Natural Environment Research Council

Institute of Geological Sciences

Mineral Reconnaissance Programme Report

A report prepared for the Department of Industry

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Geochemical and geophysical investigations around Garras Mine near Truro, Cornwall

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with analytical contributions by B. A. R. Tait, BSc and Miss L. Hearn

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Summary

In the valley of the River Allen north of Truro there are three old mine workings and four trials arranged in a sub-linear manner, of which Garras is the principal. In the intervening unworked ground applied geochemical and geophysical investigations have been carried out. Ten soil traverses were arranged to locate and investigate the possibility of continuity of mineralisation. The results of these investigations did not indicate such continuity, though they did show that the lode at Garras Mine persists for a short distance beyond the former workings. Several low order geochemical anomalies were located but they seem to be of a restricted size and of little importance. Four geophysical anomalies were found, two of which are close to Garras Mine, and two are thought not to be due to mineralisation.

In view of these disappointing results, these investigations have been brought to a close.

INTRODUCTION

In 1973 an investigation into the economic potential of the Garras area was undertaken as part of the Department of Industry's Mineral Reconnaissance Programme. The features of the area which attracted attention were the distance over which mineralised structures occurred; the restricted extent of the old workings as indicated by old shafts, surface trials, dumps etc; the persistence at depth of mineralisation in the most extensively mined working (up to 70 fathoms in Garras Mine); and the high silver content of the lead ore, reputedly 1730 g/tonne (Dines, 1956).

The Allen Valley was relatively undisturbed by past mining activity which thereby enabled soil sampling to be undertaken with little fear of spurious results due to contamination. It was considered that since the valley lies outside the main established mining areas it would not have been subjected to the intense scrutiny of past generations of mineral prospectors.

Location and Topography

The area under investigation extends from the northern boundary of the City of Truro to Newlyn Downs, which is a distance of 5 miles. The area is devoted to agriculture and forestry, and is cut by the River Allen and its tributaries which form a dendritic pattern draining to the south. The lower part of the valley is deeply incised and the valley sides are well wooded. The ancient road pattern follows the interfluvial ridges, and the A30 Redruth to Bodmin road runs along the watershed between the River Allen and the Gannel river system draining to the north beyond the area. There are no communities of any size in the area, though the villages of Zelah and Shortlanesend are nearby. Within the area there are three hamlets, Idless, St Allen, and Gwarnick. The land rises to 450 ft above sea level at Newlyn Downs, but in the remainder of the area the summits of the ridges lie at about 350 ft.

Geology

The area under investigation lies wholly within the outcrop of the Gramscatho Beds (mainly of Middle Devonian age) which are here represented by interbedded sandstones, grits, siltstones and slates. To the north this lithology is underlain by the more calcareous succession of the Meadfoot Beds and a short distance west occur the easternmost outcrops of Mylor slates, which also may underlie the Gramscatho sediments. Everywhere in the area the beds dip southwards at moderate angles and, where clearly recognisable, the slaty cleavage also dips in this direction, usually at a shallower inclination.

Cornwall may be divided into two structural units separated by a line from Perranporth to Pentewan, a line the significance of which is a matter of some debate. Garras lies in the southern region where the major fold axes generally trend north-eastwards. Potassium-

