053001

Bass Basin part IX

EASTERN BASS STRAIT MARINE SEISMIC SURVEY

FINAL SUBSIDY REPORT

BY

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ABSTRACT

The Eastern Bass Strait Marine Seismic Survey was conducted in the Bass and Gippsland Basins of Victoria and Tasmania. The data from this survey have been integrated with previous survey data in both basins and an interpretation is presented of all of the Bass Basin and the portion of the Gippsland Basin that qualified for subsidy.

The Gippsland Basin began in the late Mesozoic era with continental deposits being laid down on a peneplaned, sharply folded, lower Cretaceous surface. The basin is controlled on the south by an E-W trending down-to-the-north fault system and on the north by a combination of faulting and folding. Local structural movement occurred from upper Cretaceous through uppermost Eocene, accompanied by deltaic deposition and local erosion. At the close of the Eocene major local structure movement occurred. Beginning with the Oligocene, marine conditions persisted over most of the basin into Pliocene time when the seas withdrew to their present position.

Faulting, local structural movement, and local erosion have resulted in eleven structural prospects and four structural leads being outlined in the Gippsland area of this report.

The Bass Basin is of Tertiary age and originated as an embayment of the South Australia-Otway sea. An en-echlon system of faulting on the northeast and southwest flanks of the basin developed prior to the Cenozoic era and has had subsequent movement through the close of the Oligocene. Overall basin movement throughout most of the Tertiary has been characterised by general subsidence. However, local areas remained relatively stable and are expressed today as structural highs. Deposition underwent a transition from continental deltaic to marine deposits as the seas transgressed to the east. Each discrete lower and mid-Tertiary interval wedges out towards the north, south, and east flanks of the basin forming good potential stratigraphic traps.

Two untested anticlinal prospects and extensive structurally isolated stratigraphic wedge outs have been delineated in the Bass Basin.

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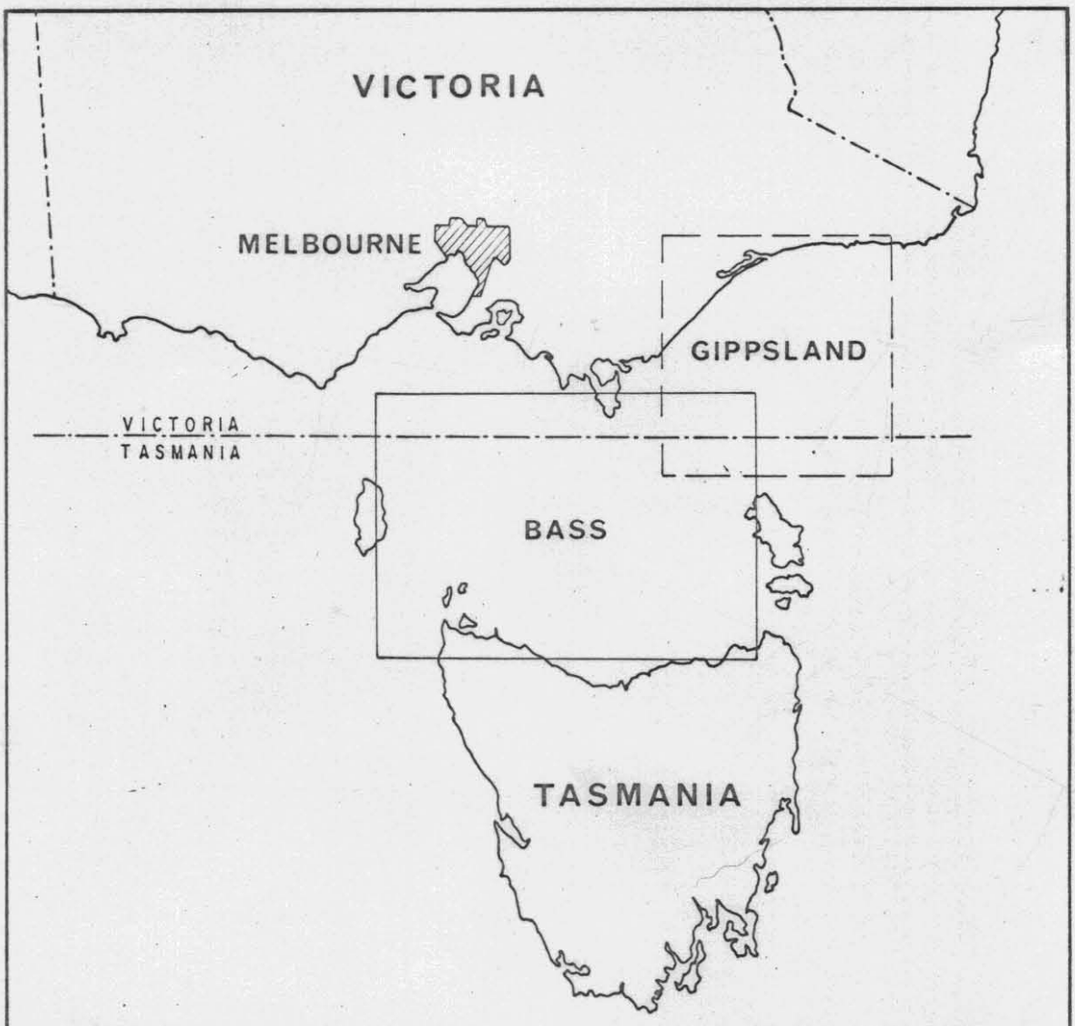
Variable Density Section (two (2) copies each)

Lines ES-3, ES-32-34, ES-38-72, ES-74-81
ET-16, ET-23, ET-26, ET-43, ET-45, ET-47-87.

FRONTISPIECE



ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

LOCALITY MAP
EASTERN BASS STRAIT
MARINE SEISMIC SURVEY

50 0 100
MILES

MARCH, 1967

5 cm

Esso Exploration and Production Australia Inc. Sydney, N.S.W.

INTRODUCTION

The Eastern Bass Strait Marine Seismic Survey was carried out for Esso Exploration and Production Australia Inc. by Geophysical Service International. The survey commenced on February 14, 1966 and finished on October 14, 1966. The survey consisted of two independent sets of program, one in the Gippsland Basin in PEP's 38 and 39 and EL 1/60 and the other in the Bass Basin parts of EL 1/60 and PEP 40 (frontispiece). Since these are separate geological provinces they can be regarded as two independent surveys and they will be treated as such throughout the interpretive portion of this report.

All the program in the Bass Basin was subsidized.

In the Gippsland Basin, the area within a twenty mile radius of Barracouta A-1 and B-1 wells, was not eligible for subsidy when the original survey application was made and results from the shooting within these circles are not included in this report.

OBJECT OF SURVEY

A) Gippsland Basin

The seismic program in the Gippsland Basin had three main objects:

i. To further detail the prominent structural features discovered by previous seismic surveys within the Paleocene to Oligocene section.

ii. To obtain as much valid data as possible from the pre-Paleocene section, especially across the known shallower structural features.

iii. To obtain reconnaissance seismic information in areas where no previous work had been done, with the object of developing possible structural leads and to better outline the geological framework of the basin.

B) Bass Basin

The seismic program in the Bass Basin had two main objects:

i. To detail several structural leads found by previous reconnaissance seismic surveys.

ii. To add to and extend the previous reconnaissance grid around the flanks of the basin, with an object of exploring the possible stratigraphic trap potential of the basin and uncovering additional structural leads.

DATA QUALITY AND RELIABILITY

A) Gippsland Basin

Seismic Data - The interpretation that follows incorporates all the available geological and geophysical information in the area. However its validity is largely influenced by the quality of the seismic data.

Three seismic surveys are incorporated in this interpretation. The previous Haematite Gippsland Marine Seismic Survey and the Esso Gippsland Shelf Marine Seismic Survey have been discussed in earlier subsidy reports.

The data quality in the Eastern Bass Strait Survey was generally fair to good, though in places there was a marked deterioration, especially below 1.5 seconds.

The reliability of the interpretation is a function of the data quality and the closeness of the seismic grid. Fig. 3 is a schematic representation of the horizons mapped and the basinward extent to which they can be followed. The Top of Lakes Entrance (Plate VIII) and Latrobe Topographic Surface (Plate IX) have been interpreted with considerable confidence. The only deterrent to specific reliability is grid size. The Horizon near the Top of the Cretaceous (Plate X) varies considerably in reliability. In the eastern third of the area the interpreted configuration is considered to be reliable. In the remaining area, a marked decrease in definition occurs to the west and especially to the north-west. There the interpretation relies largely on phantoming to produce a continuous picture. The Basement horizon (Plate XI) has only been mapped where it can be interpreted with confidence. Thus it is confined to the margins of the basin and its reliability is a function of grid size.

It should be noted that the change in contour interval on the maps from 100 feet to 500 feet indicates the areas where the interpretation is less reliable, due either to data quality or grid size.

Velocity Data - Velocity information is available from most wells both onshore and offshore and also from the velocity functions used to make the dynamic corrections prior to stacking. This indicates that abrupt and significant lateral velocity variations occur in many places in the Gippsland Basin.

These variations are apparently due to two main factors.

In almost all cases the velocity changes within the Miocene are associated with rapid lateral lithological variations from marl to limestone or sandstone. Fortunately many of these changes result in some form of anomalously dipping reflection event and are thus detectable. Much of the lithological variation appears to be associated with some type of channel-filling within the Miocene section.

Large scale structural relief also seem to result in significant lateral velocity variations over these structures due to the rapid variation in types and thicknesses of particular stratigraphic units across these structures. This is especially noticeable in the structures formed during the Eocene - Oligocene (Barracouta, Marlin, Snapper, Dolphin, etc.) where structural growth has been accompanied by rapid thinning of the Lakes Entrance Formation.

The random and abrupt nature of the velocity variation and the sparseness of accurate data make it impossible to make an accurate contour map of the average velocity variation in the offshore Gippsland area at this time. However an attempt was made to approximate these variations by mapping the results of the well surveys and the various velocities used by G.S.I. to make dynamic corrections to the seismic data. These were plotted and a regional pattern of the general velocity variation was established. The area of most significant change was in the vicinity of the Barracouta-Snapper-Cod-Marlin-Tuna structures. Elsewhere more of a constant velocity situation seemed to exist. A general velocity curve was calculated for this area, (Fig. 4).

These data were used to determine the depth to horizons where the dynamic correction data indicated that changing velocities existed. Elsewhere the general velocity curve was used to map the depth to horizons. In the area of overlap between the various curves a velocity gradient was assumed. In all cases the velocity gradient was chosen to coincide with an area of steep dip on the flanks of the structures. Plate VII indicates the velocity patterns used.

B) Bass Basin

Seismic Data - All available geological and geophysical data has been incorporated in this report. The seismic grid in the basin, except for local detailing, is reconnaissance and therefore the interpretation presented is of a regional nature.

The Eastern Bass Strait Marine Seismic Survey data quality is generally good, ranging from poor to very good. The six-fold C.D.P. technique produced superior data to the single-fold reconnaissance shooting due to multiple attenuation.

Data from all the previous Bass Basin seismic surveys have been integrated with the Eastern Bass Strait Marine Seismic Survey. These surveys are the Haematite "Bass Basin Marine Seismic Survey", Esso's "Bass Basin Marine Seismic Survey", and Esso's "King Island East Marine Seismic Survey". The Haematite data has not been processed with any attempt to attenuate the water bottom multiples and therefore the correlations are not as reliable as for the more recent surveys. FM recording used for the Eastern Bass Strait and the King Island East surveys gives better resolution than the earlier AM recording.

Velocity Data - Accurate velocity control within this basin is available from well velocity surveys and sonic logs obtained in Esso Bass Nos. 1 and 2. Additional velocity information was obtained from a study of the dynamic corrections necessary to make N.M.O. corrections.

These studies indicated that only slight variations in average velocity occurred throughout the basin.

Hence it was considered appropriate to determine a single mean time-depth curve applicable throughout the whole basin. The time-depth chart for the curve obtained as shown in Fig. 5.

INTERPRETATION

A) Gippsland Basin

This interpretation incorporates all of the seismic data recorded in PEP's 38 and 39 and the Gippsland Basin portion of EL 1/60 with the exception of the areas not eligible for subsidy. However, structural attitudes within the omitted areas are covered adequately by previous Gippsland Basin reports.

Four structure maps and two isopach maps have been constructed. Fig. 3 illustrates the extent to which the four mapped horizons can be carried over the basin.

The prospects which have been definitely established by previous surveys and to which further detail has been added in the Eastern Bass Strait Marine Seismic Survey are Barracouta, Snapper, Marlin, Kingfish, Gurnard and Bream. Features which previously could have been classed as structural leads and which are now definite prospects are Tuna, Dolphin and Halibut, complete new prospects which were found and detailed by this survey are Mackerel and Flounder. New leads are Flathead, Sole, Herring, and Cod South.

General Geologic History - From Ordovician through Permian times, the Tasman geosyncline occupied a large part of what is now eastern Australia. It extended south from northern Queensland through Victoria and Tasmania and probably continued on to the southeast for some distance. This trough was several hundred miles wide and included all the area now ascribed to the Gippsland Basin. During this time, 40,000 + feet of sediments were deposited in this geosyncline and it was folded by several major orogenic cycles. These orogenics were accompanied by intrusive and extrusive vulcanism and resulted in local metamorphism. It is this sequence of rocks that probably serve as the source for the major part of the clastics deposited during late Mesozoic and Tertiary time in the Gippsland Basin.

Prior to lower Cretaceous time the Tasman geosyncline area became stable and was peneplained. In lower Cretaceous time, a new sedimentary trough began to develop and received sediments through the Tertiary. This trough trended east-west and extended from the Otway Basin in the west at least as far east at the continental slope of the Gippsland Basin. Deposited in this trough in early Cretaceous time were more than 20,000 feet of greywackes and sub-greywackes interbedded with shale and occasional thin beds of coal. This section is referred to as the Strezlecki Group in the Gippsland Basin and is correlative with the Otway Group of the Otway Basin.

Near the end of lower Cretaceous time the Strezlecki Group was sharply folded. Dipmeter data in a few of the onshore wells indicate 30° dip to be common and where seismic data is obtained the beds also appear to be steeply dipping. The area then stabilized, and following peneplanation of the Strezlecki Group, general subsidence allowed almost uninterrupted deposition of the upper Cretaceous to Pliocene sequence. The lower sediments of this sequence consist of a thick (500 + feet) section of alternating sandstones, coals and shales which make up the Latrobe Deltaic Complex, which ranges in age from upper Cretaceous to uppermost Eocene. Clastic sediments in this group probably were sourced from the Paleozoics present on the surface to the north. It is postulated that the delta complex was deposited in a north-south trending trough with initial subsidence occurring in the eastern portion of the Gippsland Basin. As deposition continued, the depositional axis gradually migrated to the west. Within the delta complex local structural growth accompanied by erosion and/or non-deposition causes local angularity of beds.

Following deposition of the Latrobe Delta Complex the rate of basin subsidence increased and marine conditions persisted over most of the basin into Pliocene time.

During Pliocene the sea withdrew to approximately its present position. Onshore upper Pliocene to recent sands and gravels are locally developed. Also during this period the Balook and Narracan surface structures are postulated to have developed. However, little is known about the stratigraphic relations around these structures and it is possible that structural growth may have been initiated as early as Eocene time.

Regional Structure - Regionally the Gippsland Basin geological development has been controlled in the south by a major down-to-the-north E-W trending fault system, which was active between lower Cretaceous and upper Eocene time, (Plate XI). To the north the present basin is bounded by a combination of faulting and folding.

The local structural movement that occurred during the Latrobe Delta development, from upper Cretaceous to uppermost Eocene, was characterised by normal faulting accompanied by some domal uplift (Plate X). The dominant trend of this faulting was NW-SE, and the magnitude of throw decreased significantly toward the top of the delta.

At the close of the Eocene, a widespread trend of structural movement developed and in places persisted well into Miocene time. This trend was practically orthogonal to the older NW-SE trend. It is best represented by the ENE-WSW structural uplift of the Dolphin-Barracouta trend and the E-W uplift of the Kingfish-Bream trend. (Plates VIII and IX). Generally, the younger the movement the more E-W has been its trend. Also the younger structural movements are not accompanied by the same extent of normal faulting as were the upper Cretaceous and Eocene movements.

A most important feature which should be recognised when considering the structures on top of the Latrobe deltaic complex (Plate IX) is the topographic nature of the horizon. It is the combination of structural uplift and topographic relief that give rise to the closure on most of the features.

Individual Structures - Herring - This is purely a structural lead. There are indications of structural reversal in the Strezlecki Group, though no closure is evident. This is associated with a basement high. A small amount of closure is also present on the Latrobe topographic surface (Plate IX).

Flounder - This prospect is a basal Latrobe delta structure, best illustrated on the horizon near the top of the Cretaceous (Plate X). Its structural development was arrested during late delta deposition and no closure occurs on the Latrobe topographic surface (Plate IX).

Tuna - This prospect has structural closure throughout all the Latrobe delta section and even a small amount of closure at the top of the Lakes Entrance. Closure on the Latrobe topographic surface is a combination of erosion and structural movement (Plate IX). On the top of Cretaceous horizon it is more complex and is a faulted anticline with two culminations.

Marlin - This structure has closure throughout the Latrobe delta section and a small amount on the top of the Lakes Entrance. The structure within the Latrobe becomes complicated by faulting at depth. At the Latrobe topographic surface the closure is a combination of erosion and structural movement. This condition persists until the base of the major erosion canyon is reached. Below this level closure independent of erosion is still present (Plate X). The structural syncline, as distinct from the erosional syncline, between Tuna and Marlin exists east of the canyon.

Halibut - This structure is similar to Marlin in that it is dependent on the canyon for closure throughout the Latrobe. However below the base of the canyon there is no structural closure.

Mackerel - This structure is essentially an erosional remnant on the Latrobe topographic surface. The deep structural lead on the top of Cretaceous horizon is poorly controlled.

Kingfish - This prospect is a large feature on which the most pronounced movement occurred in the Miocene, though some late Eocene and Oligocene movement also occurred. Thinning of the lower Miocene sediments across the structure is very obvious on the seismic sections. It is also a prominent structure on the Cretaceous horizon and some form of structural feature may have been present in upper Cretaceous time.

Gurnard - This prospect is a separate culmination on the Kingfish-Bream trend and exhibits all the characteristics, on a smaller scale, as the Kingfish feature.

Bream - This prospect is also of the same type as Kingfish and Gurnard except for the presence of a small N-S trending graben which is of Miocene or younger age. This graben bisects the E-W trending axis of the structure.

Dolphin - This is virtually a Latrobe topographic feature only, with no deep prospects. It was formed by a north-south trending stream channel cutting across a later Eocene eastward plunging nose. The erosion surface caused by the channel provides west closure.

Flathead - This lead appears to be an east-west trending faulted anticline that developed during Miocene time.

Sole - This lead, only portion of which is in PEP-38, appears to be a small east-west trending anticline with primary movement occurring during Miocene time.

B) Bass Basin

Generalized Geologic History - The good quality of the seismic data and excellent correlation between reflections and geologic markers in Esso Bass-1 and Esso Bass-2 make possible a reliable interpretation of the

regional Bass Basin geologic history.

Basement is an irregular surface composed of igneous and metamorphic Paleozoic and Mesozoic rocks. Prior to Tertiary deposition a system of faults developed on the northeast and southwest flanks of the basin. The faults generally are en-echlon and in some instances a system of regional horsts and grabens are found. These faults are on trend with the northeastern Tasmania fault systems.

The Bass Basin is of Tertiary depositional origin and began as a large embayment of the South Australia-Otway Sea, bounded by Victoria and Tasmania to the north and south and the Bassian rise to the east. Structural movement throughout most of the Tertiary has been in the form of subsidence with the present highs remaining as stable areas.

