Natural Environment Research Council

Institute of Geological Sciences

Mineral Reconnaissance Programme Report

A report prepared for the Department of Industry

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Mineral Reconnaissance Programme

Report No. 70

Regional geochemical and geophysical surveys in the Berwyn Dome and adjacent areas, North Wales

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 The information contained herein must not be published without reference to the Director, British Geological Survey.

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On 1 January 1984 the Institute of Geological Sciences was renamed the British Geological Survey. It continues to carry out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects; it also undertakes programmes of British technical aid in geology in developing countries as arranged by the Overseas Development Administration.

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SUMMARY

This report describes stream sediment and gravity surveys carried out across the Berwyn Dome and adjacent areas. The gravity survey confirmed the presence of a broad regional Bouguer anomaly low in the central part of the Dome, on which is superimposed several smaller irregular highs and lows. Some of these local anomalies possibly reflect small igneous bodies but more detailed gravity surveys would be needed to determine their form. Near Corwen the Bryneglwys Fault coincides with a 4.5 mGal anomaly but southwards the two features diverge, suggesting that the density interface is related either to a splay fault or to the eastern margin of the Lower Palaeozoic Montgomery trough. Some other structural trends are weakly reflected on the Bouguer anomaly and aeromagnetic maps, but there is no clear correlation with known base metal mineralisation. The Bouguer anomalies cannot be attributed to particular structures with any certainty but are probably due to a number of factors, including variation in the Precambrian basement and changes in the lithology and thickness of Lower Palaeozoic sedimentary rocks. There is no evidence for a large granitic body in Lower Palaeozoic rocks underlying the mineralisation at Llangynog. The aeromagnetic map suggests the presence of a magnetic basement at a depth of 3–4 km centred beneath the northwestern margin of the Dome.

The stream sediment survey involved the collection of a −100 mesh stream sediment, panned concentrate and water sample from each of the 399 sites sampled. The sample density was 1 site per 1.5 km^2. Cu, Pb, Zn, Ba, Fe, Mn, Co, V, Cr, Ni, Zr, Mo and Sn were determined in the stream sediments, Cu, Pb, Zn, Ba, Fe, Mn, Ce, Sn, Sb, Ti, Ni and As in the panned concentrates and Cu, Pb and Zn in stream waters. Major variations in the results are related to (i) hydrous oxide precipitation processes, (ii) contamination from human activities, (iii) base metal and baryte mineralisation, (iv) monazite concentrations in panned concentrates, (v) hitherto unrecorded gold mineralisation and (vi) lithological variations. The latter were related principally to shale–sandstone variation, but groups of elements attributable to the presence of basic intrusions, phosphatic rocks, coal measures, sandstones, limestones and volcanics were also discerned.

Threshold levels were established from cumulative frequency curve analysis, and some anomalous sites were examined in the field. Anomalies did not form prominent coherent groups and were generally weak and scattered, with a wide variety of element groupings reflecting a range of causes. Many anomalous panned concentrates were examined mineralogically to try to determine whether anomalies were related to chemically extreme background lithologies, contamination, or mineralisation. All the anomalies were related to one or more of the major causes of variation, although because of the very limited amount of follow-up work carried out the precise cause of many anomalies remains uncertain. No anomaly is considered to represent a strong prospect but several deserve further limited investigation, notably those associated with (i) gold mineralisation in the northwest of the area, (ii) baryte, perhaps accompanied by base metal mineralisation, associated with Caradocian volcanics and phosphatic rocks at several localities, (iii) mineralisation associated with Llandeilian limestones and volcanic rocks north of Llanrhaeadr, and (iv) copper mineralisation associated with intrusives near the eastern margin of the Dome, where survey data is most incomplete.

INTRODUCTION

This report describes a geochemical drainage survey and regional gravity survey of the Berwyn Dome and its environs. The available aeromagnetic data were interpreted in conjunction with the gravity survey results.

The area surveyed forms a rural part of Central Wales lying between the towns of Llangollen, Bala, Welshpool and Oswestry (Figure 1). The western part of the area is characterised by peat and heather covered hills rising to 827 m on Cadair Berwyn. These are the source of the east flowing rivers which cross the area. The high ground is crossed by few roads, and habitation is restricted to the valleys. Locally the high ground is forested, particulary in the southeast about the Lake Vyrnwy reservoir. Elsewhere land use on the high ground is restricted to sheep grazing and grouse moor. The eastern part of the area is lower, with undulating grass and tree covered hills crossed by the rivers Dee, Ceiriog, Tanat, Cain and Vyrnwy. This part of the area is crossed by numerous minor roads and contains many farms and small villages. Mixed farming is the principal land use.

Rock exposure is generally poor, thick glacial deposits covering much of the low ground and the north-facing slopes of the high ground. Extensive alluvial deposits lie adjacent to the major rivers. The most resistant rocks form prominent scarps, but outcrops of other rocks are confined largely to the steep sides of the river valleys in the west and to stream sections, quarries and road cuttings.

Published geological, geochemical and geophysical data on the area are very limited. The eastern part of the area is described in the Oswestry memoir of the Geological Survey (Wedd and others, 1929). Prior to this, Sedgewick (1845) crossed the area in his traverse of North Wales and Jukes (1881) described aspects of the geology in detail. Groom and Lake (1908) and later Wills and Smith (1922) described the northern flank of the Dome, King (1923) examind the southwest of the area, and Cope (1915) described the igneous rocks. More recently Whittington (1938) remapped the area around Llansantffraid ym Mechain, MacGregor (1958, 1961) examined the Llandeilo Limestone, Cummins (1957, 1958a, 1958b, 1969) included the west of the area in his studies of Silurian greywackes, and Brenchley (1964, 1969, 1972,

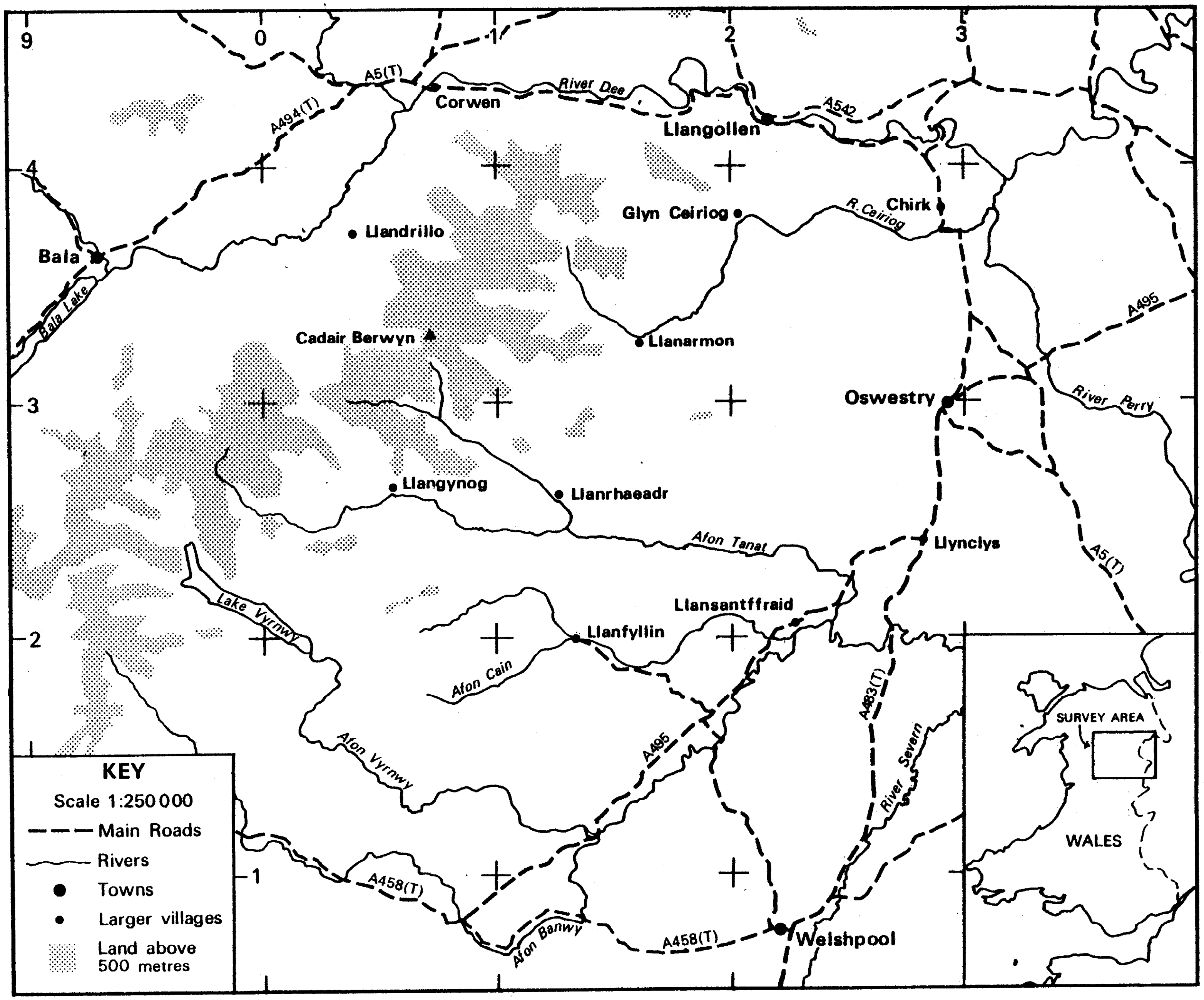


Fig. 1: Location of the survey area

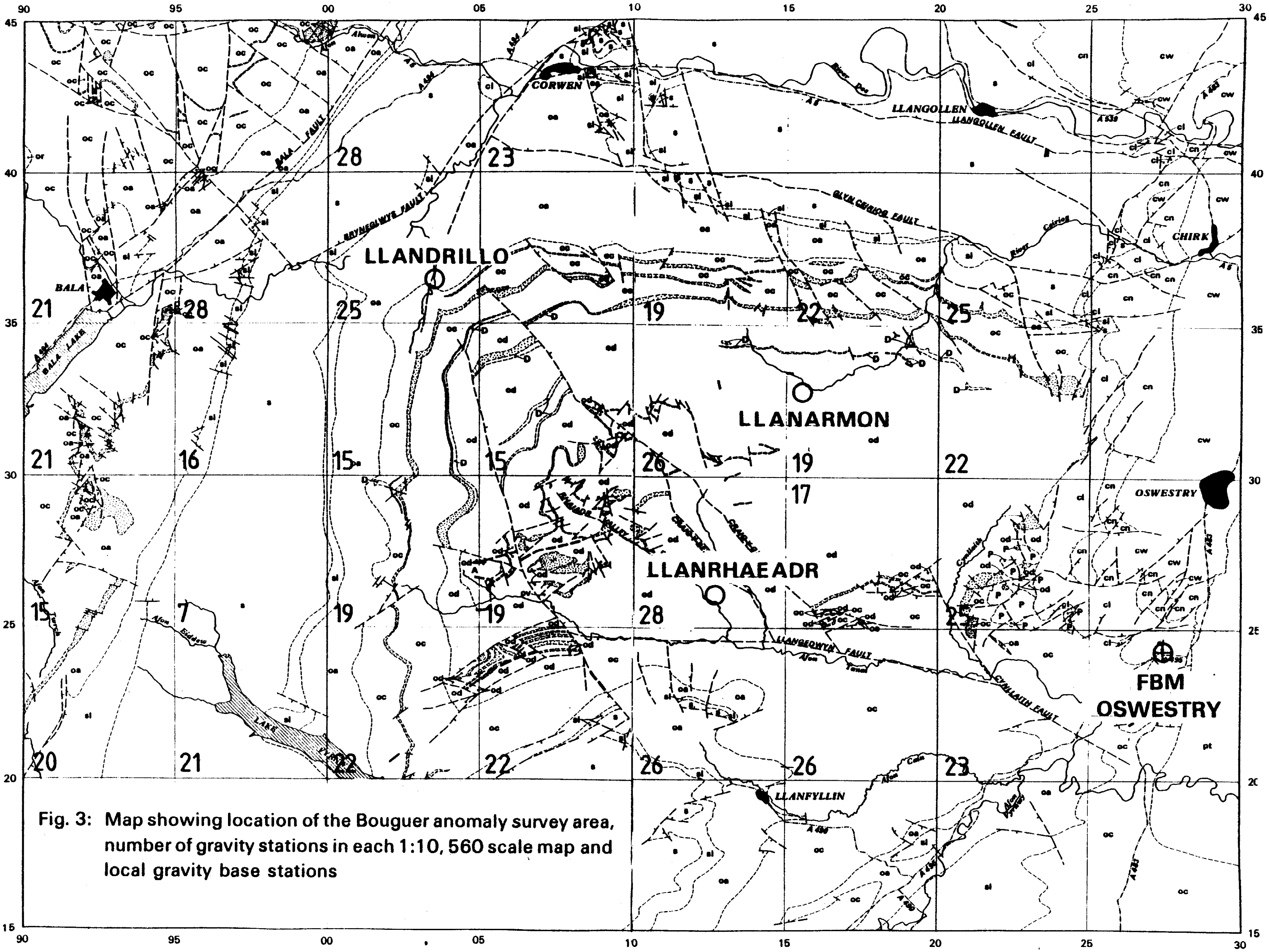


Fig. 3: Map showing location of the Bouguer anomaly survey area, number of gravity stations in each 1:10, 560 scale map and local gravity base stations

1978; Brenchley and Pickerill, 1980) has studied the Caradocian sequence in some detail. The metal mines at Llangynog have been described by Dewey and Smith (1922), Wilson and others (1922), Wren (1968), Foster-Smith (1978) and Bick (1978), whilst the phosphatic rocks first described by Davies (1867, 1875, 1892) have been examined more recently by Dines (Oakley and Dines, 1940; Dunham and Dines, 1945) and Cave (1965).

No detailed geochemical studies have been carried out in the area though Cave (1965) presents some trace element analyses of the phosphatic rocks. The only regional data available are those contained in the Imperial College Geochemical Atlas (1978), where the scale is small and the data only suitable for examining broad regional changes. Similarly, there is a lack of detailed geophysical studies. The area is covered at a small scale by the regional gravity map of Maroof (1974) and at a somewhat larger scale by the regional work of Griffith and Gibb (1965) and Powell (1956), whose maps suggest the presence of a gravity low in the Berwyn Hills. More detailed magnetic data are provided by the aeromagnetic map of the United Kingdom (Geological Survey, 1965).

The objective of this study was to provide basic information about a little known area of past mining activity, to indicate areas where more detailed work may be worthwhile and to answer some basic questions regarding the mineralisation, notably the possibility of a 'hidden' granite beneath the Llangynog mineralisation.

GEOLOGY AND MINERALISATION

SEDIMENTARY AND VOLCANIC ROCKS

The area is composed largely of Ordovician sedimentary rocks, Llandeilian to Ashgillian in age, flanked on the margins by Silurian strata except in the east where the Lower Palaeozoic outcrops are terminated by the Carboniferous overstep (Figure 2).

The most complete account of the stratigraphy is of the central and eastern part of the district given in the Oswestry memoir of the Geological Survey (Wedd and others, 1929), where the succession was summarised broadly as shown in Table 1. The subdivision of the Ordovician into beds and groups is based entirely upon the occurrence of local tuff (ash) horizons with some shelly and graptolite faunal control. These tuff horizons, especially within the Llandeilian are not persistent and cannot be applied across the whole area.

The Caradocian stratigraphic succession has recently been revised using modern terminology by Brenchley (1978), but the broad lithological pattern differs little from that given in Table 1. Brenchley (*op. cit.*) also gives a succession for the Caradocian in the western part of the area, which is simpler because there are less tuffaceous horizons on which to base subdivisions.

Silurian strata are described in less detail in the literature, but Cummins (1958a, 1958b) indicates that in the Wenlock and Ludlow there are considerable lithological changes across the area with mudstones and siltstones in the east giving way to greywacke grits in the west. Denbigh Grits of Wenlock age are shown as dominating outcrops on the western flank of the Dome whilst in the south of the survey area Denbigh Grits and the younger Nant Glyn Flags crop out. In the north Silurian outcrops are dominated by the Nant Glyn Flags and the younger Lower Ludlow 'Grits', which in this area are described as calcareous siltstones (Cummins, 1958).

Table 1 Generalised geological succession in the Berwyn Hills (after Wedd and others, 1929)

	Thickness ft (m)
Carboniferous	
Coal Measures	
Cefn-y-fedw Sandstone	280–450 (85–137)
Carboniferous Limestone Series	up to 1300 (400)
Unconformity	
Silurian	
Ludlow Series: grey blue mudstones and shales	uncertain
Wenlock Series: banded mudstones with grits in the west	uncertain
Upper Llandovery: pale grey shales and mudstones with thin sandstones	c.200 (60)
Lower Llandovery: blue mudstones, some limestones and shales	200 (60)
Ordovician	
Ashgillian	
Glyn Grit: sandstone in the north	up to ?100 (30)
Ddolhir Beds: sandy mudstone, some limestone	620–1000 (190–300)
Caradocian	
Pen-y-garnedd (Blaen-y-cwm) Beds:	
Pen-y-garnedd Shales: black shales with phosphate beds near the base	50 (15)
Pen-y-garnedd Limestone: lenticular limestones with shales and ashy beds	up to 100 (30)
Allt-tair-ffynnon (Bryn and Teirw) Beds (subdivisions in northern outcrop):	
Pen-y-graig Ash	up to 20 (6)
Bryn Beds: shales, sandstones, thin ashes and conglomerates	up to ?560 (170)
Pandy Ash	30–60 (9–18)
Tierw Beds: slates and sandstones with Swch Gorge Ash	uncertain
Cwmclwyd Ash	130–450 (40–137)
Llandeilian	
Mynydd-tarw Group: cleaved shales and mudstones with sandstones	great but uncertain
Mynydd-tarw Ash	10–12 (3–4)
Cleaved shales and mudstones with ashy and gritty sediments	?500 (150)
Gwern-feifod Group:	
Gardden-fawr Ash	60–80 (18–24)
Cleaved shales and mudstones with ashes	considerable but uncertain
Ash	?40 (12)
Lava	60 (18)
Blue shales	?100 (30)
Ash	25–30 (8–9)
Garwallt Group:	
Cleaved shales, occasionally ashy	500–1000 (150–300)
Garwallt Ash	15–20 (5–6)
Cleaved blue shales	c.60 (18)
Craig-y-glyn Group:	
Limestone (Llandeilo Limestone) and calcareous shales, in places sandy	370–780 (113–238)
Bedded calcareous ash (Llandeilo Ash) fossiliferous with basal conglomerate locally	200–230 (60–70)
Llanvirnian	
Cleaved blue shales and pale blue slates	(base not seen)

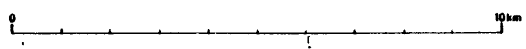


Fig. 5: Regional Bouguer anomaly map of the Berwyn Dome area.
Contours in mGal

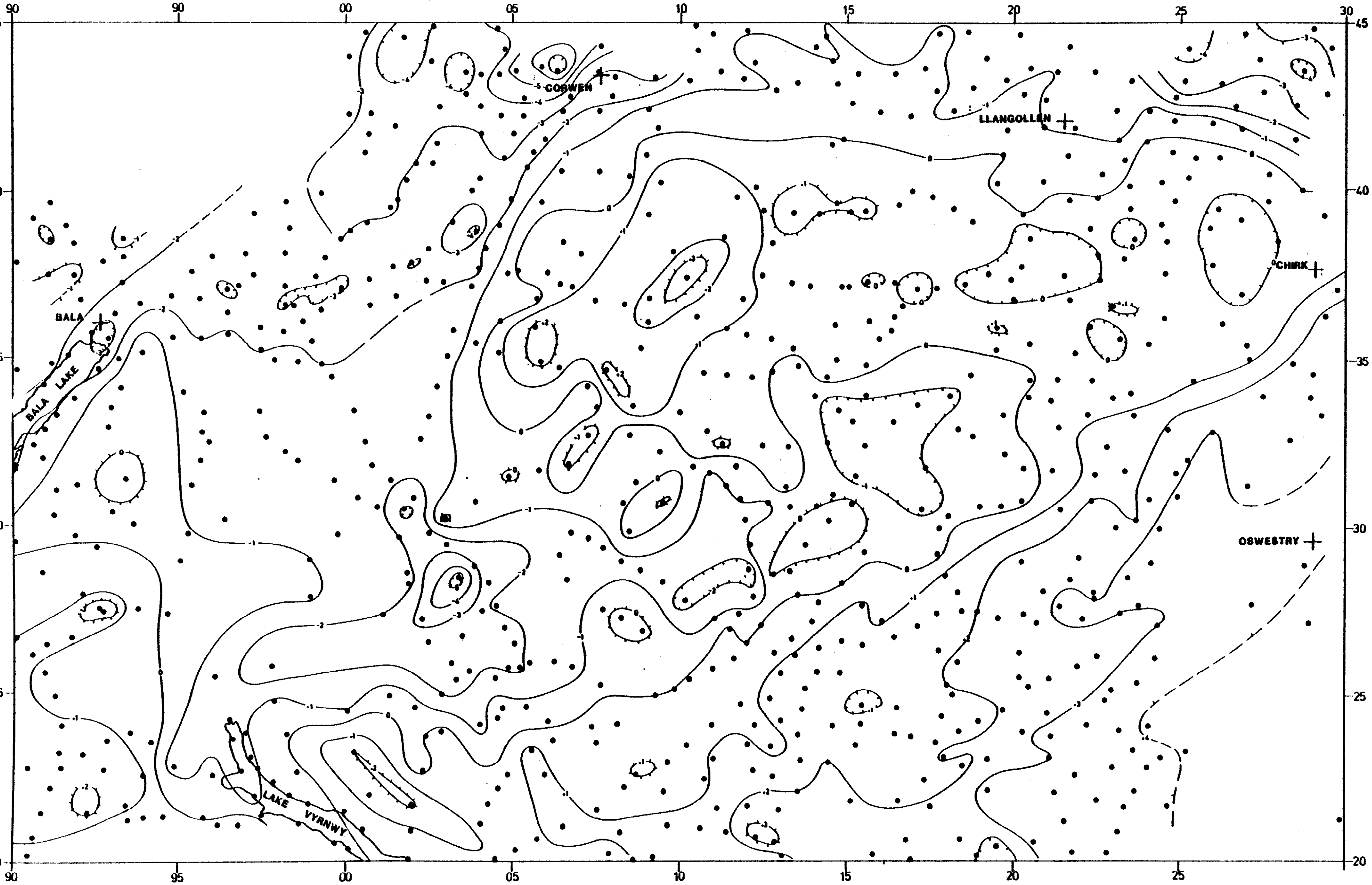


Fig. 6: Residual Bouguer anomaly map of the Berwyn Dome area.
Contours in mGal.

Ordovician strata are believed to have accumulated in shallow water conditions across the whole area (Wedd and others, 1929; Brenchley, 1978) with periodic emergence and perhaps subaerial volcanism. Deeper water conditions may have existed in the west. Cummins (1969) demonstrated that in the Silurian from Wenlock to Ludlow times, sediment accumulation within the area was controlled by the active eastern margin of a north–south trough. East of the margin shallow water mudstones and siltstones accumulated whilst in the west great thicknesses of greywacke were deposited.

The earliest volcanic activity occurs near the base of the Llandeilian with a stratified calcareous rhyolitic tuff or tuffite underlying the Llandeilo Limestone north of Llanrhaeadr [SJ 123 285]. Wedd and others (1929) considered that at this time the main centre of activity lay to the west of the dome. Minor bedded tuffs occur throughout the Llandeilian and in one instance, within the Gwern-feifod Group, there is a lava up to 18 m (60 ft) thick. In the Caradocian the tuffs are more extensive, forming persistent mappable units which accentuate the structure of the dome. At this time Wedd and others (1929) postulated two centres of activity; one concealed beneath the Carboniferous cover to the east, which was subsequently supported by Brenchley's work (1972) on the Cwm Clwyd Tuff, and the second lying to the west or northwest of the dome.

INTRUSIONS

The main group of intrusions are found close to the eastern margin of the area and are locally overlain unconformably by Carboniferous rocks. They consist of irregularly shaped plug-like masses, composed of rock described as 'porphyrite or keratophyre' (Wedd and others, 1929). The intrusions show considerable variation, but broadly they are greenish, medium grained, commonly porphyritic rocks containing albite-oligoclase feldspar, pyroxene and sometimes minor quartz. Often the rocks are extensively altered with the development of chlorite, albite, iron ores, and more rarely calcite and epidote assemblages. An especially interesting feature of the intrusions is brecciation on a micro- to mesoscopic scale. In the Bryn mass [SJ 225 255] the breccia consists entirely of angular or subangular fragments of keratophyre whereas in the Moelydd mass [SJ 243 252] it includes fossils which suggests it lies within a vent.

The other intrusions found within the area are the dolerite sills around the north and west side of the dome. The dolerites contain minor amphibole and are patchily altered with the development of epidote, chlorite, carbonate, quartz and zeolites. The intrusion below an ash band on Carnedd-y-Ci [SJ 060 340] is complex and contains keratophyric rocks. A persistent sill occurs along the northern side of the dome in the upper part of the Mynydd-tarw Group (Llandeilian) which has been described in detail in the vicinity of Hendre [SJ 190 345]; (Wedd and others, 1929, p. 82). Here also the dolerite includes keratophyric material and it was suggested that the two types were emplaced simultaneously.

At Llangynog a mass of quartz-feldspar porphyry is associated with rhyolitic lavas and substantial vein mineralisation; it probably represents the feeder zone for the lavas (Cope, 1915).

The porphyrite/keratophyre intrusions in the east are clearly of pre-Carboniferous age. Wedd and others (1929) suggest that they were emplaced after the development of cleavage in the Lower Palaeozoic rocks, although there was some element of doubt (p. 79). They are possibly Devonian in age. Similarly the dolerite sill at Hendre [SJ 190 345] 'appears to be of a later date than the cleavage' (p. 82). If this is the case, these dolerites differ from the ubiquitous dolerites associated with the Lower Palaeozoic rocks throughout the Caradocian of North Wales which are now regarded as almost entirely pre-dating the cleavage.

STRUCTURE

The structure of the Berwyn Dome is not well known; it is clearly not a simple fold. In the line of section on the Geological Survey New Series Sheet 137, drawn approximately north–south across the structure in the vicinity of Llanrhaeadr-ym-Mochnant, two anticlinal axes are separated by a syncline. The folds are generally eastward trending and broadly periclinal in form with the fold amplitude least at both ends of the dome. The southern limb is steeper and more complex, the Old Series maps showing a zone of overturning. Shackleton (1954) considered that the broad character of the fold results from shearing in this reversed foreland-facing limb and suggested that such structures could well pass down into a group of steeply inclined, reverse faults in the basement.

The closure of the dome-structure is defined on the Old Series Geological Survey maps by the outcrop of Bala limestone in an elongate outcrop, north–south, on the western margin of the dome, passing into an ENE crop in the reversed limb south of Hirnant [SJ 050 230]. However, the disposition of the tuffs shown on the Old Series Maps in the Llangynog–Hirnant district does not reflect this structure and they are clearly much disturbed by faulting, lying close to the projected line of the Tanat Fault as defined in the Oswestry Memoir (Wedd and others, 1929). It is possible that these tuff outcrops in the Llangynog district are in part intrusive.

MINERALISATION

Apart from the phosphatic black shales and limestones of the 'Nod Glas' (Cave, 1965) there is no stratigraphically controlled mineralisation known within the area.

The exploited phosphorite bed (Table 1), ranging between 6 and 18 inches thick, occurs within the Pen-y-garnedd shales a few feet above the Bala limestone (Oakley and Dines, 1940; Notholt and Highley, 1979). The bed crops out on both limbs of the Llandderfel syncline on the western margin of the area and along the southeast limb of the Berwyn anticline. Along the western outcrop it is represented only by irregular occurrences of nodules or a pyritiferous bed (Davies, 1892) and in places has been removed by pre-Ashgill erosion (Brenchley, 1978). As Cave (1965) describes more than one phosphatic horizon and mentions the development of nodules in the basal Ashgill, and as exposure is poor, it is possible that the mapped and exploited beds are not at precisely the same horizon across the whole area. The main exposures are in old workings, where the exploited bed consists of closely packed nodules set in a black shaly or tuffaceous matrix with a rich microfossil fauna or, in places, solely of phosphatic shale. Both shale and nodules contain varying amounts of pyrite and carbonaceous matter. The phosphatic shale is overlain by black shales and underlain by a thin phosphatic limestone and shales, which are frequently cut by ramifying veins up to 0.3 m wide of baryte with minor galena, sphalerite and chalcopyrite (Archer, 1959). Analyses (Davies, 1875,

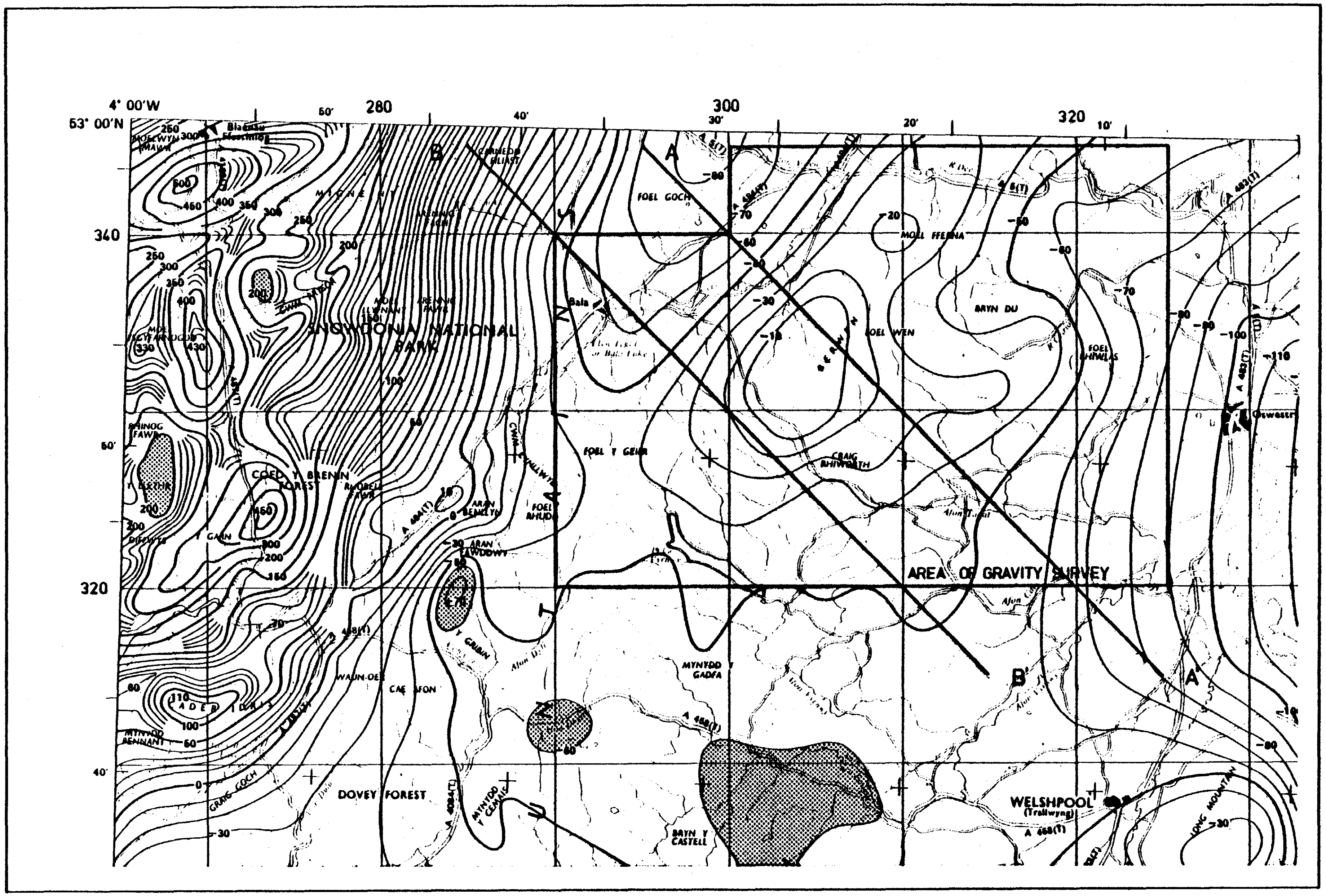


Fig. 7: Aeromagnetic map of the Berwyn Dome and surrounding area

Contours in nT.
Taken from I.G.S. 1:250,000 series
Aeromagnetic Anomaly map 52°N-04°W
Mid Wales and Marches

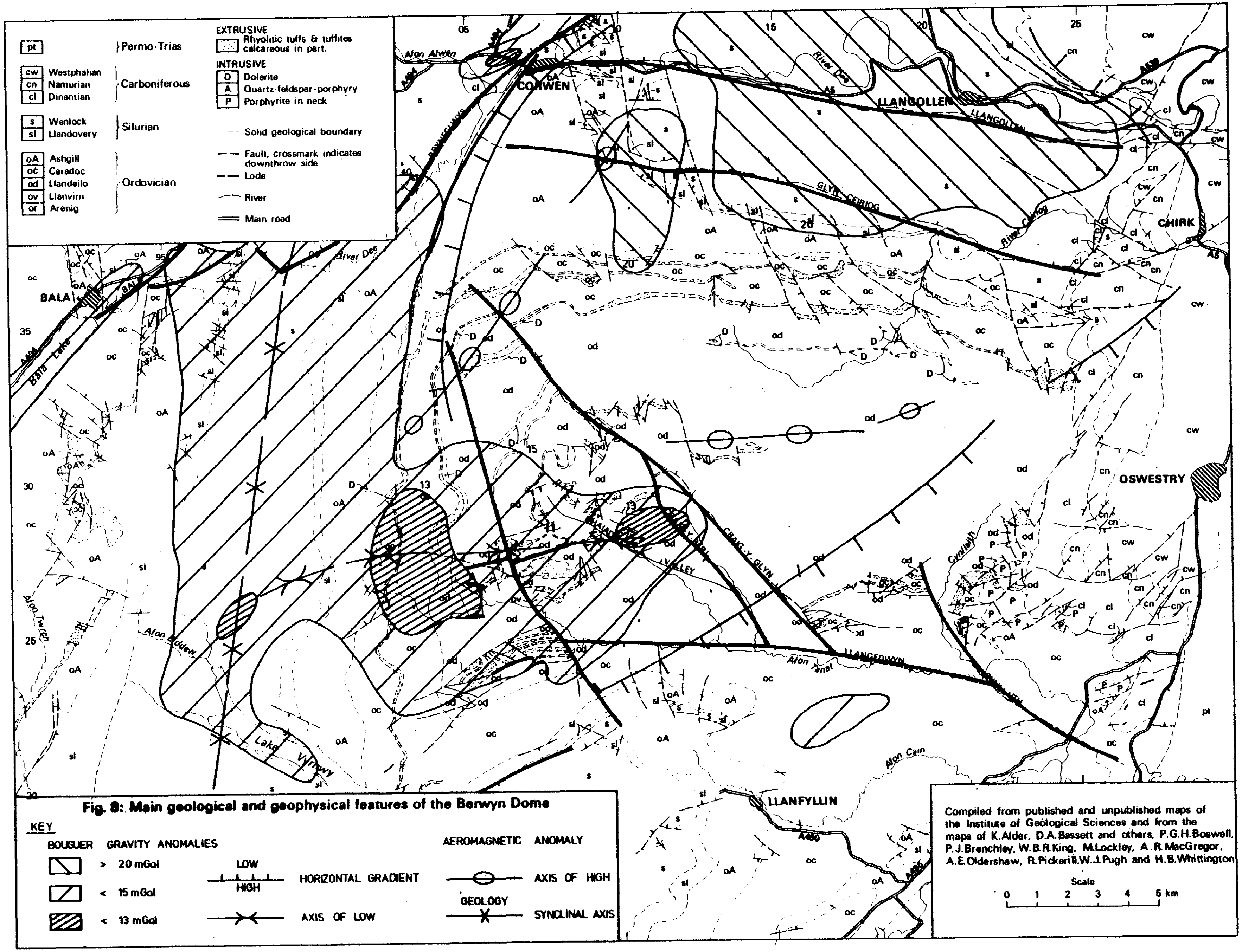


Fig. 8: Main geological and geophysical features of the Berwyn Dome

1892; Oakley and Dines, 1940) indicate the presence of 27.5–31.5% P_2O_5 in the nodules and about 21% P_2O_5 in the underlying limestone. There are no comprehensive analyses of the bed, but Ponsford (1955) showed that the sequence was not enriched in radioactive elements and Cave (1965) presented some trace element data, which indicated that in contrast to many dark shale accumulations, this sequence was not enriched in elements such as V, Mo, Co and Ni. These and other differences from anoxic black mud deposits led Cave (1965) to suggest that the Pen-y-garnedd beds were deposited on an offshore rising shelf free of detrital sedimentation.

The phosphatic deposits were discovered in 1863 and worked on a small scale at several sites until 1884. Little is known about most of the workings and many are now obscured. Known workings are listed in Appendix 2 and shown on Figures 14–20. Details of individual workings are given by Oakley and Dines (1940). Economic exploitation of the deposit is inhibited by the steep dip and thinness of the phosphatic horizon at many localities, the variation in phosphate content along the strike, the remoteness of much of its outcrop, and faulting. The possibility of extracting by-product baryte with the phosphate is perhaps the most attractive feature of the deposit but, as far as is known, this has not been examined in detail.

Vein mineralisation has been exploited mainly around Llangynog and within the Carboniferous Limestone along the eastern margin of the area. At Llangynog veins, in many cases emplaced along faults, cross Llandeilian shales, mudstones, sandstones, lavas, tuffs and the intrusions. The most productive lodes strike approximately east–west, but some north–south cross-courses such as were exploited at Cwm Orog [SJ 050 273] and Craig Rhiwarth [SJ 054 266] are also important ore-carriers. The principal ore mineral was galena; sphalerite, witherite, cerussite, baryte, pyrite, quartz and calcite are also commonly present in the lodes. Chalcopyrite occurs locally and rarely formed the principal ore mineral, as in a lode striking a few degrees south of east, slightly obliquely to the lead-bearing lode, at Craig Rhiwarth. At Nant-y-blaidd mine [SJ 090 282] a SSW trending lode is recorded which contains galena and chalcopyrite in a gangue of orthoclase with sulphur and gypsum. It is also reputed to contain 2 oz/ton gold (Archer, 1959).

The age of the mineralisation is uncertain. There appears to have been a clear host rock control on mineralisation; lodes commonly occur at the contacts between sedimentary and igneous rocks, and at Craig Rhiwarth a lode which ran mainly through igneous rock was unproductive where shales formed the walls.

The most productive lodes were those of Llangynog mine, which was discovered in 1692 and worked intermittently until 1880. An estimated 70 000 tonnes of lead ore were extracted (Bick, 1978). The most recent workings were at Cwm Orog where 60 tons of baryte were extracted in 1916. Details of the workings and mining activities are given by Dewey and Smith (1922), Wren (1968), Foster-Smith (1978) and Bick (1978).

Within the Carboniferous Limestone, on the eastern margin of the area, veins with copper, lead and zinc are found around Llynclys Hill [SJ 272 239], Crickheath Hill [SJ 272 232] and Llanymynech Hill [SJ 265 219]. At the latter site the ores are believed to have been worked by the Romans. The veins, mainly aligned NNE or ENE, contain the ore minerals galena, sphalerite, chalcopyrite, pyrite, cerussite, calamine and malachite. No details of production are known.

Some further scattered occurrences of mineralisation are recorded within the area. Minor chalcopyrite and malachite smears occur in brecciated intrusive rocks near the obscure remains of the old trials at Moelydd [SJ 242 255]. The style of mineralisation here is uncertain. Nearby, lead ore is recorded in the overlying Carboniferous Limestone on the Old Series Geological Survey maps. North of Llanrhaeadr [SJ 122 290] trials appear to have investigated quartz, carbonate, galena, sphalerite and pyrite bearing veins found in Llandeilian sandstones, shales, tuffs and limestone. No records of these workings are known. During this survey an isolated working was identified near Corwen [SH 101 428]. Here galena and sphalerite were found in a stream below a mineralised quartz vein occupying a north–south fault in the Silurian mudstone–sandstone sequence. Cope (1915) recorded abundant pyrite with chalcopyrite and pyrrhotite as secondary minerals in the Hendre Sill [SJ 192 343] and pyrite, chalcopyrite, sphalerite, galena, cerussite and manganese minerals have been reported from the quarries at Pandy [SJ 195 360].

In the extreme southeast of the area near Four Crosses [SJ 252 182, SH 257 175], two trials for hematite, one of which may contain a trace of copper, are recorded in the Ordovician shales. Both metals may be derived from the Permo-Trias which once overlay this area (Wedd and others, 1929).

The location of known metal workings within the survey area are listed in Appendix 1 and shown on the drainage survey maps. The list has been compiled from readily accessible sources and observations made during the drainage survey. It is therefore most probably incomplete. Many of the sites have not been checked and some confusion of names is evident, for example the exact extent and position of mines to the north of Llangynog variously called Craig Rhiwarth, Ochr-y-graig and North Llangynog.

GEOPHYSICAL SURVEYS

GRAVITY SURVEY

It is apparent from an inspection of the Bouguer anomaly map of Wales (Griffiths and Gibb, 1965) that the Berwyn Dome area is characterised by low Bouguer anomaly values. These values reached a minimum at [SJ 02 27], not far from the Llangynog mineralisation, but the small number of stations on which the original survey was based inhibits detailed interpretation.

The Bouguer anomaly low over the Berwyn Dome is probably due either to the rise of low density Precambrian basement rocks or the presence of a low density, acidic intrusion which could be associated with the mineralisation. A more detailed regional gravity survey was undertaken to investigate the anomaly further and this followed the general procedure adopted by the Applied Geophysics Unit (AGU) of British Geological Survey (BGS) for land gravity surveys.

The area of the gravity survey lies between SH 90E, SJ 25E, SH 10N and SH 45N. Additional observations were made around Corwen. In total 634 observations were made in an area of 750 km^2, giving an average station density of 1 per 1.18 km^2, compared with 1 per 7.6 km^2 available previously. The lower station density in the hills, due to the lack of adequate elevation control there, has resulted in an uneven distribution of stations (Figure 3).

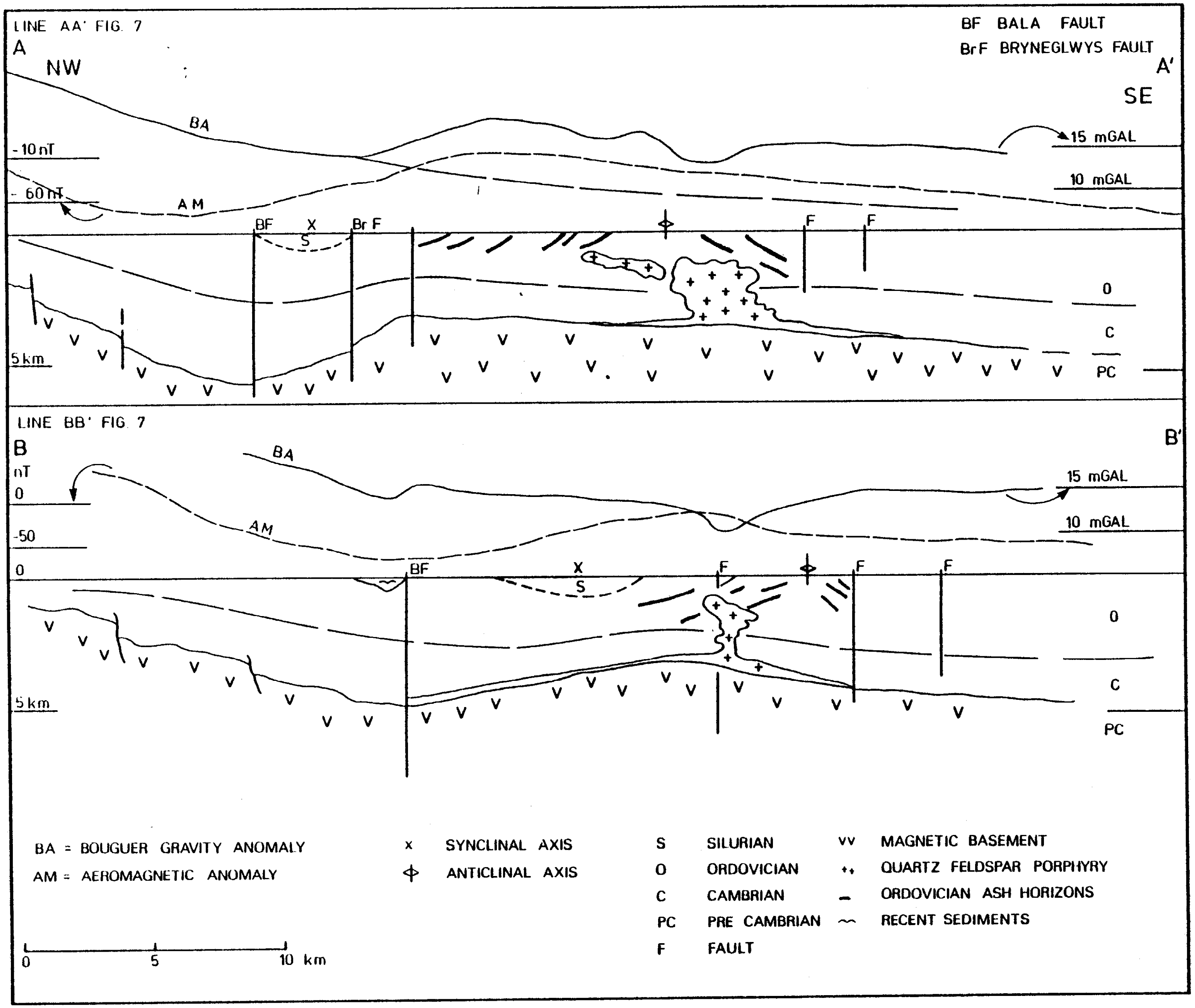


Fig. 9: Diagrammatic geological sections A-A' and B-B' (Fig. 7) across the Berwyn Dome.

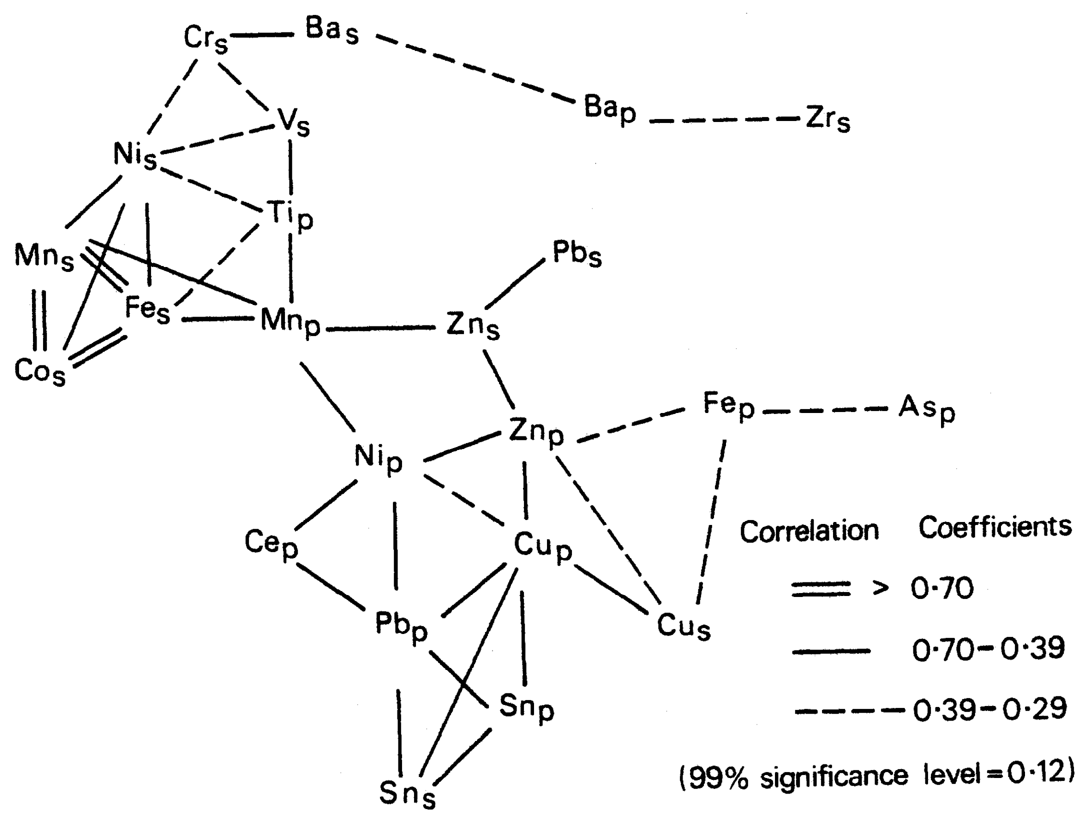


Fig. 10: Summary of positive inter-element associations based on the log-transformed correlation matrix

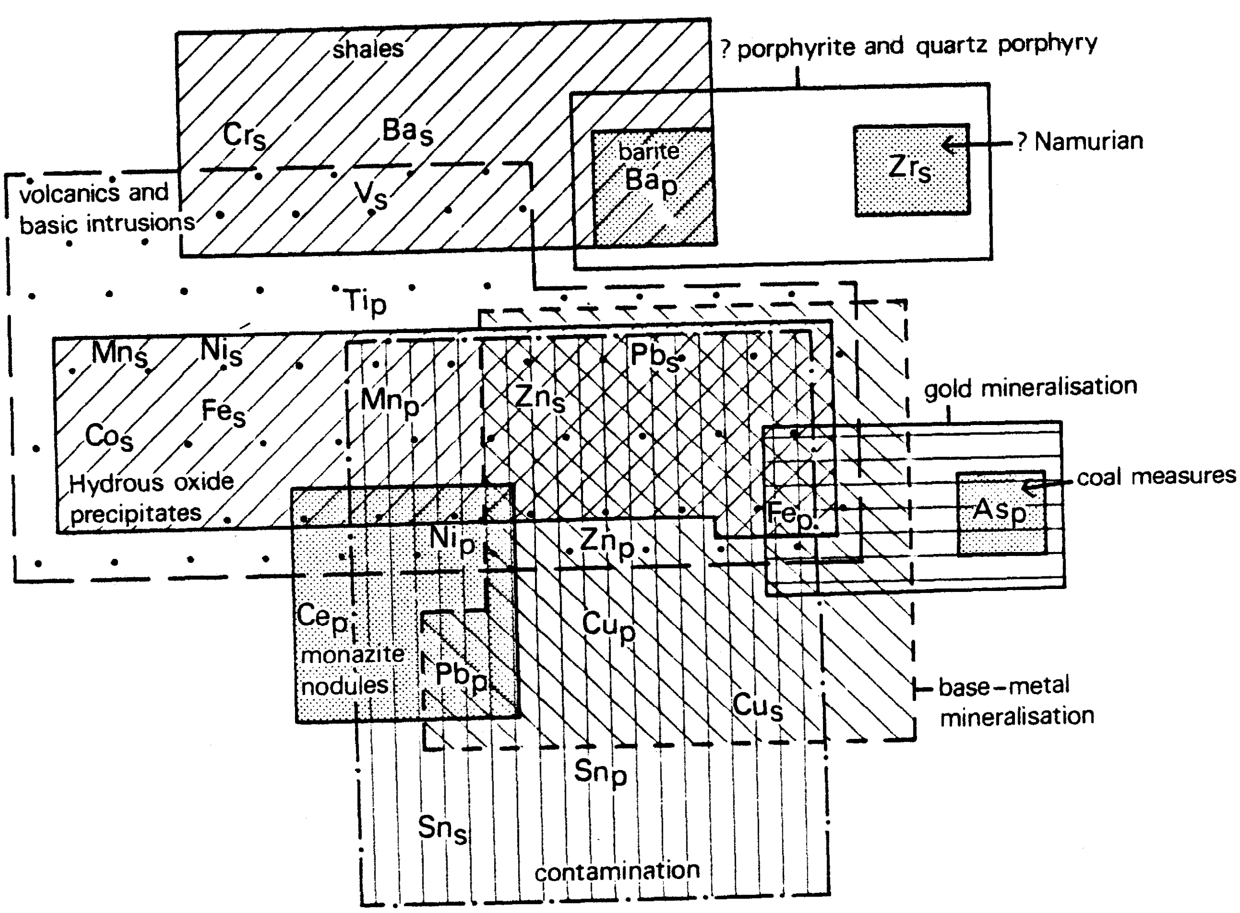


Fig. 11: Diagrammatic interpretation of the positive inter-element associations

Fieldwork and data reduction

Gravity observations. All gravity differences observed during the survey were made from three gravity bases established at Llandrillo (L), Llanrhaeadr-ym-Mochnant (LYM) and Llanarmon Dyffryn Ceiriog (LDC) (Figure 3). These bases were linked to the BGS FBM base (Masson Smith and others, 1974) at Oswestry, where the value of g is known to be 981312.99 mGal.

