Deep structure of the joint development zone and adjacent areas, Timor Sea: Survey 116 Post-cruise report

by
H I M Struckmeyer, C J Pigram, H Prasetyo and Survey 116 Shipboard Party

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DEEP STRUCTURE OF THE JOINT DEVELOPMENT ZONE AND ADJACENT AREAS, TIMOR SEA:

SURVEY 116 POST-CRUISE REPORT

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TABLE OF CONTENTS

Page

APPENDICES

FIGURES

EXECUTIVE SUMMARY

The primary objective of AGSO Survey 116 was the acquisition of high-quality deep seismic data and other geophysical data over the Indonesian - Australian Joint Development Zone (JDZ) and adjacent areas of the Timor Sea. The cruise was part of a program being undertaken by AGSO, to determine the structural architecture of the north western margin of Australia and the influence of structuring on the location, migration and trapping of hydrocarbons in the region.

The survey vessel R.V. *Rig Seismic* left Darwin on 22 January 1993 but returned to port on 30 January due to equipment problems and poor weather conditions. The ship again departed Darwin on 3 February and began seismic acquisition on 5 February. The survey was completed on 7 March and finished in Darwin on 8 March.

During the survey, 16 seismic lines were completed for a total of 3595 km at an average of 119 km per day. All of the proposed Timor Sea Tie lines were completed, however lines across Zone of Cooperation C of the JDZ and the Timor Trough in Indonesian waters were not collected because an agreement between AGSO and Indonesian authorities had not been finalised. In addition to the proposed program, the survey included 5 lines of the Malita Graben program, totalling 1028 km. These N-S lines were shot when marginal weather conditions prevented seismic acquisition in an E-W direction. The Timor Sea Tie lines were tied to 17 exploration wells.

Acquisition within the Joint Development Zone was undertaken on behalf of NOPEC, who have been authorised by the Joint Development Authority to research this area. All seismic lines were collected to specifications agreed upon by NOPEC and AGSO.

The seismic data were recorded from a 4800 m streamer, configured with 192 x 25 m active groups. The record length was 16 seconds, and the sample interval 2 ms. The seismic source consisted of dual sleeve gun arrays with a capacity of 50 litres. Navigation for the survey was provided by differential Global Positioning System (dGPS), using shore reference stations Darwin and Broome.

The seismic acquisition system was inoperable during the first week at sea during which time weather conditions also prevented acquisition. After repairs to the system, both the seismic and non-seismic acquisition systems ran without major problems. Navigational data were of good quality, with differential GPS being available at least 95% of the survey time.

INTRODUCTION

The Australian Geological Survey Organisation (AGSO) conducted a deep crustal seismic survey, AGSO Survey 116, in the Joint Development Zone (JDZ) and adjacent areas (Figure 1) in January to March 1993. The survey was the acquisition phase of Project 121.36 'Deep structure of the Joint Development Zone and adjacent areas, Timor Sea' (Pigram, 1992b). The research vessel *Rig Seismic* (Appendices 1 and 2) left Darwin on 22 January 1993, but returned to port on 30 January due to equipment problems and poor weather conditions. The ship again departed Darwin on 3 February and began seismic acquisition on 5 February. The survey was completed on 7 March and finished in Darwin on 8 March. The shipboard personnel (Appendix 3) comprised 16 AGSO scientists and technicians, 14 Australian Maritime Safety Authority (AMSA) crew, a representative from NOPEC and a representative from the Marine Geological Institute of Indonesia (MGI).

The major objectives of the cruise were:

- to 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;
- to provide modern regional seismic tie lines through key wells in the region to facilitate province-wide correlations;
- to determine the deep crustal structure of the Sahul Syncline, Sahul Platform, Timor Trough and Malita Graben;
- to examine the effects of the deep crustal structure and their various phases of reactivation on the structural development of the region.

The cruise gathered 3595 km of data on 16 lines in the Timor Sea region, tied to Surveys 98 and 100 and, when combined with Line 100/5, provides a near complete margin transect from near the Timor Trough, across the Sahul Platform to the south eastern part of the Petrel Sub-basin. The data comprise 16 second record-length, 48-fold seismic (shot using a 4800 m streamer and 50 litre dual airgun array), bathymetry, gravity and magnetics.

Background to project and seismic program

The Marine Geoscience and Petroleum Geology Program (MGPG) of AGSO began a program of deep seismic acquisition along the north western margin of Australia in 1990, with the intention of acquiring a complete, consistent regional data set covering the region from North West Cape to the western Arafura Sea by 1993/94. This portion of the Australian margin was seen to be the most prospective region outside of the Bass Strait Basins and to be a likely major 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 (e.g. Lister et al., 1991) or modern collisional tectonic concepts (e.g. Beaumont, 1980; Allen and Homewood, 1986) for the deformation of parts of this margin.

The MGPG program on the north west 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. To address the margin structural framework problems of this region, the following cruises have been undertaken or are planned:

1. Vulcan Graben (Survey 98) - 1900 km of deep seismic data - acquisition completed December 1990 (O'Brien and Williamson, 1990).

2. Petrel Sub-basin (Survey 100) - 2090 km of deep seismic data - acquisition completed May 1991 (Willcox & Ramsay, 1991).

3. North Carnarvon Basin I (Survey 101) - 1654 km of km of deep seismic data - acquisition completed June 1991 (Stagg & others, 1991).

4. North Carnarvon Basin II (Survey 110) - 2868 km of deep seismic data - acquisition completed July 1992 (Stagg 1992).

5. Australian - Indonesian Joint Development Zone and adjacent areas (this survey) - 3595 km of deep seismic data - acquisition completed March 1993.

6. Malita Graben (Survey 118) - 3602 km of deep seismic data - acquisition completed May 1993 (Hill & others, 1993).

7. Browse Basin (Survey 119) - 3460 km of deep seismic data - acquisition completed July 1993.

8. Offshore Canning (Survey 120) - 4052 km of deep seismic data - acquisition completed August 1993 (Stagg & others, 1993).

9. Scott Plateau-Roti Basin - 2500 km proposed - acquisition during late 1993.

On completion of this program of data acquisition there will be a network of over 20000 km of deep crustal seismic data linking all the major structural elements of the north western margin. The regional grid of deep seismic data in the Timor Sea area collected to date is shown in Figure 2.

Other deep crustal surveys (BIRPS)

In early 1992, the British Institutions Reflection Profiling Syndicate (BIRPS) in conjunction with the Marine Geoscience Institute of Indonesia (MGI) conducted a deep crustal survey (+20 sec records) across the Banda Arc to the east of Timor (Figure 3). These lines finished on the outer shelf just within Australian waters but will be extended across the shelf by AGSO during the proposed East Malita cruise.

EXPLORATION HISTORY

Exploration activity in the region began in the early 1960's when two consortia headed by Woodside and by ARCO won concessions covering most of the offshore Bonaparte and Browse Basins. Seismic acquisition began in 1964 and the first exploration well (Petrel -1) was drilled by ARCO in 1970 resulting in the discovery of the Petrel Gas Field. Gull -1 was also drilled in 1970 to test a large salt induced feature. It was plugged and abandoned after encountering minor hydrocarbons at several levels. Flamingo -1, which was the only well in Zone of Co-operation A (ZOCA), was drilled in 1971 to test a horst structure on the flank of the Sahul Syncline. The well is interpreted to have intersected a net 57 m thick gas accumulation in sandstones of Late Jurassic Flamingo Group and live oil from the middle Jurassic Plover Formation (Botten and Wulf 1990). The well is now thought to have been off structure. The well was plugged and abandoned as being non-commercial. When exploration ceased in the region, approximately 20 000 km of seismic data had been obtained.

With the Timor Gap not available to exploration during the late 1970's and 1980's, considerable exploration activity occurred to the west in and around the Vulcan Graben leading to the discovery of several commercial fields.

With the completion of an agreement between the Australian and Indonesian Governments to form a Zone of Cooperation, the Timor Gap was reopened for exploration for the first time since the late 1970's. Three zones with differing administrative control were established. The central area A is jointly administered by

Australia and Indonesia under the control of a Joint Authority, the northern area C is under Indonesian control, and the southern area B is under Australian control. ZOCA of the Joint Development Zone (JDZ) is currently the site of considerable exploration activity. In the 14 permit areas already leased, exploration companies have committed to an intensive program of almost 500 000 km of seismic data and a minimum of 41 wells over the next 6 years. In recent months, 3 wells (Hydra-1, Basilisk-1A, Naga-1) were drilled in ZOCA by Marathon Petroleum, all of which were dry with some oil shows in Basilisk and Naga.

REGIONAL STRUCTURE

The JDZ and adjacent areas region lies within that part of the north western margin of Australia that now forms the foreland to the Timor collision zone. Major structural elements include the Timor Trough, Sahul Platform, Sahul Syncline, Malita Graben and Darwin Shelf (Figure 4). The Timor Trough generally trends NE adjacent to Timor, but changes to a ENE trend at the eastern end of Timor adjacent to the Sunrise and Troubadour region. This marked change in trend suggests an underlying structural control inherited from the structuring associated with the formation of the margin. The Sahul Platform is a region of elevated Mesozoic and Palaeozoic sediments. To the SW the platform is cut by the NW-SE trending Sahul Syncline which separates the region from the Vulcan Sub-basin and Londonderry High of the southern Timor Sea region. The Malita Graben is an ENE-WSW trending depositional trough bounded by the Sahul Platform to the North and the Petrel Sub-basin and Darwin Shelf to the South. On its northern end, the graben swings around to a more NE trend and is referred to as the Calder Graben in this area.

Major structuring in the region culminated in the late Permian to Triassic to form the gross architecture of the margin. Many, if not all, of the structures which formed at this time have since been reactivated on several occasions during the Mesozoic and Cainozoic.

STRATIGRAPHY

The stratigraphy of the region is poorly known due to the sparsity of wells, and the nomenclature used is usually that of the Bonaparte Basin. A summary of the stratigraphy of the region is shown in Figure 5. The thickness and age of sedimentary packages varies with structural provinces. The Darwin Shelf has a thin cover of Late Carboniferous 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 as indicated by Troubadour - 1 which intersected Permian sediments at 3000 m. The Malita Graben has only been drilled at Heron - 1, which bottomed in mid-Jurassic sediments. Similarly, Flamingo - 1 on the eastern flank of the Sahul Syncline intersected more than 3500 m of Mesozoic to Cainozoic sediments and bottomed in mid-Jurassic sediments.

The major sediment packages encountered during drilling in the region comprise the Permian Kinmore Group, which consists of mostly fine-grained siliciclastics with minor sandstone and carbonate and which is conformably overlain by the Triassic to Jurassic sand-dominated Troughton Group. The Jurassic Flamingo Group comprises interbedded sandstone and shale, unconformably overlain by the Cretaceous Bathurst Island Formation, which consists mainly of marl, mudstone and limestone with minor sandstone. The Cainozoic section comprises carbonate and siliciclastic sediments.

Major potential reservoirs in the region are Late Jurassic/Cretaceous sandstones of the Flamingo Group, although Botten and Wulf (1990) list a total of 8 sandstone horizons, ranging from Triassic to Eocene in age, as potential reservoirs. The major regional seal in the Timor Sea region is the Cretaceous Bathurst Island Formation. Potential source rock intervals are known from the Early to Middle Jurassic Plover Formation, the Flamingo Group and the basal Bathurst Island Group. Regionally, the Plover Formation is known to contain good source rock beds that are currently mature.

SURVEY PARAMETERS AND ACQUISITION DETAILS

Data acquired

Data collected on Survey 116 comprise

- Deep seismic reflection data, 48 fold (shots fired every 50 m at a ship speed of 4.5 - 5.0 knots), 16 second record length 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 seismic and transit lines.
- Magnetic data on approximately 95% of seismic lines and transit lines.
- Bathymetry on all lines.

Way points used for navigation during Survey 116 are given in Appendix 4 and acquisition details are listed in Appendices 5 and 6. Acquisition in ZOCA was undertaken on behalf of NOPEC All seismic lines were collected to specifications agreed upon by NOPEC and AGSO prior to the cruise. Excerpts from the draft specifications are given in Appendix 7.

Execution of seismic program

The seismic acquisition program was executed as planned (Pigram, 1992b), except for the following additions and changes:

- Proposed lines across ZOCC and the Timor Trough in Indonesian waters were not collected because agreement between AGSO and Indonesia had not been finalised.
- Lines TST07/NOP07 (116/0701-0702) and TST08/NOP08 (116/0803-0804) were extended westwards by 170 km to tie AGSO line 98/01 and the Challis field.
- The heading of line TST04/NOP04 (116/0401-0403) was changed to firstly, tie Basilisk-1A well and secondly, to run between BHP-ASB Survey lines 203 and 205.
- Line TST10/NOP10 (116/1001) was extended to NE to tie line 116/0201.
- Line TST09/NOP09 (116/0901-0902) was extended to NE across Zone A to tie lines 116/0403, 116/0501, and line 116/0602 at the location of Troubadour-1.
- In addition, five lines of the proposed Malita Graben program, totalling 1028 km, were completed.

Cruise Narrative

The JDZ and adjacent areas cruise (AGSO Survey 116) commenced in Darwin on January 22 and finished in Darwin on March 8, 1993. Cable deployment commenced on January 23 in the survey area and was completed on January 26, but as a result of adverse weather conditions and failure of the Phoenix/amplifier system it was decided to return to port. Had the system been operating, data collection would have been impossible due to the weather, which was constantly at force 6 or 7. The vessel returned to Darwin on January 30 and remained in port until February 3, during which time the Phoenix/amplifier system was repaired. The ship again departed Darwin on February 3, cable deployment began on February 4 and seismic acquisition on line 116/0601 commenced on February 5. Data acquisition on lines across the JDZ continued with only minor interruptions for bird replacements on the cable and recording problems due to a faulty batch of tapes until February 21, when weather

conditions again deteriorated and cable noise levels on east-west lines became unacceptable. It was therefore decided to shoot north-south lines of the proposed adjacent Malita Graben program (Pigram, 1992a), which was to follow Survey 116. Acquisition on the Malita Survey line Ma01 (116/1101) commenced on February 22, followed by 116/1201-1401 (Ma02-Ma04). When the weather improved, acquisition on line 116/1501 (Ma13) was stopped and the ship returned to the JDZ while shooting the eastern part of Ma16 (116/1601). The remaining lines of the JDZ survey were completed on March 6. Two gravity cores were recovered from a site in ZOCB on March 7, and the ship returned to Darwin on March 8.