Gentle regional subsidence with swamp conditions and dominantly continental deposition prevailed during the Paleocene and lower Eocene epochs. The sediments as seen in the two wells drilled in the basin are a deltaic complex made up of interbedded sandstone, siltstone, shale, and coal. A marine pulse is evident near the top of this unit in Esso Bass-2. The close of the lower Eocene was marked by a period of gentle uplift, fault rejuvenation and a widespread unconformity.

Gentle subsidence resumed during the upper Eocene with local uplift and faulting along the older fault zones continuing. The 1500 + feet of sediments underwent a transition from non-marine to restricted marine deposition. The marine sandstones and mudstones lay apparently conformable upon and interfingers with the continental sands, shales and coal. The unit pinches out to zero on the basement beyond the limits of the Paleocene-lower Eocene sediments as the seas transgressed the erosional surface. Local volcanic activity was evident at this time. Gentle erosion around the margins of the embayment may have occurred at the close of the Eocene.

During the Oligocene, basin subsidence, transgressive seas, and marine deposition continued, depositing upwards of 1750 feet of sediments which overlapped beyond the Eocene on to basement. Local uplift and faulting were less pronounced than during the Eocene. The sediments were mostly shale and mudstone with some sandstone and tuffite. The tuffite was deposited by extensive volcanic activity which marked the close of the Oligocene. Many volcanic build-ups are recognizable on the seismic sections.

A time of major subsidence began with Miocene. The transgressive seas and marine deposition continued. Over 4000 feet of Miocene and younger Cenozoic deposits were laid down. The areas coincident with the northwest-southeast trending faults on the flanks of the basin remained relatively stable while the center portion of the basin subsided forming the basin as we see it today. The King Island-Mornington Peninsula uplift experienced its last major period of movement during the early Miocene. This feature was probably positive throughout the Tertiary period but was not elevated to its present magnitude until the early Miocene time. The Bassian rise continued to subside until it was overlapped by late Miocene sediments. This was the first known communication between the Bass and Gippsland Basins. Some mid-Miocene volcanic activity occurred. One of these build-ups was penetrated by Esso Bass-1.

A thin veneer of Quarternary sediments cover the Tertiary deposits.

Horizons Mapped - The interpretation for this report is presented by four structure and two isopach maps. These are the top of the Oligocene, top of the Eocene, and mid-Eocene Unconformity, Basement, top of the Oligocene to top of the Eocene and top of Eocene to mid-Eocene unconformity maps.

The Basement horizon has been mapped around the margins of the basin where basement is shallow enough for sufficient energy penetration to produce a reliable reflection. The general character of basement is an irregularly dipping high amplitude reflection.

The energy level on the seismic recordings drops markedly below the basement reflection which helps to isolate the sedimentary section. The structural map on Basement is presented by Plate IV.

The mid-Eocene unconformity is generally distinguished by truncations of the lower Eocene reflections. The lower Eocene reflections are low frequency pulses with normal amplitude. These discontinuous erratic reflections are characteristic of continental sediments. Structure on the mid-Eocene unconformity is presented by Plate III.

The top of the Eocene is a good continuous reflection which correlates well throughout most of the basin. The upper Eocene basal sand unit as seen in Bass-1 and Bass-2 has good porosity and is considered a major objective for Bass hydrocarbon exploration. Structure on top of the Eocene is presented by Plate II and the top of the Eocene to the mid-Eocene unconformity isopach is presented by Plate VI.

The top of the Oligocene is a high amplitude reflection often exhibiting erratic dips. The Oligocene is easily mapped because the overlying Miocene is normally a low amplitude reflection interval. Many volcanic build-ups are apparent at the top of the Oligocene and these erratic dips are considered to be evidence of local volcanic deposition. Plate I is the structure at the top of the Oligocene and Plate V is the isopach of the Oligocene interval.

Structural Anomalies - Structural anomalies are not well developed in the Bass Basin. To date only three anticlinal structures large enough to be considered as potential prospects have been delineated. One of those features was tested by Esso Bass-2 but was found to be dry and the hole was abandoned.

Five structural leads found by previous reconnaissance seismic surveys were detailed with 600% CDP control by the Eastern Bass Strait survey. None of these leads developed into a prospect.

Esso Bass-3 will test the anticlinal anomaly located at the intersections of lines B-3 and EK-34. This feature originated as a high basement fault block and remained a positive area through lower Miocene.

The remaining untested anticlinal feature is located at the intersection of lines B-21 and B-2. This anomaly appears to be on Oligocene structure and was possibly formed contemporaneously with the interpreted stock immediately to the north. Regionally the Eocene is thickest in the vicinity of this structure. This anomaly is considered less prospective than the Bass-3 feature due to its younger age.

Several small structural leads on the western flank of the basin will merit investigations should Bass-3 prove productive. On trend with the Bass-3 feature is a reversal on line ES-40. Additional data would be necessary on this feature. Two shallow low relief reversals are evident on the King Island-Mornington Peninsula trend. Evidence for these structures is weak but the local relief on the large regional feature is worth noting.

Stratigraphic Anomalies - The entire lower and middle Tertiary section of the Bass Basin may be considered a tongue of sediments wedging out to the east. This tongue lies on basement and is capped by the marls and calcarenite beds of the middle and upper Miocene. Within this wedge are interbedded sands and shales which should form numerous pinch out stratigraphic traps. The quality of the seismic data and the geometry of the Bass Basin should permit good geophysical stratigraphic prospecting.

The interval map between the top of the Eocene and the mid-Eocene unconformity (Plate VI) is characteristic of most of the Tertiary section in the Bass Basin. This map shows 1500 + feet of upper Eocene in the thickest part of the unit pinching out to zero to the northeast and south.

With almost continued subsidence of the basin and transgressive seas the entire lower and mid Tertiary section is interpreted to pinch out shelfward around the basin. The reconnaissance grid of 100% coverage has delineated the zero edge of the Eocene and Pliocene units and proven the ability of the seismograph to map this wedge.

Interbedded impervious and porous beds where combined with interval thinning and structural configuration as demonstrated in Bass create large potential mechanical stratigraphic traps. Plate II, the Structure Map of the Top of the Eocene, illustrates clearly the ideal structure relationship. The -2000 foot contour on the east side of the basin is cut at both ends by the zero edge of the unit mapped. Therefore, all of the Eocene higher than -2000 feet (that to the east of the contour) is structurally isolated. If the relationship is such that impervious beds are in contact with basement at their onlap edge the seal will be provided for underlying porous beds and potential traps formed.

Two local areas in the western part of the basin may with additional seismic control develop into potential mechanical stratigraphic traps. Magnetics suggest an embayment or trough projecting southward between King Island and Tasmania. The second area is in the northwest part of the basin where fault geometry creates a wedge shaped trough pointing towards the Anglesea area to the north.

CONCLUSIONS

The delineation of the regional and local geology has been noticeably improved by this survey. The quality of the data is generally good and reliable interpretations have been made. The objectives of the survey have been met.

Good control in the Gippsland Basin is now established for eleven prospects and four new structural leads have been developed. Extra control needed for six established prospects was obtained, three new prospects were developed from existing leads and two completely new prospects were detected and detailed.

The Bass Basin portion of the survey further defined the stratigraphic possibilities of hydrocarbon entrapment while establishing that the several structural leads detailed were not prospective. Bass has two untested structural prospects, one of which is being tested by Esso Bass-3.

APPENDIX A

FIELD OPERATIONS AND PROCEDURES

The program shot in both basins is shown on Figs. 1 and 2. Lines were shot sixfold common depth point (CDP) coverage or singlefold coverage. Shotpoints were numbered consecutively in two sets, each beginning with SP 1001, one set starting in Gippsland and the other in Bass.

The survey was located in areas of relatively flat seabed. Average water depth was 30 fathoms. Recorded water depths ranged from approximately 20 to 40 fathoms. No rapid changes were observed in the seabed from water-depth recordings. Strong currents, due to tidal variations through the Bass Strait, were prevalent.

Weather conditions varied significantly. Adverse weather and sea conditions were the major factor in preventing production work, especially from May through October.

Streamer - The neutrally buoyant streamer employed throughout the prospect has 24 equally spaced, 100-ft-long sections. Each live section has 20 crystal detectors spaced at 4¾-ft intervals, the outputs of which yield one trace. Adjacent live sections, including groups 12 and 13, were separated by 114-ft dead sections. Up to four dead sections preceded the first live section. One (two after July 7) preceding dead section contained nylon stress members to attenuate noise generated by the towing vessel. One dead section followed the last live section. A tail buoy was attached to the end of the streamer by a nylon rope.

The streamer was ballasted to ride horizontally below wave action. A variable length of non-buoyant lead-in cable connected the streamer to the towing vessel. Streamlined weights were attached to the end of the lead-in cable. Under continuous tow, the streamer became hydrodynamically stable at a depth which is a function of its speed through the water, the length of the lead-in cable and the relative buoyancy along the streamer's length.

Four pressure-sensitive depth transducers, spaced along the streamer's length, displayed streamer depth readings in the range of 0 to 50 feet. Readings were taken from meters in the instrument room. An undetected malfunction in the end transducer allowed the tail-end of the streamer to ride too deep on part of the work done by Party 904. As a result 480 miles had to be re-shot at no charge by Party 921. After June 15, a graphic presentation of streamer depth at the latter three transducers was recorded simultaneously by three penwriters.

Analog recording was done with group 1 at the head-end of the streamer. For dual recording the first head-end live section was designated as group 24, the last tail-end live section as group 1.

Infrequently, traces reversed in polarity were discovered at the beginning of a day's shooting. This occurred after streamer sections were changed. Polarity reversals were corrected immediately and noted in the Quality Control Daily report.

Recording

1) Party 921 - The output of each live streamer group was amplified by a Texas Instruments Model 8000 Amplifier System, recorded by an SIE PMR-20 frequency-modulated tape recorder and monitored by an SIE TRO-6A photo-oscillograph, simultaneously.

2) Party 904 - At the client representative's request, the output was amplified by TI Series 9000 amplifiers before recording on the SIE PMR-20.

A direct playback was made of every fifth shot on sixfold coverage and every shot on singlefold coverage from recorder heads directly to camera galvanometers. Tape modulation levels were visually monitored by a meter on the PMR-20 recorder and checked against a direct playback standard 100 percent modulated tape.

Party 921 made variable-area cross-sections (VAX sections) of every line, using 24 traces of every singlefold profile or the four near-shot traces of every sixfold profile. Profiles were played back through Texas Instruments Model 8000 Amplifier System in a straight-gain mode to a variable-area cross-section recorder and recorded sequentially on photographic film. Party 904 started the prospect making VAX sections, but discontinued the practice after the first few days due to equipment malfunction.

For selected portions of work, output of each live streamer group was amplified by a TA Series 9000 Amplifier System, dual recording by an SIE PMR-20 frequency-modulated tape recorder and a Texas Instrument Digital Field System (DFS), and monitored on photo-oscillographs, simultaneously.

A direct playback was made of every fifth shot on sixfold coverage and every shot for singlefold coverage for the FM system. A direct playback was made of every shot for the digital system. Rigorous instrument tests were given both recording systems. An Instrument Engineer was aboard during all work of this kind. Party 921 made VAX sections of every line in the same manner generally as from the FM-recorded profiles. Profiles were played back through the Series 9000 Amplifier System in a straight-gain mode and recorded sequentially on a photographic film.

Non-filter recordings, amplifier parallel tests, dynamic range tests, and other periodic, quality-control instrument tests were performed prior to production work. Ambient noise levels and straight-gain recordings were taken daily to determine signal-to-noise ratios. Dynamic range determination tests of the DFS, PGC calibration check, instrument noise tests, and GAGC oscillator test were performed.

Instrument settings for production work were established initially after consultation with the client representative.

Direct-path, shot-to-detector energy provided data for locating the shot relative to the streamer. First-arrival signal was taken from selected streamer groups and fed to waterbreak amplifiers which respond to the frequency of waterborne acoustic energy. Waterbreaks appeared on traces 26 and 27 on monitors. No waterbreaks were recorded on tape by the PMR-20 recorder. Waterbreaks were recorded in the appropriate tape channels by the DFS.

Surveying - ONI was subcontracted to GSI to provide positioning from February 14 through March 15, 1966. Shoran, a direct distance measuring device, was the system used.

On May 25, Shoran operations were resumed at Esso's request in the Gippsland Basin. The Shoran was operated by the ONI crew then under contract to Esso. The GSI Raydist equipment and personnel stood by awaiting resumption of operations in other parts of Bass and Gippsland.

Raydist navigational equipment was operated in the two-range mode by GSI personnel. Initial calibration was made by crossing the baseline and baseline extension. This calibration was set into the instrument and carried to strategically located buoys and islands, which were then used for future calibrations. In addition, a surveyed calibration point was obtained on Middle Jetty, Stanley, Tasmania.

Navigation was accomplished by comparison of Raydist dial readings to predetermined coordinates.

Setback distance from the antenna to the shotpoint was normally about 3500 ft. for split-spread shooting and about 800 ft. for off-end shooting. Off-end shooting was approximately two group intervals from first group. Variations in setback distance were noted with the postplot coordinates.

After GSI Party 921 replaced GSI Party 904, the former encountered a positioning mistie. A check of the situation by GSI established that the Raydist calibration of the Stanley Jetty was in error. Apparently Party 904 had dropped a buoy as a calibration check point, and returning to the buoy after a storm, picked up the calibration and used this as reference for the Stanley Jetty calibration. A re-calibration of the Stanley Jetty showed that the buoy had probably been moved by the storm. The coordinates of lines affected by this error were subsequently re-calculated.

The occurrence of the error would indicate that Raydist calibration checks were not rigorous enough.

There was a considerable delay in obtaining shotpoint maps of the survey where the Raydist system was used, so that at imes processed sections were at hand prior to the required maps. GSI operated the Raydist survey gear and directly handled the pre and post plotting of shotpoint and boat position coordinates. A 1:250,000 boat position map was made on board the recording boat, and used mainly as a guide for stacking at the data processing center. The shotpoint maps for the interpretation came from the post plots calculated by IBM computer. A considerable number of errors arose in the computer processing, so that every run had to be carefully checked and erroneous values had to be re-computed.

Shooting - The survey was carried out as a single boat operation. Charges were fired by one of two floating, single-conductor firing lines located on either side of the streamer. The firing line used was determined by wind and sea conditions. Charges were suspended by strings attached to rings on the floating firing line and were fired at an average depth of six feet. The blaster, controlled by the PMR-20 recorded, detonated the charges. A time-break, recording time zero originating from the blaster, was recorded on FM tape channel 27. The timebreak produced a synthetic timebreak (timing work zero) to be recorded on digital tape. Charges were loaded at 2568-ft intervals for singlefold coverage and at 428-ft intervals for sixfold CDP coverage. The explosive used was nitro-carbo-nitrate in 25-lb and 50-lb canisters.

The wiggly trace monitor records in some of the survey showed considerable variation in energy level from shot to shot. It is thought that this was due to charges detonating at varying water depths, caused from a combination of swells and waves with the one boat floating firing line shooting technique. Another disadvantage of the one boat technique is that the charge size is limited to 50-lb which has proven to be inadequate in parts of the survey.

The recording and shooting cycle was determined by the ship's traverse between predetermined shotpoint intervals. This time interval was set into a master clock (an interval timer which zeros and resets automatically) which controlled the recording and shooting sequence. Changes in the ship's speed were compensated for at the master clock. The master clock, set into a Time Coordinator Unit, controlled an interval timer on the shooting platform and the recording sequence. It also controlled sequential counters in the instrument room and on the bridge, where the navigational equipment and the fathometers are located. Raydist dial or Shoran readings were taken at the shot instant. A relay controlled by the bridge counter caused a mark to be placed on the fathogram at the shot instant.

Two continuous-recording fathometers were available on the bridge. Only one instrument was used at any given time. Lead line checks were made periodically. At the beginning of each line, the fathogram was identified by date, line number, direction of shooting, and fathometer, transducer and depth scale in use. Every tenth shot was identified by shotpoint number.

APPENDIX B

PLAYBACK PROCEDURES

The analog processing was done by GSI at their Perth Playback Center. The equipment consisted of:

1. SIE MS-600 Series Tape Transport

2. SIE Model 606 4 Channel Magnetic Delay Line

3. Single Channel MAE Unit

4. SIE PL-600 Series Cross-Section Plotter

The computation of the T-delta-T curves required for applying the NMO corrections to the data was done by GSI mostly by a trial and error method. That is, if the velocity function with its corresponding T-delta-T curve indicated improper move out correction on a trial run of a singlefold section, then the residual moveout was computed and a corrected T-delta-T curve used to obtain an improved correction. This procedure worked reasonably well for the most part. Difficulties were experienced by GSI in areas of considerable reverberations and shallow basement reflections, in sorting out the events to be used for computation of proper NMO corrections. This, at times, resulted in several re-runs to obtain the proper NMO correction.

For processing sixfold CDP, the same procedure was followed to obtain the required T-delta-T curves from a singlefold presentation, and then using the T-delta-T curves thus established for the sixfold stack. As a further check on the validity of the stack, periodically four sets of six common depth point traces were extracted from the memory drum and plotted.

Both the final corrected singlefold and sixfold stacked tapes were MAE processed, which did a reasonably good job of removing water reverberations on most sections.

The final plotting was done on variable density film. GSI was supplied with a densitometer to help keep the neutral density of the developed film at a reasonable level. The only plotter scale available for the major portion of the survey was 7.5 inches/sec. so that the negatives had to be reduced photographically in Sydney to the required 3.75 inches/sec. A gear was finally obtained by GSI to provide the 3.75 inches/sec. scale. The signal to noise ratio of the plotter was barely at the 40-db level due to problems in the drive system. In an attempt to obtain the best processing available at the GSI center in Perth, numerous supervisory visits were made by Esso personnel.

APPENDIX C

LIST OF EQUIPMENT USED

1. FM Recording

(Reference group 1 nearest vessel)

Texas Instruments Model 8000 Amplifier System

a. Recording Settings

Ultimate sensitivity	full
Initial attenuation	76 db
AGC expansion	30 db/sec
Filters	

Type	Frequency	Slope
High-cut	92 cps	18 db/oct
Low-cut	OUT	

b. Playback Settings to VAX camera

Gain	straight
Filters	

Type	Frequency	Slope
High-cut	40 cps	18 db/oct
Low-cut	14 cps	18 db/oct

SIE PMR-20 Magnetic Recorder

Head 1 - 12	Seismic traces 1 - 12
13	Noise cancelling
14	Timing signal (100 cps from PMR-20 fork)
15 - 26	Seismic traces 13 - 24
27	Timebreak
28	Not used
Modulators	Model TRM-1
Demodulators	Model TRD-1

SIE TRO-6A Photo-Oscillograph

Galvo 1-24	Seismic traces 1-24
25	Timebreak
26, 27	Waterbreaks (monitor only)
28	100 cps from PMR-20 on monitor 100 cps from tape on playback
Paper width	2-1/2 in.
Paper speed	5.932 ips
Record length	5 sec
Timing lines	Timing line generator

Waterbreak Amplifiers

Amplifier	Streamer Group	Trace
1	1	26
2	5	26
3	9,10	26
4	16,15	27
5	20	27
6	24	27

Note: Trace 25 was positioned between traces 26 and 27. Selected streamer groups used for waterbreaks are noted on observer's logs.

Variable-Area Cross-Section Recorder (VAX)

Type A, Mark II, Aeronautical and General Instruments Ltd.

