A GEOPHYSICAL SURVEY OF THE CAMPSIE AND KILPATRICK HILLS

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INTRODUCTION

The association between rift valleys and vulcanicity

There is commonly an association between the formation of rift valleys and vulcanicity. Many rifts, including the Midland Valley of Scotland, the Rhine graben and the East African rift system contain considerable amounts of volcanic material, principally lavas; and the lavas are dominantly alkaline olivine-basalts with some allied types such as phonolites and trachytes. The vulcanicity is sporadic. Long periods of time may pass without fresh outbursts of igneous activity disrupting sedimentation, as in the Upper Old Red Sandstone and Productive Coal Measures periods in the Midland Valley. Sometimes the vulcanicity is only local in extent as in the Rhine graben, and in the Millstone grit and Carboniferous Limestone sediments of the Midland Valley. Occasionally, the vulcanicity is intense with the intrusion of a large number of vents and the extrusion of a great thickness of lava amounting to several thousands of feet and extending over thousands of square miles. These phases are well represented in the Shire and Nyasa rifts of East Africa (Dixey, 1958 pp 7-19) and bythe Clyde Plateau Lavas in the Midland Valley of Scotland.

In East Africa and in Scotland, the volcanic vents tend to occur either within and near to the margins of the rift or close to major faults in the rift. Many of the vents are elongated forming agglomerate choked fissures which are sub-parallel to the Highland Boundary Fault and sets of similarly directed dykes are often present.

The sporadic occurrence of igneous activity suggests that the development of a rift valley favours but does not inevitably give rise to vulcanicity.

The association between the formation of rift valleys and the occurrence of vulcanicity may be summarised as follows: 'The conditions of rift valley formation and vulcanicity are not interdependent,but are both the result of some deeper phenomenon which frequently but not always creates a magma in a tensional stress system at a high level in the crust.'

The aims of the investigation

Syntheses of the geology of the Midland Valley of Scotland have been written by Clough and others (1925), Macgregor and MacGregor (1948), Kennedy (1958) and George (1960). Many problems remain, and in particular the Clyde Plateau Lavas, because of a lack of marker horizons and sparsity of exposure cannot be mapped in detail. Consequently their structure is poorly known in several areas and the source of many of the flows is obscure.

The immediate aim of the investigation was to elucidate the structure of the lava plateaux of the Campsie and Kilpatrick hills from the interpretation of gravity and magnetic surveys. The gravity survey is the principle method of investigation and the results are expressed in Bouguer anomalies which are interpreted by erecting structural models creating similar anomalies.

The magnetic results are treated in a similar way and are supplementary to the gravity survey.

By these means, the approximate depth to the base of the lavas is estimated over the whole of the Campsie and Kilpatrick hills, and the approximate throws of all the major faults in the area are deduced.

Models are erected to represent obscured faults within the lavas and major intrusions in the underlying sediments. Estimates of the thicknesses of the lavas beneath the sediments to the south and east of the hills are made.

The structure of the lavas of the Campsie and Kilpatrick hills, as interpreted with the help of the new evidence is then discussed in relation to the development of the Midland Valley.

THE KNOWN GEOLOGY

The Midland Valley of Scotland

The rift valley is approximately 50 miles wide, has a north-east - south-west trend and extends across Scotland into Northern Ireland. Holtedahl (1939 p 338) speculates on a possible correlation between the Midland Valley of Scotland and the South Scandinavian Syncline in Norway.

The stratigraphy and structure of the rift have been described by Macgregor and MacGregor (1948), Kennedy (1958 pp 110-133), and George (1960 pp 32-107). It is the widest of all the described rift valleys of the world (Girdler, 1963 p 3), and is defined by two large sub-parallel boundary faults, the Southern Upland fault and the Highland Boundary fault. The structure may be described as a block of Upper Palaeozoic sediments and lavas which have been down-faulted between Ordovician and Silurian greywackes to the south-east and Dalradian schistose grits to the north-west.

<u>Succession</u>. The general succession in the western Midland Valley is shown in Table 1 (Macgregor and MacGregor, 1948).

<u>Structure and early history of the rift</u>. The Lower Old Red Sandstone and Lower Palaeozoic strata are folded along north-east - south-west caledonoid axes and superimposed upon these in the Glasgow area is an east-west trending syncline of Upper Old Red Sandstone and Carboniferous strata (Kennedy 1958 p 109). Towards the east, this syncline dies out against a syncline trending north-south, the site of the Stirling and Clackmannan Coalfield.

The Highland Boundary Fault hasa long and complex history and there are divers opinions about its origins.

Table 1.

	Maximum thicknesses.
Permian?* sandstones and lavas.	2000 feet at Mauchline.
Coal Measures.	
Passage Beds, sediments and lavas.	
Scottish Carboniferous Limestone sediments.	6500 feet near Glasgow.
Calciferous Sandstone and sediments and lavas.	
Unconformity.	
Upper Old Red Sandstone sediments.	2700 feet at Kippen.
Unconformity.	
Lower Old Red Sandstone sediments and lavas.	17000-19000 feet at Kincardine.
Silurian greywackes and Ordovician greywackes and lavas.	5500 feet + at Lesmahagow (Silurian only).

*c.f. Mykura 1965.

Kennedy (1958 p 111) interprets the original structure as a post-Arenig thrust which has serpentine injected into the thrust-plane and is associated with the Caledonian orogeny. The Highland Boundary Fault inherits the plane of weakness of this thrust which Kennedy draws as a high angle structure. It is also argued that localized deformation in the Lesmahagow and adjacent districts may be interpreted as virgational folding determined by a foreland in the area of the Midland Valley. Intrusions of serpentine and the presence of thrust-planes in the Girvan district are taken to imply a reflection of the Highland Border situation and therefore the Southern Upland Fault, although younger in age, is assumed to emulate the

Highland Boundary Fault in its initiation. A compressional rift was formed in this way and the deposition of the great thickness of Lower Old Red Sandstone rocks was confined within the framework of the rift with only a few scattered outliers in the Highlands and Southern Uplands.

George (1960 p 43) argues that the Highland Boundary Fault commenced as a normal fault in pre-Arenig times down-faulting a great thickness of Dalradian rocks to the north. The Midland Valley was completely covered by Lower Palaeozoic and Lower Old Red Sandstone rocks before the true initiation of the present rift form by the rejuvenation of the Highland Boundary Fault as a normal fault with a downthrow to the south, and the inception of the Southern Upland Fault as a normal fault with a downthrow to the north. Thus a great thickness of Lower Palaeozoic and Lower Old Red Sandstone rocks were preserved in the Midland Valley whilst subsequent erosion removed the greater part of them in the Highlands and similarly the Lower Old Red Sandstone rocks in the Southern Uplands. Although reversals of throw of the boundary faults are recorded in the sediments, and a strike-slip movement is also noted on the Highland Boundary Fault, the overall pattern of the preservation of younger rocks within the subsiding rift and the near-complete erosion of rocks of the same age on the flanks persists in the Midland Valley at least to the end of the Triassic period. In Ireland, erosion is less advanced and the Carboniferous and Tertiary rocks display particularly well the transgressions of the boundaries of the rift by these strata (George, 1960 pp 39-40).

The stratigraphical evidence appears unequivocal in support of a tensional rift and the occurrence of extrusive vulcanicity is more likely in a tensional stress system than a compressional one. The extrusion of andesitic lavas in Lower Old Red Sandstone times however indicates a compressional environment since andesites are associated with orogeny especially in its later stages (Turner and

Verhoogen, 1960 p 272), and these lavas may represent a temporary reversion to a compressional stress system before the inception of the rift as a down-faulted block even in Old Red Sandstone times.

Major faults within the rift. These faults fall within four broad groups, viz:-

a. North-east - south-west faults.
b. East-north-east - west-south-west faults.
c. East-west faults.
d. North-west - south-east faults.

The north-east - south-west faults are the oldest. The Scottish Carboniferous Limestone sediments are seen to change thickness rapidly across certain members of this set (Anderson, 1942 p 90), indicating penecontemporaneous movement of these faults in Carboniferous times and their parallelism to the boundary faults of the rift suggests an earlier pre-Carboniferous history. E.M.Anderson and others express the hypothesis that the larger faults acted as strike-slip faults to accommodate a north-south directed compressive stress in Hercynian times in a north-east - south-west trending Caledonian framework. The Kerse Loch and Duskwater faults in Ayrshire are included in this category.

The east-north-east - west-south-west faults are considered to be early Carboniferous in age because of their parallelism to a dyke swarm which is intruded into the lower members of the Calciferous Sandstone series (Geikie, 1897 p 407). This set includes the western portions of the Ochil and Campsie Faults. The deviation of these two faults from an east-north-east - west-south-west trend in the west to an east-west trend in the east and the arcuate trend of the Inchgotrick Fault along its central portion suggests that the north-south relief of pressure which took place in late Carboniferous or Permian times, the Borcovician period of Anderson (1942 p 40) was accompanied by normal movement on many of the east-north-east - west-south-west faults.

The east-west set of faults includes a large number of minor faults and several major faults with throws up to and exceeding 3000 feet, for example the Campsie and Ochil Faults. In all cases, the displacement is inferred to be normal and results from a relief of pressure on a regional scale in late Carboniferous times (Anderson, 1942 pp 39-41).

The swing in strike of the Campsie and Ochil Faults has already been mentioned above, but in both cases the major displacement takes place along the east-west portions of the faults indicating that they are primarily east-west faults which swing into presumably pre-existing east-north-east - west-south-west faults.

The north-west - south-east set of faults are mainly minor ones but a few large ones with displacements of several hundred feet occur near Hamilton. These faults are inferred to be Tertiary because they are parallel to the north-west - south-east Tertiary dyke swarm and could have resulted from the same regional stress system (Anderson, 1942 p 35). In the Central Coalfield, many of these faults can be seen to be normal.

The Loch Tay faults form a set of north-north-east - south-south-west sinistral strike-slip faults which occur in the ground to the north of the Highland Boundary Fault. The Loch Tay Fault itself trails into the Highland Boundary Fault near Loch Vennacher and trends in a north-north-east direction as far as Braemar, the fault sometimes being represented as a single dislocation and sometimes as a zone of parallel faults. The age of the fault system is inferred to be proto-Armorican by Anderson (1942 pp 98-101). The Great Glen Fault is the most important member of this set. The strike-slip displacement of these faults appears to have been accommodated by the Highland Boundary Fault which is inferred to have a horizontal component of displacement (Anderson, 1942 p 95), and no major north-north-east - south-south-west fault is seen within the rift. However, a north-north-east - south-south-west trending ruck structure and associated minor rucks are described in the West Kilbride-Largs region (Patterson, 1946 pp 207-235), and these fault zones are considered to be related to the Loch Tay set of faults. These belts of disturbance vary between 1000 feet and 1350 feet in width and can be traced over a distance of 6 miles.

Igneous activity. The evolution of the Midland Valley has been punctuated by phases of igneous activity from Arenig to Tertiary times. Table 2 shows the incidence and type of igneous activity on a geological time-scale and the thicknesses of volcanic lava when these occur.

The three major periods of dyke intrusion since the inception of the rift in Old Red Sandstone times represent three periods of regional relief of pressure during Calciferous Sandstone times, Permo-Carboniferous (Borcovician) times and in the Tertiary period, and the orientation of these sets of dykes reflects the stress systems acting at the time of intrusion.

The earliest set of dykes has an east-north-east - west-south-west trend and is of Calciferous Sandstone age. Two phases of intrusion are recognised within this set, an earlier phase of trachytic dykes which cut the Upper Old Red Sandstone sediments, and sometimes the Cementstone group, but never the overlying lavas and a later phase of porphyritic olivine-basalt dykes which cut the trachytic

Table 2.

Igneous activity in the western Midland Valley

TERTIARY

Many NW-SE dykes radiating from Mull.

MESOZOIC

No igneous activity.

UPPER PALAEOZOIC

Carboniferous and Permian(?)

Lavas and tuffs with vents and plugs at Mauchline, thought to be of late Carboniferous age. E-W dykes and sills of Borcovician period.

Coal Measures:- No igneous activity.

Passage Beds:- Lavas in Arran, Ayrshire and Kintyre, (800 feet thick).

Scottish Carboniferous Limestone:- Lavas at Bathgate and Linlithgow, (3000 feet thick).

Calciferous Sandstone:- Lavas in Western Midland Valley, with plugs, dykes and sills (3000 feet thick).

Old Red Sandstone

Upper:- No igneous activity.

Lower:- Lavas in Ochils, with vents, sills and dykes, (6000 feet thick).

LOWER PALAEOZOIC

Silurian

No igneous activity.

Ordivician

Arenig:- Spillitic lavas and tuffs.

(see Macgregor and MacGregor,1948 p4

ones and penetrate the lavas (Geikie, 1897 p 407). This dyke set is significant since it suggests that a north-north-west - south-south-east directed regional component of relative tension must have been operating at a time just preceding the onset of the phase of vulcanicity which gave rise to the Clyde Plateau Lavas.

The next major phase of dyke intrusion occurred in Borcovician times (Anderson, 1942 p 40) and includes a number of large east-west trending quartz-dolerite dykes and many similarly directed smaller dykes. There are also a number of quartz-dolerite sills associated with this phase of activity and these sills occur mainly in the central and northern areas of the rift, for example the Stirling sill. The orientation of the stress system which permitted the intrusion of the east-west dykes is similar to that which brought about the development of the large east-west faults and it appears therefore that the two phenomena are related.

In Tertiary times, a number of dykes were intruded along north-west - south-east lines mostly radiating from the volcanic centre of Mull which is outside the boundaries of the rift.

The Clyde Plateau Lavas

These lavas were named by Geikie (1897 p 368) and consist mainly of olivine-basalts. They are exposed on the limbs of the easterly-pitching Glasgow syncline and form the high ground to the north, west and south of the city. Geikie estimated that the lavas once covered an area of over 2000 square miles from Stirling and Strathaven in the east, to Arran and Kintyre in the west (1897 pp 368-369).

The lavas are described by Geikie (1897 pp 383-423), Clough and others (1925, pp 135 - 149), Richey and others

(1930, pp 64-134) and Hamilton (1956, pp 280-297).

Succession. The lavas can be subdivided broadly into an Upper group of macro-porphyritic basalts and a Lower group of either micro-porphyritic basalts or micro-porphyritic and macro-porphyritic basalts. The subdivision can be recognised at many localities but the succession cannot always be correlated from one locality to another, particularly if a fault intervenes. The general succession at several localities is given in Table 3.

The succession in the Campsie and Kilpatrick hills is described in detail later (p 17). In general, there is a Lower Group of Jedburgh basalts overlain by an Upper Group dominated by Markle basalts and mugearites. The rock-types of the Renfrewshire region contrast greatly with those exposed north of the River Clyde. The Renfrewshire sequence consists of a Lower Group of Markle basalts with some Jedburgh, Dalmeny and Dunsapie types followed by an Upper Group of Dalmeny rich flows. The succession in the neighbouring fault-bounded Cathkin Braes is quite different consisting of a Lower Group of Dalmeny basalts overlain by Dunsapie basalts. The succession is obscured by faulting and the thicknesses are impossible to estimate.

In Ayrshire, the succession appears to fall into a regular pattern of a Lower Group of undifferentiated macro-porphyritic basalts overlain by an Upper Group of trachytes and allied rock-types.

There is a general trend for the lavas to become more acidic towards to the top of the sequence, that is for olivine-basalts to be followed by trachytes, but there are local reversals of this trend.

Table 3 The general succession of the Clyde Plateau Lavas.

	Lairs Hill.	Campsie Glen.	Kilpatrick Hills.	Cathkin Braes.	Renfrew Hills.	Beith.	Eaglesham & Darvel.
Upper Group	Markle basalt & mugearite	Markle basalt & mugearite	Markle basalt & mugearite	Dunsapie basalt	Dalmeny basalt	Dalmeny basalt	Trachytes
Lower Group	Jedburgh & Markle basalt & mugearite	Jedburgh basalt	Markle & Jedburgh basalt	Dalmeny basalt	Markle & Jedburgh basalt	Markle Dunsapie & Dalmeny basalt.	Macroporphyritic basalt.

<u>Structure</u> . The maximum known thickness of the volcanic pile is 2500 feet ± 500 feet in the Craigmaddie district north of Glasgow, and the lavas thin eastwards, developing a thickness of only 1000 feet at North Third where they dip under the later Carboniferous sediments and intrusive sills of the Stirling and Clackmannan Coalfield. The lavas must die out under cover of the sediments of the coalfield for they are not present in the Calciferous Sandstone sediments of east Fife (Geikie, 1897 p 372).

Contemporary isolated outcrops of lava do occur in East Lothian and Midlothian but these are considered by Geikie (1897, pp 372-373) to be independent local developments and not outliers of the western plateau.

The sections accompanying the Geological Survey's Sheet 30 show the lavas dipping beneath the later Carboniferous sediments of the Glasgow basin and it is generally assumed that the development of the lavas is continuous across the axis of the syncline. This presumed continuity may be spurious; there is some evidence for the attenuation of the lavas at the axis of the syncline. Correlation of the lava successions between neighbouring fault separated blocks is only possible in general terms (Clough and others, 1925 pp 135-142; Richey and others, 1930 pp 64-82) suggesting that the lavas were erupted at different times and from different local centres such as the large vents of Meikle Bin and Misty Law or the fissure which bounds the north-north-western limit of the Campsie Hills.

The growth of the plateau probably occurred piece-meal by the coalescence of the outpourings from isolated centres rather than by uniform and complete flooding of a depressed area by widespread outpourings.

There is a sharp contrast between the structure of the lavas and of the sediments in the centre of the rift.

The lavas form comparatively undisturbed stable blocks which are relatively unfaulted in comparison with the abundance of faults in the sediments. The sediments are folded, with dips varying from 10° to greater than 45°, although the steeper dips are associated with local rucks and are equivalent to faults. The folding within the lavas consists generally of gentle flexures with dips rarely more than 20° and usually less than 10°.

The folding of the sediments in the Glasgow area appears to represent a greater shortening than the gentle flexures in the lavas of the Kilpatrick hills to the north or the Renfrewshire and Ayrshire hills to the west and south, and to some extent the lavas of these hills may have governed the position and limits of the Glasgow syncline rather than being the result of it, particularly if the lavas are attenuated across the axis of the syncline, although this has not been proved. It is significant that to the east of Airdrie, the Glasgow syncline dies out against the north-south trending syncline which is the site of the Stirling and Clackmannan Coalfield (Geological Survey Sheet 31), and the lavas also die out beneath the Sediments of this coalfield (Geikie, 1897 p 372).

There are many intrusions associated with the lavas. The east-north-east - west-south-west dyke swarm (see p 7) cut the early stages of lava extrusion and some of these dykes may have acted as feeders to the lavas although no example of this is described. A large number of vents penetrate the lavas and others are exposed cutting the Old Red Sandstone sediments to the north-west of the Campsie hills. The vents are often small cones or plugs rarely greater than 200 or 300 yards in diameter and consist of agglomerate of Jedburgh basalt (Whyte, 1963 p 111). In some localities, the vents have elongated and coalesced to form agglomerate filled fissures with an east-north-east - west-south-west trend, the best example being nearly

2 miles long, between 100 and 300 yards wide and delimits the north-western extremity of the Campsie Hills from the volcanic neck of Dumgoyne to the Corrie of Balglass. Many vents are elongated in an east-north-east - west-south-west trend indicating that the stress system which was operating during the emplacement of the Calciferous Sandstone dykes was maintained well into Calciferous Sandstone times.

There are two large central type vents filled with trachytic material, the Meikle Bin vent in the Campsie hills and the Misty Law vent in the Renfrewshire hills. These large acidic vents are between ½ mile and 1 mile in diameter and cut all the basaltic flows, indicating that they were active at a late stage in the vulcanicity.

Many small dykes of trachyte, felsite and allied rock-types radiate from these vents. A few small trachytic sills and basic intrusions in the form of stocks are also present in close association with the vents.

The Campsie and Kilpatrick hills

The geology of these hills is described by Clough and others (1925 pp 191-198), and parts of the Clyde Plateau Lava Group are described by Geikie (1897 pp 355-423), Hamilton (1956, pp 280-297) and Whyte (1963).

Succession.

Table 4.

Formation		Lithology	Thicknesses
Scottish Carboniferous Limestone Group	Upper Limestone Group.	Sandstones, Lime-stones & shales.	800' near Kilsyth.
	Limestone Coal Group.	As above + work-able coals	1000' near Kilsyth,
	Lower Limestone Group.	Sandstones, lime-stones & shales.	400' near Lennoxtown.
Calciferous Sandstone Group.	Upper Sedimentary Group.	Sandstones, lime stones, shales.	500' at Craigmaddie.
	Clyde Plateau Lavas.	Olivine-basalts.	2500' at Craigmaddie.
	Cementstone Group.	Sandstones, lime-stones & shales.	700' at Ballagan.
Upper Old Red Sandstone.	Upper Group.	White sandstones & cornstones.	50-100'
	Middle Group.	Red & purple sand-stones & cornstones.	500'
	Lower Group.	Red sandstones, marls & breccias.	2000' at Killearn.

The Upper Old Red Sandstone rocks are exposed on the north-western flanks of the Campsie and Kilpatrick hills and on the south-east in a faulted inlier on the north side of the Campsie Fault near Kilsyth. The regional dip of these sediments is between 5^o and 10^o to the south-east. The sandstones at Kilsyth are yellow in colour and have a calcareous matrix containing pebbles of quartz and thus they differ in lithology from those north-west of the Campsie hills.

The Cementstone Group consists of sandstones, thin muddy limestones and shales with an occasional thin ironstone band, The Group is exposed above the Upper Old Red Sandstone sediments along the north-western flanks of the hills, and in small faulted inliers to the Campsie Fault between Strathblane and Kilsyth. The formation reaches its maximum thickness of 700 feet at Ballagan. To the east, the formation thins consistently and at Kilsyth it is absent and a basalt lava flow is seen resting on Upper Old Red Sandstone sediments. A little to the east of this Kilsyth locality, Cementstones are again exposed but are less than 100 feet thick.

A small inlier of Cementstones also occurs at Carron reservoir near the centre of the Campsie plateau.

A similar eastward attenuation of the Cementstone Group is seen at Gargunnock where the sediments are approximately 400 feet thick but thin to approximately 50 feet at Stirling where faulting and lack of exposure obscure the details. It is not known whether the lavas come to rest directly on Upper Old Red Sandstone sediments in this region.

In the Kilpatricks, the Cementstones are exposed only on the south-western margin where they are approximately 400 feet thick.

The Clyde Plateau Lava Group forms the main mass of the Campsie and Kilpatrick hills. In the Kilpatricks, the succession commences with four flows of Jedburgh basalt followed by a sequence of Markle basalts with intercalated mugearites and occasional Jedburgh types. Towards the top of the sequence, a few flows of Craiglockhart and Dunsapie basalt appear, displaying vertical jointing and sometimes columnar jointing forming hexagons 2 to 3 feet across.

The Campsie plateau stands on average about 400 feet higher than the Kilpatrick hills, rising to between 1200 and 1400 feet above sea-level. The base of the lava is exposed on almost all but the eastern side of the hills where the strata dip under the scarp of the Sauchie Craigs sill.

The succession at Campsie Glen is:-

Upper Group.	31-33	Markle basalt.	Total thickness greater than 1000 feet, top not seen.
	29-30	albite keratophyre and mugearite.	
	28	Jedburgh basalt.	
	27	allied to mugearite.	
	26	Markle basalt.	
	25	mugearite.	
	23-24	Markle basalt.	
Lower Group.	20-22	Jedburgh basalt.	
	19	Decomposed porphyry.	
	18	Markle basalt.	
	1-17	Jedburgh basalt.	

Cementstone sediments.

This succession is similar to the succession at Gargunnock which commences with a series of Jedburgh basalt flows followed by a sequence of Markle basalts with a few Jedburgh types. At Kilsyth, the succession differs from this pattern commencing with two Markle basalt flows followed by a sequence of intercalated Jedburgh and Markle types and topped by a sequence of Markle basalts and mugearites. The top of the lava succession is not seen at any of the above localities, but the lavas present comprise a thickness of over 1000 feet at Campsie Glen and 700 - 800 feet at Kilsyth and Gargunnock.

The Upper Sedimentary Group is exposed at Craigmaddie Muir south of Strathblane and extends eastwards to Lennoxtown where it reaches a thickness of approximately 500 feet. This group is also represented at Sauchie Craigs but it is very much attenuated, comprising less than 100 feet of sediments. In both localities, the Upper Sedimentary Group overlies the lavas and at Craigmaddie

Muir, the basal beds are represented by a fine quartz conglomerate named the Craigmaddie Muir sandstone.

Structure. In the Kilpatrick hills the regional dip of the lavas is to the east-south-east at between 3° and 7°. A number of vents pierce the lavas particularly near the north-north-west faulted boundary and often the lavas dip away from the vents at angles as great as 20°. The lateral extent of the flows is not great (Hamilton, 1956 p 281) and they are intercalated with beds of tuff and ash. A few basaltic intrusions occur as circular bosses and the plateau is cut by several east-west faults.

The Campsie Fault which forms the north-north-western boundary of the Kilpatrick hills swings in strike near to Catythirsty, and trends east-west to form the southern boundary of the Campsie hills. There are a variety of opinions about the structure of the base of the lavas along this southern boundary (Bailey, 1925 p 138), as the base is cut out by a fault over most of the ground. Where it is exposed at Ballagan and Kilsyth, the field relations differ from each other. At KILSYTH ? Ballagan, the Upper Old Red Sandstone sediments are overlain directly by Markle basalts. Bailey (1925 p 138) thought that the base of the lava is diachronous and therefore vulcanicity occurred earlier in the east at a time when the Cementstone lagoon covered the Ballagan - Campsie area (see Fig 1). Alternatively, the absence of the Cementstones at Kilsyth could be the result of non-deposition with overlap by the basal lavas from the west as a result of a topographic rise at this locality. In this case, the Markle basalts overlying the Upper Old Red Sandstone sediments would be the stratigraphical equivalents of the Markle basalts of the Upper Group at Campsie Glen (see Fig 2). This latter hypothesis is supported by the eastward attenuation of the Cementstones from Gargunnock to Stirling (see p 18) and

Fig. 1 Diachronism of base of lavas

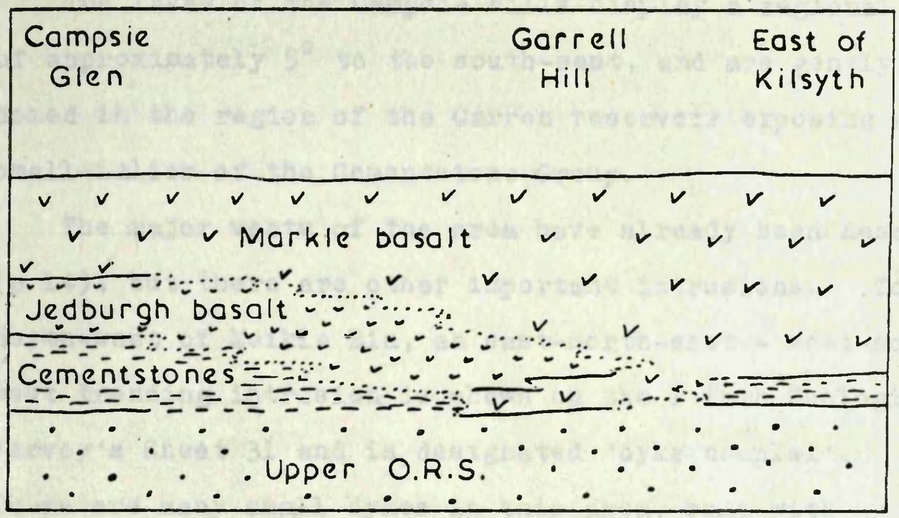
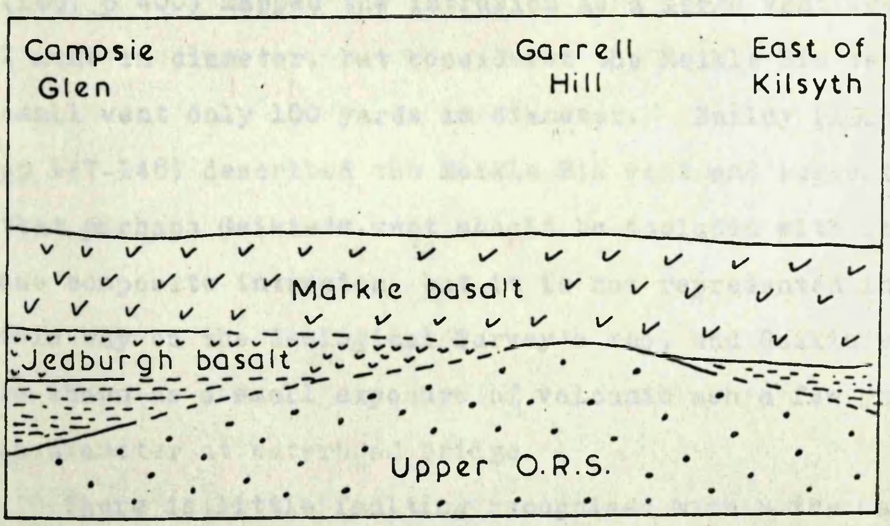


Fig. 2 Overlap of base of lavas



the attenuation of the Clyde Plateau Lavas and Upper Sedimentary Group from Craigmaddie Muir to North Third. There appears to have been an area of persistent structural uplift which lasted from the beginning of Cementstone times until at least the close of Upper Sedimentary Group times.

The lavas of the Campsie hills display a regional dip of approximately 5° to the south-east, and are gently domed in the region of the Carron reservoir exposing a small inlier of the Cementstone Group.

The major vents of the area have already been described (p 14), but there are other important intrusions. To the north-west of Meikle Bin, an east-north-east - west-south west trending intrusion is shown on the 1 inch Geological Survey's Sheet 31 and is designated 'dyke complex'. There are many small dykes in this area, some with an east-north-east - west-south-west trend, others obviously radiating from the Meikle Bin vent. The rocks are often highly altered and there is little exposure in the area, making field relations difficult to establish. Geikie (1897 p 400) mapped the intrusion as a large vent over 1 mile in diameter, but considered the Meikle Bin to be a small vent only 100 yards in diameter. Bailey (1925 pp 147-148) described the Meikle Bin vent and suggested that perhaps Geikie's vent should be included with it as one composite intrusion, but it is not represented in this way on the Geological Survey's map, and Geikie's vent is shown as a small exposure of volcanic ash a few yards in diameter at Waterhead bridge.

There is little faulting recognised within the Campsie lavas, but nearly all the small faults that are known have an east-west trend.

Comparison between the Midland Valley of Scotland and other rift systems

There are many similarities between the Midland Valley graben and other rifts. The Oslo graben is the nearest in age. It has a north-south trend and contains basaltic lava of both late Carboniferous and Permian age (Holtedahl, 1952 p 88), but little information is available about the graben in English.

The Rhine graben has been described in more detail. It originated as a late Variscan structure but its major development took place in Alpine times. Vulcanicity is more marked in the north-east branch of the rift and occurs only sporadically elsewhere. The lavas are mainly olivine-basalts rich in napheline and alkalis, and a few trachytes. This is an association which is found in the Midland Valley and is repeated in East Africa.

Chemical analysis of the German and Scottish basalts shows the presence of much carbon dioxide as an alteration agent, and in Africa, it is present in abundance giving rise to carbonatites (Holmes, 1964 pp 1067-1078).

In all cases where a considerable thickness of lava is extruded, there is a tendency for the lavas to become more acid towards the end of the volcanic phase. The trachytic central type cones of Meikle Bin and Misty Law in Scotland have their analogies in similar isolated acidic vents in East Africa. (Dixey, 1958 p 10-11).

Gregory (1921 p 18) defines rift valleys as those created 'by the sinking of the material that once filled them between parallel fractures of the type known as faults'. This definition is modified by Girdler (1963, p 2) who states that a 'rift valley means a depression between roughly parallel faults. The rocks forming the floor may or may not be the same as those forming the valley shoulders on either side.' A close examination of the Rhine rift and the East African rifts shows that the structure is generally bounded by a series of faults, sometimes en echelon, with the total throw being taken up by each fault in turn, and sometimes by a series of small parallel step faults making up the total displacement from the valley floor to the crest of the flanks. These features can be recognised in the Midland Valley rift. At Balmaha, two boundary faults can be seen which are sub-parallel to each other and less than half a mile apart. One is pre-Upper Old Red Sandstone in age, the other displays later movements. The Southern Upland Fault has a smaller throw than the Highland Boundary Fault and the throw on the southern side of the rift is partly taken up by parallel faults, particularly the Kerse Loch and Straiton faults in the south-west and the Lammermuir fault in the east.

In certain aspects, the Midland Valley is however unique. The boundary faults of the rift are remarkably straight and parallel one with the other, and with the trend of the flanking country rocks. In contrast, the boundary faults of the East African rifts usually cut across the pre-existing grain in the flanking country rocks or follow older trends for short distances, making a zig-zag pattern of the faulted valley sides.

Another feature of the Rhine and East African rifts is a bifurcation of the rift system. It is explained by Cloos (1930, <u>in</u> De Sitter, 1959 p 144) as a doming and arching up of the crust before the inception of the graben. No such bifurcation of the Midland Valley is seen in the British Isles, although the full length of the rift is not exposed. What happens to the rift to the south-west of Ireland or to the north-east of Scotland is not known except for Holtedahl's tentative correlation (<u>see</u> p 4).

THE GRAVITY SURVEY

Measurements in the field

<u>Procedure.</u> The area investigated, the Campsie and Kilpatrick hills, lies within a larger area which has been surveyed and studied by Qureshi (Ph.D. thesis, University of Glasgow, 1961).

Access to the hills for geophysical work is not good and only four traverses were made across them by Qureshi. The spacing of the stations on these traverses varied from ½ mile to 1 mile and did not provide sufficient information to define precisely the gravity field in the area. Isogals could not be interpolated meaningfully between the traverses.

The regional changes in the Bouguer anomalies are a steady rise in values to the south-east (McLean and Qureshi, 1966), so that the best way of carrying out a detailed survey in this upland area is by a parallel series of traverses along north-west - south-east lines. The spacing of the stations is at 100 yard intervals which is close enough to resolve and confirm anomalies caused by small faults with throws of as little as 100 feet.

Difficulty of access and geographic location in the open moorland made a modification of the initial plan necessary. Detailed traverses were first set out over the accessible roads and farm tracks, then further traverses were taken over the remaining open country following so far as possible those fences and walls which trend in approximately north-south or north-west - south-east directions. The fences and walls are shown on the 2½ inch Ordnance Survey maps and this permits the stations to be located to within ± 25 feet. Finally, more traverses were planned to give further detail in areas of greater interest such as the Waterhead region (see p 44).

A total of 1909 stations were established in the area of 240 square miles which with the 146 stations established by Qureshi gives a total of 2055 stations and a station density of 8.6 stations per square mile. The density rises to 15.7 stations per square mile in the 24 square miles about Waterhead.

The distribution of gravity stations is shown on the geological map (see Map 1), and details of the locations of the stations are lodged with the department of Geology of the University of Glasgow and with the Institute of Geological Sciences.

The altitude of the gravity stations is obtained by surveying with a Watts level from Ordnance Survey bench marks which are tied into the Ordnance datum at Newlyn.

The accuracy of the surveying is checked either by tying into other bench marks along and at the ends of the traverses where this is possible, or by 'double-levelling'. The maximum closing error tolerated is 1 foot.

Further to this work, two reconnaissance traverses were laid out along approximately north-south lines from Bowling to Barrhead and from Milngavie to Eastwood across the Glasgow syncline. A total of 50 stations are established along the two traverses with the stations spaced at between ½ mile and 1 mile. In practice, bench marks were selected so far as possible at ½ mile intervals and the gravimeter set up next to the bench mark. The height of the gravity station is taken as the height of the bench mark with respect to the Newlyn datum less the height of the bench mark above the ground.

Observational errors. Three gravimeters were used at different stages of the survey, namely a Frost, a Worden 'Pioneer' and a new Worden 'Prospector'. The Worden 'Prospector' was used over the whole network of base stations and for 572 field stations. Its drift characteristics were excellent, the drift being usually less than the reading error of 0.1 scale division (less than 0.01 mgal) for links completed within an hour.

The instrument was later returned to the manufacturer and the calibration constant was changed by 6×10^{-5} mgal per scale division, a value which is less than the small dial variation of 0.07% or 7×10^{-5} mgal per scale division quoted by the manufacturer.

The standard error of this instrument is ± 0.01 mgal.

The Worden 'Pioneer' and Frost gravimeters proved to be less reliable, the 'Pioneer' displaying a standard error of ± 0.015 mgal over the Milton-Kilsyth-Dennyloanhead base station links. The Frost gravimeter drifted unevenly at a higher rate than either of the Wordens, approximately 0.05 mgal per hour, resulting in a standard error of ± 0.02 mgal for this instrument.

The calibration constant of 0.09973 mgal per scale division supplied by the manufacturer for the new Worden 'Prospector' is accepted. The Worden 'Pioneer' was re-calibrated against the calibration line of the Geological Survey (Bullerwell, 1952 pp 303-315) by members of the staff of the Department of Geology of the University of Birmingham, and no error could be detected in this calibration of 0.08433 mgal per scale division when the performance of the instrument was compared to that of the 'Prospector' (<u>see</u> Table 5).

The Frost gravimeter was also calibrated along the Geological Survey calibration line (McLean, 1960 p 9) in 1959 and found to be - 0.10175 mgal per scale division.

Three loops of the base station network (<u>see</u> p 28) are read using the Frost meter and the results compared to the ' Prospector' values which are taken as standard.

The Frost gravimeter is re-calibrated for each link with respect to the 'Prospector', and the results shown

Table 5. Comparison of gravimeters.

Link.	Frost.	Pioneer.	Prospector.	Frost (re-calibration
Milton-Kilsyth	-9.23 ± 0.05	- 9.48 ± 0.03	- 9.47 ± 0.01	- 0.10451
Kilsyth-Dennyloanhead	+13.22 ± 0.02	+13.36 ± 0.01	+13.36 ± 0.005	- 0.10283
Dennyloanhead-Milton		- 3.88 ± 0.01	- 3.89 ± 0.005	
Kilsyth-Carronbridge	-13.12 ± 0.03		-13.08 ± 0.005	- 0.10144
Carronbridge-Dennyloanhead	+26.34 ± 0.02		+26.45 ± 0.02	- 0.10217
Carronbridge-Stirling	+35.70 ± 0.03		+35.70 ± 0.01	- 0.10175
Stirling-Dennyloanhead	- 9.36 ± 0.05		- 9.25 ± 0.01	- 0.10088
Milton-Fintry	- 2.32 ± 0.06		- 2.44 ± 0.005	- 0.10745
Fintry-Carronbridge	-20.23 ± 0.02		-20.12 ± 0.005	- 0.10221

The mean of the calibration factors of the Frost gravimeter is - 0.10291 mgal per dial division with a standard deviation of 0.00200 mgal per dial division and a standard error of 0.00071 mgal per dial division. The weighted mean is - 0.10223 mgal per dial division. The close agreement between the Pioneer and Prospector gravimeters indicates that no re-calibration is necessary.

in Table 5. The re-calibrated Frost calibration constants are weighted according to the gravity differences along their respective links and the weighted mean is computed. The revised constant is - 0.10223 mgal per scale division. The arithmetic mean is - 0.10291 mgal per scale division with a standard deviation of ± 0.00200 mgal per scale division and a standard error of ± 0.00071 mgal per scale division. The correction to the original constant using the weighted mean is 0.00048 mgal per scale division which would amount to a difference of 0.1 mgal for a change in gravity of 20.83 mgal.

There is little point in re-calculating the results of the four traverses which were surveyed with this instrument since the absolute error in the value of gravity due to the original calibration constant is less than 0.1 mgal for 61% of the stations, less than 0.15 mgal for 79% of the stations and less than 0.2 mgal for 98.5% of the stations.

The base station network

The area surveyed extends over 240 square miles and adjacent to it are four base stations established by Bullerwell (1952 pp 303-315). They are at Anniesland, Milton, Dennyloanhead and Stirling. The stations are convenient for the eastern and south-eastern parts of the area, but it was expedient to establish three more base stations at Kilsyth, Carronbridge, and Fintry.

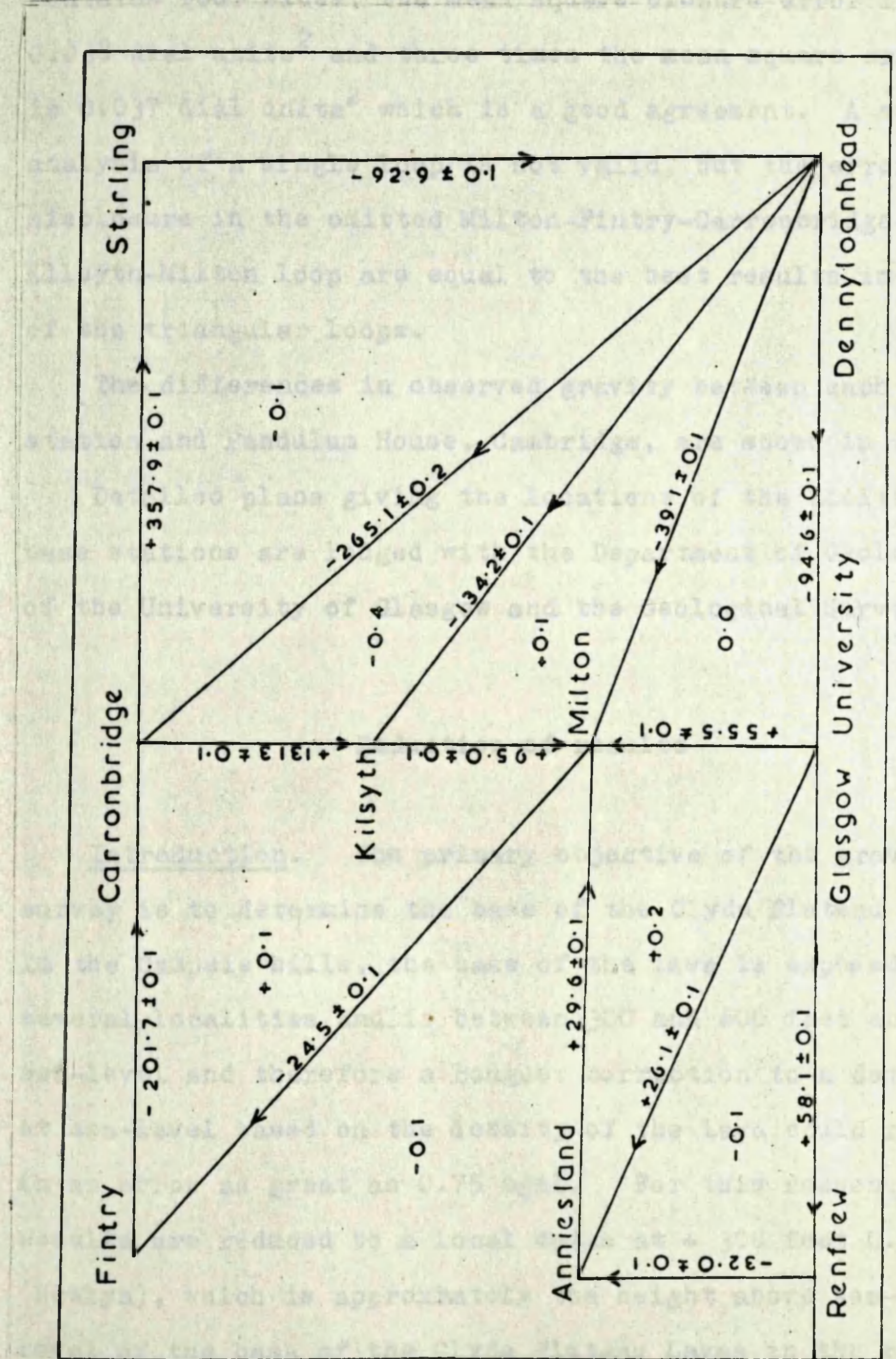
Another base station is established in the department of Geology of the University of Glasgow to check periodically on the performance of the gravimeter. The Geological Survey's base station at Renfrew Airport is also tied into the network although it was not used. The latter base station is of special importance because of its links outside Scotland.

The network is shown in Fig 3 and has a maximum closing error in any complete loop of less than 0.04 mgal.

The closing errors are adjusted by a graphical method (Smith,1951 pp 222-227) and are completely distributed.

Fig. 3.

Base station network showing closure errors and links



All values are observed dial readings for the Worden 'Prospector' which has a calibration constant of 0.09973 mgal per dial division. The readings are positive for a clockwise circuit.

In a triangular circuit, the mean square closure error is equal to three times the mean square error (Cook, 1953 p 511). In the above network, omitting the loop Milton-Fintry-Carronbridge-Kilsyth-Milton since it contains four sides, the mean square closure error is 0.038 dial units^2 and three times the mean square error is 0.037 dial units^2 which is a good agreement. A statistical analysis of a single loop is not valid, but the errors and misclosure in the omitted Milton-Fintry-Carronbridge-Kilsyth-Milton loop are equal to the best results in any of the triangular loops.

The differences in observed gravity between each base station and Pendulum House, Cambridge, are shown in Table 6.

Detailed plans giving the locations of the additional base stations are lodged with the Department of Geology of the University of Glasgow and the Geological Survey.

Reduction of results

Introduction. The primary objective of the gravity survey is to determine the base of the Clyde Plateau Lavas. In the Campsie hills, the base of the lava is exposed at several localities and is between 300 and 600 feet above sea-level and therefore a Bouguer correction to a datum at sea-level based on the density of the lava could result in an error as great as 0.75 mgal. For this reason, the results are reduced to a local datum at + 300 feet O.D. (Newlyn), which is approximately the height above sea-level of the base of the Clyde Plateau Lavas in the region of the main base station at Kilsyth. The value of gravity at Kilsyth is taken arbitrarily to be zero and the results are computed as local anomalies. This method has the advantage that no assumptions are made regarding the local geology or densities between +300 feet and sea-level in

Table 6.

Difference in observed gravity (mgal) between each base station and Pendulum House, Cambridge.

Base station	Gravity	Geol. Surv. Values.
Kilsyth.	+323.68	
Milton.	+333.17	+332.99
Fintry.	+330.72	
Carronbridge.	+310.60	
Stirling.	+346.30	+346.55
Dennyloanhead.	+337.05	+337.05
Anniesland.	+330.22	+330.16
Renfrew.	+333.41	+333.42
Glasgow University.	+327.63	

The value at Pendulum House, Cambridge, is taken as 981 265.00 mgal and the above values are calculated via the Dennyloanhead base station.

the reduction of the gravity results and the anomalies represent entirely the effects of local structures. This leads to a more accurate quantitative analysis of the results. The disadvantage of the presentation is that the results cannot be compared directly with Pendulum House, Cambridge, or with other gravity surveys because of the different datum. To allow this, the map of local Bouguer anomalies (Map 2) is converted to a map of Bouguer anomalies (Map 4) which are linked to Pendulum House, Cambridge, on the International Gravity Formula (1930), by means of an isocorrection map.

The anomalies shown in Map 2 and in the Appendix B are therefore local Bouguer anomalies calculated with respect to the Kilsyth base station, that is, the anomaly at Kilsyth is taken to be zero, where the Bouguer anomaly is defined:-

Bouguer anomaly = Observed gravity + free air correction
- Bouguer correction + terrain correction
- theoretical gravity.

<u>The altitude correction</u>. The free air correction and the Bouguer correction are combined to give a single elevation factor which is used to correct for the altitude of each station above datum. The free air correction is 0.09406 mgal per foot of altitude of the gravity station above datum. The densities used for the Bouguer correction are (<u>see</u> pp 55-78).

2.47 ± 0.01 g/cm^3 for the Scottish Carboniferous Limestone.
2.72 ± 0.03 g/cm^3 for the Clyde Plateau Lavas.
2.56 ± 0.04 g/cm^3 for the Cementstone group.
2.36 ± 0.05 g/cm^3 for the Upper Old Red Sandstone.

and are substituted in the formula.

Bouguer correction = $0.01276\,\sigma$ mgal per foot, where σ is the density of the rocks exposed at the surface and shown on the geological map. Therefore, the boundaries of the changes of density in the Bouguer correction are coincident with the boundaries of the above stratigraphical units as shown on the geological maps.

The altitude correction is the free air correction minus the Bouguer correction and takes the values
0.06254 mgal per foot for the Scottish Carboniferous Limestone.
0.05935 mgal per foot for the Clyde Plateau Lavas.
0.06139 mgal per foot for the Cementstone group.
0.06395 mgal per foot for the Upper Old Red Sandstone.

The terrain correction. The terrain corrections are made using a Hammer's zone chart (Hammer, 1939 p 188), and the value for the density of the terrain is taken to be 2.72 g/cm^3. This correction is a lengthy and time consuming operation and two methods of reducing the amount of calculation are employed.

The corrections for Hammer's zones B and C are estimated in the field and the zones D to G are calculated in the standard manner using 2½ inch to 1 mile maps. The zones H, I, and J are computed for every tenth station because the gravity stations are sufficiently close together to allow a linear interpolation of the total correction over the intervening nine stations. It is known that a change in altitude causes a change in the terrain correction according to a parabolic law (see later, and Neumann, 1963 pp 523-534), but the changes in altitude encountered over distances of 1000 yards, that is every tenth station, are so small that for Hammer's zones H, I, and J, the section of the parabola involved can be approximated to a straight line with an error of less than 0.01 mgal. Therefore this interpolation is valid within the limits of error of the survey, and saves a great deal of time.

in computing the terrain correction.

The outer zones K, L, and M of Hammer's chart are so large in area that the chart is unwieldy, even on a 1 inch to 1 mile scale and the Neumann method of correction for terrain at a great distance from the station is employed (Neumann, 1963 pp 523-534).

The method involves the computation of a standard parabola, representing the gravity effect of terrain with varying station height. This parabola is the Parabole-gabarit of Neumann (see Fig 4). Isocorrection maps of the values Z_0 and G_0 are drawn up, where Z_0 is the height at which a given terrain correction is a minimum, and G_0 in the minimum value of that terrain correction. The values Z_0 and G_0 govern the position of the axes of the parabola for a given station. In preparing the iso-correction maps, the terrain corrections for 49 stations were made for Hammer's zones K, L, and M in the standard manner, and the value for Z_0 and G_0 calculated for each station by the Neumann method (Neumann, 1963 p 528).

In this case, the values for G_0 all approximate to 0.01 mgal (see Fig 5) and thus the ordinate of the turning point of the Parabole-gabarit is fixed at Y = 0.01 mgal on Fig 4. The values for Z_0 which govern the abscissae X of the parabola are contoured and the isocorrection map drawn up on a transparent overlay which can be placed over a 1 inch to 1 mile map of the gravity stations so that the value of Z_0 for any given gravity station can be interpolated. Therefore, knowing the abscissae and ordinate of the turning point of the parabola, the terrain corrections for Hammer's zones K, L, and M at any given station of known height can be read from Fig 4. The isocorrection map for the Campsie and Kilpatrick hills is shown in Fig 6.

The terrain corrections were not calculated using an electronic computor (Bott, 1959 pp 1-10) because the close spacing of the gravity stations allowed interpolation

Fig 4

Terrain correction for Hammer's zones
K, L, and M (Neumann method).

' Parabole-gabarit ' for density 2.72 g/cm^3 .

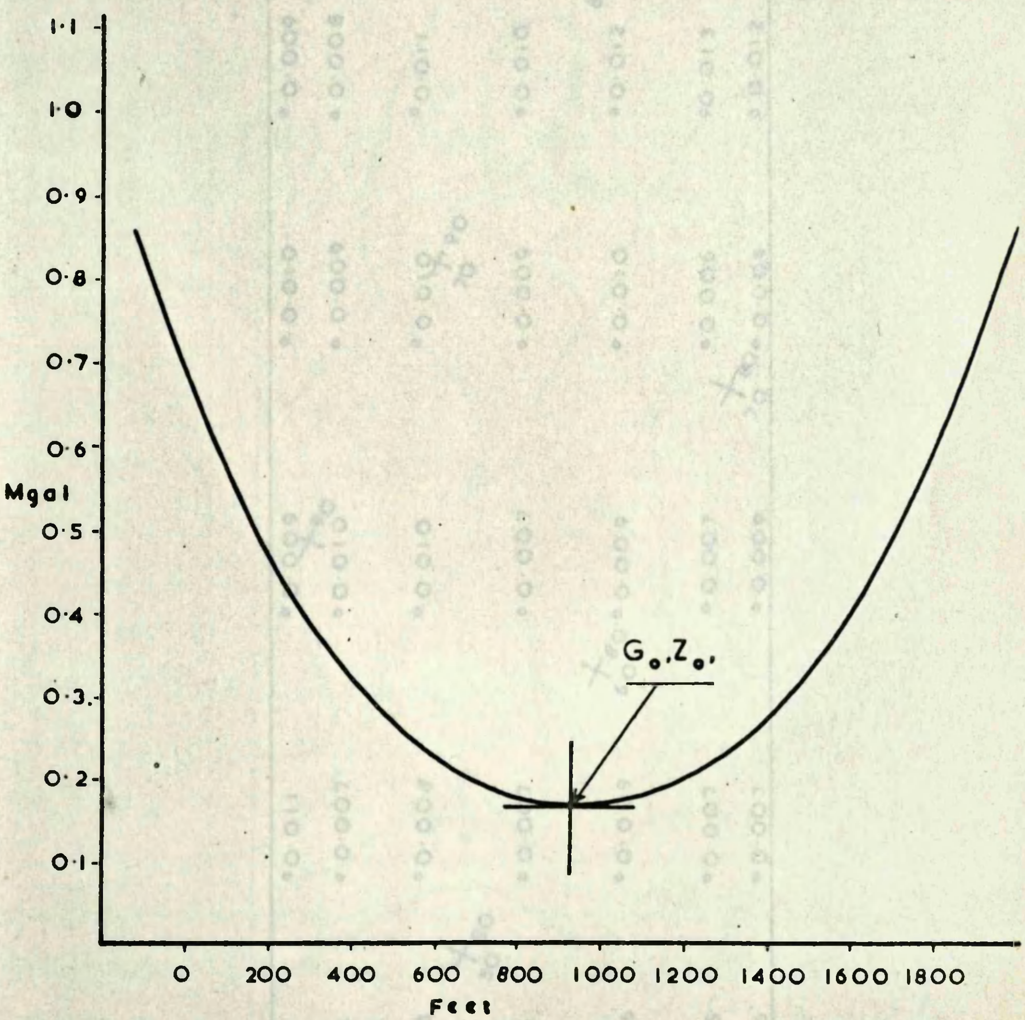
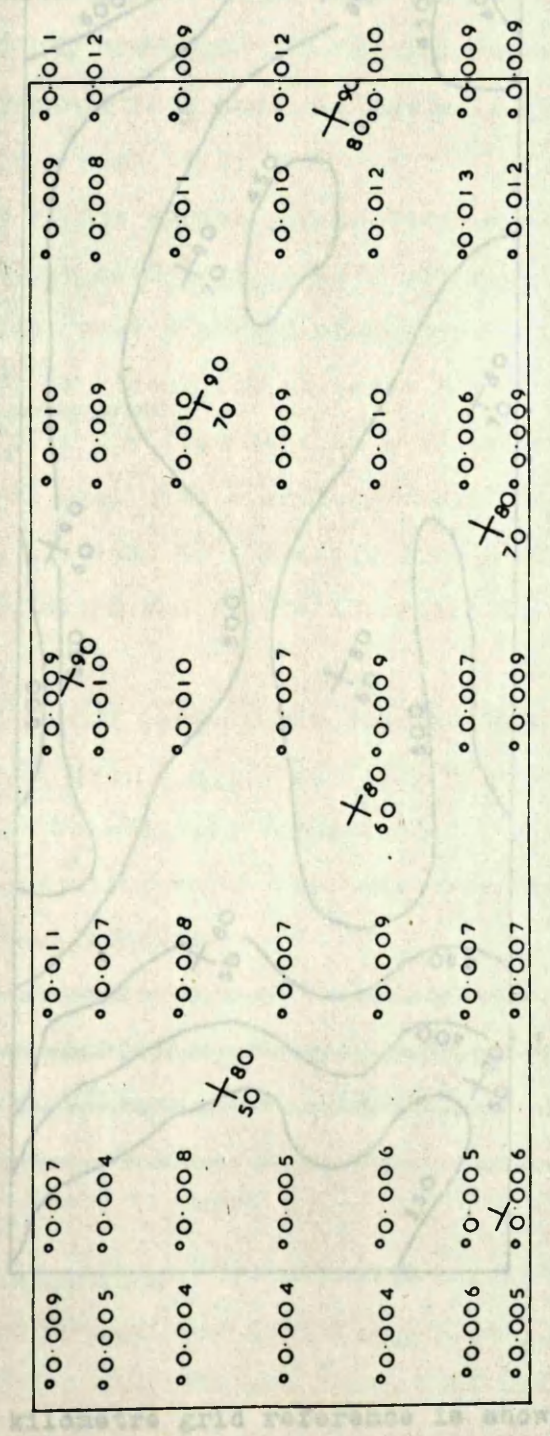


Fig 5

The values of G_0 for 49 points within the area of the survey.

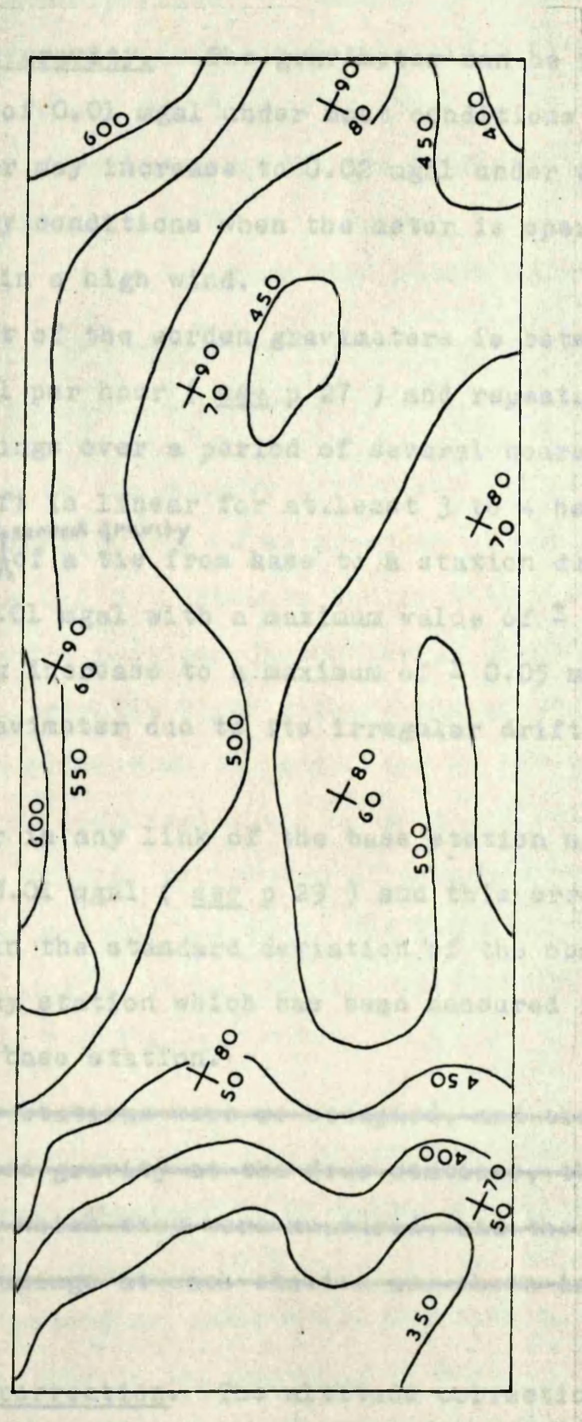
These values approximate to the plane surface G_0 = 0.01 mgal.



The ten kilometre grid reference is shown on the map and the scale is 1 inch to 3 miles.

Fig 6.

Isocorrection map Z_c (feet).



The ten kilometre grid reference is shown on the map and the scale is 1 inch to 3 miles.

and saved much time compared with sorting the data for the computor.

Summary of errors

Observed gravity. The gravimeter can be read with an accuracy of 0.01 mgal under most conditions (see p 27), but the error may increase to 0.02 mgal under adverse cross-country conditions when the meter is operated on soft ground in a high wind.

The drift of the Worden gravimeters is between 0.01 and 0.03 mgal per hour (see p 27) and repeated base station readings over a period of several hours indicates that the drift is linear for at least 3 to 4 hours. The likely error in observed gravity of a tie from base to a station due to the drift alone is ± 0.01 mgal with a maximum value of ± 0.03 mgal. The error may increase to a maximum of ± 0.05 mgal with the Frost gravimeter due to its irregular drift characteristics.

The error in any link of the base station network is less than ± 0.01 mgal (see p 29) and this error must be included in the standard deviation of the observed gravity of any station which has been measured from an intermediate base station.

~~Only four stations were re-occupied, and the values of the observed gravity at the four stations, the base stations from which they were measured, and the difference in the two readings at each station are shown in Table 7.~~

Altitude correction. The altitude correction is approximately 0.06 mgal per foot (see p 34) and the heights of all the stations are known to ± 0.1 feet, therefore the error in this correction due to the error in the levelling is ± 0.006 mgal.

Table 7.

Station.			Difference.
G.20 measured from Milton and Milton bases.			
Bouguer anomaly	+9.21	+8.93	0.28
Q.26 Measured from Milton and Milton bases			
Bouguer anomaly	+1.66	+1.54	0.12
O.34 measured from Fintry and Carronbridge bases			
Bouguer anomaly	-3.79	-3.75	0.04
V.59 measured from Carronbridge and Stirling bases			
Bouguer anomaly	-3.70	-3.51	0.19
		Root mean square value	0.09

All values in mgal.

That part of the error in the Bouguer correction due to the error in the rock density may be as great as 0.0005 mgal per foot for the Upper O.R.S. sediments and as little as 0.0001 mgal per foot for the Scottish Carboniferous Limestone sediments. In practice, only the Clyde Plateau Lavas occupy the high ground which gives rise to large Bouguer corrections, and an altitude of 1000 feet above datum could result in an error in the Bouguer correction of as great as ± 0.4 mgal. However, over most of the area, the likely error in the altitude correction including the error in the Bouguer correction is ± 0.2 mgal.

<u>Terrain correction.</u> The standard deviation of a complete terrain correction by Hammer's method is given as ± 0.1 mgal (Hammer, 1939 p 194), but this error applies only to the method of computation and does not take into account the error in the topographic maps.

The height differences of zones B and C of Hammer's zone chart are estimated in the field, and the station location is always chosen so that the correction required for these zones is minimal and in many cases negligible.

The error in the contouring on the 2½ inch to 1 mile

Ordnance Survey map can be as great as 25 feet and this introduces a maximum possible error of 0.12 mgal in zone D and 0.08 mgal in zones E and F, but is negligible thereafter. However, when the contour error is as great as this, the error is obvious from station levelling and an approximate compensation can be applied to at least halve the error.

The error due to the Neumann method is no greater than the error in the standard method of terrain correction.

The maximum total error in the terrain correction is ± 0.13 mgal and the likely error less than 0.10 mgal.

Theoretical gravity. The error in the theoretical gravity is in effect an error in fixing the latitude or location of the station. The gravity stations are plotted on 2½ inch to 1 mile Ordnance Survey maps with an accuracy of approximately 50 feet. The gravity gradient due to latitude in the region of the survey is 1.2173 mgal per mile, and therefore the error in the latitude correction is 0.02 mgal.

Total error of the gravity survey. Two errors are relevant to the quantitative analysis of the gravity survey. They consist of the accumulated standard deviation of the Bouguer anomaly at any given station with respect to Kilsyth, and the error of the difference between the Bouguer anomalies of any two neighbouring stations.

The maximum error of any given station at high altitude (that is, above 1000 feet above datum) is ± 0.41 mgal. The likely error of any given station with respect to Kilsyth is $\pm$ 0.22 mgal.

The largest source of error is the density factor in the Bouguer correction. If the same density is used in the Bouguer corrections of neighbouring stations at the same height, then the error is common to both and does not affect the difference between the Bouguer anomalies at the two stations. The error in the latitude correction is negligible and the error in the terrain correction is reduced to an error in the zones B and C. The errors in the observed gravity and free air correction remain.

Since the height differences between two neighbouring stations rarely exceed 20 feet, then the likely error between their Bouguer anomalies is ± 0.03 mgal and cannot exceed ± 0.05 mgal.

Only four stations were re-occupied, and re-computed independently, and the values of the Bouguer anomalies at the four stations, the base station from which they were measured, and the difference in the two readings at each station are shown in Table 7.

These differences do not represent the total error in a Bouguer anomaly determination since errors in re-locating the station and in levelling are negligible and the error in the density used for the Bouguer correction is common to both readings. However, errors due to the drift of the gravimeter and in the determination of the terrain and latitude corrections all contribute.

DESCRIPTION OF THE BOUGUER ANOMALIES

Presentation of results

The results of the gravity survey are presented as a map of Bouguer anomalies which is contoured at half-mgal intervals and drawn to a scale of 1 inch to 1 mile (see Map 2). Minor anomalies defined by the detailed traverses which are not large enough to be seen on the Bouguer map are presented as two-dimensional profiles (see Figs 37 to 43).

A map of 1st order residuals, that is Bouguer anomalies with the regional gradient subtracted, is presented and is the basis of the interpretation of the local anomalies (see Map 3). The second derivative of gravity is taken as an aid to interpretation in the Waterhead and Strathblane areas and contoured maps of these values are made (see Figs 20 and 21).

The data of the gravity survey are listed in Appendix 1.

The regional gravity field

The regional trend of the Bouguer anomalies (see Map 2) over the area investigated is approximately north-east - south-west and the value of gravity rises to the south-east. The regional trend agrees with the findings of Qureshi (1961, p 22) in the area to the east of Loch Lomond. The regional gradient cannot be determined with any accuracy by inspection, and the method of Baranov (1954, pp 203-226) is employed (see p 47).

