71/138
4

Pages 1-8

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1971/138

BUREAU OF MINERAL RESOURCES
LIBRARY
Copy 4
CANBERRA, A.C.T.

015113

GALILEE BASIN SEISMIC SURVEY, QUEENSLAND, 1971

OPERATIONAL REPORT

by

P.L. Harrison and A.R. Brown

The information contained in this report has been obtained by the Department of National Development as part of the policy of the Commonwealth Government to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus or statement without the permission in writing of the Director, Bureau of Mineral Resources, Geology & Geophysics.

BMR
Record
1971/138
c.4

BUREAU OF MINERAL RESOURCES
LIBRARY
Copy 3
CANBERRA, A.C.T.

Record 1971/138

GALILEE BASIN SEISMIC SURVEY, QUEENSLAND, 1971

OPERATIONAL REPORT

by

P.L. Harrison and A.R. Brown

CONTENTS

	Page
SUMMARY	
INTRODUCTION	1
OBJECTIVE AND PROGRAMME	2
RESULTS AND CONCLUSIONS	5
REFERENCES	7
APPENDIX 1 STAFF AND EQUIPMENT	9
APPENDIX 2 OPERATIONAL STATISTICS	10

ILLUSTRATIONS

Plate 1 Location Map.

Plate 2 Preliminary Record Sections.

SUMMARY

A seismic investigation of the eastern margin of the Galilee Basin in Central Queensland was made by the Bureau of Mineral Resources between August and November 1971. A seismic traverse was recorded between Lake Galilee No. 1 well and outcrops of the Drummond Group 80 km to the east.

The area was a difficult one in which to record good seismic data, many of the problems resulting from the presence of the "P" horizon, a strong fairly shallow reflection associated with the Upper Permian coal measures. Single coverage recording used over most of the traverse yielded data of fair quality only. Several 6-fold CDP multiple coverage probes provided improved quality.

Preliminary interpretation indicates that the margin between the Galilee and Drummond Basins is abrupt and probably complex. There is probably sufficient sedimentary thickness and structure to justify further petroleum exploration.

The Upper Permian coal measures rise close to the surface near the eastern margin of the Galilee Basin.

INTRODUCTION

From August to November 1971, the Bureau of Mineral Resources (BMR) conducted a seismic survey east of Lake Galilee in the Galilee Basin, Central Queensland. The area of the survey lay partly within petroleum exploration title ATP76P held jointly by Exoil N.L. (70%) and Transoil N.L. (30%), but most of the seismic traverse was within the vacant area to the east (Pl. 1).

Lake Galilee No. 1 oil exploration well (Pemberton, 1965), the only deep well in the area, bottomed in Upper Devonian sediments at a depth of 3406 m. Eighty kilometres east of the well there are outcrops of Lower Carboniferous Drummond Group sediments and a further 35 km east are outcrops of the oldest Drummond Group rocks, the late Upper Devonian Silver Hills Volcanics. Vine & Doutch (1972) consider the latter rocks to be unrelated to the Devonian sediments in the well. Vine has proposed several possible structural interpretations of the eastern margin of the Galilee Basin involving both faulting and erosion followed by onlap. It has been impossible to distinguish these by interpretation of existing regional gravity data. Further, the area is covered by Cainozoic sediments and no seismic work had been attempted before the present survey.

The area is of economic interest, as oil was recorded in a drill stem test in Lake Galilee No. 1 well in Carboniferous sediments in the interval 2890 to 2910 m and there are coal measures in the Upper Permian. Knowledge of the structure of the basin margin to the east of the well could reveal oil traps and economically mineable coal deposits.

Reconnaissance seismic reflection surveys have shown the broad extent and structure of the Galilee Basin. They include surveys using explosives by Exoil (1963a, 1963b), Amerada (1966), and a Geograph (Thumper) survey by Amerada (1967). Exoil seismic lines to the southeast of the well provided useful data in the area of the current operation. These previous surveys generally mapped structure on a strong shallow reflector, the "P" horizon, associated with the Upper Permian coal measures. Energy penetration of the "P" horizon was a problem and deeper information was rarely obtained. Amerada's Thumper survey used 5- to 12-fold CDP and did record some deeper data. The Galilee Basin was found to have gentle relief and any structure was attributed to overlapping onto older topography.

