A geophysical survey of the isle op man

Bell, Trevor

A GEOPHYSICAL SURVEY OF THE ISLE OF MAN

A thesis submitted for the degree of Master of Science in the University of Durham.

By

Trevor Bell.

ABSTRACT

A gravity survey of the Isle of Man was made during September and October, 1958. A Bouguer anomaly map was prepared which showed that the Bouguer anomaly over the whole of the Island has an average value of approximately 43 mgals. Superimposed on this 'background' anomaly are six anomalies. Three of these lie along the main axis of the Island and are interpreted as being due to granites which are possibly joined at depth. The small basin of Lower Carboniferous sandstone at Peel causes a small anomaly. At Jurby, the anomaly is probably due to basement uplift, or may be the 'background' anomaly for the whole of the Island. The Point of Ayre anomaly is caused by a trough of rocks of New Red Sandstone age, which deepens northwards. A fault with a throw of approximately 1500 feet and downthrowing to the north, cuts these New Red Sandstone rocks.

Acknowledgements

The work was undertaken under the supervision of Dr.M.H.P.Bott, to whom I am indebted for much advice, assistance and helpful discussion throughout.

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I am grateful to Mr.J.D.Cornwell, with whom I did the survey and shared in the reduction of data.
Mr. Cornwell drove the van throughout the survey.

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A GEOPHYSICAL SURVEY IN THE ISLE OF MAN

CHAPTER I

INTRODUCTION

The Isle of Man is situated almost in the middle of the Irish Sea. Its closest approach to the mainland is 16 miles, this being the distance of the Point of Ayre, its northernmost tip, from the Scottish coast. The nearest approach to England and Ireland is 31 miles. East of the Island, the sea is relatively shallow, and is never more than 20fathoms deep. To the westward, midway to the Irish coast, is a deep trough, which reaches a depth of nearly 80 fathoms. North and south of the Island, the Irish Sea never reaches a depth of more than 50 fathoms.

The Isle of Man is roughly rectangular in shape, and together with the small island off its south-western tip, the Calf of Man, occupies an area of 227 square miles. The longer axis of the Island, running north-north-east to south-south-west, from the Point of Ayre to Spanish Head, is 30 miles. The maximum width at right angles to this axis, is only about 12 miles.

Apart from the Northern Plain, which occupies an area of about 45 square miles, there is little flat ground. The rest of the Island is occupied by heather covered hills which, in the central portion are steep, but not craggy. A ridge of high land traverses the Island, running from near Ramsey, southwestwards to Port Erin, and is broken only by a through valley running from Douglas to Peel. This ridge contains all the high hills of the Island, including North and South Barrule, Beinn y Phott, and Snaefell, the latter being the highest peak, reaching a height of 2034 feet above sea-level. The ridge terminates in the south-west at Bradda Hill where it falls almost vertically for 700 feet into the sea. Parallel to this major feature are other smaller ridges, often separated from the main ridge by deep valleys.

Around the coast of the Isle of Man are many precipitous cliffs, especially along the east coast, for example at Maughold Head and Bulgham Bay. The finest cliffs however, are in the region of the Chasms and Bradda Hill.

The Island has a simple drainage pattern. Streams descend radially, often through deep valleys such as Sulby Glen and Glen Auldyn, from the central mountain ridge.

The topography of the Island can be directly correlated with sub-surface geology. All the central high land is made up of Lower Palaeozoic Manx Slate Series, and, in all, rocks of this series make up about three quarters of the total rocks of the Isle of Man. The Northern Plain is made up of sands and gravels of Quaternary age, which are underlain by Manx Slates, Carboniferous Limestone and rocks of New Red Sandstone age. In the neighbourhood of Castletown, rocks of Carboniferous Limestone age occur, and form the area of relatively low-lying ground. Also in the area around Peel on the west of the Island, rocks which have been described as Lower Carboniferous occur, giving rise to ab area of flat land.

The gravity survey of the Island was suggested by Dr. W.Bullerwell and conducted during September and October, 1958. The survey and computation of results, described in Chapters III and IV, were done jointly with Mr. J.D.Cornwell.

CHAPTER II

GEOLOGY OF THE ISLE OF MAN

Stratigraphical succession

The stratigraphical succession is given in the following table:-

Recent	Blown Sand Peat Alluvium Raised Beach
Glacial	Late glacial flood gravels Sand and gravels occuring as platforms Sand and gravel occurring as mounds Boulder clay or loam, and rubble drift
	Unconformity
Triassic	Red Saliferous Marls Sandstone of Kirklinton Type St. Bees Sandstone
Permian	Lower Red Marls and Brockram
	Unconformity
Carboniferous	Carboniferous Limestone Series Basement Sandstone and Conglomerate
	Unconformity

	Cronk Sumark Slate
	Sulby Flags
	Breccia
Manx Slate Series	Barrule Slates
	Banded Beds
	Agneash Grits
	Lonan Flags

The igneous rocks seen on the Island are as follows:-

Contemporaneous

Carboniferous	Tuff, agglomerate, etc.
	Basalt
Manx Slate Series	Tuff

Intrusive

Olivine dolerite dykes (Tertiary?)
Diabase, etc., (Greenstone) dykes
Diabase, epidiorite, chlorite schist, etc. (Alterred greenstone) dykes
Diorite and camptonite dykes
Mica-trap dykes
Microgranite dykes
Granite

The main features of the stratigraphy are discussed in the following paragraphs:-

Manx Slate Series

The Manx Slate Series are a series of slates, grits, greywackes, tuffs, flags and breccias, which have been highly folded, cleaved and faulted. An estimate of their thickness is therefore extremely difficult to make. Lamplugh (1903) gave as an estimate, a thickness of 1500 to 2000 feet, but it is quite possible that their thickness exceeds 5000 feet. The age of the series is also somewhat doubtful. Fossils are extremely rare - worm casts being the only common indications of organic life. However, one or two specimens of Dictyonema sociale have been discovered in the scree from a quarry near Sulby, thus indicating that the rocks in which they were found are Tremadocian in age. Since the specimens were found in the upper division of the Manx Slate Series in the north of the Island (the Cronk Sumark Slate) it would appear that the older divisions of the Manx Slate Series are definitely Cambrian in age. This appears to confirm Lamplugh's view that the Manx Slate Series are equivalent to the lower, and largely concealed part, of the Skiddaw Slates.

The youngest divisions of the Manx Slate Series are probably to be found beneath the drift-covered Northern Plain. Deep borings have shown Manx Slates, dipping at angles of up to 50° below the Carboniferous Limestone Series in the Andreas area. No fossils at all have been found in these rocks, but they are possibly Tremadocian or Arenigian in age.

Lower Carboniferous

In the Isle of Man, rocks of Lower Carboniferous age outcrop in two areas, near Castletown and Peel, and are present in a third area, below the drift of the Northern Plain. In the south of the Island, the succession is:-

Posidonomya (≡ Posidonia) Beds
Poolvash or Pale Limestones
Castletown or Lower Dark Limestones
Basement Conglomerate

About 600 feet of beds, ranging in age from C_2 to P_{1b} are present, and are overlain and in places, overthrust, by the Scarlett Volcanic Series. Within the Poolvash Limestone, small "reef-knolls" occur, in which numerous fossils, including goniatites, have been found. These fossils thus provide a link with the basin facies of Lancashire, Westmorland and similar areas. The succession here is totally different from that at the northern part, and a direct correlation between the two areas is not possible.

In the neighbourhood of Peel red and mottled sandstones, conglomerates and thin lenses of impure limestone occur. Fossils found in this region are derived, and include a shelly fauna of Wenlockian age. Although the age of this formation has not been fixed with absolute certainty, it is, in all probability, of Lower Carboniferous age and equivalent to the basal conglomerate of the Carboniferous in the other two areas of Carboniferous.

Beneath the glacial drift and blown sand in the northern part of the Isle of Man, the following succession of Carboniferous rocks has been proposed:-

Upper Limestone Group
Middle Limestone Group
Lower Limestone Group
Basement Beds

This sequence has been assembled by Smith (1926), from the evidence of several bore-holes, put down in an attempt to find haematite.

The Basement Beds consist of conglomerates, thin limestone and shales, resting on a surface of Manx Slates. The conglomerates usually fill hollows in the Lower Palaeozoic rock surface. The thickness of this series is quite variable and may locally exceed 150 feet. Above the Basement Beds are a series of thin limestones, shales and sandstones, giving way to more massive limestones above, constituting the Lower and Middle Limestone Groups. Towards the top of the Middle Limestone Group limestones become subordinate to shales and sandstones. In the Upper Limestone Group limestones are infrequent and shales are predominant. The whole of the Carboniferous succession dips approximately northwards at angles of from 10 to 60° and rests as far as is known on Manx Slates, with marked unconformity. There are numerous faults within the series, and the total sequence is estimated to amount to 2000 feet. This is far in excess of the Carboniferous in the south of the Island. Volcanic rocks are completely absent.

An attempt has been made (Smith, 1926), to correlate this succession with that established in West Cumberland, because of the close lithological resemblences. The limestones of the Lower and Middle Limestone Groups have been correlated with the Second to Seventh Limestones of Cumberland, and the lowest member of the Upper Limestone Group has been correlated with the First or Great Limestone. The Upper Limestone Group resembles the succession in North-east Cumberland, rather than the Hensingham Group of West Cumberland. The horizon of the Little Limestone is marked by a nine inch coal seam, which is,incidentally, the thickest coal seam discovered on the Island. Limestones occurring within this group have been correlated with the Oakwood, Corbridge and Thornboro Limestones respectively.

Palaeontological evidence for the above correlation is very scanty, but fossils obtained from one of the borings suggest that the thick massive limestone of the Isle of Man is of D_2 age. Since most of the Fourth Limestone of the Cumberland succession is of D_2 age, the correlation between the thick massive limestone and the Fourth Limestone is thought to be approximately correct. The remainder of the correlation is carried out, as previously mentioned, on the basis of lithology.

The line of hills which runs westwards from Ramsey appears to mark the position of the shore-line of the Carboniferous sea, and acted as a barrier between the two areas of deposition. The rocks occurring between the hills of Manx Slates and the base of the Carboniferous, appear to be Manx Slates also, and not, as Lamplugh tentatively suggested, of Silurian or Devonian.

Permian and Trias

Rocks of Permian and Triassic age have been discovered lying unconformably on the Lower Carboniferous at the north end of the Isle of Man. The succession, proved in borings (Gregory,1920), is as follows:-

Saliferous Marl
Sandstone of Kirklinton type (Keuper)
St. Bees Sandstone (Bunter)
Red Marls
Brockram

The beds lie conformably on each other, and have a gentle dip to the north-east of 5 to 10°.

The Red Marls and Brockram are referred to the Permian system. As in the Vale of Eden the thickness of the Brockram is quite variable, ranging in known thickness from 0 to about 60 feet. There is also considerable variation in thickness in the Red Marls, where the maximum recorded thickness is about 100 feet. However it is often difficult to separate the Red Marls from the Bunter, and hence the actual thickness may be somewhat greater. Above the Red Marls, at least 860 feet of sandstone occurs, which closely resemble the St. Bees Sandstone in both lithology and colour. Succeeding the St. Bees Sandstone is a sandstone which is comparable with the Kirklinton Sandstone. In the deep bore-hole at the Point of Ayre, 940 feet of this sandstone were encountered. Above the Kirklinton Sandstone, at least 780 feet of Saliferous Marls are present. The series includes beds of salt, marl and a few beds of gypsum. Gregory has correlated the salt horizons with those of Cheshire.

Thus it is seen that at least 2700 feet of rocks of New Red Sandstone age occur under the drift covered Northern Plain, and it is quite possible that the total thickness may exceed 3000 feet.

Quaternary Deposits

Over the whole of the Northern Plain, there is a thick covering of sands, gravels and clays, which were deposited during glacial and post-glacial times. The base of the drift becomes progressively further below sea-level from the south end of the plain, northwards. Thus from near Andreas, where the base of the drift is about 200 feet below sea-level, the base becomes lower, until, at the Point of Ayre it is over 400 feet below sea-level. Near the northern margin of the plain is a chain of hills, known as the Bride Hills, composed of drift, and rising to a height of over 300 feet in places. Assuming the base of the drift to be in the region of 250 feet below sea-level in this region, it is seen that the total thickness of drift exceeds 550 feet, in places. This is probably thicker than anywhere else in the British Isles.

Post-glacial deposits include a raised beach, which can be traced in several parts of the Island, at a height of about 18 feet above mean sea-level, and blown sand, seen mainly on the Ayres, at the north end of the Island.

Igneous Rocks

There are two major granitic intrusions on the Isle of Man, at Foxdale and Dhoon. Whilst they both outcrop along the main stratigraphical axis of the Manx Slates, they differ considerably in mineralogical content, density and mode of occurrence. The Dhoon granite is a porphyritic microgranite and is stock-like in appearance, having a steeply dipping contact with the Manx Slates. The Foxdale granite is a typical medium to coarse grained muscovite granite, and appears to be laccolithic in shape.

Of the smaller plutonic intrusions, the Oatland Complex is of interest. It is a plutonic intrusion of gabbroid type which is itself intruded by an acid rock of Dhoon type. Near the margins, some assimilation of the basic rock by the acid rock, has taken place. At Ballabunt, there is a small intrusion of quartz diorite, the exact size of which is not properly known.

Two sets of dykes of pre-Carboniferous age, possessing a strike parallel to the strike of the Manx Slates, are known. The series of felsites and microgranites, known as elvans, are definitely related to the two granitic masses, and occur in narrow belts on the flanks of the granites. The other series, the greenstone dykes, are mainly dolerites and minettes. They have no obvious relation to the granites, and are more widespread and scattered.

The Scarlett Volcanic Series are of Carboniferous age and occur in the south of the Island. They consist of porphyritic olivine basalts, tuffs and agglomerates. Owing to overthrusting, the actual relationships between this series and the underlying rocks was long in doubt, before Lamplugh worked on the area.

Many dykes of supposed Tertiary age have been listed. They are mainly tholeiites and olivine dolerites, and strike in an approximate north-westerly direction. Lamplugh notes that the number of dykes decreases with altitude, until at 700 feet above sea-level, there are no recorded examples. This may imply, he states, insufficient injection pressure to force them up through the higher ground of the Island.

Metalliferous Veins

The Isle of Man has been rich in mineral wealth, in comparison with its size. Lead and silver, zinc, copper and iron ores have all been mined extensively. There are two chief directions of strike of the veins. In the

Foxdale group of mines, the predominant direction is east-west, whereas at Laxey, the direction is north-south.

CHAPTER III

THE GRAVITY SURVEY

A gravity survey of the Island was conducted between the sixth of September and the seventh of October, 1958, with the primary object of elucidating the geological structure of the Island. The Bedford van, belonging to the Durham Colleges Geology Department, was used throughout the survey to transport the Frost Gravity Meter (No.C-2-54), and therefore the survey was restricted to roads and tracks, of which there is good coverage.

The first stage of the Survey consisted in the establishment of a network of base stations, the primary base being located at Ronaldsway Airport. From this station, six more base stations were established by the normal method of looping (see Figure 1). One of these stations, at Laxey, was originally set up by Bullerwell, in 1952. A base station was set up at Ballasalla and directly linked with the Ronaldsway Airport bases,(also set up by Bullerwell), since the latter were inconvenient to use. The closing error for the base station loops was found to be less than 0.05 mgals. Diagrams showing the locations of the base stations can be seen in the appendix.

