BRITISH GEOLOGICAL SURVEY

Investigation of the geothermal potential of the UK

Investigations of the UK heat flow field (1984–1987)

Natural Environment Research Council

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Geothermal Resources Programme

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FOREWORD

Under a programme funded by the Department of Energy, and supported by the Commission of European Communities, the British Geological Survey completed, in 1984, the first assessment of the geothermal potential of the United Kingdom. A considerable part of that programme was concerned with the definition of the heat flow pattern of the United Kingdom. At that time a new heat flow map was produced in association with the Imperial College of Science and Technology of London University, which was under contract to the BGS to measure heat flow at specific sites.

Since then the Department of Energy has commissioned a further Geothermal Energy Programme to examine specific problems associated with this form of energy and to examine particular areas in more detail. Part of this programme involved further heat flow measurements and Imperial College was sub-contracted to carry out this work. Twenty-two new heat flow measurements have been made at carefully selected sites. This report contains the results of these measurements and a revision of the heat flow map of the United Kingdom which has been undertaken in the light of these findings. The work has been supervised by Dr R A Downing, under the general direction of Mr D A Gray until August 1985 and, since then, Dr R T Haworth.

June 1987

British Geological Survey
Keyworth
Nottingham

SUMMARY

Between 1984 and 1987, twenty-two new heat flow measurements have been added to the previously reported coverage of around 200 observations. These include observations in two deep boreholes drilled as part of the BGS geothermal exploration programme. Eleven of the sites were specially drilled heat flow boreholes between 100 m and 300 m deep. The remaining observations were made in exploration boreholes at locations where additional refinement of the heat flow field was warranted.

Much of the effort in the present programme has been towards a better definition of the heat flow field associated with the high heat producing granites of the Lake District and Weardale, particularly where the granite extends in the subsurface to the edge of the Tyneside urban conurbation. The apparent high heat flow in the Bowland Forest can no longer be sustained, and the previously reported high heat flows are judged to be enhanced through convective circulation. Some refinements of the heat flow field in the Midland Valley of Scotland and in South Wales have resulted from new observations in these areas. Elsewhere the new observations have been in substantial agreement with the results of earlier work. The results from two shallow boreholes to test basement heat flow were inconclusive in the complex geological settings selected.

1 INTRODUCTION

The crisis in oil prices in the mid-1970's intensified interest in alternative resources of energy, of which geothermal energy is one option. The importance of the study of heat flow in geothermal exploration is that it provides a means of predicting temperatures at depths greater than those reached by drilling. Heat flow studies have, as a consequence, acquired a new importance during the last decade making a key contribution to geothermal resource investigations.

The various initiatives by the Department of Energy and the Commission of European Communities in geothermal resource assessment have led to a dramatic increase in heat flow measurements in the United Kingdom. By 1975 only 32 values of heat flow had been reported, and many of these were poorly constrained. In 1984, when the British Geological Survey completed its first assessment of the geothermal potential of the UK, the total number of reported heat flow values had increased to 188. This produced great improvement in the definition of the heat flow field, and in combination with other appropriate considerations, helped towards identifying the most favourable geothermal targets in the UK.

Imperial College of Science and Technology was awarded a sub-contract by the British Geological Survey to undertake a further phase of heat flow measurements between 1984 and 1987. Measurements have been made at 22 new sites and this report is a review of the improved picture of the UK heat flow field to emerge from this study.

2 SELECTION OF NEW SITES

When the British Geological Survey completed its first assessment of the geothermal potential of the UK in 1984 a new heat flow map was prepared, reproduced here as Figure 2.1. It was based on 188 heat flow observations and supported by about 100 heat flow estimates and has been described by Wheildon and Rollin (1986). It gave a sharper form to a previously poorly-defined heat flow field, the broad, high heat flow belts (Richardson and Oxburgh, 1979) now shrinking into more localised features.

The most significant of the local anomalies, which are superposed on a fairly uniform background field, are those related to granite batholiths

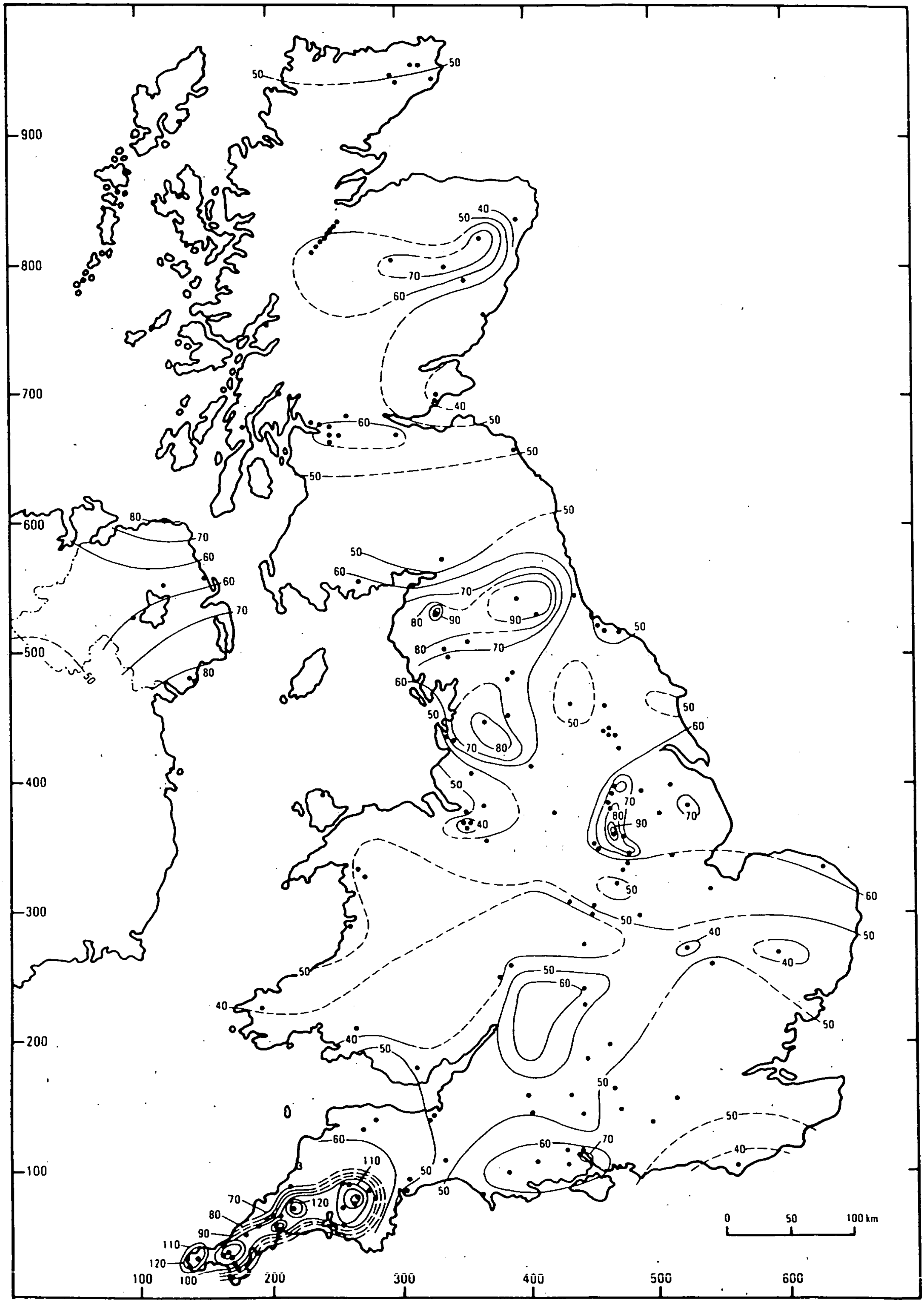

Figure 2.1 Heat flow map of the UK (1984). Units are mWm^{-2}.

with high heat productions; in south-west England, northern England and the eastern Highlands of Scotland. Other areas of relatively high heat flow are found in Nottinghamshire and the Bowland Forest. Areas with heat flow only moderately above background include an easterly extension of the Nottinghamshire anomaly embracing Lincolnshire and Humberside, the Wessex Basin and the Midland Valley of Scotland around Glasgow. There is growing awareness that in these regions the anomalies are the result of regional groundwater flow systems, with the above-average heat flows occurring on their rising limbs.

Even though the nature of the heat flow field has an important bearing on crustal processes, and in that context a wide distribution of measurements would have been most welcome, in the present investigation the objective was to provide basic data to define the geothermal resource potential of the UK. The criteria for site selection were also tailored to this end, and fell into three broad groupings:

a) To improve coverage of heat flow in potential hot dry rock (HDR) environments where coverage was judged inadequate.

b) To investigate high heat flow areas where the evidence for or against convective flow contributions to the measured value was equivocal. (A review of some of these areas has already been the subject of a separate report by the British Geological Survey (Gale and Downing, 1986)).

c) To make measurements in areas where existing coverage was sparse.

The significance of the new measurements is only seen through comparison with previous measurements in the same general area. The results presented in Section 4 are not therefore described in the order in which they were undertaken but on a regional basis, as follows:

i) Wales
ii) Central England and the Welsh Borderland
iii) Midland Valley and Southern Uplands of Scotland
iv) East Yorkshire and Humberside
v) Lancashire
vi) Cumbria, Tyne-Tees and Northumberland

Of the 22 new heat flow measurements, 11 were carried out in specially drilled boreholes. The remainder were in boreholes drilled by other agencies, and taken over on an opportunistic basis, so long as they fulfilled one or more of the selection criteria.

3 HEAT FLOW MEASUREMENTS

The methods and techniques of measurement used in this programme were the same as in the 1981-1984 programme. They are described comprehensively in the report of that work, by Wheildon and others (1985), to which the reader is referred for details. Here only specific points relevant to the present investigation are covered.

3.1 Heat flow measuring procedures

In all but one of the specially drilled heat flow boreholes and in some of the commercial boreholes, preservation of the borehole was through cementing in place a steel tube to full borehole depth. This operation was carried out in the conventional manner, pumping shallow oil-well cement down the tube and through a valve at the bottom into the annular space between the tube and borehole wall. Finally, the inside of the tube was cleared of liquid grout by driving a wiper to the bottom of the steel tube under water pressure.

Temperatures were normally monitored at regular time intervals from borehole completion to the time when successive observations indicated that the thermal disturbance due to drilling had dissipated, normally after about six months. For the two deep geothermal boreholes investigated in this study temperatures were measured using a truck-mounted Mount Sopris Series III winch linked to a microprocessor-controlled temperature logging system. For the remaining boreholes, all less than 550 m deep, a small portable winch system proved more efficient. One determination, in a hydrocarbon exploration borehole, is based on bottom hole temperatures (BHTs), acquired during geophysical logging.

For UK heat flow data it has become the practice not to apply any correction for palaeoclimate to boreholes greater than 300 m deep. However, climatic fluctuations in the last 500 years perturb geothermal gradients at shallower depths. For boreholes less than 300 m deep a climatic correction for the Present Climatic Optimum (1-70 years BP;+0.6°C), and the Little Ice Age (75-525 years BP;-0.4°C), after Wheildon and others (1980), has routinely been applied. This correction should bring shallower boreholes into agreement with uncorrected values at the 300 m level, so as to be consistent with the remainder of the UK heat flow dataset. A correction for the effect of surface topography on subsurface temperatures was also applied, according to the procedure outlined by Bullard (1940), where this was found to be necessary.

Three methods were employed to measure thermal conductivity, depending on the state and type of rock samples available. Generally, samples from boreholes specifically drilled for heat flow studies were in the form of solid cores of rock which had been waxed immediately after extraction from the core barrel to preserve their natural water content. Where these cores were of a relatively soft rock, their conductivity was determined with the needle probe apparatus. In the case of hard rock cores, discs were cut and machined to the appropriate dimensions and were then measured in the divided bar apparatus. The remainder of available samples were in the form of cuttings. These were also measured with the divided bar, using the pill-box technique. In a typical 300 m borehole measurements were made on samples at approximately 3 m intervals in the depth range over which heat flow was calculated. For deeper boreholes the sampling interval was lengthened appropriately.

3.2 Heat flow calculation

As in the previous programme the calculation of heat flow is based on the thermal resistance integral procedure of Bullard (1939). This makes use of the equation

$$T_z = T_0 + q \, \Sigma z_i/k_i$$

where T_z = temperature at depth $z = \Sigma z_i$,

T_0 = mean annual surface temperature,

q = heat flow,

k_i = conductivity of the i^{th} homogeneous lithological unit of thickness z_i.

The heat flow is determined by a linear regression of the measured temperatures T_z over the thermal resistances $\Sigma z_i/k_i$. The value of this reduction technique is that it throws into sharp relief potential errors in the conductive heat flow determination, these being represented as deviations from the linear relationship. They may arise variously from inadequate correction of the temperature profile for palaeoclimate, from local temperature disturbances caused by water flow and from an inaccurate evaluation of the summed thermal resistance through inadequate conductivity sampling. The technique does not distinguish between the different possibilities although, in favourable circumstances, reasonably objective judgements can be made. The technique is blind to a convective heat flow component affecting the borehole uniformly.

The thermal resistance plot for Morley Quarry is shown in Figure 3.1 as an example. This is a particularly well constrained dataset, but it does illustrate some typical problems. The modest temperature perturbation seen at 67 $m^2W^{-1}K$ on the thermal resistance scale, which has a corresponding depth of 240 m, is attributed to local water circulation encountered in a fault zone during drilling. Heat flow at this site is based on a linear regression of equilibrium temperatures against thermal resistance over the range 69 to 170 $m^2W^{-1}K$. Below this there is an increase in the gradient, i.e. the heat flow, for which the most likely explanation is the unreliability associated with thermal conductivity measurement. The gradient increase above the local groundwater disturbance is the likely consequence of quarrying activity between 1910 and 1940.

In boreholes where water circulation was suspected as a possible perturbing influence it was found useful to take moving averages of the geothemal gradient and deduce the corresponding thermal conductivities for a range of heat flows, through the conductive heat flow equation. If these values were inconsistent with the conductivities suggested by the lithological logs, water flow was assumed to be indicated, and an assessment of its contribution was also possible.

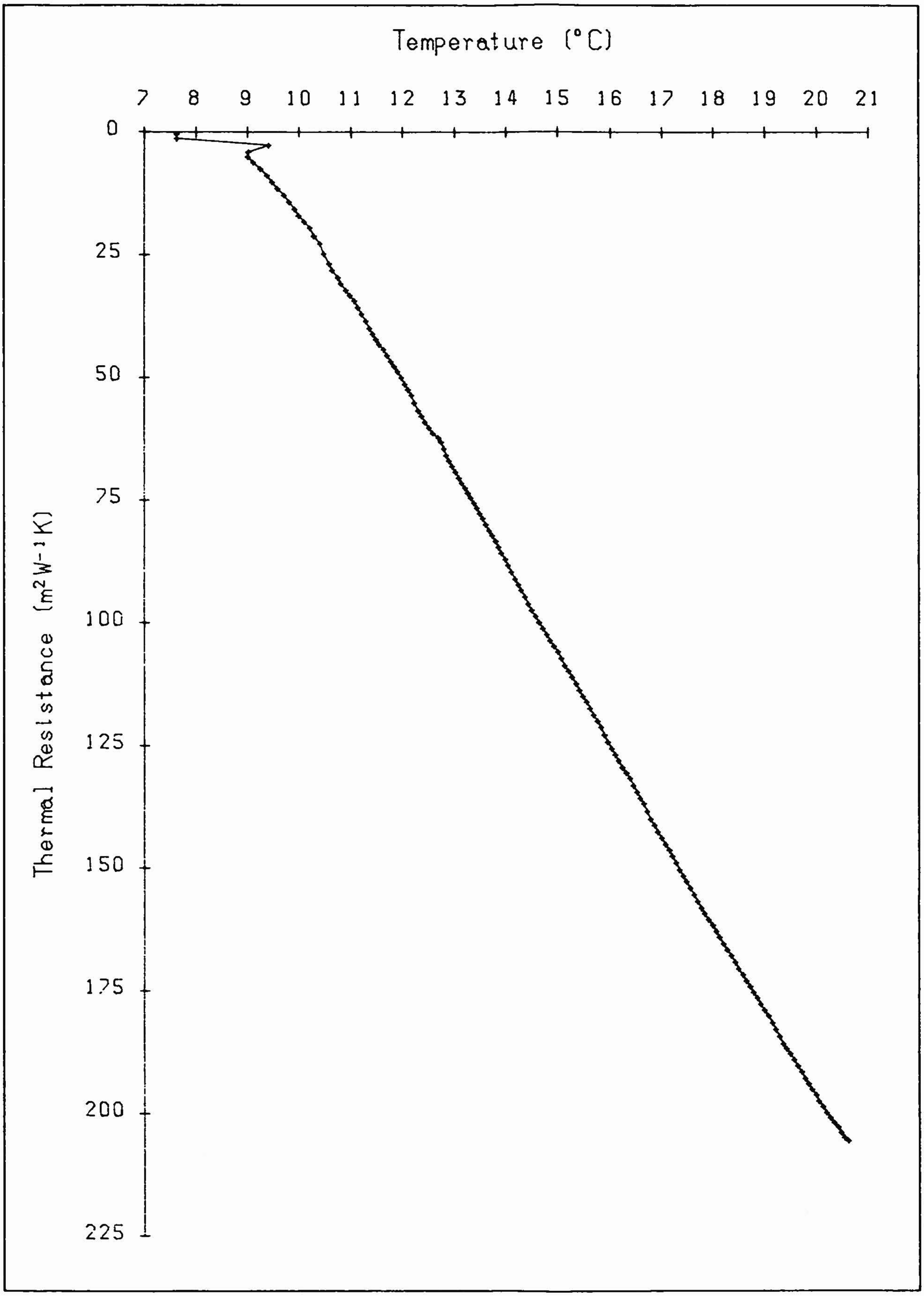

Figure 3.1 Thermal resistance plot for Morley Quarry

4 RESULTS

The results are presented as a series of regional reviews in Sections 4.1 to 4.6. For each region the new data are described. The reviews are completed in each case by a revision of the heat flow contour distribution. In Section 4.7 the heat flow contour revisions are combined to produce updated maps of the UK heat flow field based on these new results. Table 4.1 summarises the basic heat flow data for all the boreholes included in this study.

4.1 Wales

Five new heat flow measurements have been made in Wales. Three of these were in British Coal exploration boreholes in South Wales. A heat flow borehole was drilled in Central Wales, close to the culmination of the Towy Anticline near Llanwrtyd Wells, and a shallow borehole at Rhiw on the Lleyn Peninsula in North Wales, drilled by another Government department was deepened into a heat flow borehole as part of the present programme. The locations of these new holes are shown in Figure 4.6.

All the South Wales boreholes are in Coal Measures. In every case there was excellent correlation between the geothermal gradients and stratigraphy, with gradients adjacent to coal seams often being an order of magnitude greater than in surrounding formations. The correlation between conductivity and stratigraphy was similarly good. In the Carn Caglau borehole (Figure 4.1) these correlations were seen most clearly. However there was some contamination of the chip samples in the vicinity of the coal seams. Three independent determinations in the depth ranges 140 to 195 m, 223 to 273 m and 284 to 352 m yielded heat flows of 34, 35 and 40 mWm^{-2}. On the basis of these a heat flow of 37 mWm^{-2} was assigned to this site. In the Gelli Fawr borehole (Figure 4.2) temperatures were disturbed by groundwater circulation adjacent to a coal seam at 105 m depth. The Bullard gradient in the undisturbed section from 110 to 228 m yielded a heat flow of 51 mWm^{-2}. A blockage in the Newtown borehole led to the heat flow calculation being restricted to the depth range 42 m to total accessible depth at 107 m (Figure 4.3). The resulting value, at 58 mWm^{-2}, includes a palaeoclimate correction of + 9 mWm^{-2}.

The borehole at Llanwrtyd Wells (Figure 4.4) was drilled into a

Table 4.1 Summary of basic data for boreholes included in the study

Borehole name/ location	Grid reference	Date completed	Latest log	Total depth (m)	Bottom temp. (°C)	Heat flow uncorrected (mWm^{-2})	Climatic corr. (mWm^{-2})	Topo. corr. (mWm^{-2})	Heat flow corrected (mWm^{-2})
Carn Caglau	SN 8592 0018	19.10.83?	20.11.84	352.5	14.1	35.5	---	+1.3	36.8
Gelli Fawr	SN 4862 0411	14.06.84	29.08.85	228.2	13.8	50.4	---	---	50.4
Newtown	ST 0696 8481	15.02.84	27.01.86	107.4	12.4	48.6	+9.2	---	57.8
Llanwrtyd Wells	SN 8759 4922	01.02.86	11.11.86	205.0	13.1	58.5	---	-3.9	54.6
Rhiw	SH 2289 2949	31.10.85	27.01.86	57.2	9.4	39.1	+20.0	+6.4	65.5
Morley Quarry	SK 4765 1789	20.07.86	02.12.86	823.0	20.6	54.7	---	---	54.7
Bardon Hill	SK 4535 1313	27.07.84	28.06.85	151.0	12.1	53.7	+10.5	---	56.5*
Wyche (Malvern)	SO 7700 4408	18.02.85	04.09.85	86.3	10.4	39.8	+17.0	+3.9	60.7
Church Stretton	SO 4205 9538	04.04.85	05.09.85	98.6	8.3	45.8	+17.0	+1.0	63.8
Glenrothes	NO 2562 0314	03.02.86	09.12.86	279.3	14.4	56.5	---	---	56.5
Edinburgh (Leith)	NT 2830 7595	25.09.86	08.04.87	215.3	15.6	53.3	---	---	53.3
Selkirk	NT 4794 2785	12.01.86	04.06.86	186.3	10.9	56.8	+1.7	+1.9	60.4
Market Weighton	SE 8595 3486	24.03.85	30.08.85	296.9	19.6	57.2	---	---	57.2
Shipton	SE 5445 5860	?	23.10.86	549.9	20.9	56.9	---	---	56.9
Harewood	SE 3217 4404	19.10.86	10.04.87	271.0	21.5	65.2	---	---	65.2
Cleethorpes No. 1	TA 3024 0709	21.06.84	24.03.86	1850.0	64.5	73.4	---	---	73.4
Clitheroe No. 2	SD 7555 4094	06.03.85	25.10.85	294.0	15.2	40.0	---	---	40.0
Wray	SD 6316 6568	22.08.86	25.01.87	303.5	16.5	40.3	---	---	40.3
Rowlands Gill	NZ 1664 5815	02.03.86	12.08.86	237.1	18.8	103.1	---	-3.6	99.5
Newbiggin	NY 6482 2882	15.07.85	24.01.87	246.6	16.5	85.0	---	---	85.0
Dufton	NY 6853 2503	19.10.86	23.01.87	224.4	14.0	85.0	---	---	85.0
Longhorsley	NZ 1445 9263	23.08.86	BHT data	1828.8	70.8	92.0	---	---	92.0

* correction of -7.7 mWm^{-2} has been applied to account for the effect of quarrying activity

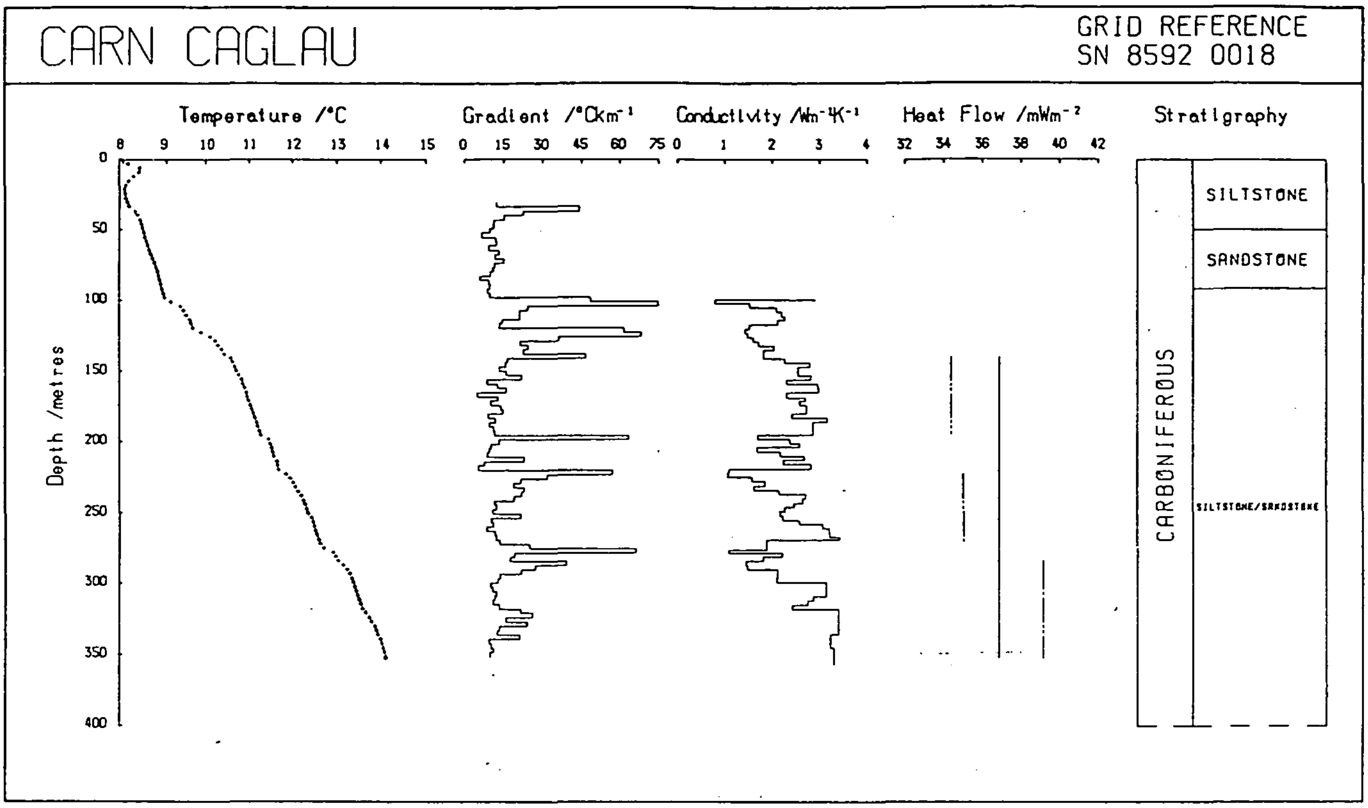

Figure 4.1 Temperature, conductivity and heat flow plots for Carn Caglau

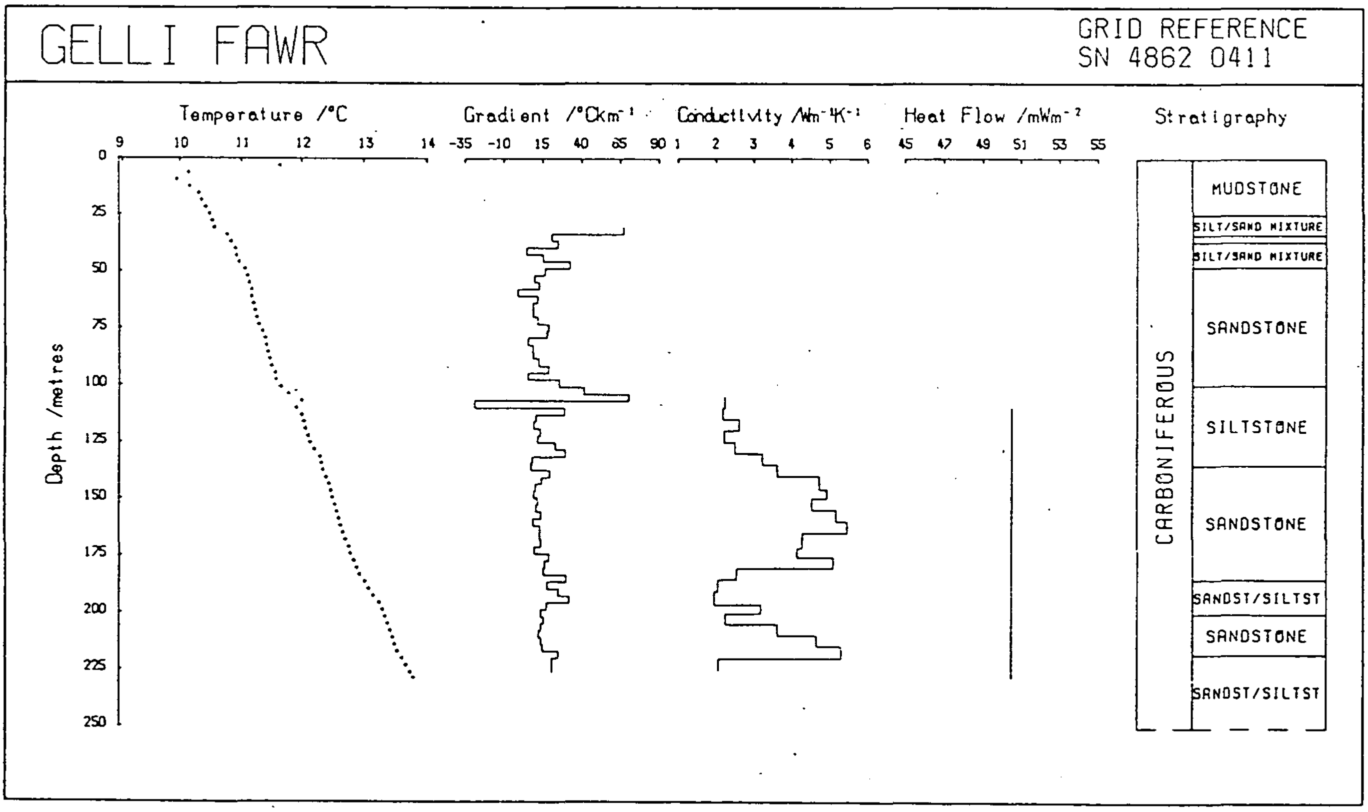

Figure 4.2 Temperature, conductivity and heat flow plots for Gelli Fawr

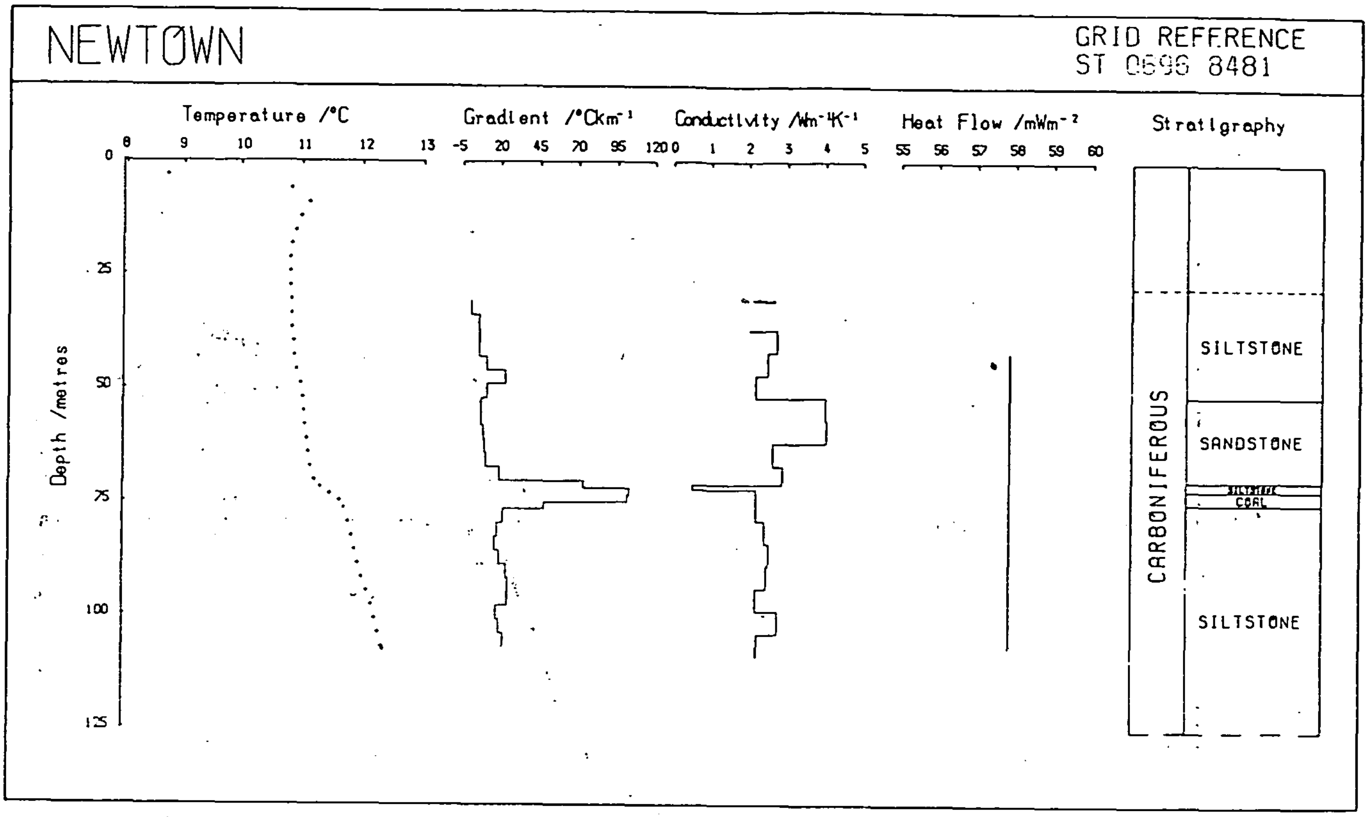

Figure 4.3 Temperature, conductivity and heat flow plots for Newtown

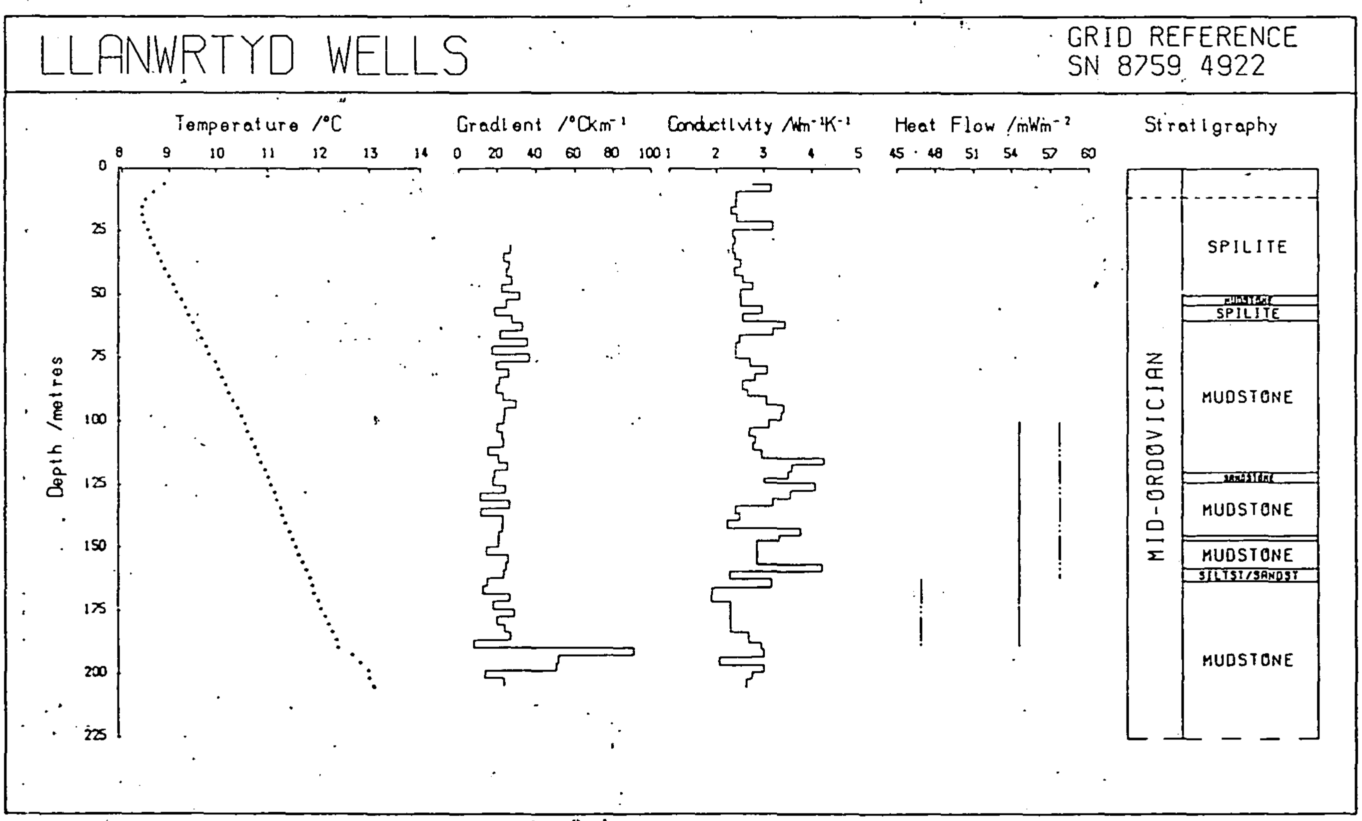

Figure 4.4 Temperature, conductivity and heat flow plots for Llanwrtyd Wells

succession of middle Ordovician mudstones, conglomerates and vesicular basalts. This borehole was uncased and temperatures are disturbed between 195 m and the bottom of the hole at 205 m. However, there is no evidence of water circulation above this zone. The heat flow determined in the depth range 100 to 189 m is 55 mWm^{-2}.

