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REPORT

ON

AIRBORNE MAGNETOMETER SURVEY

BASS STRAIT AND ENCOUNTER BAY AREAS

AUSTRALIA

FOR

HAEMATITE EXPLORATION PTY. LTD.

AERO SERVICE LIMITED
A Division of Litton Industries
SYDNEY, AUSTRALIA

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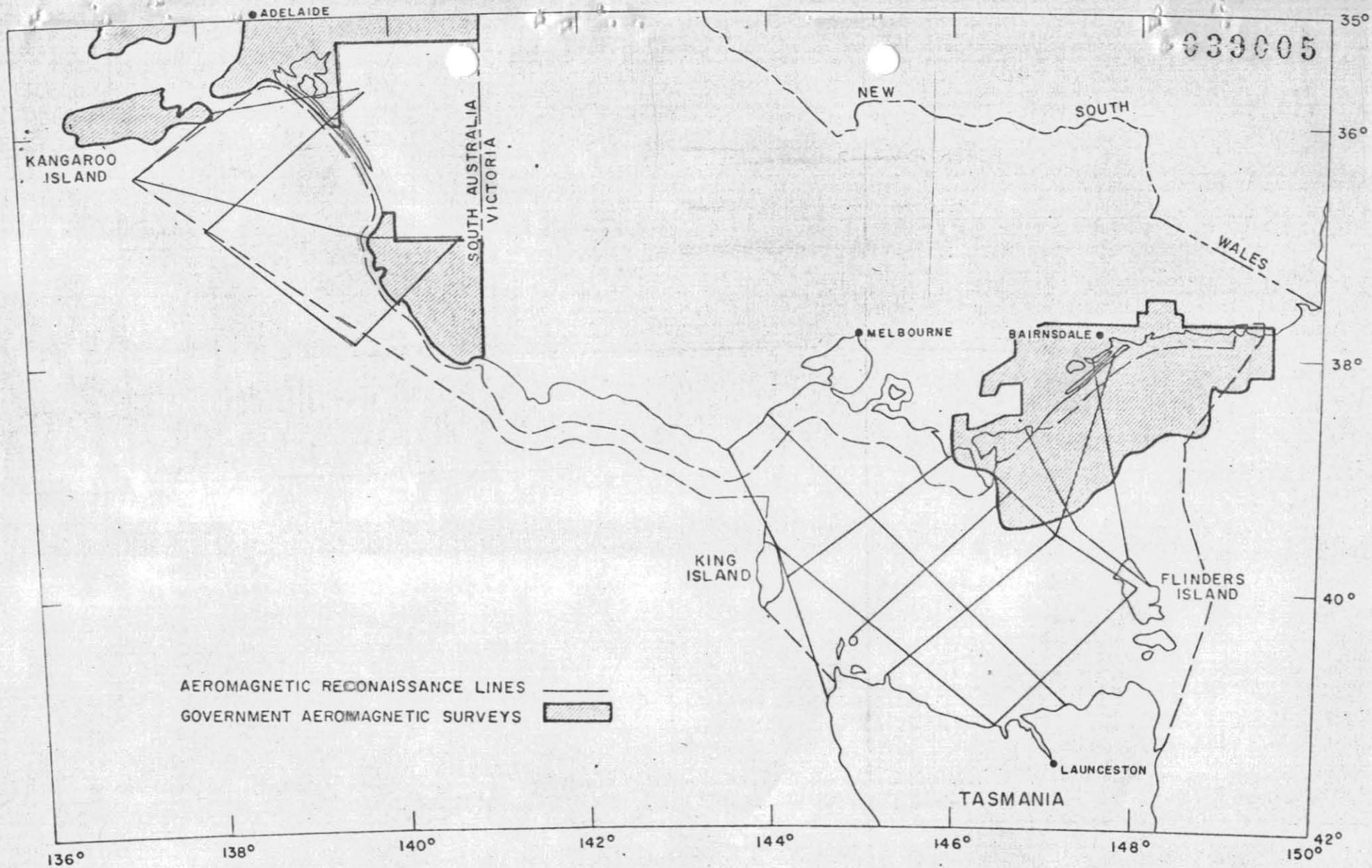
INTRODUCTION

This airborne magnetometer survey covers a large area off the southeastern coast of Australia, from Gippsland in the east, through the Bass Strait, to Encounter Bay and Kangaroo Island in the west. It was flown by Aero Service Limited for Haematite Explorations Proprietary Limited to provide information on the geology and petroleum prospects.

Survey operations began in December 1960, when some widely spaced reconnaissance lines were flown across the 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.

ACKNOWLEDGEMENTS

Many people went out of their way to assist the personnel of Aero Service Limited in completing this survey. We wish to acknowledge our debt of gratitude for the great help extended by the staff of the Broken Hill Proprietary Company Limited and the Bureau of Mineral Resources of the Commonwealth Government. In particular, our thanks go to Mr. Brian Hopkins, whose supervision of the survey smoothed our path on innumerable occasions.



