AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Record Number

BMR RECORD 1991/67

SURVEY 97

Operations Report For The Joint BMR/Woodside Petroleum High Resolution Seismic Program In The Dampier Sub-Basin October 1990

G.W. O'Brien & G.P. Bickford

AGSO

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EXECUTIVE SUMMARY

Seismic acquisition for the joint BMR-Woodside Petroleum program in the Dampier Sub-Basin started at 0800 am on October 24, 1990 and was completed at 1150 am on Sunday October 28, 1990. A total of 352 km of high resolution seismic data was collected along the 17 agreed survey lines, of which 336 km were full stack data with a total 390 magnetic tapes being used. Data quality appears to be good. In addition to the seismic, a total of 530.6 km of water column geochemical data were also collected.

INTRODUCTION

A joint BMR-Woodside scientific research program was carried out between October 22 and 28, 1990 to investigate the shallow subsurface structure of part of Woodside's permit WA-28-P in the northern Dampier Sub-Basin. In particular, the study focussed on an area between the Wanaea and Angel hydrocarbon discoveries (Figure 1). The study was conducted by the Bureau of Mineral Resources' Division of Marine Geosciences and Petroleum Geology using a high-resolution seismic system on-board BMR's research vessel R.V. *Rig Seismic* (Appendix 1). The system consisted of a 400 cu.in. watergun array and a 900 m cable of 144 channels (Figure 5; Appendix 2). An independent study of the hydrocarbon gas compositions of the seawater in the area was also carried out (see Figure 3). These water column geochemical data (total 530.6 km) were collected both independently of, and simultaneously, with seismic acquisition. These data will contribute to a study presently being conducted by BMR and TEG (of San Diego, USA) to evaluate the usefulness of direct hydrocarbon detection (DHD) as a tool in assessing hydrocarbon accumulations within Australian waters. Complete details of the DHD aspect of the program are provided in BMR Record 1991/55. During the survey, bathymetry, and gravity data were also acquired as part of routine systems operations. Magnetic and side-scan sonar data was not acquired during the survey.

CRUISE SUMMARY

R.V. *Rig Seismic* departed Fremantle at approximately 1830 hours on Thursday, October 18, 1990 and steamed to the area of the joint BMR-Woodside high resolution seismic investigation. The ship arrived in the vicinity of the Angel gas field at approximately 0730 hours on Monday October 22. The next 48 hours were spent balancing the seismic cable and testing the seismic acquisition system. During this period, water column geochemical (direct hydrocarbon detection (DHD)) data were acquired in a loose grid over the Wanaea and Angel fields (see Table 3). Seismic and DHD acquisition began at 0800 hours on Wednesday, October 24 (see Tables 1 & 2), with DHD data being collected at the same time (Table 4). Data quality was satisfactory, though noise levels on lines 3 to 13 were higher than desired. This noise was attributed to sea-state, though checking of the electronic systems was instigated to determine whether the noise was system-related. By 1200 hours on Friday October 26, 1990, a total of 13 high resolution lines had been acquired. At this time it was discovered that an earth loop had contributed to noise levels on lines 3 to 13. While it was considered highly likely that this noise would stack-out during processing, it was decided to repeat lines 3 to 9, most of which were over Cossack/Wanaea and hence were considered to be the highest priority lines. The survey then continued with an improved noise level and lines 3 to 9 were reshot (as lines 14 to 20). The other remaining lines were shot and acquisition was completed at 1150 am on Sunday October 28, 1990. Rig Seismic then sailed to Dampier Harbour, arriving at approximately 730 pm. Jim Taminga (Woodside) and Jack Pittar (BMR) and the magnetic tapes from the survey were then transferred to a pilot boat in the harbour. The tapes were then air-freighted to BMR (Canberra) for demultiplexing and copying (see later).

All of the program objectives were achieved. A total of 490.5 km of seismic was acquired during the program. Of this, 138 km were along lines that had to be reshot because of the earth loop fault. Consequently, a total of 352.5 km of high resolution seismic were collected along the 17 agreed survey lines, of which 336 km were full stack data.

NAVIGATION

The primary navigation system was Woodside's differential GPS system with a base station at King Bay near Dampier, Western Australia. Additional systems on board included GPS, transit satellite and sonar doppler (Appendix 2). All systems performed well.

SEISMIC SYSTEM PERFORMANCE

Seismic System

The seismic system performed well with few failures. Noise levels were generally low, particularly after the earth loop fault was rectified. Noise levels on the last two lines (Lines 97/023 and 97/024) were higher than desired because of deteriorating sea conditions.

Demultiplexing and Transcription of BMR Field Tapes for the BMR/Woodside Co-Operative Research Program

The field recording format for the survey was modified so that a sample rate of 1 millisecond could be recorded with a shot interval of 12.5 m, a group interval of 6.25 m, recording 144 seismic channels (160 total), 36 fold at a 2 second record length.

The field data was therefore recorded in BMR special floating point 4 bit exponent, 12 bit mantissa (total 16 bit), multiplexed format. Comprising 2080 bits seismic plus 120 word header for a total 2200 by 16 words. The data was blocked in groups of 13 with a trace every block, thereby retaining 160 trace headers for each shot record. The field tapes were demultiplexed and transcribed into standard SEG-Y format at the BMR Processing Centre and the data were then transferred to Digital Exploration Australia for further processing. The data supplied to Digital Exploration Australia were 32 bit vax floating point trace sequential (SEG-Y) and 280 tapes were transcribed and forwarded, out of a total of 390 tapes. The SEG-Y magnetic tape header format and the instantaneous floating point format are given in Appendix 3.

Lines 3 to 9 (tapes 97/039 to 97/146) were reshot as lines 97/014 to 97/020 because of noise problems. Consequently these tapes were not transcribed. The first shipment of data to Digital Exploration Australia's office was made on the 9th of November 1990, and the second and last shipment was made on the 21st of November 1990.

Watergun Array Timing

On this survey 5 S80 waterguns were used, spaced 2.5 metres apart at a depth of 5 metres. The buoys and gun string were towed on separate bridles such that the depth was constant despite changes in ship's speed and direction, and minor adjustments of depth could be made from the ship. Air pressure was kept constant at 1800PSI.

Depth for each gun was sensed using Teledyne depth sensors and the shot instant for each gun was detected by Teledyne source sensors. Since the rate at which the cavitation volume from the watergun collapses depends upon the depth, both local wave action and buoy movement have as much effect on gun timing as the normal variations due to air pressure and gun wear. To overcome these variations the depth of each gun is sensed just prior to the shot and a variation to the predicted firing time for each gun is made accordingly. Figure 4 shows the results of an in-harbour experiment to determine firing delay versus depth of our arrangement, the linear approximation we used for operation at 5 metres, and the compensation applied immediately prior to the time of firing.