Observations were made with a LaCoste and Romberg gravity meter (LCR 356) and with a Worden gravity meter (W792). Both meters had been calibrated over a known gravity difference shortly before the survey. Instrumental drift of the LaCoste gravity meter was generally less than +0.05 mGal per day; drift of the Worden meter was much larger, up to 0.80 mGal per day. The high drift of the Worden meter was probably due to large diurnal temperature and pressure variations at the time of survey, with a tendency towards positive drift of 0.03 mGal/hr in the morning and a negative drift of −0.03 mGal/hr in the afternoons. Occasionally, negative drifts in excess of 0.10 mGal/hr were observed in exceptionally hot weather. Because of the necessity of making frequent checks on instrumental drift, the Worden meter was used only on roads.

Elevations. Prime station observations were made at Ordnance Survey bench marks, triangulation points and spot heights taken from OS 1:10 560 maps and bench mark listings. Parts of the upland areas lacked OS height control and the accurate location of spot heights in other upland areas was not always easy; mislocation of stations may therefore be a source of large random errors in the data.

Altimeters were occasionally used on roads and tracks, where drift could be monitored frequently, but no altimeter observations were made for hill stations.

Rock densities. Rock densities for Lower Palaeozoic strata in Wales have been tabulated by Powell (1956) and Griffiths and Gibb (1965) and no new measurements were made for the present survey. From the values given in Table 2, it is evident that the standard deviations of densities are of the same order as probable density contrasts. Powell (1956) points out that gravity anomalies are not likely to bear a constant relationship to Lower Palaeozoic thicknesses because the densities of Precambrian and Palaeozoic rocks overlap (although the Precambrian densities given in Table 2 were based on samples from Anglesey, 60–90 km away from the Berwyn Dome). The evidence from rock density determinations is therefore far from clear, although from Table 2 it might be expected that the older rocks (Cambrian and Precambrian) have higher density values. A standard density of 2.70 g cm^{-3} was used for the Bouguer correction when reducing the Bouguer anomaly data to sea level.

Calculation of Bouguer anomaly values. The Bouguer anomaly values were calculated according to the standard methods using NGRN 73 base values (Masson Smith and others, 1974) and the 1967 International Gravity formula.

The most significant sources of error in the calculated values occur in estimating the elevation and the terrain correction. In hilly upland areas, such as the Berwyn Hills, these estimates are likely to be less accurate than in topographically flat areas. The terrain correction for each gravity station was estimated by the use of zone charts. The inner zone (A–H) terrain correction varied from about 0.50 mGal to over 5.0 mGal in cwms and valleys. They were estimated by several workers and may be liable to errors up to ±0.20 mGal. Outer zone corrections (zones I–Z, 5–60 km) were calculated by computer and were of the order of 1–4 mGal.

Table 2 Densities of some North Wales rocks

System and area	Lithology	Density g cm^{-3}	Range g cm^{-3}
Silurian			
North Wales	Shales-mudstones	2.70±0.05*	2.60-2.78
North-central Wales	Various	2.73±0.01†	
Corwen	Various	2.71±0.01*	
Ordovician			
North Wales	Shales-mudstones	2.77±0.05*	2.68-2.83
	Grits	2.65±0.03*	
	Ashes	2.70±0.07*	
	Acid lavas	2.65±0.05*	
Berwyn Hills	Various	2.67±0.04*‡	
East-central Wales	Various	2.73±0.02†	
Harlech Dome	Slates	2.77±0.03*	
		2.84±0.02*	
Nantlle	Grits	2.69±0.02*	
		2.74±0.01†	
		2.73*	
Precambrian			
	All lithologies	2.76* (weighted average)	2.63-3.05
	Dolerite	2.94±0.07*	
Intrusions			
	Granite	2.58±0.05*	

* Powell (1956)
† Griffiths and Gibb (1965)
‡ From gravity traverse determination

The Bouguer anomaly values obtained for the Berwyn Dome have been contoured manually and are shown in Figure 4. Data for individual stations are deposited, together with locations of the gravity stations, with the Applied Geophysics Unit of the BGS.

The Bouguer gravity anomaly field

The main features of this field (figure 4) are, firstly, a Bouguer anomaly ridge which extends eastwards from Corwen to Llangollen and then south to near Oswestry and, secondly, two broad elongate lows which extend north and ENE from a minimum in the Llangynog area [SJ 03 28]. The range of the Bouguer anomaly values is about 10 mGal (12–22 mGal). Superimposed on the main features are low amplitude, short wavelength anomalies caused largely by near-surface density contrasts. On a broad scale the ENE trending gravity low is associated with the major anticlinal axis and with the Llandeilian outcrop of the Berwyn Dome, but discrete lows also exist which cannot be directly related to lithology. In an attempt to resolve the anomalies of different wave-lengths (usually indicating different depths of origin), a residual anomaly map was prepared after determining a regional anomaly field due mainly to broad changes in densities of rocks at the surface or more deeply buried anomalous bodies.

Estimates of the regional Bouguer anomaly field for Central Wales have been made by Griffiths and Gibb (1965), and Maroof (1974), based on surveys consisting of comparatively few stations. Both regional trends show curvature over the Berwyn Dome which can be interpreted as a broad gravity low. The new data for the Berwyn Hills (Figure 4) also suggest an elongate low over the axis of the Dome. If a simple vertical cylinder model is

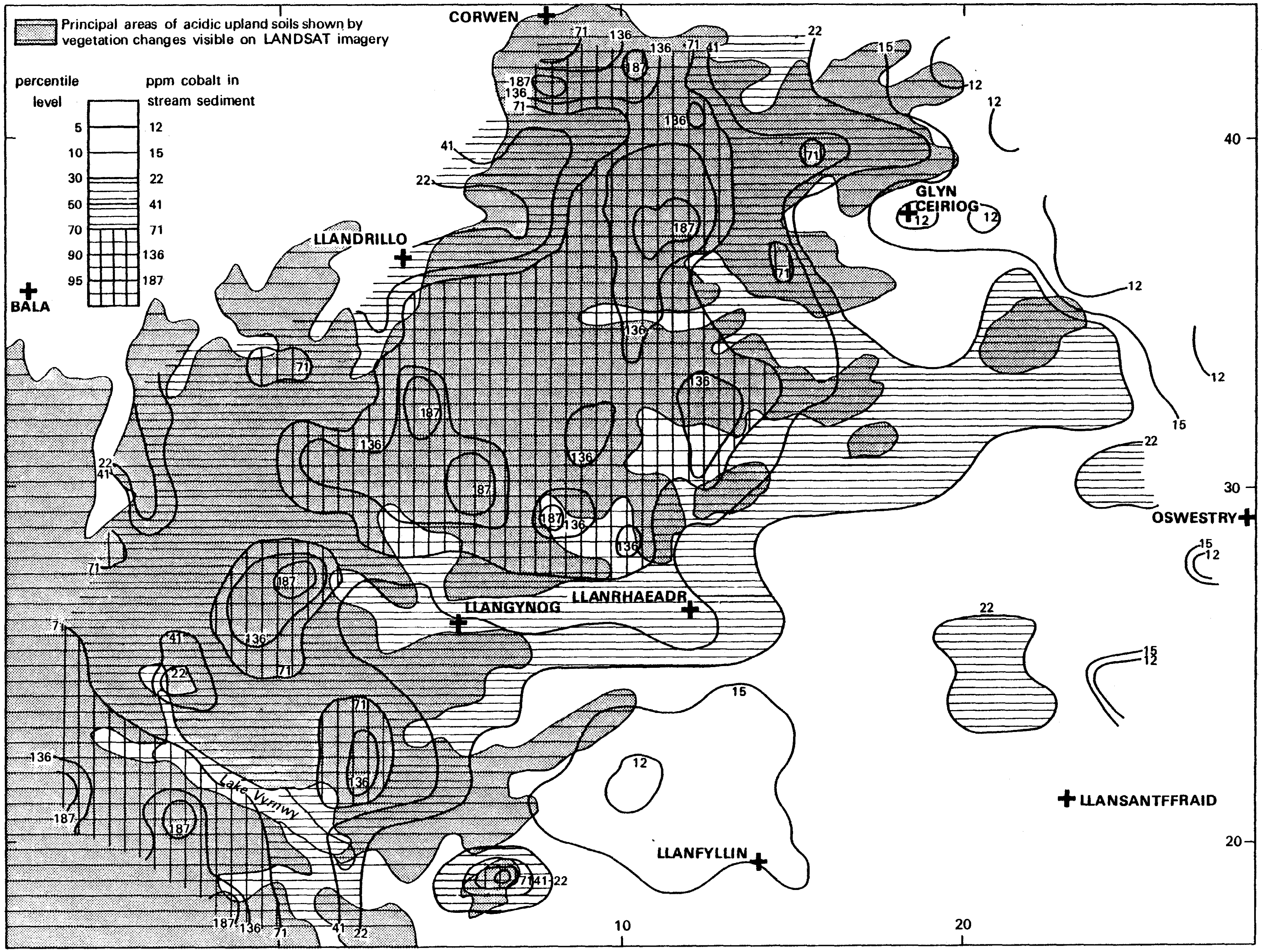


Fig. 12: Distribution of cobalt in stream sediment with respect to acid upland soils

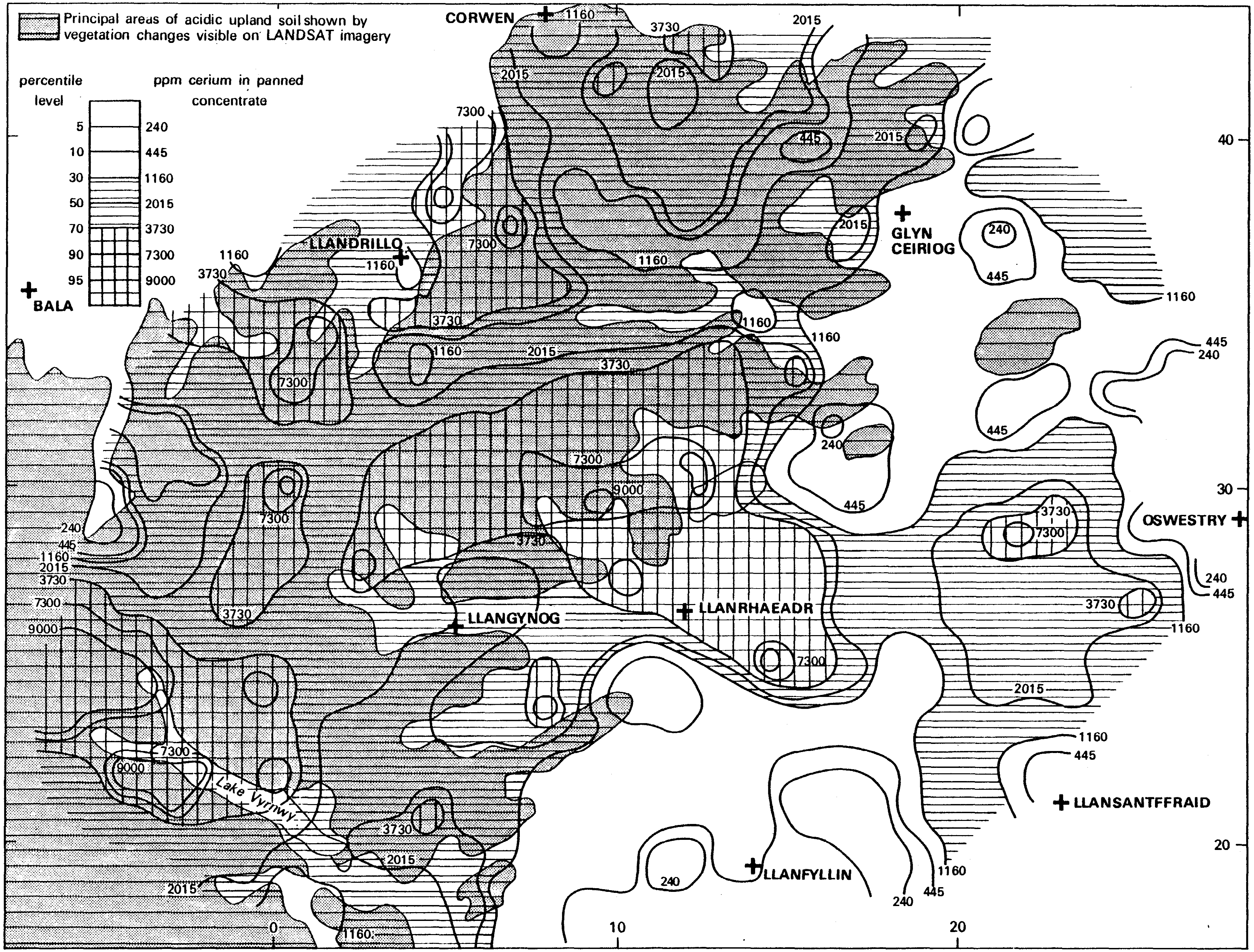


Fig. 13: Distribution of cerium in panned concentrate with respect to acid upland soils

assumed (Skeels, 1963), then, with an approximate radius of 20 km, the top surface would lie between depths of 6 and 8 km and the bottom surface between 10 and 15 km. These depths were calculated for density contrasts of -0.20 and -0.05 g cm^{-3} respectively. This interpretation is approximate, but it indicates that the source of the regional feature is a low density body within the upper crust.

As a preliminary interpretation, a regional anomaly field (Figure 5) was drawn graphically and subtracted from the observed Bouguer gravity anomaly field (Figure 4) to produce the residual anomaly map (Figure 6), in which the sources of the anomalies can be considered to occur at or close to the surface. There are still areas on this map, however, where the anomalies depart systematically from zero, particularly in the southeast corner, suggesting that the estimate of the regional field could be further improved.

The main difference between the observed and residual Bouguer anomaly maps, apart from the general reduction in the amplitude, is the almost complete removal from the residual anomaly field of the Bouguer anomaly ridge in the northeastern part of the area. This is because the ridge has a long wavelength and has been regarded as a regional feature. The ENE-trend of the anomalies over the main part of the dome has been somewhat emphasised, particularly along the southern margin where a linear contour trend extends from [SJ 04 23] to [SJ 30 37].

The above separation of regional and residual anomalies is extremely arbitrary, so in the following discussions reference will be made to both the Bouguer anomaly and residual anomaly maps (Figures 4 and 6 respectively).

It has been noted above that the lowest Bouguer anomaly values coincide approximately with the main outcrop of the oldest rocks in the area, the Llandeilo sedimentary sequence in the centre of the Berwyn Dome. This suggests that these rocks, or the underlying Precambrian basement, are responsible for the low. On the original Bouguer anomaly map (Figure 4) the lowest values occur just to the west of the Llandeilian outcrop, suggesting additionally that low density rocks are most extensively developed at depth in this direction.

If the Lower Palaeozoic sedimentary rocks have a higher density than the Precambrian basement, then it would be expected that not only would the centre of the Berwyn Dome be a Bouguer anomaly low but Bouguer anomaly highs would correspond with the outcrop of the younger rocks in the area. This tends to be the case for the Silurian rocks in the northeastern part of the area but sedimentary rocks of the same age occurring in the axis of the syncline extending NNE from Lake Vyrnwy, past Corwen (Figure 4) are associated with a Bouguer anomaly low (cf. Figure 8). Elsewhere on the maps there appears to be little relationship between Bouguer anomaly values and stratigraphic horizons. Several reasons can be put forward to explain this, including changes in the nature of the Precambrian basement or changes in the thickness and/or lithology of the Lower Palaeozoic sedimentary rocks; these alternative interpretations are discussed later.

The Bala-Bryneglwys fault system is a major structural feature which crosses the northwestern part of the area (Figure 4) and is thought to have influenced Lower Palaeozoic and later structures. The nature of the Talyllyn-Bala-Bryneglwys Fault system has been reviewed by Basset (1969). The Bala section is not directly connected with the Bryneglwys Fault at surface (Basset, *op cit.*) but it could be at depth. The phases, directions and extent of movements along this fracture are not accurately known but at Bala the post-Ordovician downthrow is of the order of 610 m to the southeast, and at Wrexham the pre-Triassic downthrow on the Bryneglwys fault is of the order of 460 m to the northwest. Later movements of the system involve downthrows to the northwest. Rast (1969) suggests that the Bala Fault marks the approximate limit of Ordovician volcanics whose absence to the southeast is ascribed to the thickening of Cambrian and Precambrian rocks (by about 3.7 km) above a magmatic layer.

At Bala, the Bouguer gravity anomaly field shows no major variation across the fault apart from a local anomaly due to thick superficial deposits. West of Corwen the Bryneglwys fault system marks the northwest boundary of the main Bouguer anomaly high, but to the southwest the gradient zone diverges from the Bryneglwys fault and follows the line of the SSW-trending, unnamed fault (Figures 4 and 6). The linear character of the contours is one of most obvious features in Figure 4 and strongly suggests a deep fault extending to the SSW from near Corwen to about [SJ 03 32]. If projected southwards this line would intersect the Bouguer anomaly low at [SJ 03 28] and continue along the strike of the Caradocian sedimentry rocks on the western edge of the dome, suggesting the possibility of an unmapped major strike fault. The same line also forms the well defined western boundaries to high areas of several elements, notably Zn (Figure 28) and Ni (Figure 32) in stream sediment

Superimposed on the broader scale features described above are smaller scale variations in the Bouguer anomaly map whose limited extent suggest a near-surface origin. Included also in these variations are the effects of observational and data reduction errors. The anomalies which appear to have some geological significance are described below.

a Low Bouguer anomaly values were recorded at stations situated in valley bottoms where the existence of thick drift or alluvium seems to provide a likely explanation. The most pronounced anomaly occurs just west of Corwen [SJ 063 436], but others occur near Bala Lake [SH 929 352] and in the valleys of the River Dee [SH 995 367, SG 039 388] and Afon Tanat [SJ 155 247].

b The cause of the roughly circular residual low of -5 mGal at (SJ 033 284) may be a plug-like acid igneous body at a shallow depth, although the known quartz-feldspar-porphyry body at Bryn [SJ 23 26], 20 km to the east, produces only a small residual anomaly of about 0.5 mGal. The central part of the anomaly northwest of Llangynog is based on only one station, in steep terrain, although the station terrain correction has been accurately repeated. Geochemical anomalies associated with faults in the volcanics nearby help to support the intrusive plug hypothesis.

c Further east the group of anomalies around [SJ 10 30] appear to be related to differential movements of blocks adjacent to the Craig-y-Glyn, Craig-y-Beri and Rhaeadr valley faults. The residual anomaly low is centred on a station over some of the oldest rocks in the area, but volcanic activity and mineralisation near here suggest another possible cause of the low (see stream sediment anomaly group 7).

The aeromagnetic anomaly field

Figure 7 shows the aeromagnetic anomalies over the Berwyn area, contoured at intervals of 10 nT above a linear regional field for the UK, and taken from the aeromagnetic map of Great Britain (Geological Survey of Great Britain, 1965).

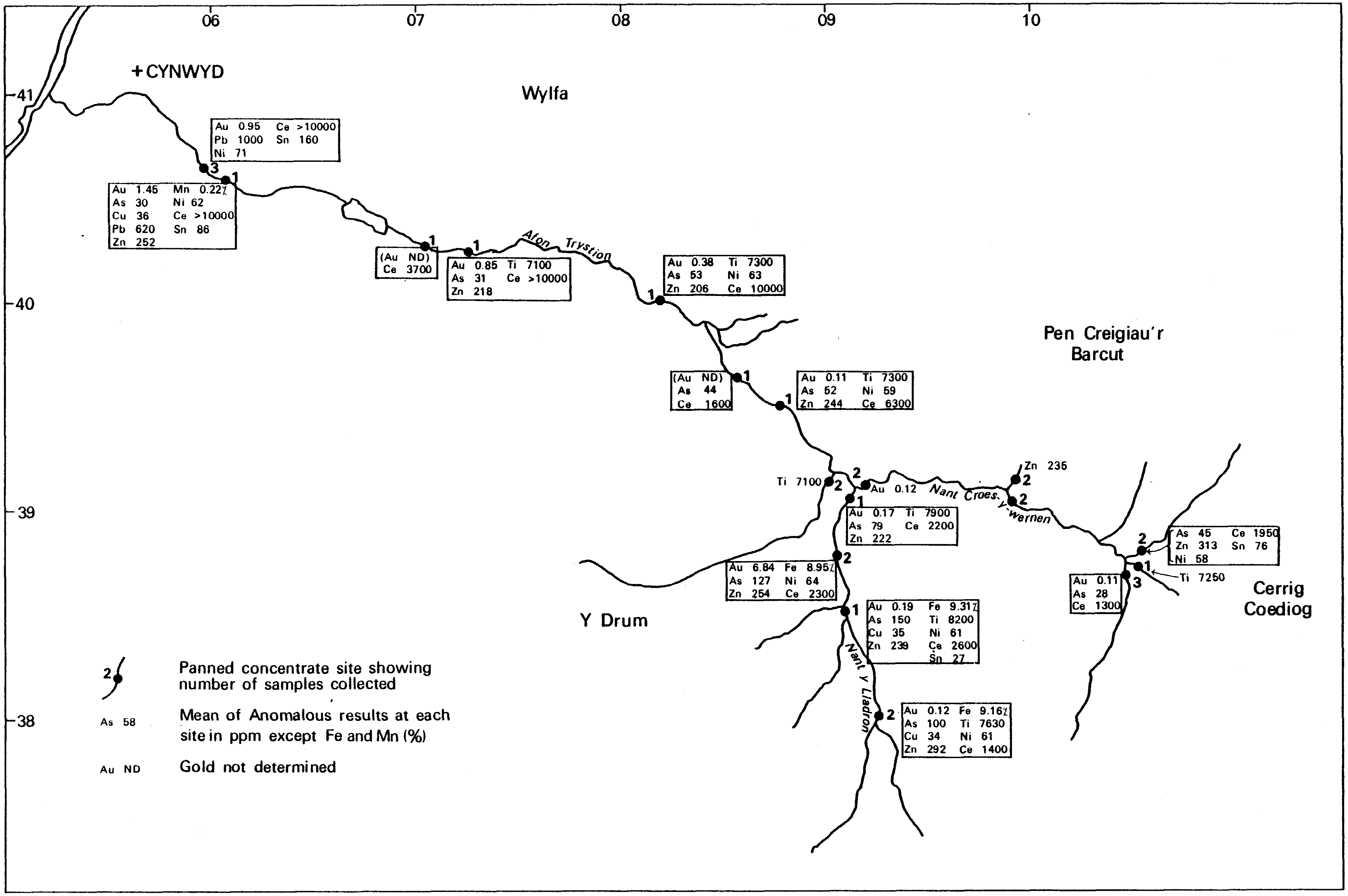
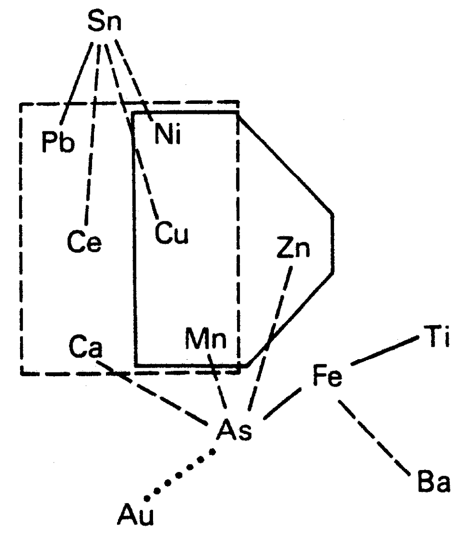


Fig. 22: Anomalous results in panned concentrates from the Afon Trystion.

Pearson method (log transformed data).



Confidence level of ties

———— >99·9%

– – – – – >99%

•••••••••• >95% (selected ties only)

Kendall rank method.

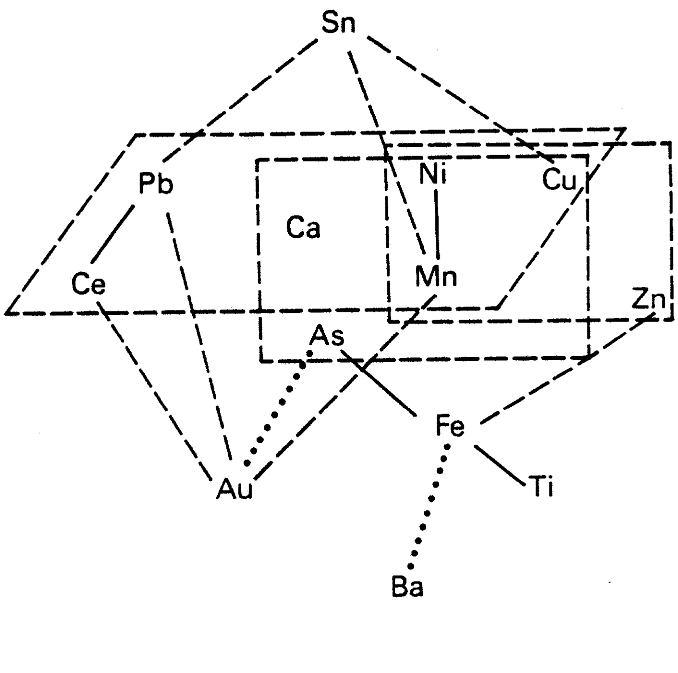


Fig.23. Summary of highly significant inter-element correlations for panned concentrates from the Afon Trystion

The main feature is a magnetic high extending NE–SW with a maximum anomaly over the northwest part of the Berwyn Dome. The line of maximum gradient to the northwest of this high runs roughly parallel with the line of the Bryneglwys Fault system near Corwen, but to the southwest it diverges slightly to the west. North of the area shown in Figure 7 the magnetic boundary continues its NE-trend, again diverging from the course of the Bryneglwys Fault.

The source of the magnetic anomaly, interpreted to be at a depth of 3–4 km, may be in Cambrian or Precambrian rocks. In the Harlech Dome area (Allen and others, 1979) the intense magnetic anomalies are confined largely to the area covered at the surface by Cambrian rocks, but the distribution of the anomalies depends on both the stratigraphy and the geological history of the area. In the Harlech Dome the igneous rocks do not always give rise to magnetic anomalies and several sedimentary horizons are magnetic. In eastern Snowdonia magnetic anomalies are associated with rocks older than Silurian. If the Berwyn Dome magnetic anomaly represents a structural high similar to the Harlech Dome or Snowdonia then it occurs to the northwest of the centre of the dome at outcrop. The Llandeilo sedimentary rocks in the centre of the dome appear to be underlain by a smaller high, indicated by an anomaly elongated to the ENE and shown in Figure 7 mainly by the -30 and -40 gamma contours near [SJ 15 31]. From the marked change in curvature of aeromagnetic contours southeast of the high, it can be inferred that the unnamed (partly mineralised) fault passing southeast through [SJ 05 32] extends in depth at least down to the level of the magnetic source rocks.

GENERAL INTERPRETATION

The main features of the regional geophysical data have been described above, and in Figure 8 a synthesis of the main relevant geological and geophysical results is presented. The faults shown by the thick lines in this figure have been indicated because there is some evidence that they affect the sources of the gravity or magnetic anomalies.

Assuming no major lateral density changes within the Palaeozoic sedimentary rocks and no major density or susceptibility variations within the Precambrian basement, the observed geophysical results across the Berwyn Hills can mostly be interpreted in terms of basement elevation.

Interpretations using this model can include the following observations:

a The Silurian sequence is of variable thickness up to about 2.0 km.

b Ordovician sedimentary rocks are of the order of 2.0 km thick.

c The Cambrian of the Harlech area is of the order of 4.6 km thick (Dr P. M. Allen, personal communication).

d The depth of the Precambrian basement might, on geological evidence, be between 2.0 and 8.6 km.

e The aeromagnetic anomaly around Llandrillo suggests a source at a depth of about 3.0 km.

The interpretations shown in Figure 9 involve a high density, magnetic Lower Cambrian or Precambrian basement, similar perhaps to the Bryn Teg Volcanic Formation in the Harlech Dome, at a depth of about 3 km in the Berwyn area. This implies a thinning of the Cambrian across the Bala-Bryneglwys Fault zone and the presence of low density bodies (acid igneous rocks?) within the Lower Palaeozoic.

The Berwyn Dome Bouguer anomaly minima are more localised than the general rise of about 4.5 mGal across the Bryneglwys Fault (Figure 6). The high horizonal gradient of the anomaly southeast of the fault suggests the source to be shallow (1–2 km), although an overestimated density for reduction of observations would contribute to this gradient. Cummins (1969) has shown this line to have been a lithological boundary between greywacke and shale facies during the Silurian. Grit facies are generally less dense than shale–slate facies by about 0.10 g cm^{-3} (Table 2). If this boundary exerted similar control during the earlier Lower Palaeozoic, this could contribute to the gravity ridge east of the fault, although a sharp density contrast as indicated by the anomaly is not consistent with the idea of a gradual facies change, but more of an active trough margin. Interpreting this rise as a simple slab anomaly for a nominal density contrast of 0.10 g cm^{-3} gives a thickness of 1.1 km.

Alternatively, the strong gravity gradient across the Bryneglwys Fault over rocks of the same age and lithology might suggest basement elevation to be a more likely explanation than Palaeozoic density variations. It should be noted, however, that from geological estimates the depth of basement could be greater than the depth to the magnetic rocks responsible for the aeromagnetic anomaly.

The diagrammatic interpretations shown for profiles AA′ and BB′ (Figure 7) in Figure 9 have in part been confirmed by the results for the LISPB line (Nunn, 1978) which show a marked rise to the southeast, across the Bala Fault, of the Precambrian basement layer (velocity 6.05 km s^{-1}) at depths of about 4 km.

MINERALISATION AND BOUGUER ANOMALIES

The relationship, if any, of the known mineralisation to the Bouguer anomalies still remains obscure. The mineral veins do not coincide with any well defined Bouguer anomaly features, suggesting that their occurrence is due to local structural control. However, several points have emerged from a study of the Bouguer anomaly map which could provide some guidance for mineral exploration by indicating structures not obvious from the geological map. The linear feature suggested by the Bouguer anomaly gradient running SSW from near Corwen is fairly pronounced and its possible continuation into the low at [SJ 033 284] suggests that it could have controlled the location of the source of this anomaly. The low needs further detailed gravity surveys before an interpretation can be made, but it has already been suggested that an igneous plug could be responsible. Other lows, such as that near Craig-y-Glyn, may also be related to volcanism and nearby, poorly documented, mineralisation.

STREAM SEDIMENT SURVEY

SAMPLING AND ANALYSIS

The survey was undertaken primarily in order to identify areas with anomalously high metal levels which might be related to bedrock mineralisation, but a secondary objective was to identify trends of regional significance. It was considered that the survey would indicate any areas of large-scale near-surface mineralisation, though drift and alluvial deposits, coupled with contamination from farms, villages and industrial sources, as well as poor stream cover, were likely to obscure small targets in the eastern part of the area.

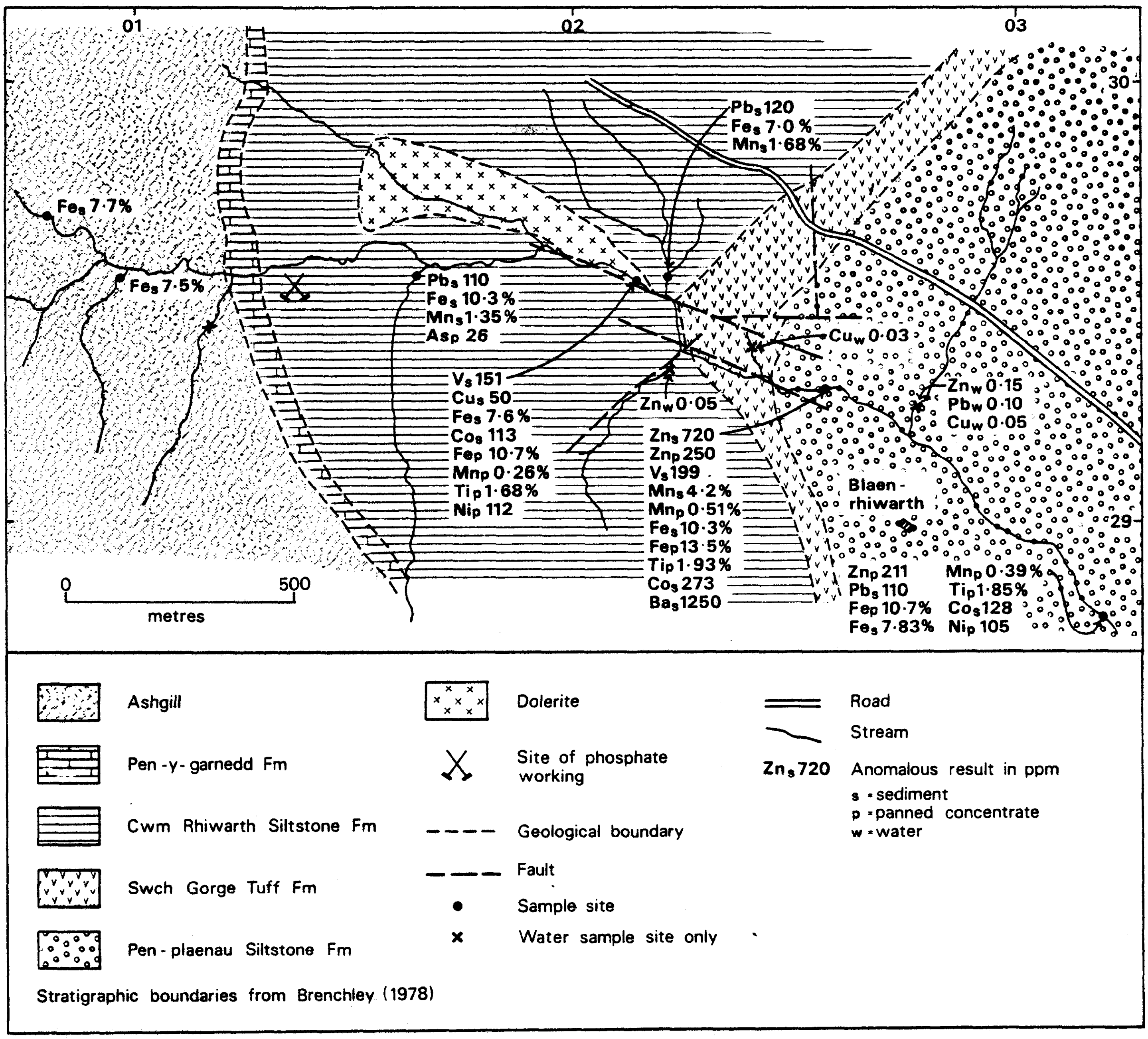


Fig. 24: Anomalous results in drainage samples from Cwm Rhiwarth.

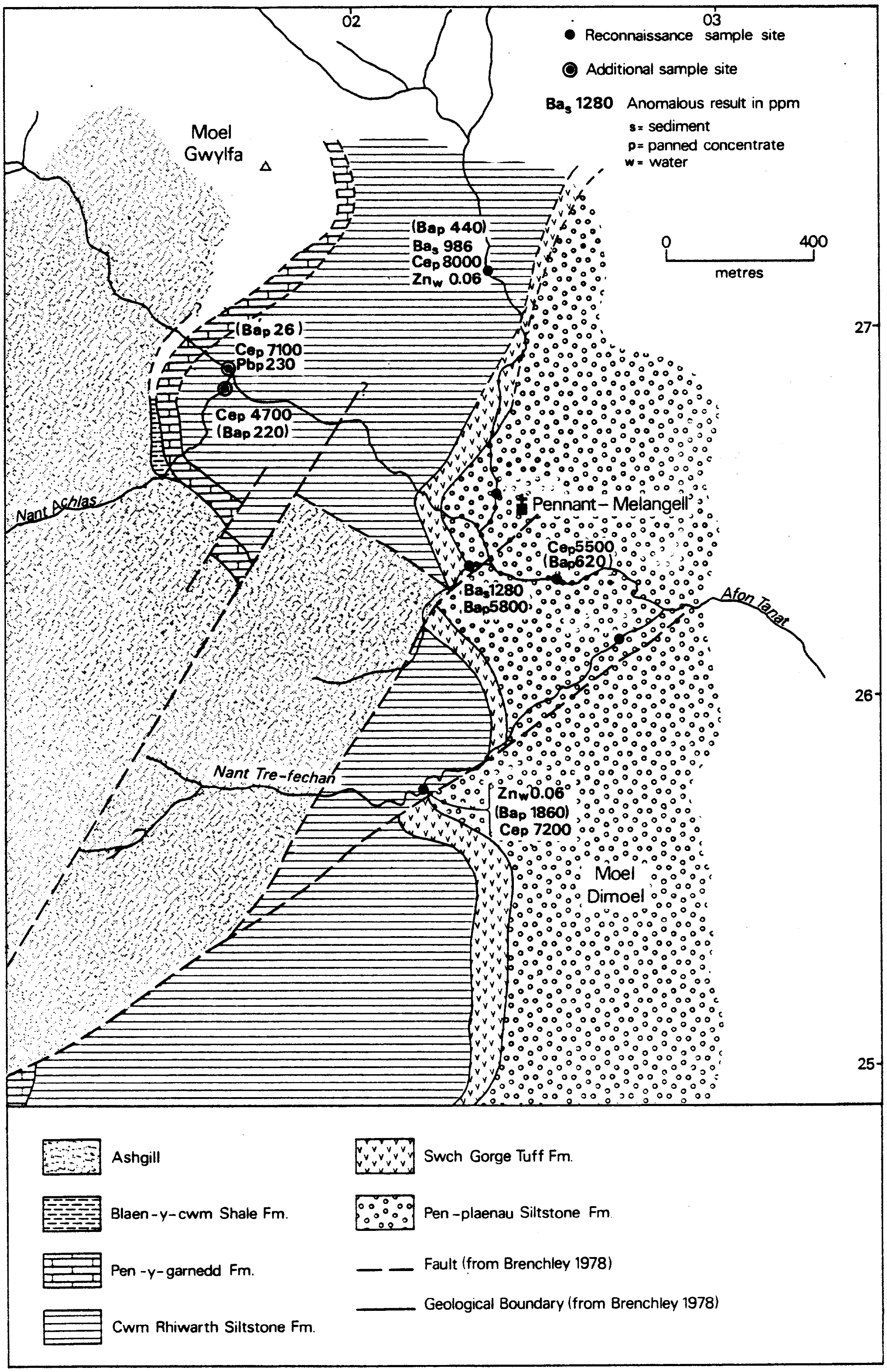


Fig. 25: Anomalous results in drainage samples from around Pennant Melangell.

The sampling pattern was constructed to avoid major centres of contamination and to yield a coverage of about 1 sample per 1.5 km^2, where stream density allowed. The exact position of sites was chosen on the ground to avoid contamination wherever possible, and to maximise the heavy mineral content of the sample. The samples were collected from the central part of the stream, so as to minimise the amount of locally derived bank material in the sample.

At each site three sample types were collected, sediment, water and panned heavy mineral concentrate. Site parameters, such as background geology, visible contamination and stream conditions were noted on computer-compatible cards. In total 399 sites were sampled, yielding an overall density of 1 sample per 1.9 km^2. Sample cover was most complete over the highland areas in the west, where sample density averaged 1 sample per 1.5 km^2, and poorest in the east where it dropped below 1 sample per 2 km^2.

The stream samples were collected using methods described in detail by Plant (1971), Leake and Aucott (1973) and Leake and Smith (1975). Briefly, water samples were collected in 30 ml polyethylene bottles, acidified in the field with 0.3 ml perchloric acid to prevent sorption of metals onto the container walls, and analysed for copper, lead and zinc by Atomic Absorption Spectrophotometry (AAS) without further sample preparation. Detection limits, in ppm, were approximately 0.01 ppm for Cu and Zn, and 0.05 ppm for Pb. Stream sediments were wet-sieved at site to pass −8 mesh BSS (2 mm nominal aperture). In the laboratory the −8 mesh BSS sample was dried and sieved and the −100 mesh BSS (0.15 mm nominal aperture) fraction was finely ground prior to analysis. Copper, lead and zinc were determined by AAS following digestion of a subsample in boiling concentrated nitric acid for one hour. Other elements were determined by Optical Emission Spectrography (OES). Detection limits were approximately Mo 1 ppm, Cu 3 ppm, Pb and Zn 5 ppm, Co, Ni and V 10 ppm, Zr 20 ppm, Mn 50 ppm, Ba 100 ppm and Fe 0.5%. Panned concentrate samples (approximately 50 g) were made at site from about 4 kg of the −8 mesh BSS fraction of the stream sediment. These were dried and split, and a 12 g subsample was ground in a tema mill for 15 mins with 3 g of 'elvacite' before pelletising and analysis by X-ray Fluorescence Spectrometry (XRF) for a range of elements. Theoretical detection limits (2σ) were As 2 ppm, Zn 3 ppm, Ni 5 ppm, Cu and Mn 6 ppm, Sn 9 ppm, Sb 11 ppm, Pb 13 ppm, Ce 21 ppm and Ba 27 ppm.

Studies were made on all three drainage sample types to establish sampling and analytical variation by (a) duplicate sampling, (b) replicate analysis and (c) replicate sampling of the same site on a number of occasions. The results form part of a wider study which will be presented elsewhere.

INTERPRETATION OF RESULTS

A complete set of analytical results is given on the fiche card (Appendix 4), and a summary of the data is shown in Table 3. For results below the detection limit the actual value reported was used except in the few cases where these were negative, in which case they were set at zero. Three variables, lead and copper in water and Sb in panned concentrate, were removed from the data matrix before computer processing because a very large proportion of the results (>90%) were below the detection limit; as a result they are not printed on the fiche card. For conciseness in the text, results in sediment, panned concentrate or water are differentiated by the subscript s, p or w after the element: for example 'copper in stream sediment' is shortened to Cu_s.

Statistical treatment of the chemical data was attempted, but as distribution analysis indicated that the majority of element distributions were of bimodel or complex form and could not be readily subdivided into geologically meaningful sub-populations only non-parametric methods could be used with certainty. This restricted and hindered analysis of the data. The following procedures were used. Regional trends were studied by means of greyscale plots using class intervals set on a percentile basis. Threshold levels were set by cumulative frequency curve analysis, and anomalies were subdivided on a percentile basis. The cause of major anomalies was sought by brief field examination of the anomalous catchments, limited resampling and the mineralogical examination of panned concentrates. The latter method proved particularly effective in distinguishing anomalies with a geological source from those caused by household, industrial or agricultural contamination. Having eliminated anomalies caused by contamination, attempts were made to identify anomalies caused by known mineralisation, high background in the rocks unrelated to mineralisation and hydrous oxide precipitates. Areas were also identified (such as around Llansilin) where sample cover was poor, and attempts were made to increase the sample density. One stream catchment, the Afon Trystion, was resampled at a higher density and the panned concentrate samples analysed for gold following the visual identification of gold in a panned concentrate from the initial survey. The results of all these studies were brought together, and a series of anomalous catchments and sites were identified.

Distribution analysis

Histogram and cumulative frequency plots were used to identify element distributions (Lepeltier, 1969; Parslow, 1974; Sinclair, 1976). Approximately lognormal distributions, plotting as straight lines within 95% confidence limits (Sinclair, 1976) on logscale probability paper are shown by Cu, Zn and Ba in stream sediment. The remaining variables give plots which clearly indicate the presence of two or more sample populations. Sigmoidal traces on logscale cumulative frequency paper, indicating the presence of two lognormally distributed populations are shown by Co_s and Pb, Zn and Mn in panned concentrate. The two Co_s sub-populations have medians of 30 and 50 ppm with a near equal split of samples between the two sub-populations. The Mn_p distribution shows a similar division with medians of 0.07 and 0.10% Mn. The patterns shown by Pb_p and Zn_p are less clear, with a large area of overlap between the two sub-populations which have medians of approximately 80 ppm and 180 ppm for Pb_p and 130 ppm and 200 ppm for Zn_p with large standard deviations. The distribution of Zn_p shows small irregularities in detail which may indicate the presence of further sub-populations which could not be clearly defined.