BASS STRAIT AND ENCOUNTER BAY AREAS

SCALE 1:5,000,000

5 cm

RECONNAISSANCE SURVEYS

The lines flown in the reconnaissance surveys are shown on the first index map. 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 35mm 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 December 12 and 14, 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 September 9, 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 the first index map. The eastern area is the Gippsland survey of the Bureau of Mineral Resources of the Government of Australia and the western areas have been surveyed by the 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. N40°E or N50°W were chosen for the entire Bass Strait and the eastern end of the Encounter Bay area. N60°E seemed to be a good direction for most of the Encounter Bay area but south of Kangaroo Island N5°E was used, fitting the trends known on the island.

Having drawn up the basic grid, extra lines were added across the areas where geologic 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 12 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% to the original pattern of lines.

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

A Series	--	N50°W
B Series	--	N40°E
C Series	--	N30°W
D Series	--	N60°E
E Series	--	N85°W
F Series	--	N 5°E
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 southeastern or southwestern 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	"	"	"	90	"
2000	"	"	"	110	"
4000	"	"	"	130	"

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 measures 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 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 very high frequency radio signal. This is picked up by a ground station, which then transmits a signal 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 one ground station or the other about fifteen times every second, and the 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 reflected on a meter on the pilot's instrument panel, telling him to steer port or 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 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 September 13 and 14, 1961 by flying line crossings between the ground stations A and D. This involves 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 could then begin. When a flight had been completed, the data was processed with the following routine:-

1. The 35mm film of the Shoran dials and the continuous strip camera operated over land were developed.
2. The readings of the Shoran dials were tabulated and corrected to give the distances from the aircraft to the two ground stations at every fiducial to the nearest .001 miles.
3. 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.
4. The magnetometer record was edited and checked for quality.
5. The record of the ground monitor station was checked to ensure that data obtained during magnetic storms and other disturbed periods would be discarded.
6. An average scale factor was computed for each line so that measurements made on the record could be transformed into horizontal distances.
7. The locations of maxima and minima were noted on the magnetometer records and plotted on the map.
8. 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.
9. 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 program would have been delayed.

Each flight was planned with consideration of the shoran ground stations then operating, and the program 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 the Bass Strait were 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 A 41 to A51 and lie on Sheet 21. Since it was uncertain how well this data would fit with the rest of the survey, these lines were replaced. 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 snowstorms 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 December 21, 1961. The lines flown and the shoran station locations are shown on the second index map.

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 equals 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 35mm 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 plotted on the magnetometer records. The measured differences in the magnetic levels between the intersections were analyzed 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 10 gammas or more have been marked.

A basic contour interval of 10 gammas has been used for the Bass Strait area and 5 gammas from the Encounter Bay area.

Finally, planimetric detail was added to the maps, and composite sheets at a scale of one inch equals eight miles were produced.

INTERPRETATION THEORY

The magnetic field of the earth is roughly 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 crust of the earth 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 primary

field of the earth, so that the local variations of the secondary field are emphasized.

