COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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Bass Strait and Encounter Bay Aeromagnetic Survey, 1960-1961

BY

HAEMATITE EXPLORATIONS PROPRIETARY LIMITED

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DEPARTMENT OF NATIONAL DEVELOPMENT

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FOREWORD

Under the Petroleum Search Subsidy Act 1959-1961, agreements relating to subsidized operations provide that the information obtained may be published by the Commonwealth Government six months after the completion of field work.

The Bureau of Mineral Resources, Geology and Geophysics is required, on behalf of the Department of National Development, to examine the applications, maintain surveillance of the operations and in due course publish the results. The growth of the exploration effort has greatly increased the number of subsidized projects and this increase has led to delays in publishing the results of operations.

The detailed results of subsidized operations may be examined at the offices of the Bureau of Mineral Resources in Canberra and Melbourne (after the agreed period) and copies of the reports may be purchased.

This Publication deals with an aeromagnetic survey carried out over an area off the south-eastern coast of Australia, and contains information furnished by Haematite Explorations Proprietary Limited and edited in the Petroleum Exploration Branch of the Bureau of Mineral Resources. The final report, dated 14th September, 1962, was written by M.S. Reford, Chief Geophysicist, Aero Service Limited. The methods employed in the survey and the results obtained are presented in detail.

J.M. RAYNER
DIRECTOR

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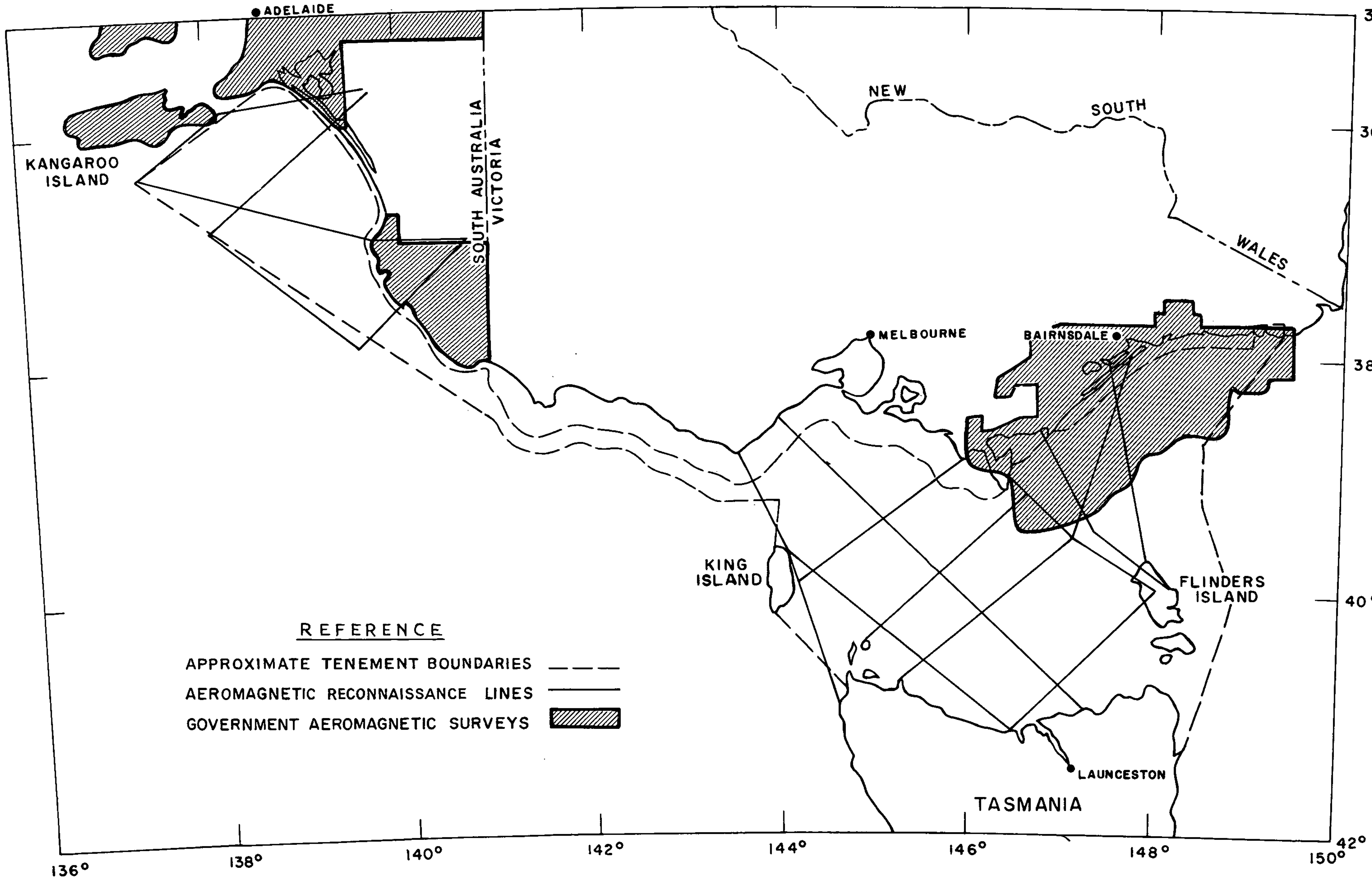


BASS STRAIT AND ENCOUNTER BAY AREAS
LOCALITY MAP

SCALE 1:5,000,000

SUMMARY

This report refers to an offshore aeromagnetic survey over the continental shelf of south-eastern Australia, from Gippsland in the east, through Bass Strait, to Encounter Bay and Kangaroo Island in the west. The survey was carried out for Haematite Explorations Proprietary Limited by Aero Service Limited during the period 17th September to 21st December, 1961. A previous reconnaissance aeromagnetic survey carried out by the same contractor over Bass Strait in December, 1960, had indicated the existence of deep Tertiary-Mesozoic sedimentary basins.

The objective of the later survey was to delineate these basins and to extend the investigation farther westward with a view to selecting areas for marine seismic surveys. 17,945 miles of aeromagnetic traverse were flown and the results of the operation are presented as contoured maps of total magnetic field intensity and of interpreted basement depth.

As a result of the survey, several areas of deep sedimentation were delineated in sufficient detail to allow for the planning of subsequent investigation by marine seismic surveys.

INTRODUCTION

The Bass Strait and Encounter Bay aeromagnetic surveys were flown by Aero Service Limited for Haematite Explorations Proprietary Limited, to provide information on the geology and petroleum prospects of an area off the south-eastern coast of Australia.

The project areas (see Fig. 1) fell within the following tenements held by Haematite Explorations Proprietary Limited:

Petroleum Exploration Permits Nos 38, 39 and 40 issued by the State of Victoria;
Exploration Licence No. 1/60, issued by the State of Tasmania;
Oil Exploration Licence No. 26, issued by the State of South Australia.

Survey operations began in December, 1960, when some widely spaced reconnaissance lines were flown across Bass Strait. These encouraged further use of the airborne magnetometer and a more detailed survey was planned. But before it began, in September, 1961, a second reconnaissance was flown over the Encounter Bay area. The final survey was completed in December, 1961. The results have been compiled into contoured maps showing the varying intensity of the earth's magnetic field, and interpreted to show contours of the basement depth and other features of interest.

RECONNAISSANCE SURVEYS

The lines flown in the reconnaissance surveys are shown on Figure 2. These patterns were laid out to sample the magnetic field in the two areas using a line spacing of 30 to 50 miles and flying in various directions. Navigation was by dead reckoning, and wherever possible the lines were planned to cross land at both ends. The pilot flew straight and level between landfalls or turning points and the locations of the lines were plotted on maps assuming a straight track and constant speed between fixes. Positions over land were determined from the 35 mm strip film exposed in flight.

The Bass Strait reconnaissance was flown with a Piper Apache aircraft at an altitude of 1000 feet above sea level. Eleven lines were surveyed, totalling about 1500 line miles, between 12th-14th December, 1960.

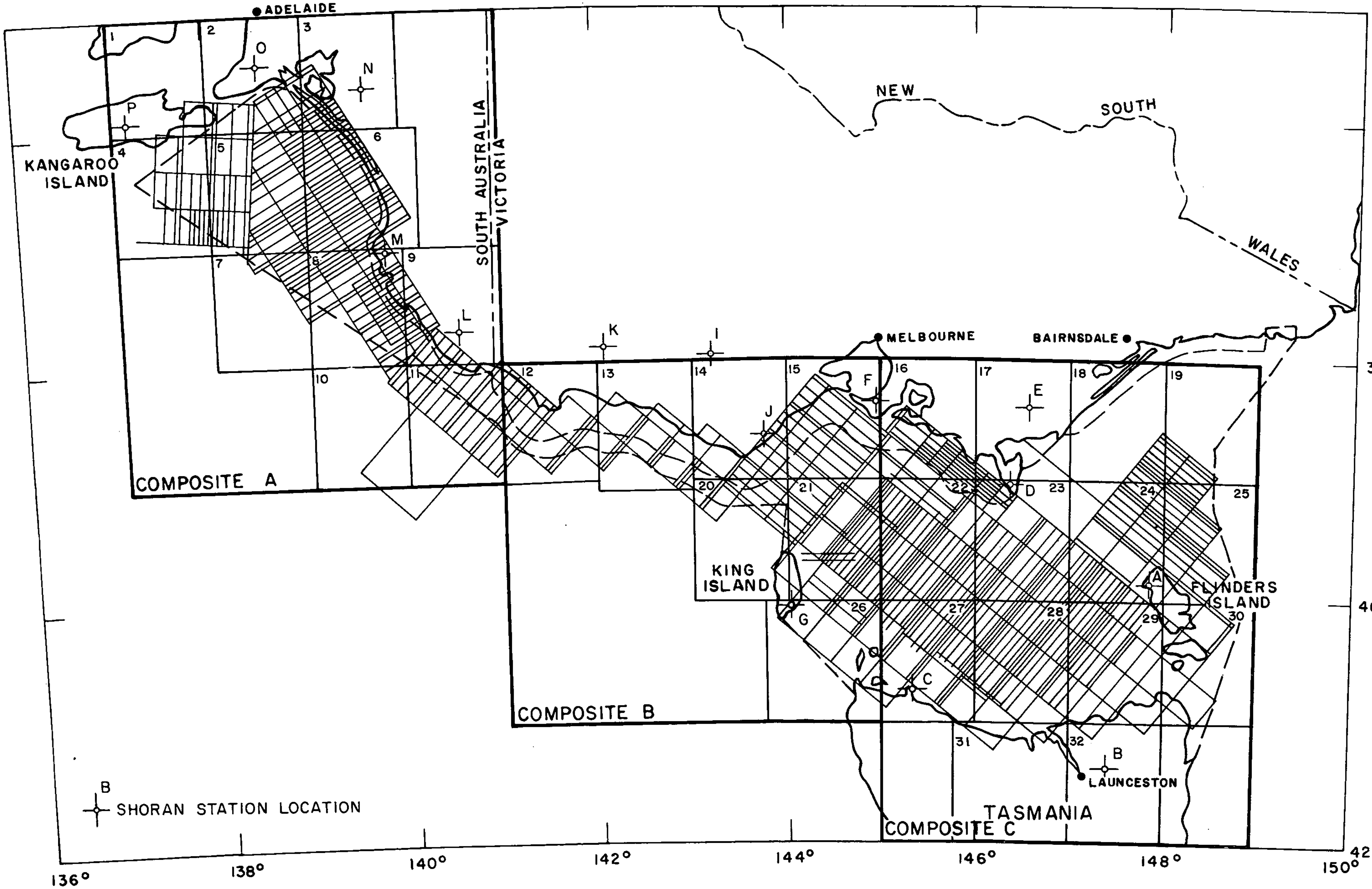
The Encounter Bay reconnaissance was flown with a Douglas DC-3 aircraft at an altitude of 2000 feet above sea level. Six lines totalling about 650 line miles were flown, all on 9th September, 1961.

The results of these reconnaissances are not presented in this report, since they have been superseded by the more detailed survey. The aeromagnetic profiles were interpreted to give general pictures of the basement surface. They showed the existence of deep basement areas, which warranted further aeromagnetic work and helped in the selection of flight line directions.

SURVEY PLANNING AND PROCEDURES

In addition to the reconnaissance data, aeromagnetic maps of some neighbouring areas were available. These are shown on Figure 1. The eastern area is the Gippsland survey of the Bureau of Mineral Resources, and the western areas have been surveyed by the

Fig. 2



BASS STRAIT AND ENCOUNTER BAY AREAS

AEROMAGNETIC SURVEY LINES AND SHEET LAYOUT

SCALE 1:5,000,000

Department of Mines of South Australia. This information, together with the known geology, was used in planning the arrangement of lines to be flown.

The basic pattern of the aeromagnetic survey is a square grid of lines, twenty miles apart. This was laid out over the whole region, so that there would be some check even where shallow basement was suspected. The grid was oriented so that one set of lines would be perpendicular to the expected strike of the magnetic features. Four directions were used: 040° or 310° were chosen for the entire Bass Strait and the eastern end of the Encounter Bay area; 060° seemed to be a good direction for most of the Encounter Bay area but south of Kangaroo Island 005° was used, fitting the trends known on the island.

Having drawn up the basic grid, extra lines were added across the areas where geological conditions seemed to be most promising. Through most of the Bass Strait survey, these extra lines were planned in swaths about the basic grid, using a line spacing of two miles. The swaths gave five lines through areas of greatest interest, three lines in areas of lesser interest, and the single line only where shallow basement was expected. The gap between adjacent swaths was never less than twelve miles.

A different pattern was used in the Encounter Bay area to give a more even distribution of lines. Each 20-mile interval was broken up by spacing lines 2, 6, 6, and 6 miles apart.

An integral part of this plan was the provision for adding extra lines across the areas of greatest interest revealed as the survey proceeded. Allowance was made for adding 20 to 25 percent to the original pattern of lines.

The flight lines were numbered to allow easy identification and adding in the extra lines. Each had a prefix letter, specifying the line direction and a number specifying the location. The letters follow the code below:

A Series	-	310°
B Series	-	040°
C Series	-	330°
D Series	-	060°
E Series	-	275°
F Series	-	005°
R Series	-	East-West

The numbers are based on the 20-mile grid pattern. Each successive line of this grid was numbered starting with 1 at the south-eastern or south-western side and rising by increments of ten, giving the series 1, 11, 21, 31 .... etc. The numbers of intermediate lines were allotted according to their positions between these grids, providing a convenient system for lines two miles apart. The net result is that the line numbers increase or decrease continuously across the survey area.

Shoran was selected as the navigation system best suited to fly the survey. This would provide fixes of the aircraft's position over water with an accuracy approaching geodetic requirements. Proposed locations of the ground stations were selected to give the coverage required. Mountains were preferred, since the range of a ground station increases considerably as it is raised above sea level. Because of the long ranges required, all survey flying was planned to be at 2000 feet above sea level instead of the usual 1000 feet or 1500 feet. At this height, the normal operating range of a ground station at:

100 feet elevation is about 70 miles
1000 feet elevation is about 90 miles
2000 feet elevation is about 110 miles
4000 feet elevation is about 130 miles

SURVEY EQUIPMENT

The aircraft carried a Gulf Research and Development Airborne Magnetometer Mark III with its detector head mounted on a "stinger" in the tail. This instrument makes a continuous record of the total intensity of the earth's magnetic field. It has a core of high magnetic permeability, wound with two coils in series opposition, which are used to drive the core cyclically to saturation. If there is no external magnetic field, the output pulses from the two coils are of equal amplitude, but if there is an external field the output pulses do not balance. By means of a compensating coil, the output pulses are continuously balanced and the current flowing through this compensating coil is a measure of the earth's magnetic field. The measuring element of the magnetometer is automatically aligned in the direction of the earth's field by two similar elements mounted so that all three are mutually perpendicular. These latter two elements orient the platform by setting themselves to give a zero reading through servo-mechanisms. The magnetometer was operated with a sensitivity of 600 gammas for a full scale deflection of ten inches.