Results for the majority of variables (Pb, Fe, Mn, Ni, Cr and Zr in sediment, Cu, Ce, Ti and As in panned concentrate) produce binormal ('dogleg') plots on log-scale cumulative frequency graphs, and many of these probably represent incomplete sigmoidal forms (Parslow, 1974). It is the top of the sigmoid (the highest values) which is incomplete and the lower population containing most of the samples (>75%) is well defined, except for the case of Ce_p where it is the low values which are largely

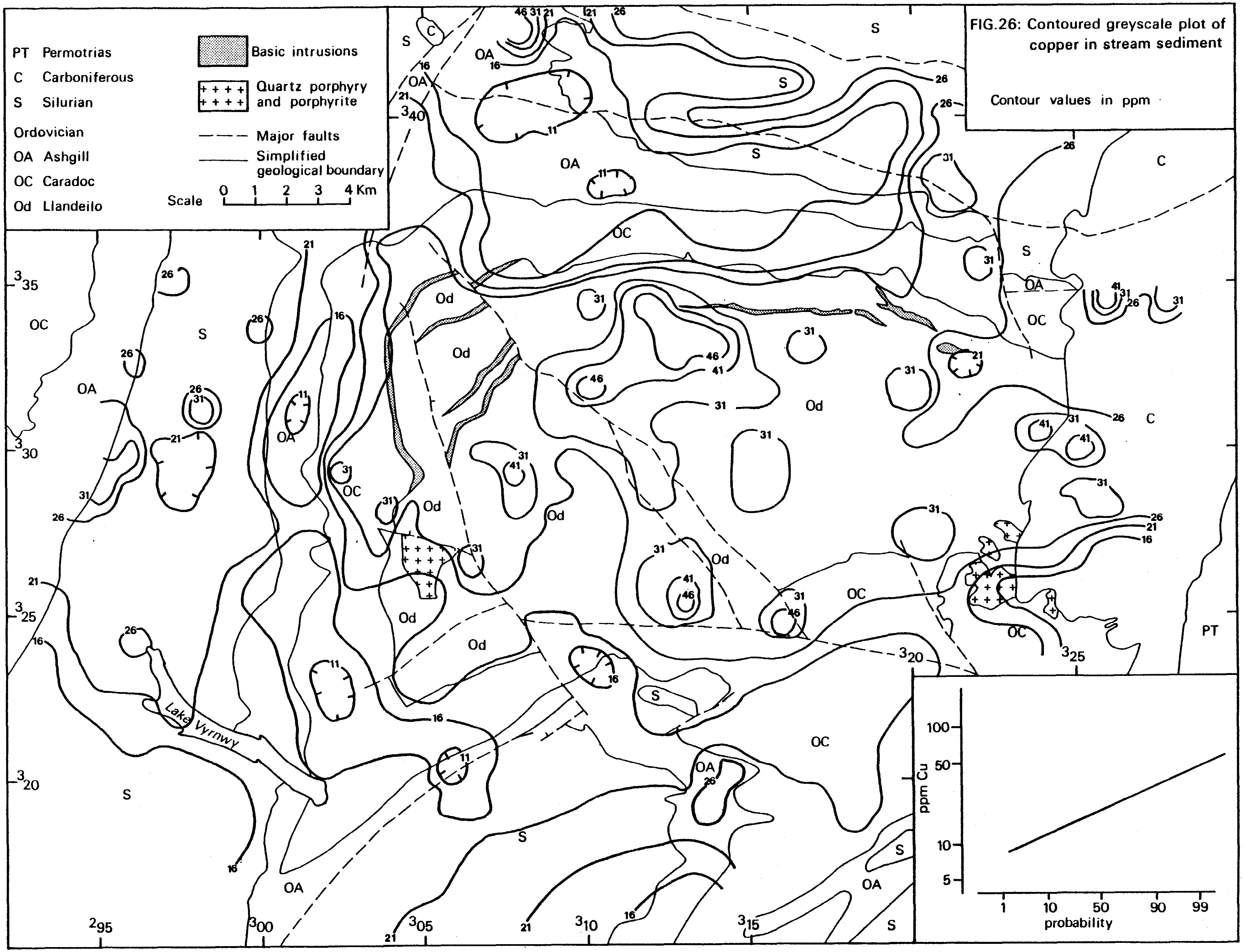


FIG.26: Contoured greyscale plot of copper in stream sediment

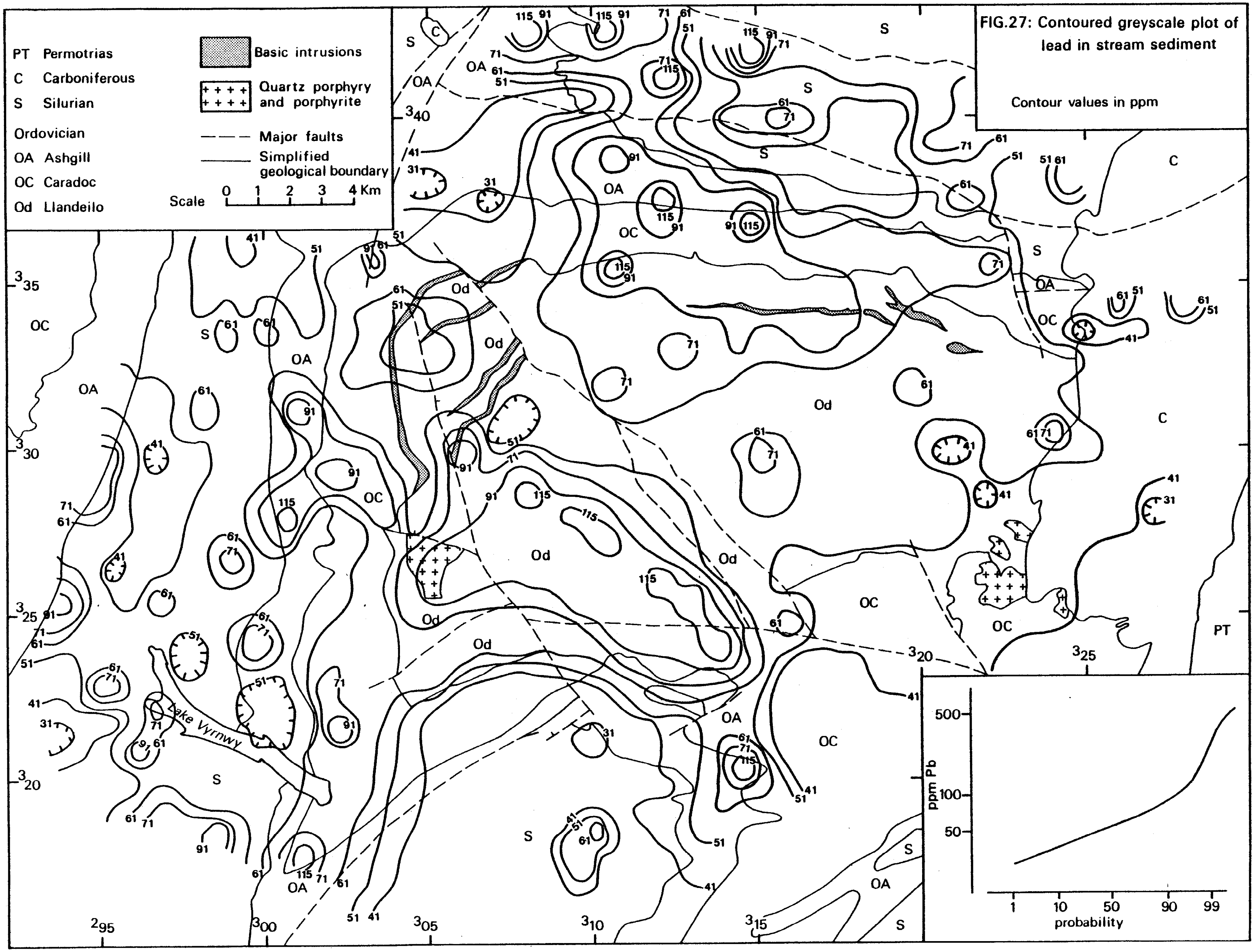


FIG.27: Contoured greyscale plot of lead in stream sediment

Table 3 Summary of analytical results in ppm for 399 stream sediment, water and panned concentrate samples

Variable	Median	Mean	Standard deviation	Maximum	Minimum	Geometric mean	Geometric mean + geometric deviation	Geometric mean + 2 geometric deviations
Sediments								
Cu	25	24.8	9.62	110	10	23.4	33.8	49.0
Pb	60	68.4	49.0	600	20	63.1	93.3	117
Zn	200	218	109	800	70	195	302	468
Ba	321	358	174	1660	92	331	501	759
Fe%	5.56	5.70	1.61	19.78	2.69	5.5	4.08	19.12
Mn	2720	4800	750	72700	300	2800	7580	35480
Co	41	c.62	c.62	447	<10	c.42.7	c.102	c.245
V	100	102	17.9	183	51	100	120	145
Cr	61	62.7	19.1	313	24	60.3	77.6	100
Ni	57	62.3	29.4	401	22	58.9	83.1	117
Zr	201	227	137	1735	87	209	302	437
Mo	1			5	<1			
Sn	<5			54	<5			
Waters								
Zn	0.01			0.23	<0.01			
Panned concentrates								
Cu	15	c.34	c.96	1229	<6	c.15	c.46	c.135
Pb	73	c.156	c.320	5436	<13	c.77	c.245	c.770
Zn	146	181	274	4935	42	151	234	363
Ba	429	1034	7339	137700	28	417	891	1905
Fe%	6.57	6.69	1.64	19.48	2.26	6.46	8.13	10.23
Mn	970	1200	700	5900	200	980	1780	3240
Ce	2015	c.3040	c.2900	>10000	89	c.1860	c.5370	c.15500
Sn	<13			4270	<9			
Ti	5190	5700	4000	68600	1600	5248	7080	9550
Ni	45	488	19.6	211	7	45.7	66.1	95.5
As	15	18.1	12.4	113	2	15.5	26.3	44.7

All results less than the detection limits set at the value reported
Cu and Pb in water and Sb in panned concentrate omitted

absent. Fe and Ni in panned concentrate are also mixtures of two populations, but in these cases the lower populations, which contain at least 70% of the samples, appear to have near normal distributions with mean values of 6.6% Fe and 45 ppm Ni.

Three variables, V_s, Ba_p and Sn_p show complex mixtures of populations which could not be clearly defined. V_s shows a near-normal form on histograms, but detailed examination indicated the presence of either two intersecting populations or three poorly defined non-intersecting populations (Sinclair, 1976). Ba_p results suffer from Ce interference, which accounts for the peculiar form of its distribution. Sn_p results are heavily bottom-censored by the detection limit, and graphical analysis indicates the presence of an upper lognormal population and a lower population of uncertain form. Mo_s, Sn_s and Zn_w also have bottom-censored distributions because a large proportion of the results (26, 74 and 27% respectively) are below the detection limit. Plots of the visible part of all three distributions indicate lognormal form. Some other variables suffer from minor bottom-censoring; these, with the percentage of results affected given in brackets, are Co_s (1%), Cu_p (12%) and Pb_p (4%). Plots also suggest that 2% of As_p and 7% of Ti_p results are also bottom censored although the levels are above the theoretical detection limits. Results for Ce_p greater than 1% were above the calibration limit and are, therefore, unreliable but no graphical evidence of top-censoring was seen.

Major causes of element variation

Inter-element relationships were explored using parametric statistical techniques such as Pearson product-moment correlations, cluster and factor analysis. It was found that the most prominent element associations were extracted by these technique, but at low significance levels (95–99%) confusing, conflicting and geologically meaningless results were obtained. This was attributed partly to the unsound database and partly to a high level of 'noise' caused by the presence of a large number of minor sources of variation. Therefore, these methods were largely discarded and only a summary of the most highly significant Pearson product-moment correlations is presented (Table 4, Figures 10 and 11). These results were used in conjunction with the spatial distribution patterns of each element as shown by anomaly maps and contoured 'greyscale' plots (Appendix 3) to deduce the causes of element variation which are outlined below.

Hydrous oxide precipitation The distributions of many elements in stream sediment samples are affected by this well documented process (e.g. Reedman, 1979). Briefly, several metals which are soluble in water in acid, peaty, upland soil conditions become relatively less soluble in waters at surface and in the majority of streams where the Eh and pH conditions are more oxidising and less acid because of the effect of atmospheric oxygen and carbon dioxide. The principal result of the physico-chemical changes is the precipitation of hydrous manganese and

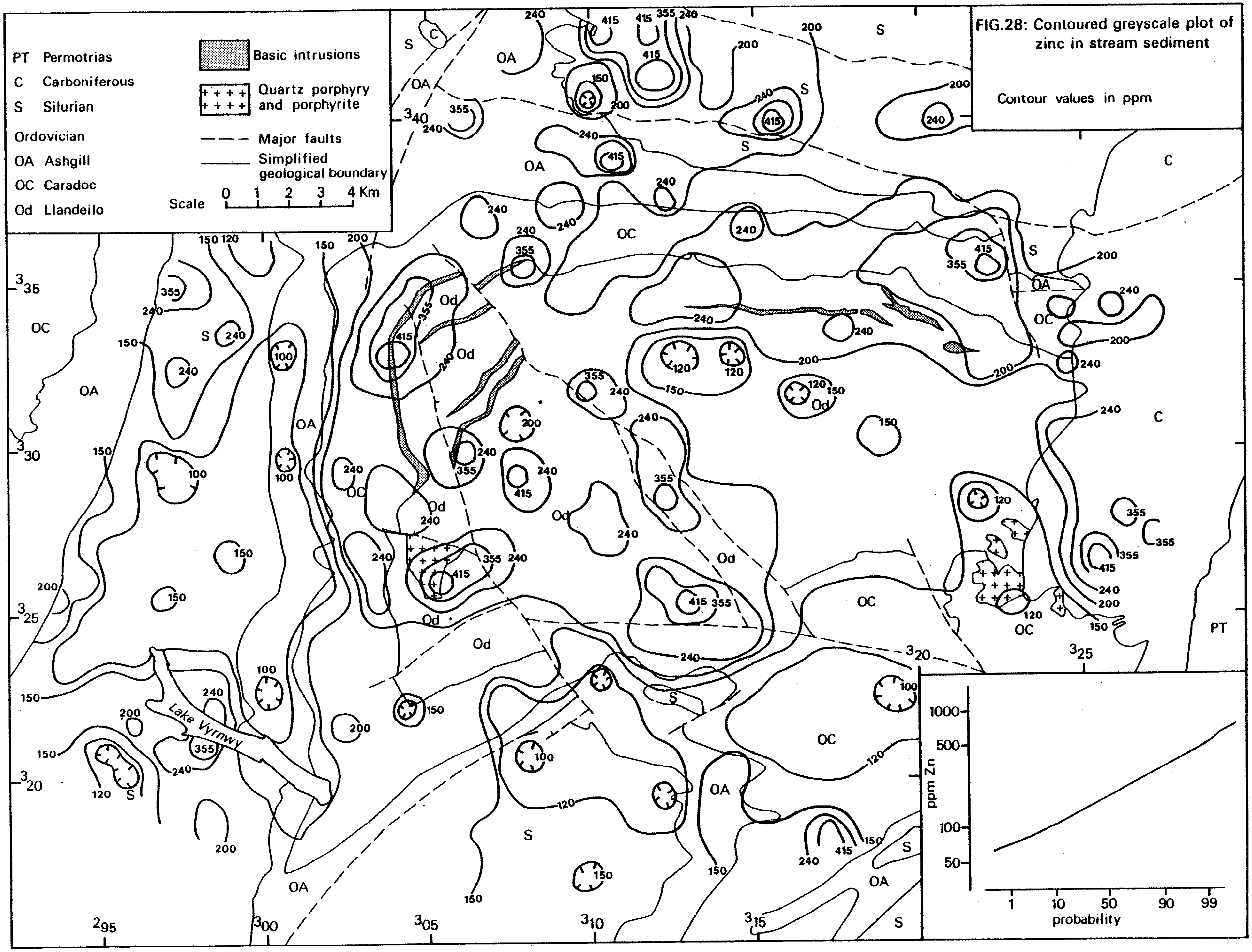


FIG.28: Contoured greyscale plot of zinc in stream sediment

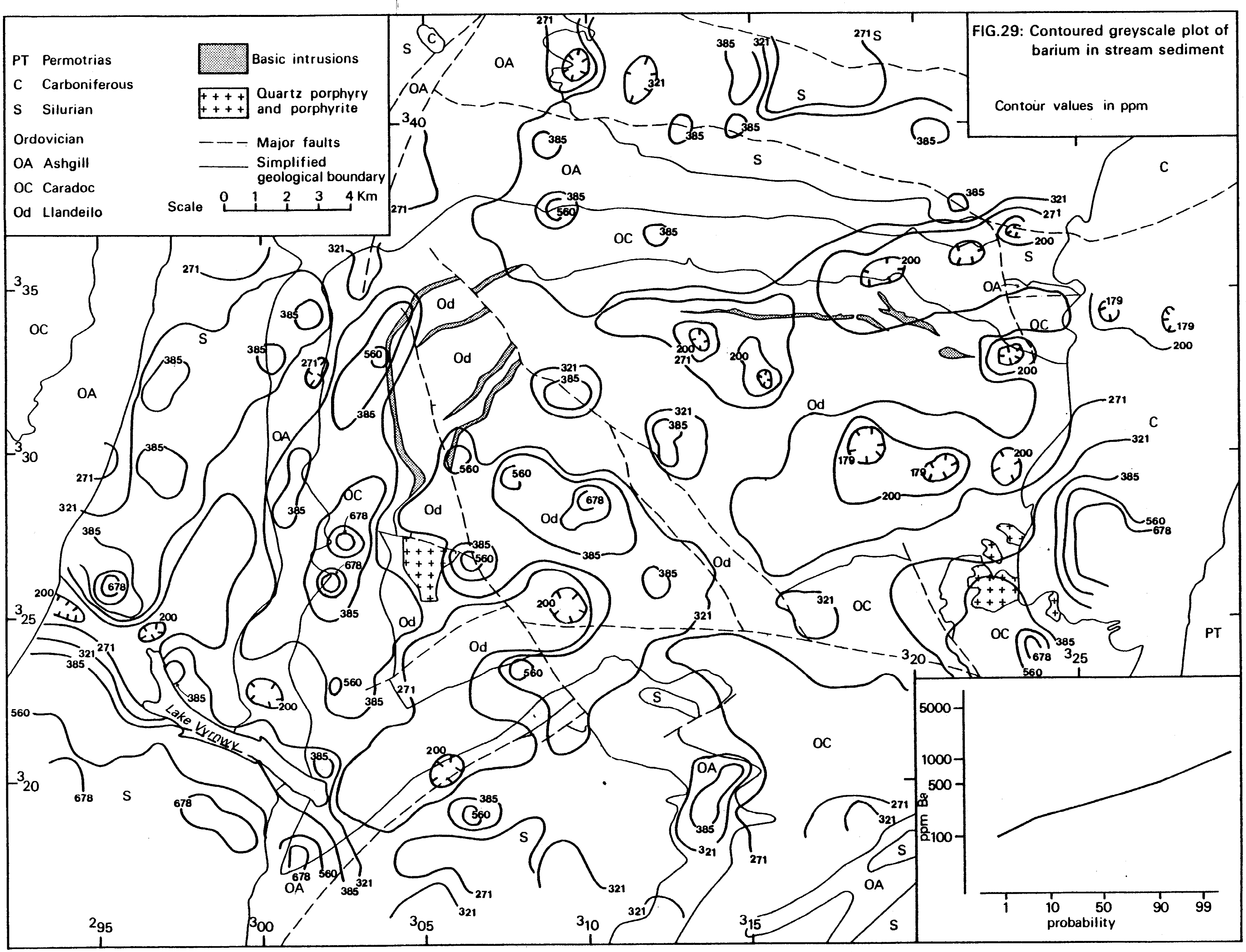


FIG.29: Contoured greyscale plot of barium in stream sediment

Table 4 Summary of highly significant inter-element correlations (Pearson method)

Variable	Correlation coefficients at 99.95% confidence level					
	0.19–0.30	0.30–0.40	0.40–0.50	0.50–0.60	0.60–0.70	> 0.70
Stream sediment (s)						
Cu	Ni_p Sn_p Fe_p Pb_p Zn_s Pb_s	Mn_p Zn_p Sn_s	Cu_p			
Pb	Mn_p Zn_p Pb_p Fe_s Cu_s $-Zr_s$	Ni_s Co_s Mn_s	Zn_s			
Zn	Ti_p Cu_s	Co_s Mn_s	Mn_p Ni_s Pb_s	Zn_p		
Ba	Zn_w Zr_s Ni_s Co_s Mn_s Fe_s	Ba_p	Cr_s			
Fe	Ni_p Ce_p V_s Ba_s Pb_s	Ti_p $-Zr_s$	Mn_p Ni_p $-Sn_p$			Co_s Mn_s
Mn	Ti_p $-Zr_s$ Ba_s	Ce_p Ni_s Zn_s Pb_s	$-Sn_p$ Mn_p			Co_s Fe_s
Co	$-Ba_p$ $-Sn_s$ Ba_s	Ti_p Ce_p Mn_p Pb_s Zn_s	Ni_s	$-Sn_p$		Mn_s Fe_s
V	Ni_p $-Zr_s$ Cr_s Fe_s	Ti_p Ni_s				
Cr	Ba_p Ni_s V_s		Ba_s			
Ni	Zn_p $-Zr_s$ Cr_s Ba_s	Ni_p Ti_p Mn_p V_s Mn_s Pb_s	Co_s Fe_s Zn_s			
Zr	As_p Sn_p $-Mn_p$ $-Ni_s$ $-V_s$ $-Co_s$ Ba_s $-Mn_s$	$-Ti_p$ Ba_p $-Fe_s$				
Mo	$-Mn_p$					
Sn	Zn_p $-Co_s$ Zn_s	Pb_p Cu_p Cu_s				
Water (w)						
Zn	Ba_s					
Panned concentrate (p)						
Cu	As_p Ni_p Fe_p	Sn_s	Sn_p Zn_p Pb_p Cu_s			
Pb	Mn_p Pb_p Cu_s	Zn_p Sn_s	Ni_p Sn_p Cu_p	Ce_p		
Zn	Mn_p Ba_p Sn_s Ni_s Pb_s	Ni_p Sn_p Fe_p Pb_p Cu_s	Cu_p Zn_s			
Ba	$-Ti_p$ Sn_p $-Ce_p$ Zn_p Cr_s $-Mn_s$ $-Co_s$	Zr_s Ba_s				
Fe	Sn_p $-Ce_p$ Mn_p Cu_p Cu_s	As_p Zn_p				
Mn	Fe_p Zn_p Pb_p $-Mo_s$ $-Zr_s$ Pb_s	Ce_p Ni_s Co_s Cu_s	Ni_p Ti_p Mn_s Fe_s Zn_s			
Ce	$-Fe_p$ $-Ba_p$ Fe_s	Mn_p Co_s Mn_s	Ni_p	Pb_p		
Sn	$-Ti_p$ Fe_p Ba_p Zr_s Cu_s	Zn_p	Pb_p Cu_p Mn_s $-Fe_s$	Sn_s $-Co_s$		
Ti	$-Sn_p$ $-Ba_p$ Mn_s Zn_s	$-Zr_s$ Ni_s V_s Co_s Fe_s	Mn_p			
Ni	Cu_p Ni_s Fe_s Cu_s	Zn_p Ni_s	Ce_p Mn_p Pb_p			
As	Cu_p Zr_s	Fe_p				

iron oxides at or near surface. Other elements may also precipitate out or be scavenged by the precipitation of iron and manganese. As a consequence the fine fraction of stream sediments in the peaty upland areas and their margins in the north and west of the survey area contain a large amount of these precipitates, clearly visible as coatings on boulders and at seepage points, which are not present in the lowland streams. A brown seepage precipitate from an adjacent area scanned by XRF was found to contain, besides major Fe, appreciable amounts of Mn, Cu, Zn, Co, Pb, Ni and Cd, as well as minor Cr, Ti, Mo, Nb, Y, Ag, Rb and As. The amounts of different elements present in a precipitate will be governed by metal availability as well as the precise physico-chemical conditions, but the above list gives an idea of the range of elements that may be concentrated by these processes. Reedman (1979) lists Cd, Co, Ni and Zn as the elements strongly scavenged by Mn hydrous oxides whilst As is strongly scavenged by Fe oxides; Cu, Mo and Pb are weakly scavenged (Nowlan, 1976). Under certain conditions Ni and Cr are also concentrated (Carlson and others, 1978).

The most strongly affected variables in this survey are Mn, Fe and Co in stream sediment. Their regional variation is completely dominated by this process, as is illustrated in Figure 12 where a contoured plot of Co_s levels is superimposed onto a generalised map of the distribution of acid soils as deduced from the associated vegetation changes (from grass and agricultural land to peat, heather and rough grass) plotted from satellite imagery.

Correlations (Table 4), regional trend maps and known geochemical behaviour suggest that levels of Ba, Pb, Zn and Ni in sediment are also greatly influenced by the process. The distribution of these elements in panned concentrates is less affected, for the fine and light fractions are removed during panning, but coatings of iron and manganese precipitates on coarse, heavy lithic fragments are only partly removed during sieving and this has resulted in Fe and Mn levels in panned concentrates also being influenced to some extent by this process. Zn levels in water are also affected, but in the opposite sense. Higher levels are recorded in some first order streams in upland areas, presumably because of increased solubility under the more acid conditions or the presence of very finely suspended precipitates. The highest metal levels in sediment attributed to the precipitation process are found over two parts of the highland area, in a belt running southeastwards from Corwen and south of Lake Vyrnwy. These variations within the highland area are attributed to the availability of metals, the belt south of Corwen containing basic intrusions relatively rich in iron and manganese.

Contamination The distributions of tin in panned concentrates and stream sediments are similar but show no relation to any known geological parameter. The mineralogical examination of panned concentrates containing high levels of tin indicates that all high levels are caused by contamination — no naturally occurring tin bearing minerals were identified. The tin-bearing phase most commonly found was poorly crystalline SnO_2 though SnO was also present. In contrast to naturally occurring SnO_2 the poorly crystalline grains did not show a positive reaction to the tinning test. Some Sn also occurred in grains of solder with Pb. It was concluded that all tin levels above background found in the Berwyn Dome were the result of contamination and that tin content could, therefore, be used as an indicator of contamination. The close correlation of tin with several other metals suggested that some anomalies of these metals were also caused by contamination and this was confirmed by mineralogical work. Copper anomalies in panned concentrate were found to be largely the result of metallic contamination, copper wire was identified and dull red flat grains, probably of copper oxide were common. In a few

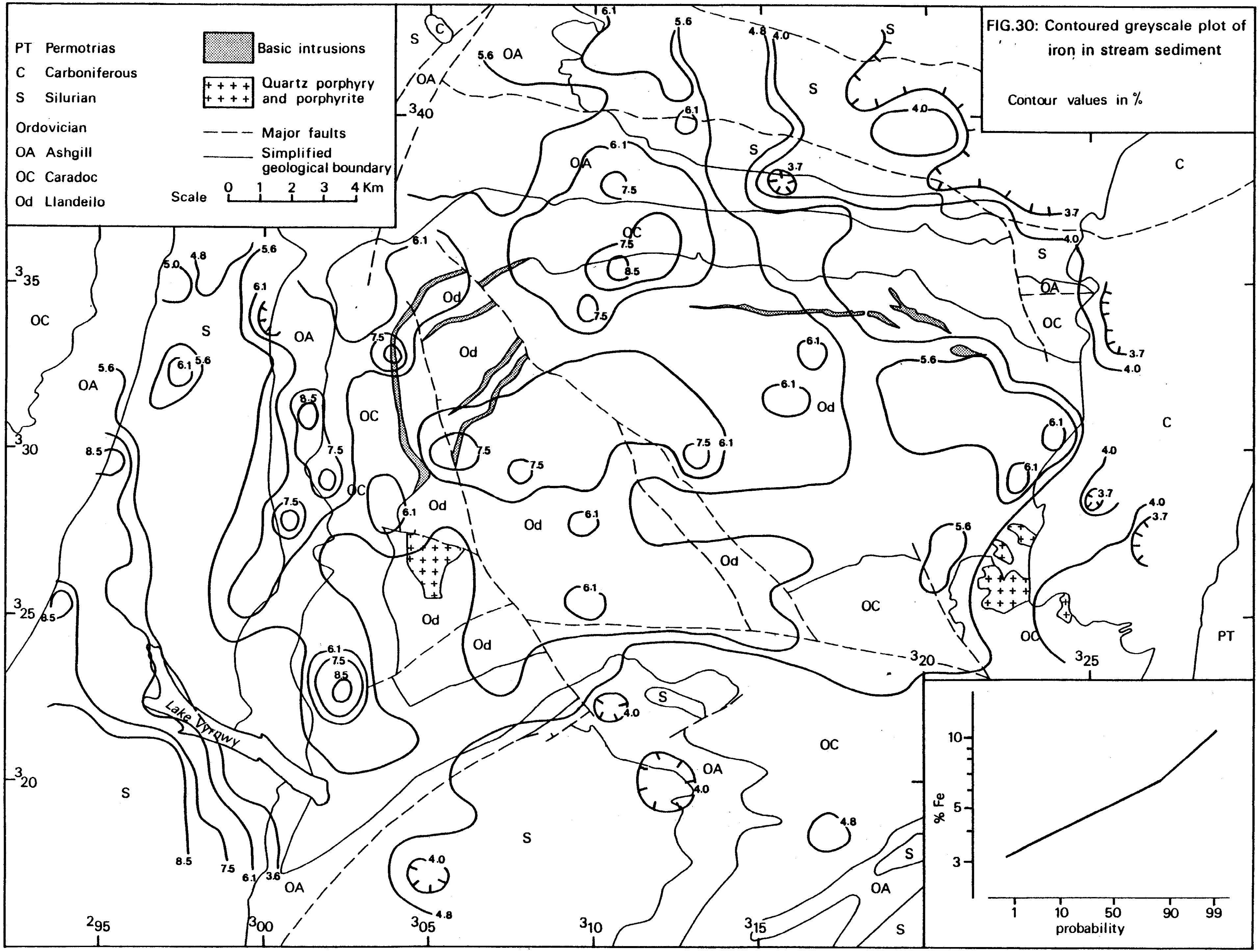


FIG.30: Contoured greyscale plot of iron in stream sediment

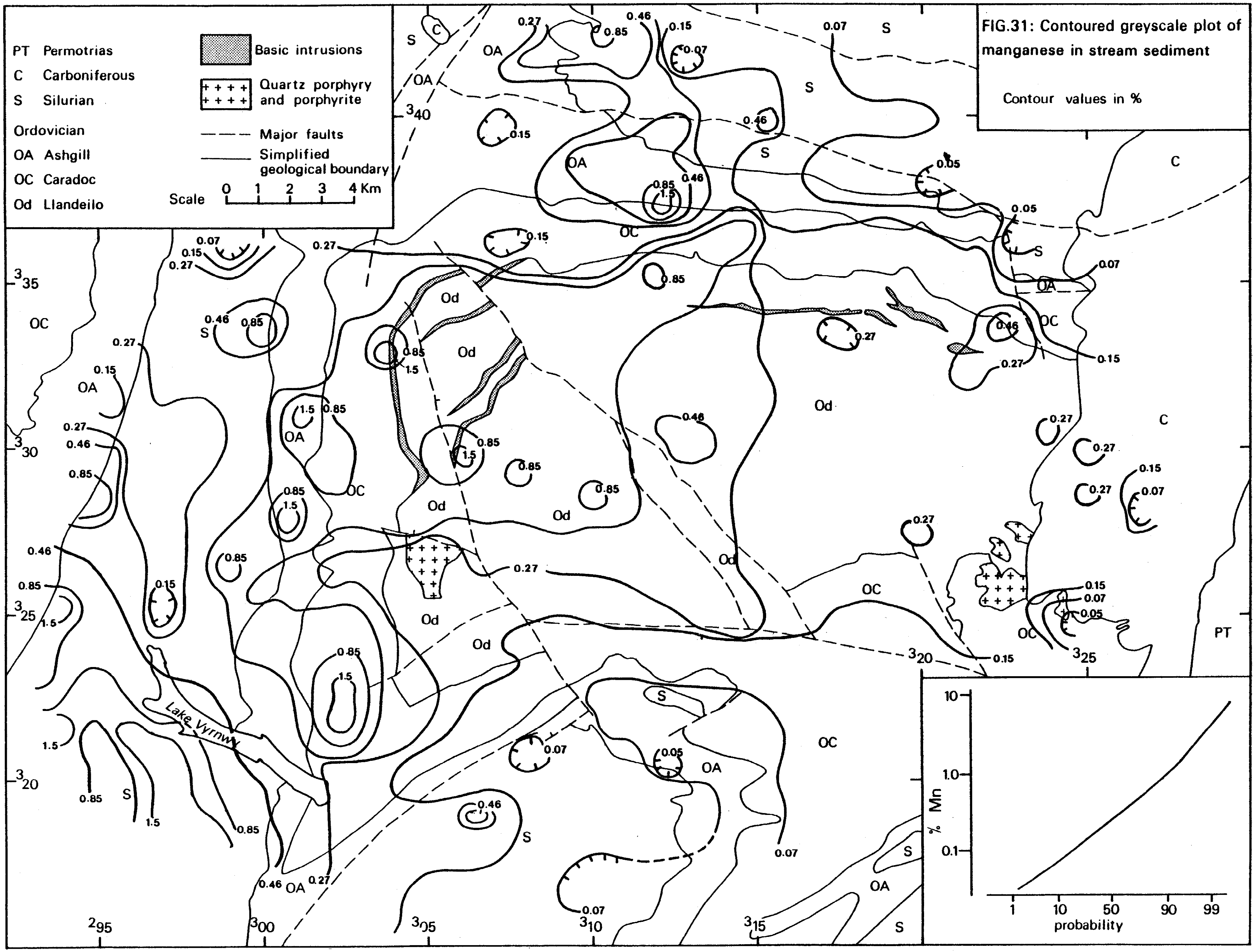


FIG.31: Contoured greyscale plot of manganese in stream sediment

samples chalcopyrite was identified, showing the presence of anomalies related to mineralisation and of mixed anomalies related to both mineralisation and contamination. Lead and zinc anomalies in panned concentrate were also found to have dual origins, galena, solder, lead metal and suspected decomposed galvanised iron being identified as the main phases responsible for the anomalies. The few Sb_p results above the detection limit are all in samples with high Sn and Pb contents, and are derived from contaminants such as lead batteries and solder. Iron occurs as a contaminant in some samples, and although not proved mineralogically, inter-element relationships suggest that some high Ni and Mn results in panned concentrates may also be caused by metallic contamination.

Tin and copper in panned concentrate, the variables most characteristic of contamination, show strong inverse correlation (Table 4) with variables (Co, Fe and Mn in stream sediment) whose variation is dominated by hydrous oxide precipitates. This is largely because the precipitates are formed over high ground in the west whilst contamination is centred on human habitations, which are largely confined to low ground with the greatest population and most industrial activity on the eastern margin of the area. A subsidiary reason is the concentration of contaminants in heavy detrital phases and precipitates in the fine grained 'light' fraction.

Base-metal mineralisation The main area of base-metal mineralisation around Llangynog is less clearly identified than might be expected, because many potential sample sites known to be downstream of old workings were not sampled. The distribution of known base-metal workings (Appendix 1), coupled with the mineralogy of panned concentrates, indicated that Cu, Pb, Zn and Ba anomalies in both sediment and concentrate were related to base-metal mineralisation. None of the elements was a good indicator of mineralisation because all gave anomalies from other sources. Therefore, additional work, usually the mineralogical examination of the concentrate, was always required to ascertain the cause of a base-metal anomaly. Statistical procedures such as factor analysis, which proved most useful discriminators of anomalies caused by mineralisation and contamination in areas such as Anglesey (Cooper and Nutt, 1982) proved ineffective here. The lack of association of metals such as Ni and As in the stream samples with the base-metal mineralisation at Llangynog confirms the relatively simple mineralogy recorded in the mines. A wider range of metals is apparently associated with the mineralisation in the Carboniferous on the eastern margin of the area, but mineralogical work suggests that the additional elements are derived from contamination.

Monazite nodules Extremely high levels of cerium are recorded over much of the area. Mineralogical examination of panned concentrates shows that cerium occurs in two mineral phases which explain the high values. Firstly, cerium is present in thin, powdery surface coatings on a variety of lithic fragments and secondly, and quantitatively more importantly, it is found in grey, flattened, ellipsoidal nodules of monazite (Cooper, Basham and Smith, 1983). The source of the monazite and exact nature of the surface coatings remains in doubt, but it is thought that the nodules have a diagenetic origin. The monazite nodules are unlikely to be derived from a single or even a small number of stratigraphic levels because of the wide distribution of high values, which appear to be related to high ground rather than to any particular lithological unit (Figure 13); this may in part be the influence of the cerium-rich coatings whose distribution with respect to the nodules and overall contribution to the cerium content of the concentrates is not known.

High levels of cerium related to monazite in panned concentrates have been recorded elsewhere in Wales (Ball and Nutt, 1976) where their occurrence is also apparently related to the disposition of Ordovician and Silurian strata and high ground. Investigations near Llanwrtyd Wells indicate that the exceptional cerium levels are largely the product of upgrading of the heavy monazites in the panned concentrates, levels in the comparable −100 mesh BSS stream sediments being close to background. The lack of very high levels in −100 mesh BSS sediment may partly be caused by the coarse grain size of the nodules. As elsewhere in Wales where these nodules have been recorded there is a highly significant correlation of Ce with Pb and Ni in panned concentrate. The reasons for this are uncertain but in a monazite-rich sample from another area plumbogummite was identified, which if present here could explain the Ce-Pb correlation, both occurring in secondary phosphates. Consequently, the availability of phosphate may play a key role in the distribution of cerium in this area, though there is no obvious correlation with the known phosphatic horizons. The Ni correlation is thought to be caused by analytical interference problems: at high levels of rare earth elements the Ni peak suffers significant overlap from the Y K_α peak. The correlation with Pb_p may also, at least in part, have a similar cause, though corrections were made for La line overlap. Cerium shows weak positive correlations with elements concentrated by the hydrous oxide precipitation process. This may be simply a reflection of the spatial association of both with high ground or indicate a more fundamental similarity in mechanism of formation, particularly of the coatings.

The formation of both coatings and nodules is still being investigated, and more detailed information on their mineralogy, chemistry and mode of occurrence is given elsewhere (Cooper, Basham and Smith, 1983).

Gold-arsenic association High levels of arsenic in the Afon Trystion correlate with the presence of gold in panned concentrate in the Nant-y-Ladron (Figure 22). It is suspected that both are related to hitherto unrecorded gold mineralisation, and the occurrence is described in more detail below.

Lithological variation The vast majority of the rocks in the area approximate to siltstone in composition, but some chemically distinct types give rise to clear element groupings.

a Dolerite intrusions in the northwest of the area, particulary that of Cerrig y Ci [SJ 060 340,] give rise to high levels of Ti accompanied by moderate increases in the levels of Zn, Fe and Mn in panned concentrates. High levels and close correlations with a wide range of transition elements in stream sediment are also recorded but their relationships are obscured by hydrous oxide precipitation effects.

b Coal Measures. Across the eastern margins of the area high levels of arsenic in panned concentrates, possibly accompanied by elevated levels of a wide range of other metals including zinc and copper, may be characteristic of the coal measures. Sample sites are few, however, and the relationship is further obscured by contamination.

c Sandstones. Zirconium in stream sediment, which shows significant negative correlations with elements concentrated in mudstones gives high levels over some sandstone lithologies, notably the Namurian. A positive Zr-Sn

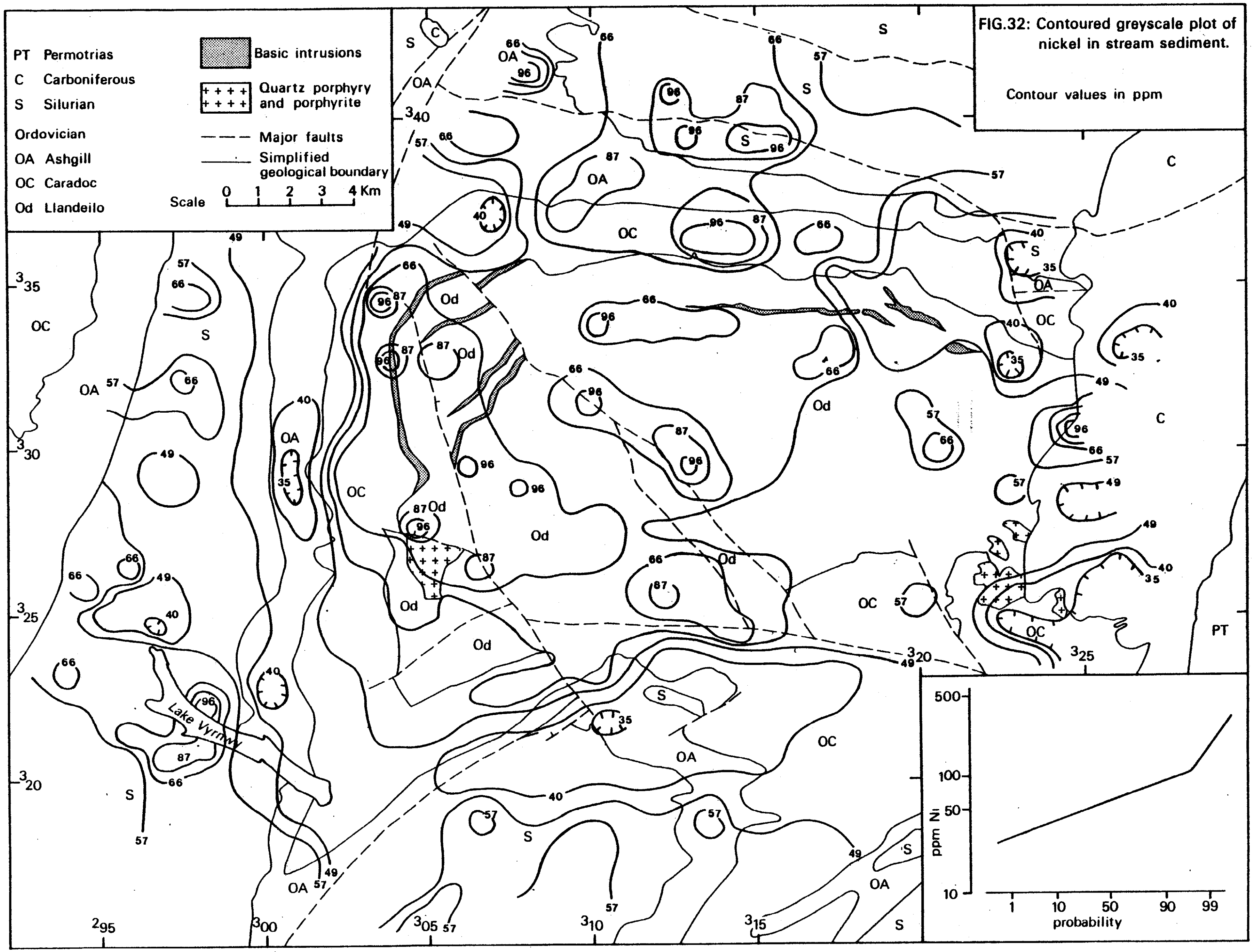


FIG.32: Contoured greyscale plot of nickel in stream sediment.

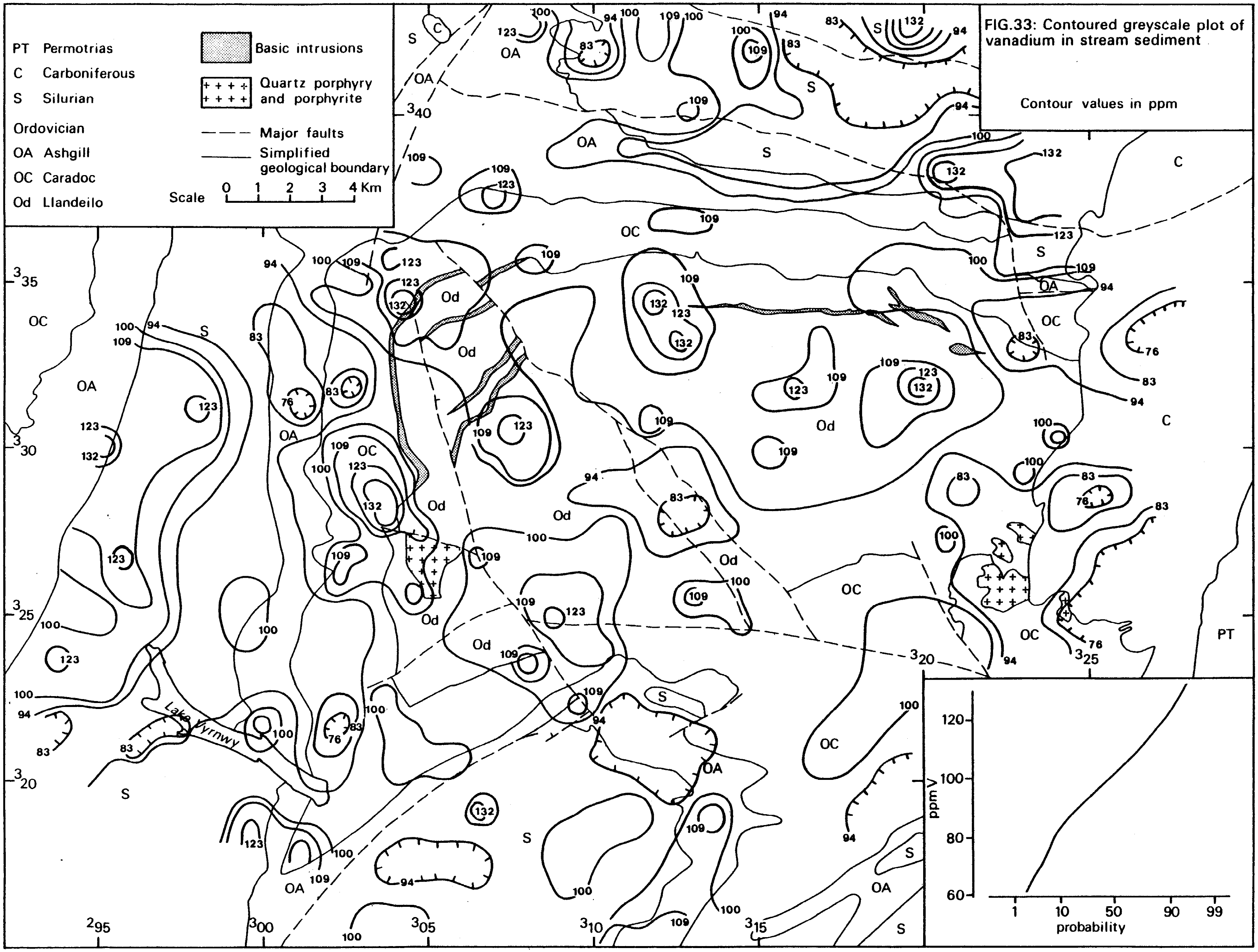


FIG.33: Contoured greyscale plot of vanadium in stream sediment

correlation is attributed to the outcrop of the Namurian in a highly contaminated area. This coincidence may also at least in part account for the Zr-As association, though both may be concentrated in different lithologies within the coal measures.

d Shales and mudstones. V_s is highly correlated with Cr, and with Ti, Ba, Cu and Ni in panned concentrate. High levels of these and more erratically a range of other transition metals are located over mudstones, though variation in several of these metals can also be related to other lithologies as well.

e Phosphatic rocks. The phosphatic rocks and their associated dark shales, limestones, baryte and sulphide concentrations do not produce a clearly recognisable geochemical signature in the drainage data. Although rock analyses indicate local primary enrichment in Ba, Mo, As, Fe, Cu, Pb and Mn, only Ba_p results give a strong indication of the presence of these rocks. The inefficient detection of the phosphatic sequence is ascribed to a number of causes: (i) exposure is poor, the sequence tending to form negative features; (ii) there are only localised primary enrichments of the elements determined; (iii) P was not determined, and (iv) elements concentrated in these rocks are also concentrated by other lithologies and geochemical processes, such as Fe and Mn by basic rocks and hydrous oxide precipitates, resulting in confused anomaly patterns.

f Volcanic rocks. Volcanic rocks in the Caradocian yield associations similar to those produced by the dolerites, except that Ti levels are lower and not so dominant a feature. The volcanics generate high correlations between (and levels of) Ni, Mn, Zn, Fe and Ti in panned concentrate. Correlations with and high levels of Pb and V in sediment are also recorded, possibly reflecting the presence of more acid volcanics or sediment.

Minor features

Several other minor sources of variation also exist, but are believed to have a relatively minor overall impact on the total variation of the dataset and are not easily or clearly defined. For instance there are indications from the greyscale maps that the Silurian greywacke in the west of the area may have distinct chemical features, and there are indications from maps and inter-element correlations that high levels of Zr and Ba may be generated by some of the more acid igneous rocks around Llangynog and Llansilin.

Definition of anomalies

The definition of thresholds and subdivision of anomalies into classes was based on a combination of cumulative frequency curve analysis and percentile division. Selection of thresholds proved difficult because of the variety of distributions and complex nature of some types. Different methods of setting thresholds were used for each of the major types of distribution.

a Lognormal distributions. The 97.5 percentile level, equivalent to the mean plus two standard deviations for a perfect distribution, was chosen as a threshold for those elements that apparently consist of a single, background population (Cu_s, Zn_s, Ba_s and the visible part of Mo_s and Zn_w).

b Bimodal distributions. The threshold level was set at the 97.5 percentile level of the lower (background) population for the four clearly defined bimodal distributions plotting as sigmoidal forms on logscale cumulative frequency paper (Co_s, Pb_p, Zn_p, Mn_p). The method ensures that any anomalous samples in the background population are unlikely to escape detection. The following percentages of the overlapping upper populations were defined as anomalous on this basis: Co_s 22%, Pb_p 10%, Zn_p 20% and Mn_p 19%. These percentages indicate the high degree of overlap in the two sample populations for all four elements. Interpretation of inter-element variation has shown that the higher populations are not directly caused by mineralisation and therefore a high proportion of upper population results falling below the threshold is not considered important from the viewpoint of mineral exploration. To set the threshold lower would include increasingly large numbers of the low population samples and produce a very high proportion of 'anomalous' samples which is not justified in terms of element levels, background geology and suspected causes of the variation.

The break point of apparently binormal ('dog-leg') plots was taken as the threshold (Lepeltier, 1969; Parslow, 1974). As several of these distributions probably represent incomplete sigmoidal forms with an undefined upper population, many of the results above threshold may belong to the lower (background) population, but very few belonging to the upper (anomalous) population will not be defined as anomalous. An exception in this group is cerium in panned concentrate where it is the low (background) population which is poorly represented. The lower population was constructed as well as the data allowed but it was not possible to define its properties precisely. The 97.5 percentile level of the lower population is in the vicinity of 1000 ppm (30 percentile level of total data) and, as this figure appeared reasonable when compared with data from similar areas with more strongly represented background populations it was taken as the threshold.

c Complex and uncertain distributions. With the exception of Sn the threshold levels of variations with uncertain distribution were arbitarily set at the 97.5 percentile level. The threshold levels for Sn in both sediment and concentrate were set lower in view of their role as indicators of contamination. It was considered that naturally occurring background levels of tin in this area would usually be below the 3σ detection limits of the analytical methods (5 ppm in sediment, 13 ppm in panned concentrate) and so all values above these levels are considered anomalous.

Above the threshold, anomalous levels of all variables were sub-divided into classes based on the 90, 95, 97.5 and 99 percentile levels. The details of these subdivisions are shown in Table 5 and the classes so defined were used in plotting anomaly maps (Figures 14–21).

Description of anomalies

Anomaly maps for the elements believed to be indicative of mineralisation in certain circumstances within this area are shown as Figures 14–19. Sn_s and Sn_p levels are shown on Figure 20 and can be used as indicators of contamination, though some contaminated sites do not contain appreciable tin and conversely a site with large amounts of tin need not necessarily contain enhanced levels of other metals. A summary of anomalies for all other elements determined is shown in Figure 21. The principal anomalies are discussed below.

