DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1974/98

GEOPHYSICAL RESULTS FROM OFFSHORE TASMANIA

Survey 11, 12, 14,

by

P.J. Cameron and J. Pinchin

Record 1974/98

GEOPHYSICAL RESULTS FROM OFFSHORE TASMANIA

by

P.J. Cameron and J. Pinchin

CONTENTS

PLATES

SUMMARY

During 1971 and 1972 Compagnie Generale de Geophysique under contract to the Bureau of Mineral Resources carried out 9100 nautical miles (16 900 km) of marine geophysical surveying around Victoria and Tasmania. The work was done as part of the Australian Continental Margin Survey to investigate the sedimentary and basement structure of the continental slope and adjacent marginal plateaus. The work around Tasmania covered the area of the continental shelf and slope to about the 4500 metre isobath, and the northern part of the Tasmania Ridge and the Cascade Plateau. Surveying over the Tasmania Ridge was curtailed because of bad weather.

Data quality is fair, though the operation of the gravity meter was adversely affected by rough seas so that some of the gravity data are unusable.

Between 1000 and 2000 m thickness of sedimentary cover was found on the continental slopes and the adjacent Tasmania Ridge and Cascade Plateau. However the cover is not continuous and is broken in many places by basement outcrops. The seismic results confirmed the faulted origin of the eastern margin of Tasmania and possibly also of the western margin; the dominant fault strike and structural trend is northwards.

The continental slope around eastern Tasmania was found to be steep, with less than 1000 m of sedimentary cover over an undulating basement. A north-trending line of basement highs occurs about half-way down the slope. On several seismic sections the base of this slope can be seen to drop abruptly to the abyssal plain, which may reflect the fault-controlled origin of this margin. The Bouguer anomaly gradient across the continental slope is greater in the east than in the west which probably indicates that the transition from continental to oceanic crust is more abrupt along the east coast of Tasmania.

Seismic sections across the continental slope off west Tasmania show several north-trending basement ridges and basement rifts. Sedimentary thickness here may be as much as 2000 m, although the basement reflection is rarely apparent.

The Bouguer anomalies recorded over the Tasmania Ridge and Cascade Plateau indicate that these areas have a crustal thickness intermediate between that of the continent and the ocean, probably about 20 km. The DSDP drill-hole at site 281 on the Tasmania Ridge bottomed in probable Precambrian schist; this result together with the seismic, magnetic, and gravity results from this survey indicates that both the Tasmania Ridge and Cascade Plateau are areas of foundered continental crust.

1. INTRODUCTION

From 1970 to 1973 the Bureau of Mineral Resources (BMR) conducted a marine geophysical survey around the continental margin of Australia and Papua New Guinea. The operational work was contracted out to Compagnie Generale de Geophysique and overall about 100 000 nautical line miles was surveyed.

The aims of the survey were to establish the general topography, sediment thickness, and geological structure of the Australian continental margin and adjacent plateaus. Bathymetric, seismic reflection, gravity, and magnetic data were recorded continuously, and seismic refraction data recorded at intervals from sonobuoys.

A total of 9100 nautical miles (n miles) was surveyed around Tasmania between February 1971 and April 1972. The traverse grid consisted mainly of east-west lines at a spacing of 20 n miles, plus a few north-south tie lines. The area surveyed, shown in Plate 1, extends from 36°S, 100 km north of Eden on the NSW coast, around Tasmania to 141°E at the Victoria/South Australia border. Bass Strait was not surveyed except for a single line. The lines extended from near the coast out to a water depth of about 4500 m, plus a few remote lines across the Tasman Sea as shown in the track chart, Plate 2. Surveying across the Tasmania Ridge which lies to the south of Tasmania was curtailed at latitude 46°S because of bad weather.

Equipment

A summary of the equipment used is given here; a detailed report on equipment performance has been prepared by the contractor (CGG, 1974).

Primary navigation control was based on the U.S. Navy TRANSIT satellite navigation system which gave fixes at roughly two hourly intervals. Intermediate ship positions were computed using the ship's gyrocompass coupled with the sonar Doppler system. The Chernikeeff electronic log or ship's log were used whenever the sonar Doppler system was inoperative.

Gravity data were obtained by a LaCoste & Romberg gravity meter (No. S24) which was mounted on a stabilized platform. Linear corrections for beam movement and ship's accelerations were applied using the analogue computers within the mater and a corrected gravity value was recorded. The total magnetic field was measured by a Varian proton precession magnetometer with the sensor towed about 200 m behind the ship.

All gravity, magnetic, and navigation data were sampled at 10-s intervals, checked and reformatted by a Hewlett Packard HP2116B computer, and recorded digitally on half-inch magnetic tape. The computer also provided at 10-min intervals the ship's dead-reckoned position and data, some of it processed, for real time assessment of system performance and for geophysical computations.

The seismic energy source was a four-electrode 120 kJ sparker, and the seismic signals were detected using both a 1000-m long six-channel hydrostreamer cable for deep reflections and a short single-channel cable for near-surface events. The seismic signals were amplified and filtered by Sercel AS626 amplifiers and recorded on a 14-channel Ampex FR 1300 FM tape recorder; Electro-sensitive paper recorders were used for display. The sparker was also used as a source for refracted seismic signals that were detected out to several miles distance by an Aquatronics Type SM 42 sonobuoy.

Operations

The survey ship, Hamme, commenced operations from Hobart on 16 February 1971 with the lines 11/001 to 11/031 south of Tasmania (see Plate 2). Despite adjustment by a LaCoste & Romberg engineer, the gravity meter did not function well in rough seas. The weather became gradually worse and surveying south of Tasmania was finally abandoned at about 46°S. The magnetometer shore station had been located at Hobart for this leg of the survey, then was moved to Eden for the second leg. During the second leg the ship left Melbourne on 7 April and sailed to Newcastle, surveying lines 12/001 to 12/061 along the east coast of NSW and out of the map area. At Melbourne the Esterline Angus chart recorder, the Raytheon recorder, and the two EG & G recorders were replaced by four EPC recorders which gave improved displays of the seismic data.

The Hamme returned south of 36°S into the map area on 17 December 1971, surveying lines 14/068 to 14/079 across the Tasman Sea, and then sailed down the east coast of Tasmania. It docked in Hobart on 24 December 1971. No magnetometer shore station was operated during this period. Lines 15/001 to 15/026 were surveyed from 28 December 1971 to 13 January 1972 with the ship sailing from Hobart, along the east coast of Tasmania, across Bass Strait, then into Launceston. The line across Bass Strait was curtailed because of bad weather. The magnetometer shore station was located at Launceston during this period. The shore station was not operated during the surveying of lines 15/027 to 15/033 and 15/061 to 15/063 when the ship sailed out of the area to Newcastle and back, but it was then re-installed at Launceston and operated there for the remainder of the survey.

The gravity meter was returned to the manufacturers in Houston, Texas from Launceston and the ship sailed to Newcastle, surveying lines 15/027 to 15/033 without it. In Houston the meter optics system was re-adjusted and the reliability of the meter in rough seas was improved. The meter was re-installed on the ship at Newcastle on 12 March 1972, and the ship surveyed lines 15/061 to 15/063 and docked at Launceston on 26 March.

The west coast of Tasmania was surveyed from 29 March to 16 April (lines 16/001 to 16/039).

2. DATA QUALITY

Over the continental shelf the sonar Doppler was able to operate from the seabed reflection and it is expected that navigational accuracy should be of the order of 0.2 n mile after post-processing of the satellite fixes. However in deeper water the sonar Doppler operated from back-scattered energy from the water. The currents in the water are unknown, and navigational accuracy off the continental shelf is likely to fall to about 1 n mile.

The main factor affecting the accuracy of the gravity meter is the effect of short-period accelerations owing to the rough seas, which causes a spurious oscillation of the meter reading. As mentioned in the previous section, the meter was sent to the manufacturer for repairs which improved its performance somewhat, but the meter was still unable to compensate for the accelerations caused by extremely rough seas. Lines 11/006, 11/008, 14/068, 14/070, 14/073, 14/074, and southern part of 16/034 show poor gravity data where the short-period oscillations (less than 10-min period) were greater than 6 mGal peak-to-peak. The lines south of Tasmania show an oscillation envelope of 2 to 4 mGal and elsewhere the data is good, within 2 mGal. Appendix I gives a listing of low-accuracy gravity results. In addition, errors in the calculation of the ship's velocity cause errors in the Eotvos correction, and the variable navigational accuracy affects the gravity data accuracy.

Minor problems and short-lived breakdowns were experienced with the magnetometer, but noise levels were generally less than 5 nT peak-to-peak and less than 3 nT over most of the area. As the shore magnetic station was not operated from 17 to 24 December 1971, and from 20 to 24 January, and from 20 to 22 March 1972, the diurnals will be taken from the recordings made at the BMR geological observatory at Toolangi for these days. This mainly affects lines 14/068 and 15/033, 15/061, 15/062 across the Tasman Sea, and the near-shore tie lines 14/074 to 14/079 along the east coast of Tasmania.

Overall estimates of the accuracy of the bathymetry, gravity, and magnetic data can be obtained from the misties at intersections, which are shown in histogram form in Plate 3. Should the errors be random as one would expect, the mean should be insignificantly different from zero and it is unlikely that the maximum mistie would depart from the mean by more than three standard deviations.

All systems show some departures from a normal distribution, and the gravity histogram shows a second peak at +6 mGal. The gravity meter zero value increased by 5 mGal during calibration and optical tests at Hobart on 3 February 1971, which partly contributed to an increase of 8 mGal in the meter zero value between 20 January at Hobart and 24 April at Eden (Garnett, pers. comm.). Therefore the asymmetric shape of the gravity mistie histogram is not surprising.

The few excessively large bathymetric misties all occur along the eastern continental slope of Tasmania in water depths of about 4000 m. A small error in positioning over the steep continental slope here could produce these 80 m to 90 m misties. The two large negative magnetic misties also occur off the east coast over areas with small intense anomalies and steep gradients.

Single-channel monitor records were made from the seismic system as the data were collected. These have been inspected briefly and regional information has been extracted. On the continental shelf the monitor records are of poor quality owing to multiple reflections and ringing; elsewhere the record quality is fair. Six-fold common depth point stacking of the multichannel data recorded on tape should improve resolution and penetration.

The data presented in this report are preliminary. The bathymetric, gravity, and magnetic data were obtained on board ship by manual scaling of the analogue records at hourly intervals. After digitization the data were processed by computer, and contour maps were drawn on a flat-bed plotter using a 'triangular' contouring program as described on each of the contour maps (Plates 5, 6, and 7).

3. GEOLOGY, PREVIOUS BATHYMETRY, AND PREVIOUS GEOPHYSICS

Geology

The controlling tectonic feature of the area from Cambrian to Permian times was the Tasman Geosyncline or Tasman Orogenic Zone (Solomon & Griffiths, 1972).

