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Cobar Basin Seismic Survey 1989: Operational Report

by K D Wake-Dyster

Record 1993/90

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COBAR BASIN SEISMIC SURVEY 1989: OPERATIONAL REPORT

by

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EXECUTIVE SUMMARY

A consortium consisting of the Bureau of Mineral Resources, Geology & Geophysics (BMR) (now called the Australian Geological Survey Organisation (AGSO)), Department of Primary Industries & Energy, Australian Government; the Department of Mineral Resources (DMR) (formerly the Department of Minerals and Energy), NSW State Government; CRA Exploration Pty. Ltd.; Geopeko Pty. Ltd.; Pasminco Pty. Ltd.; conducted the Cobar Basin Seismic Survey during October to December 1989.

The main objectives of the Cobar Basin seismic survey were to acquire deep reflection seismic data along several seismic lines across the Cobar Basin and the bounding west and east margins, and acquire high resolution seismic data across zones of known mineralisation in the Cobar Basin and bounding margins. The BMR Sercel SN368 seismic data acquisition system was used to record the deep reflection seismic data, and the DMR Sercel 338 seismic data acquisition system was used to record the high resolution seismic data. The acquisition of the seismic data would be used to test new tectonic models recently developed for the evolution of the region, and for genesis and control of mineralisation, especially in rock units of the Cobar Basin around Cobar. On a regional scale the acquisition of seismic data would be used to test models of basin formation in the Cobar region which perhaps could be applied elsewhere in the Lachlan Fold Belt.

The seismic reflection survey by the BMR, recorded 184 km of 8-fold CMP deep reflection seismic data to 20 seconds two-way travel time, along three seismic lines. The lines were positioned to investigate major structures defined by surface geology and postulated in the recently proposed tectonic models. To provide seismic reflection data of the near surface geological rock units, 2.85 km of high resolution seismic data were recorded along Line 2 by DMR, across a geological setting associated with mineralisation structures.

INTRODUCTION

1.1 Background

The Cobar seismic survey developed as an ACORP (Australian Continental Reflection Profiling) proposal by interested parties in New South Wales, to investigate the regional structures of the Cobar area using deep seismic reflection techniques. Models for the development of the Cobar Basin and structures controlling zones of mineralisation had been proposed by Glen, 1988.

For operation of the seismic survey, sponsorship funding was required. The Department of Mineral Resources (DMR) provided $95,000 in funding, with industry sponsorship being provided by CRA Exploration Pty. Ltd., Geopeko Pty. Ltd. and Pasminco Pty. Ltd., each contributing $40,000 in funding. The balance of funding for the operation of the seismic survey was provided by BMR. In addition BMR, with assistance from DMR personnel, provided seismic data processing facilities and personnel.

Prior to the major seismic survey being performed, three test seismic lines were recorded in the Cobar area to test the feasibility of using deep seismic reflection techniques to record seismic data from geological structures and boundaries within the Cobar Basin and margins. The seismic tests showed that deep seismic reflection events could be recorded. The seismic test results (Wake-Dyster and Johnstone, 1993) provided encouragement for industry sponsorship for the project.

1.2 Location

The seismic survey was located in the Cobar area of western NSW. The seismic lines are confined to the following 1:250000 mapsheets; SH 55-13 BARNATO, SH 55-14 COBAR, SI 55-02 NYMAGEE. Positioning of the seismic lines was achieved by using mainly geological, topographic and cadastral maps of the area. A general location map of the seismic lines, with structural geology elements is shown in Figure 1.

1.3 Seismic Lines

The proposed seismic lines were positioned to target the western and eastern bounding margins of the Cobar Basin and major fault structures within the basin. Three seismic lines across the basin were planned labelled 1, 2 and 3 in Figure 1. Line 3 was partitioned into three smaller seismic Lines 3A, 3B and 3C with bow-tie line intersections connecting Lines 3A and 3B, and Lines 3B and 3C. Recording spread parameters for the seismic lines are described in Appendix 5.

