INSTITIÚID ÁRD-LÉINN BHAILE ÁTHA CLIATH
SCOIL NA FISICE COSMAI

Dublin Institute for Advanced Studies
SCHOOL OF COSMIC PHYSICS

GEOPHYSICAL MEMOIRS NO. 2, PART 4

MEASUREMENTS OF GRAVITY IN IRELAND

GRAVITY SURVEY OF IRELAND
NORTH OF THE LINE SLIGO-DUNDALK

BY

A. H. COOK and T. MURPHY

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CONTENTS

ABSTRACT

A gravity survey has been carried out with a small GRAF gravimeter in Ireland north of a line from Sligo to Dundalk. In all, 350 stations were established where the values of gravity have been determined within the accuracy of $\pm$ 0·4 mgal.

The Bouguer anomaly at each station was calculated and the results analysed. Low values of the anomaly were found over granite whose density, determined by measurements, is less than that of the surrounding rocks, mainly pre-Devonian. Estimates of the probable thicknesses of the larger granite masses lie between 14,000 and 43,000 feet. High values of the Bouguer anomaly measured in the Carlingford-Mourne area are explained as due to large bodies with densities about 3·0 g/cm^3 at depths in excess of 10,000 feet. It was found that the Tertiary Igneous Centres of Slieve Gullion and the Carlingford peninsula are positioned above some of these dense masses but in the Mournes there appears no simple correlation. Another high value of the anomaly, remote from this district, is explained in a similar manner.

The similarity between the pattern of the Bouguer anomaly contours and WRIGHT's tectonic plan for north-eastern Ireland is pointed out. Explanations to account for the variations of gravity are based on this scheme and indicate that thicknesses between 4,000 and 8,000 feet of light sediments, thought to be mainly Triassic, are probably present in this area.

With the exceptions of two small areas on granite, the Bouguer anomaly is positive with a mean value about 20 mgals. The isostatic anomalies are also positive on any scheme of compensation.

Details of the densities of the rocks occurring in this area are given and the attempts to arrive at mean values.

INTRODUCTION. When the results of the Gravity Survey of Central Ireland (MURPHY, 1950) were assembled it was apparent that a large positive anomaly was to be expected in the Carlingford district of Co. Louth. To investigate this thoroughly, measurements would have to be taken over a wider area and to this end Mr. B. C. BROWNE of the Department of Geodesy and Geophysics of Cambridge University arranged that a gravity survey would be undertaken by his Department and the School of Cosmic Physics in the Dublin Institute for Advanced Studies. Later this survey was extended to embrace all of Northern Ireland and since links would have to be made to the Pendulum Stations at Dublin and Sligo (COOK, 1950) Co. Donegal was also included (*Fig.* 1). The objects then became to study, in fair detail, the expected

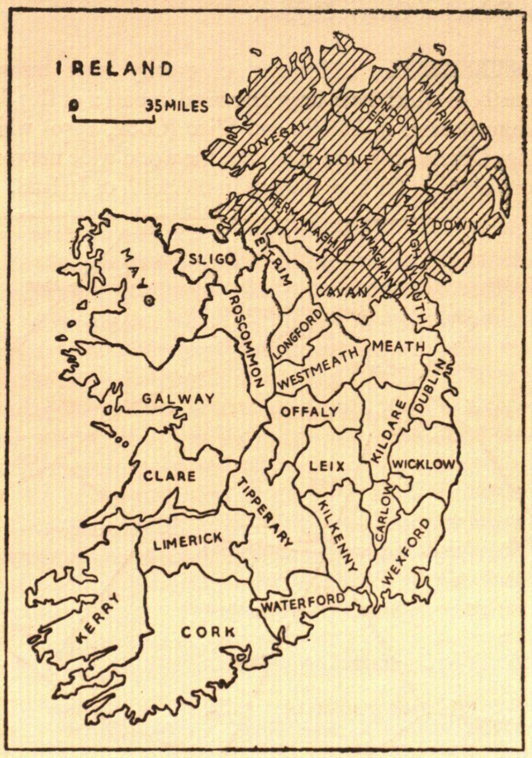

Fig. 1.—Sketch map of Ireland showing the area covered by the gravity survey.

gravity anomaly of the Carlingford peninsula, to establish stations on a country-wide network to serve as bases for more detailed study in the future and to obtain a general knowledge of the variation of gravity throughout the northern part of Ireland. This plan received the enthusiastic support and co-operation of Brigadier K. M. PAPWORTH, the Chief Survey Officer of Northern Ireland.

The survey was carried out by the authors in September 1950 and extends the observations already made by MURPHY. The gravity values were obtained by comparison with stations previously established in Ireland (see Parts 1 and 2 of this *Memoir.*)

Our thanks are due above all to Brigadier K. M. PAPWORTH who carried out the preliminaries to the survey, had prepared six-inch maps and index maps for field use, assisted us in negotiations with H. M. Customs, produced a simple method for finding the latitudes of stations, helped us from time to time with the reduction of observations and generally did all in his power to make our stay in Northern Ireland profitable and pleasurable. We also wish to thank Professor J. K. CHARLESWORTH, Queen's University Belfast, and Mr. A. FOWLER, Geological Survey of Northern Ireland, for discussions on the geology of Northern Ireland in general and on the interpretation of some of our results, and for supplying us with samples of rocks for density measurements. We are grateful to Professor H. H. READ who has allowed us to quote unpublished particulars of densities of rocks. Finally we wish to thank the following who have read parts of this paper in typescript or discussed with us various pertinent topics : Professor H. H. READ, Imperial College, London ; Dr. D. L. REYNOLDS, Edinburgh University ; Dr. J. E. RICHEY, Dundee University College ; Professor J. H. J. POOLE, Trinity College, Dublin ; Dr. S. R. NOCKOLDS, Cambridge University ; Professor O. T. JONES and Mr. B. C. BROWNE, Cambridge University.

The Ministry of Finance, Northern Ireland, bore the cost of the six inch and other maps as well as the running costs of the van for that portion of the survey which lay in Northern Ireland. The remaining maps were supplied by the Ordnance Survey of Ireland while the expenses of accommodation etc. were met jointly by the School of Cosmic Physics, Dublin and by the Department of Geodesy and Geophysics, Cambridge University, the latter with the help of a grant from the Department of Scientific and Industrial Research, London. The gravimeter was provided by the Department of Geodesy and Geophysics, Cambridge and the motor van by the Dublin Institute for Advanced Studies. The motor van was a gift from Messrs. Arthur Guinness, Son & Co. Ltd., Dublin for the various field studies of the Meteorological and Geophysical Section of the School of Cosmic Physics.

THE GRAVITY MEASUREMENTS. Differences of gravity were measured by the small GRAF Askania gravimeter using methods which have been discussed in part 2 of this *Memoir*. The measurements were based on the pendulum stations at Dublin and Sligo (COOK, 1950) which are compared with the Pendulum House, Cambridge Observatory, and thus with the world wide network of gravity measurements. *Fig.* 2 shows the comparisons between the base stations in the north of Ireland.

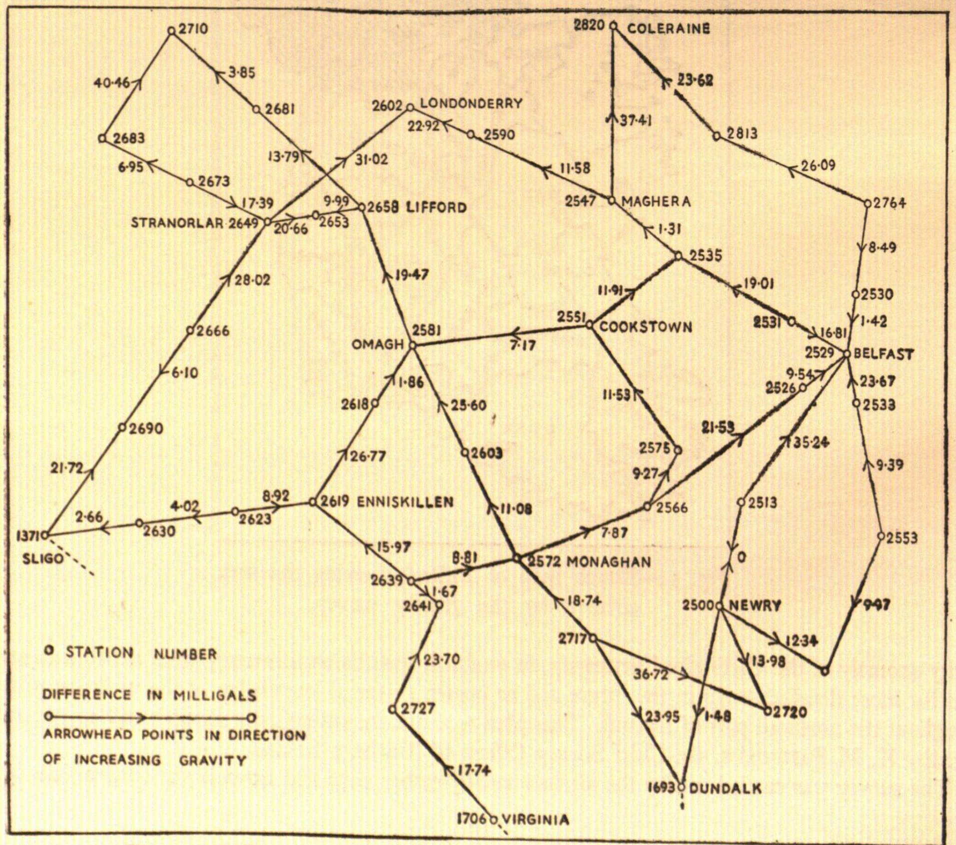

Fig. 2.—Differences of gravity measured between the base stations.

The pendulum stations at Dublin, Sligo, Galway and Cork have now been linked by MURPHY'S (1950) measurements in Central Ireland and our own in the north of Ireland as well as the earlier ones made by THIRLAWAY (1951) and an adjustment of all these measurements has been made which it is intended to publish as a separate part of this *Memoir*. This adjustment yields the values of gravity at the base stations and also a correction to the calibration factor of the gravimeter used in the survey. The adjusted values of gravity are given in the *Appendix* which includes the latitude, longitude, height and Bouguer anomaly of each station.

From the residuals of the individual measurements, the standard deviation of a measured difference of gravity is found to be 0·24 mgal. (cf. COOK, 1951). The total uncertainty of the value of gravity at any station is the resultant of this uncertainty of the comparison with the base station and the uncertainty of the comparison of the base station with Cambridge. The average value is about 0·4 mgals.

The stations given in the *Appendix* and the maps on *Folders* 1 and 2 are sufficient for most geophysical purposes. The base stations are rather farther apart than the 10 km. distance recommended by the International Union of Geodesy and Geophysics. All the particulars of the stations observed have not been tabulated but details are available on application to the School of Cosmic Physics, Dublin, or the Department of Geodesy and Geophysics, Cambridge University.

In all, 350 new stations were occupied in about six weeks of field work.

DENSITIES OF ROCKS. The densities of the rocks in an area covered by a gravity survey are required for two purposes, the calculation of the Bouguer anomaly and the interpretation of this anomaly. For the calculation of the anomaly the densities need not be known very accurately unless the heights of stations are great, since a change of 0·1 g/cm^3 in the density produces a change of only 1·28 mgals. per 1,000 ft. in the calculated Bouguer anomaly. In Interpretation on the other hand, densities must be known as precisely as possible because the variations of the anomaly arise from differences between the densities of adjacent rock masses. In Northern Ireland the densities of most of the rocks lie between 2·55 g/cm^3 and 2·75 g/cm^3 and hence small errors in the estimates of densities may cause very large errors in the differences and therefore in the interpretation of the anomaly.

The most satisfactory way of measuring the density of a formation for these purposes is to determine the gravitational attraction of a known thickness of the formation. This is best carried out by taking gravity measurements over a hill (NETTLETON, 1939) or in a mine or borehole (HAMMER, 1950; COOK and THIRLAWAY, 1952). In this way three problems are avoided, namely those of determining the mean density of the formation from the densities of samples, of deciding how far the pores of the rock are filled with water and of deciding if samples are weathered. Since the answers to these problems entail a thorough investigation of the geology of the region, which we are not in a position to undertake, our estimates of densities which were obtained from laboratory measurements on samples collected from outcrops, are subject to uncertainties from the three causes mentioned. The samples are taken mainly from small quarries and are hence from the harder, though not necessarily denser, parts of a formation. Whether they are representative of a formation we cannot at this stage state and hence there is an uncertainty in applying these determinations of density. Most rocks covered by the survey are compact and have small porosity. The density used is always that of the rock with all the pores filled with water and probably represents conditions below the water table quite satisfactorily. Weathering seems to affect granite the most seriously, fresh specimens having a density up to 0·1 g/cm^3 greater than that of weathered specimens. When reasonable care is taken in collecting a set of representative samples which are not obviously weathered, the results are not as uncertain as might be expected. PARASNIS (1952) has shown that the densities of samples taken from a number of formations in England are in agreement with values deduced from hill and mine surveys within the accuracy of the observations and without systematic departures. He found that the standard deviation of the density of a formation in the field as found from measurements of samples was about 0·03 g/cm^3. HAMMER (1950), however, found a considerable difference between the densities determined by gravimeter measurements in a mine and those found from laboratory measurements on samples.

In the course of the gravity survey we made a small collection of samples from as many different formations as possible choosing specimens which seemed to us representative of the rocks at the particular site. All sites were roadside quarries, mostly worked for road metal. In addition Professor J. K. CHARLESWORTH has sent us specimens which he states are typical of the formations in Northern Ireland. The densities of the samples in these collections have been determined by Mr. D. S. PARASNIS in the Department of Geodesy and Geophysics, Cambridge University. A third collection of data has been made available to us by Professor J. H. J. POOLE of Trinity College, Dublin; the density measurements were made by Mr. J. S. JACKSON (1951). Three other sets of data refer to particular areas. Mr. A. FOWLER, the District Geologist in Northern Ireland of the Geological Survey, has sent us some specimens of the granite of the Mourne Mountains taken from a reservoir tunnel near Annalong and Mr. PARASNIS has measured the

TABLE 1

DENSITIES OF ROCKS

Formation	Locality	Densities (g/cm³) C.M.P.	C.P.	F.P.	T.C.D.	I.C.	Published
Chalk	Cave Hill ...				2·59		
Chalk	—		2·64				
Trias							
Sandstone ...	nr. Scrabo Hill ...				2·23, 2·34		
Marl	Scrabo Hill ...				2·45, 2·45		
Sandstone ...	—		2·30				
Marl	—		2·45				
Carboniferous							
Limestone ...	Ballysadare ...				2·71		
Limestone ...	Ballintogher ...				2·70, 2·66		
Limestone ...	near Laghy ...	2·68					
Old Red Sandstone							
Calcareous Sandstone	near Omagh ...	2·65					
Silurian							
Grit	Scrabo Hill ...				2·72		
Slate	Scrabo Hill ...				2·72, 2·76		
Mudstone ...	Scrabo Hill ...				2·59		
Shale	nr. Downpatrick ...	2·52[2]					
Sandstone ...	nr. Carryduff ...	2·69[2]					
Shales and Greywackes ...	Around the N.E. end of Newry granite ...						2·71 to 2·79[1]
Dalradian							
Dolomite... ...	Gweebarra ...					2·89	
Marble	Gweebarra ...					2·67 to 2·88[3]	
Limestone ...	Lissinisk... ...				2·72		
Limestone ...	Breen				2·71		
Gneiss	Treantaboy ...				2·95		
Gneiss	near Cloghan ...	2·70					
Micaceous Schist ...	Inishowen ...	2·75					
Mica Schist ...	Malin Head ...						2·78[4]
Quartzite ...	Malin Head ...						2·67[4]
Shale	N.W. of Claudy ...	2·66					
Phyllite	N.W. of Claudy ...	2·80					
Phyllites ...	Gweebarra-Dunglow					2·50 to 2·80[5]	
Granites							
Tertiary ...	Mournes		2·59	2·60			2·60[6]
Tertiary ...	Carlingford ...				2·61		2·59[7], 2·63[7], 2·56[8]
Old Red Sandstone	Newry, Goraghwood				2·70		2·71[6]
Old Red Sandstone	Newry, normal ...						2·66[9]
Old Red Sandstone	Crossdoney ...				2·67		
Newer[10] ? ...	Barnesmore ...	2·59					
Newer	Gweebarra ...					2·63, 2·56	
Intermediate[10] ...	Gweebarra ...					2·57	
Older[10]	Gweebarra ...					2·65	
Older	Arranmore ...				2·58		
Older	Doochary ...	2·62					
Older	Finntown ...	2·61					
Caledonian ...	Leinster	2·64			2·65, 2·67		2·63[11]
Eucrite and Gabbro							
Tertiary ...	Barnavave ...				3·03		3·00[6]
Tertiary ...	Carlingford ...				2·90		
Diorite, Tertiary ...	Jenkinstown ...				2·97, 2·95		
Basalt Tertiary ...			2·77				
	Giants Causeway ...				2·83		
	Rathlin Island ...				2·82		
	Cave Hill ...				2·82		
	Greenore ...				2·94		
	Maidens				2·98		

Collectors and Observers:

C.M.P. Authors' collection, measurements by D. S. PARASNIS.
C.P. Professor CHARLESWORTH'S collection, measurements by D. S. PARASNIS.
F.P. Mr. FOWLER'S collection, measurements by D. S. PARASNIS.
T.C.D. Trinity College Dublin collection, measurements by J. S. JACKSON.
I.C. Data obtained by Dr. A. R. GINDY and others at Imperial College, London.

Remarks:

[1] REYNOLDS (1934, 1943). [2] Probably weathered. [3] Mean about 2·8. [4] Personal communication from Dr. REYNOLDS. [5] Mean of eight samples 2·69. [6] HAUGHTON (1856). [7] HAUGHTON (1856) notes two distinct varieties. [8] NOCKOLDS (1935). [9] Normal uncontaminated; personal communication from Dr. D. L. REYNOLDS. [10] Age according to cross-cutting relations. " Newer " equivalent to " Newer " in Scotland. [11] HAUGHTON (1856); mean of nine samples.

densities. Professor H. H. READ has sent us details of the densities of various metamorphic and igneous rocks near Gweebarra (Donegal) determined at the Imperial College by Dr. A. R. GINDY and others. Dr. S. R. NOCKOLDS has published (1935) densities of representative members of the Carlingford igneous complex and so has Dr. REYNOLDS. Finally a number of values for granites given by HAUGHTON (1856) are included.

These measurements are all assembled in *Table* 1. The densities measured by Mr. PARASNIS are of the rocks saturated with water. Although it is not known exactly what density has been measured by HAUGHTON the porosity of granite is so small that all densities will be very nearly the same.

