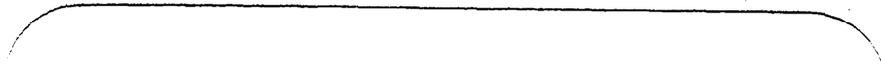


Natural Environment Research Council

BRITISH GEOLOGICAL SURVEY



Mineral Reconnaissance Programme Report





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 The information contained herein must not be published without reference to the Director, British Geological Survey.

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No. 82

**Mineral investigations near
Bodmin, Cornwall. Part 4—
Drilling at Royalton Farm**



Mineral Reconnaissance Programme

Report No. 82

**Mineral investigations near Bodmin,
Cornwall. Part 4—Drilling at Royalton
Farm**

Geology

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Geochemistry

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

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Bibliographic reference

Beer, K. E., and others. 1986. Investigations for tin around Wheal Reeth, Godolphin, Cornwall. *Mineral Reconnaissance Programme Rep. Br. Geol. Surv.*, No. 81.

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SUMMARY

Fourteen inclined percussive drillholes have shown that weak tin mineralisation persists into the hangingwall slates of the Royalton elvan for a distance of at least 50 m. Geochemically anomalous tin values are recorded along the full strike length of the former opencast workings of the Old Castle-an-Dinas Mine, but the richest concentrations are found near the western, circular-shaped pit. Even here, the grades rarely reach economically interesting levels, and then only over intervals of 1.5 m. Immediately east of the openworks there is a marked enrichment in copper and nickel, but at levels well below those of economic significance.

INTRODUCTION

Royalton Farm (SW 9502.6156) lies on the lower southeastern slope of Castle-an-Dinas Hill about midway between St. Columb Major and Roche (Figure 1). On either side of the farmhouse there is an overgrown quarry marking the site of the former Old Castle-an-Dinas Mine, which worked narrow cassiterite veinlets traversing an elvan dyke.

Little is known about this deposit, and since its last recorded working in 1873 it seems to have attracted no exploration interest. As part of the Mineral Reconnaissance Programme a limited amount of percussive drilling was commissioned to examine the possibility of mineralisation extending into the slate hangingwall of the elvan, and to test the tenor of any ore left in the walls of the quarries.

GEOLOGY AND FORMER MINING

Although the Royalton elvan can be traced by surface float over a strike length of some 6 km, in which distance it has been opened at intervals in search of tin, the dyke is now rarely exposed. It courses a little north of east, dips steeply north and is reported as 10 to 21 m wide (Dines, 1956). Float fragments show an altered yellow to orange coloured rock with abundant phenocrysts of quartz and altered feldspar in a fine grained groundmass. Where mineralised, the elvan is reported to be extensively kaolinised but at these sites fragments of tougher, tourmalinised elvan are not uncommon.

The dyke cuts through a succession of grey mudstones and silts, some of which are finely banded and all extensively jointed and cleaved; they form part of the Meadfoot Beds, of Lower Devonian age. Locally these slates are highly tourmalinised and then are tough and resistant.

To the south of Royalton Farm the slates are concealed under the edge of the broad Goss Moor alluvium, and close to its margin the land drainage is usually poor. This factor was one of the deterrents to drilling south of the quarries.

It is suggested by Collins (1912) that Old Castle-an-Dinas Mine was of considerable antiquity, but the earliest recorded working dates from only 1835. At that time the mine was apparently a shaft working and was drained to a depth of 25 fms (46 m) by a Deep Adit driven for a distance of 1.2 km. The adit was reported to have cut twelve lodes of the sixteen claimed within