1.4 Operations - Commencement, Personnel and Vehicles

The seismic survey in the Cobar area followed a BMR seismic survey in the Bowen Basin in Queensland. All personnel and vehicles from the BMR Bowen Basin survey were used on the Cobar Basin seismic survey. Hence the temporary employees were relatively experienced in BMR seismic survey operations following the seismic survey in the Bowen Basin. A list of personnel involved in the survey is shown in Appendix 2, with vehicles used for drilling and recording shown in Appendix 3.

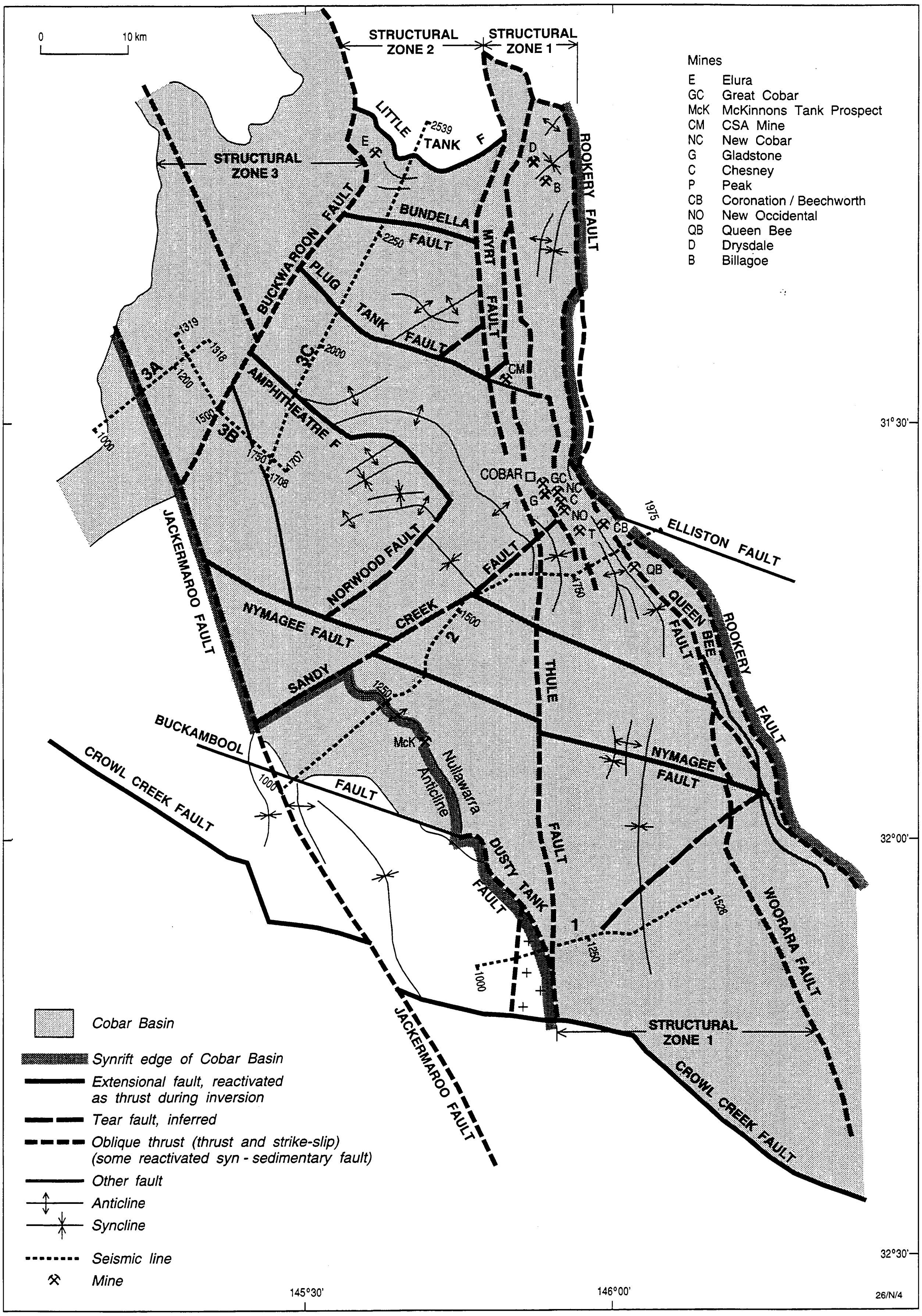

Figure 1. Location of the 1989 BMR deep seismic reflection survey lines in the Cobar Basin.