The absolute value for gravity for the survey was taken as that at Pendulum House, Cambridge, where the value is taken to be 981.26500 cm/sec^2. (Cook, 1952). Bullerwell found the value at Ronaldsway to be 202.45 mgals

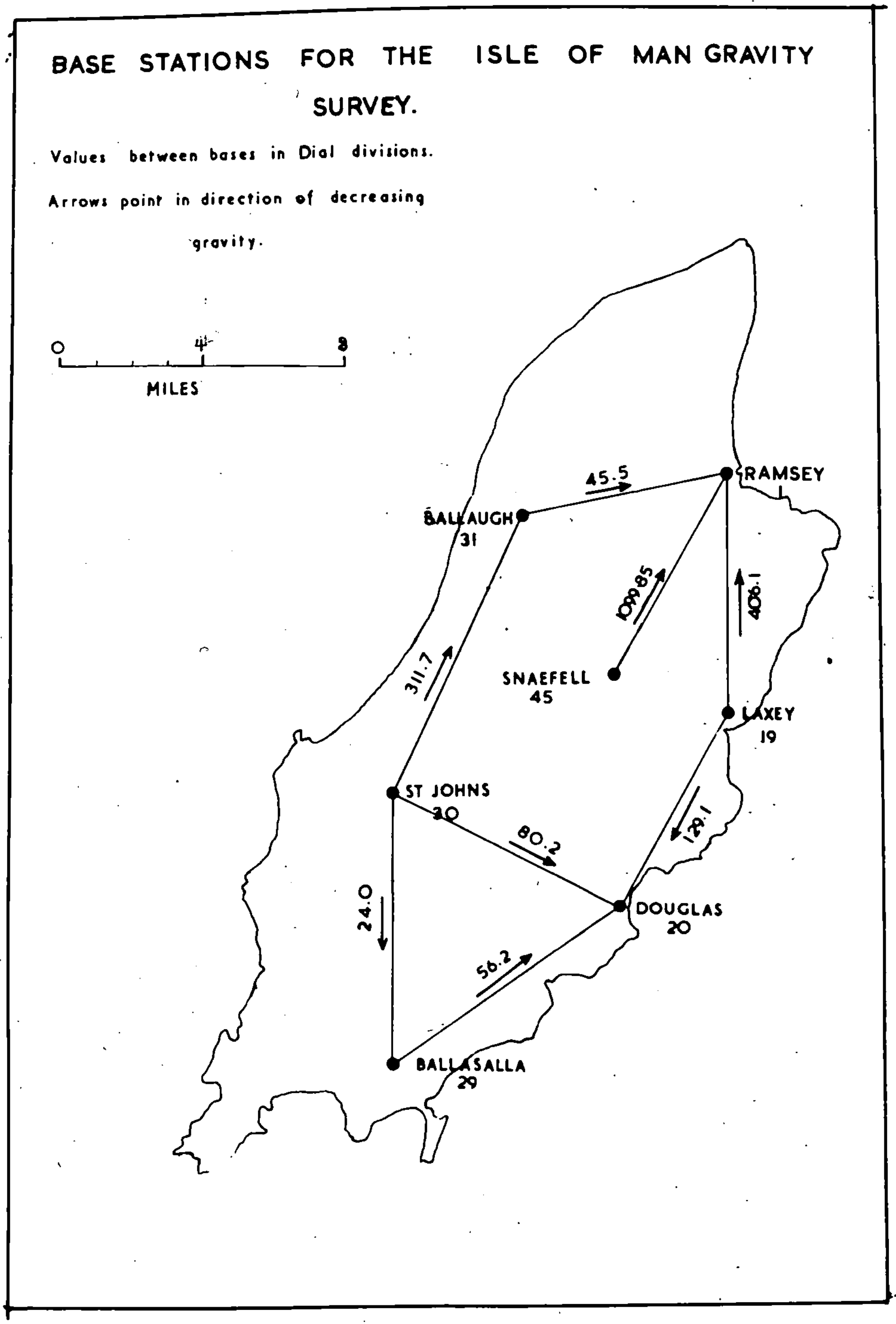
BASE STATIONS FOR THE ISLE OF MAN GRAVITY SURVEY.
Values between bases in Dial divisions.
Arrows point in direction of decreasing gravity.
0
4
8
MILES
45.5
RAMSEY
BALLAUGH
31
1099.85
406.1
311.7
SNAEFELL
45
LAXEY
19
ST JOHNS
30
80.2
129.1
24.0
DOUGLAS
20
56.2
BALLASALLA
29

FIGURE 1

above the value at Pendulum House. The value for gravity at the Ballasalla base was 0.31 mgals less than at Ronaldsway and is therefore 981.46714 cm/sec^2.

A network of intermediate stations was then established over the whole of the Island, the interval between each station being between half a mile and a mile. Altogether, 363 stations were occupied and 20 of these were repeated as a check on values previously obtained. The interval of time which elapsed between readings at base stations was never more than two hours. In this way, it was possible to estimate the amount of drift of the instrument for intermediate stations.

The stations were sited wherever possible close to bench marks and the actual elevation of the station determined by levelling to the bench mark with an Abney Level. The heights of these stations should therefore be accurate to within $\pm$ 0.2 feet. In regions where there were no bench marks spot heights were used, the gravimeter being sited, as near as possible, over the position of the spot height. The elevations of these stations will probably be accurate to within $\pm$1 foot. Some uncertainty will exist, owing to changes in the level of the road, due to repair or sinking. It was necessary to site a few stations on contours, where the error may be greater than $\pm$1 foot, but is certainly not more than $\pm$5 feet. The contours used were taken from the six-inch map, and all elevations are relative to mean sea-level at Douglas.

Towards the end of the survey, a random check was made on about 20 stations, to discover if there were any errors in the readings and reductions. From the differences in readings obtained, the standard deviation was calculated and found to be $\pm$ 0.07 mgals.

CHAPTER IV

REDUCTIONS

Densities

Estimates of the saturated densities of the rocks of the Isle of Man were made from samples collected. About ten specimens were collected from each of twenty localities and a representative selection of the various lithologies was obtained, as far as was possible. Relatively unweathered specimens were always collected. The saturated densities of the specimens was obtained by immersing the samples in water, in a vessel from which the air has been evacuated. After soaking for about 24 hours, the density was obtained by weighing the sample whilst immersed in water, and then weighing the sample in air. Density is then:-

$$\frac{\text{Weight of specimen in air}}{\text{Wt. in air - wt. in water}}$$

The results are given in the following table:-

Formation	Number of localities	Number of specimens	Saturated densities
Manx Slate Series	11	113	2.73 0.06 gr/cc
Carboniferous Limestone	3	38	2.70 0.05 gr/cc
Peel Sandstone	2	25	2.65 0.03 gr/cc
Dhoon Granite	2	26	2.71 0.01 gr/cc
Foxdale Granite	2	22	2.62 0.02 gr/cc

The error of any one determination is not greater than 0.005 gr/cc. The errors are stated as the standard deviation of the mean density of the formation. There may have been a slight increase in porosity of the rocks, due to near surface weathering and jointing, which would lead to an underestimate of the actual densities. This effect would be fairly small and the correct densities are thought to be quite close to those estimated.

Height Corrections

The height corrections were calculated by multiplying the elevation in feet, of the station, by a factor depending on the density of the rocks beneath the station. All data were reduced to sea-level, relative to Douglas.

Latitude Corrections

The latitude of each station was measured from the six inch map, to the nearest second. The theoretical value for gravity at any particular latitude was then calculated, using the International Gravity Formula. In actual fact, to save time doing repeated calculations to determine gravity, using this formula, a table was prepared from which the "latitude correction" could be read off. The "latitude correction" being the value of gravity at any latitude ϕ, minus the value of gravity at Pendulum House, Cambridge.

The previously calculated value of 0.0837 mgal per scale division for the gravimeter, (Tomaschek, 1952) was used throughout the survey. The value for gravity at any point X, relative to Ronaldsway, was then found thus:-

$g_X =$ (value in scale divisions at X - value in scale divisions at Ronaldsway) x 0.0837.

Terrain Corrections

Most of the terrain corrections for the Isle of Man are moderately large, because of the variable topography. They are insignificant only on the Northern Plain. Normally the estimation of terrain corrections is the most tedious and time consuming stage in the reduction of data of gravity surveys. However, the bulk of the terrain corrections for the Isle of Man have been calculated using an electronic computor. The computor which has been used is the Ferranti Pegasus Computor, ("Ferdinand"), belonging to Durham University, and housed at Newcastle.

The method used is one devised by Bott in 1957 and 1958, (Bott, 1959). The principle of the method consists in dividing the area into a grid of equal and convenient sized squares. The average height of each square is estimated and the total terrain correction for any station is then obtained by summing up the actual contribution from each square. The approximation used is based on the attraction of a segment of a hollow cylinder, and is as follows:-

$$\Delta g = \frac{G\rho A}{2r} \times \frac{h^2}{(r^2-p^2)}$$

Where,

Δg	=	attraction of segment
ρ	=	density of the rocks
A	=	area of the square
h	=	height difference between square and station
r	=	distance from station to centre of square
p	=	the half width of the square side

The National Grid squares of one square kilometre have proved to be a convenient size to use.

The computor programme only allows incremental terrain corrections to be calculated for squares at a distance greater than one kilometre from the station. When the distance is less than one kilometre, the errors involved in the above approximation become large. Therefore the square is 'rejected' and the number of the square containing the station is determined by the computor. The square containing the station is imagined to be at the centre of a square of side three kilometres, the adjacent squares being numbered as in figure 2:-

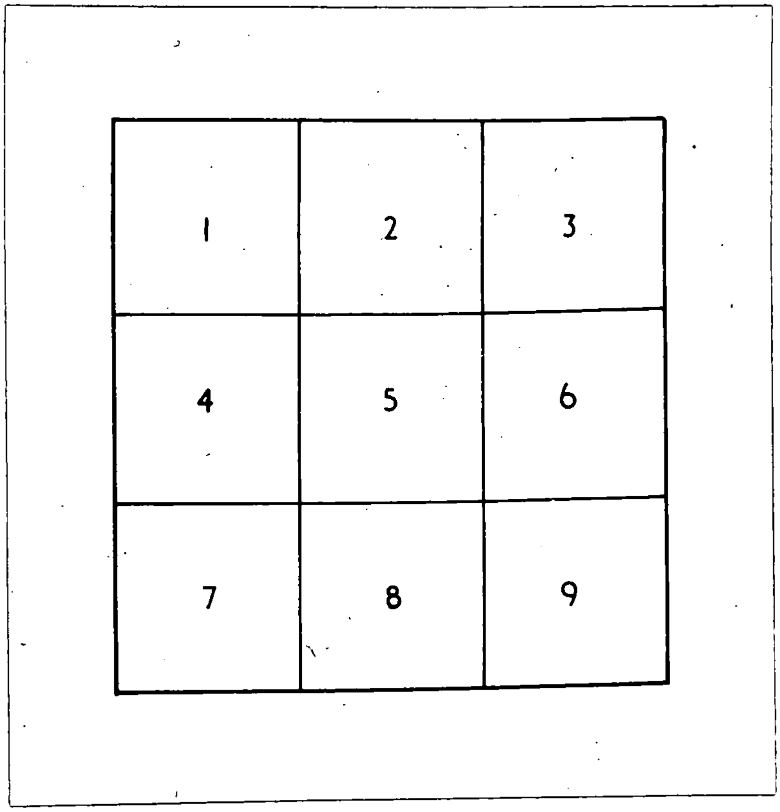

Figure 2

The square containing the station is always rejected, since the distance to the centre of the square is necessarily less than one kilometre. If the distance of the station to the centre of the square is greater than eight kilometres, the block of sixteen squares is treated as a single square. If the distance is between four and eight kilometres, the block is treated as four squares of four square kilometres (see below). The terrain correction for the rejected squares needs to be calculated by the conventional zone chart method. The total terrain correction is the sum of the two computations.

In arranging the grid, the Isle of Man was imagined to be located approximately centrally, in a square of side 96 kilometres (Figure 3). The south-west corner of the square was given the reference 0000 0000, the north-east corner having the reference 9600 9600. The actual National Grid reference of the south-west corner is 189000 434000.

The average height of each kilometre square on the Island, and of the kilometre squares immediately adjacent to the Island was estimated. Because of the low relief of the sea bed, it was possible to use larger squares, at increasing distances from the coast. Thus squares of sides 4, 8, and 16 kilometres were used, the latter forming a frame around the 96 kilometre square. This is illustrated in figure 3. The use of these larger squares saved a considerable amount of time in working out average elevations, and on computor time.

Two sets of data tapes were prepared for the computor. One set contained the coordinates and elevation of each station, and the other contained the average heights of the squares, the location of the squares, and a density factor, depending on the rock formation. The single kilometre squares were grouped into squares of 16, and the coordinates of the south-west corner used for locating the squares. The arrangement of the squares within the block of 16 was as in figure 4.

Diagram showing the limits of the area corrected for terrain corrections using the Ferranti Pegasus computor. Numbers refer to the areas of the larger squares.

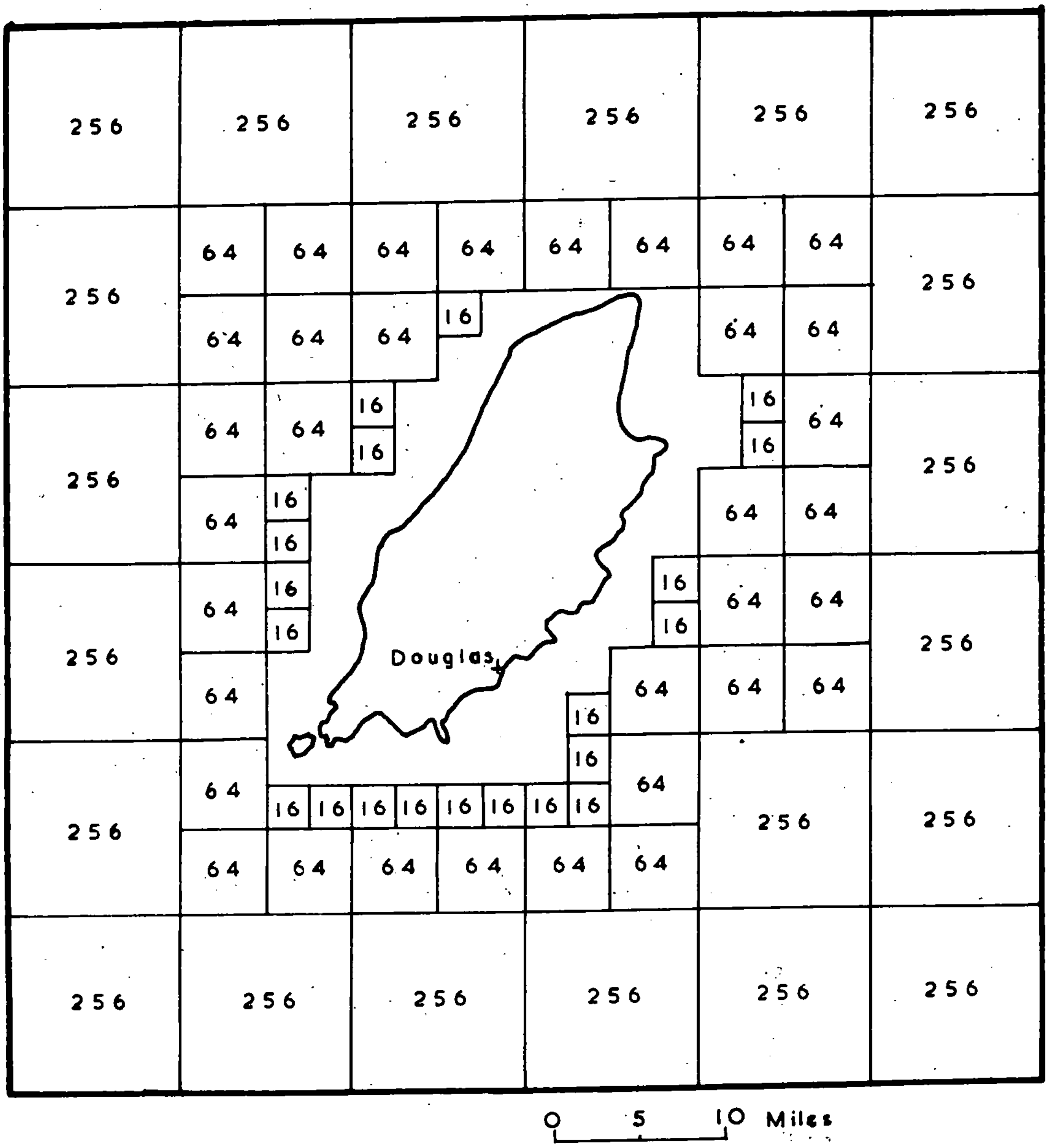

FIGURE 3

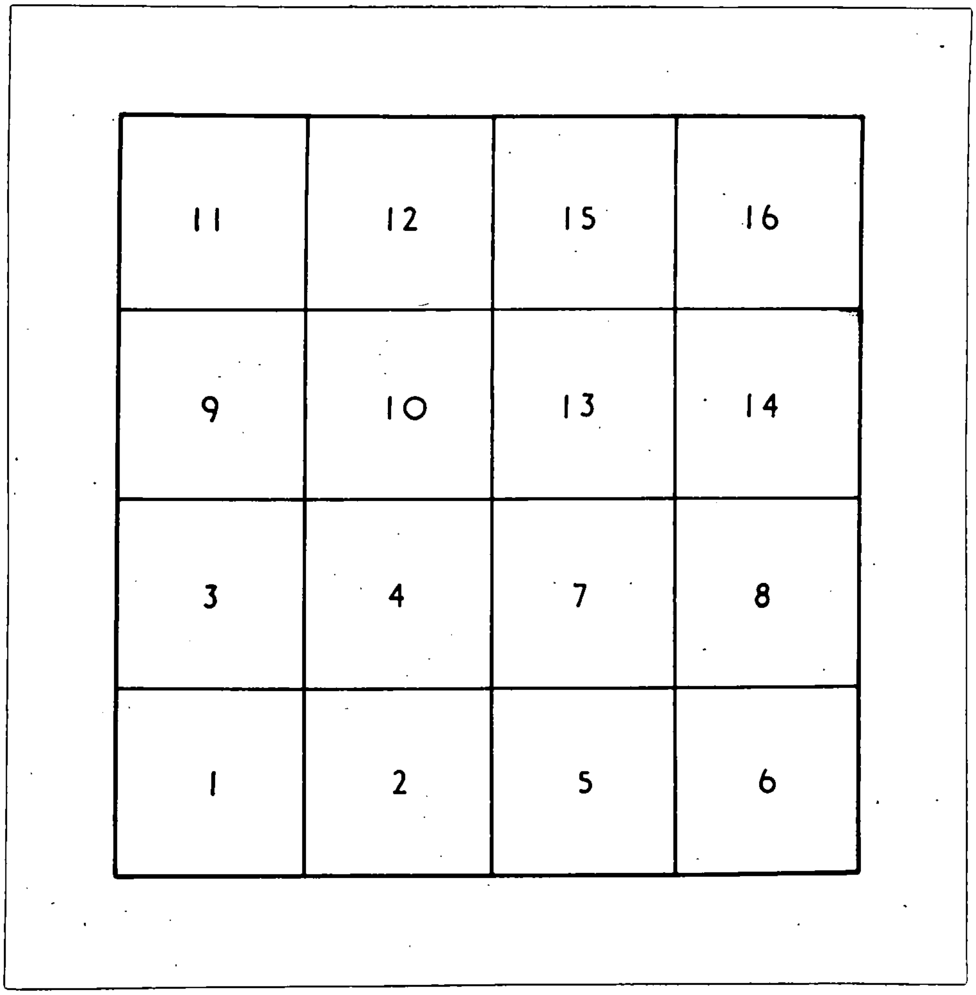

Figure 4

In the case of the larger squares, these were placed singly and the coordinates of the centre of the square noted. In addition to the coordinates, elevation and density factor, it was also necessary to record the area of these larger squares.

