Bureau of Mineral Resources, Geology & Geophysics

RECORD

BMR RECORD 1989/1

DEEP STRUCTURE OF THE GIPPSLAND AND BASS BASINS (PROJECT 9131.12)

OPERATIONAL REPORT FOR CRUISE 1 (SURVEY 82)

by

J.B. Willcox & J.B. Colwell

(with contributions by G. Heal, B. Jones, J. Mangion & C. Collins)

BMR RECORD 1989/1

DEEP STRUCTURE OF THE GIPPSLAND AND BASS BASINS (PROJECT 9131.12)

OPERATIONAL REPORT FOR CRUISE 1 (SURVEY 82)

by

J.B. Willcox & J.B. Colwell

(with contributions by G. Heal, B. Jones, J. Mangion & C. Collins)

SUMMARY

Petroleum exploration within the Gippsland Basin has been focussed on major anticlines at the Early Tertiary "top Latrobe" unconformity, and to a much lesser extent on "intra-Latrobe" traps. Little information exists on the petroleum potential deep within the basin. Similarly, in the adjacent Bass Basin, most of the exploration effort has been concentrated at or near the top of the Latrobe Group equivalent, the Eastern View Coal Measures.

Analysis of regional seimic data collected by BMR in 1982 suggests that the Bass and Gippsland Basins were initiated by NNE-SSW lithospheric extension, probably in the Early Cretaceous. A reactivation of these basin-forming extensional structures, particularly transfer faults, may have had a significant influence on petroleum migration and accumulation higher in the stratigraphic section.

This operational report describes the first of two cruises to be undertaken by the R/V Rig Seismic in the Gippsland/Bass region (Nov - Dec.1988 & March - April 1989). These cruises aim to:

(i) improve definition of the deep structure of the Gippsland and Bass Basins using basin-wide deep seismic (12+ seconds) transects,

(ii) evaluate models for basin evolution

(iii) develop concepts for petroleum migration and entrapment from the regional data and by analogy with the similar basins worldwide, and

(iv) through the provision of regional seismic data assist the petroleum industry in carrying out seismic correlations.

The cruises contribute to a number of studies by BMR of the structure, stratigraphy, evolution and resource potential of offshore basins along Australia's southeastern margin.

This first cruise (Survey 82) was broken into four parts:

(i) Equipment testing for future work: involving the measurement of drift on a HIfix radio navigation system, and testing IFP electronics for the deep recording objectives of the program,

(ii) Recording of approximately 470 km of relatively deep-water reflection profiles in the eastern Gippsland Basin (12s records, 52.4 litre air-gun array for Line 82/001 , 26.7 litre for lines 82/002 & 3).

(iii) Recording of 1090 km of seismic reflection profiles in a grid over the Boobyalla Sub-basin of the Bass Basin (mainly 10s records, 26.7 litre air-gun array).

(iv) Shooting of 2 x 200km refraction lines across the central part of the Gippsland basin from Deal Island to the Victorian coast.

CONTENTS

CONTENTS (CONT.)

FIGURES

INTRODUCTION

Although the Gippsland Basin (Fig. 1), Australia's principal liquid petroleum province, has been extensively explored during the last twenty five years (see Figs. 2 and 3) little information has been obtained about deep structures within the basin. This is primarily because of the concentration of exploration activity at the relatively shallow "top Latrobe Group" levels and the dispersion of seismic energy caused by extensive Tertiary coal measures and channels. Likewise, exploration activity in the Bass Basin has been concentrated at the top of the basin's Latrobe Group equivalent, the Eastern View Coal Measures (Fig. 4).

In 1982, BMR undertook a regional survey (Survey 40) of Bass Strait aimed at the deeper parts of the Otway, Bass and Gippsland Basins. This survey (shot by GSI), when combined with selected company data, suggested a working model in which the three Bass Strait basins were initiated by north-northeast to south-southwest lithospheric extension, largely during the Early Cretaceous (Etheridge & others, 1985; Figs 5 and 6). The extensional stage was followed by a Late Cretaceous to Pliocene thermal subsidence stage and, in the case of the Gippsland Basin, by a late stage of tectonic overprinting (Fig. 7). The work also suggested that many of the Gippsland Basin's compressional structures, which contain oil and gas, were controlled by a reactivation of major early normal and tranfer faults (Etheridge & others, op. cit.).

The main aims of the proposed study (Surveys 82 & 90 by the Rig Seismic) are (i) to better define the deep structure of the Gippsland and Bass Basins and so to assist future exploration by providing new information on potential "deep" structural and stratigraphic plays; (ii) to evaluate tectonic models of the basins' evolution (e.g. Etheridge & others' 1985 model involving transfer faults and deep detachments) and to evaluate the geothermal consequences of such models in relation to the history of hydrocarbon generation and migration; and (iii) through the provision of regional seismic data in the Gippsland Basin, assist companies in carrying out seismic correlations within the basin.

During the two-cruise study it is proposed that approximately 2500-3500 km of high-quality 96-channel seismic reflection data together with ship-shore seismic refraction data be collected (Figs. 8 & 9). These data will complement data collected aboard the Rig Seismic over the eastern part of the Gippsland Basin in 1987 (Survey 68; Colwell & others, 1987) and over the adjacent Otway-West Tasmania margins in early 1988 (Surveys 78 & 79; Exon & Lee, 1988).

This report outlines the operations for Cruise 1 (Survey 82) which departed from Adelaide on 9th November 1988 and finished in Melbourne on 8th December 1988.

GEOLOGICAL SETTING

Offshore Gippsland Basin

The geology, regional setting, and evolution of the offshore Gippsland Basin, Australia's most prolific oil and gas province, have been discussed by numerous authors, including Weeks & Hopkins (1967), Hocking (1972), Gunn (1975), Threlfall & others (1976), Partridge (1976), Robertson & others (1978b), Smith (1982), Willcox (1984), Davidson & others (1984), Stainforth (1984), Etheridge & others (1985), Bodard & others (1986), Thompson (1986), Clark & Thomas (1988) and Rahmanian & others (in press). Although its early history is unclear, the basin forms the eastern extremity of a complex rift system which extended along the southern margin of Australia during the Jurassic and Early Cretaceous as a precursor to the post-Mid Cretaceous seafloor spreading between Australia and Antarctica. It may also be partly a "failed arm" of a triradial rift or another feature associated with the Late Cretaceous (anomaly 33) to Eocene (anomaly 24) separation of Australia from the Lord Howe Rise and New Zealand (Weissel & Hayes, 1977; Shaw,1978, 1979; Jongsma & Mutter, 1978 ; Roeser & others, 1985).

Except on its eastern flank, the basin is surrounded by Paleozoic rocks of the Tasman Geosyncline (Geological Society of Australia, 1971). Up to 3500 m of greywacke, sand, shale, and minor coal of the Strzelecki Group were deposited in interlocking alluvial-fan and alluvial-plain complexes during the Late Jurassic to Early Cretaceous infra-rift and syn-rift stages of the basin (sometimes referred to as the Strzelecki Basin). These were followed during the Late Cretaceous and Eocene by deposition of up to 5000 m of predominantly fluvio-deltaic sand, shale, and coal of the Latrobe Group. Deposition of these rocks was initially accompanied by volcanism that moved westwards with time. The volcanism was most common in the central basin deep, and was associated with basement fault blocks. During the Eocene, the upper surface of the Latrobe Group was eroded and several large-scale channels of various ages developed.

Marine conditions were established over the basin in the Early Oligocene, although shallow-marine conditions and westerly prograding shorelines existed prior to this in places, particularly in the east (e.g., top Latrobe barrier sands and Gurnard Formation). Sediment type changed from the mainly coarse-grained clastics of the Latrobe Group to calcareous shale

and marl of the Lakes Entrance Formation. The marine shale was mainly deposited in a narrow wedge around the basin margins with only a thin veneer being laid down in the basin centre. During the late Early Oligocene a drop in sea level caused erosion of the shale on the margins, over structural "highs" and perhaps in the youngest of the Eocene channels. With a renewed rise in sea level deposition of shale and marl continued into the Early Miocene onlapping structural "highs" and the basin margins, and providing a good regional seal.
During the Miocene, the Lakes Entrance Formation shales and marls were gradually replaced by the bryozoan limestones and marls of the Gippsland Limestone which form much of the present-day shelf and slope. A series of submarine channels was cut into the Miocene surface of the Gippsland Limestone prior to the deposition of up to 350 m of marine calcarenite of Pliocene and Recent age.

Tectonically, the Gippsland Basin has undergone several major phases of deformation. Two structural styles appear to be present: (i) commonly poorly-defined, basin-forming, normal rotational, and transfer faults active principally during extension and basin subsidence (Early Cretaceous to Early Eocene); and (ii) en echelon anticlines and shear faults generated by compression during the Late Eocene-Early Oligocene and Middle-Late Miocene, and possibly related to a reactivation of major early normal and transfer faults (Threlfall & others, 1976; Etheridge & others, 1985; Thompson, 1985). Many of the anticlinal structures contain large hydrocarbon accumulations within coarse clastics at the top of the Latrobe Group. All of these major structures have now been drilled forcing explorationists to increasingly concentrate on intra-Latrobe fault- dependent and combined structural/stratigraphic traps.

Recently, Lowry (1987, 1988) has suggested that the uconformity which is interpreted on the northern margin of the basin as separating the Latrobe and Strzelecki Groups may be an intra-Latrobe feature (Lowry, 1987). This raises the possibility that the prospective Latrobe Group may extend to greater depths within the basin than previously thought, particularly in areas transitional between the "central deep" and flanking "platforms".

<u>Bass Basin</u>

Aspects of the geology and petroleum potential of the intracratonic Bass Basin have been discussed by Weeks & Hopkins (1967), Richards & Hopkins (1969), Robinson (1974), Brown (1976), Robertson & others (1978a), Moore & others (1984), Smith (1986), Williamson & others (1985, 1986, 1987,1988) and Williamson & Pigram (1986). Like the adjacent Gippsland Basin, the basin appears to have formed by extensional tectonics during the Late Jurassic to Early Cretaceous. It contains up to 7 km of non-marine sediments of (?) Late Jurassic to late Eocene age and up to 3.5 km of Upper Eocene to Holocene marine sediments. Cainozoic volcanics occur in places. Sedimentation in the basin was dominated initially by Cretaceous flood-plain, alluvial-fan, and lacustrine deposition, then Late Cretaceous and early Tertiary flood-plain deposition, and finally, Cenozoic shallow marine deposition.

Although the Bass Basin is not to date a petroleum producer, seismic reflection studies (Williamson and others, 1987) suggest that significant structural and stratigraphic prospects for petroleum exploration occur at Paleocene,Cretaceous, and probably Jurassic levels. Source rock studies combined with depositional models indicate that suitable source and reservoir rocks probably occur in the Upper Cretaceous to Paleocene non-marine sequences. Overall, the best potential for petroleum discoveries appears to be at mature levels within the Upper Cretaceous to Paleocene Eastern View Coal Measures (EVCM) (Williamson and others, 1985, 1986, 1987).

Mapping of the deep structure in this basin suggests that major Early Cretaceous extensional normal faults segmented by contemporaneous transfer faults under lie the central and northwestern parts of the basin (Etheridge & others, 1984, 1985, Fig. 6).

Boobyalla Sub-basin

This feature forms the southeastern part of the Bass Basin (Figs. 1 & 6) and extends onshore in northeastern Tasmania (Moore & others, 1984). The normal-fault and postulated transfer-fault orientations of the Gippsland and central and northwestern Bass Basins , which appear to indicate a common extensional azimuth of 027 degrees, are largely absent or obscured in the sub-basin. In the Bass Basin, a major tranfer fault zone at about 146 30'E defines the the western edge of the Boobyalla Sub-basin: southeastward of this zone, the fault trends and basin boundaries (Fig. 6) indicate that the extensional azimuth is approximately 080 degrees. This azimuth is considered to be more a product of rifting in the Tasman Sea, whereas the Gippsland Basin and Bass Basin proper appear to be related largely to southern margin rifting.

Sediments encountered within the Durroon-1 exploration well in the Boobyalla Sub-basin are similar to those in the central part of the Bass Basin except that a more proximal facies of the Eastern View Coal Measures is present in the sub-basin. Further towards source areas, Late Cretaceous sediments consisting mainly of poorly-sorted conglomerates occur in the Boobyalla Plains area of northeast Tasmania (Moore & others,1984).

Seismic facies studies suggest that sequences additional to or different from those of the central Bass Basin may be present in some parts of the sub-basin (Pickering, pers. comm.). This is presently the subject of investigation by a petroleum exploration company.

CRUISE OBJECTIVES

The objectives of the Gippsland/Bass program are:

- To test and develop models for the formation of the Gippsland and Bass Basins by obtaining an improved understanding of their deep structure. In particular, to test and refine an extensional model for formation of the basins, the direction of extension, and the nature and distribution of detachment and transfer faults.

- To determine the degree of crustal thinning associated with formation of the basins as well as the velocity structure of the crust beneath the basins and their margins, and allow positive identification of boundaries such as the Moho. Velocities constrain the petrological interpretation of crustal and upper-mantle layers, and by comparison with adjacent regions may point to changes in physical conditions at depth, such as temperature.

- To compare and contrast the deep structure of the Gippsland and Bass Basins and relate them to extensional basins in general.

In addition, the following objectives are more closely related to hydrocarbon exploration in the Gippsland Basin:

- To provide industry with a grid of regional seismic profiles within the Gippsland basin, with a depth of penetration sufficient to determine relationships between deep structure and hydrocarbon production. To obviate the problem of individual companies obtaining regional data beyond their lease boundaries.

- To tie seismic profiles to key wells in the basin in order to identify formation tops, velocity variations and facies variations.

- If operational time permitted, to study the relationship of the southeastern margin of the basin to the basin proper. In this area, the basin trends appear to be more closely related to the Tasman Sea margin.

- To make a regional study of the key seismic horizons, isopachs and facies variations throughout the basin.

CRUISE PLAN

Seismic Reflection Work Planned for Cruises 82 and 90

Gippsland Basin

It was proposed to record eight regional lines (Fig. 8) across the strike of the basin, and three tie-lines along strike, within the basin depocentre. Total coverage planned for the Gippsland Basin, excluding positioning and 'link lines', was about 1600 km.

The planned cross-strike ('dip') lines trend 027 degrees parallel to the presumed direction of extension, and extend beyond the limits of the Latrobe Group and the basin-boundary faults. The nominal line-spacing was approximately 15 km; however, this was modified in many areas to enable effective well-ties, avoid production platforms, and to position lines within extensional compartments between presumed transfer faults.