Local anomalies

There is a marked high of approximately 12.5 mgal (see Map 2) centred on Waterhead farm in the Campsie hills, and the Bouguer anomalies are high over the lava plateau and fall off steeply over the surrounding sediments.

The Waterhead anomaly. This is the largest anomaly in the area and has its peak near Waterhead farm in the Campsie hills approximately in the centre of the area. The anomaly rises to a maximum of + 12.5 mgal and descends on the northern flank to - 7 mgal and to - 1 mgal on the southern flank. The peak of the anomaly is approximately circular in plan but the flanks tend to elongate in a north-east - south-west direction.

The Kilpatrick hills anomaly. In the Kilpatrick hills the gravity anomalies rise steadily to the east from -6.5 mgal to - 1 mgal at a rate of approximately 1 mgal per mile.

The Milngavie Fault anomaly. This anomaly trends parallel to the east-west Milngavie Fault and remains constant in its effect from Bowling to Kirkintilloch. The gravity values rise from - 5 mgal to - 2 mgal in a distance of 1 mile.

The Campsie Fault anomaly. This anomaly is elongated in an east-west direction and is present between Strathblane and Lennoxtown. Near the Whangie, to the west, the value of gravity falls from - 0.5 mgal to - 5.0 mgal and at Campsie Glen, in the east, the anomaly falls from + 3.5 mgal to 0.0 mgal.

The Gargunnock-Stirling anomaly. In the region of the Gargunnock hills near Stirling, the value of gravity falls steeply from - 3.5 mgal to - 6.5 mgal in a distance of less than 1 mile. This anomaly is orientated in an east-west direction but is limited in extent, being effective only from Gargunnock village to Stirling. To the west of Gargunnock, the anomaly broadens out and merges into the regional gradient.

The Bannockburn anomaly. South of Stirling, at Bannockburn, the Bouguer anomalies display a north-north-west - south-south-east trend and fall steeply to the east at a rate of 1.5 mgal per mile.

Minor gravity anomalies. Examination of the detailed traverses indicates the presence of a number of small anomalies which are similar in form to the types normally associated with semi-infinite slabs or faults. Many of these anomalies can be recognised on more than one traverse, and others correspond to faults indicated on the 1 inch to 1 mile Geological Survey's maps (see Map 1). These anomalies are described in Table 8 and are represented in Figs 37 - 42.

A residual anomaly of + 1 mgal is also present between stations F50 and F63 and is shown in Fig 43.

Table 8.

Description of Minor gravity anomalies.

Fig.	Location Between stations:-	Change in g (Mgal)	Form	Remarks.
37	A42 & A45	0.3	Acute	Assoc. with dyke.
38	E10 & E27	1.0	Broad	
39	J33 & J55	1.6	Broad	
40	Q38 & Q64	4.5	Broad.	
41	R50 & R78	0.8	Acute	
42	U76 & U94	2.1	Broad	

Reconnaissance traverses

The results of the reconnaissance traverses Rc 1 and Rc 2 (see Figs 44 and 45, and Map 5) are similar to each other since the traverses are parallel and similarly orientated.

The gravity anomalies of traverse Rc 1 fall steadily from +2.5 mgal to zero in a southerly direction from the River Clyde at Bowling and then rise steeply over the Paisley Ruck and continue to rise to a maximum value of + 6.0 mgal over the exposures of the Clyde Plateau Lavas to the east of Barrhead.

Traverse Rc 2 displays a minimum value of - 3.5 mgal just south of Milngavie and then rises steadily in value to a maximum of + 8.5 mgal over the lavas to the south of Giffnock.

RESOLUTION OF THE GRAVITY FIELD INTO REGIONAL AND LOCAL COMPONENTS

In the region east of Loch Lomond, there is a consistent rise in the gravity values towards S 32° E at an average rate of 1.6 mgal per mile. This component of the regional gravity field rises less steeply over the north-western part of the Midland Valley and reaches a maximum in the central region of the rift. Further south, towards the Southern Uplands, the gravity values decrease forming an approximate mirror image of the north-western part (McLean and Qureshi, 1966 p 270).

In the Campsie and Kilpatrick hills area, this regional gravity field is distorted by the presence of large local gravity anomalies, the most significant being the Waterhead anomaly which contributes a maximum of +16.5 mgal (see p 104) and the Campsie Fault anomaly which contributes a maximum of +7.0 mgal (see p 140). In order to interpret these and other local gravity anomalies within the area of the survey, it is necessary to isolate the contribution of the Waterhead anomaly, Campsie Fault anomaly and the Clyde Plateau Lavas from the total Bouguer anomaly. This is done by calculating a low order surface which gives the best fit to the observed Bouguer anomalies according to least mean square error theory (see p 49), and subtracting it from the observed Bouguer anomalies.

Such a surface will reflect a smooth systematic change in the Bouguer anomalies in the area and the effect of randomly distributed variations in the gravity field which are small in both magnitude and areal extent will be minimised, thus giving a best mathematical approximation to the regional gravity field which except for the Waterhead and Campsie Fault anomalies is the sum of all contributions from below the base of the lavas. However, several sources of error may exist in approximations of this type. The surface will reflect variations in gravity arising from structures affecting several planes of density contrast at different depths and some arbitrarily defined local anomalies may be large enough in magnitude and areal extent or both to cause a significant distortion in the computed surface. These sources of error are discussed later (see p 50).

Computation of the Regional Gravity Field

The regional gravity field is computed by the Baranov method (1954) which is a rapid method of determining a first, second or third order surface of best fit to a collection of observed Bouguer anomaly values according to least mean square error theory. The method has an advantage over a formal method in that the computations can be made in a few hours on a calculating machine whereas a computer is necessary to solve the algebraic matrix of the formal mathematical approach. The limitation of the Baranov method is that the surface is computed from forty-nine observed values determined at specific intersections on a rectangular grid (see Baranov, 1954, p 206) and these values must be interpolated if no observations are available at the intersections, whereas the formal approach can be used with any number of observations which may have a random distribution over the area of interest.

Both the first order and third order surfaces are computed by this method.

The first order surface. The equation of the first order surface is found to be:-

$$R = 1.78 - 3.41\xi + 1.79\zeta$$

where ξ and ζ represent rectangular co-ordinate axes with the origin in the centre of the rectangle over which the regional gravity field is calculated (see Baranov, 1953).

This equation represents a plane surface of Bouguer anomaly values rising towards S 40° E at a rate of 0.68 mgal per mile.

<u>The third order surface.</u> The equation of the third order surface is found to be :-

$$R = 1.77 + 2.74\xi - 2.96\eta - 4.95\xi^2 - 0.99\xi\eta - 5.64\eta^2$$
$$- 2.30\xi^3 + 1.09\xi^2\eta + 1.33\xi\eta^2 - 0.37\eta^3$$

and the surface is shown in Fig 8.

The large gravity high at Waterhead is reduced from a maximum value of 16.5 mgal. to a maximum of only 2.5 mgal. and a severe downwarp of approximately 10 mgal. is present at the margins of the rectangle. Clearly, the Waterhead anomaly makes a considerable contribution to this surface causing severe distortion of the periphery and therefore the result has very little meaning in terms of the regional gravity field and is discarded.

A second order surface will be similarly affected by the Waterhead anomaly although to a lesser extent and so the calculation for this surface is not done. Any approximation to the regional gradient over the area of the survey must be obtained by means of the first order surface.

Sources of Error in the Computed Regional Gravity Field

Errors in the computed regional gravity field may be errors of computation or errors of interpretation. A possible error of computation in the first order surface may arise from the interpolation required to obtain Bouguer anomaly values at the pre-determined rectangular intersections (<u>see</u> Baranov, 1953 p 206). Over most of the area, the density of observations is sufficiently high for this interpolation to be unnecessary but in the north-east over Dumbarton Muir, four values are interpolated between traverses spaced up to three miles apart and a maximum error of 1 mgal. in these interpolations would give rise to a net distortion of 0.03 mgal. in the computed surface at those points.

As stated earlier (see p 47), errors may arise because large structures which are arbitrarily defined as local structures may give rise to anomalies sufficient in magnitude or areal extent to cause a significant distortion of the computed surface. These are errors of interpretation and must either be minimised in their effect or isolated and subtracted from the total surface.

The Waterhead anomaly which in magnitude dominates the whole area is in this category and since the cause of the anomaly is not known from local geology, the contribution of the anomaly to the computed surface must be minimised. This is done by adjusting the area over which the mathematical surface is computed so that the peak of the Waterhead anomaly is situated approximately in the centre thus allowing no bias to one side and this is further aided by the natural symmetry of the anomaly (see p 104).

The absolute value of all points of the computed surface will still be raised by the anomaly but this unimportant since the values of the local first order residual anomalies used for interpretation purposes are computed relative to the local background residual gravity field.

Rapid changes in the depth to the various density layers as a result of faulting produce considerable changes in the gravity field but in so far as the Clyde Plateau Lavas are affected, these changes have insufficient magnitude and extend over areas which are too small in relation to the total area surveyed to cause any distortion in the Baranov surface. To determine to what extent faulting of the pre-Clyde Plateau Lavas planes of density contrast produces gravity gradients which might contribute significantly to the first order surface, the interpretation of the largest fault in the area, the Campsie Fault (see p 140) is discussed.

This anomaly is interpreted as being the result of the summation of three anomalies caused by the effect of the fault on the Clyde Plateau Lavas, the Upper O.R.S. rocks and the Lower O.R.S. rocks respectively.

The faulted Clyde Plateau Lavas form a shallow structure giving rise to a sharp change in the gravity field (see Fig 36) which decreases to a gradient of 0.025 mgal. per mile in a southerly direction at a distance of 3 miles from the fault. The theoretical anomaly due to the Upper O.R.S. rocks (see Fig 36) is broader than the anomaly due to the lavas but is also of smaller magnitude and acts in the opposite sense. At a distance of 3 miles from the fault, this latter anomaly is reduced to a gradient of 0.33 mgal. per mile in a northerly direction.

The contribution to the Campsie Fault anomaly by the Lower O.R.S. rocks is a maximum of 5 mgal. and at a distance of 3 miles from the fault, the gravity gradient of this contribution is 0.05 mgal. per mile to the north.

The theoretical gravity gradients due to the effect of the Campsie Fault on the Clyde Plateau Lavas and the Upper O.R.S. rocks are very small and act in opposite senses and their sum is 0.008 mgal. per mile at a distance of 3 miles from the fault which as an estimate of a gradient may be safely discounted as an error in the computed regional gradient. Thus the Campsie Fault anomaly after removal of the regional gradient may be considered as isolated as a local feature at least down to Upper O.R.S. level.

In the case of the Lower O.R.S. rocks there is likely to be a contribution to the computed surface although the above estimate of 0.05 mgal. per mile must be too high to be applied over the whole area of the survey since the interpretation of the fault anomaly was made where the throw of the fault was known to be greatest (see p 140).

Since all other faults in the area give rise to anomalies which are less than half that due to the Campsie Fault in both magnitude and areal extent it is safe to assume that they are not sources of significant error in the computed surface and the anomalies are correctly isolated as local features.

Further errors in this category may arise through smooth systematic changes in the thickness of the near surface rock formations. The magnitude of these changes may be small but if the area over which they are effective is a large proportion of the area of the survey, then they will be reflected in the computed surface.

The computed surface rises to the south-east at a rate of 0.68 mgal. per mile and the Clyde Plateau Lavas of the Campsie Hills dip in this direction at a rate of approximately 1 in 140 so that the base of the lavas is 300 feet lower at Kilsyth in the south-east than it is at Gargunnock in the north-west. Assuming a density contrast of 0.17 g/cm^3 between the lavas and the underlying sediments (see p 101) the dip of the lavas will result in a gradient of 0.07 mgal per mile in the direction of the regional gradient. For interpretation purposes, any anomaly associated with the lavas is considered a local anomaly and this value of 0.07 mgal per mile must be subtracted from the computed gradient of 0.68 mgal per mile and the regional gradient becomes 0.61 mgal per mile.

Below the lavas, all contributions apart from the exceptions stated above (see p 47) are considered as part of the regional gravity field.

The Cementstone group shows a tendency to thin eastwards (see p 18 and p 20) in the eastern part of the Campsie Hills although this feature is not repeated in the Kilpatrick Hills or in the western Campsie Hills. Considering the Gargunnock area alone, the Cementstones are attenuated by approximately 350 feet in a horizontal distance of 10 miles. If this wedge of Cementstone with a density of 2.55 g/cm^3 is replaced by Upper O.R.S. rocks with a density of 2.36 g/cm^3, then the resulting gravity gradient is approximately 0.085 mgal. per mile. The component of the gradient in the direction of the computed regional gradient is approximately half the maximum value, that is , 0.0426 mgal per mile. Gradients of this magnitude will be included in the first order surface.

The Upper O.R.S. rocks are estimated to be 2600 feet thick (see p 17) and where they are exposed extensively to the north of the Campsie and Kilpatrick hills, their geology remains unvaried. These rocks dip generally to the south or south-east at shallow angles which rarely exceed 20° and are usually less than 10°. Therefore, by an analogy with the Cementstones and Lavas discussed above it is certain that if the thickness of these sandstones changes appreciably as a result of sedimentary causes and not structural causes across the confined area of interest, then the gravity gradient thus created would be included in the regional gradient as computed by the Baranov method, and this would not affect the interpretation of the local anomalies.

This same argument is valid for the case of the Lower O.R.S. rocks which extend for at least 6000 feet below the unconformity at the base of the Upper O.R.S.

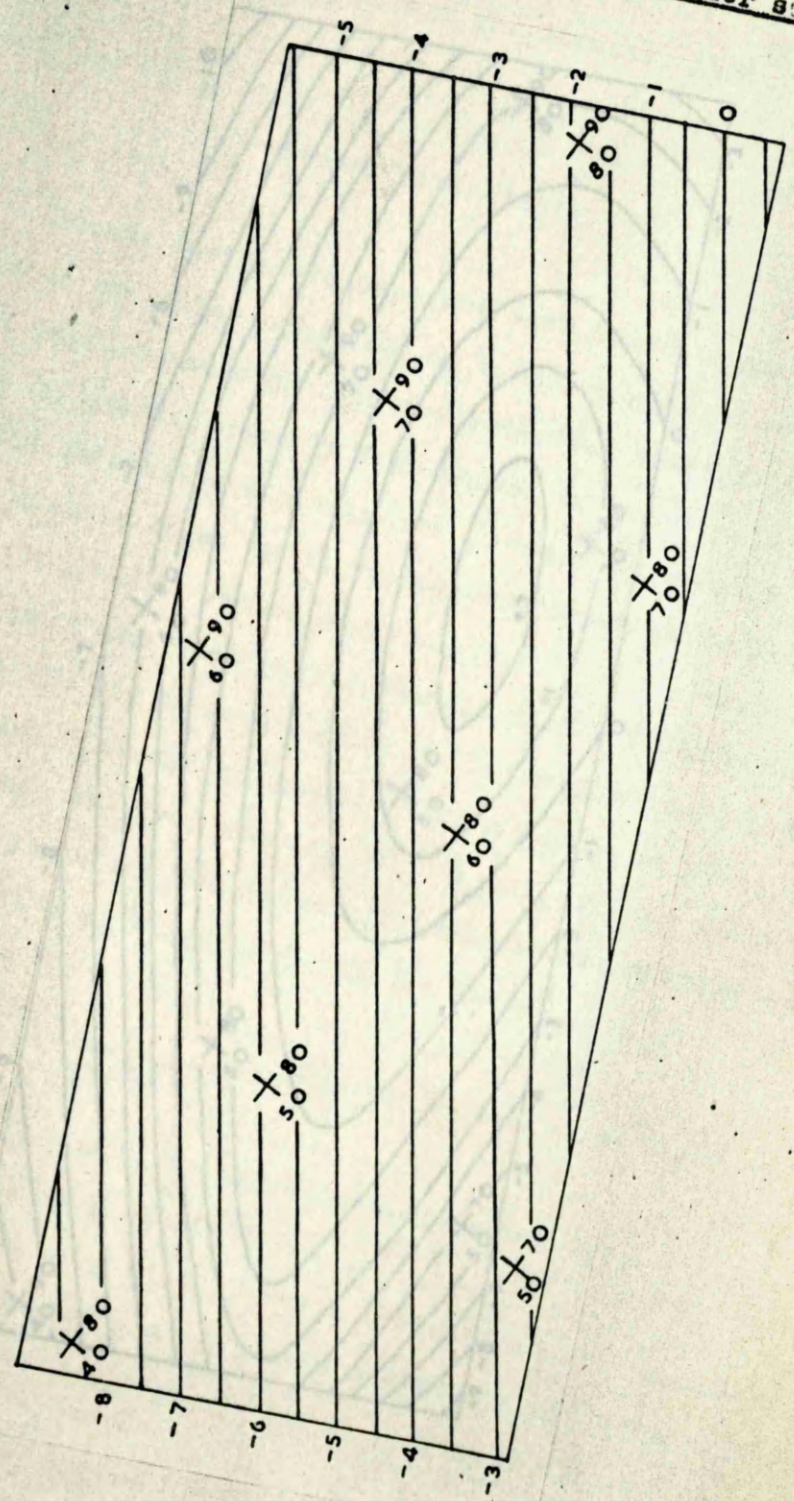
Conclusions

The regional gradient is thus represented by a plane surface which rises towards S 40° E at a rate of 0.61 mgal. per mile (see Fig 7). This value includes the value of 0.0425 mgal. per mile due to the Cementstones but excludes the value of 0.07 mgal per mile due to the lavas which are considered to give rise to local anomalies. In the region of the maximum throw of the Campsie Fault, the lava is ~~est~~ estimated to give rise to a gradient of 0.025 mgal. per mile to the south and the Upper and Lower O.R.S. strata gradients of 0.033 mgal. per mile and 0.025 mgal per mile to the north respectively.

The above figure of 0.61 mgal per mile compares well with

Fig 7

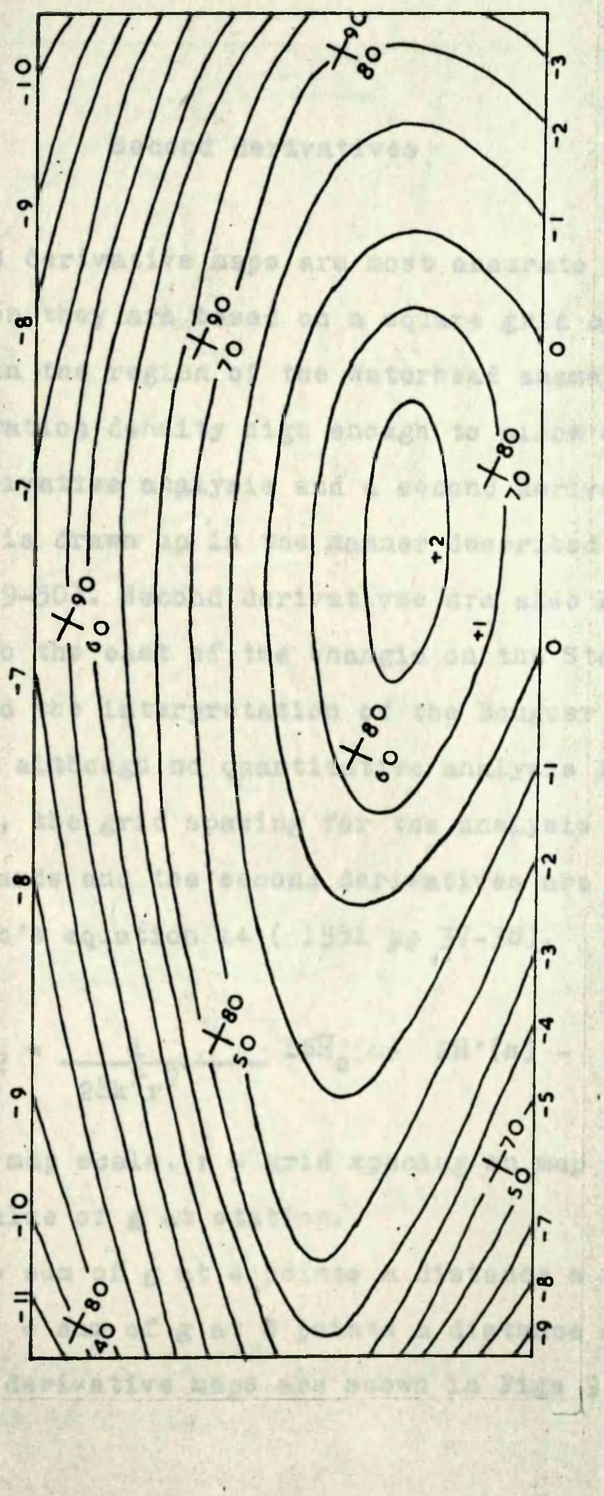
Regional gradient (mgal) 1st order surface.



Scale:1 inch to 3 miles.

Fig 8

Regional gradient (mgal) 3rd order surface.



Scale: 1 inch to 3 miles.

the value of 0.615 mgal per mile which is the gradient in the region of the southernmost Kilpatrick Hills determined from the parabola of best fit of the regional Bouguer anomaly values over the western part of the Midland Valley of Scotland (see McLean and Qureshi, 1966).

Second derivatives

Second derivative maps are most accurate and most useful when they are based on a square grid of values.

Only in the region of the Waterhead anomaly is the gravity station density high enough to allow an accurate second derivative analysis and a second derivative map of this area is drawn up in the manner described by Elkins (1951 pp 29-50). Second derivatives are also computed in the area to the east of the Whangie on the Stockiemuir road to aid the interpretation of the Bouguer anomalies in that area, although no quantitative analysis is made. In both cases, the grid spacing for the analysis is taken as s = 1000 yards and the second derivatives are calculated using Elkin's equation 14 (1951 pp 37-38).

$$\frac{d^2g}{dz^2} = -4a_2 = \frac{1}{28k^2r^2} \quad 16\bar{H}_o + 2H'(s) - 3H'(s\sqrt{5})$$

where, k = map scale, r = grid spacing on map (cm).

$\bar{H}_o$ = value of g at station.

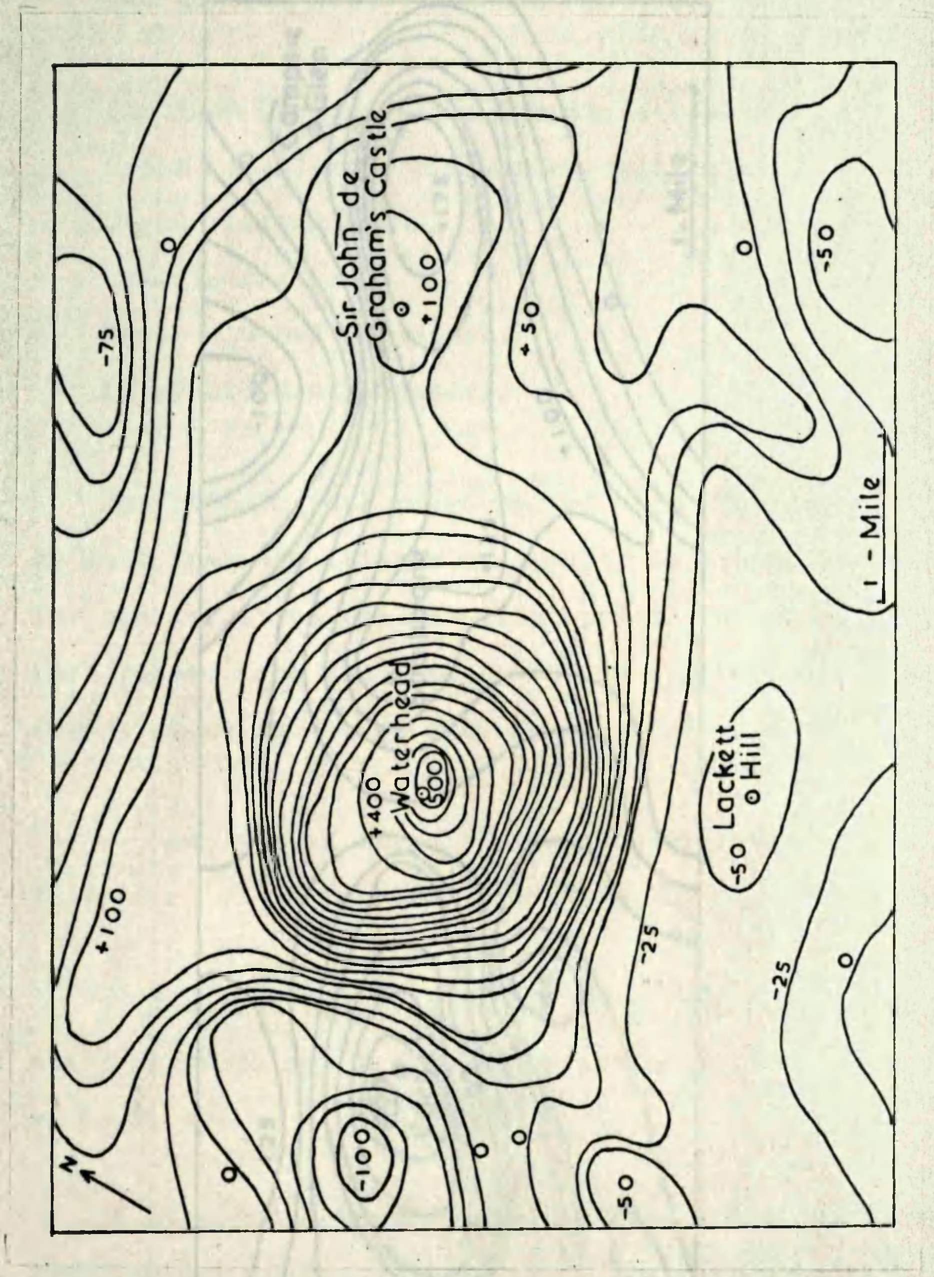
$H'(s)$ = sum of g at 4 points a distance s from station.

$H'(s\sqrt{5})$ = sum of g at 8 points a distance $s\sqrt{5}$ from station.

The second derivative maps are shown in Figs 9 and 10.

Fig 9

2nd derivative map - Waterhead farm.

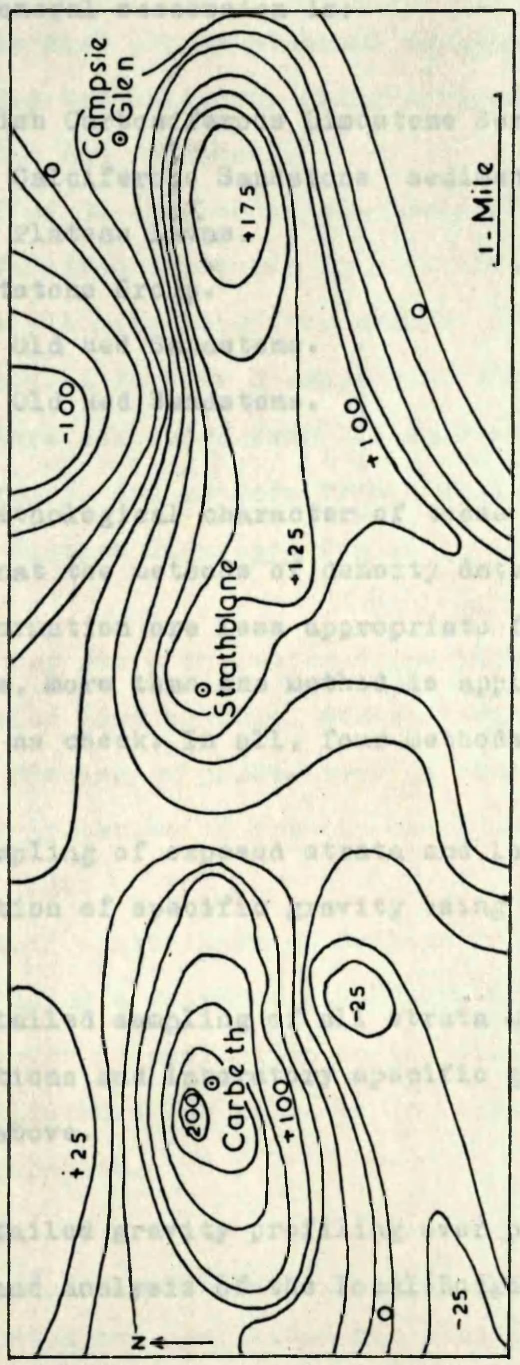


Contour interval: 25×10^{-15} c.g.s.units.

Scale: 1 inch to 1 mile.

Fig 10

2nd derivative map - Carbeth-Strathblane.



Contour interval: 25 × 10^{-15} c.g.s. units.

MEASUREMENTS OF ROCK DENSITY

To interpret the map of gravity anomalies quantitatively, the densities of all principal rock formations in the area must be determined.

The general succession is:-

Scottish Carboniferous Limestone Series.

Upper Calciferous Sandstone sediments.

Clyde Plateau Lavas.

Cementstone Group.

Upper Old Red Sandstone.

Lower Old Red Sandstone.

The lithological character of these formations differs so much that the methods of density determination suitable for one formation are less appropriate for another. In some cases, more than one method is applied to a given formation as check. In all, four methods are utilised.

1. Sampling of exposed strata and laboratory determination of specific gravity using a Walker's steelyard.

2. Detailed sampling of all strata making up well exposed cliff sections and laboratory specific gravity determinations as in 1. above.

3. Detailed gravity profiling over prominent topographic features and analysis of the local Bouguer anomalies thus obtained.

4. Gravity measurements in mineshafts.

Sampling of exposed strata

This method is the only one suitable for density determinations of both the Upper and Lower Old Red Sandstone. These formations are essentially made up of great thicknesses of sandstone with prominent basal conglomerates and breccias, the Lower Old Red Sandstone being noticeably coarser than the Upper Old Red Sandstone.

A total of 32 samples of the Lower Old Red Sandstone were selected from exposures in situ along a traverse approximately 1 mile long from Ardmore peninsula to Cardross (see Fig 11). A further 8 samples of the Upper Old Red Sandstone were collected from the same area just south of the Ochil fault, and 10 more from a well exposed cliff section at Finnich Glen (see Fig 11), making 18 samples in all.

In country where the water-table is never more than a few feet below land surface, the specific gravity of an oven-dried specimen of porous rock is considered valueless to the interpretation of gravity data, and no such measurements were made.

The specific gravities of samples collected were determined using a Walker's steelyard, and this was done within 24 hours of collection in the field. The samples were then saturated for 24 hours in vacuo and the determinations repeated.

Results of the sampling of exposed strata. The mean densities, standard deviations and standard errors of the means of the Old Red Sandstone sediments sampled are shown in Table 9.

The densities of these sediments after collection in the field do not differ significantly from the values obtained after saturation in vacuo (see Table 9) and the difference in most cases is less than the sum of their standard errors. The density value after saturation is

Fig 11

Map of density sampling localities and density profile traverses.

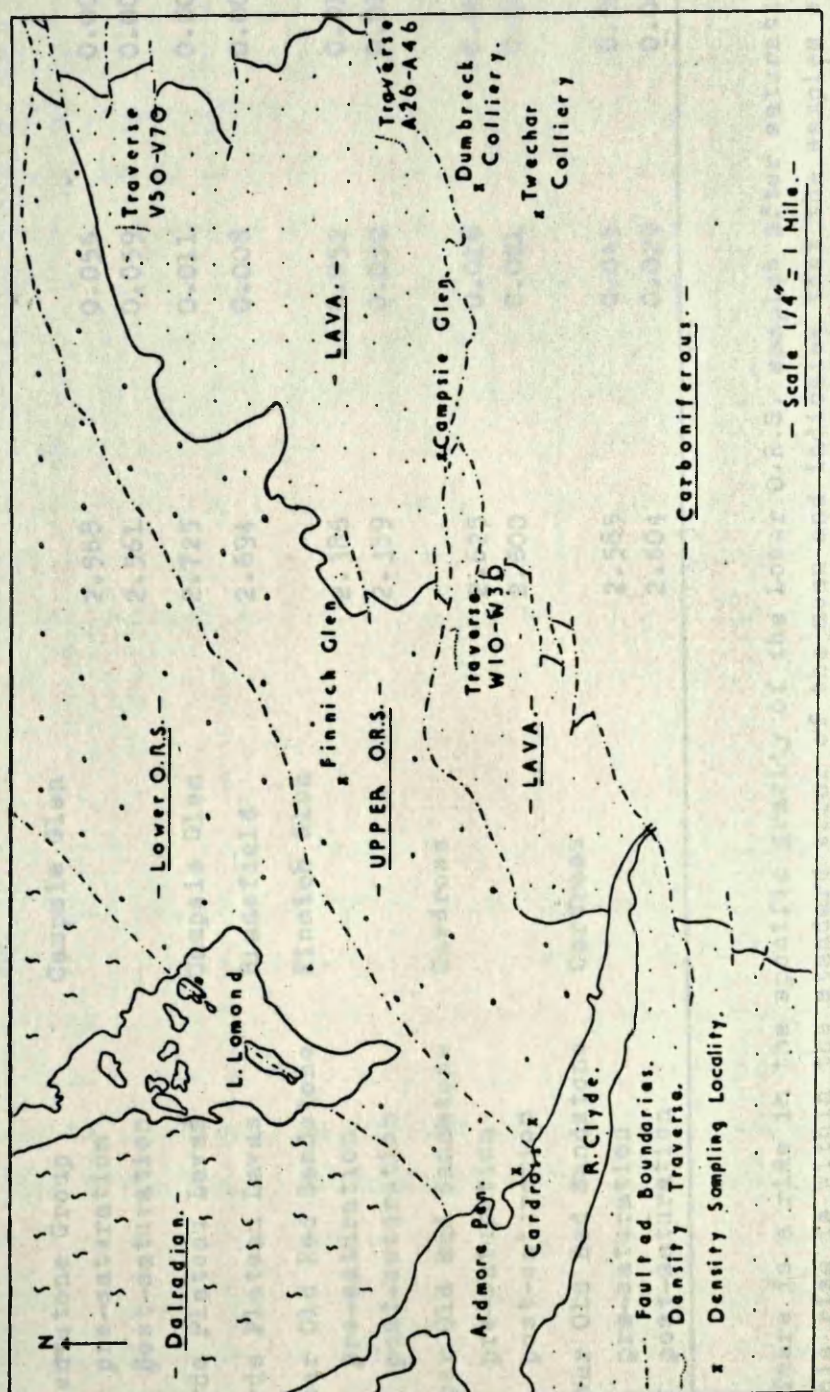


Table 9. Results of density determinations by the sampling methods.

(All values in g/cm^3)

Rock-type.	Locality.	Specific gravity.	Standard deviation.	Standard error.	No. of Samples
Cementstone Group	Campsie Glen				
pre-saturation		2.568	0.055	0.004	156
post-saturation		2.561	0.059	0.004	153
Clyde Plateau Lavas	Campsie Glen	2.725	0.011	0.001	226
Clyde Plateau Lavas	Blanefield	2.694	0.008	0.001	33
Upper Old Red Sandstone	Finnich Glen				
pre-saturation		2.386	0.052	0.016	10
post-saturation		2.359	0.052	0.016	10
Upper Old Red Sandstone	Cardross				
pre-saturation		2.625	0.016	0.006	8
post-saturation		2.600	0.021	0.008	8
*Lower Old Red Sandstone	Cardross				
pre-saturation		2.585	0.045	0.008	32
post-saturation		2.604	0.029	0.005	32

*There is a rise in the specific gravity of the Lower O.R.S. samples after saturation, but this rise is within the standard error of the mean and indicates that the samples were probably near to saturation at the time of collection.

All S.G. determinations in this table are extended to three decimal places to show the significance of the standard error. Normally, the values are rounded up to two decimal places.

considered to be more accurate for the interpretation of gravity data since most of the rocks in the area surveyed are beneath the water-table. The increase in density due to compaction at depth by the overburden cannot be determined by rock sampling at the surface and is ignored in these calculations. There is a difference in the density of the Upper Old Red Sandstone sediments at Cardross and the density of those at Finnich Glen. This agrees with Qureshi's findings (1961 p 18) south-east of the Ochil Fault, where the density of the sediments is 2.36 ± 0.03 g/cm^3 in contrast to the Clyde coast exposures between Largs and Greenock where the density is 2.49 ± 0.05 g/cm^3. Since the Upper Old Red Sandstone sediments in the area of the survey fall within the bounds of the low density Upper Old Red Sandstone sediments, then the value of 2.36 ± 0.05 g/cm^3 (<u>see</u> Table 9) is used for the interpretation of the gravity data. The corresponding value for the Lower Old Red Sandstone sediments is taken as 2.60 ± 0.03 g/cm^3.

Detailed sampling

This is a more accurate method of determining the mean density of a sequence of rocks than the above sampling method, and is necessary when cyclic repetition of a sedimentary series is present. A near complete exposure of the strata over a considerable vertical thickness must be accessible and samples of each lithological group are taken and their densities determined. The mean density of the whole sequence is obtained by weighting the density of each lithological group proportionally to its thickness and calculating the weighted mean.

This method of density determination is applied to the Cementstones of the Campsie Glen and also to the lavas of Campsie Glen and Blanefield.

<u>The Cementstone Group.</u> In Campsie Glen, the Cementstones

form an alternating sequence of limestones, sandstones and shales. Samples of each lithological group were collected and the mean density of the sequence calculated as described above. The determinations were made using a Walker's steelyard immediately after collection in the field and the determination was repeated after the samples had been saturated in vacuo for 24 hours. In some cases, however, the shales were so friable that they disintegrated in the water and the determinations could not be completed. It is also probable that the shales swelled during the saturation period and so introduced an error into the saturated density value, but this is not confirmed and it is unlikely that the error would seriously affect the mean density of the Cementstone group.

The density of the Cementstone group at Campsie Glen is taken to be 2.561 $\pm$ 0.004 g/cm^3 (<u>see</u> Table 9). This compares well with McLean's (1961 p 104) value of 2.56 g/cm^3 for the Cementstones of Ayrshire and Qureshi's (1961 p 18) value of 2.54 $\pm$ 0.09 g/cm^3 for the Cementstones of the Greenock-Gourock region. Qureshi's value of 2.34 g/cm^3 for the Cementstones at Dumbarton appears to be only of local import and is not reflected south of the Campsie hills.

<u>The Clyde Plateau Lavas</u>. For a detailed density determination, each lava flow can usually be subdivided into the following rock-types:-

Bole or weathered top.
Slaggy top.
Fresh centre rock.
Chilled base.

Several samples of each subdivision are taken and their specific gravities determined on a Walker's steelyard. Each subdivision of each lava flow is treated in the same way as each lithological unit of the Cementstone group described above (see p 63) and the average density of the sequence of lava flows is calculated.

Since the fresh lava is an impervious rock, the ground water in the Campsie region is restricted to the peaty overburden, to fissures in the rock, and to thin permeable horizons of bole or ash. As a consequence of this, all samples collected consisted of either impervious lava or permeable but highly saturated bole or ash. It was found that providing the samples were not given time to dry out, that is, more than 24 hours exposed in a warm dry room, then there was no significant difference in their specific gravities if re-determined after saturation in vacuo for a day or more. Therefore, to save time, all specific gravity determinations were carried out within 24 hours of the samples being collected.

The lavas were sampled at two localities, Campsie Glen and Blanefield, where good cliff sections allowed access to several flows. In Campsie Glen, 13 flows were sampled and measured over a vertical thickness of 314 feet. The 13 flows were not taken consecutively, in fact, as a result of incomplete exposure, this was not possible, but basal Jedburgh and Upper Markle basalt flows were included.

The exposures in the cliff section above Blanefield were not as accessible, but 5 complete flows representing 214 feet were sampled.

The mean density of the Clyde Plateau Lavas at Campsie Glen is 2.725 g/cm^3 with a standard error of $\pm$ 0.001 (<u>see</u> Table 9).

The mean density of the samples from Blanefield is 2.694 g/cm^3 with a standard error of 0.001 (<u>see</u> Table 9).

The difference in the mean densities of the samples from the two localities is too great to be explained as experimental error and the lower value from the Blanefield locality is probably due to the lavas there being very much more vesicular than the rocks exposed at Campsie Glen.

These results agree with the value of 2.72 g/cm^3 obtained for the Clyde Plateau Lavas by McLean (1961 p 105) and with the value of 2.74 ± 0.08 g/cm^3 obtained by Qureshi (1961 p 19) for the same lava group.

Detailed gravity profiling

With certain conditions which are described below, this method provides an extremely accurate and reliable means of determining the average density of a thick sequence of rocks. The conditions are

1. The gravity profile must follow a topographic gradient of at least 1 in 30 but no greater than 1 in 2 when the terrain correction becomes unreliable. It is also preferable that the topography includes a rise and fall but this is not essential if the regional gravity gradient is known.

2. If a regional gravity gradient does exist, it must be of such a simple and calculable form that it can be accurately determined and its effect removed.

3. There must be no geological structure which might give rise to local gravity anomalies.

<u>The choice of localities.</u> The absence of any suitable topographic feature precludes any attempt at density profiling in the low-lying country underlain by the Old Red Sandstone and Carboniferous sediments. The higher ground formed by the lava does however contain many steep slopes which render the area suitable for this type of density determination. A regional gravity gradient is known to exist in the area (<u>see</u> pp 47-51) but if the profile is taken over a regular topographic feature so as to include both positive and negative gradients, then the regional gradient can be isolated and subtracted.

Most geological features such as faults and intrusions liable to cause local gravity anomalies which would interfere with the density calculations are indicated on the geological maps and are avoided.

Density profiles are taken in three areas,

1. The Takmadoon Road. - traverse 'A'.
2. The Gargunnock Hills. - traverse 'B'.
3. The Carbeth Road. - traverse 'C'.

Reduction of results. If all the above conditions governing the use of a gravity profile for the determination of rock density are met, then any local base level or datum represents a surface at which the value of the Bouguer anomalies is constant or is changing in a predictable manner so that the effects of variations in altitude at any station may be isolated readily from the total observed gravity value. Hence in the calculation of the local Bouguer anomaly the value for the density of the near surface strata which gives a correlation of zero between the anomaly and topography is assumed to be the correct value. This can be determined in three ways. In Nettleton's method (1939 pp 176-183), the local anomaly is calculated for a range of density values and the results graphed over a topographic section of the traverse. The anomaly which appears to have the least correlation with the topography is assumed to be based on the correct density value. The range of calculations is time consuming and the result dependent on inspection, and the method has been refined and placed on a mathematical basis by Jung (1953 pp 29-35). This second method states that if the correlation coefficient k of the Bouguer anomalies $\Delta g''$ and the surface heights is zero, then

$$k(\Delta g'',h) = \frac{\sum (\Delta g'' - M_{(\Delta)})(h - M_{(h)})}{\sqrt{\sum (\Delta g'' - M_{(\Delta g'')})^2 \, (h - M_{(h)})^2}} = 0$$

where $M_{(\Delta g'')}$ and $M_{(h)}$ are the arithmetic means of

$\Delta g''$ and h respectively.

$$\Delta g'' = (\Delta g - \gamma) + (0.3085 - 0.04193\sigma_1)h \quad \text{M.K.S. units.}$$

$= $ Bouguer anomaly with approximate density σ_1 .

$$G = \Delta g_1'' - M_{(\Delta h'')} \ ; \quad H = h - M_{(h)} \ .$$

$$a = \frac{G.H}{H^2} \ ; \quad \sigma_2 = \frac{a}{0.04193}$$

$\sigma = \sigma_1 + \sigma_2$ = Best density value.

A criterion $\delta\sigma$ for the exactness of σ is determined from F, the standard error of $k(\Delta g, h)$ as follows:-

$$F^2 = \frac{\Sigma(G - aH)^2.H^2}{\Sigma(G - aH)^2.\Sigma H^2}$$

$$(\delta\sigma)^2 = a^2 - ((a^2/(1-F^2)) - (F^2/(1-F^2)).G^2/H^2)$$

$$= \pm \frac{|\delta a|}{0.04193}$$

The third method of density determination by gravity profiling is described by Parasnis (1952 pp 252-271) and is an improvement on Jung's method in that it is easier to work with, gives a graphical result which shows up mistakes and errors enabling them to be pin-pointed and corrected, and is more exact by taking into account the density factor in the terrain corrections which is only an estimate in the computational method.

The initial assumption is the same as before, that the local base level is a surface on which the value of the Bouguer anomaly is constant, and hence the reductions of observations at all stations can be equated. In this form all terms are known except σ, the value of density, and the following equation is derived.

$$g + k_1\Delta h = (k_2\Delta h - (T_2 - T_1)/\sigma_0).\sigma$$

where, k_1 = 0.09406 mgal/foot.

k_2 = 0.01276 mgal/foot.

Δg = change in gravity from local base station.

Δh = change in height from local base station.

$k_1 \Delta h$ = free air correction.

$\sigma k_2 \Delta h$ = Bouguer correction.

$\frac{(T_2 - T_1) . \sigma}{\sigma_0}$ = change in terrain correction from local base station.

This equation is in the form $Y = mX$, which is the equation of a straight line in which the gradient $m = \sigma$, the required density.

Density traverse A26 - A46. Inspection of the gravity profile (see Fig37) shows the Bouguer anomalies at stations A43 and A44 rise as a result of a dolerite dyke which crosses the traverse between these two stations. For this reason, stations A43 and A44 are omitted from the calculation. The density is calculated by the Parasnis method (see Table 10) to be 2.75 g/cm^3. However, by inspection of the graph, (see Fig 12, stage 1) it is seen that all the crosses corresponding to the stations on the north side of the hill lie above the circles corresponding to the stations on the south side of the hill. This indicates that a gravity gradient is present and this must be removed. The difference between the Bouguer anomalies at stations A26 and A46 after correcting for the small difference in height between the two stations is +1.39 mgal over a distance of 2000 yards. Subtracting this gradient linearly from the local anomalies of the density traverse, the results are recomputed (see Table 11) and the density becomes 2.60 g/cm^3. By inspection of the graph (see Fig 12, stage 2), the crosses corresponding to the stations on the north side of the hill lie below the

Table 10

Density determination (Parasnis method)

Traverse A. - 1st computation.

Station.	g	T_2-T_1	X.	Y.
1.	-1.067	0.052	0.557	0.169
2.	-1.443	0.108	0.536	0.161
3.	-1.453	0.065	0.849	0.248
4.	-2.419	0.149	1.436	0.376
5.	-2.316	0.079	1.505	0.441
6.	-3.801	0.134	2.583	0.735
7.	-5.306	0.034	3.242	1.129
8.	-6.841	0.071	4.563	1.481
9.	-8.794	0.099	5.223	1.810
10.	-8.935	0.009	5.871	2.006
11.	-8.598	0.019	5.753	1.934
12.	-7.804	-0.067	5.794	1.917
13.	-7.213	-0.098	5.669	1.851
14.	-5.625	-0.115	4.970	1.557
15.	-2.793	-0.138	3.467	0.990
16.	-1.246	-0.158	2.895	0.721
17.	+0.008	-0.162	2.249	0.467
18.	+1.251	-0.161	1.706	0.223

$\Sigma X = 58.868$, $\Sigma Y = 18.216$, $\Sigma XY = 82.5574$

$\Sigma X^2 = 257.2727$, $\Sigma Y^2 = 26.7937$.

$$\sigma = m = \frac{X}{Y} = \frac{\Sigma XY - (\Sigma X \Sigma Y)/N}{\Sigma Y^2 - (\Sigma Y)^2/N} = \frac{22.9830}{8.3591} = 2.7495$$

Correlation coefficient $r = \dfrac{1/N \Sigma XY - (\Sigma X \Sigma Y)/N^2}{P_x \; P_y}$

where P_x^2 and P_y^2 are the variances of X and Y.

Therefore $r = \underline{0.9913}$

Table 11.

Density determination (Parasnis method)

Traverse A - 2nd computation.

Station	G	X	Y
1.	-1.137	0.487	0.169
2.	-1.582	0.397	0.161
3.	-1.662	0.639	0.243
4.	-2.697	1.158	0.376
5.	-2.664	1.157	0.441
6.	-4.218	2.166	0.735
7.	-5.793	2.755	1.129
8.	-7.397	4.007	1.481
9.	-9.420	4.606	1.810
10.	-9.630	5.176	2.006
11.	-9.363	4.988	1.934
12.	-8.638	4.960	1.917
13.	-8.116	4.766	1.851
14.	-6.598	3.997	1.557
17.	-3.976	2.284	0.990
18.	-2.497	1.644	0.721
19.	-1.313	0.928	0.467
20.	-0.139	0.316	0.223

$\Sigma X = 46.431$, $\Sigma Y = 18.216$, $\Sigma XY = 68.7577$

$\Sigma X^2 = 176.8795$, $\Sigma Y^2 = 26.7937$

$$\sigma = m = \frac{Y}{X} = \frac{\Sigma XY - (\Sigma X.\Sigma Y)/N}{\Sigma Y^2 - (\Sigma Y)^2/N} = \underline{2.604}.$$

For Coefficient of Correlation r:-

$$r = \frac{1/N.\Sigma XY - (\Sigma X.\Sigma Y)N^2}{P_x.P_y} = \underline{0.9963}$$

Therefore $\sigma = 2.60$, with $r = 0.9963$

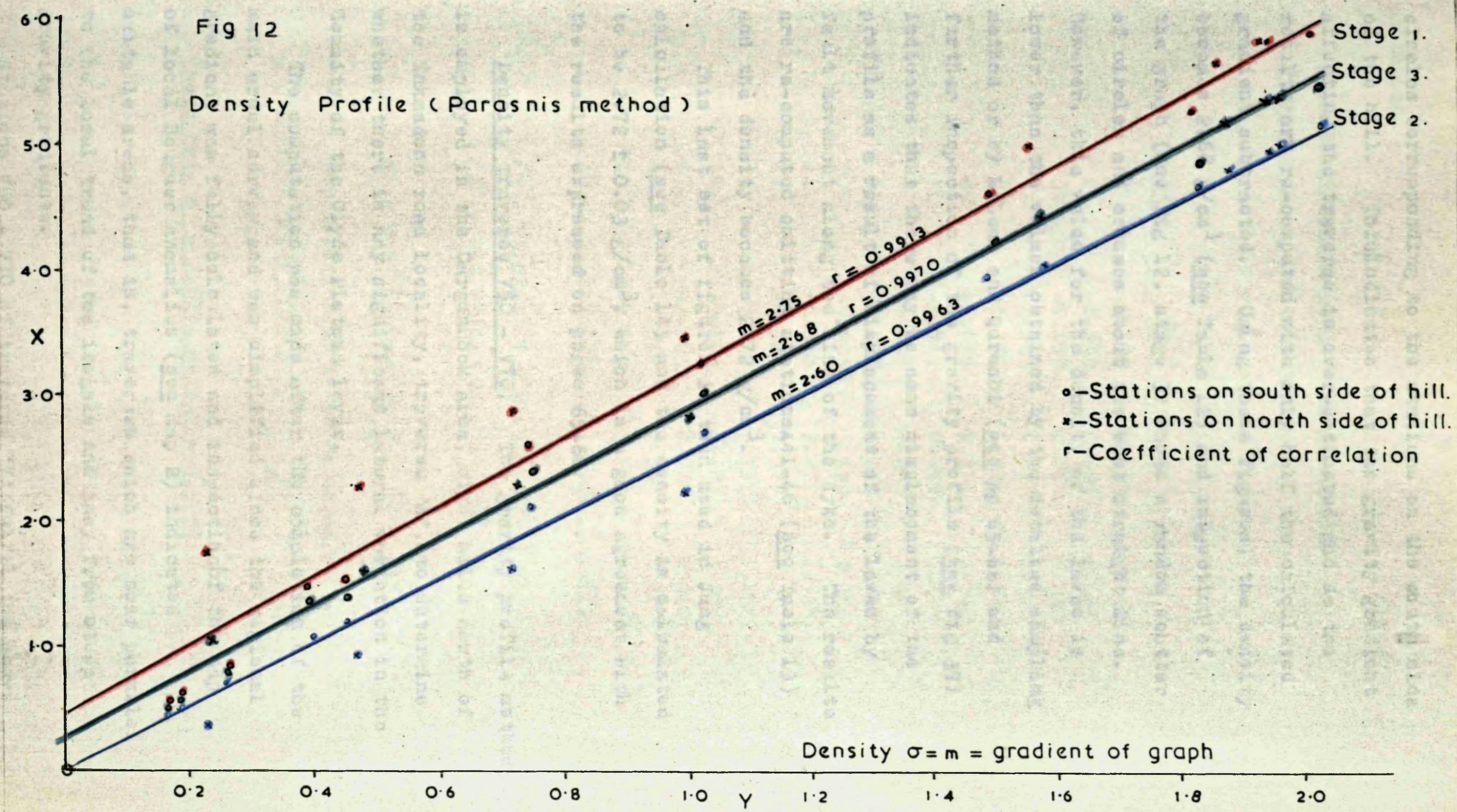


Fig 12

Density Profile (Parasnis method)

circles corresponding to the stations on the south side of the hill. This indicates that the gravity gradient affecting the traverse is over-estimated and so the results are re-computed with only half the calculated gradient subtracted. Using these figures, the density becomes 2.68 g/cm^3 (see Table 12) and inspection of the graph (see Fig 12, stage 3) shows a random scatter of circles and crosses about the best straight line. However, this value for the density of the lavas is lower than the values obtained by the detailed sampling method or by McLean and Qureshi (see pp 65-66) and further inspection of the gravity profile (see Fig 37) indicates that there may be some displacement of the profile as a result of displacement of the lavas by fault movement along the line of the dyke. The results are re-computed omitting stations A41-46 (see Table 13) and the density becomes 2.72 g/cm^3.

This last set of figures is then used in Jung calculation (see Table 14) and the density is calculated to be 2.72 ± 0.03 g/cm^3, which is a good agreement with the results expressed on pages 65-66.

Density traverse V50 - V70. The gravity profile method is employed in the Gargunnock area, eight miles north of the Takmadoon road locality, traverse 'A', to determine whether there is any significant lateral variation in the density of the Clyde Plateau lavas.

The computation was made after the completion of the main areal survey and was simplified since the regional gradient was fully calculated and inspection of the map of local Bouguer anomalies (see Map 2) indicated suitable areas, that is, traverses which are near parallel to the local trend of the isogals and away from steep gravity gradients.

Stations V50 - V70 of traverse 'V' fulfil the above conditions and using the station lowest in elevation,

Table 12.

Density determination (Parasnis method)

Traverse A - 3rd computation

Station.	ΔG	X	Y
1.	-1.102	0.522	0.169
2.	-1.513	0.466	0.161
3.	-1.557	0.745	0.248
4.	-2.558	1.297	0.376
5.	-2.490	1.331	0.441
6.	-4.010	2.374	0.735
7.	-5.549	2.999	1.129
8.	-7.119	4.285	1.481
9.	-9.107	4.919	1.810
10.	-9.283	5.523	2.006
11.	-8.980	5.371	1.934
12.	-8.221	5.377	1.917
13.	-7.665	5.217	1.851
14.	-6.113	4.483	1.557
17.	-3.334	2.876	0.990
18.	-1.872	2.269	0.721
19.	-0.652	1.589	0.467
20.	+0.556	1.011	0.223

$\Sigma X = 52.654$, $\Sigma Y = 18.216$, $\Sigma XY = 75.6646$.

$\Sigma X^2 = 214.2306$, $\Sigma Y^2 = 26.7937$.

$$\sigma = m = \frac{\Sigma XY - (\Sigma X.\Sigma Y)/N}{\Sigma Y^2 - (\Sigma Y)^2/N} = \underline{2.677}$$

For coefficient of correlation r,

$$r = \frac{1/N.\Sigma XY - 1/N^2.\Sigma X.\Sigma Y}{P_x P_y} = \underline{0.9976}.$$

Therefore $\sigma = 2.677$, with $r = 0.9976$.

Table 13.

Density determination (Parasnis method)

Traverse A - 4th computation.

Station	X	Y
1.	0.522	0.169
2.	0.466	0.161
3.	0.745	0.248
4.	1.297	0.376
5.	1.331	0.441
6.	2.374	0.735
7.	2.999	1.129
8.	4.285	1.481
9.	4.919	1.810
10.	5.523	2.006
11.	5.371	1.934
12.	5.377	1.917
13.	5.217	1.851
14.	4.483	1.557

$\Sigma X = 44.909$, $\Sigma Y = 15.815$, $\Sigma X.Y$ 70.2139

$\Sigma X^2 = 197.2638$, $\Sigma Y^2 = 25.0259$

$$\sigma = m = \frac{X}{Y} = \frac{\Sigma X.Y - (\Sigma X.\Sigma Y)/N}{\Sigma Y^2 - (\Sigma Y)^2/N} = \underline{2.721}$$

For coefficient of correlation r:-

$$r = \frac{1/N\Sigma X.Y - 1/N^2.\Sigma X.\Sigma Y}{P_x.P_y} = \underline{0.9980}$$

Therefore $\sigma = 2.721$, with a correlation coefficient of $r = 0.9980$

Table 14.

Density determination (Jung's method)

Traverse A

Station	Height	g"	H	G
1.	17.27'	+0.071	-22.552	-0.113
2.	21.04'	+0.038	-21.403	-0.146
3.	24.47'	+0.083	-20.357	-0.101
4.	40.98'	+0.294	-15.325	+0.110
5.	40.62'	+0.154	-15.435	-0.030
6.	67.87'	+0.410	-7.129	+0.226
7.	90.88'	-0.025	-0.116	-0.209
8.	121.24'	+0.322	+9.138	+0.138
9.	149.12'	+0.075	+17.636	-0.109
10.	157.41'	+0.151	+20.163	-0.033
11.	152.57'	+0.191	+18.688	+0.007
12.	144.57'	+0.240	+16.249	+0.056
13.	136.95'	+0.257	+13.927	+0.073
14.	112.64	+0.309	+6.517	+0.125

$M(h) = 91.2593, \quad M(\Delta g") = 0.184$

$$a = \frac{\Sigma G.H}{\Sigma H^2} = +0.001818$$

$$\sigma_2 = \frac{+0.001818}{0.04193} = +0.043$$

$$\sigma = \sigma_1 + \sigma_2 = 2.68 + 0.043$$

Therefore $\sigma = 2.723$

$$F^2 = \frac{\Sigma(G - aH)^2.H^2}{\Sigma(G - aH)^2.\Sigma H^2} = 0.03971$$

$$(\delta a)^2 = a^2 - (a^2/1 - F^2) - F^2/(1 - F^2).\Sigma G^2/\Sigma H^2)$$

$$= 1.8582 \times 10^{-6}$$

$$|\delta a| = 1.3632 \times 10^{-3}$$

$$\delta\sigma = \pm \frac{1.3632 \times 10^{-3}}{0.04193} = \pm 0.033$$

Therefore $\delta\sigma = \pm 0.033$

station V71, as a local base station and the elevation of station V71 above O.D. (Newlyn) as the datum, the density of the lavas of that area is calculated by the Parasnis method (see Table 15).

The value for the density is 2.74 g/cm^3.

The results are also computed by the Jung method (see Table 16), and the value for the density is found to be 2.71 ± 0.01.

The discrepancy between these two values arises either from an error in the estimation of the regional gradient or more likely from interference by a small local anomaly. Since the topographic slope from station V50 - V70 is entirely in the same direction, the source of the discrepancy cannot be isolated. However, the results do not differ significantly from the value of 2.72 ± 0.03 calculated for traverse 'A', and this is sufficient to suggest that there is no significant variation in the value of the density of the Clyde Plateau Lavas from Kilsyth to Gargunnock.

Density traverse W10 - W30. An attempt to determine the density of the lavas in the Carbeth region was made using the results of traverse W. The density value obtained, 2.82 g/cm^3 is spurious because of incalculable interference by a local anomaly which may be associated with the nearby Campsie Fault. Part of the Parasnis calculation is submitted to demonstrate how the graphical method illustrates the interference of a third unknown factor which obviously leads to erroneous result (see Table 17). The points on the graph (see Fig 13) are numbered in the order of the stations on the traverse and the best straight line through them has a gradient of 2.82. This is an algebraic compromise of a scatter of results and is misleading.

Table 15.

Density determination (Parasnis method)

Traverse V

Station	Δg	$T_2 - T_1$	X	Y
1.	-34.13	-0.136	+7.20	+19.18
2.	-32.87	-0.162	+7.21	+20.30
3.	-31.33	-0.165	+6.71	+18.03
4.	-29.10	-0.191	+6.31	+17.15
5.	-27.49	-0.202	+5.95	+15.93
6.	-26.01	-0.217	+5.71	+15.48
7.	-25.10	-0.228	+5.51	+14.77
8.	-23.99	-0.235	+5.28	+14.06
9.	-23.67	-0.239	+4.94	+11.81
10.	-19.16	-0.191	+4.32	+12.11
11.	-17.80	-0.228	+4.05	+11.07
12.	-19.23	-0.232	+4.31	+11.51
13.	-19.57	-0.228	+4.33	+11.31
14.	-17.65	-0.162	+3.90	+10.46
15.	-17.39	-0.195	+3.96	+10.84
16.	-16.03	-0.165	+3.54	+ 9.25
17.	-15.16	-0.103	+3.29	+ 8.70
18.	-14.72	-0.121	+3.17	+ 8.08
19.	- 7.38	-0.063	+1.57	+ 4.01
20.	- 5.88	-0.081	+1.36	+ 3.70
21.	- 3.80	-0.085	+0.91	+ 2.31

$\Sigma X = 93.53$, $\Sigma Y = 250.06$, $\Sigma X.Y = 1290.6529$

$\Sigma X^2 = 481.1417$, $\Sigma Y^2 = 3466.0292$.

$$\sigma = m = \frac{Y}{X} = \frac{\Sigma X.Y - (\Sigma X.\Sigma Y)/N}{\Sigma X^2 - (\Sigma X)^2/N} = \underline{2.739}$$

$$\text{And } r = \frac{1/N.\Sigma X.Y - (\Sigma X.\Sigma Y)/N^2}{P_x.P_y} = \underline{0.9913}$$

Therefore $\sigma = 2.74$, with a correlation coefficient of $r = 0.9913$

Table 16.

Density determination (Jung's method)

Traverse V

Station	Height	$\Delta g''$	H	G.
1.	551.78'	-0.38	+217.42	-0.14
2.	550.82'	-0.47	+216.46	-0.23
3.	510.89'	-0.17	+176.53	+0.07
4.	478.47'	0.00	+144.11	+0.24
5.	448.95'	-0.28	+114.59	-0.04
6.	429.08'	-0.03	+ 94.72	+0.21
7.	412.53'	-0.19	+ 78.17	+0.05
8.	393.77'	-0.27	+ 59.41	-0.03
9.	367.06'	-1.61	+ 32.70	-1.37
10.	322.94'	+0.36	- 11.42	+0.60
11.	298.31'	+0.08	- 36.05	+0.32
12.	318.64'	-0.19	- 15.72	+0.05
13.	320.56'	-0.46	- 13.08	-0.22
14.	291.83'	-0.13	- 42.53	+0.11
15.	293.82'	+0.08	- 40.54	+0.32
16.	263.15'	-0.36	- 71.21	-0.12
17.	248.84'	-0.22	- 85.52	+0.01
18.	238.34'	-0.51	- 96.02	-0.30
19.	117.99'	-0.22	-216.37	-0.02
20.	99.82'	0.00	-234.54	+0.24
21.	64.03'	-0.07	-270.33	+0.10

$M(h) = 334.36, \quad M(\Delta g'') = -0.24$

$$a = \frac{\Sigma G.H}{\Sigma H^2} = -35.97 \times 10^{-5} \; ; \; \sigma_2 = \frac{-35.97 \times 10^{-5}}{4.193 \times 10^{-2}}$$

$\sigma_2 = -0.009$

Therefore $\sigma = \sigma_1 + \sigma_2 = 2.72 - 0.009 = 2.711$

$$F^2 = \frac{\Sigma(G - aH)^2 . H^2}{\Sigma(G - aH)^2 . \Sigma H^2} = 8.7977 \times 10^{-3}$$

$$(\sigma a)^2 = a^2 - (a^2/(1-F^2) - F^2/(1-F^2) . \Sigma G^2/\Sigma H^2)$$
$$= 0.6556 \times 10^{-7}$$

$\delta a = 2.56 \times 10^{-4}$

$$\delta\sigma = \pm \frac{|\delta a|}{4.193 \times 10^{-2}} = \pm 0.006$$

Therefore the density of the lavas in the Gargunnock area is found to be $\sigma = 2.71 \pm 0.01$

Table 17.

