Natural Environment Research Council

Institute of Geological Sciences

Mineral Reconnaissance Programme Report

A report prepared for the Department of Industry

This report relates to work carried out by the Institute of Geological Sciences on behalf of the Department of Industry. The information contained herein must not be published without reference to the Director, Institute of Geological Sciences

D. Ostle
Programme Manager
Institute of Geological Sciences
Keyworth,
Nottingham NG12 5GG

No. 38

Geophysical evidence for a concealed eastern extension of the Tanygrisiau microgranite and its possible relationship to mineralisation

INSTITUTE OF GEOLOGICAL SCIENCES

Natural Environment Research Council

Mineral Reconnaissance Programme

Report No. 38

Geophysical evidence for a concealed eastern extension of the Tanygrisiau microgranite and its possible relationship to mineralisation

Geophysics
J. D. Cornwell, MSc, PhD
D. J. Patrick, BSc, PhD

Geology
R. J. Tappin, BSc

© *Crown copyright 1980*

London 1980

A report prepared for the Department of Industry

Mineral Reconnaissance Programme Reports

The Institute of Geological Sciences was formed by the incorporation of the Geological Survey of Great Britain and the Geological Museum with Overseas Geological Surveys and is a constituent body of the Natural Environment Research Council

Bibliographical reference
Cornwell, J. D., Patrick, D. J. and Tappin, R. J. 1980. Geophysical evidence for a concealed eastern extension of the Tanygrisiau microgranite and its possible relationship to mineralisation. *Mineral Reconnaissance Programme Rep. Inst. Geol. Sci.*, No. 38

Printed in England for the Institute of Geological Sciences by Four Point Printing.

CONTENTS

FIGURES

SUMMARY

A Bouguer anomaly low in the Blaenau Ffestiniog area is interpreted as being due to a concealed eastward extension of the Tanygrisiau microgranite. The geophysical evidence suggests that the granite, seen at outcrop at Tanygrisiau, 1 km south-west of Blaenau Ffestiniog, continues north-westwards at a shallow angle and that the general form of the intrusion is tabular, decreasing in width downwards The geological evidence supports this interpretation and also the existence of the extension to the east (suggested by the geophysical evidence). The magnetite-bearing granite is also thought to be responsible for a pronounced aeromagnetic anomaly which has a form supporting the gravity evidence for the eastward extension of the granite body but requires the extension of a magnetic body down to a depth of 15 km.

The mineralisation in the area consists of sulphide-bearing quartz veins occupying mainly north-easterly trending faults. There are insufficient mineral occurrences to produce any clear correlation but the distribution of the veins seems to be mainly coincident with the southern flank of the concealed granite.

INTRODUCTION

Routine regional gravity surveys have been made by the Applied Geophysics Unit (AGU) of part of North Wales, and some of the results have been incorporated in the 1:250 000 Bouguer gravity anomaly map for Liverpool Bay (Institute of Geological Sciences, 1978). The survey revealed a Bouguer anomaly low in the Blaenau Ffestiniog area which seemed to be due to a concealed extension of the Tanygrisiau microgranite. The presence of several small mines in the same area suggested that, since the origin of the mineralisation was unknown, its source might have been a granite intrusion at depth. A hydrothermal origin for the mineralisation contemporaneous with the intrusion of the granite does not seem very likely from the geological evidence although Lower Palaeozoic roof rocks of buried granites appear to have been mineralised long after granite emplacement in other localities in the UK. This part of North Wales was the site of extensive vulcanicity and Wheatley (1971) has discussed the significance of an associated magma chamber at depth and feeder channels to the formation of mineral deposits in this environment.

Additional gravity observations were therefore made in the area as part of the Mineral Reconnaissance Programme in an attempt to determine the form of the anomaly and possibly guide any future exploration by deciding if a concealed granite existed and also to delineate the area of overlying host rocks where mineralisation might be concentrated. The regional geophysical evidence is examined in this report together with a summary of the geology and a complete list of mineral occurrences in the area.

The Blaenau Ffestiniog anomaly occurs just north (Figure 6) of the Harlech Dome mineral exploration area described by Allen and others (1979).

GEOLOGY AND MINERALISATION

GEOLOGY

The area of study lies between the Harlech Dome to the south and the Dolwyddelan Syncline to the north. The sedimentary and extrusive rocks of the area (Figure 1) range from Middle Cambrian to Caradocian in age. All have been affected by Caledonian low-grade regional metamorphism.

The Cambrian succession in the area includes the Maentwrog and Ffestiniog Flags formations (Matley and Wilson, 1946), the Dolgelley Formation and the Tremadoc Series (Lynas, 1973) and consists largely of grey mudstone and siltstone. In addition, the lower part of the Maentwrog Formation contains interbedded fine-grained sandstone.

The pre-Arenig unconformity separates the Cambrian and Ordovician sequences. The latter, over a large part of the area, are divided by the supposed pre-*gracilis* unconformity, by which Caradocian rocks progressively overstep rocks of Arenig-Llanvirn age. This unconformity appears to be absent in part of the Migneint area (Lynas, 1973), where it is represented by a number of small disconformities. In the Migneint area, Lynas (1973) divided the sequence below the supposed pre-*gracilis* unconformity into the Carnedd Iago and Serw formations. The Carnedd Iago Formation contains the impersistent Garth Grit, a coarse-grained, cross-bedded sandstone, at the base; this is overlain by mudstone and siltstone with interbedded fine-grained sandstone and rare grey, feldspathic sandstone. The Serw Formation, which consists of mudstone with thick irregular lenses of

