Geological Survey Ireland

Hunting airborne magnetic survey (1979-1981)

Geological Survey Ireland is a division of the Department of Communications, Climate Action & Environment.

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Document Information

Project title: Hunting Airborne Magnetic Survey		
Current Document version v1		
	Date	

Prepared By	Date	Comment
James A. Hodgson	15/03/2017	

Reviewed By	Date	Comment
Mohammednur Ture	15/03/2017	
Aoife Brady	15/03/2017	

Approved By	Date	Comment
Aoife Brady	20/03/2017	

Version History

Ver. No.	Ver. Date	Comment	Revised By
3.0	16/03/2017		James A. Hodgson
4.0	20/03/2017		James A. Hodgson

Disclaimer

Although every effort has been made to ensure the accuracy of the material contained in this report, complete accuracy cannot be guaranteed. Neither the Geological Survey, Ireland, nor the authors accept any responsibility whatsoever for loss or damage occasioned, or claimed to have been occasioned, in part or in full as a consequence of any person acting or refraining from acting, as a result of a matter contained in this report.

Copyright

Executive Summary

Between 1979 and 1981, Hunting Geology and Geophysics Ltd. completed an airborne survey across the central Ireland and extents on behalf of the Geological Survey Ireland, who at the time were part of the Department of Industry and Energy. The data was collected on magnetic tapes with the processed results transferred to disc files and anomaly paper maps produced. A survey report was released by the Geological Survey, Ireland in 1982, however, the original data was never released. In 2007 the original data was reprocessed and digitally formatted. This data has been reassessed, re-gridded and plotted with the resultant Total Magnetic Intensity data made available for release. The revised data and supporting grids have been produced using the Geosoft Montaj (Version 9.1) software.

A secondary aim of this brief overview of the Hunting magnetic dataset is to highlight the availability of the data to all interested parties. This data may provide a regional background to further geological investigations. The data may also guide future airborne magnetic surveys, highlighting areas of interest for more detailed surveying.

Table of Contents

1. Introduction

Overview

An airborne magnetometer survey of Central Ireland, covering the majority of the Republic (48,990 km^2), was flown in three phases during the period August 1979 to September 1981. The objectives of the survey were to outline variations in the crystalline basement and sedimentary cover, to improve knowledge of the regional geological structure and to locate areas of potential mineralization. This dataset is made up of a number of maps and a report, entitled “Report on an Aeromagnetic Survey of Part of the Republic of Ireland”, which was produced in April 1982 (Appendix A). The report describes the acquisition, compilation and interpretation of the aeromagnetic data as well as generalised geological summaries of the total survey area. A series of maps at 1:63,360 and 1:250,000 scales were produced as well as thirty-one 1:63,360 sheets (numbered 12 to 51). In addition, two paper maps were published at 1:1 Million (1985) and 1:750,000 (1983) scales. These paper maps are archived in the Geological Survey, Ireland. The data has also been incorporated in to other larger regional maps.

2. Data Acquisition

The Survey

The survey was flown in three phases, from August 1979 to September 1981, over an area that was split into four blocks, IV, VA, VB and VC. Line spacing was 1km for areas IV and VB and 2km for areas VA and VC (Figure 1), approximately 80% of lines were spaced at 1km. The flying height for area IV was 450m above mean sea level, while 200m mean terrain clearance was used for areas VA, VB and VC.

An airborne magnetometer, a 35mm flight-positioning camera, altimeters and a ground magnetometer were used to capture the data. An analogue and a digital recorder were used to record the measured magnetic field values. The mean distance between observation points was 62m, while 51m and 87m were minimum and maximum observation points. Line bearing was 160/340 degrees from north as calculated from the data, which is same as N20°W/S20°E. The total number of lines flown was 917.

Location Map and Flight Pattern

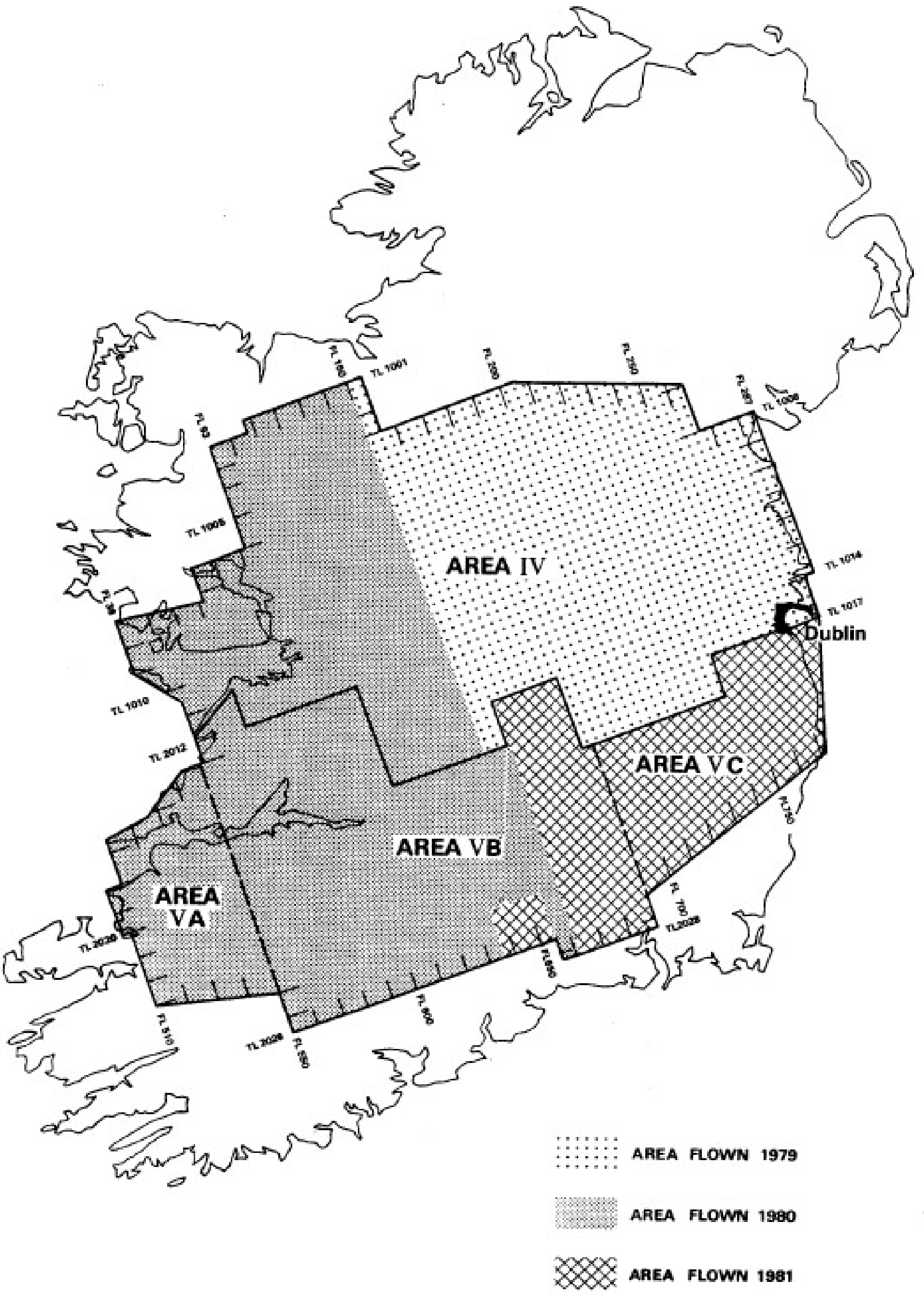


Figure 1: Location map of the Hunting airborne survey areas, taken from original survey report April 1982 (Appendix A)

Geographical Information

The following provides information on the reference system and specifications used during the Hunting airborne survey.

Reference system: Irish National Grid / Longitude/Latitude

West Easting: 467225.356 / West longitude: -9.5000

East Easting: 324955.75 / East longitude: -6.0000

North Northing: 5983637.358 / North latitude: 54.0000

South Northing: 939218.46 / South latitude: 52.0000

Technical Specification for Area IV

Flight line direction	N20ºW (True)
Tie line direction	N70ºE (True)
Line spacing	1 Km
Tie line spacing	10 Km
Flying Height	450 m AMSL

Technical Specification for Area V

Flight line direction	N20ºW (True)
Tie line direction	N70ºE (True)
Line spacing	1 Km, Area VB / 2 km, Areas VA & VC
Tie line spacing	10 Km
Flying height	200 m mean terrain clearance

Spatial Extent: a 48,990 km^2 area covering the eastern, central and western parts of the Republic of Ireland.

Survey Equipment

No details on the aircraft platform or instrumentation used during the survey are contained in the original report. Data was stored on magnetic tapes, which are currently archived at the Geological Survey Ireland.

3. Methodology

Navigation of the survey was visual with a 35mm flight positioning camera used to locate flight lines. The flight paths of the aircraft were recovered onto topographic maps at 1: 63,360 scales. All records were annotated immediately after completion of a flight, separated into individual lines and kept in envelopes. Flight logs were maintained with all relevant information on weather conditions, instrument performance, lines produced, times and fiducial numbers. In addition, a sketch map of the flight pattern was continuously updated to indicate survey progress.

The intersections between all flight lines and tie lines were found by superimposition of the respective flight track films. Flight tracks were digitised and converted to Irish UTM rectangular grid.

In the laboratory navigational and magnetometer data was processed. With regard to the navigational data, all the plotted navigation points on the 1:63,630 scale flight track overlays prepared in Ireland were digitized on a DMAC digitizer, and were inputted to a Prime 400 computer. These data were edited and converted to Irish UTM rectangular grid coordinates.

4. Data Processing & Release

Initial Data Processing (1979-1981)

The processing of magnetometer data involved a number of steps. Firstly, the field magnetic tapes were read into a Prime 400 computer and stored and edited as disc files. Secondly, using flight line and tie line data at the line intersections, a “Line minus Tie” (L-T) control analysis was applied. This control method adjusts the magnetic values and intersection positions so as to achieve the optimum fit for both. The magnetic values along the tie and flight lines between the line intersections were then adjusted to fit the adjusted intersection values. Thirdly, the regional field was then subtracted with reference to the International Geomagnetic Reference Field for November 1979, June 1980 and September 1981, as applicable for the relevant phases of the survey.

A fourth step was to give the magnetic values a datum shift of 1000nT to ensure that all values are positive and make data handling easier. Therefore the final magnetic value at any point is the controlled magnetic value minus the regional value plus 1000 (nT).

Within some areas magnetic field readings were increased by 35-36nT to match other areas. The final stage was to produce the 1:63,360 scale maps by computer showing the corrected magnetic values as intercepts along the flight lines. These were then contoured manually using a contour interval of 2nT, so as to depict low amplitude anomalies.

Data Processing 2007

In order to improve the quality of the original processed data (1979-81) and to restore the original high-frequency information additional processing was carried out by geophysical consultants Paterson, Grant and Watson Ltd., in 2007. The original dataset comprised 7 survey areas. Areas 5 and 7 were not reprocessed as they were deemed to be too noisy and overlapped the other areas which exhibited superior data quality (A map of the survey areas is shown in Figure 1). A geomagnetic inclination and declination of 68 degrees and –10 degrees were used respectively.

This additional processing comprised the following:

- Edited raw data profiles for cultural anomalies.
- Edited/rejected survey lines that were crossing or touching.
- Filtered (Naudy) profiles for spurious 1-2 point spikes and noise.
- Microlevelling of profiles, rejecting line-to-line non-geological noise.
- Generated a total field grid for each survey and continued all surveys to a common elevation (200 m). Cell size for gridding was set to 250m (approx. 1/4 of the line spacing).
- Linked surveys together and produced a unified "higher" resolution grid.

Following re-processing, all digital grids, maps and databases were geo-referenced in Airy Modified 1849 (datum), using the Irish National Grid projection (also known as the 1965 TM projection).

Following the reprocessing of the data some line-to-line levelling features remained in post process grids. This was mainly due to extensive levelling problems in the original data, which can occur at an amplitude and wavelength similar to local geological signatures.

Data Release 2017

The reprocessed 2007 levelled data set (Total Magnetic Intensity data) were knitted together using Geosoft Gridknit function using a grid cell size of 250m. The data was then resampled back to a master database. Data was reassessed with any spikes in the data removed. All tie-lines were also removed. Irish Transverse Mercator grid co-ordinates were added as additional channels to align with Geological Survey Ireland policy. An IGRF channel was not included within the final dataset as no original date or time information was available. The data is available in Geosoft xyz file format, the final data channels are defined below in Table 1 below.

It is the policy of the Geological Survey, Ireland that all data is free. Data can be downloaded from the project website www.tellus.ie or www.gsi.ie.

Table 1: Data file format

Column	Size	Name	Units	Description
1	11	X_ING	m	X coordinate, IRISH NATIONAL GRID
2	11	Y_ING	m	Y coordinate, IRISH NATIONAL GRID
3	11	X_ITM	m	X coordinate, IRENET95 ITM
4	11	Y_ITM	m	Y coordinate, IRENET95 ITM
5	11	LAT	Degree	Latitude, WGS-84
6	11	LONG	Degree	Longitude, WGS-84
7	11	Total_Field	nT	Levelled Airborne Magnetic Field

Figure 2 below shows the gridded total magnetic field from the Hunting data. Data was gridded using the minimum curvature method in Geosoft Montaj and a call size of 250m.

Interpretation of the magnetic data is contained in a report produced by the Geological Survey of Ireland in April 1982 and is shown in Appendix A.

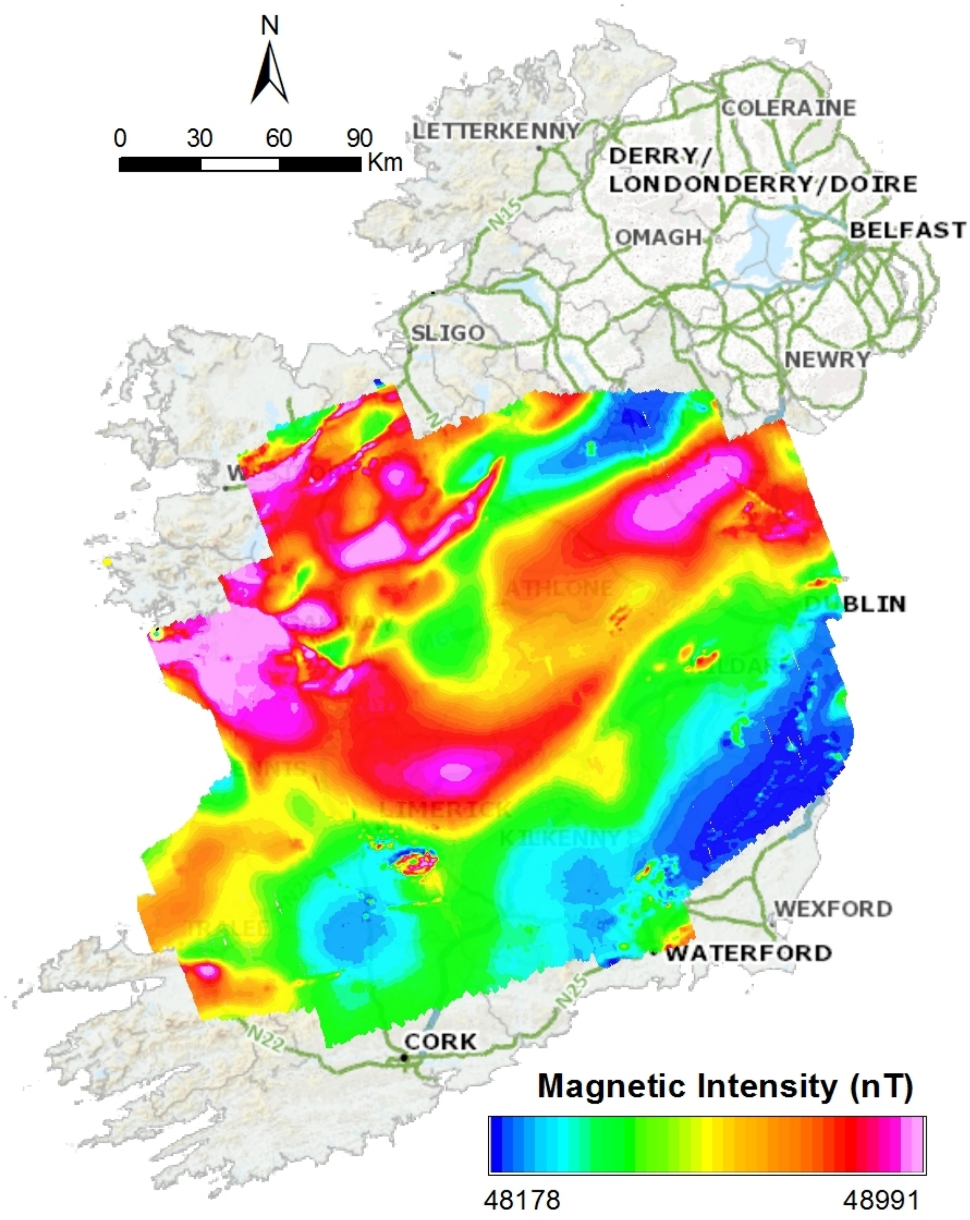


Figure 2: Merge Total Magnetic Field from Hunting survey merged data

Appendix A: Original Hunting Report

DEPARTMENT OF INDUSTRY AND ENERGY

GEOLOGICAL SURVEY OF IRELAND

REPORT ON AN AEROMAGNETIC SURVEY

OF

PART OF THE REPUBLIC OF IRELAND

HUNTING GEOLOGY AND GEOPHYSICS LIMITED,
Elstree Way,
Borehamwood, Hertfordshire,
England.
Telephone : London (01) 953 6161
Telex : 23517 HUNBOR G

April 1982

ABSTRACT

This report describes the results of an aeromagnetic survey covering most of the Republic of Ireland. The survey was flown in three phases during the period August 1979 to September 1981.

The acquisition, compilation and interpretation of the aeromagnetic data were undertaken by Hunting Geology and Geophysics Limited under contract to the Department of Industry and Energy, on behalf of the Geological Survey of Ireland.

The report represents an integration and review of the interim reports that were submitted to the Geological Survey by Hunting at the completion of each of the three phases.

The extent of the survey area was agreed under contract between the Geological Survey and the European Economic Community. Funding was provided jointly by the EEC under Contract No. 073-79-7 MMP EIR and the Department of Industry and Energy, Dublin.

The magnetic data show features which are considered relevant to mineral exploration and enhance the general geological knowledge of the area. The following major conclusions have been drawn from the interpretation of the magnetic data:-

The data have delineated a variety of magnetic sources, which exist in differing geological environments within the survey area. Shallow magnetic zones have been ascribed to two principal sources: intrasedimentary rocks, mostly igneous, of varying ages within the sedimentary sequence; and shallow basement zones, again generally associated with igneous rocks. Deep magnetic zones, represented by long-wavelength anomalies, are also attributed to two principal sources: differentiated blocks of magnetic basement or uplifted basement; and large-scale intrasedimentary structures (sills?) thought to lie close to the magnetic basement.

Shallow intrasedimentary magnetic zones over deep magnetic basement are widespread in the northeast, south and southeast of the area. Whereas the shallow basement areas occur in the eastern area over the Leinster Granite, in the main, the shallow basement and deep intrasedimentary zones are restricted to the northwestern area, namely, Strokestown, the Ox Mountain Anticline, the Galway Granite and the Curlew Mountain Pericline.

The magnetic basement in the northeast and south of the survey area is dominated by large basement blocks and is thought to be at a general depth of 7 kilometres below mean sea level in the northeast, and 5 kilometres in the south. Elsewhere, it exhibits a variable depth with numerous basement ridges and troughs, particularly to the southwest and towards the Galway Granite. Hypothetical north-south striking contacts in the southeast seem to form an important structural feature as various ridges and troughs west of the line terminate against it; the area east of this line appears to be down faulted.

Several previously unknown dykes (Tertiary ?) have been delineated in the northeastern part of the area. Other dykes in the south are thought to be unrelated to Tertiary igneous activity. Carboniferous volcanism is particularly evident in the south of the area and the Limerick Volcanics are very well defined.

The Galway Granite in the west of the survey area is distinctive and can be divided magnetically into a number of compartments, dominated by two large zones. The northeastern edge of the Galway Granite is abruptly truncated, whereas the other margins are more diffuse. The magnetic igneous rocks associated with the Ox Mountain Anticline and the Curlew Mountain Pericline are well defined and more extensive than their mapped outline. The Strokestown anomaly is thought to be related to a basement swell which also marks a major change in the character of the basement.

The Leinster Granite is well marked by magnetic anomalies associated with the contact aureole zone. In spite of the Leinster Granite being non-magnetic (compared to the Galway Granite), it is possible to split it into two major zones: the northernmost appearing to be relatively inhomogeneous compared to the zone to the south. The eastern margin of the Leinster Granite appears to exhibit more northwest-southeast faults than the western margin.

Several low-amplitude linear anomalous zones correlate with known anticlinal structures and may have acted to control the flow of mineralisation fluids. The mineral deposit at Navan correlates with the nose of an east-west trending positive anomaly of igneous origin, though local faulting may be more important in the control of mineralisation. The magnetic expression of faulting, spatially related to the Tynagh and Silvermines deposits, is marked and more extensive than indicated from geological mapping. Evidence for east northeasterly and north northwesterly cross faulting is widespread, particularly in the south and east of the area. The Gortdrum deposit is spatially related to faulting and igneous activity. Other major recent lead-zinc occurrences, such as Moate, Keel and Haberton Bridge have interesting correlations with the magnetic data, the significance of which has yet to be fully understood.

The magnetic results endorse Murphy's gravity results (1952) in that they indicate the presence of the Leinster Granite under the Lower Palaeozoic sediments well beyond the mapped boundaries, particularly in the west and northwest of the batholith.

Suitable target areas have been established, and recommendations for future work have been included.

CONTENTS

PART 1 - INTERPRETATION REPORT

APPENDICES

PART I - LIST OF TEXT FIGURES

PART I

INTERPRETATION REPORT

1. INTRODUCTION

This report describes an airborne magnetometer survey of the eastern, central and western parts of the Republic of Ireland, flown in three phases: between August and December 1979, between April and August 1980, and during September 1981. Figure 1 shows the extent of the survey which extends over four blocks, namely Areas IV, VA,VB and VC.

The first survey (1979) covered approximately 18 000 square kilometres (18 542 l.km) between 53°N and the Northern Ireland border and from the east coast to a line east of Ballinasloe. In 1980, coverage was extended westward to the Arran Island of Inishmore, north to Sligo Bay, south to Killarney and extends eastward, south of the Northern Ireland border towards Carrick-on-Suir and covered approximately 23 000 square kilometres (23 748 l.km). In 1981, the survey was continued towards the southeast coast of Ireland, covering approximately 8 000 square kilometres (6 700 l. km). Thus the total area covered under this project is approximately 49 000 square kilometres (48 990 l.km).

The objectives of the survey were to outline variations in the crystalline basement and sedimentary cover, to improve knowledge of the regional geological structure and to locate areas of potential mineralisation. The survey was undertaken by Hunting Geology and Geophysics Limited under contract to the Department of Industry and Energy on behalf of the Geological Survey of Ireland.

The statistics of the flight patterns are listed in Tables 1 and 2.

TABLE 1 FLIGHT PATTERN STATISTICS (Area IV)

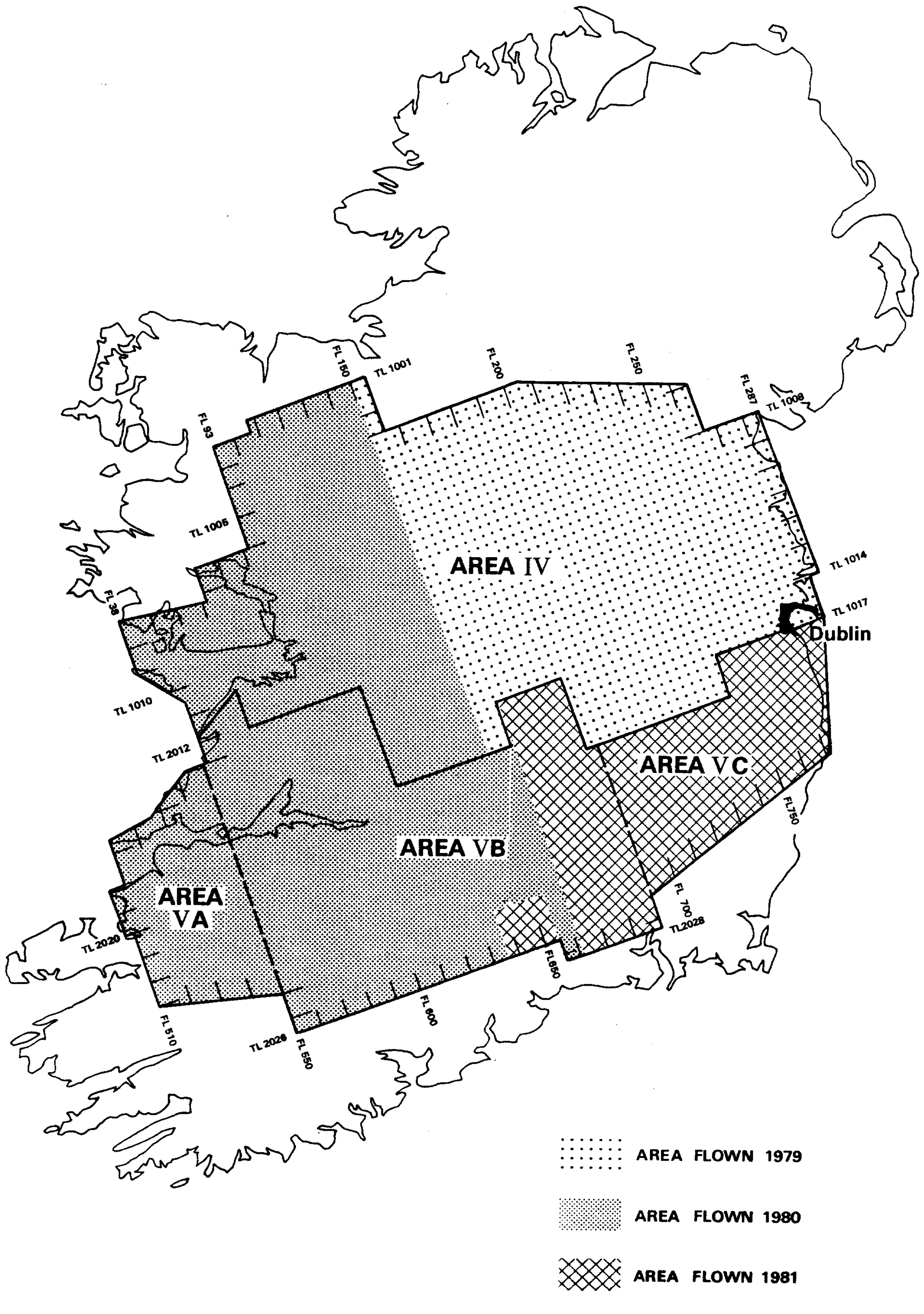
Flight line direction	-	N20°W (True)
Tie line direction	-	N70°E (True)
Line spacing	-	1 kilometre
Tie line spacing	-	10 kilometres
Flying height	-	450 metres above mean sea level (constant barometric)

TABLE 2 FLIGHT PATTERN STATISTICS (Area V)

Flight line direction	-	N20°W (True)
Tie line direction	-	N70°E (True)
Line spacing	-	1 kilometre, Area VB 2 kilometres, Areas VA and VC
Tie line spacing	-	10 kilometres
Flying height	-	200 metres mean terrain clearance.

This report outlines the geology of the areas flown and describes the aeromagnetic data and their interpretation. The flying operations, data acquisition and compilation procedures are described in Part II, the Operations Report.

Location Map and Flight Pattern



2. REGIONAL GEOLOGY

A generalised geological summary of the total survey area is presented here with particular reference to the distribution of magnetic and non-magnetic rocks (Figure 2). For more details, reference should be made to the bibliography (Section 9). Summaries on the geology will also be found in Charlesworth (1963) and more recently, Holland (1981).

