DEPARTMENT OF NATIONAL RESOURCES

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

1978/34

SEISMIC AND DETAILED GRAVITY SURVEY IN THE TOKO SYNCLINE, GEORGINA BASIN, 1977 - OPERATIONAL REPORT

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CONTENTS

ILLUSTRATIONS

SUMMARY

The Bureau of Mineral Resources conducted a combined seismic and detailed gravity survey from June to December 1977 to investigate the nature and structure of the Toko Syncline in the Georgina Basin and the nature of the Toomba fault which forms the southwest margin of the syncline. The results of previous geophysical work and exploration drilling suggest that the Toko Syncline is a prospective area for petroleum particularly gas.

The survey area lies west of Boulia and Bedourie, in the Simpson Desert, central-western Queensland and Northern Territory. A bulldozer was required for access and clearing to allow operations in the area.

The survey recorded a total of 285 km of reflection coverage with a digital DFS IV recording system. Multiple coverage was used, mainly with six-fold common-depth-point recording, but some twelve-fold in the area of the Toomba Fault. Three expanded spreads were recorded to provide vertical velocity information. Detailed gravity measurements at 500 m spacing were made on most of the seismic traverses.

Reflection quality was generally fair within the Toko Syncline, but the quality deteriorated in the region of the Toomba Fault. The quality was also poor in some areas where the weathered layer became thick, over 100 m in places. The survey tied existing seismic lines to Netting Fence No. 1 and Ethabuka No. 1 wells; completed a northeasterly cross-section over the syncline, incorporating some earlier data; and in the northeast, tied to two fully-cored holes (GSQ Mount Whelan Nos 1 & 2) drilled by the Geological Survey of Queensland during the survey. In addition, the survey recorded five traverses over the Toomba Fault, and filled several important gaps in seismic coverage in the Toko Syncline.

Two reflections, (previously unidentified), have been identified by a tie to Netting Fence No. 1 well. They correspond to the top of the Upper Cambrian Georgina Limestone, and basement. These reflections, and a third, shallower one, corresponding to the top of the Lower Ordovician Coolibah Formation, were recorded on most of the traverses.

The Toomba Fault appears to be a high angle reverse fault within the survey area. In the north, near Netting Fence No. 1 well the strata are steeply upturned in a narrow zone adjacent to the fault, but further south, near Ethabuka No. 1 well, there is a broader zone of associated folding and faulting of the sediments east of the fault.

A gap was filled between existing seismic coverage north and south of 24°S, and improved quality data was obtained to allow the reflections identified in the north to be followed to the southern part of the syncline, where the section has not been drilled.

Final processing and interpretation of the seismic data remain to be done, but the preliminary results indicate that the survey has achieved most of its objectives.