For the survey, the seismic survey camp was positioned centrally to all planned seismic lines, to avoid lost production due to camp shifts. The seismic camp was located on a property, 15 km south of Cobar on the Lerida Road, with easy access to Cobar for supplies along a sealed bitumen road. Water for the camp was obtained from the Cobar Shire Council. The seismic survey commenced drilling shotholes on 3/10/90, with seismic acquisition completed on 16/11/90. In total, 184 km of deep seismic data and 2.85 km of high resolution seismic data were recorded. Progress of the seismic survey was disrupted by wet weather and minor equipment breakdowns, as documented in Appendix 1.

1.5 Associated Geophysical Surveys

Gravity measurements were made along all seismic lines recorded during the Cobar Basin seismic survey. Gravity stations were spaced at intervals of 360 m along the seismic lines, with a closer spacing of 180 m between stations across zones having geologically mapped faults. Surveying information from the seismic survey including elevations and coordinates were used to reduce the gravity observation data. Operational details for the gravity survey are given in Appendix 7.

1.6 Objectives and Program

The major objectives of the seismic survey were;

- map the style of faulting at several places along the known eastern and northern boundaries of the Cobar Basin.
- find and map the western boundary of the basin in several places.
- map the depths to detachment surfaces of several thrusts, some being reactivated extensional faults, and the style at depth of antiform and synform features near the axis of the basin.
- on the regional scale, test models of basin formation which may apply in the Cobar region and, ultimately, perhaps elsewhere in the Lachlan Fold Belt.
- define and map possibly prospective structures on the margins of the Cobar Basin, including the known eastern and northern margins, and the poorly known western margin.
- define and map possibly prospective structures within the Cobar Basin.

1.7 Strategy

The seismic lines for the project were positioned to cross major faults and basin margins. The proposal for the seismic survey planned to collect 170 km of deep reflection seismic data (20 second two-way travel time) and 5 km of high resolution seismic reflection data over an area of mineralisation style structures. The collection of the deep reflection seismic data was to be carried out by the Bureau of Mineral Resources, Geology & Geophysics (BMR), using BMR shothole drilling rigs and seismic acquisition system as a contribution of the BMR towards the project. The high resolution seismic data was to be collected using the seismic acquisition system of the NSW Dept. of Mineral Resources with shotholes drilled by BMR. Using average seismic acquisition rates (25 km/5 day working week), it was estimated the seismic acquisition would take 7 weeks using a full size seismic survey crew and five drilling rigs. The acquisition of the seismic data by BMR, also included the responsibilities for;

- liaison with landowners and shire council,
- hiring of bulldozers and graders for seismic line clearing,
- supervision of surveying crews,
- liaison with Western Lands Council and National Parks & Wildlife Service (NPWS),
- and the contracting of an archaeologist to avoid disturbance of sacred and archaeological aboriginal sites.

1.8 Scope of this Record

This record describes the field work for the Cobar Basin seismic survey. Details of the logistics, recording parameters and personnel who took part in the survey are listed in the Appendices. The aims of the seismic survey were set out in the original project proposal and reiterated in the Sponsor's reports. Scientific results of the work are not discussed in this report; they are to be published elsewhere.

FIELD OPERATIONS

2.1 Landowner Liaison:

Prior to the seismic survey commencing, letters were forwarded to landowners affected by the seismic lines crossing their properties outlining the proposed seismic survey and planned position of the survey lines. Once in the field, contact was made with landowners to discuss the planned seismic survey line positions, and where necessary adjust positions of lines to suit logistical aspects of the survey, but at the same time maintain objectives of the survey. Most landowners were very cooperative with the seismic project provided gates were kept shut and livestock were not disturbed. Access arrangements to properties required sensitive negotiations to fit into landowner schedules, and the purchase of numerous locks and keys to property boundary gates.