BMR helicopter gravity reconnaissance surveys from 1959 to 1963 have covered the Galilee and Drummond Basins (Gibb, 1966). Reconnaissance Bouguer anomaly contours, drawn on Plate 1, show a substantial gradiant assumed to coincide with the basin margin. The detailed gravity traverses described by Anfiloff (1972) were designed to obtain more information on this gradient.

The area has been covered by regional aeromagnetic surveys by BMR (Jewell, 1960), by Exoil (1962) and by Magellan (1963). The magnetic basement contours give a basin axis location inconsistent with the results of other geophysical investigations.

The area of the survey is accessible from Charters Towers to the north and from Aramac and Clermont to the southwest and southeast respectively. The country is generally flat and lightly timbered and is used mainly for cattle grazing.

The seismic survey formed the basis for co-operation with other groups in the Geophysical Branch of the BMR. Gravity readings were taken at shot-points and on adjacent detailed traverses. Crustal refraction data were recorded from some of the larger shots.

Extensive analysis and data processing are required before a detailed interpretation of the seismic data will be possible. This report describes the work done during the field survey and presents a preliminary interpretation only.

OBJECTIVE AND PROGRAMME

Objective

The objective of the survey was to define the structural configuration of the eastern margin of the Galilee Basin and its relationship to the western margin of the Drummond Basin and, in so doing, to investigate the potential of the area for petroleum and coal exploration.

Programme as Proposed

The proposed programme was to record reflection seismic data along a traverse from Lake Galilee No. 1 well eastwards as far as the Drummond Group outcrops. The survey was planned to start with experimentation near the well to establish shooting and recording parameters. The position of the traverse was to be determined to take advantage of previous seismic lines recorded by Exoil (1963a), by the need for access tracks and a crossing of the Belyando River and the desirability of crossing the maximum gravity gradient.

The initial experimentation was proposed as follows:

1. Uphole Shoot to establish best shooting depth as well as to obtain near-surface velocity information.

2. Noise Test to study the characteristics of longitudinal and transverse coherent noise in order to choose recording frequency filters and design suitable shot-hole and geophone arrays.

3. Expanded spread to obtain deep velocity information, to identify primary and multiple reflections and to assess the effectiveness of the chosen recording parameters in cancelling coherent noise.

4. Experimental 6-fold CDP to determine how heavy a technique would be required to obtain acceptable reflection information from below the "P" horizon.

Production shooting was planned to be carried out with CDP or single coverage shooting as considered necessary, together with further experimentation when this was essential to maintain adequate checks on recording parameters and conditions.

Programme as Carried Out

The location of the seismic traverse surveyed and the main types of recording employed are shown in Plate 1. During the survey the success of the shooting and recording techniques was continuously assessed and modifications made as necessary. The detailed programme as carried out is summarized below.

Initial Experimentation. The Uphole Shoot, Noise Test, Expanded Spread, and Experimental 6-fold CDP were recorded as planned south of Lake Galilee No. 1 well. The CDP used two different shot-to-spread offsets to compare their success in cancelling multiples.

Some 33 km of the proposed traverse was then omitted as acceptable data existed from Exoil's earlier work. Recording was recommenced where the Exoil data deteriorated in quality. From here the traverse was shot continuously to the Drummond Group outcrops.

Limited experimentation, including a further Expanded Spread, was conducted initially to check that shooting and recording parameters were applicable in the new area. Following this, several shot-points of single coverage were shot at two depths for uphole stacking. The stacked section showed a reduction in random noise but little attenuation of ghost reflections. As the extent of ghosting was much less serious than near the well, no further attention was devoted to this problem.

Production Reflection Shooting. The technique then adopted for most of the traverse was split-spread single coverage with intermittent 6-fold CDP

probes to attenuate multiples and random noise and Expanded Spreads to identify multiples and obtain velocity information.

Three further 6-fold CDP probes were conducted. On the latter two the geophone station interval was increased from 45 m to 90 m in order to enable the use of longer geophone groups to attenuate longitudinal coherent noise without incurring excessive ground mixing.

Velocity Investigations and Recording Control. Throughout the survey a continuing assessment of deep velocity information was made including Expanded Spread results and data from Lake Galilee No. 1 well and previous seismic surveys. This was particularly necessary for choosing the correct velocity function for stacking of 6-fold CDP data.