The borehole at Rhiw (Figure 4.5), in lower Ordovician basalts and mudstones, was drilled to a total depth of 98 m. The subsequent cementing operation failed partially, leaving a total accessible depth of only 57 m. The heat flow, corrected for topography only, is 46 mWm^{-2}. Applying the routine correction for palaeoclimate brings the value up to 66 mWm^{-2}. The palaeoclimate correction in the depth range of this borehole is particularly sensitive to small changes in the assumed climatic history. No great confidence can therefore be attributed to this determination. A borehole depth of 100 m is regarded as the absolute minimum for a reliable determination, bearing in mind the nature of the palaeoclimate correction. However, Ansell and others (1986) determined the depth for the July 1984 earthquake in North Wales as 23 km, which implies low heat flow in the region.

The contour revisions arising from the new results in Wales are shown in Figure 4.6. The Llanwrtyd Wells determination fills the previous gap in the coverage of Central Wales. The new results for South Wales do not conflict with the postulated southward regional groundwater flow, particularly through the Carboniferous Limestone beneath the coal field (Thomas and others, 1983).

4.2 Central England and the Welsh Borderland

At the four sites in this region the common objective was to establish the heat flow and heat production characteristics of the Precambrian basement. These rocks, which form the Midlands Microcraton, are exposed to a very limited extent at the surface, but are of great significance to geothermal resource potential assessment because they are present at relatively shallow depths beneath much of Central England.

The largest exposure of Precambrian rocks is in the Charnwood Forest where two of the boreholes are located. The borehole at Morley Quarry was a deep exploration hole drilled for the BGS as part of the current geothermal

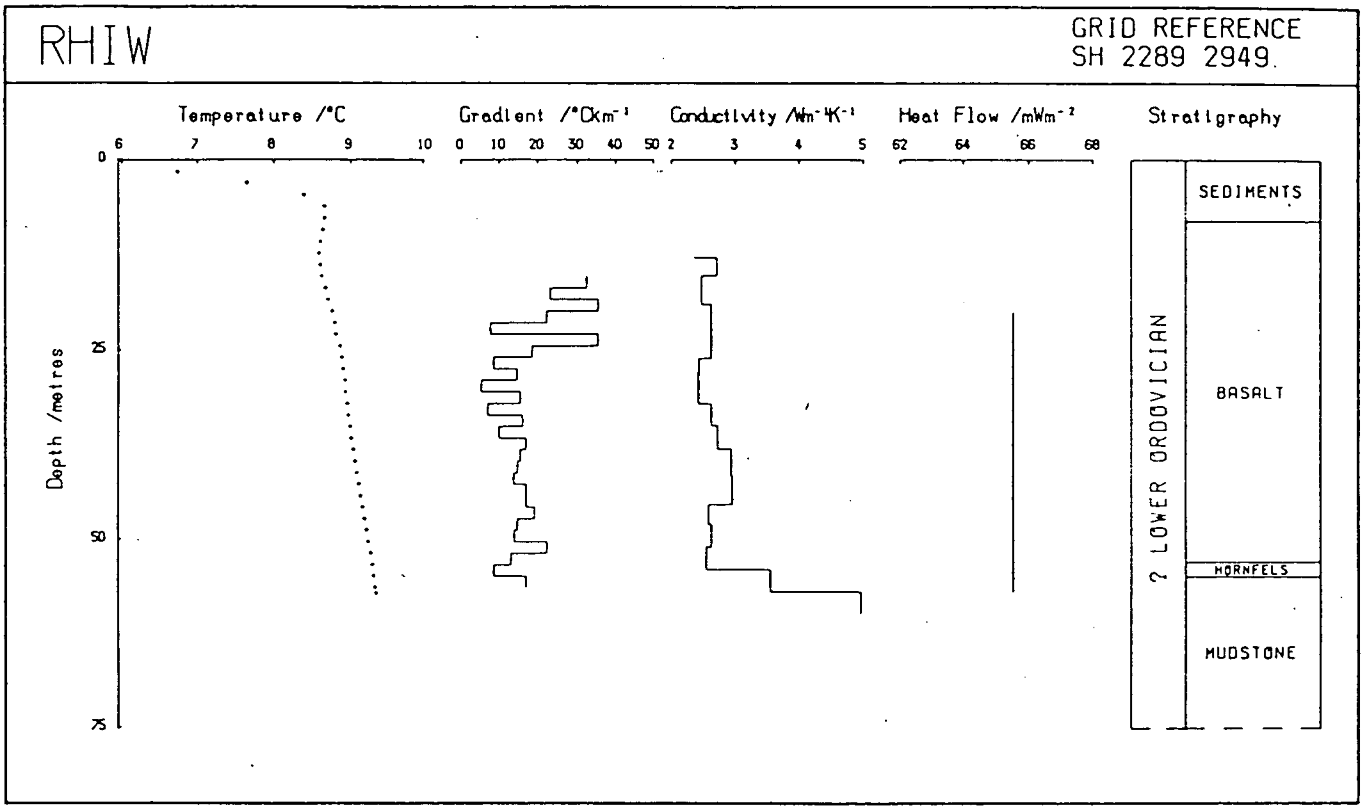

Figure 4.5 Temperature, conductivity and heat flow plots for Rhiw

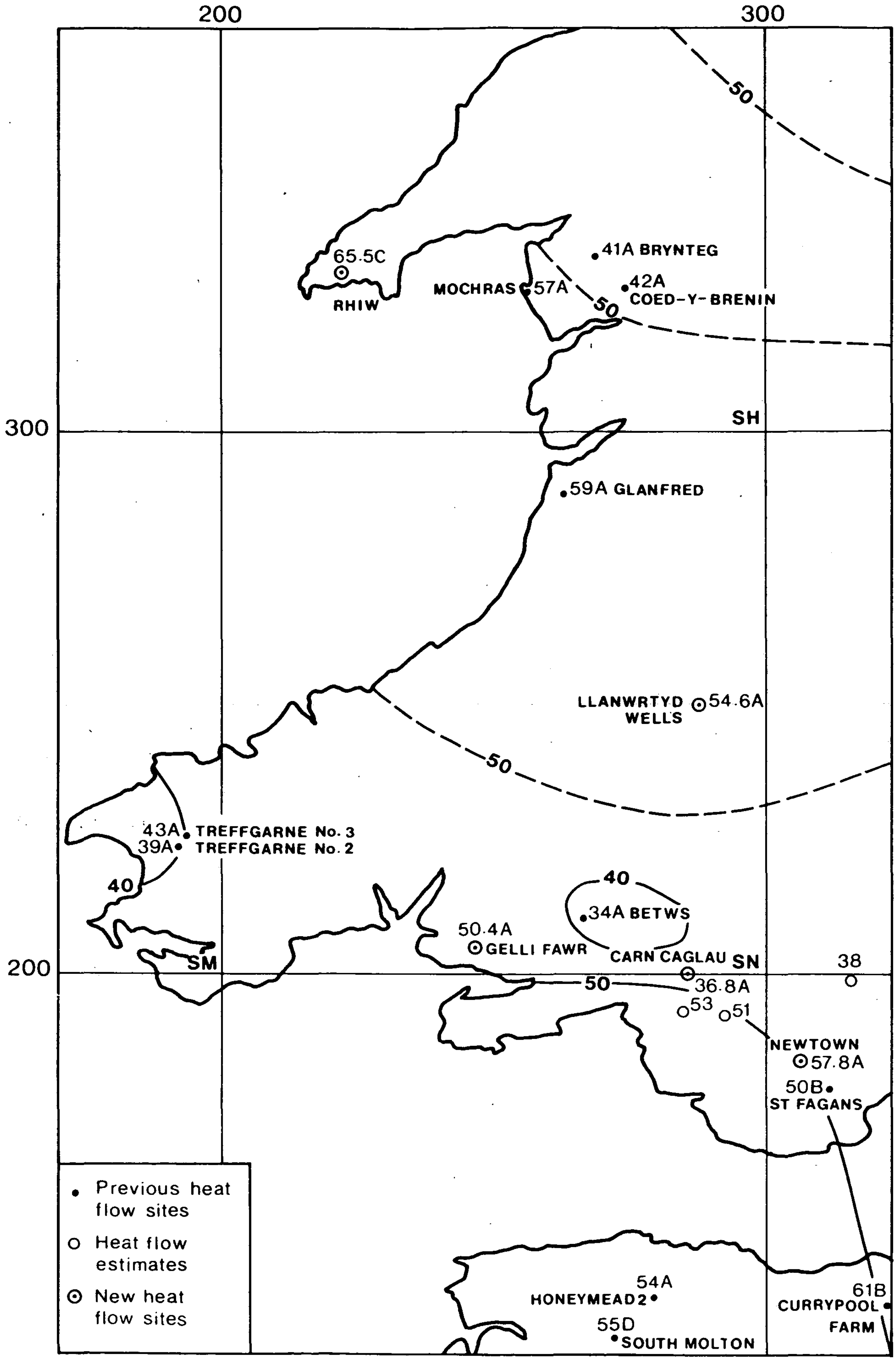

Figure 4.6 Heat flow map for Wales. Units are mWm^{-2}.

programme, to provide an insight into the composition and physical properties of the basement rocks in the Midlands. The sequence comprises Charnian meta-igneous and meta-sedimentary varieties. The borehole at Bardon Hill was much shallower, having been drilled to test roadstone reserves in the Charnian meta-igneous basement. Two shallow percussion boreholes were drilled into rocks of similar age in the Welsh Borderland. The borehole at Wyche (Malvern) cuts Malvernian meta-igneous basement brought up in a large west-facing anticlinal flexure. The other borehole at Church Stretton cuts near-vertical Longmyndian molassic sediments.

The two boreholes in the Charnwood Forest gave particularly good results. The Morley Quarry borehole (Figure 4.7) was percussion drilled to 783 m and cored thereafter to its total depth of 834 m. The heat flow of 55 mWm^{-2} is based on the Bullard gradient in the depth range 270 to 700 m. The gradient increases above and below this depth range are referred to in Section 3.2. This is the best heat flow determination at present in the Midlands Microcraton. Thermal conductivities are high, with a mean of 4.1 $Wm^{-1}K^{-1}$, and little variation exists between meta-igneous and meta-sedimentary varieties. This conductivity and the observed gradient of around 13 $°Ckm^{-1}$ could well be representative of the basement rocks of much of central England.

The Bardon Hill borehole (Figure 4.8), only 5 km from Morley Quarry, is much shallower, at 151 m. Thermal conductivities were determined on crushed core material. With temperatures corrected for recent palaeoclimate the Bullard gradient yielded a heat flow of 64 mWm^{-2} in the depth range 50 to 151 m. The temperature perturbation arising through lowering the level of the quarry floor, by some 55 m since 1850, when quarrying began, has been evaluated for a simple one-dimensional model. When this was applied as a correction to the observed data the heat flow was reduced to 57 mWm^{-2}, which brings it into consistency with the Morley Quarry value.

The results from the two specially drilled boreholes in the Welsh Borderland are less satisfactory. Both were planned as percussion boreholes to 97 m with 3 m terminal core sections giving them a total depth of 100 m. In the event, difficult drilling conditions, cementing problems and bad weather led to both holes falling somewhat short of the original objectives. This in itself was not a serious problem. What has become apparent, with hindsight, is that in such complex structural settings and hilly terrain 100 m

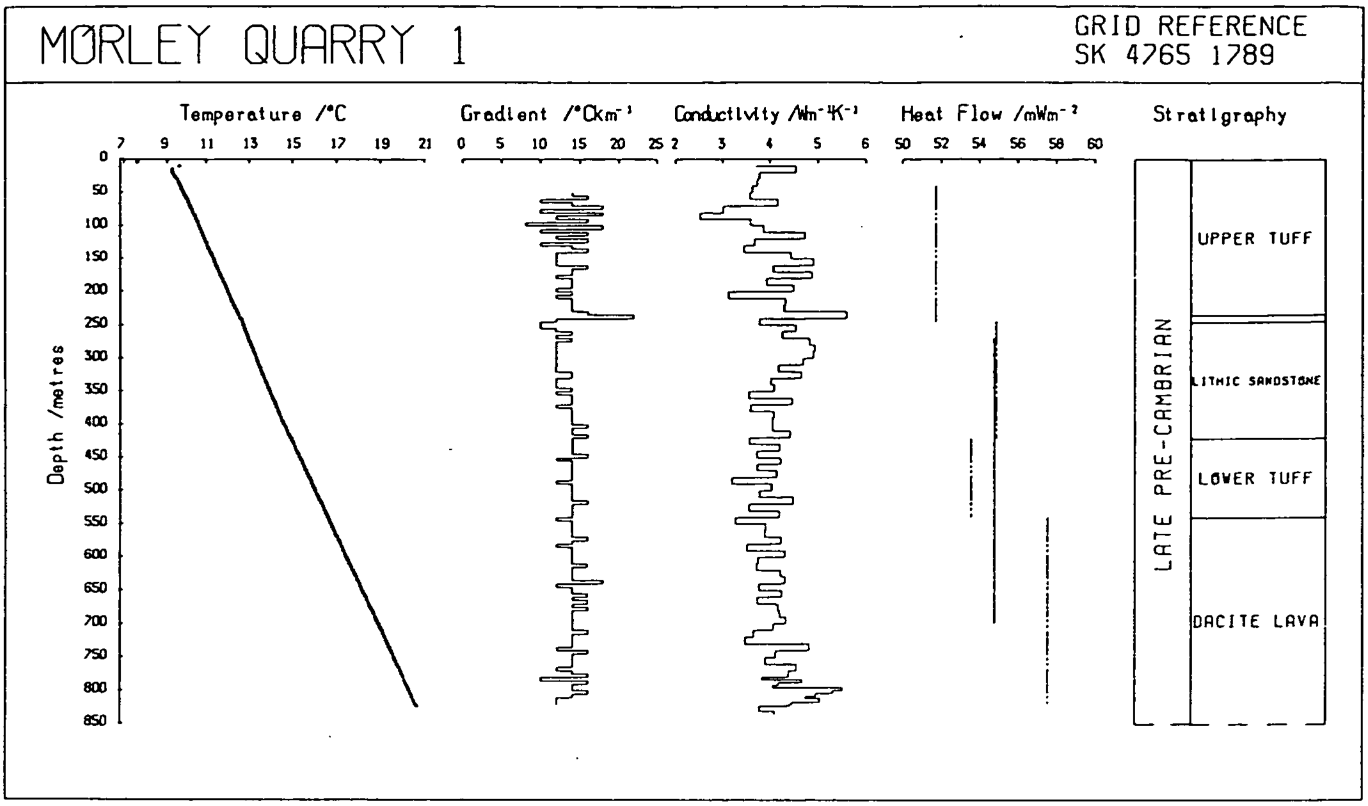

Figure 4.7 Temperature, conductivity and heat flow plots for Morley Quarry

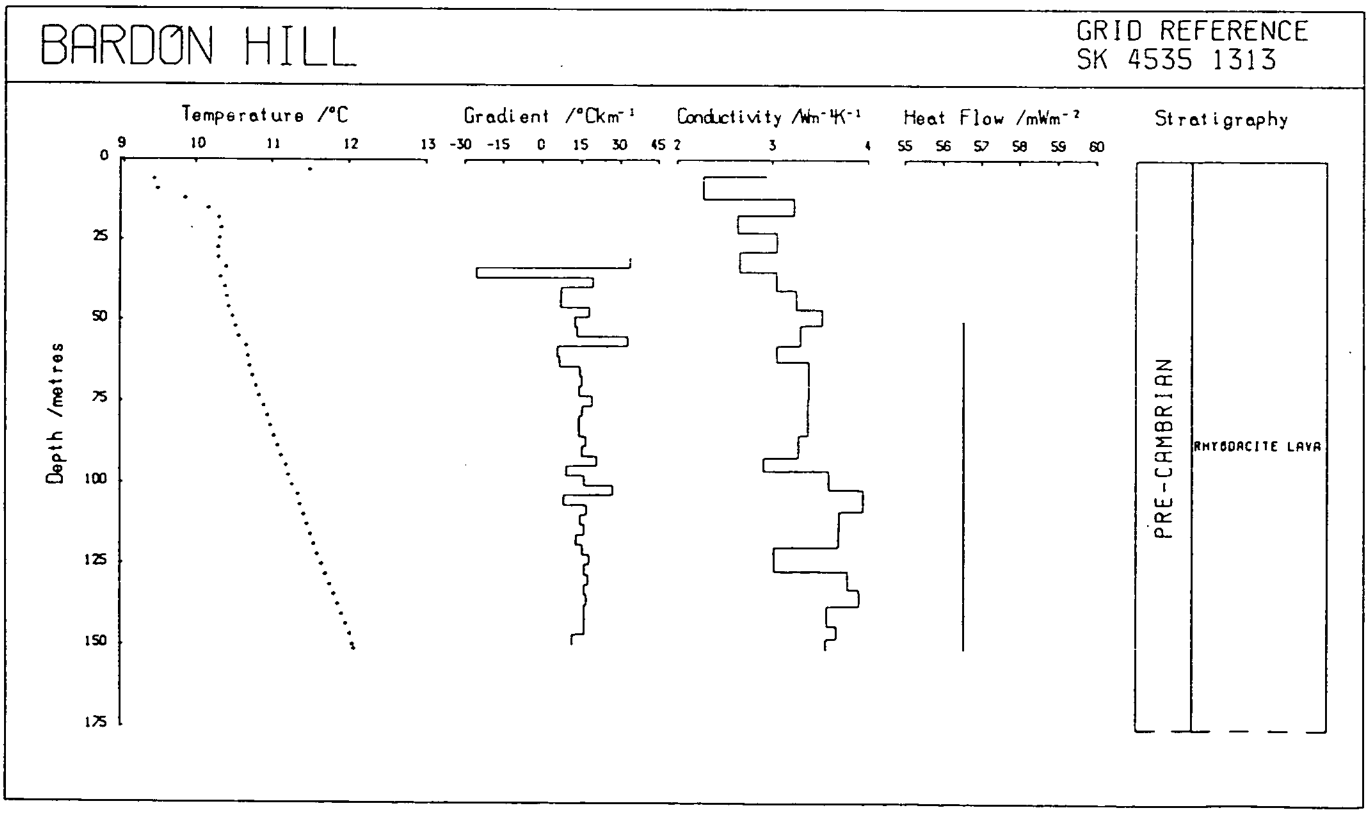

Figure 4.8 Temperature, conductivity and heat flow plots for Bardon Hill

deep boreholes are quite inadequate for heat flow determinations.

The borehole at Wyche (Figure 4.9) is located in a disused quarry, and after cementing had a total accessible depth of 87 m. The equilibrium temperature log exhibits a sharp change in gradient at around 48 m, and it appears that groundwater circulation influences temperatures above this. After applying corrections for both topography and palaeoclimate the Bullard gradient in the depth range 48 to 87 m yields a heat flow of 61 mWm^{-2}. The quarrying history at this site is not known, and so it has not been possible to evaluate its effect. What is certain is that the correction would be negative, so that probably the undisturbed heat flow is less, but by an uncertain amount. The determination of heat flow in the Church Stretton borehole (Figure 4.10) was entirely straightforward. After correcting data for topography and palaeoclimate the Bullard gradient in the depth range 30 to 98 m yielded a heat flow of 64 mWm^{-2}. As in the case of the Wyche borehole, this was rather higher than expected. Why this might be so is less clear. The Longmyndian sediments have relatively high thermal conductivities and are trapped in a tight isoclinal syncline. If the flanking Uriconian volcanics and younger formations on either side have relatively lower thermal conductivities then heat flow refraction on a regional scale could be the explanation of this relatively high heat flow.

The heat flow contour revisions arising from the addition of the four new values reported in this section are shown in Figure 4.11. Throughout the region heat flow values are close to background. In such circumstances contouring at 10 mWm^{-2} intervals is of doubtful validity, when individual values can easily be perturbed by this amount through a variety of causes. This problem is discussed further in section 4.7.

Heat production measurements were made on samples collected at regular depth intervals in each of the four boreholes using the laboratory gamma-ray spectrometry system as described by Wheildon and others (1984). The sampling interval was 20 m at Morley Quarry, 10 m at Bardon Hill, and 5 m or less in the shallow boreholes at Wyche and Church Stretton. Based on these measurements, mean heat production values for each site have been determined, and are presented as Table 4.2. In the case of Morley Quarry, where the borehole cuts quite distinct lithological units, mean values have also been assigned to each of these. It is often observed that chip samples recovered from deep percussion boreholes show a preferential loss of uranium

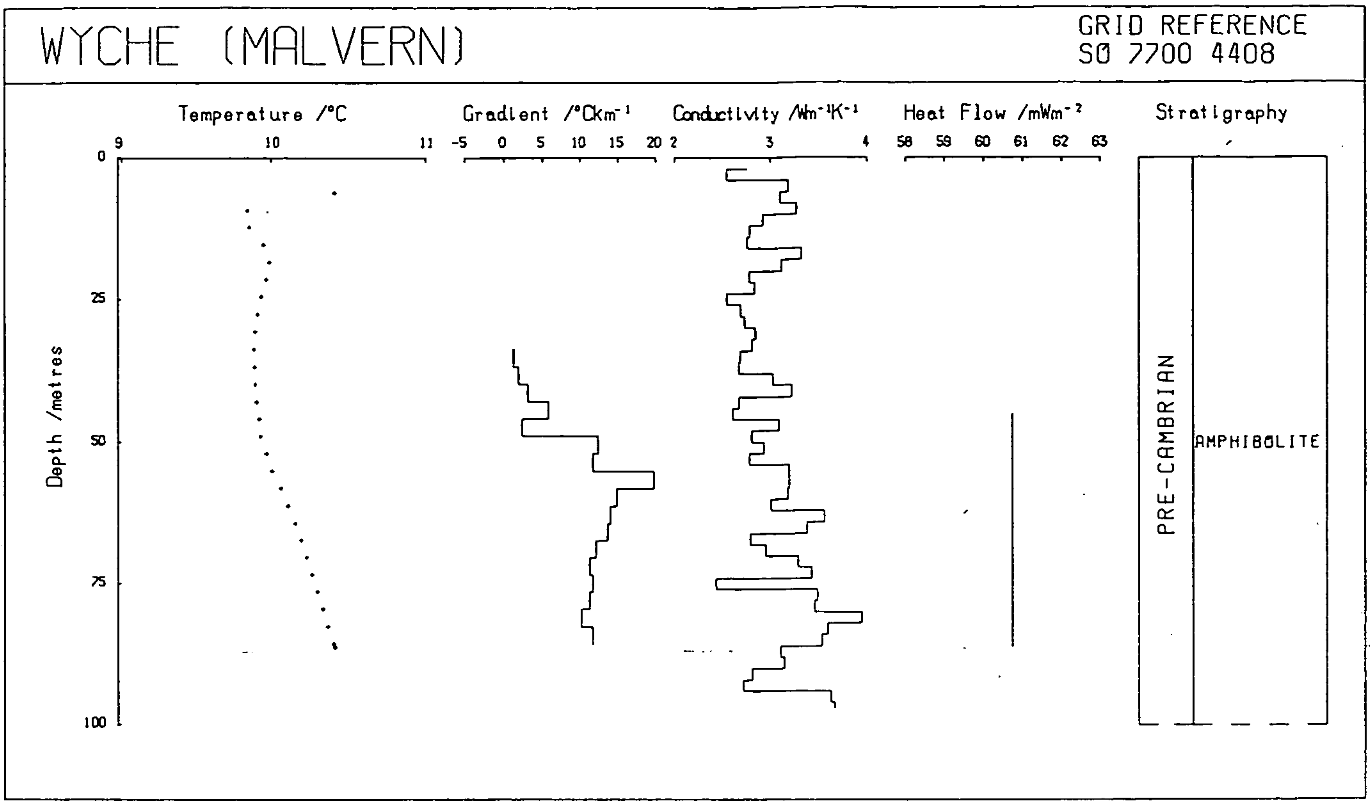

Figure 4.9 Temperature, conductivity and heat flow plots for Wyche (Malvern)

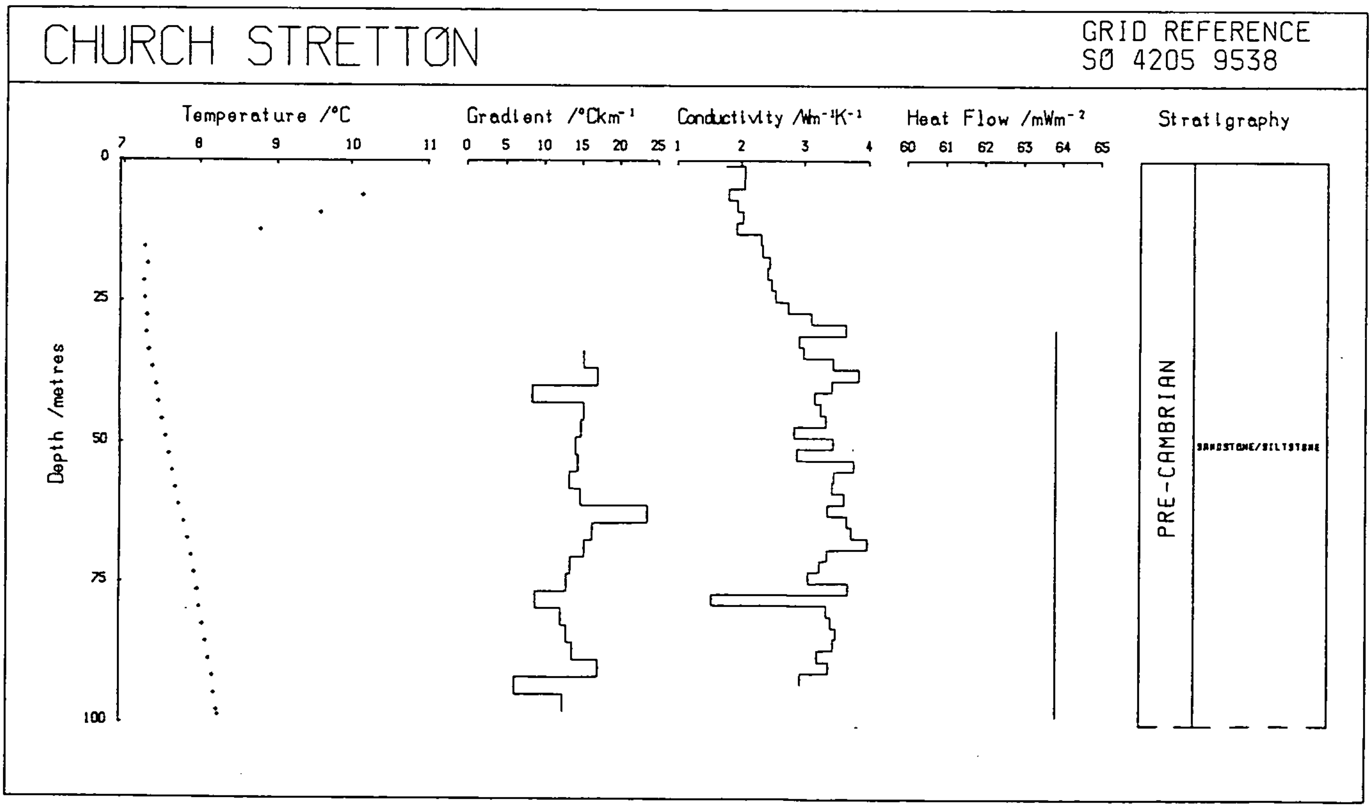

Figure 4.10 Temperature, conductivity and heat flow plots for Church Stretton

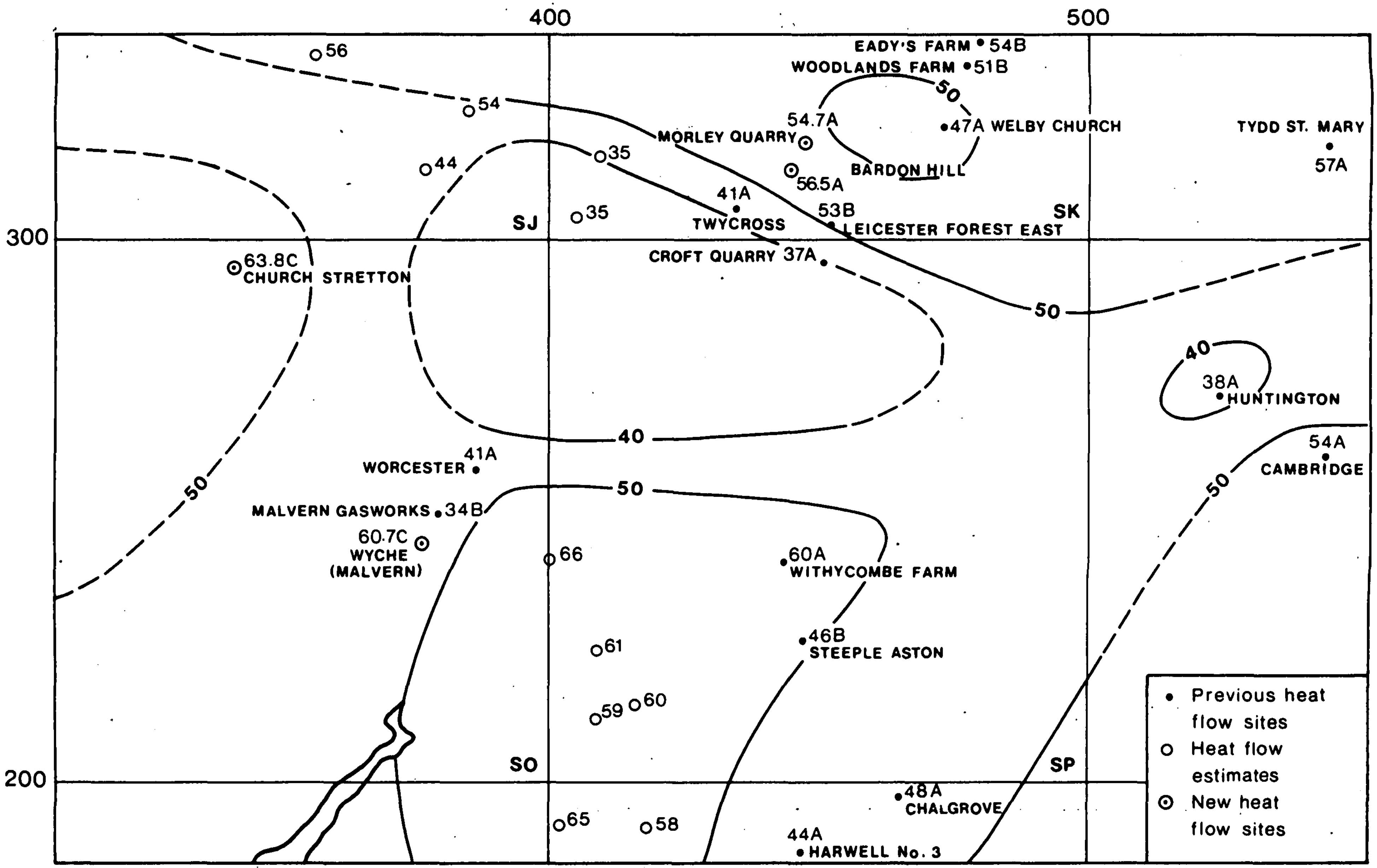

Figure 4.11 Heat flow map for Central England and the Welsh Borderland. Units are mWm^{-2}.

