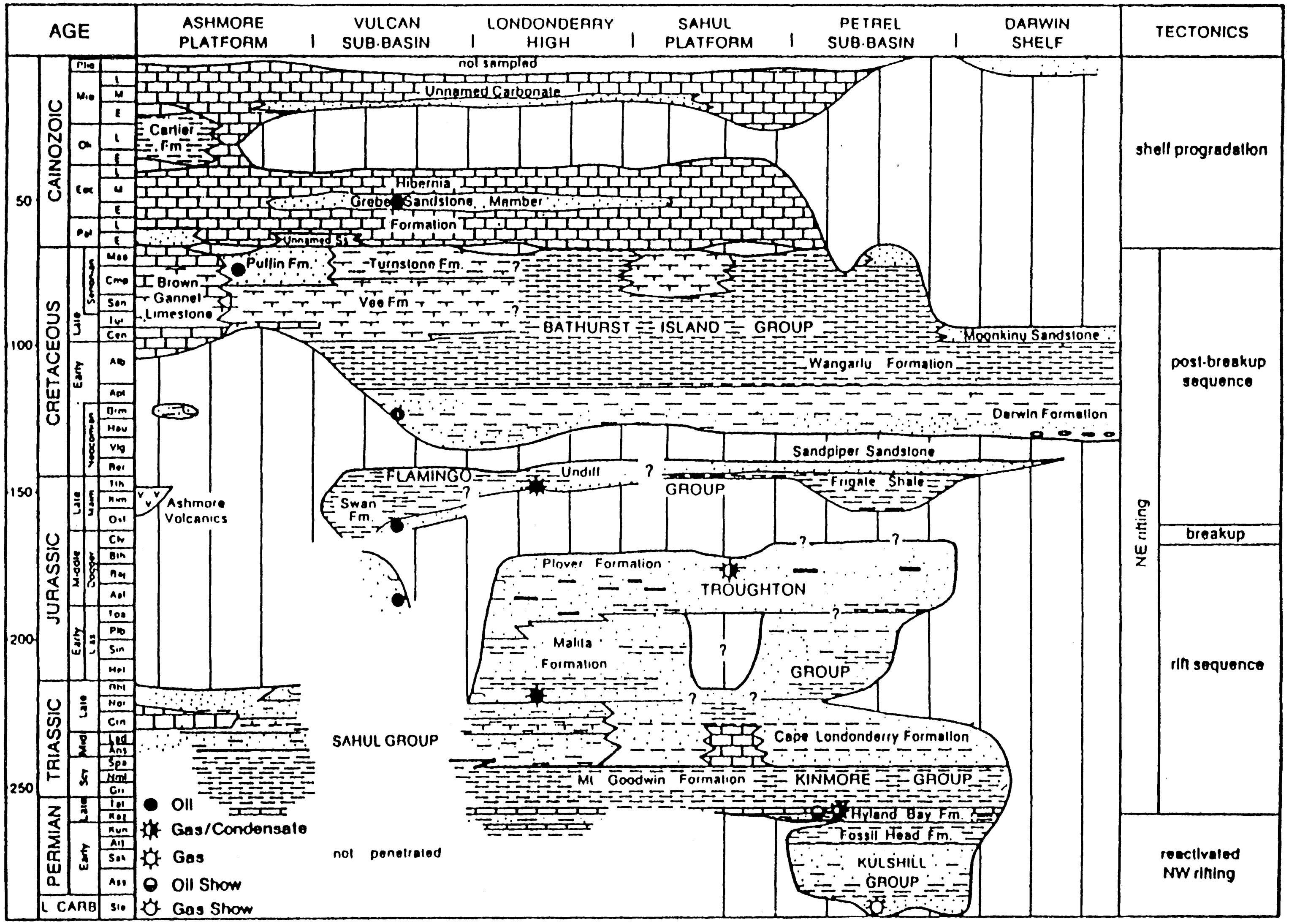


FIGURE 7. Permian to Cainozoic stratigraphy, tectonics and hydrocarbon reservoirs of the Bonaparte Basin (after Williamson and Lavering, 1990; modified after Mory, 1988).

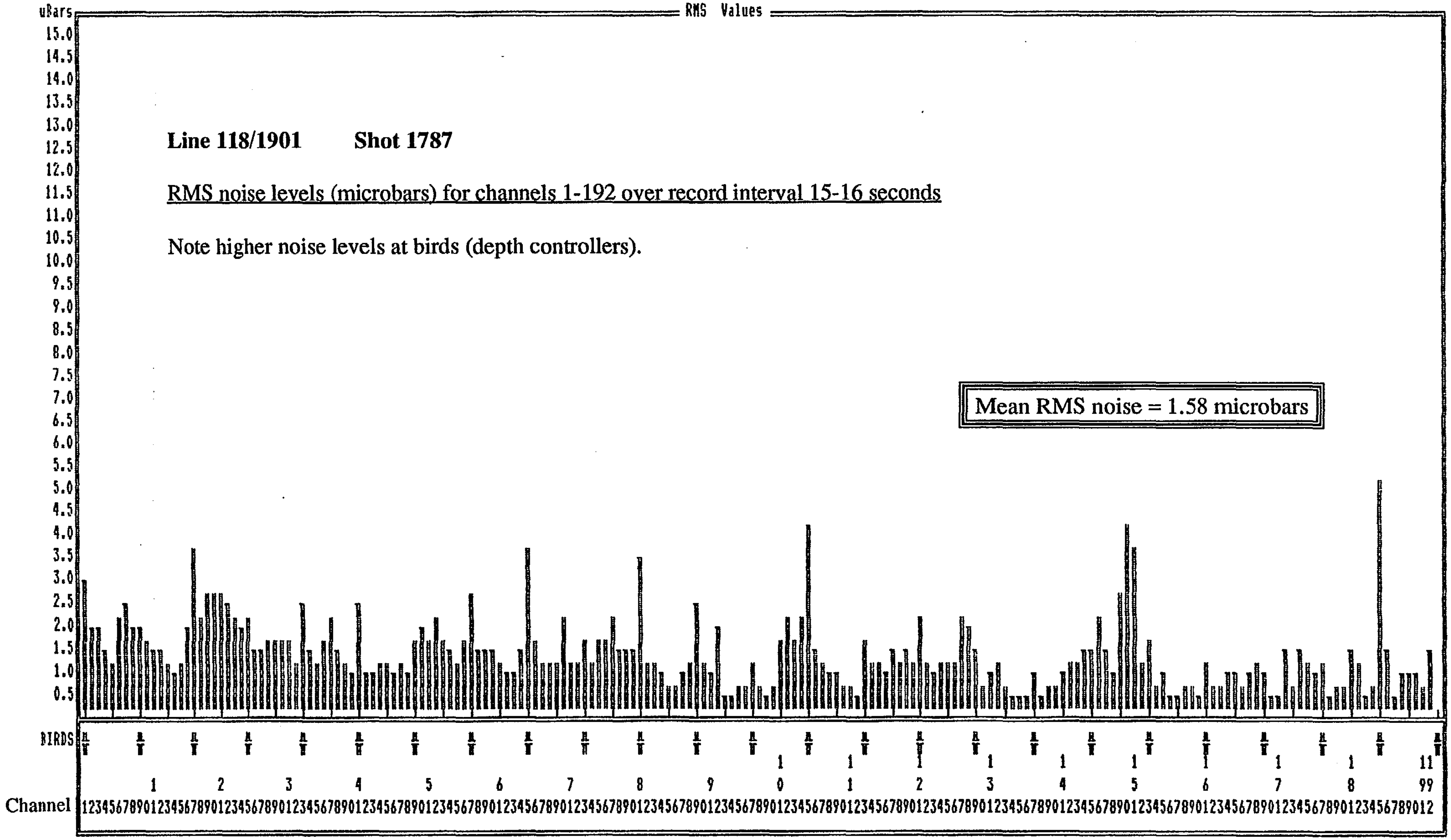
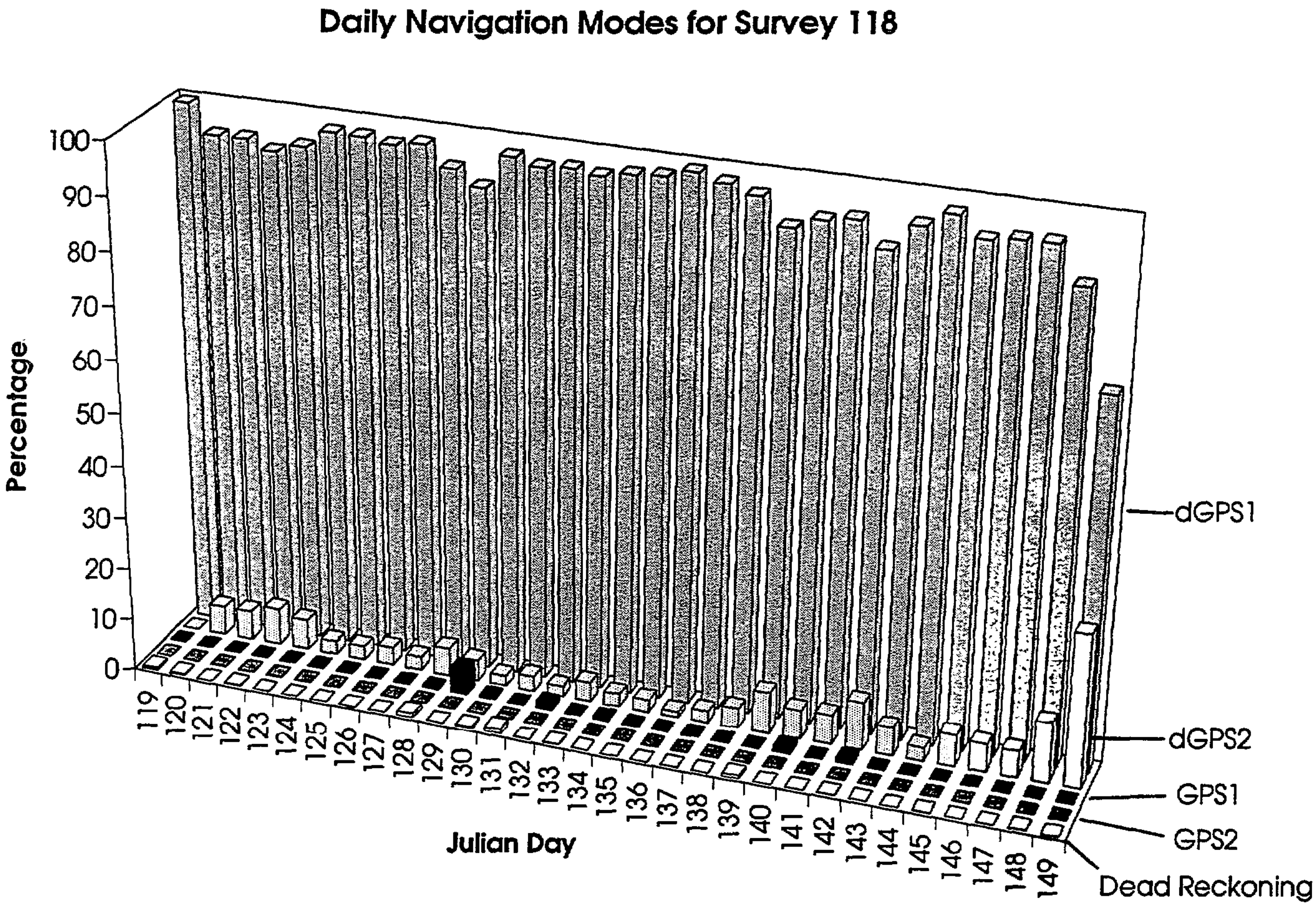


FIGURE 8. Typical noise levels along length of streamer during favourable sea conditions.