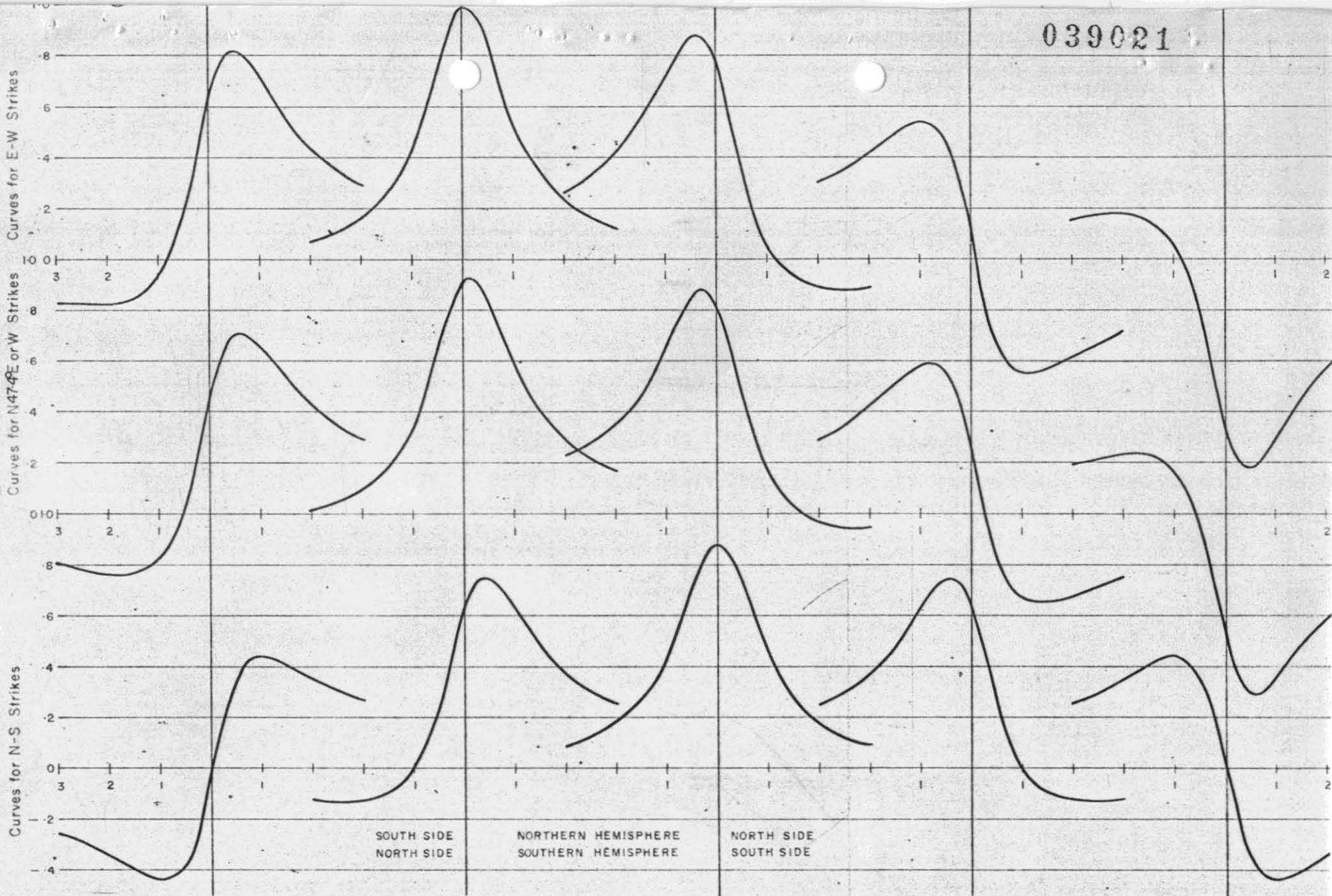
The study of magnetic anomalies and the rocks which cause them shows that the main cause of the anomalies is the varying magnetite content of the rocks. Magnetite is found as an accessory mineral in igneous and metamorphic rocks. Sediments, with the exception of iron formations, are relatively non-magnetic. 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.

A diagram has been drawn up to illustrate the way in which the anomaly of the same body in this region will vary as its dip and strike change. This particular body

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ANOMALY x DEPTH / 2kT x WIDTH

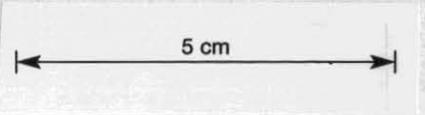


SOUTH SIDE NORTH SIDE NORTHERN HEMISPHERE SOUTHERN HEMISPHERE NORTH SIDE SOUTH SIDE

Attitude of Dyke DIP 0° DIP 45° DIP 90° DIP 45° DIP 0°

Horizontal Distance in Units of Depth to Top of Sheet

TOTAL FIELD MAGNETIC ANOMALIES CAUSED BY A THIN SHEET AT INCLINATION 70°



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° dip is symmetrical. For the same strike and zero dip, the curve is antisymmetrical. For 45° 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.

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 supra-basement 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 10% rise from 10,000 to 9000 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 analyzed.

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 hard to judge 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 makes reliable contouring impossible in some areas of these surveys. These areas are discussed in the body of the report. But we would make a distinction between areas where the basement is non-magnetic so that depths are indeterminate and areas where magnetic anomalies exist and can be analyzed 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. Figure 3 illustrates the shapes of various anomalies. 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 has been used where possible, but no attempt has been made to interpret these surveys in detail.

Interpretation of Encounter Bay SurveySheet 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. Northeasterly trends in the northeast 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 government 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 southeast 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 government 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 northeasterly 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 onto Sheets 6 and 5 and may extend further 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 connection 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 southeast corner have been interpreted as basement deepening to a little more than 3000 feet.

Unfortunately it was not possible to fly all the lines planned in the southwest corner of the sheet, because of shoran range problems. Line E1, which extends furthest

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.

We suspect that other faults cross the sheet, but have not been able to determine their locations precisely enough to warrant marking them on the map. It is most likely that there is 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 northwestern 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 northeast 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 northeast 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 northeastern 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 further 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 northeastwards, 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 southwest 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 southwest quarter of the sheet may reach 4000 feet in depth.

Magnetic trends run north-south in the southeastern 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 words "DEEPER?" on the map. Basement south end of this anomaly 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 southeast corner of the sheet. This is discussed in connection with Sheets 6 and 7.

Sheet 6

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 $36^{\circ} 20'$, 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 10 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 northeast across the southeastern 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 northwestern 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 northwest 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 southwest 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 northeast 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-east 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 onto 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 further 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 connection 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. We are confident 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 5 miles out of place.