A check on best shooting depth and near-surface velocity and weathering information was maintained with three full-scale Uphole Shoots and two limited Uphole Shoots at intervals along the traverse.

To preview recording conditions on the proposed line three single coverage probes were recorded ahead of the main recording operation. This allowed planning of future programme and anticipation of recording difficulties.

Additional Detailed Reflection Shooting. As the recording proceeded eastwards the "P" horizon became increasingly shallower until it was not recorded by the normal geophone spread. Special short reflection and refraction spreads were recorded in an attempt to follow the coal measures to where they sub-cropped under the recent sedimentary cover.

After completion of single coverage shooting to the eastern end of the traverse the shooting was repeated between SPs 1156 and 1169 using deeper holes. This was a region of confused reflection quality and an Uphole Shoot at SP 1155 and other minor investigations had indicated a deeper than usual low velocity layer. Uphole stacking was possible with the shots from the two depths.

Refraction and Deep Crustal Reflection. A refraction probe about 20 km long was shot at the eastern end of the traverse in an attempt to identify some reflections by means of their refraction velocities. The probe was not fully reversed, only the near spreads being recorded from the eastern shot-point. Reflection data will provide dip control.

The larger shots of the refraction probe were used for simultaneous recording, by the secondary seismic recorder, of deep crustal reflection data at SP 1142. Also mobile recording stations were set up by the

Regional Structural Surveys Group of the BMR to record deep crustal refraction data along a line northwards to Charters Towers.

Details of staff and equipment are given in Appendix 1. Details of surveying, drilling, shooting and recording parameters are given in Appendix 2.

The Detailed Gravity Survey conducted concurrently with the Seismic Survey has been reported by Anfiloff (1972).

RESULTS AND CONCLUSIONS

Results

Preliminary seismic record sections recorded from Lake Galilee No. 1 well to the Drummond Group outcrops are shown in Plate 2.

The area of the survey had several problems which made the recording of good quality deep seismic data difficult. These were:

1. Low energy penetration of the "P" horizon, the event at 0.6 second close to the well. So much energy was reflected by this horizon that little energy was transmitted.

2. Strong surface multiples of the "P" horizon, up to the fourth order, interfered with deeper reflection events. As it became shallower towards the east, the multiples became progressively less troublesome.

3. Random noise was a problem over the entire traverse.

4. Strong coherent noise trains were propagated, whose character varied along the traverse.

5. Ghost reflections were pronounced close to the well but were not a serious problem over most of the traverse.

6. Energy coupling in the shot-holes and at the geophones was variable with the result that Automatic Gain Control rather than Programmed Gain Control had to be used in most of the recording, so that records of variable quality were obtained.

These problems were largely although not completely overcome. Geophone and shot-hole patterns were successful in attenuating coherent noise. Large charges provided better energy penetration of the "P"

horizon. Six-fold CDP probes using carefully designed spreads substantially attenuated multiple reflections and random noise.

The reflection quality seen on the record sections varies from poor between SPs 1101 and 1122, an area of sandstone outcrop, to fair over large parts of the section and good for some of the 6-fold CDP stacked data. It is difficult to follow discrete reflections over long distances, but phantom horizons may be used to extend effective reflection continuity.

Most reflections are very close to horizontal over the greater part of the traverse, namely from the well to about S° 1125. There is some complicated structure in the region SPs 1150-1170, which presumably is the basin margin. Further processing of the data in this region will be particularly important. The curving and steeply dipping events between SPs 1163 and 1168 are provisionally identified as diffractions off fault edges. The presence of continuous although disturbed deep events at 2.0 to 2.8 seconds below the zone of complicated structure is notable. It is possible to identify several unconformities at the eastern end of the traverse and the picking of zones of conformable reflections appears to be a promising method of interpretation.

Several minor reflection and refraction probes indicated that the Upper Permian coal measures may subcrop in the region SPs 1140-1160. Two holes drilled to 100 m at SPs 1146 and 1156 did not penetrate coal.

Conclusions

The margin between the Galilee and Drummond Basins is abrupt and probably complex. There may be faulting or alternatively sharp folding. The preliminary interpretation of the seismic results suggests that there is no relationship between the Drummond Group outcrops and sediments penetrated by Lake Galilee No. 1 well.