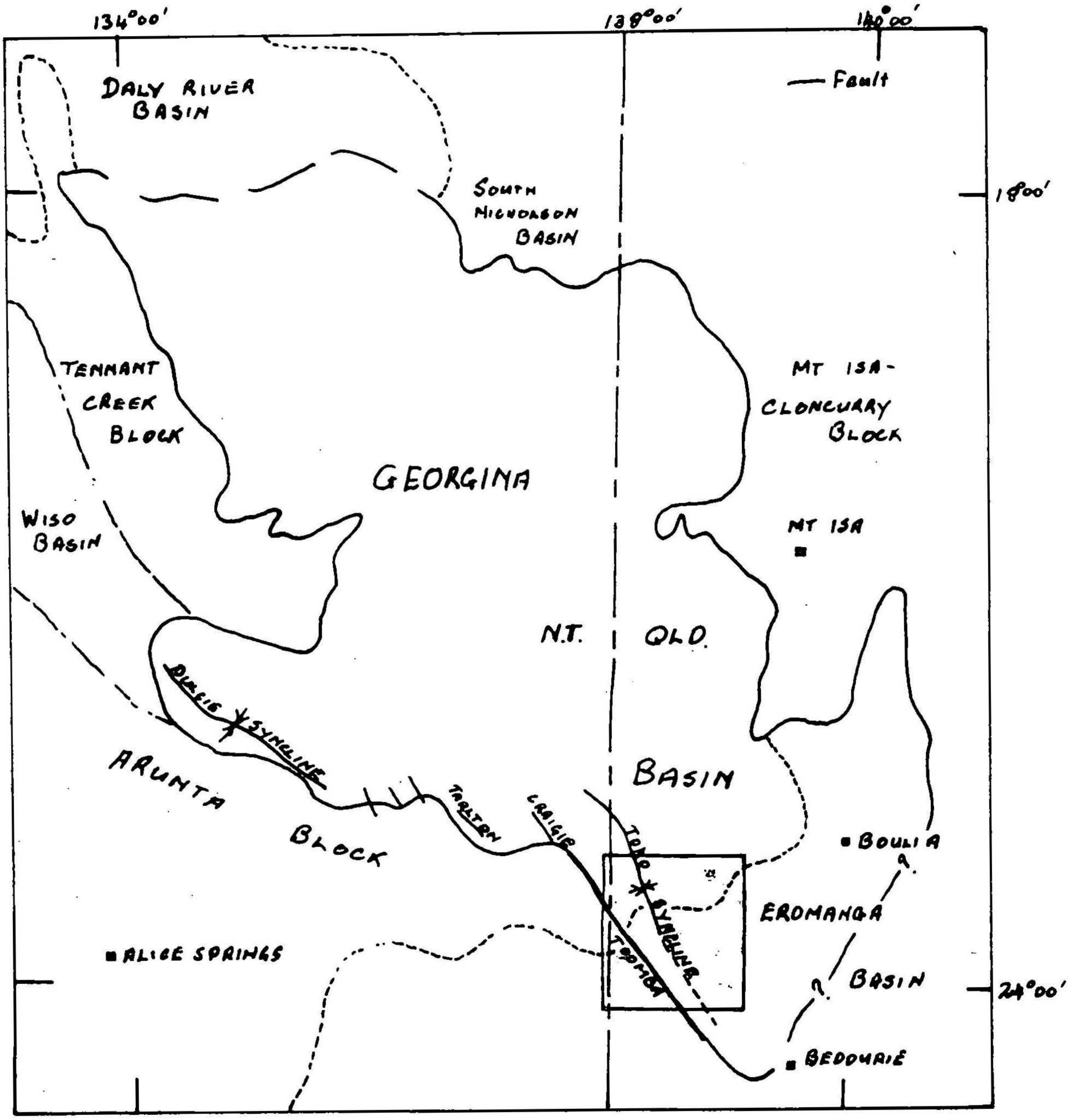
INTRODUCTION

The Bureau of Mineral Resources (BMR) conducted a seismic and detailed gravity survey from June to December 1977 in the Toko Syncline area of the Georgina Basin, west of Boulia and Bedourie in central Western Queensland and Northern Territory (Plate 1) as part of the Georgina Basin Project (Druce, 1974). The survey area north of 24°S is within petroleum exploration lease ATP160P held by Alliance Oil Development Australia N.L., and south of 24°S within ATP 66/67P held by a consortium made up by Santos Ltd, Delhi International Oil Corp., and Total Exploration (Aust) Pty Ltd.

The Toko Syncline is a deep southeast-plunging asymmetric syncline containing up to 7000 m of Late Adelaidean to Devonian sediments. The southwestern flank is steeply dipping, and is bounded by the Craigie/Toomba Fault system. The northeastern flank dips more gently, and the rocks gradually thin to the northeast. Two deep exploration wells, Netting Fence No. 1 (PAP, 1965), and Ethabuka No. 1 (Alliance, 1975), yielded information on the stratigraphy and lithology of the sequence and suggest thickening to the southeast, the deeper part of the syncline, and the possibility of stratigraphic pinchouts along the axis, as well as across the northeastern flank of the syncline. The wells also indicate the presence of source rocks and reservoir facies within the Middle Cambrian section, caprocks in the Lower Ordovician, and significant amounts of petroleum (gas) in the Lower Ordovician. A more detailed account of the geology is given in a review of the geology and previous geophysics by Mathur & Bauer (1977).

Previous geophysical work failed to provide definitive information on the nature of the deep sediments, or on the nature of the Toomba Fault, information that is necessary to evaluate the petroleum potential and understand the geological and tectonic history of this part of the Georgina Basin. Only two deep exploration wells have been drilled in the northern part of the syncline: Ethabuka No. 1 well, which only reached the Ordovician Kelly Creek Formation; and Netting Fence No. 1 well, which was drilled to basement, but not tied to the seismic lines. Gaps

PLATE 1



LOCATION OF SURVEY AREA AND STRUCTURAL SETTING OF GEORGINA BASIN

km 0 50 100 150 200 250 km

SCALE

existed between previous company lines, making correlation of horizons uncertain. Seismic horizons in the southern part of the syncline, ATP66/67P area, were unidentified because there are no deep wells in the area and there was no connection to seismic lines in the north, ATP160P area.

Results of previous seismic work in the northern area of the syncline (Alliance, 1970) indicated several anticlinal structures on its western flank. Ethabuka No. 1 well (Alliance, 1975) was drilled on one of these structures and produced gas flows within the Ordovician. Closure on a second structure, the Mirrica Structure, further west and closer to the fault zone required confirmation.

This report describes the work done during the 1977 survey to obtain the information lacking in the Toko Syncline, and presents a preliminary interpretation of the results. Detailed interpretation awaits the completion of digital processing and further analysis of the data (which are currently in progress).

OBJECTIVES

The overall objective of the seismic and gravity survey in the Toko Syncline, as discussed by Mathur & Bauer (1977) was to obtain more definite information on the thickness and structure of the Lower Palaeozoic sediments in the syncline, and the nature of its southwestern margin, the Toomba Fault. In particular:

1. To record a continuous reflection profile between Netting Fence No. 1 and Ethabuka No. 1 wells so as to identify and map seismic horizons, both along the axis of the Toko Syncline and on previous seismic lines on the western flank.

2. To record good quality reflections on the northeast flank of the syncline, particularly from below the Ordovician sediments, in order to obtain ties to stratigraphic holes drilled by Geological Survey of Queensland (GSQ).

3. To determine the nature of the Toomba Fault, its times of movement and effects on sedimentation.

4. To provide a link between existing seismic coverage in ATP 160P and ATP 66/67P, to enable identification of seismic horizons in the latter, southern area - where the section has not been drilled.