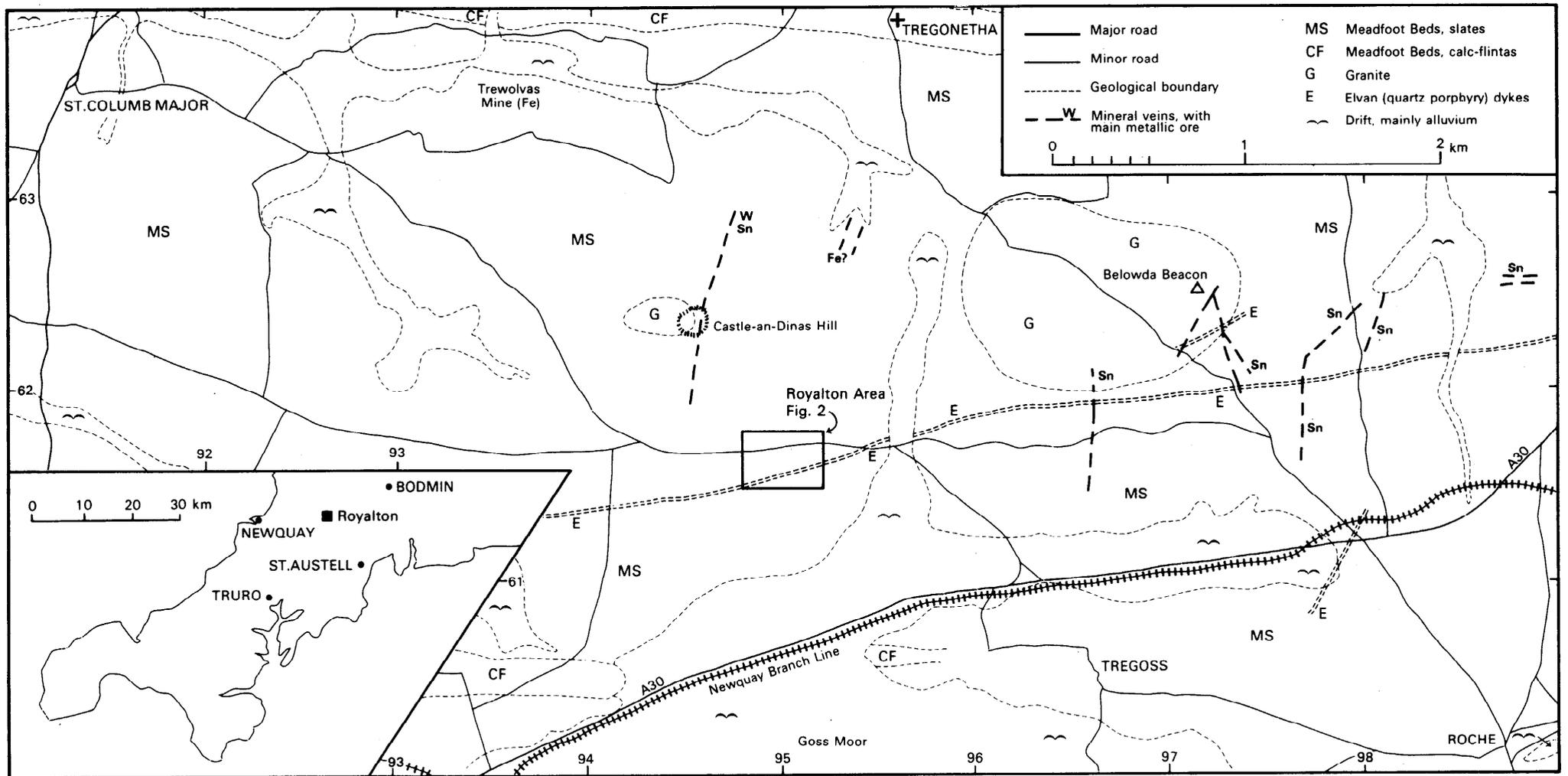


Fig. 1 Location and geology

the sett (Jenkin, 1964). At a later date, probably 1870-3, the elvan was worked opencast and a shaft in the eastern quarry was sunk to a depth of 25 fms. The ground was reputed to be carrying about 0.35% Sn but improving in depth to around 0.8%. It seems doubtful, however, that the run-of-mine ore was as rich as this. Only 24 tonnes of tin concentrate are recorded from Old Castle-an-Dinas but it is suspected that the production figures are woefully incomplete. At least 200,000 tonnes of rock have been removed from the quarries alone and at a grade of 0.2% Sn this should have yielded 450 tonnes of high-grade tin concentrates.