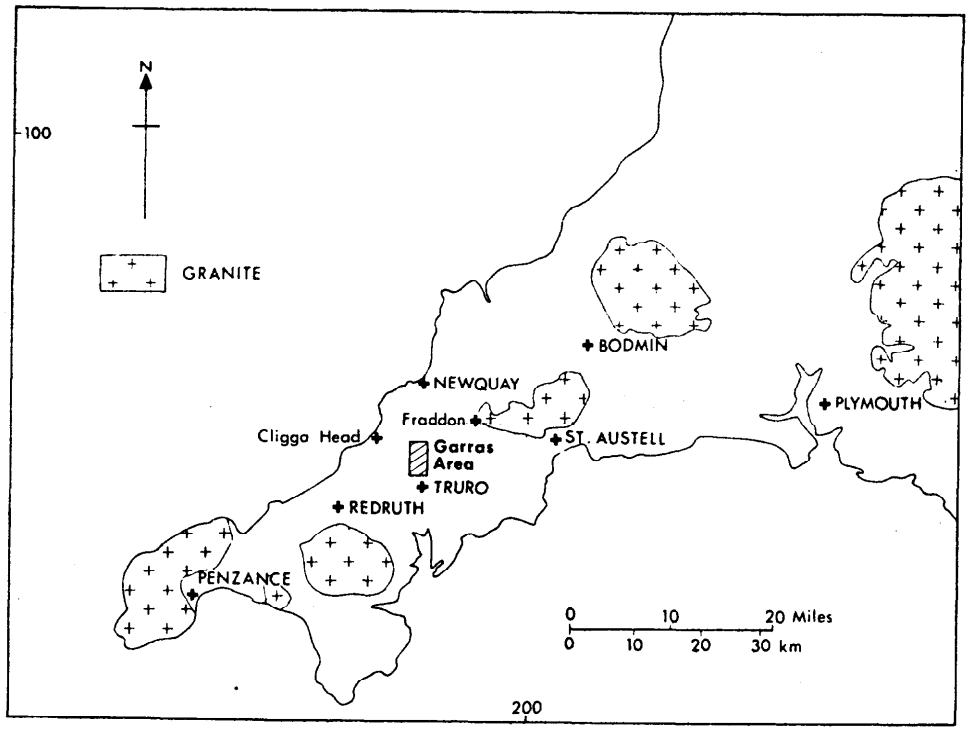

Fig. 1. Map showing location of Garras area, Cornwall

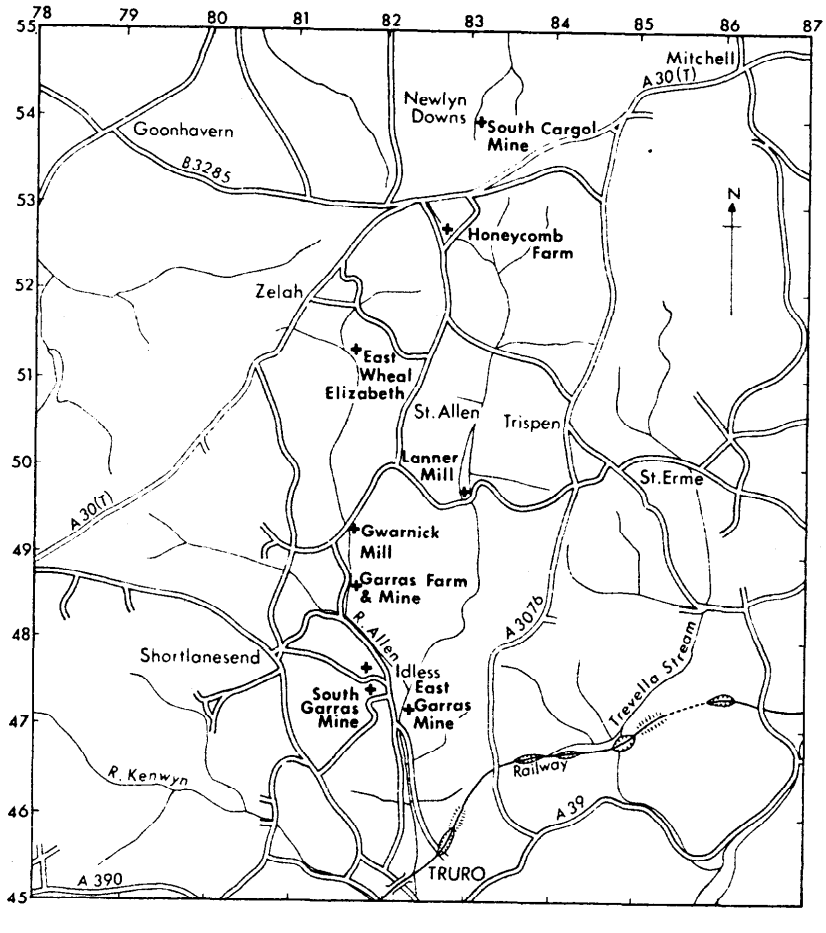

Fig. 2. Localities mentioned in the text

argon dating by Dodson and Rex (1970) indicates that this area was first subjected to intense folding in a Bretonic (end-Devonian) event; these folds are highly recumbent, commonly horizontal, tight or isoclinal and invariably face northwards. They are overprinted by a later Variscan phase of open folding in which the axes plunge gently north-east and axial planes dip at about 50° to the south-east. The most significant of these axes, that of the West Cornwall (or Truro) anticline passes to the south of the Garras region.

Bouguer anomaly maps derived by Bott and others (1958) suggest that batholithic granite, if present below the Garras area, lies at great depth. Its closest approach to surface appears to be as a ridge connection between Fraddon and Cligga, passing just north of Newlyn Downs.

Igneous activity in the area is represented by two types of minor intrusive bodies. To the west of the Garras stream a narrow lamprophyre intrusion runs approximately north-south and dips westwards at about 40°. It is always highly decomposed and was formerly pitted to provide a crude agricultural top dressing, locally known as 'morrow'. Between the pits it can be traced with relative ease by virtue of its radioactivity. Cooper, in an unpublished report (1974), records the following metal contents (in ppm): U 25, Th 120, Cr 420, Co 40, Ni 420, Cu 120, Zn 180, Pb 30, Ba 4000, Zr 1500 and up to 2.4 per cent P_2O_5. In common with other lamprophyres in south-west England this body seems to have no direct bearing upon local ore deposition though it has a similar strike to the lead lodes. Fragments of similar lamprophyric rock are recorded at three localities between the Garras stream and the River Allen, suggesting the possibility of further intrusions in this area.

An elvan dyke outcrops in a roadside corner near Lanner Mill [8306 4958] and was once worked in a small quarry some 900 m further west-south-west. Unfortunately this elvan cannot be traced further west, where it should intersect the Garras lead lode and the lamprophyre.

Former Mining

Some confusion exists as to the naming of mining sites in the Garras area; the nomenclature adopted here accords with Hamilton Jenkin (1964) and appears best to fit the recorded facts and descriptions. Resulting from his incorrect identification of sites, Dines (1956) has introduced additional confusion into his historical accounts of the mines.

The small areas of waste dump near Idless [821 473] mark the former site of South Garras Mine which, according to Hamilton Jenkin (1964), worked from 1853 to 1861. By 1860 the mine was 80 fathoms (146 m) deep working a north-south lode up to 1.8 m wide and locally containing solid galena 0.4 m in width. Dines (1956, p. 506) quotes a total production for the period 1855-1860 of 1960 tonnes of 54 per cent lead ore, 314 750 g of silver and 11 tonnes of pyrite. Provis (1874) states that two grades of ore were produced, one with 75 per cent of lead and 527 g/tonne silver, the other with 29 per cent lead and 721 g/tonne silver, but these figures do not agree with Hunt's Mineral Statistics for 1856 and 1857 which show silver contents of 1900 and 1660 g/tonne respectively. It is interesting to note that from the figures of Provis the poorer grade lead concentrate is richer in silver, suggesting the presence of a second silver-bearing mineral in addition to galena. At abandonment the mine was still producing well from its northern end, though to the south the lode was poorly mineralised.

Trading upon the success of South Garras two small trials started further east in 1855 under the names of East Garras Mine and Polwhele Lead and Silver Mine. Adits were driven at both sites but no production is known to have resulted. It was claimed that here the lodes also coursed north-south. Other small mines were worked for lead in the near vicinity but their location is now uncertain; West Garras lasted only a few weeks in 1858, Wheal Powell (1855-1858) reached at least 14 fathoms (25 m) depth, and Wheal Collins (1859-1861), sunk 40 fathoms (73 m), produced a little ore reputedly containing up to 690 g/tonne silver.

Garras Mine (otherwise Gwarnick), situated close to the Garras Farm [8186 4876] may have been active as an open cut operation in Elizabethan times. It is first recorded in 1720 as having worked 40 years previously at a depth of 15 fathoms (27 m) and yielded 1730 g of silver per tonne of lead from rather bunchy ore in which the galena reached widths of 0.9 m. Reopened in 1814, the mine worked for two years producing 813 tonnes of 65 per cent lead ore with the lead containing 1210 g/tonne silver. The lode, said to run north-north-east, was from 0.6 to 1.8 m wide and heaved 11 m (no direction quoted) at two places by slides, close to which at a depth of 70 fathoms (128 m) the ore was richest in silver. At a later date the mine was reopened only to close in 1851; no records exist of this final working.