5. To determine whether closure exists on the Mirrica Structure.

6. To record gravity along the seismic traverses at 500 m spacing to allow combined seismic and gravity modelling.

PROGRAM

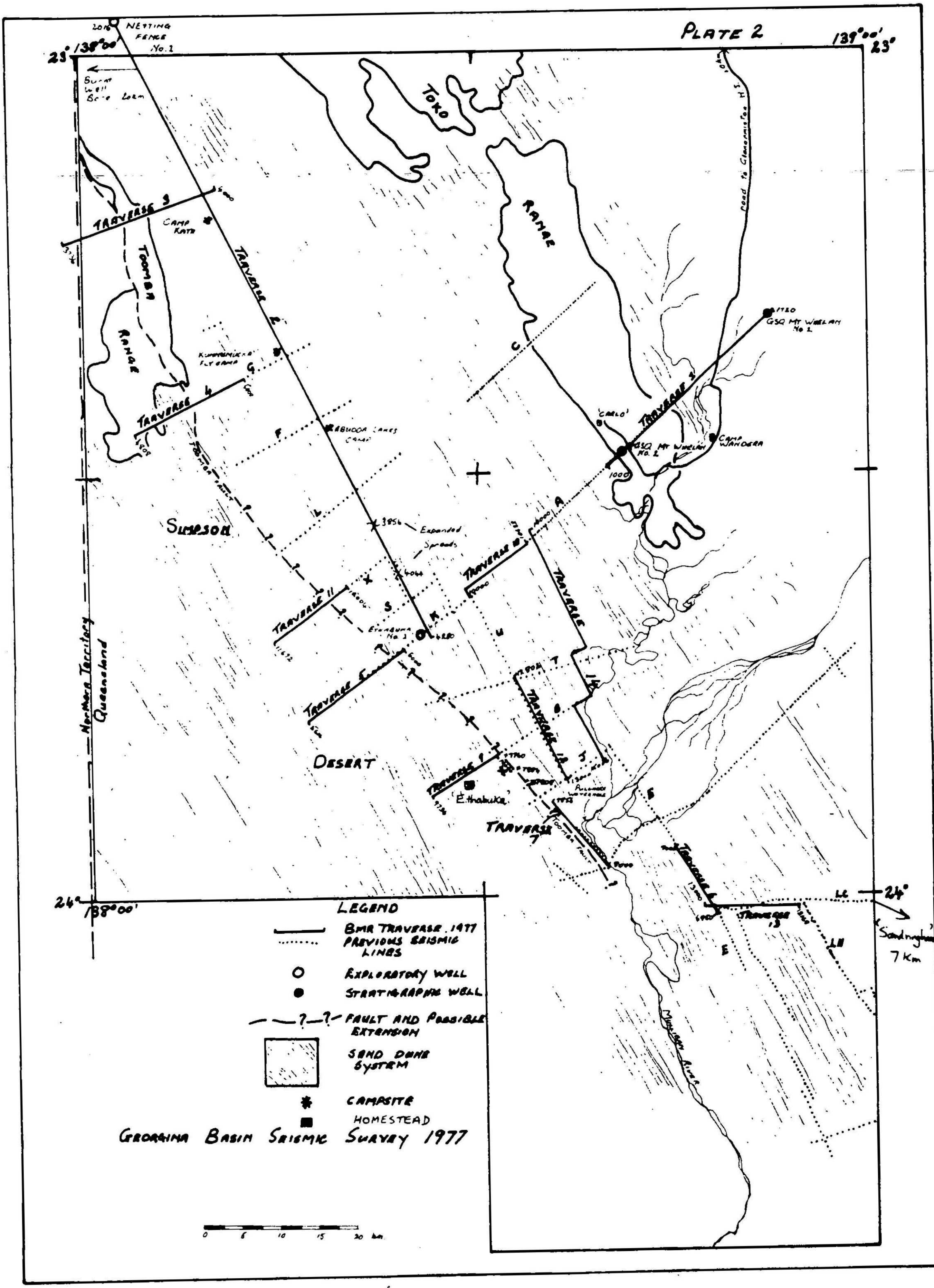
The locations of BMR and company seismic lines are shown in Plate 2. Traverse tie-points and well intersections are given in Appendix 1.

Tie between Netting Fence No. 1 and Ethabuka No. 1 wells

Traverse 2, about 90 km long, was recorded to obtain continuous seismic coverage between Netting Fence No. 1 and Ethabuka No. 1 wells via line K (Alliance, 1970), and to provide a tie between the disconnected northeasterly lines recorded by Alliance.

Northeast margin

Traverse 1 was recorded to obtain improved data quality on the northeastern flank of the syncline, where the pre-Ordovician sequence of the Toko Syncline is shallowest. It overlapped the northeastern end of Alliance Line A by 13 km and extended it 17 km to the northeast. GSQ drilled two fully cored holes on the traverse to enable identification of seismic horizons. GSQ Mount Whelan No. 1 intersected granite basement around 600 m at SP1704, and GSQ Mount Whelan No. 2, at SP1044, was drilled to 914 m and bottomed in Cambrian sediments. (J. Draper, pers. comm.). Traverse 10 was recorded to fill the gap between Alliance Lines K and A, and with Traverses 5 and 1 to give a continuous cross-section across the syncline.



TRAVERSE LOCATION MAP

Record No. 1978/34

F54/B3-307A

Toomba Fault

Traverses 3, 4, 5, 9, and 11 were recorded over the Toomba Fault, in some cases extending existing lines, to determine the nature of the fault. Traverses 9 and 11 had the additional objective of determining whether northern and southern closure exists on the Mirrica Structure.

Tie between seismic lines north and south of 24°S

Traverse 6 was recorded to fill a gap in the seismic coverage between ATP 160P in the north, and ATP 66/67P in the south. Traverse 12 was a re-shoot of part of Alliance line U to obtain a better quality tie between the two areas. Traverse 13 was designed to improve the tie to Line LH (FPC, 1965). The relatively poor data recorded on Traverse 12, compared with that on the eastern ends of Alliance Lines T, B, and J, necessitated the recording of Traverse 14, to ensure an adequate tie from north to south.

Velocity investigations

Three expanded spreads were recorded to obtain vertical velocity information. Two were located on Traverse 2, centred at SP3856 and SP4044 and each was recorded to maximum offset of 5 km. The third, with a maximum offset of 11 km, was recorded on Traverse 7, centred at SP7928. Four additional shots were recorded on Traverse 7, with offsets of 14 to 20 km from a stationary spread at stations 8000-7977. The long offset shots were designed to record refraction information which, with the velocity information from the expanded spread and other refraction and velocity information from the earlier BMR Traverse E further east (Jones & Robertson, 1967) could help to determine whether the Toomba Fault is an overthrust in that area.