Sheet 8

This area includes some features of the greatest interest. The edge of the continental shelf cuts diagonally across it, roughly from the southeast corner of the sheet to the point where the 5000 foot depth contour crosses its western edge. The magnetic field is very flat southwest of this line. But northeast 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 northwest corner by a number of strong sharp anomalies, and in the northeast 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 further 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 have been drawn below 10,000 feet, although basement depths probably exceed this considerably. The 10,000 foot contour itself could easily be 5 or more miles out of place.

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 15.

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 7 gammas, but it is clearly shown on 4 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 5 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} above sea level. They are too weak to be conclusive, but might indicate volcanics.

An attempt has been made to analyze 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° to the southwest. 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^{-5} cgs units. An irregularity on the northeastern flank was explicable by a second dyke at depth 4100 feet, width 6000 feet and susceptibility contrast 150×10^{-5} 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 northeast. On this trend basalt reaches the surface in several places from Mount Gambier northwest.

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 government 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 northeast quarter of the sheet has a generally smooth increase in intensity to the southwest, with a peak at the ends of lines B236 and 237. 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 217, and also between B196 and B197. For an accurate survey in this area, the tie lines should not be spaced more than 10 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 are continuous or clear enough to be outlined.

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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 southeast quarter, ringed to the southeast 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 southeastern 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 10 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 3,000 feet. They too probably reflect basalt. Anomaly 13-3 might have a source with depth of the order of 7,000 feet. It has two peaks on both lines B175 and 176, and a maximum relief of about 10 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 5 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 1,000 feet, and so does 14-4, which may be correlated with some small sea mounts. 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 were observed, obviously representing effects of magnetic material near the ground surface. These are generally less than 5 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, 21 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

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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 northeast, as do the trends associated with King Island. However their exact strikes and continuity are uncertain, since the line spacing is too wide. None extend 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 northeast along the coast, following the northwest flank of anomaly 14-6 and the southeast flank of anomaly 14-4. Southeast of this line the basement rocks are associated with the shallow basement near King Island. Northwest 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 2,000 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 southeastern part,

is a confused pattern of strong anomalies, reflecting shallow basement including much basic material. Second, along the northwestern side 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 connection 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 southeastern 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 northwest side of anomaly 15-4, which might be as much as 1,000 feet less than the value shown. Susceptibility contrasts across these three interfaces were calculated as 100 to 400 x 10⁻⁶ c.g.s. units. Hence a 10% 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 7,000 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 southwestern flank, a number of poorly controlled features suggest quite shallow basement. None have 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 onto 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 northwestern flanks of anomalies is 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 southeast 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 ^{5307h} northeast 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 southwest 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 government survey east of Wilson's Promontory. This line checks the depths of the Bureau of Mineral Resources interpretation reasonably well, but there is a strong possibility that the magnetic minimum at the southeast 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 above 2000 feet at its western end, where it is abruptly cut off with a peculiar bend. The anomaly broadens to the northeast, as the basement deepens. It may be associated with faulting. An analysis across it, using line A 115, 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 northeast. This break, projected through the northeastern 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 northeast end of the large maximum. An analysis across these features on line A 123 gave three interfaces at the depths shown. The deepening to the northwest 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, 5 to 9 gammas in size, but probably of intra-basement origin since it is closely associated with 18-2.

A little northwest of the peak of the regional maximum on line A117, an additional local rise of about 13 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 west 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 $143^{\circ} 30'$. 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 4. - 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 are several strong features of very different type, reflecting intra-basement contrasts. They strike between north and northeast, although the line spacing is not close enough to be sure that the peaks have been correctly joined together. For instance, the south 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 northeast 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 northwest 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 south end, the depth estimates also suggest steep dip. Another fault might branch out along the west 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 is 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. Northwesterly 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 southeast 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 northeast 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 northwest 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 southeast. 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 26-1, perhaps with horizontal as well as vertical movement.

Anomaly 22-1 was analyzed 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 northeasterly 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 northwestern corner 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 southeast, where granite is known to outcrop. 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 on Wilson's Promontory.

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

Northeast 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 northwest 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 connection 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 onto sheet 18.

Depths increase towards the northeast 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 southwest 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 southeast from these zones, the anomalies broaden and a deepening basement is indicated.

The major area of interest lies in the northwest quarter of the sheet, where the basement dips to the north and northeast. The magnetic level here drops to a broad minimum and few anomalies reach 10 gammas relief so that the depth estimates are not very well controlled.

Two anomalies warrant some attention, 25-1 averages 3 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 13 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 occur 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 northeast 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 indicates 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 is not correct.

Sheet 27

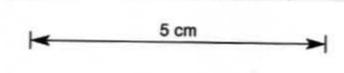
A few lines were flown across the southwestern half of the sheet. All indicate shallow basement from features of moderate to strong relief.