The terrain corrections for twelve stations were computed entirely by the zone chart method and the results are compared with the corrections calculated by the computor, in the following table:

Station number	Height of station in feet	Computor correction	Zone chart correction	Difference
1	17.0	0.589	0.586	0.003
10	40.0	0.165	0.210	0.045
29	83.3	0.206	0.182	0.022
30	142.5	0.822	0.901	0.019
44	1398.0	2.337	2.267	0.070
108	507.0	0.565	0.561	0.004
127	303.9	1.300	1.300	0.000
193	19.0	0.052	0.038	0.014
214	456.9	0.980	0.967	0.013
229	130.0	2.241	2.241	0.000
270	1266.0	1.600	1.690	0.090
353	600.0	0.522	0.574	0.052

It can be seen that by comparing results, the values obtained all agree to within 0.1 mgal.

Details of gravity values, latitudes, terrain corrections, etc., are to be found in the appendix.

CHAPTER V

BOUGUER ANOMALIES

The outstanding feature of the Bouguer anomaly map of the Isle of Man (see appendix), is the comparatively high anomaly over the whole of the Island, the average value being approximately 43 mgals. Superimposed on this "background" anomaly, are six anomalies, five of which are in a negative sense relative to the background value(figure 5).

Lying along the main stratigraphical axis of the Island are three anomalies, which have been called the Dhoon, Foxdale and Calf of Man anomalies respectively (see figure 5). These anomalies are all in a negative sense relative to the background anomaly of 43 mgals. The most prominent of these anomalies is the Foxdale anomaly. This anomaly is approximately oval in shape and has a minimum value of 27.2 mgals in Foxdale village. Along the eastern margin of the anomaly the gradients are especially steep, the maximum being in the order of 14 mgals per mile. Continuing south-westwards along the stratigraphical axis, the Bouguer anomaly rises to about 33 mgals and then begins to decrease, until at Spanish Head, the anomaly is only 30.0 mgals. It is perhaps rather unfortunate that no readings were made on the Calf of Man, as they would have helped in the delimitation of this anomaly. It is quite possible that this

SKETCH MAP OF THE ISLE OF MAN SHOWING THE MAIN ANOMALIES

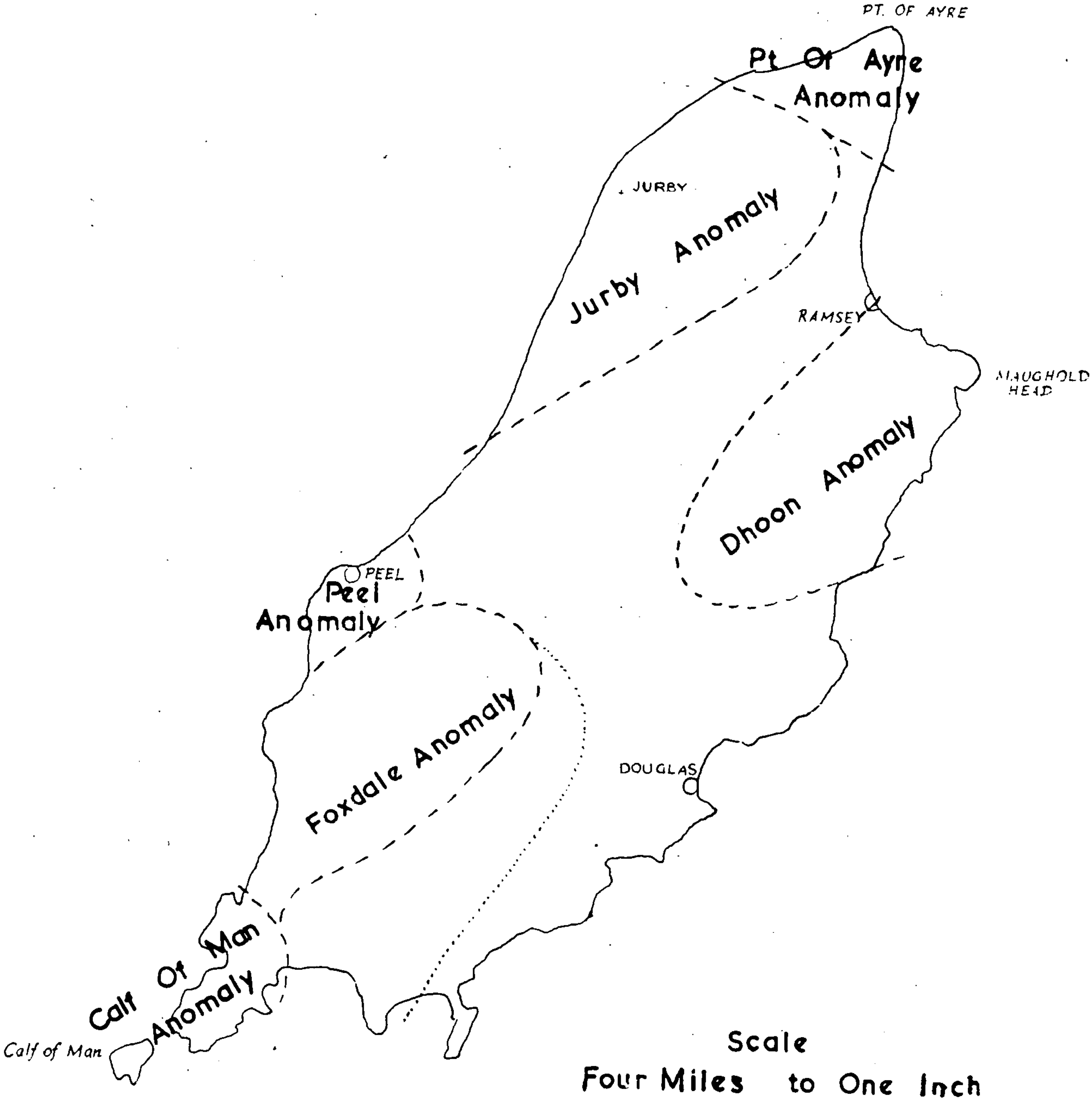

FIGURE 5

anomaly is of similar shape to that of Foxdale. The gradients over this anomaly are shallow, when compared with those over the Foxdale anomaly.

Northeastwards from Foxdale, along the main axis of the Island, the Bouguer anomaly increases to 42 mgals and then gradually decreases to 36.1 mgals. This is the Dhoon anomaly. At the centre of the anomaly, between two stations three quarters of a mile apart and each giving Bouguer values of 36.1 mgals, a value of 31.6 mgals was recorded. This anomalous station was later repeated, along with the two adjacent stations, and the same values were obtained. The elevation of this station is thought to be in error, since an explanation in terms of geology would be extremely difficult. The shape of the anomaly is roughly circular in outline.

In the neighbourhood of Peel, in the west of the Isle of Man, the isogals from the Foxdale anomaly are deflected northwards, giving rise to a small residual anomaly, which has been called the Peel anomaly. The anomaly here is in a negative sense, relative to the regional Bouguer anomaly, and is only in the order of about 1.5 mgals.

Along the north-west coast, there is a broad region of positive Bouguer anomaly,(relative to the background anomaly), which reaches a maximum of 48.2 mgals near Jurby. The gradients leading up to this anomaly are quite shallow, and do not exceed more than about 2.5 mgals per mile.

This is the Jurby anomaly.

North-eastwards from Jurby, the Bouguer anomaly decreases quite slowly, until just north of Bride, where the gradient suddenly steepens until it is 6 mgals per mile. From here, to the Point of Ayre, the gradient remains at about 5 mgals per mile. At the Point of Ayre, the Bouguer anomaly is only 32.7 mgals. The isogals of this anomaly, (the Point of Ayre anomaly), are almost parallel, running in an east-west direction.

Over the remainder of the Island, the Bouguer anomaly is fairly constant, varying between 42 and 45 mgals.

CHAPTER VI

INTERPRETATION OF THE BOUGUER ANOMALIES

The detailed interpretations of the various Bouguer anomalies have been divided between Mr. Cornwell and myself. The anomalies south of a line drawn westwards from Ramsey, have received detailed interpretations from Mr. Cornwell and are only briefly mentioned in this thesis. The Peel, Jurby and Point of Ayre anomalies are treated here in greater detail.

The most striking feature of the Bouguer anomaly map of the Isle of Man is the relatively high value of Bouguer anomaly over the whole of the Island. When Bouguer anomaly maps of adjacent areas are examined, it is seen that the Bouguer anomalies increase towards the Irish Sea region. Rocks of high density must therefore underlie the whole of the region. One possible explanation is that there is a rise in the basement rocks. Another explanation is that the whole of the Irish Sea area is underlain by basic or ultrabasic rocks. The dominant north-east, south-west strike of the isogals may correspond to the Caledonian strike of the Manx Slates.

The Dhoon, Foxdale and Calf of Man Anomalies

Lying along the main stratigraphical axis of the Island are the Dhoon, Foxdale and Calf of Man anomalies.

The centres of the first two anomalies correspond roughly to known outcrops of granitic rocks. The centre of the Dhoon anomaly is displaced to the south-west of the granite outcrop. At Foxdale, granite occurs to the south-east of the gravity minimum. It is quite clear that these two anomalies are caused by the granites which are intruded into the more dense Manx Slates (see table of densities).

Although there is no known outcrop of granite in the vicinity of the Calf of Man anomaly, but by similarity with the Foxdale and Dhoon anomalies, it may be caused by a granite unexposed on land. A point in favour of the existence of a granite is the occurrence of hydrothermal veins containing copper minerals, at Bradda Head. Copper veins of this nature often occur near to granite masses.. If a granite exists in the vicinity of the Calf of Man, it is quite probable that it is of similar type to the Foxdale granite. The trend of the isogals suggests that the two masses are joined at depth. Indeed, the Dhoon granite is probably also joined to the Foxdale granite at depth, since a broad saddle joins the two anomalies. The reason for the difference between the Dhoon and Foxdale anomalies can be explained by the fact that the former has assimilated considerable amounts of Manx Slate, and other rock material. A common origin for the three granites is therefore quite feasible.

The Peel Anomaly

On examining the Bouguer anomaly map, it can be seen that the isogals of the Foxdale anomaly are deflected northwards near Peel. When a residual Bouguer anomaly map is drawn for this region an anomaly in the order of - 1.5 mgals is obtained. It is known from geological evidence that there is a faulted trough of Lower Carboniferous sandstones and conglomerates in the Peel area, and therefore it is reasonable to assume that they cause the anomaly. Assuming the trough to be a faulted slab of rock, with a density contrast of 0.08 gr/cc. with the surrounding Manx Slates, the thickness of the sandstones and conglomerates is approximately:

$$t \doteq \frac{80 \times A}{\rho} \text{ feet}$$

$$\doteq \frac{80 \times 1.5}{0.08} \text{ feet}$$

$$\doteq 1500 \text{ feet}$$

Therefore on the assumption of this density contrast, there may be approximately 1500 feet of Lower Carboniferous rocks in the Peel area. Dawkins (1894) estimates approximately 1400 feet and Lamplugh (1903) remarks that "if the series extend so far inland as I have supposed its aggregate thickness, including the concealed portion, may possibly be as much as this (Dawkin's estimate), or even more." Geophysical evidence appears to support these two estimates.

The Jurby Anomaly

The wide spacings of the isogals over the Jurby anomaly indicate that it is not necessarily caused by a near surface feature. Manx Slates are thought to underlie the whole of the area of this anomaly. One possible explanation is that it is due to a slight rise in the basement rocks. On the other hand it is quite possible that the maximum Bouguer anomaly measured here is in fact, the 'background' value, since it is remote from the disturbing influences of the granites to the south, and the rocks of New Red Sandstone age, to the north.

The Point of Ayre Anomaly

It is known from the results of several borings for coal, at the beginning of this century, that rocks of Lower Carboniferous and Permo-Triassic age occur beneath the glacial drift of the Northern Plain, (Dawkins, 1902; Lamplugh, 1903; Gregory, 1920.) Further borings in the Andreas area, for haematite, have helped in the delimitation of the solid rocks below the drift, (Smith,1926; see figure 6.)

Map of the Northern Part of the Isle of Man, showing probable geological boundaries (After Smith.)

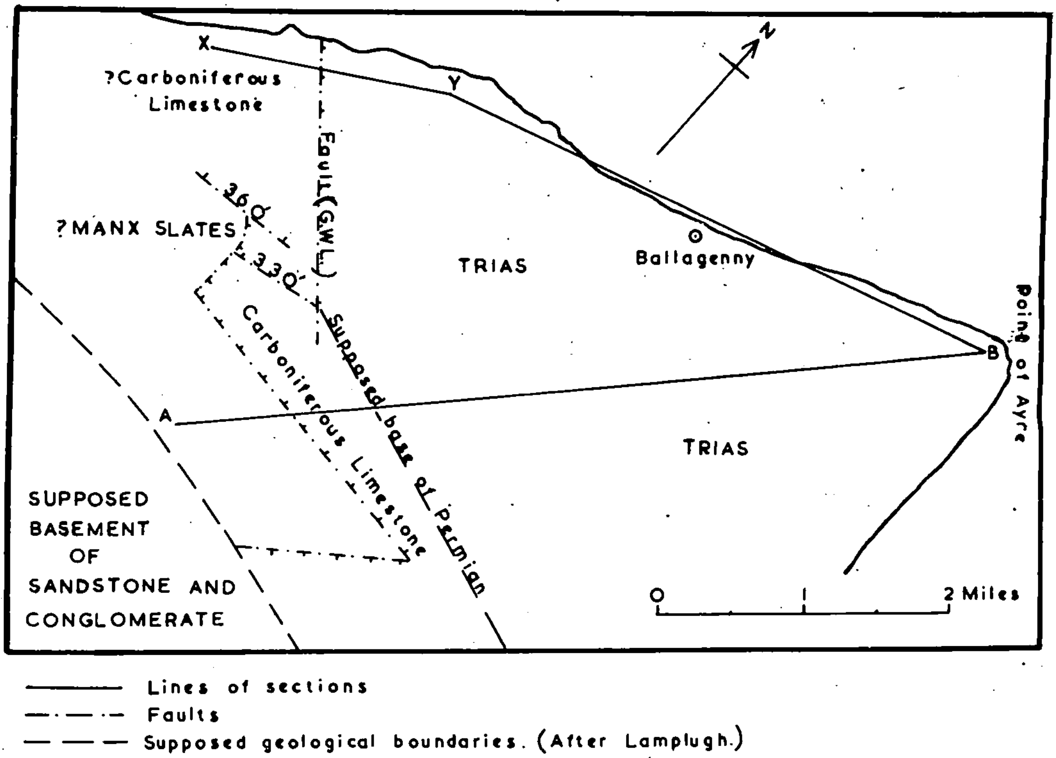

Figure 6

One possible cause of the anomaly is the presence of rocks of New Red Sandstone age, below the drift. These deposits, with an assumed density of 2.33 gr/cc., form a striking density contrast with the Manx Slates, which are supposed to underlie the area (see table of densities). The approximate east-west trend of the isogals corresponds to the almost east-west strike of the Permo-Triassic rocks, as determined in the bore-holes.

Various models have been constructed, incorporating the data from the bore-holes in an attempt to define the shape of the New Red Sandstone deposits, and to discover if there is any possibility of rocks of Carboniferous age being present. In constructing the models, it has been assumed that there are only Permo-Triassic rocks present. Therefore, on comparing the computed gravity values with the observed values, any residual anomaly could possibly be due to rocks of Carboniferous age.

The gravitational effect of the models was calculated using the Pegasus computor. The method consists of calculating the gravitational attraction of a series of infinite slabs of known thickness, at certain fixed stations. Tow sets of tapes were prepared. The first tape has the position of the stations, relative to a fixed coordinate, at which the value for gravity is required. The second tape has the coordinates of the points which determine the shape of the gravitating body, and a density factor, depending on the density of the body.

Several models were constructed for a section passing through the sites of most of the borings for coal. This is section XYB on figure 6. Between the Ballagenny bore-hole and the deepest of the three bore-holes at the Point of Ayre, there is obviously a large fault, downthrowing about 1500 feet to the north. This can be demonstrated by the fact that at the Ballagenny bore-hole, the base of the Permian is 1040 feet below sea-level. Keeping the dip constant and extrapolating to the Point of Ayre, the base of the Permian ought to be encountered at about 1400 feet below sea-level, yet it is not even encountered at a depth of almost 2900 feet. The model which agrees best with the observed profile, is the one in which a low angled fault, of throw 1500 feet, is assumed to reach the surface (of the solid rocks), at Ballagenny. (The positioning of this fault may be in error, since the section cuts the direction of strike of the rocks, and the isogals, obliquely.) The shape of the basin, from the model is shown in figure 7, below.