The following is a summary of the main events during Survey 116; dates indicated are local, i.e. Central Australian Time.

22 January: sailed from Darwin; cruise briefing and safety meeting.

23 January: deployed GPS-equipped tailbuoy and began to deploy 1200 m streamer.

24 January: Phoenix - *mux* cards shorted and fused.

25 January: deployed 3600 m streamer and attached 1200 m section.

26 January: commenced testing and fine-tuning of amplifiers after attempted repair of Phoenix/amplifier system.

27 January: lost signal from tailbuoy; retrieved cable; tailbuoy overturned but undamaged.

28 January: delayed deployment of streamer due to deterioration of weather conditions; continued problems with Phoenix/amplifier system.

29 January: further deterioration in weather, ship in area between two cyclones; it was decided to return to port.

30 January: docked in Darwin; arrival of 2 AGSO engineers who commenced repair work on Phoenix/amplifier system.

31 January to 2 February: forecasts indicate no change in weather conditions; Phoenix repaired, fine-tuning and testing of amplifiers.

3 February: sailed from Darwin; start-of-survey tests commenced.

4 February: streamer deployment and testing completed.

5 February: SOL 116/0601; 2 compressors down, guns turned off, commenced loop; SOL 116/0602.

6 February: EOL 116/0602; recovered cable after failure of 2 birds; cable redeployed; SOL 116/0501.

7 February: EOL 116/0501; line change for dog-leg; SOL 116/0502; period of marginal navigation (16 minutes; 8 m difference); cable at 11 m to minimise swell noise (5-10 μBars); ship experiencing strong head currents, possibly due to peak spring tides - at times ship speed down to 3.4 kts.

8 February: EOL 116/0502; lost transmission from tailbuoy; retrieved cable; tailbuoy serviced (recovery rope & antenna).

9 February: cable redeployed; SOL 116/0301;

10 February: EOL 116/0301; SOL 116/0401; passed Atwood Falcon on Basilisk-1A, 1.5 nm to E; EOL 116/0401; line change for dog-leg.

11 February: SOL 116/0402; EOL 116/0402; line change for dog-leg; SOL 116/0403; EOL 116/0403.

12 February: SOL 116/0201; from SP 715 ship off line to avoid shallow water; cartridge tape jammed in tape drive, LCSP 1598; it was decided to re-shoot last section of 116/0201 when looping for dog-leg on line 116/09; line change for dog-leg.

13 February: SOL 116/0202, EOL 116/0202; SOL 116/0203, EOL 116/0203.

14 February: SOL 116/0101; cartridge tape jammed in tape drive; acquisition suspended for loop; SOL 116/0102.

15 February: EOL 116/0102; SOL 116/0103, EOL 116/0103; during transit to line 116/10 replacement of birds 7 and 18 (using 'ZODIAC'), and birds 1 and 2 (by recovering front cable section); SOL 116/1001.

16 February: EOL 116/1001; SOL 116/0901.

17 February: EOL 116/0901; transit to pick up re-shoot on line 116/0201; SOL and EOL 116/0204 (charged against 116/0201); SOL 116/0902.

18 February: EOL 116/0902.

19 February: SOL 116/0801; deteriorating weather conditions - acquisition stopped due to unacceptable streamer noise levels.

20 February: SOL 116/0802.

21 February: acquisition stopped on 116/0802 due to weather conditions; cable noise levels out of spec when shooting in E/W direction; transit to N/S line 116/11 (Ma01).

22 February: SOL 116/1101, EOL 116/1101.

23 February: during transit recovered streamer and replaced all bird batteries; cable redeployed; SOL 116/1201; winds of up to 40 kts with spring tides.

24 February: EOL 116/1201.

25 February: SOL 116/1301; supply of spare Hoke-valve seal kits for 'Christmas trees' running short; arrangements made for helicopter delivery of spares.

26 February: EOL 116/1301; headed South to rendezvous with helicopter; delivery made but it did not include valve spares; second delivery more successful; SOL 116/1401.

27 February: EOL 116/1401.

28 February: SOL/1501; slight course deviation to avoid shoal at Evans Shoal-1; improved weather conditions - stopped acquisition at tie point with 116/16 to head back towards JDZ via 116/16; SOL 116/1601; gun failure at SP 1544 - rather than loop and complete line 1601, it was decided to leave the line and service the guns while transiting back to the JDZ to complete the high priority lines.

1 March: SOL 116/0701.

2 March: EOL 116/0701; line change for gun maintenance; SOL 116/0702.

3 March: EOL 116/0702.

4 March: SOL 116/0803, shot in opposite direction to original line heading; passed Challis production facility; EOL 116/0803; line change for gun maintenance.

5 March: SOL 116/0804, EOL 116/0804; line change for dog-leg.

6 March: SOL 116/0805, EOL 116/0805; this segment is a re-shoot of the previous lines 116/0801 and 116/0802; transit to coring site.

7 March: recovered two gravity cores; location: 127°56.75'E/11°44'S (Core 116/GC/001 - recovery of 3.17 m, Core 116/GC/002 - recovery of 4.4m); headed for Darwin.

8 March: arrived in Darwin.

Seismic Data Recorded

A total of 16 seismic lines were shot in the JDZ and adjacent areas (Figure 6); 6 of these were shot in the Malita Graben Survey area in addition to the proposed program. The lines were tied to 17 exploration wells (Figure 7, Appendix 8). Total seismic production was 3594.75 line-km, excluding lines which were re-shot. Seismic line information is summarised in Appendix 9 and a list of tape numbers for each seismic line is given in Appendix 10.

Line 116/01: Sahul Syncline strike line. Ties to lines 98/5, 100/06, 116/07, 116/08, 116/09, 116/10, and to Kite-1 and Cleia-1. The line was shot in 3 segments.

Line 116/02: Dip line within ZOCA across western Sahul Platform and western end of Malita Graben into Sahul Syncline. Ties to lines 100/06, 116/07, 116/08, 116/09, 116/10, and to Harbinger-1, Shalimar-1 and Flamingo-1. The line was shot in 4 segments.

Line 116/03: Dip line within ZOCB across western Malita Graben and tie line to Survey 100. Ties lines 100/07, 116/07 and 116/08. No wells were tied. The line was shot in 1 segment.

Line 116/04: Dip line within ZOCA and ZOCB across the Sahul Platform to the northern flank of the Malita Graben. Extends line 100/05 and ties to lines 116/08, 116/09, and to Basilisk-1A. The line was shot in 3 segments.

Line 116/05: Dip line within ZOCA and ZOCB across the Sahul Platform and the Malita Graben. Ties to lines 100/04, 116/07, 116/08, 116/09, and to Curlew-1 and Jacaranda-1. The line was shot in 2 segments.

Line 116/06: Dip line across the Sahul Platform and the Malita Graben. Ties to lines 116/07, 116/08, 116/09, 116/11, BIRPS-T and to Shearwater-1 and Troubadour-1. The line was shot in 2 segments.

Line 116/07: Strike line across ZOCB along the central Malita Graben. Ties to lines 98/1, 100/05, 100/06, 116/01, 116/02, 116/03, 116/05, 116/06, 116/11, and to Kite-1. The line was shot in 2 segments.

Line 116/08: Strike line across ZOCB along the northern flank of the Malita Graben. Ties to lines 98/1, 98/3, 98/4, 100/05, 100/06, 100/200, 116/01, 116/02, 116/03, 116/04, 116/05, 116/06, 116/11, BIRPS-T and to Challis-11, Halcyon-1 and Shearwater-1. The line was shot in 3 segments.

Line 116/09: Dip line across Sahul Syncline and strike line across Sahul Platform within ZOCA. The line extends Survey 98. Ties to lines 98/4, 100/06, 116/01, 116/02, 116/04, 116/05, 116/06, 116/12, and to Avocet-1A, Flamingo-1 and Troubadour-1. The line was shot in 2 segments.

Line 116/10: Dip line across the Sahul Syncline into ZOCB. The line extends Survey 98. Ties to lines 98/9, 100/06, 116/01, 116/02. No wells were tied. The line was shot in 1 segment.

Lines 116/11 to 116/16 are lines of the proposed Malita Graben program which were shot on Survey 116 in addition to lines 116/01 to 116/10.

Line 116/11: Dip line from the southern Sahul Platform across the Malita Graben. Ties to lines 100/04, 116/06, 116/07, 116/08, and to Shearwater-1.

Line 116/12: Dip line from the northern edge of the Sahul Platform across the Malita Graben onto the Darwin Shelf. Ties to lines 100/04, 116/09, and to Sunrise-1.

Line 116/13: Dip line across the Sahul Platform and Malita Graben. Ties to Heron-1.

Line 116/14: Dip line across the Sahul Platform and Malita Graben. Ties to line 116/16.

Line 116/15: northern part of proposed dip line Ma13 across the north eastern edge of the Sahul Platform, and the Malita Graben. Ties to line 116/16, and to Evans Shoal-1.

Line 116/16: eastern part of proposed line Ma16, a strike line along the southern flank of the Malita Graben. Ties to lines 116/15 and 116/14.

SUMMARY OF EQUIPMENT AND SYSTEMS REPORTS

(condensed and edited version of AGSO internal reports by
H. Miller & L. Kalinisan, L. Miller & M. Callaway, and S. Milnes)

Navigation/Geophysical (non-seismic) Data Acquisition System (DAS)

The DAS ran for the duration of the cruise with only one break in data acquisition when 43 minutes of data were lost (039.000500 to 039.004750). The concurrent seismic data were not re-shot as navigation was good at the time and as differential GPS data are recorded independently on optical disk.

Navigation

Differential GPS coverage was available at all times except when constrained by equipment and/or satellite problems, of which there were very little during this survey. Periods of Dead Reckoning were brief and created no problems. Figures 8 and 9 show the percentage of navigation modes for each day and for each line.

GPS/dGPS (Racal System)

The prime navigation systems for Survey 116 consisted of two effectively identical differential Global Positioning Systems (dGPS) supplied by RACAL Survey Ltd. Each system comprises a Trimble 4000 GPS receiver, Racal demodulator and Compaq 386 PC running real-time differential software. Base stations at Darwin and Broome were utilised and data were recorded by the DAS and also on optical disk. The dGPS was relatively consistent and operated well during the survey. The daily percentage of primary navigation was within a range of 90 to 95%. A period of high DOPS on Racal 1 each day resulted in the required switch to the secondary system.

Dead Reckoning

Dead Reckoning was used for very brief periods when the HDOP on both Racal 1 and 2 was over 3.0. On day 063, there was an extended period of DR navigation, but the dGPS came in intermittently so that the 10 minute limit was not reached.

Sonar Dopplers and Gyro-compasses

The sonar doppler and various gyro-compasses provided dead-reckoned navigation for the brief periods when GPS/dGPS coverage was not available. The Raytheon DSN-450 was used in water-track mode during the survey to provide speed through the water and operated well, but calibration may need further fine-tuning.

Magnetics

The magnetometer was deployed for most of the survey, but was retrieved on a few occasions due to shallow water and shoals. At the beginning of the survey, data were relatively noisy (6-8 nT) and spiky (15-20 nT), increasing to 100 nT before the head was retrieved for servicing on day 040. Some water was found in the head, so an older, single coil head was deployed, however noise levels were worse than before. The original head was flushed and redeployed, showing low noise levels around 2 nT for the remainder of the survey.

Gravity

The gravity meter functioned all survey with no apparent problem. Noise levels were generally within 1 mGal with an occasional 1 or 2 mGal oscillation. Ties were established in Darwin prior to and after the survey.

Bathymetry

Bathymetric data were collected during the entire survey without problems using 12 kHz and 3.5 kHz echo sounders. Water depths of 20 m to more than 1500 m were encountered. A typical bathymetric profile across a survey dip-line is shown in Figure 10.

Seismic Acquisition System

The seismic acquisition system ran throughout the survey without problems, after initial problems with the Phoenix/amplifier system were fixed.

Amplifiers and Phoenix A-D converter

Apart from initial problems which were rectified during the sojourn at Darwin, the Phoenix A-D converter and IFP amplifiers used during the survey performed reliably. Start and end of line tests during the survey consisted of the usual amplifier, oscillator, high-cut and low-cut and impulse tests, and also dynamic range tests using normalised data. The tests indicate high linearity and stability for the duration of recording. During the survey, the Channel 42 card was changed because of an abnormal response to the impulse test, and Channel 79 showed an intermittent low amplitude response which was solved by replacing the appropriate *mux* card to the amplifier cable.

Tape Drives

The Fujitsu 3480 cartridge tape drives performed reliably for most of the survey, except for two occasions when a tape was written to successfully, but jammed in the drive while unloading. The spare (DAS) drives were switched in, however, a re-shoot of the data was required as the tapes could not be read. It is very likely that the problem was caused by faulty tapes. It was found that the tape connection to the plastic leader block protruded beyond the block by 1-2 mm. The probable faulty batch of tapes was not used again, and the problem did not recur.

Seismic Cable

The seismic streamer configuration (Appendix 8) consisted of armoured tow leader (80-110 m deployed), tension cell, 3 x 50 m stretch sections, 48 x 100 m active sections (192 x 25 m active groups), a single 50 m stretch section, and a tailbuoy at the end of a 150 m rope. Twenty five remotely controlled cable levellers (birds), each with a depth transducer, were deployed along the streamer to provide depth control. Due to this high number of birds, control over the cable was maintained with up to 4 birds not functioning correctly. The cable was held at a depth of approximately 11 m to minimise swell noise. In addition to the depth controllers, 4 compass birds were deployed after active channels 36, 84, 132, and 180, and an emergency satellite transmitter (ARGOS) was also mounted on the streamer as a security measure against cable loss.