Density determination (Parasnis method)

Traverse W

Station	X	Y
1.	0.39	0.93
2.	0.84	2.21
3.	1.24	3.10
4.	1.58	4.23
5.	1.71	4.73
6.	1.83	5.07
7.	1.72	4.89
8.	1.59	4.57
9.	1.64	4.76
10.	1.84	5.49
11.	2.01	5.87
12.	1.89	5.49
13.	1.97	5.79
14.	2.05	5.78
15.	2.04	5.60
16.	2.31	6.38
17.	2.60	7.08
18.	2.83	7.80
19.	2.63	7.23
20.	2.43	6.77
21.	2.19	6.01

$\Sigma X = 39.33$; $\Sigma Y = 109.83$; $\Sigma X.Y = 224.42$

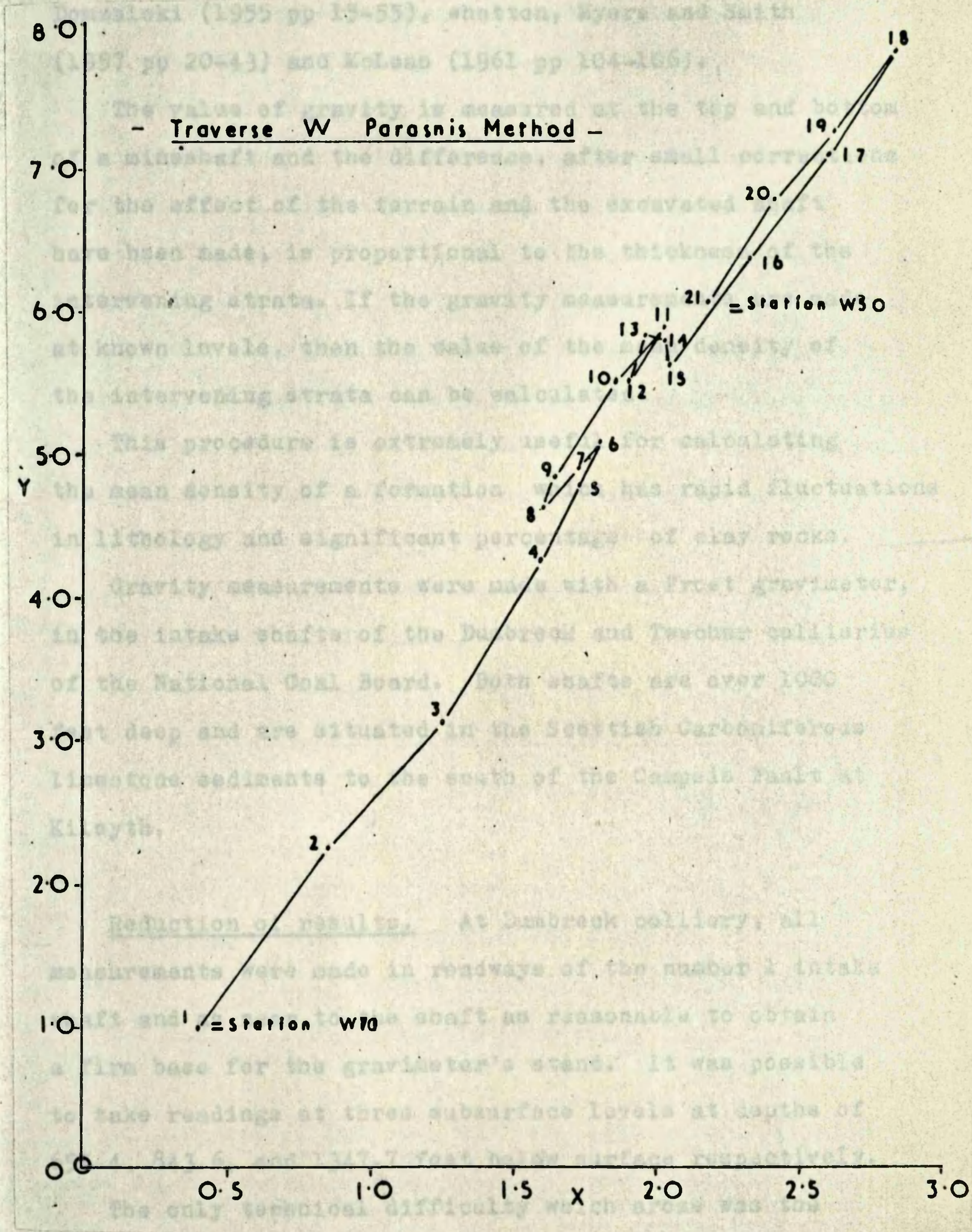
$\Sigma X^2 = 80.31$; $\Sigma Y^2 = 627.81$;

$$\sigma = m = \frac{\Sigma X.Y - (\Sigma X.\Sigma Y)/N}{\Sigma X^2 - (\Sigma X)^2/N} = 2.815.$$

$$\text{And } r = \frac{1/N.\Sigma X.Y - (\Sigma X.\Sigma Y)/N^2}{\sigma_x.\sigma_y} = 0.9936$$

Therefore $\sigma = 2.82$, with a correlation coefficient of $r = 0.9936$.

Fig 13



- Traverse W Parasnis Method -
=Station W3O
=Station W1O
Y
X
8·O
7·O
6·O
5·O
4·O
3·O
2·O
1·O
O
O·5
1·O
1·5
2·O
2·5
3·O

Mineshaft measurements

This method of density determination is similar in principle to the Parasnis method of gravity profiling, and has been described by Rogers (1952 pp 365-377), Domzalski (1955 pp 15-55), Whetton, Myers and Smith (1957 pp 20-43) and McLean (1961 pp 104-106).

The value of gravity is measured at the top and bottom of a mineshaft and the difference, after small corrections for the effect of the terrain and the excavated shaft have been made, is proportional to the thickness of the intervening strata. If the gravity measurements are made at known levels, then the value of the mean density of the intervening strata can be calculated.

This procedure is extremely useful for calculating the mean density of a formation which has rapid fluctuations in lithology and significant percentages of clay rocks.

Gravity measurements were made with a Frost gravimeter, in the intake shafts of the Dumbreck and Twechar collieries of the National Coal Board. Both shafts are over 1000 feet deep and are situated in the Scottish Carboniferous limestone sediments to the south of the Campsie Fault at Kilsyth.

<u>Reduction of results.</u> At Dumbreck colliery, all measurements were made in roadways of the number 1 intake shaft and as near to the shaft as reasonable to obtain a firm base for the gravimeter's stand. It was possible to take readings at three subsurface levels at depths of 655.4, 843.6, and 1347.7 feet below surface respectively.

The only technical difficulty which arose was the necessity to re-set the coarse adjustment of the gravimeter in order to obtain a reading at the lowest level. This trouble might have given rise to a large instrumental drift, but in fact a repeat reading at the preceding level only differed by 0.1 mgal, a discrepancy corresponding to an error in the density of $\delta\sigma = 0.005 g/cm^3$.

At Twechar colliery, only one underground measurement was possible and this was taken at the Kilsyth Coking Coal level in the gallery close to the bottom of the number 1 intake shaft at a depth of 1043.8 feet below the surface.

The free air corrections are made in the standard manner taking into account the depth of each station below the surface (see p 33).

The terrain correction for the surface station is made in the standard manner using a Hammer's zone chart (see p 34). In the Dumbreck locality, a density of 2.72 g/cm^3 is used for the third part of the surrounding area which is made up of lava, the remaining two-thirds is calculated at 2.50 g/cm^3 which is sufficiently close to the final value of the Carboniferous sediments to be satisfactory.

A value of 2.50 g/cm^3 is used for all the Twechar reductions.

The corrections for the undergound stations are calculated from the formula

$$g = \frac{2\pi\gamma\sigma(\sqrt{R_2^2 + h_1^2} + \sqrt{R_1^2 + h_2^2} - \sqrt{R_1^2 + h_1^2} - \sqrt{R_2^2 + h_2^2})}{N}$$

(derived from Hammer, 1939 p 192)

where,

R_1 and R_2 = inner and outer radii of zone.

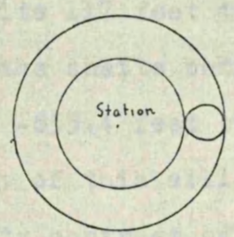
h_1 and h_2 = depth to station and depth to station + mean height of compartment above surface

N = number of compartments in zone.

At both collieries, the surface stations are situated close to the winding sheds and so a small building correction of 0.02 mgal is included in the terrain corrections for these stations.

In the case of the surface and deepest stations, corrections are made for the material excavated from the shafts. In the case of the two intermediate stations, the material missing from above the stations compensates for that missing below.

The effect of each shaft is computed separately using the same formula as for the underground terrain corrections, that is, calculating the effect of a hollow cylinder about the station which would just include the shaft between its walls:-



To give the actual shaft correction, this value is then multiplied by the following ratio,

$$\frac{\text{Areal cross-section of shaft}}{\text{Areal cross-section of erected cylinder.}}$$

A correction is also made for the material which has been excavated in the pits. For reasons of safety, few concentric roadways are excavated and no coal cut within a radius of 400 feet of either shaft. This simplifies the computation of the excavation correction since only a limited number of radiating roadways need be considered. In the calculation, use is made of the tables drawn up by Domzalski (1955 pp 50-54) for the percentage effect of slabs and blocks for different ratios of x/h where x is the distance of the block from the meter, and h is the height of the block. From these, the effect of the individual roadways are found, and hence the total effect.

Accurate plans for the Haugh Rigg, 665.4', and Kilsyth Coking Coal, 1347.7', levels are available, but not for the Coalburn Coal, 843.6' level. However, the excavations are known to be of the same order of size and so the mean of the two known excavation values is used.

Excavation correction.

Haugh Rigg level (-655.4 feet) = 0.463 mgal

Kilsyth Coking Coal level

(-1347.7 feet) = -0.703 mgal

Mean value = -0.583 mgal.

A sill of dolerite 117 feet thick is present in the highest section of the shafts between the surface and the Haugh Rigg level at -655.4 feet below ground. From samples, the density of this sill is found to be 2.96 g/cm^3 which gives a density contrast of 0.46 with the Carboniferous sediments. The effect of this sill is removed where desired by the theoretical replacement by sediment of density 2.50 g/cm^3. The attraction of the sill which is approximated to an infinite slab in the Bouguer formula is calculated to be 0.695 mgal.

The errors effecting the results of the mineshaft density determinations can be divided into three groups,

1. Indeterminate errors.
2. Negligible errors.
3. Estimated errors.

The indeterminate errors arise from two known sources, namely the imperfect barometric compensation by the gravimeter, and the effect of the high magnetic fields associated with the pit-head gear.

The barometric compensation error is reduced to a virtual calibration error by taking the gravimeter down the pit-shafts at a very slow speed and allowing it several minutes to re-adjust before reading the underground stations.

With regard to the magnetic disturbances by the pit-head gear, the instrument is known to be unaffected by moderate magnetic fields and since the fields associated with the pit-head gear is constant, its effects are neglected.

Negligible errors are associated with the shaft and excavation errors which are so small (from 0.019-0.106 mgal) that gross errors of 100% could be tolerated. An error of 0.25 mgal would only produce an error in the density of 0.01 g/cm^3, so these corrections need only be approximations and the errors ignored.

The estimated errors include the errors in the instrument reading, the depth to the underground stations, and to a lesser extent, the terrain correction.

Under ideal conditions, the gravimeter can be read to 0.01 mgal, but the conditions in the mineshaft where the instrument is required to measure two stations in a short time interval and separated by over 1000 feet of rock, represent the worst mechanical situation and the error is almost certainly nearer 0.02 mgal.

The depth is known to ± 1 foot in 1000 feet, but this effects the calculation twice and so the total error is 2 feet in 1000 feet which is equivalent to 0.02 mgal.

The error in the terrain correction is ± 0.1 mgal (see p 41).

The total error in the density determinations by measurements in mine-shafts becomes a little over ± 0.1 mgal which results in an error of ± 0.01 g/cm^3 in the calculated density.

Conclusions. The density of the Carboniferous sediments in the Twechar area is 2.47 ± 0.01 g/cm^3, or with the dolerite sill replaced by sediment, 2.42 ± 0.01 g/cm^3. The corresponding values at Dumbreck colliery 2 miles to the north-east are 2.51 ± 0.01 and 2.47 ± 0.01 g/cm^3 respectively.

The Twechar value is supported by similar work carried out by Powell (private communication) at that colliery and which gives an overall density of 2.47 g/cm^3 including the effect of the sill.

These results indicate a density gradient from Twechar to Dumbreck and this might be explained by an increase in compaction towards the north caused by the proximity of a plexus of faults including such major structures as the 'Riggin' and the Campsie Fault.

Comparing these results with those obtained by Whetton, Myers and Smith (1957, pp 20-43), the Prince of Wales colliery densities are slightly higher than those of the Central West area of Scotland, whereas Fryston colliery does correlate with Dumbreck at shallow and middle depths.

Twechar gives the lowest result of all (<u>see</u> Tables 18 - 20, and Fig 14).

Mine-shaft density determinations in the West Ayrshire coalfield (McLean, 1961 p 106) give much higher values, from 2.52 to 2.69 g/cm^3, although the latter value is effected by thick dolerite intrusions.

It is obvious from these comparisons that there is considerable lateral variation in the near surface density of Carboniferous strata.

Table 18. Calculation of results of density determinations - Dumbreck.

Station	Δg	Depth.	F/A corr.	Terr. corr.	Shaft corr.	exc. corr.	Effect of sill.	Final gravity
Dumbreck.	0	0	0	+1.097	+0.016	-	-	+1.113
Haugh.	+17.41	655.4'	-61.61	+3.296	-	-0.463	+1.39	-41.367
Coalburn.	+23.00	843.6'	-79.30	+3.800	-	-0.583	+1.39	-53.083
K.C.C.	+37.25	1347.7'	-126.68	+4.760	-0.034	-0.703	+1.39	-85.407

Depth is in feet, all other values in mgal.

Table 19. Density determinations - Dumbreck.

Station.	Δh cm.	$4\pi\gamma\Delta h$	incl. Δg sill	incl. σ sill	excl. Δg sill	excl. σ sill.
Dumbreck.	0	0	0	2.54 ± 0.02	0	-
Haugh.	19976.6	16.746	42.280	2.54 ± 0.02	40.647	2.45 ± 0.02
Coalburn.	25712.9	21.555	54.196	2.51 ± 0.02	52.826	2.45 ± 0.02
K.C.C.	41077.9	34.435	86.520	2.51 ±0.01	85.130	2.47 ± 0.02

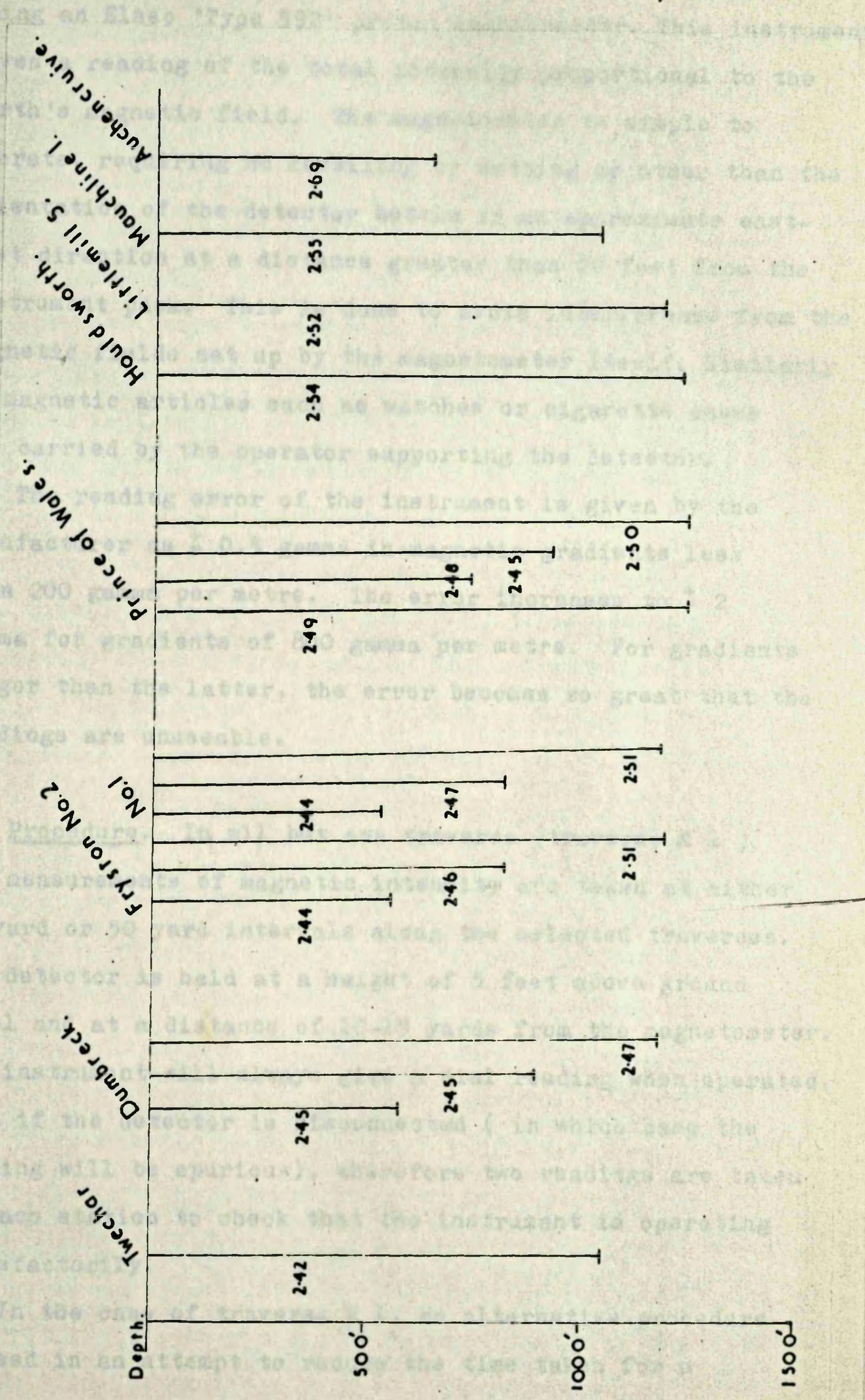
Table 20. Calculation of the results of density determinations - Twechar

Station	Δg	Depth.	F/A corr	Terr. corr.	Shaft corr	Exc. corr	Δh cm	$4\pi\gamma\Delta h$	Final gravity	σ
Twechar	0	0'	0	+0.609	+0.019	0	0	0	+0.628	-
Pit Bottom	+30.18	1043.8'	-98.78	+2.881	-0.021	-0.106	31815	26.67	-65.87	2.47

	Δg	$4\pi\gamma\Delta h$	σ
Replacing sill by sediment, $\sigma = 2.50$;	64.54	26.67	2.42
Removing sill	61.84	26.67	2.32

Fig. 14

Comparison of rock densities in different mine-shafts.



THE MAGNETIC SURVEY

Field methods

<u>The magnetometer.</u> The magnetic measurements are made using an Elsec 'Type 592' proton magnetometer. This instrument gives a reading of the total intensity proportional to the Earth's magnetic field. The magnetometer is simple to operate, requiring no levelling or setting up other than the orientation of the detector bottle in an approximate east-west direction at a distance greater than 20 feet from the instrument pack. This is done to avoid interference from the magnetic fields set up by the magnetometer itself. Similarly no magnetic articles such as watches or cigarette cases are carried by the operator supporting the detector.

The reading error of the instrument is given by the manufacturer as $\pm$ 0.5 gamma in magnetic gradients less than 200 gamma per metre. The error increases to $\pm$ 2 gamma for gradients of 800 gamma per metre. For gradients larger than the latter, the error becomes so great that the readings are unuseable.

<u>Procedure</u>. In all but one traverse (traverse M 1) the measurements of magnetic intensity are taken at either 20 yard or 50 yard intervals along the selected traverses. The detector is held at a height of 5 feet above ground level and at a distance of 10-15 yards from the magnetometer. The instrument will always give a dial reading when operated, even if the detector is disconnected (in which case the reading will be spurious), therefore two readings are taken at each station to check that the instrument is operating satisfactorily.

In the case of traverse M 1, an alternative procedure is used in an attempt to reduce the time taken for a traverse, increase the accuracy by increasing the number of readings taken in a given distance and facilitate the storage of results. To achieve this, an automatic recording and re-cycling device is attached to the magnetometer. This device re-cycles the instrument at a pre-set frequency and records the dial readings on a moving roll of sensitized paper. The detector is carried by one operator at a slow walking pace followed by two operators carrying the magnetometer and recorder side by side, and the recorder is set to re-cycle the magnetometer once every 10 seconds. In this way, 360 readings are taken in 1 hour and the distance covered is slightly over 1 mile.

This method is advantageous in that a survey can be completed more quickly and in greater detail, and since the results are being recorded automatically, the instrument operator is able to concentrate on adjusting the tuning control of the magnetometer in order to obtain the best instrument performance in all conditions. However, the method has certain disadvantages. The use of the recording device necessitates the assistance of a third operator in the team and is also a large drain on the batteries of the magnetometer.

The recorder is not fitted with a device for marking the recording paper externally and the geographic location in the field of any point on the record can only be found by interpolation between the end points of the traverse.

In practice, the detector was held stationary for one minute every 50 yards in order that the record should show a series of constant readings which could be identified and correlated with points along the traverse on the map.

The results on the recording paper are expressed in dial units and have to be converted to gammas and transposed before they can be interpreted. This operation takes up much of the time saved in the field by using the automatic recording system. The recording paper can only be read to an accuracy of ± 5 gamma and the results are subject to this additional error.

In rough country, the conventional method of taking measurements at specific stations spaced a given distance apart is used.

The magnetic traverses are made over structures defined by the gravity survey and local magnetic base stations are established close to the structure.

The magnetic base stations are not linked but plans giving the exact locations of the stations are lodged with the Department of Geology of the University of Glasgow so that they may be re-occupied if a more extensive ground magnetic survey is undertaken.

Location of traverses

The magnetic survey consists of five traverses. Traverse M 1 is a north-south traverse intended to locate an east-west trending quartz-dolerite dyke which is shown on the Geological Survey sheet 31 crossing the Crow road near Jamie Wright's well north of Lennoxtown.

The results are obtained using the automatic recording instrument described above and the local base station is set up on the Crow road. Traverses M 2 and M 3 are north-south traverses set 100 yards apart with M 2 west of M 3 and parallel to the Takmadoon road in the eastern Campsie hills. These traverses are set out to locate an east-west dyke which is shown on the Geological Survey sheet 31 as an extension of the quartz-dolerite dyke which crosses the Crow road. On these traverses, magnetic measurements are taken at stations spaced 20 yards apart and the anomalies are calculated with respect to a base station on the Takmadoon road.

Traverses M 4 and M 5 are east-west and north-south directed traverses respectively. They are located in the Waterhead area on the Crow road and are measured from the Crow road magnetic base station above Lennoxtown.

These two traverses are made to determine if there is any magnetic anomaly complementary to the large positive gravity anomaly centred on Waterhead farm.

The maghetic traverses are shown on Map 1.

Reduction of results

The dial reading of the magnetometer is converted to gammas by the following formula:-

$$\text{Magnetic intensity (in gammas)} = \frac{24050}{\text{Instrument reading}} \times 10^5$$

The results are corrected for diurnal variation of the Earth's magnetic field in the following way. During the field survey, readings are taken at the local base stations at intervals of less than 2 hours. The change in the base station reading over this time lapse is usually less than 5 gamma and is assumed to be linear for the purposes of the correction. No latitude correction is made since this would be negligible over such short traverses.

Description of results

The anomaly over the east-west dyke on Traverses M 1 extends some 40 yards in a north-south direction and has a total amplitude of 5000 gammas. The maximum turning point of the anomaly is situated to the south of the minimum turning point.

The anomalies on traverses M 2 and M 3 are similar in shape to the dyke anomaly on Traverse M 1 . They extend over 100 yards in a north-south direction and have amplitudes of 2900 and 2450 gammas respectively. The maximum turning points on the anomalies lie to the north of the minimum turning points.

1000 gammas.

The anomalies on traverses M 4 and M 5 are very shallow undulations with an amplitude of less than 500 gammas.

The magnetic anomalies are shown in Figs 34,35,50-52.

Measurements of magnetic susceptibilty

The susceptibility bridge. The magnetic susceptibilities of samples of lava are determined using a susceptibility bridge similar to the type designed by Mooney (1952, pp 531-543). The measuring coil system consists of three identical coils positioned ½ an inch apart on the same axis. The circuit diagram is shown in Fig 15, and the coil in Fig 16. The coils A and B are energised by a signal of frequency 1 k/c per second which is generated by an audio-frequency oscillator. A small amplifier is used to detect the balance point of the bridge.

The susceptibility samples are in the form of either solid cores greater than 1½ inches long and ½ an inch in diameter or as a powder contained is small flat-bottomed test-tubes which have the same internal dimensions as the over-all dimensions of the solid cores. To determine the susceptibility of a sample, the bridge is balanced by adjusting the variable resistances R_1 and R_3 until no current can be detected in the bridge circuit by the amplifier. The sample is placed in the coil system inside coil A as shown in Fig 16 and the bridge is re-balanced by re-adjusting the values of the variable resistances R_1 and R_3. The changes ΔR_1 and ΔR_3 in the resistances R_1 and R_3 are proportional to the susceptibility of the sample (Mooney, 1952 pp 535-538).

The bridge is re-balanced after the susceptibility measurement is taken to determine the instrument drift as a result of temperature change or shock.

Fig 15

Susceptibility bridge circuit

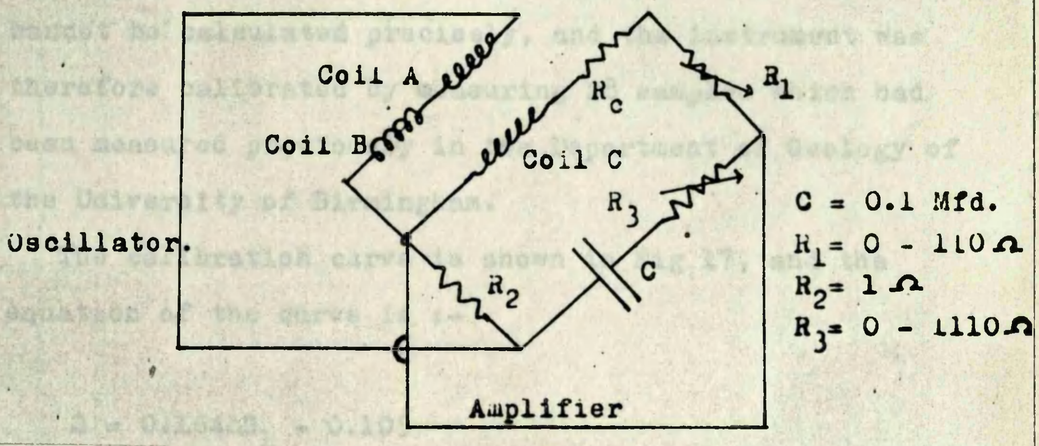
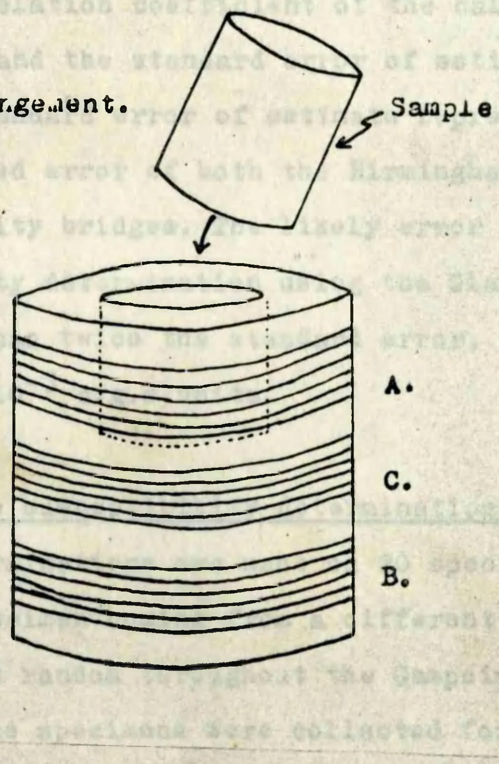


Fig. 16

Coil arrangement.



The drift is usually undetectable for periods of instrument use of less than one hour.

Instrument calibration. The geometry of the coil system is such that the calibration of the instrument cannot be calculated precisely, and the instrument was therefore calibrated by measuring 28 samples which had been measured previously in the Department of Geology of the University of Birmingham.

The calibration curve is shown in Fig 17, and the equation of the curve is :-

$$S = 0.164\Delta R_1 - 0.105$$

which is a straight line,

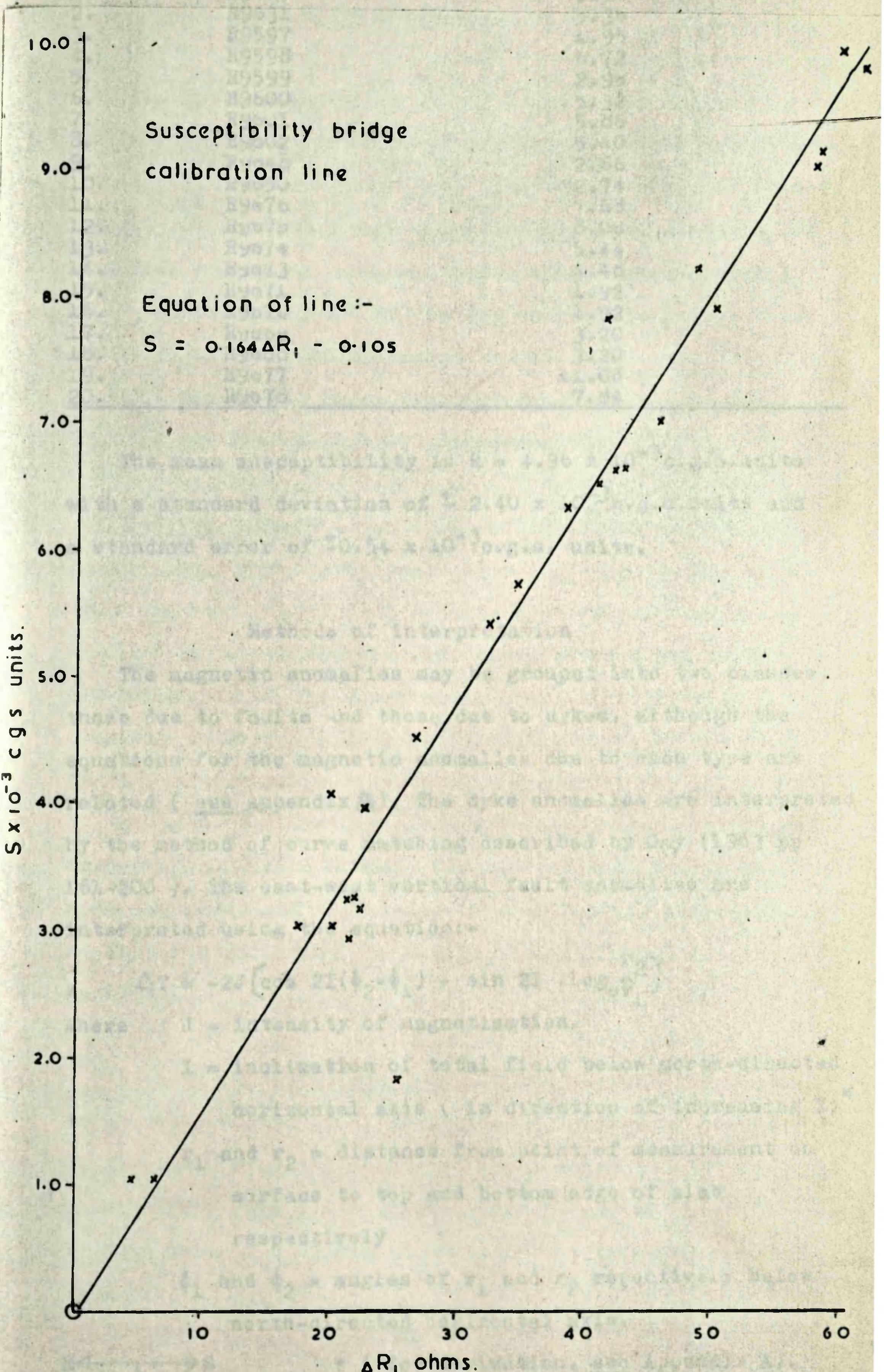
where S = magnetic susceptibility in 10^{-3} c.g.s. units.

ΔR_1 = the change in the variable resistance R_1 .

The linear correlation coefficient of the calibration line is $r = 0.976$, and the standard error of estimate is $S_y = 0.633$. This standard error of estimate represents the total accumulated error of both the Birmingham and Glasgow susceptibility bridges. The likely error of a single susceptibility determination using the Glasgow apparatus is less than twice the standard error, that is less than $\pm 1.27 \times 10^{-3}$ c.g.s.units.

Results of the susceptibility determinations. Susceptibility determinations are made on 20 specimens of fresh lava, each specimen coming from a different flow which is selected at random throughout the Campsie and Kilpatrick hills. The specimens were collected for chemical analysis by J.G.Macdonald of the Department of Geology, University of Glasgow and the code numbers of the specimens refer to their classification in the Hunterian Museum, University of Glasgow.

Fig 17.


Susceptibility bridge
calibration line
Equation of line :-
S = 0·164ΔR₁ - 0·105
S x 10⁻³ c g s units.
ΔR₁ ohms.
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
10
20
30
40
50
60

The susceptibility determinations are as follows:-

No.	Specimen	Susceptibility($\times 10^{-3}$ c.g.s.u).
1.	R9625	5.50
2.	R9631	5.36
3.	R9597	1.95
4.	R9598	6.72
5.	R9599	2.96
6.	R9600	5.32
7.	R9601	5.86
8.	R9602	5.40
9.	R9648	2.66
10.	R9650	2.74
11.	R9676	7.68
12.	R9675	8.00
13.	R9674	5.44
14.	R9673	4.48
15.	R9671	1.92
16.	R9670	1.92
17.	R9669	3.20
18.	R9668	3.20
19.	R9677	11.08
20.	R9678	7.84

The mean susceptibility is $k = 4.96 \times 10^{-3}$ c.g.s.units with a standard deviation of $\pm\, 2.40 \times 10^{-3}$ c.g.s.units and a standard error of $\pm 0.54 \times 10^{-3}$ c.g.s. units.

Methods of interpretation

The magnetic anomalies may be grouped into two classes, those due to faults and those due to dykes, although the equations for the magnetic anomalies due to each type are related (see Appendix A). The dyke anomalies are interpreted by the method of curve matching described by Gay (1963 pp 161-200). The east-west vertical fault anomalies are interpreted using the equation:-

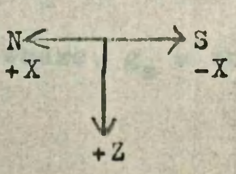
$$\Delta T = -2J\left[\cos 2I(\phi_2-\phi_1) + \sin 2I \,.\log_e\frac{r_2}{r_1}\right]$$

Where J = intensity of magnetisation.

I = inclination of total field below north-directed horizontal axis (in direction of increasing X)*

r_1 and r_2 = distance from point of measurement on surface to top and bottom edge of slab respectively

ϕ_1 and ϕ_2 = angles of r_1 and r_2 repectively below north-directed horizontal axis.



* (for derivation, see Appendix A).

THE GEOLOGICAL INTERPRETATION

Introduction

The Bouguer anomalies in the Campsie and Kilpatrick hills (see Map 2) consist of a steady regional gradient rising to the south-east (see pp 47-56), a large positive anomaly at Waterhead farm approximately in the centre of the area surveyed, and many minor anomalies associated with faults, small intrusions and variations in the thickness of the rock formations at the surface.

The map of 1st order residual anomalies (see Map 3) is used for the geological interpretation.

Density contrasts. An examination of the rock densities of the major stratigraphical units (see pp 59-90) shows that the most significant density contrast occurs at the base of the Clyde Plateau Lava group between the lavas and the sediments of the Cementstone group. This density contrast is 0.17 ± 0.01 g/cm^3 . To the south of the Campsie and Kilpatrick hills, the lavas are overlain by sediments of the Upper Sedimentary group and Carboniferous Limestone series which give a density contrast of 0.21 ± 0.02 g/cm^3 with the lavas and this value is used for the interpretation of sections which include the lavas and these later sediments.

Methods of interpretation In most areas, the Bouguer anomalies are accounted for by the adjustment of the base of of the lavas above or below the local datum at +300 feet. The lavas rarely have a dip greater than 5^o and so this adjustment is made using the Bouguer formula for an infinite slab of material,

$$g_z = 2\pi\gamma\sigma t.$$

where, g_z = the vertical component of gravity attraction

γ is the gravitational constant.

σ is the density or density contrast.

t is the thickness of the slab.

The large positive anomaly at Waterhead farm is interpreted as the effect of a deep-seated structure which is a source independent of the base of the lavas (see pp 100-111), and this effect is graphically removed before the adjustment of the base of the lavas is attempted since the anomaly effects all of the results within a radius of 6 miles from its centre.

Anomalies associated with faults or ressembling the gradient anomaly due to a fault are interpreted using Nettleton's formula for a semi-infinite slab (1940 p 113). Other anomalies which cannot be explained in terms of the base of the lavas are interpreted using limiting depth formula (Bott and Smith, 1958 pp 1-10) and formulae for simple geometrical models (Nettleton, 1942 pp 293-310; Skeels, 1963 pp 724-735).

As a result of the error in the density contrast, (see p 97), the error in the theoretical anomaly calculated using the Bouguer formula is approximately 0.1 mgal/200 feet thickness of slab.

The scale of the diagrams. It is not possible to draw all the gravity anomalies and the postulated geological structures on a uniform scale because of the large variation in the size of both, therefore the following scales are chosen:-

a. The anomalies at Waterhead and Sir John de Graham's Castle are drawn to a scale of 4 mgal/inch and the geological structure on a natural scale of 1 inch/mile (see Figs 18 and 19).

b. The anomaly between stations F50 and F63 is drawn to a scale of 1 mgal/inch and the geological structure to a natural scale of 1 inch/1200 feet (see Fig 43).

c. The anomalies on the detailed traverses (except traverse Q) are drawn to a scale of 1 mgal/inch and the geological structure is drawn to a horizontal scale of 1 inch/1200 feet (1 gravity station/¼ inch) and a vertical scale of 1 inch/200 feet (see Figs 37-39, 41-42).

The geological structure of traverse Q is drawn on a horizontal scale of 1 inch/1 mile and a vertical scale of 1 inch/1000 feet in order that all the essential details may be represented on one diagram (see Fig 40).

d. The anomalies of the reconnaissance traverses are drawn to a scale of 4 mgal/inch and the geological structure is drawn to a horizontal scale of 1 inch/1 mile and a vertical scale of 1 inch/1000 feet (see Figs 44 and 45).

The regional gradient

The regional field is computed to be a 1 st order surface rising to the south-east at a rate of 0.61 mgal/mile (see pp 47 - 56).

The area covered by the survey is not large enough to permit a geological interpretation of this gradient, but its magnitude is consistent with the findings of McLean and Qureshi (1965) which indicate the presence of a relatively high density material under the Midland Valley rift compared with the flanking highlands. It is concluded by McLean and Qureshi that the gradient is the result of a thickening of the upper part of the crust by Dalradian rocks in the Grampian Highlands and Lower Palaeozoic sediments in the Southern Uplands.

The Waterhead Anomaly

The upper part of the Waterhead anomaly is essentially circular in plan (see Map 2) but this symmetry is largely destroyed beyond a two mile radius of the maximum value of 16.5 mgal. with the anomaly more elongated along a south-west north-east axis and decreasing in magnitude more rapidly in the north and much less rapidly in the east than in the south and west.

The dominant near circular form of the observed anomaly indicates that the density model which would give rise to a similar gravity field is that approximating either to a point source mass or to a vertical line source mass. The point source mass physically represents a sphere and the vertical line source mass ~~corresponds~~ approximates to a vertical cylinder (or a group of cylinders on a common axis) or a vertical cone which may or may not be truncated as a frustum.

The distortion of the peripheral area of the observed anomaly may be due to the effects of local structures, or the departures from a simple radial symmetry of the major structure which gives rise to the anomaly, or a combination of both features.

Examination of the 2nd derivative map of the Waterhead area (see Fig 9) shows the Waterhead anomaly rising to a maximum value of +574 x 10^{-15} c.g.s. units and maintaining the near circular pattern of the Bouguer anomalies over a radius of approximately 1½ miles from Waterhead. However, to the east-north-east, at Sir John de Graham's Castle, an anomaly of + 100 x 10^{-15} c.g.s. units is isolated and indicates that an independent structure is probably responsible. It is clearly related to the more gentle decrease in magnitude of the observed anomaly to the east of Waterhead. This anomaly in the second derivative values is approximately elliptical in shape with the major axis directed towards Waterhead.

Two other near circular anomalies in the second derivative values are seen, one at Lackett Hill in the south, and a second in the west approximately 2½ miles from Waterhead (see Fig 9). These are minima having values between -50 c.g.s. units and -100 c.g.s. units and are of doubtful significance since the isogals in both these areas are interpolations between traverses.

Density Models. Using limiting depth estimation techniques (see Bott and Smith,1958) the maximum depth to the top of the gravitating body is calculated (see p 107). If to a first approximation, the gravitating body is considered to be a finite sphere, then the limiting depth estimate is the depth to its centre of gravity* and therefore, for a given range of σ** the dimensions of this body are determined. The theoretical gravity anomaly due to these spheres is compared with the observed 1st order residual anomalies after removal of the regional gradient, and the results of this comparison are used as a guide for the erection of more complex density models which are based on a vertical line source (see pp 111-119).

The first of these more complex models is one of a range of vertical cylinders (see pp 120-123) which may be erected for different density contrasts and from this range of cylinders, a range of vertical frusta are developed (see p 123).

Finally, in the case of the frusta, the density contrast is varied at different levels according to the known geology (see pp 127-129). At each stage of this interpretive procedure the theoretical gravity anomaly due to the density model in question is subtracted from the observed 1st order residual values and in each case, a positive residual anomaly of between 4 and 5 mgal. remains in the region of Sir John de Graham's Castle as indicated by the 2nd derivative analysis (see p 56) and in the cases of the spherical and cylindrical models, a negative residual anomaly of approximately -1.5 mgal remains in the region of Lackett Hill (see p 56).

Limiting depth estimates are made on these peripheral anomalies (see Bott and Smith,1958) and spherical density

** σ = density contrast

* This may also be obtained from the formula $Z=1.305X_{\frac{1}{2}}$ where Z is the depth to the centre of gravity in any units, and $X_{\frac{1}{2}}$ is the distance in the same units from the maximum to where the value of the anomaly is halved (see Nettleton, p 123).

models are erected such that their centres lie at the computed limiting depth and the maximum value of their theoretical gravity anomalies equals that of the observed anomalies (see pp 112-119). More sophisticated analyses are not warrented in these cases since the possible error in the observed anomalies (which are 2nd order residuals) is too great to permit the fine distinctions between the anomalies due to spheres and cylinders to be identified. It is recognised that a cylindrical or conical density model would be equally viable at Sir John de Graham's Castle or Lackett Hill

The total theoretical anomaly in the Waterhead- Sir John de Graham's Castle area due to the sum of two or three density models as the case may be is compared with the observed anomaly at each stage.

Theoretical anomalies. The shape of theoretical gravity anomalies due to simple geometrical density models such as homogeneous spheres and homogeneous vertical cylinders in which the height equals the diameter differ in a recognisable manner when all other variables such as the depth to the centre of gravity and the density contrast are held constant (see Fig 18). Similarly, the anomalies due to frusta are diagnostic since they may be considered as modified cylinders, that is, the top is smaller than the base or *vice versa* if the frusta are inverted. However, due to the asymmetry of a frustum in the direction of its axis, the depth of burial of the density model, or the density contrast, or the total volume or any combination of these parameters must be varied to obtain a theoretical anomaly comparable in magnitude and shape to those anomalies due to spheres or cylinders. In the case of the frusta used to interpret the Waterhead anomaly, the depth of burial is raised in each case until the maximum theoretical gravity value equals the maximum observed value at Waterhead. A comparison between the theoretical anomalies due to the sphere, cylinder, frustum 1 and frustum 2 (see p 111) used in the interpretation of the Waterhead anomaly is shown in Fig 18 and illustrates the extent to which the separate models may be distinguished. All the anomalies have the same maximum value and the anomaly due to the cylinder decreases less steeply than those due to the sphere and the frusta, except towards the extremities of the curve where it crosses the anomaly due to the sphere. Both the anomalies due to the frusta represent smaller values than the anomaly due to the sphere except at the maximum value and frustum 2 which is a shallower and smaller density model than frustum 1 gives the sharpest anomaly. These density models are shown in Fig 19. The ability to identify one of the above theoretical anomalies with the observed anomaly may be complicated by either irregularities in the shape of the anomalous mass or by changes in density contrast in the field as a result of changes in density with depth of the anomalous mass and the surrounding strata.

Limiting depth estimations. The map of 1st order residuals shows the Waterhead anomaly rising to a maximum value of +16.5 mgal. The circular form of the upper portion indicates that the anomaly is to a first approximation of the type associated with a point source mass or a vertical line source.

Maximum depth estimates are made using the formula of Bott and Smith (1958, pp 2 - 3).

Theorem 1 gives the maximum depth, h, to the top surface of the gravitating body as :-

$$h \leqslant 11{,}560 \text{ feet}$$

Corollary 1.1 gives :-

$$h \leqslant 13{,}250 \text{ feet.}$$

Fig 18

Comparison of theoretical gravity anomalies

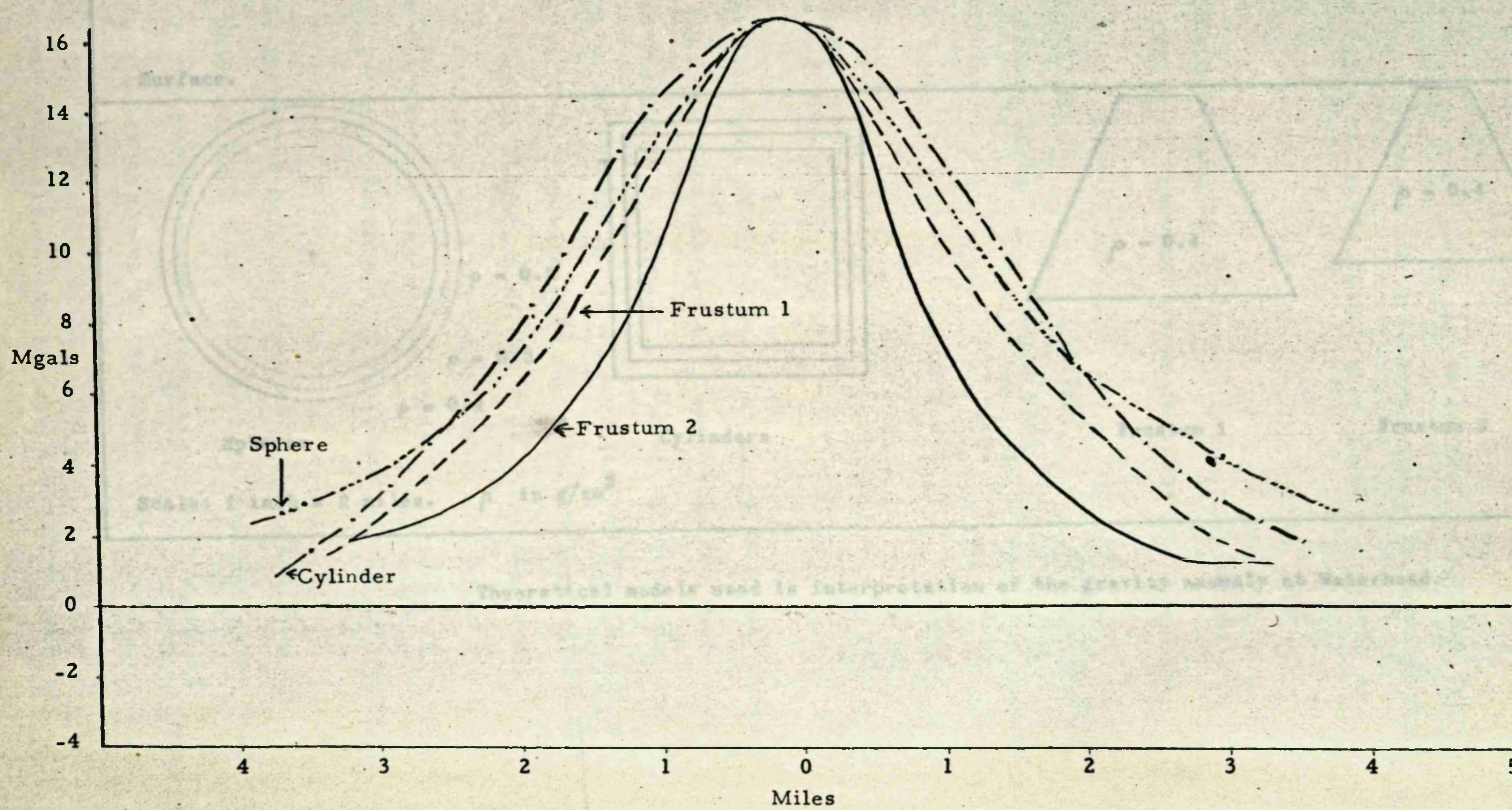
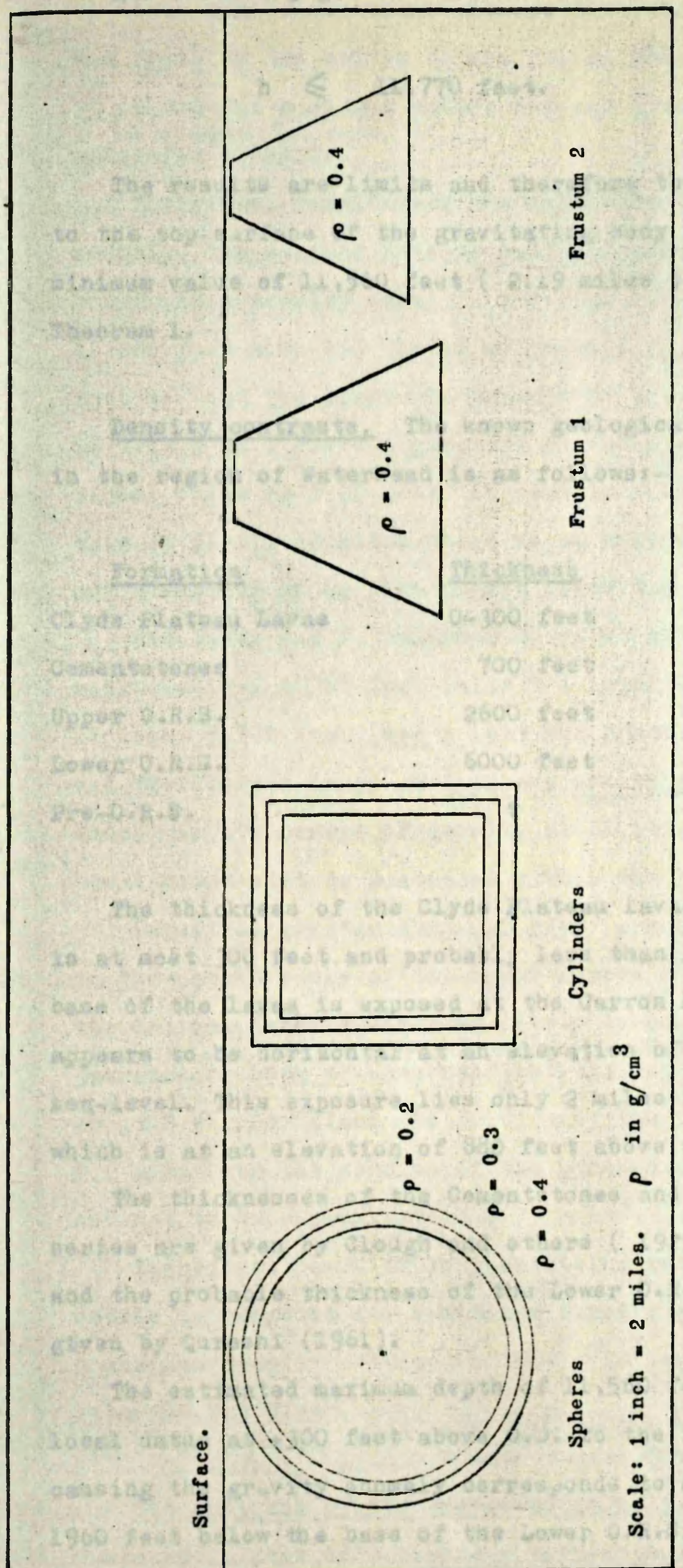


Fig 19.



Theoretical models used in interpretation of the gravity anomaly at Waterhead.

and Theorem 3 gives :-

$$h \leqslant 11{,}770 \text{ feet.}$$

The results are limits and therefore the maximum depth to the top surface of the gravitating body is taken as the minimum value of 11,560 feet (2.19 miles) as given by Theorem 1.

Density contrasts. The known geological succession in the region of Waterhead is as follows:-

Formation	Thickness	Density(g/cm^3)
Clyde Plateau Lavas	0-300 feet	2.72
Cementstones	700 feet	2.55
Upper O.R.S.	2600 feet	2.36
Lower O.R.S.	6000 feet	2.60
Pre-O.R.S.	?	2.75

The thickness of the Clyde Plateau lavas at Waterhead is at most 300 feet and probably less than 100 feet. The base of the lavas is exposed at the Carron Reservoir and appears to be horizontal at an elevation of 770 feet above sea-level. This exposure lies only 2 miles from Waterhead which is at an elevation of 880 feet above sea-level.

The thicknesses of the Cementstones and Upper O.R.S series are given by Clough and others (1925, pp 191-198) and the probable thickness of the Lower O.R.S. series is given by Qureshi (1961).

The estimated maximum depth of 11,560 feet from the local datum at +300 feet above O.D. to the top of the mass causing the gravity anomaly corresponds to a depth of 1960 feet below the base of the Lower O.R.S.

If, to a first approximation, the gravitating body is considered to be finite and to have a constant density contrast with the surrounding rocks, then the limiting depth estimate may be considered in certain circumstances to be the depth to the centre of gravity of the body. For example, it is true of a single sphere but not true if more than one sphere or a vertical line source is present.

Therefore, considering the magnitude of the observed anomaly, the minimum density contrast between the surrounding rocks and a density model in the form of a sphere of radius 11,560 feet with its centre of gravity at a depth of 11,560 feet so that the sphere is tangential to the local datum is 0.17 g/cm^3. For the purposes of calculation, the slightly higher value of 0.20 g/cm^3 is used as the minimum value and this is justified since there is no evidence in the field of any structure at or immediately below the surface.

The Lower O.R.S. sequence of rocks extend from a depth of approximately 3,300 feet below the local datum to a depth of at least 9,300 feet (see p 142) and probably to greater depths and therefore a large part of any spherical gravitating body which has its centre of gravity at 11,560 feet below the local datum must be contained within the Lower O.R.S. series. *

Densities greater than 3.0 g/cm^3 are seldom encountered in the common rocks of the upper layers of the crust and the maximum density contrast likely to occur between the ~~gravitating~~ anomalous body at Waterhead if it is spherical in shape and the surrounding rocks is about 0.4 g/cm^3 since the density of the Lower O.R.S. is 2.6 g/cm^3 and the density of the pre-O.R.S. basement is assumed to be approximately 2.75 g/cm^3.

Therefore, where it is possible, a range of density models is computed for a minimum density contrast of 0.2 g/cm^3, a maximum density contrast of 0.4 g/cm^3 and an intermediate value of 0.3 g/cm^3.

* N.B. This argument would not apply if the body is elongated vertically i.e. essentially cylindrical rather than spherical in shape.

The analysis of the Waterhead anomaly. The first model computed is that of a buried sphere with its centre at 11,560 feet below the local datum and a density contrast of 0.4 g/cm^3. This sphere which is identified by the notation A 1, has a radius of 1.65 miles and gives rise to a maximum gravity anomaly of 16.5 mgal. The theoretical gravity anomaly fits the observed anomaly very well on the northern side (see Fig 20A) and also on the eastern side within a mile to a mile and a half of the peak value (see Fig 21B).

In the west and south (see Figs 21B and 20A respectively) the observed curve decreases more rapidly away from the peak value, the difference being approximately 2 mgal in places, although the two curves match well between 2.5 and 5 miles south of Waterhead. The residual anomalies after subtraction of the theoretical profile from the observed profile are shown in Figs 20A and 21B.

Subtracting the computed gravity values due to this sphere from the map of 1st order residuals (see Plate 3) in the region of Waterhead, a map of 2nd order residuals is obtained (see Fig 22). On this map, two prominent closed residual anomalies remain. The larger of these rises to a maximum value of nearly + 4 mgal at Sir John de Graham's Castle to the east of Waterhead and coincides with the positive anomaly of + 120 x 10^{-15} c.g.s. units on the map of second derivatives. This anomaly is approximately circular in outline.

The second closed feature consists of negative residuals extending to a minimum of - 2 mgal centred on Lackett Hill to the south of Waterhead and corresponds to the anomaly of - 72 x 10^{-15} c.g.s. units on the map of second derivatives (see Fig 9).

The residual anomaly at Sir John de Graham's Castle is analysed in terms of spherical density models in the same manner as the major anomaly at Waterhead.

The maximum depth to the centre of this sphere is calculated by the Bott and Smith formulae (1958, pp 3-4) to be 9500 feet below the local datum, and the radius of the sphere for a density contrast of 0.4 g/cm^3 is 0.90 miles or 4750 feet. This sphere is identified by the notation

Fig 20

Observed and theoretical gravity anomalies at Waterhead

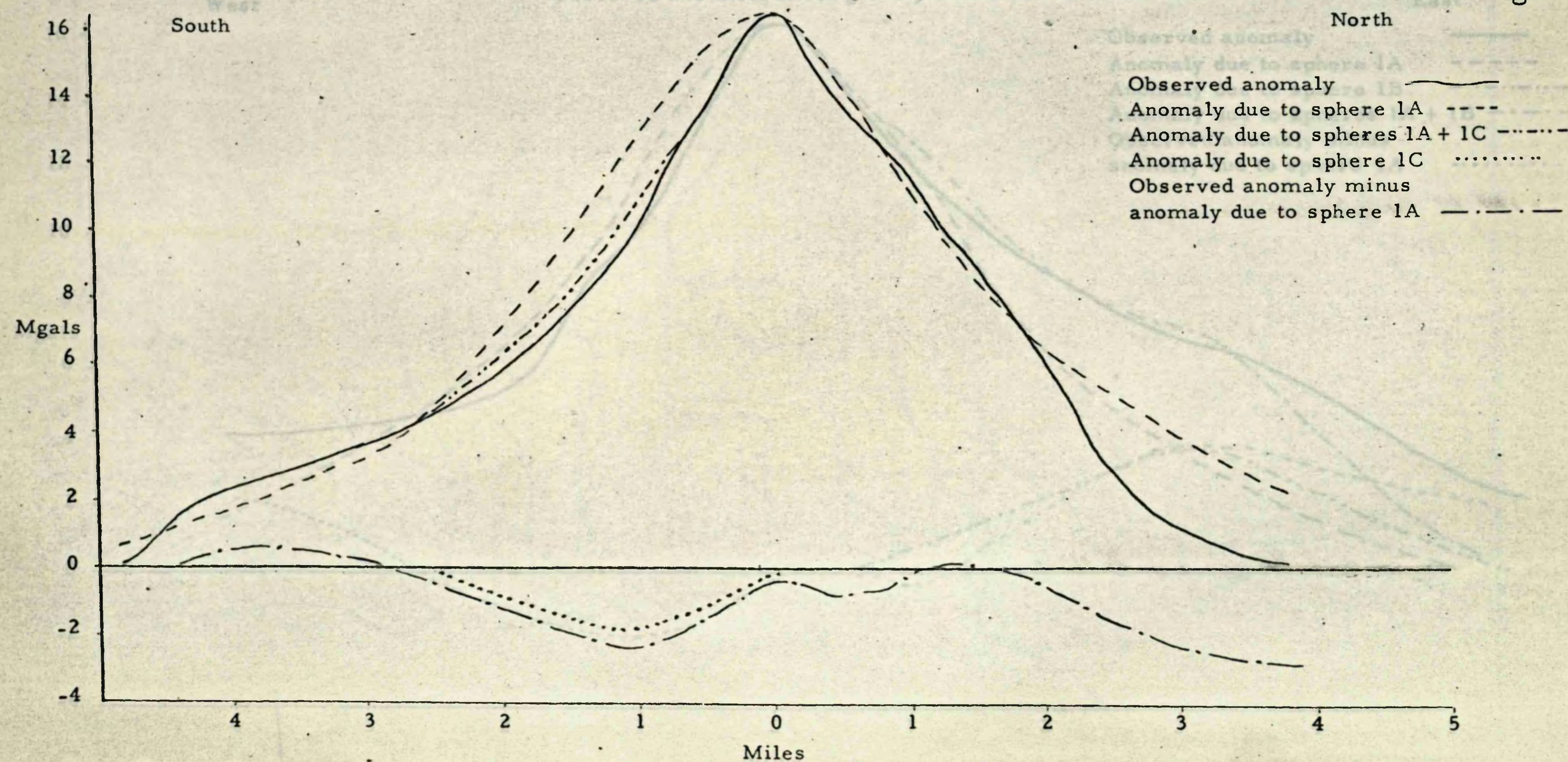
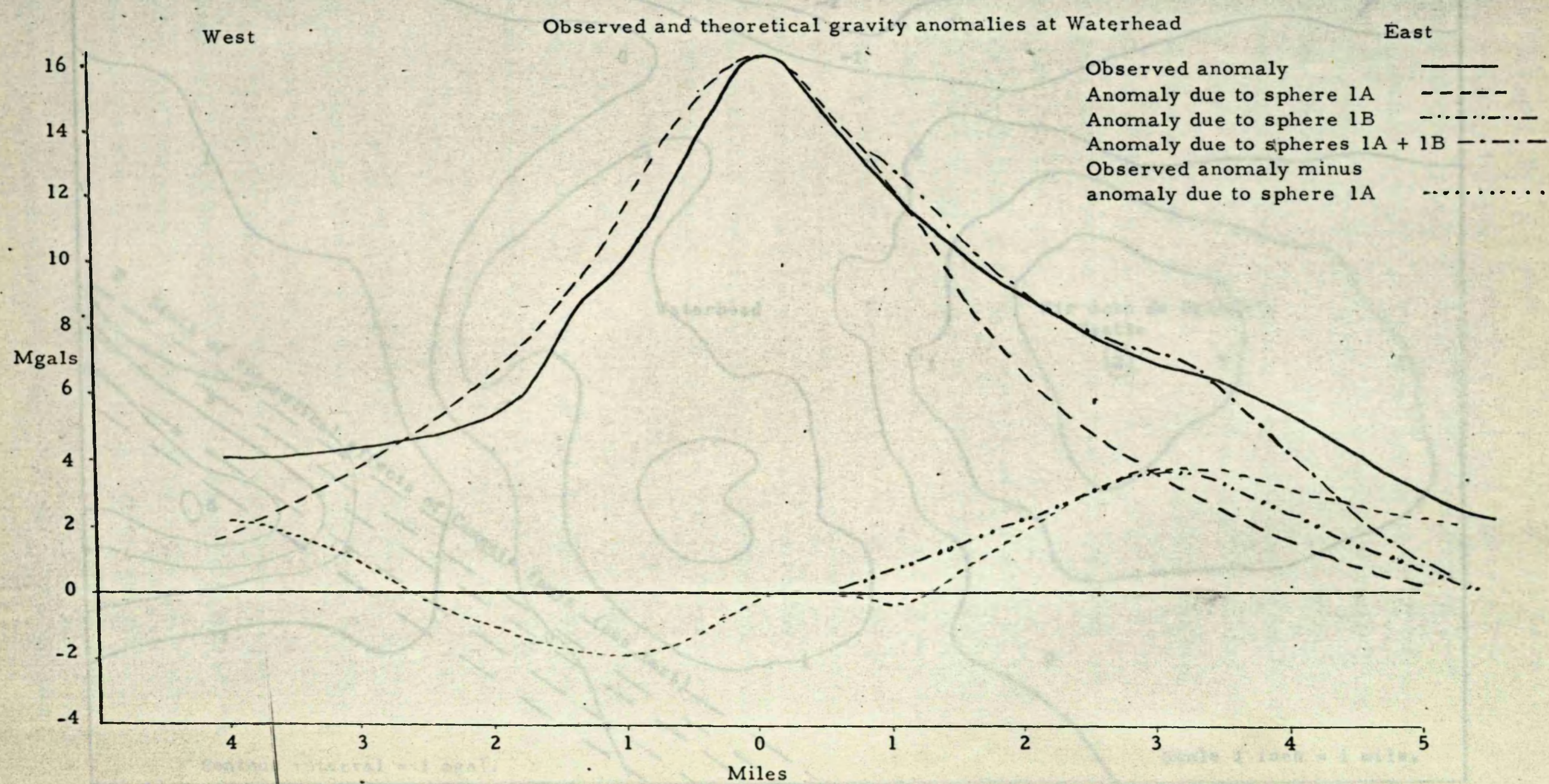


Fig 21


West
Observed and theoretical gravity anomalies at Waterhead
East
Observed anomaly
Anomaly due to sphere 1A
Anomaly due to sphere 1B
Anomaly due to spheres 1A + 1B
Observed anomaly minus
anomaly due to sphere 1A
Mgals
16
14
12
10
8
6
4
2
0
-2
-4
4
3
2
1
0
1
2
3
4
5
Miles

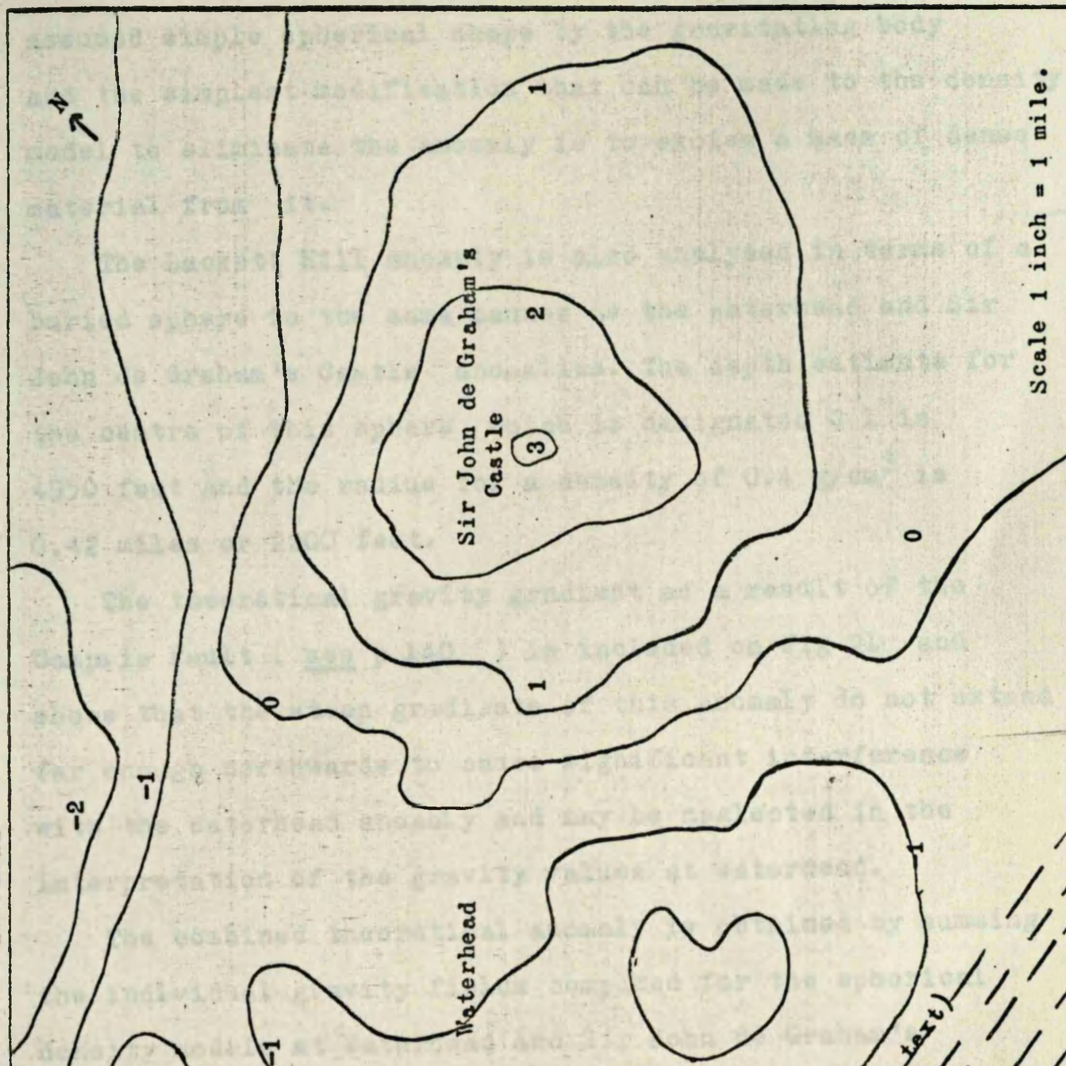


Fig. 22. 2nd Order Residual Anomalies at Waterhead

Contour interval = 1 mgal. Scale 1 inch = 1 mile.