Sedimentation in the geosyncline started in the Cambrian or before, but the boundaries of the trough in the early stages are obscure. Except for an important period of miogeosynclinal sedimentation during the Middle and Upper Ordovician, Tasmania was the site of dominantly eugeosynclinal sedimentation until the onset of the Tabberabberan Orogeny in the Middle Devonian (Jones, 1966).

The sediments of the Tasmania Basin (see Plate 4) were deposited to a maximum thickness of about 1000 m during Permian and Triassic time, and were later extensively intruded by Jurassic dolerite (Reynolds, 1965). Tertiary faulting in the eastern half of Tasmania created northwesterly-striking horst and graben structures which reach the south and east coasts. The grabens are filled with terrestial deposits and olivine basalts.

The Gippsland, Bass, and Otway Basins began to form in the Jurassic/Cretaceous as the rifting between the Australian and Antarctic parts of Gondwanaland began. These three basins extend for about 1100 km from east to west between Australia and Tasmania.

The Gippsland Basin developed as Jurassic to Lower Cretaceous sediments were deposited in an east -striking graben. A total thickness of about 6000 m of these rocks is unconformably overlain by about 2000 m of Tertiary sediments. Commercial oil and gas deposits are trapped beneath the angular unconformity at the top of the Latrobe Group (Eocene).

The Bass Basin contains up to 4000 m of Tertiary to Upper Cretaceous sediments. It is separated from the Gippsland Basin by a basement high, the Bassian Rise, and from the Otway Basin by the Mornington/King Island basement ridge. The Bass Basin is effectively a large graben or rift which has been subsiding since at least Upper Cretaceous time. Tensional relief has been provided by a system of northwest-striking normal faults along the northeastern and southwestern flanks of the basin. The sediments vary from fluvio-deltaic to marine, with several marine transgressions as in the Gippsland Basin; however no commercial hydrocarbon deposits have been discovered here.

The Otway Basin lies partly onshore and partly offshore and trends westerly from southwest Victoria into South Australia. It is primarily a Cretaceous Basin. The sediments vary from non-marine to marine and range in age from Lower Cretaceous to Pliocene. The total sediment thickness is about 7000 m. Three major sequences of Lower Cretaceous, Upper Cretaceous, and Tertiary age were deposited during different periods of structural evolution. The Lower

Cretaceous was a period of large-scale basement block-faulting resulting in large stable blocks surrounded by areas of major subsidence. In the Upper Cretaceous a prominent monoclinal downwarp or hinge-line was formed roughly parallel to the present coastline but a few miles inland from it. South of this hinge is an area of tilted normal fault blocks; most are parallel to the hinge-line and down-thrown to the southwest. The Tertiary rocks are only slightly deformed by post-depositional movement and merely show a general south regional dip. Coal has been found within the Cretaceous section and there have been some minor hydrocarbon shows, but no commercial discoveries.

<u>JOIDES drilling results</u> (Kennett et al., 1973).

From March to April 1973 on Leg 29 of DSDP, the 'Glomar Challenger' drilled at four sites in the Tasmanian area; three of them, numbers 281, 282, 283 are shown in Plate 2; number 280 is about 100 km south of the map area.

Site 280 was drilled in a water depth of 4181 m south of the Tasmania Ridge. One hundred and fifty metres of Pleistocene to Oligocene nanno-oozes was penetrated; these overlie 350 m of Eocene glauconitic and silty clay, which in turn overlie basalt.

The drill-hole at site 281 in 1591 m of water on the Tasmania Ridge penetrated 120 m of calcareous ooze of early Miocene to Holocene age. A major unconformity spanning almost all the Oligocene and late Eocene is underlain by 47 m of Eocene glauconitic sand. The hole bottomed in probable Precambrian schist, proving the continental nature of the Tasmania Ridge. The Oligocene unconformity is related to the regional unconfirmity known in the northern Tasman Sea and Coral Sea from drilling during Leg 21.

Site 282 in 4207 m of water west of Tasmania was drilled in a magnetically quiet zone. 185 m of Miocene to early Oligocene nanno-ooze was penetrated, then 102 m of Oligocene to late Eocene silty sand and clay, and the hole bottomed in pillow basalt. As at site 280 the detrital sediments of late Eocene to early Oligocene age suggest restricted circulation, and increasing biogenic deposition within the Oligocene suggests development of more open-ocean conditions.

At site 283 in the central Tasman Sea in 4766 m of water, 592 m of late Eocene to (?) late Cretaceous ooze and silty clay was penetrated; this overlies highly altered basalt. It is believed that non-deposition during the Oligocene and Neogene was due to persistent bottom currents in the central Tasman Sea, and that all the sediments are pelagic.

Previous bathymetry

The most recent bathymetric chart of the area is that by Hayes & Conolly (1972). They compiled the data from various oceanic soundings charts of the southeast Indian Ocean into one map. A summary of their description of the Australian continental margin follows.

The Tasmania Ridge, or 'South Tasman Rise' (see Appendix II) divides the continental margin of Australia here into two parts, the southeastern margin which flanks the Tasman Sea, and the southern margin which flanks the southeast Indian Ocean. Both margins have a narrow continental shelf and steep, rugged continental slope. Both are dissected by canyons which run down the slope to the abyssal plain below. The most extensive canyon system is the one off the eastern Bass Strait which has several tributaries and carries sediment down to build a sediment fan at 4000 m to 5000 m depth at the canyon mouth on the edge of the Tasman Abyssal Plain.

The Tasmania Ridge extends about 1000 km to the southeast of Tasmania. Its plateau-like surface lies 1500 m to 3000 m below sea level and there are steep scarps at its east and west sides. The west side is especially steep; between latitudes 46° and 48°S it rises 2400 m at an angle of 20°. This face is parallel to the Tasman Fracture Zone which continues across the southeast Indian Ocean to intersect the ridge system (Hayes & Conolly, op. cit.).

The East Tasman Plateau of Hayes & Conolly is named the Cascade Plateau in this report. This also has steep scarp-like sides, and Hayes & Conolly consider that this plateau and the Tasmania Ridge form one horst and graben complex which began to develop with initial rifting in the Jurassic and continued through renewed basaltic volcanic activity in the Tertiary.

Previous geophysics

There have been many detailed offshore geophysical surveys over the continental shelf, in particular over the Gippsland, Bass, and Otway Basins. A few surveys have extended over the continental slope; some results, which have a regional application, are mentioned below.

The Offshore Tasmania Aeromagnetic Survey by Esso Exploration and Production Australia Inc. and Electrolytic Zinc Co. Aust. Ltd. (1966) found that most of the offshore magnetic anomalies were a seaward extension of magnetic basement recorded onshore. Two areas of possible sedimentary deposit were located, (a) to the southwest of Tasmania within the 100-fathom line with a depth of 400 m to basement, and

(b) to the south of Tasmania where the magnetic basement appears to lie at a depth of 3300 m. Smaller zones of deep magnetic basement (3000 m) occur along the east coast.

BMR conducted an aeromagnetic survey over Tasmania and out to 120 km from the coast (Finney & Shelley, 1966). Twenty east-west high-altitude lines were surveyed at a line spacing of 16 km. The eastern offshore area showed a more disturbed magnetic field than the west. Magnetic anomalies recorded off the east coast were interpreted to be caused by volcanic intrusions at the foot of the continental slope. The magnetic basement off the west coast was interpreted to gradually deepen offshore, lying not far below the seabed.

One long line parallel to the west Tasmania coast was surveyed during the Tasmania EE-68 seismic survey (Esso Exploration and Production Australia Inc., 1968). The line was inside the continental shelf break, and using a 12-fold Aquapulse system the company was able to record good reflections down to basement. Seismic basement was shallow over the southern one-third of the line, but opposite Macquarie Harbour the basement dropped to about 2500 m (2.0 s reflection time) in a graben-type structure. The basement along the northern end of the line to opposite King Island is about 1000 m deep.

The Esso Offshore Gippsland Basin marine seismic survey EC-67 (Esso Exploration and Production Australia Inc., 1967) is considered typical of the many detailed seismic surveys in Bass Strait. The 6-fold CDP recording technique, using either an air gun or dynamite source, gave good reflections down to seismic basement. This survey was over the southwestern flank of the Gippsland Basin, and mapped the basement which dipped to the northwest into the basin and was disrupted by many northwest-striking normal faults. Reflections from the top of the Lakes Formation (Oligocene) and from the top of the Latrobe Delta Complex (Eocene) were also mapped.

4. BATHYMETRY RESULTS

The water depth contours are shown in Plate 5. The main topographic features shown on the map are the narrow continental shelf, the steep continental slope, the Tasmania Ridge, and the Cascade Plateau.

The continental shelf is narrow, 20 to 40 n miles wide except within and adjacent to Bass Strait. In general the shelf is narrower along the east coast of NSW and Tasmania than along the west coast of Tasmania and the coast of Victoria. The morphology of the continental shelf in this area is described by Davies & Marshall (1973).

The continental slope on the eastern margin of Bass Strait and Tasmania and off NSW is generally steeper and more rugged than along the western margin. The steepest continental slope occurs off NSW, where it dips smoothly at about 12° to 3000 m where the water bottom becomes rugged but has a lower average gradient. Line 12/009 off Eden shows a slope of 15°, which is the steepest continental slope recorded during the survey. Line 12/014 near the foot of the slope at the extreme north of the map shows minor canyons which may run down the slope, but no other canyons were recorded in this area.

To the east of Bass Strait the continental slope is extensively modified by the Bass Canyon; line 14/070 crosses this canyon where it is 1100 m deep and 10 n miles wide from shoulder to shoulder. Several other lines in this area cross smaller canyons which may be tributaries to the Bass Canyon. Thick sediments were recorded at the foot of this canyon, showing that it is a major route for sediment transportation.

The continental slope east of Tasmania has an average gradient of about 3°, but the upper part of the slope is generally steeper, and lines 15/003 and 15/005 show a gradient of up to 11°. On the lower part and near the foot of the slope, basement outcrops give rise to rugged topography. The tie-lines in this area run at the top and bottom of the slope and not along it, thus no canyons could be seen on the slope.

The survey lines south of Tasmania run along the slope, but only two minor canyons were recorded. The slope has an average gradient of 2°, and at the southwest corner basement faults and highs control the seabed topography.

The western slope of Tasmania has an average gradient of 3.5°. The slope is generally fairly smooth and sediment-covered, but in scattered places along the foot of the slope basement crops out and produces a more rugged surface. At the extreme south end of line 16/037 the basement protrudes 300 m above the sediment-covered slope.

To the northwest of Tasmania and south of Victoria the survey lines run at an angle to the continental slope. The average slope is only 2.5°. Many large canyons cut into the deep sediments, but the line spacing is too large to trace the routes of the canyons and to detect any tributary system. It is possible that the other areas of the continental slope have canyons which were not recorded owing to the orientation of the survey lines.