A well velocity-shoot was recorded in GSQ Mount Whelan No. 2 to obtain vertical velocities to allow the identification of seismic horizons at the well. Shots were recorded with the well geophone at eleven depths, ranging from 297 m to 912 m below surface.

(10)

Deep crustal reflection recording

In areas of good reflection quality on Traverses 1, 2 and 7 (for details, see Appendix 4), extended length records were made to obtain deep crustal information.

Gravity measurements

Detailed gravity readings were taken at 500 m intervals along each traverse, except Traverses 6, 7, 13, and 14, so that combined seismic and gravity modelling could be made.

Weathering shots

Short weathering spreads were recorded regularly on most traverses to give information on the velocity and thickness of the weathered layer.

FIELD OPERATIONS

Operational details are presented in Appendices 2 and 3. The survey area was in the Simpson Desert in western Queensland and Northern Territory, an area of spinifex covered seif dunes which trend north-northwest.

The area was a difficult one in which to conduct seismic operations owing to the isolation from supply centres, difficult and slow travel over sand-dunes, long distances from water supplies, and high temperatures from September to November.

Access to the northern part of the area from Boulia was by station roads to Carlo homestead via Glenormiston homestead, and by graded or bulldozed tracks west of Glenormiston over the Toko Range to the Netting Fence No. 1 well area. Access to the southern part of the area from Boulia was by graded roads to Ethabuka homestead via Bedourie town and Sandringham Station.

Supplies were obtained from Mount Isa, road freighted to Boulia where they were picked up by the party's supply truck. The base camps were between 200 and 300 km from Boulia. One way travel-time to Boulia varied from five hours (Camp Wandera) to fourteen hours (Abudda Lakes Camp) (Plate 2).

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Apart from a weekly flight by light aircraft from Adelaide to Boulia, the nearest regular air service was to Mount Isa. Personnel and air freight to the party travelled the 300 km from Mount Isa to Boulia by Pioneer bus.

Clearing

Clearing of traverses and access tracks was essential throughout the sand covered areas to allow passage of vehicles, especially over sand-dunes, and to minimise the fire risk which arises from hot vehicle exhausts touching the spinifex. A Caterpillar D6C hired from Ledgers Earthmoving and Hire Services, Brisbane, was adequate in size. A caterpillar D4 hired locally to clear Traverse 9, was found to be too small, particularly when clearing dunes.

Where clearing sand-dunes was not possible for operational reasons, as on Traverses 1 and 13, the operations were slowed significantly.

Geoflex ploughing

While dynamite in shot-holes was used over most of the survey, long strands of Geoflex, an explosive cord were ploughed in long strands at shallow depth, as an alternative energy source on some traverses over sand-dunes. It was used on Traverses 10, 11, and the western end of Traverse 5, where drilling would have been slow because of the need to cross large dunes and to transport drilling water over long distances. Concurrent Geoflex ploughing and drilling improved progress of the recording team, delayed earlier by slow drilling.

Standard Geoflex patterns for the relevant traverses are given in Appendix 3. Several strands of the Geoflex cord, somewhat longer than the station interval, but less than the shotpoint interval, were laid parallel, each separated by about 1 m at plough depth (about 0.6 m), and centred at the shotpoint. The strands were laid parallel to the traverse to take advantage of the directional properties of such a shot.

Drilling

Drilling progress varied, and the rate fluctuated according to the difficulty in crossing sand-dunes, the presence of flowing aquifers (requiring plugging and cementing) or hard formations (e.g. south end of Traverse 2), the variable hard and soft strata particularly near the Toomba Fault, the Permian(?) glacial boulder beds and sticky clay bands which required water injection, and the scarcity of water supplies which necessitated long water-runs.

The hole depths used initially on most traverses were selected after an analysis of previous seismic survey information (Mathur & Bauer, 1977). The hole depth was decreased, where possible, to increase production in areas of difficult drilling. The depth of weathering was calculated from weathering and production shots and hole depth was increased where necessary. (This applied where the recording crew was operating close to the drills).

Flowing water was struck in holes drilled near SP1236 on Traverse 1, SP6940-6938 on Traverse 6 and SP14312 on Traverse 14. These holes had to be plugged and cemented. Some shotpoints were omitted in a few areas where flowing water was likely to be encountered at shallow depth. In some other areas, shallow five-hole patterns were drilled instead of single deep holes, to avoid the risk of striking a flow.

The drill rigs, mounted on Mack trucks, (which are 6 x 8) were frequently towed by the AEC water tankers (6 x 6) over large sand dunes; the exception being one rig, fitted with sand tyres, which required little towing.

Bottom-hole cuttings were collected at each shot point on the drilled traverses to provide further knowledge of subcrop geology, especially over the Toomba fault.

Recording

Recording parameters are given in Appendix 3. All traverses were recorded digitally using a DFS IV recording system. Instrument settings and recording formats are given in Appendix 4.

The recording multiplicity was generally six-fold. In areas where structural changes were expected and more detail was required, coverage was increased to twelve-fold, with a reduced station interval.

All traverses recorded at $83\frac{1}{3}$ m spacing were recorded with 24 data channels, and all traverses at $41\frac{2}{3}$ m spacing with 48 data channels. This was found to be the most efficient method with the available cables.

Spread geometry was normally a split-spread with a one-trace centre gap. The gap was widened to 5 and 9 traces (Appendix 3) for the Geoflex shooting to avoid high amplitude noise on the near traces.