1 *Gold-arsenic anomalies east of Cynwed.* During the sample collection gold was noticed in a panned concentrate from the Afton Trystion [SJ 060 406]. Additional panned concentrates were collected in the catchment and analysed for gold by an instrumental neutron activation method described in detail by Plant, Goode and Herrington (1976). Anomalous results in panned concentrates are

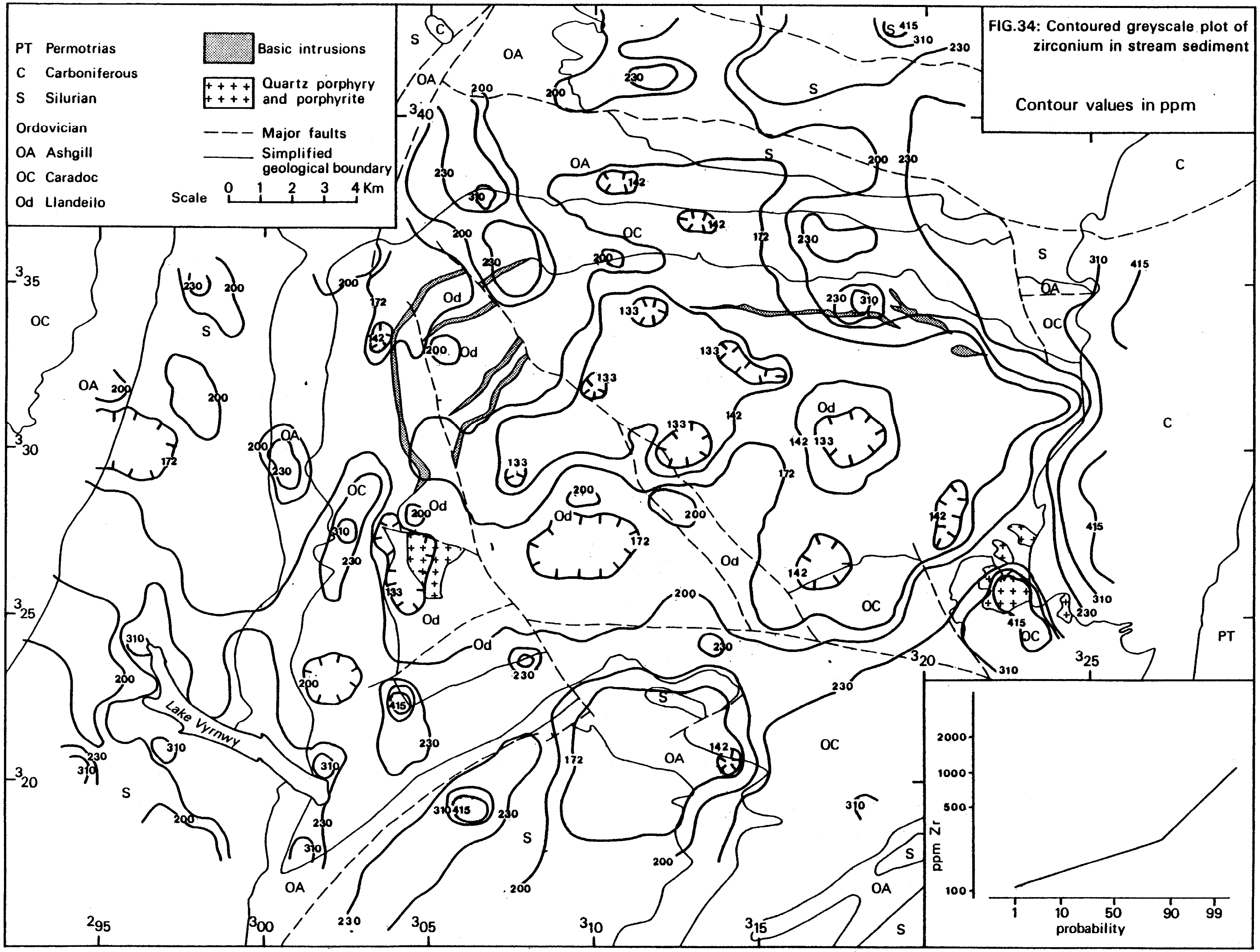


FIG.34: Contoured greyscale plot of zirconium in stream sediment

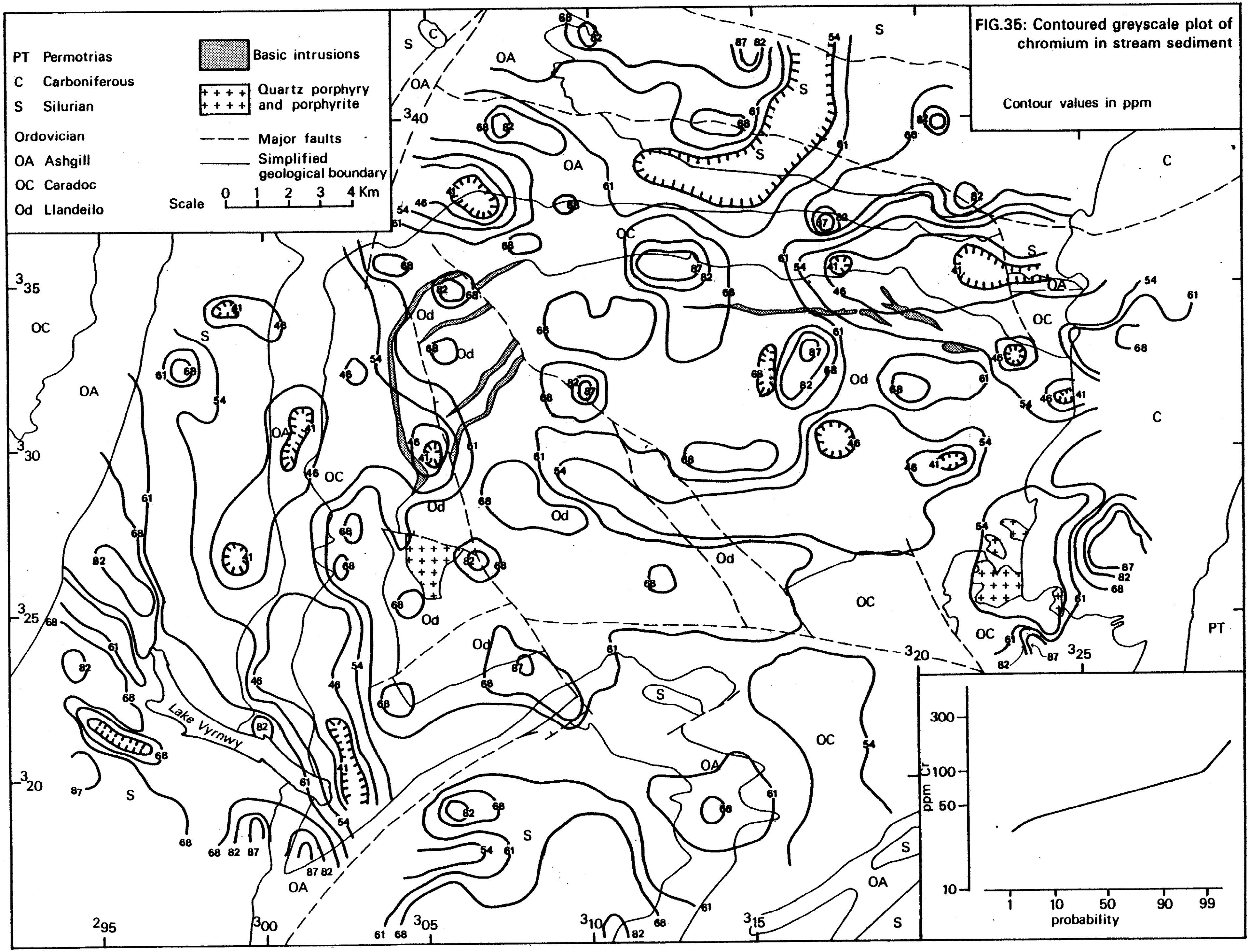


FIG.35: Contoured greyscale plot of chromium in stream sediment

Table 5 Threshold levels and class intervals for anomalous results (ppm)

Variable	Percentile level				
	<90%	90%	95%	97.5%	99%
Sediments					
Cu				46	51
Pb	*81** (85%)	91	111	161	321
Zn				501	651
Ba				751	991
Fe%	*6.60** (81%)	7.51	8.40	9.51	11.0
Mn		*11100**	14650	25600	40000
Co	*101*† (82%)	136	187	245	301
V				141	161
Cr					*101**
Ni				*106**	191
Zr	*265** (84%)	311	415	535	721
Mo				4	5
Sn	5 (74%)	13	17	23	41
Waters					
Cu				0.03	0.09
Zn				0.08	0.10
Panned concentrates					
Cu	*31** (80%)	53	95	161	501
Pb		*401*†	601	671	901
Zn	*201*† (82%)	229	291	401	1001
Ba				2201	9001
Fe%			*8.71**	10.01	12.01
Mn	*1801*†(82%)	2101	2501	2801	3501
Ce	*1000** (30%)	7301	9001	10701	12201
Sn	13 (62%)	161	261	401	561
Ti		*7000**	7501	12101	19101
Ni	*56** (78%)	69	84	103	115
As	*22** (80%)	31	38	55	75
Sb				13	30

* Break points of approximately binormal plots
† 97.5 percentile level of lower (background) population

shown in Figure 22. Attempts to establish element distributions for the 29 concentrates collected from 18 sites in the Trystion catchment were unsuccessful because of the small number of samples and the apparently complex form of the plots. Therefore, except for gold where no regional data were available, regional threshold levels were used. The cumulative frequency plot for gold is somewhat erratic but a clear inflexion point is discernible at 0.1 ppm and this was taken as the threshold level. Stream sediment data, which are only available for the reconnaissance survey sites, are confused by hydrous oxide precipitates and are not considered further except to note that anomalous levels of Co and Zn are recorded in the Nant Croes-y-wernen.

Because of the uncertain distribution of all elements, inter-element relationships were examined using both the Pearson product and the Kendall rank correlation methods. The results were very similar for both methods at high significance levels (>99%), indicating the robustness of the parametric method when used with caution, and these high correlations are summarised in Figure 23. There is no obvious grouping related to sulphide mineralisation, and the overall As-Au relationship is weak. Other correlations relate to regional features such as monazite nodules, volcanic rocks, mudstones or contamination. The strong As-Fe and Fe-Ti relation implies that there may be a tenuous link between gold mineralisation and basic rocks or a particular group of mudstones.

Gold shows an apparently complex downstream dispersion pattern. In the main stream gold levels fall upstream but increase dramatically in the Nant-y-lladron tributary, a pattern which may be caused by sampling problems associated with Au, or Au entering the stream at several points. Another complicating factor is that Au is probably entering the streams from local concentrations within the extensive drift cover, rather than directly from bedrock. Au shows a similar behaviour to Pb and Ce in the main stream, all three elements falling off upstream; this may simply be a product of stream characteristics concentrating heavy minerals at certain sites. As and Au show an apparent negative relationship in the main stream, but high As and Au values coincide in the Nant-y-lladron. Sn values show some relationship to Pb, Ce and Au with all these elements showing high values in the lowermost sites of the Afon Trystion. High Sn values, less well correlated with Pb, Ce and Au, also occur high up in the tributaries, suggesting contamination at even remote sites within this area. Zn, Mn, Cu and Ni show similar behaviour, with the highest values in the upper and lower sections of the stream system. It is suspected that high values in the lower part of the stream may have a different cause (contamination) from those in the upper reaches (?precipitates, ash bands in the rocks). Ba, Fe and Ti variation along the streams is closely related, all three elements showing a general decrease downstream which is particularly marked along the Nant-y-lladron–Afon Trystion. This pattern, but more particularly Zn, Cu and As anomalies at the southernmost site in the Nant-y-lladron may be related to the outcrop of dark graptolitic shales and possibly phosphatic beds of the Blaen-y-cwm Shale Formation (Brenchley, 1978).

A brief inspection of the Trystion catchment during sampling suggested that dispersion trains in the main stream may be influenced by a dam between the two lowermost sites, and that the lowermost site is highly contaminated by a farm upstream. The stream cuts to bedrock in several places, with the best exposures in the lowermost section. The dominant rock type, mapped as Ashgillian in age, is a cleaved grey siltstone with thin sandstone and dark mudstone bands. Evidence of faulting was seen at several localities. Minor, apparently barran quartz and carbonate veining was also noted. Quartz blocks appeared to be commonest in the Nant-y-lladron, where the highest As and Au results were recorded. Exposure in the catchment as a whole is poor with variable thicknesses of till covering interfluves.

Anomalous levels of As in catchments to the south, at [SJ 066 379], and east at [SJ 122 375 and SJ 130 371] suggest that mineralisation extends from the Nant-y-lladron in these directions, though no Au was observed in the panned concentrates at these sites.

The source and geological association of the Afon Trystion gold remains in doubt. In the Nant-y-lladron it is associated with As whilst in the Afon Trystion the pattern is confused by contamination. It is not obviously associated with sulphide mineralisation or derived from a single source. In the first instance it is probably derived from erosion of the extensive drift deposits which will form a major obstacle to any detailed search for the source and, together with hydrous oxide precipitates and contamination, are a probable cause of the confused dispersion patterns. Synthesis of the available evidence suggests that at least one source is located in the south side of the catchment, crossing the Nant-y-lladron.

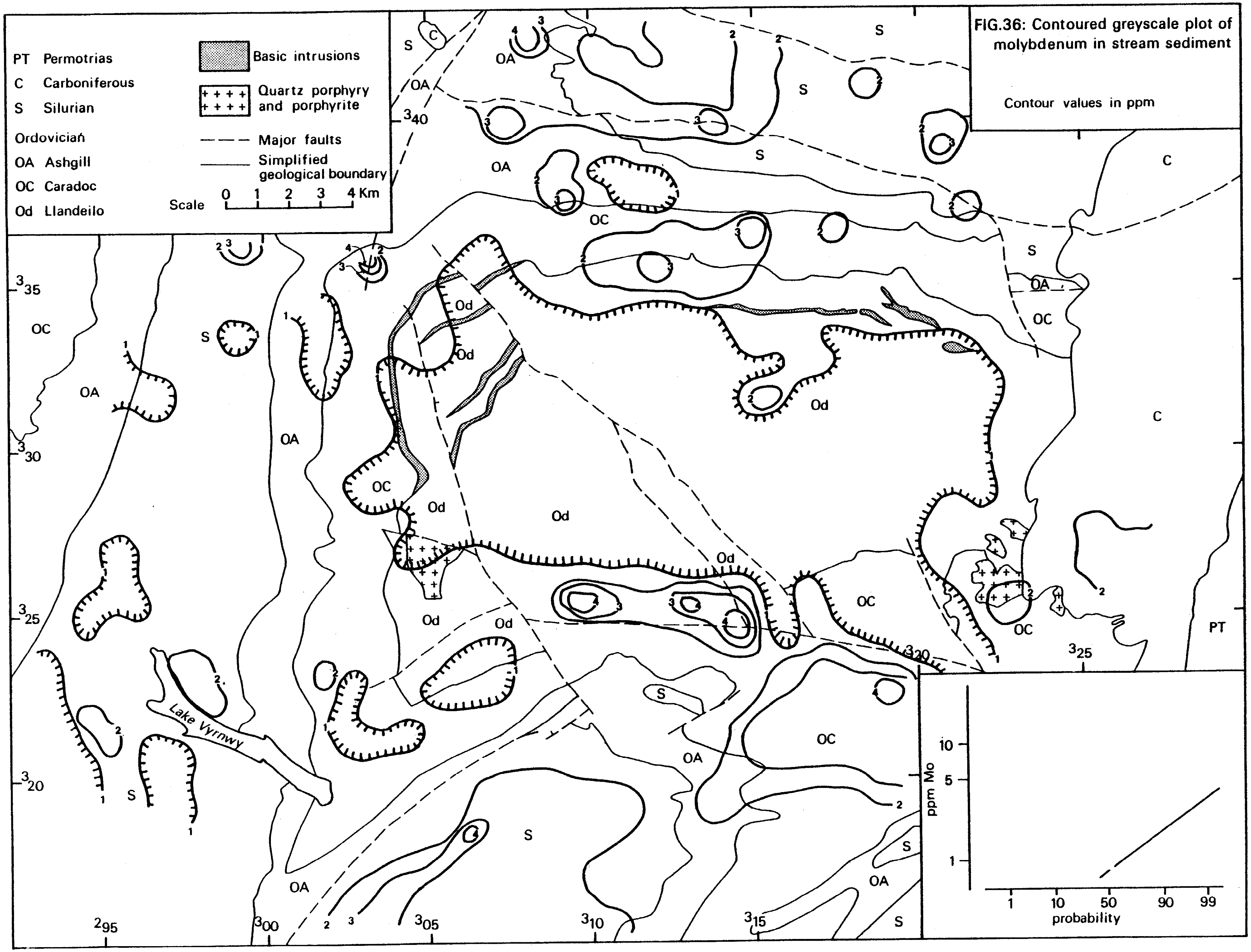


FIG.36: Contoured greyscale plot of molybdenum in stream sediment

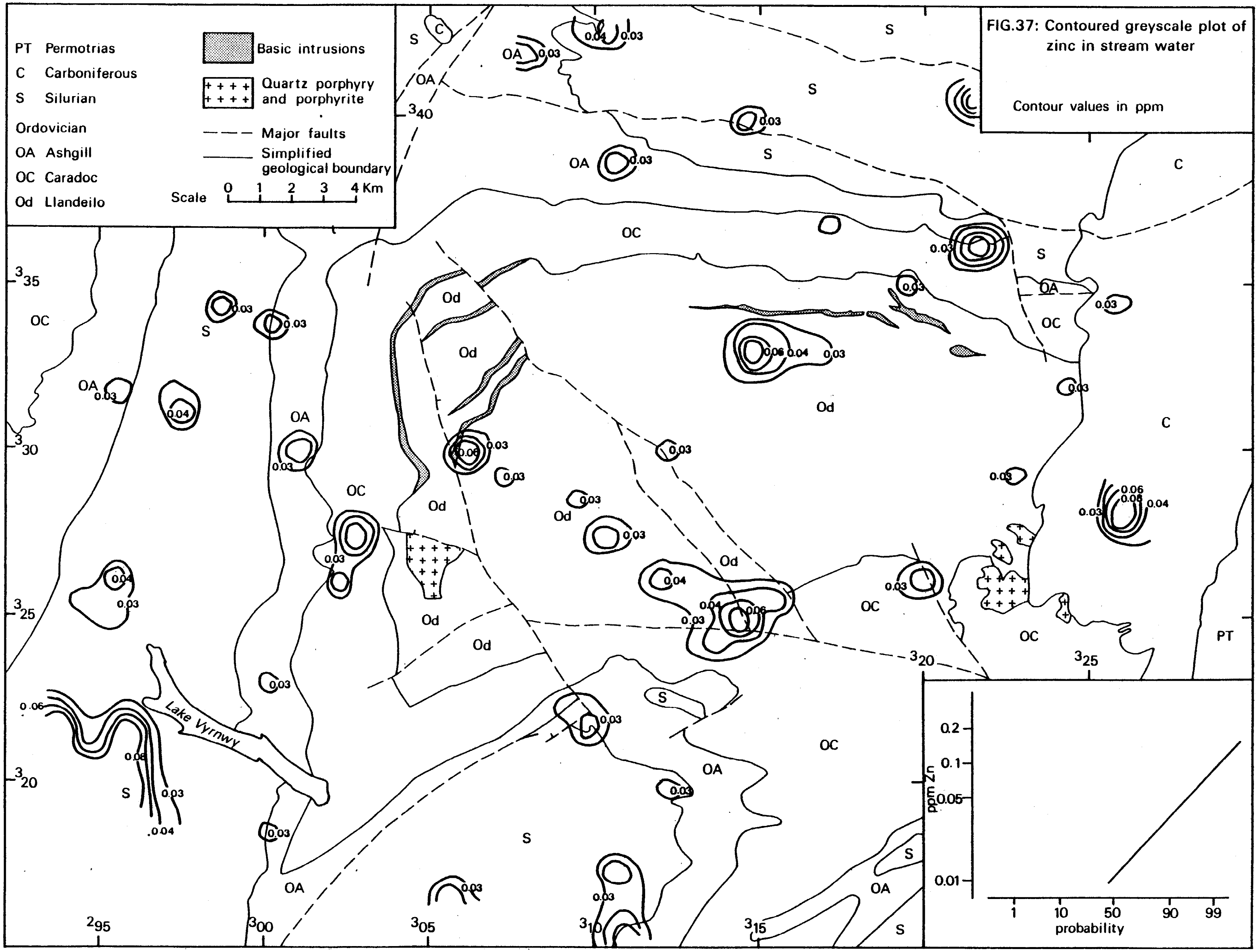


FIG.37: Contoured greyscale plot of zinc in stream water

2 *Base metal mineralisation near Corwen.* Anomalies for Pb and Co in sediment, Cu, Pb, Zn in panned concentrate, and Cu and Zn in water were recorded in Nant Llechog, 2 km east of Corwen at [SJ 102 430]. Mineralogical examination of the panned concentrate showed the presence of galena and sphalerite. Examination of the upstream section located a collapsed adit driven along a north-south quartz vein thought to be occupying a fault between dark mudstones and an interbanded siltstone-sandstone sequence. An old shaft is marked on the 1:10560 OS map in line with the adit and about 150 m south of it. No base-metal minerals were seen in the vein at the adit entrance. Between the adit and the road an old shaft, disturbed ground and the remains of old buildings suggest that this may have been the location of an appreciable, now forgotten, mineral working. Upstream of the adit another north–south fault and thin quartz veins striking at 80°E in siltstones were noted. These directions correspond with those of faults marked on the old series geological survey map. The sedimentary rocks consist of mudstones, sometimes dark, shaley and pyritiferous, siltstones and coarse sandstones.

Though the source of the galena and sphalerite in panned concentrate was not found they are believed to have come from the old quartz vein working and it is probable that further base-metal vein mineralisation is present in the area. This may be the cause of other anomalies in this area which were not examined on the ground, for example anomalous levels of zinc in the Nant Ffriddisol which is crossed upstream of the sample sites at [SJ 120 421] and [SJ 122 415] by a major NNW trending fault, and further to the east high levels of zinc in the Nant y Gro at [SJ 157 402]. Hydrous oxide precipitates may be a contributory cause to these anomalies but the very high base-metal levels in sediment, the presence of anomalies in concentrate and the lack of very high Co-Fe-Mn results in sediments from these sites suggests another cause. Sites on lower ground upstream of the main road show metal anomalies in panned concentrate, for instance Zn at [SJ 117 432] and Pb at [SJ 149 426], but all these samples contain Sn anomalies suggesting that contamination is at least a contributary cause.

Just south of Corwen a highly anomalous site [SJ 077 431] with high levels of Cu, Zn, Fe, Sn and As in concentrate and Mo and Pb in sediment in the Nant Cawrddu suggests the presence of mineralisation as well as contamination, for Mo and As are rarely produced by contamination in this area. The anomalous As result suggests a link with the As-Au mineralisation in the Afon Trystion to the south. However, the sample site about 1 km upstream of the anomaly in a southerly direction yielded no base-metal anomalies except Zn_w which can be attributed to the acid upland environment. This suggests local derivation of the anomalous metals, perhaps from hitherto unrecorded mineralisation similar to that exploited in the old working to the east.

3 *Fluorite at Llansantffraid Glyn Ceiriog.* A sample from Nant Ty'n-y-twmpath [SJ 167 373] contains large Cu and Sn and weaker Pb anomalies in the panned concentrate. Mineralogical examination indicated that these were entirely caused by metallic contamination and that fluorite was present. Old quarries are marked upstream of the sample site but have not been visited. The source of the fluorite is uncertain but is thought unlikely to be dumped material. Downstream of this site, in the River Teirw at [SJ 170 371], Sn and Cu anomalies in panned concentrate are recorded but mineralogical examination showed them to be caused by contamination. Another stream, to the east of Nant Ty'n-y-twmpath, also yields weakly anomalous Cu and Sn in panned concentrate [SJ 171 371] but in the light of the previous results it is considered to be most likely that the anomaly is caused by contamination.

To the west, the upper reaches of the River Teirw contain highly anomalous amounts of Ni in stream sediment as well as high levels of Pb and Zn in sediment. The reason for these anomalies is uncertain, but they are attributed to a combination of hydrous oxide precipitates and erosion of dark graptolitic shales of the Blaen-y-cwm Formation (Brenchley, 1978).

4 *Anomalies southeast of Glyn Ceiriog.* Scattered anomalies in this area, mostly of Cu and Sn, are attributed to contamination because of rubbish noted in the streams. However, none of the catchments or panned concentrates have been examined, so the possibility of mixed anomalies, caused by contamination and mineralisation, cannot be eliminated. Two sites in parallel streams at [SJ 217 363] and [SJ 223 359] contain high or anomalous levels of Zn in water, sediment or concentrate as well as Sn and Cu anomalies. The former may be caused or enhanced by contributions from the Pandy Tuff Formation over which both streams rise. Similarly, streams draining undifferentiated Silurian rocks to the east of Glyn Ceiriog carry high or anomalous levels of V_s and Ba_p (e.g. [SJ 208 382] and [SJ 230 386]) which may be caused by bedrock rather than contamination, the presumed cause of other anomalies at these sites. Weak Cu_p anomalies in the Nant Gwryd at [SJ 233 364] and [SJ 235 365] are accompanied by high levels of Sn_p and are attributed to contamination.

5 *Transition metal anomalies south of Llandrillo.* High levels of a large group of metals in streams draining the Carnedd y Ci area are attributed to the presence of basic intrusions named the Cym Dywyll sill and Carnedd y Ci sill by Cope (1915). The Cadair Berwyn sill may also contribute, but it outcrops astride the interfluve. The description of Cope (1915) indicates that the Carnedd y Ci intrusion is complex, consisting of altered albite diabase and keratophyre, whilst the Cwm Dywyll intrusion is a 'typical welsh dolerite' locally rich in ilmenite. This feature explains the main characteristics of the geochemical anomalies, as all the highly anomalous sites for Ti_p ([SJ 057 349], [SJ 043 350], [SJ 042 346], [SJ 039 333], [SJ 038 331]) are within the outcrop or downstream of this intrusion. Other metal anomalies in panned concentrate, for Zn, Mn and Fe, are attributed to the relatively high levels of iron oxides and mafic minerals in the intrusions compared with sedimentary rocks. The tuff horizon may accentuate the high levels. Anomalies in sediments for Co, Zn, Fe and Mn are the result of these factors plus enhancement by secondary hydrous oxide precipitation processes.

6 *Cu, Co, Cr and V anomalies to the west, north and east of Llanarmon.* Samples from the catchment of the river Ceiriog in this area yield high or weakly anomalous results for one or more of Cu, Zn, Co, Cr or V in sediment, panned concentrate or water. Sites in streams draining the southeast side of the valley ([SJ 117 344], [SJ 135 341], [SJ 127 334], [SJ 146 331]) are dominated by anomalies in sediment, suggesting that heavy minerals such as sulphides are not the cause of the anomalies. A brief examination of the most anomalous site [SJ 117 344] revealed some small excavations, thought to have been

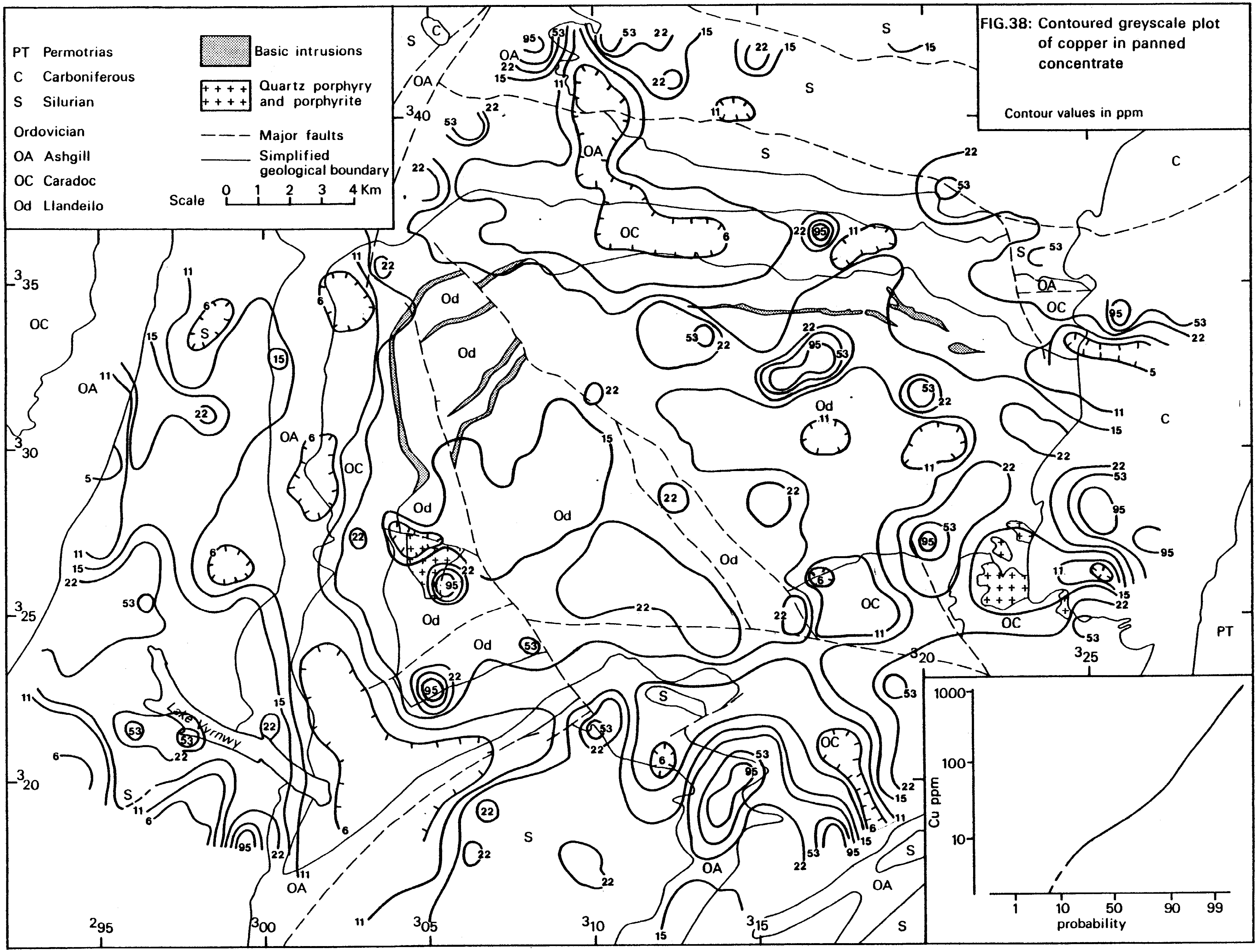
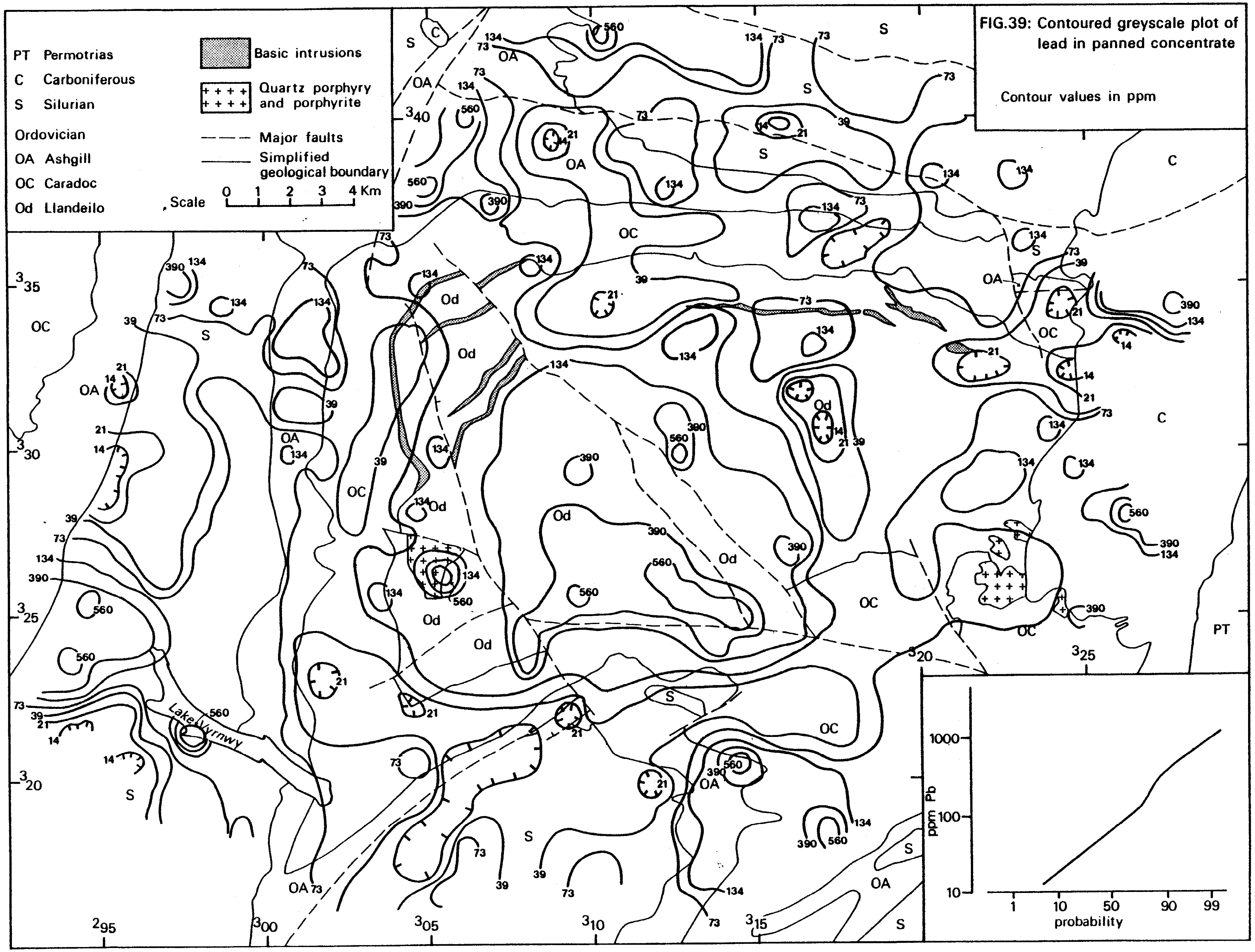


FIG.38: Contoured greyscale plot of copper in panned concentrate
Contour values in ppm
PT Permotrias
C Carboniferous
S Silurian
Ordovician
OA Ashgill
OC Caradoc
Od Llandeilo
Basic intrusions
Quartz porphyry and porphyrite
Major faults
Simplified geological boundary
Scale 0 1 2 3 4 Km
Lake Vyrnwy
Cu ppm
probability

FIG.39: Contoured greyscale plot of lead in panned concentrate

Contour values in ppm



trials for slate. Analysis of a quartz-veined siltstone from one of the workings showed no metal enrichment above average values recorded in siltstones, but a pyritiferous shale from the same site contains high levels of Ni, As and Fe (Table 6, Nos. 1 and 2). Pyritiferous shales and abundant float blocks of barren quartz were also noted in the catchment. This and other streams in the area contain anomalous or high levels of Co, V, Zn and Mn in sediment and, in the upper reaches, Zn_w. The assemblage suggests that the anomalies are caused by hydrous oxide precipitation processes in combination with a high background generated by mudstones and perhaps tuffaceous horizons within the Mynydd-tarw Group. The weak anomalies in panned concentrates are also ascribed to these causes with the addition of contamination at some sites.

To the east of Llanarmon, anomalous levels of Cu_p, Pb_p and Sn_p in streams draining Llangadwaladr ([SJ 185 345], [SJ 176 341], [SJ 169 335]) were shown by mineralogical study to be entirely the result of contamination. Weakly anomalous levels of Ba_p at these sites (600–750 ppm) and high but not anomalous levels of Cu_s were attributed to the background geology. Although not examined mineralogically, contamination is also believed to be the most likely cause of anomalies for Sn, Cu and Zn in the panned concentrate collected south of the village at [SJ 157 323], for upstream samples taken above the roads are not anomalous.

7 *Anomalies in the Iwrch Valley.* Anomalous levels of Cu_p, Pb_p and Zn_p in samples collected near and downstream of Craig-y-glyn are related to old mine workings hereabouts. A brief examination of the sites indicated that quartz-carbonate veins with galena and sphalerite within limestones, calcareous siltstones, ashes and shales of the Llandeilian Craig-y-glyn Group have been exploited. Details of the mines are not known, and the workings are collapsed and at least partly grassed over. Exploitation appears to have been from a series of levels and shafts along the Iwrch Valley and the tributary by Pen y Graig farm, extending from [SJ 122 290] in the north to [SJ 124 284] in the south. Collapsed adit directions suggest that one vein trends SSW from near Pen y Graig farm, but otherwise the controlling structural directions and style of mineralisation remain in doubt. The presence of a gravity low in this area is an interesting feature. It may simply reflect the relative closeness to basement, but might also be construed as indicating the presence of an intrusion, such as a volcanic plug with which the volcanism and mineralisation might be associated.

Examination of tip material suggests that sulphide mineralisation is weak, but analysis of a composite tip sample (Table 6, No. 3) inferred the presence of appreciable baryte (10% Ba) in addition to minor galena (0.9% Pb) and sphalerite (0.3% Zn). With the exception of Pb, the panned concentrate anomalies are weak and the absence of a Ba_p anomaly suggests that the majority of tip material is not entering the drainage system. The Ni_p and some part of the Pb_p anomalies are related to the high levels of Ce_p and not to mineralisation. All samples taken in the Iwrch catchment contain high Ce_p, Ni_p and Pb_p, related to the presence of monazite nodules and coatings. Several sites in the upper catchment also contain sub-anomalous levels of Zn_s, Co_s and Zn_p. These are attributed to a high background generated by mudstones and ashes of the Mynydd-tarw Group enhanced by hydrous oxide precipitates.

In addition to these anomalies, the site at [SJ 104 319] contains anomalous Cu_s, Zn_w and a very high level (0.12 ppm) of Cu_w. The catchment is mapped as Mynydd-tarw Group and contains shales, ashy shales, ashes and sandstones (Wedd and others, 1929) cut by several northerly-trending faults. A brief examination of the site revealed abundant float quartz but repeat and additional water samples taken upstream failed to yield anomalous results. The cause of the majority of the anomalous metal values is probably the same as that thought to generate anomalies across the interfluve to the north, i.e. a combination of background geology and hydrous oxide precipitates, but the possibility of mineralisation cannot be eliminated at this stage as the cause of the Cu_w anomaly in particular is unresolved.

8 *Baryte south of Llandrillo.* A panned concentrate from Nant Crechwyl [SJ 025 319] contains an isolated Ba_p anomaly which mineralogical examination related to barium in shale fragments and rare, rounded grains of baryte. The site also produced weak Cu_w (0.02 ppm) and Zn_p (340 ppm) anomalies. The source of the baryte is uncertain. It is possibly derived from fault-associated veins in the Swch Gorge Tuff Formation, similar to those discovered in Cwm Rhiwarth.

9 *Cobalt and associated anomalies in the upper Afon Rhaeadr.* Sample sites in first and second order streams close to and above Tan-y-pistyll contain high or anomalous levels of Co, Fe, Mn, Cu, Pb, Zn and Ni in stream sediment and Cu and Zn in water. The sediment anomalies are attributed to a combination of hydrous oxide precipitates and a high background from the Llyn Lluncaws, and Cwm Dywyll basic intrusions. This conclusion is supported by high or weakly anomalous levels of Ti_p at these sites and an analysed rock sample from the margin of the Llyn Lluncaws intrusion, which contains relatively high levels of Fe (7.67%), Mn (0.14%), V (221 ppm) and Co (28 ppm) compared with most of the sedimentary rocks (Table 6, No. 4). At the two sites near Tan-y-pistyll, levels may also be enhanced by contributions from the volcanic rocks. Anomalous levels of Zn_w were confirmed by re-sampling and are attributed to a combination of acid upland waters and a high available background. At [SJ 052 302] an exceptional level of Cu_w (0.12 ppm) was recorded, but resampling failed to reproduce the anomaly and the site is contaminated. High and anomalous levels of Ce_p Ni_p and Pb_p are attributed to monazite coatings and nodules.

Weakly anomalous levels of Zn_p and perhaps some of the other anomalies such as Cu_s and Pb_s may have yet another source, for a brief visit to the catchment revealed the presence of quartz veining and pyrite apparently associated with both the volcanics and the basic intrusion. One of the quartz veins, at [SJ 057 300], had an adit cut into it but no sulphide besides pyrite was seen. Some of the volcanics were quite strongly veined, possibly altered, and merit further investigations.

10 *Anomalies associated with base-metal mining centred on Llangynog.* Many of the anomalies in the Rhaeadr, Tanat and Hirnant valleys are caused by old base-metal mines. Generalised sites of these workings are shown on the anomaly maps. Sites known to be contaminated by old workings were avoided, wherever possible, whilst maintaining the sampling density, reducing the overall impact of the known mineralisation on the results. The old mine workings generate anomalies characterised by high levels of Cu, Pb and Zn in concentrate and lower

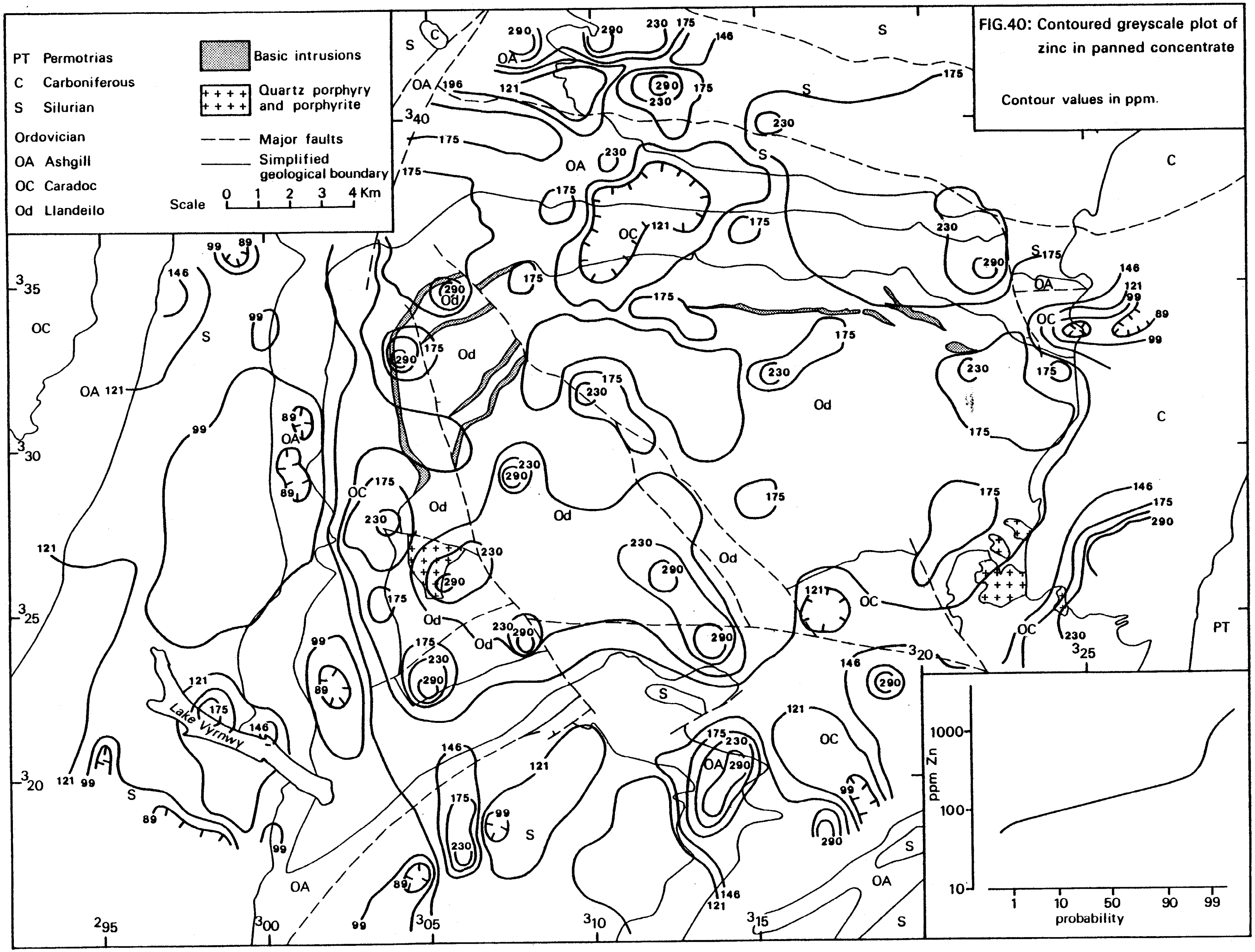


FIG.40: Contoured greyscale plot of zinc in panned concentrate

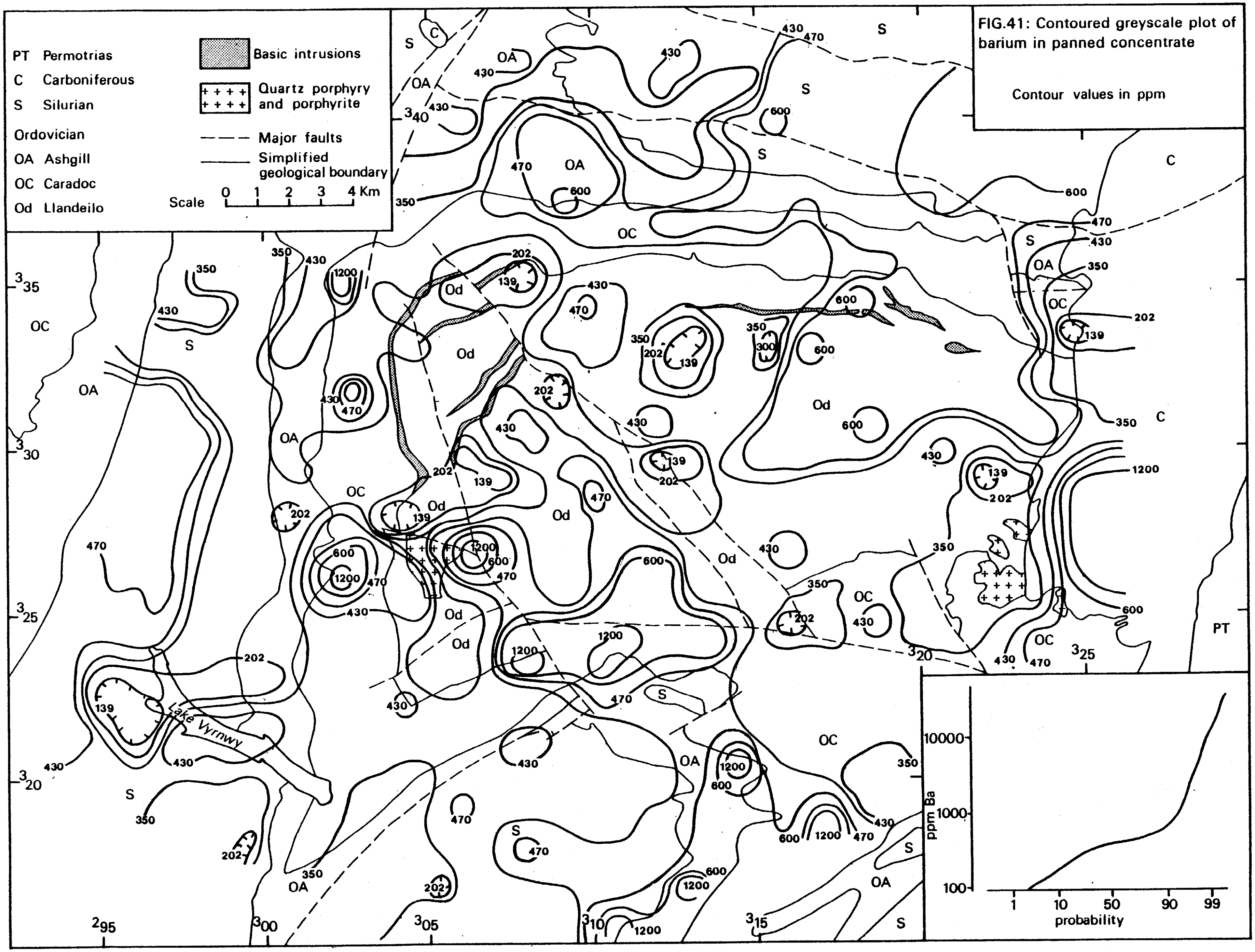


FIG.41: Contoured greyscale plot of barium in panned concentrate

Contour values in ppm

Table 6 Rock analyses

Sample	National Grid reference	Cu	Pb	Zn	Ba	Fe %	Mn %	Ni	As	Mo	Ti %	Ca %	Ce
1 Quartz-veined siltstone from old trial, Llanarmon	SJ 1180 3430	5	60	10	147	0.37	0.260	9					
2 Pyritiferous shale from old trial, Llanarmon	SJ 1180 3430	41	39	169	492	15.20	0.215	56	83	4	0.61	0.27	67
3 Composite sample from tips, Pen y Graig	SJ 1255 2875	35	9420	2670	102060	2.30	0.586	5					
4 Margin of quartz veined intrusive, Cwm Rhiwiau	SJ 0592 3039	10	20	120	195	7.67	0.137	26	(V = 221, Cr = 36, Co = 28)				
5 Vein material from brecciated volcanics, Blaen Rhiwarth	SJ 0235 2940	6	28	45	247600	0.77	0.117	16	8	16	0.10	2.79	
6 Brecciated limestone with minor sulphides, Blaen Rhiwarth	SJ 0230 2940	20	<13	14	2590	2.34	0.027	7	6	5	0.28	1.45	49
7 Quartz-carbonate vein material, Berwyn phosphate mine	SJ 0141 2950	<6	<13	13	<27	0.37	0.103	<5	<2	2	0.01	25.63	29
8 Dark pyritiferous shales, Berwyn phosphate mine	SJ 0141 2950	10	47	98	318	6.03	0.019	10	63	5	0.27	1.97	111
9 Calc-mudstone with sulphide veinlets, Berwyn phosphate mine	SJ 0141 2950	13	<13	84	191	2.17	0.414	<5	21	3	0.04	18.26	32
10 Composite sample from ash bands, Pen-y-garnedd phosphate working	SJ 1092 2375	16	36	145	539	5.22	0.033	9	5	3	0.23	1.23	77
11 Calc-mudstone with pink veinlets, Pen-y-garnedd	SJ 1092 2375	9	19	67	291	1.79	0.137	<5	<2	3	0.08	12.99	66
12 Brecciated nodular bed, Pen-y-garnedd	SJ 1092 2375	48	<13	7	105	2.30	0.309	<5	4	<2	0.04	21.20	14
13 Shales with ash bands, Pen-y-garnedd phosphate working	SJ 1092 2375	10	14	26	389	2.83	0.084	10	11	4	0.32	5.49	81
14 Ash band with shale intercalations, Pen-y-garnedd phosphate working	SJ 1092 2375	11	66	41	490	13.73	0.167	32	204	27	0.17	7.03	33
15 Phosphatic nodules, float blocks, Pen-y-garnedd	SJ 0978 2304	18	<13	38	206	4.39	0.231	23	26	<2	0.24	11.40	39
16 Veined, brecciated, sulphide-bearing shale, Pen-y-garnedd	SJ 0968 2300	522	2270	56	209600	1.19	0.021	20	6	13	0.26	0.36	
17 Mudstone with baryte vein, Pen-y-garnedd	SJ 0978 2304	10	167	62	18540	3.79	0.028	10	19	<2	0.31	1.54	
18 Quartz vein in shale, Lake Vyrnwy	SH 9443 2259	109	17	52	252	4.88	0.076	29	6	3	0.56	1.46	46
19 Composite sample from old trial near Moelfre	SJ 1722 2840	80	580	160	187	10.16	0.318	65					
20 Composite sample from tips, Moelydd	SJ 2422 2546	40	<13	81	53	6.02	0.056	18	<2	4	0.45	1.43	46
21 Brecciated intermediate intrusive with chalcopyrite, Moelydd	SJ 2418 2550	7990	<13	42	43	4.37	0.030	14	11	<2	0.44	0.23	25
22 Brown-weathering siltstones and shales, Afon Cedig	SH 9814 2630	36	15	95	466	8.12	0.034	30	14	3	0.69	0.27	59
23 Dark pyritiferous shale, Llanwddyn	SJ 0375 1940	38	58	46	873	6.07	0.057	25	33	12	0.72	0.07	65

Sb and Sn were also determined, but all results were less than detection limits (11 and 9 ppm respectively)

All results in ppm except where indicated levels in sediments from the same sites. Some Pb_p anomalies are confused by the presence of high Ce_p and mineralogical examination indicates that the Cu_p anomalies are caused by contamination and not sulphide mineralisation. Ba_p anomalies are rare unless, as in Cwm Hirnant, the Pen-y-garnedd phosphatic beds are also present in the catchment. The reason for this is uncertain, as panned concentrates are normally sensitive indicators of baryte mineralisation which is recorded in several of the mines (Appendix 1). The lack of Ba_p anomalies may be caused by the biased sampling away from known workings, but suggests that baryte is only a minor constituent of the base metal mineralisation.