Very few lines extended onto the continental rise in the area. Lines 12/007, 15/031, and 15/032 off NSW recorded a gentle rise which reached the abyssal plain at 4600 m depth. Line 15/062 which was surveyed out across the Tasman Abyssal Plain recorded a flat terrace for 20 n miles, then the seabed dipped gently out to 65 n miles from the foot of the slope. However, this is exceptional and will be discussed in the seismic results.

East of Tasmania the lines extended a short way onto the continental rise which began at a depth of about 4000 m. No rise can be seen on the seismic sections to the west of Tasmania, where the continental slope extends to beyond 4000 m, the maximum depth surveyed.

The Tasmania Ridge is joined to Tasmania by a smooth saddle about 3200 m deep. The ridge is a rugged feature about 100 n miles wide which extends southwards beyond the limit of the survey area. It appears to be built of a number of north-trending basement ridges whose east and west margins are fault-controlled. Flat-lying sediments fill the valleys between the ridges. The western margin is very steep, and most likely has a faulted origin; from the abyssal plain at 4800 m depth there is an abrupt rise to about 2500 m at an average gradient of 16°. Several peaks on the Tasmania Ridge reach a depth of 2000 m. A broad channel with a smooth sediment-covered floor lies to the east of the Tasmania Ridge, and separates it from the Cascade Plateau.

The Cascade Plateau lies to the east of south Tasmania, separated from the mainland by a broad 3300-m deep channel. The plateau is about 80 n miles in diameter, and its surface rises smoothly to an average depth of about 2800 m; however, the smooth seabed is broken by the central peak which rises to a depth of 1200 m. The eastern side of the plateau is much steeper than the other three, and may have a faulted origin. On line 11/006 the eastern margin of the plateau drops by 1500 m at a gradient of 14°.

The few lines that cross the Tasman Abyssal Plain recorded a smooth surface with an almost imperceptible eastward dip out to 130 n miles from the foot of the continental slope. Farther east the seafloor becomes progressively more rugged as the abyssal hills are approached, with hard oceanic basement ridges which rise up to 750 m above the average seabed level.

On line 15/062 at 154°E (survey time 15.85.1400) a peak rises to 2400 m; 2500 m above the seabed, this is possibly one of the southernmost seamounts of the Tasmantid Seamount Chain. Line 15/061 lies entirely within the rugged abyssal hills zone.

5. GRAVITY RESULTS

The Bouguer anomaly contours are shown in Plate 6. The most noticeable features on this map are the regional gradient which lies over the continental slope, and the two regional gravity depressions, one over the Tasmania Ridge and the other over the Cascade Plateau.

The regional gravity gradient is generally wider than the corresponding continental slope, and in most of the area the gravity field over the continental shelf is dominated by the gradient. However, over the shelf to the north of Flinders Island a westerly-trending gravity high is superimposed on the regional gradient. This is probably associated with the basement high to the south of the Gippsland Basin. The Bouguer anomaly values south of Tasmania show small highs which occur over the shallow basement here. At the western end of Bass Strait a gravity low lies to the south of King Island; this low correlates with the deepening of the metamorphic basement. A complex pattern of gravity highs to the west of King Island is probably associated with shallow metamorphic basement. Over the shelf north of King Island in the region of the Otway Basin there are indications of a gravity low superimposed upon the regional gradient.

The regional gravity gradient is most likely caused by the change in crustal thickness from the continent to the ocean. The gradient is steeper along the east side of Bass Strait and Tasmania than along the west side, which seems to indicate that the change from continental to oceanic crust is more abrupt on the east side. The average gradient east of Eden is about 2 mGal/km; to the east of Bass Strait the gradient is modified by the gravity effects of the Gippsland Basin and also probably by the effect of the Bass Canyon and its related sediment apron. To the east of Tasmania the average Bouguer anomaly gradient is about 2 mGal/km; to the west of Tasmania the average gradient is only 1 mGal/km and it decreases farther to the northwest of the map area. The regional gradient contours west of Tasmania are quite contorted. Several minor positive anomalies are superimposed on the regional gradient, and correspond to basement highs seen on the seismic sections. The oval-shaped positive anomaly of +170 mGal about 50 n miles southwest of Tasmania also marks a basement high at the base of the continental slope.

A regional gravity depression with values of about +110 to +120 mGal is associated with the Tasmania Ridge and the gravity field here is separated from that of Tasmania by a gravity ridge of about +140 mGal. The west side of the

Tasmania Ridge is marked by an exceedingly steep gravity gradient of 11 mGal/km. The gravity contours over the Ridge show a faint northerly trend.

The Cascade Plateau also has an associated regional gravity depression with Bouguer anomaly values of +110 to +120 mGal; there are no steep gravity gradients in this area and no particular trend or pattern can be discerned in the contours. The central peak of the Cascade Plateau has an associated free air anomaly of +50 mGal; the Bouguer correction, which was made assuming a flat infinite slab of density 2.2 g/cm^3, has removed the gravity anomaly over this peak. At first glance this may seem surprising as the seamount is probably composed of igneous or metamorphic rocks with a density of 2.6 g/cm^3 or more and one would expect a residual Bouguer anomaly over it. However, the simple Bouguer correction does not take account of the terrain effect which would be significant over a small-diameter steep-sided seamount. A computer calculation of the gravity effect of the seamount using a density of 2.6 g/cm^3 and considering the approximate profile of the seamount yields a figure very similar to that actually applied by the simple Bouguer correction.

A simple estimation of crustal thicknesses in the area has been made from the gravity anomaly values. Assuming a standard continental crustal thickness of 33 km and assuming isostatic equilibrium, the Tasmania Ridge and the Cascade Plateau appear to have an intermediate crustal thickness of about 20 km. The Bouguer anomaly map shows that the crust may thin slightly before thickening again under the Tasmania Ridge.

The remote survey lines across the Tasman Sea recorded Bouguer anomaly values which are constant at about +200 mGal from the foot of the continental slope out to 156°E; the north-south line 15/061 gives values of about +230 mGal. This change in Bouguer anomaly value is probably related to the sudden thinning of sediments over the more rugged parts of the abyssal hills at the east of the map.

6. MAGNETIC RESULTS

The magnetic anomaly contours are shown in Plate 7. The anomalies are generally small features, about 20 to 100 km across, which are superimposed on a background field of about -200 nT. The rapid fluctuations, sometimes about 100 nT in 3 km, which were recorded in places on the continental shelf do not appear on the map because the contours are drawn using hourly measurements and give insufficient detail.

Over the eastern Bass Strait the magnetic field shows the broad low-amplitude anomalies that would be expected because of the large depth to magnetic basement beneath the Gippsland Basin. The basement high to the north of Flinders Island which forms the southern margin of the Gippsland Basin does not appear to have any strong magnetic expression.

On the continental shelf west of Tasmania, a magnetic dipole anomaly of -50 and -350 nT north of Macquarie Harbour probably marks a basement high. The anomalies to the west and south of King Island are examples of a disturbed magnetic field pattern caused by the shallow metamorphic and igneous basement on the continental shelf. The smaller features are not shown on the map, as explained above, but a very high magnetic gradient is apparent.

The continental shelf west of Bass Strait and south of Victoria is magnetically quiet as would be expected from the great depth of sediments in the Otway Basin.

The continental slope in the survey area is marked by separate groups of intense magnetic anomalies. The east side of Tasmania and Bass Strait shows a more disturbed magnetic field than the south or west.

The continental slope of NSW at the northern edge of the map shows a group of intense magnetic anomalies with values ranging from -200 to +1150 nT. The seismic sections show shallow basement in places, but it should be noted that there are areas with shallow seismic basement elsewhere on the slope which do not have associated intense magnetic anomalies. To the east of Bass Strait several positive magnetic anomalies were recorded over the foot of the continental slope. These are the most northerly in a chain of positive magnetic anomalies which stretches down the east coast of Tasmania to the latitude of Hobart. At the foot of the continental slope off eastern Bass Strait and off Flinders Island the seismic sections show a north-trending line of basement highs, possibly igneous bodies, and these are the probable source of the magnetic anomalies here.

Another group of positive magnetic anomalies with values up to +650 nT lies about 30 n miles off the east coast of Tasmania north of 43°00'S. These also correlate with intrusive-type features which intrude into the sediments of the continental slope.

The western continental slope off Tasmania, Bass Strait, and south of Victoria is magnetically quiet. This could indicate an appreciable thickness of sediments, or, because seismic basement appears to be shallow at the foot of the slope off the southwest tip of Tasmania, the basement is probably of a different composition to that which causes the intense magnetic anomalies off the east coast.

A large dipole magnetic anomaly with values ranging from -450 to +200 nT is associated with the faulted western margin of the Tasmania Ridge. There is a faint northerly trend to the magnetic field contours over the Tasmania Ridge. The magnetic anomaly of +250 nT correlates well with one of the topographic peaks on the ridge. The area between the Tasmania Ridge and Cascade Plateau is magnetically quiet, probably owing to the greater water depth and sedimentary cover.

The Cascade Plateau is an area with a more disturbed magnetic field, particularly over its eastern margin. The magnetic features all appear to be associated with the basement highs seen on the seismic section. The magnetometer chart for line 11/006 shows a broad peak located on either side of the central seamount of the Cascade Plateau, while the broad central magnetic low is broken by a very sharp magnetic peak. This central magnetic peak occurs at survey time 11.05.1630 and does not appear on the contour map owing to the hourly sampling interval. A comparison of the magnetometer chart and the seismic section shows a correlation between the two broad magnetic highs and basement highs, and the sharp central magnetic peak may be caused by a dyke or igneous plug at the top of the seamount.

The remote survey lines in the Tasman Sea recorded a magnetic field characterised by low-amplitude short wavelength anomalies. The low amplitude is probably due to the deep water. The survey line spacing was much too great to detect any magnetic lineations, and no symmetry in the magnetic profiles has been detected which would be indicative of sea-floor spreading.

7. SEISMIC RESULTS

Some representative reduced seismic cross-sections are shown in Plate 8, and a sketch of sediment distribution in Plate 9. Sediment thicknesses are calculated assuming a sediment velocity of 2000 m/s.

Continental Shelf

The continental shelf is widest in the Gippsland Basin where up to 4000 m of sediments is visible on multiple-coverage seismic sections (Esso Exploration and Production Australia Inc., 1967). However, only 2000 m of sediments is visible on the BMR single-channel monitor sections, the quality of which is adversely affected by multiple reflections and reverberations. Drilling results from Sailfish No. 1 northeast of Flinders Island (Gardner, 1972) enables the identification of one prominent reflector at a depth of 1000 m as the top of the Eocene (Section C-C', Plate 8). The basement appears to outcrop under about 150 m of water between Flinders Island and Tasmania. North of Flinders Island there appears to be a basement high, but the seismic section is too confused by multiples to determine the basement depth.

