INTERPRETATION REPORT

of

AIRBORNE MAGNETOMETER SURVEY

over

THE WARATAH - ZEEHAN AREA

NORTHWEST TASMANIA

for

ABERFOYLE TIN DEVELOPMENT PARTNERSHIP

Aero Service Limited

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Geologist.

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INTRODUCTION

In March of 1965 an agreement was reached between Aero Service Limited, with offices in Ramsgate, N.S.W., Australia, and Aberfoyle Tin Development Partnership, with offices in Melbourne, Victoria, Australia, to perform an airborne magnetometer survey over the Waratah - Zeehan area in the northwestern part of Tasmania. The survey was flown during the months of April and May of 1965, and the following pages and accompanying maps constitute a final operational report and interpretation of the survey.

The surveyed area forms a block whose eastern boundary is defined by a line trending south-southwest from the intersection of Highway 8 with the Waratah - Guildford road to approximately two miles northwest of the Pinnacles, and then striking due south to Mt. Dundas. Its southern boundary is defined by an east - west line extending from Mt. Dundas to Zeehan. The southwestern limit is marked by a line extending from Zeehan past Pieman River to Stringer River and then striking north parallel to Corrinna - Waratah Road up to Savage River where it follows the river's course in a northeasterly direction, and finally strikes due east to the intersection of Highway 8 and the Waratah - Guildford Road.

The primary purpose of the aeromagnetic survey and the interpretation was to locate and define geologic information as it is reflected in the aeromagnetic records. Specifically this would include the depths to the anomaly sources, their strikes

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and dips, their susceptibility contrasts, and the location of contacts, faults, intrusives and any other structural or lithologic information which may be indicated by the magnetic data. The interpretation map is presented at a scale of 1 : 63,360, and the isomagnetic maps at the scales of 1 : 31,680 and 1 : 63,360.

The survey was planned to be flown at 500 feet above terrain clearance along east - west profiles, one quarter of a mile apart. The above information is illustrated in a more detailed form on the index map, figure 2..

All depth estimates referred to in this report are in feet sub-surface. Circled numbers on the map refer to anomalies mentioned or discussed in the report. Lettered numbers on the map refer to magnetic and structural features such as magnetic trends, faults and other features of interest. The statistical data relevant to the aircraft, instruments, area and daily operations is tabulated in an appendix at the end of this report.

Field Production Performance :

The rugged topography of the survey area, in addition to the required low altitude flying, frequently caused navigational difficulties during the production phase of the survey. Much effort and time was involved to adhere as much as possible to the pre-planned traverses. Several of these had to be reflown to meet this condition. Furthermore, the required specification of carrying the survey at a constant altitude above terrain clearance

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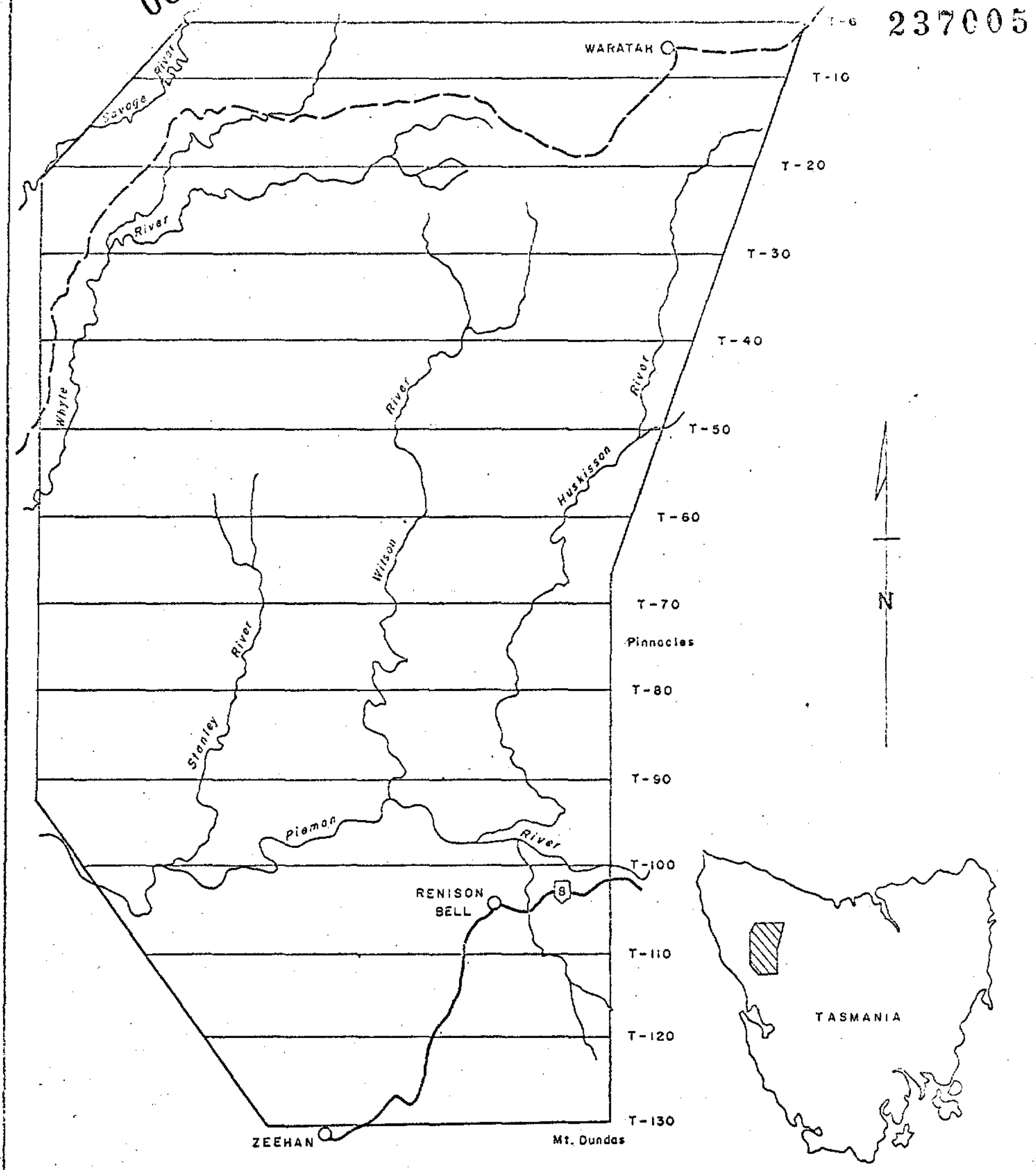

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LOCALITY MAP

AEROMAGNETIC SURVEY

WARATAH - ZEEHAN AREA

ABERFOYLE TIN DEVELOPMENT PARTNERSHIP

SCALE 1 : 250,000

MILES 2 1 0 2 4 6 8 MILES

FIG. 2

imposed on the aircraft severe operational conditions frequently approaching the limits of its performance range. Under these harsh conditions the pre-planned 500 feet terrain clearance could not be attained along most of the traverses. The variations in altitude ranged roughly from 300 feet to 1200 feet above terrain clearance, as shown by the altimeter tapes. This effect of altitude variation was taken into account during the quantitative analysis of the anomalies.

The effect of altitude variations made itself clearly visible during the compilation stage and in the contouring of the magnetic values. This effect is usually shown on the isomagnetic map by the "herring-bone" features along adjacent traverses. It is most conspicuous in places where a contour bends suddenly after crossing a traverse, and runs parallel to the next traverse before crossing it at the proper magnetic value. Again, much was done to eliminate such features wherever it was felt it could be accomplished without seriously altering the existing magnetic picture.

Features HB-1, HB-2 and HB-3 are some examples of the "herring-bone" effect shown by the magnetic contours. It is believed, for example, that anomaly 53 is in reality a straight north - south trending feature which does not possess the slight bend in its outline as shown by the magnetic map. There are other instances where it is uncertain whether the bends represent the true outline of the anomaly or a "herring-bone" effect. Feature HB-4 of anomaly 51 belongs to this class.

INTERPRETATION PROCEDURE and THEORY

The Earth's Magnetic Field :

The earth is surrounded by a magnetic field, the vast majority of which originates from within the earth. It is a potential field similar to the earth's gravity field, however it varies considerably both in intensity and in direction. The intensity of the field at the poles is approximately 60,000 gamma and at the equator approximately 25,000 gamma. At the poles the entire field is made up of the vertical component and at the magnetic equator the entire field is made up of the horizontal component. Each component varies between the poles and the equator as a cosine function of the angle it makes with the total field vector.

Superimposed on this broad regional field are local variations ranging in amplitude from less than a gamma to several thousand gammas. This is the secondary field resulting from induction of the magnetic material in the earth by the primary field. It is the amount, location and kind of magnetic materials in the earth's crust which causes these variations, and they are of prime interest in magnetic exploration.

Polarized magnetic materials within the crust resulting from this regional field are oriented in the same direction as the regional field. However, the additive effect of remanent magnetization will distort this symmetry.

As the temperature of the earth increases downward, it reaches a point where magnetic properties of rocks cease. This point is known as the Curie Point and is located at approximately 13 miles below the surface of the earth. Therefore, a relatively small volume of the earth's total mass is involved in the local variations in the magnetic intensity observed at and above the surface of the earth. The earth's regional field, however, emanates from deep within the earth and the resultant regional anomalies observed at the surface are extremely broad and often many miles in diameter. The local variations, of interest in exploration, have short frequencies, so they can be easily separated from the regional field.

Rock Magnetism :

In general it can be stated that sedimentary rocks are the least magnetic, igneous rocks are the most magnetic, and metamorphic rocks lie in between.

The magnetic minerals in the earth's crust are magnetite, ilmenite, pyrrhotite and Franklenite. Magnetite is the most abundant magnetic material. It accounts for the majority of the local magnetic variations in the earth's crust. In the earth's inducing field, the particles of the magnetic minerals align themselves in the direction of the earth's field and produce an anomaly which is a function of the total field and of the susceptibility of the particles concerned.

The susceptibility of various rock types ranged from a value less than 0.0001 c.g.s. units for sedimentary rocks to 0.0001 and 0.002 c.g.s. units for acid igneous rocks, 0.001 c.g.s. units to 0.004 c.g.s. units for basic igneous rocks, and considerably higher for rocks containing large amounts of magnetite. The value for magnetite varies considerably, depending upon its physical state. Generally, in an igneous or even in a low grade magnetite deposit, the figure 0.3 c.g.s. units is accepted and can be used to obtain a rough estimate of the amount of magnetite in the rock. In some deposits where large crystals of pure magnetite are common, the susceptibility can increase ten-fold.

Susceptibility :

The measurement of the extent to which a material becomes magnetized or polarized in an inducing field is called its susceptibility. This constant when multiplied by the incuding field (in this case the earth's regional field) is an expression of the intensity of polarization. The formula can be written :

$$I = kH$$

It is necessary to add to this quantity, especially in magnetic prospecting for iron, the remanent magnetization. The formula then becomes :

$$I = kH \div R$$

The remanent magnetization can be in the same direction as the earth's magnetic field, or it can be in one or more directions opposing this field. In many cases it is so randomly oriented that its total effect is negligible. If the effect of the remanent magnetization is great and in some direction other than the direction of the earth's magnetic field, it is sometimes evident in the shape of the magnetic anomaly. If it is not evident in the shape of the anomaly, the only recourse is a field investigation and a laboratory measurement of oriented samples.

For a magnetic inclination of the earth's field of 70°, which corresponds to the survey area in Tasmania, a normal magnetic anomaly for a thin dyke striking and dipping in various directions can be seen in the diagram, figure 3. The location of the causative body with respect to the anomaly is also shown.

The formula for the susceptibility of a magnetic body in an inducing field can be written as follows:

$$K = \frac{\Delta T}{4T \sin \varphi \times \theta}$$

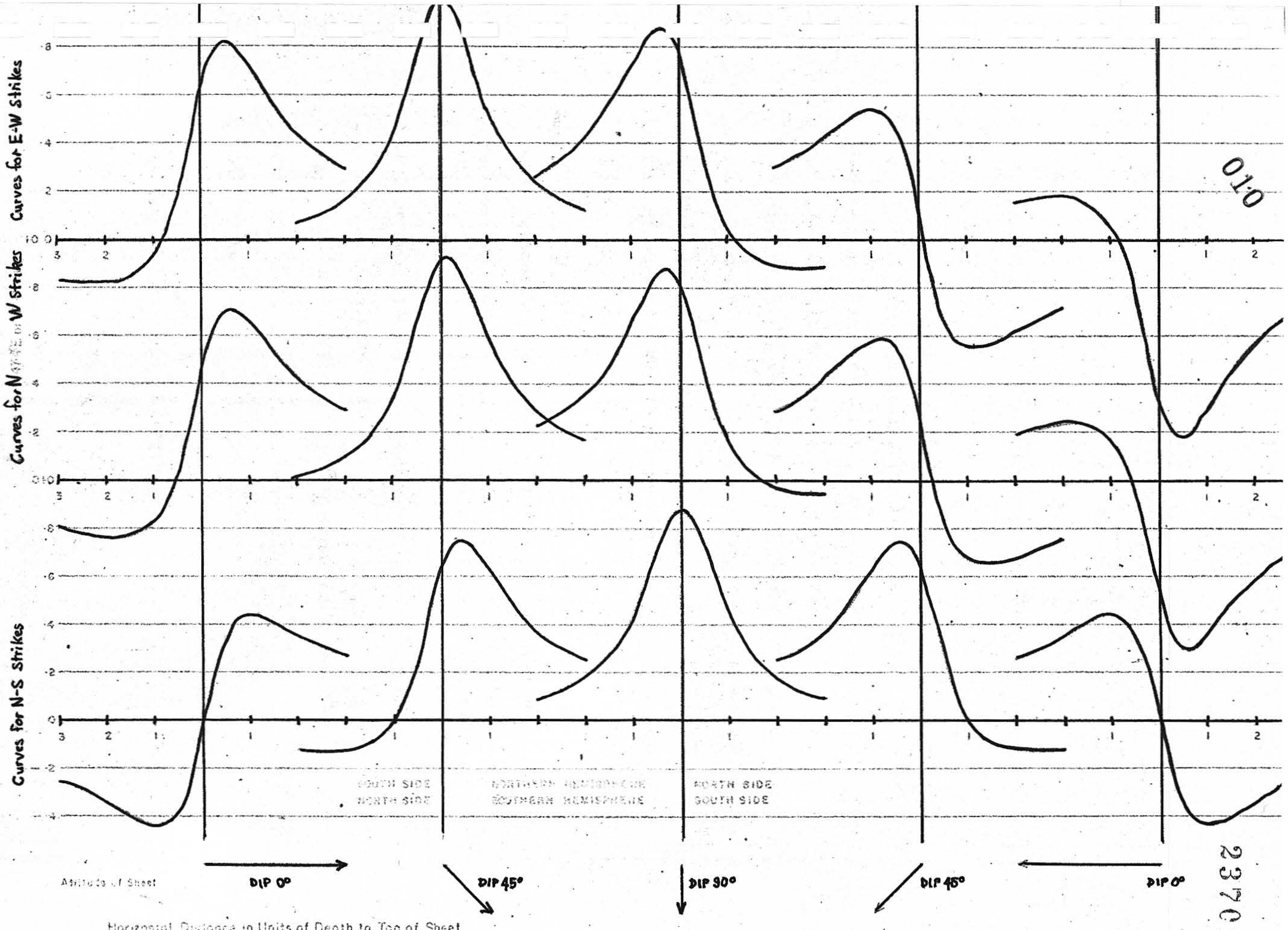
where K = magnetic susceptibility

ΔT = the magnetic variation of the anomaly (measured from high peak to low peak)

T = total magnetic field

φ = half the angle subtended by the strike length of the body at the point of observation over its centre

θ = half the angle subtended by the width of the body at the point of observation over its centre, measured in radians



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

Fig. 3.