The site of the separation mill for this mine is not readily identifiable in the fields around the farm, though it may be presumed to have been close to the stream, south or south-east of Royalton. Nor is there any evidence of the large tonnage of waste sand which must have been discarded.

In the absence of reliable descriptions, any consideration of the form and extent of the deposit is mainly speculative. It is believed that the cassiterite occurred in narrow parallel veinlets, probably of quartz-tourmaline-mica composition, spaced at fairly close intervals (0.3 m or less) and aligned roughly north-south (Dines, 1956). Whether the veins are confined solely to the elvan is uncertain, but the lowest parts of the opencast workings seem to be restricted to the dyke width. It must be presumed that the near-surface extent of viable ore is reflected in the size of the openworks and, if this be true, it is evident that tin mineralisation was developed along 200 m of elvan strike. There is no obvious geological control upon the location of a sheeted vein deposit at Royalton Farm; it can only be assumed that it has been developed around the intersection of the elvan and an unidentified major north-south structure, either a fault or mineral lode.

PERCUSSIVE DRILLING

Fourteen inclined percussive air-flush boreholes were drilled to the maximum possible depth in a short investigative programme, north of the old quarries. Of these, eleven were spaced along an east-west traverse about 50 m north of the quarry rims, one sought possible easterly extensions of the mineralisation, and the other two examined the quarry walls. Sites and attitudes of the drillholes are shown in Figure 2.

Drill chippings and dust were collected over 5 ft (1.5 m) intervals and sampled for field and laboratory assay. The remaining material was retained and several 5 ft samples were hand panned to confirm the abundance of cassiterite. All samples were checked by portable scintillometer for total radioactivity but, owing to the degree of kaolinitic alteration, there was no reliable discrimination between slate and elvan cuttings. Subsamples were ground to 200 mesh BSS sieve size for X-ray fluorescence determination of Ce, Ba, Sb, Sn, Pb, Zn, Cu, Ca, Ni, Fe, Mn and Ti. Because a tungsten carbide button bit was employed in drilling, no W determinations were carried out.