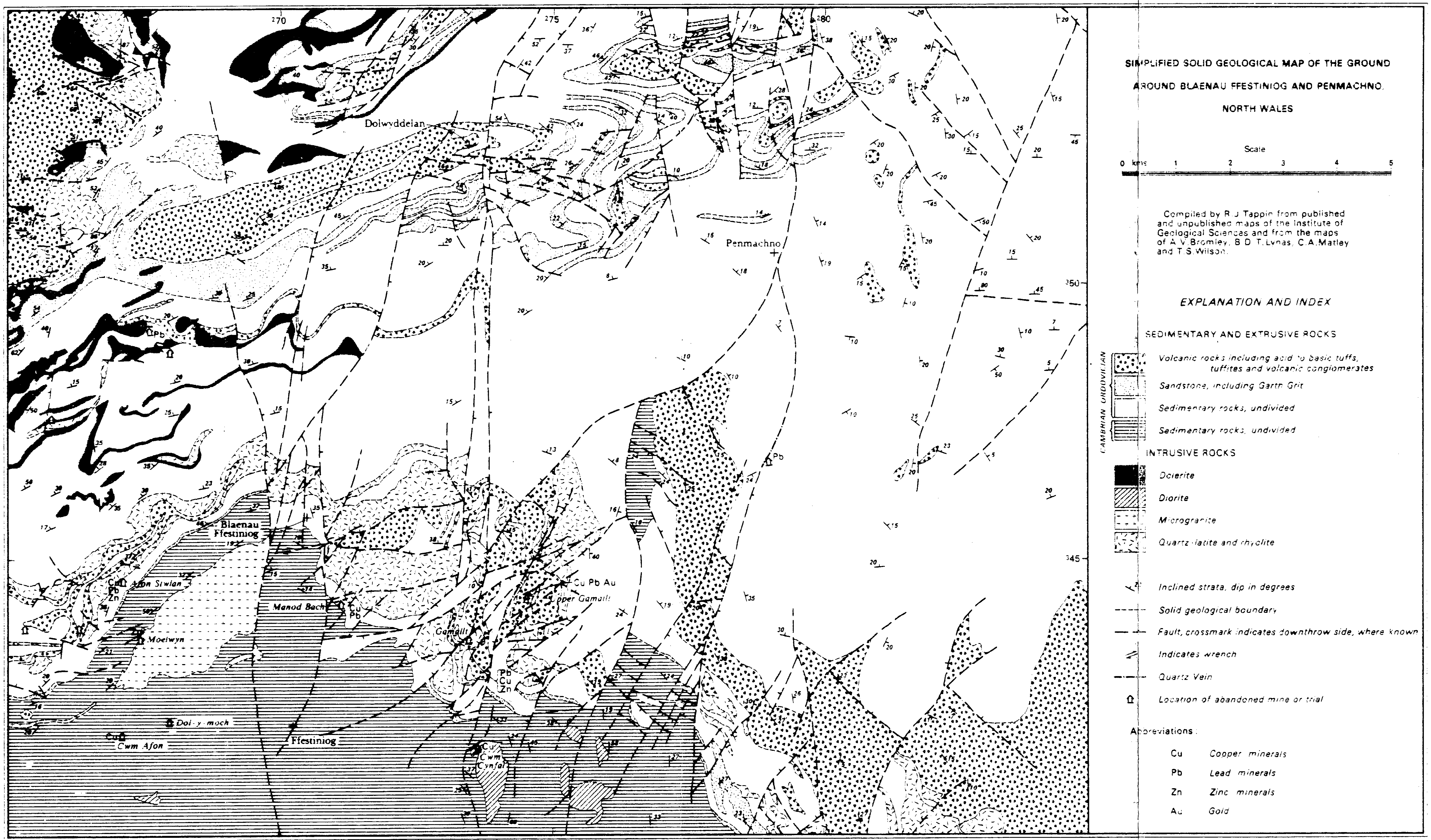

Fig. 1. Simplified geological map of the Blaenau Ffestiniog area.

laharic breccia and volcanic conglomerate, is developed only locally. Where the pre-*gracilis* unconformity is absent, the succession passes up into mudstone, volcanic conglomerate, sandstone and welded ash flows of the Rhiw Bach Formation.

Above the supposed pre-*gracilis* unconformity, the lower part of the sequence, including the Nant Hir Formation of Lynas (1973), consists of mudstone and siltstone with common sandstone beds. Volcanic rocks, the Moelwyn Volcanic 'Series' (Bromley, 1965) and Llyn Conwy Formation (Lynas, 1973), occur near the base of this lower part, with the Penamnen Tuffs and Lledr Valley Tuffs (Howells and others, 1978) somewhat higher in the sequence. They consist largely of acid lava, tuff, ash-flow tuff and volcanic conglomerate. The Snowdon Volcanic Group forms the uppermost part of the sequence and consists of the Upper and Lower Rhyolitic Tuff formations separated by the basic Bedded Pyroclastic Formation.

Intrusive rocks in the area include dolerites, diorites, quartz-latites and rhyolites, and the Tanygrisiau microgranite. The dolerites occur as sills or sill-like bodies and are extensively altered. They are probably late Ordovician in age and are younger than the diorites and acid intrusives (Lynas, 1973). The diorites, which are altered and porphyritic, usually occur as sill-like bodies in Cambrian rocks. Quartz-latites and rhyolites, however, form sills or large intrusive bodies within the Ordovician succession. The quartz-latites tend to intrude older rocks than do the rhyolites. Both types are commonly strongly autobrecciated. The diorites, quartz-latites and rhyolites are all affected by the regional cleavage.

Bromley (1969) described the Tanygrisiau microgranite as an equigranular rock made up of albite-oligoclase, alkali feldspar (microperthite), quartz and chloritized biotite. Magnetite, zircon and allanite are common accessories. The roof facies is fine-grained and vesicular and shows sericitic alteration of orthoclase; the plagioclase is altered to albite, calcite and quartz, and mafic minerals to chlorite. The microgranite is thought to be of end-Silurian age and Bromley (1969) suggests that emplacement was by stoping. Radioactive dating of metamorphosed contact rocks (Thomas and others, 1966) gave an age of 408 ± 7 Ma for the emplacement of the granite.

There is an extensive thermal metamorphic aureole in which the metamorphism is of albite-epidote hornfels facies. This is more extensive north and west of the microgranite outcrop and Bromley (1969) estimates that about 600 m of Cambrian-Ordovician rocks are metamorphosed above the roof.

STRUCTURE

The Dolwyddelan Syncline is easterly trending. To the south of it the Ffestiniog Anticline trends north-south and is continuous with the main structure of the Harlech Dome. There are numerous lesser folds. Faults striking east-west and north-easterly are the most common although they generally show small displacement. The less common northerly-trending faults show large displacements. The principal cleavage in the area is a slaty cleavage showing a north-east to easterly trend.

MINERALISATION

Mineralised quartz veins were worked in mines in a number of places. Most are situated on north-east-trending faults and, according to Lynas (1973), may be related to the Hercynian Orogeny. They are concentrated just west of the main outcrop of the Tanygrisiau microgranite and also in an area to the east which appears to coincide with the southern edge of the concealed extension of the intrusion. The following list of occurrences has been compiled from various published reports (Dewey and Eastwood, 1925; Dewey and Smith, 1922; Foster-Smith, 1977a, b).

Upper Gamallt [approximate grid reference SH 7440 4435] This mine was worked for lead and copper. Mixed sulphides occur in a silicified fault breccia on the Bryn Du Fault. Galena, chalcopyrite and sphalerite are most abundant. Gold has been recorded.

Gamallt [approximate grid reference SH 736 436] Disseminated galena, sphalerite and pyrite occur with some chalcopyrite, malachite and azurite in a quartz and calcite gangue on the Sarn Helen Fault.

Manod Bach [approximate grid reference SH 7715 4420] Galena, sphalerite, chalcopyrite and pyrite occur with quartz gangue in a vein.

Cwm Cynfal [SH 7362 4163]
Chalcopyrite and 'peacock copper' are recorded in quartz gangue along a dip fault.

Moelwyn [SH 6736 4380]
Sphalerite occurs in a quartz-cemented vein breccia.

Mine in Oernant Valley [SH 789 468]
Name unknown but a lead mine is marked on the old series geological map. Lynas records galena and minor chalcopyrite in the Oernant Fault breccia.

Mine on Moel Fleiddiau [SH 6762 4930]
This was probably worked for lead.

Trial on Moel Lledr [SH 6804 4876]
Nothing is known about this trial shaft.

Trial in Cwm-y-foel [SH 6580 4753]
A trial level close to a north-south fault.

Afon Stwlan [SH 6713 4463]
Copper, lead and zinc ores are reported to have been worked at this small mine.

Trials at Pant-mawr [SH 6536 4375]
No details of these trial levels are known.