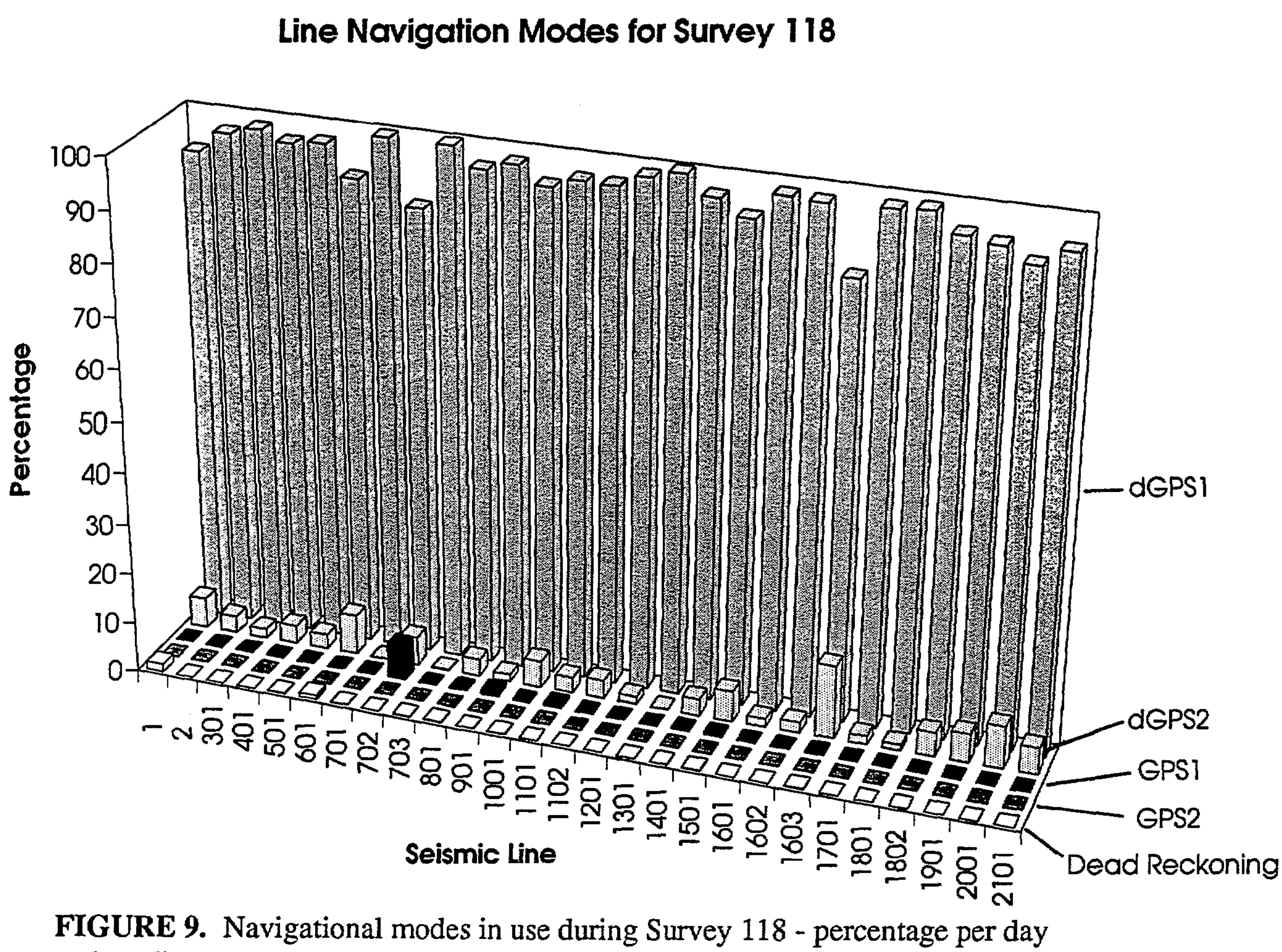
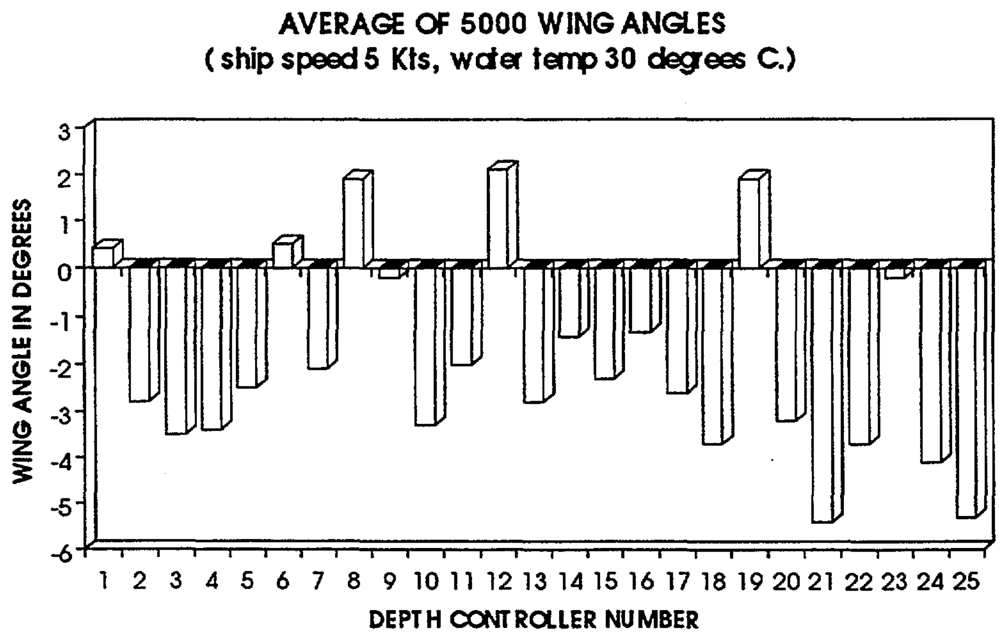


FIGURE 9. Navigational modes in use during Survey 118 - percentage per day and per line.



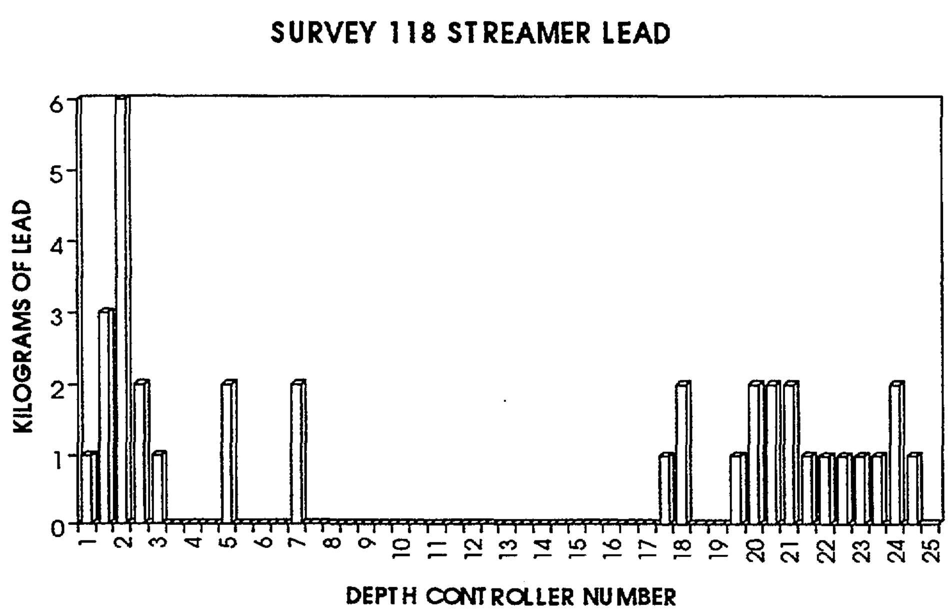


FIGURE 10. Depth controller wing angles and streamer lead.

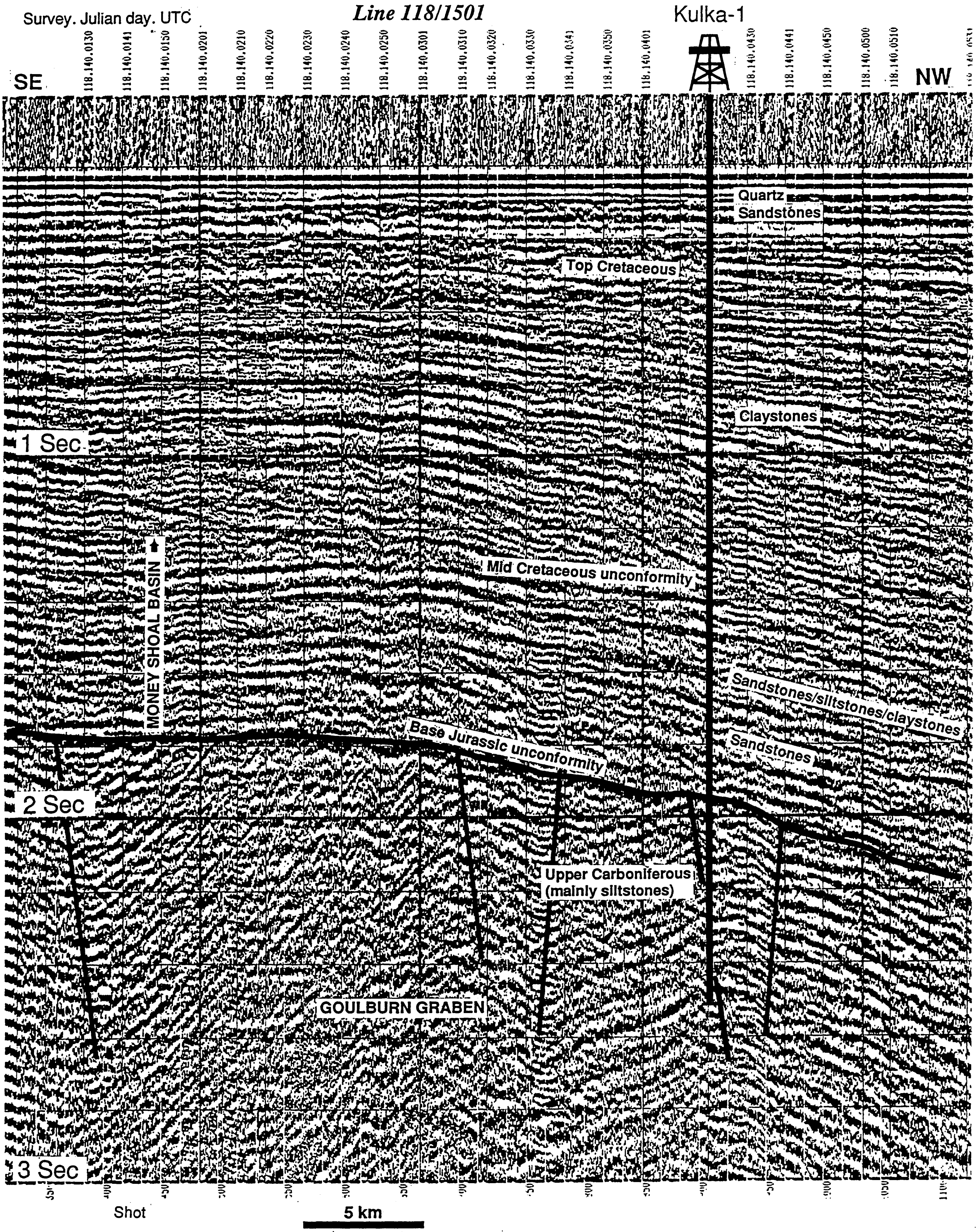


FIGURE 11. Shipboard monitor seismic section and interpretation of part of line 118/1501 through Kulka-1 well, Money Shoal Basin / Goulburn Graben.