B 1. The negative 2nd order residual anomaly at Lackett Hill is interpreted as the effect of a departure from the assumed simple spherical shape by the gravitating body and the simplest modification that can be made to the density model to eliminate the anomaly is to excise a mass of dense material from it.

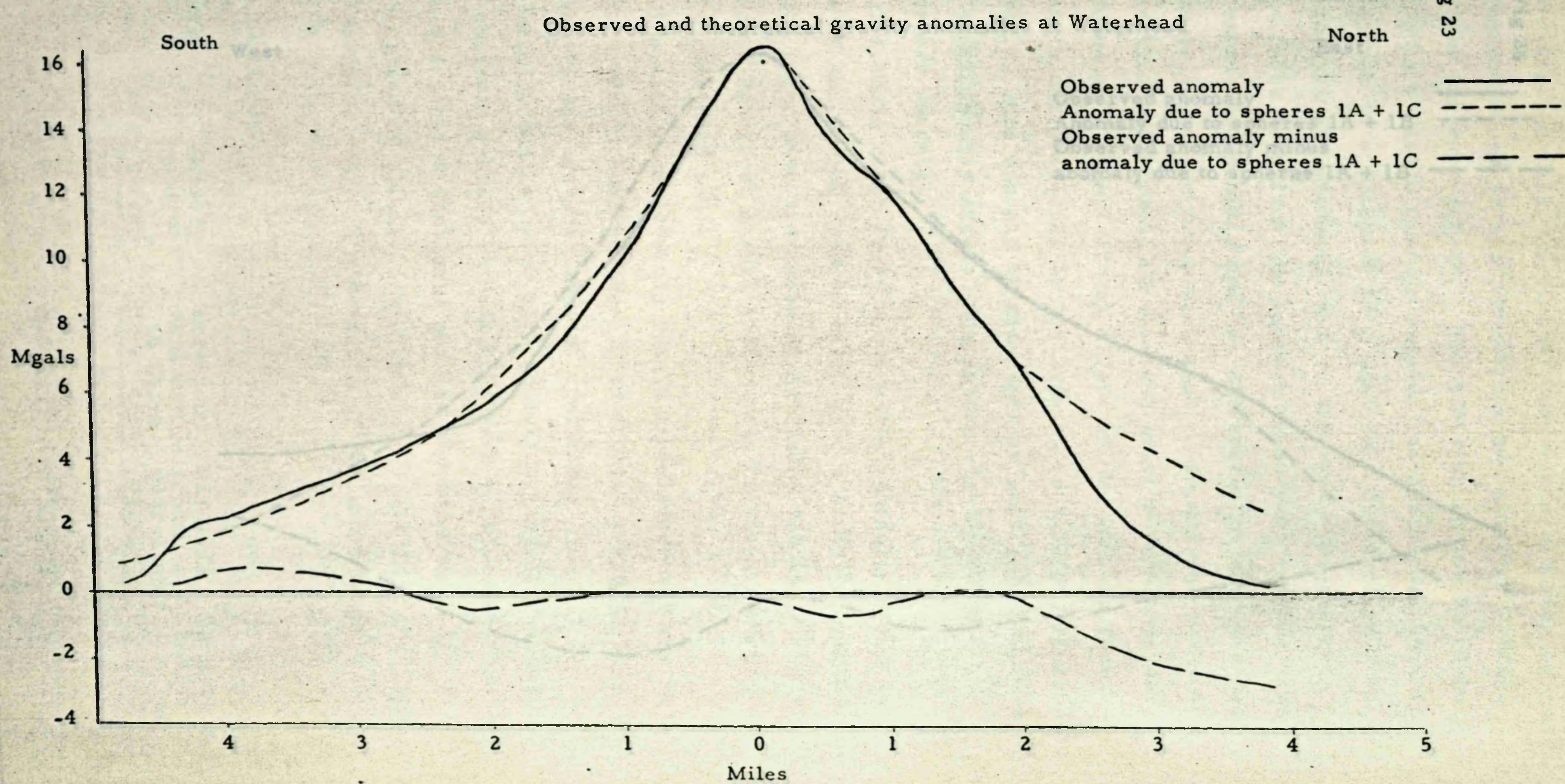
The Lackett Hill anomaly is also analysed in terms of a buried sphere in the same manner as the Waterhead and Sir John de Graham's Castle anomalies. The depth estimate for the centre of this sphere which is designated C 1 is 4950 feet and the radius for a density of 0.4 g/cm^3 is 0.42 miles or 2200 feet.

The theoretical gravity gradient as a result of the Campsie Fault (see p 140) is included on Fig 21 and shows that the steep gradients of this anomaly do not extend far enough northwards to cause significant interference with the Waterhead anomaly and may be neglected in the interpretation of the gravity values at Waterhead.

The combined theoretical anomaly is obtained by summing the individual gravity fields computed for the spherical density models at Waterhead and Sir John de Graham's Castle and subtracting the field computed for the incised sphere at Lackett Hill. The north-south and east-west profiles of this combined theoretical anomaly are compared with the observed anomaly (see Figs 23 and 24 respectively)

Residual anomalies are obtained by subtracting the theoretical profile from the observed profile in each case and are shown on the same respective figures. In the north-south profile (see Fig 23), the absolute value of the residual anomaly is generally less than 1 mgal except in the extreme north where it becomes approximately 2 mgal and the general indication is that the correlation between the observed and theoretical curves is good. However, the observed profile has a distinctly narrower form with more convex sides and a sharper peak than the

Fig 23


Observed and theoretical gravity anomalies at Waterhead
South
North
Observed anomaly
Anomaly due to spheres 1A + 1C
Observed anomaly minus
anomaly due to spheres 1A + 1C
Mgals
16
14
12
10
8
6
4
2
0
-2
-4
4
3
2
1
0
1
2
3
4
5
Miles

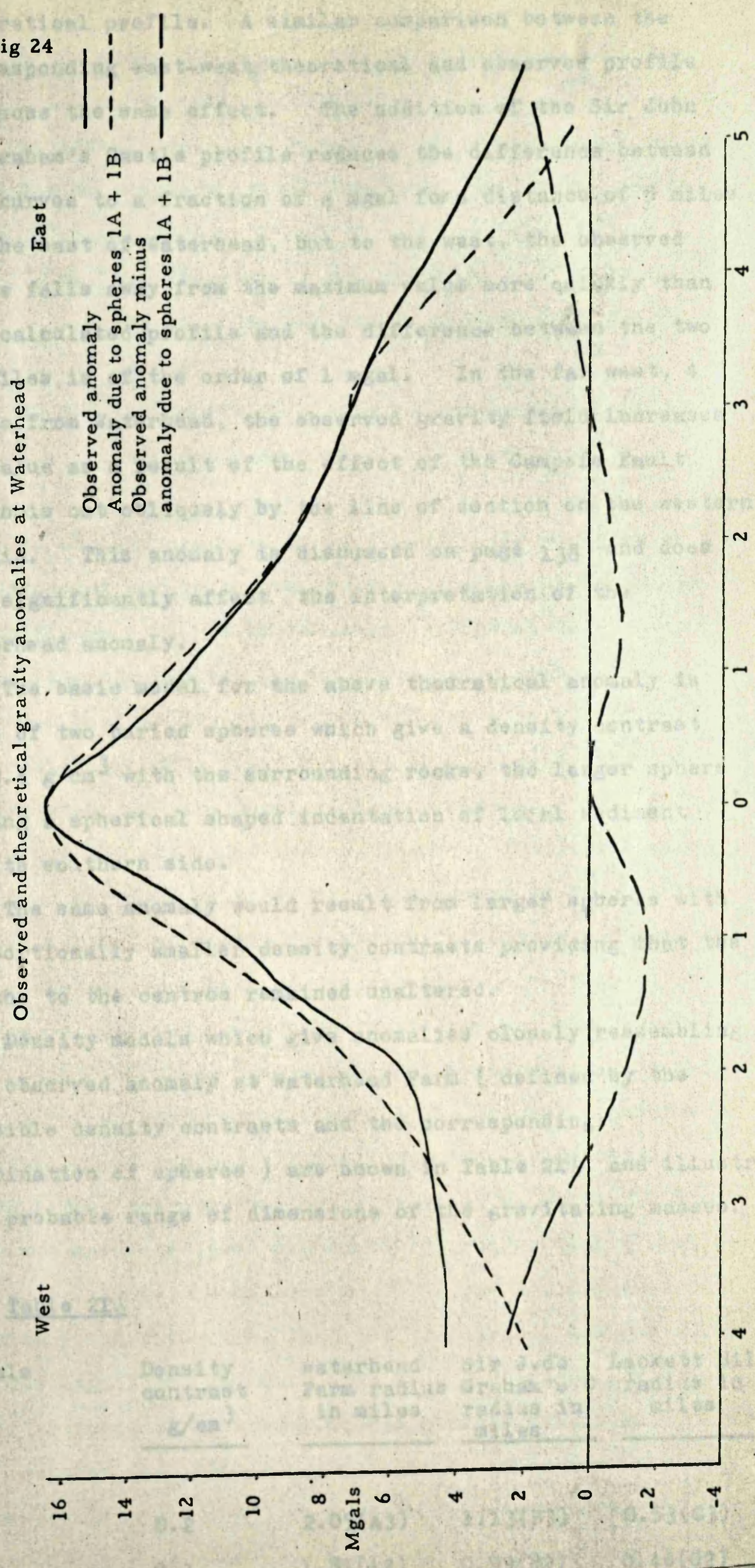


Fig 24

Observed and theoretical gravity anomalies at Waterhead theoretical profile. A similar comparison between the corresponding east-west theoretical and observed profile produces the same effect. The addition of the Sir John de Graham's Castle profile reduces the difference between the curves to a fraction of a mgal for a distance of 5 miles to the east of Waterhead, but to the west, the observed curve falls away from the maximum value more quickly than the calculated profile and the difference between the two profiles is of the order of 1 mgal. In the far west, 4 miles from Waterhead, the observed gravity field increases in value as a result of the effect of the Campsie Fault which is cut obliquely by the line of section on the western margin. This anomaly is discussed on page 138 and does not significantly affect the interpretation of the Waterhead anomaly.

The basic model for the above theoretical anomaly is made of two buried spheres which give a density contrast of 0.4 g/cm^3 with the surrounding rocks, the larger sphere having a spherical shaped indentation of local sediment on its southern side.

The same anomaly would result from larger spheres with proportionally smaller density contrasts providing that the depths to the centres remained unaltered.

Density models which give anomalies closely ressembling the observed anomaly at Waterhead Farm (defined by the possible density contrasts and the corresponding combination of spheres) are shown in Table 21A, and illustrate the probable range of dimensions of the gravitating masses.

Table 21A

Models	Density contrast g/cm^3	Waterhead Farm radius in miles	Sir J.de Graham's C radius in miles	Lackett Hill radius in miles
	0.2	2.05(A3)	1.13(B3)	0.53(C3)
Spheres	0.3	1.85(A2)	0.99(B2)	0.46(C2)
	0.4	1.65(A1)	0.90(B1)	0.42(C1)

In the above Table 21A, the identification code for each model is shown in parenthesis.

The anomaly due to a vertical cylinder closely resembles that due to a sphere if the following conditions hold:-

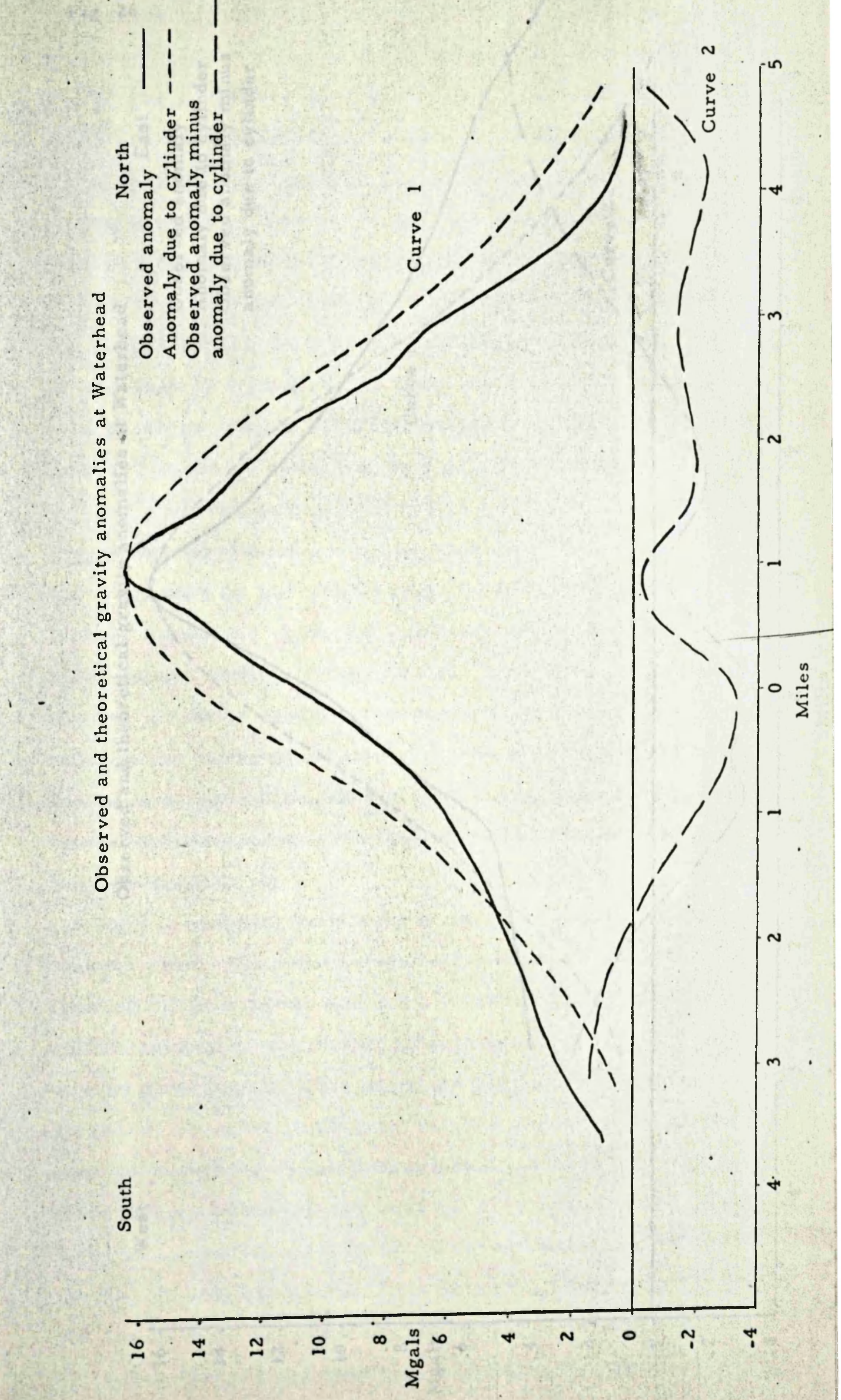
a. the diameter of the cylinder equals its height.
b. the cylinder has the same total mass as the sphere.
c. the centre of gravity of the cylinder is at the same depth as that of the sphere.

The anomaly produced by such a cylinder would be a worse approximation to the observed anomaly at Waterhead (see Fig 25). It is, however, important to compute the dimensions and the gravitational attraction of a cylinder because its dimensions and the form of its theoretical gravity field may act as a guide to the construction of more complex density models.

Using the method devised by Skeels (1963), the anomaly due to a vertical cylinder of volume equal to that of the sphere A 1 is calculated for a density contrast of 0.4g/cm^3. The diameter and height of the cylinder is calculated to be 2.88 miles, and the depths to the top and base are 0.75 miles and 3.63 miles respectively. The anomaly due to this body is shown as Curve 1 (in Figs 25 and 26) and the residual anomalies which remain after the subtraction of Curve 1 from the observed curve is shown as Curve 2. The absolute value of these residuals is greater than 4 mgal within 1 mile to the west and south of the maximum observed turning point indicating that the cylindrical density model is less likely to resemble the true geological structure than the range of spherical models already computed.

Further confirmation of this is obtained from the use of Skeels method (1963) as a means of interpreting the observed anomaly. Instead of determining the theoretical anomaly due to a density model of given dimensions, the

Fig 25



Observed and theoretical gravity anomalies at Waterhead
North
South
Observed anomaly
Anomaly due to cylinder
Observed anomaly minus
anomaly due to cylinder
Curve 1
Curve 2
Mgals
16
14
12
10
8
6
4
2
0
-2
-4
4
3
2
1
0
1
2
3
4
5
Miles

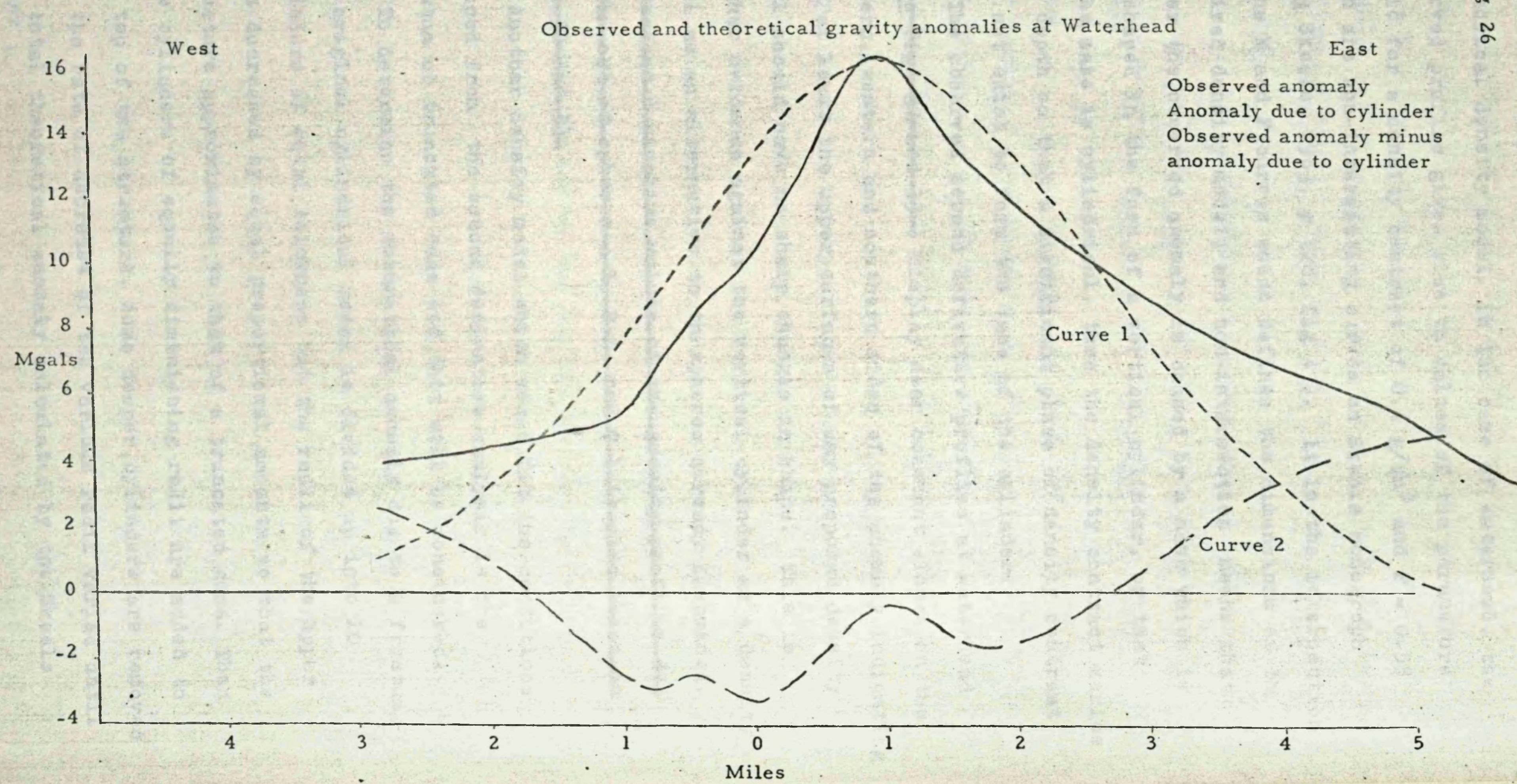

Observed and theoretical gravity anomalies at Waterhead
West
East
Observed anomaly
Anomaly due to cylinder
Observed anomaly minus
anomaly due to cylinder
Curve 1
Curve 2
Mgals
16
14
12
10
8
6
4
2
0
-2
-4
4
3
2
1
0
1
2
3
4
5
Miles

Fig 26

observed anomaly is used to determine the dimensions of a cylindrical density model. In the case of Waterhead, the observed profile gives rise to values of the parameters M = 18 for a density contrast of 0.4 g/cm^3 and F = 0.55 which are non-intersecting curves on Skeels nomograph (see Skeels, 1963, p 728, fig 4). It is the intersection of the M and F curves which defines the dimensions of the required density model, and non-intersection means that either the observed anomaly is caused by a mass which is not shaped in the form of a vertical cylinder, or that if the mass is cylindrical, then the density contrast varies with depth so that a significant plane of density contrast does not exist to form the base of the cylinder.

The observed second derivative profiles at Waterhead ~~(see Figs 32 and 33)~~ display near constant slopes on the eastern, western and southern sides of the anomaly indicating that at least the upper surfaces of any proposed density model should have no sharp changes in shape. This is further evidence against the vertical cylinder as a density model as an alternative to the spheres already discussed. ~~The second derivative values of the gravity profiles due to the set of spheres A 1, B 1, and C 1 is also shown on Figs 32 and 33.~~

Another density model which would fit the conditions deduced from the second derivative analysis is the frustum or truncated cone and this will be considered.

To determine the theoretical anomaly due to a frustum, the original cylindrical model is divided up into 10 cylinders of equal thickness but the radii of the upper ones decreased by equal proportional amounts so that the structure approximates to that of a truncated cone. Then more cylinders of equally diminishing radii are added to the top of the structure, some deeper cylinders are removed and the rate of decrease of the various radii varied until the total theoretical anomaly calculated by the Skeels method (

method (1963, pp 724 – 735) due to all the cylinders gives a reasonable fit to the observed anomaly.

The dimensions of three frusta for density contrasts of 0.2 g/cm^3, 0.3 g/cm^3, and 0.4 g/cm^3 which give an identical set of anomalies resembling the observed anomaly at Waterhead Farm is shown in Table 22B .

Table 22B.

	Frustum 1 A	Frustum 1 B	Frustum 1 C
Depth to upper surface	0.46 mls	0.32 mls	0.26 mls
Depth to lower surface	3.05 mls	3.22 mls	3.34 mls
Upper radius	0.59 mls	0.67 mls	0.74 mls
Lower radius	1.88 mls	2.14 mls	2.35 mls
Density contrast	0.4 g/cm^3	0.3 g/cm^3	0.2 g/cm^3

(see Fig 19)

The theoretical anomaly due to this range of models is shown as Curve 1 in Figs 27 and 28 .

The theoretical anomaly displays a very good fit to the observed curve on the north and west sides and is reasonably close on the south side but falls considerably short to the east where the Sir John de Graham's Castle anomaly contributes to the gravity field. The computed anomaly still appears to be a little broader than the observed curve near to the maximum value and in an attempt to improve this fit still further, the theoretical anomaly due to a second frustum is calculated for a position nearer to the surface and of narrower top cross section. The dimensions of this model for a density contrast of 0.4 g/cm^3 are:-

Depth to upper surface	=	0.18 miles
" " lower "	=	2.48 miles
Upper radius	=	0.44 miles
Lower "	=	1.58 miles
Density contrast	=	0.4 g/cm^3

(see Fig 19).

Fig 27

Observed and theoretical gravity anomalies at Waterhead

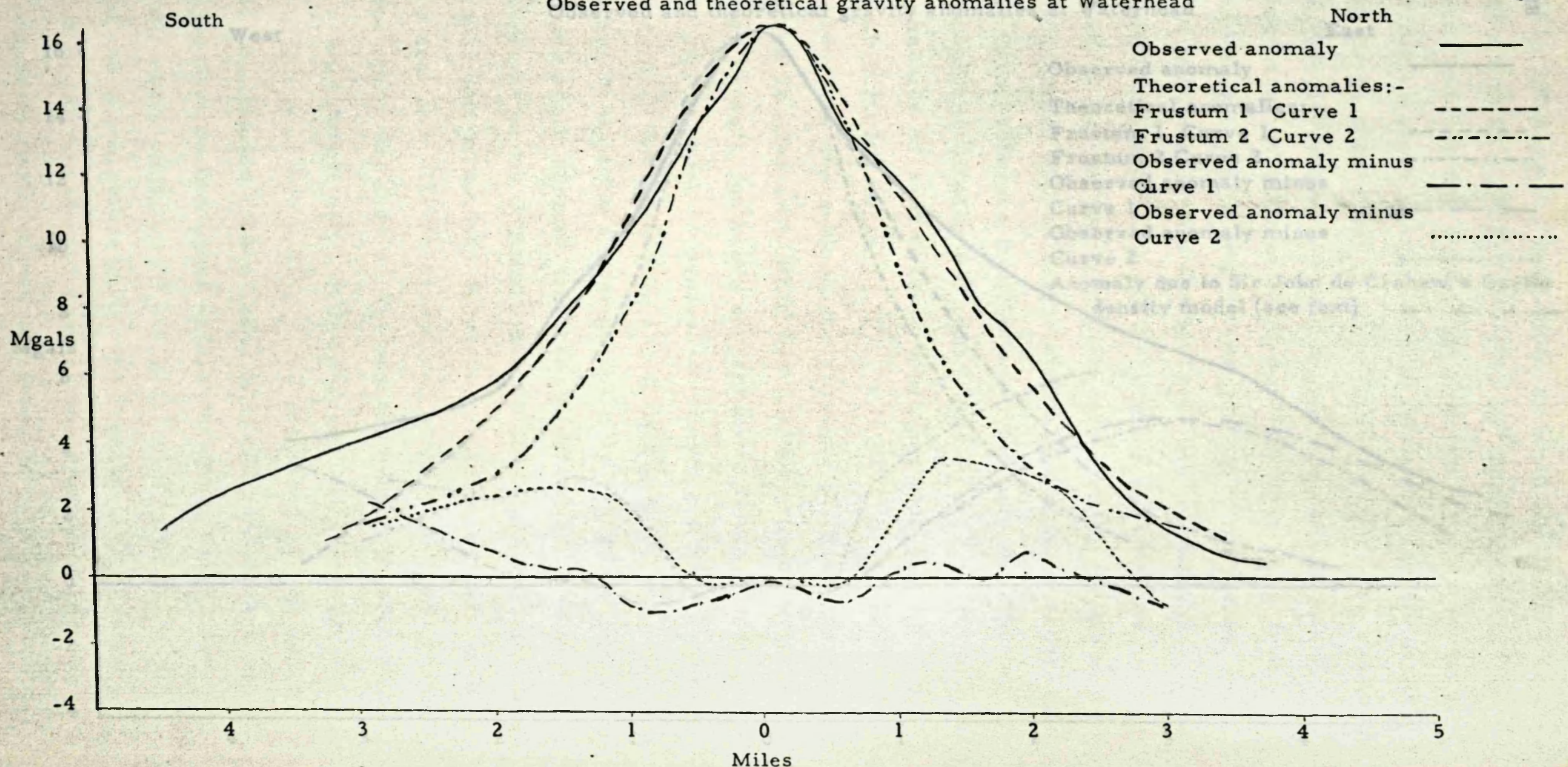
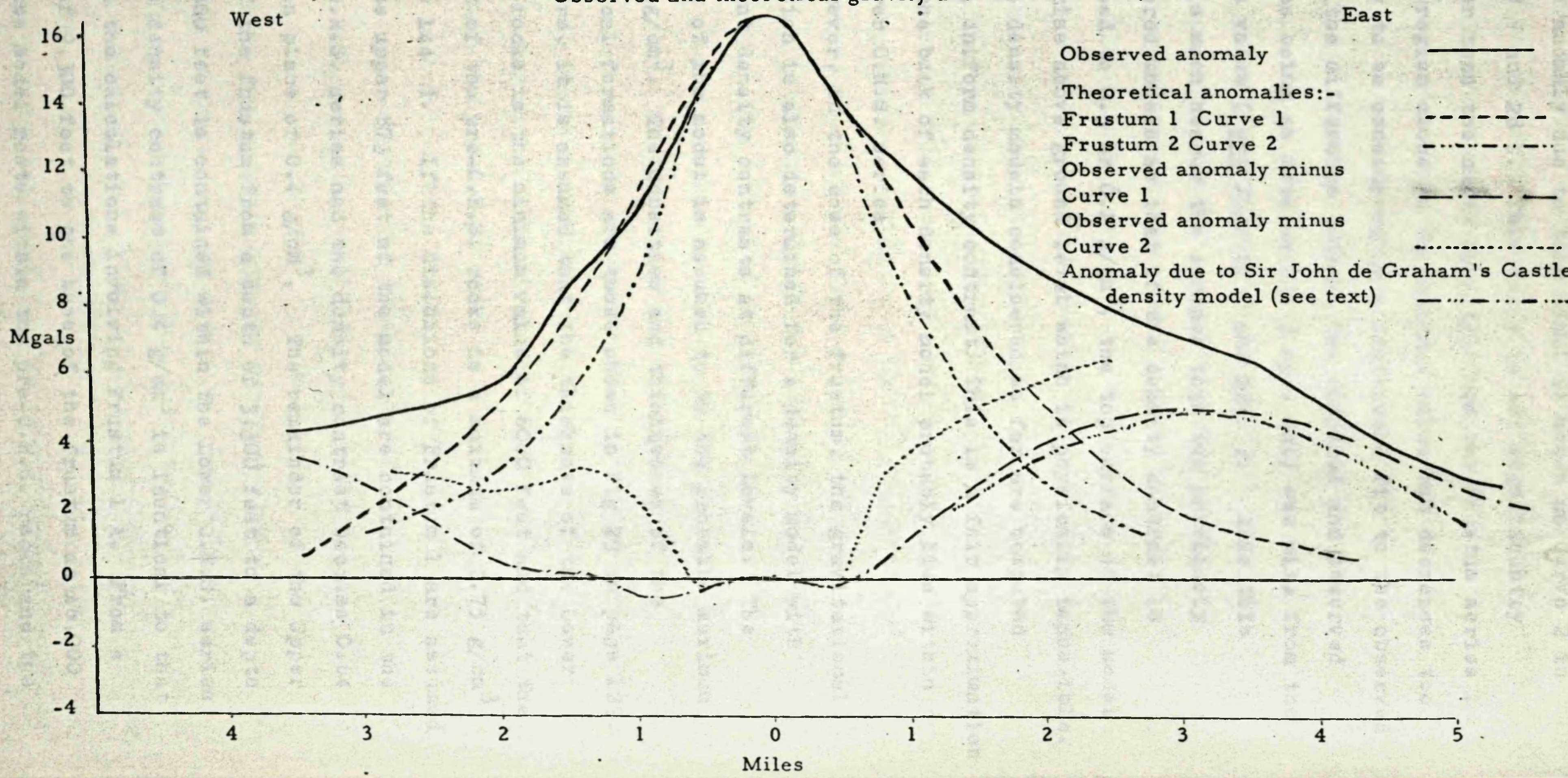


Fig 28

Observed and theoretical gravity anomalies at Waterhead



The anomaly due to this model is shown as Curve 2 in Figs 27 and 28. This curve is not significantly narrower than the curve computed from the Frustum series 1 in the region close to the maximum value but decreases too steeply to be considered as a reasonable fit to the observed curve, the difference between the computed and observed profiles being as much as 2 - 3 mgal only one mile from the maximum value (<u>see</u> Figs 27 and 28). Also this model is much nearer the surface than the previously considered models so that if the density contrast is decreased to 0.3 or 0.2 g/cm^3, the top surface of the model would rise above ground level which is physically impossible. All the density models considered so far are computed using a uniform density contrast. This is a fair approximation since the bulk of each density model probably lies within the Lower O.R.S. series.

However, in the case of the frustum, the gravitational attraction is also determined for a density model with different density contrasts at different levels. The density of the model is assumed to be the probable maximum of 3.0 g/cm^3. The densities and thicknesses of the geological formations are those shown in Fig 29 on page 129. Therefore, it is assumed that the thickness of the Lower O.R.S. rocks is the minimum value of 6000 feet and that the density of the pre-O.R.S. rocks is a maximum of 2.75 g/cm^3 (<u>see</u> p 144). If the dimensions of Frustum 1 are assumed then the upper 873 feet of the model are contained in the Upper O.R.S. series and the density contrast becomes 0.64 g/cm^3 in place of 0.4 g/cm^3. The remainder of the Upper part of the frustum from a depth of 3,300 feet to a depth of 9,300 feet is contained within the Lower O.R.S. series and the density contrast of 0.4 g/cm^3 is identical to that used in the calculations involving Frustum 1 A. From a depth of 9,300 feet to the base of the frustum at 16,000 feet, the model rests within the pre-O.R.S. rocks and the density contrast is 0.25 g/cm^3 (<u>see</u> Fig 29). The gravity attraction due to this modified version of Frustum 1 rises to a maximum value of only 14.5 mgal which is 2 mgal less than the observed anomaly at Waterhead. The simplest modification which can be made to this layered frustum to improve the correlation between its theoretical gravity field and the observed anomaly is to add the effect of a small vertical cylinder placed on the top of the frustum. The height of this cylinder is 310 feet and its diameter is 620 feet for a density contrast of 0.64 g/cm^3.

The anomaly due to this model, Frustum 3, is shown in Figs 30 K and 31 I and appears to exhibit a slightly better fit to the observed anomaly than that due to the set of Frusta 1 A, 1 B, and 1 C.

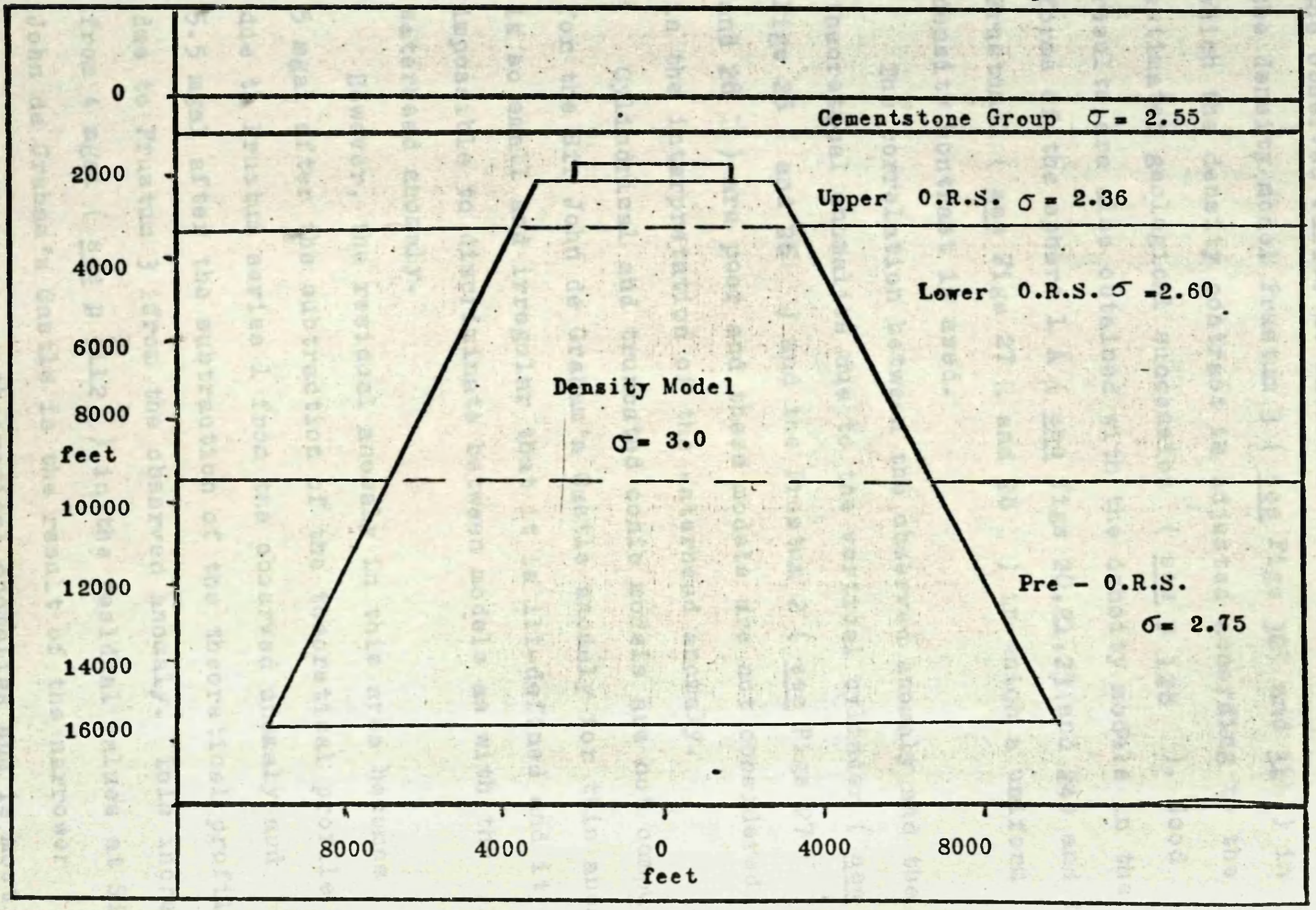
A comparison between the residual values after the subtraction of the theoretical anomalies from the observed anomaly in the cases of all the density models computed shows that in the case of Frustum 3, the smallest residual values are produced in the region of Waterhead (see Fig 30). The effect of the layered frustum with smaller density contrasts based on a density of 2.9 g/cm^3 for the model is not calculated in detail because the size of the model required is larger than could be accommodated within the known geological section in a meaningful way.

In order to maintain approximately the same gravity profile as that due to Frustum 3, the volume of the model has to be considerably increased whilst the basic shape remains approximately the same. However, the greater part of the enlarged model rests within the pre-O.R.S. rocks with a density contrast of only 0.15 g/cm^3. To compensate for this low density contrast without distorting the base of the model, the upper part must be extended upwards to the surface and since there is no field evidence in the Waterhead area of the existence of any such structure, the model is abandoned.

From an examination of the 2nd order residual anomalies

Fig 29

Density Model - Frustum 3



(see Figs 20,21,23 - 28,30 and 31), that is, the residual anomaly remaining after the subtraction of the theoretical anomaly from the observed anomaly, it is seen that the theoretical anomaly which gives the best correlation with the observed values at Waterhead is that associated with the density model Frustum 3 (see Figs 30 and 31) in which the density contrast is adjusted according to the estimated geological succession (see p 128). Good results are also obtained with the density models in the forms of the sphere 1 A (see Figs 20,21,23 and 24) and the Frustum 1 (see Figs 27 and 28) in which a uniform density contrast is used.

The correlation between the observed anomaly and the theoretical anomalies due to the vertical cylinder (see Figs 25 and 26) and the Frustum 2 (see Figs 27 and 28) are poor and these models are not considered in the interpretation of the Waterhead anomaly.

Cylindrical and truncated conic models are not computed for the Sir John de Graham's Castle anomaly for this anomaly is so small and irregular that it is ill-defined and it is impossible to discriminate between models as with the Waterhead anomaly.

However, the residual anomaly in this area becomes 5 mgal after the subtraction of the theoretical profile due to Frustum series 1 from the observed anomaly and 5.5 mgal after the subtraction of the theoretical profile due to Frustum 3 from the observed anomaly. This increase from 4 mgal (see p 112) in the residual values at Sir John de Graham's Castle is the result of the narrower profiles of the above theoretical anomalies and is most easily accounted for by increasing the size of the range of spherical density models in the area of the Castle.

The depth to the centre of these spheres is 9500 feet below the local datum (see p 112) and the radii for the set associated with Frustum set 1 are shown below for density

Fig 30

Observed and theoretical gravity anomalies at Waterhead

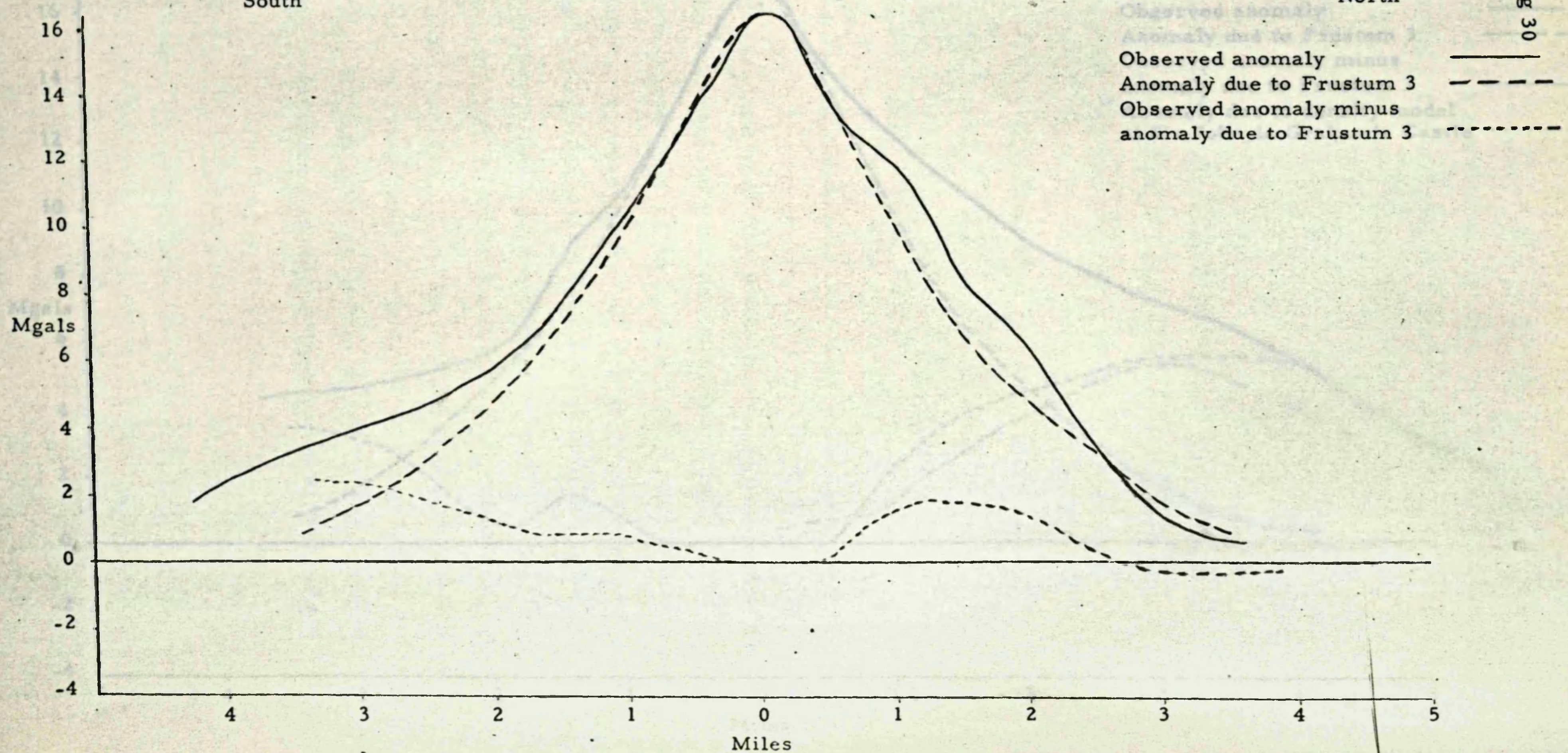
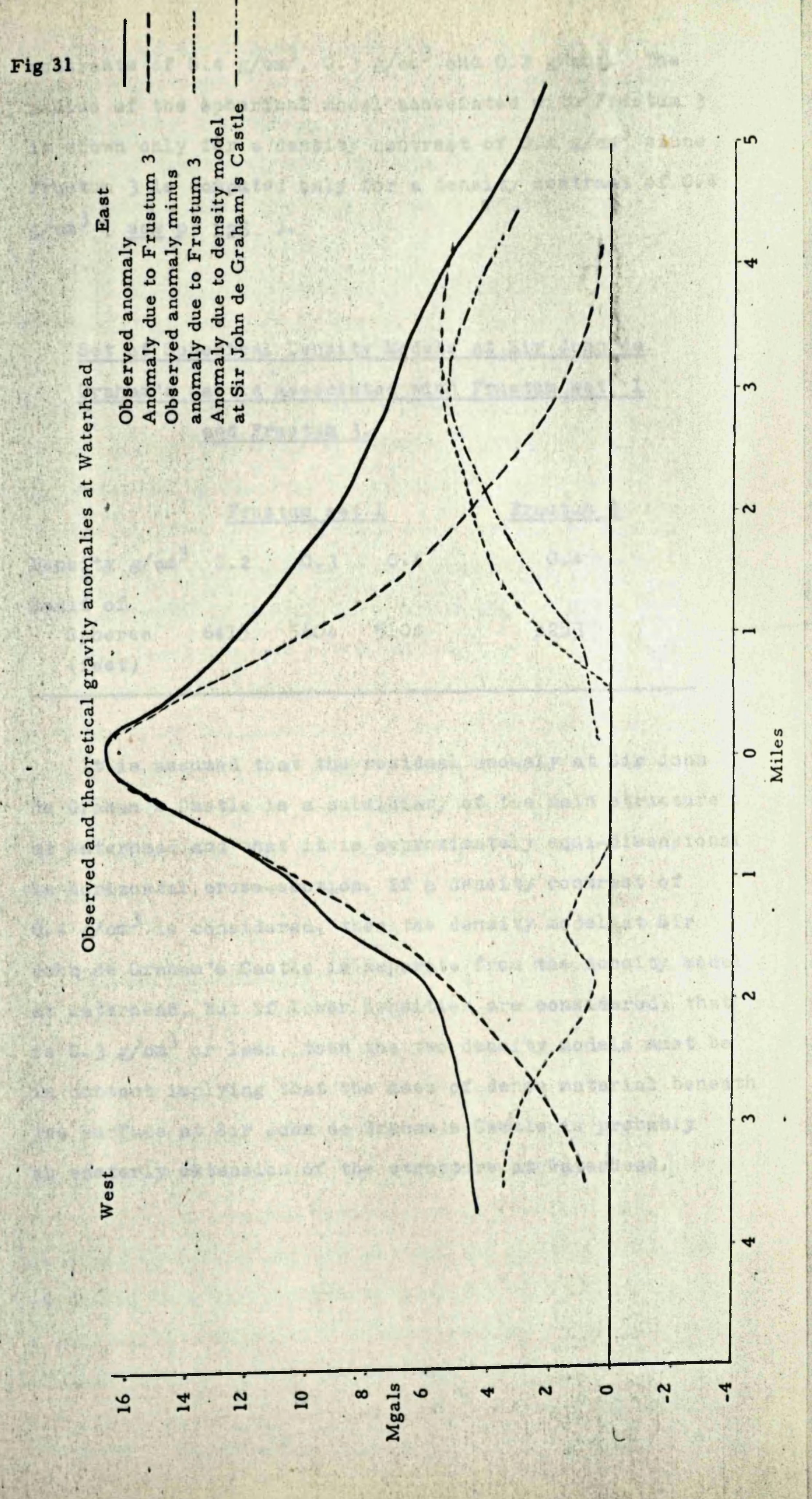


Fig 31


Observed and theoretical gravity anomalies at Waterhead
West
East
Observed anomaly
Anomaly due to Frustum 3
Observed anomaly minus
anomaly due to Frustum 3
Anomaly due to density model
at Sir John de Graham's Castle
Mgals
16
14
12
10
8
6
4
2
0
-2
-4
4
3
2
1
0
1
2
3
4
5
Miles

contrasts of 0.4 g/cm^3, 0.3 g/cm^3 and 0.2 g/cm^3. The radius of the spherical model associated with Frustum 3 is shown only for a density contrast of 0.4 g/cm^3 since Frustum 3 is computed only for a density contrast of 0.4 g/cm^3 (see p 128).

Set of Spherical Density Models at Sir John de Graham's Castle Associated with Frustum set 1 and Frustum 3.

	Frustum set 1			Frustum 3
Density g/cm^3	0.2	0.3	0.4	0.4
Radii of Spheres (feet)	6415	5604	5104	5253

It is assumed that the residual anomaly at Sir John de Graham's Castle is a subsidiary of the main structure at Waterhead and that it is approximately equi-dimensional in horizontal cross-section. If a density contrast of 0.4 g/cm^3 is considered, then the density model at Sir John de Graham's Castle is separate from the density model at Waterhead, but if lower densities are considered, that is 0.3 g/cm^3 or less, then the two density models must be in contact implying that the mass of dense material beneath the surface at Sir John de Graham's Castle is probably an easterly extension of the structure at Waterhead.

<u>Magnetic results at Waterhead.</u> The results of the magnetic traverses (traverses M4 and M5) show no marked anomalies and are unusually constant compared with the results of traverses over lavas in other localities in the Campsie Hills (<u>see</u> Figs 34 and 35 and p 136).

<u>Geological interpretation of the density models.</u> The rock-types which lie within the density range 2.8 - 3.0 g/cm^3 and which may be present in the sediments of the Old Red Sandstone of the Midland Valley are rocks of basic igneous type. It is inferred therefore that the Waterhead anomaly is produced by a large basic intrusion, the form and magnitude of which is approximately that of one of the range of computed models, and the mass under Sir John de Graham's Castle is an extension of the main intrusion and not isolated from it. The 2nd order negative anomaly which is a result of over-estimation of the magnitude of the large spherical density models (<u>see</u> spheres A1, A2, and A3, p 119) in the region of Lackett Hill, may be explained by a sandstone filled indentation in the surface of the igneous intrusion.

<u>Geological evidence</u>. Following the discovery of the Waterhead anomaly, the local geology was re-examined. J.G. Macdonald (personal communication) confirms the open anticlinal structure of the lavas in the Carron Valley - Waterhead area from his detailed mapping. There is little exposure in this area and field relations are difficult to establish, but small exposures of a gabbroic intrusion are present and the lavas surrounding Waterhead farm for a distance of ½ - ¾ of a mile display a zone of alteration with an increase in the proportion of iron pyrites in the basalt indicating that the area had been exposed at one time to hydrothermal alteration from some hitherto unknown source.

Fig 34

Magnetic anomalies in the Waterhead area.

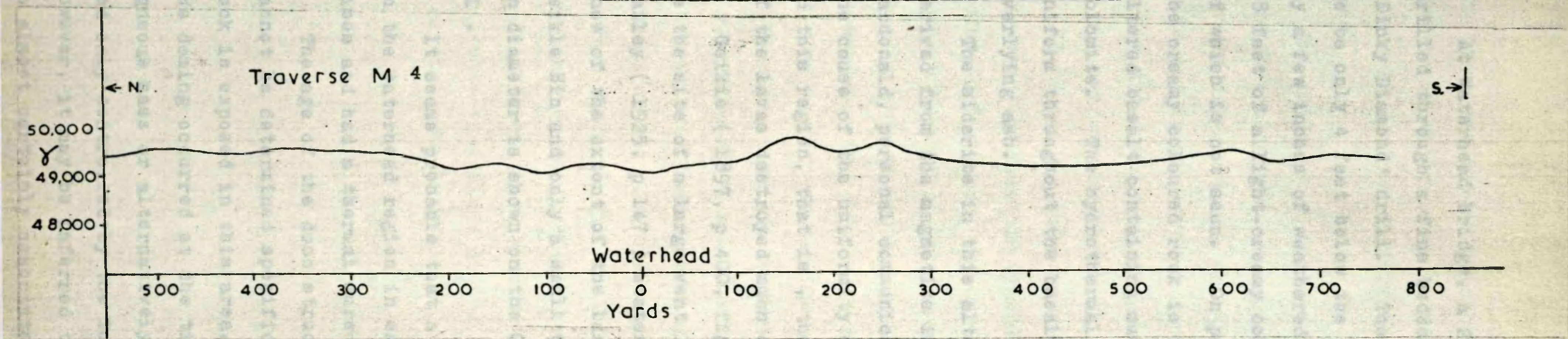
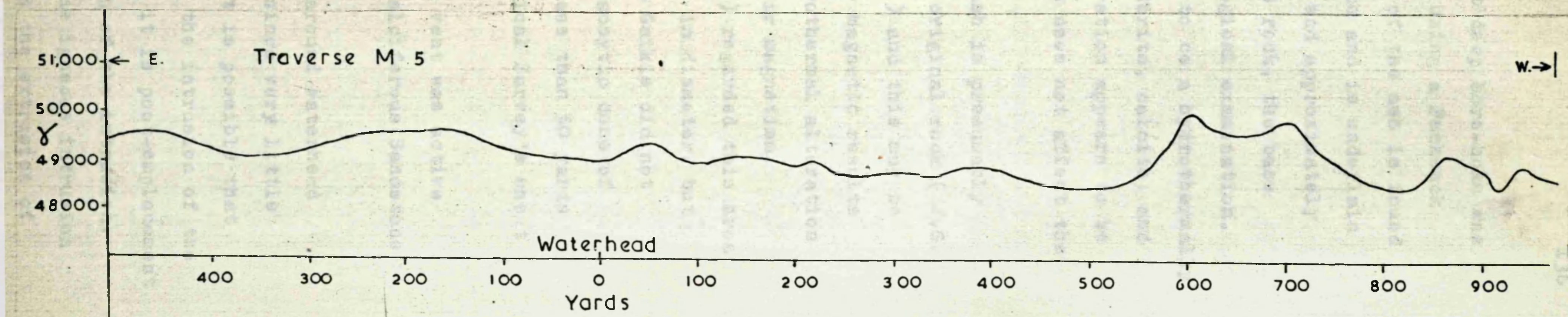


Fig 35

Magnetic anomalies in the Waterhead area.



At Waterhead bridge, a 22-foot deep bore-hole was drilled through a fine bedded ash using a Packsack 'Dinky Diamond' drill. The base of the ash is found to be only 4 feet below the surface and is underlain by a few inches of weathered clay and approximately 18 feet of a light-creamy coloured rock, the base of which is not seen. On petrological examination, the creamy coloured rock is found to be a hydrothermally altered basalt containing much siderite, calcite, and dolomite. The hydrothermal alteration appears to be uniform throughout the basalt, but does not affect the overlying ash.

The siderite in this altered ash is presumably derived from the magnetite in the original rock (J.G. Macdonald, personal communication) and this may be the cause of the uniformity of the magnetic results in this region, that is , the hydrothermal alteration of the lavas destroyed much of their magnetism.

Geikie (1897, p 400, fig 128) regarded this area as the site of a large vent 1 mile in diameter, but Bailey (1925, p 147) states that Geikie did not know of the extent of the large trachytic cone of Meikle Bin and only a small vent less than 50 yards in diameter is shown on the Geological Survey's sheet 31 .

It seems probable that a large vent was active in the Waterhead region in early Calciferous Sandstone times and had a thermal aureole.

The age of the dome structure around Waterhead cannot be determined specifically since very little rock is exposed in this area. It is possible that the doming occurred at the time of the intrusion of the igneous mass or alternatively that it is post-emplacement and only controlled by the location of the intrusion. However, it may be inferred that the igneous intrusion is almost certainly associated with the extrusion of the lavas and probably represents a high level magma chamber in which magma having risen from greater depths underwent further differentiation before extrusion as lava.

The presence of the unaltered ash above the altered lava flow at Waterhead suggests the date of the Waterhead vent as very early in the volcanic history of the Campsie Hills and it was perhaps one of the first intrusions to appear and could have supplied some of the lower basalts of the eastern Campsies.

It is not possible to determine how many local vents were supplied from the Waterhead magma chamber and J.G. Macdonald (personal communication) believes that the Jedburgh basalts of the Western Campsies were derived from the line of fissure eruptions to the north-west, the evidence for this being in the flow directions detected in the crystalline structures of the fabric of the basalts. At its nearest point, this line of fissures is approximately 5 miles north-west of Waterhead and so it is unlikely that these eruptions were connected directly to the Waterhead magma chamber.

From chemical analyses of the lavas, J.G. Macdonald (personal communication) considers that the probable composition of the intrusion at Waterhead, if it is a plutonic equivalent of the lavas, would be that of an olivine-gabbro.

The Kilpatrick Hills anomaly

The gravity anomalies in the Kilpatrick hills rise to a maximum value of 5.5 mgal at Craigmaddie (<u>see</u> Map 3) where the top of the lava succession is seen. The base of the lavas is exposed at Bowling in the west, and a general dip of $2^\circ - 3^\circ$ to the south-east is required to account for the gravity gradient.

At Craigmaddie, the total thickness of the lava is calculated to be 2,250 feet using the Bouguer formula (<u>see</u> pp 33-34).

The Campsie Fault anomaly

This is the second largest anomaly within the area of the survey, both in magnitude and in areal coverage although in these respects, it is much smaller than the waterhead anomaly described above (<u>see</u> pp106-137). The anomaly is elongated in an east-west direction and extends from the Whangie to Campsie Glen (<u>see</u> Map 3), a distance of approximately eight miles. It is parallel to the Campsie Fault and is situated just to the south of this structure. It is generally about 2 miles wide over most of its length. The magnitude of the anomaly reaches a maximum of 7 mgal near its eastern extremity at Campsie Glen and decreases evenly westwards to 2 mgal at the Whangie.

Clearly, the principal cause of the anomaly is the preservation of a thick pile of lava flows on the southern and downthrown side of the Campsie Fault. In the west, the throw of the fault can be determined by simply computing the thickness of lava required to give the observed gravity anomaly using the Bouguer formula for an infinite slab of material (<u>see</u> p 33). Since the base of the lavas is exposed on the northern side of the fault in cliff sections at about datum level (300 feet above O.D.) in the Strathblane and Campsie Glen area, very little further correction is necessary to estimate the total throw of the fault. However, in the east, the throw of the fault increases to approximately 3,000 feet at Campsie Glen and there must be a significant contribution to the gravity field from deeper planes of contrast. Therefore, a more sophisticated density model is erected in this area to explain the anomaly and the problem is further complicated by a system of smaller, parallel faults to the south. These smaller faults intersect the detailed traverse Q (see Map 1) and are interpreted below (see p 150), but their effect must be included in any density models used in the interpretation of the Campsie Fault anomaly to obtain a meaningful correlation between the observed and theoretical profiles.

To the west of Carbeth, at the Whangie, the local anomaly related to the Campsie Fault is +2.0 mgal which may be produced by a block of lava 800 feet thick below the local datum at +300 feet above O.D. The base of the lavas is not seen on the northern side of the fault at this locality and Upper O.R.S. rocks are exposed at the surface therefore the 800 feet thickness of lava represents a lower limit for the throw of the Campsie Fault at the Whangie.

However, at Strathblane, only 4 miles to the east, the base of the lavas is exposed at a height of 200 feet above the local datum on the upthrown side of the fault. In this region, the lavas are almost flat-lying and therefore the throw of the Campsie Fault at the Whangie is approximately 1000 feet.

At Carbeth, there appears to be interference from the gravity effects of local structures and the map of 2nd derivatives (see Fig 10) shows an isolated anomaly of $+200 \times 10^{-5}$ c.g.s. units. The interpretation of this area is discussed later (see p150). To the east of Carbeth, the local anomaly related to the Campsie Fault increases to +5.0 mgal suggesting an increase in the thickness of the downthrown block of lavas to approximately 2,000 feet below the local datum. Carbeth is only 2 mile west of the exposure of the base of the lavas at Strathblane (see above) and therefore an estimation of the throw of the Campsie Fault arrived at by adding the thickness of the block of lavas on the downthrown side to the height above the local datum of the base of the lavas on the upthrown side can be made with more certainty than at the Whangie. In this case, the total throw is approximately 2,200 feet.

At Lennoxtown, the anomaly reaches its maximum value of +7.0 mgal which represents a thickness of lava of 2,750 feet. In Campsie Glen, less than half a mile to the north, the base of the lavas is exposed at approximately 500 feet above O.D., that is, 200 feet above the local datum, therefore a first estimate of the total throw of the fault is 2950 feet. To the east of Lennoxtown, the anomaly decreases rapidly in magnitude and becomes difficult to distinguish or to interpret with certainty.

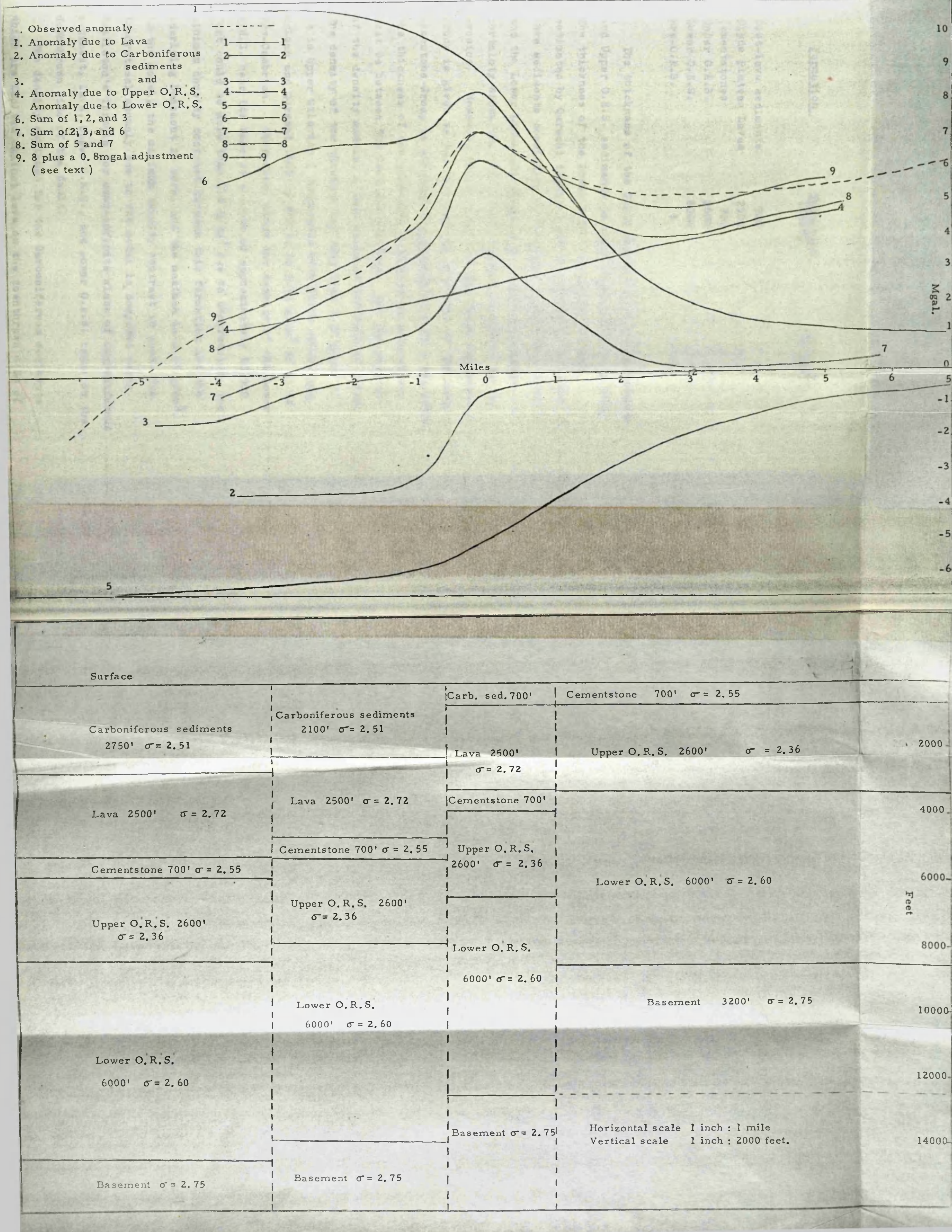
In considering a vertical displacement of 2950 feet at Lennoxtown, it is not strictly valid to interpret the anomaly solely in terms of the displacement of the base of the lavas. The effects of deeper planes of contrast must be considered.

The geology of this locality is described (see Clough and others, 1925, pp 191-198) and it is possible to erect density models based on probable stratigraphical thicknesses and it is necessary only to confirm the known structure by demonstrating agreement between the observed and theoretical anomalies.

A fault model of a more sophisticated nature is erected and includes two smaller parallel faults to take account of the parallel faults to the south of the Campsie Fault (see Fig 36).