Trials at Moelwyn Bach [SH 6632 4372]
No details of these trial levels are known.

Dol-y-moch [SH 6805 4217]
This small mine was probably worked for copper ores.

Cwm Afon [SH 6704 4167]
Chalcopyrite was reported to have been won from an east-west vein, some 3 m wide.

BOUGUER GRAVITY ANOMALIES

SURVEY AND RESULTS

On the Bouguer anomaly map (Institute of Geological Sciences, 1978) based on AGU regional gravity survey results, the generally uniform gradient observed over much of North Wales is interrupted in the Blaenau Ffestiniog area by an east-north-east elongated low about 13 km long and 5 km wide. The south-west end of this anomaly coincides with the outcrop of the Tanygrisiau microgranite and the Bouguer anomaly gradients are particularly high in this area, thus indicating that the anomaly is likely to be due to the low density microgranite and not a more deep-seated body.

The original AGU regional gravity stations were established on the roads but the coverage was not adequate to define all of the anomaly, much of which occurs over the high ground lying between the Penmachno valley and the Vale of Ffestiniog. An additional survey was therefore made as part of the Mineral Reconnaissance Programme and this concentrated on obtaining data for the less accessible upland areas. This survey, nearly all by field parties travelling on foot, established 33 new gravity stations.

All the Bouguer anomaly values were calculated using a density of 2.70 g/cm^3 for the Bouguer correction and were tied in to the 1973 National Gravity Reference Net (Masson Smith and others, 1974). Terrain corrections made for the individual stations are often large and liable to error in the Blaenau Ffestiniog area where there are extensive slate quarries, large tips and subterranean workings.

The Bouguer anomaly map prepared from data from both surveys (Figure 2) includes part of the strong regional gradient which forms a pronounced feature over much of North Wales (Powell, 1956). In the Blaenau Ffestiniog area this gradient consists of a fairly regular increase of about 0.6 mGal/km towards the north-north-west and distorts the form of the local Bouguer anomaly low in Figure 2. By removing the effect of an almost linear regional gradient (shown in Figure 3) from the observed data, a residual anomaly map was prepared (Figure 3); this represents the effect of anomalous bodies at a higher level in the crust than the cause of the regional gradient.

The residual Bouguer anomaly map (Figure 3) emphasises the bend in the contours about halfway along the anomaly and shows the gradient generally to be steeper on the southern flank. A Bouguer anomaly gradient of 3 mGal/km was observed along the line of gravity stations crossing the southern edge of the Tanygrisiau microgranite near SH 69 44 (Figure 2). The anomaly values approach zero only in the east; in the west there is an indication of another low appearing at the southern edge of the map. The minimum anomaly (-7 mGal) occurs near the outcrop of the intrusion at Tanygrisiau and there is a closure of -6 mGal at SH 76 47.

The densities of Cambrian and Ordovocian rocks in the Blaenau Ffestiniog area can be estimated from values given by Powell (1956); only one site was sampled for the present study (Table 1). Here the mean density of six samples from the Tanygrisiau intrusion was found to be 2.63 ± 0.03 g/cm^3 (2.1 ± 0.6% porosity), a fairly typical value for granite. The density of Cambrian rocks was estimated from a density traverse at Maentwrog and found to be 2.73 ± 0.15 (Powell, 1956). This value lies between a mean density of 2.77 ± 0.03 g/cm^3 based on measurements of Upper Cambrian slate samples and 2.69 g/cm^3 for Cambrian grit. The density contrast between the Tanygrisiau microgranite and the Cambrian rocks is therefore likely to be about 0.10 g/cm^3. Susceptibility measurements on samples of the Tanygrisiau microgranite gave a mean value of 0.2×10^{-3} emu.

Table 1. Densities of the main rock types in the Blaenau Ffestiniog area

	Lithology	*Density g/cm^3*
Ordovician	Various	2.77 ± 0.08*
	Sediments	2.77 ± 0.05
	Grits	2.65 ± 0.03
	Acid lavas	2.65 ± 0.05
	Intermediate lavas	2.75 ± 0.03
Cambrian	Various	2.73 ± 0.11*
	Slates	2.77 ± 0.03
Tanygrisiau microgranite		2.63 ± 0.03

**Density traverses*

The granite density is based on samples from one site at SH 690 444 and the remaining values are taken from Powell (1956).

INTERPRETATION

A comparison of the Bouguer anomaly data (particularly Figure 3) with the geological map (Figure 1) tends to support the original supposition