Bass Basin

It was planned to record six dip lines across the main basin-forming structures (Fig. 9). The lines were to cross five of the major fault-bounded compartments mapped by Etheridge & others (1984, 1985). In addition, one NW - SE tie-line was to be run along the central axis of the basin, and one tie-line in the Boobyalla Sub-basin.
Total coverage within the basin, excluding link lines, was to be about 900 km.

Reflection Cable Geometry and Recording Parameters

The recording geometry and parameters were discussed at length in Willcox & others (1988). It was concluded that the cruise objectives could best be met by use of a 3600m, 96-channel, 37.5m-group cable, used for 48-fold recording with a 2 or 4 millisec sampling interval to give a record length of up to 16 seconds. Record lengths of about 12 seconds would probably be appropriate in the in the Gippsland Basin, whilst a record length of 10 seconds could be used in the Bass Basin - the basin-forming tilt-blocks occurring at about 3 - 4 seconds record time.

Onshore Refraction Recording

As vertical reflection profiling may not unequivocally resolve the deeper structure under the basins, we planned to record long-offset seismic refraction/wide-angle reflection data concurrently with the conventional reflection program. This was expected to provide information on the lower crust and upper mantle, both below and beyond the boundaries of the survey.

It was planned to locate digital instruments to record the ship's 3200 cubic inch airgun source in Gippsland and on Deal Island at the ends of Line 'E', and on Wilson's Promontory and northwest Tasmania off the ends of Line 'M '(Figs.8 & 9), giving reversed refraction traverses of approximately 200 km length. As much data as possible would be recorded from the other lines. Other recorders were planned to be deployed elsewhere on land to extend the range of the refraction traverses and provide additional data at different offsets and azimuths.

Digital recorders were developed to record the air-guns semi-continously while the ship completed each traverse.

As the noise level was expected to be high, the development of special processing techniques to enhance the signal-to-noise was considered. The large number of shots recorded at each recording site, and close shot spacing, would allow various stacking techniques to be applied.

OPERATIONS

The actual work carried out varied considerably from that in the cruise plan, however the overall objectives were the same. Firstly, the Gippsland/Bass Basin operation was reprogrammed to occupy two cruises - to enable approximately 2 weeks to be taken up with the testing of equipment needed to meet the requirements of precision navigation (particularly over well sites) and deep seismic recording. This testing included:

- Measurement of the 'drift' on three HIFIX stations installed on the Victorian coast, by coming alongside for 48 hour periods at Barrys Beach and Port Welshpool.
- Complete inflation of the seismic streamer with SOL-T (cable fluid) and accurate leading, in order to induce positive buoyancy and minimise noise levels.
- Comparison of IFP (instantaneous floating point) and Integer (fixed gain) recording electronics, by duplicating recording along two seismic lines (82/001 v 101 and 82/002 v 102) in the easternmost deepwater part of the Gippsland Basin (Figs. 10, 11 & 12).

Secondly, while the Integer/IFP testing was still in progress, two 'refraction only' lines (201 & 202; Figs. 10-12) were shot between Deal Island and the Victorian coast, spaced approximately 10 km apart, on either side of a major transform fault zone. This was followed by completion of Line 82/003 using Integer Mode.

The failure of two of the four compressors on board after completion of lines 001 and 101 resulted in the use of only a single air-gun array of 1600 cubic inch (26 litre) capacity for the remainder of the survey. The reduced power output of the seismic source was considered insufficient for the continuation of deep-penetration seismic work in the central part of the Gippsland Basin, and consequently operations were moved to the southeastern part of the Bass Basin (Boobyalla Sub-basin), where the sedimentary section was known to be thinner and where the basin-forming tilt-blocks were well within range of the seismic system. A ten line program of high-quality seismic acquisition was completed in this area (Figs. 13, 14 & 15).

Details of all lines, including recording parameters, are given in Appendices 3 - 5.

SYSTEMS PERFORMANCE

by G. Heal, B. Jones & J. Mangion

Non-seismic

The non-seismic data acquisition system (DAS) ran for the duration of the survey with only six short breaks in data collection, caused by computer overload. This downtime totalled 71 minutes.

Navigation

Positioning of the ship is derived from three largely independent systems; Global Positioning System (GPS), dead reckoning with updates from the Transit Satellite System, and radio navigation using Hifix. All onboard navigation is done within the WGS coordinate system, as this is the system used by the Transit Satellites.

- Global Positioning System

Under optimum conditions a GPS Magnavox T-set receiver should give continuous absolute positioning within about 20 metres r.m.s.. However, the system is in the experimental stage with only seven of the proposed 24 satellites in orbit. This severely limits it's usefulness and reliability.

Tests performed with the GPS receiver while berthed at Adelaide revealed that the receiver was not navigating correctly. For those periods of four satellite coverage, the receiver was calculating a very large frequency bias. This may indicate problems with the local oscillator within the receiver. This fault resulted in the GPS being unreliable and consequently it was not used at any stage during the survey for navigating.

- Dead-reckoning System

The primary dead reckoning system consists of a Robertson gyro compass, Magnavox MX610D sonar-doppler and MX1107RS satnav receiver. A lower grade system of Robertson gyro, Raytheon DSN450 sonar-doppler, and MX1142 satnav receiver is used as a backup.

In general, the system performed well, with most dead-reckoning positions being in close proximity to the Transit satellite fixes. The exceptionally good weather conditions and the shallowness of the survey areas contributed to the good results.

- Hifix

The Decca Hifix radio navigation system was operated for the entire survey with varying results. BMR Marine has been experimenting for some time to extend the effective range of the system by operating it in circular mode with all stations slaved to their own atomic standard. Such a system is affected by individual drift of the rubidium standards. One of the aims of Survey 82 was to determine the drifts. This was to be done at Barry's Beach. However, on arrival at the berth only very weak signals were received. This was probably due to the geographical position of the ship in relation to the shore stations and to the presence of large steel structures near the ship.

Another drift test was attempted at Port Welshpool. The drifts observed over a period of four days were unexpectedly variable. They ranged from 4.7 to -0.7 centilanes per ten minutes. The only observable trend was that the variation in drift rate appeared to decrease with time. By the third day, the drift rate for stations at Seaspray and Point Hicks began to stabilise. The ship then set sail for the eastern part of the Gippsland Basin, and the drift for the other two stations (Golden Beach and Lake Tyers) was derived while navigating from the two calibrated stations.In general, the positions derived from the Hifix chain during the Gippsland leg of the survey were acceptable. A combination of favourable shore-station geometry, low atmospheric noise, stable drift rates and short ranges to the shore stations all contributed to the accuracy of the positioning. Comparison of the Hifix positions to Transit satellite positions typically showed differences of less than 200m.

The Bass Basin portion of the cruise required the relocation of a station to improve geometry. The station from Golden Beach was transferred to Cape Liptrap. The moving of this station resulted in no Hifix navigation being available for the first four days of the Bass Basin program. However, once the moved station began transmitting, the Hifix navigation resumed with high precision. Minor problems were encountered with occasional signal "jumps" or "shifts".

Bathymetry

Bathymetric data were derived from the Raytheon 12 kHz echo sounder. This echo sounder produced excellent results for the duration of the cruise, with continuous soundings along all lines.

Gravity

Gravity data were obtained using the Bodenseewerk KSS-31 Gravity Meter. The system was reliable with gravity data being recorded throughout the survey.

Seismic

Software:

The need to have a 37.5 metre shot interval meant that it was necessary to quicken the software used for the gun controller and the signal level calculations. New gun controller software was implemented without problem and worked well for the duration of the cruise. The new signal-level calculation software was developed prior to and during the cruise.

While the ship was berthed at Adelaide, the new Syntron bird controller CUS 8301 was interfaced to the seismic system. The software to read the values from the controller was written during the transit from Adelaide to Barry's Beach. The software worked well, reading in depth and wing angles from twenty two birds in 364 milliseconds.

The seismic shooting undertaken during the survey fully tested the robustness of the new software. During fifteen days there were 45 system crashes. Each of these resulted in approximately 15 to 20 shots being lost.

Examination of system registers after each crash indicated that many were caused when the the next shot interrupt occurred while the previous shot had not fully been processed and written to tape. By changing recording parameters to 10 second record length with 4 msec sampling rate the incidence of system crashes dropped sharply.

Hardware

The use of an instantaneous floating point (IFP) amplifier was a key element in the planned mapping of the deep basement structures in the Gippsland Basin. However, prior to the cruise, the electronic noise levels within the IFP were found to be far higher than acceptable. Also, timing errors were preventing sufficient settling time for full data analysis.

After intensive examination, testing and modification of the IFP card and associated amplifiers and power sources during the early part of the cruise, it was revealed that card's noise levels were at least partly inherent in it's design. As a result, only two short test lines were shot using the IFP; the remainder of the lines were shot with a set binary gain integer converter combination.

During the last week of the cruise, an intermittent fault developed in the first bank of pre-amplifiers, corresponding to channels 1 to 24. The fault caused an internal oscillator used for pre-amplifier calibration to turn on while data recording was in progress. The problem was finally traced to a faulty power board which was replaced.

Only minor problems occurred with the gun arrays and seismic cable. The new depth controllers worked extremely well. Several firing lines on the starboard gun bundle needed to be switched out. Six active sections were replaced due to electrical problems or fish bites during, or at the end of the survey. One adaptor section was found to be faulty resulting in channels 92 - 96 being reversed for the first part of line 001.

Prior to the cruise, new clutches were fitted to two of the four diesel motors which power the seismic compressors. Both units failed partway through the survey necessitating the relocation of the seismic operations to the Boobyalla Sub-basin.

REFRACTION RECORDING

by C. Collins

The refraction study was undertaken jointly by BMR and the Department of Earth Sciences, Monash University. Seismic recorders were deployed on land to record long offset wide-angle reflection and refraction data using the ship's air guns as the energy source. The study was designed to yield information on crustal thickness and velocities, the total thickness of sediments in the basins, and the relationship between the deep structure of the basins to that of Victoria and Tasmania.

Location of recording traverses and stations

Two main refraction traverses were recorded across the Gippsland Basin from Deal Island to the Victorian coast near Orbost (Fig. 10; lines 201 & 202). They were separated by about 10 km and ran either side of an inferred major transfer-fault zone (Fig. 12). Other lines (including some run in the Boobyalla Sub-basin), although not shot as refraction profiles, were also received by the land stations.

A digital recorder was deployed on Deal Island, and two others deployed near Orbost at different offsets from the coast. Two analogue recorders were placed near Orbost, one on the coast and the other about 30 km inland. Three others were deployed along a 30 km-long line perpendicular to the coast between Seaspray and Rosedale. The sixth was deployed at the southern tip of Wilsons Promontory as a backup in the south should the Deal Island recorder fail.

Energy source

The ship's 3200 cubic inch (52.4 litre) airgun array operating at 2000 psi was used as the energy source. The firing rate and ship speed were selected so as to give a shot interval of 50 metres for lines 201 and 202 (20 sec at 4.85 knots, 17.7 sec at 5.5 knots). On all other lines, the shot interval was 37.5 metres (18.2 sec at 4 knots in the Gippsland Basin, 16.2 sec at 4.5 knots and 18.2 sec at 4 knots in the Bass Basin). Most of these lines were shot with a 1600 cubic inch array. The firing times of the airguns were obtained in Universal Time by synchronising the ship's DAS system clock with time signals derived from the VLF Omega Navigation broadcast.

Recording Equipment

The six analogue recorders were run continuously during the survey; the three digital recorders were operational only for the main Gippsland Basin traverses (lines 201 and 202). The analogue recorders were four-channel tape-recording systems with a maximum recording period of about 16 days. The output from a single

Willmore Mk II seismometer with a period of 0.75 seconds was amplified at two gain levels and band-pass filtered 0.01-20 Hz before frequency modulation and recording. Also recorded were a coded clock signal and Omega radio time signals.

The digital recorders were developed at Monash University, and are based upon a portable PC/AT with a 20 megabyte hard disc and analogue-to-digital converter. The signal from a Willmore Mk III seismometer of 0.75 sec period was amplified and band-pass filtered 0.01-20 Hz before digitizing at 20 msec sample interval. The gain level of the amplifier was set by monitoring the signal so that maximum gain without saturation was maintained. Timing was derived from the internal clock of the PC synchronised with Omega radio time signals. Data were transferred from disc to magnetic tape periodically.

ACKNOWLEDGEMENTS

We acknowledge the co-operation and assistance of Henry Foreman (Master) and the crew of the *Rig Seismic* during this cruise.

Co-operative arrangements with the School of Earth Sciences, Monash University, enabled successful completion of the refraction experiment.

We thank Esso Australia Ltd for permission to berth the ship at Barrys Beach.

REFERENCES

Bodard, J.M., Wall, V.J., & Kanen, R.A., 1986 - Lithostratigraphic and depositional architecture of the Latrobe Group, offshore Gippsland Basin. In Glenie, R.C. (ed.): Transactions of the Second South-eastern Australia Oil Exploration Symposium, PESA, Melbourne, Australia, 113-136.

Brown, B.R., 1976 - Bass Basin : Some aspects of the petroleum geology. In Leslie, R.B., Evans, H.J. & Knight, C.L., (eds.), Economic geology of Australia and Papua New Guinea, Vol. 3, Australian Institute of Mining and Metallurgy, 67-82.

Brown, B.R., 1986 - Offshore Gippsland Basin Silver Jubilee. In Glenie, R.C. (ed.) : Transactions of the Second Southeastern Australia Oil Exploration Symposium, PESA, Melbourne, Australia, 29-56.

Clark, A.B.S. & Thomas, B.M., 1988 - The intra-Latrobe play : a case history from the Basker/Manta Block (VIC P19), Gippsland Basin. APEA Journal, 28, 100-112.

Colwell, J.B., Coffin, M.F. & others, 1987 - Rig Seismic research cruise 13: structure and stratigraphy of the northeast Gippsland Basin and southern New South Wales margin - initial report. Bureau Mineral Resources Australia Report, 283.

Davidson, J.K., Blackburn, G.J. & Morrison, K.C., 1984 - Bass and Gippsland Basins : a comparison. APEA Journal, 24(1), 101-109.

Etheridge, M.A., Branson, J.C. & Stuart-Smith, P.G., 1985 - Extensional basin-forming structures in Bass Strait and their importance in hydrocarbon exploration. APEA Journal, 25(1), 344-361.

Etheridge, M.A., Falvey, D.A., Lockwood, K.L., Stuart-Smith, and Scherl, S., 1984 - Basin forming structures and their relevance to hydrocarbon exploration in Bass Basin, southeastern Australia : BMR Journal of Australia Geology and Geophysics, 9,197-206.

Exon, N.F. & Lee, C.-S., 1988 - Research cruise proposal : Project 9131.13 - Geological framework and hydrocarbon resource assessment of the Bass, eastern Otway and NW Tasmanian basins (unpublished).