The waterguns worked well during the survey, though an unusually high number of shot sensors failed.

DIRECT HYDROCARBON DETECTION

Direct hydrocarbon detection data were acquired in two phases. The first phase consisted of eight lines on which only DHD data were acquired. These data were collected while the seismic system was being set up and tested. A list of these lines is given in Table 3. The second phase of DHD data collection was carried out simultaneously with high resolution seismic acquisition and consisted of 17 lines (Table 4). No DHD data were acquired during the reshooting of seismic lines 97/003 to /009, though a total of 530.6 km of DHD data were acquired during the program.

Results

No significant hydrocarbon anomalies were detected on any of the lines, in spite of the fact that many of the lines ran over major hydrocarbon accumulations. This indicated that the major reservoir horizons are well-sealed and that little opportunity exists for significant vertical hydrocarbon migration to shallow depths. However, minor increases in total hydrocarbon were observed over some of the wells/fields. The largest increases in THC was observed on Line 97/022 approximately over Montague #1 where the value increased from a background level of 16ppm to a high of 22.8ppm. There was no increase in any of the light hydrocarbon gases. An increase in i-heptane and i-octane was also observed over the same well. Although no major anomalies were found in this area DHD is useful in indicating that all structures are well sealed and that the completions on all of the wells are secure, with the possible exception of Montague #1. The DHD 'fish' was towed between 10 and 20 metres above the sea floor with the exception of the immediate vicinity of the well heads were the fish was between 20 and 25 metres above the sea floor. Conductivity, temperature and bathymetric data were also collected in conjunction with the hydrocarbon data. Total hydrocarbon values dropped suddenly on lines VP970AB and 970CD within 10 metres of the sea floor. The decrease in THC data appears to be related to changes in water temperature and conductivity.

ACKNOWLEDGEMENTS

This report was partly compiled using contributions from F. Brassil, E. Chuydk, J. Marshall, P. Napier & J. Pittar. I wish to thank all BMR and DOT staff who contributed to the success of the program, as well as Franz Wehebrink and Paul Senycia of Woodside Petroleum Limited for helpful discussions prior to and during the survey.

TABLES

Table 1. Proposed coordinates for seismic lines shot during the cooperative BMR/Woodside survey.

BMR LINE #	WOODSIDE LINE#	WOODSIDE WAYPOINTS	LATITUDE (S)	LONGITUDE (E)
LINE 97/001	9	L9-START	19 31.54217	116 30.43317
	9	L9-B1	19 36.46267	116 25.09617
	9	L9-B2	19 37.47150	116 23.90283
	9	L9-END	19 39.57567	116 20.91883
LINE 97/002	15	L15-START	19 37.38067	116 21.60117
	15	L15-B1	19 34.04233	116 28.32067
	15	L15-B2	19 31.75733	116 32.86600
	15	L15-END	19 29.87533	116 36.63417
LINE 97/003	8	L8-START	19 27.212	116 40.53850
	8	L8-B	19 30.77683	116 35.07417
	8	L8-END	19 39.568	116 22.42917
LINE 97/004	1	L1-START	19 39.473	116 25.43383
	1	L1-END	19 35.88033	116 20.96567
LINE 97/005	2	L2-START	19 34.3685	116 21.69317
	2	L2-END	19 38.53133	116 27.05450
LINE 97/006	3	L3-START	19 38.58283	116 30.04617
	3	L3-END	19 31.08	116 20.48400
LINE 97/007	4	L4-START	19 32.938	116 24.84967
	4	L4-END	19 36.46617	116 29.17100
LINE 97/008	5	L5-START	19 35.48267	116 30.11533
	5	L5-END	19 31.97417	116 26.4555
LINE 97/009	6	L6-START	19 31.36917	116 27.91917
	6	L6-END	19 34.89367	116 31.44950
LINE 97/010	16	L16-START	19 38.58583	116 30.16517
	16	L16-END	19 26.35300	116 29.40300
LINE 97/011	17	L17-START	19 27.09033	116 28.22533
	17	L17-END	19 28.09033	116 33.96983
LINE 97/012	7	L7-START	19 28.09033	116 33.96988
	7	L7-END	19 33.37567	116 38.62483
LINE 97/013	12	L12-START	19 33.64533	116 38.12767
	12	L12-END	19 27.77233	116 36.49683
LINE 97/014	8	L8-START	19 27.212	116 40.53850
	8	L8-B	19 30.77683	116 35.07417
	8	L8-END	19 39.568	116 22.42917
LINE 97/015	1	L1-START	19 39.473	116 25.43383
	1	L1-END	19 35.88033	116 20.96567

LINE 97/016	2	L2-START	19 34.3685	116 21.69317
	2	L2-END	19 38.53133	116 27.05450
LINE 97/017	3	L3-START	19 38.58283	116 30.04617
	3	L3-END	19 31.08	116 20.48400
LINE 97/018	4	L4-START	19 32.938	116 24.84967
	4	L4-END	19 36.46617	116 29.17100
LINE 97/019	5	L5-START	19 35.48267	116 30.11533
	5	L5-END	19 31.97417	116 26.4555
LINE 97/020	6	L6-START	19 31.36917	116 27.91917
	6	L6-END	19 34.89367	116 31.44950
LINE 97/021	10	L10-START	19 30.36817	116 30.81017
	10	L10-END	19 37.34933	116 21.92117
LINE 97/022	14	L14-START	19 39.49333	116 22.93483
	14	L14-B	19 32.46033	116 21.31700
	14	L14-END	19 29.20517	116 20.69800
LINE 97/023	11	L11-START	19 33.9095	116 23.80967
	11	L11-END	19 32.33	116 38.70033
LINE 97/024	13	L13-START	19 33.51250	116 37.38150
	13	L13-END	19 26.87250	116 39.87667

Table 2. Actual coordinates for seismic lines shot during the cooperative BMR/Woodside survey.