In the Afon Rhaeadr all the sites downstream of Tan-y-pistyll are contaminated by material from the workings at Craig-y-mwn [SJ 078 288]. The tips from these workings are also thought to be responsible for anomalies near Tan-y-graig [SJ 081 286]. Downstream, anomalies are probably regenerated by material from Nant-y-blaidd and Ty'n-y-llwyn. Mineralisation evidently does not cross the valley here, for streams sampled at [SJ 097 285] and [SJ 098 285] only yielded Ce and Pb anomalies in concentrate and weak Co, Mn and Pb anomalies in sediment, related in the first instance to hydrous oxide precipitates. Weak Ti_p anomalies at some sites in this area suggest that there is a contribution from basic intrusions and volcanics in the upper part of the catchment which may, therefore, also enhance Zn, Co, Mn and Fe levels. No gold was seen in the panned concentrates despite the record of gold at Nant- y-blaidd (Wren, 1968).

The Afon Tanat was not sampled and as a consequence the only anomalies related to the mines at Llangynog are found in two tributaries. Anomalies at [SJ 052 258] are caused by tips from Llangynog mine whilst anomalies at [SJ 064 265] are derived from Cwm Llanafon. A brief inspection of the latter site suggests that the anomalies come in the first instance from hardcore in a track by the stream and contamination from a farm dump, rather than mine workings. As Cwm Llanafon mineis not recorded as containing baryte, the unusual feature of this anomaly is the very high Ba_p (7100 ppm). There is a possibility that there is an unknown source in the area, or that the records are incomplete, but a third possibility is that the hardcore in the track was brought in from elsewhere.

In the Hirnant valley anomalies at [SJ 047 228] are downstream of Hirnant mine, though the association of anomalies in panned concentrate (Cu, Pb, Sn) suggests that they may be caused by refuse dumping rather than metal mining. A nearby sample [SJ 048 226] from the main stream contains a large Zn_p anomaly which has several causes including refuse dumping (galvanised iron) and mineralisation (sphalerite). The source of the sphalerite is uncertain, but it must be local as upstream sites are not anomalous. There is little exposure in the vicinity of the sample site, and it is thought most likely that the sphalerite is derived from Hirnant mine, either by dumping or conceivably from drift deposits.

Two sample sites with Craig Ddu mine in their catchment are not anomalous, but further downstream, near Pentre, are two highly anomalous sites. The first, in the Hirnant [SJ 079 239], contains anomalous levels of Cu, Pb, Zn, Ba, Ce and Sn in panned concentrate, which mineralogical examination related to the presence of baryte, galena, monazite and contamination (lead glass, Pb and Cu metal). Blocks of sheared shales with quartz and carbonate veins carrying minor pyrite and galena were found in the unconsolidated deposits, but no bedrock source was identified. The anomaly is either caused by dumped material from Craig Ddu or, more likely, there is another source in the vicinity. The second highly anomalous site is in the Nant y Brithyll [SJ 082 239] and contains high Ba_p and Sn_p. Mineralogical study of the concentrate identified baryte and a grain of chalcopyrite. Another panned concentrate taken 0.5 km upstream also contains very high Ba_p (16000 ppm) but the uppermost site in the catchment is not anomalous. Between the two anomalous sites the stream runs nearly parallel to the strike of the rocks and cuts dark shales and siltstones. Near the lower site an adit is cut into the shales. Further cuts, not visited, are present on the hillside to the south. These are believed to be part of Bwlch Creolen mine, but did not appear to contribute material to the anomalous site. The source of the anomalies remains in doubt: they show features in common with anomalies caused by the Pen-y-garnedd phosphatic rocks, but that horizon is not mapped as outcropping within the catchment. Either hitherto unknown baryte mineralisation is located in the catchment, or material from Bwlch Creolen has been dumped here.

11 *Anomalies in Cwm Rhiwarth.* Samples from the upper part of Cwm Rhiwarth are characterised by anomalous levels of Fe, Mn, Ti and Ni in panned concentrate, accompanied by high or anomalous levels of Fe, Mn, Co, Cu, Pb and Zn in sediment and at a few sites Cu and Zn in water. An additional set of samples collected just below the gorge section above Blaen Rhiwarth at [SJ 025 293] confirmed the anomalies and yielded higher results for Zn, V, Fe, Mn, Co, Ni and Ba in sediment and Fe, Mn, Ti and Ni in panned concentrate than the primary survey samples (Figure 24). A brief visit to this area suggested that the anomalies had several different sources.

Firstly, in the gorge section wher the Swch Gorge Tuff Formation crosses the stream the rocks are shattered and contain quartz and carbonate veins. Except for pyrite, no sulphide mineralisation was seen, but analysis of two samples of veined and brecciated rocks (Table 6, Nos. 5 and 6) indicated the presence of baryte, and levels (not visited) are marked on the 6 inch scale OS map in the slope to the north of the stream [SJ 0235 2972]. Secondly, the volcanic rocks are being rapidly eroded in the gorge section and no doubt contribute to the recorded anomalies, though the analytical results suggest that they may not be the major source. A third possible source, for transition metal anomalies in particular, may be a basic intrusion outcropping further upstream and described by Cope (1915). The presence of anomalies in the stream at [SJ 021 295], above the Swch Gorge Tuff, suggests that this, perhaps with contributions from volcaniclastic rocks in the Cwm Rhiwarth Siltstone Formation, is a major source of anomalies. A fourth possible source of anomalies is the Pen-y-garnedd phosphatic rocks which have been exploited in the upper part of the catchment at Berwyn Mine. However, analyses of three rock samples taken from the grassed over tips of the old workings (Table 6, Nos. 7–9) show few metal enrichments, and suggest that the phosphatic rocks are not the cause of the stream anomalies recorded here.

Anomalous levels of several metals in sediment are thought to be enhanced by hydrous oxide precipitates, which may also in part control anomalous levels in water. It is concluded that, although the bulk of the anomalies may be caused by basic intrusions and volcanics enhanced by hydrous oxide precipitation processes, there is some evidence for mineralisation contributing to the anomalies. The form of the mineralisation is uncertain. That seen in

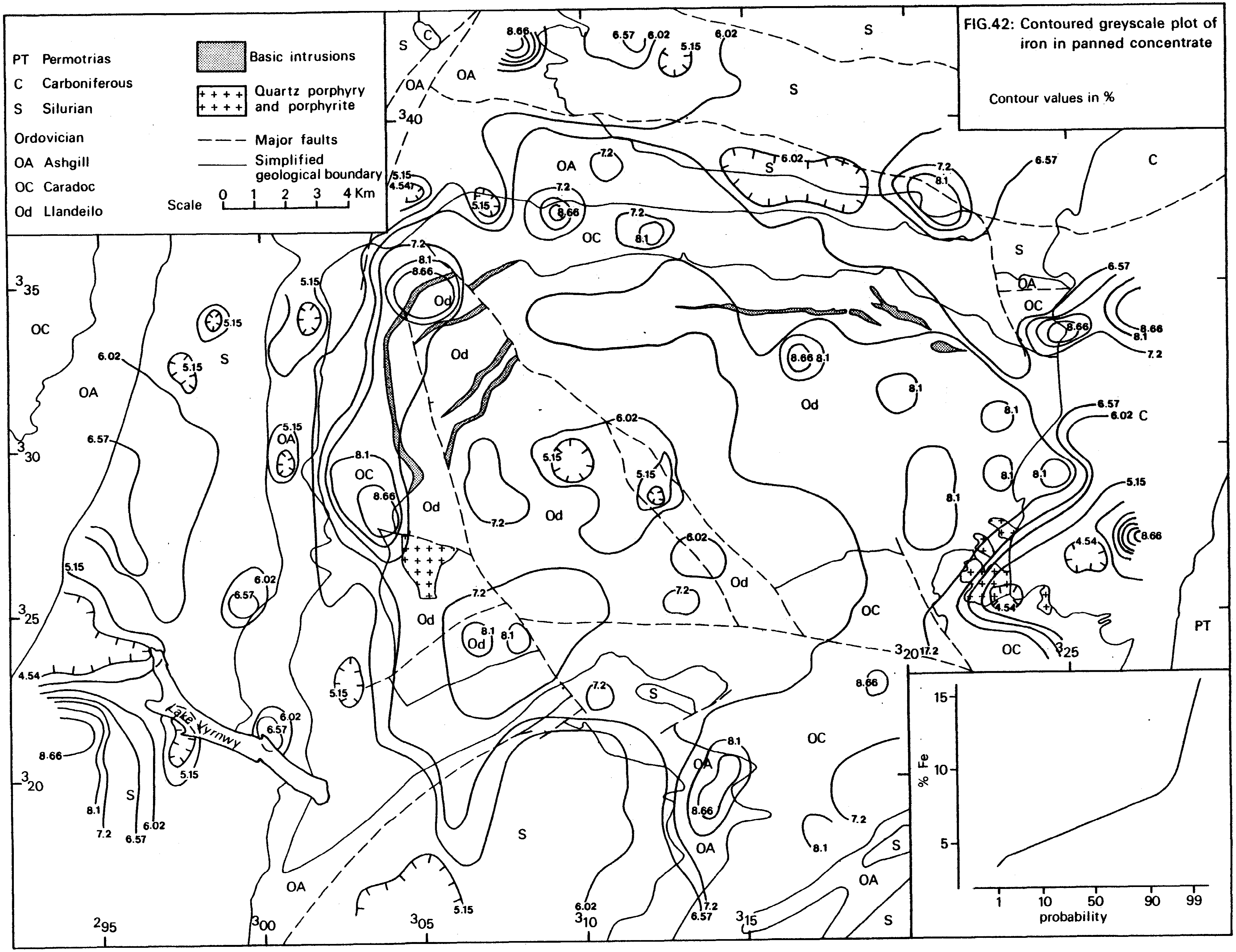


FIG.42: Contoured greyscale plot of iron in panned concentrate

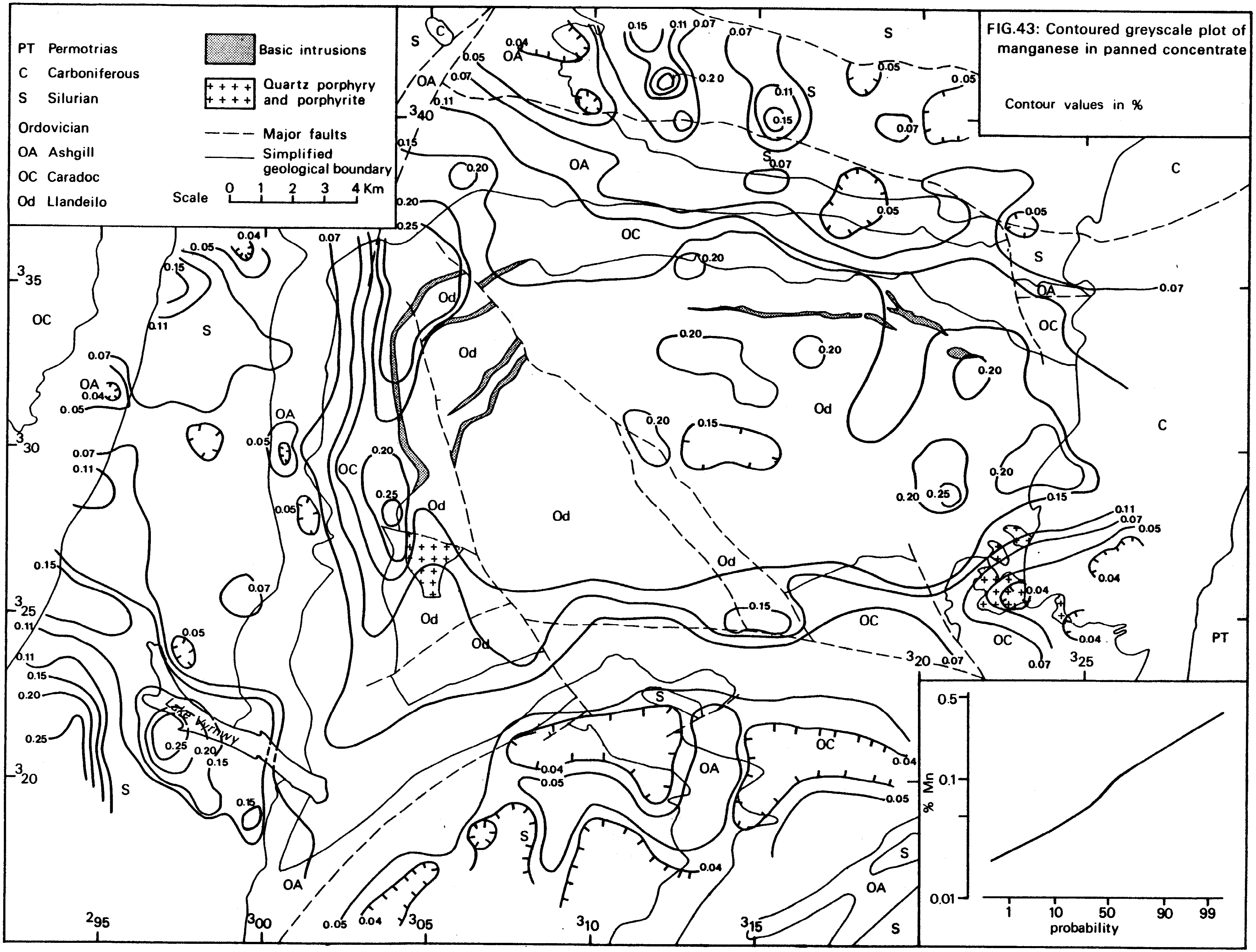


FIG.43: Contoured greyscale plot of manganese in panned concentrate

the gorge is apparently fault controlled and involved only minor sulphide, but the presence of water anomalies for Cu, Pb or Zn at several sites in the vicinity of the gorge, coupled with a pronounced gravity low suggesting the presence of a small acid intrusion, may indicate more substantial hidden mineralisation in the vicinity.

12 *Barium anomalies spatially related to the Pen-y-garnedd Formation phosphatic rocks.* Three groups of Ba_p anomalies are spatially related to phosphatic sedimentry rocks which occur in Upper Caradocian strata termed the Pen-y-garnedd Beds (Wedd and others, 1929), the Nod Glas (Cave, 1965) and the Pen-y-garnedd and Blaen-y-cwm shale formations (Brenchley, 1978). The shales and limestone bands below the exploited phosphorite bed are frequently traversed by ramifying veins of baryte up to nine inches wide (Dunham and Dines, 1945) and would seem, therefore, to be the likely source of the Ba_p anomalies, but detailed examination of the three areas suggests that the position is not so straightforward.

(i) Llanfyllin. The highly anomalous panned concentrate from a contaminated site north of the village [SJ 146 199] was found to contain sphalerite, galena and baryte as well as contaminants. There is no record of base-metal mineralisation in the catchment, but the Pen-y-garnedd Beds are mapped close to the stream for about 1 km and it is suggested that mineralisation associated with these rocks may be the source. The mineralisation is probably of vein type as noted elsewhere, but the possibility of a syngenetic concentration also exists.

Ba_p anomalies are recorded from two sites to the southwest of Llanfyllin at [SJ 130 165] and [SJ 107 149]. Mineralogical examination of the concentrate from the latter site showed that barium occurs mainly in shale fragments though some baryte is also present. Weak Cu_p and Sn_p anomalies are attributed to contamination recorded at the site. Anomalies at the former site are attributed to similar causes, Pb_p and Sn_p to contamination and Ba_p to baryte and shale fragments. The source of the baryte is uncertain: both sites are close to the outcrop of the Pen-y-garnedd Beds but the catchment bedrock consists of Ashgill and Wenlock age rocks. No mineral veins are known in the area and the catchments have not been examined. At [SJ 107 149] and two other sites upstream sampled for water only [SJ 106 158, SJ 107 158], Cu_w, Pb_w or Zn_w anomalies were recorded but resampling failed to reproduce them.

To the southwest of the village another contaminated and highly anomalous site is recorded in the River Abel draining Ashgillian rocks [SJ 139 191]. Mineralogical examination of the concentrate showed that in addition to contaminants copper is contained in pyrite and lead in rare pitted grains of galena. The anomaly has not been investigated and the source of the sulphides is uncertain.

Examination of the panned concentrate from a highly anomalous (Cu_p, Pb_p, Zn_p, Ba_p, Sn_p, Zn_p) and contaminated site [SJ 173 179] southeast of Llanfyllin showed the presence of minor, anhedral, pitted grains of galena, sphalerite and possible chalcopyrite in addition to metallic contaminants. Baryte is suspected but was not positively identified. The cause of the anomaly is uncertain, it may be due to local dumping of mine tip material, for the next site downstream is not anomalous. As the site is on the edge of the sampled area no samples were taken upstream for 5 km, but 3 km upstream the Pen-y-garnedd Formation is crossed and mineralisation associated with these beds, perhaps along faults, may be an alternative reason for the anomaly.

(ii) Pen-y-garnedd. Two sites at Pen-y-garnedd [SJ 109 239, SJ 104 235] yield Ba_p and Sn_p anomalies. The former, which is the weaker, also gives a Pb_p anomaly and the latter an As_p anomaly. Baryte was found in both samples and chalcopyrite in the latter. Investigation of the stream section suggested that the anomalies are caused by old mineral workings, for phosphate at Pen-y-garnedd [SJ 108 238] and phosphate and base-metals at Bwlch Croelen [SJ 092 229].

Samples from the old workings at Pen-y-garnedd show no metal enrichment when compared with average shales (Table 6, Nos. 10–14, Turekian and Wedepohl, 1961) except for an ashy shale which contains high levels of As, Mo, Pb and Fe. Further upstream mine tip material containing sulphides was found in walls and a farmyard [SJ 104 236], and about 1 km above the more highly anomalous site old mine tips and buildings are located by the stream [SJ 098 230]. Rock samples of veined and brecciated siltstone from here contain baryte and sulphide minerals and on analysis were found to contain high levels of Cu, Pb, Ba, Mo and As compared with average shales (Table 6, Nos. 15–17). This is considered to be the principal source of both stream anomalies, but it is uncertain what style of mineralisation is represented here and whether the tip material is nominally derived from the exploitation of phosphate or base-metal vein mineralisation, as records indicate that both were exploited in the vicinity.

(iii) Pennant Melangell. Elevated Ba levels in three samples from Pennant Melangell prompted additional sampling; the anomalous results from which are shown in Figure 25. Ba_p levels in samples with very high levels of Ce_p are reduced by analytical interference of Ce on Ba (shown in brackets on Figure 25), which confuses detailed interpretation of the results. Phosphatic rocks outcrop in the area, and an old working for phosphate is recorded at [SJ 014 266], but in detail anomalous streams show little relationship to the mapped outcrop of the base of the Blaen-y-cym Shale Formation (Figure 25) or this working. A brief survey of Nant Tre-fechan showed the presence of faults, quartz veining, pyritiferous shales and an old trial, apparently in a quartz vein. Therefore, although the pattern is confused by Ba-Ce interference and the Swch Gorge Tuff Formation may contribute to Ba_s anomalies, the possibility of another source of baryte beside the veins associated with the known phosphatic horizon is a distinct possibility.

The results from all three anomalous areas suggest that whilst some Ba_p anomalies are generated by known baryte veins underlying the Pen-y-garnedd phosphatic horizon other baryte bearing veins, spatially less closely associated with the phosphorite, may exist and that in some places base-metal concentrations may also be developed. A possible source of mineralisation or remobilising fluids may be suggested by the presence of a pronounced gravity low to the north of here.

13 *Anomalies around Lake Vyrnwy.* The majority of anomalies in this area are caused by hydrous oxide precipitation processes. The following groups of anomalies are distinguished:

(i) High and anomalous levels of Co, Mn, Zn and Fe in sediment samples from Afon Dolau Gwynion (e.g. [SJ 022 214]) are attributed to secondary precipitation processes. In this case anomalies may be enhanced by high metal availability from the Swch Gorge Tuff Formation. Panned concentrate results indicate that a mineral vein shown crossing the stream on the Old Series GS maps

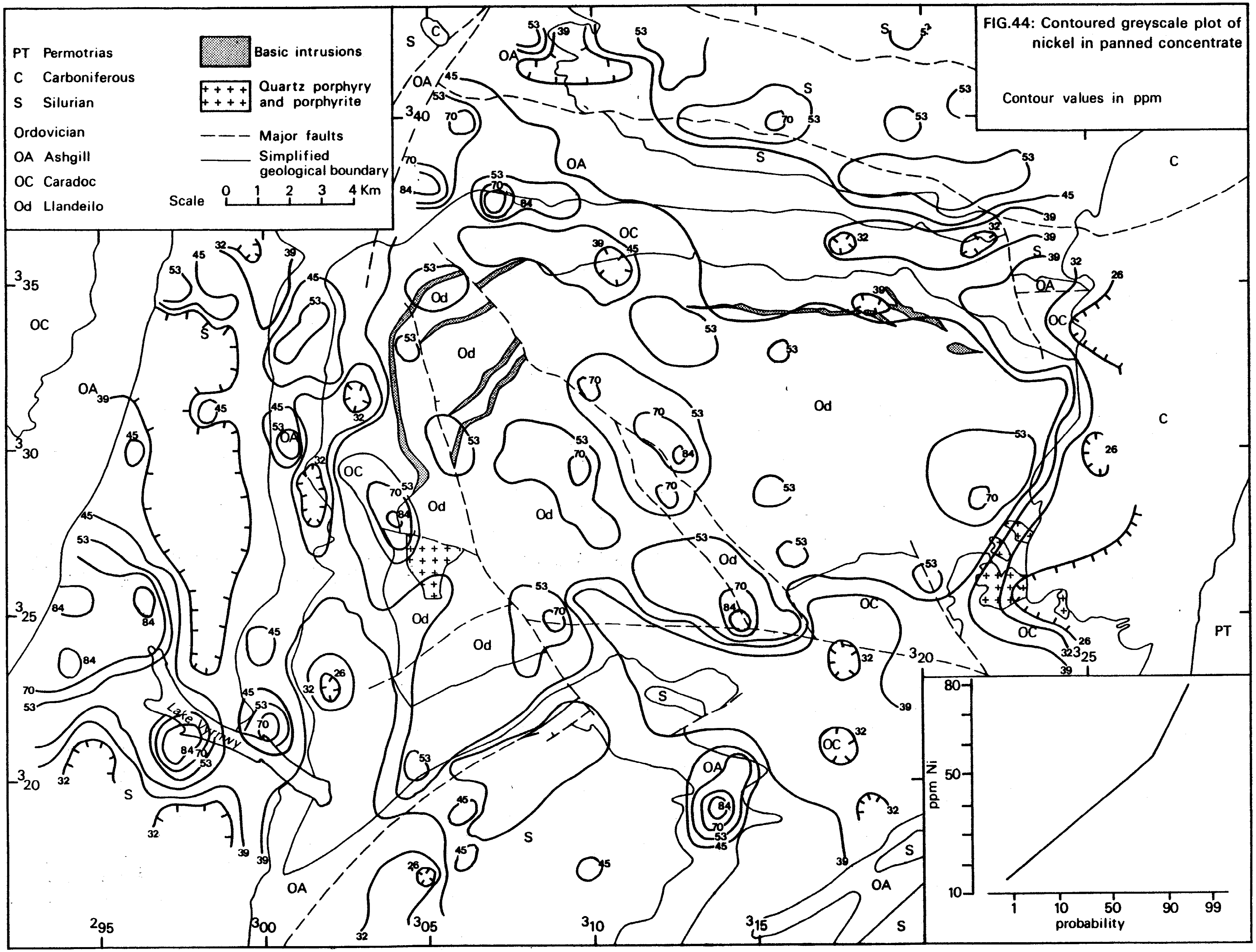


FIG.44: Contoured greyscale plot of nickel in panned concentrate

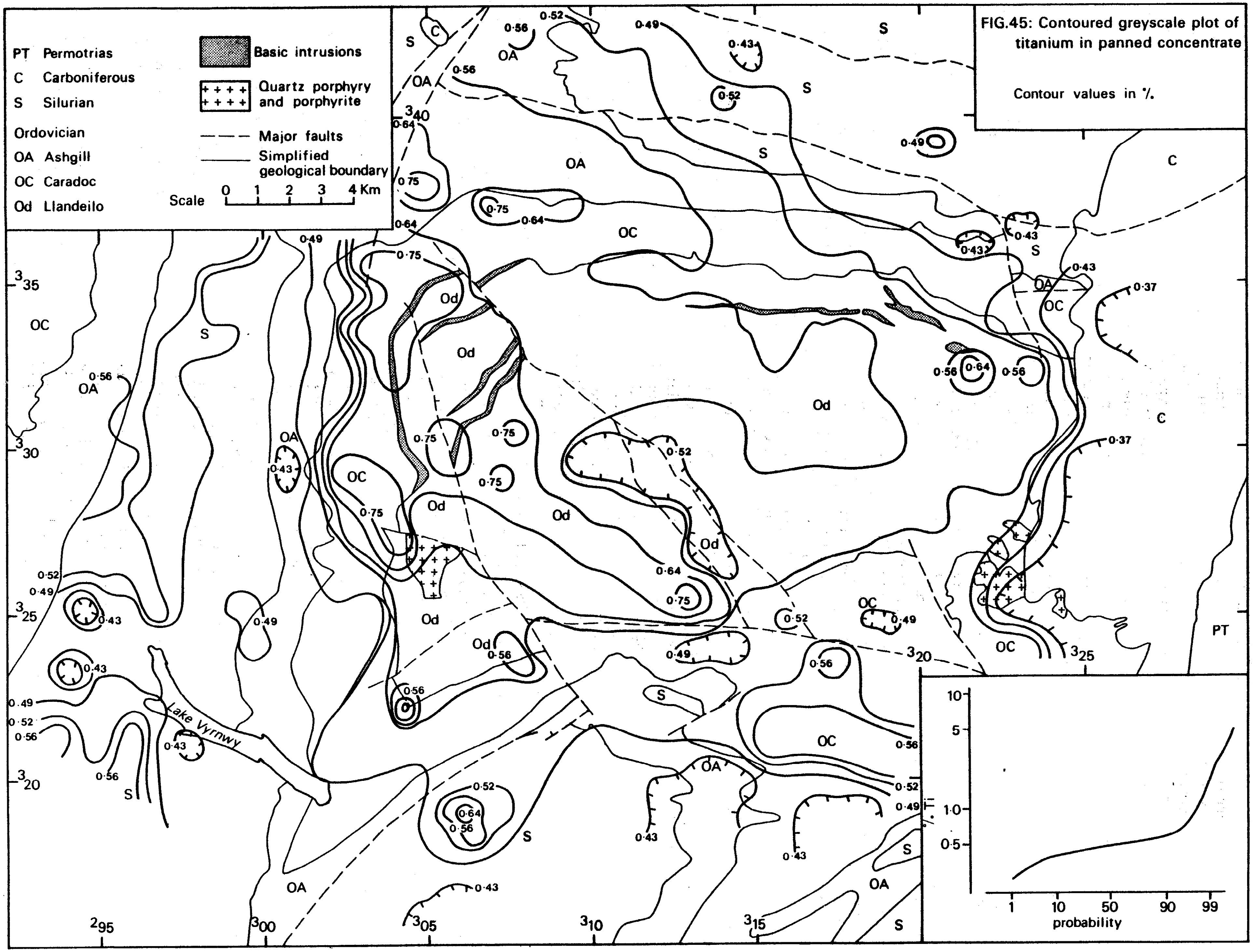


FIG.45: Contoured greyscale plot of titanium in panned concentrate

makes little direct contribution. To the north similar anomalies in first order streams forming the headwaters of the Afon Tanat (e.g. [SJ 005 277]) are also thought to be produced by precipitation processes. To the south and west of Lake Vyrnwy high and anomalous levels of Co, Mn, Fe and Zn in sediment accompanied on occasion by high or anomalous levels of Pb_s and Ba_s in the Afon Cownwy (e.g. [SH 968 188]), Afon Hirddu (e.g. [SH 961 209]) the Eunant (e.g. (SH 947 229)) and Afon Eiddew (e.g. (SH 938 252)) are believed to be produced by the same process.

Determinations of pH on soils near the stream in the upper reaches of the Afon Hirddu gave results in the range 4.0–4.9 whilst the stream yielded values of 4.9–6.5. Heavy black encrustations were noted on pebbles and brown gelatinous precipitates developed at seepage points near the stream, all of which supports a precipitate origin for these anomalies. Fe_p and Mn_p anomalies in the Afon Hirddu are believed to be caused by retentive Fe/Mn oxide coatings on lithic fragments. All these anomalies may be enhanced by the presence of local vein mineralisation described below.

(ii) Ce in panned concentrate anomalies. Very high levels of Ce_p are recorded in the Lake Vyrnwy catchment, notably in the Afon Hirddu (e.g. [SH 956 213]) the Eunant (e.g. [SH 937 237]), Afon Eiddew (e.g. [SH 938 253]) and Afon Nadroedd (e.g. [SH 953 259]). Levels are generally not quite so high on the northeast side of the catchment, but an exception is the sample collected in Nant y Greolen [SH 994 243]. The immediate cause of the anomalies is monazite in two forms: flattened, oblate, grey spheroids and powdery coatings on detrital grains. As elsewhere, high values here cannot be related to any particular horizon and the source of the oblate spheroids and origin of the powdery coatings is uncertain. Anomalous levels of Pb_p and Ni_p frequently accompany the Ce anomalies and as elsewhere are attributed to analytical interference problems.

(iii) Minor sulphide mineralisation. Besides hydrous oxide precipitate and monazite nodule anomalies the sample collected at [SH 974 213] contains weakly anomalous Cu_p which mineralogical examination showed to be caused by chalcopyrite. A possible trial along a fault was found in the stream bank [SH 969 210] but no chalcopyrite or other mineralisation was found. To the northwest, in the Eunant, a quartz vein containing minor pyrite and chalcopyrite (Table 6, No. 18) was found in shales upstream of another weak Cu_p anomaly [SH 946 227]. Further Cu_p anomalies are located at several points to the north of here, particularly in the Afon Nadroedd (e.g. [SH 953 259]); these have not been investigated but on the available evidence weak quartz-chalcopyrite-pyrite mineralisation in the greywacke would appear to be a likely cause. A Cu_p anomaly, accompanied by high Sn_p, is also found in the Afon Cownwy [SH 992 184] but the mineralogy of the concentrate indicates that the anomaly is caused entirely by contamination.

(iv) High levels of arsenic in panned concentrate. High or weakly anomalous levels of As_p in the range 22–37 ppm are widely distributed across the south, north and west of the Vyrnwy catchment, from the Afon Cownwy on the southern limit of the survey area to the Afon Cedig in the north. Only two slightly higher values are recorded, 39 ppm at [SH 964 245] and 40 ppm at [SH 995 241]. The cause of the high levels and anomalies is unknown. Nearly all occur over the Wenlock greywacke succession and an As-bearing detrital mineral in the greywacke is, therefore, thought to be the most likely source.

(v) Anomalies of uncertain affinity. The water sample collected at the bottom of Nant Cwm-lloi [SH 953 260] gave a highly anomalous Zn (0.23 ppm) result, but repeat and additional upstream sampling failed to reproduce the anomaly. Follow-up sampling of another anomalous water sample (Zn 0.05 ppm, Pb 0.20 ppm), from the Afon Cedig [SH 986 265], failed to reproduce the Pb anomaly but showed the presence of high Zn_w (0.06 ppm) and Cu_w (0.04 ppm) in a tributary [SH 982 263] which ran through a gorge cut in weathered ferruginous siltstones. The analysis of a sample of the siltstone (Table 6, No. 22) showed no unusual features. The cause of these water anomalies and an isolated Pb_s and Cr_s anomaly near Llanwddyn [SJ 008 178] is uncertain. The Llanwddyn anomaly may be related to the outcrop of the Blaen-y-cwm Shale Formation phosphatic and pyritiferous rocks (Table 6, No. 23), or a NNW trending fault which may contain mineralisation exploited on the same structure 2 km to the south at Moel Achles [SJ 003 157].

14 *Anomalies in Afon Lleiriog attributed to contaminaation.* Two groups of base-metal anomalies are found in the catchment of Afon Lleiriog and both appear to be caused by contamination. Firstly, north of Pentre'r-felin [SJ 159 255] a large Cu, Pb and Sn anomaly in a panned concentrate from a tributary was shown by mineralogical work to be caused entirely by contaminants such as Cu and Pb metals and Pb glass. Downstream, weak Sn_p and Cu_s anomalies are attributed to dispersion from this anomaly. The cause of a weak water anomaly (Zn 0.04 ppm, Cu 0.02 ppm) in a tributary at [SJ 157 255] is, however, less certain; neither the sediment nor the concentrate taken at the site yielded anomalous results except for Pb_p and Ce_p.

The second small group of anomalies is centred on high and anomalous Cu, Sn, Pb and Ce in a concentrate collected at [SJ 154 289]. Again mineralogy indicated that Cu and Sn were held in contaminants. Anomalies for Cu and Sn in a nearby tributary [SJ 153 289] are also most likely to be caused by contamination.

15 *Base-metal anomalies in the Moelfre–Llansilin area.* Sample density in this area is low because of poor stream cover and contamination, but there are some indications of mineralisation. A panned concentrate collected from the stream draining Llyn Moelfre near Llansilin at [SJ 205 275] contains anomalous levels of Cu and Sn, which are caused by contamination and possible chalcopyrite. Above Llyn Moelfre water samples were collected, one of which contained weakly anomalous levels of Cu (0.02 ppm) and Zn (0.10 ppm). This anomaly may be related to an adit found on the hillside at Ceunant-du [SJ 172 284]. No records of mineral working are known from this area but a bulk rock sample from the working confirmed the presence of weak base-metal mineralisation (Table 6, No. 19).

High levels of base-metals in samples from sites in the Cynllaith and its tributaries to the northeast of Llansilin are all accompanied by high Sn and Ce and are therefore attributed to contamination and monazite nodules, though they have not been examined in detail.

16 *Intrusions southeat of Llansilin.* This area is very poorly covered by the survey because of inadequate surface drainage. Cu, Pb, Zn and Sn anomalies in panned concentrate at [SJ 248 245] can be related to a mixture of contamination, Cu mineralisation in the Moelydd intrusion, and Pb mineralisation in the Carboniferous limestone (Wedd and others, 1929). The former is probably the

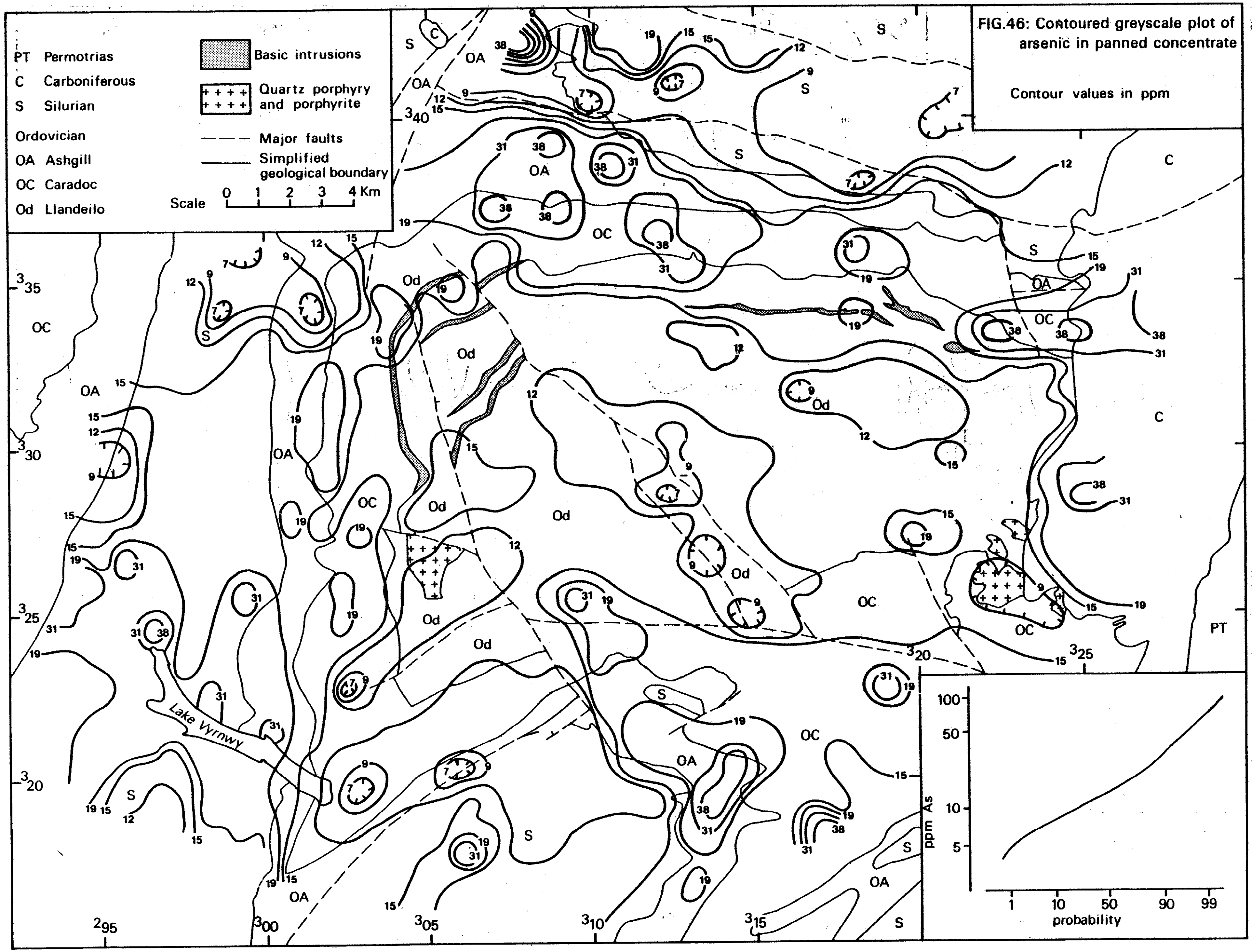


FIG.46: Contoured greyscale plot of arsenic in panned concentrate

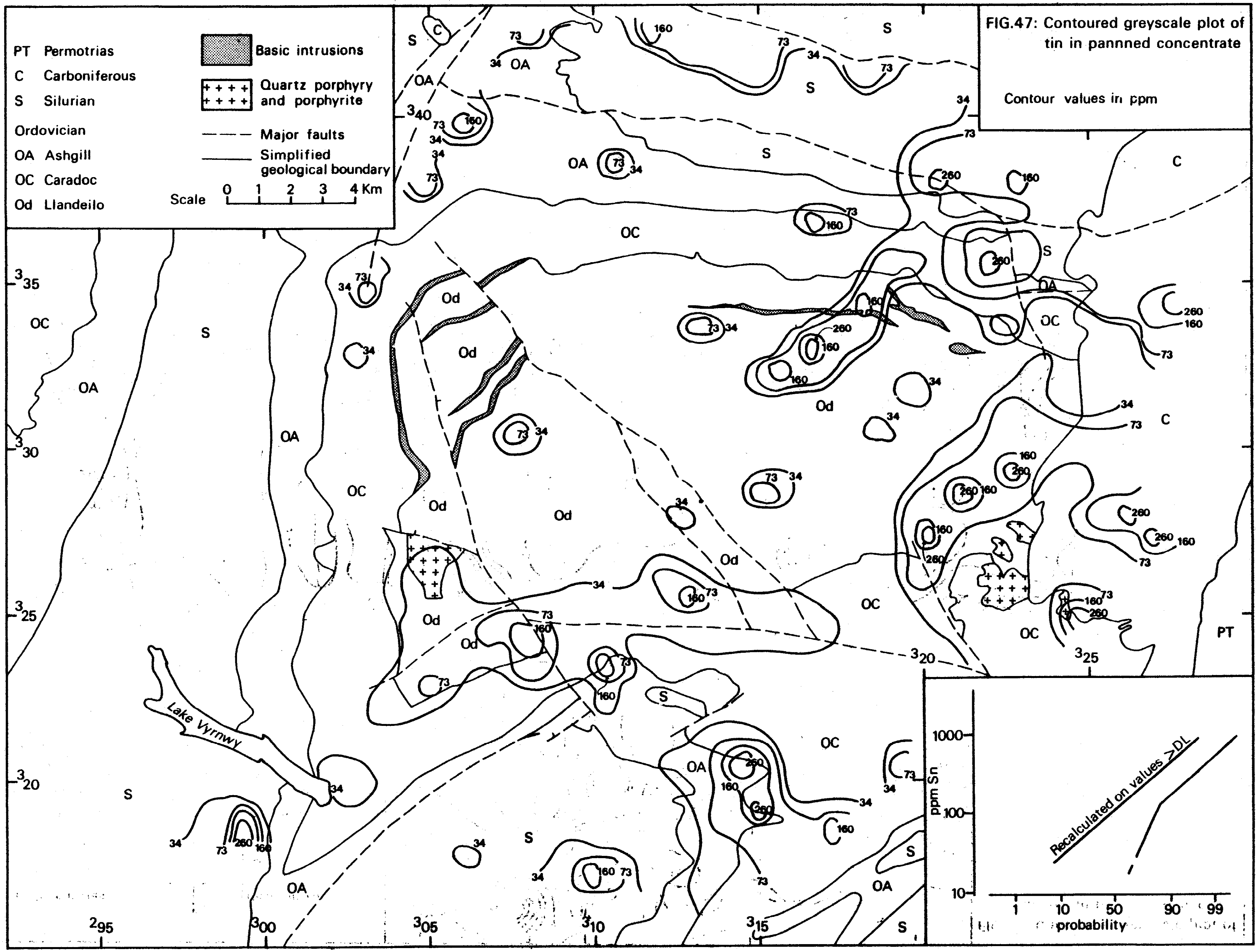


FIG.47: Contoured greyscale plot of tin in pannned concentrate

main contributor as a sample collected closer to the mineralisation [SJ 241 250] was not anomalous. The occurrence of copper mineralisation in the Moelydd intrusion prompted the water sampling of springs and streamlets in the area to improve sample cover, for work at Coed-y-brenin (Peachey, Cooper and Vickers, 1980) had indicated that water sampling could be an effective means of detecting extensive copper mineralisation in intermediate intrusions. No anomalous results were reported from this work, with the exception of a sample from [SJ 224 246] which was discoloured and contained suspended matter.

A brief visit to the Moelydd intrusion showed it to consist of a shattered brecciated and altered fine-grained rock of rather variable composition, perhaps representing a volcanic vent as suggested by Wedd and others (1929). A collapsed adit was found at [SJ 242 255] in apparently barren, brecciated, calcite and quartz veined igneous rocks. A sample from the small tips showed no base-metal enrichments when compared with average analyses of dioritic igneous rocks (Table 6, No. 20; Vinogradov, 1962). However, a block of brecciated intermediate intrusive found in the base of the track near the adit contained chalcopyrite in vugs and cavities and copper secondary minerals on joint surfaces. No gangue minerals accompanied the sulphide, and analysis (Table 6, No. 21) indicated that copper was the only metal enriched. The stream sediment and water sampling results suggest that mineralisation is very localised and does not involve extensive development of sulphides as might be found about a porphyry deposit. Detailed geochemical and geophysical work perhaps followed by drilling would be required to investigate this mineralisation further for, if the Moelydd intrusion does represent a vent deposit, any sulphide mineralisation may be in a steeply plunging pipe-like body.

17 *Dark shales near Llanfechain.* A panned concentrate collected from Nant Pen-y-groes near Llanfechain [SJ 193 227] over undifferentiated Caradocian sedimentary rocks contains anomalous levels of Cu, Zn, Fe, Sn and As. Mo, is also anomalous. Pyrite was noted in the pan and dark shales in the stream. None of the metal levels is very high and the cause is believed to be pyritiferous shales.

18 *Anomalies over Carboniferous Rocks.* The base of the Carboniferous formed the margin of the survey area but a few samples were collected over the Carboniferous. Anomalous results appear to fall into two groups, those in the River Morda catchment southwest of Oswestry and those along the Morlas Brook near Selattyn. This distribution is unreal and generated by incomplete sampling. Samples collected in the Morda catchment contain anomalous levels of Cu, Pb, Zn, Ni, Sn and Fe in panned concentrate, which mineralogical study of the samples from [SJ 273 277] and [SJ 256 283] showed to be caused entirely by contamination. Ba_p anomalies in the same samples are caused by baryte. A visit to the stream section above the most anomalous site [SJ 256 283] failed to clarify the source of the baryte; some was probably derived from veined Carboniferous limestone aggregate used in a ford, but a weaker anomaly persists above this source and it is possible that there is baryte mineralisation in the bedrock hereabouts.

Mineralogical examination of panned concentrates collected in Morlas Brook at [SJ 282 348], [SJ 273 344], [SJ 261 347] and [SJ 246 347] suggests that all the anomalies are caused by contamination. An interesting feature of the first of these samples, collected over Coal Measures, is the presence of a high level of Ce_p (2400 ppm) present as coatings of monazite in the light fraction, whilst all the samples collected upstream over older rocks have much lower Ce_p contents (<1000 ppm).

The known mineralisation in the Carboniferous did not register in the survey results because of poor surface drainage cover and incomplete sampling.

CONCLUSIONS AND RECOMMENDATIONS

1 The drainage survey recorded a large number of anomalies in the area, but these did not form coherent groups. They were in general weak, scattered, and involved a wide range of element groupings, suggesting several causes. No single feature was dominant and no major group of anomalies was detected which could be related to significant hitherto undiscovered mineralisation.

2 Some areas were not effectively covered by the drainage survey, notably the area around Llangynog where contamination from known base-metal mineralisation effectively masked any other mineralisation of broadly similar type. Coverage of the eastern part of the area was also unsatisfactory. Here lack of surface drainage and contamination were the problems and in the area south of Llansilin even substantial mineralisation at surface could have escaped detection.

3 As little follow-up work was carried out and there are so many potential causes for the drainage anomalies, the sources of many of them remains uncertain. Although no anomaly is considered an outstanding prospect, several deserve limited further investigation. These are:

- i Gold anomalies in the Afon Trystion.
- ii Baryte mineralisation, possibly accompanied by base metals, in association with Caradocian volcanic rocks or phosphatic rocks at several localities, such as Carn Rhiwarth and around Llanfyllin.
- iii Base-metal mineralisation in Llandeilian limestones and volcanics north of Llanrhaeadr, where there is some evidence of past mineral workings.
- iv Copper mineralisation in the intrusions southeast of Llansilin, particularly that at Moelydd.
- v Base-metal vein mineralisation south of Corwen and, possibly, west of Llansilin.
- vi Baryte mineralisation in the Carboniferous.

4 The observed gravity and magnetic results have little obvious relationship to the surface geology but can mostly be interpreted in terms of basement elevation, with a high density magnetic Lower Cambrian or Precambrian basement (perhaps similar to the Bryn Teg Volcanic Formation in the Harlech Dome) at a depth of 3–4 km. This interpretation implies thinning of the Cambrian across the Bala–Bryneglwys Fault and the presence of acid igneous rocks within the Lower Palaeozoic.

5 A SSW trending gradient in the Bouguer gravity anomaly field, coincident in the north with the Bryneglwys Fault, suggests the presence of a deep major fault. Basement elevation or sediment facies changes are the most likely causes of the gradient. If this fault was active in Lower Palaeozoic times it may have exerted control on sediment deposition, forming an active eastern margin to the Welsh Basin (Montgomery Trough) in this area.

6 There is no evidence for a large granitic body in Lower Palaeozoic rocks underlying the Berwyn Hills

which could be responsible for the mineralisation at Llangynog. The relationship, if any, of the known mineralisation to the Bouguer anomalies remains obscure. More detailed gravity surveys of specific Bouguer anomaly features, such as those near Craig-y-Glyn [SJ 10 30] and the low northwest of Llangynog [SJ 03 28], are required to determine their cause and possible relationships to nearby mineralisation.

