British Geological Survey

Mineral Reconnaissance Programme

Mineral investigations in the Teign Valley, Devon. Part 2: base metals.

Department of Trade and Industry

MRP Report 123
Technical Report WF/92/6

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K E Beer, T K Ball, D C Cooper, A D Evans, R C Jones,
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SUMMARY

This report describes the search for new base metal reserves in the Teign Valley between Dunsford and Chudleigh, an area worked for lead and zinc ores, with associated silver and copper, in the late 19th century. A programme of geochemical drainage and soil surveys was followed by geophysical surveys and diamond drilling.

Chemical analyses were carried out on waters, stream sediments and panned concentrates collected from secondary drainage. The water samples, including effluences from old mine workings, were only rarely anomalous in base metals. However, stream sediment and panned concentrate analyses revealed copper, lead, zinc and arsenic anomalies caused by the Teign Valley lode zone and manganese anomalies which reflected areas of former open-cast mining. One cluster of anomalies suggested possible lead-zinc-copper-arsenic-barium mineralisation to the east of the River Teign.

Soil sampling was carried out mainly across interfluve ridges to the west of the river. Interpretation of the soil analyses confirmed the common occurrence of anomalous lead, zinc and copper within the Teign Valley lode zone and indicated that a few parallel mineralised structures may also be present. Some anomalies suggested the presence of disseminated mineralisation within the bedded succession of shales, cherts and tuffs.

Induced polarisation (IP) geophysical surveys were carried out in four separate areas containing geochemical anomalies using the dipole-dipole array. Locally, more detailed measurements were made using the gradient array. Anomalies believed to be related to concealed sulphide mineralisation were recorded in all four areas. In the Dunsford area, chargeability anomalies coincident with lead anomalies in soil may be caused by disseminated mineralisation. Near Bridford, anomalies with different characteristics were attributed to disseminated and vein-style mineralisation. The presence of a small high-grade galena vein was suggested by anomalies to the east of the main vein at Wheal Exmouth. Sixteen interlinked traverses north-east of Bovey Tracey defined two significant anomalies compatible with the presence of sulphide mineralisation; soil geochemistry indicated significant lead with copper but only minor zinc enrichment.

Four short inclined diamond drillholes were sited north-east of Bovey Tracey, between Lower and Higher Coombe, to investigate the clusters of geochemical anomalies which IP data suggested were caused by sulphide mineralisation. The mineralisation was found to comprise disseminated and thin, discontinuous strata-bound veinlets of sulphides within shales, cherts and tuffs close to the Lower-Upper Carboniferous boundary. Galena and sphalerite with a little chalcopyrite, arsenopyrite and loellingite are associated with pyrite, quartz and siderite.

Chemical analysis of drillcore revealed appreciable zinc concentrations in some sections, one containing 2% zinc over 3 m. Lead values are lower, with a maximum of 0.2% over 1 m; several 1-3 m lengths containing 0.1% lead are present. Copper concentrations are very variable; the best intersection contained 0.14% over 1 m.

Finely disseminated galena and sphalerite have not been reported previously from the Teign Valley and their discovery opens up the potential for this type of deposit concealed within the Carboniferous condensed sequence both here and in other areas of south-west England.

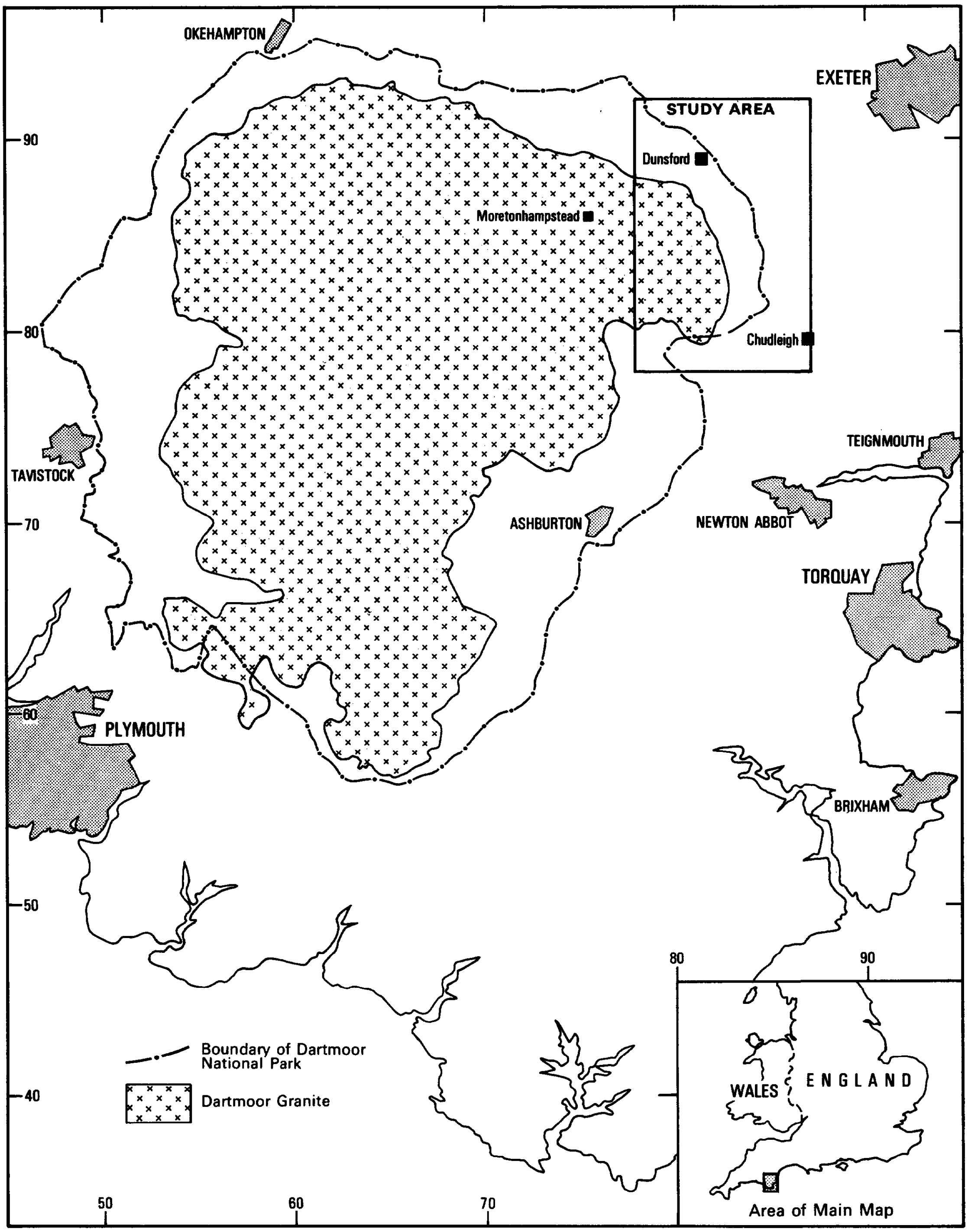

Figure 1 Location of the study area

INTRODUCTION

The area of south-west England covered by this report (Figure 1) stretches along both sides of the middle section of the River Teign between Dunsford [SX 813 892]* and Chudleigh Knighton [846 774]; it extends some 4.5 km out from the north-eastern edge of the Dartmoor Granite (Figures 1 and 2). In this part of its course the Teign flows south or south-east in a relatively narrow and deep valley which cuts sharply through folded Upper Palaeozoic strata (Figure 2). Zinc and argentiferous lead ores, some siderite and fluorspar were worked between about 1840 and 1890 from small mines immediately west of the river; baryte was mined almost continuously from 1855 to 1958. During the early 19th century small tonnages of manganese oxides were extracted from shallow depths. Now the area has reverted to agriculture and tourism; the only extractive operation is a small stone quarry with associated pre-cast concrete works at Crockham [850 808].

The area is served by a network of narrow and sinuous lanes which in the south join the A38 Exeter-Plymouth highway and in the north feed into the western side of Exeter city. The closest rail-heads are at Exeter [912 933] and Newton Abbot [868 712], with comprehensive port facilities at Teignmouth [939 727].

The aims of the investigation were threefold: (a) to seek a wider range of metalliferous ores and styles of mineralisation than were formerly mined in the vicinity; (b) to check for extensions to known veins or for closely parallel veins west of the river, and (c) to explore for similar mineralisation in the ground to the east of the river.

The investigative approach comprised comprehensive drainage geochemical surveys involving the collection and chemical analysis of water and stream sediment samples from all significant secondary streams feeding into the River Teign. At the majority of sites sediment was panned to yield heavy mineral concentrates. Subsequently, soil samples were taken for chemical analysis from a series of traverse lines sited mainly along the interfluve ridges west of the river. Investigation of the barium potential, reported previously (Beer and Ball, 1977a; 1977b), then followed. This report describes the subsequent search for sulphide mineralisation which made use of the same basic (stream sediment and soil) data.

Induced Polarisation (IP) geophysical surveys were carried out to search for concealed sulphide mineralisation in four sub-areas where soil samples contained anomalous levels of base metals. On the basis of the geochemical and geophysical results, four cored diamond drillholes were drilled between Higher and Lower Coombe.

GEOLOGICAL SETTING

The area lies close to the northern margin of British Geological Survey 1:50,000 scale Geological Sheet 339, a sheet which has been re-surveyed by a team from Exeter University under contract to the British Geological Survey. Figure 2 is compiled from this work and from a publication by Selwood and McCourt (1973) dealing with the area of the Bridford Thrust.

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* National Grid Reference; all localities mentioned in this report lie within the grid square designated by the letters SX.

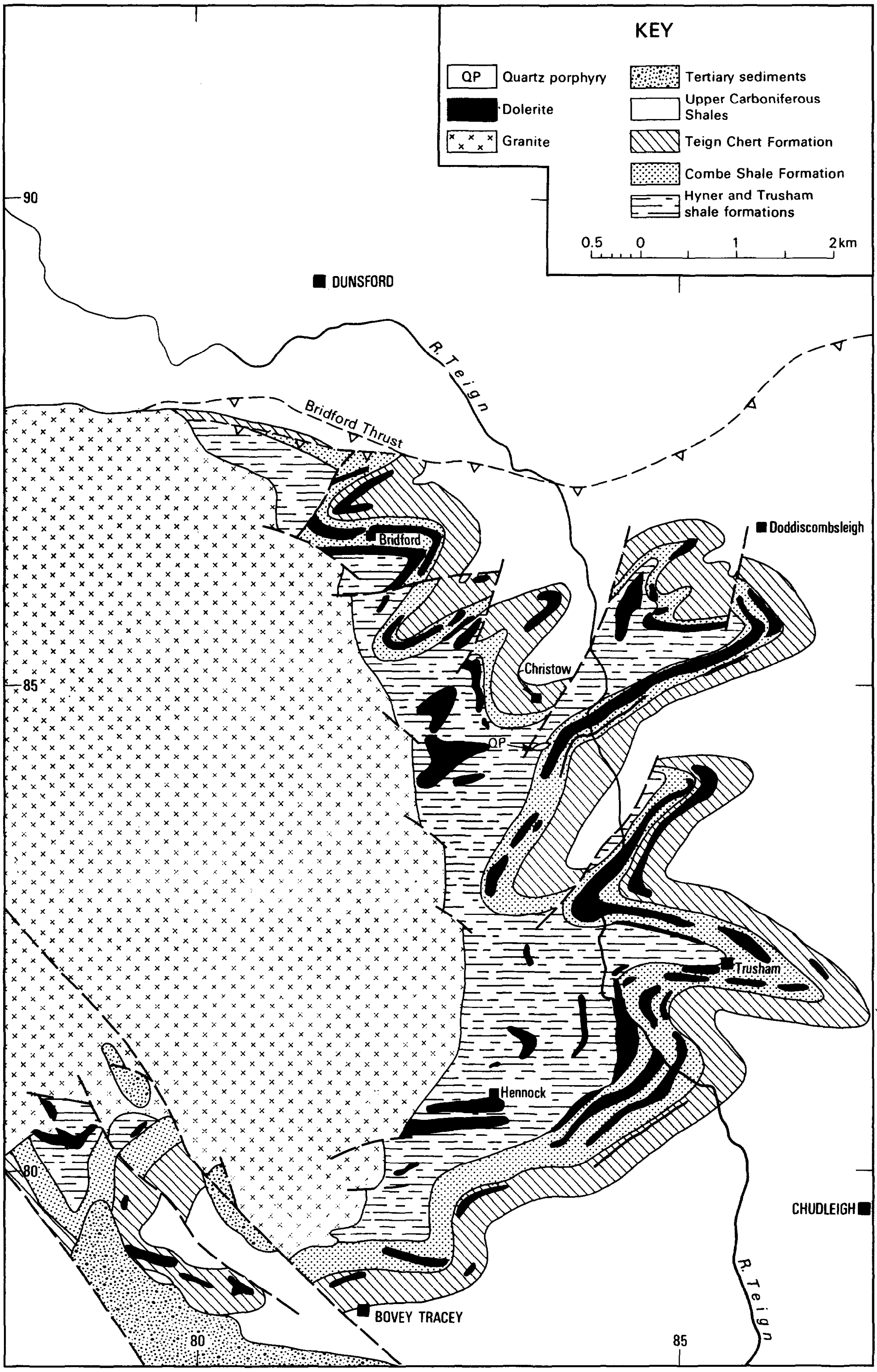


Figure 2 Geology of the Teign Valley (after BGS Sheet 339; Selwood and McCourt, 1973)

The greater part of the middle Teign Valley is underlain by rocks of Devonian and Carboniferous age which Selwood et al. (1984) have subdivided into the sequence shown in Table 1.

Table 1 Geological succession in the middle Teign Valley

UPPER CARBONIFEROUS	
Crackington Formation	grey shales and turbiditic sandstones; >300 m
Ashton Shale Member	black shales with thin siltstones and sandstones; 90-200 m
LOWER CARBONIFEROUS	
Teign Chert Formation	cherts and shales with thin tuffs and limestones; 230 m
Combe Shale Formation	bluish-black shales; 45-150 m
Trusham Slate Formation	olive-green and grey micaceous shales; 60 m
UPPER DEVONIAN	
Hyner Shale Formation	blue and bluish-grey shales with calcareous horizons and siliceous nodules

Lithologies in this succession are mainly self-explanatory. In the Teign Chert Formation, pyroclastic layers, usually of keratophyric composition, are developed at two, or perhaps three, horizons. They outcrop widely throughout the valley and their associated lenses of manganese minerals have been worked to shallow depths (Beer, 1978). Albite-dolerite sills, which vary from a few metres to 60 m thick, are intruded mainly into the shale formations and only rarely into the cherts. Although of widespread occurrence, individual sills are of limited areal extent. Formerly they were quarried for building stone and aggregate but now only the Crockham Quarry remains sporadically active.

The outcrop of the Upper Palaeozoic sedimentary rocks (Figure 2) reflects a series of broad but rather tight folds, the axes of which trend in a north-east to south-west direction in the north of the area, but are nearer east-west in the south. Axial-plane dips are almost vertical in the south but northwards they become progressively more overturned, and ultimately dip at 60°. A generally eastward fold plunge, varying from 40° to 55°, probably reflects some tilting caused by the rising Dartmoor Granite.

The fold limbs are dislocated commonly by faults trending north-north-east, interpreted (Selwood et al., 1984) as stretch thrusts and regarded as contemporaneous with the main folding, and thus of pre-granite age. Such faults are seen to attenuate the fold limbs which they intersect. In the north of the area, the Teign Valley succession over-rides Crackington Formation sediments of the Central Devon Synclinorium along the low-angle and southerly dipping, pre-granite Bridford Thrust (Selwood and McCourt, 1973). Field brash of calc-silicate rocks seen to the north-west of Dunsford, however, suggests that some Lower Carboniferous rocks are also present in this over-ridden block. Normal faulting with north-south and west-north-westerly trends is also recognisable in the area and appears to post-date the granite.

None of these post-granite faults is known to be appreciably mineralised, and it seems particularly significant that the north-south Teign Valley lode zone, worked for lead, zinc, silver and baryte over a 7 km length (Figure 3), transects all lithologies without any obvious displacement of their outcrop. Nor do available mine plans show any late east-west veins intersecting the lode zone, although there are some clay-filled "slides" with this direction. It seems, therefore, that the lode zone may represent the last phase of mineralisation in the Teign Valley, the ore minerals filling major fractures generated by cooling contraction in the granite envelope. Subsequent periods of movement have scarcely affected that part of the zone which is known from mining.

The structure of the lode zone indicates that it was not a line of important post-granite tectonic dislocation. A close parallelism to the granite contact and to the hidden form of the batholith (Bott et al., 1958) suggest that it was opened by contractional tensions during the cooling of the Dartmoor Granite and that it is an upward reflection of the steep eastern wall of the batholith. The sharp definition of this eastern termination also leads to speculation that it may be defined by a fundamental arcuate fracture within basement rocks (Beer, 1978).

MINERALISATION AND FORMER MINING

Volcanogenic manganese mineralisation, in part redistributed and concentrated by granitic metasomatism, is confined to the Teign Chert Formation. The ores, mainly wad and psilomelane, occur as impregnations and replacements both in the tuffs and the cherts; rhodochrosite or rhodonite may also be present (Dines, 1956). The larger opencast or mine workings are shown in Figure 3; all were shallow. The manganese production was small and lasted from about 1800 until 1830, although some of the workings were probably reactivated briefly around 1870.

A cluster of veins in the granite around Great Rock [822 818] was formerly worked for micaceous specular hematite to supply the paint industry. The presence of tourmaline in these veins, the degree of wall-rock alteration, and a metallogenic correlation with cassiterite-hematite veining further west, is interpreted as indicative of a high-temperature hydrothermal mineralising event. Mining began about 1866, although there may have been much earlier surface diggings, and the last mine closed in 1959.

Neither manganese nor micaceous hematite were sought in the present investigation.

Low-temperature hydrothermal mineralisation formed the Teign Valley lode zone. Towards its southern end, in South Exmouth [836 808], Frankmills [836 820] and Wheal Exmouth [837 830] mines, the mineralisation is concentrated in one major north-south vein with some smaller sub-parallel branches (Figure 3). At Wheal Exmouth there are reports of other parallel structures, both west and east of the Main Lode, which were reputedly explored underground but are not shown on any existing mine plans. No corroborative field or mining evidence can be adduced to support local reports of east-west copper veins in the vicinity of Wheal Exmouth and Wheal Adams (= Reed Mine) [836 837], but copper in the form of tetrahedrite occurs in the north-south veins. Eight main veins, together with several smaller ones, have been reported from Bridford Mine [830 864] by various writers but only five have been worked for baryte. Individual veins vary considerably in width, usually from about 0.6 to 2 m, but locally they swell to as much as 12 m. All are steeply inclined and they dip in either direction; some amalgamate at depth or are connected to each other by flat-lying linking veinlets. A stockwork is described in the footwall of No. 1 Vein (Vipan, 1959),

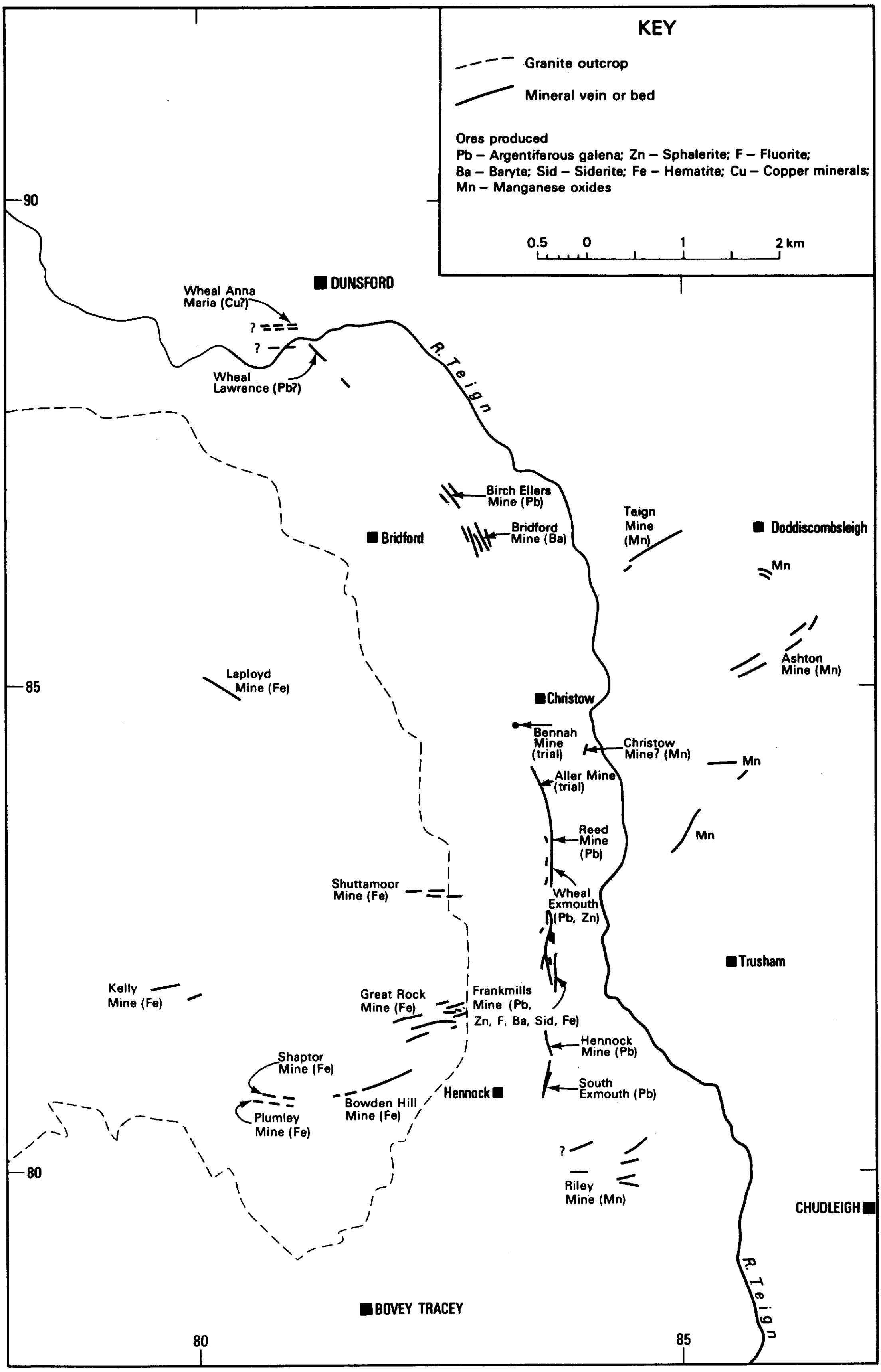


Figure 3 Mineralisation in the Teign Valley

but this type of mineralisation is not evident and has never been recorded from the sulphide-rich areas further south.

Mineralogically the veins are simple, with galena, sphalerite, pyrite, chalcopyrite and tetrahedrite set in a gangue of chalcedonic quartz, baryte, calcite, siderite and locally fluorite. Only the ore-metals extracted for profit are shown by the mines in Figure 3.

No detailed descriptions of the sulphide mineralisation survive, but it can be deduced from dump evidence and mining records that galena was distributed widely as scattered spots and crystals, often locally as continuous narrow veinlets and occasionally as irregular lenses up to 30 cm wide. Sphalerite appears to have occurred mainly as irregular large clusters, commonly associated with quartz and always of a ruby red colour. Pyrite is especially well developed in the slaty wall-rocks or brecciated slate inclusions within the lode, where it is usually fine-grained. There are only localised developments of finely scattered chalcopyrite but tetrahedrite occurs widely as spots of pinhead size, most commonly in the baryte gangue. Quartz and baryte are present throughout the strike length and some sections of the veins may be composed largely of one or the other; in some cases both may be attractively banded or interbanded. Details of the Bridford baryte veins have been published by Dines (1956) and Vipan (1959). Small crystals and clusters of calcite are widespread but this mineral never occurs as a major vein constituent. Fluorite and siderite appear to be of late introduction, filling cavities and minor fractures, especially in the more brecciated parts of the veins.

There is evidence along the strike length that lithology exerts some control upon the mineral composition of the veins (Polkinghorne, 1951; Beer, 1978). Galena is best developed where the host rock is slate, and baryte occurs to the near exclusion of quartz in the Teign Chert Formation.

Lead mining began around 1812 and ceased in 1880; Bridford Mine, which had started for lead, produced baryte continuously from 1875 to 1958. According to Dines (1956) the Teign Valley mines returned a total of 28816 tonnes of lead ore, 1590 tonnes of zinc ore, 11457 kg of silver, 185 tonnes of siderite, 182 tonnes of fluorspar and about 407000 tonnes of high grade white baryte. However, it is almost certain that these returns were incomplete and the totals are therefore under-estimates of the ore extracted.

In the past 25 years the valley area has received scant attention from mineral exploration interests, in part because of its location within the Dartmoor National Park. Dump appraisal studies have examined the availability and commercial viability of baryte and base metals in the waste tips of Frankmills Mine, Wheal Exmouth and Reed Mine, but no further activity has resulted.

DRAINAGE GEOCHEMISTRY

Sampling and analysis

Stream sediment and panned concentrate samples were collected from streams draining into the River Teign between Clifford Barton [780 900] and Chudleigh Knighton [845 774] (Figure 4) and at most of these sites samples of stream water were also taken. No sampling was undertaken in the River Teign itself.

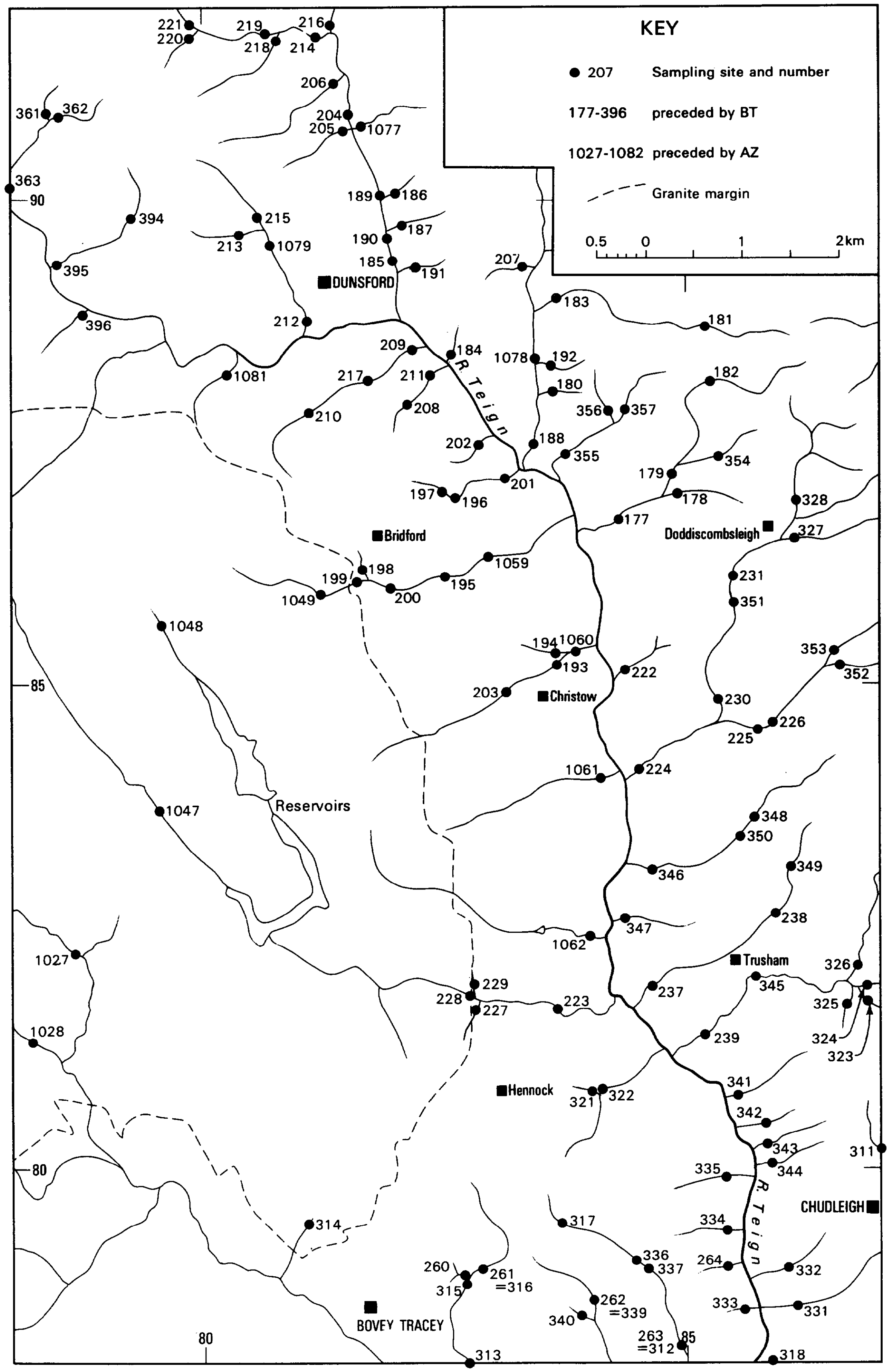


Figure 4 Location of drainage sampling sites

Stream sediment was wet-screened at site to pass 2 mm mesh and the coarser fraction discarded. Approximately 1 kg of the -2 mm fraction was bagged and another 2 kg washed free of clay and organic detritus before hand-panning to a concentrate of about 50 g weight. In the laboratory, the -2 mm sediment samples were oven-dried, sieved, and a sub-sample of the -0.25 mm (60 mesh BSS) fraction taken for analysis. Panned concentrates were dried and a split milled to provide powder for analysis. At some sites insufficient sediment could be collected to make a panned concentrate.