2.2 NPWS and Archaeologist:

As the result of trying to obtain access to the western end of Line 2, a PAA (Protected Archaeological Area) was highlighted on the eastern boundary of 'Pine Ridge Additional'. Access to the area required liaison with NPWS (National Parks and Wildlife Service of NSW), who informed the seismic survey that an archaeological site avoidance survey would be required for all the planned seismic lines, especially where line clearing using a bulldozer was needed. The NPWS emphasized the point that if an archaeological site was disturbed or destroyed by the seismic survey, the BMR could be liable for prosecution under the NPWS Act. NWPS recommended that a contract archaeologist be hired to ensure that areas to be cleared by bulldozer, were searched for possible archaeological sites before being cleared.

As a result of the action by NPWS, an archaeologist was contracted, with approximately half of the seismic line length requiring archaeological surveying. Several scarred trees and some aboriginal tools were located, however the proposed seismic line required no deviations to avoid archaeological sites.

NPWS provided the archaeological clearance for the majority of Line 2, as it followed existing tracks, roads and fence lines (i.e. areas which have already been disturbed). Similarly the western end of Line 3 (Part 3A) followed a track along a boundary fence and archaeological clearance was provided by NPWS.

2.3 Surveying:

Guidance of the bulldozer line clearing and surveying of coordinates and elevations for shotpoints and geophone stations was carried out by the Australian Land Information Group (AUSLIG), Dept. of Administrative Services, Aust. Govt., as part of surveying services for the BMR. Pegging and chainage of the seismic lines was also provided by AUSLIG. Final surveying information consisted of AMG coordinate and elevation values for geophone stations, shotpoints and bendpoints in the seismic lines. The survey data was provided both in hard copy paper printouts and PC floppy disk files in ASCII format.

2.4 Bulldozing and Line Clearing:

Bulldozing of the seismic line was used to provide access for shothole drilling rigs and seismic recording vehicles. Where possible existing tracks were used to minimise costs in clearing and limit the amount of vegetation removed.

A Cat D6 equipped with rippers and tree pusher was contracted from Fryers Earthmoving for the majority of the survey. The D6 operated for 146.5 hours clearing a line length of 93 km, with an average clearing rate of 0.63 km/hr. The majority of the line was cleared using a single blade width cut, however in densely wooded areas, two blade width line cuts were made. Bulldozer progress slowed as the result of rain on the 25/10/90 and 26/10/90, making ground conditions too soft for bulldozing operations.

Due to the lost time in bulldozing, a second bulldozer (Cat D7) was contracted from D. & R. Hyde of 'Kia-ora', to assist in clearing the remainder of the seismic line on the eastern end of Line 3. The Cat D7 was used for 24 hours, clearing 24 km of seismic line, at an average clearing rate of 1.0 km/hr.

2.5 Drilling and Explosives:

Shothole drilling conditions proved to be very good, with the majority of shotholes drilled to 40 m depth. Very hard drilling was encountered on the western end of Line 1, requiring tungsten carbide rollers bits for drilling. Drilling statistics are detailed in Appendix 1, with each rig averaging approximately 6 holes of 40 m depth per working day. At the request of sponsors, bottom hole samples were collected from all shotholes for geochemical analysis.

Dyno-Westfarmers 'Tovex' was used as the explosive source, supplied in 1 kg charge size containers. Partial detonations of long length shot charges were a problem on the seismic survey in Queensland prior to the Cobar Basin seismic survey. To overcome partial detonations, modifications to the shot charge assembly were made. On average shot charge sizes were 10 kg, with the shot charge assembled by joining ten 1 kg containers together. A length of 'Aquaflex' explosive cord was then taped down the side of the charge to aid in detonation of the whole charge. The new charge assembly proved very successful with no partial detonations occurring. In total, 7410 kg of 'Tovex' was used, with 6420 kg on the regional deep reflection seismic survey and 990 kg on the high resolution survey. Further statistics are detailed in Appendix 1.

2.6 Seismic Recording:

Acquisition of the seismic data commenced on Line 2 (line with highest priority), with recording in the east, heading westward. Acquisition parameters are detailed in Appendices 4 & 5. Line 2 was recorded using a split-spread recording arrangement with furthest geophone offsets from the shotpoint of 2880 m. After a review of the shot records from Line 2, the shooting spread arrangements for Line 1 and 3 were changed, to take into account possible strongly dipping structures in either direction. Line 1 and 3 were recorded off-end, with alternate shots fired into opposite ends of the spread, providing reverse seismic profiling of the lines. Furthest geophone offsets using the reverse profiling technique were 5760 m, allowing a greater chance of recording reflections from dipping structures at the wider geophone offsets.

