Natural Environment Research Council

Institute of Geological Sciences

Mineral Reconnaissance Programme Report

A report prepared for the Department of Industry

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 The information contained herein must not be published without reference to the Director, Institute of Geological Sciences

D. Ostle
Programme Manager
Institute of Geological Sciences
154 Clerkenwell Road
London EC1R 5DU

No. 15

Investigation of stratiform sulphide mineralisation at Meall Mor, South Knapdale, Argyll

INSTITUTE OF GEOLOGICAL SCIENCES

Natural Environment Research Council

Mineral Reconnaissance Programme

Report No. 15

Investigation of stratiform sulphide mineralisation at Meall Mor, South Knapdale, Argyll

Geology

C. G. Smith, BSc, PhD

W. G. McCourt, BSc

Mineralogy

N. J. Fortey, BSc

Geophysics

C. E. Johnson, BSc, MSc

M. E. Parker, BSc

Geochemistry

J. S. Coats, BSc, PhD

U. McL.Michie, BSc

A Report prepared for the Department of Industry

Mineral Reconnaissance Programme Reports

1. The concealed granite roof in south-west Cornwall
2. Geochemical and geophysical investigations around Garras Mine, near Truro, Cornwall
3. Molybdenite mineralisation in Precambrian rocks near Lairg, Scotland
4. Investigation of copper mineralisation at Vidlin, Shetland
5. Preliminary mineral reconnaissance of Central Wales
6. Report on geophysical surveys at Struy, Inverness-shire
7. Investigation of tungsten and other mineralisation associated with the Skiddaw Granite near Carrock Mine, Cumbria
8. Investigation of stratiform sulphide mineralisation in parts of central Perthshire
9. Investigation of disseminated copper mineralisation near Kimelford, Argyllshire, Scotland
10. Geophysical surveys around Talnotry mine, Kirkcudbrightshire, Scotland
11. A study of the space form of the Cornubian granite batholith and its application to detailed gravity surveys in Cornwall
12. Mineral investigations in the Teign Valley, Devon. Part 1—Barytes
13. Investigation of stratiform sulphide mineralisation at McPhun's Cairn, Argyllshire
14. Mineral investigations at Woodhall and Longlands in north Cumbria
15. Investigation of stratiform sulphide mineralisation at Meall Mor, South Knapdale, Argyllshire

Edinburgh 1978

The Institute of Geological Sciences was formed by the incorporation of the Geological Survey of Great Britain and the Geological Museum with Overseas Geological Surveys and is a constituent body of the Natural Environment Research Council

Bibliographical reference
Smith, C. G. and others. 1978. Investigation of stratiform sulphide mineralisation at Meall Mor, South Knapdale, Argyll.
Miner. Reconnaissance Programme Rep. Inst. Geol. Sci., No.15

Photocopied in England for the Institute of Geological Sciences by Museum Print and Design

CONTENTS

ILLUSTRATIONS

*Figures in envelope

Summary

A co-ordinated geochemical-geophysical-geological investigation of copper mineralisation in the Meall Mór area, South Knapdale, Argyll was carried out in 1976 and followed by a drilling programme of 3 shallow holes in early 1977. The mineralisation occurs in a zone of weak stratiform sulphide mineralisation (the pyrite zone) with a strike length of 10km in the Upper Erins Quartzite of the Middle Dalradian.

The geochemical drainage survey showed the existence of a strongly anomalous distribution of Cu and Sb in the Abhainn Srathain draining south from Meall Mór and detailed soil sampling over the pyrite zone outlined a broad area enriched in copper. Deeper soil sampling confirmed the anomalously high copper values and a coincident IP anomaly was found stretching from Meall Mór south to the old mine workings on Abhainn Srathain, and is probably caused by a local enrichment of pyrite and chalcopyrite within the pyrite zone.

Three boreholes were drilled; two on coincident geochemical and geophysical anomalies, and the third beneath the old mines at Abhainn Srathain. Copper values in the first two holes range up to 0.24% Cu over 4.27m, but up to 1.06% Cu over 2.67m in the third and this enrichment may be related to a later remobilisation of the disseminated chalcopyrite. The results of subsequent drilling at two other sites are given in Appendix III.

INTRODUCTION

Background

The existence of base-metal concentrations of economic proportions in the south-west highlands of Scotland was known prior to the 16th century, though mining activity apparently did not reach its zenith until the 19th century. These deposits are mostly contained "in a belt of highly mineralised country which stretches from Islay to beyond Loch Tay" (Wilson, 1921) with the greatest concentration being in the Loch Fyne area. The majority of the mineralised occurrences in the Loch Fyne area are vein type (Fig. 1); only a few were positively identified as being stratiform, though it is possible that many of the so called "replacement deposits" are of this type.

A number of sulphide occurrences in South Knapdale extend 5 km or so north-east and south-west of Meall Mór. Most comprise iron and copper, but significant amounts of lead with some gold and silver are also present. Where the northerly extension of this zone reaches the west coast of Loch Fyne an extensive development of pyritiferous schist is exposed which may be related to similar rocks (Smith and others, 1977b) at Creggan's Point (Fig. 1), though presently accepted lithostratigraphic correlations between the two areas (Harris and Pitcher, 1975) suggest they may have slightly differing ages. If the two horizons are correlated, the the mineralised zone in South Knapdale represents a southerly extension of a zone of weak stratiform sulphide mineralisation which has considerable lateral extent in the Middle Dalradian of central Perthshire (Smith and others, 1977a). Hereafter this will simply be referred to as "the pyrite zone".

An exploratory geochemical drainage survey, which was carried out in 1975 and 1976, and preliminary field investigation by one of the authors (U McL.M) suggested that the apparently isolated stratiform sulphide occurrences in South Knapdale lie within a definite horizon of copper enrichment. The additional presence of copper, lead and zinc vein deposits (including the auriferous Stronchullin mine) suggests that, in general, South Knapdale is enriched in base metal sulphides.

<u>Location and geographical setting</u>

Bounded by the Sound of Jura, West Loch Tarbert and Lochs Fyne and Coalisport, South Knapdale is the roughly oval shaped area which lies at the head of the Kintyre peninsula. The area under investigation comprises approximately

20 km^2 of South Knapdale (Fig. 1) midway between Tarbert and Lochgilphead and 60 km due west of Glasgow. The nearest railhead, Oban, is 70 km away by road. Port facilities for vessels of limited draught are available at Tarbert and Ardrishaig.

From the western shore of Loch Fyne the ground rises by way of a pronounced convex slope to the broad ridge which runs south-south-west from Meall Dubh (Fig. 2) to the plateau summit of Meall Mór (335 m), the second highest point in South Knapdale. This is the easternmost of a series of parallel ridges which dominate the scenery of Knapdale and whose orientation reflects the grain of the underlying rocks.

Drainage in the eastern part of the area is to the east, whereas streams emanating in the west flow initially south-south-west or north-north-east before draining into the easterly flowing streams, a situation resulting from river capture by the more active easterly flowing streams. In a few cases the streams follow fault zones on basic dykes which, presumably, were more easily eroded than the adjacent Erins Quartzite.

Most of the water courses provide an almost complete geological section. Elsewhere exposure is quite patchy ranging from almost complete on the summit of Meall Mor to nearly nil in the largely drift-covered Abhainn Strathain and upper Artilligan Burn valleys.

The area is largely utilised for sheep farming. A narrow strip of mature woodland persists along the length of the lower coastal slopes, and, since 1961, the Forestry Commission has planted extensively in the Abhainn Srathain valley as far west as the old mines where, significantly, tree growth is frequently stunted. The population of the area is small, all permanent habitation being confined to the coastal strip, which is served by the A83 Glasgow-Campbeltown trunk road. The television transmitting station on the summit of Meall Mór is, in part, served by a forestry track, at present being extended and improved, from Meall Mhor House.

General geology

South Knapdale is underlain almost exclusively by rocks of the Dalradian supergroup (Harris and Pitcher, 1975) which are described in the memoir to 1-inch sheets 28 and 29 (Peach and others, 1911). These consist mainly of Lower Cambrian sedimentary rocks which were probably deposited in a north-easterly trending sedimentary trough (Knill, 1959, 1963). Prior to polyphase deformation and greenschist facies metamorphism during the Caledonian orogeny, they were intruded by an extensive suite of gabbroic and doleritic sills. The whole assemblage has a persistent north-north-easterly trend and lies on the inverted south-east limits of the Ardrishaig Anticline, which forms the root zone of a major recumbent fold, the Tay Nappe (Johnstone, 1966; Roberts, 1974). A limited number of post-Caledonian dykes are present; most are probably related to the Mull Tertiary centre, but one is a Permo-Carboniferous quartz-dolerite.

Although most of the stratiform copper showings in the eastern part of South Knapdale were too small to attract the early miners, no fewer than 10 trials and abandoned workings have been noted within an area of 0.15 km^2 in the Abhainn Srathain, 1-2 km south of Meall Mór. Few mining records exist, particularly regarding operational dates and tonnage, but it has been suggested that the absence of any definite lodes and the excessive cost of mule packing the ore soon rendered the mines unremunerative (Peach and others, 1911). The limited size of the excavations would seem to indicate that the vein deposits were equally unproductive and even the accidental discovery of anomalously high gold values (550 ppm) failed to revitalise the Stronchullin mine.

SCOPE OF THE PRESENT SURVEY

The investigation described in this report is, in effect, a follow up to the regional geochemical drainage survey, employing geological, geophysical and more detailed geochemical techniques. Details of the geochemical survey relevant to this area are also included, but the results of the regional survey will be presented in a separate report.

The principal aims of the survey were:

a. to assess the economic potential of the area.

b. to investigate the relationship between the stratiform sulphide occurrences and the possible southerly continuation of the Middle Dalradian pyrite zone.

c. to study the sulphide and silicate paragenesis in an attempt to elucidate the ore genesis.

Geological mapping on a scale of 1:10 560 was undertaken between September 1976 and April 1977. In the area of the Abhainn Srathain mines a scale of 1:2 500 was utilised. Geophysical measurements of induced polarisation (IP) effect, resistivity and total magnetic field were carried out in June and October 1976. Subsequent to the geochemical drainage surveys of 1975 and 1976, soil and rock samples were collected, and a more detailed drainage survey of Abhainn Srathain was carried out.

Three inclined boreholes were sunk between December 1976 and March 1977, using the IGS Winkie drill. BH1 and BH2 were to investigate coincidental IP and copper in soil anomalies. BH3 was sited amongst the old workings in the Abhainn Srathain mine complex and, in addition to evaluating the richest copper showing, it was intended to provide information on the relationship between the sulphide mineralisation and the metabasic rocks. After geological examination, the drill core was split and one half was prepared for chemical analysis. Selected specimens from the remainder, together with rock samples were submitted for mineralogical examination. Finally, downhole measurements of IP effect, resistivity and selfpotential (SP) were made on BH1 and BH2.

GEOLOGY

The Middle Dalradian metasedimentary rocks of the Meall Mór area belong to 3 lithostratigraphical units, which in ascending stratigraphical order are Lower Erins Quartzite (not investigated) Stronchullin Phyllite and Upper Erins Quartzite. The Stronchullin Phyllite is correlated with the St. Catherine's Graphitic Schist (Roberts, 1966, 1974) in the succession of Northern Loch Fyne and the Lower and Upper Erins Quartzites are considered to represent lateral facies variations in the Ardrishaig Phyllite and Ben Lui Schist Formations. However, if these correlations are accepted, then the zone of pyritous schists in the Upper Erins Quartzite of the Meall Mór area cannot be the south-westerly extension of the Middle Dalradian pyrite zone, since the latter lies within the Ardrishaig Phyllite (or its northern equivalent). However, as discussed below, the separation of the three formations is not clear cut and latitude exists in definite correlations coupled to a facies variation to more arenaceous sedimentation in the south west.

Stronchullin Phyllite

The Stronchullin Phyllite marks the western limit of the area mapped in the course of this survey. Since the majority of the mineralised occurrences lie within the Upper Erins Quartzite, the Stronchullin Phyllite was not studied in detail.

North of a line joining the summits of Meall Beag and Meall Mór the formation appears to comprise interbedded quartzite, quartzose schist, phyllite (occasionally calcareous) and black graphitic schist. The latter occurs principally in the Stronchullin and Artilligan Burns and in the stream north-east of Meall Beag, where it contains quartzite bands. South of this, the only exposure visited was in the headwaters of Abhainn Srathain north-north-west of Cruach nan Cuilean. There the formation is dominantly psammitic with quartz-schist, siliceous schist and bands of massive quartzite, and were it not for the additional presence of black graphitic schist the assemblage would be difficult to distinguish from the Erins Quartzite. Indeed, as phyllitic bands occur sporadically throughout the Erins Quartzite (and are of considerable thickness south of the area mapped) the identification of the Stronchullin Phyllite as a separate stratigraphic unit would appear to be heavily dependent on the presence of graphitic schist and since the graphitic schist is only locally developed its validity as a stratigraphic unit is questionable. Peach and others (1911) also had certain reservations about its existence considering it to be merely a "portion of the Ardrishaig Phyllite and of subordinate importance".

Upper Erins Quartzite

The Upper Erins Quartzite, despite its name, probably contains less than 40% of true quartzite in the Meall Mór area. Though within the formation there is a complete gradation from orthoquartzite to mica-schist (phyllite), it is dominantly psammitic, with quartz-schist and siliceous schist being the most commonly encountered rock types.

Quartzite is locally important, forming bands several tens of metres in thickness, which in places have considerable lateral persistence. It is mostly pale grey or white, but a pistachio green variety occurs locally where epidote is present in quantity. Devoid of micas, the quartzite is quite a massive rock with no visible macroscopic bedding. Gritty bands are occasionally seen with clasts, predominantly of white quartz, up to 4 mm across. Where micas are present they form small wisps or, more commonly, partings and stripes, which mostly parallel the large-scale bedding.

In addition to quartz, the quartzites and quartz-schists contain in varying amounts, albite, orthoclase (and/or) microcline, muscovite, biotite, chlorite, garnet, carbonate, epidote and magnetite (locally porphyroblastic) with accessory zircon, apatite and sphene. The additional presence of hornblende was noted in one rock.

The pelitic units range in thickness from 10 cm to several metres, though zones of interbanded pelite and psammite are more commonly developed than the larger pelites. They typically comprise a fine alternation of quartzite, compositionally comparable with the larger units but, in places hematite-stained, and chlorite-schist with minor biotite, epidote, calcite, sphene, zircon and rare garnet. Biotite forms porphyroblasts, in both psammitic and pelitic units, providing evidence of post-tectonic growth, presumably at the expense of chlorite.

Brownish-weathered meta-limestone bands were noted on the south-eastern shoulder of Meall Mór and in the Artilligan Burn. Fragments of a similar rock were noted in one of the spoil heaps at the Abhainn Srathain mines. On Meall Mór the band which is folded ranges from 2-4 m in thickness but cannot be traced along strike for more than 5-6 m. In the Artilligan Burn the band does not exceed 2 m in thickness and, though it can be traced for 150 m along the stream bed, no further exposures were recorded. To the east, it passes into a dolomitic schist comprising muscovite (30%), dolomite (c. 30%), chlorite and quartz with pyrite and traces of pyrrhotite. It is probable that these limestones only developed locally, but, as the three occurrences are approximately at the same horizon, tectonic disruption of an originally continuous horizon cannot be entirely ruled out.

Epidiorites

The metasedimentary rocks of South Knapdale contain a considerable volume of amphibolite which is considered to be metamorphosed basic igneous rock. The bulk of these bodies are, in fact, metamorphosed basic sills, belonging to a group widely known in the Middle and Upper Dalradian of the South-West Highlands as epidiorites (Wiseman, 1934; Mercy, 1965) and probably form part of an extensive feeder system for the Upper Dalradian Tayvallich lavas. However, the existence, in the Meall Mór area of hornblende-bearing quartzite and of probable Middle Dalradian metavolcanic horizons in central Perthshire (Elles, 1926; Smith and others, 1977a; Sturt, 1961) suggests the possible presence of contemporaneous magmatism.

These epidiorites occur as tabular bodies ranging in thickness from 0.5 to 250 m, which, though mostly concordant, on occasion display a cross-cutting relationship. Unbroken bodies seldom exceed 1 km in length, but disrupted remnants of once continuous units can be traced for many kilometres along strike. Most comprise a medium to fine grained dark green hornblendic rock which, more often than not, has a well-developed schistosity. Porphyroblasts of biotite, pale pink garnet and (rarely) magnetite are present. Plagioclase (andesine) was absent from all but one of the sliced rocks, its place presumably being taken by epidote, calcite, chlorite and quartz. In places hornblende has been replaced by chlorite.

<u>Epidotisation</u>

The presence of epidote in the Dalradian rocks of the Meall Mór area is restricted to a zone 250 m wide, which extends along strike 400 m north-north-east and 1300 m south-south-west of Abhainn Srathain mine and, incidentally, coincides with the maximum abundance of copper occurrences (p.15). Within this zone the distribution of epidote is quite patchy, with certain horizons notably enriched. It appears to have developed preferentially in the psammitic units and is particularly noticeable in the finely interbanded rocks, where the bright green contrasts markedly with the dark green chloritic material. The only recorded epidotised epidiorite in the Meall Mór area forms the central feature of the Abhainn Srathain mine complex and is well documented in the log of BH3 (Appendix I). It will be noted that, even here, the distribution is far from universal with both enriched bands and irregular blotches common.

In thin section, the epidote-rich rock is seen to contain, in addition, pale green hornblende, garnet and dark green hornblende.

Although relatively rare in the Meall Mór area, epidotic lenses and bands occur commonly in the epidiorites and related extrusive rocks of the South-West Scottish Highlands (Graham, 1976). The close spatial association with chalcopyrite in this area suggests some genetic relationship between the two minerals. Unfortunately, it has not yet been possible to determine whether the larger concentrations are the result of local remobilisation or of epigenetic introduction. Work on this aspect of the investigation is continuing.