This approximation is based on a uniformly magnetized body with a horizontal top, a rectangular cross section and vertical sides extending to infinite depths. These assumptions are valid within the usable limits of the formula, and when applied to the anomalies with discretion.

In applying susceptibilities computed in this way, certain points should be considered. Generally the length of the body is easily approximated, and not critical. Both the width and the depth are critical and usually neither one can be determined precisely from the survey data. From a height (h) of 2,000 feet, it is impossible to determine with accuracy the width of any body less than approximately 2,000 (h) feet across. This is illustrated in figure 4, where the solid curve represents a dyke striking north - south, and dipping 90°, with a width equal to the height above the dyke ($w \approx h$) at the point of observation. The dashed line represents the same conditions above except that the dyke has a width taken to be 1,000 feet or ($w = \frac{1}{2}h$). Though the amplitudes of the two features for a given susceptibility will be considerably different, their general shapes are very similar. The amplitude cannot be taken as a criterion of width since it is greatly influenced by susceptibility and depth.

Therefore, it is advisable to assume an arbitrary standard width. In practice, this is not a disadvantage, since a standard width allows easy comparison of different anomalies

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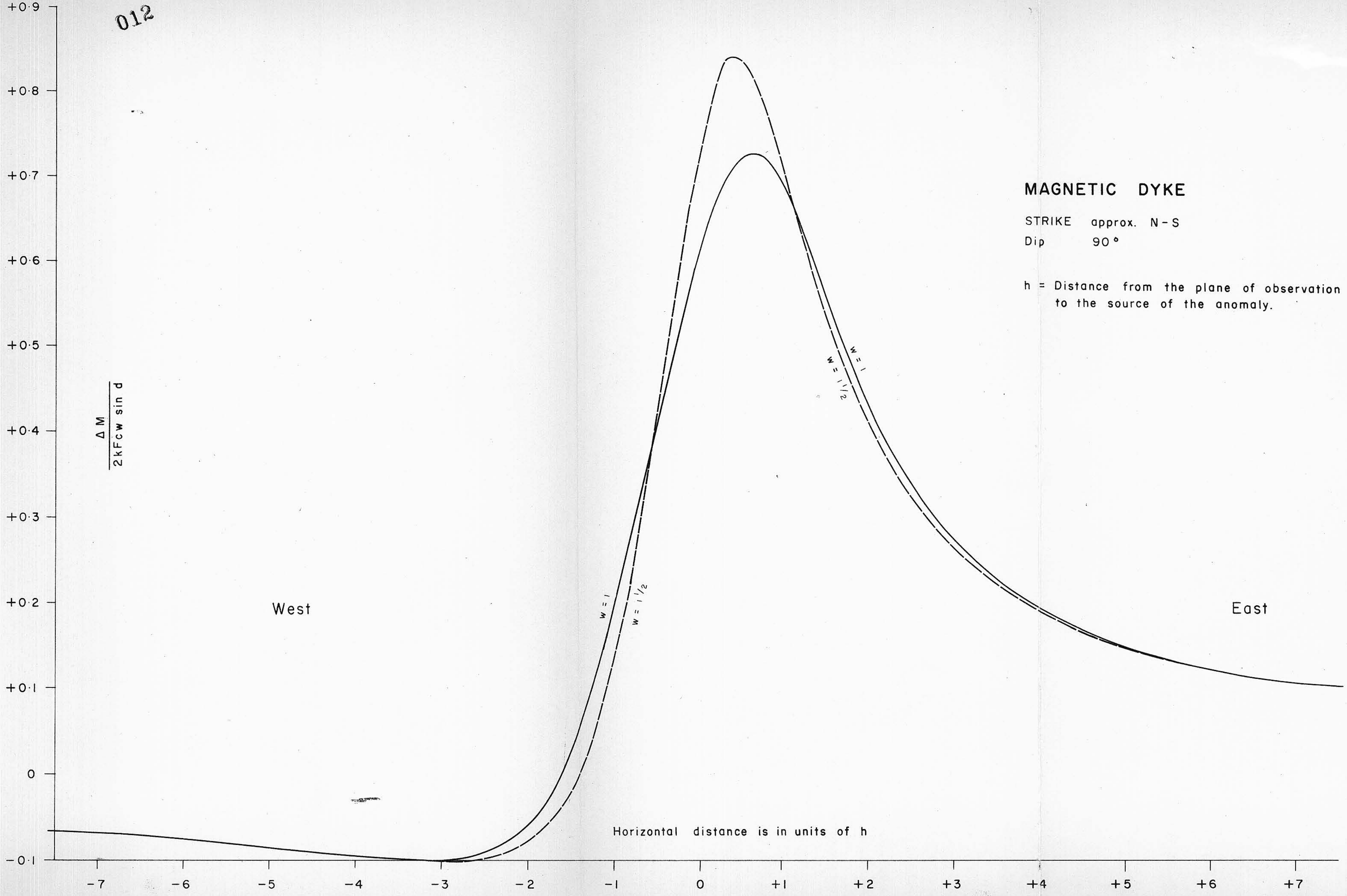

FIG. 4

for determining their relative economic interest or priority value. Furthermore, a reasonable standard width can usually be determined from magnetic and geologic consideration.

The last aspect of susceptibility calculations which must be considered is its relationship to the magnetite content. A susceptibility value is a function of the volume (and not the mass) of the magnetite present. An accurate determination of the amount of magnetite present (by volume) depends largely upon the susceptibility value assigned to pure magnetite. Various figures have been determined for pure magnetite, and they can be found in several of the standard texts. The figures vary with the type of magnetite and the form in which it occurs, and range from 0.3 to 1.5 and, in some cases, even 10. Curves illustrating variation of magnetic susceptibility with percentage magnetite by volume, and percentage magnetite by volume vs. percentage magnetite by weight are shown in figures 5 and 6.

Determination of the Magnetic Anomalies:

It is possible to determine the probable sources of magnetic anomalies by means of Poisson's equation of the magnetic dipole. The mathematical statement of Poisson's equation of the vector potential is:

Equation (1) $$W = -\frac{KT}{\gamma 6} \quad \frac{dU}{di}$$

where W = the vector potential

KT = the magnetic moment per unit volume

K = susceptibility

T = strength of inducing field

U = the gravitational potential

i = the coordinate direction of the magnetic moment, or the direction of induction, or polarization

γ = the gravitational constant

6 = the density

By means of equation (1), it is possible to determine the total magnetic field anomaly as follows:

Equation (2)

$$T = -\frac{dW}{di} = \frac{KT}{\gamma 6} \frac{d^2U}{di^2}$$

The evaluation of equation (2) is possible by various means, and this has been done using the following surface integral:

Equation (3)

$$T = KT \iint \left\{ (\sin^2\phi/\rho^2)\ y \left[(ZX^2/\rho^2) - 1 - (X^2Z/R^3) - (2X^2Z/\rho^2 R) + (Z/R) \right] + 2 \sin\phi \cos\phi\ (X/R^3) + \cos^2\phi\ (Z/R^3) \right\} dX\ dY$$

where ϕ = 90° - inclination

X = distance north or south from the origin of the co-ordinates to the surface element dx dy

Y = distance east or west from the origin of the co-ordinates to the surface element dx dy

$\rho^2 = X^2 + Y^2$

$R^2 = X^2 + Y^2 + Z^2$

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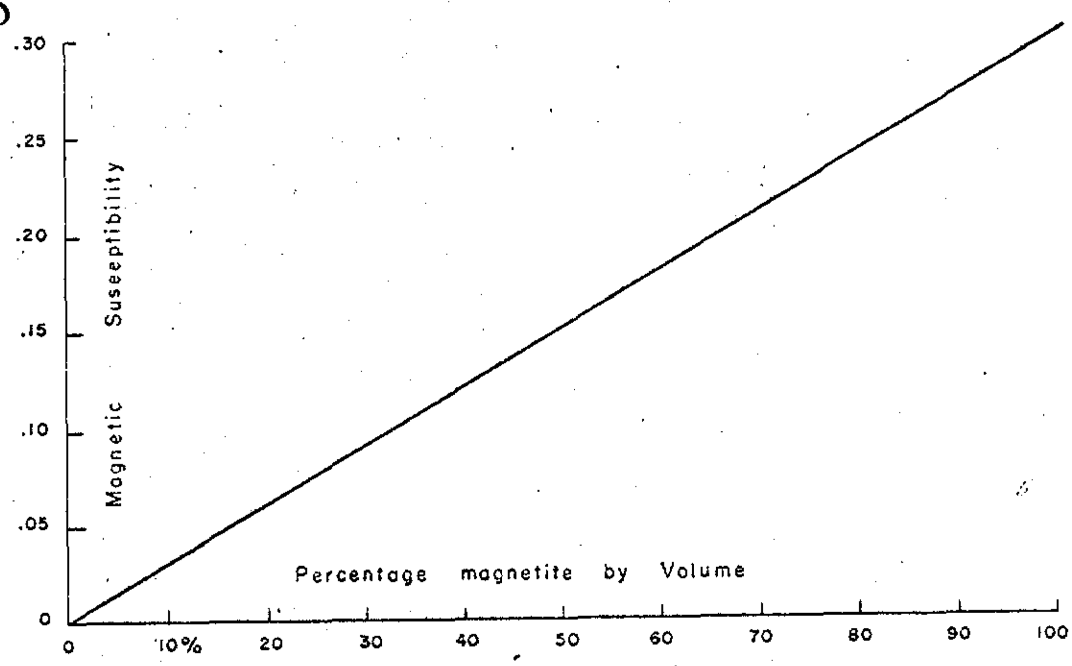

Fig. 5

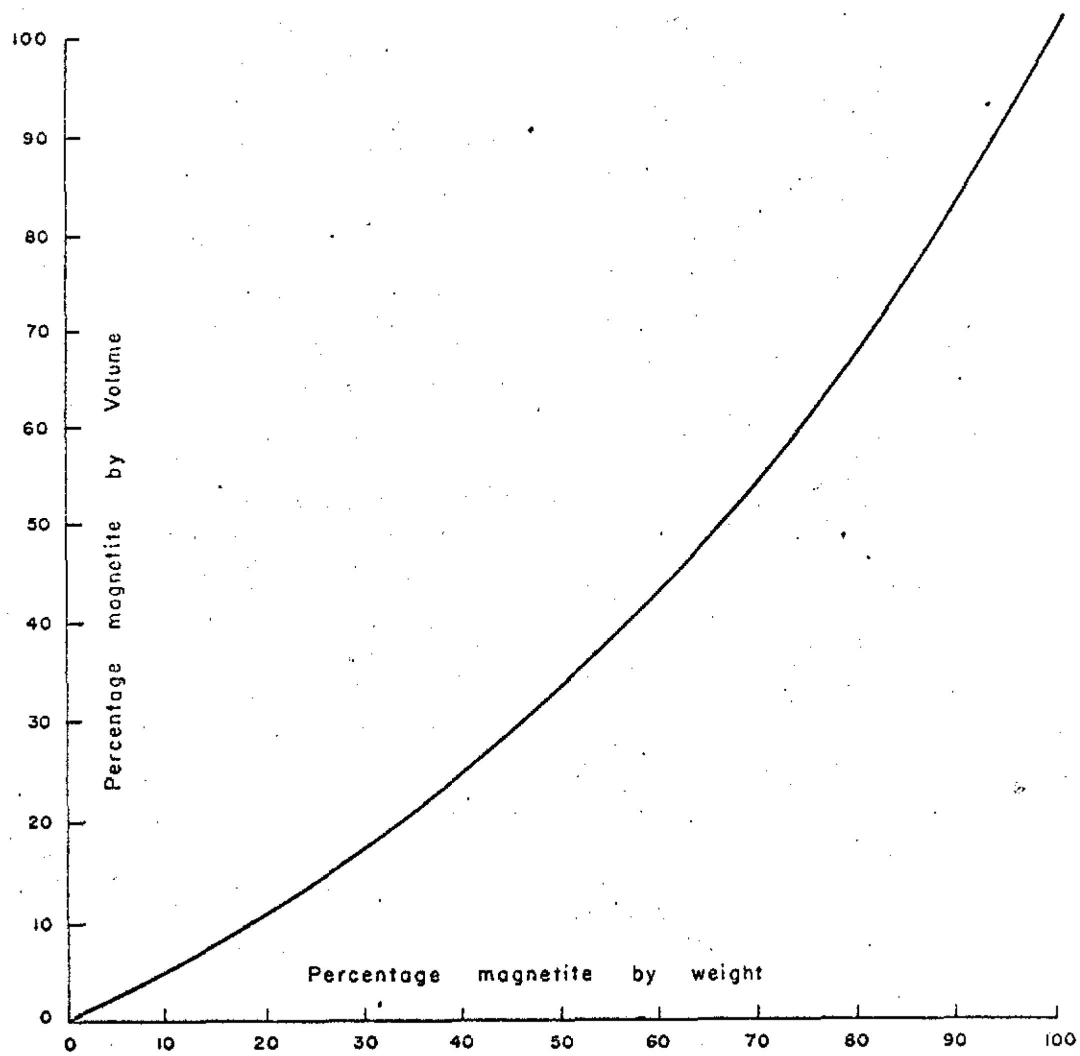

Fig. 6

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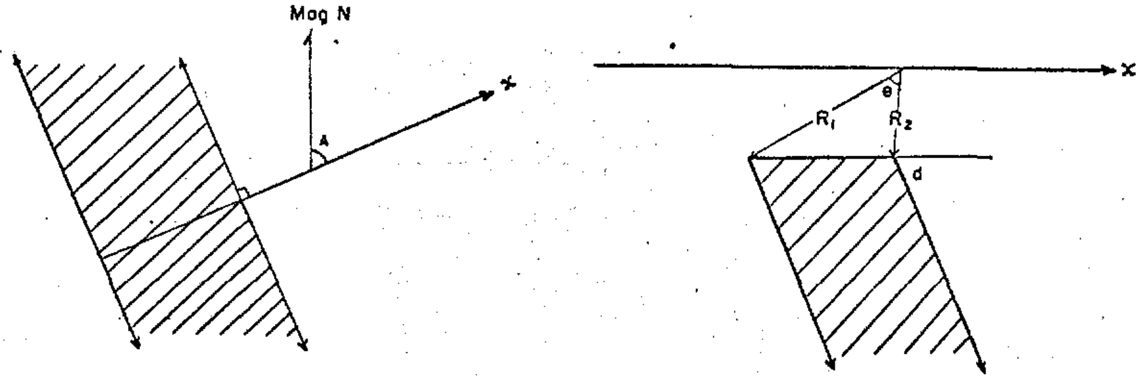