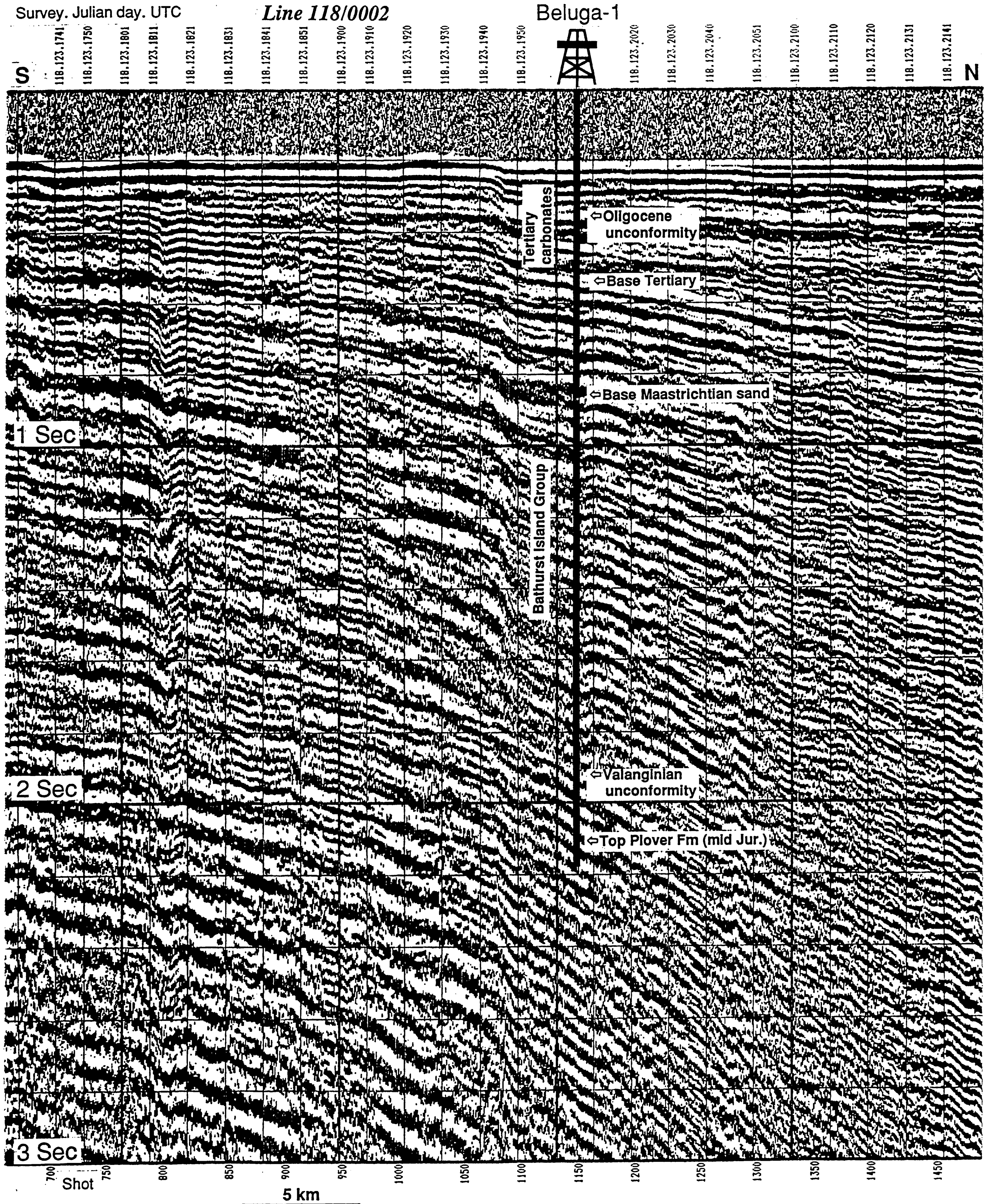


FIGURE 12. Shipboard monitor seismic section and interpretation of part of line 118/0002 through Beluga-1 well, eastern Malita Graben.

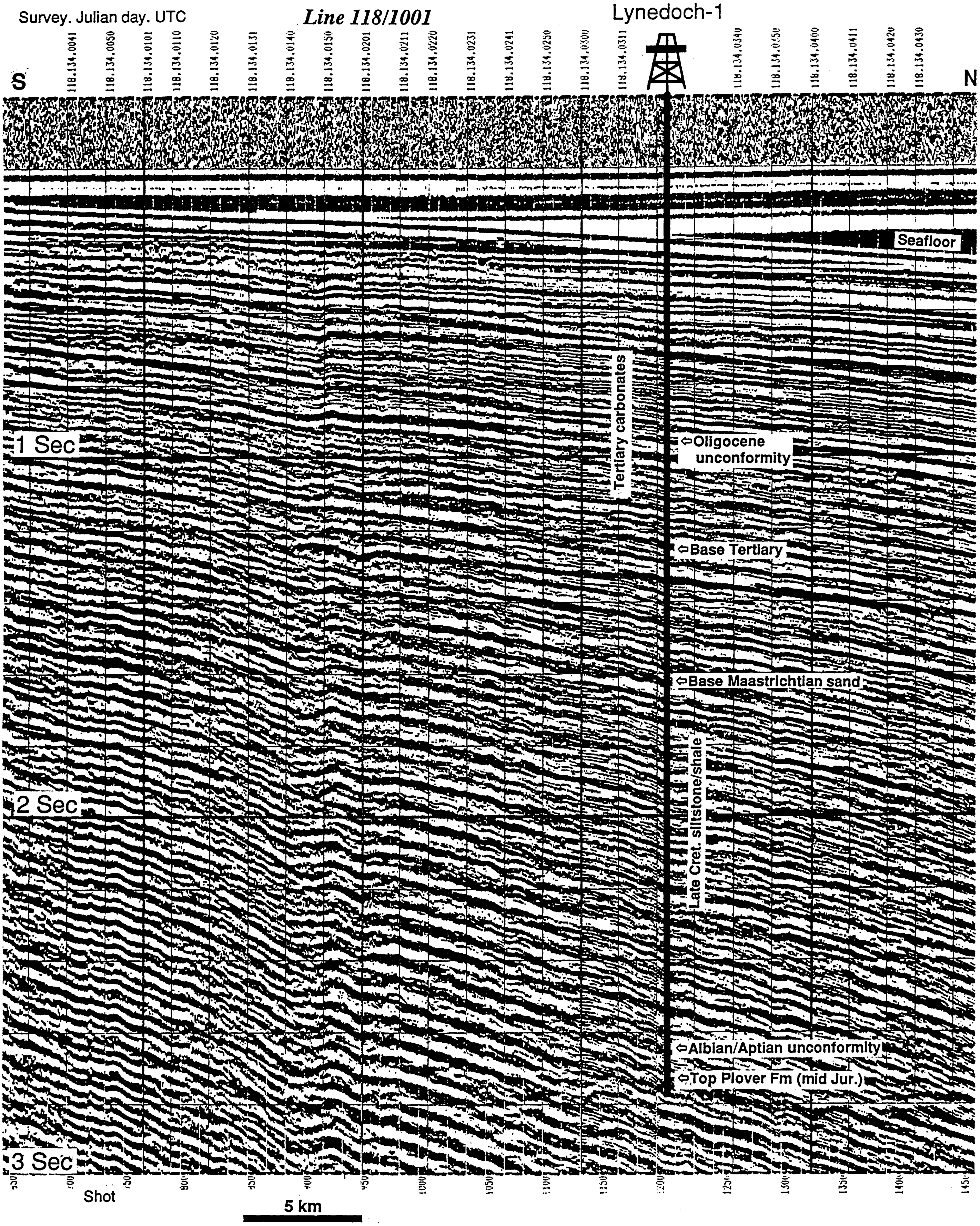


FIGURE 13. Shipboard monitor seismic section and interpretation of part of line 118/1001 through Lynedoch-1 well, eastern Malita / Calder Graben.