2.1 Stratigraphy

2.1.1 Cambrian

The Cambrian is found in three separate areas within Ireland: Howth, just north of Dublin Bay; north of Wicklow to Bray; and a long strip extending southwestwards from Cahore Point to the southcoast of County Wexford.

At Howth, the massive quartzites and greywackes with breccias and well-cleaved slates are minutely folded and crushed. The closely packed anticlines and synclines plunge steeply east or northeast and were later affected by longitudinal and transverse faults.

In the southeast (County Wexford and Wicklow) the Cambrian comprises a succession of greywackes, slates, quartzites and conglomerates attaining a thickness of several thousand feet. Contemporaneous igneous rocks are unknown.

2.1.2 Ordovician-Silurian

The Ordovician and Silurian rocks consist mainly of slates and greywackes, with thin limestones and cherts, which occur as nodules or as continuous bands often with a strong development of contemporaneous volcanic rocks.

These beds were deposited on the floor of a geosynclinal basin orientated in the Caledonoid direction. The southern shore lay off the southeast corner of Ireland, while the northern shore lay roughly along the south side of the Dalradian outcrop in N.W. Ireland.

In general the Silurian occupies a broad central belt which crosses the country diagonally from northeast to southwest. On either flank is the Ordovician, broad to the southeast and narrow to the northwest.

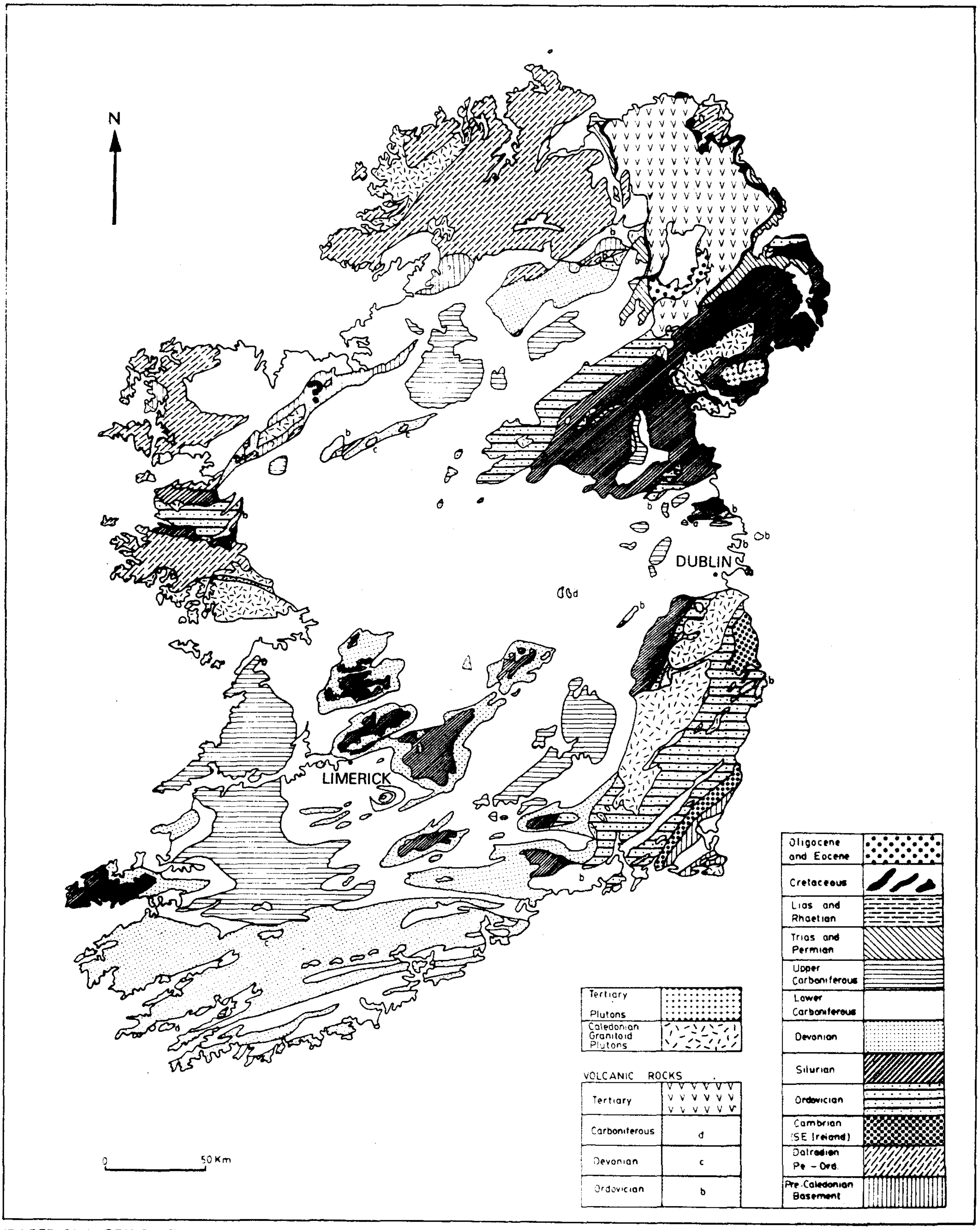
Outcrops of Ordovician-Silurian rocks fall into the four following geological regions (1) Leinster, (2) Central Inliers, (3) 'Southern Uplands' (Longford Down Massif), (4) N.W. Ireland (Cos. Leitrim and Fermanagh).

Igneous activity was widespread during the Ordovician period. Volcanic rocks are predominantly sub-aqueous and range from andesite to rhyolite, with a notable development of spilites. The spilites, which typify early subsidence of many geosynclines, were followed in later Ordovician times by more acid magma. The igneous activity began in the western margins, (near Charlestown for example) and later moved eastward to Meath, Dublin and Kildare (Mitchell, 1957).

2.1.3 Devonian

Due to widespread tectonic activity associated with the Caledonian Orogeny, the Old Red Sandstone overlies the Ordovician and Silurian unconformably. The strata comprise grits and fine-grained sandstones, frequently conglomeratic, with some flaggy and micaceous sandstones and red shales.

Generalised Geological Map of Ireland



(BASED ON WORK OF THE GEOLOGICAL SURVEY OF IRELAND 3rd EDITION 1962)

Subaerial volcanoes were active along the borders of the Old Red Sandstone region. The lavas, chiefly andesites, occur in the Curlew Mountains. Important outcrops of acid to intermediate volcanic rocks, probably Devonian, occur at Loch Guitane near Killarney and at several other localities.

2.1.4 Carboniferous

The Carboniferous rocks underlie approximately two thirds of the country. The Lower Carboniferous, mostly limestone, floors a vast expanse in the Central Plain, broken locally by inliers of older rocks. The Carboniferous rocks overstep the basement and overlap each other in ascending sequence. During the Carboniferous period, the Leinster and Longford-Down massifs acted as relative highs, with the main sedimentation occurring in the surrounding troughs.

The limestones are in part characterised by massive reefs, which extend over 3 000 square miles from West Kerry and Clare to Waterford and Kilkenny in the east and intermittently in Dublin, Westmeath and Longford.

Upper Carboniferous rocks occur in Meath, northeast of Dublin, in the Kingscourt Outlier, and extensively in the N. Kerry-Clare Basin. Generally, this sequence is a regressional facies. These beds comprise a variable group of shales, sandstones, massive grits and occasionally conglomerates.

Surface mapping which began in 1960 over four basins in the Carboniferous, led to a series of seismic surveys and nine bore holes as part of an investigation for hydrocarbons and mineralisation in the Carboniferous strata of Ireland (Sheridan, 1977). The four basins investigated were:-

(a) The Central Basin

(b) The Southeast Basin

(c) The Southwest Basin

(d) The Northwest Basin

(a) Central Basin

The Central Basin, located in east-central Ireland, is approximately 2 100 square miles in areal extent. "The Carboniferous strata are bounded on the north by the Lower Palaeozoic Longford-Down massif, on the southeast by the granitic Palaeozoic complex of the Leinster Mountains, on the south by the Lower Palaeozoics of the Chair of Kildare, and to the southwest by Slieve Bloom with its core of Lower Palaeozoic strata. The basin is open to the west where it merges with the widespread, but depositionally thin, Carboniferous outcrop of Co. Galway. Thus the western limits of the Central Basin are arbitrary."

"The basinal area as defined contains several Caledonoid northeast-southwest orientated folds and associated downwarps. The most prominent swell is in the vicinity of Sion Hill, Co. Westmeath, ten miles east of Mullingar, where the entire

Lower Carboniferous section is breached. Gravity measurements suggest that several of the anticlinal trends may be associated with major regional "basement" controlled faults."

(b) Southeast Basin

"The Southeast Basin has an area of about 1 300 square miles. To the north it is bounded by the Chair of Kildare, to the east by the Leinster Mountains, to the south by the Variscan Thrust complex and to the west by Slieve Bloom.

The basin contains three major structural depressions in which rocks from Namurian to Coal Measures in age have been preserved: the asymmetric Slieve Ardagh syncline; the Durrow syncline; and the saucer-shaped Castlecomer coalfield area. These depressions essentially surround the Lower Carboniferous strata of the Freshford inlier. To the east the basin appears homoclinal, with regular west dip off the Leinster Mountains. A northeasterly caledonoid orientation predominates in the basin, modified in the central and eastern parts by a nearly north-south alignment. Small structural closures on narrow anticlinal trends are numerous in the Slieve Ardagh and Castlecomer coalfield areas. Some of these may result from the compression of the younger, less competent beds and the structural style may not be representative of deformation in the underlying Lower Carboniferous. Gravity studies suggest that much of the Southeast Basin overlies a southwesterly extension of the Leinster granite."

(c) Southwest Basin

"The Southwest Basin, the largest of the original onshore prospective areas, is some 4 300 square miles. It is bounded to the north by the granite/Lower Palaeozoic complex of the Galway shelf area, to the east by a succession of anticlinal and topographic highs. (Slieve Aughty, Slieve Bernagh, the Galty Mountains, etc), all with Lower Palaeozoic cores, and to the south by the Variscan thrust front. The western boundary is open to the Atlantic. Much of the basinal area is covered by Namurian beds, with some true Coal Measures preserved in structural lows (Nevill, 1958b, 1961)."

As in the Central Basin, mapping establishes that anticlinal flexures do not rim the "basin" margins. Parallel or en-echeolon folds, with an east to slightly northeast orientation, plunge off the deeply breached anticlinoriums which form the eastern margin of the basin. There is no single large structurally depressed area; equally deep synclines appear to complement the anticlinal traces. However, seismic data suggest an axial deep, south of the River Shannon, between Athea and Abbeyfeale, with a probable minimum thickness of 12 000 feet of Carboniferous strata.

(d) Northwest Basin

The Northwest Basin, some 3 600 square miles in area is composed of a series of structural downwarps, often fault bounded, in which Lower Carboniferous deposits may reach a cumulative thickness of 9 400 feet. Drilling for hydrocarbons took place in the Lough Allen Basin, the Slieve Rushen downwarp and the Slieve Beagh Syncline.

Lough Allen Basin

The Lough Allen Basin is a major structural depression largely covered by Namurian sediments, lying between the metamorphic complex of the Ox Mountains to the northwest and the Lower Devonian inlier of the Curlew Mountains to the southeast. The Namurian and Upper Visean rocks in the central parts of the Lough Allen Basin are generally deformed by a series of low-dipping, generally northwest/southeast folds, essentially normal to the Caledonoid northeast/southwest grain of this part of Ireland.

Igneous Activity

Contemporaneous lavas, frequently slaggy and amygdaloidal or columnar, occur sporadically in the Carboniferous strata. They are interstratified with Lower Carboniferous rocks. Around Croghan Hill is a vent of tuff and ash with intrusions of basalt.

Carboniferous igneous rocks occur near Limerick, Pallas Green and Herbertstown, and they extend into County Tipperary and produce a gravity high (Murphy, 1960). In County Limerick the eruptions took place in two stages. The earlier phase yielded a graded series of trachytes, trachyandesites, trachy-basalts and olivine-basalts in the form of lavas, ashes and sills which were focussed on numerous vents, of which Derk Hill and Kilteely Hill are the most notable. The later eruptions (lavas, tuffs, vent agglomerates) and sills show greater differentiation; the flows include analcite-bearing basalts and glassy picrite-basalts which form Pallas Hill. The lavas generally give rise to steep escarpments with more gentle inwardly inclined dip slopes; the effects of numerous cross faults are easily discerned. Igneous rocks of Lower Carboniferous age occur also in separate localities still further south: in the Carboniferous Slate on Bear Island at Black Ball Head (intrusive tuff), Bantry Bay, north of Bandon (olivine-dolerite), and in County Cork where basaltic ash is interstratified with the Carboniferous Limestone at Subulter Hill, northwest of Mallow.

2.1.5 Permo-Trias

In this period there was considerable erosion, consequently the Permo-Trias is sèparated from the Carboniferous rocks by a major unconformity. The Permo-Trias occurs in the Kingscourt Outlier and contains continental rocks (sandstones, shales, conglomerates and grits) which attain a few thousand feet. None of these formations occur in the south of the country.

2.1.6 Tertiary Igneous Activity

Northeast Ireland was subject to an extensive outburst of Tertiary volcanic activity of alkaline type. The basaltic lavas are most common in County Antrim, but are thought to have spread over the Longford Down massif of Counties Armagh and Down. Apart from the lava outcrop in the Kingscourt Outlier, Tertiary lavas have not been found in the Central Plain.

Tertiary dykes are especially abundant over the northern half of Ireland, from Dundalk to County Sligo, but they may occur further south also. The dykes trend dominantly northwesterly, but a northeasterly direction is also present. The dykes range in width from a few centimetres to many metres and average about 3 metres. Widths of 10 or more metres are unusual.

2.1.7 Quaternary

The whole of Ireland, with the possible exception of the highest mountains in the southwest of the island, has been covered by an ice sheet at least once in the past 3 million years. Drift deposits cover much of the Central Plain, allowing relatively few outcrops of the underlying older rocks. Blanket and basin peat have developed over large areas of glacial-till since the end of the Ice Age.

2.2 Tectonic Setting

2.2.1 Pre-Caledonian Cycles

With the exception of a small area in the southeast, and possibly of other less confidently dated areas in the west, such as the Ox Mountains and north County Mayo, all the Lower Palaeozoic and exposed Precambrian rocks in Ireland were formed during the Caledonian 'cycle'. The Irish Caledonides have been divided into (1) a northwestern orthotectonic belt, principally composed of late Precambrian and Cambrian sediments and volcanics (Moine and Dalradian) that have been intensely deformed and metamorphosed, probably during the Ordovician, and (2) a paratectonic belt to the southeast which consists of Cambrian to Silurian sedimentary and volcanic rocks that have been deformed but not metamorphosed to any marked degree. The change in the Pre-Caledonian basement is thought to occur in the region of the Navan-Silvermines fault.

2.2.2 The Caledonian Orogeny

The Caledonian Orogeny consisted of a series of earth-movements which lasted from Ordovician to Devonian times. The Lower Palaeozoic sediments and their associated volcanic rocks were tightly folded and intruded by granitic masses. As a consequence the beds are now dipping steeply throughout the country, with fold axes trending northeast-southwest.

Metamorphism occurred generally throughout the region with argillaceous rocks developing a well-formed slaty cleavage.

The close fault network in outcrops range in age from Caledonian to Alpine and it is thus difficult to differentiate them. However, two major faults existed later in the orogenic cycle; the'Highland Boundary Fault' and 'Southern Uplands Fault'.

2.2.3 The Armorican Orogeny

The Armorican (Hercynian) orogeny strongly affected rocks in the southern part of the country. In the northern part of the country the Armorican folds are slewed around into the Caledonian direction. The folding was more intense in the southern part of the country with the Old Red Sandstone and Carboniferous buckled into anticlines and synclines arranged en echelon and trending eastnortheast - westsouthwest. In the Central Plain the folding has exposed older Lower Palaeozoic rocks as inliers in the Carboniferous cover.

Faulting was important in this period, trending generally northeastwards or east northeastwards.

2.2.4 The Alpine Orogeny

The Alpine earth movements, folding and fracturing, can be seen in Northern Ireland, but are not evident in the south, although Armorican folds may have been steepened and faults reactivated along pre-existing fracture lines.

2.3 Mineral Deposits

The most important mineral deposits in the survey area occur in the Lower Carboniferous, with the lower stages (Courceyan, Chadian and Arundian) being the most important hosts for the copper-lead-zinc mineralisation. These deposits include Abbeytown, Aherlow, Ballinalack, Ballyvergin, Carrickittle, Gortdrum, Keel, Mallow, Navan, Pallas Kenry, Silvermines and Tynagh.

In addition to these Lower Carboniferous deposits are the sulphide ores of Avoca which are possibly related to the Ordovician volcanics.

Sevastopulo (1979) has stated that at Navan the lead-zinc mineralisation occurs within late Courceyan limestones and is concentrated between two converging faults: fault A, a northeast-trending high-angle reverse fault, and fault B, which has normal displacement and trends east-west. Thin red beds, which overlie Lower Palaeozoics, pass upwards into laminated sandstones and siltstones, overlain by argillaceous bioclastic limestones. The overlying 'Pale Beds', which form the host to the sulphides, consist of variably sandy bioclastic limestones and oolites, with a well marked unit of micrites near their base. Higher limestones are generally shaly, and are overlain by mudbank limestones.

The Keel zinc-cadmium-lead deposit occurs on the southern down-thrown side of an eastnortheast - trending normal fault within basal clastics, marine sandstones, mudstones and carbonates, overlain by limestones and shales and Waulsortian bank limestone. The bulk of the mineralisation is confined to Courceyan strata, which is partly dolomitized and much of it is clearly associated with faulting.

At Ballinalack, the lead-zinc mineralisation occurs mainly in the mudbank limestones, with smaller amounts in the lower part of the sequence on the western side of a northnortheast -trending fault.

The Abbeytown deposit near Ballisadare, County Sligo consists of sphalerite, galena and pyrite, which occur as high grade replacement bands, disseminations, and in breccias in faulted limestones close to the base of the Carboniferous. Recent exploration drilling in west-central County Kildare has encountered widespread lead-zinc mineralisation in fractured, clean, fine-grained shelf limestones.

The Gortdrum, Ahelow, Mallow and Ballyvergin copper deposits occur in limestones and shales of Courceyan 1, 2 and early Courceyan 3 but mineralisation is likely to be much younger. Each of the deposits is spatially related to a structure of probable Hercynian age. At Aherlow the sulphides occur in a steeply dipping zone, clearly discordant with the host limestone and shales.

At Gortdrum, altered dykes, probably related to post-Courceyan volcanism, are mineralised. The stratigraphy of the Courceyan host rocks in each of the deposits appears to be quite normal. The occurrence of igneous rocks at Gortdrum is judged to be incidental to the origin of the ore, but the presence of a large massive intrusive plug may have promoted the formation of open fractures in the surrounding limestones and shales during deformation.

A common factor to these deposits, with the exception of Ballyvergin, is their position just to the north of the Devonian Munster Basin.

In contrast to the copper deposits, the evidence shows that some of the lead-zinc mineralisation appears to be broadly comparable in age to their host rocks.

In the Silvermines district, a number of zinc-lead deposits with differing styles of mineralisation and differing host rocks have been mined, or are known from drilling. They all lie within, or adjacent to, the major eastnortheast-trending complex Silvermines Fault Zone, which has the net effect of juxtaposing the Silurian and Old Red Sandstone rocks of the Silvermines Mountains and the limestones of the valley to the north.

There are several unusual features of the stratigraphy and geological setting of the Silvermines deposits that may be linked directly or indirectly with mineralisation.

(1) The Silvermines succession (Old Red Sandstone and sub-Waulsortian limestone) is abnormally thin and the usually pure middle Courceyan 3 limestone is dolomitized.

(2) The Waulsortian limestones and equivalent strata are also abnormally thin in the mineralised area; they thicken generally northward away from the fault complex. In at least one case the thickness is strongly influenced by a north-west-trending fault. (Taylor S. and Andrews C.J., Silvermines orebodies, County Tipperary, Ireland. Trans. Inst. Min. Metall.(Sect. B; Appl. Earth Sci.) 8 7, 1978, 1311-24).

(3) The Silvermines district coincides with a gravity low (T. Murphy, 1974).

The Tynagh primary deposit consists mainly of galena and sphaelerite in Waulsortian mudbank limestones of Courceyan 4 age, which are preseved on the north side of the Tynagh fault.

Unusual features of the Tynagh deposit within the mine stratigraphy involve the Waulsortian limestone and its equivalents. The true Waulsortian facies limestones, the main host to the mineralisation, occur only close to the fault.

Correlations between the mineral occurrences and the magnetics are given in Section 5.6.

Three features are common to most of the deposits:

(a) They lie close to the shelf-basin margins

(b) They lie within Lower Carboniferous rock (Courceyan to Arundian in age)

(c) A spatial association of mineralisation and faulting is exhibited.

The sulphide ores at Avoca, Co. Wicklow occur in a series of lenticular lenses in the Ordovician rocks. The ore bodies extend conformably along the strike for about 5.5 km and dip 50° - 55° southeast. Actual limits of the lenses are ill defined and are echeloned by north - south cross faults, with shifts of several hundred feet. The dominant mineralisation of iron pyrites is accompanied byzinc blende, galena, chalcopyrite and bornite.

3. MAGNETIC INTERPRETATION METHODS

3.1 Theory

The magnetic method of geophysical prospecting depends on the presence of varying amounts of magnetic minerals (mainly disseminated magnetite) which can occur in different rocks.

The magnetisation of such rocks is caused by induction in the Earth's field and partly by residual (remanent) magnetism. Induced magnetisation has the same direction as the inducing magnetic field of the Earth and depends primarily upon the magnetic susceptibility of rocks. Remanent magnetisation is independent of the strength and direction of the present day Earth's field and represents a permanent magnetisation of rocks acquired during an earlier geological period. Consequently the induced and remanent components of magnetisation are not necessarily similar in either magnitude or direction. They combine vectorially with the Earth's field to produce a resultant total magnetic field intensity; it is the scalar magnitude of this parameter that is measured during magnetic surveys by total field magnetometers. Anomalies are observed where there are magnetic susceptibility contrasts or variations in the direction of magnetisation. Therefore in an area where there are no magnetic anomalies, either the magnetic susceptibility of the region is negligible or the magnetic susceptibility and magnetisation direction are effectively constant.

The shape and magnitude of a magnetic anomaly caused by a magnetic body depends upon:

(a) The inclination and intensity of the Earth's magnetic field.

(b) Shape and size, and orientation of the body in the Earth's field.

(c) The magnetic susceptibility contrast between the body and the adjacent rocks.

(d) The magnitude and direction of any remanent magnetisation.

(e) The distance between the body and the magnetometer; that is, the depth of burial plus the flying height of the aircraft.

Usually the induced component of the field is stronger than the remanent component. Sometimes the reverse is true so the anomaly shape depends on the direction and magnitude of remanent magnetisation.

A theoretical magnetic anomaly can be computed when the shape, depth and orientation of the body are known as well as the magnetic vector, susceptibility contrast and the inclination of the Earth's field. In this case the solution is unique. However for the inverse problem, for a given magnetic anomaly there corresponds, theoretically, an infinite number of solutions as to the size, shape and depth of burial of the body. Thus, the interpretation of magnetic anomalies depends largely on comparisons with theoretical anomalies which can be calculated for relatively simple geometrical models together with some prior knowledge of the geology. The latter is needed in order that the simple models chosen may approximate to known or likely geological bodies and structures. (Figures 3 and 4).

In Ireland the approximate parameters of the Earth's magnetic field are:

Total intensity	-	48 000 - 48 500 nT
Inclination	-	69° North
Declination	-	11° West

3.2 Susceptibility Measurements

Magnetic susceptibility values have been collected and collated (P. Morris, 1973). Appendix 1 gives the ranges of the susceptibility values for different rock types in Ireland.

3.3 Qualitative Interpretation

Qualitative interpretation is based on the principle that certain rock types contain differing amounts of the various magnetic minerals. Some sediments and granites will contain less magnetic materials than basic igneous or metamorphoric rocks. In most cases, rock types can be differentiated from each other by their magnetic signature, provided there is a susceptibility contrast between them. However, care must be taken, as for instance, some granites can be more magnetic than the basement in which they may be situated. Dykes can produce elongated anomalies which may reach several tens of kilometres in length.

The principal structural elements identified qualitatively are faults and other contacts between zones with different magnetic characteristics. The presence of faults, both of the normal and tear type, may be indicated by the disturbance of a group of anomalies. It is sometimes possible to derive the direction and amplitude of the throw on a fault by an analysis of the associated anomaly or anomalies.

Magnetic zones are distinguished on the basis of a number of characteristics which include amplitude, the frequency of anomalies within a zone, degree of linearity and local variation in the amplitude and polarity response. The above characteristics may represent definite geological units; for example a metasedimentary unit may display an open, relatively featureless intensity pattern and variable anomaly orientation, whereas volcanic units may show high amplitude circular anomalies.

Contacts between magnetic zones may be abrupt due to faulting or marked compositional changes, or gradual due to minor facies variations. Often contacts can be recognised because of a change of anomaly strike direction at the boundary between adjacent areas.

3.4 Quantitative Interpretation

The aim of the quantitative interpretation is to determine from observed magnetic anomalies the shapes, dimensions, susceptibilities and depths to the tops of the causative magnetic bodies. Depth estimates may be used to find the depths to an intrasedimentary horizon (e.g. volcanics) or, more commonly, to the crystalline basement. If depth estimates aim to define the top of the basement, and if rock of strong susceptibility contrast is intruded into the basement without reaching the top of it, then the calculations will give the depth of this body and not the depth to the top of the basement.

When such intrusions penetrate through the top of the basement, two cases arise:

(i) the basement is deep, and magnetic sediments or basic intrusions within the sediments are at significantly different levels. Two series of depth estimates can be obtained, one with scattered shallow values corresponding to magnetisation contrasts within the sediments whilst the other, with more homogeneous deeper values, can be attributed without major error to the basement; or

(ii) the basement is shallow, and it is more difficult to distinguish basement anomalies from those associated with magnetic rocks between the basement and the ground surface. However, the distinction can be made, provided that certain characteristic structures, identifiable from the magnetics and in agreement with existing information, can be considered to be unique to the basement.

When the magnetic record is flat, it can be deduced that either the basement is sufficiently deep not to affect the magnetometer or that it is homogeneous and lies at an undetermined depth.

Regional geological information, and the experience gained from the study of similar problems, often allow doubts to be removed or a choice to be made from several alternatives arising from the calculations.

To summarise, it must be remembered that the magnetic surface interpreted from aeromagnetic data may not always conform with the surface of the crystalline basement rocks. Magnetic basement is not necessarily synonymous with economic or seismic basement for instance.

It is also convenient to define three categories of anomaly, based on whether the position of the causative magnetisation contrast is within, at, or above basement surface (c.f. Steenland, 1965; Sheriff 1973). Intrabasement anomalies are caused by magnetisation contrasts wholly within the basement, and of vertical dimensions greater than the depth to basement. Suprabasement anomalies are caused by magnetisation contrasts at or near basement surface and of vertical dimensions substantially less than the depth of the basement surface, (e.g. basement step).

Intrasedimentary anomalies are caused by magnetisation contrasts above the basement surface and of vertical dimensions substantially less than the depth of the basement.

3.4.1 Depth Estimates

Straight Slope Estimates

This method uses the horizontal length of the straight part of an anomaly flank (at the inflection point) as a depth index. For anomalies of amplitude greater than a few tens of nT (gammas) and where the straight slope occupies about half of the total amplitude, the straight slope length is divided by 1.1; the model assumed in this case is the bottomless prism (Vacquier et al, 1951). Alternatively, for anomalies of a few tens of nT (gammas) or less, the index length is divided by 0.7; the model implicit in this case being a depth-limited prism or plate (Steenland, 1965).