PLAN VIEW — CROSS SECTION

TOTAL INTENSITY MAGNETIC ANOMALY

$$\Delta T = \underbrace{2kTb^2 \sin d}_{\text{AMPLITUDE FACTOR}} \left[\underset{\text{ANGLE TERM}}{\theta} \sin(2I-d) + \underbrace{\log \frac{R_2}{R_1}}_{\text{LOG TERM}} \cos(2I-d) \right]$$

ASSUMPTIONS: THE DYKE IS UNIFORMLY MAGNETISED BY INDUCTION
IT HAS INFINITE STRIKE LENGTH AND EXTENDS TO INFINITE DEPTH
IT HAS PARALLEL SIDES AND A HORIZONTAL TOP

CONVENTIONS and SYMBOLS: THE x AXIS IS PERPENDICULAR TO THE STRIKE, AND POSITIVE ON THE NORTH SIDE OF THE STRIKE LINE

d = ANGLE OF DIP MEASURED FROM POSITIVE x AXIS.
"d" CAN VARY FROM 0 TO 180 DEGREES

A = ANGLE BETWEEN POSITIVE x AXIS AND MAGNETIC NORTH
"A" CAN VARY FROM 0 TO 90 DEGREES

i = INCLINATION OF EARTH'S MAGNETIC FIELD FROM HORIZONTAL
"i" IS POSITIVE IN THE NORTHERN HEMISPHERE AND NEGATIVE IN THE SOUTHERN HEMISPHERE

k = MAGNETIC SUSCEPTIBILITY OF DYKE

T = TOTAL INTENSITY OF EARTH'S MAGNETIC FIELD

$b^2 = 1 - \cos^2 i \ \sin^2 A$

$\operatorname{Tan} I = \dfrac{\operatorname{Tan} i}{\cos A}$

NOTE THAT THE ANGLE θ IS MEASURED IN RADIANS AND THE LOGARITHM HAS THE BASE "e"
θ R_1 AND R_2 ARE ILLUSTRATED IN THE DIAGRAM

Fig. 7.

In equation (3), it is assumed that the lower end of the anomalous mass is at infinity.

The function for equation (3) has been evaluated in "Interpretation of Aeromagnetic Maps" by Vacquier et al., GSA Memoir 47. This equation can be simplified and applied in many cases to two dimensional bodies which have an infinite depth and an infinite strike length (Reford, 1964). The simplified form is shown in figure 7.

Interpretation Procedures :

In general it can be stated that broad magnetic anomalies have their source further from the point of observation than sharp anomalies. The inflection points on the slopes of the anomalies are functions of the distance between the source and the point of observation.

The interpretation of a magnetic anomaly is not unique. A given magnetic anomaly may be explained by a variety of causes. However, most of the causes can be ruled out by common geological and geophysical reasoning. During the interpretation it is necessary to keep in mind at all times this potential ambiguity, and realize that although the stated cause of an anomaly is that which seems most probable, there are other parameters which could produce a similar effect.

In practical interpretation, there may be very little scope for mathematical analysis. Published works on analysis nearly always rely on assumptions of simple geometrical forms, distinct boundaries and uniform magnetization within each form or unit. Nature seldom provides such simple cases. Magnetic contacts are frequently gradational rather than distinct, and structures with a relatively high degree of specific magnetization quite often show irregular rather than uniform magnetization. When depths and other quantities are calculated from anomalies a range is usually given or an upper and lower limit, within which the answer lies. In the case of depth estimates, a maximum and a minimum depth is usually given.

The Fluxgate Magnetometer :

The most convenient method of measuring local variations of the earth's magnetic field from an aircraft is with a total field magnetometer. The most efficient and practical instrument at this time is the Gulf Mark III, saturable core unit.

Briefly, this instrument consists of a core of ferro-magnetic material with suitable non-linear magnetization properties. Wound on this core are two coils in series opposition. The core is cyclically driven to saturation by an alternating current. Due to a slight difference in the windings, implemented by a shunt over one coil, the coils become saturated at different times. Variations in the ambient field produce variations in the time delay of saturation between the two coils and this is measured and recorded. Two co-planar coils mounted mutually perpendicular

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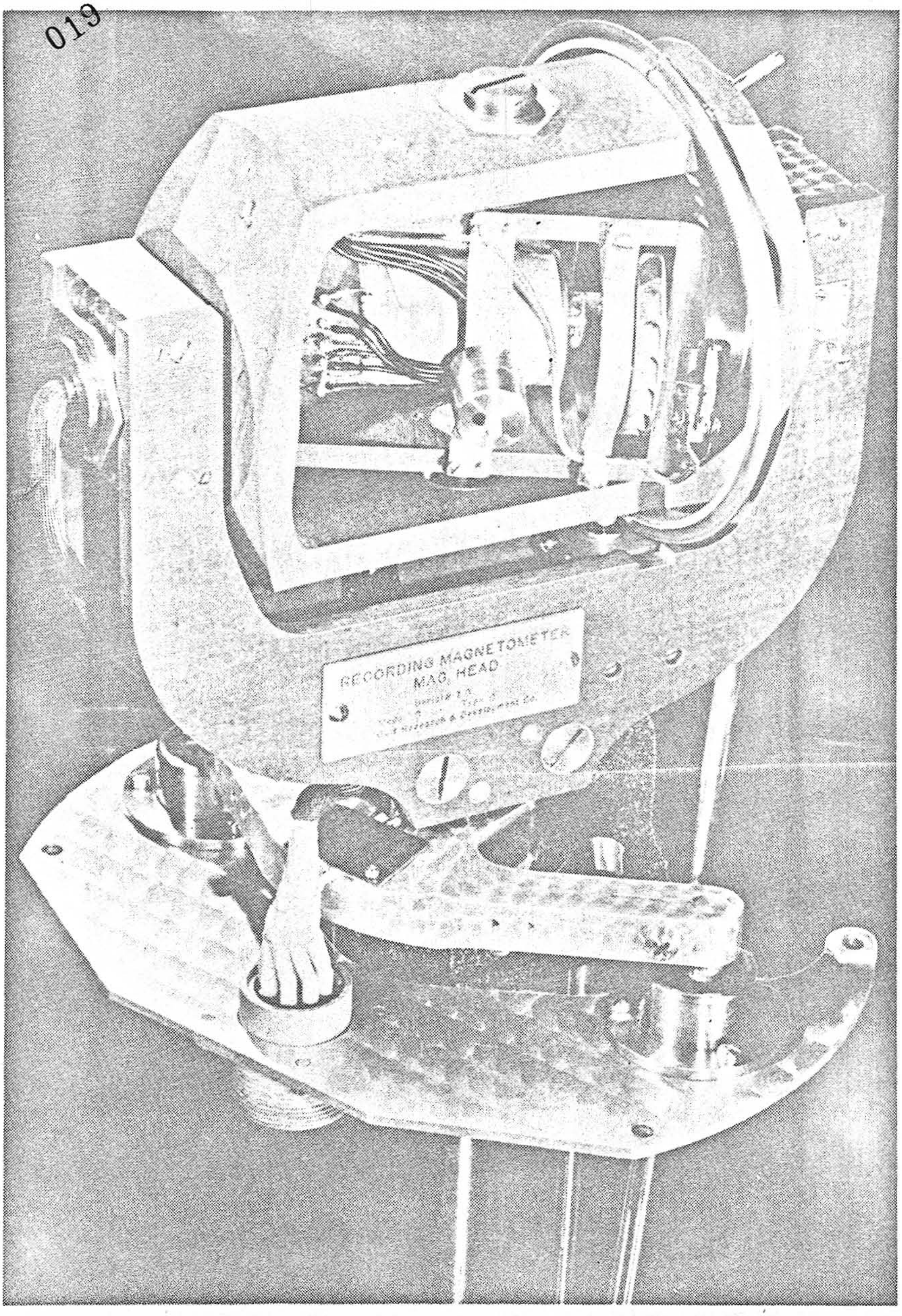

Fig. 8.

to the detector coil are held in zero field by servo-motors, thereby holding the detector coil in total field.

For a more detailed description of the fluxgate principle see Wyckoff (1948).

INTERPRETATION

Magnetic Pattern :

In this section an attempt is made to differentiate the anomalies on the map into groups of similar characteristics. The characteristics which are taken into consideration include the size, the shape and the magnitude of the anomalies, their trends, and their relationship with each other. In a later section the significance of these characteristics will be pointed out, and their geological causes will be discussed.

The magnetic pattern of the survey can be easily divided into several zones of distinctive magnetic characteristics. These zones are discussed as follows:

Zone A - This zone is outlined by a magnetic high trend which borders the western and the northwestern boundary of the survey area. It consists of several high amplitude anomalies elongated in the same direction as the magnetic trend. This trend extends from Traverse T.79 south to Traverse T.12 north, changing direction from north to northeast at about Traverse T.26. It seems certain to continue further north and south beyond its recorded limits. In some segments, such as between Traverses T.52 and T.27, the axis of the high trend falls outside the boundary of the survey area. The amplitudes of the anomalies increase in a northerly direction starting with a 700 gamma amplitude in anomaly 1 and climbing to 4,150 gammas in anomaly 3, and up to 13,750 gammas in anomaly 4.

North of Traverse T.46 a secondary high trend branches out from the main trend and approximately holds the same direction as the latter. The anomalies of this secondary trend are of similar size and outline as those of the main one, but are of much lesser amplitude. For example, the intensities of anomalies 5 and 6 are 100 gammas and 400 gammas respectively.

Zone B - This zone is distinguished by a very broad plateau-like high upon which occur several features that are described below. The southern, southwestern and western boundaries of this broad high are well-defined by a very steep magnetic gradient of about 400 gammas to 500 gammas. This gradient delineates the flank of a neatly defined positive trend (B1) which constitutes the edge of the plateau-like high, and consists of anomalies 7, 8, 9 and 10. Anomaly 11, which marks the continuation of B1 further south, is offset about one mile southwest of anomaly 10.

B1 has its southern limit at anomaly 12, where it curves almost 180° to form a second trend parallel to itself, containing anomalies 13 and 14.

The eastern boundary of this zone is not as well defined as its western boundary. The 6,200 gamma contour can be taken as its eastern limit. The rise in the gradient here is interrupted by a shelf-like area which contains several positive and negative anomalies, such as anomalies 15 and 16, and their associated negatives. Commencing with the 6,400 gamma contour the magnetic gradient rises again until it culminates in anomalies 17, 18 and 19. A brief examination of Zone B conveys the idea that the latter group makes up an ill-defined trend analogous to that formed by the neatly arranged series in trend B1. These two trends are connected with each other at their northern end by a lower amplitude trend (B2) in which anomaly 20 is the most conspicuous.

Zone C - This zone is of small areal extent and is occupied by a magnetic high which supports two well-established narrow positive trends that strike in a north - south direction and consist of low to medium amplitude anomalies. A third, much less conspicuous trend may be distinguished in anomaly 21. It is important at this stage to note the two negative anomalies 22 and 23, which bound the major positive trend. In the section entitled "Qualitative Analysis", the significance of the negative anomalies will be explained. Other points to be noted are, first, Zone C clearly disrupts the smooth, broadly curved contours of Zone D immediately south of it, second, the over-all magnetic value of Zone C is much lower than that of Zone B, and third, the sudden abutting of the magnetic pattern of Zone C against Zone B.

Zone D - One of the larger features of the survey area is included in this zone. Except for three very minor anomalies, (24, 25 and 26), its most striking characteristic is its complete lack of magnetic anomalies. The magnetic contours cross this zone in a broad east - west arc in the northern half and increase in value steadily due south. In the southern half the contours assume a northeasterly - southwesterly and northwesterly - southeasterly attitude.

Zone E - This is the largest and probably the most conspicuous zone on the magnetic map. It contains many of the highest amplitude and important anomalies, and also the most pronounced trends. The magnetic pattern of this zone can be divided into two major classes :-

1. Linear trends
2. Circular features

The Linear Trends - The two strongest positive anomalous trends (E1 and E2) in the survey area have their start in the far southern limit of this zone. Trend E1 changes direction from a northeasterly bearing in its southernmost end, to a northerly bearing immediately south of Pieman River, and finally to a northwesterly course north of this river. In its southern end E1 is not as clearly defined as it is further north. This is due to its comparitively lower amplitude and narrower width in its southern portion, coupled with the fact that some neighbouring anomalies (e.g. anomaly 27) of similar magnitude seem to be closely associated with it. North of Pieman River E1 becomes very pronounced because of its increased width and amplitude. A series of high intensity anomalies (28 .. 4,800 gammas; 29 .. 2,400 gammas, etc.), line up to make this trend one of the notable features of the magnetic map. In some places negative anomalies (30 and 31) divide E1 into two branches. An observation worth noting in regard to Trend E1 is its abrupt abutting against Zone D.