Structures

Examples of undisputed sedimentary structures are quite rare in the Meall Mór area, but, where present, would seen to confirm that the succession is inverted. Most of the metamorphic rocks possess a fabric which ranges from a simple mineral alignment in the epidiorites to a penetrative schistosity in the more micaceous metasedimentary rocks. In the metasedimentary rocks the schistosity is generally parallel to the bedding.

Amongst the minor folds in the Upper Erins Quartzite two differing styles were noted, probably reflecting separate deformational episodes. Those of the earlier episode are relatively uncommon and comprise isoclines which fold the schistosity. In many cases it was impossible to measure the axial plunge, but, in general, it ranges from horizontal to steep to the north-north-east. Curvilinear axes were observed on the shore section. With their constant north-westerly vergence these folds are probably representative of Robert's (1974) B_{2a} deformation episode, being formed at a late stage in the creation of the Ardrishaig Anticline (the schistosity being an early product). At some localities they are refolded by members of a more widespread set which are more variable in shape and have no constant vergence. They are evidently related to the B_{2b} episode of the second deformation. Their axes are either horizontal or plunge gently to the south-south-west. Folds of this episode are probably responsible for the great variation in thickness of the pyrite zone in the immediate vicinity of Meall Mór.

With the exception of three strike faults, the major displacements all trend approximately east-west. Two displace the Stronchullin Phyllite bands and are demonstrably sinistral, but no sense of movement could be detected on those which occur exclusively in the Upper Erins Quartzite, their presence being indicated by deep gulleys which show intense shearing, minor brecciation and pervasive hematisation.

SULPHIDE MINERALISATION

Pyrite Zone

A definite horizon of weak pyrite enrichment has been delimited in the Upper Erins Quartzite over a strike length of at least 10 km. Its cross-strike width varies from 200 to 800 m. Estimates of true thickness are confused by folding, but it is certainly less than 200 m (compared with the average of 180 m suggested for the thickness of the pyrite zone of central Perthshire by Smith and others, 1977a). In the northern part of the Meall Mór area a further zone of pyrite enrichment, ranging in width from 30 to 70 m was recorded 200-300 m to the west, but it is not clear whether this represents a separate horizon or a tectonic repetition of the main zone.

In detail the pyrite zone resembles that described from central Perthshire. However, in South Knapdale the average grain size is somewhat less and trails of grains are more common than isolated crystals. Though the incidence of base metal showings, particularly copper, is noticeably higher, pyrite remains the dominant sulphide phase forming up to 23% of the quartzites and 13% of the pelites.

Copper

Small quantities of chalcopyrite occur sporadically throughout the pyrite zone, but within an area which coincides approximately with the maximum development of epidotic rocks (p. 9) the frequency of occurrence and the volume of copper sulphides increases sharply. In the metasedimentary rocks, particularly the quartzites, the chalcopyrite occurs as threads and trails of small grains which parallel the early schistosity/bedding and develop preferentially on micaceous partings. It is invariably associated with and, in places, intergrown with pyrite.

The larger volume of the individual chalcopyrite occurrences within the enriched area (relative to other parts of the pyrite zone) is apparently related to a different style of mineralisation in which somewhat larger crystals of chalcopyrite form essentially stratiform, but locally cross-cutting, veinlets. The intimate association of these veinlets with the disseminated chalcopyrite, and with segregated quartz suggests they developed by remobilisation rather than by introduction from a distant source. Two contrasting styles of mineralisation are apparent also in the epidiorites and, although the stratiform type is broadly comparable with that in the metasedimentary rocks, the vein type is much coarser and more irregularly developed. This is particularly apparent in the Abhainn Srathain mine epidiorite where chalcopyrite (and, for that matter, pyrite) form irregular patches (5 cm) and veinlets often associated with quartz and calcite. However, it should also be noted that this body is atypical of the epidiorites being heavily epidotised and having neither foliation nor disseminated sulphides.

Although chalcopyrite is the principal copper bearing mineral bornite is also occasionally present along with microscopic amounts of covellite. Secondary malachite invariably accompanies the sulphides whereas azurite is only rarely developed.

Outwith the pyrite zone the only copper occurrence of note is where a tributary of the Artilligan Burn flows through a deep gorge eroded along a fault. On the north side roughly 100m from the western end of the gorge [NR 8390 7615], the strongly hematised phyllites are veneered with malachite. Similar cupriferous schists are present a few meters to the east in a small scree which, in the absence of similar features around, was identified as a possible spoil heap, although no workings were recorded. Pieces of malachite-coated and deeply weathered copper sulphide which were recovered from the drift immediately above the scree assayed Cu 26%, Pb 150 ppm, Zn 260 ppm, Ag 25 ppm, Co 600 ppm, Ni 860 ppm, Mo 10 ppm, and As 43 ppm. Trenching of the scree failed to reveal the source of the fragments but their restricted distribution and the concentrated nature of the ore would seem to indicate a small vein occurrence of limited size and economic interest.

Zinc

Although not recorded in outcrop macroscopic sphalerite is present in BH1 and BH3 and on a microscopic scale it is widely distributed in the quartzites and epidotised epidiorites. In the quartzites it is present in stratiform trails, whereas a peripheral growth on pyrite is the usual form in the epidotised epidiorite.

Lead

Galena is the least common of the base metal sulphides in the Meall Mór area and though it is known to occur with stratiform pyrite and chalcopyrite (Peach and others, 1911) the two new occurrences (BH2 and upper Abhainn Srathain) are both in quartz $\pm$ feldspar veins.

Antimony

Like sphalerite, stibnite was recorded mostly in thin section, though a possible macroscopic occurrence is present in BH2, within a quartz-feldspar vein.

GEOPHYSICAL SURVEYS

Measurements

Altogether thirty east-west lines covered an area extending from 00 in the area of the Abhainn Srathain mines NNE to line 5100N near the coast and SSW to line 1350S (Figs 3,4 and 5). North of 1500N the line separation was 300m, and south of this, over Meall Mór itself and in the region of the mines, the separation was 150m.

Huntec Mark III IP equipment was used to measure chargeability and apparent resistivity for both surface and downhole surveys. On the surface a dipole-dipole array was used with dipole length 30m and centre to centre dipole separation 90m (n=3). At this separation, anomalies might be detected from sources up to 45m depth, if little conductive overburden were present. Pseudo depth sections for n=2 to n=6 were completed on lines 00 and 150S, in the area of the mines. Chargeability was defined as the time integral of the decay voltage (normalised with respect to the transmitter voltage) measured between 75 and 525ms after termination of a two second square wave transmitted pulse. The chargeability M_{75}^{525} thus calculated was found experimentally to be 0.75 of the value M_{240}^{1140} which has generally been used for surveys conducted under the DI programme.

For the downhole surveys measurements were taken at metre intervals using a pole-dipole array with one current electrode at the base of the sonde, two potential electrodes 0.5m and 1.0m above this, and the second current electrode on the ground surface approximately 50m from the borehole or effectively at infinity compared with the electrode separation on the sonde.

Total magnetic field was measured at 15m intervals along the lines using a Geometrics proton magnetometer. Slingram EM was tried near the old mines but no anomalies were found.

Results

Chargeability and resistivity profiles for n=3, total magnetic field profiles, and positions of boreholes 1 to 3 are shown in Figs. 3, 4, and 5. Chargeabilities of greater than 20ms and resistivities less than 2500 ohm m have been shaded to indicate anomalous zones. Fig.6 indicates anomaly trends which can be followed through on more than one profile. Figs. 7 and 8 show chargeability and resistivity pseudo sections for lines 00 and 150S. Figs. 9 and 10 show chargeability, resistivity and SP logs for boreholes 1 and 2.

(1) Surface IP surveys

Chargeability anomalies occurred in the area of the mines on lines 00 and 150S where the survey was started, decreased south of 450S, and did not occur on lines 1050S and 1350S. The anomalies continued to the north of 00, as far as 5100N near the coast, giving a total length of about 6.5km for the anomalous chargeability zone, which extends NNE/SSW approximately along the geological strike. Chargeability anomalies are of the order 20 to 50ms and are often associated with low resistivity (Fig. 6). Exceptions to this occur on lines 600S to 1350S where chargeability anomalies are diminished, line 2400N where the chargeability anomaly could be masked by the extensive bog, and lines 4800N and 5100N where the chargeability remains high over a very broad zone.

The anomalous chargeability zone lies within the Erins quartzite and is closely associated with the mapped pyrite zone (Fig. 3.).
The Erins Quartzite contains bands of epidiorite and hornblende-schist but there is no obvious correlation of these bands with IP anomalies. The westward extension of line 00 shows a chargeability high and resistivity low which is associated with the black schists of the Stronchullin Phyllites Formation. Detailed geological investigation, evidence of previous mining activity, and the trend of the main IP anomalous zone indicate that the probable cause of the anomalies is stratiform sulphide enrichment. Similar

anomalies could also be caused by the presence of phyllite bands or differential weathering of rock types within the Erins Quartzite.

IP anomalies on lines 150S to 450N and the eastern anomalies on lines 900N to 1350N occur at the western boundaries of the pyrite zone (Fig. 3). Since the pyrite zone is well defined in these areas owing to good exposure, this effect is probably due to the westerly dip of the sulphide horizon, which can affect the n=3 IP response at a depth of up to 45m.

The decrease in magnitude of IP anomalies south of 450S may be due to the masking effects of conductive overburden, or a decrease in quantity of sulphides as suggested by the soil copper anomaly map. At 700N the westward shift in the main anomalous zone could be due to a fault, but geological investigations indicate that folding is more probable. North of 700N the IP anomaly has two distinct peaks with variable separation, which merge into one broad anomalous zone on lines 4800N and 5100N. The lack of correlation of resistivity and chargeability on lines 4800N and 5100N might be explained by more finely disseminated mineralisation.

The pseudo sections for line 00 (Fig. 7) indicate that the causing body is near the surface with a possible width of 60m centred at 90mE. The pseudo sections for line 150S (Fig.8) have a less definitive pattern showing weaker anomalies at about 60mE and 90mE.

(ii) Downhole surveys

The IP log for BH1 (Fig.9) shows six distinct chargeability anomalies of the order 40ms centred at depths 11m, 19m, 24m, 27m, 42m, and 47m, and a close correlation of low resistivity values. A comparison of the IP and core logs indicates a correlation of IP anomalies with 'common' pyrite and smaller quantities of chalcopyrite. SP anomalies correlate with IP anomalies at depths 11m, 24m, and 42m, and may indicate more massive pyrite. The Cu analysis log shows three main anomalous zones containing up to 1200ppm Cu, two of which were covered by the IP and SP logs and which correlate with the IP anomalies centred at 11m and 19m. The third zone of Cu anomalies at 2-6m depth could not be geophysically logged because of casing at the top of the borehole.

BH2 IP and SP logs (Fig. 10) show a close correlation of chargeability, resistivity, and SP anomalies, which occur in two main zones at depths 7-12m and 22-33m. These two zones correspond with higher concentrations of pyrite noted in the core log, and anomalous zones in the Cu analysis log of 700ppm and up to 3000ppm Cu respectively.

It is apparent from the quantities of Cu found in BHS 1 and 2 that pyrite is the main cause of the downhole IP anomalies, but the correlation of Cu and IP anomalies indicates an association of chalcopyrite with pyrite. BH3 near the old mines, intersected "scattered" pyrite and some chalcopyrite with very high concentrations of chalcopyrite at 3m and 27m. It is likely that pyrite and chalcopyrite contribute to the small IP anomaly on line 150S.

(iii) Magnetic surveys

The aeromagnetic map shows that the survey area is situated over the south eastern end of a magnetic 'high' centred 2km NW of Meall Mór. Typical regional gradients are about 10 gammas per km over the survey area, but the surface magnetic profiles (Fig. 5) show narrow, local anomalies of several hundred gammas magnitude, throughout the area.

South of 700N many anomalies coincide with narrow bands of epidiorite in which samples containing magnetite have been found. At the eastern margins of lines 2400N to 3300N a broad band of epidiorite has a strong magnetic anomaly. The profile along line 1800N (not plotted) gave approximately 1,000 gamma variation caused by basic dykes along the east-west fault just north of the line.

Other magnetic anomalies could be caused by magnetite bearing schists within the Erins Quartzite, found in the area to the west of the old mines (150S to 450S). There is no significant correlation of magnetic and IP anomalies, indicating that appreciable quantities of pyrrhotite are not associated with the sulphide mineralisation, and that the quantities of magnetite present are insufficient to affect the IP response significantly.

Discussion

The IP anomalies of the ground surveys appear to be caused mainly by disseminated pyrite within an enriched sulphide horizon. The IP and SP downhole logs, which respond mainly to the large quantities of pyrite, and the Cu core analysis logs indicate a fairly close association of the pyrite with minor chalcopyrite. Over the survey area detailed geological investigation has shown that the quantity of chalcopyrite within the sulphide zone is variable, therefore it is suggested that IP anomalies on selected lines from 450N to 5100N should be drilled, if and where these anomalies coincide with soil Cu anomalies.

Further geophysical surveys would be useful to extend one or two traverses in an east-west direction to check the possible extent of sulphide enrichment, and to cover the area south of 1350S covered by the geochemical surveys. Pseudo sections over selected existing lines might indicate dip and depth extent of the mineralisation thereby providing more precise drilling targets.

GEOCHEMICAL SURVEYS

Regional drainage survey

As this report is a detailed study of the Meall Mór area of South Knapdale, only that part of the regional drainage survey which falls within the 10 killometres square with its SW corner at National Grid Reference NR800700 is discussed. A sample density of just over one sample per square kilometre was chosen on the basis of experience elsewhere in the Highlands.

Sampling and data treatment

Samples of the active sediment in the streams were collected at each site by wet sieving through -100 mesh nylon bolting cloth. The samples after drying were ground and analysed for Cu, Pb, Zn, Co, Ni and Ag by atomic absorption spectrophotometry using a hot nitric acid attack. At the same sample site a heavy mineral concentrate was collected by panning the -30 mesh to +100 mesh fraction. After drying and splitting the sample was ground and Ba, Sb, Sn, Pb, Zn, Cu, Ni and Fe were determined by X-ray spectrometry.

The frequency distribution of each element was plotted on a logarithmic concentration - probability graph as described by Parslow (1974). Class intervals for the regional geochemical maps were chosen on the basis of the inflexion points in the curves and simple multiples of these concentrations. The populations are generally divided into three classes; background, slightly anomalous, and highly anomalous (Table I).

Table I

		Class I Background	Class II Slightly anomalous	Class III Highly anomalous	Class IV
Stream sediments	Cu	0-50	51-100	100	
	Pb	0-40	41-80	80	
	Zn	0-250	251-500	500	
	Co	0-50	50		
	Ni	0-40	41		
Panned concentrates	Ba	0-500	501-1200	1201	
	Sb	0-9	10-27	27	
	Sn	0-9	9-100	100	
	Pb	0-50	51-100	100	
	Zn	0-80	81-400	400	
	Cu	0-50	51-450	450	
	Ni	0-80	81		
	Fe(%)	0-7.00	7.01-14.00	14.01-21.0	21.0

All values in ppm except Fe (%)

These class intervals in general correspond to those obtained from geochemical drainage surveys of other larger areas of the Highlands of Scotland.

Factor Analysis

Because several populations can be identified in the distribution of each element the use of multivariate statistics is not strictly valid because of the violation of the basic assumptions of these methods. However, these techniques of correlation, such as factor analysis, are useful in picking out groupings of elements that may have been overlooked in the large data matrix. A few highly anomalous samples may produce a high correlation between two elements even though these might have an antipathetic relationship in the 'background' samples. The methods employed appear to be robust enough to overcome these drawbacks and to bring out factors that are clearly meaningful. Because of a large number of zero values that were present in the data matrix for such elements such as Sb and Sn, which are clearly important in the interpretation, the factor analysis was performed on the untransformed data. As a check on the method it was also performed on the log transformed data and this produced a similar but slightly less 'clean' solution.

Silver was omitted from further study as all the values were at or below the limit of detection (1ppm Ag). The number of factors was chosen as those with eigenvalues greater than 1.0 (Guttman's lower limit) and the elements with loadings greater than 0.5 in the rotated factor matrix are given in Table II.

Table II

Rotated Factor Matrix with elements 0.5

Factor I	Ni_{ss} (0.85),	Co_{ss} (0.79),	Zn_{ss} (0.78)
Factor II	Sn_{pc} (0.94),	Pb_{pc} (0.93),	Pb_{ss} (0.52)
Factor III	Sb_{pc} (0.91),	Cu_{pc} (0.87),	Cu_{ss} (0.68)
Factor IV	Ni_{pc} (0.88),	Zn_{pc} (0.85),	Fe_{pc} (0.81)
Factor V	Ba_{pc} (0.89)		

ss = stream sediment pc = panned concentrate

The give factors are interpreted as follows; I - secondary environmental effects. II - a combined factor relating to contamination by dumped material (tin cans and lead shot) and lead mineralisation. III - copper-antimony mineralisation. IV - concentration of magnetite in the panned concentrate. V - occurrence of baryte.

Results

Each element will now be discussed in turn beginning with the elements grouped in the mineralisation factor which is the most important from an economic aspect. Individual analyses will not be presented but are available for inspection. The areal distributions are plotted in figures 11-23, whose boundaries are those of the 10 km square N.G.R. NR8070.

The stream sediment samples which are highly anomalous in copper were collected on Abhainn Srathain, on Allt an Erins (N.G.R. NR85377546), and a tributary of Artilligan Burn (Fig. 1). The samples on the Abhainn Srathain downstream from the old mines, were covered by the more detailed survey described below.

The anomaly in small western tributary of Artilligan Burn is related to the small copper occurrence described on page .