Table 4.2 Heat production data for Precambrian basement

Borehole	Lithological unit	Depth interval metres	Potassium %	Uranium ppm	Thorium ppm	Th/U ratio	Heat production μWm^{-3}
Morley Quarry	Upper Tuff	0-245	1.8	1.0	4.5	4.5	0.7
	Lithic Sst	245-422	2.2	1.4	7.1	5.1	1.1
	Lower Tuff	422-451	1.6	1.3	5.7	4.6	0.9
	Dacite Lava	541-830	0.8	0.7	2.6	3.8	0.4
	mean value	0-830	1.4	0.9	4.2	4.3	0.7
Bardon Hill	Rhyodacite Lava	0-150	0.6	0.5	1.6	3.3	0.3
Wyche (Malvern)	Amphibolite	0- 97	2.9	2.7	9.6	4.1	1.6
Church Stretton	Sandstone/ Siltstone	0- 92	0.9	1.2	4.9	4.3	0.7

and thorium when compared with measurements on solid material from corresponding depths. This appeared not to be the case at Morley Quarry, the laboratory results being in good agreement with those from a downhole gamma-ray spectrometric survey carried out as part of the BGS logging programme in this borehole.

These new heat production data have been combined with the corresponding heat flow data, and added to the most recent UK compilation by Lee (1986) in Figure 4.12. The new data slightly enlarge the cluster of points for measurements in basement rocks of England and Wales. The distribution of this cluster suggests that the average heat flow for basement rocks in the UK must be around 55 mWm^{-2}, with an average heat production of around 1 μWm^{-3}.

4.3 Midland Valley and Southern Uplands of Scotland

Previous heat flow studies in this region indicate values slightly above background in the Midland Valley around Glasgow. In the present study two new measurements have been made in the eastern part of the Midland Valley, at Glenrothes and Edinburgh, to investigate whether the above-average heat flows are more extensive. Previously there was only one measurement in Scotland south of the Midland Valley. The measurement at Selkirk, in the Southern Uplands, goes some way towards filling this gap. The new borehole locations and their relationships with the previous coverage are shown in Figure 4.16.

The borehole at Glenrothes (Figure 4.13) was drilled as part of the BGS Geothermal Resources Programme to test the Devonian Knox Pulpit Formation as a potential geothermal aquifer. It cuts a thick dolerite sill and the Carboniferous Pathhead Beds and Cementstone Group before entering the Devonian. The original cored borehole, to 560 m depth, was lost during the cementing operation but, fortunately, a (non-equilibrium) temperature log had been run prior to its loss. A percussion borehole at the same site, but limited in depth to 279 m, provided the equilibrium temperature data. Using the method of Barelli and Palama (1981), the original openhole BHT was adjusted to equilibrium, making it possible to determine heat flow for the full original depth range. The heat flow calculation using the equilibrium temperatures in the percussion borehole was 59 mWm^{-2}, and that for the original borehole to 560 m depth, using the BHT adjusted to equilibrium was

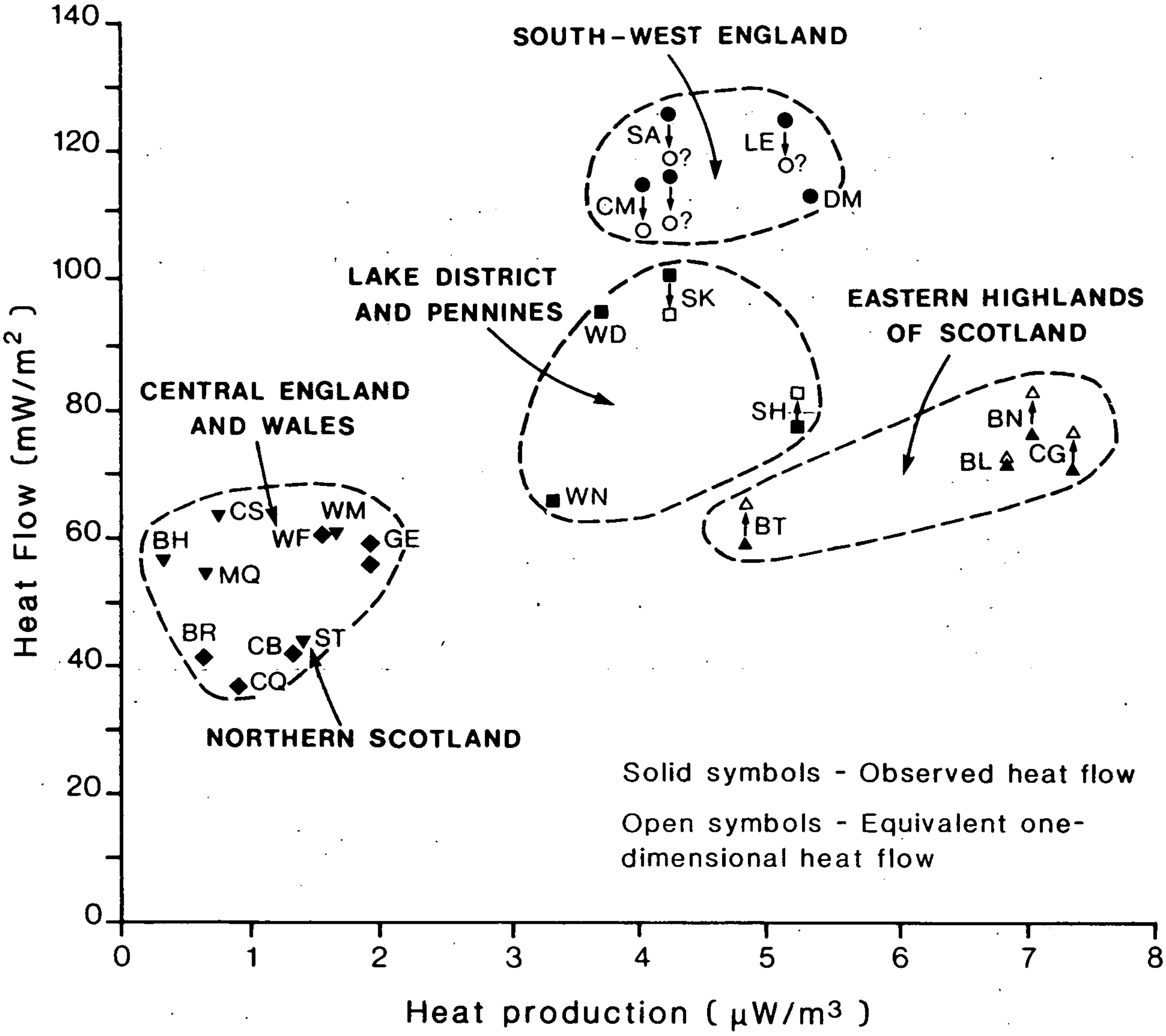

Figure 4.12 Heat flow - heat production diagram for the UK
Codes identify granites or boreholes as follows: CM = Carnmenellis Granite, BD = Bodmin Granite, LE = Lands End Granite, SA = St Austell Granite, DM = Dartmoor Granite, WD = Weardale Granite, WN = Wensleydale Granite, SH = Shap Granite, SK = Skiddaw Granite, CG = Cairngorm Granite, BT = Mount Battock Granite, BL = Ballater Granite, BN = Bennachie Granite, ST = Strath Halladale Granite, CQ = Croft Quarry Borehole, BR = Bryn Teg Borehole, CB = Coed-y-Brenin Borehole, GF = Glanfred Borehole, TW = Thorpe-by-Water Borehole, WF = Withycombe Farm Borehole, MQ = Morley Quarry Borehole, BH = Bardon Hill Borehole, WM = Wyche (Malvern) Borehole, CS = Church Stretton Borehole.

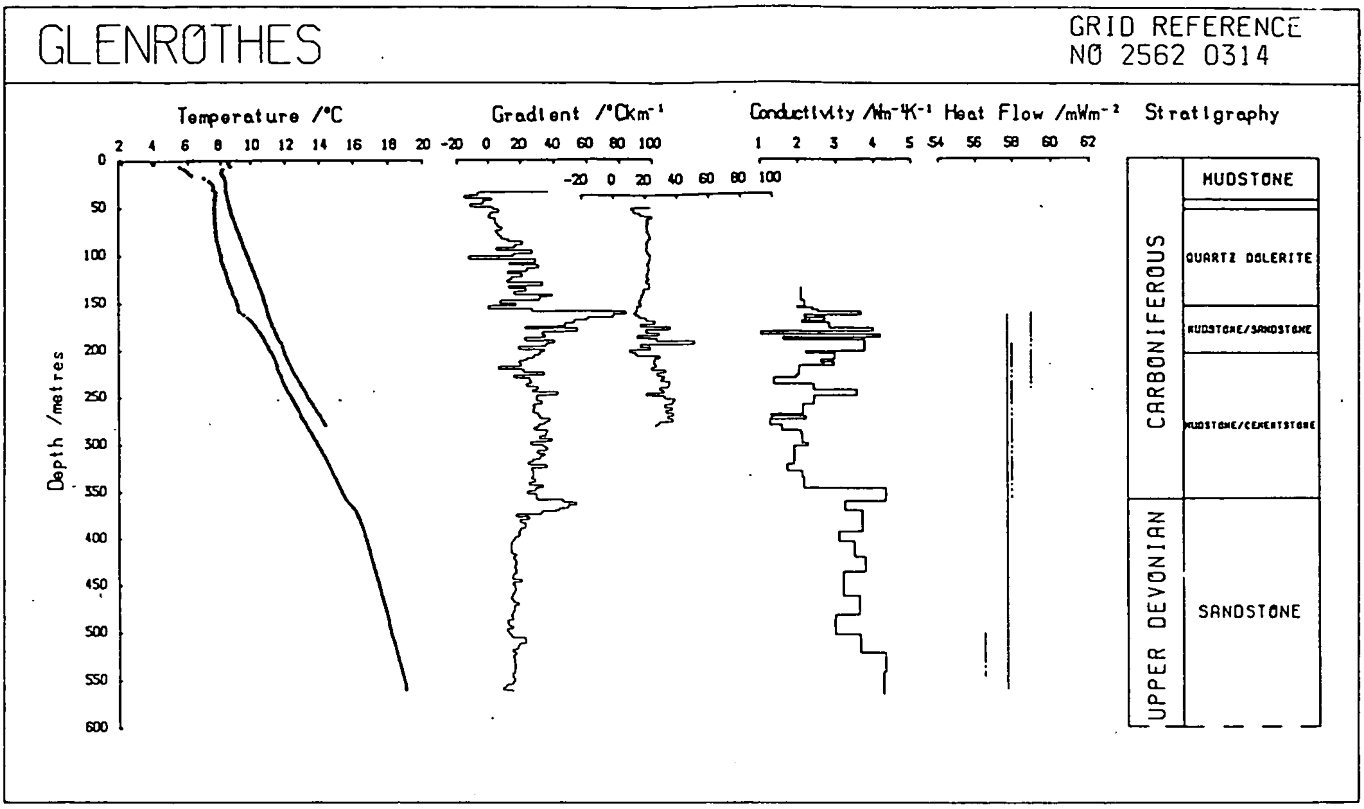

Figure 4.13 Temperature, conductivity and heat flow plots for Glenrothes

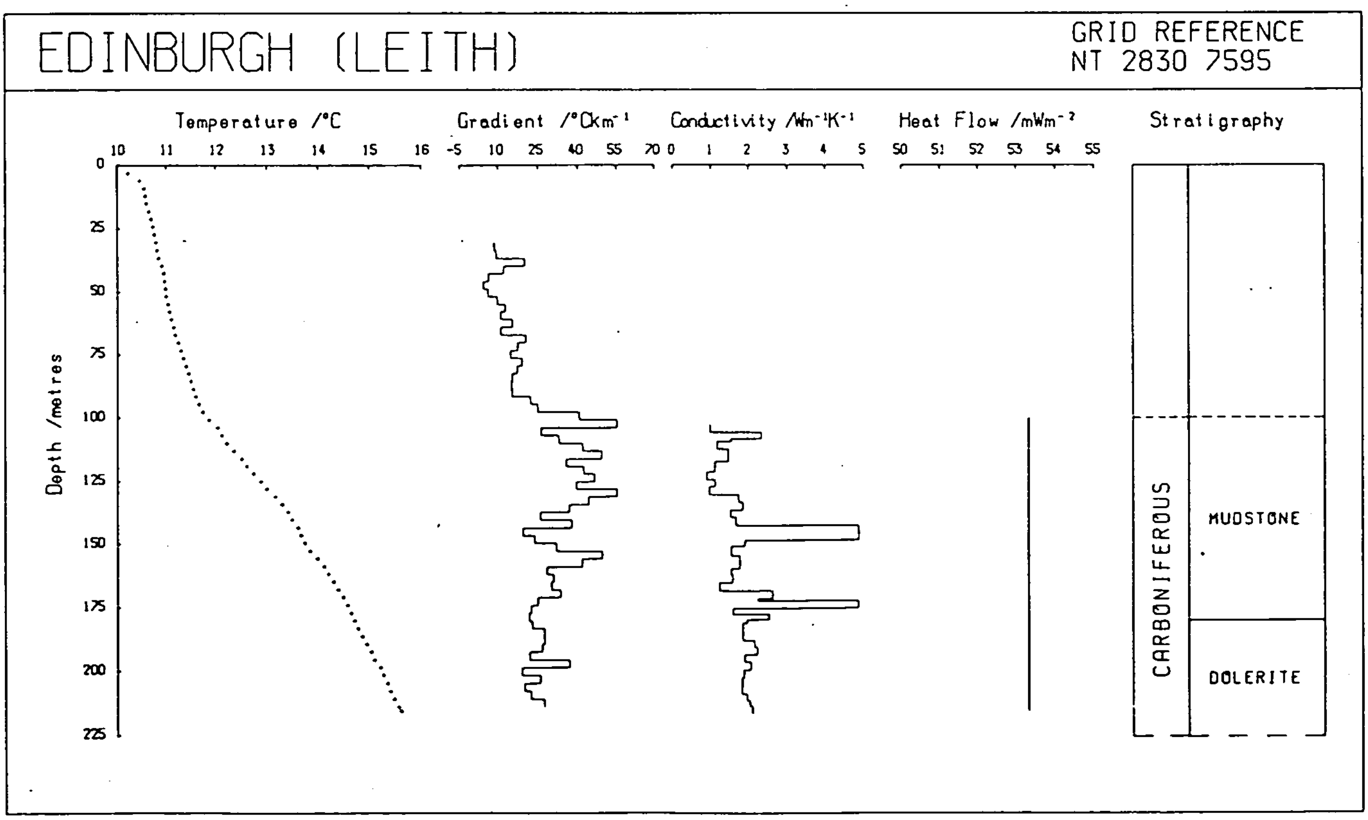

Figure 4.14 Temperature, conductivity and heat flow plots for Edinburgh (Leith)

58 mWm^{-2}. It was clear from a comparison of the equilibrium percussion borehole log and the original deep open hole borehole log that the temperature gradients observed in the deeper parts of the latter were close to their equilibrium values. The preferred value is, in fact, that derived from the open hole temperature log in the depth range 501 to 547 m, at 57 mWm^{-2}. With the loss of the original borehole went the opportunity to acquire a high quality equilibrium log to 560 m depth. This would have provided an opportunity to make a critical assessment of water flow within and around the borehole, only hinted at in the original open hole log. In the absence of the full equilibrium log some uncertainty about the amplitude of a convective component, if present, must remain.

The borehole designated Edinburgh (Figure 4.14) was drilled at Leith Docks. It cuts Carboniferous mudstones with inter-bedded sandstones and siltstones and a thick dolerite sill. Artesian flow was encountered during drilling and the equilibrium temperatures are clearly disturbed above the 100 m level. The Bullard gradient in the depth range 100 to 215 m is 53 mWm^{-2}.

The Selkirk borehole (Figure 4.15) intersects a steeply dipping Silurian succession of greywackes with thin inter-bedded siltstones and mudstones and one dolerite dyke. Heat flow calculated for the depth range 124 to 186 m is 60 mWm^{-2}, which includes small corrections for topography and palaeoclimate.

The new results are incorporated into Figure 4.16. Evidence of groundwater flow was seen in temperature gradient perturbations in both boreholes in the Midland Valley. The extent of a convective component, if present in these measurements, cannot be assessed. As they stand, the new measurements lend no support to extending the 60 mWm^{-2} closure further east, and the contours remain virtually unchanged. Likewise the new value for the Southern Uplands leads to no change in the contour pattern there.

4.4 East Yorkshire and Humberside

The four new heat flow determinations reported in this section improve the coverage in the area between the Nottinghamshire and northern England heat flow anomaly zones. Their locations, together with previous coverage are shown in Figure 4.21.

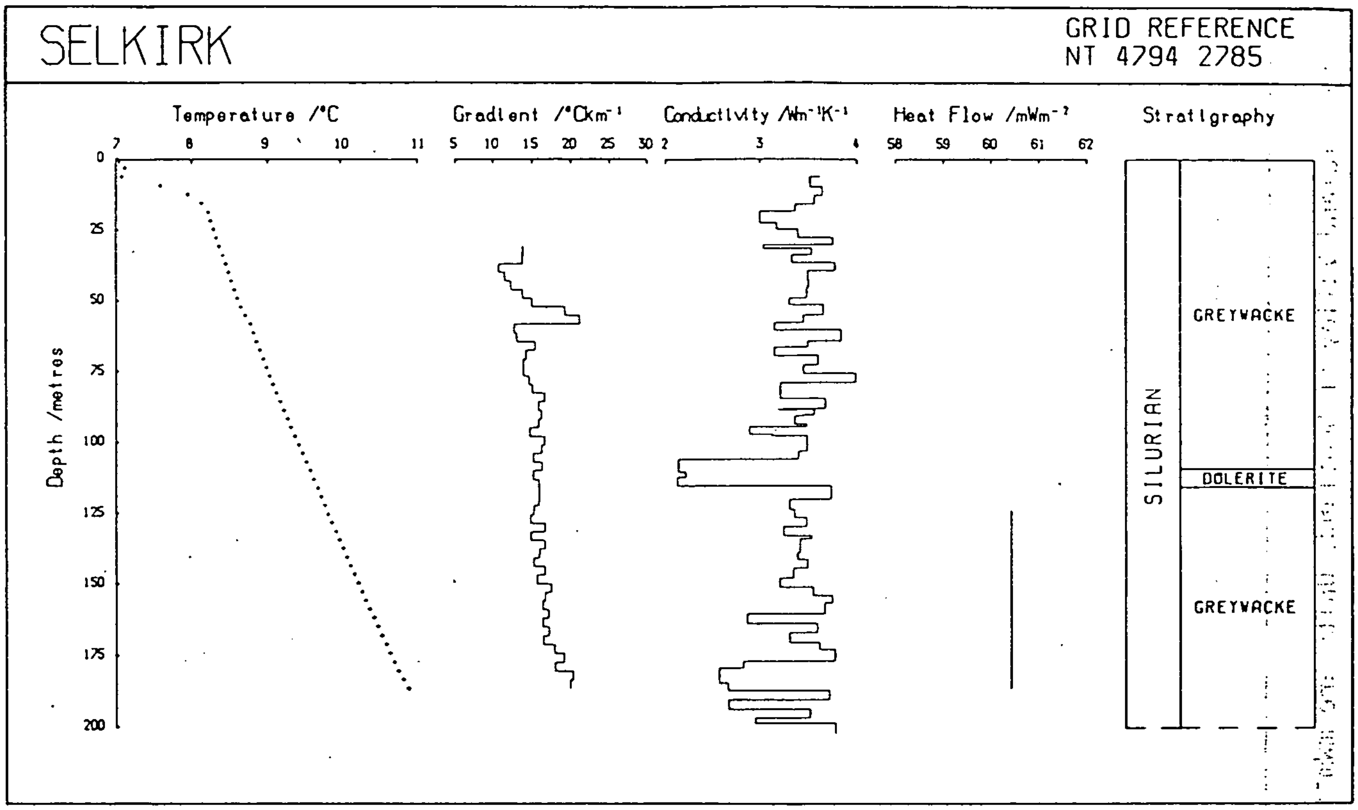

Figure 4.15 Temperature, conductivity and heat flow plots for Selkirk

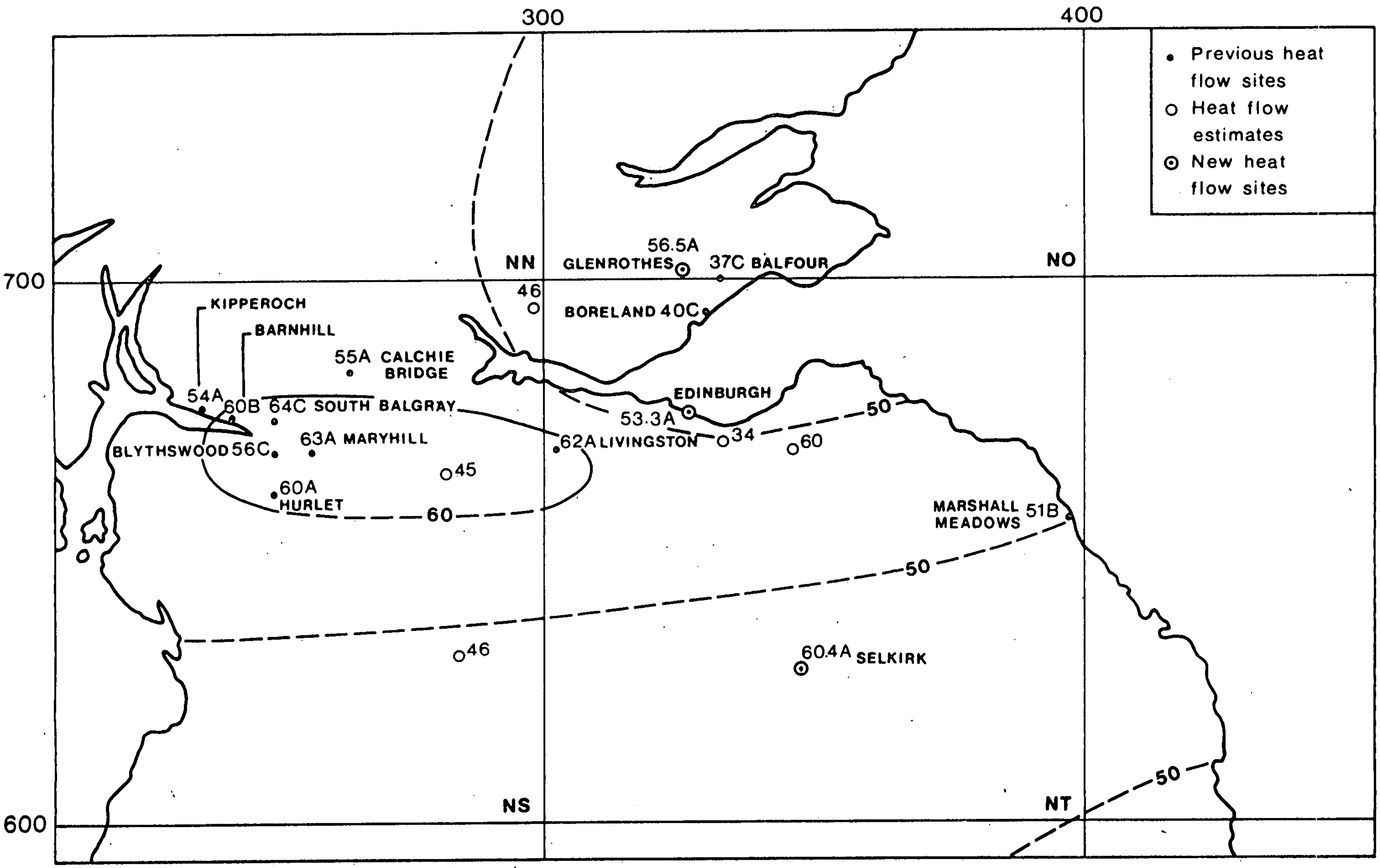

Figure 4.16 Heat flow map for the Midland Valley of Scotland. Units are mWm^{-2}.

Two heat flow boreholes were drilled. The one at Market Weighton was to determine heat flow over a possible concealed Caledonian granite, postulated by Bott and others (1978) on the basis of geophysical evidence. The other borehole at Harewood was drilled to extend heat flow coverage to the east. The Shipton borehole was made available by British Coal. The fourth site, Cleethorpes No. 1, was a geothermal exploration well drilled for the Department of Energy to test the Permian and Triassic aquifers in the East Yorkshire and Lincolnshire Basin.

The Market Weighton borehole (Figure 4.17) cuts Triassic strata comprising the Mercia Mudstone and Sherwood Sandstone groups. The temperature observations imply downward migration of groundwater in the upper section of the Mercia Mudstone. The thermal resistance plot shows least disturbance in the Sherwood Sandstone and it was here that the Bullard gradient was determined, in the depth range 208 to 297 m, to yield a heat flow of 57 mWm^{-2}. The possibility of downward migration of groundwater causing a reduction of apparent heat flow cannot be ruled out. However, the evidence available does not support the existence of a high heat production granite batholith at depth.

The Shipton No. 2 borehole (Figure 4.18) intersects Triassic and Permian before entering the Upper Coal Measures. Representative samples of the sequence were taken from the adjacent Beningbrough borehole. Conductivities were assigned to the Shipton sequence through careful matching of the lithological logs for the two holes. Although chip samples were available to represent the upper part of the borehole, geophysical logs were not, making it impossible to correct the thermal conductivity measurements on chips for porosity. The determination had therefore to be restricted to a depth range where solid core material was available on which to determine conductivities reliably. A heat flow of 57 mWm^{-2} was determined from the Bullard gradient in the depth interval 360 to 490 m.

The cored section of the Harewood borehole (Figure 4.19), between 100 m and total depth at 271 m, is entirely within a monotonous mudstone sequence in the Carboniferous Millstone Grit Series. The mean conductivity of these mudstones is 1.20 ± 0.15 $Wm^{-1}K^{-1}$. Such low conductivity must be accompanied by a high geothermal gradient; at 56 $°Ckm^{-1}$ it exceeds all previously reported values for the UK. Heat flow determined over the depth range 110 to 271 m is 65 mWm^{-2}.