Trend E2 can be described best by discussing its outline north of Pieman River first, and leaving the description of its rather complex pattern further south to the end. E2 is even more prominent than E1 in that it stretches almost completely from the southern boundary to the northern boundary of the survey area, and is more sharply defined along certain segments. Immediately north of Pieman River E2 strikes due north as far as Traverse T.96, where it changes direction slightly to west of north up to Traverse T.80. Between traverses T.80 and T.78 it bends sharply to a west-northwest direction, and then continues due north. North of this section (Traverses T.80 - T.72) E2 is displaced about 1½ miles west in relation to that south of it. North of Traverse T16 it curves in a northwesterly direction and crosses Traverses T.15 to T.13, then bends abruptly south at fiducial 6659 of Traverse T.13. The unconformity of the strike of anomaly 51 with the rest of those in the locality makes the possibility of the extension of Trend E2 further south through anomalies 52 and 53, less re-assuring. However, as mentioned earlier, the true outline of this anomaly is most probably not as is presented on the magnetic map because of the "herring-bone" effect that may be involved in it.

It seems that the southward extension of Trend E2 is not as sharply defined as its northward extension prior to its westward curvature. Several saddle-like lows transverse the positive trend. Also, anomalies outside the trend, such as anomaly 54, run parallel to it, and fall well in line with other anomalies (No.53) within it.

In its westward sweep north of Traverse T.16, E2 broadens considerably to include anomalies 58 to 64. It is not known whether other loosely associated anomalies (55, 56 and 57) are also a part of this trend or belong to those of Zone F.

Returning to the southern end of Trend E2, we see that it has its start at anomaly 32 as a northeastward striking feature. North of Traverse T.120 it is split by a negative anomaly (No. 39) into two northward striking branches which merge again to form a single feature extending north, past Pieman River, to the northern boundary of the survey area. A low amplitude high branches out from E2 at Traverse T.120 and runs due south to Traverse T.129.

In addition to Trend E2, a third trend (E3) has its start at anomaly 32 also. Although it contains some high amplitude anomalies, it is not as distinctive as the trends E1 and E2. The reason is perhaps due to its irregular outline. Immediately north of Traverse T.115 it splits into two northeastward (E3a) and northward (E3b) striking branches. The latter branch seems to be closely associated with E1 to the east of it. A long, narrow negative trend is the only feature that separates these positions from each other. As for anomaly 32, it extends further south beyond the southern limit of the survey area, and the partially recorded anomaly 35 appears to be a part of it.

Associated with the positive trends of Zone E, are several negative anomalies and trends that are significant enough to be worthy of attention. They are very closely associated with the positive trends, and follow remarkably well the latter's trends and all the changes of strike. In the lower portion of the map these negatives are anomalies 33 and 34, which flank the positive anomaly 32, and the negative trends are E3c, E4, E5, E6, E7a, E7B and E8. In the northern portion, the negatives are exemplified by trends E9 (this trend will be described in more detail later on), E10, E12, E15, E16 and the north - south striking portion of E13 and 14.

<u>The Circular Features</u> - The second major group of anomalies of Zone E are the three medium to large size circular positive anomalies (38, 65 and 66) and their associated trends. The significant characteristics common to these anomalies is first, their nearly circular outline and second, the ring of negative anomalies that almost completely surrounds the positive features except along the northern flank of anomaly 38 where they are not present.

The circular features are of medium amplitude ranging from 200 gammas for anomaly 38, to 500 gammas for anomaly 65, and up to 900 gammas for anomaly 66. The amplitudes of the surrounding negatives are much lower.

Three minor anomalies are superimposed on anomaly 38. The negatives associated with this feature are trend E4 to the east and the shallow semi-circular low formed by the bending of 6,450 gamma contour upon itself to the south and west of the anomaly. As stated above, no negatives are present along its northern flank.

The outline of anomaly 65 is not as circular as that of anomaly 38. A small, very high intensity positive of about 2,000 gammas is superimposed on it. The negative trends E7a and E7b form its eastern, southern and western boundaries. On the north it is bound by the negative anomalies 67 and 68. Several positive extensions, E17 and E18, and trends, E19 and E20, have their start at anomaly 65. Here also, the association of the negative trends with the positive ones is noteworthy.

Anomaly 66 is the smallest of these circular features and yet the highest in amplitude. It is connected with anomaly 54 to the east by a narrow positive extension. The negative trends E11, E12 and E13, completely surround it. A narrow, positive trend develops at its southwestern position and extends in a southeasterly direction to form anomaly 67.

<u>Zone F</u> - This zone consists of a multitude of small anomalies irregular in outline and complex in relationship with each other. No clear anomaly trends can be recognized here, and yet a critical examination may help to detect a vague tendency for the anomalies to be elongated in a northwesterly direction. Almost all the anomalies here are of low to medium intensity, the average amplitude being approximately 100 gammas or slightly more.

Zone G - In this zone no definite magnetic patterns can be identified. Its anomalies do not seem to belong either to Zone E to the north, or Zone F to the west. Perhaps not enough of this zone is included within the survey area to reveal its characteristic pattern.

Trend E9 (Zones F and G) - This trend transgresses Zones F and G but appears to be a part of Zone E. It is located east of Trend E2 and extends north from Traverse T.64 to approximately Traverse T.10. It is not known whether it extends further south beyond Traverse T.64 because the succeeding traverses do not extend far enough east to record its existence. Despite its great length, E9 does not appear as clearly defined as the negative trends mentioned elsewhere. It changes its direction frequently, holding the same bearing only for short distances. Several minor anomalies of Zone F greatly distort its outline with the result that only a critical search for it will reveal its presence.

Zone H - This zone is very simple in contrast to Zone E east of it. It consists of a low, magnetic gradient which increases more or less uniformly in a south-westerly direction until it culminates in the anomalies of Zone I. Only one minor positive closure (anomaly 68) is recorded in this zone. Anomaly 38 of Zone E restricts Zone H to a considerable extent, reducing it from a broad feature to a very narrow one just north of the town of Zeehan.

<u>Zone I</u> - Only a narrow portion of this zone is recorded along the southwestern boundary of the survey area. It consists of two anomalies (72 and 73) and one high trend, I1. The two anomalies are circular features with amplitudes of about 30 gammas. Trend I1 is elongated in a northeast - southwest direction and reaches its highest points in anomalies 69, 70 and 71, with amplitudes of 100 gammas, 150 gammas and over 110 gammas respectively.

Qualitative Analysis :

The regional magnetic pattern and the various Zones discussed in the previous section, reflect very remarkably the known geology of the area (1 inch = 1 mile geologic maps). Starting with Zone A, we can correlate it with the older Precambrian rocks. The high amplitude anomalies of this Zone are most likely the expressions of the amphibolite dykes in which magnetite is found. The 13,750 gamma anomaly 4 is the reflection of the large iron ore deposits discovered in the Savage River area. Zones B and C can be directly correlated with the exposed basic and ultrabasic rocks in the northern part of the survey area, while Zone D is easily seen to be the expression of Meredith Granite. The syenite which bounds the ultrabasic rocks on the east, occupies the shelf-like break in the gradient that marks the eastern boundary of Zone B. Anomaly 16 is the expression of gabbro exposed immediately east of the syenite (Reid, 1923).

The anomalies and trends present in Zone E correlate in some places very readily with the exposed geology, while in other places they pose some problems to be solved and questions to be answered satisfactorily. Anomaly 32 in the southernmost portion of Zone E is the expression of the ultrabasic Serpentine and Pyroxenite exposed east and south of Mt. Razorback, and in a like manner anomaly 36, which is a part of Trend E3, is the effect of similar lithologies. Trend E1 can be easily related to the exposed serpentine belt southeast of Renison Bell, and the western flank of the Huskisson River syncline. Trend E2, south of Traverse T.60 can be correlated with the line connecting the large exposures of similar lithologies along the eastern flank of the above syncline. The correlation can be extended south of Pieman River to include the ultrabasics at Colbrook Hill.

Ultrabasics are not exposed along some respective segments of E2, such as the segment bound between Traverses T.120 and T.112. That the above lithologies are still present under the sedimentary cover throughout the entire area corresponding to E2, can be deduced from the small isolated ultrabasic outcrops about one quarter mile south of Carbine Hill and on the ridges east of Severn Creek (Zeehan Geologic Map, Tasmania Department of Mines).

In view of the correlation just made between the magnetic trends and the lithologies, it can be deduced that the entire E3 trend, including its two branches, represents similar ultrabasic lithologies as those exposed elsewhere. This means that ultrabasics underlie the sediments in the Renison Bell and Dundas areas.

One of the most interesting features of the magnetic map is the persistence of E2 in a northerly direction, as described earlier. We have already noted that E2 south of Traverse T.60 is the effect of the partly exposed ultrabasics, and similarly we can easily correlate its westward curvatures and southward extension in its northernmost end with the ultrabasics exposed west and southwest of Waratah. Therefore, there is no alternative but to reach the conclusion that E2 is the expression of ultrabasic lithologies along its entire length. These lithologies are presumed to be covered by Silurian, Ordovician and Cambrian sediments and Tertiary volcanics from Traverse T.60 in the south to Waratah in the north.

The granite outcrop exposed two miles south of Renison Bell falls near fiducial 9600 of Traverse T.114 and has no visible effect on the magnetic pattern.

Small isolated ultrabasic exposures of the "Five Mile District" on the Geologic Map of Zeehan are seen to occur along the eastern flank of anomaly 38. This suggests lithologies similar to those associated with the trends discussed above as the cause of anomaly 38. A similar observation can be made in regard to anomaly 66. As for anomaly 65, its striking magnetic similarity with the above two anomalies leads one to conclude that it is also the expression of ultrabasic rocks.

Coming now to Zone F, its magnetic pattern is typical of the response that basaltic volcanics give to aeromagnetic recording. Zone G occurs over an area shown by the geologic map to contain Lower Paleozoic sediments on the surface. Its anomalies do not seem to coincide with any geologically known features.

The uniform southwesterly increase in the magnetic values of Zone H cannot be related to the exposed geology of the area. It is believed that such an increase reflects the gradual corresponding rise, beneath Oonah Formation, of the basement which is composed of the older metamorphosed Precambrian rocks.

Trend I and its anomalies can be directly correlated with the Jurassic dolorite exposed along the southwestern limit of the area. The sources of anomalies 72 and 73 cannot be attributed to the exposed rocks. They could be due also to dolorite that has not been exposed yet by erosion.

Several faults have been mapped on the basis of the magnetic pattern. Much of the evidence for the faulting is derived from the position and the shape of the anomalies relative to each other. The displacement of the anomalies within the magnetic trends is in most cases the primary criteria for the presence of faults shown on the interpretation map. Some of the faults or segments of them in the southeastern portion of the area, correspond to similar features on the geological map of Zeehan. Faults f1, f2, f3, f6 (corresponds to Kapi Fault), f7 to f9 and f12, fall in this category. No fault on the geologic map is present to correlate exactly with F12. However, it should be noticed that two other faults on the geologic map are in such a position as to strongly favour the presence of f12. One of these faults runs parallel to f12 and is located three quarters of a mile north of Pieman River, and the second fault is in alignment with the extension of f12 further west.

In other parts of the area, detailed geologic maps are lacking, and this makes it difficult to correlate faults mapped on the basis of magnetic evidence with those that are perhaps

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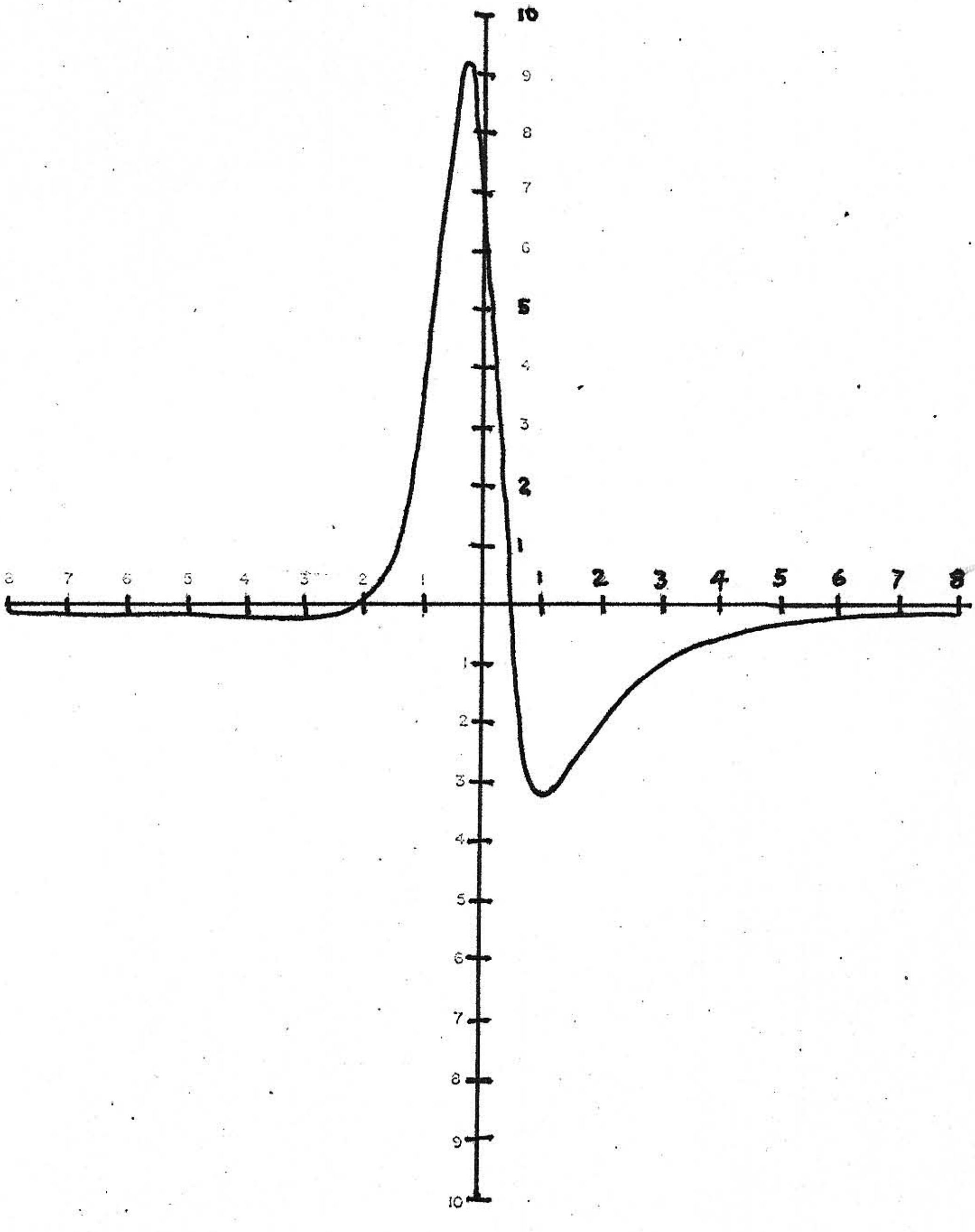


HORIZONTAL CYLINDER

INCLINATION = 70°

SCALE

1 UNIT = DEPTH TO CENTRE OF CYLINDER

0 1 2 3 4 5 6

5 cm

FIG. 9

exposed on the surface. Of the more conspicuous faults in the area is f13, which has been mapped on the evidence of 1½ miles horizontal shift to the west of Trend E2.