Traverse 2, SP 2024-2404, was recorded with an off-end spread, shot off trace 1. The spread was changed to a split spread from SP 2408 onwards to minimise interference between first-arrival energy and shallow reflections on far-offset traces. A variety of spreads including split, off-end, and asymmetrical, were used on Traverse 14 to ensure ties at the right-angle bends.

On many of the cross-traverses over the dunes, the drill rigs could not always be positioned to drill at a shotpoint because of the slope. In such instances, the hole was offset along the traverse by one station interval, or as on Traverse 13 by a multiple of station intervals, and the spread "was displaced" an equal number of station intervals in the opposite direction to maintain the same multiplicity of subsurface coverage. This problem was less severe with Geoflex ploughing, and shot-points were only shifted where elevation differences may have caused vertical cancellation of signal.

In some areas drill-holes were omitted where there was a high risk of striking flowing water at shallow depth. This occurred on Traverse 1, between SP 1236-1268 resulting in a 500 m subsurface gap and on Traverse 14, at SP 14132, resulting in a 250 m subsurface gap. A gap in coverage on Traverse 2 exists from SP 3964-4120, where data on Alliance Line W were of sufficiently good quality not to warrant re-shooting. Alliance Line K was partially re-shot on the western end.

Delays in recording were encountered because of slow drilling on Traverses 2, 3, 4, and 5, but in the latter part of the survey, the Geoflex traverses occupied the recording crew over the periods of slow drilling.

The survey recorded 286 km of reflection coverage in 86 days, giving an average recording rate of 3.3 km/day (66.5 km/month). 27 recording days were lost because of camp-shifts (12 days), waiting on holes to be drilled (10 days), instrument problems (2 days), bush-fires (2 days) and rain (1 day).

The three drill rigs drilled holes along 257 km of traverse in 238 rig days and gave an average combined drilling rate of 3.2 km/day (64.7 km/month). 74 rig days were lost because of mechanical breakdowns.

Gravity

Operational details are given in Appendix 3. Detailed gravity measurements were recorded every 500 m, except over the Toomba fault on Traverse 3 where an 8.3 m interval was used. Priority was given to the traverses over more structurally complex areas. The data were tied to benchmarks located in the Carlo and Sandringham Station areas, and near Netting Fence No. 1 well. These benchmarks are part of the isogal network catalogued in the BMR National Gravity Repository (Barlow, 1976).

Data processing

Field processing included static computations and data control checks to provide the processing contractors - GSI, Sydney - with enough information to produce a preliminary stacked section (brute stack).

Static corrections were computed using the depth of weathering calculated from production records and weathering shots. Weathering shots and direct up-hole times, recorded for shots near each cab-position, enabled the weathering velocity to be calculated. Values of depth of weathering were interpolated between shotpoints. Elevations for the stations were provided by the surveyors.

Elevation datum, and weathering and correction velocities are given in Appendix 5.

The data control checks provided a basis for trace editing in processing and included checks for dead, noisy, and reversed traces, static pulsing, etc. Static pulsing, a problem common in desert areas, caused spikes across all or several data channels on some records. Specifying record-time and trace number(s) enabled the spikes to be removed in processing.

Shot noise and especially the air blast from Geoflex shooting cannot be edited from the records without losing data. Velocity and frequency filtering should reduce their effects.

PRELIMINARY RESULTS

Generally, record quality within the Toko Syncline east of the Toomba Fault was fair to good, while west of the fault it was poor. The traverses that crossed the fault showed an abrupt decrease in reflection quality over the fault. Some weak, discontinuous reflections were recorded west of the fault on some traverses.

Traverse 2, recorded between Netting Fence and Ethabuka wells, recorded fair to good quality reflections. Two reflections were identified at Netting Fence No. 1 well; these correlated to the top of Georgina Limestone (Upper Cambrian), and basement, corresponding to granite, in the well. These two reflections could be followed on most of the traverses in the survey area. A shallower horizon, the top of Coolibah Formation (Lower Ordovician), previously identified on a company line at Ethabuka No. 1 well, could be followed on the southern part of Traverse 2, but was difficult to follow on the preliminary record section near Netting Fence No. 1 well.

On Traverse 1, recorded over the northeast margin of the syncline, fair quality reflections were recorded in the southwest, but the quality deteriorated in the northeast, where the reflections became shallower. Three reflections, the top of Coolibah Formation, top of Georgina Limestone, and basement, were followed onto the traverse from Ethabuka No. 1 well via

Alliance Lines K and A and BMR Traverse 10. GSQ Mount Whelan No. 2, drilled near the southwestern end of Traverse 1, confirmed the identification of the Coolibah reflector. GSQ Mount Whelan No. 1, drilled at the northeastern end of the traverse, intersected granite at 600 m. Although the basement reflection is weak on Traverse 1, there are indications that it may tie to the granite in the well. A suite of fairly strong and steeply dipping straight events, recorded at the northeastern end of the traverse, is considered to be reflected refractions from a fault which may lie about 5 km northeast of the end of the traverse.

Five traverses were recorded over the Toomba Fault. The two northernmost traverses 3 and 4, both recorded good quality horizontal reflections, east of the fault; on these traverses there was an abrupt loss of reflections in the area of the fault. The surface geology (Reynolds, 1968) indicates that the Palaeozoic strata dip steeply just east of the fault. The subsurface location of the fault is not definite, but the fault is inferred to be reverse, to explain the steep upturning of the rocks. Both traverses recorded some weak reflections west of the fault, presumably from within the Adelaidean sequence, which outcrops there. Further south, on Traverse 11, there is evidence that the fault is a high-angle reverse fault, because there are outcrops of granite 500 m north of the traverse, at SP11812, (Reynolds, 1968) yet reflections can be followed below the granite. Further south again, on Traverse 5, there is complex folding and faulting, and there appear to be two high-angle reverse faults at the basin margin. The evidence for this is provided by reflections and by diffractions indicating truncation of the reflections. Traverse 9, the southernmost traverse over the fault, did not show any reflections.