Navigation guidance was provided by Shoran. This is a distance measuring system. The aircraft transmits a series of pulses of very high frequency radio energy. These pulses are picked up by a ground station, which then re-transmits a series of pulses back to the aircraft. The total time taken for the signal to travel from the aircraft to the ground and back to the aircraft is a measure of the distance between the aircraft and the ground station. Using two ground stations gives two distances and fixes the position of the aircraft. Various minor corrections must be applied to the distances measured. The aircraft receives a signal from the two ground stations alternately about fifteen times every second, and the corresponding distances are shown in miles on two dials in the aircraft. These positions are recorded by photographing the dials.

A refinement of the system is the "Straight Line Board" used for navigation in the aircraft. A map of the area (at a scale of 1:500,000 on this survey) is set on a flat surface. Pins are placed at the ground station locations. Servo motors drive screws through these pins, so that the screw length corresponds to the measured Shoran distance. The ends of the screws from the two ground stations are coupled together, so that their junction traces the path of the aircraft as it flies across the map. A special track is set on the board along the desired flight path, and the distance screws move a carriage along this track. As it moves, any discrepancy between the desired and the actual track is indicated on a meter on the pilot's instrument panel, telling him to steer to port or to starboard. Deviations as small as 50 feet from the desired track cause substantial meter deflections.

The aircraft uses signals from two ground stations at any one time. Six sets of ground equipment were used, each being self contained with its own petrol driven generating plant. Usually four were manned and ready to operate at one time, to give some flexibility, while the other two were being moved from one site to the next.

In addition, over land the flight path was recorded on 35 mm film by a continuous-strip Aeropath camera. The altitude above the ground or water was recorded with an STR-30 radio altimeter.

Fiducial marks were placed on all the records at 30-second intervals at the same time as the Shoran dials were photographed.

To ensure that data were not obtained in magnetically disturbed periods, a Gulf Magnetic Storm Monitor was operated at the aircraft's base throughout the survey. On a number of occasions the Bureau of Mineral Resources supplied magnetograms from the Toolangi magnetic observatory (near Melbourne), and these were used to check the records from the monitor.

SURVEY OPERATIONS

Work began at the eastern end of the survey. The Shoran equipment was calibrated on 13th and 14th September, 1961, by flying "line crossings" between the ground stations A and D. This involved flying back and forth between the two stations, recording the distance to each at about 3-second intervals. The sum of the distances is least when the aircraft is on the straight line between them. Properly corrected, this minimum sum is the distance between the stations. In this case, the geodetic positions of the stations were known, and the "line crossings" established the residual errors of the Shoran equipment.

At a later stage of the survey, the "line crossing" technique was used to determine the positions of station G on King Island and station P on Kangaroo Island. The positions were both checked by measuring the distances from three stations, and the computed positions were mutually consistent within 25 feet. It was possible to set up the other thirteen ground stations on triangulation sites whose geodetic positions were known or close enough to such sites that little ground surveying was required.

Flying of the magnetometer survey was then begun. When a flight had been completed, the data were processed with the following routine:

(i) The 35 mm film of the Shoran dials and the continuous strip camera operated over land were developed.

(ii) The readings of the Shoran dials were tabulated and corrected to give (to the nearest 0.001 mile) the distances from the aircraft to the two ground stations at every fiducial.

(iii) The aircraft track was plotted on a set of 1:250,000 scale maps using the Shoran distances and checked to ensure that it followed the desired track closely enough.

(iv) The magnetometer record was edited and checked for quality.

(v) The record of the ground monitor station was checked to ensure that data obtained during magnetic storms and other disturbed periods would be discarded.

(vi) An average scale factor was computed for each line so that measurements made on the record could be transformed into horizontal distances.

(vii) The locations of maxima and minima were noted on the magnetometer records and plotted on the map.

(viii) The lengths of all "straight slopes" were measured on the records, transformed into feet and noted on the map. The definition and significance of these "straight-slope" lengths is discussed in the section of this report entitled "Interpretation Background".

(ix) The records were correlated to reveal the locations and strikes of magnetic features on the map.

As the survey proceeded, the general picture of the magnetic features was revealed, and the "straight-slope" lengths were used to draw preliminary contours of the basement depth. This made it possible to plan the locations of extra lines in the most promising areas. Quick decisions were necessary, since the Shoran stations had to be moved immediately the work at one site had been finished or else the whole programme would have been delayed.

Each flight was planned with consideration of the Shoran ground stations then operating, and the programme yet to be flown. The available Shoran coverage was the prime factor, since several areas fell at the limits of range. Many lines had to be flown in segments instead of continuously. However, the aircrew became adept at changing from one pair of ground stations to another while continuing along a line and tried to keep the number of segments to a minimum.

One group of lines in Bass Strait was flown above the specified altitude because no coverage was then available at 2000 feet. These are lines B105 (2500 feet), B107, B109, B110, B112 and B113 (all 3000 feet); all run from A41 to A51 and lie on Sheet 21. Since it was uncertain how well these data would fit with the rest of the survey, these lines were to be reflown later at 2000 feet. However, it seemed that more useful information would be obtained by east-west lines in this area so lines R1 and R2 were flown instead. As it happened, both sets of lines fitted together quite well and the higher altitude lines have been incorporated in the maps.

In contrast to this poor coverage, lines B206 and B226 were flown on a day when remarkably large ranges were obtained. These lines extend beyond the continental shelf on Sheets 10 and 11 and were expected to go beyond the Shoran range. However, by good fortune, distances measured exceeded 150 miles.

Undoubtedly the greatest problem in the survey was weather. Very strong winds were found in Bass Strait in September and October. Seventy-five knot winds with snow-storms occurred on Mount Barrow. Two Shoran antenna masts and several tents were completely destroyed in storms, and others were blown down and damaged.

Flying was completed on 21st December, 1961. The lines flown and the Shoran station locations are shown on Figure 2.

COMPILATION PROCEDURES

The first stage of preparing the final maps of the survey was to plot the flight path of the aircraft on sheets at a scale of 1 inch to 2 miles. For this purpose every fiducial was plotted from the tabulated Shoran distances using steel tapes. The positions over land were checked by means of the 35 mm strip film.

The plotted fiducials were joined to make continuous lines, and points where lines crossed each other were identified by interpolating between fiducials. These points of intersection were transferred to the magnetometer records. The measured differences in the magnetic levels between the intersections were analysed and adjusted for consistency. A regional correction taken from published maps and tables was applied to remove the broad effects of the main magnetic field of the earth. Next, using an arbitrary datum, base lines were drawn on all the records. All variations of the magnetic field were measured from these base lines.

Locations of contour lines, maximum and minimum values, were marked on the records and transcribed onto the maps. Contours of the total magnetic intensity were drawn through these points. In many areas, the combination of shallow basement and wide intervals between flight lines made it most difficult to draw contours. Where possible, the contours have been drawn to conform with the closer control used on the adjacent magnetic surveys. In other areas attempts have been made to produce a coherent pattern of magnetic trends. There are undoubtedly some places on the maps where false trends have been introduced. There are also areas where it seemed unwise to attempt to contour the data; on such lines the locations of magnetic maxima and minima with a relief of ten gammas or more have been marked.

A basic contour interval of ten gammas has been used for the Bass Strait area and five gammas for the Encounter Bay area.

Finally, planimetric detail was added to the maps, and composite sheets at a scale of 1:500,000 were produced.

INTERPRETATION THEORY

The magnetic field of the earth is approximately that of a dipole with its axis along the line joining the north and south magnetic poles. This field, acting on magnetic minerals in the earth's crust, induces a secondary field which reflects the distribution of these minerals. The primary field varies slowly from one place to another, but the secondary field varies much more rapidly, since any magnetic field is an inverse function of the distance from the magnetic sources. The airborne magnetometer records these variations in the total magnetic field along continuous profiles. The regional correction removes the greater part of the earth's primary field, so that the local variations of the secondary field are emphasized.

The study of magnetic anomalies and of the rocks that cause them shows that the main cause of the anomalies is the varying magnetite content of the rocks. Magnetite is found as an accessory mineral in igneous and metamorphic rocks. Sediments, with the exception of iron formations, are relatively non-magnetic. In addition to this induced magnetic field, the rocks may have acquired remanent magnetism; in other words, they may act as permanent magnets. The two are not necessarily in the same direction, nor of equivalent intensities. An increasing degree of attention is now being devoted to permanent magnetism, particularly in dealing with volcanic and intrusive rocks, where it may be strong, and in a direction markedly different from the present magnetic field of the earth.

The magnetometer profiles will normally reflect changes arising from the basement rocks or igneous material above the basement. These rocks will cause anomalies, the strength of which depends on the distance between the rocks and the point of observation, the size and shape of the rock mass, and the magnetite content of the rock.

The way in which the anomaly of a body in this region will vary as its dip and strike change is illustrated in Figure 3. This particular body is the thin sheet, of infinite strike length, extending to great depths, and magnetized by induction.

Suitable magnetic features can be used to calculate the depth to the top of the rocks causing them. These depth calculations can be made in different ways. In this interpretation two methods have been used. One is a detailed analysis developed by the author from the work of H.A. Ackerman. The other is based on the work of Vacquier, Steenland, Henderson and Zietz (Geological Society of America, Memoir 47, 1951), using uniform slopes on the flanks of magnetic features. Some remarks on the fundamental ideas and applications of these methods may be helpful.

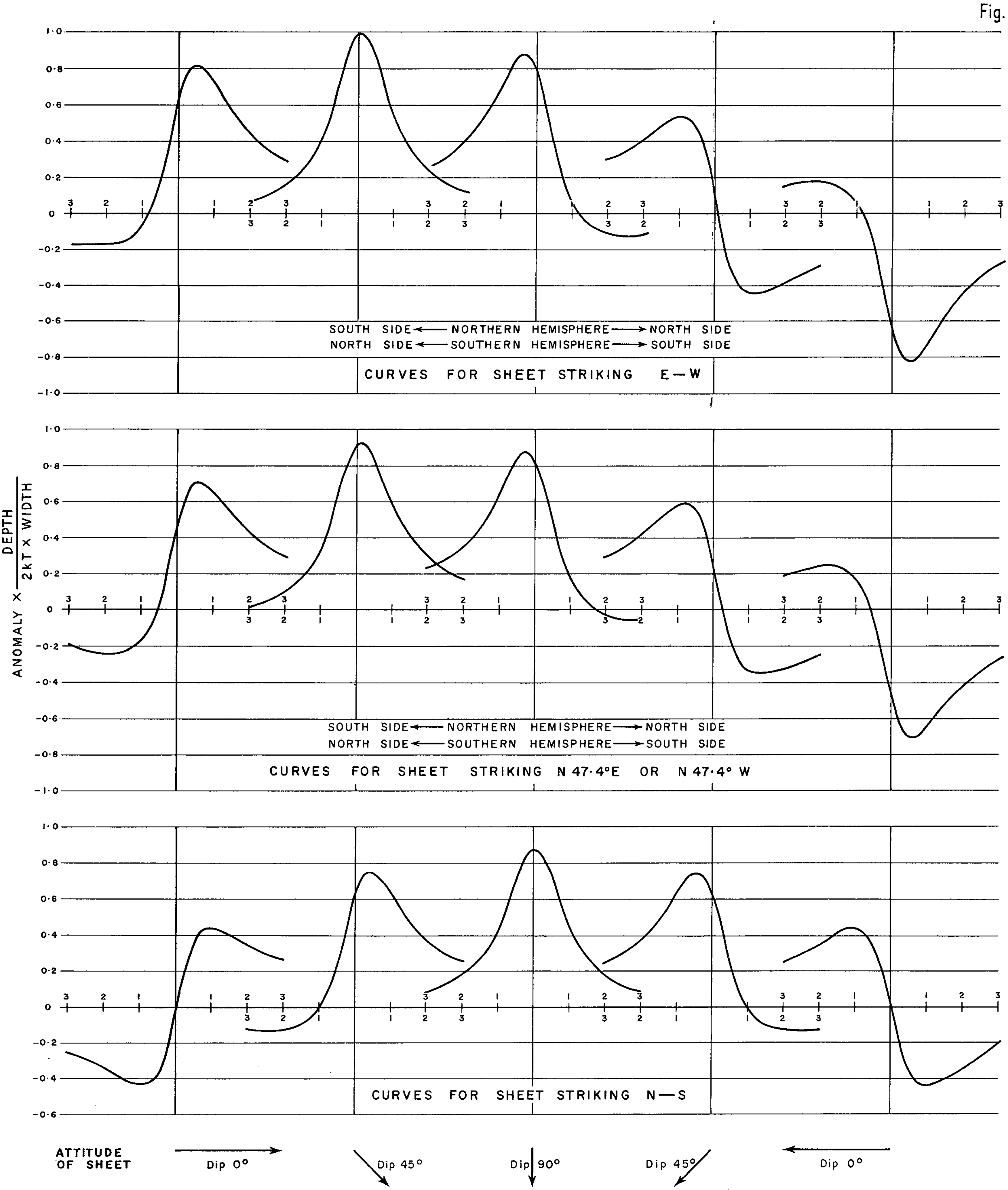
The analytical method is based on the fact that magnetic anomalies caused by long, uniformly magnetized bodies are made up of two components, one symmetrical about a centre point, and the other antisymmetrical. On the diagram of thin sheet anomalies the curve for N-S strike and 90^{o} dip is symmetrical. For the same strike and zero dip, the curve is antisymmetrical. For 45^{o} dip, the curves include both symmetrical and antisymmetrical components.

The profile across a suitable anomaly can be separated into the two components by a folding process. If the folding centre has been correctly chosen, it may be possible to interpret both components to give the location, depth and width of the body. This is done by fitting the component curves to the shapes of theoretical models. The thin sheet is the simplest to use, but by using the horizontal derivative instead of the total intensity, the interface is equally easy to interpret. Once the location and shape of the model have been interpreted, dip and susceptibility contrast can be calculated assuming that the body is magnetized by induction. The closeness of fit between the model and field curves gives a measure of the expected reliability of the interpretation. Any number of points may be used, and in some cases the complete anomaly curve may be computed from the model to see how closely it matches the original curve.

The weakness of the analytical method is that it may be impossible to match the field curve with a simple theoretical model. Closely spaced, interfering anomalies can be most difficult, and so too are bodies of finite length, width and thickness. However, these weaknesses apply to all current methods of magnetic interpretation. The virtues of this analytical method are balanced by the time required for its application, which can become prohibitive.

Measurement of the horizontal lengths of the uniform gradients along anomaly flanks provides a quick and invaluable complement to the analytical method. It is impossible to predict these lengths on a theoretical basis, but factors to transform them into depths can be found empirically, using basement depths that are known or interpreted by other methods. In the G.S.A. Memoir the "straight-slope" lengths have been measured on anomalies computed from theoretical models.

Fig. 3



TOTAL FIELD MAGNETIC ANOMALIES CAUSED BY A THIN SHEET

(INCLINATION OF EARTH'S FIELD 70°)

Horizontal distances measured in units of depth to top of sheet

MK

The danger of the "straight-slope" method is to apply it to anomalies caused by bodies very different from the theoretical models. However, experience has shown that it can be applied in a variety of conditions provided that no great reliance is placed on a single depth figure. Essentially some sort of averaging process is required. The analytical method is preferable, but it is laborious. The time required for a solution of complex anomalies is so great that it can be used only in selected cases. A combination of the two methods gives the advantages of the speed of one and the accuracy of the other.

Depths determined from magnetic data are not exact figures. It should not be inferred that the body causing a given anomaly has been found as a unique solution, even when the observed and computed anomalies match exactly. It is perhaps the simplest solution, but in actual fact an infinite number of other solutions could have the same magnetic effect. These are unlikely to lie much deeper, but could easily be shallower than the simple dyke. Therefore, depth estimates made from magnetic data are often called "maximum depths".

These anomalies caused by changes in composition of the underlying rocks may have amplitudes of 1000 gammas or more. Another type of anomaly, sometimes called a suprabasement feature, may be caused by structural relief on the basement surface. Such anomalies rarely exceed 50 gammas in size, and are usually much smaller. If the susceptibility of the basement is known, the maximum relief caused by a local rise of the basement surface may be calculated, for example a ten percent rise from 10,000 to 9,000 feet.