Recording of Line 3 commenced after the completion of Line 2, as it was the line of next highest priority. However due to wet weather and soft ground, conditions became impossible to work on this line. To keep recording active, operations were moved to Line 1 which was not affected greatly by the rain, and gave a chance for Line 3 to dry out and be continued at a later date. Line 1 was then recorded from west to east, however it was forseen that with the remaining available survey time that proposed parts of the seismic line would have to be cut from the program. Twenty kilometres of the eastern end of Line 1 was cut from the program (because it was designated as lowest priority) to enable a chance of completing Line 3, provided dry weather prevailed for the remainder of the survey. Fortunately dry weather conditions prevailed, with recording of Line 3 completed after finishing the shortened Line 1.

As outlined in Appendix 1, two recording days were lost due to equipment breakdowns in the seismic acquisition system and three extra days due to the adverse wet weather conditions.

2.7 High Resolution Seismic Recording:

The high resolution recording was positioned along Line 2, with three short high resolution lines recorded over faults. The seismic acquisition system of the NSW Dept. of Mineral Resources, which is geared towards recording high resolution seismic data, was used for this purpose. BMR personnel assisted in the deployment of the high resolution recording equipment. The location of the high resolution seismic lines and spread arrangements in relation to the deep reflection seismic work are outlined in Appendix 6. In addition to the high resolution recording, all high resolution shots were also recorded using the BMR seismic recording system set out in its normal spread configuration.

2.8 Seismic Line Restoration:

Due to the movement of heavy vehicles (drilling rigs & water tankers) along the bulldozed seismic lines, some sections of the seismic lines turned into two parallel deep trenches of fine dust. The areas affected were mainly on the western and eastern ends of Line 3. To rehabilitate the affected areas, a grader was hired for several days to grade the dust back into the deep ruts. Provided further traffic flow along the seismic lines was limited, time and some rain should harden the tracks back to a stable soil situation, with regrowth of grasses and woody weeds. The affected properties included 'Cubba', 'Bundoon Belah' and on the eastern end of the Line 3, 'Allednub'. The restoration on 'Allednub' was done using a Cat D6 bulldozer by backblading.

2.9 Seismic Data Processing

Data processing of the seismic data was carried out at the BMR Seismic Data Processing Centre using DISCO software running on a VAX based computer platform. The majority of the processing was done by Bruce Goleby (BMR) with cooperative assistance from Derecke Palmer (DMR). A brief summary of the data processing sequence applied to the seismic data is shown in Table 1.

First break arrival picking was performed to allow refraction computational methods to be used to compute shot and receiver statics for processing the seismic reflection data. The first break arrival data was also used by Derecke Palmer to develop laterally varying velocity models for the near surface layers along the seismic lines.

TABLE 1

Processing sequence for the seismic sections using the BMR/AGSO Disco processing system.

1. Demultiplex field tapes (SEGD to SEGY Disco internal format).
2. Crooked geometry definition.
3. Quality control displays and trace editing.
4. Resample to 4 ms, 20 sec record lengths.
5. CDP Sort (to crooked line).
6. Spherical divergence correction.
7. Statics computation using first break refraction analysis.
8. Trace Balance - single gate.
9. Spectrum Equalisation.
10. F-K Filter.
11. Digistack on Shot Gathers.
13. Normal Moveout correction.
14. First Break mute applied.
15. Median Stack.
16. CDP Balance - single gate.
17. Bandpass Filtering.
18. Digistack
19. Display section with gravity data.

PRELIMINARY RESULTS

Agreements reached at the initiation of the project allowed sponsors exclusive access to data and results of the project for a period of two years on completion of data acquisition, before general release to the public at large.

As part of the project schedule, the first sponsors meeting was held in Cobar on 21st March 1990 where final processed seismic sections were presented to the sponsors with preliminary data interpretations. As interpretation of the seismic data progressed, further sponsors meetings were held to bring sponsors up to date with the new geological and tectonic models being developed for the Cobar Basin.