Line #	Start (GMT)	End (GMT)	Latitude Start Finish	Longitude Start Finish	Line Length nm/km	Bearing
97/001	297/0008	297/0305	19 30.8	116 31.2	14.24	225.6
			19 40.3	116 19.9	26.39	
97/002	297/0347	297/0752	19 38.3	116 19.8	19.21	62.2
			19 29.3	116 37.8	35.60	
97/003	297/1001	297/1652	19 26.8	116 41.1	23.02	235.3
			19 40.3	116 21.4	42.65	
97/004	297/1859	297/2029	19 40.1	116 26.3	7.51	310.5
			19 35.2	116 20.1	13.91	
97/005	297/2148	297/2326	19 33.7	116 20.9	8.22	129.5
			19 38.9	116 27.5	15.24	
97/006	298/0100	298/0335	19 39.1	116 30.7	13.22	309.8
			19 30.7	116 20.0	24.49	
97/007	298/0712	298/0840	19 32.4	116 24.2	7.51	130.9
			19 37.2	116 30.1	13.91	
97/008	298/1002	298/1133	19 36.8	116 31.5	8.05	315.5
			19 31.3	116 25.7	14.92	
97/009	298/1232	298/1352	19 30.9	116 27.5	6.92	136.7
			19 35.9	116 32.4	12.82	
97/010	298/1547	298/1833	19 39.7	116 30.2	14.04	356.6
			19 25.7	116 29.4	26.02	
97/011	298/2009	298/2131	19 27.0	116 27.5	7.12	100.5
			19 28.2	116 34.6	13.20	
97/012	298/2304	299/0038	19 27.7	116 33.6	8.22	140.3
			19 33.9	116 39.1	15.24	
97/013	299/0201	299/0328	19 34.2	116 38.3	7.12	345.3
			19 27.2	116 36.3	13.20	
97/014	299/0641	299/1345	19 26.7	116 41.4	23.44	235.4
			19 40.5	116 21.2	43.43	
97/015	299/1507	299/1647	19 40.8	116 27.1	8.22	310.5
			19 35.5	116 20.5	15.24	
97/016	299/1801	299/1934	19 34.0	116 21.2	7.69	129.5
			19 38.9	116 27.5	14.25	
97/017	299/2327	300/0202	19 39.1	116 30.6	13.22	309.8
			19 30.7	116 20.0	24.49	
97/018	300/0338	300/0507	19 32.5	116 24.3	7.51	130.9
			19 37.3	116 30.2	13.91	
97/019	300/0552	300/0720	19 36.5	116 31.1	7.51	315.5
			19 31.1	116 25.5	13.91	
97/020	300/0852	300/1102	19 32.8	116 29.3	4.11	136.7
			19 35.9	116 32.5	7.62	
97/021	300/1258	300/1530	19 29.8	116 31.6	13.11	230.2
			19 38.0	116 21.0	24.29	
97/022	300/1701	300/1921	19 40.2	116 23.1	11.87	347.8
			19 28.6	116 20.6	21.99	
97/023	300/2118	301/0021	19 34.0	116 23.2	15.38	83.6
			19 32.3	116 39.4	28.51	
97/024	301/0213	301/0351	19 33.9	116 37.2	8.22	19.5
			19 26.3	116 40.1	15.24	

Table 3. Direct hydrocarbon detection survey lines, Dampier Sub-Basin.

Line Number	Latitude Start Latitude Finish	Long. Start Long. Finish	J. Day Start J. Day Finish	GMT Start GMT Finish	Line Length nM/km
97/AB	19 25.165 19 34.559	116 35.058 116 43.470	295 295	0850 1234	12.00/22.24
97/CD	19 35.542 19 25.675	116 41.164 116 32.153	295 295	1349 1626	12.9/23.9
T97/DQ	19 25.547 19 34.381	116 32.045 116 18.582	295 295	1628 2000	15.4/28.54
97/QR	19 34.500 19 44.826	116 18.868 116 27.212	296 296	0125 0408	13.0/24.09
97/OP	19 44.980 19 33.041	116 27.729 116 20.454	296 296	0414 0712	16.0/29.65
97/ MN	19 36.2 19 42.8	116 24.8 116 30.3	296 296	0723 1040	15.0/27.80
970 /KL	19 31.1 19 41.7	116 23.3 116 31.6	296 296	1045 1617	13.0/24.09
97/IJ	19 29.880 19 40.537	116 25.853 116 34.328	296 296	1713 2045	13.0/24.09
97/GH	19 40.652 19 32.527	116 35.59 116 32.628	296 296	2046 2259	13.6/25.2

Table 4. Geochemical data collected simultaneously with seismic data: Dampier Sub-Basin

Line Number	Latitude Start Latitude Finish	Long. Start Long. Finish	J. Day Start J. Day Finish	GMT Start GMT Finish	Line Length (nm) (km)
97/001	19 31.599	116 30.397	297	0000	12.0
	19 39.667	116 20.8	297	0253	22.24
97/002	19 37.251	116 21.863	297	0408	17.2
	19 29.81	116 36.75	297	0731	31.87
97/003	19 27.212	116 40.530	297	1006	21.0
	19 37.800	116 22.100	297	1637	38.91
97/004	19 39.345	116 25.281	297	1910	5.53
	19 35.628	116 20.623	297	2200	10.25
97/005	19 34.538	116 21.911	297	2200	6.5
	19 38.505	116 27.014	297	2318	12.04
97/006	19 38.467	116 29.904	298	0110	11.7
	19 30.919	116 20.282	298	0328	21.68
97/007	19 31.958	116 23.646	298	0538	5.4
	19 36.906	116 29.718	298	0835	10.01
97/008	19 35.548	116 30.175	298	1021	5.0
	19 31.523	116 25.988	298	1129	9.27
97/009	19 31.474	116 28.026	298	1239	4.9
	19 35.219	116 31.774	298	1341	9.08
97/010	19 38.894	116 30.187	298	1554	12.2
	19 26.170	116 29.396	298	1824	22.61
97/011	19 27.132	116 28.505	298	2017	5.5
	19 28.002	116 33.511	298	2124	10.19
97/012	19 28.197	116 34.072	298	2310	6.92
	19 33.476	116 38.692	299	0030	12.82
97/013	19 33.286	116 38.025	299	0210	6.0
	19 27.671	116 36.468	299	0320	11.12
97/021	19 30.482	116 30.625	300	1309	11.0
	19 37.639	116 21.548	300	1522	20.38
97/022	19 39.197	116 22.870	300	1710	10.5
	19 28.995	116 20.659	300	1914	19.46
97/023	19 33.883	116 24.037	300	2126	14.1
	19 32.354	116 38.880	301	0014	26.13
97/024	19 33.136	116 37.541	301	0220	7.0
	19 26.784	116 39.920	301	0342	12.97