The Negative Anomalies - The negative anomalies and trends of the magnetic map in general, and of Zone E in particular, are of special interest. In Zone E almost all of the elongated positive anomalies and trends have two associated negative counterparts bounding their flanks. As for the circular positive features, they are completely surrounded by their negative counterparts (see section of magnetic pattern of Zone E). Zone A, in direct contrast, has only one negative associated with each positive anomaly.

A positive trend which is associated with two negative counterparts is indicative of a magnetic body in the shape of a horizontal cylinder (figure 9), while a corresponding circular feature is the expression of a magnetic body in the form of a sphere or short vertical cylinder. In other words, the lower ends of the ultrabasic lithologies indicated by the magnetic anomalies in Zone E, are only a very finite distance beneath their upper ends.

The association of a single negative with a positive anomaly in Zone A is the evidence of a dyke-type magnetic body (Figure 4) whose vertical extent is much greater than any of those of Zone E.

Quantitative Analysis :

An anomaly which is represented on the magnetic record by a curve, can be mathematically analysed to yield information concerning the depth, dip, dimensions and susceptibility contrasts of the causative body. Except for a few cases mentioned below, no attempt was made to obtain the susceptibility contrasts and dimensions of the sources of most anomalies for reasons which will be explained in the succeeding section. However, in order to gain a clear picture of the structural framework of the area, some magnetic trends and anomalies were analyzed for the dip of their source rocks.

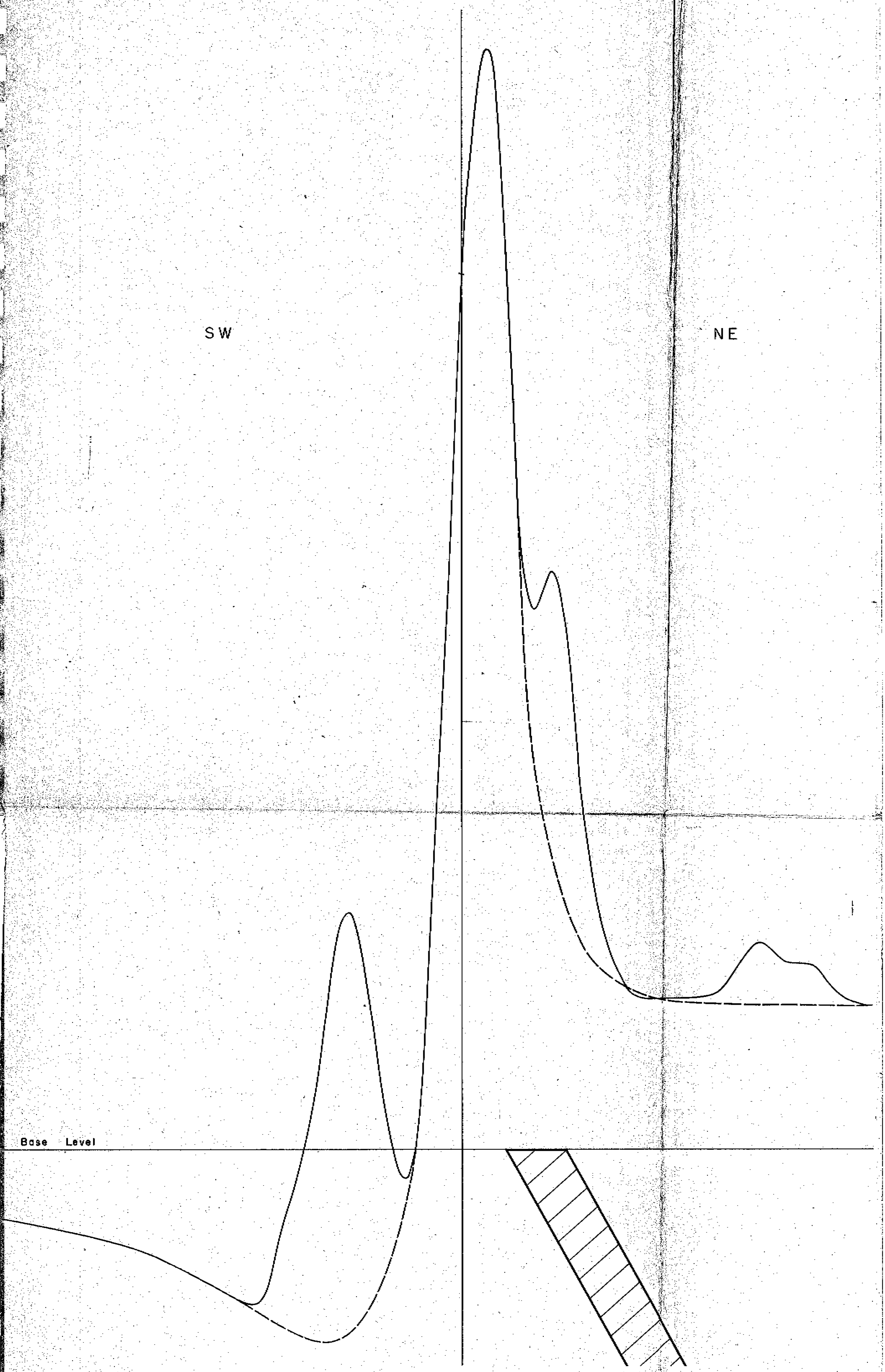
Using the formula on page 7, susceptibility contrasts were obtained for some of the anomalies of Zone A to ascertain their merits as far as the presence of iron ore is concerned. The two high intensity anomalies 3 and 4 were submitted for such an analysis. Anomaly 4 stems from the Savage River magnetite deposit which is already in the developmental stage. For the purpose of analysis, this anomaly was divided into two portions.

The northern portion yielded a susceptibility contrast of .127 c.g.s. units, and the southern portion a susceptibility contrast of .216 c.g.s. units. Referring to figures 5 and 6, we see that the susceptibility contrasts of .127 c.g.s. and .216 c.g.s. units correspond to 37% magnetite by volume and 54% magnetite by weight, and 72% magnetite by volume and 84% magnetite by weight respectively. It is evident from these figures and from the areal extent of anomaly 4, that it is the indication of the presence of large quantities of iron ore of economic scale.

Coming now to anomaly 3, its susceptibility contrast is computed to be .0216 c.g.s. units, which is equivalent to about 8% magnetite by volume or 15% magnetite by weight. We see, therefore, that this anomaly does not fall in the same category as anomaly 3 as far as the content of magnetite is concerned.

As mentioned above, several anomalies were analyzed to furnish proper values of the dips, and in some cases the depths of their source bodies. The process of analysis involves the comparison of the recorded anomaly profiles with the theoretical curves. This naturally means that better results would be obtained if anomalies to be analyzed were free from effects of adjoining anomalies. Unfortunately most of the anomalies in the survey area do not fall within this category. Therefore, the selection of the anomalies for analysis could be made only from a rather limited number in the survey area. The results obtained from the analysis are listed in Table 1. For illustrative purposes, figures 10 and 11 show the recorded magnetic profiles of Trends E1 and E2, and their "smoothed-out" counterparts which were used for the detailed analysis.

It is thought that it would have been desirable had more dips been obtained in certain places, such as along Trend E2.



TREND E1

TRAVERSE NO. 71

i = 72°
T = 62,800 gamma
Depth = exposed
Width = 1750 feet
Dip = 61° NE

5 cm

Horizontal Scale = 2700 feet / inch
Vertical Scale = 50 gamma/inch

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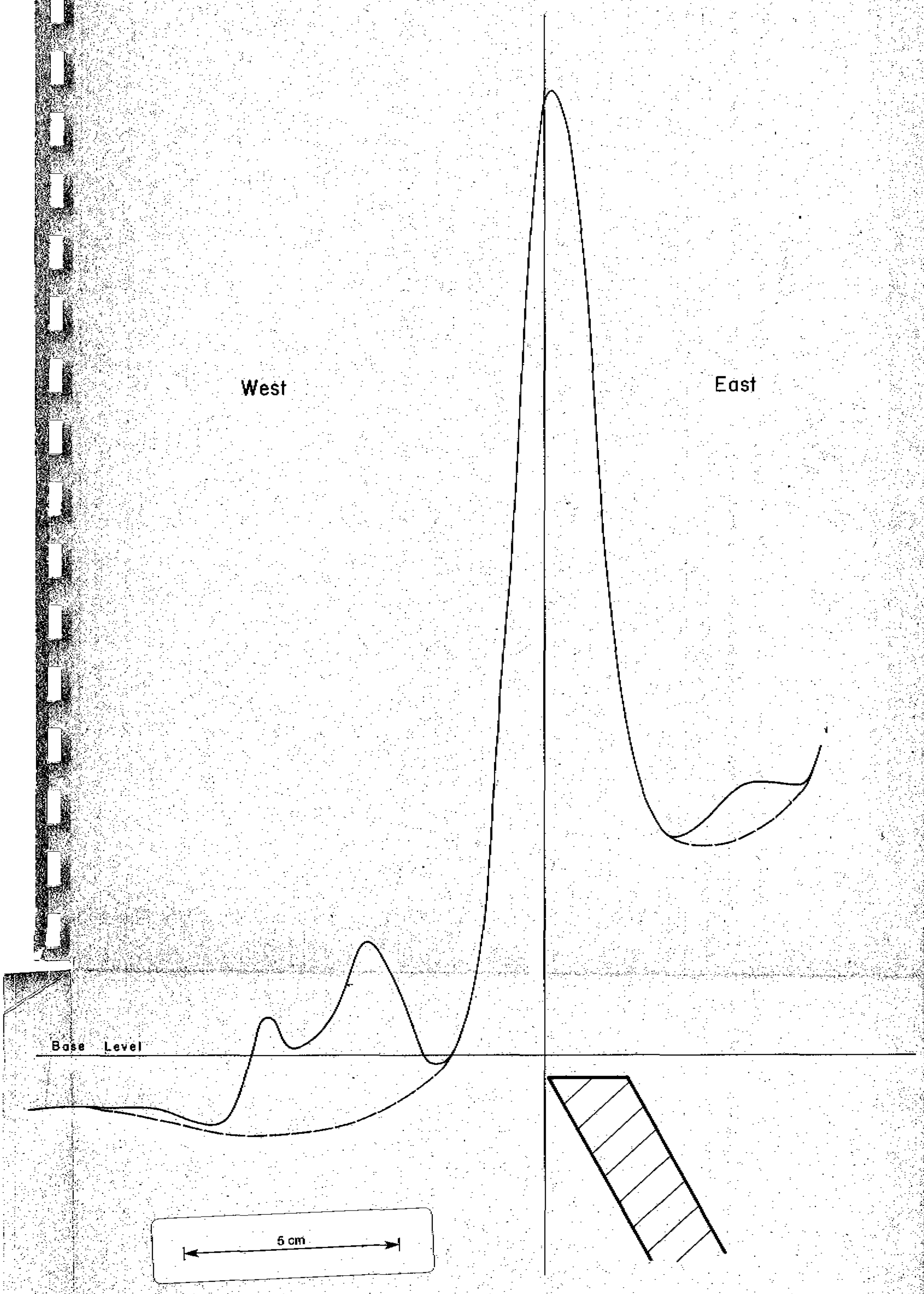
FIG. 10



TRENDE2

TRAVERSE NO. 38

i = 72°
T = 62,800 gamma
Depth = 200 feet sub-surface
Width = 1700 feet
Dip = 61° E

Horizontal Scale = 2640 feet / inch
Vertical Scale = 50 gamma/inch

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FIG. 11

In order that an anomaly be analyzed it is necessary to reconstruct it first from the "zigzag-like" pattern shown on the magnetometer tape. This task is rather difficult, and distortions are introduced in its shape, especially if it possesses high amplitudes of 1,000 gammas or more. This is the problem that had to be faced here, and so fewer dips are shown in some places than the writer would have hoped to see.

- TABLE I -

Anomaly or Trend			Dip	Depth Sub-Surface
Anomaly 7a	(Traverse	T.11)	30°W	80'
" 17a	"	T.20	72°W	Exposed
" 9	"	T.20	60°E	"
" 54	"	T.21	69°E	200'
Trend E2	"	T.22	40°E	150'-300'
Anomaly 53	"	T.31	58°E	200'
" 6a	"	T.33	78°W	100'
Trend E2	"	T.38	61°E	100-200'
" E2	"	T.44	45°E	150' ?
" E1	"	T.71	61°E	0-50'
Anomaly 2	"	T.72	40°W	250'
" 1	"	T.72	88°E	Exposed
Trend E19	"	T.80	55°E	100'
" E2	"	T.91	78°E	50'-100'
" E2 (west of fiducial 9576)	"	T.114	42°E	250'-300'

A brief study of Table I will show the sources of all the trends and anomalies to be either exposed or at a shallow depth.

Furthermore, it is most likely that Trends E1, E2, E3 and anomaly 32 are the expressions of the same ultrabasic sheet-like body that has been complexly folded. The sources of both Trends E1 and E2 are shown to be dipping in an easterly direction, thus forming an assymmetrical fold. A quick examination of the corresponding geologic map shows that a synclinal structure must be assigned to the assymmetrical fold. In Zone B the structure is probable quite complex, as evidenced from, one, the change in the dip direction of anomalies 9 and 7a, and two, the complicated relationship of anomalies 10 to 20 with each other.

RELATION of ORE to ANOMALIES

The interpretation map shows the position of several mines and workings in the Dundas, Renison Bell and Waratah areas. The fact that emerges from the examination of the positions of the mines in relation to the nearby anomalies, is that almost always the discovered ores are located along the flanks of the anomalies and only a few can be argued at all to fall on top of the anomalies. The significance of this observation will be discussed in the next section.