ACKNOWLEDGEMENTS

The contribution and effort by all members of the surveying, drilling and seismic crews are gratefully acknowledged. The cooperation and assistance of the project sponsors Department of Mineral Resources, CRA Exploration Pty. Ltd., Geopeko Pty. Ltd. and Pasminco Pty. Ltd. throughout the seismic survey was gratefully appreciated. The cooperation of landowners was generally very good, with some landowners being very tolerant to the seismic survey activities.

REFERENCES

GLEN, R., 1988. Basin inversion, thrusts and ore deposits at Cobar, New South Wales: a preliminary report. Geological Survey of New South Wales, Quarterly Notes, 73, 21-26.

WAKE-DYSTER, K.D. and JOHNSTONE, D.W., 1993. Gunnedah Basin and Cobar Basin Seismic Test Survey, 1989. Australian Geological Survey Organisation, Record 1993/89.

APPENDIX 1

Operational Statistics

Drilling crew arrived Cobar	29-09-1989
Recording crew arrived Cobar	06-10-1989
Drilling commenced	03-10-1989
Recording commenced	16-10-1989
Drilling crew returned to Canberra	22-11-1989
Recording crew returned to Canberra	29-11-1989

Total line kilometres;	
Normal production reflection seismic	184 km
High Resolution seismic (Line 2)	2.85 km
Seismic lines recorded	1,2,3A,3B,3C

Recording:

Number of (Production) recording days worked		19
Number of (Testing) recording days worked		1
Number of (High Resolution) recording days worked		5
Recording days lost:		
Due to camp setting up & dismantling		2
Due to adverse wet weather		3
Due to recording equipment breakdown	2	

Reflection:

CDP fold coverage	8
Number of Testing shots	8
Number of Production shots	547
Average number of production shots/ recording day	29
Average surface coverage/ recording day	9.6 km
Maximum number of production shots in one day	51
Explosives used (Dyno-Westfarmers Tovex, 1kg)	6420 kg
Detonators used	613
Average charge size/ production shot	
(Line 1, 2, 3 (SP1000-2224))	10.0 kg
(Line 3 SP2225-2539)	25.6 kg

High Resolution Reflection:

Total number of shots	98
Explosives used (Dyno-Westfarmers Tovex, 1kg)	990 kg
Detonators used	99
Average charge size/ high resolution shot	10.0 kg

Drilling:

Number of drilling rigs	5
Total number of rig days worked	104
Rig days lost:	
Due to setting up & dismantling camp	10
Due to adverse wet weather	10
Due to equipment breakdowns & maintenance	26
Due to lack of surveyed seismic line	20
Reflection shotholes;	
Total number of shotholes	557
Total metres drilled	26125 m
Average depth/ shothole	39.9 m
High Resolution shotholes;	
Total number of shotholes	98
Total metres drilled	3920 m
Average depth/ shothole	40.0 m
Average number of holes/ rig/ working day	6.3

APPENDIX 2

Seismic Survey Personnel

Bureau of Mineral Resources:

Seismic survey Party Leader		K.D. Wake-Dyster
Drilling Supervisor		E.H. Cherry
Party Clerk		R. Dickinson
Geophysicist (& Assist. Party Leader)		D.W. Johnstone
Technical Officer (Engineering)		J. Whatman
		G. Jennings
Technical Officer (Science)		G.B. Price
Drillers		E. Lodwick
		D. Eaton
	(Contract)	T. Shanahan
	(Contract)	J. Gebbett
	(Contract)	P. Van Mil
Mechanics		A. Crawford
		J. Keyte
Field Assistants (Explosives)		R.D.E. Cherry
		A.C. Takken
	(Contract)	S. Pardalis
Temporary Personnel (Contract):		
Assistant Drillers		B.E. Dickinson
		F. Ceichan
		D.J. O'Reilly
		R.J. Lewis
		D. Westende
Cooks		B. Cassilles
		L. Price
Assistant Cooks		D. Calder
		S. Black
Field Hands		E. Tong
		P.R. Skidmore
		A.P. Miinin
		S. Fletcher
		J.B. Schejnin
		D.J. Bourke
		T. Begbie
		R. Leggett
		D.A. Noakes
		Z. Petrovic

