Natural Environment Research Council

BRITISH GEOLOGICAL SURVEY

Mineral Reconnaissance Programme Report

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Mineral investigations near Bodmin, Cornwall. Part 5—The Castle-an-Dinas wolfram lode

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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.

The British Geological Survey is a component body of the Natural Environment Research Council.

Bibliographic reference

Beer, K. E., and **others.** 1986. Mineral investigations near Bodmin, Cornwall. Part 4—Drilling at Royalton Farm *Mineral Reconnaissance Programme Rep. Br. Geol. Surv.*, No. 82.

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SUMMARY

A gridded soil survey to the south of Castle-an-Dinas Wolfram Mine produced a pattern of anomalies indicative of at least two sub-parallel zones of tungsten veining extending some 300 m south of the St. Columb-Belowda road. Between the Royalton elvan and the northern edge of the Goss Moor alluvium there is a broad area of anomalously high tin values. Percussive drilling later confirmed widespread tin mineralisation beneath the soil anomaly but in the case of tungsten the in-situ mineralisation was confined almost entirely to one zone and in that to within about 50 m south of the road. This zone can be correlated with the Wolfram Lode in the mine.

To the north of the former workings three sets of traverses, spaced out over a projected strike stretching about 1100 m from the most northerly stoping, were also sampled from fairly short percussive drillholes. Over this distance it was possible to trace two zones of tungsten-tin mineralisation, sometimes with copper, one correlatable with the Wolfram Lode and the other sub-parallel and some 90 m to the west.

Close to surface these lode extensions are sub-economic but, from the evidence accumulated to date, it appears that viable ore grades are located only in the metamorphosed slates within about 200 m from the granite contact.

It is believed that the potential south of the old workings can be estimated at about 1000 tonnes of recoverable tungsten metal. To the north, however, the strike length of possible mineralisation is less predictable, but there is little doubt that this area offers the better target for exploration.

INTRODUCTION

This report discusses the results of geochemical investigations to the north and south of the Castle-an-Dinas hill [SW 945623*], some 2 km north of the A30 trunk road and 3.5 km east of the town of St. Columb Major (Figure 1). The two areas were examined at different dates and slightly different approaches were adopted at each. Analytical procedures were consistent, however, allowing comparison of the chemical results.

The primary aim was to determine whether the tungsten-tin mineralisation formerly exploited in the Castle-an-Dinas Wolfram Mine could be traced at surface beyond the workings of that mine. From a broader viewpoint the acquisition of further information on the distribution of tungsten and tin would not only permit a better understanding of the factors controlling the disposition of ore concentrations but, perhaps, also indicate potential targets for deeper exploration.

Since the closure of Castle-an-Dinas Mine in 1956 the area has reverted to a wholly agricultural economy with a seasonal interest in tourism. It is well served by minor roads which connect to the A30 Bodmin-Redruth and A39 Wadebridge-Truro routes, and has easy access to industrial services at St. Austell. The nearest railway is the Par-Newquay branch line which here runs parallel and close to the A30.

* All localities quoted in this report lie within the National Grid 100 km square designated SW.

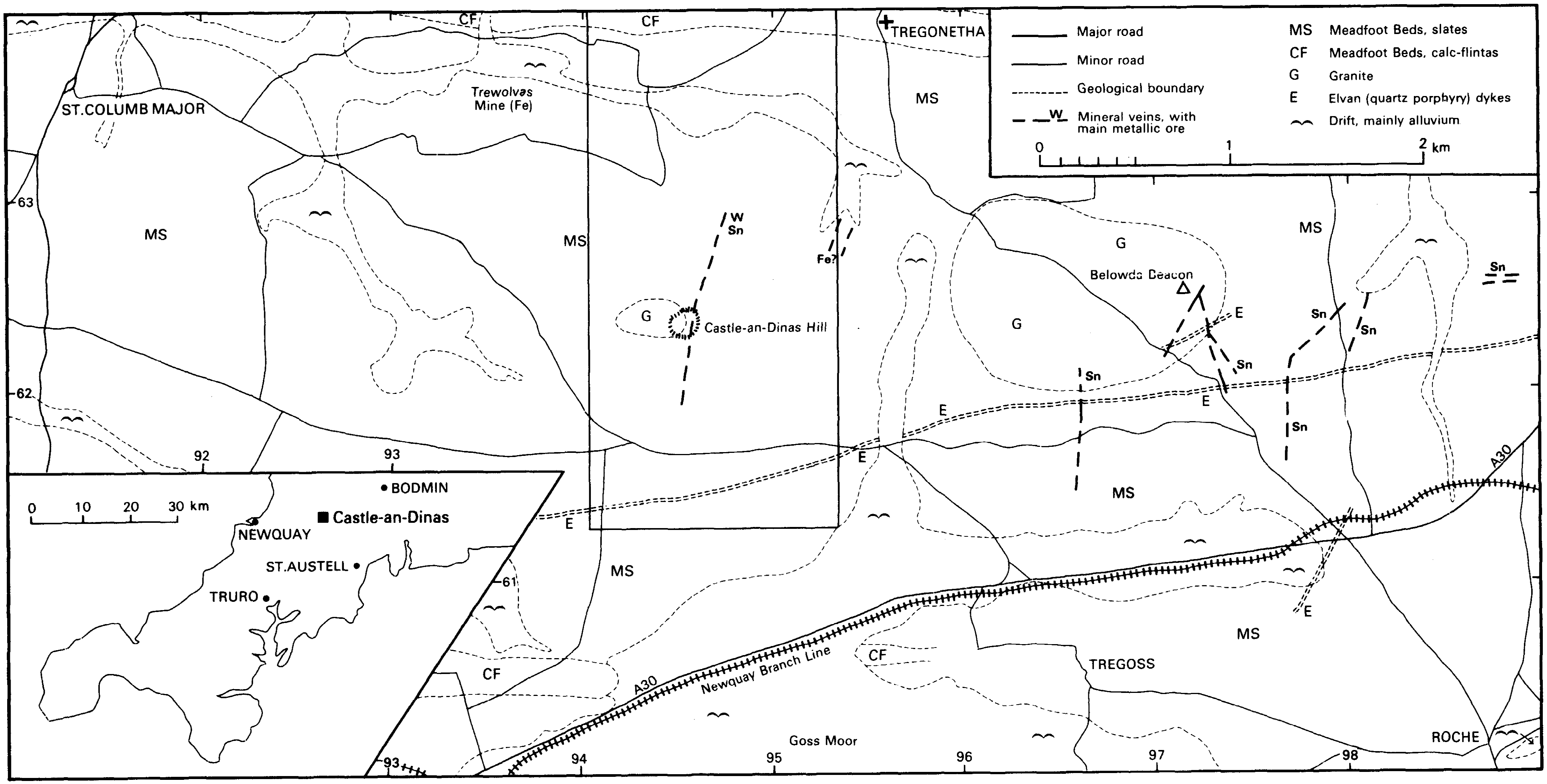

Fig. 1 Location and geology

GEOLOGY AND FORMER MINING

Geological exposure in this area is poor and the form of the granite which crops out around the Castle-an-Dinas hill fort (Figure 1) is known only from the mine records. These show a gently dipping northern contact and a somewhat steeper, but irregular, southern granite contact (Figure 3). Sheet-like apophyses penetrate the enclosing slates,and granite veinlets both follow and traverse the mineral lode (Dines, 1956, pp.521-5).

The granite is intruded into grey slates of the Meadfoot Beds (Lower Devonian) which, for the main part, are soft, well-cleaved and friable. Close to the contact they are thermally metamorphosed and locally are intensely silicified or tourmalinised; similar induration is found in the lode walls. At its most intense development this induration converts the slates to distinctively tough, finely striped, quartz-tourmaline rocks and, adjacent to the lode, locally into a striped quartz-wolframite variant in which wolframite replaces most of the tourmaline.

Immediately north of Criftoe Farm [948639], shown on some maps as Crofthow, an east-west belt of calc-silicate rocks forms a prominent ridge upon which stands the hamlet of Tregonetha [956639]. These rocks probably represent original marls and impure limestones metasomatised by boron and silica-rich emanations from the upwelling St. Austell Granite pluton. Predominantly hard, but brittle and well-jointed, they contain thin interbedded layers of soft and usually dark grey slate.

To the south of Castle-an-Dinas the slates are cut by an elvan dyke which trends slightly north of east and can be traced over a strike length of more than 5 km. It is no longer exposed over its full width but from earlier descriptions it would seem to vary from 10 to 20 m wide with a steep northerly dip. Locally it contains mineralised stringers which have been worked in bulk for tin (Dines, 1956, pp.525-6).

A short distance south of this elvan course the solid geology is obscured by the poorly drained alluvial deposits of Goss Moor. In the past these have been explored by tin-streamers, and parts of the alluvium were extensively worked for cassiterite. Similar streaming activities were carried out in the River Menalhyl which bounds the north and east of Castle-an-Dinas hill.

It was evidence from this streaming which led to the discovery of the Castle-an-Dinas Wolfram Lode in 1915 and to the subsequent development of the mine, the only one in Cornwall sunk primarily for tungsten production. The lode has an unusual north-south strike, is almost vertical and varies from 0.3 to 2 m in width. Most of this width consists of white vein quartz, locally crushed and stained by iron and manganese oxides, with the ore minerals usually developed near its walls. Wolframite is the most prominent ore mineral, occurring as sheaves of generally coarse bladed crystals; the economic parts of the lode seem to have averaged about 0.8 % WO_3. Cassiterite is also present, usually as scattered small crystals associated with, or included in, lode wolframite,and as finer and more disseminated grains in the wall rocks. Arsenic is present in the form of loellingite (there is no arsenopyrite here) occurring as large, irregular clusters, especially close to the granite margin in the deeper mine levels. A variety of minor minerals have been recorded from the lode but the most ubiquitous is brown siderite, found as a late filling in cavities and fractures.

Within the Cornubian mining field this lode is unique in two major respects. Its north-south strike is typically that of the late-stage, low temperature phase of mineralisation which yields ores of Pb, Zn, Ag, Ni, Co, U, Fe and Mn in gangues of calcite, barite, fluorite and chalcedonic quartz.

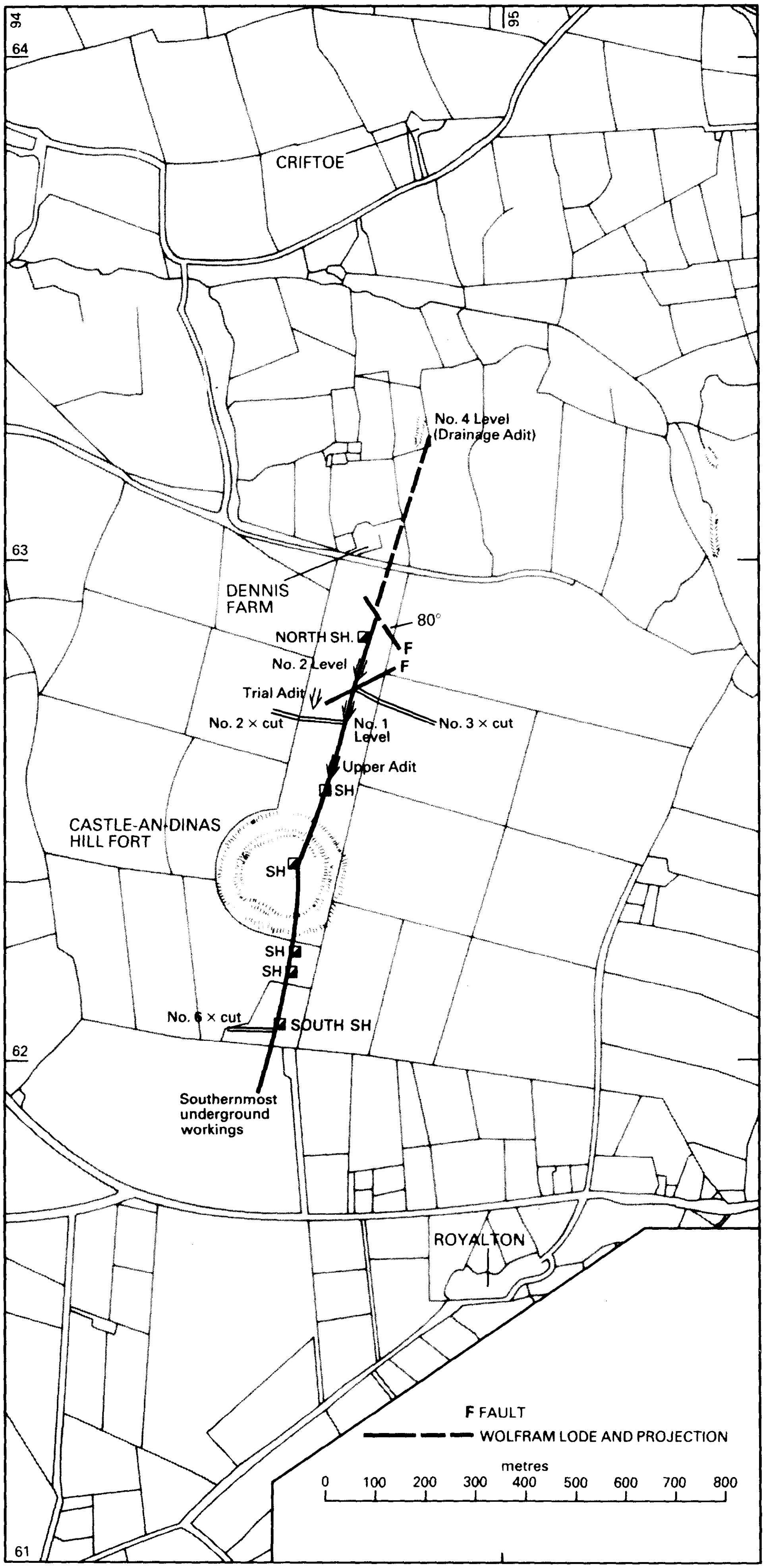

Fig. 2 Castle-an-Dinas area

By contrast the Castle-an-Dinas lode is clearly of high temperature type with an assemblage more characteristic of east-north-easterly veins. More significant in economic terms is its relationship to the granite, the intrusion of which has completely cut off the lode; there is virtually no metalliferous mineralisation within the granite body and the trend of the vein is only vaguely marked by a zone of jointing and alteration. The economically viable ore is concentrated within a zone extending up to 200 m from the granite contact (Figure 3). Not only is the lode of pre-granite age, but it appears that during intrusion of the granite the ore minerals were remobilised, to be concentrated within the existing structure at the margin of the intrusive body.