Geological Society of Australia, 1971 - Tectonic Map of Australia and New Guinea, 1:5,000,000-, Sydney.

Gunn, P.J., 1975 - Mesozoic-Cenozoic tectonic and igneous activity, S.E. Australia. Journal of the Geological Society of Australia, 22(2), 215-222.

Hocking, J.B., 1972 - Geological evolution and hydrocarbon habitat, Gippsland Basin. APEA Journal, 12(1), 132-137.

Jongsma, D. & Mutter, J.C., 1978 - Non-axial breaching of a rift valley : evidence from Lord Howe Rise and southeastern Australian margin. Earth and Planetary Science Letters, 39, 226-234.

Lowry, L.C., 1987 - A new play in the Gippsland Basin. APEA Journal, 27(1), 164-172.

Moore, W.R., Baillie, P.W., Forsyth, S.M., Hudspeth, J.W., Richardson, R.G. & Turner, N.J., 1984 - Boobyalla Sub-basin: a Cretaceous onshore extension of the southern edge of the Bass Basin. APEA Journal, 24(1), 110-117.

Partridge, A.D., 1976 - The geological expression of eustacy in the Early Tertiary of the Gippsland Basin. APEA Journal, 16(1), 73-79.

Rahmanian, V.D., Moore, P.S., Mudge, W.J., & Spring, D.E., in press - Sequence stratigraphy and habitat of hydrocarbons, Gippsland Basin, Australia. World Petroleum Provinces , Geological Society of London Special Publication.

Richards, K.A. & Hopkins, B.M., 1969 - Exploration in the Gippsland, Bass and Otway Basins, Australia. ECAFE Symposium on the development of petroleum resources of Asia and the Far East, Canberra, Australia.

Robertson, C.S., Cronk, D.K., Mayne, S.J., & Townsend, D.G., 1978a - A review of petroleum exploration and prospects in the Otway Basin region. Bureau of Mineral Resources Record, 1978/91, 49p.

Robertson, C.S., Lockwood, K.L., Nicholas, E. & Soebarkah, J., 1978b - A review of petroleum exploration and prospects in the Gippsland Basin. Bureau of Mineral Resources Record, 1978/11, 57 p.

Robinson, V.A., 1974 - Geological history of the Bass Basin, APEA Journal, 14, 44-49.

Roeser, H.A. & others, 1985 - Geophysikalishe, geologische und geochemische Untersuchungen auf dem Lord-Howe Rucken, Teil 1, <u>Bundesanstalt fur Geowissenschaften und Rohstoffe Abschlussbericht</u>, 98262, 193 p.

Shaw, R.D., 1978 - Sea-floor spreading in the Tasman Sea : a Lord Howe Rise - eastern Australian reconstruction. <u>Australian Society of Exploration Geophysicists Bulletin</u>, 9, 75-81.

Shaw, R.D., 1979 - On the evolution of the Tasman Sea and adjacent continental margins. Ph.D. thesis, Sydney University, 312p.

Smith, G.C., 1982 - A review of the Tertiary-Cretaceous tectonic history of the Gippsland Basin and its control on coal measure sedimentation. <u>Australian Coal Geology</u>, 4, 1-38.

Smith, G.C., 1986 - Bass Basin geology and petroleum exploration. <u>In</u> Glenie, R.C. (ed.) : Transactions of the Second Southeastern Australia Oil Exploration Symposium, PESA, Melbourne, Australia, 257-284.

Stainforth, J.G., 1984 - Gippsland hydrocarbons - a perspective from the basin edge. <u>APEA Journal</u>, 24(1), 91-100.

Thompson, B.R., 1986 - The Gippsland Basin - development and stratigraphy. <u>In</u> Glenie, R.C. (ed): Transactions of the Second Southeastern Australia Oil Exploration Symposium, PESA, Melbourne, Australia, 57-64.

Threlfall, W.F., Brown, B.R. & Griffith, B.R., 1976 - Gippsland Basin - offshore. <u>In</u> Leslie, R.B., Evans, H.D. & Knight, C.L. (eds): Petroleum, Economic Geology of Australia and Papua NewGuinea, Australasian Institute of Mining and Metallurgy, 41-67.

Weeks, L.G. & Hopkins, B.L., 1967 - Geology and exploration of three Bass Strait Basins, Australia. <u>Bulletin of the American Association of Petroleum Geologists</u>, 51(5), 742-760.

Weissel, J.K. & Hayes, D.G., 1977 - Evolution of the Tasman Sea reappraised. <u>Earth and Planetary Science Letters</u>, 36, 77-84.

Willcox, J.B., 1984 - "Deepwater" Gippsland Basin. <u>Abstracts, Australian Geological Convention, Sydney</u>, 5.

Willcox, J.B., Colwell, J.B., & Moore, A. M. G., 1988 - Deep structure of the Gippsland and Bass Basins

(Project 9131.12B) - research cruise proposal. Bureau Mineral Resources Record 1988/18, 49p.

Williamson, P.E. & Pigram, C.J., 1986 - Geohistory, basin subsidence and maturation in the Bass Basin. Proceedings of the Petroleum Exploration Society of Australia, 285-301 .

Williamson, P.E., Colwell, J.B., Scherl, A.S., Lockwood, K.L., & Branson, J.C., 1985 - Pre-Eocene stratigraphy, structure, and petroleum potential of the Bass basin. APEA Journal, 25, 362-381.

Williamson, P.E., Pigram, C.J., Colwell, J.B., Scherl, A.S., Lockwood, K.L. & Branson, J.C., 1986 - New deeper exploration frontiers in the Bass Basin, Australia. Oil & Gas Journal, Sept 8, 1986, 121-126.

Williamson, P.E., Pigram, C.J., Colwell, J.B., Scherl, A.S., Lockwood, K.L. & Branson, J.C., 1987 - Review of stratigraphy, structure and hydrocarbon potential of Bass Basin, Australia. American Association of Petroelum Geologists Bulletin, 71(3), 253-280.

Williamson, P.E., Pigram, C.J., Colwell, J.B., Scherl, A.S., Lockwood, K.L. & Branson, J.C., 1988 - Continental Margins Program Folio 1 - Bass Basin Study.

APPENDIX 1: List of Geophysical Equipment

Seismic System

Streamer: 3600m Teledyne hydrophone analogue streamer configured as 96 x 37.5m groups.
- 10 hydrophones per 12.5m group
- ~15 microvolts noise; maximum ambient at 5 knots
- Syntron RCL-3 individually adressed cable levellers

Source Array:
- 52.4/73.4 litre (3200/4480 cubic inch), 28-element tuned Texas Instruments air-gun array; 20 elements (3200 cubic inch) equally divided into two strings in use at any one time.
- Teledyne gun signature phones, gun depth sensors, and I/O SS-8 shot sensors
- 4 x Price A - 300 compressors, each rated at 300scfm @ 2000 psi

Recording
- BMR designed and built seismic acquisition system based on Hewlett-Packard minicomputers
- 96 channel digitally controlled preamp/filters
- bit accuracy
  - 12 bit floating point with 4 bit dynamic accuracy
  - 15 bit integer card
- 6250 bpi Telex tape drives
- data read after write in demultiplexed SEG-Y format
- 2 or 4 msec sampling with 96 channels
- streamer noise, leakage, and individual group QC
- source array timing QC
- recording oscillator and 4 seismic monitor QC

Bathymetric System

- Raytheon deep-sea echo-sounder; 2 kW output at 12 kHz

Gravity Meter

- Bodenseewerk Geosystem KSS - 31 marine gravity meter

Navigation Systems

GPS System - Magnavox T-Set GPS navigator

Prime Transit System
- Magnavox MX1107RS dual channel satellite receiver
- Magnavox MX610D dual-axis sonar doppler speed log
- Robertson gyro-compass

Secondary Transit System
- Magnavox MX1142 single channel satellite receiver
- Raytheon DSN450 dual-axis sonar doppler speed log
- Robertson gyrocompass

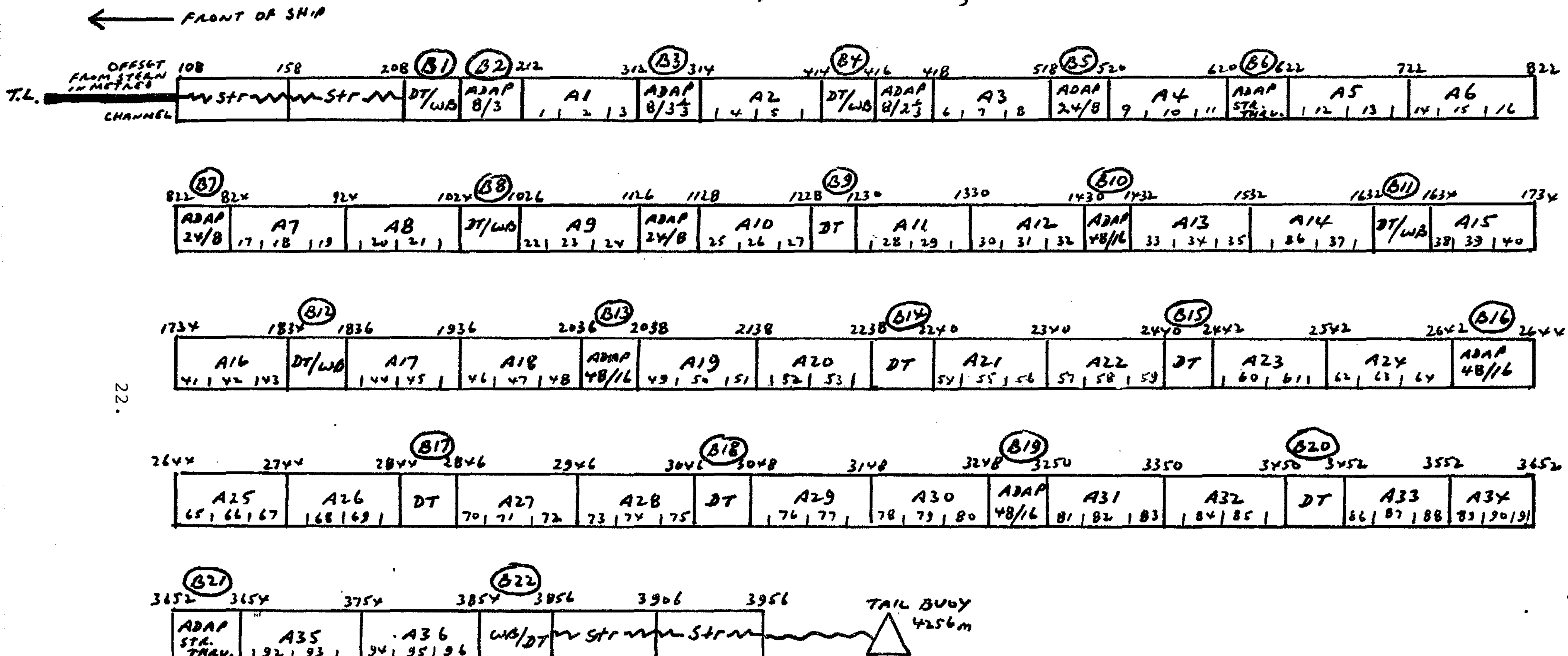
Radio Navigation
- Decca HIFIX-6

Data Acquisition System

- data acquisition system built around Hewlett-Packard 2117 F-Series minicomputer, with tape drives, disc drives, 12" and 36" plotters, line printers and interactive terminals

SURVEY 82 CABLE

96 CHANNEL, 3600m ACTIVE, 37.5m GROUPS



A1 : Active section (100m long)
Str : Stretch section (50m long)
ADAP: Adaptor section (2m long)
(B1) : Depth controller, bird
DT/WB: Depth transducer/waterbreak section (2m long)
DT : Depth transducer section (2m long)
TL : Tow leader

Offsets with 108m leader out over stern:
Channel 1: 231m behind ship, 206m behind guns
Channel 96: 3835m behind ship, 3810m behind guns.

Arrangement of lead weights on cable sections

Section	Weights (BACK → GROUP FRONT)	TOTAL
ACTIVE 1 (88/006)	½ — 1 — 1½ — ½ — 1½ — 1 — ½ — 1½	8.0 kg
1 (86/004)	1 — 1 — 1 — 1 — 1	5.0 kg
2 (84/029)	1 — 1 — 1 — 1	4.0 kg
3 (84/006)	½ — 1 — ½ — 1 — ½ — 1 — ½	5.0 kg
4 (84/026), 5 (83/035), 6 (86/007), 7 (84/005)	½ — 1 — ½ — 0 — ½ — 1 — ½	4.0 kg
8 (83/104)	½ — ½ — ½	1.5 kg
9 (84/021), 10 (84/028)	½ — ½ — 1 — ½ — ½ — ½	3.5 kg
11 (88/001)	½ — 1 — ½ — 1½ — ½ — 1 — ½	5.5 kg
12 (88/004)	½ — 1 — ½ — 1½ — ½ — 1½ — ½	6.0 kg
13 (88/009)	½ — 1 — ½ — 1½ — ½ — 1 — ½	5.5 kg
14 (88/011)	½ — 1 — ½ — 1½ — 1/2 — 1½ — ½	6.0 kg
15 (88/010)	½ — 1½ — ½ — 1½ — ½ — 1½ — ½	6.5 kg
16 (88/007)	½ — 1½ — ½ — 1½ — ½ — 1½ — ½	6.5 kg
17 (88/003)	½ — 1½ — ½ — 1 — ½ — 1½ — ½	6.0 kg
18 (88/005)	½ — 1 — 1½ — 1½ — 1½ — 1 — ½	7.5 kg
19 (87/001)	1 — 1½ — 1½ — 1½ — 1½ — 1½ — ½	9.0 kg
20 (87/011)	1 — 1½ — 1 — 1½ — 1½ — 1 — 1	8.5 kg
21 (1287-153-09), 22 (1287-153-12)	1 — ½½ — 1 — ½½ — 1 — ½ — 1	6.5 kg
23 (?)	1 — ½½ — 1 — ½½ — 1 — ½ — 1	6.5 kg
24 (?)	1 — ½½ — 1 — ½½ — ½ — 1 — 1	6.5 kg
25 (043)	1½ — ½ — 1½ — 1½ — 1½ — ½ — 1	8.0 kg
26 (019)	1 — ½ — 0 — 1½ — ½ — ½ — 1	5.0 kg
27 (102)	1 — ½ — ½ — 1½ — ½ — 0 — 1	5.0 kg
28 (86/039)	1 — 1½ — 1½ — 2 — 1½ — 2 — ½	10.0 kg
29 (83/001)	1½ — 1½ — 2½ — 2½ — 2 — 1½ — 1½	13.0 kg
30 (84/041)	½ — 1½ — 1½ — 1½ — 1½ — 1½ — ½	8.5 kg

								TOTAL
ACTIVE 31 (88/002)	½	½	1½	1½	1½	½	½	6.5 kg
32 (84/030)	0	½	1	½	1	½	0	3.5 kg
33 (86/038)	1½	1½	1½	1½	1½	1½	1½	10.5 kg
34 (84/018)	1½	1	1½	2	2	1	1½	10.5 kg.
35 (83/009)	1½	1	1½	1½	1½	1	1½	9.5 kg
36 (83/022)	1½	1	1½	2	2	1	1½	10.5 kg.