Chemical analysis for the dissolved contents of As, Cu, Pb and Zn were carried out on up to 109 water samples (Table 2). 112 stream sediments were analysed for Ag, Cu, Pb and Zn using atomic absorption spectrophotometry (AAS) and for U by Delayed Neutron Analysis (DNA). Ba, Co, Cr, Fe, Mn, Mo, Ni, Sn, V and Zr were determined in 110 of the samples by Optical Emission Spectrometry (OES); B, Be, Nb, and Y were determined on subsets, also by OES (Table 3). As was determined colorimetrically on 66 sediment samples. 82 panned concentrates were analysed by X-Ray Fluorescence Spectrometry for Ba, Ca, Ce, Cu, Fe, Mn, Ni, Pb, Sb, Sn, Sr, Ti and Zn; Ag and Zr were determined on subsets of 25 and 71 samples respectively. As was determined colorimetrically on all panned concentrate samples.

Results

Table 2 summarises the water analyses, and statistics for stream sediment and panned concentrate results are given in Tables 3 and 4. Log-probability plots were prepared for all the analysed elements (except B and Be) in each sample type and used to define anomalous results.

Water samples

Generally the stream water samples contained low levels of the four metals analysed and a high proportion of As and Pb levels were below the detection limit of the analytical method. The threshold for all elements was taken as the mean of the values above the detection limit (Table 2).

Table 2 Summary of stream water analyses

All results				Results above detection limit*		
Element	**Number**	**Mean**	**Median**	**Number**	**Range**	**Mean**
As	55	-	<0.015	13	0.015-0.075	0.024
Cu	95	0.012	0.01	56	0.01-0.07	0.02
Pb	95	-	<0.05	11	0.05-0.20	0.07
Zn	109	0.06	0.02	84	0.01-1.40	0.08

Results in ppm
* Detection limits: As 0.015 ppm; Cu and Zn 0.01 ppm; Pb 0.05 ppm

The distribution of anomalous concentrations of the four metals determined in water samples (Figure 5) fails to show any consistent pattern which can be related to geology or known mineralisation, and it is presumed that some of the anomalies may arise from contamination. Streams which drain former mining sites, even those where the drainage adits are still active,

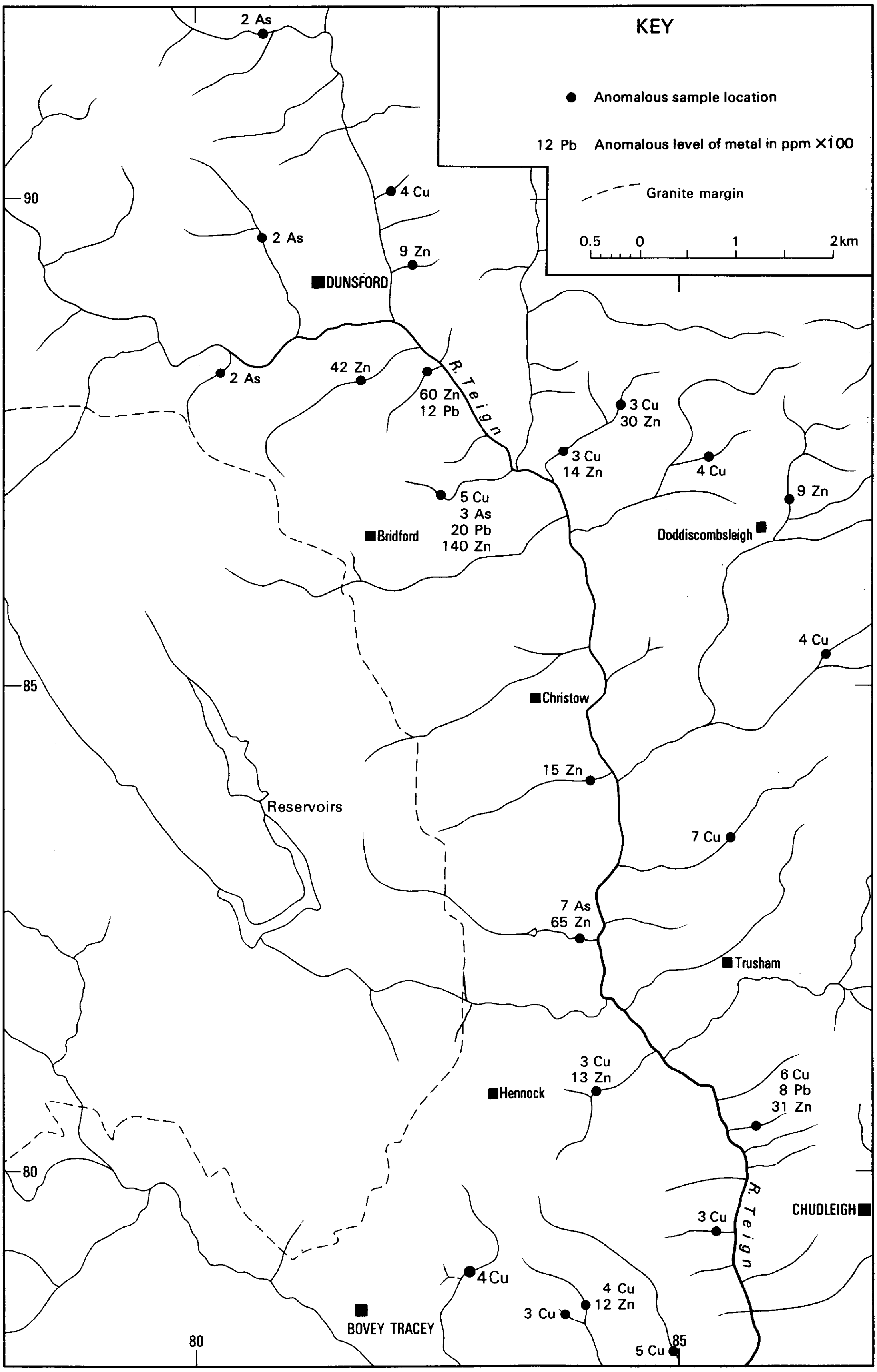


Figure 5 Anomalous levels of arsenic, copper, lead and zinc in stream water samples

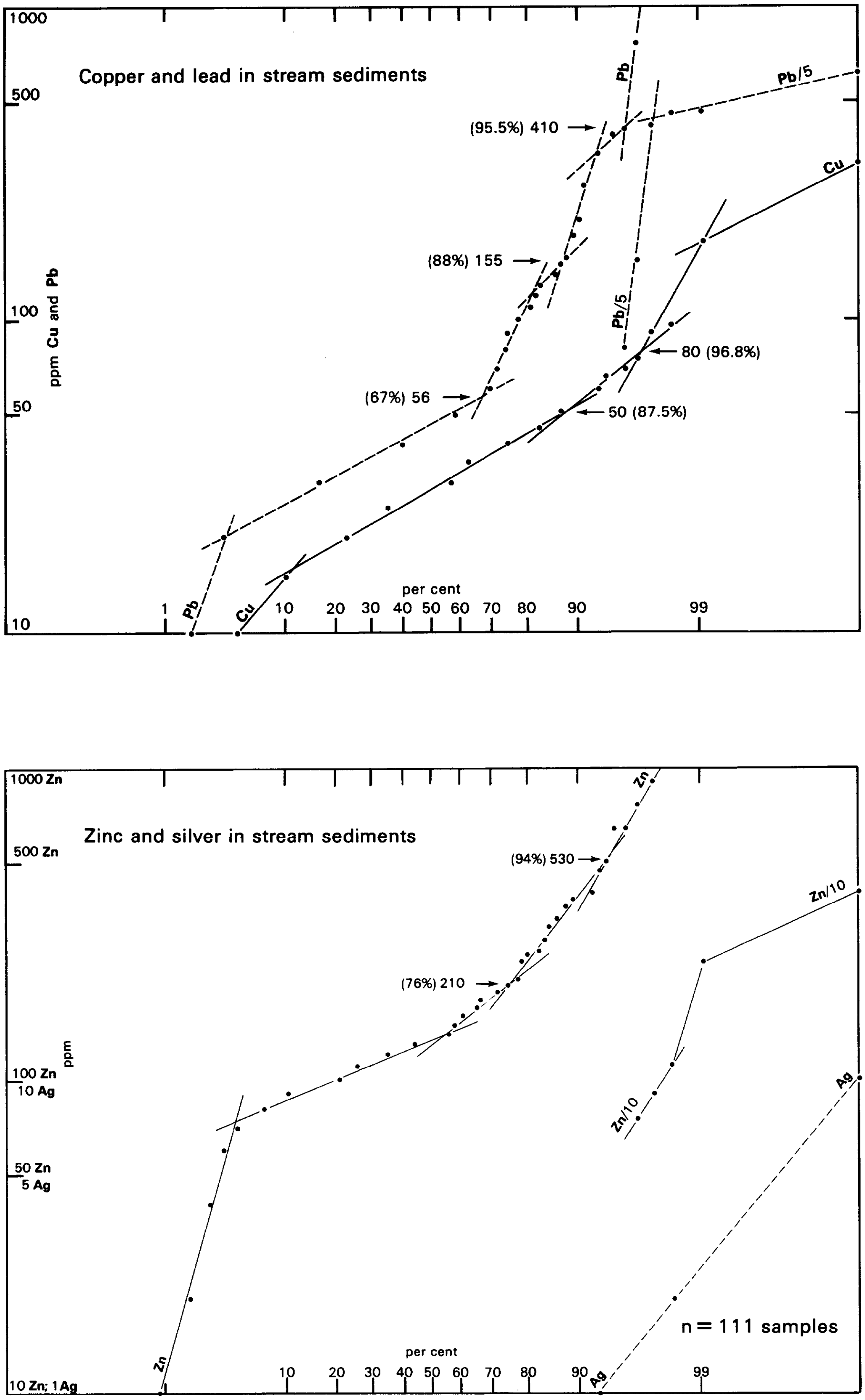


Figure 6 Log-probability plots for copper, lead, silver and zinc in stream sediment samples

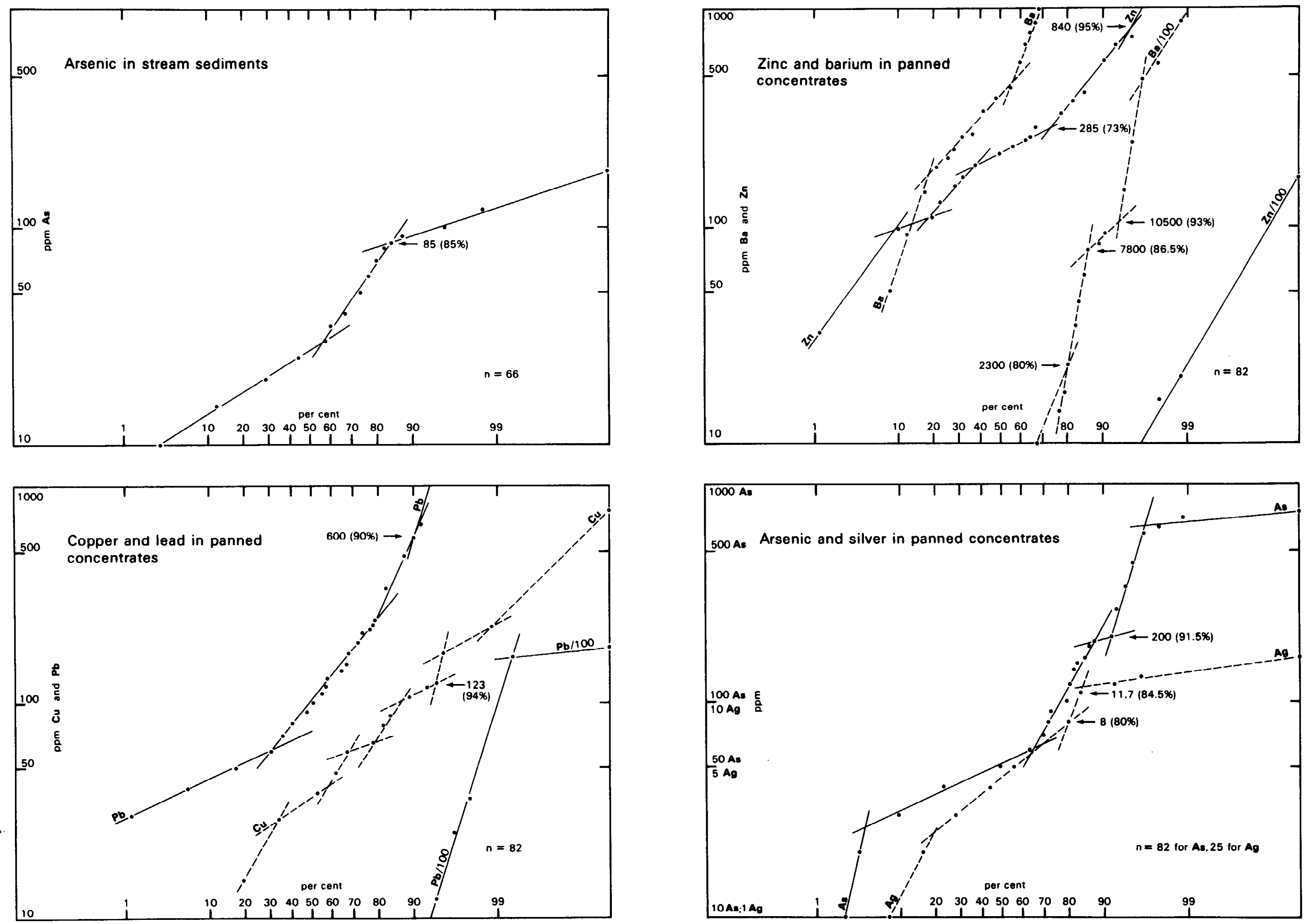


Figure 7 Log-probability plots for arsenic in stream sediments and arsenic, barium, copper, lead, silver and zinc in panned concentrates

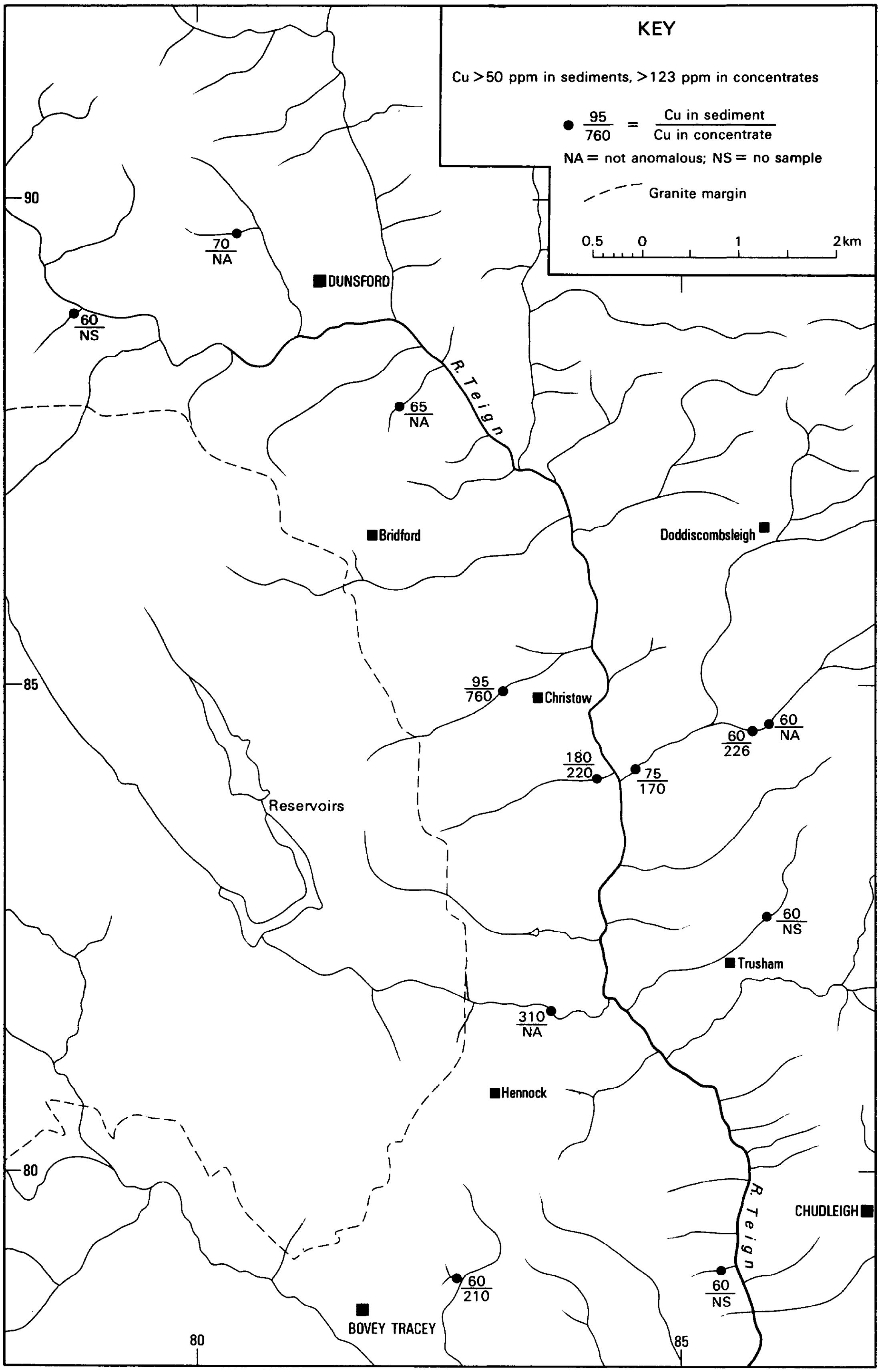


Figure 8 Copper anomalies in stream sediments and panned concentrates

commonly show only low levels of dissolved metals; the notable exception is the stream which drains Birch Ellers (= Birch) Mine [825 870], north-east of Bridford, where high levels of all four metals are recorded. To the north of here, Zn is high in two streams which lie to the south-east of Wheal Lawrence [813 884]. The more northerly of these streams passes near old trials on the presumed southward extension of the Pb-Zn vein in that mine. In the more southerly stream the sample contains high levels of both Zn and Pb (Figure 5).

Two samples from a stream which passes the farms of Easternhill [848 883] and Lowley [840 878] and joins the Teign near Sheldon [839 870] contain high levels of Zn and appreciable amounts of Cu. There is neither any record of mineralisation in this vicinity nor evidence of mining trials and so the source of the anomalies is uncertain; they may be caused by contamination.

Further south, As and Zn are high in water from the stream flowing between Canonteign House [835 828] and Hyner [839 820]. This stream crosses a formerly worked section of the Wheal Exmouth lode and passes around some small waste dumps, but it is not fed directly by mine-water. East of the Teign, water from a short tributary flowing close to Northwood Farm [857 805] proved to be anomalous in Cu, Pb and Zn, though not in As. No metalliferous mineralisation is known in the immediate vicinity, nor are there any trials nearby, and consequently the source of these anomalies remains uncertain.

A sample containing high levels of Cu and Zn is reported from the stream east of Hennock [830 810] at a point close to Teign Village [838 810]. This location is just below the widely spread dump areas of South Exmouth Mine, and it is from there that the high metal contents are undoubtedly derived. Another sample, with similar levels of the same metals, was collected further south in a stream close to Dunley Farm [840 785]. Although this location might appear to lie on the southerly strike extension of the Teign Valley lode zone, investigations for baryte (Beer and Ball, 1977b) show that this zone either does not persist so far south or is moved by faulting.

Stream sediments and panned concentrates

Anomalous levels of base metals in stream sediments and panned concentrates were determined from log-probability plots (Figures 6 and 7). The areal distribution of anomalies is shown in Figures 8-12.

Copper. Cu in stream sediment results produce a log-probability plot (Figure 6) indicating the presence of background and mineralised sample populations. Anomalous samples were taken as those exceeding 50 ppm Cu, as this departure point from the background lognormal population accorded most closely with previous regional results from south-west England. This level places 12.5% of the samples in the anomalous set. Cu in panned concentrates, by contrast, yields a plot (Figure 7) which is complex in detail but near lognormal in general form. In this case the threshold was set at 123 ppm Cu, placing 6% of the samples in the anomalous group.

Most Cu in stream sediment anomalies are close to the threshold; only two samples are significantly anomalous. The richer of these (310 ppm), in the stream north of Hennock (Figure 8), is thought to contain Cu from the nearby waste dumps of Frankmills Mine. The panned concentrate taken from the same site is not anomalous, indicating no detrital dispersion of Cu minerals and suggesting that the Cu could be held mainly in secondary form, perhaps adsorbed on

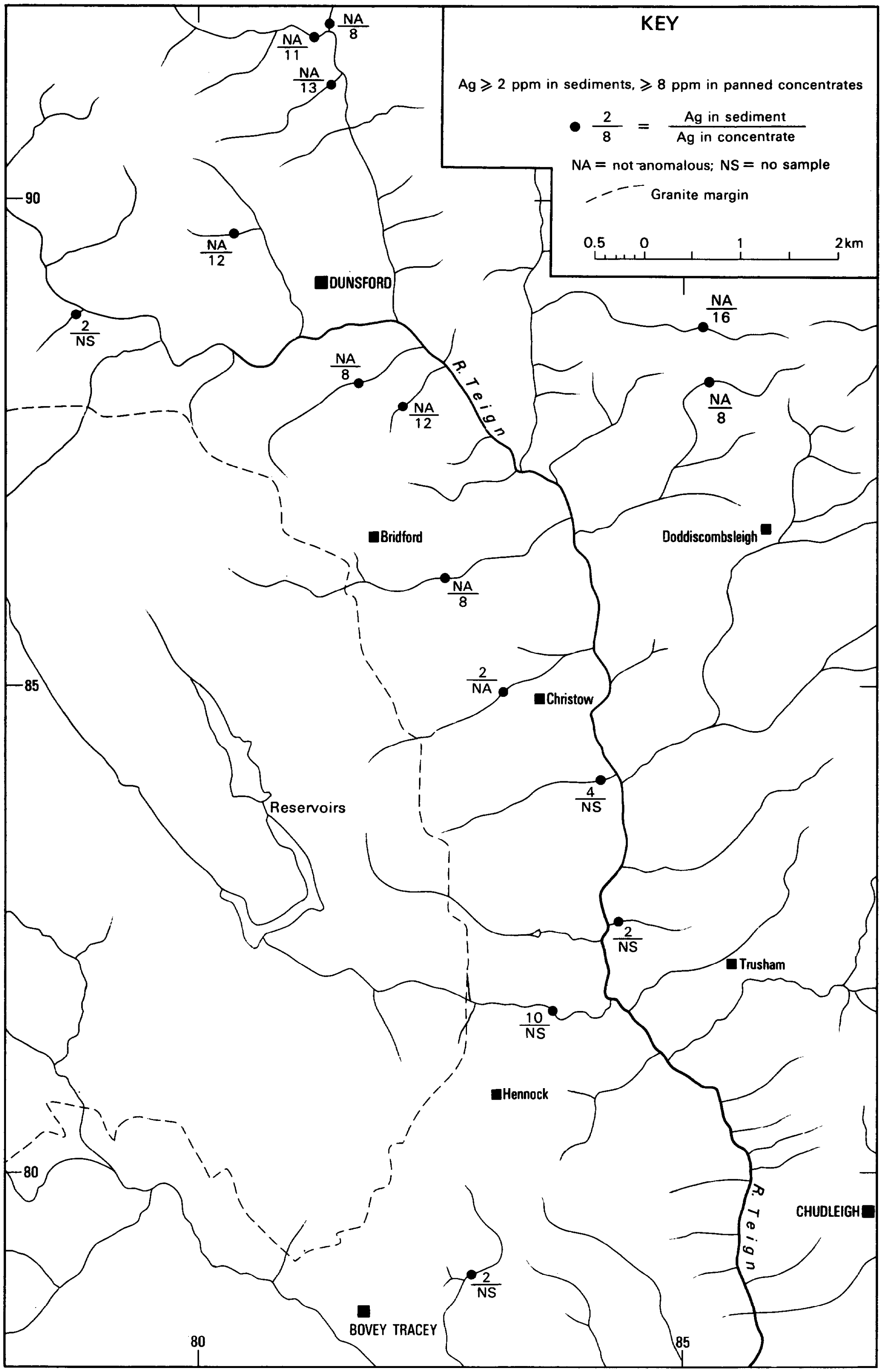


Figure 9 Silver anomalies in stream sediments and panned concentrates

Fe/Mn oxides. The other highly anomalous sample (180 ppm) comes from a small stream south of Christow, draining the vicinity of Reed Mine. The similarity of Cu levels in sediment and panned concentrate from this site (Figure 8) indicates that much of the Cu is contained in a light phase.