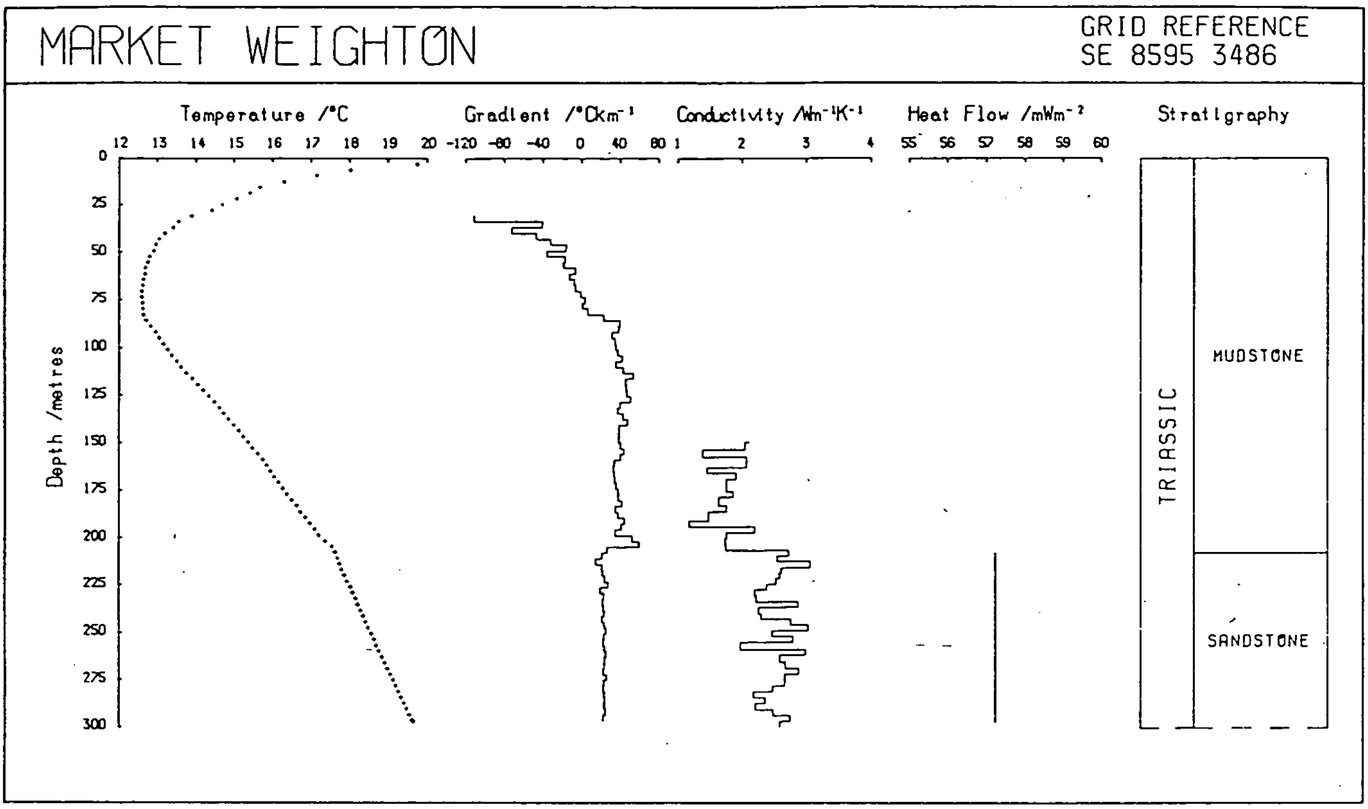

Figure 4.17 Temperature, conductivity and heat flow plots for Market Weighton

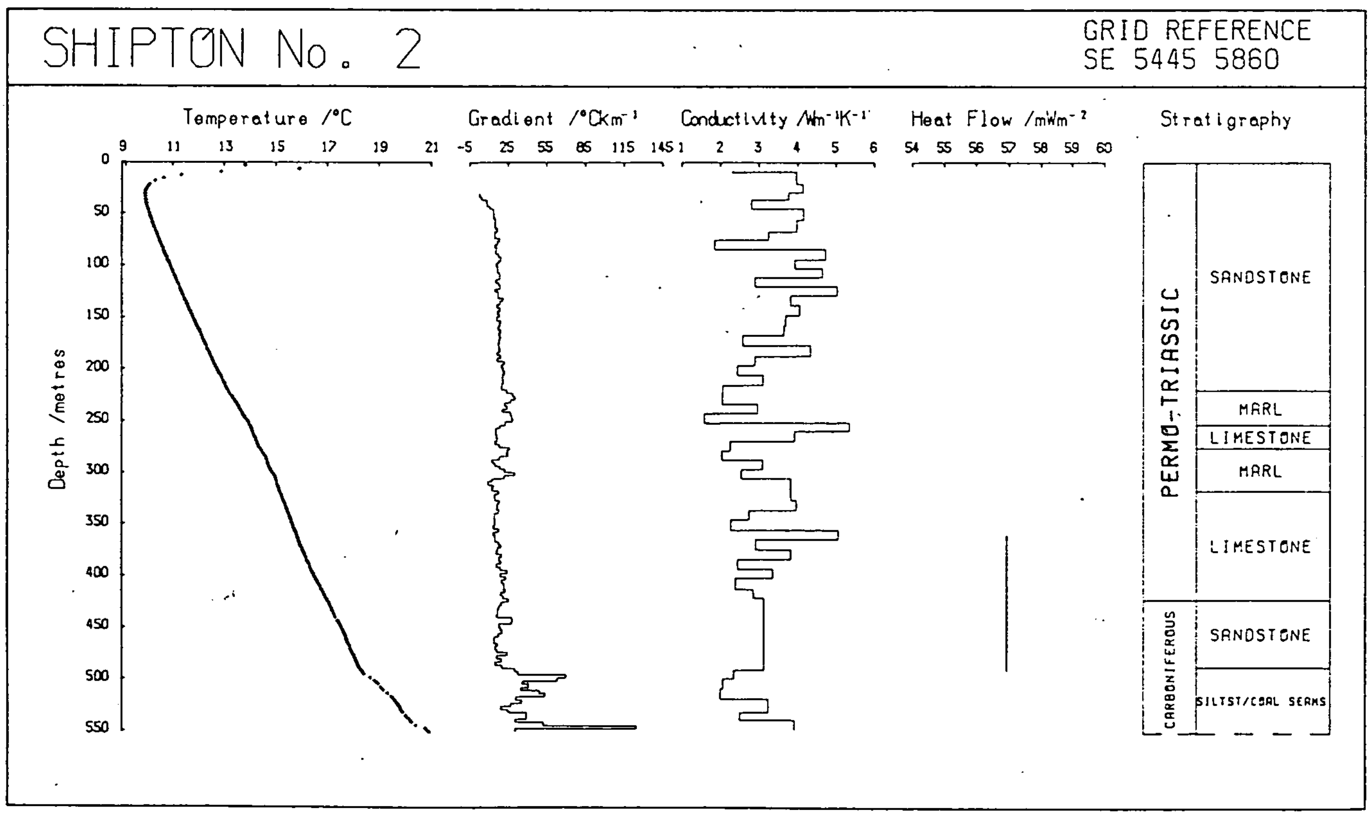

Figure 4.18 Temperature, conductivity and heat flow plots for Shipton

The Cleethorpes No. 1 well (Figure 4.20) penetrates a sequence from the Upper Cretaceous to the Carboniferous terminating in the Coal Measures at 2100 m depth. Only one temperature logging run was practicable at this site and this was carried out to a depth of 1850 m 22 months after completion of the hole. Thermal conductivities were determined on chip samples at 20 m intervals in the depth range 100 to 1860 m and on 10 Sherwood Sandstone core samples from between 1112 and 1322 m depth. Porosity correction to the chip conductivity data was possible in the Sherwood Sandstone only and there was good correspondence between the corrected values and those determined on core samples at similar depths. In addition, a Bullard plot of the data showed this to be the least disturbed section and the heat flow determination was based on data from this unit between 1080 and 1470 m depth. The resulting value was 72 mWm^{-2}. Similar values were determined in other sections of the borehole. In the Upper Chalk between 120 and 280 m a value of 76 mWm^{-2} was determined. Between the base of the Ancholme Clay and Redbourne Groups, over the depth range of 480 and 600 m, a value of 74 mWm^{-2} was obtained. Elsewhere in the borehole the temperatures were either disturbed or the determined thermal conductivities were higher than expected for the units in question. This applied chiefly to the clays, which were presumed to have undergone irreversible compositional changes since they were extracted from the borehole. The final heat flow at this site is based on a mean of the three determinations detailed above and this is 73 mWm^{-2}.

On the basis of the four new determinations in this region, small modifications to the boundaries of the heat flow anomaly have been made and Figure 4.21 shows the new heat flow pattern for this region.

4.5 Lancashire

In the Geothermal Map of the UK, published by the BGS in 1985, a high heat flow closure appears over the Bowland Forest and is linked by the 60 mWm^{-2} contour to the northern England high heat flow anomaly. Main support for the anomaly comes from the Clitheroe No. 1 borehole with a reported heat flow of 84 mWm^{-2} (Wheildon and others, 1985). There being no evidence for buried high heat production granites, Wheildon and Rollin (1986) speculated on the possibility of groundwater flow as the source of this anomaly. Two heat flow boreholes have been drilled to test its extent, and are designated Clitheroe No. 2 and Wray. These and the sites of earlier heat flow measurements and estimates are shown in Figure 4.28.

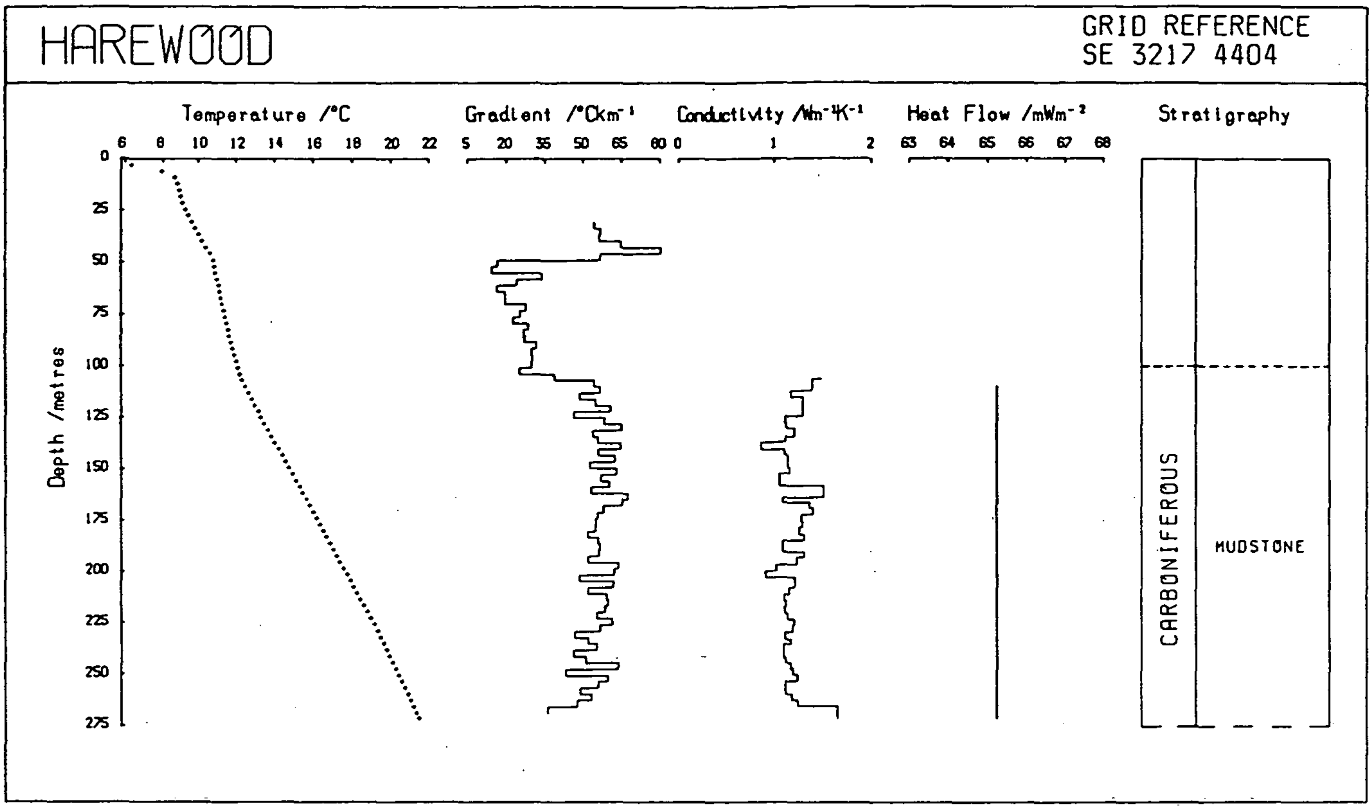

Figure 4.19 Temperature, conductivity and heat flow plots for Harewood

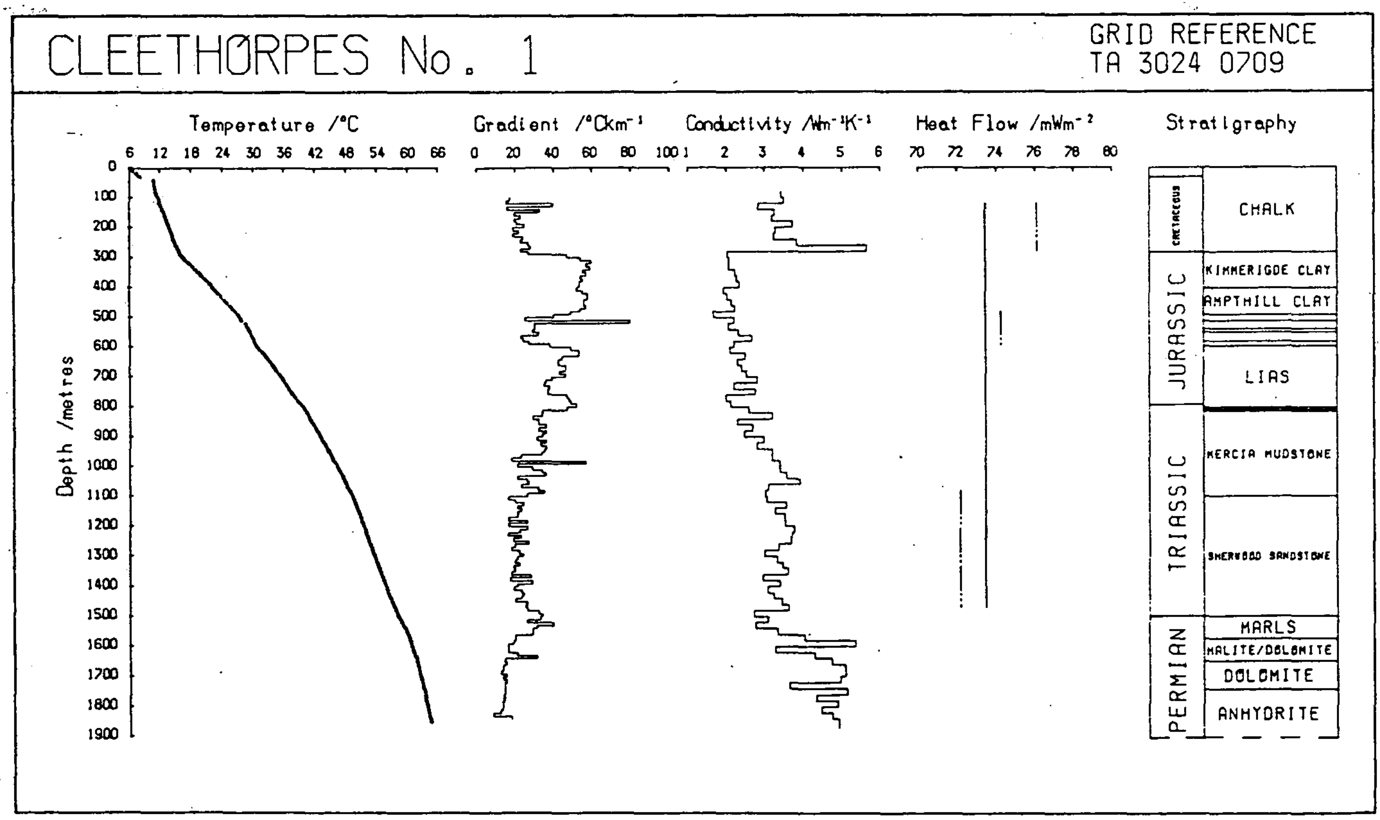

Figure 4.20 Temperature, conductivity and heat flow plots for Cleethorpes No.1

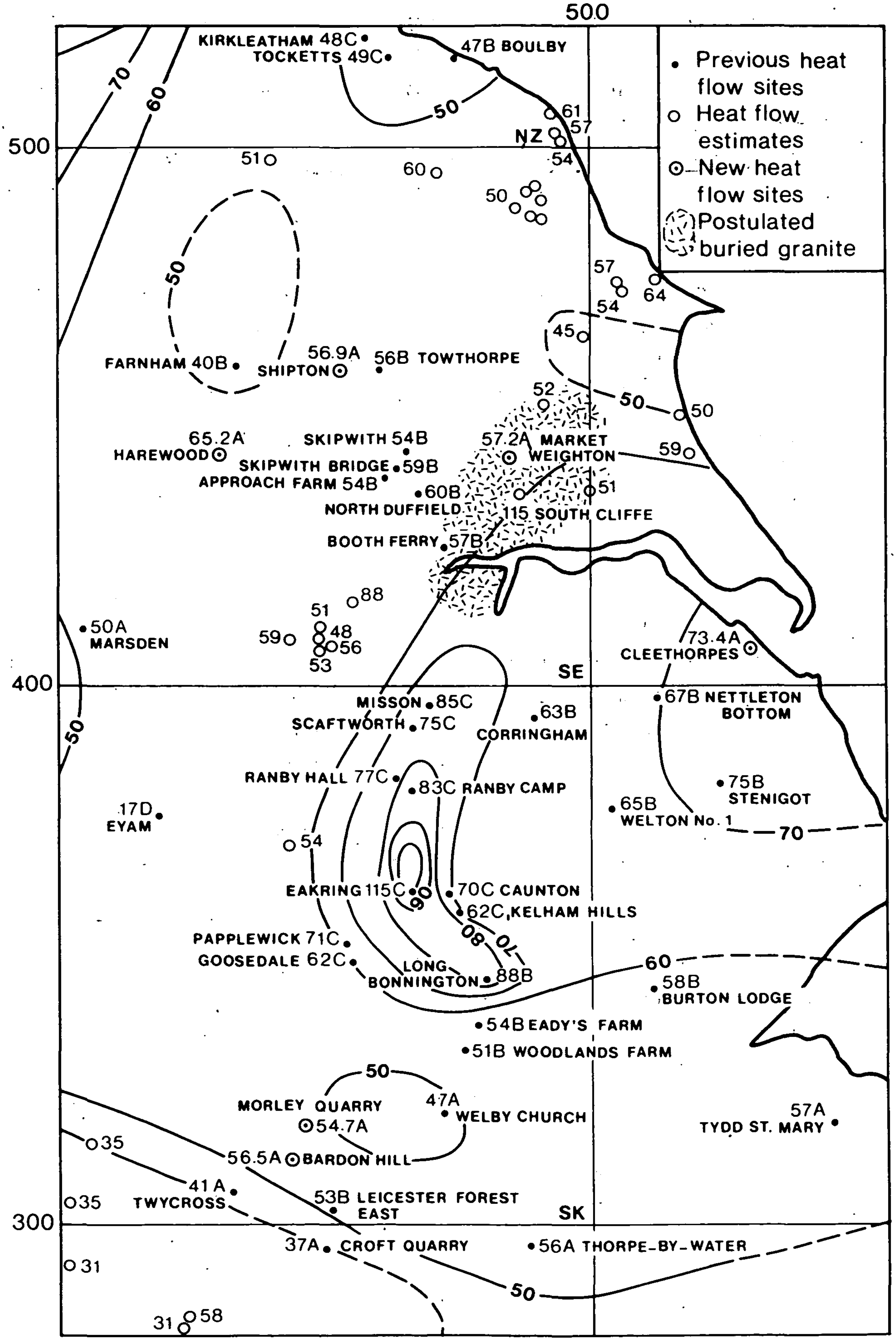

Figure 4.21 Heat flow map for East Yorkshire and Humberside. Units are mWm^{-2}.

The Clitheroe No. 2 borehole (Figure 4.22) was drilled in the Worston Shale Group of the Carboniferous Limestone Series. This is essentially a sequence of calcareous mudstones and interbedded impure limestones. The borehole at Wray (Figure 4.23) intersects mudstones, sandstones and siltstones of the Millstone Grit Series. The depth intervals over which the Bullard gradients were used to determine heat flow were 81 to 300 m for Clitheroe No. 2 and 100 to 303 m at Wray. In both cases the gradients yielded heat flows of 40 mWm^{-2}.

These results convincingly demonstrate that the anomaly associated with Clitheroe No. 1 is confined in area. The borehole was originally drilled as one of a suite of exploration holes into the mineralised Clitheroe fault. The implication is that groundwater flow in this instance is an entirely local phenomenon along discrete flow paths in this complex fault system. Clitheroe No. 1 has therefore been ignored in the contour revision shown in Figure 4.28.

4.6 Cumbria, Tyne-Tees and Northumberland

The main emphasis in this region has been towards improving coverage in and around the Alston Block. It forms part of the BGS investigation of the buried Weardale Granite as a potential hot dry rock resource, close to major centres of population in the Tyne-Tees region. Four new heat flow measurements have been made and are designated Rowlands Gill, Newbiggin, Dufton and Longhorsley. Rowlands Gill was specially drilled to test heat flow over a buried cupola on the north-east flank of the Weardale Granite. The other three were commercial boreholes.

The Rowlands Gill borehole (Figure 4.24) intersects Lower Coal Measures and Millstone Grit sediments mainly comprising rapidly alternating sequences of sandstones, siltstones, mudstones, limestones and some thin coal seams. The complexity of the lithology was such that a good representation of thermal resistance was possible only by combining mean thermal conductivities for each of the above units (with the exception of coal) with thicknesses taken from the stratigraphic log. Water circulation was evident in the upper part of the borehole and the determination is based on the linear section of the thermal resistance plot from 131 m to total depth at 241 m, yielding a heat flow of 100 mWm^{-2}.

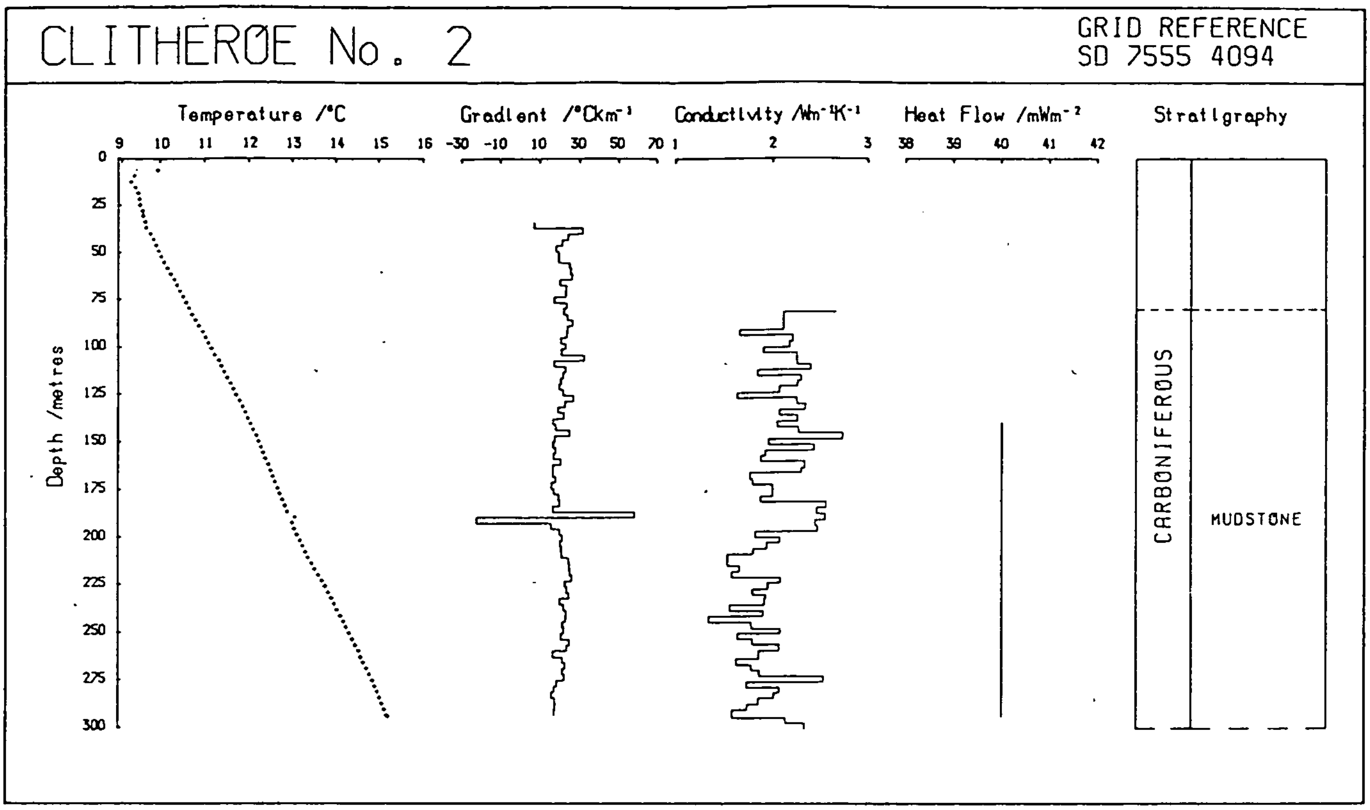

Figure 4.22 Temperature, conductivity and heat flow plots for Clitheroe No.2

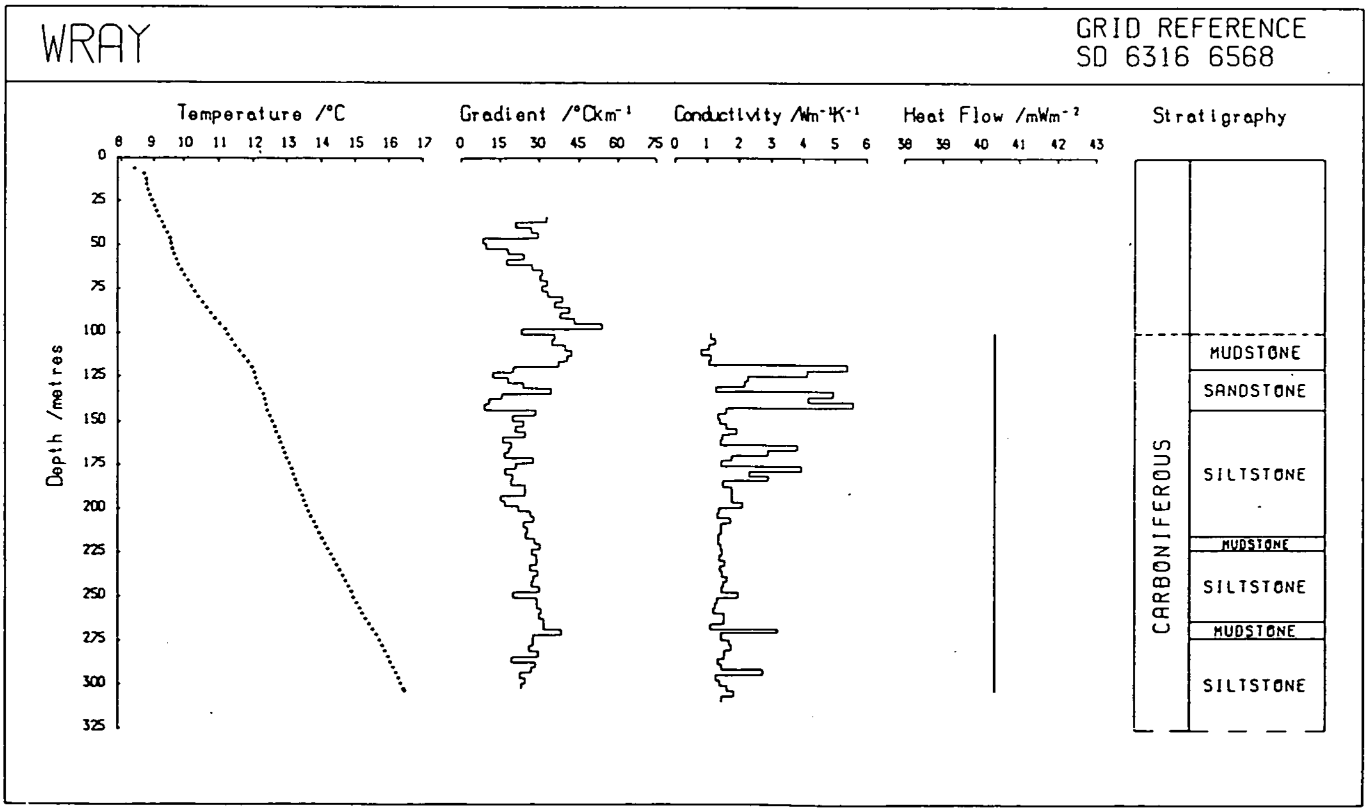

Figure 4.23 Temperature, conductivity and heat flow plots for Wray

The Newbiggin and Dufton boreholes (Figures 4.25 and 4.26), in the Vale of Eden, were drilled by British Gypsum Limited as part of their routine exploration programme for gypsum and anhydrite. They intersect St. Bees Sandstone and the full thickness of the Eden Shales. Coring was restricted to target gypsum and anhydrite beds, with open hole drilling outside these zones. Arrangements were made to deepen the Newbiggin borehole to intersect 30 m of Penrith Sandstone, from which short sections of core were recovered for thermal conductivity control. During the cementing operation most of the deepened part of the borehole was unfortunately lost and the only section for which good thermal conductivity control remained was subject to temperature disturbance as a result of water flow at the base of the Eden Shales. The heat flow is therefore based on observed gradients and thermal conductivity estimates. Using thermal conductivity values for matching lithologies from the Becklees borehole (see Figure 4.28) and appropriate mudrock conductivity values as suggested by Bloomer (1981) a heat flow of 85 mWm^{-2} emerges.

At Dufton, no attempt was made to deepen the borehole into the Penrith Sandstone. Its close proximity and lithological similarity to Newbiggin was a sufficient basis to estimate heat flow through a comparison of geothermal gradients in the two holes. The correspondence of the geothermal gradient signatures at equivalent levels in the Eden Shales was remarkable. It arose substantially through the juxta-position of low conductivity shales and high conductivity anhydrite as virtually identical sequences in the two boreholes. So close are the two geothermal gradient amplitudes that a value of 85 mWm^{-2}, identical to that at Newbiggin, is the best estimate of heat flow at this site.

The borehole at Longhorsley (Figure 4.27) was drilled by Candecca Resources as part of a hydrocarbon exploration programme and cuts Carboniferous sediments. Thermal conductivities were measured on chip samples and corrected for porosities derived from the geophysical logs. The geothermal gradient was based on the mean annual surface temperature and Bottom Hole Temperatures at 1195 m (casing point) 12 hours after circulation, and total depth at 1828 m, 8 hours after circulation. Combining the geothermal gradient and thermal conductivity data leads to a heat flow of 92 mWm^{-2}. The borehole is close to the Causey Park Fault system and the possibility exists that this high value may be the result of groundwater flow.