A substantial thickness of sediments persists up to the eastern margin of the Galilee Basin and several unconformities are evident. The area appears to have sufficient petroleum potential to justify more detailed exploration.

The Upper Permian coal measures reach very shallow depths near the basin margin.

REFERENCES

AMERADA PETROLEUM CORPORATION, 1966 - Geophysical Report, Bowen Downs Seismic Survey, ATP 76P, by Petty Geophysical Engineering Co. and Namco Geophysical Co. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Rep. (unpubl.).

AMERADA PETROLEUM CORPORATION, 1967 - Towerhill Geograph Seismic Survey, ATP 76P, Queensland, by Ray Geophysics (Australia) Pty Ltd. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Rep. (unpubl.).

ANFILOFF, W., 1972 - Galilee Basin Detailed Gravity Survey. Bur. Miner. Resour. Aust. Rec. (in prep.).

EXOIL, N.L., 1962 - Airborne Magnetometer Survey of the Aramac-Mt Coolon Area, Drummond Basin, Central Queensland, Australia, by Adastra Hunting Geophysics Co. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Rep. (unpubl.).

EXOIL, N.L., 1963a - Seismic Survey Report, Lake Galilee and Lake Buchanan Areas, ATP 76P, Queensland, by Austral Geo Prospectors Pty Ltd. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Rep. (unpubl.).

EXOIL, N.L., 1963b - Seismic Survey Report, Torrens Creek Seismic Survey, ATP 76P, Queensland Australia, by Austral Geo Prospectors, Pty Ltd. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Rep. (unpubl.).

GIBB, R.A., 1966 - North Eromanga and Drummond Basins Reconnaissance Gravity Surveys, Queensland, 1959-1963. Bur. Miner. Resour. Aust. Rec. 1966/210 (unpubl.).

JEWELL, F., 1960 - Great Artesian Basin Aeromagnetic Reconnaissance Survey, 1958. Bur. Miner. Resour. Aust. Rec. 1960/14 (unpubl.).

MAGELLAN PETROLEUM CORPORATION, 1963 - Tambo-Augathella Aeromagnetic and Gravity Surveys, Queensland, 1959-60. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Publ. 31.

PEMBERTON, R.L., 1965 - Lake Galilee No. 1 well Completion Report by Exoil N.L. and Transoil N.L. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Rep. (unpubl.).

VINE, R.R., and DOUTCH, F., 1972 - Explanatory Notes on the Galilee 1:250,000 Geological Sheet (in prep.).

APPENDIX 1

STAFF AND EQUIPMENT

Staff

Party Leader	A.R. Brown (10.8.71 - 10.9.71) P.L. Harrison (from 11.9.71)
Geophysicist	E.J. Riesz
Observer	L.E. Hemphill
Assistant Observers	R. Enders W. Gunner
Shooters	R.D.E. Cherry H. Pelz
Surveyor	A.J. Hoffmann, on contract to Department of the Interior
Toolpusher	B.G. Findlay
Drillers	L.A.C. Keast T.P. Shanahan K. Reine
Drill Assistants	E. Reid S.E. Heggie
Mechanic	E.C. McIntosh
Clerk	A.D. Preston-Stanley
Field Hands	Fifteen

Equipment

Main Recorder	Seismic Amplifiers SIE PT-700 Oscillograph SIE TRO-6 Magnetic Recorder (FM) SIE PMR-20
Second Recorder	Seismic Amplifiers TI8000 Oscillograph VT-6 Magnetic Recorder (AM) DS7-700
Geophones	Hall Sears HS-J, Hz Refraction, 4.5 Hz
Drilling Rigs	Foxmobile (2) Mayhew 1000 (2)

Other vehicles, camping and miscellaneous equipment.