Traverse 6 recorded fair quality reflections and will provide a good tie between the seismic coverage north and south of 24^{o}S. Traverse 12, aimed at recording improved quality data to allow reflections near Ethabuka No. 1 well to be followed to the southern part of the syncline, obtained poor results, so Traverse 14 was recorded as an alternative tie. Traverse 14 recorded fair to good quality reflections and will allow reflections to be tied between the two areas. Traverse 13, which was intended to improve the tie between Traverse 6 and FPC Line LH recorded fair quality reflections.

CONCLUSIONS

The preliminary results of the BMR seismic survey in the Toko Syncline in 1977 indicate that most of the objectives of the survey have been achieved.

Two main reflections have now been identified by a tie to Netting Fence No. 1 well. These correspond to the top of Georgina Limestone (Upper Cambrian), and basement. A third reflection, previously identified in Ethabuka No. 1 well as the top of the Coolibah Formation (Lower Ordovician) was also identified in GSQ Mount Whelan No. 2 well on the northeast flank of the syncline. These three reflections can be followed over most traverses in the syncline.

Traverses recorded over the Toomba Fault have indicated that the fault is high-angle reverse. In the north, near Netting Fence No. 1 well, the Palaeozoic strata are steeply upturned in a narrow zone east of the fault, whereas, further south near Ethabuka No. 1 well, there is a wider zone of associated folding and faulting of the sediments east of the fault.

The gap in the existing seismic coverage between ATP 160P and ATP 66/67P was filled and improved quality data were obtained on several traverses between Ethabuka No. 1 well and FPC lines in the southern part of the syncline. This allows the reflections identified in the northern area to be traced south, where the section has not been drilled. A more reliable interpretation of all the seismic data in the Toko Syncline is now possible.

In future, the efficiency of field operation in the Simpson Desert area can be improved by providing for additional drilling power for shot-holes, better bulldozing facilities for ploughing Geoflex and clearing traverses, the use of light aircraft for transporting supplies, personnel and mail, and by conducting the field work during colder and drier months of April to September.

REFERENCES

ALLIANCE (OIL DEVELOPMENT AUSTRALIA N.L.), 1970 - Toko Range seismic survey, PEL 5 & 6, ATP160P, Qld, Bureau of Mineral Resources, Australia - File 70/284 (unpubl.).

ALLIANCE, 1975 - Ethabuka No. 1 well completion report. Bureau of Mineral Resources, Australia, - File 73/224 (unpubl.).

BARLOW, B.C., 1970 - National Report on Gravity in Australia. Bureau of Mineral Resources, Australia Record 1970/62 (unpubl.).

DRUCE, E.C., 1974 - Georgina Basin Project 1974-1980, A Proposal Bureau of Mineral Resources, Australia - Record 1974/44 (unpubl.).

FPC (FRENCH PETROLEUM COMPANY (AUST), PTY LTD), 1965 - Bedourie seismic survey. Bureau of Mineral Resources, Australia - File 64/4503 (unpubl.).

JONES, P. & ROBERTSON, C.S., 1967 - Southeastern Georgina Basin seismic survey, Queensland 1963-1964. Bureau of Mineral Resources, Australia - Record 1967/90 (unpubl.).

MATHUR, S.P. & BAUER, J.A., 1977 - Southeastern Georgina Basin seismic survey Queensland and Northern Territory, 1977 preview report. Bureau of Mineral Resources, Australia - Record 1977/25 (unpubl.).

PAP (PAPUAN APINAIPI PETROLEUM CO. LTD), 1965 - Netting Fence No. 1 well completion report. Bureau of Mineral Resources, Australia - File 64/4068 (unpubl.).

REYNOLDS, M.A., 1968 - Mount Whelan, Qld, - 1:250 000 Geological Series. Bureau of Mineral Resources, Australia, Explan. Notes. SF/54-3.

APPENDIX 1

TIES BETWEEN BMR TRAVERSES, COMPANY LINES AND EXPLORATION WELLS

Traverse 1	
SP1000	ALLIANCE A SP 166
SP1044	GSQ MT WHELAN NO 2
SP1704	GSQ MT WHELAN NO 1
Traverse 2	
SP2016	NETTING FENCE NO 1
SP2692	TRAVERSE 3 SP3976
SP3256	(GEOFLEX EXPT TRAV. 4. SP 100) (ALLIANCE G SP196)
SP3476	ALLIANCE F SP194
SP3736	ALLIANCE L SP191
SP3964	ALLIANCE X SP200 (500 m SW)
SP4120	ALLIANCE S SP195
SP4228	ALLIANCE K SP190
Traverse 4	
SP4988	ALLIANCE G SP187
Traverse 5	
SP5976	ALLIANCE K SP184
Traverse 6	
SP6988	BMR E SP1947
SP6868	TRAVERSE 13 SP13012
Traverse 9	
SP9976	ALLIANCE B SP185
Traverse 10	
SP10006	ALLIANCE U SP165
SP10025	TRAVERSE 10 SP10506
SP10618	ALLIANCE A SP129
SP10006	ALLIANCE K SP199
Traverse 11	
SP11976	ALLIANCE X SP192

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Traverse 12

SP12988	ALLIANCE J SP191
SP12898	ALLIANCE B SP192
SP12814	ALLIANCE T SP179
SP12988	ALLIANCE U SP198 (310.5 m NW along U)

Traverse 13

SP13156	FPC LH SP2190 (119 m north of SP13156)