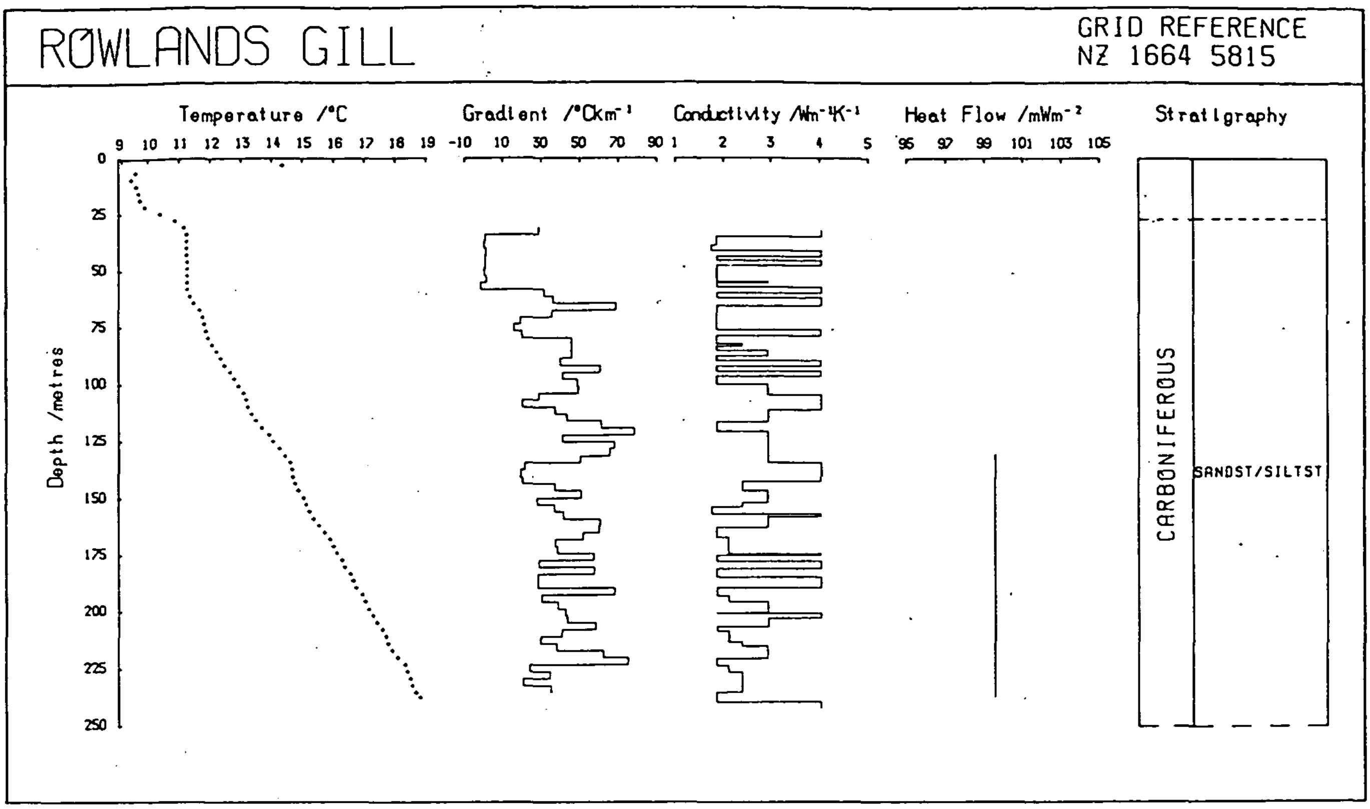

Figure 4.24 Temperature, conductivity and heat flow plots for Rowlands Gill

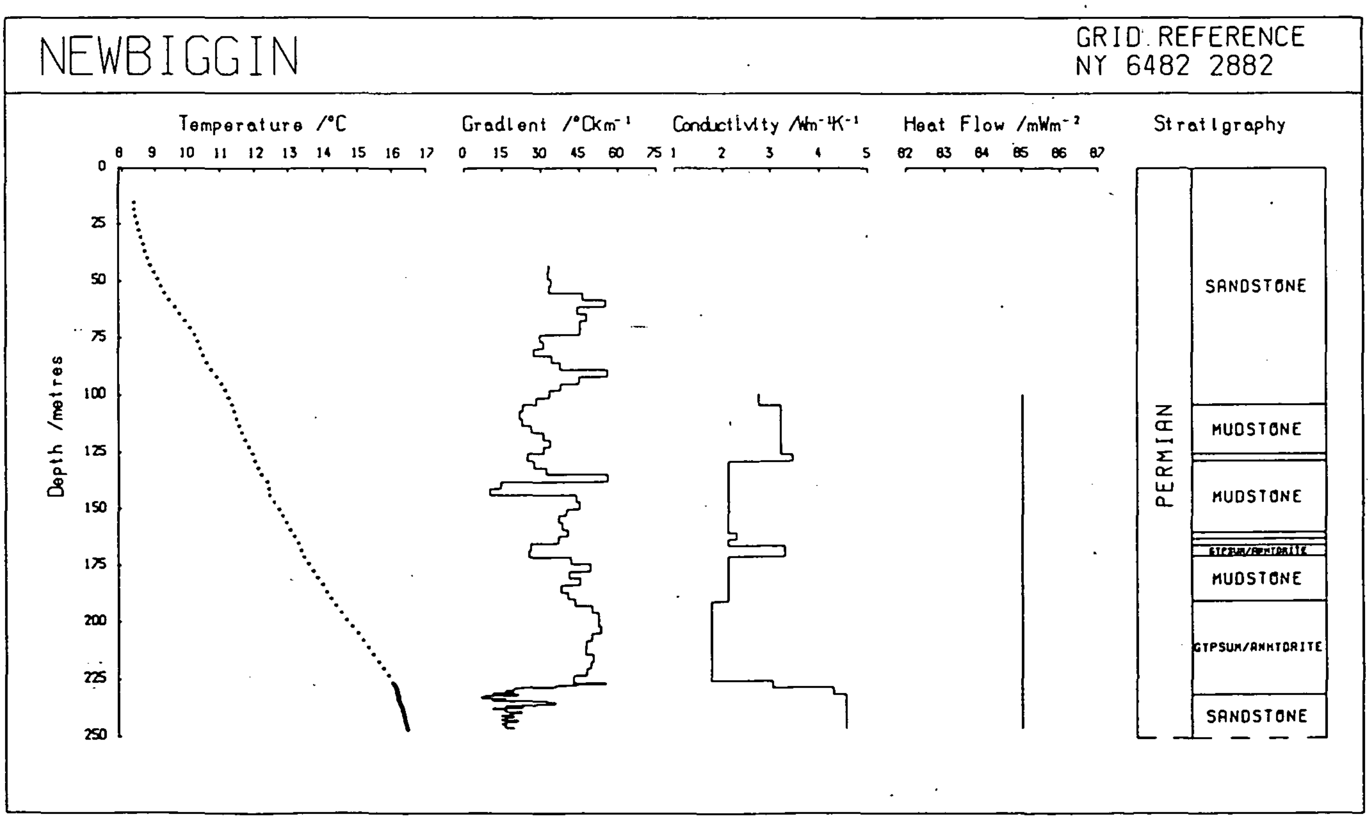

Figure 4.25 Temperature, conductivity and heat flow plots for Newbiggin

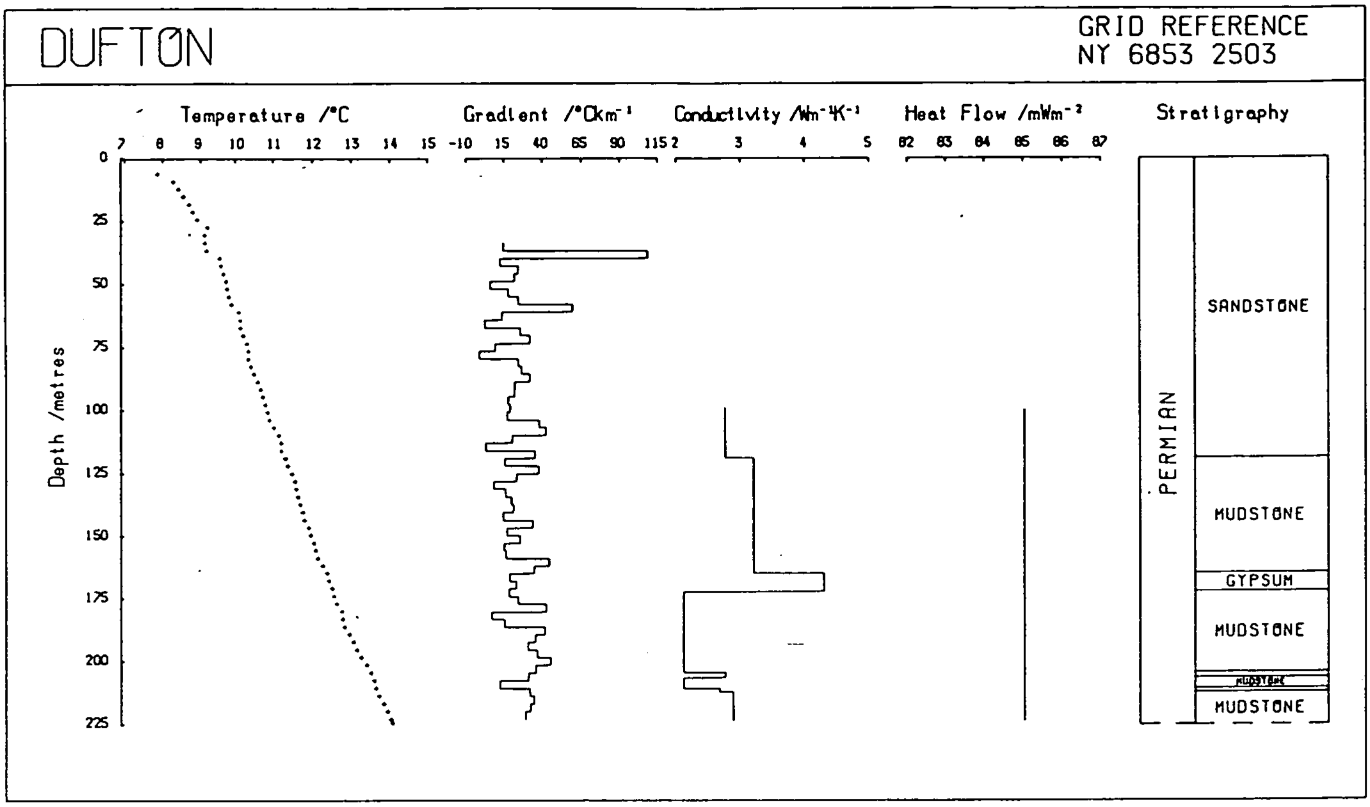

Figure 4.26 Temperature, conductivity and heat flow plots for Dufton

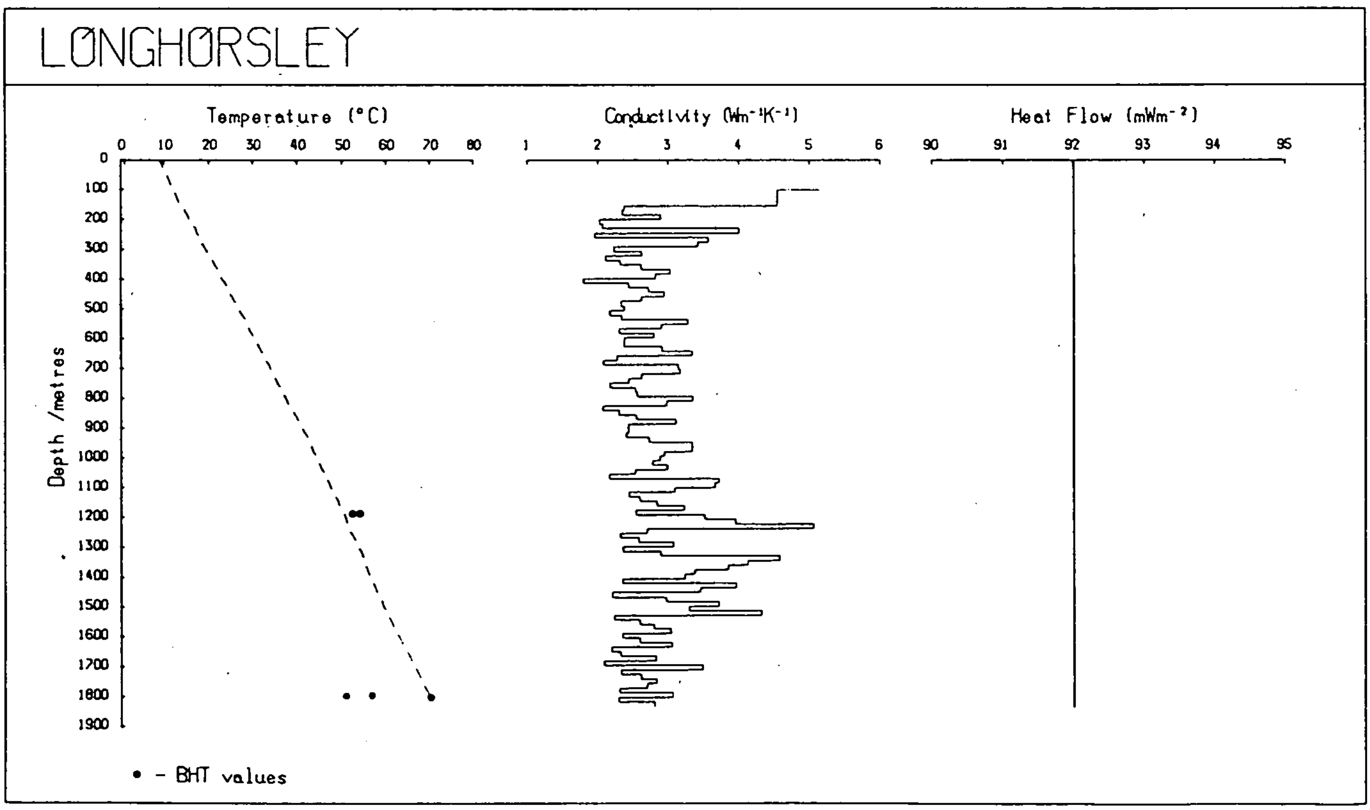

Figure 4.27 Temperature, conductivity and heat flow plots for Longhorsley

The heat flow contour revisions for this region are shown in Figure 4.28. The most significant change has been to extend the high heat flow anomaly associated with the Weardale Granite to the north-east. The revised contours are now in better conformity with the assumed space form of the granite, as derived from gravity interpretations (Bott, 1967). Nevertheless, a greater density of heat flow coverage is required to define the deep geothermal regime with confidence.

4.7 Revised heat flow maps of the UK

The heat flow contour revisions carried out in each of the regions described in Sections 4.1 to 4.6 have been transferred to the UK heat flow map shown in its revised form as Figure 4.29. Bearing in mind that this map is based on 210 heat flow measurements and supported by over 100 heat flow estimates, the detail is greater than that in any comparable land area in the world. The most important changes from the 1984 version (Figure 2.1) are the extension to the north-east of the northern England heat flow anomaly and the elimination of the regional high heat flow in the Bowland Forest area.

A histogram of all 210 measured heat flows is shown in Figure 4.30. The heat flows follow a bimodal distribution with a mean of 68 ± 26 mWm^{-2}. However, this is biased towards the high side because of the large proportion of measurements (about 25 % of the total) being made on or close to the high heat production granite batholiths of south-west England, northern England and the Eastern Highlands of Scotland. If these measurements are removed from the dataset the mean (of 155 observations) is reduced to 56 ± 16 mWm^{-2} and a normal distribution results, the mean and median now being coincident. Since heat transport by convection may have introduced an unquantifiable error in the measured heat flows (assumed to be purely conductive), the agreement between the mean and the median probably implies that the effects of convection have cancelled each other out. Another way of reducing the bias introduced by a variable density of coverage is by using values averaged on a 10 km grid, derived from the heat flow map; the area-weighted mean thus produced is 54 ± 12 mWm^{-2}.

These mean values support the adoption of 55 mWm^{-2} as the nominal background field value and it is reasonable to regard 60 mWm^{-2} as the threshold for heat flow anomalies. Also, it is generally true that coverage

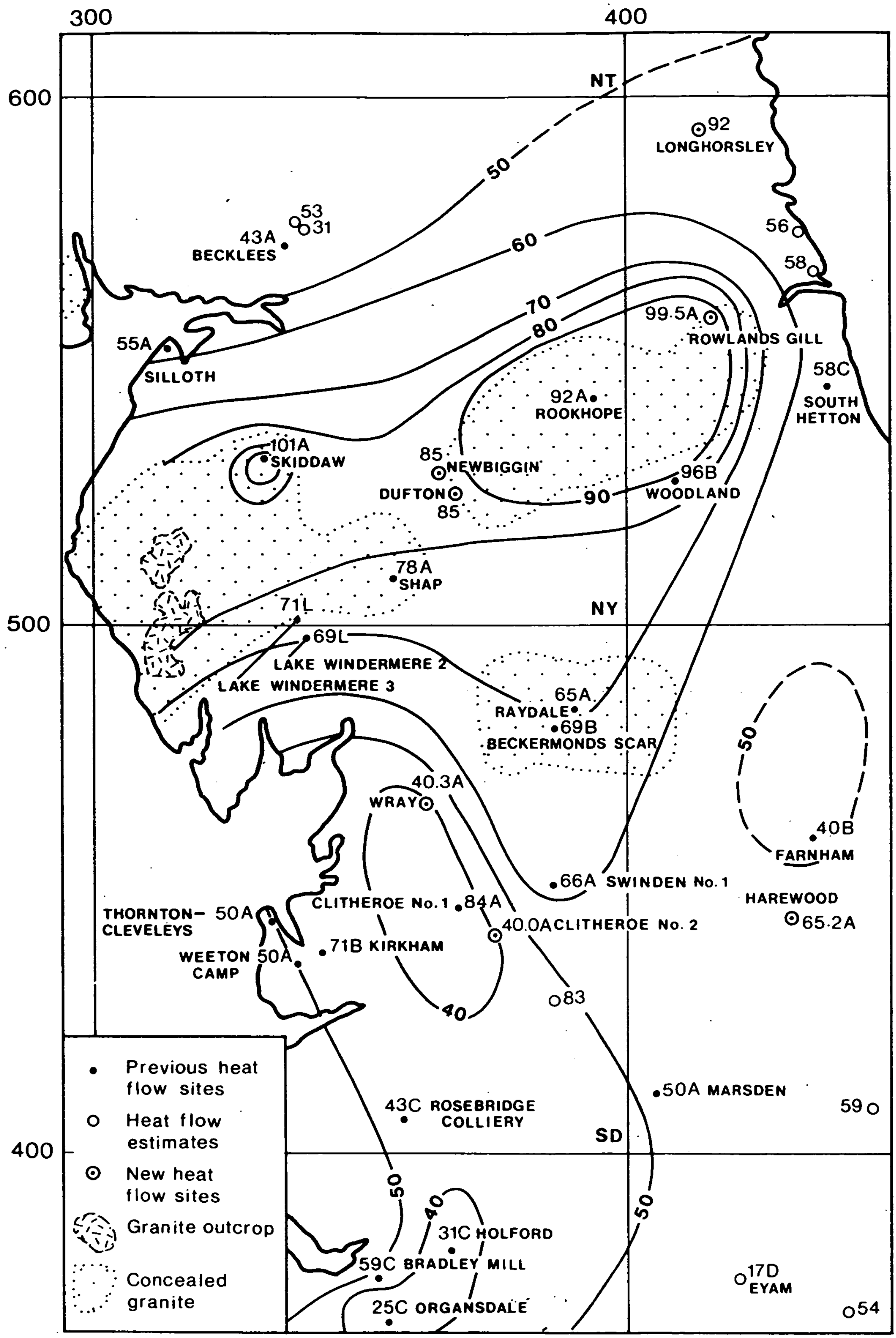

Figure 4.28 Heat flow map for Northern England. Units are mWm^{-2}.

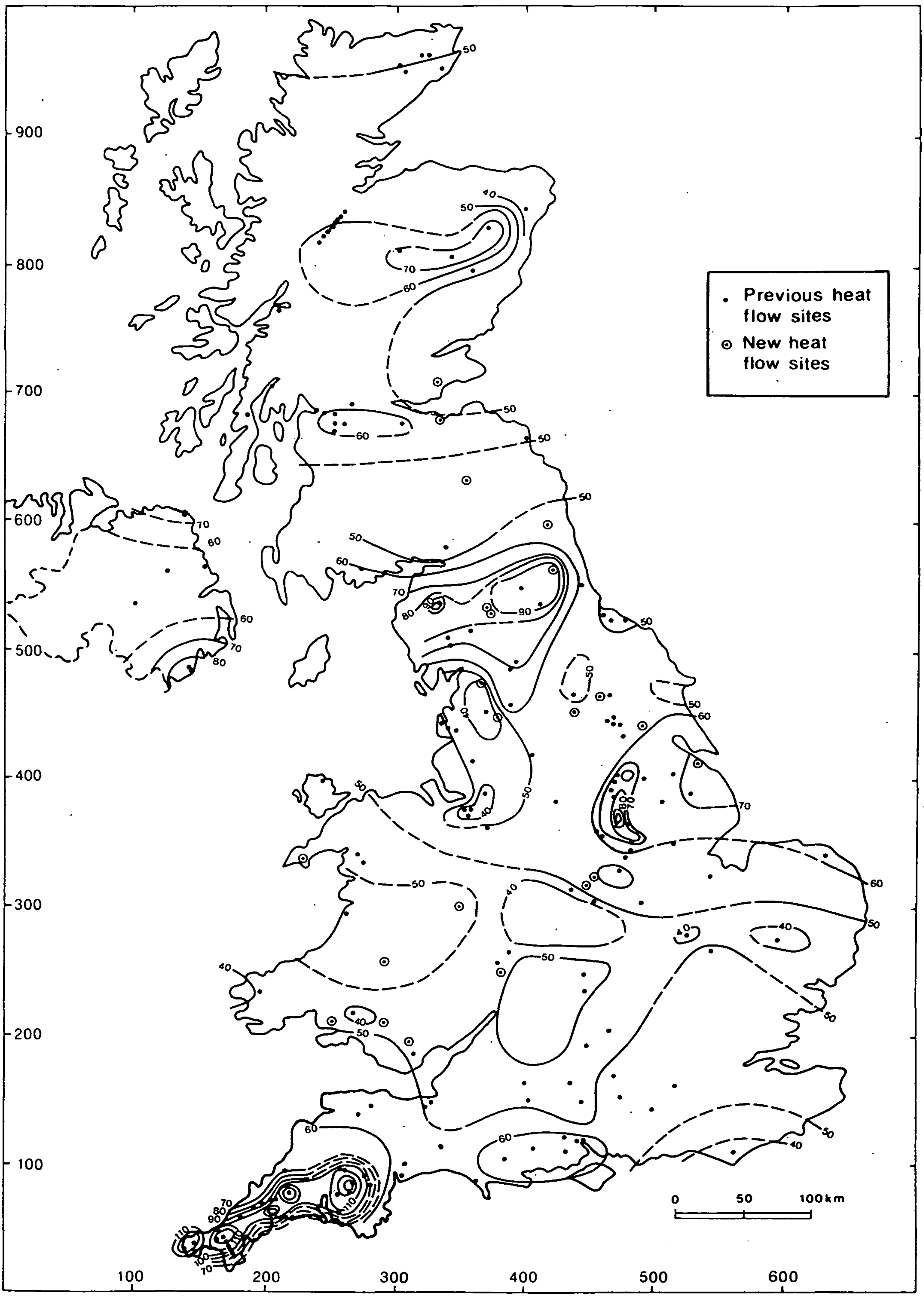

Figure 4.29 Heat flow map of the UK (1987). Units are mWm^{-2}.

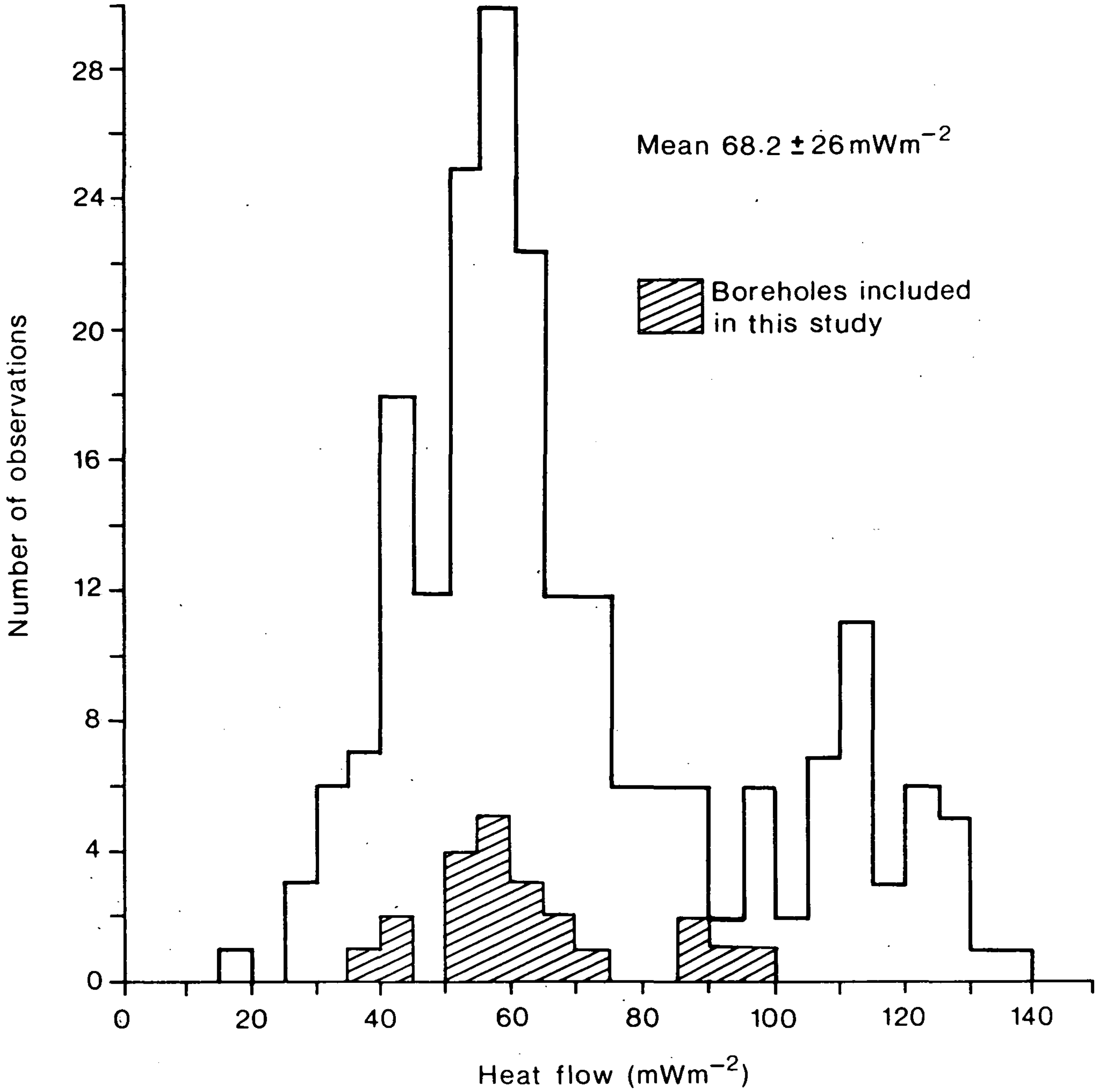

Figure 4.30 Histogram of heat flow data for the UK

in high heat flow areas is rather better than elsewhere, and therefore the contours can be drawn with greater confidence. In areas of average and low heat flow, coverage tends to be sparse and contouring the present data at the 40 and 50 mWm^{-2} levels carries with it considerable uncertainty and could produce spurious and misleading features on the map. Insofar as it is the high heat flow anomalies that are of special interest in the present investigation in any case, a more useful representation of the heat flow field is achieved through omitting contours below 60 mWm^{-2}, recognising that below that level there is a variable background with a mean close to 55 mWm^{-2}. Figure 4.31 is a representation of the heat flow field in this form.

5 CONCLUSIONS

The important changes in the UK heat flow field arising from these new measurements have been to extend the northern England heat flow anomaly rather further to the north-east, and to remove the Bowland Forest anomaly, which has been demonstrated to be an entirely local feature. A case has been presented for removing the 40 and 50 mWm^{-2} contours from the heat flow map. The resulting map may appear to be less informative, but is more realistic. Undulations around the background value, probably best represented at present by the basement heat flow value at Morley Quarry, must be extremely complex. All measurements within younger non-metamorphic strata must be regarded as being of *apparent* conductive heat flow, influenced to some generally unquantifiable extent by groundwater flow. Proper definition of variations in this background field, except in areas such as Eakring, where a large number of observations are available, is impossible with the available data. To define it on a national scale would require far more heat flow measurements, involving inordinate expenditure of effort and money, and is an unattainable goal at present.

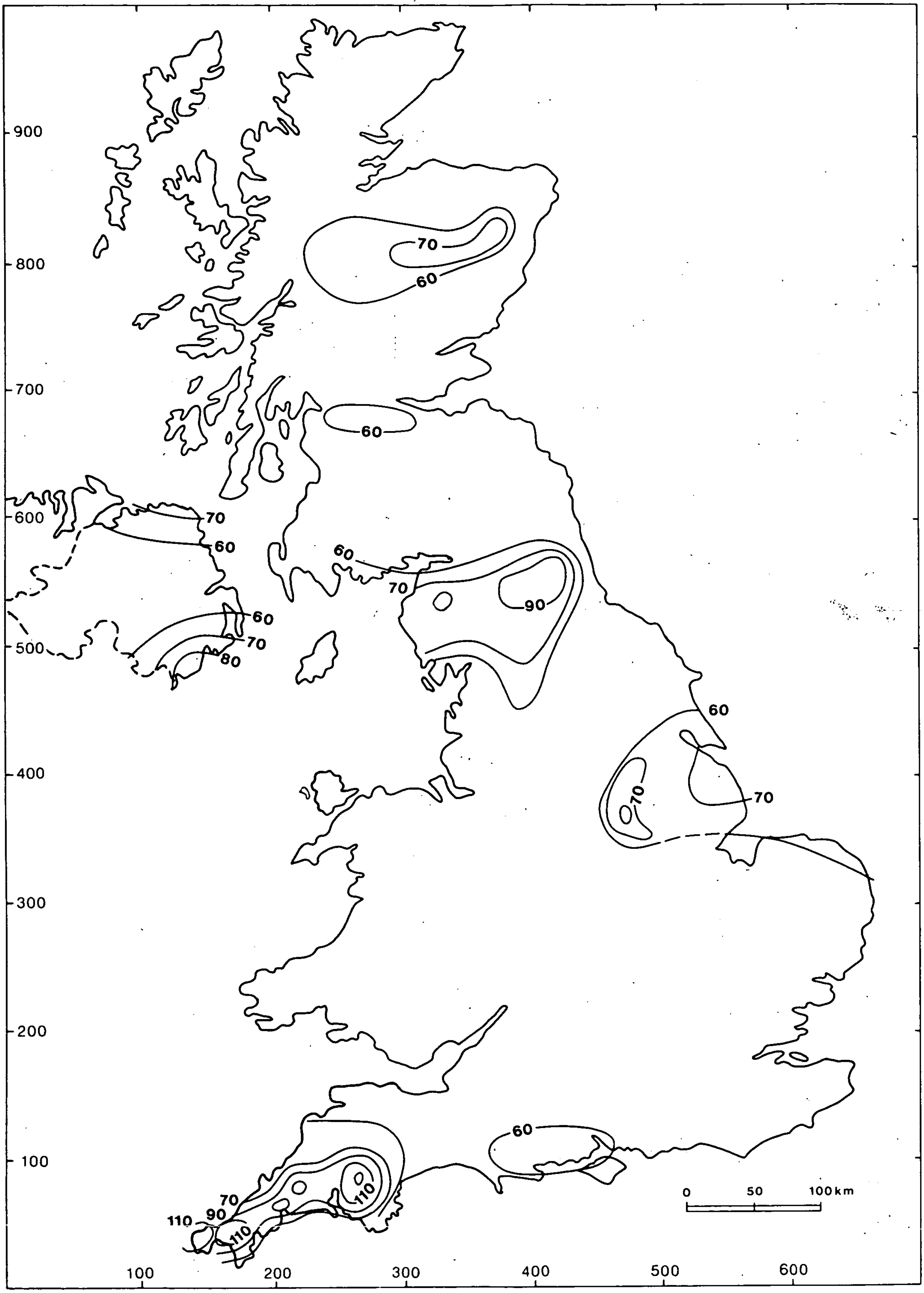

Figure 4.31 Heat flow map of the UK (1987, omitting contours below 60 mWm⁻²) Units are mWm⁻².

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Appendix 1. TABLES OF HEAT PRODUCTION DATA

The following Tables and Figures list and show in graphical form the heat production data acquired to support the heat flow determinations in basement rocks in central England. All the measurements were carried out on crushed rock samples using the laboratory gamma-ray spectrometry system referenced in the text.