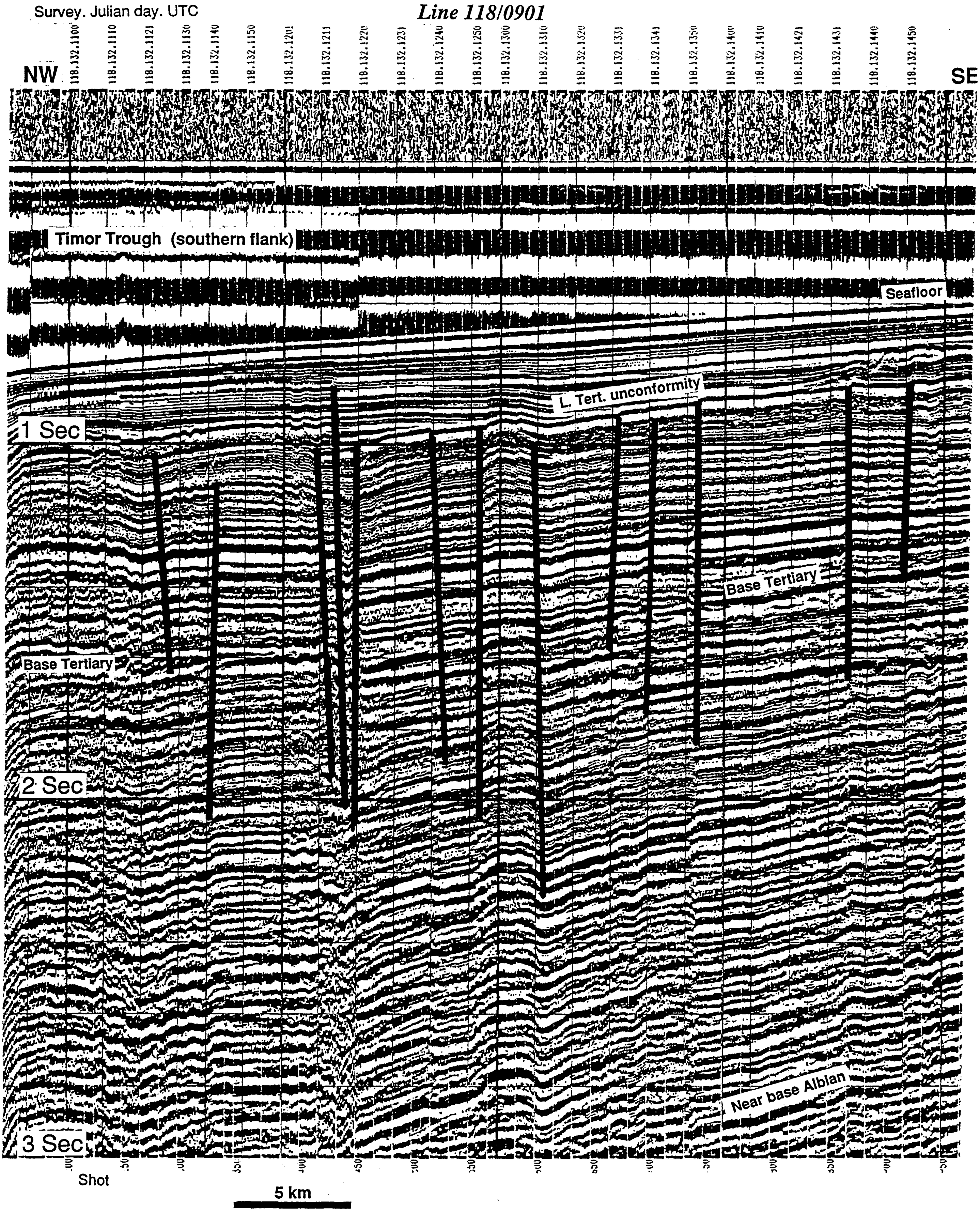


FIGURE 14. Shipboard monitor seismic section and interpretation of part of line 118/0901 across the Sahul Platform and southern flank of the Timor Trough. The section shows intense Tertiary high-angle (?normal) faulting.

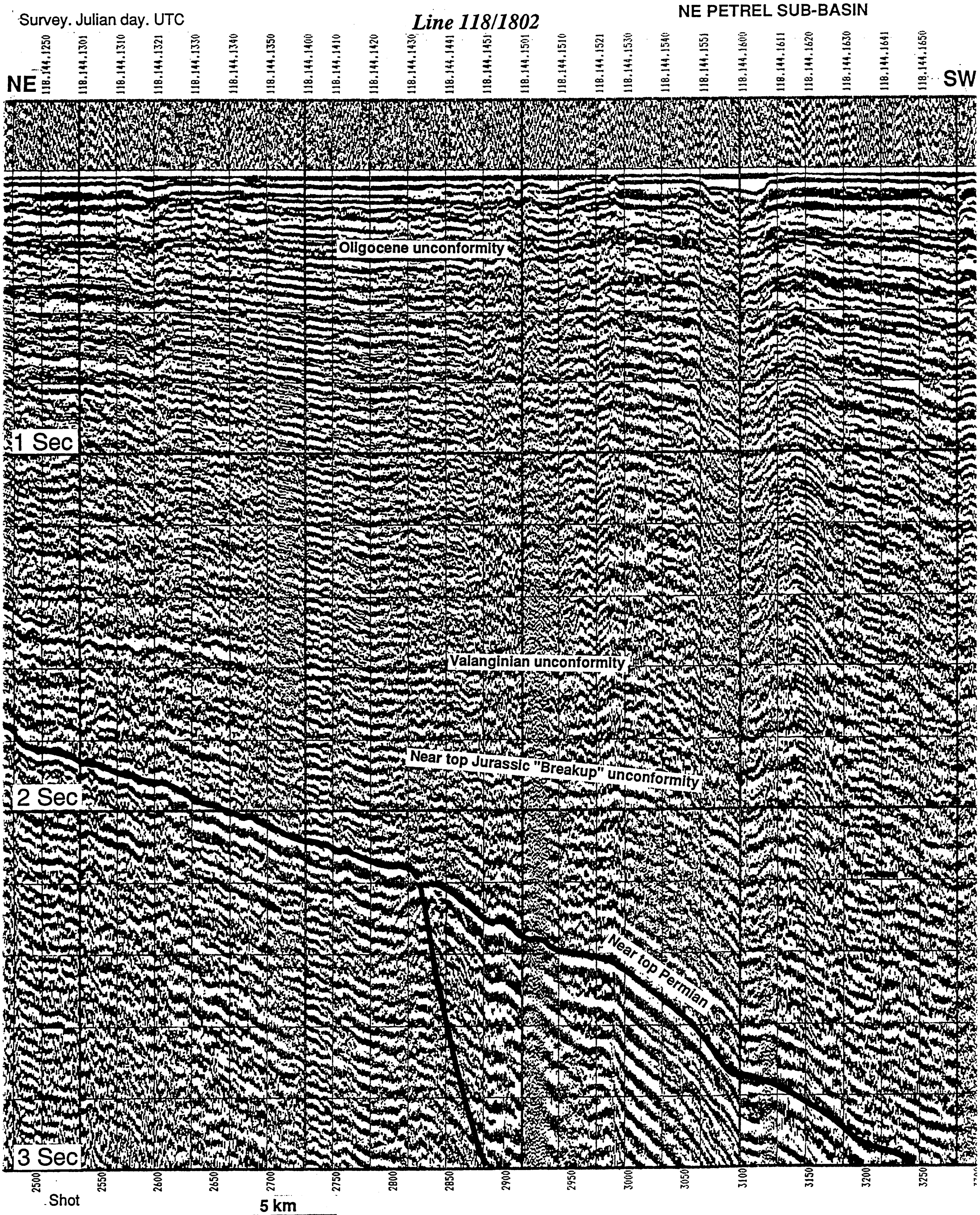


FIGURE 15. Shipboard monitor seismic section and interpretation of part of line 118/1802 across the NE margin of the Petrel Sub-basin. The Permian dips steeply basinward (SW) to more than 3 seconds TWT.

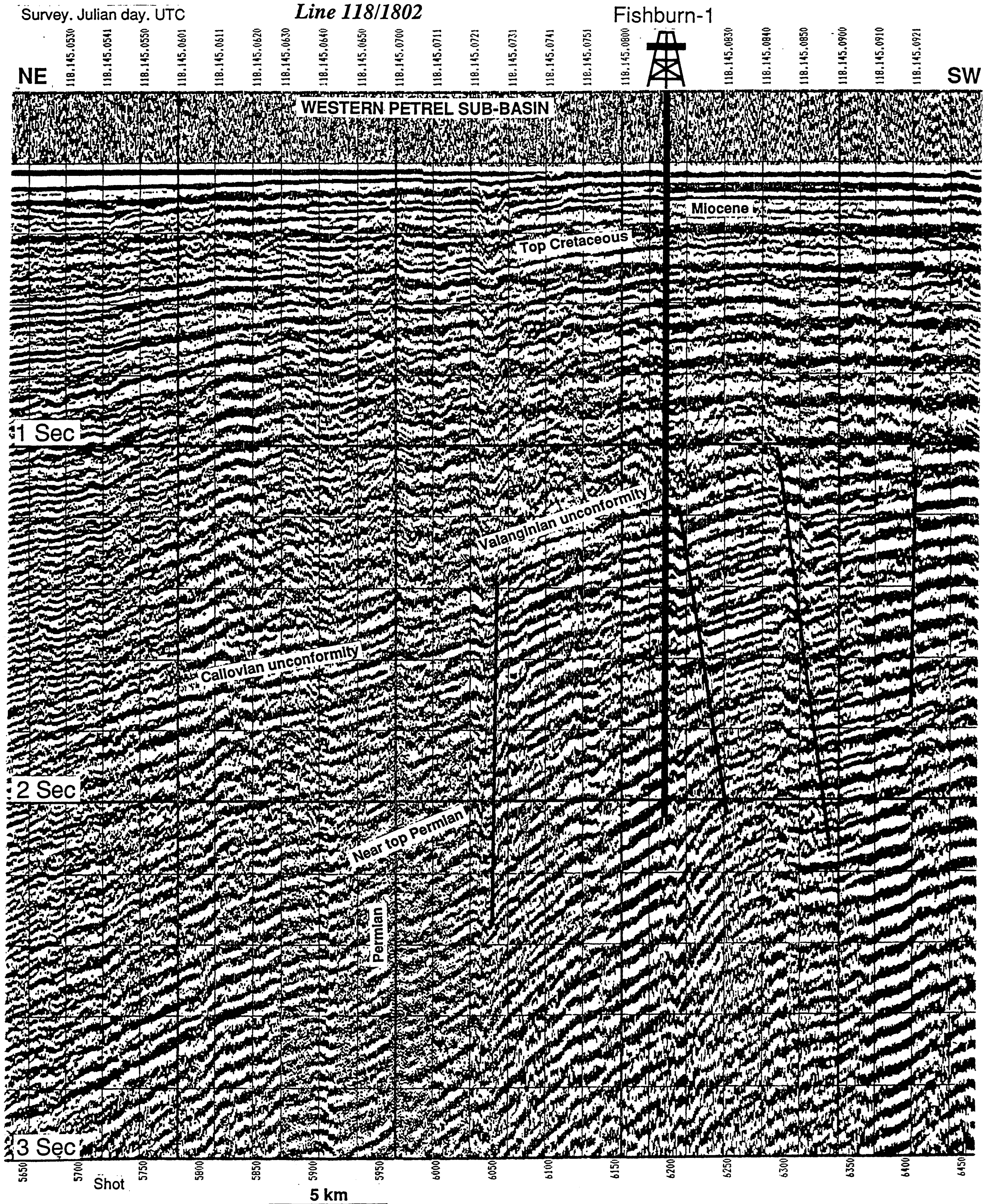


FIGURE 16. Shipboard monitor seismic section and interpretation of part of line 118/1802 through Fishburn-1 well, western Petrel Sub-basin.