The frequency distribution of copper in panned concentrates shows two marked inflexion points at 50 and 450 ppm but the areal pattern (Fig.12) is more scattered than that of the stream sediments. The samples from the Abhainn Srathain are not so anomalous (but are higher in the follow-up samples). The grouping in the lower part of the Allt Mor is interesting as the pyrite zone crosses the stream in this region and the soil sampling was extended down to this area. Compared with (unpublished) results obtained from the Middle Dalradian elsewhere in Scotland the fairly large number of samples in the slightly anomalous class is an indication that the eastern half of the region is relatively enriched in copper.

The presence of antimony in the panned concentrates was unexpected and no antimony mineral was known from the area before the investigation began. It is strongly correlated with copper, as shown by Factor III, and as seen in the more detailed stream sampling is a sensitive indicator of the mineralisation. Again two of the Cu-rich panned concentrates from the Allt Mor contain high Sb indicating that this association extends that far south and more detailed study is necessary on this stream. Regionally the eastern half of the area has significantly higher antimony values and the pyrite zone and the succeeding beds probably have an original enrichment in that metal. Siliceous muds and sinters near volcanic vents are enriched in stibnite (Wedepohl, 1969) and this could be the explanation for the high Sb content in the pyrite zone. Alternatively the antimony could be the result of a later, low temperature hydrothermal activity which is unrelated to the stratigraphy.

Zinc, cobalt and nickel (Figures 14, 15 and 16) in the stream sediment samples behave similarly and probably reflect the influence of secondary environmental effects such as fixation on secondary iron oxides and organic material. Their frequency distributions are essentially lognormal with only small strongly anomalous populations and the levels of these elements are also low in a regional context. This indicates little widespread Zn, Co or Ni mineralisation.

Zinc in panned concentrates samples (Fig.17) however probably does illustrate the pattern of small sphalerite-bearing veins. For example, the highly anomalous sample near the bottom of Artilligan Burn is downstream of a small trial recorded by Wilson (1921) as carrying more zinc than lead. Similarly another anomalous sample is from the third-lowest south bank tributary of the Stronchullin Burn which drains the area of the old Stronchullin 'Gold Mine'. From the material on the dumps and as recorded by Wilson the workings were on a sphalerite-bearing quartz vein. The overall pattern of zinc in panned concentrates is complicated by the presence of the element in iron oxides, such as magnetite and the association of Fe, Ni, and Zn in panned concentrates in Factor IV is related to the amount of primary iron oxides in the sediment. Iron is also present in the heavy mineral assemblage as pyrite and thus there is a moderate loading of this element (0.43) on the Cu-Sb factor.

The presence of tin in the panned concentrate samples is evidence that the sample is contaminated by metallic waste and samples with greater than detection limit of the method of analysis (about 9 ppm Sn) are of doubtful value. The correlation of high Sn with Pb in panned concentrates (and sediments) means that the distribution map for Pb in panned concentrates needs to be viewed in conjunction with the Sn map to remove the effect of contamination. Specially noticeable is the fact that the contaminated samples group along the inhabited area on the coastline. The distribution of lead is however also affected by small galena-bearing veins which are scattered through the region (Fig 1.) and the group of strongly anomalous samples in the southern tributaries of the Stronchullin and Artilligan Burns probably reflect these occurrences (Fig. 22).

Barium in panned concentrates has a very irregular frequency distribution and a very sharp break in the curve at 500 ppm which only flattens off at 4% Ba. This is caused by the presence or absence of the discrete heavy mineral phase, baryte. The element does not seem to be significantly correlated to any other determined and baryte is probably present in small amounts which contributed locally to a heavy mineral sample

Detailed drainage survey of Abhainn Srathain.

From the regional survey the main area of interest was identified as the Abhainn Srathain around the area of the old mines. More detailed sampling was carried out every 100 metres up this stream and further samples taken on some of the tributaries draining the general area.

Figure 24 shows the distribution of Cu in the stream sediment samples. The main stream draining the old workings (the sites of the old trials are mostly marked by the chalcopyrite occurrences) is strongly anomalous throughout most of its length except where it drains the Stronchull in Phyllite. The highest value (245 ppm) is on the north-eastern tributary and this area appeared to have the best potential for the occurrence of a larger disseminated Cu source, rather than vein-style mineralisation.

Copper is panned concentrates shows a similar pattern (Fig. 25) but the peak values are further downstream, which is unusual in that the stream sediment anomalies are usually further downstream of the source because of hydromorphic dispersion. One reason for this apparent contradiction could be the difficulty of standardizing the efficiency of the panning process. To test this hypothesis the percentage of iron and the Cu/Fe ratio have been plotted (Fig. 25, 27). Iron shows a similar pattern to copper but the Cu/Fe ratio (which should be unaffected by panning efficiency) shows two clear groups; the first with Cu/Fe of around 10×10^{-4} or less, and the second with ratios from 19 to 71×10^{-4}. The samples in the main stream, whilst all anomalous, show a fairly regular decline from 71 to 19×10^{-4}

and indicate a contribution from the dumped material taken from the trials in the stream bank.

Antimony has a similar pattern to copper in the panned concentrates (Fig. 28) with a highly anomalous group downstream of the old workings. The sample taken from the NE tributary of the main stream with a Cu content of 693 ppm has only a low Sb content of 7 ppm and this may indicate that the disseminated copper source (which was postulated above) has a lower antimony content than the veins which are exposed in the old trails. The dispersion of antimony downstream from the old workings is fairly limited with values decreasing within 300 m to being only moderately anomalous. Presumably the element is present in not very resistant sulphide minerals such as stibnite or tetrahedrite and enters the stream water or is absorbed on to the fine fraction of the sediment on breakdown of these minerals. It is a sensitive indicator of the mineralisation but its limited dispersion means that it is mainly of use in a follow-up investigation.

Barium, despite its irregularity in the regional survey, shows a definite relationship to the mineralised area (Fig. 29) with a slight cut-off upstream of the old levels on the main stream and a fairly long dispersion. No barium minerals are known from the exposures or from the dumps but baryte is probably irregularly distributed in small amounts, although not present in the thin sections examined mineralogically.

Rapid optical examination of heavy mineral fractions from panned concentrates showing anomalous metal levels provided the following information. Anomalous levels of copper, zinc and barium were caused by the presences of grains of chalcopyrite, sphalerite and baryte respectively. No positive sources for lead anomalies were identified, but the absence of obvious contaminants such as lead shot or lead glass suggests that a secondary lead mineral is involved. Anomalous levels of antimony may be due to small grains of stibnite intergrown with much larger grains of pyrite as observed in several rock specimens. One concentrate with an anomalous tin level was examined, but no Sn-bearing mineral was located. Minute flecks of a metallic contaminant were observed in this specimen, and it is possible that they are rich in this element.

Soil and Rock Sampling

Methods

After some of the drainage results were available, and a brief field examination by one of the authors (U.McL.M), a linear zone of copper occurrences was outlined for further geochemical and geophysical investigations. Soil samples were collected at 50 m intervals on E-W traverse lines spaced 150 m apart with a 1" diameter hand auger which can sample down to 1.30 m. The soil profile generally consists of an organic-rich black peat horizon overlying a grey-brown sandy-clay which commonly contains small locally derived rock fragments. There is no evidence of any exotic drift. The drainage is usually free but, especially in some of the peat-filled hollows, it can be impeded and gleying is then developed. Generally the soil directly overlying the bedrock was sampled except in areas where the peat thickness exceeded the auger length. All the hand auger samples were therefore not collected from the same soil horizon and this may account for some of the observed trace element variation.

The soil samples, after drying, were sieved, and the -60 mesh fraction ignited and analysed for Cu, Pb, Zn and Ag by atomic absorption spectrophotometry.

Data treatment

The analytical results for Cu, Pb, Zn and Ag were plotted on the 150 m traverse lines by a computer program (JSCØ2), omitting the more detailed sampling to avoid biasing the results overmuch to the central area. Both the untransformed and the $\log_{10}$ transformed data were plotted but the former were easier to interpret because the amount of information to be assimilated was reduced (only samples with greater than 50 ppm Cu were visible as peaks). However for Zn and Pb, but not Ag, the large range meant that only a few peaks were visible.

Results

Of the elements determined, copper showed the most significant variation (Fig. 31). A probability - logarithmic concentration plot for copper in the soil samples shows a pronounced 'kink' at 100 ppm and a clearly anomalous population above this level. The main feature of the distribution map is the concentration of strongly anomalous values between lines 1050N and 450S. Northwards from this area the main central anomaly appears to die out north of line 1050N but a narrow feature to the east carried on at a reduced level as far as line 1800N.

The detailed survey of the central area (Fig. 30) shows two main trends: a broad anomalous zone to the west, over 50 m wide, which runs from 50E on line 00 to 200E on line 650N and in a direction NO15^{o}E; and a series of narrow (less than 50 m wide) anomalies which lie further east and trend at about N 030^{o}E. The broad anomaly appears to die out south of line 50S unless it joins the eastern anomaly around 450S before falling below threshold (100 ppm Cu) on line 900S. Northwards the main anomaly swings round to the west of north (around Meall Mor), between lines 600N and 700N, and comparison with the geophysical survey (Fig. 3) shows that the chargeability anomaly does likewise. The narrow eastern anomalies lie <u>en echelon</u> but this distribution may be only a function of sample density.

There is one very high value (Cu 1870 ppm, Pb 30 ppm, Zn 1.35%) on line 2250N but this traverse follows the same fault as that producing high Cu in panned concentrates in the drainage survey. The stream runs along the fault further to the west and a rock with 26% Cu was subsequently discovered nearby. The high soil anomaly is probably related to a similar minor vein occurrence. Further north, there are few significant anomalies, and most of these (discussed below) occur on the north flank of Meall Dubh (lines 4450-4900N).

South of the main area there is a small group of anomalous values of minor amplitude and wavelength, on lines 1350 - 1800S and another group on lines 2250 - 2500S, with peaks of 250-500 ppm Cu. The same mineralisation is probably responsible for the Cu-Sb drainage anomalies in the Allt Mor and more detailed work on this stream section and an extension of the geophysical survey southwards are merited.

Zinc shows a sympathetic variation with Cu, which can only be clearly seen in the logarithmic plots because of the distorting effects on the scale of the untransformed plot of the high 1.35% Zn sample mentioned earlier. In the central area between lines 900N - 450S there is a close correlation of the Zn and Cu peaks; but the Cu seems to have a larger variance with high values not always accompanied by Zn. A linear group of anomalies on lines 4350-4800N probably overlies a small sphalerite and chalcopyrite-bearing vein which provides sediment to the stream draining the north flank of Meall Dubh and gives panned concentrate anomalies for Zn.

The lead distribution is irregular with no clearly defined trend of values greater than the threshold of 150 ppm; and overall values are low (Median = 23 ppm). There is some grouping of anomalies in the main central Cu-rich area but the only closely defined group outside of this lies between 2400W and 2500W on line 3550S and 2625W on line 4040S. Even here the peak value, 300 ppm Pb, is low.

Very little information can be deduced from the data on silver as the concentration of this element is very near the detection limit of the analytical method. The sample with the highest lead content, 780 ppm at 2025W on line 4170S, has a silver content of 6 ppm but the highest silver content 8 ppm at 1020E on line 3600N is not associated with high lead. There also seems to be little correlation of Ag with the copper content of the soil.

Power Auger Survey

After the soil results became available deeper sampling was considered necessary to test the possibility that the broad anomaly in the central part of the area was due to eluvial or hydromorphic surface enrichment from a set of narrow veins.

The latter could have contributed copper to the groundwater over a large area, and which might have become precipited near a physical feature such as a break of slope. Also, the soil horizons sampled by the hand auger differed because of the varying depth of peat, so that some of the geochemical variability (particularly the alternation of high and low copper values on some traverses) could have been caused by changes in soil type. Commonly, the peak copper value overlies a depression in which the soil type is a peat (for example, Figure 32).

Powered auger holes or shallow pits to bedrock were put down at 154 sites in the central area on the main geophysical and geochemical anomalies, and on lines 2400N, 2700N, and 3000N where the peat thickness exceeded 1.30m. A sample of the soil immediately overlying the bedrock was collected and, where possible, a rock sample was taken from the same site or within a metre of it. Samples were prepared and analysed by the same methods as for the soil survey, rocks being jaw-crushed and split before fine grinding.

The results of this deeper soil survey were broadly consistent with those of the hand auger sampling. The anomalously copper-rich western area was confirmed, with little or no displacement. There were slight variations at individual sites, as expected in soil sampling where small sulphide-rich rock fragments may cause local disturbances to the broad geochemical pattern. The overall distribution remains the same as in figure 30 and is demonstrated on the two selected traverse lines 00 and 450N (Fig. 32). A positive result of the deeper sampling was confirmation that the western anomaly continues through 90W on line 300S to line 450S, there being no gap in the anomalous zone as suggested by figure 30. Sampling beneath deep peat on lines 2400-3000N did not establish any copper values above the threshold, although the results are inconclusive at 840 and 870E on line 2400N, where the reddish brown sandy-clay exceeded 8.0m in thickness and could not be bottomed.

There was little or no correlation between the copper contents of the soils and rocks collected at the same site. This may be due to severe leaching of copper from weathered bedrock or to inadequate sample density in view of the variability in the trace metal content of the rocks. On the two selected traverses shown in figure 32, there is an approximate correlation between the rock and soil values but commonly the peak values in the soil overlie depressions where a satisfactory rock sample could not be collected. The range of values in the rock samples was from 5-1320 ppm Cu which is similar to that in the soils and to that determined in a small number of rocks collected in the initial field survey of the pyrite zone on Meall Mor. Grab samples of ore from the old mines at Meall Mor assayed up to 7% Cu but representative sampling of this material was not considered justified because of the considerable cost involved.

Interpretation

The main soil anomalies in the central region between lines 450S and 700N are tentatively interpreted as being caused by two different styles of mineralisation. The western broad anomaly, which is coincident with the main chargeability anomaly, is attributed to a general disseminated enrichment of copper mostly within the pyrite zone. The reasons for this conclusion are the substantial width of the anomaly (up to 200m); coincidence of the geophysical anomaly (probably caused mainly by disseminated pyrite) and the parallelism, in part, to the western margin of the pyrite zone. Whereas the transgression of the western pyrite zone boundary by the geophysical anomaly could be explained by the westerly dip of the strata that of the geochemical anomaly is difficult to explain. Further investigation in this area is necessary to account for this apparent contradiction. The eastern anomaly, or group of anomalies, is considered to be related to narrow copper-rich veins possibly associated with amphibolite ('epidiorite') bodies which may have acted as structural traps. This is the style of mineralisation seen about the old mine with narrow, irregular chalcopyrite-rich veins. The small width of individual veins is believed to be the reason for the lack of a geochemical (and geophysical) anomaly across the line of the old workings. The en echelon nature of the anomalies, the small width (< 50m) and the slightly different strike direction, distinguish them from the broad main western anomaly. Alternatively the eastern group of anomalies might be caused by thin disseminations of copper within the pyrite zone. The broad main western anomaly, on the basis of the soil survey, is suggested as the best target for future exploration and drilling because of the possibility of locating stratiform enrichment in copper of economic proportions.

Summary

1. The regional geochemical drainage survey has shown the existence of a Cu-Sb association and a strongly anomalous distribution of metals in the Abhainn Srathain, but significant values also extend from Allt Mor in the south to Stronchillin Burn in the north. There is a regional enrichment in copper and antimony.

2. The detailed soil survey has outlined a broad anomalous area to the south of Meall Mór and a series of narrow linear anomalies further to the east.

3. Deeper sampling of the soil profile by mechanical auger has confirmed the metal distribution indicated by the shallower, hand auger sampling.

4. The soil anomalies are believed to be caused by two distinct styles of mineralisation; a broad disseminated copper source and narrow copper-rich veins. The geophysical chargeability anomaly is coincident with the broad geochemical anomaly and is probably caused by disseminated pyrite and chalcopyrite.

5. The larger, disseminated copper occurrence offers the more promising target for future investigation by drilling.

DRILLING RESULTS

Three inclined boreholes (BH) were sunk, using the IGS modified Winkie drill, during the course of this investigation. BH1 was situated to the north of the Abhainn Srathain mines at 90E on line 00 (Fig.30). BH2 was situated to the north of BH1 at 175E on line 450N. BH3 was situated amongst the old workings of the Abhainn Srathain mine complex, and lies at 150E on line 180S. All three boreholes were inclined at 50^{o} on azimuths of 120^{o} (magnetic) and the core size was TAX (33.5mm).

The siting of the boreholes was controlled by geochemical and geophysical considerations. BH1 and BH2 were sunk to investigate coincident IP and copper in soil anomalies, BH1 being located on a 100 ppm copper in soil contour and the line of drilling such that it passed beneath a 300 ppm copper in soil anomaly, while BH2 was sunk towards a 1420 ppm copper in soil anomaly. BH3 was sunk at the old mine workings to evaluate both the area of richest copper showing and also to provide information on the apparent relationship between sulphide mineralisation and the epidiorite.

<u>Borehole 1.</u>

The geological summary log for BH1, fig33, shows it to be made up of six rock types, epidiorite; quartzite; micaceous quartzite; quartz-chlorite-mica schist; chlorite-mica-quartz schist and chlorite-mica schist. Quartzite is the most abundant while epidiorite is relatively uncommon comprising less than 15% of the core. Pyrite is widely distributed throughout the length of the core and local concentrations, for example, at 11m, 24m and 42m show a correlation with IP anomalies. The copper analysis log (Appendix II) shows three anomalous zones coinciding with visible chalcopyrite, for example, averaging 675ppm Cu between 2.10m and 5.43m and 800ppm between 8.81m and 9.23m. In particular it is significant that the Cu profile shows a fall in the level of copper below approximately 23m. Similarly with the exception of a trace of chalcopyrite at 36m there is no chalcopyrite recorded from the core below 25m.