Peters' Half-Slope Method

This method (Peters, 1949) uses the horizontal distance between the points, situated either side on an inflection, at which the slope of the anomaly curve is one half of the maximum slope at the point of inflection. For depth of burial this distance is commonly divided by 1.2 to 2.0 according to whether the anomaly represents a narrow or broad body.

Bean's Method

The method due to Bean (1966) uses both limbs of an anomaly and yields measurements of inclination of magnetisation, and susceptibility in addition to estimated depth. Essentially the depth determination is a sophisticated Peters' method whereby a more appropriate Peters' factor is computed for each anomaly. It is accurate, rapid to use, and can also be used on incompletely defined anomalies.

Modified Peters' Method

This method uses the half-maximum-slope separations on both major limbs of asymmetric anomalies in addition to the ratio of the gradients of the two slopes.

Koulomzine Method (1972)

This method is applicable to a dipping two-dimensional dyke of infinite extent, and when fully utilised gives two independent estimates of depth, width and dip and the lateral position of the centre. This method requires considerable redrawing and so is slow. However, it gives a quick method of determining the zero level of the anomaly and this can be invaluable prior to application of a quicker depth method. The full method determines symmetric and asymmetric anomaly components. The procedure is involved but accurate (if applied to the correct anomaly); and as depth methods specific to symmetric and asymmetric anomalies are then used, the resultant estimates are more reliable.

Inflection Tangent Intersection Method

This method was outlined by Naudy (1965). Hunting have developed it by means of computer programs that generated model anomalies and then analysed the various depth-dependent horizontal and vertical parameters. These were then plotted as master curves, normalised both in depth and magnetisation units. The critical horizontal and vertical parameters are measured on each observed anomaly and the resulting set of values is compared with the master curves until a fit is observed between the two, when the estimated depth can be read directly from the master curves.

Moo (1965)

This method considers horizontal distances between critical points such as maxima, minima, points of inflection, half slopes, tangents of slopes at inflection points and presents three depth-estimation methods.

One depends on the half-slope method; the second uses the distance between the maximum and minimum of the anomaly curve; the third method is based on the measurement of the horizontal distance from the anomaly maximum to the inflection point on the north flank.

Am (1972)

This method uses the half-slopes, inflection points, maxima and minima to derive indices for depth estimation. This method is similar to Bean's, but can be used on one flank of the anomaly if the other is severely disturbed.

50 - 75 Method

This method uses the half-slopes and three-quarters-slopes in much the same way as Bean's method to gain a depth estimation.

The above methods are primarily two dimensional (i.e. the anomaly length in plan is about five times greater than the width). Three-dimensional anomalies were generally interpreted by the straight slope method applied to several limbs, or by comparison with model curves.

All depth estimates have been related to sea level, and defined as being negative if below sea level and positive above. Magnetic intensities are quoted in either gamma (1 gamma = 10^{-5} Oersted) or in nanoTesla, nT (1nT = 10^{-9} weber metres $^{-2}$). Gamma and nanoTesla are numerically equivalent.

3.5 Horizontal and Vertical Gradients

The production by computer of horizontal and vertical gradients from total magnetic field data provides a powerful interpretive aid. The horizontal gradient can be described as the variation of the magnetic field with respect to the horizontal distance travelled i.e. dT/dx. The vertical gradient can be described as the variaton of the magnetic field with respect to height above the ground, i.e. dT/dh. In airborne surveys the horizontal and vertical gradients are expressed in terms of gammas or nanoTeslas per sampling interval. These can be converted to gammas per metre by dividing the distance covered in one fiducial interval (approximately 50 - 60 m).

Vertical gradients are more responsive to local shallow influences than broad or regional effects. The smaller anomalies are more readily apparent in an area of strong regional disturbances. In high magnetic latitudes the vertical gradient can be used to locate the edges of steeply dipping geologic contacts and may also be used to obtain estimates to the top of shallow magnetic sources (Hood, 1965), (Hood and McClure 1965), (Hood 1979).

The horizontal gradient is useful in determining with great accuracy the inflection points, half-slopes and three-quarters-slopes of an anomaly, caused by deep or shallow sources. Any regional gradients inherent in an anomaly may be easily and quickly subtracted. Thus, horizontal gradients are useful in obtaining accurate and rapid depth estimates from a magnetic anomaly.

Figure 5 gives horizontal and vertical gradient responses over a typical model.

3.6 Interpretation Procedure

The interpretation presented in this report results from the analysis of the following data:

(a) the total intensity contour maps at 1:63,360 scale;

(b) Calcomp (computer plotted) profiles of the corrected magnetic intensity and horizontal and vertical gradient data at the same scale;

(c) profiles constructed from the contour maps;

(d) the analogue records.

The interpretation procedure comprised the following stages:

(i) A review of the existing geological and geophysical data.

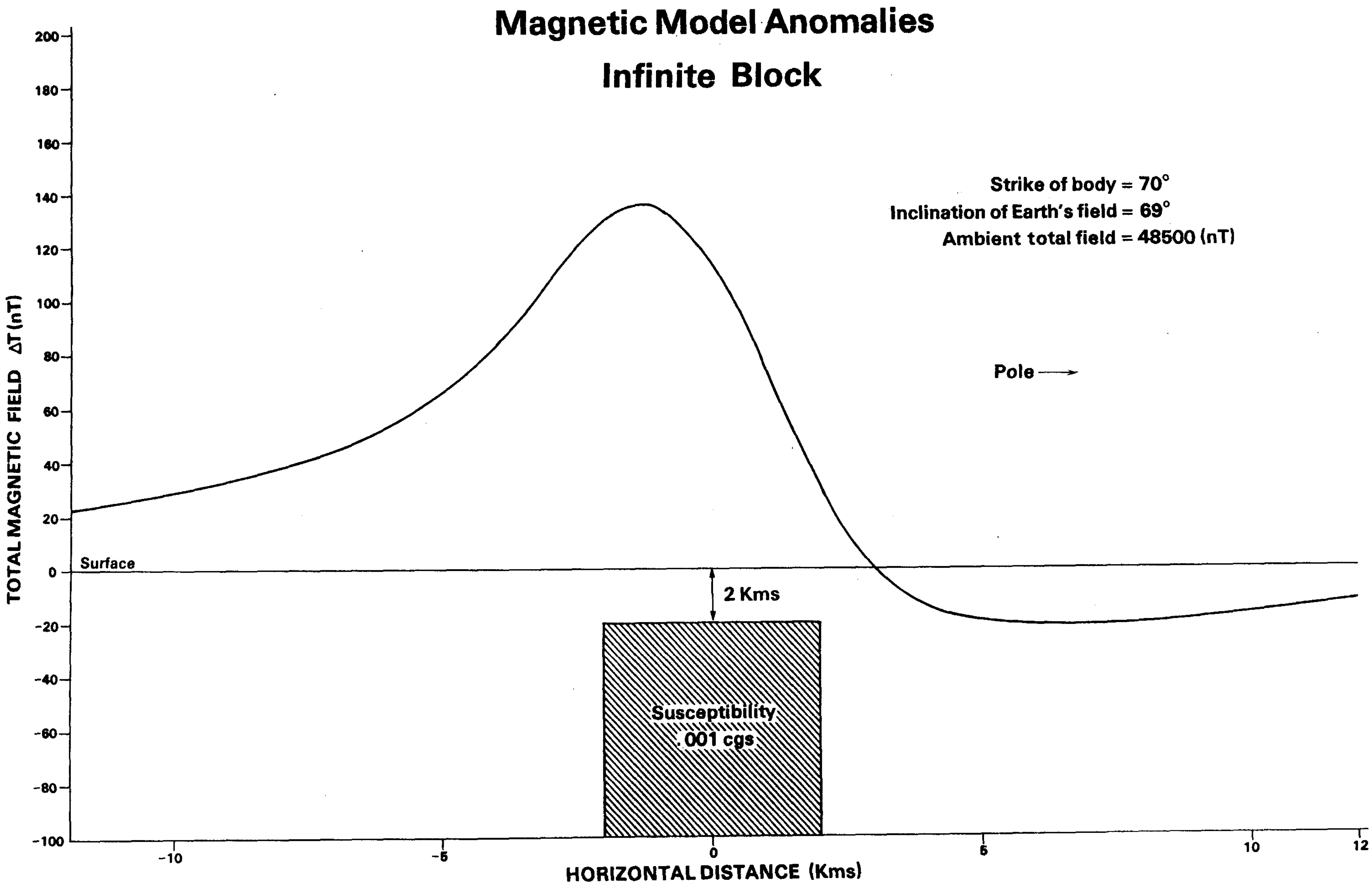
(ii) An examination of the residual total intensity contour maps to enable a selection of flight lines for Calcomp production. Sufficient Calcomp profiles were produced to enable quantitative interpretation to be made on all the anomalies of interest.

(iii) An examination of the total intensity contour maps in order to delineate areas of similar magnetic expression, identification of contacts, and magnetic discontinuities.

(iv) Quantitative analysis of Calcomp profiles over the better defined anomalies using the three sets of data to generate dimensions of theoretical models of anomalies. The various depth estimate methods applied to each profile produced a mean result which was in turn averaged with results of adjacent profiles giving a final mean depth for each body.

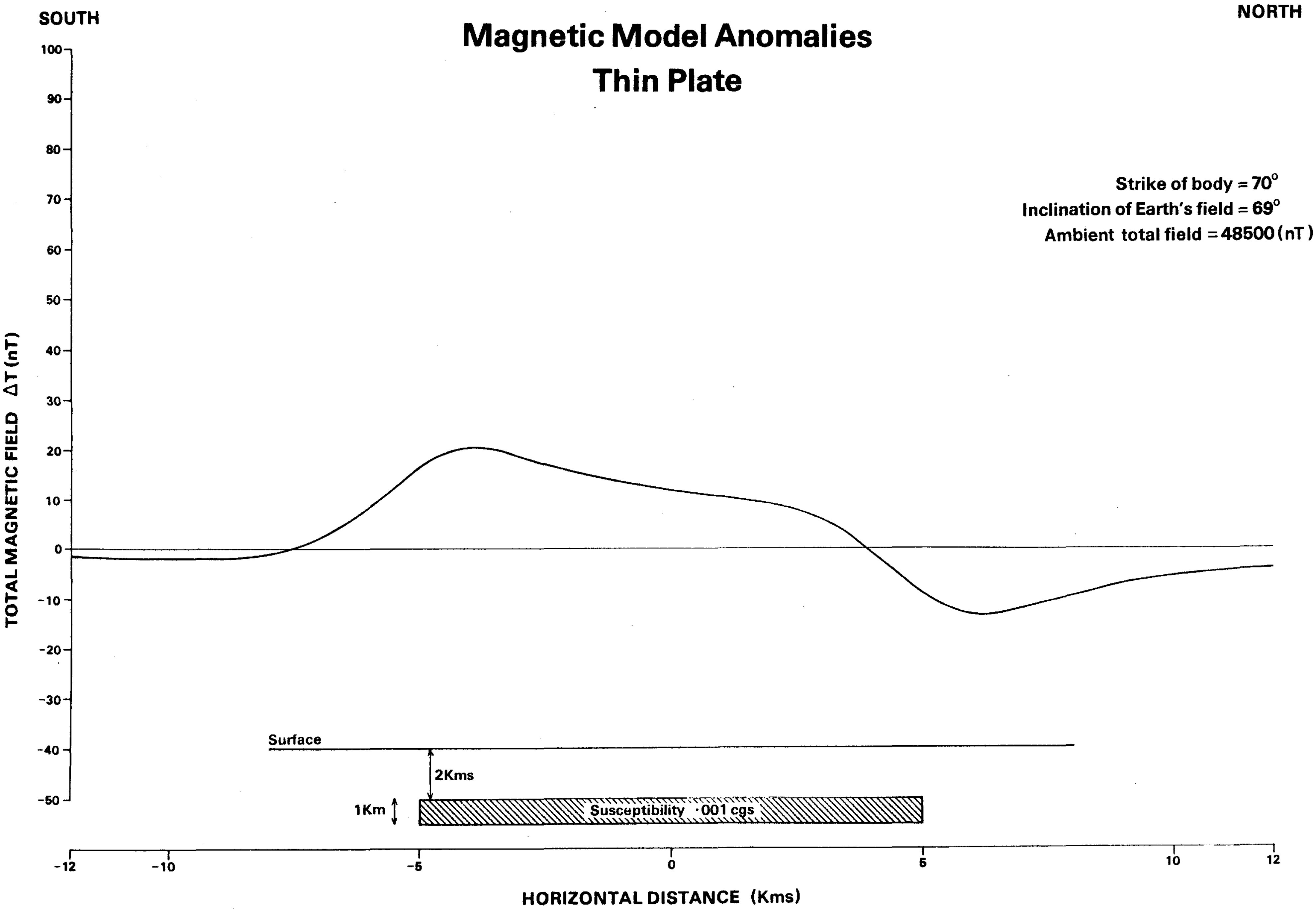
(v) The residual total intensity contour maps were examined in detail to determine magnetic characteristics that could relate to local mineral occurrences and hence define target areas for research.

The results of the above steps were compiled onto the interpretation work sheets.



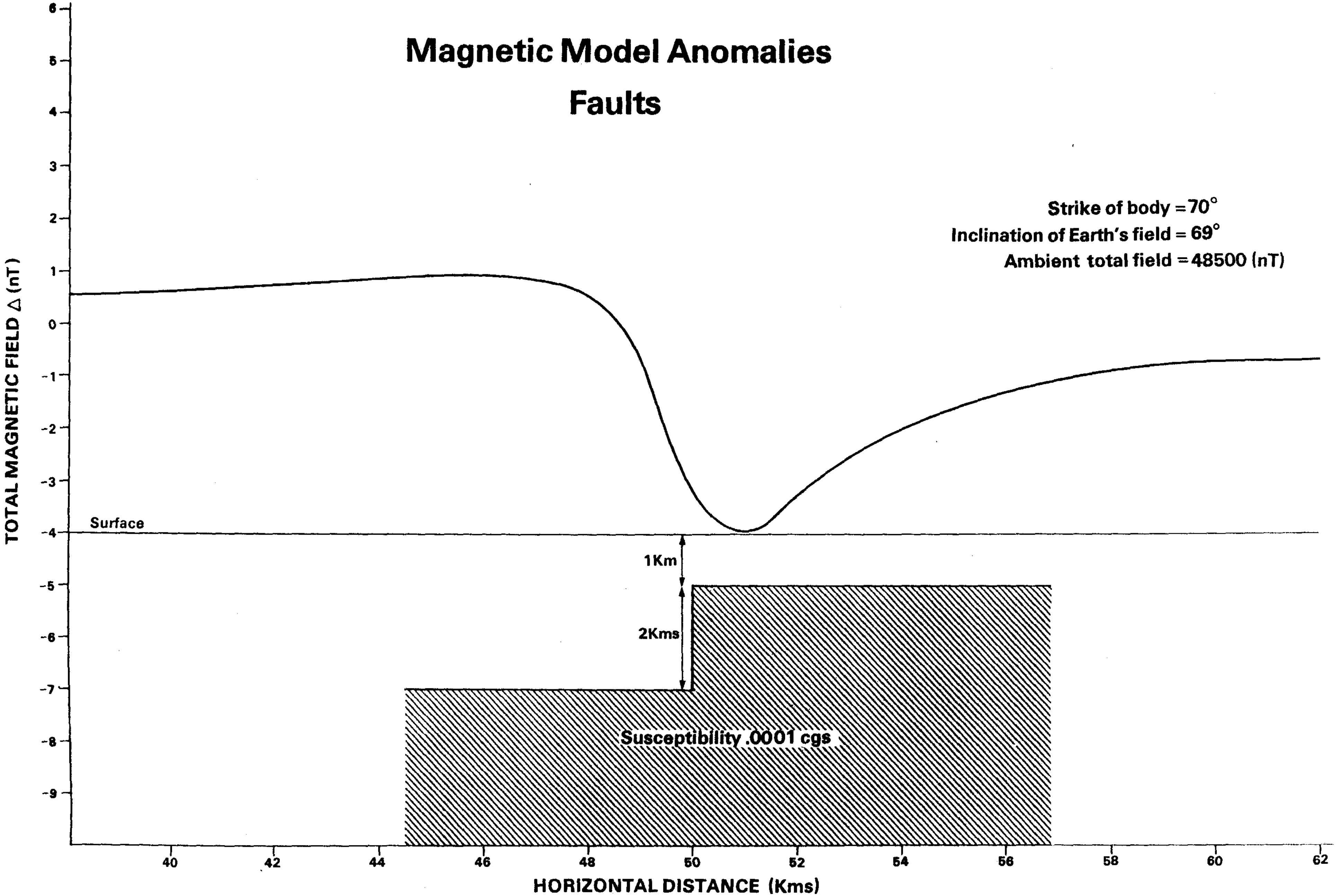
Magnetic Model Anomalies
Infinite Block
Strike of body = 70°
Inclination of Earth's field = 69°
Ambient total field = 48500 (nT)
Pole
Surface
2 Kms
Susceptibility
.001 cgs
TOTAL MAGNETIC FIELD ΔT (nT)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-10
-5
0
5
10
12
HORIZONTAL DISTANCE (Kms)

FIGURE 3a



SOUTH
NORTH
Magnetic Model Anomalies
Thin Plate
Strike of body = 70°
Inclination of Earth's field = 69°
Ambient total field = 48500 (nT)
TOTAL MAGNETIC FIELD ΔT (nT)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
Surface
2Kms
1Km
Susceptibility ·001 cgs
-12
-10
-5
0
5
10
12
HORIZONTAL DISTANCE (Kms)

FIGURE 3b



Magnetic Model Anomalies
Faults
Strike of body = 70°
Inclination of Earth's field = 69°
Ambient total field = 48500 (nT)
TOTAL MAGNETIC FIELD Δ (nT)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
Surface
1Km
2Kms
Susceptibility .0001 cgs
40
42
44
46
48
50
52
54
56
58
60
62
HORIZONTAL DISTANCE (Kms)

FIGURE 3c

Magnetic Model Anomalies

Faults

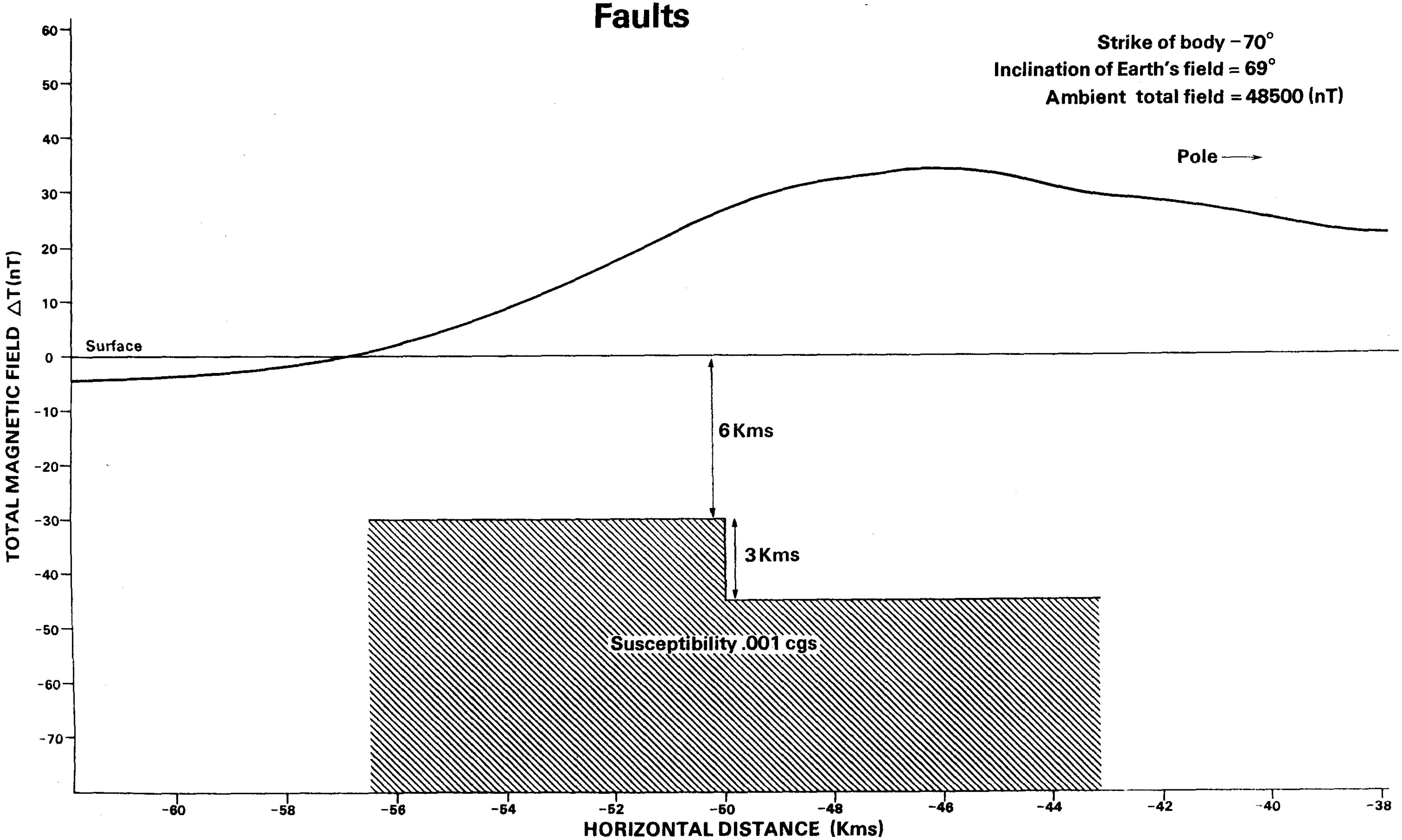


FIGURE 3d

Total field magnetic anomalies caused by a thin sheet at inclination 70°

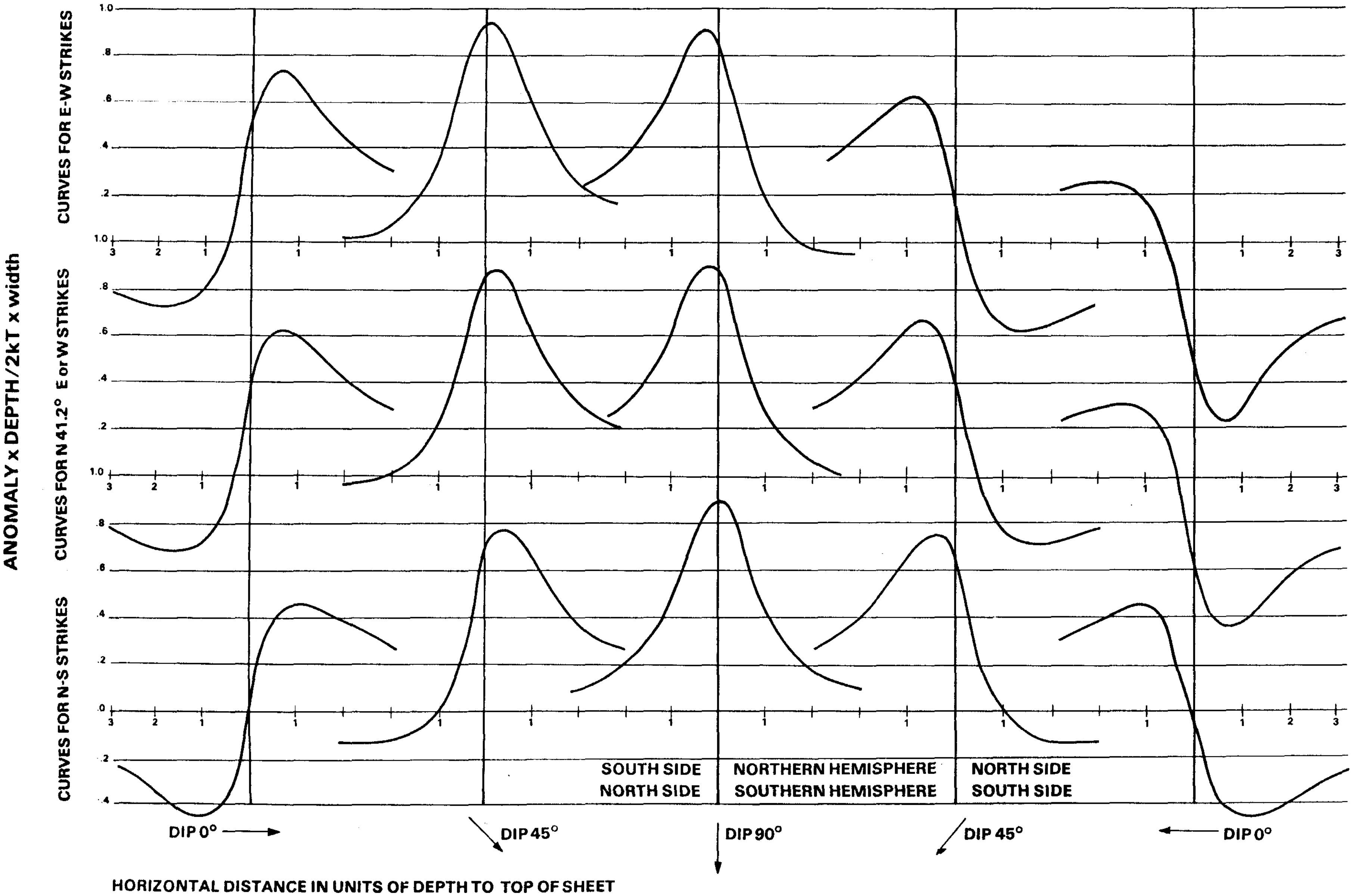


FIGURE 4

Vertical and horizontal gradient profiles over an infinite magnetic block

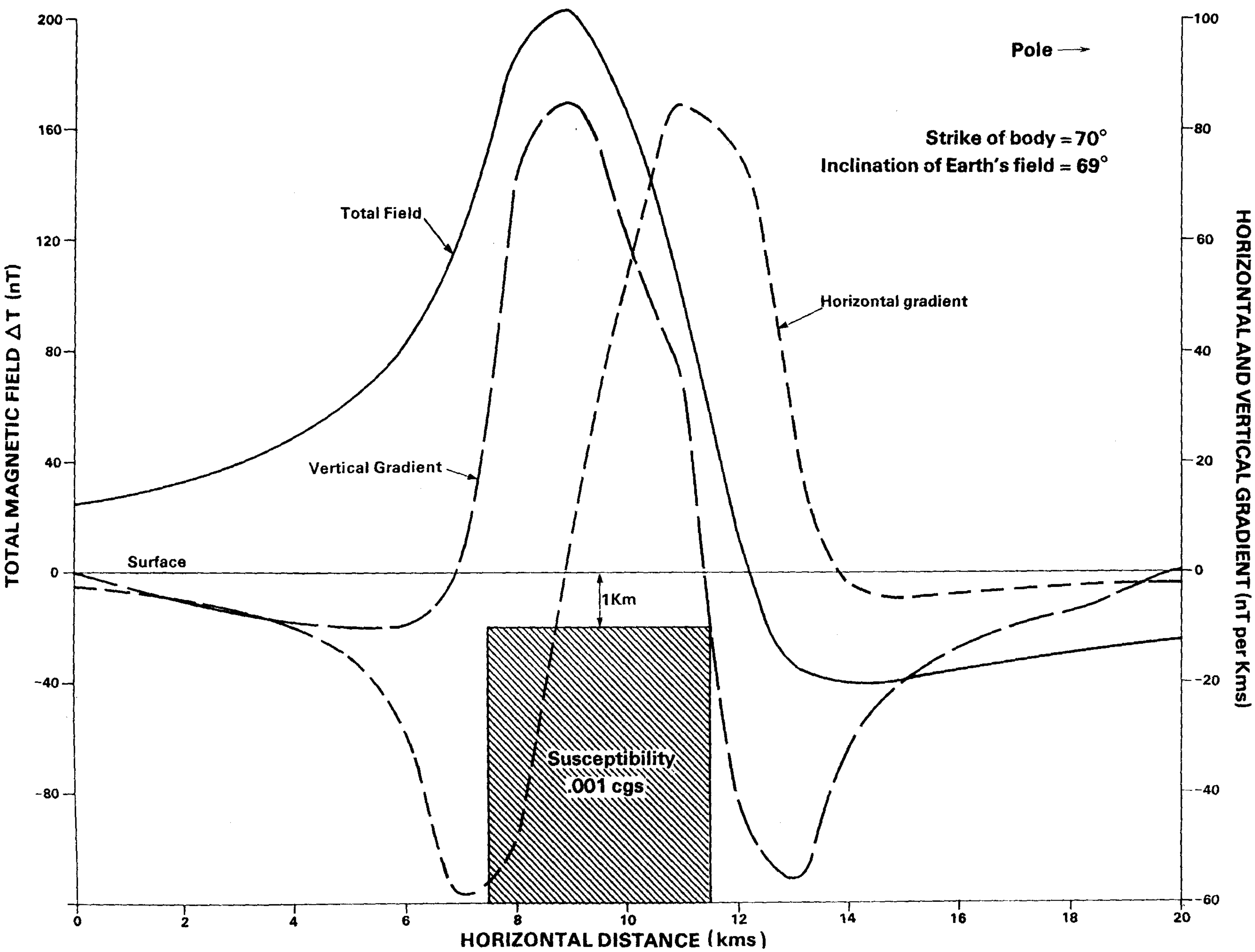


FIGURE 5

4. PRESENTATION OF RESULTS

The results of the aeromagnetic survey in Ireland are presented in the following forms and each map is produced at two scales: 1:63,360 and 1:250,000.