NOTES ON TABLE 1

The Chalk. The porosity as determined by Mr. PARASNIS is 5 per cent. The results compare as follows with English Chalk, of which there seem to be two types in Southern England (PARASNIS, 1952):

Locality	Density	Void Ratio	Mineral Density
	g/cm³	%	g/cm³
Southern England, a	1·95	72·4	2·64
Southern England, b	1·95	57·5	2·50
Antrim	2·60	5	2·72

The void ratio is the ratio of the volume of the pores in the rock to the volume of minerals.

The differences of density and porosity are striking. The reason for the remarkably low apparent mineral density of the English Chalk has been discussed by PARASNIS (loc. cit.).

Triassic Sandstones and Marls. The porosity of the sandstone as determined by Mr. PARASNIS is 32 per cent. and of the marl, 25 per cent. Results of measurements made on similar formations in the English Midlands will be found in papers by COOK and THIRLAWAY 1952, COOK, HOSPERS and PARASNIS 1952, and PARASNIS 1952. The comparison between the results is as follows:

Triassic		Density	Void Ratio	Mineral Density
		g/cm³	%	g/cm³
Sandstones:	England	2·25	35	2·67
	Ireland	2·35	32	2·72
Marl:	England	2·44	23	2·76
	Ireland	2·45	25	2·81

The Irish and English triassic rocks thus seem to be very similar.

Carboniferous Limestones. The values, which do not vary much from place to place, are slightly less than those in the Welsh Borders and the Bristol district which are from 2·72 to 2·75 g/cm³.

Old Red Sandstone. The specimens are appreciably calcareous which probably accounts for the density, 2·65 g/cm³, being considerably greater than the value for the Welsh Borders, which is about 2·5 g/cm³.

Silurian. Dr. REYNOLDS states (1943, p.235) that the unaltered Lower Palaeozoic country rock in the Newry region has a specific gravity of from 2·71 to 2·79 g/cm³.

Dalradian. The Dalradian rocks comprise a great variety, schists, gneisses, marbles, limestones and quartzites being the main types. From the maps of recent workers (BAILEY and McCALLIEN, 1934; McCALLIEN, 1935 and 1937; HARTLEY, 1938) it seems that the schists and phyllites are dominant, the others being important only locally.

Average values, with some indication of scatter, for the different types are:

	g/cm³
Schists and Phyllites	2·74 ± 0·03
Gneisses	2·83 ± 0·07
Marble and Limestone	2·75 ± 0·05
Quartzite Probably	2·65

The results obtained by different observers have been given equal weight irrespective of the number of separate samples.

Granites. The main masses are the Tertiary granites of the Mourne Mountains with Carlingford and Slieve Gullion, the Old Red Sandstone Newry granite, and the granites of north-west Donegal. There are smaller masses at Barnesmore (Co. Donegal) and Crossdoney (Co. Cavan).

Dr. GINDY'S specimens come from the district west of the Gweebarra mouth. The age classification has purely local significance and is based on cross-cutting relations. The densities increase with the age of the granites except for a porphyritic type of newer granite and this is thought to be due to increasing assimilation of the country rock. An average density of 2·60 g/cm³ for the whole mass is supported by the other observations. Professor READ states that he believes the Barnesmore granite may be similar to the newer granite of north-west Donegal, a view with which the density of 2·58 g/cm³ is consistent.

The values for the Mourne granite are all in good agreement. At Carlingford there are apparently two types, the one (Slievenaglogh) a potash granite with mica of density about 2·60 and the other (Grange Irish) very fine grained with hornblende and of density about 2·64 g/cm³ (HAUGHTON, 1856).

The densities of the specimens of the Newry granodiorite which come from Newry and Goraghwood quarries cannot be considered as representative, for at Goraghwood the granodiorite shows extensive assimilation of the country rock and types with very high density are recorded (REYNOLDS, 1943).

Discussion of the Density Measurements

The data are not very suitable for discussing whether the independent workers have obtained significantly different values of the densities of the same rocks, for in no case is it known whether the samples have come from sites sufficiently close to each other. The two observers most quoted are PARASNIS and JACKSON and there appears to be no significant difference between their results. The other results are, in general, for rocks which are in some way exceptional, so that they cannot be compared with the results of PARASNIS and JACKSON.

Table 2 summarises *Table* 1 by giving the mean values, standard deviations of mean values and the number of determinations for the densities of the major types of rock. The means have been calculated without regard to the volumes of different types of rocks in the formation because, in general, data for the more precise computation are not available.

TABLE 2

SUMMARY OF DENSITY MEASUREMENTS

Rock	Mean Density	Standard Deviation of Mean	No. of Determinations	Remarks
	g/cm³	g/cm³		
Chalk	2·62	—	2	
Trias Sandstone	2·33	0·045	4	
Marl	2.45	—	2	
Carboniferous Limestone	2·69	0·01	4	
Silurian	2·70	0·03	5	The value of 2·52 g/cm³ is omitted
Dalradian :				
Shales and Phyllites	2·74	0·03	3	
Marble and Limestone	2·75	0·05	3	
Donegal granite	2·60	0·013	7	Age differences neglected
Leinster granite	2·65	0·009	4	
Mourne granite	2·60	0·003	3	
Newry granite	2·66	—	1	
Eucrites, diorites and Gabbro	2·97	0·025	5	
Basalt	2·88	0·035	6	

From the discussion given by PARASNIS (1951) it is likely that most of the variance of the observations is due to genuine variations of the formations from place to place

CALCULATION OF THE BOUGUER ANOMALY. The Bouguer anomaly is based on the International Formula of 1930 for the normal value of gravity at sea level, γ_o :

$$\gamma_o = 978\cdot049\ (1 + 0\cdot0052884 \sin^2 \varphi - 0\cdot0000059 \sin^2 2\varphi)$$

where φ is the Latitude. The correction for the height of the station is $(0\cdot09406 - 0\cdot0128\ \varrho)h$ mgals. where ϱ is the density of the rocks in g/cm³ and h is the height of the station in feet. Since the values of gravity are obtained as differences, $(g - g_{P.H.})$, from the value, $g_{P.H.}$, at the Pendulum House, Cambridge Observatory, it was convenient to construct a table of $(g_{P.H.} - \gamma_o)$ so that the anomaly was calculated as

$$(g - g_{P.H.}) + (g_{P.H.} - \gamma_o) + (0\cdot09406 - 0\cdot0128\ \varrho)h \text{ mgals.}$$

No corrections have been applied for irregular topography since it did not seem that the survey was sufficiently detailed to warrant the refinement and very few stations require this correction.

The following " rounded-off " values of densities were used in the calculation of the Bouguer anomaly. They do not all agree with the values in *Table* 2 since they were adopted before all that information was available but the differences are not important.

	g/cm³
Trias	2.3
Carboniferous Limestone	2.7
Old Red Sandstone	2.65
Silurian and Ordovician	2.7
Dalradian	2.75
Granites	2.65
Gabbro	2·9

The value of 2·66 g/cm³, corresponding to a variation of 0·06 mgal. per foot, was used for the basalt-covered districts of Antrim. The basalt itself has a density of 2·9 g/cm³ but the thickness is only known in a few places, apart from the margins, and seems very variable from about 200 ft. to 1000 ft. It is underlain by Chalk (about 100 ft.), Trias and Coal Measures, all having densities less than 2·66 g/cm³ The data for making an exact estimate of the attraction of this very variable set of rocks are not available and therefore the figure given above was used.

The results are shown on the maps at the end of the paper. *Folder* 1 gives the location of the stations with their index numbers and *Folder* 2 is a general map of the geology of the North of Ireland with the gravity data superposed.

GENERAL FEATURES OF THE GRAVITY FIELD. The average Bouguer anomaly over the north of Ireland is not very different from 20 mgals. and it can be seen that there are large areas, in Donegal, Londonderry, Armagh, Monaghan and Down, where the anomaly is within two or three milligals of this general average. These are the areas where Lower Palaeozoic or Dalradian rocks outcrop and all but one of the prominent departures from the average value of just over 20 mgals. occur where rocks of density appreciably different from 2·75 g/cm³ occur at the surface. In north-west Donegal and in Down the very low values of the anomaly are associated with bodies of granite of density 2·65 g/cm³ or less just as they are in Leinster (Part 2 of this *Memoir*), while in Antrim and north Down the low values seem to be due to deposits of Coal Measures and Mesozoic rocks of density less than 2·5 g/cm³ Of the very high values of the anomaly, those in the Carlingford and Slieve Gullion district are associated with Tertiary igneous rocks which have densities of up to 3·0 g/cm³ The only large variation from the average value that is not associated with a definite surface feature is that just south of Omagh where the Old Red Sandstone is probably thin and is certainly not denser than the older sedimentary rocks.

The areas in which the anomaly departs greatly from the value of about 20 mgals. are relatively small and well defined and do not affect the classification of the north of Ireland with the other Lower Palaeozoic and Pre-Cambrian regions in the west of the British Isles where, over large areas, the Bouguer anomaly varies only slightly, between about +10 and +20 mgals. (see BULLARD and JOLLY, 1936; WHITE, 1949). As over these other regions, the isostatic anomalies over the north of Ireland are positive on any scheme of compensation. Discussion of this general feature seems out of place in a paper on the north of Ireland alone.

THE GRANITE MASSES OF WESTERN DONEGAL, BARNESMORE, NEWRY AND CROSSDONEY. The Bouguer anomaly at stations in the neighbourhood of these masses is shown in *Folder* 2 and in *Figs.* 3 and 4. For each mass the anomaly is very much less over the granite than over the surrounding country rock. It will be shown that this arises from the granite being less dense than the country rock and from estimates of the difference in densities the thickness in granite masses will be deduced.

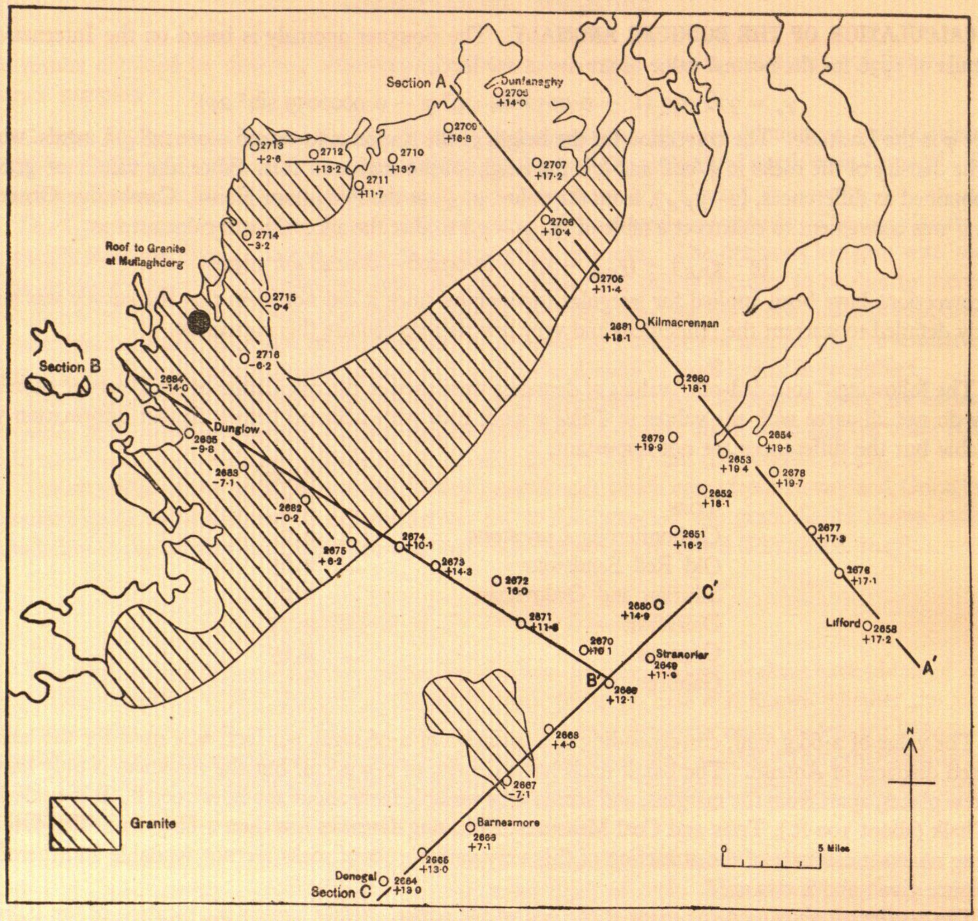

Fig. 3.—Map of the Donegal area showing the positions of the stations in relation to the granite outcrops and the values of the Bouguer anomaly at each station.

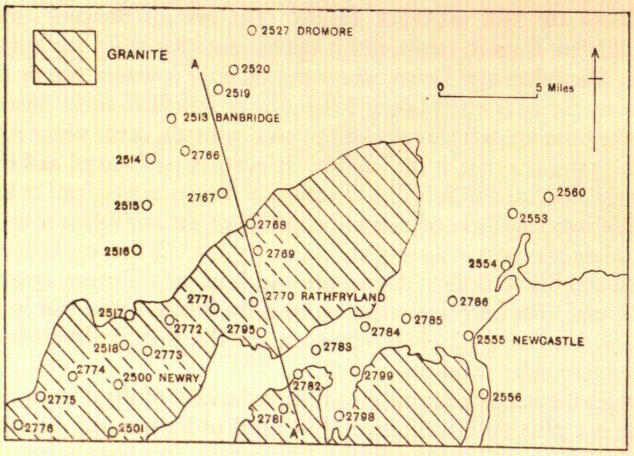

Fig. 4.—Map of the area around Newry showing the positions of the stations and the outcrop of the granite.

It will be seen from *Table* 2 that representative values of rock densities are

	g/cm^3
Granite	2·60 to 2·65
Silurian	2·70
Dalradian	2·75

The Dalradian and the Lower Palaeozoic rocks are then about 0·10 g/cm^3 and 0·05 g/cm^3 denser respectively than granite and so granite masses ten to twenty thousand feet deep would explain the anomalies encountered. On the other hand it has been argued (Garland, 1950) that negative values over granite masses are not due to the granite but to the isostatic compensation of mountain ranges now worn away of which the positions are marked at present by the granite masses. We therefore estimate the maximum depths at which the masses which cause the observed anomaly over these four granite areas could possibly be. This may be done from the inequality given by Bullard and Cooper (1948)

$$z < \frac{1}{\pi} x_m \log 4\pi f \varrho_m h \frac{1}{g_m}$$

where z is the depth of the centre of gravity of the anomalous mass, x_m is the distance from a maximum to a minimum value of the anomaly of which the difference is g_m, $2\pi f \varrho_m h$ is equal to the observed change of gravity if the width of the mass is large compared with the thickness and depth. In other circumstances it may be possible to calculate $2\pi f \varrho_m h$ by a result due to Kogbetlianz (see Barnesmore, below).

The results for the different masses are as follows :

Locality	Section in *Fig.* 3	x_m	g_m	$2\pi f \rho_m h$	$z_{max.}$
		ft.	mgals.	mgals.	ft.
N.W. Donegal	AA′	17,000	7·5	7·5	3,800
Dunglow	BB′	33,000	14	28	14,000
Barnesmore	CC′	33,000	19·5	33·4*	13,000
Newry		36,000	12	33*	20,000

*For the calculation of these figures see below.

Form and Thickness of the Granite Masses

West Donegal. Professor H. H. Read informs us that the Donegal granite is being divided by the research team working under him into Older, Intermediate and Newer granites on the basis of field relations, ratio of migmatitic to magmatic characters and appropriate compositions. The boundary of the granite is sketched in *Fig.* 3. The density of the Newer granite is, as seen from *Table* 1, about 0·05 g/cm³ less than that of the Older granite. The Dalradian rocks of Donegal are predominantly (about 70 per cent.) phyllites, of which the density is 2·74 g/cm³ The quartzites probably have a density of 2·65 g/cm³ and the marbles and limestone of up to 2·9 g/cm³ but these are only locally important and the density of the Dalradian as a whole can be taken as 2·75 g/cm³

Along the northern traverse, AA′ in *Fig.* 5, the anomaly is about 7·5 mgals. less over the granite than over the surrounding Dalradian rocks. Taking the latter to be 0·15 g/cm³ denser than the granite, the thickness of the granite is 3,900 feet. In making this estimate it is assumed that the granite has a rectangular cross section as shown on the figure but the gravity measurements are not sufficient to show whether this is correct or whether some other form of cross section, one tapering downwards for example, may not equally fit the observations.

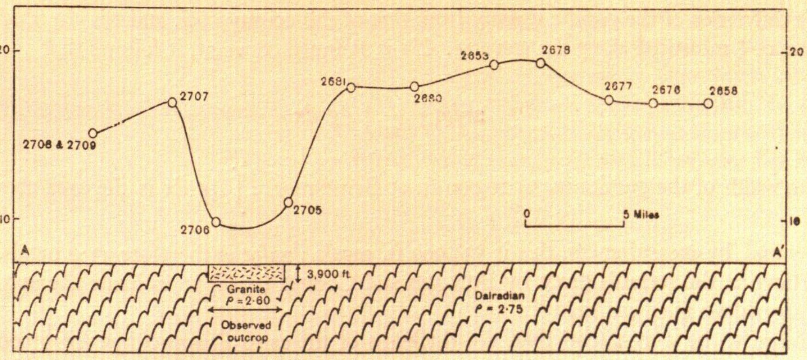

Fig. 5.—Bouguer anomaly profile and suggested geological interpretation along line through Kilmacrenan, section AA′ in *Fig.* 3.

Along the southern section, BB′ in *Fig.* 6 the maximum change of anomaly is about 28 mgals., the corresponding granite thickness is 14,600 feet and the probable form, a wedge thickening from the boundary of the granite to 14,600 ft. west of Dunglow, is shown in the figure. The kink in the curve of the anomaly between stations 2683 and 2685 is probably due to the rather denser Older granite which outcrops between

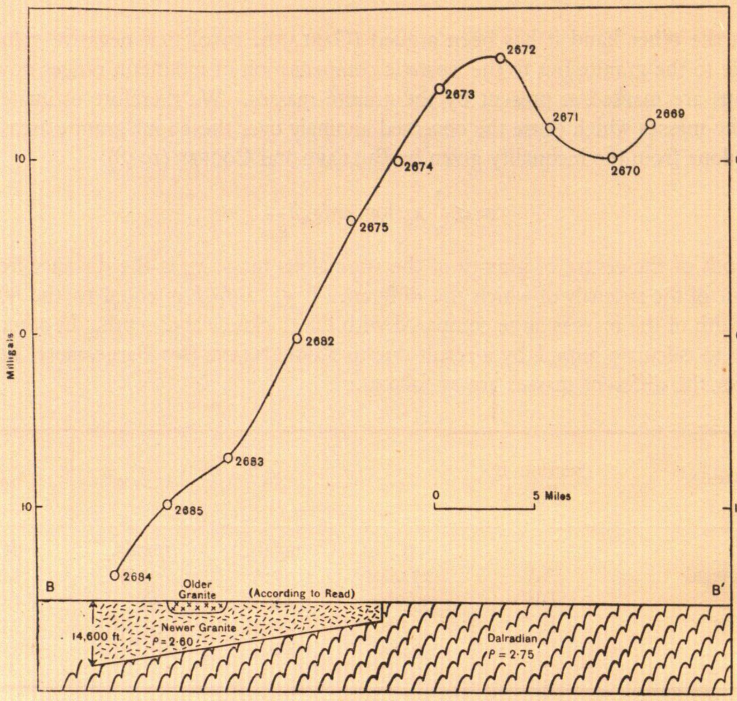

Fig. 6.—Bouguer anomaly profile and suggested geological interpretation along a line through Dunglow, section BB′ in *Fig.* 3.

these stations. It must form a fairly thin roof to the Newer granite for if it were the full 10,000 feet thick, it would cause an increase of 6 mgals.