The seismic results from line 15/026 along the Bass Strait show that the sediments thicken from zero near Flinders Island to at least 2500 m at the west end of the line; again multiple reflections obscure true events.

The sections across the shelf of eastern Tasmania show a wedge of sediments increasing to a thickness of about 500 m at the top of the continental slope (section D-D', Plate 7).

South of Tasmania the shelf has only thin sedimentary cover of about 200 m, which varies slightly with the small undulations in the basement. In places the basement appears to outcrop, giving some slight relief to the otherwise flat shelf.

Records from the shelf off southwest Tasmania show only 100 to 200 m of sediment overlying shallow basement. This thickness appears to increase as the continental slope is approached, but basement is difficult to identify in places. (See section B-B', Plate 8).

On the shelf northwest of Tasmania, south of King Island, lines 16/019 and 16/021 cross the King Island Sub-Basin. The Esso drill-hole Clam No. 1 (Lunt, 1969) intersected basement identified as Precambrian low-grade metamorphic phyllite at a depth of about 1500 m. The basement reflection near the drill-hole can be readily identified on line 16/019, and rises to 800 m about 10 km to the west. The basement then remains level at 800 m depth until it plunges beneath the continental slope. This rise forms the western boundary of the King Island Sub-Basin, and the eastern boundary is formed by the King Island High between King Island and Tasmania.

Line 16/034 along the west continental shelf of Tasmania crossed several sedimentary basinal areas. Opposite Macquarie Harbour the seismic section shows reflections which dip down towards 2000 m depth, but seismic basement is not visible and may be much deeper than this. Line 16/034 also shows reflections up to 1500 m deep in the King Island sub-basin and the Otway Basin. Folded and dipping reflections which display a sedimentary character can be seen, but again no reflection can be identified as basement.

The basement ridge separating the Bass and Otway Basins extends north of King Island, and is visible on the eastern end of lines 16/025 and 16/027 (Section A-A', Plate 8).

Continental Slope

The thickness of the sediments on the slope of the eastern margin is less than 1000 m, and generally ranges from 200 to 600 m above a rugged basement. A line of basement highs, halfway down the slope, extends from line 15/003 (see section D-D', Plate 8) to line 15/021 (section C-C', Plate 8). These basement highs could mark a major fault plane on the continental slope. Basement highs which protrude well above the seabed occur at the junction of the slope and abyssal plain on lines 15/023 and 15/024. This junction is often abrupt (e.g. Lines 15/013, 015, 019, 023), and on several sections the abyssal plain oceanic basement can be seen abutting against the basement of the continental slope; thus the junction may be fault-controlled.

To the southwest of Tasmania a northwest-trending trough containing a maximum thickness of 1400 m of sediments can be seen on lines 11/002, 009, and 011. Basement highs on the east and west margins of the trough limit it to a width of 40 km at line 11/002, and 15 km at line 11/011. The east and west boundaries may be fault-controlled; the north and south extent of this feature cannot be traced any farther than lines 11/002 and 11/011.

The continental slope on the western margin has thick sedimentation (at least 1500 m); however, the basement reflection cannot be seen on many seismic sections (see section B-B', Plate 8).

In the area to the north of latitude 42°20' there are indications of a widespread angular unconformity (Plate 8, Section A-A'). About the first 400 m of section appears as a well layered sequence of reflections which changes, usually abruptly, to a sequence of less horizontally-continuous and weaker reflections. This sequence appears more transparent than the overlying sequence. The thickness of the overlying bed may vary from 200 to 600 m, depending on the seabed topography. South of Macquarie Harbour although thick sediments are present this unconformity is not apparent, but this may be due to poorer-quality sections.

A basement high, possibly an igneous body, is present on the western ends of lines 16/019, 023, and 025. To the eastern side of this basement high, a small anticline about 10 km across is visible in the reflections below the unconformity. Possible igneous outcrops rise about 400 m above the general level of the seabed at the foot of the slope on the western end of lines 16/003, 007, and 009.

Tasmania Ridge

The basement topography of the Tasmania Ridge is rugged, and the sediment cover thin, except within some small deep pockets.

These pockets are about 30 km across, up to 1600 m deep, and an unconformity within the sediments shows evidence for two periods of sedimentation. The margins of some may be fault-controlled. Section F-F' of Plate 8 shows the structure across the Tasmania Ridge.

Cascade Plateau

On the Cascade Plateau the sediments are fairly continuous and average cover varies from about 500 to 1000 m with some deeper pockets. The basement is generally rugged. A basement high forms the central seamount on the plateau. It appears from the seismic sections that the basement structures were formed before the sediments were deposited. There is no upward deformation of the sediments close to the basement highs; on the contrary, there appears to have been a channelling effect which eroded or prevented deposition of these sediments. Part of section E-E' of Plate 8 is across the southern part of the plateau.

Other areas

The greatest volume of sediments south of Tasmania occurs in the broad channel between the Tasmania Ridge and Cascade Plateau. Horizontally-bedded sediments, with an average thickness of at least 1200 m, extend across the channel. Resolution of the seismic reflections in the channel is poor, and basement is not visible.

The abyssal plain, at a depth of about 4500 m, is generally flat. Between 1000 and 2000 m of flat-lying sediments cover basement, and abut against the continental slope and the lower slopes of the ridge and plateau areas. Two sedimentary regimes can generally be distinguished. The upper generally shows a fairly continuous sequence of reflections, while the lower shows a lack of reflections and is termed 'transparent'.

The seismic section along line 15/062 shows the change in sedimentary character which occurs from west to east across the Tasman Abyssal Plain. A flat terrace which is formed of well stratified sediments abuts against the foot of the continental slope and extends about 20 n miles from it. From the edge of the terrace, where the stratified layer is 800 m thick overlying 1000 m of 'transparent' sediments, there is a gradual drop in the sea floor to the abyssal plain. The uppermost stratified layers terminate at the terrace edge, and re-appear to form the top 200 m of sediments in the abyssal plain. Farther east towards the abyssal hills the stratified layer pinches out, and only the transparent layer remains.

It is possible that there were two sources or two transportation routes for the two areas of stratified sediments. The sediments which form the terrace may have been deposited via the Bass Canyon as this is the only area in which such a terrace is seen. The sediments in the abyssal plain are probably derived from the continent or continental margin as they do not appear farther away from the continent. They have possibly been transported from the continental margin off NSW and then southwards to cover the abyssal plain.

The remote survey lines across the abyssal hills of the Tasman Sea recorded a generally rugged basement with 500 to 1000 m of sedimentary cover. Only one sedimentary layer can be distinguished as the seismic data quality is fairly poor.

The results of the seismic refraction probes are tabulated in Appendix IV. No estimates of depth or dip of refractors has been made. Refraction velocities in the range 1750 to 4000 m/s were measured in sediments, and in the range 5000 to 6500 m/s in probable basement.

8. INTERPRETATION AND CONCLUSIONS

Around much of the narrow continental shelf of Tasmania and off NSW, the seismic sections show a wedge of sediments which thickens to about 500 m at the top of the continental slope.

Seismic reflections are visible on the sections from the Gippsland Basin down to a reflection time of about 2 s. It is possible to identify some of the reflectors by comparison with the drilling results of wells such as Sailfish No. 1 (Gardner, 1972); some reflectors appear to be continuous from the shelf and down much of the continental slope.

The Bass Canyon and its tributaries appears to be a major route for the transportation of sediment from the continental shelf of eastern Bass Strait down onto the Tasman Abyssal Plain where the sediment forms a terrace 20-n miles wide at the foot of the continental slope.

Along the continental shelf west of Tasmania the sediments thicken to at least 2000 m opposite Macquarie Harbour and to about 1500 m in the King Island Sub-Basin.

The Bouguer anomaly contours opposite Macquarie Harbour show a gentle west-trending trough superimposed on the regional gradient, and this is most likely caused by the thicker sediments. The King Island Sub-Basin is apparent on the Bouguer anomaly map as a minor gravity low, and the northern igneous basin margin is marked by very intense magnetic anomalies.

Deep seismic reflections, a quiet magnetic field, and a gravity low and broadening of the regional gravity gradient over the continental shelf south of Victoria are all indicative of the deep sediments of the Otway Basin. However, none of the data indicate the southerly extent of these sediments down the continental slope.

Seismic, bathymetry, and gravity data show that the eastern continental margin of Tasmania is more abrupt than the western margin. The regional gravity gradient is steeper along the east margin than along the west, the eastern continental slope is steeper than the western, and in places the abyssal plain terminates abruptly against the eastern continental slope.

Most of the data point to tensional forces and rifting in the development of the continental margin. A line of basement highs which have a strong associated magnetic field lies on and at the foot of the eastern continental slope, stretching from off NSW to opposite Hobart. These rocks are probably of Jurassic age, equivalent to the Jurassic igneous intrusions and dolerites found onshore. The initial rifting on the ancient continent of Gondwanaland, and the separation of the Australian and Antarctic contents began in the mid-Jurassic (Griffiths, 1971). The basement ridges could be igneous bodies which have developed along the lines of weakness and fault planes in the crust at this time. North-trending faults and graben-type rifts such as the one to the southwest of Tasmania are visible on the seismic sections across the continental slopes.

The date of the angular unconformity which is visible on the seismic sections of the continental slope in the northwest of the map area is uncertain. It could be genetically related to the Oligocene unconformity found at the JOIDES site 281 on the Tasmania Ridge (Kennett et al., 1973). At site 282 there is a lithologic change during the early Oligocene from silty sand and clay to nanno-ooze, from which it can be inferred that the restricted and terrigenous sedimentation gave way to pelagic sedimentation as the rift between the Australian and Antarctic continents widened. Thus the lower, more transparent seismic layers below the unconformity may be Eocene to Oligocene silty sands and clays, while the upper stratified layers may be nanno-ooze.

The gravity results on the Tasmania Ridge and Cascade Plateau show that the crust has an intermediate thickness of about 20 km. The basement of the Tasmania Ridge is rugged, and sediments occur only in scattered pockets. Magnetic features on the ridge do not correlate closely with basement topography and the ridge is probably not entirely an igneous feature but a metamorphic, continental block similar in age and composition to the Precambrian rocks of western Tasmania. This is confirmed by the results from Joides hole 281 of Leg 29. The steep western flank of the ridge is probably part of a north-trending fault and rift system.