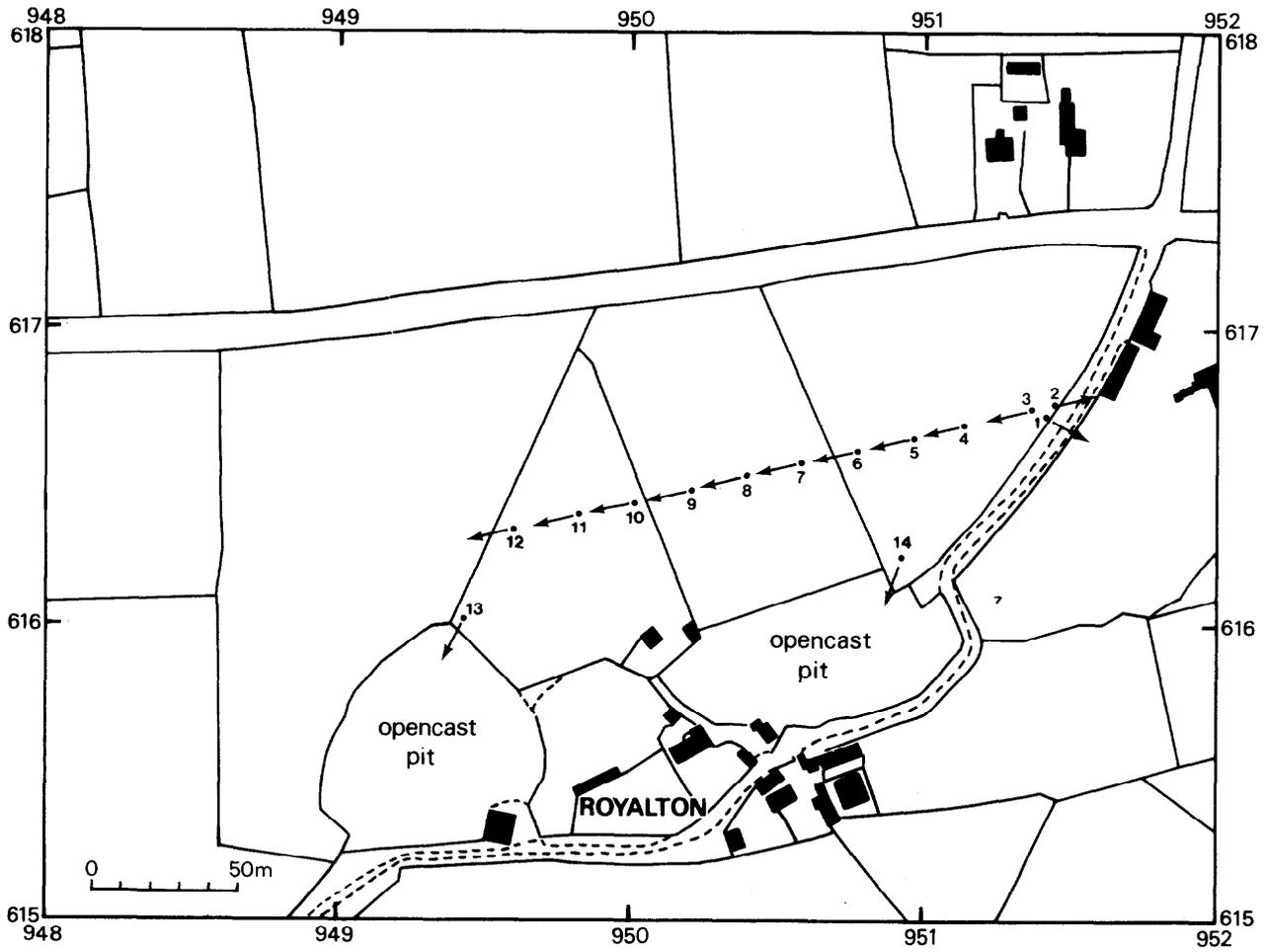


Fig.2 Percussion drillhole locations

ANALYTICAL RESULTS

The analytical statistics are shown in Tables 1 and 2 and anomalous levels of the major metals are plotted in borehole sections in Figures 3 and 4.

Table 1. Analytical statistics (279 samples)

Element	Range	Mean	Standard deviation	Median	Median for slates*	Median for elvans**
Ce	19-180	65.76	23.51	64	133	68
Ba	110-910	469.3	103.9	465	1340	446
Sb	0-10	2.656	2.273	3		
Sn	14-18917	288.9	1163.0	125	13	16
Pb	0-349	33.89	39.66	18	43	75
Zn	10-432	70.06	60.65	49	173	74
Cu	6-553	140.1	105.7	110	24	16
Ca(%)	0.007-0.164	0.0270	0.0203	0.022	0.03	0.12
Ni	7-87	28.35	18.70	22	105	8
Fe(%)	0.972-14.050	4.6534	2.1699	4.384	5.9	1.31
Mn(%)	0.004-0.077	0.0120	0.0086	0.010	0.05	0.02
Ti(%)	0.213-1.567	0.6438	0.1202	0.645	0.47	0.11

Figures in ppm, except where otherwise indicated.

* Meadfoot Beds slates, Henley, 1974a.