FIGURES

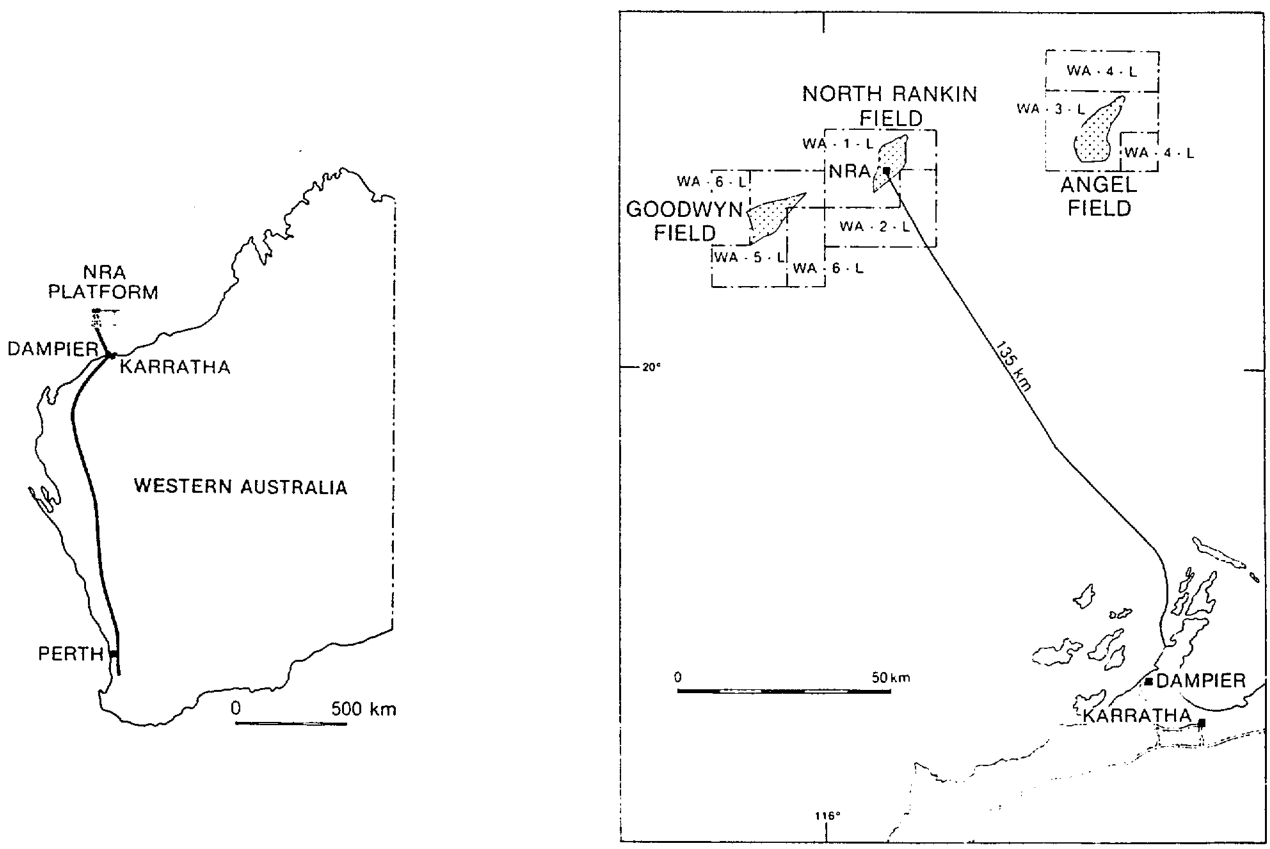


Figure 1. Location map, cooperative BMR/Woodside survey area.

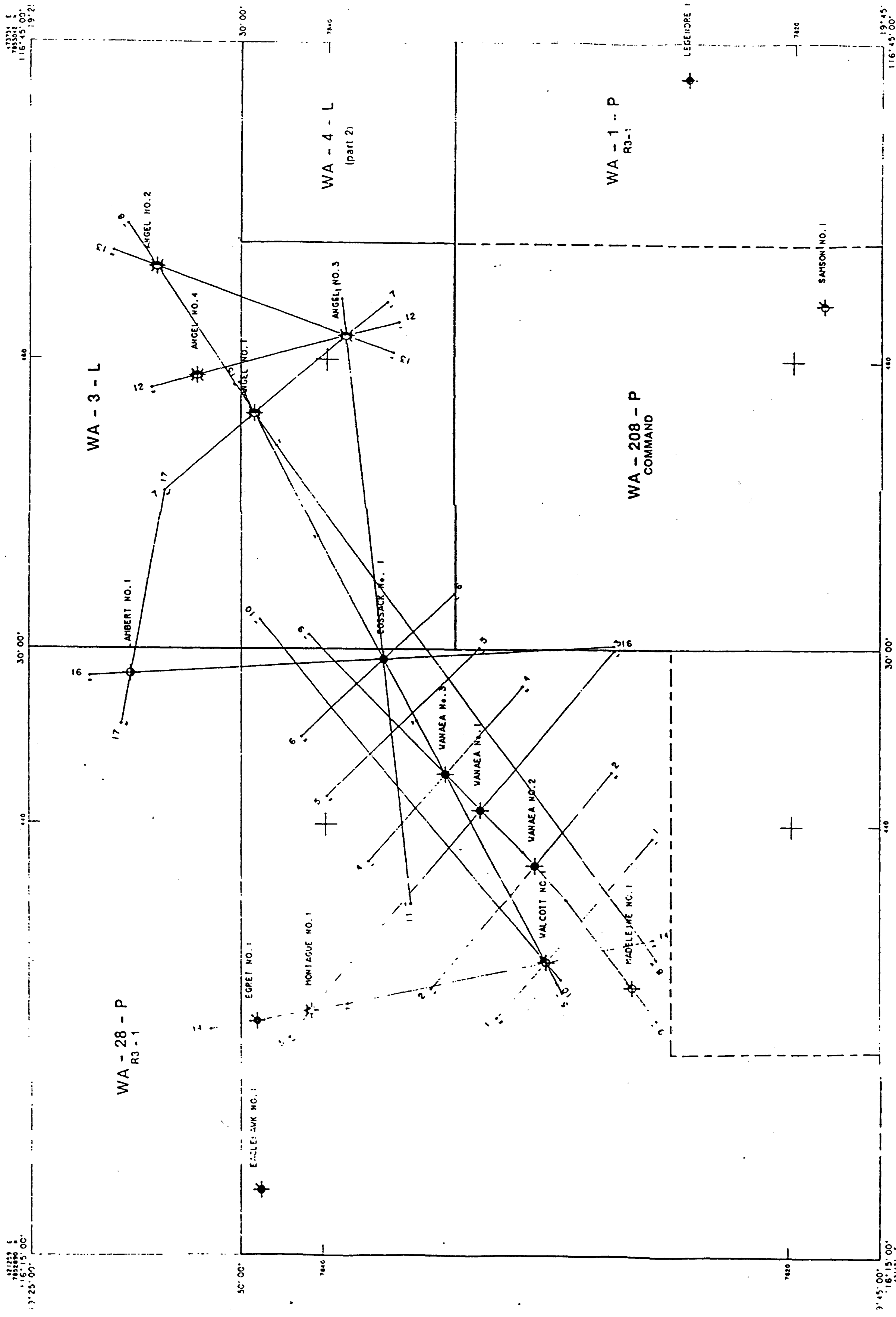


Figure 2. Survey map showing the location of the combined high resolution seismic and geochemical survey lines, Dampier Sub-Basin.