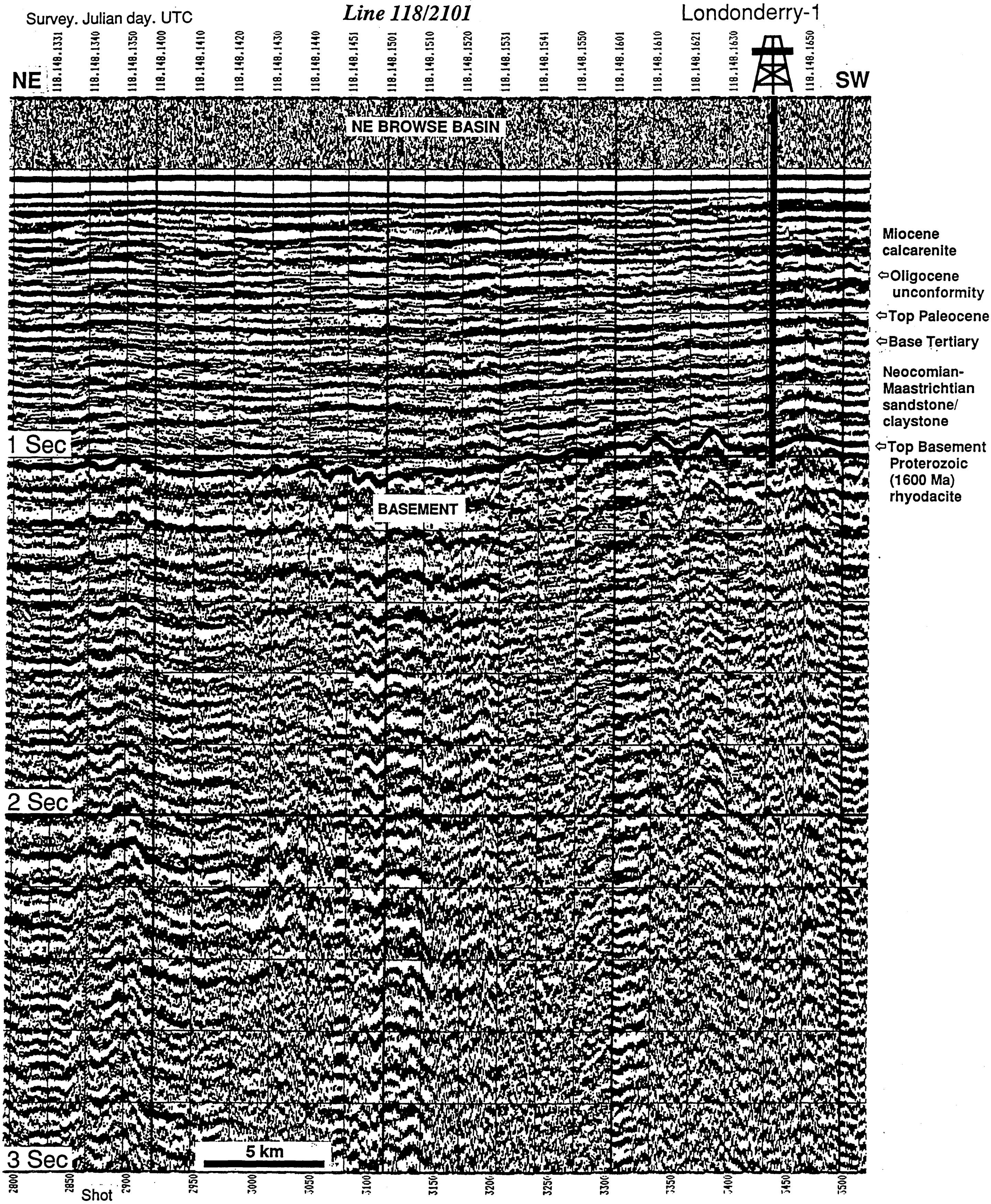


FIGURE 17. Shipboard monitor seismic section and interpretation of part of line 118/2101 through Londonderry-1 well, NE Browse Basin. Basement (Proterozoic) is relatively shallow - at ~1150 m depth.

APPENDIX 1
INFORMATION ON RESEARCH VESSEL *RIG SEISMIC*

R.V. *Rig Seismic* is a seismic research vessel with dynamic positioning capability, chartered and equipped by AGSO to carry out the Continental Margins Program. The ship was built in Norway in 1982 and arrived in Australia to be fitted out for geoscientific research in October 1984. It is registered in Newcastle, New South Wales, and is operated for AGSO by the Australian Maritime Safety Authority (AMSA).

Gross Registered Tonnage:			1545 tonnes
Length, overall:			72.5 metres
Breadth:			13.8 metres
Draft:			6.0 metres
Engines:	Main:	Norma KVMB-12	2640 H.P./825 r.p.m.
	Aux:	3 x Caterpillar	564 H.P./482 KVA
		1 x Mercedes	78 H.P./56 KVA
	Shaft generator:		AVK 1000 KVA; 440 V/60 Hz
	Side Thrusters:		2 forward, 1 aft, each 600 H.P.
Helicopter deck:			20 metres diameter
Accommodation:			39 single cabins and hospital

APPENDIX 2
SCIENTIFIC EQUIPMENT ON *RIG SEISMIC*

General

Raytheon echo sounders: 3.5 kHz (2 kW), 16 transducer sub-bottom profiler and 12 kHz (2 kW)

Geometrics G801/803 magnetometer/gradiometer

Bodenseewerk Geosystem KSS-31 marine gravity meter

Navigation

Racal SKYFIX differential GPS system

2 Trimble 4000 series GPS receivers, with Racal satellite data demodulators and software running on Compaq 386 PCs

Magnavox MX 610D and Raytheon DSN 450 dual-axis sonar dopplers

Sperry gyro-compasses (2); plus Ben paddle log

Seismic Streamer

FJORD Instruments seismic receiving array, transformerless coupling

6.25 m, 12.5 m, 18.75 m and 25 m group lengths available
10 Teledyne T-1 hydrophones per 6.25 m group
Nominal sensitivity of 20 volts/bar for standard group
Up to 288 seismic channels and 12 auxiliary channels
Up to 6000 metres active streamer length

Syntron RCL-3 cable levellers; individual remote control and depth readout (x 25)

Syntron compass birds (x 4)

Seismic Source

Haliburton Geophysical Service 32 x 150 cubic inch airguns (sleeve guns) in two 16 gun arrays; the normal operating array is 2 x 10 guns, giving a total of 3000 cubic inches normal operating array volume

Seismic Systems S-15 and S-80 high resolution water gun array consisting of 5 x 80 cubic inch

Air compressor system: 6 x A-300 Price compressors, each providing 300 scfm at 2000 psi (62 litres/min at 14 MPa)

Recording Instrumentation & Recording Options

Digital seismic acquisition system designed and built by AGSO running on DEC μVAX 3500:

0.5, 1, 2 and 4 millisecond sampling rate
2 to 20 second record length
Low noise charge-coupled preamplifiers
Phoenix A/D converter and instantaneous floating point amplifier (operating at 200 kHz)
Maximum of 320 channels including seismic and auxiliaries
LC filters: 8, 12, 24 and 48 Hz at 18 dB/octave
HC filters: 64, 128, and 512 Hz at 72 dB/octave
Data stored on Fujitsu 3480 cartridge tape drives
Data in demultiplexed (modified) SEG-Y format

Non-seismic data acquisition system (DAS) based on Hewlett-Packard 2117 F-series computer, 2 Mbyte memory and 290 Mbyte disk storage

Other Equipment

Reftek and Yaesu sonobuoy receivers

EG & G model 990 sidescan sonar with 1000 m of cable

Nichiyu Giken Kogyo model NTS-11AU heatflow probe

Geological & Geochemical

Australian Winch and Haulage deepsea winch with 10 000 metres of 18 mm wire rope and hydrographic winch with 4000 m of 6 mm wire rope

Coring and rock dredging systems (various) and vibracorer

Light hydrocarbon extractor and gas chromatographs for continuous DHD (direct hydrocarbon detection) in bottom water

Hydrocarbon gas analyses in sediments

Geochemical analysis equipment for environmental monitoring

15 metre A-frame with a 12.5 ton load capability, using a variety of winches, supporting towed arrays and future capability for large scale deep coring and drilling

APPENDIX 3
CREW LIST - SURVEY 118

Scientific Crew

Peter Hill	Cruise Leader
Doug Ramsay	Ship Manager
Ed Chudyk	Quality Control / Systems Expert
Richard Mleczko	Quality Control / Systems Expert
Martin Callaway	Electronics Technician
Claude Saroch	Electronics Technician
Ken Revill	Science Technician
Jim Bedford	Science Technician
Tiernan McNamara	Science Technician
Mark Alcock	Science Technician
Mark James	Mechanical Technician
Simon Milnes	Mechanical Technician
Richard Schuler	Mechanical Technician
David Sewter	Mechanical Technician
Andrew Hislop	Mechanical Technician
Stephanie Baldwin	PhD Student, University of Sydney

Crew of the *Rig Seismic*

Bob Hardinge	Master
Mike Gusterson	Chief Officer
Danny Watson	Second Officer
Brian Troke	Chief Engineer
Russ Heaton	Second Engineer
Ian McCullough	Electrician
Don Brown	Integrated Rating
Tiger Lyons	Integrated Rating
Mike Pitcher	Integrated Rating
John Fraser	Integrated Rating
Henk Dekker	Chief Steward / Cook
Barrie Moore	Cook
Steve Staveley	Steward
Ted Strange	Steward / IR

APPENDIX 4
EXPLORATION WELLS TIED DURING SURVEY 118

WELL	OPERATOR	DATE	TD (m)	OLDEST SEQUENCE	STATUS
LYNEDOCH 1	Shell	1973	3967	Jurassic (Plover Fm)	Minor gas in Early Cretaceous limestones, P&A
LONDONDERRY 1	BOC of Australia	1973	1145	Neocomian sandstone over Proterozoic rhyodacite	Dry, P&A
KULKA 1	Diamond Shamrock Oil Co.	1984	3998	Late Carboniferous	Oil shows in Jurassic sandstones and Carboniferous clastics, P&A
EVANS SHOAL 1	BHP Petroleum	1988	3712	Middle Jurassic (Plover Fm)	Gas in M. Jurassic sandstones, P&A
TUATARA 1	BHP Petroleum	1990	3875	Devonian (?Arafura Gp)	Dry, P&A
BELUGA 1	BHP Petroleum	1991	3100	?Jurassic	Gas shows, P&A
FISHBURN 1	BHP Petroleum	1992	2780	mid Permian	Shows, P&A

APPENDIX 5
WAY POINTS USED IN SURVEY 118

Line no.	Reference no. (pre-cruise)		Latitude (deg/min S)	Longitude (deg/min E)
118/0001	MA13N	SOL(end 116/1501)	10 26.401	129 33.038
		EOL	11 07.200	129 36.800
118/0002	MA12	SOL	11 00.000	129 59.700
		BELUGA	10 34.338	129 57.912
		EOL (Indo bord)	09 25.000	129 52.200
118/0301	MA10A	SOL	09 30.000	129 48.000
		EOL (ZOCA)	10 03.000	128 06.300
118/0401	MAX1	SOL(end 116/0902)	09 40.636	128 11.724
		EOL (Indo bord)	09 25.000	128 43.975
118/0501	MA05	SOL (Indo bord)	09 25.000	128 57.100
		EVANS SHOAL	10 04.805	129 31.993
		BELUGA	10 34.338	129 57.912
		EOL	11 04.250	130 23.800
118/0601	MA06	SOL	10 55.700	130 30.000
		EOL	09 42.600	129 50.400
118/0701	MA15	SOL	09 53.700	129 50.950
& 0702		LYNEDOCH	09 51.630	130 18.822
& 0703		TUATARA	09 44.000	131 51.675
		EOL	09 43.000	132 03.550
118/0801	MA10B	SOL	09 20.700	132 08.550
		EOL	09 30.000	129 48.000
118/0901	MA07	SOL (Indo bord)	09 25.000	129 30.000
& 0902		LYNEDOCH	09 51.630	130 18.822
		EOL	10 11.500	130 54.900
118/1001	MA11	SOL	10 17.400	130 19.800
		LYNEDOCH	09 51.630	130 18.822
		EOL(Indo bord)	09 23.700	130 17.700
118/1101	MA08	SOL (Indo bord)	09 22.300	130 26.500
& 1102		EOL	10 11.400	131 37.900
118/1201	MA17	SOL	10 12.400	131 32.400
		TUATARA	09 44.000	131 51.675
		EOL (Indo bord)	09 03.400	132 19.300

118/1301	MA18	SOL	09 20.200	132 05.350
		EOL(end 106/07P4)	09 29.780	132 37.973
118/1401	MAX2	SOL	09 28.800	132 37.200
		EOL	10 17.000	132 13.700
118/1501	MA14	SOL	10 06.000	132 37.750
		KULKA	10 03.684	132 32.755
		TUATARA	09 44.000	131 51.675
		EOL (Indo bord)	09 17.400	130 56.600
118/1601	MA09	SOL (Indo bord)	09 14.700	131 12.000
& 1602		BELUGA	10 34.338	129 57.912
& 1603		EOL	10 40.000	129 52.600
118/1701	MA16N	SOL(end 116/1601)	10 32.116	129 14.775
		EOL	10 59.914	128 30.673
118/1801	PSB	SOL	11 26.500	128 58.000
		FISHBURN	12 58.079	127 35.060
		EOL	13 31.000	127 05.000
118/1901	GRA	SOL	13 15.500	127 27.000
		EOL	12 47.500	124 52.000
118/2001	MAX3	SOL	12 57.076	125 44.971
		EOL(end 116/0702)	12 36.614	125 24.440
118/2101	LON	SOL(on 116/0702)	12 36.000	125 26.000
		LONDONDERRY	13 36.801	124 30.785

All co-ordinates WGS84.