APPENDIX 2

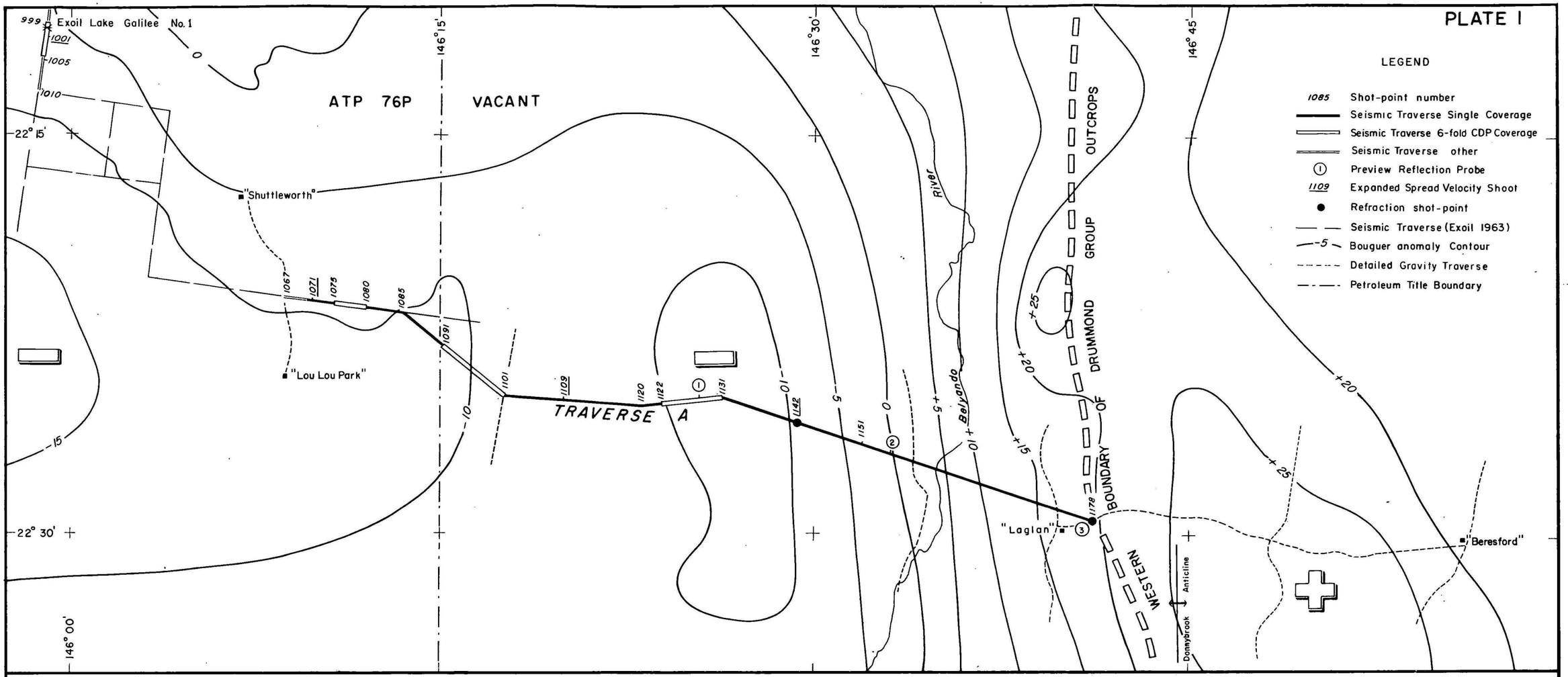
OPERATIONAL STATISTICS

All measurements during the survey were in metric units apart from weight of charge.

Sedimentary Basins	Galilee and Drummond
Camp Sites	Shuttleworth (6.8.71 - 21.10.71), Laglan (21.10.71 - 27.11.71)
Survey commenced	9th August 1971
Survey completed	25 November 1971
Kilometres of traverse surveyed	65
Topographic survey control	Department of the Interior benchmarks.
Total number of holes drilled	1,268
Total depth drilled in metres	32,476
Explosives Used	60,000 lb Geophex
Shot-point interval (basic)	540 metres
Geophone station intervals	45 metres 90 metres
Common geophone groups	32, in 4 lines of 8 parallel to traverse, spacing in line 6 metres, spacing between lines 8 metres. 32, in 2 lines of 16, parallel to traverse, spacing in line 6 metres, spacing between lines 8 metres. 16, in 2 lines of 8, parallel to traverse, spacing in line 6 metres, spacing between lines 8 metres.
Common hole patterns	3 single in one line parallel to traverse, spacing 20 metres. 5 in one line parallel to traverse, spacing 12 metres. 10 in two lines of 5 parallel to traverse, spacing in line 12 metres, spacing between lines 20 metres.