Amplifier Output	VAX Galvo	VAX Trace
1 - 24	1 - 24	1 - 24

2. Dual Recording SP's 7546-9611

(Reference group 24 nearest vessel)

Texas Instruments Series 9000 Amplifier System

a. Recording Settings

Initial Gain. 40 db
GAGC * 40 db/sec (80 db/sec)

Filters

Type	Frequency	Slope
High-cut	112 cps	24 db/oct
Low-cut	OUT	

*Available switches from GAGC amplifiers 4, 8, 16, 20 to 5, 9, 15, 19, respectively, if necessary.

b. Playback Settings to VAX camera

Gain straight

Filters

Type	Frequency	Slope
High-cut	50 cps	24 db/oct
Low-cut	18 cps	24 db/oct

SIE PMR-20 Magnetic Recorder

Head 1-12	Seismic traces 1 - 12
13	Noise cancelling
14	100 cps from PMR-20 fork
15 - 26	Seismic traces 13 - 24
27	Timebreak
28	Not used

Texas Instruments Digital Field System

Streamer group 1 - 24	DFS channel 1 - 24
Waterbreak Group	DFS channel
1	25
5	26
20	27
24	28
10	29
15	31

DFS channel 30 Gain Recovery voltage

SIE TRO-6A Photo-Oscillograph (FM system)

Galvo 1 - 24	Seismic traces 1-24
25	Timebreak
26, 27	Waterbreak traces (monitor only)
28	100 cps from PMR-20 on monitor 100 cps from tape on playback

Paper width	2-1/2 in.
Paper speed	5.932 ips
Record length	5 sec
Timing Lines	Timing line generator

SIE TRO-6A Photo-Oscillograph (Digital System)

Galvo 1 - 24	Seismic traces 1 - 24
25	Gain recovery voltage
26, 27	Waterbreak traces
28	100 cps external fork
Timing lines	Monitor, DFS clock pulse Playback, DFS clock pulse
Paper width	6 inc.
Paper speed	9.454 ips (6.769 ips)
Record length	5.23 sec
Timebreak	Monitor True TB on tr 4 Timing word zero (TWO) on tr 8 Playback TWO on tr 8

Texas Instruments DFS Waterbreak Amplifiers

Amplifier	Streamer Group	Trace
1	1	26
2	5	26.
3	10	26
4	15	27
5	20	27
6	24	27

Variable-Area Cross-Section Recorder (VAX)

Amplifier Output	VAX Galvo	VAX Trace
1 - 24	24 - 1	24 - 1

Marconi Marine Recording Echometer

Scale	Range
A	0 - 60 fm
B	50 - 110 fm
C	0 - 240 fm
D	200 - 440 fm

Only scales A and C mark a zero depth on the fathogram

TYPICAL SPREAD DETAILS

Type	24-group, neutrally buoyant
Length	Center group 1 to center group 24 - 4922 ft
Group interval	214 ft
Interval between groups 12 and 13	214 ft
Length live section	100 ft
Length dead section	114 ft
Type detector	Crystal
Detectors per group	20
Detector interval	4-3/4 ft

Depth of fathometer transducer below mean waterline

Forward Transducer	7 ft
Aft Transducer	13 ft

Distance from Raydist antenna to shotpoint

Sixfold off-end	800 ft
Singlefold split	3500 ft

(Variations for specific shotpoints given in detail with data transmitted to Central Processing Office)

Charge Size	25 lb, 50 lb
Average shot depth	6 ft
Average shot offset	20 ft
Average detector depth	35 ft

APPENDIX D

POSITIONING SYSTEMS

DM Raydist - This is a direct ranging system using the phase comparison principle. Two base stations and a mobile station provide a two-way fix. Raydist measures the relative phase between two continuous wave radio transmitters by comparing the phase of the output of two receivers on the mobile unit. One receiver is tuned to pick up the audio beat between two hetrodyning transmitters, and the other receiver picks up a return link from the beach. This return link is a transmitter modulated by the same audio tone - the boat between the two hetrodyning transmitters. Out of one receiver on the boat there is a phase change every wavelength of RF, and out of the link receiver there is the unchanging phase of the modulated wave from the link transmitter.

One of the hetrodyning transmitters is on the boat. To keep from blocking the hetrodyning receiver on boat, it is necessary to operate on harmonically related frequencies. The transmitters operate on frequencies bearing the relationship of F and 2F plus A, where A is the hetrodyne or audio difference. This is 400 cycles/sec. This requires a special receiver; one side to pick up F and multiply by two, the other side to pick the 2F plus A, mix the two and generate the audio tone. (Refer to Plate D(a)-1, Basic Elements of the DM System.)

The Red station has one of the hetrodyning transmitters, a link transmitter and a receiver. The receiver picks the 2F plus A from the boat, and the F from the local transmitter. The output of the receiver modulates the Red link transmitter.

The Green station has one receiver and a link transmitter. The receiver picks up the F from the Red station, and the 2F plus A from the mobile station. The output of this receiver modulates the Green link transmitter.

The mobile unit carries the other hetrodyning transmitter that transmits 2F plus A. It has a receiver that picks up the F from the Red station, and the 2F plus A from the local transmitter. The output of this receiver is phase-compared to the output of the Red link receiver to give Red range and the output of the receiver is likewise compared to the output of the Green link receiver to give Green range.

Red and Green range are presented as mechanical revolution on a dial. An odometer is attached to keep a total count; a strip chart recorder keeps permanent record of the lanes traversed.

The Red station was located on Wilsons Promontory,

440 183 yd E
1177 142 yd N.

Green stations were located at Flinders Island,

573 122 yd E
1099 996 yd N

and at Stanley, Tasmania,

332 319 yd E
983 524 yd N.

The field charts and base station coordinates were based on the Australian Transverse Mercator, Clarke 1858 Spheroid, Belt 7, Central Meridian 146° East.

The Shoran Radiopositioning System - The shoran system is a radar transponder type of radiopositioning system. The Shoran mobile station equipment measures the distance from its location to those of two fixed ground beacon stations. The position of the mobile unit is thus fixed at the intersection of the two circular distance or range arcs so determined. The position of the ground beacon stations or base stations is normally accurately known, so that the corresponding position of the mobile station can be accurately computed or determined by graphical methods. Should the position coordinates of the base stations not be accurately known, the mobile station may still be positioned relative to the baseline determined by the base station locations.

The Shoran mobile unit measures the distances of the two base stations by measuring the time required for pulses of radio signals to travel from the mobile station to each base station and return. The time intervals so measured are related to the corresponding distances by using the highly constant velocity characteristic of radio waves in air through the simple relationship.

Total distance covered = Elapsed time x velocity.

Because of this relationship, it is possible to graduate the indicating dials in the mobile unit in terms of distance rather than elapsed time. The Shoran dials are graduated in terms of statute miles rather than nautical miles.

The basic equipment units used to create the round-trip signal paths originating and terminating at the mobile station are shown in figure D(b)-1. This equipment consists of a signal source (labeled pulse generator in figure D(b)-1), a transmitter, receiver and indicator unit comprising the mobile station, and a receiver coupled to a transmitter at each base station.

Pulse signals originating at the mobile station are radiated from the mobile transmitter and received by one of the base stations. At this base station, the pulse is sent from the output of the receiver to the input of the transmitter, and is then retransmitted back to the mobile station. After passing through the mobile receiver, the pulse is routed to an indicating circuit where its time lag, or lapse, with respect to the original outgoing pulse is determined, and indicated in terms of distance rather than units of time.

Other pulses are transmitted to the second base station, using a different radio frequency to permit their discrimination from those intended for the first base station. These pulses are received and retransmitted by the second base station, and on their return to the mobile station are similarly sent though the indicating circuits for measurement of the time required for their round trip and the indication of corresponding distance. Thus the equipment provides continuous, essentially simultaneous, indications of the distances to both base stations.

The Shoran system operates in the VHF/UHF portion of the radio spectrum. Normally, three separate frequencies are used. Two of these are transmitted alternately by the mobile station to interrogate each base station in turn, as previously described. The third frequency is utilized by the base stations to retransmit the received pulses back to the mobile station. Both base stations transmit on the single frequency in order to utilize a single receiver at the mobile station.

The propagation characteristics of VHF/UHF radio signals is such that they tend to travel in straight lines. While they are refracted in the atmosphere to some small extent, they do not tend to follow the earth's curvature as do radio signals of considerable lower frequency. They lack the ability to "see" beyond the radio horizon. Thus the Shoran system is essentially a "line of sight" system, with the maximum range being limited, to a large extent, by the heights of the mobile and base station antennas.

The instrumental accuracy of the Shoran equipment, when properly calibrated, is ± 50-75 feet on a single range. The overall position accuracy is related

to the range accuracy by the angle of intersection, at the mobile station, between the two Shoran range circles. This is illustrated in Figure D(b)-2. In normal geophysical operations, this angle of intersection is held between 30 and 150 degrees. Refer to Figure D(b)-4 for examples of areas of coverage for different angles of intersection of the Shoran range circles.

In computing (or determining graphically) the position from a pair of Shoran ranges, cognizance must be maintained that a position ambiguity may exist. Each pair of ranges (one to each base station) actually determines two independent positions, one on each side of the Shoran baseline, as illustrated in Figure D(b)-3. One position is the "mirror image", so to speak, of the other. Further, the Shoran mileage dials repeat every 100 miles of range. To eliminate this ambiguity one must know, from other means, the correct side of the baseline and the distance to each base station within the proper multiple of 100 miles.

AREA OF OPERATION

The area surveyed extended approximately 40 miles into the Tasman Sea off the southeast coast of Australia. It was bounded by the town of Sea Spray on the south and Conran Point on the northeast. (Plat 1)

The initial program assigned by the client consisted of approximately 250 miles of seismic lines distributed over the program area in a manner designed to detail previous surveys of the area.

Mapping and Basic Control - Coordinates for the Shoran base station locations were obtained from the Department of Lands and Surveys, Melbourne, Victoria, Australia. The final map was based on the Australian Transverse Mercator Projection, Belt 7 Central Meridian 146° West.

Following is a list of the Shoran base stations along with their coordinates and descriptions:

701 Mount Elizabeth (Plat 2)

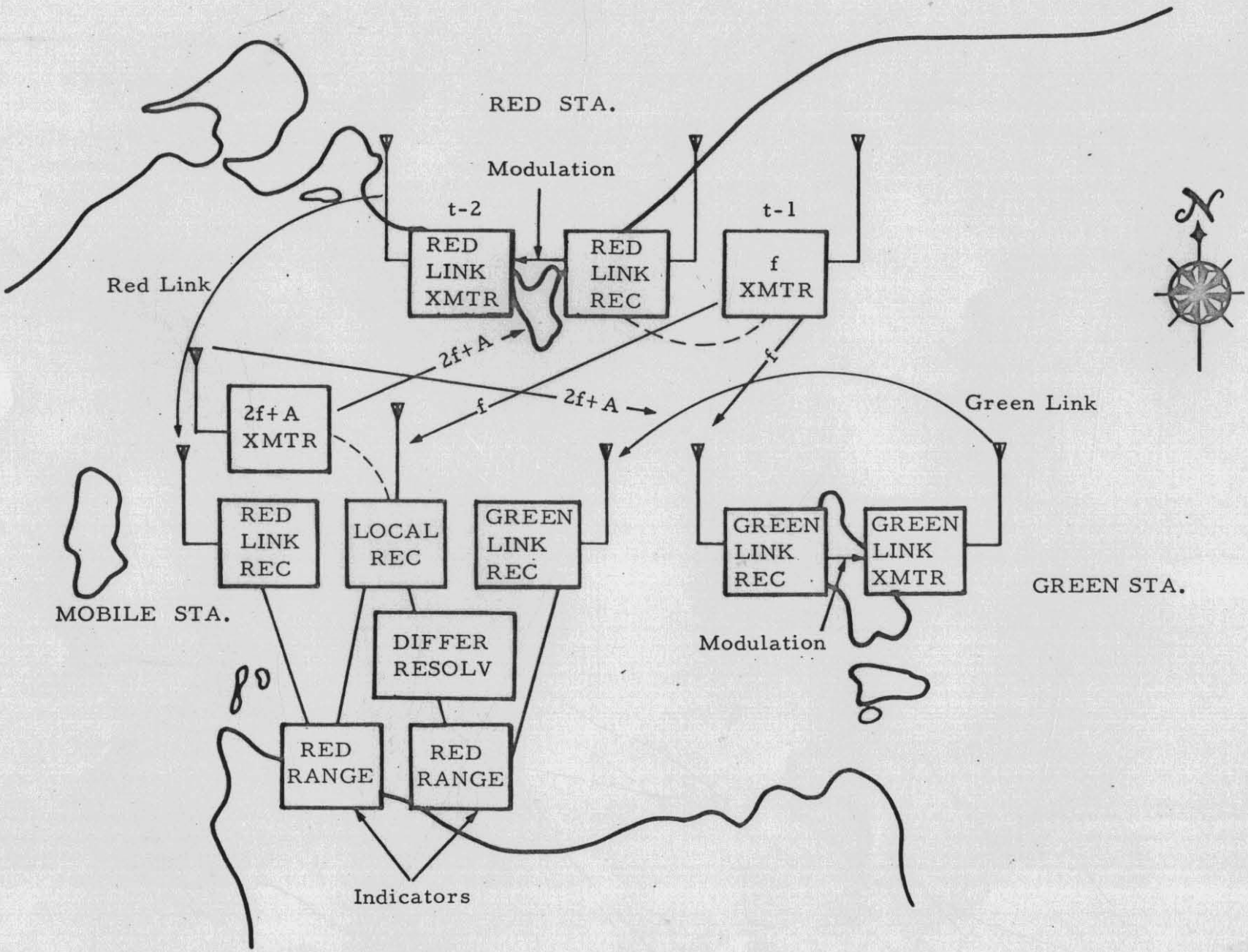
Longitude	147°55'55".408	E	586,877.50 yards
Latitude	37°29'27".199	N	374,498.06 yards
Elevation	3085 feet		

731 Blackwarry (Plat 4)

Longitude	146°38'55".650	E	461,979 yards
Latitude	38°24'16".200	N	265,299 yards
Elevation	2100 feet		

728 Mount Raymond (Plat 3)

Longitude	148°36'01".791	E	650,793 yards
Latitude	37°42'48".852	N	345,904 yards
Elevation	975 feet		

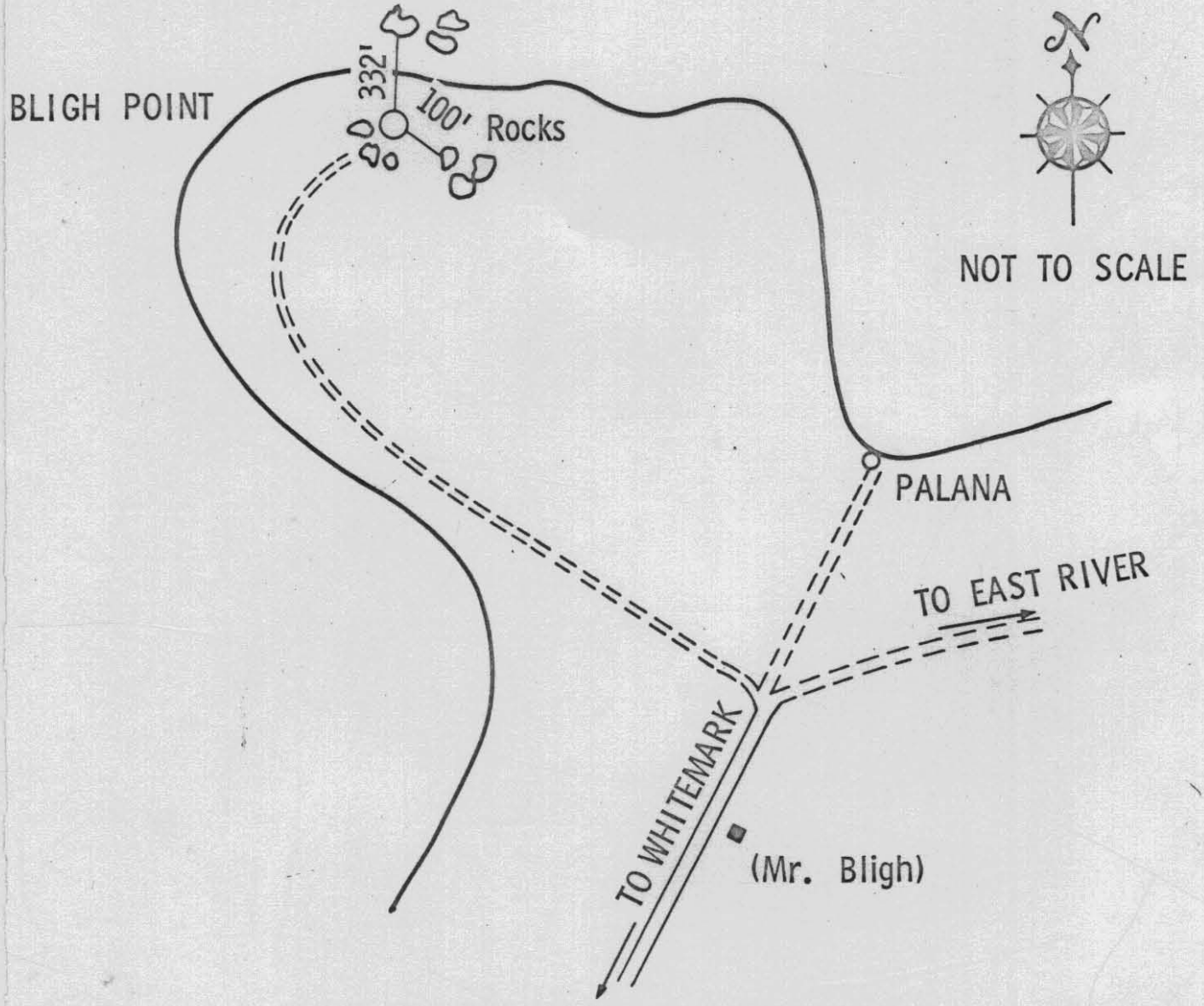


BASIC ELEMENTS TYPE DM RAYDIST SYSTEM

PLATE D(a)-1

0530254

Station Co-ords: 573 122 yd E
1099 996 yd N



At Track junction take left-hand fork and follow this track approximately 3½ mi to the end. Station is situated adjacent to some rocks.

Station is marked by a G.I. pipe 6 in. high.

Contact Mr. Bligh
C/o P.O.
Whitemark, Flinders Island

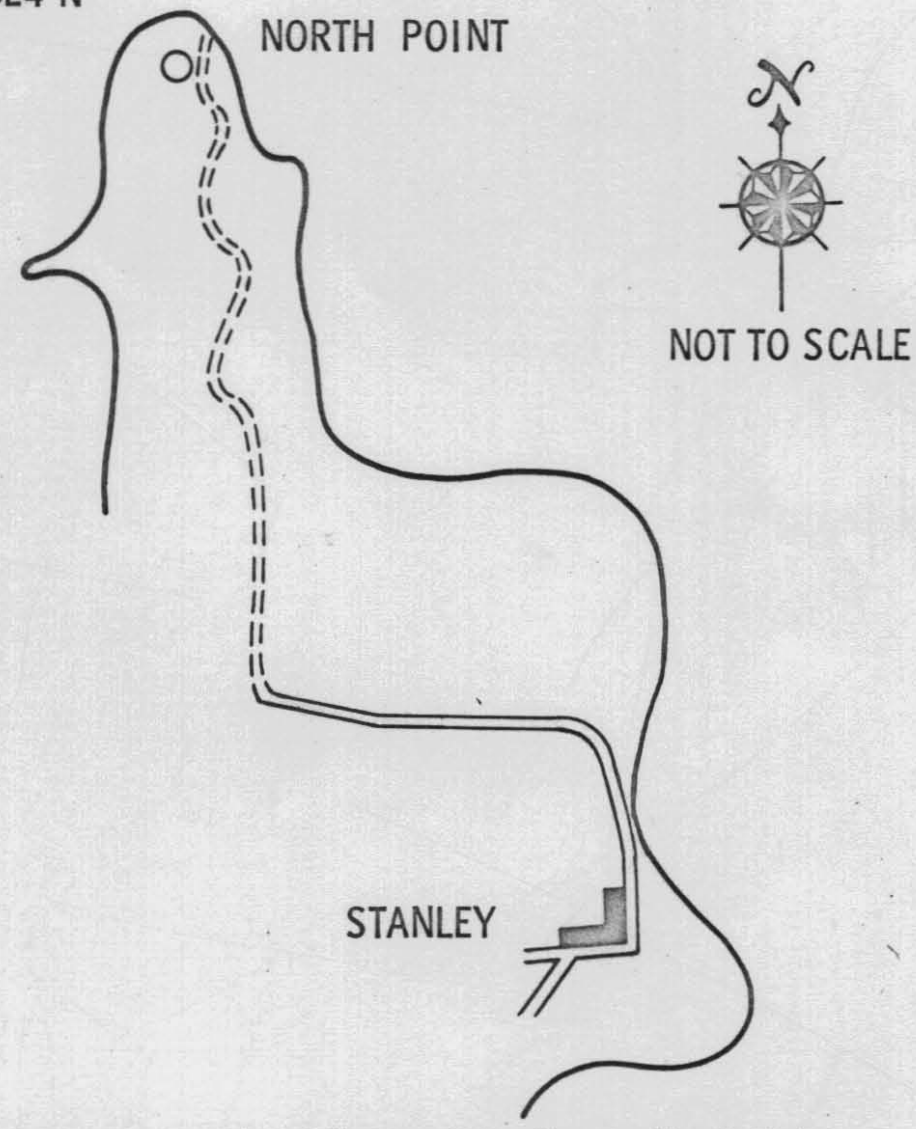
REFER TO TASMANIA 1:250,000 Sheet No. 2

ACCESS DIAGRAM TO RAYDIST STATION "FLINDERS ISLAND" AT BLIGH PT., FLINDERS ISLAND.