The thicknesses just estimated are probably very nearly the original thicknesses of the granite since a portion of the roof is believed to occur at Mullaghderg, marked on the map (COLE, 1919).

Barnesmore. The age of the Barnesmore granite is probably the same as that of the Newer granite to the west. Its density is about 2·60 g/cm³ so that it may be 0·15 g/cm³ lighter than the surrounding rocks. The maximum change of anomaly does not give the thickness of granite directly since it is clear from the variation of anomaly that the mass is not much less thick than it is wide. However, if it is assumed to have a rectangular cross section the thickness can be estimated. It can be shown (KOGBETLIANZ, 1944) that if Δg is the anomaly at a distance x measured along a traverse such as that across Barnesmore then

$$\int_{-\infty}^{+\infty} \Delta g \, dx = 2\pi f \varrho \int_{-\infty}^{+\infty} t \, d\xi$$

where ϱ is the difference of the granite density from that of the county rock and t is the thickness of the granite at distance ξ measured along the traverse. If t is assumed constant, it follows that

$$2\pi f \varrho t = \frac{1}{w} \int_{-\infty}^{+\infty} \Delta g \, dx$$

where w is the width of the granite mass, 10,000 ft. at Barnesmore; $\int_{-\infty}^{+\infty} \Delta g \, dx$ is the area above the curve given in *Fig.* 7 and, by measurement, this is 534,000 ft. mgals.; $2\pi f \varrho t$ is therefore 33·4 mgals. This value is that used above in the formula given by BULLARD and COOPER (1948) to estimate the maximum depth at which the anomalous mass can lie.

If ϱ is taken to be 0·15 g/cm³ then the thickness of the mass is approximately 17,000 feet; the attraction of a prism of cross section 16,000 ft. wide and 17,000 ft. deep is shown on *Fig.* 7. The agreement between the calculated and observed anomaly is fairly good.

Newry. This mass is known to have been formed in the Caledonian period of activity but after the Caledonian folding (REYNOLDS, 1934). Dr. REYNOLDS informs us that the density of the normal granodiorite is 2·66 g/cm³ The values of about 2·7 g/cm³ from specimens from Goraghwood and Newry quarries cannot be accepted as typical since in these places the country rock and granodiorite have contaminated each other and rock types of very high density are developed locally (REYNOLDS, 1943). The densities of the

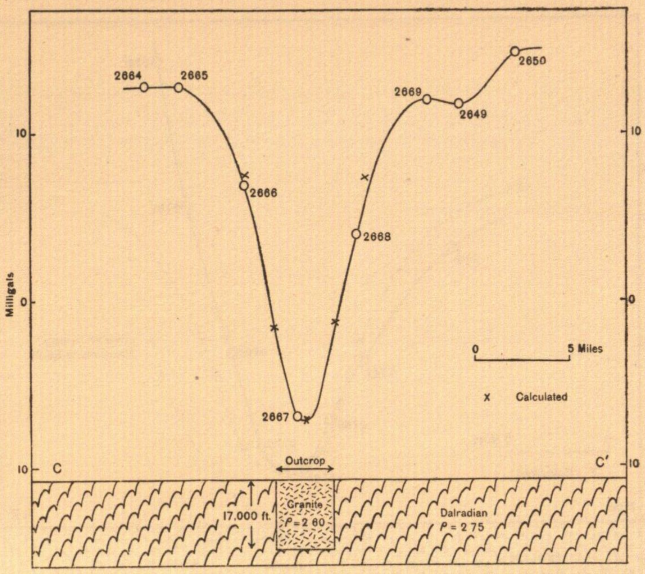

Fig. 7.—Bouguer anomaly profile across the granite outcrop at Barnesmore and suggested geological interpretation, section CC′ in *Fig.* 3.

Silurian rocks given in *Table* 1 appear rather variable, possibly because the samples with the lowest density are weathered. Dr. REYNOLDS states (1943, p.235) that the unaltered country rocks have densities of from 2·71 to 2·79 and she has informed us that this is the range of densities of a variety of shales and greywackes collected about a mile from the extreme eastern end of the complex. A mean density of 2·72 g/cm^3 seems reasonable for these rocks. The difference from the granite is then 0·06 g/cm^3

The lowest anomaly over the granite is 3·1 mgals. about 2 miles north of Rathfryland. It is a little difficult to know what average value to take for the anomaly over the Lower Palaeozoic rocks of the district. To the south and east the anomaly is very considerably disturbed by the Tertiary igneous centres (described later) while to the north-west in the neighbourhood of Banbridge they are disturbed by the Bann Valley depression. It seems best to take the average value of the anomaly over the Lower Palaeozoic rocks of the whole of North-East Ireland, about 21 mgals. This agrees with the figure MURPHY (1950) obtained for the Lower Palaeozoic rocks north of Dublin.

The thickness of the granite is therefore at least 25,000 feet while the width of the outcrop at Rathfryland is about 32,000 feet so that the cross section of the mass is roughly a square. Since the variation of anomaly to the south-east of Rathfryland is not just that for the granite, it is assumed that the calculated attraction should reproduce the observed attraction only to the north-west of Rathfryland. It was found that if the coutcrop of the granite was a true plan of the mass then the calculated anomaly could be made to have the same gradient as that observed but that it was too large and had a minimum value south-east of that observed. This indicates that the axis of the granite mass is further to the north-west than that of the observed outcrop and it was found that the separation should be one mile. This makes the granite eight miles wide instead of six as seen at the outcrop. Such an arrangement is quite plausible for, according to a section given by REYNOLDS (1934), the contact with the country rock is vertical on the south-east and nearly horizontal on the north-west. The mass of granite of which the attraction is shown in *Fig.* 8 then has the following dimensions :

Width : 43,000 ft., south-east margin at observed granite margin.
Thickness : 43,000 ft.

Crossdoney (*Co. Cavan*). According to the Geological Survey Memoir this is a " metamorphic " granite. The strike of the country rock (Ordovician) is said to be undisturbed and grit bands merge into the granite.

The density of the granite is 2·67 g/cm^3 and that of the country rock is taken to be 2·72 g/cm^3, the same as that of the Lower Palaeozoic rocks further north. The Carboniferous Limestone has a density very nearly the same as the Lower Palaeozoic rocks. There are insufficient stations to determine the form of the mass of granite in plan or section except that the plan of the mass is like the outcrop roughly radially symmetrical. The lowest anomaly observed is 3·8 mgals. and the anomaly over the country rock is about 10·5 mgals. Since the attraction of a cylinder very long compared with its radius is $2\pi f\varrho r$ (ϱ density difference, r radius) the radius of the granite at Crossdoney must be at least 10,000 feet while the mean radius of the

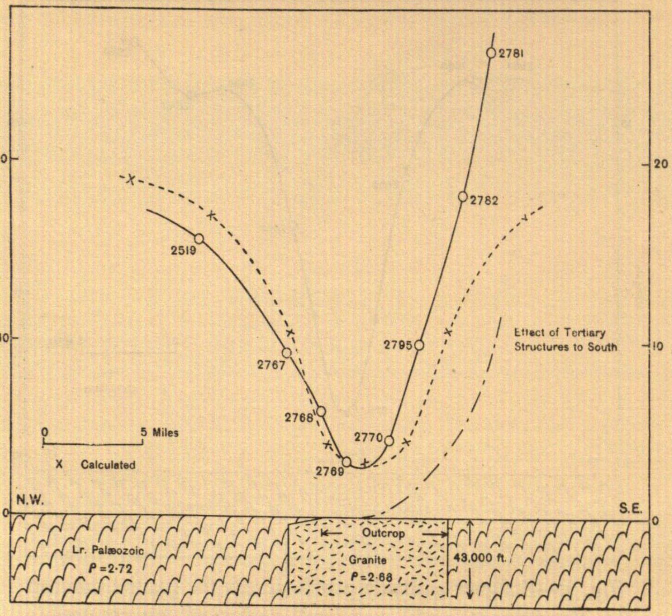

Fig. 8.—Bouguer anomaly profile and suggested geological interpretation along a line through Rathfryland, section AA′ in *Fig.* 4.

outcrop is about 7,000 feet. The thickness of the granite would then have to be at least 25,000 feet. This cylinder sets one limit to the possible form of the granite. The other limit is a laccolithic form with the greatest thickness of granite at Crossdoney, thinning out radially to nothing at Cavan. The thickness at Crossdoney would then be about 10,000 feet. This is a plausible structure in view of the small disturbance to the strike of the country rock noted in the Survey Memoir.

Discussion

It can be asserted quite definitely that the variation of the Bouguer anomaly over all the granite masses is due to the granite itself being less dense than the surrounding rocks. It can also be concluded that the thicknesses estimated above are probably the minimum possible, for they are based on the surface densities of the rocks and in view of the considerable metamorphism suffered by the Dalradian and Lower Palaeozoic rocks their densities will probably not change greatly with depth so that the only likely change with depth is that the density of the granite should increase due to the denser minerals concentrating at the bottom. If this occurred, greater thicknesses of granite would be needed. In Donegal however, the denser forms of granite seem to lie above the less dense and the figures given may therefore be taken with reasonable confidence, remembering however that an error of 0·01 g/cm^3 in the difference of density means an error of 1,000 feet in the thickness at Dunglow. If it should be supposed that a mass of granite is due to metamorphism of the sediments then it would be quite possible for the density to be less at depth than at the surface and hence for the true thicknesses to be less than those calculated.

The general form of the N.W. Donegal mass is clearly that of a sheet which thins outwards from a centre west of Dunglow.* Whether the tongue running north-east has a horizontal lower surface as shown on the north-eastern section (AA′) cannot be determined with the present observations. It is quite possible that it may taper downwards with a maximum thickness greater than that calculated above and a more detailed survey might decide the question. This mass must continue out into the Atlantic and is similar in this respect to the granites in Galway.

The form of the Newry granite is obviously quite different and although it is possible that the sides may slope inwards it is reasonably certain that they do not slope outwards. Because of the attraction of the heavy masses to the south more detailed observations would probably not add very much to the present inferences. The thickness of the granite, 14 km., is comparable with the thickness of the upper half, or " granitic " layer of the crust of the earth and an interesting implication is that the " granitic layer " under north-east Ireland is appreciably denser than the Newry granite, itself a rather dense granite apparently, through the entire thickness. This confirms locally the conclusion that has been drawn from studies of surface geology that granite is not a typical component of the " granitic layer " (BULLARD et al., 1950) but is opposed to GARLAND'S view (1950).

* It has recently been shown (PITCHER, 1952) that there is a ring complex in the granite just north of Dunglow similar to the Glencoe cauldron subsidence.

THE TERTIARY IGNEOUS CENTRES OF THE MOURNES, SLIEVE GULLION AND CARLINGFORD. These four igneous centres (there are two centres in the Mournes) are ring complexes similar to the Tertiary ring complexes of western Scotland. Like them they are characterised by an approximately circular form, by arcuate boundary fractures and by the subsidence of the country rock making room for the intrusions. They lie at the southern end of the line which joins the Scottish centres (RICHEY, 1932).

Slieve Gullion (REYNOLDS, 1950) shows a well developed ring fracture marked by volcanic vents. Inside the ring there is a series of volcanic ejecta some of which were thrown out as tuff and others of which are pillow lavas, showing that at one stage a lake occupied the centre of the volcano. A remarkable feature (RICHEY, 1932) is that the complex coincides very closely with the south-western end of the Newry granite. The Carlingford complex (RICHEY, 1932) is emplaced in Silurian and Carboniferous rocks and shows a ring of coarse gabbro or eucrite with granophyre inside it. There is a large number of minor intrusions which RICHEY has identified as cone sheets. In the Mournes (RICHEY, 1928), unlike any other Tertiary centres, no basic intrusions occur. There are four successive intrusions of granite and there are clear exposures of both horizontal roof and vertical walls. RICHEY's conception of the form of the intrusions is incorporated in *Fig.* 9. As a result of studies of the joints in the Mournes and in the plateau basalts of Antrim it seems likely that the age of the intrusion of the Mourne granities is that of the interbasaltic period. The Slieve Gullion and Carlingford complexes are cut by large N.W.-S.E. faults.

The Bouguer anomaly observed over the Slieve Gullion and Carlingford complexes is the highest yet found in the British Isles if that of +60 mgals. in the St. Kilda group (BROWNE and COOPER, 1950) be excluded. The highest value of the anomaly lies on the line joining the centres of the two complexes and over the actual rings the anomaly appears to fall off symmetrically from this centre line. Towards the north-east the anomaly does not fall to the value characteristic of the Lower Palaeozoic country, about 21 mgals., until well north of the Mourne mountains. It is clear from *Fig.* 9 that the anomaly on the granite exposures in the Mournes is no less than on the adjacent Lower Palaeozoics.

The densities used in interpreting the Bouguer anomaly are

	g/cm^3
Country rock, mostly Silurian	.... 2.72
Granite, granophyre	.... 2.60
Gabbro, eucrite, basalt	.... 3.00

The values for the igneous rocks probably have an uncertainty of $\pm 0{\cdot}05$ g/cm^3, that for the country rock perhaps $\pm 0{\cdot}05$ g/cm^3 also.

It is quite evident that on Slieve Gullion the Tertiary acid rocks have no effect at all on the anomaly and must therefore be very thin. This agrees with Dr. REYNOLDS' view of the origin of these rocks, that they are composed of fragments abraded from the Newry granite by ascending vapours and tuff flows. No underground extension of these rocks would therefore be expected. In addition, the Newry granite is not seriously affecting the anomaly which is almost as high here as in the Carlingford complex from which the Newry granite is absent. When this behaviour is compared with the very low anomaly over the Newry granite at Rathfryland it is clear that in the Slieve Gullion complex the Newry granite must be quite thin. The granite in the Mournes also is quite thin, for on comparing the value of the anomaly at the one station (2781) on the granite with those at the stations on the edge of the granite (2780, 2782, 2797, 2798, 2799) it is seen that the former 26 mgals. is not significantly less than the mean of the latter, 31 ± 4 mgals. The granite is therefore not thick enough to have any significant effect on the anomaly. It may be said that bearing in mind the scatter of the anomaly, the granite in the Western Mournes is not more than 3,000 to 4,000 feet thick. (The corresponding attraction is -4 to -5 mgals.) This result confirms RICHEY's interpretation of the form and mode of intrusion of these masses reproduced in *Fig.* 9. The gravity results however, apply to the Western Mournes and RICHEY's interpretation to the Eastern Mournes. Thus the relatively light acid rocks have little influence on the anomaly and are therefore unimportant in bulk and changes in the anomaly are almost entirely due to masses of heavy basic igneous rocks beneath the Slieve Gullion-Carlingford area and the Mourne Mountains.

Although the density of observations is greater here than anywhere else in the north of Ireland yet they are still too sparse to enable more than the main features of the variation of the anomaly to be determined. On the south and west of the area the anomaly over the Lower Palaeozoic rocks is about 21 mgals. From this value the anomaly rises smoothly to about 55 mgals. over the centre of the Slieve Gullion and Carlingford complexes. The profiles shown in *Figs.* 10 and 11 are quite smooth and the masses causing the increase in the anomaly could all be placed at depths of more than 20,000 feet. Similarly the contours of equal anomaly that can be drawn through the observations are generally smooth and regularly spaced and on the south-west are linear for quite long distances. No doubt with more observations more detail would be revealed. With the existing data, however, it is not possible to do more than get an idea of the form, extent and

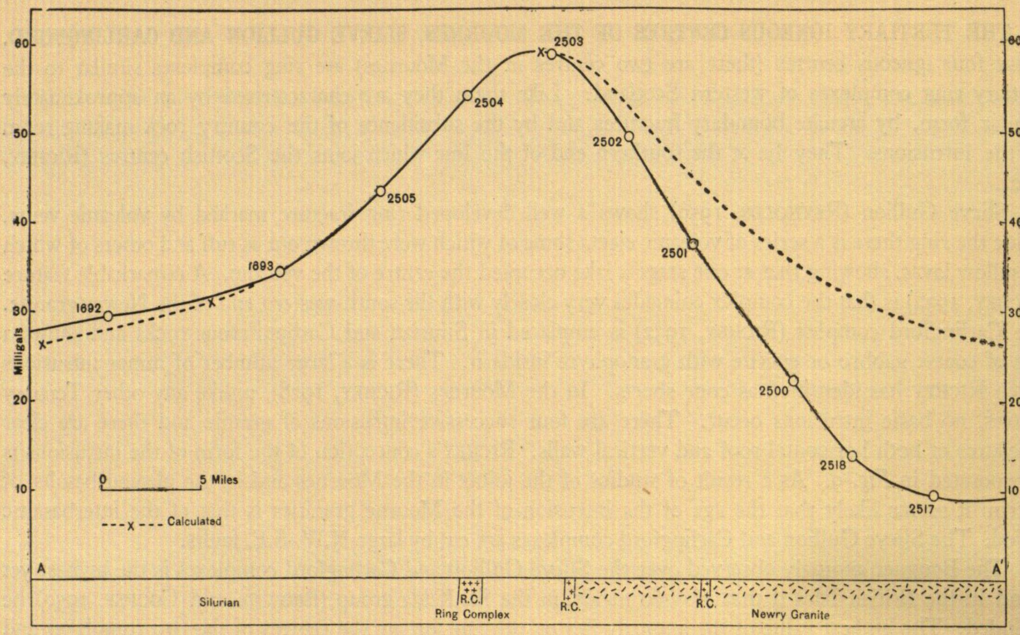

Fig. 10.—Bouguer anomaly profile and geological section along line AA′ in *Fig.* 9.

effective mass of the bodies causing the increase in anomaly. Neither in plan nor in section can the detailed form be determined, nor can any precise idea of the depth of the bodies be obtained from the gravity data. For the following calculations it is assumed that the masses are formed of rocks having a density of 3·0 g/cm^3, the highest value found for the basic rocks at the surface. The effect of departures from this assumption is considered later. It is also assumed that below Slieve Gullion and Carlingford the mass indicated by the gravity data is the reservoir of magma postulated by ANDERSON (1924) in his theory of the formation of cone sheets and ring dykes. According to this theory the reservoir has the form of a cupola which extends to a great depth below, and the apex, to which the cone sheets converge, lies on top of the cupola.