The geological succession used in the density models is as follows:-

Fig 36 Observed and theoretical anomalies over the Campsie Fault



Formation	Thickness (feet)	Density (g/cm^3)
Post-lava sediments	700	2.51
Clyde Plateau Lavas	2500	2.72
Cementstones	700	2.55
Upper O.R.S.	2600	2.36
Lower O.R.S.	6000	2.60
Pre-O.R.S.	?	2.75

The thickness of the Clyde Plateau Lavas, Cementstones and Upper O.R.S. sediments is known (see Table 4, p 17). The thickness of the Lower O.R.S. sediments is that estimated by Qureshi (1961). The thickness of the post-lava sediments consisting of the Upper Sedimentary Group and the Lower Limestone Group is not known with great certainty since the top of the sequence is absent due to erosion. However, the thickness of the Upper Sedimentary Group is given as 500 feet and the thickness of the Lower Limestone Group is 400 feet (see Table 4. p 17) therefore the thickness of the post-lava sediments at Lennoxtown must be between 500 feet and 900 feet. For the purposes of the density models, a mean value of 700 feet is taken. The density of the basement may vary from 2.65 g/cm^3 if it is Upper Silurian (comparable with North Wales, see McLean and Qureshi 1965, p 278), to 2.75 g/cm^3 if it is Pre-Cambrian. Therefore, since the density of the Lower O.R.S. near its base at a depth of approximately 10,000 feet could be more than 2.6 g/cm^3 due to compression, the minimum density contrast between this formation and the uderlying basement is zero, and the maximum is 0.15 g/cm^3. In the model, the maximum density contrast is used. The theoretical anomaly due to the model is computed using Nettleton's formula for semi-infinite slabs of Carboniferous sediment, lava, Upper O.R.S., and Lower O.R.S. rocks on the downthrown side of the fault.

The density contrast for the Carboniferous sediments which are faulted against lava on the downthrown side of the fault to the south is 0.21 g/cm^3. The density contrast for the lava which is faulted against Upper O.R.S. sediments on the upthrown side of the fault is 0.36 g/cm^3. The density contrast for the Upper O.R.S. on the down-thrown side of the fault is 0.24 g/cm^3 and the density contrast for the Lower O.R.S. is 0.15 g/cm^3. The thickness of the slabs and their densities and density contrasts are shown in Fig 36.

These total theoretical anomalies are compared with the observed curve after removal of the regional gradient and it is seen that the theoretical values are consistently about 0.8 mgal. less than the observed values (see Fig 36).

Clearly such a constant discrepancy may be easily eliminated by making minor adjustments either to the densities used in the model, or to the thicknesses used, or a combination of both. However, there is no real significance to such adjustments other than to make the fit of the theoretical curve appear better since the absolute value of the local observed anomaly is determined from an estimate of the regional background anomaly.

The Gargunnock - Stirling anomaly

The decrease in the value of gravity to the north of Gargunnock cannot be explained in terms of the known solid geology. The ground in this region is very flat and the River Forth meanders across the area immediately to the north. The negative anomaly could be accounted for by the presence of a deep buried channel representing a former course of the river although there is no confirmatory evidence for this.

Assuming that the buried channel is filled with either recent river alluvium or more likely boulder clay since the surrounding area displays many glacial features, then a probable density contrast between these deposits in either case with a probable density of approximately 2.0 g/cm^3 and the Upper O.R.S. sediments with a density of approximately 2.36 g/cm^3 after rounding up to two decimal places (see p 62) would be 0.36 g/cm^3. Using the simple Bouguer correction and the above density contrast, the depth of the buried channels is computed to be 280 feet.

The Bannockburn anomaly

Part of this gravity gradient is due to the deep sedimentary basin forming the Stirling and West Fife coalfield. The dip of the sediments overlying the lavas is approximately 10^o to the east, therefore using Heiland's equation 7.43o (1940, p 153) for a two-dimensional right-triangular section and a density contrast of 0.21 g/cm^3 between the lavas and the overlying sediments, then the gravity gradient due to the dip of the sediments is 0.91 mgal per mile.

The observed gradient is 1.5 mgal per mile and so a residual gradient of 0.59 mgal per mile remains and this can be accounted for by assuming an attenuation of the lavas.

From the map of 1st order residual anomalies, the lavas are calculated to be 800 feet thick at North Third and 600 feet thick west of Dunipace, therefore the expected eastward limit of the lavas in this region is approximately 3.5 miles east of North Third along a north-west - south-east line from Stirling to Dennyloanhead.

Minor gravity anomalies

The anomaly between stations A42 and A45 (see Fig37). This anomaly shows a rise of approximately 0.3 mgal over an east-west quartz-dolerite dyke and the back-ground gravity profile is displaced approximately 0.2 mgal. It appears that the dyke has intruded along a pre-existing fault which is down-thrown to the south. The throw of the fault if calculated using the Bouguer formula from the displacement of the back-ground profile is 120 feet. However, the lavas are inferred to be approximately 700 feet thick at this point and the anomaly is too acute to be the result of displacement of the base of the lavas and the source of the anomaly must be much closer to the surface, probably an unusually dense lava flow preserved at the surface on the southern side of the fault, or a dense sill of dyke material intruded near the surface on the southern side, and therefore the throw must be less than 120 feet.

To obtain more information, magnetic traverses M 2 and M 3 are made over this dyke and the results are discussed on pages 165-168.

The anomaly between stations E 27 and E 10 (see Fig 38). This anomaly is accounted for by a fault which has a throw of approximately 400 feet. The base of the lava is thus stepped from datum level to 400 feet below. The ground level is 450 feet above datum.

The anomaly between stations J 33 and J 55 (see Fig 39) This broad anomaly coincides with the east-north-easterly extension of the Campsie Fault near Dunipace. The anomaly is accounted for by a slab of lava 630 feet thick which is preserved on the downthrown side of the fault. The throw of the fault is calculated to be approximately 1600 feet and the thickness of the slab represents the maximum development of the Clyde Plateau Lavas in this region.

Fig 37.

Gravity anomalies - traverse A

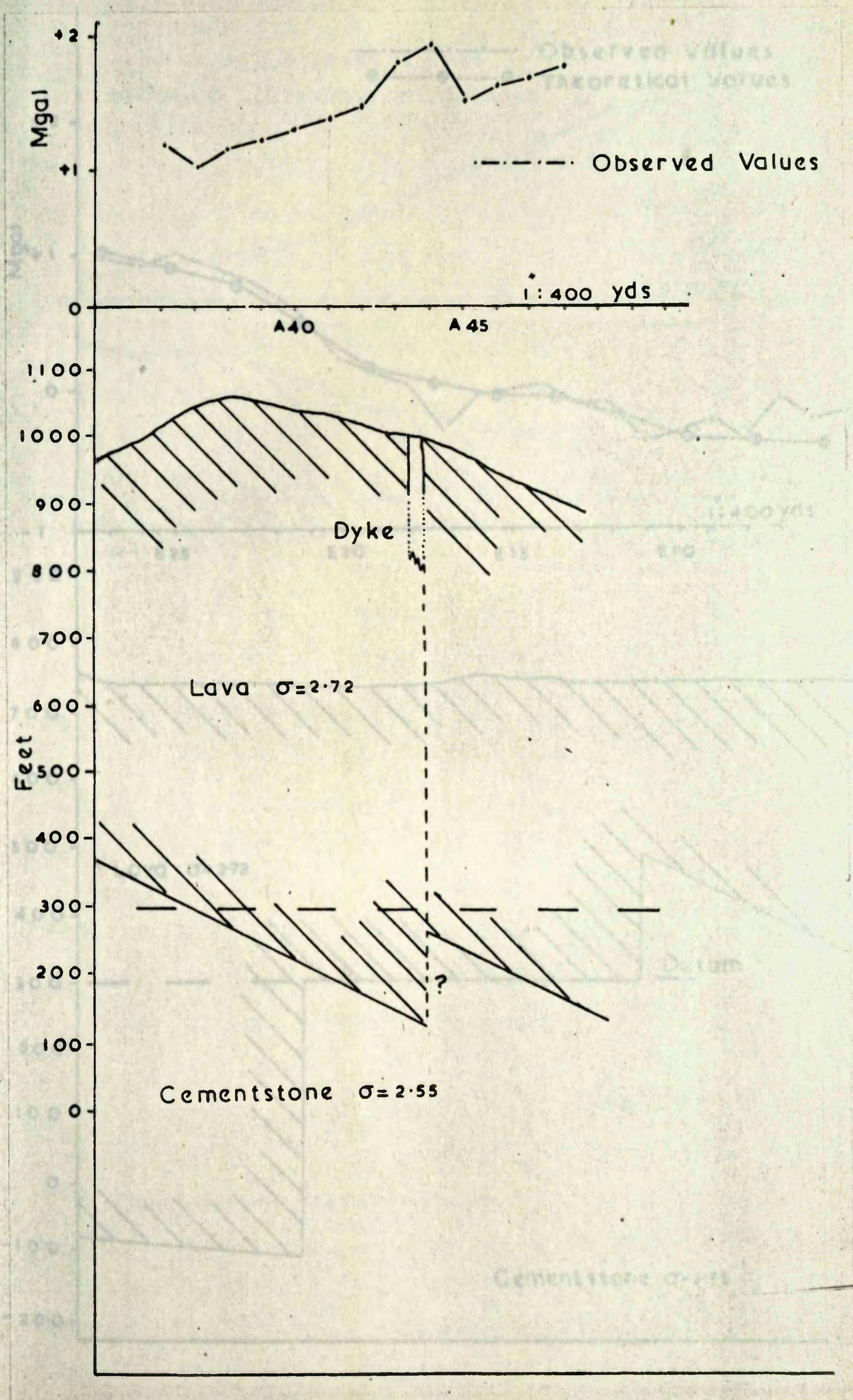


Fig 38

Gravity anomalies - traverse E

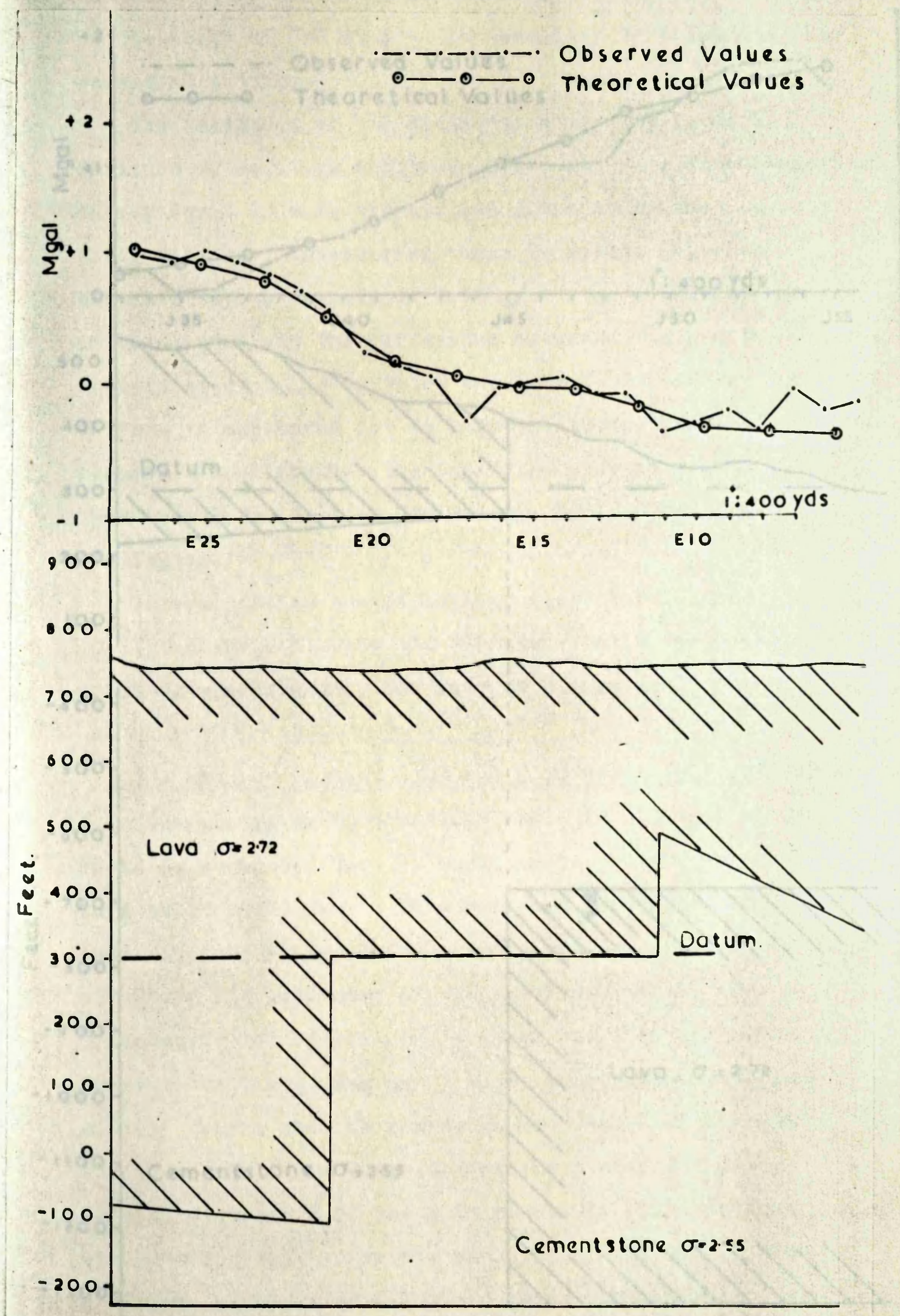
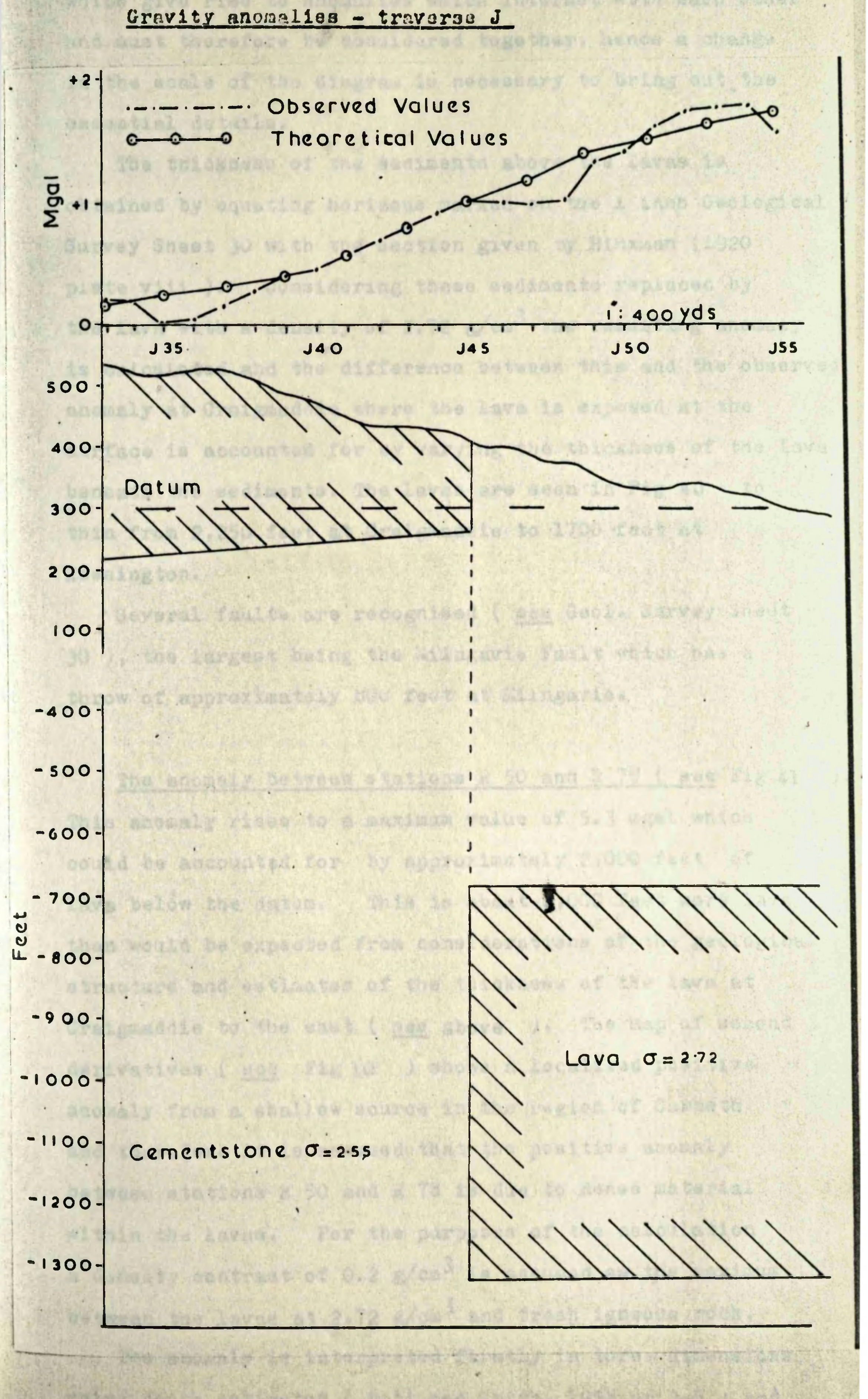


Fig 39


Gravity anomalies - traverse J
Observed Values
Theoretical Values
Mgal
+2
+1
0
1 : 400 yds
J35
J40
J45
J50
J55
500
400
300
200
100
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-1300
Feet
Datum
Lava σ = 2·72
Cementstone σ = 2·55

<u>The anomalies between stations Q 36 and Q 64</u> (<u>see</u> Fig 40). The traverse extends over several faults which give rise to anomalies which interact with each other and must therefore be considered together, hence a change in the scale of the diagram is necessary to bring out the essential details.

The thickness of the sediments above the lavas is obtained by equating horizons marked on the 1 inch Geological Survey Sheet 30 with the section given by Hinxman (1920 plate viii). Considering these sediments replaced by the lava with a density of 2.72 g/cm^3 the resulting anomaly is calculated and the difference between this and the observed anomaly at Craigmaddie where the lava is exposed at the surface is accounted for by varying the thickness of the lava beneath the sediments. The lavas are seen in Fig 40 to thin from 2,250 feet at Craigmaddie to 1700 feet at Kessington.

Several faults are recognised (<u>see</u> Geol. Survey Sheet 30), the largest being the Milngavie Fault which has a throw of approximately 800 feet at Milngavie.

<u>The anomaly between stations R 50 and R 78 (see</u> Fig 41). This anomaly rises to a maximum value of 5.3 mgal which could be accounted for by approximately 2,000 feet of lava below the datum. This is about 1,000 feet more lava than would be expected from considerations of the geological structure and estimates of the thickness of the lava at Craigmaddie to the east (<u>see</u> above). The map of second derivatives (<u>see</u> Fig 10) shows a localized positive anomaly from a shallow source in the region of Carbeth and therefore it is assumed that the positive anomaly between stations R 50 and R 78 is due to dense material within the lavas. For the purposes of the calculation a density contrast of 0.2 g/cm^3 is assumed as the maximum between the lavas at 2.72 g/cm^3 and fresh igneous rock.

The anomaly is interpreted firstly in three dimensions using depth estimates (Bott and Smith, 1958 pp 3-5) and

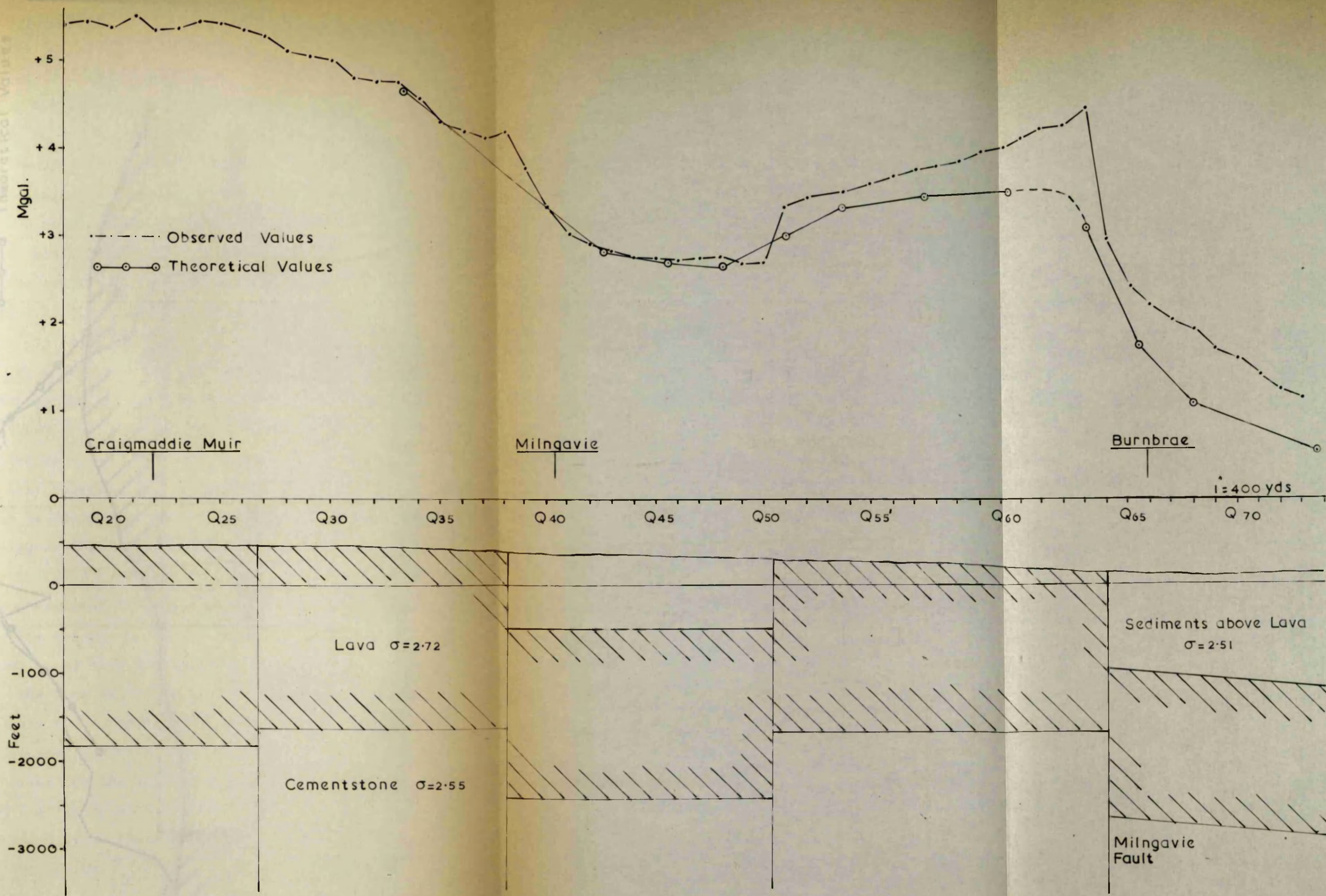
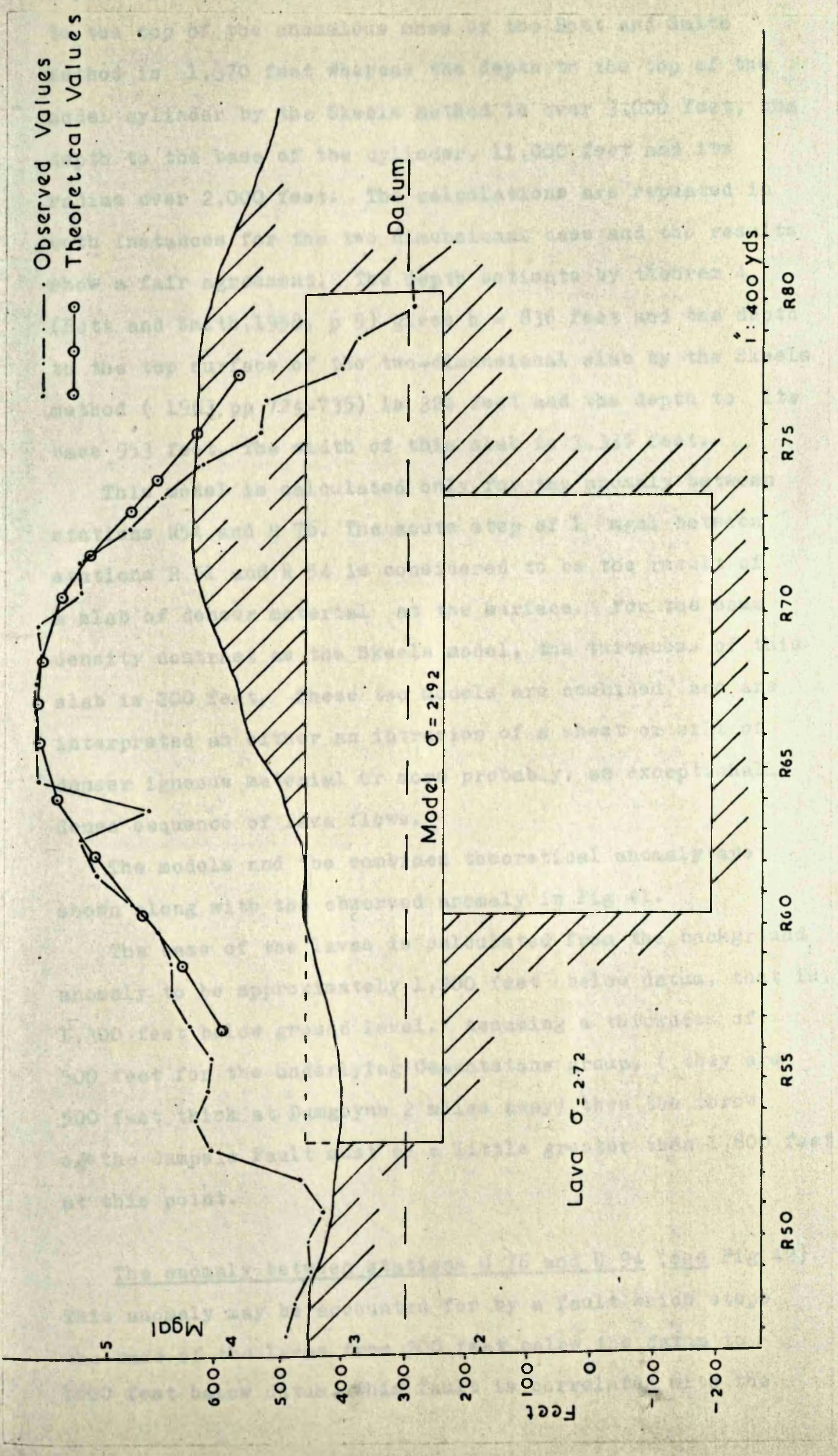


Fig 40 Observed and theoretical anomalies - Traverse Q, Milngavie.

Fig. 41

Gravity anomalies - traverse R



theoretical models (Skeels, 1963 pp 724-735). There is a poor agreement between the two methods, the limiting depth to the top of the anomalous mass by the Bott and Smith method is 1,370 feet whereas the depth to the top of the model cylinder by the Skeels method is over 3,000 feet, the depth to the base of the cylinder, 11,000 feet and its radius over 2,000 feet. The calculations are repeated in both instances for the two dimensional case and the results show a fair agreement. The depth estimate by theorem 4 (Bott and Smith,1958, p 5) gives h = 836 feet and the depth to the top surface of the two-dimensional slab by the Skeels method (1963 pp 724-735) is 324 feet and the depth to its base 953 feet. The width of this slab is 3,335 feet.

This model is calculated only for the anomaly between stations R54 and R 76. The acute step of 1 mgal between stations R 51 and R 54 is considered to be the result of a slab of denser material at the surface. For the same density contrast as the Skeels model, the thickness of this slab is 200 feet. These two models are combined, and are interpreted as either an intrusion of a sheet or sill of denser igneous material or more probably, an exceptionally dense sequence of lava flows.

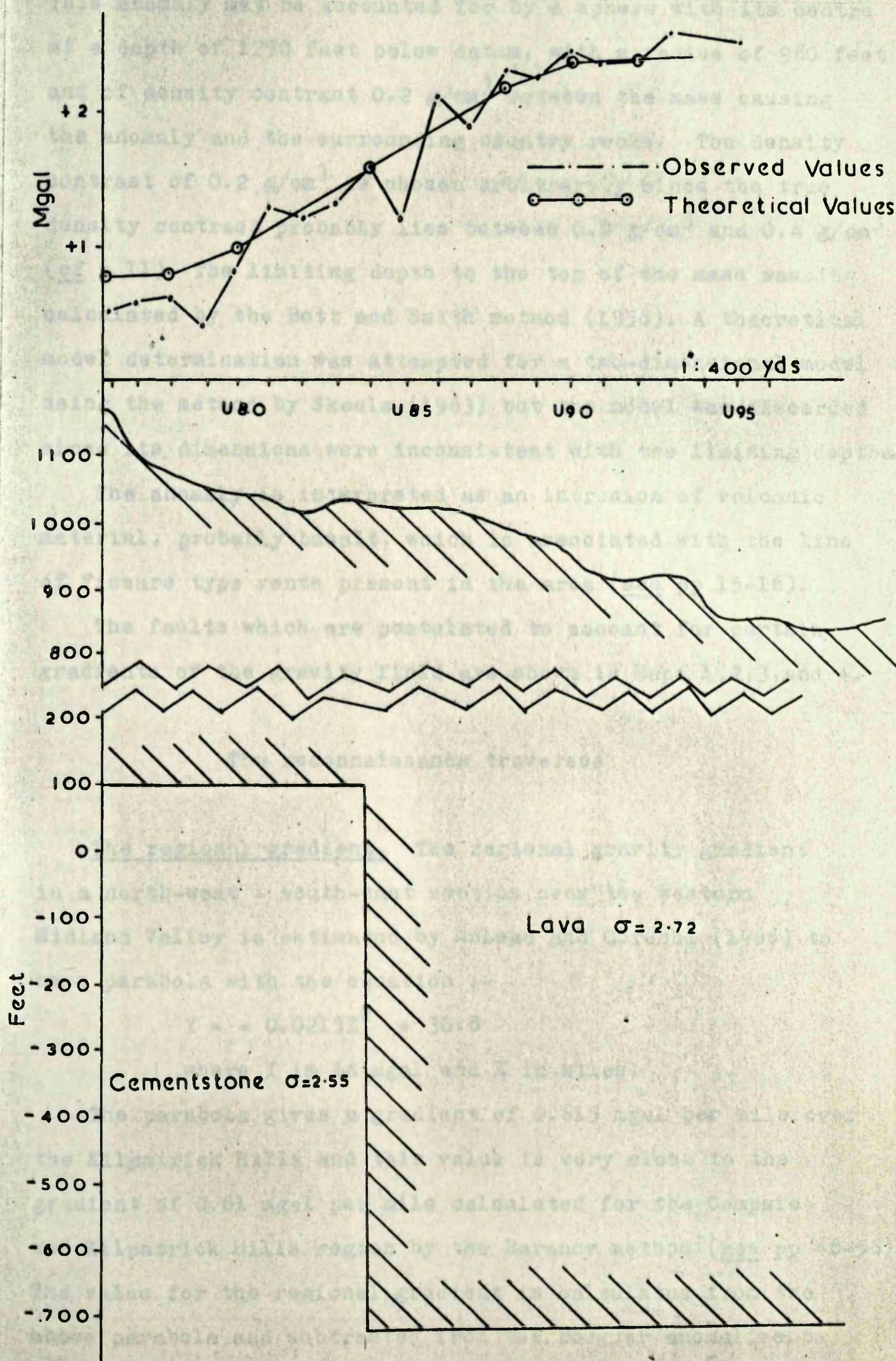
The models and the combined theoretical anomaly are shown along with the observed anomaly in Fig 41.

The base of the lavas is calculated from the background anomaly to be approximately 1,200 feet below datum, that is, 1,300 feet below ground level. Assuming a thickness of 500 feet for the underlying Cementstone group, (they are 500 feet thick at Dumgoyne 2 miles away) then the throw of the Campsie Fault must be a little greater than 1,800 feet at this point.

The anomaly between stations U 76 and U 94 (see Fig 42). This anomaly may be accounted for by a fault which steps the base of the lavas from 200 feet below the datum to 1000 feet below datum. This fault is correlated with the

Fig. 42

Gravity anomalies - traverse U



large anomaly between stations Q 38 and Q 40. The throw of the fault appears to be constant at about 850 feet.

The anomaly between stations F 50 and F 63 (see Fig 43). This anomaly may be accounted for by a sphere with its centre at a depth of 1250 feet below datum, with a radius of 980 feet and of density contrast 0.2 g/cm^3 between the mass causing the anomaly and the surrounding country rocks. The density contrast of 0.2 g/cm^3 is chosen arbitrarily since the true density contrast probably lies between 0.2 g/cm^3 and 0.4 g/cm^3 (cf p 11). The limiting depth to the top of the mass was calculated by the Bott and Smith method (1958). A theoretical model determination was attempted for a two-dimensional model using the method by Skeels (1963) but the model was discarded since its dimensions were inconsistent with the limiting depths.

The anomaly is interpreted as an intrusion of volcanic material, probably basalt, which is associated with the line of fissure type vents present in the area (see pp 15-16).

The faults which are postulated to account for certain gradients of the gravity field are shown in Maps 1,2,3,and 4.

The reconnaissance traverses

The regional gradient. The regional gravity gradient in a north-west - south-east section over the western Midland Valley is estimated by McLean and Qureshi (1966) to be a parabola with the equation :-

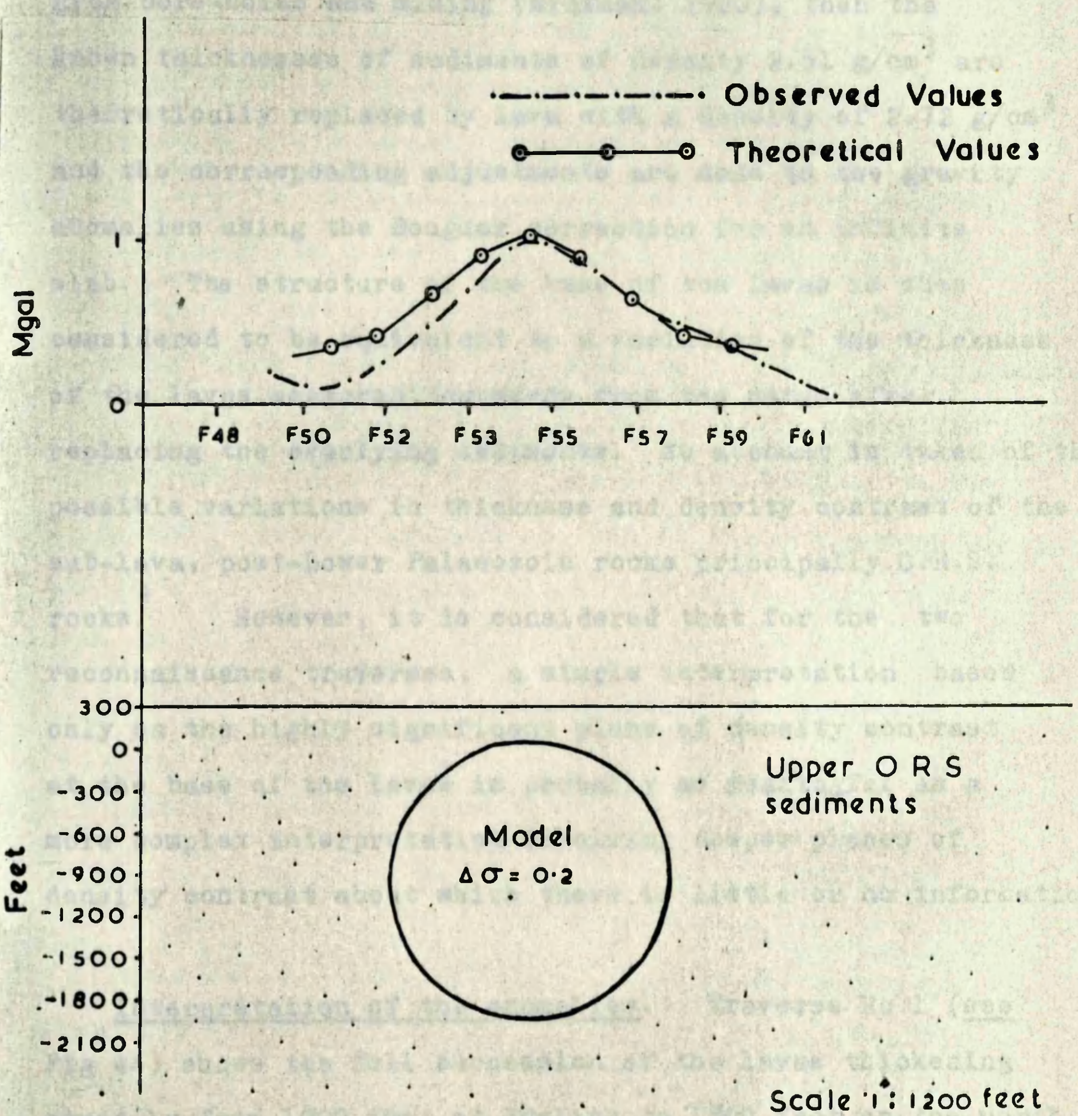
$$Y = - 0.0215X^2 + 30.8$$

where Y is in mgal and X in miles.

The parabola gives a gradient of 0.615 mgal per mile over the Kilpatrick Hills and this value is very close to the gradient of 0.61 mgal per mile calculated for the Campsie and Kilpatrick Hills region by the Baranov method (see pp 48-56). The value for the regional gradient is calculated from the above parabola and subtracted from the Bouguer anomalies to give the 1st order residuals which are used for the geological

Fig. 43

Gravity anomalies - traverse F



interpretation. The regional gravity field is computed to represent only the sub-Upper Palaeozoic component of the total gravity field (McLean and Qureshi, 1966 p 274).

In the interpretation which follows, since the displacements of the major faults and thicknesses of the sediments above the lavas are known in moderate detail from bore-holes and mining (Hinxman, 1920), then the known thicknesses of sediments of density 2.51 g/cm^3 are theoretically replaced by lava with a density of 2.72 g/cm^3 and the corresponding adjustments are made to the gravity anomalies using the Bouguer correction for an infinite slab. The structure of the base of the lavas is then considered to be equivalent to a variation of the thickness of the lavas measured downwards from the datum after replacing the overlying sediments. No account is taken of the possible variations in thickness and density contrast of the sub-lava, post-Lower Palaeozoic rocks principally O.R.S. rocks. However, it is considered that for the two reconnaissance traverses, a simple interpretation based only on the highly significant plane of density contrast at the base of the lavas is probably as meaningful as a more complex interpretation involving deeper planes of density contrast about which there is little or no information.

Interpretation of the anomalies. Traverse Rc 1 (see Fig 44) shows the full succession of the lavas thickening steadily from 1000 feet at Bowling to 1800 feet on the north side of the Paisley Ruck.

The lava appears to thicken rapidly across the Ruck to 2400 feet and maintains this thickness up to the faulted boundary of the lavas in the south (see Map 5). South of this boundary, the lava is exposed at the surface and is estimated to have a present thickness of 2600 feet with the top of the sequence now eroded.

Traverse Rc 2 (see Fig 45) shows the total thickness of the lava to be 1700 feet south of Milngavie compared with 2250 feet further north at Craigmaddie Muir (see Fig 40). South of Milngavie, the lavas appear to thicken to 2000 feet as far as Giffnock; then thicken rapidly to 3000 feet.

The accuracy of this interpretation depends on the accuracy with which the thickness of the overlying sediments is known, and in order to obtain the best determination, limestone and coal horizons which are shown on the Geological Survey's sheet 30 in close proximity to the localities of the gravity stations are identified on the vertical sections at the side of the geological map and the total thickness of the sediments beneath the gravity stations are thus calculated. However, folding of the sediments may introduce an error which cannot be determined on a simple reconnaissance survey, but the variation in the thickness of the lavas appears to be systematic, the lavas being thicker to the south-east of the Paisley Ruck than to the north-west of it and generally thinner across the core of the Glasgow syncline than on the flanks.

General sections across the Campsie and Kilpatrick hills

The sections shown in Figs 46 - 49 show the general structure of the lava of the Campsie and Kilpatrick hills based on the interpretation of the 1st order gravity anomalies by adjustment of the base of the lavas above or below the local datum.

Fig 44

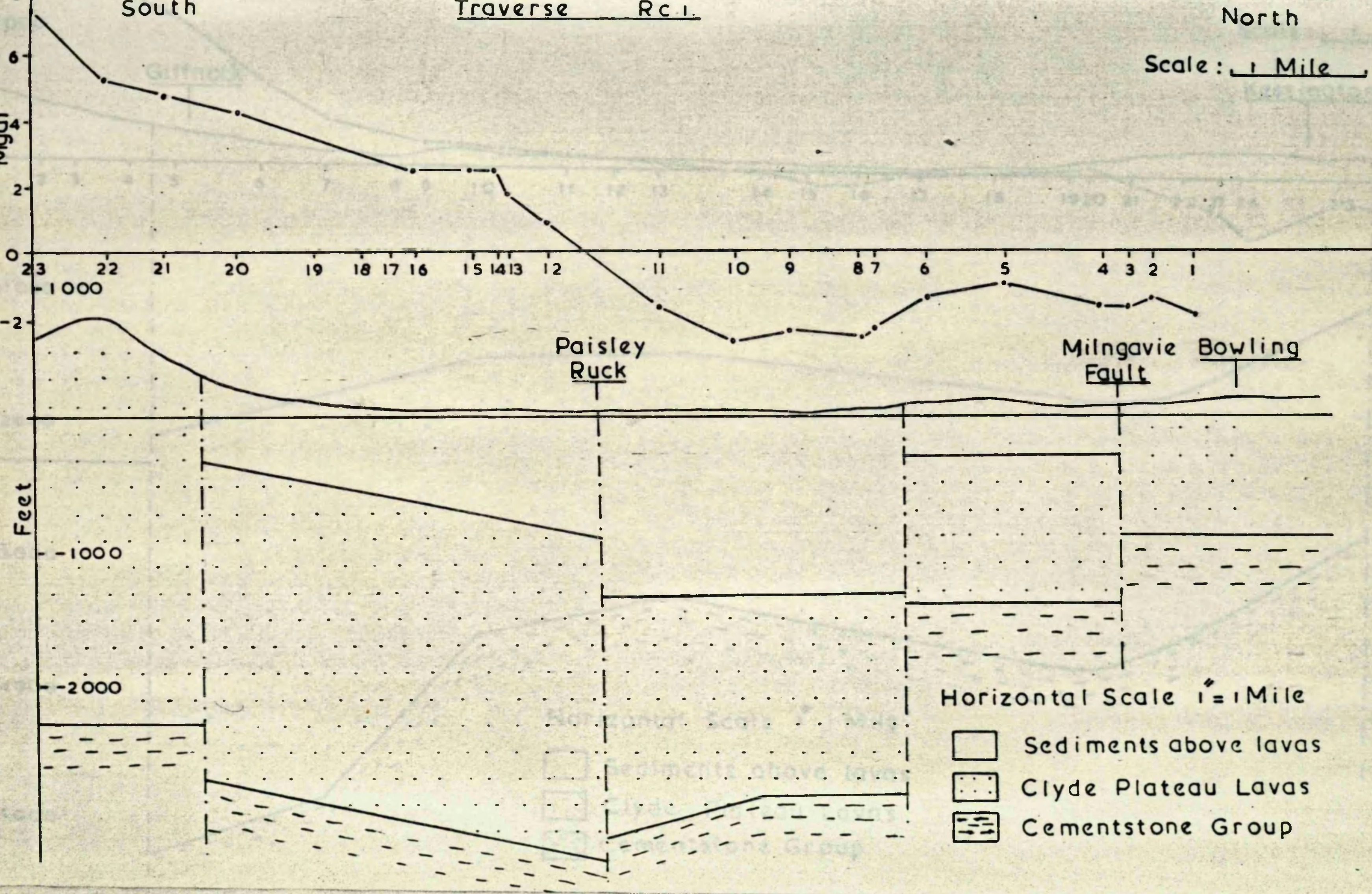

South
Traverse Rc1.
North
Scale: 1 Mile
Mgal
8
6
4
2
0
-2
23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
1000
Paisley Ruck
Milngavie Fault
Bowling
Feet
-1000
-2000
Horizontal Scale 1" = 1 Mile
Sediments above lavas
Clyde Plateau Lavas
Cementstone Group

Fig 45

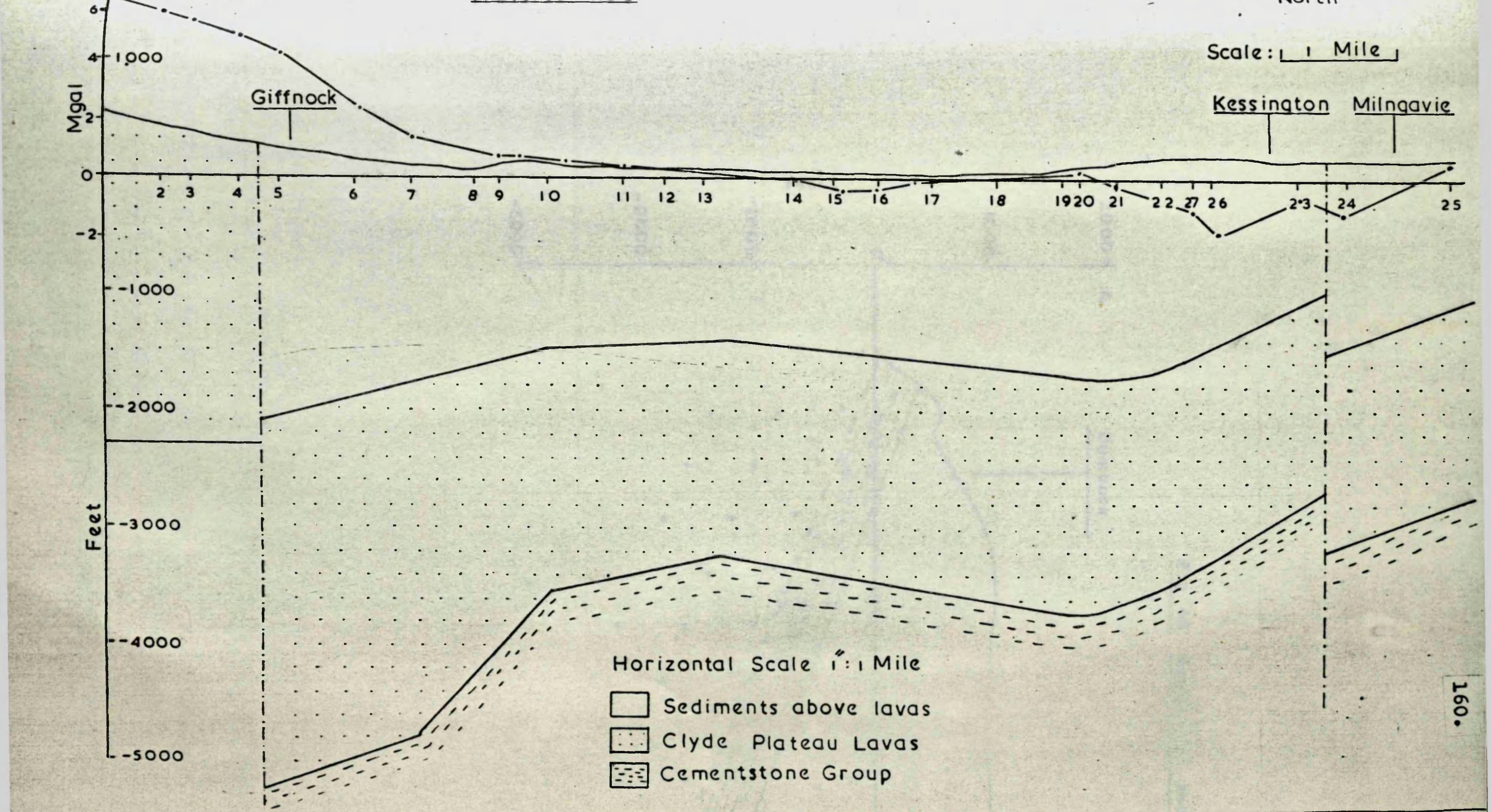

South
Traverse Rc.2.
North
Scale: 1 Mile
Giffnock
Kessington
Milngavie
Mgal
6
4
2
0
-2
1,000
-1000
-2000
-3000
-4000
-5000
Feet
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 1920 21 22 27 26 23 24 25
Horizontal Scale 1": 1 Mile
Sediments above lavas
Clyde Plateau Lavas
Cementstone Group

Fig 46 Geological section

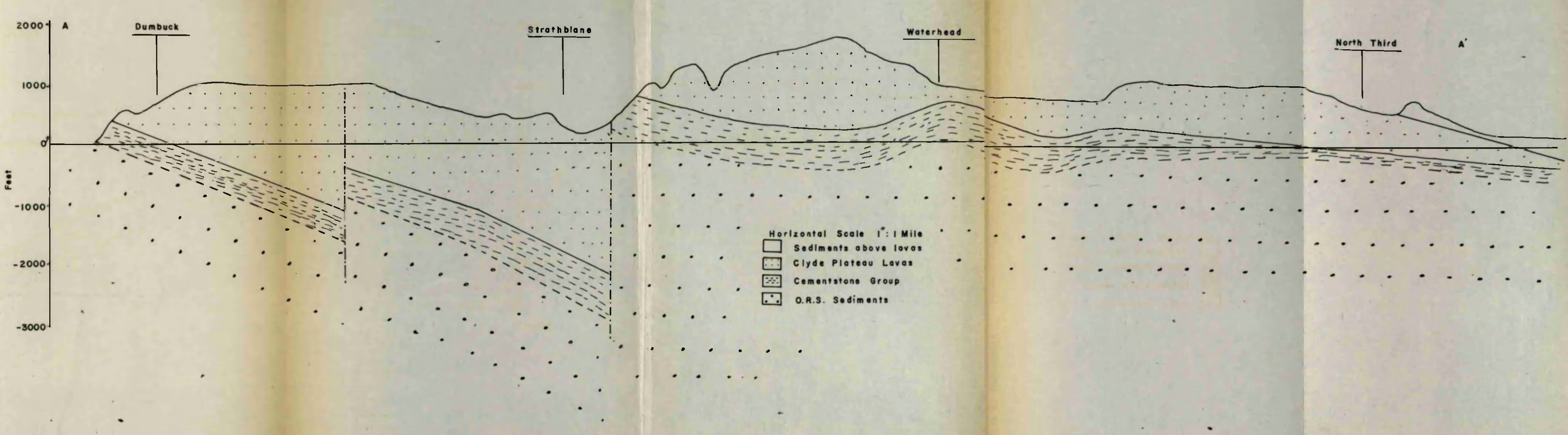


Fig 47

Geological section

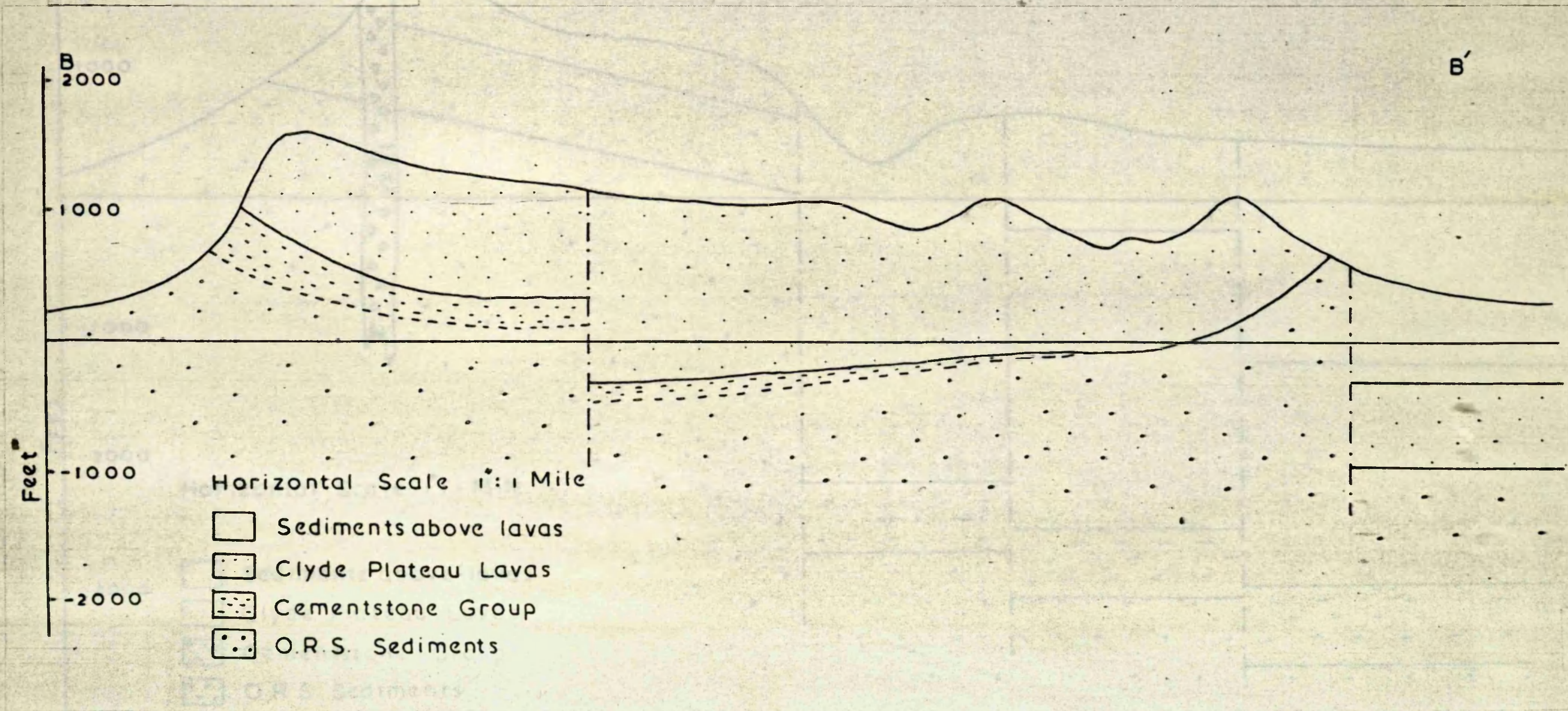
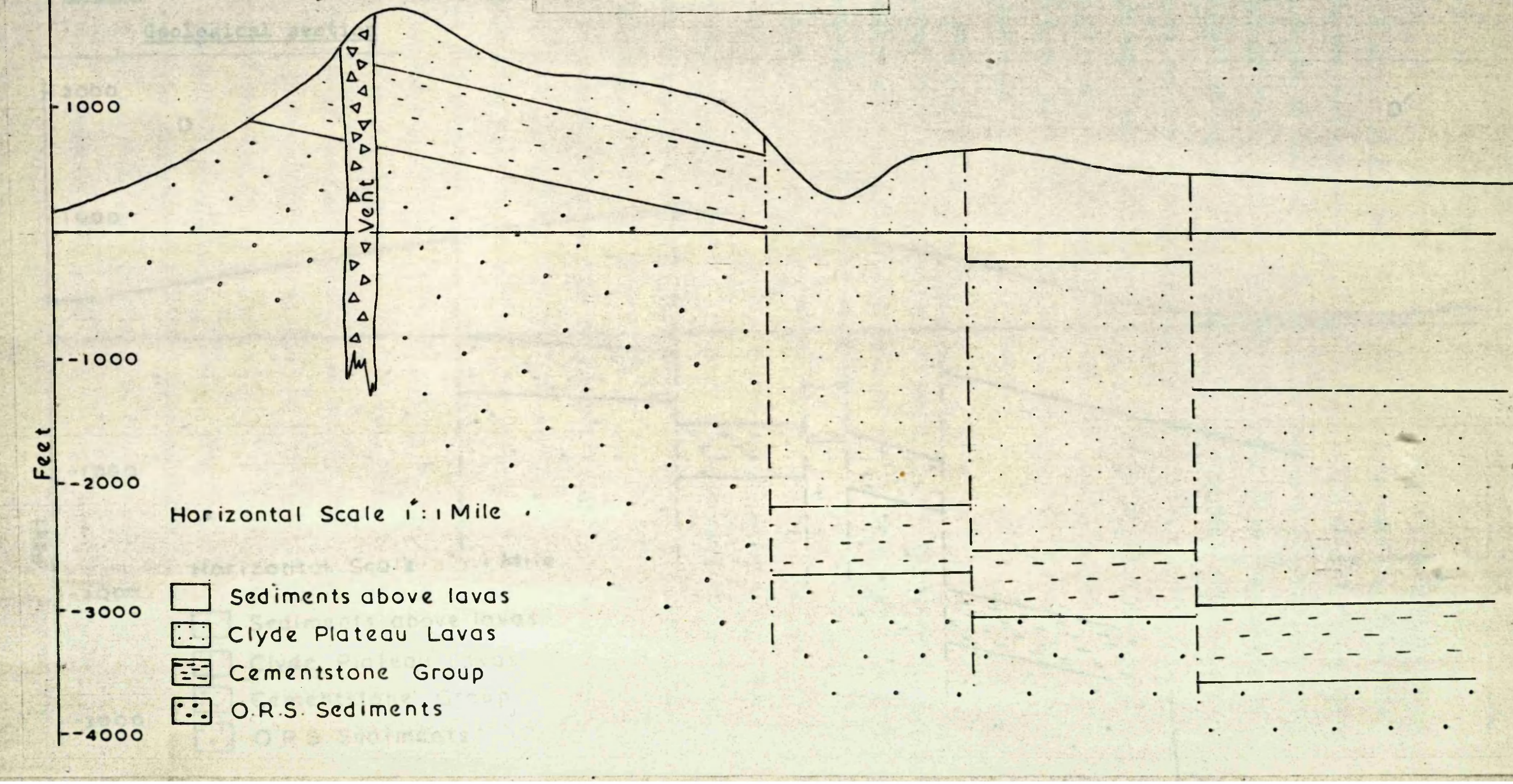


Fig 48

Geological section



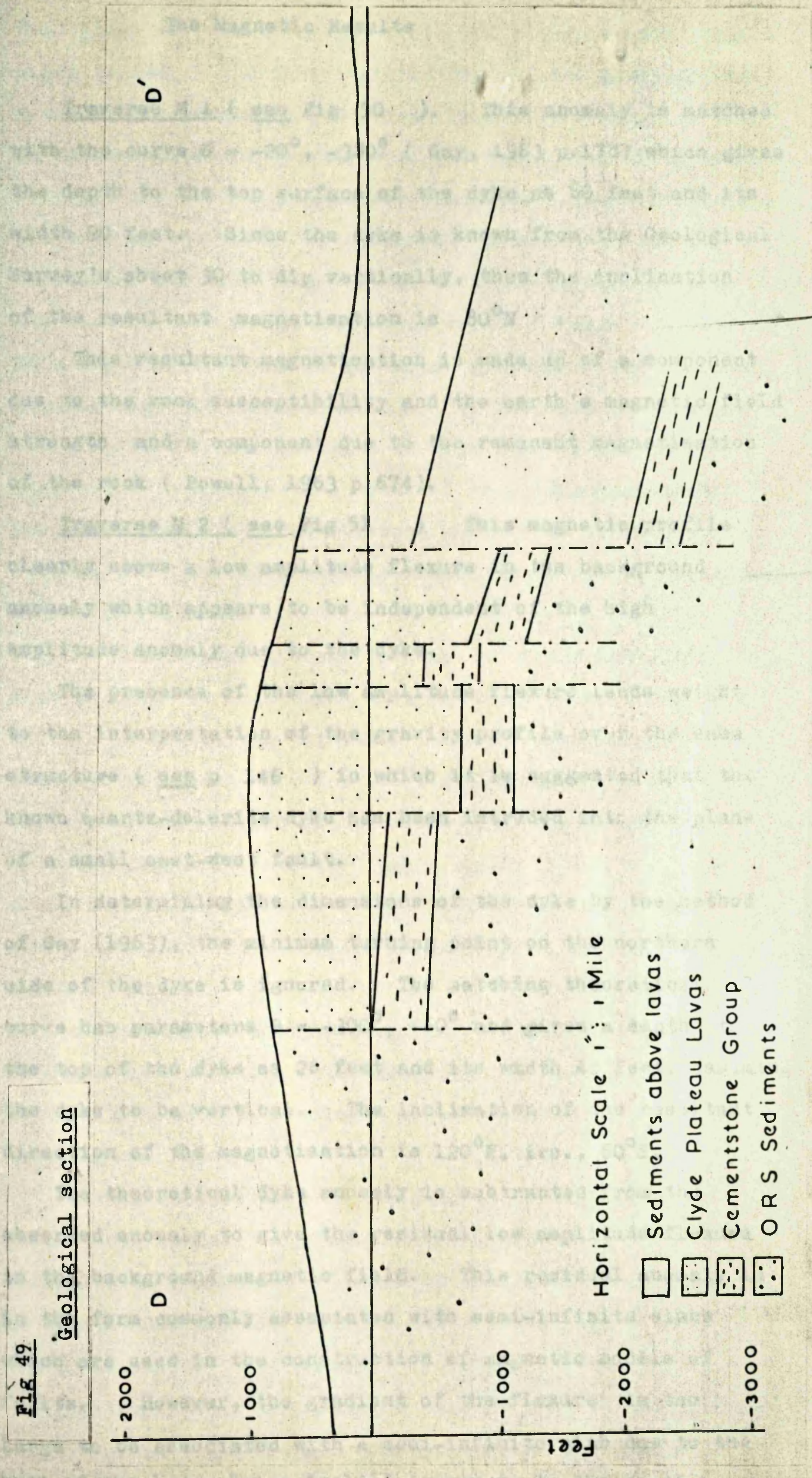


Fig 49
Geological section

The Magnetic Results

Traverse M 1 (see Fig 50). This anomaly is matched with the curve $\theta = -20^{o}, -380^{o}$ (Gay, 1963 p.178) which gives the depth to the top surface of the dyke as 60 feet and its width 90 feet. Since the dyke is known from the Geological Survey's sheet 30 to dip vertically, then the inclination of the resultant magnetisation is $80^{o}N$.

This resultant magnetisation is made up of a component due to the rock susceptibility and the earth's magnetic field strength and a component due to the remanent magnetisation of the rock (Powell, 1963 p.674).

Traverse M 2 (see Fig 51) This magnetic profile clearly shows a low amplitude flexure in the background anomaly which appears to be independent of the high amplitude anomaly due to the dyke.

The presence of the low amplitude flexure lends weight to the interpretation of the gravity profile over the same structure (see p 146) in which it is suggested that the known quartz-dolerite dyke has been intruded into the plane of a small east-west fault.

In determining the dimensions of the dyke by the method of Gay (1963), the minimum turning point on the northern side of the dyke is ignored. The matching theoretical curve has parameters $\theta = -300^{o}, +60^{o}$ and gives a depth to the top of the dyke as 26 feet and its width 48 feet, assuming the dyke to be vertical. The inclination of the resultant direction of the magnetisation is $120^{o}N$, i.e., $60^{o}S$.

The theoretical dyke anomaly is subtracted from the observed anomaly to give the residual low amplitude flexure in the background magnetic field. This residual anomaly is in the form commonly associated with semi-infinite slabs which are used in the construction of magnetic models of faults. However, the gradient of the flexure is too large to be associated with a semi-infinite slab due to the base of the lavas being faulted downwards to the south.

Geological evidence from the field and other gravity results (see p. 146) indicate that the base of the lavas are at a depth of approximately 800 feet below the surface on the downthrown side and the throw of the fault from the gravity evidence alone is approximately 100 feet. These dimensions are used as the basis for a magnetic model, that is, a horizontal semi-infinite slab of rock 100 feet thick with its vertical end in the east-west vertical plane, and buried at a depth of 700 feet to its upper surface. The corresponding magnetic anomaly given by the equation on page 100 for a susceptibility contrast of 4.96×10^{-3} c.g.s.units (see p. 100) changes by a total of only 40 gammas in the 200 yards over which the observed anomaly is effective, whereas the observed gradients indicate that a much shallower source is present.

The theoretical anomaly is computed for a semi-infinite slab of lava 50 feet thick at a depth of 80 feet from the surface to the top of the slab. The susceptibility contrast is chosen as 4.8×10^{-3} c.g.s.units which is twice the standard deviation of the susceptibility determined by the bridge measurements (see p 100) for the lavas. Since this model represents lava faulted against lava, the above susceptibility contrast is assumed to be the probable maximum value.

The theoretical anomaly computed for this shallower model is added to the values determined for the step at the base of the lavas and the resultant is shown as anomaly 'b' (see Fig 51).