Comparison of the geochemical and geological data shows that whilst copper shows little correlation with rock type, Ni and Zn (Appendix II) have a close correspondence with the chloritic units and possibly indicates a volcanic origin for these metasediments.

Borehole 2.

The distribution of rock types in BH2 is broadly comparable with BH1, quartzite and micaceous quartzite being by far the most abundant units forming approximately 70% of the core, while significantly epidiorites are absent (Fig. 34). Again pyrite is more widely distributed than chalcopyrite and comparison of IP and SP logs with the geological log shows good agreement. There is a close correlation of chargeability, resistivity and SP anomalies in two main zones between 7-12m and 22-33m which also correspond to areas of pyrite concentration in the core log. The copper analysis log shows three distinct peaks in excess of 500 ppm, one of which averages 0.24% Cu over 4.27m. Comparison of the copper profile with the core log again shows good broad agreement between Cu-rich zones and recorded chalcopyrite. For example below 30.40m where chalcopyrite is the dominant sulphide.

Again as noted in BH1 the presence of chalcopyrite in the core appears to be independent of rock type. It will be noted that although epidiorite is absent the mean Cu content between 28.75m and 33.02m is double the peak value in BH1.

Borehole 3.

BH3 is significantly richer in copper than either BH1 or BH2 with almost the entire core above 28m showing Cu values in excess of 500 ppm, and averages 1.06% Cu over 2.67m at the top of the borehole (2.45m - 5.12m) (Fig. 35). Most of the core consists of epidiorite but micaceous quartzite, chlorite-mica-quartz schist and chlorite-schist are also represented.

There is a zone of some 23.6m which shows strong epidotisation of the host rock. Chalcopyrite is ubiquitous and accounts for the high copper values.

The very high value, greater than 2.7% between 2.45 and 3.31m, results from the presence of chalcopyrite in segregations within the host quartzite. Because the drill encountered debris from old workings above 2.45m further ore-grade material may have been removed by the 19th century miners. Elsewhere there appears to be some correlation between epidotisation and high Cu values.

In summary it can be stated that there is a strong correlation between the geological, geophysical and geochemical data. The IP anomalies can be directly correlated with the presence of pyrite and the high Cu values to visible chalcopyrite. In BH1 the further correlation of Cu and IP anomalies point to a close association of chalcopyrite with pyrite. The possible correlation between Cu enrichment and the presence of epidiorite in BH1 and BH3 is interesting although evidence from BH2 suggests that it may not be significant.

CONCLUSIONS

The investigation has delimited a broad zone of weak stratiform sulphide mineralisation with a strike length of at least 10km in the Upper Erins Quartzite of South Knapdale. This is believed to be a southerly extension of the Middle Dalradian pyrite zone of upper Loch Fyne and Central Perthshire which is considered to have affinites with certain Swedish economic grade stratiform deposits (Smith and others, 1977a).

A coincident IP anomaly persists throughout much of the length of this zone and probably results from the disseminated pyrite which comprises the bulk of the visible sulphide. The presence of a broad multicomponent peak on most of the IP traverses is consistent with the variable concentration of the sulphides within the zone. A considerably better IP response was obtained over the pyrite zone in South Knapdale than in central Perthshire. This may result from an increase in total sulphides but is considered more likely to reflect the differing form of the pyrite, in particular comparatively smaller intergranular spacing.

In South Knapdale the pyrite zone contains anomalously high concentrations of copper, relative to the adjoining rocks, and the whole area is enriched in this metal with respect to the Middle Dalradian of upper Loch Fyne and central Perthshire. The quantity of copper varies considerably throughout the zone, but apart from occasional enrichments marginal to epidiorites, this cannot be correlated with lithological variation. A notable enrichment occurs just south of Meall Mór in an area which includes the Abhainn Srathain mines and, which in parts, contains strongly epidotised rocks, though the relationships between the two minerals has not been firmly established.

Chalcopyrite is the dominant copper-bearing mineral with minor amounts of bornite and covellite and secondary malachite. In most occurrences chalcopyrite occurs as a fine dissemination but in the enriched area this form is supplemented by veins which probably originated by remobilisation of adjacent disseminations.

Any further economically orientated studies should be centred on the south flank of Meall Mór, where the most promising drilling targets are the broad copper in soil anomalies between lines 400 and 700N. because even though the copper grades encountered in BH2 are lower than those in BH3 the large size of the geochemical soil anomaly means that there is likely to be a greater tonnage of copper.

As part of the more scientifically orientated studies on ore genesis a further five shallow inclined drill holes were proposed which in conjunction with the first three would provide an almost complete cross strike section of the pyrite zone in the neighbourhood of the Abhainn Srathain mines. However, because of more pressing requirements elsewhere only two of the holes were completed. The results of this drilling are contained in Appendix III of this report. More detailed laboratory work, including fluid inclusion and sulphur isotope studies on the available material is in hand.

REFERENCES

ELLES, G.L. 1926. The geological structure of Ben Lawers and Meall Corranaich (Perthshire). Q.J. Geol. Soc London. Vol 82, pp 304-331.

GRAHAM, C.M. 1976. Petrochemistry and tectonic significance of Dalradian metabasaltic rocks of the SW Scottish Highlands. J.Geol. Soc London Vol. 132 (1), pp 61-84.

HARRIS, A.L. and PITCHER, W.S. 1975. The Dalradian Supergroup. In 'A correlation of the Precambrian rocks in the British Isles'. Spec. Rep. Geol. Soc London No. 6. pp 52-75.

JOHNSTONE, G.S. 1966. The Grampian Highlands 3rd Edit. British Regional Geology, Geol. Surv. G.B.

KNILL, J.L.. 1959. Palaeocurrents and sedimentary facies of the Dalradian metasediments of the Craignish-Kilmelfort district, Proc. Geol. Assoc. Vol. 70, pp 273-284.

__________ 1963. A sedimentary history of the Dalradian Series (In Johnson, M.R.W. and Stewart, F.W., ed The British Caledonides Edinburgh, Oliver and Boyd, pp 99-121).

MERCY, E.L.P. 1965. Caledonian igneous activity. (In Craig, G.Y. ed The Geology of Scotland. Edinburgh, Oliver and Boyd, pp 229-267.

PARSLOW, G.R. 1974. Determination of background and threshold in exploration geochemistry. J. Geochem. Explor. Vol. 3. pp 319-336.

PEACH, B.N. ET AL. 1911. The Geology of Knapdale, Jura and North Kintyre. Explanation of Sheet 28, with parts of 27 and 29. Mem. Geol. Surv. G.B.

ROBERTS, J.L. 1966. Sedimentary affiliations and stratigraphic correlation of the Dalradian rocks in the SW Highlands of Scotland. Scott. J. Geol. Vol. 2 pp 200-223.

__________ 1974. The structure of the Dalradian rocks in the SW Highlands of Scotland. J. Geol. Soc London Vol 130 (2) pp 93-124.

SMITH, C.G. and others. 1977a. Investigation of stratiform mineralisation in parts of central Perthshire. Miner. Reconnaissance Prog. Rep. Inst. Geol. Sci. No 8, 83 pp.

____________ 1977b. Investigation of stratiform sulphide mineralisation at McPhun's Cairn, Argyllshire. Miner. Reconnaissance Prog. Rep. Inst. Geol. Sci. No. 13. pp. 44.

STURT, B.A. 1961. The geologlcal structure of the area south of Loch Tunnel. Q.J. Geol. Soc. London Vol. 117 pp 131-156.

WEDEPOHL, K.H. (Ed) 1974. Handbook of Geochemistry Vol. II pt 3 Chapter 51. (Berlin: Springer-Verlag).

WILSON, G.V. 1921. The lead, zinc, copper and nickel ores of Scotland. Mem. Geol. Surv. Spec. Rep. Min. Res. G.B. Vol XVII pp 134.

WISEMAN, J.D.H. 1934. The Central and South-west Highland Epidiorites: A study in progressive metamorphism. Q.J. Geol. Soc. London. Vol. 90 pp 354-417.

ACKNOWLEDGEMENTS

The Institute would like to thank the landowners for their co-operation and particularly the Forestry Commission for the hire of the Muskeg tractor.

Special acknowledgement must be given to Messrs B Scarth and K Jacobs (Metalliferous Minerals and Applied Geochemistry Unit) who performed the powered auger sampling and the Winkie drilling, often in near Arctic conditions. Several members of the Analytical and Ceramics Unit were responsible for the analytical work and mention should be made of B P Allen, V A Judge, M E Stuart, and T K Smith. Staff of the London and Edinburgh Drawing Office prepared most of the illustrations. Miss C Collingborn was responsible for producing the report and Miss P Raymond typed the final version.

The investigation has been under the overall supervision of Dr M S Garson, Programme Liaison Officer for the Mineral Reconnaissance Programme.

APPENDIX I

DRILL-CORE LOGS

Borehole inclinations are with respect to the horizontal. Structural inclinations are with respect to the plane normal to the core axis.

SECTION OF MEALL MHOR BOREHOLE NO. 1

BOREHOLE INCLINED AT 50° TOWARDS 120° M

Surface Level approx. 267 m O.D.

Communicated 8/2/77 by IGS - HIGHLANDS & ISLANDS UNIT

Date of boring or sinking Dec. 1976 Borer IGS GEOCHEMICAL DIVISION

One-inch Map 58 Six-inch Map ARGYLL 191 NE

958116 4M 2/75 J.F.&S. 275

	Thickness		Depth from Surface	
	Metres		Metres	
OVERBURDEN, comprising one large and several smaller fragments of epidiorite. Only 5 cm seen.	1	25	1	25
QUARTZITE, pale grey, variably micaceous with probably, in addition some feldspar. Mica generally forms thin partings consisting principally of dark ?biotite and occasionally of chlorite. Foliation as defined by mica partings generally inclined at low angle (≤10°). Band of psammite between 1.63 and 1.74 m. Mica content of quartzite less below 1.74 m. Pinkish calcite veinlets with occasional pyrite between 1.67 and 2.10 m. Also quartz vein with marginal chloritic selvages (2.43 - 2.52 m), which contains pyrite and subordinate chalcopyrite. Thin stratiform trails of chalcopyrite, generally less than 1 mm thick, appear below 2.56 m, and in the lowest 15 cm the overall sulphide content increases, though chalcopyrite is largely replaced by pyrite as the principal sulphide. Also trails may be replaced by sporadic larger crystals. Overall, total sulphide content is less than 1%.	1	67	2	92
CHLORITE-SCHIST, in general, very heterogeneous consisting mainly of finely interbanded chlorite and psammite material, (with rare quartzite). Also appreciable amount of sericite in upper 25 cm. Foliation/banding mostly low angle (≤10%), but, in parts, highly crumpled. Numerous quartz veins and segregations with chlorite selvages. Pyrite present throughout forming about 1 - 2%, though locally thin bands may have up to 50%. Crystals generally ≤1 mm but 3 - 4 mm examples occur in the chlorite selvages (mentioned above) and, more rarely, in bands of epidiorite?. Chalcopyrite is also fairly common, being associated with pyrite. Sulphides die out in lowest 44 cm where the rock is very finely banded	3	13	6	05
EPIDIORITE, medium to fine grained, dark grey hornblende-schist with biotite (and rare hornblende) porphyroblasts almost throughout. Upper 15 cm relatively fine grained and schistose - possibly a relict chilled margin. Similar features present at base, though restricted to lowest 5 cm. Inclination of foliation at top is 25°, steepening to 50° at 7.90 m and then returning to 25° at base.				

c/forward 6 05

Description	Thickness Metres		Depth from Surface Metres	
b/forward	6	05		
Pyrite, scarce to absent with only traces of chalcopyrite pyrite, however, is common in lowest 5 cm with crystals ≤1 mm. Pyrite and subordinate chalcopyrite present in 5 mm thick quartz-carbonate vein between 7.15 and 7.35 m.	2	76	8	81
QUARTZITE, pale grey granular rock, with chlorite/ sericite partings which increase in number below upper 15 cm. Also rare biotite partings. Pyrite present throughout, generally as finely divided crystals, but also as thin stringers parallel to the foliation. Chalcopyrite is also common but probably subordinate to pyrite. Overall total sulphide content is 2 - 3%.	-	42	9	23
QUARTZ-CHLORITE-SCHIST, highly crumpled, finely striped rock with quartz segregations and no variable sulphides	0	32	9	55
MICACEOUS QUARTZITE Foliation inclined at 65°. Pyrite present throughout, but frequently forms enriched stringers.	0	19	9	74
SERICITE-CHLORITE-SCHIST, highly schistose and crumpled Pyrite occure almost throughout, principally as stringers and lenses	-	38	10	12
QUARTZITE, fine grained, mid to dark grey, homogeneous rock with chlorite and biotitic partings throughout. Pale pink garnets are common in the upper 30 cm together with occasional feldspars. Dark pelitic bands, ≤1.5 cm and probably composed of chlorite may represent volcanic horizons. Stringers of pyrite aligned along bedding are present throughout with subordinate associated chalcopyrite. Peletic bands and chlorite selvages (adjacent to quartz lenses) are noticeably enriched in sulphides.	1	51	11	63
HIGHLY MICACEOUS PSAMMITE, fine grained, mid grey and very homogeneous. Pelitic costituet principally chlorite, but subordinate biotite forms porphyroblasts. Pale pink garnet porphyroblasts, up to 2 mm across are common in the upper 50 cm. Occasional, fine, generally discontinuous pale bands are probably of quartz. Inclination 10 - 20°. Pyrite tends to occur rarely as single well-formed crystals up to 4 mm across. More tabular crystals have their long axis in the plane of the foliation. Rare thin calcite veinlets. NB. A most unusual looking rock - may be marginal facies of epidiorite.	1	25	12	88
CHLORITE-BIOTITE-SCHIST, possibly a more micaceous variant of the above unit. Well developed schistocity, thin discontinuous quartzose partings and pink garnet porphyroblasts. Finely disseminated pyrite.	1	27	14	15
c/forward	14	15		

(5630) 397785 6m 8/76 CP(A)Ltd.

SECTION OF MEALL MHOR BOREHOLE NO.1

Six-inch (County and Quarter Sheet) ARGYLL 191 NE

	Thickness Metres		Depth from Surface Metres	
b/forward	14	15		
Devoid of sulphide except for disseminated pyrite in lowest 30 cm and 2 mm thick vein of chalcopyrite at 14.85 m	1	17	15	32
BIOTITE-CHLORITE-?HORNBLENDE-SCHIST, finer grained less evidently schistose than succeeding chlorite-biotite-schist band, with small garnets at certain horizons. Pyrite generally scarce.	-	38	15	70
EPIDIORITE (hornblende-schist), medium to fine grained, mid grey, thinly striped rock in which much of the original hornblende is replaced by chlorite. Biotite not very evident, and unit includes quartz-chlorite segregations. Epidote, with minor calcite is patchily developed between 16.00 and 16.12 m. Poorly developed lineation. Banding/foliation inclined at 15°. Pyirte generally scarce, but more common close to quartz chlorite segregations.	-	63	16	33
EPIDIORITE, coarser than above and less obviously schistose, particularly between 16.50 and 16.83 m where rock is also coarse grained. Epidote and pyrite commonly developed in coarsest patches. Rare calcite and haematite on joints. General decline in amphibole content in lowest 30 cm.	-	92	17	25
EPIDIORITE, lighter than above due to marked increase in quartz content. Hornblende occasionally present but mafic content mostly of biotite and chlorite. Some garnetiferous bands. Horizontal foliation. Occasional calcite on joints. Notably enriched in pyrite relative to the above unit	-	75	18	00
MICACEOUS PSAMMITE, medium grained, mid to dark grey rather granular rock. Mafics dominated by biotite but chlorite and garnets (up to 1mm) common. Possibly a slight increase in mica content in lowest 40 cm. Wavy foliation, principally horizontal, but gradually steepening downwards eg 20° at 20.50 m and 65° below 21.00 m. Pyrite present throughout (overall 1 - 2%) but rare zones of enrichment ($\geq$50% over 1 cm) occur generally as stringers parallel to the foliation, but also as discrete crystals 2 mm. Chalcopyrite present in similar form, and often associated with pyrite, though always subordinate (overall probably $<$0.1%)	4	14	22	14
c/forward	22	14		

	Thickness		Depth from Surface	
	Metres		Metres	
b/forward	22	14		
BIOTITE-CHLORITE-QUARTZ-SCHIST of "green bed" type. Finely interbanded light (quartz with scarce feldspar and epidote) and dark (biotite and probably subordinate, chlorite) stripes. Highly schistose throughout. In lowest 75 cm striping not so obvious - probably as a result of reduction in thickness of individual units. In consequence schistosity planes much closer together producing a more fissile rock. Apart from the lowest 75 cm, small scale folding and crumpling give rise to variation in the inclination of the foliation eg - 60° in upper metre, subvertical, 23.40-24.25 m, and variable, but generally $<10^{\circ}$, below 24.25 m. Pyrite sporadic distribution throughout but overall probably $<1\%$ and may even be $<0.5\%$. Locally 2-3% over 5 cm. Tends to occur as discrete crystals - well formed cubes common, but irregular or lensoid shapes also present. Crystals mostly 1-2 mm across but may be ≤ 7-8 mm. Striated crystals common. No chalcopyrite seen. Calcite in rare veinlets and on joints	3	54	25	68
EPIDIORITE, fine grained, compact, mid to dark greenish grey hornblende-biotite-schist with quartzose streaks and probably some chlorite. Lineation present throughout. Foliation well developed in upper 20 cm (inclination 10°) but rather patchily developed below. Pyrite distributed erratically throughout tending even more than in above rock to form discrete crystals. These are often tabular with their larger axea paralleling the foliation. Quartz vein between 26.28 and 26.34 m inclined at 20° with angular fragments of country rock, and single pyrite crystals with associated sphalerite. Trace of calcite on joints.	-	93	26	61
BIOTITE-CHLORITE-QUARTZ-SCHIST, similar to unit above preceeding epidiorite, both probably representing schistose margin of epidiorite. Finely banded in parts, particularly towards base. Traces of ?fibrous amphibole. In general highly crumpled, apart from upper 20 cm where follation has fairly constant 0-5° inclination. Sporadic pyrite crystals, mostly 1-2 mm. Overall form $\leq 1\%$ calcite on joints.	-	57	27	18
MICACEOUS QUARTZITE with biotite, muscovite, sericite and chlorite. There spelitic material is present in two forms - finely disseminated crystals and partings composed exclusively of biotite and chlorite. Latter die out at 28.13 m. Inclination of foliation mostly 5° but steepens below 28.45 m and between 28.62 and 29.12 m is vertical. Pyrite is irregularly distributed with some enriched zones but no sympathetic relationship with pelitic content.				
c/forward	27	18		

(5630) 397785 6m 8/76 CP(A)Ltd.