(i) The residual total intensity magnetic contour map showing contours at 2 nT intervals, with topographic detail shown in a subdued form. The magnetic value of any point is derived by:

Final corrected magnetic value = Controlled Value - regional value + 1 000.

(ii) The geophysical interpretation maps show interpreted magnetic information and relevant geological information.

(iii) Compacted master digital magnetic tapes and all analogue recordings of the magnetic field and altitude.

(iv) Further results of the survey are shown as 1:63,360 horizontal Calcomp profiles for a selected number of flight lines containing the corrected magnetic, vertical and horizontal gradient data. (Appendix VI, Operations Report).

5. INTERPRETATION OF THE RESULTS

5.1 Data Presentation

Geophysical data are presented on 31 sheets at a scale of 1:63,360. The sheet numbers are those devised by the Geological Survey of Ireland and combine four original one inch sheets into one.

The magnetic contour map shows that the variation of the total field is extremely variable throughout the whole area. The anomaly wavelengths suggest two types of magnetic sources are present:

(a) those that are deep and attributed to basement features and,

(b) those which are shallow and relate to sources either within the sedimentary sequence above the basement or represent areas thought to be shallow basement.

For the sake of convenience, the magnetics are described in two sections, one relating to intrasedimentary and shallow basement features and the other to deep basement sources.

The data are described by reference to magnetic zones on the interpretation map, starting in the east and progressing to the west. The interpretation defines 68 shallow zones (denoted by S M numbers) and 43 basement zones shown by B M numbers).

5.2 Zonal Description - Intrasedimentary Structures and Shallow Basement Areas

5.2.1 SM-1 (Sheet 27)

SM-1 extends from just northwest of Swords to Lambay Island striking regionally eastwest and is associated with Ordovician igneous rocks which outcrop. The zone contains high frequency anomalies displaced slightly north of the Swords anticline and having a northeast - southwest trend as well as the dominant east-west one. Composite magnetic bodies are present, which appear to deepen to the west below the sedimentary rocks. The igneous bodies are apparently abruptly terminated on three sides, as postualted from steep magnetic cut-offs. Changes of wavelength across a line which runs northeast - southwest (F1), and parallel to the coast, suggests faulting with a possible downthrow to the west. The low to the north of SM-1 may be an edge effect. However Robinson (1973) has suggested that as it is not entirely complementary to the magnetic high, it could be caused by a thin plate of magnetic material at depth, situated between the Howth and Portrane peninsulas.

5.2.2 SM-2 (Sheet 27)

Around the Dublin area, north of Dublin and near Summerhill (County Meath), are four circular anomalies 2-3 kilometres in diameter, and with anomalous amplitudes of less than 15 nT. They are interpreted as pipe-like bodies whose depths to top lie between one and three kilometres below sea level. They may be the remnants of old igneous feeder plugs at depth.

5.2.3 SM-3 (Sheet 27)

This zone is situated northeast of Clane (County Kildare), where it trends northeast-southwest. It veers in the north to trend north northeast - south southwest. The anomaly is less than 10 nT and is thought to be due to a plate of magnetic material (an Ordovician lava sequence?) either in the sedimentary succession or representing a supra-basement feature (a basement uplift?) or a combination of the two. The anomaly correlates with the northeast extension of the Kildare anticline, but the magnetic source lies about 1 kilometre below sea level in the southwest and appears to deepen towards the northeast, and this is consistent with the plunge of the mapped anticline. The anomaly trends appear to be displaced in the southwest and in the northeast by possible faults (F2 and F3).

The delineation of anticlinal structures is important in Lower Carboniferous areas as:

(a) they bring closer to the surface the lowest units of the sequence, which are the major ore-bearing horizons;

(b) they may be important controlling features in the movement and trapping of ore-bearing solutions.

The correlation of SM-3 with a geologically known anticline in the southwest may indicate that it defines a structural high for its whole length, and thus be of benefit for exploration.

F3 should be followed up to see whether fracturing occurs in this position in the Carboniferous.

5.2.4 SM-4 (Sheets 26, 27, 32 and 33)

This is a zone of high-frequency, shallow-source anomalies attributed to Ordovician andesites and basalts in the Kildare anticline. The data suggest magnetic blocks steeply dipping to the southeast, which is consistent with geologic information. The northern boundary of the zone is very abrupt, whereas the southern boundary is less so, indicating contacts which are steep and sloping respectively. Truncation of anomaly trends suggests possible faults F4, F5 and F6, and all should be investigated as they are likely to intersect Lower Carboniferous strata.

5.2.5 SM-5 (Sheet 21)

This important triangular zone stretches from Collon in the north to just south of Duleek in the south. This zone contains high-frequency anomalies indicating shallow magnetic sources, and it has been divided into three sub-divisions (SM-5a, SM-5b, and SM-5c) based on magnetic pattern. The northwestern edge (F7) is abrupt and has moderate correlation with a major mapped fault. The southern boundary is steep but not as abrupt, whereas the eastern boundary is broken up by major faults trending northwest-southeast (F15 and F20). F15 appears to have been filled with Tertiary dyke material, which gives it its characteristic negative anomaly and extends for at least 44 kilometres, displaced at times by apparent cross faults, and possibly running into the Kingscourt outlier. Indeed it is also possible that F7 (the northwest boundary) may be filled with Tertiary dyke material (D2?), as the band of lows on the northwest boundary of SM-5 is not entirely complementary to the highs and appear to be somewhat over-deepened to be simply an edge effect.

Sub-zone SM-5a contains shallow, small point source anomalies which is a typical volcanic type pattern, (of County Antrim plateau, Northern Ireland). Sub-zone SM-5b and SM-5c consist of linear trending anomalies; the trend in SM-5b being east-west, whereas, that of SM-5c is north northeast - south southwest. The difference in trends may be a consequence of folding. The linear pattern of SM-5b and SM-5c probably indicates steeply dipping lava sequences or dyke swarms. Ordovician igneous rocks outcrop between Slane and Navan, and also near Duleek in this zone and these rocks are most likely to contribute to much of the magnetic pattern. The inference is that igneous rocks are present for much of the area between the two outcrop areas beneath a thin cover of Carboniferous strata. However, this hypothesis assumes no major contribution from igneous rocks of a later age, (i.e. Carboniferous or Tertiary) which may also be present.

The whole zone appears to be broken up by a number of interpreted faults and these should be thoroughly investigated for their economic potential.

The volcanic rocks near Balbriggan, south of SM-5, hardly perturbate the magnetic pattern, which suggests these rocks are thin or generally have a low susceptibility contrast with the surrounding country rocks.

5.2.6 SM-6 (Sheet 21)

This small zone is situated just east of Kingscourt and is arcuate, trending northeast-southwest in the south and turning to near north-south in the north. It defines an area of negative, high-frequency anomalies, which correlate with Tertiary igneous rocks. Just south of SM-6 a number of point-source anomalies correspond to small areas of Tertiary basalt. The limited areal extent of the zone suggests that subsurface Tertiary igneous material is not extensive.

The large north-south fault on the western edge of the Kingscourt outlier has no magnetic expression.

5.2.7 Dykes D4 - D10 (Sheets 21, 15 and 20)

The characteristic features regarding these postulated dykes are their northwest-southeast trend and negative anomaly. Some seem to extend for a short distance, whereas others, such as D9 run for 30 kilometres and may connect with D15 situated to the northwest. These dykes are thought to be Tertiary in age and fill older fracture zones. Each negative anomaly may actually represent a swarm of dykes and not just one.

5.2.8 SM-7 (Sheets 14 and 15)

This zone is situated just southwest of Castleblaney and contains northwest-southeast trending linear, reversely magnetised anomalies. D11 and D12 are interpreted Tertiary dykes, one of which continues for a great distance into Northern Ireland (Stubblefield, 1964).

5.2.9 SM-8 (Sheets 14 and 20)

SM-8 is a small zone of high frequency point source anomalies situated near Bellananagh. The zone shows good correlation with a mapped granite, but the magnetics suggest that rocks of a more basic character may also be present; alternatively, the hornfels zone may contain abundant magnetite as is the case with the Dartmoor granite, England (Dunham, 1972).

F25 defines a possible fault trending north-south and it is also likely that the eastern boundary of SM-8 delineates another fault due to its abruptness and linearity.

5.2.10 Dykes D13 - D18 (Sheet 14)

A number of dyke-like anomalies exist in County Cavan, some trending almost east-west and some striking northwest-southeast. These dykes are considered to be Tertiary, and D16 appears to continue for a considerable distance into Northern Ireland along the banks of Upper Lough Erne, probably related to a major fracture, (Stubblefield, 1964). It is possible that D16, D15 and D9 are the same dyke.

5.2.11 SM-9 (Sheets 20 and 26)

This small zone, situated northwest of Mullingar, represents a reversely magnetised depth-limited body at shallow depth. It occurs in Carboniferous strata and is thought to be a small basic body probably of Tertiary age.

5.2.12 SM-10 (Sheet 26)

This fairly extensive zone of high frequency anomalies has been divided into two sub-zones, SM-10a and SM-10b. Sub-zone SM-10a defines two parallel northeast-southwest striking bodies, whereas SM-10b depicts point-source anomaly types. Outcrops of Carboniferous lavas occur in this zone at Croghan Hill, Philipstown, Offaly. SM-10a probably represents the presence of Carboniferous dykes whereas SM-10b may relate to lavas or small feeder pipes.

The northern boundary of SM-10 may be faulted due to its steep magnetic gradient, its linearity and the fact that it lines up with F7 near Navan, suggesting a link between the two. F26 is another possible fault, truncating and displacing magnetic trends. Both fault lines deserve investigation, even though they intersect Middle Carboniferous rocks and especially since the Gortdrum deposit is spatially associated with Carboniferous igneous rocks.

5.2.13 SM-11 (Sheet 26)

SM-11 describes an intermediate wavelength feature which trends northeast-southwest. Its peak-to-peak amplitude is only about 10 nT with its source located just over three kilometres below sea level. It correlates reasonably well with an anticline which passes just to the southeast of Kinnegad. It is very similar to SM-3 and is interpreted in the same way. It may represent a structural high and thus is an exploration target.

5.2.14 SM-12 (Sheets 26 and 32)

This zone lies to the northwest of SM-4. It is characterised by an intermediate wavelength anomaly of 88 nT peak-to-peak amplitude. The depth to the top of the causative body is estimated to be just over 1 kilometre. It appears to be a deeper version of SM-4 and is interpreted as a block of magnetic material, probably igneous and of Ordovician age, dipping to the southeast. In the western part of the zone another block of the same material exists; however the displacement of trends suggests faulting may have occurred (F47). The relationship between SM-12 and SM-4 may be that their causative magnetic sources lie in the hinge zones of a syncline and anticline respectively. Alternatively, SM-12 may be simply downfaulted by a fault running north-northeast on its southeastern boundary with respect to SM-4.

5.2.15 SM-13 (Sheet 32)

This zone is situated west of SM-12 and looks very similar to it, but appears shallower. The anomaly is probably a block of igneous rock within Ordovician (?) strata.

5.2.16 SM-14 (Sheets 32 and 38)

SM-14 appears to represent a southwesterly continuation of SM-4. It comprises an anomaly of intermediate wave-length with an amplitude of about 25 nT. Its trend is northeast-southwest and the magnetic source is estimated to be approximately 2 to 3 km subsurface. The trend of the contours, particularly in the south and southwest (almost north-south) reflects the tectonic framework of the Leinster coalfield.

The zone appears to be faulted in two places, based on an analysis of the contour patterns; F28 strikes about N60°W and occurs 1 to 2 km northeast of Port Laoise, and the second fault occurs near the southwestern end of the zone, 7 to 8 km northeast of Rathdowney, and stikes about N30°W.

Dyke-like bodies have been shown in places on Sheets 32 and 38. They appear to occur in Carboniferous sediments and have variable strike direction and lateral extent. Sometimes, they are located near towns such as Bagenalstown and Castlecomer, and have been interpreted as having a geological origin rather than being due to cultural interference although there is no geological evidence for such igneous activity in these areas except when near to the Leinster Granite.

5.2.17 SM-15, SM-16 and SM-17 (Sheets 25, 26 and 31)

These three zones show very similar characteristics and are very like SM-11, and SM-3. They all trend roughly east northeast or northeast and have small amplitudes (less than 10 nT). The northern boundaries of SM-15 and SM-17 both correlate well with inliers. These zones may be caused by plate-like structures sitting in an anticline hinge zone in the sedimentary sequence (i.e. defining structural highs) as previously mentioned or they may be deep fault structures, which have had the effect of doming the cover rocks. Either of the two possibilities are interesting for exploration.

If these zones represent faults then the location of the fault line would be situated close to the inflection point of the steepest slope (Figures 3c and 3d).

5.2.18 SM-18 (Sheet 25)

This is a zone of high frequency, seemingly reversely magnetised bodies trending in an east-west sense. The zone is situated to the west of Athlone and the magnetic source is shallow. The anomalies may be caused by igneous rocks (Tertiary).

5.2.19 SM-19 (Sheet 19)

This zone defines two small shallow magnetic blocks (probably igneous) which give rise to high frequency anomalies. The anomalies are sited east of Slieve Bawn.

5.2.20 SM-20 and BM-10 (Sheets 19 and 25)

SM-20 defines a very weak anomaly shown up as a deformation of the contours superimposed on the gradient between BM-5 and BM-6. The anomaly may represent one of the following (or a combination of):

(a) a deep intrasedimentary structure e.g. a lava sequence in the sedimentary succession;

(b) a basement high;

(c) a plate-like body within the basement, but with no associated basement topography.

Its boundaries are very ill-defined and as it correlates moderately with the Longford inlier, it is probably best explained as representing basement topography.

5.2.21 **SM-21 and BM-12 (Sheets 13 and 14)**

SM-21 is located on the northern margins of the survey area and is bounded by probable major faults F37 and F38, which will be discussed in a later section. SM-21 delineates an intermediate wavelength anomaly which trends east northeast - west southwest in the southwest and almost north-south in the north. It is part of a positive anomaly which continues well into Northern Ireland. From an examination of the Northern Ireland aeromagnetic data (1964) and the magnetic pattern of SM-21 the combination of a deep and shallow source is suspected to contribute to the nature of this positive anomaly. The shallow source may be due to igneous rocks, whereas, the deeper one may be:

(a) an extensive mass of igneous rocks (Devonian) in the sedimentary sequence, or

(b) magnetic basement.

5.2.22 SM-22 and SM-22a (Sheet 19)

This is a well defined magnetic zone which runs south southwest from Drumsna in the north, through Strokestown and then plunges and strikes more northeast - southwest just north of Roscommon towards the edge of the survey area. It has been referred to before as the Strokestown Anomaly (Murphy, 1955). This striking feature contains one of the highest magnetic values on the map (1,087 nT). It is composed of a string of high to intermediate frequency, positive anomalies which are abruptly terminated on both its northwestern and southeastern boundaries.

The wavelengths of the anomalies appear to increase towards the southwest indicating that the magnetic source deepens in this direction. Depth estimates show that anomalies in the northeast are due to rocks close to the surface, whereas, those in the southwest are about one kilometre below sea level.

Vertical gradient data show that a complex series of bodies are present in this zone. Displacement and non-unidirectionality of trends suggests faulting within this zone (F39-F42). Faulting (F35, F36, F38) is also suspected on the northwestern and southeastern boundaries of the zone due to the abrupt magnetic gradients, their linearity in the geographical sense and the fact that F36 correlates well with a known geologic fault on the western edge of an inlier. The boundaries may be the site of a series of faults parallel and close to one another. The magnetic lows to the northwest and southeast of the zone are thought not to be complementary to it, and are discussed in a later section.

The Strokestown anomaly is located over Lower Carboniferous strata and significantly its eastern boundary correlates with the northwestern edges of two mapped inliers. Outcrops of intermediate igneous rocks occur in the Lower Palaeozoic rocks and are situated in this zone.

The existence of a faulted zone should be an interesting exploration target area and postulated faults should be investigated to see if they occur in the Lower Carboniferous. Special emphasis could be placed on the northeastern parts of the zone where the Carboniferous is likely to be thin and where possible intersection of fault lines occur (F38, F36 and F37). Further examination of this area is presented in Section (5.5(d)).

5.2.23 SM-23 (Sheet 13)

This zone is situated at the northwestern extremities of the survey area. It consists of high to intermediate frequency, positive anomalies trending dominantly east-west. Outcrops of volcanic rock exist in the Devonian sequence of the Curlew Mountain Pericline north of Boyle; this zone is attributed to them. South and southwest of SM-23, linear, reversely magnetised anomalies occur which are suspected to be Tertiary dykes (D19 and D20).

5.2.24 SM-24 (Sheet 19)

This zone is located to the south of SM-32 and has similar magnetic response and a parallel trend. The western part of the zone appears to be deeper than the east from wave-length considerations but this is not confirmed from depth estimates. SM-32 and SM-24 are separated from each other by a magnetic low trend; a second magnetic low is seen to the south of SM-24 and geologically this area may represent a parallel series of anticlines and synclines. These trends are abruptly truncated in the west by a fault F44; on the western side of this fault a major magnetic low has developed. Depth estimates in this area indicate that the basement is deeper on the western side of the fault. In addition, relative displacement of magnetic trends also suggest displacement along a north northwest-south southeast line. The magnetic lows described above, together with SM-24 and SM-32, lie within larger basement zones BM-18 and BM-17.

5.2.25 SM-25 and BM-18 (Sheets 18, 13 and 12)

This zone outlines part of the southern end of the Curlew Mountain Pericline but is more extensive to the southwest of the mapped area. Towards the northeast the mapped outcrop of Devonian and Lower Carboniferous rocks diverge from the strong linear magnetic pattern of the SM-25 zone.

The main characteristic of the SM-25 zone is a strong linear northeast-southwest trend of magnetic anomalies with localised anomaly variability suggesting a complex assemblage of magnetic rocks. The most striking feature of the zone is the long linear magnetic high trends similar to those encountered in SM-26 and SM-29. Changes in the magnetic anomaly pattern in SM-25 indicate complex faulting in a north northwest - south southeast direction and along the northern margins of the zone. The southern edge of the zone appears to decay relatively rapidly except in the area of BM-18. The sinuous nature of the magnetic trends also suggests folding along the major axis. Localised high-frequency anomaly areas within the zone probably represent the presence of more magnetic rocks, probably volcanic, though some areas of known outcrop do not exhibit a characteristic signature. The shallow depth extention of the zone, relative to known outcrop in the southwest, and the divergence to the northeast, suggests that the magnetic response reflects a continuation of igneous rocks that are indicated from the geological information.

5.2.26 SM-26 (Sheets 12 and 18)

This zone represents the southern part of the northern magnetic complex defined by SM-27, SM-28 and SM-29. The zone consists of a number of magnetic anomalies with an east-west trend. In the northeastern part of the zone, anomalies exhibit a longer wave-length than those in zone SM-29 suggesting a deepening towards the southeast. A linear magnetic high in this part of the zone is thought (from Calcomp analysis) to be due to a dipping dyke. In the central and southwestern part of the zone the anomaly wavelength gradually increases to the south and southwest suggesting a gradual deepening. Depth estimates on the flanks of the southern anomalies indicate a depth of approximately 1.0 kilometre below sea level. Linear magnetic trends in the northern part of the southwest of SM-26 are parallel to the mapped outline of intrusive rocks, poor in silica. These mapped intrusives do not appear to exhibit a particular magnetic signature.

5.2.27 SM-27 (Sheets 12 and 18)

This zone is generally more magnetic than SM-28 and is more closely related to the mapped outline of the intrusive suite; data in the northeast of the zone suggests a continuation of a similar magnetic pattern in this direction. The geological information indicates further, similar intrusive material to the northeast. In the southwest the SM-27 zone contains a number of east-west trending positive magnetic anomalies which are laterally displaced. These anomalies are thought to be due to dykes, cross-cut by faults in a northwest-southeast direction.

5.2.28 SM-28 (Sheet 12)

This zone is situated on the north western margins of the survey area and characterised by an open magnetic pattern within a generally more magnetic area. The zone lies within the mapped outline of acid intrusive rocks.

The margins of this weekly magnetic area have relatively steep magnetic gradients and high frequency magnetic anomalies occur within the gradient. These latter anomalies are randomly orientated and may represent localised differentiation or the presence of dykes. The mapped outline of the intrusives in the area is larger than the limit of the SM-28 zone and the differences in the character of anomalies within surrounding zones reflects the complex nature of the intrusive suite. SM-28 demarcates a relatively large area of the more weakly magnetic rock types. The northern limit of SM-28 is not clearly defined because of the lack of data in the area.

5.2.29 SM-29 (Sheets 12 and 18)

For most of its length the SM-29 is parallel to the outline of the SM-27 zone and as such represents the magnetic signature from rocks mapped as schists and gneisses.

A small part of the SM-29 zone due south of SM-28 contains a number of high frequency, northeast-southwest trending magnetic anomalies. Their position and localised nature suggest an affinity with the contact of the northern intrusive rocks. In the southwestern part of SM-29 anomaly, trends become more variable but a relatively strong east-west trend is evident. A number of linear magnetic highs in this part of the zone are thought to be due to dykes. However, the complex nature of the magnetic data suggests that a number of magnetically different rock types exist within this zone. The magnetic low in the SM-29 zone suggests a possible extension of the intrusive suite to the southwest.

The southern boundary of SM-29 and the northern boundary of SM-26 are marked by a long (35 kilometres), linear, narrow (0.5 kilometres) magnetic high anomaly. The anomaly is parallel to the northern intrusive boundary for most of its length but is nearer east-west in the northeastern part. Magnetically, the anomaly may be due to a major dyke(s), a sharp basement flexure (anticline) or the differentiation of a more magnetic rock type i.e. a magnetic band within gneissic or schistose rocks. Similar magnetic high trends are seen in the southwest, on the northwestern part of Sheet 18; lateral displacement of these high trends suggests complex faulting.

5.2.30 SM-30 (Sheet 24)

This zone consists of a high frequency magnetic high anomaly with a northeast-southwest trend to the east of SM-33. The wavelengths of magnetic anomalies increase to the east of SM-33 and SM-30 probably represent an extension of rock types in SM-33 at shallow depth, beneath the Carboniferous Limestone, away from the areas of outcrop.

5.2.31 SM-31 (Sheet 18)

This zone is located to the west of BM-21 on the western edge of Sheet 18. The zone is not completely defined but has similar characteristics and trends to the SM-25 zone to the northeast; the southern part of the zone appears to be deeper than the northern part. The eastern and southern margins of the zone appear to be abruptly terminated, suggesting faulting.

5.2.32 SM-33 and SM-33A (Sheets 23 and 24)

These zones are located on the eastern edge of Sheet 23, north of the Galway Granite, and within the rocks mapped as granite, felsite and other silica-rich intrusive rocks, schist and gneiss, Silurian quartzites and Lower Avonian Shales and Sandstones, Carboniferous Slate Series and Calciferous Sandstone Series. The magnetic anomalies within SM-33 are of a high frequency nature i.e. shallow or outcropping and of variable orientation suggesting that no dominant stress direction has been defined magnetically. Unlike the northern strongly defined trends, seen in SM-26 and SM-25 for example, there are also small approximately circular sub-zones such as SM-33A, and these are typical of intrusive material. A linear, narrow magnetic high trend has however, been identified in the northern part of SM-33 which is thought to represent a dyke; a possible extension of this feature is seen south of Long Abbey to the west of SM-30. Variability of anomaly orientation indicates complex fault or contact effects; the eastern margin of SM-33 is truncated abruptly suggesting downfaulting or a sharp contact.

5.2.33 SM-34 (Sheets 23 and 24)

This zone outlines a series of strongly linear positive magnetic anomalies on the northeastern edges of the Galway Granite in particular on the southwestern side of F48.

The location and nature of these anomalies suggest metamorphic affinities associated with the granite margins.

5.2.34 SM-35 and SM-36 (Sheets 23 and 24)

The SM-35 zone outlines areas within the main part of the granite, distinguished by their magnetic intensity and orientation characteristics. The main bulk of the granite (SM-46) is characterised by variable magnetic orientation and an ambient magnetic intensity of between 900 and 1000 nanoTesla (nT). The SM-34 zone exhibits an intensity maximum of 1300 nT, whereas SM-35 is generally 1100 nT or more with variable orientation as an approximately north-south group. This links with SM-36, a relatively large zone with an intensity of 1243 nT. The zones are located to the northwest and north of Spiddal and may represent a differentiation from the main mass, possibly part of the Spiddal granite. West of SM-35 and SM-36, the character of the magnetic pattern changes from a random orientation to a strongly linear east-west trend, represented by SM-38, SM-39, SM-40, SM-41, SM-42 and SM-43.

5.2.35 **SM-38, SM-39, SM-40 and SM-43 (Sheets 23 and 29)**

The northern zones, SM-38 and SM-39, exhibit less linearity than the southern zones. There is also an increase in magnetic intensity southwards which reaches a maximum of 1223 nT in SM-42. The intensity decreases southwards from SM-42 across a steep magnetic gradient. SM-38, located south of Mace Head, forms a complicated pattern, generally of low magnetic intensity (less than 1000 nT.) The zone is situated on the Carna Granite. Zone SM-39, to the east of SM-38, contains small bands of magnetic positives and negatives and it is difficult to assign a particular origin to the zone. SM-43, east of SM-39, has similar character to SM-38.

SM-40 defines a strongly linear east-west trending group of high frequency magnetic anomalies abruptly truncated in the east by SM-37; in fact, the general linearity in this western area is abruptly truncated by more randomly orientated anomalies. This would be expected if this area represents an intrusive body in a metamorphic belt. The change in magnetic pattern occurs on a north northeast - south southwest line through Costello; some of the trend is maintained, however, for approximately four miles west of Costello. This region probably represents a transition zone.

5.2.36 SM-42 (Sheets 23 and 29)

This zone represents a linear east-west trending magnetic high, which is well defined on the southern part of sheet 23; isolated groups of anomalies of similar type are seen to the southeast on sheet 29. The main part of the zone in the west is located north and west of Lettermullen, close to the schists and gneisses mapped at Golam Head.

5.2.37 SM-41 (Sheet 29)

This zone consists of strongly linear east-west trending anomalies south of SM-42, and with a magnetic intensity of less than 1000 nT. South of this zone the magnetic pattern changes abruptly across steep gradient. The zone is located over Carboniferous rocks and may be due to metamorphics at shallow depth (approximately 1.0 kilometre) beneath the Carboniferous.

5.2.38 SM-37 and SM-45 (Sheet 23 and 29)

Zone SM-37, located to the east of SM-42 and to the southeast of Lettermore, is characterised by high frequency magnetic negatives and a distinctive, almost oval, boundary.