Seven streamer sections were changed during the survey, one (L059) due to open circuit channels, the others due to punctures or fish bites. The cable was retrieved 3 times during Survey 116 as a result of failure of bird batteries or tailbuoy radio transmission failure.

Tailbuoy

The tailbuoy generally performed well during the survey, however, 4 days before completion of the survey, transmission from the tailbuoy ceased completely. The tailbuoy was still visible on radar and it was assumed that electronics were switched off when the battery voltage reached 10.5 V. On retrieval at the end of the survey, a small amount of salt water was found in the battery compartment, and both propellers were broken off.

Mechanical

Seismic source

The seismic source for Survey 116 was provided by two arrays of sleeve guns, towed from the magnetometer booms at a distance of 43 m at a depth of 7 to 8 m. The arrays consisted of sixteen 150 cubic inch sleeve guns in each array. During seismic recording, 10 guns were fired from each array with the airguns grouped in clusters of 4, 3, 2, and 1 guns.

Before the start of the cruise all solenoids had been stripped, cleaned and rebuilt. During the course of the survey, guns were replaced when bad timing occurred with the first option being a change of the solenoid before replacement and stripping of the gun. Both arrays were used extensively throughout the survey. Generally, the arrays were running well and only one 'loop' had to be sailed while on line to allow airgun repairs.

The Christmas trees had been modified and re-installed before the start of Survey 116. During the cruise, Hoke valves failed continuously and new replacement kits had to be flown in. Overall, more than 30 spare seal kits were used during the cruise.

Gun controller

The gun controller generally performed well during the cruise. Intermittent timing problems could in many cases be rectified by 'resting' the relevant gun for a number of hours. During the first day of shooting, a virtually continuous autofire indication (not real) on starboard gun #5 occurred. It was swapped with #4 at the gun bundle

patch panel allowing #5 (#4 selected) to be fired without the autofire indication appearing. This configuration was maintained for the rest of the cruise.

Compressors

High pressure air at 2000 psi was supplied by running four air compressors at 1700/1800 rpm with two compressors on stand-by. All units operated satisfactorily requiring only minor maintenance.

PRELIMINARY RESULTS

The greater part of the survey area is located in shallow water with water depths rarely exceeding 100m (Figure 11). Consequently, on 3-second records monitored during acquisition, data are obscured by sea bottom multiples. On dip lines (116/501, 116/601, 116/401, 116/201) running across the northern edge of the Sahul Platform, i.e. the continental slope, some preliminary findings on the structural style and sequence stratigraphy of the younger sections can be presented. Figure 12 shows a recent graben structure along the northern edge of the Sahul Platform (Line 116/501) with offsets of up to 40 ms from platform to graben. Thickening of the sedimentary sequence within the structure is only apparent in the uppermost section of probable Pliocene to Pleistocene age, indicating the approximate age of the structure. However, it is possible that it is a reactivation feature of older structuring events. Further probable reactivation events can be recognised on a number of sections. The example in Figure 13 (Line 116/201) shows compressive ?reactivation faulting which affects the Oligocene and ?Early Miocene markers. A further reactivation event of possible Middle to Late Miocene age can be recognised affecting deposition of the overlying ?Pliocene to Pleistocene prograding sequence. Thus, at least three reactivation events in the Neogene section can be identified. The Oligocene/Early Miocene event appears to have resulted in more distinct compressive features.

Interpretation of the age of sedimentary packages identified in Figures 12 and 13 is tentative. The Middle Miocene? marker represents the top of a probable carbonate sequence overlain by thin ?Pliocene to Pleistocene clastics, which thicken rapidly down slope. The ?Oligocene marker probably corresponds to the "base Miocene" unconformity of Whibley & Jacobsen (1990) and Baldwin (1992), and the "Mid Oligocene event" in the Vulcan Graben of Pattillo & Nicholls (1990). This unconformity typically shows strong erosive features and is underlain by a ?Palaeogene sequence of progrades which locally display intense internal channelling. The regionally mappable 'near top Permian' marker was tentatively

identified at approximately 2 seconds TWT at the northern edge of the Sahul Platform (Figure 14), where the overlying section thins significantly onto the platform. A striking feature on many Survey 116 lines is the presence of ?Pleistocene to Recent patch reefs (Fig. 15). The location of at least some of these reefs is controlled by young structures. The reefs are raised up to about 65 m above the seafloor and generally occur at water depths greater than 30 m. They may represent parts of a Pleistocene barrier reef complex (e.g. Whibley & Jacobsen, 1990), which initially experienced rapid growth with commencing flexure of the margin, but then drowned due to the high subsidence rates.

ACKNOWLEDGEMENTS

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APPENDIX 1: 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.

Gross Registered Tonnage:		1545 tonnes
Length, overall:		72.5 metres
Breadth:		13.8 metres
Draft:		60 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*

- FJORD Instruments seismic receiving array: 6.25 m, 12.5 m, 18.75 m and 25 m group lengths, up to 288 channels; up to 6000 metres active streamer length

- Syntron RCL-3 cable levellers; individual remote control and depth readout

- Haliburton Geophysical Service 32 x 150 cubic inch airguns 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)

- Digital seismic acquisition system designed and built by AGSO running on DEC μ VAX 3500:
- 0.5msec-4msec sampling interval, 2sec-16sec record length
- Phoenix A/D converter and instantaneous floating point amplifier
- Data stored on Fujitsu 3480 cartridge tape drives
- Data in demultiplexed (modified) SEG-Y format.

- Reftek and Yaesu sonobuoy receivers

- Raytheon echo sounders: 3.5 KHz (2 K.W.), 16 transducer sub bottom profiler and 12 KHz (2 K.W.)

- Geometrics G801/803 magnetometer/gradiometer

- Bodenseewerk Geosystem KSS-31 marine gravity meter

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

- Nichiyu Giken Kogyo model NTS-11AU heatflow probe

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

Navigation equipment

- RACAL SKYFIX differential GPS system
- Magnavox T-Set Global Positioning System navigator
- Magnavox MX 1107RS and MX 1142 transit satellite receivers
- Magnavox MX 610D and Raytheon DSN 450 dual axis sonar dopplers
- Sperry, Arma Brown and Robertson gyro-compasses; plus Ben paddle log

APPENDIX 3: Crew List - Survey 116

Scientific Crew

C. Pigram	Cruise Leader
S. Dutton	Ship Manager
H. Struckmeyer	Scientist
H. Prasetyo	Scientist, Marine Geological Institute of Indonesia (MGI)
A. Taylor	NOPEC Representative
H. Miller	Quality Control/Systems Expert
L. Kalinisan	Quality Control/Systems Expert
L. Miller	Electronics Technician
M. Callaway	Electronics Technician
J. Bedford	Science Technician
T. Hunter	Science Technician
M. Alcock	Science Technician
S. Thompson	Science Technician
S. Milnes	Mechanical Technician
J. Roberts	Mechanical Technician
D. Sewter	Mechanical Technician
A. Hislop	Mechanical Technician
R. Schuler	Mechanical Technician

Crew of the *Rig Seismic*

R. Hardinge	Master
M. Gusterson	Mate
W. Boot	Extra Mate
B. Troke	Chief Engineer
R. Heaton	2nd Engineer
I. McCulloch	Electrician
M. Pitcher	Integrated Rating
J. Fraser	Integrated Rating
S. Lyons	Integrated Rating
P. Morcombe	Integrated Rating
H. Dekker	Chief Steward
W. Leary	Cook
S. Staveley	Steward
E. Strange	Steward*
S. O'Rourke	Steward*

*Strange for O'Rourke 2.2.93

APPENDIX 4: Way Points used for Survey 116

Line No.	Reference No. (pre-cruise)		Latitude (deg/min S)	Longitude (deg/min E)
116/0101	TST01	SOL	12 10.115	126 27.674
	(NOP01)	KITE - 1	12 04.068	126 26.206
		CLEIA - 1	10 55.102	126 09.975
116/0102		SOL (Cleia-1)	10 55.102	126 09.975
		EOL	10 27.515	125 58.874
116/0201	TST02	SOL	10 04.715	126 04.514
	(NOP2)	FLAMINGO - 1	11 01.482	126 28.991
116/202		SOL (Flamingo-1)	11 01.482	126 28.991
		SHALIMAR - 1	12 02.233	126 39.065
116/0203		SOL (Shalimar-1)	12 02.233	126 39.065
		HARBINGER - 1	12 13.200	126 44.685
		EOL	12 20.914	126 49.274
116/0301	TST03	SOL	12 22.114	127 33.074
	(NOP3)	EOL	11 16.714	127 00.074
116/0401	TST04	SOL	11 19.114	127 36.674
	(NOP4)	BASILISK - 1A	10 48.196	127 17.870
116/0402		SOL (Basilisk-1A)	10 48.196	127 17.870
		EOL	10 39.060	127 07.200
116/0403		SOL (Eol/0402)	10 39.060	127 07.200
			10 06.540	126 49.680
		EOL	09 50.435	126 41.174
116/0501	TST05	SOL	09 29.314	127 36.073
	(NOP5)	EOL	10 08.314	127 52.873
116/0502		SOL	10 08.314	127 52.873
		JACARANDA - 1	11 28.164	128 09.906
		CURLEW - 1	11 46.147	128 15.907
		EOL	11 50.914	128 18.074
116/0601	TST06	SOL	10 55.714	128 24.073
	(NOP6)		10 30.731	128 18.690
			09 43.978	128 07.498
		EOL	09 24.874	128 02.413
116/0701	TST07	SOL	10 46.714	128 27.673
	(NOP7)	EOL	11 25.714	127 39.674
116/0702		SOL	11 37.047	127 17.986
		KITE - 1	12 04.068	126 26.206
		EOL	12 35.900	125 25.800
116/0803	TST08	SOL	12 06.900	124 54.500
	(NOP8)	HALCYON - 1	11 56.268	125 28.303
		EOL	11 38.597	126 24.945

116/0804		SOL (Eol/803)	11 38.597	126 24.945
		EOL	11 16.714	127 34.874
116/0805		SOL (Eol/804)	11 16.714	127 34.874
		SHEARWATER - 1	10 30.731	128 18.690
116/0901	TST09	AVOCET - 1A	11 22.369	125 45.304
	(NOP9)	FLAMINGO - 1	11 01.481	126 28.991
116/0902		SOL (Flamingo-1)	11 01.481	126 28.991
		TROUBADOUR - 1	09 43.978	128 07.498
116/1001	TST10	SOL	10 19.913	126 20.072
	(NOP10)	EOL	11 00.137	125 31.712
116/1101	Ma01	SOL	10 14.914	128 10.073
		SHEARWATER - 1	10 30.731	128 18.690
		EOL	11 31.894	128 55.573
116/1201	Ma02	SOL	11 26.314	129 09.073
		SUNRISE - 1	09 35.320	128 09.300
		EOL	09 25.914	128 04.073
116/1301	Ma03	SOL	09 25.920	128 23.076
		HERON - 1	10 26.364	128 57.156
		EOL	10 59.914	129 16.073
116/1401	Ma04	SOL	11 05.014	129 39.073
		EOL	09 24.814	128 43.700
116/1501	Ma13	SOL	09 24.814	129 26.973
		EOL	10 21.000	129 32.500
116/1601	Ma16	SOL	10 13.114	129 44.873
		EOL	10 59.914	128 30.673

All coordinates: WGS84

Note: way points used for navigation do not necessarily indicate the actual start and end points of seismic lines.

APPENDIX 5: Seismic Acquisition Parameters

Seismic Cable Configuration

standard	length	4800 m
	group length	25 m
	no. channels	192

Seismic Source

	airgun array capacity	50 litres (3000 cu in)
	airgun pressure	1800 psi (normal)
		1600 psi (minimum)
	shot interval	19.4 sec @ 5 knots
		21.6 sec @ 4.5 knots

Fold

	standard	4800 %

Recording Parameters

	record length	16 s
	sample interval	2 ms

APPENDIX 6: Seismic Acquisition Geometry

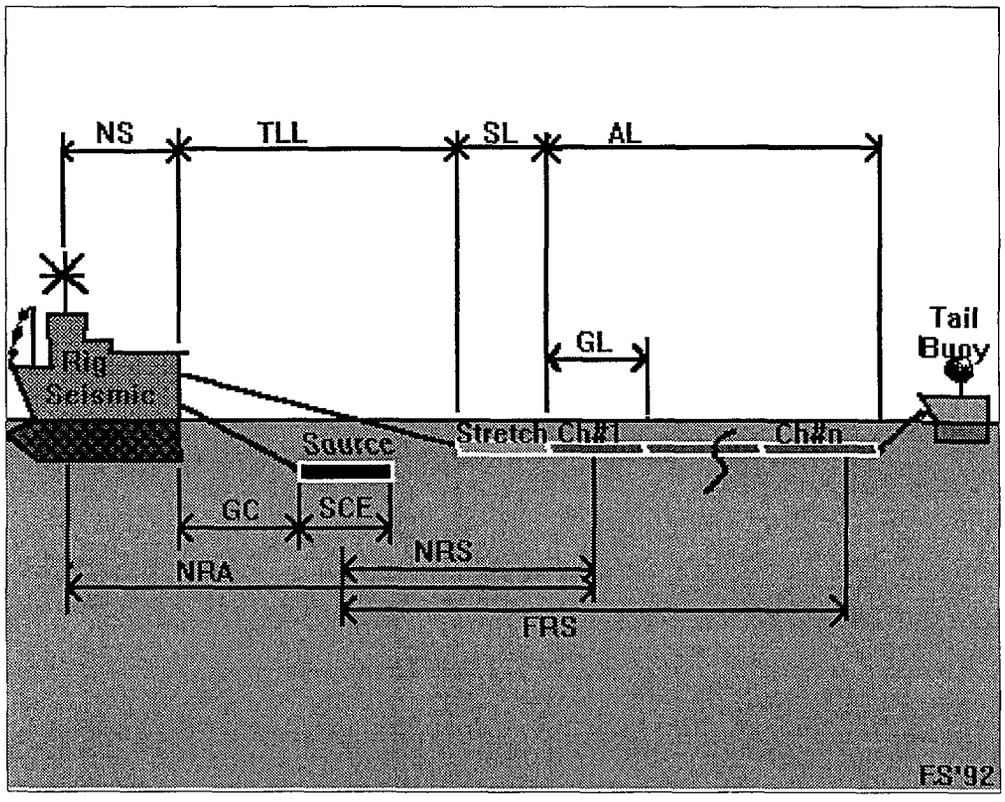
Survey:	**JDZ and adjacent areas**		**Survey No. 116**	
Group Length (GL):	25	m	Date: February 1993	
No. of Active Channels (N):	192		Gun Length (SCE):	13.5 m
Active Length (AL = GLxN):	4800	m	Gun Chain Length (GC):	43 m
Stretch Length (SL):	150	m	Antenna to Stern (NS):	46 m

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 = 150 m

APPENDIX 7: Excerpts from Draft Cruise Specifications

Navigation

- Primary: Racal 1 differential GPS system using 4 or more satellites and having a HDOP of 3.0 or less; differential corrections from Darwin reference station.
- Secondary: Racal 2 differential GPS system using 3 satellites and having a HDOP of 3.0 or less; differential corrections from Broome reference station; to be used for not more than 1 hour if primary system unavailable.
- Tertiary: Dual axis sonar doppler / gyro to be within 20 metres accuracy over 10 minutes; to be used for not more than 10 minutes continuously.