Table 3 Summary of stream sediment analyses

Element	n	Range	Median	Mean	Standard Deviation
Ag	*112	<1-10	1	-	-
As	66	<10-180	30	44.24	34.08
B	7	100-5600	750	-	-
Ba	110	<100-56000	420	1322	5420
Be	7	3-18	8	-	-
Co	110	10-160	32	36.75	22.48
Cr	110	<10-420	129	136.6	75.74
Cu	*112	<3-310	30	37.88	33.57
Fe	110	13000-255656	52526	59530	34716
Mn	110	<50-13000	2629	3055	2190
Mo	110	<1-13	2	2.29	2.09
Nb	61	<16-75	23	28.79	25.32
Ni	110	10-240	75	72.97	37.21
Pb	*112	10-3080	50	168.4	459.5
Sn	110	<5-5773	29	201.4	709.4
U	*112	0.8-16.5	2.9	3.54	2.47
V	110	7-420	108	137.3	80.13
Y	61	18-142	32	44.07	23.97
Zn	*112	10-4000	140	248.8	444.1
Zr	110	96-2074	420	509.9	327.7

Results in ppm
n = number of samples analysed
* summary statistics refer to 111 samples (excluding BTC 363)

A feature of the Cu results is the group of anomalies in a stream to the south of Doddiscombsleigh (Figure 8). The anomalies are confined to the southern branch which flows past Higher Ashton [856 847] and two anomalies are located close to that village. Because there are no workings for Cu in the vicinity the high values might be dismissed as contamination but, as will be noted later, the same samples are also anomalous in Pb and Zn. Such a metal combination points strongly to either local sulphide mineralisation or a dump of material transported from the mines.

Silver. The Ag in stream sediment log-probability plot (Figure 6) is uninformative, due to the large number of analytical results at or below the detection limit. Based on the results of previous work in south-west England, values in excess of 2 ppm Ag may be regarded as anomalous. On this basis 2% of the samples are anomalous. The distribution of Ag in panned concentrates is constrained by the small number of analysed samples (25). The threshold level was set at 8 ppm Ag, making 20% of the samples anomalous (Figure 7). For sites at which analyses of both media are available, sediment and concentrate anomalies show a lack of concordance (Figure 9). However, there is a relationship between the high values of Ag in stream sediment and Pb in stream sediment anomalies: the two highest Ag anomalies occur in samples with two of the four highest Pb values, and all Ag in stream sediment anomalies except one occur in samples bearing anomalous Pb

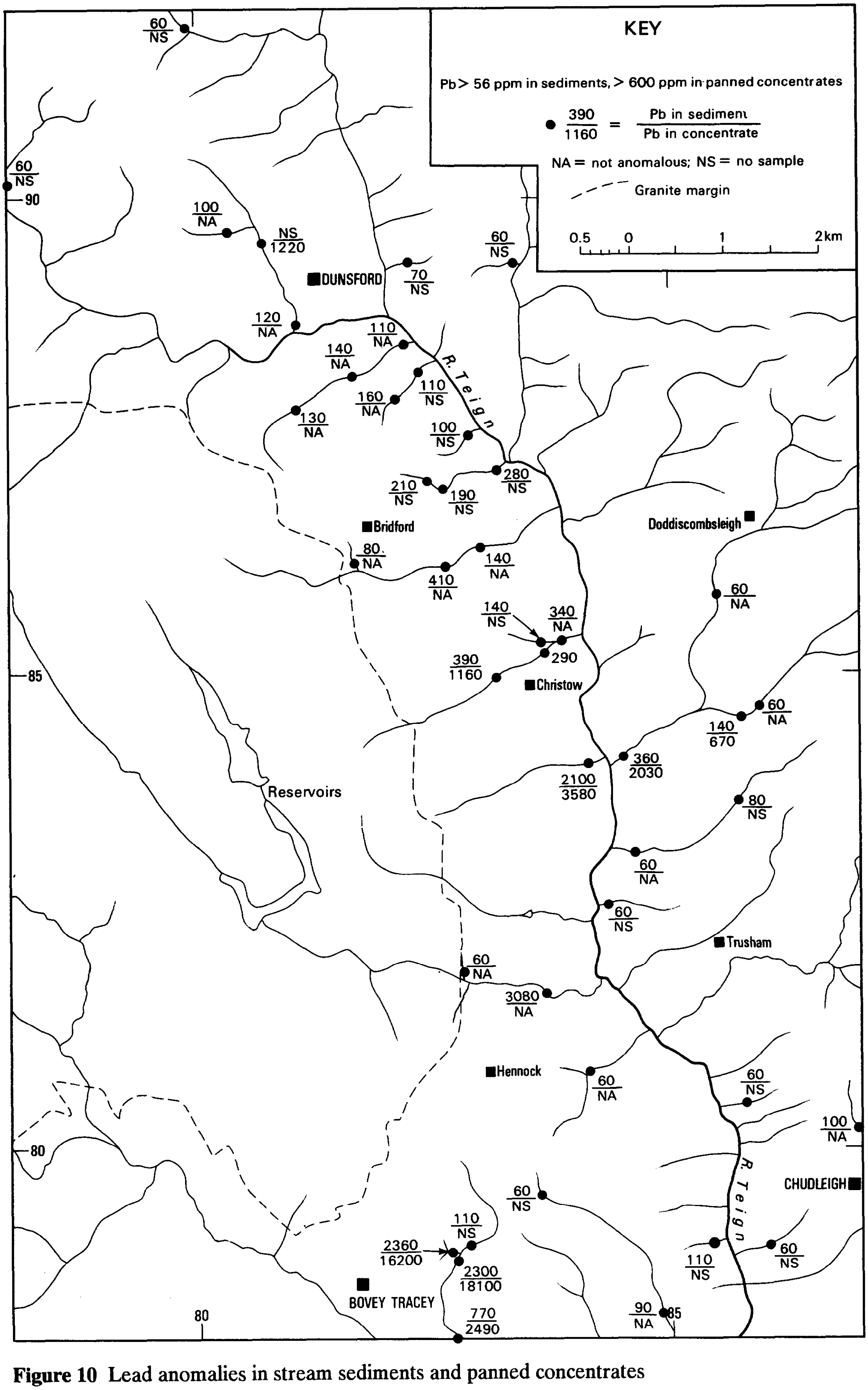


Figure 10 Lead anomalies in stream sediments and panned concentrates

concentrations (Figures 9 and 10). No such relationship is evident in the concentrates, suggesting that galena does not carry appreciable Ag.

Lead. Pb in stream sediment results yield a log-probability plot (Figure 6) which is complex in detail but consists basically of a mixing of low (background) and high (mineralised) populations. Taking cognizance of the regional background, the change in slope of the plot at 56 ppm Pb was taken as the lower cut-off for samples which may reflect the presence of mineralisation. This value separates out 33% of the results as being anomalous. Panned concentrates also yield a log-probability plot containing background and mineralised populations of Pb (Figure 7), from which an anomalous set with 10% of the samples (>600 ppm Pb) has been taken (Figure 10).

Table 4 Summary of panned concentrate analyses (82 samples)

Element	Range	Median	Mean	Standard Deviation
Ag †	1-16	5	6.16	3.95
As	<10-750	60	109.0	146.7
Ba	<10-255433	420	7214	30366
Ca	880-62600	2700	6872	11038
Ce	<10-404	61	90.04	92.87
Cu	<3-760	35	59.78	90.64
Fe	25000-394500	76100	83373	50005
Mn	200-37600	1095	3343	7049
Ni	6-256	48	59.54	46.84
Pb	30-18100	100	680.6	2662
Sb	<4-69	4	9.366	14.76
Sn	<3-22077	320	1103	3022
Sr	<5-1715	55	96.22	211.0
Ti	900-236600	4600	16307	40375
Zn	32-16800	220	507.8	1838
Zr #	<10-1875	153	299.6	396.2

Results in ppm
† 25 samples
# 71 samples

Streams draining the Teign Valley lode zone yield samples with anomalous levels of Pb in stream sediment. Only a few display coincident panned concentrate anomalies (Figure 10) but this is partly the result of setting a high threshold for the concentrates and the absence of concentrate samples from some sites. South of Hennock, a cluster of sediment and panned concentrate anomalies in the stream a short distance east of Bovey Tracey might be indicative of a westward faulted continuation to the lode zone or some other form of base metal mineralisation. In the north, around Dunsford, only weak anomalies in stream sediment are recorded. As noted above, Pb anomalies in the stream which flows through Higher Ashton [856 847] are accompanied by high values of Cu and Zn and are either caused by contamination or, more likely, mineralisation.

Zinc. Zn in stream sediment values yield a multimodal log-probability plot (Figure 6). Regional datasets from south-west England suggest that the change in slope of the plot at 210 ppm is the

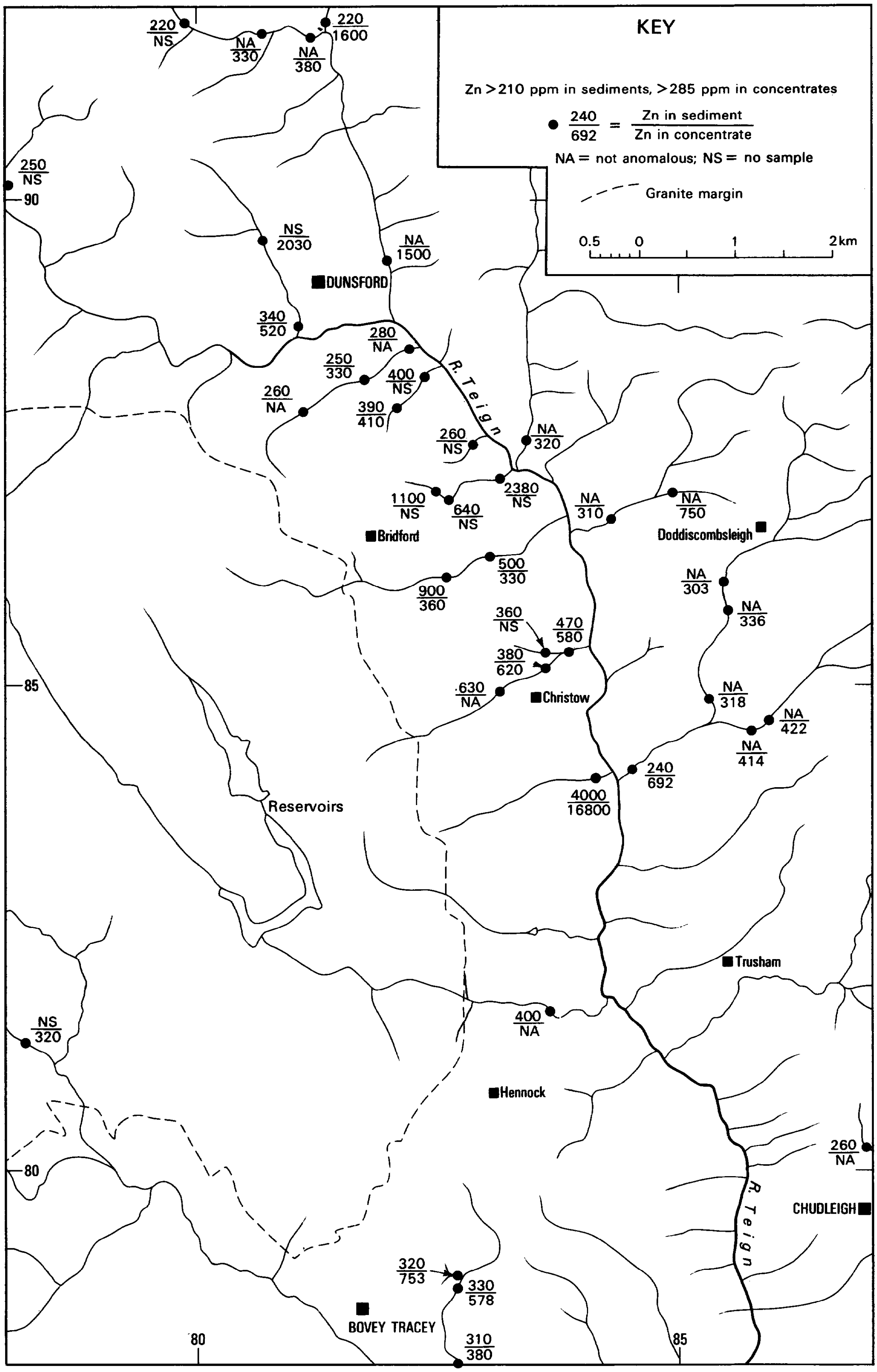


Figure 11 Zinc anomalies in stream sediments and panned concentrates

most appropriate threshold point, and on this basis 24% of the samples are defined as anomalous. The panned concentrates give a plot (Figure 7) with a clear change in slope at 285 ppm Zn which was taken as the threshold point. Samples above this point comprise 27% of the total.

Areal distribution of these anomalies differs from that which might be predicted. All the streams which drain the Teign Valley lode zone to the north of Reed Mine yield sediment samples with anomalous Zn contents, with many also yielding anomalous panned concentrates (Figure 11). However, south of Reed Mine the streams are markedly lacking in Zn anomalies, except for the cluster east of Bovey Tracey. There is no obvious explanation for this feature; Frankmills Mine and Wheal Exmouth were both rich in sphalerite and it is a common mineral in their waste dumps. Two panned concentrate anomalies just north of Dunsford may be caused or enhanced by detrital contaminants. Near the northern margin of the study area the anomalies, with one exception, are rather weak. That exception, coincident anomalies in sediment (220 ppm) and concentrate (1600 ppm), may be caused by sphalerite associated with the baryte which is seen as occasional field float in this area. Concentrate anomalies west and south of Doddiscombsleigh are probably caused by contamination; it is thought that galvanised agricultural wire may be a primary cause. Further south, in the Higher Ashton stream, Zn anomalies are associated with high Cu and Pb values.

Arsenic. This element is known to occur as a minor constituent in some slates and as an accessory metal in the mineral veins, where it accompanies Cu in tetrahedrite. For stream sediments, the log-probability plot (Figure 7) indicates the presence of background and mineralised sample populations. The change in slope at 85 ppm was taken as threshold, placing 15% of the samples in the anomalous group. As in panned concentrates (Figure 7) has a multimodal distribution and the threshold level was set at 200 ppm As, separating out 8.5% of the samples as anomalous.

A large number of the anomalous samples, which cluster around Bridford and Dunsford (Figure 12), appear to be associated with the baryte-rich northern end of the Teign Valley lode zone. It is not apparent why this part of the lode zone should be anomalous in As, and another source may be responsible. The central part of the lode zone, mined for Pb and Zn, produces only two samples anomalous in As. In the southern part of the area, the stream east of Bovey Tracey is anomalous in As as well as Pb and Zn (Figures 10-12).

Other elements. In the Teign Valley lodes Sb occurs in tetrahedrite at levels of about 20% (see Appendix 1). Sb was determined only in the concentrate samples, where high values (>34 ppm) correlate with Zn rather than with Cu. The areal distribution of these high values, although scattered, seems related to the Teign Valley vein mineralisation.

Ba occurs as a minor constituent in most of the rock types and locally as a major gangue mineral in sulphide lodes. The log-probability plots for Ba in sediments and concentrates reflect those sources, and the distribution of anomalies is illustrated in the previous report on this area (Beer and Ball, 1977b). As might be expected, large Ba anomalies are located in streams which flow over the Teign Valley lode zone, particularly to the north of Reed Mine. However, some high values such as that in a sediment sample from near Whitemoor [862 866], in a concentrate from west of Apridge [848 870] and in both sample media from a site at Lower Ashton [845 842], have no obvious source and may be caused by undiscovered mineralisation or transported mine waste.

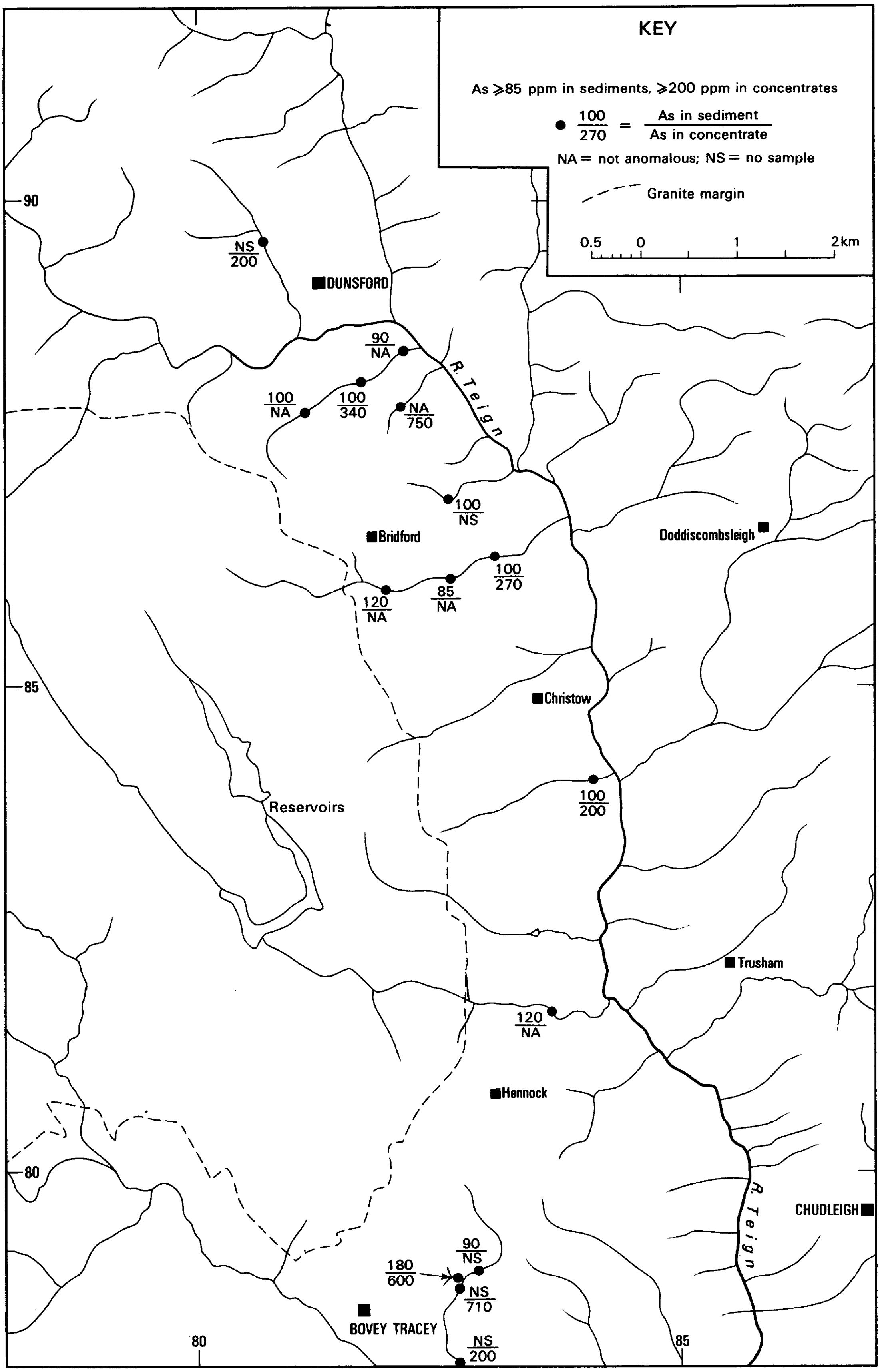


Figure 12 Arsenic anomalies in stream sediments and panned concentrates

Recorded occurrences of Mn oxides near Christow, Doddiscombsleigh and Lower Ashton [844 842] are all sources of high Mn. Clusters of high Mn concentrations in samples from around Bridford, Dunsford and north and west of Doddiscombsleigh suggest the possibility of manganiferous beds in those areas. There is no obvious correlation between the higher levels of Mo in the sediments and the geology. No Sn is associated with the Teign Valley lode zone, but some streams carry cassiterite derived from the granite or from the Bovey Beds. Sn also occurs as a contaminant.

All high uranium values in the sediments can be explained in terms of derivation from the Dartmoor Granite. They occur in samples on the granite, close to the contact, or immediately downstream from it. Significantly, however, not all granite-derived sediments report high levels of U, and it may be reasonable to attribute a large part of the U content to secondary phases, rather than to discrete uranium-bearing minerals such as monazite, xenotime or zircon.

Assessment

Variations in the degree and nature of the sulphide mineralisation and in the baryte/quartz content of the gangue are reflected in sediment or concentrate analyses. Similarly, most of the formerly mined Mn occurrences generate drainage anomalies.

Northward from Wheal Anna Maria [807 886], most northerly of the Teign Valley Pb mines (Figure 3), there is evidence of Zn with more restricted Ba, Pb and Ag mineralisation. The existence of veining was already evident from scattered baryte float in the fields above Dunsford. There is no record of mineral exploration in this area and, although largely in the National Park, it was considered worthy of further investigation by soil geochemistry.

To the south of the lode zone workings, drainage anomalies suggest the presence of base metal mineralisation, notably to the east of Bovey Tracey in the vicinity of Higher and Lower Coombe. The findings of investigations seeking Ba mineralisation on a southerly continuation of the lode zone (Beer and Ball, 1977b) indicated that these anomalies are unlikely to be reflecting a southerly continuation of that zone. Whatever their relationship, if any, to the main lode zone, anomalies in this southern area also merited further study.

In the central, worked part of the lode zone a notable feature of the drainage samples is the paucity of Cu anomalies. Also, there is no regular pattern of Sb or As anomalies associated with the known sulphide mineralisation.

Amongst anomalies east of the River Teign are three clustered in the stream passing through Higher Ashton. All are anomalous in Cu, Pb and Zn, with one anomalous in Ba. Such an association suggests the presence of hitherto unsuspected Pb-Zn mineralisation and calls for future investigation.

SOIL SAMPLING SURVEY

Sampling and analysis

Based upon the drainage sampling results a programme of traverse-based soil sampling was drawn up in order to define more closely the sources of the stream anomalies. To avoid the problems raised by downhill creep, the traverses were sited wherever possible along the interfluves between

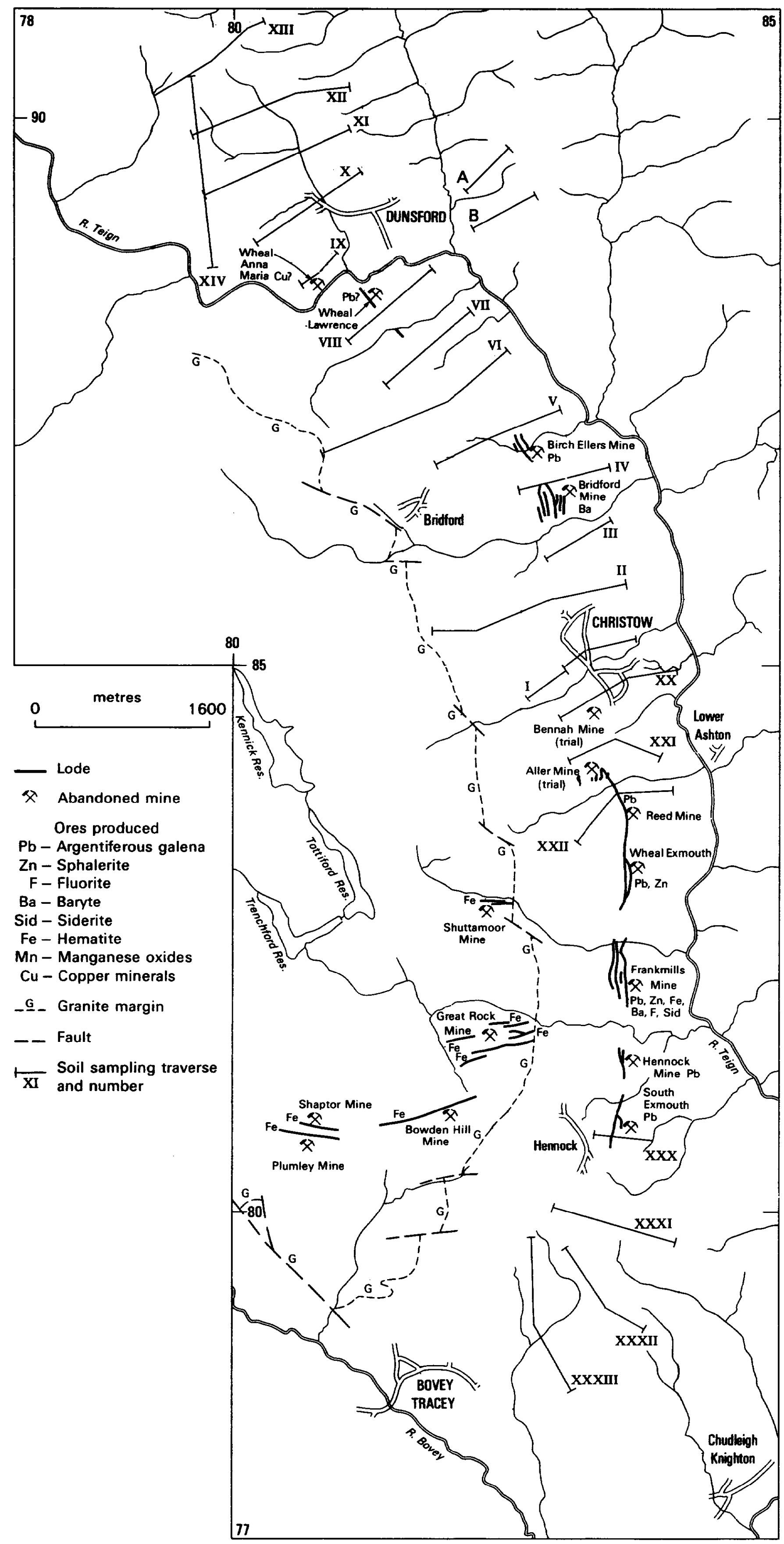


Figure 13 Soil sampling traverse locations

tributary streams. Initially attention was focussed upon the area west of the river. It was planned that later resources would be applied to the Ashton area but, due to changing priorities, the drainage anomalies there have not been followed-up. The location of the soil sampling traverses is shown on Figure 13 in relation to the principal mine workings.

In addition, during geophysical surveys near Whidley House [806 891], Windhill Gate [818 870] and Higher Coombe [831 795], further soil samples were taken at some of the measurement stations; these sites are shown in Figures 18, 19 and 20 and are termed infill samples.

All the samples were obtained by hand augering and, if attainable, were taken from a depth of about 1 m and in the C-horizon. Normally sampling sites were spaced 50 m apart along traverses, but part of traverse 4 was sampled at 10 m intervals. After oven-drying and disaggregation the samples were screened at 0.25 mm (60 mesh BSS). The oversize fraction was discarded whilst the undersize fraction was split to provide sub-samples for chemical analysis. A total of 577 samples were collected along the soil survey traverses and prepared for analysis, together with 149 duplicates. Geophysical lines yielded another 84 samples for analysis plus 5 duplicates.