Table No.	Borehole name
A1.1	Morley Quarry
A1.2	Bardon Hill
A1.3	Wyche (Malvern)
A1.4	Church Stretton

Figure No.	
A1.1	Morley Quarry
A1.2	Bardon Hill
A1.3	Wyche (Malvern)
A1.4	Church Stretton

Table A1.1 Morley Quarry - heat production results

Depth interval	Potassium %	±	Uranium ppm	±	Thorium ppm	±	Th/U Ratio	±	Heat production μWm^{-3}	±
0- 10	1.21	0.04	0.41	0.13	1.83	0.26	4.43	1.96	0.35	0.05
10- 30	2.06	0.05	0.71	0.15	3.11	0.32	4.37	1.39	0.59	0.07
30- 50	0.98	0.06	1.25	0.21	6.77	0.45	5.40	1.28	0.88	0.09
50- 70	1.88	0.06	1.20	0.21	7.51	0.45	6.26	1.49	1.00	0.09
70- 90	2.47	0.07	1.34	0.22	6.86	0.45	5.10	1.16	1.04	0.09
90-110	1.88	0.06	1.43	0.21	6.51	0.43	4.56	0.96	0.99	0.09
110-130	1.19	0.06	1.63	0.23	7.25	0.47	4.45	0.90	1.02	0.10
130-150	2.32	0.06	0.87	0.17	3.81	0.34	4.36	1.22	0.70	0.07
150-170	2.37	0.05	0.80	0.15	2.97	0.31	3.71	1.07	0.63	0.06
170-190	1.05	0.04	0.67	0.15	2.65	0.31	3.99	1.36	0.45	0.06
190-210	1.54	0.04	0.58	0.13	1.97	0.26	3.37	1.18	0.43	0.05
210-230	2.43	0.05	0.70	0.14	2.73	0.30	3.89	1.22	0.59	0.06
230-250	2.50	0.07	1.36	0.24	8.55	0.51	6.31	1.48	1.17	0.10
250-270	2.27	0.07	1.49	0.22	7.14	0.45	4.80	1.01	1.08	0.09
270-290	2.25	0.07	1.28	0.21	7.55	0.44	5.92	1.32	1.06	0.09
290-310	2.37	0.07	1.32	0.22	7.63	0.47	5.77	1.31	1.08	0.10
310-330	2.03	0.07	1.30	0.22	7.48	0.45	5.77	1.31	1.03	0.09
330-350	2.43	0.06	1.34	0.19	5.17	0.38	3.85	0.82	0.92	0.08
350-370	2.23	0.07	1.81	0.22	7.14	0.45	3.95	0.74	1.16	0.09
370-390	1.85	0.06	1.58	0.21	7.38	0.44	4.66	0.91	1.08	0.09
390-410	1.94	0.06	1.28	0.20	6.17	0.42	4.80	1.09	0.93	0.09
410-430	1.32	0.05	0.81	0.16	3.76	0.33	4.67	1.35	0.59	0.07
430-450	1.82	0.07	1.66	0.23	7.95	0.48	4.80	0.95	1.14	0.10
450-470	1.68	0.06	1.25	0.19	6.06	0.39	4.84	1.03	0.89	0.08
470-490	1.79	0.07	1.71	0.22	7.16	0.46	4.19	0.81	1.10	0.09
490-510	1.32	0.04	0.75	0.15	3.55	0.30	4.74	1.32	0.56	0.06
510-530	1.74	0.06	1.34	0.19	5.71	0.39	4.28	0.91	0.90	0.08
530-550	0.83	0.03	0.24	0.12	1.31	0.24	5.40	3.56	0.23	0.05
550-570	0.37	0.03	0.44	0.13	2.07	0.26	4.73	1.96	0.29	0.05
570-590	0.70	0.04	0.55	0.13	2.08	0.27	3.79	1.40	0.35	0.06
590-610	0.56	0.04	0.85	0.16	3.58	0.34	4.22	1.21	0.52	0.07
610-630	0.33	0.03	0.58	0.13	2.53	0.28	4.39	1.49	0.35	0.06
630-650	0.30	0.03	0.63	0.14	2.66	0.28	4.24	1.37	0.37	0.06
650-670	0.23	0.03	0.71	0.13	2.25	0.26	3.17	0.93	0.36	0.05
670-690	1.70	0.05	0.71	0.15	2.86	0.30	4.05	1.25	0.54	0.06
690-710	1.35	0.04	0.86	0.14	2.54	0.29	2.95	0.83	0.52	0.06
710-730	0.61	0.03	0.80	0.13	2.58	0.25	3.24	0.83	0.44	0.05
730-750	0.65	0.03	0.70	0.12	2.10	0.25	3.00	0.88	0.38	0.05
750-770	0.75	0.04	0.72	0.13	2.40	0.27	3.35	1.01	0.42	0.06
783	0.44	0.04	0.77	0.13	2.58	0.27	3.38	0.94	0.41	0.06
787	0.13	0.03	0.85	0.12	2.14	0.25	2.53	0.66	0.38	0.05
791	1.24	0.04	0.60	0.13	2.61	0.27	4.35	1.40	0.45	0.06
795	0.17	0.03	0.70	0.13	2.59	0.27	3.71	1.10	0.37	0.06
799	2.25	0.05	0.70	0.13	2.80	0.27	4.01	1.15	0.58	0.06
803	1.35	0.04	0.66	0.13	2.30	0.26	3.48	1.06	0.45	0.05
808	1.09	0.04	0.68	0.13	2.45	0.26	3.62	1.07	0.44	0.05
811	0.92	0.04	0.80	0.14	2.92	0.29	3.65	1.02	0.49	0.06
816	0.21	0.03	0.73	0.14	3.04	0.28	4.17	1.18	0.41	0.06
820	1.12	0.05	0.75	0.16	3.18	0.32	4.22	1.32	0.52	0.07
822	0.77	0.04	0.79	0.16	2.64	0.32	3.36	1.07	0.45	0.07
830	0.94	0.05	0.75	0.16	3.62	0.33	4.85	1.47	0.53	0.07
834	0.67	0.04	0.66	0.14	2.63	0.28	3.98	1.26	0.41	0.06
Mean	1.36		0.94		4.17		4.29		0.65	
Std. dev.	0.74		0.38		2.18		0.84		0.29	

Table A1.2 Bardon Hill - heat production results

Depth interval	Potasium %	±	Uranium ppm	±	Thorium ppm	±	Th/U Ratio	±	Heat production μWm^{-3}	±
5- 10	0.40	0.03	0.63	0.11	1.60	0.22	2.53	0.78	0.31	0.05
10- 20	0.55	0.03	0.58	0.12	1.70	0.25	2.92	1.03	0.32	0.05
20- 30	0.37	0.03	0.70	0.11	1.28	0.23	1.82	0.62	0.30	0.05
40- 50	0.50	0.03	0.62	0.12	1.64	0.25	2.63	0.91	0.32	0.05
50- 60	0.45	0.03	0.44	0.11	1.26	0.23	2.84	1.23	0.24	0.05
60- 70	0.19	0.03	0.41	0.11	1.51	0.24	3.72	1.64	0.23	0.05
70- 80	0.17	0.03	0.51	0.11	1.07	0.22	2.08	0.86	0.22	0.05
80- 90	0.50	0.03	0.22	0.12	1.82	0.26	8.22	5.70	0.23	0.05
90-100	0.62	0.04	0.76	0.13	1.79	0.26	2.35	0.73	0.38	0.05
100-110	1.02	0.04	0.62	0.12	1.81	0.26	2.91	0.99	0.38	0.05
110-120	0.50	0.03	0.43	0.12	1.81	0.25	4.20	1.71	0.28	0.05
130-140	1.26	0.04	0.56	0.13	1.46	0.26	2.62	1.06	0.36	0.05
140-150	0.80	0.04	0.46	0.12	1.72	0.25	3.74	1.51	0.31	0.05
Mean	0.56		0.53		1.57		3.27		0.30	
Std. dev	0.31		0.14		0.25		1.63		0.06	

Table A1.3 Wyche (Malvern) - heat production results

Depth interval	Potasium %	±	Uranium ppm	±	Thorium ppm	±	Th/U Ratio	±	Heat production μWm^{-3}	±
2- 5	2.11	0.07	1.56	0.21	8.53	0.45	5.49	1.04	1.18	0.09
5-10	1.79	0.06	1.23	0.20	7.34	0.43	5.95	1.32	0.99	0.09
10-15	1.99	0.06	1.51	0.20	6.82	0.41	4.51	0.87	1.04	0.09
15-20	3.13	0.09	3.62	0.28	11.49	0.55	3.18	0.40	2.01	0.12
20-25	2.69	0.07	2.71	0.21	7.39	0.40	2.73	0.36	1.45	0.09
25-30	2.04	0.07	2.23	0.23	8.57	0.46	3.84	0.60	1.35	0.10
30-35	2.34	0.06	1.40	0.18	6.42	0.38	4.57	0.86	1.02	0.08
35-40	2.66	0.07	1.80	0.23	8.74	0.47	4.87	0.87	1.31	0.10
40-45	2.30	0.08	2.46	0.26	11.50	0.55	4.67	0.73	1.63	0.11
45-50	2.25	0.07	1.81	0.21	8.05	0.42	4.45	0.75	1.22	0.09
50-55	1.13	0.05	1.32	0.18	5.76	0.36	4.37	0.85	0.84	0.07
55-60	1.11	0.05	1.53	0.17	5.77	0.35	3.78	0.66	0.89	0.07
60-65	4.01	0.09	1.90	0.27	12.87	0.59	6.78	1.29	1.74	0.12
65-70	3.30	0.09	5.33	0.30	10.98	0.55	2.06	0.22	2.42	0.12
70-75	3.64	0.10	3.49	0.33	14.99	0.67	4.29	0.59	2.26	0.14
75-80	5.24	0.11	2.98	0.34	15.08	0.69	5.07	0.81	2.29	0.14
80-85	4.67	0.09	5.05	0.27	8.62	0.48	1.71	0.19	2.32	0.11
85-90	4.32	0.09	4.39	0.25	7.62	0.45	1.74	0.20	2.05	0.10
90-95	2.99	0.09	3.99	0.29	11.69	0.57	2.93	0.36	2.10	0.12
95-97	3.71	0.10	3.61	0.32	14.13	0.64	3.91	0.53	2.24	0.14
Mean	2.87		2.70		9.62		4.05		1.62	
Std. dev	1.13		1.29		3.00		1.35		0.55	

Table A1.4 Church Stretton - heat production results

Depth interval	Potasium %	±	Uranium ppm	±	Thorium ppm	±	Th/U Ratio	±	Heat production μWm^{-3}	±
0- 2	0.86	0.05	0.94	0.19	4.61	0.38	4.90	1.37	0.64	0.08
2- 4	0.73	0.05	0.75	0.18	3.82	0.37	5.08	1.74	0.52	0.08
4- 6	0.51	0.04	0.69	0.17	3.89	0.35	5.65	1.91	0.49	0.07
6- 8	0.26	0.04	0.86	0.18	3.75	0.36	4.37	1.35	0.50	0.08
8-10	0.34	0.04	0.79	0.16	3.42	0.32	4.34	1.28	0.47	0.07
10-12	0.38	0.04	0.60	0.15	3.01	0.31	5.03	1.82	0.40	0.06
12-14	0.26	0.04	0.55	0.14	1.95	0.28	3.54	1.41	0.30	0.06
12-14*	0.27	0.04	0.94	0.14	3.96	0.28	4.23	0.91	0.54	0.06
14-16	0.35	0.04	1.29	0.15	4.25	0.29	3.30	0.60	0.65	0.06
16-18	0.34	0.03	1.05	0.13	4.34	0.27	4.14	0.78	0.60	0.06
18-20	0.33	0.03	1.14	0.13	3.79	0.26	3.32	0.60	0.58	0.05
20-22	0.47	0.04	1.34	0.14	4.09	0.27	3.06	0.52	0.67	0.06
22-24	0.36	0.04	1.16	0.14	4.48	0.28	3.85	0.71	0.64	0.06
24-26	0.28	0.03	1.11	0.12	4.01	0.25	3.60	0.62	0.59	0.05
26-28	0.89	0.05	1.45	0.17	6.15	0.34	4.25	0.73	0.88	0.07
28-30	1.00	0.05	1.47	0.16	5.82	0.33	3.97	0.67	0.87	0.07
30-32	1.28	0.05	1.44	0.16	6.55	0.34	4.55	0.75	0.94	0.07
32-34	0.93	0.04	1.08	0.13	4.62	0.27	4.27	0.78	0.68	0.06
34-36	1.15	0.05	1.36	0.16	6.12	0.33	4.50	0.77	0.87	0.07
36-38	1.10	0.05	1.51	0.17	6.69	0.35	4.44	0.73	0.95	0.07
38-40	1.14	0.05	1.49	0.16	6.11	0.33	4.09	0.67	0.91	0.07
40-42	1.31	0.05	1.52	0.17	6.35	0.34	4.17	0.69	0.95	0.07
42-44	1.09	0.05	1.31	0.16	6.21	0.33	4.75	0.82	0.86	0.07
44-46	1.10	0.05	1.62	0.17	6.49	0.35	4.00	0.64	0.96	0.07
46-48	0.80	0.05	1.47	0.17	6.83	0.36	4.64	0.79	0.92	0.07
48-50	1.06	0.06	1.60	0.21	7.59	0.43	4.74	0.88	1.03	0.09
50-52	1.39	0.05	1.26	0.17	5.45	0.35	4.32	0.87	0.83	0.07
52-54	1.13	0.05	1.18	0.17	5.46	0.35	4.64	0.96	0.78	0.07
54-56	0.90	0.05	0.98	0.17	4.77	0.33	4.88	1.16	0.66	0.07
56-58	0.96	0.05	1.16	0.17	5.08	0.34	4.40	0.95	0.73	0.07
58-60	1.23	0.05	1.32	0.18	5.69	0.36	4.29	0.86	0.84	0.08
60-62	1.16	0.05	1.20	0.17	4.96	0.33	4.15	0.85	0.75	0.07
62-64	0.86	0.04	1.02	0.16	4.41	0.32	4.31	0.98	0.65	0.07
64-66	1.44	0.05	1.22	0.18	5.63	0.36	4.62	0.98	0.83	0.08
66-68	0.89	0.05	0.95	0.17	5.03	0.33	5.28	1.27	0.67	0.07
68-70	0.92	0.05	1.02	0.17	4.79	0.33	4.70	1.09	0.68	0.07
70-72	1.12	0.04	1.02	0.15	4.37	0.31	4.30	0.95	0.66	0.06
72-74	1.34	0.05	0.90	0.16	4.49	0.32	4.98	1.26	0.66	0.07
74-76	1.68	0.05	1.11	0.17	4.83	0.33	4.35	0.95	0.77	0.07
76-78	1.13	0.05	1.11	0.17	5.02	0.33	4.51	0.98	0.74	0.07
78-80	1.14	0.05	1.06	0.16	4.26	0.31	4.03	0.90	0.67	0.07
80-82	1.14	0.05	1.35	0.16	4.73	0.34	3.52	0.68	0.78	0.07
82-84	1.19	0.05	1.15	0.16	4.22	0.34	3.68	0.81	0.69	0.07
84-86	1.08	0.05	1.11	0.15	4.65	0.32	4.17	0.84	0.70	0.06
86-88	1.13	0.05	1.12	0.16	4.77	0.35	4.25	0.92	0.72	0.07
88-90	1.07	0.05	0.99	0.15	4.43	0.32	4.46	1.01	0.66	0.07
90-92	1.08	0.05	1.17	0.16	4.71	0.33	4.03	0.82	0.72	0.07
Mean	0.91		1.15		4.91		4.31		0.71	
Std. dev	0.37		0.25		1.09		0.52		0.16	

* measurements repeated

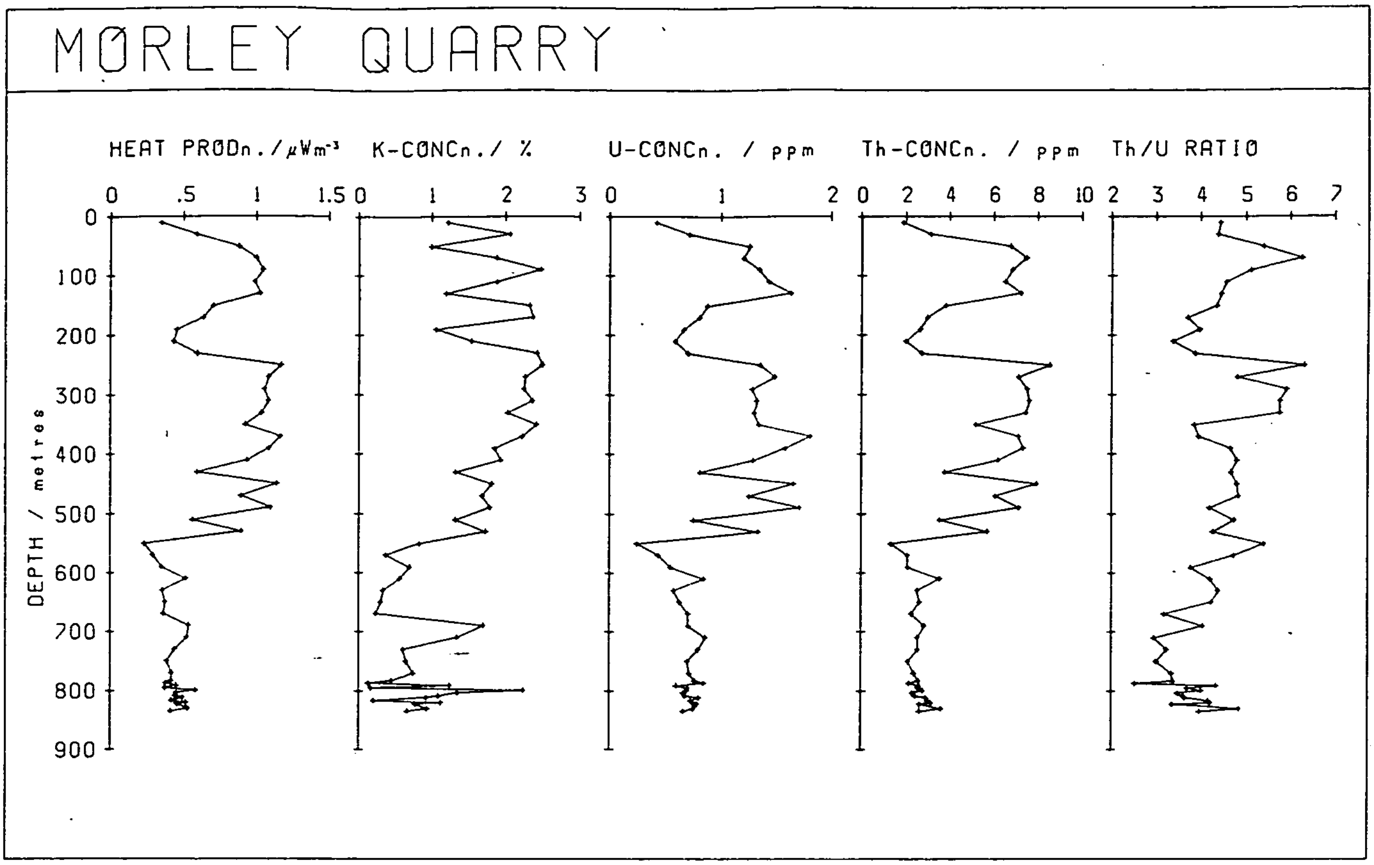

Figure A1.1 Heat production data for Morley Quarry

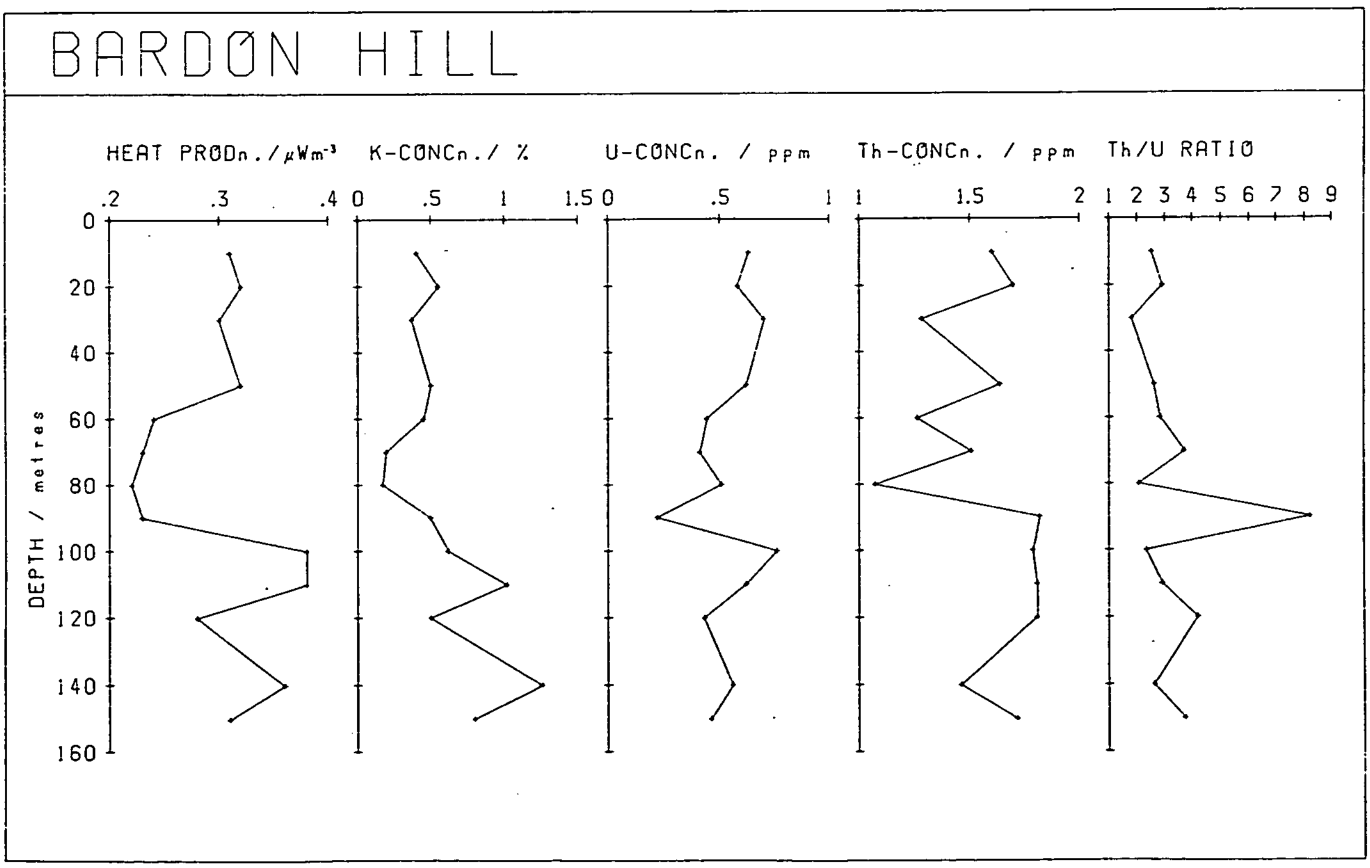

Figure A1.2 Heat production data for Bardon Hill

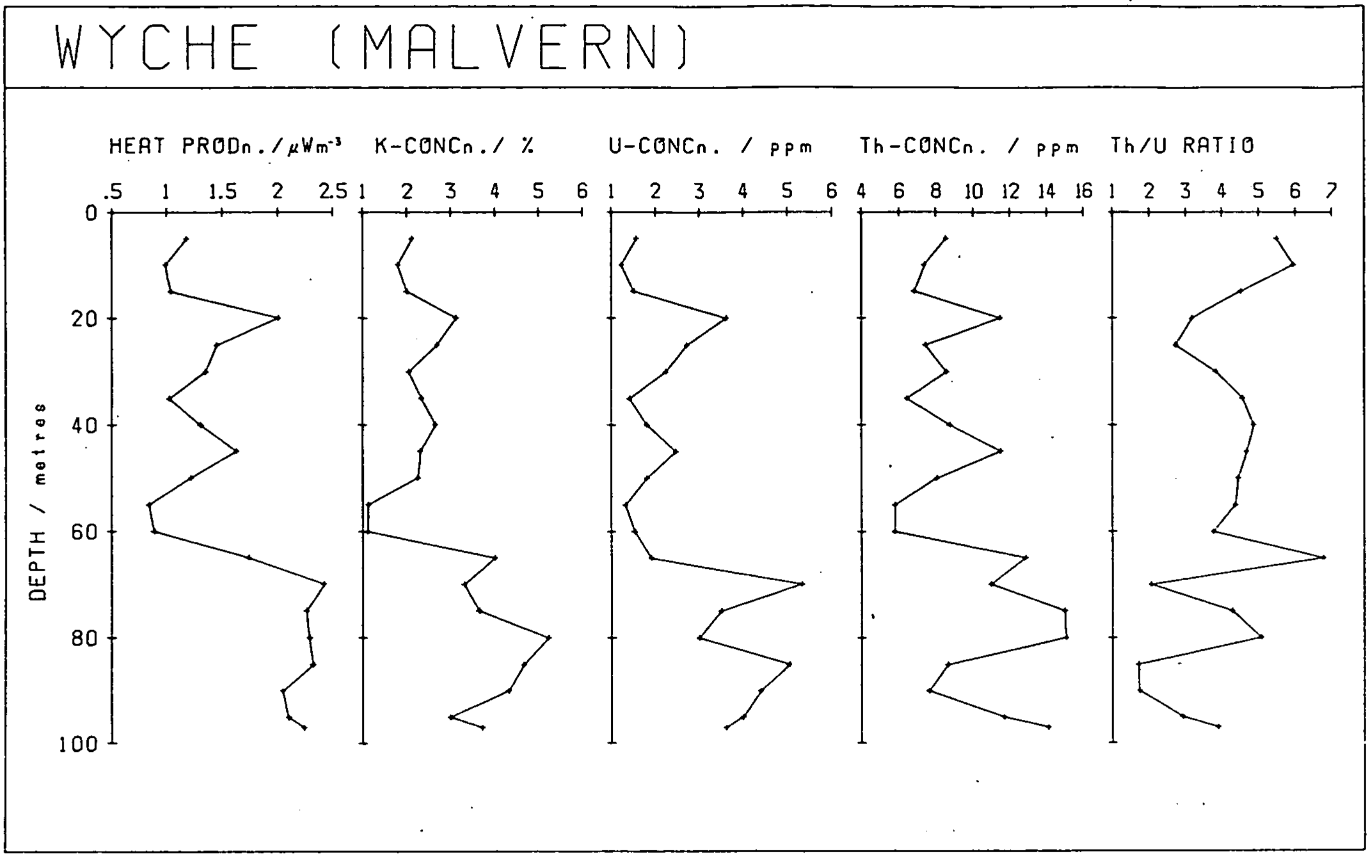

Figure A1.3 Heat production data for Wyche (Malvern)

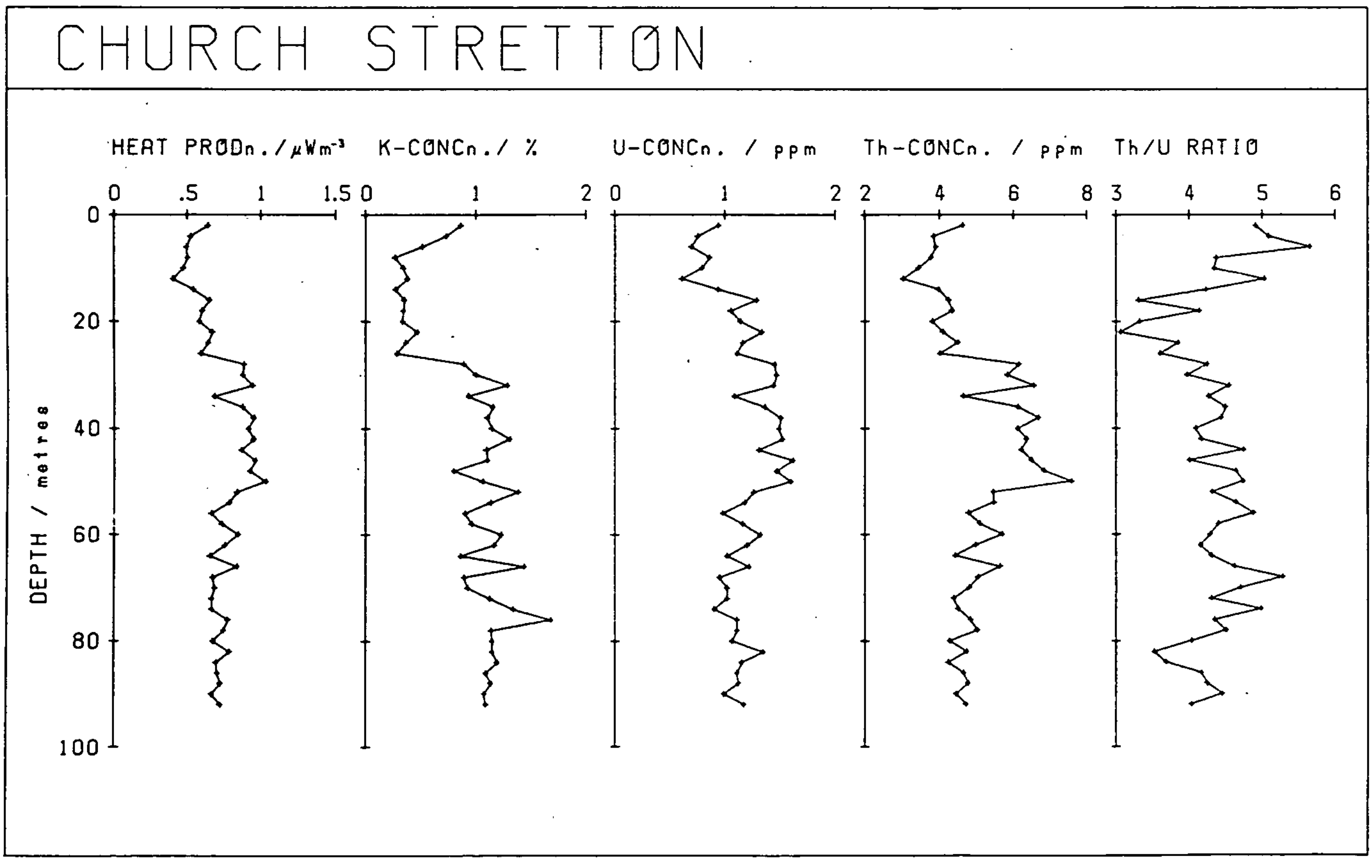

Figure A1.4 Heat production data for Church Stretton

Appendix 2. TABLES OF TEMPERATURE DATA

The tabulated temperature data present the equilibrium or latest temperature data for each of the boreholes studied. These data do not include palaeoclimate or topography corrections. The following is a list of tables for quick reference:

Table A2.1 EQUILIBRIUM TEMPERATURE LOG

Carn Caglau (South Wales) Grid reference: SN 8592 0018

Depth meters	Temperature °C	Depth meters	Temperature °C	Depth meters	Temperature °C
0.00	7.79	119.03	9.69	238.06	12.19
3.05	8.21	122.08	9.88	241.11	12.25
6.10	8.48	125.13	10.09	244.16	12.28
9.16	8.46	128.19	10.20	247.21	12.32
12.21	8.34	131.24	10.26	250.27	12.35
15.26	8.23	134.29	10.34	253.32	12.42
18.31	8.15	137.34	10.41	256.37	12.45
21.36	8.12	140.39	10.55	259.42	12.48
24.42	8.13	143.45	10.60	262.47	12.51
27.47	8.15	146.50	10.64	265.53	12.54
30.52	8.19	149.55	10.68	268.58	12.58
33.57	8.22	152.60	10.73	271.63	12.62
36.62	8.36	155.65	10.80	274.68	12.69
39.68	8.43	158.71	10.82	277.73	12.90
42.73	8.47	161.76	10.86	280.79	12.95
45.78	8.51	164.81	10.91	283.84	13.01
48.83	8.54	167.86	10.92	286.89	13.12
51.88	8.57	170.91	10.96	289.94	13.21
54.94	8.59	173.97	10.99	292.99	13.27
57.99	8.62	177.02	11.04	296.05	13.31
61.04	8.66	180.07	11.08	299.10	13.35
64.09	8.69	183.12	11.11	302.15	13.38
67.14	8.73	186.17	11.14	305.20	13.41
70.20	8.76	189.23	11.17	308.25	13.45
73.25	8.81	192.28	11.20	311.31	13.48
76.30	8.84	195.33	11.24	314.36	13.52
79.35	8.88	198.38	11.43	317.41	13.56
82.40	8.91	201.43	11.47	320.46	13.62
85.46	8.92	204.49	11.50	323.51	13.70
88.51	8.95	207.54	11.53	326.57	13.75
91.56	8.98	210.59	11.56	329.62	13.82
94.61	9.01	213.64	11.63	332.67	13.86
97.66	9.03	216.69	11.65	335.72	13.90
100.72	9.18	219.75	11.66	338.77	13.96
103.77	9.41	222.80	11.84	341.83	13.99
106.82	9.48	225.85	11.93	344.88	14.02
109.87	9.55	228.90	12.00	347.93	14.05
112.92	9.61	231.95	12.06	350.98	14.08
115.98	9.65	235.01	12.13	352.48	14.07

Table A2.2 EQUILIBRIUM TEMPERATURE LOG

Gelli Fawr (South Wales) Grid reference: SN 4682 0411

Depth meters	Temperature °C	Depth meters	Temperature °C	Depth meters	Temperature °C
0.00	26.10	79.33	11.39	158.65	12.59
3.05	11.64	82.38	11.41	161.70	12.62
6.10	10.14	85.43	11.43	164.75	12.65
9.15	9.94	88.48	11.46	167.81	12.69
12.20	10.16	91.53	11.50	170.86	12.73
15.26	10.31	94.58	11.55	173.91	12.76
18.31	10.35	97.63	11.57	176.96	12.82
21.36	10.42	100.68	11.65	180.01	12.86
24.41	10.48	103.73	11.77	183.06	12.91
27.46	10.51	106.79	11.99	186.11	13.00
30.51	10.55	109.84	11.90	189.16	13.05
33.56	10.76	112.89	11.99	192.21	13.13
36.61	10.82	115.94	12.02	195.26	13.22
39.66	10.89	118.99	12.05	198.32	13.27
42.71	10.91	122.04	12.09	201.37	13.31
45.77	10.95	125.09	12.12	204.42	13.36
48.82	11.05	128.14	12.19	207.47	13.40
51.87	11.10	131.19	12.28	210.52	13.44
54.92	11.13	134.24	12.31	213.57	13.48
57.97	11.17	137.30	12.33	216.62	13.52
61.02	11.16	140.35	12.39	219.67	13.60
64.07	11.20	143.40	12.43	222.72	13.66
67.12	11.22	146.45	12.46	225.77	13.72
70.17	11.25	149.50	12.49	228.22	13.78
73.22	11.28	152.55	12.52		
76.27	11.34	155.60	12.55		

Table A2.3 EQUILIBRIUM TEMPERATURE LOG

Newtown (South Wales) Grid reference: ST 0696 8481

Depth meters	Temperature °C	Depth meters	Temperature °C	Depth meters	Temperature °C
0.00	5.08	39.66	10.85	74.73	11.62
3.05	8.77	42.71	10.87	76.26	11.69
6.10	10.81	45.76	10.90	79.31	11.76
9.15	11.11	48.81	10.97	82.36	11.82
12.20	10.97	51.86	11.00	85.41	11.86
15.25	10.88	54.91	11.03	88.46	11.92
18.30	10.82	57.96	11.05	91.51	12.00
21.35	10.80	61.01	11.08	94.56	12.07
24.40	10.80	64.06	11.10	97.61	12.15
27.45	10.80	67.11	11.14	100.66	12.20
30.50	10.81	70.16	11.19	103.71	12.26
33.55	10.81	71.68	11.31	106.76	12.33
36.60	10.83	73.21	11.47	107.37	12.35