AUSLIG

(Surveyor in charge, Sydney)	G. Hall
Surveyor	R. Harris
Technical Officers & Chainmen	5

Contract Bulldozers:

- Fryer's Earthmoving
  34 Bourke Road, COBAR   Cat D6

- D. & R. Hyde
  "Kia-ora" Station, COBAR   Cat D7

APPENDIX 3

Seismic Survey Vehicles

Recording:

Recording truck	Mercedes 911 4tonne 4X4	ZBE-748
Workshop truck	Mercedes 911 4tonne 4X4	ZBE-689
Water truck	Mercedes 911 4tonne 4X4	ZBE-781
Cable truck	Mercedes 911 4tonne 4X4	ZBE-633
Stores truck	Mercedes 911 4tonne 4X4	ZBE-169
Computer truck	International 1830C 8 tonne	ZUE-121
Geophone carrier	Toyota tray top 4X4	ZBE-791
Geophone carrier	Toyota tray top 4X4	ZBE-792
Geophone carrier	Toyota tray top 4X4	ZBE-793
Geophone carrier	Toyota tray top 4X4	ZBE-794
Shooting truck	Toyota tray top 4X4	ZBE-734
Personnel carrier	Toyota troop carrier 4X4	ZBE-796
Personnel carrier	Toyota troop carrier 4X4	ZBE-731
Reconnaisance	Nissan Patrol S/W 4X4	ZBE-862
Kitchen	4 wheel trailer	ZTL-914
Ablutions	4 wheel trailer	ZTI-344
Generator	4 wheel trailer	ZTV-021
Stores	4 wheel trailer	ZTV-020
Workshop spares	4 wheel trailer	ZTL-674
Water	2 wheel trailer	ZTV-018

Drilling:

Drilling rig	Mayhew 1000/Mack R600 6X8	ZSU-606
Drilling rig	Mayhew 1000/Mack R600 6X8	ZSU-471
Drilling rig	Mayhew 1000/Mack R600 6X8	ZSU-472
Drilling rig	Mayhew 1000/Mack R600 6X8	ZSU-473
Drilling rig	Mayhew 1000/Mack R600 6X8	ZSU-529
Drill W/Tankers	Mack R875 6X6 8645 litres	ZSU-863
Drill W/Tankers	Mack R875 6X6 8645 litres	ZSU-864
Drill W/Tankers	Mack R875 6X6 8645 litres	ZSU-865
Drill W/Tankers	Mack R875 6X6 8645 litres	ZSU-866
Drill W/Tankers	Mack R875 6X6 8645 litres	ZSU-911
Water tanker	Mercedes 911 4tonne 4X4	ZBE-782
Workshop	Mercedes 911 4tonne 4X4	ZBE-647
Explosives truck	International 1830C 8tonne	ZUE-136
Stores truck	Mercedes 911 4tonne 4X4	ZBE-645
Preloading truck	Toyota tray top 4X4	ZBE-735
Personnel carrier	Toyota troop carrier 4X4	ZBE-730
Personnel carrier	Toyota troop carrier 4X4	ZBE-733
Office	4 wheel trailer	ZTL-739
Drilling spares	4 wheel trailer	ZTL-514
Kitchen	4 wheel trailer	ZTL-917
Ablutions	4 wheel trailer	ZTI-343
Workshop spares	4 wheel trailer	ZTV-023
Stores	4 wheel trailer	ZTL-916
Generator	2 wheel trailer	ZTL-984
Welding	2 wheel trailer	ZTL-501
Water	2 wheel trailer	ZTL-016

APPENDIX 4

Spread and Recording Parameters

Spread length	5760 m
Number of recording channels	96
Number of station units available	144
Geophone station interval (Production seismic)	60 m
(High resolution)	10 m
CDP fold coverage	8
Number of geophone/ geophone string	16
Geophone pattern (GSC-20D)	in-line
Geophone spacing	4 m
Blaster type	OYO Model 1340
Sercel SN368 instrument settings:	
Recording format	digital
Tape format	SEG-D
Number of input channels:	
Data	96
Auxiliary	4
Tape: 9 track, 6250bpi, GCR format, 0.5inch, 8.5inch reels, 1200ft.	
Record length	20 seconds
Sample rate	2 ms
Input filters;	
Low-cut	8 Hz/18db/Oct
Hi-cut (anti-alias)	178 Hz
Pre-amplifier Gain	7**2
Playback Parameters;	
Low-cut filter	12 Hz
Hi-cut filter	90 Hz
Slope	18 ms
Seismonitor gain	42 db
Output Adjust	4 db
Gain Curve	1
Release Time	10 ms
Compression Delay	8 ms
Early Gain	0 db
AGC	1
Recovery Delay	32 ms