DISCUSSION of RESULTS

Putting together all the observations, ideas and facts brought forward in the previous sections, a reasonably clear picture of the geologic structure can be constructed, taking also into account the established regional, and in some areas, the local geology.

In order to gain a clear understanding of the tectonic developments throughout the successive geologic periods, it will be best to review these events in a chronological manner with reference to figure 12. It must be understood that figure 12 is very simple and diagrammatic, and illustrates in broad outline only the general structure of interest in this report. In the following discussion it is assumed that the reader is familiar with the geology of the area as described in the references listed in the bibliography.

Figure 12a: In the Middle or Upper Cambrian times ultrabasics in the form of a thick sill intruded the Crimson Creek Formation and the Dundas Group somewhere near their contact. It is difficult to ascertain from the magnetic map the source of these ultrabasic rocks. Probably they were injected from a major north - south trending zone of weakness not very far east of the boundary of the survey area. Perhaps this zone of weakness is what we identify as the Great Lyell Shear Zone. However, no strong argument can be presented against the probability of a different source.

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<u>Figure 12b</u>: In Ordovician times a narrow belt bordering the zone of weakness on the east began to subside gradually to form the Owen Graben.

Mt. Read Volcanics and the Precambrian rocks to the east of the subsiding belt supplied the graben with detritus (Jukes Breccia and Owen Conglomerate, known collectively as the Junee Group) during the Ordovician. In late Ordovician or early Silurian the Gordon Limestone was deposited, signalling a marine transgression and was followed by the Eldon Group.

<u>Figures 12c, 12d and 12e</u>: In the Middle Devonian the Tabberabberan Orogeny made itself felt by mild folding which gradually increased in intensity and resulted in the overturning of fold limbs. Continued stresses finally produced a major subsidiary fault or faulted zone linked with the Great Lyell Shear. The stresses appear to have acted along an east - west direction. The area east of this subsidiary fold was pushed further down, thus emphasising the Owen Graben.

A second period of folding ensued shortly afterwards with stresses acting at 45 degrees with those of the earlier period. As a result complex structures evolved mostly along northwest - southeast directions. In the northern part of the area between Waratah and Hazelwood River, more complex structures appear to have developed than in the Renison Bell - Dundas area. The reason the structural complexity of the area as a whole can be conceived at all from the magnetic map is mainly due to the thick

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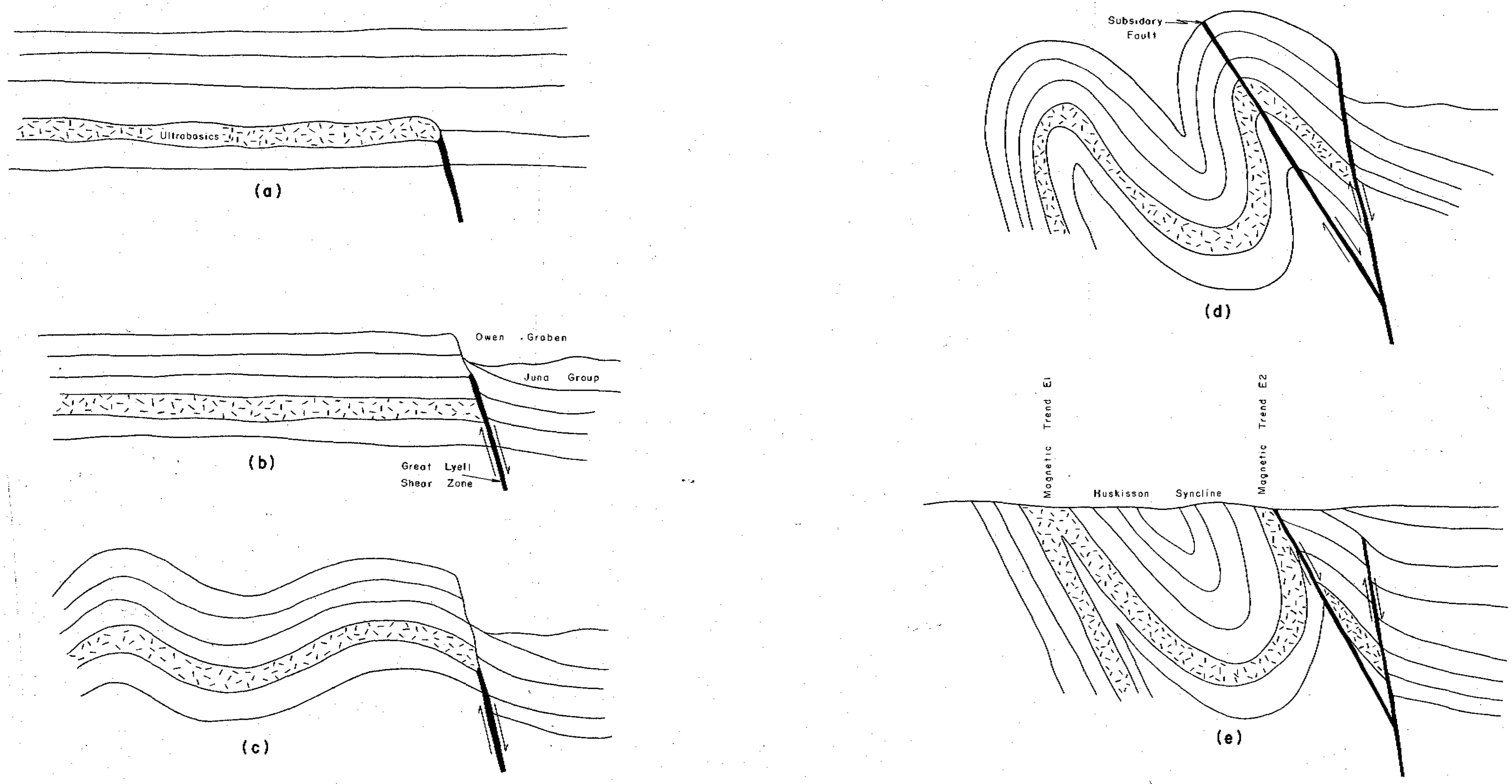

FIG. 12 – GEOLOGIC CROSS SECTION

ultrabasic Cambrian sill which has been subjected to the consecutive deformational forces.

The Tabberabberan Orogeny continued with the rise of granite beneath the whole of the area, uplifting in the process the folded complex structure. In some places, as in the Meredith Granite outcrop area, it rose higher than other places. The rich mineralized solutions which separated from the magma after the crystallization of the granite were forced into the complicated systems of old and new faults, fissures and joints. Some of these fractures dated back to the time of the intrusion of the ultrabasic sill. They had acted as hosts for the mineralized solutions associated with the ultrabasics. During the Tabberabberan Orogeny they were possibly repeated this role, in conjunction with newly developed fractures, receiving the residual ore-laden solutions of the rising granite underneath, (footnote on p. 53, B. Campana, S.B. Dickinson, D. King and R.S. Matheson, 1958). In some areas quartz porphyries, the local differentiation products of the granite, found their way into the overlying strata. Examples of quartz porphyries in the form of small plugs and dykes are found in Renison Bell and the Waratah areas. The rise of the granite magma also supplied the necessary H_2O and CO_2 to alter the ultrabasics to serpentine (B.L. Taylor, 1955; A.M. Bateman, 2nd Edition, 1952).

The strong likelihood of the occurrence of the events described above should explain adequately the presence of ore deposits such as tin and other certain minerals which are closely related to granites in areas (Renison Bell - Waratah) shown by the magnetics to contain ultrabasic lithologies. The location of the ores in the intricate systems of faults and fractures surrounding the ultrabasic rocks and not within these rocks, renders the magnetic anomalies indicative of the ultrabasics uninteresting within themselves, and therefore the computation of their susceptibility contrasts will be unwarranted. As a matter of fact, according to the theory of magmatic differentiation, the greater percentage of the high temperature magnetic minerals such as magnetite and pyrrhotite will be among the first group of minerals to be extracted to a great extent from the cooling magma. Therefore, the magma will be richer with the ore-bearing solutions which are very likely to be injected elsewhere. The location of most mines and mineral workings along the edges and borders of the anomalies should make such places the prime targets for exploration in the future. Sections 3 and 4 in the discussion of The Cleveland Mine by A.M. Reid (1923) are very significant in connection with the ideas presented above.

A very convincing argument in support of the granite below - folded sediments above relationship; can be advanced by critical examination of the prolongation of Trend E1 beyond its northern limits across Zone D and into Zone C. Mention has already been made of the northern end of this strong positive trend abutting against Zone D, which is the expression of the Meredith Granite. The strike of Zone C conforms very well with the extended trend of E1. Other similarities between this trend and Zone C can be further noticed by the fact that Zone C is comprises of two secondary positive trends identical to that of Trend E1 north of Traverse T.72. This similarity even includes the individual secondary trends in as far as the amplitude of the eastern trend is higher in both areas than that of the western trend. The suggestion is very strong then, to think of Zone C as an isolated segment of Trend E2. The ultrabasics indicative of the missing segment of E1 in Zone D must have been either:

(1) Engulfed by and incorporated into the intruded granite magma, or

(2) Uplifted higher than other localities by the gradual rise of the granite, and was eroded away

The first possibility is very unlikely due simply to the fact that no anomalies whatsoever are present in Zone D within the belt which connects E1 with Zone C. It is somewhat unreasonable to assume that so highly magnetic ultrabasics, as we have in the rocks of E1, could have been incorporated within the acidic magma without emphasising the magnetic character of the latter. The second possibility is the more plausible of the two. The lack of ultrabasic outliers on the granite could very well be due to the erosional forces which act much more effectively in areas raised higher than others.

It is not certain what the position of anomalies 38, 65 and 66 is in the tectonic framework presented above. Their remarkable circular outlines (especially of anomaly 38), and their location west of Trend E1, makes it somewhat difficult to attribute them to interference folding. That these anomalies are expressions of ultra-basic rocks in certain, since sparse outcrops of serpentines, pyroxenites and peridoties are present in the areas of anomalies 38 and 66, as noted previously. Brief examination of the drainage, geology and topography of the area in the vicinity of anomaly 38 reveals several points worth noting. First, the broad curvature of Parting River as it runs parallel to the western margin of the anomaly. The east - west course of the uppermost reaches of the left tributary of Henty River makes a sudden 90^{o} turn due south as it approaches the area of the anomaly. Second, the comparatively flat topography which occurs directly over the anomaly area. Third, a series of faults which occur on the periphery of the anomaly. On the east, two curved faults are shown about three-quarters of a mile east of "The Five Mile District". On the south side a fault is shown with its upthrown side on the north. A long dashed fault parallel to the western major tributary of Henty River is shown to occur along its southwestern and western boundaries. It seems that it has its eastern side upthrown, since it brings the Cambrian Crimson Creek Formation east of it, in touch with the Silurian Crotly Quartzite to its west.

On the northern side the Dunkley Fault is shown as a long and wavey feature. The Crimson Creek Formation along this fault is in touch with the Proterozoic Oonah Quartzite and Slate. There is no reason why a south side upward movement cannot be postulated for the Dunkley Fault. The difference in the erosional characteristics between the quartzite on one side and the greywackes and mudstones on the other, has resulted in the hilly topography of the Oonah and Crotty Quartzites overlooking the lower flat area occupied by the Crimson Creek Formation over anomaly 38. Unfortunately, not enough dips are shown on the geologic map in the vicinity of the anomaly to make their contribution worthwhile.

The drainage (see map of Tasmania 1 : 250 000, Lands and Surveys Department) in the vicinity of anomaly 66 is also distinctive in that the anomaly occurs on the concave side of the Whyte River just south of the Corinna-Waratah road. The anomalous drainage is further emphasised by the annular configuration of two tributary creeks located almost exactly over the outline of the anomaly.

The structural significance of the magnetic relationship between Zones B and C is not clear. The magnetic value of Zone B is at least 650 gammas higher than that of Zone C. The direction of the trends in Zone B immediately next to Zone C is 45 degrees out of alignment with those of the latter zone.

The abutting of the southern end of Zone C against Zone B is also rather significant. These observations suggest that Zone B possesses more basic lithologies which were subjected to different directions of stress than those of Zone C. Field geology does not support this view as far as the lithologies are concerned. Both areas contain similar types of rocks. Furthermore, to the best knowledge of the writer, there are no field data available in regard to the structure of both Zones B and C. Perhaps the second period of the deformation mentioned earlier, which for some reason affected Zone B and not Zone C, generated several factors which are the cause of the higher magnetic values of Zone B. Some of these factors are :

(1) The percentage of the magnetic minerals.

(2) The sizes of the magnetic minerals.

(3) The degree of parallelism of the axes of the magnetic minerals.

(4) The temperature and stress cycles which the rock has undergone.

(5) Folding and changes in attitude.

Finally, the magnetic survey brings forth a few interesting observations more or less of academic nature, whose explanations may require support from other sources:-

(1) The relationship of Syenite with the surrounding ultrabasics in Zone B. On the magnetic map the Syenite occupies the shelf-like area

along the eastern gradient boundary of the zone. An anomaly (No. 15) of about 160 gammas is shown to be present here. Another partly recorded anomaly (No. 16) of about 250 gammas is also shown to occur here. Examination of the geologic map (Reid, 1923) indicates that the latter anomaly is partly located on the Gabbro mass immediately west of the Syenite, and partly on the latter lithology. It is possible that the gabbro extends completely underneath the Syenite and thus anomaly 15 could be an expression of this extension.

(2) The completely non-magnetic character of the Meredith Granite is puzzling. Similar occurrences of non-magnetic granite are known elsewhere in Australia. Granitization of the sediments during the Tabberabberan Orogeny may be advanced as the cause of such a phenomenon. This explanation will raise the same arguments used in rejecting the idea of the acidic magma incorporating a segment of Trend E1, as discussed previously.

Another point to be raised is the gradual regional increase of the magnetic values in Zone D from north to south by about 100 gammas. The regional magnetic gradient of 5.8 gammas per mile in a southwesterly direction will account for only 41 gammas. The balance of 59 gammas must be caused by another factor of widespread occurrence. The gradual rise of the magnetic contours until they culminate in the Precambrian rocks of Zone A, leads one to strongly suspect that the unaccounted balance of 59 gammas is due to the gradual rise of the Precambrian rocks acting as the basement beneath the granite. This conclusion is in conflict with the well-established idea that granite batholiths, and stocks for that matter, are bottomless.