Gun Array

- Start of line cannot proceed if air pressure is below 1600 psi, if any guns are not firing consistently within +/- 2 ms, if there is less than one spare gun per group and if the standard array groups of 2 x (4, 3, 2, 1) are unable to be fired.
- Work on any line has to be stopped if there is a loss of more than 10 consecutive recordings, a cumulative misfire rate of 5% or more, and if more than 2 guns of the standard configuration are inactive or more than one group of the same size becomes inactive.

Streamer Noise

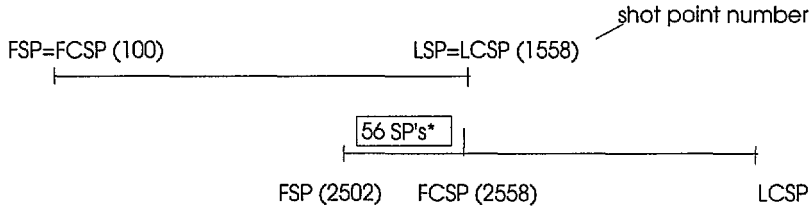
The noise recorded is not to exceed 6 μBars RMS except

- for the 16 groups nearest the vessel (12 μBars);
- for the 8 groups nearest the tailbuoy (9μBars);
- for the 2 traces either side of the depth controller and compass birds (12 μBars).

Shotpoint numbering, overlaps and run-outs

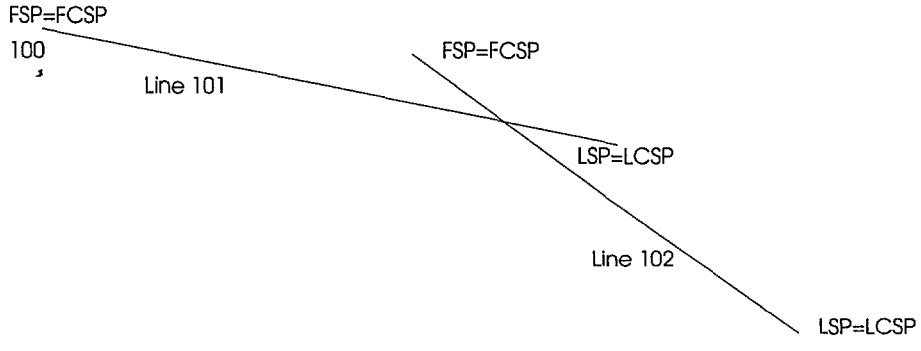
- start at SP 100, increase by 1000 shotpoints at circles; no duplicate SP's;
- lines to be completed in one direction only;
- a minimum surface overlap of 2 kms at circles;
- at doglegs, a minimum surface overlap of 4 kms on each line segment, i.e. 4 kms run-out at deviation point and 4 kms run-in to the deviation point to continue the line;
- after circle, the feathering angle shall be preferably to the same side;
- 2 km run-out at end of line;
- no change of heading closer than 3 kms from a well location and no change of more than 7 degrees in one point

Equipment failure loop (e.g. gun maintenance, tape drive failure)



*approximate

Dogleg loop



FSP: first shot point
FCSP: first chargeable shot point
LSP: last shot point
LCSP: last chargeable shot point (last shot point needed to achieve 48 fold at end of line)

APPENDIX 8: Exploration Wells tied during Survey 116

WELL	OPERATOR	DATE	TD m	OLDEST SEQUENCE	STATUS
FLAMINGO - 1	ARCO	1971	3700	JURASSIC	oil and gas shows
HERON - 1	ARCO	1971	4209	JURASSIC	gas shows
TROUBADOUR - 1	BOCAL	1974	3459	PERMIAN	gas/condensate
SHEARWATER - 1	ARCO	1974	3178	JURASSIC	dry
CURLEW - 1	ARCO	1974	2035	JURASSIC	oil and gas shows
SUNRISE - 1	BOCAL	1974	2341	JURASSIC	gas/condensate
JACARANDA - 1	TRICENTROL	1984	3783	JURASSIC/CRET.	oil and gas shows
CHALLIS - 11	BHP	1990	1700	TRIASSIC	dry
AVOCET - 1A	BOND	1986	2217	JURASSIC	gas shows
SNOWMASS - 1	BHP	1987	1700		dry
EVANS SHOAL - 1	BHP	1988	3712	JURASSIC	gas shows
KITE - 1	WMC	1990	2311	JURASSIC	dry
HALCYON - 1	LASMO	1991	2090	TRIASSIC	gas
HARBINGER - 1	KUFPEC	1991	2765	JURASSIC	dry
SHALIMAR - 1	KUFPEC	1991	2750	JURASSIC	minor shows
CLEIA - 1	PHILLIPS	1992	3789	JURASSIC	minor shows
BASILISK - 1A	MARATHON	1993	3030		oil shows

APPENDIX 9: Survey 116 Line Summary

Line No.	Ref.-No. (pre-survey	Date (start of line	Start Time Julian	End Time Julian	LOCATION				FSP	LSP	Length (km)	Total (km)
					Start		Stop					
			ddhhmmss	ddhhmmss	Latitude	Longitude	Latitude	Longitude				
					deg/minS	deg/minE	dg/minS	deg/minE				
116/0601	TST06	5/02/93	35145754	36000331	10 55.776	128 24.095	10 15.201	128 14.973	587	2126	76.95	76.95
116/0602	TST06	5/02/93	36081803	36191800	10 16.706	128 15.333	09 23.493	128 02.045	3070	5104	101.70	178.65
116/0501	TST05	6/02/93	37121513	37213700	09 29.303	127 36.076	10 09.680	127 53.466	100	1725	81.25	259.90
116/0502	TST05	7/02/93	38030853	39033420	10 06.844	127 52.487	11 50.856	128 17.485	2613	6591	198.90	458.80
116/0301	TST03	9/02/93	40012503	40164011	12 22.129	127 33.080	11 16.743	127 00.088	102	2809	135.35	594.15
116/0401	TST04	10/02/93	41031931	41115832	11 19.160	127 36.701	10 42.831	127 16.394	102	1645	77.15	671.30
116/0402	TST04	11/02/93	41175905	41205830	10 44.787	127 18.521	10 38.354	127 05.803	2536	3056	26.00	697.30
116/0403	TST04	11/02/93	42012555	42124707	10 40.470	127 07.962	09 50.425	126 41.174	3944	6036	104.60	801.90
116/0201	TST02	12/02/93	42220727	43104642	10 04.685	126 04.499	11 02.874	126 29.595	103	1597	74.70	876.60
116/0202	TST02	13/02/93	43154044	44043234	10 59.934	126 28.735	12 03.750	126 39.322	3330	5720	119.50	996.10
116/0203	TST02	13/02/93	44084802	44123529	12 00.909	126 38.383	12 17.951	126 47.118	6608	7316	35.40	1031.50
116/0101	TST01	14/02/93	44184604	45035152	12 09.335	126 27.449	11 24.857	126 16.980	102	1791	84.45	1115.95
116/0102	TST01	14-Feb-93	45095845	45163804	11 26.457	126 17.250	10 53.727	126 09.643	2737	3982	62.25	1178.20
116/0103	TST01	15/02/93	45215412	46042552	10 56.506	126 10.541	10 26.107	125 58.312	4871	6081	60.50	1238.70
116/1001	TST10	15/02/93	46124138	47015956	10 20.284	126 24.053	11 01.064	125 30.489	102	2569	123.35	1362.05
116/0901	TST09	16/02/93	47094600	47203827	11 24.754	125 40.315	11 00.800	126 30.409	102	2125	101.15	1463.20
116/0204	TST02	17/02/93	48040704	48054126	10 40.252	126 20.445	10 47.558	126 23.246	8544	8834	14.50	1477.70
116/0902	TST09	17/02/93	48104558	49125019	11 02.436	126 27.780	09 40.636	128 11.724	3013	7863	242.50	1720.20
116/1101	Ma01	22/02/93	52195528	53140303	10 14.875	128 10.047	11 33.169	128 56.342	103	3452	167.45	1887.65
116/1201	Ma02	23/02/93	54082222	55121346	11 26.964	129 09.426	09 24.555	128 03.512	102	5228	256.3	2143.95
116/1301	Ma03	25/02/93	55194547	56175811	09 25.931	128 23.080	11 01.211	129 16.811	102	4142	202	2345.95
116/1401	Ma04	26/02/93	57092342	58083444	11 04.989	129 39.067	09 23.511	128 42.988	102	4380	213.9	2559.85
116/1501	Ma13	28/02/93	58181527	59064811	09 24.778	129 26.975	10 26.401	129 33.038	102	2395	114.65	2674.50
116/1601	Ma16	28/02/93	59131425	59205517	10 12.866	129 45.260	10 32.116	129 14.775	217	1544	66.35	2740.85
116/0701	TST07	1/03/93	60051848	61012945	10 40.894	128 34.834	11 37.047	127 17.986	105	3603	174.90	2915.75
116/0702	TST07	2/03/93	61073444	62085331	11 36.340	127 19.338	12 36.614	125 24.440	4550	9271	236.05	3151.80
116/0803	TST08	4/03/93	62183104	63131919	12 07.357	124 53.041	11 38.577	126 24.945	102	3600	174.90	3326.70
116/0804	TST08	5/03/93	63203937	64113218	11 39.059	126 23.426	11 16.761	127 36.322	4544	7317	138.65	3465.35
116/0805	TST08	6/03/93	64164828	65064828	11 17.847	127 33.797	10 26.832	128 22.397	8205	10793	129.40	3594.75

FSP = First Shot Point LSP = Last Shot Point

APPENDIX 10: Seismic Tape Listing

Line No.	FSP	FCSP	LCSP	LSP	First Tape	Last Tape
116/0101	102	102	1791	1791	116/0370	116/0396
116/0102	2737	2793	3982	3982	116/0398	116/0417
116/0103	4871	4871	6081	6081	116/0419	116/0438
116/0201	103	103	1597	1597	116/0277	116/0300
116/0202	3330	3330	5720	5720	116/0317	116/0353
116/0203	6608	6608	7316	7316	116/0358	116/0368
116/0204	8544	8544	8834	8834	116/0514	116/0518
114/0301	102	102	2809	2809	116/0162	116/0203
116/0401	102	102	1645	1645	116/0205	116/0230
116/0402	2536	2536	3056	3056	116/0232	116/0241
116/0403	3944	3944	6036	6036	116/0243	116/0275
116/0501	100	100	1725	1725	116/0066	116/0094
116/0502	2613	2613	6591	6591	116/0096	116/0158
116/0601	587	587	2126	2126	116/0006	116/0030
116/0602	3070	3126	5104	5104	116/0033	116/0065
116/0701	105	105	3603	3603	116/0977	116/1030
116/0702	4550	4606	9271	9271	116/1033	116/1105
116/0803	102	102	3600	3600	116/1108	116/1161
116/0804	4544	4600	7317	7317	116/1164	116/1206
116/0805	8205	8205	10793	10793	116/1209	116/1248
116/0901	102	102	2125	2125	116/0480	116/0511
116/0902	3013	3013	7863	7863	116/0521	116/0595
116/1001	102	102	2569	2569	116/0440	116/0477
116/1101	103	103	3452	3452	116/0648	116/0699
116/1201	102	102	5228	5228	116/0703	116/0781
116/1301	102	102	4142	4142	116/0784	116/0846
116/1401	102	102	4380	4380	116/0848	116/0913
116/1501	102	102	2395	2395	116/0916	116/0951
116/1601	217	217	1544	1544	116/0953	116/0975