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APPENDIX 1 Metal mines and trials in the Berwyn Dome and its environs

Name *Other possible names*	Area	Grid reference	Metals
Bwlch Creolen	Pen-y-garnedd	SJ 089 232	Pb, (Ba)
Cefn-briw	Llandrinio	SJ 252 182	Fe
Craig Ddu	Hirnant	SJ 062 240	Pb, (Ba)
Craig Rhiwarth *Ochr-y-graig* *?North Llangynog*	Llangynog	SJ 054 266 ?SJ 053 273	Pb, Zn, (Ba)
Craig-y-mwn	Cwm Rhaeadr	SJ 078 288	Pb, Zn, Ag, ?Cu, (Ba)
Craig-yr-arian	Llangynog	SJ 023 245	?
Cwm Orog	Llangynog	SJ 050 273	Pb, Zn, Ag, (Ba)
Cwm Llanafon	Llangynog	SJ 066 273	Pb, Zn
Galltymain *Alltymain*	Meifod	SJ 164 147	?Pb, (Ba)
Hirnant *Clochnant* *Bryn Coch*	Hirnant	SJ 044 230	Pb, (Ba)
Llangynog *Chirk Castle* Pengwern	Llangynog	SJ 054 256	Pb, Zn, Cu (Ba)
Llanymynech *Carreg Hofa* *Carreg Nova*	Llynclys	SJ 265 219	Pb, Cu, Zn
Moel Achles	Llangynog	SJ 003 157	?Pb
Mynydd Blaen-y-glyn	Llanrhaeadr	SJ 124 284	Pb
Nant-y-blaidd	Cwm Rhaeadr	SJ 090 282	Pb, Cu, ?Au
Ogof	Llynclys	SJ 266 223	Pb, Zn, Cu
Tyn-y-llwyn	Llanrhaeadr	SJ 093 280	?Pb
Unknown	Corwen	SJ 101 428	?Pb, Zn
Unknown *?Rhysnant*	Llandrinio	SJ 257 175	Fe, ?Cu
Unknown	Llangynog	SJ 061 273	Pb, Zn, (Ba)
Unknown	Llangynog	SJ 082 240	?
Unknown *?Craig-y-glyn*	Llanrhaeadr	SJ 122 290 SJ 121 288	Pb, Zn
Unknown *?Pen-y-graig*	Llanrhaeadr	SJ 125 287	?Pb, Zn
Unknown *? Ceunant-du*	Llansilin	SJ 172 284	?
Unknown *?Moelydd*	Llanyblodwel	SJ 242 255	Cu
Unknown *?Moelydd*	Llanyblodwel	SJ 245 252	?Pb
Unknown	Llynclys	SJ 272 232	?
Unknown	Llynclys	SJ 272 239	?Pb

APPENDIX 2 Phosphate workings in the Berwyn Dome

Name *Alternative names*	Area	Grid reference	Metals
Berwyn *Blaen Rhiwarth* *?Craig Rhiwarth*	Berwyn	SJ 014 295	P, Ba
Cwmgwynen	Llanfyllin	SJ 083 221	P, Ba
Greenhall Park *Green Park*	Llanfyllin	SJ 157 189	P
Pennant *Blaen-y-cwm*	Llangynog	SJ 014 266	P, Ba
Pwll-y-wrach	Pen-y-garnedd	SJ 070 212	P, Fe
Tyn-y-twll	Llanfyllin	SJ 131 210	P
Unknown	Pen-y-garnedd	SJ 106 241	?P
Unknown (?Pen-y-garnedd)	Pen-y-garnedd	SJ 109 238	P, Ba
Unknown (?Bwlch Croelen)	Pen-y-garnedd	SJ 092 229	P, Ba, (?Pb, Zn)
Unknown	Llanfyllin	SJ 146 176	P
Unknown	Llangynog	SJ 017 258	P

APPENDIX 3

REGIONAL GEOCHEMICAL TRENDS RELATED TO LITHOSTRATIGRAPHY

Lithostratigraphic variation is the major source of regional geochemical variation within the dataset, but precise discrimination of rock units was not the main aim of the survey and this gave rise to several problems that limited a full regional study. However, an interpretation of regional trends was attempted, partly to establish background levels over different lithologies to aid anomaly interpretation, and partly to provide some additional information on the geology which is still poorly known in some areas.

For studying regional variation trends, computer-generated, moving-average greyscale maps were used. These were hand-contoured over a geological base with contour intervals set on a percentile basis at the 5, 10, 30, 50, 70, 90 and 95% levels. The maps were produced at a scale of 1:150 000; at this scale each greyscale cell covers 0.24 km^2 and the moving average contains 9 cells (Figures 26–47).

The main problem which hindered interpretation was the uneven sample distribution. Several lithologies, such as the porphyrite intrusions, were not effectively represented by any group of samples because of inadequate surface drainage. A second, related problem is that as a result of the geological structure several lithologies form long, thin, sinuous outcrops, crossed at right angles by streams. As a consequence, many samples contain material from several contrasting lithologies and do not characterise a particular rock type. The problem is aggrevated by the dispersion of rock material in the extensive glacial deposits. Only the Llandeilo and parts of the Caradocian and Wenlock outcrop over large areas covering entire catchments. A third problem is that because geochemical mapping was not the principal aim of the survey several elements useful in this respect, such as boron, were not determined. In contrast, many of the elements determined are strongly influenced by other sources of variation, such as hydrous oxide precipitates, mineralisation and contamination, and it was found that of the elements determined only those little affected by these processes, such as zirconium, were useful indicators of lithological change. Finally, basic geological descriptions of some rocks, particularly the Silurian and intrusives, are old or incomplete which reduces the interpretation of the geochemical data to speculation in some areas. In spite of these problems, however, examination of the contoured plots (Figures 26–47) does show a number of features of interest.

Sedimentary rocks of Llandeilo age are clearly defined by relatively low levels of Zr_s and Mo_s, and high Ni, Mn and Ti in panned concentrates and Cu_s. Fe_p is also high, except over the outcrop of the lower horizons (Gwern-feifod to Craig-y-glyn rocks) where As in panned concentrate levels are particularly low. Ba_s levels appear to be low, particularly over the higher beds, whilst in the area west of Llanarmon Dyffryn Ceiriog levels of V, Cr, Cu and Co in sediment appear particularly high, even when enhancement caused by secondary precipitation is taken into account. Available descriptions of the Llandeilo provide no explanation for these concentrations. The chemistry suggests that the Mynydd-tarw Group, which contains intercalations of sandstone and grit in the east, is dominated by dark mudstone (perhaps containing tuffaceous horizons) in the northwest.

The main outcrops of the Caradoc show a high background for the majority of elements determined because of the combination of volcanic rocks, mudstones and siltstones. Dolerite intrusions also contribute to the high levels of transition group metals, for these, together with the volcanics, cannot be readily discriminated at this scale because of their sinuous outcrop. Pb_p and Cu_s are the only variables to show low levels over Caradocian rocks and the Pb_p pattern is irregular and confused by other sources of variation. Ni_p yields low levels in the north and south, whilst high levels in the west may be generated by basic intrusions rather than Caradocian sediments and volcanics. South of the Tanat Valley Caradocian rocks contain no mapped volcanics and, in contrast to the northern outcrops, show low levels of Mn_p and Ni_p and Zn_s which may be attributed to this difference. Facies changes in Caradocian sedimentary rocks across the area are effectively masked by the strong chemical features of the volcanics and dolerite intrusions.

The dark shale sequence (Nod Glas) at the top of the Caradoc, underlain in the west and south of the area by a limestone and containing one or more phosphatic bands, is characterised by high levels of a variety of elements, some of which enable it to be distinguished from the underlying sequence. The clearest features are high levels of Ba_s and more erratically Ba_p, reflecting the presence of associated baryte veins. Less predictably Cu and Cr in sediment and Cu_p show distinct lows over the upper Caradoc except in the south around Llanfyllin. The reasons for these lows is presumably that the Nod Glas rocks do not show the metal enrichments normally associated with black shales (Cave, 1965).

The base of the Ashgill is marked by an unconformity in this area (Cave, 1965; Brenchley, 1978) which in terms of regional geochemistry is the single most important feature in the Lower Palaeozoic sedimentary sequence in this area. It coincides with the change from rocks dominated by high levels of first series transition metals and other elements concentrated in basic igneous rocks and mudstones, to lower levels of these elements and higher levels of the few elements determined which are concentrated in arenaceous rocks.

Rocks of Ashgill age are characterised in general by low levels of Cu_s and high As_p. Mn_p also tends to be low. Several variables, such as Fe_p, Zn_p and Cr_s, show apparent changes along strike, with high levels in the northern outcrops near Corwen and low levels in the west, near Lake Vyrnwy, which may be caused by lateral facies changes in rocks of this age across the area.

The outcrop of Llandovery strata is too thin and intermittent for any chemical features to be readily identified, though it must be broadly similar to the surrounding rocks for any great contrast would be expected to show. The overlying Wenlock strata occupy distinct areas in the north, west and south, each of which show distinct chemical features. This is to be expected as according to Cummins (1957, 1969) the Wenlock age rocks in the west of the area are dominated by outcrops of greywackes (Denbigh Grits) whilst in an eastward direction the margin of the subsiding basin is crossed and sedimentary rocks of the same age consist of a relatively thin sequence of siltstones and mudstones. These conditions apparently persisted until Ludlow times, though the position of the trough margin changed. The western outcrops, dominated by Denbigh Grits, are characterised by low levels of the majority of elements determined. Zn_s and Zn_p levels contrast particularly clearly with other lithologies. Some elements show variation along the outcrop which may be generated by secondary environmental factors but variation in others, which are normally little affected by these processes, suggest that there may be a change in the grit facies in a north–south direction (along the Montgomery trough of Cummins). For instance, Cu_p and As_p decrease whilst Cu_s increases northwards. Three variables, Ba_p, Ti_p and V_s, show a zone of high values along the western base of the Silurian for reasons which are uncertain. The northern and southern outcrops of Silurian rocks which are apparently dominated by outcrops of Ludlow Grits and Nant Glyn Flags respectively (Cummins, 1958) contain similar levels of the majority of elements but Zn_p which is high and As_p which is low in the north show a distinct contrast.

The porphyrite intrusions and acid to intermediate volcanic rocks may generate high levels of Ba_s and Zr_s but their outcrop area is small and coverage is insufficient to be certain.

Discrimination of Carboniferous rocks is hampered by the small number of samples and high degree of contamination, but the Carboniferous Limestone and younger rocks as a whole shows a strong contrast to the adjacent Lower Palaoezoic rocks, with low levels of Fe, Ni and V and high levels of Zr, Cr and Zn in stream sediment and low Ti_p. Zr_s appears to be particularly high over the Namurian and Coal Measures, where As_p is also very high.

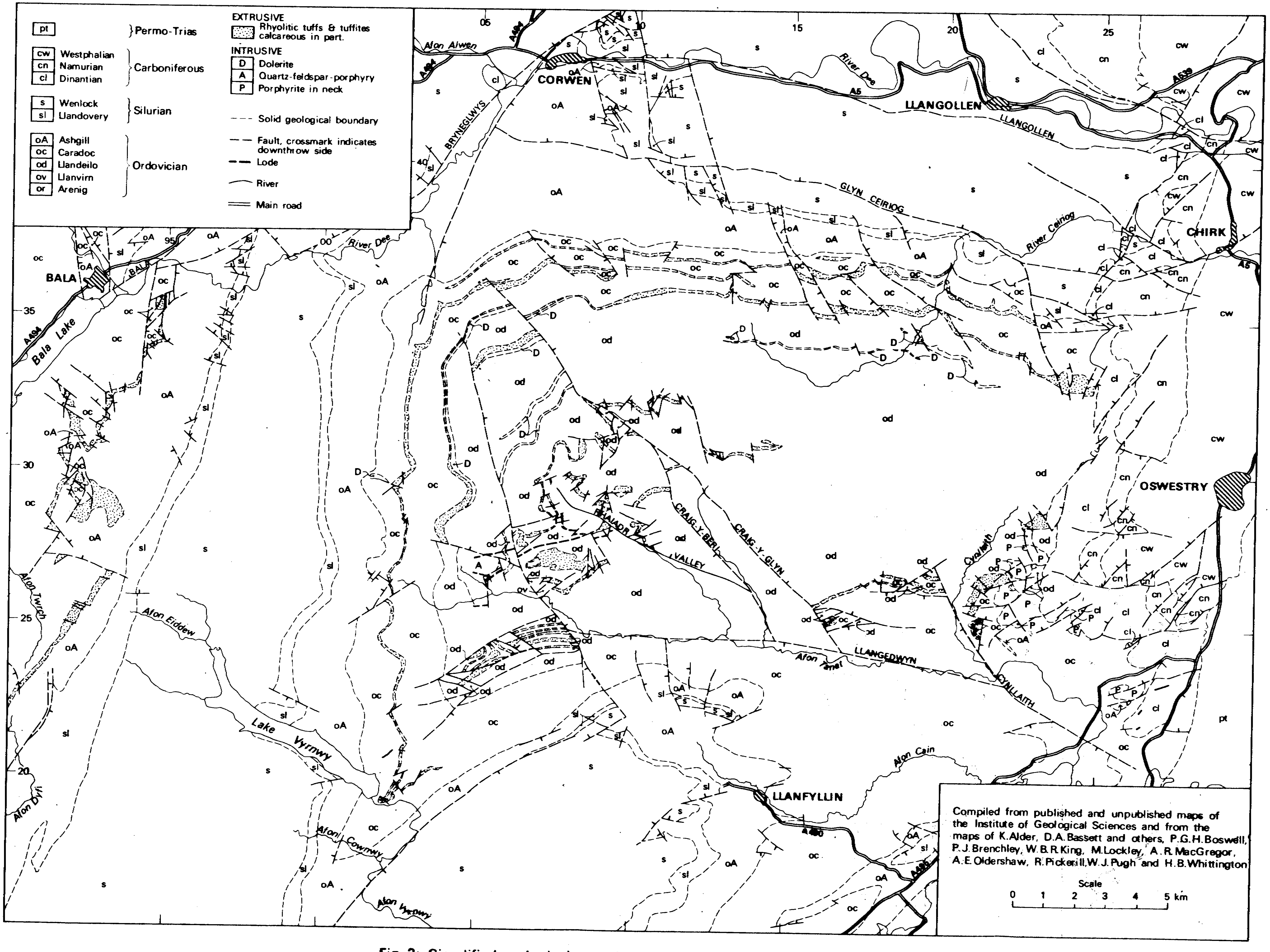


Fig. 2: Simplified geological map of the Berwyn Dome and adjacent areas

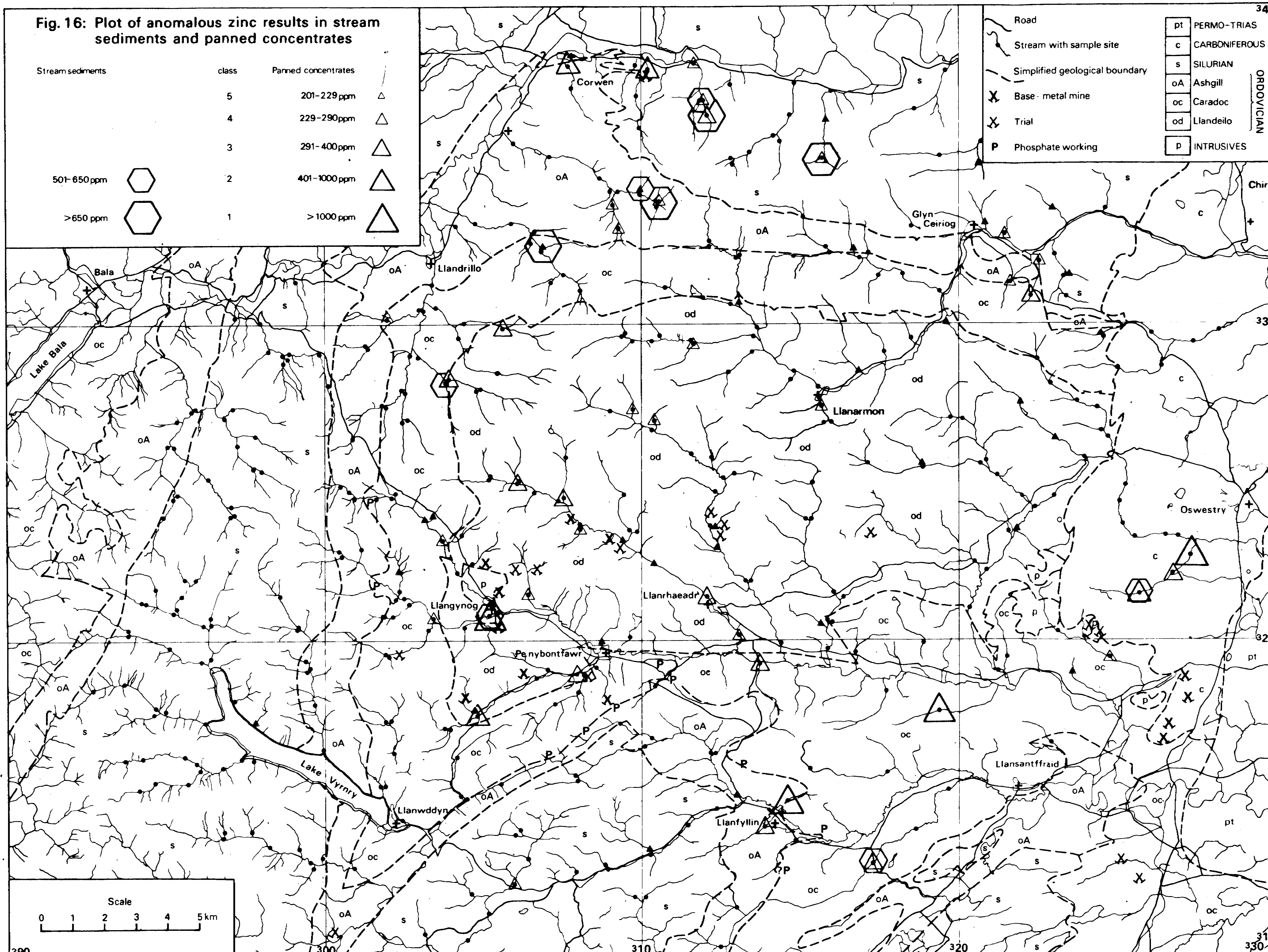


Fig. 16: Plot of anomalous zinc results in stream sediments and panned concentrates

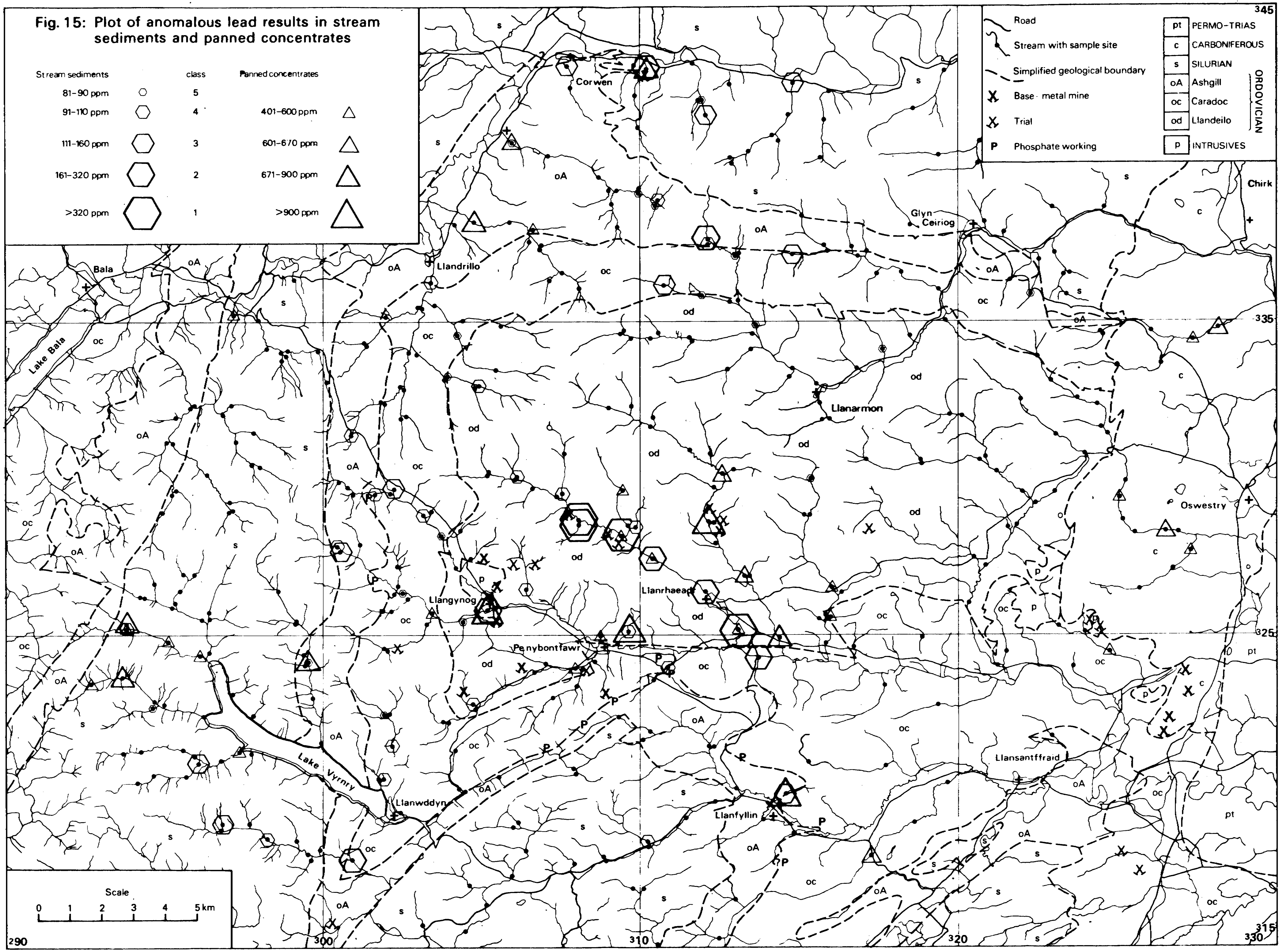


Fig. 15: Plot of anomalous lead results in stream sediments and panned concentrates

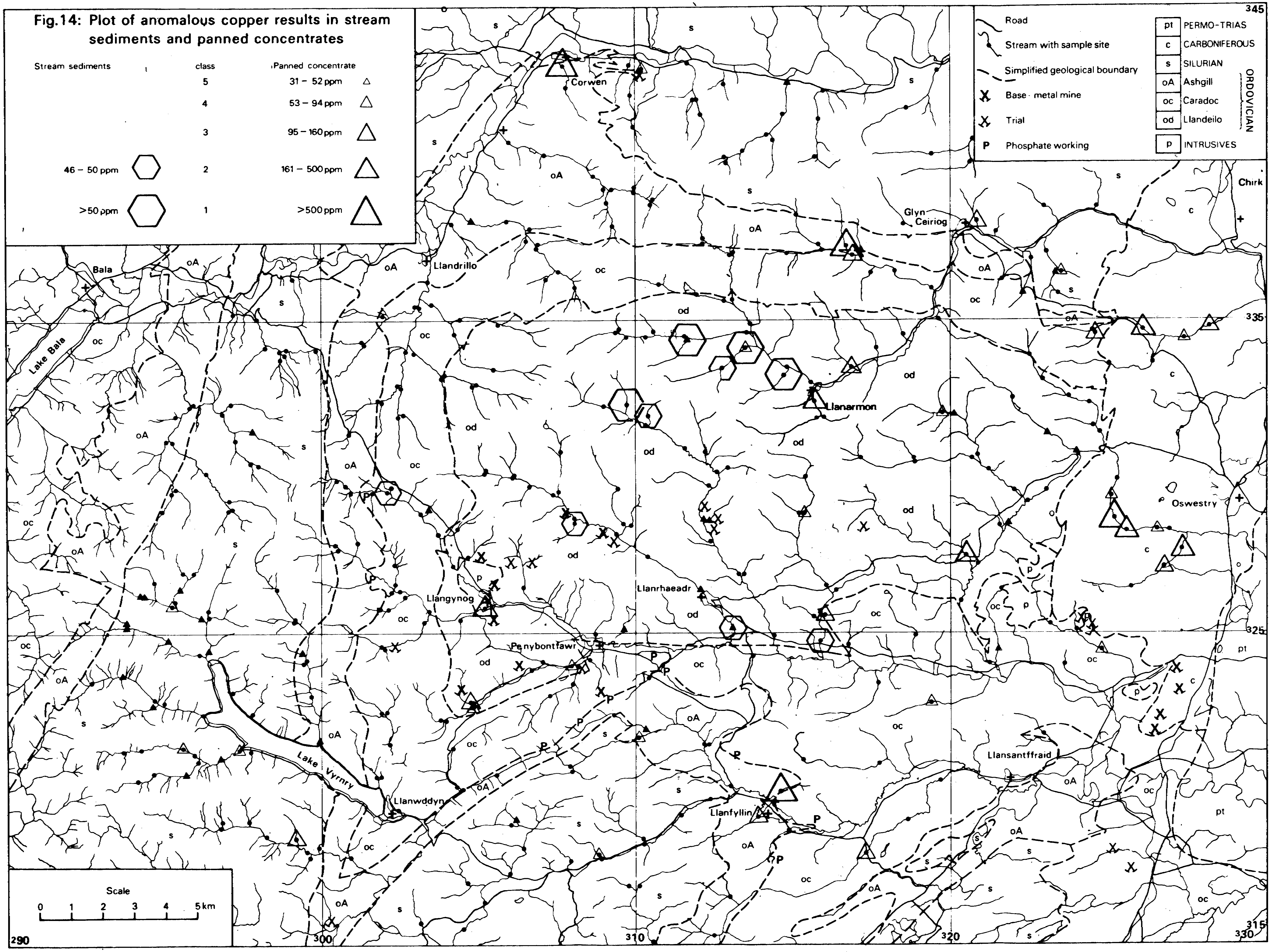


Fig.14: Plot of anomalous copper results in stream sediments and panned concentrates

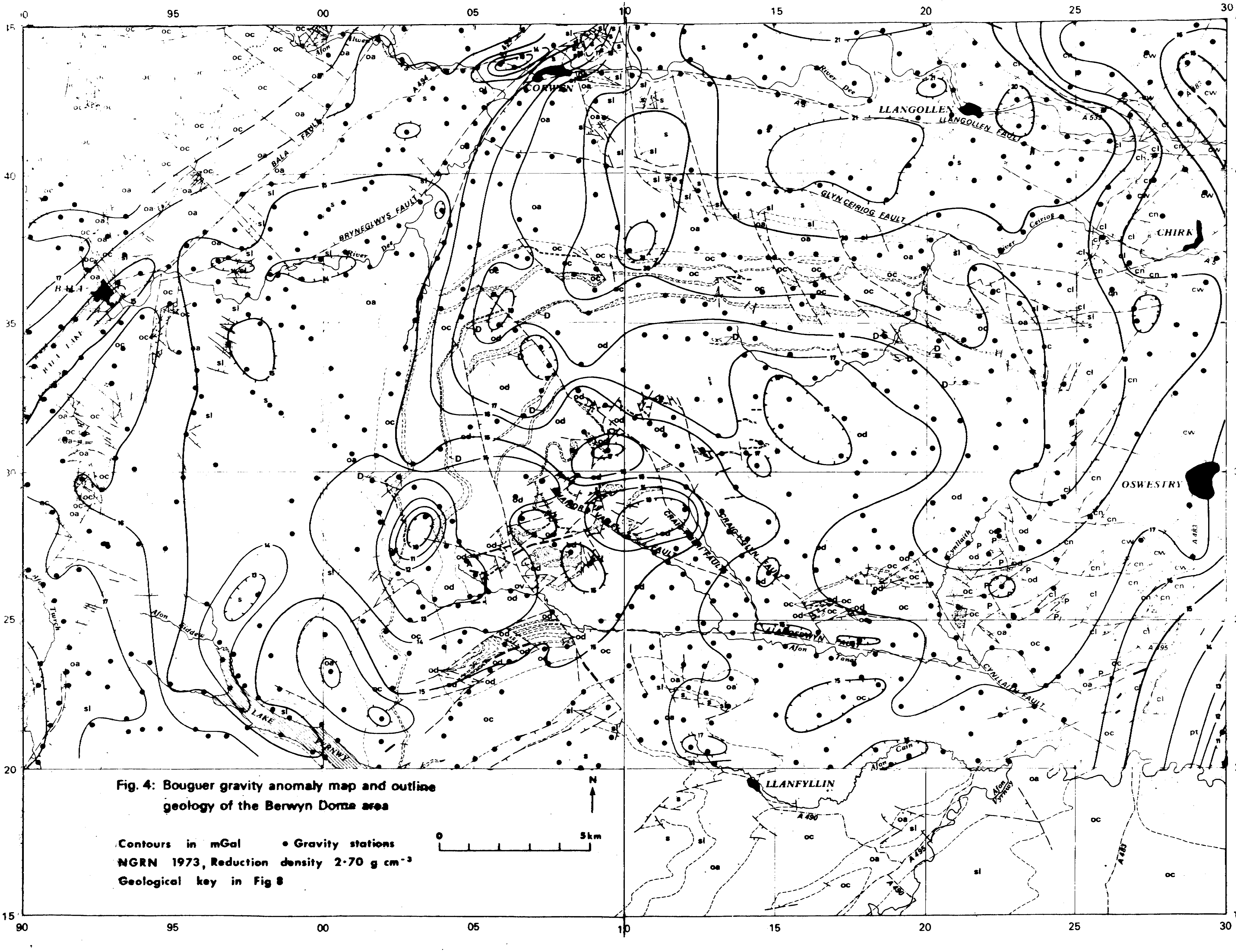


Fig. 4: Bouguer gravity anomaly map and outline geology of the Berwyn Dome area

Contours in mGal • Gravity stations

NGRN 1973, Reduction density 2·70 g cm^{-3}

Geological key in Fig 8

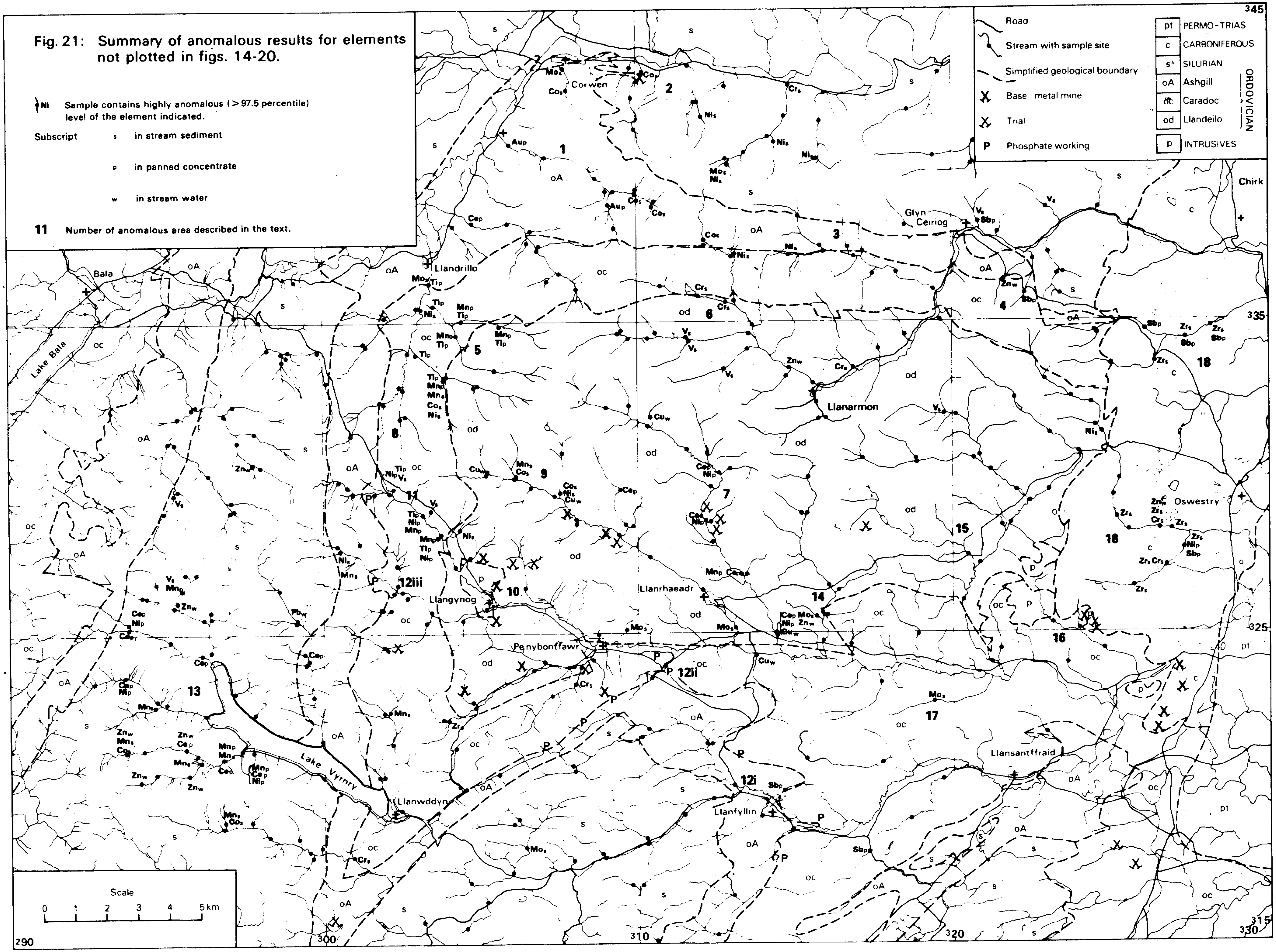


Fig. 21: Summary of anomalous results for elements not plotted in figs. 14-20.

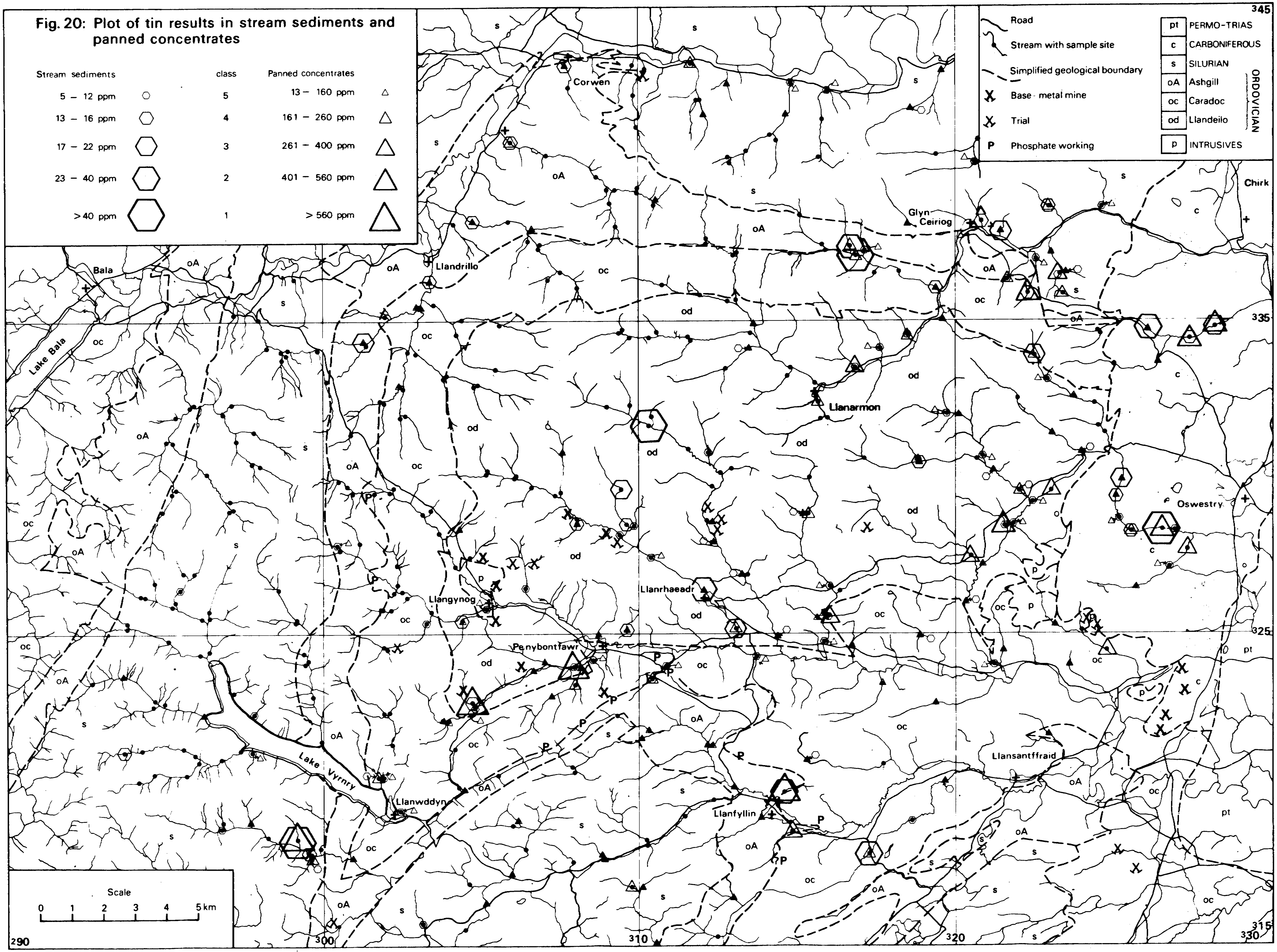


Fig. 20: Plot of tin results in stream sediments and panned concentrates

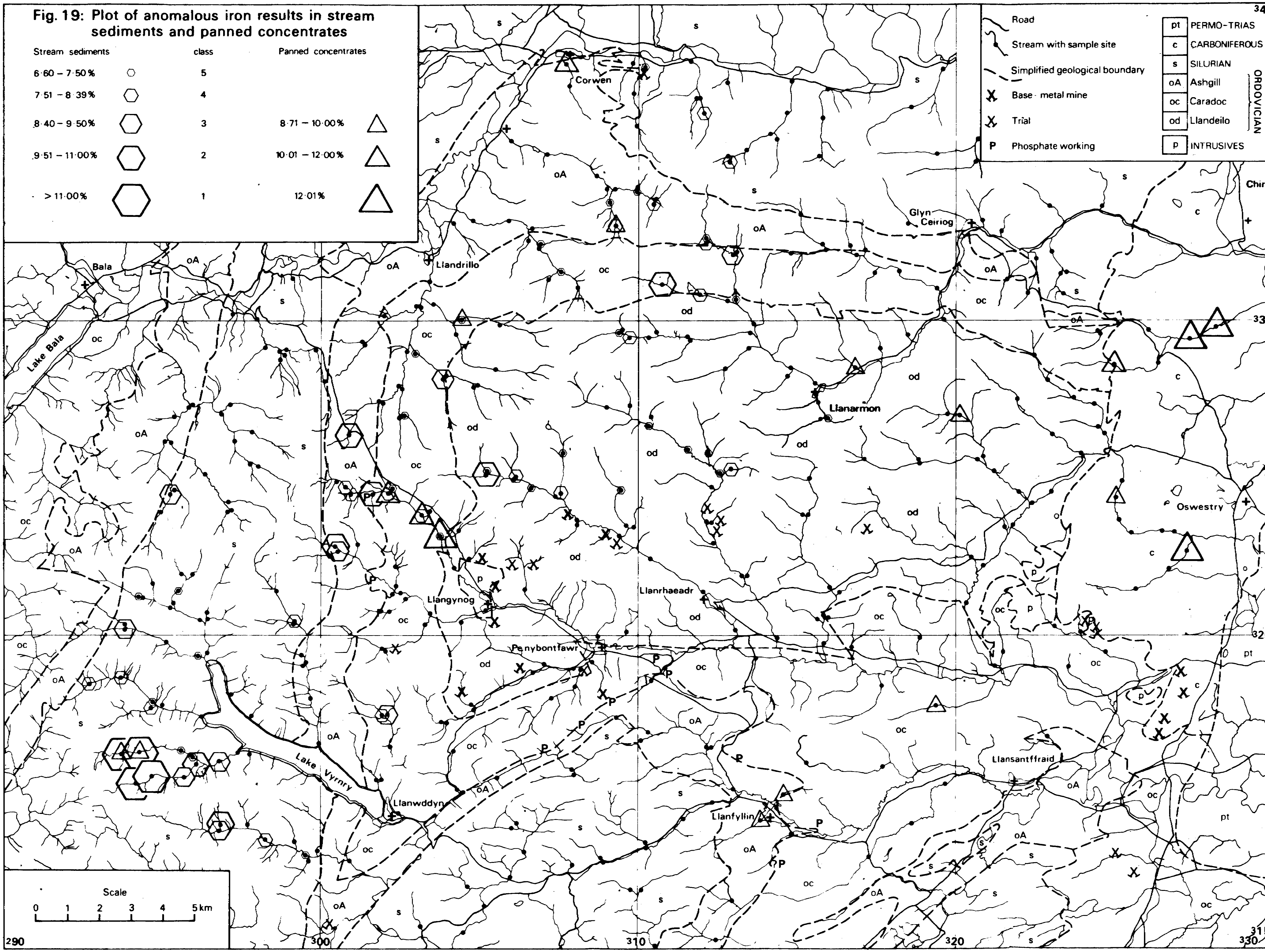


Fig. 19: Plot of anomalous iron results in stream sediments and panned concentrates

Fig.18: Plot of anomalous arsenic results in panned concentrates

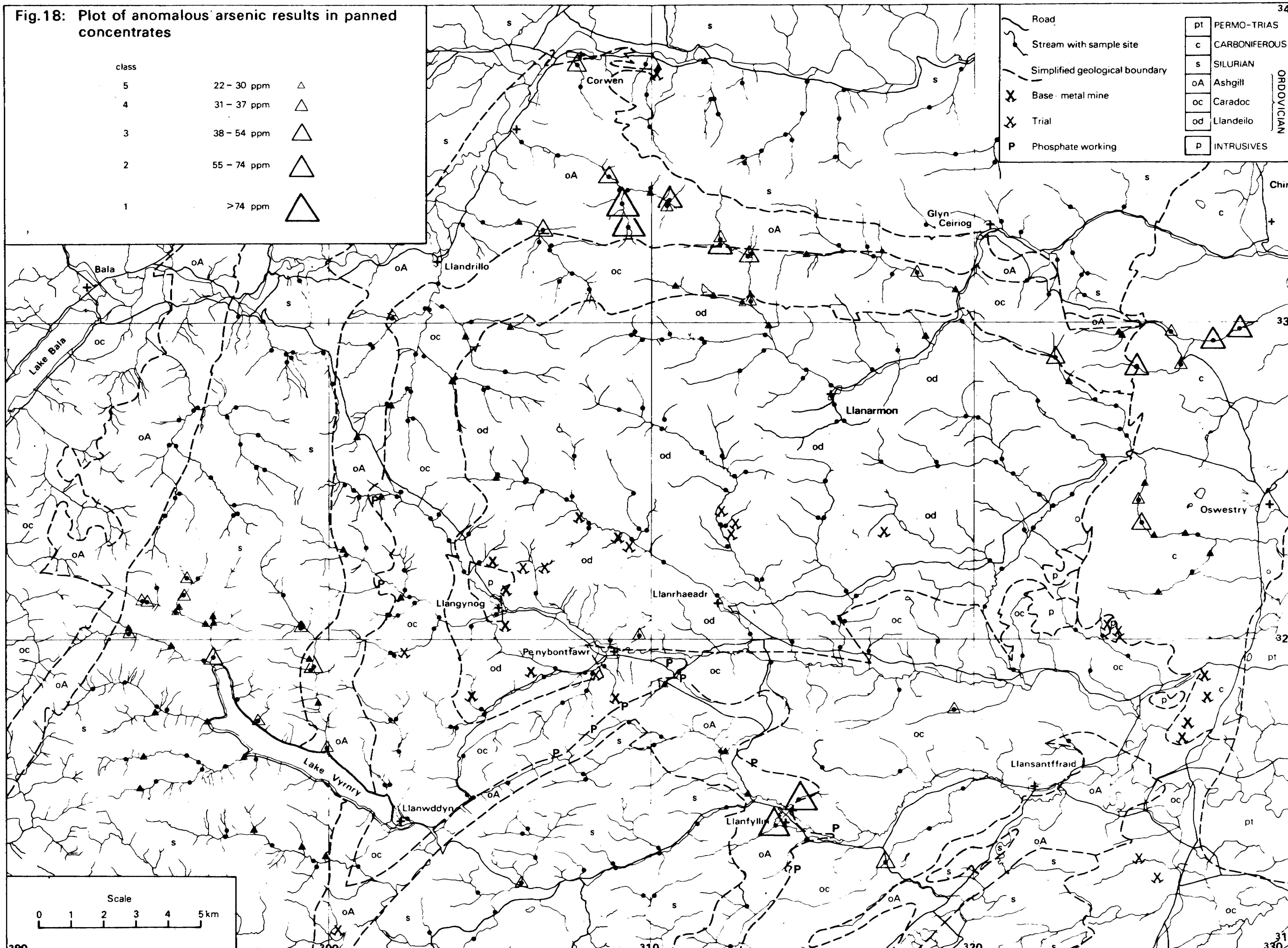
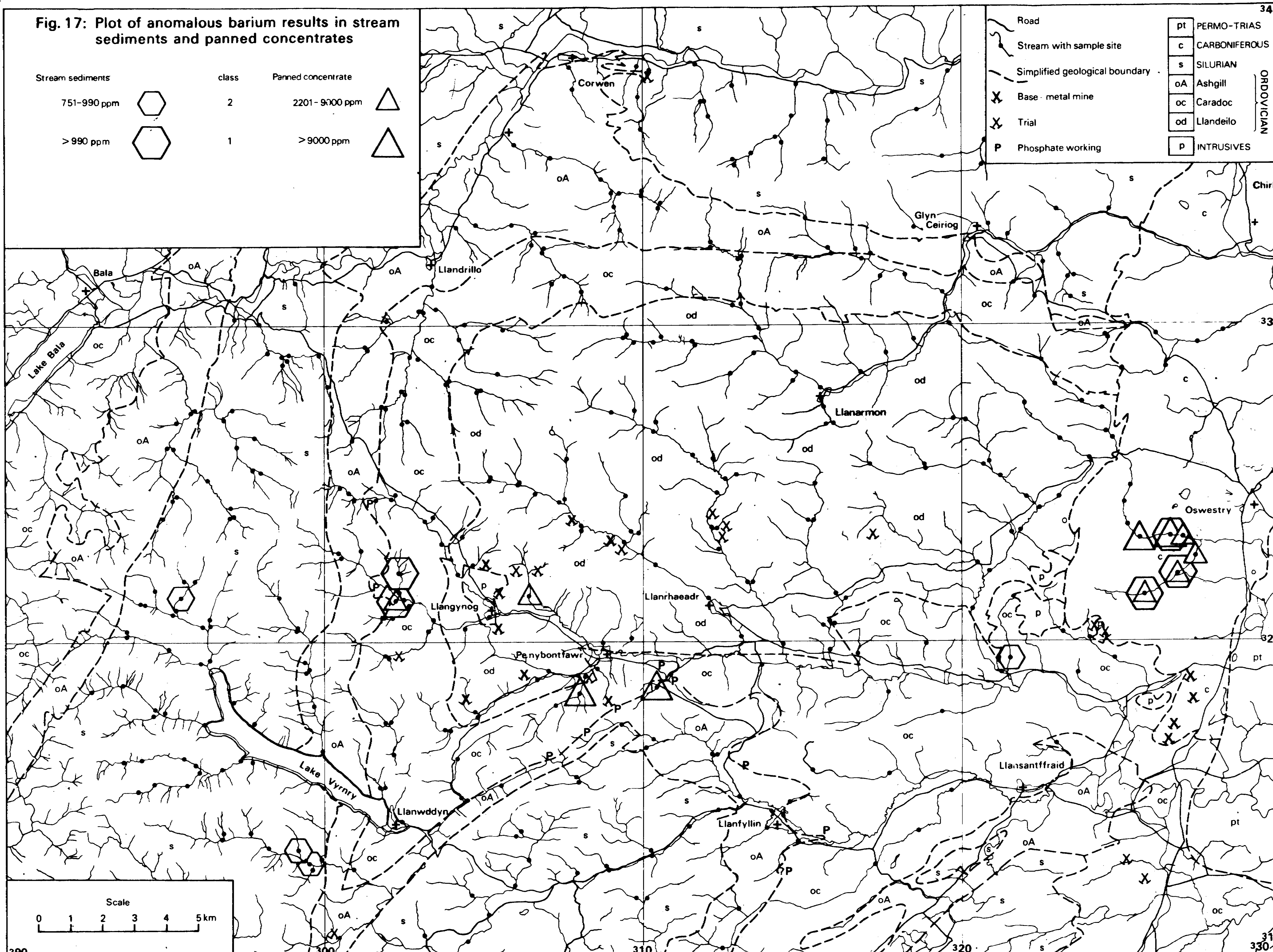


Fig. 17: Plot of anomalous barium results in stream sediments and panned concentrates



DATA DESCRIPTION
....

FILE TITLE :WN902010 BERWYN DOME DRAINAGE DATA

NO. OF FIELDS : 33 NO. OF RECORDS : 400 WORDS PER RECORD : 30

CARD INPUT FORMAT

	SAMPNUMB	EASTING	NORTHING	CU SED	PB SED	ZN SED	BA SED	FE SED	MN SED	CO SED
FIELD LENGTH	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **
FIELD TYPE	F	F	F	F	F	F	F	F	F	F
UPPER LIMIT	1617.	32819.	34322.	110.	600.	800.	1663.	19.778	7.271	447.
LOWER LIMIT	1001.	29270.	30000.	10.	20.	70.	92.	2.695	0.030	7.
ABSENT DATA VALUE	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.000	-1.000	-1.

DICTIONARY SEGMENT

	SAMPNUMB	ZN WATER	CU PAN	PB PAN	ZN PAN	BA PAN	FE PAN	MN PAN	CE PAN	SN PAN
FIELD LENGTH	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **
FIELD TYPE	F	F	F	F	F	F	F	F	F	F
UPPER LIMIT	1617.	0.23	1329.	5436.	4935.	137728.	19.48	0.587	20000.	4270.
LOWER LIMIT	1001.	0.0	5.	0.	42.	28.	2.26	0.023	89.	0.
ABSENT DATA VALUE	-1.	-1.00	-1.	-1.	-1.	-1.	-1.00	-1.000	-1.	-1.

DICTIONARY SEGMENT

	SAMPNUMB	TI PAN	KI PAN	AS PAN	V SED	CR SED	NI SED	ZR SED	MO SED	SN SED
FIELD LENGTH	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **	1 ** **
FIELD TYPE	F	F	F	F	F	F	F	F	F	F
UPPER LIMIT	1617.	6.061	211.	113.	183.	313.	401.	1735.	5.	54.
LOWER LIMIT	1001.	0.158	7.	12.	51.	24.	22.	87.	0.	0.
ABSENT DATA VALUE	-1.	-1.000	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.