PLATE D(a)-2

053026

Station Co-ords: 332319 E
983524 N



Station is situated on the western side of the track leading to North Point.

It is marked by two cement-filled 5-gal drums which are sunk 3/4 of their depth into the ground.

The station is on the property of the Van Dieman Land Co. and Company permission should be obtained before using the station.

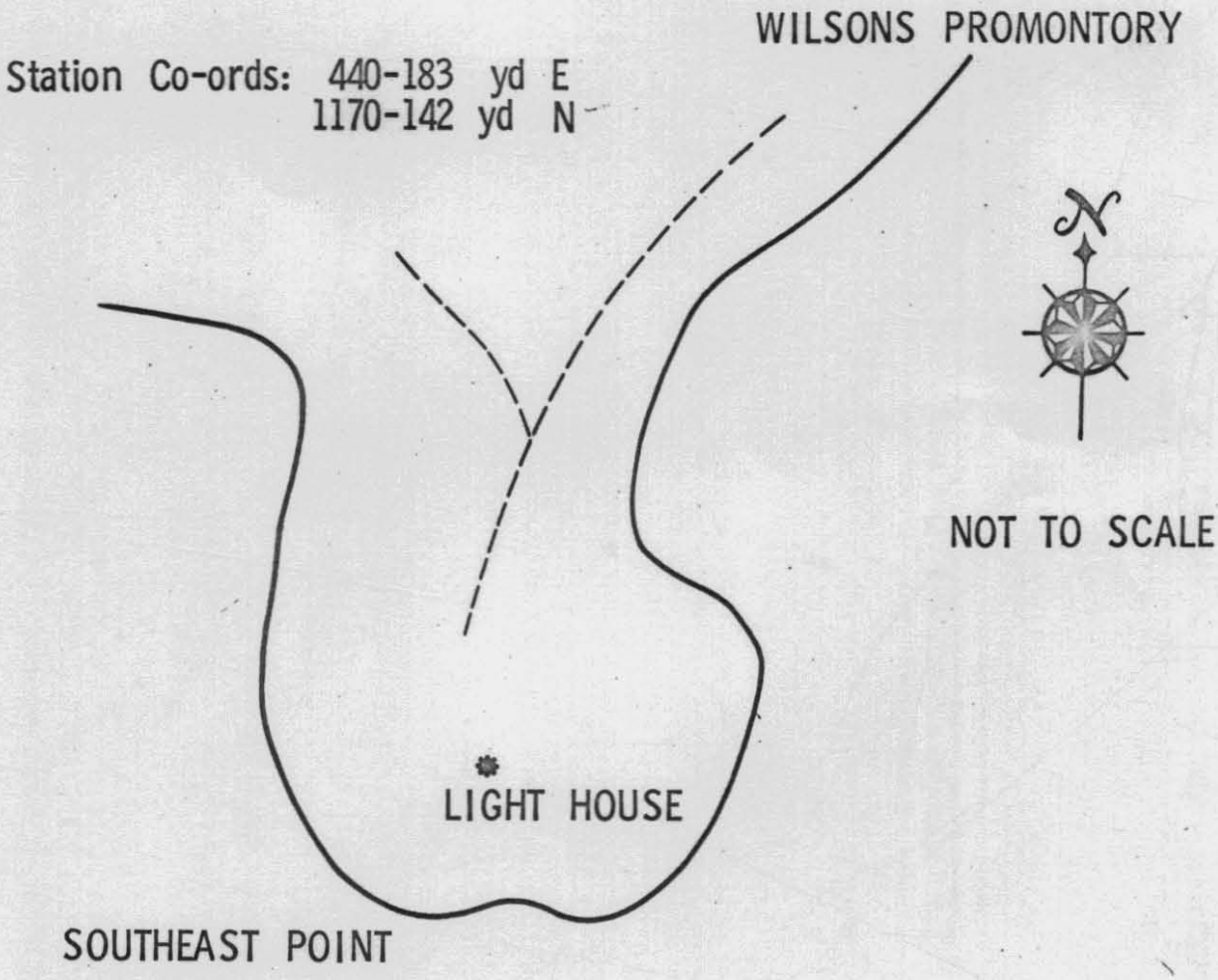
Contact Mr. R. L. Hyland (Co. attorney)
V. D. L. Co.
Burnie, Tasmania

REFER TO TASMANIA 1:250,000 Sheet No. 1

ACCESS DIAGRAM TO RAYDIST STATION "STANLEY" AT NORTH POINT, TASMANIA.

PLATE D(a) - 3

053027

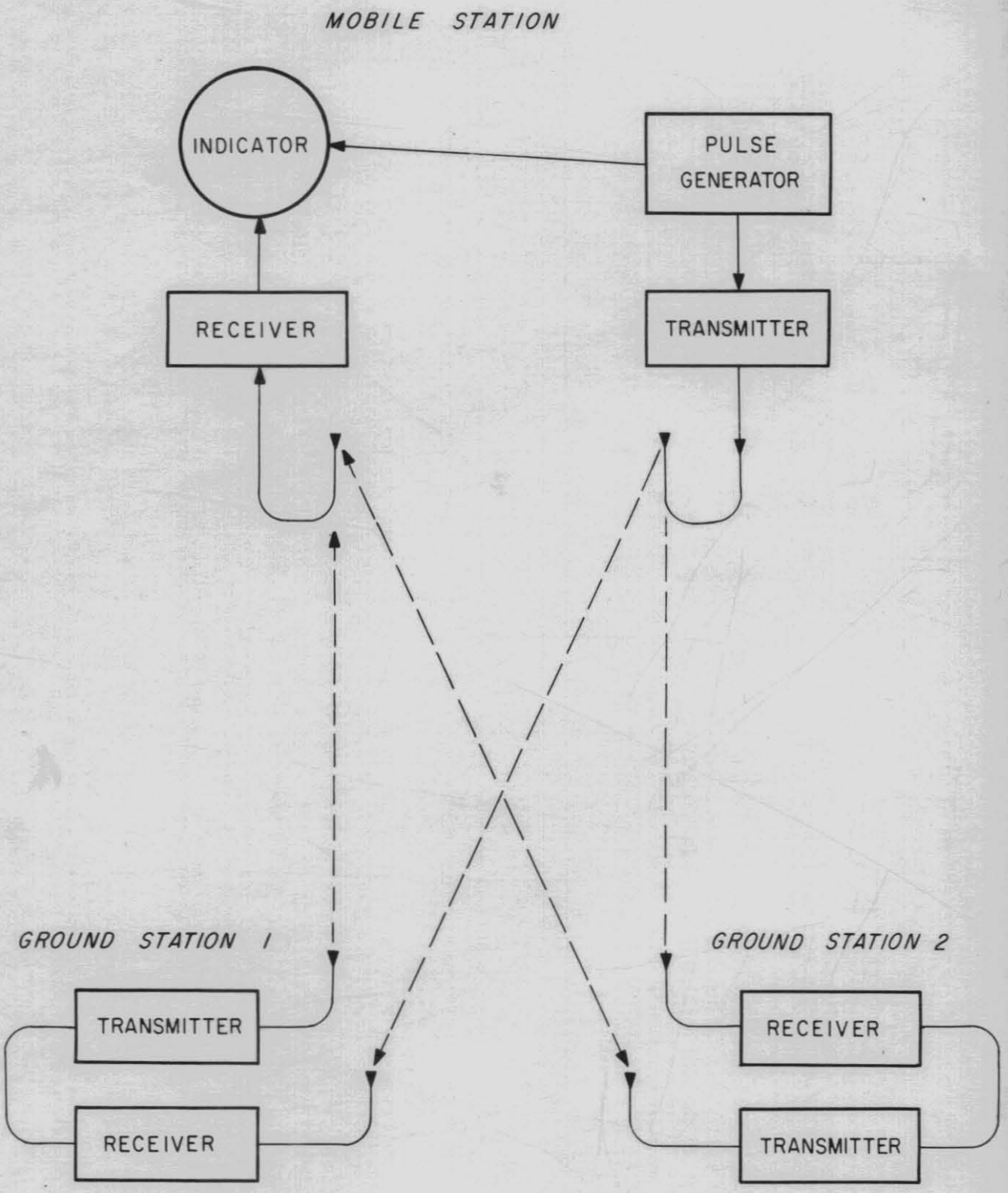


This station is situated at the lighthouse on Southeast Point in Wilsons Promontory National Park, the Raydist antenna being suspended from the western side of the tower. There is no vehicular access to this station. Equipment and supplies may be taken by boat obtainable from Port Albert. Permission to use site obtainable from Regional Director
Dept. Shipping & Transport
P. O. Box 4317
Melbourne, Vic.

REFER TO WARRAGUL 1:253440 J 55/10-11.

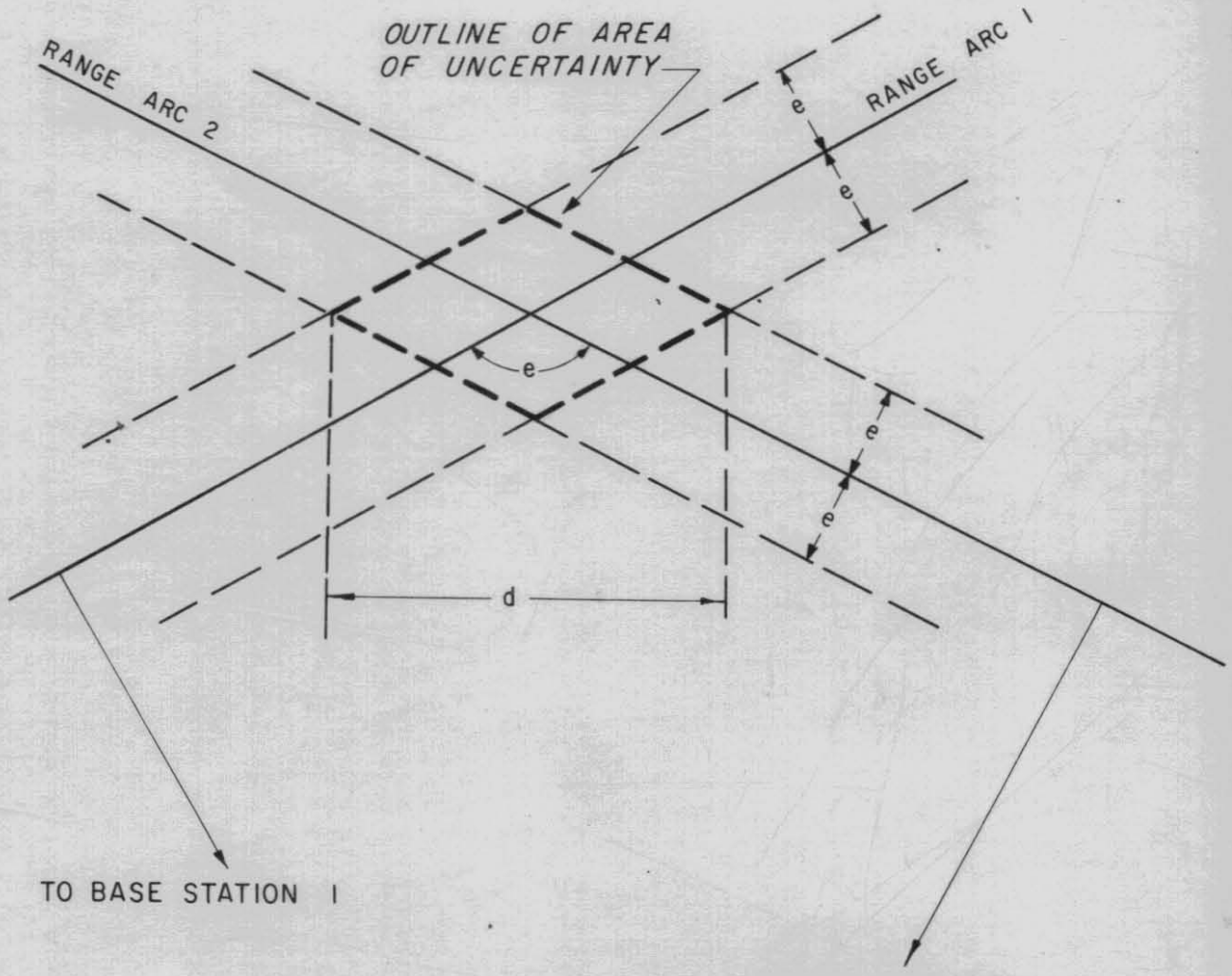
ACCESS DIAGRAM TO RAYDIST STATION "WILSONS PROMONTORY" AT SOUTHEAST POINT.

PLATE D(a)-4



SIMPLIFIED BLOCK DIAGRAM OF BASIC RADIO EQUIPMENT OF A SHORAN SYSTEM.

FIGURE D(b)-1



$$d = \frac{2e}{\sin \frac{\theta}{2}}$$

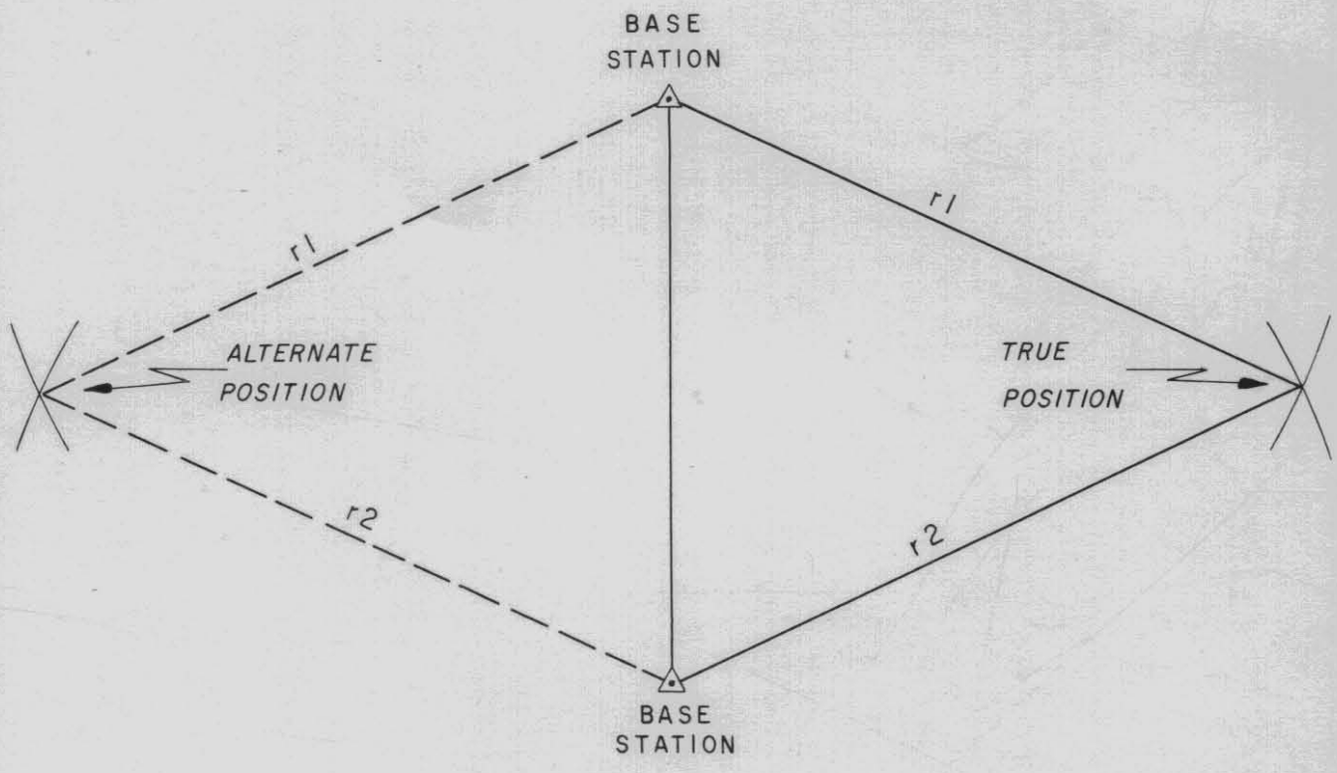
e = RANGE ERROR

θ = ANGLE OF INTERSECTION OF RANGE CIRCLES

5 cm

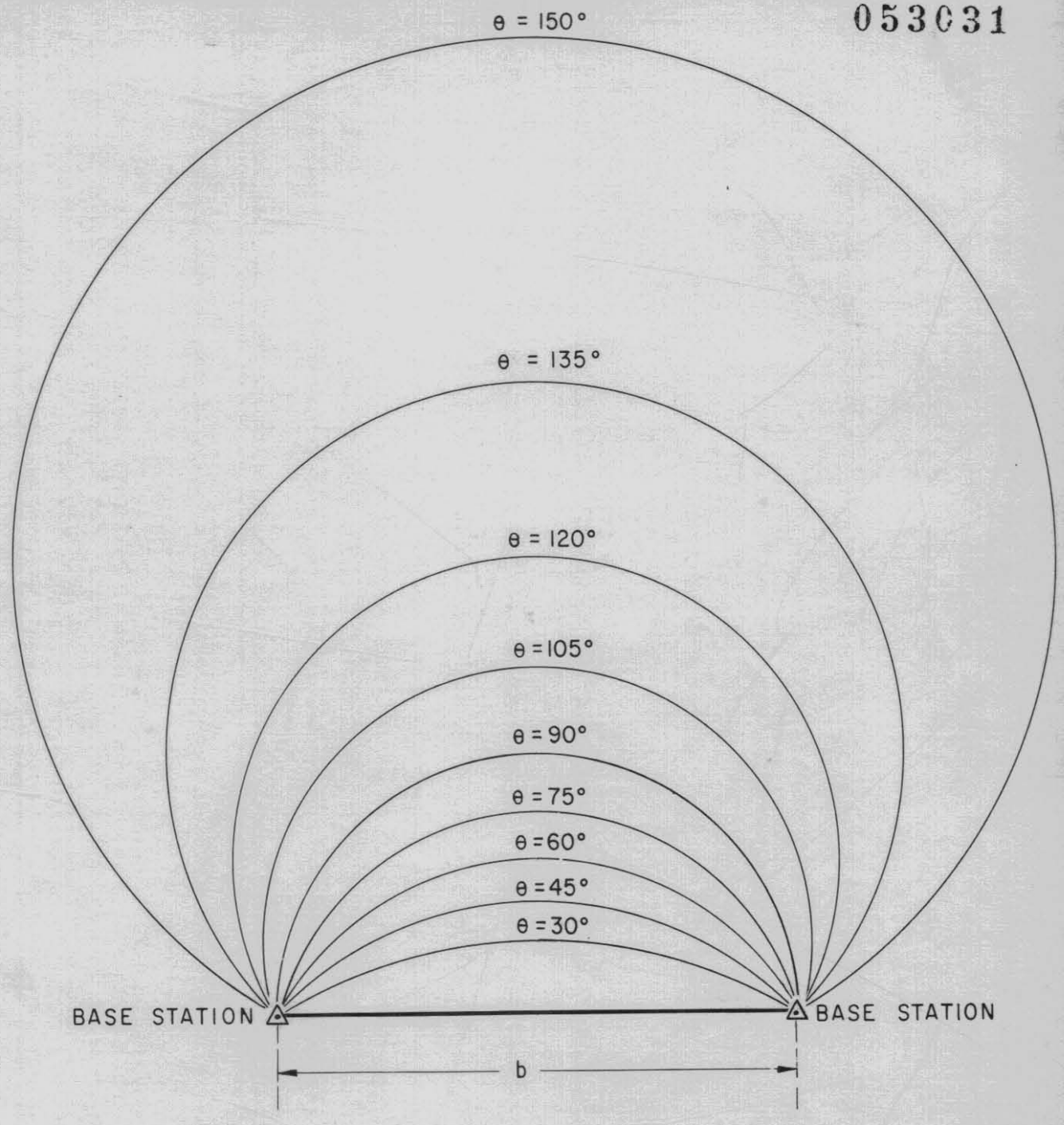
AREA OF UNCERTAINTY OF POSITION DUE TO ERROR IN RANGE MEASUREMENT.