FSP = First Shot Point FCSP = First Chargeable Shot Point

LSP = Last Shot Point LCSP = Last Chargeable Shot Point

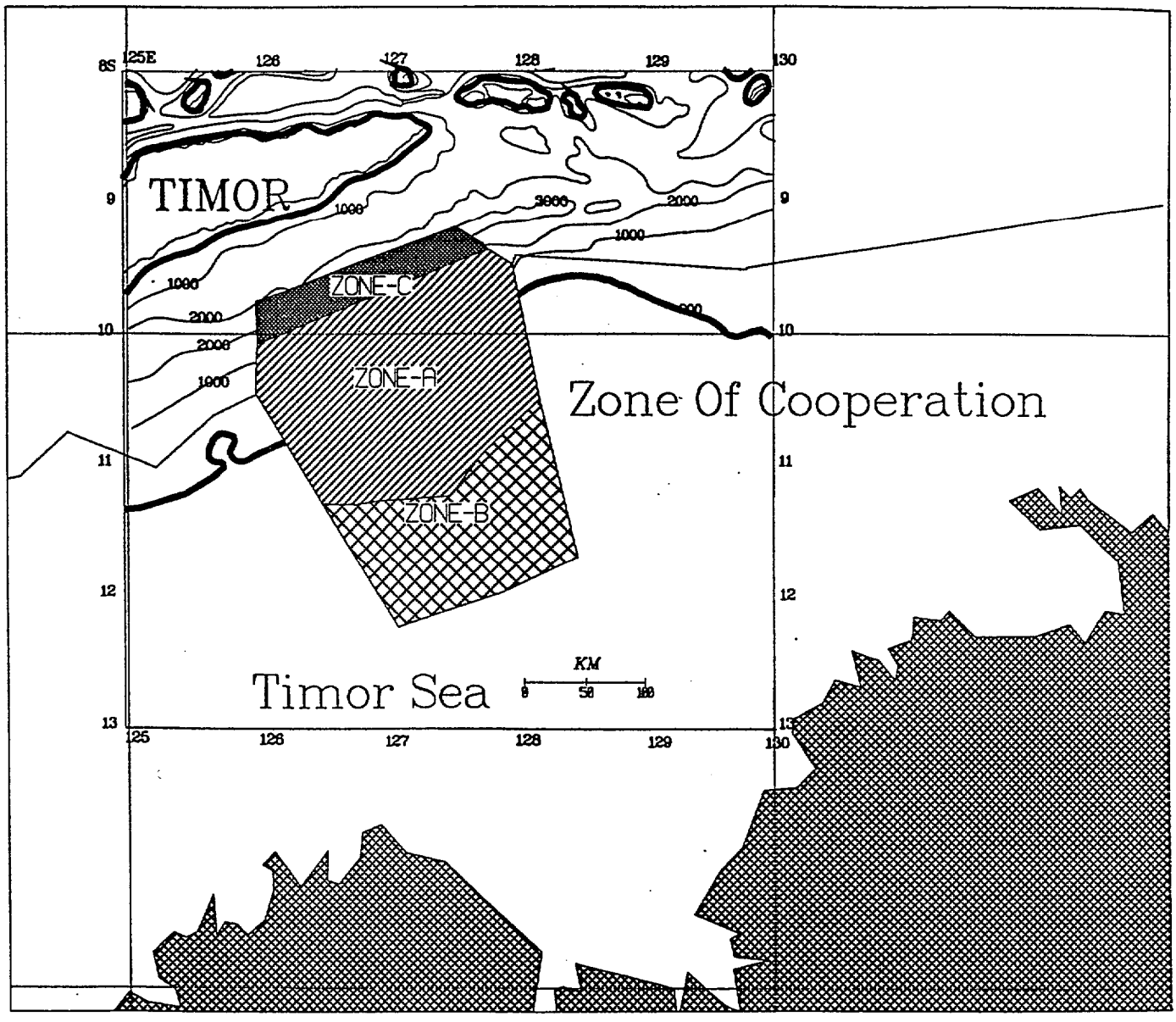


Figure 1: Location map for Zone of Cooperation.

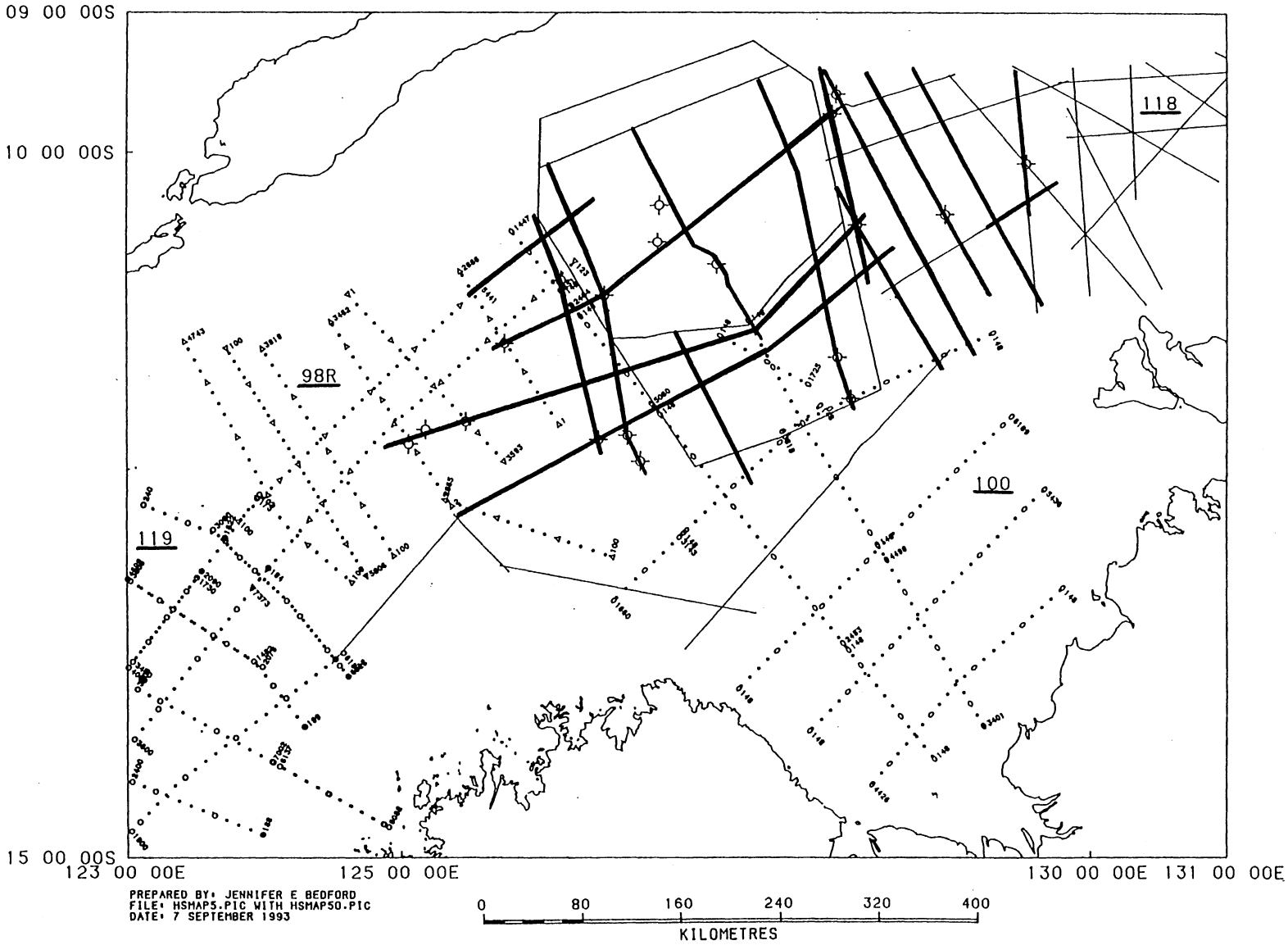


Figure 2: Regional grid of AGSO deep seismic data collected to date (Survey 116 depicted in bold).

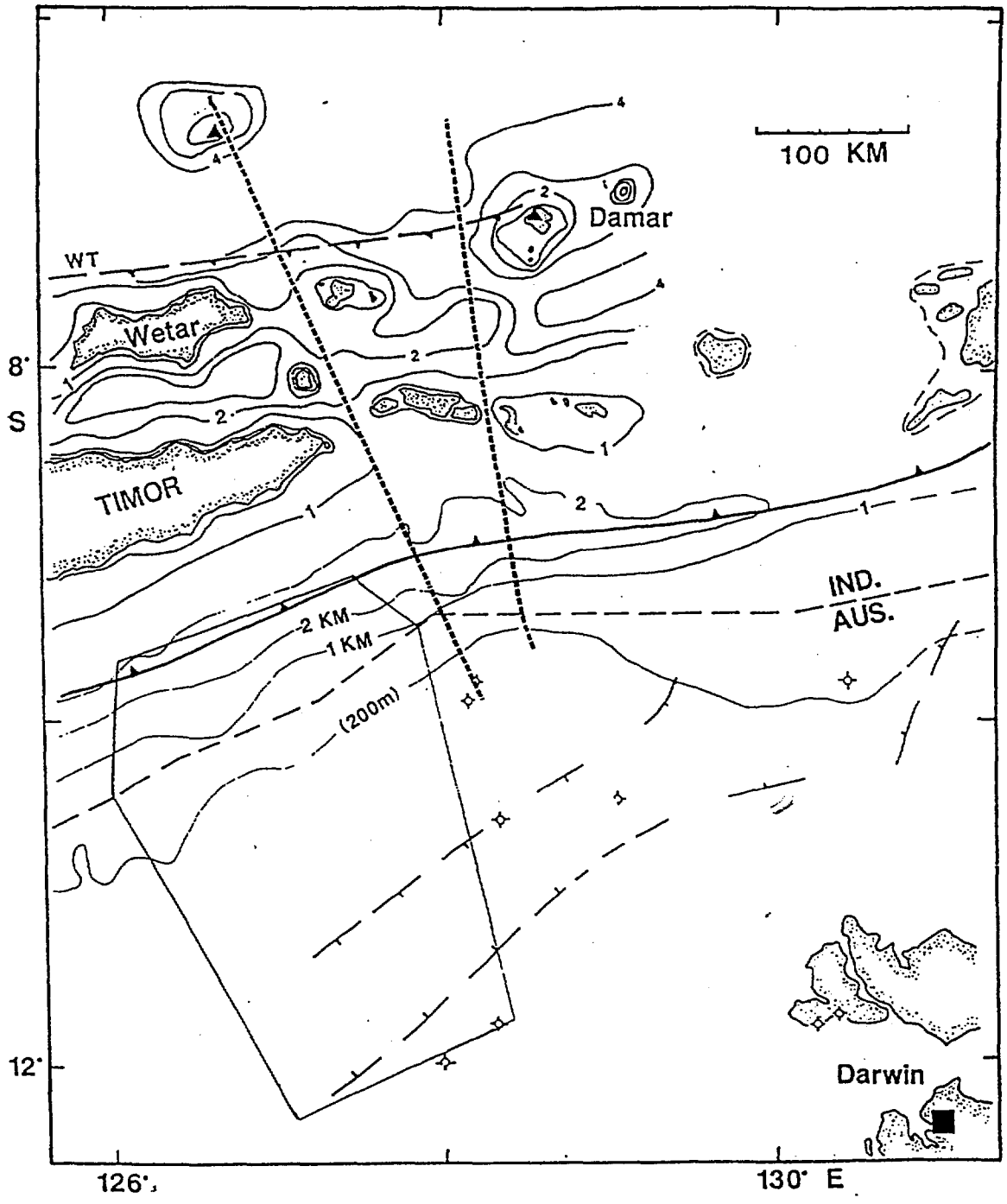


Figure 3: Location map showing the approximate location of the deep crustal lines shot across the Banda Arc by BIRPS in 1992.

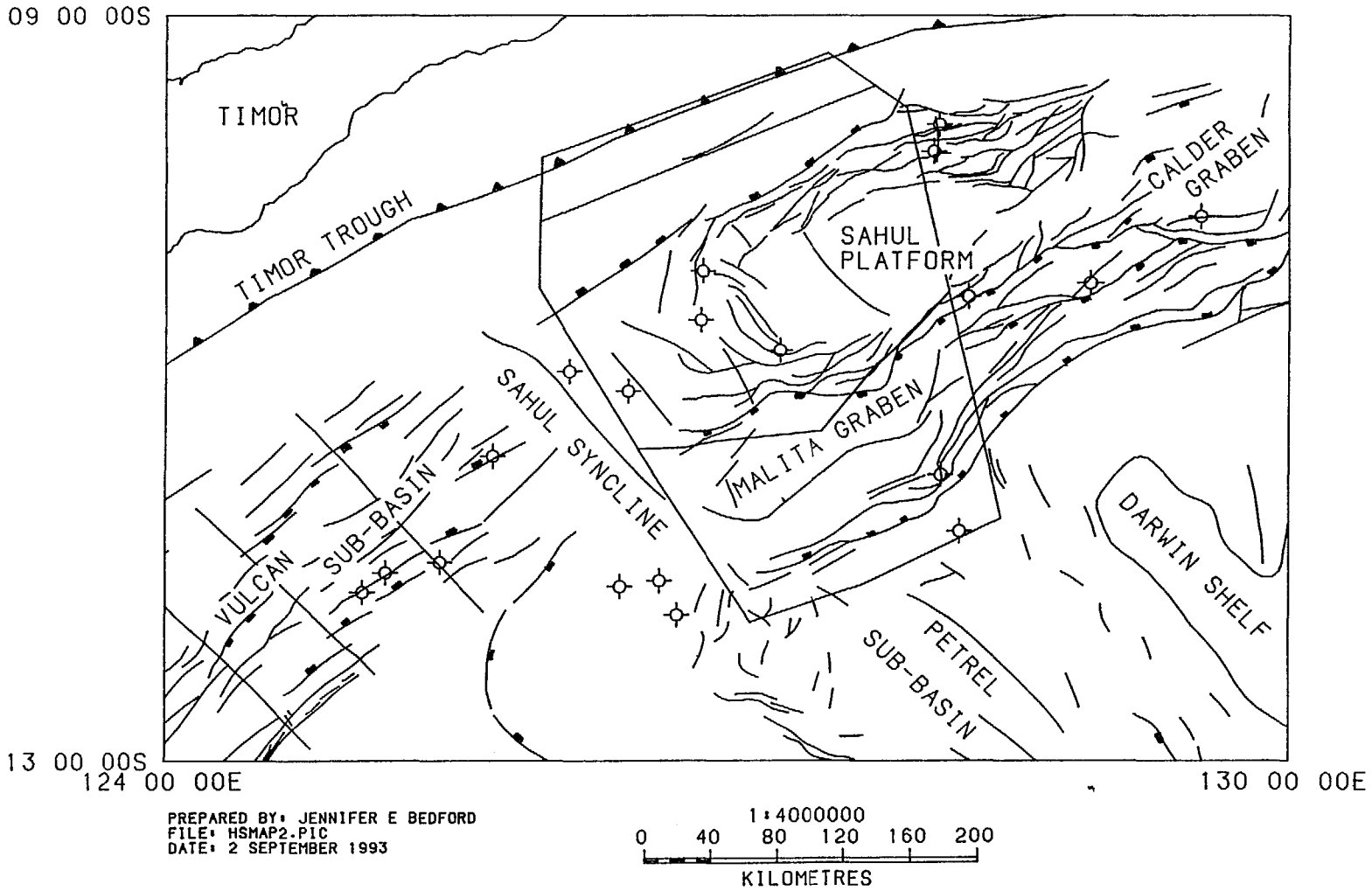


Figure 4: Structural framework map of the JDZ and adjacent regions.