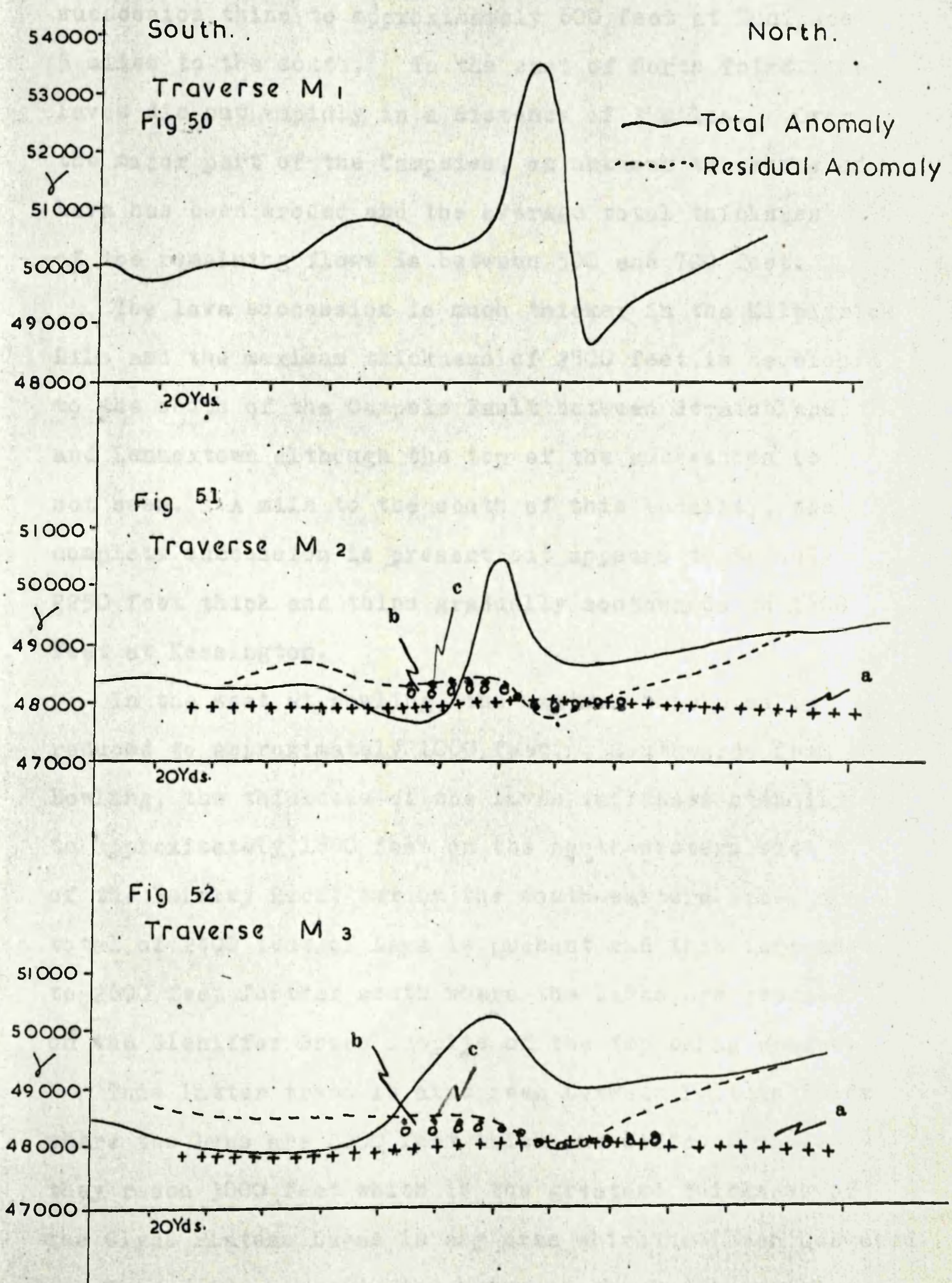
The correlation between the observed anomaly and the theoretical anomaly is significantly improved if the susceptibility contrast of 6.2×10^{-3} c.g.s.units for the dyke is substituted for the value of 4.8×10^{-3} c.g.s.units in the calculations (see anomaly 'c', Fig 51).

The theoretical anomalies 'b' and 'c' may be interpreted either as the result of the preservation of one or more lava flows of unusually high susceptibility on the downthrown side of the fault or as the result of the intrusion into the lavas of a sill of quartz-dolerite emanating from the dyke. In both models, the total thickness of these rocks is 50 feet and the depth to the top surface is 80 feet. This implies that from the model containing lavas of high magnetic susceptibility, the throw of the fault must be approximately 130 feet. The implication does not necessarily hold in the case of the model containing the quartz-dolerite sill since the intrusion may have taken place after the formation of the fault.

In summary, the magnetic results permit an estimation of the dimensions of a known quart-dolerite dyke which barely makes a significant contribution to the gravity profile (see p 146) and they confirm the presence of the east-west fault seen as a dislocation on the gravity profile but with the magnetic profiles, no estimation of the fault is possible.

Traverse M 3 (see Fig 52). This anomaly is similar to that of traverse M 2 and the interpretation methods are the same. The residual step anomaly after removal of the dyke anomaly is of the same order as that of traverse M 2, and the same magnetic model as used in traverse M 2 is erected for interpretation purposes. The inclination of the resultant magnetisation is 125°N, i.e., 55° S.

The reversals of the relative positions of the maximum and minimum values of the anomalies on traverses M 2, M 3 and traverse M 1 must be the result of a reversal of the direction of remanent magnetisation and therefore it may be that the correlation shown on the Geological Survey Sheet 31 between the dyke on the Takmadoon road (Traverses M 2,M 3) and the dyke on the Crow road (Traverse M 1) is incorrect. However, this is not certain since the r relative contributions of induced and remanent magnetisation vary greatly along east-west Permo-Carboniferous dykes (Powell 1963) and this may be such a case.


South.
North.
Traverse M 1
Fig 50
Total Anomaly
Residual Anomaly
γ
54000
53000
52000
51000
50000
49000
48000
20Yds.
Fig 51
Traverse M 2
51000
50000
49000
48000
47000
b
c
a
20Yds.
Fig 52
Traverse M 3
51000
50000
49000
48000
47000
b
c
a
20Yds.

CONCLUSIONS

Variations in the thickness of the Clyde Plateau Lavas

In the Campsie Hills, the lavas develop their maximum thickness of 800 feet at North Third in the east, and the succession thins to approximately 600 feet at Dunipace 5 miles to the south. To the east of North Third, the lavas die out rapidly in a distance of 3 miles. Over the major part of the Campsies, an unknown thickness of lava has been eroded and the average total thickness of the remaining flows is between 500 and 700 feet.

The lava succession is much thicker in the Kilpatrick Hills and the maximum thickness of 2500 feet is developed to the south of the Campsie Fault between Strathblane and Lennoxtown although the top of the succession is not seen. A mile to the south of this locality, the complete succession is present but appears to be only 2250 feet thick and thins gradually southwards to 1700 feet at Kessington.

In the west at Bowling, the maximum thickness is reduced to approximately 1000 feet. Southwards from Bowling, the thickness of the lavas increases steadily to approximately 1800 feet on the north-western side of the Paisley Ruck, but on the south-eastern side, a total of 2400 feet of lava is present and this increases to 2600 feet further south where the lavas are exposed on the Gleniffer Braes inspite of the top being eroded.

This latter trend is also seen between Pollokshields where the lavas are 2000 feet thick and Giffnock where they reach 3000 feet which is the greatest thickness of the Clyde Plateau Lavas in any area which has been surveyed.

The rapid change in thickness of the lava succession across the Paisley Ruck is similar to the changes in thickness of the Carboniferous Limestone sediments across many of the large east-north-east - west-south-west faults in Ayrshire (Kennedy, 1958 pp 122-124). The Inchgotrick Fault in particular is also seen to control the thickness of the Clyde Plateau Lavas in the Sorn area (Richey, and others, 1930 p 65). It appears therefore that the Paisley Ruck was active either as a normal fault contemporaneously with the extrusion of the Clyde Plateau Lavas thus controlling the development of the lava piles or as a strike-slip fault at a later date thus bringing lava of different thicknesses into juxtaposition.

The great thickness of lava which is present between Strathblane and Lennoxtown probably represents the maximum accumulation of the extrusions of both the vents of the Kilpatrick Hills and those of the western Campsie group. Similarly, the 3000 feet of lava at Giffnock probably represents the maximum accumulation of lava in this region although the source of these lavas is obscure and little information is available about the thickness of the lava in the surrounding districts except that they are known to thin to the south-west where at Ardrossan, only two flows are present (Richey and others, 1930 p 65).

The attenuation of the lavas beneath the Glasgow syncline suggests that the Lennoxtown-Strathblane and Giffnock area were once either local depressions which became filled with accumulating lavas from local vents or local lava piles around sources and perhaps magma chambers and in both cases were at times connected during phases of maximum activity.

Structure of the lava plateaux

The general structure of the lavas of the Campsie and Kilpatrick hills is summarised in the sections shown in Figs 43-46.

The lack of visible folding within the lavas is confirmed by the survey and the dome structure which gives rise to the inlier of Cementstones at the Carron reservoir is seen to extend westwards to Waterhead although the base of the lavas is not exposed in this area.

In the Kilpatrick Hills, the general dip of the lavas is between 2^{o} and 3^{o} to the south-east although local dips of up to 20^{o} occur in the region of some of the vents.

Very little faulting is present within the lavas. Several east-west faults with throws of approximately 500 feet and which are known in the younger sediments to the east and south of the Campsie hills are seen to extend into the lava plateaux much further than they could be visibly mapped in the field. The largest of these are the faults at Strathblane, just south of the Campsie Fault and at North Third in the east. Three faults are recognised east of Waterhead at Carron reservoir and these faults have an east-north-east - west-south-west trend. No other fault trends can be distinguished.

The origin of the lavas of the Campsie and Kilpatrick hills

The alkali olivine-basalts of the Kilpatrick Hills are considered to have risen to the surface from a magma chamber which is at great depth since it cannot be detected by the gravity survey, but in low pressure environment as a result of the early Carboniferous tensional stress system (see p 11).

In the Campsie Hills, the creation of a magma chamber beneath Waterhead would cause a delay in the migration towards the surface of the basaltic magma and allow further differentiation to take place producing the more acid trachytes, mugearites and phonolites which are found in the upper stages of the lava succession. It is probable therefore that this differentiation occurred towards the end of the phase of vulcanicity in the

Campsie Hills since the magma chamber, which has an estimated volume of between 20 and 40 cubic miles, is not large enough to have supplied all the basalt of the Campsie Hills without replenishment from a deeper source which would disturb the differentiation process.

This hypothesis is in accordance with the basalt fractionation scheme put forward by O'Hara (1965, p 37 table 1).

Although it appears likely that many of the later trachytes, phonolites, and mugearites have been extruded through the Meikle Bin vent, the presence of the zone of alteration about Waterhead farm suggests that Geikie's interpretation (1897, p 400) that a large vent occupied this region is correct. This being so, it is probable that this vent gave rise to many of the earlier flows, particularly the Markle basalts to the east at Garrel Hill. The presence of the overlying unaltered ash beds at Waterhead suggests that this vent ceased to be active at an early stage of the volcanic phase.

It is inferred that the lavas of the western Campsie Hills above Strathblane are products of the Dumgoyne and Dumfoyne set of vents and the large fissure to the north-east (<u>see</u> p 111).

The hypotheses which have been put forward concerning the role of the Waterhead magma chamber in the development of the Calciferous Sandstone vulcanicity north of the River Clyde, and also the significance of the variation of the thickness of the lava succession in the western Midland Valley would be greatly strengthened if similar gravity surveys were carried out over the remaining areas of the Clyde Plateau Lavas.

In particular, a survey in the neighbourhood of the trachytic vent of Misty Law would prove whether the geological environment is analogous to the Meikle Bin area, that is, if a basic igneous intrusive could be detected beneath the lava. Similarly, south of Barrhead, a gravity survey would indicate whether the Moyne Moor anticline is the result of regional tectonics or a local platonic intrusion as is the case at Waterhead.

The relation of the vulcanicity to the Midland Valley rift

The detailed geophysical analysis of the Campsie and Kilpatrick hills covers only 240 square miles of a total exposure of 750 square miles of the Clyde Plateau Lavas in the western Midland Valley. Insufficient information is available to indicate any significant structural control of the development of the lava piles except for the tentative hypothesis that the north-east - south-west Paisley Ruck may have been effective.

The only fault systems which appear to effect the lavas north of the River Clyde are the east-north-east - west-south-west set which are parallel to the Calciferous Sandstone dykes (see p 7) andto the fissure-vents of the north-west Campsie Hills (see p 14) and the east-west set belonging to the Borcovician period (see p 8).

It is the major east-west faults which divide up the lava plateaux, the Campsie Fault separating the Campsie lavas from the Kilpatrick lavas and the Milngavie Fault separating the Kilpatrick lavas from those of Renfrewshire. South of the River Clyde, the lava plateaux are divided by east-north-east - west-south-west structures in Ayrshire, for example, the Duskwater Fault. Sinc e the exposures of the Clyde Plateau Lavas south of the River Clyde are also west of the Campsie and Kilpatrick blocks, the swing intrend of the dividing faults may be associated with the swing in trend of the regional isogals about a north-south line through Loch Lomond further to the north (Qureshi, 1961 p 23), but there is insufficient information available concerning the trend of the regional Bouguer anomalies in the Glasgow area to allow an elaboration of this hypothesis.

ACKNOWLEDGEMENTS

The author is indebted to the Faculty of Science of the University of Glasgow for the provision of a grant and to Professor T. Neville George for his nomination, without which the project could never have been attempted.

He is deeply grateful to Dr. A.C. McLean for suggesting the problem, for his continued guidance, and for many helpful suggestions during his critical reading of the manuscript.

The author is grateful to Professor D.H. Griffiths, Professor of Geophysics, of the University of Birmingham, for the loan of a gravimeter for part of the survey.

He also wishes to acknowledge Dr. D.W. Powell and Mr. J.G. Macdonald for their many helpful discussions at all stages of the work, and to thank Mr. W.Welsh of the National Coal Board for permission to take gravity readings in the mine-shafts of Dumbreck and Twechar collieries, and the technical staff of the Department of Geology of the University of Glasgow, in particular, Messrs. R. Morrison, R. Cumberland, and W. Nielson, for their willing assistance in the field.

REFERENCES

ANDERSON, E.M. 1951. The dynamics of faulting. 2nd edition. Edinburgh.

BAILEY, E.B. 1925. In CLOUGH, C.T. and others. British Regional Geology: The Glasgow District. Mem. geol. Surv. U.K.

BARANOV, V. 1954. Sur une methode analytique de calcul de l'anomalie regionale. Geophys. Prospect. 2, 203-226.

BOTT, M.H.P., and R.A. SMITH. 1958. The estimation of the limiting depth of gravitating bodies. Geophys. Prospect. 6, 1-10.

BOTT, M.H.P. 1959. The use of electronic digital computors for the evaluation of gravimetric terrain corrections. Geophys. Prospect. 7, 45-54

BULLERWELL, W. 1952. Gravimeter observations comparing pendulum stations at Cambridge, York, Newcastle-on-Tyne, Edinburgh, and Aberdeen. Mon. Not. R. astr. Soc. geophys. Suppl. 6, 303-315.

CLOUGH, C.T. and others. 1925. British Regional Geology: The Glasgow District. Mem. geol. Surv. U.K.

COOK, A.H. 1953. Adjustment of the principal gravity observations in Great Britain. Mon. Not. R. astr. Soc. geophys. Suppl. 6, 494-521.

DIXEY, F. 1956. The East African Rift System. Colon. Geol. Miner. Resour. Ser. 1.

DOMZALSKI, W. 1955. Three-dimensional gravity survey. Geophys. Prospect. 3, 15-55.

ELKINS, T.A. 1951. The second derivative method of gravity interpretation. Geophysics. 16, 29-50.

GAY, S.P. 1963. Standard curves for interpretation of magnetic anomalies over long tabular bodies. Geophysics. 28, 161-200.

GEIKIE, A. 1897. Ancient volcanoes of Great Britain, London.

GEORGE, T.N. 1960. The stratigraphical evolution of the Midland Valley of Scotland. Trans. geol. Soc. Glasg. 24, 32-107.

GIRDLER, R.W. 1962. Initiation of Continental Drift. Nature, Lond. 194, 521-524.

——— 1963a. Geophysical evidence on the nature of magmas and intrusions associated with rift valleys. Bull. Volcan. 26, 37-47.

——— 1963b. Geophysical studies of rift valleys. Physics and Chemistry of the Earth. 5, 1-34.

HAMILTON, J. 1956. Mineralogy of basalts from the western Kilpatrick Hills and its bearing on the petrogenesis of Scottish Carboniferous Olivine-basalts. Trans. Edinb. geol. Soc. 16, 280-297.

HAMMER, S. 1939. Terrain corrections for gravity stations. Geophysics. 4, 184-209.

——— 1950. Density determinations by underground gravity measurements. Geophysics. 15, 637-652.

HEILAND, C.A. 1940. Geophysical exploration, New York.

HINXMAN, L.W., and others . 1920. The economic geology of the Central Coalfield of Scotland - Area lV. Mem. geol. Surv. U.K.

HOLMES, A. 1964. Principles of physical geology. London and Edinburgh.

HOLTEDAHL, O. 1939. Correlation notes of Scottish-Norwegian Caledonian geology. Norsk. geologisk. tiddskrift. 19, 326-339.

——— 1951. The structural history of Norway and relation to Great Britain. Quart. J. geol. Soc. Lond.108, 65-98.

HUBBERT, M.K. 1948. Line integral method of computing gravity. Geophysics. 13, 215-225.

JUNG, K. 1953. Some remarks on the interpretation of gravitational and magnetic anomalies. Geophys. Prospect. 1, 29-35.

KENNEDY, W.Q. 1958. The tectonic evolution of the Midland Valley of Scotland. Trans. Geol. Soc. Glasg. 23, 110-133.

LAMBERT, W.D. and F.W. DARLING. 1931. Tables for theoretical gravity according to the new International Formula. Bull. Geod. 32, 327-340.

MACGREGOR, M. and A.G. MACGREGOR. 1948. British Regional Geology: The Midland Valley of Scotland. Mem. Geol. Surv. U.K.

MCLEAN, A.C. 1960. A gravimetric survey in the south-west of Scotland. Ph.D. thesis, Glasgow.

______ 1961. Density measurements of rocks in south-west Scotland. Proc. R. Soc. Edinb. (B), 68, 103-111.

______ and I.R. QURESHI, 1966. Regional anomalies in the western Midland Valley of Scotland. Trans. Roy. Soc. Edinb., 66, 267-283.

MOONEY, H.M. 1952. Magnetic susceptibility measurements in Minnesota. Geophysics. 17, 531-543.

MORONEY, M.J. 1962. Facts from Figures. London.

MYKURA, W. 1965. The age of the lower part of the New Red Sandstone of south-west Scotland. Scot. J. Geol. 1, (10, 9-18.

NETTLETON, L.L. 1939. Determination of density for reduction of gravimeter observations. Geophysics. 4, 176-183.

______ 1940. Geophysical prospecting for oil. New York and London.

______ 1942. Gravity and magnetic calculations. Geophysics. 7, 293-310.

NEUMANN, R. 1963. Contribution au calcul simplifie des corrections de relief a grande distance en gravimetrie. Geophys. Prospect. 11, 523-534.

O'HARA, M.J. 1965. Primary magmas and the origin of basalts. Scot. J. Geol. 1, (1), 19-40.

PARASNIS, D.S. 1952. A study of rock densities in the English Midlands. Mon. Not. R. Astr. Soc. Geophys. Suppl. 6, 252-271.

PATTERSON, E.M. 1949. The O.R.S. rocks of the West Kilbride - Largs district, Ayrshire. Trans. geol. Soc. Glasg. 21, 207-236.

POWELL, D.W. 1963. Significance of differences in magnetisation along certain dolerite dykes. Nature, Lond.199, 674-676.

QURESHI, I.R. 1961. A gravity survey of the region of the Highland Boundary Fault between Callander Cowal. Ph.D. thesis, Glasgow.

RICHEY, J.E. and others. 1930. British Regional Geology: The geology of north Ayrshire. Mem. geol. Surv. U.K.

ROGERS, G.R. 1952. Subsurface gravity measurements. Geophysics. 17, 365-377.

RUNCORN, S.K. 1962. Towards a theory of continental drift. Nature, Lond. 93, 311-314.

SAETHER, E. 1945. Studies on the igneous rock complex of the Oslo region. Skr. norske. Vidensk-Akad. 6, 9-60.

SKEELS, D.C. 1963. An approximate solution of the problem of maximum depth in gravity interpretation. Geophysics. 28, 724-735.

SMITH, A.E. 1951. Graphic adjustment by least squares. Geophysics. 16, 222-227.

TURNER, F.J. and J. VERHOOGEN. 1960. Igneous and metamorphic petrology. New York.

WHETTON, T.T., J.O. MYERS, and R. SMITH. 1957. Correlation of rock density determination for gravity survey interpretation. Geophys. Prospect.20-43.

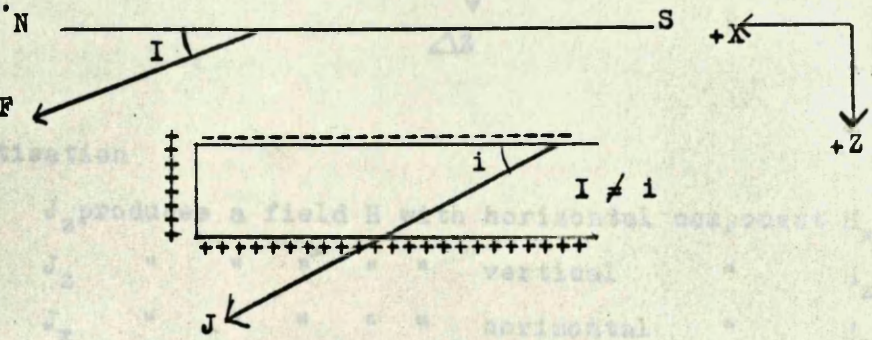
WHYTE, F. 1963. Volcanic vents in the Campsie and Kilpatrick hills. Ph.D. thesis, Glasgow.

APPENDICES

APPENDIX A

Derivation of the total field magnetic anomaly for a vertical east-west striking fault with arbitrary magnetisation.

Fig A.



F = Intensity of the Earth's field.

I = Intensity of the Earth's field below N-directed (+x) axis.

J = Intensity of magnetisation of slab in a vertical plane, perpendicular to strike.

i = Inclination of magnetisation of slab in a vertical plane, perpendicular to strike and measured below N-directed axis.

N.B. Slab is bounded on the north, and extends to infinity in the south.

In Fig A, the intensity of magnetisation of the horizontal surfaces is :-

$J_z = +J \sin i$ (lower surface) 1

$= -J \sin i$ (upper surface)

and similarly for the vertical surface :-

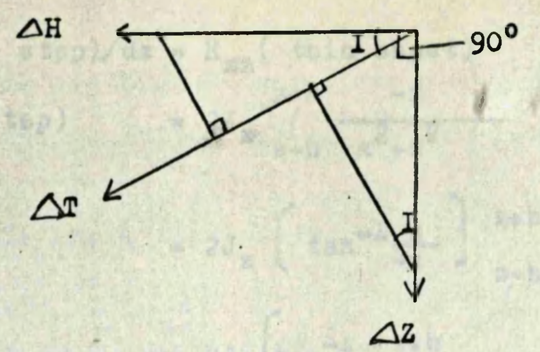
$J_x = +J \cos i$ 2

The resultant anomaly intensity in direction of F is:-

$\Delta T = \Delta Z \sin I + \Delta H \cos I$ 3

(<u>see</u> Fig B)

Fig B.



Magnetisation

J_z produces a field H with horizontal component H_{xz} ..4

" J_z " " " " " vertical " H_{zz} ..5

" J_x " " " " " horizontal " H_{xx} ..6

" J_x " " " " " vertical " H_{zx} ..7

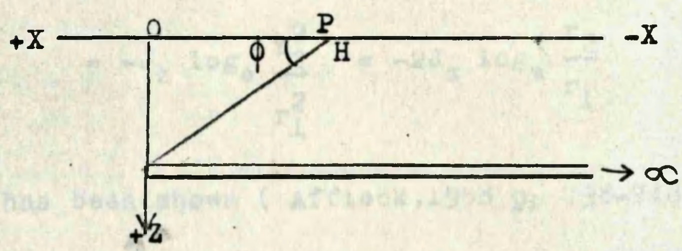
Therefore,

$$Z = H_{zz} + H_{zx} \text{ and,}$$

$$H = H_{xx} + H_{xz}.$$

Effect of J_z.

Fig C.



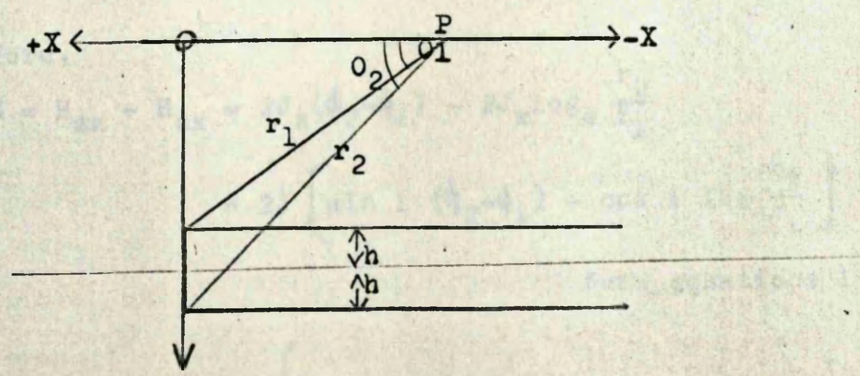
$$H_{zz}(\text{thin sheet}) = + 2J_z \cos \phi/r$$

$$= - 2J_z\, x/(x^2+z^2)$$

where $\cos \phi = -x/r$ and $r^2 = x^2+z^2$

By integrating the effect of a stack of thin sheets from z - h to z + h, the effect of a step is found as follows (<u>see</u> Fig D):-

Fig D



$$d(H_{zz}\text{ step})/dz = H_{zz}(\text{ thin sheet})$$

$$H_{zz}(\text{step}) = 2J_z \int_{z-h}^{z+h} \frac{-x}{x^2+z^2}\, dz$$

$$= 2J_z \left[\tan^{-1}\frac{z}{-x} \right]_{z-h}^{z+h} \quad \ldots\ldots\ldots\ldots 7$$

$$= 2J_z \left[\tan^{-1} \frac{z+h}{-x} - \tan^{-1} \frac{z-h}{-x} \right]$$

$$= 2J_z \left(\phi_2 - \phi_1 \right)$$

Similarly,

$$H_{xz}(\text{thin sheet}) = -\frac{2J_z}{r} \sin\phi = -2J_z \frac{z}{z^2+x^2} \quad \ldots\ldots 8$$

$$= d(H_{xz}\text{ step})/dz$$

so,

$$H_{xz}\text{ step} = -2J_z \int_{z-h}^{z+h} \frac{z}{z^2+x^2}\, dz = J_z \log_e \frac{x^2+(z+h)^2}{x^2+(z-h)^2}$$

$$= -J_z \log_e \frac{r_2^2}{r_1^2} = -2J_z \log_e \frac{r_2}{r_1}$$

It has been shown (Affleck,1958 pp 738-748) that

$H_{xz}/J_z = H_{zx}/J_x$ for any uniformly

magnetised body, and that

$H_{zz}/J_z = -H_{xx}/J_x$ for any body with a strike

from $-\infty$ to $+\infty$.

Therefore,

$$\Delta Z = H_{zz} + H_{zx} = 2J_z(\phi_2-\phi_1) - 2J_x \log_e \frac{r_2}{r_1}$$

$$= 2J \left[\sin i\ (\phi_2-\phi_1) - \cos i\ \log_e \frac{r_2}{r_1} \right]$$

from equations 1 and 2

and,

$$\Delta H = H_{xx} + H_{xz} = 2J \left[-\cos i\ (\phi_2-\phi_1) + \sin\ (I+i)\ \log_e \frac{r_2}{r_1} \right]$$

Therefore,

$$\Delta T = \Delta Z \sin I + \Delta H \cos I$$
$$= -2J \left[\cos (I+i).(\phi_2-\phi_1) + \sin (I+i) \log_e \frac{r_2}{r_1} \right]$$

But if the magnetisation is induced, then I=i

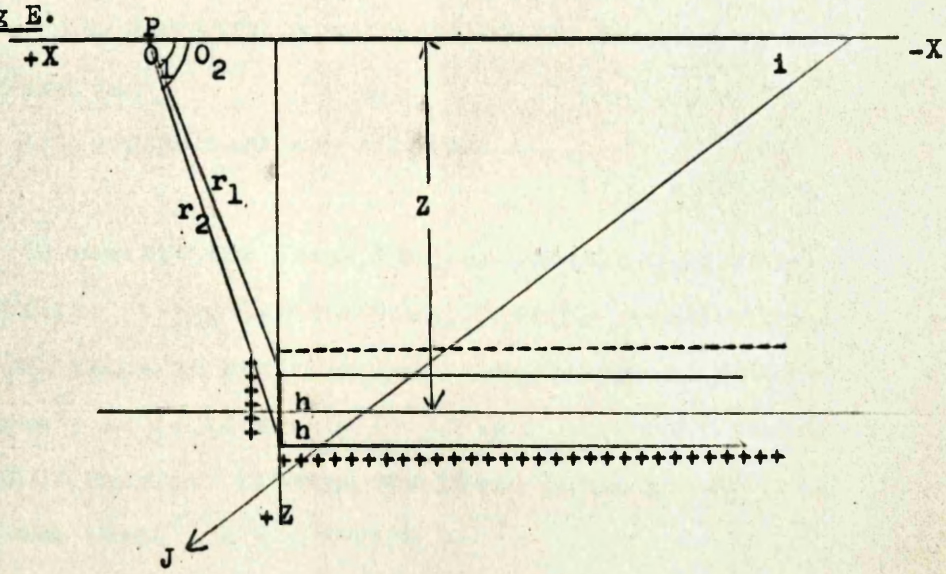
Therefore,

$$\Delta T = - 2J \left[\cos 2I(\phi_2-\phi_1) + \sin 2I.\log_e \frac{r_2}{r_1} \right]$$

This equation for the total field magnetic anomaly due to a horizontal semi-infinite slab with an east-west strike is essentially the same as the equation for the total anomaly due to a thick dyke with an east-west strike, horizontal top surface and sides which extend to an infinite depth.

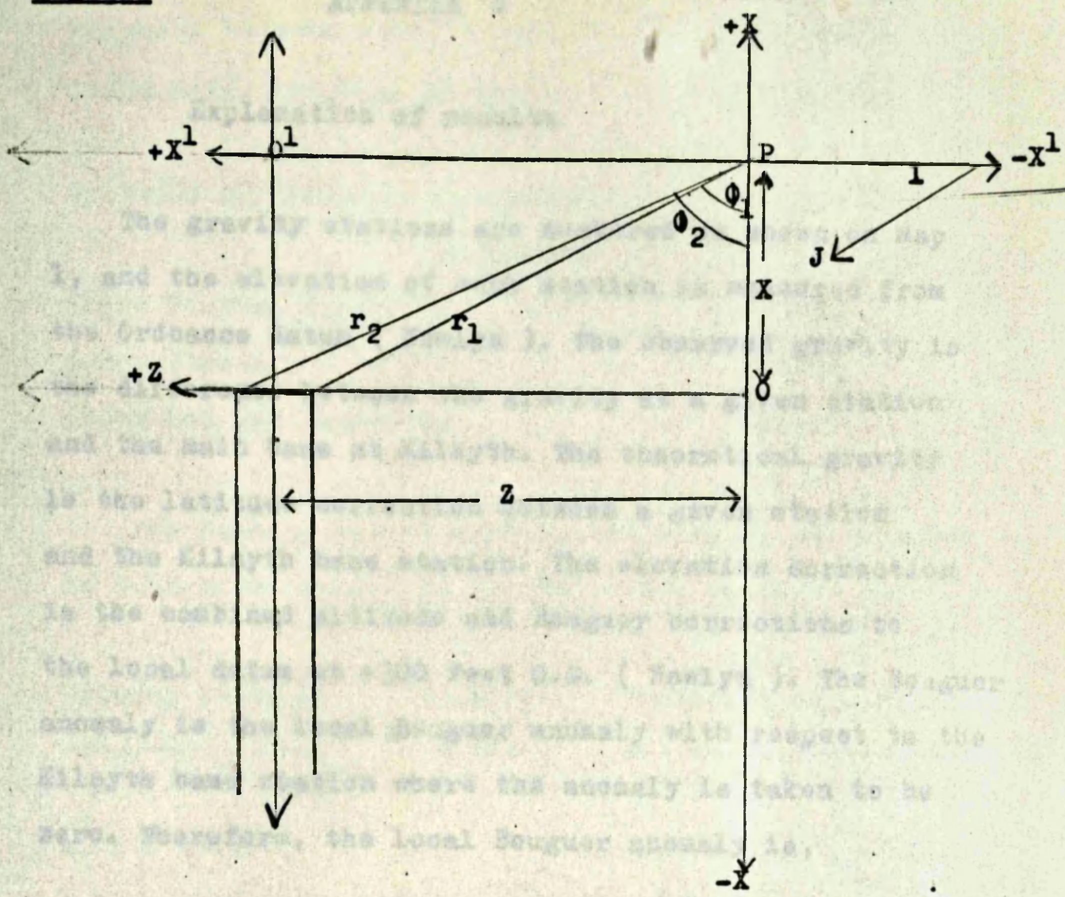
This is easily shown if Fig D is re-drawn so that the point P where the magnitude of the anomaly is to be computed is in the positive horizontal direction (see Fig E) and then the axes are transposed such that $X^1 = Z - z$ and $Z^1 = -X + x$ (see Fig F).

Fig E.



Therefore, in the case of a vertical semi-infinite dyke, the term $(\phi_2-\phi_1)$ is an even function of X and the term $\log_e r_2/r_1$ is an odd function and in the case of a horizontal semi-infinite slab, the term $(\phi_2-\phi_1)$ is an odd function of X and the term $\log_e r_2/r_1$ is an even function.

Fig F.



APPENDIX B

Explanation of results

The gravity stations are numbered as shown on Map 1, and the elevation of each station is measured from the Ordnance datum (Newlyn). The observed gravity is the difference between the gravity at a given station and the main base at Kilsyth. The theoretical gravity is the latitude correction between a given station and the Kilsyth base station. The elevation correction is the combined altitude and Bouguer corrections to the local datum at +300 feet O.D. (Newlyn). The Bouguer anomaly is the local Bouguer anomaly with respect to the Kilsyth base station where the anomaly is taken to be zero. Therefore, the local Bouguer anomaly is,

Observed gravity - theoretical gravity + elevation correction + terrain correction - 3.87 (the combined elevation and terrain corrections at the Kilsyth base station).

All corrections are in mgal.

To convert the local Bouguer anomalies to Bouguer anomalies on the International Gravity Formula, based on the value at Pendulum House, Cambridge of 981.265 cm/sec^2, it is necessary to include a correction for the slab of material between the local datum at +300 feet and sea level (O.D., Newlyn).

The correction is added to the local Bouguer anomalies and is as follows,

Material between local datum (+300 feet) and O.D. (Newlyn).	Correction (Mgal)
Scottish Carboniferous Limestone sediments	+14.36
Clyde Plateau Lavas	+13.34
Cementstones	+14.06
Upper Old Red Sandstone	+14.78

The density factor used in the Bouguer corrections is 2.72 g/cm^3 except in the following cases,

Between stations	density g/cm^3	formation at surface.
A. 1 - A.12	2.51	Carboniferous Limestone. sediments
A.13 - A.17	2.36	Upper O.R.S.
F.51 - F.73	2.55	Cementstone Group
G.110- G.120	2.51	Carboniferous Limestone sediments.
J.49 - J.72	2.51	" "
L. 3 - L.50	2.51	" "
M.65 - M102	2.51	" "
N.74 - N.142	2.36	Upper O.R.S.
O. 1 - O.26	2.55	Cementstone Group
Q.38 - Q.72	2.51	Carboniferous Limestone sediments
R. 1 - R.12	2.51	" "
S. 1 - S.41	2.36	Upper O.R.S.
V.85 - V.106	2.36	" "

GRAVITY DATA SHEET NO. 1

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
Base.	349.6	0	0	2.94	0.93	0
A.1	354.0	+0.44	-0.03	3.24	0.90	+0.68
A.2	372.3	-0.98	-0.09	4.34	0.79	+0.20
A.3	395.8	-1.86	-0.14	5.75	0.81	+0.69
A.4	420.9	-3.13	-0.20	7.26	0.68	+0.74
A.5	437.3	-4.12	-0.25	8.24	0.71	+0.70
A.6	455.6	-5.21	-0.30	9.34	0.81	+0.76
A.7	458.6	-5.70	-0.37	9.51	0.70	+0.28
A.8	467.1	-6.08	-0.42	10.02	0.66	+0.32
A.9	476.1	-6.54	-0.49	10.56	0.73	+0.39
A.10	488.0	-7.16	-0.53	11.28	0.68	+0.40
A.11	500.1	-7.88	-0.60	12.01	0.93	+0.61
A.12	517.4	-8.75	-0.68	13.04	0.79	+0.53
A.13	563.4	-11.85	-0.72	15.81	0.72	+0.09
A.14	604.8	-14.84	-0.77	18.29	0.59	-0.59
A.15	632.7	-16.64	-0.81	19.96	0.88	-0.47
A.16	659.4	-18.28	-0.84	21.56	0.95	-0.48
A.17	674.5	-18.91	-0.91	22.47	0.95	-0.26
A.18	697.9	-20.35	-0.95	23.88	1.27	-0.02
A.19	723.3	-22.49	-1.06	25.40	1.40	-0.61
A.20	737.1	-22.71	-1.11	26.23	1.17	-0.23
A.21	763.9	-24.05	-1.16	27.83	1.06	-0.14
A.22	770.1	-23.99	-1.23	28.20	1.15	+0.33
A.23	815.8	-27.19	-1.29	30.95	1.35	+0.02
A.24	845.0	-28.57	-1.34	32.70	1.05	+0.02
A.25	858.2	-28.99	-1.37	33.49	1.20	+0.49
A.26	897.0	-31.78	-1.44	35.82	1.07	-0.12
A.27	914.3	-32.77	-1.48	36.86	1.30	+0.08
A.28	918.1	-33.11	-1.51	37.08	1.45	+0.07
A.29	921.5	-33.09	-1.53	37.29	1.34	+0.16
A.30	938.0	-34.04	-1.57	38.28	1.57	+0.42
A.31	937.7	-33.89	-1.61	38.26	1.38	+0.31
A.32	964.9	-35.34	-1.66	39.89	1.53	+0.62
A.33	987.9	-36.77	-1.71	41.28	1.28	+0.25
A.34	1018.3	-38.26	-1.77	43.10	1.39	+0.65
A.35	1046.2	-40.15	-1.85	44.77	1.48	+0.45

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
A.36	1054.4	-40.22	-1.85	45.27	1.24	+0.57
A.37	1049.6	-39.82	-1.91	44.98	1.27	+0.66
A.38	1041.6	-38.98	-1.94	44.50	1.04	+0.74
A.39	1034.0	-38.34	-1.99	44.04	0.94	+0.77
A.40	1009.7	-36.69	-2.03	42.58	0.88	+0.84
A.41	1002.6	-35.97	-2.08	42.15	0.95	+1.17
A.42	989.4	-35.00	-2.12	41.37	0.93	+1.30
A.43	963.5	-33.71	-2.19	39.82	0.80	+0.84
A.44	941.1	-32.10	-2.25	38.46	0.74	+0.97
A.45	920.9	-30.71	-2.39	37.25	0.73	+1.00
A.46	901.9	-29.41	-2.45	36.11	0.73	+1.12
A.47	872.3	-27.65	-2.51	34.34	0.67	+0.98
A.48	854.8	-26.82	-2.57	33.29	0.63	+0.65
A.49	837.7	-25.64	-2.64	32.26	0.60	+0.71
A.50	851.4	-26.45	-2.69	33.08	0.51	+0.58
A.51	816.5	-24.12	-2.79	30.99	0.72	+0.96
A.52	793.4	-22.23	-2.84	29.60	0.71	+1.36
A.53	769.2	-21.14	-2.01	28.15	0.65	+0.88
A.54	756.2	-20.06	-2.96	27.37	0.65	+1.13
A.55	741.5	-18.91	-3.03	26.49	0.53	+1.21
A.56	740.4	-18.82	-3.09	26.42	0.48	+1.11
A.57	736.5	-18.56	-3.14	26.19	0.39	+1.00
A.58	741.4	-18.83	-3.21	26.49	0.44	+1.02
A.59	735.5	-18.79	-3.26	26.13	0.41	+0.61
A.60	717.7	-17.32	-3.34	25.06	0.42	+0.96
A.61	711.2	-16.99	-3.41	24.67	0.45	+0.85
A.62	691.8	-15.71	-3.47	23.51	0.50	+0.96
A.63	681.0	-15.12	-3.52	22.86	0.51	+0.86
A.64	675.7	-15.03	-3.57	22.54	0.58	+0.66
A.65	636.8	-12.77	-3.64	20.21	0.65	+0.59
A.66	634.7	-12.81	-3.65	20.08	0.68	+0.44
A.67	631.8	-12.59	-3.68	19.91	0.75	+0.53
A.68	640.7	-13.13	-3.74	20.44	0.76	+0.47
B. 1	668.6	-14.94	-3.74	22.12	0.72	+0.29
B. 2	695.4	-16.30	-3.79	23.72	0.68	+0.43
B. 3	705.9	-16.77	-3.85	24.36	0.70	+0.57

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
B. 4	729.0	-18.06	-3.91	25.74	0.57	+0.46
B. 5	755.4	-19.56	-3.96	27.33	0.56	+0.49
B. 6	763.5	-20.08	-4.02	27.81	0.51	+0.35
B. 7	762.0	-19.96	-4.07	27.72	0.60	+0.41
B. 8	767.0	-20.41	-4.12	28.02	0.52	+0.12
B. 9	759.8	-19.84	-4.17	27.59	0.50	+0.19
B.10	764.1	-20.02	-4.22	27.85	0.51	+0.27
B.11	760.7	-19.87	-4.26	27.64	0.46	+0.09
B.12	737.9	-18.51	-4.32	26.27	0.45	+0.02
B.13	708.3	-16.50	-4.36	24.50	0.46	+0.22
B.14	706.2	-16.61	-4.42	24.37	0.42	-0.11
B.15	712.8	-16.86	-4.43	24.77	0.39	-0.03
B.16	729.8	-17.79	-4.49	25.79	0.40	+0.03
B.17	733.0	-17.96	-4.54	25.98	0.33	-0.05
B.18	724.5	-17.54	-4.62	25.47	0.32	-0.25
B.19	713.9	-16.92	-4.66	24.83	0.31	-0.32
B.20	694.9	-15.85	-4.71	23.69	0.33	-0.42
B.21	678.9	-14.63	-4.77	22.73	0.37	-0.18
B.22	662.9	-13.47	-4.84	21.27	0.35	-0.07
B.23	680.1	-14.59	-4.91	22.80	0.28	-0.30
B.24	694.1	-15.45	-4.96	23.65	0.29	-0.34
B.25	706.8	-16.28	-5.02	24.41	0.34	-0.42
B.26	725.3	-17.27	-5.11	25.52	0.34	-0.39
B.27	742.1	-17.90	-5.18	26.52	0.33	-0.10
B.28	741.2	-17.79	-5.24	26.47	0.28	-0.15
B.29	728.3	-16.88	-5.27	25.70	0.26	-0.06
B.30	744.8	-18.06	-5.34	26.69	0.24	-0.34
B.31	764.8	-19.12	-5.41	27.89	0.31	-0.20
B.32	783.7	-20.26	-5.47	29.02	0.38	-0.20
B.33	778.0	-19.67	-5.52	28.68	0.33	-0.05
B.34	744.4	-17.68	-5.55	26.67	0.33	-0.10
B.35	717.1	-15.63	-5.60	25.03	0.36	+0.29
B.36	705.4	-14.93	-5.71	24.33	0.42	+0.24
B.37	700.8	-14.71	-5.78	24.05	0.36	+0.05
B.38	695.0	-14.12	-5.79	23.70	0.29	+0.21
B.39	693.6	-13.95	-5.84	23.62	0.25	+0.21
B.40	694.6	-13.98	-5.89	23.67	0.24	+0.17

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
B.41	692.2	-13.18	-5.92	23.53	0.26	+0.20	
B.42	684.2	-13.25	-5.97	23.05	0.26	+0.22	
B.43	670.1	-12.22	-6.02	22.21	0.29	+0.39	
B.44	655.0	-11.56	-6.07	21.30	0.31	+0.11	
B.45	642.9	-10.79	-6.12	20.57	0.33	+0.12	
B.46	634.8	-10.42	-6.17	20.09	0.34	-0.03	
B.47	632.4	-10.30	-6.21	19.94	0.36	-0.08	
B.48	627.6	- 9.92	-6.27	19.66	0.41	+0.01	
B.49	604.9	- 8.73	-6.26	18.29	0.37	-0.20	
B.50	584.0	- 7.69	-6.30	17.04	0.32	-0.50	
B.51	563.4	- 6.45	-6.33	15.81	0.56	-0.28	
B.52	542.5	- 5.43	-6.37	14.55	0.62	-0.50	
B.53	524.2	- 4.30	-6.37	13.45	0.64	-0.45	
C. 1	589.5	- 6.67	-8.38	17.17	0.50	-1.25	
C. 2	598.5	- 7.29	-8.33	17.70	0.52	-1.27	
C. 3	630.0	- 9.18	-8.25	19.57	0.48	-1.25	
C. 4	631.3	- 9.09	-8.21	19.65	0.58	-0.95	
C. 5	639.7	- 9.67	-8.17	20.15	0.64	-0.92	
C. 6	653.2	-10.58	-8.17	20.94	0.73	-0.95	
C. 7	689.4	-12.67	-8.19	23.09	0.66	-0.98	
C. 8	724.8	-14.91	-8.13	25.19	0.64	-1.08	
C. 9	742.8	-16.07	-8.09	26.26	0.65	-1.12	
C.10	778.5	-18.09	-8.03	28.37	0.61	-1.01	
C.11	785.5	-18.60	-7.99	28.79	0.61	-1.06	
C.12	798.3	-19.31	-7.97	29.55	0.65	-0.95	
C.13	800.7	-19.56	-7.95	29.69	0.77	-0.92	
C.14	819.4	-20.64	-7.95	30.80	0.61	-1.05	
C.15	842.3	-22.00	-7.94	32.16	0.56	-1.09	
C.16	860.3	-23.02	-7.90	33.22	0.59	-0.98	
C.17	873.0	-24.06	-7.82	33.98	0.60	-1.17	
C.18	888.3	-24.90	-7.76	34.89	0.52	-1.12	
C.19	906.0	-25.90	-7.72	35.94	0.55	-1.00	
C.20	924.9	-27.43	-7.66	37.05	0.60	-1.31	
C.21	932.8	-27.92	-7.63	37.53	0.58	-1.30	
C.22	946.0	-28.61	-7.61	38.30	0.61	-1.18	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
C.23	949.5	-28.63	-7.57	38.52	0.62	-0.93
C.24	972.6	-30.02	-7.68	39.89	0.63	-0.85
C.25	983.9	-30.72	-7.46	40.55	0.64	-0.86
C.26	992.1	-31.05	-7.40	41.04	0.58	-0.70
C.27	1001.9	-31.73	-7.35	41.62	0.70	-0.63
C.28	999.7	-31.46	-7.32	41.49	0.74	-0.42
C.29	991.2	-30.80	-7.30	40.99	0.83	-0.15
C.30	989.6	-30.68	-7.24	40.89	0.85	-0.05
C.31	1016.5	-32.64	-7.18	42.49	0.92	-0.28
C.32	1049.7	-35.08	-7.06	44.45	0.84	-0.82
C.33	1064.6	-36.18	-7.10	45.34	0.81	-0.98
C.34	1076.7	-36.70	-7.02	46.06	0.81	-0.72
C.35	1087.5	-37.45	-6.99	46.70	0.80	-0.81
C.36	1089.5	-37.72	-6.93	46.82	0.80	-0.90
C.37	1091.4	-37.61	-6.87	46.93	0.76	-0.66
C.38	1098.1	-38.02	-6.83	47.33	0.76	-0.53
C.39	1099.1	-37.64	-6.75	47.38	0.84	-0.05
C.40	1121.3	-38.97	-6.70	48.70	0.71	-0.18
C.41	1137.3	-39.94	-6.66	49.65	0.71	-0.11
C.42	1150.7	-40.87	-6.22	50.44	0.82	-0.10
C.43	1149.1	-40.70	-6.77	50.35	0.85	+0.06
C.44	1139.5	-40.18	-6.53	49.78	0.80	00.00
C.45	1119.0	-38.99	-6.53	48.57	0.93	+0.01
C.46	1104.6	-37.82	-6.51	47.71	0.91	+0.42
C.47	1075.8	-36.56	-6.47	46.01	0.74	-0.15
C.48	1037.3	-34.18	-6.47	43.72	0.80	0.00
C.49	1029.0	-	-	-	-	-
C.50	1014.8	-32.17	-6.44	42.39	0.65	+0.56
C.51	1005.2	-31.61	-6.40	41.82	0.57	+0.49
C.52	1010.9	-31.62	-6.40	42.16	0.55	+0.82
C.53	995.0	-30.88	-6.39	41.22	0.59	+0.67
C.54	1000.5	-31.07	-6.31	41.54	0.57	+0.84
C.55	1023.2	-32.43	-6.29	42.89	0.49	+0.79
C.56	1037.5	-33.39	-6.23	43.73	0.61	+0.83
C.57	1045.3	-33.77	-6.21	44.20	0.59	+0.94
C.58	1050.1	-33.87	-6.17	44.48	0.60	+1.17
C.59	1068.4	-35.10	-6.19	45.57	0.55	+1006

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
0.60	1069.1	-34.72	-6.17	45.61	0.61	+1.46
0.61	1063.3	-34.56	-6.07	45.26	0.64	+1.30
0.62	1049.1	-33.81	-6.10	44.42	0.69	+1.19
0.63	1023.9	-32.29	-6.10	42.93	0.68	+1.35
0.64	1033.4	-32.89	-6.00	43.49	0.60	+1.29
0.65	1041.2	-33.05	-5.91	44.43	0.66	+2.17
0.66	1030.9	-32.41	-5.98	43.34	0.65	+1.73
0.67	1028.4	-32.26	-5.96	43.20	0.64	+1.75
0.68	1013.3	-31.00	-5.94	42.30	0.63	+2.12
0.69	997.2	-29.87	-5.94	41.34	0.78	+2.54
0.70	997.7	-29.97	-5.92	41.37	0.75	+2.36
0.71	979.4	-29.24	-5.94	40.29	0.81	+2.05
0.72	972.5	-28.68	-5.94	39.88	0.87	+2.26
0.73	966.3	-28.19	-5.96	39.51	0.83	+2.31
0.74	946.6	-27.02	-5.96	38.34	0.95	+2.44
0.75	940.8	-26.61	-5.97	38.00	1.10	+2.64
0.76	927.2	-26.00	-6.00	37.19	1.06	+2.38
0.77	918.7	-25.23	-6.02	36.69	0.91	+2.48
0.78	904.5	-24.22	-6.00	35.85	1.01	+2.77
0.79	890.1	-23.34	-5.96	34.99	0.96	+2.78
0.80	889.0	-23.10	-5.94	34.93	1.05	+3.07
0.81	880.7	-22.72	-5.94	34.44	0.97	+2.88
0.82	868.3	-21.84	-5.92	33.72	0.95	+3.04
0.83	851.2	-20.72	-5.92	32.69	0.66	+2.84
0.84	847.4	-20.65	-5.92	32.46	0.65	+2.67
0.85	857.8	-21.05	-5.88	33.08	0.56	+2.84
0.86	858.2	-20.70	-5.83	33.10	0.51	+3.22
0.87	841.4	-19.30	-5.79	32.10	0.56	+3.70
0.88	836.5	-18.87	-5.72	31.82	0.55	+3.80
0.89	831.4	-18.51	-5.69	31.51	0.54	+3.98
0.90	818.3	-17.71	-5.65	30.73	0.56	+4.06
0.91	811.2	-17.34	-5.57	30.31	0.54	+4.07
0.92	789.1	-15.76	-5.43	29.00	0.63	+4.57
0.93	784.9	-15.47	-5.38	28.76	0.56	+4.60
0.94	776.6	-14.74	-5.33	28.26	0.51	+4.83
0.95	760.3	-13.74	-5.32	27.30	0.51	+4.88
0.96	748.5	-13.24	-5.30	26.59	0.48	+4.66

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
E. 1	741.6	-13.00	-5.30	26.19	0.43	+4.45
E. 2	723.9	-11.75	-5.22	25.14	0.46	+4.74
E. 3	726.7	-11.81	-5.20	25.30	0.50	+4.92
E.44	737.5	-12.46	-5.14	25.94	0.45	+4.92
E. 5	747.3	-13.03	-5.14	26.53	0.43	+4.82
E. 6	747.2	-13.19	-5.10	26.52	0.42	+4.78
E. 7	746.0	-13.00	-5.30	26.45	0.43	+4.92
E. 8	744.3	-13.31	-5.06	26.35	0.48	+4.59
E. 9	744.6	-13.36	-5.04	26.36	0.54	+4.63
E.10	743.5	-13.40	-5.03	26.30	0.50	+4.50
E.11	744.1	-13.64	-5.04	26.33	0.50	+4.33
E.12	744.2	-13.44	-4.95	26.34	0.50	+4.58
E.13	746.3	-13.77	-4.90	26.47	0.54	+4.46
E.14	753.4	-14.31	-4.95	26.88	0.58	+4.43
E.15	757.1	-14.76	-4.91	27.10	0.71	+4.37
E.16	761.8	-15.05	-4.76	27.39	0.64	+4.35
E.17	749.9	-14.67	-4.74	26.68	0.66	+4.06
E.18	746.1	-14.30	-4.68	26.45	0.67	+4.27
E.19	743.2	-14.23	-4.61	26.28	0.67	+4.24
E.20	742.9	-14.34	-4.55	26.26	0.71	+4.21
E.21	742.9	-14.33	-4.47	26.26	0.68	+4.27
E.22	744.4	-14.50	-4.45	26.35	0.66	+4.19
E.23	744.4	-14.51	-4.39	26.34	0.64	+4.21
E.24	744.1	-14.64	-4.37	26.33	0.68	+4.13
E.25	745.0	-14.65	-4.33	26.39	0.61	+4.15
E.26	746.3	-14.99	-4.29	26.46	0.62	+3.93
E.27	753.2	-15.58	-4.23	26.87	0.65	+3.84
E.28	762.3	-16.19	-4.18	27.42	0.60	+3.78
E.29	754.2	-15.87	-4.14	26.93	0.55	+3.60
E.30	749.40	-15.77	-4.10	26.65	0.56	+3.47
E.31	745.4	-15.81	-4.06	26.41	0.51	+3.18
E.32	744.8	-16.18	-4.00	26.37	0.52	+2.84
E.33	747.9	-16.40	-3.94	26.56	0.50	+2.85
E.34	757.7	-17.16	-3.90	27.14	0.53	+2.83
E.35	763.4	-17.61	-3.87	27.48	0.46	+2.59
E.36	764.3	-17.72	-3.85	27.53	0.46	+2.55
E.37	755.4	-17.46	-3.85	27.00	0.49	+2.31
E.38	758.5	-17.51	-3.85	27.19	0.49	+2.45

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
E.39	764.5	-17.94	-3.83	27.55	0.47	+2.38	
E.40	759.0	-17.68	-3.83	27.22	0.53	+2.42	
E.41	764.8	-18.05	-3.83	27.56	0.50	+2.31	
E.42	773.6	-18.65	-3.83	28.08	0.53	+2.26	
E.43	776.3	-18.95	-3.83	28.24	0.55	+2.14	
E.44	789.2	-19.78	-3.83	29.01	0.65	+2.18	
E.45	796.1	-20.35	-3.83	29.42	0.75	+2.11	
E.46	801.5	-20.61	-3.83	29.74	0.79	+2.22	
E.47	799.1	-20.74	-3.86	29.59	0.77	+1.90	
E.48	794.7	-20.58	-3.86	29.33	0.80	±1.83	
E.49	795.9	-20.87	-3.86	29.40	0.82	+1.63	
E.50	790.8	-20.60	-3.86	29.10	0.90	+1.67	
E.51	775.1	-19.67	-3.87	28.17	0.84	+1.60	
E.52	763.6	-19.04	-3.87	27.49	0.68	+1.39	
E.53	761.2	-18.97	-3.88	27.34	0.65	+1.27	
E.54	754.1	-18.69	-3.87	26.92	0.57	+1.05	
E.55	744.6	-18.22	-3.88	26.36	0.66	+1.05	
E.56	739.6	-17.94	-3.88	26.06	0.69	+1.06	
E.57	735.3	-17.78	-3.88	25.81	0.61	+0.89	
E.58	731.1	-17.52	-3.88	25.56	0.65	+0.94	
E.59	719.5	-16.93	-3.88	24.87	0.60	+0.79	
E.60	711.3	-16.50	-3.87	24.38	0.57	+0.71	
E.61	702.1	-16.08	-3.88	23.84	0.67	+0.68	
E.62	697.9	-15.85	-3.86	23.65	0.57	+0.64	
E.63	697.1	-15.69	-3.85	23.59	0.55	+0.73	
E.64	696.3	-15.48	-3.86	23.50	0.56	+0.85	
E.65	694.3	-15.42	-3.89	23.38	0.61	+0.81	
E.66	700.9	-15.80	-3.90	23.77	0.60	+0.80	
E.67	701.3	-15.84	-3.95	23.79	0.46	+0.59	
E.68	707.8	-16.12	-3.99	24.18	0.62	+0.81	
E.69	702.7	-15.99	-4.02	23.87	0.72	+0.71	
E.70	713.4	-16.72	-4.02	24.51	0.82	+0.75	
E.71	721.2	-17.33	-3.96	24.97	0.83	+0.64	
E.72	733.0	-18.00	- 3.92	25.67	0.76	+0.64	
E.73	739.3	-18.49	-3.91	26.05	0.81	+0.59	
E.74	724.9	-18.38	-3.88	25.78	0.85	+0.50	
E.75	724.7	-18.03	-3.86	25.18	1.24	+0.66	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
E.76	713.1	-17.35	-3.85	24.49	0.95	+0.38
E.77	707.3	-16.57	-3.80	24.15	1.07	+0.51
E.78	706.3	-16.98	-3.79	24.09	1.11	+0.65
E.79	697.9	-16.62	-3.78	23.59	0.94	+0.26
E.80	682.4	-15.60	-3.77	22.67	0.73	+0.16
E.81	677.1	-15.35	-3.74	22.36	1.03	+0.41
E.82	674.2	-15.30	-3.73	22.19	0.73	+0.00
E.83	672.0	-15.23	-3.74	22.05	1.15	+0.47
E.84	664.3	-14.60	-3.73	21.60	1.16	+0.54
E.85	660.4	-14.32	-3.76	21.36	0.94	+0.36
E.86	652.9	-13.81	-3.75	20.92	0.94	+0.42
E.87	650.1	-13.82	-3.76	20.76	0.79	-0.08
F. 1	727.0	-11.82	-5.11	25.31	0.44	+4.95
F. 2	724.1	-11.62	-5.15	25.14	0.46	+4.96
F. 3	735.5	-12.40	-5.18	25.82	0.51	+4.88
F. 4	727.4	-11.94	-5.21	25.34	0.58	+4.90
F. 5	710.0	-10.76	-5.24	24.31	0.61	+5.05
F. 6	698.7	-10.10	-5.27	23.64	0.62	+5.02
F. 7	690.6	-10.04	-5.28	23.16	0.62	+4.59
F. 8	683.4	- 8.90	-5.31	22.73	0.61	+5.26
F. 9	678.6	- 8.71	-5.32	22.45	0.67	+5.22
F.10	677.0	- 8.46	-5.32	22.35	0.69	+5.39
F.11	671.9	- 8.25	-5.34	22.05	0.63	+5.22
F.12	667.1	- 7.92	-5.38	21.76	0.76	+5.35
F.13	669.8	- 8.05	-5.41	21.93	1.07	+5.67
F.14	675.5	- 8.71	-5.46	22.26	0.85	+5.07
F.15	690.8	- 9.72	-5.51	23.16	0.85	+4.91
F.16	702.7	-10.79	-5.55	23.88	0.86	+4.53
F.17	711.7	-11.13	-5.56	24.39	0.85	+4.48
F.18	713.7	-11.23	-5.57	24.53	0.92	+4.78
F.19	712.2	-11.17	-5.57	24.44	1.01	+4.84
F.20	698.0	-10.47	-5.57	23.60	0.94	+4.63
F.21	681.9	- 9.42	-5.54	22.64	1.08	+4.89
F.22	657.4	- 8.47	-5.53	21.19	1.25	+4.57
F.23	634.0	- 6.98	-5.56	19.80	1.28	+4.67
F.24	615.9	- 5.68	-5.56	18.73	1.25	+4.87

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
F.25	594.9	- 4.50	-5.53	17.48	1.47	+5.05
F.26	574.3	- 3.34	-5.56	16.26	1.54	+5.03
F.27	554.3	- 2.52	-5.58	15.07	1.63	+4.73
F.28	540.5	- 1.69	-5.58	14.25	1.65	+4.78
F.29	538.8	- 1.32	-5.56	14.16	1.74	+5.15
F.30	527.5	- 0.74	-5.54	13.48	1.77	+5.10
F.31	524.5	- 0.51	-5.50	13.28	1.67	+5.07
F.32	524.1	- 0.57	-5.48	13.28	1.62	+4.98
F.33	516.8	- 0.38	-5.44	12.85	1.57	+4.73
F.34	503.6	+ 0.84	-5.40	12.07	1.51	+5.15
F.35	510.6	+ 0.78	-5.33	12.48	1.41	+5.47
F.36	524.8	+ 0.42	-5.30	13.33	1.39	+5.97
F.37^1	528.4	+ 0.23	-5.29	13.54	1.28	+5.89
F.37^2	529.9	+ 0.06	-5.30	13.63	1.15	+5.67
F.38	522.4	+ 0.45	-5.31	13.19	1.16	+5.02
F.39	516.2	+ 0.82	-5.30	12.82	1.43	+5.90
F.40	513.8	+ 0.21	-5.29	12.67	1.31	+5.03
F.41	495.5	+ 1.30	-5.28	11.59	1.64	+5.38
F.42	473.0	+ 2.25	-5.31	10.25	1.64	+4.96
F.43	460.0	+ 2.60	-5.35	9.48	1.74	+4.60
F.44^1	452.8	+ 2.98	-5.37	9.06	1.97	+4.77
F.44^2	445.5	+ 3.01	-5.38	8.62	1.83	+4.21
F.45	439.0	+ 3.31	-5.40	8.24	1.77	+4.05
F.46	428.0	+ 3.68	-5.41	7.58	2.01	+3.99
F.47	415.6	+ 4.09	-5.41	6.82	1.94	+3.57
F.48	401.4	+ 4.85	-5.42	6.01	2.40	+3.97
F.49	391.4	+ 5.10	-5.45	5.42	2.44	+3.64
F.50	382.5	+ 5.25	-5.48	4.89	2.68	+3.48
F.51	369.0	+ 6.01	-5.50	4.25	2.66	+3.55
F.52	353.6	+ 7.01	-5.50	3.30	2.61	+3.55
F.53^1	339.6	+ 7.71	-5.47	2.44	2.53	+3.34
F.53^2	330.6	+ 8.64	-5.41	1.83	2.22	+3.46
F.54	334.3	+ 8.59	-5.37	2.11	2.11	+3.57
F.55	328.0	+ 8.78	-5.38	1.72	2.07	+3.32
F.56	319.9	+ 9.02	-5.39	1.22	2.21	+3.19
F.57	316.0	+ 9.02	-5.41	0.93	2.25	+2.97
F.58	313.7	+ 8.96	-5.41	0.84	2.15	+2.67

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
F.59	311.0	+ 8.89	-5.40	+ 0.68	2.20	+2.50	
F.60	308.8	+ 8.94	-5.38	+ 0.54	2.42	+2.45	
F.61	304.6	+ 8.87	-5.37	+ 0.28	2.22	+2.13	
F.62	301.4	+ 8.84	-5.37	+ 0.09	2.25	+1.94	
F.63	299.7	+ 8.79	-5.37	- 0.02	1.81	+1.80	
F.64	297.1	+ 8.68	-5.38	- 0.18	2.33	+1.58	
F.65	298.4	+ 8.49	-5.42	- 0.10	2.30	+1.40	
F.66	309.1	+ 7.61	-5.47	+ 0.56	2.28	+1.11	
F.67	311.6	+ 7.22	-5.51	+ 0.71	2.28	+0.83	
F.68	304.7	+ 7.50	-5.56	+ 0.29	2.16	+0.52	
F.69	298.8	+ 7.66	-5.60	- 0.08	2.25	+0.36	
F.70	285.7	+ 8.33	-5.63	- 0.88	2.36	+0.31	
F.71	284.8	+ 8.20	-5.65	- 0.94	2.39	+0.13	
F.72	286.0	+ 8.04	-5.67	- 0.86	2.40	+0.04	
F.73	293.9	+ 7.23	-5.70	- 0.38	2.07	-0.65	
G. 1	340.2	+ 8.29	-5.50	+ 2.30	2.37	+ 3.59	
G. 2	344.4	+ 8.43	-5.49	+ 2.60	2.23	+ 3.90	
G. 3	344.7	+ 8.48	-5.46	+ 2.64	2.04	+ 3.83	
G. 4	359.9	+ 8.13	-5.42	+ 3.55	2.20	+ 4.59	
G. 5	372.7	+ 7.69	-5.36	+ 4.30	1.87	+ 4.63	
G. 6	393.2	+ 6.62	-5.30	+ 5.52	1.88	+ 4.85	
G. 7	420.4	+ 5.02	-5.25	+ 7.13	1.73	+ 4.76	
G. 8	447.2	+ 3.69	-5.21	+ 8.73	1.81	+ 5.15	
G. 9	471.9	+ 2.52	-5.15	+10.19	1.80	+ 5.49	
G.10	499.3	+ 1.26	-5.07	+11.82	1.65	+ 5.79	
G.11	516.6	+ 0.59	-5.00	+12.84	1.65	+ 6.21	
G.12	540.7	- 0.45	-4.94	+14.27	1.68	+ 6.69	
G.13	555.4	- 0.85	-4.90	+15.14	1.63	+ 7.15	
G.14	572.7	- 1.46	-4.86	+16.17	1.58	+ 7.56	
G.15	589.8	- 2.45	-4.82	+17.18	1.58	+ 7.62	
G.16	600.1	- 2.87	-4.77	+17.79	1.50	+ 7.78	
G.17	621.0	- 3.61	-4.73	+19.03	1.35	+ 8.17	
G.18	639.0	- 4.40	-4.69	+20.10	1.36	+ 8.50	
G.19	655.1	- 5.00	-4.63	+21.05	1.31	+ 8.86	
G.20	671.9	- 5.91	-4.59	+22.05	1.25	+ 8.93	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
G.21	695.0	- 6.84	-4.52	23.42	1.17	+ 9.36
G.22	721.9	- 8.39	-4.35	25.01	1.25	+ 9.55
G.23	745.6	- 9.53	-4.40	26.42	1.13	+ 9.75
G.24	758.6	-10.13	-4.36	27.19	1.05	+ 9.88
G.25	768.4	-10.53	-4.31	27.77	1.09	+10.15
G.26	784.6	-11.40	-4.26	28.73	0.95	+10.14
G.27	795.1	-11.56	-4.22	29.35	0.79	+10.49
G.28	810.7	-12.28	-4.15	30.28	0.74	+10.72
G.29	829.4	-13.03	-4.08	31.39	0.61	+11.02
G.30	845.4	-13.85	-3.99	32.34	0.64	+11.27
G.31	848.2	-14.11	-3.95	32.51	0.63	+11.21
G.32	854.6	-14.36	-3.88	32.88	0.80	+11.57
G.33	859.1	-14.53	-3.84	33.15	0.65	+11.58
G.34	870.0	-15.00	-3.78	33.80	0.71	+11.86
G.35	882.5	-15.61	-3.69	34.54	0.69	+12.06
G.36	891.8	-16.33	-3.65	35.09	0.72	+11.98
G.37	899.3	-17.08	-3.57	35.53	0.74	+11.75
G.38	921.2	-18.63	-3.52	36.83	0.72	+11.53
G.39	929.7	-19.15	-3.45	37.34	0.74	+11.61
G.40	937.8	-19.83	-3.37	37.81	0.74	+11.48
G.41	954.4	-21.15	-3.34	38.80	0.65	+11.09
G.42	971.1	-22.58	-3.26	39.79	0.76	+10.84
G.43	988.2	-22.88	-3.20	40.80	0.75	+10.60
G.44	1001.0	-25.04	-3.14	41.57	0.79	+10.31
G.45	1016.4	-26.49	-3.05	42.48	0.71	+ 9.78
G.46	1028.1	-27.55	-2.99	43.17	0.82	+ 9.58
G.47	1031.4	-28.23	-2.93	43.36	0.83	+ 9.15
G.48	1029.0	-28.52	-2.87	43.23	0.85	+ 8.82
G.49	1026.2	-28.73	-2.81	43.06	0.97	+ 8.72
G.50	1028.6	-29.34	-2.75	43.20	1.06	+8.29
G.51	1032.5	-30.02	-2.70	43.43	1.14	+ 7.98
G.52	1040.9	-30.84	-2.67	43.93	1.13	+ 7.68
G.53	1046.9	-31.68	-2.63	44.28	1.11	+ 7.21
G.54	1052.2	-32.41	-2.59	44.60	1.22	+ 6.95
G.55	1056.3	-32.99	-2.54	44.84	1.10	+ 6.54
G.56	1057.1	-33.34	-2.48	44.89	1.27	+ 6.47
G.57	1064.7	-34.13	-2.43	45.34	1.26	+ 6.17
G.58	1076.9	-34.94	-2.42	46.06	1.28	+ 6.11