Castle-an-Dinas Wolfram Mine was developed on eight levels to a depth of 160 m below the hilltop. The uppermost two levels, both adits, and No.4 Level, the drainage adit, emerge on the north side of the hill (Figure 2), and the latter, north-east of Dennis Farm, now provides the only access to the mine. Granite was first encountered in the floor of No. 2 Level and was fully penetrated in Levels 3, 4 and 7.

At the southern end of the workings the lode split into two or three branches which, though narrow, were still well mineralised. Near the northern end of the levels the lode was cut by two east-west faults, each with a lateral displacement of only 4 m, but beyond these the lode was "lost" after meeting another, apparently more major fault.

Reports of wolframite-bearing quartz float in surrounding fields have periodically encouraged speculation about parallel mineralised structures, but crosscuts for 154 m west on No. 2 Level and for 181 m east on No. 3 Level are recorded on the mine plan as being in barren slate.

The mine was never a large operation, producing at best about 260 tonnes of concentrate per year, and its closure was dictated mainly by low tungsten prices, not by the exhaustion of reserves (Hosking and Trounson, 1959). Improvements in the market value of wolframite have periodically renewed interest in the property and in 1977/8 St. Piran Explorations Ltd. drilled three boreholes and undertook limited crosscutting on No. 4 Level to seek the northern continuation of the lode.

The geological setting, lode characteristics and mining history of Castle-an-Dinas Wolfram Mine have been described by Davison (1919 and 1920), Dewey and Dines (1923), Kear (1952) and Dines (1956) and some of the less common minerals were recorded by Russell (1925 and 1944) and by Hey and Bannister (1938).

SOIL GEOCHEMISTRY

Geochemical soil sampling was employed only to the south of the mine workings (Figure 2) and here was confined to the large field east of Blackacre [942615] in order to extend the geochemical coverage reported by Hosking and Montambeault (1956), whose traverses were restricted to an area north of the Belowda - St. Columb road (Figure 6). The present survey provided infill between the road and the northern feather edge of the Goss Moor alluvial tract.

Sampling stations were based on a rectangular grid with north-south lines spaced at 30 m intervals and east-west lines at 20 m intervals. Samples were obtained from about 1 m depth, usually in the C horizon. At this level the sample was commonly grey to yellowish grey clay but in some areas, which proved on analysis to be anomalous in tungsten content, the