From the dumps of both South Garras and Garras Mines it is possible to obtain occasional specimens carrying spotty galena but no large samples were found. Pyrite is abundant and there are traces of arsenopyrite, rare sphalerite, some pyromorphite and occasional anglesite in a gangue essentially of banded or

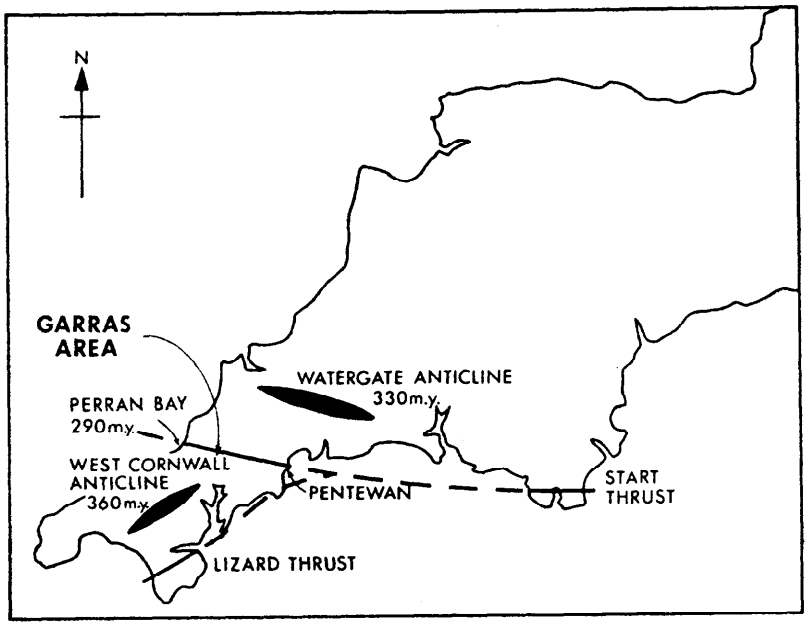

Fig. 3. Structural map of Mid-Cornwall and West Cornwall

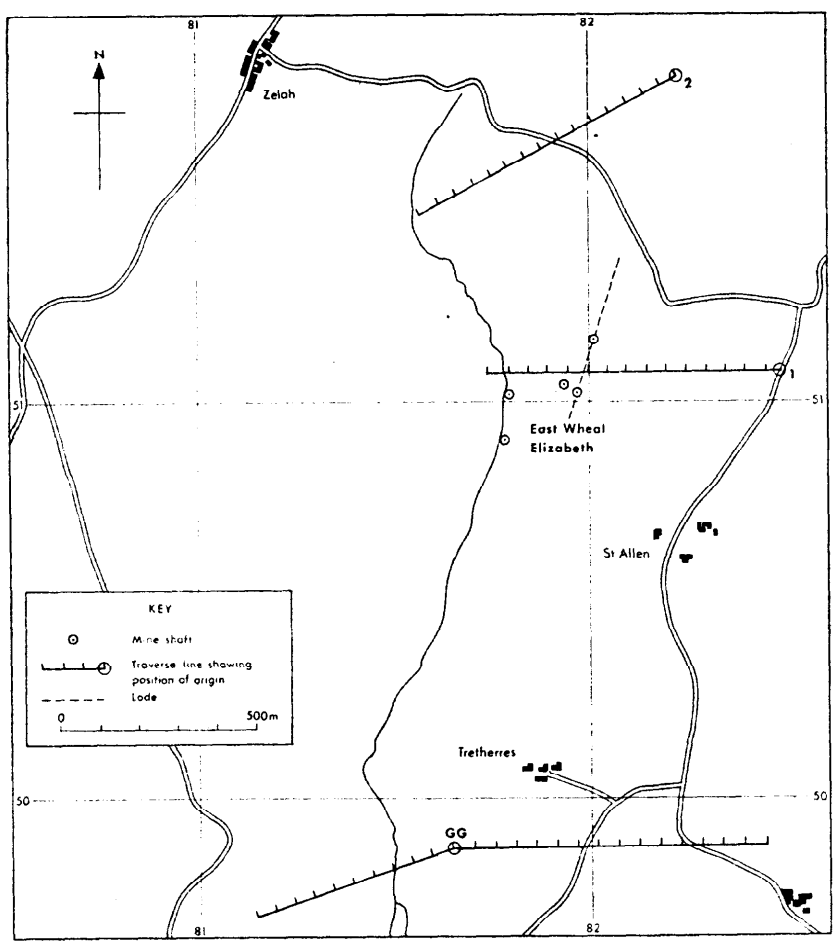

Fig. 4. Geophysical traverse lines near Garras Mine, Cornwall

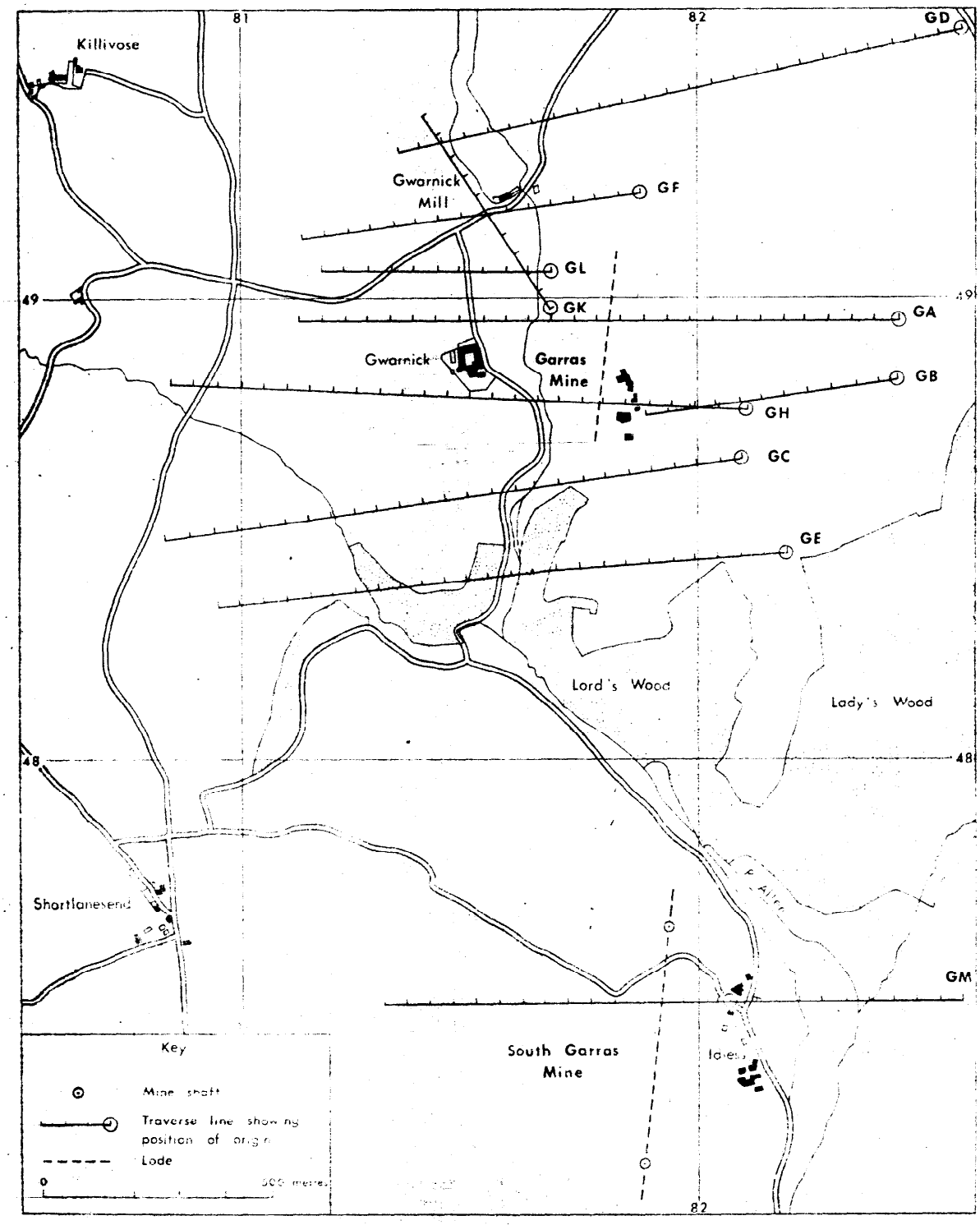

Fig. 4a. Geophysical traverse lines near Garras Mine, Cornwall

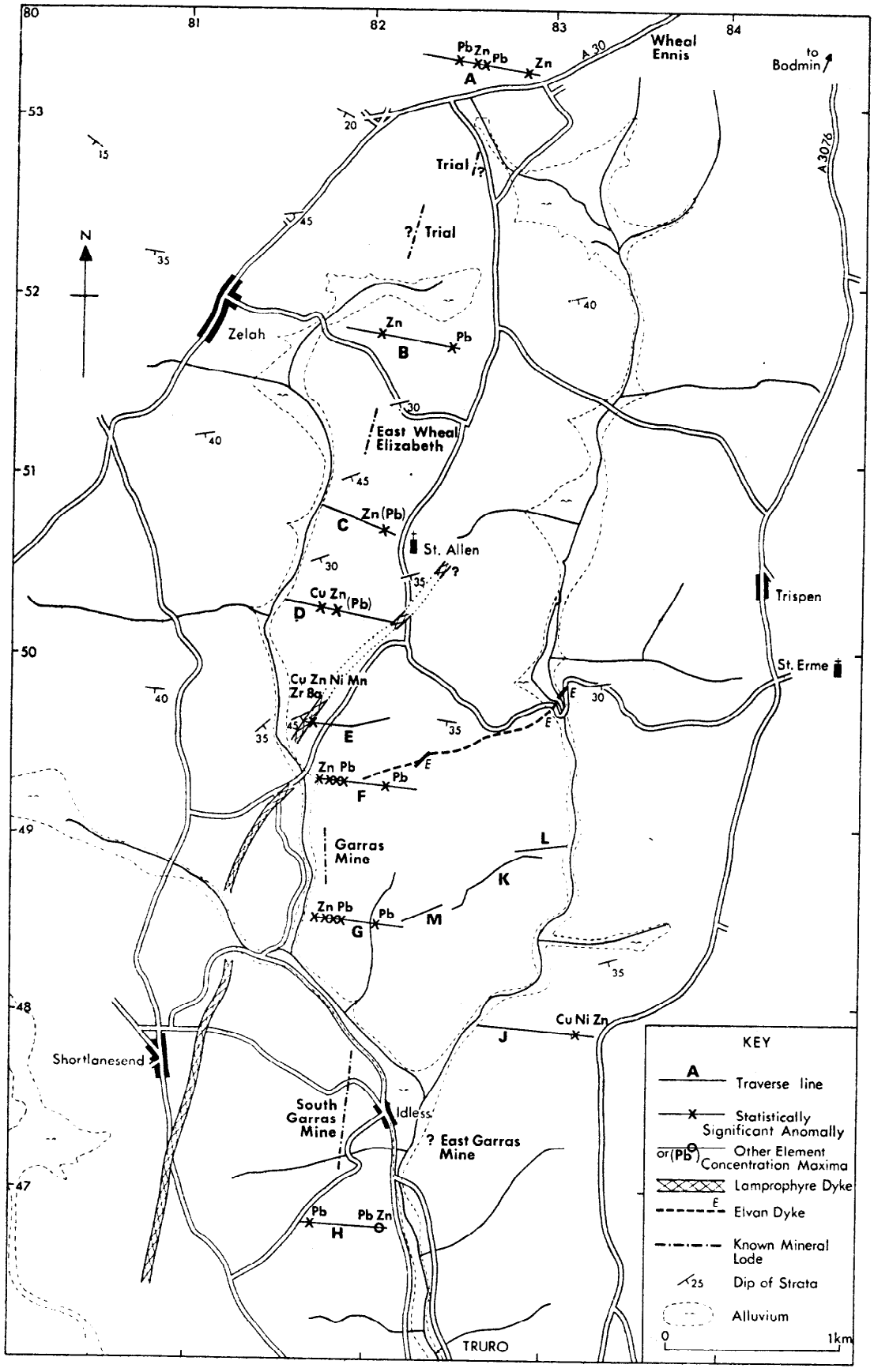

Fig. 5. Garras: geochemical soil anomalies

sugary quartz with occasional carbonates, mainly siderite. A little fluorite has also been noted in the dump material.

Six hundred metres north-north-west of St Allen lie the remains of East Wheal Elizabeth [8200 5115] which is reported to have produced 82 tonnes of copper in 1831. From the value quoted it can be deduced that the ore carried about 9 per cent copper metal. The history of this mine is unknown except that it was working in 1870 under the name of Great Chiverton Consols and was then 40 fathoms (73 m) deep. The dumps are mixed up with later quarry and, despite diligent search, no copper minerals have been found; the only metallic ores seen were pyrite and a little galena.