** Henley, 1974b.

Cerium results when plotted show a distribution which is close to log-normal, but with nine samples which are anomalously high (more than 115 ppm). These are widely scattered through the boreholes and show no consistent association with the other elements nor with the apparent lithology. Ce shows a poor statistical correlation with Ba and Ti.

Barium values vary widely, and in a log-probability plot they fall into three populations. Ten samples are anomalously low in Ba, less than 255 ppm, and are widely scattered through the boreholes. They are not consistently associated with other metal anomalies, but four also show low Ti levels. Values above 540 ppm are interpreted as slightly anomalous, and three above 790 ppm are distinctly so; these are accompanied by highly anomalous Ti and elevated Ce values, reflecting the poor but positive correlation factors shown in the matrix (Table 2). The absence of significant correlation between Ba and Pb or Zn suggests that there is no barite-galena or barite-sphalerite mineralisation.

Table 2. Correlation matrix (279 samples).

Ce	1.00											
Ba	0.35	1.00										
Sb	0.05	0.08	1.00									
Sn	0.06	0.18	0.10	1.00								
Pb	0.01	0.06	0.16	0.05	1.00							
Zn	0.01	0.11	0.07	0.04	0.04	1.00						
Cu	0.07	0.23	0.12	0.12	0.16	0.51	1.00					
Ca	0.04	0.35	0.08	0.37	0.00	0.01	0.11	1.00				
Ni	0.12	0.16	0.10	0.07	0.20	0.54	0.74	0.03	1.00			
Fe	0.04	0.04	0.09	0.03	0.01	0.30	0.57	0.12	0.62	1.00		
Mn	0.19	0.16	0.12	0.04	0.14	0.53	0.63	0.09	0.82	0.47	1.00	
Ti	0.27	0.42	0.09	0.02	0.01	0.08	0.06	0.04	0.10	0.04	0.07	1.00

Negative coefficients underlined

Ce	Ba	Sb	Sn	Pb	Zn	Cu	Ca	Ni	Fe	Mn	Ti
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Antimony values are consistently low and show no significant correlation with other metal contents.

Tin exhibits an extremely wide range of values and in log probability plot shows a complex distribution pattern suggestive of at least three populations. Most samples (70%) contain less than 200 ppm, with three anomalously low (below 20 ppm). About 25% of the samples carry significant tin values (201-700 ppm) and the remaining fourteen are anomalously high, up to almost 2% Sn. Levels of Sn in the range 201-700 ppm are shown ornamented in Figure 3, and any amount in excess of 700 ppm is left blank. The extremely high value in BH 13 distorts the statistical evaluation but there is no significant correlation with the sulphide ore metals and only poor correlation with Ca.

Perhaps surprisingly, enhanced levels of Sn do not feature prominently in the uppermost borehole samples, suggesting that there has been little movement of residual cassiterite released by surface weathering. It is probable, however, that the high Sn value near the top of BH 13 may be due to a concentration of residual cassiterite at the base of the overburden.

The distribution of Sn values, particularly those above 700 ppm, is indicative of scattered clusters of cassiterite veinlets or joint coatings, with these clusters best developed towards the western end of the borehole traverse (Figure 3). In assessing these values it should be emphasised that a value of 700 ppm represents only one millimetre of pure cassiterite distributed over a sampling true width of one metre. On this basis it can be concluded that no economically significant tin mineralisation is developed in the slates to the north of the elvan within the lateral range between the bottoms of BHs 2 and 12. Nor do the veinlets worked in the two quarries appear to persist in quantity into the immediate slate hangingwall. The Sn values, however, are very high for sedimentary rocks and represent a primary halo of dispersion around the orebody.

Lead shows a wider range of values than is normally expected in this type of lithology, and a log-probability plot indicates an irregular distribution of values. An unusually large number (6% of the total) are abnormally low, less than 3 ppm, and about 13% of the samples yield high Pb analyses, in excess of 78 ppm, with ten of these anomalously high at levels above 120 ppm. There is no significant correlation between Pb and other elements (Table 2).