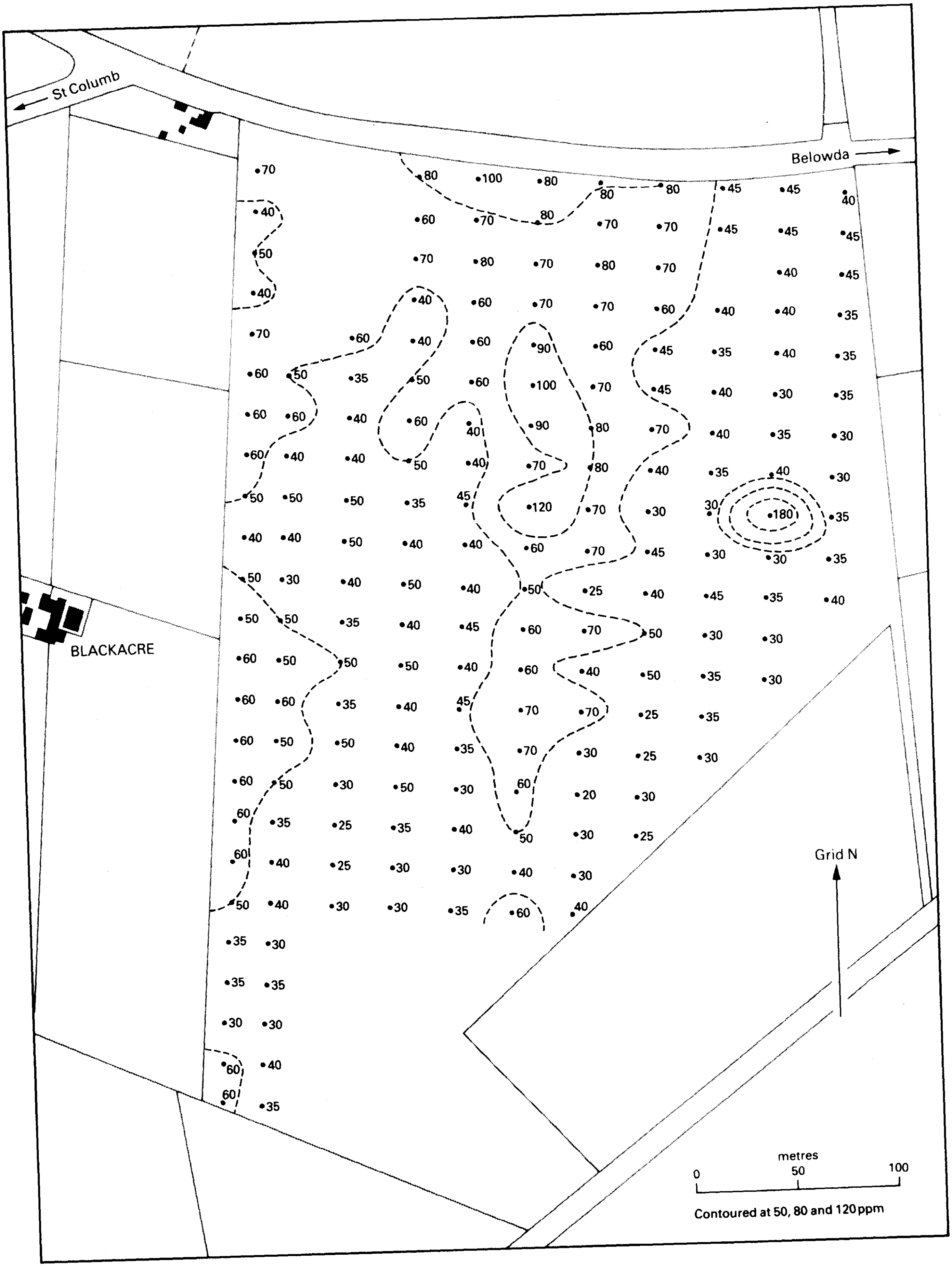

Fig. 4 Geochemical soil grid for tungsten

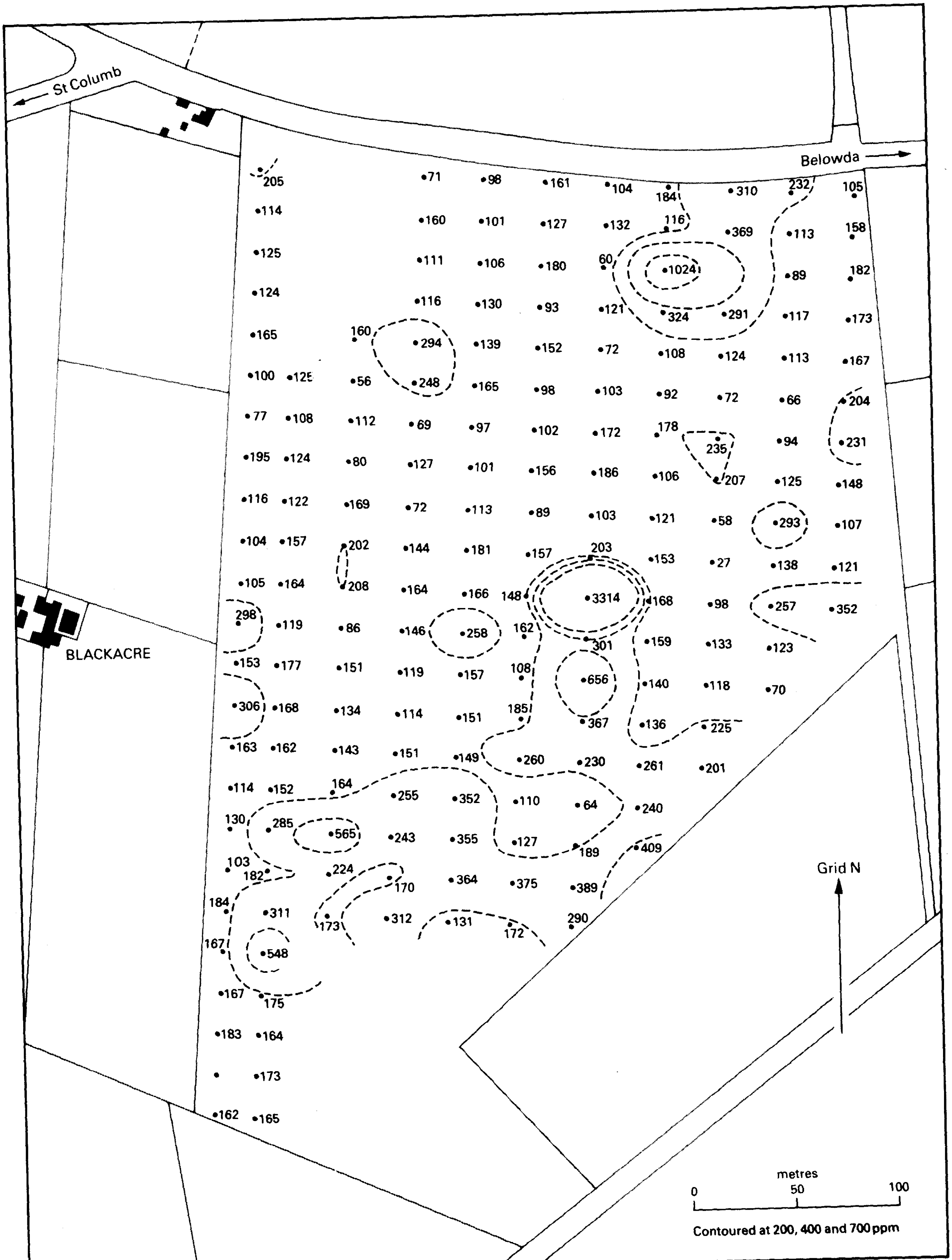

Fig. 5 Geochemical soil grid for tin

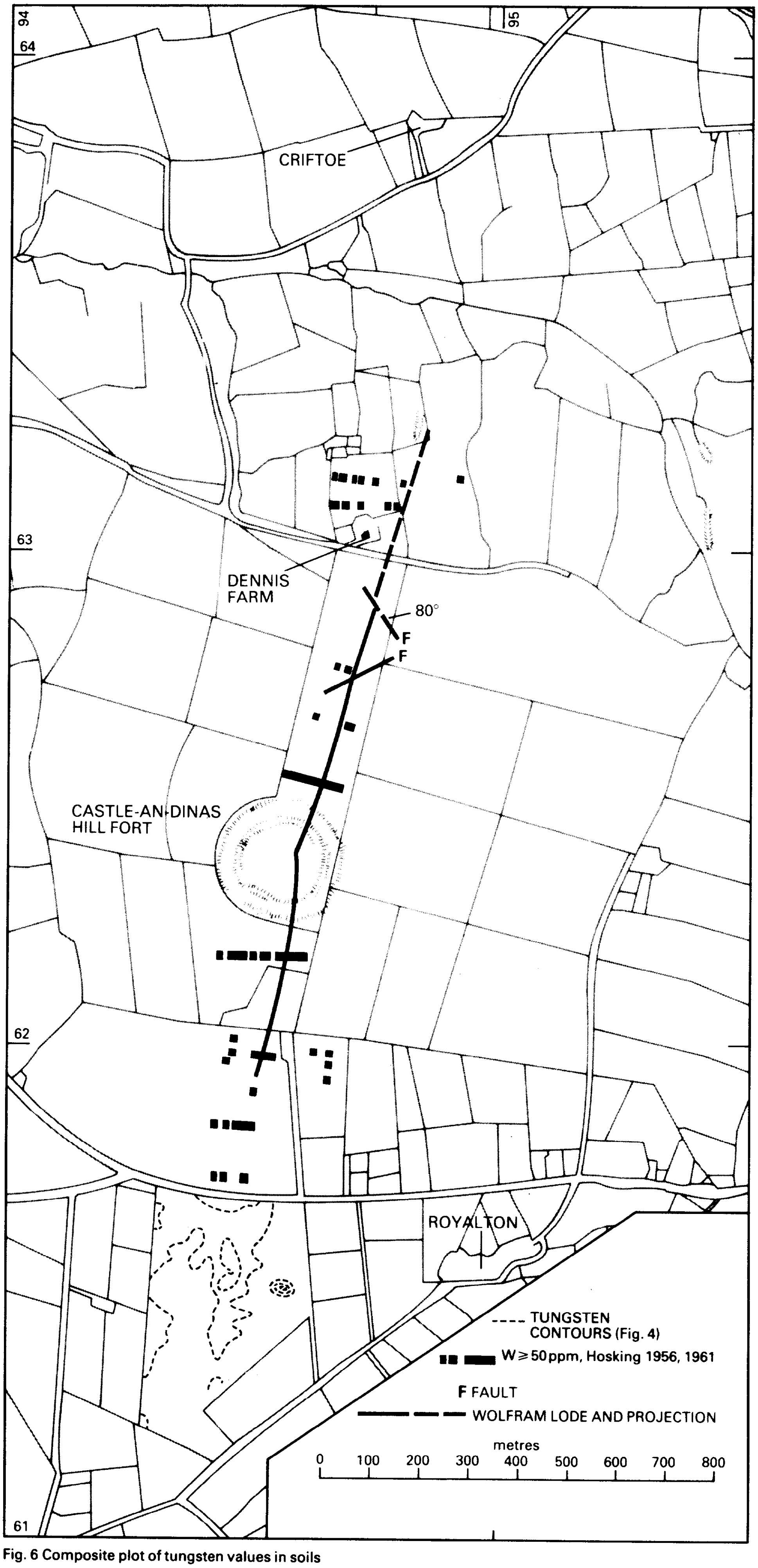

Fig. 6 Composite plot of tungsten values in soils

clay was intensely red in colour. Near the southern corner of the field conditions were very wet and many samples were rejected as unsatisfactory; there was some doubt whether the C horizon was reached in this corner.

After drying and disaggregation the minus 60 mesh (BSS) fraction was ground for analysis. Only tin and tungsten were determined, the former by optical emission spectrography, the latter by colourimetry. Results are plotted in Figures 4 and 5 and are combined with the data from Hosking and Montambeault (1956)and Hosking and Curtis (1961) in Figure 6. Arithmetic means and standard deviations for the 189 samples are: W = 49.1 +/- 19.5 and Sn = 193.7 +/- 253.0 ppm. Log-probability plots provide no clear separation into population groups and, in consequence, contour intervals in these diagrams are set at levels which are controlled by the drillhole analytical results. It must be emphasised that there is no direct relationship between the analyses of this investigation and those of the two previous studies, but concordance in the trend of anomalies is obvious.

Figures 4 and 6 show a well-defined southerly extension of the Castle-an-Dinas Wolfram Lode for at least 650 m beyond the underground workings and a possible parallel structure some 150 m to the west. The circular anomaly in the east of the field is apparently centred upon a single spuriously rich sample. Tungsten values in the anomalous zones are generally low, little more than twice background level, and appear to tail off southwards. Tin anomalies (Figure 5) are more scattered. Pronounced northern and central anomalies lie marginal to the main tungsten anomaly and may reflect cassiterite distributed at the margin or in the wallrocks of quartz-wolframite veining. It is also probable that the central anomaly and the broader one to the south are related to the Royalton elvan which passes through this part of the field.

PERCUSSIVE DRILL SAMPLING

In the southern area inclined percussive holes were drilled from stations along selected traverses to investigate at bedrock depth the areas of interesting soil anomalies. The traverse locations are shown in Figure 7. In the northern area traverses were widely spaced between Dennis and Criftoe farms to intersect the conjectured strike of extensions to the Wolfram Lode and any close parallel structures (Figure 8). In both areas the holes were sited to provide full, overlapping traverse coverage.

This drilling technique is most effective only down to water table, beyond which the cuttings are returned as slurry, and hence varying lengths of holes reflect variations in the standing water level. The intention to analyse for tungsten debarred the use of tungsten carbide bits and for this drilling programme hardened cobalt steel chisel inserts were custom-made. For the most part these performed satisfactorily, though they required frequent resharpening, but in the calc-silicate rocks progress was extremely slow and wear was excessive.

Dust and chippings blown up the holes were collected over intervals of 5 ft (1.5 m) and checked by portable isotope fluorescence meter for high tin values. A small sub-sample was later ground for laboratory X-ray fluorescence analysis; only Sn and W were determined on the southern area samples, but those for the northern area were also analysed for Ce, Pb, Zn, Cu and Fe.

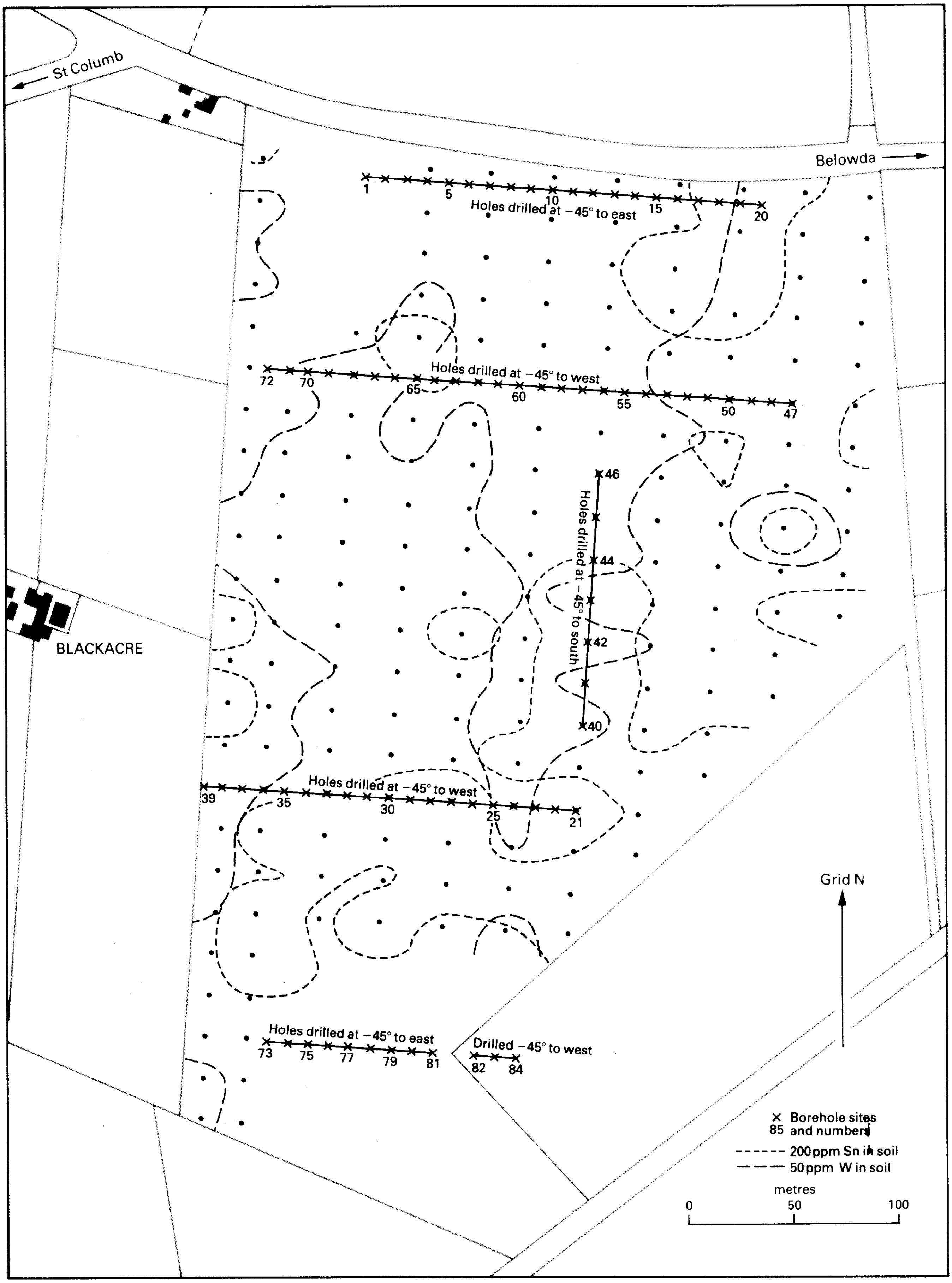

Fig. 7 Percussive drilling traverses in southern area

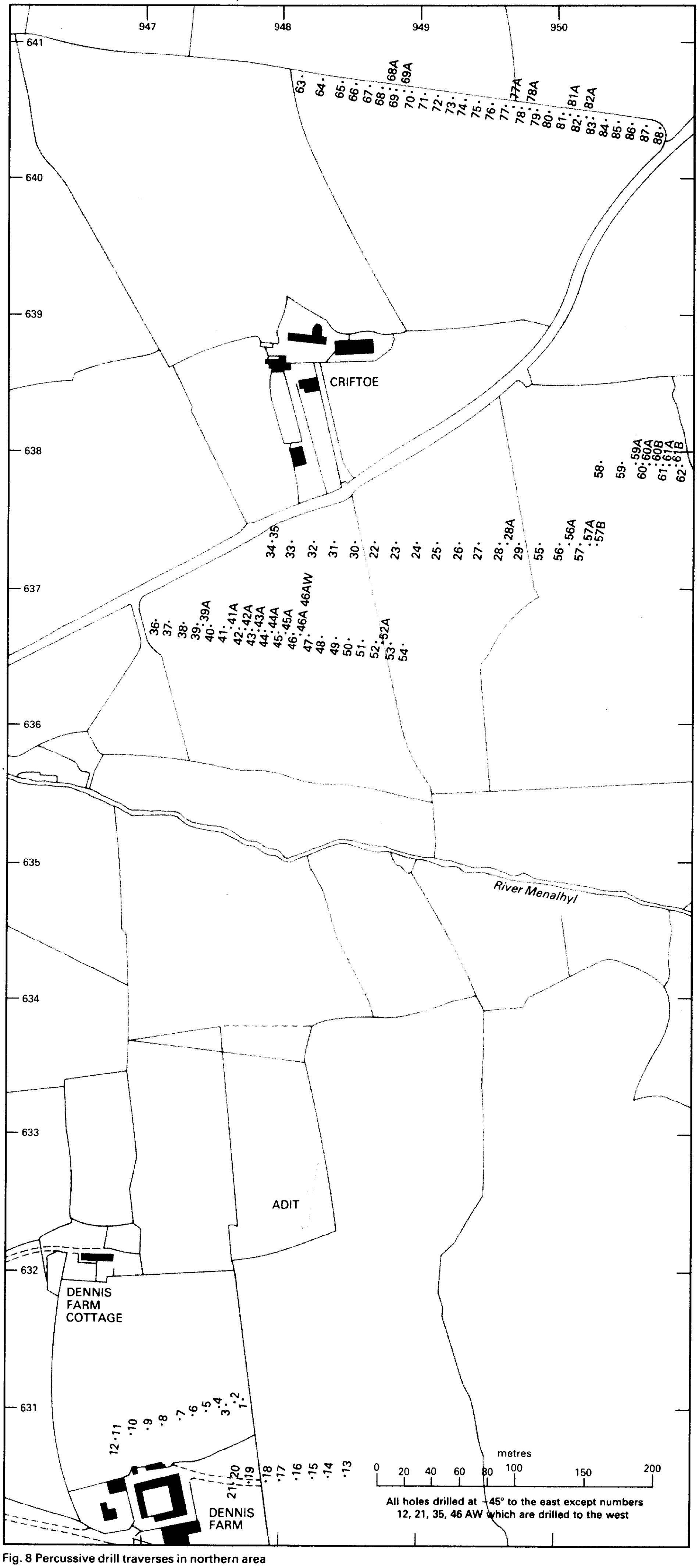

Fig. 8 Percussive drill traverses in northern area

DRILLHOLE GEOCHEMISTRY

Southern area

Of 768 samples collected, four were damaged in transit, five not analysed for tungsten and six not analysed for tin. Elemental statistics, in ppm, are as follows:

Element	No. of Samples	Range ppm	Median ppm	Arith. mean ppm	Stand. devn. ppm
W	759	0 - 300	10	19.14	24.60
Sn	758	0 - 2793	131	227.09	284.29

From 753 samples a W:Sn product moment correlation coefficient of 0.10 is derived and this poor degree of accord is evident in the sectional plot (Figure 9).

Log-probability plots show three population distributions for both metals with breaks of slope at 200 and 700 ppm Sn, and at 35 and 50 ppm W. Some 7 % of the samples carry anomalously high tungsten. In an attempt to maintain comparability between the north and south areas and between drillhole results and soil values, Figures 9 to 12 are plotted to show samples containing 200 ppm Sn and 50 ppm W, or more.