CRUISE : 82 – GIPPSLAND BASIN DATE : NOV. 88

TOTAL ACTIVE LENGTH : 3600 m. Number of Chans = 96 (37.5 m GROUPS)

LENGTH (m) #	SECTION	SERIAL # TELY.	BMR	LEADS	BIRDS BATTS	COMMENTS
VAR.	Tow Leader					
50+	Stretch # 1	1287-153	-D			
50+	Stretch # 2	1287-153	-C			
-			-			
-			-			
-						
2	DT# 1 WB# 1		020		3769 (B1)	
2	Adaptor 8 >3		88/102		3763 (B2)	
100	*Active# 1	88/006	~~88/004~~	5x1 = (5) kg		88/006 has 3x1½, 3x1, 1x½ pb.
2	Adaptor 8 >3½		88/104		3767 (B3)	
100	*Active# 2		84/029	4x1 = (4) kg		
-			-			
2	DT#2 WB#2		001		3771 (B4)	CABLE DT NOT CALIBRATED
-			-			
-			-			
2	Adaptor 8 >2⅔		88/113			
-			-			
100	*Active# 3		84/006	3x1, 4x½ = (5) kg		
-			-			
2	Adaptor 24 >8		88/117		3768 (B5)	Fixed wiring prob.
-			-			
100	*Active# 4		84/026	2x1, 4x½ = (4) kg		
-			-			
2	ADAP. STR. THRU.		041		3770 (B6)	
100	*Active# 5		83/035	2x1, 4x½ = (4) kg		
100	*Active# 6		86/007	2x1, 4x½ = (4) kg		
-			-			
-			-			
-			-			
2	Adaptor 24 >8		88/115		3764 (B7)	
-			-			
100	*Active# 7		84/005	4x½, 2x1 = (4) kg		
100	*Active# 8		83/104	3x½ = (1.5) kg		
2	DT#3 WB2		005		3760 (B8)	
100	*Active# 9		84/021	5x½, 1x1 = (3.5) kg		
-			-			
2	ADAPTOR 2X78		88/116			
100	*Active# 10		84/028	5x½, 1x1 = (3.5) kg		
-			-			
-			-			
2	DT# 4		021		3759 (B9)	
100	Active# 11		88/001	1x1½, 2x1, 4x½ = (5.5) kg		
100	Active# 12		88/004	2x1½, 1x1, 4x½ = (6.0) kg		
2	ADAPTOR 48716		88/107		3762 (B10)	Replaced skin
100	Active# 13		88/009	1x1½, 2x1, 4x½ = (5.5) kg		
100	Active# 14		88/011	2x1½, 1x1, 4x½ = (6.0) kg		
2	DT# 5 WB#3		034		3766 (B11)	CABLE DT SENSOR U/S.
100	Active# 15		88/010	3x1½, 4x½ = (6.5) kg		
100	Active# 16		88/007	3x1½, 4x½ = (6.5) kg		
2	DT# 6 WB# 4	583-014-	063		3757 (B12)	
100	Active #17		88/003	1x1, 2x1½, 4x½ = (6.0) kg		
100	Active 18		88/005	3x1½, 2x1, 2x½ = (7.5) kg		

Record every cable section
Record leads as n X wt. (e.g. 5 X 1, 7 X 1/2)

File : 'CFOR1:ZZ:30

* GECO skin.

Actives 1–18 + 31 from Canberra prior to cruise.
The rest from S. Perth II.

86/004 changed out because of low response on channels 1 & 2.

CRUISE : 82 - GIPPSLAND BASIN   DATE : NOV. 88

TOTAL ACTIVE LENGTH : 3600 m.   Number of Chans = 96 (37.5m) GROUP.

LENGTH (m) #	SECTION	SERIAL # TELY.	SERIAL # BMR	LEADS	BIRDS BATTS	COMMENTS
-			-			
-			-			
-			-			
-			-			
-			-			
-			-			
-			-			
2	Adaptor 48 >16		88/109		3758 (B13)	
100	Active# 19		87/001	6x1, 8x½ (9.0Kg)		
-			-			
100	Active# 20		87/011	7x1, 3x½ (8.5Kg)		
-			-			
2	DT# 7		032		3761 (B14)	
100	Active# 21	1287-153-	109	4x1, 5x½ (6.5Kg)		
100	Active# 22	1287-153-	112	4x1, 5x½ (6.5)		
-			-			
2	DT# 8		014		3775 (B15)	
100	Active# 23	?	?	4x1, 5x½ (6.5Kg)		
100	Active# 24	?	?	4x1, 5x½ (6.5Kg)		
2	Adaptor 48 >16		88/106		3773 (B16)	
-						
100	Active# 25	694-047-28	043	5x1, 6x½ (8Kg)		
100	Active# 26		019	3x1, 4x½ (5Kg)		
2	DT# 9		017		3776 (B17)	
100	Active# 27	684-047-22	102	3x1, 4x½ (5Kg)		
100	Active# 28		86/039	8x1, 4x½ (10Kg)		
2	DT# 10		036		3777 (B18)	
100	Active# 29		83/001	10x1, 6x½ (13Kg)		
100	Active# 30		84/041	5x1, 7x½ (8.5)		Section skin poor.
2	Adaptor 48 >16		88/105		3778 (B19)	
-			-			
100	Active# 31		88/002	3x1, 4x½ (6.5)		
100	Active# 32		84/030	2x1, 3x½ (3.5Kg)		
2	DT# 11		009		3774 (B20)	
100	Active# 33		86/038	7x1, 7x½ = (10.5)		
100	Active# 34		84/018	7x1, 7x½ = (10.5Kg)		
2	ADAPTOR STR. THRU.		048		3765 (B21)	
100	Active# 35		83/009	7x1, 5x½ = (9.5Kg)		
100	Active# 36		83/022	8x1, 5x½ = (10.5Kg)		
-			-			
-			-			
-			-			
-			-			
-			-			
-			-			
-			-			
-			-			
-			-			
-			-			
2	DT# 12 WB# 5		028		3772 (B22)	
50+50	Stretch #2		??			
1	Tail Plug		-			
300	Tail Rope		-			
KOAM	Tail Bouy		-			

Record every cable section
Record leads as n X wt. (e.g. 5 X 1, 7 X 1/2)

File : 'CFOR1:ZZ:30

N.B. Actives 19 to 36 (excluding 31) from S.A. Basin II cruise.

APPENDIX 3: Shooting and Recording Parameters

(A) Lines 82/001 & 101, Gippsland Basin , reflection data

Source:	2 x 1600 cubic inch air-gun array
Shot spacing:	37.5m
Shot interval:	18.2 seconds at 4 knots
Cable length:	3600m active; 4200m to tail buoy
Group interval:	37.5m
No. of channels:	96
Near offset:	231m behind stern; 206m behind guns
Far offset:	3835 behind stern; 3810 behind guns
Cable depth:	10m
Recording fold:	48
Record length:	12 seconds
Sample rate:	Initially 2 ms, changed to 4 ms after SP 1700 on Line 82/001
Filter settings:	8 Hz low cut 128 Hz high cut; 64 Hz after SP 1700
Amplifier gain:	128 - 1024 on Integer system for Line 82/001 IFP on Line 82/101
Field tape density:	6250 bpi
Tape format:	SEG-Y

(B) Lines 82/002,003 & 102, Gippsland Basin, reflection data

As above, except:

Source:	1 x 1600 cubic inch array
Amplifier gains:	256 - 512 on Integer system for Line 82/002 IFP on Line 82/102 128 - 512 on Integer system for Line 82/003

(C) Lines 82/201 & 202, Gippsland Basin, refraction data

Source:	2 x 1600 cubic inch array
Shot distance:	50m
Shot interval:	20 seconds at 4.85 knots,19.4 seconds at 5 kts, 17.7 seconds at 5.5 knots
Recorders:	Digital and analogue. Sited on Victorian coast and Deal Island.

(d) Lines 82/301 - 310, Bass Basin (Boobyalla Sub-basin), reflection data

Source:	1 x 1600 cubic inch array
Shot spacing:	37.5m
Shot interval:	16.2 seconds at 4.5 knots; 18.2 seconds at 4.0 knots
Cable length:	3600m active; 4200m to tail buoy
Group interval:	37.5m

No. of channels:	96
Near offset:	231m behind stern; 206m behind guns
Far offset:	3835m behind stern; 3810m behind guns
Cable depth:	10m
Source depth:	10m
Recording fold:	48
Record length:	12 seconds for Line 82/301
	10 seconds for all others
Sample rate:	2 ms for Lines 82/302 - 306 (SP 2200)
	4 ms all others
Filter settings:	8 Hz low cut
	128 Hz high cut for Lines 82/302- 306 (SP 2200)
	64 Hz all others
Amplifier gains:	128 - 256 Integer system
Field tape density:	6250 bpi
Tape Format:	SEG-Y

APPENDIX 4: Line Details

Line (82/)	Start Time	Stop Time	Data Collected	Seismic Tapes	Length km	nm	Well Tie	Mode
(A) Gippsland Basin:								
001	325.1802	327.0005	48f,b,g	001-053	183	99	Sole Pisces	I
002	331.1933	332.0258	"	074-085	47	25	H'head Chimaera	I
003	332.1609	333.1726	"	098-123	105	57	Chimaera Basker Hapuku	I
101	327.0650	327.1826	"	054-073	87	47	Sole	IFP
102	332.0636	332.1319	"	086-097	47	25	H'head Chimaera	IFP
(NB. Repeat of Lines 82/001 & 002)								
201	328.2319	330.0158	Refract.	Shore	195	105		
202	330.0519	331.0130	"	monitors	193	104		
(NB. Refraction experiment with Monash University)								

Total Gippsland Basin reflection data: 469 km, 253 nmi
refraction data: 388 km, 209 nmi

Line (82/)	Start Time	Stop Time	Data Collected	Seismic Tapes	Length km	nm	Well Tie	Mode
(B) Bass Basin (Boobyalla Sub-basin):								
301	334.0823	335.0205	48f,b,g	124-152	152	82		I
302	335.0652	336.0205	"	153-193	157	85		I
303	336.0531	336.1747	"	194-219	100	54		I
304	336.2024	337.0612	"	220-241	75	40	Chat	I
305	337.1036	338.0120	"	242-274	118	63		I
306	338.0709	338.1826	"	275-298	94	51	Durroon	I
307	338.2119	339.1001	"	299-319	111	60		I
308	339.1430	340.0340	"	320-342	110	59	Chat	I
309	340.0923	340.2141	"	343-362	104	56	Durroon	I
310	341.0033	341.0857	"	363-377	66	36		I

Total Bass Basin reflection data: 1087 km, 586 nmi

###

Notes:
48f = 48 fold seismic data
b = bathymetric data
g = gravity data

I = integer recording mode
IFP = instantaneous floating point mode

APPENDIX 5: Way Points

Way Point Lat (S)	Way Point Long (E)	Well Tie		Line
(A) Gippsland Basin:				
39 29.5	148 16.5	-	)	
39 03.632	148 30.776	Pisces - 1	)	82/001 (S-N)
38 07.051	149 02.134	Sole - 1	)	82/101 (N-S),
37 58.5	149 06.8	-	)	part repeat of 001
37 58.5	149 06.8	-	)	
38 10.604	148 50 055	Hammerhead - 1	)	82/002 (S-N)
38 15.973	148 43.386	Chimaera - 1	)	82/102 (N-S), repeat of 002
38 15.973	148 43.386	Chimaera - 1	)	
38 18.476	148 41.955	Basker -1	)	82/003
38 33.368	148 33.006	Hapuku -1	)	
39 07.5	148 13.0	-	)	
39 25.0	147 22.5	-	)	
38 18.0	148 10.5	-	)	82/201
37 50.0	148 22.0	-	)	
37 51.0	148 15.5	-	)	
38 24.5	147 58.5	-	)	82/202
39 24.0	147 16.0	-	)	
(B) Bass Basin (Boobyalla Sub-basin):				
39 35.0	146 47.0	-	)	
40 44.30	146 09.81	Tasmanian Devil - 1	)	82/301
40 50.5	146 05.0	-	)	
40 46.0	145 49.0	-	)	82/302
40 15.0	147 33.0	-	)	
40 07.0	147 25.0	-	)	82/303
40 25.0	146 23.0	-	)	
40 17.0	146 18.5	-	)	
40 10.91	146 41.98	Chat -1	)	82/304
40 03.0	147 08.0	-	)	
39 51.5	146 59.0	-	)	82/305
40 51.0	146 30.0	-	)	
40 39.5	146 47.0	-	)	

40 32.09	147 12.85	Durroon - 1	)	82/306
40 21.0	147.49.0	-	)	
40 30.0	147 57.0	-	)	82/307
40 51.1	146 42.8	-	)	
40 50.0	147 01.5	-	)	
40 10.91	146 41.98	Chat - 1	)	82/308
39 55.0	146 32.5	-	)	
40 00.0	146 57.0	-	)	
40 32.09	147 12.85	Durroon - 1	)	82/309
40 52.5	147 23.0	-	)	
40 48.0	147 33.5	-	)	82/310
40 15.0	147 16.0	-	)	

Note: All positions have been adjusted to World Geodetic System 1972 (WGS72) from Australian Geodetic.