The Cascade Plateau has in general between 1000 and 1500 m of sediment cover. Igneous intrusions on the plateau give rise to prominent topographic, seismic, and magnetic features. The steep eastern flank of the plateau, and the steep magnetic gradients there, may be due to normal faulting along the eastern margin. The close relation between the Bouguer anomaly and magnetic anomaly patterns and the similarity in the appearance of seismic basement between the Cascade Plateau and the Tasmania Ridge leads to the conclusion that, like the Tasmania Ridge, the Cascade Plateau is underlain by continental crust. The plateau may have been partly separated from the Australian continent during the initial rifting along the east margin, and then left attached to the Australian plate as the Tasman Sea opened in the early Palaeocene (Griffiths & Varne, 1972).

The broad channel between the Tasmania Ridge and Cascade Plateau contains at least 1000 m of sediments. This channel can receive sediments from three different sources; the Cascade Plateau, the Tasmanian continental slope, and the Tasmania Ridge, hence it is more likely to contain thick sediments than other deep-water areas around this part of the continental margin.

A crustal thickness of about 15 km is estimated for the abyssal plain and abyssal hill areas of the Tasman Sea. The survey lines probably did not extend far enough across the Sea to record any magnetic pattern that might point to sea-floor spreadings. The basement becomes increasingly rugged and the sediments thinner away from the coast and by about 155°E the basement peaks penetrate through the sediments to form the abyssal hills.

This survey has provided a large volume of data upon which much detailed interpretation remains to be done. A gravity survey of Bass Strait is now required to complete the gravity coverage of this part of Australia. The Tasmania Ridge south of Latitude 46° is recommended as an area for future marine surveying to complete the work there abandoned by this survey owing to bad weather.

Geological samples from the continental slope are now needed in order to identify and date the seismic reflectors and provide a further step in unravelling the history of this area of the Australian continental margin.

9. REFERENCES

BRANSON, J.C., in prep. - Eastern Tasmania and NSW coast, continental margin survey preview report. Bur. Miner. Resour. Aust. Rec. (unpubl.).

CGG, 1974 - Marine geophysical survey of the continental margins of Australia, Gulf of Papua, and Bismarck Sea, 1970-73: equipment description. Bur. Miner. Resour. Aust. Rec. 1974/111 (unpubl.).

CONOLLY, J.R., 1969 - Western Tasman sea floor NZ J. Geol. Geophys, 12, 310-43.

DAVIES, P.J., & MARSHALL, J.F., 1973 - BMR marine geology cruise in Bass Strait and Tasmanian waters - February to May, 1973. Bur. Miner. Resour. Aust. Rec. 1973/134 (unpubl.).

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC., & ELECTROLYTIC ZINC CO. AUST. LTD, 1966 - Offshore Tasmania aeromagnetic survey. Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. 66/4626 (unpubl.).

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC., 1967 - Gippsland Basin EC-67 marine seismic survey. Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. 67/11184 (unpubl.).

ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC., 1968 - Tasmania EE-68 marine, seismic, and magnetic survey. Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. 68/3013 (unpubl.).

FINNEY, W.A., & SHELLEY, E.P., 1966 - Tasmania aeromagnetic survey. Bur. Miner. Resour. Aust. Rec. 1966/139 (unpubl.).

GARDNER, W.M., 1972 - Well completion report, Sailfish No. 1 (for N.S.W. Oil and Gas Company N.L.) Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. 71/472 (unpubl.).

GRIFFITHS, J.R., 1971 - Continental margin tectonics and the evolution of southeast Australia. APEA J., 1971, 75-9.

GRIFFITHS, J.R., & VARNE, R., 1972 - Evolution of the Tasman Sea, Macquarie Ridge, and Alpine Fault. Nature, phys. Sci., 235(57), 83-6.

HAYES, D.E., & CONOLLY, J.R., 1972 - Morphology of the southeast Indian Ocean. Amer. Geophys. Un. Antarctic Oceanology II: Aust. - N.Z. Sector, Antartic Res. Ser. 19.

JONES, H.A., 1966 - Appraisal of the Lower Palaeozoic rocks of the southern part of the Tasman Geosyncline for phosphorite. Bur. Miner. Resour. Aust. Rec. 1966/226 (unpubl.).

KENNETT, J.P., HOUTZ, R.E., et al., 1973 - Deep sea drilling in the roaring 40s. Geotimes, July, 1973.

LUNT, C.K., 1969 - Well completion report, Clam No. 1 (for Esso Exploration and Production Australia Inc.). Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. 69/2016 (unpubl.).

REYNOLDS, M.A., 1965 - The sedimentary basins of Australia and the stratigraphic occurrence of hydrocarbons. Bur. Miner. Resour. Aust. Rec. 1965/196 (unpubl.).

SOLOMON, M., & GRIFFITHS, J.R., 1972 - Tectonic evolution of the Tasman Orogenic Zone, Eastern Australia. Nature, phys. Sci., 237.

TILBURY, L.A., in prep. - Western Tasmanian and eastern Great Australian Bight continental margin survey preview report. Bur. Miner. Resour. Aust. Rec. (unpubl.).

APPENDIX I

LOW-ACCURACY

During the following periods the gravity results are considered unreliable i.e. variations of 5 mGal or more occur in periods less than 10 minutes on the gravity trace.

SURVEY	DAY/TIME			HOURS
SURVEY 11	04 1900	to	06 1600	45
	22 1140		22 1500	3.20
	23 1600		23 2300	7
				55.20
SURVEY 14	72 0000		72 0100	1
	72 0400		72 1620	12.20
	74 2250		72 2400	1.10
	75 0000		75 1100	11
				25.30
SURVEY 15	07 1240		07 1800	5.20
SURVEY 16	02 0800		02 1300	5
	03 1300		03 1640	3.30
	12 1600		13 0200	10
	15 0200		15 2030	18.30
				37

TOTAL 117 h, 50 min

APPENDIX II

NOTES ON BATHYMETRIC NAMES

Tasmania Ridge Named by Conolly (1969), has also been named the 'South Tasmanian Rise' (Hayes & Conolly, 1972).

Cascade Plateau This is a new name proposed in this paper for the feature which has previously been named 'East Tasman Rise' (Hayes & Conolly, op. cit.).

APPENDIX III

COMPUTATION OF GRAVITY AND MAGNETIC ANOMALIES

Gravity

The free air anomaly is calculated from the observed gravity by correcting for the ship's motion in an easterly direction (eotvos correction) and subtracting the theoretical gravity value.

i.e. F.A.A. = observed + 7.5 v cos ϕ - theoretical

where 7.5 v cos ϕ = Eotvos correction

V = eastward velocity

ϕ = geocentric latitude.

To calculate the Bouguer anomaly, a water depth correction is made by adding the attraction produced if the water layer is replaced by a slab of material of density 2.2 i.e. the density of the underlying sediments. This removes the topographic effect and leaves as the main causes of the anomaly the basement topography and the crust mantle interface.

Magnetic

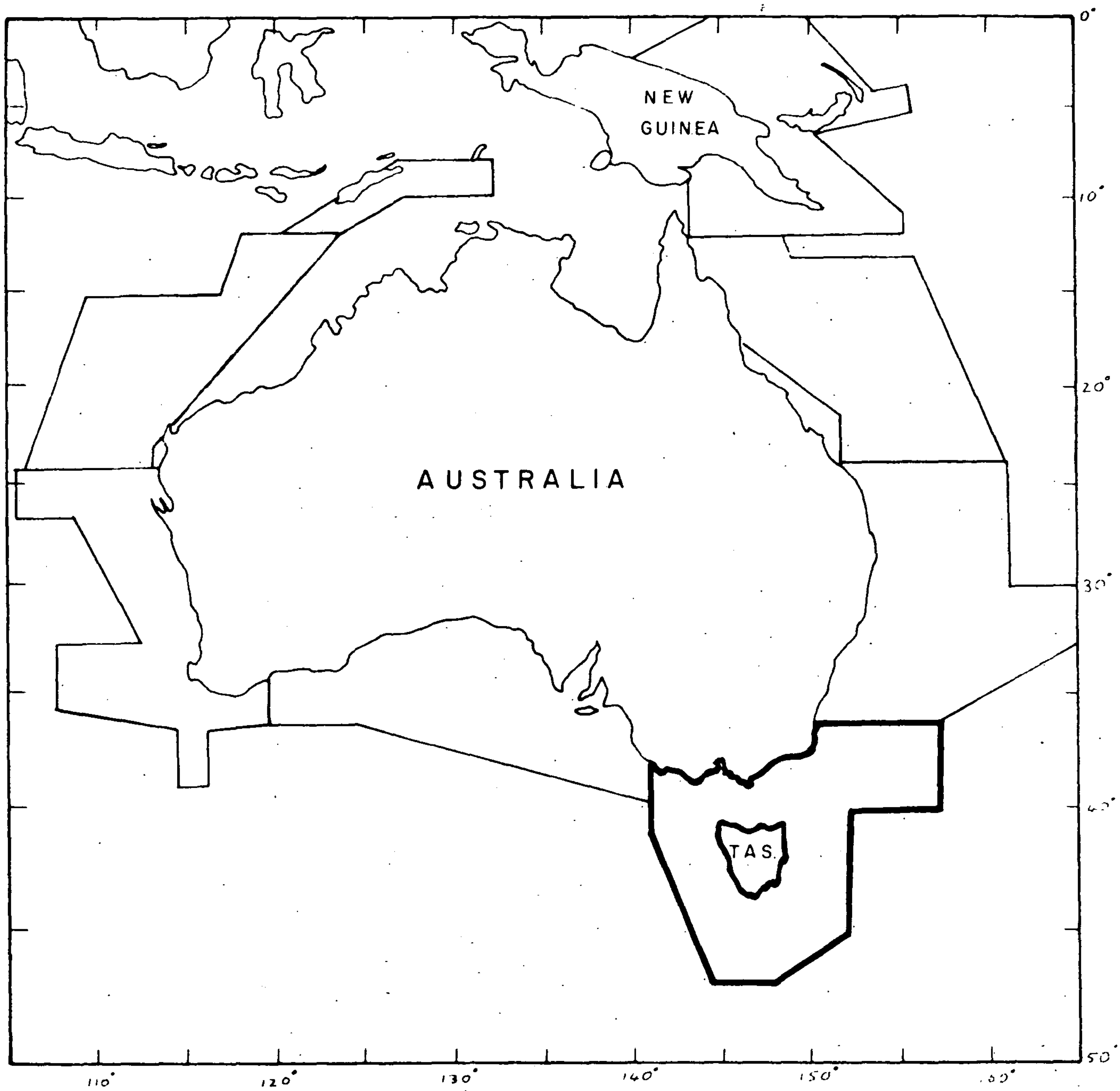
The magnetic anomaly is calculated from the absolute field value by subtracting the International Geomagnetic Reference Field (IGRF) and the diurnal. i.e. Anomaly = Absolute - IGRF - diurnal.