For the interpretation of Figure 9 it has been assumed that the uppermost sample (0 to 9 ft inclined depth) represents the soil and sub-soil section in which there is a residual concentration of cassiterite and the immobile weathering products of wolframite. Whilst this assumption is certainly strictly valid for the northern part of the field, it is probable that the weathering regolith thickens southwards. Comparison of Figures 4, 5 and 9 shows some, though not good, correlation between the soil results and metal levels in these uppermost drilling samples. Marked divergences presumably reflect the differing depths sampled and the irregular distribution of the particulate residual ore minerals.

It is apparent from Figure 9 that the near-surface tin and tungsten values bear no consistent or direct relationship to the levels of these metals in the bedrock below, confirming the assumption of residual weathering concentrations of their ores. On the expectation that most bedrock mineralisation would conform to the local north-south vein trend, the sections have been plotted with the traverses placed to accentuate that trend.

Anomalous tungsten values in bedrock are largely confined to the northernmost traverse and in only one instance is there any suggestion of continuity of mineralisation southwards (Figures 11 and 12) - that between holes 11 and 56. From such a distribution it may be deduced that the Castle-an-Dinas Wolfram lode does not persist southwards as a recognisable structure but, as indicated in the southernmost mine workings, splits into several thin veinlets which are individually uneconomic and can be traced near-surface only as far as the Belowda - St. Columb road.

In the case of tin the distribution is dramatically reversed, with a strong concentration of anomalous values in the southern part of the field (Figure 12). Indeed, the concentration is so dense that no clear orientation of mineralisation can be discerned. Proximity to the cassiterite-bearing basal gravels of the Goss Moor alluvial tract raises the question of whether these drilling samples are truly bedrock. The frequency of "background" values in the middle and lower sections of many holes suggests that the drift cover in this area is seldom thicker than 19 ft (downhole inclined

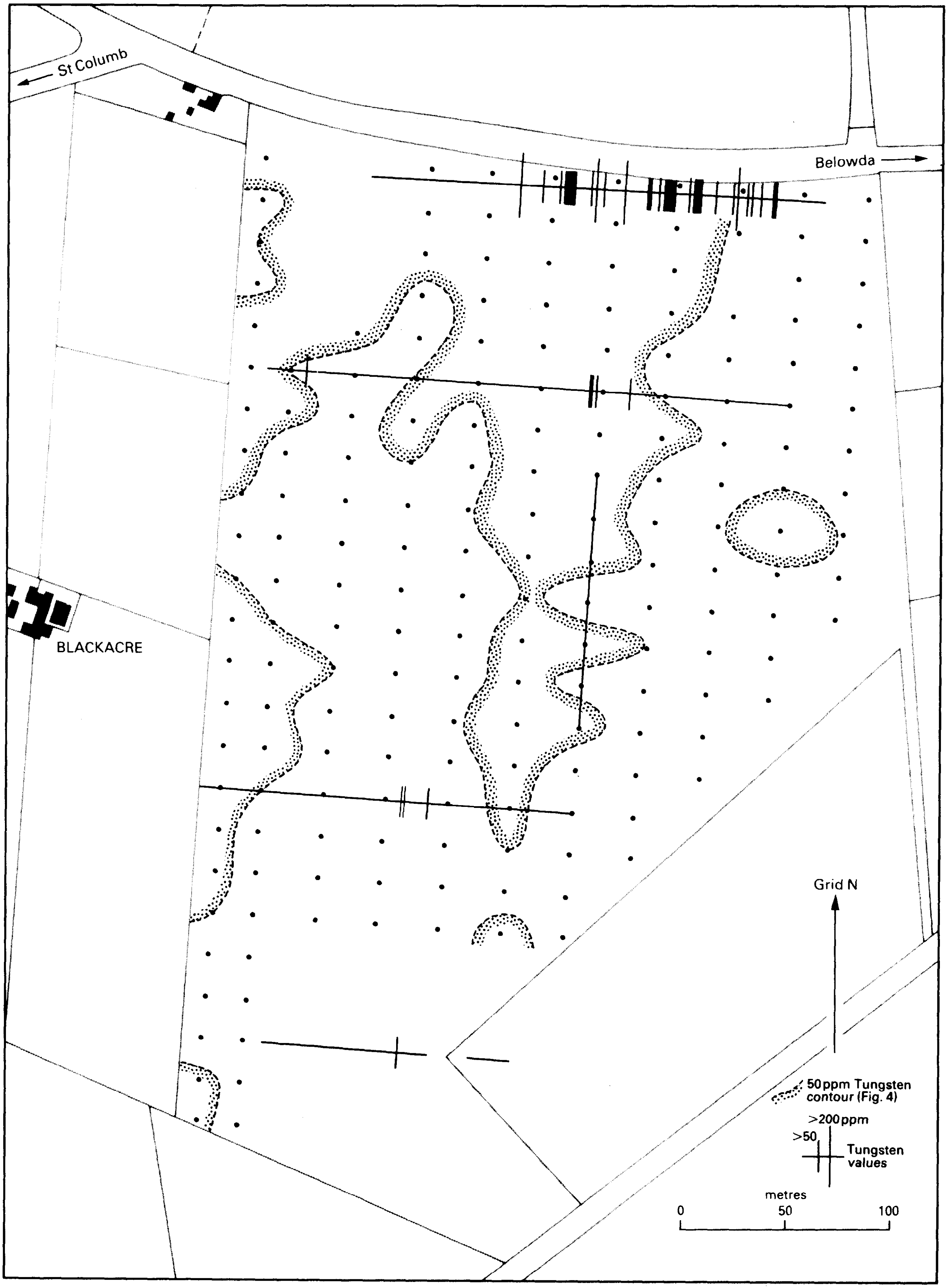

Fig. 11 Distribution of anomalous tungsten values in bedrock, southern area

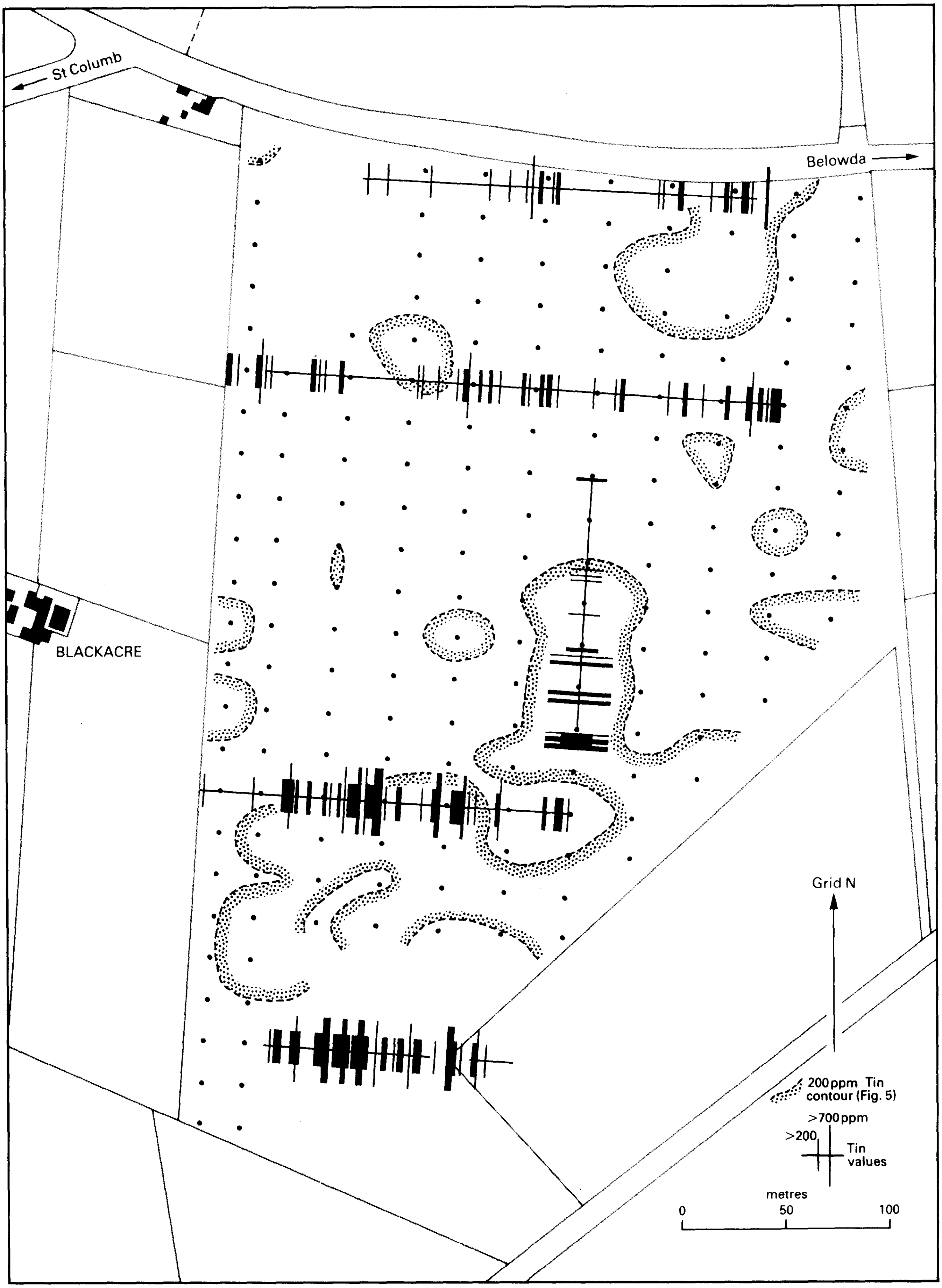

Fig. 12 Distribution of anomalous tin values in bedrock, southern area

measurement) and this interpretation accords with the driller's reports of penetration facility. It is reasonably certain, therefore, that the high tin values recorded in the lower parts of these boreholes do represent bedrock contents.

In the absence of further data it is possible only to speculate upon the reasons for this polarised tin distribution. Significantly, the tin-rich zone lies entirely to the south of the presumed course of the Royalton elvan, and it may be advocated that this dyke acted as an impounding structure during phases of tin mineralisation when fluids were migrating northwards from the St. Austell Granite heat source. It is pertinent to recall that investigations at Royalton Farm, a mere 400 m to the east, revealed only scattered tin veining, of relatively low grade, in the hangingwall slates to the north of this elvan (Beer, Turton and Ball, 1986).

Northern area

Traverses to the north of the main mine workings were irregularly spaced in order to avoid contamination from former mine workings and the difficult boggy areas around the River Menalhyl. South of the latitude of Criftoe Farm (Figure 8) the holes all penetrate grey slates, but the northernmost traverse is sited within a band of calc-silicate rocks with interbedded thin slate and cherty mudstone layers.

From experience elsewhere in SW England, significant differences would be expected in the degree or nature of mineralisation in the various traverse lines. The line close to Dennis Farm is influenced by its proximity to the Castle-an-Dinas Granite and the northernmost line by the effects of pervasive boron metasomatism. Accordingly, the statistical treatment in Tables 1 and 2 has been carried out on the basis of three separate traverse groupings.

Table 1. Elemental statistics (in ppm), percussion drill samples, northern area

	Element	Range	Arith. mean	Standard deviation	Median
	W	10-680	43.48	64.75	35
	Sn	12-1983	210.43	266.74	111
Southern	Cu	5-1088	113.74	99.60	93
Traverses	Pb	0-134	18.19	20.21	12
(Holes 1-21)	Zn	15-216	55.61	31.66	50
210 samples	Fe	15860-105300	54700	19100	53830
	Ce	37-186	71.71	18.99	68
	W	0-100	24.18	16.35	15
	Sn	1-2377	47.67	158.39	17
Central	Cu	3-202	38.41	23.57	34
Traverses	Pb	0-160	6.62	13.38	4
(Holes 22-62)	Zn	10-211	69.79	27.27	72
502 samples	Fe	11820-111030	58782	16090	60720
	Ce	32-127	65.61	12.02	64
	W	10-100	20.82	13.01	15
	Sn	4-541	104.57	94.00	79
Northern	Cu	0-601	28.39	55.90	17
Traverse	Pb	0-317	15.16	25.51	11
(Holes 63-88)	Zn	24-516	109.13	71.20	90
261 samples	Fe	11870-127150	47888	20894	43670
	Ce	14-205	69.35	21.15	69