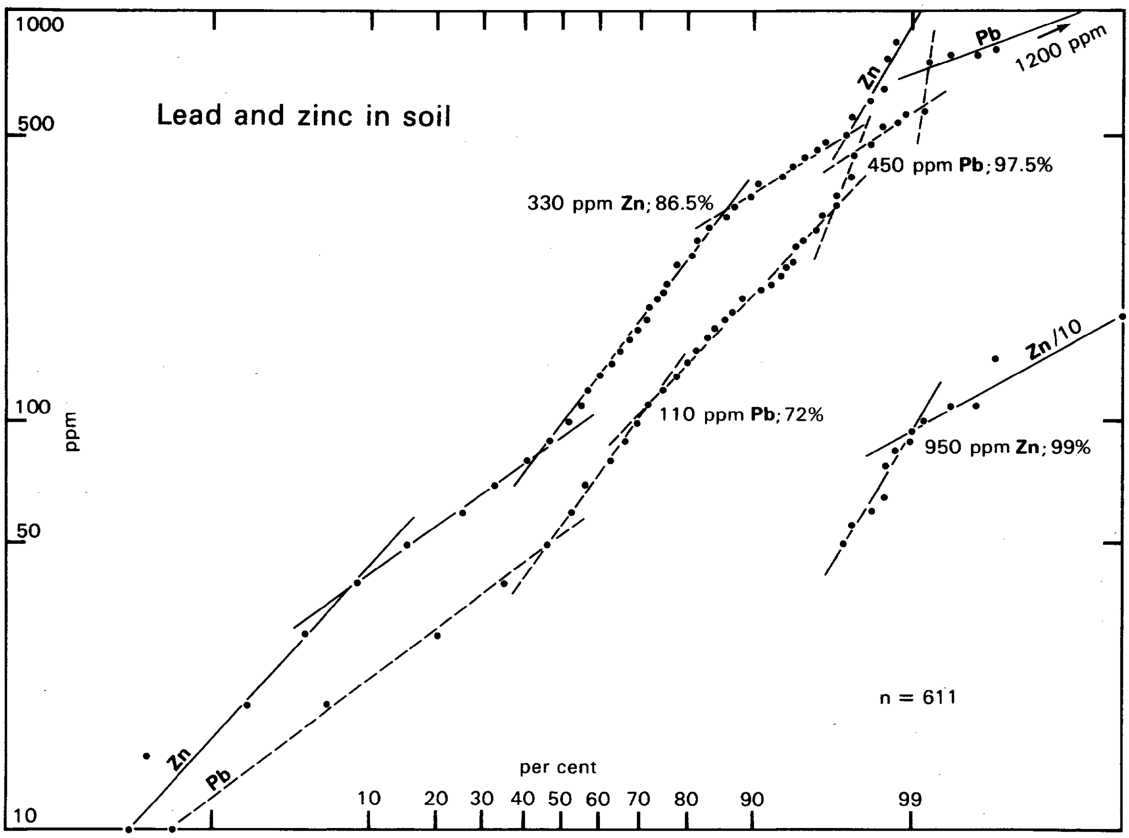
All soil survey traverse samples (but not duplicates) were analysed by AAS for Cu, Pb and Zn, most (512) for Ag, and 240 for Co and Ni. Gravimetric determinations of Loss on Ignition and repeat analyses for Ba, Pb and Zn were carried out on one batch of 34 samples. All samples, and most duplicates, were analysed for Ba, Co, Fe, Mn, Mo and Ni by OES. As was determined by a colorimetric method on 307 of the samples and U measured by DNA analysis on all samples. Subsets were analysed by OES for the other elements listed in Table 5. The infill samples collected along geophysical survey lines were analysed by AAS for Ag, Pb and Zn only; Ag was not determined on the five duplicates.

Results

Chemical analyses of soil samples are summarised in Tables 5 and 6.

Log-probability plots were prepared for all elements except those with a high proportion of results below the detection limit, but only those for As, Cu, Pb and Zn are included in this report (Figure 14). Threshold levels applied to all the data were determined from the main soil survey dataset. The log-probability plots for Pb and Zn (Figure 14) are broadly similar and multimodal. For Pb a change in slope at 110 ppm was taken as the threshold, providing a large set (28%) of anomalous samples, all of which are presumed to reflect the presence of metalliferous mineralisation, probably in disseminated as well as vein modes. A more highly anomalous subset, with contents greater than 450 ppm Pb, probably represents solely vein-type mineralisation and this group constitutes 2.5% of the samples. The equivalent points on the Zn plot both define much smaller anomalous sets: the lower threshold, set at 330 ppm, segregates 13.5% of the samples whilst the higher, set at 950 ppm, contains 1% of the samples (Figure 14).

The Cu plot (Figure 14) shows a change in slope at 40 ppm which was taken as the threshold value. The upper 28% of samples are thereby defined as anomalous. The 99% value is 145 ppm, a high level for soils in south-west England and taken to indicate that significant Cu mineralisation is present. Although many samples from this area are moderately anomalous in both Zn and Pb, samples are rarely anomalous in all three metals and correlation of metal contents is notably poor.



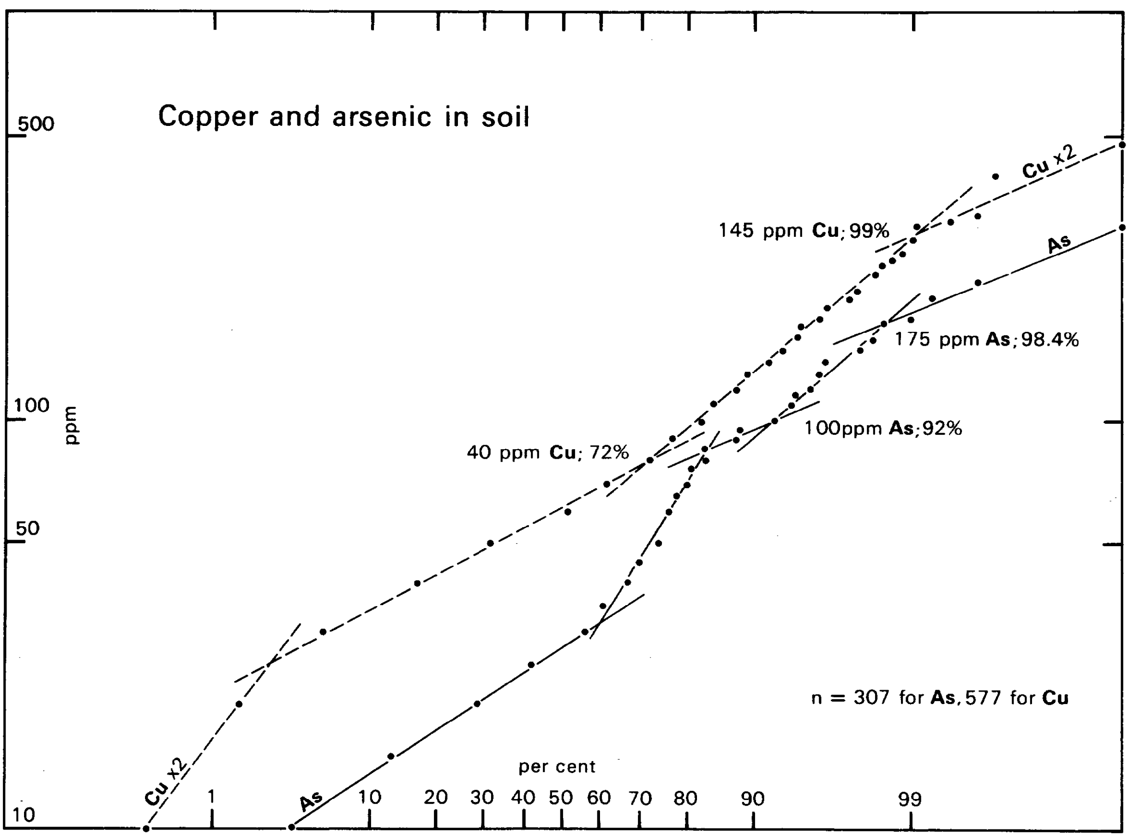


Figure 14 Log-probability plots for arsenic, copper, lead and zinc in soil samples

Table 5 Summary statistics for traverse soil analyses

Element	n	Range	Median	Mean	Standard Deviation
Ag	512	<1-3	<1	-	-
As	307	10-300	30	46.53	39.98
Ba	760	<100-7500	320	1125	4490
Co(AAS)	240	<3-100	10	16.23	12.44
Co(OES)	726	<10-420	24	21.63	21.48
Cr	307	<10-560	180	216.8	97.31
Cu	577	5-240	30	39.73	25.28
Fe_2O_3	726	<1.0-56.0	7.5	8.55	5.30
LoI	34	1.0-40.0	7.0	9.03	8.12
Mn	726	<50-24000	750	1521	2197
Mo	726	<1-56	2	2.38	4.24
Ni(AAS)	240	<5-140	20	30.92	22.25
Ni(OES)	726	<10-420	41	43.46	41.26
Pb	611	10-1200	60	102.1	116.3
Sn	307	<5-320	<5	-	-
U	580	<0.5-24.1	3.6	4.06	1.73
V	307	42-1000	240	258.9	135.0
Y	307	<5-130	32	33.42	24.18
Zn	611	10-1820	100	168.2	176.1
Zr	307	<56-1800	420	493.5	399.6

Fe_2O_3 and LoI quoted in percent, other results in ppm
n = number of samples analysed, including duplicates

The As log-probability plot (Figure 14) indicates the presence of a well defined background lognormal population and one or more higher sets. Changes in slope at c. 100 ppm accord with the threshold of previously acquired datasets from Devon and Cornwall and may be related to arsenopyrite distributed throughout some of the sedimentary rocks. The most anomalous samples (>175 ppm) probably reflect the presence of As in lode mineralisation, this being almost entirely contained in tetrahedrite. Nowhere is there any evidence of As-rich mineralised beds similar to those near the granite contact at Belstone (Beer et al., 1989).

The other lode element of potential economic interest is Ba, which has been considered in detail in a previous publication (Beer and Ball, 1977b). The log-scale cumulative frequency plots for Ba in soil, from both reconnaissance and follow-up surveys, clearly indicated the presence of background and mineralised populations. The threshold for the reconnaissance samples was set at 1000 ppm (Beer and Ball, 1977b).

Fe_2O_3 yields a log-probability plot indicating the presence of two or more populations with a small but highly anomalous set (1.2%) containing >17.5% Fe_2O_3. The plot for Mn is near lognormal but complex in detail. The distribution of V is near lognormal, whilst the Cr plot indicates a distinct set (16.5%) of samples containing more than 280 ppm Cr. It is thought that the two populations reflect different Cr levels in shales and tuffs. Sn values reach 320 ppm, suggesting the presence of mineralisation or contamination, but the log-probability plot forms a straight line and provides no evidence of an anomalous population. The Mo plot is close to lognormal but provides evidence of a

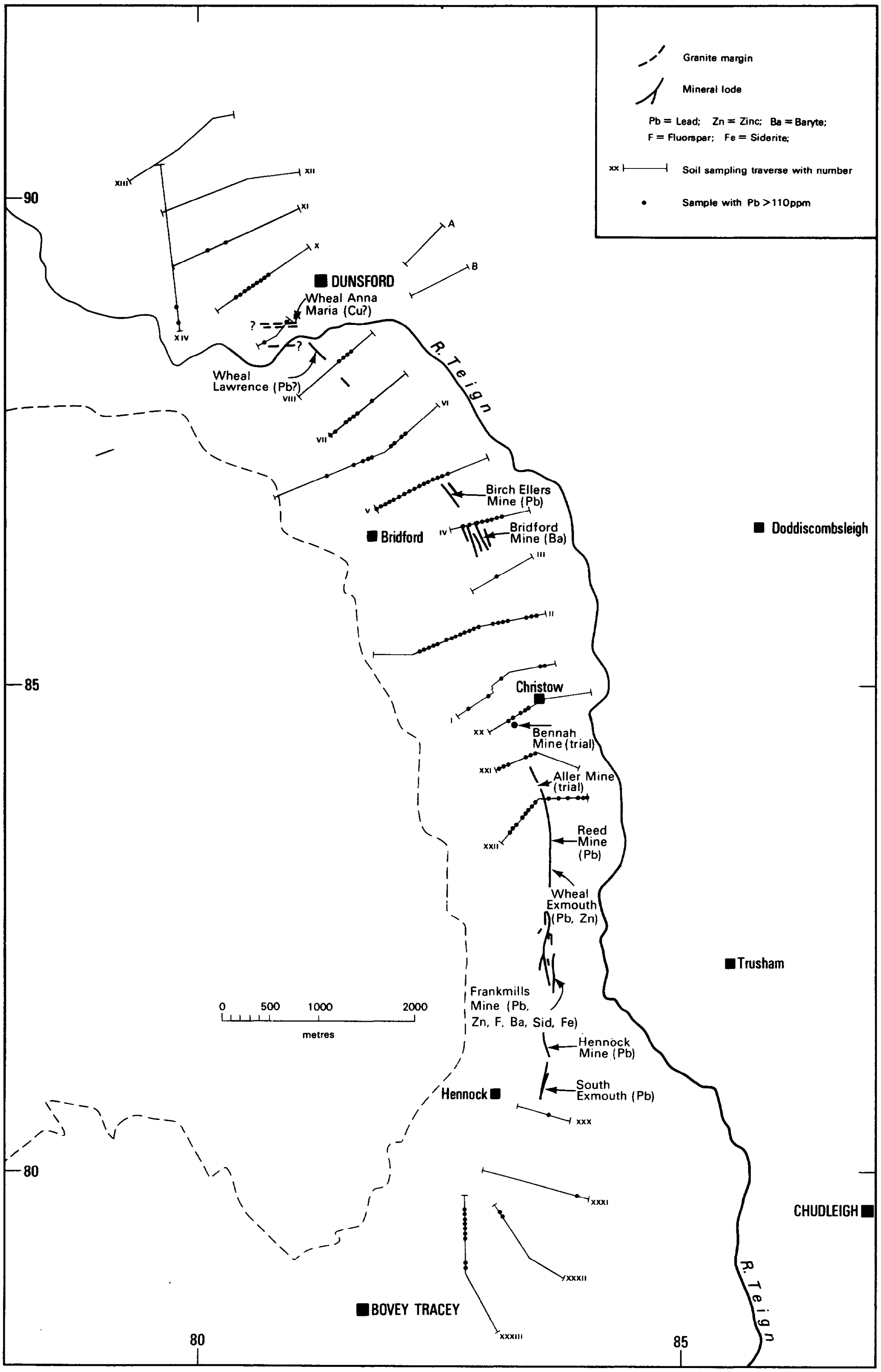


Figure 15 Lead-in-soil anomalies

small (1.3%) anomalous set above 10 ppm. The plots for Y and Zr suggest the presence of two or more populations that are believed to reflect differing concentrations of these elements in the sedimentary succession (sandstone-shale) and volcanic rocks. Finally, U yields a sigmoidal log-probability plot most readily interpreted as a mixing of material from background and enriched (mineralised) sources.

Table 6 Summary statistics for 89 infill soil analyses

Element	Range	Median	Mean	Standard Deviation
Ag^+	<1-3	1	-	-
Pb	40-1810	160	199.1	203.2
Zn	40-440	150	170.0	89.56

Results in ppm
$^+$ 84 analyses

One of the features of the analytical results is a lack of any close positive correlation between those elements represented within the metalliferous mineralisation (Cu, Pb, Zn, As and Ba). Because reported contents of Ag are close to or below the detection limit, it is not possible to comment meaningfully on the relationship of this element to the other metals.

Assessment

The areal distribution of metal anomalies in soils is shown in Figures 15, 16 and 17 and discussion of these diagrams is structured under five areal headings, as follows:- (i) northern area, (ii) peripheral area, (iii) northern vein area, (iv) central vein area, and (v) southern area.

Northern area

This area, which might contain extensions to the known Teign Valley veins, lies north of the River Teign and north-west of the village of Dunsford. Wheal Anna Maria, northernmost of the Teign Valley mines, lies at the southern end of this area but its exact site is a matter of some doubt. Although it might reasonably be expected that mineral veining should continue north of this mine, albeit in tenuous form, the only evidence for such continuation is a scattering of baryte debris in some fields (Beer and Ball, 1977b); there is no sign of former exploration activity.

A significant grouping of Pb anomalies around Whidley House [806 891], west of Dunsford, prompted geophysical surveys in this area. Infill soil samples collected along one of the geophysical traverse lines confirmed the presence of Pb around the house and defined another group of anomalies further west (Figure 18). Few Zn anomalies are associated with the Pb but one is notably high in value (Figure 18). Neither Cu nor As appear to accompany the Pb and Zn in substantial amounts, nor are those metals commonly enriched in the area (Figure 17). Such distributions tally closely with the drainage geochemical results. The geophysical data collected here (see below) suggest that the geochemical anomalies may be related to disseminated mineralisation, rather than any northward extension of the Teign Valley lode zone.

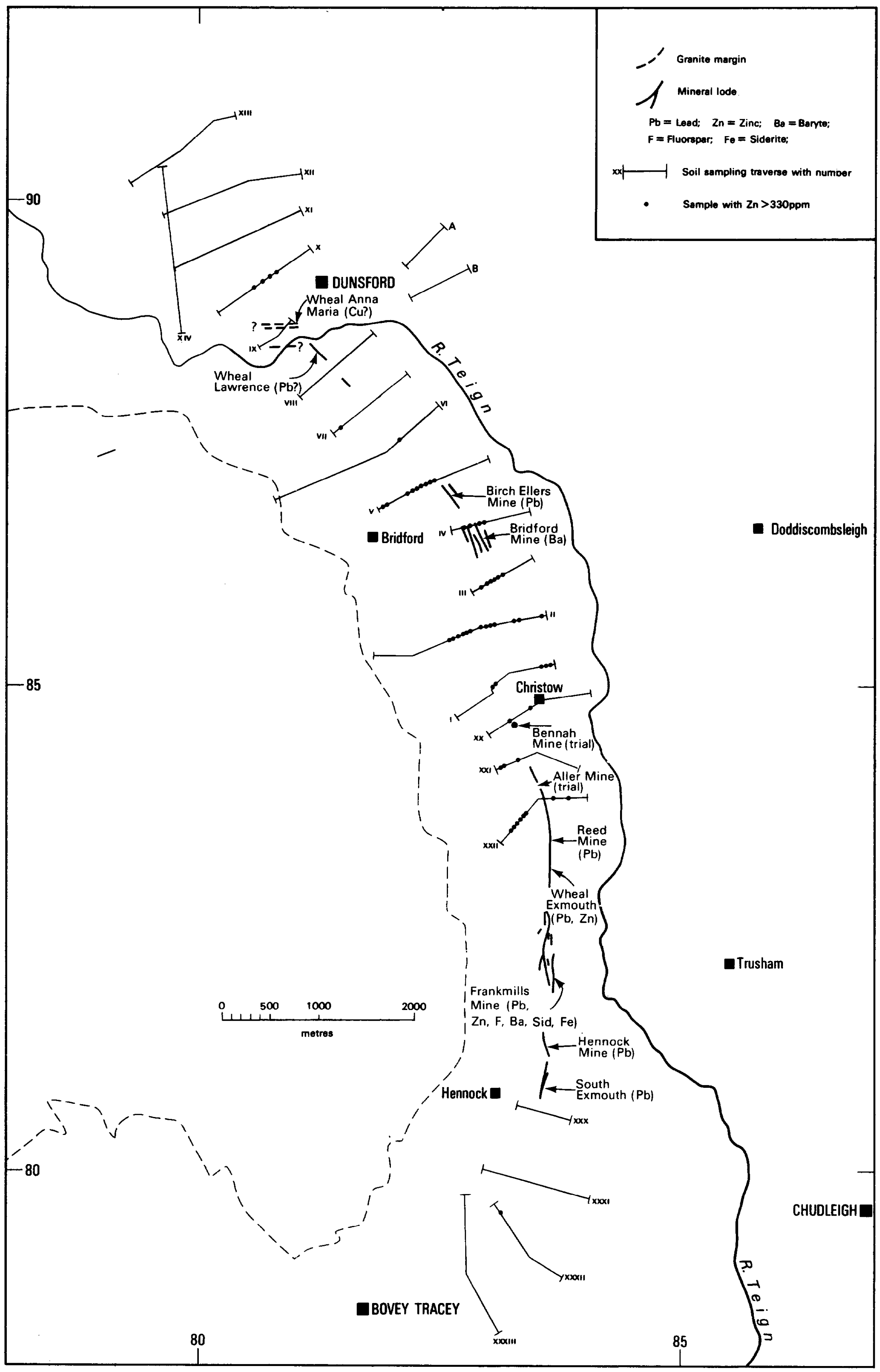


Figure 16 Zinc-in-soil anomalies

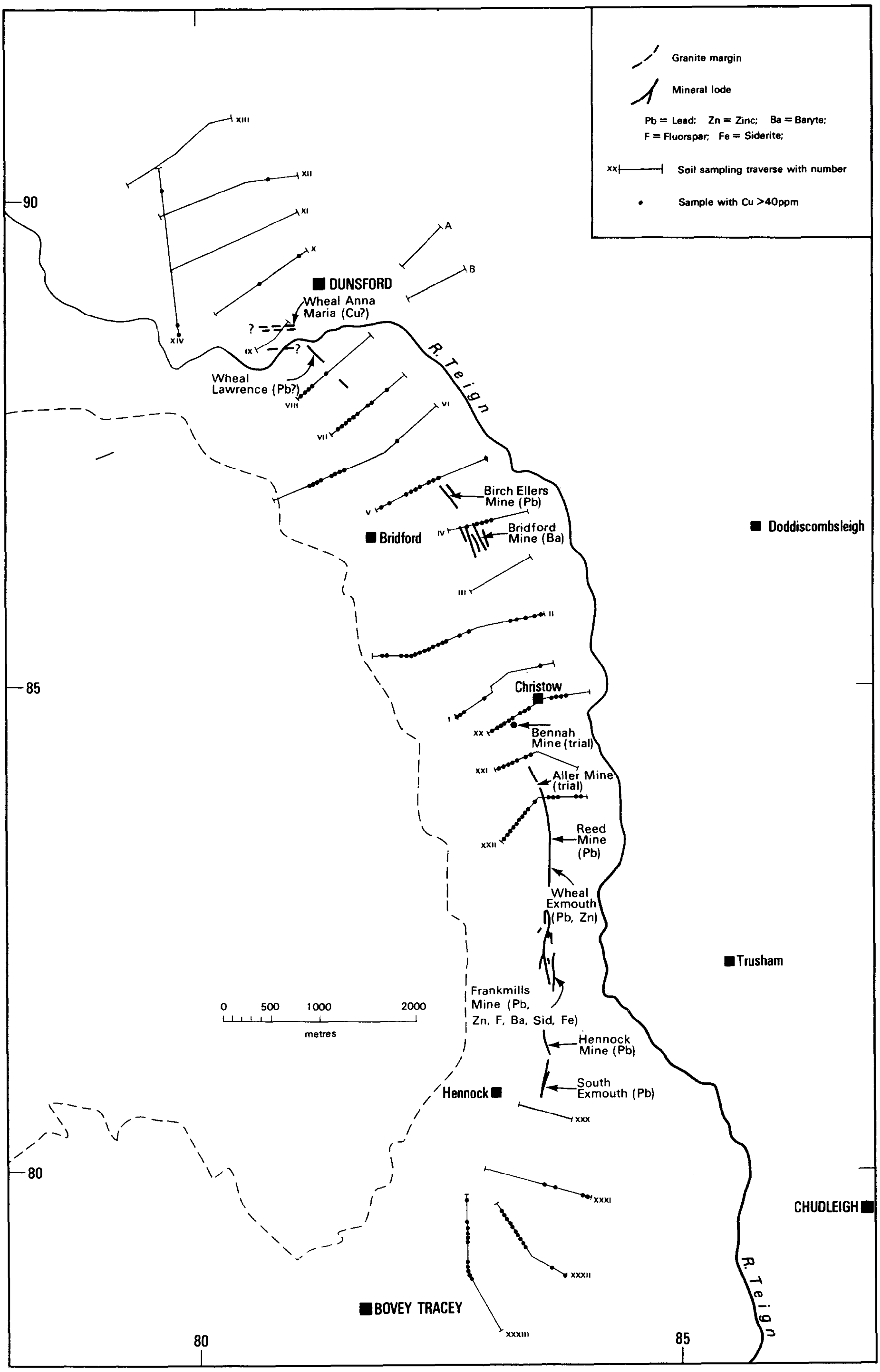


Figure 17 Copper-in-soil anomalies

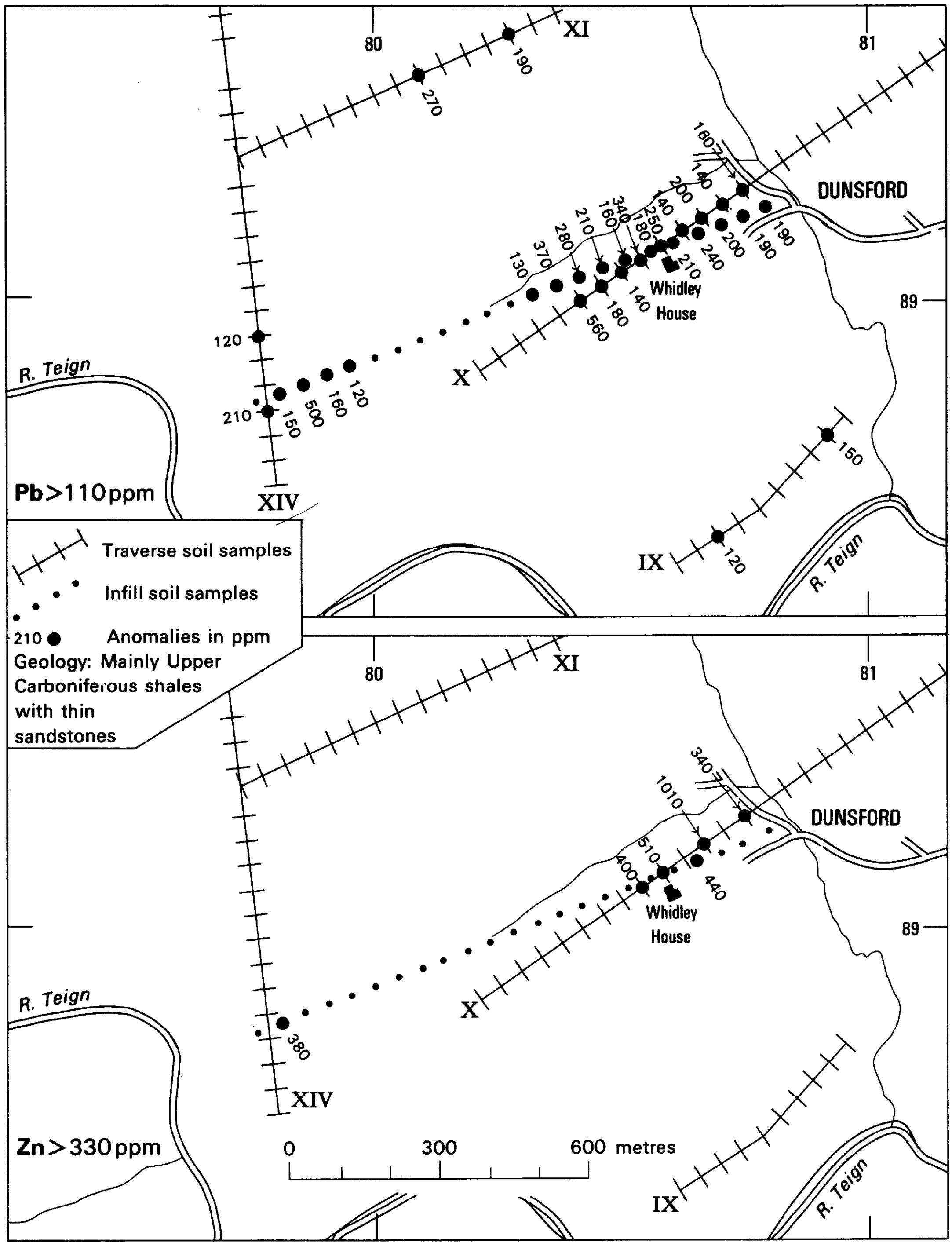


Figure 18 Lead and zinc anomalies near Whidley House, Dunsford

Peripheral area

This area contains two traverse lines (A and B) which lie to the east of Reedy [821 893], which is east of Dunsford (Figure 13). Weak Pb anomalies were reported in the drainage here, but no Cu, Pb nor Zn anomalies were recorded in the soils from these traverses; As was not determined.

Northern vein area

Extending from Christow village northwards to the River Teign near Dunsford (Figure 13), this area contains the Bridford Mine which was a major baryte producer until 1958. Another wide lode with good baryte was reported to the north in Birch Ellers Mine, but it has never been worked. In the south, between Bridford Mine and Christow, no mining activity has been recorded but it seems improbable that no prospecting was done during the last century.