These two types of feature may form various combinations. For instance the magnetic effect of structural relief across a fault can be obscured by the larger anomaly caused by a change in rock type across the fault.

INTERPRETATION BACKGROUND

The interpretation given here is based on a detailed review of the magnetometer records and maps. All possible uniform gradients have been measured, located on manuscript sheets and correlated from line to line. These gradients have been used to locate the flanks of magnetic anomalies and outline their shapes. Regularly shaped anomalies in critical places were selected for analysis. The resulting depths were used as keys for the transformation of "straight-slope" lengths into depths. For the most part, multiplying these lengths by a factor of 1.5 seemed to give satisfactory results. Erratic values were checked and revised or discarded as unreliable. The resulting figures were judiciously averaged and referred to a datum of sea level. Finally, depth contours were drawn wherever possible, with an interval of 1000 feet. These contours represent average depths, and individual depth figures are shown only where profiles have been analysed.

No attempt has been made to draw any contours above the level of 1000 feet below sea level. Generally both the 1000 and 2000-foot contours run over areas of complex sharp anomalies and a much closer line spacing would be required to give precise control of these shallow depths.

It is very difficult to estimate the greatest depth in the bottom of a basement low under ideal circumstances. Depth estimates may easily be too great. For instance the bodies causing the magnetic anomalies may lie well below the basement surface. This makes it difficult to determine whether or not to use the largest depth figures in drawing structure contours. The complications caused by the occurrence of nearly non-magnetic basement rocks make reliable contouring impossible in some areas of these surveys; these areas are discussed later. But a distinction should be made between areas where the basement is non-magnetic so that depths are indeterminate and areas where magnetic anomalies exist and can be analysed giving some reasonable control for drawing depth contours.

In using the magnetic contours, it is important to keep in mind that the magnetic features are primarily caused by changes in composition of the basement rocks. In this region, a magnetic maximum will occur over the more magnetic basic rocks. As a general rule the boundaries of a basic rock body will lie at, or within the inflection points on the anomaly flanks. There are so many anomalies, particularly in the shallow basement areas, that the maps would become impossibly confused if any attempt were made to outline individual rock units. However, some individual anomalies of possible structural significance have been numbered, to allow convenient reference. If they are on clear cut features, the contours serve to outline them. But outlines have been drawn around the more interesting features in the deeper basement areas, where the outline of the anomaly is obscured by stronger regional features. Question marks are used to locate minor and poorly controlled anomalies. Possible faults are shown along features of considerable strike length, where suggested by character of the magnetic features, and sometimes the depth estimates.

In making this interpretation, data from neighbouring surveys have been used where possible, but no attempt has been made to interpret these surveys in detail.

INTERPRETATION OF ENCOUNTER BAY SURVEY

Sheet 1

Only scattered lines cross this sheet, but a detailed survey of Kangaroo Island has been made by the South Australian Department of Mines. Using both sets of data, a line has been drawn on the map dividing a zone with many sharp anomalies, to the south, from one with broader anomalies to the north. This line probably reflects a fault, downthrown to the north. South of the line, the basement is probably less than 1000 feet deep. No reliable depth estimates have been obtained to the north.

Sheet 2

The lines flown across this sheet have revealed a complex pattern of anomalies with relief reaching several hundred gammas. These anomalies are caused by changes in composition of the basement rocks. The trends shown by the magnetic contours cannot be considered reliable because they are inadequately controlled. North-easterly trends in the north-eastern part of the sheet have been guided by the aeromagnetic survey of the South Australian Department of Mines. The structural pattern of the area is complicated, for the north-south trends along the western margin of the Murray Basin are here swinging into the east-west trends of Kangaroo Island.

The basement is generally shallow, but there are two areas where it may become deeper. One is a broad zone in the western half of the sheet, where depths between 1000 and 2000 feet are expected. This zone seems to extend through Backstairs Passage, between Kangaroo Island and the mainland. The extension of the fault marked on Sheet 1 into this area is obscure. The small closure of the 1000-foot contour east of Kangaroo Island may reflect a dyke with a sharp magnetic anomaly similar to those found by the South Australian Department of Mines survey at the eastern end of Kangaroo Island and the western end of the mainland.

The 2000-foot contour on the east side of the sheet encloses an area where the magnetic level is low, and the few anomalies broaden. The maximum depth might be some 3000 feet. However, an alternative interpretation of shallow basement of granitic rocks, is a distinct possibility. These alternatives should be kept in mind if the area is to be explored further.

In the south-eastern corner of the sheet a strong, north-trending anomaly, 5-1, probably reflects a basic rock mass associated with a structural "high".

Sheet 3

Most of the magnetic trends on this sheet show a continuation of the north-south pattern revealed by the South Australian Department of Mines survey. One of these trends is particularly strong, developing into a 500-gamma anomaly near the coast on line D69. It probably reflects a basic dyke. The other features also indicate changes in the basement rock types.

Broader north-easterly trends appear in the southern part of the sheet. A fault is suggested, partly by the changing trends and partly by a marked increase in the depths that have been interpreted. This possible fault extends on to Sheets 6 and 5 and may extend farther north. It might be related to one of the major north-south faults along the western edge of the Murray Basin.

The deepening basement suggested along the western edge of the sheet has been discussed in connexion with Sheet 2.

Sheet 4

The magnetic features over most of the sheet reflect a shelf of shallow basement rocks extending south from Kangaroo Island. East-west trends predominate, indicating marked contrasts in basement rock types. In the southern part of the sheet the magnetic pattern becomes different, with the appearance of some anomalies, 4-1 and 4-2, approaching 500 gammas in size, nearly circular in shape, but perhaps with a tendency to north-south strikes. These features reflect plug like masses of basic rock and seem to be associated with basement "highs".

Broadening magnetic features in the south-eastern corner have been interpreted as basement deepening to a little more than 3000 feet.

It was not possible to fly all the lines planned in the south-west corner of the sheet, because of Shoran range problems. Line E1, which extends farthest into this corner, shows that the magnetic field becomes almost flat west of the "low" marked as 4500 L. This flattening could mark a continuation of the fault suggested on Sheets 7 and 8 to the east, which more or less follows a similar flattening.

It is suspected that other faults cross the sheet, but it has not been possible to determine their locations precisely enough to warrant marking them on the map. It is most likely there is a fault running roughly east-west where the basement drops off from the shelf, between the 1000 and 2000-foot depth contours. In addition to the deepening, the change in the general magnetic pattern suggests faulting.

Sheet 5

The magnetic field varies violently across this area, reflecting complex structures within the basement rocks. In the north-western quarter of the sheet, east-west trends predominate and the basement appears to form a shallow shelf. Proceeding eastwards, these trends seem to terminate and the north-eastern quarter of the sheet is occupied by a jumble of features. The flight line spacing here is too wide to give any certainty to most of the trends shown and the contours might be drawn in many different ways. The contouring becomes more reliable along the eastern side of this quarter, where the features become more regular and estimates suggest a deepening basement. A possible fault has been drawn along the edge of this area, based partly on the increasing depths and partly on the change in magnetic character which suggests a boundary zone between basement rocks of different types.. In the extreme north-eastern quarter of the sheet a local anomaly, 5-1, indicates a body of basic rock which seems to be structurally "high". The exact position of the 1000-foot depth contour as it wanders across the north-eastern quarter of the sheet is uncertain, especially since the magnetic trends are uncertain.

The southern edge of the shelf area is marked by a very strong anomaly, 5-2, with a relief of nearly 700 gammas. A possible fault is shown along its southern side. This might extend farther at both ends. To the west, the continuity is broken by a group of sharp anomalies which control the southward break of the 1000-foot depth contour. To the east, it might turn north-eastwards, along the southern flank of Anomaly 5-6, which could reflect a body similar to that causing Anomaly 5-2. Alternatively it might turn southwards, following the western flank of Anomaly 5-8.

As on Sheet 4, the pattern changes in the southern half of the area. The anomalies broaden and strong, nearly circular anomalies have been mapped. These reflect basic rock masses. Anomaly 5-3, in the south-west corner, seems to be associated with a basement "high". Anomaly 5-4 is not, but an offshoot to the south, marked as Anomaly 5-5 seems remarkably shallow. This feature might indicate a dyke intruded at the same time as the larger mass to the north, and it may well be related to a north-south fault.

Estimates indicate that the basement in the south-western quarter of the sheet may reach 4000 feet in depth.

Magnetic trends run north-south in the south-eastern corner of the sheet. The contours indicate that depths here are between 1000 and 2000 feet. However, there are signs that depths may exceed 2000 feet on either side of Anomaly 5-8, and this possibility is suggested by the word "DEEPER?" on the map. At the south end of this anomaly, the basement may rise above 1000 feet, and there are strong possibilities that faults may follow one or both of its flanks.

A possible fault is shown in the extreme south-eastern corner of the sheet. This is discussed in connexion with Sheets 6 and 7.

<u>Sheet 6</u>

The magnetic features on this sheet are very diverse. Along the eastern and western sides are a series of long, strong and sharp magnetic maxima, interpreted as reflecting dyke-like features in shallow basement. Similar trends have been mapped over land to the north and south by the South Australian Department of Mines surveys. Faults have been suggested along the edges of these zones, indicating a possible graben running across the sheet in a north-south direction.

This graben should be considered with great caution. South of latitude 36°20'S., and within the 3000-foot depth contour, the magnetic field is very flat. The basement rocks here are almost non-magnetic. There are a few anomalies less than ten gammas in size. These suggest that the basement may reach a depth of about 4000 feet. These figures cannot be relied on for accuracy. The existence of a graben in this area requires confirmation by some other type of survey.

A similar uncertainty exists in the possible deep area suggested by the dashed 1000 and 2000-foot contours striking north-east across the south-eastern quarter of the sheet. They outline an area where there is an absence of local magnetic anomalies. A granite outcrop has been found near the coast in this area. Hence it seems most likely that the basement here is shallow and that the lack of anomalies is caused by a lack of magnetic minerals in the basement rocks. The depth contours probably run nearly north-south across the western end of the area as suggested by the alternative location of the 2000-foot contour. However, it might be worth checking the granite outcrop in the field to make sure that it is true basement.

The extension of the 4000-foot depth contour onto the southern part of the sheet is questionable in a similar way.

There is more certainty about the existence of a deep basement area in the north-western part of the sheet. Some broad magnetic features provide reasonable depth estimates. Line C36 was selected as most suitable for analysis, yielding an interface at a depth of about 3000 feet. This figure confirmed similar values from "straight-slope" measurements along the gradient band to the south. Proceeding westwards, the maximum depth is uncertain, but almost certainly exceeds 4000 feet. Depths are uncertain between the 2000 and 3000-foot contours east of this deep but might locally exceed 3000 feet.

Four possible faults are shown on the sheet. Two run north-south along the flanks of the suggested graben. Both follow boundary zones indicating changes in basement rock type and both might be extended. The fault marked in the north-western corner of the sheet is suggested both by the depth contours and a change in magnetic character from one side to the other. It runs onto Sheets 3 and 5. In the south-western corner of the sheet, discontinuities and character changes in the magnetic pattern suggest the possibility of a fault involving horizontal movement. This might be extended north-east along one flank of Anomaly 6-5. These suggestions are not exhaustive, but indications from the magnetic data are not considered positive enough to warrant marking other faults at this time.

There are several local anomalies of interest on this sheet. 5-1 is caused by a basic rock body that seems to be associated with a structural "high". 6-1 has an amplitude of about 15 gammas and might reflect a rise of the basement surface. Anomalies 6-2 and 6-3 are narrow linear features similar in character and strike to those found over the shallow basement areas to the east and west. They might be associated with structure on the basement surface. 6-4 and 6-6 are also similar and have relatively shallow sources. The former is closely associated with 6-5, which appears to reflect a more plug-like mass in the basement, although its shape is not accurately known since it is clearly shown by only one flight line. The true shape of Anomaly 6-7 is not precisely known, but it may have an east-west strike, unusual for the area. Its major cause is a change of composition of the basement rocks. Anomalies 6-8 and 6-9 are weak features, both clearly shown on three lines. Both are strongest at their northern ends with peak relief of about 9 and 22 gammas respectively. They may reflect local rises of the basement surface, although they do not appear very promising. Anomaly 6-10 is a broad, weak feature of no particular interest. Anomaly 6-11 reflects an isolated, plug-shaped body of basic rock in the basement. Its very isolation may indicate a significant structural feature, but it has no obvious relation to neighbouring trends. It appears to be associated with a slight nose on the basement surface.

A large magnetic maximum is located in the south-eastern corner of the sheet, roughly outlined by the 4475-gamma contour with a nose extending northwards. This is interpreted as reflecting a large body of basic rock at a depth of 3000 to 4000 feet. Local offshoots rise higher, one running north by east within the 1000-foot depth contour, and another may go from the northern nose into the shallow basement area to the north.

Sheet 7

The magnetic contours here provide an excellent illustration of the contrast between the many sharp anomalies over shallow basement to the north, and the broad, smooth changes over deep basement to the south.

A possible fault, involving horizontal movement, is marked in the shallow basement area. It continues on to Sheets 5 and 6, and follows some abrupt terminations and dislocations of the magnetic features, which suggest that the rocks on the south side have moved eastward.

A few miles farther south another possible fault is shown. Fault may be a misnomer for this line, which indicates the southernmost limit of the relatively strong and sharp anomalies. Its significance is further discussed in connexion with Sheet 8. It is interesting to note that the edge of the continental shelf has a marked change in strike close to the point where this line meets the eastern edge of the sheet.

South of this line, only weak anomalies of doubtful value have been found. It has not been possible to trace them from one flight line to the next with any degree of certainty. The query is located between a 5-gamma anomaly, the strongest in this deep basement zone, on line D35, and a 3-gamma feature on line D34. This might perhaps reflect local structure, but it is not a clear indication.

Depth contours have been drawn down to the 8000-foot level. It is possible that depths greater than this will be found on the sheet, but there are no magnetic features to use for depth estimates. Indeed the depth control is so poor that the 8000-foot contour could easily be five miles out of position.

Sheet 8

This area includes some features of the greatest interest. The edge of the continental shelf cuts diagonally across it, roughly from the south-eastern corner of the sheet to the point where the 5000-foot depth contour crosses its western edge. The magnetic field is very flat south-west of this line, but north-east of it are a number of interesting anomalies.

The shallowest basement has been found along the northern edge of the sheet. This is controlled in the north-western corner by a number of strong, sharp anomalies, and in the north-eastern corner, following the southern edge of a broad magnetic maximum. A possible fault is marked along the southern limit of these anomalies. In fact it does not follow any clear feature and may be an ill-defined boundary zone rather than a fault. However, its eastern end follows a steep gravity gradient suggestive of faulting, and it may be extended farther east following abrupt terminations of sharp magnetic anomalies shown by the South Australian Department of Mines surveys.

This zone, whatever its true nature, seems associated with the structure underlying the continental shelf. Immediately south of it, the basement seems to dip steeply southwards. There are few magnetic features to control the placement of depth contours, and none has been drawn below 10,000 feet, although basement depths probably exceed this considerably. The 10,000-foot contour itself could easily be five or more miles out of position.

The east-west strike of the depth contours turns to north-south along the coast line, where a series of large magnetic maxima have been mapped. These follow two major trends, one along the coast, and the other running east-west across it. The former is discussed under Sheet 9. The latter is marked by Anomalies 8-4 and 9-2. Anomaly 8-4 reflects a large body of basic rock in the basement, the anomaly broadening as the basement drops off to the west. It may well be associated with structure affecting the sediments above.

The depth contours swing around these maxima and run eastwards to the east boundary of the sheet. This swing may be exaggerated for it is partially controlled by some odd characteristics of Anomaly 8-5. Two sharp features were found here on line D14, with

15 to 20 gammas relief. They might be interpreted as indicating basement as shallow as 3000 feet, or possibly volcanics well above the basement. The contours shown follow a median depth, indicated by broader anomalies on lines D12 and D15.