Common hole depths	25 metres 32 metres 50 metres
Charge sizes	15-400 lb per shot
Normal tamping	Solid
Normal recording mode	Automatic gain control
Normal recording filters	LL16-KK100
Datum for corrections	200 metres A.S.L.
Weathering velocity	600-1000 metres per second
Sub-weathering velocity used	2000 metres per second

PLATE I



LEGEND

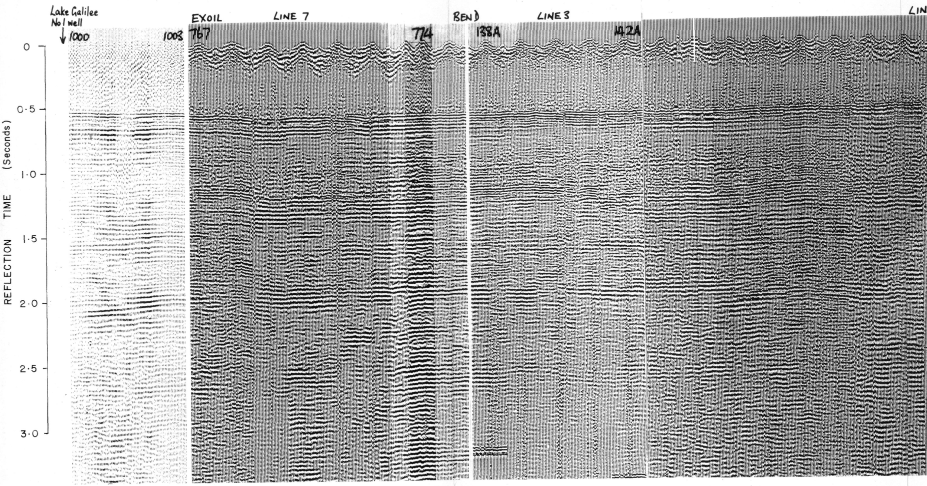
- 1085 Shot-point number
- Seismic Traverse Single Coverage
- Seismic Traverse 6-fold CDP Coverage
- Seismic Traverse other
- ① Preview Reflection Probe
- 1109 Expanded Spread Velocity Shoot
- ● Refraction shot-point
- Seismic Traverse (Exoil 1963)
- -5- Bouguer anomaly Contour
- Detailed Gravity Traverse
- Petroleum Title Boundary