All four traverses to the north of Bridford (5-8) show clustered Pb anomalies (Figure 15) suggestive of branching mineralised veins with a north-westerly trend. The most northerly of these is probably close to the former position of Wheal Lawrence and the most southerly lies immediately north of Birch Ellers Mine. Only on this latter traverse (5) is there any correlation between the Pb anomalies and those of Zn (Figures 15 and 16). Anomalous Cu tends to occur with Zn on traverse 5 and substanitial As anomalies (up to 300 ppm As) occur at the south-west end of traverse 8 and on the south-western half of traverse 7, mostly in samples containing Cu anomalies. Elsewhere in this section the anomaly relationships are inconsistent. A continuous U enrichment over 500 m of traverse 5, at levels of 5.5 to 24.1 ppm U, is hard to explain; no uraniferous minerals are known to occur within the Teign Valley lodes and the traverse is far removed from the granite contact. No similar clustering of U values is seen elsewhere in the mined section of the lode zone.

A geophysical measurement line close to traverse 6 was sampled for soils and the results for Pb and Zn are shown in Figure 19. Anomalous Pb values are almost continuous along this geophysical line, suggesting an even wider zone of mineralisation than is seen in traverse 5, but only one Zn anomaly is present in the vicinity (on traverse 6). Depending upon the degree of natural and any artificial dispersion, these anomalies suggest the presence of several branching or anastomosing veinlets and/or mineralisation within the host rocks.

It is to be expected that traverse 4, lying immediately north of Bridford Mine, should show some Pb anomalies (Figure 15) and some high Zn and Cu values (Figures 16 and 17). Extending over some 400 m they span most of the known breadth of mineral veining in the mine. As values only reach 100 ppm in these samples, but resampling of the traverse at 10 m intervals yielded samples containing up to 175 ppm As. To the south, traverse 3 shows only one minor Pb anomaly but several for Zn and none for Cu or As.

Traverse 2 crosses unmined ground just north of Christow village, but it shows clusters of Pb anomalies spread over 1250 m, accompanied in part by anomalous Zn and Cu. As was only determined in samples collected from the eastern half of the traverse, where only one anomalous value was recorded (110 ppm). The anomaly pattern suggests the occurrence of several parallel mineralised veins (structures which surprisingly were not tried during periods of former mining activity) or mineralisation within the host rocks. Unfortunately, the locality lies within the Dartmoor National Park and close to Christow village.

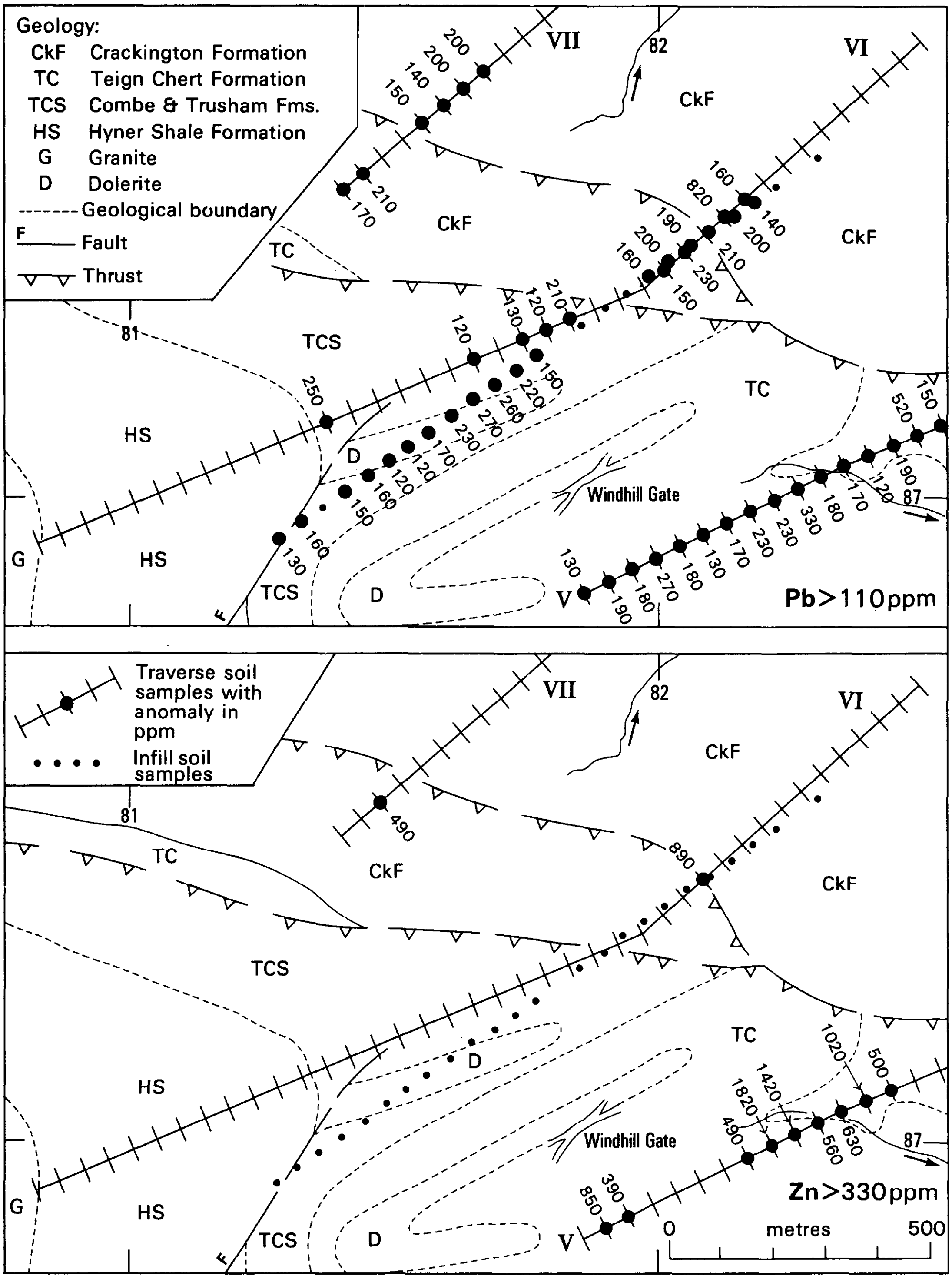


Figure 19 Lead and zinc anomalies near Windhill Gate, north of Bridford

Central vein area

This is an area, between Christow and Reed Mine, in which former mining trials revealed a series of parallel vein structures but failed to locate viable quantities of ore. Traverses 1, 20 and 21 show small groups of Pb anomalies, some associated with high Zn (Figures 15 and 16). To the south, traverse 22 shows almost continuous Pb anomalies, many of them accompanied by high levels of Zn, extending over a breadth of some 800 m. This spread correlates reasonably well with mineralisation located in Reed Mine. Cu anomalies are scattered on traverse 1, but are abundant on the other three (Figure 17); almost all Pb-Zn anomalies are accompanied by high Cu. As was only determined on samples from traverse 1 and the eastern end of traverse 21; the only anomaly recorded was a value of 150 ppm 100 m from the western end of traverse 1.

This geochemical pattern suggests that Cu mineralisation, presumably in the form of tetrahedrite the commonly prevalent Cu species in the veins, is particularly well developed in this area. The most prominent Pb and Zn anomalies are on the southernmost traverse. Along that line they at least in part reflect a vein cluster which was only marginally economic in Reed Mine. It appears, therefore, that the central vein area has, at best, only a limited future potential.

Southern area

This area might contain southern extensions to the Teign Valley lodes: South Exmouth, the southernmost mine in the Teign Valley, lies immediately to the north of traverse 30. Although reportedly worked for Pb, this mine seems to have produced very little metallic ore and its dumps contain large amounts of baryte. This suspected paucity of Pb is borne out by the single weak Pb anomaly on traverse 30 (Figure 15); no other ore metal anomalies were reported in this sample.

A group of Pb anomalies at the northern end of traverse 33 (Figure 15) at Higher Coombe have no associated Zn anomaly (Figure 16). Cu anomalies accompany some of the Pb anomalies and also occur to the south and on the adjacent traverse (32), where there are also two Pb anomalies and a high Zn value (Figure 17). It is pertinent to observe that specimen amounts of chalcopyrite occur within baryte gangue on the South Exmouth mine dumps. As was not determined on samples from these traverses (30-33). Near coincident high levels of Mo and U are present in some samples containing high levels of base metals on traverses 32 and 33. The maximum values from this section (20 ppm U and 42 ppm Mo) were recorded in a sample 100 m from the eastern end of traverse 31.

Infill soil samples collected at Higher Coombe revealed a larger area of anomalous Pb concentration and confirmed the minor role of Zn (Figure 20). Such a distribution of Pb does not fit comfortably into the north-south vein pattern of the Teign Valley. Projected southwards from South Exmouth mine and through the baryte veining at Warmhill [834 804] (Beer and Ball, 1977b), the lode zone lies well to the east of the Higher Coombe cluster. In consequence it is necessary to entertain the possibility of a different style of mineralisation being represented here. No geochemical or geological evidence is available to suggest the form of such mineralisation, but IP survey results are consistent with disseminated sulphide mineralisation largely concordant with the bedding. The presence of enhanced U levels with this Pb enrichment, unusual in south-west England, also suggests a different style of mineralisation.

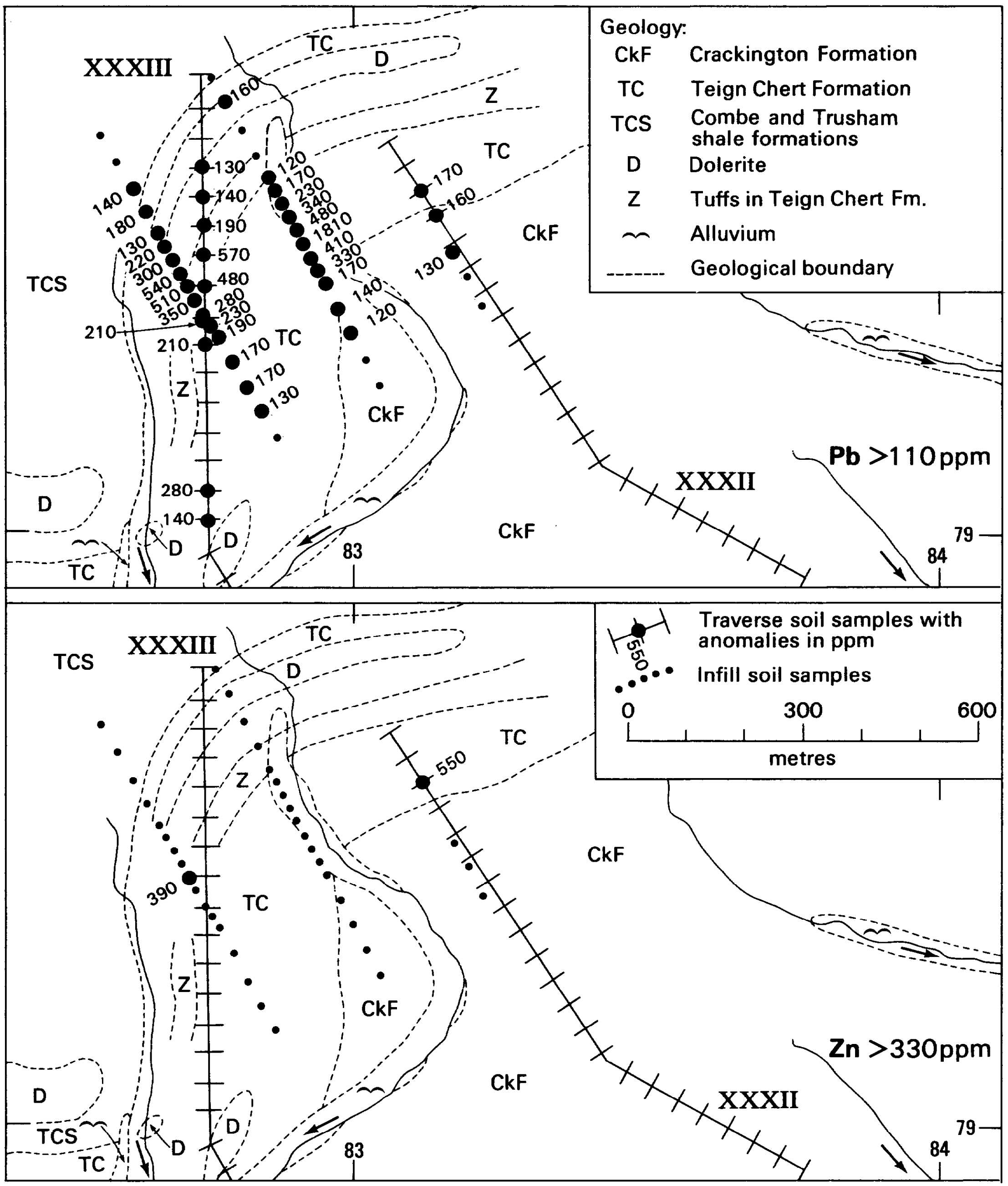


Figure 20 Lead and zinc anomalies in the Higher Coombe area

GEOPHYSICAL SURVEYS

The geophysical surveys carried out as part of the Teign Valley study have been described by Tombs and Rollin (1974), with a subsequent phase of work being reported the following year (Tombs and Rollin, 1975). Those aspects of the geophysical surveys targeted towards potential baryte mineralisation have been described in the earlier Mineral Reconnaissance Programme Report on this topic (Beer and Ball, 1977b). For the investigation of the potential base metal mineralisation, the induced polarisation (IP)/resistivity method was used throughout except for the addition of some trial gravity survey work. All of the geophysical traverse data gathered in the Teign Valley study are presented as maps and/or pseudo-sections and/or profiles by Tombs and Rollin (1975).

Methods

The IP/resistivity method is employed to map the location of anomalously conductive ground, and can thus detect massive sulphides, either stratiform or in veins; simultaneously, the chargeability effect is measured, this being the capacity of the ground to retain - albeit briefly and in small measure - some proportion of an applied electrical potential. This chargeability (or IP) effect is commonly enhanced when base metal sulphides are present in disseminated form (though particular lithologies can also be responsible for such anomalies). The procedures for the use of the IP method adopted under the Mineral Reconnaissance Programme are described by Burley et al. (1978), whilst a thorough treatment of both the method and the interpretation of data is provided by Sumner (1976).

For the Teign Valley study, IP/resistivity measurements were made along a total of 32 traverses, divided amongst four sub-areas thus: Whidley House - 3; Bridford - 9; Frankmills - 6; Higher Coombe - 14. The locations of these areas with respect to each other are shown in Figure 21, and individual location maps are provided by Figures 22-25. Note that traverse L1 (Figure 23), traverses L5, L8, and L9 (Figure 24) and traverses L39, L40 and L41 (Figure 25) were surveyed with the gravity method only.

For the IP survey Huntec MkIII equipment was used throughout, deployed in a dipole-dipole array except for two small areas surveyed in detail with a gradient array. The operating parameters used were: current on and off times of two seconds; the decay curve sampled to evaluate the time integral over the interval 75 to 975 milliseconds (ms) after switch-off; a fundamental dipole unit of 50 m (25 m on traverse L6); and dipole centre-to-centre spacings of n=2, 3, 4, 5, and 6.

Though the gravity traverses measured were largely aimed at detecting baryte deposits (Beer and Ball, 1977b), as a trial three gravity traverses were measured at Higher Coombe over a zone suspected to contain base metal mineralisation. A Worden gravity meter was employed.

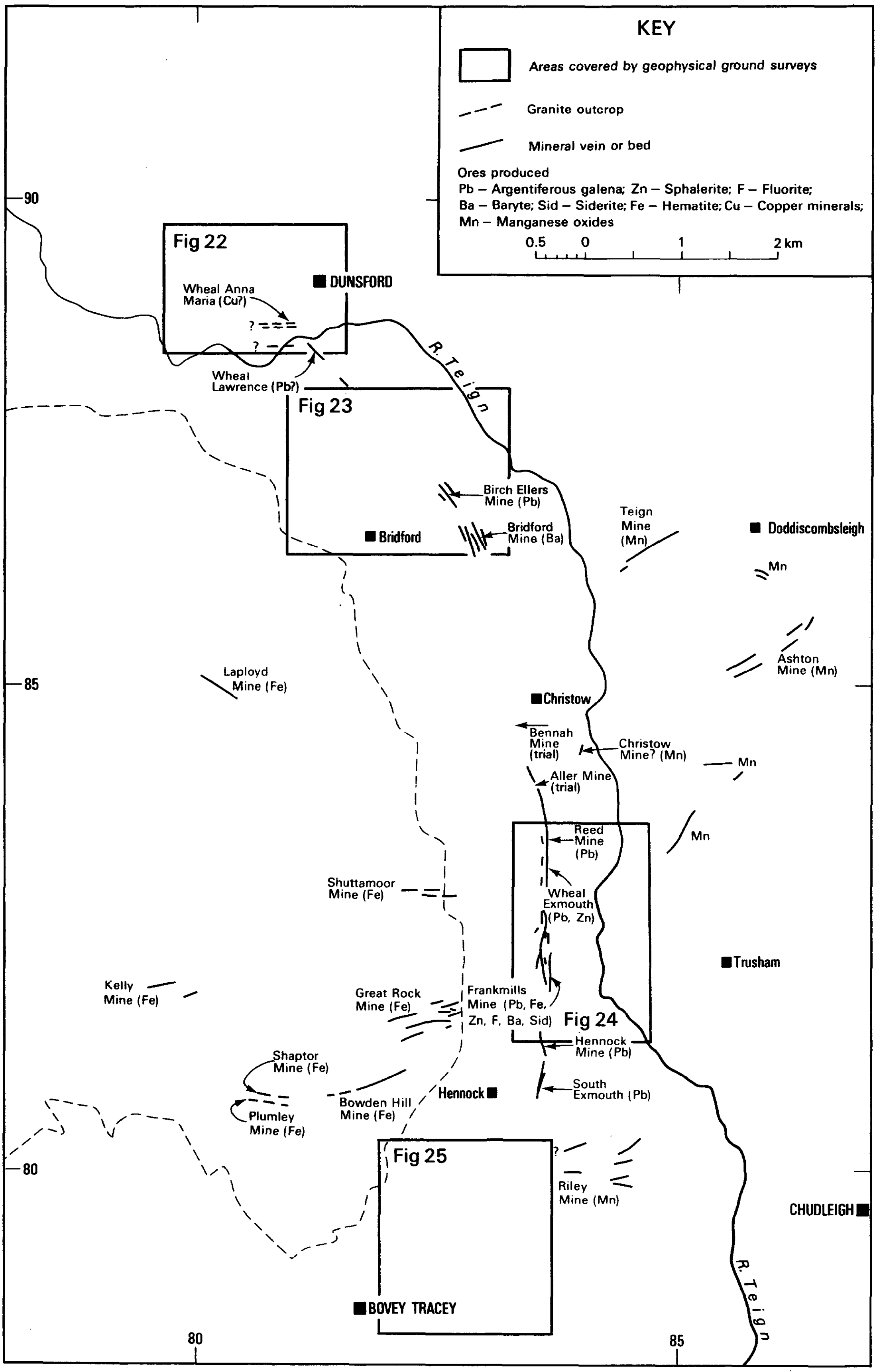


Figure 21 Areas covered by geophysical ground surveys

Results

The four areas are discussed from north to south.

Whidley House
A significant grouping of anomalous lead values in soil (and some high zinc levels) found near to Whidley House, Dunsford (Figures 15, 16 and 18), prompted the geophysical survey here. Three traverses totalling 2700 m were measured (Figure 22). The area covered is immediately to the north-west of the old Wheal Anna Maria mine.

Geophysical traverses L24 and L26 (Figure 22) proved a zone of low apparent resistivity and high chargeability extending the length of these two traverses west of their intersection with traverse L37. Because of the traverse geometry, the strike of the boundary of this zone cannot be determined precisely, but must be approximately south-east. The zone correlates in part with the locations of soil samples anomalous in lead. The anomalous zone is too broad for it to be accounted for by a mineral vein of typical local trend, and it may therefore represent some fairly uniform sulphide dissemination.

Bridford
Nine traverses totalling 7650 m were measured near Windhill Gate [818 871], north of Bridford (Figure 23).

Between the Bridford and Birch Ellers mines the geological structure comprises a system of faulted anticlines and synclines, and the apparent resistivity results reflect the trends of these features. In particular, sharp changes in resistivity on traverses L22 and L27 are consistent with the mapped position of the Bridford Thrust; this follows a slightly sinuous course from (approximately) the west end of traverse L23 to the east end of traverse L21.

Anomalous chargeabilities were recorded on most of the traverses in the area. Some of these may be related to faulting (clay gouge, or faulting-in of anomalous lithologies for example). Other anomalies show a character and/or trend suggesting that mineralisation may be the source. This is reinforced by a spatial correlation with anomalous levels of lead, zinc and copper in soils.

The locations of some of the more closely-confined anomalies could be construed as being indicative of a single high-chargeability zone trending north-west for 1.5 km from the ground west of Shipping [829 868]. Some extension or branch of the Teign Valley vein system would therefore seem a reasonable interpretation. However, this can only be a tentative suggestion given the relatively large distances between some of the traverses.

Some of the broader zones of anomalous chargeability are suggestive of disseminated mineralisation. A measure of concordance with mapped boundaries may imply that lithological controls have been operative; if so, then the preferred lithologies are the Teign cherts and the Combe shales, especially where these rocks occur close to dolerites.

Frankmills
Six traverses were measured in the area north and south of the old Frankmills mine (Figure 24). These totalled 3300 m, each extending across the principal lode zone. No soil sampling was carried out hereabouts.