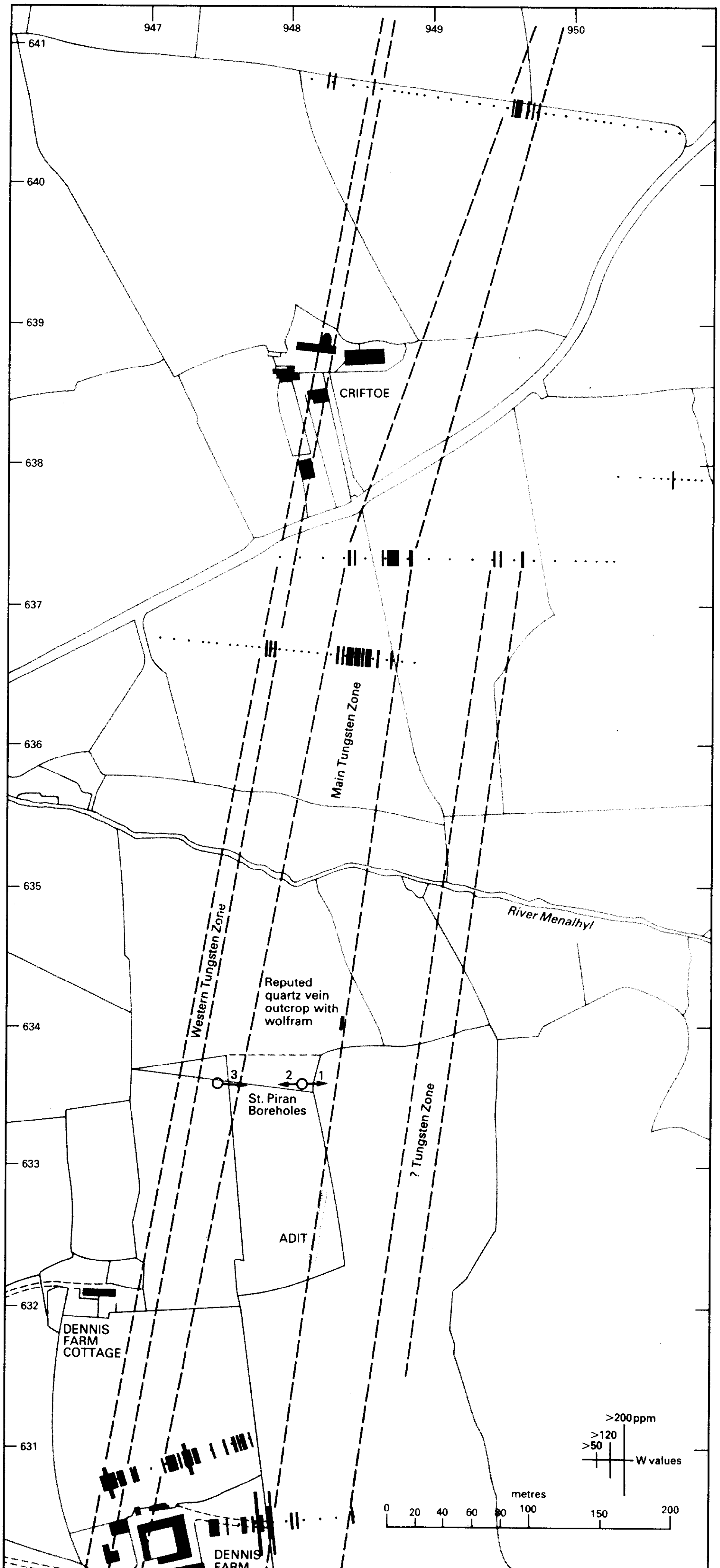

Fig. 13 Distribution of anomalous tungsten values in bedrock, northern area

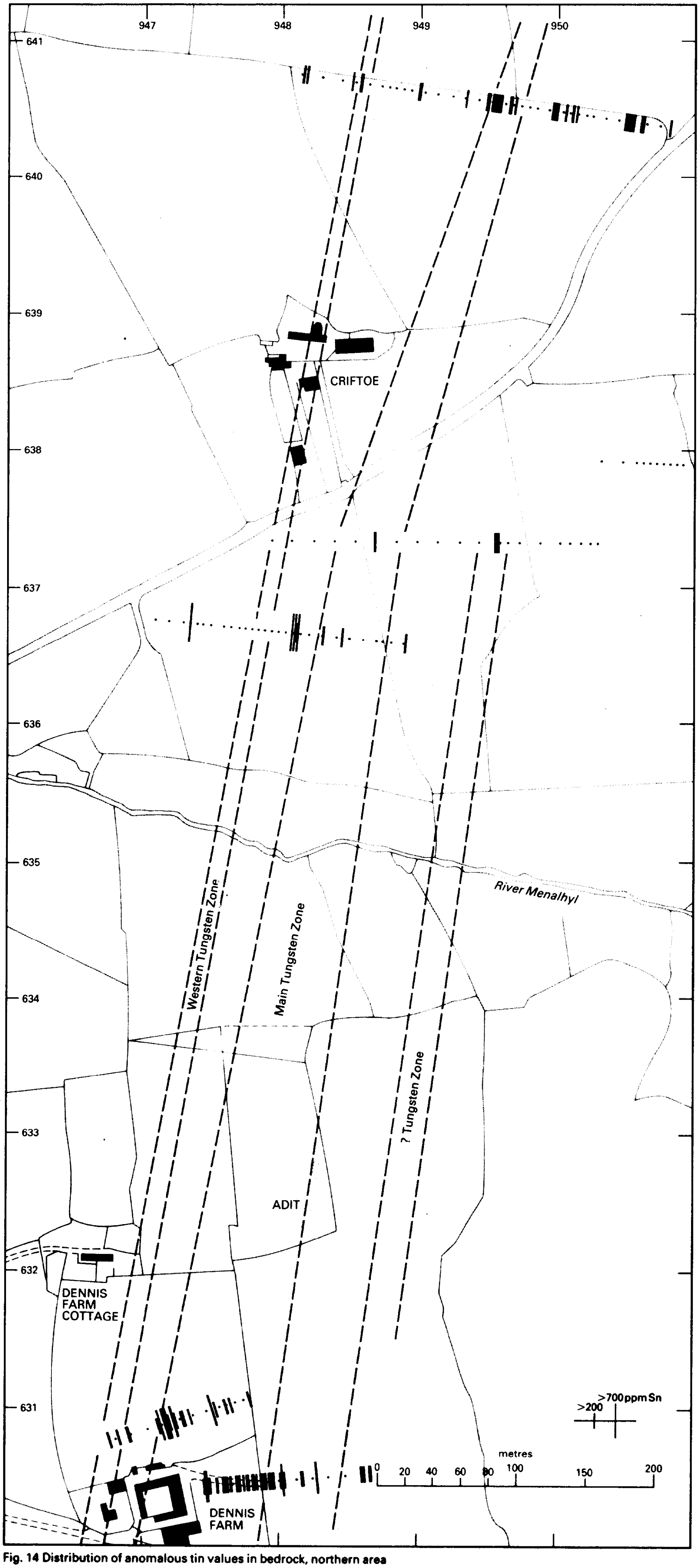

Fig. 14 Distribution of anomalous tin values in bedrock, northern area

These influences are reflected clearly in the distribution of various elements as seen in log-probability plots of the analyses and in the differences of inter-element correlation factors displayed in Table 2.

Tungsten The average level of tungsten and the range of individual values is similar both in slates of the central traverses and in calc-silicate rocks of the northern line. Log-probability plots show a significant difference in the tungsten distribution, however. The slates show a background range from zero to a surprisingly high level of 76 ppm, accounting for 98 % of the samples. It is assumed that the anomalous 2 percentile contains wolframite deposited on joints or in small quartz veins. In the calc-silicate rocks the tungsten distribution is log-normal. This element might be presumed to be taken up in the lattices of the mafic minerals. The best positive correlation, however, is with Cu, which is usually present as chalcopyrite. Less positive correlation with Zn and Fe may reflect some involvement in the mafic content. Notably, in neither slates nor calc-silicate rocks is there a strong correlation with Sn.

Table 2. Correlation matrices, percussion drill samples, northern area

Negative values underlined

		W	Sn	Cu	Pb	Zn	Fe	Ce
	W	1.000						
	Sn	0.444	1.000					
Southern	Cu	0.076	$\underline{0.020}$	1.000				
Traverses	Pb	0.145	0.914	$\underline{0.020}$	1.000			
(Holes 1-21)	Zn	$\underline{0.120}$	$\underline{0.121}$	0.543	$\underline{0.051}$	1.000		
	Fe	0.399	0.130	0.006	0.110	0.095	1.000	
	Ce	$\underline{0.015}$	$\underline{0.041}$	$\underline{0.058}$	0.114	$\underline{0.073}$	0.115	1.000

		W	Sn	Cu	Pb	Zn	Fe	Ce
	W	1.000						
	Sn	0.060	1.000					
Central	Cu	0.227	0.570	1.000				
Traverses	Pb	0.040	0.787	0.133	1.000			
(Holes 22-62)	Zn	$\underline{0.364}$	$\underline{0.070}$	0.201	0.145	1.000		
	Fe	$\underline{0.342}$	0.043	0.031	$\underline{0.026}$	0.758	1.000	
	Ce	0.158	0.183	0.122	0.176	0.063	0.096	1.000

		W	Sn	Cu	Pb	Zn	Fe	Ce
	W	1.000						
	Sn	0.128	1.000					
Northern	Cu	0.482	0.240	1.000				
Traverse	Pb	0.307	0.299	0.719	1.000			
(Holes 63-88)	Zn	0.086	0.402	0.443	0.558	1.000		
	Fe	0.280	0.689	0.440	0.407	0.612	1.000	
	Ce	$\underline{0.017}$	0.173	0.004	0.093	0.318	0.305	1.000

The granite influence on the southern traverse is very apparent. In the log-probability plot there is a poorly defined break of slope at about 70 ppm, above which lie some 10 % of the sample values, but a marked break at 170 ppm. These uppermost values are found on samples known to include quartz-tungsten veining. It is notable that the plot for these southern samples shows them, at all distribution levels, to be markedly richer in W than those from the other traverses. Table 2 emphasises the differences between the traverses; in the south there is a distinct positive correlation between W and both Sn and Fe, but none between W and Cu and only a weak one between W and Zn.

Tin In the calc-silicate zone the variance of Sn values is smaller than in the slates and hornfelses but the average Sn content is markedly higher. This is interpreted as a clear indication of the metasomatic origin of the contained tin; the form in which it is present - oxide, sulphide or silicate - has not been investigated, however. Within these rocks the strongest elemental correlations, all positive, are with Fe and Zn, suggesting an association between tin and the mafic content of the rocks and, consequently, a strong possibility of tin in silicate form. Correlation with Pb is somewhat weak despite the possible analytical interference between these two metals. The log-probability plot shows a marked break of slope at 110 ppm with some 40 % of the samples being above this value.

At all distribution levels the Sn contents in slates of the middle traverses are lower than those in calc-silicate rocks. However, the average value, about 48 ppm, is more than twice that found by Henley (1974) in sediments around Perranporth. Surprisingly, the log-probability plot shows no break of slope around this level of concentration. Indeed, its only break is at 190 ppm, above which are represented only 2 % of the samples. The interference of Sn on Pb during XRF analysis may be reflected in these slate results by the high positive correlation factor. Slightly weaker positive correlation is seen with Cu, suggesting that the copper halo which surrounds the Castle-an-Dinas Granite cupola also carries some tin enrichment.

As would be expected, the Sn levels in the hornfelses of the southern traverse are distinctly higher than those in either of the other two groups. The log-probability plot, however, reveals a complex pattern of distribution indicative of two distinct populations. About 43 % of the samples, containing less than 95 ppm, constitute the lower set and show a break of slope at 49 ppm. This tin content is interpreted as being introduced or redistributed by the emplacement of the main St. Austell Granite. A higher set with a poorly defined change of slope at about 200 ppm is believed to represent samples with hydrothermal mineralisation, itself probably redistributed by the later intrusion of the Castle-an-Dinas Granite. Results from the hornfels samples show an even stronger Sn-Pb correlation, wholly due to interference. The only significant correlation is that between Sn and W; there are only the weakest of positive correlations with other elements analysed.

Copper The Cu contents tend to decrease steadily away from the granite though the richest calc-silicate samples contain more than the richest slates. Average values in both slates and calc-silicates are similar to those quoted by Henley (1974) for slates and sandstones, but not cherty slates, in the Perranporth area. In the northern traverse the contents vary widely and it is highly probable that some of the copper was introduced during metasomatism of originally calcareous rocks containing relatively low levels of Cu. This is borne out by the log-distribution plot which shows two changes of slope, at 16 ppm and 58 ppm. Within the calc-silicate rocks Cu shows a strong positive correlation with Pb and moderate positive correlation with Zn, W and Fe, an association suggestive of metasomatic derivation.

Slates of the middle traverses exhibit a narrower range of Cu values and, therefore, a smaller standard deviation, but a higher average content than the calc-silicate rocks. Their log-probability plot has breaks of slope at 30 and 66 ppm, dividing the plot into sectors which probably represent background slates, "copper halo" samples and hydrothermally mineralised samples. In this set, Cu correlates best with Sn and distinctly less well with W and Zn.

The southern traverses show both the highest values of copper and the widest range. In the log-probability plot there is no sign of a break of slope at very low Cu concentrations and it is concluded that at this distance from the pluton all samples are influenced by granitic "halo" effects and hydrothermal deposition. Breaks occur at 60 and 255 ppm; only 19 % of the samples contain less than 60 ppm and only 3 % more than 255 ppm. In the southern traverse Cu correlates strongly only with Zn.

Lead Because of the interference between Pb and Sn there is no point in seriously examining the apparent behaviour of this element.