Note: SOL and EOL are way points for navigation at the start and end of lines - they do not necessarily indicate the actual start and end points of seismic lines (see Appendix 6 for these data).

SURVEY 118 LINE SUMMARY

Line No.	Reference No. (pre-survey)	Date (start of line)	FGSP	LGSP	Start Time Julian ddd hhmm	End Time Julian ddd hhmm	Start Lat. S dd mm.mmm	Start Long. E ddd mm.mmm	End Lat. S dd mm.mmm	End Long. E ddd mm.mmm	Length (km)	Cumulative Length (km)
118/0001	MA13N	3/05/93	214	1858	122 2235	123 0727	10 24.472	129 32.862	11 08.666	129 36.940	82.2	82.2
118/0002	MA12	3/05/93	159	3793	123 1423	124 0954	11 01.361	129 59.800	09 23.576	129 52.084	181.7	263.9
118/0301	MA10A	5/05/93	160	4199	124 1618	125 1308	09 29.360	129 49.951	10 03.462	128 04.883	201.95	465.85
118/0401	MAX1	6/05/93	138	2136	125 1927	126 0652	09 41.622	128 09.684	09 26.526	129 01.490	99.9	565.75
118/0501	MA05	6/05/93	324	5124	126 1328	127 1520	09 27.028	128 58.876	11 05.396	130 24.803	240	805.75
118/0601	MA06	8/05/93	205	3452	127 2140	128 1431	10 58.653	130 31.602	09 41.273	129 49.678	162.35	968.1
118/0701	MA15	9/05/93	164	1600	128 1938	129 0325	09 53.807	129 49.460	09 50.815	130 28.649	71.8	1039.9
118/0702	MA15	9/05/93	2078	4370	129 0918	129 2240	09 51.067	130 25.607	09 45.946	131 28.026	114.6	1154.5
118/0703	MA15	10/05/93	5638	7033	130 0458	130 1309	09 46.036	131 25.960	09 42.870	132 05.030	69.75	1224.25
118/0801	MA10B	11/05/93	184	5480	130 1920	131 2345	09 20.571	132 10.437	09 30.123	129 46.000	264.8	1489.05
118/0901	MA07	12/05/93	169	2090	132 1049	132 2109	09 22.866	129 26.100	09 48.100	130 12.347	96.05	1585.1
118/0902	MA07	13/05/93	3280	5165	133 0337	133 1343	09 47.398	130 11.067	10 12.215	130 56.215	94.25	1679.35
118/1001	MA11	14/05/93	159	2297	133 2147	134 0907	10 19.872	130 19.839	09 22.251	130 17.646	106.9	1786.25
118/1101	MA08	15/05/93	153	1655	134 1510	135 0005	09 21.064	130 24.697	09 44.223	130 58.358	75.1	1861.35
118/1102	MA08	15/05/93	2778	4656	135 0603	135 1751	09 43.168	130 56.832	10 12.228	131 39.113	93.9	1955.25
118/1201	MA17	16/05/93	172	3490	135 2344	136 1858	10 16.587	131 29.557	09 02.174	132 20.136	165.9	2121.15
118/1301	MA18	17/05/93	151	1504	137 0355	137 1224	09 19.903	132 04.369	09 30.335	132 39.869	67.65	2188.8
118/1401	MAX2	18/05/93	166	2350	137 1641	138 0424	09 25.238	132 38.941	10 18.302	132 13.052	109.2	2298
118/1501	MA14	20/05/93	232	4871	140 0040	141 0149	10 11.300	132 49.191	09 16.591	130 54.924	231.95	2529.95
118/1601	MA09	21/05/93	194	1204	141 1016	141 1551	09 14.340	131 12.338	09 34.942	130 53.196	50.5	2580.45
118/1602	MA09	22/05/93	2285	2994	141 2041	142 0030	09 32.843	130 55.151	09 46.958	130 42.032	35.45	2615.9
118/1603	MA09	22/05/93	4184	7002	142 0647	142 2140	09 44.935	130 43.889	10 41.056	129 51.610	140.9	2756.8
118/1701	MA16N	23/05/93	187	2205	143 0502	143 1608	10 31.273	129 16.108	11 00.733	128 29.381	100.9	2857.7
118/1801	PSB	24/05/93	210	1100	144 0043	144 0600	11 25.155	128 59.214	11 43.772	128 42.400	44.5	2902.2
118/1802	PSB	24/05/93	2441	7883	144 1228	145 1703	11 42.271	128 43.751	13 32.113	127 03.985	272.1	3174.3
118/1901	GRA	26/05/93	268	4351	146 0702	147 0430	13 16.909	127 34.807	12 56.804	125 43.499	204.15	3378.45
118/2001	MAX3	27/05/93	160	1394	147 1301	147 1942	12 59.400	125 47.309	12 35.564	125 23.374	61.7	3440.15
118/2101	LON	28/05/93	272	3513	148 0002	148 1706	12 32.662	125 29.025	13 38.249	124 29.473	162.05	3602.2

APPENDIX 7
SEISMIC ACQUISITION PARAMETERS

Seismic Cable Configuration

Length (active section)	4800 m
Group length	25 m
No. channels	192
Towing depth	10 or12 m, depending on sea state

Seismic Source

Dual airgun array capacity	50 litres (3000 cu in)
Airgun pressure	1800-2000 psi (normal)
	1600 psi (minimum)
Shot interval	50 m (19.4 sec shot rate @ 5 knots)
Towing depth	10 m

Fold

4800 %

Recording Parameters

Record length	16 seconds
Sample interval	2 ms
Passband setting	8-128 Hz

APPENDIX 8

Seismic Acquisition Geometry

Survey:	**Malita**	**Survey No.**	**118**
Group Length: GL =	25 m	Date:	May 1993
No. of Active Channels: N =	192	Gun Length: SCE =	13.5 m
Active Length: AL = (GLxN) =	4800 m	Gun Chain Length: GC =	43 m
Stretch Length: SL =	150 m	Antenna to Stern: NS =	46 m

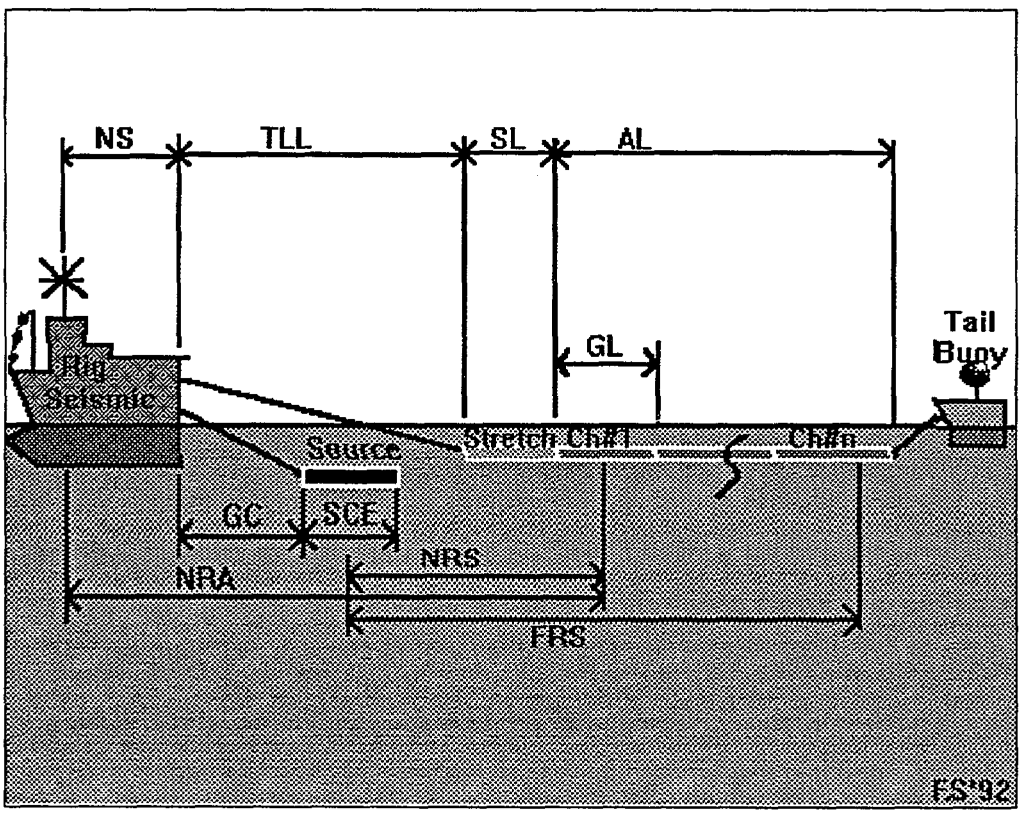
DT Birds located after Channels: 0,8,16,24,32,40,48,56,64,72,80,88,96,104,112,
120,128,136,144,152,160,168,176,184,192