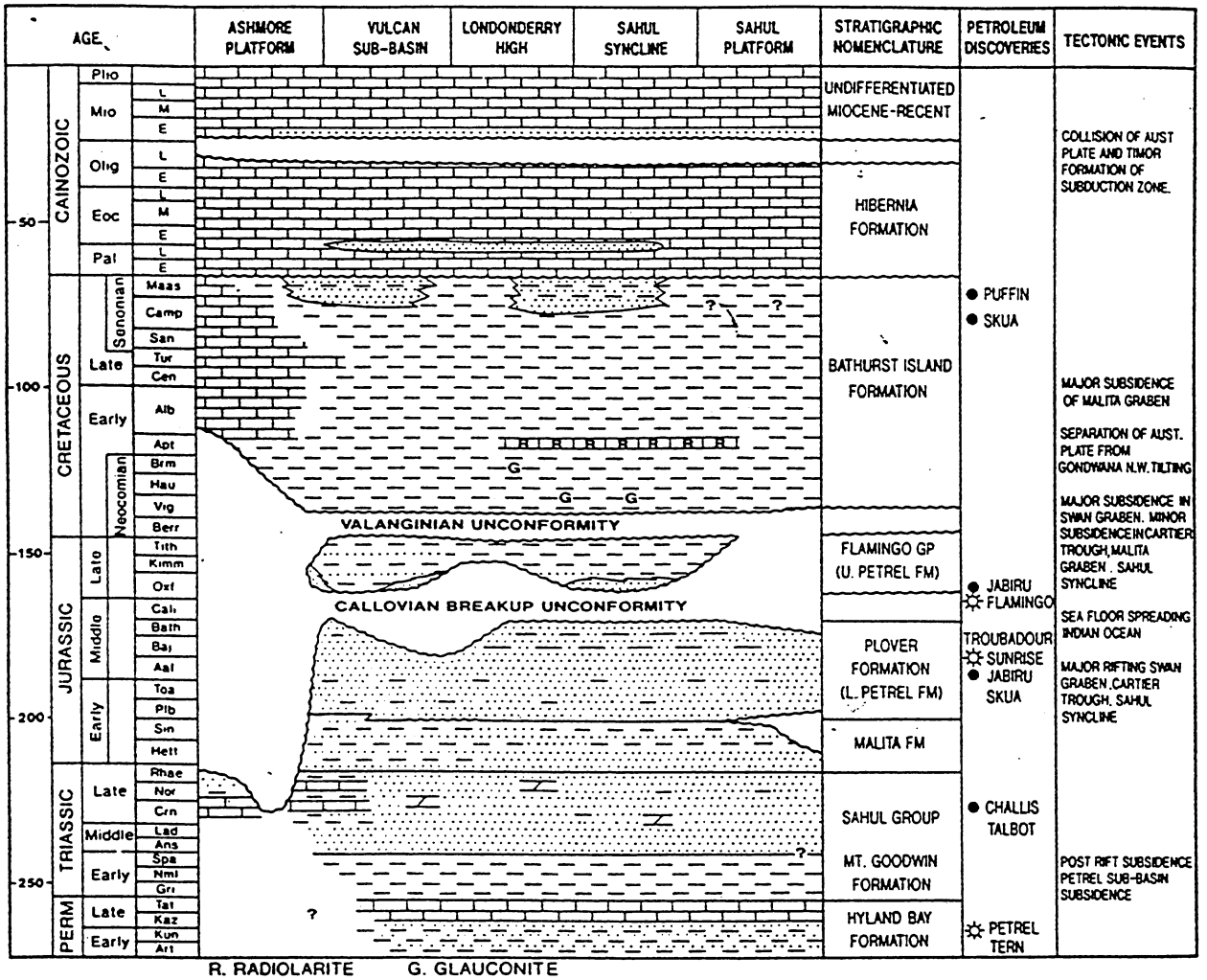


Figure 5: Stratigraphic column for the JDZ and adjacent regions (from Botten & Wulf, 1990).

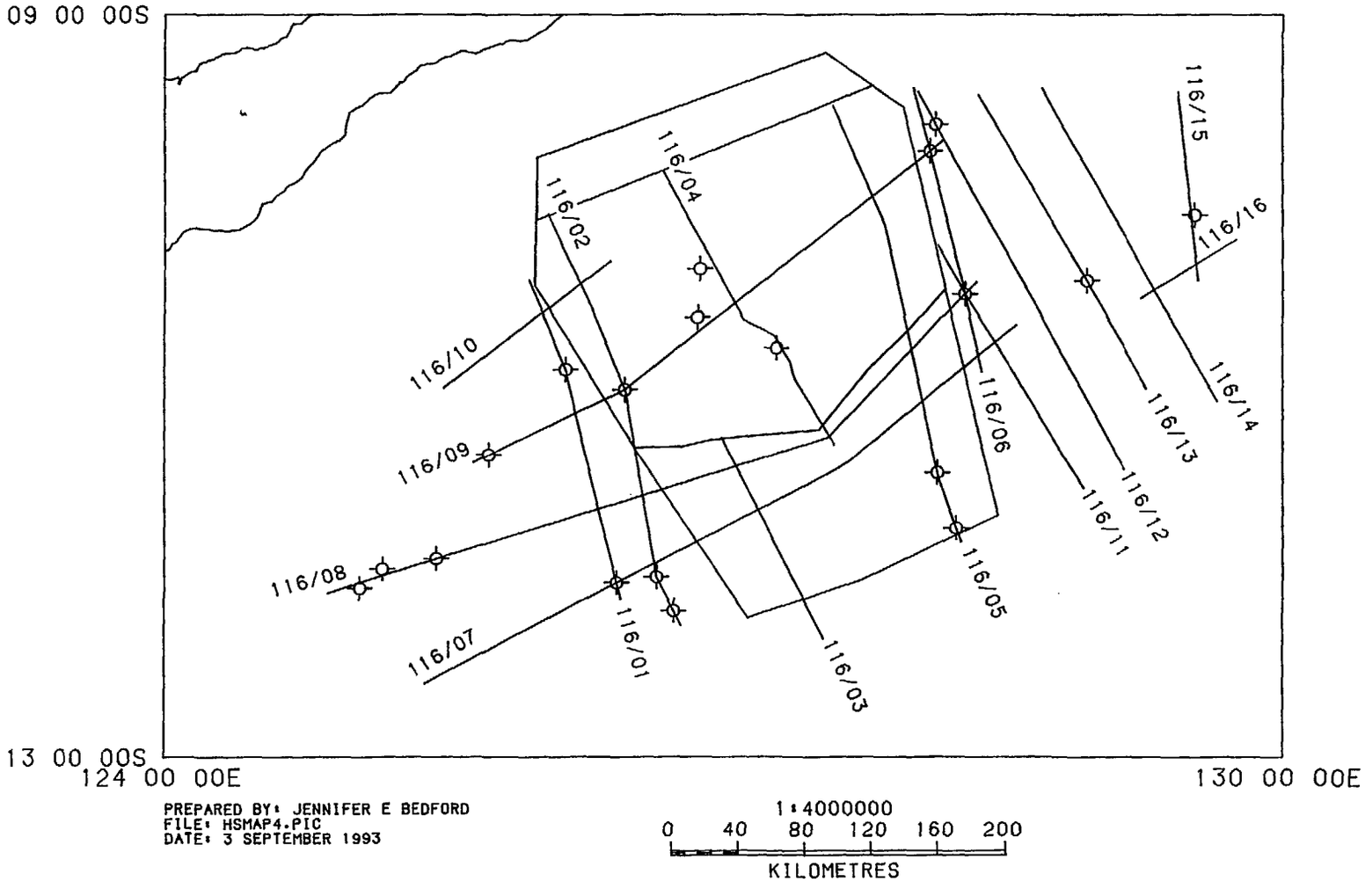


Figure 6: Location of seismic lines shot during Survey 116.

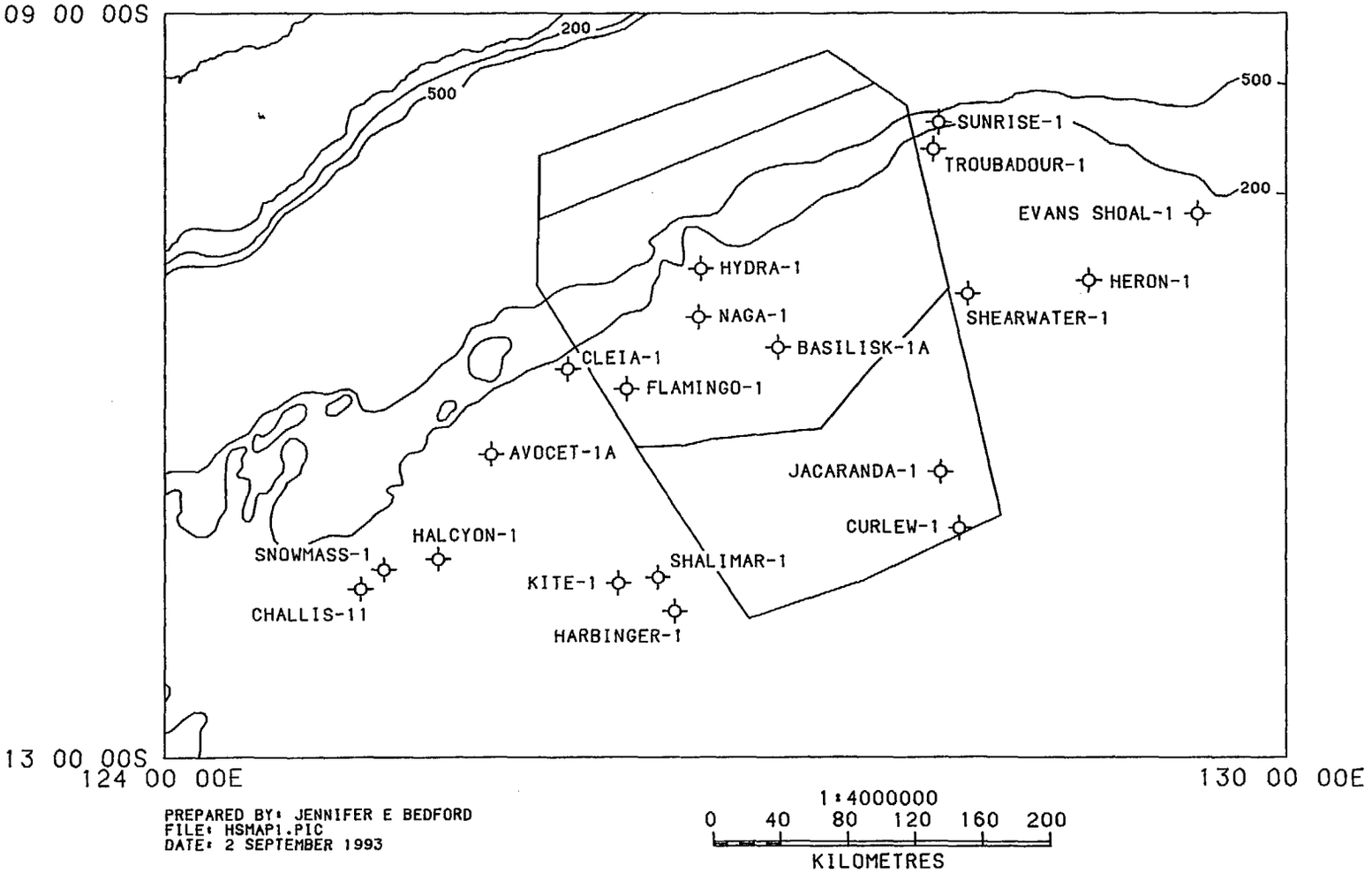


Figure 7: Important exploration wells in the survey area.