Zinc From Table 1 it can be seen that zinc values tend to increase at distance from the granite with the range of values becoming much wider in the calc-silicate samples. The average values for each of the traverse groups are all lower than those determined by Henley (1974) on his Perranporth sediments. In the case of the non-aureole slates they are about 40 % of Henley's figures. It seems possible that this difference may arise from analytical bias.

For the southern traverse a log-probability plot shows a clear change of slope at 65 ppm, with the suggestion of another at 38 ppm. Some 20 % of the samples exceed 65 ppm Zn. Table 2 shows that Zn correlates fairly strongly and positively with Cu but with no other element. In the middle traverses the slates show a similar range of values to those in the hornfelses and the average contents are of a similar order. The log-probability graph shows a different distribution, however. There is only one break of slope, this a very sharp one at 70 ppm, and above this value lie 55 % of the samples. This distribution may be adduced as evidence of a Zn halo around the granite. Strong correlation with Fe suggests that much of the Zn may be chemically co-precipitated, however. The positive correlation with Cu is weak.

Within the calc-silicate rocks Zn levels are generally higher and the range even wider than in slate lithology. Background values seem to extend up to 275 ppm with some 2.5 % of the samples being anomalously higher than that value. As in the slates there is a strong positive correlation with Fe but, in addition, there are moderately strong and positive correlations with Pb, Cu, Sn and Ce. This association of elements supports a metasomatic derivation.

Iron Ranges of Fe within the three groupings are rather similar and there is also reasonable accord between the averages for both slates and hornfelses. The calc-silicate average, however, is decidedly lower. Thermal and hydrothermal redistributions of Fe in the slates into new mineral forms in the hornfelses, notably biotite, tourmaline and wolframite, are presumably the cause of major variations in elemental correlation factors. Particularly notable is the change from inverse to a direct moderate correlation with W, a similar change of sign with Ce, and the markedly reduced correlation factor with Zn.

Log-probability plots for Fe are not very informative.

Cerium The lower limits for Ce are closely similar in the slates and the hornfelses but the range is extended in the latter. Log-probability plots show the slates of the middle traverses to have a log-normal distribution of Ce. The plot for the southern traverse closely follows that for the middle one to 95 ppm where there is a sharp break, with some 5 % of the samples containing anomalously high Ce levels. The calc-silicate plot again is closely similar but has two sharp breaks of slope, one at 48 ppm below which are 12 % of the samples, the other at 110 ppm above which are only 2 %. In the slates and hornfelses there is no significant correlation between Ce and the other elements; in the calc-silicate rocks Zn and Fe correlate moderately well and positively. In such lithologies it is to be expected that cerium would be held within the mafic constituents, as most of the zinc may also be held.

Comments. Ideally, Figure 10 should take account of the somewhat differing distributions of tin and tungsten within the various lithologies represented north of the Castle-an-Dinas Granite. Not only would this be confusing but it would also obscure direct comparison with results from the area south of the granite. In consequence it was decided to plot at 50 and 120 ppm W and 200 and 700 ppm Sn,the intervals used for the southern area.

This figure is plotted from a base line drawn through holes 20, 1, 50, between 30 and 22, and through 71, which direction approximates to the expected strike of any Wolfram Lode extension. The section indicates that this assumption is not too far from the truth, with the main mineralised zone represented in holes 19-21, 1-3, 48-50, and 22-23 and 30 in their respective traverses. Slight easterly deflection of the trend is required to include the tungsteniferous parts of the calc-silicate belt in holes 76-77A. It seems acceptable to correlate this trend with the Wolfram Lode and, if this be correct, the northerly continuation should be as depicted in Figure 15.

Comparison of Figures 10, 13 and 14 shows that tin and tungsten have a somewhat different distribution within the mineralised zones and that there is no simple relationship between the two. The main zone is also the exclusive location for the highly anomalous copper values, those greater than 180 ppm (Appendix 1). Within these plotted results there are suggestions of further structures, in particular a strong one some 90 m to the west of the main zone. The remaining high values, and especially those for tin, probably represent small localised veinlets.

Highly anomalous zinc values, in excess of 170 ppm, are located mainly in the calc-silicate belt where their distribution is apparently random. In the southern traverses there are three anomalous samples, all within the main mineralised zone; in the middle traverses one high zinc value, it being located well outside that zone.

DISCUSSION AND CONCLUSIONS

In cases such as Castle-an-Dinas, where there is a simple type of mineralisation and good geological information, it seems advantageous to seek vein extensions by immediate recourse to drilling. As was seen to the south of the mine, soil sampling gives a broad general picture but the results are not directly representative of tungsten distribution in the underlying rocks, nor do they provide any definite indication of in-situ metal grades.

Drilling by percussive methods is both fast and relatively cheap and the technique has now progressed so that adequate samples can be obtained from water-laden rocks below water table. The analytical results are more meaningful than those from cored boreholes, especially for ores of sporadic and coarse distribution (such as wolframite). One obvious drawback is the lack of observational data inherent in coreless drilling, but this can be

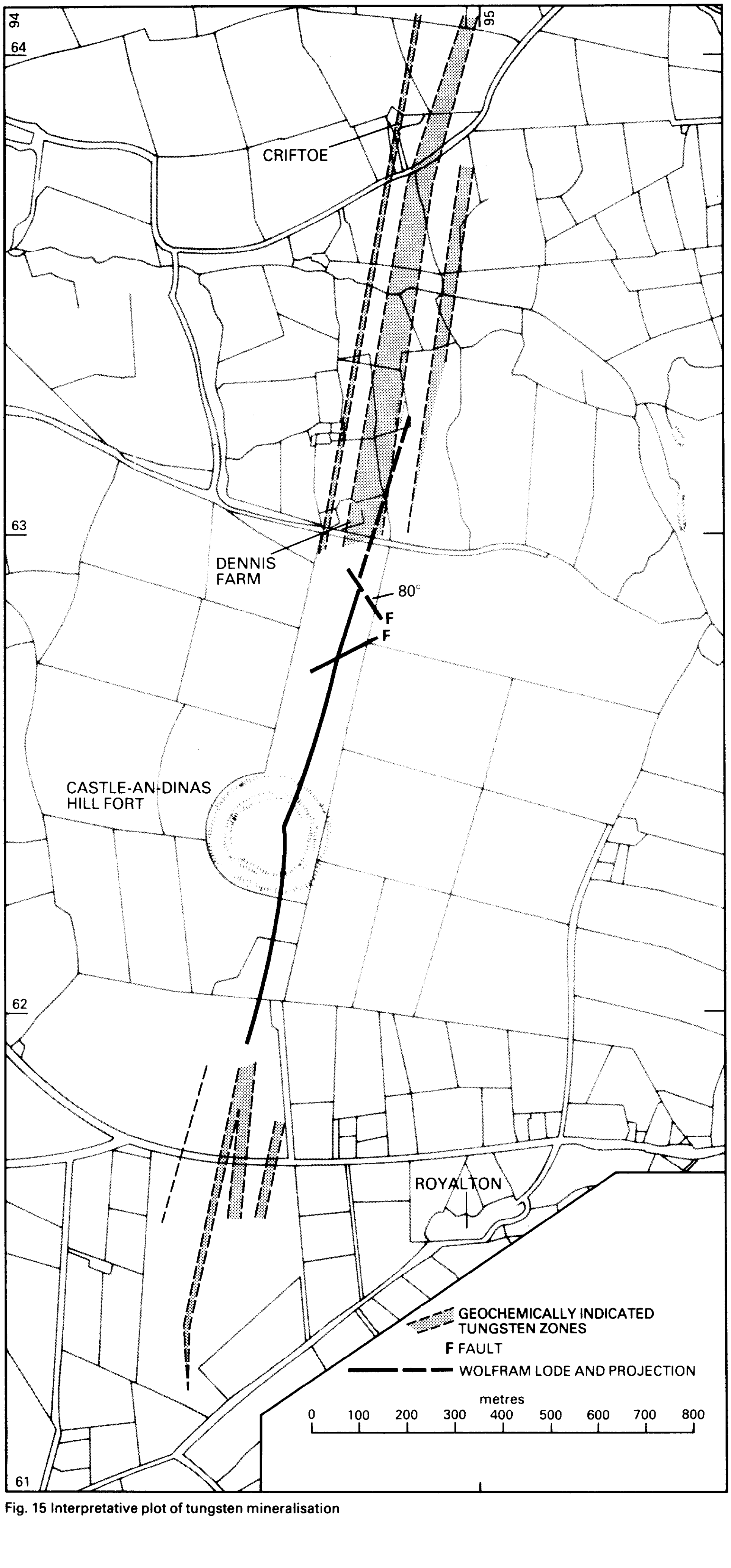

Fig. 15 Interpretative plot of tungsten mineralisation

partially overcome by examination of the drill chippings; the ratio of chippings to flour and the size of the chippings can be influenced to some extent by the choice of drilling bit.

At the time of the Castle-an-Dinas investigation it was not possible to sample effectively below the water table and many of the drill holes are shorter than would have been wished. Nonetheless, this technique has outlined mineralised zones to the north and south of the former mine which are interpretable as extensions of the main Wolfram Lode (Figure 15). There are also indications of smaller, perhaps more weakly mineralised, parallel structures. The best of the analysed samples reports less than 0.07 % W and, therefore, the mineralisation is well below the level of economic interest. This, indeed, was also the finding from the three cored boreholes drilled by St. Piran Exploration Ltd. Both drilling programmes indicate that the mineralisation is contained in a succession of parallel, relatively narrow quartz veins; it seems clear that, both north and south of the former workings, there is no single, wide, quartz-wolframite lode but a series of small structures within a broad mineralised zone. Within this zone outcrops and field float of quartz-wolframite lode material have been reported at some 1650 ft (503 m) and 3000 ft (915 m) north of the northernmost stopes. The former locality is noted on the old mine plans and is shown in Figure 14, the latter occurrence is mentioned in Hosking and Trounson (1959) but is not located specifically.

Correlation of mineralised intersections in the southern and middle traverses of the northern area, over a distance of some 550 m, is perhaps a little speculative, though all factors point to this being acceptable. Unfortunately, analysis of samples from the St. Piran boreholes, about midway between the traverses, were not sufficiently accurate to confirm the correlation; the disposition of quartz veins, however, accords with the percussive drilling results. The limited distribution of anomalous tungsten and copper levels within the northern traverse, and a close association with tin, leads to the conclusion that the Wolfram Lode zone and a parallel zone to the west can both be traced through the calc-silicate belt. This finding is somewhat surprising as it might have been expected that all three metals would have diffused more widely within these permeable and reactive rocks.

The Wolfram Lode zone has now been traced over a strike length of 2.8 km. Southwards it is not recognisable for more than about 50 m south of the Belowda - St. Columb road (Figures 11 and 15) whilst northwards it reaches, but has not been sought north of, the calc-silicate belt. To judge by the mine section (Figure 3) the structure was only rarely of workable grade at surface and most of the economic ore has been obtained within 200 m of the granite contact. This then raises the question - do the northern and southern extensions have potential at depths greater than has been so far tested?

From Figure 3 it appears that the southern contact of the granite is steeply dipping but, to fit the model determined by Tombs (1977), this attitude must change at relatively shallow depth. This granite shape, together with the apparent disappearance of tungsten values at the Belowda - St. Columb road, limits the ore potential south of the mine workings to a block some 250 m long and about 200 m deep lying under a non-pay, near-surface block of about 100-200 m depth. Assuming an extraction width of 1.5 m, an average grade of 0.7 % W and a recovery of 75 %, such a block might yield 1100 tonnes of tungsten. It might require a further 200 m of depth development, however, to reach and extract this ore.

The northern contact, on the other hand, is gently sloping in the mine (Figure 3) and is expected to remain that way for some considerable distance (Tombs, 1977, Figure 5(c)). If economic mineralisation were to persist above this contact then the potential for this northern area could be considerable - about 440 tonnes of tungsten per 100 m of strike length. From the northernmost workings to the calc-silicate belt is some 1100 m. Again, there would be a necessitated depth development of about 200 m.

The possibility of such potential has long been recognised. The lode was lost when the workings encountered a fault just north of Main (=North) Shaft (Figures 2 and 3) and the location of the northern extension gave rise to considerable speculation but, until recently, no activity. Attempts by St. Piran Exploration Ltd in 1978 to find the lode by crosscutting a short way east from No. 4 (Adit) Level and by drilling from north of the adit mouth both proved unrewarding. In the light of our geochemical work it seems that the crosscut should have been driven west from the level and that the drillholes were started too close to the mineralised zone and could not penetrate it at a depth close enough to the granite contact.

Great uncertainty attaches to the parallel structures indicated by the drilling results. A trial adit about 70 m west of the entrance to No. 1 Level (Figure 2) would probably line up with the most interesting of these but, according to the plans, the nearby No. 2 Crosscut was driven all its length in barren slates. Similarly there is no record of mineralisation in No. 3 Crosscut.

Assessment of the potential of the lode zone extensions depends to a large extent upon the mineralisation model adopted for this deposit. From percussive and rotary drilling it is clear that the mineralised zone is moderately wide (up to about 40 m) on either side of the workings and, though not straight, its strike is a reasonably constant 10 degrees east of north. Within this zone it would seem certain that the mineralisation is patchy and, except in a few spots on the hill, uneconomic at the surface. Tungsten is spatially associated with tin and copper, though statistical correlation between these metals is not strong.