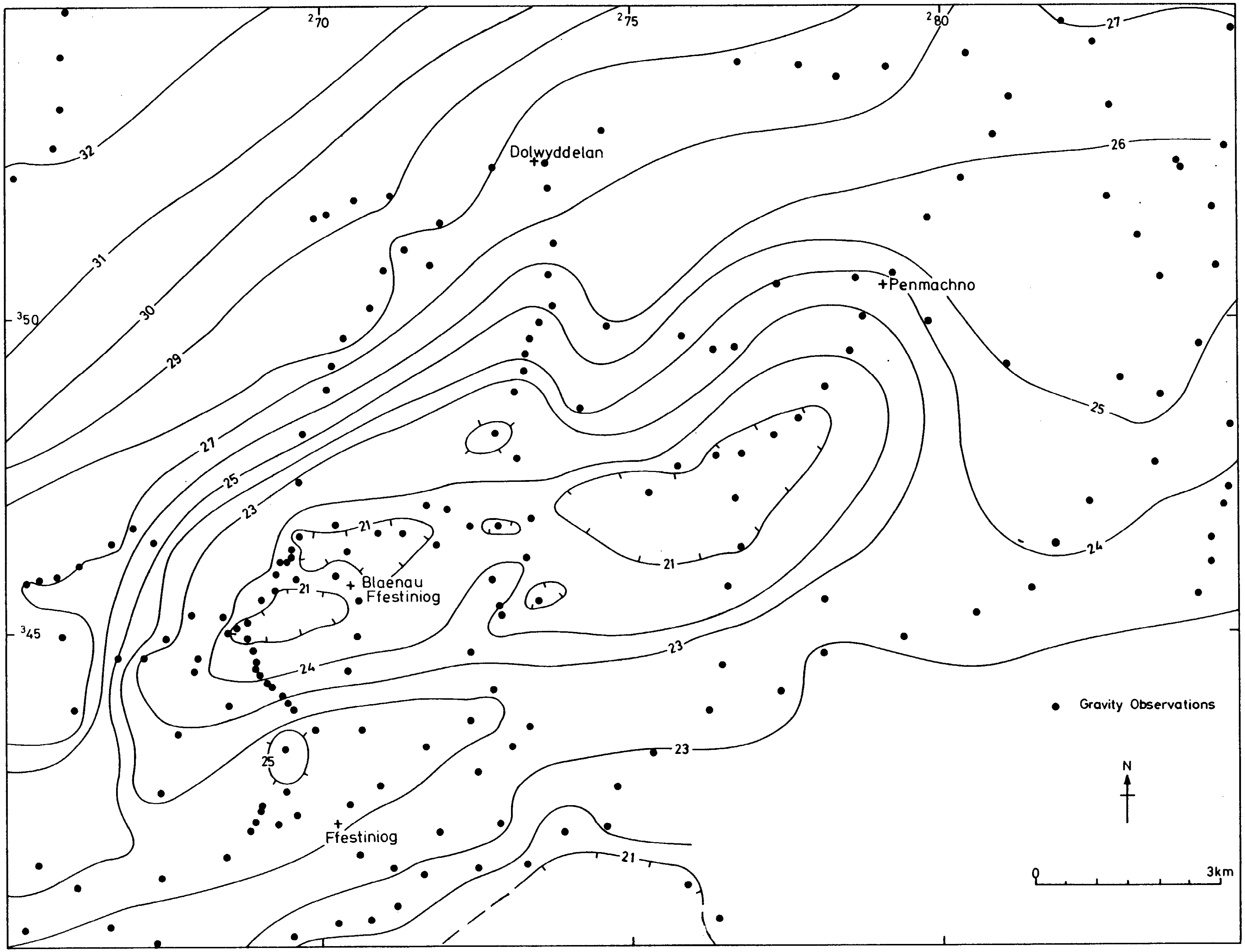

Fig 2. Bouguer anomaly map of the Blanenau Ffestiniog area with contours at 1 mGal (= 10 gravity units) intervals.

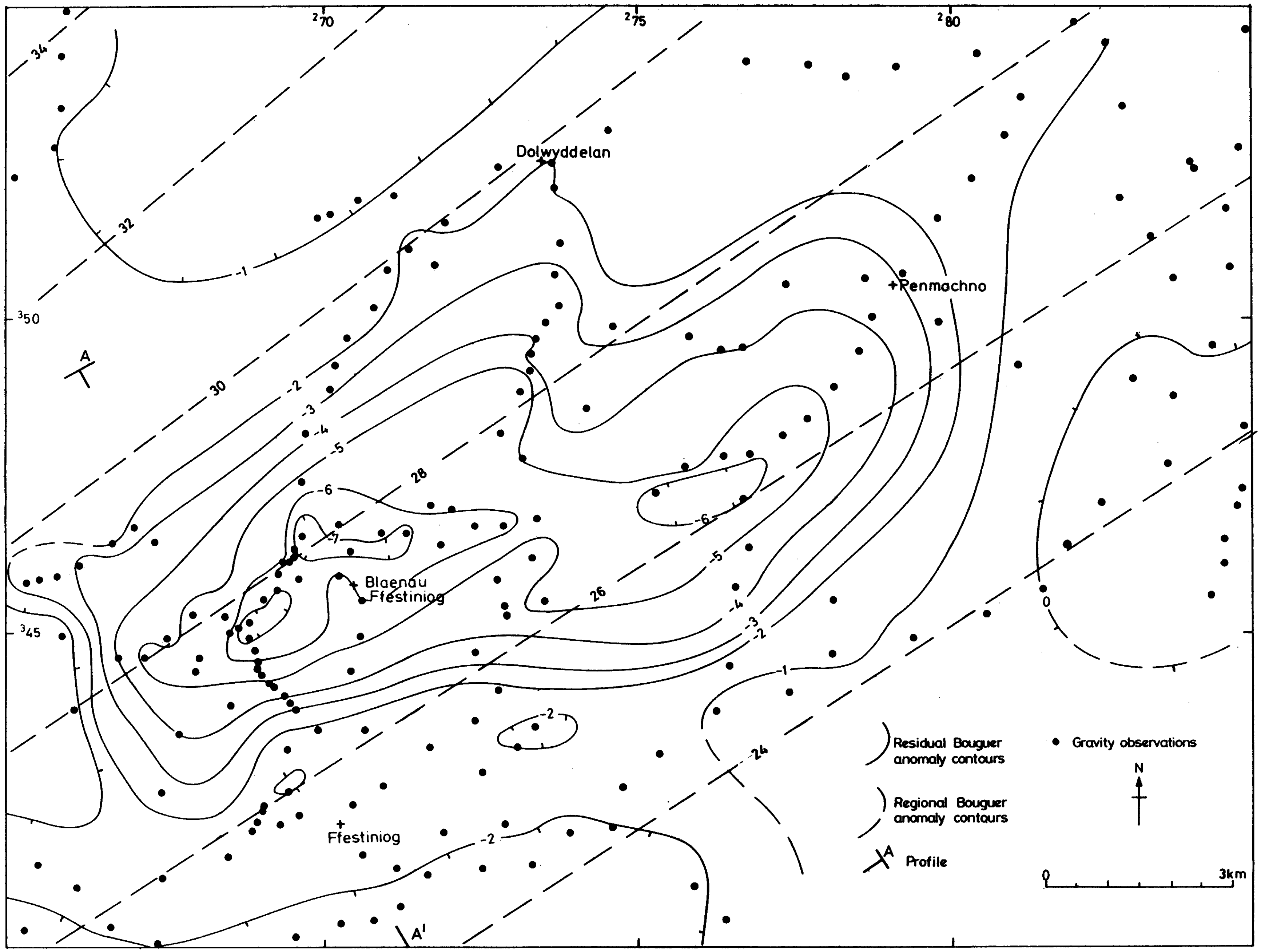

Fig. 3. Residual Bouguer anomaly map (with contours at 1 mGal intervals) and regional field (shown by dashed lines with contours at 2 mGal intervals).

that the most likely explanation for the Bouguer anomaly low is a low density granite similar to that exposed at Tanygrisiau. The rhyolites and tuffs east of the outcrop of the Tanygrisiau microgranite (Figure 1) might contribute to part of the anomaly but fail to explain the eastern extension towards Penmachno. The form of the residual Bouguer anomaly (Figure 3) suggests that the granite body would have to extend at depth to the east-north-east for about 9 km east of the fault which forms the eastern boundary of the granite outcrop but there is some evidence for this in the form of two patches of thermally metamorphosed Cambrian sediments (Figure 7). Lynas (1973) described these rocks as hornfels identical to that formed adjacent to the Tanygrisiau granite.

Attempts to provide interpretations of the observed Bouguer profile through Tanygrisiau (Figure 4) were made using a density contrast of $-0.1\ g/cm^3$. The results showed that it was necessary to postulate that the south-eastern margin of the granite dipped steeply to the north-west and that the north-western margin dipped at a small angle for a distance of 2 to 3 km before steepening northwards (Figure 4). The lower part of the low density body is more difficult to define and several models will produce a theoretical curve comparable with the observed profile.

The model shown in Figure 4 was selected so that its lower surface coincided with the inclined surface of the interpreted magnetic body but it is remarkably consistent with the form of the granite suggested by Bromley (1969). The magnetic body, however, extends further to the north-west whereas the low density body apparently wedges out at a depth of 6 km, although the gravity effect of this deep-seated portion is small and could be overlooked in the interpretation. A change of 1 mGal or less in the estimate of the regional anomaly field could result in a granite model which would extend further downwards and northwards than that shown in Figure 4. The average dip of about 60° derived for the low density model is greater than the general dip at the surface of the Cambrian and Ordovician sediments north of the microgranite.