Most of the anomalously low Pb values are clustered in BH 9 and BH 10; they show no consistent elemental association, but many are accompanied by moderately high Ca and Ce, and some by high Ba. Three of the four basal samples from BH 14 show anomalously low Pb and Ti levels and probably reflect an altered elvan host rock. Anomalously high Pb values are clustered near the base of BH 12 and two in the middle of BH 8. In most cases they are associated with moderately to anomalously high Sn levels.

Zinc levels also vary quite widely but plot into distinct populations. About 14% of the samples carry moderately high Zn contents, in excess of 130 ppm, and of these twelve above 225 ppm are anomalously high. Seven of them are clustered in the lower half of BH 6 where, in association with neighbouring moderately high Zn values, they constitute a markedly zinc-rich zone. Although such a distribution might suggest the presence of a specialised Zn-bearing lithological horizon, there is no consistency of associated elements providing a geochemical signature indicative of rock-type variation. The remaining five high Zn samples are scattered, four being associated with elevated copper values.

Zinc correlates equally significantly with copper, nickel and manganese, and poorly with iron. In the absence of a known volcanic suite in this area, it may be presumed that this correlation is indicative of widespread mesothermal metalliferous metasomatism, probably introduced along north-south fractures.

Copper levels at Royalton are notably higher than is normal over much of South-west England (e.g. Henley, 1974a). Two main populations are displayed in the log-probability plot, with 73% below 200 ppm and the 27% above that figure being interpreted as anomalously high. Background levels of Cu in the killas of Cornwall are usually below 100 ppm. Six samples containing less than 20 ppm seem to be abnormally low; they are scattered through the more westerly boreholes. Four samples are abnormally high, at levels above 450 ppm.

Copper correlates significantly with Ni, Mn, Fe and Zn, an association suggestive of mesothermal metallisation. There is, however, only poor correlation with Ba and a slight negative covariance with Sn.

The distribution of high Cu values is shown in Figure 4. Patchy clustering of the Cu-rich samples may reflect the presence of small (north-south?) mineralised veinlets. Chalcopyrite and secondary copper carbonates were noted in some of the panned concentrates from these samples.

Calcium exhibits a wide variation which may, in part, be distorted by contamination from agricultural applications of lime. Nonetheless, there are several samples in the middle and lower portions of some boreholes exhibiting significantly elevated calcium contents and, presumably, reflecting the calcareous nature of some layers in the Meadfoot Beds.

The range of **nickel** values is restricted, as might be anticipated in a succession which is not known to contain any volcanic horizons. Background levels vary from 7 to 40 ppm, a span which closely matches that found elsewhere in the killas of Cornwall (Henley, 1974a). Some 17% of samples

show elevated Ni contents, of which almost half (7.5%) are high, above 68 ppm. The latter, though scattered through several boreholes, are locally clustered at the base of BH 2 and in the middle of BH 11. Here they are invariably associated with elevated levels of Mn, and in some cases with Cu. Although the small rock chippings from these samples appear to be of slate, their geochemical signature is suggestive of a basic volcanic affinity, which raises the possibility of tuffaceous horizons within the slate succession. Their composition, however, is not dissimilar to that of the Meadfoot slates of the Perranporth area (Henley, 1974a).

Nickel correlates significantly with Mn, Cu, Fe and Zn, only poorly with Ba and Ce, inversely and poorly with Pb, and not at all with Ca. Discounting the uppermost two samples from each borehole, the samples most seriously affected by farming, raises the Ni-Ca correlation coefficient to 0.22. If, indeed, there are tuffaceous horizons present, this factor is surprisingly low.

A log-probability plot for iron defines a normal range from 1.450 to 7.000% Fe. Three abnormally low Fe values occur scattered through BHs 7 and 8, two of them accompanied by abnormally low Cu. Some 13% of the samples show high Fe contents with seven of these exceptionally high, at levels above 9.000% Fe. Most of the latter are associated with elevated levels of base metal content and are presumed to indicate the presence of hydrothermally deposited Fe oxides. Correlation with Ni, Cu and Mn is good but that with Zn is weaker.