GALILEE BASIN SEISMIC SURVEY 1971 LOCATION MAP

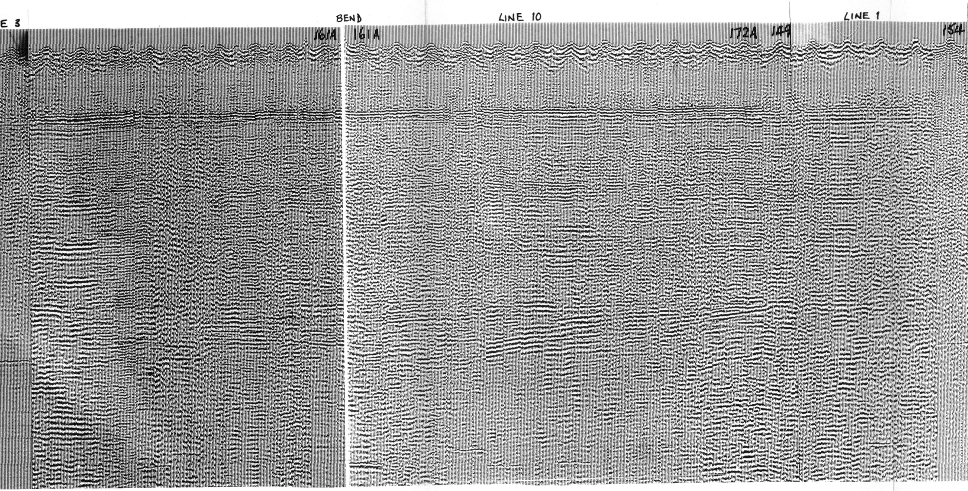
5 0 5 10 15 20 25 30 KILOMETRES

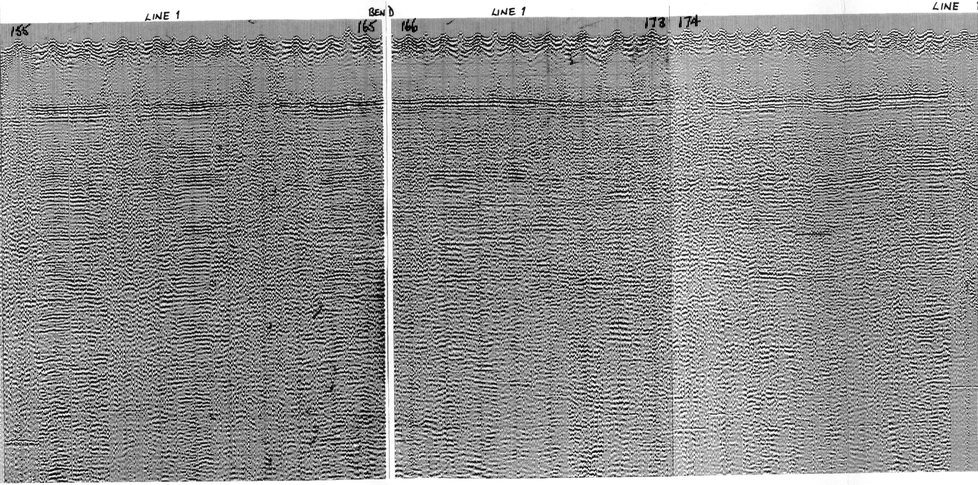
5 0 5 10 15 MILES

F55/B3-73

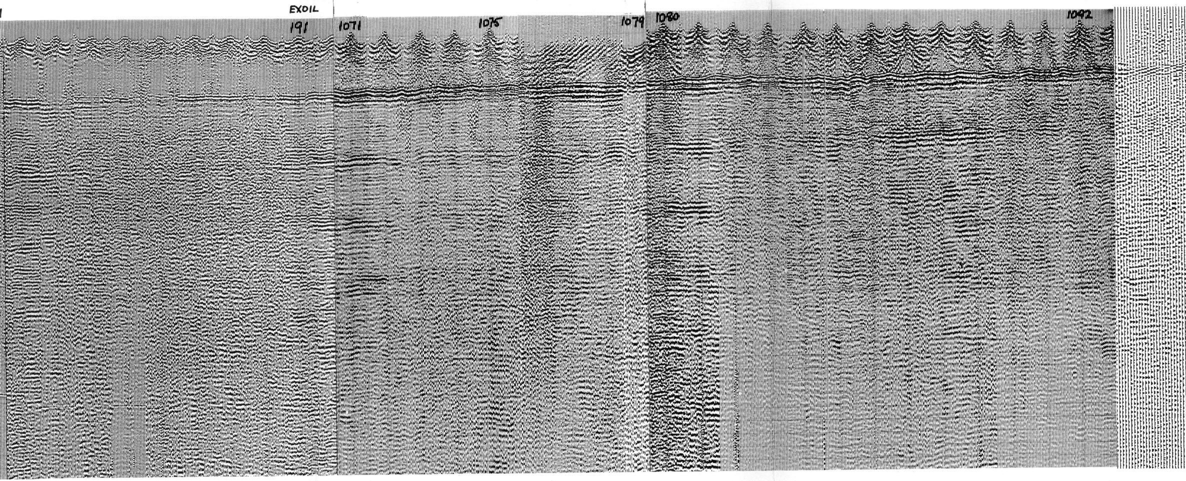


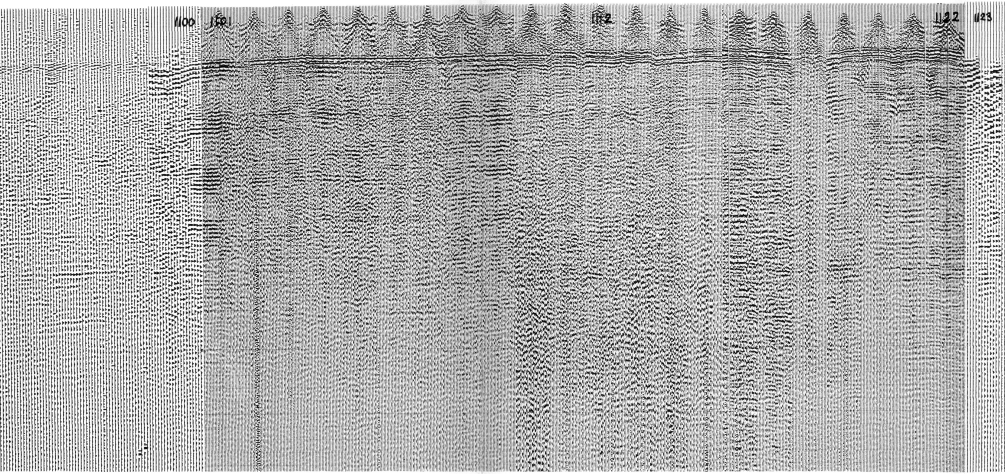
Based on F55/B3-74 and F55/B3-75