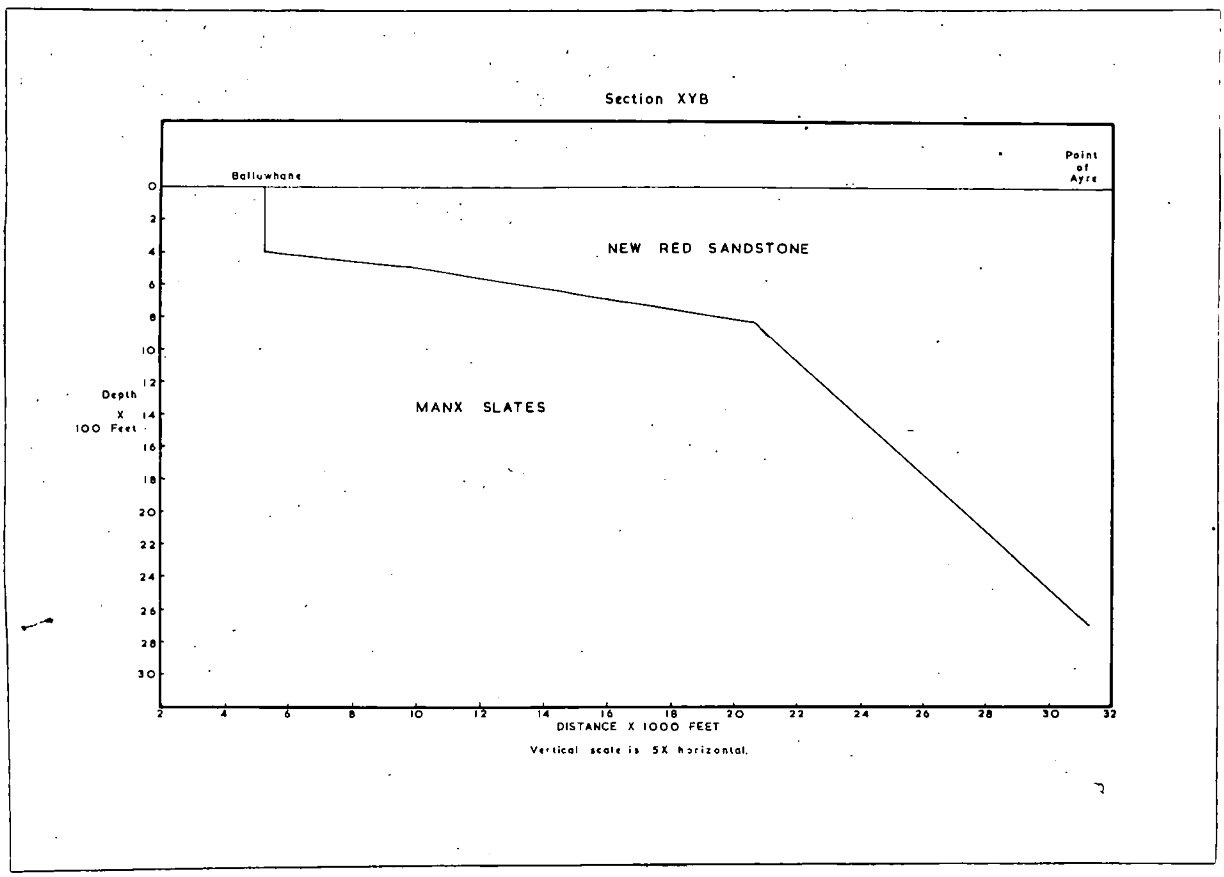

Figure 7

The observed and calculated gravity profiles are shown in figure 8, below.

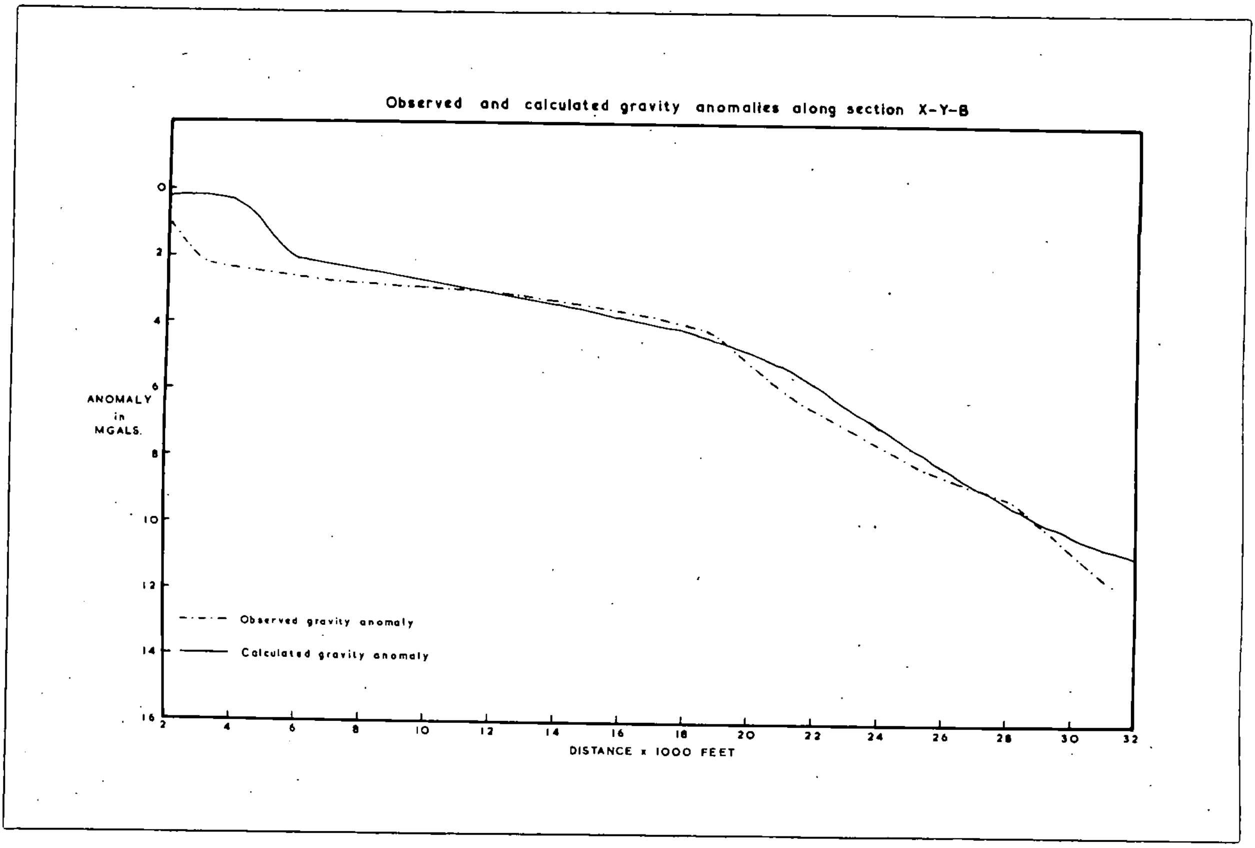

Figure 8

Another possibility, is that the low angled fault could be replaced by a series of high angled faults. This is probably more likely, geologically.

There is a residual anomaly of almost 1 mgal, between the 20,000 and 26000 feet coordinates. This may indicate the presence of Lower Carboniferous rocks. Assuming a density contrast of 0.08 gr/cc with the Manx Slates, which presumably underlie the basin, a thickness of approximately 1000 feet would cause an anomaly of 1 mgal. In the

Ballagenny boring, rocks described as 'Yoredale rocks', followed by 'Lower Carboniferous' were encountered,(Dawkins, 1902.) Thus it would appear that these rocks are responsible for the anomaly.

Section AB is almost at right angles to the direction of strike of the Permo-Triassic rocks, and has been constructed by extrapolating data from bore-holes, along the strike of the rocks, on to the line of the section. About 12 models were prepared for this section, and the model giving the nearest profile to the observed profile, is shown in figure 9, followed by the observed and calculated gravity curves shown in figure 10.

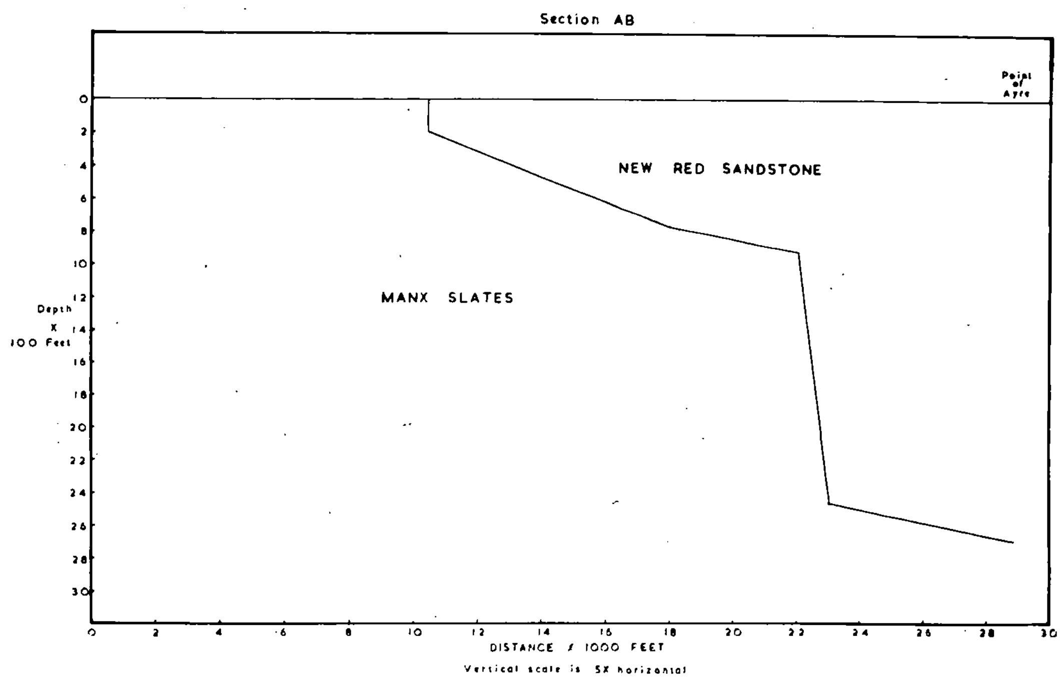

Figure 9

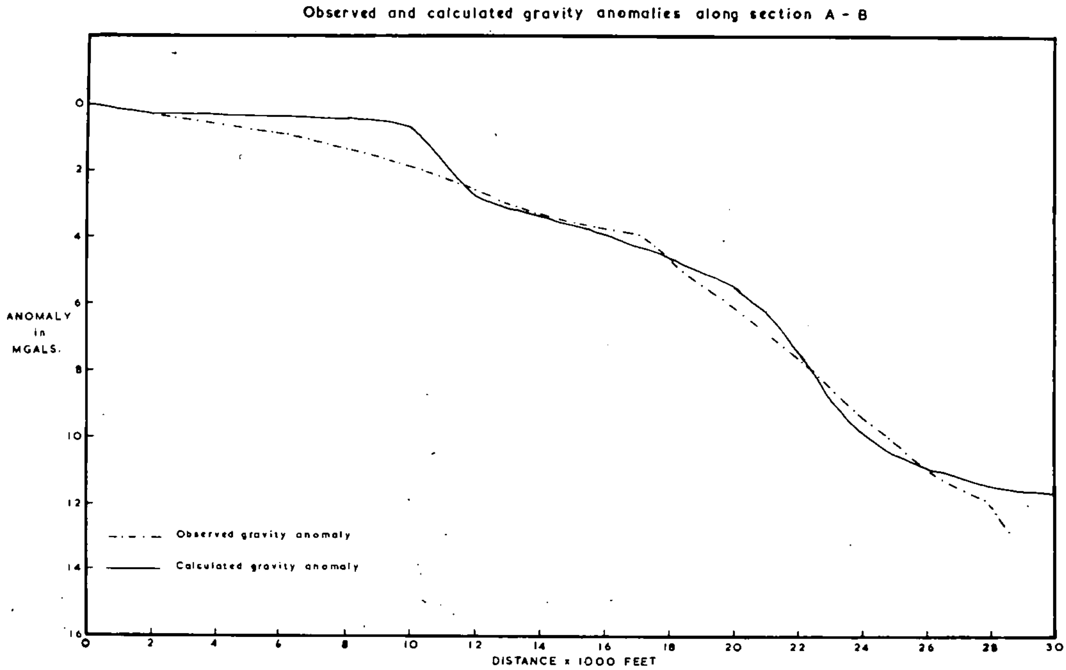

Figure 10

Here the curves agree quite closely, and the fault is thought to have been located fairly accurately. A throw to the north of 1500 feet was again assumed, when constructing the model.

The residual anomaly along this section is not so great as along section XYB, the maximum being approximately 0.6 mgals. This would indicate a thickness of only 500 to 600 feet of Carboniferous.

Near the Point of Ayre, the anomaly gradient steepens, indicating either another fault, or perhaps a thickening of the Carboniferous or Permo-Trias.. Insufficient readings were taken to enable a definite interpretation.

CHAPTER VII

CONCLUSIONS

The gravity survey has shown that over the whole of the Isle of Man there is a moderately high Bouguer anomaly. There are gravity minima around the two known outcrops of granite on the Island, and a third minimum lies along the same axis as these two minima, indicating that a third granite is possibly present, south-west of the Calf of Man. The three granites are probably all joined at depth, and have a common origin.

The residual anomaly in the Peel area is due to a faulted basin of approximately 1500 feet of sandstones, conglomerates and thin limestones, of probable Lower Carboniferous age.

The gravity maximum at Jurby could be due to basement uplift, or may represent the 'background anomaly' for the Island.

At the north end of the Isle of Man there is a basin of rocks of Permo-Triassic age, which overlie in parts, rocks of Lower Carboniferous age. These Permo-Triassic rocks strike almost east-west and dip northwards at about 10 degrees. About a mile and a half north of Bride, and running approximately along the strike of the rocks of New Red Sandstone age, is a fault with a downthrow to the north of approximately 1500 feet.

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GEOL. DEPT. (DURHAM COLLEGES) SURVEY

~~GEOLOGICAL SURVEY AND MUSEUM~~

GRAVITY BASE STATION NO. 1

TOWN: RAMSEY

COUNTY: ISLE OF MAN.

1" MAP: Sheet 87

6" MAP: 5

DESCRIPTION

Bircham Avenue (off Ballaugh road) by entrance to car park. Level with end wall of no.19, 3' from pavement edge.

GRAVITY 230.03

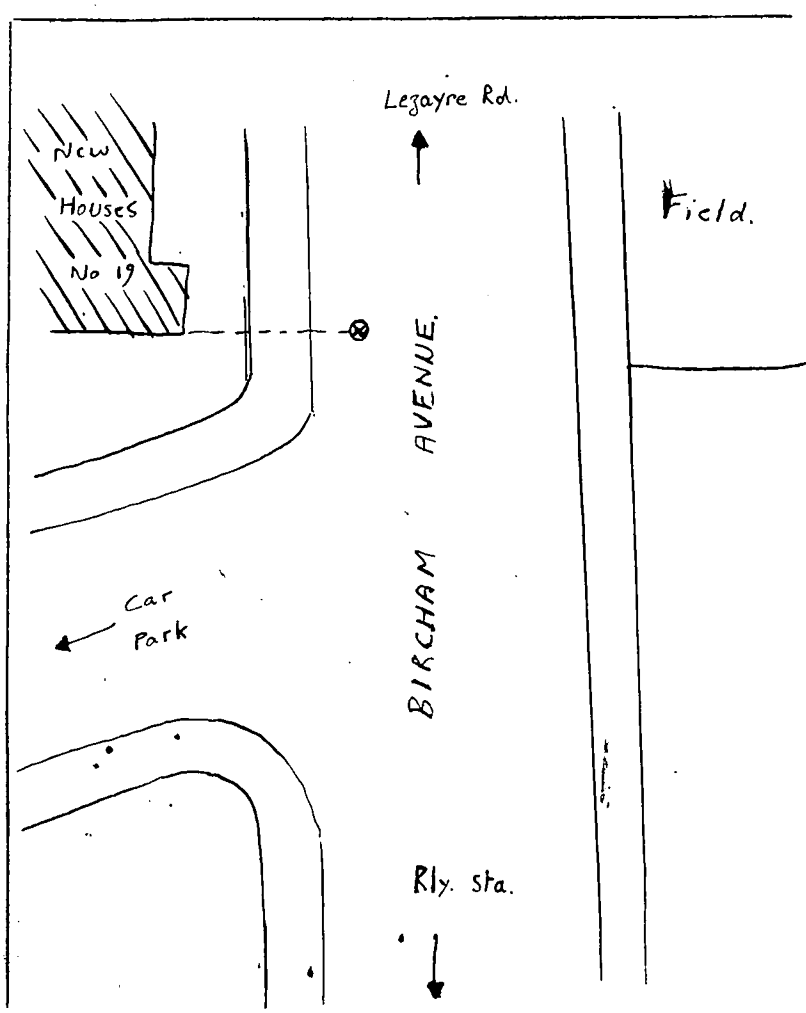
ELEVATION 17.0'

LATITUDE 54° 19' 21" N

LONGITUDE 4° 23' 17" W

DATE 6th September, 1958.

OBSERVER T. Bell & J.D.Cornwell.



GEOL. DEPT.(DURHAM COLLEGES) SURVEY

~~GEOLOGICAL SURVEY AND MUSEUM~~

GRAVITY BASE STATION NO. 19

TOWN: LAXEY **COUNTY:** ISLE OF MAN

1" MAP: 87 **6" MAP:** 11

DESCRIPTION

Meter in line with wall and 4' from corner. Settlement named "Ballamoar" on 6" map. Approximately 200 yards north of milestone (Douglas 9)
This station corresponds with the Geological Survey's Gravity Base Station No. 311.