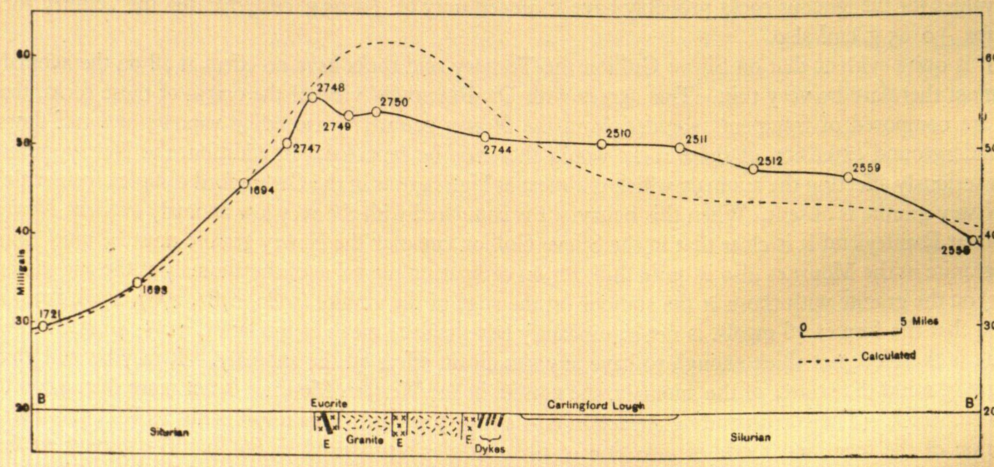

Fig. 11.—Bouguer anomaly profile and geological section along line BB′ in *Fig.* 9.

The main mass below Slieve Gullion and Carlingford must thus have a roughly semi-circular cross section above and in plan must be elongated along the line joining the two centres. A simple form that fulfils these conditions is a cylinder with a horizontal axis. Of such a cylinder the attraction observed at the surface would not be expected to differ very much from that of two cupolas and many more observations would be needed before it would be possible to distinguish the two structures; in addition the attraction at the surface will not vary greatly with different dispositions of masses at depth below the axis of the cylinder. By trial and error the cylinder below the Slieve Gullion-Carlingford area was found to have an axis approximately below the line joining stations 2776 and 2720 at a depth of 4 miles. The diameter was found to be 5·5 miles so that the upper surface would be about 6,000 feet below sea level. The length of the cylinder would be 20 miles. This cylinder would not account for the high anomaly just south of the

Mourne mountains and so another with an axis approximately below the line joining stations 2558 and 2507 was added. This cylinder, with the axis placed arbitrarily at the same depth as the first, was calculated to have a diameter of 4 miles so that the top would lie about 10,000 feet below sea level.

In *Fig.* 12 the value of the Bouguer anomaly is given together with a figure for the anomaly after the effects of the two cylinders and the Lower Palaeozoic rocks (21 mgals.) have been subtracted. The resulting residual anomaly represents the effect of the Newry Granite and other departures from the simple structure assumed for the calculation. The former effect is well brought out and it can be seen that a contour line at the -10 mgal. level would agree well with the granite outcrop. Elsewhere, with a few exceptions, the residual anomaly lies within the range ± 3 mgals. showing that the assumed structure can account for the major variation of the anomaly.

For the purposes of calculation these bodies have been assumed to be cylinders of rock of density $3 \cdot 0$ g/cm^3. Other forms and densities could give the same attraction at the surface and in fact the cylinders are not the most likely forms geologically. It is impossible from the gravity data alone to say that the top of the dense mass does not lie very close to the surface but if ANDERSON's theory of the formation of ring dykes and cone sheets is accepted, and if the dense mass revealed by the gravity results is identified with the magna reservoir of that theory, then the top of the mass must lie at about 10,000 feet below sea level in the Carlingford area. However it should be realised that even with the top of the mass fixed by a plausible geological argument, there is still a variety of possible forms for the mass, of which the horizontal cylinder is the simplest for the calculation of attraction and the cupola extending downwards to great depth is favoured on geological grounds.

The orders of magnitude of the changes in the dimensions of the disturbing masses that would have to be made if the density were not $3 \cdot 0$ g/cm^3 can be estimated from the model of the horizontal cylinder. There is not much evidence from the surface for the presence of rocks having densities very different from this value except that the absence of basic rocks at the surface in the Mournes may suggest that the acidic rocks are more important here and the average density of the disturbing masses accordingly lower than in the other complexes. If the mass has the form of a horizontal cylinder then for the same surface attraction the axis will lie always at the same depth below the surface and therefore the radius must be less than this depth, 4 miles. The density of the rocks must therefore be greater than $2 \cdot 8$ g/cm^3. An upper limit to the densities of the rocks may be fixed by the fact that the heaviest rocks known in complexes of this type are the ultrabasic peridotites of Skye which have a density of $3 \cdot 3$ g/cm^3 (HARKER, 1904). No such rocks are seen at the surface in the Irish complexes.

In *Fig.* 13 geological sections of Slieve Gullion have been drawn to illustrate the most plausible inter-

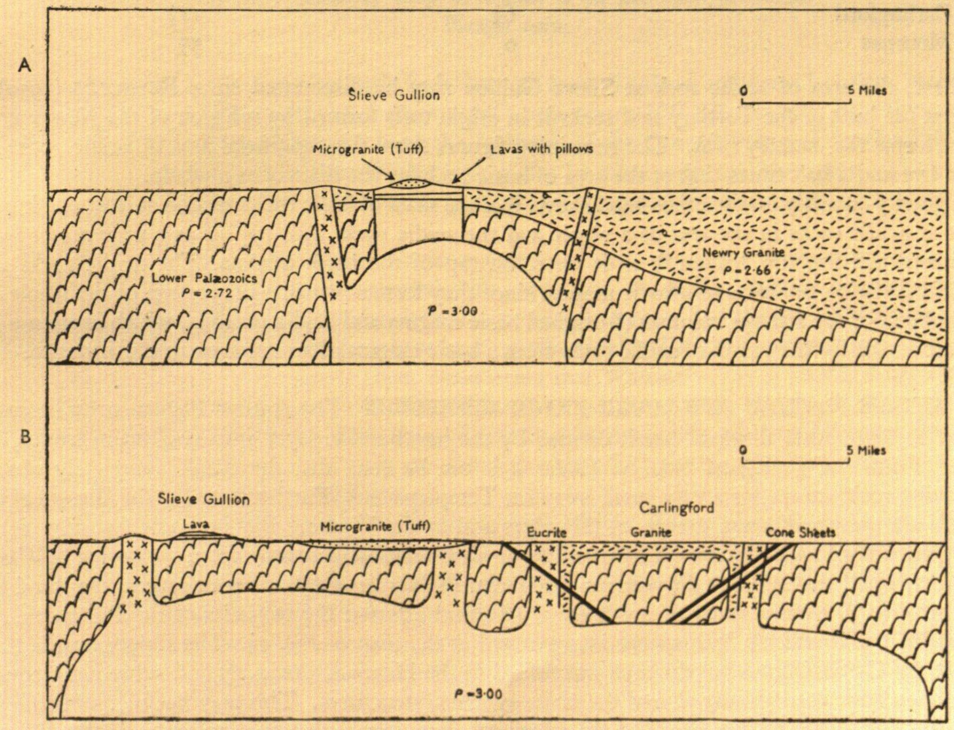

Fig. 13.—Geological sections through the Slieve Gullion and Carlingford igneous complexes interpreted from the gravity data and the surface geology as given by REYNOLDS.
A : Section SW—NE B : Section NW—SE

pretation of the anomaly, a cupola of basic rock of density about 3·0 g/cm³, with the top about 10,000 feet below the surface. The surface geology follows Dr. D. L. REYNOLDS' interpretation. The relation between the ring features in the Mournes and the body of dense rock is not so clear, for the axis of the latter lies well to the south of the centre of the Mournes and there is no evidence of a connection between the two granite bodies and the basic mass inferred from the gravity data. If the latter is the reservoir of basic magna from which the granite was formed by differentiation, the absence of basic rocks in the Mournes may be explained in part by the distance between the reservoir and the outcrop of the granite.

Returning to *Fig.* 12 it can be seen that in two areas the residual anomaly is outside the range ± 3 mgals. Within the Carlingford complex the residual anomaly at stations 2749, 2750, 2751 is approximately -5 mgals. This disagreement between the calculated and observed anomaly, also seen in *Fig.* 11 is probably the result of assuming too large a cylinder of dense rock but it might be the effect of the granite which outcrops here and for which no allowance has been made in the calculation. It would be speculative to attempt to deduce dimensions for the granite mass but further measurements might make this possible. The other area where the calculated and observed anomalies are at variance is at stations 2511, 2512 and 2559 where the residual anomaly is about $+5$ mgals. This is probably caused by oversimplification in assuming the dense mass to be a single cylinder. Outside these, there is only one outstanding difference, at station 2555 where the residual anomaly is $+9$ mgals. This value, on Silurian rocks, is outside the limits of error and must be produced by an isolated dense mass which does not appear at the surface.

The range of ± 3 mgals. in the residual anomaly is quite reasonable as it is known that rocks, both denser and less dense than the country rock, occur in considerable quantity. For example, two thousand feet of granite would produce a decrease in anomaly of nearly 3 mgals. Further the calculated attraction cannot be computed more closely than these limits since very simple forms must be chosen.

In general, the variation in the Bouguer anomaly can be explained fairly well by this system of two dense masses with centres of gravity about four miles below the surface but naturally in an area where rocks occur with such a range of densities as here, it would be impossible to explain all the variations from station to station without a close study of the surface geology.

The gravity survey may effect the study of petrogenesis in this area for the results show that the total mass of heavy basic rock is very much greater than that of light acidic rock. RICHEY (1948, p.55) gives the following figures for the superficial areas of outcrops of acidic and basic rocks.

	Gabbro and Dolerite sq. miles	Granophyre and Granite sq. miles
Slieve Gullion	6	22
Carlingford	6¼	11½
Mournes	0	55

Of these, the area of acidic rock at Slieve Gullion may be discounted since REYNOLDS (1950) has claimed that the bulk of the Tertiary acid rocks is in origin tuffs formed by refusion of the Newry granite which here forms the country rock. The remaining figures show the superficial area of acidic rocks to be more than five and a half times that of the area of basic rock for the district as a whole.

The gravity anomaly on the other hand shows that the mass of basic rock must be at least one hundred times that of acidic rocks in the area as a whole and the acidic rocks thus appear as a very minor feature of the igneous activity, the " scum ", as it were, on top of the basic magma. The acidic rocks could well be differentiation products of a basic magma since they form so small a proportion of the whole mass and the problem of the relative volumes of original basic magma and acidic product, which is often a difficulty in accounting for the origin of acidic rocks from a basic magma, does not arise in this instance.

THE ANTRIM PLATEAU AND LOUGH NEAGH DEPRESSION The Antrim Plateau owes its present appearance to large scale flows of basalt divided by the interbasaltic layer into two main groups, both Cainozoic. From the geological map on *Folder* 2 it can be seen that the basalt completely obscures the underlying rocks except for a very small area near Templepatrick. Furthermore the thicknesses of these basalt flows are quite unknown, except on the edges and at the Washing Bay borehole (see *Fig.* 17) and they vary from a few hundred to over a thousand feet. It is reasonable to infer from the boring at Washing Bay (WRIGHT, 1924) that in large depressions the thickness may be of the order of several thousand feet.

WRIGHT (1919), from a study of north-eastern Ireland inferred the tectonics of the Palaeozoic rocks covered by the basalt and his findings are incorporated in the map of *Fig.* 14. His supposition is that at the close of the Carboniferous era the area was folded in the Hercynian orogeny and subsequent covering and denudation have not radically altered the major synclinal structures. This may not be quite true since ALLAN (1940) has shown that in Scotland the Highland Boundary fault was developing during Devonian times. WRIGHT then expects to find underneath the basaltic layer a series of anticlines composed of Lower Palaeozoic rocks and synclines of Old Red Sandstone and Carboniferous sediments. He traces the Highland

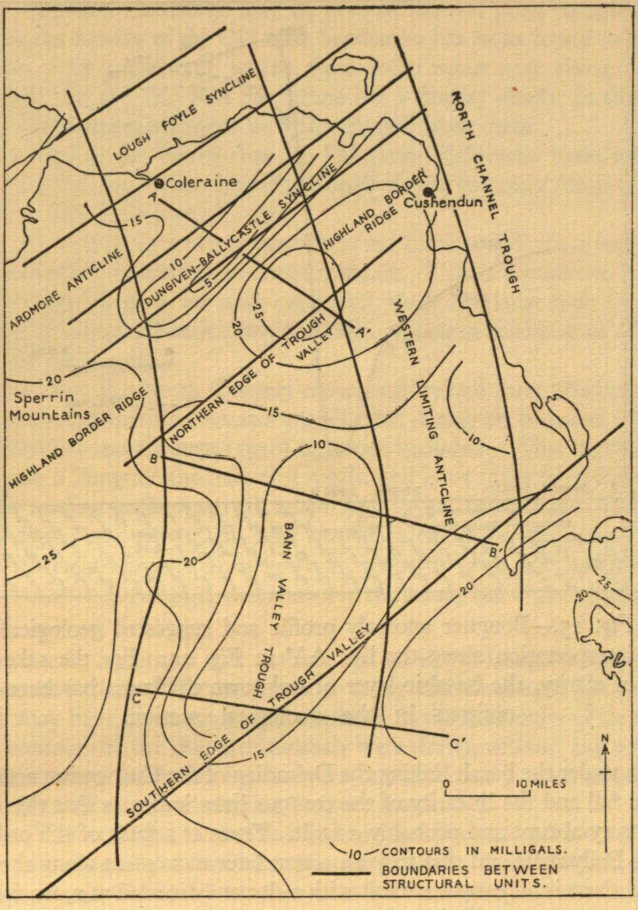

Fig. 14.—Combination of Wright's structural map and Bouguer anomaly map of *Folder* 2 in the Antrim-Lough Neagh area.

Boundary fault and the Southern Uplands fault through from Scotland and considers that, as in the Lowland valley of Scotland, the deepest depressions will occur where NW-SE synclines cut the main NE-SW depression. It is such depressions that form the coalfields of the Central Valley of Scotland and WRIGHT supposed that, in Ireland also, similar depressions might be filled with coal measures. The evidence he produced for the tectonics of the region is fairly good and his speculations concerned the materials which filled the synclinal troughs

Turning now to the gravity map on *Folder* 2 a series of areas where the Bouguer anomaly is approximately 20-25 mgals. can be seen interspersed with areas over which the anomaly is less than 10 mgals. corresponding broadly to the structural ridges and troughs, respectively, inferred by WRIGHT. In *Fig.* 14 the Bouguer anomaly contours of *Folder* 2 have been combined with WRIGHT's tectonic map. The agreement between the two systems is extremely good, considering that WRIGHT's map is mainly diagrammatic, and nowhere is there complete disagreement. We will therefore assume that the regions of low gravity anomaly indicate tectonic depressions filled with rocks less dense than the surrounding Lower Palaeozoic and Dalradian rocks and we will be more concerned with the materials with which the troughs are filled because it is only here that we are at variance with WRIGHT.

When discussing the anomaly over the Newry granite a figure of 21 mgals. was arrived at as representative of the anomaly over the Lower Palaeozoic rocks of north-east Ireland. In Inishowen the anomaly over the Dalradian rocks is about 25 mgals. and elsewhere it lies between this figure and 20 mgals. One reading at station 2846 on the Dalradian east of Ballycastle gave 19 mgals. It then seems convenient to assume a value of 23 mgals. over the whole area as a base value and we shall ignore changes of anomaly occurring over the anticlines as unimportant and concentrate on calculating the thicknesses of the lighter rocks which compose WRIGHT's troughs.

The most pronounced feature of the gravity map occurs over the Dungiven-Ballycastle syncline. The profile AA' in *Fig.* 14 from Coleraine through Ballymoney has been drawn in *Fig.* 15. Here, on the South-east the anomaly falls very rapidly from 26 mgals. to 3 mgals. The high value indicates that the Highland

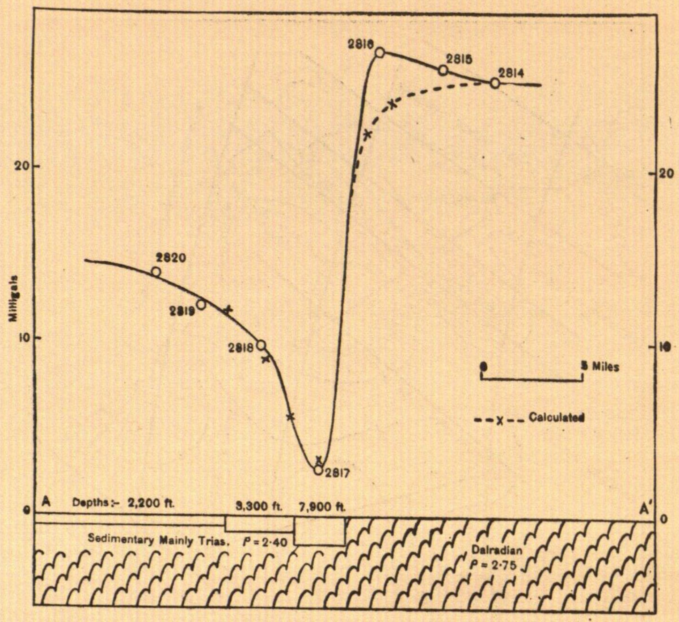

Fig. 15.—Bouguer anomaly profile and suggested geological interpretation along the line AA' in *Fig.* 14. For the sake of clarity, the basaltic layer of unknown thickness has been omitted in the geological section.

Border Ridge continues under the basalt linking the Dalradian of the Cushendun area to that of the Sperrin Mountains. The rapid fall and the linearity of the contour lines indicates that this side of the Dungiven-Ballycastle syncline is very abrupt and probably a fault. There is a fault of the order of 1,000 feet at the edge of the basalt near Ballycastle and this may represent later movement along the main fault. Again in the Ballycastle coalfield there is an east west fault with a throw estimated at 2,000 feet so that this syncline probably has large faults associated with it and a fault running through Ballymoney is quite likely.

On the north-west the profile shows an increase in anomaly to only 15 mgals., that is about 10 mgals. lower than on the south-east. This is interpreted as meaning that under Coleraine there is a considerable thickness of light sediments resting on the Palaeozoic floor.

Further north-west the anomaly falls again slightly supporting WRIGHT's theory of another syncline, the Lough Foyle syncline, about which nothing can be said until more geophysical data are available.

The difference of 20 mgals. between the anomaly over the Highland Border Ridge and that over the Dungiven-Ballycastle syncline is explained as due to the comparatively less dense rocks filling the tectonic depression. If, as WRIGHT suggests, these rocks are Carboniferous, they may have an average density of about 2·65 g/cm., for the density of Carboniferous limestone is about 2·70 g/cm^3 but that of the Coal Measures may be as low as 2·50 g/cm^3 (cf. COOK and THIRLAWAY, 1952; COOK, HOSPERS and PARASNIS, 1952). The thickness of Carboniferous rocks would then be about 15,000 feet but this is inconsistent with the gradient of the anomalies which is 8 mgal./mile between stations 2816 and 2817 whereas the maximum gradient that can be produced by a deposit of thickness 15,000 feet and difference of densities of 0·10 g/cm^3 is 2 mgals./mile.