Of the other anomalies on the sheet, 8-6 is a very promising feature that might well reflect a local rise of the basement surface. Its peak value is only seven gammas, but it is clearly shown on four lines. Its westernmost extension to a fifth line, D11, is less certain. Anomaly 8-3 probably reflects a minor intra-basement contrast. Anomalies 8-1 and 8-2 are not structurally interesting, but are outlined as the two weakest features controlling the location of the possible fault.

Scattered throughout the sheet are minor anomalies of less than five gammas. Most of these are shown by a single line and are not considered reliable enough to deserve any particular attention.

Sheet 9

The dominant magnetic feature on this sheet is a maximum trend along the coast. This reflects a body of basic rocks, which becomes shallower around Anomalies 9-2 and 9-3. It is worth noting that lines C36 and D14 have minor features superimposed on the large anomaly which suggest that igneous material may be found as shallow as 2000 feet below sea level. They are too weak to be conclusive, but might indicate volcanics.

An attempt has been made to analyse this trend, using line D8. The horizontal derivative had a complex curve. This could be fitted quite well by two dyke-shaped bodies dipping about 60^{o} to the south-west. The major part of the anomaly was explicable by a dyke at depth 16,000 feet, width 22,500 feet, and susceptibility contrast 2900×10^{-6} cgs units. An irregularity on the north-eastern flank was explicable by a second dyke at depth 4100 feet, width 6000 feet, and susceptibility contrast 150×10^{-6} cgs units. This confirms the concept of a large, deep body with parts reaching above its general top. The reduction in susceptibility contrasts may be partly caused by an incorrect determination of width and partly because the second dyke should be cut off at a depth of 16,000 feet, rather than representing a true change in composition. This throws considerable doubt on the validity of the depth contours in going away from these shallower parts. The drop off may be much more rapid than the contours on the map imply. The situation along this trend may be similar to that over the parallel magnetic maximum about 12 miles to the north-east. On this trend basalt reaches the surface in several places from Mount Gambier north-west.

Following this line of thought, relatively shallow igneous material can be expected beneath Anomalies 9-1, 9-2, 9-3, 9-4 and 9-5. The shallowest depths are probably under 9-2 and 9-3, which seem related to an east-west trend extending through Anomaly 8-4. The anomaly outlines have been drawn with reference to the South Australian Department of Mines aeromagnetic survey. This reveals that the coastal and Mount Gambier magnetic maxima join north of Beachport and form a single feature continuing to the north. The gravity map only partially supports this interpretation, possibly because it includes major effects from the sedimentary rocks. But a particularly strong gravity "high" is located on the coast just north of Beachport, and this is clearly related to magnetic Anomalies 8-4, 9-2 and 9-4.

The broad regional minimum trend across the southern part of the sheet is probably related to the continental margin. The magnetic field decreases towards it from the north with increasing distance from the basic rock bodies which follow the coast line. The broad weak maximum to the south is caused by intra-basement contrasts beneath the continental slope.

Sheet 10

The magnetic field in the north-eastern quarter of the sheet has a generally smooth increase in intensity to the south-west, with a peak at the ends of lines B236 and B237. The pull in the contours between these lines is unduly sharp and may be caused by a small diurnal change when B236 was flown. Basement depths are most probably more than 10,000 feet in this area, but there are no features suitable for depth estimates. The magnetic maximum is related to intra-basement contrasts.

The long extensions of lines B206 and B207 over the edge of the continental shelf are shown on the sheet, partially by an inset. These lines show nothing except broad smooth regional changes and are quite remarkably featureless. They indicate a uniform basement, presumably at great depth.

Sheet 11

The magnetic contours across this sheet show regional features of the broadest type. The east-west minimum axis along the northern edge gives way to a maximum in the western corner and a minimum on the eastern side.

Scattered along the profiles are a number of sharper anomalies averaging two or three gammas. These are presumed to be noise effects, possibly diurnal. The contours may not be perfectly reliable, for they are sharply bent between lines B216 and B217, and also between B196 and B197. For an accurate survey in this area, the tie lines should not be spaced more than ten miles apart, and stricter diurnal limits would be advisable.

Despite these adverse comments, better control would be unlikely to reveal any features of particular geological interest. All indications here are that the basement is very deep, probably more than 15,000 feet.

Depth estimates across the area have not been considered reliable enough to contour, as the magnetic relief is too small. The regional trends reflect changes of composition of the basement rocks. None of the local anomalies is continuous or clear enough to be outlined.

INTERPRETATION OF BASS STRAIT SURVEY

Sheet 12

Along the northern edge of this sheet, numerous sharp anomalies have been mapped. These are outlined by dashed lines, and are clearly caused by basalt flows, known along the coast. The anomalies are generally some tens of gammas in size, and have near surface origins. Two areas offshore, where sharp anomalies of less than ten gammas have been found, are marked by queries. They may be caused by minor volcanic bodies.

The magnetic field is very flat through the rest of the area, most of which is occupied by a broad magnetic "low". There is a broad local maximum in the centre of the south-eastern quarter, ringed to the south-east by the 4080-gamma contour. It cannot be outlined reliably, and is not considered very promising.

No proper depth estimates could be made outside the basaltic areas, for the field is too flat. All indications are that the basement depth exceeds 10,000 feet.

Control is poor across the south-eastern half of the sheet, but extra flight lines would not add much useful information.

Sheet 13

The flight pattern across this sheet leaves large gaps, and only samples the magnetic field. At two places along the coast, and near Lady Julia Percy Island, there are very sharp anomalies, which indicate the presence of basalt. Most of them have less than ten gammas relief, but a few are much larger.

Anomalies 13-4 and 14-3 outline areas including a number of sharp anomalies, ranging from a few to more than 60 gammas in size. These are probably zones of basalt. Anomalies 13-1 and 13-2 are reasonably continuous narrow zones whose sources probably lie at depths no greater than 3000 feet. They, too, probably reflect basalt. Anomaly 13-3 might have a source with depth of the order of 7000 feet. It has two peaks on both lines B175 and B176, and a maximum relief of about ten gammas. Its cause is unknown, but might be volcanic. Other minor anomalies with less continuity are scattered over the sheet, the more prominent being marked by queries.

Except for these anomalies, the magnetic field over this area shows only minor variations. Basement is probably deep and uniform, but no reliable depth estimates could be made.

Sheet 14

Flight lines across the western half of this sheet were very scattered. On the eastern half the line spacing was closer, averaging five miles apart. There is a marked change in character from one side to the other, which cannot be attributed to the change in line spacing. To the west, the field is generally flat, with zones of sharp anomalies rarely exceeding 20 gammas. To the east, long and strong anomalies have been mapped with amplitudes up to 400 gammas.

The situation over the western half is similar to that observed on Sheet 13, and the geology is probably similar: deep basement with local anomalies caused by volcanic rocks. Anomaly 14-3 contains many sharp anomalies of this type, with depths of about 1000 feet, and so does 14-4, which may be correlated with some small "hills" on the ocean bed. Anomalies 14-1 and 14-2 are broader and stronger than these features. They may reflect volcanic rocks that are more deeply buried, with their tops at depths of two or three thousand feet. Anomaly 14-5 is similar in character, but may cover a larger area.

Along the coast in both halves of the sheet a group of very sharp anomalies was observed, obviously representing effects of magnetic material near the ground surface. These are generally less than five gammas in size, but include some stronger features. B.M. Hopkins and C.P. Taylor made a field trip to determine the origin of these anomalies, and made some ground magnetometer traverses. They report (Geological Notes - Ground Magnetometer Surveys, 21st December, 1961) that anomalous readings up to 600 gammas were found. They also discovered ferruginous Tertiary sands related to the anomalies. It seems reasonable to conclude that the near surface effects are caused either by these sands, or, particularly in the west, by basalt. In any event, the magnetic effects of the true basement are obscured, and no basement depths can be determined in these zones.

The major anomalies in the eastern half of the sheet have been numbered for convenient reference. They are all long features, striking north to north-east, as do the trends associated with King Island. However, their exact strikes and continuity are uncertain, since the line spacing is too wide. None extends across the Otway coast. In fact they appear to die out as they approach the coast. This may be an indication of a major fault striking north-east along the coast, following the north-west flank of Anomaly 14-6 and the south-east flank of Anomaly 14-4. South-east of this line the basement rocks are associated with the shallow basement near King Island. North-west they show patterns typical of deep basement.

The major anomalies are so strong that they certainly reflect changes of composition within the basement rocks. It is surprising that they indicate a depth of less than 2000 feet for the most part.

East of Anomalies 14-7 and 14-8 there is a magnetic minimum, caused by intra-basement contrasts, and possibly deeper. It could be faulted on both sides. Anomaly 14-9 is an intra-basement feature that seems to be associated with a rise of the basement surface.

Sheet 15

Magnetic features of three different types have been mapped on this sheet. First, in the south-eastern part, there is a confused pattern of strong anomalies, reflecting shallow basement including much basic material. Second, along the north-western side there are two zones of sharp features caused by magnetic material near the ground surface. The northern one probably reflects basalt, and the western one, where the effects are much weaker, probably reflects the ferruginous sand discussed in connexion with Sheet 14. Third, in the centre of the sheet, the magnetic field drops to a broad "low", broken by a number of anomalies of various characteristics.

The anomalies around the south-eastern side of this minimum provide fair control for depth estimates, although more flights would be helpful. Analysis along line A67 gave fair results, except that it was difficult to fix the depth value on the north-western side of Anomaly 15-4, which might be as much as 1000 feet less than the value shown. Susceptibility contrasts across these three interfaces were calculated as 100 to 400 x 10^{-6} cgs units. Hence a 10 percent structural rise is unlikely to cause more than a 5-gamma anomaly in this region. The depth contours show a basement "low" in this region; its maximum depths may exceed 7000 feet.

The north side of this "low" is not well controlled, for the depth contours are largely controlled by two anomalies, 15-1 and 15-2, which may be related to intrusives or volcanics above the main basement level. Anomaly 15-2 is largely negative, implying permanent magnetism as is often found in lava flows. This small basin might continue northwards, with depths of over 5000 feet, beyond the survey boundary.

On its south -western flank, a number of poorly controlled features suggest quite shallow basement. None has been singled out as especially significant except Anomaly 15-6. This has more than 20 gammas relief, implying an intra-basement origin, but it may be associated with a basement "high".

Anomalies 15-3, 15-4, and 15-5 are much more interesting. They seem to have considerable strike length, and may be caused by changes in basement rock type associated with faulting. A possible fault is marked along one side of 15-5 and extending south on to Sheet 21. It might well continue north and tie into a fault recognized on shore but such an extension is not clearly shown by the magnetic contours. The band of steep gradient along the north-western flanks of Anomalies 15-3 and 15-4 is most suggestive of a fault.

Sheet 16

Almost the whole area surveyed here shows sharp anomalies caused by magnetic material at a depth of less than 1000 feet. Near Phillip Island, this is presumably basalt. Off Cape Liptrap, in the south-eastern corner of the sheet, the very strong anomaly, 16-2, is attributed to gabbro. The linear western side of this feature may be associated with faulting. A similarly strong feature, 16-1, may also reflect gabbro.

The level of magnetic activity decreases in the central part of the sheet, where a deeper area has been outlined by a 2000-foot contour. Some of the "straight-slope" lengths in this area suggest that depths may reach 4000 feet or more, but these were not considered reliable enough to warrant deeper contours. Sharp features on two lines control the local closure of the 2000-foot contour within the deep.

It is possible that narrow zones of deeper basement might be found along the western side of Anomaly 16-2, or, less probably over the magnetically low zone enclosed by the 4000-gamma contours north-east of line A87 around line B111. Both zones could be explained by the presence of granitic rocks and this alternative is considered more likely.

Sheet 17

In the small area surveyed in the south-western corner of the sheet the large anomaly, 16-2, is attributed to gabbro rising virtually to the surface. East of this is a magnetic minimum succeeded by a maximum discussed under Sheet 23.

A single line was flown across the area covered by the Bureau of Mineral Resources survey east of Wilson's Promontory. This line checks the depths of the Bureau's interpretation reasonably well, but there is a strong possibility that the magnetic minimum at the south-eastern end (between the marks 3394L and 4068H) may be related to granitic rocks no deeper than 2000 feet, instead of a south trending syncline.

Sheet 18

The area surveyed here overlaps that flown by the Bureau of Mineral Resources. Both show a singular feature, outlined as Anomaly 18-1. This magnetic maximum reflects a dyke-like body that seems to rise above the general basement level. Both interpretations agree that it rises about 2000 feet at its western end, where it is abruptly cut off with a peculiar bend. The anomaly broadens to the north-east, as the basement deepens. It may be associated with faulting. An analysis across it, using line A115, produced a reasonable fit from a dyke at depth 5100 feet, width about 9000 feet, and susceptibility contrast about 700×10^{-6} cgs units.

The eastern part of the sheet is occupied by a broad magnetic maximum, which, with its subsidiary anomaly, 18-2, is cut off quite sharply to the north-east. This break, projected through the north-eastern end of 18-1 could reflect a fault. Both the large maximum and Anomaly 18-2 reflect intra-basement contrasts. Both may be associated with noses on the basement surface. The depth contours swing broadly round the north-eastern end of the large maximum. An analysis across these features on line A123 gave three interfaces at the depths shown. The deepening to the north-west agrees with figures from "straight-slope" lengths and led to drawing a southward embayment of the 6000-foot contour.

Anomaly 18-3 is a weak feature, five to nine gammas in size, but probably of intra-basement origin since it is closely associated with 18-2.

A little north-west of the peak of the regional maximum on line A117, an additional local rise of about thirteen gammas was observed. This was so sharp that it could indicate igneous material above 3000 feet and is the sole basis for the local closures of the 4000 and 5000-foot contours, numbered as Anomaly 18-4. The feature is not confirmed by either of the adjacent lines and its origin is obscure. It could indicate an intrusive rising above the basement surface.

Sheet 19

In this area the magnetic field drops away from a regional maximum on the western side. Anomaly 19-1 outlines a weak, gentle feature of no great interest. Anomaly 19-2 indicates a broad feature which is not sufficiently controlled to be evaluated properly. All indications are that the basement depth is greater than 10,000 feet except along the western side. There are no magnetic features suitable for making depth estimates in the deeper zone.

Sheet 20

As on Sheet 14, there is a break in the magnetic pattern roughly at longitude 143°30'E. West of this line the features are rather weak, with anomalies from shallow sources superimposed on a gentle regional pattern. Anomaly 14-4 outlines a zone of these anomalies, yielding depth estimates as shallow as 1000 feet below sea level. These may be caused by volcanics. Anomaly 20-2 includes two similar features, one of 24 gammas and the other of four. This implies that additional flight lines might reveal a larger area covered by such anomalies between Anomalies 14-4 and 20-2. The true basement level may be very great.

In the eastern half of the sheet there are several strong features of very different type, reflecting intra-basement contrasts. They strike between north and north-east, although the line spacing is not close enough to be sure that the peaks have been correctly joined together. For instance, the southern end of Anomaly 14-8 might be joined southwards with the main peak of 20-4. However, it is clear that the general direction of these trends conforms with the structures around King Island.

Anomaly 20-3 is clearly part of this group, but 20-1 is intermediate between it and the shallower volcanic-type anomalies to the west.

There is a broad magnetic "low" east of the strong features and bounded on the east by two similar but weaker anomalies, 14-9 and 20-5. There are some features within the "low" which imply increased depths and it has been contoured to show a basement "low" exceeding 4000 feet in depth. This structure is not well controlled. It might well be faulted on either flank.

Anomaly 20-5 yielded some shallow depth estimates, implying that it is related to a structural nose running north from King Island.

Sheet 21

The magnetic characteristics on this sheet are divided by a central zone of shallow basement. Within this zone are many sharp anomalies, some very strong and probably indicative of basic rocks. Few lines traverse the zone, which was discovered in the reconnaissance survey for it has little prospect of including oil fields. It forms part of a shelf of shallow basement running north-east from King Island to the mainland.

It is rather surprising that shallowest parts seem to lie on the western flank of the zone, forming a nose that pushes out of the north-western corner of the sheet to form the southern boundary of the small basin outlined on Sheet 15.