APPENDIX 5

Seismic line recording spread parameters

Line 1:

Line Orientation (High SP numbers East, Trace 1 to the West)	E-W
Length	31.8 km
First Geophone station	995
Last Geophone station	1526
First Shotpoint	995
Last Shotpoint	1526
Geophone station interval	60 m
Shotpoint interval	360 m

Line 2:

Line Orientation (High SP numbers East, Trace 1 to the West)	E-W
Length	59.7 km
First Geophone station	980
Last Geophone station	1975
First Shotpoint	1000
Last Shotpoint	1975
Geophone station interval	60 m
Shotpoint interval	360 m

Line 3:

Part A:

Line Orientation (High SP numbers East, Trace 1 to the West)	E-W
Length	19.1 km
First Geophone station	1000
Last Geophone station	1318
First Shotpoint	1001
Last Shotpoint	1318
Geophone station interval	60 m
Shotpoint interval	360 m

Part B:

Line Orientation (High SP numbers South-east, Trace 1 to the North-west)	SE-NW
Length	23.3 km
First Geophone station	1319
Last Geophone station	1707
First Shotpoint	1319
Last Shotpoint	1707
Geophone station interval	60 m
Shotpoint interval	360 m

Part C:

Line Orientation (High SP numbers North-east, Trace 1 to the South-west)	NE-SW
Length	49.9 km
First Geophone station	1708
Last Geophone station	2540
First Shotpoint	1708
Last Shotpoint	2539
Geophone station interval	60 m
Shotpoint interval	360 m

Line intersections for Line 3:

Line 3(Part A) SP 1250+21.5 m / Line 3(Part B) SP 1372
Line 3(Part B) SP 1658-11.8 m / Line 3(Part C) SP 1758

APPENDIX 6

High Resolution Seismic recording spread parameters

Recording system	Sercel 338HR
Number of channels	48
Geophones	Single 40 hz

Line 2:

Site 1:

Line Orientation (High SP numbers East, Trace 1 to the West)	E-W
Length	1.17 km
First Geophone station	1785.0
Last Geophone station	1804.5
First Shotpoint	1785.0
Last Shotpoint	1804.5
Geophone station interval	10 m
Shotpoint interval	30 m

Site 2:

Line Orientation (High SP numbers East, Trace 1 to the West)	E-W
Length	1.14 km
First Geophone station	1850.0
Last Geophone station	1869.0
First Shotpoint	1850.0
Last Shotpoint	1869.0
Geophone station interval	10 m
Shotpoint interval	30 m

Site 3:

Line Orientation (High SP numbers East, Trace 1 to the West)	E-W
Length	0.54 km
First Geophone station	1881.0
Last Geophone station	1890.0
First Shotpoint	1881.0
Last Shotpoint	1890.0
Geophone station interval	10 m
Shotpoint interval	30 m

APPENDIX 7

Operational details, Gravity survey

1. The gravity survey commenced on the 21st November 1989 and completed on the 8th December 1989.

2. 868 new gravity stations were read with a spacing of 360m between stations in areas interpreted to have simple structure, and 180m spacing in areas where structures are interpreted to be more complex.

3. BMR gravity meter, LaCoste-Romberg S/N G132 was used on the survey. For data reduction a calibration scale factor of 1.05741 mgal/counter reading, was adopted.

4. The survey was tied to the following base stations.

Station	Value (Isogal65 mgal)	Lat	Long	Elev (m)
8090.0143	979403.07	31.540000	145.795000	218.

5. All stations were seismic geophone stations and were surveyed optically to third-order standard.

6. The gravity observer was H. Reith (BMR).