Manganese does not follow Fe as closely as might usually be expected in South-west England. The range of values is considerable, with the majority of samples forming a normal population between limits of 0.007 and 0.019% Mn. Contents above this level are regarded as anomalous and in twelve samples above 0.030% Mn as highly anomalous. The latter samples also carry high or abnormally high Cu values, and some show high Ti levels. Clustering of Mn-enriched samples is particularly notable near the base of BH 2, at the base of BH 6 and over a broad zone in the middle of BH 11, but in none of these sections was any obvious lithological change recorded.

Correlation with Ni is very strong, with Cu and Zn good and with Fe moderate. Whilst much of this correlation may reflect a scavenging of mobile elements during primary and secondary dispersion, there remains a suggestion that it may also be related to the presence of pyroclastic layers in the lithological succession.

Although the **titanium** levels vary widely throughout the boreholes, a log-probability plot shows an essentially gaussian distribution. Very low values (less than 0.540% Ti) are recorded in the basal seven samples of BH 14 and these seem to correlate satisfactorily with dust samples predominantly of elvan. Titanium correlates moderately well only with Ba, and less positively with Ce.

CONCLUSIONS

Tin, at geochemically significant levels (greater than 200 ppm), is found in all the boreholes, but is best developed towards the western end of the traverse (Figure 3). Whilst this may be presented as evidence that tin metallisation persists some 50 or 60 m, at least, into the hangingwall slates above the Royalton elvan, it is apparent that nowhere in the standing ground north of the pits is there economically viable tin ore at present metal prices. Whatever the original grade of ore in the Old Castle-an-Dinas Mine openworks, and the data from BHs 13 and 14 suggest that it was very

low, the orebody seems to have been totally worked out, at least in a northerly direction. Only at the extreme western end, in BHs 10, 12 and 13, do grades approach a potentially interesting value, and then only over short separate intervals. It must be assumed that the one high-grade sample near the top of BH 13 includes detrital cassiterite concentrated at the base of the weathering regolith.

A feature of the geochemistry is the high background level for copper in this area, at least twice the norm for most Cornish localities. Particularly rich copper concentrations are reported in the extreme east of the area, in BHs 1 and 2 (Figure 4), where they are accompanied by enhanced levels of nickel. The central part of the traverse shows generally average copper levels, but in the extreme west a few scattered anomalous values are again associated with nickel. None, however, approaches economic interest.

Neither zinc nor lead are distinctly associated with the copper, nor do they correlate with tin. The excellent correlation between copper, nickel and manganese leads to suspicions that the Meadfoot Beds in this district possibly contain pyroclastic tuff horizons hitherto unrecognised due to lack of exposure.

The drilling results provide no evidence as to the factors which control the location and extent of the Old Castle-an-Dinas "orebody". They do, however, support the model erected by Dines (1956) of clustered narrow cassiterite-bearing veinlets contained mainly within the elvan dyke and striking generally north-south. A primary dispersion halo of Sn and Cu around the orebody appears to be recognisable.