(3) A similar situation in Zone E inasfar as the magnetic gradients are concerned, is also present in Zone H, except for the fact that it is much more pronounced here. It should be noticed that if it was not for anomaly 65 and trends E19 and E20, Zone D would have

extended as far south as to encompass all of Zone H. The same explanation can be advanced for the southwest increasing gradient of this zone as that of Zone D.

RECOMMENDATIONS

Local ground magnetometer surveys in conjunction with detailed geologic mapping is recommended as the next stage in the exploration program following the aeromagnetic survey.

In specific areas the ground magnetometer surveys will provide a detailed magnetic picture which the aeromagnetic survey will obviously not be able to supply. A very good example in this regard can be seen by comparing the ground magnetic map (Plate 2, Davidson, R.J., Williams, L.W., Loh, R.P., Horvath, J. and Kennecke, 1957) with the aeromagnetic pattern obtained in this survey of the area immediately south of Renison Bell (the area between Traverses T.107 and T.109). While the aeromagnetic survey in this locality records the sub-regional picture in terms of major anomalies and anomalous trends, its traverse spacing and the altitude at which it is recorded do not aid in the registration of the minor anomalies such as those revealed by the ground survey. Much closer traverse spacing at ground level is needed to record such minor anomalies that are associated with the ore deposits of the area. These anomalies can be visualized as minor features superimposed on major aeromagnetic anomalies that are indicative of lithologic variations. Having previously noted the manner of association of the known ore deposits with the aeromagnetic anomalies, it would be advisable to conduct local ground magnetic surveys in other areas where the aeromagnetic pattern favours the presence of what may be termed ore deposits. Hence, it is recommended that ground surveys be conducted along the flanks of anomalies 38, 65 (and especially along its associated trends and extensions), 54 and 66. The flanks of the positive trends of Zone E should also be surveyed, and in particular those south of Renison Bell, and west and southwest of Waratah. Anomalies 59, 60, 61, 63 and possibly 64 should be included in the early stages of survey.

Detailed geologic mapping should be carried out in the above areas with the aim of marking the attitudes of the beds, detecting any structures such as faults, and recognising lithologies and mineral showings. All this information will help greatly in the interpretation of the ground magnetic data.

Respectfully submitted,

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APPENDIX No. 1

FIELD CREW

A. Holtzclaw - Pilot

Responsibility - Commander-680F Aircraft

Experience - 9,000 hours flight time and 10 years' experience in aerial photography and geophysical flying

L. Taylor - Co-pilot

Responsibility - Navigation Commander-860F Aircraft

Experience - 6,000 hours flight time, 4,000 of which have been gained in aerial survey work

R. Welshe - Magnetometer Operator

Responsibility - Magnetometer and all electronic equipment

Experience - Four years' experience with the Company in charge of all electronic equipment 3,000 airborne hours as Electronics Technician

M. Chatenay - Data Technician

Responsibility - Supervision, editing and checking of all magnetic data received, including flight path verification

Experience - 4 years' experience - geophysical data reduction

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APPENDIX No. 2

SURVEY PROCEDURES AND EQUIPMENT

Compilation Procedures :

The initial phase of a survey is performed in the office prior to entering the field with the aircraft. Maps or photographs of the area must be obtained. The proposed traverses are then plotted on these maps.

The flight crew uses these maps in the field to position the lines as accurately as possible as they are shown on the maps.

In the aircraft is a 35 mm. Aeropath camera synchronized with all the other recorders. This camera records the actual course that the pilot flew and the synchronizing device affords correlation with the geophysical records. The film is used in the office along with base maps or photo mosaics of the area to recover the true flight path and these positions are then plotted on a manuscript with geographic co-ordinates.

The "raw" magnetic values as they appear on the record paper cannot be plotted directly on this manuscript because they are subject to various sources of error which include diurnal drift, instrument drift, heading effects and altitude variations. These errors result in various levels for the magnetic records. It is necessary to remove these and place all of the records on a convenient level or base. This is done by locating the exact value of the intersection of all the traverses with the control lines which were flown for this purpose. The intersection is then plotted on each magnetic record and the difference in the traverse and the tie line values is recorded and adjusted. Then a linear drift between traverses can be applied so that they will read at the intersection point the same value as the tie line. A base line is then constructed on each of the traverses from which all magnetic values are then read.

In a mineral survey it is common practice not to remove the regional variation; that is, the variation in the earth's magnetic field. This regional variation does not effect the analysis at all, and it sometimes helps in indicating sub-regional anomalies due to large scale tectonic elements which may be lost by removing the regional gradient. Therefore, a southward increase in the magnetic values can be seen on the map. That is, the general background base intensity in the northern part of the survey will be somewhat lower than the general background base intensity of the southern part of the survey.

Since in magnetic surveying there is no interest in the actual value of the magnetic field but only in the variations or changes relative to one another, the value of the base line is arbitrary and is chosen at some convenient level for contouring and map reading.

The magnetic value must then be transferred to the map and this is done by use of a transcriber, (a variable ratio machine).

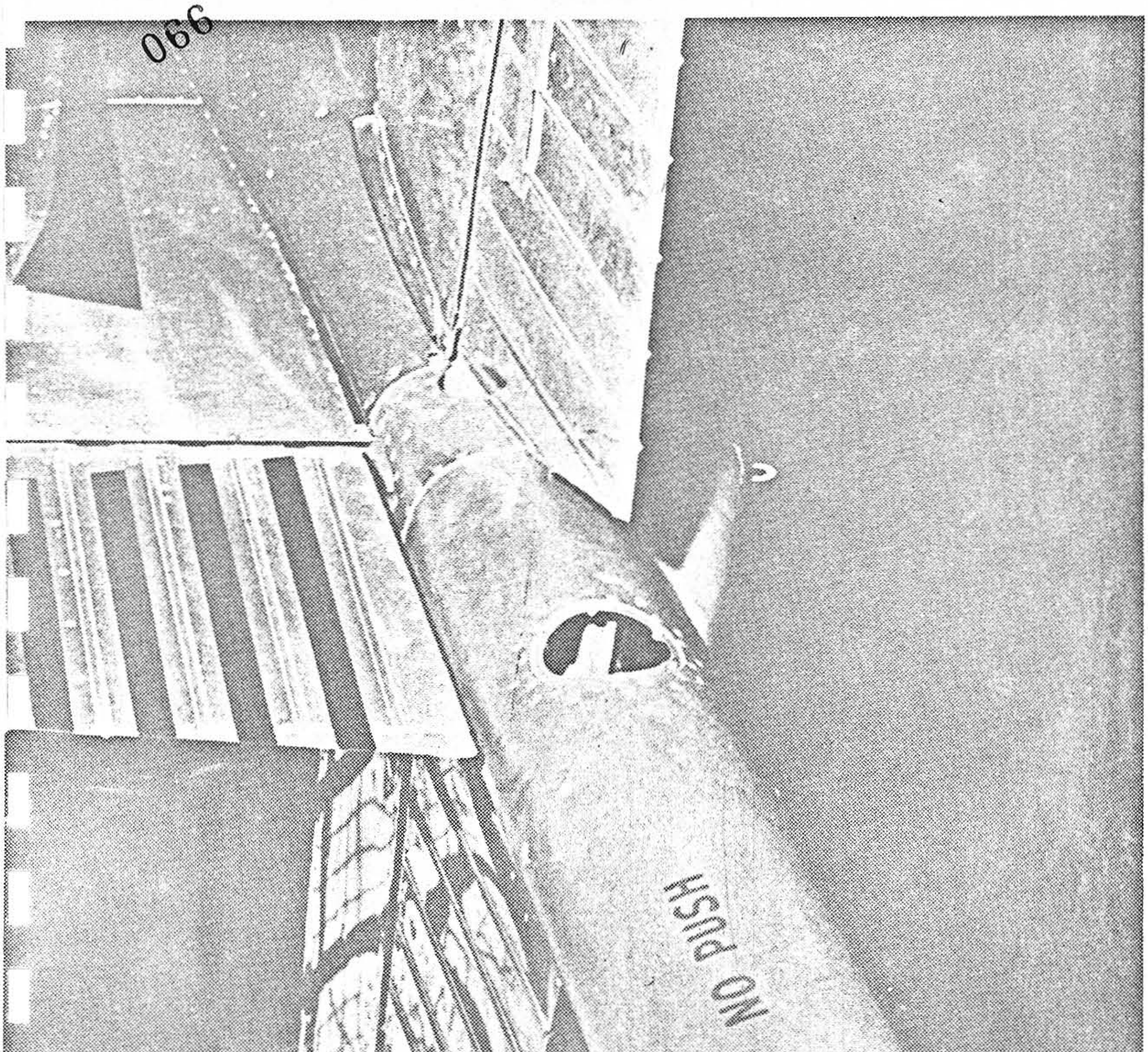

Fig. 13.

067

CORRELATION OF AIRBORNE GEOPHYSICAL RECORDS

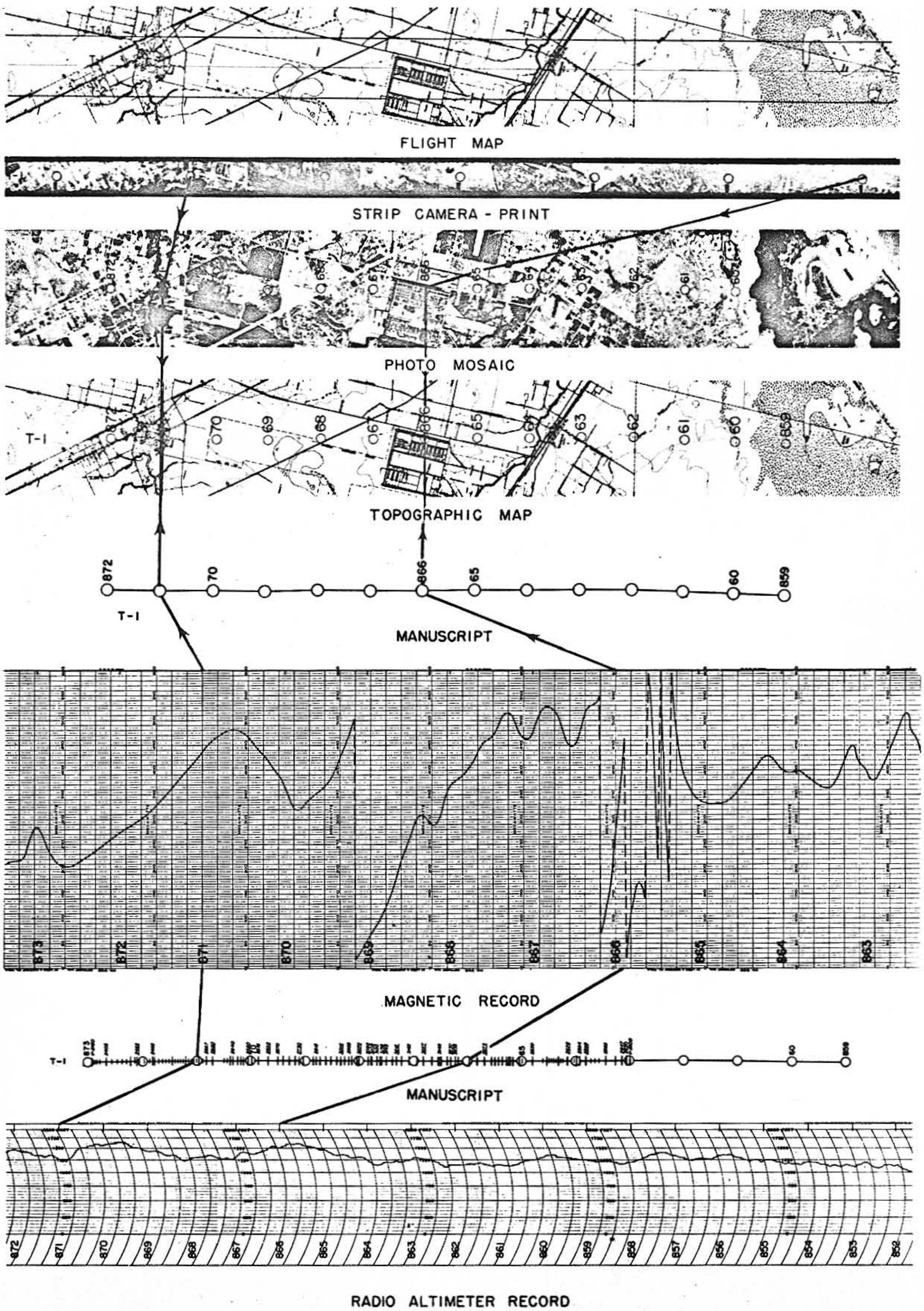

Fig.14.

The correlation of all data is illustrated in Fig. 14.

Contouring of the magnetic maps is a simple process to explain but it is a very complex and time-consuming operation. The process is simply that of connecting up points of equal value along each of the flight lines. The complexity of the operation lies in the fact that each of the magnetic trends (magnetic highs and lows) must be properly related from traverse to traverse.

The final operation is the drafting of the sheets at the delivery scale with an appropriate grid and legend.

In the course of survey operations magnetic storms may occur and result in incorrect magnetometer readings from the aircraft. To monitor these magnetic storms and ensure that the flight crew is not recording data during the storms or to ensure that the data is rejected and re-flown, a Gulf Storm Monitor is operated throughout the period of the survey. This is a flux-gate type instrument. It is similar to the magnetometer used in the aircraft but it does not require the same orienting devices. It is permanently oriented in the earth's magnetic field near the operational base and monitored periodically.