FIGURE D(b)-2



POSITION AMBIGUITY IN CIRCULAR RANGE SYSTEM

FIGURE D(b)-3



ALL ARCS ARE PORTIONS OF CIRCLES THROUGH BASE STATION POSITIONS OF RADIUS GIVEN BY:–

$$r = \frac{b}{2 \sin \theta}$$

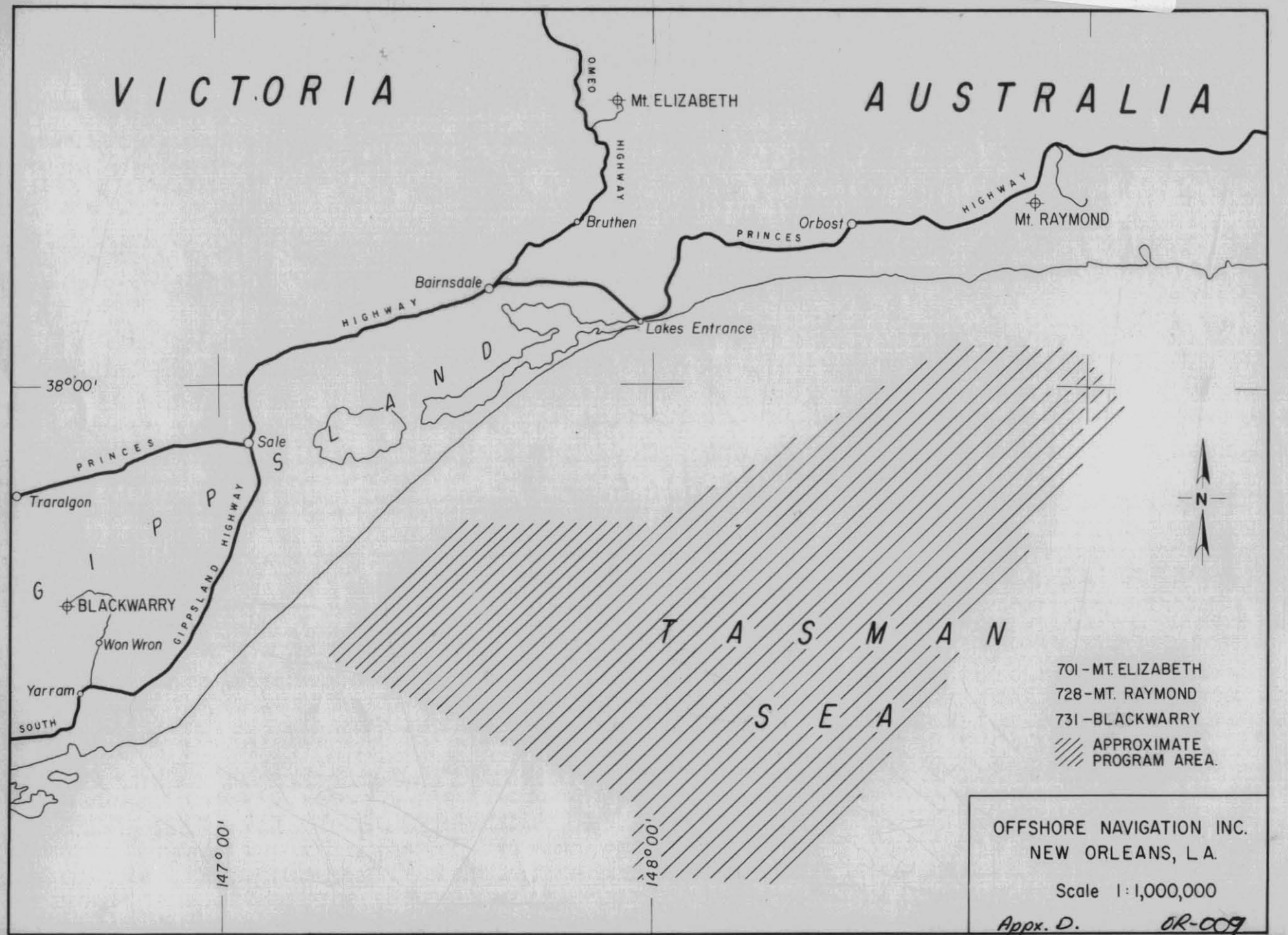
WHERE θ IS ANGLE OF INTERSECTION BETWEEN RANGE CIRCLES.

5 cm

RELATIVE AREA OF COVERAGE, CIRCULAR RANGING SYSTEM

FIGURE D(b)-4

053032



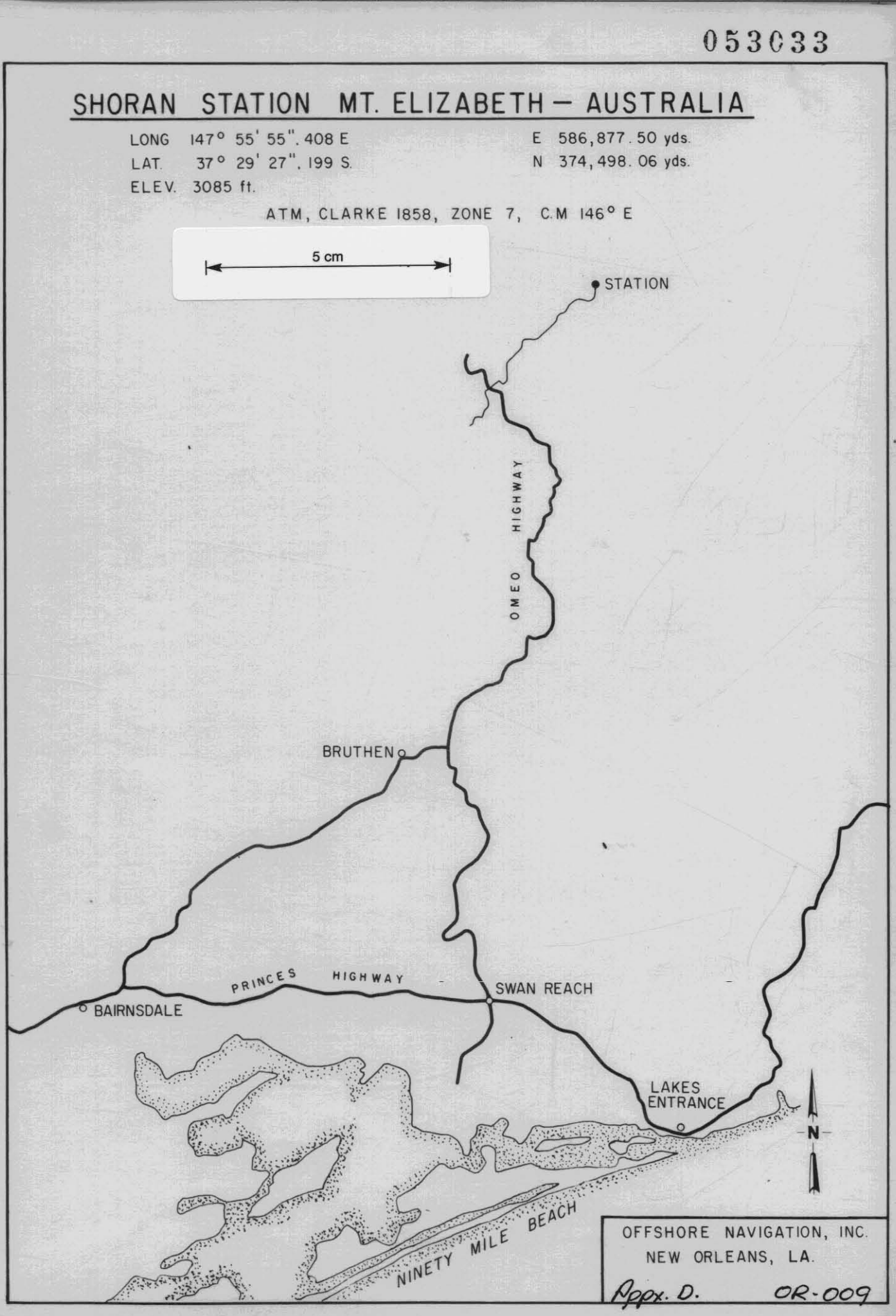
PLAT. 1

SHORAN STATION MT. ELIZABETH — AUSTRALIA

LONG 147° 55' 55". 408 E
LAT. 37° 29' 27". 199 S.
ELEV. 3085 ft.

E 586,877.50 yds.
N 374,498.06 yds.

ATM, CLARKE 1858, ZONE 7, C.M 146° E



OFFSHORE NAVIGATION, INC.
NEW ORLEANS, LA.

Appx. D. OR-009

PLAT. 2

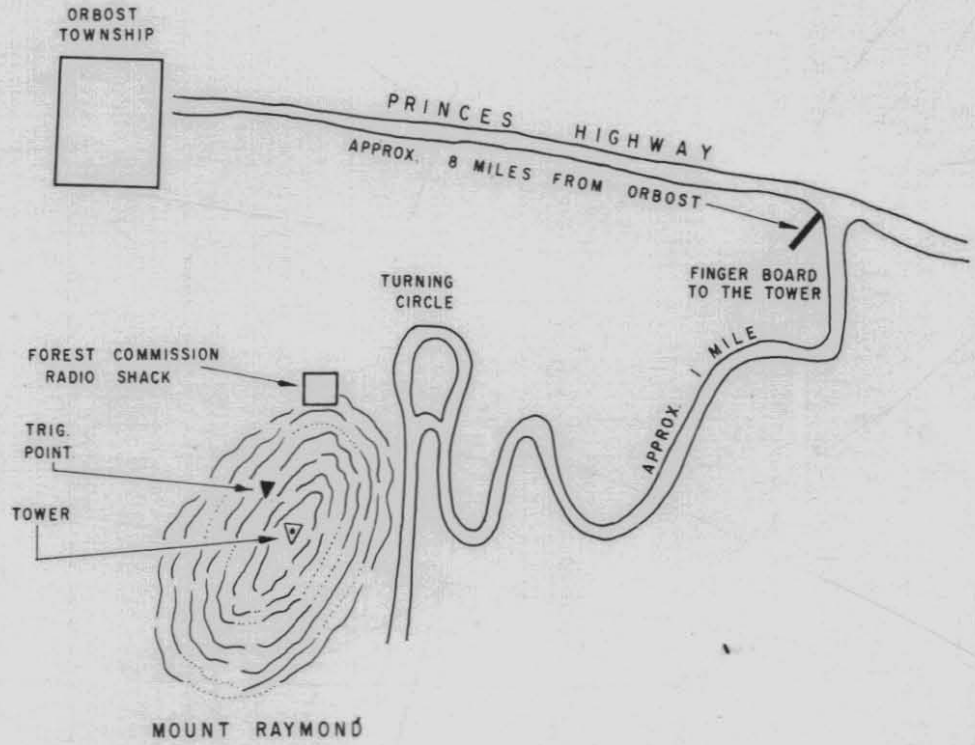
053034

SHORAN STATION 728 (MT. RAYMOND) — AUSTRALIA

LONG. 148° 36' 01".791 E
LAT. 37° 42' 48".852 S
ELEV. 975 ft.

E 650,793 yds.
N 345,904 yds.

AUSTRALIAN T.M., BELT 7, C.M. 146° E



5 cm

OFFSHORE NAVIGATION, INC.
NEW ORLEANS, LA.

Appx D. OR-009

PLAT. 3

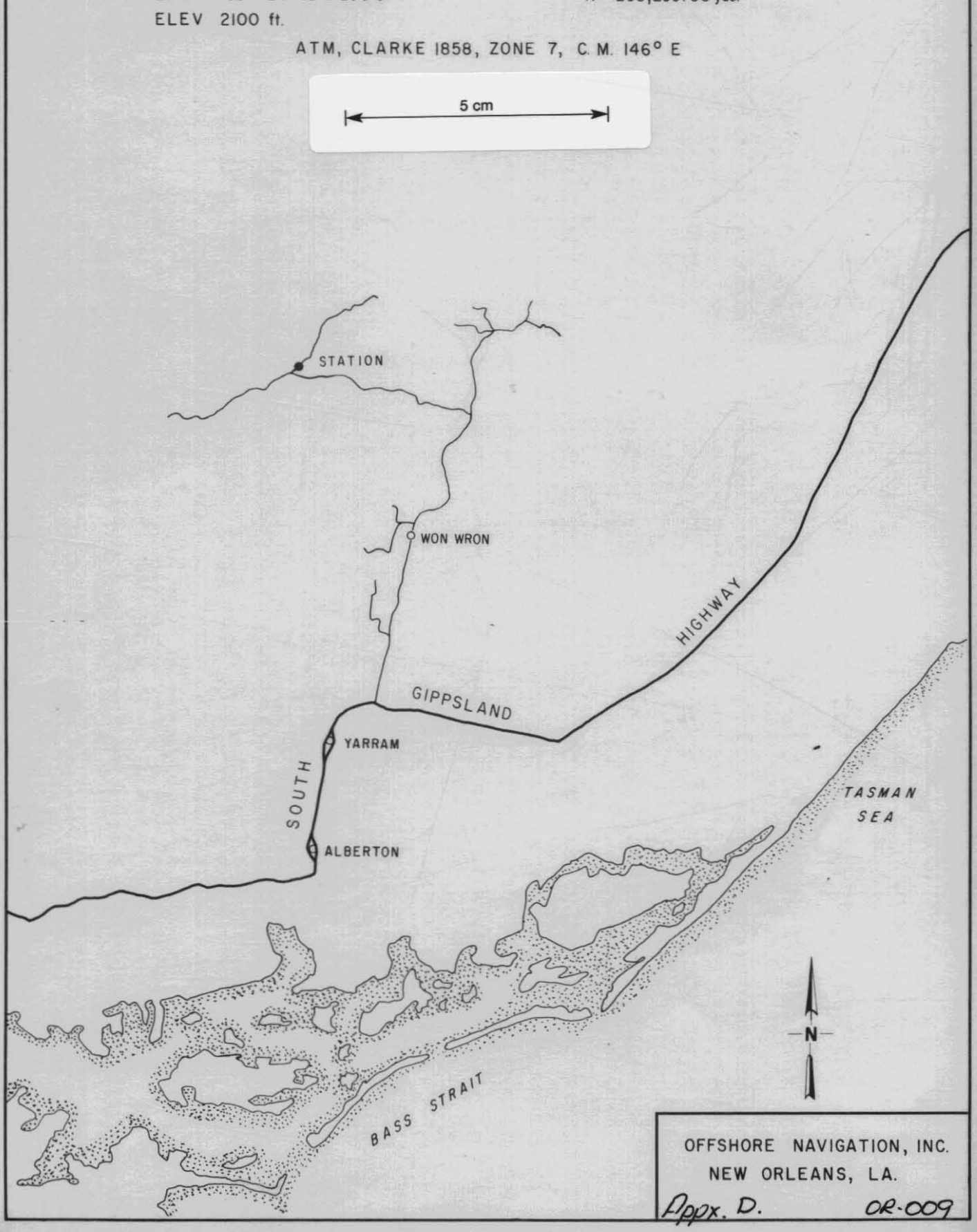
053035

SHORAN STATION BLACKWARRY - AUSTRALIA

LONG. 146° 38' 55". 650 E
LAT. 38° 24' 16". 200 S
ELEV 2100 ft.

E 461,979.00 yds.
N 265,299.00 yds.