Compass Birds located after channels: 36,84,132,180

Source Near Offset: NRS = TLL + SL + GL/2 - (GC + SCE/2) = TLL + 112.75 m

Source Far Offset: FRS = NRS + (N-1)GL = TLL + 4887.75 m

Field Tape Format: AGSO 16 BIT Floating Point SEG-Y, 3480 data cartridge



TTL (tow leader length) typically 90 m

Stretch section at end of active section = 50 m

Tail buoy rope = 50 m

SEISMIC STREAMER PARAMETERS & NOISE LEVELS

Line No.	Streamer Depth & SP Range	TLL (tow leader length) & SP Range	Tailbuoy Feather Angle (deg.) S/P	Mean RMS Noise (microbars)
118/0001	10m SP 102 to EOL	95m SP 102 to 385	3.5S to 7S	2
		90m SP 386 to 419		
		85m SP 420 to 480		
		80m SP 481 to 524		
		75m SP 525 to EOL		
118/0002	10m SP 101 to EOL	95m SP 101 to 478	4.5S to 7.5P	2.3
		100m SP 479 to 996		
		95m SP 997 to EOL		
118/0301	10m SP 103 to 379	95m SP 103 to 211	11S to 2P	2.2
	12m SP 380 to 1040	90m SP 212 to 2452		
		92.5m SP 2453 to 3597		
		85m SP 3598 to EOL		
118/0401	12m SP 102 to EOL	90m SP 102 to 601	7.5S to 1S	2.2
		95m SP 602 to EOL		
118/0501	10m SP 102 to EOL	95m SP 102 to EOL	11.5S to 6P	2.3
118/0601	10m SP 103 to EOL	95m SP 103 to 2643	8.5S to 0.5S	2.2
		90m SP 2644 to 2648		
		85m SP 2649 to 3178		
		90m SP 3179 to EOL		
118/0701	10m SP 102 to EOL	90m SP 102 to EOL	9S to 0.5S	2
118/0702	10m SP 2003 to EOL	90m SP 2003 to EOL	10S to 5P	2.1
118/0703	10m SP 5502 to 5723	90m SP 5502 to 5769	7S to 0.5S	2.3
	12m SP 5723 to EOL	80m SP 5770 to 6877		
		90m SP 6878 to EOL		
118/0801	12m SP 103 to EOL	90m SP 103 to 744	2S to 4P	1.9
		95m SP 745 to 2220		
		90m SP 2221 to EOL		
118/0901	10m SP 101 to EOL	90m SP 101 to EOL	4.5S to 0.5S	2
118/0902	10m SP 3202 to EOL	90m SP 3202 to 4663	5S to 2.5P	1.8
		85m SP 4664 to EOL		
118/1001	10m SP 102 to EOL	90m SP 102 to 1301	7S to 1.5P	1.9
		85m SP 1302 to EOL		
118/1101	10m SP 102 to 585	85m SP 102 to 199	8.5S to 6.5S	~3
	12m SP 586 to EOL	90m SP 200 to EOL		
118/1102	12m SP 2702 to EOL	95m SP 2702 to 2916	6.5S to 3.5S	~4
		90m SP 2917 to EOL		
118/1201	12m SP 102 to EOL	100m SP 102 to 803	2S to 8P	2
		90m SP 804 to 1511		
		95m SP 1512 to 2836		
		100m SP 2837 to EOL		
118/1301	12m SP 101 to EOL	90m SP 101 to 1354	3.5S to 2.5S	~3
		85m SP 1355 to EOL		
118/1401	10m SP 101 to EOL	95m SP 101 to 479	6S to 1P	2.3
		100m SP 480 to 572		
		105m SP 573 to EOL		

SEISMIC STREAMER PARAMETERS & NOISE LEVELS (cont.)

Line No.	Streamer Depth & SP Range	TLL (tow leader length) & SP Range	Tailbuoy Feather Angle (deg.) S/P	Mean RMS Noise (microbars)
118/1501	12m SP 102 to EOL	95m SP 102 to 199	5S to 2P	2.8
		100m SP 200 to 887		
		105m SP 888 to 2266		
		100m SP 2267 to 3436		
		105m SP 3437 to 4367		
		100m SP 4368 to EOL		
118/1601	10m SP 102 to EOL	90m SP 102 to EOL	5S to 0.5P	2.3
118/1602	10m SP 2203 to EOL	90m SP 102 to EOL	3.5S to 1S	2.4
118/1603	10m SP 4102 to EOL	90m SP 4102 to 4807	8S to 5.5P	2.3
		95m SP 4808 to 4826		
		100m SP 4827 to 5916		
		95m SP 5917 to 6710		
		90m SP 6711 to EOL		
118/1701	10m SP 102 to EOL	95m SP 102 to 1635	17S to 3P	2.2
		90m SP 1636 to EOL		
118/1801	10m SP 102 to EOL	90m SP 102 to EOL	15.5S to 0	2.2
118/1802	10m SP 2303 to EOL	90m SP 2303 to 5987	20S to 17.5P	2.1
		100m SP 5988 to 6846		
		95m SP 6847 to EOL		
118/1901	12m SP 103 to EOL	95m SP 103 to 343	5.5S to 6P	2
		90m SP 344 to 360		
		100m SP 361 to 661		
		105m SP 662 to 1078		
		100m SP 1079 to 1106		
		95m SP 1107 to 1299		
		90m SP 1300 to 1366		
		85m SP 1367 to 2064		
		90m SP 2065 to 2224		
		95m SP 2225 to 2274		
		100m SP 2275 to 2499		
		105m SP 2500 to 3699		
		100m SP 3700 to 3816		
		95m SP 3817 to EOL		
118/2001	12m SP 102 to EOL	95m SP 102 to EOL	2.5S to 10.5P	2.2
118/2101	12m SP 102 to EOL	95m SP 102 to 1372	3.5S to 3P	2.4
		90m SP 1373 to 2032		
		100m SP 2033 to 2783		
		95m SP 2784 to 2900		
		90m SP 2901 to EOL		

Note on Column 4
Maximum deviations in the tailbuoy feather angle (Starboard / Port in degrees) for each line were extracted from the Bridge log

APPENDIX 10

WATER DEPTHS AT START & END OF SEISMIC LINES

Line No.	FGSP	Water Depth (m)		LGSP	Water Depth (m)
118/0001	214	90		1858	36
118/0002	159	73		3793	484
118/0301	160	418		4199	76
118/0401	138	110		2136	474
118/0501	324	455		5124	32
118/0601	205	52		3452	345
118/0701	164	85		1600	232
118/0702	2078	234		4370	125
118/0703	5638	117		7033	118
118/0801	184	179		5480	420
118/0901	169	530		2090	267
118/0902	3280	273		5165	107
118/1001	159	110		2297	413
118/1101	153	408		1655	174
118/1102	2778	186		4656	90
118/1201	172	82		3490	209
118/1301	151	178		1504	136
118/1401	166	149		2350	73
118/1501	232	73		4871	351
118/1601	194	294		1204	254
118/1602	2285	268		2994	226
118/1603	4184	228		7002	36
118/1701	187	127		2205	60
118/1801	210	61		1100	64
118/1802	2441	63		7883	82
118/1901	268	69		4351	83
118/2001	160	74		1394	100
118/2101	272	109		3513	96

APPENDIX 11

SEISMIC TAPE LISTING

Line No.	FSP	FGSP	LGSP	LSP	First Tape	Last Tape
118/0001	102	214	1858	1920	118/001	118/028
118/0002	101	159	3793	3817	118/029	118/086
118/0301	103	160	4199	4260	118/087	118/150
118/0401	102	138	2136	2199	118/151	118/183
118/0501	102	324	5124	5162	118/184	118/261
118/0601	103	205	3452	3495	118/262	118/314
118/0701	102	164	1600	1600	118/315	118/338
118/0702	2003	2078	4370	4505	118/339	118/377
118/0703	5502	5638	7033	7089	118/378	118/402
118/0801	103	184	5480	5528	118/403	118/487
118/0901	101	169	2090	2183	118/488	118/520
118/0902	3202	3280	5165	5204	118/521	118/551
118/1001	102	159	2297	2342	118/552	118/586
118/1101	102	153	1655	1754	118/587	118/613
118/1102	2702	2778	4659	4699	118/614	118/644
118/1201	102	172	3490	3531	118/645	118/697
118/1301	101	151	1504	1530	118/698	118/719
118/1401	101	166	2350	2398	118/720	118/755
118/1501	102	232	4871	4923	118/756	118/830
118/1601	102	194	1204	1257	118/831	118/848
118/1602	2203	2285	2994	3171	118/849	118/863
118/1603	4102	4184	7002	7050	118/864	118/909
118/1701	102	187	2205	2255	118/910	118/943
118/1801	102	210	1100	1292	118/944	118/962
118/1802	2303	2441	7883	7931	118/963	118/1049
118/1901	103	268	4351	4397	118/1050	118/1116
118/2001	102	160	1394	1440	118/1117	118/1137
118/2101	102	272	3513	3601	118/1138	118/1191

APPENDIX 12

MAGNETIC DATA ACQUISITION DETAILS			
Start Time Julian ddd hhmm	End Time Julian ddd hhmm	Sensor Distance Astern (m)	Profile Length km (approx.)
123 2331	124 0640	250	66
124 0719	124 1115	250	36
124 1215	125 0054	250	117
125 0109	~125 0140	75	5
125 0152	125 0625	235	42
125 0657	125 0730	75	5
125 0746	126 0135	235	165
126 0146	127 0703	235	271
127 0720	127 0900	75	15
127 0909	127 1336	235	41
127 1358	127 1615	75	21
127 2212	128 0243	75	42
128 0635	129 0326	235	193
129 0800	132 0200	235	611
132 0910	138 0728	235	1300
140 0022	142 2053	235	634
142 2106	143 0411	135	65
143 0420	148 1707	135	1200
		Total	4829

APPENDIX 13
LOCATIONS OF GPS AERIALS AND ECHO-SOUNDER TRANSDUCERS

	Distance from stern (m)	Height above waterline (m)	Distance from centreline (m)
Racal #1 Trimble aerial	47	14.8	5.4 port
Racal #2 Trimble aerial	53.3	14.9	4.8 port
MX100 aerial - Instrument Room	46		
MX100 aerial - bridge	48		
3.5 kHz echo-sounder transducer (forward)	60	n/a	0.5 starboard
12 kHz echo-sounder transducer (HDR stem)	38.4	n/a	0

APPENDIX 14
NON-SEISMIC DATA ACQUISITION CHANNELS

The following is a list of channel allocations for the non-seismic data of Survey 118.

The main data set is saved on magnetic tape every minute in blocks of 128 x 6 floating point words. This represents 128 data channels of 6 records per block.