Traverse 14

SP14006	ALLIANCE A SP135
SP14522	ALLIANCE T SP190
SP14900	ALLIANCE B SP199
SP14988	ALLIANCE J SP198

Intersections on segments of Traverse 14

14199	14306
14332	14506
14578	14706
14745	14900

APPENDIX 2

PERSONNEL AND EQUIPMENT

PERSONNEL

Party Leader	P.L. Harrison		
Geophysicists	J.A. Bauer	(6/6 - 20/11)	
	D.L. Schmidt		
	A. Nelson (GSQ)		
Party Clerk	S. D'Arcy		
Technical Staff	J.K. Grace STO II	(28/6 - 20/8)	
	D. Gardner TO I		
	D.E. Johnstone TTO	(25/8 to end)	
	C. Allen TO I (acting)	(28/6 - 21/7)	
Field Assistants	R.D.E. Cherry		
	L. Rickardsson		
Tool Pusher	A. Zoska		
Drillers	E. Lodwick		
	K. Huth	(23/6 - 17/9)	
	K. Reine		
	J. Henry	(15/10 to end)	
Mechanics staff	D.K. McIntyre		
wages	J. Keyte		
	A. Crawford	(4/11 to end)	
Surveyors	L. Walter	(6/6 - 5/8)	From Dept. of Administrative Services
	R. Ling	(1/8 - 25/8)	
	J. Wenborn	(30/8 - 21/10)	
	D. Forte	(18/10 to end)	
TO (Surveying)	I. Kaczerepa	(6/6 - 5/8)	
	P. Davies	(1/8 to end)	
Chainmen	Two		
Field Hands including cook and cook's offsider	Twelve		

EQUIPMENT

Recording System	Texas Instruments DFS IV
Camera	SIE TRO-6
Geophones - production	GSC 20D 8hz, 1280 units
weathering	GSC 12hz, 24 units
Cables - production	SCG-5, 265 m, 18 units
weathering	146 m, 2 units

Transceivers	Codan, 6424 SSB, 6 units
	Pye Cambridge, FM100, 6 units
	Phillips, FM828, 4 units
Rota-Long Switch	I/O Rota-Long, 1 unit
Radio shooting equipment	I/O RFU
Gravity meter	Worden W169, 1 unit

VEHICLES

Recording truck	International D1610, 3 tonne 4 x 4
Shooting truck	" " "
Workshop truck	" " "
Flat-top truck	" " " (2)
Water tanker	" " " (3)
Stores truck	" D1310, 30 cwt 4 x 4
Geophone carrier	Landrover, LWB (3)
Personnel carrier	" " (3)
	SWB (1)
Drill Rig/Prime mover	Mayhew 1000/Mack 8 x 6 (3)
Drill tanker	AEC Militant 6 x 6 (3)

TRAILERS

Office caravan	4-wheel
Kitchen caravan	"
Ablution caravan	"
Explosives magazine	"
Workshop trailer	"
General Purpose trailer	" (2)
Drill trailer	2-wheel
	4-wheel
Generator	2-wheel
Drill mechanic's trailer	"

APPENDIX 3

OPERATIONAL STATISTICS

Sedimentary Basin	Georgina, survey area approx. 23°-24°S/138°E-139°E	
Campsites	Wanders	17/6 - 25/7/77
	Kate	26/7 - 29/8/77
	Abudda Lakes	30/8 - 19/9/77
	Pulchera	20/9 - 2/12/77

Seismic Operations	TRAV. 1	TRAV. 2	TRAV. 3	TRAV. 4	TRAV. 5	TRAV. 6	TRAV. 7	TRAV. 9	TRAV. 10	TRAV. 11	TRAV. 12	TRAV. 13	TRAV. 14	TOTAL
Recording commenced	30 JUN	28 JUL	10 AUG	24 AUG	29 SEPT	21 OCT	14 NOV	22 NOV	5 OCT	4 NOV	22 SEPT	29 OCT	17 NOV	
Recording completed	21 JUL	21 SEPT	15 AUG	1 SEPT	28 OCT	25 OCT	25 NOV	24 NOV	14 OCT	9 NOV	28 SEPT	3 NOV	21 NOV	
Station numbers	1000-1716	1976-4280	3736-4000	4808-5000	5616-6000	6850-7000	7856-8000	9736-10000	10000-10036 10500-10632	11672-12004	12802-13000	13000-13168	14000-15000	
Direction	NE	SSE	ENE	NE	NE	NW & NE	SE	NE	NW	NE	SE	E	SW & SE	
Length - subsurface (km)	28.8	94.5 gap 6.5	21	15	15	11.5	1.0 EXPANDED	10.5	12	12.9	15.5	13	35	285.7
Coverage	12/6 fold	6 fold	6 fold	6 fold	12 fold	6 fold	SPREAD	6 fold	6 fold	12 fold	6 fold	6 fold	1/3/6 fold	
No of production shots	183	521	126	98	127/42	64		61	61	139	88	73	55	1636
No of production recording days	17	21	4	4	10	3	3	2	5	5	4	4	4	86
Recording non-production days	4	11	NIL	3	1	NIL	1	1	3	1	1	NIL	1	27
Production rate - recording (km/month)*1	34	90	105	75	30	77	-	105	48	52	78	65	1 fold 182 3/6 fold 157	
Energy source	Dynamite	Dynamite	Dynamite	Dynamite	Dynamite/ geoflex	Dynamite	Dynamite	Dynamite	Geoflex	Geoflex	Dynamite	Dynamite	Dynamite	
Bulldozing, length(km)	NIL	90	22	16	16	NIL	NIL	11	14	14	16.5	14	36	249.5
Total metres drilled (m)	5373	17056	3857	2043	4599	2571	1793	2007	-	-	3029	2522	2126	46976
Normal hole pattern	single	single	single	single	single	single/5 hole	1-12 hole	single	-	-	single	single	single/5 hole	
Normal hole depth (m)	27/36	23/36	36	23/36	36	36/13.7	36	36	-	-	23/36	36	36/9	
No. of productive rig days	43	60	14	19	28	10	10	9	-	-	15	14	16	238
No. of non-productive rig days*2	3	44	1	2	5	11	NIL	NIL	-	-	2	1	5	74
No. of days to plough Geoflex	-	-	-	-	3	-	-	-	5	6	-	-	-	14
Production rate - drilling (km/rig month)*2	12.1	16.7	26.7	13.3	6.5	10	-	21.1	-	-	17.1	16	32.5	
Production rate - ploughing (km/month)*3	-	-	-	-	22	-	-	-	44	40	-	-	-	
Normal charge size/shot (kg) or Geoflex pattern gr/m - grains/metre	22.7	13.6-22.7	13.6-22.7	13.6	22.7 5x60mx1m 40gr/m	13.6	up to 1091	27.3	3x90mx3m 40gr/m	4x60mx1m 40gr/m	22.7	13.6-22.7	1 fold 22.7 3/6 fold 13.6	
Spread geometry	Split	offend/split	Split	Split	Split	Split	-	Split	Split	Split	Split	Split	Split(mainly)	
No. of data channels	48	24	24	24	48	24	24	24	24	48	24	24	24	
Station interval (m)	412/3	83⅓	83⅓	83⅓	412/3	83⅓	83⅓	83⅓	83⅓	412/3	83⅓	83⅓	83⅓	
Geophone pattern	8 in line	8/16 in line	16 in line	16 in line	8 in line	16 in line	16 in line	16 in line	16 in line	8 in line	16 in line	16 in line	16 in line	
Record quality	poor/fair	fair/good	poor/good	poor/good	poor/good	fair	fair	poor	fair	poor/good	fair	fair/good	fair/v. good	