The zone's location suggests it relates to the Lettermore Granodiorites, but evidence is not conclusive. The SM-45 zone, located to the southeast, exhibits a similar character to SM-37 but may be fault-bounded. SM-45 is close to the mapped outline of a third granodiorite west of Inveran; and SM-36, to the north of SM-45, may then represent the response from the Murvey Granite.

5.2.39 SM-44 (Sheets 24 and 30)

This magnetic zone is very distinctive, with an approximately circular shape 13 kilometres in diameter. Interestingly the zone comprises two magnetically distinct halves; in the north a magnetic negative is bounded on its southern margins by a group of magnetic positives which project towards Spiddal. The northwestern boundary of SM-44 passes through Spiddal and as such does not represent the mapped Spiddal Granite.

The southern half of the zone consists of a distinctive magnetic negative, with positives on its northern and eastern edges.

The boundary of SM-44 is very distinct and exhibits steep gradients. The gravity low over the Galway Granite is centred on this zone, which may represent a fundamental unit within the main complex.

5.2.40 SM-46A (Sheet 29)

This zone is very distinctive magnetically, and represents a north-south area, approximately 15 kilometres long and 10 kilometres wide, located south of a line between Cashla Bay and Inveran. The zone has an ambient magnetic intensity varying between 1000 and 1100 nT, and with east-west trending anomalies. The zone has sharp boundaries similar to SM-44 and may represent a large fundamental unit of the Galway Granite Complex, probably the Errisbeg Townland Granite extended southwards.

5.2.41 SM-46 (Sheets 24, 29 and 30)

This zone covers the main mass of the Galway Granite Complex and is defined by random magnetic anomaly orientation and a general intensity level between 900 and 1100 nT. Within SM-46, sub-zones have been defined on the basis of anomaly orientation, degree of linearity, anomaly wavelength and intensity variability (SM-34 to SM-46A).

The area has been divided into compartments by the 'possible fault' symbol on the interpretation maps. These lines may be due to faults or contacts between areas of differing magnetic characteristics. Evidence for faulting can be related to lateral displacement of magnetic anomalies, or by a change of anomaly wavelength indicating deepening, as seen on the northern coast of Galway Bay (F49).

5.2.42 SM-47 and SM-47A (Sheets 30 and 31)

Zone SM-47 forms a well defined region between SM-46 and BM-7. The northern half of the zone has a relatively open magnetic pattern consisting mainly of magnetic gradient influences from nearby magnetic source rocks; as such, the zone would represent an area of deep or non-magnetic basement rocks. In contrast, the southern half of the zone, across the Area IV/Area V boundary, contains a number of high-frequency magnetic anomalies, which may relate to near-surface magnetic rocks. The northern half of the zone was flown at a higher level than the southern half. Although this increase would attenuate the magnetic effect from near-surface magnetic rocks, it would be insufficient to eliminate the anomalies, and the change in magnetic patterns from north to south represents a change of lithologies.

SM-47A forms a roughly circular pattern which may relate to a near-surface intrusive body.

5.2.43 SM-48 (Sheet 30)

The northern edge of SM-48 is marked by a change in magnetic character, generally associated with an increase in anomaly wavelength which coincides with the boundary between areas IV and V. To the south of SM-48 the flying height for the survey was changed from 450 metres above sea level to 200 metres mean terrain clearance. This alters the distance between magnetic sources and the magnetometer, and thereby artificially changes the anomaly wavelengths across the boundary between the two sets of data. This in turn produced an artificial boundary to the southern edge of the Galway Granite. Fortunately, in the central part of Sheet 30, north of the boundary between Area IV and Area V, the character of magnetic anomalies changes without the influence of the change in flying height; and the strong east-west magnetic trends in the southern part of zone SM-46 give way to a more northeasterly direction and to a corresponding increase in wavelength. This sharp change in magnetic character suggests faulting or a major contact along the northern edge of SM-48.

However, the magnetic anomalies within zone SM-48 maintain similarities with those in the main Galway Granite complex (SM-46) and therefore the influence of the complex may well extend to the southern boundary of SM-48, where the magnetic data suggest a rapid deepening of the magnetic basement. Zone SM-48 is abruptly truncated by a major fault (F47) which appears to form the eastern limit of the Galway Granite. F47 cuts across a magnetic high zone (the easternmost part of SM-46), trending northeast-southwest, effectively defining the eastern limit of high-frequency magnetic anomalies in this part of the area. The fault F47 is thought to represent the eastern limit of the Galway Granite complex. This simple conclusion runs into difficulty, however, because of zone SM-47.

5.2.44 SM-50, SM-51, SM-52, SM-53 and SM-54 (Sheet 36, 37, 43 and 44)

These zones of high-frequency magnetic anomalies indicate localised highly magnetic rocks outcropping or at shallow depth. This magnetic response is consistent with the volcanic rocks of Visean age which outcrop in several areas of County Limerick. Anomaly orientation within the zones is variable and indicates a series of faults trending north northeast and north northwesterly. Zones SM-50 and SM-52 are the most prominent features in this region and the outcrop of SM-52 matches the magnetic pattern almost exactly. The magnetic pattern of SM-50 is less consistent with the mapped outcrop on the 1:750,000 scale Geology Map of Ireland. Zones SM-53 and SM-54 are located on the southern margins of SM-52. The eastern zone, SM-54, is approximately circular and it contains a number of high-frequency anomalies of variable orientation, suggesting an intrusive body. The anomaly amplitudes are of the order of 200 gammas less than those in the SM-52 zone.

Depth estimates within SM-53 and SM-54 indicate sources at approximately 500 metres sub-surface.

Zone SM-53 contains fewer anomalies than SM-54 but displays a strong gradient on its western boundary. Zones SM-53 and SM-54 probably represent either a deeper version of rocks in outcrop (SM-50 and SM-52), or an intrusive body. If the SM-53 and SM-54 zones are related to a near-surface intrusive, then this would form part of the basement high BM-30.

Zone SM-51 is located to the north of SM-52, west of Abington, and probably represents a similar volcanic rock type remote from the main zones of activity.

An analysis of the Calcomp profiles over the main areas of volcanics indicated a dual wavelength character on some profiles. A short-wavelength pattern, representing shallow volcanics, appears to be superimposed on a longer wavelength component which is interpreted to represent deeper, weakly magnetic, basement.

Attempts were made manually to smooth out the high-frequency components and estimate depths from the long wavelength resultant. As expected, a large scatter in the depth to basement was observed and so it is inconclusive whether the volcanics are directly associated with a magnetic basement feature as was suspected from the analysis within BM-30.

5.2.45 SM-55 (Sheet 37)

Northeast of SM-51, and due south of the Silvermines deposit, zone SM-55 outlines a weakly magnetic area on the southern flanks of a major magnetic high, BM-13. The geological origin of this zone is not established but may represent a small-scale, magnetic basement flexure.

5.2.46 SM-60 (Sheet 43)

This zone, in conjunction with a similar anomaly group, forms two long (27 km and 20 km) bands of magnetic anomalies, which have the appearance of dykes in a generally non-magnetic basement area. SM-60 proper extends from Kilmallock in a northwesterly direction towards Foynes and comprises a series of positive and negative anomalies. The line of magnetic anomalies to the northeast of Kilmallock is continuous towards Tipperary. This zone is interpreted as a dipping dyke, although it may be related to the faulting that is mapped to the south. The fact that the railway diverges from the zone reduces the possibility of cultural interference, but towns are situated along both magnetic areas and at their junction (Kilmallock). The discrete nature of anomalies in SM-60 suggests a fault-controlled localisation of intrusive material. The magnetic areas are spatially related to other volcanic material in the area (Limerick Volcanics) but no direct connection is observed. The easterly dyke appears to dip away from the Limerick Volcanics.

5.2.47 SM-61 (Sheet 30)

This zone takes the form of a short linear group of magnetic highs which are probably related to faulting in the Slieve Aughty Inlier.

5.2.48 SM-63 (Sheet 33)

SM-63 extends from east of Blessington, along the western margin of the Leinster Granite in the south to Baltinglass. The zone is generally fairly narrow except between Donard and Baltinglass where it gradually widens to about 8 km wide at Baltinglass. The zone is characterised by high-frequency anomalies, indicating shallow magnetic rocks.

The western margin of the Leinster Granite in this area is characterised by intrusive andesitic rocks of Ordovician age. These igneous rocks are well reflected by the magnetic pattern; the magnetic pattern indicates a much wider extent of andesitic rocks all along the margin of the Leinster Granite, but particularly so around Baltinglass, Deerpark and Donard.

5.2.49 SM-64 (Sheets 27 and 33)

SM-64 covers a wide area between Tallaght and Brittas, Co. Dublin, along the northwestern margin of the Leinster Granite. The zone is very similar to SM-63 except that it is dominated by a single, broadly circular magnetic low anomaly, having an amplitude of 15-20 nT. This may be due to a sill-like intrusive.

It is known that outside the contact aureole, there are numerous Caledonian dykes of andesitic composition and ranging in width from less than 0.5 to 4.5 m. Centred in the Tallaght area, these dykes continue southwards toward Brittas in a group along the western margin of the Leinster Granite.

The rocks in this zone are apparently affected by northwest-southeast faulting. This zone in part corresponds with a gravity high of about 2 mgal.

5.2.50 SM-65 and SM-65A (Sheets 33, 36, 39)

SM-65 is similar to SM-63 and SM-64, in that it is characterised by high-frequency, short-wavelength anomalies. The level of magnetisation is much greater than in SM-64 and is comparable with SM-63. The zones begin in the northeastern corner of Sheet 33, and have variable width from 25 km at the northern end to about 13 km near the southern end. The zone has a general Caledonian strike being parallel to, and along the eastern margin of, the Leinster Granite. The zone widens locally, away from the Leinster Granite onto the

Ordovician-Silurian rocks, as far as the coast. It continues southwards onto Sheet 39 but with a small change in strike direction near Shillelagh, becoming more easterly. The zone extends as far as the southwestern edge of Sheet 38.

That part of Zone SM-65 that runs along the Leinster Granite, is shown on geological maps as an aureole zone consisting of mica schists and altered Lower Silurian rocks. As mentioned above, the magnetic zone extends eastward well beyond the aureole zone onto the Ordovician-Silurian rocks. The eastern margin of the Leinster Granite is well marked by several dykes of dioritic-andesitic composition and also dykes of quartz porphyry.

The magnetic character of this zone is generally similar to that of Zones SM-63 and SM-64, in that there are numerous closed anomalies of short wave-length. This indicates shallow magnetic rocks, and the pattern is consistent with either banded metamorphic rocks, dykes or sills. The dyke symbols shown on Sheet 33 are meant to give position but not an accurate width of the bodies as these appear to be very variable.

The rocks around Rathdrum, Co. Wicklow are a mixture of diorites, felsites, dioritic ash and felspathic ash. The general analysis of the magnetics in this zone is that these volcanic rocks are much more widely spread than shown on the published geological maps.

SM-65A lies along the coast near Bray, Co. Wicklow and has a very small extent. Its magnetic character is consistent with a thin plate model within the Cambrian sedimentary rocks.

5.2.51 SM-66 and SM-66A (Sheets 38 and 45)

SM-66 occurs at the southwestern end of the main outcrop of the Leinster Granite, along its western margin. In this respect, as well as from the overall magnetic signature, the zone is very similar to Zones SM-63 and SM-64, and the magnetic anomalies are ascribed to similar sources; that is, dioritic and andesitic intrusives. The eastern margin of SM-66 accurately defines the contact between the Leinster Granite and the aureole zone.

By contrast, the western margin of SM-66 transgresses rocks of the Devonian and Lower Limestone of Carboniferous age. The southwestern margin of SM-66 is abruptly terminated by a northwest-southeast fault near Carrick-on-Suir which also coincides with an intrabasement contact between BM-41 and BM-1B.

The southern margin of SM-66 is not readily comparable with surface geology except at about 5 km northwest of New Ross where it coincides with an occurrence of diorite.

Within SM-66, and some 5 km to 9 km west southwest of the main outcrop of the Leinster Granite, some major outcrops of granite have been mapped. These seem to be bounded on their eastern and western margins by northwest-southeast faults. These isolated granite outcrops are apparently not very thick and are intruded by diorites and andesites.

Zone SM-66A, north of Mullinavat, is in effect a small part of SM-66. It is bounded on the east and west by two faults, one of them being F62. It comprises an isolated anomaly of 4 nT amplitude. It differs from SM-66 in having lower intensity of mangetisation and gentle gradients.

5.2.52 **SM-67 (Sheet 45)**

This zone is at the southern extremity of the survey and is incompletely defined. It lies south of SM-66, being separated by BM-1B. It extends from west of Portlaw in the west and eastwards to Oldcourt (about 6 km south of New Ross). A large part of the zone in the west lies over the known volcanic belt which runs northeast-southwest from Gorey in Co. Wexford to Stradbally in Co. Waterford. For that part of the zone west of W aterford, the only significant area is near Portlaw where there is a positive anomaly of 70 nT amplitude and 3 km diameter. It lies over the alluvium-covered Lower Carboniferous shown on the geological maps. According to depth estimates, the source for the anomaly must lie immediately under the alluvium and is possibly a thick plate of magnetic material on the basement surface.

5.2.53 **SM-68 (Sheet 38)**

This small zone contains magnetic anomalies, with an amplitude from 5 nT to 17nT and having trends of northeast-southwest to east northeast-west southwest. In spite of the fact that the anomalies are over Kilkenny town, they are considered to be genuine since they extend well to the south and southeast. The northern part of the zone is defined by a magnetic low and a corresponding high located over Kilkenny, and is thought to be due to a dyke-like intrusive; the southern anomalies may be due to thin plate-like bodies i.e. a sill or lava flow.

The rocks around Kilkenny are Upper Limestone and Calp (Middle Limestone) in a syncline though no volcanicity is reported. However, about 2 km southeast of Kilkenny, "dolomite, apparently metamorphosed" is shown on geological maps. Thus the igneous rocks identified by SM-68 could have provided the necessary environment for metamorphism.

5.3 **Zonal Description - Basement Structures**

In the following sections, shallow zones SM-56, SM-57 and SM-59 are discussed in conjunction with basement zones BM-36, then respectively SM-32 in conjunction with BM-11, SM-49 and SM-49A in conjunction with BM-39, SM-62 in conjunction with BM-18, and finally SM-58A, SM-58B and SM-58C in conjunction with BM-28, BM-31 and BM-32.

5.3.1 **BM-1, BM-1A and BM-1B (Sheets 27, 32, 33, 38, 39, 44 and 45)**

BM-1 has been identified as a zone of fairly uniform magnetic gradients with a pattern signifying relatively non-magnetic rocks, consistent with weakly magnetic granites extending to the southeast over the Leinster Granite except for an area covered by Sheet 31. The pattern of magnetic contours exhibited over the Leinster Granite seems to continue in all directions well beyond the mapped limits of the batholith, except for its eastern margins. This suggests that the granite may continue under the cover of Lower Palaeozoic rocks in the west and southwest.

This is corroborated by gravity data in these areas. Murphy's gravity map of 1962 shows a large negative gravity anomaly having a Caledonian strike corresponding to the Leinster Granite, with its centre around 6 km southeast of Carlow, which is on the eastern edge of the major syncline forming the Leinster coalfields. The axis of this gravity low continues further southwest, though with an amplitude reduced to almost half, where it lies about 16 km southwest of Kilkenny over the Slieveardagh Hills. Passing still further southwest, the low continues over the Galty Mountains, with a decrease in amplitude. There also occur isolated gravity lows south southwest of Thomastown and immediately north of Carrick-on-Suir, so confirming the similarity between the gravity and magnetic response due to the Leinster Granite.

BM-1A and BM-1B are essentially two subdivisions of BM-1. BM-1A occurs in Sheet 33, north of the line joining Baltinglass and Lugnaquilla Mountain. Over the northern part of the Leinster Granite the magnetic contours in BM-1A have a separate pattern reflecting a different petrological composition and possibly different environment at the time of granite emplacement in this region.

BM-1B occurs in the southern part of Sheet 45 and between SM-66 and SM-67. Its western margin is apparently faulted and is in contact with BM-41. It overlies the narrow syncline of the Carboniferous limestones, southeast of Carrick-on-Suir, continuing eastwards over Ordovician rocks towards New Ross. The eastern margin is not defined due to lack of data. The pattern of magnetic contours is comparable with BM-1 and so it suggests a possible southwestern extension of the Leinster Granite.

5.3.2 BM-2 (Sheets 21, 26, 27, 32, 33 and 38)

BM-2 lies northwest of BM-1 and is identified on Sheets 21, 26, 27, 32 and 33. It has been established that BM-1 extends to the southwest across Sheet 32 and onto Sheet 38, from Skerries in the northeast to Durrow and Ballyraget in the southwest. Not unlike BM-1, it exhibits a featureless magnetic signature with the northern and southern boundaries being marked by a steepening in the magnetic gradient. The northern boundary may represent faulting parallel to the Caledonian trend. On Sheet 32 the northern boundary of BM-2 lies over the Lower Palaeozoic inlier of the Slieve Bloom Mountains, and it appears to be faulted by a northwest striking fault F61. In fact this fault also similarly affects the BM-7/BM-13 boundary. The BM-2/BM-1 boundary in the southern part of Sheet 32 swings abruptly to the south, passing by Castlecomer on Sheet 38 in the heart of the Leinster coalfield, and continues until a few kilometres north of Kilkenny after which it swings gently to the northwest.

The magnetic pattern in BM-2 indicates a relatively homogeneous mass of material. The disturbance in magnetic pattern in the areas around Abbeyleix, Donaghmore and Durrow are, as noted before, probably due to intrasedimentary sources.

5.3.3 BM-7 (Sheets 20, 21, 25, 26, 27, 31 and 32)

BM-7 is located directly northwest of BM-2 and extends in the Caledonoid direction, almost the whole width of the survey area from north of Drogheda, to north of Birr in the southwest. The zone is very similar to BM-1 and BM-2 in that it has little magnetic expression, except where it is disturbed by superficial sources, such as SM-10 and SM-5 for example. The northern boundary of the zone is fairly well defined with BM-6 and the southern boundary is defined by BM-2 and on Sheets 31 and 32, by BM-13.

There are a number of possibilities regarding the structural inter-relationship between BM-1, BM-2 and BM-7 as seen by the magnetics, but one of the most likely is that all three zones represent blocks which are relatively homogeneously magnetised with BM-7 having a greater magnetisation than BM-2 which in turn has a greater magnetisation than BM-1. The contacts of the blocks are then delineated by regions of steeper magnetic gradients.

5.3.4 BM-3 (Sheet 21)

This zone describes a long wavelength positive anomaly situated in the vicinities of Drogheda and Duleek. Superimposed on the anomaly is part of zone SM-5, which has been previously described. It is suggested that there is a genetic connection between the two zones, in that BM-3 possibly relates to a magnetic body at depth, which has been tapped and produced igneous activity at a higher level (SM-5).

5.3.5 BM-4 (Sheets 15 and 21)

This zone defines a long wavelength negative anomaly which is located between Dundalk and Drogheda. It is the westerly extension of the Solway Firth Low situated in the Irish Sea (Bott, 1968).

The interpretation of these long wavelength features will be discussed in Section 5.3.6. It seems possible that deep basement faults F23 and F22 may exist. F22 shows good correlation with a fault seen on SEASAT Data.

5.3.6 BM-5 and BM-6 (Sheets 13, 14, 15, 19, 20, 21, 25 and 26)

Undoubtedly the dominant features on the map are the two long wavelength anomalies, one positive and the other negative, which parallel the Caledonoid trend, and each have an amplitude of some 150 nT. The anomalies measure between 20 and 40 kilometres across and some 130 kilometres in length. The positive anomaly has been studied before and referred to as the Virginia Anomaly (Murphy, 1955). These large, long wavelength anomalies are not a unique feature of Ireland, but occur elsewhere in the British Isles (Hall and Dagley 1970), for instance in the Irish Sea and the Southern Uplands belt in the UK.

Three suggestions are put forward regarding the geometry of the source of these anomalies and each is discussed in turn:

(a) they represent a basin, defined by the magnetic low, and doming of the magnetic basement, defined by the high;

(b) they represent a single prism in the basement, dipping to the south at a shallow angle;

(c) they are caused by two basement blocks, one reversely and the other normally magnetised.

The presence of a basin and dome situation would require either a strong susceptibility contrast between the sediments and the basement (approximately between 0.001 and 0.01 cgs) or an unrealistically severe basement topography. Together with other evidence (Bott, 1968) this suggestion is unlikely.

Suggestion (b) requires the magnetic low and high to be complementary. Examination of the present aeromagnetic map and aeromagnetic maps from the UK indicate this is unlikely. The UK survey (Hall and Dagley 1970) shows that positive and negative anomalies appear in bands independent of one another. Further the shape produced by a prism dipping to the south at about 30 degrees does not fit well with the observed data.

The third suggestion seems to be the most realistic. Modelling (Appendix 2), has shown that a good fit may be obtained with two oppositely polarised basement blocks, 27 kilometres wide and both 6.5 kilometres deep, having low susceptibility contrasts. This gives reinforcement to Bott's hypothesis (1968) that the anomalies are due to differential structural, metamorphic and especially igneous processes related to the Caledonian Orogeny. The origin of BM-4 is probably the same as BM-5.

The northern boundary of BM-5 is defined by a steep boundary that defines a fault (The Southern Uplands fault), which runs up the northern edge of the Longford - Down massif.

The contact between these two blocks may be a line of weakness which may have moved throughout geological time. If this is the case then subsidiary parallel faults may be present. The fault running through Keel may be one of these. In zone BM-6 the magnetic value decreases towards the southwest and does so in a series of steps, which suggest either a series of north northwest - south southeast faults (F29 and F30) or facies variations in the block.

In the extreme west BM-5 is thought to extend west of the Strokestown anomaly. Its wavelength is shorter, which indicates a shallowing of the basement in these areas.

Superimposed in zone BM-5 and BM-6 are a number of small high frequency anomalies, which occur almost entirely north of the unconformity between the Lower Palaeozoic and Carboniferous rocks. Small areas of shallow lavas or other igneous rocks in the Lower Palaeozoic may account for this, whereas they are too deep to be detected below the Carboniferous covered areas.

5.3.7 BM-13 (Sheets 31 and 32)

This zone is defined by long-wavelength, positive anomalies located over Lower Palaeozoic inliers. The sources for these anomalies seem to be deeper (about 3.5 km) in the southwest than in the northeast over the Slieve Bloom Mountains (about 2.5 km). Its northern and southeastern boundaries are possibly delineated by faults, although there is little magnetic evidence to support this.

5.3.8 BM-8 (Sheets 19 and 25)

This zone defines two magnetic negatives which are apparently displaced by a fault running northwest - southeast (F32). They are intermediate to long wavelength features, which could be caused by non-magnetic blocks in the basement surrounded by relatively more magnetic material.

5.3.9 BM-9 (Sheets 24 and 25)

This zone contains a number of positive magnetic anomalies of intermediate wavelength and with a variable orientation. Depth estimates indicate that the sources of the anomalies lie between 500 and 2000 metres below sea level, and so they may be related to SM-22 but at a deeper level. Therefore zone BM-9 is ascribed to either shallow magnetic basement rocks or a series of plate-like bodies above the magnetic basement; a relationship between this zone and the Strokestown anomaly is not excluded.

5.3.10 BM-11 and SM-32 (Sheets 18 and 19)

This circular magnetic high is particularly distinctive and is thought due to the presence of a deepseated intrusive body, possibly granitic. This particular feature has been modelled on the computer and reveals the following characteristics:

(1) Depth to the top of 4.0 kilometres (below sea level).

(2) A 10 kilometre square top.

(3) A dip of 42^0 to the north.

The northern part of the anomaly abuts the BM-18 zone; the eastern and western parts of the anomaly appear to be associated with faulting and the southeastern part of the anomaly correlates with an outcrop of Lower Carboniferous rocks, northeast of Castlereagh, (but only for part of the mapped outlines). (See Appendix II Model D).

The most likely origin of zone SM-32 is a minor intrusive. A similar magnetic feature to the north of Frenchpark may represent a northeasterly extension of SM-32. The western end of SM-32 dies out rapidly and this may be due to a contact or more likely a north northwest - south southeast fault. Further evidence of faulting is suggested from the displaced nature of the magnetic contours in BM-11. This area may be of interest for further exploration since mineralisation has been established north of Frenchpark.

5.3.11 BM-14 (Sheets 13 and 19)

This zone is situated in the northwestern extremities of the survey area near Boyle. It is composed of a magnetic gradient containing a featureless regime. BM-14 may represent the southern limb of a positive anomaly similar to SM-21 (BM-12) and is possibly genetically related to SM-23. It could represent the source of the igneous rocks in the basement, which are seen in the SM-23 at a higher level. Indeed if this were the case, BM-14 and BM-12 may be the same zone.

The southern boundary is ill-defined. The western and eastern boundaries are defined by faults F38 and F43, postulated from a displacement and truncation of magnetic trends.

5.3.12 BM-15 and BM-16 (Sheets 12, 13 and 18)

Zone BM-15 includes the weakly magnetic negative area between the two areas of older rock outcrops in the area. It has not been possible to obtain depth estimates here but the rocks appear to be complexly down-faulted in the south, and to dip gently on the northern flanks. Fault patterns projected from the magnetic data in the near-surface areas of the Ox Mountain and Curlew Mountain areas, together with a rapidly steepening magnetic gradient in the west of BM-15, suggest that the western end of BM-15 is abrupt and may form an enclosed basin area. The magnetic low continues on the east of the zone but narrows because of the influence of the magnetic high BM-16.

5.3.13 BM-17 (Sheets 18, 19, 24 and 25)

Zone BM-17 is extensive and for most of the northwest area covered by Carboniferous Limestone, it represents the magnetic basement. Within this major zone are a number of smaller zones thought to represent differentiation of the magnetic basement area. Depth estimates within BM-17 suggest that the basement gradually deepens to 1.0 kilometre below sea level in the region to the south of SM-26 across the southwestern extension of SM-25, along the southern boundary of SM-25, and to the west and south of BM-11. The magnetic basement on the western side of sheets 18 and 24 also appears to be less than 1.0 kilometre deep. The magnetic basement deepens rapidly in an arcuate form on the southern and western edges of BM-21. In this region the depth estimates indicate a local deepening to at least 3 kilometres and some estimates exceed 4.0 kilometres below sea level. In the south of Sheet 24 a localised basement low is indicated parallel to the northern boundary of the Galway Granite, whilst in the east of Sheet 24 is a large northeast - southwest trending basement low. A basement swell apparently separates the magnetic basement low to the north on Sheet 18 from another to the southeast on Sheet 24. This swell follows a line of projection of the large positive anomaly (represented by BM-19) across the northern part of Sheet 24 to the shallow (1400 metres) magnetic zone SM-30.

5.3.14 **BM-18 and SM-62 (Sheets 12, 13, 18 and 19)**

The BM-18 zone is characterised by an area of negative magnetic trends on the northern flanks of a large positive anomaly (BM-11) and on the southern edge of SM-25. The northern part of BM-18 lies within the mapped boundary of Devonian and Lower Carboniferous rocks but has similar magnetic character to the area north of SM-25, suggesting a narrow synclinal structure. However, the magnetic response may also relate to a rhyolite or other weakly magnetic rock type, known to exist in this general area. Zone SM-62 comprises two positive anomalies with perpendicular trends, probably separated by faulting; further evidence for a fault is seen in the relative displacement of positive anomalies within zone SM-25 to the north. The two positive anomalies in zone SM-62 have similar magnetic character to those seen in zones SM-25, SM-29, SM-26 and SM-22 (the Strokestown Anomaly), and are ascribed to similar rock types.

5.3.15 BM-19 (Sheets 18 and 19)

This zone outlines a large positive magnetic anomaly, approximately circular but elongated towards the west, which is attributed to the same origin as the BM-11 zone, a deep-seated intrabasement intrusion.