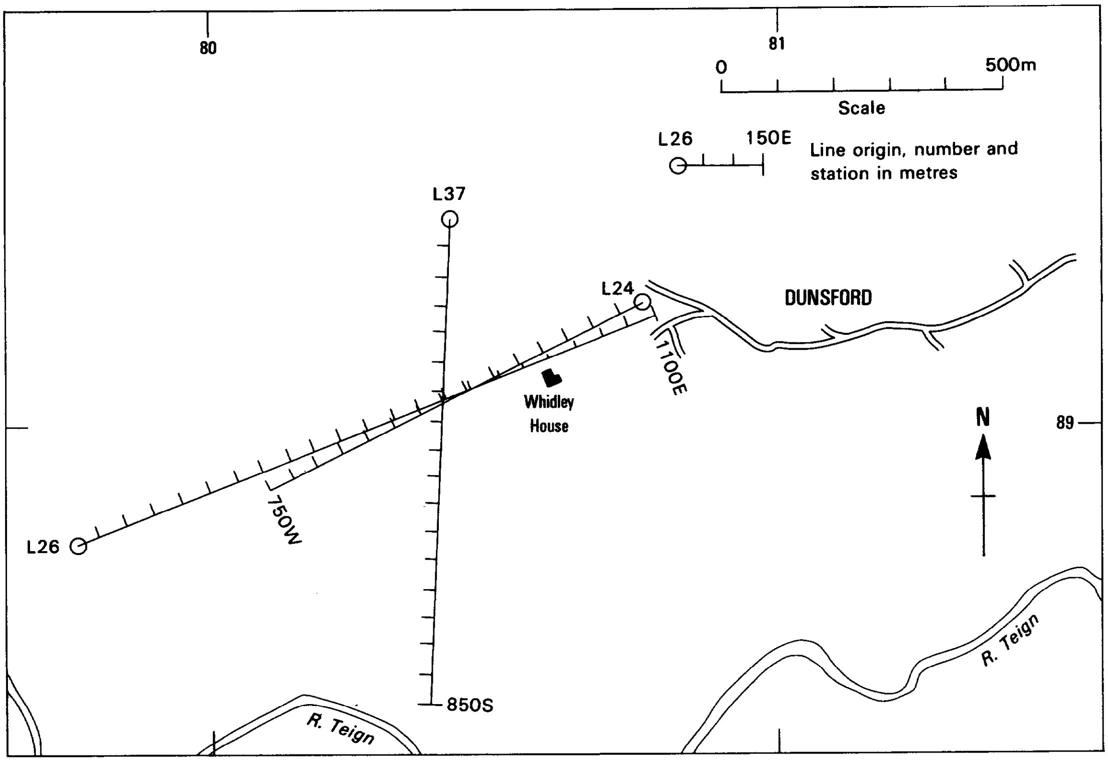


Figure 22 Geophysical traverses near Whidley House, Dunsford

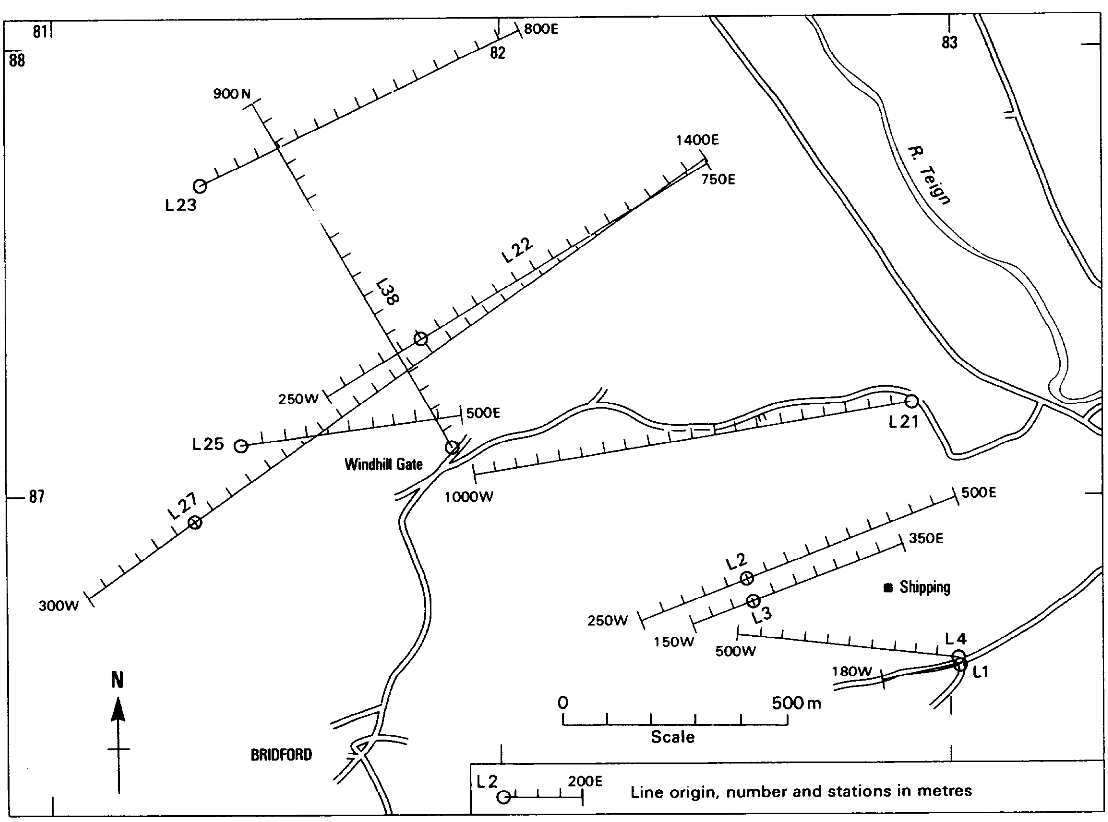


Figure 23 Geophysical traverses near Windhill Gate, north of Bridford

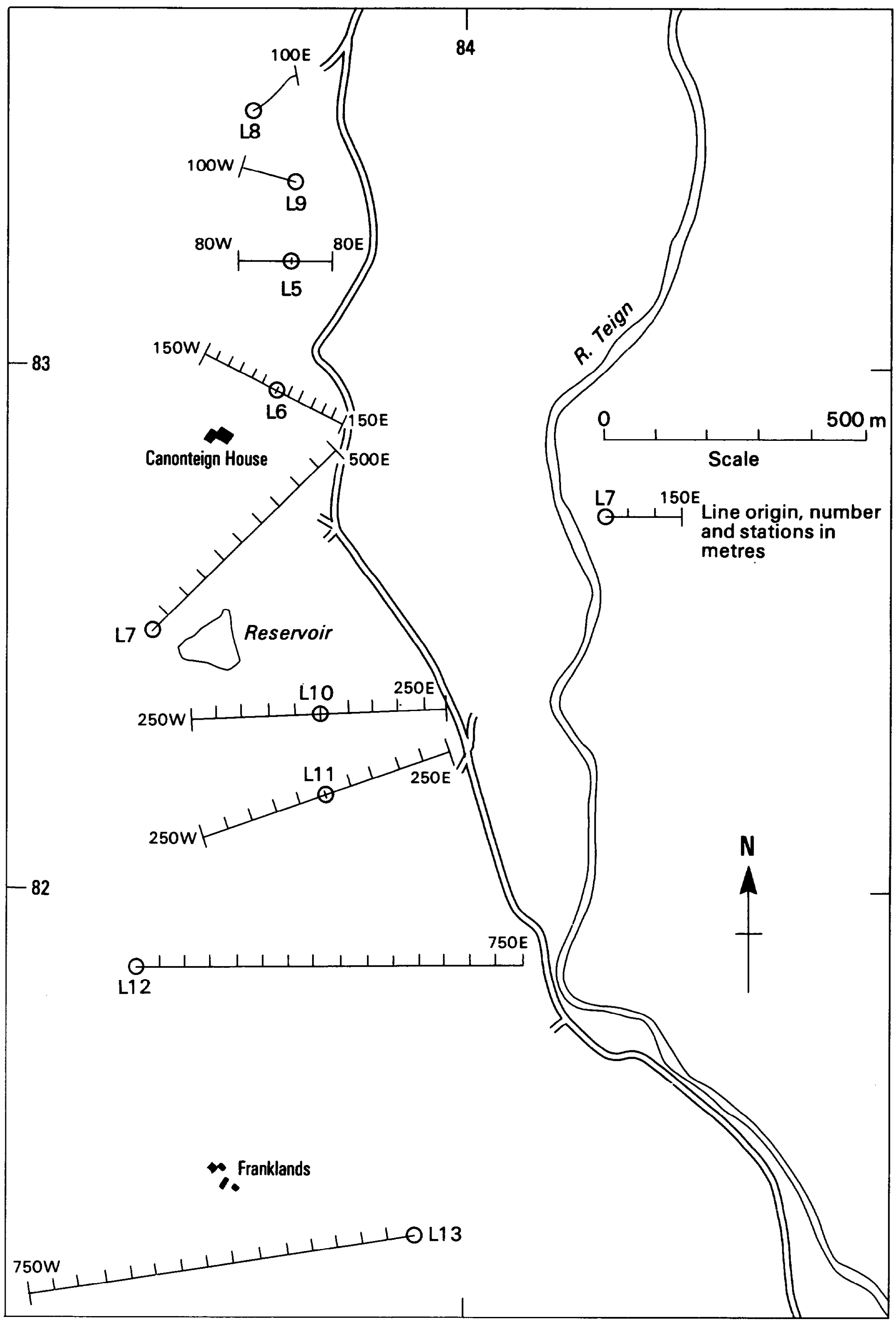


Figure 24 Geophysical traverses in the Frankmills area

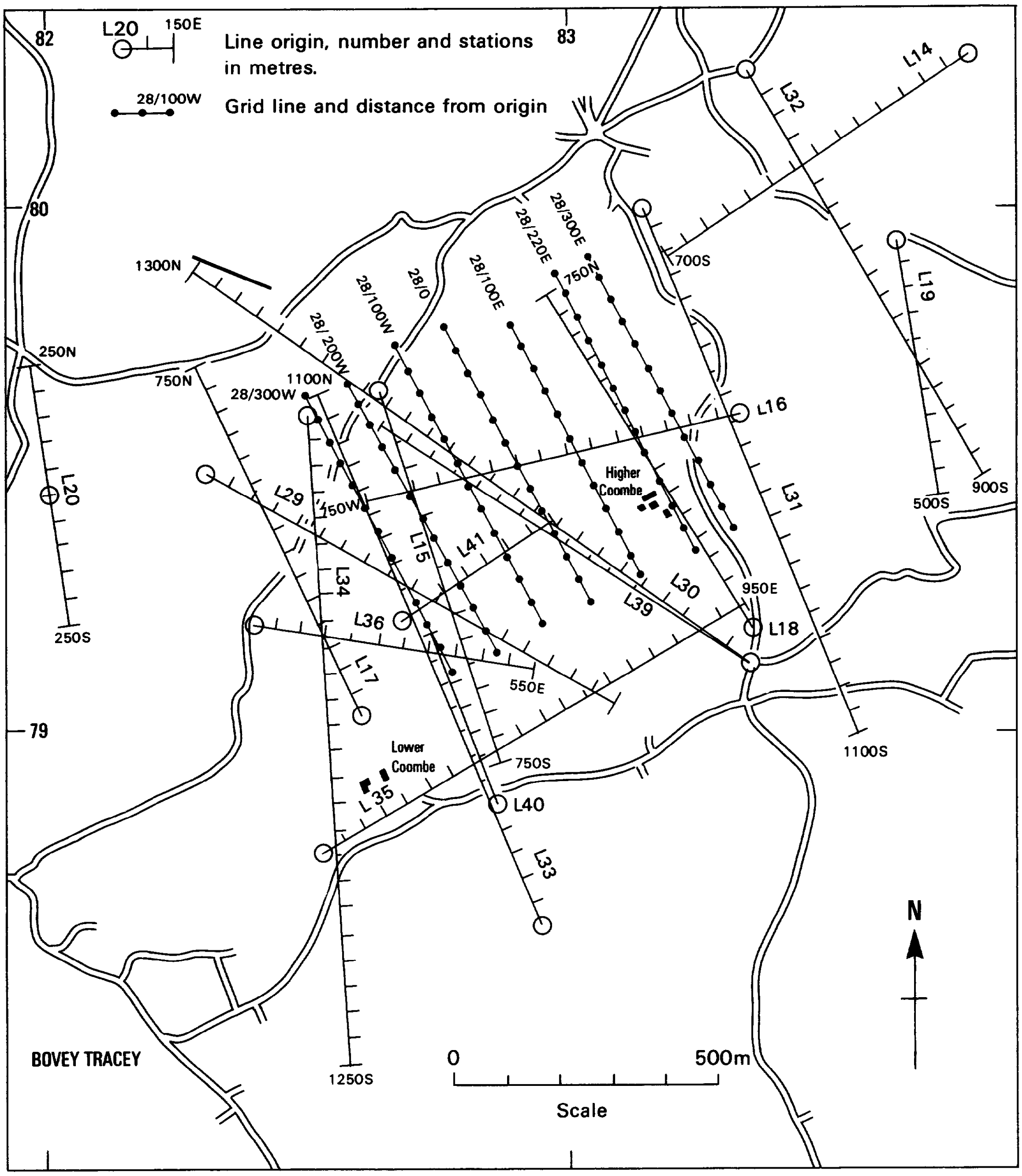


Figure 25 Geophysical traverses in the Higher Coombe area

No significant features are seen in the data for traverses L10, L11, L12 and L13. The only strong chargeability anomaly was found close to the main valley road at the eastern end of traverse L6. Detailed measurements made with a gradient array over a very confined area (200 m x 100 m) show that the source of the anomaly has a northerly trend. The coincidence of high chargeability and low resistivity make it probable that the anomaly is due to a vein carrying significant galena, possibly a previously unrecorded member of the suite mined at Wheal Exmouth. A moderate anomaly at the eastern end of traverse L7 may be due to an extension of the vein to the south.

Higher Coombe

Fourteen dipole-dipole IP/resistivity traverses, three trial gravity traverses, and a grid of gradient array IP measurements were measured over an area around Higher Coombe Farm (Figure 25), where soil sampling results had shown the area to be anomalous for lead and copper. Chargeability anomalies were recorded over much of the area, confirming the area as one of major exploration interest. The data are of sufficient interest to be presented here in contoured form, superimposed on the mapped geological boundaries (Figures 26 and 27).

The dominant features of the data are seen in Figure 26. Chargeabilities rise to over 200 ms at two sites within east-north-east-trending, well-defined 'highs'. Coincident resistivity 'lows' show minima of less than 20 ohm-metres at the same sites. At the more southerly of the two sites the resistivity and chargeability contours reflect the local strike, whilst at the more northerly site the contours cross-cut (although picking up the bedding to the east). The gradient array grid (covering 600 m x 600 m of ground largely to the west of Higher Coombe Farm) has also detected the northerly chargeability maximum, and values in excess of 200 ms are again seen (Figure 27). These are offset a little to the south of the site of the maximum seen in Figure 26, and coincide with a cluster of soil anomalies.

Neither of the chargeability anomalies described seems likely to be due to a westward-faulted southern extension of the principal Teign Valley vein system, as the nearest known mineralisation has a north-south-trend. Also, the anomalies trend for the most part with the bedding, whilst the known veins to the north are nowhere reported to show this relationship.

The presence of substantial disseminated mineralisation, at both sites apparently within the Teign Chert Formation, seemed a reasonable interpretation of the data. The anomalies are more closely defined than those described above and so were chosen for testing by drilling, as described below.

Three trial gravity traverses were measured (L39, L40 and L41), but the data show no correlation with the IP/resistivity anomalies. This was not regarded as detracting from the prospect, as modelling showed that even a major sulphide enrichment would provide only a weak gravity anomaly: 0.16 mGal for an extensive zone 200 m wide, extending to 200 m depth, and carrying 2% galena.

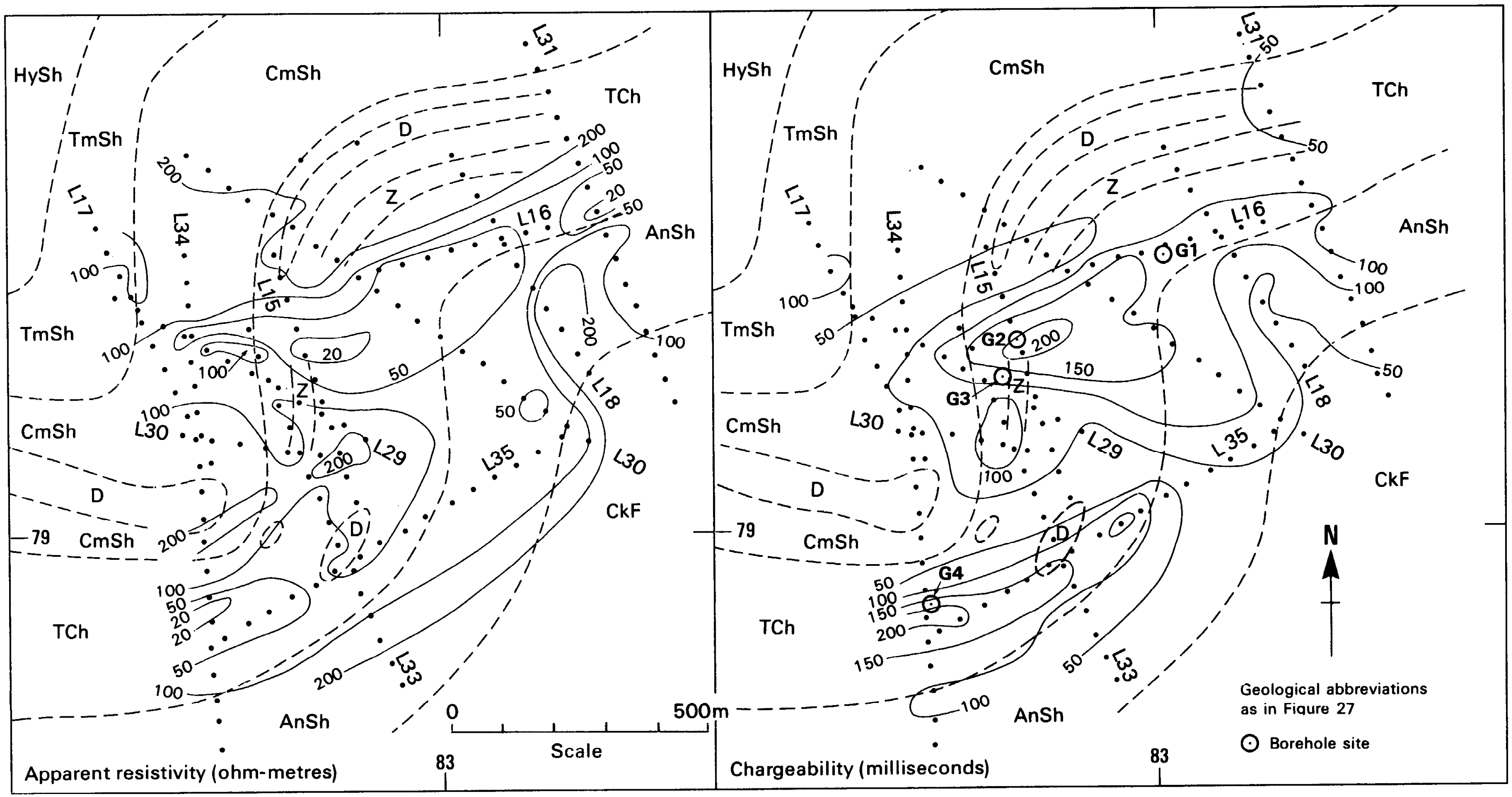


Figure 26 Contoured dipole-dipole results, Higher Coombe area

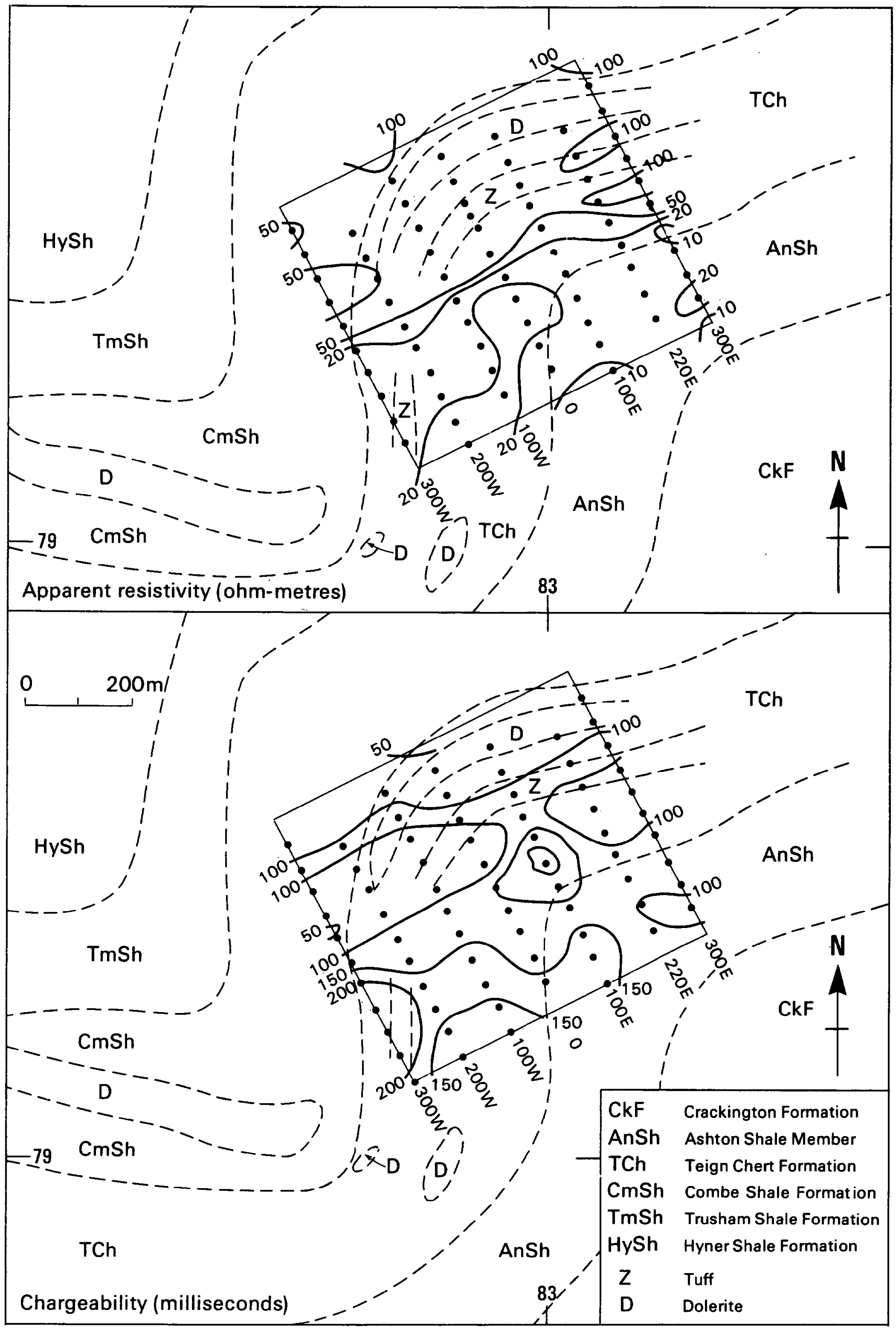


Figure 27 Contoured gradient array results, Higher Coombe area

DRILLING

Confirmation of the soil geochemistry and geophysical interpretations could only be obtained by a programme of diamond drilling. Two of the prime factors in siting the small number of drillholes were, firstly, that the holes should add significantly to an understanding of the mineralisation and, secondly, ease of access. On this basis the Higher Coombe area, which lies outside the Dartmoor National Park and where the surface investigation suggested strongly that previously unrecorded mineralisation might be present, was selected for drilling.

Based upon the geochemical and geophysical results, four sites were selected for the drilling of shallow cored boreholes in the ground between Higher Coombe and Lower Coombe (Figure 28). Borehole G1 was located in a small valley upstream of Higher Coombe farmhouse over ground mapped as Teign Chert Formation (Figure 28). This hole was directed to test the source of an IP gradient array chargeability anomaly (Figure 27). A downhole length of about 100 m was proposed to allow intersection of the boundary between high and low measured resistivities. The drill site lies within a cluster of lead-in-soil anomalies and fairly close to the maximum; zinc is not anomalous at this point (Figure 20). It was considered that such critical siting would guarantee discrimination between disseminated and vein mineralisation.

Boreholes G2 and G3 were sited fairly close together (Figure 28). The northern hole (G2) was to investigate a dipole-dipole chargeability maximum and was orientated to examine a discrepancy between geological and geophysical strike directions (Figure 26). The geological map indicated that the hole would start in tuffs, which might show whether the metal anomalies were related to volcanic rocks. Borehole G3 was sited to investigate a gradient array IP anomaly which appears to lie in shales of the Teign Chert Formation, sandwiched between volcanic tuffs and dolerite. Such a location is suggestive of disseminated mineralisation. The planned vertical hole was impossible to drill due to continuous caving of soft strata close to surface and alternative siting of an inclined hole nearby avoided this band. The final hole, borehole G4, was situated a short distance south-west of Lower Coombe and was drilled to examine a strong chargeability anomaly (Figure 26).

Drilling proved to be more difficult than had been anticipated, the main problems being alternating stratal hardness and frequent intense rock fracturing. Several of the shale horizons intersected were highly plicated, tuffs were commonly decomposed and cherty bands intensely broken. The programme was carried out during a period of drought and the downhole flushing had to be maintained at low pressures using settled, but not filtered, recycled water.

All boreholes were started at NX size and, after casing at the top, were drilled wireline to complete at BQ size. Drilling data and geological logs for all four boreholes are contained in Appendix 2.

Geological results

According to the mapped geology (Figure 28) all boreholes should have started in the Teign Chert Formation but the uppermost parts of G1, G2 and G3 were found to be of banded shales or blocky mudstones with no significant cherts or sandstones. This lithology can be correlated with the Ashton Shale Member, the uppermost part of the Crackington Formation. This points to some discrepancy in mapped geology between boreholes G1 and G4 and, perhaps, a fault might be

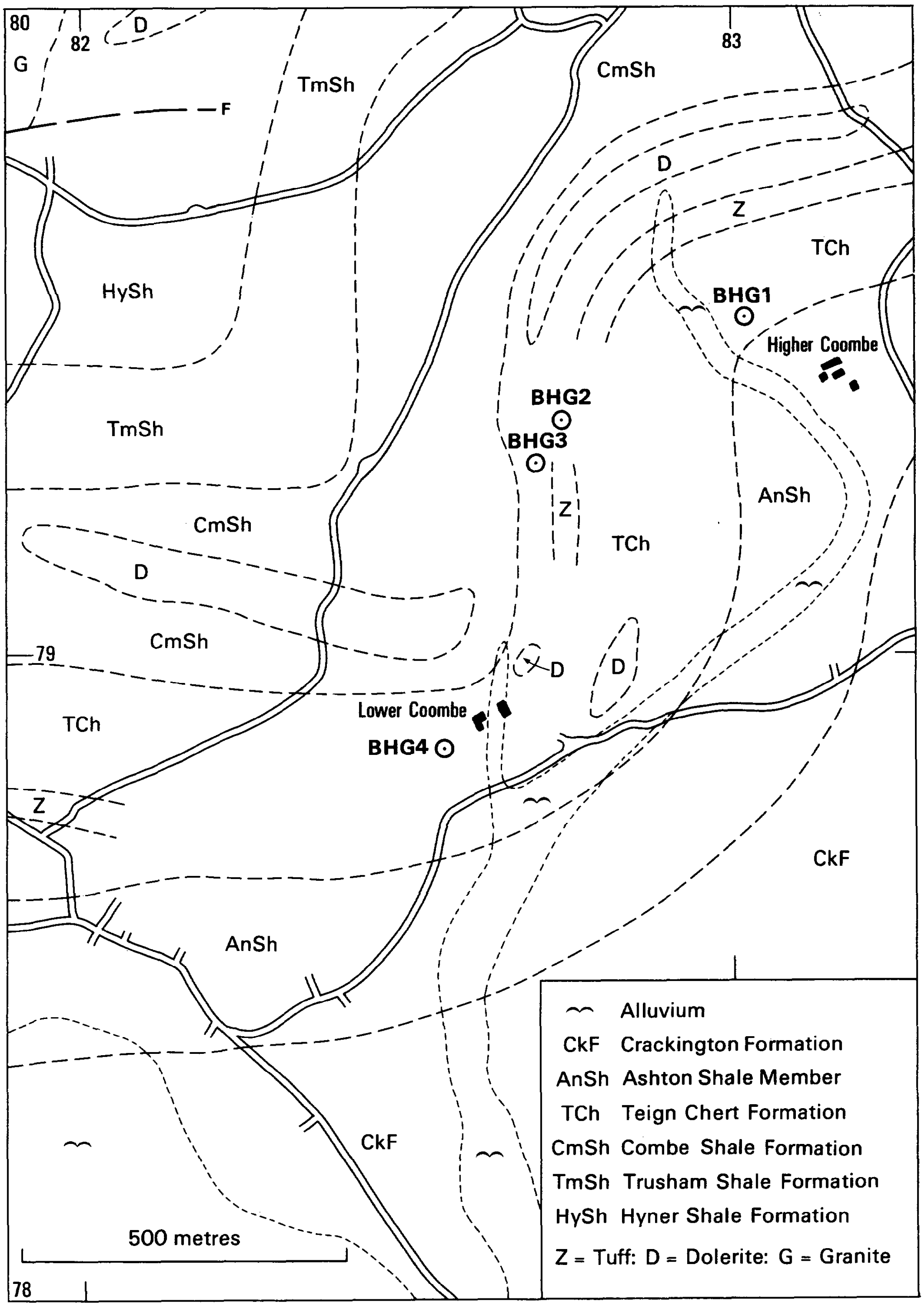


Figure 28 Drill sites in relation to mapped geology

invoked hereabouts. Indeed, gouge in such a fault zone may have prevented the drilling of G3 at its originally planned site.

Core lithology was otherwise much as expected from surface mapping, although no dolerite sills were encountered. As in outcrop, the tuffaceous bands were highly decomposed with some reduced to sand consistency. Pure cherts were reported only rarely; most contained significant amounts of argillaceous material and none were demonstrably radiolarian. Plication was locally conspicuous, especially in the argillaceous layers, and was assumed to be wholly tectonic. Disturbed bedding in some chert bands, however, may indicate sedimentary slumping and this should also have affected the shales.

Visible base metal mineralisation was not common in the cores. There were rare clusterings of thin quartz veinlets carrying spots or aggregates of sphalerite and galena, with even rarer stringers containing concentrations of both sulphides. Only minor chalcopyrite was noted, but disseminations of pyrite/marcasite, in some places accompanied by other unidentified sulphides, were common and loellingite was noted locally (Appendix 2).

Borehole geophysics

Only borehole G1 was logged geophysically and this was carried out by BPB Instruments Ltd. The geophysical borehole logs are held in the National Geological Records Centre at the BGS headquarters at Keyworth. Self-potential, focussed-electric, temperature, gamma-ray, caliper and density logs were run but none of the log responses seems in any way to reflect the occurrence or tenor of sulphide mineralisation.

From the gradient array resistivities measured at surface it was anticipated that a boundary between high and low resistivity strata would be intersected at around 60 m downhole. No such boundary is apparent in the focussed-electric log. The gamma-ray, focussed-electric and self-potential logs, however, all show a change at about 54 m from a smooth to peaked trace. At approximately the same depth the LS density log appears to show a datum shift. At this depth the lithological log shows a contact between uniform light grey mudstones and a succession of dark grey mudstones with thin cherty bands (Appendix 2). Based upon these data, the contact has been taken as the junction between Crackington Formation (Ashton Shale Member) and Teign Chert Formation.

Most of the smaller features of the density and gamma logs reflect changes in borehole diameter as indicated by the caliper trace. No explanation is immediately forthcoming for the remaining features, especially the large but narrow self-potential peaks. The latter appear not to be due to thin chert bands, nor to vein quartz, nor to obvious sulphide mineralisation. This view is supported by the observation that a decrease in their frequency below 74 m is not matched by a similar change in geology.

Geochemical results

As most of the core was recovered at BQ size and was usually well broken or even fragmented, it was difficult to derive a representative sample without incurring some degree of personal selective bias. In these circumstances it was decided to take the full core for crushing. After jaw crushing each sample was split prior to Tema milling. The resulting powder was then sub-sampled for AAS determination of Ag, Co, Cu, Ni, Pb and Zn.

Statistical summaries of the analytical results for each drillhole are given in Table 7 and the inter-element correlation matrices in Table 8. Variations of element distribution with depth are plotted as Figures 29-32 (Ag varies little and is not included); these plots also show the main stratigraphic sub-divisions.