The western side of the shallow zone is probably faulted, and a possible fault is shown, following the steep gradient of a more or less continuous series of intra-basement anomalies. At the southern end, the depth estimates also suggest steep dip. Another fault might branch out along the western boundary of Anomaly 21-1

A basement "low" is indicated along the western side of the sheet. It is poorly controlled and might be a spurious effect coming from granitic rocks.

A band of steep magnetic gradient follows the eastern side of the shallow zone on Sheets 21 and 26. This curves in and out to such a degree it does not seem to follow a single fault. A pattern of north-south faults, en echelon, seems more reasonable but the data are not precise enough to suggest exact locations at this time.

The level of magnetic activity decreases to the east and there is less basic rock material. North-westerly strikes appear indicating that the structural pattern is more closely related to the Bass Strait trends than those associated with King Island. Sufficient magnetic features exist to give fair control of the depth contours down to the 10,000-foot level. No local anomalies of particular interest have been outlined in this region.

In the extreme south-eastern corner of the sheet, a very strong maximum controls a northward nose of the 2000-foot contour. This is more completely revealed on Sheet 26, where it is discussed further.

Sheet 22

The north-eastern quarter of the area includes a mass of anomalies, poorly controlled, but clearly indicating shallow basement. A more coherent pattern reflects relatively shallow basement in the north-western corner. Between these zones the magnetic features broaden, indicating deeper basement. In fact, they broaden to the point where depths could exceed 5000 feet. Control was considered inadequate to draw any contours below 2000 feet and the area is marked "DEEPER?".

The basement dips southwards away from the shallow areas with three indications of noses pushing southwards.

In the southern third of the sheet a large magnetic maximum has been numbered 22-1. This should be viewed in relation to Anomaly 28-1, to the south-east. The two seem to have similar origins. They are separated by a striking magnetic minimum, running north-south across Sheets 22 and 27. The depth contours suggest that the deepest basement areas in the Bass Strait are associated with these three major features. Both depths and magnetics suggest a fault along the eastern side of Anomaly 22-1, perhaps with horizontal as well as vertical movement.

Anomaly 22-1 was analysed along line B87. A good fit was obtained with interfaces at depth 4500 feet on the south side and 10,200 feet on the north side. Both faces dip about 60°SW. To complete the curve it was necessary to add a third interface, at depth 15,800 feet and with north-easterly dip between them. This has been ignored in contouring the basement surface, first because the figures are not precise and because it may indicate a contrast well below the basement surface.

Anomaly 22-2 includes sharp anomalies shown by three lines, indicating depths of less than 2000 feet. These might reflect shallow igneous material associated with the fault indicated to the east. These shallow figures may have exaggerated the relief shown on the underlying basement "high". Anomaly 22-3 outlines less positive indications of shallow basement to the east. A sharp 20-gamma anomaly is clearly shown on one line only. If genuine, this is most likely indicative of volcanics.

Anomaly 22-4 outlines a narrow feature of about 20 gammas relief. This is of intra-basement origin, but may be associated with relief on the basement surface.

Anomaly 22-5 is a nose pushing out from Anomaly 28-1. "Straight-slope" measurements on its flanks suggest a broad nose on the basement surface, but this may be exaggerated.

Sheet 23

The interpretation of magnetics on this sheet has presented serious problems. In the north-western corner there are many sharp features, indicating very shallow basement. These terminate with a clear cut maximum trend just west of Wilson's Promontory. From here eastwards, there are only scattered anomalies, rarely exceeding five gammas, across the Promontory and islands to the south-east, where granite is known to crop out. Obviously the granite contains little magnetic material. The dashed 1000 and 2000-foot contours through the area are not to be relied on. In particular the 1000-foot contour west of Wilson's Promontory shows the limit of the granite rather than representing depth. This is where it would be placed if no geological information were available.

South of the 2000-foot contour many magnetic features are available to control the depths. No anomalies have been singled out for special attention since all of them appear to be caused by intra-basement contrasts without significant structural associations.

Sheet 24

The shallow basement trend along the islands through the centre of the sheet is crossed by only a few lines. But these lines reveal little magnetic activity, with anomalies generally less than ten gammas giving the only indications of shallow basement. The granite here is almost non-magnetic as on Wilson's Promontory.

To the south, this condition persists as far as the 4100-gamma contour in the south-western corner. This throws doubt on the validity of the deeper basement area shown in the south-western corner of the sheet. It requires confirmation by other methods of exploration.

North-east of the islands, scattered stronger anomalies exist, indicating a general northerly dip. Poor control and lack of anomalies makes the location of the 2000 and 3000-foot contours uncertain in the north-western quarter of the sheet. The appearance of a 50-gamma anomaly, 18-1, gives a definite location for the 2000-foot contour. This anomaly is discussed in connexion with Sheet 18. Its sudden change in strike and termination here must reflect structure within the basement.

Anomaly 24-1 is a strong feature associated with a rise of the basement surface. This marks the beginning of a basement ridge extending north on to Sheet 18.

Depths increase towards the north-eastern corner of the sheet, and the location of the 6000-foot contour has been confirmed by rough analysis on line A119.

Sheet 25

The scattered flight lines in the south-western corner of the sheet give clear indications of shallow basement. Some anomalies in the ten and twenty-gamma ranges have been found in addition to the weak variations associated with the granites of this region. One strong anomaly, exceeding 160 gammas, also indicates shallow basement along the east side of the survey. Opening to the south-east from these zones, the anomalies broaden and a deepening basement is indicated.

The major area of interest lies in the north-western quarter of the sheet, where the basement dips to the north and north-east. The magnetic level here drops to a broad minimum and few anomalies reach ten gammas relief so that the depth estimates are not very well controlled.

Two anomalies warrant some attention; 25-1 averages three gammas in size but forms a continuous narrow feature twenty miles long. It could indicate structure on the basement surface. Anomaly 25-2 is similar but weaker and not so well defined. Anomaly 25-3 is also similar but stronger. It has a sharp narrow peak on line A117 with thirteen gammas relief and possibly indicating a basement "high" as suggested by the closed 4000-foot depth contour.

Anomaly 25-4 is of intra-basement origin, probably unrelated to structure on the basement surface. There are other anomalies in this deeper basement zone, but they cannot be clearly correlated from line to line and are not deemed worthy of note.

Sheet 26

The scattered flight lines across the sheet indicate very shallow basement for the most part. On the western side a huge anomaly marks the limit of the basic rocks associated with the northerly trends near King Island. Its eastern flank is probably related to faulting.

A similar group of strong anomalies occurs on the eastern side of the sheet. They too reflect shallow basement and basic rocks and their western flank could be faulted.

Between these areas, a small basin has been outlined; it is very poorly controlled.

On the north-eastern side of this basin, a series of minor anomalies were observed on line A37, in addition to a broader "high" outlined as Anomaly 26-1. This indicated shallower basement, but the general configuration both of magnetic and structural features looks odd, and it may be that the data obtained on this line are not correct.

Sheet 27

A few lines were flown across the south-western half of the sheet. All indicate shallow basement from features of moderate to strong relief.

Strong anomalies, reflecting basic rocks, lie in the north-western and south-eastern quarters out to the 2000-foot depth contour. However, the most persistent basement "high" trend extends north near the centre of the sheet, through a region of moderate anomalies. It gives way to a trough on the west, controlled by depth estimates around the edge of a large magnetic minimum. To the east the basement seems to drop sharply and a possible fault is shown. This runs beside Anomaly 22-2, where some sharp features control a closure of the 2000-foot contour. Similarly, sharp features force the sharp northward pull of the 2000-foot contour and the closed 1000-foot contour on the basement high trend. All might be related to volcanics associated with faulting. If this is true of Anomaly 22-2, the basement rise beneath it would be smaller than that shown.

Good control is present to show the basement deepening in the north-eastern quarter of the sheet, where a huge magnetic maximum, 28-1, makes its appearance. It seems to be associated with the deepest part of the Bass Strait basin. "Straight-slope" lengths suggest that Anomaly 27-2, on its flank may be associated with a basement "high". The existence of such a "high" requires confirmation by other methods of exploration. South-west of it lies Anomaly 27-3 which probably reflects only intra-basement contrasts. So does the nose outlined as Anomaly 27-1.

Sheet 28

This area probably includes the deepest basement in the Bass Strait basin associated with the huge magnetic maximum marked as Anomaly 28-1. Line B55 gave excellent analytical results across its east end and these have been used to draw a diagram illustrating the process. First the horizontal derivative was computed. The sharpest feature was fitted to an interface, giving a symmetrical component. By judicious placement of the centre lines, the remainder of the curve could be fitted with one antisymmetrical and one symmetrical component. Having tabulated the key figures of these components the corresponding anomaly components were computed and added together with the regional slope. The result gives an excellent fit to the original data implying that the analysis is reasonable. The sub-sea depths of 8500 feet and 10,500 feet were used but the 28,500 feet for the northernmost figure seems excessively large and not representative of the basement surface. The susceptibility contrasts of about 1000 x 10^{-6} cgs units imply basic rock. A 1000-foot rise of the basement surface in this area would cause a magnetic anomaly no greater than ten gammas (see Fig. 4).

A local basement "high" near Anomaly 27-2 requires confirmation, as discussed previously.

The basement surface rises to the east of the hugh maximum, as shown by measurements on the flanks of two groups of north-west trending anomalies. Both groups reflect intra-basement contrasts but seem to be associated with basement "highs". Anomalies 28-4, 28-5, and 28-6 are weak features on one flank, none exceeding eight gammas relief, but of no great interest.

Many anomalies control the basement rise shown along the southern part of the sheet. One, 28-3, may be associated with a structural rise. The north-east strike shown by this feature is carried on by Anomaly 28-2 probably reflecting an offshoot of the basic material causing 28-1. This offshoot also marks the sudden end of the huge anomaly and is probably associated with faulting that might persist through to parallel structures in Tasmania. However, the extension is not clear in the southern part of the sheet where control is inadequate to show the magnetic trends with certainty.

Anomaly 28-7 outlines a 12-gamma feature of no great interest.

Sheet 29

Two bands of strong anomalies traverse the sheet in a north-westerly direction. Both appear to be related to basement ridges. This interpretation is weakened by the strong chance that the basement "low" in the north-eastern part of the sheet is spurious. This area is probably underlain by granite which includes little magnetic material. However, the minor anomalies observed across it, and the Anomaly 29-1 give depth estimates of 2000 feet or more.

Again the basement "low" shown between the ridges lies over a general magnetic minimum where the absence of sharp features may be more indicative of weak polarization contrasts within the basement than increased depths. An analysis on Anomaly 29-2 gave a depth of 2100 feet from a thin sheet model which fitted the curve only moderately well.

Control is poor in the south-eastern half of the sheet but clearly reveals the shallow basement around the edge.

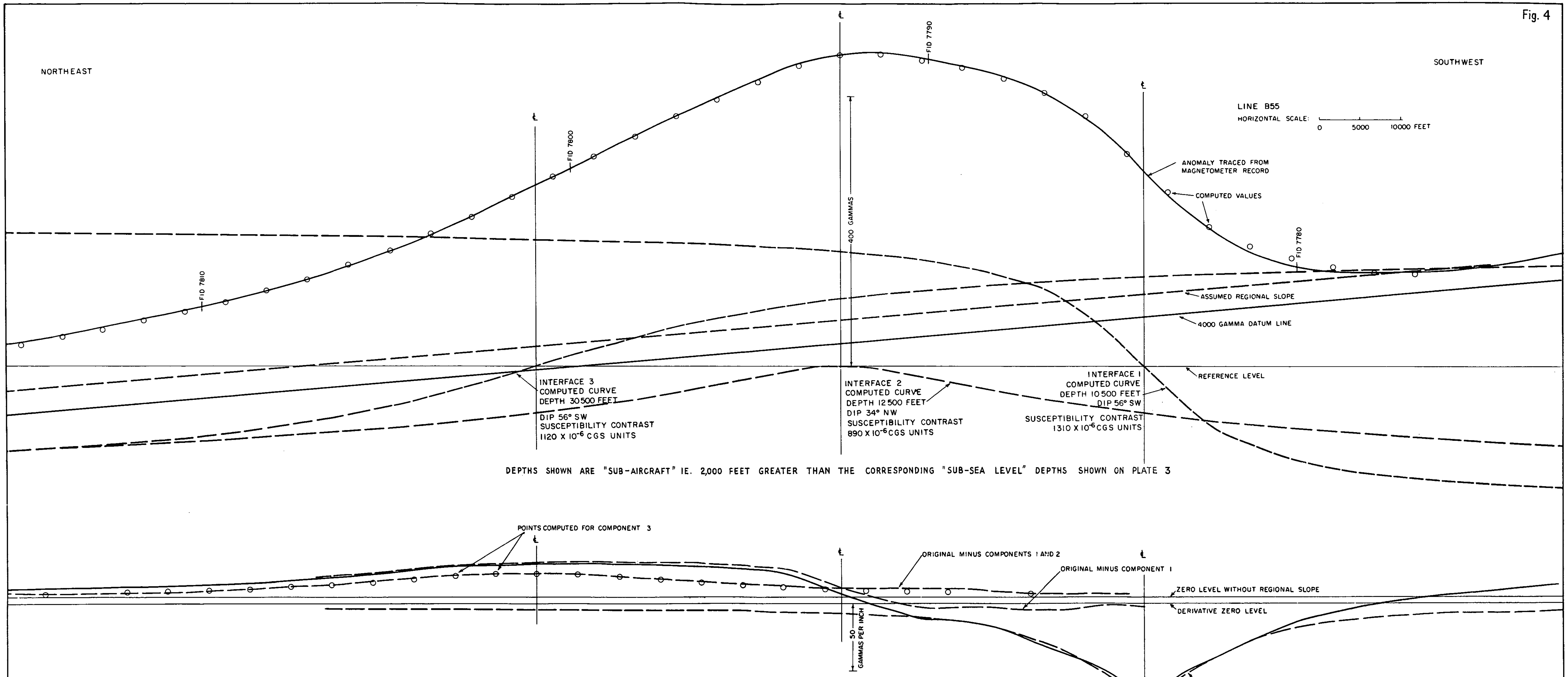
Sheet 30

The reconnaissance lines in this area reveal shallow basement except in the east where some weak features suggest a possible deeper area.

Sheets 31 and 32

The reconnaissance lines across these sheets serve only to show that the basement is shallow.

Fig. 4



DETAILED ANALYSIS OF PROFILE B.55 ACROSS ANOMALY 28-1

CONCLUSIONS AND RECOMMENDATIONS

These surveys have provided a great deal of information about the basement surface and structure. They have also given an opportunity for judging the approach of flying reconnaissance surveys before starting a more complete survey and of interpreting the results in the field so that extra lines might be added as the survey proceeded. It is believed that the results justify this approach both because preliminary interpretation was available far sooner than would otherwise be possible and because a maximum of information was obtained with a minimum of flying.

There is no question that the airborne magnetometer could provide additional information about basement structure if more lines were flown. For instance, a blanket coverage of the basin area with a line spacing no greater than one and a half miles would define trends more precisely, would allow recognition of more faults along the basin edges and more minor anomalies which could reflect local rises of the basement surface. For this latter purpose a closer tie-line spacing would be advisable. However, it is believed that the major features of the interpretation would not require much revision as a result of the extra control. Any decision about the amount of flying must be based upon economic considerations. The data acquired in this survey provide ample justification for the use of the airborne magnetometer, and much information that justifies further exploration in selected areas by other methods. It is recommended that the results of the aeromagnetic work be kept under review as new information is collected, so that full use can be made of all information on the region.

Geological conditions have hindered the interpretation in parts of the area. These are the granite of the Wilson's Promontory - Flinders Island trend, which includes little magnetic material and provides few features to interpret, and the near surface magnetic material along the coast from Port Phillip Bay to Portland, which masks the effects of the basement rocks. In these areas additional flying would not be very useful.

Results of the survey indicate that only in the Bass Strait have reliable indications of the maximum basement depths been obtained. Further exploration is warranted in the following areas:

(i) Across the north trending basement trough indicated on Sheet 6.