Three trial shafts are visible near Honeycomb Farm [8260 5272, 8227 5238 and 8222 5221] but there are no records of these workings. There is said to be an adit behind the farmhouse but this could not be located in the stream bank.

In the extreme north of the area two former mines on Newlyn Downs claim to contain extensions of the celebrated East Wheal Rose lead-silver mineralisation within their workings. Wheal Ennis [8354 5336] was active between 1851 and 1854 reaching a depth of 40 fathoms (73 m) in a reputedly rich galena-pyrite lode.

Five other lead lodes were claimed in the sett, but no production is recorded from the property. South Cargoll Mine [8330 5360] was worked at one time, as part of East Rose. Recorded production for the period 1851-1855, when it worked independently, is 437 tonnes of 55 per cent lead ore and 58 800 g silver. Presumably from the same lode system its northern neighbour, Cargoll Mine, produced 14 200 tonnes of 70 per cent lead ore and over 31 million g of silver between 1845 and 1884.

GEOCHEMICAL INVESTIGATIONS

Introduction

Two basic methods of investigation were adopted. First, a primary stream sample survey was carried out over a wide area, covering the catchments of the River Allen and neighbouring drainage. This survey has been merged with other similar work in Devon and mid-Cornwall, which is to be considered as a whole at a later date. The second method employed was the collection of soil samples at 25 m intervals along nine traverse lines aligned east-west (perpendicular to the postulated structures). Subsequently another three soil traverses were made covering the ground to the east of Garras Farm. Samples were collected with a 1 inch diameter soil auger from a depth of about 1 m. About 100 g of minerallic (B/C) horizon material was collected, and was dried. The work was carried out under the supervision of Mr. C. B. Campbell in 1973 and Dr T. K. Ball in 1974. The samples were collected by one of the authors (RCJ) assisted by Mr S. C. Lambert and a party of voluntary workers.

Sample Preparation and Analysis

The samples were dried in their bags at the Institute's Exeter office, and were delivered to the Institute's Gray's Inn Road office for preparation and analysis. The samples were sieved to pass 60 mesh, and were ground to about 200 mesh. Subsamples were taken for analysis by the following methods for the following elements: delayed neutron analysis for uranium; atomic absorption spectrophotometry for copper, lead, zinc and silver; optical emission spectrography for manganese, iron, cobalt, nickel, yttrium, zirconium and barium.

Analytical Results

The results for the first nine traverse lines, comprising 224 samples, were received during 1974. Substantial variation was noted in the concentrations of copper, lead, zinc, manganese, nickel and barium (see Figs. 6 and 7). For each of these elements a log concentration vs. probability diagram was constructed. Barium and zinc were observed to constitute single log-normal populations. The other elements showed two populations with the smaller one containing the higher concentrations. Inflection points in the log x probability plots were found at 45 ppm (96 per cent) for copper, 85 ppm (92 per cent) for lead, 65 ppm (91 per cent) for nickel, and 1100 ppm (75 per cent) for manganese.

Interpretation of Results

In comparison with other areas in south-west England none of the anomalies can be regarded as being of a very high order. However some importance can be attached to anomalies of copper and lead since they are spatially related to postulated extensions of known structures.

High copper, zinc, nickel, manganese, zirconium, and barium values at the western end of line E are considered to be due to the proximity of the lamprophyre.