Table 7 Summary statistics for core analyses

	Maximum	Minimum	Mean	Standard Deviation	Standard Error
Borehole G1 (n=104)					
Ag	3	<1	-	-	-
Co	145	15	39.1	20.0	2.0
Cu	515	10	170.8	105.4	10.3
Ni	295	20	103.4	55.3	5.4
Pb	850	10	79.7	126.5	12.4
Zn	2580	10	220.0	340.5	33.4
Borehole G2 (n=66)					
Ag	5	1	1.44	0.91	0.11
Co	110	10	44.6	24.9	3.1
Cu	575	10	212.6	133.9	16.5
Ni	560	20	157.1	120.5	14.8
Pb	2190	30	226.4	396.5	48.8
Zn	21200	120	1393	2876	354
Borehole G3 (n=82)					
Ag	4	<1	-	-	-
Co	230	5	38.4	31.1	3.4
Cu	1000	5	188.6	171.7	19.0
Ni	290	20	86.4	50.2	5.6
Pb	790	10	161.0	231.4	25.6
Zn	4500	40	324.6	609.7	67.3
Borehole G4 (n=77)					
Ag	6	<1	-	-	-
Co	70	10	36.1	15.1	1.7
Cu	1400	10	207.0	217.0	24.7
Ni	460	30	140.7	74.0	8.4
Pb	1230	30	302.1	252.9	28.8
Zn	6600	210	1567	1312	149

Results in ppm
n = number of samples

The widest range of Cu values is seen in borehole G4, but the hole with the highest mean Cu content is G2. For Pb and Zn the greatest range is found in G2; in the case of Zn this reflects one very rich sample. Despite this, the hole best mineralised in these two metals is G4. The highest Ag values also occur in G4. Mean Co values are similar in all four holes, but variations in the standard deviations reflect differing ranges of Co content from hole to hole. Ni values, probably because they reflect the content of volcanic debris, vary considerably between the holes.

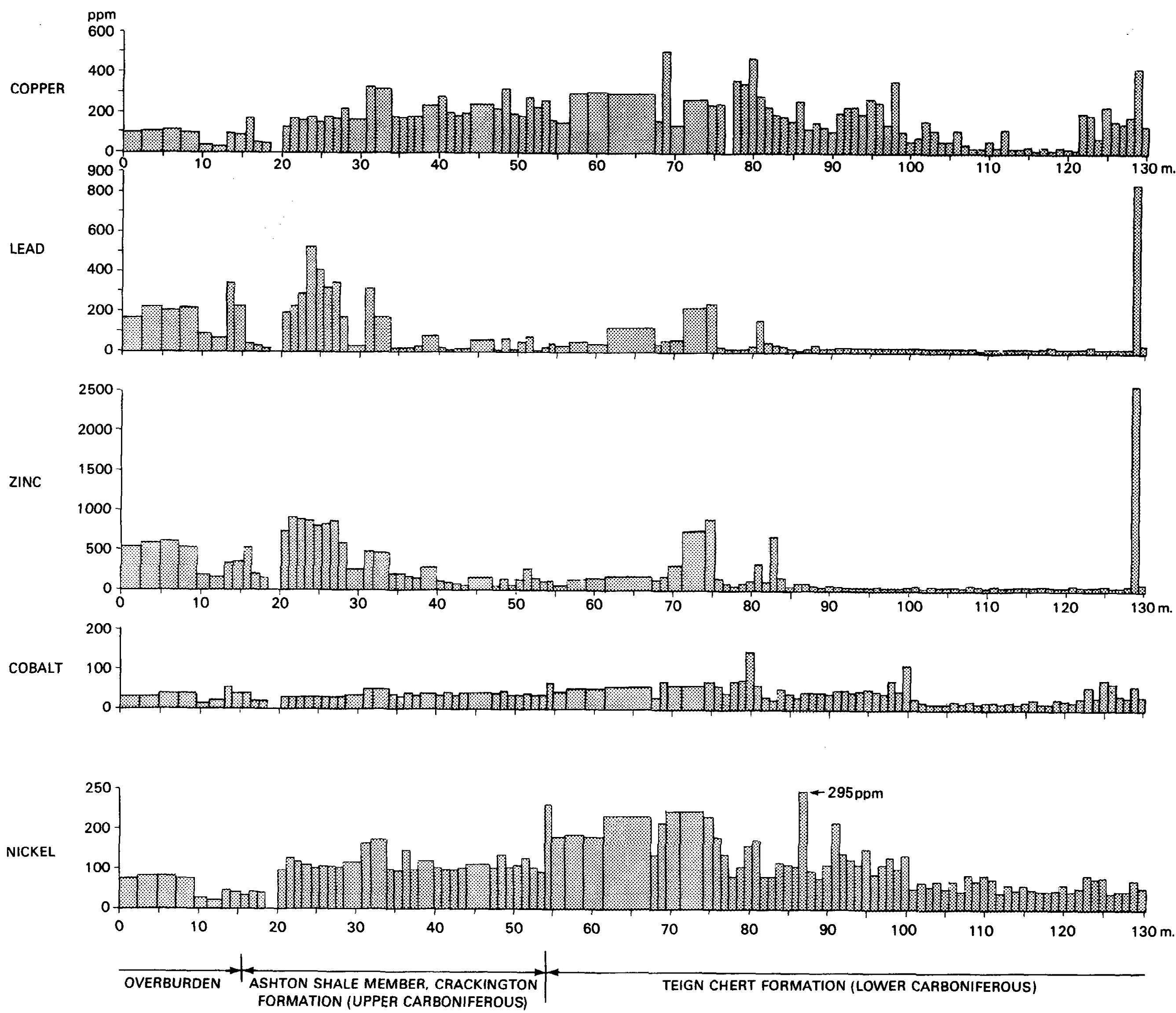


Figure 29 Geochemistry and geology, borehole G1

For many element pairs, correlation coefficients are similar in all four holes (Table 8). Notable exceptions are those for Pb/Zn in G3 and G4, and Cu/Ni in G3.

Table 8 Correlation matrices for core analyses

Borehole 1	Cu	Pb	Zn	Co	Ni
Cu	1.000	0.212	0.256	0.651	0.528
Pb		1.000	0.920	0.080	0.070
Zn			1.000	0.076	0.113
Co				1.000	0.545
Ni					1.000

Borehole 2	Cu	Pb	Zn	Co	Ni
Cu	1.000	0.208	0.225	0.469	0.599
Pb		1.000	0.849	0.260	0.320
Zn			1.000	0.286	0.360
Co				1.000	0.850
Ni					1.000

Borehole 3	Cu	Pb	Zn	Co	Ni
Cu	1.000	0.337	0.379	0.342	0.115
Pb		1.000	0.374	-0.088	-0.352
Zn			1.000	0.071	0.044
Co				1.000	0.658
Ni					1.000

Borehole 4	Cu	Pb	Zn	Co	Ni
Cu	1.000	0.253	0.230	0.186	0.460
Pb		1.000	0.426	-0.059	-0.104
Zn			1.000	0.355	0.297
Co				1.000	0.643
Ni					1.000

Borehole G1

Because of the wide range of values for Cu, Pb and Zn, calculated means for these elements have little significance; both the standard deviation and standard error are high (Table 7). From Table 8 it can be seen that Pb and Zn in this borehole are very highly correlated and there are also significant positive correlations between Cu/Co, Cu/Ni and Co/Ni.

Cu levels are high along most of the borehole section with the highest values reported from 68.4-69.4 m (515 ppm), 79.4-80.4 m (480 ppm) and 128.4-129.4 m (430 ppm) within zones containing disseminations or veinlets of pyrite (Figure 29; Appendix 2). It may be that such pyrite contains a small amount of Cu, but it is more likely that minor quantities of chalcopyrite are concealed within the fine-grained mineralisation. As a general rule there is little or no correlation between Cu and Pb or Zn (Table 8).

Pb and Zn are high at depths of 20-28 m and 71-75 m, but their highest concentrations (850 ppm Pb and 2580 ppm Zn) are between 128.4 and 129.4 m, where they are associated with high Cu (430 ppm) in a sheared zone with sulphide veining, recognised as rich in pyrite and arsenopyrite (Appendix 2). Recovery from the 20-28 m intersection was poor and no visible sulphides were recorded; the 71-75 m intersection is located in the Teign Chert Formation where there are veinlets and disseminations of fine sulphide (Appendix 2).

The Co distribution shows little variation and levels are generally low; two samples, from 79.4-80.4 m and 99.4-100.4 m, contain more than 100 ppm. Ni values show a marked increase in the middle sections of the borehole, with several samples containing around 200 ppm, and a maximum of 295 ppm was recorded between 86.4 m and 87.4 m in the upper part of the Teign Chert Formation. No tuffaceous material was recorded in this part of the core.

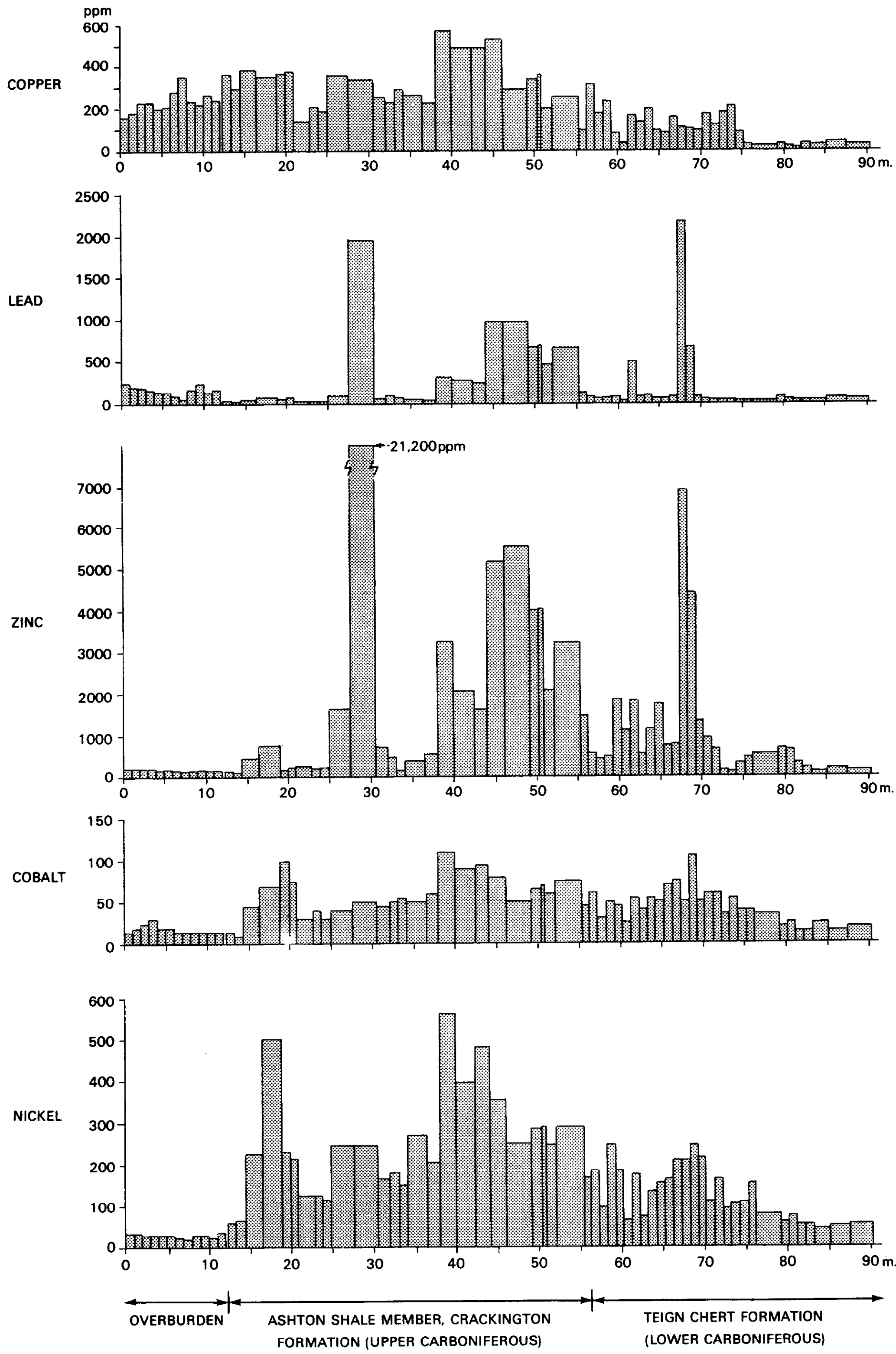


Figure 30 Geochemistry and geology, borehole G2

Borehole G2

The correlation matrix (Table 8) is similar to that for data from borehole G1 but with closer correlation between Co and Ni. There is a wide range of all metal values in samples from this hole (Table 7) with one especially high Zn value (more than 2%) and several Ni contents in excess of 250 ppm.

Enriched Cu values extend down to below 70 m, mainly in argillaceous sediments of the Ashton Shale Member and the fault zone separating them from the underlying Teign Chert Formation. The richest samples come from that fault zone although no cupriferous minerals were observed in the core. The Cu distribution in rocks correlates poorly with that of Pb and Zn, but more positively with Co and Ni. The rocks of the Ashton Shale Member show markedly higher contents of both Cu and Ni than do those of the Teign Chert Formation. Within the fault zone elevated Cu contents (maximum 575 ppm over 2 m) are accompanied by a substantial enrichment in Pb and Zn.

Pb values in borehole G2 are generally low, particularly in the Teign Chert Formation: the Zn distribution is similar (Figure 30) and the Pb-Zn correlation is highly significant (Table 8). Two outstandingly rich samples occur at 27.5-30.5 m (1960 ppm Pb, 21200 ppm Zn) and 67.2-68.2 m (2190 ppm Pb, 6900 ppm Zn), the former within the Ashton Shale Member and the latter in the Teign Chert Formation; neither depth was reported as well mineralised (Appendix 2). A general increase in Pb and Zn content to maximum values of 980 ppm Pb and 5520 ppm Zn over 3 m is evident in the tectonised zone at the base of the Ashton Shale Member.

The close correlation between Co and Ni is clearly reflected in the downhole plots for these metals (Figure 30). The most marked enrichment is in the tectonised zone at the base of the Ashton Shale Member, although rich samples are also reported from c. 19 m depth in the same unit. There is a small Co-Ni peak at 67.2-68.2 m which corresponds to the peak in Pb and Zn noted above.

Borehole G3

All metals except Ag show a wide range of values (Table 7). The poor statistical correlation between Pb and Zn in this borehole (Table 8) is caused by much greater Pb enrichment in overburden: Pb-Zn correlation in bedrock is good (Figure 31).

Several high Cu values occur near the base of the Ashton Shale Member although the highest Cu value is in the Teign Chert Formation (Figure 31). Pb and Zn show similar features, with high values near the base of the Ashton Shale Member where quartz veining and sulphide mineralisation is recorded (Appendix 2). The highest values of both Cu (1000 ppm) and of Zn (4500 ppm) occur in shattered ground in the bottom 15 m of the borehole in adjacent sample lengths (Figure 31); both are associated with moderately high levels of Pb (respectively 380 ppm and 640 ppm). Quartz veining, spots and veinlets of pyrite and, locally, sphalerite were seen in this section (Appendix 2). The highest Pb concentrations (up to 790 ppm) are in decomposed material logged as overburden in the top 15 m of the hole. Moderate Cu enrichment (up to 500 ppm) is also present but Zn levels are relatively low (maximum 480 ppm).

The correlation of Co and Ni (Table 8) is illustrated in the downhole plot (Figure 31). The sample containing the largest amounts of these two metals was taken between 84.8 m and 86.4 m, a section of the Teign Chert Formation containing decomposed, probably tuffaceous, horizons and, possibly,

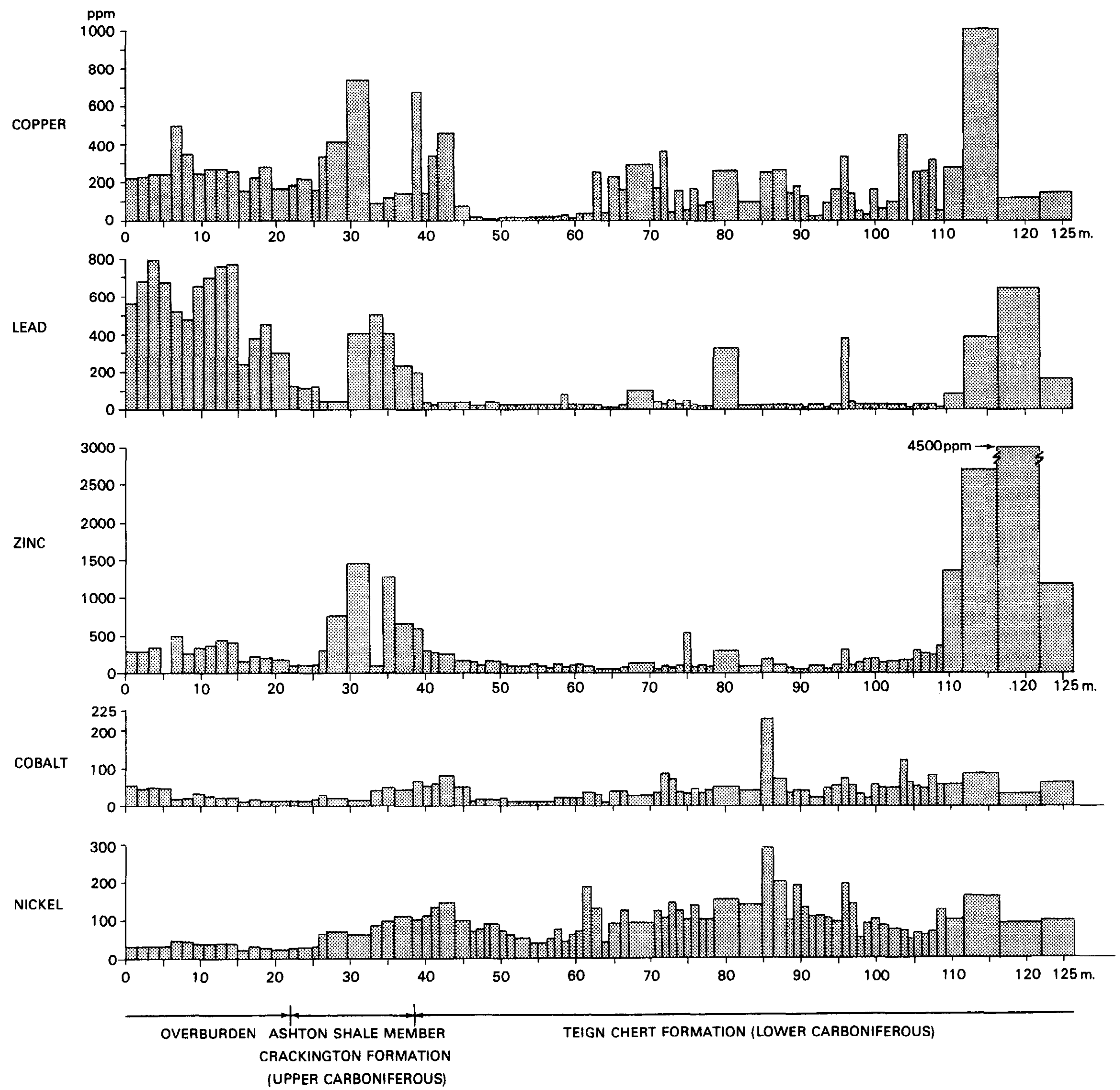


Figure 31 Geochemistry and geology, borehole G3

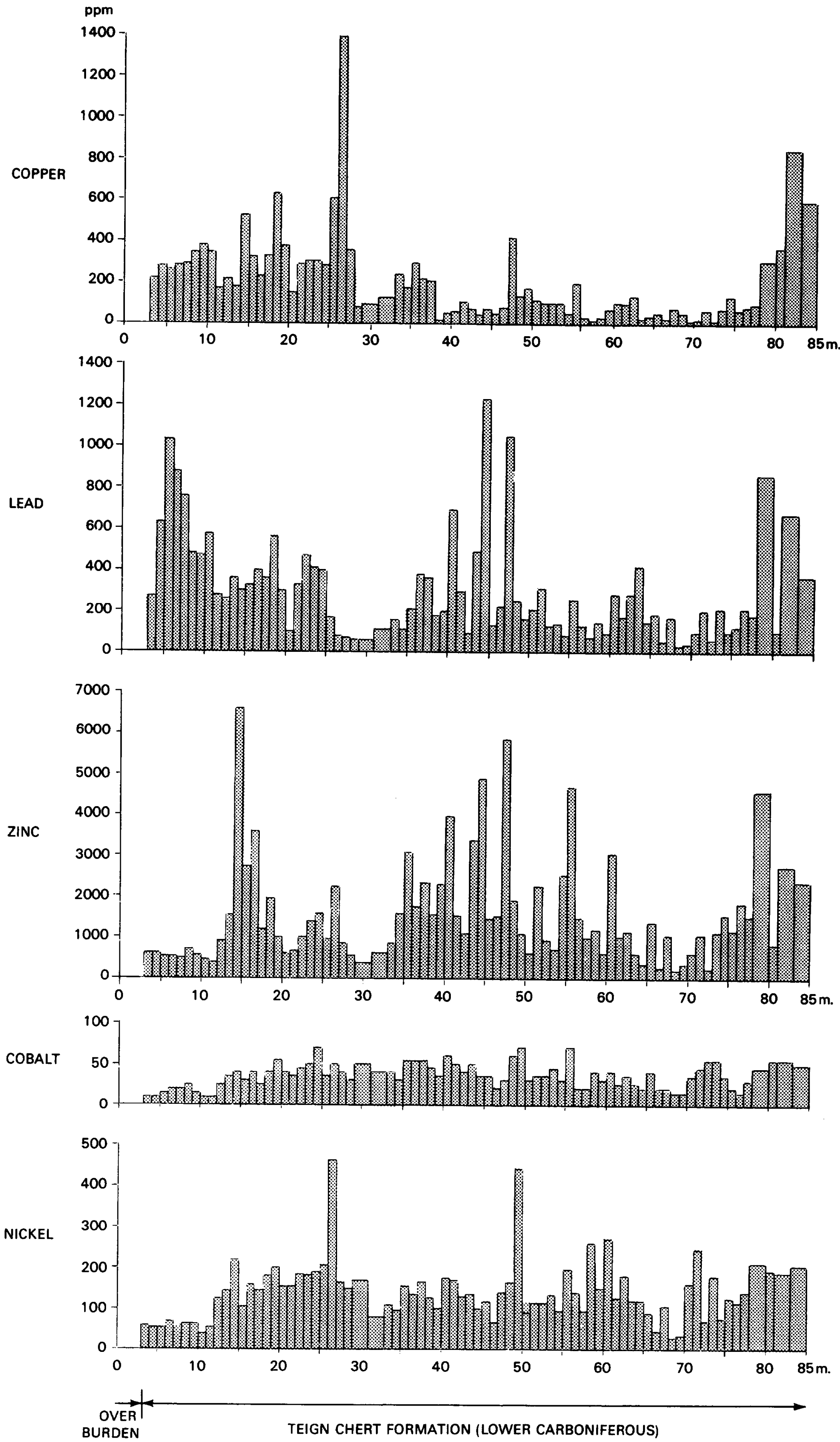


Figure 32 Geochemistry and geology, borehole G4

manganiferous rocks as well as scattered sulphide occurrences (Appendix 2). A high nickel value (185 ppm) accompanied by little Co enrichment occurs in a fault zone between 60.4 m and 62.5 m.

Borehole G4

Metal values in this core vary widely (Figure 32). The highest Cu value in any of the four boreholes (1400 ppm) as well as the highest Ag content (6 ppm) are reported from this borehole, which intersected only rocks of the Teign Chert Formation. The highest Ag values occur in samples containing moderate to high Zn levels (> 1000 ppm) and some enrichment in Cu and Pb.

The uppermost 28 m of core contained many samples moderately rich in both Cu and Pb, some of which also carried high Zn values. The sample length containing the highest Cu content (1400 ppm) also contains the highest Ni (460 ppm) concentration and appreciable amounts of Zn (2250 ppm). This sample came from grey siliceous slates (26-27 m) in which no sulphide mineralisation was recorded (Appendix 2). Further high Cu values (310-850 ppm) came from near the bottom of the hole, below 78 m, associated with high Pb and Zn (up to 860 ppm and 4570 ppm respectively) and with moderately high Ni (up to 210 ppm). At this depth the rock was recorded as quartz-veined grey chert carrying pyrite, sphalerite and traces of chalcopyrite.

This borehole is the richest of the four in Pb (Table 7) with samples from more than half the length of the hole containing more than 200 ppm Pb. Substantial enrichments occur in three sections, near the top, middle and bottom of the hole. All three are associated in general terms with Zn and Cu enrichments; they correlate reasonably well with sulphide mineralisation recorded in the lithological log (Appendix 2).

Zn is also abundant in this borehole, again with some clustering of high values near the top, middle and base of the hole. The richest sample, containing 6600 ppm Zn, was collected between 14 m and 15 m where the rocks are sulphide-bearing cherts and a mineralised breccia, cut by a sphalerite bearing quartz vein (Appendix 2).

The Co distribution (Figure 32) is more uniform than in any of the other boreholes. Ni, on the other hand, shows considerable variation in distribution with two distinct high values between 26.0-27.0 m and 49.0-50.0 m (460 ppm and 440 ppm respectively). The former length also contains the highest Cu concentration recorded in the hole and substantial Zn enrichment (see above). There is no mineralisation evident in the upper section but the lower (49-50 m) carries abundant sulphide; at neither depth can any correlation be made with rocks of tuffaceous affinity.

CONCLUSIONS AND RECOMMENDATIONS

Drilling between Higher and Lower Coombe has shown that within the Carboniferous succession as developed in the Teign Valley, some horizons carry galena and sphalerite mineralisation, together with some copper (chalcopyrite and/or tetrahedrite), either finely disseminated through the sedimentary rocks or as small blebs within clusters of thin quartz veinlets. Larger veining was not encountered during drilling and it is thought that the distribution of disseminated mineralisation is not spatially related to the Teign Valley lode zone. Indeed, the four boreholes were sunk well to the west of the lode zone extension found during examination of the area's barium potential (Beer and Ball, 1977b). This is not to suggest, of course, that elsewhere in the valley there will not be similar disseminations in close proximity to the north-south lode zone. The mineralisation occurs around the Lower/Upper Carboniferous boundary, partly in argillites of the Ashton Shale Member (at the base of the Crackington Formation) and partly in the Teign Chert Formation, again mainly in the shale layers.

There remains a long strike length of potentially metalliferous rock to be investigated and it will be important to establish whether the mineralisation is limited to one particular stratigraphic level or if it is repeated elsewhere in this highly condensed Lower Carboniferous succession.

The mineralisation revealed in the boreholes is sub-economic, but it is possible that higher grades may exist elsewhere in the area. Close to the Teign Valley lodes any disseminated sulphides may be at least partly masked by the signatures of the higher grade vein-style ores. Some of the geochemical and geophysical anomalies reported above suggest that such mineralisation may be present.

The occurrence of disseminated mineralisation at specific stratigraphic horizons within the Carboniferous succession greatly widens the potential areas for future investigation in south-west England.

Drainage anomalies east of the River Teign near Higher Ashton not followed-up by this investigation merit further attention.

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APPENDIX 1 Tetrahedrite mineralogy and composition

Mineralogy

From mineralised rock specimens collected on the waste dumps of Wheal Exmouth and Frankmills Mine, two were submitted for microscopic examination by Dr J A T Smellie. He reported as follows:-

Specimen 035, Wheal Exmouth. The dominant mineral phases are galena and tetrahedrite. Tetrahedrite commonly shows marginal alteration, mainly to chalcopyrite, some chalcocite, possible bornite and/or bournonite and minor covellite. There is also the possibility that some Ag-bearing phases occur in this zone but microscopically this is difficult to resolve. The galena is quite fresh and contains minor exsolution pools of tetrahedrite.

Specimen 076, Frankmills Mine. Mineralisation consists of galena and tetrahedrite as major phases with minor sphalerite, chalcopyrite and small amounts of covellite due to some alteration of chalcopyrite and isolated tetrahedrite phases.