GRAVITY 196.04

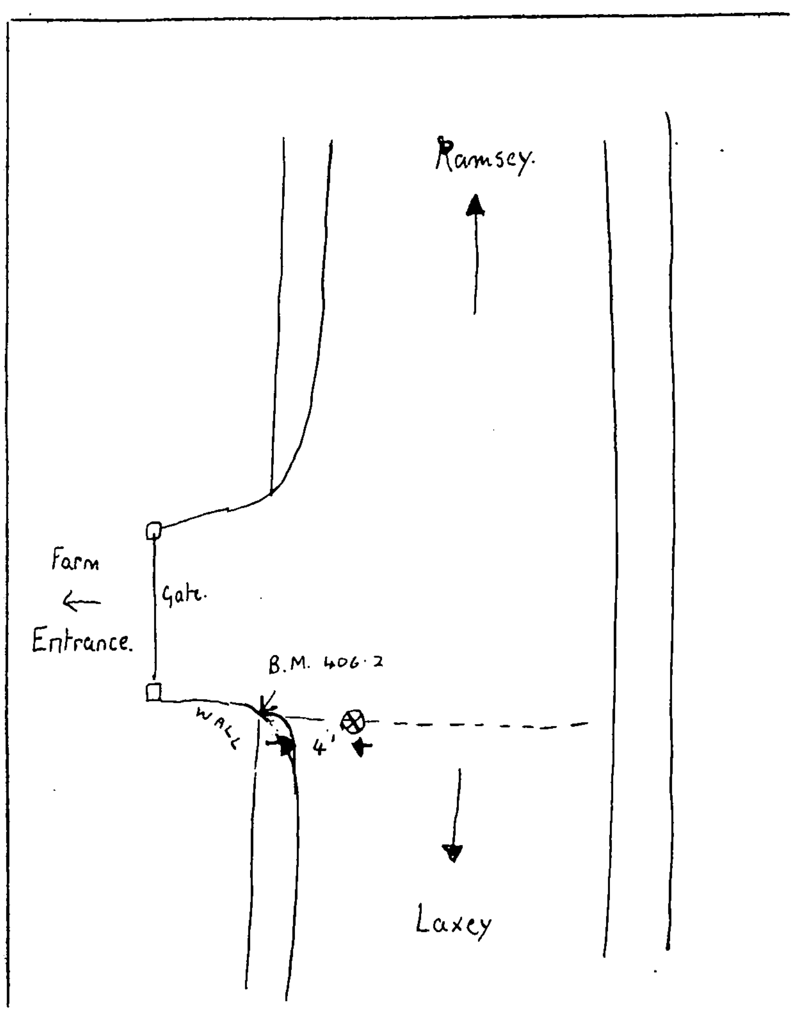
ELEVATION 403.3'

LATITUDE 54° 13' 58" N

LONGITUDE 4° 22' 41" W

DATE 8th September 1958.

OBSERVER T.Bell & J.D.Cornwell.



GEOL. DEPT.(DURHAM COLLEGES) SURVEY

~~GEOLOGICAL SURVEY AND MUSEUM~~

GRAVITY BASE STATION NO. 20.

TOWN: DOUGLAS. **COUNTY:** ISLE OF MAN.

1" MAP: 87 **6" MAP:** 13.

DESCRIPTION

On main road in Douglas between "House of Keys" and "School" on 1" map. Opposite house named "Beverly Mount", level with southern wall on western side of road 3' from pavement.

GRAVITY 206.85

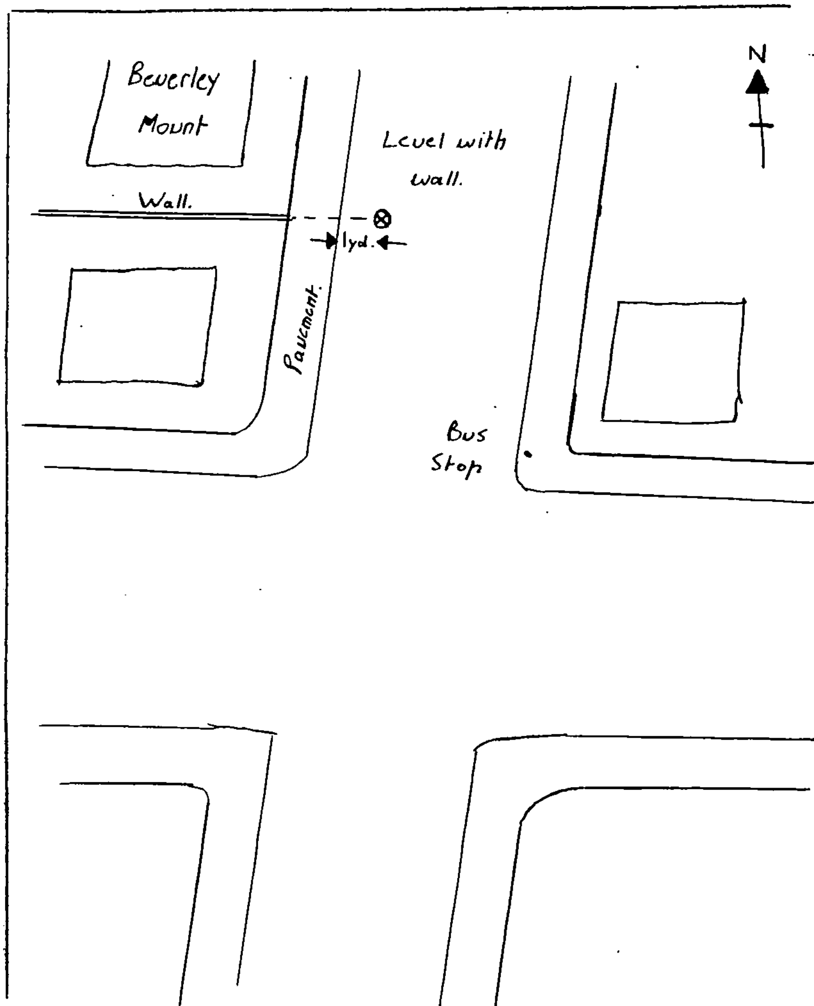
ELEVATION 157.5

LATITUDE 54° 09' 37" N

LONGITUDE 4° 29' 05" W

DATE 8th September 1958.

OBSERVER T.Bell & J.D.Cornwell.



GEOL. DEPT. (DURHAM COLLEGES) SURVEY

~~GEOLOGICAL SURVEY AND MUSEUM~~

GRAVITY BASE STATION NO. 29

TOWN: Ballasalla. **COUNTY:** ISLE OF MAN.

1" MAP: 87 **6" MAP:** 16.

DESCRIPTION

On road to Port Erin, just out of village centre, on south side of road. Level with west wall of white house (opposite church) 3′ from pavement.

GRAVITY 202.14.

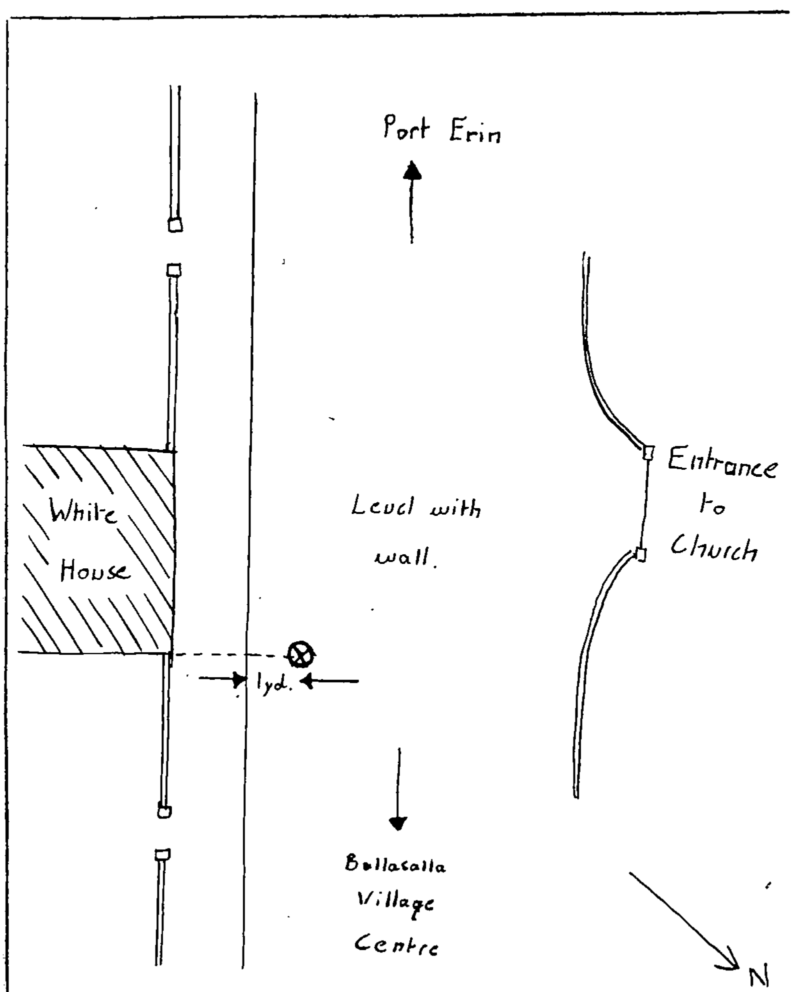
ELEVATION 83.3'

LATITUDE 54° 05' 54" N

LONGITUDE 4° 37' 52" W

DATE 9th September 1958.

OBSERVER T.Bell & J.D.Cornwell.



GEOL. DEPT.(DURHAM COLLEGES) SURVEY

~~GEOLOGICAL SURVEY AND~~ XXXXXXX

GRAVITY BASE STATION NO. 30

TOWN: St. JOHNS

COUNTY: ISLE OF MAN

1" MAP: 87

6" MAP: 9

DESCRIPTION

On west side of Foxdale-St. Johns road south of level crossing. Near cottage on west side of road, level with northerly gatepost. 3 from pavement edge.

GRAVITY 200.13

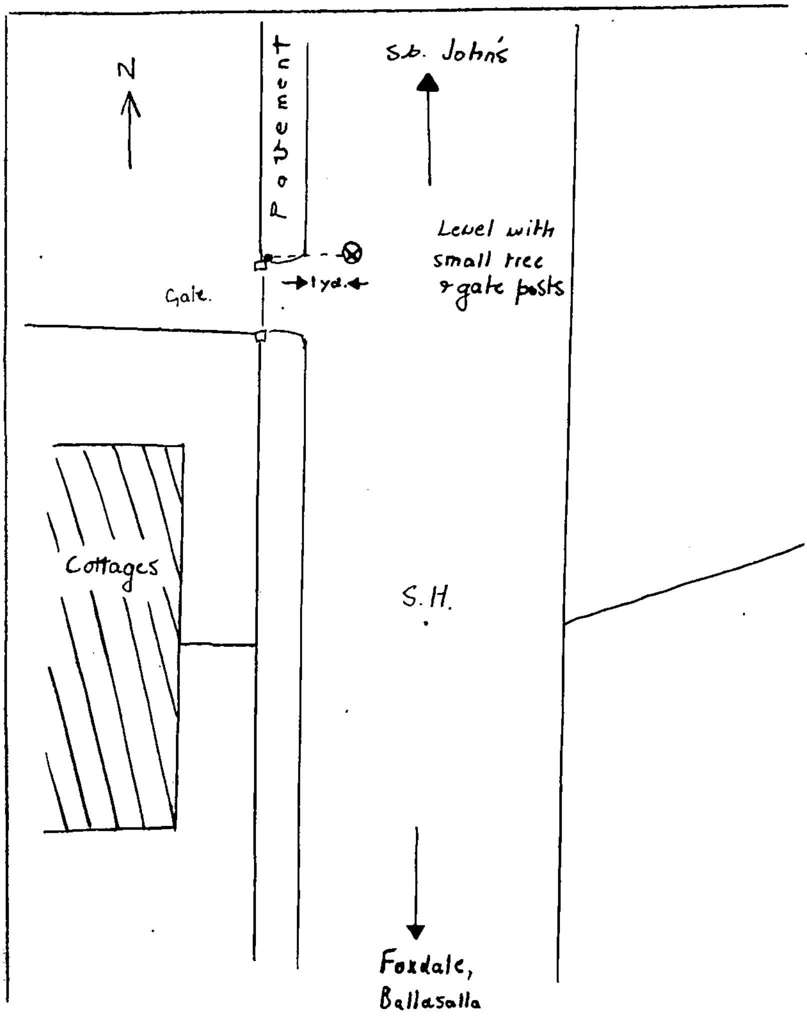
ELEVATION 142.5

LATITUDE 54° 11' 51" N

LONGITUDE 4° 37' 57" W

DATE 9th September 1958.

OBSERVER T.Bell & J.D.Cornwell.



GEOL. DEPT. (DURHAM COLLEGES) SURVEY.

XGEOLOGICALXXSURVEYXXANDXXMUSEUMX

GRAVITY BASE STATION NO. 31.

TOWN: BALLAUGH COUNTY: ISLE OF MAN

1" MAP: 87 6" MAP: 4

DESCRIPTION

On Peel - Ballaugh road just west of Ballaugh bridge. Level with Sycamore tree on south side of road, 3' 7" from hedge, 19' 3" from gatepost.

GRAVITY 226.23

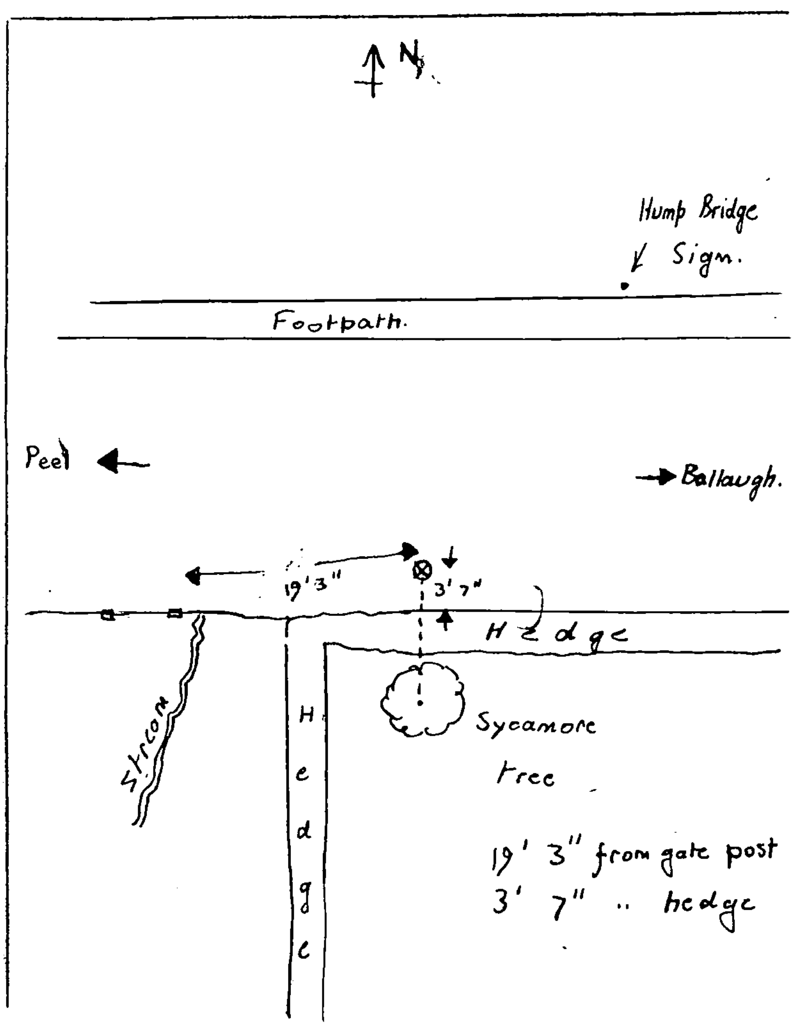
ELEVATION 106.0'

LATITUDE 54° 18' 32" N

LONGITUDE 4° 32' 35" W

DATE 10th September 1958.

OBSERVER T.Bell & J.D.Cornwell.



GEOL. DEPT. (DURHAM COLLEGES) SURVEY

~~GEOLOGICAL SURVEY AND MUSEUM~~

GRAVITY BASE STATION NO. 45

TOWN: SNAEFELL

COUNTY: ISLE OF MAN

1" MAP: 87

6" MAP: 7

DESCRIPTION

On Kirk Micheal road by junction with mountain road, between Ramsey and Douglas. On nearside of road going West. Level with fourth concrete post east of gate , four feet from roadside.