(ii) Along the coast of South Australia and Victoria from Kingston to Cape Otway.

(iii) Across the small basin outlined on Sheet 15.

(iv) Across the broad basin in Bass Strait.

(v) Along the Gippsland coast and north-east of the Wilson's Promontory - Flinders Island axis.

In planning marine seismic lines it would probably be wise to follow the same scheme used in the aeromagnetic work : laying out a broad grid to sample the area and check the magnetic interpretation and allowing for extra lines to be added over areas of interest revealed as the survey proceeds. It would be possible to plan the original grid so as to cross many of the features of possible structural interest given in this interpretation. By proceeding in this way, the magnetics would be useful in planning the extra lines, permitting extrapolations of structure away from the seismic reconnaissance lines.

APPENDIX 1

OPERATIONAL INFORMATION
BASS STRAIT AND ENCOUNTER BAY AEROMAGNETIC SURVEYS

Bass Strait Reconnaissance Survey

Aircraft	:	Piper Apache MJL
Pilot	:	L. Taylor
Magnetometer Operator	:	D. Hill
Survey Base	:	Essendon (Melbourne)
Survey Dates	:	12th-14th December, 1960
Distance surveyed	:	1500 miles

Final Surveys

Aircraft	:	Douglas DC-3, N9032H	
Field Project Manager	:	G. Mervyn	
Pilots	:	A. Thomae	L. Taylor
Magnetometer Operators	:	D.W. Davidson	R. Welshe
Shoran Operators	:	F. Clements	M.J. Fouquet
		D. Hill	J.V. Neals
		T. O'Rourke	L. Subick
		S. Ward	
Engineer	:	H. Hughes	
Data Analyst	:	R. Butler	
Compilation Supervisor	:	R. Lambert	
Geophysicist	:	M.S. Reford	

Encounter Bay Reconnaissance Survey

Survey Base	:	Essendon (Melbourne)
Survey Data	:	9th September, 1961
Distance surveyed	:	650 miles

Bass Strait Shoran Survey

Survey Bases	:	Essendon (Melbourne)
	:	Devonport and Mount Gambier
Survey Dates	:	17th September to 1st December, 1961
Operational Days	:	42 days
Delays	:	15 days weather
		2 days diurnal
		3 days weather and diurnal
		7 days ground stations inoperative
		1 day illness
		6 days data compilation
Total Delays	:	34 days
Total Duration	:	76 days

Bass Strait Shoran Survey (Contd)

Flights	:	
Flight programme completed		23 flights
Part of programme completed		13 flights
No programme completed		3 flights
Moving Base		3 flights
Moving ground crew		1 flight
Line crossings only		2 flights
Total		45 flights

NOTE: Two flights were made on 18th September, and three flights on 26th November, 1961.

Reason for premature abandonment of flights:	
Bad weather	6 flights
Shoran failure or lack of range	8 flights
Magnetometer trouble	1 flight
Aircraft trouble	1 flight
Total	16 flights

Distances surveyed	:	
Flown		13,360 miles
Data not accepted		1,407 miles
Data accepted		11,953 miles
Data chargeable		11,823 miles
Average production per flight		300 miles
Maximum production per flight		702 miles

Encounter Bay Shoran Survey

Survey Bases	:	Mount Gambier and Adelaide
Survey Dates	:	1st-21st December, 1961
Operational Days	:	14 days
Delays	:	4 days weather
		2 days diurnal
		1 day ground station failure
Total Delays	:	7 days
Total Duration	:	21 days
Flights	:	
Flight programme completed		12 flights
No programme completed		1 flight
Moving Base		2 flights
Line crossings		1 flight
Total		16 flights

NOTE: Two flights were made on 5th December and on 21st December, 1961.

Distances surveyed	:	
Flown		6399 miles
Data not accepted		407 miles
Data accepted		5992 miles
Average production per flight		500 miles
Maximum production per flight		768 miles

APPENDIX 2

NOTES ON GEOLOGICAL INTERPRETATION OF MAGNETIC FEATURES - BASS STRAIT AND ENCOUNTER BAY AREAS

by

Haematite Explorations Proprietary Limited

SUMMARY

The geological study of the underwater shelf areas of south-eastern Australia can only be based on the projection of geological boundaries, structures and trends from Victoria, Tasmania and South Australia, and on geophysical evidence.

No previous geophysical work had been done in the area over which these subsidized aeromagnetic surveys were carried out, but in the assessment of the results, information has been drawn from earlier geophysical surveys in the surrounding areas:

(i) Aeromagnetic surveys over Kangaroo Island, and the Mt Lofty Ranges, and the Murray Basin in South Australia; the Gippsland Basin and the adjacent off-shore area in Victoria; and over north-west Tasmania;

(ii) Gravity surveys over the Gambier Sunklands, South Australia; and over the Otway Basin and Port Phillip Bay, Victoria;

(iii) Seismic surveys over the Gambier Sunklands, South Australia; and over the Otway and Gippsland Basins, Victoria.

The recent aeromagnetic surveys have outlined areas of basinal deposition which may have been favourable for the accumulation of petroleum. Sedimentation in these basins was probably confined to late Jurassic, Cretaceous and Tertiary times, although there is evidence to indicate that Middle Devonian-Permian sediments may underlie the Bass Strait and Gippsland areas, but are not confined to the basins.

The geological review of the magnetic results deals with the geological history and the eventual breakdown of this area of the Tasman Geosyncline to form the basins of deposition referred to in the previous paragraph. It is thus the summation of:

(i) Interpretation of the magnetic features; and

(ii) Theoretical aspects of the formation of Bass Strait and of other similar structures in the bordering States.

The magnetic results are expected to produce additional information when they are re-examined in conjunction with the results of the proposed seismic survey.

GEOLOGICAL REVIEW - AEROMAGNETIC RESULTS

Magnetic features may be related to:

Basement

Precambrian - Cambrian	Strong features
Ordovician - Silurian granite intrusives	Weak features
Faulting	Features depend on the rock types in juxtaposition

Basic Rocks in Sedimentary Section

Eocene or Pliocene	Tertiary basalt
Jurassic (Tasmania)	Dolerite

Only the more important basins of sedimentation which have been defined as a result of the magnetometer survey, are discussed below.

Encounter Bay Area - Otway Basin (Gambier Sunklands)

This area is clearly divided into two parts. North of an east-west line, just south of latitude 37°S, shallow basement features predominate whereas to the south of it the depth of sedimentation increases rapidly within the Gambier Sunklands of the Otway Basin.

(i) Basement Complex

The Encounter Bay area from Kangaroo Island to the Coorong forms part of the Mt Lofty - Kangaroo Island arc of Precambrian metamorphics, flanked to the east and south by geosynclinal deposits of the Kanmantoo Group (Cambrian). Basement trends are east-west beneath the continental shelf south of Kangaroo Island. Farther eastward these become complex and variable until north-south trends are predominant adjacent to the small graben (between longitudes 139°10'E, and 139°40'E.) and also on the Padthaway Horst where they have been defined by aeromagnetic survey of the Murray Basin.

The graben, bounded by north-south down-to-basin faulting, contains an estimated 3000 to 4000 feet of sediments. The faulting on the western side of the graben is probably an extension of the eastern boundary faults of the Mt Lofty Ranges.

The sediments within the graben may be the result of deposition from the Murray River which flowed westwards until reaching the early Tertiary fault escarpments of the Mt Lofty Ranges, then turned to the south along the strike direction of the fault blocks. Deposition in the graben may have been confined to post-Cretaceous times.

Another small graben of moderate sedimentary depth occurs on the margin of the continental shelf (south-western part of Sheet 5) but sedimentation in this area is more probably related to the main Otway Basin than to discharge from the Murray River.

Areas of shallow magnetic relief within the basement complex may be correlated with post-Cambrian granitic intrusions such as outcrop on Kangaroo Island, near Victor Harbour, and Kingston, and in isolated areas on the Padthaway Horst.

(ii) Gambier Sunklands of the Otway Basin

The faulted margin of the sunklands extends eastwards onshore to the zone of the Lucindale Fault, as outlined by aeromagnetic data obtained by the S.A. Mines Department. The inference drawn from comments in the aeromagnetic report concerning the magnetics in the sunklands area is that a very deep sedimentary section exists throughout, with the exception of the pronounced basement "high" near Beachport. Estimates of depths-to-basement from the magnetic profiles are based on insufficient features to determine properly depth variations. The basin structure as outlined by the depth-to-basement contours only shows that the section is thick and that the basement slopes steeply to the south.

Near Beachport, two major features, both related to basic rocks within the basement, have been studied. One feature (8 - 4* : 9 - 2) extends westwards from the coastline at Beachport with increasing depth to basement in this direction. The second (9 - 5) was analysed in the aeromagnetic report as a typical dyke model of basic material dipping south-west at 60°, 22,000 feet in width and with its upper part 16,000 feet below sea level. A related minor feature (within 9 - 5) is thought to be related to basic intrusives at 4000 feet below sea level. These two features indicate a steep slope of the basement surface to the south. The common apex of these major features is the basement "high" as outlined by the gravity and magnetic anomalies centred approximately five miles north of Beachport.

The report shows the similarity between this coastal magnetic feature (9 - 5) and a belt of magnetic relief trending north-westwards from Mt Gambier to Beachport, as recorded by the S.A. Mines Department survey. The latter belt follows the zone of vulcanicity (Mt Gambier - Mt Burr) and the coastal feature may have a similar origin but with no surface expression of the volcanics. An area is shown on Composite Map "A" in the vicinity of Beachport which may be underlain by volcanics within the sedimentary section. Structural control for these zones of vulcanicity may be provided by faulting within the sunklands.

A broad magnetic "low", related to the present continental margin, trends south-eastwards in the south-eastern part of Sheet 8 and deviates to a more easterly direction (Sheet 9) away from the present margin . It crosses the coastline north of Douglas Point and is probably related to the margin of the continent in some earlier geological period, possibly Cretaceous-Eocene.

Otway Basin

Geological evidence in Victoria shows that the Otway and Gippsland Basins are at present separated by the Mornington Peninsula which has a south-west trend. The continuation of this trend, ie. the Phillip Island - King Island basement "high", forms the ridge between the Otway Basin and the Bass Basin as defined by the airborne magnetometer "depth-to-basement" estimates.

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* (8-4) refers to area number 4 on Sheet 8, as marked on the composite map.

The ridge is a broad feature, up to 35 miles wide, and its crest has a gradual slope to the south-east. To the north-west it appears to be faulted down-to-basin by a continuation of the Selwyn Fault. Smaller north-south faults are postulated on either side of the basement ridge, those on the north-western side forming part of a mosaic fault block pattern with areas of positive basement relief and also of deeper sedimentation. The largest area of moderate sediment depth is east of Lorne and probably extends into Port Phillip Bay. The Younger Basalts (Pliocene) mask the basement magnetic relief along the northern side of the basin but the Anglesea Well and the results of the Bureau of Mineral Resources gravity survey of Port Phillip Bay suggest deep basement in that direction.

North-west of a line trending south-west along and beyond the Otway coast, the magnetics indicate deep basement with shallow basaltic activity in the offshore area. Areas of small "sea knolls" with up to 210 feet of relief above the ocean floor at 39°S, $143^{\circ}25'$E, and $39^{\circ}07'$S, $143^{\circ}15'$-$20'$E, may be related to these basalts.

The prominent basement trends south-east of Cape Otway may be correlated with the structural trends of King Island and hence may represent basement at a shallow depth. The rapid rise of the basement floor east and south-east of Cape Otway may be related to a fault zone on which later, and reversed, movement elevated the Otway Ranges to their present relief during the Tertiary epeirogenic movements.

The magnetic survey along the western Victorian coast provided only sparse coverage and no conclusions can be drawn regarding the structure of the deeper parts of the Otway Basin. In places, shallow volcanics have been fortuitously found by the flight pattern.

The Phillip Island - King Island ridge is overlain by Older Basalt (Eocene) on Phillip Island and along the southern coast of Mornington Peninsula. The basalt appears to extend along the basement ridge for a distance of some 30 miles southwards from Cape Schank. The band of "steep magnetics" along the southern side of the ridge suggests a series of north-south faults displacing a northeast-southwest fault as shown diagrammatically on Sheet 21, Composite Map "B".

Bass Basin

The major deep basinal structure within Bass Strait trends north-west to south-east across Sheets 22, 27 and 28 and conservative estimates indicate thicknesses of sediments up to 12,000 feet.

(i) Margin of Basin

A basinal area of shallow depth occurs south of Wonthaggi and is bounded on the south-eastern side by a trend which forms the extension of one of the epeirogenic boundary faults of the South Gippsland Highlands. On either side of this basin, which deepens to the south-west, large magnetic anomalies occur. Those which are south of Cape Liptrap may reflect an offshore extension of outcropping (?) Cambrian greenstone and diabase and, if so, these offshore rocks are probably faulted, along their western boundary, against Devonian limestones. The large anomaly south of Phillip Island (south-west Sheet 16) may also be related to (?) Cambrian rocks as the normal basement in the Wonthaggi area comprises weakly magnetic Silurian metamorphic rocks.

There is evidence that the Bassian Rise, a submarine ridge connecting Flinders Island and Wilson's Promontory, is composed of granite intrusives in Silurian metamorphics. Resistant granite forms the many islands along the Rise. "Basement" is virtually non-magnetic with small anomalies up to five gammas but similar profiles were recorded over the granitic rocks of Flinders Island. There is a sharp change in basement rock types in the area west of Wilson's Promontory towards Cape Liptrap.

Geological evidence from Tasmania, Flinders Island and Wilson's Promontory suggests that the whole of Bass Strait east of longitude 146°30'E, is probably underlain by a "basement" of weakly magnetic Silurian rocks with granite intrusives. It seems likely that many anomalous features, trending north-west to south-east and with magnitudes up to 250 gammas, may be related to dolerite sills as noted on the north-east part of Tasmania (Ringarooma Bay). Some of these areas are shown on the map. The dolerites intrude Precambrian, Lower and Middle Palaeozoic rocks, as dykes, and spread out as sills within the Permian and Triassic sediments of Tasmania. The magnetics may therefore relate to north-west trending dykes within the sediments of the Mathinna Group (Silurian) or to sills in Permian strata, preserved on down-faulted blocks in a similar manner to the dolerites of the Launceston Basin.

Basement magnetics become more pronounced along the south-western side of the Bass Basin, east of the southern tip of King Island, and the magnetic trends conform to the north-south trends in the Precambrian and Lower Palaeozoic rocks of King Island and of the north-western part of Tasmania. Tertiary volcanics extend along the north-west coast of Tasmania from Devonport to Cape Grim. Only isolated flight lines crossed this area of shallow basement and the submarine boundaries of the basalts may be indicated in a broad sense by the value of the magnetics, as shown diagrammatically on Composite Map "C".

"Depth-to-basement" estimates do not indicate any connexion between the Bass Basin and the Launceston graben which, although they have similar areal extent and strike direction, differ greatly in the depth of sedimentation.

A small graben, parallel to the Otway structures, is shown between King Island and the islands off north-west Tasmania, but is separated from the main Bass Basin by shallow basement.

(ii) Deep Sedimentary Basin

There are two major magnetic features of the Bass Basin which occur in its deepest part. They are separated by a north-south trending magnetic "low" which may reflect the effects of a north-south fault along longitude 145°30' E.

The major features, shown on Sheets 22 and 28, both appear to be related to basic intrusion and analyses indicate that these bodies have similar strikes, dips and thicknesses.

The magnitudes of the magnetic anomalies probably indicate intrusive basic material rather than variations in the basement rock types as they are known in Victoria and Tasmania. Massive dolerite intrusives may be the source of the magnetic anomalies in dyke form within the Palaeozoic basement, or as a sill in Permian or Triassic strata. If a sill, the depth to the basement may be considerably greater than that shown. The estimate of 15,800 feet to the third interface on Anomaly 22 - 1 and the north-east dip of that feature possibly indicate the attitude of the basement. However, the manner of intrusion of the dolerite, which is considered to have taken place in Middle Jurassic time is not of significance.