APPENDIX IV

REFRACTION PROBES

Survey No.	Day/Time	Duration (minutes)	Results (velocities in m/s)
11	11 0300	90	no refractions obtained
11	23 0000	90	no refractions obtained
11	32 0510	10	Sonobuoy failure:
			geophone did not release
11	32 0540	100	no refractions obtained
11	34 1214	155	no refractions obtained
15	09 0038	90	poor record
			1 fair refraction 5700 m/s
			1 poor refraction 2000 m/s
15	10 1553	70	2 refractions 5500 m/s
			2200 m/s
15	12 0209	85	3 refractions, poor resolution
			4000 m/s
			2200 m/s
			2100 m/s
15	15 0205	10	failure
15	15 0215	10	failure
15	15 0227	70	2 good refractions
			6500 m/s
			3000 m/s
16	05 0815	9	failure
16	05 1103	10	failure
16	06 0622	68	1 fair refraction 1750 m/s
			1 very weak refraction 300 m/s
16	09 0224	10	failure
16	09 0300	57	2 good refractions
			5000 m/s
			1900 m/s
16	12 0320	10	failure
16	13 2210	7	failure
16	14 0614	76	2 fair refractions
			3500 m/s
			2100 m/s
16		98	2 good refractions
			3500 m/s
			2700 m/s

PLATE 1



REPORT AREA

SCALE AT LAT. 0°

0 500 1000 km

GEOPHYSICAL RESULTS FROM
OFFSHORE TASMANIA

LOCALITY MAP

Record No. 1974/98 *Drawn by author* A/B8-74A

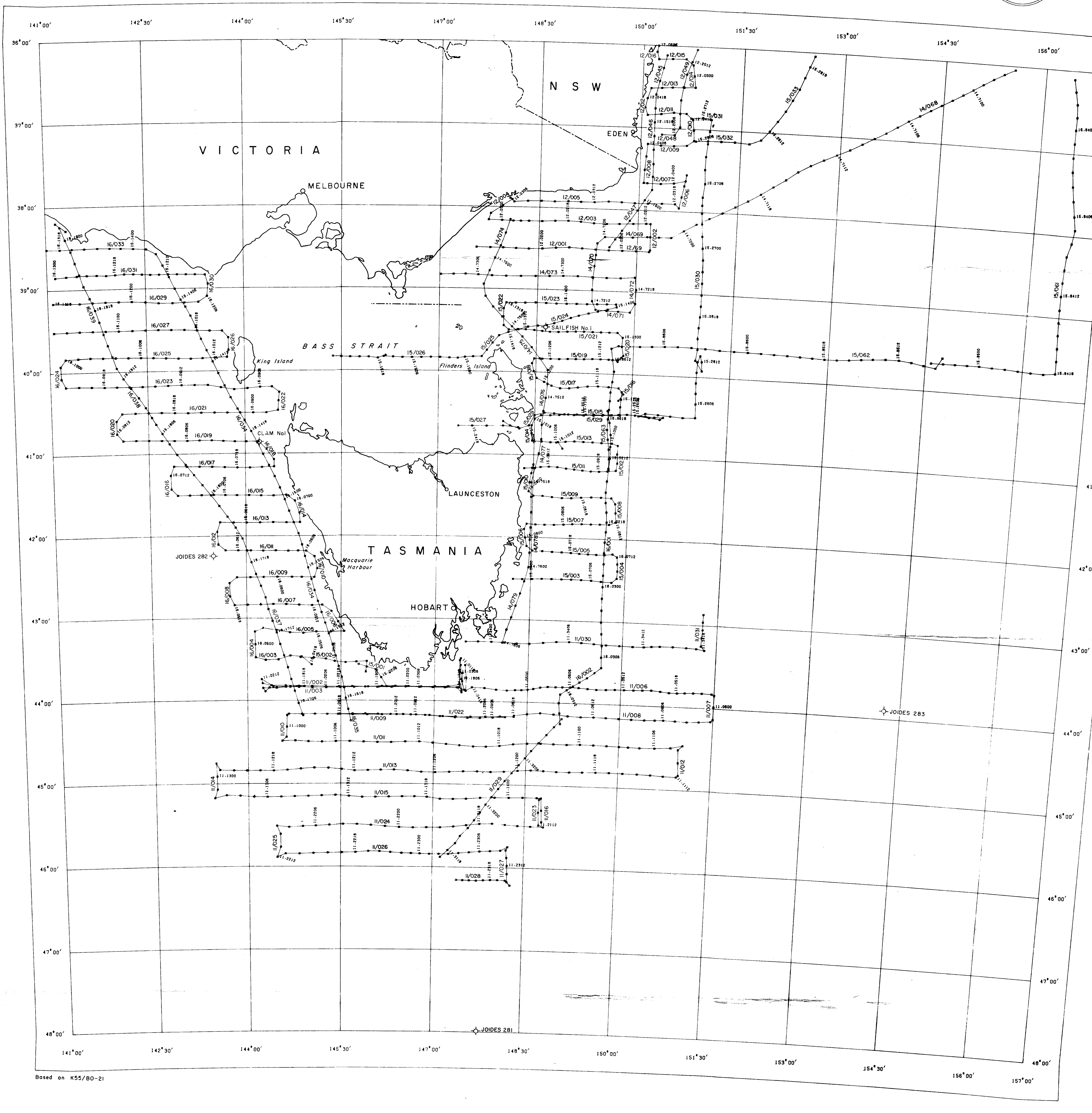
PLOTTED 73/09/12

TASMANIA

AUSTRALIA 1: 2,500,000

013071

PLATE 2



AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0′ AND 36° 0′ SOUTH

B M R 1970-73 MARINE SURVEYS

TASMANIA

TRACK CHART

AREA 4

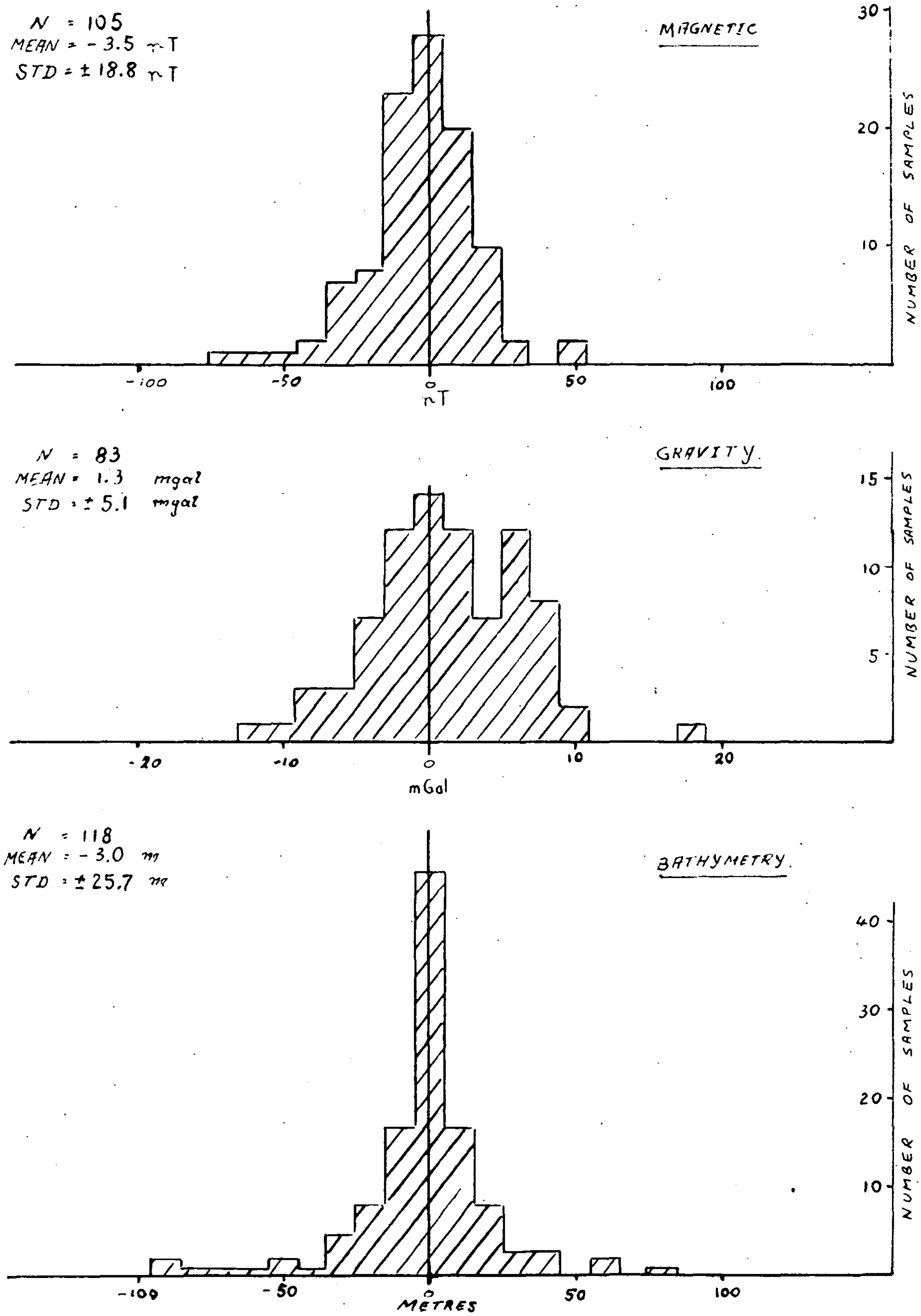
NOTE: The information contained in this map has been obtained by the Department of Minerals and Energy, as part of the policy of the Australian Government, to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus or statement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

KILOMETRES
50 0 50 100 150 200 250
0 50 100
NAUTICAL MILES

The ship's position is plotted from hourly values based on preliminary data and tied to the satellite navigation fixes. The track line is a linear interpolation between these hourly positions. No adjustments have been applied for misties at traverse intersections.