5.3.16 BM-20 (Sheet 24)

Zone BM-20, located on the northeastern side of the Galway Granite, comprises a large positive magnetic anomaly with surrounding negative lobes. An analysis of the Calcomp profiles over this large region, (23 km by 20 km), strongly suggests a sill or a depth-limited block of basement, uplifted relative to the surrounding basement areas. An analysis of the positive magnetic trends indicates that a dyke or dyke swarm may be associated with the feature, which also correlates a large gravity high, (Murphy 1952).

5.3.17 BM-21 (Sheet 18)

This zone is located within the BM-17 zone, south of SM-25. It is attributed to a magnetic body, probably within the basement, which has caused the magnetic positive and negative (dipole) anomaly. Depth estimates put the body 1700 metres below sea level.

5.3.18 BM-22 (Sheet 24)

This zone is similar to BM-20 to the west but trends in a northeast - southwest direction. The magnetic intensity in BM-22 is 172 nT less than that in BM-20; this may be accounted for partly by the difference in size of the two anomalies (BM-20 is approximately three times the area of BM-22). Depth estimates indicate that the sources of both anomalies lie at the same depth but no information is available on the thickness of these bodies which are postulated as sills. The magnetic pattern suggests that the western margin of BM-22 is faulted.

5.3.19 BM-23 (Sheets 29, 30, 35 and 36)

Zone BM-23 covers a very large negative magnetic area of which only the eastern margins are clearly visible from the data. In the north the zone abuts the high frequency anomalies associated with the Galway Granite. The eastern margins are thought to represent faulting along the western edges of the Galway Granite, and the southern part of the zone forms the 'nose' of a long wavelength negative magnetic anomaly. In the south of the zone major basement high and low trends are indicated; the basement high appears to lie at a depth of 4.0 kilometres below sea level and trends approximately east-west, veering to the northeast. However, the basement low trends northwest - southeast and may reach 9.0 kilometres below sea level. The southeastern end of this basement low occurs to the north of Foynes. This basement low is truncated in the south by an east-west trending basement high whose eastern end is marked by SM-49 and SM-49A.

5.3.20 BM-39, SM-49 and SM-49A (Sheet 36)

SM-49 and SM-49A are located within zone BM-39 which is represented by a positive anomaly of intermediate wavelength, indicating a depth of approximately 3.0 kilometres below sea level. SM-49 comprises positive anomalies of high frequency, (and therefore shallow depth), superimposed on BM-39. SM-49A is thought to represent a slightly deeper version of SM-49 to the west. The anomalies within SM-49 are randomly orientated with a roughly circular outline and the three zones taken together are attributed either to a near-surface intrusion or a basement uplift; a combination of the two alternatives is also possible.

The western end of BM-39 is truncated by the interpreted fault F60. This appears to have a relative northwest - southeast displacement of 15 kilometres if, as is suspected, BM-39 was originally an eastern extension of BM-32 (SM-58C). The southern part of BM-39 also is thought to be fault-bounded (F53).

5.3.21 BM-24 (Sheets 29 and 30)

This zone represents a radial expansion of SM-48, composed of a simple magnetic gradient. This zone may represent the deepest rocks associated with the Galway Granite complex.

5.3.22 BM-25 (Sheet 36)

This zone contains a large (22 km by 11 km) negative magnetic anomaly with a northwest - southeast trend. The eastern boundary of this anomaly is abruptly terminated suggesting faulting or a contact. F56 marks the eastern limit of BM-25. In addition, the change of contour direction along the northwestern part of the anomaly is also indicative of faulting.

Depth estimates calculated within and around the zone suggest a local deepening of the magnetic basement, forming a northeasterly extension of the major basement low described in connection with BM-23.

5.3.23 BM-27 (Sheets 35 and 36)

This zone forms the southern boundary of BM-24, the southeastern boundary of BM-23, the eastern boundary of BM-28, the northern boundary of BM-39, the northwestern boundary of BM-34 and the western boundary of BM-25. The zone contains magnetic gradients caused by the influence of anomalies seen in the above zones; as such the BM-27 zone represents part of the basement which is either very deep or non-magnetic and is related to a southeastern extension of the major basement low described in connection with BM-23.

5.3.24 BM-26 (Sheets 30 and 31)

This zone, to the south of SM-47, exhibits similar characteristics to the BM-33 zone with magnetic gradients from the influence of large basement blocks of more magnetic material. As such, the zone would represent a deep magnetic basement or non-magnetic basement of unknown depth. Interference of the magnetic gradients by high-frequency magnetic anomalies indicates the presence of near-surface, probably intra-sedimentary, magnetic rocks.

Depth estimates on the southern and eastern flanks of the magnetic area defining the Galway Granite reveal a gentle deepening eastwards and a rapid deepening to the south and southwest.

The interpreted faulting on the northern boundary of SM-48 is positioned to the south of high-frequency anomalies which, on analysis, indicate depths of less than 1.0 kilometre below sea level with occasional local deepening to 1.4 kilometres. South of this interpreted fault, the magnetic basement deepens rapidly to 4.0 kilometres below sea level, over a horizontal distance of 13 kilometres. A magnetic basement trough, greater than 5.0 kilometres below sea level, develops at a distance of 19 kilometres south of the interpreted fault.

Fault F47 marks the eastern limit of this southern deepening of the Galway Granite. The scarcity of reliable depth estimates in zones SM-47 and BM-26 poses a problem when contouring the basement surface east of F47. The presence of high-frequency anomalies on the southern part of SM-47 adds to the problem.

If these high-frequency anomalies are related to intrasedimentary magnetic rocks then the depths of their upper surface should be ignored and the depth contours west of F47 could be interpolated across F47 and simply decay uniformly to the south. However, if the high-frequency anomalies relate to shallow basement then the basement surface would contour as indicated on the map. In this case the boundary between SM-47 and BM-26 is a fault with a vertical displacement of the order of 4.0 kilometres.

Evidence for the existence of faulting in an approximate east-west direction abounds in the eastern and southeastern parts of the area as well as the northern and southern boundaries of Galway Bay. Further evidence for the existence of a magnetic basement swell is seen to the southwest, where depth estimates indicate shallower basement (4.0 kilometres below sea level), separating the two major magnetic basement troughs, trending towards SM-47.

To the east of SM-47 the magnetic basement appears to deepen very gradually to 3.0 kilometres below sea level over a horizontal distance of approximately 48 kilometres. East of the SM-47/BM-7 boundary, the magnetic character changes to become very open and of long-wavelength, typical of deep or non-magnetic basement. An analysis of Calcomp profiles over this particular region (BM-7, BM-8) indicates the presence of parallel, approximately east-west trending faults, and depth estimates have been calculated from the magnetic anomalies observed. Basement depths may be greater than those indicated since such estimates can only be carried out on reasonably well defined anomalies available in any particular area.

If the fault F47 marks the eastern limit of the main Galway Granite then this fault follows the eastern +5 milligal gravity contour on the 1:750,000 'Gravity Anomaly Map of Ireland'. The +10 milligal contour extends in a sinuous form beyond the position of F47 and forms the eastern side of a localised 'gravity ridge'. The eastern side of this 'ridge' is marked by a continuation of the +10 milligal contour, which defines the outline of an extensive gravity low to the east.

In the west, high-frequency (shallow-depth) magnetic anomalies continue to St. Macdara's Island in the north and Onaght on Inishmore in the south. The 1.0 kilometre basement depth contour passes approximately 4 kilometres to the south of Golam Head, then continues southward to approximately 6 kilometres south of Greatman's Bay. From that point the contour runs parallel to the north of Galway Bay; to the south of Castle Point the contour continues northward to the north of Galway Bay where it turns sharply southwards to Black Head and joins the contours that represent the deepening of the Galway Granite described in connection with SM-48.

The distribution of depth estimates in the Galway Bay indicates that magnetic basement rocks (Galway Granite) lie within 1.0 kilometre below sea level, in the area east of a line from Black Head to Inveran and north of the southern Galway Bay coastline.

The southwestern part of the Galway Granite is particularly well defined, with the high-frequency anomalies abruptly terminated to produce a steep magnetic gradient. This sharp transition of magnetic character probably represents a faulted boundary to the Galway Granite or, less likely, a contact without any relative vertical movement. Partially defined anomalies on the western and southwestern edges of the area indicate the development of longer wavelengths and this suggests a rapid deepening and faulting on this western side of the Galway Granite.

Depth estimates in this part of the area indicate a northeast-southwest basement trough, approximately at right angles to the axis of the Arran Islands. The trough axis runs (approximately) through the northern half of Killeany Bay on Inishmore. The maximum depths are of the order of 2.0 to 2.5 kilometres below sea level, but may extend at greater depth to the southwest. Southeast of this basement trough, depth estimates suggest the development of a small (10 km by 5 km) basement swell at 1.0 kilometre below the sea surface. Inisheer, the smaller of the Arran Island group, is situated on the western end of this basement ridge.

Southeast of the Arran Islands the magnetic basement deepens to a parallel basement trough, approximately 25 km long, which is thought to lie between 5 and 7 kilometres below sea level. This latter basement trough has been described previously in connection with the deepening of the magnetic basement due south of Galway Bay.

5.3.25 BM-28, BM-31, BM-32 and SM-58A, B, C (Sheets 35 and 42)

Zone BM-28, located on the southwestern edge of the survey area, represents the extension of the influence of zones BM-31 and BM-32. These latter zones contain well-defined positive magnetic anomalies that form a sinuous pattern commencing with a broad magnetic high BM-31 southeast of Kerry Head. The anomaly pattern is orientated approximately north-south, east of the Mouth of the Shannon and at this point is narrow (approximately 3 kilometres). The positive magnetic trend once again veers to northeast - southwest with an increase in the width of the anomaly to 10 kilometres, east of Loop Head. The northern BM-32 anomaly is associated with three high-frequency magnetic high trends SM-58A, SM-58B and SM-58C which, from their nature and orientation, resemble dyke-like intrusive bodies. The possible faulted extension of these magnetic high trends has been discussed in connection with BM-39.

Depth estimates in this part of the area indicate local basement deepening to the west and northwest of this line of magnetic high anomalies (southeast of Loop Head and northeast of Kilkee). This suggests that the rocks represented by the positive magnetic anomalies may have acted as a barrier to the western and southwestern development of these basins. If the anomalies of zones SM-58A, B and C are intrasedimentary then they may be related to the widespread volcanic activity in the Chadian, and could be associated with such activity in the southeast of Limerick, west of BM-32. This suggestion is very tentative, requiring more-detailed information from the River Shannon area.

5.3.26 BM-29 (Sheets 42 and 43)

This zone represents a positive magnetic anomaly directed north northwest - south southeast, approximately perpendicular to zone BM-28, and this suggests either faulting or a major contact on the northwestern flanks of the anomaly.

The east-west trend of BM-38 is truncated by the BM-29 anomaly in the southwest though not entirely, since a negative magnetic trend continues to the south of BM-29. In the north the positive magnetic anomaly gradually diminishes in intensity and disappears into the general gradient. The eastern limit is very distinctive and bounded by fault F57. This line is interpreted to represent a major change in the character of the magnetic basement for the following reasons:

(1) Magnetic trends observed in large magnetic zones such as BM-34 change from a uniform east-west to a more random orientation in smaller magnetic zones such as BM-29, BM-38, BM-31 and BM-32.

(2) Magnetic homogeneity, i.e. large areas of similar magnetic response, gives way to a complex, magnetically variable, area across F57.

(3) Magnetic basement depths indicate an increased complexity of magnetic basement swells and depressions compared with large areas of uniform depth east of the F57 line.

However, depth estimates in the vicinity of F57 show no vertical displacement that is discernible within the accuracies of the various depth estimate methods. Therefore, F57 is more likely to mark an unfaulted contact between magnetic basement materials of different magnetic properties. Faulting with vertical displacement is more likely to be associated with BM-31 and BM-32 to the west of F57.

Regional gravity data over this part of the area (Sheet 43) do not offer any conclusions concerning a fundamental magnetic basement contact.

5.3.27 BM-33 (Sheet 30)

This zone represents the transition between BM-24 and BM-26 and contains a poorly defined negative magnetic anomaly trending in a northeast-southwest direction. The zone probably represents an area of non-magnetic basement between the two magnetically distinct basement blocks.

5.3.28 BM-34, BM-1, BM-30, BM-35 (Sheets 35, 36, 37, 43, 44, 49 and 50)

This zones comrpises a major, long-wavelength negative magnetic area which contains a number of high-frequency zones particularly in the northeast, southwest and western sections. Depth estimates in the west and southwest of the zone indicate a basement trough at a depth of approximately 5 kilometres below sea level trending east-west. In the north a narrow basement ridge at 4 kilometres depth becomes more open to the east where the trend changes to a more northeasterly direction. In the southeast a relatively small basement ridge, parallels the main central trough. In the east of BM-34 the character of the magnetic pattern changes significantly with development of an arcuate, generally north-south trending, positive anomaly. Undoubtedly some of this development is influenced by magnetic interference from shallow magnetic rocks close to the south of the Limerick Volcanics, but this would not explain the pattern in the south, remote from the Limerick Volcanics. In addition, the magnetic patterns on the southeast of BM-34 and the southwest of BM-35 indicate a fundamental break between the magnetic low represented in BM-34 to the magnetic lows represented by BM-1 and BM-35.

Apart from the obvious high-frequency anomalies within BM-34, the magnetic gradient is well defined and regular, suggesting that the magnetic basement rocks are generally homogeneous. This contrasts with BM-1 and BM-35, east of BM-30, and these differences increase the likelihood of a difference of basement rock type across BM-30. Depth estimates in this part of the area suggest that a basement ridge develops across the grain of the magnetic basement, trending initially north-south veering northwesterly towards the Limerick Volcanics.

The basement relief associated with this ridge is generally of the order of 1.0 kilometre, increasing to 2 kilometres locally. This interpreted basement ridge is of interest primarily in mineral exploration. Southwest of the Limerick Volcanics, on a line approximately parallel to the interpreted basement ridge, Waulsortian "reef-facies" are extensive and this facies is one of the most favoured host-lithologies for the major base metal occurrences discovered in Ireland.

This basement ridge area must therefore be considered as a priority area for mineral investigation, particularly if reef formation was controlled by such a basement feature.

Zones BM-1 and BM-35 have similar characteristics in this part of the area, with irregular gradients and many high-frequency interference patterns, but BM-35 is more localised and may represent a smaller basement block.

Regional gravity data over this part of the area indicate that the part of BM-1 on sheet 44 coincides approximately with the major gravity low in the area, located to the southeast of BM-34. However, BM-35 lies to the southeast of the gravity low. This major gravity anomaly, however, does not coincide with BM-1; and the northern part of BM-1 on sheet 37 is to the north of the gravity minimum.

5.3.29 BM-37 and BM-38 (Sheet 42)

Zone BM-38 outlines an elongate, east-west negative magnetic anomaly which may be directly related to a much larger positive anomaly to the south. If these are related to each other then the development of this negative indicates that BM-37 and BM-38 form part of the same anomaly, and this is ascribed to a basement block dipping to the south. If the positive and negative magnetic components are not associated with the same feature, then zone BM-38 represents a syncline (i.e. basement trough) and the BM-37 zone a basement swell. This latter conclusion is consistent with the distribution of depth estimates in this part of the area.

5.3.30 BM-40 (Sheet 42)

This zone represents an area of magnetic gradient on the western edge of the area surveyed. Although the magnetic pattern is only partially defined, it may mark the continued deepening of the magnetic basement.

5.3.31 BM-36, SM-57, SM-59 and SM-56 (Sheets 50 and 51)

BM-36 is located along the southwestern margins of the survey area, southeast of BM-37. The zone represents a large positive magnetic region which may originate from magnetic rocks at an estimated depth of approximately 4 kilometres below sea level. Superimposed on this magnetic high area is an elongate, high-frequency positive anomaly, trending east-west, which is interpreted to originate at a depth of approximately 1.6 kilometres below sea level (SM-57). SM-57 extends for approximately 40 kilometres with a rapidly decreasing wavelength to the east until the shortest wavelength occurs over a known outcrop of basic igneous rock east of Kanturk. Although SM-57 can be traced easily from the magnetic data it is not uniformly intense or well defined.

The zone is composed of a number of pockets of elongate, well defined magnetic anomalies, linked together by a general positive magnetic trend. In this form the zone may represent a line of isolated intrusive bodies controlled along a line of weakness; lateral displacement of magnetic positives along a north northeast - south southeast line may indicate faulting.

Zone SM-56, south of the eastern extent of SM-57, exhibits a similar magnetic pattern to SM-57 and may be a deeper equivalent of basic igneous material, or a fault-displaced continuation of SM-57.

On the western side of F59, BM-36 has an approximately circular outline and the localised nature of this zone, and the possible association with SM-57, suggest that BM-36 represents a deep intrusive body.

SM-59 is located between the eastern tip of SM-57 and the western end of SM-56 and outlines a small magnetic positive area with a small well developed negative to the south. Local variability indicated from the depth estimates in the area suggest that SM-59 may represent a basement swell with the magnetic negative representing a local basement trough.

Depth estimates in the southern part of the area (Sheet 50) indicate a local basement low and high with a northeasterly and northwesterly trend respectively. These trends are poorly defined because of the limited available depth values and may be modified when more data are collected. East of this area the depth estimates outline the southern margin of the major basement low to the north (Sheets 43 and 44).

5.3.32 BM-41 (Sheets 44 and 45)

This zone lies immediately southwest of BM-1 and magnetically is very different. The magnetic contours run north-south for the most part and the zone is dominated by a long wavelength low anomaly located over a Lower Palaeozoic inlier at Slievenamon Mountain. The magnetic pattern is dominated by a series of positive and negative trends, striking almost east-west. BM-41 is possibly folded and locally intruded by east-west striking dykes. The magnetic low anomaly centred over the Slievenamon Mountain inlier may be due to a batholith which has been reversely magnetised. The likely presence of igneous material is suggested by zones BM-1, BM-1B, SM-66 and SM-67 to the east, which are all related to the Leinster Granite and igneous bodies of dioritic and andesitic material.

5.3.33 BM-42 (Sheet 39)

BM-42 lies along the southern limit of the present survey, south and southeast of SM-65. It is comparable with SM-65 except that the magnetic anomalies in BM-42 are of longer wavelength. Because the zone is ill-defined due to lack of magnetic data further south, it is difficult to predict the nature of the source rocks but it would seem that it is similar to SM-65 but at a relatively greater depth. On the other hand, the possibility that the source rocks are of granitic composition cannot be ruled out.

5.3.34 BM-43 (Sheet 33)

BM-43 lies directly south of SM-65A and east of SM-65. It overlies Cambrian rocks of the Bray Series and the Ordovician/Silurian rocks east of the aureole zone. Its main feature is a long-wavelength positive magnetic anomaly with isolated lows around its perimeter. The source of the anomaly is not very deep - 1 km or so below sea level. This positive magnetic anomaly appears to be related to the Manx High (Inamdar, pers. comm.) which seems to extend from the Isle of Man to Ireland. It is interpreted as a thick plate of magnetic material with a wide base thus giving rise to negative anomalies along its perimeter.

5.4 Basement Topography Within the Survey Area

The magnetic basement is seen to slope towards the north from 3 kilometres below sea level (around Kildare) to between 9 and 10 kilometres immediately east of Longford. North of this local basement depression the magnetic basement shallows relatively sharply to a line south of Cavan and then assumes a gentle shallowing northwards. South of the localised depression the magnetic basement assumes a deep trough 7 kilometres below m.s.l., and 25 kilometres broad. It is extensive to the northeast but dies out in the southwest around Kilconnell. South of the main axis of this basement trough the basement shallows to form a basement ridge 3 kilometres below m.s.l. It is slightly offset from the axis of the Slieve Bloom Mountains, trending parallel to the main magnetic basement trough. The magnetic low in this area is truncated by the development of a major east-west trending basement ridge on the eastern flank of the Galway Granite Complex.

North of BM-5, in the eastern part of the survey area, a strong magnetic gradient is interpreted as a major fault (F37, the Southern Uplands Fault), which may have upthrown the magnetic basement to the north. Seismic refraction data from the UK (Bamford, 1977) give some support to this idea. Although magnetic basement depths in this part of the area are scattered, interpolation of depths (shallowing to the north) is in broad agreement with this particular concept. However, depths obtained in zone SM-21 may not relate to basement material, but to an intrasedimentary source as discussed in section 5.2.21.

In the western part of the area, the character of the magnetic basement changes dramatically, initially to the west of a line defined by faults F31, F32 and F33, and then further westward by fault F46 and northwestward by faults F34, F35, F36 and F38. The long-wavelength, open magnetic pattern gives way to a very complex area of short-wave-length anomalies indicating shallow basement and probably a change in the composition of the basement rocks. Although this change occurs over the faulted area described above, the 1:250,000 total intensity magnetic contour map vividly displays the change along a line trending generally north northeasterly on the western edge of sheet 14 in the north, east of the Strokestown Anomaly on sheet 19, east of BM-9 on sheet 25 and on the western edge of SM-46 (the short wavelength anomalies thought to be associated with the Galway Granite).

The basement topography changes rapidly to the east of the Strokestown Anomaly. The deep basement shallows from 7 kilometres (below m.s.l.) to 1 kilometre or less in a horizontal distance of approximately 12 kilometres. This basement shallowing is probably associated with faulting and folding; indeed west of the Strokestown Anomaly the basement deepens again to 2 kilometres (below m.s.l.) over a horizontal distance of approximately 7 kilometres. The basement topography to the west of the basement ridge of sheets 19 and 25 is complex but appears to consist of two large basins, approximately 30 km by 9 km in the north, and 30 km by 25 km in the south, with a minor basin on the northeastern flanks of the Galway Granite. Depth estimates in the north indicate a gradual deepening of the magnetic basement south of the Ox Mountains and the Curlew Mountains to a maximum depth of 3 to 4 kilometres (below m.s.l.) in the northern region. South of this basement trough an approximately east-west trending ridge is indicated (shallower than 3 kilometres). South of this ridge the magnetic basement deepens into the southern broad depression. Outside these low areas the magnetic basement shallows to the north, east, west and very sharply on the northern flank of the Galway Granite in the south. An analysis of Calcomp profiles in this part of the area indicated the presence of large sill-like bodies. Depth estimates in these areas may not relate to true magnetic basement.

This enclosed northwestern area is truncated in the south by shallow magnetic basement which includes the Galway Granite and an eastward, east-west trending high area which extends to the eastern part of sheet 31.

South and southeast of the Galway Granite the magnetic contour pattern appears to be less complex. The magnetic basement to the immediate southwest of the Galway Granite appears to form a parallel, northeast - southwest trending ridge and trough (few magnetic data are available to the west to confirm this). The basement trough is estimated at a depth of 2 kilometres (below m.s.l.) and the basement ridge at a depth of 1 kilometre. East of these features, and south of the Galway Granite, the magnetic basement appears to deepen gently southwards to a local magnetic basement low with a depth approximately 5 kilometres (below m.s.l.). The southern flank of this low is marked by a swell at 4 kilometres (below m.s.l.). The eastern end of this part of the area is characterised by the development of a strong northeast-southwest basement trough (down to 5 kilometres below m.s.l.). The northern edge of this trough is marked by a major east-west ridge (east of the Galway Granite), and the southern edge by an approximately east-west trending basement feature west of F56.

The eastern side of the northeast - southwest trending trough is marked by a northwest - southeast basement ridge, with a subsidiary high to the northeast trending northeast - southwest. Further east, is an east-west trending basement with a depth of 5 kilometres (Sheet 37, northern part).

The south of this area is dominated by a major basement trough (50 km by 28 km), trending east-west, attaining a depth of 5 kilometres (below m.s.l.). To the north is a long narrow (50 km by 7 km) basement ridge (Sheet 43). The eastern end of the trough is marked by a basement ridge, locally trending approximately north-south and at a depth of 3 kilometres (below m.s.l.), and also by a more general, larger high, trending east-west at 4 kilometres below m.s.l. North of this eastern high area a local basement depression is indicated with a depth of 6 kilometres below m.s.l. at the junction of sheets 37 and 44.

In the southwest of the area, west of a line defined by the faults F56, F57 and F58, the magnetic basement appears to be very complex. The development of the narrow magnetic basement ridge (sheet 43) described above has apparently caused a bifurcation of a basement trough to the west on sheets 35 and 42. The central part of this trough at a depth of 7 kilometres occurs in the western part of the area in the region of the Mouth of the Shannon.

The magnetic basement trough at the 5 kilometre level develops eastwards in the form of narrow (approximately 10 km) 'channels' to the north and south of the ridge on sheet 43. The southern 'channel' is less extensive than the northern 'channel' but both display local deepening to 6 kilometres below m.s.l. The northern channel swings back on itself around a magnetic basement swell situated at the junction between sheets 35 and 36. The continuation of this 'channel' northeastwards from Askeaton, culminates in the development of a basement depression which may be as deep as 9 kilometres below m.s.l. In the extreme southwest of the area a number of magnetic basement ridges and troughs are indicated.

In the southeast of Ireland, the survey has revealed that basement zones BM-2 and BM-1 are characterised by numerous ridges and troughs, having a strike direction varying from northeast - southwest to generally east - west. Eastwards parts of the area have average depths of about 3 km below m.s.l., but northwest of Kilkenny, there exists a trough with depth values of 7 km below m.s.l., the axis of which corresponds with the northern margin of the southwestern extension of the main Leinster coalfield.

It should be noted that the contacts between zones BM-1 and BM-2 and between BM-1 and BM-41 play a significant role in controlling the development of the extension of these ridges and troughs. These contacts seem to set the eastern limits of these structures. Southeast of Port Laoise, and east of Abbeyleix the BM-2/BM-1 contact runs almost north-south to Castlecomer; if this contact were to be extended further south, it would coincide with a major fault, east of Kilkenny and merge with the BM-41/BM-1 contact near Callan. It can therefore be inferred that BM-1 has been the most stable of these zones. It is also possible that contacts BM-2/BM-1 and BM-41/BM-1, particularly the parts which strike north-south, could be fault lines. As can be seen east of this line on BM-1, north of Carlow there is an east-west trough with depth values more than 3 km below m.s.l. Immediately west of this line on BM-2 there is an east-west ridge with depth values less than 2.5 km below m.s.l., where there seems to be a sudden increase in depth of about 1 km from west to east.

Over the Leinster Granite, the basement appears to be shallowing southeastwards except along the Wicklow coast. There are a number of local ridges and troughs of variable strike, located over the Leinster Granite or its mapped boundaries. The depth values vary between 1 and 3 km below m.s.l. Along the Wicklow coast and over the Cambrian, there are east-west ridges and troughs whose full extent to the east is not defined as they lie outside the survey area. Here the depth values seem to be in the range of 1 to 2.5 km below m.s.l.

Further to the southeast, basement topography is not well defined because of the limited extent of the survey area and also because of interference from shallow magnetic sources.

5.5 Correlations between Gravity and Magnetic Data

In this section a comparison is made between the magnetic data and some of the gravity data recorded in Central Ireland (Murphy, 1952 and Thirlaway, 1951).

(a) The Bouguer gravity profile between Longford and Kingscourt.

The gravity anomaly measured over this area is not constant and generally less than 20 mgals; no correlation exists between the gravity data and the surface geology. The source of the anomaly is expected to be produced by rocks under the Lower Palaeozoics. Murphy considered a granitic mass, (a possible extension of the Newry granite) with a density of 2.65 gcm^{-3} situated beneath Lower Palaeozoic rocks with a density of 2.73 gcm^{-3}, to account for the observed gravity anomaly. This granite is centred beneath Granard.

The aeromagnetic data indicate a steep magnetic gradient along a line from Longford to Kingscourt (BM-5/BM-6) and this would not agree with the concept of a granitic mass in the area. However, such a body may explain the magnetic pattern seen in BM-5 to the north of the area. Depth estimates indicate a local magnetic basement deepening to the east of Longford which may extend to 9 or 10 kilometres below sea level or 2 to 3 kilometres below the average magnetic basement level in the area. This deepening is too localised, however, to account for the observed gravity effect. The possibility that the low is more extensive than indicated cannot be ruled out because of the scatter of depth estimates in the area. Computer modelling using densities indicated by Murphy tends to rule out the basement low as a possible cause for the observed gravity low.