SECTION OF MEALL MHOR BOREHOLE NO. 1

Six-inch (County and Quarter Sheet) ARGYLL 191 NE

	Thickness Metres		Depth from Surface Metres	
b/forward	27	18		
Overall, decreases below 28.56 m. Usually forms discrete crystals (1-2 mm with maximum of 6 mm), which on occasion are concentrated in trains parallel to the foliation. No chalcopyrite seen, 5 mm thick feldspathic vein between 27.24 and 27.32 m, pink in centre and white on margins, inclined at 70°.	2	10	29	28
CHLORITE-SCHIST, dark greenish grey, medium to fine grained in upper 16 cm. Increase in grain size below this may be the result of segregation as it is accompanied by the appearance of irregular quartz and minor calcite patches. Some interbanded quartzite between 29.66 and 29.69 m at which depth the chlorite-schist is of the usual coarse grained type. Below the upper 20 cm the entire unit is quite noticeably broken and haematised. The foliation is inclined at 25° around 29.67 m but some crumpling is evident below. Pyrite is present throughout, ranging in habit from a fine dissemination in the upper 16 cm to the typically coarse development in chloritic selvages. Around the quartzite bands, pyrite is noticeably enriched in the pelitic layers. Overall distribution 2-3%.	-	57	29	85
MICACEOUS-QUARTZITE, pale grey granular rock with rare chlorite/biotite partings. There is a general increase in biotite content between 30.60 and 30.90 m and from 31.72 to 31.95 m the rock appears more feldspathic. An epidote rich band is present between 30.62 and 30.70 m. Inclination of foliation generally ≤10° but local variations (≤50°) occur. Pyrite is disseminated throughout and overall forms 0.5-1%. The micaceous layers are slightly enriched where trails of crystals are common - much as in above units. Veins thin calcite veinlets with biotite and rare pyrite common. Quartz vein with dolomite (ranging in colour from white to pale orange), chlorite and occasional pyrite between 31.39 and 31.56 m. Further quartz vein with pinkish ?feldspar and abundant pyrite between 31.75 and 31.96 m.	2	53	32	38
CHLORITE-SERICITE-QUARTZ-SCHIST finely striped, pale to mid green rock comprising alternating chlorite - and quartz - rich layers. Considerable folding with consequent lensing of layers. Pyrite, occurs throughout (though concentrated in upper 10 cm) both as discrete crystals and trails. Variations in content are not lithologically controlled.	-	28	32	66
c/forward	32	66		

	Thickness Metres		Depth from Surface Metres	
b/forward	32	66		
MICACEOUS QUARTZITE, pale grey, with only rare thin chlorite/biotite partings. Inclination generally horizontal. Pyrite throughout, forming 1% overall. Noticeably enriched between 32.81 and 32.84 m in a paler, slightly calcareous band, where it forms ≤25%. Barren quartz vein between 32.90 and 32.96 m though pyrite present in marginal chlorite.	-	37	33	03
QUARTZ-BIOTITE-CHLORITE-SERICITE-SCHIST typically consists of mostly finely interbanded light and dark material. However proportions vary considerably over unit - viz in upper 40 cm quartzite material dominant, with bands, up to 3 cm thick devoid of micaceous partings. Below this, darker material predominates with probable increase in biotite content. Gradual increase again in quartzite content below 33.85 m. Pyrite less common than above (≤0.5%), occuring as rare isolated crystals. Quartz-carbonate segregations, generally barren between 33.72 and 33.82 m.	1	12	34	15
QUARTZITE, pale grey, ?feldspathic in upper 25 cm, and micaceous, with rare chloritic partings in upper 40 cm. Below, micaceous and chloritic partings become more common and even, locally dominant. As a result the unit contains thin bands of quartz-chlorite-biotite-sericite-schist which have a conspicuous schistosity. Inclination variable due to late minor folding but mostly fairly steep. Pyrite, throughout, but erratically distributed with only rare enriched zones, generally occuring in more schistose part.	1	60	35	75
CHLORITE-SERICITE-QUARTZ-SCHIST, finely striped, with closely-spaced schistocity palnes resulting in extremely fissile rock. Band of micaceous quartzite between 35.82 and 35.91 m. Quartz and minor calcite segregations common in lowest 13 cm, and constituting entire lower 7 cm of unit. Pyrite quite restricted - most commonly seen in quartzitic band and adjacent to carbonate-quartz segregations at 35.91 m which also includes traces of chalcopyrite.	-	43	36	18
MICACEOUS QUARTZITE with chlorite, sericite, biotite partings which die out below 36.37 m. However , rock retains its appreciable (disseminated) mica content, particularly in lowest 15 cm. Occasional quartz segregations with marginal coarse chlorite sporadic pyrite crystals throughout- ≤ 5 mm - overall probably 0.5-1%.	-	80	36	98
CHLORITE-SERICITE-QUARTZ-SCHIST with light and dark stripes inclined at 80°. Pyrite present as irregular distribution and also in calcite veinlet.	-	11	37	09
c/forward	37	09		

(5630) 397785 £m 8/76 CP(A)Ltd.

SECTION OF MEALL MHOR BOREHOLE NO.1

Six-inch (County and Quarter Sheet) ARGYLL 191 NE

	Thickness Metres		Depth from Surface Metres	
b/forward	37	09		
CHLORITE-BIOTITE-QUARTZ-SCHIST, darker than above but fine striping retained. Considerable folding with both "s" and "z" shapes and occasional development of strain-slip cleavage associated with horizontal crenulation. In general, unit broken into small pieces and stained with haematite. Pyrite rare to absent.	-	73	37	82
QUARTZITE, pale grey, micaceous to sparsely micaceous. Probably feldspathic in upper 32 cm, below which slight darkening may reflect its absence. Rather more feldspathic again between 38.37 and 38.70 m. Bands of chlorite-sericite-biotite-quartz-schist from 38.81 to 38.92 m and at 40.00 m there is a further schistose horizon this time surrounding quartz segregations. Rather more micaceous (partings) in lowest 15 cm. Inclination genarlly about 60°. Haematite relatively common on joints, but most noticeable in schistose bands and in zone of movement between 40.37 and 40.74 m. Zone of movement from 40.37 to 40.51 m consists of reddish (feldspathic? or haematite) quartzite with chloritic partings. Haematite occurs on foliation plane and, along with, calcite, on joints. From 40.51 to 40.60 m core is reduced to small fragments. Original rock probably quartz-sericite-schist with traces of chlorite. The pelitic stripes have largely been replaced by haematite, whereas the psammitic layers show incipient brecciation. Remainder of zone consists of unbroken, but haematised schist. Below this disturbed zone there are several more pelitic horizons, all having strong haematisation. Haematite and calcite are frequently seen on joints within the quartzite. The overall distribution of pyrite is erratic (probably $<0.5\%$). Slight enrichment is evident in the pelitic units and occasionally in the quartzite, where, over about 8 cm, it may form ≤ 2-3%. Between 38.21 and 38.40 m there is a 1.5-2 cm thick zone in which pyrite forms $\leq 60\%$. Remainder appears to consist of quartz and haematite/limonite. This may be a vein but its parallel to the bedding/foliation.	3	44	41	26
QUARTZ-BIOTITE-CHLORITE-SERICITE-SCHIST, heterogeneous admixture of quartzitic and pelitic units ranging from coarser than average striping (1-5 mm) to banding (10 cm). Coarser bands are of quartzite which may be devoid of pelitic partings. Pelitic units seldom devoid of quartz.				
c/forward	41	26		

	Thickness		Depth from Surface	
	Metres		Metres	
b/forward	41	26		
Variations - sericite practically absent in upper 50 cm. Pink feldspar, generally in the form of thin laminae, occasionally seen. Foliation/banding has variable inclination - viz steeply inclined or occasionally vertical in upper 2 m, whereas in lowest metre generally 10-20°. Folding common, ranging from tight isoclines with vertical strain slip cleavage to broad open late flexures. Pyrite throughout (3-5%) with two bands (≤4 cm thick) having 40%. In places it is distinctly concentrated in the pelitic units but it may equally well occur as a dissemination through the quartzite. Although trains of grains are present, the pyrite mostly occurs as discrete crystals (average 1 mm; max 9 mm). Well-formed cubes are common	3	36	44	62
QUARTZITE, greenish grey (probably as a result of finely divided chlorite) with partings and bands (up to 1.5 cm thick) of chlorite and sericite. Small flakes of biotite sporadically developed with occasional ?feldspar lits. Rare quartz feldspar segregations. Late flexures and folds common giving rise to variations in inclination from 20-70°. Pyrite rare to absent above 46.50 m. Reappears below this dominantly as (often discontinouus) trains which are not always related to foliation or pelitic units. Genrally 1-2 mm thick but may be 5 mm. More rarely it occurs as discrete crystals in quartzite. Genrally forms ≤0.5%.	3	06	47	68
CHLORITE-SERICITE-QUARTZ-FELDSPAR-SCHIST, finely striped with probably 50:50 distribution of light and dark material. Quartz-feldspar band in lowest 10 cm comprises relatively coarse intergrowth. Pronounced crinkling in horizontal banding/foliation. Pyrite throughout but only poorly developed in coarse quartz-feldspar band. Probably forms 0.5 to 1%, occuring mainly as discrete crystals with occasional trains.	-	42	48	10
QUARTZITE pale greenish grey, much as above, with sericite and chlorite. Partings of same + ?biotite become more evident below 48.60 m, and near base bands of chlorite/sericite occur rarely. Pink feldspar also occur rarely. Inclination (of foliation) genarally 70-90° but horizontal between 49.22 and 49.32 m. Pyrite present throughout forming (overall) 1-2%. Shows slight increase downwards, in sympathy with pelites, and some zones of enrichment. A few quartz-feldspar veinlets are present.	1	33	49	43
c/forward	49	43		

(5630) 397785 6m 8/76 CP(A)Ltd.

SECTION OF MEALL MHOR BOREHOLE NO. 1

Six-inch (County and Quarter Sheet) ARGYLL 191 NE

	Thickness Metres		Depth from Surface Metres	
b/forward	49	43		
CHLORITE-SERICITE-SCHIST, core reduced to quite small fragments of dark green rock, with closely spaced schistocity planes, separated occasionally by quartz or quartz/pink feldspar stripes. Since the feldspar is similar to that in the quartz-feldspar veinlets, these stripes may be injection features. Although minor folding is common, the foliation is, in general subhorizontal. Pyrite occurs throughout (about 1%) with some enriched horizons, generally as discrete crystals. Veins of quartz and calcite occur rarely.	-	66	50	09
BORE COMPLETE	50	09		

SECTION OF Meall Mhor BH 2

Borehole inclined at 50° towards 120° M

Surface Level ... O.D.

Communicated by IGS Highlands and Islands Unit

Date of boring or sinking ... Borer IGS Geochemical Division

One-inch Map 58 Six-inch Map Argyll 191 NE

958116 4M 2/75 J.F.&S. 275

	Thickness Metres		Depth from Surface Metres	
OVERBURDEN 24 cm only of broken and weathered schist	3	81	3	8
CHLORITE-SERICITE-QUARTZ-SCHIST, finely banded dark green rock with occasional quartzite bands ≤ 5 mm. Small flakes of biotite are generally present in the lighter bands, whereas some of the quartzite bands have pink garnets ≤1 mm across. The inclination of the foliation, as a result of late brittle folding, ranges from 65-90°. The unit is also highly crumpled in parts				
Occasional pyrite and chalcopyrite in patches	1	05	4	8
SPARESLY MICACEOUS QUARTZITE, white, with only rare discontinuous dark partings. However, between 5.11 and 5.22 m there is a zone rich in chlorite sericite laminae and, in the lowest 8 cm the rock is slightly darker. Rare biotite porphyroblasts occur. Inclination of foliation 55-60°. Speccartite and discontinuous laminae of pyrite <0.1% with rare chalcopyrite	0	65	5	51
Core lost except for a few fragments of chlorite-sericite-schist	0	47	5	9
QUARTZ-SCHIST, much as above, though the quartz is occasionally suppressed. Quartz segregations are occasionally seen. Despite crumpling the banding is generally steeply inclined. Some tight folding. Sporadic pyrite - generally discrete anhedra, but occasionally forms trains along schistosity. Overall probably ≤0.5%, chalcopyrite is rare. A few quartz-feldspar veins are present, one of which carries pyrite; carbonate veins are less common. Limonite coats some of the joints.	2	10	8	0
QUARTZITE, off white to pale grey with irregularly-spaced sericite partings inclined at 45°				
Pyrite and chalcopyrite present in partings. Limonite coats joints and surrounds pyrite	0	95	9	0

c/f

	Thickness		Depth from Surface	
	Metres		Metres	
b/f	0	95	9	03
SILICEOUS SCHIST (highly micaceous quartzite), darker than above quartzite (probably reflecting the increase in chlorite content), with bands of quartz-chlorite-sericite-schist ≤16 cm, inclined at 55-70° Pyrite is irregularly distributed with the usual concentration in micaceous partings. There are also some enriched horizons in the quartzite. Overall, pyrite forms 0.5-1%, but the chlorite-sericite partings have about 5% and conspicuous limonite. Pyritous laminae common between 10.23 and 10.46 m	1	50	10	53
MICACEOUS TO SPARSELY MICACEOUS (?) FELDSPATHIC QUARTZITE, inclined at 55°. Trains of pyrite and chalcopyrite <1 cm thick. The latter is particularly evident from 11.50 to the base. 4 cm thick vein of quartz and feldspar between 11.24 and 11.32 m carrying pyrite, chalcopyrite and sphalerite.	1	39	11	92
SILICEOUS SCHIST, essentially quartzite with closely-spaced sericite/chlorite partings, inclined at 60° Finely disseminated pyrite forming about 2-3%	0	30	12	22
HIGHLY MICACEOUS QUARTZITE, almost a siliceous schist, and quite coarse in parts. Also probably quite feld-spathic. Inclination 50°. Pyrite is quite scarce in the upper part and has probably an overall distribution of 0.5-1%. It occurs as a dissemination and as trails of grains	0	84	13	06
SPARSELY MICACEOUS QUARTZITE, inclined at 60°. Pyrite generally as discrete crystals ≤1 mm, which often form a fine dissemination, constitutes 0.5%. Like chalcopyrite and sphalerite it is occasionally concentrated along micaceous partings. Rare limonite on joints.	2	44	15	50
MICACEOUS QUARTZITE (almost a quartz-schist), quite coarse in parts and possibly feldspathic. Below 16.05 m frequently discontinuous chloritic partings become common, though not universal. Inclination 60°. Pyrite occurs as a fine dissemination of well-formed cubes ≤1 mm. Content increases around 17.00 m from 0.5 to 0.5-1%. Noticeably enriched (2-3%) between 17.00 and 17.20 m	3	49	18	89

c/f

(249/1589) D. No. 248420 5,000 7/72 M. & S., Ltd. G249

SECTION OF Meall Mhor BH 2

Six-inch Map (County and Quarter Sheet) Argyll 191 NE

	Thickness Metres		Depth from Surface Metres	
b/f	3	49	18	89

QUARTZITE, pale grey rock, darker than above - possibly reflecting a decrease in feldspar content. Chloritic partings also absent. However, several pelitic-rich horizons occur - notably between 20.42-20.53 m (where it is accompanied by thin quartz-feldspar segregations) and 20.94-21.06 m. General decrease in pelitic material between 21.60 m. and 22.60 m. Possible volcanic horizon 1 cm thick at 21.45 composed of yellowish white feldspar and hornblende. Enriched in pyrite, particularly at margins, relative to adjacent quartzite. Inclination - 60° at 18.95 m, 65° at 20.68 m and 70° at 22.60 m. From 20.85 to 20.94 m the core is broken into smaller fragments and the closely-spaced joints are lined with clay.

Pyrite throughout much of unit - present as fine dissemination in quartzite ($\leq$1%), as filamental and thread-like concentrations in micaceous partings and as discrete cubes $\leq$1 mm across. Enriched zones present - 20.42 - 20.53 m (associated with pelitic-rich zone), 20.68-20.78 m (with associated dark?sulphide) and between 22.30 and 22.45 m along with rare thin quartz veinlets. Veins - all inclined between 60 and 80°

(1) 19.28-19.60 m - massive white quartz with subordinate pink and white feldspar (pink colouration probably the result of alteration - having a tendency to concentrate on vein margins and in cracks. At its base the vein occupies the whole of the core, whereas, in the upper 14 cm it is 2-2.5 cm thick. Vein contains irregular patches of pyrite, up to 1 cm across, which, on occasion are intergrown with galena. ? Stibnite rarely present.

(2) 19.85-20.10 m, ranges in thickness from 6-8 mm and contains variable proportions of quartz and feldspar, the latter being occasionally dominant. Pyrite is extremely coarse, often forming euhedral cubes $\leq$7 mm across.