Topographic survey controls	Dept. Admin. Services Benchmarks
Explosives used	Totals 29,841 kg Dynamite; 62,000 m Aquaflex; 4000 m x 10gr/m & 2400 m x 20gr/m geoflex
Detonators used	Totals 1600 x 45 m lead, 50 x 10 m lead, 880 x No. 8 Submarine dets

Gravity Operations	TRAV. 1	TRAV. 2	TRAV. 3	TRAV. 4	TRAV. 5	TRAV. 6	TRAV. 7	TRAV. 9	TRAV. 10	TRAV. 11	TRAV. 12	TRAV. 13	TRAV. 14
No. of Stations	67	193	56	44	37	-	-	23	38	36	42	-	-
Survey No. *5	7711	7711	7712	7711	7711			7711	7712	7712	7712		
Ties to Isogal network	5908.1050 5908.1009	5910.4304 5910.4305									5908.1025		

Station Interval (m)	500 m (Some 83 m on traverse 3)
Meter reader	A. NELSON (GSQ)
Meter no.	W169 - WORDEN GRAVIMETER
Calibration factor	0.10095
Calibration details	CANBERRA MT AINSLIE MAY 1977, JAN 1978
Levels	Dept. Admin. Services, Australian Survey Office

Note:

The figures quoted here exclude Geoflex experiments on Traverse 4 and expanded spread SP 4044, Traverse 2. Expanded spread SP 3856 was shot in conjunction with production shooting.

*1. One month is defined as 20 production-recording days.

*2. One rig month is defined as 20 days including all stoppages except well shoot, GSQ Mt Whelan No 2 (5 rig day Camp shifts (5 days) Maintenance end of survey (5 rig days). A non-productive rig day includes all stoppage except above.

*3. Ploughing rate excludes breakdowns & any other non-productive days. One month is defined as 20 productive days.

*4. Split spreads have double centre gap except
Trav. 5 7 trace gap SP5718
9 trace gap SP5716-5640
Trav. 10 5 trace gap SP10550-10818
Trav. 11 9 trace gap

*5. Survey nos refer to location of data in BMR National Gravity Repository. Benchmark nos are as in Repository.

APPENDIX 4

DFS IV INSTRUMENT SETTINGS

Tape Format	SEG B NRZI			
	½", 800 bpi			
	24/48 channel			
Sample rate	1 millisec	TRAV. 2 SP 2024-2308		
	2 millisec	elsewhere		
Record length	normally 6 sec			
	18 sec. records:	TRAV 1	1676	
			1652	
			1628	Single-fold
			1604	
			1580	
			1472	
		TRAV 2	2780-2848	
			Six-fold	
	20 sec. records:	TRAV 7 (all records)		
Recording Filters	hi cut:	124hz @ 72dB/octave		
	lo cut:	8hz @ 36dB/octave on TRAV 1 SP1032-1092		
		12hz @ 36dB/octave elsewhere		
	50hz Notch:	out		
Gain Constants	36dB			
(Input Module)	(+6dB 500 Ω input transformers)			

APPENDIX 5

DATUM, AND CORRECTION VELOCITIES

TRAVERSE	FIRST LAYER WEATHERING VELOCITY	SECOND LAYER WEATHERING VELOCITY	SUB-WEATHERING VELOCITY
1	750	1775	3300
2	750	-	2900
3	750-1500	-	2900
4	560-750	-	2900
5	880	-	3450
6	900	2100-2700	5000
7	1250	2000	4000
9	600	-	2500
10	600-900	1050-1350	2900
11	1000-1500	-	2900
12	600-1000	2000-2800	5000
13	500	2000	4000
14	600	1800-5000	3300-5600

DATUM (ALL TRAVERSES) : 91 m above M.S.L.