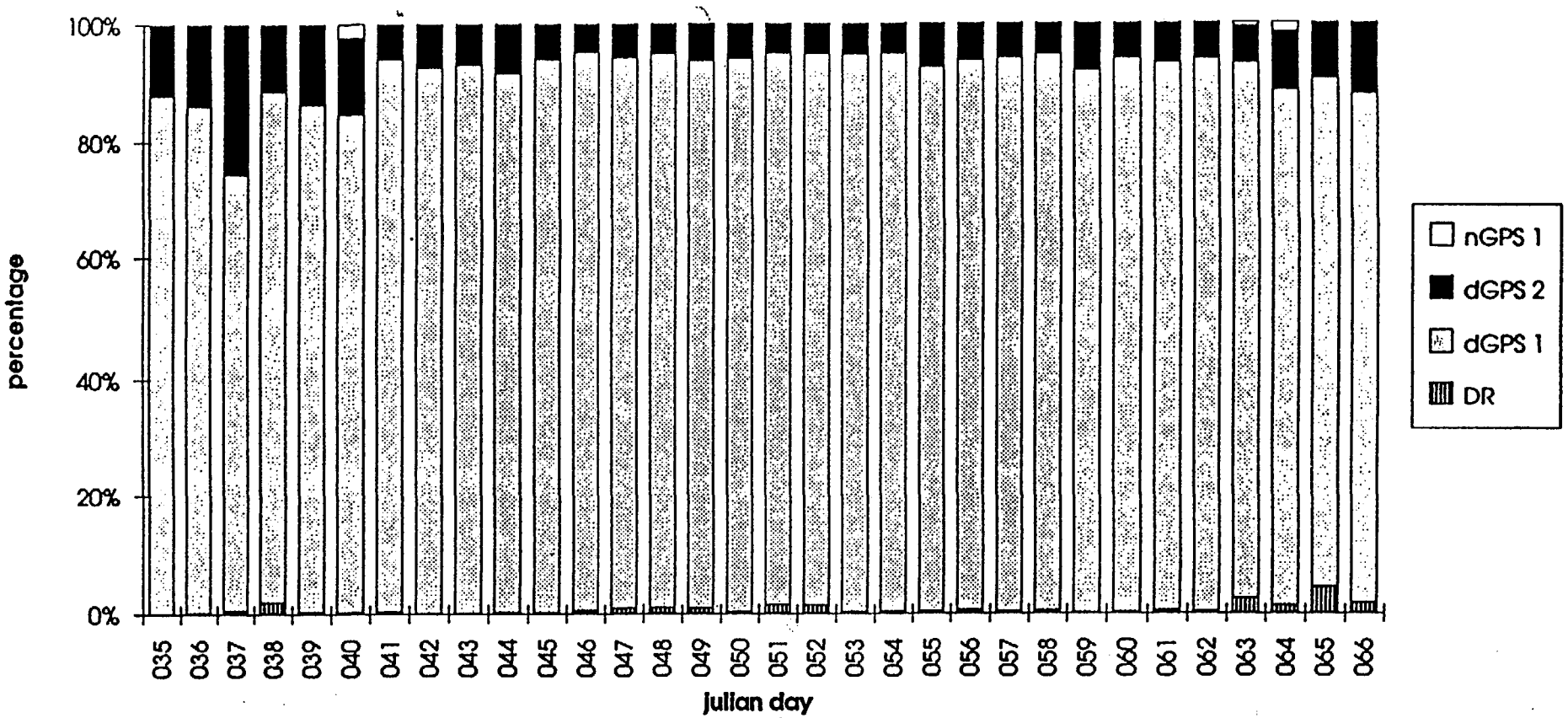


Figure 8: Daily navigation percentages during Survey 116 (nGPS = non-differential GPS, dGPS = differential GPS, DR = Dead Reckoning).

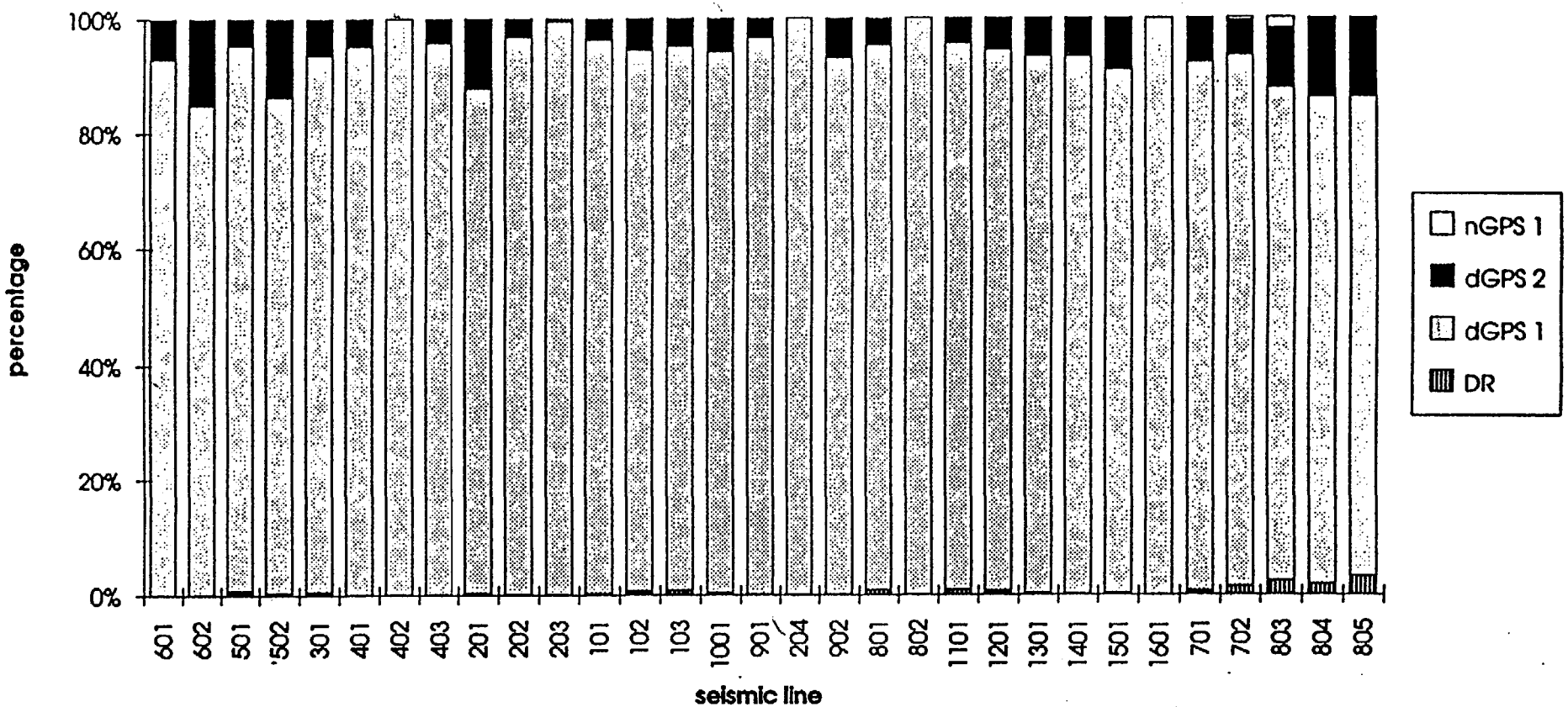


Figure 9: Line navigation percentages during Survey 116 (nGPS = non-differential GPS, dGPS = differential GPS, DR = Dead Reckoning).

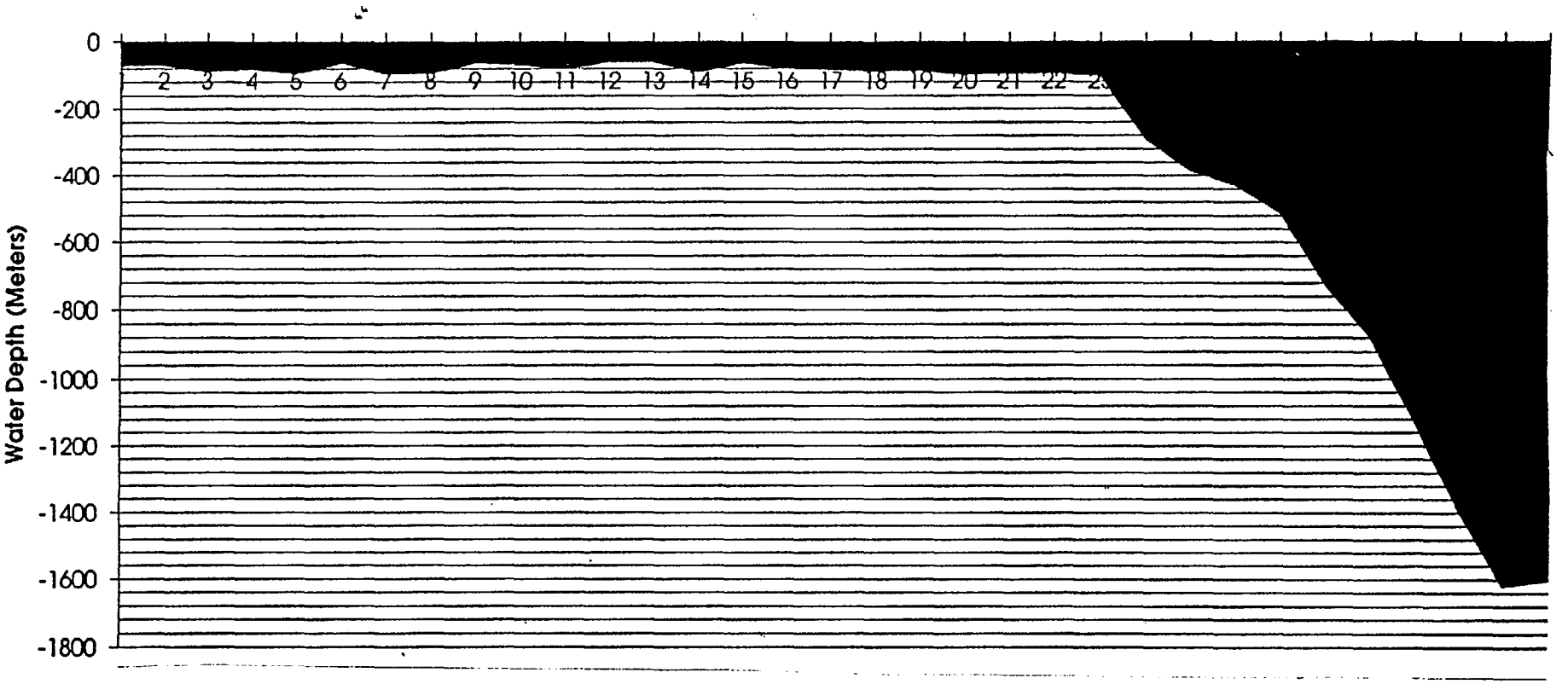


Figure 10: Typical bathymetric profile across a dip line (116/0202).

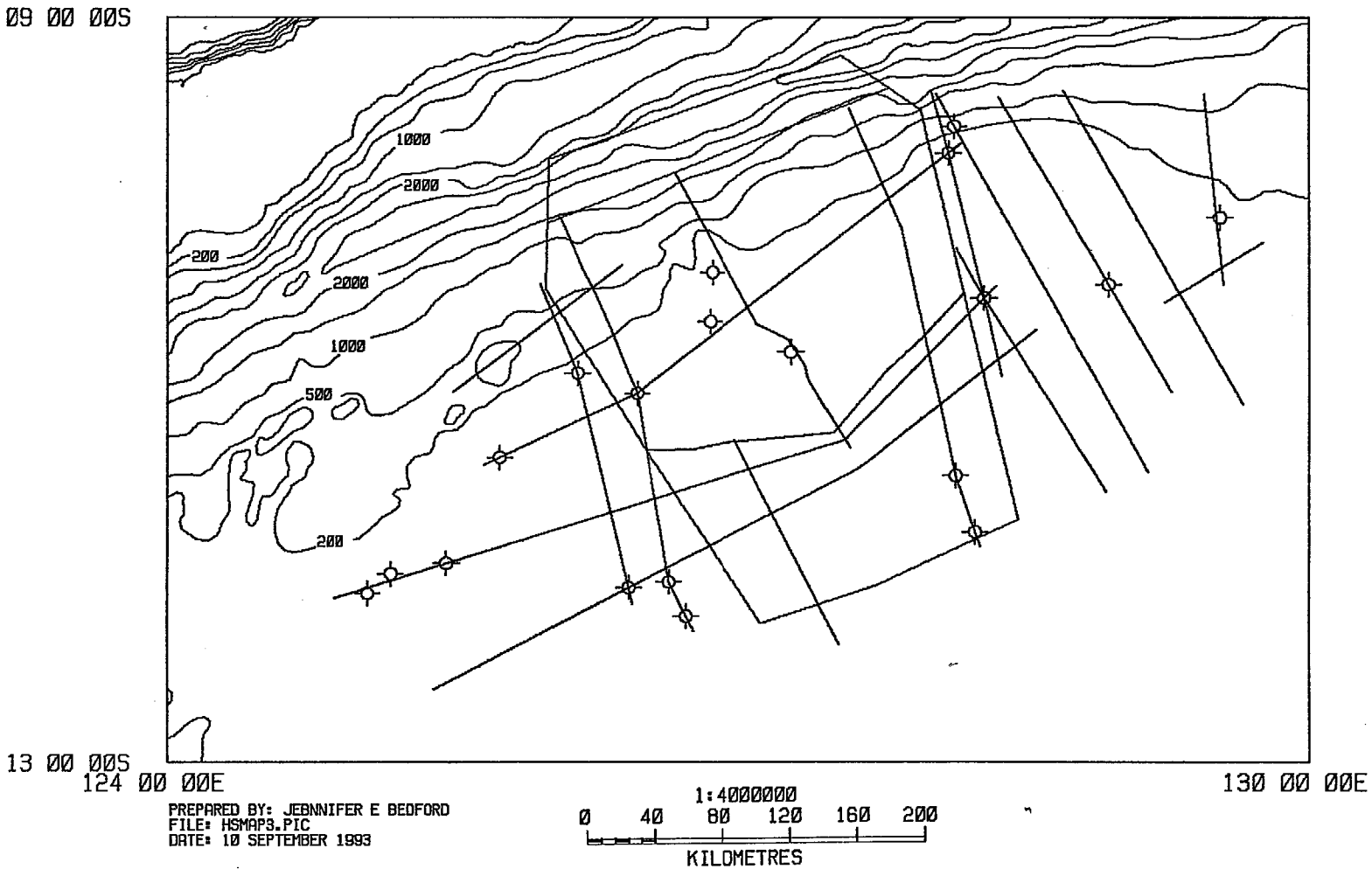


Figure 11: Bathymetry in the survey region.