(3) 21.13-21.38 m, two quartz-feldspar veins $\leq$8 mm thick with marginal reddish-pink alteration and traces of pyrite

	4	17	23	06

CHLORITE-SERICITE-QUARTZ-SCHIST, with wavy foliation having overall inclination of 70°.

Pyrite extremely common, possibly $\sim$5% (with ? chalcopyrite). Thin smear of clay on joints.

	0	29	23	35

c/f			23	35

	Thickness		Depth from Surface	
	Metres		Metres	
b/f	0	29	23	35
QUARTZITE, pale grey with micaceous wisps and partings (much as above). Below 23.93 m mica content diminishes. Pyrite disseminated throughout, and with an overall distribution of 1-2% is richer than the above unit. Below 24.56 m, although the proportion of finely disseminated pyrite remains unchanged, enriched zones appear with up to 15%. Biotite is particularly noticeable in some of these zones. Traces of pyrite appear 2 cm from the base. Quartz-feldspar veins with marginal deep red (? haematite) staining and occasional pyrite are present between 23.70 and 23.88 m. Pyrite and haematite films on joints.	0	93	25	28
QUARTZ-SERICITE-CHLORITE-SCHIST, very finely interbanded light and dark rock with wavy foliation inclined (generally) at 55°. Pyrite common, but tends to be concentrated along micaceous layers	0	25	25	53
SPARSELY MICACEOUS QUARTZITE, pale grey with prominent development of chloritic partings near base. Pyrite disseminated throughout with the usual film-like concentrations on micaceous partings. Individual crystals ⩽2 mm. Pyrite content increases towards base and there is noticeable concentration along contact between units	0	33	25	86
CHLORITE-SERICITE-SCHIST with irregular patches of quartz and feldspar. Pyritous, but not as rich as overlying quartzite. Traces of clay on joints	0	16	26	02
QUARTZITE, paler than above rocks, probably indicating a decrease in the amounts of feldspar and mica. Highly micaceous and schistose phase between 26.78 and 26.90 m (practically a quartz-mica-schist), and in lowest 3-4 cm there are several quartz-feldspar segregations. Foliation inclined at 60°. Finely disseminated pyrite (and traces of chalcopyrite) throughout with enriched zones associated with mica. There is also a significant increase (⩽5-10%) in pyrite content around 27.00 m. In the lowest 3-4 cm, although the overall sulphide content remains unchanged, the proportion of chalcopyrite increases with crystals ⩽3 mm	1	33	27	35
c/f	1	33	27	35

(249/1589) D. No. 248420 5,000 7/72 M. & St., Ltd. G249

SECTION OF Meall Mhor BH 2

Six-inch Map (County and Quarter Sheet) Argyll 191 NE

	Thickness		Depth from Surfa	
	Metres		Metres	
b/f	1	33	27	35
<u>QUARTZ-SERICITE-CHLORITE-SCHIST</u>, above 28.30 m consists of finely banded rock with variable proportions of quartz and pelitic material and occasional bands of micaceous quartzite. Below this unit consists mainly of micaceous quartzite with irregular dark green chloritic partings and stripes, with only rare sericitic partings. Chloritic bands become more evident in lowest 40 cm. Wavy foliation in upper 40 cm generally inclined between 45 and 65°, but highly crumpled below. <u>Pyrite</u> present throughout, being particularly common in the quartzitic bands between 27.60 and 27.80 m where it is present as a dissemination of crystals ≤2 mm. It is less common in sericite-rich portions, but is commonly associated with chlorite. Haematite is associated with pyrite in lowest 10 cm, and patches of chalcopyrite occur around 28.20 m. <u>Carbonate veins</u> - two present between (1) 27.40 and 27.60 and (2) 27.78 and 28.80 m. Comprise coarsely crystalline pink ? dolomite with subordinate pale yellow calcite and minor quartz, containing rare angular country rock fragments. A few large crystals of pyrite occur on the margins.	1	40	28	75
<u>QUARTZITE</u>, pale grey ranging from sparsely to highly (particularly between 29.52 and 29.72 m) micaceous. Biotite is the dominant mica, but rare chlorite/sericite partings are present in upper 55 cm. Chlorite/sericite bands common between 29.42 and 29.52 and between 30.03 and 30.06 m. Overall <u>pyrite</u> content much less than above, principally due to the loss of the highly disseminated portion. Enriched streaks persist, they too are thinner than above. <u>Chalcopyrite</u> is, however, commoner than above, particularly below 30.40 m where it is probably the dominant sulphide. <u>Veins</u> (1) 0.5 cm thick quartz feldspar vein with abundant pyrite at 29.30 m. (2) Between 29.85 and 30.06 m a limited stockwork of feldspathic veins - pinkish, with white centres in larger examples. Contain well-formed <u>pyrite</u> cubes 8 mm with <u>chalcopyrite</u> and rare <u>sphalerite</u>. The latter two sulphides also occur in the adjacent quartzite. (3) Quartz vein, with patches of <u>chalcopyrite</u> 1 cm across and forming ≤1%, is present between 30.06 and 30.34 m	2	87	31	62
c/f			31	62

	Thickness		Depth from Surface	
	Metres		Metres	
b/f	2	87	31	62
QUARTZITE, similar to above but has a higher proportion of pelitic bands. These range from thin (1-2 mm) partings to bands (≤10 cm thick) and comprise chlorite, sericite and ? biotite. Inclination 25-30° at 31.90 m. Possibly as a result of the increased pelitic content, the proportion of sulphides exceeds that of the preceeding unit. Pyrite becomes more common in the pelitic bands. Chalcopyrite commonly occurs below 32.72 m, occasionally within quartzite, but mostly surrounding or within quartz ± feldspar veins and segregations	0	40	33	02
QUARTZ VEIN, massive, white with limonite on joints	1	03	34	05
QUARTZITE, with interbanded chlorite-sericite-shist units ranging in thickness from 5 mm-9 cm. Thin bands of more feldspathic quartzite present between 34.98 and 35.02 m and dominant below 35.38 m. Also some pinkish feldspathic laminae between 34.29 and 34.36 m. Inclination 40° at 34.13 m. Pyrite present throughout, though pelitic bands relatively enriched. Content ranges from 0.5-1% in quartzites to 10% in pelites. Crystal sizes generally greater than above being frequently in the order of 1.1-1.2 cm. Also traces of ? sphalerite between 34.44 and 34.66 m. Quartz vein between 34.17 and 34.32, steeply inclined and 4 cm thick	1	48	35	53
QUARTZ-BIOTITE-CHLORITE-SERICITE-SCHIST, fine banded which characterises this rock disappears between 35.85 and 36.55 m - apparently because the quartz bands are lensed. Banding inclined at 35° near top, and despite late open brittle folding seldom exceeds 20° in remainder. Below 36.25 m becomes highly crumpled - and there is no dominant inclination. Pyrite present throughout, particularly common in upper 70 cm (≤5%) but decreases below this to probably 1-2%. Crystals ≤1.2 cm. Chalcopyrite visible below 36.25 m. Quartz + rather more mafic looking feldspars veins/segregations common between 36.25 and 36.60 m	1	66	37	19
QUARTZITE, pale grey with greenish colour banding in upper 20 cm and lowest 50 cm. Below 37.39 m rock becomes more sericitic. Inclination 30° at 37.25 m steepening rapidly				
c/f			37	19

(249/1589) D. No. 248420 5,000 7/72 M. & St., Ltd. G249

SECTION OF Meall Mhor BH 2

Six-inch Map (County and Quarter Sheet) Argyll 191 NE

	Thickness		Depth from Surfa[ce]	
	Metres		Metres	
b/f			37	19
below 35.45 (as a result of large-scale folding) and then reverting to about 20° below 38.10 m. There is also a small breccia zone between 37.58 and 37.68 m, where the core is reduced to small fragments and has limonite on joints. May be associated with late stage brittle folding. Pyrite present throughout, showing the usual quantitative association with pelitic material. Occurs principally as discrete crystals (≤1 cm) which, nevertheless form trains parallel to the foliation/banding. Probably ranges in content from <1% in poorly micaceous quartzites to 3% in the more micaceous portions and even 5-10% in a band of chlorite-sericite-schist between 38.66 and 38.77 m.	1	69	38	88
QUARTZ-MICA-SCHIST, mid to dark grey, finely and coarsely interbanded quartzite (dominant) and biotite-schist, with occasional darker chloritic bands. Sericite is common in the more pelitic horizons below 39.95 m. A fairly compact rock in which the schistosity is not always evident. Inclination 20° at top and at 41.00 m. Pyrite present throughout probably forming ≤ 2-3%. Form similar to that in above unit. Vein of white quartz between 40.14 and 40.16 m, and in lowest 90 cm numerous thin quartzo-feldspathic veinlets, generally parallel to the core axis	2	34	41	22
CHLORITE-SERICITE-SCHIST, fine banding noticeably affected by late brittle folds ('S' and 'Z' forms). Between 41.30 and 41.43 m the rock was partly replaced by quartz and feldspar prior to the late folding. Pyrite irregularly distributed throughout, lending to increase in concentration below 41.43 m. In lowest 12 cm a quartz-feldspar vein up to 2 cm thick, carry pyrite and more rarely chalcopyrite with ? sphalerite.				
End of bore	0	34	41	56

SECTION OF Meall Mhor BH3

Surface Level .... O.D.

Communicated Feb 1977 by IGS Highlands and Islands Unit

Date of boring or sinking Feb 1977 Borer IGS Geochemical Division

One-inch Map 58 Six-inch Map Argyll 191 NE

958116 4M 2/75 J.F.&S. 275

	Thickness		Depth from Surface	
	Metres		Metres	
Fragments of micaceous quartzite carrying strataform chalcopyrite and vein quartz, probably part of spoil heap. 12 cm only seen.	2	45	2	45
MICACEOUS QUARTZITE, pale grey with frequent iron staining, noticeably etched and weathered and generally in small pieces. Seritic and dark ?chloritic partings. Inclination of foliation 50° at top, steepening to 80° between 2.85 and 3.05 m and then reverting to 50° at base of unit. Some thin (0.5 cm) concordant quartz-feldspar veinlets at top and bottom of unit.				
Chalcopyrite, possibly forming up to 2%, occurs in distinct stratiform layers generally less than 1 cm but occasionally up to 1.5 cm thick - particularly rick between 2.88 and 3.07 m (≤20%) where it appears to occur in chlorite-quartz aggregates and is weathered black. In the lowest 10 cm the mineral is less weathered and forms larger pieces.	0	86	3	31
PSAMMITE, upper 40 cm darker than above rock, possibly due to an increase in the pelitic content. In addition rock contains distinct chlorite-sericite bands which have associated quartz and pink ?carbonate. Below this, a more homogeneous pale grey micaceous psammite persists. Conspicuous epidote in lowest 5 cm. Inclination of foliation 35-45° rare concordant quartz + occasional carbonate veinlets and chlorite strings (probably segregations) pyrite occurs in sporadic crystals 9 cm of core lost in upper 55 cm	0	81	4	12
CHLORITE-BIOTITE-QUARTZ-SCHIST, finely striped - possibly a green bed. Inclination c 45°				
Pyrite present throughout, c 2-3%, generally in trails parallel to foliation/bedding 0.8 cm thick. Larger trains appear to be associated with quartz segregations.	0	08	4	20
PSAMMITE (highly micaceous quartzite) pale grey with thin epidotised bands dominant in lowest 10-15 cm. Biotitic band c 1 cm thick 9 cm from base. Crystals of coarse dark amphibole appear 5 cm from base and increase in size and				
c/f	0	08	4	20

	Thickness	Depth from Surface
	Metres	Metres
b/f	0 · 08	4 20

quantity downwards, and in the lowest zone they are coarsely intergrown with epidotised quartzite, calcite and chalcopyrite. Inclination 30°.

Pyrite in scattered grains up to 5 mm is particularly noticeable between 4.20 and 4.50 m where it may be up to 1%. | 0 45 | 4 65 | 4.60 m cx450

EPIDIORITE upper 20 cm of a finely striped rock, comprising alternating hornblendic (partly replaced by mica) quartzose and chloritic laminae - some of the coarser quartz and chlorites resemble segregations. Occasional pink garnets and pyrite enriched horizons. 4.77 m cx 4[illegible]
A few epidotic bands occur principally in the quartzose bands. Below this, banding fades away possibly as a result of the increase in epidote content. Riddled with irregular veinlets and patches of ?calcite + Quartz ± carbonate segregations less common. 5.05 cm cx 4[illegible]

Chalcopyrite, stratiform, occurs generally in the upper part. Occasional pyrite patches up to 1.5 cm. | 0 47 | 5 12 |

EPIDOSITE (epidotised epidiorite) with conspicuous light and dark colour banding - the result of variable amounts of epidote. This banding is generally very irregular, frequently wavy and occasionally gives way to a blotchy texture, particularly below 11.00 m. True epidosite bands are up to 15 cm thick. Inclination 20° at top, 7.00 and 9.00 m, 25° at 16.95 and 20° at 18.95 m. Banding apparent again below 11.20 m generally inclined at 20-30°. Below 15.67 m amount of epidotisation drops markedly and rock may more accurately be termed an epidotised epidiorite with bands of epidosite. Below 17.00 m becomes quite noticeably striped - the result of an increasing proportion of lighter material - mostly calcite but also some quartz. Striping temporarily obscured between 18.40 and 18.905m by strong epidotisation but reappears again below. In lowest 23 cm numerous regularly-spaced epidotic bands which display significant along-strike variations in thickness (1 cm)
Calcite is present throughout as irregular lenses (segregations - some quasi-parallel to banding), up to 4 x 4 cm, and distinct cross-cutting veinlets up to 0.5 cm thick. A "pepper and salt" texture is generally present suggesting both white and black calcite are present. Dark mineral is absent from larger patches. Some veins have marginal hematite. Quartz-calcite veinlets - 2 cm thick 10.25-10.31 m - 1 cm thick inclined at 60° and with minor pyrite and chalcopyrite at 17.42. Further quartz vein with minor calcite and inclined at 20° between 18.48 and 18.50 m

	Thickness	Depth from Surface
c/f	0 47	5 12

	Thickness		Depth from Surface	
	Metres		Metres	
b/f	14	23	19	35
below 22.20 with core broken and fractured between 22.75 and 23.03. <u>Pyrite</u>: variable over section but relatively common in the main; common between 19.43 and 19.45 with crystals up to 2 cm, absent below this reappears at 20.05 gen. as isolated crystals with enriched zones at 20.30 and between 21.02-21.10. More finely divided below 21.20. Abundant (<u>Ca</u> 5%) between 21.59 and 21.93 apparently related to high epidote content, similarly below 22.70 (2-3% sulphide) where it is partly mashed by haematite. <u>Chalcopyrite</u> Sparse compared with <u>pyrite</u> present as splashes at 19.54, 19.77, 20.18, 20.61 and as fine disseminations between 21.22-21.43. Small stringers, parallel to foliation at 22.07-22.12, 22.21, 22.40,22.50.	3	83	23	18
EPIDOTISED PSAMMITE Irregular bands of epidosite present, conspicuous cracks and tension gashes produce pseudobreccia appearance in places. Latter particularly noticeable in epidosite, infilled with dark fibrous mineral between 24.20-25.40. Banding inclined 35-40° at 23.50 and at 30° at 25.50 m. Quartz-feldspar veins, 5 mm minor <u>chalcopyrite</u> at 25.10 m; Carbonate-haematite vein steeply inclined at 26.02 m. <u>Pyrite</u> common above ? (≤1%) ranging in form from disseminations to trails of grain < 5 mm; chalcopyrite rare. Dark unidentified (?) sulphide at 25.64 m	3	40	26	58
EPIDIORITE - fine mafic schist. Upper 5 cm, highly schistose alternating chlorite and psammite stripes passing down in fairly coarse rock with quartz-amphibolite and thin epidotic stripes. Becoming finer below 26.81 with thicker epidotic bands and no definite amphibolite. Banding inclined 40°. <u>Chalcopyrite</u> strings throughout overall < 1% mostly concentrated in upper 15 cm; rare patchy <u>pyrite</u>	0	57	27	15
EPIDOTISED QUARTZITE Pale greenish grey with darker bands between 27.17 and 27.29 also below 27.85. Darker bands probably chlorite and biotite ± (?) amphibole in upper group. Banding inclined 25° at 27.31 m and 40° at 27.95.				
c/f	0	57	27	15

(249/1589) D. No. 248420 5,000 7/72 M. & St., Ltd. G249

SECTION OF Meall Mhor BH3

Six-inch Map (County and Quarter Sheet) Argyll 191 NE

	Thickness Metres		Depth from Surface Metres	
b/f	0	47	5	12

Overall sulphides are rather sparse forming irregular crystals and occasional clusters. Below 17.00 m total sulphide content probably around 1% of which chalcopyrite is more than half.

18.09 cx 456 Pyrite, subordinate to chalcopyrite in upper 50 cm but forms larger grains (≤2.5 cm) often associated with calcite (and with peripheral sphalerite at 9.91 and 10.11-10.15 m). More massive patches again with traces of ?sphalerite 10.53-10.83 m . ?Sphalerite again appears 10.84-11.04 m. Pyrite present in shears 11.21-11.25 m and in massive patches at 12.23 and 12.70. Very common with associated rare chalcopyrite in relatively unepidotised epidiorite (13.40-13.50 m) - and in massive patches with fine chalcopyrite 14.15-14.26 and 15.42-15.47 m. Well formed crystals (cube and pyritohedra) common between 16.45 and 16.95 m. Core enriched in pyrite down to 18.40 m - below which rare single crystals only seen.