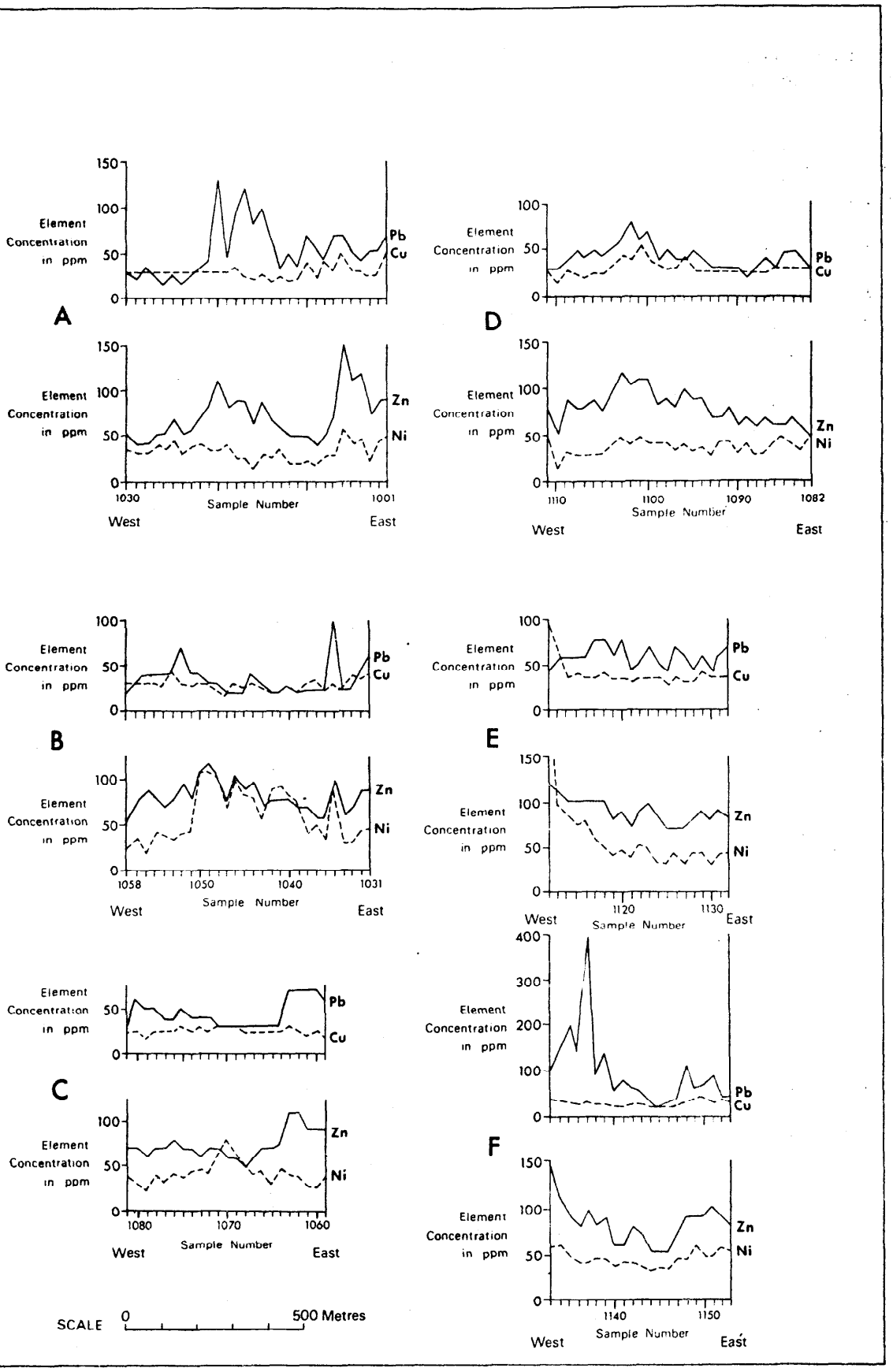

Fig. 6. Cu, Pb, Zn and Ni concentrates in soil sample traverses in the vicinity of the Garras Mine

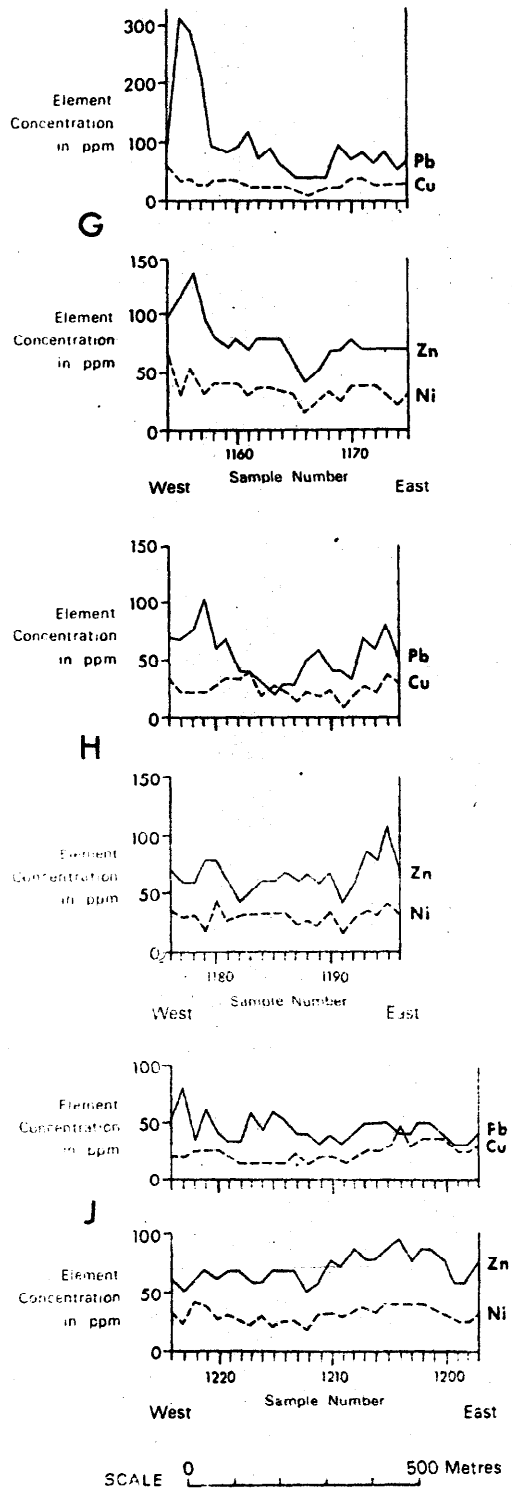

Fig. 7. Cu, Pb, Zn and Ni concentrates in soil sample traverses in the vicinity of the Garras Mine

On line J anomalous concentrations of copper, nickel and zinc have been noted in one sample. Though the geochemical data are not conclusive it is possible that the line intersects either a small unknown lamprophyre or a nickel-bearing vein at that point. The element assemblage would be most unusual if it were caused by any type of vein mineralisation common in Cornwall, since it is associated with a zirconium anomaly.

Line A exhibits a zone of 120 m in width in which there are three lead anomalies associated with an increase in the zinc concentration. Insufficient is known to link this with lodes within the South Cargoll sett, but from the geographic position there is little likelihood of the land having been contaminated from the waste material of that mine. At the eastern end of the line there is a 50 m wide zinc anomaly (maximum 150 ppm) which corresponds with increases in the concentrations of copper and lead to 50 ppm and 70 ppm respectively. The significance of this anomaly is obscure.

Line B contains a broad rise in the zinc concentration to 120 ppm which is aligned with two trial shafts 600 m to the north and the major lead anomaly on line A. There is also a single sample containing 100 ppm lead and 100 ppm zinc, which lies on a line between the trial shaft at Honeycomb Farm and a zinc anomaly (with an accompanying lead maximum) on line C (in 2 samples) 100 m west of St Allen Church. The above line C anomaly, the only one on the line, is 25 m wide, and contains 110 ppm zinc and 70 ppm lead.

Line D contains an anomaly 50 m wide (maximum concentrations 55 ppm copper, 80 ppm lead, 120 ppm zinc) which lies on the southward projection of the East Wheal Elizabeth lode, though that structure has not been detected on the intervening line C.

Lines F and G lie north and south of Garras Mine, and clearly show the position of the lead lode. Hill creep has probably broadened the anomalous zone on line F. Two-hundred and fifty metres east of the mine there is a relatively small weak anomaly, of a similar size to those in lines A to D, which may represent a small structure parallel to the main lode.

Line H contains two anomalies, neither of which lie on the supposed southward projection of the South Garras Lode. One contains 110 ppm lead and 80 ppm zinc, the other contains 80 ppm lead and 110 ppm zinc, and both are difficult to relate to known structures.

GEOPHYSICAL INVESTIGATIONS

Introduction

The survey was carried out in June and July 1974 under the supervision of one of the authors (JMCT) assisted by Mr K. E. Rollin.

The area presented problems in the siting of the traverse lines due to the presence of standing crops and patches of dense scrub land. Work in the vicinity of Gwarnick Mill was obstructed by difficulties in obtaining land access. The position of the traverse lines are shown in Fig. 4.

Interference from electric power lines was experienced but could normally be recognised or eliminated by using a higher transmitter current.