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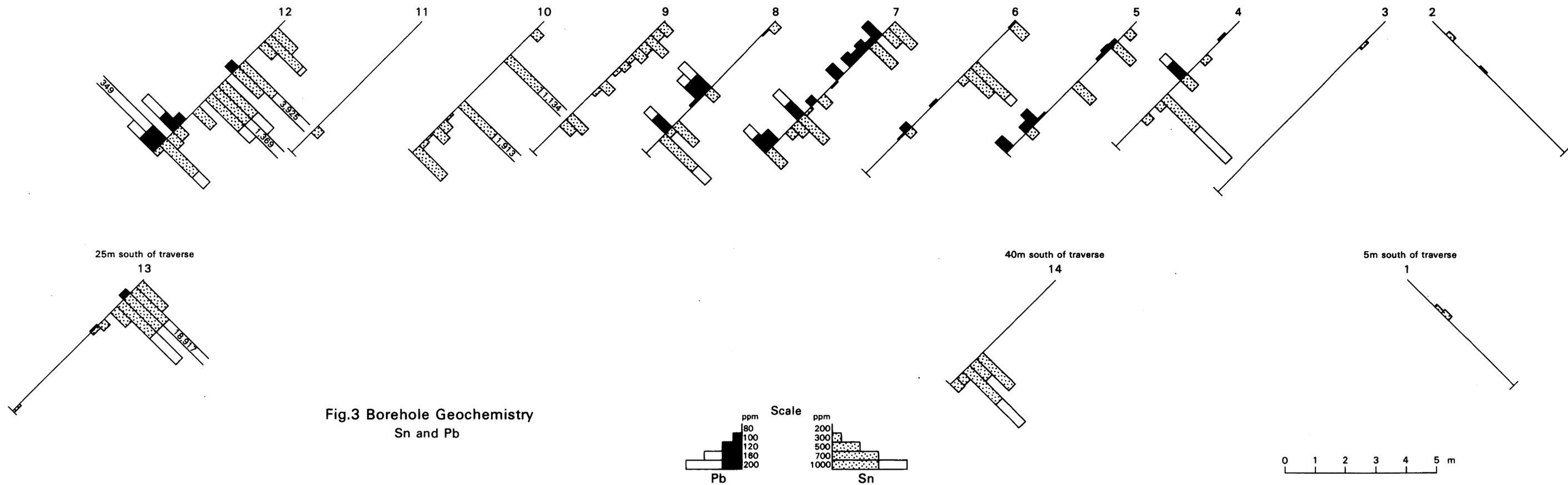
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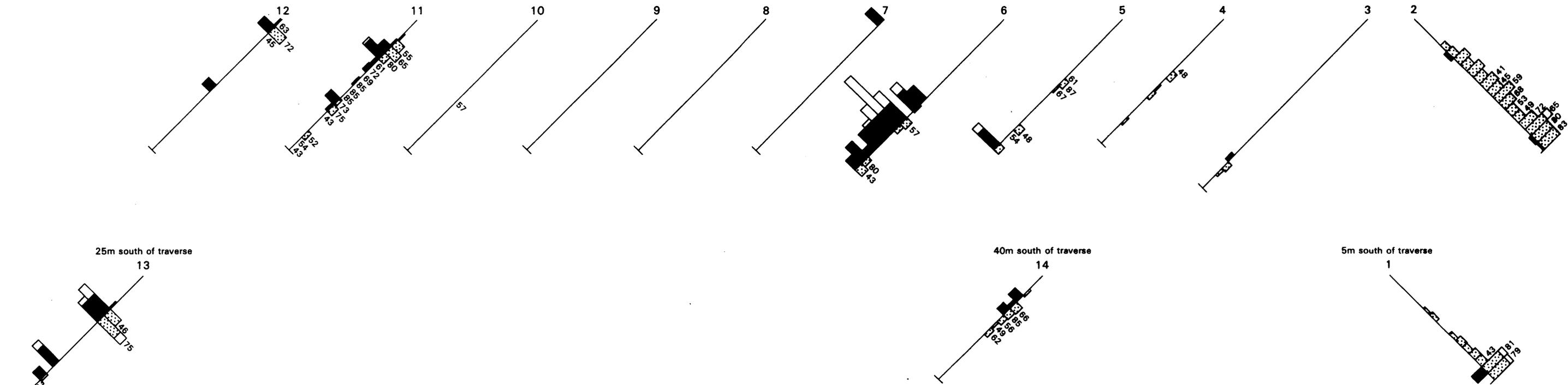


Fig.4 Borehole Geochemistry
Cu,Zn and Ni