Since WRIGHT's paper, borings in a fault trough near Kingscourt and in the coalfields near Coalisland (Report of the Geological Survey Board for 1949) have shown the occurrence of thick deposits of Triassic sediments in Ireland. These are similar in density and thickness to the Trias of England and hence it would be more reasonable to assume that deep synclines, such as the Dungiven-Ballycastle one, are also filled with Triassic deposits as well as with some Permian and Carboniferous rocks.

In *Fig.* 15 under the profile, a geological section has been drawn with a deep trough on the south-east. The north-west side consists, probably, of a series of step faults but only one is included to simplify calculations. The calculated profile is shown by the dotted line where it deviates from the measured values. Elsewhere the fit is fairly good. The main trough, as calculated, is 2·5 miles wide and 7,900 ft. deep and at the north-west extreme under Coleraine there seems to be a sedimentary deposit about 2,200 ft. thick. These calculations are based on a density of the sediments of 2·40 g/cm^3, the sediments therefore being assumed to be mainly Triassic and Permian. There is not much point in trying to analyse these thicknesses into their constituent parts as there is no evidence that even Carboniferous strata are present. Some of these sediments belong undoubtedly to Jurassic and Cretaceous ages but these, throughout Ireland, are nowhere very thick, usually no more than a few hundred feet.

The possibility that Old Red Sandstone may be present has not been considered because of density considerations. In Wales the density of the Old Red Sandstone has been found to be as low as 2·5 g/cm³. In Ireland, samples gave 2·65 g/cm³ and, where these rocks occur near Omagh, no low anomaly was encountered. We conclude that the Old Red Sandstone has a density similar to that of the Irish Carboniferous strata and in the calculations it cannot be differentiated from them.

Further evidence to support the theory that the Dungiven-Ballycastle basin is one of several mainly composed of Trias will be given later when a similar trough almost certainly composed of Triassic deposits is discussed in connection with Strangford Lough.

Returning to the profile of *Fig.* 15 it can be seen there is a distinct difference between the observed and calculated values at station 2816 amounting to about 3 mgals. This is thought to be produced by a local thickening of the basaltic layer or if, as we have suggested, there is a large fault in this region, it may be produced by a large mass of intruded basalt along the fault. An extra thickness of about 1,500 ft. of basalt would produce an anomaly of this size.

WRIGHT has suggested that the North Channel separating Ireland from Scotland is a large trough and the steep sides shown by the submarine contours suggest that it may be bounded by faults. On *Folder* 1, a station occupied by BROWNE and COOPER (1950) has been included. This reading in the centre of the channel, at station 45, gave a Bouguer anomaly of 3 mgals. and is 15 miles from Larne where the anomaly is 5 mgals. The nearest reading in Scotland (BULLARD and JOLLY, 1936) is at Campbeltown on Dalradian rocks and the anomaly found was 21 mgals., very similar to the figure in Ireland. It seems then that WRIGHT's North Channel trough is another large basin probably once filled with easily eroded Triassic sediments. The effect of this trough is quite well shown in the steady fall in the anomaly by about 10 mgals. as Larne is approached.

The remaining large scale feature of this tectonic system is the Lough Neagh depression. There is good agreement between the extent of WRIGHT's trough valley and the area of low anomaly but the lack of readings over the lough may have given too much emphasis to the continuity of this feature. It is best to point out here that the contours of the Bouguer anomaly were drawn without any reference to the geology or WRIGHT's tectonic lines immediately the figures were calculated, to prevent prejudice, but the sparsity of readings must be borne in mind when referring to these maps.

From borehole data (WRIGHT, 1924) and privately from the Geological Survey it is known that Lough Neagh represents a depression not only in the Palaeozoic floor but also in the basaltic plateau for thick basalt is found below the Lough Neagh Clays. Thus subsidence has been going on while the Lough Neagh Clays were deposited and up to very recent times. Three strata of very different densities—Lough Neagh Clays, 2·0 g/cm³, Trias, 2·4 g/cm³ and Basalt, 2·9 g/cm³—thus fill the depression in the Dalradian.

The profiles BB′ and CC′ in *Fig.* 14 are drawn in *Figs.* 16 and 17. These show that the width of the trough is about 13 miles north of the Lough and about 15 miles south of the Lough. The northern profile shows a fall of anomaly of about 11 mgals. from a level of 16 mgals. which is considerably lower than the 23 mgals. chosen to represent the average figure over the Dalradian. This probably means the profile has not been extended far enough in each direction. On the west there is a small depression centred on Maghera and on the east there is a gap in the readings due to the presence of Belfast Lough. The difference of anomaly will be taken from the 23 mgal. base line and then it is the same as that measured at the southern end i.e. 18 mgals. If we ignore the details of the stratification and assume a mean density of 2·40 g/cm³ for the light sediments then their thickness is calculated as 4,000 ft.

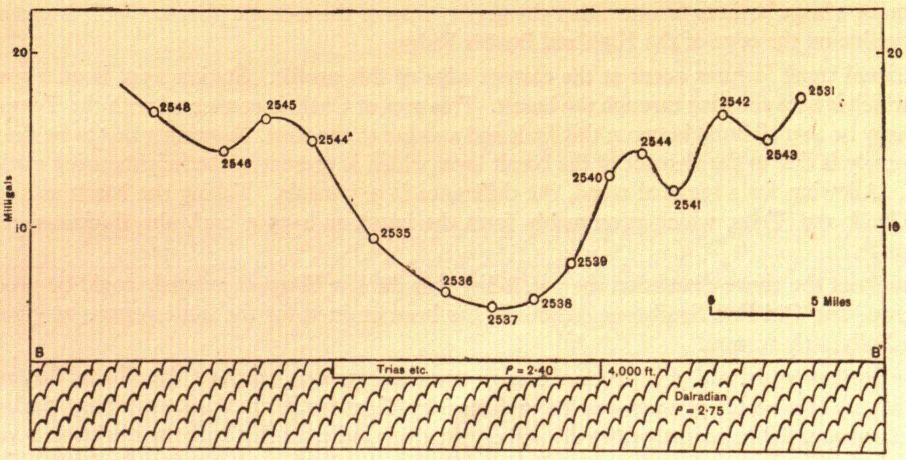

Fig. 16.—Bouguer anomaly profile and suggested geological interpretation along a line north of Lough Neagh, section BB′ in *Fig.* 14. The basaltic layer has been omitted in the geological section.

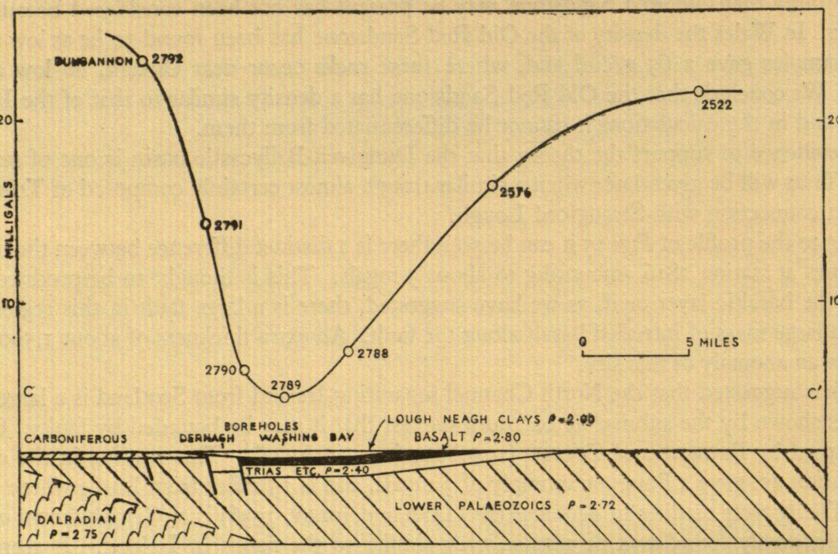

Fig. 17.—Bouguer anomaly profile and suggested geological interpretation along a line north of Lough Neagh, section CC′ in *Fig.* 14.

On the south, from boring data, it is surmised that at 2789 there are about 1,000 ft. of Lough Neagh Clays. These, having a very low density about 2·0 g/cm^3, could account for 9·5 mgals. However they are underlain by basalt whose thickness, again from borings, is known to be in excess of 700 ft. Estimates put it in excess of 1,000 ft. but how much more is uncertain. Since the trough was sinking before and at the time of the basalt flows a great thickness of basalt is to be expected and further, after the flows the continued sinking would lessen the denudation so that a thickness greater than that of the Antrim Plateau can be expected, maybe more than two thousand feet. With this in mind there is still to be explained 12 mgals. anomaly produced by light sediments under the basalt. Again taking 2·40 g/cm^3 as an average density, their thickness is about 2,500 ft. There is then, under station 2789, 1,000 ft. of Lough Neagh Clays, 2,000 ft. of Basalt and 2,500 ft. of Trias, Permian and Carboniferous but mainly Trias. If one or two of the above densities or thicknesses becomes known more definitely there is still a great uncertainty in the estimation of the thickness of the Trias.

Along the northern traverse there are no Lough Neagh Clays so that the total change of anomaly must be produced by sediments under the basalt. Here again the thickness of basalt is not known and can be, owing to the subsidence, as great as that estimated for the southern traverse. If the thickness is 1,000 ft. or less, then the estimate of 4,000 ft. of light sediments stands but if much greater, the thickness of light sediments must be increased.

It has been mentioned before that a minimum occurs at Maghera. Unfortunately there are not enough readings to the east and the west to enable the shape of this feature to be delineated. There does not seem to be room for a large basin to fit into either the gravity map or the tectonic plan so that it is probably only a small syncline on the edge of the Highland Border Ridge.

Additional small features occur at the eastern edge of this profile. Station 2541 is on a small patch of Chalk which is here showing through the basalt. This area of Chalk is connected with the Templepatrick fault and may be a small horst between this fault and another to the west. Assuming this to be the case, the fall in anomaly is due to the absence of the basalt layer which is present at the neighbouring stations 2544 and 2542. Allowing for a regional trend, the difference is 3·5 mgals. Taking the basalt as 2·90 g/cm^3 and the Chalk and Trias, which presumably form the horst, as 2·35 g/cm^3, the thickness of basalt is about 1,500 ft.

Throughout the above discussion the possibility that the low Bouguer anomaly could be produced by Carboniferous and Old Red Sandstone sediments has been omitted for the same reasons as given for the Dungiven-Ballycastle feature.

At the north-western end of Strangford Lough two readings were taken on the alluvial flat, at stations 2810 and 2812. These were presumed to be underlain by Trias similar in thickness to that under Belfast. However the abrupt fall in anomaly from the adjacent stations indicates that here the thickness is very much greater, of the order of 1,000 ft., whereas at Belfast it is estimated to be only one hundred feet. Thus again there seems to be a trough in the Palaeozoic floor and in this case it is almost certainly filled with Trias.

It is interesting to speculate as to the origin of the Lough which at its northern end is quite a distinct feature. At Scrabo Hill there is a large mass of intrusive basic rocks and this may be the north-western extreme of a fault trough the main area of which is now covered by water.

Summing up this section it can be said that the gravity survey has shown the existence of a series of troughs in a floor of thick, dense Palaeozoic rocks very much as Wright inferred from the geology of the rocks not obscured by basalt. The materials filling the troughs are thought to be mainly Triassic similar to known troughs in Ireland and particularly England but not in Scotland. Whether there is an appreciable thickness of Carboniferous strata present cannot be answered by this survey and neither can anything be said of any coal deposits. However, if there are Coal Measures present under thick deposits of Triassic sandstones and these are in turn covered by an impervious layer of basalt then the presence of oil or gas is a distinct possibility particularly in the Dungiven-Ballycastle syncline. The difference of densities between the different rocks composing the ridges and troughs makes the interpretation of gravity surveys relatively easy and a more detailed survey could prove of immense value especially in the economically important regions near Dungannon. Furthermore the Triassic deposits probably contain economic minerals as elsewhere in Ireland and England and should repay geophysical exploration.

THE SOUTH-WESTERN DISTRICT. The measurements in this region lie on the roads from Omagh to Sligo, Letterkenny, Cookstown and Monaghan, and from Enniskillen to Monaghan. The surface geology is well known along all these roads.

Around Monaghan the observations were taken on Lower Palaeozoic rocks and between Omagh and Letterkenny and for part of the road between Omagh and Cookstown on Dalradian rocks. As elsewhere on these rocks north of Sligo, the anomaly is very uniform and differs only slightly from about 20 mgals.

The Tyrone Igneous Series (Hartley, 1933) occur west of Cookstown and here the anomaly shows large variations reaching 31·8 mgals. at station 2588. The series, of which the age is unknown except that it is pre-Silurian, includes dense basic rocks which are probably the cause of the high anomaly.

Between Omagh and Aughnacloy the measurements were made over Old Red Sandstone and although this is less dense than the Lower Palaeozoic and Dalradian rocks, the anomaly is higher than that over the neighbouring older rocks. This suggests that the Old Red Sandstone is underlain by rocks appreciably

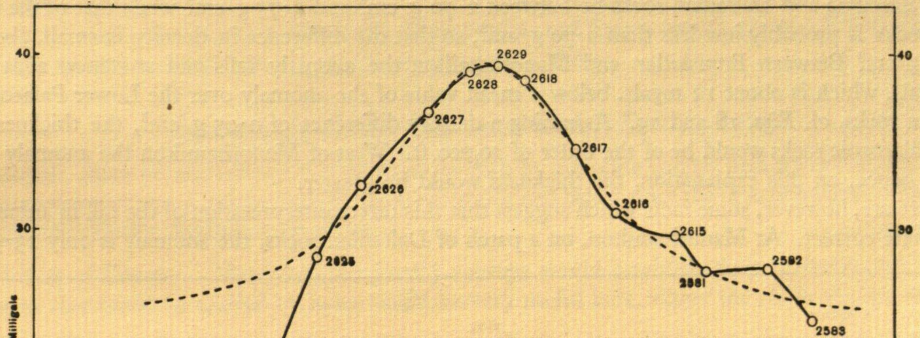

Fig. 18.—Bouguer anomaly profile and suggested geological interpretation along a line from Enniskillen to Omagh. The village of Dromore, mentioned in the text, lies between stations 2629 and 2618 and should not be confused with the town of the same name in Co. Down. The part marked "Lower Palaeozoics" probably includes some Dalradian.

denser than 2·75 g/cm³ and it seems natural to suppose that the Tyrone Igneous series extends south-westwards under the Old Red Sandstone.

The most striking feature of this region is the rise of the anomaly from Enniskillen and Omagh to +39·4 mgals. near Dromore, indicating the presence of a considerable mass of heavy basic material below Dromore. If it is assumed that this material has a density of 2·9 g/cm³ and that the density of the surrounding rocks is 2·75 g/cm³, then the anomaly could be produced by a sphere of this material with a diameter of 54,000 feet and with the centre at 41,000 feet below the surface. A sphere was chosen for the calculations because there are no observations to show how far the mass extends to the north-west and to the south-east of Dromore. From the general north-east and south-west strike of the area a body with a north-west and south-east axis does not seem very likely.

In *Fig.* 18 the profile from Omagh to Enniskillen is drawn together with the attraction of the sphere with the dimensions given above. The agreement is good but forms, other than that of a sphere, could give the same attraction if placed at a suitable depth. Two, in particular, may be geologically plausible. The mass may be a cupola of Tertiary age such as those which presumably underlie the Carlingford district but of which the effects are not seen at the surface unless the north-west and south-east dyke-swarms of Donegal are assocaited with it. The top of such a cupola would be at about 20,000 feet below the surface.

The other main period of basic igneous activity in the north of Ireland is that represented in the Tyrone Igneous Series (it is probably Ordovician) and it is possible that the Dromore feature is due to a mass of basic material of this series such as that which is the cause of the high anomaly at station 2588. This material probably extends to the base of the Old Red Sandstone. More observations over the Tyrone Igneous Series and in the Dromore district are very desirable.

Measurements were taken over the Lower Carboniferous rocks around Enniskillen and north of Omagh. In the latter region the small areas of these rocks seem to have no influence on the anomaly. South of Aughnacloy, towards Monaghan, Lower Carboniferous rocks occur and north of Aughnacloy, towards Omagh, Old Red Sandstone but throughout there is very little change in anomaly, indicating that rocks underlying the Old Red Sandstone have such a dominant effect on the anomaly that they mask any effect due to the Old Red Sandstone and Carboniferous rocks.

Between Enniskillen and Sligo the measurements were taken over Carboniferous rocks almost entirely and the anomaly is markedly lower than over the Dalradian rocks to the north-east. The densities of the Lower Palaeozoic and Dalradian rocks lie between 2·70 g/cm³ and 2·75 g/cm³, while that of the Carboniferous rocks is probably just less than 2·70 g/cm³, so that the difference in density is small, about 0·03 to 0·05 g/cm³. Between Enniskillen and Manorhamilton the anomaly falls and at station 2621 reaches 11·6 mgals. which is about 12 mgals. below a mean value of the anomaly over the Lower Palaeozoic and Dalradian rocks, cf. *Figs.* 18 and 19. Assuming a density difference of 0·05 g/cm³, the thickness of the Upper Palaeozoic rocks would be of the order of 20,000 ft. West of Manorhamilton the anomaly is lower still and hence, on this explanation, the thickness would be greater.

There are, however, some facts which suggest that this direct interpretation of the fall in anomaly may not be quite correct. At Manorhamilton, on a patch of Dalradian rocks, the anomaly is only 13·9 mgals.