(b) The Bouguer gravity profile along a southwest-northeast line through Galway.

The Bouguer anomaly along a line between Tuam in the northeast, through Galway, and south to Ennistymon is well defined and the contours in the north follow the outcrop of the granite; but the outlines indicate that the centre of the mass lies in Galway Bay. The main conclusions from the gravity data are that the Galway Granite is about twice as large in extent as the mapped outcrop; to the east about 13 kilometres further under the limestone, and to the south about 16 kilometres under Galway Bay and under the limestones of North Clare. The boundary is not reached in the west. To the north and south of the granite, rocks of Carboniferous age outcrop; in the south the increase in thickness of sediment probably attains 800 metres; in the north, the Carboniferous and Devonian deposits are thought not to be more than 800 metres thick. Lower Palaeozoics or Dalradian rocks containing dense intrusives were postulated to account for the increase in the Bouguer gravity in the north of the profile.

The most striking feature from the aeromagnetic data is a line of discontinuity on the northeastern side of the Galway Granite. The high-frequency magnetic response from the Galway Granite changes across this line to long-wavelength anomalies in the northeast. Depth estimates in the area suggest that the magnetic basement on the northeastern side of the granite is as deep as 3 kilometres locally,but the magnetic basement shallows to the northeast.

Calcomp profile analysis in this region suggests the presence of a large sill probably associated with dykes on the down-thrown side of the fault. This plate-like magnetic body may explain the gravity high on the northern side of the Galway Granite.

The magnetic data indicate an eastern extension of those anomalies that are probably associated with the Galway Granite, of 16 kilometres which is in broad agreement with Murphy's results. The southern extension of high-frequency anomalies, suggests that the Galway Granite continues for at least 20 kilometres southwest of Galway City and possibly a further 10 kilometres to the southwest. Depth estimates in this area indicate that the magnetic basement deepens gently to the south and reaches a depth of 4 kilometres in an area approximately 42 kilometres southwest of Galway City. A basement depth of 2 kilometres is indicated 20 kilometres southwest of Galway City.

The continuation of high-frequency anomalies to the west ends abruptly between Inisheer and Inishmaan in the Aran Islands, suggesting that the Galway Granite does not continue at shallow depth beneath Inishmaan and Inishmore.

(c) The Sligo-Cork Traverse. (Thirlaway, 1951)

In the north of the area the anomalies increase towards Longford before decreasing by about 15 milligals. This low was thought to be due to thickening of the Old Red Sandstone by a maximum of approximately 800 metres. Such rocks outcrop close to the centre of this gravity low. Where Silurian rocks outcrop, anomalies tend to be high. South of Galway the anomalies vary in a way expected from the surface geology with highs on the strike of Silurian rocks exposed in the core of Slieve Bernagh and on the strike of Slieve Aughty. The nature of the Old Red Sandstone boundary north of Limerick and the sharp fall of the anomalies suggest that this is a faulted boundary, though density of observations was limited in the area to show this clearly. The maximum increase in thickness of the Old Red Sandstone required to explain the anomaly at Limerick is approximately 800 metres, though some of the anomaly can be explained by thickening of the Carboniferous Limestones.

The aeromagnetic data over the part of the area covered by the traverse indicate the following characteristics:

In the north, the gravity anomaly increase is seen over the SM-25 zone, thought to represent shallow igneous rocks on the northern side of the Curlew Mountains. Further south, the gravity low coincides with a large north-south trending magnetic low and the northeastern edge of a magnetic basement low indicated from the depth estimates. The fault indicated north of Limerick is not observed from the magnetic data though numerous east-west faults have been established in the general area.

(d) The Strokestown Anomaly.

This anomaly was studied by Murphy (op.cit.) and the following discussion compares the gravity data over the area at 1:63,360 scale and the aeromagnetic data.

The magnetic anomaly at Strokestown consists of a long linear northeast-southwest magnetic high with an approximately linear, coincident gravity high. The Bouguer gravity high can be divided into two parts: the eastern high correlates almost exactly with the topographic expression of the Silurian rocks. The gravity high is restricted along its length (approximately 29 kilometres) to the observed outcrop of older rocks, and narrows sharply northwards. The gravity and magnetic highs are offset in the eastern part. The western part of the gravity high, centred approximately on Strokestown in the north, extends in a northeast-southwest direction for a distance of approximately 26 kilometres but then assumes a more east-west trend. The gravity high is located to the north of the axis of the magnetic highs but diverges in the southwest.

The gravity pattern outlined above suggests a correlation with anticlinal structures, i.e. shallow basement areas probably associated with intrusives represented by the magnetic anomalies.

Indeed, depth estimates in this general area indicate two magnetic basement high areas trending parallel to the eastern gravity high. The two high areas are offset from each other to the east of Strokestown, and diverge from the axis of the magnetic highs in the southwest. This suggests that the western gravity high is related more to the presence of the intrusives than to a magnetic basement high indicated from the depth estimates.

Two magnetic profiles were constructed across the Strokestown anomaly ($A - A^1$ and $B - B^1$) and one gravity profile ($C - C^1$) (see interpretation map) was constructed across the northwestern gravity low. Computer modelling was carried out in order to establish the nature of possible structures that might account for the anomalous area.

Model A, in the north of the anomaly, was evaluated with the idea of a deep-seated (infinite depth-extent) dyke 1.7 kilometres wide, generating periodic lava flows. These conformable lava flows may have been subsequently folded or were intruded into pre-existing folded rocks. The thickness of intrusive material necessary to produce the observed response (using a susceptibility contrast of 1.02×10^{-3} c.g.s. units/cc) is 1.5 kilometres. This could be accounted for if intrusion had continued intermittently over an extended period of time. The presence of such a configuration (Model A) in this area would indicate a fundamental association with the magnetic basement and deformation in the area may account for repeated intrusive activity. The presence of vertical accumulation of lava flows may explain the limited extent of the magnetic anomaly with the lavas thinning northward and possibly extending southwards over a larger area (MB-9).

Model B across the southern part of the anomaly (across the northeast-southwest trend) involves a dyke of approximately the same dimensions as that in Model A but without a lava 'cap'.

The gravity model (C) was calculated across the northeast-southwest trending gravity low on the northwestern side of the Strokestown anomaly using a density contrast of $-0.3\ gcm^{-3}$.

The model indicates a relatively rapid deepening in a north northwest direction to a maximum of 3.6 kilometres and a more gentle shallowing north northwestward of this low. The aeromagnetic data indicate a similar configuration for the magnetic basement in the area.

5.6 Correlation of the Magnetic Data with Mineral Occurrences

The mineral localities shown on the interpretation map have been taken from Cole (1956) and from information regarding recent large lead-zinc discoveries made available by the Geological Survey. The approximate positions of mineral occurrences are shown.

The lead-zinc ore deposit at Navan corresponds to the nose of a positive magnetic anomaly in SM-5b. The anomalies in SM-5 have been attributed to igneous rocks, probably of Ordovician age. However, if Carboniferous igneous rocks should exist, then a genetic relationship is possible. The ore deposit is known to be located (Sevastopulo, 1979) at the junction of a northeast-southwest and east - west fault. The northeast - southwest fault may be F7 or an off-shoot of it, and the east-west fault is probably depicted by the northern boundary of SM-5b (F45). A copper-lead occurrence is situated to the east of Navan on this same contact. Therefore, this boundary would appear to be worth investigation especially where F7 cross cuts it.

The Ballinalack deposit is located on the nose of the long wavelength positive anomaly in BM-6. BM-6 is regarded as being caused by a deep source and thus there is no definite correlation although the magnetic contours trend the same way as the north northeast fault at Ballinalack.

The deposit at Keel is located in an east northeast trending fault and is situated on a quasi-regional gradient between BM-5 and BM-6 and close to a bulge in the magnetic contours caused by SM-20. As has been suggested before, this fault may be one of a number parallel to BM-5/BM-6, subsidiary to a major fault/contact. If this is the case then this contact zone is worthy of an investigation in Lower Carboniferous areas.

The mineralisation at Moate lies close to the Moate inlier. It is situated on a magnetic gradient and close to the easterly projection of SM-17. Other mineral sites are located close to zone SM-15, which has a similar pattern to SM-17.

The newly found mineralisation at Harberton Bridge, County Kildare, is located on a steep gradient between SM-12 and SM-4. The relationship between SM-4 and SM-12 has been discussed in Section 5.2.14. The gradient may define a north northeast - south southwest fault line, which should be investigated.

The Tynagh deposit is located on the southwestern edge of a long-wavelength negative magnetic anomaly, centred on Balinasloe and orientated approximately northeast - southwest. Depth estimates indicate that the deposit is located over a magnetic basement ridge about 1.0 kilometre below sea level. Coherent magnetic contour flexures on the southern side of the negative magnetic anomaly indicate faulting in an east northeasterly direction, roughly coincident with the Tynagh deposit. In addition, a north northeast - south southwest fault, F46, interpreted from the contour trends, and cross-cut by the former fault, is located close to the deposit. An important feature of all the large deposits in the Lower Carboniferous is their association with east northeasterly and northeasterly trending faults except Abbeytown (A. Evans, 1976). At the Tynagh Mine the main fault zone has been shown to extend vertically for more than 500 metres. If the flexures seen on the magnetic map represent this fault then the fault extends for at least 75 kilometres to the east and northeast and 5 kilometres to the west of the Tynagh deposit. A controlling influence from F46 cannot be established here but may be important.

Similar fault patterns are observed from the magnetic data further south in the Silvermines area. "In the Silvermines district a number of zinc-lead deposits with differing styles of mineralisation and different host rocks have been mined, or are known from drilling. They all lie within, or are adjacent to, the major east northeast trending, complex, Silvermines Fault Zone. This has the net effect of juxtaposing the Silurian and Old Red Sandstone rocks of the Silvermines Mountains and the Limestones of the valley to the north " (G. Sevastopulo, 1979). In addition, mineralisation is thought to be related to northwest trending faults. The magnetic data suggest the presence of faults of both types, and these appear to extend over a wide area (the priority follow-up area on the interpretation map (Sheet 37)). In fact the general pattern of faulting extends over a much wider area. The magnetic evidence for northwest faulting increases to the south and southwest of Silvermines (Sheets 36, 37, 43 and 44), reinforced by the presence of volcanic rocks indicated on these sheets. North of Silvermines, faulting with these dominant northwest-southeast and east northeast - west southwest directions is less obvious from the magnetic data. This may be related to a change in magnetic basement across the area, separating the Northwest and Southeast Plates of Ireland.

The Gortdrum, Aherlow and Mallow copper deposits are located in a magnetically similar area and in particular the Gortdrum and Aherlow deposits are located on the eastern edges of BM-30 (Sheet 44), thought to represent a basement high area (depth estimates are scattered in the area). "The occurrence of intrusive igneous rocks at Gortdrum is judged to be incidental to the origin of the ore, but the presence of a large massive intrusive plug may have promoted the formation of open fractures in the surrounding limestones and shales during deformation" (Sevastopulo, 1979 from a personal communication by P. Taylor).

The Gortdrum deposit is located on the eastern flanks of a circular magnetic feature (SM-53 and SM-54) thought to be an intrusive body at shallow depth, and because of the reduced magnetic intensity relative to the generally basaltic Limerick Volcanics on the northern rim of SM-53 and SM-54 the intrusive body may be an acid igneous type. North northeast faulting is indicated along the eastern margins of the zone, located close to the Gortdrum deposit.

The Aherlow deposit is remote from the above interpreted intrusive body to the southeast, south of the Gortdrum deposit, along the eastern margins of the magnetic high area (BM-30); again faulting is indicated close to the deposit.

The Mallow deposit is located on Sheet 50, and north northeasterly faulting is indicated to the west of the deposit. Lateral displacement of the SM-57 zone is indicated by a similar magnetic pattern in the southeast.

The Ballyvergin copper deposit is located in a magnetically different area, on Sheet 36, west of a north-south lineation (F47). The deposit is located in a magnetic gradient area on the western edge of a basement trough (5 kilometres below m.s.l.).

The mineral deposits at Avoca, Co. Wicklow are located on Sheet 39, on a gradient of one of the local magnetic highs, which is part of zone SM-65. The association of the mineral occurrence with the magnetic high indicates a possible genetic link with igneous rocks as indicated by the magnetic anomaly.

Discussion

Three large magnetic anomalies dominate the southern and southeastern parts of the survey area (BM-1, BM-30 and BM-34). Magnetic basement topography, deduced from depth estimates, indicates that these zones represent large areas with low relief. As such they would be expected to represent stable blocks within the magnetic basement.

Zones BM-34 and BM-1 are divided by a magnetic basement ridge, which appears to lie on a projected arc from the Limerick Volcanics. Relatively steep magnetic gradients on the edges of this zone are thought to be due to faulting. The presence of a basement ridge in this area may also have some association with the development of Walsortian 'reef' facies in this area.

The Carboniferous volcanic rocks at Pallas Green extend as dykes and plugs across to the Gortdrum deposit where they are intensely altered. The dykes carry minor copper and lead values. Thin tuff beds at Aherlow may be connected with this centre and Morrissey et al (1971) suggests that the tuffs at Tynagh (70 km to the north) may also represent wind-borne ash from the Pallas Green centre.

These tuffs, however, may represent material from a concealed igneous centre, and Williams (1971) considered that the association between mineralisation and volcanism in Ireland is closer than now apparent.

Interesting, SM-74A (Sheet 30), 20 kilometres to the southwest of Tynagh, exhibits a similar magnetic response to SM-53/54 west of the Gortdrum deposit. Therefore the tuffs may be more local than originally suggested.

Of the other mapped mineral localities, two of them lie on or very close to interpreted deep magnetic contacts.

5.7 Summary

The eastern and southeastern parts of the survey area are composed of an open, long-wavelength magnetic pattern representing deep magnetic basement rocks (BM-6) about 6 km below sea level. Magnetic basement at intermediate depths of between 3 and 6 km is indicated by the magnetic patterns associated with BM-5 and BM-7. Zones BM-1, BM-2, BM-3, BM-4, BM-12, BM-13, BM-41, BM-42 and BM-43 are thought to represent basement generally at or less than 3 km below m.s.l.

Superimposed on these deep basement areas are a number of high-frequency magnetic zones. Zones SM-1, 4, 5, 8, 12, 19, 63, 64, 65, 66 and 67 are interpreted to reflect igneous rocks of Lower Palaeozoic age. Devonian igneous rocks are probably responsible for the zones SM-21 and SM-23. Zones SM-10 and SM-68 are attributed to Carboniferous igneous activity.

Cross-cutting the northeast of the survey area are a number of linear magnetic patterns thought to be due to Tertiary dykes (D1, D9 and D15 are the most persistent).

The main mass of the Leinster Granite is represented by part of Zones BM-1 and BM-1A. The latter occurs over the northern part of the Leinster Granite and has a distinctly different magnetic pattern compared to that in the southeastern part of the Granite, thus splitting the main mass into two major units may have a differing history of magmatic differentiation.

The western part of the survey area is in marked contrast to the east. A north northeasterly line divides the area (clearly distinct on the 1:250,000 magnetic intensity contour map, east of Strokestown and across the eastern side of the Galway Granite). The change in magnetic character occurs in a complex manner east of this line. The relatively uniform basement in the east gives way to a complex shallow basement enclosed by: the Ox Mountain Anticline and Curlew Mountain Pericline in the north; the Strokestown basement high in the east; the Galway Granite in the south; and the Sheeffry Hills and Maumturk Mountains in the west.

In the northwest of this part of the area zones SM-26, SM-27, SM-28 and SM-29 are related to the igneous complex of the Ox Mountain Anticline. The magnetic expression of these rocks extends to the south and southwest of the mapped outline. A narrow, positive magnetic trend, which is dominant in the area, is thought to be due to a dyke, or a series of dykes, or a banded magnetic rock unit (D21).

A parallel group of magnetic zones with similar character approximately correlates with the outline of igneous rocks on the northern flank of the Curlew Mountain Pericline (SM-25). Zone SM-25 is extensive and diverges from the mapped outline of the Curlew Mountain Pericline, and as such does not appear to reflect the presence of the volcanic rocks in the Devonian sequence known in the area. The northern edge of SM-26 coincides with the Curlew Mountains fault. In the southwest of SM-26 the magnetic pattern continues at shallow depth and may be related to SM-31 whose eastern margin is abruptly truncated and probably down faulted. Narrow linear magnetic anomalies (D22) are attributed to dykes or banded magnetic rocks.

Between the Ox Mountain Anticline and the Curlew Mountain Pericline the magnetic anomalies are of longer wavelength indicating deepening of the source rocks. Zone BM-15 is interpreted to represent a basin or trough, which may be enclosed or shallow at its southwestern end, deepening to the northeast, into the Lough Allen Basin. Zone BM-15 shallows gently to the northwest and is down faulted abruptly in the southeast.

The southern edge of zone SM-25 is less abrupt than the northern edge and anomaly wavelengths increase gradually southwards. In the east the magnetic pattern is more complex with the introduction of BM-11, BM-18 and SM-34, and SM-24 thought to represent complex, relatively shallow sources 1 to 2 km deep (except for BM-11 which magnetic modelling indicates may be much deeper). This area, west and northwest of Strokestown, is thought to have suffered intense deformation and intrusion.

To the west of this area the magnetic data indicate an area of deeper basement (approximately 3 km) which extends to the Galway Granite in the southwest and to zone SM-33 in the west. Magnetic anomalies in this area suggest the presence of: sill-like magnetic bodies such as BM-20; igneous intrusive rocks such as BM-19; differentiated basement blocks (e.g. BM-21); and areas of shallow basement areas such as BM-9 and SM-20.

In the west, zones SM-33 and SM-33A are interpreted as part of the Galway Granite, remote from the main mass. Zone SM-33 contains a linear magnetic anomaly group (D23) which may be a dyke or magnetic band of rock in the Connemara Schist. The eastern edge of this zone is probably down faulted; and zone SM-30 is ascribed to a shallow extension of magnetic basement rocks seen in SM-33.

The main mass of the Galway Granite is represented magnetically by zone SM-46. Within this zone two major sub-units have been defined, SM-46A and SM-44. Zone SM-44 coincides with the centre of the gravity low over the granite and exhibits a well defined circular pattern on the south of Spiddal in Galway Bay. Zone SM-46A, west of SM-44, is also distinctive but is elongated north-south and probably faulted along most of its length.

In the west of the main SM-46 zone, the magnetic anomalies are high-frequency and trend strongly east-west, and their linearity increases from north to south. On the southern edges, in the west, the magnetic pattern changes abruptly (SM-41/BM-23), and this is attributed to a change in the magnetic basement. On the northeastern margins of the granite the character of the magnetic basement changes abruptly along a northwesterly line. On the high-frequency side of this line the anomalies tend to be linear, and zone SM-34 relates to metamorphic rocks. On the low-frequency side of the line (to the northeast) the magnetic basement is apparently 3 km below m.s.l., shallowing to the northwest towards zone SM-33. On the east, the magnetic anomalies continue to F47 and possibly further east at shallow depth (SM-47). On the southern edge of the granite the magnetic anomalies increase in wavelength and the east northeast fault separates SM-46 from SM-48, where the anomalies begin to change in character from the shallow anomalies of the granite to the deep basement areas BM-24. The depth estimates south of SM-48 indicate a complex series of basement ridges and troughs with an east-west to northeast-southwest trend (BM-24, BM-23 and BM-28). East of F56 the orientation of magnetic basement features is complex with northeast and northwest trends.

Further south, the magnetic pattern is more open suggesting deep basement, and the south central part of the area is dominated by two very large magnetic lows, 47 kilometres wide and an overall length (to the limit of the data in the east) of 260 kilometres, (BM-34 and BM-1). The western low (BM-34) is separated from the eastern low (BM-1) by a magnetic high (?) area (BM-30) which lies on a projection of the line of shallow magnetic rocks, of Visean age, the Limerick Volcanics (SM-50 and 52). The size of the large magnetic lows, their magnetic character, and the relationship between these and other magnetic anomalies which appear to 'flow' around them (a similar picture is indicated from depth estimates) suggests that this magnetic pattern relates to a stable basement block of a relatively homogeneous composition. With these considerations in mind the zones may relate to an extension of the Leinster Granite at a general depth of 5 km below m.s.l., or to another similar granitic body. Gravity data indicate that a major gravity low is located to the south of these magnetic lows.

Zone BM-34 is spatially, if not genetically, related to igneous activity: in the northeast (SM-50, SM-51, SM-52, SM-53 and SM-54); in the centre by SM-60; in the south west by SM-57; and, possibly, in the northwest by zones SM-49 and SM-49A (the magnetic response in this last zone could be explained partially by cultural features).

According to depth estimates, BM-30, which separates BM-34 from BM-1, is related to a basement ridge, and may have been important in the development of reef limestones in the area. As such, and because of the numerous mineral deposits related to the Waulsortian reef limestones, the zone is worthy of more detailed study. A continuation of this high zone may exist across the area to link up with SM-47, but this is not confirmed from depth estimates.

West of BM-34, along a line defined by F56, F57 and F58, the magnetic pattern is more complex. Zones BM-32 and BM-31 form a sinuous positive magnetic trend which cuts across a more northwest-southeast trend and which appears to be associated with the development of deep basement lows in the west. (Data, however, are limited on the western edge of the survey area). In the southwest of BM-34, the magnetic pattern trends east-west and BM-36 may represent a deep seated intrusive body.

Northwest of BM-34 (between the Galway Granite and BM-34) the magnetic pattern consists mainly of magnetic gradients and is deceptively simple. Depth estimates indicate a complex series of basement highs and lows, trending initially east-west then northeast-southwest. The variability in basement relief is consistent with the idea of deformation of magnetic basement rocks between two stable basement blocks; the Galway Granite and BM-34 (the Leinster granite or a similar body).

North of BM-34 (east of F47) the magnetic pattern is similar to the pattern in SM-53, SM-54 and BM-30, and is probably bounded by north-south faults or contacts. The magnetic anomalies in this area (BM-26) may relate to a transition zone of basement material. East of this zone the magnetic pattern is dominated by extensions of long-wavelength anomalies from the northeast of the area and by a large magnetic high BM-13.

Correlations between Murphy's gravity work and the aeromagnetic data indicate a reasonable agreement in the vicinity of the Galway Granite, the Leinster Granite, Strokestown and the Sligo-Cork traverse. However, in the Granard district no evidence of a granitic mass, as postulated by Murphy (1952) is seen from the magnetic data; a local basement low, east of Longford, is unlikely to account for the observed gravity low.

There is good correlation between the aeromagnetic data and known mineral occurrences, especially with regard to faulting and possible igneous associations. In particular, faulting at Tynagh, and cross-faulting at Silvermines. Further south to Gortdrum and Aherlow deposits are spatially related to zone BM-30 and a shallow zone, possibly an intrusive, (SM-53/54). A similar zone is seen west of Tynagh (SM-47A), east of Galway.

6. CONCLUSIONS

(1) From the magnetic data 43 deep magnetic zones and 68 shallow magnetic zones have been delineated.

(2) The aeromagnetic data have indicated that the magnetic basement in the survey area is very complex and can be divided into five distinct units:-

(a) A large homogeneous basement area in the northeast (Sheet 20) with a depth of 7 km below m.s.l. The dominant features of the deep magnetic zones are the 'Virginia anomaly' (BM-6) and a similar anomaly, negative instead of positive, to the north (BM-5). These anomalies are best explained as two basement blocks, one reversely magnetised and the other positively polarised. These blocks are probably related to differential igneous or metamorphic processes, enacted during the Caledonian Orogeny.

(b) A very complex, inhomogeneous, basement area in the northwest with an average depth of 3 km below m.s.l. (Sheets 18, 19, 24 and 25).

(c) A large homogeneous area in the south and southeast of the survey area, thought to relate to an extension of the Leinster Granite with a depth of 5 km below m.s.l. (Sheets 38, 39, 43, 44 and 45).

(d) A very complex magnetic basement area in the southwest, with an average depth of 5 km (Sheets 35, 36 and 42).

(e) A large central area north of BM-34 and BM-1 with an average depth of 3 km below m.s.l.

(3) The transition between the northeast and northwest magnetic basement areas occurs along faults F38, F36, F34, F33, F32 and F31 east and southeast of Strokestown.

(4) More generally this line of transition can be extended to the southwest of Strokestown to link with F46, F54, F56 and F57, thus dividing the area into two parts.

(5) Depth estimates indicate the existence of a large flat-bottomed area (7 km) to the east of Strokestown; a shallow northwestern basin (3 km) bound by a basement high (Strokestown) in the east and southeast; by the Galway Granite in the south and southwest, by the Ox Mountains and Curlew Mountains in the north and by outcropping basement rocks in the west.

The area between the Galway Granite and BM-34 is very variable, and the complex nature of the basement relief is consistent with the idea of intense deformation between two stable basement blocks.

From depth considerations the area can be divided into north-south blocks by an east - west basement ridge east of Galway.

(6) Shallow magnetic basement areas related to the Galway Granite, the Ox Mountains, Curlew Mountains and Strokestown are well defined.

The magnetic pattern associated with the igneous rocks on the northern flanks of the Curlew Mountains and the Ox Mountains are very similar and in a general sense are similar to the Strokestown area.

The Galway Granite is particularly well defined; and F48 on the northeast flank of the granite is very distinctive and thought to indicate faulting to the northeast. Extensions of anomalies associated with the granite are seen to the east, south and to a lesser extent the west. (SM-47 and SM-48).

(7) Other shallow magnetic zones are thought to relate to igneous rocks of varying ages in the sedimentary cover sequence. Some zones, for example SM-4, SM-5, SM-50 and SM-52, indicate thick bodies, whereas, others are caused by thin plate-like bodies e.g. SM-3 and SM-15.

Zones SM-1, SM-4,SM -5, SM-8, SM-12,SM-19, SM-63, SM-64, SM-65, SM-66 and SM-67 are thought to be caused by igneous rocks of Lower Palaeozoic age. However, SM-5 and SM-22 may have contributions from Tertiary and Carboniferous ages. Devonian igneous rocks are probably responsible for zones SM-21, SM-23, whereas zones SM-10, SM-50, SM-51, SM-52 and SM-68 are considered to be Carboniferous.

Tertiary igneous activity is seen in the form of generally northwest - southeast striking dykes, some of which (D1, D9 and D15) persist over considerable distances. These dykes are common in the northeastern part of the surveyarea. SM-60 has a similar trend in the south of the area on sheet 43.

Other shallow magnetic zones are of indeterminate age.

(8) Zones SM-3, SM-11, SM-14, SM-15, SM-16, SM-17, SM-24, and to some extent SM-20, are similar low-amplitude anomalies, trending generally northeast to east northeast. Some of the zones correlate reasonably well with inliers. Therefore, these zones may depict areas of structural highs or in some cases deeper faults which are important in exploration. In areas where the geology is not well known, these features could be useful exploration targets. The deposit at Moate lies close to the eastern projection of SM-17 and mineral localities are found close to SM-15.

(9) The Navan ore deposit correlates with the nose of a shallow positive anomaly of igneous association. The significance of this correlation is unknown and is possibly fortuitous. More important, perhaps, is the proximity of F7 and the northern boundary of SM-5b which may be faulted (F21). Interpreted faults within this zone, especially those which trend in the sector between north and east and the northern contact of zone SM-5b, just to the east of Navan are certainly worth following up.

(10) There is a well displayed assocaition between the Tynagh deposit and faulting as indicated from the magnetic data. The faulting can be traced further to the east and west of the Tynagh Mine area.

(11) The cross-faulting associated with the Silvermines area is well defined and a network of faults in the immediate area must be considered as important for further investigation. Many more faults probably exist parallel to the faults outlined.

(12) The spatial association of the Gortdrum and Aherlow deposits with SM-53/54 may be important and a larger BM-30 zone, thought to represent a basement high, may be very important in future mineral exploration.

(13) Mineralisation at Harberton Bridge occurs on a magnetic gradient between SM-12 and SM-4. The gradient may have some physical significance and is worthy of attention.