K55/B8-25-2

Record No. 1974/98

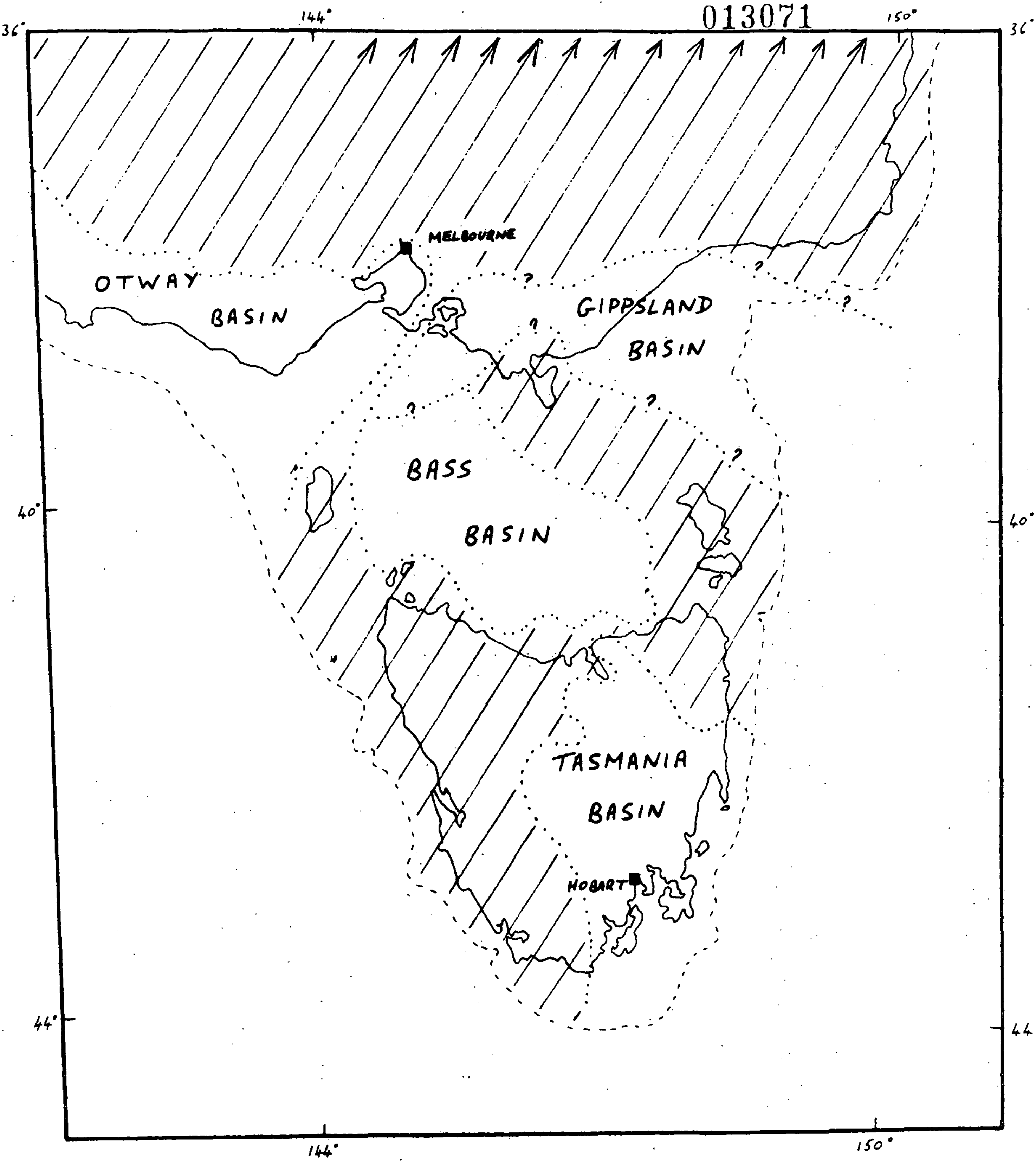


MAGNETIC, GRAVITY, & BATHYMETRIC MISTIES

Record No. 1974/98 Drawn by author K55/B8-26A

PLATE 4

013071



...... MAIN SEDIMENTARY BASIN BOUNDARY

– – – 200 METRE ISOBATH

/// MAINLY IGNEOUS AND METAMORPHIC ROCKS

0 100 200 300
KILOMETRES

SEDIMENTARY BASINS IN THE TASMANIAN REGION

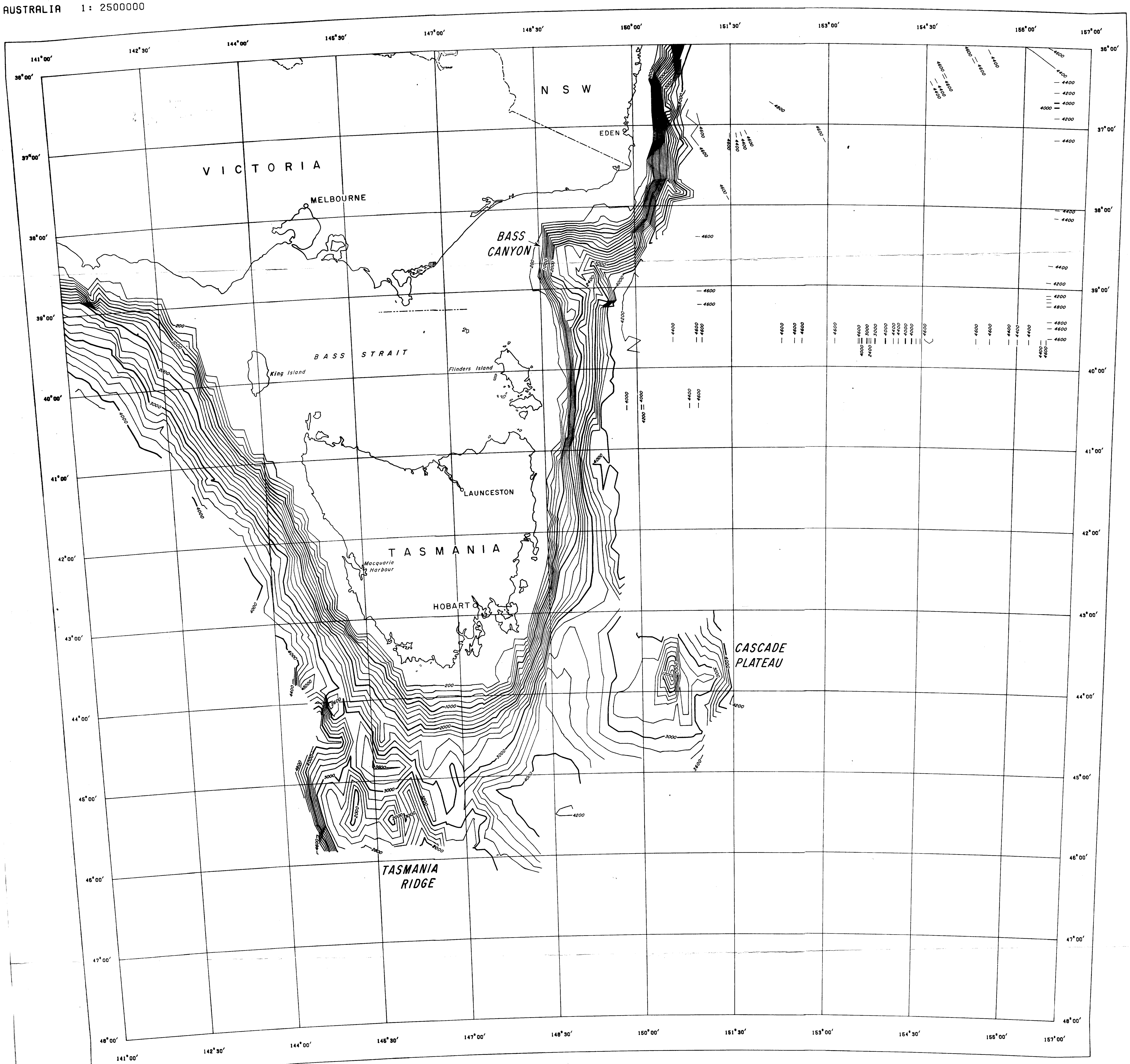
Record No. 1974/98 Drawn by author K55/B8-27A

TASMANIA

PLOTTED 73/07/26

AUSTRALIA 1: 2500000

PLATE 5



Based on K55/B0-21

B M R 1970-73 MARINE SURVEYS

WATER DEPTH (METRES)

AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

TASMANIA

AREA 4

K55/B8-24-1

NOTE: *The information contained in this map has been obtained by the Department of Minerals and Energy, as part of the policy of the Australian Government, to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus or statement without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.*

KILOMETRES
50 0 50 100 150 200 250
0 50 100
NAUTICAL MILES

Contour interval : 200 metres

Water velocity assumed constant at 1500 m/s

Data used are preliminary, and are based on hourly values extracted on board the survey vessel. No adjustments have been applied for misties at traverse intersections.

Contour lines are drawn by computer using a triangular contouring program. A triangular plate is defined by three adjacent stations whose circumscribing circle contains no other stations. Linear interpolation is then used on the other triangular plate. Should any side of an acceptable triangle exceed 40 nautical miles, that plate is not contoured.

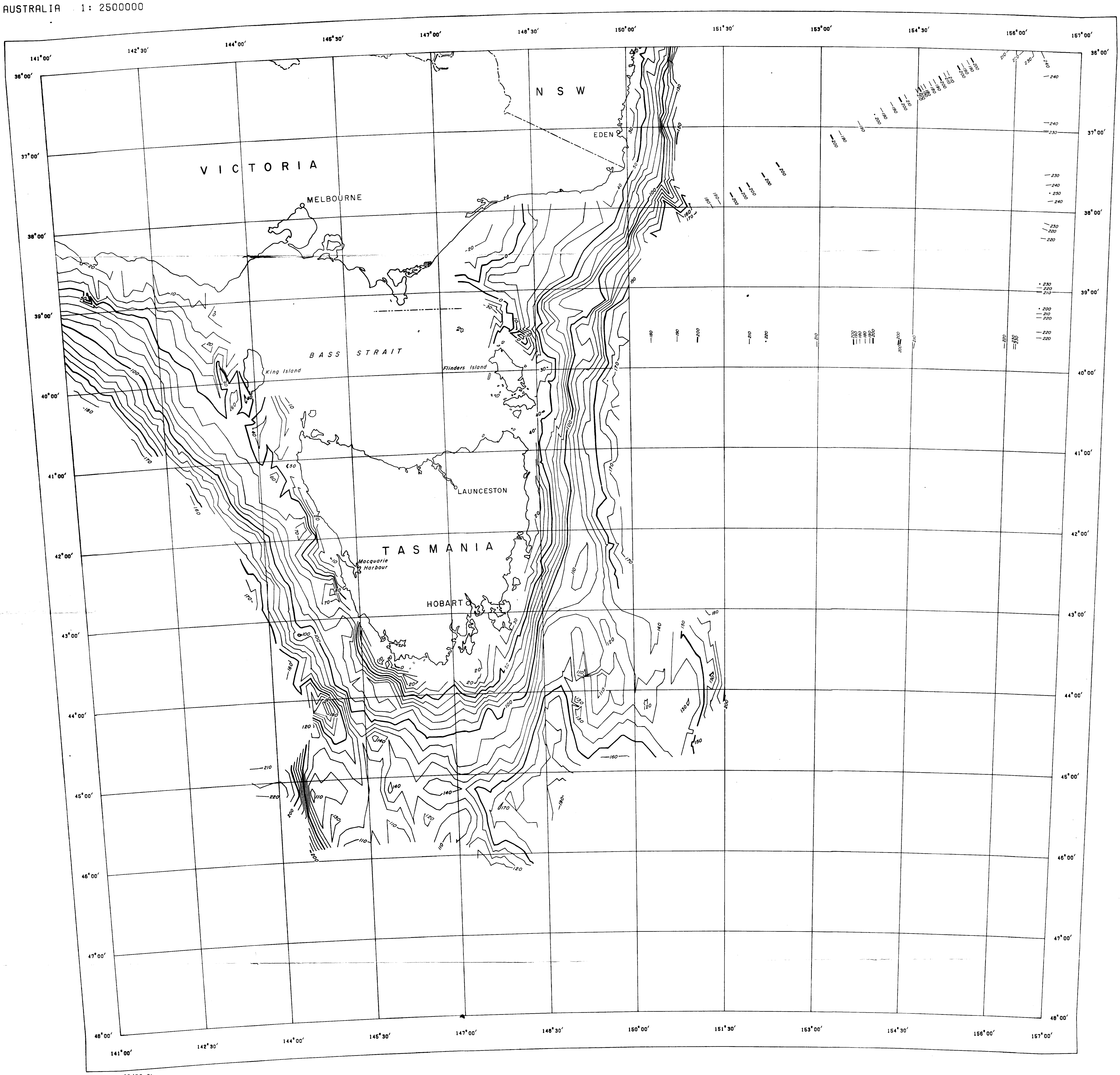
Record No. 1974/98

TASMANIA

PLOTTED 73/07/26

AUSTRALIA 1: 2500000

PLATE 6



Based on K55/B0-21

DENSITY = 2.20 g/cm^3

AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B M R 1970-73 MARINE SURVEYS