In the preferred interpretation (Figure 5), the Tanygrisiau microgranite is regarded as being at least partly responsible for the magnetic anomaly. The explanation for the much greater extent of the magnetic body is not clear but could be one of the following:

a. the full extent of the low density body has not been recognised, perhaps because the regional field has been incorrectly estimated;

b. the rocks surrounding the microgranite decrease in density at depth (i.e. in the Pre-cambrian basement) so that the density contrast disappears;

c. part of the magnetic anomaly is due to a higher density facies of the intrusion, contact metasomatism or completely unrelated magnetic host rocks.

East of the outcrop of microgranite at Tanygrisiau the residual Bouguer anomaly decreases only slightly and there is a small closure of -6 mGal at SH 76 47. The absence of significant change in values provides some evidence that the top of the concealed portion of the intrusion remains at approximately the same level for about 9 km. Additional geophysical evidence for a comparatively shallow origin is provided by the existence of steep gradients of about 2.5 to 3.0 mGal/km. Interpretations of two north-west to south-east profiles crossing the central and eastern parts of the anomaly minimum were made using the method of Skeels (1963) and gave maximum depths of less than one kilometre. More exact estimates of the maximum depths would require more detailed gravity observations and interpretations allowing for the variable topographic elevation in the area. The cross-sectional model of the microgranite extension could be similar to those shown in Figures 4 and 5 as the magnetic anomaly does not change abruptly in this direction (Figure 6). However, the absence of granite outcrops means that the interpretation of the gravity evidence is more uncertain than in the west.

AEROMAGNETIC SURVEYS

The Blaenau Ffestiniog Bouguer anomaly low occurs within the area of very high and variable magnetic anomalies covering a large part of north-west Wales (Geological Survey of Great Britain, 1965). The low is situated just to the north of the peak of one of the strongest anomalies in this area and over the flanking magnetic gradient (Figure 6). Detailed ground surveys would be necessary to demonstrate the distribution of the magnetic rocks at outcrop but the susceptibility measurements confirm the presence of magnetite in samples of the Tanygrisiau microgranite noted by Bromley (1969), who also commented on the existence of a number of abnormal rock types along the south-east margin of the intrusion.

The large area of smooth, evenly spaced contours to the north of the magnetic peak (Figure 6) suggests the existence of a large magnetic body extending northwards and to a fairly great depth. It seems likely that this body is an extension of the Tanygrisiau intrusion, although it is possible that the source of the magnetic gradient is the same as that underlying the Harlech Dome which is responsible for the gradient east of that structure (Figure 6).

The possibility that the low-density granite model alone could also explain the magnetic anomaly is unlikely as the theoretical curve (Figure 4B) is not comparable with the observed curve.

The uninterrupted magnetic gradient zone

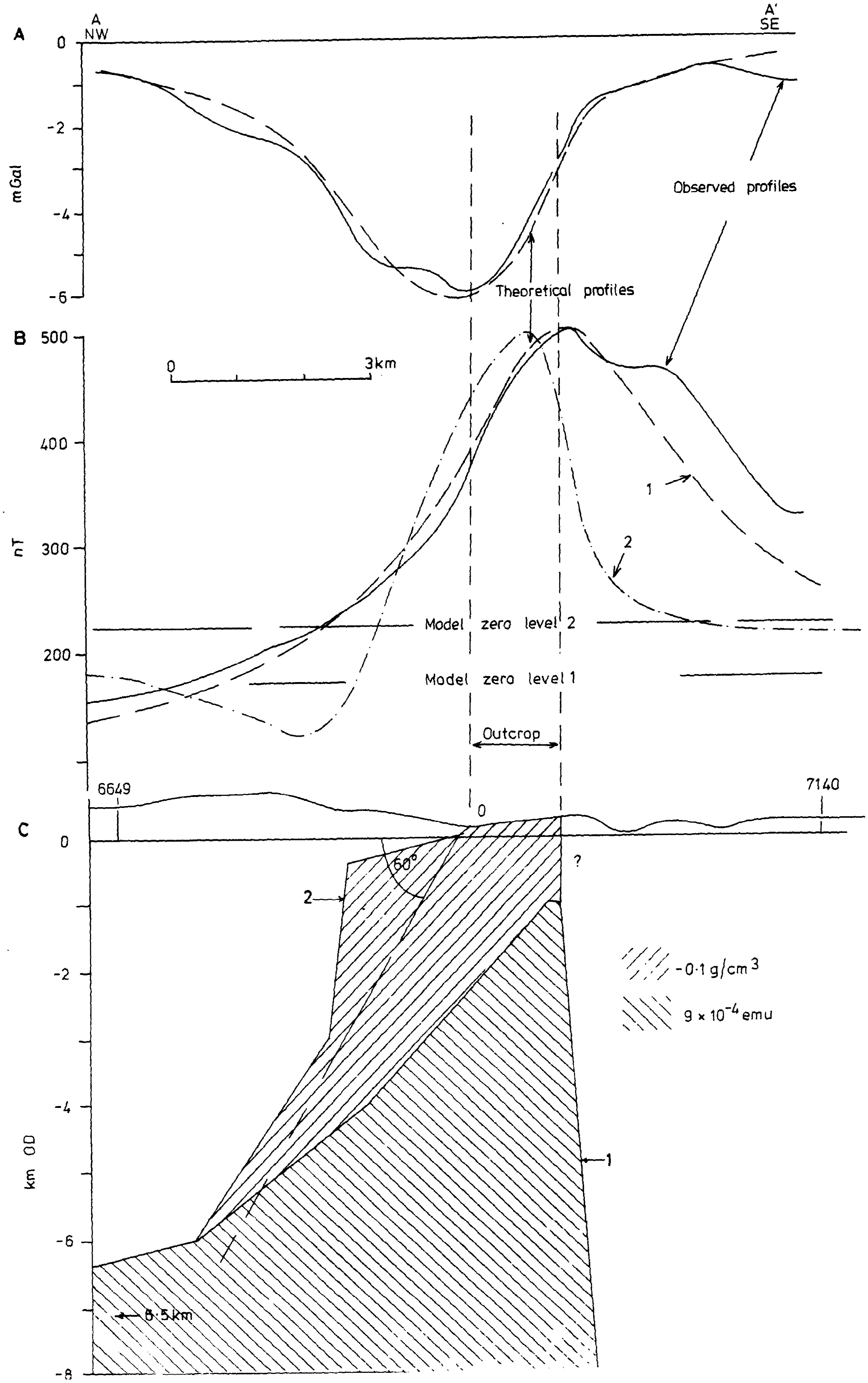

Fig. 4. Residual Bouguer anomaly (A) and aeromagnetic (B) profiles AA' (Fig. 3) and theoretical profiles for the models shown (C). The magnetic profile 1 is for the magnetic body 1 indicated in (C) and the profile 2 has been computed for the low density body 2 only. An end correction has been applied to the theoretical Bouguer anomaly profile.