(14) Contracts between basement blocks show some correlation with mineralisation. The Keel deposit occurs in a fault, which may be one of many parallel subsidiaries to the BM-5/BM-6 contact. Occurrences lie close to the BM-13/BM-7, and BM-2/BM-7 interpreted contacts. These contacts may be the sites of basement faulting, which could have affected the cover sequence.

(15) The magnetic data has not been useful in delineating surface faults in a direct sense. Many surface features can be explained as igneous, or as cultural and do not look like fault profiles. The definition of fault lines, as has been discussed has been made from a close scrutiny of the surrounding magnetic pattern and quantitative data on either side of these lines. These interpreted fault lines although seemingly present at the same level as the magnetic sources could also occur at the surface. They may be interesting in exploration terms if they cut the Lower Carboniferous.

The lack of magnetic expressions concerning surface faults suggests that the susceptibility contrasts across the faults are either not present or very slight such that anomalies are not detectable.

(16) There is no magnetic evidence for any major north-south fissure running through Longford, Keel and Moate as proposed by Russell (1968).

(17) Correlations between gravity and magnetic data have been established, particularly over the Leinster and Galway Granites, but the gravity low in the Granard has not been satisfactorily explained.

7. RECOMMENDATIONS

(1) The first recommendation should be to review this interpretation together with other data sets, such as detailed gravity, aerial photographs, Seasat, Landsat and detailed geological and geochemical information. No attempt was made in this report to go into great detail with these other forms of data.

(2) The correlation between the Navan lead-zinc and the positive magnetic anomaly should be examined to see whether igneous activity had any influence on the mineralisation, or whether this correlation is merely fortuitous.

(3) The faults in the Navan, Slane and Duleek area (particularly those striking between north and east) together with the northern boundary of SM-5b are worth investigation. Follow-up of these structures should begin by reviewing existing geological, Seasat and geochemical data at these locations. Exploration may proceed by field geology, and geochemical overburden sampling on profiles normal to the suspected fault. Geophysical techniques may be used to aid the geochemistry, particularly V.L.F. E.M.

It must be remembered when following up these fault lines, that there may well be a positional error on them of ± 500 metres. This is due to error inherent in interpreting the position of the fault. It does not reflect the navigational accuracy. With deeper basement faults, this error will most likely be much greater. Therefore, this should be kept in consideration when following-up these faults and traverses should be made long enough to cater for this.

(4) A similar exploration strategy may be pursued when following up zones SM-3, SM-11, SM14, SM-15, SM-16, SM-17 and SM-24. Priority would be given to the zones in the southwest of the area and especially the northern edge of SM-15.

(5) The gradient on which the Harberton Bridge deposit occurs and faults within SM-4 should be checked in the same manner as outlined in paragraph three.

(6) Geochemical traverses should be conducted in zone SM-22 over interpreted fault lines, particularly in the northeast where the magnetic sources are shallow and where F36, F37 and F38 are likely to intersect. Electrical and electromagnetic geophysical methods could be used as an aid to geochemistry.

(7) Other interpreted fault lines and basement contacts (BM-13/BM-7, BM-2/BM-17 and BM-5/6 for example should be checked to see if they have surface expression in the Lower Carboniferous and should be assessed for their mineralisation potential.

(8) A long seismic refraction line orientated in the north northwest - south southeast perhaps through Longford would be useful for deep crustal studies and remove some ambiguities in the magnetic interpretation.

(9) The extension of the magnetic expression of the east northeasterly fault near Tynagh should be investigated for further mineralisation.

(10) The fault pattern associated with the Silvermines deposit is thought to be extensive and therefore it represents a target area for further investigation.

(11) The possible igneous association of zones SM-53/54 with the Gortdrum and Aherlow deposit should be investigated in detail; and the larger zone BM-30 should be investigated, perhaps with a small, seismic reflection survey.

Hunting Geology and Geophysics Limited would be pleased to offer their services in any capacity regarding the follow-up of this survey.

8. ACKNOWLEDGEMENTS

Hunting Geology and Geophysics Limited would like to thank the members of the Geological Survey of Ireland for their help and cooperation in performing this survey. Special thanks are due to Dr. C. Williams, Mr. D. Inamdar, and Mr T. McIntyre.

9. BIBLIOGRAPHY

Geophysics

Am, K.	1972	The arbitrarily magnetised dyke: Interpretation by characteristics. Geophysical Exploration Volume 10.
Bean, R.J.	1966	A rapid graphical solution for the aeromagnetic anomaly of the two-dimensional tabular body. Geophysics, Volume 31, No.5.
Bott, M.	1968	The geological structure of the Irish Sea Basin in Geology of Shelf Seas. Ed. by Donovan, D. Published by Oliver and Boyd.
Dunham, K.	1972	Aeromagnetic map of Great Britain, Sheet 1, 1:625,000. Institute of Geological Sciences.
Fuller, B.D.	1967	Two-dimensional frequency analysis and design of grid operators. In Mining Geophysics, published by S.E.G. Tulsa, Oklahoma, Volume II.
Hall, D. and Dagley, P.	1970	An analysis of the smoothed aeromagnetic map of Great Britain and Northern Ireland. Institute of Geological Sciences, Rep No. 70/10.
Hood, P.	1965	Gradient measurements in aeromagnetic surveying. Geophysics, Volume 30, No.5.
Hood, P. and McClure, D.J.	1965	Gradient measurements in ground magnetic prospect-ting. Geophysics,Volume 30, No.3.
Hood, P. et al	1979	Magnetic methods applied to base metal exploration, in Geophysics and Geochemistry in the search for metallic ores, Geological Survey of Canada. Economic Geology, Report 31.
Inamdar, D.	1973	A total field magnetic survey of County Wicklow. Report series of the Geological Survey of Ireland.
Koulomizine, T. et al	1970	New method for the direct interpretation of magnetic anomalies caused by inclined dykes of infinite length. Geophysics, Volume 35, No.5.
Moo, J.K.	1965	Analytical aeromagnetic interpretation of the inclined prism. Geophysical Prospecting, Volume 13, No.2.
Morris, P.	1952	Density, magnetic and resistivity measurement on Irish rocks, Comm. of Dublin, Inst. for Advanced Studies, Geophysical Memoirs, No. 2,Part 3.
Murphy, T.	1952	Measurements of gravity in Ireland, gravity survey of Central Ireland, Dublin Inst. for Advanced Studies, Geophysical Memoirs, No. 2,Part 3.

Murphy, T. 1974 A vertical force magnetic survey of the counties Roscommon, Longford, Westmeath and Meath. Dublin Inst. for Advanced Studies, Geoph. Bulletin No. 11.

Nettleton, L.L. 1976 Gravity and magnetics in oil prospecting. Published by McGraw-Hill.

Peters, L.J. 1949 A direct approach to magnetic interpretation and its practical application. Geophysics, Volume No.3.

Reford, M.S. 1965 Magnetic anomalies over thin sheets. Geophysics, Volume 29, No.4.

Robinson, K.W. 1973 A total field magnetic survey of County Dublin and part of County Meath. Report series of the Geological Survey of Ireland.

Sherriff, R. 1973 Encyclopedic Dictionary, Exploration Geophysics. S.E.G. Tulsa.

Steenland, N.C. 1965 Oil fields and aeromagnetic anomalies. Geophysics Volume 30, No.5.

Stubblefield, J. 1964 Aeromagnetic map of part of Great Britain and Northern Ireland, 1:250,000; Sheet 7, Institute of Geological Sciences.

Stubblefield, J. 1965 Aeromagnetic map of Great Britain, Sheet 2, 1:625,000; Institute of Geological Sciences.

Vacquier, V. et al 1951 Interpretation of aeromagnetic maps. Geological Society of America, Mem 47.

Geology

Bamford, D. et al 1977 LISPB - III Upper Crustal structure of Northern Britain. Journal Geology Society, London, 133.

Charlesworth, J.K. 1963 Historical Geology of Ireland. Published by Oliver and Boyd, Edinburgh and London.

Cole, G. 1956 Memoir and map of localities of minerals of economic importance and metalliferous mines in Ireland. Mineral memoir Ireland, Geological Survey of Ireland.

Evans, A. 1976 Genesis of Irish base metals. In Handbook of Stratabound and Strataform ore deposits. Published by Elsevier.

Holland, C.H. (Ed.) 1981 A Geology of Ireland. Published by Scottish Academic Press, Edinburgh.

Horne, R.R.	1975	Possible transverse fault control of base metal mineralisation in Ireland and Britain. Irish Nat. Journal. Vol. 18 No. 5.
Mitchell, G.	1957	Ordovician Volcanoes, Adv. Sci., No. 54.
Morrissey, C.J. et al	1971	Mineralisation in the Lower Carboniferous of Central Ireland. Transactions of Institution of Mining and Metallurgy, Volume 81.
Russell, M.J.	1968	Structural controls of base metal mineralisation in Ireland in relation to continental drift. Transactions of Institution of Mining and Metallurgy, Volume 77.
Russell, M.J.	1978	Downward - excavating hydrothermal cells and Irish type ore deposits, importance of an underlying thick Caledonian prism. Transactions of Institution of Mining and Metallurgy, Volume 87.
Sevastopulo, G. D.	1979	The stratigraphic setting of base-metal deposits in Ireland. In: Prospecting in areas of glacial terrains. Published by The Institution of Mining and Metallurgy.
Sheridan, D. J.R.	1977	The hydrocarbons and mineralisation proved in the Carboniferous strata of deep boreholes in Ireland. Proc. Forum on Oil and Ore in sediments, Imperial College, London.
Williams, C.E.	1971	Syngenetic ore deposition - a modern parallel. In:The genesis of base metal deposits in Ireland. Irish Geological Association Symposium, Galway. (Abstract only)

APPENDIX I

MAGNETIC SUSCEPTIBILITY VALUES

APPENDIX I

Ranges of magnetic susceptibility values for rocks in Ireland (Taken from P. Morris, 1973)

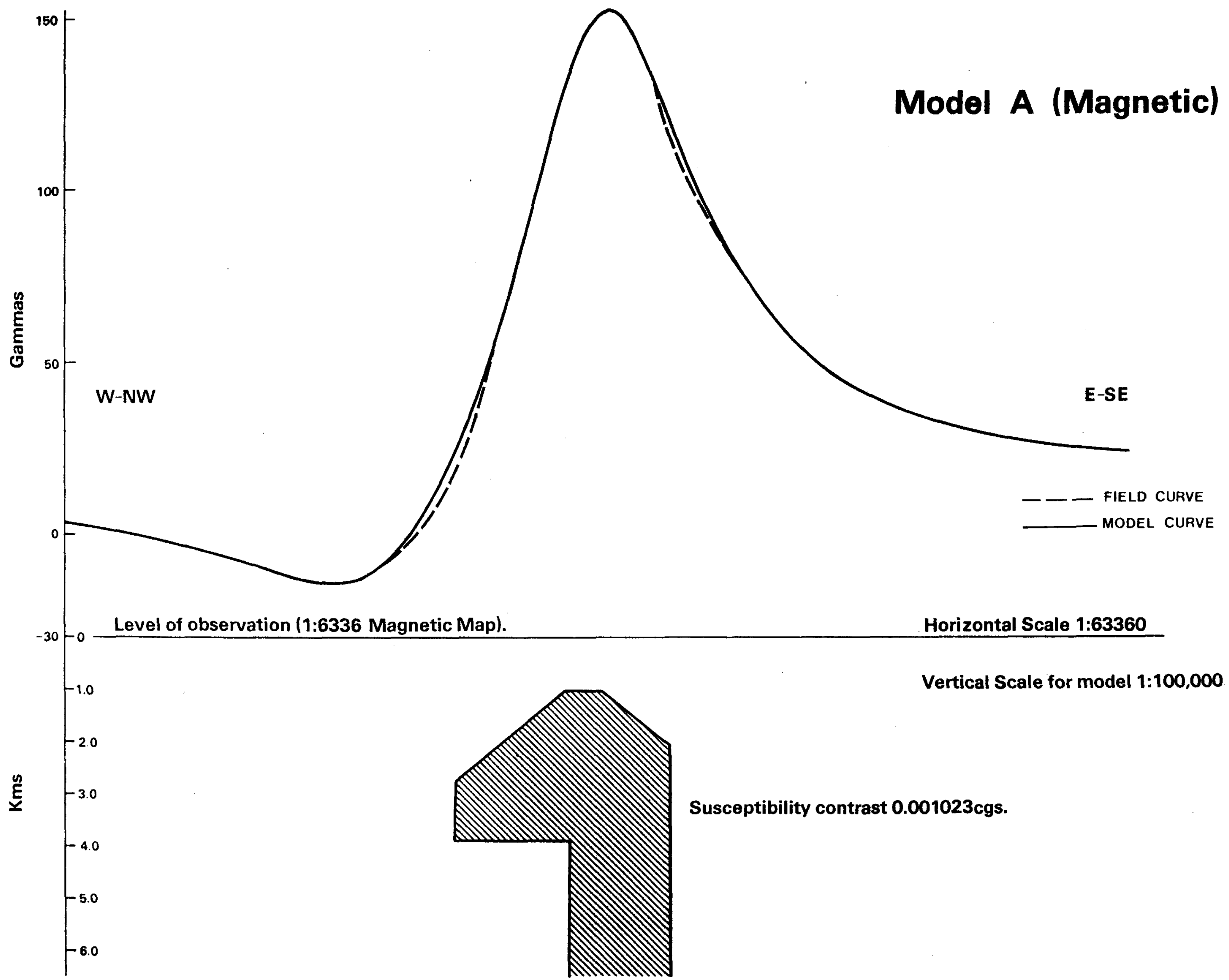
Age	Rock Type	Susceptibility		Remanence	
Precambrian	Schist	5 -	50	0 -	18
	Gneiss	3 -	3,500	0 -	65
	Metaquartzite	0 -	40	0 -	22
	Granite Gneiss	3 -	980	0 -	35
	Psammite	5 -	730	0 -	75
	Granulite	2 -	44	0 -	500
	Semi-Pelite	6 -	3,900	0 -	72
	Amphibolite	0 -	17	6 -	78
	Basic rocks	45 -	2,800	0 -	10,000
Cambrian	Sandstones and Quartzite	0 -	15	0 -	4
Ordovician	Rhyolite - Andesite	15 -	44,000	0 -	10,000
	Basic rocks	30 -	6,000	0 -	800
	Pyroclastic rocks	0 -	3,100	0 -	310
	Slates	22 -	29	0 -	2
Silurian	Pyroclastic rocks	9 -	2,000	0 -	150
	Slates	22 -	33	0	
	Sandstone	21 -	33	0 -	3
	Shale	17 -	28	0	
Devonian	Granite-Diorite	0 -	550	0 -	90
	Pyroclastic rocks	0 -	53,000	0 -	800
	Sandstones	0 -	25	0 -	30
Carboniferous	Sandstones	0 -	56	0 -	180 (nearly all 0 though)
	Limestone	0 -	87	0-	80
	Basic rocks	17 -	5,900	24 -	400
	Pyroclastic rocks	3 -	7,000	0 -	6,000
Tertiary	Basic rocks	2,400 -	8,700	230 -	3,900

Susceptibility and remanence figures are given in units of 10^{-6} emu/cc.
Zero indicates samples too weak to measure.

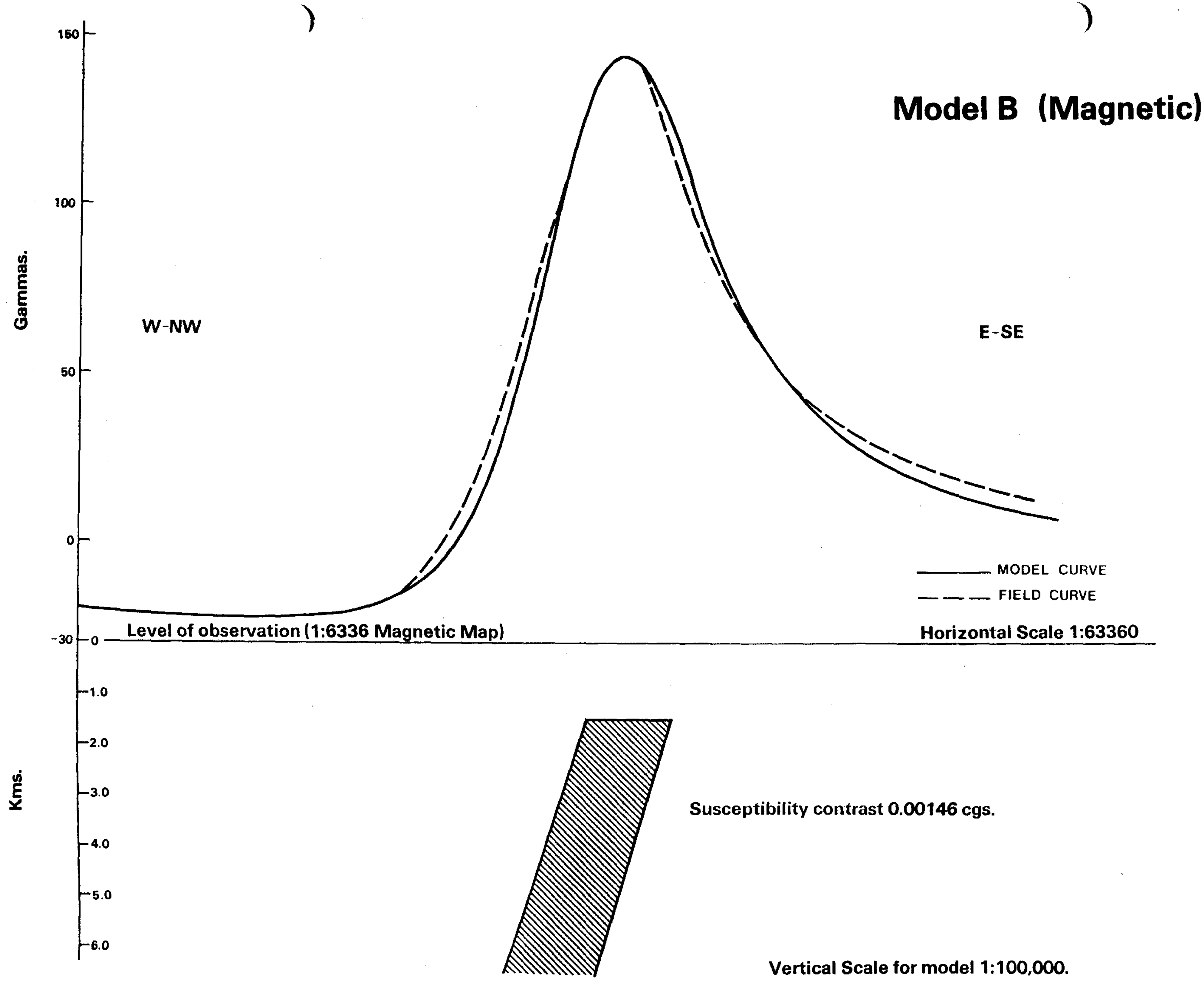
APPENDIX II

A COMPUTER CALCULATED PROFILE FOR:

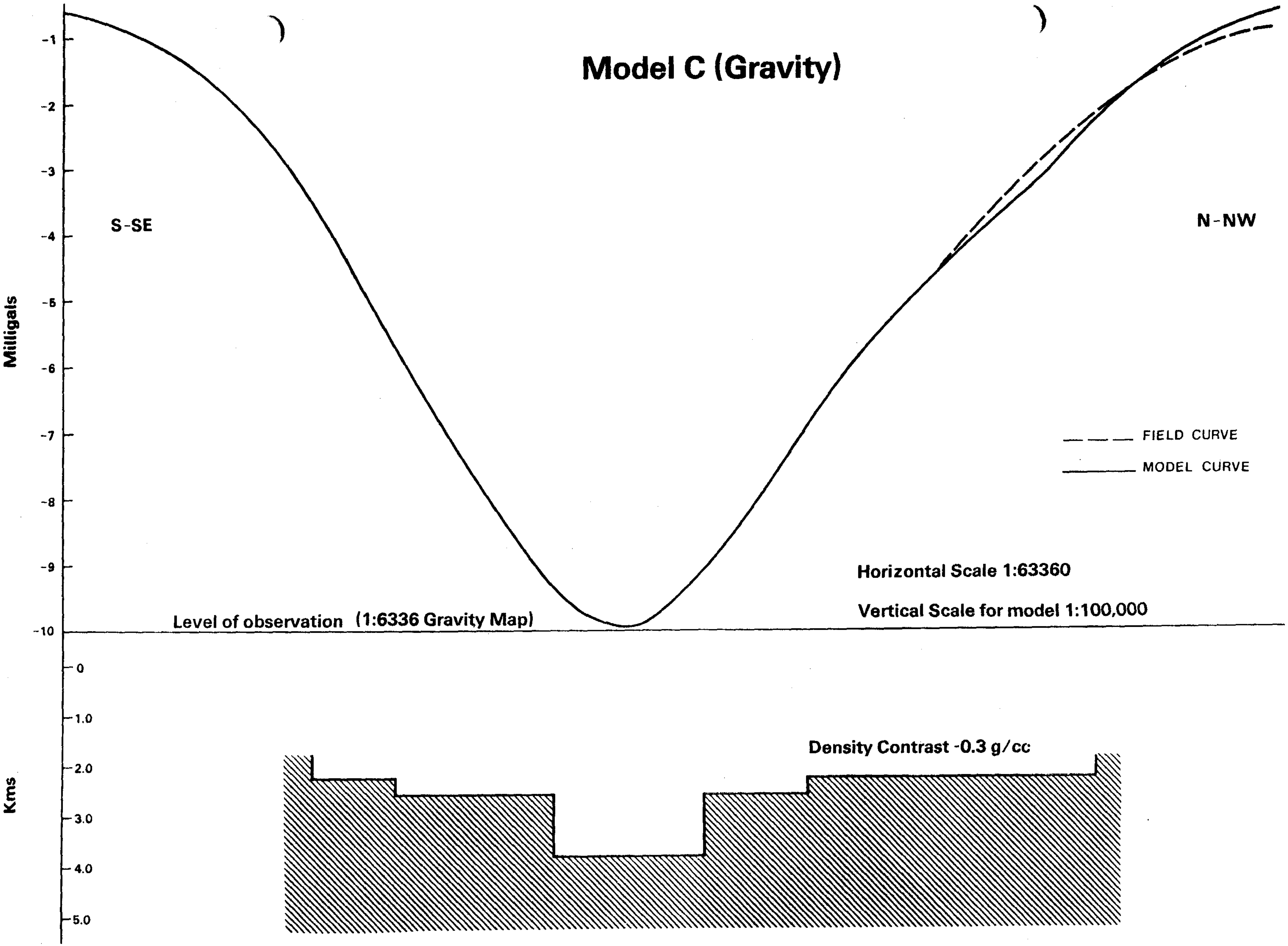
BM-5/BM-6
MAGNETIC MODEL A
MAGNETIC MODEL B
MAGNETIC MODEL D
GRAVITY MODEL C



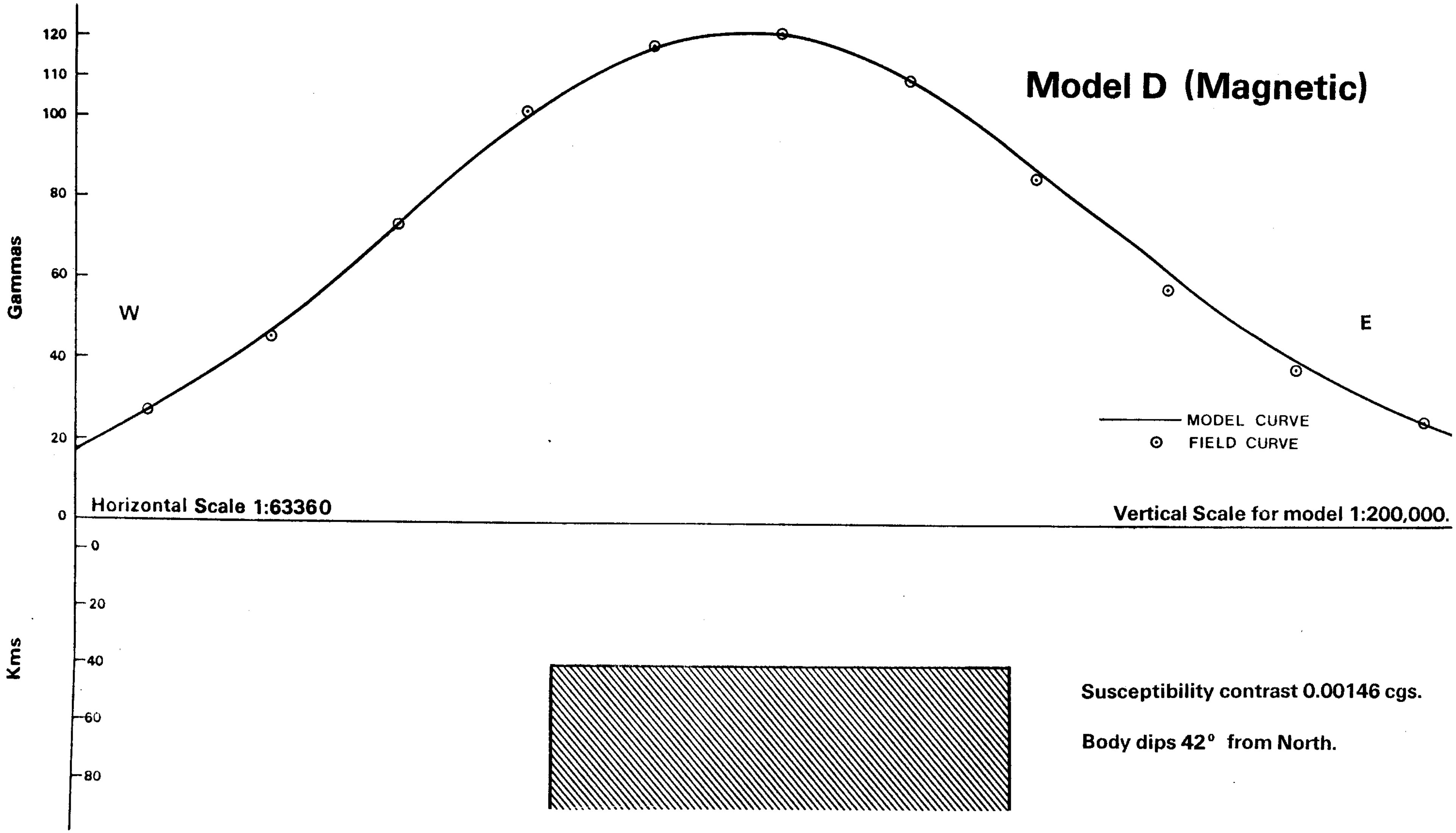
Model A (Magnetic)
150
100
50
0
-30
Gammas
W-NW
E-SE
FIELD CURVE
MODEL CURVE
Level of observation (1:6336 Magnetic Map).
Horizontal Scale 1:63360
Vertical Scale for model 1:100,000
0
1.0
2.0
3.0
4.0
5.0
6.0
Kms
Susceptibility contrast 0.001023cgs.



Model B (Magnetic)
Gammas.
150
100
50
0
-30
W-NW
E-SE
MODEL CURVE
FIELD CURVE
Level of observation (1:6336 Magnetic Map)
Horizontal Scale 1:63360
Kms.
0
1.0
2.0
3.0
4.0
5.0
6.0
Susceptibility contrast 0.00146 cgs.
Vertical Scale for model 1:100,000.



Model C (Gravity)
Milligals
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
S-SE
N-NW
FIELD CURVE
MODEL CURVE
Horizontal Scale 1:63360
Vertical Scale for model 1:100,000
Level of observation (1:6336 Gravity Map)
Kms
0
1.0
2.0
3.0
4.0
5.0
Density Contrast -0.3 g/cc


Model D (Magnetic)
Gammas
120
110
100
80
60
40
20
0
W
E
MODEL CURVE
FIELD CURVE
Horizontal Scale 1:63360
Vertical Scale for model 1:200,000.
Kms
0
20
40
60
80
Susceptibility contrast 0.00146 cgs.
Body dips 42° from North.

A Magnetic Model for BM5/BM6