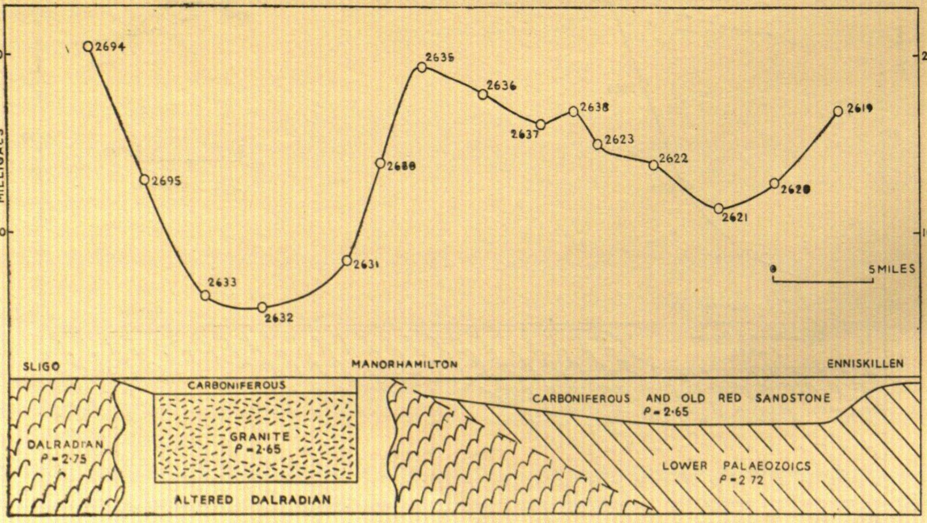

Fig. 19.—Bouguer anomaly profile and suggested geological interpretation along a line from Sligo to Enniskillen.

which is 5 mgals. lower than measurements taken further east on Carboniferous rocks. THIRLAWAY (Part 2 of this *Memoir*) put forward the suggestion that the granite of the Ox Mountains extended north-eastwards and caused the fall in anomaly he observed south of Sligo. The same explanation could be advanced to account for the similar, but somewhat lower, value east of Sligo. In *Fig.* 19 a tentative explanation on these lines is sketched below the gravity profile. The granite mass is considered to have the form of a vertical cylinder 53,000 ft. in diameter and 21,000 ft. deep. The density is taken to be 0·1 g/cm³ less than that of the surrounding rocks. This rather simple explanation cannot be wholly true as it is known that the structure of the Dalradian inlier at Manorhamilton is complicated and will effect the anomaly considerably and the effect of the Carboniferous rocks over the granite is virtually ignored, these being put quite arbitrarily as 2,500 ft. thick. It is a possible explanation which could be investigated and nothing useful can then be said about the relation between the low anomaly and the possibility of a thick deposit of Carboniferous rocks west of Manorhamilton.

East of Manorhamilton there is still a problem because results obtained outside this district show that a direct interpretation of the anomaly in terms of Old Red Sandstone and Lower Carboniferous thicknesses is unlikely. An examination of the observations between Dublin and Sligo made by THIRLAWAY (Part 2 of this *Memoir*) and of observations by one of us in Central Ireland (MURPHY, Part 3 of this *Memoir* and *Bulletin* No. 1) shows that the lowest values of the Bouguer anomaly do not occur where the surface geology indicates the Old Red Sandstone and Lower Carboniferous basins to be deepest. Thus the lowest value of the anomaly in Central Ireland occurs in the neighbourhood of Athlone where an anticline brings Old Red Sandstone to the surface; and the anomaly rises on passing from the Lower Palaeozoics north of Longford to the Lower Carboniferous of Carrick-on-Shannon, while THIRLAWAY ascribed most of the variation of anomaly between Dublin and Sligo to a regional variation and not to the Upper Palaeozoic rocks.

Thus there is no evidence that there is a marked difference in density between the Upper and Lower Palaeozoic rocks. In the calculation made earlier in this section this difference in density was put at 0·05 g/cm³ and if this is reduced then the calculated thickness of the Upper Palaeozoic rocks will be increased proportionally above the already high figure of 20,000 ft. If, on the other hand, the density difference is taken as 0·1 g/cm³ then the thickness of Old Red Sandstone and Carboniferous rocks would be about 10,000 ft. and this was used in drawing the geological sections in *Figs.* 18 and 19 but in view of what has been said the estimates of the thickness of the rocks between Enniskillen and Manorhamilton must be treated with reserve.

North of Sligo, the anomaly rises again to 20 mgals. and here a small outcrop of Dalradian occurs which is probably once again the top of the pre-Palaeozoic floor.

Suggestions for Further Geophysical Work in Northern Ireland

General. More measurements of rock densities both by sampling and by field measurements in gravity surveys are very necessary, particularly in the areas mentioned below since the interpretations of the Bouguer anomaly are critically dependent on them.

Granites of Donegal. More detailed gravity surveys would establish their underground extent. A gravimeter that could be carried by hand would be very useful here, where the roads are few and poor.

Basalt Plateau. Further surveys along the known fault belts might locate the centres of the igneous activity which produced the basalt flows.

Tertiary Igneous Centres. The present survey has shown the existence of large underground basic bodies probably connected with these centres and further gravity surveys would prove of value in helping to account for these features. Magnetic surveys being much simpler and easier to carry out would help, particularly in the Mournes which are free from basaltic extrusive rocks.

Dromore. This feature is quite outstanding and should be investigated in more detail both by gravity and magnetic surveys. Here again a gravimeter that could be transported by hand would be very useful.

Lough Neagh Clays. The density, composition and compaction of these clays have not been investigated and the interpretation of the present survey, in areas where these occur, has had to be necessarily very vague.

Economic Importance. This survey has shown that the density differences between the pre-Carboniferous and later rocks are so great that gravity surveys would probably prove of value in elucidating the structure of the faulting near Dungannon and in the fault basin at Strangford both of which are important if the Triassic and Carboniferous minerals are to be investigated with a view to exploitation. The establishment of WRIGHT's tectonic structure for north-eastern Ireland will again raise the question of the possibility of coalfields of economic proportions both in the Lough Neagh basin and the Ballycastle syncline and geophysical investigations are the most convenient methods which can be applied in the areas hidden beneath the basalt flows.

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Details of Gravimeter Stations and Gravity Values

Station Number	Six Inch Map Sheet Number		Latitude N	Longitude W	Height above M.S.L.	Density	g(Station) minus g(Cambridge)	Bouguer Anomaly
			° ′ ″	° ′ ″	ft.	g/cm³	mgals.	mgals.
2500**	Down	46	54 10 51	6 19 55	74.5	2.65	197.29	22.1
2501	Armagh	29	54 08 43	6 20 30	399.5	2.65	189.9	37.3
2502	Armagh	29	54 07 25	6 21 04	361.5	2.65	202.5	49.6
2503	Louth	1	54 05 48	6 21 35	311.0	2.65	212.5	58.8
2504	Louth	4	54 03 53	6 21 03	242.5	2.70	209.1	54.0
2505	Louth	4	54 02 08	6 22 59	44.5	2.70	208.0	43.5
2506	Down	54	54 06 08	6 15 34	9.0	2.70	222.4	50.0
2507	Down	54	54 00 03	6 13 49	18.0	2.70	217.5	45.8
2508	Down	54	54 05 50	6 11 53	18.0	2.70	215.8	44.4
2509	Down	54	54 04 37	6 10 56	19.0	2.70	218.7	49.1
2510	Down	55	54 04 03	6 08 02	69.0	2.70	216.5	50.7
2511	Down	55	54 04 20	6 05 10	97.0	2.70	214.7	50.2
2512*	Down	55	54 04 03	6 02 20	134.0	2.70	209.60	47.7
2513*	Down	27	54 21 08	6 15 42	196.5	2.70	197.32	14.7
2514	Down	34	54 19 43	6 17 21	318.5	2.70	186.7	13.4
2515	Down	34	54 17 50	6 17 46	307.0	2.70	182.1	10.7
2516	Down	40	54 16 04	6 18 35	256.0	2.70	181.9	10.1
2517	Down	40	54 13 48	6 19 09	96.0	2.70	187.6	9.5
2518	Down	46	54 11 58	6 19 47	90.0	2.65	189.7	13.8
2519	Down	27	54 22 05	6 12 52	288.0	2.70	194.1	15.6
2520	Down	27	54 22 51	6 11 11	258.0	2.70	198.2	16.8
2521	Down	21	54 24 42	6 09 15	236.0	2.70	205.8	20.5
2522	Down	21	54 25 53	6 07 26	416.0	2.70	197.8	21.5
2523	Down	21	54 27 00	6 06 12	354.0	2.70	204.8	23.2
2524	Down	14	54 27 42	6 04 55	293.0	2.70	209.1	22.9
2525	Down	14	54 29 19	6 03 46	133.0	2.70	220.5	22.4
2526*	Antrim	68	54 30 26	6 02 46	130.0	2.30	223.05	23.9
2527	Antrim	64	54 32 16	6 01 18	94.0	2.30	225.4	21.3
2528	Antrim	64	54 33 20	5 59 25	111.0	2.30	226.2	21.7
2529**	Antrim	61	59 35 07	5 56 06	41.0	2.30	232.58	21.0
2530*	Antrim	61	54 37 21	5 56 16	119.5	2.30	231.23	21.5
2531*	Antrim	56	54 40 04	5 57 14	385.0	2.67	215.52	17.3
2532*	Down	9	54 32 44	5 54 26	322.5	2.70	216.00	24.4
2533*	Down	9	59 30 55	5 53 15	382.0	2.70	208.91	23.3
2534*	Down	4	54 35 38	5 52 00	91.5	2.30	232.77	23.7
2535**	Antrim	42	54 44 58	6 27 24	55.0	2.67	234.29	9.3
2536	Antrim	49	54 44 33	6 22 00	299.5	2.67	216.0	6.3
2537	Antrim	49	54 44 38	6 18 20	122.5	2.67	225.8	5.4
2538	Antrim	49	54 43 47	6 15 40	68.5	2.67	228.3	5.8
2539	Antrim	50	54 42 49	6 13 12	67.5	2.67	228.9	7.8
2540	Antrim	50	54 42 10	6 10 35	133.5	2.67	229.2	12.9
2541	Antrim	51	54 42 06	6 05 41	168.0	2.67	226.2	12.0
2542	Antrim	51	54 41 47	6 01 59	327.5	2.67	220.3	16.3
2543	Antrim	56	54 41 04	5 59 43	387.0	2.67	214.4	14.9
2544	Antrim	50	54 41 51	6 08 15	145.5	2.67	229.2	14.1
2544a	Londonderry	42	54 46 16	6 31 32	82.0	2.67	240.0	14.9
2545	Londonderry	42	54 47 33	6 34 10	112.0	2.67	241.4	16.2
2546	Londonderry	37	54 48 45	6 36 57	203.0	2.70	235.8	14.3
2547**	Londonderry	36	54 50 32	6 40 32	233.0	2.30	235.29	14.3
2548	Londonderry	36	54 48 37	6 42 17	173.0	2.30	238.8	16.6
2549	Londonderry	41	54 46 08	6 40 21	190.0	2.70	235.9	17.3

Station Number	Six Inch Map Sheet Number		Latitude N	Longitude W	Height above M.S.L.	Density	g(Station) minus g(Cambridge)	Bouguer Anomaly
			° ′ ″	° ′ ″	ft.	g/cm³	mgals.	mgals.
2550	Londonderry	46	54 41 26	6 40 11	163.0	2.30	233.2	20.5
2551**	Tyrone	29	54 38 50	6 44 41	246.0	2.30	222.40	18.7
2552	Londonderry	46	54 43 53	6 40 05	228.0	2.70	237.8	24.7
2553*	Down	37	54 17 23	5 50 10	141.0	2.70	199.59	19.0
2554	Down	44	59 15 20	5 50 42	13.0	2.70	205.3	20.1
2555	Down	49	54 12 41	5 53 18	26.0	2.70	215.0	34.2
2556	Down	49	54 10 18	5 52 25	80.0	2.70	199.0	24.9
2557	Down	53	54 07 50	5 53 41	81.0	2.70	204.9	34.3
2558	Down	56	54 05 58	5 54 35	84.0	2.70	209.4	41.7
2559	Down	56	54 04 18	5 58 46	97.0	2.70	212.7	48.2
2560	Down	37	59 18 05	5 46 25	95.0	2.70	206.3	22.0
2561	Down	37	54 19 34	5 42 58	5.0	2.70	215.3	23.5
2562	Down	30	54 21 43	5 44 17	73.0	2.70	212.5	21.7
2563	Down	23	54 24 18	5 46 12	90.0	2.70	217.2	23.8
2564	Down	23	54 26 56	5 49 10	190.0	2.70	215.7	24.4
2565	Down	16	54 28 39	5 50 15	287.0	2.70	211.4	23.5
2566**	Armagh	12	54 21 55	6 35 38	244.5	2.70	201.37	20.5
2567	Armagh	12	54 20 25	6 39 33	155.0	2.70	202.9	18.8
2568	Armagh	16	54 19 09	6 42 35	232.0	2.70	203.5	25.8
2569	Armagh	15	54 17 36	6 46 27	243.0	2.70	196.4	21.5
2570	Armagh	15	54 17 33	6 50 37	140.5	2.70	201.8	21.0
2571	Monaghan	10	54 16 02	6 54 31	154.0	2.70	199.0	21.2
2572**	Monaghan	9	54 14 47	6 57 54	193.5	2.70	193.33	19.7
2573†	Armagh	12	54 21 10	6 38 57	—	—	201.6	—
2574	Armagh	9	54 23 32	6 30 42	116.5	2.67	206.4	15.7
2575*	Armagh	9	54 25 32	6 26 10	62.0	2.67	210.76	13.9
2576	Armagh	6	54 27 21	6 21 42	132.0	2.67	211.7	16.4
2577	Down	13	54 27 38	6 17 46	199.0	2.67	208.6	16.9
2578	Down	13	54 28 44	6 13 41	232.0	2.60	209.3	18.3
2579	Antrim	67	54 29 43	6 10 03	128.0	2.30	219.0	20.7
2580	Antrim	67	54 30 00	6 05 49	106.0	2.30	221.9	21.8
2581**	Tyrone	35	54 35 55	7 17 27	222.0	2.70	229.66	27.5
2582	Tyrone	35	54 36 53	7 13 11	359.0	2.75	223.1	27.5
2583	Tyrone	27	54 38 39	7 10 08	540.0	2.75	211.6	24.1
2584	Tyrone	27	54 39 54	7 05 44	575.0	2.75	210.9	23.7
2585	Tyrone	27	54 38 56	7 01 40	589.0	2.75	211.3	26.4
2586	Tyrone	28	54 39 29	6 57 43	491.0	2.75	215.8	25.6
2587	Tyrone	28	54 39 17	6 53 27	437.0	2.75	222.8	28.3
2588	Tyrone	29	54 38 36	6 51 14	391.0	2.75	228.0	31.8
2589	Tyrone	29	54 38 18	6 48 14	224.5	2.75	226.7	21.1
2590*	Londonderry	29	54 54 38	7 08 29	256.0	2.75	246.72	19.8
2591	Londonderry	30	54 53 42	7 04 31	388.0	2.75	240.8	23.0
2592	Londonderry	30	54 53 55	6 58 35	330.0	2.70	244.2	22.8
2593	Londonderry	24	54 55 37	6 56 06	202.0	2.70	249.8	18.4
2594	Londonderry	31	54 54 32	6 53 06	531.5	2.70	232.9	22.8
2595	Londonderry	31	54 54 04	6 49 58	663.0	2.70	222.5	20.8
2596	Londonderry	31	54 53 09	6 47 25	810.0	2.70	212.3	20.7
2597	Londonderry	36	54 50 49	6 43 38	263.0	2.70	235.9	15.1
2598	Londonderry	23	54 55 19	7 11 15	339.0	2.75	243.0	20.1
2599	Londonderry	23	54 56 52	7 13 30	285.0	2.75	247.4	19.1

Station Number	Six Inch Map Sheet Number		Latitude N	Longitude W	Height above M.S.L.	Density	g(Station) minus g(Cambridge)	Bouguer Anomaly
			° ′ ″	° ′ ″	ft.	g/cm³	mgals.	mgals.
2600	Londonderry	14	54 58 34	7 16 18	87.0	2.75	262.9	20.4
2601	Londonderry	14	55 00 08	7 19 20	9.0	2.75	270.9	21.6
2602*	Londonderry	14	55 01 25	7 20 22	52.0	2.75	269.44	20.9
2603	Tyrone	60	54 26 42	7 00 33	387.5	2.70	204.23	25.0
2604	Tyrone	60	54 25 05	6 58 54	219.5	2.70	211.4	24.6
2605	Monaghan	3	54 23 27	6 58 20	159.0	2.70	211.5	23.4
2606	Monaghan	6	54 19 35	6 57 38	178.0	2.70	202.9	21.4
2607	Monaghan	6	54 17 11	6 58 01	275.5	2.70	192.0	19.7
2608	Monaghan	3	54 21 34	6 58 10	182.0	2.70	206.4	22.3
2609	Tyrone	52	59 27 41	7 02 00	268.5	2.70	214.1	26.4
2610	Tyrone	52	54 28 40	7 05 01	515.0	2.65	199.2	25.2
2611	Tyrone	52	54 29 06	7 07 54	558.0	2.65	196.9	24.8
2612	Tyrone	52	54 30 08	7 10 06	425.0	2.65	206.5	25.0
2613	Tyrone	43	54 31 54	7 13 23	410.0	2.65	211.7	26.7
2614	Tyrone	43	54 33 32	7 15 40	313.0	2.65	217.7	24.5
2615	Tyrone	34	54 34 42	7 20 35	336.5	2.65	223.0	29.6
2616	Tyrone	42	54 33 19	7 22 24	304.5	2.65	224.3	30.9
2617	Tyrone	42	54 32 14	7 24 52	300.0	2.65	226.6	34.6
2618*	Tyrone	50	59 30 50	7 27 06	319.5	2.65	227.53	38.5
2619**	Fermanagh	22	54 20 30	7 38 53	156.5	2.65	200.48	16.6
2620	Fermanagh	26	54 18 44	7 42 21	172.0	2.70	193.2	12.5
2621	Fermanagh	26	54 17 51	7 46 00	207.0	2.70	189.0	11.6
2622	Fermanagh	25	54 17 41	7 50 49	188.5	2.70	192.1	13.9
2623*	Cavan	2	54 17 08	7 54 33	206.0	2.70	191.33	15.0
2624	Fermanagh	22	54 22 20	7 37 59	168.0	2.65	208.8	22.8
2625	Fermanagh	16	54 24 02	7 36 55	190.0	2.65	215.4	28.4
2626	Fermanagh	16	54 25 17	7 34 22	242.0	2.65	218.1	32.5
2627	Tyrone	56	59 26 38	7 30 26	321.0	2.65	219.6	36.7
2628	Tyrone	50	54 28 02	7 28 09	428.0	2.65	217.3	39.0
2629	Tyrone	50	54 29 28	7 27 48	326.0	2.65	226.0	39.4
2630*	Leitrim	11	54 18 12	8 10 43	153.0	2.75	195.13	13.9
2631	Leitrim	7	54 18 43	8 14 23	192.0	2.70	187.9	8.4
2632	Leitrim	6	54 19 23	8 19 17	181.0	2.70	186.7	5.7
2633	Leitrim	6	54 20 00	8 22 37	363.0	2.70	177.4	6.3
2634	Sligo	9	54 18 16	8 26 00	270.0	2.70	184.4	10.2
2635	Leitrim	12	54 18 08	8 07 31	288.0	2.70	192.2	19.3
2636	Leitrim	12	54 17 34	8 03 32	321.0	2.70	188.1	17.9
2637	Leitrim	13	54 17 05	7 59 14	221.0	2.70	191.5	16.2
2638	Cavan	1	54 17 12	7 56 38	228.0	2.70	191.9	16.8
2639**	Fermanagh	40	54 10 47	7 20 55	212.0	2.70	184.46	17.6
2640	Fermanagh	40	54 10 22	7 16 03	166.0	2.70	186.5	17.4
2641*	Monaghan	12	54 11 20	7 12 14	200.0	2.70	186.11	17.6
2642	Monaghan	12	54 12 50	7 08 22	206.0	2.70	189.0	18.8
2643	Monaghan	9	54 13 53	7 04 02	210.0	2.70	190.8	19.4
2644	Fermanagh	34	54 12 50	7 23 51	195.0	2.70	188.8	17.9
2645	Fermanagh	34	54 14 35	7 25 55	194.0	2.70	193.2	19.9
2646	Fermanagh	34	54 16 13	7 29 37	161.0	2.70	197.7	20.0
2647	Fermanagh	27	54 17 31	7 32 22	167.0	2.70	196.1	16.9
2648	Fermanagh	27	54 18 59	7 34 51	158.0	2.70	196.9	15.0
2649**	Donegal	78	54 48 10	7 46 04	111.0	2.75	238.23	11.9