GRAVITY 137.97

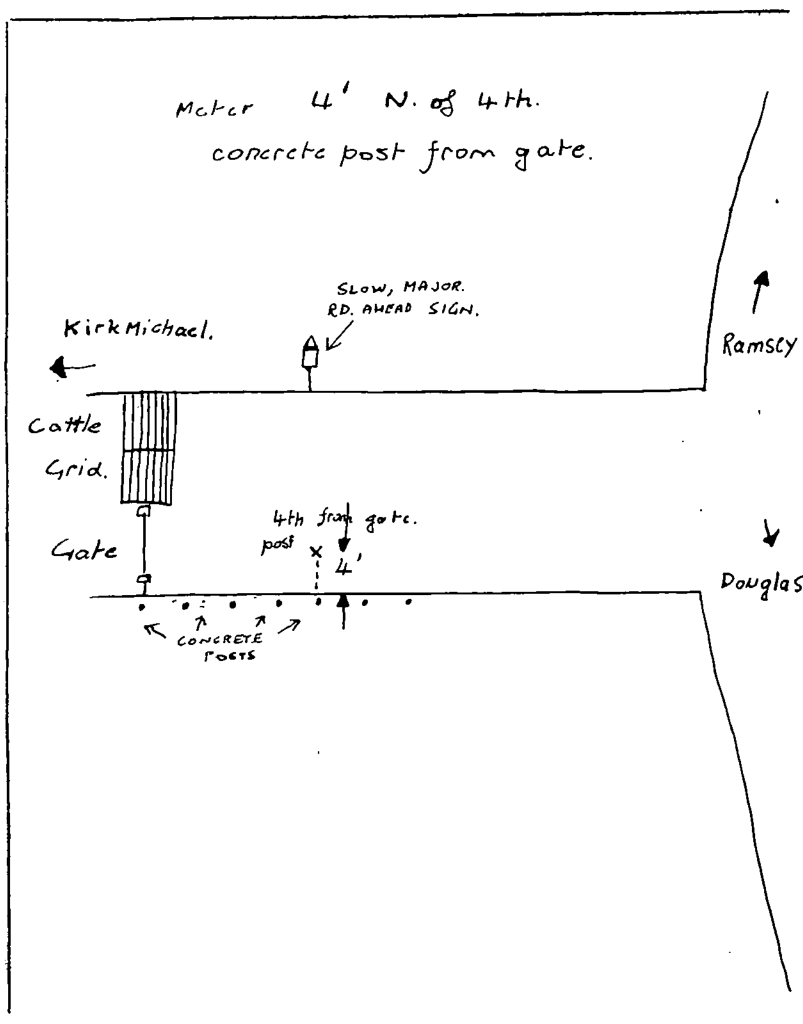
ELEVATION 1388.9'

LATITUDE 54° 14' 35" N

LONGITUDE 4° 28' 18" W

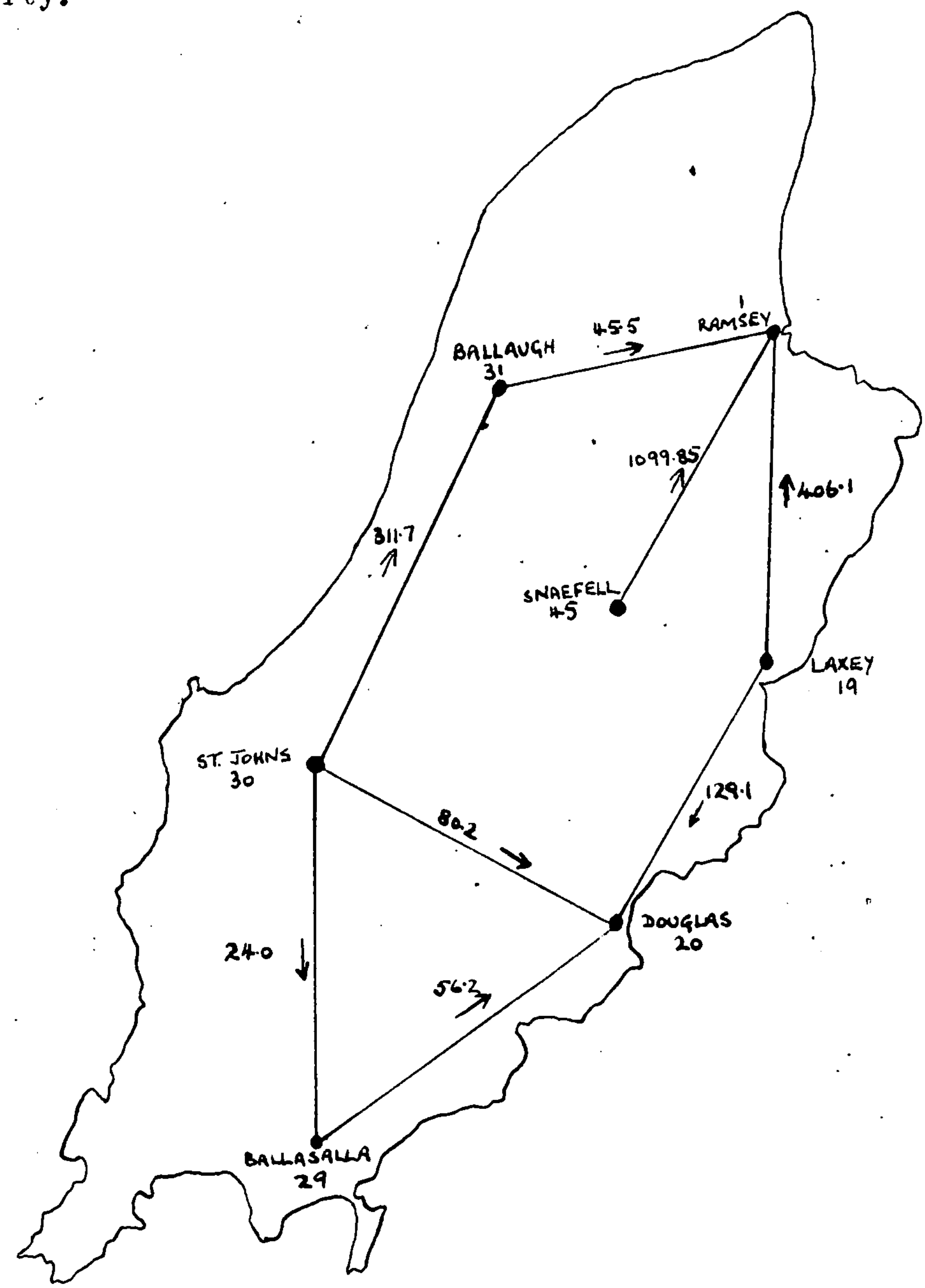
DATE 15th September 1958.

OBSERVER T.Bell & J.D.Cornwell .



ISLE OF MAN GRAVITY SURVEY, BASE STATIONS.

Values between bases in scale divisions. Arrows point in direction of decreasing gravity.



1	2			3				4	5	6		7		8	9	10	11	
OBSERVER'S STATION NUMBER	LATITUDE N.			LONGITUDE (E. or W.)				ELEVATION feet (Newlyn O.D.)	STATION TO WHICH CONNECTED	GRAVITY DIFFERENCE		TOTAL GRAVITY		FREE AIR ANOMALY (milligals)	BOUGUER ANOMALY ON I.G.F. (milligals)	DENSITY VALUES USED IN BOUGUER REDUCTION	TERRAIN	
										MEAN VALUE (milligals)	DEVIATION	MEAN VALUE	DEVIATION				CORRECTION (milligals)	ZONE
1	54	19	21	4	23	17	W	17.0	BASE			230.03			43.51	2.0	0.59	
2	54	20	02	4	23	36	W	70.0	1			229.02			44.81	"	0.25	
3	54	20	28	4	24	12	W	73.9	1			230.24			45.64	"	0.21	
4	54	20	53	4	24	49	W	74.0	1			230.42			45.17	"	0.15	
5	54	19	15	4	24	15	W	44.3	1			228.29			44.07	"	0.88	
6	54	18	34	4	24	33	W	114.0	1			220.63			42.74	2.75	2.55	
7	54	19	51	4	24	46	W	28.0	1			231.52			44.87	2.0	0.42	
8	54	19	52	4	25	52	W	21.0	1			232.16			45.01	"	0.43	
9	54	20	09	4	26	36	W	32.0	1			232.05			45.13	"	0.31	
10	54	20	53	4	26	33	W	40.0	1			232.90			45.34	"	0.17	
11	54	20	53	4	25	41	W	58.6	1			231.35			45.06	"	0.16	
12	54	24	54	4	22	10	W	31.0	1			226.79			32.74	"	0.04	
13	54	24	31	4	21	54	W	25.0	1			228.79			34.85	"	0.04	
14	54	24	15	4	21	44	W	21.0	1			229.88			36.08	"	0.04	
15	54	23	59	4	21	43	W	25.0	1			230.65			37.48	"	0.05	
16	54	23	45	4	21	54	W	38.3	1			230.70			38.83	"	0.06	
17	54	23	31	4	22	25	W	31.0	1			231.74			39.69	"	0.06	
18	54	23	10	4	22	55	W	82.0	1			228.98			40.95	"	0.08	
19	54	13	58	4	22	41	W	403.3	1			196.04			40.72	2.75	1.49	
20	54	09	37	4	29	05	W	157.5	19 [illegible]			206.85			42.09	"	0.32	
21	54	09	52	4	28	02	W	22.0	19			215.78			43.15	"	0.80	
22	54	10	24	4	27	24	W	227.5	19			204.67			43.05	"	0.45	
23	54	11	01	4	26	28	W	296.0	19			200.93			42.80	"	0.78	
24	54	11	37	4	25	30	W	307.0	19			201.47 ~~201.35~~			42.87	"	0.53	
25	54	12	04	4	24	43	W	310.0	19			201.35 ~~202.60~~			42.40	"	0.65	
26	54	12	44	4	24	20	W	299.0	19			202.60 ~~[illegible]~~			42.33	"	0.93	
27	54	13	20	4	23	48	W	209.5	19			207.43			41.74	"	1.65	
28	54	18	24	4	26	13	W	824.0	1			179.98			43.05	"	1.40	
29	54	05	54	4	37	52	W	83.3	20 & 30			202.14			38.25	2.70	0.21	
30	54	11	51	4	37	57	W	142.5	29			200.13			31.84	2.75	0.88	

Information supplied by:— .... (Name)

.... (Address)

....

Telephone:—..............................

Date:—..............................

Notes.

In returning information users are asked to insert overleaf any of the listed particulars which are readily available. If this is not convenient, information may be supplied in any form from which the details indicated in the column headings may be derived, *e.g.* a map showing station positions and elevations and gravity links and values.

The following points supplement the column headings overleaf:—

Cols. 2 and 3. Should be given to the nearest second.

Col. 4. Should be given in feet, referred to NEWLYN datum where possible. Use of any other datum (*e.g.* LIVERPOOL) should be noted in Col. 12.

Col. 5. Where a station is directly connected to a number of stations a separate line entry should be completed for each link. In the case of normal loops Col. 5. should show the local base.

Col. 6. *i.e.* measured gravity difference (and standard deviation where an estimate is possible) between the stations shown in Col. 1 and Col. 5.

Col. 7. Should show the gravity value (and its standard deviation) at the station entered in Col. 1, either as the difference from Pendulum House (CAMBRIDGE), or as a total value based on the assumed value 981.265 at Pendulum House.

Col. 9. Should if possible show the Bouguer Anomaly (in milligals) against the International Gravity Formula at Mean Sea Level (NEWLYN), based on 981.265 at Pendulum House. Use of any other height or gravity reference level should be noted in Col. 12.

Col. 11. Enter any terrain correction incorporated in the Bouguer Anomaly given in Col. 9. and the outermost zone compensated (HAMMER nomenclature).

Users are asked to return with this form site descriptions from which it will be possible to re-occupy the station and accurately plot its position on the O.S. 6" map. Station Description Sheets have been circulated with this form.

Please indicate clearly any information which you require to be treated as confidential. References to publications should be given in Col. 12 (Remarks).

Information should be addressed to:—

The Director, Geological Survey and Museum, London, S.W.7.

All information will be acknowledged on receipt.

C.B.H. 18342 - Wt.9335 - Dd.0458 - 5000 - 5/50

1 OBSERVER'S STATION NUMBER	2 LATITUDE N.			3 LONGITUDE (E. or W.)				4 ELEVATION feet (Newlyn O.D.)	5 STATION TO WHICH CONNECTED	6 GRAVITY DIFFERENCE MEAN VALUE (milligals)	DEVIATION	7 TOTAL GRAVITY MEAN VALUE	DEVIATION	8 FREE AIR ANOMALY (milligals)	9 BOUGUER ANOMALY ON I.G.F. (milligals)	10 DENSITY VALUES USED IN BOUGUER REDUCTION	11 TERRAIN CORRECTION (milligals)	ZONE
31	54	18	32	4	32	35	W	106.0	1 & 30			226.23			47.07	2.00	0.68	
32	54	14	26	4	24	34	W	308.7	19			201.32			40.35	2.75	2.09	
33	54	14	48	4	24	43	W	552.0	19			186.61			39.16	"	1.78	
34	54	15	08	4	25	44	W	587.2	19			183.15			39.94	"	4.42	
35	54	15	20	4	26	19	W	774.0	19			172.99			40.04	"	3.96	
36	54	15	02	4	24	59	W	658.0	19			179.33			39.32	"	3.31	
37	54	16	53	4	23	52	W	961.9	19			163.15			37.98	"	2.87	
38	54	18	01	4	32	05	W	173.0	31			220.23			45.88	"	1.83	
39	54	17	21	4	30	25	W	943.2	31			171.27			42.88	"	1.41	
40	54	16	50	4	31	03	W	1003.2	31			166.47			42.79	"	1.85	
41	54	16	05	4	31	01	W	780.0	31			178.98			42.35	"	0.99	
42	54	15	51	4	31	26	W	820.6	31			176.18			42.84	"	1.56	
43	54	15	04	4	32	21	W	1044.0	31			159.24			40.29	"	1.66	
44	54	14	53	4	28	29	W	1398.0	31			138.57			41.45	"	2.34	
45	54	14	35	4	28	18	W	1388.9	1			137.97			40.48	"	2.08	
46	54	20	37	4	28	02	W	66.1	1			230.11			44.94	2.00	0.39	
47	54	21	08	4	22	59	W	51.0	1			231.78			44.60	"	0.15	
48	54	21	35	4	23	07	W	95.6	1			229.20			44.39	"	0.11	
49	54	21	08	4	23	55	W	86.5	1			229.59			44.84	"	0.13	
50	54	09	08	4	30	35	W	92.0	20			210.58			42.67	2.75	0.34	
51	54	08	32	4	32	00	W	208.0	20			202.64			42.54	"	0.45	
52	54	08	15	4	33	16	W	445.0	20			186.90			41.09	"	0.37	
53	54	07	45	4	34	00	W	402.0	20			188.83			41.16	"	0.32	
54	54	07	17	4	33	34	W	297.0	20			196.21			43.56	"	0.28	
55	54	07	56	4	31	48	W	302.6	20			196.63			42.88	"	0.38	
56	54	08	23	4	30	29	W	153.0	20			205.75			42.57	"	0.40	
57	54	08	23	4	29	20	W	380.0	20			191.41			42.27	"	1.05	
58	54	09	17	4	32	25	W	340.0	20			194.70			41.19	"	0.34	
59	54	10	02	4	31	02	W	108.0	20			209.62			41.54	"	0.52	
60	54	10	21	4	32	30	W	207.0	20 & 30			203.10			40.24	"	0.35	

Information supplied by:— .... (Name)

.... (Address)

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C.B.H. 18342 - Wt. 9335 - Dd. 0458 - 5000 - 5/50

1	2			3				4	5	6		7		8	9	10	11	
OBSERVER'S STATION NUMBER	LATITUDE N.			LONGITUDE (E. or W.)				ELEVATION feet (Newlyn O.D.)	STATION TO WHICH CONNECTED	GRAVITY DIFFERENCE		TOTAL GRAVITY		FREE AIR ANOMALY (milligals)	BOUGUER ANOMALY ON I.G.F. (milligals)	DENSITY VALUES USED IN BOUGUER REDUCTION	TERRAIN	
										MEAN VALUE (milligals)	DEVIATION	MEAN VALUE	DEVIATION				CORRECTION (milligals)	ZONE
61	54	11	05	4	34	01	W	181.0	20 & 30			203.16			38.21	2.75	0.83	
62	54	11	34	4	35	22	W	177.0	20 & 30			199.90			35.24	"	2.04	
63	54	11	52	4	36	56	W	166.0	20 & 30			200.09			33.17	"	0.88	
64	54	11	03	4	38	24	W	262.0	30			189.60			30.28	"	1.68	
65	54	10	10	4	38	16	W	446.0	30			175.35			27.54	"	1.04	
66	54	10	12	4	37	05	W	524.0	30			173.24			29.36	"	0.40	
67	54	9	53	4	35	38	W	586.0	"			173.72			34.13	"	0.60	
68	54	9	16	4	34	13	W	485.0	"			183.70			39.05	"	0.62	
69	54	10	05	4	33	39	W	197.0	"			202.09			39.11	"	0.44	
70	54	12	48	4	37	50	W	192.0	30 & 31			203.55			37.45	"	1.50	
71	54	13	27	4	37	02	W	282.6	"			201.67			41.86	"	3.40	
72	54	14	09	4	36	42	W	571.5	"			189.50			43.04	"	0.69	
73	54	14	55	4	35	23	W	521.0	"			194.25			44.25	"	1.23	
74	54	15	59	4	34	42	W	285.0	"			211.15			46.05	"	1.57	
75	54	16	41	4	34	57	W	207.9	"			217.33			45.98	"	0.88	
76	54	17	35	4	34	33	W	129.0	"			223.27			46.97	2.00	0.61	
77	54	18	12	4	33	43	W	118.0	"			225.85			47.94	2.00	0.64	
78	54	19	08	4	25	24	W	56.0	"			227.35			45.05	"	1.83	
79	54	19	09	4	26	33	W	61.0	"			227.52			45.82	"	2.10	
80	54	19	18	4	27	31	W	62.0	"			228.17			45.49	"	1.26	
81	54	19	39	4	28	16	W	49.0	"			230.43			45.60	"	0.45	
82	54	20	17	4	28	08	W	42.1	"			232.51			46.03	"	0.25	
83	54	20	53	4	27	28	W	62.3	"			232.20			46.19	"	0.16	
84	54	21	41	4	27	22	W	81.0	"			231.53			45.56	"	0.10	
85	54	21	51	4	26	22	W	83.0	"			231.51			45.43	"	0.09	
86	54	21	29	4	25	04	W	69.8	"			231.92			45.48	"	0.11	
87	54	18	30	4	21	00	W	57.0	"			222.87			39.99	2.75	0.83	
88	54	18	10	4	19	57	W	204.0	"			212.36			38.40	"	0.60	
89	54	18	50	4	22	21	W	82.3	"			222.61			41.29	2.00	1.37	
90	54	21	59	4	23	26	W	100.0	"			229.33			44.23	"	0.10	

Information supplied by:— .... (Name)

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C.B.H. 18342 - Wt.9335 - Dd.0458 - 5000 - 5/50