Gippsland Basin

The Bureau of Mineral Resources aeromagnetic survey (1956) of the offshore Gippsland area covered the major part of this Basin and the present survey was planned to extend the coverage over the southern part adjacent to the Bassian Rise.

The two surveys matched well, as shown by the magnetic record between Wilson's Promontory and Cape Liptrap and by the characteristic change in strike of the belt of magnetic maxima at 39°S, 147°30'E. Interpretation of the Bureau's results was carried out by J.H. Quilty (BMR Record 1962/53) and this interpretation has been accepted. The following comments therefore, deal principally with the southern part of the basin.

North-easterly basement trends as recorded from the Bureau of Mineral Resources survey are evident beneath the southern part of the Gippsland Basin, and no variation in basement trends are evident under the whole of the Gippsland Basin extending eastward from Western Port Bay to east of Lakes Entrance.

The belt of magnetic maxima shown by both surveys was analysed and indicated a typical dyke model 9000 feet wide at a depth of 5000 feet. Rising above the general basement level, it is composed of basic material but cannot be related to any surface feature.

Marginal down-to-basin faulting, in particular the major fault extending eastward from Lake Wellington along the northern side of the basin indicates breakdown of the north-western edge of the Gippsland Basin (Refer BMR Record 1962/53). A complementary marginal fault, trending east-west (south-east of Sheet 18) is postulated to terminate basement magnetic trends on the southern flank of the basin area and is supported by depth-to-basement estimates and the configuration of the basin. Surface expression of this fault is shown by the sharp change of alignment of the continental margin at 38°45'S, 148°20'E.

GEOLOGICAL COMMENTS ON SOUTH-EASTERN AUSTRALIA

The following notes comprise a summary of the geological history of the area under review, and a discussion of a possible method of formation of Bass Strait with reference to the main geological features of south-eastern Australia.

Basement Framework

Deposition in the Tasman Geosyncline began in an easterly direction commencing with the Cambrian Kanmantoo Group along the eastern flank of the Archaean-Proterozoic core of the Mt Lofty Ranges. It ended with the major Bowning and Tabberabberan orogenic movements of the Silurian-Devonian during which the granitic intrusions in north-east Tasmania and the Bassian Rise were emplaced. The regional grain of the early and mid-Palaeozoic rocks is meridional with local variations from north-west to north-east. Some faunal relationship has been established between the Cambrian rocks of Victoria and Tasmania but there are no rocks in Victoria which are equivalent to the (?) Precambrian rocks of

Tasmania. The Tyennan Geanticline of Tasmania must therefore constitute a separate basement complex to the south of the Tasman Geosyncline. However, after the early Palaeozoic, the geological environment in Tasmania and Victoria became similar as it is believed that the Mathinna Group of Tasmania can be correlated with the Silurian sediments of Victoria, and likewise the granitic intrusions within these sediments are probably of the same or similar age.

Terrestrial sediments were deposited in late Devonian-Carboniferous times in broad synclinal depressions formed during the previous orogenic movements. These sediments occur in Victoria in the Mt Wellington-Mansfield belt and at the Grampians.

There were three major thrust belts associated with the late Palaeozoic orogeny in Victoria (Thomas, 1958). The most westerly of these, the Stavely Belt along the eastern side of the Grampians, may have influenced the location of the west coast of Tasmania and King Island.

Late Palaeozoic - Mesozoic Sedimentation

Deposition in Tasmania in Permian - Middle Triassic times covered most of the island and extended into Bass Strait. Sediments, often tuffaceous, were alternatively marine and fresh water. Dolerite intrusions took place, probably during Jurassic time, as dykes along faults between blocks of sediments, and as sills in the Permian and Triassic strata.

Formation of Bass Strait

S.W. Carey (ANZAAS, Sydney, 1962) suggested that the formation of Bass Strait resulted from east-west transcurrent faulting in Victoria, through Gippsland and south of the Dividing Range. The movement was postulated as south-block-west, the westerly shift producing a series of en echelon faults which "moved" Tasmania to its present position.

The Stavely thrust belt may have originally continued to the south as far as Tasmania, and subsequently displaced by faulting. The fault zone may thus now define the continental margin along the western coasts of Tasmania and King Island.

It is postulated that this breakdown occurred after the dolerite intrusion in Tasmania and the resultant movement of Tasmania relative to the mainland produced the major graben in southern Victoria which received sedimentation during Upper Jurassic to Lower Cretaceous times.

Late Mesozoic - Tertiary

At the conclusion of the deposition of great thicknesses of arkosic sediments in the Victorian graben, normal down-to-basin faulting took place in western Victoria and South Australia so allowing marine transgression and deposition of the Middle Cretaceous Belfast Group. Typical features in the Otway Basin were down-to-basin fault blocks with horst and graben topography superimposed across the basin strike direction. Similar features are not apparent on the landward expression of the Gippsland Basin.

The Bass Basin appears to be separated from both the Otway and Gippsland Basins and the control of deposition and facies variation within the Bass Basin cannot be interpreted at this stage. From evidence around its margins it is expected that a great part of the section will be Tertiary sediments.

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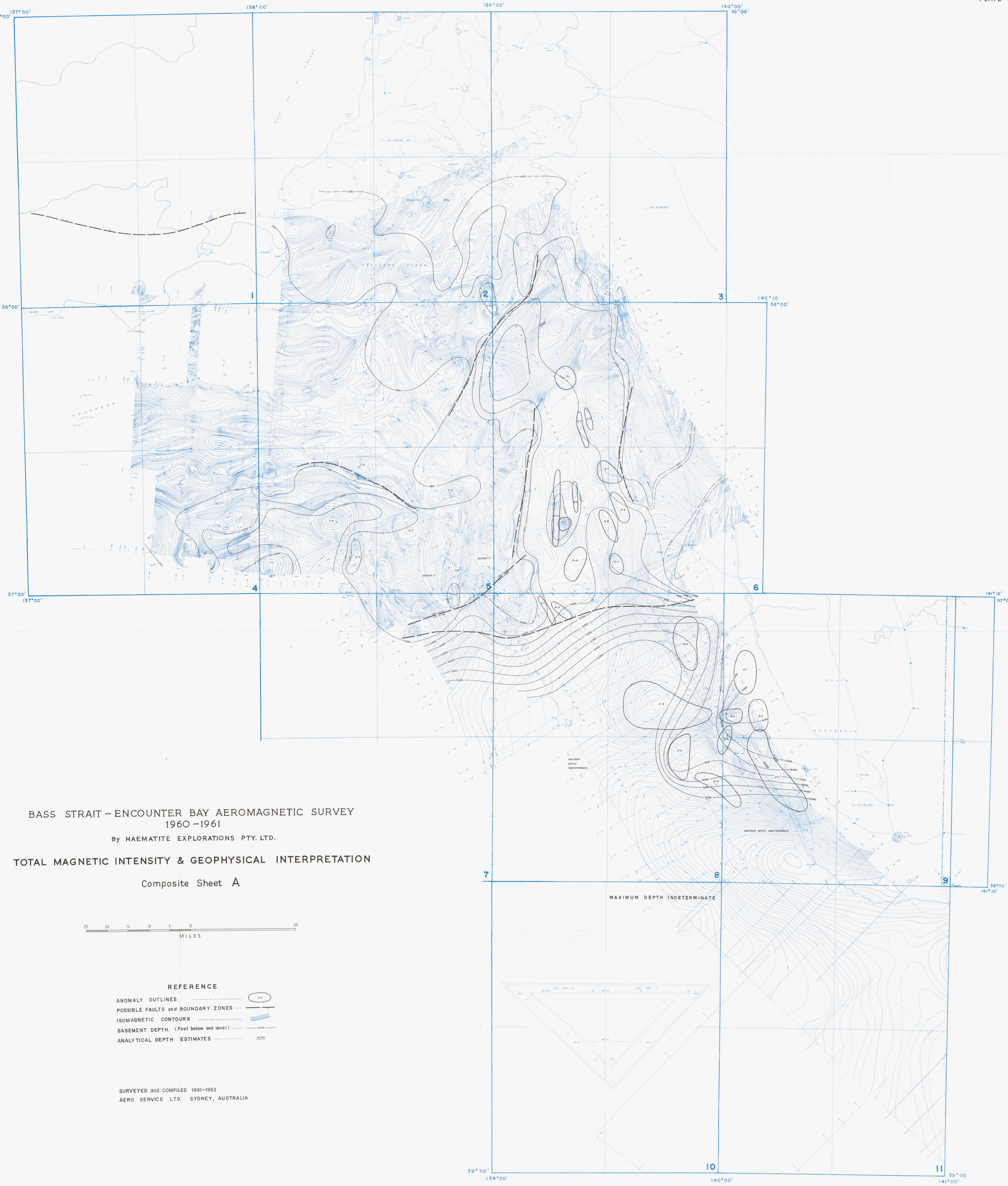
PLATE 1



BASS STRAIT – ENCOUNTER BAY AEROMAGNETIC SURVEY 1960 – 1961

By HAEMATITE EXPLORATIONS PTY. LTD.

TOTAL MAGNETIC INTENSITY & GEOPHYSICAL INTERPRETATION

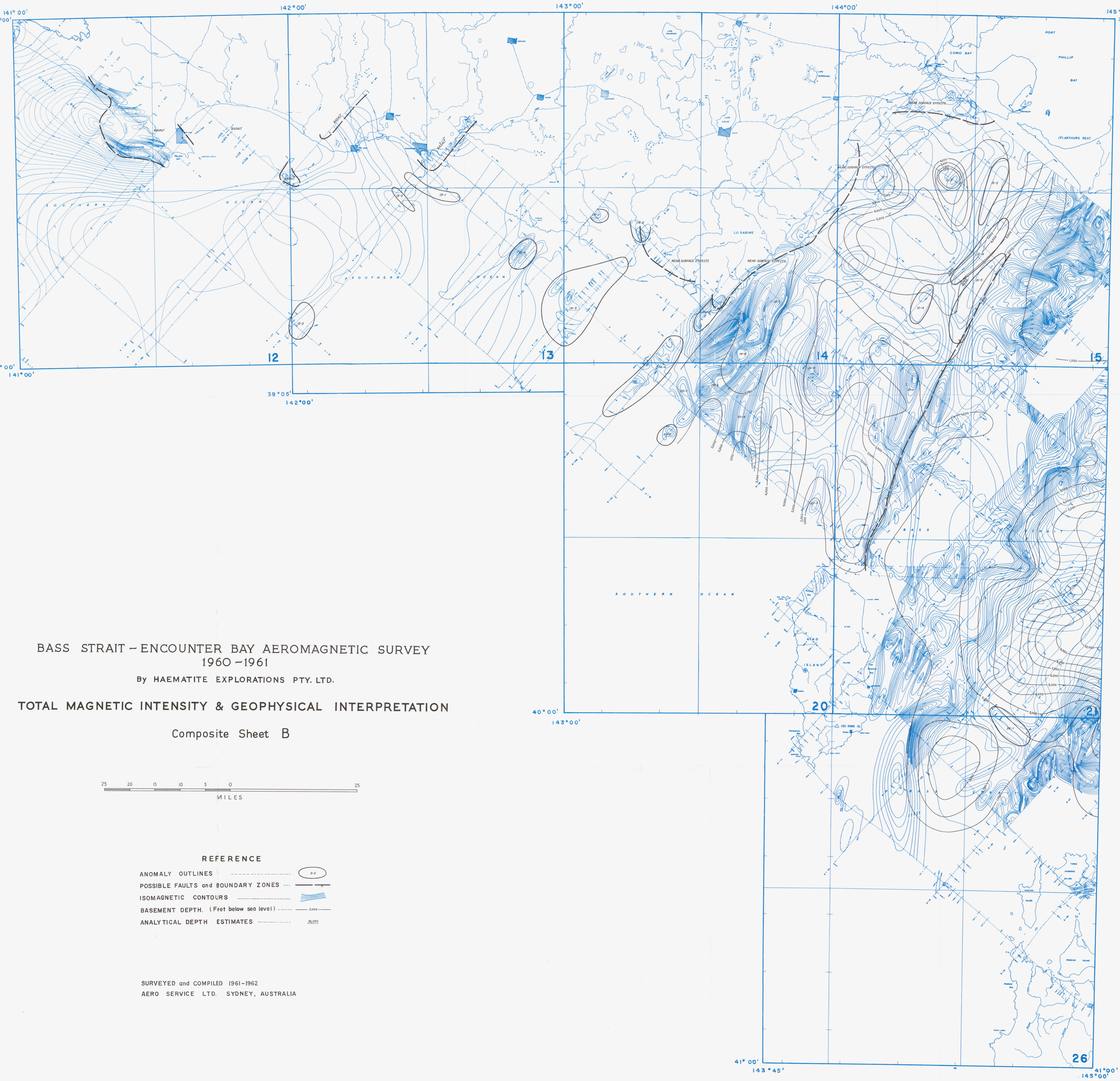
Composite Sheet A

25 20 15 10 5 0 25
MILES

REFERENCE

ANOMALY OUTLINES
POSSIBLE FAULTS and BOUNDARY ZONES
ISOMAGNETIC CONTOURS
BASEMENT DEPTH. (Feet below sea level)
ANALYTICAL DEPTH ESTIMATES

SURVEYED and COMPILED 1961–1962
AERO SERVICE LTD. SYDNEY, AUSTRALIA



BASS STRAIT – ENCOUNTER BAY AEROMAGNETIC SURVEY
1960 – 1961

By HAEMATITE EXPLORATIONS PTY. LTD.

TOTAL MAGNETIC INTENSITY & GEOPHYSICAL INTERPRETATION

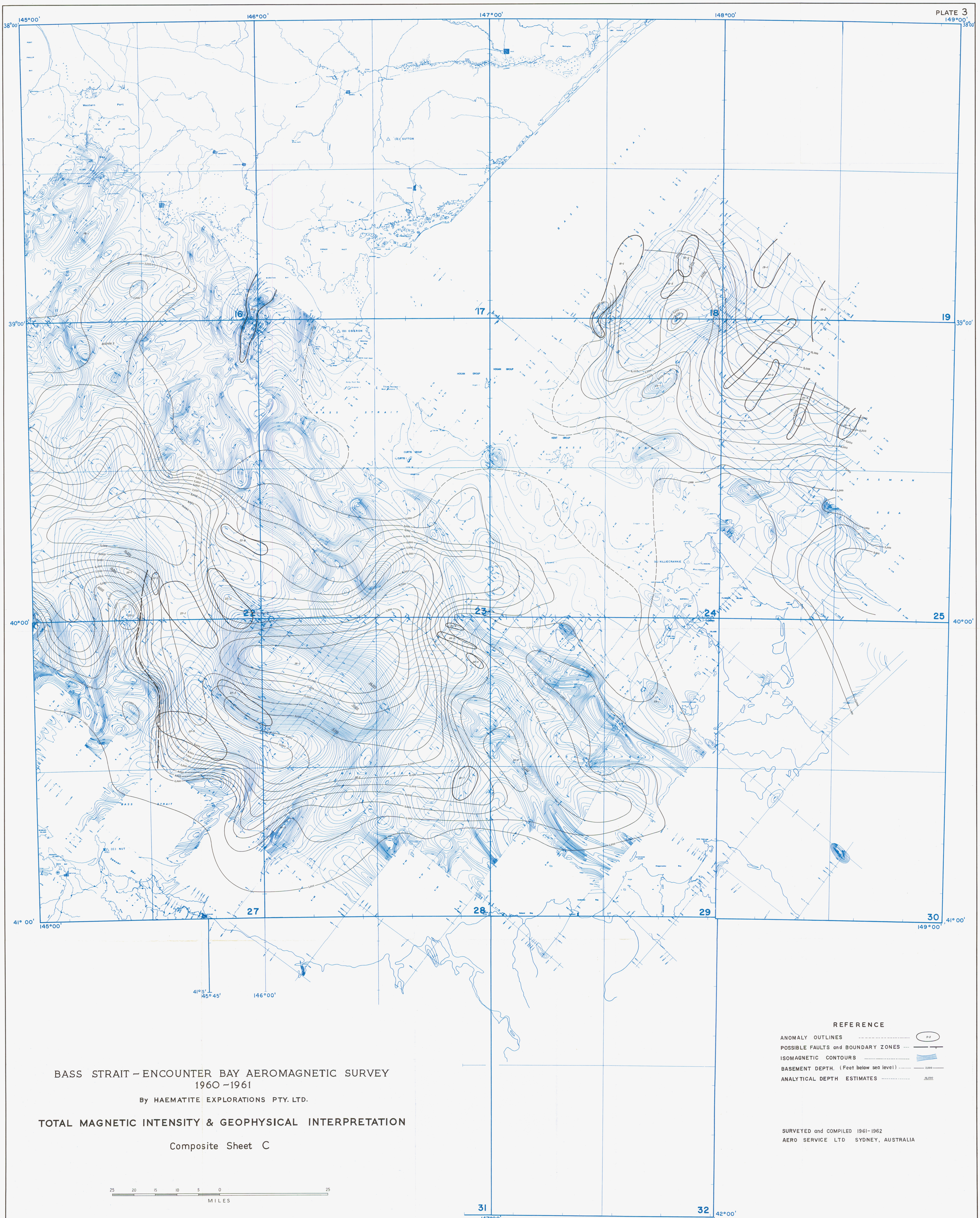
Composite Sheet B

25 20 15 10 5 0 25
MILES

REFERENCE

ANOMALY OUTLINES	
POSSIBLE FAULTS and BOUNDARY ZONES	
ISOMAGNETIC CONTOURS	
BASEMENT DEPTH. (Feet below sea level)	2,000
ANALYTICAL DEPTH ESTIMATES	15,000

SURVEYED and COMPILED 1961–1962
AERO SERVICE LTD. SYDNEY, AUSTRALIA



BASS STRAIT – ENCOUNTER BAY AEROMAGNETIC SURVEY 1960 – 1961

By HAEMATITE EXPLORATIONS PTY. LTD.