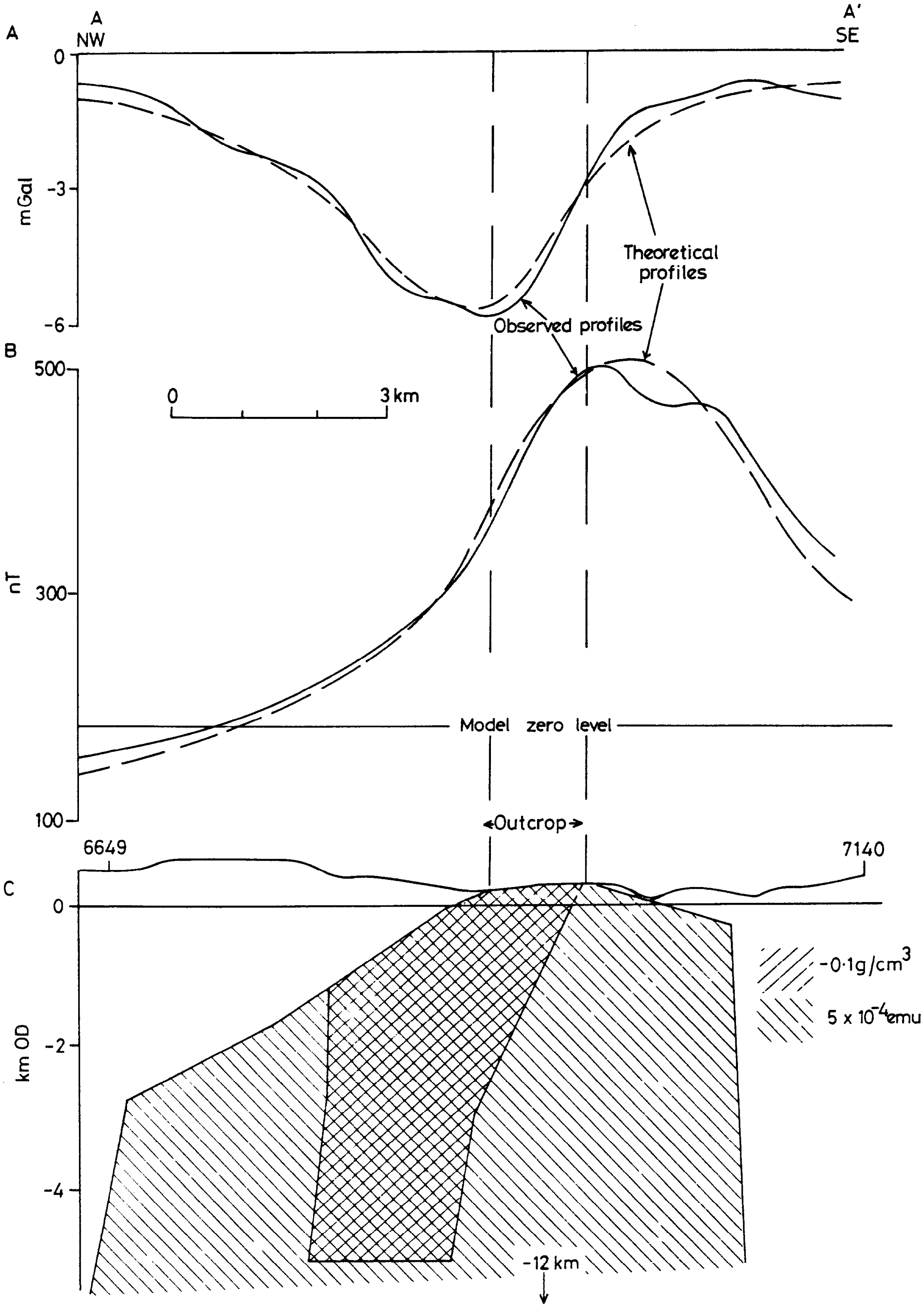

Fig. 5. Geophysical profiles as in Fig. 4 with theoretical profiles for alternative models shown.

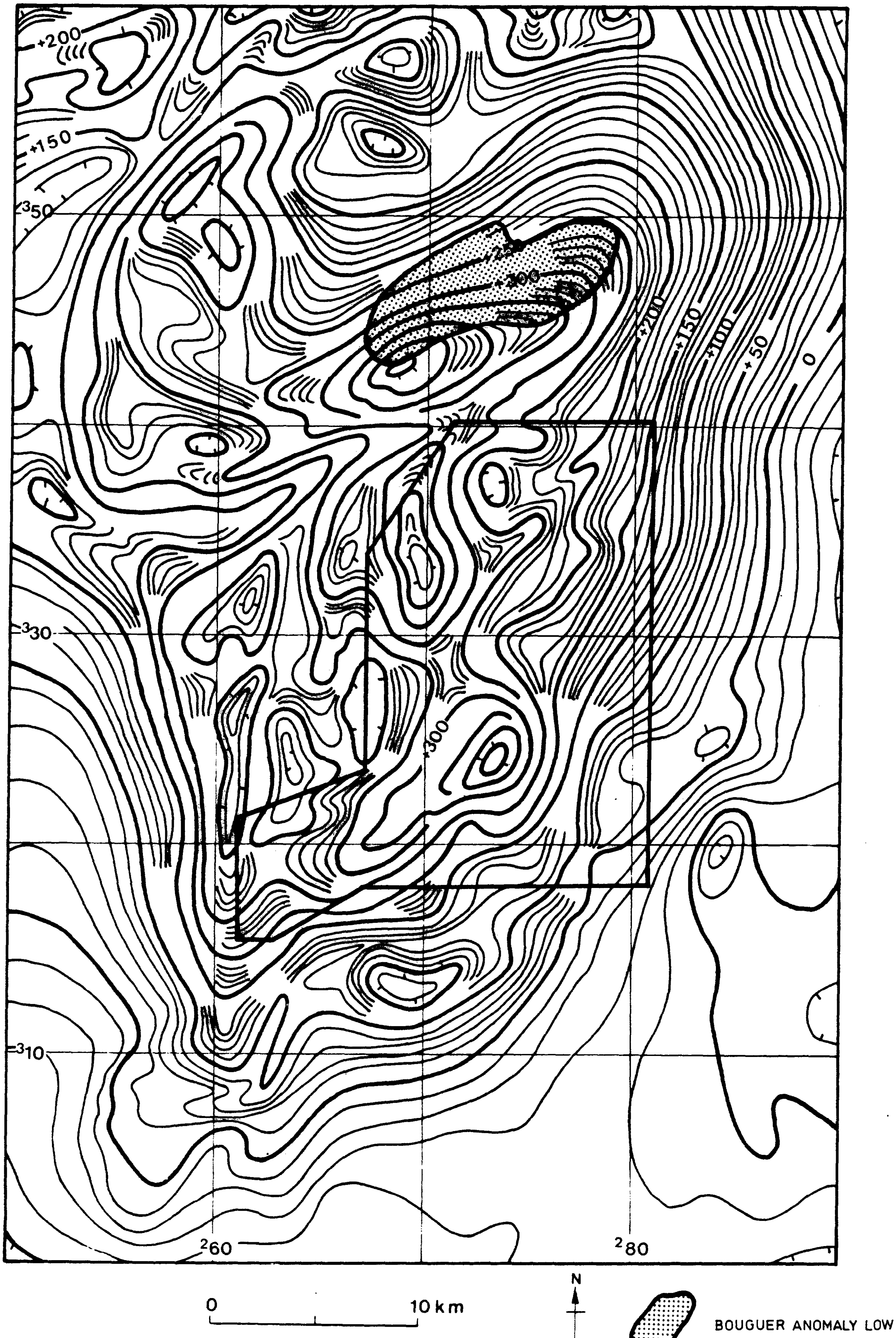

Fig. 6. Aeromagnetic map of part of north Wales and the residual Bouguer anomaly low (shown by the −4 mGal contour) in the Blaenau Ffestiniog area. The area covered by the detailed airborne geophysical survey of the Harlech Dome (Allen and others 1979) is outlined.

beneath – and to the north of – the Blaenau Ffestiniog Bouguer anomaly low contrasts with the very irregular anomaly pattern of the surrounding areas but is similar to the zone at the eastern margin of Figure 6 where the magnetic bodies of the Harlech Dome are covered by a considerable thickness of non-magnetic sediments. It seems probable that the preservation of this zone, free from other magnetic disturbances, in the Blaenau Ffestiniog area must be due to the fact that the magnetic body is overlain by another, largely non-magnetic mass of rocks.