1 OBSERVER'S STATION NUMBER	2 LATITUDE N.			3 LONGITUDE (E. or W.)				4 ELEVATION feet (Newlyn O.D.)	5 STATION TO WHICH CONNECTED	6 GRAVITY DIFFERENCE MEAN VALUE (milligals)	DEVIATION	7 TOTAL GRAVITY MEAN VALUE	DEVIATION	8 FREE AIR ANOMALY (milligals)	9 BOUGUER ANOMALY ON I.G.F. (milligals)	10 DENSITY VALUES USED IN BOUGUER REDUCTION	11 TERRAIN CORRECTION (milligals)	ZONE
91	54	22	26	4	23	35	W	142.2	1			~~192.68~~ 227.13			44.35	2.00	0.15	
92	54	22	53	4	22	23	W	100.0	"			~~193.32~~ 228.43			42.10	"	0.14	
93	54	23	01	4	23	21	W	170.0	"			~~193.~~ 223.82			42.37	"	0.31	
94	54	23	20	4	24	24	W	120.0	"			228.36			42.81	"	0.20	
95	54	22	52	4	24	54	W	181.0	"			223.66			43.27	"	0.50	
96	54	21	45	4	24	14	W	96.0	"			230.00			44.97	"	0.10	
97	54	22	34	4	24	53	W	150.0	"			226.77			44.34	"	0.16	
98	54	12	06	4	39	01	W	103.8	30			204.03			34.08	2.75	1.85	
99	54	12	14	4	40	22	W	100.1	"			206.88			35.71	"	1.04	
100	54	12	26	4	41	34	W	85.0	"			209.38			36.49	"	0.50	
101	54	12	54	4	41	46	W	100.8	"			209.62			37.10	"	0.63	
102	54	13	22	4	41	40	W	37.6	"			214.78			37.67	"	0.40	
103	54	13	10	4	40	33	W	137.0	"			208.42			37.52	2.65	0.30	
104	54	12	52	4	38	21	W	182.2	"			205.59			37.89	2.75	0.58	
105	54	12	38	4	38	23	W	215.0	"			201.89			36.70	"	0.82	
106	54	09	24	4	38	15	W	680.0	"			162.89			29.84	"	0.91	
107	54	08	34	4	38	14	W	636.0	"			168.27			33.77	"	0.87	
108	54	07	58	4	38	14	W	507.0	"			177.79			36.25	"	0.57	
109	54	08	10	4	37	11	W	379.0	"			186.04			36.44	"	0.38	
110	54	08	44	4	36	29	W	393.0	"			184.88			35.35	"	0.40	
111	54	09	40	4	36	27	W	432.0	"			180.25			31.73	"	0.44	
112	54	10	59	4	37	39	W	590.2	"			169.97			29.07	"	0.63	
113	54	09	55	4	39	44	W	910.0	30 & 29			148.99			29.28	"	1.43	
114	54	09	17	4	30	41	W	983.5	"			143.52			29.56	"	1.84	
115	54	08	47	4	41	00	W	1000.0	"			142.08			30.59	"	2.72	
116	54	08	07	4	41	20	W	829.0	"			153.89			32.08	"	1.53	
117	54	07	26	4	41	08	W	607.0	"			167.84			33.40	"	1.02	
118	54	06	38	4	40	51	W	349.0	"			184.58			35.54	"	0.49	
119	54	16	10	4	36	29	W	134.0	31 & 30			221.17			46.28 ~~45.33~~	"	0.95	
120	54	15	26	4	37	28	W	238.8	"			212.70			45.34 ~~44.09~~	"	1.25	

Information supplied by:— .... (Name)

.... (Address)

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C.B.H. 18342-Wt.9335-Dd.0458-5000-5/50

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121	54 14 53	4 38 17 W	219.0	31 & 30			212.76			44.94	2.75	1.17	
122	54 14 19	4 38 46 W	234.1	"			209.21			42.88	"	0.96	
123	54 13 52	4 39 51 W	99.3	"			214.19			40.28	2.65	0.54	
124	54 13 35	4 40 35 W	173.0	"			208.33			39.06	"	0.35	
125	54 12 53	4 40 50 W	93.0	"			208.40			35.27	"	0.31	
126	54 12 32	4 40 02 W	94.0	"			206.93			35.09	2.75	0.65	
127	54 10 38	4 38 29 W	303.9	"			186.10			29.49	"	1.30	
128	54 09 52	4 38 08 W	579.0	"			166.91			27.20	"	0.88	
129	54 11 47	4 41 52 W	206.0	30			199.76			35.39	"	0.93	
130	54 11 05	4 42 10 W	281.8	"			193.39			34.44	"	0.90	
131	54 10 39	4 43 13 W	269.0	"			193.67			34.63	"	0.95	
132	54 10 00	4 43 57 W	177.0	"			198.46			35.17	"	1.19	
133	54 09 29	4 42 37 W	707.0	"			162.01			30.92	"	1.40	
134	54 09 00	4 42 10 W	683.0	"			161.76			29.78	"	1.23	
135	54 10 25	4 39 43 W	714.7	"			162.27			29.90	"	1.00	
136	54 10 32	4 35 38 W	501.0	"			174.73			29.04	"	0.45	
137	54 09 11	4 35 41 W	400.0	"			185.64			35.84	"	0.36	
138	54 09 54	4 34 35 W	300.0	"			194.31			37.70	"	0.48	
139	54 10 27	4 34 23 W	300.0	"			194.87			37.49	"	0.49	
140	54 13 23	4 38 11 W	449.0	30 & 31			192.42			40.06	"	0.91	
141	54 13 55	4 37 35 W	565.0	"			188.54			41.98	"	0.64	
142	54 14 47	4 36 53 W	604.0	"			189.35			44.13	"	0.94	
143	54 08 09	4 39 43 W	672.0	29 & 30			165.17			33.24	"	1.06	
144	54 07 40	4 40 00 W	450.0	"			178.37			33.99	"	0.66	
145	54 08 30	4 39 07 W	700.0	"			163.26			33.15	"	1.39	
146	54 07 20	4 38 23 W	322.0	"			188.86			37.06	"	0.32	
147	54 06 45	4 38 32 W	227.0	"			194.31			37.74	"	0.34	
148	54 06 09	4 38 32 W	164.0	"			197.27			37.84	2.70	0.21	
149	54 04 40	4 38 39 W	29.0	29			203.44			38.00	"	0.11	
150	54 04 34	4 37 28 W	15.0	"			206.11			39.96	"	0.09	

Information supplied by:— .... (Name)

.... (Address)

....

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C.B.H. 18342 - Wt. 9335 - Dd. 0458 - 5000 - 5/50

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151	54 04 54	4 36 49 W	19.0	29			207.12			40.76	2.70	0.12	
152	54 03 55	4 37 09 W	33.5	"			205.03			40.97	"	0.13	
153	54 04 06	4 39 44 W	17.5	"			202.75			37.44	"	0.11	
154	54 04 47	4 39 55 W	27.3	"			202.59			36.89	"	0.11	
155	54 05 35	4 40 25 W	61.3	"			199.97			35.39	"	0.22	
156	54 05 39	4 39 24 W	67.8	"			201.87			37.46	"	0.21	
157	54 05 12	4 39 01 W	48.1	"			202.30			37.27	"	0.13	
158	54 05 52	4 41 13 W	81.0	"			199.39			35.58	2.75	0.42	
159	54 05 46	4 42 18 W	90.9	"			197.57			34.38	"	0.32	
160	54 05 26	4 43 41 W	86.5	"			195.33			32.42	"	0.38	
161	54 05 42	4 45 05 W	96.0	"			194.19			31.73	"	0.65	
162	54 05 07	4 45 17 W	61.0	"			194.26			30.22	"	0.30	
163	54 05 06	4 42 41 W	50.0	"			198.62			33.87	"	0.21	
164	54 05 00	4 41 12 W	41.0	"			200.45			35.31	2.70	0.16	
165	54 04 28	4 40 57 W	27.0	"			200.87			35.72	"	0.17	
166	54 18 16	4 23 16 W	682.0	18&45			185.62			41.18	2.75	2.07	
167	54 17 47	4 24 12 W	1019.0	"			163.66			40.44	"	3.33	
168	54 17 29	4 24 42 W	1166.0	"			154.19			40.64	"	3.30	
169	54 16 57	4 25 42 W	1254.6	"			147.68			40.32	"	3.52	
170	54 16 43	4 26 17 W	1318.0	"			144.20			39.78	"	2.39	
171	54 16 14	4 26 40 W	1381.4	"			139.87			39.78	"	2.28	
172	54 15 42	4 26 55 W	1369.0	"			139.00			40.17	"	3.51	
173	54 15 02	4 27 44 W	1346.0	"			141.05			40.24	"	1.94	
174	54 10 46	4 28 13 W	431.0	20&45			192.22			42.19	"	0.57	
175	54 10 29	4 29 23 W	234.8	20			203.24			41.91	"	0.43	
176	54 10 45	4 30 21 W	255.0	"			202.18			41.60	"	0.37	
177	54 10 58	4 31 38 W	371.9	"			194.45			40.49	"	0.41	
178	54 11 14	4 32 56 W	405.0	"			191.55			39.65	"	0.90	
179	54 14 54	4 22 18 W	602.0	19&1			181.81			38.43	"	3.05	
180	54 15 26	4 22 16 W	541.3	"			185.18			36.06	2.71	1.44	

Information supplied by:— .... (Name)

.... (Address)

....

Telephone:—....................

Date:—....................

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C.B.H. 18342 - Wt.9335 - Dd.0458 - 5000 - 5/50

1 OBSERVER'S STATION NUMBER	2 LATITUDE N.	3 LONGITUDE (E. or W)	4 ELEVATION feet (Newlyn O.D)	5 STATION TO WHICH CONNECTED	6 GRAVITY DIFFERENCE MEAN VALUE (milligals)	DEVIATION	7 TOTAL GRAVITY MEAN VALUE	DEVIATION	8 FREE AIR ANOMALY (milligals)	9 BOUGUER ANOMALY ON I.G.F. (milligals)	10 DENSITY VALUES USED IN BOUGUER REDUCTION	11 TERRAIN CORRECTION (milligals)	ZONE
181	54 16 00	4 22 36 W	493.0	1 & 19			189.00			36.32	2.75	1.75	
182	54 16 54	4 22 21 W	425.6	"			195.20			37.11	"	1.60	
183	54 17 35	4 22 01 W	522.3	"			191.20			37.72	"	1.47	
184	54 18 01	4 21 46 W	523.1	"			192.76			38.95	"	1.71	
185	54 18 36	4 29 24 W	118.2	1 & 45			223.34			45.38	"	2.28	
186	54 18 06	4 29 01 W	158.0	"			217.02			43.67	"	3.82	
187	54 17 29	4 29 21 W	205.0	"			210.77			43.03	"	5.78	
188	54 16 46	4 29 19 W	380.0	"			200.97			42.81	"	4.03	
189	54 16 20	4 29 52 W	644.1	"			187.11			43.01	"	1.90	
190	54 15 55	4 28 52 W	1027.0	"			162.95			41.85	"	1.72	
191	54 15 25	4 28 29 W	1181.9	"			151.93			41.83	"	2.87	
192	54 23 46	4 24 22 W	38.8	1			232.82			40.95	2.00	0.06	
193	54 24 07	4 24 34 W	19.0	"			233.14			39.40	"	0.05	
194	54 23 16	4 25 32 W	115.0	"			228.39			42.51	"	0.11	
195	54 23 14	4 26 44 W	75.9	"			230.90			42.34	"	0.06	
196	54 23 42	4 26 36 W	50.0	"			233.03			42.03	"	0.06	
197	54 23 11	4 27 21 W	79.0	"			230.55			42.30	"	0.09	
198	54 23 28	4 28 31 W	98.0	"			228.13			40.84	"	0.15	
199	54 17 55	4 19 00 W	207.8	"			210.70			37.39	2.75	0.67	
200	54 17 36	4 19 52 W	99.5	"			216.57			37.35	"	0.69	
201	54 17 50	4 20 56 W	255.0	"			207.38			37.62	"	1.31	
202	54 07 05	4 32 26 W	323.0	20 & 29			193.44			42.25	"	0.51	
203	54 06 43	4 34 27 W	172.3	"			201.07			41.25	"	0.25	
204	54 06 12	4 33 51 W	100.0	"			205.24			41.94	"	0.29	
205	54 06 07	4 35 34 W	263.6	"			194.10			40.81	"	0.54	
206	54 06 26	4 36 20 W	212.0	"			196.91			39.86	"	0.27	
207	54 05 26	4 36 27 W	101.3	29			202.86			40.72	~~[illegible]~~ 2.70	0.21	
208	54 07 13	4 34 51 W	258.3	"			196.41			40.99	2.75	0.29	
209	54 08 00	4 34 59 W	325.7	"			192.52			40.00	"	0.33	
210	54 07 36	4 36 08 W	372.0	"			188.43			39.16	"	0.28	

Information supplied by:— .... (Name)

.... (Address)

....

Telephone:—..

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C.B.H. 18342 - Wt.9335 - Dd.0458 - 5000 - 5/50

1 OBSERVER'S STATION NUMBER	2 LATITUDE N.			3 LONGITUDE (E. or W.)				4 ELEVATION feet (Newlyn O.D.)	5 STATION TO WHICH CONNECTED	6 GRAVITY DIFFERENCE		7 TOTAL GRAVITY		8 FREE AIR ANOMALY (milligals)	9 BOUGUER ANOMALY ON I.G.F. (milligals)	10 DENSITY VALUES USED IN BOUGUER REDUCTION	11 TERRAIN	
										MEAN VALUE (milligals)	DEVIATION	MEAN VALUE	DEVIATION				CORRECTION (milligals)	ZONE
211	54	06	58	4	36	45	W	291.0	29			192.09			38.92	2.75	0.25	
212	54	06	30	4	37	22	W	249.5	"			192.97			38.16	"	0.39	
213	54	06	54	4	39	45	W	357.8	"			185.55			36.56	"	0.40	
214	54	07	06	4	42	29	W	456.9	"			176.72			33.86	"	0.98	
215	54	06	16	4	42	06	W	255.0	"			190.22			36.11	"	0.43	
216	54	06	27	4	42	58	W	400.0	"			179.65			33.98	"	0.58	
217	54	06	52	4	43	28	W	550.0	"			169.88			32.86	"	0.99	
218	54	06	12	4	43	41	W	505.6	"			171.62			33.07	"	1.12	
219	54	11	53	4	28	25	W	582.7	1&29			184.46			42.07	"	0.86	
220	54	12	37	4	28	24	W	918.0	"			164.96			41.98	"	1.55	
221	54	13	51	4	28	11	W	1220.5	"			147.22			40.65	"	1.86	
222	54	14	46	4	30	37	W	1349.0	"			142.59			42.37	"	1.97	
223	54	13	25	4	25	10	W	522.2	19			189.41			41.38	"	0.99	
224	54	12	34	4	27	26	W	821.0	"			172.17			43.20	"	1.21	
225	54	12	56	4	26	39	W	856.0	"			168.61			41.27	"	1.30	
226	54	12	28	4	25	47	W	686.0	"			178.03			41.32	"	1.29	
227	54	11	41	4	26	33	W	542.0	"			186.74			42.12	"	0.75	
228	54	11	51	4	23	41	W	300.0	"			200.57			41.62	"	0.93	
229	54	13	58	4	24	18	W	130.0	"			211.88				"	2.24	
230	54	18	45	4	31	26	W	93.0	31			226.24			46.56	2.00	1.37	
231	54	19	04	4	30	02	W	63.0	"			228.55			46.18	"	1.16	
232	54	19	18	4	28	50	W	62.0	"			228.63			45.44	"	0.77	
233	54	19	44	4	29	33	W	50.0	"			231.21			46.17	"	0.36	
234	54	20	32	4	29	56	W	34.6	"			234.15			46.74	"	0.19	
235	54	20	38	4	31	20	W	35.0	"			235.04			47.27	"	0.15	
236	54	20	16	4	32	13	W	38.0	"			234.56			47.74	"	0.17	
237	54	19	48	4	33	13	W	19.0	"			234.40			46.97	"	0.19	
238	54	19	02	4	33	44	W	130.0	"			225.34			46.97	"	0.45	
239	54	19	08	4	32	01	W	68.0	"			230.21			47.32	"	0.42	
240	54	19	28	4	32	37	W	56.5	"			231.58			47.26	"	0.26	

Information supplied by:— .... (Name)

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C.B.H. 18342 - Wt.9335 - Dd.0458 - 5000 - 5/50