ATM, CLARKE 1858, ZONE 7, C.M. 146° E



OFFSHORE NAVIGATION, INC.
NEW ORLEANS, LA.
Appx. D. OR-009

PLAT. 4

APPENDIX E

SURVEY STATISTICS

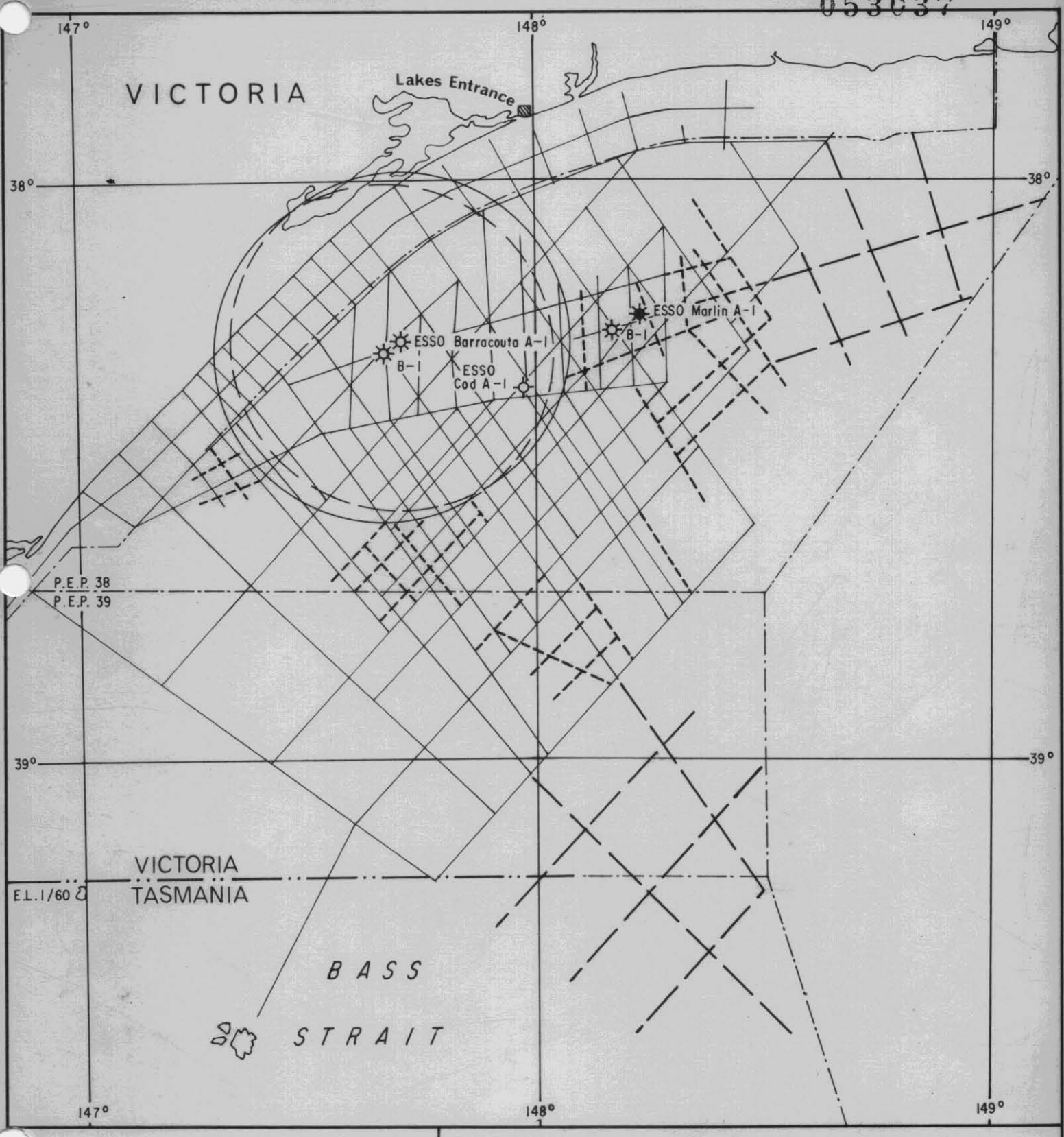
Client	Esso Exploration and Production Australia Inc.	
GSI Parties	904 and 921	
Area of Survey	Gippsland and Bass Basin (Victoria and Tasmania)	
Date Commenced	(904) February 14, 1966 (921) June 15, 1966	
Date Finished	(904) June 9, 1966 (921) October 14, 1966	
Shotpoint Spacing	Sixfold CDP, 428 ft Singlefold, 2658 ft	
Total Miles	2713.57	
Reshooting Miles	483.30	
Chargeable Miles	2230.27	
Bass Victoria	600 percent CDP	20.46
	Singlefold	116.28
Gippsland Victoria	600 percent CDP	392.28
	Singlefold	215.90
Bass Tasmania	600 percent CDP	396.55
	Singlefold	1009.10
Gippsland Tasmania	600 percent CDP	
	Singlefold	79.70
Total		2230.27

Explosives (Nitro-Carbo-Nitrate)

	Powder	Caps	Boosters
Bass Victoria	31,250 lb	597	590
Gippsland Victoria	242,032 lb	4,783	4,773
Bass Tasmania	362,500 lb	7,718	7,688
Gippsland Tasmania	10,600 lb	216	216
Total	900,375 lb	18,331	18,277

Elapsed Days on prospects	237
Production Days	97-1/2
Non-Production Days	142-1/2
Weather	102-1/2
Travel	8
Ship Repair	1
In Port	19
Calibration	6
Seismic Instruments	0
Navigation	4
Tests	2

053037



Previous seismic control

Completed C D P program

Completed single fold program

5 cm

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

GIPPSLAND BASIN
COMPLETED PROGRAM FOR EASTERN BASS STRAIT MARINE SEISMIC SURVEY

MARCH 1967

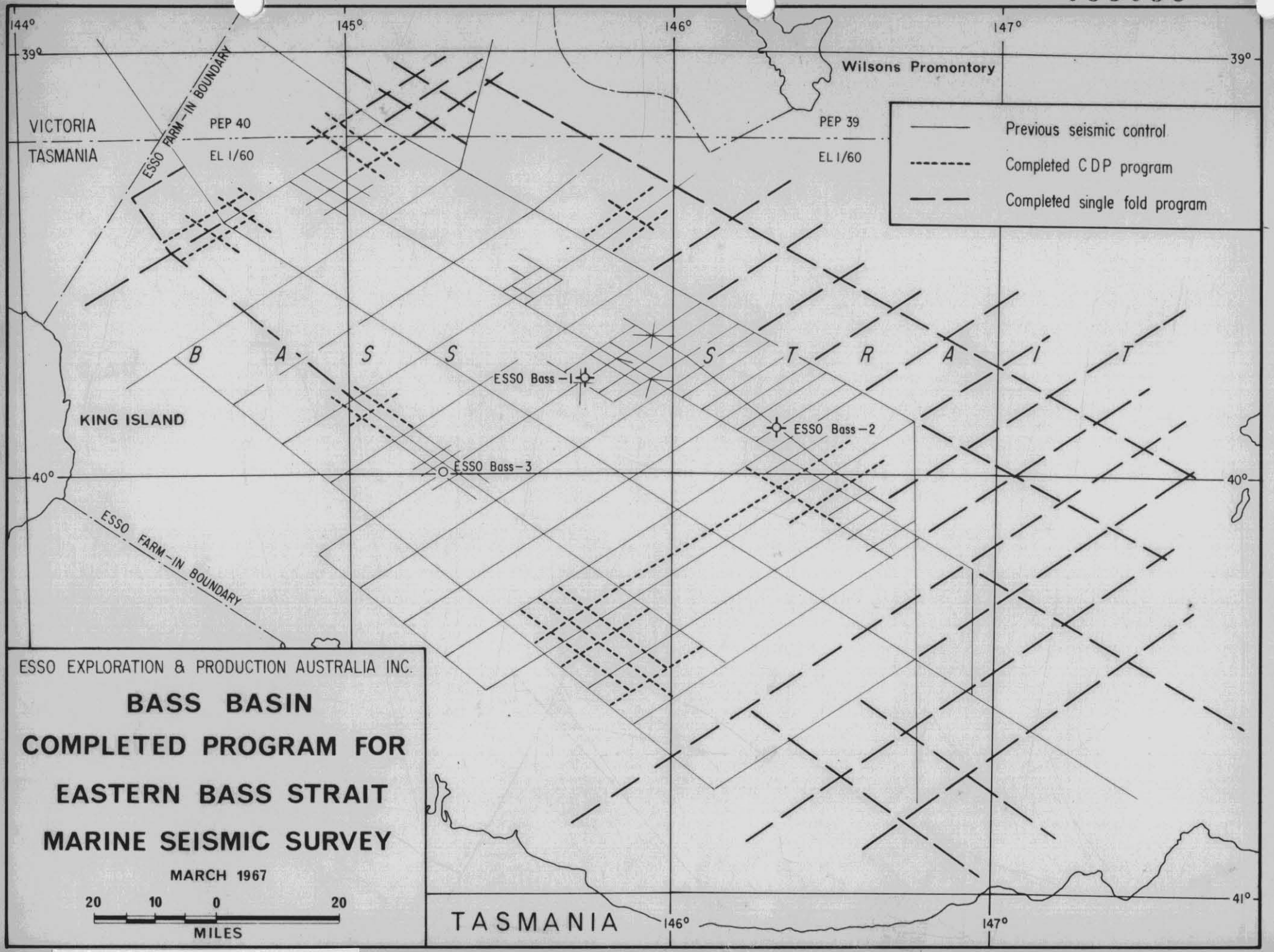
20 10 0 20

MILES

OR-009

FIGURE 1

053038



OR-009

FIGURE 2

053039

SCHEMATIC SKETCH OF CONTOURED HORIZONS - ILLUSTRATIVE PURPOSES ONLY.
GIPPSLAND BASIN

A. FULL LINES REPRESENT CONTOURED HORIZONS AND THE GENERAL BASINWARD EXTENT TO WHICH THEY CAN BE RELIABLY FOLLOWED.

B. DASHED LINES REPRESENT INTERPRETATION OF GENERALISED REGIONAL TRENDS WHICH ARE NOT CAPABLE OF SPECIFIC SEISMIC MAPPING.

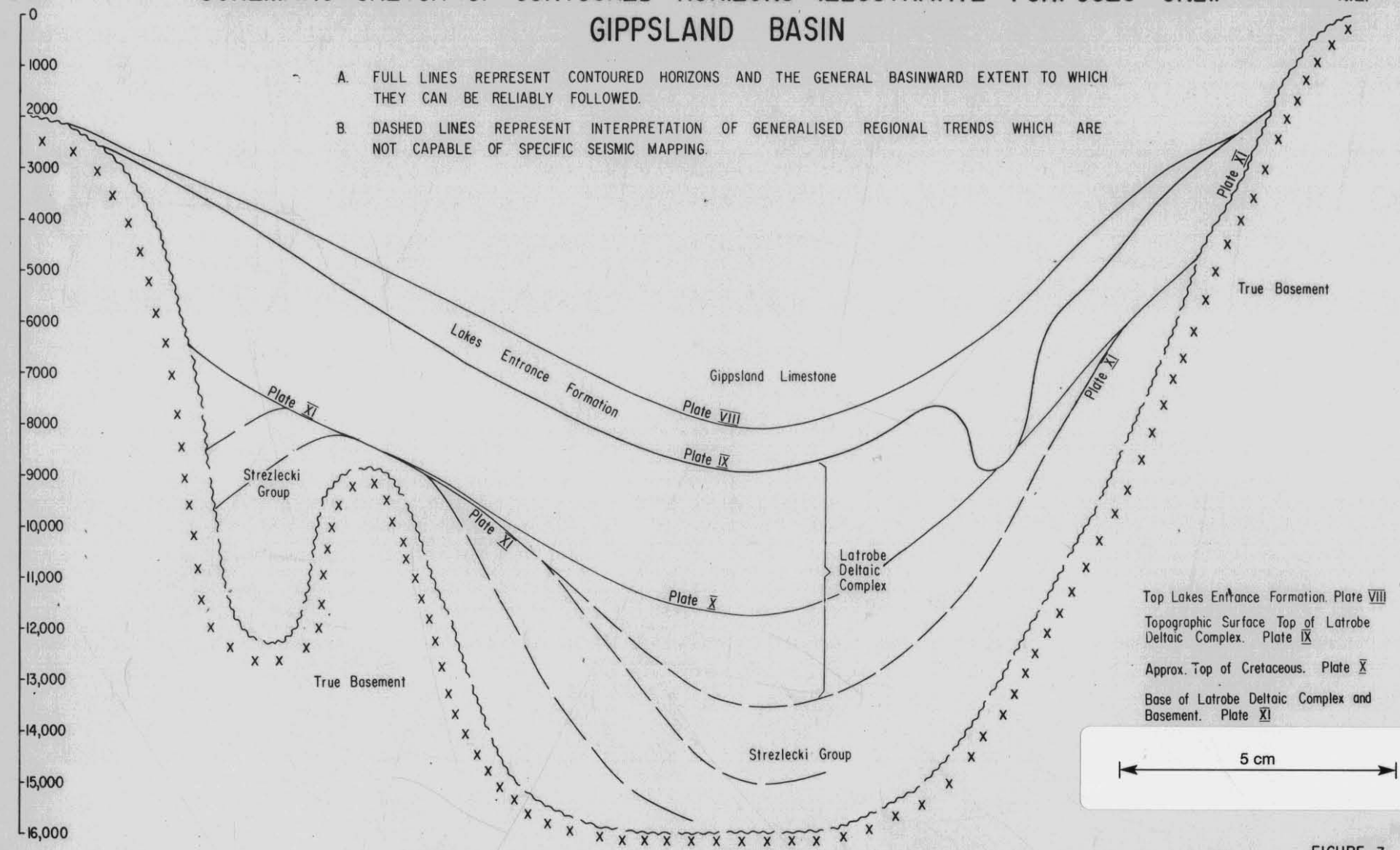


FIGURE 3.

OR-009

GIPPSLAND BASIN

GENERALIZED TIME vs DEPTH CHART

Depth	Two-way Time
0	0
500	.211
1000	.337
1500	.461
2000	.578
2500	.680
3000	.780
3500	.881
4000	.975
4500	1.081
5000	1.182
5500	1.275
6000	1.369
6500	1.459
7000	1.547
7500	1.636
8000	1.721
8500	1.800
9000	1.883
9500	1.960
10000	2.036
10500	2.108
11000	2.181
11500	2.258
12000	2.330

FIGURE 4

BASS BASIN

GENERALIZED TIME vs DEPTH CHART

Depth	Two-way Time
0	0
500	.170
1000	.340
1500	.460
2000	.593
2500	.724
3000	.852
3500	.980
4000	1.106
4500	1.220
5000	1.340
5500	1.445
6000	1.555
6500	1.650
7000	1.745
7500	1.826
8000	1.905
8500	1.972
9000	2.040
9500	2.100
10000	2.170
10500	2.225
11000	2.290
11500	2.340
12000	2.400
12500	2.460
13000	2.510

FIGURE 5

PEP 40

PEP 36

PEP 39

WILSONS PROMONTORY

VICTORIA
TASMANIA

EAST MONCOEUR
WEST MONCOEUR

HOGAN GP

CURTIS GP

KENT GP

FLINDERS ISLAND

KING ISLAND

THREE HUMMOCK ISLAND

HUNTER ISLAND

ROBBINS ISLAND

TASMANIA

TASMANIA

EL 1/60

EL 1/60

ESSO-HAEMATITE FARM-IN BOUNDARY

ESSO-HAEMATITE FARM-IN BOUNDARY

Top of Oligocene too shallow to map with present spread configurations in this area

ZERO EDGE OF OLIGOCENE

ZERO EDGE OF OLIGOCENE

LEGEND

- Dry hole
- Well location
- —1500— Structure contour
- D / U Fault
- Petroleum tenement boundary
- Areas of Oligocene Volcanic build-ups

- Q Quaternary
- Tl Tertiary (Marine)
- T Tertiary (Non-Marine)
- P Permian
- DS Devonian and Silurian
- € Cambrian
- pCu Precambrian (Unmetamorphosed)
- Tb Tertiary (Basalt)
- Jd Jurassic (Syenite) } Igneous
- Dg Devonian (Granite)

- B-10 Hematite Bass seismic survey
- ES-10 Esso Bass seismic survey
- EK-10 East King Island seismic survey
- ES-12 Eastern Bass Strait seismic survey

MAP INDEX



ESSO EXPLORARATION AND PRODUCTION AUSTRALIA INC.

THE BASS BASIN

VICTORIA - TASMANIA

STRUCTURE CONTOUR MAP ON TOP OF OLIGOCENE

5 cm

053642

CONTOUR INTERVAL 250 FEET

DATUM : SEA LEVEL

Scale 1:250,000

0 4 8 12

MILES

AUTHORS : C.C. MORGAN & W.C. PRESLEY — DRAFTED BY A.F. STRAHAN & M. WINTO

TO ACCOMPANY FINAL REPORT EASTERN BASS STRAIT MARINE SEISMIC SURVEY, MARCH, 1967

PLATE I

Bass Basin part IX

OR-009

PEP 40

PEP 36

PEP 39

WILSONS PROMONTORY

VICTORIA
TASMANIA

EAST MONCOEUR
WEST MONCOEUR

HOGAN GP

CURTIS GP

KENT GP

ESSO-HAEMATITE FARM-IN BOUNDARY

ZERO EDGE OF EOCENE

KING ISLAND

FLINDERS ISLAND

EL 1/60

THREE HUMMOCK ISLAND

HUNTER ISLAND

ROBBINS ISLAND

TASMANIA

Area of no data beneath Oligocene volcanic build-up

LEGEND

- Dry hole
- Well location
- -1500- Structure contour
- D / U Fault
- Petroleum tenement boundary
- Areas of Eocene Volcanic build-ups
- Stock
- Stock with flat surface (may be sill with deeper inflections masked)
- Q Quaternary
- T1 Tertiary (Marine)
- T Tertiary (Non-Marine)
- P Permian
- DS Devonian and Silurian
- C Cambrian
- pCu Precambrian (Unmetamorphosed)
- Tb Tertiary (Basalt)
- Jd Jurassic (Tyennte) } Igneous
- Dg Devonian (Granite)

- H-10 Haematite Bass seismic survey
- EB-10 Esso Bass seismic survey
- EK-10 East King Island seismic survey
- ES-52 Eastern Bass Strait seismic survey