APPENDIX 6: Crew List

BMR

J.B. Willcox	Co-chief scientist
J.B. Colwell	Co-chief scientist
G. Heal	Systems specialist
B. Jones	Systems specialist
R. Whitworth	Systems specialist (part of survey only)
P. Napier	Scientist/observor
A. Moore	Scientist/observor
C. Collins	Scientist/observor
K. Revill	Science technician
M. O'Connor	Science technician
J. Bedford	Science technician
J. Mowat	Science technician
D. Pryce	Science technician
L. Hatch	Science technician
J. Mangion	Electronics technician
G. Burren	Electronics technician
P. Harris	Mechanical technician
J. Roberts	Mechanical technician
C. Dyke	Mechanical technician
I. Patterson	Field Hand
A. Mellick	Field Hand

DOT

H. Foreman	Master
S. Johnson	Chief Engineer
D. Harvey	Chief Officer
T. Walters	Second Officer
T. Ireland	Second Engineer
W. Hanson	Electrician
L. Clarke	E.A./seaman
J. Fraser	A.B. 1
G. Pretsel	A.B. 2
J. Kemp	A.B. 3
B. Fowler	Chief steward/cook
G. Conley	Cook
J. Caminiti	Steward
M. Cumner	Steward/seaman

APPENDIX 7: HIFIX Station Locations

		Lat (deg S)*	Long (deg E)*
(1)	Point Hicks	37 48.095	149 16.454
(2)	Lake Tyers	37 51.888	148 04.078
(3)	Golden Beach	38 13.570	147 22.857
(4)	Seaspray	38 22.919	147 10.943
(5)	Cape Liptrap	38 53.570	145 55.308

Note: Stations 1 -4 used for Gippsland Basin
Stations 4 & 5 used for Bass Basin

* Corrected to WGS 72 from Australian Geodetic

APPENDIX 8: Non-seismic Data Channels

The data is saved on magnetic tape every 60 seconds in blocks of 128 x 6 floating point words.

1. SS.DD from RTE clock
2. .HHMMSS from RTE clock
3. .HHMMSS from master clock
4. Latitude
5. Longitude
6. Speed
7. Course
8. not used
9. not used
10. Depth 1
11. Depth 2
12. F/A Magnavox sonar-doppler
13. P/S Magnavox sonar-doppler
14. F/A Raytheon sonar-doppler
15. P/S Raytheon sonar-doppler
16. Paddle log
17. not used
18. Instrument room gyro
19. Bridge gyro
20. not used
21. not used
22. not used
23. not used
24. not used
25. Hifix Fine A
26. Hifix Fine B
27. Hifix Fine C
28. Hifix Coarse A
29. Hifix Coarse B
30. Hifix Coarse C

31.)
\-) not used
50.)

51. Latitude calc. from Mag s.d.
52. longitude calc. from Mag. s.d.
53. Speed calc. from Mag. s.d.
54. Course calc. from Mag. s.d.
55. Latitude calc. from Ray. s.d.
56. Longitude calc. from Ray. s.d.
57. Speed calc. from Ray. s.d.
58. Course calc. from Ray. s.d.
59. Latitude calc. from spare log
60. Longitude calc. from spare log
61. Speed calc. from spare log
62. Course calc. from spare log
63. Latitude calc. from radio nav.

64. Longitude calc. from radio nav.
65. Speed calc. from radio nav.
66. Course calc. from radio nav.
67. GMT from MX1107 sat. nav.
68. Dead reckoned time from 1107
69. Latitude 1107
70. Longitude 1107
71. Speed 1107
72. Heading 1107
73. GMT from MX1142 sat. nav.
74. Dead reckoned time 1142
75. Latitude 1142
76. Longitude 1142
77. Speed 1142
78. Heading 1142
79. Gravity (mGal * 100)
80. ACX (m/s/s * 10000)
81. ACY (m/s/s * 10000)
82. Sea state
83. not used
84. not used
85. not used
86. Shot time HHMMSSD
87. Shot point number

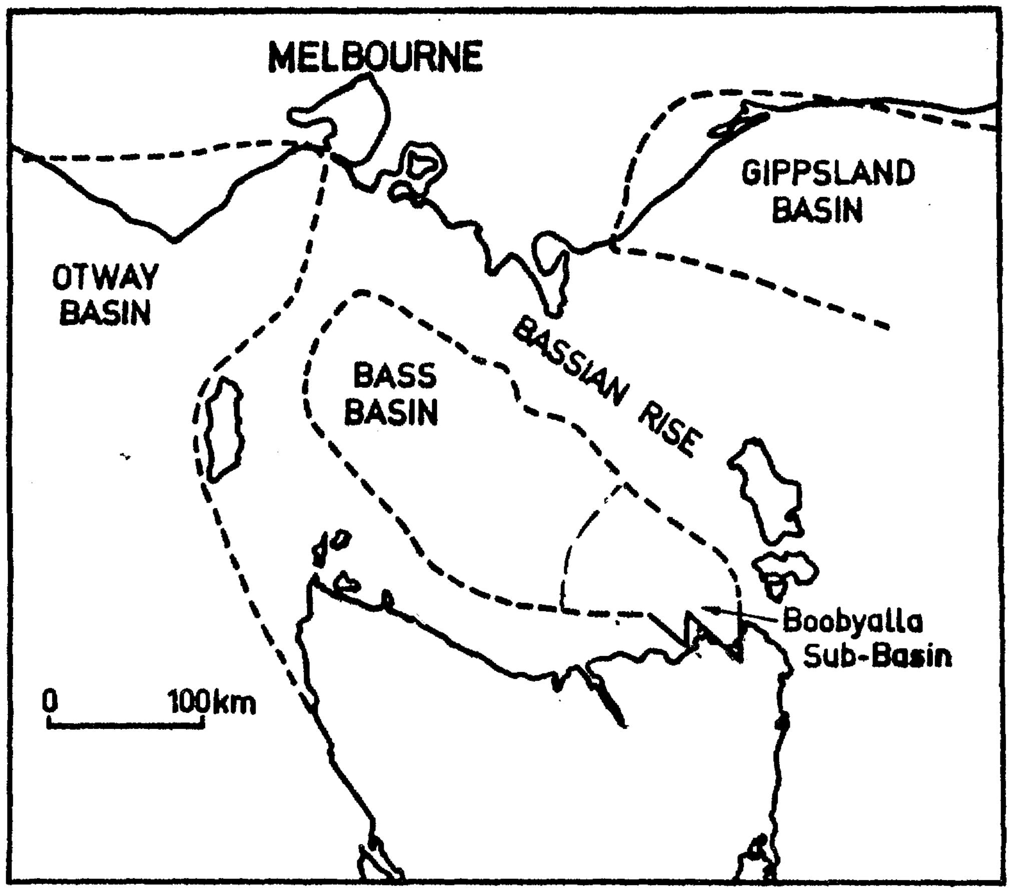


Figure 1. Locality map.

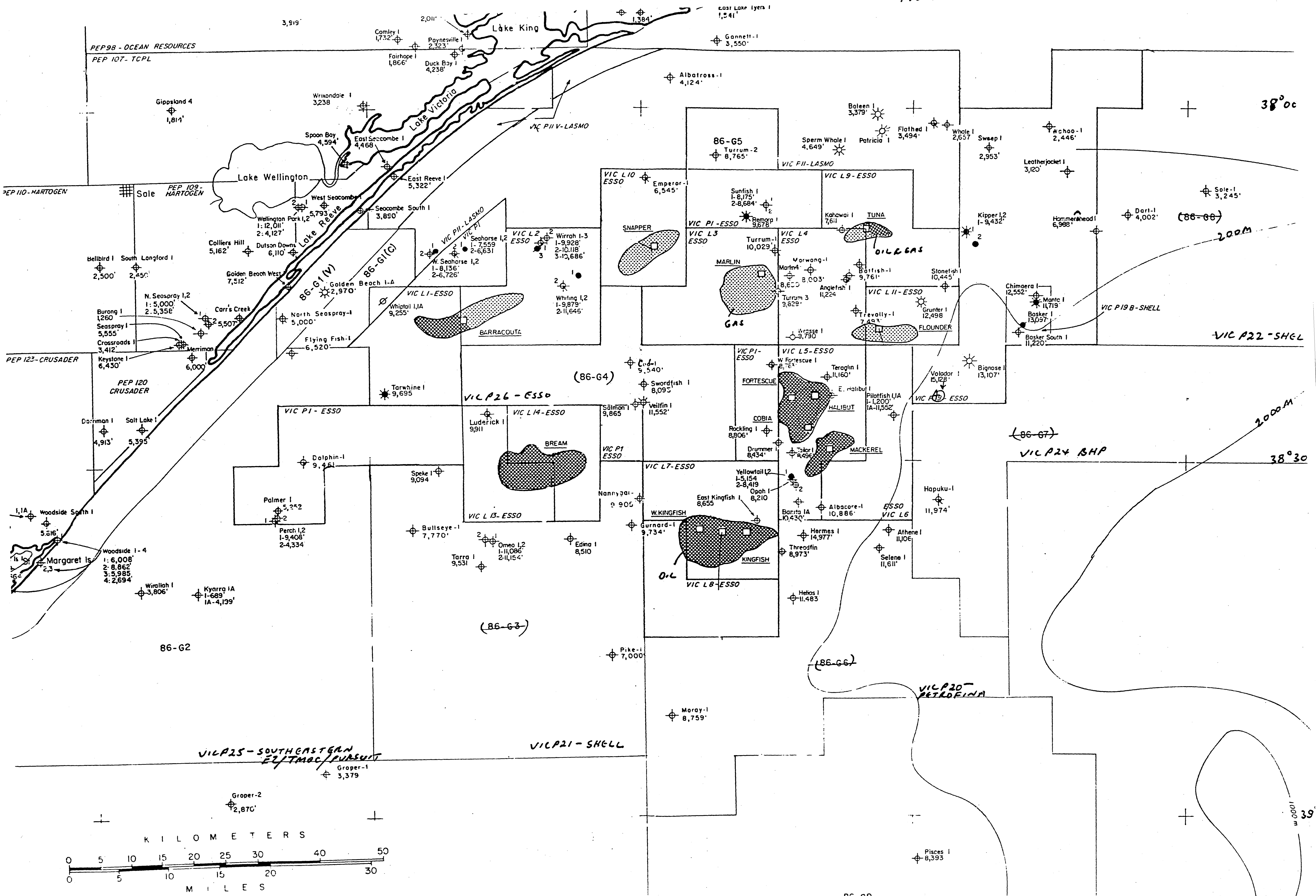


Figure 2. Location of petroleum exploration wells, oil and gas fields, and lease areas within the Gippsland Basin.

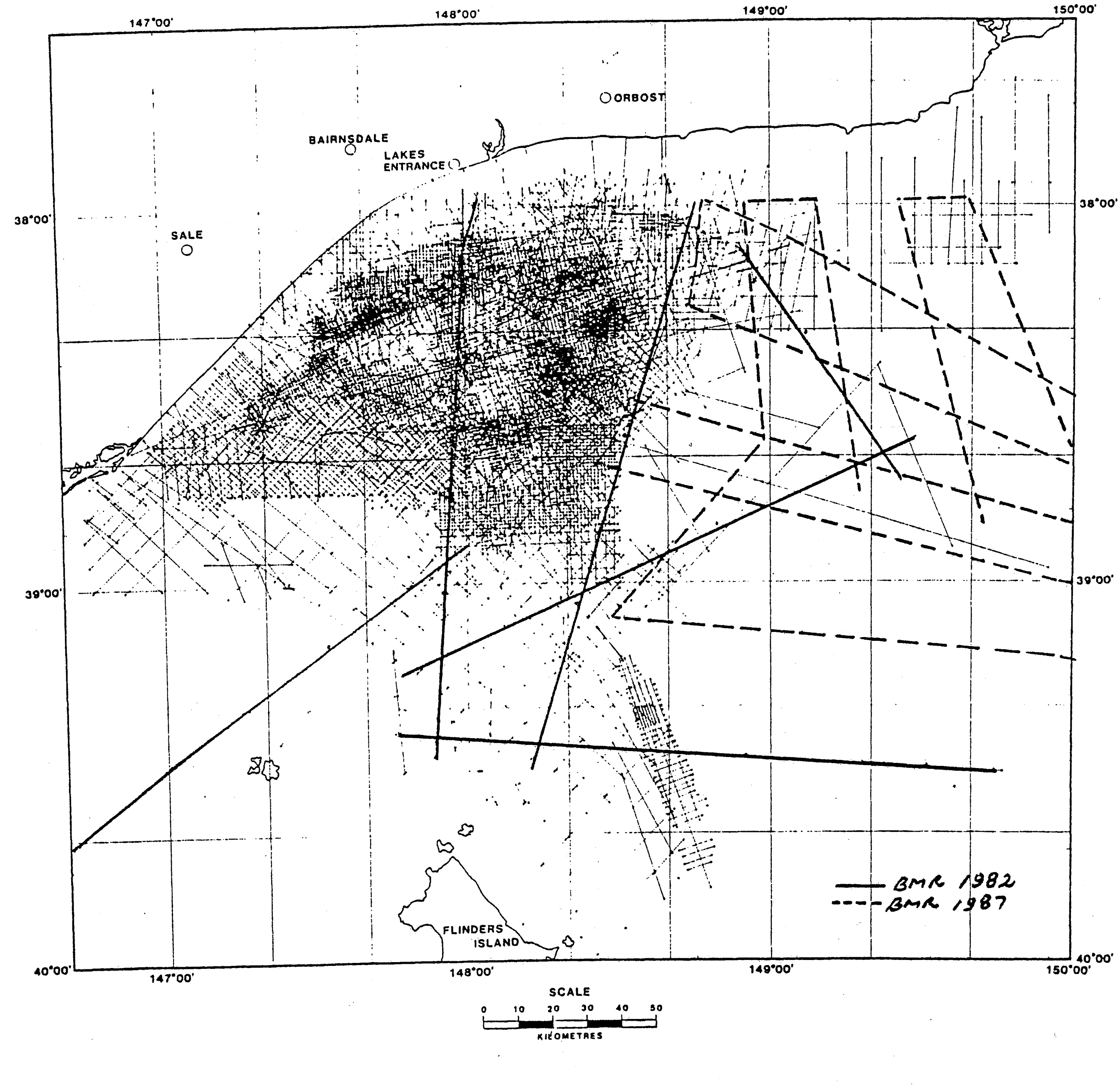


Figure 3. Seismic line density within the Gippsland Basin showing most lines shot between 1962 and 1987 (after Brown, 1986). BMR's 1982 and 1987 lines are highlighted.