Strong anomalies, reflecting basic rocks, lie in the northwestern and southeastern 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 northeast 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. Southwest of it lies anomaly 27-3 which probably reflects only intra-basement contrasts. So does the nose outlined as anomaly 27-1.

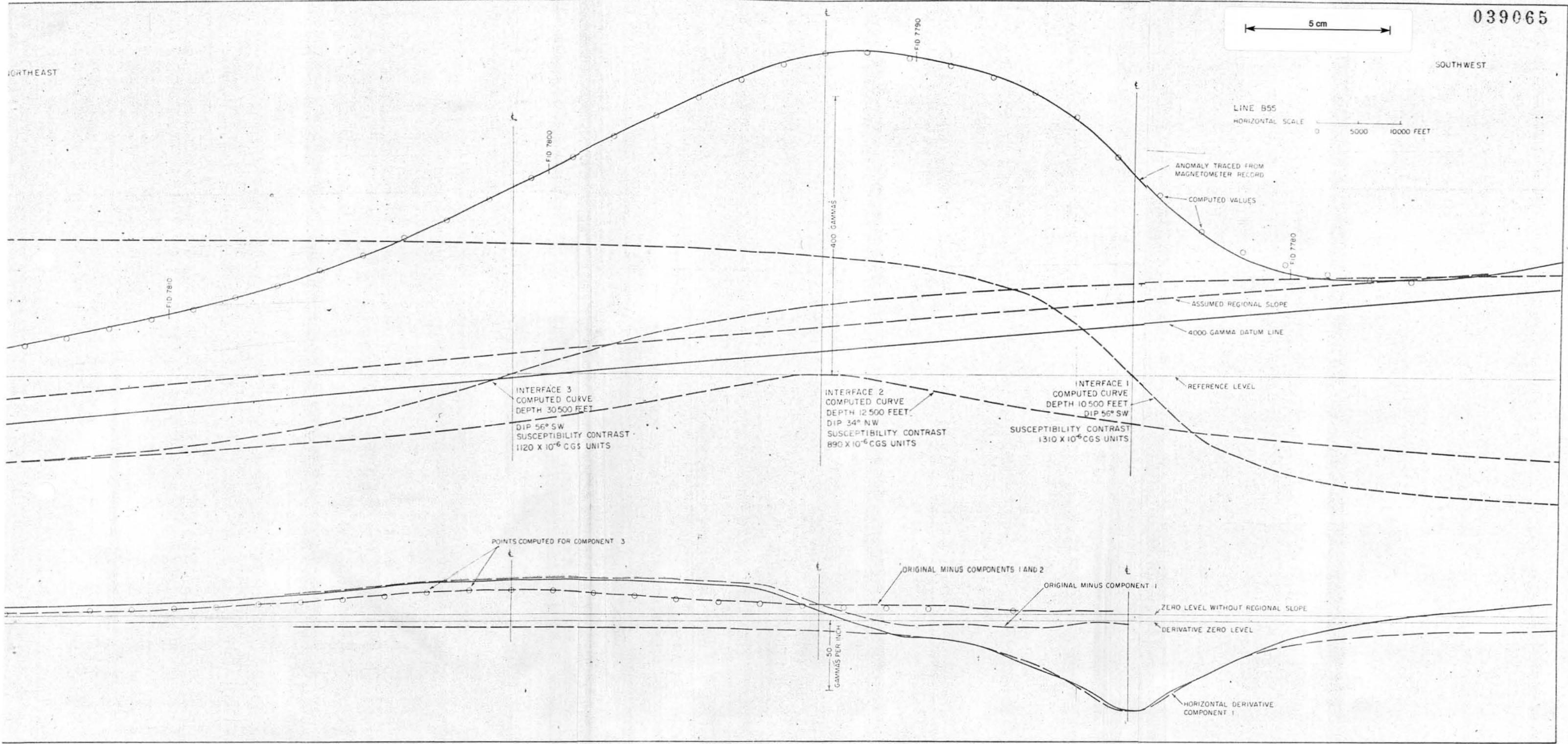
Sheet 28

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 and 10,500 feet were used but the 28,500 feet for the northernmost figure seems



NORTHEAST

SOUTHWEST



excessively large and not representative of the basement surface. The susceptibility contrasts of about 1000×10^{-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 10 gammas.

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

The basement surface rises to the east of the huge maximum, as shown by measurements on the flanks of two groups of northwest 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 8 gammas relief, but of no great interest.

Many anomalies control the basement rise shown along the south part of the sheet. One, 28-3, may be associated with a structural rise. The northeast 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 northwesterly direction. Both appear to be related to basement ridges. This interpretation is weakened by the strong chance that the basement low in the northeastern 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 southeastern 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.

CONCLUSIONS AND RECOMMENDATIONS

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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. We believe 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 areas with a line spacing no greater than $1\frac{1}{2}$ 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, we do not believe that the major features of the interpretation would require much revision as a result of the extra control. Any decision about the amount of flying must be based upon economic considerations that are beyond our province. We do believe that the data acquired in this survey provides ample justification for the use of

the airborne magnetometer, and much information that justifies further exploration in selected areas by other methods. We recommend 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.