MAP INDEX



ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

THE BASS BASIN

VICTORIA - TASMANIA

STRUCTURE CONTOUR MAP ON TOP OF EOCENE

5 cm

053043

CONTOUR INTERVAL 250 FEET — DATUM SEA LEVEL

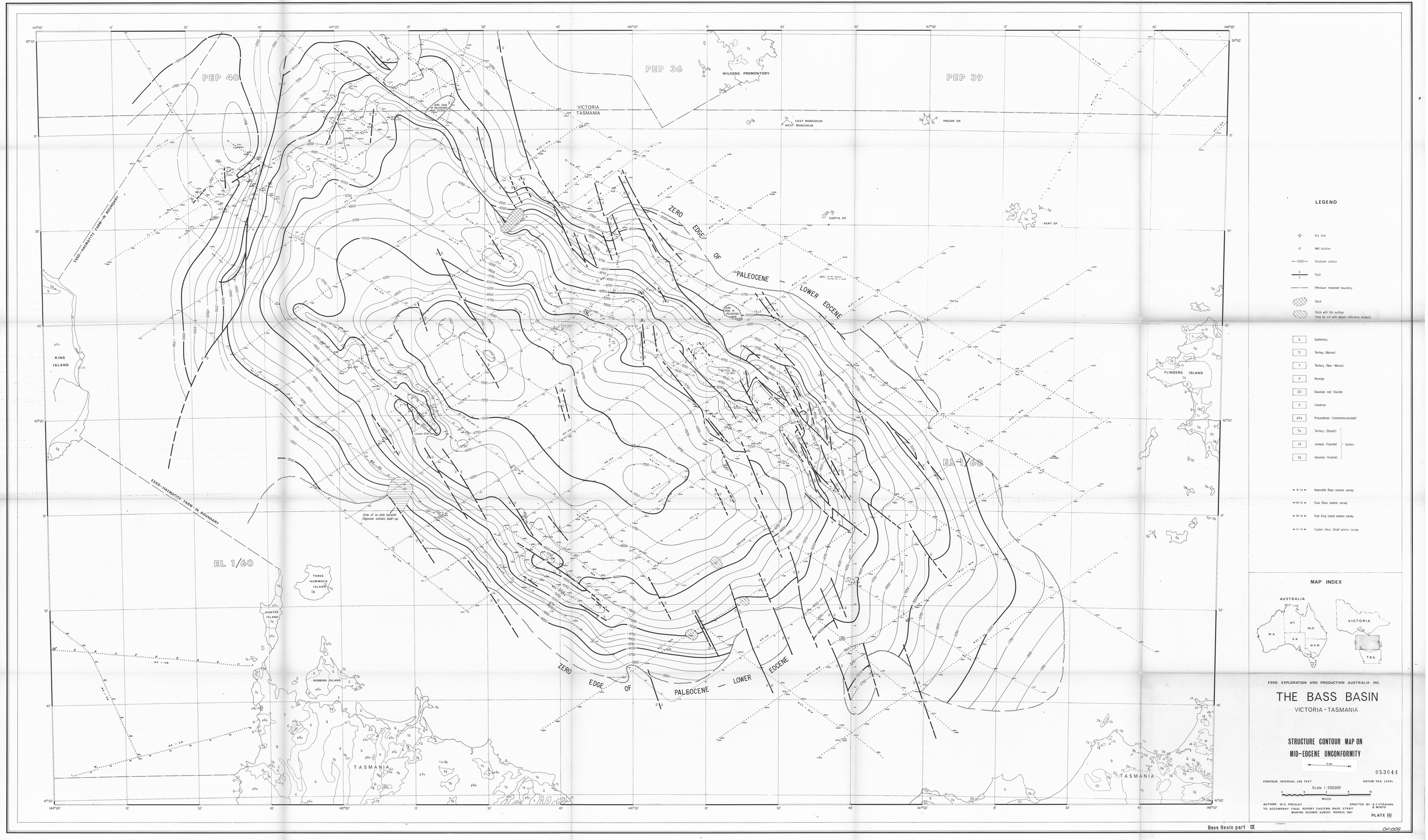
Scale 1:250,000

0 4 8 12 MILES

AUTHORS: P.E. TOWEY & W.C. PRESLEY — DRAFTED BY: A.F. STRAHAN, B. MINTO

TO ACCOMPANY FINAL REPORT EASTERN BASS STRAIT MARINE SEISMIC SURVEY, MARCH, 1961

PLATE II


PEP 40
PEP 36
PEP 39
WILSONS PROMONTORY
VICTORIA
TASMANIA
EAST MONCOEUR
WEST MONCOEUR
HOGAN GP
CURTIS GP
KENT GP
ZERO EDGE OF PALEOCENE — LOWER EOCENE
ESSO-HAEMATITE FARM-IN BOUNDARY
KING ISLAND
FLINDERS ISLAND
EL 1/60
THREE HUMMOCK ISLAND
HUNTER ISLAND
ROBBINS ISLAND
TASMANIA
LEGEND
Dry hole
Well location
Structure contour
Fault
Petroleum tenement boundary
Stock
Stock with flat surface (may be sill with deeper reflections masked)
Q Quaternary
Tl Tertiary (Marine)
T Tertiary (Non-Marine)
P Permian
DS Devonian and Silurian
€ Cambrian
p€u Precambrian (Unmetamorphosed)
Tb Tertiary (Basalt)
Jd Jurassic (Syenite)
Dg Devonian (Granite)
Igneous
B-10 Haematite Bass seismic survey
EB-10 Esso Bass seismic survey
EK-10 East King Island seismic survey
ES-52 Eastern Bass Strait seismic survey
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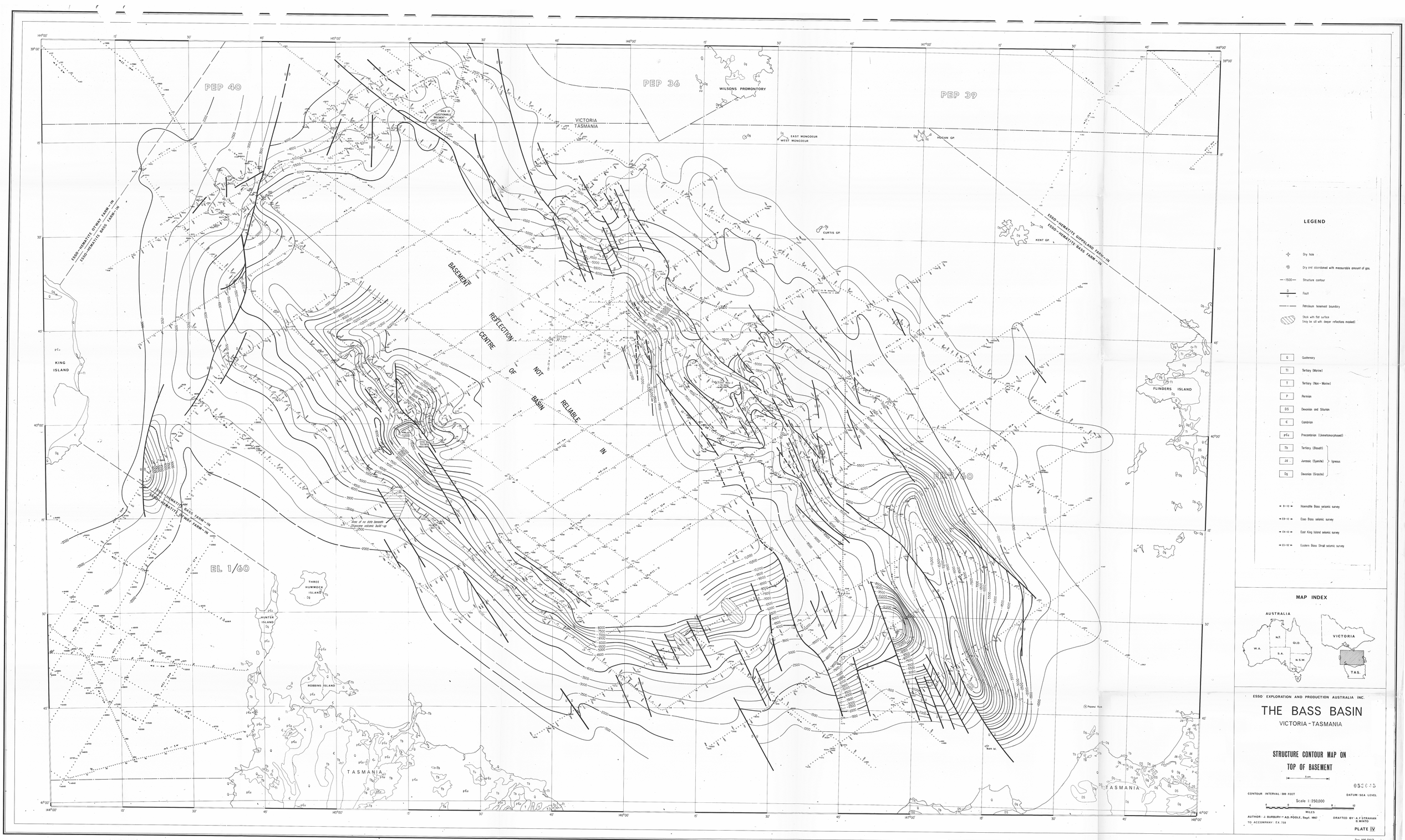
AUSTRALIA
W.A.
N.T.
QLD.
S.A.
N.S.W.
VIC.
T.
VICTORIA
TAS.
ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.
THE BASS BASIN
VICTORIA - TASMANIA
STRUCTURE CONTOUR MAP ON
MID-EOCENE UNCONFORMITY
053044
CONTOUR INTERVAL: 250 FEET
DATUM: SEA LEVEL
Scale 1:250,000
MILES
AUTHOR: W.C. PRESLEY
DRAFTED BY: A.F. STRAHAN
B. MINTO
TO ACCOMPANY: FINAL REPORT EASTERN BASS STRAIT MARINE SEISMIC SURVEY, MARCH, 1967
PLATE III
Bass Basin part IX
CH-009


PEP 40
PEP 36
PEP 39
EL 1/60
EL 1/60
VICTORIA
TASMANIA
WILSONS PROMONTORY
EAST MONCOEUR
WEST MONCOEUR
HOGAN GP.
CURTIS GP.
KENT GP.
KING ISLAND
FLINDERS ISLAND
THREE HUMMOCK ISLAND
HUNTER ISLAND
ROBBINS ISLAND
TASMANIA
TASMANIA
ESSO-HEMATITE OTWAY FARM-IN
ESSO-HEMATITE BASS FARM-IN
ESSO-HEMATITE GIPPSLAND FARM-IN
ESSO-HEMATITE BASS FARM-IN
ESSO-HEMATITE BASS FARM-IN
ESSO-HEMATITE OTWAY FARM-IN
BASEMENT REFLECTION NOT RELIABLE IN CENTRE OF BASIN
Area of no data beneath Oligocene volcanic build-up
LEGEND
Dry hole
Dry and abandoned with measurable amount of gas.
Structure contour
Fault
Petroleum tenement boundary
Stick with flat surface (may be sill with deeper reflections masked)
Q Quaternary
Tl Tertiary (Marine)
T Tertiary (Non-Marine)
P Permian
DS Devonian and Silurian
Є Cambrian
pЄu Precambrian (Unmetamorphosed)
Tb Tertiary (Basalt)
Jd Jurassic (Syenite)
Dg Devonian (Granite)
Igneous
B-10 Hoematite Bass seismic survey
EB-10 Esso Bass seismic survey
EK-10 East King Island seismic survey
ES-52 Eastern Bass Strait seismic survey
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AUSTRALIA
W.A.
N.T.
QLD.
S.A.
N.S.W.
VIC.
VICTORIA
TAS.
ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.
THE BASS BASIN
VICTORIA - TASMANIA
STRUCTURE CONTOUR MAP ON TOP OF BASEMENT
5 cm
053045
CONTOUR INTERVAL: 500 FEET
DATUM: SEA LEVEL
Scale 1:250,000
MILES
AUTHOR: J. BURBURY - AD. POOLE, Sept. 1967
TO ACCOMPANY: EX. 750
DRAFTED BY: A. F. STRAHAN B. MINTO
PLATE IV
CR-009
Dwg 995/1977

PEP 40

PEP 36

PEP 39

VICTORIA
TASMANIA

WILSONS PROMONTORY

EAST MONCOEUR
WEST MONCOEUR

HOGAN GP

CURTIS GP

KENT GP

Top of Oligocene not mappable in this area

ESSO-HAEMATITE FARM-IN BOUNDARY

EL 1/60

KING ISLAND

FLINDERS ISLAND

THREE HUMMOCK ISLAND

HUNTER ISLAND

ROBBINS ISLAND

TASMANIA

THICK

LEGEND

- Dry hole
- Well location
- —1500— Isopach line
- D / U Fault
- Petroleum tenement boundary
- Areas of Oligocene Volcanic build-ups

- Q Quaternary
- T1 Tertiary (Marine)
- T Tertiary (Non-Marine)
- R Permian
- DS Devonian and Silurian
- € Cambrian
- pCu Precambrian (Unmetamorphosed)
- Tb Tertiary (Basalt)
- Jd Jurassic (Syenite) } Igneous
- Dg Devonian (Granite)

- Hoemskite Boss seismic survey
- Esso Boss seismic survey
- East King Island seismic survey
- Eastern Bass Strait seismic survey

MAP INDEX

AUSTRALIA
N.T.
QLD.
W.A.
S.A.
N.S.W.
VIC.
TAS.

VICTORIA

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

THE BASS BASIN

VICTORIA - TASMANIA

ISOPACH MAP

TOP OLIGOCENE TO TOP EOCENE

5 cm

ISOPACH INTERVAL : 250 FEET

053046

Scale 1: 250,000

4 0 4 8 12
MILES

AUTHOR W.C. PRESLEY

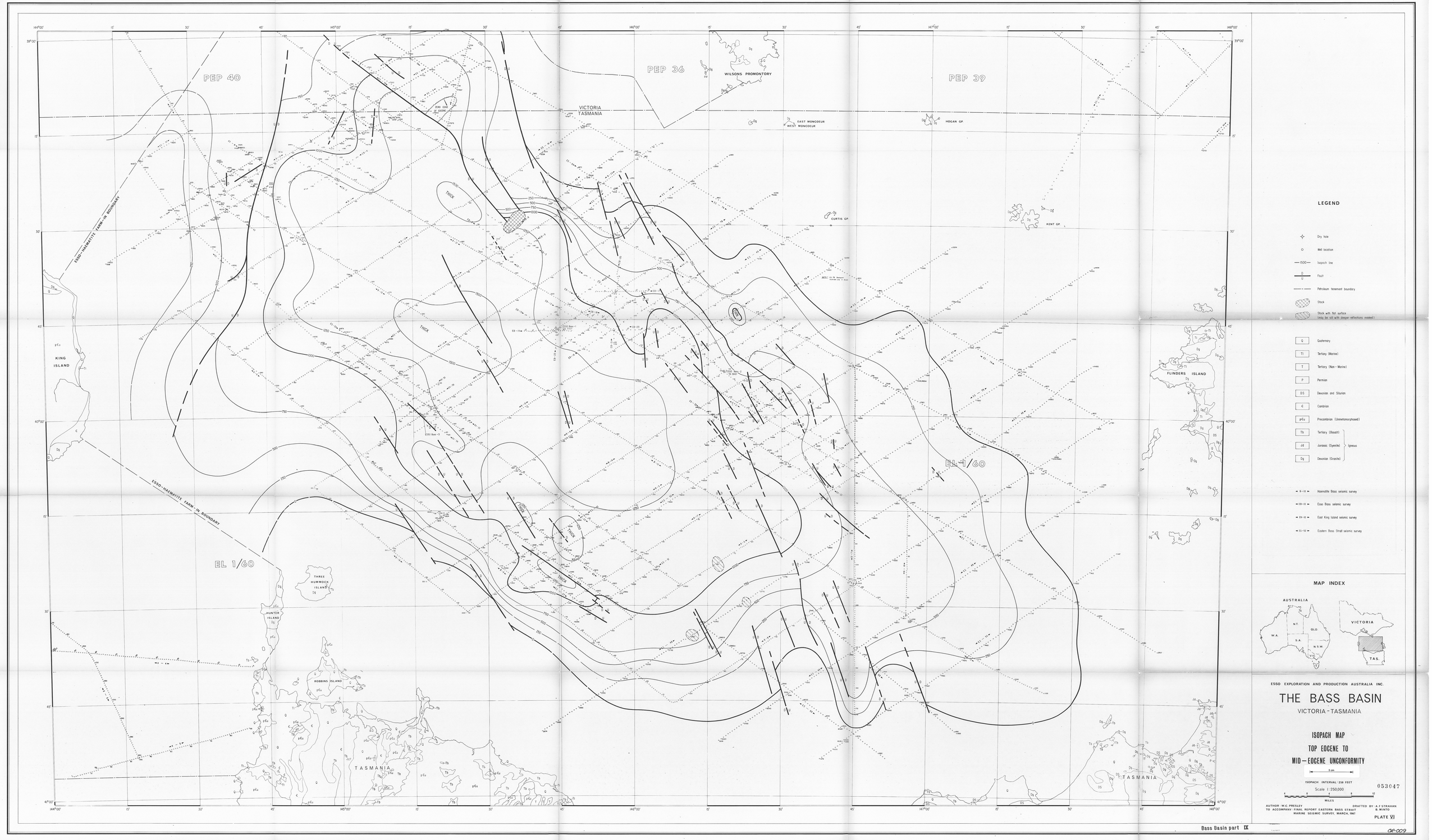
DRAFTED BY A.F. STRAHAN
R. MINTO

TO ACCOMPANY: FINAL REPORT EASTERN BASS STRAIT MARINE SEISMIC SURVEY, MARCH, 1967

PLATE V

66-009

Bass Basin part IX


PEP 40
PEP 36
PEP 39
WILSONS PROMONTORY
VICTORIA
TASMANIA
EAST MONCOEUR
WEST MONCOEUR
HOGAN GP
CURTIS GP
KENT GP
KING ISLAND
FLINDERS ISLAND
THREE HUMMOCK ISLAND
HUNTER ISLAND
ROBBINS ISLAND
TASMANIA
EL 1/60
ESSO-HAEMATITE FARM-IN BOUNDARY
LEGEND
Dry hole
Well location
Isopach line
Fault
Petroleum tenement boundary
Stock
Stock with flat surface (may be sill with deeper reflections masked)
Q Quaternary
Tl Tertiary (Marine)
T Tertiary (Non-Marine)
P Permian
DS Devonian and Silurian
Є Cambrian
p€u Precambrian (Unmetamorphosed)
Tb Tertiary (Basalt)
Jd Jurassic (Syenite)
Dg Devonian (Granite)
Igneous
B-10 Haematite Bass seismic survey
EB-10 Esso Bass seismic survey
EK-10 East King Island seismic survey
ES-52 Eastern Bass Strait seismic survey
MAP INDEX
AUSTRALIA
W.A.
N.T.
QLD.
S.A.
N.S.W.
VIC.
T.
VICTORIA
TAS.
ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.
THE BASS BASIN
VICTORIA - TASMANIA
ISOPACH MAP
TOP EOCENE TO
MID-EOCENE UNCONFORMITY
ISOPACH INTERVAL: 250 FEET
Scale 1:250,000
MILES
053047
AUTHOR: W.C. PRESLEY
TO ACCOMPANY: FINAL REPORT EASTERN BASS STRAIT MARINE SEISMIC SURVEY, MARCH, 1967
DRAFTED BY: A.F. STRAHAN
B. MINTO
PLATE VI
Bass Basin part IX
OR-009

Bairnsdale

Lakes Entrance

Maffra

Sale

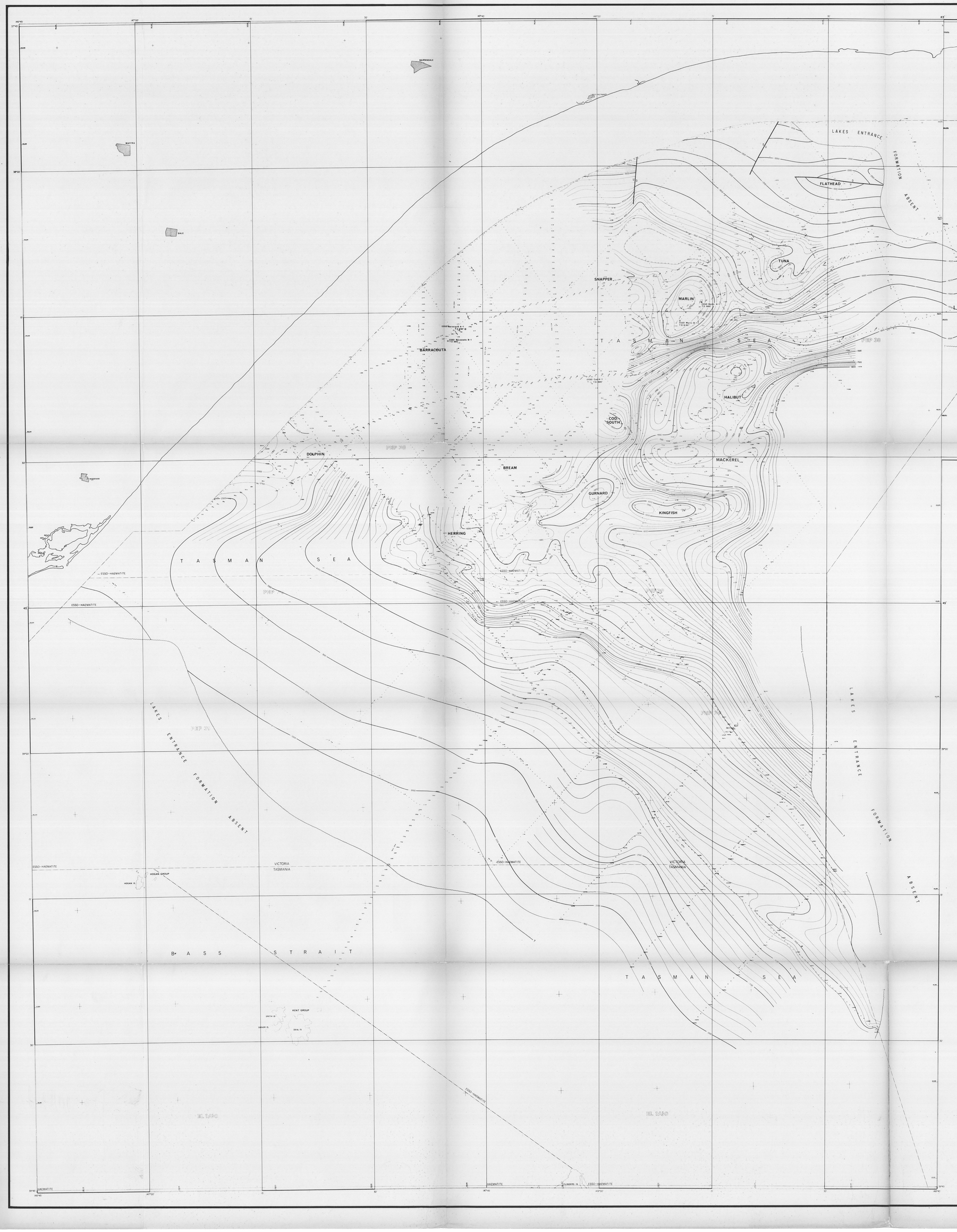
Woodside

WOODSIDE

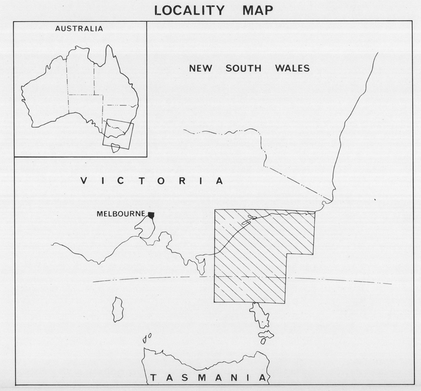
ESSO-HAEMATITE

ESSO-HAEMATITE

ESSO-HAEMATIT



LOCALITY MAP



LEGEND

- Oil and gas well
- Gas well
- Dry and abandoned
- Seismic shot point
- Petroleum tenement boundary
- Fault = "U" upthrown side / "D" downthrown side