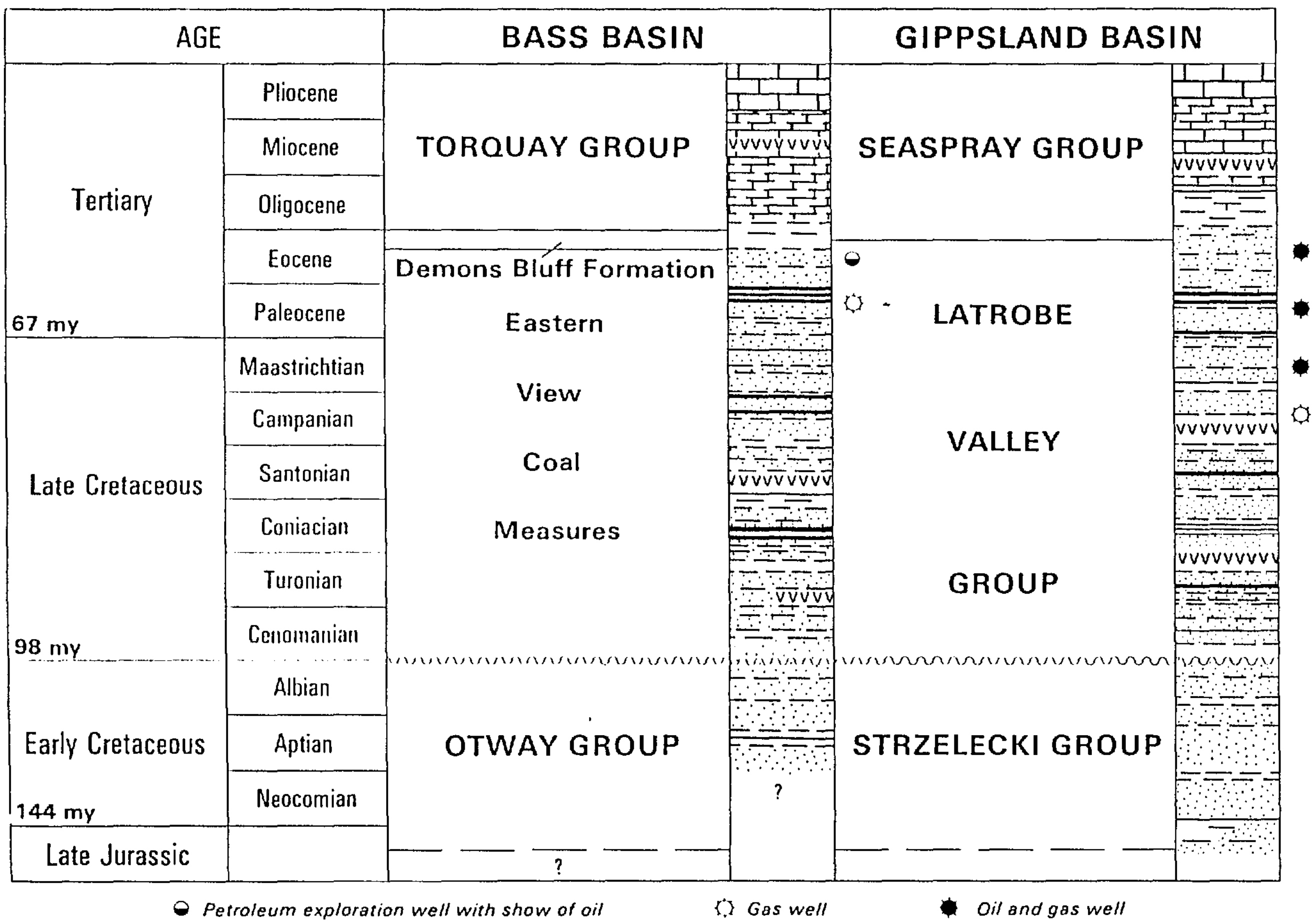


Figure 4. Comparative stratigraphy of the Bass and Gippsland Basins.

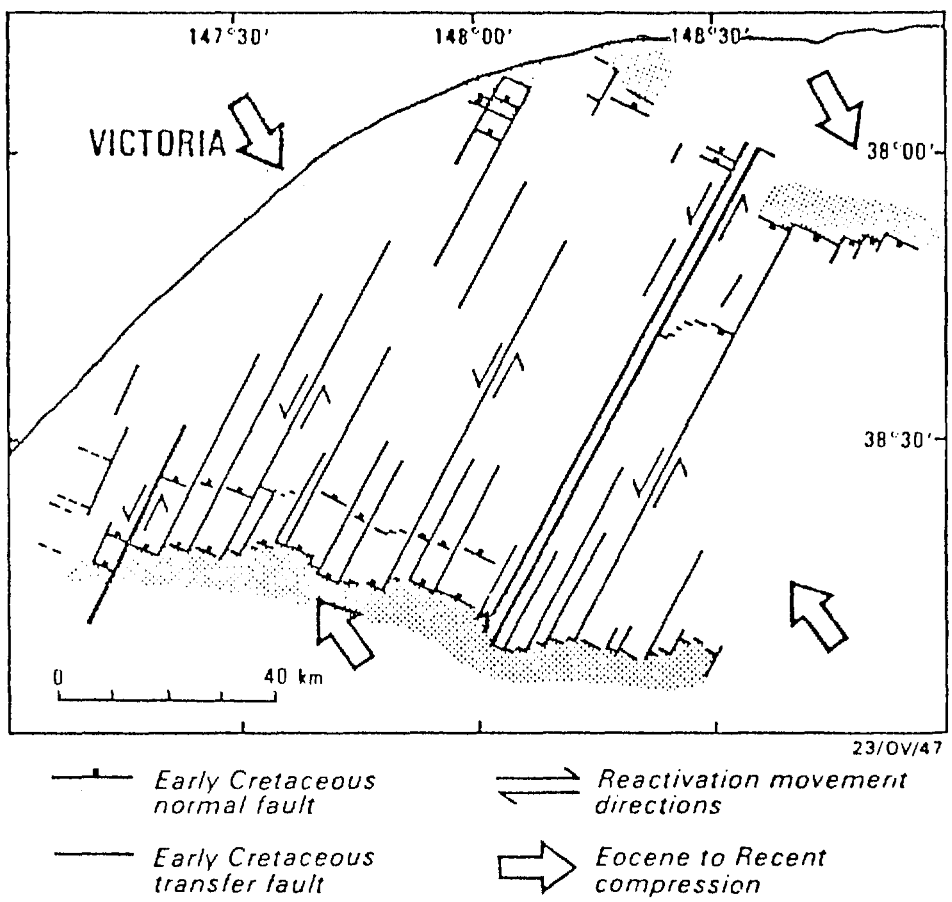


Figure 5. Map of Early Cretaceous structures within the Gippsland Basin showing how Tertiary northwest-southeast compression gives rise to left-lateral wrench reactivation of transfer faults, and oblique reverse reactivation of normal faults (after Etheridge & others, 1985).

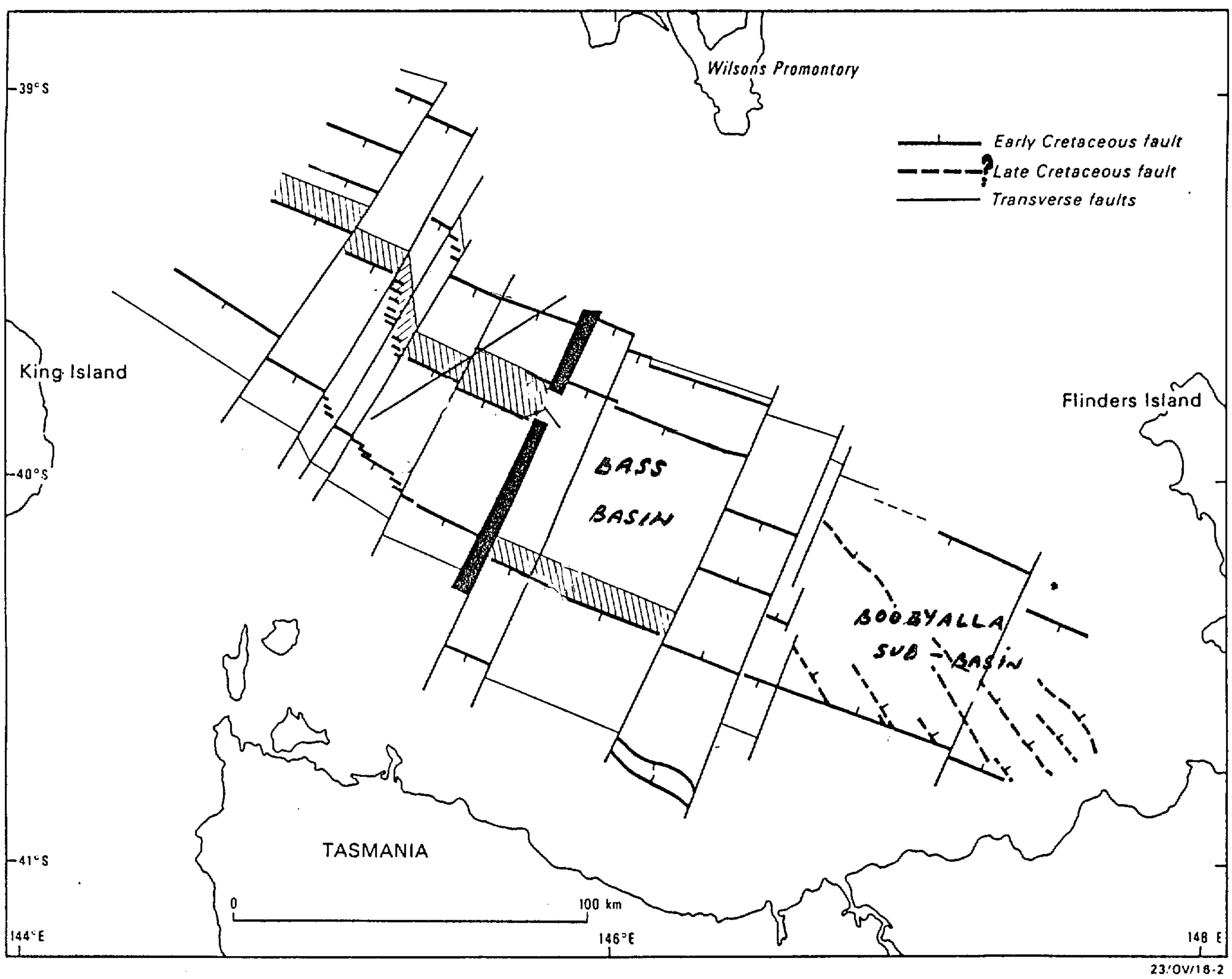


Figure 6. Basin-forming structures in the Bass Basin (after Etheridge & others, 1984, 1985).

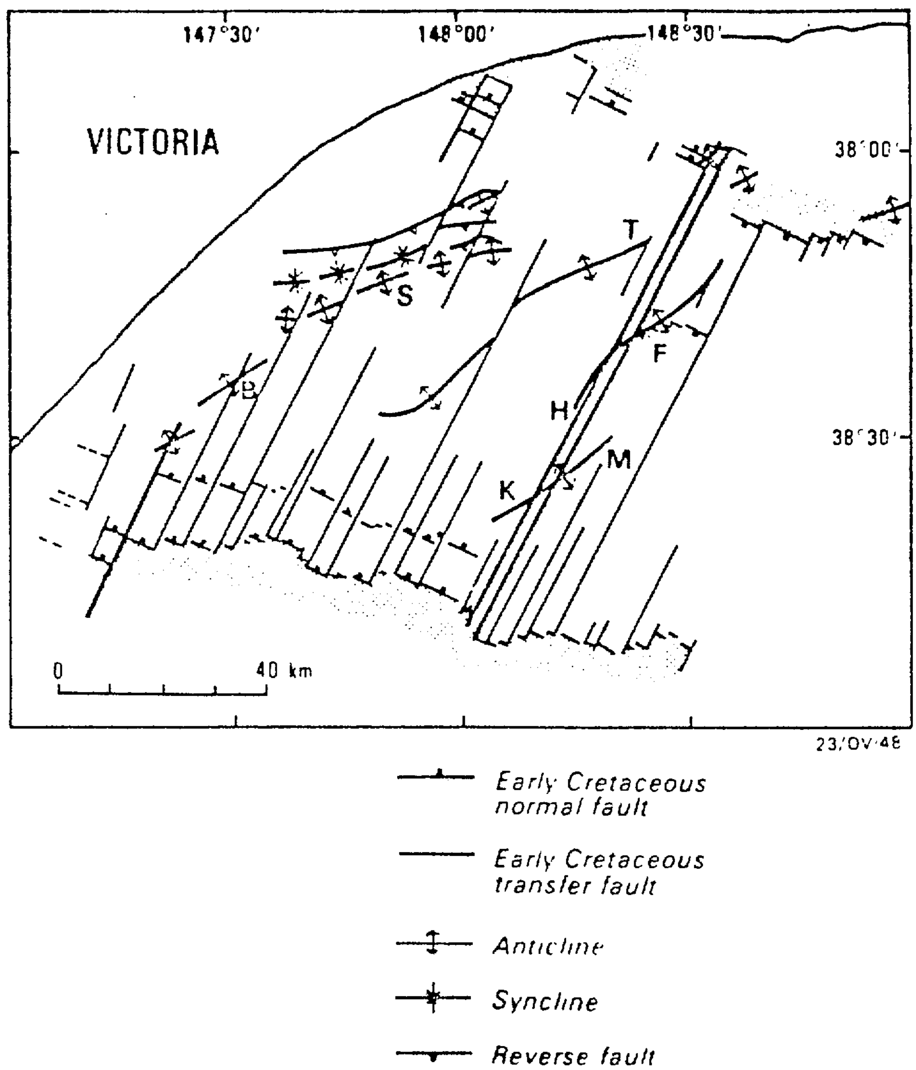


Figure 7. Map of Late Tertiary compressional structures within the Gippsland Basin (most of them hydrocarbon reservoirs) superimposed on the Early Cretaceous extensional structures (after Etheridge & others, 1985)