Geologic 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.

One of the disappointments of the survey is that only in the Bass Strait do we consider that reliable indications of the maximum basement depths have been obtained. We believe that further exploration is warranted in the following areas:-

1. Across the north trending basement trough indicated on Sheet 5.
2. Along the coast of South Australia and Victoria from Kingston to Cape Otway.
3. Across the small basin outlined on Sheet 15.
4. Across the broad basin in the Bass Strait.
5. Along the Gippsland coast and northeast 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.

Respectfully submitted,

M S Reford

September 14, 1962

M.S. Reford,
Chief Geophysicist,
Aero Service Limited.

Bass Strait Shoran Survey

Survey Bases	:	Essendon (Melbourne)
		Devonport and Mount Gambier
Survey Dates	:	September 17 to December 1, 1961
Operational Days	:	42 days
Delays	:	15 " weather
		2 " diurnal
		3 " weather and diurnal
		7 " ground stations inoperative
		1 " illness
		6 " data compilation
Total Delays	:	34 "
Total Duration	:	76 "
Flights	:	
- Flight program completed		23 flights
- Part of program completed		13 "
- No program completed		3 "
- Moving Base		3 "
- Moving ground crew		1 "
- Line crossings only		2 "
		<hr/>
Total		45 "

Note: 2 flights were made on September 18 and 3 flights on November 26

Reason for Premature Abandonment of Flights :	
- Bad weather	6 flights
- Shoran failure or lack of range	8 "
- Magnetometer trouble	1 "
- Aircraft trouble	1 "
	<hr/>
Total	16 "

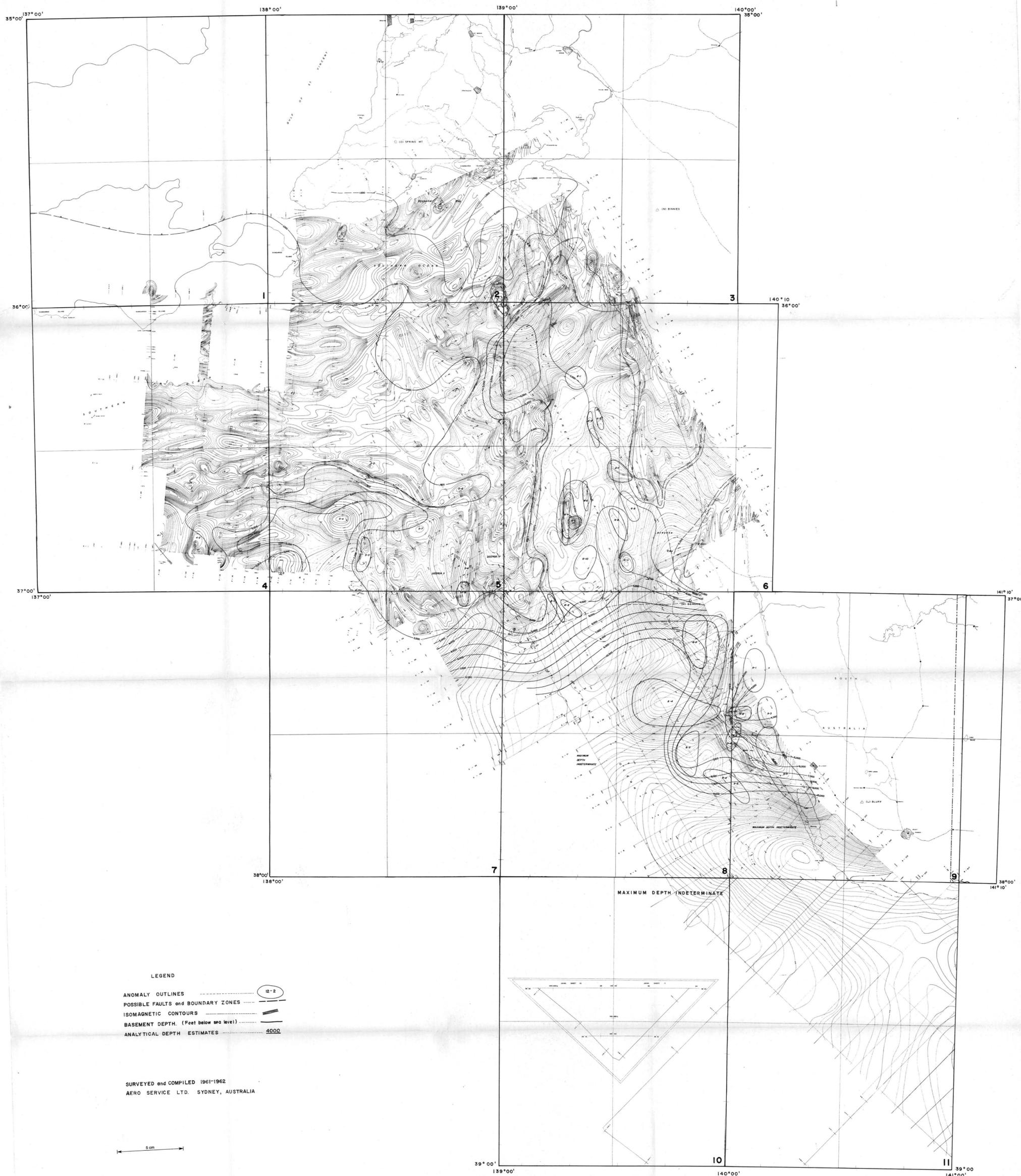
Distances Surveyed :	
- Flown	13360 miles
- Data not accepted	1407 "
- Data accepted	11953 "
- Data chargeable	11823 "
	<hr/>
- Average production per flight	300 miles
- Maximum production per flight	702 "