The north-south trend of the Wolfram Lode is matched by the tin veining at Royalton, lodes at the nearby Belowda Mine and the vein swarm at Mulberry, a short distance east. Structures of this direction bearing hypothermal mineral species are widely accepted as being early events within the mineralisation sequence. Certainly the Wolfram Lode is earlier than the Castle-an-Dinas Granite which completely cuts it out and veins it (Kear, 1952; Dines, 1956). But there is some uncertainty about the age of this granite; it is sufficiently different from the main St. Austell Granite to promote speculation that it is, in fact, a late stage intrusion. So far, no reliable isotopic age has been published for Castle-an-Dinas (D.P.F. Darbyshire, pers. comm.).

The concept of the Castle-an-Dinas Granite being a late phase has immediate appeal as it permits the erection of a simple model for the tungsten deposit, one in accord with the current views on Cornubian mineralisation. In this model, high temperature tungsten-tin-bismuth-copper mineralisation was introduced into the Wolfram Lode zone as a series of interconnected sub-parallel quartz veins during the emplacement of the main St. Austell Granite.

It is believed that this granite assumed a broad ridge-like form beneath Castle-an-Dinas with its roof at some depth (0.5 km?) below the present surface. The ore distribution is envisaged as both low grade and patchy, much like that indicated in the percussive boreholes. Late in the igneous cycle the Castle-an-Dinas Granite was punched through the roof of the existing granite and during its final emplacement modified the mineralised zone in two important ways. Firstly, the mineralised zone was totally replaced by granite, its original course now marked by a zone of jointing and alteration in which there are irregular lenses of quartz, some bearing occasional wolframite. Secondly, silica and metals have been driven upwards and outwards to be recrystallised in the immediate exocontact zone; here the zone develops wider quartz lodes and the wolframite attains economic levels.

If this is a reasonably correct interpretation of the mineralisation history then it follows that the quantity of any hidden ore is largely related to the length of contact between the mineralised zone and the late granite. Such a constraint affects only the northern potential but there is no way of quantifying the effect. A further implication of this model is that a similar remobilisation and concentration should be developed along the western mineralised zone. It would be expected that evidence of this should have been found in the No. 2 and No. 6 Crosscuts (Figure 2) but, as far as is known, this was not the case.

If further exploration at Castle-an-Dinas is contemplated it is obvious that this needs to examine the downward continuation of mineralisation north of the known stoping. It may be reasonably assumed that some ore remains at greater depth in the south but the amount is unlikely to offset the costs of mine dewatering, rehabilitation and deepening. Given sufficient potential in the north, however, the southern block might constitute an attractive bonus.

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APPENDIX 1.

XRF analyses of selected drill samples, northern area.

BH	Depth (m)	Sn	W	Cu	Zn	Ce	Fe
CDN 1	0.9- 2.4	115	65	93	57	60	8.407
	5.5- 7.0	629	35	160	52	93	9.296
CDN 2	0.9- 2.4	60	50	84	74	49	5.455
	2.4- 4.0	82	65	74	34	63	6.165
	4.0- 5.5	90	50	112	21	56	4.415
CDN 3	0.9- 2.4	103	65	71	50	88	7.932
	2.4- 4.0	98	50	74	64	59	5.817
	5.5- 7.0	34	50	69	73	64	5.769
CDN 4	0.9- 2.4	184	50	94	47	62	4.623
	5.5- 7.0	281	10	127	48	62	6.069
	7.0- 8.5	657	35	97	29	59	6.264
	10.1-11.6	105	15	169	216	68	5.437
	11.6-13.1	441	35	216	86	90	5.852
CDN 5	0.9- 2.4	193	80	53	36	64	4.778
	5.5- 7.0	1050	15	65	21	67	3.652
	8.5-10.1	438	15	212	97	78	6.815
CDN 6	11.6-13.1	57	35	208	76	63	3.646
	13.1-14.6	85	15	189	67	66	3.594
CDN 7	0.9- 2.4	87	50	48	33	56	4.406
	2.4- 4.0	337	130	34	42	78	8.733
	4.0- 5.5	216	180	113	42	64	10.348
	5.5- 7.0	174	50	50	22	93	4.341
	7.0- 8.5	49	80	19	15	76	3.470
	10.1-11.6	416	100	57	54	98	8.398
	11.6-13.1	56	50	57	18	91	3.375
	13.1-14.6	77	50	164	55	65	9.698
	14.6-16.2	42	15	288	154	77	7.192
CDN 8	0.9- 2.4	63	50	73	38	60	5.508
	2.4- 4.0	1246	65	78	56	93	10.454
	4.0- 5.5	1164	80	71	51	60	10.288
	5.5- 7.0	1185	65	42	53	54	8.946
	7.0- 8.5	618	65	43	40	48	6.956
	8.5-10.1	150	50	52	22	70	4.380
	11.6-13.1	1039	35	65	62	96	6.815
CDN 9	11.6-13.1	232	15	78	50	61	3.341
	13.1-14.6	874	65	76	68	50	6.759
CDN 10	0.9- 2.4	91	65	54	32	46	4.564
	2.4- 4.0	122	80	39	35	63	7.493
CDN 11	0.9- 2.4	61	50	34	32	138	6.527
	2.4- 4.0	227	80	79	42	71	5.779
	4.0- 5.5	328	100	84	31	85	7.505
	5.5- 7.0	180	50	62	40	111	6.515
	13.1-14.6	290	15	123	58	78	4.039
	14.6-16.2	229	65	32	41	76	5.668

BH	Depth (m)	Sn	W	Cu	Zn	Ce	Fe
CDN 12	2.4- 4.0	59	65	37	30	67	6.809
	4.0- 5.5	130	65	28	38	108	6.235
	5.5- 7.0	275	65	34	57	99	7.212
	7.0- 8.5	73	90	5	20	80	4.156
	8.5-10.1	72	130	11	25	82	6.797
	10.1-11.6	186	130	54	46	82	7.888
	11.6-13.1	173	115	28	32	91	6.491
	13.1-14.6	149	115	24	37	82	6.064
	14.6-16.2	126	100	42	30	83	5.645
CDN 13	14.6-16.2	453	15	141	54	70	5.365
	17.7-19.2	380	10	90	40	159	5.399
	23.8-25.3	222	35	119	43	69	5.169
	25.3-26.8	602	35	211	53	63	4.970
CDN 14	14.6-16.2	48	50	65	54	62	4.902
CDN 15	2.4- 4.0	1491	15	97	50	69	5.931
CDN 16	0.9- 2.4	135	40	221	52	70	8.013
	4.0- 5.5	271	10	168	72	68	10.216
	5.5- 7.0	567	15	104	34	77	4.213
CDN 17	0.9- 2.4	453	35	153	33	52	5.926
	2.4- 4.0	1983	15	75	59	62	6.189
	4.0- 5.5	439	50	38	20	59	3.288
	10.1-11.6	66	50	136	66	76	10.002
CDN 18	2.4- 4.0	328	35	51	19	74	3.122
	4.0- 5.5	235	15	152	33	63	6.579
	5.5- 7.0	241	15	68	32	67	4.865
	7.0- 8.5	226	25	110	53	76	5.034
CDN 19	0.9- 2.4	381	680	189	51	61	7.343
	2.4- 4.0	519	280	199	51	56	7.938
	4.0- 5.5	95	50	193	33	74	4.782
	5.5- 7.0	235	50	168	62	61	5.625
	10.1-11.6	289	40	197	20	90	3.490
	11.6-13.1	614	155	132	38	65	5.951
	13.1-14.6	495	140	226	25	89	5.858
	14.6-16.2	530	515	247	59	79	8.422
CDN 20	2.4- 4.0	230	65	115	86	57	1.614
	4.0- 5.5	234	50	125	60	53	3.105
	5.5- 7.0	238	50	99	68	51	4.648
	8.5-10.1	114	35	221	141	70	4.571
	10.1-11.6	281	40	378	112	37	5.689
	11.6-13.1	146	35	225	53	49	4.927
	13.1-14.6	618	60	186	36	71	3.073
	14.6-16.2	213	25	174	51	55	3.660

BH	Depth (m)	Sn	W	Cu	Zn	Ce	Fe
CDN 21	2.4- 4.0	386	25	150	47	48	2.291
	5.5- 7.0	397	10	78	23	67	2.394
	7.0- 8.5	347	35	54	18	70	1.896
	8.5-10.1	397	15	33	19	69	1.586
	10.1-11.6	273	25	83	55	67	6.319
	11.6-13.1	104	60	115	49	65	2.121
	13.1-14.6	69	25	242	41	63	3.079
	14.6-16.2	81	10	312	138	56	4.880
	16.2-17.7	375	10	219	131	44	3.653
	17.7-19.2	111	40	667	188	81	5.226
	19.2-20.7	65	40	1088	212	84	7.619
	20.7-22.3	173	100	511	115	73	4.040
	22.3-23.8	116	100	190	34	80	2.864
	23.8-25.3	370	65	170	42	69	2.922
	25.3-26.8	417	90	145	30	63	2.687
	26.8-28.3	918	80	120	33	69	3.228
	28.3-29.9	853	90	89	28	62	2.957
	29.9-31.4	293	35	98	43	70	2.685
CDN 22	2.4- 4.0	17	100	39	44	59	3.378
	4.0- 5.5	31	75	84	34	48	1.955
	5.5- 7.0	53	85	78	27	66	2.016
	7.0- 8.5	54	65	59	24	54	1.782
	8.5-10.1	63	75	52	14	63	1.844
	10.1-11.6	66	85	53	33	76	2.410
	11.6-13.1	30	50	59	63	74	5.966
CDN 23	0.9- 2.4	52	60	79	46	60	4.164
	2.4- 4.0	30	60	40	38	82	3.325
CDN 26	20.7-22.3	12	50	18	70	59	6.118
CDN 27	7.0- 8.5	11	65	79	63	70	5.233
	16.2-17.7	410	35	11	38	65	4.629
	17.7-19.2	253	10	7	30	68	3.919
CDN 28	7.0- 8.5	65	50	13	23	87	3.582
CDN 29	2.4- 4.0	12	15	34	175	78	6.906
	4.0- 5.5	5	15	32	201	63	6.859
CDN 30	14.6-16.2	185	15	202	94	79	5.946
	17.7-19.2	281	100	65	21	46	3.984
CDN 31	4.0- 5.5	28	60	11	20	58	5.923
	5.5- 7.0	72	70	54	39	53	4.155
	10.1-11.6	21	85	30	42	82	5.502
	20.7-22.3	16	25	45	211	76	6.357
CDN 38	7.0- 8.5	1758	10	59	72	55	5.123
CDN 43	7.0- 8.5	24	50	46	74	80	6.770
CDN 43A	4.0- 5.5	21	80	79	62	111	6.614
	5.5- 7.0	35	80	59	50	77	6.075
CDN 44	2.4- 4.0	17	70	80	57	83	6.815
	4.0- 5.5	17	70	103	71	77	7.175

BH	Depth (m)	Sn	W	Cu	Zn	Ce	Fe
CDN 46	4.0- 5.5	2377	35	72	82	127	7.098
CDN 46AW	2.4- 4.0	339	15	47	74	89	6.163
	4.0- 5.5	1700	35	42	59	80	5.627
	7.0- 8.5	516	0	26	48	50	3.737
CDN 48	0.9- 2.4	339	15	40	64	56	5.948
	5.5- 7.0	42	60	113	59	67	6.528
	7.0- 8.5	55	60	94	46	67	4.966
	11.6-13.1	168	60	182	78	93	5.956
CDN 49	0.9- 2.4	64	55	60	53	83	5.277
	2.4- 4.0	28	65	75	25	71	2.156
	4.0- 5.5	79	100	68	25	72	2.124
	5.5- 7.0	232	100	73	20	77	2.135
	8.5-10.1	27	50	41	10	41	1.264
	10.1-11.6	12	65	27	15	61	1.249
	11.6-13.1	38	50	47	37	81	2.600
	13.1-14.6	69	50	48	32	53	2.675
CDN 50	2.4- 4.0	65	55	35	32	72	2.870
	5.5- 7.0	134	55	51	48	96	3.656
	7.0- 8.5	30	50	40	52	78	6.246
	8.5-10.1	16	80	47	46	70	5.081
	10.1-11.6	13	55	43	51	76	5.912
	13.1-14.6	9	50	40	52	76	4.869
CDN 51	4.0- 5.5	27	50	32	57	74	4.405
CDN 52	4.0- 5.5	51	50	51	85	104	4.066
CDN 54	2.4- 4.0	433	15	32	75	76	5.485
CDN 60	4.0- 5.5	154	50	33	20	32	3.672
CDN 63	2.4- 4.0	211	15	142	105	23	3.728
	5.5- 7.0	214	15	56	108	60	3.542
	16.2-17.7	44	50	23	30	14	1.264
CDN 64	0.9- 2.4	59	50	36	64	62	2.684
	16.2-17.7	194	10	23	179	108	4.818
	17.7-19.2	168	15	11	175	68	7.634
CDN 65	0.9- 2.4	138	10	51	176	62	5.266
	2.4- 4.0	130	10	77	196	46	5.863
	11.6-13.1	315	15	175	516	205	12.676
CDN 66	5.5- 7.0	281	60	49	156	150	7.474
	7.0- 8.5	212	35	16	103	52	6.236
CDN 68	5.5- 7.0	91	15	8	269	62	5.100
	7.0- 8.5	101	15	7	206	72	4.642
	8.5-10.1	108	10	7	256	74	4.760