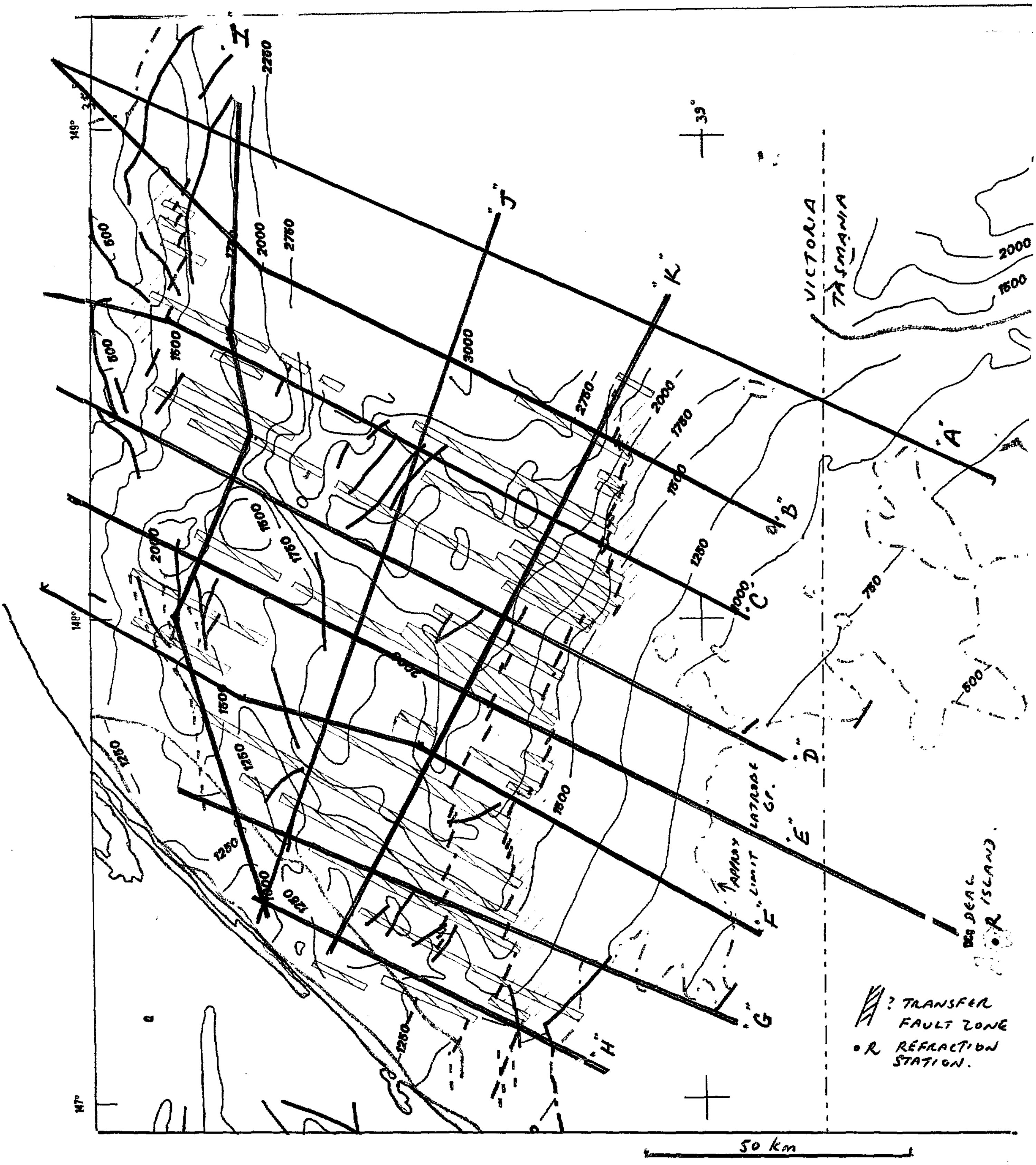


Figure 8. Sketch map of the Gippsland Basin showing the location of transfer fault zones (after Etheridge & others, 1985) and proposed Rig Seismic lines.

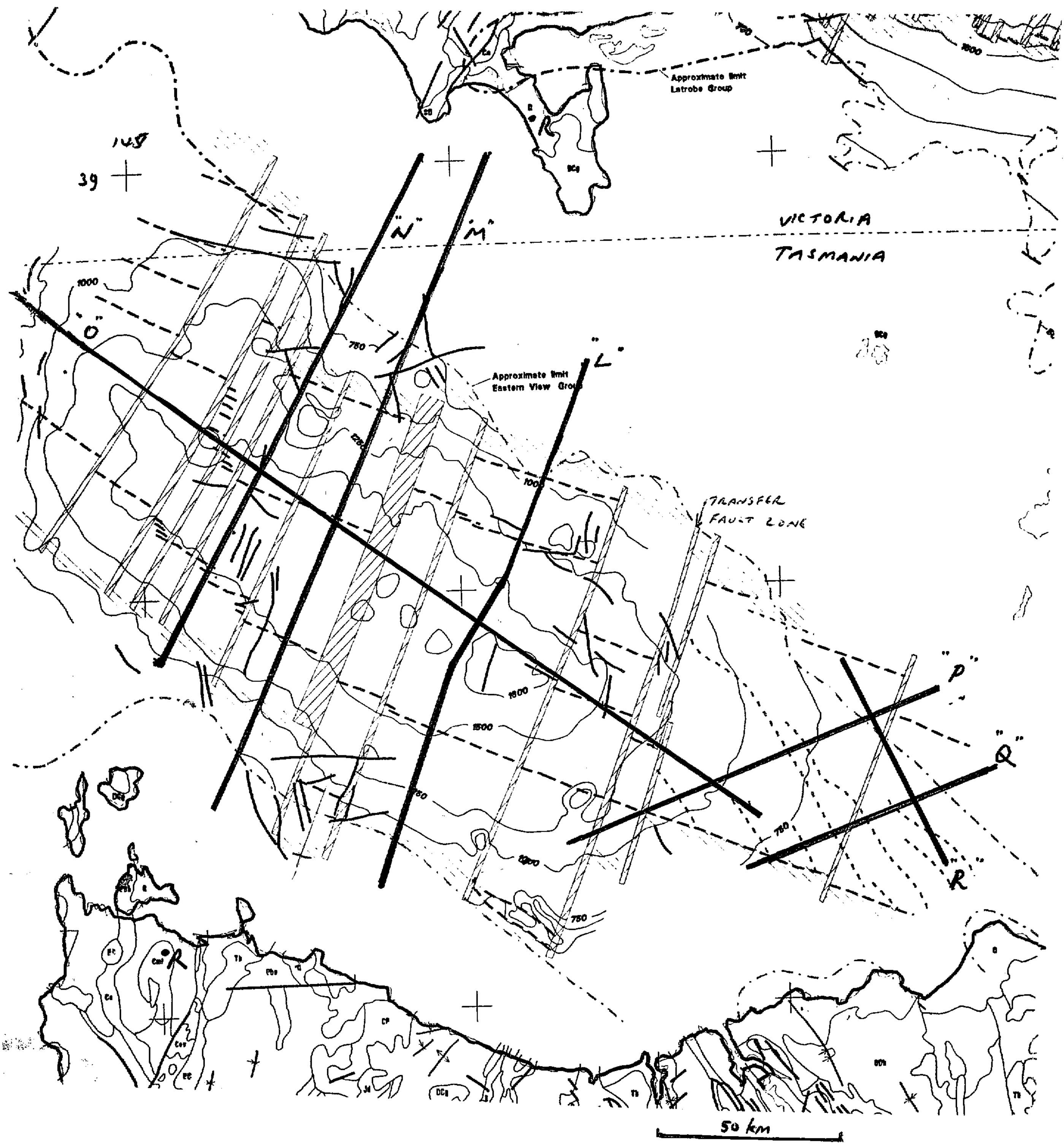
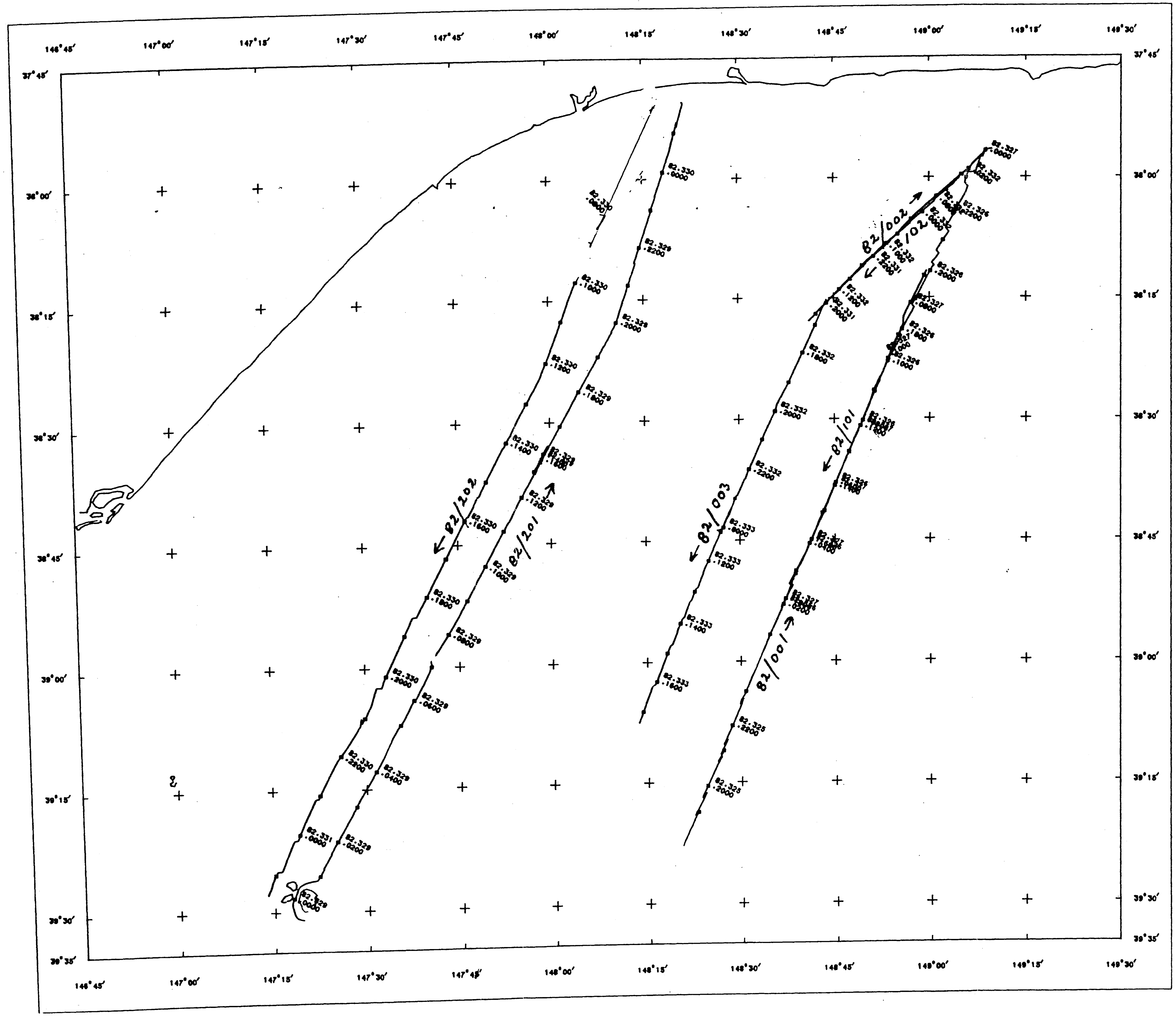


Figure 9. Sketch map of the Bass Basin showing location of transfer fault zones (after Etheridge & others, 1984, 1985) and proposed Rig Seismic lines.

EDITION OF 1988/12/03

SCALE 1:999999



SHEET NO.1 - LC

WORLD GEODETIC SYSTEM 1972
LAMBERT'S CONFORMAL PROJECTION
WITH STANDARD PARALLELS
AT 38°00' AND 39°30' SOUTH

Figure 10. Location of Survey 82 Gippsland Basin lines (raw navigation).

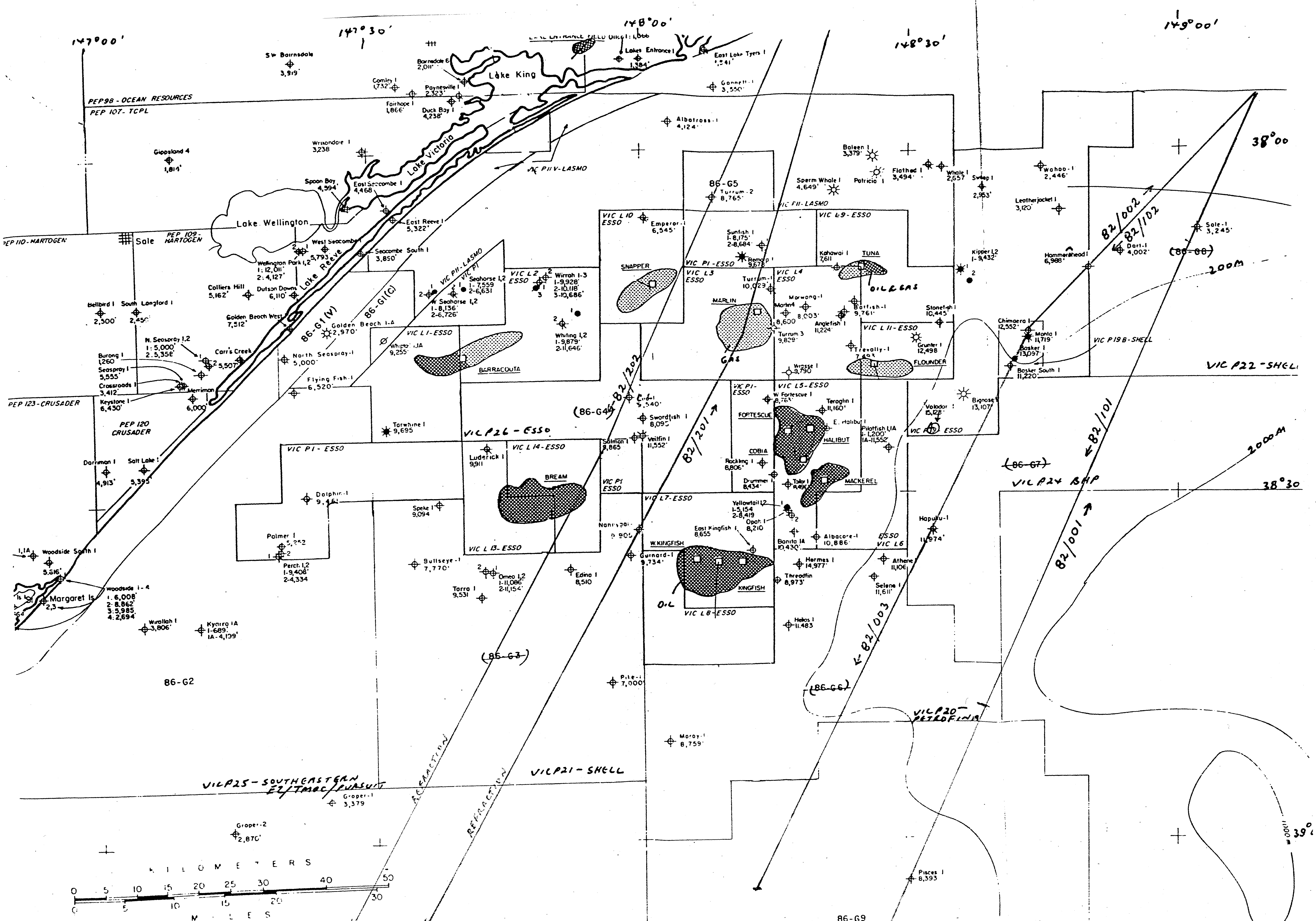


Figure 11. Location of Survey 82 lines in relation to petroleum exploration wells, oil and gas fields, and lease areas within the Gippsland Basin.