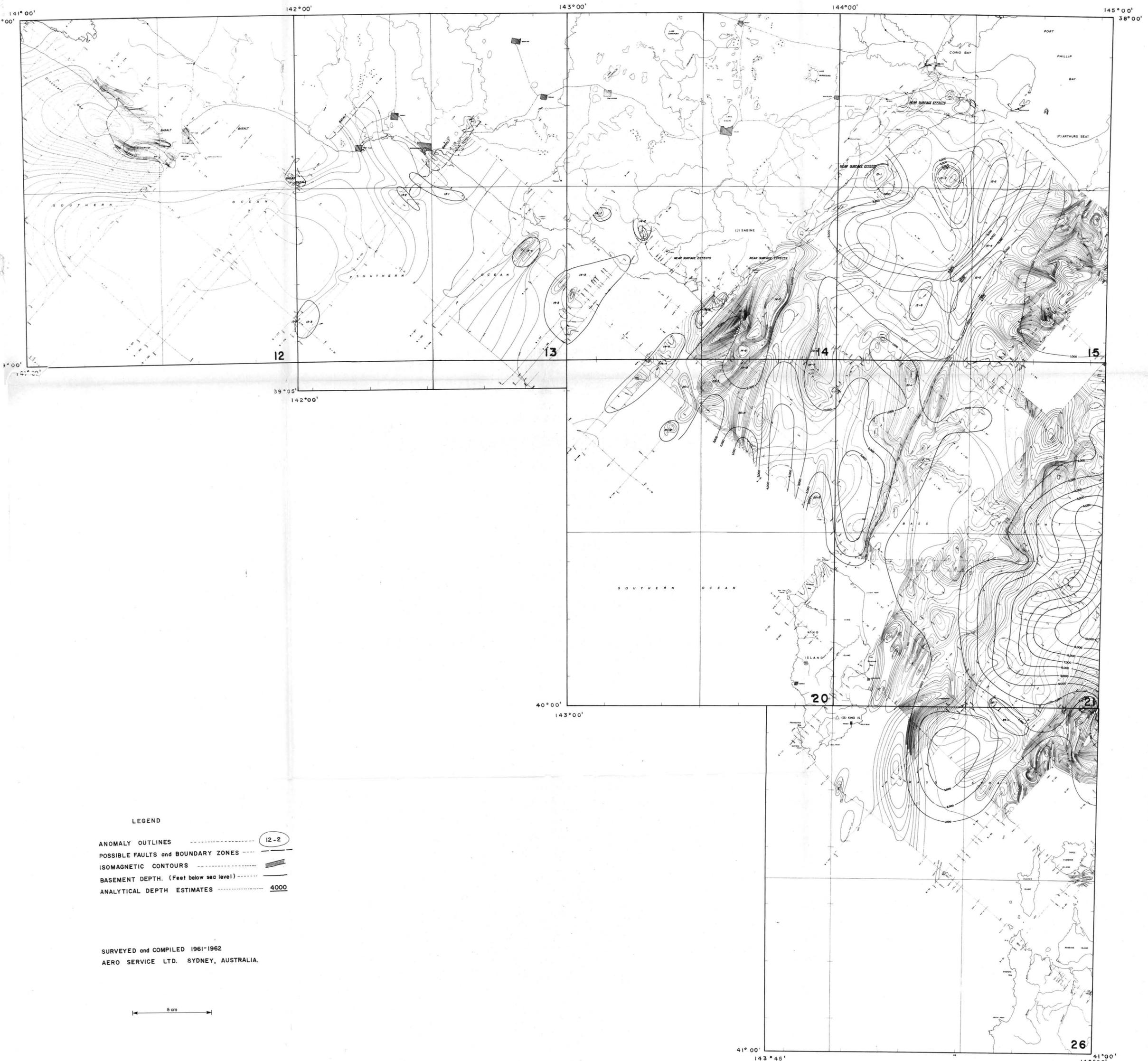
Encounter Bay Shoran Survey

Survey Bases	:	Mount Gambier and Adelaide
Survey Dates	:	December 1 to 21, 1961
Operational Days	:	14 days
Delays	:	4 " weather
		2 " diurnal
		1 " ground station failure
Total Delays	:	7 "
Total Duration	:	21 "
Flights	:	
- Flight program completed		12 flights
- No program completed		1 "
- Moving Base		2 "
- Line crossings		1 "
		<u>16</u> "
Total		