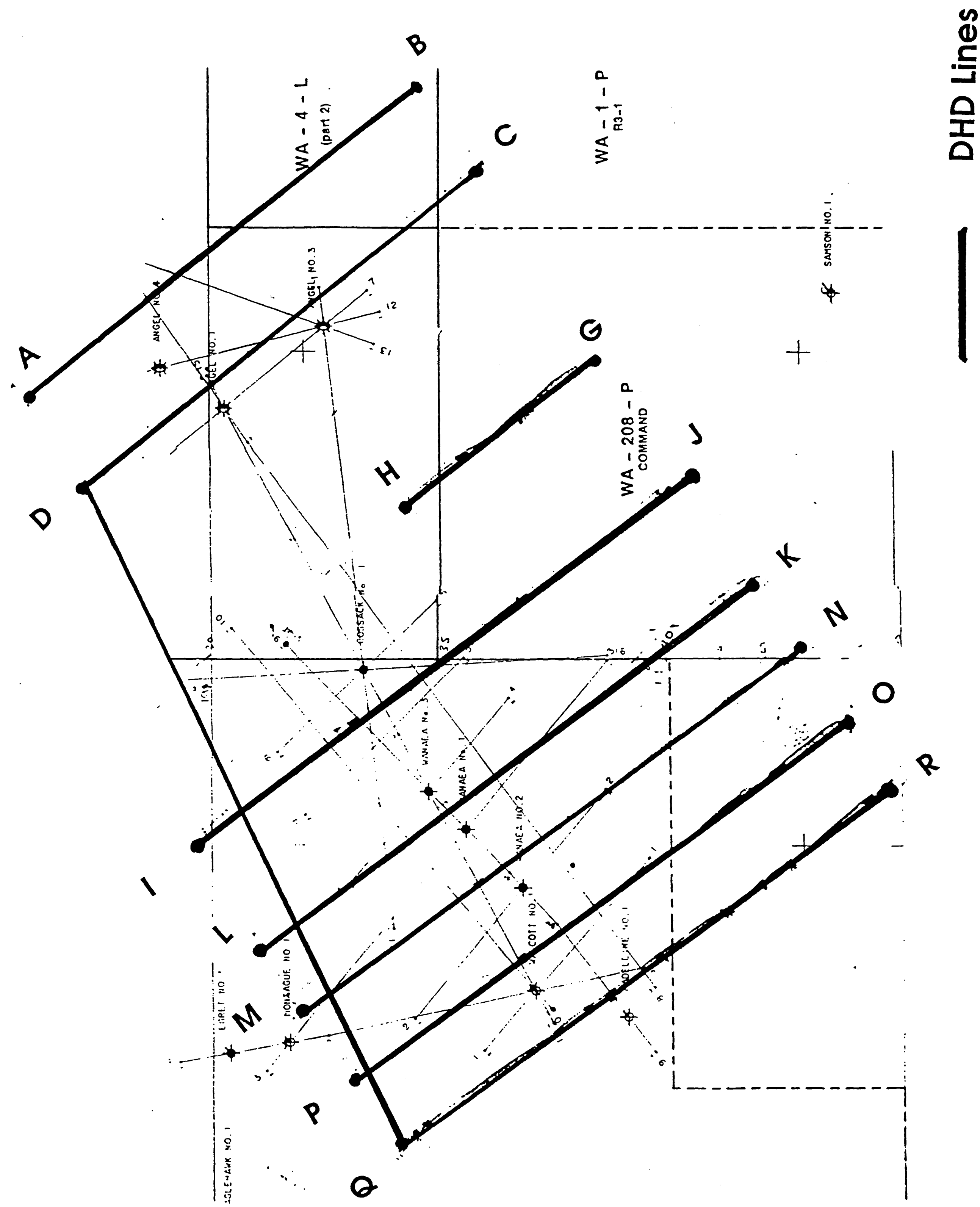


Figure 3. Survey map showing the location of the geochemical survey lines, Dampier Sub-Basin.