Geophysical Instrumentation and Methods

Geophysical measurements were made using the time-domain induced polarisation method with a dipole-dipole array of dipole length 50 m. The Huntec Mk III receiver used in this survey records apparent resistivity and also four m (chargeability) values sampled at 105, 195, 375 and 735 ms after switch-off. A weighted sum, Mc (= $m_1 + 2m_2 + 4m_3 + 8m_4$) gives a better measure of mineral content than any individual m value. Results are normally plotted as 'pseudo-sections' (Figs. 8 and 9) which may be taken as somewhat distorted electrical cross-sections beneath the traverse line.

In these surveys the transmitted current cycle was 2s on and 2s off, followed by the same with reversed polarity. A Huntec LOPO Mk III transmitter was used with metal stake electrodes; the current was generally of the order of 200 mA. Occasionally a Huntec Mk I transmitter was used giving a current about ten times greater.

The presence of electrically conductive mineralisation is indicated by high chargeability and sometimes low resistivity. In the present survey it is considered that in a mineral prospecting context Mc values greater than 50 (arbitrary units) are probably significant and values greater than 100 very significant when compared with traverses over known lodes elsewhere in south-west England. Variations in chargeability above the background reflect differences in mineral concentration, average particle size or proximity to a dipole. Clay

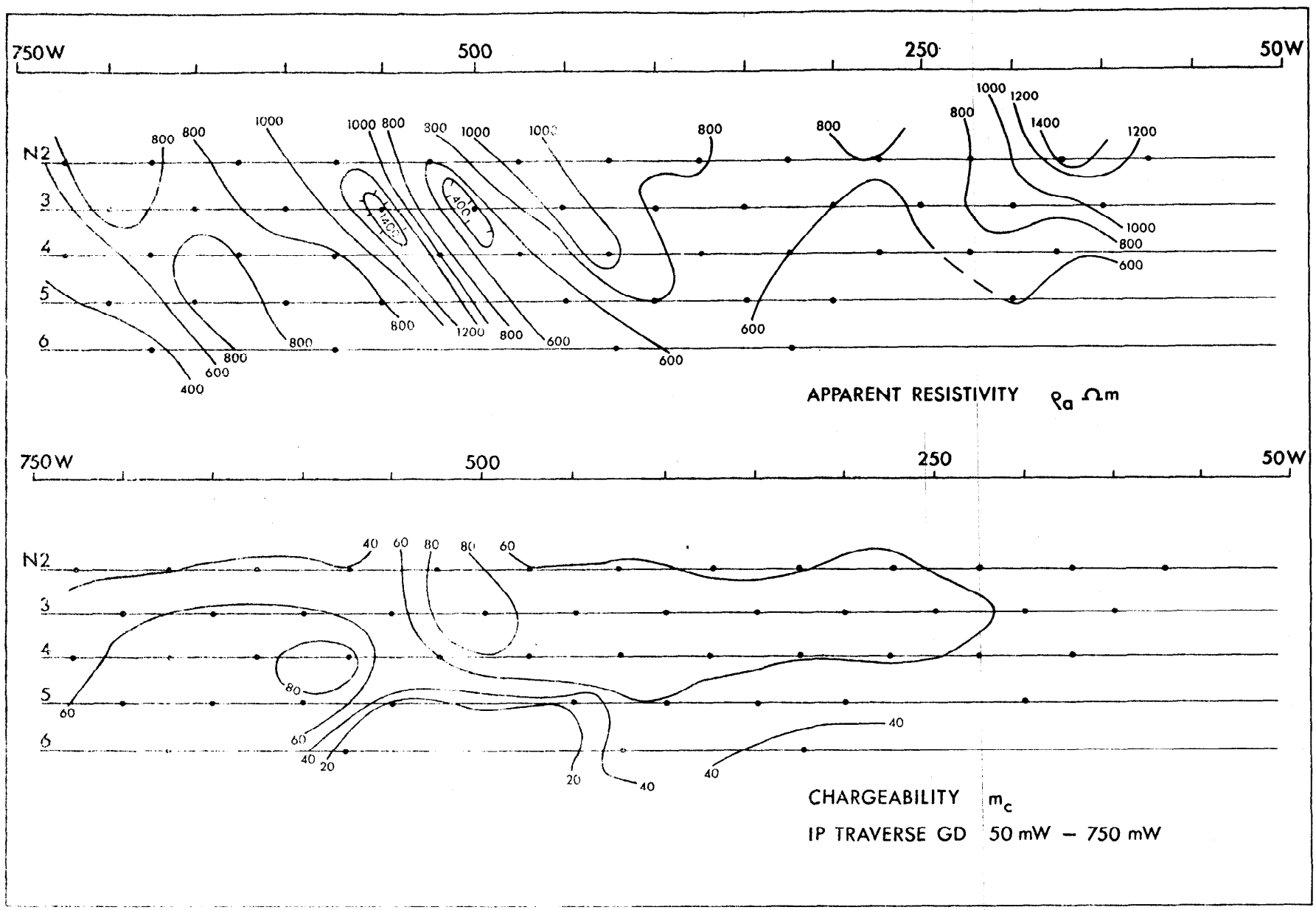

Fig. 8. Apparent resistivity and chargeability along geophysical traverse line GD