Between SPs 767 and 191 the data was recorded during the Lake Galilee Seismic Survey (Exoil N.L., 1963 a)





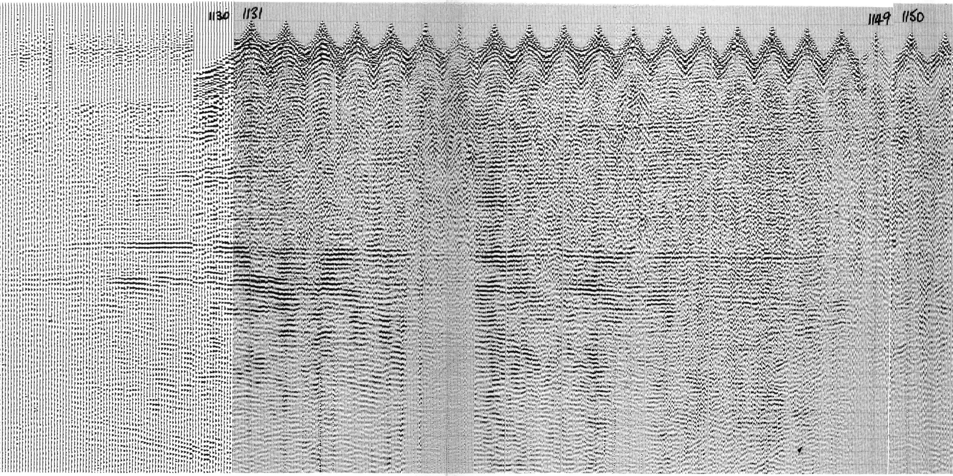
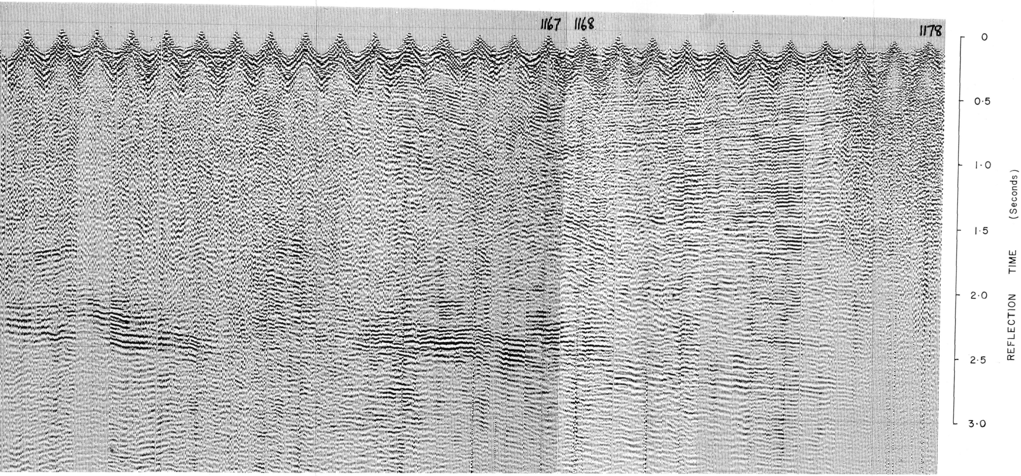


PLATE 2



F55/B3-76

GALILEE BASIN SEISMIC SURVEY 1971
PRELIMINARY RECORD SECTIONS