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
G.59	1090.9	-35.85	-2.39	46.90	1.49	+6.28	
G.60	1088.6	-35.87	-2.38	46.76	1.23	+5.87	
G.61	1094.3	-39.20	-2.36	47.10	1.19	+2.86	
G.62	1097.7	-36.52	-2.33	47.30	1.23	+5.71	
G.63	1103.9	-37.18	-2.30	47.67	1.15	+5.47	
G.64	1109.9	-37.84	-2.27	48.03	1.18	+5.23	
G.65	1106.6	-37.98	-2.22	47.83	1.22	+4.98	
G.66	1094.0	-37.42	-2.18	47.08	1.22	+4.83	
G.67	1085.3	-37.18	-2.12	46.57	1.28	+4.68	
G.68	1080.0	-37.26	-2.07	46.25	1.39	+4.44	
G.69	1071.9	-37.10	-2.01	45.78	1.48	+4.28	
G.70	1061.8	-36.80	-1.95	45.17	1.71	+4.26	
G.71	1053.8	-36.56	-1.92	44.70	1.61	+3.96	
G.72	1042.4	-36.18	-1.88	44.03	1.86	+3.96	
G.73	1032.3	-35.94	-1.82	43.43	1.85	+3.65	
G.74	1023.5	-35.73	-1.77	42.90	1.84	+3.37	
G.75	1013.3	-35.38	-1.70	42.30	1.94	+3.29	
G.76	1001.2	-35.00	-1.64	41.58	1.98	+3.05	
G.77	992.0	-34.52	-1.56	41.04	2.07	+3.16	
G.78	991.9	-34.38	-1.49	41.03	1.88	+3.17	
G.79	973.6	-34.22	-1.42	39.95	2.17	+2.61	
G.80	961.6	-33.93	-1.32	39.23	2.45	+2.56	
G.81	949.4	-33.42	-1.79	38.51	2.00	+1.43	
G.82	943.9	-33.92	-1.26	38.18	2.21	+2.34	
G.83	936.4	-32.33	-1.22	37.74	2.12	+2.44	
G.84	922.5	-31.75	-1.15	36.91	2.64	+2.78	
G.85	907.2	-31.04	-1.10	36.01	2.13	+2.13	
G.86	891.0	-30.19	-1.06	35.04	2.59	+2.51	
G.87	865.5	-29.12	-1.03	33.53	2.62	+2.13	
G.88	840.8	-27.82	-1.01	32.07	2.97	+2.34	
G.89	816.3	-26.35	-0.96	30.62	3.00	+2.44	
G.90	802.4	-25.39	-0.93	29.79	3.00	+2.60	
G.91	782.5	-24.22	-0.86	28.61	3.10	+2.76	
G.92	756.9	-22.28	-0.83	27.09	2.92	+3.03	
G.93	731.2	-21.15	-0.78	25.57	2.58	+2.35	
G.94	707.1	-19.19	-0.69	24.14	3.21	+2.88	
G.95	681.7	-18.80	-0.65	22.64	2.99	+2.31	

GRAVITY DATA SHEET NO. 14

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
G. 96	662.8	-18.08	-0.62	+21.51	3.17	+2.11
G. 97	646.5	-17.26	-0.58	+20.55	3.34	+2.18
G. 98	629.5	-16.75	-0.55	+19.54	3.82	+2.19
G. 99	616.0	-16.21	-0.53	+18.74	3.25	+1.38
G.100	599.8	-15.18	-0.48	+17.78	3.21	+1.46
G.101	583.2	-14.14	-0.43	+16.79	3.48	+1.83
G.102	564.6	-13.07	-0.40	+15.69	3.35	+1.70
G.103	546.1	-12.02	-0.32	+14.59	3.29	+1.67
G.104	522.9	-10.59	-0.28	+13.22	3.02	+1.50
G.105	499.1	- 8.85	-0.27	+11.81	3.00	+1.82
G.106	479.4	- 7.37	-0.23	+10.46	2.83	+2.00
G.107	460.1	- 5.73	-0.22	+ 9.49	2.82	+2.49
G.108	445.7	- 5.02	-0.20	+ 8.64	2.85	+2.40
G.109	431.6	- 4.52	-0.17	+ 7.81	2.92	+2.17
G.110	418.8	- 3.89	-0.15	+ 7.37	2.96	+2.42
G.111	410.5	- 3.32	-0.11	+ 6.85	2.70	+2.25
G.112	397.2	- 2.58	-0.06	+ 6.03	2.64	+2.16
G.113	372.4	- 0.77	-0.01	+ 4.49	2.40	+2.24
G.114	357.0	+ 0.37	+0.04	+ 3.53	2.17	+2.24
G.115	335.8	+ 1.65	+0.10	+ 2.22	2.19	+2.29
G.116	246.7	+ 8.48	+0.38	- 3.30	1.52	+3.21
G.117	246.9	+ 8.52	+0.45	- 3.29	1.34	+3.15
G.118	231.4	+ 8.31	+0.51	- 4.25	1.28	+1.98
G.119	229.7	+ 7.53	+0.55	- 4.36	1.30	+1.15
G.120	230.3	+ 7.52	+0.62	- 4.32	0.99	+0.94
H. 1	917.1	-34.17	-0.35	+36.59	2.02	+0.22
H. 2	951.8	-36.13	-0.43	+38.65	1.96	+0.18
H. 3	1038.2	-37.98	-0.49	+43.77	2.29	+3.73
H. 4	1144.6	-47.80	-0.59	+50.09	2.24	+0.07
H. 5	1142.1	-47.73	-0.66	+49.94	2.17	-0.15
H. 6	1172.3	-49.58	-0.73	+51.73	2.13	-0.32
H. 7	1244.6	-53.67	-0.82	+56.01	2.14	-0.21
H. 8	1285.5	-55.94	-0.92	+58.44	1.90	-0.39
H. 9	1315.7	-57.37	-1.02	+60.23	1.91	-0.07
H.10	1317.2	-57.38	-1.10	+60.32	1.86	-0.12
H.11	1315.7	-56.71	-1.17	+60.23	1.75	+0.28

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
H.12	1306.5	-56.16	-1.24	+59.68	1.69	+0.14	
H.13	1287.5	-54.77	-1.27	+58.56	1.53	+0.18	
H.14	1257.5	-52.60	-1.32	+56.78	1.57	+0.56	
H.15	1253.4	-52.32	-1.38	+56.54	1.45	+0.43	
H.16	1288.0	-54.71	-1.45	+58.59	1.39	-0.15	
H.17	1300.3	-54.79	-1.51	+59.32	1.37	+0.52	
H.18	1322.9	-55.87	-1.54	+60.66	1.43	+0.81	
H.19	1321.7	-55.52	-1.57	+60.59	1.40	+1.03	
H.20	1347.3	-56.92	-1.62	+62.10	1.63	+1.32	
H.21	1358.6	-57.28	-1.68	+62.78	1.78	+1.73	
H.22	1336.7	-55.89	-1.75	+61.48	1.54	+1.51	
H.23	1311.3	-54.25	-1.91	+59.97	1.45	+1.49	
H.24	1274.3	-51.68	-1.90	+57.78	1.38	+1.71	
H.25	-	-	-	-	-	-	
H.26	1239.2	-49.27	-2.09	+55.70	1.49	+1.96	
H.27	1174.3	-45.00	-2.17	+51.85	1.35	+2.18	
H.28	1129.0	-42.19	-2.20	+49.16	1.32	+2.22	
H.29	1092.2	-40.15	-2.26	+46.98	1.14	+1.84	
H.30	1058.0	-37.84	-2.30	+44.95	1.00	+1.94	
H.31	1008.2	-34.71	-2.33	+42.00	1.02	+2.11	
H.32	951.9	-31.10	-2.39	+38.65	1.24	+2.53	
H.33	925.6	-29.64	-2.45	+37.10	1.10	+2.24	
H.34	885.1	-26.95	-2.48	+34.70	1.04	+2.44	
H.35	824.7	-23.79	-2.53	+31.11	1.14	+2.60	
H.36	828.9	-23.41	-2.57	+31.37	0.97	+2.49	
H.37	814.8	-22.46	-2.61	+30.52	0.99	+2.57	
H.38	787.3	-21.02	-2.63	+28.89	1.45	+2.82	
H.39	789.7	-21.42	-2.66	+29.04	1.64	+2.72	
H.40	793.8	-21.54	-2.72	+29.28	1.73	+2.89	
H.41	784.0	-20.92	-2.76	+28.70	1.67	+2.82	
H.42	797.0	-21.74	-2.80	+29.47	1.31	+2.37	
H.43	840.4	-24.22	-2.83	+32.04	1.05	+2.17	
H.44	850.2	-24.72	-2.85	+32.63	0.91	+2.10	
H.45	867.6	-25.88	-2.86	+33.66	0.78	+1.88	
H.46	879.2	-26.53	-2.84	+34.35	0.76	+1.87	
H.47	870.3	-26.00	-2.82	+33.82	0.73	+1.86	
H.48	860.8	-25.41	-2.85	+33.26	0.66	+1.79	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
H.49	855.7	-25.25	-2.89	+32.95	0.65	+1.59	
H.50	858.0	-25.54	-2.93	+33.09	0.66	+1.41	
H.51	856.0	-25.43	-2.95	+32.97	0.74	+1.46	
H.52	854.5	-25.37	-2.99	+32.88	0.84	+1.49	
H.53	839.0	-24.64	-3.02	+31.96	0.89	+1.32	
H.54	832.9	-24.28	-3.04	+31.60	0.82	+1.23	
H.55	815.1	-23.25	-3.05	+30.55	0.54	+0.92	
H.56	808.5	-22.76	-3.09	+30.16	0.59	+1.03	
H.57	812.5	-23.14	-3.11	+30.39	0.56	+0.83	
H.58	802.5	-22.56	-3.16	+29.80	0.57	+0.80	
H.59	792.6	-22.05	-3.18	+29.21	0.52	+0.63	
H.60	789.2	-21.56	-3.20	+29.01	0.50	+0.88	
H.61	784.5	-21.10	-3.24	+28.73	0.53	+1.05	
H.62	770.4	-20.15	-3.29	+27.89	0.51	+1.09	
H.63	750.8	-18.95	-3.32	+26.73	0.54	+1.13	
H.64	752.4	-19.23	-3.33	+26.82	0.57	+0.96	
H.65	768.8	-20.34	-3.32	+27.80	0.58	+0.85	
H.66	780.9	-21.15	-3.33	+28.52	0.63	+0.80	
H.67	779.1	-21.08	-3.34	+28.41	0.70	+0.82	
H.68	770.4	-20.59	-3.36	+27.90	0.64	+0.72	
H.69	802.8	-22.52	-3.37	+29.81	0.59	+0.64	
H.70	816.7	-23.55	-3.40	+30.64	0.64	+0.46	
H.71	806.3	-22.90	-3.42	+30.02	0.89	+0.72	
H.72	786.4	-21.41	-3.45	+28.85	0.60	+0.72	
H.73	772.2	-20.47	-3.48	+28.00	0.69	+0.87	
H.74	744.3	-18.78	-3.52	+26.35	0.71	+0.89	
H.75	720.5	-17.35	-3.56	+24.94	0.78	+0.95	
H.76	710.8	-16.80	-3.60	+24.36	0.49	+0.58	
H.77	707.0	-16.37	-3.64	+24.13	0.59	+0.84	
H.78	705.1	-16.30	-3.68	+24.02	0.58	+0.75	
H.79	703.1	-16.20	-3.73	+23.90	0.60	+0.72	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
I. 1	828.9	-32.08	-0.10	31.36	0.45	-4.24
I. 2	828.0	-32.15	-0.09	31.31	0.38	-4.42
I. 3	828.3	-32.07	-0.07	31.33	0.38	-4.32
I. 4	827.6	-32.17	-0.04	31.29	0.36	-4.43
I. 5	827.8	-32.31	-0.03	31.30	0.37	-4.54
I. 6	829.2	-32.07	-0.04	31.38	0.39	-4.21
I. 7	832.4	-32.05	-0.07	31.57	0.41	-3.99
I. 8	831.0	-31.94	-0.12	31.49	0.46	-3.98
I. 9	832.5	-31.90	-0.11	31.57	0.47	-3.84
I.10	837.8	-32.09	-0.09	31.89	0.51	-3.65
I.11	840.7	-31.91	-0.09	32.07	0.48	-3.32
I.12	849.0	-32.66	-0.07	32.56	0.51	-3.13
I.13	852.2	-32.23	-0,05	32.74	0.49	-2.92
I.14	836.5	-31.33	-0.05	31.81	0.49	-2.95
I.15	828.3	-30.89	-0.07	31.33	0.58	-2.92
I.16	821.6	-30.17	-0.12	30.93	0.59	-2.64
I.17	812.9	-30.01	-0.16	30.42	0.64	-2.98
I.18	805.8	-29.21	-0.20	29.99	0.62	-2.67
I.19	799.5	-28.56	-0.22	29.62	0.71	-2.32
I.20	787.5	-27.81	-0.22	28.91	0.78	-2.21
I.21	769.9	-26.88	-0.17	27.87	0.72	-2.33
I.22	754.3	-25.56	-0.14	26.94	0.72	-1.91
I.23	736.2	-24.55	-0.13	25.87	0.66	-2.02
I.24	718.5	-23.53	-0.10	24.82	0.65	-2.03
I.25	702.1	-22.08	-0.09	23.85	0.64	-1.85
I.26	687.4	-21.92	-0.09	22.97	0.69	-2.22
I.27	678.7	-21.30	-0.09	22.46	0.59	-2.21
I.28	670.2	-20.43	-0.10	21.95	0.58	-1.87
I.29	659.5	-19.65	-0.11	21.32	0.55	-1.76
I.30	644.1	-18.56	-0.11	20.40	0.59	-1.55
I.31	628.5	-17.63	-0.13	19.48	0.58	-1.57
I.32	616.9	-16.54	-0.17	18.79	0.59	-1.20
I.33	604.2	-15.42	-0.18	18.04	0.53	-0.90
I.34	599.2	-15.14	-0.17	17.74	0.44	-1.00
I.35	600.9	-14.85	-0.17	17.85	0.43	-0.61
I.36	589.7	-14.13	-0.20	17.18	0.43	-0.59
I.37	575.9	-13.15	-0.19	16.36	0.42	-0.43
I.38	564.1	-12.27	-0.18	15.66	0.38	-0.28

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
I.39	558.8	-11.72	-0.16	15.34	0.37	-0.40	
I.40	558.6	-11.55	-0.23	15.33	0.54	+0.22	
I.41	555.6	-11.42	-0.29	15.16	0.37	-0.05	
I.42	551.0	-11.04	-0.36	14.88	0.37	-0.02	
I.43	544.6	-10.74	-0.42	14.51	0.36	-0.16	
I.44	541.5	-10.54	-0.44	14.32	0.36	-0.17	
I.45	547.8	-10.62	-0.46	14.69	0.38	+0.12	
I.46	551.1	-10.94	-0.47	14.89	0.40	+0.01	
I.47	573.6	-12.30	-0.54	16.22	0.39	-0.10	
J. 1	658.3	-14.35	-3.77	21.32	0.59	-0.08	
J. 2	663.9	-14.73	-3.80	21.66	0.53	-0.21	
J. 3	663.2	-14.60	-3.84	21.62	0.49	-0.20	
J. 4	658.7	-14.35	-3.86	21.35	0.50	-0.23	
J. 5	640.8	-13.36	-3.88	20.28	0.90	+0.07	
J. 6	634.0	-13.02	-3.90	19.88	0.75	-0.16	
J. 7	649.2	-13.81	-3.89	20.78	0.58	-0.27	
J. 8	648.5	@13.81	-3.85	20.74	0.56	-0.23	
J. 9	647.7	-13.63	-3.82	20.70	1.02	+0.40	
J.10	647.1	-13.47	-3.85	20.66	0.91	+0.38	
J.11	653.7	-13.81	-3.89	21.05	0.74	+0.22	
J.12	664.8	-14.47	-3.93	21.71	0.68	+0.12	
J.13	676.6	-15.27	-3.97	22.42	0.68	+0.01	
J.14	687.4	-15.97	-4.04	23.06	0.67	-0.15	
J.15	704.1	-16.89	-4.07	24.05	0.58	-0.20	
J.16	705.4	-16.92	-4.09	24.13	0.50	-0.25	
J.17	686.3	-15.64	-4.13	22.99	0.62	-0.03	
J.18	666.2	-14.34	-4.12	21.80	0.56	+0.05	
J.19	652.5	-13.38	-4.10	20.98	0.68	+0.31	
J.20	644.6	-12.83	-4.10	20.51	0.63	+0.34	
J.21	640.1	-12.63	-4.14	20.24	0.68	+0.28	
J.22	620.1	-11.26	-4.20	19.05	0.59	+0.31	
J.23	606.5	-10.40	-4.23	18.25	0.67	+0.42	
J.24	591.6	- 9.74	-4.23	17.36	0.54	+0.06	
J.25	579.6	- 9.12	-4.20	16.64	0.47	-0.08	
J.26	572.5	- 8.78	-4.18	16.22	0.53	-0.08	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
J.27	566.0	- 8.42	-4.17	15.83	0.36	-0.27
J.28	560.3	- 7.95	-4.13	15.49	0.39	-0.07
J.29	551.9	- 7.52	-4.09	14.99	0.36	-0.13
J.30	546.0	- 7.02	-4.04	14.64	0.33	+0.17
J.31	538.9	- 6.65	-4.02	14.22	0.31	-0.02
J.32	533.4	- 6.23	-4.00	13.89	0.29	+0.08
J.33	527.0	- 5.94	-3.93	13.51	0.33	+0.05
J.34	526.4	- 6.06	-3.94	13.48	0.30	-0.11
J.35	524.4	- 5.91	-3.91	13.36	0.30	-0.03
J.36	520.7	- 5.58	-3.84	13.14	0.28	+0.13
J.37	499.5	- 4.24	-3.18	11.87	0.32	+0.27
J.38	484.2	-3.26	-3.75	10.96	0.30	+0.42
J.39	466.8	- 2.14	-3.68	9.93	0.34	+0.55
J.40	449.9	- 1.11	-3.61	8.92	0.40	+0.73
J.41	433.7	- 0.10	-3.55	7.96	0.43	+0.37
J.42	431.3	+ 0.08	-3.38	7.31	0.39	+0.90
J.43	432.5	+ 0.11	-3.45	7.39	0.35	+1.04
J.44	412.6	+ 1.37	-3.38	6.70	0.50	+1.32
J.45	401.3	+ 2.12	-3.35	6.03	0.41	+1.34
J.46	389.9	+ 2.73	-3.36	5.35	0.46	+1.31
J.47	371.3	+ 3.89	-3.35	4.24	0.48	+1.39
J.48	353.8	+ 5.21	-3.37	3.20	0.57	+1.74
J.49	333.9	+ 6.60	-3.38	2.10	0.50	+1.95
J.50	330.4	+ 7.08	-3.40	1.89	0.47	+2.17
J.51	344.1	+ 6.47	-3.40	2.74	0.41	+2.35
J.52	334.9	+ 7.07	-3.40	2.16	0.41	+2.37
J.53	318.3	+ 8.11	-3.36	1.14	0.36	+2.38
J.54	298.1	+ 9.13	-3.34	-0.11	0.39	+2.19
J.55	284.5	+ 9.10	-3.30	-0.92	0.40	+1.37
J.56	290.8	+ 9.33	-3.26	-0.55	0.38	+2.01
J.57	279.8	+9.92	-3.25	-1.20	0.35	+1.90
J.58	257.8	+11.25	-3.22	-2.51	0.30	+1.85
J.59	229.7	+12.89	-3.19	-4.19	0.32	+1.79
J.60	221.5	+13.34	-3.19	-4.67	0.26	+1.67
J.61	213.0	+13.83	-3.20	-5.18	0.29	+1.65
J.62	198.2	+14.54	-3.17	-6.06	0.25	+1.44
J.63	191.5	+14.89	-3.15	-6.46	0.27	+1.41
J.64	183.7	+15.44	-3.13	-6.92	0.28	+1.51

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
J.65	184.4	+15.40	-3.15	-6.38	0.21	+1.42
J.66	184.6	+15.27	-3.13	-6.37	0.21	+1.32
J.67	172.6	+15.99	-3.13	-7.58	0.19	+1.29
J.68	167.0	+16.45	-3.09	-7.91	0.22	+1.47
J.69	171.7	+15.99	-3.07	-7.64	0.20	+1.29
J.70	163.8	+16.37	-3.08	-8.11	0.22	+1.20
J.71	155.1	+16.97	-3.09	-8.63	0.26	+1.28
J.72	152.5	+17.22	-3.12	-8.78	0.22	+1.30
K. 1	322.7	+ 2.81	-0.07	+ 1.35	2.09	+2.31
K. 2	384.2	- 0.96	-0.15	+ 4.99	2.57	+2.58
K. 3	391.6	- 1.44	-0.14	+ 5.43	2.31	+2.10
K. 4	462.4	- 5.98	-0.20	+ 9.63	2.65	+2.21
K. 5	545.7	-10.81	-0.26	+14.57	2.56	+2.13
K. 6	615.1	-15.85	-0.32	+18.69	2.66	+1.29
K. 7	695.6	-20.19	-0.40	23.46	2.60	+1.58
K. 8	760.2	-24.10	-0.45	27.29	2.34	+1.18
K. 9	803.6	-27.26	-0.53	29.86	2.49	+0.68
K.10	862.1	-31.64	-0.59	33.33	2.46	-0.32
K.11	931.5	-35.33	-0.64	37.45	2.37	-0.03
K.12	988.7	-38.94	-0.69	40.84	2.60	-0.08
K.13	1075.1	-44.34	-0.77	45.96	2.73	-0.30
K.14	1136.2	-48.03	-0.86	49.59	2.81	-0.37
K.15	1214.6	-52.75	-0.95	54.24	2.64	-0.70
K.16	1266.0	-56.16	-1.02	57.28	2.93	-0.86
K.17	1330.7	-60.07	-1.09	61.12	2.67	-1.25
K.18	1381.8	-62.96	-1.13	64.15	2.85	-0.08
K.19	1403.2	-64.54	-1.15	65.47	2.99	-1.11
K.20	1432.8	-66.54	-1.20	67.18	3.04	-1.40
K.21	1464.8	-68.73	-1.24	69.07	3.28	-1.51
K.22	1485.2	-70.07	-1.31	70.28	3.14	-1.84
K.23	1512.2	-71.79	-1.37	71.89	3.31	-1.84
K.24	1539.9	-74.16	-1.42	73.53	3.54	-2.39
K.25	1554.9	-74.59	-1.50	74.42	3.76	-1.87
K.26	1541.2	-73.78	-1.54	73.60	3.24	-2.37

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
K.27	1577.3	-76.17	-1.60	+75.74	3.40	-2.51
K.28	1600.2	-77.36	-1.66	+77.10	3.70	-2.10
K.29	1628.1	-79.35	-1.71	+78.76	3.82	-2.35
K.30	1666.0	-81.65	-1.76	+81.00	3.82	-2.46
K.31	1656.1	-80.84	-1.79	+80.42	3.77	-2.33
K.32	1625.7	-78.76	-1.84	+78.61	3.38	-2.49
K.33	1628.2	-78.74	-1.88	+78.76	3.30	-2.44
K.34	1601.2	-76.70	-1.96	+77.16	3.56	-1.82
K.35	1569.5	-74.54	-2.03	+75.23	3.48	-1.69
K.36	1553.9	-73.46	-2.09	+74.36	3.23	-1.84
K.37	1556.3	-73.70	-2.14	+74.50	3.05	-2.19
K.38	1583.5	-75.09	-2.23	+76.11	3.35	-1.74
K.39	1621.7	-77.52	-2.32	+78.38	2.63	-2.72
K.40	1643.7	-78.99	-2.47	+79.68	2.62	-3.22
K.41	1617.9	-77.07	-2.55	+78.15	2.33	-3.02
K.42	1600.6	-75.74	-2.64	+77.13	2.31	-2.83
K.43	1586.8	-75.06	-2.73	+76.31	2.23	-3.13
K.44	1589.6	-75.16	-2.80	+76.47	2.22	-3.15
K.45	1596.4	-75.85	-2.88	+76.88	2.28	-3.46
K.46	1622.4	-77.31	-2.98	+78.42	2.36	-3.39
K.47	1632.6	-78.40	-3.05	+79.02	2.42	-3.69
K.48	1625.4	-77.95	-3.12	+78.60	2.49	-3.86
K.49	1640.5	-78.80	-3.16	+79.49	2.58	-3.78
K.50	1653.2	-80.16	-3.21	+80.84	2.59	-3.82
K.51	1678.0	-81.34	-3.26	+81.72	3.28	-3.48
K.52	1720.4	-84.08	-3.21	+84.23	4.13	-2.91
K.53	1757.6	-86.94	-3.34	+86.44	4.55	-3.17
K.54	1807.9	-90.77	-3.40	+89.42	5.47	-3.16
K.55	1853.2	-93.89	-3.45	+92.10	6.02	-3.11
K.56	1897.0	-97.01	-3.54	+94.70	5.88	-3.85
L. 1	520.5	- 4.58	-6.66	+13.13	0.43	-1.55
L. 2	495.5	- 2.11	-6.69	+11.61	0.60	-0.46
L. 3	472.7	- 0.94	-6.70	+10.71	0.64	-0.16
L. 4	448.6	+ 0.51	-6.71	+ 9.21	0.75	-0.11
L. 5	424.9	+ 1.71	-6.72	+ 7.75	0.84	-0.39

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
L. 6	408.1	+ 2.75	-6.72	+6.70	0.84	-0.30
L. 7	386.7	+ 3.97	-6.73	+5.38	0.90	-0.35
L. 8	368.2	+ 5.35	-6.73	+4.23	0.89	-0.13
L. 9	357.0	+ 6.12	-6.75	+3.53	0.84	-0.13
L.10	349.2	+ 6.80	-6.79	+3.05	0.77	-0.04
L.11	343.3	+ 7.25	-6.82	+2.68	0.67	-0.19
L.12	338.6	+ 7.59	-6.85	+2.39	0.96	+0.12
L.13	337.3	+ 7.77	-6.87	+2.31	0.69	-0.07
L.14	340.6	+ 7.73	-6.90	+2.52	0.67	+0.15
L.15	335.0	+ 8.06	-6.91	+2.17	0.52	-0.03
L.16	319.6	+ 8.78	-6.96	+1.21	0.50	-0.34
L.17	300.5	+10.05	-7.00	+0.03	0.41	-0.38
L.18	289.3	+10.85	-7.02	-0.56	0.42	-0.58
L.19	283.3	+11.26	-7.03	-1.04	0.37	-0.31
L.20	269.7	+12.17	-7.07	-1.88	0.35	-0.30
L.21	259.3	+12.84	-7.17	-2.52	0.33	-0.39
L.22	259.2	+12.87	-7.25	-2.53	0.33	-0.45
L.23	268.8	+12.31	-7.31	-1.94	0.29	-0.52
L.24	282.5	+11.56	-7.39	-1.09	0.24	-0.55
L.25	291.9	+10.95	-7.48	-0.50	0.21	-0.69
L.26	293.8	+10.77	-7.53	-0.39	0.21	-0.81
L.27	286.1	+11.07	-7.57	-0.86	0.24	-0.99
L.28	284.9	+11.10	-7.64	-0.94	0.18	-1.17
L.29	287.5	+10.94	-7.68	-0.78	0.17	-1.22
L.30	288.5	+10.70	-7.72	-0.71	0.21	-1.39
L.31	285.1	+11.06	-7.80	-0.92	0.18	-1.35
L.32	281.8	+10.37	-7.87	-1.13	0.19	-2.41
L.33	281.4	+11.12	-7.96	-1.16	0.24	-1.63
L.34	270.3	+11.85	-8.04	-1.84	0.27	-1.63
L.35	252.1	+13.08	-8.11	-2.97	0.31	-1.56
L.36	233.9	+14.14	-8.18	-4.10	0.27	-1.74
L.37	218.3	+15.21	-8.26	-5.06	0.29	-1.69
L.38	200.8	+16.28	-8.34	-6.15	0.30	-1.78
L.39	186.5	+17.04	-8.41	-7.04	0.20	-2.08
L.40	171.3	+18.07	-8.48	-7.98	0.23	-2.03
L.41	157.5	+19.02	-8.56	-8.83	0.20	-2.04
L.42	152.0	+19.30	-8.63	-9.18	0.18	-2.20
L.43	150.5	+19.45	-8.68	-9.27	0.17	-2.20

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
L.44	146.4	+19.63	-8.74	- 9.52	0.17	-2.33
L.45	144.9	+19.76	-8.80	- 9.62	0.17	-2.36
L.46	146.0	+19.69	-8.86	- 9.55	0.16	-2.43
L.47	149.9	+19.41	-8.91	- 9.30	0.15	-2.52
L.48	154.0	+18.84	-8.96	- 9.06	0.15	-2.90
L.49	154.0	+18.85	-9.00	- 9.05	0.16	-2.91
L.50	160.6	+18.44	-9.04	- 8.64	0.16	-2.95
M. 1	538.8	- 4.67	-6.67	+14.22	0.38	-0.61
M. 2	549.0	- 5.37	-6.69	+14.82	0.34	-0.77
M. 3	554.9	- 5.78	-6.72	+15.17	0.45	-0.75
M. 4	563.5	- 6.36	-6.74	+15.69	0.33	-0.95
M. 5	572.4	- 6.55	-6.77	+16.21	0.34	-0.64
M. 6	573.8	- 6.68	-6.81	+16.29	0.40	-0.67
M. 7	577.7	- 6.76	-6.84	+16.53	0.37	-0.57
M. 8	595.5	-77.69	-6.88	+17.59	0.34	-0.51
M. 9	604.3	- 8.11	-6.90	+18.11	0.34	-0.43
M.10	613.7	- 8.66	-6.92	+18.67	0.37	-0.41
M.11	617.4	- 8.87	-6.93	+18.89	0.34	-0.44
M.12	624.0	- 9.22	-6.94	+19.28	0.43	-0.26
M.13	630.4	- 9.81	-6.99	+19.67	0.49	-0.51
M.14	634.0	- 9.95	-7.01	+19.88	0.40	-0.55
M.15	621.5	- 9.25	-7.05	+19.14	0.36	-0.67
M.16	585.5	- 7.33	-7.11	+17.00	0.42	-0.99
M.17	584.7	- 7.02	-7.05	+16.95	0.47	-0.62
M.18	592.4	- 7.37	-7.19	+17.40	0.52	-0.53
M.19	602.5	- 7.80	-7.27	+18.00	0.43	-0.51
M.20	611.5	- 8.22	-7.30	+18.54	0.40	-0.45
M.21	618.5	- 8.58	-7.36	+18.95	0.44	-0.42
M.22	628.6	- 9.22	-7.42	+19.56	0.43	-0.52
M.23	631.1	- 9.30	-7.48	+19.71	0.40	-0.64
M.24	629.0	- 9.25	-7.55	+19.58	0.40	-0.69
M.25	633.2	- 9.33	-7.61	+19.83	0.44	-0.60
M.26	622.8	- 8.69	-7.71	+19.21	0.69	-0.26
M.27	608.1	- 7.77	-7.75	+18.34	0.49	-0.56
M.28	621.2	- 8.64	-7.83	+19.12	0.45	-0.77

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
M.29	632.1	- 9.25	-7.89	+19.77	0.45	-0.79
M.30	632.9	- 9.25	-7.94	+19.81	0.53	-0.72
M.31	609.1	-7.89	-7.99	+18.40	0.48	-0.87
M.32	589.2	- 6.68	-8.04	+17.21	0.48	-1.00
M.33	581.7	- 6.23	-8.10	+16.77	0.45	-0.98
M.34	598.2	- 7.31	-8.15	+17.75	0.49	-1.09
M.35	614.9	- 9.14	-8.22	+18.74	0.54	-1.94
M.36	621.4	- 8.64	-8.29	+19.13	0.50	-1.17
M.37	596.3	- 7.08	-8.32	+17.63	0.52	-1.12
M.38	584.1	- 6.18	-8.37	+16.91	0.55	-0.96
M.39	563.8	- 5.13	-8.45	+15.70	0.56	-1.19
M.40	546.5	- 4.08	-8.52	+14.67	0.63	-0.97
M.41	517.1	- 2.43	-8.58	+12.92	0.57	-1.39
M.42	474.2	- 0.04	-8.66	+10.37	0.64	-1.56
M.43	449.7	+ 1.36	-8.72	+ 8.91	0.63	-1.69
M.44	442.5	+ 1.84	-8.77	+ 8.48	0.60	-1.72
M.45	435.0	+ 2.28	-8.79	+ 8.04	0.63	-1.39
M.46	452.2	+ 1.17	-8.85	+ 9.06	0.64	-1.53
M.47	453.4	+ 1.04	-8.89	+ 9.13	0.57	-1.70
M.48	457.7	+ 0.90	-8.96	+ 9.39	0.60	-1.94
M.49	463.9	+ 0.44	-9.02	+ 9.75	0.63	-2.07
M.50	451.1	+ 1.17	-9.05	+ 8.99	0.63	-2.13
M.51	425.4	+ 2.85	-9.09	+ 7.46	0.63	-1.92
M.52	395.6	+ 4.67	-9.10	+ 5.69	0.63	-1.99
M.53	360.2	+ 6.77	-9.12	+ 3.58	0.59	-2.05
M.54	337.0	+ 8.32	-9.15	+ 2.20	0.66	-1.84
M.55	322.7	+ 9.01	-9.14	+ 1.35	0.66	-1.92
M.56	295.1	+10.80	-9.16	- 0.29	0.67	-1.85
M.57	282.9	+11.50	-9.21	- 1.02	0.49	-2.11
M.58	274.0	+12.28	-9.23	- 1.55	0.50	-1.87
M.59	266.4	+13.01	-9.24	- 2.00	0.59	-1.84
M.60	260.5	+13.43	-9.27	- 2.35	0.58	-1.81
M.61	253.5	+13.39	-9.27	- 2.77	0.47	-1.89
M.62	249.0	+13.87	-9.25	- 3.04	0.43	-2.19
M.63	245.1	+14.10	-9.23	- 3.27	0.46	-2.14
M.64	240.2	+14.43	-9.23	- 3.56	0.44	-2.12
M.65	236.9	+14.72	-9.24	- 3.76	0.40	-2.08

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
M.66	240.1	+14.49	- 9.25	- 3.71	0.43	-1.91	
M.67	264.4	+12.74	- 9.25	- 1.90	0.35	-1.93	
M.68	289.4	+11.49	- 9.23	- 0.65	0.40	-1.86	
M.69	290.3	+11.38	- 9.25	- 0.60	0.59	-1.75	
M.70	300.7	+10.80	- 9.27	+ 0.05	0.55	-1.74	
M.71	312.1	+10.42	- 9.30	+ 0.75	0.50	-1.51	
M.72	331.6	+ 9.73	- 9.33	+ 1.96	0.47	-1.04	
M.73	342.6	+ 8.45	- 9.34	+ 2.64	0.36	-1.76	
M.74	346.1	+ 8.27	- 9.40	+ 2.86	0.37	-1.77	
M.75	324.2	+ 9.80	- 9.46	+ 1.50	0.37	-1.66	
M.76	323.7	+ 9.90	- 9.51	+ 1.47	0.42	-1.59	
M.77	331.7	+ 9.50	- 9.55	+ 1.96	0.57	-1.41	
M.78	315.7	+10.42	- 9.61	+ 0.98	0.47	-1.63	
M.79	311.9	+10.95	- 9.67	+ 0.74	0.54	-1.31	
M.80	292.2	+12.20	- 9.71	- 0.48	0.47	-1.39	
M.81	272.1	+13.40	- 9.79	- 1.73	0.57	-1.42	
M.82	245.1	+14.98	- 9.86	- 3.34	0.42	-1.67	
M.83	222.3	+16.49	- 9.91	- 4.82	0.46	-1.65	
M.84	205.0	+17.55	- 9.97	- 5.89	0.31	-1.87	
M.85	190.3	+18.31	-10.01	- 6.80	0.34	-2.03	
M.86	190.2	+18.48	-10.06	- 6.81	0.28	-1.98	
M.87	178.6	+19.21	-10.13	- 7.53	0.28	-2.04	
M.88	156.8	+20.53	-10.19	- 8.88	0.22	-2.19	
M.89	140.0	+21.51	-10.24	- 9.92	0.24	-2.28	
M.90	138.1	+21.40	-10.28	-10.04	0.22	-2.57	
M.91	136.9	+21.34	-10.34	-10.11	0.22	-2.76	
M.92	125.4	+21.81	-10.37	-10.83	0.21	-3.05	
M.93	127.4	+21.72	-10.41	-10.70	0.19	-3.07	
M.94	142.0	+20.96	-10.48	- 9.80	0.20	-2.99	
M.95	139.3	+20.90	-10.52	- 9.97	0.19	-3.27	
M.96	127.4	+21.78	-10.57	-10.70	0.20	-3.16	
M.97	115.5	+22.60	-10.63	-11.44	0.20	-3.13	
M.98	122.1	+22.11	-10.67	-11.03	0.19	-3.27	
M.99	121.9	+21.96	-10.71	-11.04	0.18	-2.48	
M.100	120.5	+22.68	-10.75	-11.13	0.19	-2.88	
M.101	119.6	+22.80	-10.78	-11.18	0.19	-2.84	
M.102	121.5	+22.59	-10.75	-11.07	0.19	-2.91	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
N. 1	242.9	+ 8.10	+0.25	- 3.40	1.59	+2.67	
N. 2	247.3	+ 7.87	+0.21	- 3.14	1.63	+2.70	
N. 3	253.0	+ 7.75	+0.19	- 2.80	1.61	+2.88	
N. 4	258.4	+ 7.73	+0.14	- 2.48	1.67	+3.19	
N. 5	268.5	+ 7.36	+0.10	- 1.88	1.67	+3.38	
N. 6	273.3	+ 7.38	+0.06	- 1.59	1.62	+3.60	
N. 7	272.6	+ 7.52	+0.08	- 1.63	1.56	+3.66	
N. 8	275.9	+ 7.58	+0.11	- 1.43	1.54	+3.93	
N. 9	276.5	+ 7.38	+0.14	- 1.40	1.45	+3.70	
N.10	269.5	+ 7.85	+0.18	- 1.82	1.47	+3.81	
N.11	264.2	+ 8.24	+0.19	- 2.13	1.41	+3.84	
N.12	259.3	+ 8.50	+0.20	- 2.42	1.39	+3.80	
N.13	254.1	+ 8.80	+0.20	- 2.73	1.47	+3.87	
N.14	258.1	+ 8.57	+0.20	- 2.49	1.46	+3.87	
N.15	251.5	+ 8.90	+0.23	- 2.88	1.46	+3.84	
N.16	250.5	+ 8.72	+0.27	- 2.95	1.48	+3.66	
N.17	250.4	+ 8.73	+0.30	- 2.95	1.40	+3.61	
N.18	250.7	+ 8.67	+0.34	- 2.93	1.39	+3.60	
N.19	249.1	+ 8.68	+0.39	- 3.03	1.42	+3.59	
N.20	251.6	+ 8.50	+0.39	- 2.88	1.45	+3.59	
N.21	248.9	+ 8.53	+0.39	- 3.04	1.44	+3.45	
N.22	250.1	+ 8.42	+0.37	- 2.93	1.48	+3.47	
N.23	250.9	+ 8.17	+0.37	- 2.92	1.57	+3.32	
N.24	252.8	+ 7.92	+0.33	- 2.81	1.61	+3.18	
N.25	258.7	+ 7.49	+0.35	- 2.46	1.59	+3.10	
N.26	256.1	+ 7.55	+0.34	- 2.61	1.66	+3.07	
N.27	255.6	+ 7.16	+0.26	- 2.64	1.72	+2.63	
N.28	257.3	+ 6.84	+0.27	- 2.54	2.15	+2.85	
N.29	261.2	+ 6.72	+0.19	- 2.31	2.11	+2.84	
N.30	269.9	+ 6.18	+0.19	- 1.79	2.50	+3.21	
N.31	279.6	+ 5.20	+0.19	- 1.22	2.29	+2.59	
N.32	286.9	+ 4.52	+0.19	- 0.78	2.20	+2.27	
N.33	298.3	+ 3.83	+0.19	- 0.10	2.13	+2.18	
N.34	295.5	+ 4.06	+0.20	- 0.27	1.96	+2.08	
N.35	294.6	+ 4.13	+0.20	- 0.32	1.95	+2.09	
N.36	301.5	+ 3.88	+0.23	+ 0.09	1.66	+1.99	
N.37	298.7	+ 4.22	+0.22	- 0.07	1.75	+2.25	
N.38	296.4	+ 4.33	+0.20	- 0.22	1.76	+2.20	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
N.39	296.8	+ 4.28	+0.17	-0.19	1.78	+2.17
N.40	295.7	+ 4.48	+0.13	-0.26	2.01	+2.47
N.41	292.6	+ 4.84	+0.09	-0.44	2.04	+2.66
N.42	293.1	+ 4.72	+0.04	-0.41	2.38	+2.86
N.43	296.0	+ 4.41	0.00	-0.24	2.59	+2.94
N.44	299.5	+ 3.96	-0.05	-0.03	2.52	+2.53
N.45	305.6	+ 3.04	-0.06	+0.34	2.18	+1.63
N.46	319.5	+ 2.17	-0.06	+1.16	2.45	+1.85
N.47	327.9	+ 1.62	-0.07	+1.66	2.05	+1.39
N.48	331.5	+ 1.50	-0.06	+1.87	1.80	+1.24
N.49	331.9	+ 1.62	-0.04	+1.90	1.79	+1.40
N.50	334.0	+ 1.66	-0.03	+2.02	1.73	+1.51
N.51	331.6	+ 2.03	-0.01	+1.88	1.67	+1.70
N.52	321.8	+ 2.81	0.00	+1.29	1.56	+1.79
N.53	314.5	+ 3.24	0.00	+0.86	1.68	+1.91
N.54	317.3	+ 3.29	0.00	+1.03	1.62	+2.08
N.55	301.2	+ 3.68	0.00	+0.07	1.62	+1.50
N.56	290.4	+ 4.55	0.00	-0.57	1.67	+1.78
N.57	276.1	+ 5.18	0.00	-1.42	1.72	+1.61
N.58	277.3	+ 5.01	+0.01	-1.35	1.65	+1.45
N.59	289.9	+ 4.52	+0.02	-0.60	1.61	+1.68
N.60	259.4	+ 6.06	+0.06	-2.42	1.59	+1.42
N.61	247.7	+ 6.72	+0.04	-3.12	1.48	+1.25
N.62	238.3	+ 6.92	+0.01	-3.67	1.66	+1.05
N.63	239.3	+ 6.77	-0.04	-3.61	1.77	+1.02
N.64	247.3	+ 6.44	-0.07	-3.14	1.91	+1.27
N.65	263.0	+ 5.40	-0.09	-2.20	1.76	+1.00
N.66	265.6	+ 5.60	-0.11	-2.05	1.84	+1.41
N.67	254.1	+ 6.03	-0.13	-2.73	1.88	+1.18
N.68	244.8	+ 6.59	-0.14	-3.29	1.84	+1.13
N.69	220.0	+ 8.03	-0.15	-4.76	1.97	+1.22
N.70	204.1	+ 8.80	-0.17	-5.71	1.95	+1.00
N.71	194.0	+ 8.93	-0.21	-6.31	2.02	+0.56
N.72	178.2	+ 9.43	-0.26	-7.25	1.95	0.00
N.73	175.8	+ 9.34	-0.35	-7.39	1.90	-0.35
N.74	161.8	+10.03	-0.39	-8.23	2.10	-0.38
N.75	156.7	+10.51	-0.44	-8.53	1.99	-0.35
N.76	164.7	+ 9.84	-0.50	-8.05	1.95	-0.63

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
N.77	170.5	+ 9.38	-0.53	- 8.30	1.97	-1.35	
N.78	177.6	+ 8.96	-0.56	- 7.85	1.93	-1.39	
N.79	159.2	+10.08	-0.61	- 9.02	1.98	-1.44	
N.80	145.1	+10.86	-0.68	- 9.93	1.97	-1.62	
N.81	148.1	+10.62	-0.69	- 9.74	1.96	-1.78	
N.82	157.1	+10.21	-0.82	- 9.16	1.88	-1.76	
N.83	153.9	+10.70	-0.89	- 9.36	1.85	-1.57	
N.84	151.6	+10.76	-0.94	- 9.52	1.88	-1.69	
N.85	152.6	+10.42	-1.00	- 9.45	2.01	-1.89	
N.86	170.7	+ 9.38	-1.06	- 8.29	1.78	-2.16	
N.87	185.4	+ 8.22	-1.11	- 7.34	1.85	-2.25	
N.88	197.5	+ 7.63	-1.15	- 6.57	1.78	-2.18	
N.89	205.9	+ 6.94	-1.21	- 6.03	1.85	-2.32	
N.90	191.3	+ 7.85	-1.28	- 6.97	1.86	-2.41	
N.91	171.3	+ 8.88	-1.32	- 8.25	2.01	-2.55	
N.92	153.5	+10.06	-1.39	- 9.39	2.10	-2.55	
N.93	145.4	+10.50	-1.44	- 9.91	2.32	-2.35	
N.94	134.1	+11.33	-1.47	-10.64	2.31	-2.32	
N.95	117.8	+12.24	-1.49	-11.68	2.41	-2.39	
N.96	111.1	+12.59	-1.55	-12.11	2.39	-2.55	
N.97	110.7	+12.71	-1.59	-12.13	2.05	-2.83	
N.98	113.3	+12.59	-1.64	-11.97	1.99	-2.90	
N.99	113.0	+12.71	-1.70	-11.98	1.92	-2.92	
N.100	110.2	+12.95	-1.73	-12.16	1.77	-3.04	
N.101	106.8	+13.22	-1.78	-12.38	1.71	-3.10	
N.102	106.4	+13.12	-1.83	-12.41	1.71	-3.28	
N.103	106.7	+12.97	-1.88	-12.39	1.43	-3.74	
N.104	99.9	+13.24	-1.95	-12.83	1.72	-3.69	
N.105	97.5	+13.44	-2.01	-12.98	1.78	-3.64	
N.106	103.2	+12.93	-2.09	-12.62	1.70	-3.95	
N.107	99.8	+13.29	-2.16	-12.83	1.72	-3.85	
N.108	98.2	+13.50	-2.23	-12.93	1.72	-3.81	
N.109	97.5	+13.27	-2.33	-12.98	1.59	-4.32	
N.110	109.0	+12.49	-2.45	-12.24	1.51	-4.56	
N.111	107.8	+12.44	-2.53	-12.32	1.60	-4.68	
N.112	103.4	+12.76	-2.63	-12.61	1.60	-4.75	
N.113	100.6	+13.00	-2.69	-12.78	1.52	-4.82	
N.114	97.0	+13.08	-2.77	-13.01	1.77	-4.80	

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GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
N.115	90.6	+13.62	-2.81	-13.42	1.69	-4.79
N.116	90.0	+13.79	-2.85	-13.46	1.46	-4.93
N.117	86.3	+13.89	-2.91	-13.70	1.44	-5.15
N.118	85.8	+13.96	-2.95	-13.73	1.36	-5.23
N.119	83.1	+13.97	-2.99	-13.90	1.36	-5.43
N.120	81.2	+13.94	-2.93	-14.03	1.40	-5.59
N.121	77.1	+14.21	-3.08	-14.29	1.30	-5.73
N.122	70.8	+14.29	-3.13	-14.69	1.20	-6.20
N.123	72.0	+14.16	-3.13	-14.61	1.10	-6.35
N.124	71.5	+14.10	-3.15	-14.64	1.01	-6.55
N.125	64.0	+14.19	-3.25	-15.13	0.95	-6.74
N.126	72.4	+14.11	-3.21	-14.59	0.91	-6.75
N.127	74.2	+14.14	-3.39	-14.48	0.84	-6.76
N.128	75.2	+14.06	-3.46	-14.41	0.76	-6.92
N.129	66.6	+14.84	-3.54	-14.96	0.77	-6.76
N.130	78.5	+13.90	-3.63	-14.20	0.65	-7.15
N.131	79.2	+13.92	-3.68	-14.15	0.61	-7.17
N.132	78.2	+14.05	-3.73	-14.21	0.58	-7.17
N.133	76.5	+14.31	-3.79	-14.33	0.58	-7.10
N.134	78.2	+14.42	-3.86	-14.22	0.54	-6.99
N.135	80.8	+14.27	-3.92	-14.05	0.51	-7.07
N.136	82.1	+14.41	-3.94	-13.97	0.51	-6.86
N.137	84.1	+14.34	-4.04	-13.84	0.48	-6.93
N.138	80.7	+14.51	-4.11	-14.06	0.45	-7.08
N.139	82.6	+14.45	-4.17	-13.94	0.44	-7.04
N.140	79.3	+14.75	-4.23	-14.15	0.40	-7.10
N.141	85.1	+14.34	-4.27	-13.78	0.41	-7.17
N.142	87.1	+14.26	-4.31	-13.65	0.42	-7.15
O. 1	475.5	- 3.43	-10.25	+10.81	0.92	-5.83
O. 2	497.8	- 4.86	-10.20	+12.19	0.92	-5.83
O. 3	519.8	- 6.29	-10.15	+13.54	1.00	-5.78
O. 4	526.0	- 6.74	-10.10	+13.92	1.02	-5.78
O. 5	533.1	- 7.16	-10.04	+14.36	1.15	-5.57
O. 6	531.0	- 7.19	- 9.99	+14.23	1.09	-5.74
O. 7	533.3	- 7.37	- 9.95	+14.37	1.29	-5.54
O. 8	524.9	- 6.98	- 9.89	+13.85	1.43	-5.47

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
O. 9	515.8	- 6.59	-9.84	+13.29	1.53	-5.49	
O. 10	508.7	- 6.27	-9.79	+12.85	1.76	-5.33	
O. 11	505.1	- 6.20	-9.71	+12.63	1.70	-5.46	
O. 12	488.3	- 5.18	-9.63	+11.60	1.79	-5.30	
O. 13	513.6	- 6.70	-9.56	+13.16	2.03	-4.95	
O. 14	516.2	- 7.08	-9.49	+13.31	1.62	-5.52	
O. 15	527.3	- 7.56	-9.41	+14.00	1.95	-4.90	
O. 16	536.9	- 8.28	-9.34	+14.59	2.01	-4.90	
O. 17	557.3	- 9.51	-9.27	+15.85	1.61	-5.20	
O. 18	586.6	-11.31	-9.16	+17.65	1.91	-4.85	
O. 19	635.6	-14.33	-9.05	+20.67	1.74	-4.85	
O. 20	680.4	-17.01	-8.91	+23.43	2.12	-4.25	
O. 21	721.5	-19.56	-8.84	+25.96	1.99	-4.33	
O. 22	758.3	-21.64	-8.80	+28.23	1.95	-4.14	
O. 23	791.7	-23.78	-8.73	+30.29	1.88	-4.22	
O. 24	831.0	-26.22	-8.65	+32.71	2.02	-4.02	
O. 25	872.6	-28.58	-8.58	+35.27	1.80	-3.98	
O. 26	901.3	-30.30	-8.51	+37.04	1.73	-3.92	
O. 27	955.0	-32.57	-8.43	+38.84	1.63	-4.41	
O. 28	1006.1	-35.71	-8.36	+41.87	0.99	-5.09	
O. 29	1036.9	-37.26	-8.32	+43.70	1.07	-4.69	
O. 30	1052.8	-38.02	-8.26	+44.64	0.93	-4.59	
O. 31	1063.2	-38.23	-8.23	+45.26	0.89	-4.29	
O. 32	1063.7	-38.24	-8.19	+45.29	0.83	-4.19	
O. 33	1073.0	-38.67	-8.19	+45.84	0.78	-4.11	
O. 34	1075.3	-38.58	-8.21	+45.97	0.90	-3.79	
O. 34	1075.3	-38.59	-8.16	+45.97	0.90	-3.75	
O. 35	1074.4	-38.62	-8.17	+45.92	0.82	-3.92	
O. 36	1046.8	-36.79	-8.11	+44.28	0.81	-3.70	
O. 37	1018.8	-34.90	-8.06	+42.62	1.26	-2.95	
O. 38	1030.8	-35.66	-8.05	+43.33	0.89	-3.36	
O. 39	1060.1	-37.31	-8.08	+45.07	0.93	-3.26	
O. 40	1081.3	-38.53	-8.02	+46.33	0.92	-3.17	
O. 41	1093.3	-39.32	-7.99	+47.04	0.96	-3.18	
O. 42	1097.1	-39.44	-7.92	+47.27	1.00	-2.96	
O. 43	1116.5	-40.39	-7.83	+48.42	0.88	-2.79	
O. 44	1118.6	-40.39	-7.76	+48.54	0.94	-2.54	
O. 45	1119.6	-40.50	-7.69	+48.60	1.02	-2.44	

-2.31

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
0.46	1109.5	-39.64	-7.61	+48.00	1.01	-2.31
0.47	1084.7	-38.17	-7.55	+46.53	1.10	-1.96
0.48	1065.8	-37.15	-7.49	+45.41	1.03	-2.07
0.49	1051.2	-36.13	-7.38	+44.54	0.98	-1.86
0.50	1036.7	-35.14	-7.33	+43.69	0.89	-1.76
0.51	1025.8	-34.29	-7.31	+43.04	0.64	-1.79
0.52	1019.5	-33.67	-7.19	+42.67	0.81	-1.35
0.53	1008.4	-33.04	-7.25	+42.01	0.65	-1.44
0.54	998.7	-32.27	-7.21	+41.43	0.75	-1.17
0.55	996.5	-31.98	-7.20	+41.30	0.71	-1.04
0.56	1004.7	-32.37	-7.20	+41.79	0.64	-1.01
0.57	996.8	-31.94	-7.13	+41.32	0.74	-0.88
0.58	915.6	-26.97	-7.04	+36.51	0.85	-0.52
0.59	903.8	-26.02	-7.00	+35.80	0.88	-0.21
0.60	903.4	-25.87	-6.94	+35.78	0.85	-0.05
0.61	902.4	-25.81	-6.87	+35.72	0.83	0.00
0.62	900.7	-25.65	-6.82	+35.62	0.86	+0.14
0.63	884.7	-24.62	-6.76	+34.67	0.89	+0.31
0.64	873.0	-23.60	-6.71	+33.98	0.92	+0.72
0.65	866.9	-23.01	-6.66	+33.62	1.04	+1.12
0.66	941.3	-27.44	-6.61	+38.03	0.70	+0.81
0.67	939.0	-26.94	-6.57	+37.89	0.69	+1.20
0.68	928.0	-26.09	-6.52	+37.24	0.62	+1.38
0.69	933.1	-26.23	-6.47	+37.54	0.90	+1.87
0.70	938.0	-26.44	-6.42	+37.83	0.70	+1.80
0.71	932.6	-26.40	-6.53	+37.51	0.62	+1.51
0.72	930.3	-26.18	-6.28	+37.37	0.71	+1.75
0.73	912.6	-25.00	-6.23	+36.33	0.63	+1.87
0.74	893.3	-23.69	-6.13	+35.18	0.54	+2.03
0.75	864.6	-21.90	-6.06	+33.48	0.62	+2.27
0.76	849.1	-20.83	-5.98	+32.56	0.53	+2.41
0.77	845.2	-20.57	-5.92	+32.33	0.45	+2.42
0.78	822.2	-18.93	-5.87	+30.96	0.45	+2.74
0.79	824.1	-18.83	-5.83	+31.08	0.45	+3.00
0.80	839.0	-19.68	-5.79	+31.96	0.46	+3.08
0.81	842.3	-19.74	-5.73	+32.16	0.39	+3.21

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
P. 1	748.0	-12.65	-5.06	+26.66	0.41	+ 5.49
P. 2	771.9	-14.11	-5.02	+28.09	0.41	+ 5.50
P. 3	797.4	-15.36	-5.00	+29.61	0.70	+ 6.08
P. 4	797.2	-15.29	-4.92	+29.59	0.61	+ 6.12
P. 5	783.5	-14.40	-4.88	+28.78	0.42	+ 6.05
P. 6	770.9	-13.85	-4.79	+28.03	0.44	+ 5.96
P. 7	758.9	-13.50	-4.75	+27.31	0.51	+ 5.70
P. 8	760.9	-13.75	-4.71	+27.43	0.54	+ 5.64
P. 9	767.2	-14.24	-4.68	+27.81	0.59	+ 5.61
P.10	773.5	-14.30	-4.63	+28.18	0.44	+ 5.82
P.11	800.1	-15.61	-4.55	+29.77	0.48	+ 6.22
P.12	792.1	-15.30	-4.48	+29.29	0.43	+ 6.07
P.13	787.4	-14.80	-4.42	+29.01	0.46	+ 6.38
P.14	771.3	-13.83	-4.37	+28.05	0.49	+ 6.47
P.15	750.8	-12.61	-4.30	+26.83	0.53	+ 6.58
P.16	742.5	-12.11	-4.26	+26.34	0.56	+ 6.66
P.17	744.1	-12.12	-4.23	+26.43	0.48	+ 6.69
P.18	746.4	-12.18	-4.11	+26.57	0.61	+ 6.92
P.19	748.2	-12.05	-4.17	+26.68	0.64	+ 7.23
P.20	751.7	-12.02	-4.14	+26.88	0.65	+ 7.50
P.21	753.3	-12.14	-4.12	+26.98	0.75	+ 7.60
P.22	756.8	-12.22	-4.15	+27.19	0.61	+ 7.56
P.23	760.4	-11.99	-4.05	+27.40	0.57	+ 7.96
P.24	766.6	-12.08	-4.02	+27.27	0.62	+ 7.82
P.25	769.8	-12.15	-4.09	+27.96	0.55	+ 8.40
P.26	781.9	-12.41	-3.95	+28.68	0.54	+ 8.89
P.27	780.6	-12.87	-4.02	+28.60	0.52	+ 8.36
P.28	786.5	-13.05	-3.99	+28.95	0.56	+ 8.60
P.29	770.2	-11.65	-4.01	+27.98	0.67	+ 9.12
P.30	773.7	-11.55	-4.01	+28.19	0.68	+ 9.44
P.31	778.1	-11.61	-4.00	+28.46	0.60	+ 9.58
P.32	789.4	-12.00	-4.01	+29.13	0.58	+ 9.83
P.33	788.1	-11.69	-4.00	+29.05	0.57	+10.06
P.34	797.3	-12.04	-3.98	+29.60	0.58	+10.29
P.35	801.1	-12.09	-4.00	+29.82	0.54	+10.40
P.36	806.4	-12.03	-3.97	+30.14	0.48	+10.75
P.37	807.8	-11.92	-3.89	+30.22	0.49	+11.03

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
P.38	809.8	-11.94	-3.89	+30.35	0.61	+11.27
P.39	813.7	-12.08	-3.90	+30.58	0.49	+11.23
P.40	815.7	-12.00	-3.84	+30.70	0.51	+11.50
P.41	818.8	-12.08	-3.78	+30.88	0.48	+11.64
P.42	823.0	-12.08	-3.76	+31.13	0.50	+11.93
P.43	826.6	-12.10	-3.74	+31.34	0.48	+12.12
P.44	831.8	-12.56	-3.81	+31.65	0.48	+12.00
P.45	836.3	-12.66	-3.63	+31.92	0.49	+12.25
P.46	843.9	-13.07	-3.65	+32.37	0.51	+12.29
P.47	852.6	-13.45	-3.62	+32.89	0.54	+12.49
P.48	862.8	-14.40	-3.56	+33.50	0.57	+12.24
P.49	882.8	-15.88	-3.53	+34.69	0.64	+12.05
Q. 1	234.0	+ 7.65	-0.07	- 3.93	1.52	+ 1.30
Q. 2	249.4	+ 7.64	+0.01	- 3.01	1.40	+ 1.57
Q. 3	267.8	+ 5.92	+0.08	- 1.91	1.22	+ 1.44
Q. 4	285.5	+ 4.72	+0.13	- 0.86	1.20	+ 1.32
Q. 5	306.6	+ 3.36	+0.13	+ 0.39	1.14	+ 1.15
Q. 6	322.1	+ 2.49	+0.17	+ 1.31	1.08	+ 1.18
Q. 7	336.7	+ 1.51	+0.22	+ 2.18	0.91	+ 0.94
Q. 8	356.0	+ 0.59	+0.29	+ 3.33	0.88	+ 1.22
Q. 9	351.5	+ 0.65	+0.38	+ 3.06	0.76	+ 0.98
Q.10	355.3	+ 0.71	+0.45	+ 3.29	0.66	+ 1.44
Q.11	361.8	+ 0.49	+0.52	+ 3.68	0.66	+ 1.43
Q.12	368.4	- 0.01	+0.58	+ 4.07	0.60	+ 1.37
Q.13	376.6	- 0.54	+0.62	+ 4.50	0.55	+ 1.26
Q.14	379.0	- 0.77	+0.71	+ 4.70	0.53	+ 1.30
Q.15	397.3	- 1.64	+0.79	+ 5.79	0.49	+ 1.56
Q.16	420.6	- 3.18	+0.95	+ 7.18	0.45	+ 1.53
Q.17	436.6	- 4.27	+1.05	+ 8.13	0.38	+ 1.42
Q.18	439.1	- 4.49	+1.12	+ 8.28	0.34	+ 1.38
Q.19	447.3	- 4.96	+1.22	+ 8.77	0.31	+ 1.47
Q.20	444.1	- 4.84	+1.34	+ 8.58	0.28	+ 1.47
Q.21	444.6	- 4.82	+1.40	+ 8.61	0.28	+ 1.60
Q.22	445.8	- 5.08	+1.58	+ 8.68	0.28	+ 1.49