Alternative models broadly satisfying the observed aeromagnetic and Bouguer anomaly profiles are shown in Figures 4 and 5. In Figure 4 it has been assumed that the magnetic body is not the same as the low-density body but the two have one surface in common. The magnetic body has to be extended further to the north-west at depth below the low-density body. The models shown in Figure 5 are based on the assumption that the low-density body is also magnetic. In this model the gradual decrease of magnetic values fits the observed profile more satisfactorily to the north-west and has been achieved by extending the model to a depth of 12 km. The extension of the magnetic body to the south-east probably includes the effect of adjacent anomalies and is not necessarily a realistic representation of the intrusion in this area.

The magnetic body (Figure 6) seems to extend to the SSW past the sharply truncated end of the Bouguer anomaly low at Grid line 67E (Figure 3). To the NNE the magnetic anomaly follows the Bouguer anomaly low very closely (Figure 6) but the magnetic values decrease in this direction away from the peak at SH 69 43. This decrease is not consistent with the gravity evidence, described earlier, which was interpreted to indicate a fairly level top to the low-density body.

GENERAL SIGNIFICANCE OF RESULTS

The evidence for ascribing the Bouguer anomaly low in the Blaenau Ffestiniog area to the Tanygrisiau microgranite and its concealed extensions includes the coincidence of the outcrop of the lower-density microgranite with the anomaly and agreement between the cross-sections through the intrusion deduced from the geological and geophysical evidence. It is likely, therefore, that the eastern part of the Bouguer anomaly low represents the effect of an extension towards Penmachno, which would explain the presence of two areas of Cambrian sediments apparently affected by the thermal aureole of a concealed granite. Using evidence provided by the Bouguer anomaly map (Figure 3) and assuming that the cross-section of the granite shown in the models is generally valid, it is possible to indicate an area of roof rocks over the flat-topped intrusion (Figure 6). This area includes most of the very extensive slate workings around Blaenau Ffestiniog and Penmachno.

The inclined cross-section of the Tanygrisiau microgranite (Figures 4 and 5) is unlike any other published models of Caledonian, or younger, granites in the UK, which show steep, outward-dipping contacts with the host rocks. The almost sheet-like form in Figures 4 and 5 is perhaps suggestive of intrusion along a fault inclined at a low angle to the bedding in the Cambrian sediments. If the source of the magnetic anomaly represents the full extent of the intrusion (Figure 5), the model shape would still be asymmetric but more comparable with other published examples.

The evidence for a relationship between the supposed form of the concealed microgranite and surface faults varies over the area. The western end of the anomaly (Figures 1 and 7) is terminated abruptly and looks as if it could be determined by a fault striking north or north-westwards but none has been mapped in the area. The eastern end of the anomaly is crossed by the fault passing through Penmachno but the granite appears to fall away more regularly towards the north-east here (Figure 7). The north-south fault forming the eastern boundary of the granite outcrop has only a slight effect on the Bouguer anomaly map but bends the contours, particularly on the north side of the anomaly, suggesting that the north to south striking fault running near Grid line 74E (the Cwm Teigl Fault (Figures 1 and 7)) has caused an apparent southerly displacement of the eastern half of the concealed intrusion by about 2 km. Lynas (1973, p. 496) noted that this fault could have had some dextral strike slip movement.

The known mineralisation in the area (galena, chalcopyrite, pyrite and sphalerite) is associated with quartz veins, occupying mainly north-east trending faults. The general distribution of the veins does not show any marked correlation with the 'roof' area of the concealed granite (Figure 7) in a way comparable, for example, with the situation on the Isle of Man, where the main veins, including the Foxdale Lode, occur in Manx Slates overlying the flat tops of concealed Caledonian granites (Cornwell, 1972) with an age about 150 Ma greater than that of the mineralisation. The absence of any mineralisation in the Blaenau Ffestiniog area has been partially confirmed by the extensive slate workings (although the occurrence of workable slates appears to coincide with the area overlying the concealed granite). However, the quartz veins and the locations of old mine workings do seem to occur in a zone generally following the southern margin of the concealed microgranite. The age of the veins is unknown but it has been suggested (Lynas, 1973) that the mineralisation could be as late as Carboniferous and, therefore, considerably younger than the Tanygrisiau microgranite. The relationship between