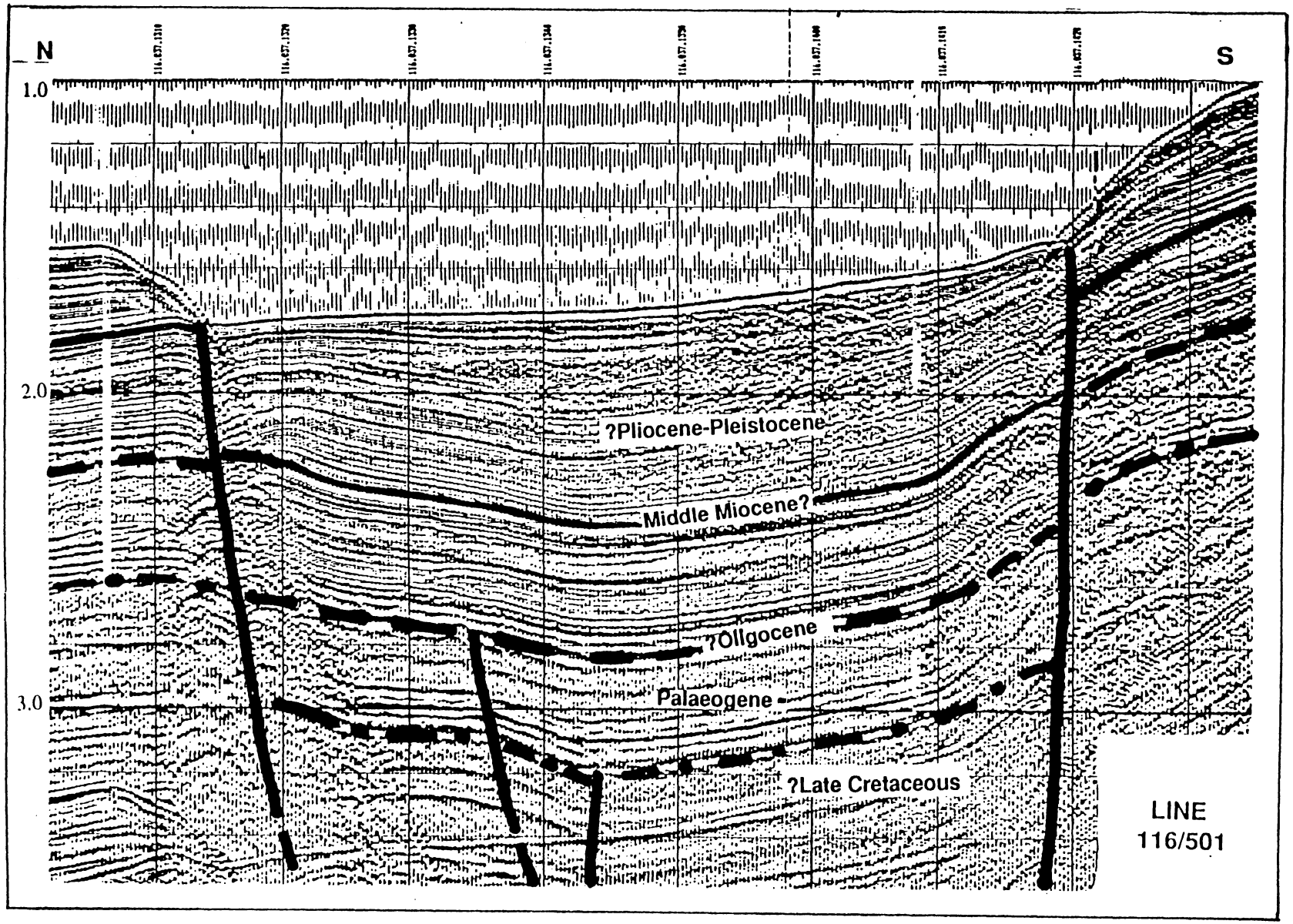


Figure 12: Shipboard monitor seismic section showing recent graben structure on the northern edge of the Sahul Platform.

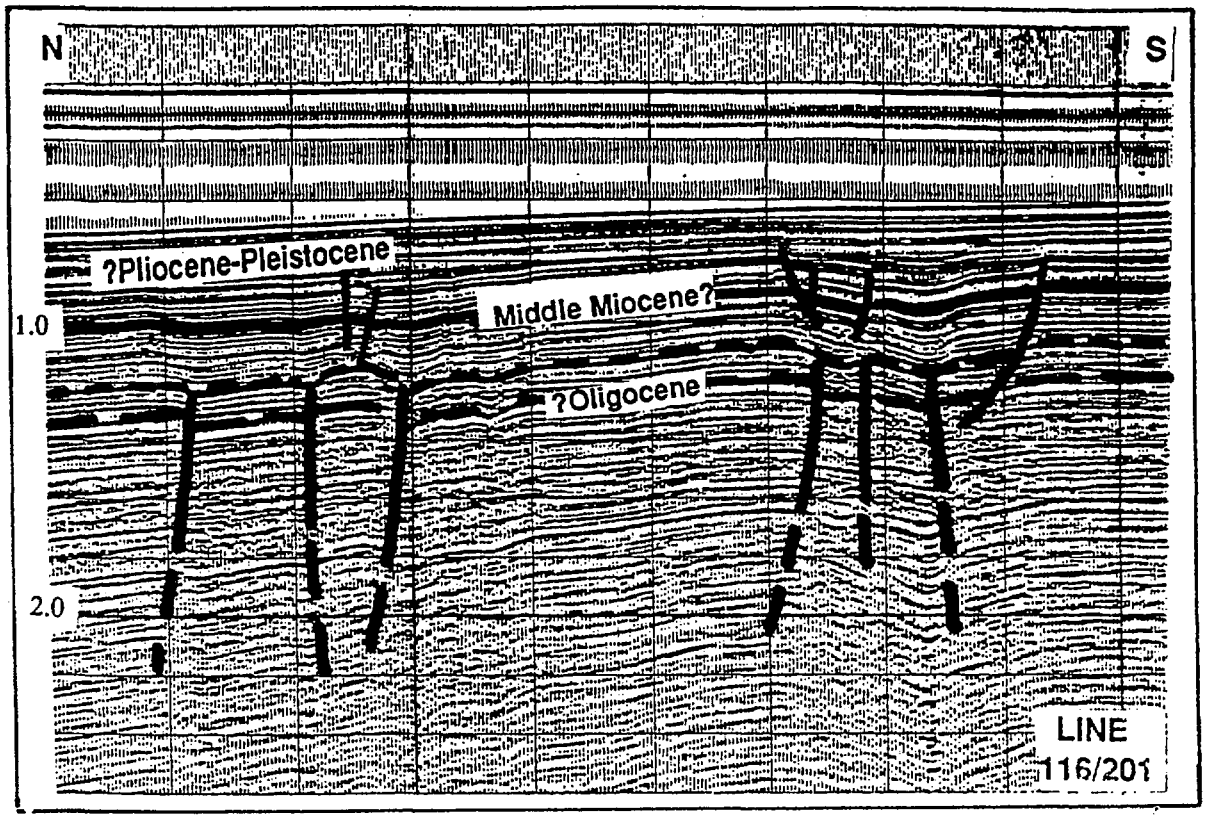


Figure 13: Shipboard monitor seismic section showing Cainozoic reactivation features.

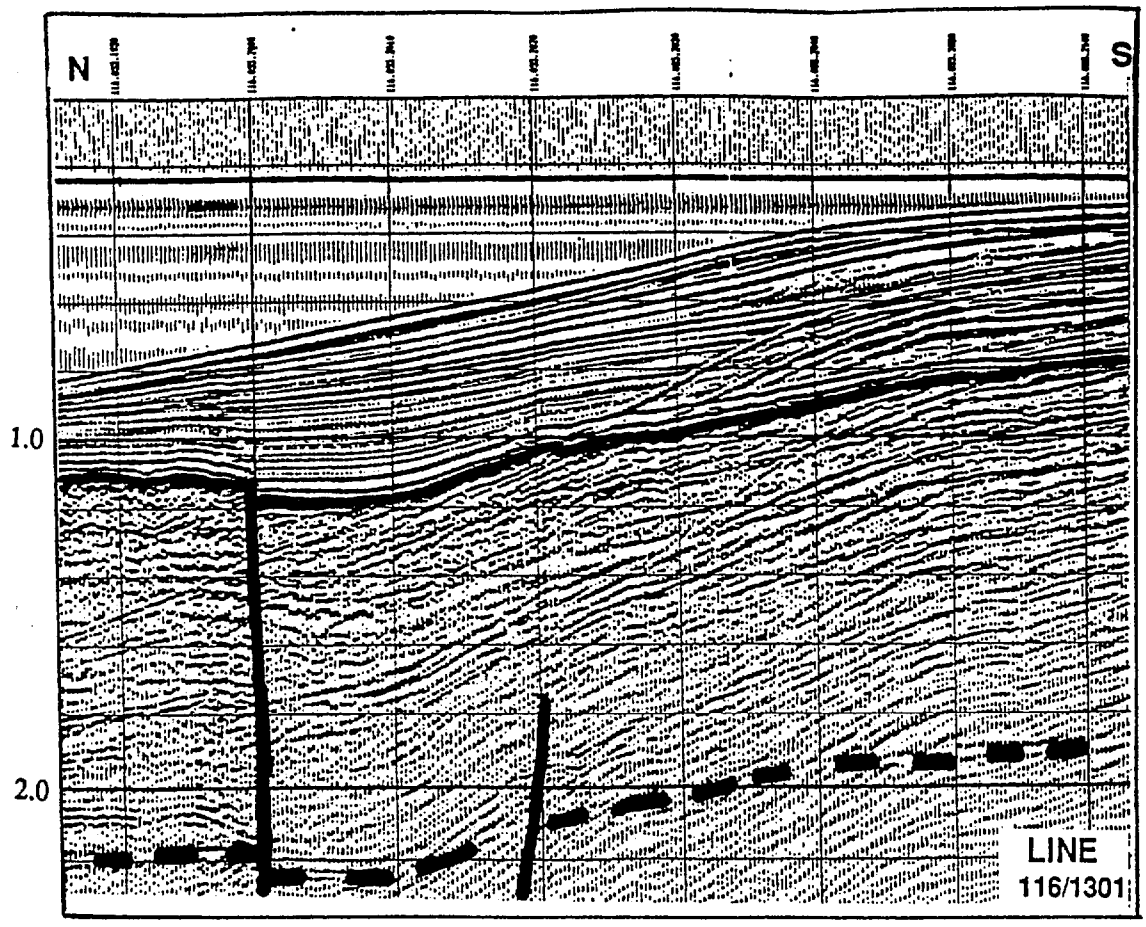


Figure 14: Unconformity at top of carbonate sequence (?Middle Miocene) overlain by prograding ?Pliocene to Pleistocene clastics. Possible ?top Permian reflector in lower part of section.

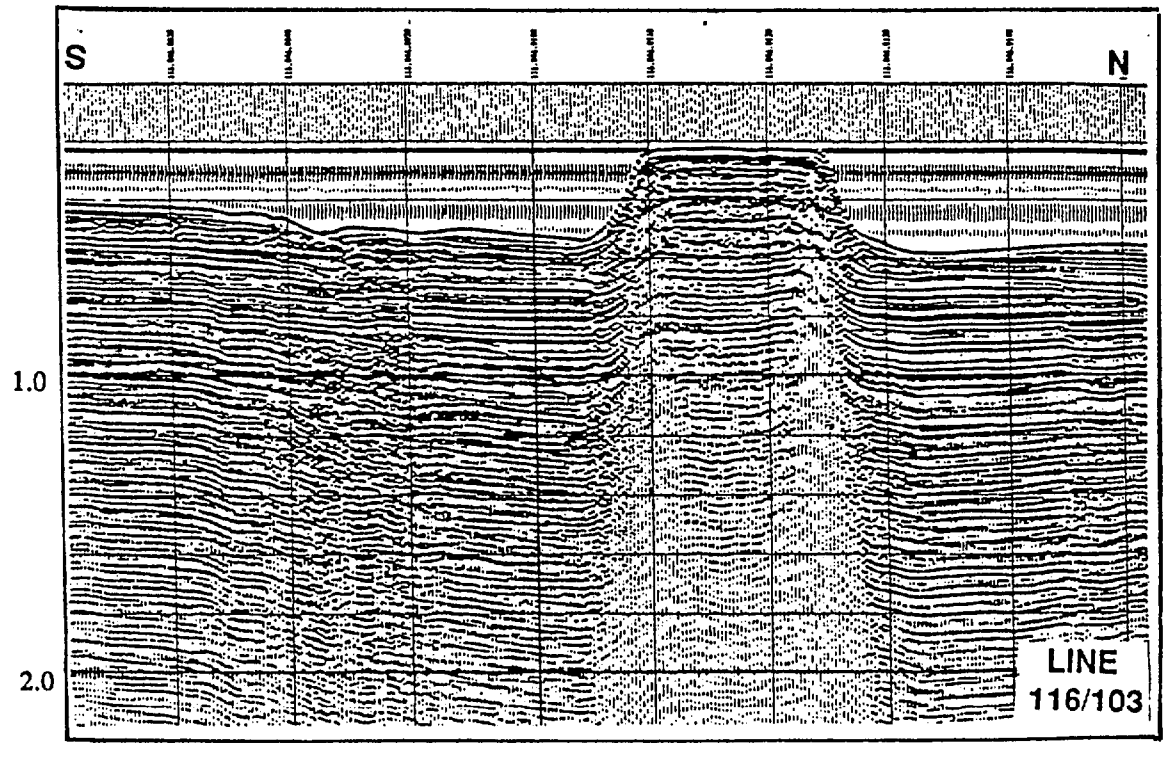


Figure 15: Drowned (?) patch reef at 33m water depth on upper slope. Apparent drowning is typical for this area.