Microprobe analysis

A small separated grain of tetrahedrite was taken from polished thin section No. 1568 which had been prepared from a retained portion of Specimen 035, described above. This grain was submitted for microprobe analysis to establish its composition and formula, and its position within the tennantite-tetrahedrite series.

Element	Wt%	Abs. Error (± Wt%)	Molecular Composition	
Cu	38.83	0.2	9.78}	
Fe	1.09	0.02	0.31}	
Zn	6.80	0.03	1.66}	a=11.77
Ag	0.13	0.01	0.02}	
As	4.86	1.0	1.04}	
Sb	22.72	0.6	2.99}	b=4.03
S	26.47	1.2	13.21	{3b=12.09 {z=1.12
Mn	0.00	0.01		
Pb	0.16	0.01		
Total	101.06			

Formulae of members of the tennantite-tetrahedrite series may be calculated using the methods described by Sakharova (1966). In general terms the formula is expressed as:

$$(Cu,Fe,Zn,Ag)_a\,[(Sb,As)_b\,S_{3b}]\,S_z\,,$$

where a should = 3b = 12, z (the "compensating sulphur") should = 1.
For the Wheal Exmouth tetrahedrite, therefore, the formula is:

$$(Cu,Fe,Zn,Ag)_{11.77}\,[(Sb,As)_{4.03}\,S_{12.09}]\,S_{1.12}$$

The proportion of the end members of the tennantite-tetrahedrite series may be represented by the ratio Sb x 100% / (Sb + As), thus this specimen contains 74.3% of tetrahedrite end member.

APPENDIX 2 Borehole Logs

Borehole G1

Site: Collar at SX 83024 79498, 160 m at 305° from Higher Coombe farmhouse.
Collar altitude: c. 121.3 m.
Drillhole inclinations: at collar: 45° towards 332°;
at 60 m: 41° towards 326°;
at 130 m: 41° towards 328°.
Completed depth: 130.19 m.

Division	*Description*	*Thickness*	*Depth*
OVER BURDEN	Only sand fragments recovered.	9.57 m	9.57 m
	Fragmental recovery from boulders and pebbles of chert, dolerite and vein quartz, together with sand and clay washings.	5.90 m	15.47 m
CRACKING-TON FM. (Ashton Shale Member)	Grey shale, intensely shattered, infrequently recovered as full core. Heavily iron-stained, with a suggestion of some completely oxidised sulphide veins. A thin horizon of dark grey chert occurs at c. 17.50 m.	3.05 m	18.52 m
	Black or very dark grey sand with rare fragments of black mudstone recovered. This is presumably a shatter zone in softer rock.	9.48 m	28.00 m
	An incomplete recovery of dull grey mudstone. Core consists of rare short lengths of core, many irregular broken fragments and some washings. Tough, dark grey to black chert horizons, usually thin (c. 0.1 m), at about 30.65 m and 31.80 m. These are heavily jointed, locally brecciated or full of tension gashes. Finely veined by quartz and pyrite with traces of chalcopyrite and coated on joint surfaces by marcasite.	5.90 m	33.90 m
	Light grey to greenish grey, almost featureless, mudstone with traces of fine sulphide, pyrite or marcasite on some joint surfaces. Locally very fractured and imperfectly recovered. There are rare thin layers of a more yellowish colour suggestive of tuff which are slightly siliceous with locally abundant pyrite disseminated in the quartz-rich parts. There are occasional suggestions of colour banding at about 65° to the core length and also of spotting. Very soft from 52.88 m to the base of the section. Around 50.00 m there are occasional narrow veinlets of quartz and chlorite with traces of chalcopyrite and pyrite.	20.21 m	54.11 m
TEIGN CHERT FM.	Tough, dark grey chert with pale grey to white, finely crystalline quartz-pyrite layers which dip at 80° to the core length and several tension gashes and bedding partings filled by quartz. The sulphide seems to be mainly pyrite, perhaps with some marcasite, and this is associated with fine rosettes of white mica and/or chlorite. There are also fine clusters and disseminations of fine pyrite in the chert.	0.74 m	54.85 m
	A poor recovery of dark grey mudstone with occasional thin horizons of dark and tough chert. There are occasional thin films of sulphide on fracture surfaces of the mudstones, which locally may show considerable brecciation and rare contorted bedding. There is a heavily quartz veined zone between 61.43 m and 67.47 m, of which only fragments were recovered. Elsewhere much of the recovery comprises black sand. There is very little sulphide to be seen except in cherts and even there only in minor amounts.	12.62 m	67.47 m

Borehole G1 continued... Brought forward 67.47 m

TEIGN CHERT FM.	Mainly dark grey mudstone, occasionally banded, often shattered, contorted or brecciated and quartz veined. Recovered as fragments down to 74.15 m and thereafter as slightly more continuous core. Finely quartz-veined in the uppermost metre with abundant finely divided pyrite and/or marcasite as frequent small clusters in the quartz veinlets. Dark grey to black chert horizon at 68.45 m to 69.86 m with some scattered pyrite veinlets and thin quartz stringers. The sulphide content is low. Below this the mudstone is heavily brecciated and veined by quartz and siderite with which is associated a little fine sulphide. This gives way at 70.75 m to massive black mudstone. A thin, poorly cored black chert layer at 71.10 m carries a 5 cm quartz vein with much fine pyrite. This is recovered as fragments only and is succeeded, down to 74.15 m, by totally comminuted black mudstone. There is much more colour variation in the zone below with some of the layers being discoloured by pale yellowish brown (ferruginous?) material.	6.93 m	74.40 m
	Variably coloured, banded cherts and cherty mudstones. Predominantly dark grey but with pale yellowish brown and pale grey pure cherts. Banding is at about 45° to the core length. Occasional veinlets of pale brown quartz-siderite with fine pyrite. Some bands of pyrite are parallel to the banding as are some zones of disseminated fine pyrite. Sphalerite may also be present.	4.70 m	79.10 m
	Mainly grey, greenish grey and yellowish brown, generally soft and friable slaty shales, banded at about 45° to the core length. There are interbedded dark grey to near black cherty mudstones and rarer very pale grey cherts. The cherty mudstones carry finely disseminated pyrite and a few pyrite veinlets; the slates bear little or no sulphide. Locally, recovery is very poor where the rock is especially friable. Cherts become more frequent in depth and especially frequent below 83.65 m. Sulphide is very rare in the cherty bands but markedly richer in the black cherty mudstone layers.	8.10 m	87.20 m
	Black muddy cherts, mainly massive but with some banding at about 70° to the core length. Some narrow zones of pale grey chert and/or brown ferruginous altered rock are present, the latter siliceous and probably also cherty. Abundant pyrite occurs in irregular veinlets together with ferruginous material, quartz and siderite. These veinlets are often sub-parallel to either the core length or the bedding. Some zones of more disseminated pyrite are present within the bedding. Cream coloured ?chert with porcellaneous texture, sometimes banded and intricately contorted (slumping?) is found from 89.67 m to 90.40 m and from 93.10 m to 93.50 m. Both appear to be bedded into the mudstones with the bedding at 70° to 85° to the core length. The contacts are not sharp but rapidly gradational. There is considerable internal colour variation. From 93.60 m to 94.03 m there is a pale cream porcellaneous spotted phase, apparently interbedded, but the contacts are cut by a small fault which is locally mineralised. Similar rock is seen in a small faulted zone between 96.76 m and 96.95 m where it is accompanied by prominent coarse spotting, consisting apparently of quartz and pyrite. Bands of apparently similar composition, but perhaps less pure and somewhat muddier, alternate with dark grey chert down to 98.44 m.		

Borehole G1 continued... Brought forward 87.20 m

TEIGN CHERT FM.

There is a major creamy chert zone from 98.44 m to 101.03 m. Locally it is very spotted, with much colour variation due, apparently, to included slaty material and some textural variation. It is mainly well jointed with some fractures filled by pyrite accompanied by arsenopyrite. There are some scattered irregular blebs of quartz. This section is more brecciated towards its base.

Below 101.03 m the succession of porcellaneous cream chert alternating with grey muddy chert remains the same but neither carries more than traces of sulphide. Some of the pale whitish cream rock appears to vein the grey, or is at least brought in along minor planes of movement. There is a pinkish fine-grained horizon at 105.45 m. At 106.57 m the banding is at 55° to the core length. At 109.82 m a 40 mm vein of white quartz with traces of pyrite dips at 70° to the core length.

From 100.50 m onwards the rock is extremely well jointed and the recovery is usually fragmental. At 113.70 m the banding dips at 35° to the core length and at 116.60 m at 50°.

Below this depth there are many thin, brown or creamy, porcellaneous bands, some associated with marginal layers of white quartz-rich rock. Some of the brown bands are softer than normal, perhaps due to ferruginous alteration. Thin layers of metamorphosed but not spotted slate are interbedded. There is a very ferruginous, dark red-brown layer, 25 mm wide, at 117.62 m, a cream to pink porcellaneous layer with some quartz-rich banding at 118.50-118.90 m, and another at 120.00-120.52 m, both carrying a little pyrite or marcasite. The latter band shows diffuse gradational changes, suggesting that it may represent the conversion of chert to calc-flinta. 34.04 m 121.24 m

A zone of bleached, altered chert, sometimes softened or ferruginous, with many fracture coatings and veinlets of sulphide. The major sulphide is apparently pyrite but there are traces of chalcopyrite and probably some arsenopyrite, both usually associated with quartz. Some of the mineralisation appears to be confined to the banding which dips at c. 60° to the core length. 2.51 m 123.75 m

Grey, fairly massive muddy cherts. Banding is not apparent. Moderately well jointed with several fractures lined by pyrite, marcasite and traces of chalcopyrite. 1.69 m 125.44 m

TUFF

Greenish grey ?tuff. The upper limit is poorly defined and there may be some volcanic material in the overlying recrystallised chert. A small breccia vein with abundant sulphide (mainly pyrite) occurs at 125.85 m; it is 20 mm wide and dips at 20° to the core length. There are some rounded clasts, suggestive of a gas diatreme. Narrow sulphide veinlets are scattered throughout the rest of the section. Narrow chert bands are intersected at 127.30-127.45 m, 127.60-128.20 m, 128.45-129.05 m and 139.09-139.19 m. An intensely sheared zone with massive sulphide veining, mainly pyrite and arsenopyrite, occurs at 128.85-129.05 m. There is heavy pyrite veining in the fractured zone above it. 4.75 m 130.19 m

END OF BOREHOLE

Borehole G2

Site: Collar at SX 82750 79350, 360 m at 079° from Lower Crownley farmhouse.
Collar altitude: c. 143.3 m.
Drillhole inclination: at collar : 45° towards 307°.
Completed depth: 91.83 m.

Division	*Description*	*Thickness*	*Depth*
OVER BURDEN	Soil and subsoil. Only clayey washing returns.	12.32 m	12.32 m
CRACKING-TON FM. (Ashton Shale Member)	Fragmental recovery of pale grey, broken and altered mudstones and slates; perhaps some altered chert. Ferruginous around 14.32 m; ferruginous stained muddy chert at 15.55 m.	7.71 m	20.03 m
	Fairly massive, dark grey mudstone, locally altered and partially bleached in some parts. Bedding attitude not evident. Altered sulphide is present forming fracture fillings and coatings. Many joint surfaces dip at 45° to the core length. There are rare thin quartz veins, one or two ptygmatic.	18.02 m	38.05 m
FAULT?	Only sand recovered down to 55.72 m, except for broken quartz at 42.15-42.24 m, 47.40 m and 50.30 m and some cherty mudstone at 43.80 -44.00 m.		
	Fragmental, bleached, whitish, clayey material (completely altered mudstone?) with some pyrite scattered as blebs and disseminated grains of sphalerite in quartz veins.	18.17 m	56.22 m
TEIGN CHERT FM.	Broken, dark, massive mudstone with some gashes filled with pyrite. Locally at 57.35-57.99 m it is soft and decomposed within a banded section of cream cherts with thin dark grey shales. The banding dips at 30° to the core length. There is again a series of somewhat decomposed and ferruginous cherty bands from 59.20 m to 61.32 m. Thin sandstone(?) bands occur around 59.10 m, 62.45-62.60 m, 63.35 m and 64.10-64.60 m. Some of these carry disseminated and banded pyrite, some of which is coarsely crystallised.	8.69 m	64.91 m
	Pale grey chert and dark grey cherty mudstone interbanded at about 30° to the core length. Some soft dark grey mudstone layers, one of which at 67.20-68.66 m is decomposed. Very little sulphide is present in the upper part of the section, but the core is heavily veined and contains disseminated fine pyrite in speckled creamy coloured chert around 69.40 m and 69.80 m.		
	Between 70.50 m and 73.00 m there are frequent veinlets and patches of pyrite which is often coarsely crystalline.		
	Below 73.20 m the mudstone is markedly spotted by chiastolite - the only band to show such features.	8.89 m	73.80 m
	Mainly chert with some bands of intensely chertified mudstone. The uppermost 1.9 m is brownish in colour and with an irregular internal flaser structure. It is a well-jointed rock, often intensely shattered and recovered as fragments only. Locally it may be somewhat decomposed and many joints are clay coated. No sulphides are evident. The banding dips at 30° to the core length. Traces of chalcopyrite occur around 83.85 m associated with quartz veining. The rock becomes very fractured towards the base of the section with an extremely poor core recovery.	17.53 m	91.33 m

Borehole G2 continued... Brought forward 91.33 m

TEIGN CHERT FM.	Comminuted fragments of chert.	0.50 m	91.83 m

END OF BOREHOLE

This borehole was abandoned in an intensely fractured zone which was proving unduly difficult to penetrate.

Borehole G3

Site: Collar at GR SX 82707 79292, 320 m at 088^{o} from Lower Crownley farmhouse.
Collar altitude: c. 126.5 m.
Drillhole inclinations: at collar: 60^{o} towards 306^{o} ;
at 58.7 m: 60^{o} towards 306^{o};
at 119 m: 58^{o} towards 306^{o}.
Completed depth: 126.20 m

Division	*Description*	*Thickness*	*Depth*
OVER BURDEN	Almost entirely a pale brown sand and clay recovery.	21.86 m	21.86 m
CRACKING-TON FM. (Ashton Shale Member)	Altered dark grey slates, variably bleached or ferruginous in nature. Rather broken recovery of very well-jointed rock with a cleavage at 35^{o} to the core length. There is ferruginous quartz veining between 32.00 m and 32.60 m and further quartz veining at 36.05 m and 38.20-38.80 m. A little pyrite is seen on most joint faces, but a 20 mm band of massive fine pyrite at 38.30 m is associated with a quartz-veined zone in which there are several small stringers of sulphide. At 37.78 m the bedding (or cleavage?) dips at 10^{o} to the core length.	16.94 m	38.80 m
TEIGN CHERT FM.	Soft brown mudstone to 39.55 m, then alternating bedded pale cream and grey cherts, banded at 15-20^{o} to the core length. There are abundant spots, irregular patches and occasional veinlets of sulphide, mainly pyrite.	2.62 m	41.42 m
	Dark grey, soft mudstone, yielding a rather poor recovery. Above 43.18 m the core is intensely broken. There are a few thin zones of pale chert. Local abundant disseminations of fine pyrite.	4.31 m	45.73 m
	Variably coloured, thinly bedded cherts and mudstones interbanded at c. 25^{o} to the core length. The core is well fractured and often poorly recovered. From 48.65 m to 49.60 m there is a zone of intense brecciation, perhaps a fault. Very little sulphide within this section. At depth the beds become thicker. Below 56.95 m there is a crosscutting network of narrow pyrite veinlets.	14.69 m	60.42 m
FAULT ZONE	Shattered, brecciated chert re-cemented by ferruginous cement and cut by vuggy quartz veining.	2.08 m	62.50 m
TEIGN CHERT FM.	Tough, grey, cherty mudstone and lighter coloured cherts bedded at about 20^{o} to the core length. The core is very broken, locally softened and ferruginous within zones of contortion, quartz veining or pyrite veining.		
	Throughout there is a laced network of pyrite veins, most about 5 mm thick but some up to 15 mm. Several crystals of pyrite are scattered through the rock host and locally there are lensoid clusters of fine pyrite. Massive bedded fine sulphides occur at 71.47-71.62 m closely associated with green chlorite; the banding dips at 20^{o} to the core length. Sulphide mineralisation continues down to 76.05 m. Some alteration around 75.50 m.		
	Softened, ferruginous and quartz-veined from 65.64 m to 66.05 m and from 67.00 m to 67.30 m. Some greenish, slightly softer chloritic(?) zones below 70.60 m. An intensely broken zone from 67.65 m to 70.51 m was recovered as sand. Further poor, sandy recoveries at 78.50-83.00 m and 86.00-86.36 m.		

Borehole G3 continued... Brought forward 62.50 m

TEIGN CHERT FM.	Decomposed and soft rock, probably tuffaceous, at 85.90-87.28 m, 88.24-88.40 m and 90.20-90.60 m. Some pink coloured chert layers (?manganiferous) are associated with the tuff horizons, and at 90.40 m there are thin black horizons, perhaps rich in manganese oxides. Banding there dips at about 40° to the core length. Sulphides are scattered below 78.33 m, becoming more widely developed again below 90.55 m. There is quartz veining at 83.10 m, 83.70 m and 84.50 m. The rock is well broken. Sulphides occur as disseminations and lenses, rarely as veinlets. Further ashy tuff bands are present at 96.90 m and 97.40 m, both somewhat decomposed and soft. There are two porcellaneous bands at 100.00 m.	38.95 m 101.45 m
FAULT ZONE	Very broken ground with much fragmented and softened rock together with some quartz veining, probably a major fault zone. Some short lengths are relatively less altered and disturbed, for example at 103.04 m and 105.90 m. Other sections are well brecciated and some so comminuted and decomposed as to be recoverable only as sand or clay, and then with great difficulty. Spots and veinlets of pyrite occur locally and some patches include sphalerite. There is major quartz veining around 111.50 m and several veinlets of sulphide are present below 121.00 m. Below about 122.0 m the recovery is solely of clay gouge with small fragmental pieces of chert or cherty mudstone.	23.91 m 125.36 m
	No core recovery.	0.84 m 126.20 m

END OF BOREHOLE

Considerable difficulty in drilling was experienced because of the continuous collapse of the borehole walls within the fault zone. Acid, sulphate-rich water produced by oxidation of pyrite/marcasite prevented complete setting of both Portland and alumina cement.

Borehole G4

Site: Collar at GR SX 82544 78842, 90 m at 226° from Lower Coombe farmhouse.
Collar altitude: c. 88.5 m.
Drillhole inclinations: at collar: 58° towards 347° ;
at 60.0 m: 58° towards 337°.
Completed depth: 85.20 m

Division	*Description*	*Thickness*	*Depth*
OVER BURDEN	Fragments of cream, grey and near black chert, some black flinty mudstone and rare vein quartz together with sand and clay. A larger boulder of quartz at the base.	3.11 m	3.11 m
TEIGN CHERT FM.	Weathered fragmental cream, grey and black chert with some softer cherty slate, black when fresh but weathering to grey. Bedding is contorted and occasional recoveries of clay (at 7.60 m and 10.10 m) suggest the presence of a fault zone.	7.45 m	10.56 m
	Dark grey to almost black, dull, cherty slates alternating with dark grey, tough, banded cherts. The bedding varies in attitude from 30° to 45° to the core length.	1.94 m	12.50 m
	Dark grey cherts, well banded in parts with the banding at about 30° to the core length. Several narrow quartz veins carry spots, lenses and disseminations of pyrite and occasional spots of sphalerite. At 14.20 m there is a mineralised breccia composed of angular masses of chert cemented by finely comminuted cherty material and cut by a sphalerite-bearing quartz vein.	2.30 m	14.80 m
	Darkish grey cherts significantly lightened by silicification around numerous narrow quartz veins which carry small pockets or strings of pyrite. The bedding is very variable in attitude and locally there is some brecciation.	1.94 m	16.74 m
	Alternating dark grey cherts and black siliceous slates with a variability of bedding attitude which suggests proximity to a zone of movement. A very small amount of pyrite is present.	2.96 m	19.70 m
	Light grey, sometimes greenish, flinty chert with vestiges of contorted bedding. Small flasers of black flinty shale suggest that it is a chertified mud. Abundantly mineralised with pyrite as spots and small veinlets, but no other sulphides seen.	2.49 m	22.19 m
	Massive, dull, black, highly siliceous and tough mudstone with several very fine ramifying veinlets of pyrite. Well jointed, with the recovery often consisting of broken fragments. Small cherty horizons at 24.50 m and 24.80 m show a dip of 20° to the core length.	3.86 m	26.05 m
	Greenish grey, finely banded, slightly siliceous slates with thin layers of chert. Banding dips at 25° to the core length.	1.65 m	27.70 m
	Black cherty mudstone with some fine banding at 30° to the core length. A little pyrite, mainly as fine veinlets. The rock is well jointed and recovered as small fragments.	5.60 m	33.30 m
	Greenish grey, rather siliceous slates, becoming somewhat cherty. The very broken recovery includes small fragments rich in pyrite, which may be tuffaceous or of granular veinstuff.	1.66 m	34.96 m
	A broken recovery with fragments of very dark carbonaceous mudstone and granular green tuff, both with locally abundant bands and veinlets of pyrite. Thin bands of greenish grey, cherty slate.	1.14 m	36.10 m

Borehole G4 continued... Brought forward 36.10 m

TEIGN CHERT FM.	Greenish grey to black, rather soft, well banded slates with bedding at 10-35° to the core length and occasional clear cleavage planes at 45°. Much of the recovery is fragmental. The rock becomes tougher with depth and fragments are larger. A few granular, probably tuffaceous, bands with disseminated pyrite but otherwise little or no sulphide is evident.	4.13 m	40.23 m
	Black or dark grey mudstone, rarely finely banded at 50° to the core length. Cleavage is not evident. Rare thin veinlets of pyrite.	1.17 m	41.40 m
	Grey, greenish grey and occasionally black, finely banded slates, dull and soft compared to the overlying section. The banding dips at 40° to the core length. Rare thin ash layers with traces of pyrite. These grade into the containing mudstones.	2.20 m	43.60 m
	Black, siliceous mudstone, finely banded at 25-40° to the core length. Very thin bedded layers of pyrite are abundant and there are some fine-grained layers of sphalerite which is recognisable only with difficulty.	2.24 m	45.84 m
	Interbanded greenish grey and blackish grey muddy cherts banded at 40° to the core length. The greener bands are usually speckled and have the appearance of tuffs. Very scattered fine pyrite blebs and rare narrow sulphide veinlets.	1.29 m	47.13 m
	Mainly highly contorted, intensely veined and locally brecciated dark cherty mudstone with abundant quartz blebs, lenses, veins and networks. The banding is most irregular and may even be parallel to the core length; usually it is sinuous. Pyrite is scattered abundantly throughout the core as irregular vein and cavity fillings, and it may be accompanied by sphalerite, loellingite and, near to the top, by galena.	2.97 m	50.10 m
	Dark and light grey cherts banded at 0-35° to the core length. Well jointed throughout with the fractures filled by white quartz. Several zones of intense fracturing, minor brecciation and local quartz veining, with associated intense developments of fine pyrite (and sphalerite?). These zones dip at about 25° to the core length. Everything is cut by late-stage veinlets of brownish cream siderite, which is associated with some pyrite. A near black, muddy chert horizon at 52.80-53.05 m carries conspicuous pyrite bands and, though contorted, the bedding tends to be nearly normal to the core length. A similar band occurs at 55.15-55.85 m (here the dip is not apparent) and is marked by considerable brecciation, quartz veining and pyrite fracture fillings. These two horizons may be the same bed folded. Between them the chert is well veined by quartz, pyrite, late siderite and a solitary narrow veinlet of nearly pure sphalerite.	5.75 m	55.85 m
	Intensely shattered and quartz veined pale grey cherts. Quartz occurs as irregular patches and a multitude of fine veinlets carrying fine pyrite. There are several open tension gashes but most are filled by yellowish cream coloured siderite which also carries scattered blebs of pyrite, some fine sphalerite and probable traces of galena. Locally the rock becomes a true cataclastic breccia.	2.55 m	58.40 m
	Greenish grey and dark grey chertified slates banded at 40-55° to the core length. Very well jointed rock in which the recovered core is often highly broken. Rare pyrite bands and more frequent, though not abundant, fine and extremely irregular veinlets.	1.42 m	59.82 m

Borehole G4 continued... Brought forward 59.82 m

TEIGN CHERT FM.	Black, banded, cherty mudstones with the bedding at about 35° to the core length. Abundant pyrite is developed in irregular zones and is often accompanied by patchy developments of quartz giving rise to a mottled appearance. There are traces of chalcopyrite with the pyrite and probably accompanying sphalerite. Particularly rich pyrite zones occur at 60.90 m and 61.13 m. Quartz-rich zones with abundant pyrite occur at 62.49-62.67 m (zone at 25° to the core length with a little chalcopyrite); at 62.83-63.08 m and 63.44-63.82 m (both quartz and siderite, the top of the zone at 15° to the core length), and at 65.66-66.34 m (a little siderite but virtually no pyrite). Rock intensely veined and impregnated by quartz and siderite from 64.32 m to 65.15 m, with only small blebs of pyrite.	6.69 m	66.51 m
	Banded grey cherts with a very variable bedding attitude due to folding, but generally at about 30-40° to the core length. Bedding becomes more commonly to totally disturbed towards the base of this section. Abundant minor tension gashes are filled by white quartz and there are rare larger quartz veins. Although present, pyrite is not conspicuous.	2.43 m	68.94 m
BRECCIA ZONE	Irregular and angular fragments of light and dark grey chert set in a finely clastic and siliceous matrix. It becomes a light greenish colour with depth, still extremely siliceous though with some softened (decomposed?) patches. Very frequent quartz veining and some siderite. A considerable amount of irregularly disposed pyrite and perhaps some sphalerite. Intensely quartz veined in the basal metre of this section, with the bottom of the zone marked by a highly silicified breccia which dips at 60° to the core length.	1.57 m	70.51 m
TEIGN CHERT FM.	Interbedded dark siliceous mudstones and cherts. The bedding attitude is irregular, sometimes folded and often totally tectonised. Zones of intense deformation and disturbance are often rich in quartz, either as discrete veins or as irregular patches which grade into the host rock. Pyrite is present throughout as veinlets, bands and disseminations. There may be some associated sphalerite. In a vuggy area at 76.30 m there is abundant crystalline pyrite and loellingite with quartz, some siderite and possibly scorodite. There are similar patches of grey loellingite just below this, always in the same mineral association.	5.84 m	76.35 m
	A pale coloured zone consisting almost entirely of siderite replacing chert. Usually a yellow to pale greenish colour and veined by many stringers of white quartz. Veinlets and patches of pyrite, some with loellingite, are fairly common throughout. Texturally, some patches can be seen to have been brecciated prior to replacement by siderite.	0.91 m	77.26 m
	Highly disturbed, darkish grey cherts which are intensely plicated and abundantly veined by irregular quartz and pyrite veinlets. Patches of silicification and irregular pods of siderite. Some thicker bands of pyrite with quartz and sphalerite.	3.20 m	80.46 m
	Dark grey, tough chert with local developments of cuboid pyrite in the chert and occasional veinlets of fine pyrite with traces of chalcopyrite. Traces of banding at 40° to the core length, but often it is contorted with variable bedding attitudes. Sulphides frequently developed below c. 82.00 m, usually as patchy clusters of fine-grained pyrite with a little sphalerite. A little quartz veining occurs at 84.75 m. There are some narrow bands of brecciation. The core is very broken near the base of the borehole.	4.74 m	85.20 m

END OF BOREHOLE