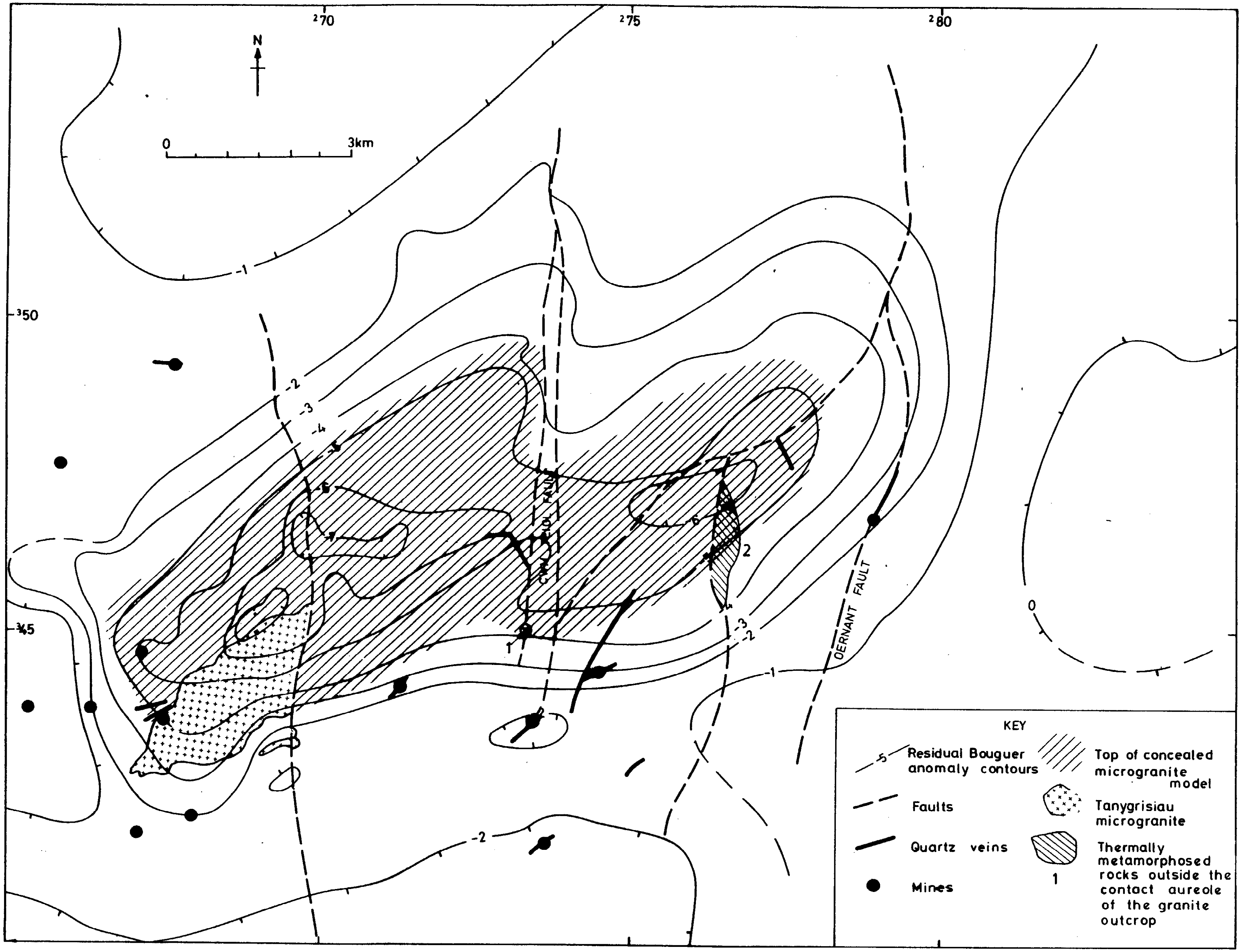

Fig.7. Residual Bouguer anomaly contour map with some relevant geological features.

the microgranite and mineralisation is, therefore, likely to be an indirect one, with perhaps the steep southern flank of the intrusion providing a faulted channel for mineralising fluids.

CONCLUSIONS

Further gravity observations in the Blaenau Ffestiniog area have confirmed the presence of a Bouguer anomaly low first indicated during regional gravity surveys. Examination of the geological evidence and interpretation of the geophysical results indicate that the low is due to a 12 km long microgranite body represented at the surface only by the small outcrop at Tanygrisiau. Evidence from the aeromagnetic map confirms the eastward extension of the granite but indicates that the magnetic body extends to a greater depth than the model for the low density body.

There is insufficient information on mineral occurrences to be able to suggest any direct relationship with the concealed granite but the area overlying the south flank of the intrusion and perhaps directly over its top might be worth further exploration, particularly at depth.

REFERENCES

Allen, P. M., Cooper, D. C. and Smith, I. F. 1979. Mineral exploration in the Harlech Dome, North Wales. *Miner. Reconn. Programme Rep. Inst. Geol. Sci.*, No. 29, 172 pp.

Bromley, A. V. 1965. Intrusive quartz latites in the Blaenau Ffestiniog area, Merioneth. *Geol. J.*, Vol. 4, 247–256.

— 1969. Acid plutonic igneous activity in the Ordovician of North Wales. *In* The Pre-Cambrian and Lower Palaeozoic rocks of Wales. (University of Wales Press, Cardiff), 387–408.

Cornwell, J. D. 1972. A gravity survey of the Isle of Man. *Proc. Yorkshire Geol. Soc.*, Vol. 39, 93–106.

Dewey, H. and Eastwood, T. 1925. Copper ores of the Midlands, Wales, the Lake District and the Isle of Man. *Spec. Rep. Miner. Resour. Geol. Surv. G.B.*

— **Smith, B.** 1922. *In* Lead and zinc in the pre-Carboniferous rocks of West Shropshire, and North Wales. Part II – North Wales. *Spec. Rep. Miner. Resour. Geol. Surv. G.B.*

Foster-Smith, J. R. 1977a. The mines of Anglesey and Caernarvonshire. *Br. Min.*, No. 4, 40 pp.

— 1977b. The mines of Merioneth. *Br. Min.*, No. 6, 41 pp.

Geological Survey of Great Britain. 1965. Aeromagnetic map of Great Britain, 1:625 000, Sheet 2, (Southampton: Ordnance Survey).

Howells, M. F., Francis, E. H., Leveridge, B. E. and Evans, C. D. R. 1978. *Capel Curig and Betws-y-Coed: Description of 1:25 000 Sheet SH 75.* Classical areas of British geology, Institute of Geological Sciences. (London: Her Majesty's Stationery Office.)

Institute of Geological Sciences. 1978. 1:250 000 Series, Bouguer gravity anomaly map (Provisional Edition), Liverpool Bay sheet, 53°N–04°W. (London: Institute of Geological Sciences.)

Lynas, B. D. T. 1973. The Cambrian and Ordovician rocks of the Migneint area, North Wales. *J. Geol. Soc. London*, Vol. 129, 481–503.

Matley, C. A. and Wilson, T. S. 1946. The Harlech Dome, north of the Barmouth Estuary. *Q. J. Geol. Soc. London*, Vol. 102, 1–40.

Masson Smith, D., Howell, P. M., Abernethy-Clarke, A. B. D. E. and Proctor, D. W. 1974. The national gravity reference net 1973 (NGRN 73). Prof. Pap. New Ser. *Ordn. Surv. G.B.*, No. 26.

Powell, D. W. 1956. Gravity and magnetic anomalies in North Wales. *Q. J. Geol. Soc. London*, Vol. 111, 375–397.

Skeels, D. C. 1963. An approximate solution of the problem of maximum depth in gravity interpretation. *Geophysics*, Vol. 28, 724–735.

Thomas, J. E., Dodson, M. H., Rex, D. C. and Ferrara, G. 1966. Caledonian magmatism in North Wales. *Nature, London*, Vol. 209, 866–868.

Wheatley, C. J. V. 1971. Aspects of metallogenesis within the Southern Caledonides of Great Britain and Ireland. *Trans. Inst. Min. Metall.*, Sect. B, Vol. 80, 211–223.

Institute of Geological Sciences
154 Clerkenwell Road
London ECIR 5DU

Your ref

Our ref

Date 16th February 1981

Mrs E.C. Jones, Department of Industry (3 copies)
Dr B. Kelk, NERC Swindon
Director, IGS Ex. Rd.

Main Library (9 copies for Open File for Exhibition Road, Edinburgh, Leeds & Keyworth)

GC Library, GIR (2 copies for Open File)
Assistant Director, Geochemistry & Petrology Division, GIR
Assistant Director, Special Surveys Division, KW
Head of EMAGU, KW
Head of MIU, Ex. Rd.
Head of AGU, PG (2 copies)
Head of EPU, PG
Dr K. Beer, Exeter Office (2 copies, includes 1 for Open File)

Mr Camell, Department of Industry (4 copies, for House of Lords/ Commons Libraries)
Mr Finnegan, Welsh Office

Mineral Reconnaissance Programme Report Series

Herewith report no.38. Copies of this report are to be placed on Open File here and at the other IGS Offices on Monday, 2nd March, 1981.

Catherine Collingborn

Catherine Collingborn
pp. D. Ostle, Programme Manager

I.G.S. KEYWORTH