DICTIONARY SEGMENT

WN902010 BERWYN DOME DRAINAGE DATA

SAMPNUMB	EASTING	NORTHING	CU SED	PB SED	ZN SED	BA SED	FE SED	MN SED	CO SED
1001.	29624.	32241.	20.	60.	190.	241.	6.040	0.822	95.
1002.	29740.	32134.	75.	60.	150.	406.	6.412	1.430	91.
1003.	30186.	32034.	10.	40.	120.	495.	4.772	0.183	26.
1004.	30180.	32071.	25.	100.	170.	526.	5.225	0.316	42.
1005.	29995.	32158.	25.	50.	170.	368.	5.560	0.403	62.
1006.	29468.	32665.	15.	40.	120.	534.	5.649	0.272	45.
1007.	29438.	32621.	25.	50.	150.	465.	6.243	0.491	61.
1008.	29532.	32602.	25.	50.	110.	746.	5.507	0.312	63.
1009.	29532.	32591.	20.	50.	130.	434.	5.757	0.559	71.
1010.	29667.	31872.	10.	50.	90.	579.	9.024	0.385	52.
1011.	29684.	31880.	20.	120.	300.	627.	10.820	7.271	439.
1012.	29770.	31898.	15.	60.	260.	708.	6.540	1.244	101.
1013.	29828.	31844.	15.	100.	210.	561.	7.912	2.268	235.
1014.	29922.	31842.	25.	70.	190.	759.	5.913	0.404	44.
1015.	29964.	31793.	20.	80.	160.	726.	5.356	0.707	51.
1016.	29946.	31798.	15.	50.	180.	851.	7.058	1.467	84.
1017.	30086.	31787.	20.	170.	180.	743.	5.405	0.410	53.
1018.	29612.	32557.	25.	50.	120.	540.	5.596	0.369	55.
1019.	29270.	32346.	15.	60.	130.	491.	7.927	0.971	135.
1020.	29367.	32367.	20.	50.	120.	430.	7.627	0.915	122.
1021.	29468.	32288.	20.	70.	220.	568.	7.408	1.811	177.
1022.	29464.	32272.	30.	90.	200.	489.	7.879	3.256	119.
1023.	29421.	32130.	15.	40.	140.	216.	11.279	0.842	67.
1024.	29455.	32053.	15.	70.	80.	191.	12.285	0.798	79.
1025.	29638.	32558.	20.	70.	240.	287.	4.537	0.079	20.
1026.	30386.	32226.	20.	70.	230.	308.	5.448	0.421	45.
1027.	29644.	32555.	30.	60.	100.	291.	5.323	0.241	74.
1028.	29641.	32450.	25.	60.	110.	199.	4.488	0.128	19.
1029.	30476.	32279.	25.	100.	200.	293.	5.799	0.435	56.
1030.	29498.	32896.	35.	90.	160.	296.	5.546	0.886	97.
1031.	29530.	32972.	25.	80.	130.	199.	8.823	0.526	67.
1032.	29578.	32974.	40.	60.	140.	282.	5.155	0.157	22.
1033.	29530.	33115.	30.	60.	120.	260.	4.882	0.155	20.
1034.	29515.	33120.	30.	50.	150.	317.	5.244	0.088	16.
1035.	29584.	33231.	25.	60.	140.	315.	5.774	0.119	25.
1036.	29592.	33232.	30.	50.	160.	384.	4.407	0.191	30.
1037.	33481.	32263.	25.	60.	250.	203.	4.856	0.232	27.
1038.	30666.	32382.	25.	60.	190.	258.	5.812	0.288	31.
1039.	30703.	32411.	25.	80.	170.	217.	5.577	0.103	21.
1040.	29610.	32438.	30.	60.	110.	245.	7.278	0.390	67.
1041.	30420.	32133.	15.	60.	170.	217.	5.818	0.340	68.
1042.	30443.	31956.	15.	40.	150.	269.	[illegible]	0.074	21.
1043.	30557.	32059.	10.	40.	170.	198.	4.215	0.077	22.
1044.	30436.	32004.	20.	50.	110.	215.	5.221	0.070	21.
1045.	30796.	32394.	25.	80.	200.	244.	5.601	0.149	21.
1046.	30081.	32970.	15.	70.	170.	525.	7.746	0.891	90.
1047.	30166.	32958.	15.	110.	220.	370.	10.315	1.353	68.
1048.	30088.	33141.	10.	100.	140.	321.	10.852	1.641	146.
1049.	31202.	32004.	20.	50.	120.	232.	3.961	0.036	13.
1051.	31228.	32140.	25.	50.	120.	220.	3.799	0.063	15.
1052.	31318.	32144.	20.	50.	140.	373.	4.243	0.062	11.
1053.	31022.	32203.	20.	40.	120.	287.	3.782	0.050	11.
1054.	31002.	32166.	20.	20.	120.	374.	4.150	0.075	12.
1055.	32156.	32845.	30.	60.	150.	269.	4.833	0.185	16.
1056.	32084.	32714.	35.	60.	170.	309.	5.930	0.241	21.
1058.	31456.	31902.	30.	140.	200.	477.	4.609	0.084	14.
1061.	29385.	32533.	[illegible]	80.	150.	176.	5.926	0.621	63.
1062.	29375.	32521.	20.	100.	220.	326.	8.669	1.680	174.
1063.	29515.	32476.	25.	60.	120.	233.	6.352	0.571	57.
1064.	29506.	32094.	20.	120.	150.	429.	10.951	2.935	202.
1065.	29604.	32109.	20.	70.	200.	245.	7.191	3.099	124.
1066.	29380.	33406.	30.	70.	150.	363.	6.133	0.946	93.
1067.	32232.	32945.	30.	50.	190.	282.	5.832	0.284	21.
1068.	32244.	32918.	30.	60.	160.	270.	4.781	0.178	16.
1069.	32179.	32844.	20.	40.	100.	307.	5.531	0.258	24.
1070.	32037.	32680.	30.	50.	160.	347.	5.834	0.187	24.
1071.	32143.	32395.	30.	50.	140.	351.	5.128	0.168	22.
1072.	30940.	32849.	30.	80.	200.	466.	5.364	0.568	74.
1073.	30976.	32545.	25.	100.	270.	680.	6.120	1.229	139.
1074.	31046.	32747.	25.	210.	260.	461.	6.194	0.345	60.
1075.	30013.	33297.	25.	60.	90.	502.	5.065	0.393	53.

WN902010 BERWYN DOME DRAINAGE DATA

SAMPNUMB	ZN WATER	CU PAN	PB PAN	ZN PAN	BA PAN	FE PAN	MN PAN	CE PAN	SN PAN
1001.	0.01	22.	129.	113.	118.	5.92	0.145	5705.	16.
1002.	0.02	82.	573.	133.	470.	4.03	0.313	10853.	0.
1003.	0.02	9.	104.	110.	403.	6.07	0.061	2098.	162.
1004.	0.01	10.	46.	100.	381.	6.85	0.052	1649.	29.
1005.	0.01	45.	262.	152.	470.	6.65	0.110	7732.	0.
1006.	0.02	4.	90.	111.	190.	6.02	0.051	4983.	0.
1007.	0.01	37.	385.	132.	470.	4.82	0.082	9229.	0.
1008.	0.23	19.	28.	107.	486.	7.02	0.068	1081.	0.
1009.	0.01	54.	345.	137.	470.	4.88	0.089	8816.	0.
1010.	0.03	4.	73.	88.	200.	5.79	0.067	4099.	9.
1011.	0.04	2.	25.	80.	359.	4.99	0.078	1021.	0.
1012.	0.02	6.	64.	135.	328.	5.38	0.176	2606.	41.
1013.	0.02	4.	24.	86.	376.	5.64	0.099	1308.	0.
1014.	0.02	96.	210.	133.	300.	7.36	0.084	2144.	569.
1015.	0.03	19.	106.	79.	456.	5.17	0.077	546.	166.
1016.	0.01	7.	91.	106.	132.	4.81	0.149	5148.	0.
1017.	0.0	10.	86.	103.	427.	5.73	0.082	752.	25.
1018.	0.01	40.	349.	112.	470.	4.88	0.104	8869.	0.
1019.	0.01	21.	425.	112.	470.	4.39	0.085	9849.	0.
1020.	0.01	37.	867.	142.	470.	2.26	0.126	12311.	16.
1021.	0.01	13.	154.	132.	86.	5.85	0.162	6608.	0.
1022.	0.03	34.	147.	108.	61.	5.30	0.099	6351.	0.
1023.	0.02	6.	7.	127.	531.	9.95	0.271	121.	0.
1024.	0.05	7.	16.	89.	387.	6.87	0.056	1445.	0.
1025.	0.02	14.	20.	97.	553.	6.79	0.059	689.	0.
1026.	0.0	5.	32.	126.	372.	6.41	0.081	1371.	37.
1027.	0.0	30.	21.	98.	507.	7.38	0.062	373.	0.
1028.	0.01	44.	316.	112.	470.	5.45	0.110	8874.	0.
1029.	0.0	153.	176.	203.	268.	7.73	0.112	4113.	624.
1030.	0.0	9.	5.	120.	584.	7.00	0.123	206.	[illegible]
1031.	0.0	5.	5.	115.	575.	7.12	0.060	221.	1.
1032.	0.0	21.	31.	135.	455.	6.73	0.085	1995.	4.
1033.	0.0	13.	53.	116.	321.	6.03	0.063	3027.	0.
1034.	0.0	9.	32.	122.	412.	6.14	0.059	2071.	0.
1035.	0.0	11.	50.	123.	431.	6.36	0.087	2392.	0.
1036.	0.0	22.	54.	126.	343.	5.90	0.115	2858.	0.
1037.	0.0	59.	68.	762.	294.	6.62	0.096	2625.	34.
1038.	0.0	17.	93.	181.	252.	8.34	0.117	3181.	124.
1039.	0.0	10.	71.	155.	318.	7.60	0.128	2150.	21.
1040.	0.01	18.	436.	113.	470.	4.19	0.128	10383.	2.
1041.	0.01	5.	32.	132.	372.	7.08	0.067	1933.	2.
1042.	0.0	3.	222.	148.	470.	5.09	0.063	6851.	150.
1043.	0.0	0.	21.	167.	369.	6.66	0.064	1335.	0.
1044.	0.0	7.	70.	126.	244.	6.82	0.064	3526.	3.
1045.	0.01	87.	408.	359.	1120.	8.34	0.149	6012.	610.
1046.	0.15	5.	74.	94.	263.	5.36	0.102	3615.	0.
1047.	0.02	2.	77.	95.	240.	5.93	0.074	3899.	0.
1048.	0.03	8.	36.	84.	398.	6.02	0.069	2385.	3.
1049.	0.01	5.	56.	224.	365.	6.37	0.036	1243.	35.
1051.	0.01	12.	66.	125.	441.	6.98	0.051	810.	57.
1052.	0.01	5.	22.	122.	468.	6.31	0.037	461.	14.
1053.	0.0	37.	74.	137.	602.	7.27	0.052	1223.	58.
1054.	0.04	78.	40.	101.	369.	5.79	0.048	517.	14.
1055.	0.01	34.	272.	105.	335.	8.56	0.249	5225.	558.
1056.	0.01	27.	50.	181.	424.	8.14	0.155	1199.	49.
1058.	0.02	1061.	5436.	1295.	2047.	8.86	0.069	824.	4270.
1061.	0.03	51.	786.	115.	470.	3.25	0.165	11999.	0.
1062.	0.02	33.	522.	136.	470.	4.54	0.154	10323.	0.
1063.	0.03	33.	403.	123.	470.	5.30	0.168	9267.	0.
1064.	0.01	29.	134.	99.	130.	6.10	0.096	5876.	0.
1065.	0.01	16.	76.	102.	245.	6.54	0.178	5964.	0.
1066.	0.05	7.	72.	95.	217.	5.61	0.070	4259.	0.
1067.	0.01	25.	291.	167.	28.	7.21	0.205	6008.	133.
1068.	0.03	26.	113.	156.	429.	8.40	0.137	1267.	84.
1069.	0.01	35.	323.	201.	470.	7.07	0.182	7607.	74.
1070.	0.05	25.	170.	184.	232.	7.91	0.153	3375.	103.
1071.	0.01	22.	129.	165.	202.	7.86	0.135	3635.	65.
1072.	0.03	17.	194.	165.	352.	6.68	0.200	6125.	0.
1073.	0.02	9.	44.	134.	548.	7.26	0.152	1360.	0.
1074.	0.04	24.	421.	219.	470.	6.26	0.190	7797.	14.
1075.	0.02	27.	273.	104.	470.	4.66	0.092	8464.	0.

WN902010 BERWYN DOME DRAINAGE DATA

SAMPNUM	TI PAN	NI PAN	AS PAN	V SED	CR SED	NI SED	ZR SED	MO SED	SN SED
1001.	0.490	50.	22.	98.	48.	61.	205.	1.	0.
1002.	0.383	110.	25.	83.	56.	58.	256.	1.	0.
1003.	0.511	38.	5.	89.	73.	42.	367.	1.	9.
1004.	0.489	37.	13.	92.	77.	45.	350.	2.	8.
1005.	0.450	70.	35.	111.	84.	55.	277.	1.	0.
1006.	0.552	58.	12.	106.	82.	56.	[illegible]	0.	0.
1007.	0.457	92.	31.	112.	87.	71.	225.	1.	0.
1008.	0.533	40.	27.	122.	88.	52.	216.	0.	0.
1009.	0.466	77.	30.	106.	84.	61.	206.	1.	0.
1010.	0.504	40.	14.	117.	78.	45.	178.	1.	9.
1011.	0.456	25.	9.	83.	67.	70.	217.	0.	0.
1012.	0.498	31.	24.	99.	67.	64.	240.	1.	0.
1013.	0.462	20.	16.	88.	55.	61.	182.	1.	0.
1014.	0.440	40.	23.	115.	85.	62.	242.	1.	51.
1015.	0.427	23.	15.	110.	80.	48.	256.	1.	9.
1016.	0.434	42.	17.	127.	91.	66.	256.	2.	16.
1017.	0.471	33.	12.	125.	94.	63.	314.	0.	0.
1018.	0.455	86.	30.	116.	82.	56.	210.	0.	0.
1019.	0.469	83.	13.	119.	81.	63.	224.	0.	0.
1020.	0.341	145.	12.	127.	86.	68.	225.	1.	0.
1021.	0.521	58.	15.	112.	84.	85.	163.	1.	0.
1022.	0.473	52.	28.	107.	67.	75.	206.	0.	0.
1023.	0.566	39.	20.	86.	46.	52.	163.	2.	0.
1024.	0.512	31.	21.	84.	45.	37.	175.	2.	0.
1025.	0.514	34.	29.	103.	52.	43.	236.	1.	0.
1026.	0.500	37.	15.	115.	69.	54.	213.	1.	0.
1027.	0.528	36.	28.	119.	60.	46.	240.	2.	0.
1028.	0.456	78.	39.	102.	51.	32.	249.	1.	0.
1029.	0.539	51.	21.	130.	57.	50.	250.	0.	14.
1030.	0.596	42.	10.	120.	70.	50.	201.	2.	0.
1031.	0.590	41.	8.	150.	58.	52.	163.	1.	0.
1032.	0.560	50.	10.	114.	67.	50.	146.	1.	0.
1033.	0.516	42.	16.	116.	60.	43.	159.	1.	0.
1034.	0.561	45.	11.	125.	72.	43.	174.	2.	0.
1035.	0.559	45.	12.	134.	61.	54.	162.	0.	0.
1036.	0.517	42.	13.	105.	56.	49.	230.	1.	0.
1037.	0.527	47.	8.	84.	42.	54.	196.	1.	10.
1038.	0.534	51.	14.	[illegible]	63.	53.	178.	0.	0.
1039.	0.563	40.	14.	104.	70.	56.	204.	0.	0.
1040.	0.445	81.	19.	100.	69.	64.	320.	1.	0.
1041.	0.519	43.	11.	107.	66.	61.	234.	0.	0.
1042.	0.464	64.	6.	104.	55.	45.	256.	[illegible]	0.
1043.	0.494	39.	5.	103.	54.	40.	220.	1.	0.
1044.	0.495	45.	14.	99.	65.	51.	271.	1.	0.
1045.	0.497	68.	14.	94.	66.	55.	139.	1.	9.
1046.	0.466	34.	19.	100.	53.	50.	169.	1.	0.
1047.	0.499	35.	26.	94.	49.	44.	155.	1.	0.
1048.	0.519	34.	22.	68.	35.	38.	188.	1.	0.
1049.	0.466	41.	22.	88.	54.	37.	182.	1.	0.
1051.	0.499	41.	27.	84.	54.	37.	161.	1.	0.
1052.	0.493	35.	13.	101.	58.	40.	142.	1.	0.
1053.	0.493	45.	17.	93.	56.	34.	147.	1.	0.
1054.	0.449	37.	9.	95.	59.	40.	171.	1.	0.
1055.	0.489	59.	10.	80.	57.	35.	132.	1.	9.
1056.	0.520	52.	15.	109.	69.	56.	96.	1.	0.
1058.	0.394	56.	88.	100.	66.	46.	141.	2.	33.
1061.	0.366	112.	24.	83.	47.	46.	175.	0.	0.
1062.	0.440	90.	31.	93.	56.	58.	134.	1.	0.
1063.	0.468	75.	30.	98.	52.	45.	159.	1.	0.
1064.	0.467	47.	20.	90.	40.	43.	101.	2.	0.
1065.	0.505	43.	20.	69.	36.	46.	87.	0.	0.
1066.	0.484	38.	15.	83.	42.	49.	170.	1.	0.
1067.	0.537	69.	10.	100.	64.	62.	147.	0.	8.
1068.	0.536	47.	14.	88.	54.	47.	175.	1.	0.
1069.	0.514	77.	13.	91.	68.	60.	205.	0.	7.
1070.	0.517	54.	14.	77.	60.	62.	201.	0.	9.
1071.	0.501	51.	18.	78.	56.	54.	190.	0.	8.
1072.	0.579	59.	15.	66.	51.	59.	209.	0.	13.
1073.	0.563	43.	12.	91.	54.	34.	206.	1.	6.
1074.	0.738	68.	13.	101.	67.	76.	146.	0.	11.
1075.	0.458	63.	16.	81.	56.	49.	236.	1.	0.

SAMPNUMB	EASTING	NORTHING	CU SED	PB SED	ZN SED	BA SED	FE SED	MN SED	CO SED
1076.	30605.	30000.	25.	70.	420.	423.	5.256	0.443	99.
1077.	30605.	33001.	25.	110.	400.	571.	8.243	2.715	257.
1078.	30732.	32949.	25.	80.	200.	354.	5.726	0.412	76.
1079.	30753.	32955.	45.	110.	440.	592.	8.102	1.319	332.
1080.	30807.	32869.	30.	600.	250.	385.	5.578	0.584	99.
1081.	30810.	32865.	50.	510.	390.	530.	6.160	0.731	112.
1082.	30948.	32817.	35.	350.	260.	583.	6.245	0.519	85.
1083.	31213.	32638.	40.	230.	410.	538.	5.989	0.395	54.
1085.	30920.	33222.	40.	60.	210.	395.	6.248	0.534	153.
1086.	30973.	33225.	60.	50.	360.	392.	6.491	0.470	89.
1087.	31045.	33190.	50.	60.	340.	557.	6.249	0.551	143.
1089.	31163.	33089.	35.	60.	260.	307.	6.708	0.405	39.
1090.	31224.	33072.	30.	60.	260.	462.	6.695	0.714	140.
1091.	31284.	33024.	25.	50.	170.	367.	7.584	0.607	71.
1092.	31266.	33018.	40.	60.	330.	387.	6.613	0.617	108.
1093.	31374.	32428.	30.	170.	320.	248.	4.246	0.138	14.
1094.	29898.	33408.	25.	50.	230.	413.	6.116	0.765	86.
1095.	29867.	33409.	20.	80.	290.	246.	5.633	0.721	92.
1096.	29824.	33426.	20.	50.	210.	224.	4.984	0.299	31.
1097.	30139.	33425.	15.	50.	120.	446.	7.044	0.646	107.
1098.	30132.	33434.	28.	40.	130.	339.	6.357	0.259	39.
1099.	30200.	33516.	20.	60.	160.	284.	5.057	0.320	56.
1100.	30192.	33248.	15.	50.	140.	333.	6.501	0.308	56.
1101.	30194.	33242.	10.	40.	140.	194.	6.079	0.522	61.
1102.	29720.	33528.	30.	60.	370.	344.	6.051	0.515	84.
1103.	29797.	33506.	25.	50.	300.	306.	4.665	0.438	46.
1104.	31609.	32654.	30.	50.	190.	244.	5.632	0.199	17.
1105.	31634.	32633.	25.	50.	180.	281.	4.580	0.101	13.
1106.	31238.	32972.	35.	60.	250.	283.	5.869	0.431	47.
1107.	31222.	32855.	35.	60.	490.	418.	4.882	0.332	26.
1108.	31218.	32858.	30.	70.	290.	241.	5.948	0.367	56.
1109.	31245.	32795.	30.	70.	290.	281.	4.908	0.385	31.
1110.	31337.	32683.	35.	60.	250.	382.	6.367	0.308	46.
1111.	31340.	32684.	30.	60.	210.	337.	5.835	0.228	22.
1113.	31574.	32552.	30.	50.	150.	239.	4.667	0.167	18.
1114.	31590.	32557.	30.	60.	200.	452.	6.466	0.295	24.
1115.	30056.	32776.	20.	110.	200.	386.	9.857	1.463	192.
1116.	30055.	32772.	25.	170.	450.	418.	9.496	2.572	224.
1117.	30113.	32790.	20.	10.	90.	292.	4.195	0.053	12.
1120.	31595.	32555.	45.	10.	190.	239.	4.770	0.144	18.
1121.	31588.	32470.	50.	70.	190.	299.	5.766	0.201	22.
1122.	31677.	32467.	30.	50.	130.	334.	4.942	0.150	19.
1123.	31898.	32490.	25.	50.	140.	318.	5.556	0.073	17.
1124.	30850.	32418.	20.	80.	160.	205.	5.364	0.093	19.
1125.	30330.	32538.	15.	50.	240.	339.	5.042	0.285	33.
1126.	30344.	32568.	20.	70.	250.	394.	5.085	0.235	29.
1127.	30440.	32540.	20.	90.	240.	469.	6.058	0.236	38.
1128.	30517.	32584.	20.	320.	520.	389.	4.635	0.153	25.
1129.	30641.	32649.	40.	100.	390.	625.	5.914	0.288	64.
1132.	30428.	32834.	25.	50.	300.	371.	[illegible].426	0.498	71.
1133.	30016.	32386.	20.	50.	150.	321.	5.295	0.123	20.
1134.	30722.	32298.	20.	40.	110.	284.	5.898	0.115	21.
1135.	29718.	32312.	25.	50.	150.	399.	4.928	0.358	57.
1136.	29778.	32240.	20.	60.	270.	365.	4.860	0.567	59.
1137.	30871.	32499.	20.	50.	120.	265.	6.107	0.121	19.
1139.	31088.	32393.	25.	110.	270.	348.	4.681	0.114	28.
1140.	31042.	31355.	15.	60.	100.	521.	4.834	0.082	15.
1141.	30938.	31239.	20.	40.	130.	385.	4.852	0.072	15.
1142.	30221.	32956.	20.	120.	400.	414.	6.989	1.683	97.
1143.	30214.	32955.	[illegible]	80.	300.	290.	7.555	1.814	113.
1145.	30318.	32880.	35.	110.	410.	364.	7.826	1.915	128.
1147.	30376.	32807.	35.	90.	270.	269.	7.216	0.484	68.
1148.	30416.	32717.	25.	70.	210.	276.	5.571	0.289	36.
1149.	30464.	32748.	30.	60.	210.	307.	6.092	0.269	48.
1150.	30794.	32077.	20.	30.	90.	232.	3.875	0.070	11.
1151.	30880.	32071.	20.	40.	110.	275.	4.269	0.058	16.
1152.	31540.	32998.	35.	90.	180.	357.	5.908	0.196	25.
1153.	31232.	31965.	20.	40.	190.	298.	3.881	0.070	13.
1154.	31144.	31913.	25.	50.	110.	279.	4.406	0.078	15.
1155.	31027.	31841.	25.	110.	230.	289.	4.279	0.197	17.
1156.	31024.	31823.	25.	40.	110.	355.	4.034	0.060	15.

WN902010 BERWYN DOME DRAINAGE DATA

SAMPNUMB	ZN WATER	CU PAN	PB PAN	ZN PAN	BA PAN	FE PAN	MN PAN	CE PAN	SN PAN
1076.	0.02	18.	41.	347.	408.	7.56	0.185	1706.	0.
1077.	0.06	15.	124.	133.	98.	7.16	0.178	5338.	0.
1078.	0.03	20.	218.	151.	119.	7.36	0.184	5333.	11.
1079.	0.02	15.	264.	294.	470.	6.63	0.202	7622.	0.
1080.	0.02	14.	301.	188.	220.	7.21	0.164	4656.	0.
1081.	0.05	16.	207.	268.	471.	7.63	0.139	859.	73.
1082.	0.0	15.	464.	256.	214.	7.16	0.196	4934.	0.
1083.	0.05	52.	621.	313.	625.	6.69	0.186	6680.	82.
1085.	0.02	14.	135.	145.	1519	7.05	0.145	4868.	3.
1086.	0.02	26.	205.	285.	470.	6.67	0.183	6923.	0.
1087.	0.04	21.	92.	258.	254.	6.90	0.170	4027.	0.
1089.	0.01	18.	349.	178.	470.	5.85	0.205	8675.	0.
1090.	0.02	16.	396.	164.	470.	5.52	0.191	9184.	0.
1091.	0.02	8.	73.	133.	176.	7.05	0.121	4332.	1.
1092.	0.01	29.	663.	158.	470.	4.12	0.194	11316.	0.
1093.	0.05	36.	391.	299.	644.	6.94	0.064	636.	36.
1094.	0.0	12.	116.	116.	121.	5.23	0.090	5499.	0.
1095.	0.01	9.	76.	114.	213.	5.20	0.098	4221.	2.
1096.	0.04	0.	162.	114.	470.	4.27	0.065	6595.	2.
1097.	0.01	6.	219.	94.	470.	4.25	0.050	7363.	0.
1098.	0.01	6.	245.	113.	470.	4.34	0.089	7924.	86.
1099.	0.0	2.	27.	125.	1654.	5.82	0.097	1697.	0.
1100.	0.03	14.	118.	111.	488.	6.13	0.052	4540.	0.
1101.	0.01	8.	166.	107.	57.	6.12	0.084	6090.	4.
1102.	0.02	16.	442.	172.	470.	6.53	0.185	7204.	34.
1103.	0.01	9.	97.	126.	220.	5.47	0.136	4386.	6.
1104.	0.02	16.	442.	172.	470.	6.53	0.185	7204.	34.
1105.	0.01	5.	24.	146.	419.	7.12	0.085	649.	0.
1106.	0.05	12.	203.	158.	77.	6.85	0.225	6446.	10.
1107.	0.01	32.	127.	223.	221.	6.24	0.136	4173.	39.
1108.	0.0	45.	966.	145.	470.	2.66	0.204	12269.	11.
1109.	0.01	12.	162.	209.	257.	7.15	0.201	4224.	72.
1110.	0.01	27.	663.	193.	470.	4.53	0.285	10575.	22.
1111.	0.0	16.	30.	153.	391.	7.45	0.141	1294.	4.
1113.	0.04	7.	299.	212.	470.	6.36	0.095	6481.	43.
1114.	0.0	10.	53.	171.	433.	7.83	0.142	1185.	13.
1115.	0.01	19.	121.	101.	141.	6.05	0.092	5330.	38.
1116.	0.0	10.	81.	117.	263.	5.53	0.139	3994.	0.
1117.	0.02	10.	46.	92.	336.	5.36	0.035	2397.	0.
1120.	0.02	118.	484.	163.	229.	6.58	0.086	2863.	363.
1121.	0.01	24.	288.	165.	163.	7.62	0.154	5425.	56.
1122.	0.0	8.	115.	115.	318.	6.37	0.096	2109.	69.
1123.	0.0	8.	45.	140.	450.	7.36	0.059	240.	32.
1124.	0.02	6.	72.	146.	439.	7.12	0.077	377.	35.
1125.	0.02	7.	60.	137.	400.	6.26	0.122	1351.	0.
1126.	0.01	40.	461.	290.	470.	5.60	0.156	7676.	9.
1127.	0.0	13.	93.	174.	456.	7.15	0.102	723.	57.
1128.	0.03	228.	1523.	1773.	330.	5.96	0.099	3493.	46.
1129.	0.0	13.	65.	234.	7127.	7.19	0.153	1759.	3.
1132.	0.02	20.	138.	150.	83.	5.62	0.100	5716.	25.
1133.	0.02	8.	47.	140.	1215.	7.53	0.076	614.	153.
1134.	0.01	13.	87.	124.	384.	7.64	0.084	2258.	31.
1135.	0.02	17.	84.	108.	213.	5.56	0.047	3910.	2.
1136.	0.0	5.	76.	211.	184.	5.23	0.107	4054.	0.
1137.	0.02	19.	443.	218.	292.	7.64	0.113	2573.	63.
1139.	0.02	17.	132.	153.	1818.	6.94	0.065	168.	32.
1140.	0.01	15.	103.	125.	9131.	7.04	0.052	326.	252.
1141.	0.03	7.	16.	125.	461.	6.60	0.051	537.	8.
1142.	0.02	7.	28.	120.	428.	6.73	0.125	1627.	0.
1143.	0.02	18.	24.	158.	492.	10.69	0.263	1225.	0.
1145.	0.0	11.	81.	211.	239.	10.72	0.336	3444.	0.
1147.	0.0	9.	99.	240.	50.	12.48	0.362	4334.	0.
1148.	0.01	8.	68.	196.	271.	7.98	0.205	2604.	12.
1149.	0.0	9.	8.	153.	353.	7.13	0.114	1305.	7.
1150.	0.01	15.	47.	143.	413.	5.54	0.032	2333.	0.
1151.	0.02	6.	6.	120.	477.	6.04	0.037	304.	0.
1152.	0.01	13.	88.	166.	541.	7.64	0.140	420.	9.
1153.	0.03	14.	18.	112.	425.	5.95	0.041	221.	10.
1154.	0.01	15.	25.	109.	455.	6.66	0.051	208.	[illegible]
1155.	0.01	27.	57.	205.	380.	5.70	0.041	[illegible]	9.
1156.	0.02	14.	22.	101.	450.	5.62	0.031	244.	5

SAMPNUMB	TI PAN	NI PAN	AS PAN	V SED	CR SED	NI SED	ZR SED	MO SED	SN SED
1076.	0.681	58.	11.	98.	77.	86.	149.	1.	0.
1077.	1.147	59.	15.	92.	65.	104.	166.	0.	0.
1078.	0.824	58.	18.	95.	70.	73.	163.	0.	0.
1079.	0.628	67.	15.	115.	80.	113.	133.	0.	0.
1080.	0.769	54.	15.	96.	71.	65.	141.	0.	0.
1081.	0.590	47.	10.	99.	77.	91.	175.	1.	16.
1082.	0.648	55.	11.	96.	80.	74.	145.	0.	7.
1083.	0.635	61.	14.	100.	80.	88.	194.	1.	28.
1085.	0.627	52.	9.	96.	74.	75.	207.	0.	0.
1086.	0.563	70.	11.	111.	88.	100.	131.	0.	5.
1087.	0.569	62.	12.	88.	72.	93.	140.	0.	0.
1089.	0.532	77.	10.	110.	82.	79.	163.	0.	0.
1090.	0.491	81.	8.	97.	65.	93.	142.	0.	9.
1091.	0.556	52.	9.	94.	71.	104.	133.	1.	0.
1092.	0.439	104.	7.	89.	63.	95.	127.	0.	0.
1093.	0.480	37.	18.	82.	55.	40.	255.	1.	6.
1094.	0.515	42.	14.	85.	53.	71.	250.	0.	0.
1095.	0.507	38.	11.	91.	43.	68.	215.	0.	0.
1096.	0.471	48.	7.	87.	39.	46.	206.	1.	0.
1097.	0.476	55.	9.	98.	57.	52.	178.	0.	0.
1098.	0.543	69.	4.	117.	53.	46.	185.	0.	21.
1099.	0.488	41.	10.	130.	49.	48.	216.	1.	0.
1100.	0.524	48.	16.	96.	58.	49.	192.	0.	0.
1101.	0.536	54.	23.	93.	48.	48.	159.	0.	0.
1102.	0.537	69.	15.	92.	53.	85.	198.	1.	14.
1103.	0.486	41.	14.	89.	48.	71.	231.	1.	0.
1104.	0.537	69.	12.	98.	62.	58.	166.	0.	6.
1105.	0.519	40.	9.	96.	60.	43.	134.	1.	0.
1106.	0.558	61.	18.	86.	53.	58.	98.	0.	0.
1107.	0.542	46.	12.	78.	53.	57.	256.	1.	0.
1108.	0.369	130.	3.	102.	59.	71.	216.	0.	0.
1109.	0.614	52.	17.	82.	53.	49.	218.	1.	0.
1110.	0.460	102.	9.	102.	71.	76.	184.	1.	9.
1111.	0.560	42.	8.	90.	59.	62.	208.	0.	1.
1113.	0.484	51.	9.	92.	47.	41.	164.	0.	0.
1114.	0.540	45.	32.	115.	86.	71.	178.	0.	2.
1115.	0.476	42.	24.	82.	50.	59.	134.	2.	7.
1116.	0.474	42.	17.	103.	50.	115.	206.	1.	0.
1117.	0.508	32.	12.	103.	60.	38.	199.	1.	0.
1120.	0.472	38.	15.	102.	52.	47.	226.	1.	12.
1121.	0.529	57.	10.	108.	64.	66.	160.	0.	7.
1122.	0.492	37.	12.	95.	60.	52.	198.	1.	0.
1123.	0.479	34.	12.	103.	59.	50.	159.	0.	11.
1124.	0.522	39.	13.	92.	56.	56.	218.	1.	6.
1125.	0.502	36.	16.	92.	64.	55.	191.	1.	6.
1126.	0.465	63.	21.	100.	66.	55.	231.	1.	0.
1127.	0.538	41.	9.	117.	69.	[illegible]	156.	1.	13.
1128.	0.495	44.	14.	92.	65.	53.	181.	1.	9.
1129.	0.571	56.	9.	116.	85.	95.	179.	1.	6.
1132.	0.516	51.	17.	91.	65.	127.	204.	0.	0.
1133.	0.507	41.	12.	102.	69.	58.	204.	1.	0.
1134.	0.515	49.	10.	97.	70.	66.	174.	0.	0.
1135.	0.477	38.	18.	92.	62.	66.	238.	2.	0.
1136.	0.445	38.	33.	90.	64.	102.	211.	2.	11.
1137.	0.558	73.	11.	128.	60.	72.	169.	0.	0.
1139.	0.512	38.	19.	95.	57.	51.	230.	1.	0.
1140.	0.505	40.	29.	117.	67.	60.	228.	1.	7.
1141.	0.507	37.	9.	112.	70.	46.	177.	1.	0.
1142.	0.567	34.	16.	98.	47.	58.	211.	0.	0.
1143.	1.682	112.	7.	151.	45.	96.	176.	1.	0.
1145.	1.048	105.	13.	128.	51.	63.	140.	1.	0.
1147.	2.760	121.	9.	140.	57.	71.	161.	2.	0.
1148.	0.837	71.	13.	108.	56.	59.	159.	0.	0.
1149.	0.542	45.	9.	114.	65.	84.	165.	0.	0.
1150.	0.468	39.	11.	95.	64.	32.	255.	1.	0.
1151.	0.520	37.	9.	103.	56.	48.	212.	1.	0.
1152.	0.567	45.	10.	119.	70.	66.	180.	1.	0.
1153.	0.426	43.	11.	89.	66.	49.	171.	1.	0.
1154.	0.434	45.	10.	104.	58.	54.	147.	2.	0.
1155.	0.426	43.	12.	105.	69.	63.	147.	2.	0.
1156.	0.445	41.	12.	100.	69.	57.	162.	2.	0.

WH302010 BERWYN DOME DRAINAGE DATA

SAMPNUMB	EASTING	NORTHING	CU SED	PB SED	ZN SED	BA SED	FE SED	MN SED	CO SED
1157.	30993.	31787.	25.	50.	130.	361.	4.409	0.103	19.
1158.	30897.	31780.	25.	60.	160.	316.	4.429	0.129	20.
1159.	30795.	31776.	25.	40.	130.	248.	3.778	0.083	18.
1162.	29859.	32645.	25.	80.	170.	266.	6.005	0.076	150.
1163.	29924.	32540.	15.	60.	130.	450.	8.169	0.518	100.
1164.	29918.	32536.	15.	60.	110.	226.	5.050	0.369	68.
1165.	29944.	32405.	15.	60.	80.	180.	4.084	0.261	52.
1166.	29952.	32412.	20.	90.	140.	267.	5.486	0.354	59.
1167.	31577.	33190.	35.	60.	190.	210.	6.930	0.273	38.
1169.	31570.	33234.	30.	60.	190.	169.	5.390	0.176	28.
1170.	31573.	33296.	30.	70.	210.	222.	5.600	0.220	43.
1171.	31462.	33313.	55.	80.	120.	221.	5.785	0.421	128.
1172.	31487.	33350.	30.	70.	220.	181.	6.148	0.339	54.
1173.	31348.	33412.	60.	70.	180.	170.	5.721	0.381	119.
1174.	31823.	33659.	20.	70.	240.	288.	5.331	0.150	23.
1175.	31935.	33607.	25.	70.	260.	193.	4.319	0.121	19.
1176.	29970.	32296.	20.	50.	100.	197.	4.757	0.193	30.
1178.	30248.	31929.	20.	70.	200.	229.	4.902	0.187	19.
1179.	29990.	31808.	20.	60.	300.	296.	6.161	0.722	71.
1180.	30596.	31732.	30.	50.	150.	224.	4.540	0.172	21.
1181.	31960.	33502.	25.	70.	260.	222.	4.480	0.205	21.
1182.	31849.	33453.	35.	70.	210.	238.	4.603	0.100	21.
1183.	31765.	33415.	30.	90.	250.	318.	5.298	0.406	29.
1185.	31686.	33350.	35.	80.	240.	315.	6.250	0.259	26.
1186.	31535.	32884.	30.	60.	180.	242.	5.770	0.167	22.
1187.	31526.	32887.	40.	70.	240.	213.	4.797	0.189	19.
1188.	31882.	33351.	30.	60.	140.	173.	4.814	0.122	17.
1189.	31884.	33062.	25.	50.	160.	183.	5.330	0.150	30.
1190.	31716.	33061.	30,	60	180.	237.	5.723	0.222	34.
1193.	32088.	33068.	25.	50.	170.	188.	5.967	0.321	19.
1194.	32070.	33057.	20.	50.	160.	215.	5.642	0.130	20.
1195.	31274.	33345.	50.	80.	120.	283.	5.822	0.411	140.
1196.	31169.	33448.	25.	60.	230.	265.	6.379	0.474	73.
1197.	31160.	33437.	110.	80.	320.	232.	5.686	0.563	107.
1198.	31034.	33451.	35.	70.	230.	379.	6.695	0.792	174.
1199.	31370.	33402.	25.	90.	290.	375.	5.891	0.560	71.
1200.	31357.	33461.	35.	60.	230.	320.	5.716	0.255	43.
1201.	32012.	33202.	30.	60.	160.	277.	5.498	0.214	25.
1202.	32198.	33243.	20.	60.	270.	364.	5.657	0.301	40.
1203.	32378.	33250.	25.	60.	200.	334.	4.732	0.262	35.
1204.	31920.	33748.	20.	116.	200.	407.	8.300	0.216	40.
1205.	[illegible]	33758.	15.	170.	310.	349.	7.300	1.754	264.
1206.	[illegible]	33708.	10.	90.	220.	396.	8.567	0.630	101.
1207.	31512.	33709.	20.	60.	140.	329.	5.294	0.107	24.
1208.	31484.	33716.	15.	130.	380.	433.	6.105	0.739	89.
1209.	32480.	33140.	25.	50.	220.	297.	4.782	0.223	23.
1210.	30316.	33546.	20.	60.	240.	315.	4.762	0.354	46.
1211.	30298.	33546.	20.	50.	160.	331.	4.483	0.293	37.
1212.	31514.	33927.	15.	50.	130.	358.	3.662	0.091	17.
1213.	31579.	33742.	15.	70.	200.	343.	4.953	0.137	23.
1214.	31584.	33726.	15.	50.	200.	397.	5.179	0.117	17.
1215.	31669.	33731.	25.	60.	250.	388.	4.830	0.125	25.
1216.	31699.	33706.	25.	60.	190.	269.	4.950	0.123	19.
1217.	31714.	33715.	20.	50.	170.	441.	6.192	0.087	23.
1218.	31759.	33669.	20.	70.	270.	265.	4.198	0.198	20.
1219.	30289.	33410.	30.	80.	350.	135.	6.627	0.938	171.
1220.	31840.	33824.	15.	50.	180.	357.	3.914	0.965	11.
1221.	31196.	33582.	20.	90.	160.	358.	7.994	1.420	90.
1222.	31310.	33572.	20.	80.	330.	350.	7.013	0.557	75.
1223.	31294.	33560.	25.	80.	230.	381.	6.440	0.732	67.
1224.	31938.	34028.	15.	50.	230.	124.	4.339	0.155	23.
1225.	30273.	33415.	20.	60.	190.	346.	5.383	0.423	52.
1226.	30256.	33286.	20.	70.	250.	479.	6.307	0.841	94.
1227.	30244.	33293.	15.	60.	150.	362.	6.281	0.464	65.
1228.	30262.	33202.	15.	70.	160.	333.	6.809	0.950	113.
1229.	30247.	33195.	25.	50.	340.	461.	4.652	0.424	35.
1230.	30350.	33553.	25.	60.	230.	318.	6.266	0.458	72.
1231.	30560.	33492.	30.	60.	330.	317.	6.264	0.500	89.
1232.	30428.	33504.	30.	60.	380.	315.	6.969	0.715	112.
1233.	30424.	33456.	30.	90.	370.	426.	6.311	0.660	130.
1234.	30543.	33350.	20.	80.	340.	262.	6.124	0.729	127.

WN902010 BERWYN DOME DRAINAGE DATA

SAMPNUMB	ZN WATER	CU PAN	PB PAN	ZN PAN	BA PAN	FE PAN	MN PAN	CE PAN	SN PAN
1157.	0.0	57.	112.	150.	439.	5.76	0.049	652.	109.
1158.	0.0	22.	14.	130.	435.	5.24	0.051	174.	40.
1159.	0.01	16.	25.	119.	515.	5.73	0.040	660.	0.
1162.	0.02	3.	80.	94.	224.	5.69	0.063	4434.	0.
1163.	0.05	15.	70.	96.	260.	6.02	0.096	3890.	0.
1164.	0.01	19.	38.	101.	409.	7.29	0.063	2312.	0.
1165.	0.02	8.	109.	79.	84.	4.65	0.044	5368.	0.
1166.	0.0	30.	770.	127.	243.	6.58	0.065	3844.	0.
1167.	0.02	18.	57.	151.	358.	7.96	0.215	2289.	2.
1169.	0.01	383.	94.	276.	394.	7.94	0.177	1935.	218.
1170.	0.04	15.	126.	161.	174.	7.10	0.179	4947.	0.
1171.	0.03	19.	51.	124.	389.	7.69	0.209	2290.	0.
1172.	0.08	11.	64.	174.	364.	7.49	0.187	2355.	2.
1173.	0.01	92.	240.	190.	127.	6.97	0.190	5987.	90.
1174.	0.0	5.	37.	180.	513.	6.40	0.070	638.	0.
1175.	0.01	13.	112.	187.	362.	6.35	0.065	2655.	113.
1176.	0.03	22.	116.	107.	348.	5.84	0.059	4902.	0.
1178.	0.02	1.	69.	121.	244.	5.37	0.050	2996.	59.
1179.	0.03	26.	0.	120.	400.	5.92	0.102	1062.	1.
1180.	0.0	42.	99.	269.	353.	6.45	0.051	2604.	44.
1181.	0.03	14.	129.	214.	515.	7.71	0.137	680.	13.
1182.	0.01	27.	59.	163.	757.	7.01	0.191	374.	200.
1183.	0.0	21.	91.	181.	558.	7.48	0.164	473.	137.
1185.	0.03	115.	263.	208.	607.	8.96	0.215	982.	268.
1186.	0.0	89.	358.	175.	470.	6.19	0.195	7714.	172.
1187.	0.0	26.	143.	199.	389.	7.84	0.194	3454.	91.
1188.	0.0	9.	78.	139.	423.	7.58	0.129	1132.	112.
1189.	0.03	15.	32.	217.	967.	7.72	0.143	851.	25.
1190.	0.01	8.	9.	149.	516.	7.67	0.146	445.	10.
1193.	0.01	12.	55.	145.	429.	8.14	0.154	1122.	56.
1194.	0.01	4.	82.	148.	231.	7.62	0.144	3508.	2.
1195.	0.01	23.	136.	130.	138.	7.09	0.206	5142.	0.
1196.	0.0	17.	59.	171.	334.	7.55	0.213	2080.	4.
1197.	0.04	33.	26.	229.	438.	7.71	0.193	966.	0.
1198.	0.01	13.	17.	151.	452.	7.62	0.165	748.	11.
1199.	0.0	11.	42.	177.	548.	7.45	0.262	454.	92.
1200.	0.01	16.	21.	162.	466.	7.58	0.139	739.	0.
1201.	0.01	51.	80.	157.	504.	8.75	0.152	803.	117.
1202.	0.01	10.	21.	228.	483.	8.09	0.241	287.	0.
1203.	0.0	10.	51.	142.	428.	6.57	0.189	1333.	38.
1204.	0.02	0.	31.	157.	579.	8.30	0.105	995.	0.
1205.	0.0	11.	138.	118.	388.	7.20	0.068	2071.	0.
1206.	0.01	2.	36.	119.	455.	7.34	0.072	1643.	2.
1207.	0.02	0.	19.	117.	507.	6.77	0.048	795.	1.
1208.	0.02	8.	55.	198.	515.	6.89	0.165	1938.	0.
1209.	0.0	13.	23.	185.	461.	7.05	0.136	623.	12.
1210.	0.01	14.	102.	133.	192.	6.16	0.168	4446.	30.
1211.	0.01	5.	105.	113.	227.	5.36	0.036	3482.	126.
1212.	0.01	13.	31.	125.	471.	5.99	0.088	1403.	0.
1213.	0.0	9.	63.	179.	440.	6.14	0.104	1722.	0.
1214.	0.03	4.	34.	155.	531.	6.54	0.059	1604.	0.
1215.	0.0	567.	187.	216.	612.	7.03	0.061	1815.	206.
1216.	0.01	137.	176.	176.	195.	6.71	0.089	4848.	205.
1217.	0.03	46.	161.	176.	525.	7.18	0.049	2720.	158.
1218.	0.01	6.	38.	188.	454.	6.33	0.096	568.	0.
1219.	0.02	13.	26.	183.	355.	7.38	0.237	1377.	0.
1220.	0.02	13.	33.	193.	561.	5.94	0.044	730.	13.
1221.	0.01	10.	47.	133.	487.	7.04	0.143	1976.	0.
1222.	0.01	2.	65.	204.	407.	7.20	0.194	2336.	5.
1223.	0.0	16.	62.	142.	350.	7.54	0.245	2601.	6.
1224.	0.01	9.	106.	200.	382.	6.50	0.075	2785.	7.
1225.	0.01	5.	81.	118.	389.	6.84	0.132	2128.	0.
1226.	0.0	7.	41.	121.	386.	6.37	0.117	2272.	0.
1227.	0.01	8.	67.	104.	359.	6.50	0.081	3046.	49.
1228.	0.01	10.	30.	82.	418.	5.67	0.073	1457.	1.
1229.	0.02	11.	68.	191.	1577.	6.29	0.117	3348.	0.
1230.	0.0	16.	35.	178.	371.	7.55	0.265	740.	0.
1231.	0.01	19.	99.	300.	202.	8.12	0.309	4027.	0.
1232.	0.01	22.	150.	180.	470.	9.36	0.587	5346.	6.
1233.	0.0	12.	44.	176.	302.	7.66	0.343	1498.	0.
1234.	0.01	13.	57.	154.	324.	7.20	0.172	3012.	0.

WN902010 BERWYN DOME DRAINAGE DATA

SAMPNUMB	TI PAN	NI PAN	AS PAN	V SED	CR SED	NI SED	ZR SED	MO SED	SN SED
1157.	0.437	42.	17.	110.	76.	62.	205.	2.	0.
1158.	0.399	37.	8.	100.	60.	64.	100.	2.	0.
1159.	0.447	41.	11.	100.	64.	52.	212.	2.	0.
1162.	0.483	39.	16.	89.	41.	50.	194.	1.	0.
1163.	0.473	41.	27.	120.	60.	63.	150.	2.	0.
1164.	0.522	38.	37.	89.	42.	42.	196.	1.	0.
1165.	0.480	39.	12.	105.	47.	38.	213.	2.	0.
1166.	0.470	44.	40.	101.	49.	52.	231.	1.	0.
1167.	0.561	49.	17.	122.	56.	69.	146.	2.	0.
1169.	0.542	52.	13.	97.	48.	66.	129.	1.	0.
1170.	0.558	50.	15.	102.	54.	66.	145.	0.	0.
1171.	0.580	46.	9.	98.	55.	51.	131.	0.	3.
1172.	0.573	53.	14.	94.	58.	70.	154.	1.	0.
1173.	0.560	60.	9.	111.	80.	60.	135.	0.	6.
1174.	0.525	36.	36.	110.	51.	58.	233.	1.	0.
1175.	0.501	42.	30.	98.	45.	40.	199.	1.	16.
1176.	0.475	43.	24.	89.	44.	40.	244.	1.	0.
1178.	0.457	36.	3.	97.	41.	41.	185.	1.	0.
1179.	0.495	40.	24.	107.	43.	74.	163.	0.	6.
1180.	0.451	47.	36.	94.	47.	56.	191.	1.	6.
1181.	0.563	44.	16.	99.	45.	49.	180.	1.	0.
1182.	0.532	39.	27.	94.	51.	48.	369.	1.	7.
1183.	0.566	46.	15.	108.	56.	68.	227.	0.	11.
1185.	0.616	50.	11.	118.	95.	69.	145.	1.	9.
1186.	0.541	74.	7.	108.	59.	62.	197.	0.	0.
1187.	0.560	54.	19.	95.	49.	50.	180.	1.	0.
1188.	0.578	45.	8.	100.	49.	48.	129.	1.	13.
1189.	0.587	49.	11.	111.	51.	55.	123.	1.	0.
1190.	0.563	46.	12.	103.	46.	57.	121.	0.	0.
1193.	0.564	49.	14.	108.	61.	68.	131.	0.	10.
1194.	0.353	54.	7.	100.	53.	67.	161.	0.	0.
1195.	0.592	54.	13.	175.	70.	61.	136.	0.	0.
1196.	0.589	54.	13.	193.	61.	91.	98.	1.	0.
1197.	0.606	50.	15.	172.	56.	83.	125.	0.	0.
1198.	0.587	45.	13.	115.	69.	99.	140.	1.	0.
1199.	0.561	41.	28.	109.	91.	51.	128.	1.	0.
1200.	0.570	40.	9.	107.	65.	87.	165.	0.	0.
1201.	0.557	52.	9.	110.	65.	62.	142.	0.	0.
1202.	0.647	53.	15.	105.	66.	76.	168.	0.	0.
1203.	0.580	38.	12.	95.	52.	57.	175.	1.	0.
1204.	0.623	40.	56.	115.	59.	70.	162.	2.	0.
1205.	0.591	45.	33.	107.	59.	84.	157.	0.	0.
1206.	0.607	44.	52.	110.	62.	72.	111.	1.	0.
1207.	0.582	40.	13.	135.	72.	193.	179.	1.	0.
1208.	0.559	44.	29.	100.	55.	401.	170.	3.	0.
1209.	0.495	39.	13.	95.	60.	270.	157.	1.	0.
1210.	0.731	41.	21.	96.	59.	189.	160.	1.	0.
1211.	0.326	43.	7.	88.	51.	50.	197.	1.	0.
1212.	0.529	43.	13.	87.	48.	43.	166.	0.	0.
1213.	0.522	44.	13.	107.	74.	71.	219.	1.	0.
1214.	0.560	40.	12.	100.	59.	51.	178.	2.	0.
1215.	0.500	49.	14.	90.	60.	81.	211.	1.	28.
1216.	0.526	53.	19.	90.	67.	62.	277.	2.	54.
1217.	0.519	41.	17.	117.	93.	77.	227.	2.	10.
1218.	0.499	29.	18.	73.	40.	41.	261.	1.	0.
1219.	1.273	52.	14.	110.	59.	97.	160.	1.	0.
1220.	0.470	54.	5.	87.	71.	62.	177.	1.	0.
1221.	0.535	50.	22.	113.	313.	50.	182.	3.	0.
1222.	0.591	47.	37.	97.	55.	63.	160.	2.	0.
1223.	0.555	45.	28.	114.	137.	54.	160.	2.	0.
1224.	0.489	65.	11.	80.	62.	59.	215.	1.	0.
1225.	0.549	39.	19.	92.	43.	54.	190.	1.	0.
1226.	0.486	33.	13.	90.	45.	56.	176.	1.	0.
1227.	0.530	40.	16.	93.	47.	48.	162.	0.	0.
1228.	0.441	24.	20.	82.	43.	47.	228.	1.	0.
1229.	0.526	41.	11.	56.	60.	47.	169.	1.	0.
1230.	1.706	49.	17.	124.	73.	75.	172.	1.	0.
1231.	1.400	63.	24.	115.	83.	66.	153.	0.	0.
1232.	6.061	63.	14.	115.	67.	82.	174.	1.	0.
1233.	2.616	53.	22.	130.	60.	85.	147.	1.	0.
1234.	0.646	53.	14.	123.	69.	96.	212.	1.	0.