BH	Depth (m)	Sn	W	Cu	Zn	Ce	Fe
CDN 69	0.9- 2.4	100	15	2	246	80	5.698
	2.4- 4.0	44	25	0	187	60	2.326
	4.0- 5.5	85	15	3	466	41	5.806
	5.5- 7.0	40	10	4	171	61	2.373
	7.0- 8.5	37	25	6	170	80	3.102
CDN 69A	0.9- 2.4	20	10	10	206	76	4.130
	8.5-10.1	103	15	7	255	91	5.427
CDN 70	2.4- 4.0	71	10	8	180	75	4.750
	7.0- 8.5	236	25	13	176	88	6.623
	8.5-10.1	218	15	14	152	67	5.378
CDN 71	0.9- 2.4	151	15	20	320	51	8.789
	2.4- 4.0	150	15	9	331	98	8.384
	8.5-10.1	55	10	13	277	177	4.430
CDN 73	10.1-11.6	156	10	6	193	78	6.031
CDN 74	0.9- 2.4	225	15	12	159	87	8.293
	2.4- 4.0	107	25	7	191	81	7.569
CDN 75	7.0- 8.5	213	15	24	113	83	5.068
	8.5-10.1	280	10	21	207	87	6.629
	11.6-13.1	474	10	5	155	70	8.508
	13.1-14.6	541	10	2	161	64	9.594
CDN 76	0.9- 2.4	219	15	52	193	75	7.936
	2.4- 4.0	307	35	50	207	85	9.511
	4.0- 5.5	293	60	44	135	62	6.361
	5.5- 7.0	288	35	70	132	74	7.593
	7.0- 8.5	282	60	138	177	72	11.027
	8.5-10.1	296	100	191	148	90	11.201
	10.1-11.6	211	50	139	225	53	12.715
	11.6-13.1	170	50	163	151	28	7.534
	13.1-14.6	178	35	98	175	48	8.771
	14.6-16.2	89	35	212	173	45	9.232
CDN 77	2.4- 4.0	124	35	320	497	68	6.942
	4.0- 5.5	220	90	370	244	73	9.714
	5.5- 7.0	259	60	601	400	71	11.668
	7.0- 8.5	167	25	164	206	69	11.399
CDN 77A	2.4- 4.0	212	50	68	213	109	11.119
	8.5-10.1	21	50	10	36	38	1.773
CDN 80	2.4- 4.0	225	15	4	173	103	7.227
	4.0- 5.5	213	10	5	166	101	7.419
	5.5- 7.0	200	25	5	200	99	6.397
	7.0- 8.5	220	15	6	157	73	7.777
CDN 81	2.4- 4.0	265	10	14	106	90	5.446
CDN 81A	2.4- 4.0	216	10	0	206	66	8.230
	4.0- 5.5	255	10	5	149	68	7.667
	7.0- 8.5	229	15	13	74	65	4.864

BH	Depth (m)	Sn	W	Cu	Zn	Ce	Fe
CDN 85	5.5- 7.0	409	25	5	95	94	7.569
	7.0- 8.5	418	10	9	130	90	6.975
	8.5-10.1	386	10	7	126	86	5.905
	10.1-11.6	317	15	22	150	90	9.105
	11.6-13.1	276	40	26	107	86	5.785
	13.1-14.6	227	10	16	66	84	4.474
CDN 86	5.5- 7.0	192	10	9	188	79	6.832
	7.0- 8.5	339	25	5	178	68	7.353
	8.5-10.1	316	15	6	115	91	6.907
	10.1-11.6	273	15	26	89	103	5.281
CDN 88	8.5-10.1	364	10	5	76	80	10.576

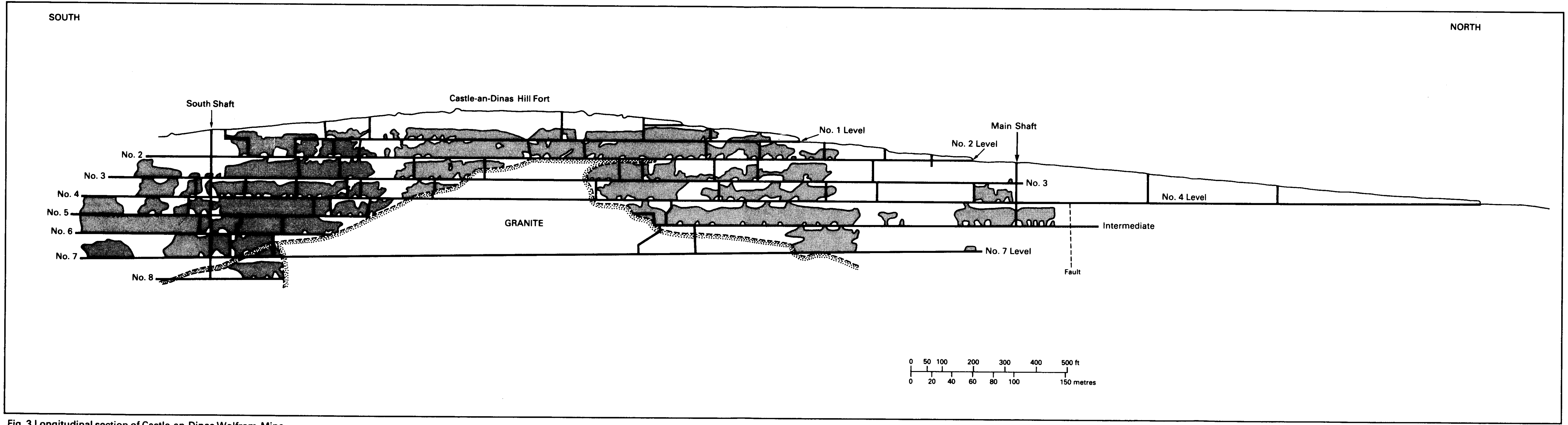

Fig. 3 Longitudinal section of Castle-an-Dinas Wolfram Mine

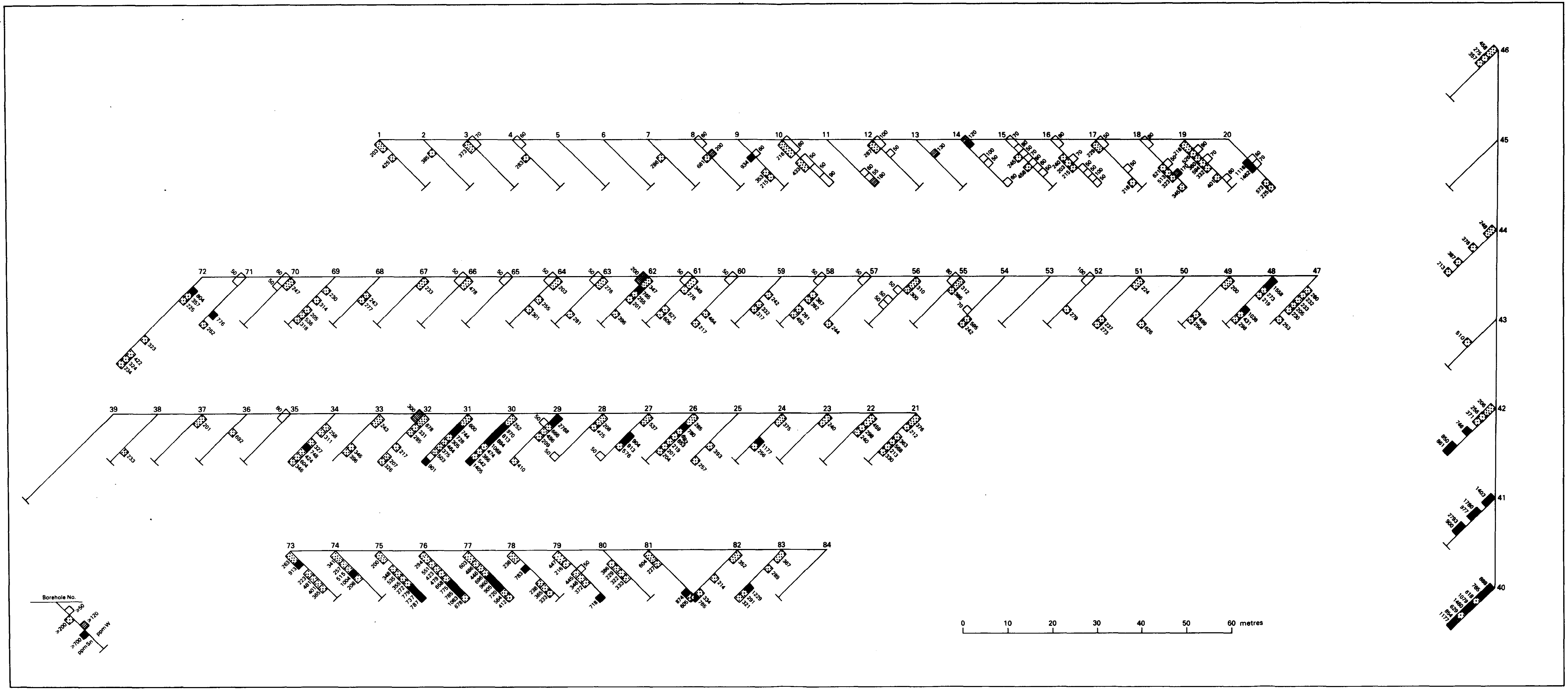

Fig. 9 Drilling results, southern area

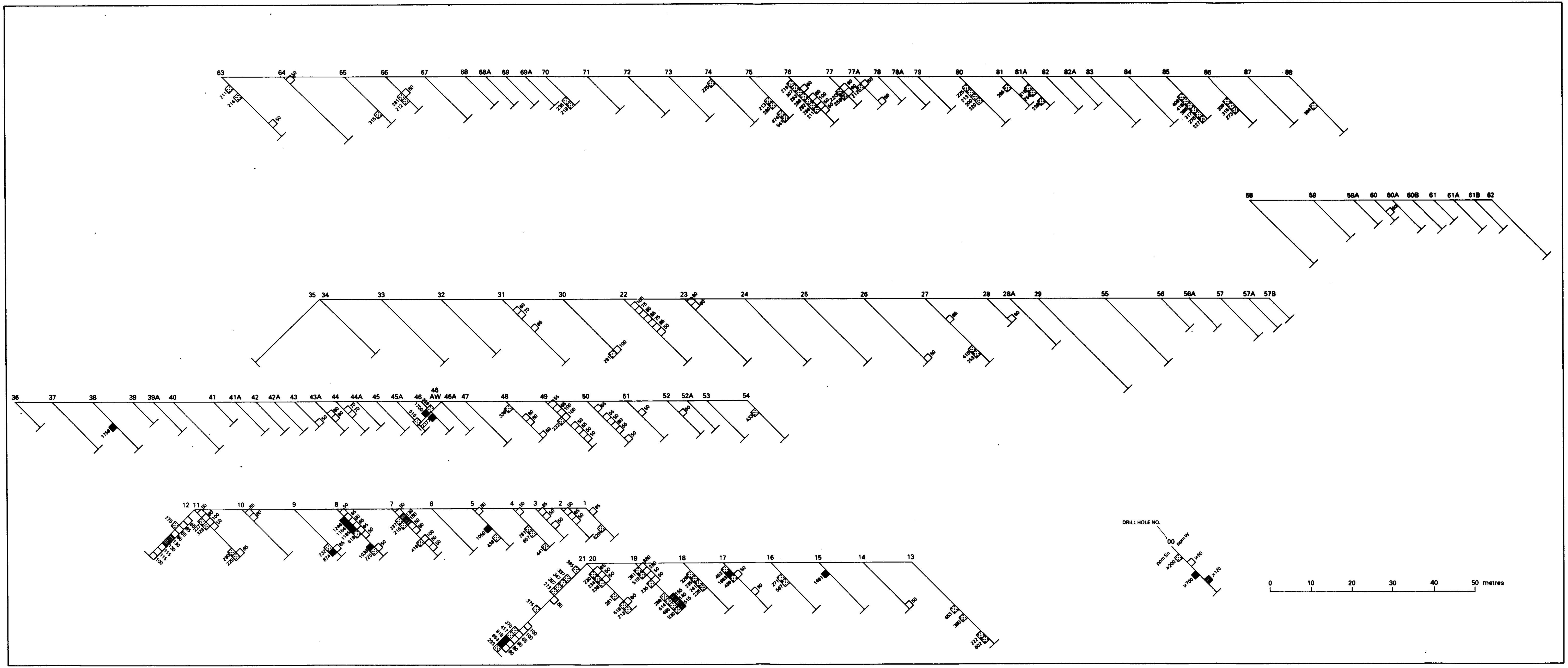

Fig. 10 Drilling results, northern area