237070

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APPENDIX No. 3

STATISTICS

Client:	Aberfoyle Tin Development Partnership
Contractor:	Aero Service Limited
Commencement of Flying:	13th April, 1965
Termination of Flying:	7th May, 1965
Aircraft:	Commander 680-F
Aircraft Base:	Hobart, Tasmania
Lost Time:	
Weather:	5 days
Diurnal:	Nil
Instrument Maintenance:	Nil
Aircraft Maintenance:	Nil
Ferry:	3 days
Other:	Nil
Magnetometer:	Gulf Mark III Fluxgate Type, continuous recording, total field magnetometer
Magnetometer Installation:	Inboard (tailcone)
Recorder:	Gulf 10" recorder
Tape Speed:	3 inches per minute
Full Scale Deflection:	600 gamma
Camera:	Aeropath AS-5 continuous strip, 35 mm. camera
Fiducial Interval:	30 seconds
Terrain Clearance:	500' M.T.C. (pre-planned) 300' - 1200' (actually flown)

237071

070

Terrain Clearance Control:	APN-1 Radioaltimeter
Magnetic Storm Control:	Gulf Storm Monitor (Fluxgate type)
Flight Direction:	Traverse E - W Tie Lines N - S
Area:	515 sq. miles approx.
Mileage:	2,500 line miles approx.
Line Spacing:	$\frac{1}{4}$ mile
Compilation Scale:	1 : 31,680
Final Map Scale:	1 : 31,680
Composite Scale:	1 : 63,360
Inclination of earth's magnetic field:	72^{o}
Declination:	$11^{o}30'$
Total Magnetic Field:	62,800 gamma
Regional (Not Removed):	5.8 gamma/mile (southwesterly direction)
Crew:	Pilot - A. Holtzclaw Co-pilot - L. Taylor Magnetometer Operator - R. Welshe Data Technician- M. Chatenay

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237072

071

APPENDIX No. 4

GEOPHYSICAL SURVEY

Altitude : 500' M.T.C. **Job No.** 1700

Sensitivity : 600 gamma

Index to Profiles

Line No.	Start	End	Flight	Date Flown
T - 6 E	7940	8180	30	1. 5.65.
T - 7 W	8470	8760	33	6. 5.65.
T - 8 E	8150	8460	"	"
T - 9 W	7850	8140	"	"
T - 10 E	7500	7840	"	"
T - 11 W	7200	7490	"	"
T - 12 E	6840	7190	"	"
T - 13 W	6560	6830	"	"
T - 14 E	6180	6500	32	5. 5.65.
T - 15 W	5840	6170	"	"
T - 16 E	5510	5830	"	"
T - 17 W	5100	5440	"	"
T - 18 E	4770	5090	"	"
T - 19 W	4440	4750	"	"
T - 20 E	4100	4430	"	"
T - 21 W	3670	3930	"	"
T - 22 E	3320	3660	"	"
T - 23 W	1980	2230	39	7. 5.65.
T - 23 W	2980	3300	32	5. 5.65.
T - 24 E	2630	2960	"	"
T - 25 W	2320	2620	"	"
T - 26 E	1960	2310	"	"
T - 27 E	8990	9310	31	2. 5.65.
T - 28 W	8710	8980	"	"

072

237073

APPENDIX No. 4

GEOPHYSICAL SURVEY

Altitude : 500' M.T.C. Job No. 1700

Sensitivity: 600 gamma

Index to Profiles

Line No.	Start	End	Flight	Date Flown
T - 29 E	8370	8670	31	2. 5.65.
T - 30 W	8080	8360	"	"
T - 31 E	7780	8070	"	"
T - 32 W	7430	7710	"	"
T - 33 E	7130	7420	"	"
T - 34 W	6830	7120	"	"
T - 35 E	6520	6820	"	"
T - 36 W	6220	6510	"	"
T - 37 E	5920	6210	"	"
T - 38 W	5600	5880	"	"
T - 39 E	5300	5590	"	"
T - 40 W	5000	5290	"	"
T - 41 E	4680	4990	"	"
T - 42 W	4370	4670	"	"
T - 43 E	4070	4360	"	"
T - 44 W	3760	4060	"	"
T - 45 E	3450	3750	"	"
T - 46 W	3150	3440	"	"
T - 47 E	8950	9270	"	"
T - 48 E	3760	4070	27	21. 4.65.
T - 49 W	3480	3750	"	"
T - 50 E	3190	3470	"	"
T - 50 W	9280	9400	33	6. 5.65.
T - 51 W	2910	3170	27	21. 4.65.
T - 52 E	2630	2900	"	"

APPENDIX No. 4

GEOPHYSICAL SURVEY

Altitude : 500' M.T.C. Job No. 1700

Sensitivity : 600 gamma

Index to Profiles

Line No.	Start	End	Flight	Date Flown
T - 53 W	2360	2620	33	21. 4.65.
T - 53 E	9410	9630	33	6. 5.65.
T - 54 E	2000	2350	27	21. 4.65.
T - 55 W	4540	4820	25	15. 4.65.
T - 56 E	9930	6040	33	6. 5.65.
T - 56 W	2480	2830	31	2. 5.65.
T - 57 E	2170	2470	"	"
T - 58 E	1700	2030	30	1. 5.65.
T - 59 W	1390	1690	"	"
T - 60 W	9640	9910	33	6. 5.65.
T - 61 W	7470	7760	30	1. 5.65.
T - 62 E	7200	7460	"	"
T - 63 W	6910	7190	"	"
T - 64 E	6610	6900	"	"
T - 65 W	3830	4090	2	14. 4.65.
T - 66 E	4110	4390	"	"
T - 67 E	3560	3820	"	"
T - 68 W	3290	3550	"	"
T - 69 E	3000	3280	"	"
T - 70 W	2730	2990	"	"
T - 71 E	2450	2720	"	"
T - 72 E	0120	0400	33	6. 5.65.
T - 73 E	1090	2160	2	14. 4.65.
T - 74 W	1610	1880	"	"

APPENDIX No. 4

GEOPHYSICAL SURVEY

Altitude : 500' M.T.C. **Job No.** 1700

Sensitivity : 600 gamma

Index to Profiles

Line No.	Start	End	Flight	Date Flown
T - 75 W	0410	0670	33	6. 5.65.
T - 76 W	1030	1300	2	14. 4.65.
T - 77 E	0620	1010	"	"
T - 78 W	0350	0610	"	"
T - 79 E	0070	0340	"	"
T - 80 W	9810	0060	"	"
T - 81 E	0680	0800	33	6. 5.65.
T - 81 E	9540	9800	2	14. 4.65.
T - 82 W	9370	9530	"	"
T - 82 E	0810	0930	33	6. 5.65.
T - 82 W	9370	9530	2	14. 4.65.
T - 83 E	8930	9190	"	"
T - 84 W	8670	8920	"	"
T - 85 E	8390	8660	"	"
T - 86 W	0940	1150	33	6. 5.65.
T - 86 W	8240	8380	2	14. 4.65.
T - 87 E	7820	8060	"	"
T - 88 W	7550	7800	"	"
T - 89 E	7280	7540	"	"
T - 90 W	7010	7115	"	"
T - 90 E	1160	1360	33	6. 5.65.
T - 91 E	5230	5490	1	13. 4.65.
T - 92 W	4860	5010	"	"
T - 92 W	5030	5130	"	"
T - 93 E	4570	4840	"	"

APPENDIX No. 4

GEOPHYSICAL SURVEY

Altitude : 500' M.T.C. Job No. 1700

Sensitivity : 600 gamma

Index to Profiles

Line No.	Start	End	Flight	Date Flown
T - 94 W	4310	4560	1	13. 4.65.
T - 95 E	4030	4300	"	"
T - 96 W	3760	4000	"	"
T - 97 E	3528	3737	"	"
T - 98 W	3260	3500	"	"
T - 99 E	3010	3250	"	"
T -100 W	2760	3000	"	"
T -101 E	2530	2726	"	"
T -102 W	2240	2480	"	"
T -103 E	1976	2170	"	"
T -104 W	1744	1940	"	"
T -105 E	1490	1700	"	"
T -106 W	1200	1410	"	"
T -107 E	0970	1190	"	"
T -108 W	0770	0960	"	"
T -109 E	0560	0760	"	"
T -110 W	0360	0541	"	"
T -111 E	0150	0314	"	"
T -112 W	1730	1950	32	5. 5.65.
T -112 W	1370	1470	33	6. 5.65.
T -113 E	1500	1720	32	5. 5.65.
T -113 E	1480	1600	33	6. 5.65.
T -114 W	9540	9730	1	13. 4.65.
T -115 E	9330	9530	1	"

076

237077

APPENDIX No. 4

GEOPHYSICAL SURVEY

Altitude : 500' M.T.C. Job No. 1700

Sensitivity : 600 gamma

Index to Profiles

Line No.	Start	End	Flight	Date Flown
T - 116 W	9140	9320	1	13. 4.65.
T - 117 E	8930	9130	"	"
T - 118 W	8750	8920	"	"
T - 119 E	8543	8740	"	"
T - 120 W	8390	8550	"	"
T - 121 W	1300	1490	32	5. 5.65.
T - 122 E	1120	1290	"	"
T - 123 W	6400	6600	30	1. 5.65.
T - 123 W	0940	1110	32	5. 5.65.
T - 124 E	0760	0930	"	"
T - 125 W	0580	0790	"	"
T - 126 E	0390	0570	"	"
T - 127 W	0210	0380	"	"
T - 128 E	0030	0200	"	"
T - 129 W	9830	0020	"	"
T - 130 E	9640	9820	"	"
TL- 1 S	9170	9480	30	1. 5.65.
TL- 2 N	9570	0050	"	"
TL- 2 S	1610	1740	33	6. 5.65.
TL- 3 S	0070	0550	30	1. 5.65.
TL- 4 N	0620	1050	"	"

237078

077

APPENDIX No. 4

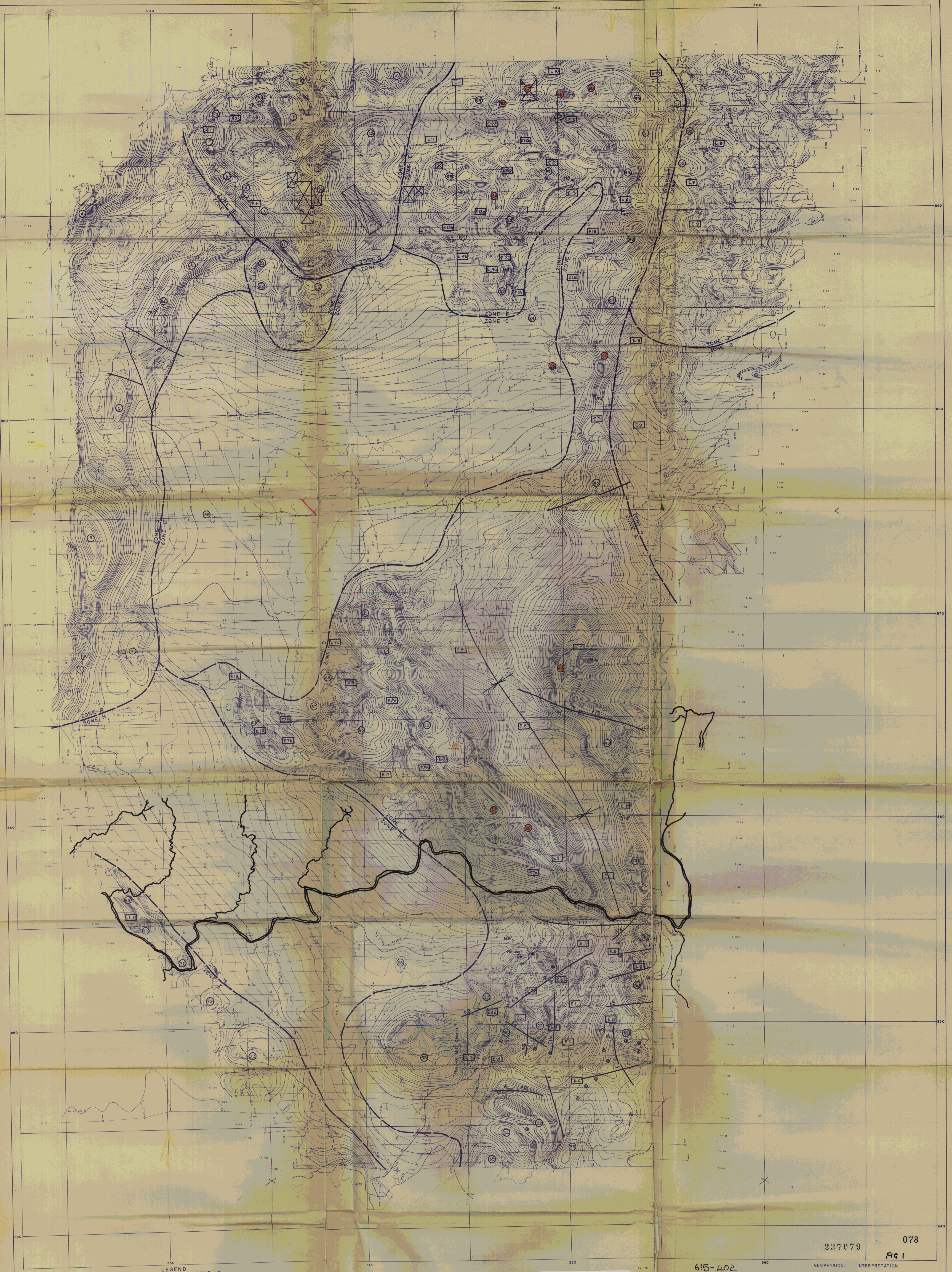
GEOPHYSICAL SURVEY

Altitude : 500' M.T.C. Job No. 1700

Sensitivity : 600 gamma

Index to Profiles

Line No.	Start	End	Flight	Date Flown
TL- 5 N	8190	8480	30	1. 5.65.
TL- 6 NW	7940	8180	"	"
TL- 7 SW	8770	8940	33	6. 5.65.
TL- 7 NE	8740	8800	30	1. 5.65.



LEGEND

- (72) Anomaly Number
- [E 20] Anomalous Trend
- 61° Dip of Source Body
- HB_2 "Herring-Bone" Effect
- ZONE D / ZONE E Anomalous Zone Boundaries
- f 9 Fault
- Fold Axis
- ⊗ Mines and Mineral Workings

INTERPRETATION BY PAPKEN A. ZARZAVATJIAN

GRID INCREMENT — 5,000 YDS. STATE GRID SYSTEM.

5 cm

615-402

237079

078

FIG 1

CONTROL LINE INTERVAL	VARIABLE
TRAVERSE INTERVAL	1/4 MILE
CONTOUR INTERVAL	10 GAMMA
BASE INTENSITY	ARBITRARY
ALTITUDE 500 F FEET MEAN TERRAIN	CLEARANCE

HORIZONTAL CONTROL DERIVED FROM PUBLISHED TOPOGRAPHIC MAPS

GEOPHYSICAL INTERPRETATION

TOTAL MAGNETIC INTENSITY

AEROMAGNETIC SURVEY — WARATAH - ZEEHAN AREA
N. W. TASMANIA

ABERFOYLE TIN DEVELOPMENT PARTNERSHIP

SCALE 1:63,360

MILES 1 1/2 0 1 2 3 MILES

FLOWN AND COMPILED 1965
AERO SERVICE LTD., SYDNEY, AUSTRALIA.