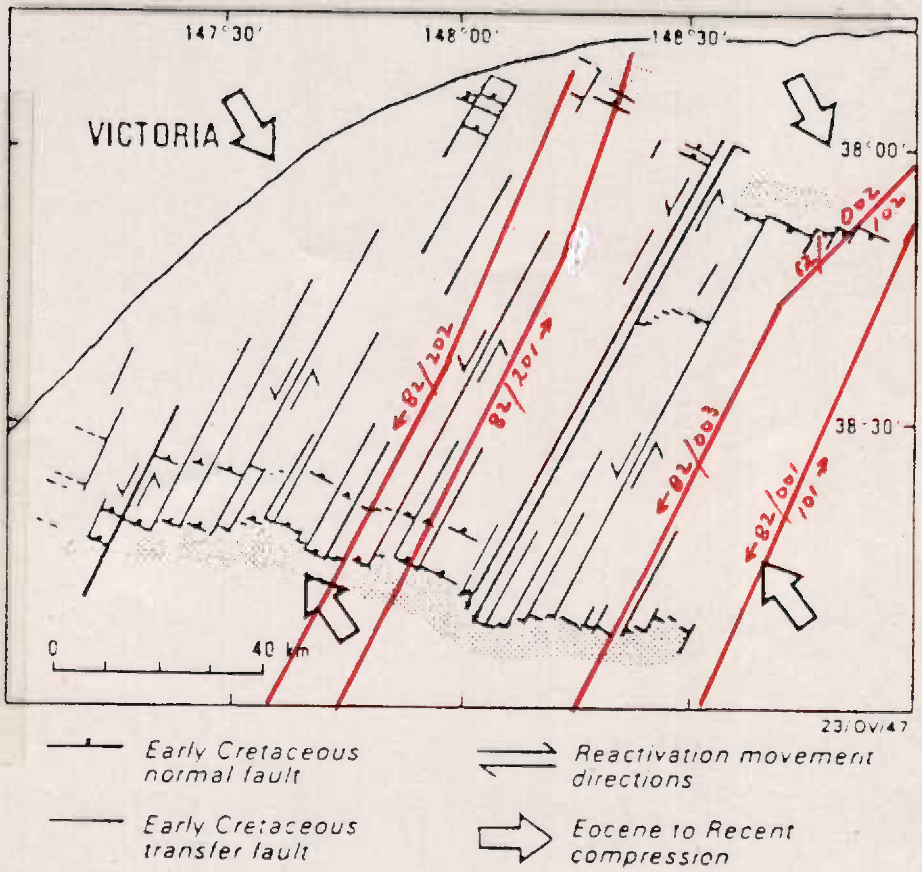
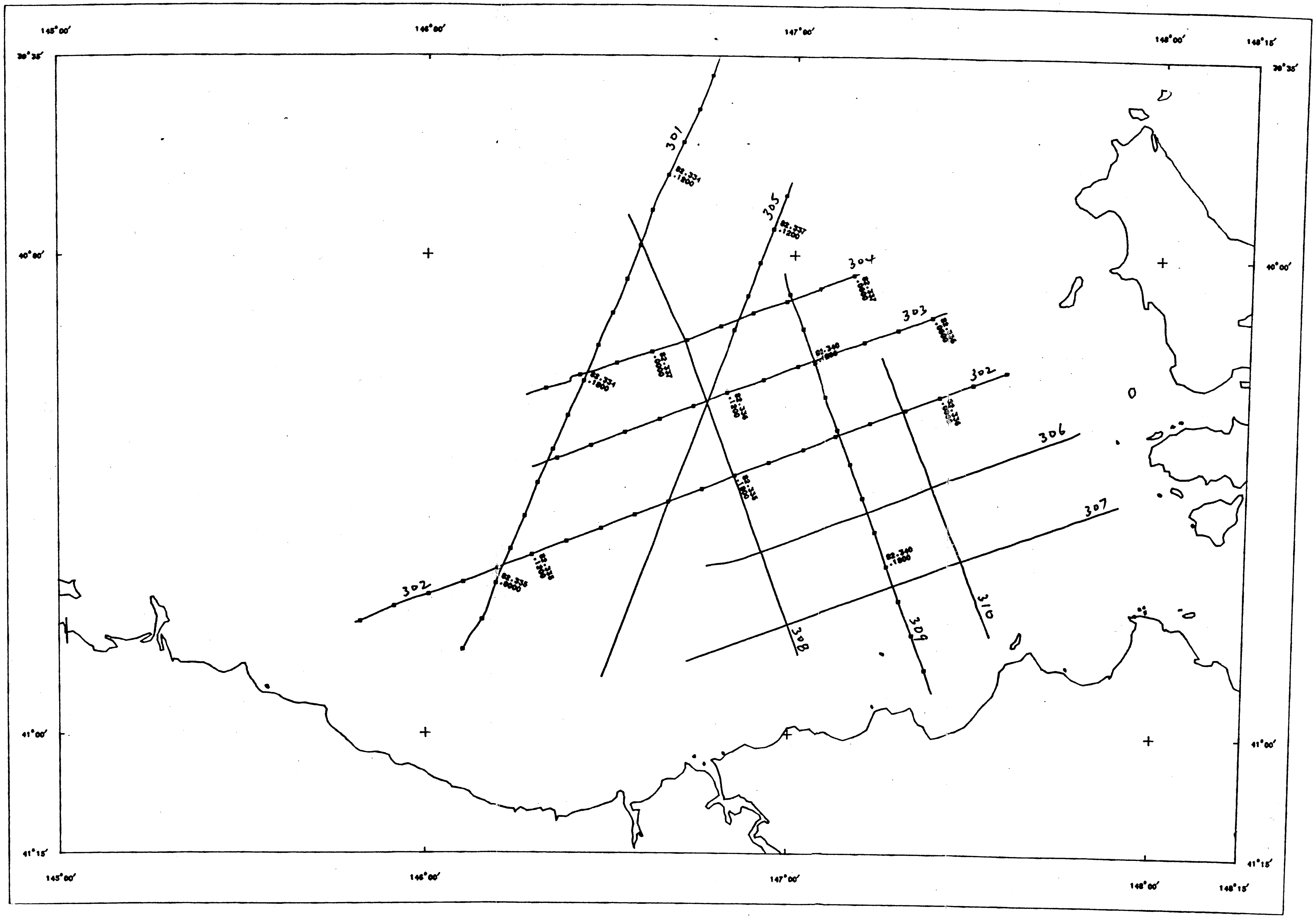


Figure 12. Location of Survey 82 Gippsland Basin lines in relation to the Early Cretaceous basement structures of Etheridge & others (1985).

SCALE 1:999999

SEISMIC LINES ONLY

EDITION OF 1988/12/08



WORLD GEODETIC SYSTEM 1972
LAMBERT'S CONFORMAL PROJECTION
WITH STANDARD PARALLELS -
AT 39°51' AND 40°59' SOUTH

Figure 13. Location of Survey 82 Bass Basin lines (raw navigation).

TRACK MAP

BASS BASIN
SEISMIC LINES ONLY

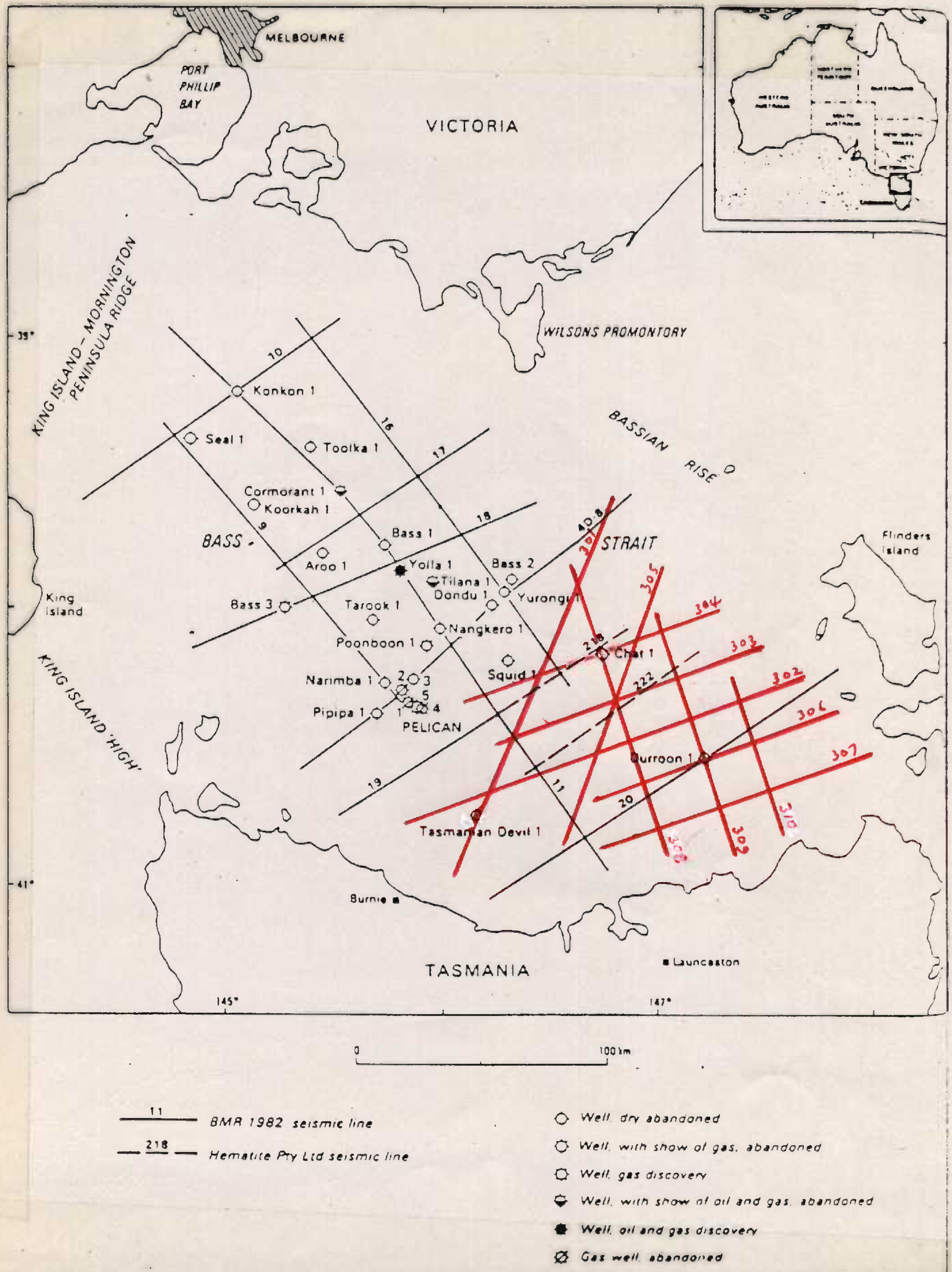


Figure 14. Location of Survey 82 Bass Basin lines in relation to petroleum exploration wells and BMR's 1982 (Survey 40) lines.

R8900107

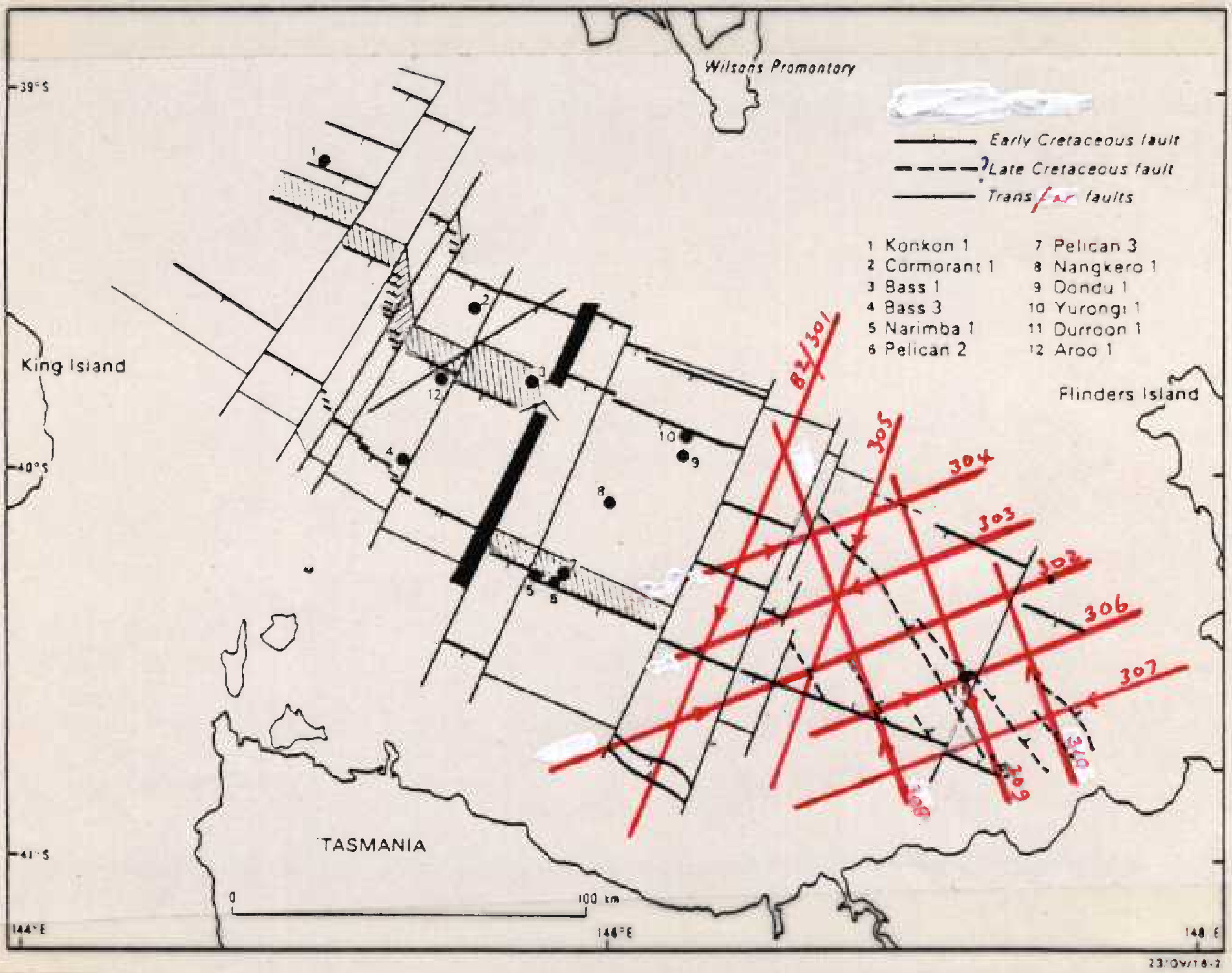


Figure 15. Location of Survey 82 Bass Basin lines in relation to the basin-forming structures mapped by Etheridge & others (1984, 1985).