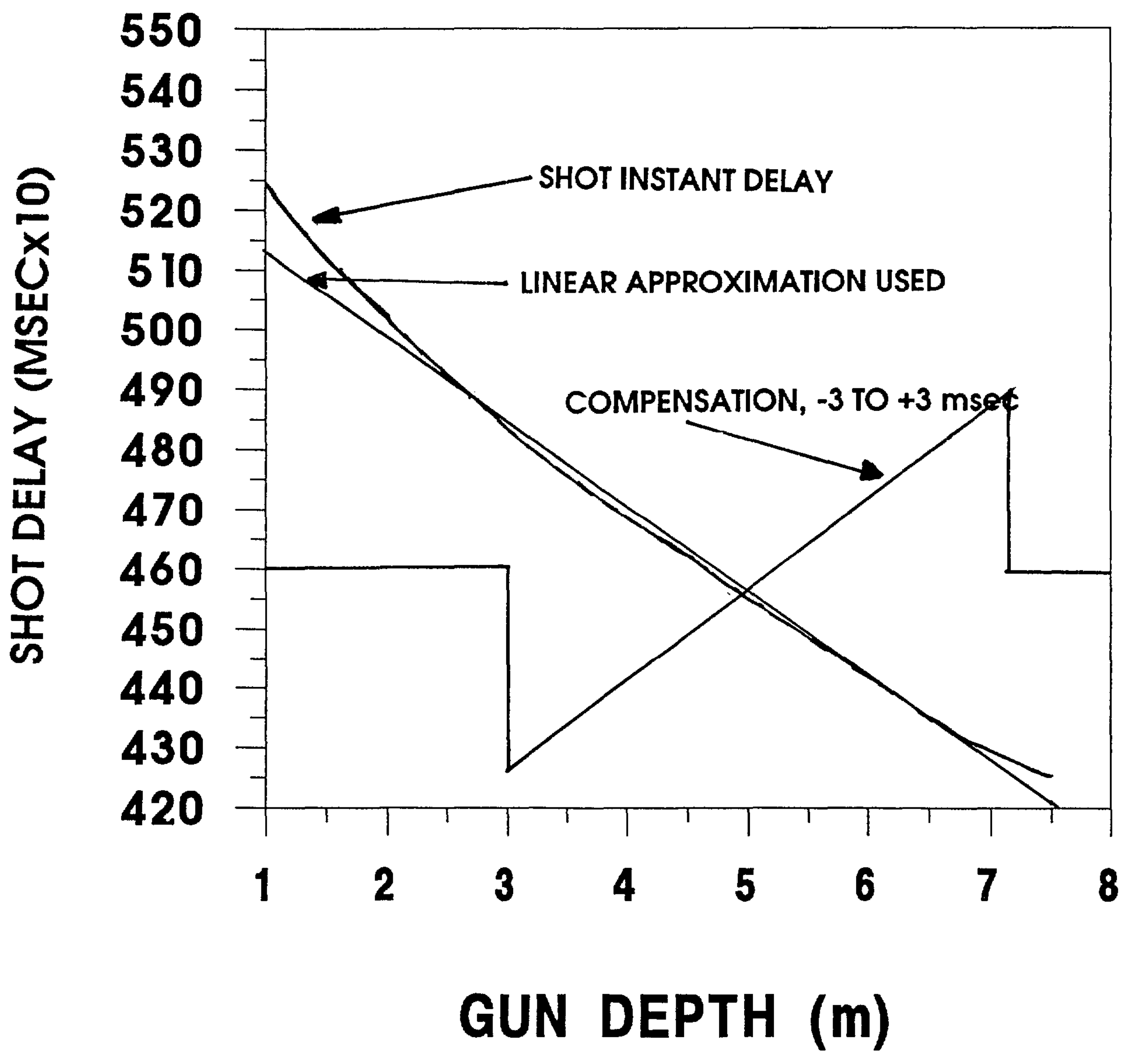
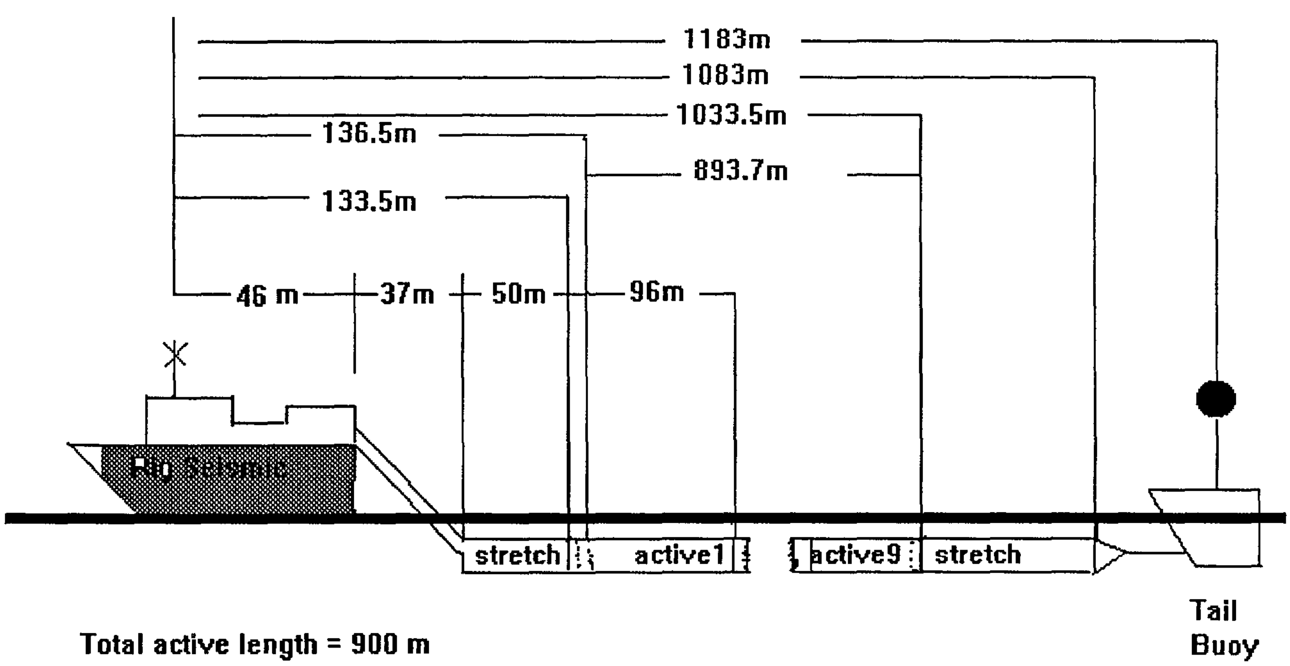


Figure 4. Relationship between shot delay and gun depth for the system employed during the BMR/Woodside high resolution survey, Dampier Sub-Basin.



Total active length = 900 m
Near offset (source) = 54.5 m
Near offset (antenna) = 136.5 m
Cable depth = 5 m
Far offset source = 948.2 m

Figure 5. Schematic of the seismic cable employed during the BMR/Woodside high resolution survey, Dampier Sub-Basin.

APPENDIX 1

GENERAL DETAILS:-RESEARCH VESSEL RIG SEISMIC

R/V Rig Seismic is a seismic research vessel with dynamic positioning capability, chartered and equipped by BMR 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 BMR by the Federal Department of Transport and Communications.

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

SURVEY PERSONNEL

BMR

Cruise Leader:- G.W. O'Brien

Deputy Cruise Leader:- J.F. Marshall

Scientific Staff:- G. Bickford, J. Bishop & R. Whitworth

Systems Officers:-F. Brassil & E. Chudyk

Technical Staff:- J. Bedford, R. Curtis, B. Dickinson, S. Davey, P. Davies, C. Green, L. Hatch, T. McNamara, S. Milnes, J. Pittar, D. Pryce, A. Radley, D. Sewter, C. Tindall, J. Whatman & P. Vujovic,

D.O.T.