Chalcopyrite relatively common in upper 50 cm but still probably less than 0.5%. Slight enrichment (with pyrite) 6.45-6.50 m. Probably forms up to 0.5% between 6.69 and 6.83 m. Further large irregular patches with calcite and peripheral sphalerite - 7.25-7.27 and 7.37-7.41 m. Also present in smaller grains with sphalerite (and subordinate to pyrite) in calc vein 7.61-7.65 m. Traces visible 8.12 and 8.72 with subordinate pyrite and below this seems to occur as very finely divided crystals but is not disseminated throughout. A few larger (≤1 cm) patches at 9.17 m and in a calcite vein 10.24-10.27. Trace at 11.84 and thin concordant trails at 12.77 and 14.80 m. Also occasional spots and rare patches at 14.97 m and (subordinate to pyrite) at 15.18 m. Notable increase in chalcopyrite between 15.85 and 16.37 m. Occurs again at 16.68, 16.70 and 16.82 m but subordinate to pyrite. Splashes between 17.12 and 17.14 m - trails 17.45-17.61, both forms common 18.00-18.15 m while they are up to 0.5 cm and often associated with pyrite. — 14 | 23 | 19 | 35

EPIDOTISED EPIDIORITE, paler than above due partly to the increase in calcite content and partly to the replacement of hornblende by pale green amphibole. Regularly spaced epidote bands ≤2 cm inclined 30° at 19.45 m, bands thicker below 20 m (≤9 cm) but become less common. Below this v. homogeneous epidiorite with less intense epidotisation; haematite staining along joints

c/f	14	23	19	35

(249/1589) D. No. 248420 5,000 7/72 M. & St., Ltd. G249

SECTION OF ....Meall Mhor BH3

Six-inch Map (County and Quarter Sheet)..............Argyll 191 NE

	Thickness		Depth from Surface	
	Metres		Metres	
b/f	0	57	27	15
Quartz-calcite veinlets at 27.20 and 27.85 former with blackened <u>pyrite</u> Rare <u>pyrite</u> elsewhere.				
Evidence of some movement at base epidotic band cut by tension cracks.	1	01	28	16
CHLORITE-SCHIST ?Greenbed. Fine grained dark green rock with interbanded pale greenish grey epidotic quartzite units ranging in thickness <0.5 m to >3.0 m, and rare epidorite. Both these relatively competent units show brittle deformation, ranging from tension cracks to brecciation. Inclination 30° at 24.70 though folding is not uncommon.				
Rare quartz-carbonate veinlets and isolated porphyblasts.				
<u>Pyrite</u> present as stringers parallel to foliation below 30.42 m	2	52	30	68
CHLORITE-SCHIST Fine grained and paler than above with no banding but irregular patches and lenses of epidorite with prominent tension gashes. Schistosity inclined at 30°.	0	43	31	11
SEMI-PELITE interbanded green-grey psammite and dark chlorite-biotite schist banding inclined at 40°, haematite on joints. Calc-quartz vein 31.29-31.34 m	0	35	31	46
PSAMMITE Greenish-grey with paler bands of (?) epidorite and darker chloritic bands; while (?) carbonate veinlets and patches. Schistosity inclined at 30°				
<u>Pyrite</u> widely scattered below 31.75 m, locally good cubes $\leqslant$ 3mm and minor chalcopyrite.				
CHLORITE-SERICITE-SCHIST Variable in appearance upper 50 cm eg numerous epidorite bands with tension gashes and ubiquitous ?calcite 'spots' and quartz calcite veins and segregations. Below 33.00 and 33.60 finely striped alternating chlorite schist and carbonate bands; below 33.78 m psammitic band <5 cm.	1	04	32	50
Between 34.06 and base returns to finely striped unit with, in addition, psammite bands.				
Folding evident in pelitic units, outwith banding inclined 40° at 32.85 and 40-50° at base.				
c/f	0	35	31	46

	Thickness		Depth from Surface	
	Metres		Metres	
b/f	0	35	31	46
Pyrite common <1% between 33.06 and 37.42; rare outside this zone	2	91	34	37
MICACEOUS PSAMMITE 'Salt and pepper' texture with pale sometimes epidosite stripes in lowest 20 cm, and darker partings. Banding inclined 20° at base. Widely scattered idioblastic pyrite	0	55	34	92
E o BH				

APPENDIX II

Drill-core Assays

Methods

The drill-core was split, and one half crushed in a jaw crusher and finally ground in an agate tema mill. Samples MMD 201-243 were ground by mistake in a tungsten carbide mill and are slightly contaminated with cobalt as a result. The ground samples were analysed for Cu, Pb, Zn, Co, Ni and Ag by atomic absorption spectrophotometry.

MEALL MOR BOREHOLE 1.

MMD	Depth (m) From	To	Thickness (m)	Cu	Pb	Zn	Co	Ni	Ag
				All values in ppm					
201	0.00	1.25	1.25	35	10	60	50	20	1
202	1.25	2.10	0.85	15	10	40	35	15	1
203	2.10	3.00	0.90	700	10	40	45	15	1
204	3.00	3.43	0.43	60	10	100	25	25	1
205	3.43	4.43	1.00	1250	10	140	50	20	2
206	4.43	5.055	0.625	550	20	180	30	25	2
207	5.055	5.435	0.38	1120	20	120	60	30	2
208	5.435	6.065	0.63	225	10	90	35	30	1
209	6.065	6.965	0.90	295	20	110	40	40	1
210	6.965	7.945	0.98	340	10	100	35	35	1
211	7.945	8.81	0.865	355	10	110	45	35	1
212	8.81	9.23	0.42	800	10	80	25	20	1
213	9.23	10.12	0.89	5	10	70	25	30	1
214	10.12	11.12	1.00	610	10	140	40	25	1
215	11.12	12.12	1.00	320	10	130	40	35	1
216	12.12	13.12	1.00	110	10	120	45	90	1
217	13.12	14.12	1.00	160	10	130	50	85	1
218	14.12	15.09	0.97	265	10	90	40	75	1
219	15.09	16.08	0.99	150	10	120	45	75	1
220	16.08	17.07	0.99	140	10	70	45	60	1
221	17.07	18.07	1.00	145	10	120	50	50	1
222	18.07	19.07	1.00	1140	10	190	55	20	1
223	19.07	20.02	0.95	730	10	130	65	15	1
224	20.02	21.05	1.03	1000	10	130	65	10	1
225	21.05	22.02	0.97	155	10	160	45	20	1
226	22.02	23.01	0.99	280	10	370	50	90	1

MMD	Depth (m) From	To	Thickness (m)	All values in ppm Cu	Pb	Zn	Co	Ni	Ag
227	23.01	- 23.99	0.98	70	10	370	50	85	2
228	23.99	- 24.93	0.94	200	20	350	55	125	2
229	24.93	- 25.68	0.75	70	10	190	50	165	1
230	25.68	- 26.56	0.88	60	20	160	50	105	1
231	26.56	- 27.17	0.61	30	20	160	50	115	2
232	27.17	- 28.05	0.88	65	20	60	45	15	1
233	28.05	- 28.94	0.89	90	10	130	55	10	0
234	28.94	- 29.81	0.87	115	10	260	50	10	1
235	29.81	- 30.57	0.76	30	10	110	50	10	0
236	30.57	- 31.14	0.57	50	10	70	55	10	0
237	31.14	- 31.69	0.55	35	10	50	95	10	0
238	31.69	- 32.05	0.36	35	10	30	80	5	0
239	32.05	- 32.67	0.62	60	10	260	55	25	1
240	32.67	- 33.52	0.85	125	20	270	35	35	1
241	33.52	- 34.43	0.91	20	10	80	40	15	0
242	34.43	- 35.05	0.62	55	10	100	45	20	1
243	35.05	- 36.04	0.99	140	10	180	60	20	1
244	36.04	- 37.07	0.93	95	10	110	10	15	0
245	37.07	- 37.71	0.64	35	20	170	30	45	1
246	37.71	- 38.62	0.91	30	10	50	10	15	0
247	38.62	- 40.31	1.69	25	10	50	15	25	0
248	40.31	- 41.31	1.00	10	20	70	25	30	1
249	41.31	- 41.95	0.64	25	20	100	25	30	1
250	41.95	- 42.56	0.61	10	20	100	25	35	1
251	42.56	- 44.10	1.54	5	20	90	25	35	0
252	44.10	- 44.63	0.53	5	10	80	20	30	1
253	44.63	- 46.01	1.38	25	10	50	10	20	0
254	46.01	- 46.97	0.96	15	10	60	15	20	0

MMD	Depth (m) From	To	Thickness (m)	All values in ppm Cu	Pb	Zn	Co	Ni	Ag
255	46.97	- 47.55	0.58	5	10	40	5	15	0
256	47.55	- 48.04	0.49	5	20	110	20	35	1
257	48.04	- 49.37	1.33	5	20	50	20	20	0
258	49.37	- 50.04	0.67	40	30	160	25	40	1

MEALL MOR BOREHOLE 2.

MMD	Depth (m) From	To	Thickness (m)	Cu	Pb	Zn	Co	Ni	Ag
				All values in ppm					
259	3.81 -	4.86	1.05	130	20	130	20	40	0
260	4.86 -	5.98	1.12	70	20	50	10	15	0
261	5.98 -	8.08	2.10	75	20	140	15	35	1
262	8.08 -	9.03	0.95	440	20	40	10	15	0
263	9.03 -	10.53	1.50	740	10	50	15	30	0
264	10.53 -	11.92	1.39	390	50	20	5	15	0
265	11.92 -	13.06	1.14	135	20	140	15	15	0
266	13.06 -	16.13	3.07	240	30	120	10	15	0
267	16.13 -	18.59	2.46	125	30	120	10	15	0
268	18.59 -	20.44	1.85	175	230	60	10	10	1
269	20.44 -	21.60	1.16	20	30	20	10	10	0
270	21.60 -	22.56	0.96	40	20	10	10	5	0
271	22.56 -	23.06	0.50	75	10	40	15	15	1
272	23.06 -	23.35	0.29	5	70	30	10	5	0
273	23.35 -	25.28	1.93	150	20	230	10	5	0
274	25.28 -	25.53	0.25	390	20	140	30	20	1
275	25.53 -	25.86	0.33	105	10	40	20	10	0
276	25.86 -	26.02	0.16	65	50	30	15	15	0
277	26.02 -	27.35	1.33	305	10	20	10	5	0
278	27.35 -	28.75	1.40	720	160	210	20	25	2
279	28.75 -	30.40	1.65	2150	230	120	15	10	2
280	30.40 -	31.62	1.22	3080	40	140	15	5	2
281	31.62 -	33.02	1.40	2240	20	260	25	20	1
282	33.02 -	34.05	1.03	35	10	10	5	5	0
283	34.05 -	35.53	1.48	55	30	360	20	35	1
284	35.53 -	37.19	1.66	740	50	200	40	60	2

MMD	Depth (m)		Thickness (m)	All values in ppm					
	From	To		Cu	Pb	Zn	Co	Ni	Ag
285	37.19 -	38.88	1.69	60	10	30	20	10	0
286	38.88 -	41.22	2.34	150	20	80	25	20	1
287	41.22 -	41.56	0.34	110	40	100	20	25	1

MEALL MOR BOREHOLE 3

MMD	Depth (m) From	To	Thickness (m)	All values in ppm Cu	Pb	Zn	Co	Ni	Ag
288	2.45 -	3.31	0.86	27000	30	250	15	20	16
289	3.31 -	4.12	0.81	1600	20	50	10	20	3
290	4.12 -	4.65	0.53	2750	10	20	10	10	3
291	4.65 -	5.12	0.47	4800	20	30	10	10	5
292	5.12 -	6.62	1.50	1700	10	20	5	5	3
293	6.62 -	7.75	1.13	1200	10	20	5	5	3
294	7.95 -	9.38	1.43	680	20	10	5	5	3
295	9.38 -	10.88	1.50	860	10	20	10	5	3
296	10.88 -	12.25	1.37	1000	10	30	10	5	4
297	12.25 -	13.75	1.50	810	10	20	5	10	3
298	13.75 -	14.25	0.50	610	10	30	5	10	4
299	14.25 -	16.95	2.70	2400	20	40	10	10	4
300	16.95 -	18.45	1.50	3100	20	90	20	10	6
301	18.45 -	19.90	1.45	320	20	10	15	5	4
302	19.90 -	21.11	1.21	2300	10	30	15	5	3
303	21.11 -	22.18	1.07	4500	20	520	20	10	3
304	22.18 -	23.68	1.50	870	20	670	20	10	2
305	23.68 -	25.18	1.50	2500	10	20	15	10	2
306	25.18 -	26.31	1.13	20	10	30	10	10	2
307	26.48 -	27.15	0.67	15500	10	120	20	15	10
308	27.15 -	28.16	1.01	240	10	20	5	5	3
309	28.16 -	29.16	1.00	10	10	90	15	30	2
310	29.16 -	30.68	1.52	45	10	60	10	20	1
311	30.68 -	31.64	0.96	15	10	70	10	35	2
312	31.64 -	32.50	0.86	65	10	50	10	10	2
313	32.50 -	33.61	1.11	20	20	100	20	40	2

MMD	Depth (m)		Thickness (m)	All values in ppm					
	From	To		Cu	Pb	Zn	Co	Ni	Ag
314	33.76 -	34.37	0.61	10	20	110	15	25	1
315	34.37 -	34.92	0.55	25	20	30	10	10	1

APPENDIX III

ADDITIONAL BOREHOLES

The three boreholes (BH 1-3) sunk in the Meall Mor-Abhainn Srathain area provided valuable information on the distribution of sulphides and base metal concentrations in the pyrite zone. To complete the 'in core' cross section of the pyrite zone a further five holes were proposed (Fig. A3.1).

The eastern bank of the Abhainn Srathain was shown as the most suitable site for the additional drill holes because:

a. The almost continuous exposure of bedrock in the adjacent stream gorge provided good geological control.

b. There are significant showings of copper minerals in the bedrock of the area although no geophysical or (soil) geochemical anomalies were recorded.

Because of drilling commitments elsewhere only two out of the five proposed sites were occupied. BH 4 was sunk 125 m SSW of the Abhainn Srathain mine workings (BH 3). BH 5 was placed initially 210 m south of BH 3, but because of site instability (due to wet peat) was stepped 8 m to the WNW (BH 5A) after completing 13.70 m. All holes were inclined at 50° on an azimuth of 300° magnetic and the core size used was TAX (33.5 mm core diameter). The results of the chemical assays are given in Table A3.I, and these were obtained by atomic absorption spectrophotometry for Cu, Pb, Zn, Co, Ni and Ag, and by X-ray fluorescence for As.

Results

Borehole 4

The core obtained from BH 4 consists (Fig. A3.2) of quartzite and micaceous quartzite (60%) with bands of quartz-chlorite-mica-schist, chlorite-mica-quartz-schist and chlorite-mica-schist. Pyrite is overall the dominant sulphide being present throughout in small amounts in most rock types. Chalcopyrite is locally dominant over pyrite, particularly in chlorite-mica-schist bands. Despite this, copper assays only exceeded 1000 ppm in the zone between 19.20 and 20.20 m. The irregular patchy distribution of the chalcopyrite may mean that it is slightly overestimated in the borehole log.

TABLE A3.I

CHEMICAL ASSAYS ON BOREHOLES 4,5 and 5A

Sample Number		Depth(m) From	To	Thickness	Cu (ppm)	Pb	Zn	Co	Ni	Ag	As	Ba	Fe (%)
BH4													
MMD	316	1.00	1.97	0.97	80	10	60	10	30	1	2	457	3.99
	317	1.97	3.31	1.34	70	20	60	20	41	1	5	1514	6.10
	318	3.31	5.34	1.03	5	10	20	10	20	0	2	503	3.49
	319	5.34	6.60	1.26	10	10	40	20	30	0	8	1804	5.67
	320	6.60	8.02	1.42	10	10	50	20	30	1	1	1325	5.61
	321	8.02	10.66	2.64	5	20	20	10	20	1	3	550	3.74
	322	10.66	11.50	0.84	25	10	20	10	10	0	3	374	2.63
	323	11.50	12.86	1.36	70	10	30	10	30	1	0	1267	4.31
	324	12.86	14.40	1.54	10	20	50	10	40	1	2	1336	4.96
	325	14.40	15.63	1.23	0	20	50	10	40	1	10	808	4.68
	326	15.63	17.71	2.08	5	20	30	10	30	1	2	652	3.85
	327	17.71	19.15	1.44	70	20	60	20	30	1	0	1271	5.51
	328	19.15	20.21	1.06	7500	20	55	20	50	1	1	2292	6.97
	329	20.21	21.03	0.82	300	20	40	10	50	1	5	705	4.83
	330	21.03	21.90	0.87	900	20	30	10	50	1	2	1072	6.76
	331	21.90	23.20	1.30	70	20	50	20	40	0	1	891	4.73
	332	23.20	24.47	1.27	40	60	40	20	40	0	5	730	5.44

BH4 Cont.