Note: 2 flights were made on December 5 and on December 21

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





LEGEND

- ANOMALY OUTLINES 12-2
- POSSIBLE FAULTS and BOUNDARY ZONES
- ISOMAGNETIC CONTOURS
- BASEMENT DEPTH. (Feet below sea level)
- ANALYTICAL DEPTH ESTIMATES 4000

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5 cm

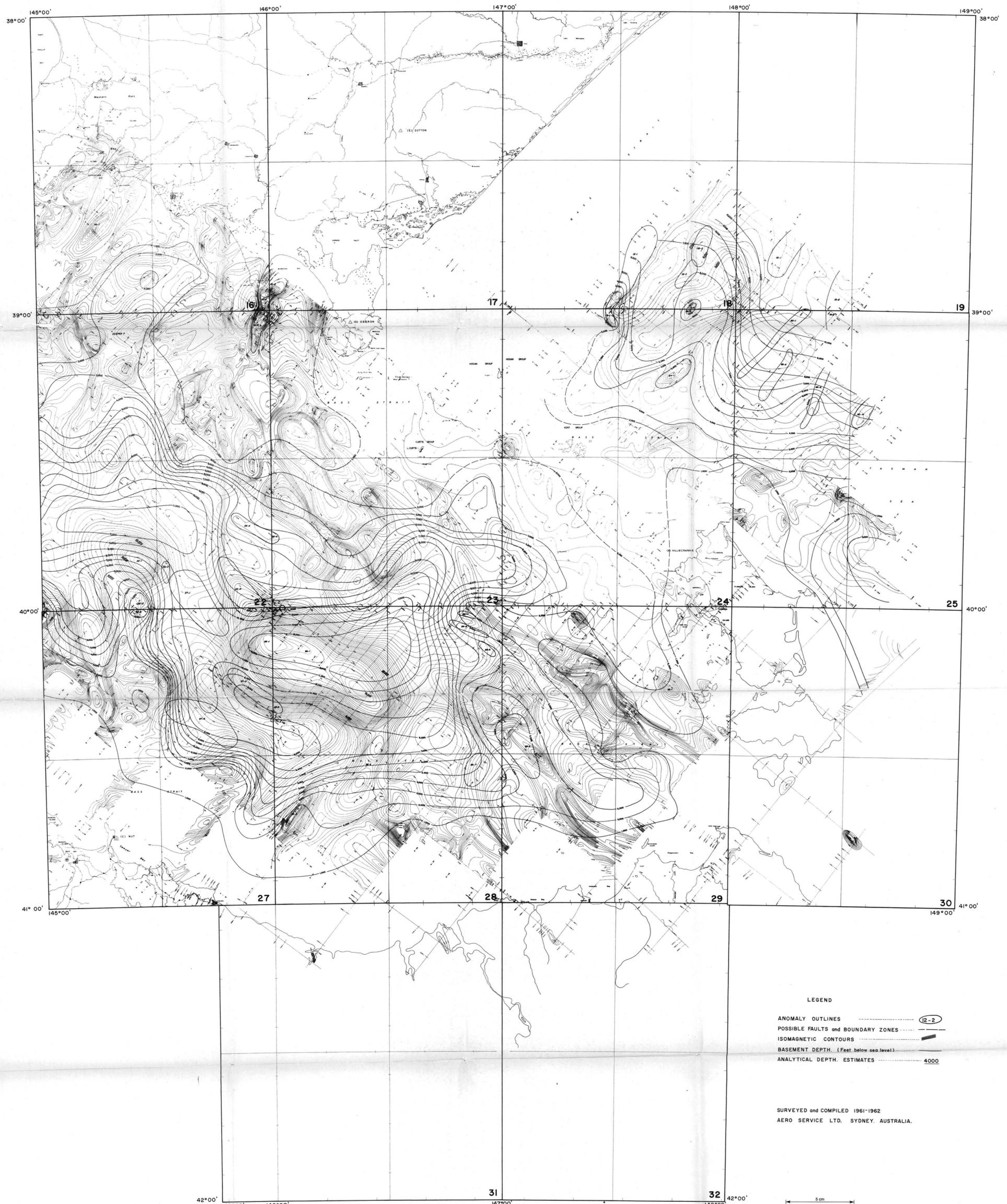
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CR-085

COMPOSITE B'

039075



COMPOSITE C1

HAEMATITE EXPLORATIONS PTY. LTD.

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