Master:- A. Codrington

Chief Officer:- W. McKay

Second Officer:- M. Gusterson

APPENDIX 2

SCIENTIFIC EQUIPMENT

GEOPHYSICAL SCIENTIFIC EQUIPMENT

NON-SEISMIC SYSTEMS

General

Raytheon echo sounders: 3.5 Khz (2 KW) and 12 Khz (2 KW)

Geometrics G801/803 magnetometer/gradiometer

Bodenseewerk Geosystem KSS-31 marine gravity meter

E.G. & G. model 990 side scan sonar

Nichiyu Giken Kogyo model NTS-11Au heatflow probe

Navigation

Trimble Differential GPS System (Woodside)

Magnavox T-set Global Positioning System

Magnavox MX 1107RS and MX 1142 transit satellite receivers

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

Arma Brown and Robertson gyro-compasses; plus Ben paddle log

Decca HIFIX-6 radio-navigation system, modified for long range operations

SEISMIC SYSTEM

Seismic cable:

Fjord Instruments, transformerless analogue

Maximum of 288 seismic channels, 12 auxiliary channels

10 Teledyne T-1 hydrophones per 6.25 metre group

Nominal sensitivity 20 Volts/Bar for standard group

Oil blocks to reduce low frequency noise

6.25, 12.5, (18.75), and 25.0 metre groups available

288 seismic channels, 12 auxiliary channels

Maximum towable length 6000 metres

3600 metres available at present (Sept 1990)

Energy Source:

5 x 80 cu.in. SSI S-80 watergun array
Gun depths 3 to 5 metres, spacing 2.5 metres
16 x 150 cu.in. HGS sleeve gun array (2 arrays)
16 x 160 cu.in. HGS Mod III airgun array (2 arrays)
Gun depths 5 to 15 metres, spacing 0.5 metres
Gun groups separated by 2.5 metres
Various gun groupings available
Configured as 6, 5, 3, and 2-gun groups
Usually fired as 4, 3, 2, and l-gun groups
Compressor capacity 1200 scfm nominal at 2000 psi

Recording Parameters:

Low noise charge-coupled preamplifiers
Preamplifier gain from 1 to 128 in 6 dB steps
Maximum of 320 channels including seismic and auxiliaries
LC filters 4, 8, 16, and 32 Hertz at 18 dB/octave
HC filters 90, 180, 360 and 720 Hertz at 140 dB/octave
Sampling rates of 0.5, 1, 2, and 4 millisecs
Record lengths from 2 secs to 20 secs
SEG-Y recording format with extension
IFP operating at 200 khz with special floating point format
Data recorded as 4-bit binary exponent and 12-bit mantissa

Other:

Reftek receiver and sonobuoys
Yaesu sonobuoy receiver and Spartan SSQ-57A sonobuoys
Raytheon echo sounders: 3.5 Khz (2 KW) and 12 Khz (2 KW)
Geometrics G801/803 magnetometer/gradiometer

SEISMIC SYSTEM CONFIGURATION FOR HIGH RESOLUTION PROGRAM. DAMPIER SUB-BASIN

The recording parameters used during the experimental high resolution seismic survey in the Dampier Sub-Basin were as follows and are depicted in Figure 2.

Source

5 X S80 water guns
80 cu in per gun (air)
2000 psi air pressure

gun spacing 2.5 metres
gun depth 5 metres.

Streamer

Fjord Instruments transformerless.
10 Teledyne T-I hydrophones per 6.25m group.
900 m cable, 144 seismic channels,
group interval 6.25 m.
depth 5m nominal.

Field Data

8 hz - 256 hz passband
1 ms blocked multiplexed
up to 3 sec record length
nominal 4.85 second shot rate
shot interval 12.5m for 36 fold CDP coverage
Shot-to-group 1 offset : 100 m if achievable

Seismic data supplied in SEG-Y format, special floating point format, 4 bit binary exponent, 12 bit mantissa. Conversion routines supplied.

High Resolution Source Rationale

BMR has been developing a seismic energy source specifically for use in high resolution surveys. The energy source is built around five S-80 waterguns of 80 cu.in. capacity manufactured by Seismic Systems Incorporated of Houston USA. The primary objective is to have an energy source that has a variable output energy level but an invariant power spectrum and signal waveform. By using multiple waterguns separated by more than their interaction distance, we can use from one to five guns without changing the output signal shape. It also has the advantage of a "clean" signal without bubble pulse that might obscure near-surface detail in the field. These advantages are considered to outweigh the disadvantage of a non-minimum phase energy source. Preliminary tests of the watergun array have been encouraging. Reliability and repeatability of individual gun signatures has been good.

GEOCHEMICAL SCIENTIFIC EQUIPMENT

Water Column Geochemistry

The Direct Hydrocarbon Detection (DHD) method continuously analyzes C_1-C_8 hydrocarbons within seawater. Thermogenic hydrocarbons migrating up faults from source rocks and/or hydrocarbon reservoirs debouch into the seawater at the seafloor, producing higher concentrations of light hydrocarbons within the water column. These seep gases have molecular compositions that are distinctively different from that of the biogenically-produced hydrocarbons which are mainly produced by *in situ* processes in seawater. If the hydrocarbons are present in sufficient amounts, the molecular composition of the thermogenic hydrocarbons may be used to infer whether the primary source of the seep was oil, condensate or dry gas.

The method used on the RV `Rig Seismic' is as follows. Seawater is continuously delivered into the geochemical laboratory onboard the ship via a submersible fish (which is towed approximately 10 m above the seafloor). The seawater is degassed in a vacuum chamber and the resulting headspace gas is injected into three gas chromatographs which sequentially sample the flowing gas stream and measure a variety of light hydrocarbons. Total hydrocarbons (THC) are measured every thirty seconds, light hydrocarbons (c_1-C_4) are measured every two minutes and C_5 to C_8 are measured every 8 minutes. These data, as well as fish altitude (above the seafloor), the depth of the fish, hydrographic (temperature and salinity) and navigation data are recorded on computer. All these data are recorded and displayed continuously so that any hydrocarbon anomalies in the water column can be quickly recognised and additional measurements can be made when appropriate. Detection sensitivity is approximately 10 parts per billion in the stripped headspace sample. At a ship speed of 4 knots, the measurement of THC is made every 70 m, C_1-C_4 every 250 m and C_5 to C_8 every 1400 m.

APPENDIX 3

DATA FORMATS

SEGY-Y MAGNETIC TAPE HEADERS

The BMR field tapes are written in a modified SEG-Y format.

The records are written in 16-bit fixed point format (sample code 3) as defined in the report: *Recommended Standards for Digtital Tape Formats, Geophysics, vol 40, No 2 (April 1975) pp 344-352.*

The first 3200 bytes on the tape are the ASCII reel identification header.

The next 400 bytes are the binary coded block part of the reel identifaction header.

The 240 byte trace headers are in 16-bit fixed point format and is standard for the non-optional words.