Station Number	Six Inch Map Sheet Number		Latitude N	Longitude W	Height above M.S.L.	Density	g(Station) minus g(Cambridge)	Bouguer Anomaly
			° ′ ″	° ′ ″	ft.	g/cm³	mgals.	mgals.
2650	Donegal	69	54 50 26	7 45 04	255.0	2.75	235.9	14.9
2651	Donegal	61	54 52 59	7 44 05	513.0	2.75	225.7	16.2
2652	Donegal	61	54 55 02	7 41 46	397.0	2.75	237.2	18.1
2653**	Donegal	53	54 56 32	7 40 13	85.0	2.75	258.97	19.4
2654	Donegal	54	54 57 02	7 37 18	151.0	2.75	255.9	19.5
2655	Donegal	54	54 59 05	7 33 03	89.0	2.75	263.9	20.8
2656	Donegal	47	54 59 46	7 29 00	85.0	2.75	266.7	22.4
2657	Donegal	47	55 01 56	7 26 38	54.0	2.75	271.6	22.5
2658*	Donegal	71	54 49 53	7 29 14	55.0	2.75	249.24	17.2
2659	Tyrone	10	54 46 52	7 28 14	101.0	2.75	241.1	16.1
2660	Tyrone	17	54 41 01	7 26 00	104.5	2.75	238.7	18.0
2661	Tyrone	17	59 42 36	7 21 40	197.0	2.75	233.4	20.1
2662	Tyrone	25	54 40 28	7 21 05	210.0	2.70	232.2	22.9
2663	Tyrone	25	54 37 59	7 20 26	235.0	2.70	229.0	24.6
2664	Donegal	93	54 39 00	8 06 22	28.5	2.70	231.2	13.0
2665	Donegal	94	54 40 08	8 03 08	142.5	2.70	225.9	13.0
2666*	Donegal	94	54 41 17	7 59 51	320.0	2.75	211.20	7.0
2667	Donegal	86	54 43 06	7 57 00	345.0	2.65	197.7	− 7.1
2668	Donegal	86	54 45 08	7 53 51	600.0	2.75	197.2	4.0
2669	Donegal	77	54 47 04	7 49 17	215.5	2.75	230.6	12.1
2670	Donegal	77	54 48 21	7 51 05	122.0	2.75	236.0	10.1
2671	Donegal	68	54 49 24	7 55 35	223.0	2.75	233.3	11.8
2672	Donegal	67	54 51 04	7 57 30	411.0	2.75	228.7	16.0
2673*	Donegal	67	54 51 42	8 02 36	534.0	2.75	220.57	14.3
2674	Donegal	67	54 52 19	8 05 29	426.0	2.75	223.7	10.1
2675	Donegal	58	54 52 34	8 09 02	358.0	2.65	223.7	6.2
2676	Donegal	70	54 51 50	7 31 18	17.0	2.75	254.1	17.1
2677	Donegal	62	54 53 32	7 33 34	246.0	2.75	243.2	17.3
2678	Donegal	54	54 55 55	7 36 27	92.0	2.75	258.1	19.7
2679	Donegal	53	54 57 20	7 43 56	191.0	2.75	254.5	19.9
2680	Donegal	45	54 59 30	7 43 47	150.0	2.75	260.6	20.5
2681*	Donegal	45	55 01 37	7 46 50	106.5	2.75	263.30	17.6
2682	Donegal	58	54 54 08	8 12 28	23.0	2.65	239.7	− 0.2
2683*	Donegal	57	54 55 32	8 17 30	148.0	2.65	227.24	− 7.1
2684	Donegal	49	54 58 31	8 24 23	35.0	2.65	231.4	−14.0
2685	Donegal	49	54 56 53	8 21 38	43.0	2.65	232.8	− 9.8
2686	Donegal	100	54 36 48	8 05 10	78.5	2.70	222.7	10.8
2687	Donegal	103	54 34 29	8 07 27	125.0	2.70	218.7	12.8
2688	Donegal	107	54 31 36	8 08 27	261.0	2.70	206.6	13.0
2689	Donegal	107	54 29 38	8 12 29	47.0	2.70	217.7	14.0
2690*	Donegal	106	54 28 40	8 16 12	58.0	2.70	218.29	16.8
2691	Sligo	3	54 27 33	8 22 53	82.0	2.70	216.3	17.7
2692	Sligo	2	54 25 46	8 27 10	109.5	2.70	213.4	18.9
2693	Sligo	5	54 24 03	8 30 35	116.0	2.70	212.5	20.9
2694	Sligo	5	54 21 33	8 31 21	214.0	2.70	202.4	20.3
2695	Sligo	8	54 18 53	8 28 41	52.0	2.70	201.0	12.9
2696	Donegal	38	55 04 18	7 26 53	57.0	2.75	271.2	18.9
2697	Donegal	19	55 10 45	7 24 22	260.0	2.75	274.0	24.5
2698	Donegal	10	55 13 27	7 24 19	257.0	2.75	278.4	24.9
2699	Donegal	10	55 15 38	7 24 52	50.0	2.75	292.9	24.1

Station Number	Six Inch Map Sheet Number		Latitude N	Longitude W	Height above M.S.L.	Density	g(Station) minus g(Cambridge)	Bouguer Anomaly
			° ′ ″	° ′ ″	ft.	g/cm³	mgals.	mgals.
2700	Donegal	3	55 16 45	7 21 08	71.0	2.75	296.1	27.0
2701	Donegal	11	55 14 53	7 15 49	103.0	2.75	289.5	25.0
2702	Donegal	4	55 17 31	7 15 42	14.0	2.75	302.5	29.0
2703	Donegal	2	55 20 27	7 19 01	72.0	2.75	298.9	24.7
2704	Donegal	1	55 22 26	7 22 00	74.0	2.75	303.1	26.1
2705	Donegal	35	55 03 25	7 50 27	281.0	2.75	249.2	11.4
2706	Donegal	35	55 05 37	7 54 13	199.0	2.65	256.0	10.4
2707	Donegal	26	55 07 48	7 54 54	58.0	2.75	274.4	17.2
2708	Donegal	15	55 10 45	7 58 06	11.0	2.75	278.2	14.0
2709	Donegal	25	55 09 06	8 02 03	202.0	2.75	267.3	16.8
2710*	Donegal	25	55 07 58	8 06 12	173.0	2.75	267.42	16.7
2711	Donegal	24	55 06 48	8 08 38	59.0	2.75	267.4	11.7
2712	Donegal	24	55 08 01	8 12 23	111.0	2.65	267.4	13.2
2713	Donegal	23	55 07 31	8 16 44	346.0	2.65	242.0	2.6
2714	Donegal	32	55 04 48	8 17 24	57.0	2.65	249.8	− 3.2
2715	Donegal	41	55 02 07	8 15 30	192.0	2.65	240.6	− 0.4
2716	Donegal	41	55 59 41	8 17 24	172.0	2.65	232.6	− 6.2
2717**	Monaghan	25	54 04 10	6 40 04	293.0	2.70	174.65	22.1
2718	Louth	3	54 02 34	6 35 21	318.0	2.70	173.9	25.1
2719	Louth	8	54 00 20	6 17 09	18.0	2.70	217.9	54.4
2720*	Louth	8	53 59 53	6 11 35	142.0	2.70	211.32	55.9
2721	Monaghan	25	54 05 53	6 42 16	308.0	2.70	175.0	20.9
2722	Monaghan	20	54 07 32	6 45 00	318.0	2.70	176.0	20.1
2723	Monaghan	19	54 09 59	6 47 48	407.0	2.70	172.2	18.1
2724	Monaghan	14	54 12 14	6 50 21	372.0	2.70	179.6	20.2
2725	Monaghan	10	54 14 12	6 52 38	154.0	2.70	196.6	21.4
2726	Monaghan	9	54 16 38	7 03 59	254.0	2.70	194.4	21.6
2727*	Cavan	20	54 00 33	7 21 20	217.0	2.70	162.39	10.4
2728	Cavan	15	54 03 28	7 22 21	178.0	2.70	171.3	12.8
2729	Cavan	11	54 06 22	7 21 38	171.0	2.70	177.4	14.3
2730	Monaghan	16	54 08 40	7 19 05	165.0	2.70	182.4	15.7
2731	Monaghan	11	54 10 25	7 14 21	168.0	2.70	186.3	17.3
2732	Cavan	21	53 59 13	7 19 04	297.0	2.70	155.6	10.3
2733	Cavan	26	53 58 15	7 14 34	331.0	2.70	152.7	10.8
2734	Cavan	26	53 56 28	7 13 27	396.0	2.70	144.4	8.9
2735	Cavan	32	53 54 03	7 10 38	370.0	2.70	143.0	9.6
2736	Cavan	33	53 52 33	7 07 32	379.0	2.70	141.9	11.1
2737	Cavan	39	53 50 34	7 05 40	337.0	2.70	143.2	12.7
2738	Cavan	20	53 59 02	7 24 18	241.0	2.70	156.5	8.2
2739	Cavan	25	53 57 03	7 25 58	172.0	2.70	153.4	3.8
2740	Cavan	25	53 55 46	7 24 16	262.0	2.70	147.6	5.1
2741	Cavan	25	53 58 01	7 28 20	192.0	2.70	157.4	7.6
2742	Louth	9	53 59 55	6 07 46	59.0	2.70	206.9	46.4
2743	Louth	9	54 01 32	6 08 55	13.0	2.70	214.7	49.2
2744	Louth	5	54 03 37	6 12 16	98.0	2.70	215.0	51.5
2745	Louth	5	54 05 05	6 15 23	36.0	2.70	221.0	51.7
2746	Armagh	29	54 08 45	6 19 13	13.0	2.65	209.1	33.2
2747	Louth	7	54 00 51	6 18 47	13.0	2.90	215.1	50.5
2748	Louth	8	54 01 05	6 17 55	76.0	2.90	214.0	52.7
2749	Louth	8	54 01 59	6 16 48	557.5	2.65	186.8	53.4

Station Number	Six Inch Map Sheet Number		Latitude N	Longitude W	Height above M.S.L.	Density	g(Station) minus g(Cambridge)	Bouguer Anomaly
			° ′ ″	° ′ ″	ft.	g/cm³	mgals.	mgals.
2750	Louth	5	54 02 18	6 15 59	631.0	2.65	183.4	54.0
2751	Louth	5	54 03 09	6 16 13	642.0	2.65	184.1	54.1
2752	Louth	5	54 04 09	6 16 40	429.0	2.90	201.7	56.2
2753	Louth	5	54 04 51	6 16 11	234.0	2.70	209.8	52.6
2754	Louth	3	54 03 46	6 28 31	206.0	2.70	194.7	37.5
2755	Antrim	56	54 38 15	5 01 12	898.5	2.67	181.8	16.9
2756	Antrim	56	54 38 10	5 05 32	528.5	2.67	203.3	16.4
2757††	Antrim	55	——	——	—	—	212.1	—
2758	Antrim	59	54 37 41	6 12 32	288.0	2.67	212.7	12.1
2759	Antrim	58	54 37 27	6 15 16	163.0	2.67	217.8	10.0
2760	Antrim	58	54 37 42	6 18 02	56.0	2.67	221.9	7.3
2761	Antrim	51	54 42 10	5 58 04	337.0	2.67	218.8	14.7
2762	Antrim	45	54 44 51	5 57 35	395.0	2.67	217.8	13.4
2763	Antrim	46	54 47 23	5 56 09	441.0	2.67	215.6	10.4
2764*	Antrim	40	54 49 50	5 52 26	316.0	2.67	222.81	6.6
2765	Antrim	40	54 51 00	5 48 08	12.0	2.60	241.0	4.9
2766	Down	34	54 19 54	6 14 40	265.5	2.70	189.0	12.3
2767	Down	34	54 18 23	6 12 04	282.0	2.70	182.9	9.3
2768	Down	34	54 17 07	6 10 05	459.0	2.70	167.1	5.9
2769	Down	41	54 15 48	6 09 41	339.0	2.65	169.4	3.1
2770	Down	41	54 14 08	6 10 07	368.0	2.65	166.4	4.3
2771	Down	41	54 13 47	6 12 51	227.0	2.65	175.0	4.9
2772	Down	47	54 13 19	6 16 09	215.0	2.65	183.0	13.1
2773	Down	47	54 11 59	6 17 57	106.0	2.65	187.1	12.2
2774	Armagh	26	54 11 04	6 23 22	266.0	2.65	188.5	24.5
2775	Armagh	25	54 10 18	6 25 49	325.0	2.65	193.8	34.5
2776	Armagh	25	54 09 12	6 27 35	371.0	2.65	201.0	46.0
2777	Armagh	28	54 07 44	6 30 05	370.0	2.65	196.1	43.2
2778	Armagh	28	54 06 04	6 31 36	305.0	2.70	189.0	34.4
2779	Armagh	28	54 06 54	6 27 38	307.0	2.65	206.1	50.6
2780	Down	51	54 07 18	6 09 46	384.5	2.70	187.2	35.5
2781	Down	52	54 09 30	6 07 44	610.0	2.65	167.1	26.1
2782	Down	48	54 10 58	6 06 38	421.0	2.65	172.7	18.1
2783	Down	48	54 12 07	6 04 58	509.5	2.70	167.5	16.4
2784	Down	48	54 13 04	6 01 22	637.0	2.70	164.7	19.9
2785	Down	49	54 13 18	5 58 15	475.0	2.70	175.4	20.6
2786	Down	43	54 13 59	5 54 45	109.0	2.70	198.6	21.0
2787	Armagh	5	54 26 55	6 29 10	99.0	2.67	209.8	13.1
2788	Armagh	5	54 28 33	6 31 49	65.0	2.30	208.1	7.4
2789	Armagh	4	54 28 54	6 36 10	66.0	2.30	206.1	4.8
2790	Tyrone	55	54 29 25	6 38 32	81.0	2.30	208.1	6.4
2791	Tyrone	55	54 29 31	6 41 22	79.0	2.30	215.5	14.3
2792	Tyrone	54	54 30 00	6 45 09	246.0	2.70	215.5	23.2
2793	Tyrone	46	54 33 03	6 44 27	237.0	2.70	221.3	24.1
2794	Tyrone	38	54 36 15	6 43 29	223.0	2.70	224.2	21.6
2795	Down	48	54 12 49	6 09 14	343.0	2.65	169.6	8.2
2796	Down	57	54 02 22	6 04 01	13.0	2.70	205.2	38.5
2797	Down	52	54 06 56	6 02 09	586.0	2.65	180.2	41.5
2798	Down	52	54 09 33	6 03 14	1209.0	2.65	138.8	33.8
2799	Down	48	54 11 08	6 02 08	1155.0	2.70	136.4	25.1

Station Number	Six Inch Map Sheet Number		Latitude N	Longitude W	Height above M.S.L.	Density	g(Station) minus g(Cambridge)	Bouguer Anomaly
			° ′ ″	° ′ ″	ft.	g/cm³	mgals.	mgals.
2800	Down	5	54 35 38	5 47 07	110.0	2.30	229.9	22.0
2801	Down	5	54 35 59	5 43 55	192.0	2.30	223.2	20.5
2802	Down	6	54 36 23	5 40 06	176.5	2.70	230.5	25.0
2803	Down	6	54 37 29	5 38 01	127.0	2.70	235.5	25.5
2804	Down	2	54 38 17	5 35 23	91.5	2.70	238.4	25.0
2805	Down	3	54 38 28	5 32 03	24.0	2.70	241.8	24.1
2806	Down	6	54 34 16	5 33 34	110.0	2.70	232.0	25.5
2807	Down	6	54 36 14	5 36 03	92.0	2.70	235.4	25.1
2808	Down	2	54 40 29	5 37 22	20.0	2.70	246.5	25.8
2809	Down	2	54 39 17	5 40 27	90.5	2.70	240.9	26.1
2810	Down	6	54 34 24	5 41 51	11.0	2.30	227.5	14.9
2811	Down	10	54 33 38	5 45 46	53.0	2.30	231.1	22.4
2812	Down	10	54 33 14	5 43 13	34.0	2.30	227.6	18.2
2813*	Antrim	27	54 56 10	6 19 40	317.0	2.67	248.97	23.9
2814	Antrim	23	54 58 33	6 20 43	295.0	2.67	254.8	25.9
2815	Antrim	23	55 00 58	6 22 11	282.5	2.67	259.6	25.6
2816	Antrim	17	55 02 45	6 25 43	283.0	2.67	263.1	26.6
2817	Antrim	17	55 04 10	6 30 14	122.0	2.67	250.8	2.6
2818	Antrim	16	55 05 17	6 33 48	137.0	2.67	258.6	9.7
2819	Londonderry	7	55 06 45	6 37 22	88.0	2.67	266.0	12.1
2820*	Londonderry	7	55 07 51	6 40 13	28.5	2.67	272.67	13.7
2821	Antrim	2	55 12 25	6 39 28	12.0	2.67	278.5	12.1
2822	Antrim	32	54 53 37	6 18 32	312.0	2.67	240.4	18.5
2823	Antrim	32	54 51 39	6 16 40	144.0	2.67	247.3	18.2
2824	Antrim	38	54 50 45	6 13 40	363.0	2.67	234.8	20.1
2825	Antrim	38	54 49 51	6 10 20	483.0	2.67	221.2	15.0
2826	Antrim	39	54 49 38	6 05 41	594.0	2.67	210.8	11.5
2827	Antrim	39	54 49 31	6 00 27	695.0	2.67	203.0	10.0
2828	Antrim	39	54 49 10	5 56 42	1012.0	2.67	181.5	8.0
2829	Londonderry	11	55 05 09	6 40 55	152.0	2.67	260.4	12.6
2830	Londonderry	11	55 02 25	6 40 56	256.0	2.67	246.2	8.6
2831	Londonderry	18	54 59 36	6 40 50	229.0	2.67	242.4	6.1
2832	Londonderry	26	54 57 12	6 40 58	432.0	2.67	237.5	17.8
2833	Londonderry	26	54 55 25	6 40 11	360.0	2.67	239.6	18.1
2834	Londonderry	32	54 53 12	6 39 58	305.0	2.67	238.9	17.2
2835	Londonderry	7	55 05 28	6 43 52	299.0	2.67	255.0	15.5
2836	Londonderry	10	55 04 37	6 48 50	792.0	2.67	223.9	15.3
2837	Londonderry	10	55 03 28	6 53 27	152.0	2.30	262.4	17.7
2838	Londonderry	9	55 02 58	6 58 09	87.0	2.70	269.1	20.5
2839	Londonderry	7	55 08 15	6 37 07	112.0	2.67	266.3	11.7
2840	Antrim	12	55 07 55	6 32 29	152.0	2.67	262.5	10.8
2841	Antrim	12	55 08 33	6 28 27	195.0	2.67	258.1	8.1
2842	Antrim	8	55 09 24	6 23 46	221.0	2.67	254.2	4.6
2843	Antrim	8	55 10 33	6 19 46	347.0	2.67	249.0	5.3
2844	Antrim	8	55 11 43	6 15 40	139.0	2.67	268.2	10.4
2845	Antrim	9	55 11 59	6 12 20	166.0	2.70	270.8	14.2
2846	Antrim	9	55 09 26	6 07 07	703.5	2.70	239.5	18.5
2847	Antrim	13	55 07 40	6 19 33	315.0	2.67	258.4	16.9
2848	Antrim	13	55 05 26	6 21 16	348.0	2.67	256.5	20.1

* Intermediate base station
** Base station
† Armagh Observatory
†† Belfast Airport

g(Cambridge) = 981·265 cm./sec²
The Irish Ordnance datum is about 8 ft. below Mean Sea Level.