TOTAL MAGNETIC INTENSITY & GEOPHYSICAL INTERPRETATION

Composite Sheet C

SURVEYED and COMPILED 1961-1962
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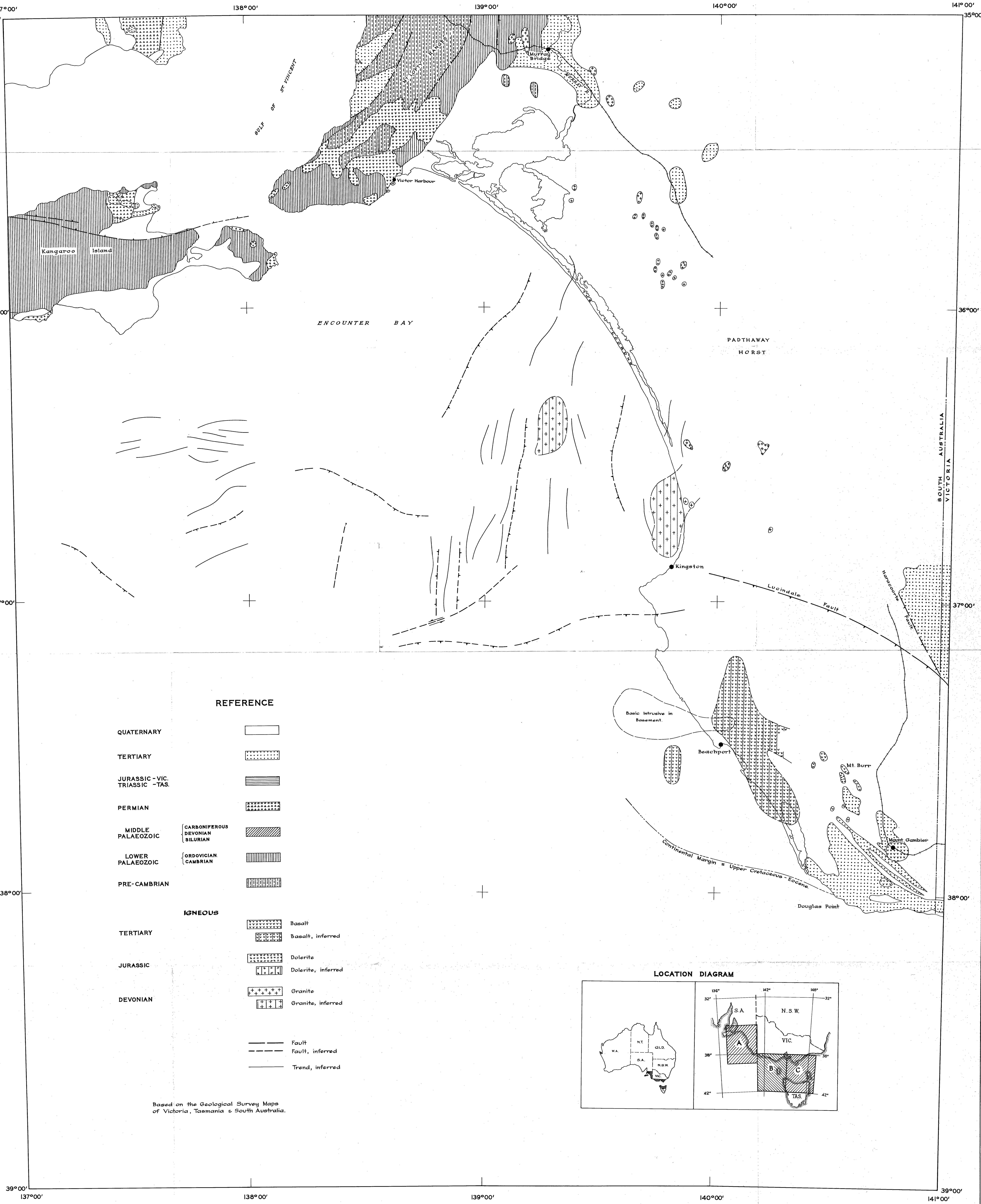
PLATE 4



COMPOSITE A

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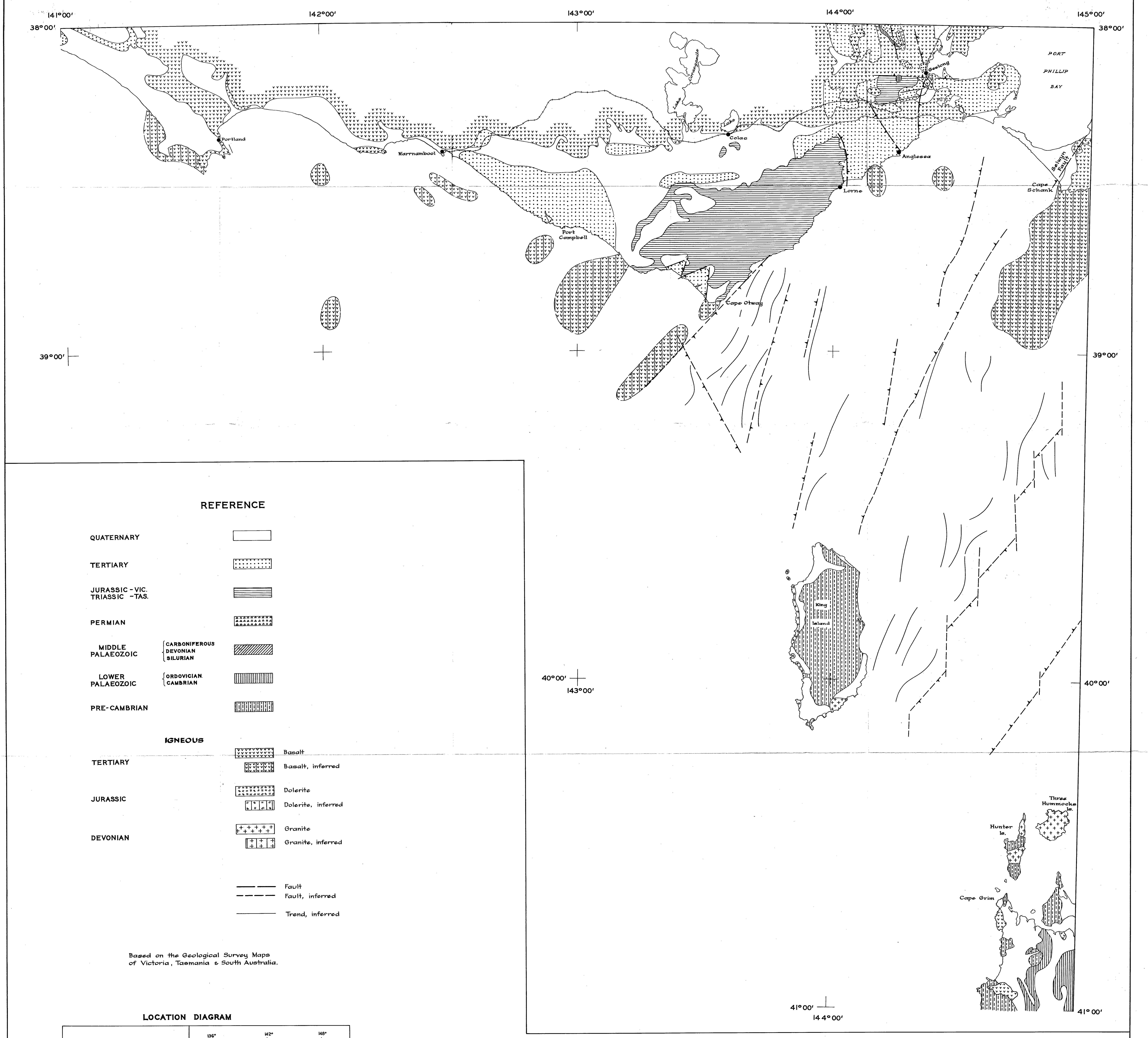
TRANSVERSE MERCATOR PROJECTION.

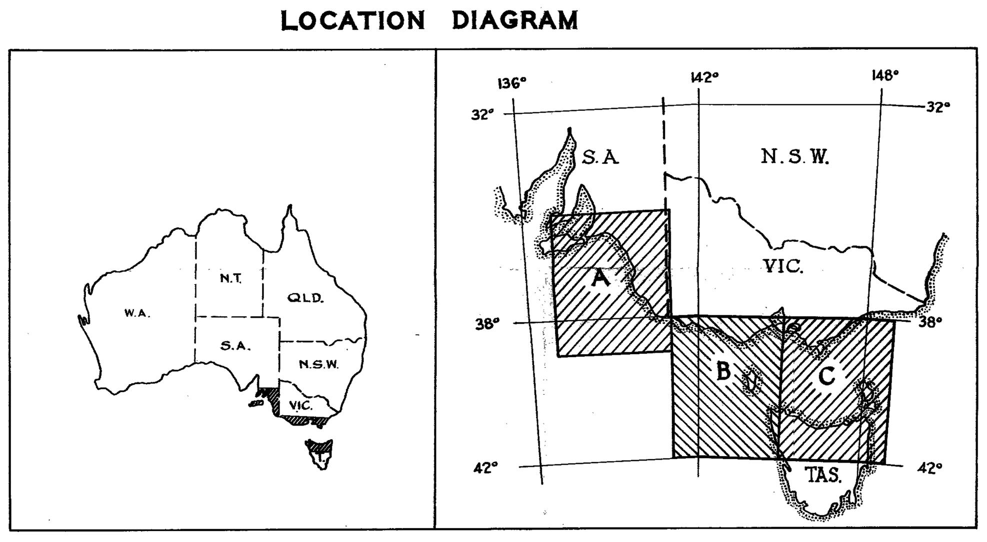
HAEMATITE EXPLORATIONS PTY. LTD.

GEOLOGICAL INTERPRETATION OF MAGNETIC FEATURES

(TO ACCOMPANY APPENDIX 2) JAN. 1963



LOCATION DIAGRAM



COMPOSITE B

1 : 500,000

TRANSVERSE MERCATOR PROJECTION

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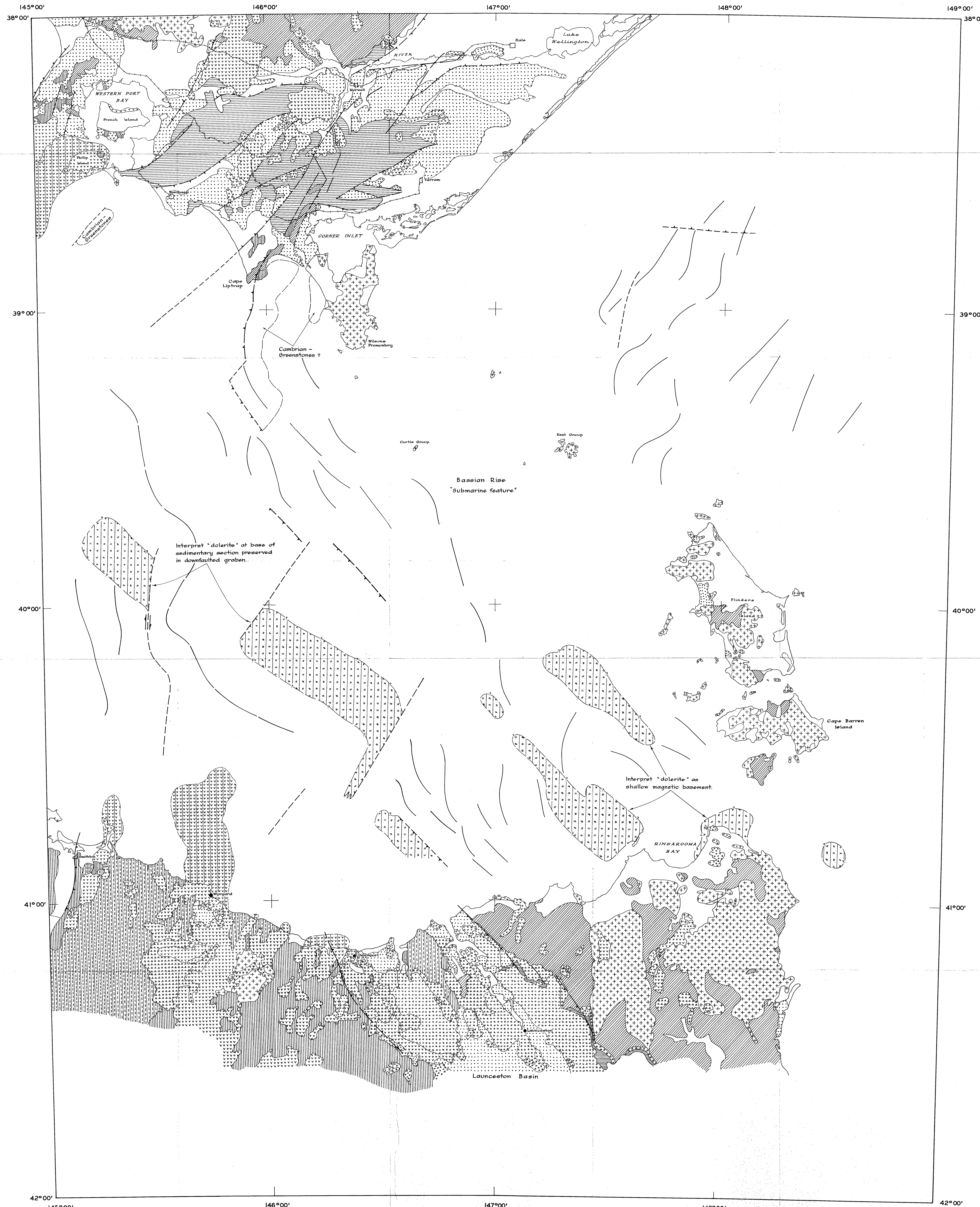
GEOLOGICAL INTERPRETATION OF MAGNETIC FEATURES

(TO ACCOMPANY APPENDIX 2) JAN. 1963



COMPOSITE C

1:500,000

TRANSVERSE MERCATOR PROJECTION

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GEOLOGICAL INTERPRETATION OF MAGNETIC FEATURES

(TO ACCOMPANY APPENDIX 2) JAN. 1963