1	Survey and day number from DAS RTE computer clock	(sss.ddd)
2	Acquisition UTC from DAS RTE computer clock	(.hhmmss)
3	Acquisition UTC from master clock	(.hhmmss)
4	Latitude, best estimate	(radians)
5	Longitude, best estimate	(radians)
6	Speed, best estimate	(knots)
7	Course, best estimate	(degrees)
8	Magnetometer #1	(nT)
9	Magnetometer #2	(nT)
10	Depth from 12 kHz echo sounder	(metres)
11	Depth from 3.5 kHz echo sounder	(metres)
12	F/A Magnavox sonar doppler	(3920 counts/nm)
13	P/S Magnavox sonar doppler	(3920 counts/nm)
14	F/A Raytheon sonar doppler	(200 counts/nm)
15	P/S Raytheon sonar doppler	(200 counts/nm)
16	Paddlewheel log	
17	Not used	
18	Instrument Room Sperry gyro heading (synchro)	(degrees)
19	Instrument Room SG Brown gyro heading	(degrees)
20	Bridge Sperry gyro heading (stepper)	(degrees)
25	Racal dGPS #2 UTC time	(hhmmss)
26	Racal dGPS #2 latitude	(radians)
27	Racal dGPS #2 longitude	(radians)
28	Racal dGPS #2 height	(metres)
29	Racal dGPS #2 course	(degrees)
30	Racal dGPS #2 speed	(knots)
31	Racal dGPS #2 number of satellites	
32	Racal dGPS #2 PDOP	
33	Racal dGPS #2 HDOP	
34	Racal dGPS #2 3-D position error	(metres
35	Racal dGPS #2 2-D position error	(metres)
36	Racal dGPS #2 differential quality	(see Racal #1)
37	Racal dGPS #2 flag	(see below)
38	RACAL dGPS System #2 Time of record - Time of fix	
39	Not used	
40	MX100 uncertainty	(metres)
41	MX100 number of satellites	

42	MX100 time	(GMT seconds)
44	MX100 latitude	(radians)
45	MX100 longitude	(radians)
47	MX100 speed	(knots)
48	MX100 course	(degrees)
49	Not used	
50	MX100 GMT	(.hhmmss)
51	Latitude calculated from Magnavox s.d.	(radians)
52	Longitude calculated. from Magnavox s.d.	(radians)
53	Speed calculated from Magnavox s.d.	(knots)
54	Course calculated from Magnavox s.d.	(degrees)
55	Latitude calculated from Raytheon s.d.	(radians)
56	Longitude calculated from Raytheon s.d.	(radians)
57	Speed calculated from Raytheon s.d.	(knots)
58	Course calculated from Raytheon s.d.	(degrees)
59	Latitude calculated from spare log	(radians)
60	Longitude calculated from spare log	(radians)
61	Speed calculated from spare log	(knots)
62	Course calculated from spare log	(degrees)
63	Latitude calculated from radio nav	(radians)
64	Longitude calc. from radio nav	(radians)
65	Speed calculated from radio nav	(knots)
66	Course calculated from radio nav	(degrees)
79	Gravity	(mGal * 100)
80	ACX	(m/s/s * 10000)
81	ACY	(m/s/s * 10000)
82	Sea state	
83	Magnetic anomaly 1	(nT)
84	Magnetic anomaly 2	(nT)
85	Magnetic difference	(nT)
86	Shot time	(hhmmssd)
87	Shot point number	
88	Northerly set drift	(radians/10 secs)
89	Easterly set/drift	(radians/10 secs)
94	Time from tail buoy	(seconds)
95	Latitude of tail buoy	(radians)
96	Longitude of tail buoy	(radians)
97	Delta latitude of tail buoy	(n. miles)
98	Delta longitude of tail buoy	(n. miles)
99	Feather angle of tail buoy	(degrees)
100	Distance on tail buoy	(n miles)
110	Racal #1 dGPS UTC time	(hhmmss)
111	Racal #1 dGPS latitude	(radians)
112	Racal #1 dGPS longitude	(radians)
113	Racal #1 dGPS height	(metres)
114	Racal #1 dGPS course	(degrees)

115	Racal #1 dGPS speed	(knots)
116	Racal #1 dGPS number of satellites	
117	Racal #1 dGPS PDOP	
118	Racal #1 dGPS HDOP	
119	Racal #1 dGPS 3-D position error	(metres)
120	Racal #1 dGPS 2-D position error	(metres)
121	Racal #1 dGPS differential quality	(see below)
122	Racal #1 dGPS flag	(see below)
123	Racal dGPS #1 Time of record - time of fix	

Racal dGPS "flag" is a 5 digit number n1,n2,n3,n4,n5, as follows;

n1: Operating Mode	0 = no solution
	1 = 4 SV
	2 = 3 SV + altitude aiding
	3 = 3 SV + clock aiding
	4 = 2 SV + altitude aiding + clock aiding
	5 = all-in-view
n2: Receiver Code	7 = C/A, L1 only, carrier aided
n3: Receiver Dynamics	0 = static, 1...9 represents low...high
n4: Position Quality	0...9 represents bad...good
n5: Differential Quality	0 = no corrections, 1..9 represents bad...good

MARINE GRAVITY TIE DATA BOOKING SHEET

							GMT diff(hrs)	wharf ht (ASL)	
	PRE SURVEY 118	30-Apr-93		Julian day	120		9.5	5.60	m
	area	observer(s)	port	scale factor		meter	load line	meter to wharf ht	7.10
	MALITA GRABEN	T.MCNAMARA	DARWIN	0.10125		WORDEN	4.50	m	
	station	isogal number	time	reading	wharf ht (ASL)	station value	time GMT	ships gr value	remarks
A	WHARF		14:11	789.7	5.50	micrometers/sec²	04:41	-2038.84	
B			14:30	806.2					
C	DARWIN DA		14:35	798.0		9783032.8			
A	WHARF		14:42	789.5	5.60		05:12	-2038.78	
B			14:50	806.3					
C	DARWIN DA		14:55	798.4		9783032.8			
A	WHARF		15:04	789.1	5.70		05:34	-2038.71	
B			15:16	805.7				ships	ave value @
C	DARWIN DA					9783032.8		120	05:10:00
A	WHARF								-2038.78

GRAVITY TIE CALCULATIONS

ISOGAL STATION #	0.0000	A-B=	-16.63 meter units	-1.684	mgals
		B-C=	8.05 meter units	0.815	mgals
		A-C=	-8.60 meter units	-0.871	mgals

Type of Tie	ABCABCAB	Av. Grav. Interval(meter units)	-8.60 m.div.
Average time of tie(local):	14:40:00	(difference between Isogal and wharf)	
Survey time(GMT):	05:10:00	Ave Gravity Interval(mgals)	-0.871 mgals
		Observed Gravity meter(wharf)	978302.41 mgals
		B.C. for S.L. to wharf ht.	
		(using Bouguer correction)	0.235 mgals
		Gravity value at S.L.	978302.64 mgals
		(wharf height)	
F.A.C. from meter to wharf height	2.191		
B.C. from meter to wharf height		meter value at S.L.(wharf height)	-2040.670 mgals
(Bouguer correction)	0.297	meter zero:	980343.31 mgals

APPENDIX 15
GRAVITY TIE DATA, PRE SURVEY 118

APPENDIX 16
GRAVITY TIE DATA, POST SURVEY 118

MARINE GRAVITY TIE DATA BOOKING SHEET

							GMT diff(hrs)	wharf ht (ASL)	
	POST SURVEY 118	31-May-93		Julian day	151		9.5	4.85	m
	area	observer(s)	port	scale factor		meter	load line	meter to wharf ht	6.15
	MALITA GRABEN	T.MCNAMARA	DARWIN	0.10125		WORDEN	4.30	m	
	station	isogal number	time	reading	wharf ht (ASL)	station value	time GMT	ships gr value	remarks
A	WHARF		12:25	820.0	5.00	micrometers/sec^2	02:55	-2038.73	
B	PEARL MUSEUM		12:35	834.7					
C	DARWIN DA		12:41	830.7		9783032.8			
A	WHARF		12:51	821.7	4.90		03:21	-2038.75	
B	PEARL MUSEUM		13:00	835.5					
C	DARWIN DA		13:06	831.0		9783032.8			
A	WHARF		13:20	822.4	4.80		03:50	-2038.74	
B	PEARL MUSEUM		13:28	836.1				ships	ave value @
C	DARWIN DA		13:35	831.2		9783032.8		151	03:35:00
A	WHARF		13:43	822.7	4.70		04:13	-2038.74	**-2038.74**

GRAVITY TIE CALCULATIONS

ISOGAL STATION #	0.0000	A-B=	-14.07	meter units	-1.424 mgals
		B-C=	4.47	meter units	0.452 mgals
		A-C=	-9.60	meter units	-0.972 mgals

Type of Tie	ABCABCABCA	Av. Grav. Interval(meter units)	-9.60 m.div.
Average time of tie(local):	13:05:00	(difference between Isogal and wharf)	
Survey time(GMT):	03:35:00	Ave Gravity Interval(mgals)	-0.972 mgals
		Observed Gravity meter(wharf)	978302.31 mgals
		B.C. for S.L. to wharf ht.	
		(using Bouguer correction)	0.203 mgals
		Gravity value at S.L.	978302.51 mgals
		(wharf height)	
F.A.C. from meter to wharf height	1.898		
B.C. from meter to wharf height		meter value at S.L.(wharf height)	-2040.380 mgals
(Bouguer correction)	0.258	meter zero:	980342.89 mgals

APPENDIX 17
MAGNETOMETER CABLE LENGTH

i) Cable length details:

Circumference of drum	1.45 metres
Circumference of 1st layer	1.56 metres
∴ length per wrap on drum	1.50 metres
33 wraps on 1st layer	49.5 metres

Assuming length per wrap increases by 0.1 metres per layer -

32 wraps at 1.6 metres on 2nd layer	51.2 metres
32 wraps at 1.7 metres on 3rd layer	54.4 metres
32 wraps at 1.8 metres on 4th layer	57.6 metres
32 wraps at 1.9 metres on 5th layer	60.8 metres
5 wraps at 2.0 metres on 6th layer	10.0 metres

∴ total length of cable on drum, with magnetometer head dangling from pulley at end of magnetometer boom, is 283.5 metres.

Leaving 12 wraps of cable @ 1.5 metres each on drum for safety:-

Length of cable out = (283.5 - 18) ≈ **265 metres.**

ii) Length of cable deployed:

From stern	Wraps on drum	
265 metres	12 on drum	**
250 metres	22 on drum	
235 metres	All 1st layer	
200 metres	21 on 2nd layer	
150 metres	19 on 3rd layer	
100 metres	15 on 4th layer	
75 metres	29 on 4th layer	***
71 metres	All 4th layer	

** Probable maximum cable out - 12 wraps on drum for safety

*** Probable minimum cable out - leaves magnetometer head 15 metres behind end of gun array; otherwise bring head right in to pulley, preferably when guns not firing.

- Assumes cable laid evenly on drum with no gaps.
- Should end up with 5 wraps on 6th layer, when magnetometer head is dangling from pulley at end of boom.

Scale 1:500 000

WORLD GEODETIC SYSTEM 1972
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

Symbols on tracks are at half-hourly intervals.
Annotation is at hourly intervals - with survey number (118), Julian day and UTC time.

AGSO SURVEY 118

KILOMETRES
NAUTICAL MILES

Survey 118 navigation based on WGS84 datum

Enclosure 1
SURVEY 118 TIME-ANNOTATED SHIP'S TRACKS:
MALITA - WESTERN GOULBURN GRABEN AREA

AGSO Record 1993/47

Scale 1:500 000

WORLD GEODETIC SYSTEM 1972
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

Symbols on tracks are at half-hourly intervals.
Annotation is at hourly intervals - with survey number (118), Julian day and UTC time.

AGSO SURVEY 118

Survey 118 navigation based on WGS84 datum

Enclosure 2
SURVEY 118 TIME-ANNOTATED SHIP'S TRACKS:
NE BROWSE BASIN - PETREL SUB-BASIN AREA

KILOMETRES
NAUTICAL MILES

R9304704

AGSO Record 1993/47

AGSO SURVEY 118 "MALITA"

Survey 118 navigation based on WGS84 datum
Well locations from AGSO PEDIN data base

AGSO Record 1993/47

AGSO SURVEY 118 "MALITA"

Survey 118 navigation based on WGS84 datum
Well locations from AGSO PEDIN data base