Table A2.4 EQUILIBRIUM TEMPERATURE LOG

Llanwrtyd Wells (Central Wales) Grid reference: SN 8759 4922

Depth meters	Temperature °C	Depth meters	Temperature °C	Depth meters	Temperature °C
0.00	11.26	70.19	9.81	140.38	11.36
3.05	11.00	73.24	9.87	143.44	11.43
6.10	8.97	76.30	9.98	146.49	11.49
9.16	8.75	79.35	10.04	149.54	11.56
12.21	8.58	82.40	10.12	152.59	11.60
15.26	8.50	85.45	10.19	155.64	11.68
18.31	8.51	88.50	10.25	158.70	11.76
21.36	8.55	91.55	10.32	161.75	11.83
24.41	8.62	94.61	10.41	164.80	11.87
27.47	8.68	97.66	10.48	167.85	11.91
30.52	8.75	100.71	10.55	170.90	11.99
33.57	8.83	103.76	10.62	173.95	12.05
36.62	8.91	106.81	10.69	177.01	12.14
39.67	8.99	109.87	10.76	180.06	12.20
42.73	9.07	112.92	10.81	183.11	12.27
45.78	9.15	115.97	10.87	186.16	12.35
48.83	9.22	119.02	10.95	189.21	12.38
51.88	9.32	122.07	11.01	192.27	12.66
54.93	9.39	125.13	11.06	195.32	12.81
57.98	9.45	128.18	11.13	198.37	12.97
61.04	9.54	131.23	11.17	201.42	13.01
64.09	9.64	134.28	11.25	204.47	13.08
67.14	9.70	137.33	11.29	204.99	13.10

Table A2.5 EQUILIBRIUM TEMPERATURE LOG

Rhiw (North Wales) Grid reference: SH 2289 2949

Depth meters	Temperature °C	Depth meters	Temperature °C	Depth meters	Temperature °C
0.00	4.95	19.80	8.80	39.60	9.10
1.52	6.78	21.32	8.84	41.12	9.12
3.05	7.69	22.85	8.85	42.65	9.14
4.57	8.43	24.37	8.90	44.17	9.17
6.09	8.70	25.89	8.93	45.69	9.19
7.62	8.70	27.42	8.94	47.22	9.22
9.14	8.68	28.94	8.97	48.74	9.24
10.66	8.65	30.46	8.97	50.26	9.27
12.18	8.63	31.98	9.00	51.78	9.30
13.71	8.64	33.51	9.01	53.31	9.32
15.23	8.66	35.03	9.03	54.83	9.33
16.75	8.71	36.55	9.05	56.35	9.36
18.28	8.75	38.08	9.07	57.19	9.37

Table A2.6 EQUILIBRIUM TEMPERATURE LOG

Morley Quarry (Leicestershire) Grid reference: SK 4765 1789

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
2.00	7.71	265.00	12.87	530.00	16.45
5.00	7.82	270.00	12.93	535.00	16.52
10.00	9.73	275.00	13.00	540.00	16.59
15.00	9.41	280.00	13.06	545.00	16.65
20.00	9.42	285.00	13.12	550.00	16.72
25.00	9.52	290.00	13.18	555.00	16.79
30.00	9.63	295.00	13.24	560.00	16.86
35.00	9.72	300.00	13.30	565.00	16.93
40.00	9.79	305.00	13.36	570.00	17.00
45.00	9.86	310.00	13.42	575.00	17.08
50.00	9.95	315.00	13.48	580.00	17.15
55.00	10.02	320.00	13.54	585.00	17.21
60.00	10.10	325.00	13.61	590.00	17.28
65.00	10.15	330.00	13.68	595.00	17.35
70.00	10.22	335.00	13.74	600.00	17.42
75.00	10.31	340.00	13.80	605.00	17.49
80.00	10.36	345.00	13.86	610.00	17.56
85.00	10.45	350.00	13.93	615.00	17.64
90.00	10.51	355.00	13.99	620.00	17.71
95.00	10.59	360.00	14.06	625.00	17.78
100.00	10.63	365.00	14.13	630.00	17.85
105.00	10.72	370.00	14.20	635.00	17.92
110.00	10.77	375.00	14.26	640.00	18.01
115.00	10.85	380.00	14.33	645.00	18.07
120.00	10.91	385.00	14.40	650.00	18.14
125.00	10.99	390.00	14.47	655.00	18.21
130.00	11.04	395.00	14.54	660.00	18.29
135.00	11.11	400.00	14.61	665.00	18.36
140.00	11.19	405.00	14.69	670.00	18.44
145.00	11.25	410.00	14.76	675.00	18.51
150.00	11.31	415.00	14.83	680.00	18.59
155.00	11.37	420.00	14.91	685.00	18.66
160.00	11.43	425.00	14.98	690.00	18.73
165.00	11.51	430.00	15.05	695.00	18.80
170.00	11.58	435.00	15.12	700.00	18.87
175.00	11.65	440.00	15.19	705.00	18.94
180.00	11.71	445.00	15.26	710.00	19.01
185.00	11.78	450.00	15.34	715.00	19.09
190.00	11.85	455.00	15.40	720.00	19.16
195.00	11.92	460.00	15.47	725.00	19.23
200.00	11.98	465.00	15.54	730.00	19.30
205.00	12.05	470.00	15.61	735.00	19.37
210.00	12.11	475.00	15.68	740.00	19.43
215.00	12.18	480.00	15.75	745.00	19.51
220.00	12.25	485.00	15.82	750.00	19.58
225.00	12.32	490.00	15.88	755.00	19.65
230.00	12.39	495.00	15.95	760.00	19.72
235.00	12.47	500.00	16.02	765.00	19.79
240.00	12.58	505.00	16.09	770.00	19.85
245.00	12.64	510.00	16.16	775.00	19.92
250.00	12.69	515.00	16.23	780.00	20.00
255.00	12.74	520.00	16.31	785.00	20.05
260.00	12.80	525.00	16.38	790.00	20.13

Table A2.6 (cont.) EQUILIBRIUM TEMPERATURE LOG

Morley Quarry (Leicestershire) Grid reference: SK 4765 1789

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
795.00	20.20	810.00	20.42	823.00	20.62
800.00	20.27	815.00	20.48		
805.00	20.35	820.00	20.54		

Table A2.7 EQUILIBRIUM TEMPERATURE LOG

Bardon Hill (Leicestershire) Grid reference: SK 4535 1313

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	16.05	51.85	10.52	103.70	11.34
3.05	11.50	54.90	10.56	106.75	11.37
6.10	9.45	57.95	10.66	109.80	11.42
9.15	9.49	61.00	10.68	112.85	11.46
12.20	9.85	64.05	10.70	115.90	11.51
15.25	10.16	67.10	10.74	118.95	11.55
18.30	10.30	70.15	10.79	122.00	11.60
21.35	10.33	73.20	10.83	125.05	11.65
24.40	10.30	76.25	10.89	128.10	11.70
27.45	10.28	79.30	10.94	131.15	11.76
30.50	10.29	82.35	10.98	134.20	11.81
33.55	10.39	85.40	11.02	137.25	11.86
36.60	10.32	88.45	11.07	140.30	11.91
39.65	10.38	91.50	11.12	143.35	11.96
42.70	10.40	94.55	11.18	146.40	12.01
45.75	10.42	97.60	11.21	149.45	12.04
48.80	10.48	100.65	11.26	150.92	12.06

Table A2.8 EQUILIBRIUM TEMPERATURE LOG

Wyche (Malvern) (Heref/Worcs) Grid reference: SO 7700 4408

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	16.59	30.57	9.89	61.15	10.11
3.06	12.48	33.63	9.88	64.21	10.15
6.11	10.41	36.69	9.89	67.26	10.19
9.17	9.84	39.75	9.89	70.32	10.23
12.23	9.85	42.80	9.90	73.38	10.26
15.29	9.95	45.86	9.92	76.44	10.30
18.34	9.98	48.92	9.93	79.49	10.33
21.40	9.96	51.98	9.97	82.55	10.36
24.46	9.93	55.03	10.00	85.61	10.40
27.52	9.91	58.09	10.06	86.31	10.41

Table A2.9 EQUILIBRIUM TEMPERATURE LOG

Church Stretton (Salop) Grid reference: SO 4205 9538

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	14.16	36.66	7.43	73.32	7.98
3.06	11.56	39.72	7.48	76.38	8.02
6.11	10.14	42.77	7.51	79.44	8.05
9.17	9.60	45.83	7.55	82.49	8.09
12.22	8.82	48.88	7.60	85.55	8.13
15.28	7.32	51.94	7.64	88.60	8.17
18.33	7.36	54.99	7.69	91.66	8.22
21.39	7.31	58.05	7.73	94.71	8.24
24.44	7.32	61.10	7.77	97.77	8.28
27.50	7.35	64.16	7.84	98.62	8.29
30.55	7.35	67.21	7.90		
33.61	7.38	70.27	7.94		

Table A2.10 EQUILIBRIUM TEMPERATURE LOG

Glenrothes (Fife, Scotland) Grid reference: NO 2562 0314

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	6.48	94.60	9.65	189.20	11.62
3.05	8.68	97.65	9.72	192.25	11.77
6.10	8.77	100.70	9.79	195.30	11.83
9.15	8.31	103.75	9.86	198.35	11.90
12.21	8.23	106.81	9.93	201.40	11.93
15.26	8.32	109.86	9.99	204.46	11.97
18.31	8.42	112.91	10.06	207.51	12.06
21.36	8.46	115.96	10.13	210.56	12.14
24.41	8.49	119.01	10.19	213.61	12.22
27.46	8.50	122.06	10.26	216.66	12.31
30.52	8.50	125.12	10.33	219.71	12.38
33.57	8.50	128.17	10.39	222.77	12.48
36.62	8.55	131.22	10.46	225.82	12.57
39.67	8.58	134.27	10.52	228.87	12.67
42.72	8.65	137.32	10.58	231.92	12.76
45.77	8.67	140.37	10.64	234.97	12.87
48.83	8.74	143.42	10.69	238.02	12.98
51.88	8.77	146.48	10.75	241.07	13.07
54.93	8.81	149.53	10.80	244.13	13.16
57.98	8.86	152.58	10.85	247.18	13.23
61.03	8.93	155.63	10.89	250.23	13.33
64.08	9.00	158.68	10.94	253.28	13.45
67.13	9.07	161.73	10.98	256.33	13.56
70.19	9.13	164.79	11.03	259.38	13.66
73.24	9.19	167.84	11.09	262.44	13.78
76.29	9.26	170.89	11.17	265.49	13.88
79.34	9.33	173.94	11.22	268.54	13.99
82.39	9.40	176.99	11.34	271.59	14.10
85.44	9.46	180.04	11.40	274.64	14.21
88.50	9.53	183.09	11.49	277.69	14.30
91.55	9.59	186.15	11.53	279.34	14.35

Table A2.10a OPEN HOLE TEMPERATURE LOG

Glenrothes (Fife, Scotland) Grid reference: NO 2562 0314

Depth meters	Temperature °C	Depth meters	Temperature °C	Depth meters	Temperature °C
0.00	2.13	161.84	9.54	323.67	14.62
3.05	4.09	164.89	9.77	326.72	14.70
6.11	5.69	167.94	9.96	329.78	14.78
9.16	5.98	171.00	10.11	332.83	14.86
12.21	6.20	174.05	10.25	335.88	14.94
15.27	6.39	177.10	10.32	338.94	15.02
18.32	7.16	180.16	10.49	341.99	15.10
21.37	7.48	183.21	10.59	345.04	15.20
24.43	7.67	186.26	10.69	348.10	15.28
27.48	7.75	189.32	10.76	351.15	15.35
30.53	7.72	192.37	10.88	354.21	15.44
33.59	7.88	195.42	10.99	357.26	15.52
36.64	7.86	198.48	11.04	360.31	15.66
39.70	7.82	201.53	11.15	363.37	15.82
42.75	7.82	204.58	11.24	366.42	15.97
45.80	7.81	207.64	11.33	369.47	16.10
48.86	7.78	210.69	11.40	372.53	16.19
51.91	7.78	213.74	11.45	375.58	16.24
54.96	7.80	216.80	11.51	378.63	16.31
58.02	7.81	219.85	11.53	381.69	16.37
61.07	7.81	222.91	11.60	384.74	16.44
64.12	7.82	225.96	11.70	387.79	16.50
67.18	7.83	229.01	11.75	390.85	16.56
70.23	7.85	232.07	11.82	393.90	16.61
73.28	7.88	235.12	11.90	396.95	16.67
76.34	7.89	238.17	11.97	400.01	16.71
79.39	7.91	241.23	12.06	403.06	16.76
82.44	7.93	244.28	12.14	406.11	16.80
85.50	7.97	247.33	12.27	409.17	16.84
88.55	8.04	250.39	12.36	412.22	16.87
91.60	8.09	253.44	12.45	415.28	16.91
94.66	8.10	256.49	12.55	418.33	16.96
97.71	8.18	259.55	12.63	421.38	17.01
100.77	8.23	262.60	12.71	424.44	17.05
103.82	8.19	265.65	12.79	427.49	17.10
106.87	8.28	268.71	12.88	430.54	17.15
109.93	8.32	271.76	12.98	433.60	17.20
112.98	8.41	274.81	13.09	436.65	17.24
116.03	8.48	277.87	13.19	439.70	17.29
119.09	8.52	280.92	13.29	442.76	17.33
122.14	8.58	283.98	13.37	445.81	17.39
125.19	8.63	287.03	13.48	448.86	17.43
128.25	8.66	290.08	13.58	451.92	17.47
131.30	8.76	293.14	13.67	454.97	17.52
134.35	8.80	296.19	13.79	458.02	17.57
137.41	8.87	299.24	13.87	461.08	17.61
140.46	8.92	302.30	13.97	464.13	17.65
143.51	9.04	305.35	14.08	467.18	17.69
146.57	9.13	308.40	14.16	470.24	17.74
149.62	9.15	311.46	14.27	473.29	17.79
152.68	9.20	314.51	14.36	476.34	17.83
155.73	9.20	317.56	14.44	479.40	17.87
158.78	9.28	320.62	14.51	482.45	17.91

Table A2.10a (cont.) OPEN HOLE TEMPERATURE LOG

Glenrothes (Fife, Scotland) Grid reference: NO 2562 0314

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
485.51	17.95	512.99	18.35	540.47	18.75
488.56	17.99	516.04	18.40	543.52	18.79
491.61	18.02	519.09	18.44	546.58	18.83
494.67	18.06	522.15	18.49	549.63	18.88
497.72	18.09	525.20	18.53	552.68	18.92
500.77	18.13	528.25	18.57	555.74	18.95
503.83	18.16	531.31	18.62	558.79	18.97
506.88	18.23	534.36	18.66	559.83	18.98
509.93	18.30	537.41	18.71		

Table A2.11 EQUILIBRIUM TEMPERATURE LOG

Edinburgh (Leith docks) (Lothian, Scotland) Grid reference: NT 2830 7595

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	7.77	73.25	11.29	146.50	13.67
3.05	10.23	76.30	11.34	149.55	13.74
6.10	10.46	79.35	11.40	152.60	13.84
9.16	10.55	82.40	11.45	155.65	13.99
12.21	10.57	85.46	11.50	158.70	14.12
15.26	10.60	88.51	11.54	161.76	14.20
18.31	10.64	91.56	11.59	164.81	14.30
21.36	10.69	94.61	11.66	167.86	14.39
24.42	10.72	97.66	11.74	170.91	14.49
27.47	10.76	100.72	11.86	173.96	14.57
30.52	10.78	103.77	12.03	177.02	14.64
33.57	10.81	106.82	12.11	180.07	14.70
36.62	10.84	109.87	12.21	183.12	14.77
39.68	10.90	112.92	12.34	186.17	14.86
42.73	10.94	115.98	12.49	189.22	14.94
45.78	10.96	119.03	12.60	192.28	15.02
48.83	10.97	122.08	12.73	195.33	15.09
51.88	10.99	125.13	12.87	198.38	15.20
54.94	11.02	128.18	12.99	201.43	15.26
57.99	11.06	131.24	13.16	204.48	15.34
61.04	11.09	134.29	13.30	207.54	15.40
64.09	11.14	137.34	13.41	210.59	15.47
67.14	11.18	140.39	13.49	213.64	15.55
70.20	11.24	143.44	13.61	215.35	15.61

Table A2.12 EQUILIBRIUM TEMPERATURE LOG

Selkirk (Borders, Scotland) Grid reference: NT 4794 2785

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	14.95	64.08	8.90	128.15	9.88
3.05	7.14	67.13	8.94	131.21	9.94
6.10	7.09	70.18	8.99	134.26	9.98
9.15	7.63	73.23	9.03	137.31	10.03
12.21	7.99	76.28	9.07	140.36	10.08
15.26	8.18	79.33	9.12	143.41	10.13
18.31	8.27	82.38	9.16	146.46	10.18
21.36	8.30	85.44	9.21	149.51	10.23
24.41	8.34	88.49	9.26	152.56	10.28
27.46	8.37	91.54	9.31	155.62	10.33
30.51	8.41	94.59	9.36	158.67	10.38
33.56	8.46	97.64	9.40	161.72	10.43
36.62	8.50	100.69	9.46	164.77	10.48
39.67	8.53	103.74	9.50	167.82	10.53
42.72	8.57	106.80	9.55	170.87	10.59
45.77	8.61	109.85	9.60	173.92	10.64
48.82	8.65	112.90	9.65	176.97	10.70
51.87	8.69	115.95	9.70	180.03	10.75
54.92	8.75	119.00	9.74	183.08	10.82
57.97	8.82	122.05	9.79	186.13	10.88
61.03	8.86	125.10	9.84	186.31	10.88

Table A2.13 EQUILIBRIUM TEMPERATURE LOG

Market Weighton (Humberside) Grid reference: SE 8595 3468

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	27.44	100.74	13.26	201.47	17.35
3.05	19.75	103.79	13.38	204.52	17.53
6.11	18.01	106.84	13.51	207.58	17.61
9.16	17.13	109.89	13.61	210.63	17.68
12.21	16.29	112.95	13.75	213.68	17.72
15.26	15.66	116.00	13.91	216.73	17.78
18.32	15.41	119.05	14.05	219.79	17.85
21.37	15.06	122.10	14.19	222.84	17.92
24.42	14.68	125.16	14.33	225.89	18.00
27.47	14.40	128.21	14.49	228.94	18.06
30.53	13.87	131.26	14.61	232.00	18.13
33.58	13.53	134.31	14.72	235.05	18.20
36.63	13.41	137.37	14.85	238.10	18.27
39.68	13.19	140.42	15.00	241.16	18.34
42.74	13.05	143.47	15.12	244.21	18.40
45.79	12.95	146.52	15.24	247.26	18.47
48.84	12.90	149.58	15.35	250.31	18.55
51.89	12.80	152.63	15.48	253.37	18.61
54.95	12.75	155.68	15.61	256.42	18.68
58.00	12.69	158.74	15.73	259.47	18.75
61.05	12.67	161.79	15.84	262.52	18.83
64.10	12.64	164.84	15.94	265.58	18.90
67.16	12.62	167.89	16.04	268.63	18.97
70.21	12.60	170.95	16.14	271.68	19.03
73.26	12.60	174.00	16.25	274.73	19.11
76.31	12.61	177.05	16.37	277.79	19.18
79.37	12.61	180.10	16.48	280.84	19.25
82.42	12.63	183.16	16.61	283.89	19.32
85.47	12.71	186.21	16.72	286.94	19.39
88.53	12.83	189.26	16.83	290.00	19.46
91.58	12.95	192.31	16.97	293.05	19.54
94.63	13.04	195.37	17.09	296.10	19.60
97.68	13.15	198.42	17.20	296.90	19.62

Table A2.14 EQUILIBRIUM TEMPERATURE LOG

Shipton No. 2 (Yorkshire) Grid reference: SE 5445 5860

Depth meters	Temperature °C	Depth meters	Temperature °C	Depth meters	Temperature °C
0.61	8.85	161.81	11.97	323.61	15.22
3.05	13.81	164.86	12.03	326.67	15.26
6.11	15.89	167.91	12.09	329.72	15.32
9.16	12.85	170.97	12.15	332.77	15.37
12.21	11.31	174.02	12.20	335.83	15.42
15.26	10.63	177.07	12.26	338.88	15.47
18.32	10.30	180.13	12.31	341.93	15.52
21.37	10.09	183.18	12.37	344.99	15.56
24.42	9.99	186.23	12.42	348.04	15.60
27.48	9.93	189.28	12.48	351.09	15.65
30.53	9.91	192.34	12.53	354.14	15.69
33.58	9.92	195.39	12.60	357.20	15.74
36.64	9.93	198.44	12.66	360.25	15.78
39.69	9.96	201.50	12.72	363.30	15.83
42.74	9.99	204.55	12.79	366.36	15.87
45.79	10.02	207.60	12.86	369.41	15.93
48.85	10.06	210.65	12.92	372.46	15.99
51.90	10.10	213.71	12.99	375.51	16.04
54.95	10.15	216.76	13.05	378.57	16.09
58.01	10.19	219.81	13.11	381.62	16.15
61.06	10.24	222.87	13.18	384.67	16.20
64.11	10.28	225.92	13.27	387.73	16.26
67.17	10.34	228.97	13.36	390.78	16.31
70.22	10.38	232.03	13.45	393.83	16.37
73.27	10.43	235.08	13.52	396.89	16.44
76.32	10.48	238.13	13.59	399.94	16.50
79.38	10.53	241.18	13.65	402.99	16.57
82.43	10.58	244.24	13.74	406.04	16.63
85.48	10.63	247.29	13.82	409.10	16.70
88.54	10.68	250.34	13.91	412.15	16.76
91.59	10.73	253.40	13.98	415.20	16.83
94.64	10.79	256.45	14.03	418.26	16.89
97.69	10.85	259.50	14.08	421.31	16.96
100.75	10.89	262.56	14.13	424.36	17.03
103.80	10.95	265.61	14.18	427.42	17.09
106.85	11.00	268.66	14.23	430.47	17.15
109.91	11.05	271.71	14.27	433.52	17.20
112.96	11.11	274.77	14.33	436.57	17.25
116.01	11.16	277.82	14.41	439.63	17.30
119.07	11.21	280.87	14.48	442.68	17.39
122.12	11.27	283.93	14.55	445.73	17.47
125.17	11.32	286.98	14.61	448.79	17.53
128.22	11.37	290.03	14.65	451.84	17.58
131.28	11.42	293.08	14.69	454.89	17.65
134.33	11.49	296.14	14.75	457.94	17.70
137.38	11.54	299.19	14.82	461.00	17.74
140.44	11.59	302.24	14.91	464.05	17.79
143.49	11.65	305.30	14.98	467.10	17.84
146.54	11.70	308.35	15.01	470.16	17.88
149.60	11.76	311.40	15.04	473.21	17.93
152.65	11.81	314.46	15.08	476.26	18.01
155.70	11.86	317.51	15.12	479.32	18.05
158.75	11.92	320.56	15.17	482.37	18.12

Table A2.14 (cont.) EQUILIBRIUM TEMPERATURE LOG

Shipton No. 2 (Yorkshire) Grid reference: SE 5445 5860

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
485.42	18.16	509.85	19.17	534.27	20.02
488.47	18.22	512.90	19.32	537.32	20.14
491.53	18.32	515.95	19.48	540.37	20.23
494.58	18.42	519.00	19.58	543.43	20.39
497.63	18.63	522.06	19.68	546.48	20.77
500.69	18.82	525.11	19.77	549.53	20.87
503.74	18.93	528.16	19.82	549.87	20.92
506.79	19.06	531.22	19.90		

Table A2.15 EQUILIBRIUM TEMPERATURE LOG

Harewood (Yorkshire) Grid reference: SE 3217 4404

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	8.43	91.56	11.82	183.12	16.68
3.05	6.54	94.61	11.91	186.17	16.85
6.10	8.17	97.66	12.00	189.22	17.02
9.16	8.84	100.72	12.10	192.28	17.19
12.21	8.98	103.77	12.17	195.33	17.35
15.26	9.07	106.82	12.29	198.38	17.55
18.31	9.14	109.87	12.46	201.43	17.74
21.36	9.21	112.92	12.63	204.48	17.88
24.42	9.34	115.98	12.78	207.54	18.07
27.47	9.49	119.03	12.95	210.59	18.23
30.52	9.67	122.08	13.14	213.64	18.41
33.57	9.83	125.13	13.28	216.69	18.60
36.62	10.01	128.18	13.46	219.74	18.78
39.68	10.18	131.24	13.66	222.80	18.95
42.73	10.38	134.29	13.82	225.85	19.13
45.78	10.62	137.34	13.99	228.90	19.31
48.83	10.80	140.39	14.19	231.95	19.45
51.88	10.85	143.44	14.36	235.00	19.61
54.94	10.89	146.50	14.55	238.06	19.78
57.99	11.00	149.55	14.71	241.11	19.92
61.04	11.07	152.60	14.91	244.16	20.07
64.09	11.12	155.65	15.08	247.21	20.27
67.14	11.18	158.70	15.27	250.26	20.40
70.20	11.24	161.76	15.43	253.32	20.58
73.25	11.32	164.81	15.63	256.37	20.76
76.30	11.40	167.86	15.83	259.42	20.91
79.35	11.47	170.91	16.01	262.47	21.07
82.40	11.56	173.96	16.18	265.52	21.21
85.46	11.64	177.02	16.35	268.58	21.32
88.51	11.72	180.07	16.52	270.99	21.48

Table A2.16 EQUILIBRIUM TEMPERATURE LOG

Cleethorpes No. 1 (Humberside) Grid reference: TA 3024 0709

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	5.31	530.00	28.86	1060.00	48.14
10.00	6.68	540.00	29.16	1070.00	48.37
20.00	7.49	550.00	29.45	1080.00	48.69
30.00	8.17	560.00	29.77	1090.00	49.04
40.00	10.82	570.00	30.00	1100.00	49.30
50.00	10.92	580.00	30.24	1110.00	49.46
60.00	11.01	590.00	30.51	1120.00	49.66
70.00	11.06	600.00	30.89	1130.00	49.90
80.00	11.18	610.00	31.38	1140.00	50.11
90.00	11.35	620.00	31.91	1150.00	50.34
100.00	11.70	630.00	32.44	1160.00	50.55
110.00	11.87	640.00	32.88	1170.00	50.76
120.00	12.02	650.00	33.30	1180.00	50.92
130.00	12.42	660.00	33.72	1190.00	51.18
140.00	12.58	670.00	34.18	1200.00	51.34
150.00	12.91	680.00	34.64	1210.00	51.60
160.00	13.11	690.00	35.07	1220.00	51.82
170.00	13.34	700.00	35.53	1230.00	51.98
180.00	13.54	710.00	35.92	1240.00	52.21
190.00	13.75	720.00	36.28	1250.00	52.40
200.00	14.00	730.00	36.63	1260.00	52.67
210.00	14.19	740.00	37.01	1270.00	52.87
220.00	14.41	750.00	37.38	1280.00	53.05
230.00	14.60	760.00	37.75	1290.00	53.27
240.00	14.84	770.00	38.22	1300.00	53.51
250.00	15.07	780.00	38.70	1310.00	53.72
260.00	15.34	790.00	39.19	1320.00	53.92
270.00	15.62	800.00	39.71	1330.00	54.14
280.00	15.85	810.00	40.18	1340.00	54.33
290.00	16.12	820.00	40.52	1350.00	54.53
300.00	16.59	830.00	40.86	1360.00	54.71
310.00	17.13	840.00	41.15	1370.00	54.99
320.00	17.73	850.00	41.47	1380.00	55.16
330.00	18.30	860.00	41.79	1390.00	55.45
340.00	18.89	870.00	42.15	1400.00	55.66
350.00	19.44	880.00	42.47	1410.00	55.85
360.00	20.01	890.00	42.83	1420.00	56.08
370.00	20.55	900.00	43.17	1430.00	56.32
380.00	21.10	910.00	43.48	1440.00	56.55
390.00	21.63	920.00	43.84	1450.00	56.75
400.00	22.16	930.00	44.17	1460.00	57.01
410.00	22.68	940.00	44.53	1470.00	57.26
420.00	23.23	950.00	44.88	1480.00	57.52
430.00	23.81	960.00	45.22	1490.00	57.84
440.00	24.39	970.00	45.45	1500.00	58.18
450.00	24.95	980.00	45.63	1510.00	58.51
460.00	25.51	990.00	46.20	1520.00	58.77
470.00	26.08	1000.00	46.41	1530.00	59.17
480.00	26.62	1010.00	46.70	1540.00	59.48
490.00	27.11	1020.00	47.04	1550.00	59.77
500.00	27.51	1030.00	47.40	1560.00	60.06
510.00	27.76	1040.00	47.61	1570.00	60.26
520.00	28.56	1050.00	47.87	1580.00	60.46

Table A2.16 (cont.) EQUILIBRIUM TEMPERATURE LOG

Cleethorpes No. 1 (Humberside) Grid reference: TA 3024 0709

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
1590.00	60.65	1680.00	62.20	1770.00	63.44
1600.00	60.81	1690.00	62.32	1780.00	63.58
1610.00	60.97	1700.00	62.47	1790.00	63.71
1620.00	61.13	1710.00	62.60	1800.00	63.84
1630.00	61.34	1720.00	62.75	1810.00	63.97
1640.00	61.65	1730.00	62.89	1820.00	64.09
1650.00	61.79	1740.00	63.03	1830.00	64.17
1660.00	61.94	1750.00	63.17	1840.00	64.35
1670.00	62.07	1760.00	63.31	1850.00	64.49

Table A2.17 EQUILIBRIUM TEMPERATURE LOG

Clitheroe No. 2 (Lancashire) Grid reference: SD 7555 4094

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
3.05	11.16	103.82	11.22	204.59	13.24
6.11	9.94	106.87	11.32	207.64	13.31
9.16	9.39	109.93	11.37	210.69	13.37
12.21	9.31	112.98	11.44	213.75	13.45
15.27	9.42	116.03	11.51	216.80	13.52
18.32	9.48	119.09	11.57	219.85	13.60
21.37	9.50	122.14	11.63	222.91	13.68
24.43	9.52	125.19	11.70	225.96	13.75
27.48	9.58	128.25	11.78	229.01	13.82
30.54	9.59	131.30	11.85	232.07	13.90
33.59	9.64	134.36	11.91	235.12	13.96
36.64	9.67	137.41	11.98	238.17	14.03
39.70	9.76	140.46	12.04	241.23	14.10
42.75	9.84	143.52	12.09	244.28	14.17
45.80	9.90	146.57	12.17	247.34	14.24
48.86	9.96	149.62	12.22	250.39	14.31
51.91	10.02	152.68	12.28	253.44	14.37
54.96	10.08	155.73	12.33	256.50	14.45
58.02	10.16	158.78	12.39	259.55	14.52
61.07	10.24	161.84	12.45	262.60	14.57
64.12	10.32	164.89	12.50	265.66	14.64
67.18	10.38	167.94	12.55	268.71	14.71
70.23	10.45	171.00	12.61	271.76	14.78
73.28	10.52	174.05	12.66	274.82	14.85
76.34	10.58	177.10	12.71	277.87	14.91
79.39	10.65	180.16	12.77	280.92	14.96
82.44	10.72	183.21	12.84	283.98	15.01
85.50	10.79	186.26	12.89	287.03	15.06
88.55	10.87	189.32	13.07	290.08	15.12
91.61	10.94	192.37	13.00	293.14	15.17
94.66	11.02	195.43	13.05	293.96	15.20
97.71	11.08	198.48	13.11		
100.77	11.15	201.53	13.18		

Table A2.18 EQUILIBRIUM TEMPERATURE LOG

Wray (Lancashire) Grid reference: SD 6316 6568

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
3.05	7.67	106.82	11.46	210.59	13.87
6.10	8.52	109.87	11.59	213.64	13.95
9.16	8.82	112.92	11.72	216.69	14.02
12.21	8.87	115.98	11.84	219.74	14.11
15.26	8.88	119.03	11.95	222.80	14.21
18.31	8.93	122.08	12.02	225.85	14.29
21.36	8.99	125.13	12.05	228.90	14.38
24.42	9.06	128.18	12.11	231.95	14.47
27.47	9.13	131.24	12.19	235.00	14.55
30.52	9.18	134.29	12.29	238.06	14.64
33.57	9.25	137.34	12.34	241.11	14.73
36.62	9.35	140.39	12.37	244.16	14.81
39.68	9.42	143.44	12.40	247.21	14.90
42.73	9.50	146.50	12.49	250.26	14.97
45.78	9.59	149.55	12.55	253.32	15.06
48.83	9.62	152.60	12.62	256.37	15.15
51.88	9.65	155.65	12.69	259.42	15.24
54.94	9.70	158.70	12.76	262.47	15.33
57.99	9.78	161.76	12.81	265.52	15.43
61.04	9.83	164.81	12.87	268.58	15.53
64.09	9.92	167.86	12.93	271.63	15.65
67.14	10.01	170.91	12.98	274.68	15.73
70.20	10.11	173.96	13.07	277.73	15.82
73.25	10.21	177.02	13.13	280.78	15.90
76.30	10.30	180.07	13.19	283.84	15.99
79.35	10.40	183.12	13.25	286.89	16.05
82.40	10.52	186.17	13.31	289.94	16.14
85.46	10.63	189.22	13.38	292.99	16.22
88.51	10.76	192.28	13.46	296.04	16.29
91.56	10.88	195.33	13.51	299.10	16.37
94.61	11.01	198.38	13.56	302.15	16.44
97.66	11.17	201.43	13.63	303.46	16.48
100.72	11.25	204.48	13.71		
103.77	11.36	207.54	13.80		