TASMANIA

BOUGUER ANOMALIES

AREA 4

K55/B2-34-1

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

KILOMETRES 50 0 50 100 150 200 250

0 50 100 NAUTICAL MILES

Contour interval : 10 milligals

Data used are preliminary, and are based on hourly values extracted on board the survey vessel. No adjustments have been applied for misties at traverse intersections.

Contour lines are drawn by computer using a triangular contouring program. A triangular plate is defined by three adjacent stations whose circumscribing circle contains no other stations. Linear interpolation is then used on the triangular plate. Should any side of an acceptable triangle exceed 40 nautical miles, that plate is not contoured.

Record No. 1974/98

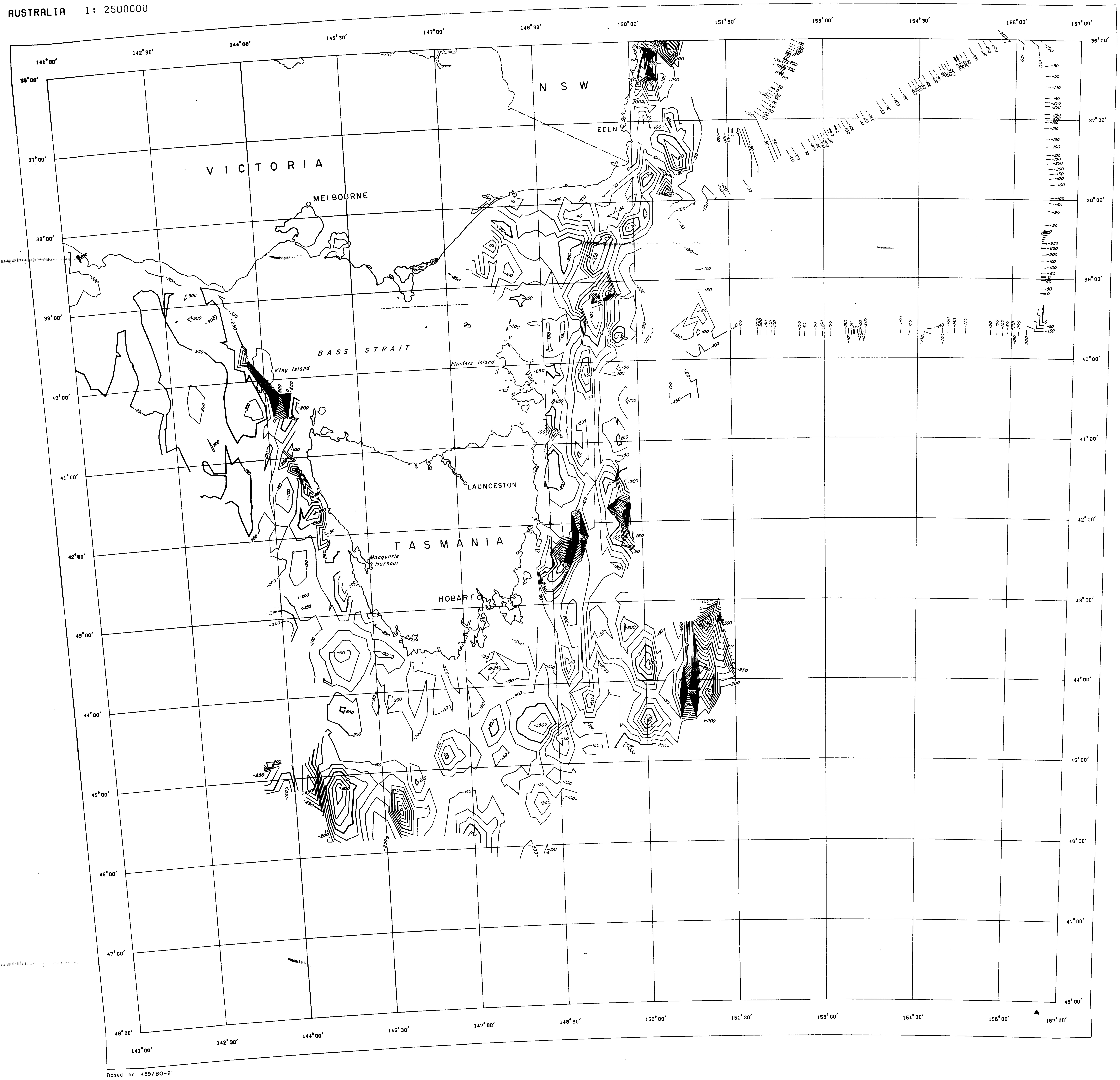
TASMANIA

013071

PLATE 7

PLOTTED 73/07/24

AUSTRALIA 1: 2500000



Based on K55/80-21

AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B M R 1970-73 MARINE SURVEYS

Magnetic values reduced to the International Geomagnetic Reference Field

MAGNETIC ANOMALIES

KILOMETRES 50 0 50 100 150 200 250

NAUTICAL MILES 0 50 100

Contour interval : 50 gammas

TASMANIA

AREA 4

K55/B1-34-1

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

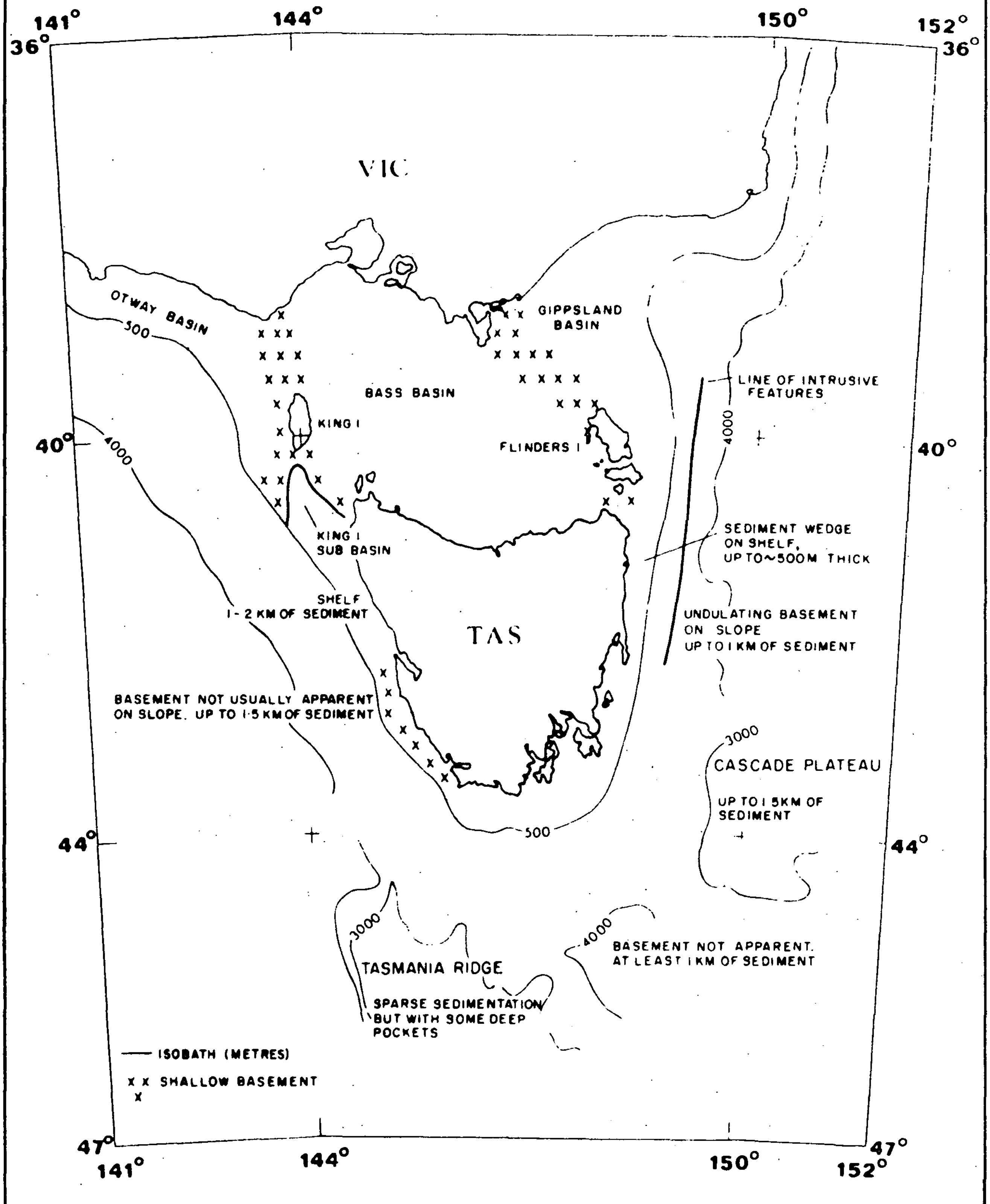
Data used are preliminary, and are based on hourly values extracted on board the survey vessel. No adjustments have been applied for misties at traverse intersections.

Contour lines are drawn by computer using a triangular contouring program. A triangular plate is defined by three adjacent stations whose circumscribing circle contains no other stations. Linear interpolation is then used on the triangular plate. Should any side of an acceptable triangle exceed 40 nautical miles, that plate is not contoured.

Record No. 1974/98

SEISMIC SECTIONS

LOCATION OF REDUCED SEISMIC SECTIONS



SEDIMENT DISTRIBUTION IN THE TASMANIAN AREA