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
Q.23	452.1	-5.49	+1.56	+9.05	0.25	+1.50
Q.24	459.5	-5.76	+1.62	+9.49	0.23	+1.71
Q.25	462.1	-5.97	+1.69	+9.65	0.23	+1.73
Q.26	460.9	-6.02	+1.75	+9.58	0.22	+1.66
Q.27	455.2	-5.74	+1.82	+9.24	0.22	+1.67
Q.28	444.9	-5.32	+1.88	+8.62	0.23	+1.54
Q.29	447.7	-5.57	+1.94	+8.79	0.20	+1.49
Q.30	448.3	-5.71	+1.97	+8.83	0.23	+1.45
Q.31	450.0	-5.96	+2.00	+8.93	0.22	+1.32
Q.32	443.5	-5.68	+2.02	+8.54	0.25	+1.26
Q.33	437.0	-5.31	+2.05	+8.15	0.25	+1.27
Q.34	434.0	-5.40	+2.12	+7.98	0.30	+1.13
Q.35	415.4	-4.52	+2.16	+6.87	0.27	+0.91
Q.36	389.3	-3.20	+2.22	+5.31	0.41	+0.87
Q.37	376.5	-2.65	+2.29	+4.56	0.45	+0.78
Q.38	364.4	-2.14	+2.35	+4.00	0.38	+0.72
Q.39	346.9	-1.23	+2.39	+2.91	0.30	+0.50
Q.40	353.2	-2.08	+2.47	+3.30	0.32	+0.14
Q.41	338.4	-1.56	+2.55	+2.38	0.26	-0.24
Q.42	333.6	-1.40	+2.61	+2.08	0.26	-0.32
Q.43	333.7	-1.52	+2.62	+2.09	0.24	-0.44
Q.44	327.5	-1.26	+2.63	+1.70	0.22	-0.58
Q.45	320.9	-0.91	+2.71	+1.29	0.22	-0.56
Q.46	314.2	-0.61	+2.77	+0.88	0.22	-0.61
Q.47	307.6	-0.27	+2.86	+0.47	0.23	-0.58
Q.48	301.3	+0.03	+2.96	+0.08	0.22	-0.58
Q.49	290.5	+0.46	+3.02	-0.59	0.26	-0.72
Q.50	280.8	+1.02	+3.06	-1.19	0.25	-0.73
Q.51	271.4	+2.17	+3.15	-1.77	0.22	-0.10
Q.52	261.5	+2.81	+3.22	-2.39	0.21	-0.02
Q.53	254.3	+2.97	+3.29	-2.83	0.21	-0.23
Q.54	255.4	+3.01	+3.30	-2.77	0.21	-0.12
Q.55[1]	256.5	+3.00	+3.30	-2.70	0.20	-0.07
Q.55[2]	256.4	+2.93	+3.30	-2.70	0.22	-0.12
Q.56	256.2	+3.04	+3.34	-2.72	0.21	0.00
Q.57	248.1	+3.81	+3.40	-3.22	0.19	+0.31
Q.58	230.1	+4.61	+3.47	-4.34	0.23	+0.10
Q.59	212.6	+5.59	+3.56	-5.42	0.25	+0.11

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
Q.60	198.6	+6.26	+3.63	-6.29	0.22	-0.04
Q.61	187.3	+6.57	+3.69	-6.99	0.22	-0.38
Q.62	181.5	+7.23	+3.75	-7.35	0.19	-0.05
Q.63	177.6	+7.46	+3.79	-7.59	0.20	-0.01
Q.64	177.2	+7.98	+3.86	-7.61	0.18	+0.54
Q.65	146.2	+7.56	+3.96	-9.54	0.19	-1.70
Q.66	131.8	+8.36	+4.04	-10.43	0.22	-1.68
Q.67	124.2	+8.71	+4.11	-10.90	0.21	-1.74
Q.68	119.6	+8.55	+4.19	-11.19	0.22	-2.10
Q.69	121.0	+8.24	+4.24	-11.10	0.22	-2.27
Q.70	118.0	+8.22	+4.31	-11.28	0.22	-2.40
Q.71	125.5	+7.68	+4.38	-10.82	0.23	-2.40
Q.72	129.0	+7.31	+4.46	-10.60	0.21	-2.49
R. 1	279.9	-2.25	+4.36	-1.24	0.24	-2.76
R. 2	288.8	-2.63	+4.27	-0.69	0.27	-2.65
R. 3	294.6	-2.98	+4.22	-0.33	0.33	-2.63
R. 4	303.6	-3.29	+4.17	+0.22	0.50	-2.29
R. 5	326.3	-4.37	+4.08	+1.63	0.38	-2.15
R. 6	329.5	-4.34	+3.98	+1.83	0.31	-2.09
R. 7	325.8	-3.41	+3.90	+1.60	0.37	-1.41
R. 8	320.8	-2.79	+3.78	+1.29	0.34	-1.25
R. 9	312.6	-2.19	+3.71	+0.78	0.38	-1.25
R.10	304.1	-1.52	+3.63	+0.25	0.40	-1.13
R.11	312.9	-1.92	+3.53	+0.80	0.37	-1.10
R.12	302.9	-1.21	+3.43	+0.18	0.48	-0.99
R.13	328.3	-2.72	+3.37	+1.69	0.50	-1.03
R.14	357.1	-4.12	+3.31	+3.40	0.36	-0.92
R.15	385.0	-5.77	+3.21	+5.06	0.36	-1.01
R.16	398.3	-6.38	+3.15	+5.85	0.40	-0.85
R.17	403.7	-6.83	+3.08	+6.17	0.40	-1.05
R.18	394.3	-6.05	+3.00	+5.61	0.38	-0.93
R.19	396.0	-6.21	+2.90	+5.72	0.44	-1.02
R.20	400.7	-6.39	+2.82	+5.99	0.44	-1.01
R.21	400.8	-6.52	+2.75	+6.00	0.49	-1.15

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
R.22	389.3	-5.74	+2.65	+5.31	0.60	-1.05
R.23	399.1	-6.32	+2.55	+5.90	0.47	-1.27
R.24	405.0	-6.71	+2.46	+6.25	0.62	-1.25
R.25	387.6	-5.53	+2.37	+5.21	0.67	-1.15
R.26	383.3	-5.37	+2.26	+4.96	0.67	-1.35
R.27	387.9	-5.73	+2.16	+5.23	0.65	-1.56
R.28	383.5	-5.41	+2.07	+4.97	0.50	-1.95
R.29	382.1	-5.16	+1.99	+4.89	0.65	-1.50
R.30	399.6	-5.90	+1.90	+5.93	0.58	-1.37
R.31	409.3	-6.39	+1.85	+6.51	0.56	-1.34
R.32	406.9	-5.98	+1.76	+6.36	0.60	-1.13
R.33	414.8	-6.43	+1.69	+6.83	0.54	-1.24
R.34	422.3	-6.81	+1.58	+7.28	0.60	-1.22
R.35	409.1	-5.57	+1.49	+6.49	0.74	-0.72
R.36	402.0	-5.20	+1.40	+6.07	0.57	-1.03
R.37	408.2	-5.46	+1.33	+6.44	0.69	-0.87
R.38	412.7	-5.75	+1.22	+6.71	0.64	-1.15
R.39	421.6	-6.04	+1.10	+7.24	0.66	-0.91
R.40	441.9	-7.46	+1.02	+8.45	0.61	-1.25
R.41	456.9	-8.35	+0.97	+9.34	0.62	-1.29
R.42	469.8	-8.91	+0.93	+10.10	0.70	-1.05
R.43	484.5	-9.72	+0.79	+10.98	0.69	-1.13
R.44	485.4	-9.76	+0.75	+11.04	0.63	-1.21
R.45	477.6	-9.30	+0.70	+10.57	0.73	-1.17
R.46	457.6	-8.12	+0.62	+9.38	0.71	-1.26
R.47	450.5	-7.75	+0.58	+8.96	0.63	-1.45
R.48	447.9	-7.56	+0.52	+8.80	0.55	-1.56
R.49	427.7	-6.47	+0.47	+7.60	0.48	-1.79
R.50	419.5	-5.84	+0.42	+7.12	0.41	-1.75
R.51	402.2	-5.21	+0.37	+6.08	0.67	-1.96
R.52	409.1	-5.29	+0.30	+6.50	0.51	-1.85
R.53	400.7	-4.15	+0.25	+6.00	0.64	-1.13
R.54	398.7	-3.82	+0.20	+5.87	0.62	-1.00
R.55	404.1	-4.11	+0.15	+6.19	0.50	-1.14
R.56	411.3	-4.49	+0.11	+6.63	0.40	-1.22
R.57	424.3	-5.02	+0.05	+7.40	0.36	-1.08
R.58	430.9	-5.25	0.00	+7.79	0.36	-0.97
R.59	445.5	-6.10	-0.05	+8.66	0.37	-0.99

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
R.60	452.9	- 6.43	-0.12	+ 9.10	0.40	-0.92
R.61	452.3	- 6.14	-0.19	+ 9.06	0.42	-0.72
R.62	451.6	- 5.90	-0.24	+ 9.02	0.50	-0.49
R.63	478.0	- 7.29	-0.28	+10.59	0.44	-0.41
R.64	491.1	- 8.65	-0.29	+11.37	0.45	-0.99
R.65	523.8	- 9.63	-0.34	+13.32	0.41	-0.11
R.66	543.6	-10.79	-0.39	+14.50	0.41	-0.14
R.67	559.1	-11.71	-0.43	+15.42	0.45	-0.14
R.68	567.4	-12.19	-0.48	+15.92	0.42	-0.20
R.69	590.2	-13.57	-0.53	+17.27	0.47	-0.23
R.70	608.4	-14.59	-0.57	+18.36	0.45	-0.22
R.71	622.1	-15.78	-0.62	+19.17	0.45	-0.65
R.72	628.1	-16.02	-0.69	+19.53	0.42	-0.63
R.73	635.0	-16.55	-0.76	+19.94	0.48	-0.76
R.74	623.0	-16.09	-0.81	+19.22	0.43	-1.12
R.75	632.1	-17.09	-0.87	+19.77	0.43	-1.63
R.76	628.8	-17.41	-0.93	+19.57	0.43	-2.21
R.77	633.9	-17.76	-0.99	+19.87	0.47	-2.28
R.78	628.5	-18.00	-1.05	+19.55	0.46	-2.91
R.79	616.0	-17.38	-1.15	+18.81	0.49	-3.05
R.80	604.2	-16.99	-1.22	+18.11	0.45	-3.52
R.81	584.3	-16.28	-1.28	+16.92	0.56	-3.60
R.82	568.6	-15.82	-1.36	+15.99	0.60	-3.93
R.83	548.1	-14.54	-1.45	+14.77	0.57	-4.32
R.84	525.3	-13.48	-1.52	+13.41	0.61	-4.85
R.85	513.1	-12.91	-1.59	+12.68	0.60	-5.09
S. 1	35.4	+ 9.88	+3.20	-16.96	0.55	-7.20
S. 2	33.7	+ 9.86	+3.26	-17.06	0.53	-7.28
S. 3	33.0	+ 9.88	+3.32	-17.12	0.52	-7.27
S. 4	34.4	+ 9.79	+3.38	-17.02	0.56	-7.16
S. 5	34.0	+ 9.52	+3.44	-17.05	0.56	-7.40
S. 6	33.7	+ 9.50	+3.49	-17.06	0.56	-7.37
S. 7	38.2	+ 9.34	+3.53	-16.78	0.58	-7.20
S. 8	40.8	+ 9.12	+3.56	-16.61	0.63	-7.18

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
S. 9	42.0	+ 9.08	+3.61	-16.54	0.66	-7.06
S.10	42.5	+ 8.86	+3.63	-16.50	0.70	-7.18
S.11	47.9	+ 8.43	+3.67	-16.15	0.69	-7.23
S.12	46.9	+ 8.52	+3.71	-16.22	0.78	-7.08
S.13	45.2	+ 8.31	+3.73	-16.33	0.82	-7.32
S.14	39.8	+ 8.71	+3.80	-16.67	0.94	-7.09
S.15	38.1	+ 8.68	+3.84	-16.78	1.09	-7.04
S.16	36.1	+ 8.85	+3.90	-16.91	0.93	-7.10
S.17	31.6	+ 9.01	+3.94	-17.20	1.08	-7.04
S.18	28.3	+ 9.29	+4.00	-17.41	1.23	-6.76
S.19	27.0	+ 9.31	+4.05	-17.49	1.09	-6.91
S.20	25.2	+ 9.23	+4.08	-17.61	1.38	-5.79
S.21	26.2	+ 9.15	+4.14	-17.55	1.34	-6.79
S.22	26.4	+ 9.23	+4.18	-17.53	1.30	-6.69
S.23	28.1	+ 9.28	+4.30	-17.42	1.14	-6.67
S.24	31.6	+ 9.15	+4.24	-17.20	1.28	-6.40
S.25	34.6	+ 8.84	+4.28	-17.21	0.82	-7.14
S.26	39.2	+ 8.66	+4.24	-16.71	0.89	-6.79
S.27	42.0	+ 8.53	+4.23	-16.53	1.00	-6.64
S.28	42.3	+ 8.58	+4.22	-16.51	0.98	-6.60
S.29	37.4	+ 8.71	+4.18	-16.83	1.18	-6.63
S.30	36.7	+ 8.94	+4.16	-16.83	1.25	-6.40
S.31	32.3	+ 9.06	+4.18	-17.15	1.65	-6.13
S.32	28.1	+ 9.45	+4.20	-17.42	1.43	-6.17
S.33	24.7	+ 9.78	+4.24	-17.64	1.45	-6.04
S.34	21.5	+ 9.66	+4.26	-17.85	1.51	-5.69
S.35	22.4	+10.11	+4.29	-17.79	1.66	-5.60
S.36	22.8	+10.17	+4.31	-17.76	1.65	-5.50
S.37	21.0	+10.28	+4.35	-17.88	1.53	-5.53
S.38	20.3	+10.36	+4.39	-17.92	1.51	-5.52
S.39	22.9	+10.55	+4.43	-17.76	1.68	-4.97
S.40	25.6	+10.61	+4.47	-17.59	1.57	-4.81
S.41	31.5	+10.38	+4.53	-17.21	1.34	-4.83
S.42	42.0	+10.02	+4.54	-15.30	1.26	-3.35
S.43	51.5	+ 9.56	+4.54	-14.74	1.36	-3.15
S.44	60.3	+ 9.10	+4.52	-14.21	1.15	-3.31
S.45	69.3	+ 8.62	+4.52	-13.68	1.34	-3.07

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
S.46	78.6	+ 8.01	+4.50	-13.13	1.39	-3.10	
S.47	88.5	+ 7.40	+4.48	-12.54	1.50	-3.03	
S.48	99.3	+ 6.70	+4.46	-11.90	1.83	-2.78	
S.49	110.1	+ 5.92	+4.44	-11.26	2.03	-2.74	
S.50	120.1	+ 5.96	+4.46	-10.67	2.02	-2.10	
S.51	125.6	+ 5.01	+4.48	-10.34	1.77	-2.95	
S.52	128.2	+ 4.98	+4.54	-10.19	1.72	-2.82	
S.53	126.7	+ 5.27	+4.56	-10.28	1.71	-2.61	
S.54	119.5	+ 5.65	+4.58	-10.70	1.71	-2.63	
S.55	106.4	+ 6.46	+4.62	-11.48	1.87	-2.38	
S.56	89.3	+ 7.32	+4.64	-12.49	1.53	-2.87	
S.57	70.4	+ 8.51	+4.66	-13.62	1.44	-2.83	
S.58	54.2	+ 9.08	+4.68	-14.58	1.50	-3.19	
S.59	43.6	+ 9.76	+4.71	-15.20	1.58	-3.02	
S.60	37.1	+10.11	+4.75	-15.60	1.91	-2.70	
S.61	33.6	+10.01	+4.76	-15.80	1.85	-3.05	
S.62	37.1	+ 9.71	+4.76	-15.60	1.88	-3.12	
S.63	47.4	+ 9.25	+4.76	-14.98	1.95	-2.89	
S.64	57.1	+ 8.58	+4.78	-14.40	1.82	-3.09	
S.65	67.1	+ 8.06	+4.80	-13.81	1.76	-3.06	
S.66	74.9	+ 7.86	+4.84	-13.35	1.67	-2.85	
S.67	82.0	+ 7.53	+4.86	-12.93	1.50	-2.91	
S.68	89.3	+ 7.04	+4.88	-12.49	1.34	-3.10	
S.69	95.7	+ 6.53	+4.92	-12.11	1.34	-3.19	
S.70	101.8	+ 6.11	+4.94	-11.75	1.25	-3.32	
S.71	108.8	+ 5.68	+4.97	-11.34	1.21	-3.35	
S.72	114.1	+ 5.39	+4.99	-11.02	1.05	-3.46	
S.73	116.7	+ 5.50	+5.01	-10.87	0.97	-3.28	
S.74	124.4	+ 5.06	+5.03	-10.41	1.03	-3.16	
S.75	132.9	+ 4.60	+5.07	- 9.91	0.91	-3.20	
S.76	125.4	+ 5.36	+5.09	-10.35	0.85	-2.92	
S.77	114.5	+ 6.17	+5.13	-11.00	0.83	-2.74	
S.78	104.0	+ 7.09	+5.13	-11.62	0.82	-2.45	
S.79	93.4	+ 7.92	+5.17	-12.25	0.87	-2.16	
S.80	93.7	+ 8.15	+5.17	-12.23	0.90	-1.90	
S.81	102.5	+ 7.65	+5.19	-11.71	0.86	-1.90	
S.82	114.6	+ 6.71	+5.18	-10.99	0.77	-2.20	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
S.83	125.0	+6.16	+5.20	-10.38	0.69	-2.20	
S.84	135.0	+5.66	+5.20	-10.23	0.72	-2.52	
S.85	138.9	+5.41	+5.20	- 9.99	0.69	-2.56	
S.86	131.1	+6.11	+5.20	-10.47	0.71	-2.32	
S.87	123.7	+6.36	+5.20	-10.93	0.68	-2.56	
S.88	129.8	+6.10	+5.22	-10.55	0.70	-2.40	
S.89	143.1	+5.41	+5.22	- 9.73	0.65	-2.32	
S.90	156.7	+4.55	+5.22	- 8.88	0.63	-2.35	
S.91	170.9	+3.75	+5.22	- 8.00	0.61	-2.29	
S.92	182.9	+2.99	+5.22	- 7.26	0.55	-2.37	
S.93	193.8	+2.06	+5.22	- 6.58	0.57	-2.60	
S.94	190.4	+2.33	+5.23	- 6.80	0.56	-2.55	
S.95	188.7	+2.38	+5.23	- 6.90	0.53	-2.63	
S.96	186.5	+2.46	+5.24	- 7.04	0.53	-2.68	
S.97	184.3	+2.38	+5.27	- 7.17	0.50	-2.89	
S.98	182.4	+2.62	+5.27	- 7.29	0.70	-2.57	
S.99	182.2	+2.76	+5.27	- 7.30	0.49	-2.65	
S.100	182.2	+2.91	+5.26	- 7.30	0.48	-2.52	
T. 1	744.7	-12.46	-4.29	+26.37	0.62	+6.37	
T. 2	764.1	-13.74	-4.23	+27.52	0.58	+6.26	
T. 3	775.2	-14.54	-4.21	+28.18	0.68	+6.24	
T. 4	761.9	-13.85	-4.20	+27.39	0.77	+6.24	
T. 5	752.3	-13.27	-4.19	+26.82	0.94	+6.43	
T. 6	749.6	-13.53	-4.19	+26.66	1.14	+6.21	
T. 7	764.7	-14.56	-4.19	+27.55	0.98	+5.91	
T. 8	793.2	-16.44	-4.18	+29.25	1.48	+6.24	
T. 9	793.9	-16.68	-4.15	+29.29	0.87	+5.46	
T.10	788.9	-16.63	-4.11	+28.99	0.76	+5.14	
T.11	785.1	-16.61	-4.07	+28.77	0.67	+4.89	
T.12	766.7	-15.77	-4.03	+27.67	0.66	+4.66	
T.13	752.4	-15.20	-3.99	+26.83	0.61	+4.38	
T.14	751.1	-15.41	-3.92	+26.75	0.67	+4.22	
T.15	754.7	-15.92	-3.86	+26.96	0.63	+3.96	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
T.16	756.9	-16.12	-4.36	+27.09	0.55	+3.29
T.17	755.2	-15.98	-3.73	+26.99	0.59	+4.00
T.18	749.8	-15.69	-3.27	+26.77	0.76	+4.60
T.19	745.0	-15.97	-3.62	+26.39	0.66	+4.19
T.20	746.5	-15.42	-3.56	+26.48	0.65	+4.28
T.21	745.1	-15.30	-3.48	+26.40	0.69	+4.44
T.22	749.3	-15.79	-3.40	+26.64	0.63	+4.21
T.23	761.8	-16.74	-3.34	+27.38	0.61	+4.04
T.24	761.3	-16.98	-3.31	+27.36	0.62	+3.82
T.25	776.8	-18.05	-3.31	+28.27	0.63	+3.67
T.26	778.5	-18.46	-3.30	+28.38	0.60	+3.35
T.27	770.7	-18.23	-3.28	+27.91	0.52	+3.05
T.28	770.3	-18.28	-3.26	+27.89	0.52	+3.00
T.29	773.0	-18.32	-3.24	+28.05	0.53	+3.15
T.30	772.4	-18.52	-3.20	+28.02	0.55	+2.98
T.31	786.5	-19.62	-3.14	+28.85	0.57	+2.79
T.32	769.4	-18.68	-3.09	+27.84	0.60	+2.80
T.33	760.0	-18.55	-3.04	+27.28	0.62	+2.44
T.34	772.5	-19.54	-2.98	+28.02	0.66	+2.29
T.35	785.6	-20.48	-2.91	+28.80	0.69	+2.23
T.36	795.9	-21.14	-2.85	+29.41	0.68	+2.23
T.37	782.6	-20.54	-2.80	+28.62	0.77	+2.18
T.38	786.1	-20.88	-2.78	+28.83	0.84	+2.14
U. 1	36.8	+ 8.93	+4.23	-15.61	1.70	-4.62
U. 2	64.4	+ 7.26	+4.16	-13.97	1.45	-4.97
U. 3	96.5	+ 5.30	+4.11	-12.07	1.52	-5.01
U. 4	126.0	+ 3.75	+4.06	-10.32	1.51	-4.87
U. 5	160.8	+ 1.68	+4.01	- 8.25	1.30	-5.13
U. 6	196.2	- 0.36	+3.93	- 6.16	1.40	-5.06
U. 7	228.3	- 2.07	+3.85	- 4.25	1.01	-5.33
U. 8	254.3	- 3.31	+3.81	- 2.71	1.05	-5.03
U. 9	286.1	- 5.08	+3.72	- 0.82	0.93	-5.12
U.10	314.1	- 6.69	+3.71	+ 0.84	0.83	-5.18
U.11	343.5	- 8.59	+3.74	+ 2.58	0.98	-5.16

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
U.12	343.3	- 8.92	+3.76	+ 2.86	1.08	-5.09	
U.13	366.5	-10.34	+3.79	+ 3.94	1.47	-5.01	
U.14	407.6	-13.07	+3.75	+ 6.38	1.49	-5.32	
U.15	452.9	-15.62	+3.74	+ 9.07	1.50	-5.18	
U.16	496.7	-19.76	+3.71	+11.67	1.64	-6.61	
U.17	533.9	-19.92	+3.73	+13.87	1.20	-4.99	
U.18	562.4	-21.46	+3.69	+15.56	1.40	-4.68	
U.19	595.6	-23.59	+3.64	+17.53	1.34	-4.95	
U.20	628.0	-25.40	+3.54	+19.45	1.59	-4.69	
U.21	648.2	-26.63	+3.48	+20.65	1.57	-4.80	
U.22	661.6	-27.49	+3.44	+21.44	1.28	-5.20	
U.23	679.9	-28.72	+3.36	+22.53	1.41	-5.29	
U.24	717.5	-31.09	+3.31	+24.76	1.11	-5.78	
U.25	744.8	-32.68	+3.25	+26.38	1.25	-5.67	
U.26	720.3	-30.80	+3.20	+24.93	1.45	-5.09	
U.27	738.1	-32.14	+3.15	+25.97	1.56	-5.33	
U.28	770.3	-34.07	+3.10	+27.89	1.40	-5.55	
U.29	797.2	-35.80	+3.08	+29.48	1.19	-5.92	
U.30	808.5	-36.56	+2.99	+30.16	1.97	-5.31	
U.31	786.6	-34.97	+2.93	+28.85	1.65	-5.41	
U.32	821.0	-37.79	+2.89	+30.90	1.86	-6.01	
U.33	859.6	-39.61	+2.84	+33.18	1.75	-5.71	
U.34	884.7	-41.36	+2.78	+34.67	1.62	-6.16	
U.35	904.7	-42.56	+2.74	+35.86	1.71	-6.12	
U.36	950.0	-44.87	+2.69	+38.55	1.70	-5.80	
U.37	982.0	-46.92	+2.64	+40.44	1.66	-6.05	
U.38	999.9	-47.99	+2.58	+41.51	1.61	-6.16	
U.39	1037.2	-49.98	+2.53	+43.72	1.50	-6.10	
U.40	1074.3	-52.31	+2.47	+45.92	1.72	-6.07	
U.41	1084.1	-52.82	+2.42	+46.50	1.66	-6.11	
U.42	1077.7	-52.34	+2.35	+46.12	1.46	-6.28	
U.43	1075.1	-51.86	+2.32	+45.96	1.32	-6.13	
U.44	1073.9	-51.97	+2.25	+45.89	1.27	-6.43	
U.45	1065.3	-51.60	+2.18	+45.38	1.21	-6.70	
U.46	1053.9	-50.88	+2.16	+44.71	1.17	-6.71	
U.47	1054.7	-50.67	+2.10	+44.75	1.19	-6.50	
U.48	1086.6	-52.16	+2.12	+46.64	1.34	-5.93	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
U.49	1132.2	-54.66	+2.15	+49.35	1.30	-5.73
U.50	1158.2	-56.51	+2.16	+50.89	1.13	-6.20
U.51	1226.7	-60.84	+2.14	+54.95	1.34	-5.78
U.52	1207.9	-59.29	+2.13	+53.84	1.42	-5.77
U.53	1189.9	-58.24	+2.12	+52.78	1.72	-5.49
U.54	1152.2	-55.73	+2.11	+50.54	1.16	-5.79
U.55	1108.3	-52.99	+2.10	+47.94	1.08	-5.74
U.56	1137.5	-56.58	+2.10	+49.67	1.08	-7.60
U.57	1219.7	-59.58	+2.09	+54.51	1.40	-5.45
U.58	1197.0	-58.24	+2.07	+53.19	1.25	-5.60
U.59	1175.3	-56.68	+2.01	+51.90	1.13	-5.51
U.60	1191.0	-57.65	+1.98	+52.84	1.21	-5.49
U.61	1193.9	-57.83	+1.93	+53.01	1.28	-5.58
U.62	1223.0	-59.75	+1.89	+54.73	1.17	-5.83
U.63	1224.8	-59.74	+1.87	+54.84	1.19	-5.71
U.64	1239.3	-60.55	+1.83	+55.70	1.23	-5.66
U.65	1246.3	-61.10	+1.80	+56.11	1.40	-5.66
U.66	1206.6	-58.44	+1.75	+53.74	1.14	-5.68
U.67	1171.0	-55.81	+1.71	+51.65	1.04	-5.28
U.68	1161.0	-55.35	+1.67	+51.06	1.03	-5.46
U.69	1187.0	-57.03	+1.63	+52.60	1.10	-5.57
U.70	1152.3	-54.98	+1.59	+50.54	1.04	-5.68
U.71	1110.3	-52.21	+1.56	+48.05	1.02	-5.45
U.72	1169.0	-49.79	+1.52	+51.53	1.39	+0.78
U.73	1056.6	-49.24	+1.47	+44.87	1.04	-5.73
U.74	1056.8	-49.24	+1.49	+44.83	1.02	-5.72
U.75	1109.6	-53.22	+1.54	+48.01	1.13	-6.41
U.76	1171.7	-56.85	+1.74	+51.69	1.54	-5.75
U.77	1105.6	-52.44	+1.81	+47.77	1.14	-5.59
U.78	1071.5	-50.28	+1.87	+45.75	0.93	-5.55
U.79	1050.3	-49.05	+1.94	+44.49	0.85	-5.64
U.80	1041.8	-48.04	+2.00	+43.99	0.77	-5.15
U.81	1037.6	-47.37	+2.07	+43.74	0.75	-4.68
U.82	1005.0	-45.60	+2.15	+41.76	0.82	-4.74
U.83	1036.2	-47.38	+2.25	+43.66	0.74	-4.60
U.84	1021.7	-46.16	+2.33	+42.79	0.70	-4.21
U.85	1017.8	-46.39	+2.41	+42.52	0.70	-4.63
U.86	1020.7	-45.83	+2.50	+42.74	0.82	-3.64

GRAVITY DATA SHEET NO.44

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
U.87	1001.9	-44.98	+2.60	+41.62	0.75	-3.88	
U.88	988.4	-43.75	+2.69	+40.82	0.75	-3.36	
U.89	968.1	-42.74	+2.81	+39.62	0.80	-3.38	
U.90	953.0	-42.06	+2.92	+38.72	1.16	-3.13	
U.91	914.1	-39.52	+2.97	+36.41	0.81	-3.20	
U.92	905.0	-38.98	+3.01	+35.88	0.84	-3.12	
U.93	919.0	-39.83	+3.07	+36.71	1.04	-2.88	
U.94	890.2	-36.86	+3.09	+34.99	0.85	-1.79	
U.95	852.1	-36.14	+3.10	+32.74	1.26	-2.91	
U.96	844.0	-35.63	+3.15	+32.26	0.93	-3.16	
U.97	839.6	-35.71	+3.21	+32.00	1.00	-3.37	
U.98	835.8	-35.31	+3.28	+31.77	0.99	-3.14	
U.99	838.4	-36.07	+3.35	+31.93	1.24	-3.52	
U.100	842.0	-36.10	+3.42	+32.14	1.09	-3.32	
U.101	839.6	-36.05	+3.47	+32.00	0.93	+3.52	
U.102	836.8	-36.18	+3.53	+31.83	1.01	-3.68	
U.103	843.5	-36.42	+3.58	+32.23	1.32	-3.16	
U.104	803.4	-34.17	+3.63	+29.85	1.27	-3.31	
U.105	767.9	-32.04	+3.68	+27.75	1.19	-3.29	
U.106	751.2	-31.12	+3.73	+26.76	1.28	-3.22	
U.107	735.3	-30.41	+3.79	+25.81	1.24	-3.44	
U.108	718.0	-29.26	+3.81	+24.79	1.24	-3.29	
U.109	702.2	-28.13	+3.85	+23.85	1.14	-3.20	
U.110	690.3	-27.07	+3.89	+23.14	1.15	-2.76	
U.111	680.7	-26.27	+3.95	+22.57	1.14	-2.49	
U.112	665.3	-25.33	+4.00	+21.66	1.33	-2.23	
U.113	644.1	-24.05	+4.04	+20.41	1.36	-2.11	
U.114	624.6	-22.85	+4.06	+19.25	1.18	-2.23	
U.115	609.7	-21.87	+4.10	+18.37	1.07	-2.20	
U.116	595.0	-21.03	+4.13	+17.49	1.14	-2.14	
U.117	580.3	-19.94	+4.18	+16.62	1.17	-1.84	
U.118	565.8	-19.16	+4.19	+15.76	1.23	-1.85	
U.119	552.0	-18.20	+4.23	+14.94	1.06	-1.84	
U.120	536.8	-17.40	+4.25	+14.04	0.99	-1.99	
U.121	532.1	-17.00	+4.28	+13.76	0.82	-2.01	
U.122	506.8	-15.36	+4.32	+12.26	0.91	-1.74	
U.123	493.5	-14.53	+4.35	+11.47	0.92	-1.66	
U.124	478.2	-13.55	+4.36	+10.57	0.81	-1.68	

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
U.125	463.4	-12.65	+4.39	+ 9.69	0.80	-1.64
U.126	449.7	-11.67	+4.41	+ 8.88	0.74	-1.51
U.127	436.2	-10.73	+4.45	+ 8.08	0.65	-1.42
U.128	434.2	-10.36	+4.48	+ 7.96	0.73	-1.04
U.129	417.9	- 9.52	+4.52	+ 6.99	0.73	-1.15
U.130	401.5	- 8.61	+4.55	+ 6.02	0.71	-1.20
U.131	386.7	- 7.82	+4.59	+ 5.14	0.64	-1.32
U.132	365.7	- 6.70	+4.66	+ 3.90	0.56	-1.45
U.133	351.0	- 6.05	+4.74	+ 3.03	0.63	-1.52
U.134	340.3	- 5.44	+4.81	+ 2.39	0.63	-1.48
U.135	313.1	- 4.05	+4.88	+ 0.78	0.56	-1.70
U.136	294.1	- 3.16	+4.95	- 0.35	0.55	-1.88
U.137	272.0	- 2.01	+5.02	- 1,66	0.56	-1.96
U.138	245.3	- 0.15	+5.10	- 3.24	0.51	-1.65
U.139	235.8	+ 0.24	+5.14	- 3.81	0.44	-1.86
U.140	209.4	+ 1.53	+5.20	- 5.37	0.45	-2.01
U.141	209.5	+ 1.53	+5.25	- 5.37	0.40	-2.06
V. 1	1012.4	-31.94	-6.43	+42.24	0.56	+0.56
V. 2	1028.2	-32.70	-6.45	+43.18	0.59	+0.75
V. 3	1047.1	-33.80	-6.49	+44.30	0.61	+0.75
V. 4	1073.2	-35.54	-6.54	+45.85	0.58	+0.48
V. 5	1090.4	-36.43	-6.60	+46.87	0.65	+0.62
V. 6	1089.8	-36.59	-6.67	+46.84	0.62	+0.33
V. 7	1102.6	-37.22	-6.75	+47.59	0.68	+0.43
V. 8	1106.8	-37.44	-6.83	+47.85	0.68	+0.39
V. 9	1129.1	-38.92	-6.89	+49.17	0.57	+0.06
V.10	1150.0	-40.32	-6.99	+50.41	0.56	-0.21
V.11	1153.6	-40.60	-7.06	+50.62	0.55	-0.36
V.12	1165.4	-41.27	-7.13	+51.32	0.54	-0.41
V.13	1174.2	-41.66	-7.18	+51.84	0.58	-0.27
V.14	1173.8	-41.71	-7.18	+51.81	0.60	-0.33
V.15	1173.4	-41.80	-7.21	+51.79	0.64	-0.45
V.16	1173.4	-41.82	-7.27	+51.79	0.68	-0.49
V.17	1171.4	-41.87	-7.31	+51.67	0.71	-0.67
V.18	1176.0	-42.69	-7.36	+51.95	0.70	-1.27

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
V.19	1180.7	-42.55	-7.43	+52.23	0.67	-0.95
V.20	1189.9	-43.01	-7.49	+52.77	0.62	-0.98
V.21	1196.6	-43.77	-7.59	+53.17	0.64	-1.42
V.22	1211.4	-44.61	-7.65	+54.04	0.71	-1.38
V.23	1224.2	-45.67	-7.73	+54.81	0.85	-1.61
V.24	1228.9	-45.87	-7.75	+55.08	0.77	-1.64
V.25	1213.2	-45.31	-7.83	+54.15	0.77	-2.09
V.26	1209.5	-45.10	-7.92	+53.93	0.70	-2.26
V.27	1209.2	-44.85	-7.99	+53.91	0.72	-2.08
V.28	1208.9	-45.57	-8.07	+53.90	0.83	-2.78
V.29	1210.2	-44.95	-8.16	+53.97	0.73	-2.28
V.30	1210.1	-45.13	-8.17	+53.97	0.79	-2.41
V.31	1206.8	-44.91	-8.22	+53.77	0.86	-2.37
V.32	1208.4	-45.19	-8.27	+53.87	0.86	-2.60
V.33	1207.9	-45.00	-8.29	+53.84	0.82	-2.50
V.34	1209.1	-45.19	-8.33	+53.91	0.89	-2.59
V.35	1207.8	-45.05	-8.38	+53.83	0.93	-2.54
V.36	1208.6	-45.25	-8.41	+53.88	0.95	-2.70
V.37	1208.4	-45.42	-8.43	+53.87	1.00	-2.85
V.38	1222.5	-46.15	-8.48	+54.70	1.04	-2.76
V.39	1256.7	-48.35	-8.57	+56.73	1.09	-2.97
V.40	1269.0	-49.32	-8.67	+57.46	1.08	-3.32
V.41	1276.9	-49.62	-8.74	+57.93	1.17	-3.15
V.42	1311.1	-51.72	-8.81	+59.96	1.26	-3.18
V.43	1328.5	-53.09	-8.89	+60.99	1.30	-3.56
V.44	1352.8	-54.66	-8.97	+62.43	1.38	-3.69
V.45	1369.8	-55.67	-9.03	+63.44	1.53	-3.60
V.46	1375.6	-55.64	-9.07	+63.79	1.47	-3.32
V.47	1385.9	-56.69	-9.11	+64.39	1.52	-3.76
V.48	1391.4	-57.23	-9.17	+64.72	1.59	-3.96
V.49	1415.2	-58.95	-9.22	+66.13	1.76	-4.15
V.50	1407.9	-58.66	-9.26	+65.70	1.82	-4.27
V.51	1387.0	-57.39	-9.31	+64.46	1.75	-4.36
V.52	1367.0	-55.85	-9.35	+63.28	1.74	-4.05
V.53	1334.6	-53.62	-9.41	+61.35	1.67	-3.88
V.54	1304.3	-52.01	-9.47	+59.55	1.64	-4.16
V.55	1285.2	-50.33	-9.53	+58.24	1.60	-3.91
V.56	1268.7	-49.62	-9.58	+57.44	1.57	-4.06

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
V.57	1249.9	-48.51	- 9.64	+56.33	1.55	-4.14	
V.58	1223.2	-48.20	- 9.70	+54.75	1.54	-5.48	
V.59	1179.1	-43.86	- 9.77	+52.13	1.67	-3.70	
V.60	1154.5	-42.32	- 9.83	+50.67	1.57	-3.78	
V.61	1174.8	-43.75	- 9.87	+51.88	1.56	-4.05	
V.62	1176.7	-44.09	- 9.92	+52.00	1.57	-4.32	
V.63	1148.0	-42.17	- 9.99	+50.29	1.75	-3.99	
V.64	1150.0	-41.92	-10.05	+50.40	1.66	-3.78	
V.65	1119.3	-40.55	-10.11	+48.58	1.74	-4.21	
V.66	1105.0	-39.68	-10.18	+47.74	1.91	-4.08	
V.67	1094.5	-39.24	-10.25	+47.11	1.86	-4.39	
V.68	974.1	-31.90	-10.34	+39.98	2.02	-4.11	
V.69	956.0	-30.41	-10.43	+38.90	1.97	-3.84	
V.70	920.2	-28.32	-10.53	+36.78	1.96	-3.98	
V.71	856.2	-24.52	-10.62	+32.98	2.19	-3.84	
V.72	736.7	-16.74	-10.69	+25.90	2.31	-3.09	
V.73	713.8	-15.36	-10.76	+24.54	2.38	-3.07	
V.74	670.4	-12.65	-10.83	+21.97	2.07	-3.31	
V.75	616.2	- 9.68	-10.89	+18.75	2.22	-3.47	
V.76	579.1	- 8.16	-10.94	+16.55	2.30	-4.12	
V.77	552.8	-66.84	-10.97	+14.99	2.19	-4.50	
V.78	522.6	- 4.96	-10.96	+13.20	2.49	-4.10	
V.79	498.7	- 2.74	-10.95	+11.78	2.55	-3.23	
V.80	483.6	- 2.11	-10.99	+10.89	2.81	-3.27	
V.81	445.9	- 0.09	-11.04	+ 8.65	2.28	-4.07	
V.82	407.4	+ 2.13	-11.11	+ 6.37	2.22	-4.26	
V.83	366.3	+ 4.68	-11.16	+ 3.93	2.15	-4.27	
V.84	-	-	-	-	-	-	
V.85	331.0	+ 7.02	-11.23	+ 1.98	2.12	-3.98	
V.86	290.4	+10.04	-11.34	- 0.61	2.15	-3.63	
V.87	269.0	+11.62	-11.40	- 1.98	1.54	-4.09	
V.88	250.6	+13.13	-11.46	- 3.16	1.50	-3.86	
V.89	226.7	+14.74	-11.50	- 4.69	1.31	-4.01	
V.90	221.0	+15.06	-11.56	- 5.06	1.32	-4.11	
V.91	204.9	+15.91	-11.58	- 6.09	1.61	-4.02	
V.92	165.5	+18.43	-11.60	- 8.61	1.31	-3.74	
V.93	125.9	+21.08	-11.66	-11.15	1.32	-4.58	
V.94.	98.2	+23.07	-11.72	-12.92	1.25	-4.19	

The elevations of stations V.95 - V.101 are unobtainable and the stations have been abandoned.

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
V.102	46.9	+26.70	-11.82	-16.22	1.26	-3.95
V.103	44.6	+27.03	-11.90	-16.36	0.99	-4.11
V.104	43.4	+27.12	-11.98	-16.44	0.92	-4.25
V.105	41.2	+26.92	-12.25	-16.58	0.90	-4.88
V.106	39.6	+26.77	-12.12	-16.68	0.84	-5.06
W. 1	180.3	+10.34	- 0.38	- 7.10	1.77	+0.76
W. 2	168.3	+11.07	- 0.37	- 7.80	1.66	+0.68
W. 3	164.5	+11.23	- 0.37	- 8.03	1.52	+0.48
W. 4	177.7	+10.50	- 0.39	- 7.25	1.28	+0.27
W. 5	182.9	+10.31	- 0.39	- 6.94	1.29	+0.40
W. 6	198.7	+ 9.27	- 0.38	- 6.01	1.29	+0.30
W. 7	232.1	+ 7.30	- 0.39	- 4.03	0.98	-0.01
W. 8	263.8	+ 5.37	- 0.40	- 2.14	0.98	-0.06
W. 9	297.7	+ 3.49	- 0.37	- 0.14	0.86	-0.03
W.10	329.8	+ 1.37	- 0.29	+ 1.77	0.91	-0.11
W.11	364.2	- 0.66	- 0.29	+ 3.81	0.88	-0.13
W.12	394.0	- 2.58	- 0.31	+ 5.57	0.84	-0.36
W.13	417.8	- 3.73	- 0.30	+ 6.98	0.75	-0.17
W.14	429.5	- 4.36	- 0.30	+ 7.68	0.81	-0.04
W.15	437.4	- 4.78	- 0.29	+ 8.15	0.75	-0.04
W.16	426.8	- 3.99	- 0.28	+ 7.52	0.68	+0.06
W.17	413.7	- 3.13	- 0.27	+ 6.74	0.57	+0.04
W.18	413.4	- 2.93	- 0.26	+ 6.72	0.42	+0.08
W.19	429.5	- 3.75	- 0.28	+ 7.68	0.45	+0.24
W.20	443.0	- 4.64	- 0.29	+ 8.48	0.45	+0.13
W.21	434.8	- 4.25	- 0.31	+ 7.99	0.48	+0.04
W.22	440.6	- 4.52	- 0.31	+ 8.34	0.48	+0.12
W.23	445.9	- 5.07	- 0.30	+ 8.65	0.46	+0.13
W.24	445.1	- 5.20	- 0.29	+ 8.60	0.45	-0.31
W.25	466.2	- 6.47	- 0.26	+ 9.86	0.45	-0.29
W.26	487.1	- 7.75	- 0.27	+11.10	0.38	-0.41
W.27	505.9	- 8.80	- 0.29	+12.21	0.43	-0.32
W.28	489.8	- 7.89	- 0.28	+11.25	0.40	-0.38

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
W.29	475.2	- 7.05	- 0.23	+10.39	0.42	-0.34
W.20	454.8	- 5.96	- 0.19	+ 9.18	0.37	-0.47
W.31	450.2	- 5.64	- 0.15	+ 8.91	0.39	-0.36
W.32	448.5	- 5.71	- 0.10	+ 8.80	0.42	-0.46
X. 1	461.5	- 6.15	+ 1.64	+ 9.58	0.31	+1.51
X. 2	467.3	- 6.35	+ 1.63	+ 9.92	0.30	+1.63
X. 3	476.2	- 6.87	+ 1.61	+10.45	0.31	+1.63
X. 4	488.3	- 7.65	+ 1.60	+11.17	0.30	+1.55
X. 5	500.8	- 8.49	+ 1.58	+11.91	0.30	+1.43
X. 6	507.4	- 9.09	+ 1.54	+12.30	0.30	+1.18
X. 7	506.8	- 9.04	+ 1.51	+12.26	0.29	+1.15
X. 8	515.7	- 9.75	+ 1.49	+12.79	0.30	+0.96
X. 9	511.7	- 9.53	+ 1.47	+12.56	0.29	+0.93
X.10	487.6	- 7.82	+ 1.41	+11.12	0.30	+1.14
X.11	478.6	- 7.33	+ 1.35	+10.59	0.28	+1.02
X.12	481.9	- 7.44	+ 1.31	+10.79	0.34	+1.13
X.13	500.4	- 8.74	+ 1.24	+11.88	0.25	+0.76
X.14	519.9	- 9.69	+ 1.20	+13.04	0.29	+0.97
X.15	535.6	-10.75	+ 1.17	+13.97	0.35	+0.88
X.16	542.2	-11.00	+ 1.11	+14.36	0.32	+0.92
X.17	553.2	-11.64	+ 1.06	+15.02	0.41	+0.98
X.18	561.1	-12.18	+ 1.01	+15.48	0.35	+0.80
X.19	561.0	-12.16	+ 1.00	+15.48	0.32	+0.77
X.20	563.7	-12.37	+ 0.98	+15.63	0.32	+0.69
X.21	571.9	-12.90	+ 0.95	+16.12	0.34	+0.64
X.22	580.5	-13.55	+ 0.93	+16.64	0.35	+0.50
X.23	563.6	-12.83	+ 0.90	+15.63	0.32	+0.15
X.24	563.4	-12.82	+ 0.93	+15.62	0.32	+0.18
X.25	558.3	-12.57	+ 0.96	+15.32	0.34	+0.18
X.26	556.0	-12.71	+ 1.02	+15.18	0.34	-0.04
X.27	548.6	-12.26	+ 1.09	+14.74	0.34	+0.04
X.28	536.2	-11.55	+ 1.13	+14.01	0.31	+0.03
X.29	519.6	-10.71	+ 1.20	+13.02	0.31	-0.05

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
X.30	536.3	-11.67	+1.27	+14.01	0.36	+0.10
X.31	560.0	-13.19	+1.34	+15.42	0.45	+0.15
X.32	562.4	-13.50	+1.39	+15.56	0.52	+0.10
X.33	529.9	-11.67	+1.45	+13.64	0.41	-0.04
X.34	492.4	- 9.53	+1.54	+11.41	0.45	0.00
X.35	455.1	- 7.40	+1.59	+ 9.19	0.54	+0.05
X.36	413.4	- 4.76	+1.61	+ 6.72	0.63	+0.33
X.37	379.5	- 2.76	+1.67	+ 4.72	0.48	+0.24
X.38	349.4	- 1.01	+1.73	+ 2.93	0.56	+0.34
X.39	328.5	+ 0.14	+1.82	+ 1.69	0.64	+0.42
X.40	351.6	- 1.27	+1.86	+ 3.06	0.50	+0.32
X.41	361.5	- 2.06	+1.92	+ 3.65	0.39	+0.03
X.42	381.2	- 3.39	+1.93	+ 4.81	0.36	-0.16
X.43	397.1	- 4.48	+1.94	+ 5.76	0.37	-0.28
X.44	412.9	- 5.70	+1.96	+ 6.70	0.37	-0.54
X.45	412.4	- 5.70	+1.97	+ 6.67	0.36	-0.57
X.46	423.2	- 6.46	+2.02	+ 7.31	0.41	-0.59
X.47	411.4	- 5.64	+2.04	+ 6.61	0.44	-0.82
X.48	390.9	- 4.79	+2.12	+ 5.39	0.47	-0.68
X.49	355.3	- 2.86	+2.20	+ 3.28	0.51	-0.74
X.50	367.0	- 3.76	+2.24	+ 3.98	0.57	-0.85
X.51	393.8	- 5.47	+2.24	+ 5.56	0.75	-0.79
Y. 1	818.2	-12.15	-3.92	+30.43	0.46	+10.95
Y. 2	824.0	-12.57	-3.85	+31.07	0.50	+11.28
Y. 3	834.3	-13.32	-3.78	+31.68	0.54	+11.25
Y. 4	844.9	-14.24	-3.71	+32.31	0.53	+11.02
Y. 5	855.3	-15.12	-3.55	+32.93	0.64	+10.93
Y. 6	869.5	-16.45	-3.59	+33.77	0.65	+10.51
Y. 7	883.8	-17.60	-3.49	+34.62	0.76	+10.41
Y. 8	900.3	-18.89	-3.43	+35.60	0.78	+10.21
Y. 9	912.3	-19.95	-3.38	+36.31	0.93	+10.04
Y.10	927.2	-21.26	-3.29	+37.19	1.17	+ 9.94
Y.11	941.8	-22.85	-3.24	+38.06	1.21	+ 9.35
Y.12	958.2	-24.32	-3.19	+39.03	1.23	+ 8.88

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)
Y.13	997.5	-26.00	-3.14	+40.17	1.37	+8.53
Y.14	993.5	-27.49	-3.08	+41.12	1.39	+8.07
Y.15	1008.3	-28.57	-3.00	+42.00	1.56	+8.12
Y.16	1019.1	-29.77	-2.95	+42.64	1.72	+7.77
Y.17	1045.9	-31.53	-2.87	+44.23	1.49	+7.45
Y.18	1104.3	-35.21	-2.80	+47.69	1.09	+6.89
Y.19	1143.6	-37.39	-2.76	+50.02	1.34	+7.34
Y.20	1188.7	-40.37	-2.68	+52.70	1.34	+7.12
Y.21	1234.1	-43.13	-2.58	+55.39	1.30	+7.11
Y.22	1296.0	-47.51	-2.54	+59.07	1.68	+6.63
Y.23	1381.9	-53.47	-2.50	+64.16	2.07	+6.39
Y.24	1438.4	-56.99	-2.44	+67.51	2.67	+6.88
Y.25	1488.9	-60.76	-2.38	+70.50	2.56	+6.05
Y.26	1557.0	-65.87	-2.33	+74.54	3.09	+5.56
Y.27	1598.6	-68.42	-2.26	+77.01	2.99	+5.45
Y.28	1662.3	-73.12	-2.18	+80.78	3.95	+5.56
Y.29	1705.2	-76.08	-2.10	+83.33	4.24	+5.52
Y.30	1749.5	-79.16	-1.99	+85.95	4.35	+5.28
Y.31	1749.5	-79.06	-1.95	+85.96	3.84	+4.92
Y.32	1757.8	-79.74	-1.90	+86.45	3.71	+4.65
Y.33	1747.7	-79.05	-1.85	+85.85	3.92	+5.00
Y.34	1727.4	-78.20	-1.86	+84.64	3.69	+4.44
Y.35	1712.0	-77.32	-1.78	+83.73	3.58	+4.33
Y.36	1693.7	-76.25	-1.75	+82.65	3.53	+4.30
Y.37	1682.6	-76.06	-1.66	+81.99	3.53	+3.93
Y.38	1646.5	-73.60	-1.58	+79.85	3.03	+3.83
Y.39	1605.9	-71.22	-1.49	+77.44	2.70	+3.56
Y.40	1547.0	-68.07	-1.41	+73.95	3.09	+3.69
Y.41	1468.7	-63.02	-1.33	+69.30	2.71	+3.79
Y.42	1354.3	-56.15	-1.24	+62.52	2.53	+3.80
Y.43	1246.0	-50.01	-1.21	+56.10	2.70	+3.71
Y.44	1224.9	-48.35	-1.24	+54.85	2.94	+4.32
Y.45	1191.0	-46.81	-1.26	+52.84	3.26	+4.16
Y.46	1171.0	-45.39	-1.26	+51.65	3.09	+4.21
Y.47	1123.5	-42.94	-1.26	+48.83	3.26	+4.02
Y.48	1104.8	-41.58	-1.28	+47.72	2.71	+3.70
Y.49	1069.6	-39.29	-1.31	+45.64	2.31	+3.48
Y.50	1042.5	-37.77	-1.36	+44.03	2.45	+3.48
Y.51	1025.4	-36.48	-1.39	+43.02	1.91	+3.19
Y.52	996.7	-34.57	-1.39	+41.31	1.95	+3.43

GLASGOW UNIVERSITY GEOLOGY DEPARTMENT

Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
Z. 1	698.0	- 7.10	-4.56	+23.60	1.21	+9.28	
Z. 2	742.0	- 9.75	-4.48	+26.21	1.13	+9.24	
Z. 3	786.6	-12.45	-4.40	+28.85	1.29	+9.42	
Z. 4	863.2	-16.94	-4.37	+33.40	1.22	+9.44	
Z. 5	926.1	-20.62	-4.30	+37.13	1.58	+9.92	
Z. 6	993.9	-24.71	-4.24	+41.15	1.92	+10.25	
Z. 7	1058.1	-28.62	-4.18	+44.96	1.44	+8.86	
Z. 8	1100.5	-31.10	-4.12	+47.47	1.50	+9.88	
Z. 9	1155.2	-34.95	-4.08	+50.72	1.59	+9.41	
Z.10	1149.8	-34.15	-3.99	+50.39	1.13	+9.51	
Z.11	1135.3	-33.49	-3.96	+49.53	1.05	+9.26	
Z.12	1108.7	-31.63	-3.90	+47.96	0.91	+9.47	
Z.13	1092.2	-37.15	-3.84	+46.98	1.08	+8.74	
Z.14	1085.2	-31.14	-3.78	+46.56	0.97	+8.74	
Z.15	1072.6	-30.84	-3.78	+45.82	1.11	+8.44	
Z.16	1087.2	-32.74	-3.47	+46.68	1.04	+7.64	
Z.17	1123.7	-35.31	-3.73	+48.85	1.04	+6.98	
Z.18	1150.1	-37.76	-3.70	+50.41	1.13	+6.21	
Z.19	1161.1	-38.42	-3.64	+51.06	1.22	+6.32	
Z.20	1187.9	-40.18	-3.63	+52.65	1.32	+6.29	
Z.21	1225.9	-42.59	-3.59	+57.90	1.31	+6.16	
Z.22	1267.8	-45.39	-3.56	+57.39	1.39	+5.96	
Z.23	1309.2	-47.81	-3.54	+59.84	1.59	+6.21	
Z.24	1350.6	-	-	+62.30	1.74	-	
Z.25	1382.1	-53.00	-3.48	+64.21	1.85	+5.71	
Z.26	1417.8	-55.90	-3.45	+66.28	1.89	+4.95	
Z.27	1450.4	-58.23	-3.42	+68.21	1.94	+4.63	
Z.28	1486.3	-60.71	-3.41	+70.34	2.11	+4.46	
Z.29	1511.9	-62.54	-3.38	+71.87	2.18	+4.26	
Z.30	1529.7	-63.80	-3.30	+72.93	2.24	+4.15	
Z.31	1584.3	-68.45	-3.30	+76.16	2.50	+3.04	
Z.32	1631.1	-71.07	-3.27	+78.93	2.77	+3.49	
Z.33	1663.3	-73.37	-3.24	+80.84	2.88	+3.24	
Z.34	1694.0	-75.43	-3.22	+82.66	3.01	+3.15	
Z.35	1711.3	-76.63	-3.19	+83.69	3.12	+3.12	
Z.36	1729.2	-78.12	-3.19	+84.75	3.10	+2.67	
Z.37	1759.9	-80.26	-3.17	+86.57	3.27	+2.54	
Z.38	1778.8	-82.19	-3.16	+87.69	3.47	+1.94	

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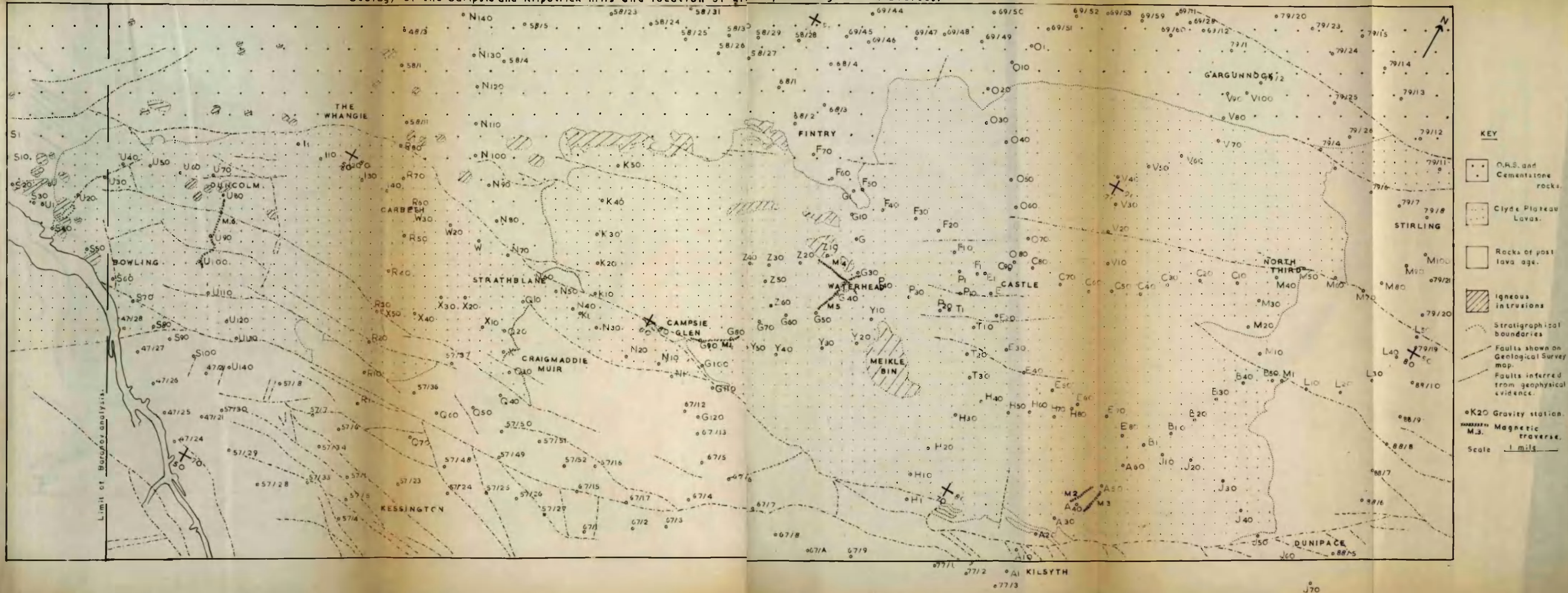
Station	Elev. (ft.)	Obs. Grav. (mgal)	Theoret. Grav. (mgal)	Elev. Corr. (mgal)	Terr. Corr. (mgal)	Bouguer Anomaly (mgal)	
Z.39	1793.9	-82.64	-3.15	+88.59	3.51	+2.44	
Z.40	1807.5	-84.04	-3.12	+89.40	3.56	+1.93	
Z.41	1805.1	-83.64	-3.04	+89.25	3.39	+2.19	
Z.42	1808.6	-83.86	-2.99	+89.46	3.25	+1.99	
Z.43	1807.5	-83.79	-2.94	+89.39	3.05	+1.94	
Z.44	1796.0	-83.40	-2.92	+88.71	3.16	+1.68	
Z.45	1777.0	-82.16	-2.90	+87.59	3.18	+1.84	
Z.46	1746.0	-79.61	-2.87	+85.75	3.16	+2.56	
Z.47	1709.4	-77.31	-2.86	+83.59	3.16	+2.70	
Z.48	1668.0	-74.13	-2.86	+81.12	2.94	+3.20	
Z.49	1637.1	-71.72	-2.86	+79.29	2.93	+3.77	
Z.50	1589.3	-68.34	-2.86	+76.45	2.60	+3.98	
Z.51	1560.2	-65.96	-2.86	+74.73	2.59	+4.63	
Z.52	1545.8	-65.26	-2.83	+73.88	3.07	+4.99	
Z.53	1504.0	-62.38	-2.79	+71.40	2.78	+5.14	
Z.54	1448.4	-58.75	-2.75	+68.10	2.59	+5.32	
Z.55	1409.1	-55.76	-2.69	+65.77	2.55	+6.00	
Z.56	1339.5	-51.82	-2.64	+61.64	1.90	+5.21	
Z.57	1303.4	-49.59	-2.61	+59.50	1.85	+5.28	
Z.58	1264.2	-47.10	-2.57	+57.18	1.70	+5.34	
Z.59	1233.5	-45.17	-2.53	+55.36	1.60	+5.45	
Z.60	1197.3	-42.91	-2.49	+53.21	1.42	+5.36	
Z.61	1175.1	-41.58	-2.45	+51.89	1.43	+5.42	
Z.62	1153.4	-40.14	-2.41	+50.61	1.30	+5.49	
Z.63	1128.5	-38.87	-2.38	+49.13	1.30	+5.31	
Z.64	1108.0	-37.81	-2.32	+47.91	1.27	+5.18	

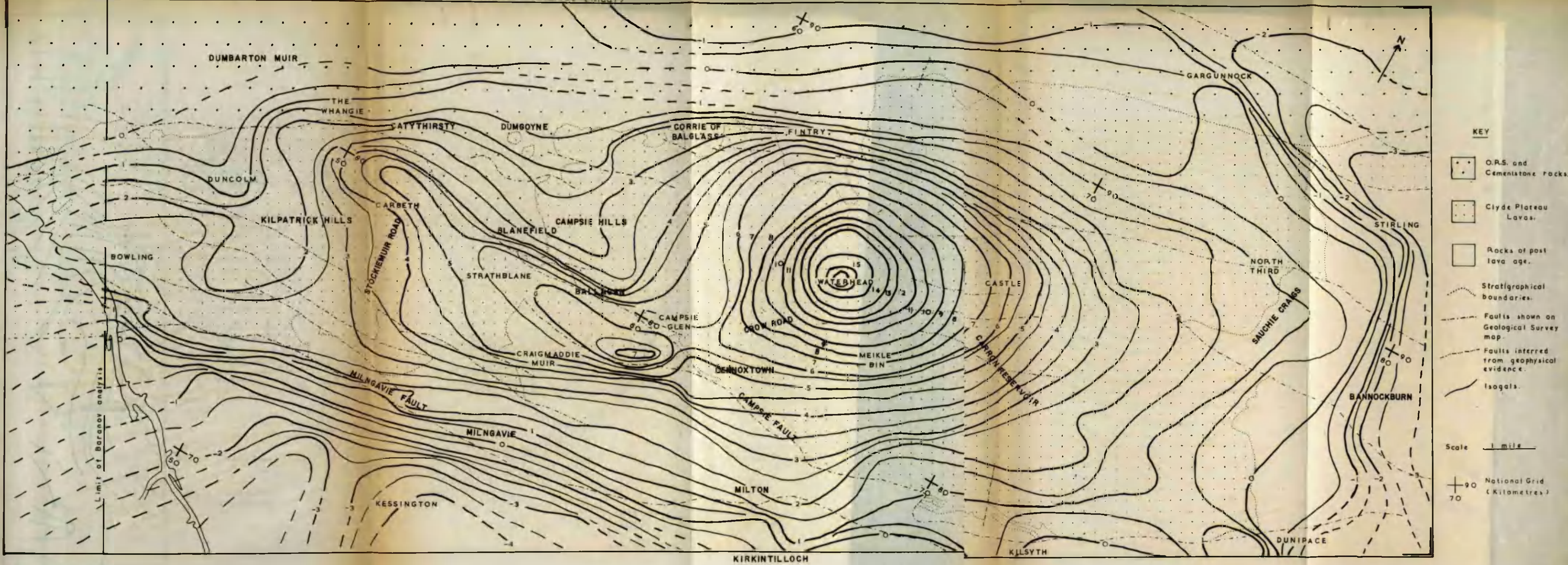
MAP 1

Geology of the Campsie and Kilpatrick hills and location of gravity and magnetic traverses.



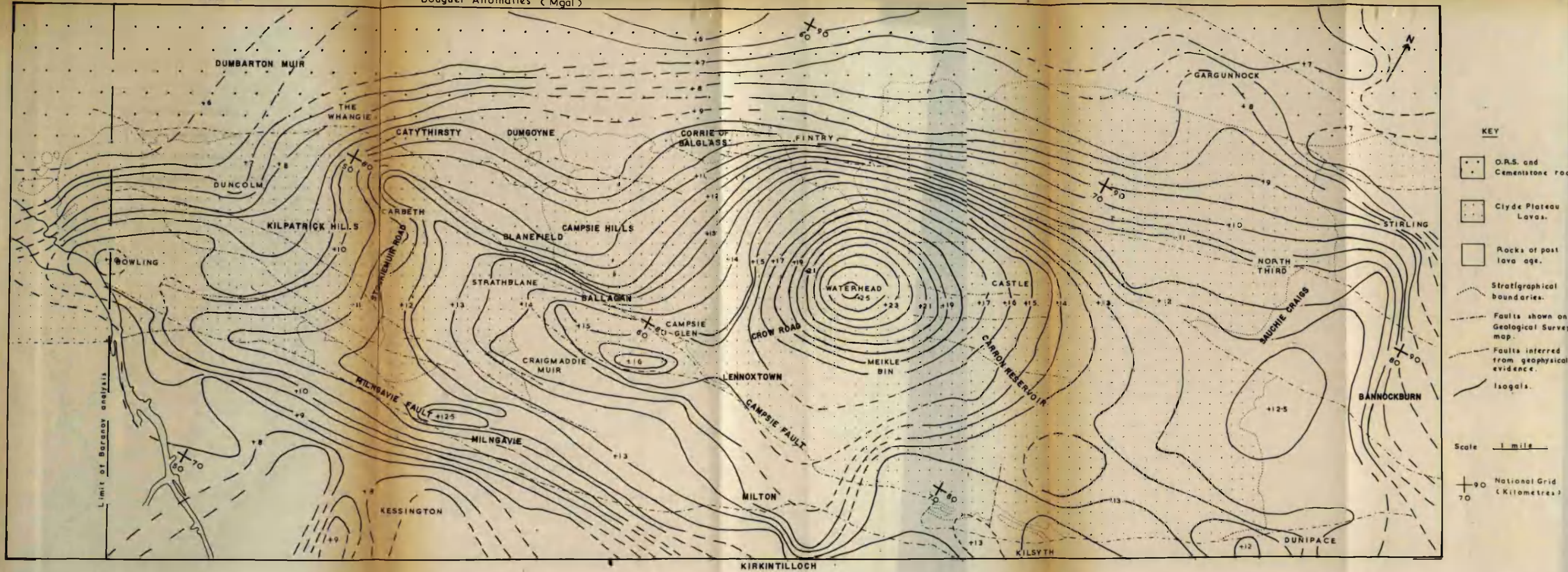
MAP 2 Local Bouguer anomalies (Mgal)

MAP 3 1st order residual anomalies (Mgal)



MAP 4

Bouguer Anomalies (Mgal)



Map 5 The Glasgow District - Reconnaissance Traverses