SAMPNUMB	EASTING	NORTHING	CU SED	PB SED	ZN SED	BA SED	FE SED	MN SED	CO SED
1235.	30490.	33299.	30.	110.	230.	295.	5.869	0.394	75.
1236.	30478.	33294.	30.	60.	190.	273.	6.180	0.767	100.
1237.	30396.	33328.	30.	90.	450.	327.	6.308	0.811	232.
1238.	30381.	33312.	25.	80.	590.	632.	9.014	6.091	447.
1239.	31385.	31909.	30.	70.	180.	416.	4.981	0.133	25.
1240.	31489.	31870.	25.	50.	140.	265.	3.899	0.055	14.
1243.	31729.	31792.	30.	70.	650.	303.	5.940	0.217	21.
1245.	31858.	31900.	20.	40.	130.	326.	4.505	0.120	17.
1247.	30206.	32248.	10.	60.	200.	575.	9.203	3.562	144.
1248.	30235.	32659.	25.	70.	260.	444.	5.225	0.212	24.
1249.	30251.	32633.	25.	90.	320.	502.	6.000	0.412	45.
1250.	30260.	32617.	25.	50.	170.	310.	4.553	0.184	26.
1251.	30219.	32144.	15.	110.	320.	313.	6.090	2.553	174.
1252.	30192.	32240.	10.	90.	170.	285.	7.760	0.925	129.
1253.	29560.	32698.	25.	70.	200.	387.	6.369	0.410	104.
1254.	29592.	32694.	25.	50.	120.	360.	5.630	0.422	57.
1255.	29424.	32625.	25.	60.	230.	297.	6.619	0.642	70.
1256.	30980.	31689.	20.	50.	110.	354.	4.486	0.061	14.
1257.	31010.	31689.	20.	40.	130.	312.	4.152	0.062	16.
1258.	29800.	33038.	20.	50.	170.	374.	4.474	0.300	71.
1259.	29770.	33040.	20.	50.	90.	344.	5.009	0.143	42.
1260.	29725.	33110.	25.	60.	170.	373.	4.533	0.238	47.
1261.	29781.	33140.	40.	70.	130.	354.	5.546	0.137	49.
1262.	29708.	33232.	25.	60.	250.	436.	6.[illegible]91	0.627	104.
1263.	29683.	33206.	25.	50.	180.	430.	5.570	0.415	62.
1264.	29536.	33197.	20.	40.	130.	250.	5.750	0.111	42.
1267.	31071.	31495.	[illegible]	50.	140.	420.	4.722	0.073	19.
1268.	31252.	31529.	15.	40.	130.	354.	4.759	0.097	20.
1269.	31300.	31655.	15.	40.	130.	281.	4.156	0.060	16.
1270.	31171.	34322.	35.	80.	170.	406.	6.260	0.499	93.
1271.	30516.	31637.	20.	60.	160.	335.	4.740	0.112	22.
1272.	30440.	31546.	25.	40.	150.	379.	4.950	0.135	20.
1277.	31300.	34022.	25.	50.	290.	427.	5.292	0.355	66.
1278.	31302.	34020.	30.	50.	410.	511.	7.509	0.606	95.
1279.	31345.	34041.	25.	50.	240.	333.	5.14[illegible]	[illegible].325	42.
1280.	31442.	34068.	30.	70.	280.	463.	5.4[illegible]	[illegible]	44.
1281.	31420.	34096.	20.	40.	200.	323.	4.61[illegible]	[illegible]	26.
1282.	[illegible]	34155.	20.	50.	220.	420.	5.120	[illegible].152	29.
1283.	31406.	34257.	30.	120.	230.	427.	5.216	0.130	26.
1285.	31192.	34215.	20.	70.	100.	277.	6.490	0.272	56.
1286.	31199.	34296.	20.	90.	520.	307.	5.793	0.442	113.
1287.	31217.	34152.	20.	130.	800.	373.	7.990	0.755	160.
1288.	31286.	34267.	15.	50.	130.	33[illegible].	3.013	0.849	15.
1290.	30996.	34117.	10.	40.	90.	334.	5.094	0.157	54.
1291.	29704.	32904.	20.	40.	100.	372.	4.721	0.145	31.
1292.	29712.	32904.	15.	50.	100.	443.	6.394	0.664	76.
1293.	29700.	32926.	20.	40.	50.	446.	5.137	0.111	44.
1294.	29636.	33012.	20.	40.	100.	423.	4.813	0.184	35.
1295.	29636.	33012.	20.	40.	100.	418.	5.352	0.180	36.
1296.	30986.	34220.	15.	80.	180.	111.	6.293	0.560	170.
1297.	31022.	34380.	25.	170.	430.	407.	7.347	1.105	319.
1298.	30986.	34318.	15.	80.	100.	229.	5.777	0.414	103.
1299.	30781.	34230.	10.	80.	270.	285.	5.722	0.828	262.
1301.	30929.	33804.	15.	60.	390.	579.	7.505	0.396	83.
1302.	30910.	33881.	15.	60.	340.	460.	7.037	0.335	69.
1303.	31056.	33884.	15.	100.	780.	328.	6.175	0.671	173.
1304.	31050.	33074.	10.	90.	170.	355.	8.386	0.810	243.
1305.	31050.	33874.	10.	90.	160.	116.	7.936	0.811	249.
1306.	30995.	33918.	15.	80.	540.	321.	5.493	0.512	96.
1307.	30995.	33910.	10.	90.	290.	418.	7.117	0.979	247.
1308.	30922.	33918.	15.	80.	250.	237.	5.216	0.345	124.
1309.	30905.	33918.	10.	70.	120.	334.	5.237	0.223	84.
1310.	30860.	33966.	15.	60.	250.	469.	5.731	0.199	61.
1311.	30708.	34028.	10.	40.	210.	277.	5.092	0.121	41.
1312.	30599.	34065.	15.	90.	360.	345.	5.480	0.250	53.
1313.	3[illegible]684.	33746.	15.	60.	710.	623.	6.706	0.154	103.
1314.	308[illegible]6.	33600.	15.	60.	360.	382.	6.541	0.157	94.
1315.	30712.	33634.	15.	40.	140.	308.	5.629	0.113	73.
1316.	30742.	33664.	15.	60.	280.	338.	6.131	0.045	88.
1317.	30742.	33664.	10.	70.	280.	388.	6.775	0.162	92.
1318.	31085.	33610.	15.	130.	160.	398.	9.508	0.238	137.

SAMPNUMB	ZN WATER	CU PAN	PB PAN	ZN PAN	BA PAN	FE PAN	MN PAN	CE PAN	SN PAN
1235.	0.02	17.	24.	198.	472.	8.09	0.170	506.	0.
1236.	0.63	16.	60.	168.	307.	7.32	0.117	2944.	0.
1237.	0.0	15.	35.	354.	418.	7.96	0.233	858.	0.
1238.	0.01	17.	39.	139.	324.	7.84	0.301	1394.	0.
1239.	0.0	111.	352.	332.	476.	9.59	0.063	2644.	116.
1240.	0.01	14.	195.	155.	562.	6.36	0.036	491.	343.
1243.	0.0	110.	634.	333.	1495.	8.66	0.054	444.	251.
1245.	0.0	0.	16.	98.	315.	5.57	0.060	102.	7.
1247.	0.01	0.	33.	89.	370.	5.05	0.061	1975.	0.
1248.	0.02	22.	77.	176.	866.	6.47	0.068	2927.	0.
1249.	0.02	20.	142.	180.	621.	5.99	0.143	5454.	0.
1250.	0.01	13.	33.	114.	1202.	6.02	0.069	1677.	[illegible]
1251.	0.02	4.	24.	95.	428.	5.70	0.071	1864.	0.
1252.	0.02	0.	21.	81.	397.	5.72	0.066	1531.	0.
1253.	0.0	20.	33.	127.	521.	7.11	0.059	1471.	0.
1254.	0.0	24.	23.	103.	502.	7.23	0.089	1329.	7.
1255.	0.02	37.	225.	123.	473.	5.71	0.129	7452.	0.
1256.	0.01	30.	107.	103.	448.	6.41	0.029	431.	173.
1257.	0.05	10.	95.	99.	399.	5.34	0.029	383.	157.
1258.	0.0	10.	27.	99.	492.	5.66	0.047	1142.	1.
1259.	0.08	19.	21.	99.	611.	6.69	0.056	446.	0.
1260.	0.04	15.	24.	140.	547.	6.49	0.062	675.	0.
1261.	0.01	35.	87.	116.	199.	5.82	0.087	3222.	0.
1262.	0.02	6.	34.	114.	331.	5.15	0.085	2553.	3.
1263.	0.03	17.	25.	117.	562.	6.24	0.097	924.	2.
1264.	0.03	8.	10.	105.	558.	6.13	0.023	779.	8.
1267.	0.06	36.	77.	139.	2128.	6.17	0.039	612.	152.
1268.	0.02	15.	10.	112.	452.	6.28	0.034	172.	10.
1269.	0.01	13.	71.	120.	1351.	6.09	0.038	1584.	68.
1270.	0.0	27.	161.	236.	306.	7.21	0.153	4201.	168.
1271.	0.04	18.	258.	180.	201.	4.84	0.049	5509.	24.
1272.	0.01	12.	40.	104.	526.	5.42	0.044	715.	0.
1277.	0.02	13.	43.	180.	493.	6.26	0.088	1618.	0.
1278.	0.01	12.	139.	199.	146.	5.81	0.138	5418.	6.
1279.	0.02	12.	64.	158.	355.	5.95	0.068	3248.	1.
1280.	0.04	13.	22.	170.	538.	6.44	0.055	517.	3.
1281.	0.01	11.	65.	156.	330.	6.14	0.053	2867.	8.
1282.	0.02	12.	161.	163.	290.	5.99	0.059	3500.	331.
1283.	0.02	38.	310.	167.	419.	6.18	0.134	3688.	358.
1285.	0.02	17.	43.	102.	376.	6.14	0.051	2015.	0.
1286.	0.02	18.	54.	254.	375.	5.85	0.115	1879.	0.
1287.	0.02	26.	47.	354.	433.	5.74	0.235	1745.	24.
1288.	0.02	12.	301.	121.	470.	4.83	0.048	6373.	83.
1290.	0.01	0.	74.	101.	264.	6.02	0.039	3656.	8.
1291.	0.0	20.	33.	103.	543.	7.20	0.119	1513.	6.
1292.	0.02	7.	15.	90.	525.	6.19	0.039	736.	6.
1293.	0.02	14.	52.	95.	383.	6.16	0.046	2987.	0.
1294.	0.01	16.	18.	99.	510.	6.38	0.056	708.	2.
1295.	0.0	14.	14.	103.	534.	6.64	0.046	395.	0.
1296.	0.01	4.	83.	117.	233.	5.61	0.047	3862.	0.
1297.	0.04	53.	760.	950.	482.	6.31	0.075	2522.	1.
1298.	0.03	1.	30.	88.	354.	5.15	0.030	1960.	0.
1299.	0.04	0.	28.	127.	448.	5.37	0.048	1559.	2.
1301.	0.01	25.	41.	255.	721.	6.72	0.355	978.	0.
1302.	0.0	29.	80.	238.	488.	8.63	0.133	2178.	0.
1303.	0.05	23.	100.	267.	373.	7.28	0.098	2817.	145.
1304.	0.02	8.	17.	108.	528.	6.61	0.052	792.	0.
1305.	0.02	3.	30.	107.	483.	6.30	0.046	1328.	6.
1306.	0.05	7.	32.	226.	497.	6.33	0.064	1133.	2.
1307.	0.02	3.	34.	134.	491.	6.58	0.083	1293.	1.
1308.	0.0	7.	16.	147.	550.	6.43	0.063	456.	0.
1309.	0.01	6.	19.	131.	541.	6.35	0.041	853.	0.
1310.	0.0	15.	11.	185.	514.	6.99	0.079	1598.	0.
1311.	0.0	12.	84.	181.	310.	6.38	0.095	3738.	9.
1312.	0.0	30.	663.	178.	470.	5.34	0.111	8902.	211.
1313.	0.01	3.	29.	226.	651.	6.36	0.206	1157.	0.
1314.	0.0	56.	148.	183.	139.	6.55	0.127	5819.	0.
1315.	0.01	12.	80.	161.	280.	7.14	0.130	3744.	7.
1316.	0.01	8.	62.	152.	291.	7.11	0.126	3565.	0.
1317.	0.0	13.	62.	123.	302.	5.62	0.071	2108.	3.
1318.	0.01	8.	33.	113.	387.	7.05	0.075	2008.	0.

WN902010 BERWYN DOME DRAINAGE DATA

SAMPNUMB	TI PAN	NI PAN	AS PAN	V SED	CR SED	NI SED	ZR SED	MO SED	SN SED
1235.	0.711	47.	13.	103.	72.	75.	151.	1.	0.
1236.	0.734	55.	10.	112.	60.	104.	163.	1.	0.
1237.	0.807	64.	12.	118.	70.	79.	195.	1.	0.
1238.	1.910	51.	25.	104.	58.	146.	141.	0.	0.
1239.	0.393	102.	83.	117.	72.	65.	206.	2.	0.
1240.	0.454	41.	18.	89.	62.	47.	245.	1.	0.
1243.	0.393	40.	54.	98.	49.	54.	251.	1.	34.
1245.	0.371	27.	12.	92.	53.	44.	318.	1	12.
1247.	0.456	29.	7.	90.	49.	44.	174.	0.	0.
1248.	0.507	41.	15.	111.	65.	49.	250.	1.	0.
1249.	0.493	50.	16.	116.	72.	57.	177.	1.	0.
1250.	0.500	34.	17.	94.	53.	46.	184.	1.	0.
1251.	0.508	33.	14.	75.	37.	49.	204.	0.	0.
1252.	0.471	25.	13.	86.	42.	42.	171.	2.	0.
1253.	0.558	44.	32.	106.	62.	69.	195.	1.	0.
1254.	0.548	43.	21.	107.	59.	52.	201.	1.	0.
1255.	0.527	64.	33.	100.	65.	68.	175.	1.	0.
1256.	0.461	49.	12.	107.	76.	60.	217.	1.	0.
1257.	0.436	41.	13.	94.	72.	63.	186.	1.	0.
1258.	0.486	33.	14.	99.	51.	59.	183.	1.	0.
1259.	0.528	39.	16.	124.	54.	42.	254.	1.	0.
1260.	0.514	36.	16.	102.	53.	50.	248.	2.	0.
1261.	0.471	49.	15.	125.	57.	66.	141.	1.	0.
1262.	0.470	35.	9.	121.	71.	78.	205.	1.	0.
1263.	0.518	39.	15.	122.	61.	63.	187.	0.	0.
1264.	0.581	37.	15.	103.	64.	58.	213.	0.	0.
1267.	0.455	39.	17.	120.	83.	64.	209.	2.	0.
1268.	0.483	31.	16.	112.	67.	52.	197.	1.	0.
1269.	0.477	45.	20.	107.	53.	45.	261.	0.	0.
1270.	0.506	59.	24.	111.	69.	89.	213.	1.	11.
1271.	0.427	53.	12.	99.	77.	59.	220.	2.	0.
1272.	0.426	33.	15.	109.	75.	60.	204.	2.	0.
1277.	0.527	50.	14.	104.	69.	95.	174.	1.	0.
1278.	0.495	84.	16.	116.	54.	192.	171.	4.	0.
1279.	0.518	54.	10.	103.	85.	95.	192.	3.	0.
1280.	0.484	61.	9.	92.	71.	124.	183.	2.	0.
1281.	0.521	51.	11.	97.	68.	76.	189.	1.	0.
1282.	0.484	52.	11.	107.	71.	87.	246.	2.	0.
1283.	0.422	53.	16.	121.	110.	83.	174.	2.	10.
1285.	0.522	40.	21.	111.	69.	70.	168.	2.	0.
1286.	0.542	48.	11.	106.	62.	76.	276.	1.	0.
1287.	0.492	56.	7.	94.	58.	110.	243.	1.	0.
1288.	0.492	58.	10.	100.	73.	69.	171.	1.	0.
1290.	0.521	41.	7.	102.	68.	41.	212.	2.	0.
1291.	0.517	42.	19.	94.	55.	44.	226.	1.	0.
1292.	0.526	31.	11.	112.	69.	54.	139.	1.	0.
1293.	0.506	37.	17.	114.	58.	38.	213.	2.	0.
1294.	0.504	35.	17.	106.	58.	45.	140.	1.	0.
1295.	0.519	36.	16.	119.	61.	52.	152.	2.	0.
1296.	0.528	39.	17.	74.	46.	61.	195.	1.	0.
1297.	0.517	48.	23.	94.	70.	85.	110.	2.	0.
1298.	0.524	31.	3.	90.	84.	64.	290.	1.	0.
1299.	0.534	37.	2.	90.	64.	135.	191.	2.	0.
1301.	0.699	55.	77.	108.	71.	93.	166.	3.	0.
1302.	0.650	64.	113.	103.	63.	74.	160.	2.	0.
1303.	0.589	59.	62.	87.	57.	87.	184.	0.	0.
1304.	0.620	35.	29.	113.	66.	51.	134.	0.	0.
1305.	0.628	38.	32.	115.	56.	62.	146.	2.	0
1306.	0.594	43.	10.	95.	65.	87.	203.	0.	0.
1307.	0.596	42.	26.	104.	66.	87.	167.	1.	0.
1308.	0.594	37.	13.	96.	63.	77.	169.	2.	0.
1309.	0.590	38.	14.	99.	63.	55.	322.	1.	0.
1310.	0.607	46.	44.	106.	72.	64.	199.	1.	0.
1311.	0.576	46.	19.	103.	93.	74.	182.	3.	0.
1312.	0.542	71.	18.	103.	66.	75.	237.	[illegible]	15.
1313.	0.728	41.	16.	112.	59.	86.	219.	3.	0.
1314.	0.597	52.	19.	111.	66.	77.	238.	1.	0.
1315.	0.567	45.	14.	97.	64.	49.	291.	0.	0.
1316.	0.583	42.	12.	99.	67.	57.	312.	1.	0.
1317.	0.606	42.	10.	119.	72.	52.	224.	1.	0.
1318.	0.520	37.	27.	108.	64.	54.	201.	2.	0.

WN902010 DERWTN DOME DRAINAGE DATA

SAMPNUMB	EASTING	NORTHING	CU SED	PB SED	ZN SED	BA SED	FE SED	MN SED	CO SED
1319.	30681.	33742.	20.	60.	270.	395.	5.588	0.130	62.
1320.	30681.	33742.	15.	50.	260.	199.	4.831	0.349	42.
1321.	30660.	33796.	15.	30.	160.	285.	5.124	0.080	11.
1322.	30658.	33770.	25.	50.	330.	357.	6.149	0.675	27.
1323.	30605.	33822.	20.	40.	230.	281.	4.388	0.235	21.
1324.	30479.	33815.	25.	30.	240.	253.	5.441	0.189	21.
1325.	32169.	33634.	20.	60.	380.	192.	3.786	0.136	23.
1326.	30525.	33020.	35.	70.	350.	179.	7.231	0.976	189.
1327.	30520.	33015.	20.	70.	360.	185.	9.508	1.882	186.
1328.	30660.	32976.	35.	40.	240.	254.	7.407	0.708	145.
1329.	30660.	32976.	35.	40.	180.	180.	6.438	0.378	96.
1330.	32229.	33589.	35.	90.	500.	259.	5.157	0.538	69
1331.	32332.	33590.	25.	50.	148.	226.	4.564	0.084	17.
1332.	32332.	33645.	25.	40.	120.	292.	3.981	0.048	9.
1333.	32258.	33687.	30.	50.	340.	283.	5.048	0.144	15.
1334.	32364.	33654.	25.	50.	220.	313.	4.314	0.049	10.
1335.	32309.	33704.	25.	40.	170.	179.	3.950	0.043	9.
1336.	31955.	34288.	30.	70.	200.	297.	3.452	0.052	10.
1338.	31979.	33204.	40.	70.	210.	317.	5.881	0.199	26.
1340.	32882.	33816.	30.	60.	200.	403.	3.390	0.046	13.
1341.	32082.	33816.	35.	60.	210.	356.	3.800	0.049	12.
1342.	32900.	33861.	30.	50.	190.	334.	3.658	0.052	16.
1343.	32464.	33854.	25.	70.	160.	372.	3.501	0.058	12.
1344.	32144.	33784.	35.	70.	200.	439.	4.082	0.063	13.
1345.	31857.	34176.	30.	70.	190.	250.	3.443	0.052	13.
1346.	32064.	34068.	30.	70.	300.	429.	4.260	0.116	21.
1347.	32158.	34112.	25.	80.	248.	264.	3.478	0.052	12.
1349.	32458.	33468.	25.	50.	238.	376.	4.045	0.167	25.
1350.	32460.	33467.	25.	40.	420.	305.	4.762	0.320	65.
1351.	32500.	33361.	25.	30.	170.	233.	4.222	0.145	17.
1352.	32642.	33372.	25.	40.	200.	225.	3.166	0.147	13.
1353.	32726.	33440.	25.	60.	190.	179.	2.695	0.088	18.
1354.	32726.	33440.	25.	60.	210.	196.	3.043	0.097	13.
1355.	32530.	32988.	45.	60.	260.	335.	4.802	0.272	23.
1356.	32510.	32920.	30.	50.	250.	268.	4.662	0.231	19.
1357.	30758.	33079.	30.	50.	170.	207.	6.557	0.353	107.
1358.	30948.	32964.	25.	50.	160.	339.	6.626	0.544	110.
1359.	30948.	32964.	20.	50.	120.	292.	5.698	0.463	91.
1360.	31594.	33192.	20.	30.	120.	315.	6.622	0.196	21.
1361.	32512.	32920.	30.	50.	220.	175.	3.960	0.221	18.
1362.	32555.	32826.	35.	50.	300.	685.	4.812	0.194	17.
1363.	32696.	32828.	20.	30.	160.	339.	3.707	0.061	12.
1364.	32732.	32768.	35.	70.	400.	934.	3.543	0.772	17.
1365.	32248.	33389.	30.	60.	280.	339.	4.726	[illegible]	56.
1366.	32819.	33478.	40.	60.	238.	161.	2.911	0.092	11.
1367.	32819.	33478.	35.	70.	200.	106.	3.081	0.083	15.
1368.	32623.	33466.	45.	70.	310.	168.	3.699	0.141	34.
1371.	32127.	33021.	30.	40.	160.	149.	4.814	0.102	17.
1374.	32294.	33311.	25.	50.	280.	174.	3.866	0.311	37.
1375.	32144.	33235.	25.	60.	310.	255.	4.803	0.215	24.
1376.	32455.	33162.	25.	50.	150.	151.	5.211	0.159	19.
1377.	32404.	33080.	45.	80.	250.	211.	6.290	0.291	23.
1378.	32305.	32955.	30.	60.	160.	194.	6.297	0.119	17.
1380.	32404.	32504.	20.	60.	140.	233.	2.925	0.063	10.
1381.	31060.	33460.	25.	70.	230.	246.	6.098	0.545	59.
1382.	30049.	32994.	15.	40.	70.	248.	4.135	0.030	7.
1383.	30098.	32955.	15.	80.	130.	393.	7.509	0.852	64.
1384.	31078.	33167.	35.	80.	220.	92.	6.401	0.584	117.
1385.	31038.	33167.	40.	80.	200.	310.	6.742	0.718	138.
1386.	33488.	32446.	15.	40.	140.	124.	3.465	0.047	10.
1387.	32293.	32179.	25.	60.	140.	283.	4.665	0.082	15.
1391.	30950.	33465.	30.	70.	200.	125.	5.751	0.466	45.
1392.	30950.	33465.	30.	60.	160.	219.	5.725	0.440	34.
1393.	30944.	33460.	30.	70.	240.	320.	7.470	0.788	105.
1394.	30974.	33454.	40.	70.	200.	324.	7.802	0.516	118.
1395.	32316.	33137.	30.	60.	200.	279.	6.130	0.236	20.
1396.	30437.	33978.	25.	60.	210.	232.	5.394	0.422	37.
1397.	30202.	32457.	20.	70.	200.	271.	5.331	0.720	67.
1398.	30284.	32453.	20.	60.	120.	396.	6.388	0.747	73.
1399.	29878.	33393.	30.	60.	240.	266.	5.908	0.348	41.
1400.	29873.	33390.	25.	60.	200.	460.	4.637	0.529	42.

MN902010 BERWYN DOME DRAINAGE DATA

SAMPNUMB	ZN WATER	CU PAN	PB PAN	ZN PAN	BA PAN	FE PAN	MN PAN	CE PAN	SN PAN
1319.	0.01	12.	31.	166.	470.	7.06	0.150	899.	4.
1320.	0.01	16.	58.	175.	359.	7.24	0.164	2682.	0.
1321.	0.0	13.	517.	155.	470.	4.81	0.110	9987.	13.
1322.	0.01	15.	43.	183.	424.	7.08	0.183	1787.	7.
1323.	0.0	8.	136.	180.	298.	6.41	0.230	5004.	0.
1324.	0.0	36.	618.	184.	237.	4.25	0.202	10859.	118.
1325.	0.10	15.	122.	261.	475.	5.92	0.085	308.	176.
1326.	0.01	16.	186.	163.	470.	6.46	0.177	6523.	2.
1327.	0.0	14.	148.	125.	116.	7.39	0.171	5040.	0.
1328.	0.0	16.	48.	153.	350.	7.60	0.142	2204.	0.
1329.	0.0	17.	47.	151.	333.	7.42	0.135	2178.	2.
1330.	0.01	46.	159.	303.	540.	6.31	0.116	596.	427.
1331.	0.0	27.	114.	149.	439.	6.62	0.059	5162.	224.
1332.	0.03	44.	332.	147.	327.	6.40	0.052	2227.	876.
1333.	0.0	10.	69.	268.	474.	6.90	0.094	690.	29.
1334.	0.01	64.	144.	213.	405.	6.07	0.048	1340.	82.
1335.	0.01	9.	61.	157.	483.	5.96	0.048	551.	41.
1336.	0.0	16.	102.	163.	339.	6.35	0.078	3232.	37.
1338.	0.0	64.	59.	159.	500.	8.24	0.135	954.	33.
1340.	0.0	133.	199.	226.	736.	8.44	0.068	1817.	264.
1341.	0.0	59.	240.	203.	593.	8.63	0.076	2082.	446.
1342.	0.01	29.	168.	215.	533.	6.93	0.084	1928.	243.
1343.	0.0	24.	122.	153.	604.	6.38	0.065	2125.	88.
1344.	0.0	25.	82.	235.	683.	7.22	0.060	163.	42.
1345.	0.0	15.	233.	149.	574.	6.23	0.048	1858.	105.
1346.	0.0	16.	23.	191.	839.	6.17	0.049	198.	3.
1347.	0.14	15.	45.	209.	673.	6.08	0.048	319.	3.
1349.	0.01	22.	38.	231.	345.	7.31	0.115	918.	3.
1350.	0.0	119.	8.	176.	267.	4.75	0.096	221.	0.
1351.	0.02	4.	29.	66.	108.	11.42	0.082	868.	9.
1352.	0.0	0.	7.	42.	164.	5.49	0.045	139.	20.
1353.	0.02	11.	516.	105.	285.	15.87	0.111	1088.	131.
1354.	0.02	78.	252.	63.	199.	10.36	0.048	609.	424.
1355.	0.01	16.	134.	128.	218.	5.41	0.108	773.	135.
1356.	0.0	70.	432.	140.	339.	9.12	0.251	1160.	27.
1357.	0.0	21.	306.	162.	470.	6.61	0.161	7826.	108.
1358.	[illegible]	12.	578.	147.	470.	5.53	0.142	8899.	0.
1359.	0.0	10.	573.	150.	470.	4.50	0.177	10832.	0.
1360.	0.01	3.	0.	126.	527.	7.57	0.146	166.	2.
1361.	0.0	55.	202.	128.	537.	7.44	0.171	1336.	28.
1362.	0.02	384.	283.	149.	137728.	5.95	0.108	996.	289.
1363.	0.43	2.	38.	95.	2392.	3.57	0.051	436.	35.
1364.	0.44	309.	497.	4935.	8371.	19.48	0.081	239.	272.
1365.	0.01	19.	113.	168.	478.	6.14	0.104	446.	214.
1366.	0.01	96.	431.	112.	305.	11.44	0.071	1738.	467.
1367.	0.0	61.	641.	117.	288.	19.11	0.106	2398.	354.
1368.	0.03	244.	207.	129.	228.	8.02	0.879	553.	158.
1371.	0.02	11.	65.	160.	434.	8.13	0.226	1503.	49.
1374.	0.01	14.	31.	192.	553.	6.41	0.171	349.	13.
1375.	0.02	7.	11.	185.	541.	6.71	0.134	222.	0.
1376.	0.03	13.	118.	138.	311.	6.78	0.134	2822.	0.
1377.	0.0	39.	243.	193.	485.	8.09	0.223	1531.	155.
1378.	0.03	17.	306.	168.	151.	8.11	0.228	5744.	299.
1380.	0.0	6.	27.	109.	296.	4.64	0.048	520.	5.
1381.	0.02	9.	34.	144.	437.	7.76	0.140	1209.	7.
1382.	0.04	11.	378.	77.	470.	2.68	0.039	9216.	0.
1383.	0.01	2.	30.	79.	385.	5.28	0.066	1793.	0.
1384.	0.0	20.	212.	178.	470.	6.74	0.172	6010.	0.
1385.	0.0	19.	286.	167.	470.	6.16	0.178	7908.	0.
1386.	0.0	53.	556.	265.	508.	5.06	0.040	1461.	396.
1387.	0.01	24.	69.	155.	484.	7.78	0.082	362.	78.
1391.	0.01	20.	36.	136.	479.	7.47	0.194	1193.	0.
1392.	0.07	21.	44.	151.	432.	7.80	0.217	1631.	0.
1393.	0.01	11.	21.	135.	437.	7.59	0.167	1663.	0.
1394.	0.0	34.	28.	159.	472.	7.77	0.193	1026.	2.
1395.	0.0	74.	97.	220.	555.	8.41	0.160	1282.	75.
1396.	0.02	12.	69.	136.	369.	7.09	0.113	1982.	0.
1397.	0.03	7.	72.	102.	235.	5.49	0.082	3947.	0.
1398.	0.04	12.	37.	97.	442.	5.91	0.037	2302.	0.
1399.	0.03	17.	91.	115.	225.	5.37	0.124	4341.	0.
1400.	0.02	12.	48.	127.	353.	5.32	0.132	2701.	1.

SAMPNUMB	TI PAN	NI PAN	AS PAN	V SED	CR SED	NI SED	ZR SED	MO SED	SN SED
1319.	0.571	41.	12.	100.	65.	55.	227.	0.	0.
1320.	0.589	45.	16.	92.	44.	46.	202.	1.	9.
1321.	0.929	90.	39.	124.	24.	38.	357.	1.	4.
1322.	0.607	41.	20.	121.	37.	56.	245.	1.	0.
1323.	0.591	47.	22.	93.	40.	44.	291.	1.	0.
1324.	0.850	102.	19.	111.	42.	48.	226.	1.	14.
1325.	0.425	32.	15.	84.	39.	43.	270.	1.	11.
1326.	0.712	64.	11.	106.	30.	77.	140.	0.	0.
1327.	0.992	58.	26.	126.	46.	70.	165.	1.	0.
1328.	0.704	52.	12.	131.	49.	84.	204.	0.	0.
1329.	0.672	52.	13.	108.	51.	55.	162.	6.	0.
1330.	0.504	40.	17.	118.	31.	53.	276.	2.	16.
1331.	0.501	35.	17.	118.	36.	36.	222.	1.	0.
1332.	0.475	37.	15.	91.	46.	29.	359.	1.	7.
1333.	0.460	37.	19.	100.	53.	42.	276.	1.	9.
1334.	0.425	45.	11.	127.	72.	42.	231.	2.	7.
1335.	0.429	37.	10.	137.	52.	35.	250.	2.	0.
1336.	0.496	55.	12.	135.	66.	43.	394.	1.	0.
1338.	0.563	50.	12.	170.	78.	63.	186.	1.	12.
1340.	0.473	59.	16.	133.	65.	42.	309.	1.	12.
1341.	0.469	63.	15.	141.	67.	46.	234.	1.	15.
1342.	0.460	60.	10.	145.	74.	52.	245.	1.	13.
1343.	0.481	53.	14.	136.	69.	51.	241.	1.	7.
1344.	0.470	55.	16.	94.	83.	55.	301.	2.	22.
1345.	0.482	53.	8.	158.	68.	50.	253.	2.	12.
1346.	0.489	53.	7.	95.	89.	81.	248.	2.	5.
1347.	0.484	54.	7.	79.	65.	47.	220.	1.	9.
1349.	0.500	42.	30.	80.	52.	43.	262.	1.	0.
1350.	0.206	22.	50.	98.	51.	65.	235.	1.	0.
1351.	0.422	18.	54.	86.	65.	40.	367.	1.	0.
1352.	0.178	7.	12.	62.	71.	33.	579.	1.	0.
1353.	0.360	20.	64.	51.	73.	24.	565.	2.	0.
1354.	0.186	32.	60.	65.	56.	30.	414.	1.	13.
1355.	0.297	25.	22.	97.	67.	56.	347.	1.	21.
1356.	0.310	34.	33.	85.	68.	46.	400.	1.	[illegible]
1357.	0.789	63.	12.	130.	63.	61.	134.	0.	0.
1358.	0.540	71.	7.	105.	60.	73.	175.	1.	19.
1359.	0.492	91.	11.	95.	40.	50.	193.	0.	0.
1360.	0.563	47.	8.	126.	84.	57.	256.	0.	0.
1361.	0.333	28.	37	77.	61.	44.	415.	1.	14.
1362.	0.245	28.	23.	89.	56.	54.	372.	2.	15.
1363.	0.299	15.	19.	61.	64.	43.	720.	1.	9.
1364.	0.150	211.	22.	59.	76.	62.	924.	2.	0.
1365.	0.452	34.	51.	92.	51.	40.	273.	2.	10.
1366.	0.266	19.	53.	65.	51.	33.	541.	1.	10.
1367.	0.301	22.	71.	63.	71.	40.	436.	2.	10.
1368.	0.250	22.	36.	95.	49.	43.	406.	1.	23.
1371.	0.545	57.	16.	91.	39.	50.	184.	0.	0.
1374.	0.524	37.	22.	75.	30.	35.	231.	1.	9.
1375.	0.516	42.	14.	91.	40.	57.	238.	1.	0.
1376.	0.467	49.	21.	97.	41.	57.	223.	1.	0.
1377.	0.550	52.	13.	121.	50.	65.	221.	1.	11.
1378.	0.532	66.	14.	104.	55.	60.	185.	1.	0.
1380.	0.262	19.	10.	61.	38.	27.	184.	1.	0.
1381.	0.567	49.	11.	106.	56.	63.	154.	0.	0.
1382.	0.385	61.	10.	100.	30.	34.	247.	2.	0.
1383.	0.475	29.	15.	98.	46.	29.	249.	0.	0.
1384.	0.560	65.	11.	111.	67.	55.	160.	1.	43.
1385.	0.552	60.	12.	108.	63.	65.	141.	0.	30.
1386.	0.317	23.	12.	60.	81.	22.	225.	0.	0.
1387.	0.500	39.	16.	86.	60.	39.	187.	0.	0.
1391.	0.560	40.	15.	97.	40.	50.	138.	0.	0.
1392.	0.550	51.	10.	93.	50.	53.	139.	0.	0.
1393.	0.561	49.	10.	104.	70.	89.	166.	1.	0.
1394.	0.586	50.	13.	89.	49.	66.	211.	0.	0.
1395.	0.540	53.	12.	99.	61.	56.	145.	1.	0.
1396.	0.679	[illegible]	15.	89.	57.	41.	187	0.	0.
1397.	0.461	37.	21.	70.	40.	34.	234	1.	0.
1398.	0.511	37.	10.	90.	50.	70.	[illegible]	1.	1.
1399.	0.490	44.	16.	76.	52.	33.	143.	1.	0.
1400.	0.479	35.	12.	101.	54.	46.	205.	2.	0.

SAMPNUMB	EASTING	NORTHING	CU SED	PB SED	ZN SED	BA SED	FE SED	MN SED	CO SED
1400.	32052.	32752.	35.	60.	160.	277.	5.098	0.314	21.
1411.	29776.	32134.	25.	70.	39[illegible].	293.	6.120	0.704	80.
1412.	29496.	32202.	20.	60.	90.	280.	5.451	0.161	33.
1413.	31578.	34024.	30.	80.	700.	340.	5.708	0.727	123.
1415.	31584.	34130.	20.	60.	270.	214.	3.989	0.209	39.
1416.	31603.	34233.	25.	60.	210.	208.	3.780	0.076	20.
1417.	31603.	34233.	30.	70.	230.	238.	3.911	0.099	22.
1451.	31970.	32025.	25.	40.	130.	225.	4.636	0.130	17.
1452.	31779.	32086.	20.	40.	120.	221.	5.105	0.077	18.
1453.	31934.	32276.	20.	50.	100.	260.	5.153	0.102	10.
1454.	31771.	32341.	20.	40.	110.	301.	4.835	0.114	20.
1457.	29910.	33635.	25.	40.	110.	196.	4.277	0.063	16.
1459.	30330.	33614.	30.	100.	250.	327.	5.964	0.341	46.
1462.	30776.	34305.	55.	160.	280.	285.	5.636	0.107	60.
1463.	32064.	34008.	25.	80.	200.	258.	4.102	0.069	15.
1464.	31532.	32097.	20.	40.	120.	236.	4.377	0.067	18.
1465.	31444.	32400.	30.	60.	290.	276.	5.938	0.307	42.
1466.	31308.	32518.	50.	400.	450.	364.	5.749	0.296	39.
1469.	30966.	32514.	25.	100.	220.	198.	6.156	0.254	24.
1481.	30320.	31563.	20.	40.	190.	288.	4.894	0.176	24.
1482.	30470.	31694.	20.	40.	130.	251.	3.796	0.102	16.
1483.	30642.	31808.	20.	40.	130.	254.	4.271	0.163	27.
1503.	29941.	32435.	25.	70.	118.	700.	6.288	1.471	101.
1512.	29550.	32642.	30.	50.	170.	701.	6.768	0.346	35.
1515.	29600.	32102.	15.	60.	270.	613.	8.675	4.530	214.
1519.	32528.	32066.	35.	50.	270.	563.	3.714	0.362	22.
1523.	30610.	31886.	15.	40.	180.	479.	4.842	0.297	42.
1526.	30624.	31895.	15.	50.	280.	581.	6.049	0.525	98.
1528.	32654.	32834.	40.	70.	400.	1535.	5.706	0.369	29.
1530.	32672.	32708.	15.	40.	320.	1663.	3.485	0.220	17.
1533.	32570.	32648.	15.	40.	530.	994.	3.869	0.255	10.
1534.	30330.	32892.	25.	50.	270.	642.	6.727	0.272	43.
1539.	32364.	32394.	30.	40.	150.	722.	5.665	0.193	25.
1547.	32521.	32526.	15.	50.	120.	540.	3.995	0.232	18.
1550.	32150.	32436.	20.	40.	130.	767.	5.417	0.206	27.
1583.	30800.	32345.	20.	40.	170.	638.	5.453	0.241	28.
1584.	30396.	32221.	20.	40.	100.	435.	4.411	0.373	58.
1592.	29558.	32134.	20.	40.	220.	402.	6.604	2.351	123.
1593.	29562.	32048.	10.	50.	100.	677.	8.647	0.795	78.
1610.	29415.	32029.	10.	50.	140.	711.	11.051	1.320	79.
1611.	29373.	32123.	15.	30.	190.	675.	19.770	6.147	290.
1615.	30216.	32570.	15.	30.	90.	714.	4.460	0.164	30.
1616.	30235.	32721.	20.	40.	320.	986.	4.574	0.415	37.
1617.	30226.	32636.	15.	30.	120.	1279.	4.789	0.151	34.
-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.000	-1.000	-1.

WN902810 BERWYN DOME DRAINAGE DATA

SAMPNUMB	ZN WATER	CU PAN	PB PAN	ZN PAN	BA PAN	FE PAN	MN PAN	CE PAN	SN PAN
1400.	0.0	166.	166.	160.	300.	8.22	0.157	2631.	270.
1411.	0.0	21.	16.	126.	510.	5.78	0.154	629.	33.
1412.	0.0	11.	50.	86.	318.	5.33	0.035	3012.	0.
1413.	0.0	15.	13.	261.	628.	6.14	0.100	179.	0.
1415.	0.0	15.	50.	201.	503.	6.10	0.119	2172.	2.
1416.	0.0	16.	48.	175.	531.	6.22	0.055	730.	32.
1417.	0.0	13.	42.	170.	534.	6.31	0.055	797.	23.
1451.	0.01	24.	107.	176.	296.	6.75	0.033	2107.	101.
1452.	0.01	0.	27.	111.	359.	7.35	0.040	89.	10.
1453.	0.01	53.	78.	1214.	374.	9.60	0.061	1259.	21.
1454.	0.02	21.	59.	130.	352.	7.77	0.050	794.	23.
1457.	0.02	6.	36.	83.	359.	5.45	0.029	913.	10.
1459.	0.01	29.	128.	131.	371.	7.15	0.124	2735.	37.
1462.	0.02	1229.	150.	447.	372.	11.02	0.038	929.	125.
1463.	0.01	20.	94.	218.	804.	6.67	0.056	1503.	127.
1464.	0.02	30.	36.	119.	394.	7.40	0.036	153.	27.
1465.	0.09	18.	832.	172.	470.	3.27	0.173	10636.	47.
1466.	0.03	33.	580.	268.	209.	7.38	0.137	5600.	221.
1469.	0.02	45.	1119.	184.	384.	7.41	0.080	2217.	64.
1481.	0.01	14.	34.	94.	279.	5.10	0.040	1496.	7.
1482.	0.01	10.	18.	80.	241.	5.15	0.034	275.	4.
1483.	0.01	18.	43.	86.	354.	6.45	0.038	514.	1.
1503.	0.02	41.	31.	99.	470.	5.28	0.087	20000.	0.
1512.	0.01	36.	38.	117.	454.	8.19	0.282	5282.	0.
1515.	0.01	34.	11.	108.	470.	4.31	0.424	15000.	0.
1519.	0.01	559.	65.	135.	1802.	6.73	0.124	441.	45.
1523.	0.01	21.	15.	181.	513.	7.53	0.076	2280.	1.
1526.	0.01	33.	23.	143.	317.	6.52	0.069	1187.	18.
1528.	0.11	63.	623.	133.	47430.	4.99	0.074	4229.	426.
1530.	0.03	103.	75.	309.	5423.	3.81	0.033	1649.	38.
1531.	0.02	6.	101.	510.	5842.	4.05	0.040	3946.	54.
1534.	0.01	34.	31.	227.	308.	7.30	0.127	5980.	9.
1539.	0.01	29.	184.	207.	506.	7.28	0.074	2825.	44.
1547.	0.02	15.	55.	141.	288.	4.54	0.038	1389.	29.
1550.	0.03	35.	92.	124.	393.	6.50	0.074	1166.	45.
1583.	0.0	21.	155.	176.	15780.	7.41	0.111	8321.	389.
1584.	0.01	18.	21.	108.	443.	7.61	0.072	627.	45.
1592.	0.09	54.	18.	112.	114.	6.51	0.134	12187.	4.
1593.	0.09	36.	12.	107.	397.	7.10	0.063	2131.	2.
1610.	0.08	4.	18.	101.	398.	8.34	0.271	433.	0.
1611.	0.08	10.	9.	127.	466.	8.89	0.227	1603.	0.
1615.	0.06	21.	28.	102.	1664.	5.87	0.096	7230.	0.
1615.	0.06	23.	22.	220.	441.	6.70	0.117	8029.	1.
1617.	0.04	21.	25.	135.	5814.	6.80	0.048	563.	0.
-1.	-1.00	-1.	-1.	-1.	-1.	-1.00	-1.000	-1.	-1.

UN902810 BERWYN DOME DRAINAGE DATA

SAMPNUMB	TI PAN	NI PAN	AS PAN	V SED	CR SED	NI SED	ZR SED	MO SED	SN SED
1408.	0.515	53.	20.	94.	53.	45.	204.	1.	0.
1411.	0.461	32.	18.	106.	50.	87.	193.	1.	10.
1412.	0.498	35.	11.	118.	60.	43.	232.	2.	8.
1413.	0.517	76.	8.	98.	49.	150.	214.	1.	0.
1415.	0.515	59.	8.	84.	38.	77.	258.	1.	0.
1416.	0.489	50.	10.	82.	51.	59.	292.	1.	8.
1417.	0.489	51.	13.	82.	52.	63.	306.	1.	9.
1451.	0.598	37.	17.	88.	56.	46.	218.	3.	9.
1452.	0.560	32.	12.	108.	51.	46.	231.	3.	0.
1453.	0.503	40.	34.	105.	56.	49.	232.	4.	0.
1454.	0.599	30.	16.	97.	53.	38.	225.	3.	0.
1457.	0.583	28.	7.	107.	62.	46.	200.	3.	0.
1459.	1.727	40.	16.	120.	71.	56.	254.	4.	14.
1462.	0.594	60.	53.	124.	63.	58.	267.	5.	15.
1463.	0.581	49.	8.	98.	74.	63.	231.	3.	9.
1464.	0.608	33.	19.	95.	56.	39.	268.	3.	7.
1465.	0.497	110.	8.	109.	65.	78.	196.	4.	7.
1466.	0.787	54.	12.	119.	67.	78.	215.	4.	20.
1469.	0.613	39.	33.	121.	67.	63.	180.	4.	13.
1481.	0.522	27.	14.	109.	55.	49.	234.	3.	7.
1482.	0.489	26.	18.	91.	54.	42.	268.	3.	0.
1483.	0.567	37.	16.	91.	54.	56.	246.	4.	0.
1503.	0.553	80.	22.	121.	86.	61.	428.	1.	0.
1512.	0.616	58.	31.	143.	95.	73.	286.	0.	7.
1515.	0.482	101.	18.	117.	65.	89.	411.	0.	0.
1519.	0.208	29.	41.	61.	54.	42.	622.	1.	6.
1523.	0.737	53.	17.	96.	82.	56.	513.	-0.	0.
1526.	0.551	39.	14.	134.	73.	60.	533.	2.	0.
1528.	0.374	31.	20.	89.	103.	57.	716.	1.	49.
1530.	0.433	21.	21.	68.	131.	34.	1735.	1.	11.
1531.	0.318	19.	28.	60.	92.	34.	1474.	2.	0.
1534.	0.645	54.	20.	154.	89.	60.	492.	0.	0.
1539.	0.537	43.	14.	129.	87.	50.	458.	1.	0.
1547.	0.340	18.	9.	85.	48.	31.	470.	2.	0.
1550.	0.486	31.	3.	135.	82.	45.	531.	1.	0.
1583.	0.577	62.	13.	125.	98.	64.	319.	1.	0.
1584.	0.679	44.	13.	98.	75.	47.	632.	1.	0.
1592.	0.583	51.	21.	105.	74.	80.	437.	1.	0.
1593.	0.608	39.	16.	103.	70.	48.	309.	1.	0.
1610.	0.550	30.	29.	93.	83.	52.	347.	3.	0.
1611.	0.602	53.	15.	78.	80.	68.	228.	0.	13.
1615.	0.560	43.	19.	104.	70.	46.	308.	0.	0.
1616.	0.624	48.	19.	97.	80.	60.	333.	0.	0.
1617.	0.612	41.	25.	122.	85.	54.	303.	0.	3.
-1.	-1.000	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.