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

THE GIPPSLAND BASIN

VICTORIA – TASMANIA

STRUCTURE CONTOUR MAP
TOP OF LAKES ENTRANCE FORMATION

5 cm

CONTOUR INTERVAL : 100 FEET

DATUM : SEA LEVEL

Scale 1 : 250,000

4 2 0 4 8

MILES

AUTHOR : K.A. RICHARDS & P.E. TOWEY

DRAFTED BY : B. EDWARDS

TO ACCOMPANY : FINAL REPORT, EASTERN BASS STRAIT MARINE SEISMIC SURVEY

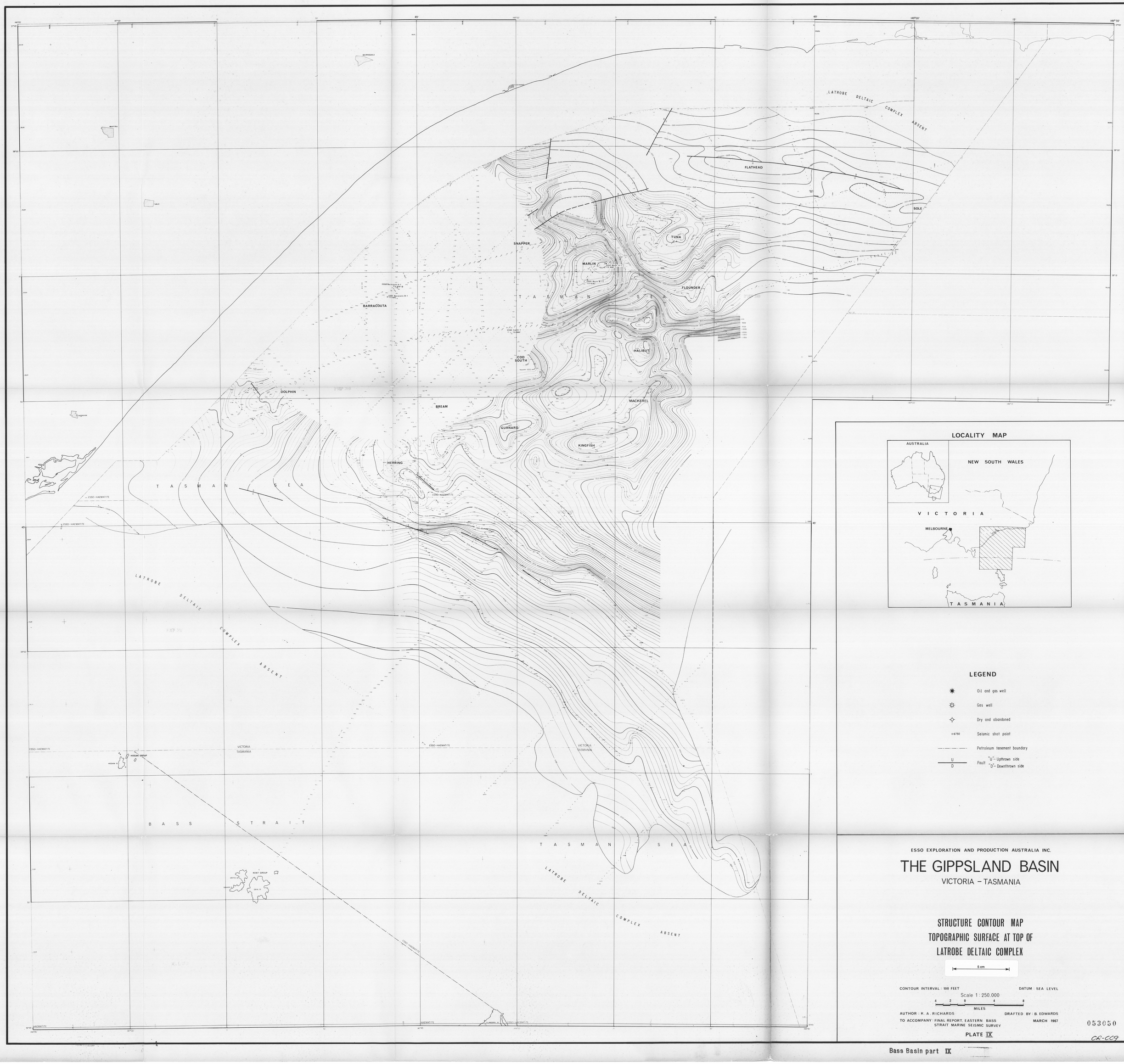
MARCH 1967

PLATE VIII

053649

OR-009

Bass Basin part IX



LOCALITY MAP

LEGEND

- Oil and gas well
- Gas well
- Dry and abandoned
- ○6750 Seismic shot point
- Petroleum tenement boundary
- U / D Fault — "U"– Upthrown side, "D"– Downthrown side

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

THE GIPPSLAND BASIN

VICTORIA – TASMANIA

STRUCTURE CONTOUR MAP
TOPOGRAPHIC SURFACE AT TOP OF
LATROBE DELTAIC COMPLEX

5 cm

CONTOUR INTERVAL : 100 FEET

DATUM : SEA LEVEL

Scale 1 : 250,000

4 2 0 4 8

MILES

AUTHOR : K. A. RICHARDS

DRAFTED BY : B. EDWARDS

TO ACCOMPANY : FINAL REPORT, EASTERN BASS STRAIT MARINE SEISMIC SURVEY

MARCH 1967

PLATE IX

053650

OR-009

Bass Basin part IX

LATROBE PINCHES OUT AGAINST BASEMENT OR STREZLEKI

FLATHEAD

SOLE

SNAPPER

TUNA

MARLIN

FLOUNDER

BARRACOUTA

HALIBUT

COD SOUTH

HORIZON INTERSECTS CANYON

MACKEREL

DOLPHIN

BREAM

GURNARD

KINGFISH

HERRING

HORIZON TERMINATES AGAINST BASEMENT OR STREZLEKI

HORIZON TERMINATES AGAINST BASEMENT OR STREZLEKI

T A S M A N S E A

PEP 38

PEP 39

PEP 37

PEP 30

PEP 31

ESSO-HAEMATITE

VICTORIA
TASMANIA

HOGAN GROUP

KENT GROUP

B A S S S T R A I T

T A S M A N S E A

BAIRNSDALE

MAFFRA

SALE

WONSON

FLINDERS IS

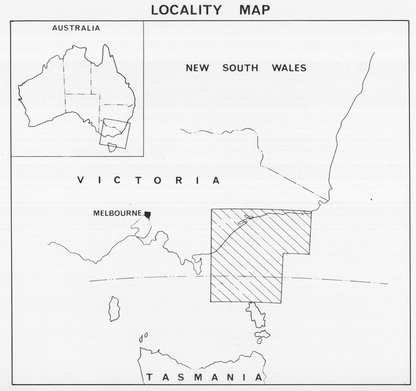
HOGAN IS

SMITH IS

DEVER IS

DEAL IS

LOCALITY MAP



LEGEND

- Oil and gas well
- Gas well
- Dry and abandoned
- ○ 6750 — Seismic shot point
- Petroleum tenement boundary
- U / D — Fault "U"— Upthrown side "D"— Downthrown side

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

THE GIPPSLAND BASIN

VICTORIA – TASMANIA

STRUCTURE CONTOUR MAP REFLECTION HORIZON NEAR TOP OF CRETACEOUS

5 cm

CONTOUR INTERVAL : 100 FEET

DATUM : SEA LEVEL

Scale 1 : 250.000

4 2 0 4 8

MILES

AUTHORS : K. A. RICHARDS & F.G. MOORE

DRAFTED BY : B. EDWARDS

TO ACCOMPANY : FINAL REPORT, EASTERN BASS STRAIT MARINE SEISMIC SURVEY

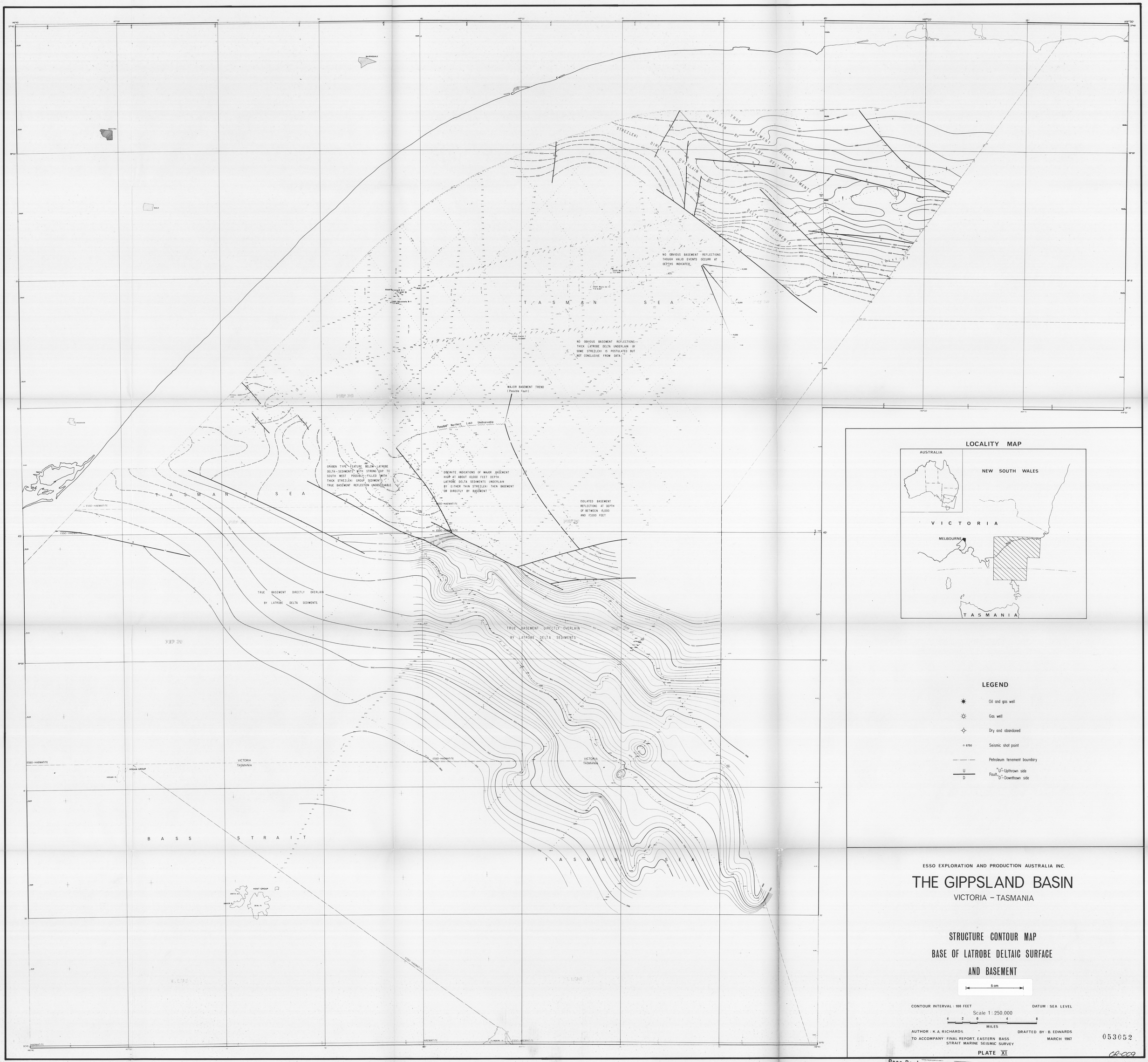
MARCH 1967

PLATE X

053051

OR-009

Bass Basin part IX



ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

THE GIPPSLAND BASIN

VICTORIA – TASMANIA

STRUCTURE CONTOUR MAP
BASE OF LATROBE DELTAIC SURFACE AND BASEMENT

5 cm

CONTOUR INTERVAL : 100 FEET

DATUM : SEA LEVEL

Scale 1 : 250.000

4 2 0 4 8

MILES

AUTHOR : K.A. RICHARDS

DRAFTED BY : B. EDWARDS

TO ACCOMPANY : FINAL REPORT, EASTERN BASS STRAIT MARINE SEISMIC SURVEY

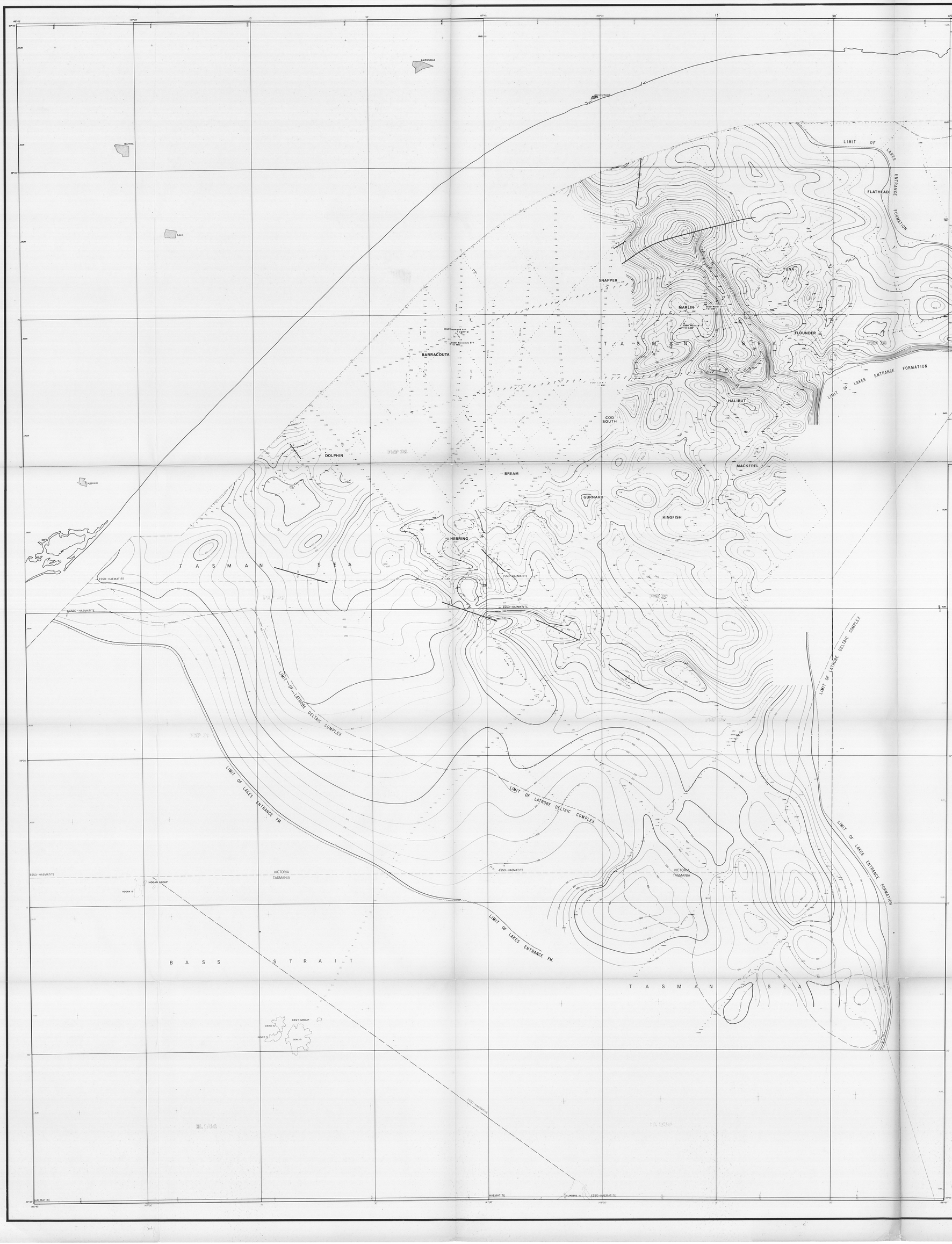
MARCH 1967

PLATE XI

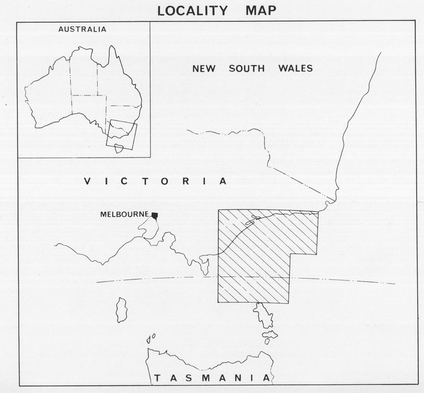
053052

OR-009

Bass Basin part IX



LOCALITY MAP



LEGEND

- Oil and gas well
- Gas well
- Dry and abandoned
- ○ 6750 — Seismic shot point
- Petroleum tenement boundary
- Fault — U – Upthrown side, D – Downthrown side

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

THE GIPPSLAND BASIN

VICTORIA – TASMANIA

ISOPACH MAP
LAKES ENTRANCE FORMATION

5 cm

ISOPACH INTERVAL: 100 FEET

Scale 1 : 250,000

4 2 0 4 8

MILES

AUTHOR : K.A. RICHARDS, F.G. MOORE

DRAFTED BY : B. EDWARDS

TO ACCOMPANY : FINAL REPORT, EASTERN BASS STRAIT MARINE SEISMIC SURVEY

MARCH 1967

PLATE XII

053053

OR-009

Bass Basin part IX

LATROBE DELTAIC COMPLEX ABSENT

LESS THAN 500 FEET

REFLECTION HORIZON PINCHES OUT AGAINST BASEMENT OR STREZLEKI

REFLECTION HORIZON PINCHES OUT AGAINST BASEMENT OR STREZLEKI

FLATHEAD

TUNA

SNAPPER

MARLIN

FLOUNDER

BARRACOUTA

HALIBUT

COD SOUTH

HORIZON INTERSECTS CANYON

DOLPHIN

BREAM

MACKEREL

GURNARD

KINGFISH

HERRING

HORIZON TERMINATES AGAINST BASEMENT OR STREZLEKI

T A S M A N S E A

LATROBE DELTAIC COMPLEX ABSENT

LATROBE DELTAIC COMPLEX ABSENT

LATROBE DELTAIC COMPLEX ABSENT

LATROBE DELTAIC COMPLEX ABSENT

ESSO-HAEMATITE

VICTORIA TASMANIA

HOGAN GROUP

HOGAN IS

B A S S S T R A I T

T A S M A N S E A

KENT GROUP

SMITH IS

DOVER IS

DEAL IS

PEP 38

PEP 37

PEP 39

PEP 40

EL 1/69

L1/69

LOCALITY MAP

AUSTRALIA

NEW SOUTH WALES

V I C T O R I A

MELBOURNE

TASMANIA

LEGEND

- Oil and gas well
- Gas well
- Dry and abandoned
- ⊙6750 Seismic shot point
- Petroleum tenement boundary
- Fault = U Upthrown side, D Downthrown side

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.

THE GIPPSLAND BASIN

VICTORIA – TASMANIA

ISOPACH MAP INTERVAL TOP OF LATROBE TO REFLECTION NEAR TOP OF CRETACEOUS

5 cm

ISOPACH INTERVAL: 100 FEET

Scale 1 : 250.000

4 2 0 4 8

MILES

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TO ACCOMPANY : FINAL REPORT, EASTERN BASS STRAIT MARINE SEISMIC SURVEY MARCH 1967

PLATE XIII

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OR-009

Bass Basin part IX