1 OBSERVER'S STATION NUMBER	2 LATITUDE N.			3 LONGITUDE (E. or W.)				4 ELEVATION feet (Newlyn O.D.)	5 STATION TO WHICH CONNECTED	6 GRAVITY DIFFERENCE MEAN VALUE (milligals)	6 DEVIATION	7 TOTAL GRAVITY MEAN VALUE	7 DEVIATION	8 FREE AIR ANOMALY (milligals)	9 BOUGUER ANOMALY ON I.G.F. (milligals)	10 DENSITY VALUES USED IN BOUGUER REDUCTION	11 TERRAIN CORRECTION (milligals)	ZONE
241	54	19	54	4	31	32	W	43.0	31			233.67			47.81	2.0	0.26	
242	54	19	26	4	30	59	W	38.0	"			232.32			46.97	"	0.45	
243	54	20	30	4	32	52	W	64.0	"			233.60			48.22	"	0.16	
244	54	21	05	4	32	19	W	80.0	"			233.24			48.08	"	0.12	
245	54	21	33	4	31	40	W	90.0	"			231.99			46.84	"	0.11	
246	54	22	15	4	30	49	W	81.9	"			232.21			45.49	"	0.09	
247	54	22	54	4	29	38	W	35.0	"			234.49			43.70	"	0.16	
248	54	22	32	4	28	49	W	61.7	"			232.96			44.45	"	0.08	
249	54	22	18	4	27	51	W	69.5	"			232.31			44.66	"	0.08	
250	54	21	50	4	28	29	W	42.0	"			234.36			45.51	"	0.10	
251	54	21	53	4	29	58	W	74.0	"			232.76			46.02	"	0.09	
252	54	21	26	4	30	48	W	83.0	1 & 31			232.06			46.59	"	0.10	
253	54	21	00	4	31	15	W	63.2	"			233.02			46.84	"	0.13	
254	54	20	49	4	29	11	W	39.0	"			233.97			46.42	"	0.16	
255	54	22	17	4	25	41	W	90.0	"			230.90			44.68	"	0.08	
256	54	22	22	4	26	31	W	71.0	"			232.52			44.89	"	0.08	
257	54	22	46	4	26	47	W	66.5	"			231.98			43.45	"	0.07	
258	54	23	00	4	28	11	W	119.0	"			227.37			42.22	"	0.18	
259	54	22	54	4	29	02	W	128.0	"			227.71			43.30	"	0.17	
260	54	21	58	4	32	03	W	52.6	"			234.22			46.05	"	0.24	
261	54	18	07	4	34	43	W	85.0	"			227.18			46.95	"	0.46	
262	54	07	30	4	43	46	W	658.0	30			163.36			33.24	2.75	2.43	
263	54	08	16	4	42	19	W	1160.3	"			132.45			31.46	"	3.03	
264	54	16	06	4	35	28	W	272.3	31 & 45			212.96			46.59	"	1.21	
265	54	14	04	4	35	16	W	504.3	"			192.68			43.27	"	1.59	
266	54	14	35	4	34	50	W	650.0	"			186.55			44.62	"	1.21	
267	54	15	10	4	34	39	W	756.8	"			180.83			45.31	"	2.16	
268	54	14	53	4	33	50	W	874.5	"			171.90			44.02	"	2.45	
269	54	14	46	4	33	00	W	1015.0	"			163.11			42.77	"	1.56	
270	54	14	40	4	31	42	W	1266.0	"			147.74			42.41	"	1.60	

Information supplied by:— .... (Name)

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C.B.H. 18342 - Wt. 9335 - Dd. 0458 - 5000 - 5/50

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271	54	11	48	4	33	57	W	500.0	20 & 45			185.46			37.14	2.75	1.71	
272	54	11	35	4	31	33	W	281.4	"			200.92			40.27	"	0.74	
273	54	12	24	4	31	18	W	361.0	"			197.54			41.75	"	1.27	
274	54	12	58	4	31	04	W	476.8	"			191.58			42.09	"	1.55	
275	54	13	50	4	31	13	W	594.0	"			185.55			43.02	"	2.84	
276	54	14	10	4	31	50	W	1042.6	"			159.82			41.99	"	1.57	
277	54	12	37	4	30	16	W	402.0	45			195.26			41.86	"	1.56	
278	54	13	16	4	29	44	W	600.0	"			185.10			42.50	"	1.61	
279	54	13	47	4	29	25	W	650.5	"			180.35			40.99	"	2.29	
280	54	12	02	4	30	44	W	288.1	"			201.86			41.02	"	1.17	
281	54	11	27	4	30	03	W	332.0	"			198.51			41.71	"	0.62	
282	54	11	15	4	28	52	W	400.0	"			194.74			42.82	"	1.20	
283	54	16	58	4	20	07	W	332.8	1			200.95			36.94	"	1.24	
284	54	16	25	4	20	41	W	330.0	"			200.03			36.25	"	0.86	
285	54	17	01	4	21	12	W	336.2	"			201.14			36.89	"	0.86	
286	54	16	08	4	21	21	W	210.0	18 & 19			201.13			31.56	"	1.74	
287	54	15	51	4	20	48	W	34.6	"			216.37			36.79	"	1.68	
288	54	14	36	4	23	20	W	688.2	"			178.80			39.50	"	1.62	
289	54	13	39	4	26	19	W	510.0	19			190.22			41.69	"	1.54	
290	54	14	08	4	26	12	W	579.2	"			185.85			40.71	"	1.53	
291	54	13	53	4	25	16	W	467.0	"			192.64			40.80	"	1.09	
292	54	11	04	4	25	42	W	200.0	"			207.00			42.83	"	0.49	
293	54	10	47	4	25	07	W	182.0	"			207.44			42.60	"	0.47	
294	54	11	20	4	24	45	W	281.0	"			201.62			41.81	"	0.45	
295	54	18	53	4	28	33	W	133.8	1 & 20			223.40			45.31	"	1.63	
296	54	11	18	4	26	59	W	400.0	"			195.11			42.59	"	0.67	
297	54	11	52	4	27	11	W	500.0	"			189.55			42.20	"	0.75	
298	54	11	30	4	27	45	W	400.0	"			194.92			42.19	"	0.75	
299	54	08	31	4	34	20	W	571.4	20			178.11			39.68	"	0.67	
300	54	08	56	4	34	54	W	385.0	"			189.07			38.72	"	0.35	

Information supplied by:— .... (Name)

.... (Address)

....

Telephone:—..............................

Date:—..............................

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Col. 11. Enter any terrain correction incorporated in the Bouguer Anomaly given in Col. 9. and the outermost zone compensated (HAMMER nomenclature).

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C.B.H. 18342 - Wt.9335 - Dd.0458 - 5000 - 5/50

1 OBSERVER'S STATION NUMBER	2 LATITUDE N.	3 LONGITUDE (E. or W)	4 ELEVATION feet (Newlyn O.D)	5 STATION TO WHICH CONNECTED	6 GRAVITY DIFFERENCE MEAN VALUE (milligals)	6 DEVIATION	7 TOTAL GRAVITY MEAN VALUE	7 DEVIATION	8 FREE AIR ANOMALY (milligals)	9 BOUGUER ANOMALY ON I.G.F. (milligals)	10 DENSITY VALUES USED IN BOUGUER REDUCTION	11 TERRAIN CORRECTION (milligals)	ZONE
301	54 08 24	4 35 52 W	321.0	20			191.14			37.76	2.75	0.32	
302	54 10 01	4 36 15 W	535.0	"			174.03			31.14	"	0.50	
303	54 09 28	4 35 03 W	502.0	"			180.90			37.05	"	0.71	
304	54 08 56	4 33 37 W	556.0	"			180.01			40.24	"	0.84	
305	54 08 50	4 28 33 W	17.0	"			214.55			42.71	"	0.41	
306	54 10 28	4 30 47 W	203.0	1 & 20			203.12			39.81	"	0.31	
307	54 11 56	4 32 37 W	600.0	"			181.72			40.59	"	1.18	
308	54 12 17	4 32 30 W	500.0	"			188.05			41.03	"	1.65	
309	54 11 33	4 40 50 W	362.7	30			188.33			33.85	"	1.37	
310	54 10 43	4 41 40 W	237.4	"			191.62			32.67	"	3.00	
311	54 10 22	4 41 15 W	381.4	"			180.62			30.61	"	2.94	
312	54 10 04	4 40 38 W	644.2	"			165.68			29.72	"	1.07	
313	54 09 57	4 38 49 W	941.0	"			146.46			29.20	"	2.08	
314	54 10 30	4 37 40 W	563.0	"			170.80			28.83	"	0.47	
315	54 09 30	4 43 39 W	212.4	29 & 30			193.67			33.58	"	1.59	
316	54 09 03	4 43 04 W	785.7	"			156.54			31.33	"	2.02	
317	54 08 40	4 42 53 W	927.2	"			147.86			32.03	"	2.50	
318	54 07 43	4 43 02 W	1000.0	"			139.94			31.22	"	3.97	
319	54 04 54	4 43 33 W	65.0	29			194.63			31.05	"	0.21	
320	54 04 27	4 43 15 W	56.5	"			195.56			32.40	"	0.48	
321	54 04 27	4 45 22 W	348.7	"			176.54			31.00	"	0.87	
322	54 04 13	4 45 53 W	467.4	"			168.78			30.78	"	1.08	
323	54 04 04	4 46 37 W	311.0	"			178.10			30.68	"	0.67	
324	54 03 50	4 47 28 W	70.2	"			191.34			30.04	"	0.65	
325	54 04 37	4 45 56 W	382.0	"			174.53			30.86	"	1.01	
326	54 05 40	4 46 28 W	350.0	29 & 30			177.61			31.35	"	1.82	
327	54 06 15	4 45 06 W	123.3	"			192.42			31.35	"	1.22	
328	54 06 04	4 43 26 W	300.0	"			182.01			31.13	"	0.73	
329	54 09 38	4 40 14 W	960.0	"			145.28			29.24	"	1.75	
330	54 18 38	4 33 44 W	136.3	1 & 31			225.25			47.72	2.00	0.39	

Information supplied by:— .... (Name)

.... (Address)

....

Telephone:—..........................

Date:—..........................

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C.B.H. 18342 - Wt. 9335 - Dd. 0458 - 5000 - 5/50

1 OBSERVER'S STATION NUMBER	2 LATITUDE N.	3 LONGITUDE (E. or W.)	4 ELEVATION feet (Newlyn O.D.)	5 STATION TO WHICH CONNECTED	6 GRAVITY DIFFERENCE MEAN VALUE (milligals)	DEVIATION	7 TOTAL GRAVITY MEAN VALUE	DEVIATION	8 FREE AIR ANOMALY (milligals)	9 BOUGUER ANOMALY ON I.G.F. (milligals)	10 DENSITY VALUES USED IN BOUGUER REDUCTION	11 TERRAIN CORRECTION (milligals)	ZONE
331	54 19 27	4 31 54 W	50.0	1 & 31			231.94			47.29	2.00	0.34	
332	54 24 50	4 21 49 W	33.0	"			227.41			33.64	"	0.09	
333	54 24 42	4 22 28 W	33.0	"			228.41			34.79	"	0.04	
334	54 18 16	4 24 59 W	176.0	"			215.22			43.03	2.75	4.16	
335	54 18 34	4 27 13 W	600.0	"			195.29			44.67	"	1.16	
336	54 18 12	4 27 08 W	850.0	"			178.58			43.42	"	1.36	
337	54 17 46	4 31 22 W	504.0	31			199.16			44.55	"	1.69	
338	54 15 24	4 31 53 W	850.0	"			173.59			43.13	"	2.06	
339	54 16 19	4 34 07 W	437.2	"			202.37			45.90	"	1.70	
340	54 20 28	4 31 46 W	37.0	1			234.85			47.67	2.00	0.16	
341	54 16 10	4 22 03 W	327.7	1 & 19			198.97			36.14	2.75	1.59	
342	54 16 02	4 21 02 W	105.3	"			211.58			36.10	"	1.86	
343	54 15 45	4 22 30 W	620.2	"			186.89			36.39	"	1.96	
344	54 14 27	4 22 21 W	503.2	"			189.05			39.62	"	2.18	
345	54 13 41	4 39 00 W	250.0	30 & 31			206.48			40.83	"	0.80	
346	54 13 05	4 40 11 W	120.6	"			209.57			37.92	2.65	0.39	
347	54 12 17	4 40 49 W	78.2	"			209.05			36.16	2.75	0.69	
348	54 12 19	4 36 10 W	500.0	30			184.06			36.88	"	1.56	
349	54 12 46	4 36 01 W	750.0	"			171.26			38.14	"	1.53	
350	54 11 20	4 34 38 W	161.3	"			202.92			37.07	"	1.47	
351	54 10 37	4 35 00 W	500.0	"			180.34			34.67	"	0.64	
352	54 10 58	4 36 42 W	500.0	"			176.69			30.51	"	0.63	
353	54 10 40	4 37 03 W	600.0	"			168.67			28.70	"	0.52	
354	54 11 01	4 39 53 W	850.0	"			159.87			35.14	"	1.50	
355	54 09 42	4 30 22 W	69.0	1 & 30			212.61			42.21	"	0.61	
356	54 12 02	4 29 17 W	500.0	"			189.02			41.61	"	0.93	
357	54 13 42	4 27 15 W	900.0	"			165.64			40.95	"	2.45	
358	54 09 04	4 38 18 W	723.3	30			161.78			31.74	"	0.90	
359	54 09 21	4 36 24 W	362.0	"			185.65			33.46	"	0.45	
360	54 09 50	4 37 23 W	600.0	"			168.27			30.64	2.62	0.67	

Information supplied by:— .... (Name)

.... (Address)

....

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C.B.H. 18342 - Wt.9335 - Dd.0458 - 5000 - 5/50

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										MEAN VALUE (milligals)	DEVIATION	MEAN VALUE	DEVIATION				CORRECTION (milligals)	ZONE
361	54	08	28	4	41	29	W	1053.0	29 & 30			139.05			30.40	2.75	1.98	
362	54	05	27	4	45	34	W	125.0	"			191.16			30.63	"	0.51	
363	54	14	53	4	32	09	W	1169.0	45			154.04			42.68	"	1.60	

Information supplied by:— .... (Name)

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....

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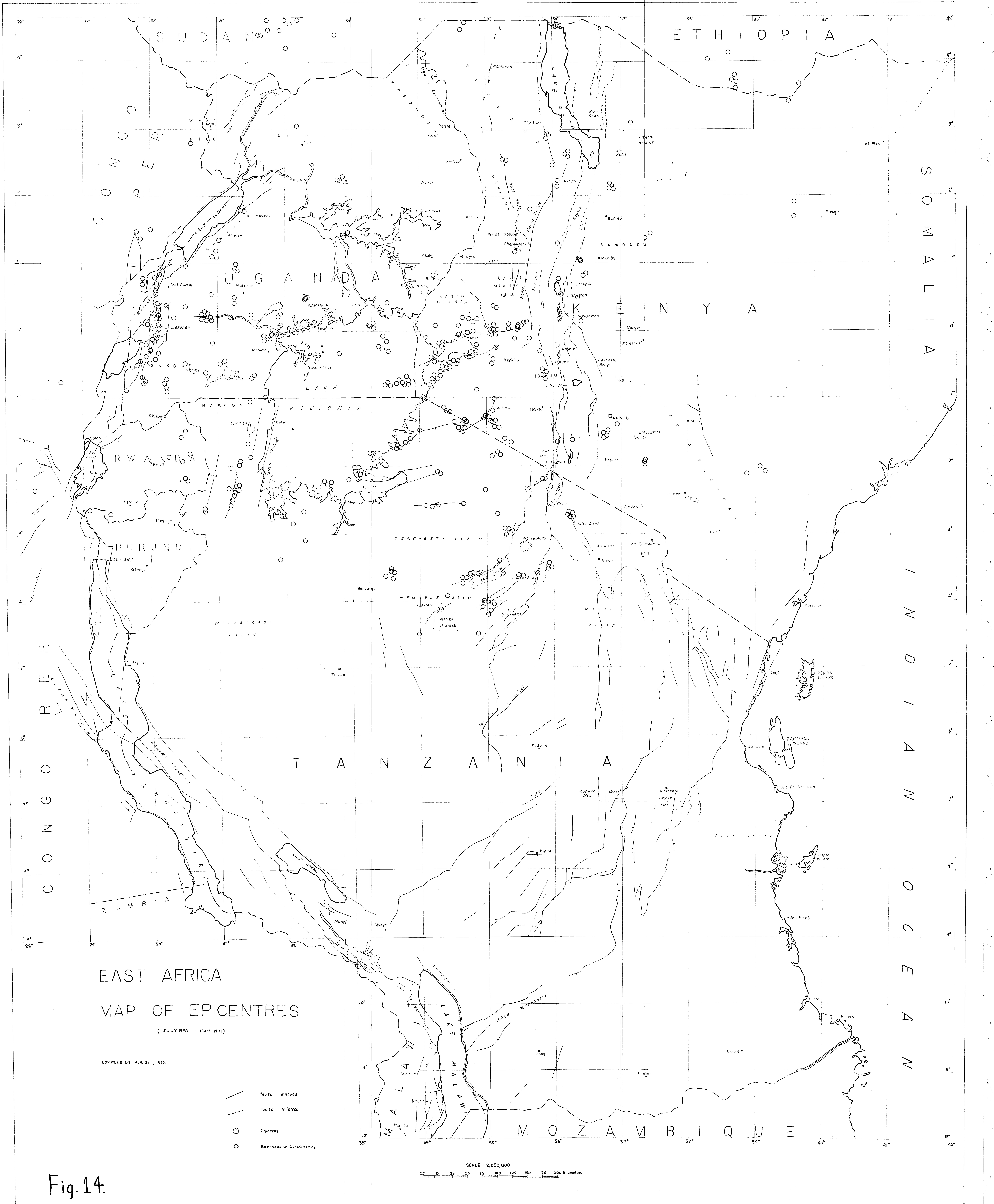
EAST AFRICA
MAP OF EPICENTRES
(JULY 1970 - MAY 1971)
COMPILED BY R.R. Gill, 1972.
faults mapped
faults inferred
Calderas
Earthquake epicentres
SCALE 1:2,000,000
Kilometers
SUDAN
ETHIOPIA
SOMALIA
KENYA
UGANDA
TANZANIA
RWANDA
BURUNDI
ZAMBIA
MALAWI
MOZAMBIQUE
CONGO REP
INDIAN OCEAN
LAKE RUDOLF
LAKE ALBERT
LAKE VICTORIA
LAKE TANGANYIKA
LAKE MALAWI
LAKE RUKWA
LAKE KIVU
SERENGETI PLAIN
DAR-ES-SALAAM
ZANZIBAR ISLAND
PEMBA ISLAND
MAFIA ISLAND
NAIROBI
KAMPALA
Fort Portal
Tabora
Dodoma
Mbeya

Fig. 14.