6°
BALLYCASTLE
COLERAINE
BALLYMONEY
55°
BALLYMENA
LARNE
MAGHERA
COOKSTOWN
BANGOR
BELFAST
LISBURN
ANNON
PORTADOWN
ARMAGH
DOWNPATRICK
NEWCASTLE
NEWRY
DUNDALK
54°
6°

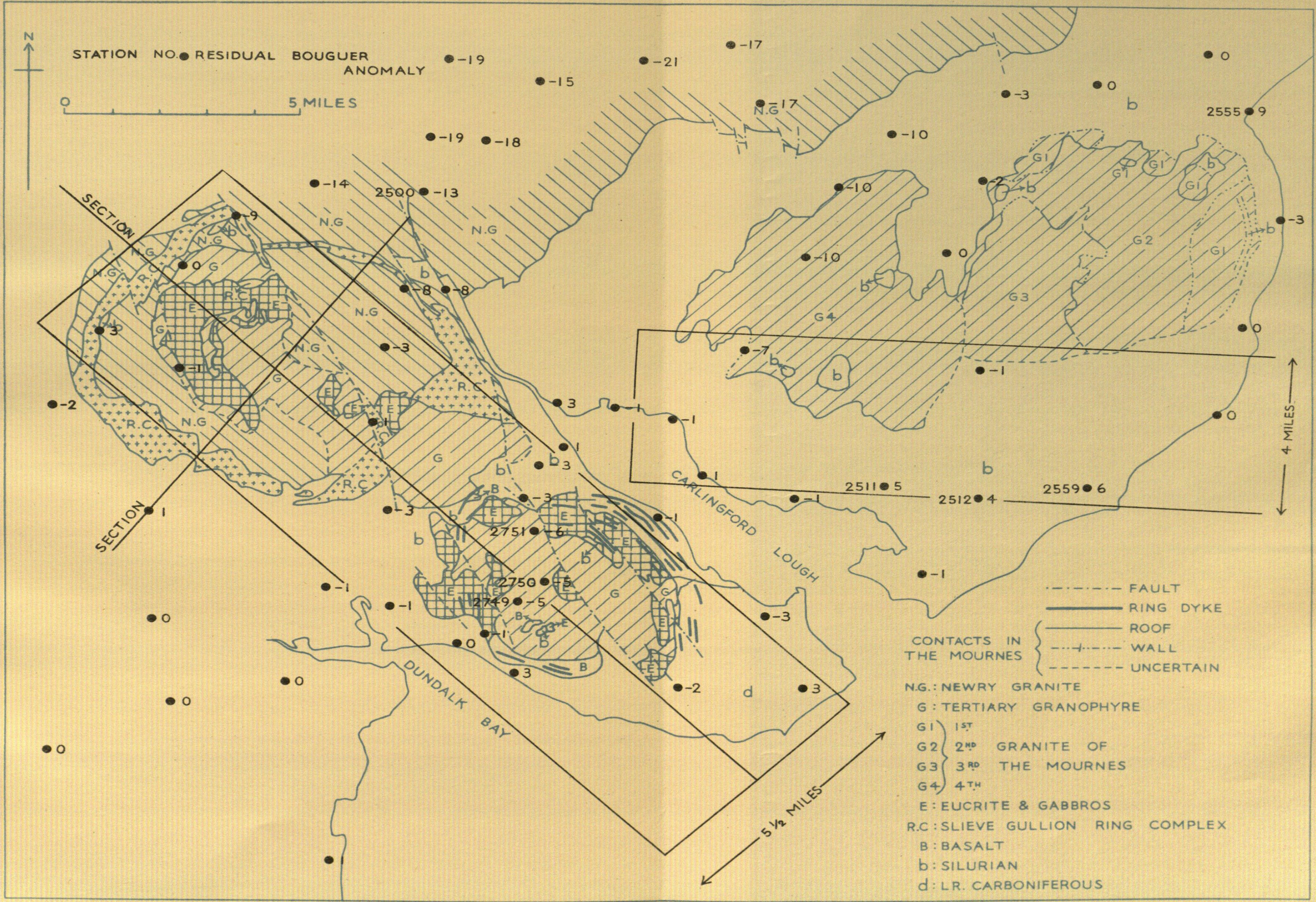
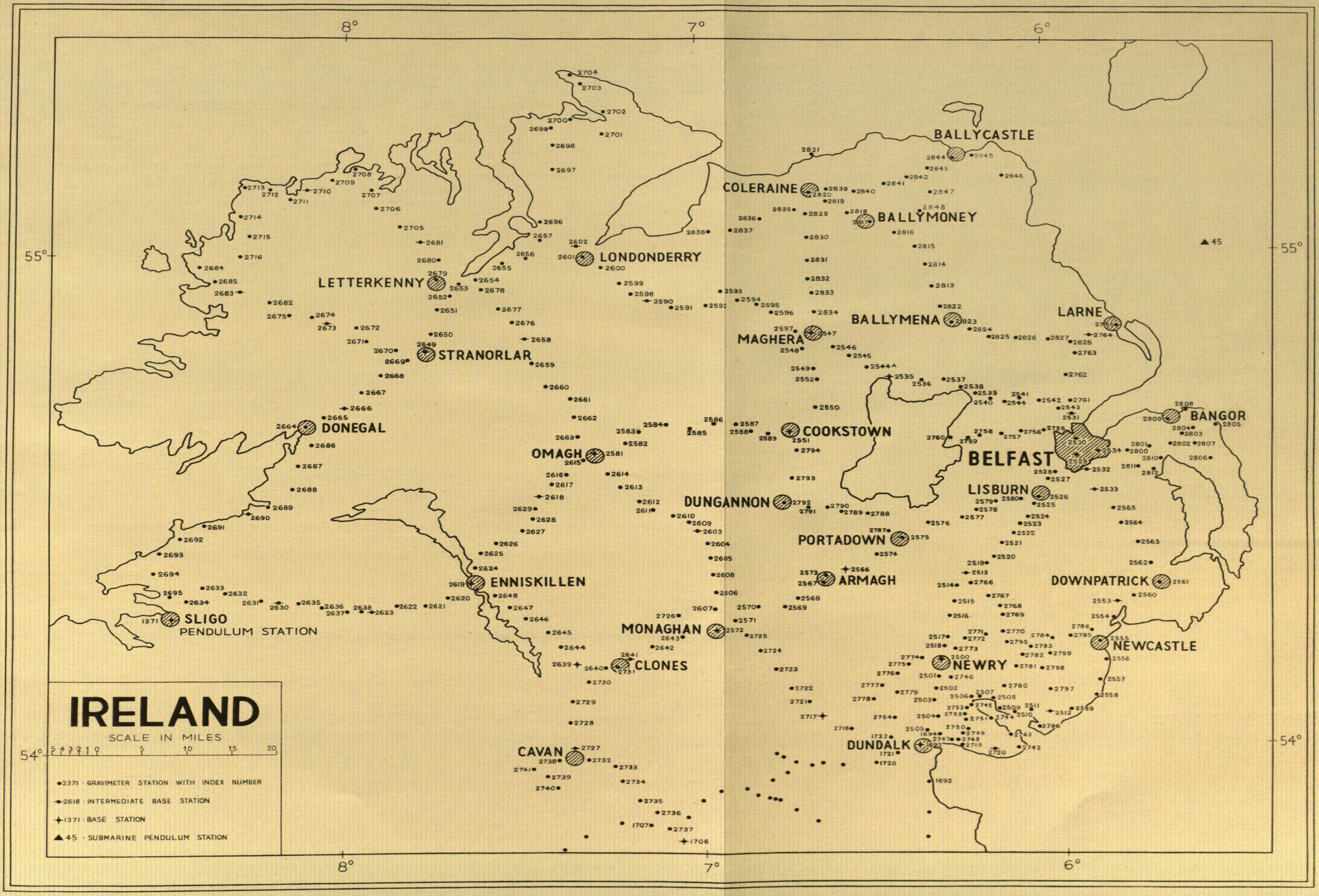


Fig. 12.—The map of *Fig.* 9 showing the outline plans of the assumed cylinders of basic rock and values of the "residual" anomaly after the deduction of the effects due to the postulated dense rock masses and the Palaeozoic rocks. The sections marked are drawn in *Fig.* 13.



IRELAND
SCALE IN MILES
5 4 3 2 1 0 5 10 15 20
●2371 · GRAVIMETER STATION WITH INDEX NUMBER
●2618 · INTERMEDIATE BASE STATION
✛1371 · BASE STATION
▲45 · SUBMARINE PENDULUM STATION
8°
7°
6°
55°
54°
BALLYCASTLE
COLERAINE
BALLYMONEY
LONDONDERRY
LETTERKENNY
STRANORLAR
BALLYMENA
LARNE
MAGHERA
DONEGAL
COOKSTOWN
BANGOR
OMAGH
BELFAST
DUNGANNON
LISBURN
PORTADOWN
ENNISKILLEN
ARMAGH
DOWNPATRICK
SLIGO
PENDULUM STATION
MONAGHAN
NEWCASTLE
CLONES
NEWRY
DUNDALK
CAVAN

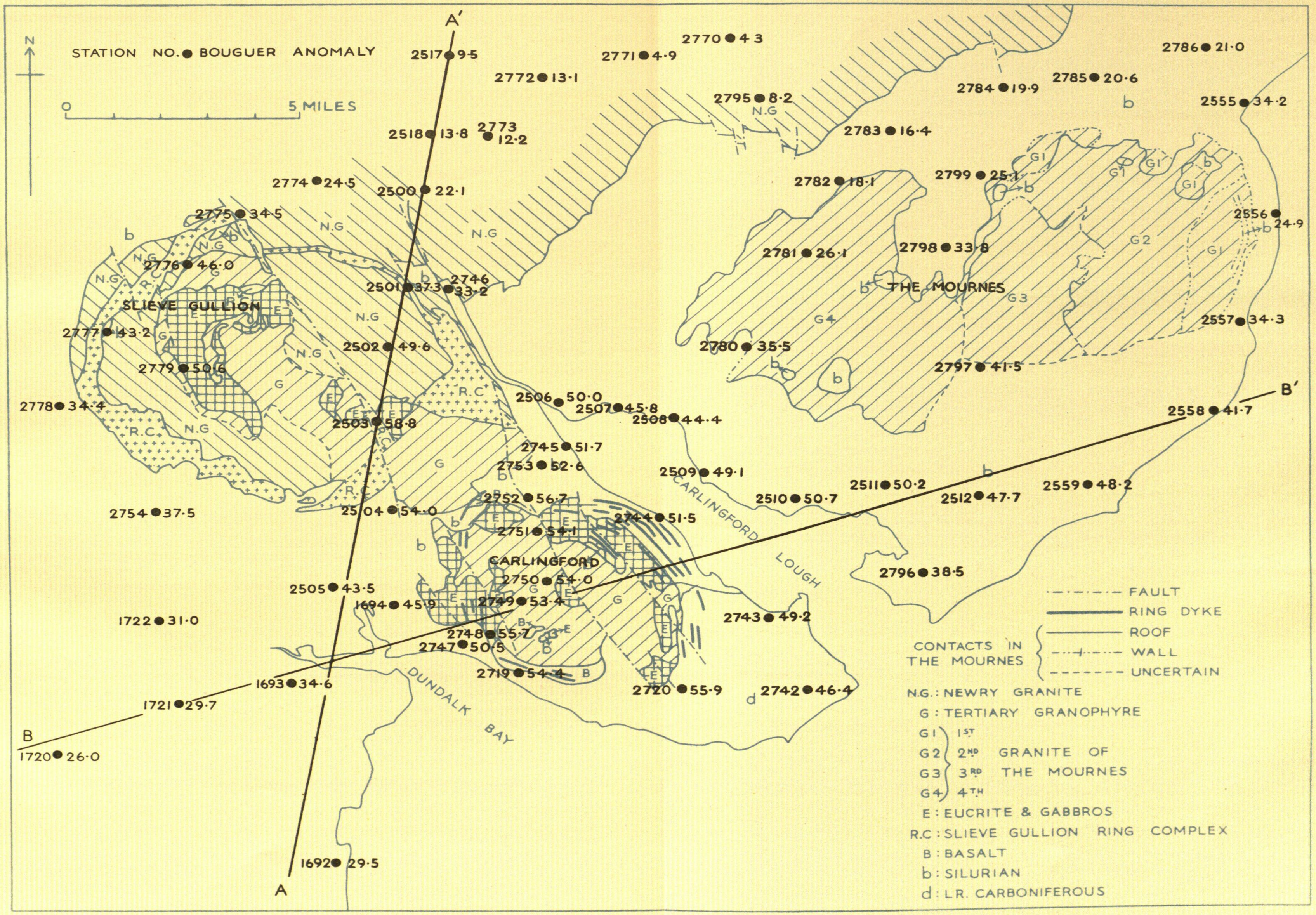
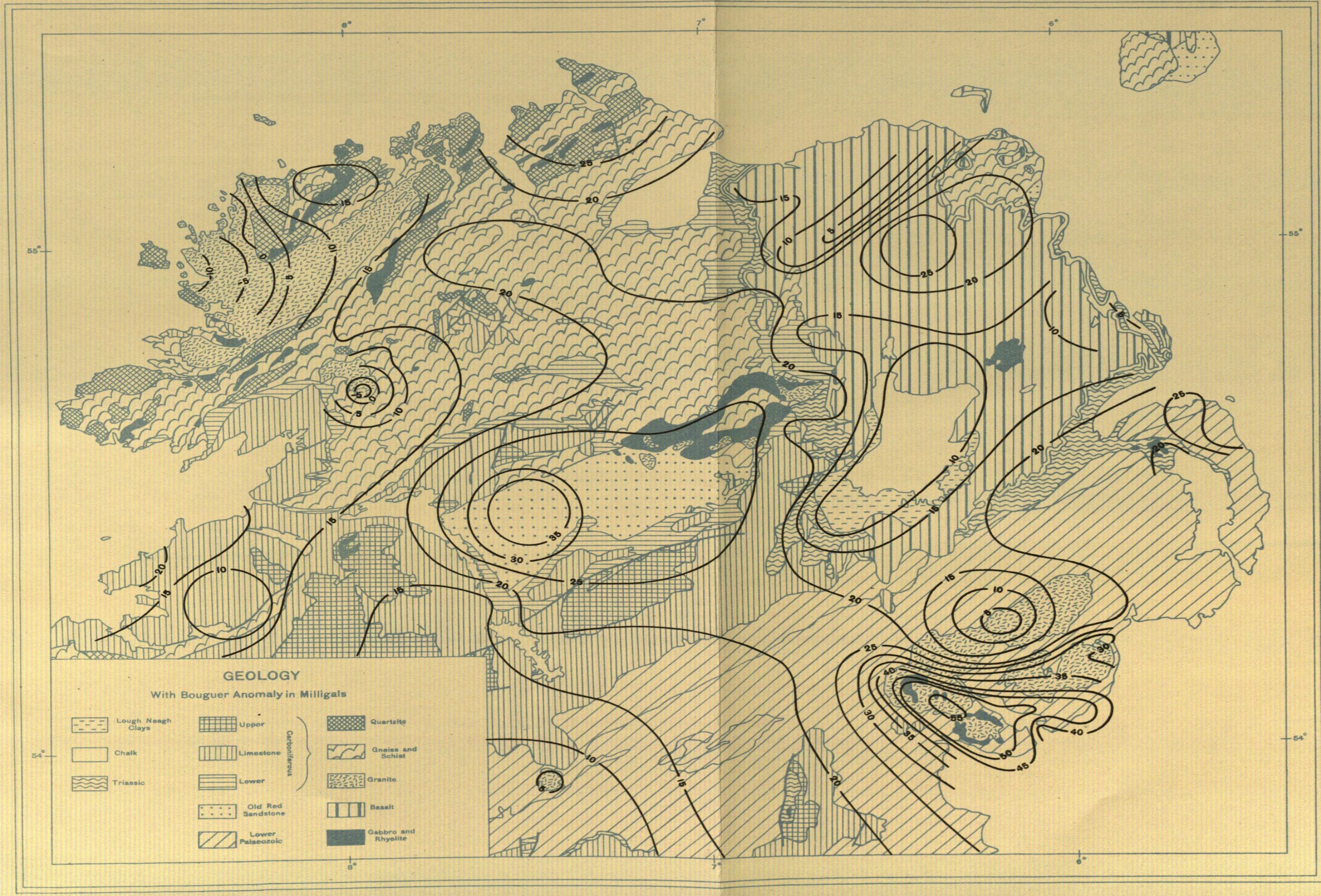


Fig. 9.—Sketch map of the geology (after REYNOLDS and RICHEY) in the area of the Tertiary Igneous Centres with the positions of the stations and values of the Bouguer anomaly.


GEOLOGY
With Bouguer Anomaly in Milligals
Lough Neagh Clays
Chalk
Triassic
Upper
Limestone
Lower
Carboniferous
Old Red Sandstone
Lower Palaeozoic
Quartzite
Gneiss and Schist
Granite
Basalt
Gabbro and Rhyolite
8°
7°
6°
55°
54°

GEOPHYSICAL MEMOIRS

No. 1 : L. W. POLLAK and U. N. EGAN, Eight-Place Supplement to Harmonic Analysis and Synthesis Schedules for three to one hundred equidistant values of empiric functions ; Dublin 1949.

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Part 2 : Index.

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Part 4 : A. H. COOK and T. MURPHY, Gravity Survey of Ireland North of the line Sligo-Dundalk ; Dublin 1952.

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