The trace data is in BMR's Instantaneous Floating Point format (IFP). The format of these data is given in this appendix

SEGY-Y MAGNETIC TAPE HEADERS

A.1 DEFINITION OF TAPE HEADERS

Binary reel header for SEG-Y format magnetic tapes

WORD	DESCRIPTION	FORMAT
1-2	SURVEY NUMBER	I-32
3-4	LINE NUMBER (only one line per tape)	I-32
5-6	TAPE NUMBER	I-32
7	NUMBER OF SEISMIC TRACES PER SHOT	I-16
8	NUMBER OF AUXILIARY CHANNELS	I-16
9	SAMPLE INTERVAL (microsecs) (for this tape)	I-16
10	SAMPLE INTERVAL (microsecs) (for original recording)	I-16
11	NUMBER SAMPLES PER DATA TRACE (for this tape)	I-16
12	NUMBER SAMPLES PER DATA TRACE (for original recording)	I-16
13	DATA FORMAT CODE 1. floating point (4 bytes) 3. fixed point (2 bytes) ?. floating point (2 bytes)	I-16
14	CDP FOLD	I-16
15	TRACE SORTING 1. as recorded (preset to this)	I-16
16	VERTICAL SUM CODE 1. no sum (preset to this)	I-16
17-26	unassigned	
27	AMPLITUDE RECOVERY METHOD 1. none (preset to this)	I-16
28	MEASUREMENT SYSTEM 1. metres	I-16
29-200	unassigned	

SEGY-Y MAGNETIC TAPE HEADERS

Standard portions of SEG-Y format used by Marine Division

WORD	DESCRIPTION	FORMAT
1-2	TRACE SEQUENCE NO. WITHIN LINE	I-32
3-4	TRACE SEQUENCE NO. ON TAPE	I-32
5-6	FIELD SHOT POINT NUMBER	I-32
7-8	CHANNEL NUMBER WITHIN SHOT	I-32
9-14	unassigned	
15	TRACE IDENTIFICATION CODE	I-16
	*1 - seismic data	
	*2 - dead	
	*3 - dummy	
	4 - time break	
	5 - uphole (land only)	
	6 - sweep	
	7 - timing	
	*8 - water break	
	*9 - oscillator test	
	*10 - noise test	
	*11 - cable/oscillator test	
	*12 - airgun signature	
	*13 - airgun shuttle sensor	
	*14 - sonobouy	
	Note: * indicates implemented in this system	
16	NO. OF VERTICALLY STACKED TRACES (preset to 1)	I-16
17	NO. OF HORIZONTALLY STACKED TRACES (preset to 1)	I-16
18	DATA USE	I-16
	1. production (preset to this)	
	2. test data	
19-20	DISTANCE FROM SOURCE TO RECEIVER (negative value as opposite to travel direction)	I-32
21-22	GROUP DEPTH (negative as below sea level)	I-32
23-24	SURFACE ELEVATION AT SOURCE (preset to 1)	I-32
25-26	SOURCE DEPTH (negative as below sea level)	I-32
27-28	DATUM ELEVATION AT RECEIVER GROUP	I-32
29-30	DATUM ELEVATIONAT SOURCE	I-32
31-32	WATER DEPTH AT SOURCE	I-32
33-34	WATER DEPTH AT GROUP	I-32
35	DEPTH SCALAR (preset to -10)	I-16
36	CO-ORDINATE SCALER (preset to 1)	I-16
37-54	unassigned	
46	AUX. GAIN (set temporarily)	I-16
55	RECORDING DELAY IN (millisecs)	I-16
56-57	unassigned	
58	NUMBER OF SAMPLES IN RECORD	I-16
59	SAMPLE INTERVAL (microsecs)	I-16
60	GAIN TYPE OF FIELD INSTR.	I-16
	1. fixed gain (preset to this)	
	3. floating point gain	

61	SEISMIC AMPLIFIER GAIN	I-16
62-74	unassigned	
75	LOW-CUT FILTER FREQUENCY	I-16
76	HIGH-CUT FILTER FREQUENCY	I-16
77	LOW-CUT FILTER SLOPE db/octave (preset at 18 dB/octave)	I-16
78	HIGH-CUT FILTER SLOPE db/octave (preset at 72 dB/octave)	I-16
79	SHOT INSTANT -year data recorded	I-16
80	SHOT INSTANT -day of year	I-16
81	SHOT INSTANT -hour of day	I-16
82	SHOT INSTANT -minute of hour	I-16
83	SHOT INSTANT -second of minute	I-16
84	TIME BASE CODE 1. local 2. GMT (preset to this) 3. other	I-16
85-90	unassigned	

<u>Usable words in SEG-Y trace header - July 1991</u>

WORD	DESCRIPTION	FORMAT
37	NUMBER OF SOURCE GUNS	I-16
38	GUN TRIGGER DELAYS FOR "CHANNEL" GUN IN 10ths OF MILLISECS	I-16
39	NUMBER OF SOURCE GUNS	I-16
40	GUN FIRING ERROR FOR "CHANNEL" GUN IN 10ths OF MILLISECS	I-16
41	NUMBER OF CABLE BIRD DEPTH SENSORS	I-16
42	DEPTH OF "CHANNEL" BIRD IN 10ths OF METRES	I-16
43	NUMBER OF CABLE BIRD WING ANGLES	I-16
41	ANGLE OF "CHANNEL" BIRD WING IN 10ths OF DEGREES	I-16
91	SHOT INSTANT - fraction of sec (msecs)	I-16
92	INTERVAL FROM LAST SHOT (msecs)	I-16

A.2 INSTANTEOUS FLOATING POINT FORMAT

The trace data is in 16-bit floating point format as follows:

```
1   1   1   1   1   1
5   4   3   2   1   0   9   8   7   6   5   4   3   2   1   0
---------------------------------------------------------------
| s|  exponent      |              mantissa                   |
---------------------------------------------------------------
```

The data is in 2's complement format with bits 0-10 the mantissa, bits 11-14 the exponent and bit 15 the sign.

The mantissa normally varies between 1024 and 2047 except when the exponent is zero.

The exponent can vary from 0 to plus or minus 9 only, a number is illegal if it has an exponent with an absolute value greater than 9.

The converted integer ranges of the floating point number for each exponent range and the equivalent voltage ranges (for positive values) are:

Exponent	Integer Range	Voltage Range
0	0 - 2047	0.0 - 0.01953125
1	2048 - 4097	0.01953125 - 0.0390625
2	4098 - 8193	0.0390625 - 0.078125
3	8192 - 16383	0.078125 - 0.15625
4	16383 - 32767	0.15625 - 0.3125
5	32768 - 65535	0.3125 - 0.625
6	65536 - 131071	0.625 - 1.25
7	131072 - 262143	1.25 - 2.5
8	262144 - 524287	2.5 - 5.0
9	524288 - 1048575	5.0 - 10.0

There are a total of 11264 IFP numbers possible for both positive and negative numbers.