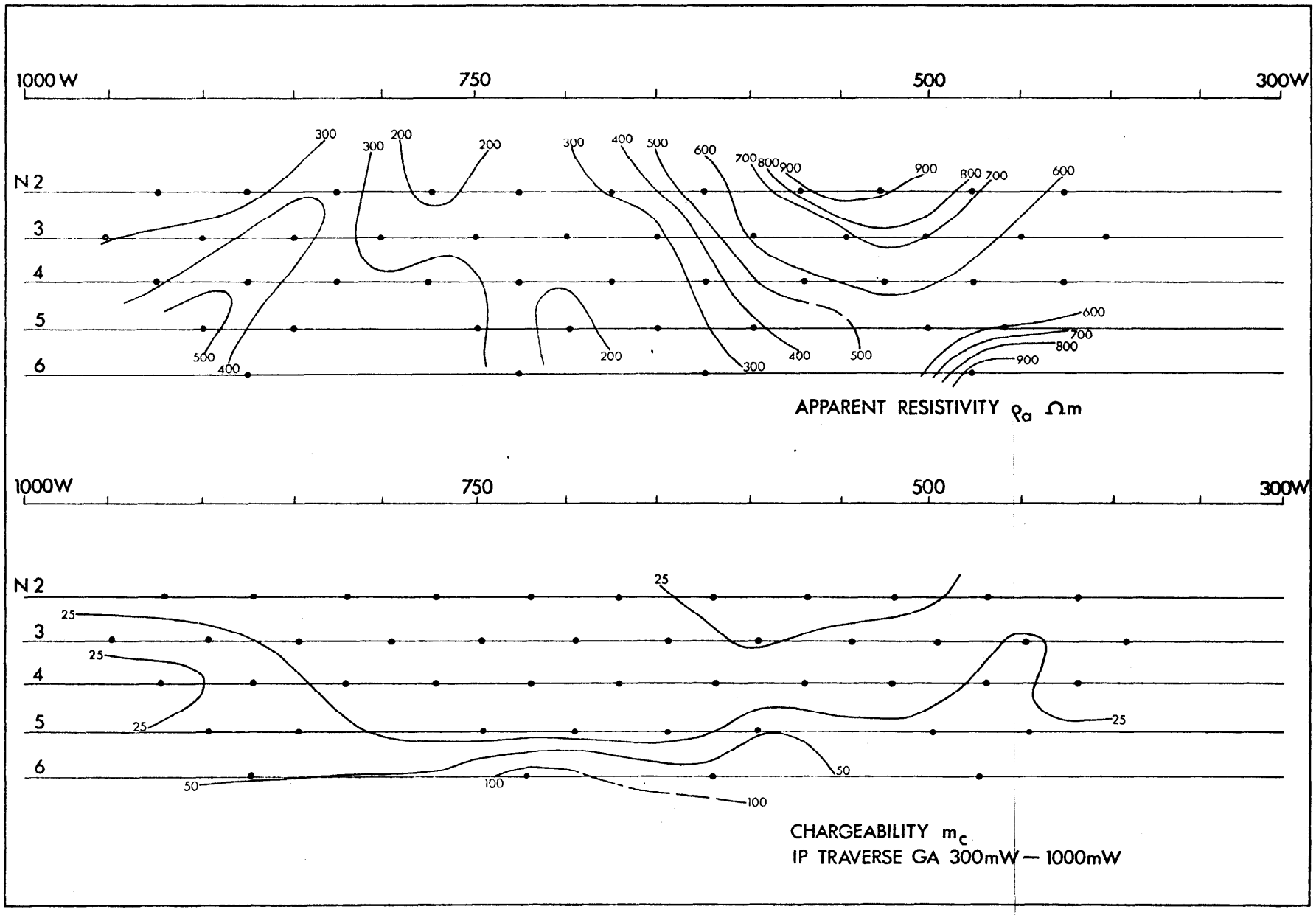

Fig. 9. Apparent resistivity and chargeability along geophysical traverse line GA

minerals can cause an IP effect of a somewhat lower order than that due to mineralisation and by a different mechanism.

Results and their Interpretation

Lines 1 and 2 did not give rise to any anomalies even in close proximity to the dumps of East Wheal Elizabeth. The only anomaly on line GG occurs at about 100 W and is based on only one receiver position; considering the lack of repeatability the anomalous values of Mc seem spurious. Resistivity values are not anomalous.

Line GD (Fig. 8). The broad zone of anamalous chargeability extending from 150 W to 700 W corresponds with a zone of above background gamma radioactivity which may indicate that the cause is a bed of argillaceous rocks amongst siltier sediments. Such argillites do contain disseminated sulphides in certain areas, though there is no evidence to suggest that this is the case at Garras. An alternative interpretation that the anomaly is due to mineralisation (other than of pyrite) cannot be favoured in the light of the geochemical results.

Line GF. Anomalies on this line were found to be due to the Gwarnick Mill lamprophyre quarry and its partial infilling with refuse, as well as some power line interference.

Lines GK, GL. There were no genuine anomalies on these lines.

Line GA. (Fig. 9). There is a zone of chargeability of about 100 units against a background of 25 units which occurs near 725 W at a depth of 150 m. A resistivity minimum (200 Ωm) coincides with this, though it may be influenced by topography. Negative Mc values above this maximum are difficult to explain but may be an interference effect. Since the anomaly corresponds with the northward continuation of the lead lode at Garras Mine it is assumed that it is the cause of the anomaly. It is of interest to note that the centre of the anomalous zone is at about 150 m depth which is a little below the bottom of the Garras Mine workings; however the depth resolution of this technique is not sufficient to assess the significance of this.

Line GH. An anomaly of doubtful significance occurs at 350 W; however it is so close to the lead lode that it is possibly genuine.

Line GC. A small chargeability anomaly at depth at 900 W on this line lies close to a suspected fault, which displaces the lamprophyre nearby. Though the fault is unlikely to cause this effect a substantial development of clay gouge or minor mineralisation of the structure may produce the anomaly. There is no known mineralised structure in the vicinity. Resistivity values are not anomalous.

Lines GB, GE and GM. There are no significant anomalies on these lines.

CONCLUSIONS

Consideration of the available geological, geophysical and geochemical data and the distribution of anomalies leads to the conclusion that the formerly mined structures are impersistent along their strikes at or near surface, and patchy in their mineralisation. Elsewhere new anomalous areas are of very restricted extent. Since the recognition of faulting in the area is so difficult one cannot tell whether the structures are displaced laterally. Similar displacements of the lamprophyre near Garras and South Garras Mines suggest that these mines are on the same structure. The lamprophyre outcrop also suggests the possibility of a sinistral tear fault aligned along the Allen valley in the vicinity of Gwarnick Mill [8165 4925], but the anomaly on line F lies along the line of the Garras lode, which is incompatible with the presence of such a fault.

The negative indications obtained in the course of the geochemical and geophysical investigations described above are disappointing and can perhaps best be explained by a limited vertical, rather than horizontal, extension of the ore bodies originally worked, as at Garras Mine. Other workings, such as East Wheal Elizabeth, seem to give virtually no geophysical indication of the lode in spite of the existence of fairly extensive dumps.

The geophysical evidence has only shown with any certainty the known lode at Garras Mine. This implies that it is the largest mineralised structure present, which also is supported by the geochemical results. Alternative interpretations have been given for the anomalies on lines GC and GD elsewhere in this report.

It would seem unlikely that there is any mineralised structure of economic proportions contained within the ground which has been examined or beneath it to a depth of 150 m.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to Mr K.E. Beer who revised and amended the sections of this report on Geology and Mining History, and to Dr T.K. Ball and Mr C.B. Campbell who have provided some guidance and criticism of the work to the authors.

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