Table A2.19 EQUILIBRIUM TEMPERATURE LOG

Rowlands Gill (Tyne and Wear) Grid reference: NZ 1664 5815

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
0.00	19.94	82.39	12.05	164.78	15.71
3.05	14.34	85.44	12.19	167.83	15.87
6.10	9.58	88.49	12.33	170.88	15.98
9.15	9.44	91.54	12.46	173.93	16.10
12.21	9.60	94.59	12.64	176.98	16.27
15.26	9.68	97.65	12.77	180.03	16.36
18.31	9.72	100.70	12.91	183.09	16.53
21.36	9.89	103.75	13.06	186.14	16.62
24.41	10.38	106.80	13.15	189.19	16.70
27.46	10.86	109.85	13.21	192.24	16.91
30.51	11.13	112.90	13.33	195.29	17.00
33.57	11.22	115.95	13.46	198.34	17.12
36.62	11.22	119.01	13.64	201.39	17.25
39.67	11.22	122.06	13.88	204.45	17.38
42.72	11.22	125.11	14.01	207.50	17.56
45.77	11.23	128.16	14.21	210.55	17.68
48.82	11.23	131.21	14.41	213.60	17.77
51.87	11.23	134.26	14.57	216.65	17.89
54.93	11.23	137.31	14.63	219.70	18.08
57.98	11.23	140.37	14.69	222.75	18.31
61.03	11.32	143.42	14.75	225.81	18.38
64.08	11.43	146.47	14.86	228.86	18.49
67.13	11.64	149.52	15.02	231.91	18.55
70.18	11.75	152.57	15.10	234.96	18.66
73.23	11.81	155.62	15.21	237.06	18.80
76.29	11.85	158.67	15.34		
79.34	11.91	161.73	15.52		

Table A2.20 EQUILIBRIUM TEMPERATURE LOG

Newbiggin (Cumbria) Grid reference: NY 6482 2882

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
12.21	7.95	91.58	11.17	174.01	13.85
15.26	8.23	94.64	11.33	177.06	14.00
18.32	8.33	97.69	11.44	180.12	14.13
21.37	8.42	100.74	11.53	183.17	14.28
24.42	8.53	103.80	11.62	186.22	14.38
27.48	8.60	106.85	11.68	189.27	14.51
30.53	8.71	109.90	11.75	192.33	14.64
33.58	8.83	112.95	11.82	195.38	14.80
36.63	8.93	116.01	11.91	198.43	14.97
39.69	9.04	119.06	12.01	201.48	15.12
42.74	9.16	122.11	12.10	204.54	15.28
45.79	9.31	125.17	12.19	207.59	15.43
48.84	9.43	128.22	12.27	210.64	15.59
51.90	9.55	131.27	12.37	213.70	15.73
54.95	9.67	134.32	12.49	216.75	15.88
58.00	9.83	137.38	12.58	219.80	16.03
61.06	9.97	140.43	12.65	222.85	16.17
61.09	9.94	143.48	12.68	225.91	16.30
64.11	10.10	146.53	12.81	228.96	16.41
67.16	10.25	149.59	12.99	232.01	16.45
70.21	10.41	152.64	13.09	235.07	16.52
73.27	10.51	155.69	13.21	238.12	16.58
76.32	10.60	158.75	13.33	241.17	16.63
79.37	10.72	161.80	13.45	244.22	16.68
82.43	10.84	164.85	13.56	246.67	16.72
85.48	10.94	167.90	13.65		
88.53	11.06	170.96	13.73		

Table A2.21 EQUILIBRIUM TEMPERATURE LOG

Dufton (Cumbria) Grid reference: NY 6853 2503

Depth metres	Temperature °C	Depth metres	Temperature °C	Depth metres	Temperature °C
3.05	6.69	79.35	10.33	155.65	12.06
6.10	7.97	82.40	10.41	158.70	12.11
9.16	8.39	85.46	10.49	161.76	12.25
12.21	8.52	88.51	10.59	164.81	12.35
15.26	8.66	91.56	10.65	167.86	12.41
18.31	8.79	94.61	10.72	170.91	12.48
21.36	8.88	97.66	10.77	173.96	12.54
24.42	9.00	100.72	10.83	177.02	12.61
27.47	9.26	103.77	10.89	180.07	12.74
30.52	9.18	106.82	11.00	183.12	12.76
33.57	9.20	109.87	11.13	186.17	12.81
36.62	9.24	112.92	11.19	189.22	12.93
39.68	9.58	115.98	11.20	192.28	13.04
42.73	9.61	119.03	11.31	195.33	13.13
45.78	9.69	122.08	11.35	198.38	13.25
48.83	9.75	125.13	11.47	201.43	13.38
51.88	9.77	128.18	11.54	204.48	13.49
54.94	9.83	131.24	11.56	207.54	13.59
57.99	9.90	134.29	11.61	210.59	13.62
61.04	10.08	137.34	11.67	213.64	13.72
64.09	10.12	140.39	11.74	216.69	13.82
67.14	10.13	143.44	11.78	219.74	13.92
70.20	10.21	146.50	11.89	222.80	14.01
73.25	10.31	149.55	11.94	224.38	14.05
76.30	10.34	152.60	12.01		

Table A2.22 BOTTOM HOLE TEMPERATURES

Longhorsley (Northumberland) Grid reference: NZ 1445 9263

Depth metres	time since circulation hrs.	Temperature °C
1186.4	8.5	52.6
1195.7	12.7	52.2
1828.8	8.5	70.0
further mud circulation for 15.5 hrs.		
1828.8	7.0	57.2
	12.0	57.2
further mud circulation for 14.0 hrs.		
1828.8	7.0	50.6

Appendix 3. TABLES OF THERMAL CONDUCTIVITY DATA

The tabulated conductivity data present the measured and, where appropriate, corrected values. No distinction has been made between the methods of conductivity measurement. The following is a list of tables for quick reference:

Table A3.1 THERMAL CONDUCTIVITY RESULTS

Carn Caglau (South Wales) Grid reference: SN 8592 0018

Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$
99.00	2.88	174.00	2.55	249.00	2.25
102.00	0.77	180.00	2.71	252.00	2.14
105.00	1.51	183.00	2.40	255.00	2.20
108.00	2.08	186.00	3.14	258.00	2.55
111.00	2.18	192.00	2.83	261.00	3.04
114.00	2.25	195.00	2.85	264.00	3.18
117.00	2.10	198.00	1.67	267.00	3.19
120.00	1.50	201.00	2.35	269.00	3.40
123.00	1.40	204.00	2.55	276.00	1.86
126.00	1.47	207.00	1.65	278.00	1.06
129.00	1.57	210.00	2.16	281.00	2.19
132.00	1.68	213.00	2.66	284.00	1.79
135.00	2.02	216.00	2.22	287.00	1.43
141.00	1.80	219.00	2.81	290.00	1.45
144.00	2.25	222.00	1.07	296.00	2.10
147.00	2.78	225.00	1.04	299.00	2.07
153.00	2.52	228.00	1.54	309.00	3.12
156.00	2.80	231.00	1.84	312.00	2.85
159.00	2.29	234.00	1.60	315.00	2.73
162.00	2.96	237.00	2.13	318.00	2.40
165.00	2.96	240.00	2.69	336.00	3.38
169.00	2.29	243.00	2.62	345.00	3.21
171.00	2.68	246.00	2.45	357.00	3.27

Table A3.2 THERMAL CONDUCTIVITY RESULTS

Gelli Fawr (South Wales) Grid reference: SN 4682 0411

Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$
105.30	2.20	150.00	4.91	196.04	1.93
110.00	2.20	155.00	4.50	200.04	3.16
115.00	2.15	160.00	5.14	205.00	2.22
120.00	2.58	165.00	5.44	209.80	3.60
125.00	2.19	171.43	4.25	214.57	4.63
130.00	2.48	175.53	4.11	220.00	5.27
135.00	3.20	180.30	5.06	225.03	2.03
140.00	3.60	185.22	2.52		
146.00	4.70	190.44	2.02		

Table A3.3 THERMAL CONDUCTIVITY RESULTS

Newtown (South Wales) Grid reference: ST 0696 8481

Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$
37.00	2.00	129.00	2.10	220.00	3.31
42.00	2.72	132.00	2.46	225.00	0.57
47.00	2.47	135.00	2.36	230.00	1.78
52.00	2.16	140.00	2.44	235.00	3.15
57.00	4.00	145.00	2.89	240.00	3.12
62.00	4.02	150.00	0.89	245.00	2.54
67.00	2.63	155.00	1.69	250.00	1.45
71.00	2.87	160.00	1.57	255.00	3.66
72.00	0.50	165.00	2.52	260.00	4.41
79.00	2.20	170.00	3.16	265.00	2.22
84.00	2.40	175.00	1.77	270.00	2.49
89.00	2.51	180.00	1.47	275.00	3.57
94.00	2.46	185.00	2.70	280.00	4.02
99.00	2.18	190.00	2.71	285.00	3.64
104.00	2.76	195.00	2.44	290.00	2.30
109.00	2.21	200.00	2.65	295.00	0.68
114.00	3.64	205.00	2.55	300.00	2.61
119.00	2.38	210.00	2.68		
124.00	2.70	215.00	2.66		

Table A3.4 THERMAL CONDUCTIVITY RESULTS

Llanwrtyd Wells (Central Wales) Grid reference: SN 8759 4922

Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$
6.30	2.76	68.80	2.48	130.30	3.54
9.10	3.16	72.20	2.39	133.30	3.17
12.60	2.42	74.90	2.41	136.20	2.39
15.25	2.42	77.90	2.71	138.80	2.49
17.90	2.31	81.20	3.07	142.10	2.23
21.15	2.43	83.70	2.81	144.90	3.77
24.40	3.18	87.20	2.54	146.90	3.31
27.15	2.34	89.80	2.66	156.20	2.85
29.80	2.38	93.20	3.05	158.90	4.21
33.20	2.34	96.20	3.41	162.00	2.28
35.90	2.39	99.20	3.36	165.40	3.16
39.10	2.49	102.30	3.10	170.90	1.89
42.25	2.39	105.60	2.68	183.20	2.29
45.10	2.55	108.30	2.82	187.35	2.67
47.80	2.76	110.90	2.76	189.90	2.93
51.30	2.49	114.10	2.95	193.10	3.00
54.20	2.51	116.80	4.25	196.30	2.05
57.30	2.97	119.50	3.57	199.00	2.99
60.25	2.54	122.20	3.48	201.90	2.74
63.00	3.43	123.80	3.00	205.15	2.64
65.80	3.18	127.20	4.06		

Table A3.5 THERMAL CONDUCTIVITY RESULTS

Rhiw (North Wales) Grid reference: SH 2289 2949

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
12.80	2.36	32.00	2.41	51.00	2.63
15.20	2.71	34.90	2.62	54.00	2.54
18.90	2.46	38.00	2.72	57.00	3.55
23.00	2.62	41.60	2.93	59.90	4.96
26.00	2.63	45.35	2.95		
28.00	2.42	47.95	2.57		

Table A3.6 THERMAL CONDUCTIVITY RESULTS

Morley Quarry (Leicestershire) Grid reference: SK 4765 1789

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
10.00	3.70	320.00	4.16	630.00	4.22
20.00	4.53	330.00	4.65	640.00	4.30
30.00	3.75	340.00	4.00	650.00	3.75
40.00	3.71	350.00	4.07	660.00	4.23
50.00	3.61	360.00	3.54	670.00	3.71
60.00	3.57	370.00	4.46	680.00	4.15
70.00	4.16	380.00	3.57	690.00	4.18
80.00	3.00	390.00	4.07	700.00	4.32
90.00	2.50	400.00	4.03	710.00	4.04
100.00	3.59	410.00	4.03	720.00	3.63
110.00	3.86	420.00	4.41	730.00	3.45
120.00	4.73	430.00	3.56	740.00	4.81
130.00	3.66	440.00	4.18	750.00	4.09
140.00	3.44	450.00	3.70	760.00	3.86
150.00	4.43	460.00	4.22	770.00	4.53
160.00	4.91	470.00	3.72	780.00	4.37
170.00	4.05	480.00	4.13	783.92	3.80
180.00	4.88	490.00	3.18	787.75	4.66
190.00	3.91	500.00	4.03	791.91	4.15
200.00	4.50	510.00	3.76	795.80	4.03
210.00	3.11	520.00	4.48	799.72	5.51
220.00	4.31	530.00	3.54	804.03	5.28
230.00	4.29	540.00	4.18	808.25	4.93
240.00	5.58	550.00	3.25	811.87	4.72
250.00	3.76	560.00	3.89	816.83	5.02
260.00	4.53	570.00	3.86	820.22	4.43
270.00	4.23	580.00	4.22	822.80	4.38
280.00	4.82	590.00	3.49	830.43	3.74
290.00	4.92	600.00	4.30	834.20	4.08
300.00	4.90	610.00	3.72		
310.00	4.69	620.00	3.70		

Table A3.7 THERMAL CONDUCTIVITY RESULTS

Bardon Hill (Leicestershire) Grid reference: SK 4535 1313

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
5.10	2.93	57.70	3.29	119.50	3.68
12.20	2.27	62.70	3.04	127.00	3.01
17.30	3.23	74.10	3.38	132.60	3.78
22.70	2.63	85.20	3.37	137.70	3.90
28.70	3.05	91.90	3.27	143.80	3.56
34.80	2.65	96.10	2.90	147.60	3.66
40.70	3.04	102.00	3.59	151.40	3.55
46.50	3.25	108.70	3.94		
51.40	3.52	114.40	3.69		

Table A3.8 THERMAL CONDUCTIVITY RESULTS

Wyche (Malvern) (Heref/Worcs) Grid reference: SO 7700 4408

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
2.00	2.75	36.00	2.68	70.00	2.94
4.00	2.54	38.00	2.66	72.00	3.29
6.00	3.18	40.00	3.02	74.00	3.43
8.00	3.10	42.00	3.22	76.00	2.42
10.00	3.28	44.00	2.67	78.00	3.49
12.00	2.91	46.00	2.60	80.00	3.45
14.00	2.78	48.00	3.09	82.00	3.94
16.00	2.75	50.00	2.79	84.00	3.59
18.00	3.33	52.00	2.93	86.00	3.52
20.00	3.11	54.00	2.77	88.00	3.09
22.00	2.77	56.00	3.19	90.00	3.13
24.00	2.83	58.00	3.19	92.00	2.79
26.00	2.53	60.00	3.17	94.00	2.70
28.00	2.69	62.00	3.00	96.00	3.63
30.00	2.72	64.00	3.56	97.00	3.66
32.00	2.84	66.00	3.37		
34.00	2.80	68.00	2.78		

Table A3.9 THERMAL CONDUCTIVITY RESULTS

Church Stretton (Salop) Grid reference: SO 4205 9538

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
1.00	1.75	33.00	2.90	65.00	3.67
3.00	2.06	35.00	2.99	67.00	3.74
5.00	2.04	37.00	3.46	69.00	3.99
7.00	1.78	39.00	3.85	71.00	3.35
9.00	1.93	41.00	3.42	73.00	3.23
11.00	2.02	43.00	3.16	75.00	3.05
13.00	1.91	45.00	3.25	77.00	3.69
15.00	2.31	47.00	3.34	79.00	1.53
17.00	2.32	49.00	2.82	81.00	3.35
19.00	2.44	51.00	3.46	83.00	3.42
21.00	2.40	53.00	2.87	85.00	3.50
23.00	2.47	55.00	3.78	87.00	3.45
25.00	2.54	57.00	3.46	89.00	3.20
27.00	2.75	59.00	3.43	91.00	3.38
29.00	3.12	61.00	3.63	93.00	2.92
31.00	3.65	63.00	3.35		

Table A3.10 THERMAL CONDUCTIVITY RESULTS

Glenrothes (Fife, Scotland) Grid reference: NO 2562 0314

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
135.13	2.08	204.00	2.20	321.05	1.87
147.91	2.06	210.15	2.95	328.23	1.69
151.89	2.16	213.06	2.60	334.76	2.10
154.16	2.17	216.07	2.94	346.34	2.13
155.26	1.96	226.42	2.02	359.65	4.29
157.52	2.38	229.37	1.93	369.88	3.20
160.00	2.52	236.08	1.34	380.74	3.68
163.06	3.65	242.05	2.41	392.10	3.68
165.98	2.15	248.11	3.55	403.02	3.06
169.00	2.70	257.36	2.41	419.77	3.46
171.47	2.08	267.25	2.11	435.28	3.75
174.05	2.81	270.58	1.27	461.25	3.15
177.00	2.82	273.30	2.19	481.19	3.59
180.34	3.98	279.38	1.24	501.56	2.94
183.57	1.01	285.37	1.56	521.08	3.61
186.50	4.16	288.57	2.06	541.13	4.27
189.50	1.61	298.06	2.09	564.53	4.21
201.30	3.74	301.40	2.25		

Table A3.11 THERMAL CONDUCTIVITY RESULTS

Edinburgh (Leith docks) (Lothian, Scotland) Grid reference: NT 2830 7595

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
102.58	0.95	164.98	1.56	219.19	2.13
105.48	0.96	168.13	1.21	225.20	2.36
108.02	2.34	171.44	2.62	234.32	2.18
109.15	1.51	172.11	2.22	237.03	2.16
112.12	1.15	175.06	4.86	241.30	2.86
117.22	1.44	177.31	1.57	244.63	1.35
121.08	1.09	179.45	2.51	247.19	1.24
124.42	0.87	180.90	1.94	250.30	2.05
127.13	1.10	187.66	1.84	256.30	2.33
130.26	0.93	190.25	2.15	259.12	1.22
133.09	1.73	193.27	2.22	261.49	1.14
136.27	1.84	196.15	1.88	264.71	2.02
139.10	1.50	199.18	2.04	267.13	3.57
142.51	1.65	202.19	1.86	270.13	3.38
148.10	4.88	205.27	1.82	273.40	2.05
150.60	1.88	208.45	1.80	276.21	4.36
154.24	1.52	211.05	1.95	279.30	3.85
159.43	1.76	213.25	2.01	282.02	4.83
162.05	1.51	216.23	2.09	284.35	1.85

Table A3.12 THERMAL CONDUCTIVITY RESULTS

Selkirk (Borders, Scotland) Grid reference: NT 4794 2785

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
6.10	3.61	72.30	3.59	138.52	3.41
9.50	3.51	75.40	3.44	141.00	3.38
12.60	3.64	78.60	3.99	144.04	3.49
15.50	3.55	84.20	3.21	147.51	3.34
18.00	3.36	87.80	3.68	150.73	3.20
22.20	2.99	88.10	3.18	153.83	3.54
24.30	3.17	90.00	3.55	156.50	3.75
27.40	3.38	90.50	3.44	160.19	3.66
30.00	3.75	93.30	3.36	163.50	2.85
31.20	3.03	94.15	3.48	166.78	3.59
33.40	3.53	96.70	2.88	170.08	3.30
36.30	3.33	97.30	3.12	172.65	3.61
39.20	3.77	102.68	3.48	176.46	3.77
42.30	3.49	105.72	3.39	178.96	2.82
45.10	3.49	110.20	2.13	184.16	2.56
48.80	3.47	111.90	2.21	186.88	2.65
51.20	3.30	115.06	2.12	190.10	3.72
54.60	3.65	119.80	3.73	193.40	2.66
57.40	3.44	123.23	3.30	196.42	3.52
60.00	3.15	126.17	3.36	198.40	2.94
63.90	3.84	129.32	3.48	201.76	3.78
66.00	3.49	132.47	3.24		
69.00	3.14	133.73	3.53		

Table A3.13 THERMAL CONDUCTIVITY RESULTS

Market Weighton (Humberside) Grid reference: SE 8595 3486

Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$
149.19	2.10	206.08	1.73	254.58	2.77
153.12	2.03	209.20	2.72	258.45	1.95
157.10	1.37	212.13	2.53	261.30	2.98
162.76	2.06	215.25	3.06	264.96	2.57
165.52	1.44	218.37	2.59	268.23	2.66
168.90	1.89	221.10	2.58	271.55	2.86
172.30	1.74	224.05	2.52	274.42	2.65
175.31	1.74	227.18	2.37	277.62	2.65
178.39	1.85	230.15	2.18	280.73	2.46
182.80	1.63	233.44	2.21	283.87	2.16
185.61	1.74	236.32	2.86	287.02	2.34
190.63	1.46	239.61	2.24	290.23	2.19
193.67	1.16	242.49	2.29	293.55	2.46
196.96	2.19	245.56	2.74	296.76	2.73
199.90	1.74	248.61	3.02	299.32	2.57
202.70	1.72	251.47	2.46		

Table A3.14 THERMAL CONDUCTIVITY RESULTS

Shipton (Yorkshire) Grid reference: SE 5445 5860

Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$
9.00	2.30	167.00	3.64	336.00	3.96
21.00	3.96	177.00	2.57	345.00	2.74
29.00	4.14	187.00	4.33	355.00	2.24
36.00	3.77	196.00	2.89	364.00	5.05
45.00	2.80	205.00	2.41	374.00	2.90
56.00	4.15	215.00	3.09	383.00	3.81
67.00	3.98	224.00	2.04	392.00	2.43
75.00	3.24	233.00	2.03	401.00	3.36
84.00	1.82	242.00	2.96	412.00	2.37
94.00	4.73	251.00	1.56	420.00	2.84
102.00	3.92	259.00	5.35	490.00	3.11
111.00	4.65	269.00	3.91	498.00	2.32
120.00	2.88	278.00	2.23	508.00	2.04
129.00	5.03	287.00	2.01	518.00	1.96
138.00	3.81	296.00	3.08	531.00	3.23
148.00	4.04	305.00	2.53	538.00	2.48
158.00	3.68	326.00	3.82	547.00	3.89

Table A3.15 THERMAL CONDUCTIVITY RESULTS

Harewood (Yorkshire) Grid reference: SE 3217 4404

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
102.48	3.87	175.44	1.27	235.20	1.16
106.25	1.46	178.14	1.28	241.57	1.08
111.92	1.37	181.55	1.24	244.23	1.11
115.04	1.15	184.54	1.30	247.02	1.16
124.15	1.28	190.26	1.07	250.03	1.18
127.51	1.10	192.78	1.30	253.03	1.22
130.31	1.12	196.43	1.22	259.50	1.10
134.34	1.20	199.62	1.01	262.33	1.17
137.13	1.11	202.60	0.89	265.20	1.23
140.57	0.85	207.89	1.20	271.26	1.64
143.02	1.10	211.18	1.14	274.12	1.21
149.36	1.13	214.18	1.09	277.70	1.17
152.33	1.15	217.15	1.11	283.48	1.01
158.04	1.04	220.04	1.10	286.12	1.20
163.72	1.50	223.19	1.13	291.33	1.03
166.19	1.07	226.09	1.19	294.17	1.74
169.04	1.35	229.61	1.18	300.28	1.15
172.24	1.40	232.76	1.10	306.12	1.03

Table A3.16 THERMAL CONDUCTIVITY RESULTS

Cleethorpes No. 1 (Humberside) Grid reference: TA 3024 0709

Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$
80.00	3.42	680.00	2.37	1300.00	2.99
100.00	3.43	700.00	2.53	1320.00	3.30
120.00	3.49	720.00	2.82	1340.00	3.45
140.00	2.83	740.00	2.17	1360.00	3.58
160.00	3.27	760.00	2.75	1380.00	2.94
180.00	3.20	780.00	1.97	1400.00	3.37
200.00	3.73	800.00	2.09	1420.00	3.05
220.00	3.29	820.00	2.57	1440.00	3.21
240.00	3.23	840.00	3.20	1460.00	3.41
260.00	3.83	860.00	2.26	1480.00	3.60
280.00	5.65	880.00	2.68	1500.00	2.68
300.00	2.01	900.00	2.45	1520.00	3.08
320.00	2.05	920.00	2.97	1540.00	2.75
340.00	2.04	940.00	2.79	1560.00	3.32
360.00	2.20	960.00	3.18	1580.00	4.01
380.00	2.26	980.00	3.20	1600.00	5.33
400.00	2.31	1020.00	3.40	1620.00	3.24
420.00	1.91	1040.00	3.57	1640.00	4.26
440.00	2.00	1060.00	3.90	1660.00	4.73
460.00	2.13	1080.00	3.08	1680.00	5.06
480.00	2.22	1100.00	3.00	1700.00	5.06
500.00	1.65	1120.00	3.04	1720.00	4.93
520.00	2.19	1140.00	3.54	1740.00	3.62
540.00	2.03	1160.00	3.24	1760.00	5.11
560.00	2.30	1180.00	3.50	1780.00	4.29
580.00	2.67	1200.00	3.50	1800.00	4.87
600.00	2.19	1220.00	3.74	1820.00	4.43
620.00	2.06	1240.00	3.68	1840.00	4.73
640.00	2.48	1260.00	3.67	1870.00	4.89
660.00	2.26	1280.00	3.34		

Table A3.17 THERMAL CONDUCTIVITY RESULTS

Clitheroe No. 2 (Lancashire) Grid reference: SD 7555 4094

Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$
81.03	2.65	159.86	1.88	232.06	1.92
90.53	2.11	163.43	2.33	235.48	1.91
93.30	1.65	165.96	2.30	238.47	1.55
96.68	2.21	169.01	1.76	241.33	1.90
99.96	2.17	172.05	1.79	244.51	1.34
102.80	1.90	175.00	2.00	247.99	1.78
108.67	2.25	178.05	2.00	250.26	2.08
111.75	2.40	181.06	1.88	253.11	1.63
114.76	1.84	184.15	2.56	256.18	1.79
117.55	2.30	187.17	2.46	259.55	2.07
120.55	2.26	190.50	2.55	263.67	1.86
123.62	2.06	193.59	2.44	266.65	1.62
126.64	1.63	196.58	2.46	269.56	1.78
129.73	2.25	199.76	1.81	272.66	1.86
132.62	2.34	202.30	2.07	275.64	2.54
135.75	2.07	205.82	1.94	278.77	1.73
138.83	2.25	208.62	1.79	281.40	2.06
141.91	2.04	214.95	1.53	284.32	2.01
144.90	2.27	217.96	1.66	287.46	1.85
148.22	2.73	221.10	1.57	290.53	1.73
151.13	1.95	224.00	2.07	294.60	1.58
154.38	2.43	227.34	1.95	297.54	2.13
157.02	1.92	230.04	1.78	300.52	2.34

Table A3.18 THERMAL CONDUCTIVITY RESULTS

Wray (Lancashire) Grid reference: SD 6316 6568

Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$	Depth meters	Conductivity $Wm^{-1}K^{-1}$
100.09	1.10	169.01	2.87	244.03	1.48
103.08	1.09	172.00	1.73	247.19	1.43
106.00	1.24	175.22	1.40	250.06	1.95
109.20	1.04	178.12	3.94	253.11	1.30
112.02	0.80	180.94	2.29	256.15	1.23
115.10	1.11	183.70	2.88	259.08	1.18
118.04	1.05	187.12	1.47	262.11	1.52
121.20	5.36	196.10	1.76	265.13	1.52
124.16	4.11	199.00	2.10	268.04	1.09
127.03	2.24	202.07	1.35	269.98	3.18
130.14	2.14	205.08	1.30	274.13	1.42
133.02	1.25	208.11	1.72	277.11	1.67
136.10	4.93	211.15	1.41	280.15	1.73
139.05	4.14	214.06	1.42	285.06	1.52
142.11	5.56	217.14	1.32	288.10	1.32
145.10	1.57	220.10	1.34	291.12	1.43
148.02	1.31	223.01	1.41	294.06	2.73
151.01	1.38	226.01	1.45	297.15	1.25
154.04	1.59	229.08	1.36	300.12	1.39
157.04	1.90	232.16	1.54	303.23	1.60
160.11	1.45	235.04	1.38	306.21	1.83
163.05	1.40	238.14	1.46	309.46	1.44
166.02	3.80	241.06	1.61		

Table A3.19 THERMAL CONDUCTIVITY RESULTS

Rowlands Gill (Tyne-Tees) Grid reference: NZ 1664 5815

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
31.97	4.02	91.75	4.02	177.36	1.84
34.64	4.02	93.25	1.84	180.80	4.02
38.50	1.84	94.03	1.84	184.35	1.84
40.82	1.73	96.18	4.02	189.07	4.02
43.50	4.02	99.72	1.84	192.65	1.84
45.35	1.84	104.62	2.92	195.20	2.09
47.39	4.02	111.15	4.02	200.25	2.92
51.67	1.84	116.20	2.92	200.45	1.84
54.71	1.84	119.01	1.84	202.47	4.02
55.31	2.92	120.65	1.84	206.30	2.92
57.08	1.84	134.20	2.92	208.25	1.84
59.80	4.02	142.46	4.02	212.88	2.09
61.82	1.84	146.20	2.38	214.75	2.38
65.30	4.02	151.40	2.92	220.26	2.92
75.94	1.84	153.35	2.38	223.23	1.84
78.38	4.02	156.66	1.74	226.00	2.09
82.09	1.84	157.60	4.02	234.88	2.38
83.20	2.38	162.45	2.92	239.29	1.84
85.04	1.84	166.78	1.84	241.87	4.02
87.50	2.92	174.12	2.09		
89.61	1.84	174.70	4.02		

Table A3.20 THERMAL CONDUCTIVITY RESULTS

Newbiggin (Cumbria) Grid reference: NY 6482 2882

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
232.03	4.97	233.53	5.61	249.38	3.61
232.17	5.49	233.65	5.64	249.61	2.98
232.31	5.71	233.76	3.87	258.65	3.54
232.45	5.60	247.68	3.11	258.73	3.90
232.56	5.71	247.70	3.60	258.96	3.61
232.69	5.68	247.91	3.57	259.13	3.29
232.84	5.53	248.29	3.33	259.36	3.88
232.98	5.23	248.59	3.40	259.57	3.88
233.11	5.14	248.85	2.61	259.77	3.67
233.26	5.65	249.05	3.54	259.95	3.84
233.40	5.60	249.20	3.63	260.23	3.66

Table A3.21 THERMAL CONDUCTIVITY RESULTS

Longhorsley (Northumberland) Grid reference: NZ 1445 9263

Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$	Depth metres	Conductivity $Wm^{-1}K^{-1}$
100.00	3.00	701.04	3.26	1280.20	2.78
152.40	2.60	716.28	3.28	1295.40	3.34
167.64	2.54	731.52	2.69	1310.60	2.51
182.88	2.51	746.76	2.61	1325.90	2.84
198.12	2.85	762.00	2.30	1341.10	4.30
213.36	2.49	777.24	2.72	1356.40	3.88
228.60	2.56	792.48	2.67	1371.60	3.62
243.84	4.68	807.72	3.53	1386.80	3.31
259.08	2.39	822.96	3.23	1402.10	3.17
274.32	4.14	838.20	2.18	1417.30	2.51
289.56	3.95	853.44	2.45	1432.60	3.73
304.80	2.30	868.68	2.93	1447.80	3.27
320.04	2.74	883.92	3.65	1463.00	2.33
335.28	2.18	899.16	2.77	1478.30	2.92
350.52	2.40	914.40	2.69	1493.50	3.51
365.76	2.73	929.64	2.65	1508.80	3.12
381.00	3.18	944.88	2.68	1524.00	4.06
396.24	3.04	975.36	3.29	1539.20	2.37
411.48	1.88	990.60	2.89	1554.50	2.79
426.72	2.62	1005.80	2.83	1569.70	3.02
441.96	2.85	1021.10	2.72	1585.00	3.30
457.20	3.20	1036.30	2.93	1600.20	2.50
472.44	2.61	1051.60	2.71	1615.40	2.79
487.68	2.32	1066.80	2.32	1630.70	3.32
502.92	2.36	1082.00	3.58	1645.90	2.32
518.16	2.15	1097.30	3.52	1661.20	2.48
533.40	2.33	1112.50	3.36	1676.40	3.06
548.64	3.58	1127.80	2.61	1691.60	2.20
563.88	3.14	1143.00	2.79	1706.90	3.83
579.12	2.46	1158.20	3.08	1722.10	2.48
594.36	3.02	1173.50	3.18	1737.40	2.81
609.60	2.46	1188.70	2.77	1752.60	3.07
624.84	2.53	1204.00	3.39	1767.80	2.91
640.08	3.15	1219.20	3.80	1783.10	2.46
655.32	3.52	1234.40	4.84	1798.30	3.33
670.56	2.42	1249.70	2.96	1813.60	2.43
685.80	2.29	1264.90	2.47	1828.80	3.03