Sample Number		Depth (m) From	To	Thickness	Cu	Pb	Zn	Co	ppm Ni	Ag	As	Ba	Fe (%)
MMD	333	24.47	26.18	1.71	10	30	40	10	40	0	7	932	4.57
	334	26.18	27.99	1.81	0	20	20	10	20	0	4	621	3.67
	335	27.99	29.87	1.88	5	20	20	10	30	1	1	909	4.18
	336	29.87	31.07	1.20	5	20	10	10	20	0	3	532	2.64
	337	31.01	31.87	0.86	5	20	20	10	20	1	6	1401	5.87
	338	31.87	33.62	1.75	0	20	20	10	20	1	2	638	2.97
	339	33.62	35.30	1.68	0	20	30	10	20	0	2	527	2.62
	340	35.30	37.27	1.97	5	20	10	20	30	0	1	1649	6.25
	341	37.27	38.11	0.84	0	10	10	10	20	0	1	413	2.73
	342	38.11	40.23	2.12	10	10	10	10	30	1	2	482	3.21
	343	40.23	41.49	1.26	30	10	20	20	30	1	1	1991	7.38
	344	41.49	42.97	1.48	5	20	20	10	10	0	1	548	3.78
	345	42.97	44.49	1.52	10	100	20	20	20	0	3	1477	5.91

Sample Number		Depth(m) From	To	Thickness(m)	ppm Cu	Pb	Zn	Co	Ni	Ag	As	Ba	Fe (%)
BH5													
MMD	366	5.52	6.13	0.61	250	10	150	40	40	1	4	2281	7.37
	367	6.13	6.99	0.86	270	10	220	40	40	1	9	407	11.87
	368	6.99	8.46	1.47	130	10	800	20	20	0	0	615	6.56
	369	8.46	9.35	0.89	320	10	130	30	30	0	1	361	11.47
	370	9.35	10.56	1.21	260	10	700	20	30	0	1	885	6.78
	371	10.56	11.54	0.98	140	10	240	10	5	0	5	256	1.33
	372	11.54	12.40	0.86	170	10	150	20	20	0	7	597	3.71
	373	12.40	13.56	1.16	3600	10	50	20	10	1	1	206	3.28
BH5A													
MMD	374	1.20	2.07	0.87	3100	10	70	20	20	1	2	504	6.08
	375	2.07	3.56	1.49	1300	10	170	40	40	1	1	356	10.33
	376	3.56	4.75	1.19	2950	10	60	20	20	1	0	304	6.40
	377	4.75	5.56	0.81	4500	10	200	40	40	4	1	242	9.81
	378	5.56	6.78	1.22	800	10	50	10	10	0	0	259	4.18
	379	6.78	9.07	2.29	10	20	40	10	10	0	0	238	4.64
	380	9.07	11.22	2.15	100	10	90	10	30	0	1	435	5.66
	381	11.22	11.92	0.70	150	10	60	10	20	0	1	571	3.94
	382	11.92	13.32	1.40	10	10	70	10	30	0	0	604	5.35
	383	13.32	14.80	1.48	10	10	40	10	20	1	0	68	4.32

BH5A Cont.

Sample Number		Depth(m) From	To	Thickness(m)	Cu	Pb	Zn	Co	Ni (ppm)	Ag	As	Ba	Fe (%)
MMD	384	14.80	16.00	1.20	500	10	80	20	30	0	0	328	7.37
	385	16.00	16.82	0.82	200	10	30	10	10	0	0	100	3.31
	386	16.82	17.80	0.98	70	10	10	10	5	0	8	11	1.54
	387	17.80	18.48	0.68	50	10	50	10	5	0	2	215	1.48
	388	18.48	19.80	1.32	130	10	170	5	10	0	14		
	389	19.80	21.45	1.65	445	10	100	25	25	1	1		
	390	21.45	23.28	1.83	330	10	60	25	25	1	1		
	391	23.28	25.83	1.55	340	20	70	25	25	1	1		
	392	25.83	27.56	1.73	45	10	10	5	5	1	9	not determined	not determined
	393	27.56	28.88	1.32	70	20	30	5	10	1	51		
	394	28.88	30.35	1.47	110	10	60	15	25	0	3		
	395	30.35	32.26	1.91	420	10	50	15	30	1	2		

<u>Note</u> Antimony was below the limit of detection (11ppm) of the XRF method in all the samples.

Borehole 5

BH 5 (Fig. A3.3) penetrated chlorite-mica-schist (40%), epidiorite (30%) and micaceous quartzite (30%). Pyrite is distributed throughout but is noticeably concentrated in the lowermost metre where it is reflected by a 3600 ppm copper assay. Elsewhere the copper content lies below 350 ppm, but is generally higher than in BH 4, especially in the epidiorite units.

Borehole 5A

The distribution of rock types in BH 5A (Fig. A3. 4) is broadly comparable with that in BH 4 with the additional presence of epidiorite. The uppermost 9.6 m comprise quartzite which in part is strongly epidotised. Above 5.53 m the core is strongly enriched in chalcopyrite and (subordinate) pyrite, and the ensuing rapid decline in sulphide content is accompanied by a complementary increase in epidote. The assay of BH 5A shows a broad zone of copper enrichment between 1.20 m and 5.56 m with values exceeding 1000 ppm and reaching up to 4500 ppm between 4.75 and 5.56 m. It is evident, therefore, that the copper in the core is contained principally in chalcopyrite, though it should be noted that the copper maxima coincided with an area in which probable bornite occurs.

Conclusions

In general there is close agreement between geological and geochemical data in respect of the distribution of elemental copper and copper sulphide in the three boreholes. Quartzite appears to be preferentially enriched in copper although the highest recorded concentration (7500 ppm) was in chlorite-mica-quartz-schist. In marked contrast to BH 1-3, the highest concentrations in BH 5 and 5A are mostly unrelated to epidiorite or epidotisation, though there is a significantly raised background (7,300 ppm Cu) in the epidiorite units and in BH 4, which is devoid of such features, background copper values are significantly lower.

Drill-core logs of BH 4, 5 and 5A follow.

SECTION OF MEALL MOR

Borehole 4

Inclined at 50° from the horizontal towards 300°M

Surface Level 240 m O.D.

Communicated 1977 by Highlands and Islands Unit

Date of boring or sinking May 1977 Borer IGS Geochemical Division

One-inch Map 58 Six-inch Map Argyll 191 NE

958116 4M 2/75 J.F.&S. 275

	Thickness Metres		Depth from Surface Metres	
Overburden/No recovery	1	00	1	00
QUARTZ-CHLORITE-SERICITE-SCHIST, with finely alternating light and dark stripes and irregular quartz segregations. Highly deformed by predominantly open folds with axial planes at 90° to core axis. Irregular patches and occasional euhedral crystals of pyrite present, overall 0.5%, trace chalcopyrite. Thin pinkish carbonate veinlet at base carrying pyrite.	-	25	1	25
MICACEOUS QUARTZITE, pale grey with variable sericite-chlorite content, and occasional coarse quartz-chlorite patches in upper 30 cm. Noticeably more chlorite between 1.55 and 1.71 m, with distinctive dark greenish hue. Small 'M' folds noted, and late minor folds, of large amplitude throughout giving variation in inclination from 15° to 90°. Trace of pyrite and chalcopyrite in upper 30 cm.	-	73	1	98
CHLORITE-SERICITE-QUARTZ-SCHIST, finely striped with occasional quartz-feldspar segregations which are generally subparallel to foliation. Traces of (?) dolomite. Crumpling/folding less intense than above. Inclination of foliation 40° at 2.20 m. Sericitic bands become dominant in lower 35 cm. Pyrite irregularly distributed in upper 40 cm, absent below this.	1	38	3	36
MICACEOUS QUARTZITE, slightly coarser than above and highly micaceous in lowest 6 cm. Late open folds developed. Trace amounts pyrite at 23 cm below top of unit, near to thin quartz veinlet with prominent red colouration.	-	59	3	95
QUARTZ-SERICITE-SCHIST, with minor chlorite. Highly crumpled and in parts broken into small fragments. No sulphides noted.	-	22	4	17
MICACEOUS QUARTZITE, very similar to previous micaceous quartzite unit. Contains closely spaced sericite and minor chlorite partings inclined at 40°, generally, but with a range of 20°-90° due to minor folding.	-	77	4	94
c/f			4	94

	Thickness		Depth from Surface	
	Metres		Metres	
b/f			4	94
QUARTZ-CHLORITE-SERICITE-SCHIST, darker than above with striping below 5.30 m. Folding throughout with small tight, (?) early generation and later open folds, rare pyrite. Thin dolomitic veinlets in lowest 30 cm.	-	94	5	88
SERICITE-CHLORITE-QUARTZ-SCHIST, coarse banding in upper 50-60 cm more evenly spaced below this. Irregular quartz-feldspar (?) segregations with chlorite knots, trace pyrite.	-	81	6	69
HIGHLY MICACEOUS QUARTZITE, with dark chlorite or mica and subordinate sericite. Inclination variable due to tight folding. Pyrite irregularly scattered between 6.73 and 6.90 m both in quartzite, and cross-cutting pink (?) quartz-feldspar veinlet.	-	89	7	58
SERICITE-CHLORITE-QUARTZ-SCHIST, with coarse quartz-feldspar segregation in lower 30-35 m containing chlorite-selvages. Unit highly folded. Pyrite occurs throughout and is particularly common in lowest 10 cm where it may form 2%.	-	90	8	48
MICACEOUS QUARTZITE. Mica content variable - generally present in thin partings which locally impart striped appearance. These comprise sericite and dark (?) chlorite with occasional patches of paler chlorite. Notable increase in chlorite content below 10.95 m. Inclination very variable (0°-90°) due to folding. Pyrite common ($\leqslant$1%) in upper 5 cm, then disappears only to reapper below 10.50 m as isolated crystals and concordant trails forming $<$0.5%. Quartz vein with patchy chlorite and traces of pyrite inclined at 70° between 11.05 and 11.14 m.	3	22	11	70
SERICITE-CHLORITE-SCHIST, with closely spaced schistosity inclined at 15° and occasional thin barren quartz-chlorite lenses.	-	17	11	87
QUARTZ-CHLORITE-SERICITE-SCHIST, (- with interbanded micaceous quartzite). Schistosity in upper 55 cm constant at 25°; below this predominantly parallel to core axis. Traces of pyrite associated with more pelitic bands between 12.07 and 12.20 m. 1.0 cm reddish quartz vein at 12.20 m.	-	78	12	65
SERICITE-CHLORITE-SCHIST. Development of kinks and incipient (?) strain-slip cleavage (inclined at approximately 30-35°) at 12.70-12.76 m. Quartz segregations prominent in lowest 20 cm with pinkish colouration. Isolated pyrite throughout with locally richer areas in lowest 3-4 cm.	-	44	13	09
c/f			13	09

(249/1589) D. No. 248420 5,000 7/72 M. & St., Ltd. G249

SECTION OF Meall Mor BH 4

Six-inch Map (County and Quarter Sheet) Argyll 191 NE

	Thickness Metres		Depth from Surface Metres	
b/f			13	09
HIGHLY MICACEOUS QUARTZITE, with bands of chlorite-sericite schist up to 17 cm thick with rare (?) dolomite patches. Minor fold in upper 30 cm results in steeply inclined schistosity. Elsewhere inclination seldom exceeds 10°. Upper 30 cm distinct 'pinkish hue' - ?feldspar. Pyrite and chalcopyrite in upper 15 cm, rare to absent below this.	-	83	13	92
MICACEOUS QUARTZITE, locally sparsely micaceous. No sulphides seen.	-	38	14	30
SERICITE-CHLORITE-SCHIST, with irregular quartz segregations and chlorite selvages.	-	35	14	65
QUARTZITE (+ micaceous partings) with occasional chloritic striped bands and quartz-carbonate segregations, which are strongly developed between 15.10-15.26 m almost to the exclusion of quartzite. Chlorite-mica content varies locally to micaceous quartzite. Minor folds prominent with strong folding at 16.10 m in highly micaceous portion. Pyrite present as crystals up to 3 mm and occasional trails sub-parallel to foliation. Pyrite and (?) chalcopyrite in coarse patches at 15.95 m, locally 1-2%.	1	67	16	32
CHLORITE-SERICITE-QUARTZ-SCHIST, with strong foliation which is highly crumpled throughout. Pyrite occurs as isolated coarse patches.	0	46	16	78
QUARTZITE, with thin micaceous parting which impart foliation inclined 40°. Pyrite (≤ 0.5%) present as trails sub-parallel to foliation and more rarely as isolated coarse patches. Minor chalcopyrite noted in association with the pyrite. Thin quartz - (?) carbonate veinlet at 16.84 m.	1	00	17	78
CHLORITE-SERICITE-QUARTZ-SCHIST, with variable quartz content and locally selvages and knots of chlorite and mica. Foliation inclined 25-30°, locally highly crumpled. Sulphide content variable, generally as isolated patches/crystals scattered along length, with very coarse patch, and trail/veinlet sub-parallel to foliation, noted at 18.30-18.35 m. Dominantly pyrite with trace chalcopyrite, typically 0.5% but in rich patches up to 5%. Associated red-brown haematite staining at 18.35 m. Sulphide-carrying pinkish veinlet at 18.95 m.	1	17	18	95
QUARTZITE, (with micaceous band at 18.98 m). Essentially clean white quartzite, with trails of sulphide sub-parallel to foliation at 19.08 m.	-	20	19	15
SERICITE-CHLORITE-QUARTZ-SCHIST, coarsely micaceous with "knots" of chlorite developed locally. Very irregular and poorly developed foliation. Quartz				
c/f			19	15

	Thickness		Depth from Surface	
	Metres		Metres	
b/f			19	15
veins/bands at intervals along length, 5 cm thick at 19.62 m. Chalcopyrite with subordinate pyrite forms irregularly distributed coarse patches. Overall probably ≤1% but locally exceeds 5%.	-	98	20	13
QUARTZITE, with variable mica content and some chlorite/mica rich bands. Micaceous laminae increase in number below 21.05 m, producing irregular 20°-30° foliation and in conjunction with coarse quartz rich patches impart banded appearance. Pyrite (<0.5%) typically present as trails sub-parallel to foliation, with some isolated patches. Coarse chalcopyrite patch recorded at 21.88 m, with (?) haematite staining at 20.28 m.	1	75	21	88
HIGHLY MICACEOUS QUARTZITE, with prominant foliation inclined at 30°. Crinkling of foliation at 22.28 m. Some rare pyrite in isolated patches, 0.5% noted.	-	35	22	23
QUARTZITE, with sparse thin sericitic laminae. No visible sulphide.	-	15	22	38
MICACEOUS QUARTZITE, chlorite-sericite laminae which impart strong foliation, inclined at 25°. Increase in chlorite/mica content below 22.48 m. Small vein and fold at approximately 22.75 m. Pyrite rare in upper 20-25 cm, below approximately 22.75 m increases with scattered patches and trails sub-parallel to foliation, 0.5%. Pink vein, (?) quartz feldspar minor calcite at 23.16 m and quartz vein at 22.75 m.	-	78	23	16
CHLORITE-SERICITE-QUARTZ-SCHIST. Highly micaceous with strongly crumpled foliation. Locally distinct felsic (quartz-feldspar) patches and chlorite knots impart crude striping. Weak strain-slip cleavage present and minor folds at 23.76 m. Pyrite rare in upper 35 cm. Below this increases as scattered patches and minor trails forming approximately 0.5%. Pyrite also noted in core of above fold. Thin 1.0 cm brown-red quartz vein at 23.80 m.	-	64	23	80
MICACEOUS QUARTZITE, with variable mica/chlorite content but noticeably less than above units. Foliation inclined generally at 40°-50° viz below 24.18 m but locally variable due to folding. Small (?) shatter zone at 23.90 with distinct red-brown staining; second red-brown area at 24.18 m. Pyrite and trace chalcopyrite, noted in above shatter zones, typically coarse and patchy, <0.5%. Grades down into -	-	54	24	34
QUARTZ-CHLORITE-SERICITE-SCHIST. Chlorite content falls off in lowest 5-10 cm, merging into micaceous quartzite below 24.80 m. Foliation frequently crumpled. Sulphide in coarse scattered patches 0.5-1%, locally can reach up to 2%; dominantly pyrite with very rare chalcopyrite. Cross-cutting pinkish veinlet at 24.50 m.	-	48	24	82
c/f			24	82

(249/1589) D. No. 248420 5,000 7/72 M. & St., Ltd. G249

SECTION OF MEALL MOR BOREHOLE NO.4 (Cont.)

Six-inch Map (County and Quarter Sheet) ARGYLL 191 NE

	Thickness		Depth from Surface	
	Metres		Metres	
b/forward	24	82		
MICACEOUS QUARTZITE, with laminae of chlorite and sericite, former dominant, laminae variable increasing below 27.00 m with locally chlorite-rich knots noted viz. 30.56 m. Unit only sparsely micaceous below 30.75 m. Foliation inclined 35-40° but locally variable due to minor folding particularly in mica rich zones; folding evident at 25.71 m. Pyrite generally sparse as small patches and trails ≪ 0.5%, relatively rich zone 30.00 m - 30.08 m reaching up to 0.5%. Pyrite increases below 30.30 m typically as scattered patches. Pink quartz -(?)carbonate veins noted at 24.50 m, 27.00 m, 28.50 m - 28.68 m and 30.63 m - 30.70 m; 10.0 cm quartz vein also noted at 30.75 m.	6	50	31	32
QUARTZ-CHLORITE-SERICITE-SCHIST. Distinct increase in chlorite/mica content compared with above unit producing marked schistosity which is crumpled and folded viz 32.10 m. Pyrite relatively common (approximately 0.5%), as coarse irregular patches and veinlets/trails which parallel foliation and follow minor folds. 5 cm quartz vein at 31.60 m.	-	87	32	19
MICACEOUS QUARTZITE, chlorite/mica content variable but generally poor foliation in upper 20 cm, mica laminae increasing below this. Foliation 35-40° inclination, 0.4 cm thick chlorite band at 32.88 m. Pyrite sparse in upper 20 cm as isolated patches, below this generally increases with coarse patch at 32.68 m and trail at 32.74 m; slight increase below this but still ≪ 0.5% over section. Small pyrite cubes isolated in pinkish veinlets at 34.00 m and 34.15 m; 0.3 cm quartz vein at 33.33 m.	1	22	33	41
QUARTZ-CHLORITE-SERICITE-SCHIST, with strong foliation due to chlorite-mica content, locally varies to highly micaceous quartzite. Foliation relatively constant in upper 15-20 cm 40-50°, then becomes strongly crumpled and folded at 33.42 m and below. Sulphide absent.	-	89	34	30
SPARSELY MICACEOUS QUARTZITE. Very finely laminated micaceous quartzite with more mica-rich bands along length. Slight increase in lamination below 35.30 m with mica/chlorite-rich unit at 35.65 m. Distinct increase in chlorite content in lowest 30 cm. Minor folding noted at 35.30 m. Pyrite sparse to rare, as small widely scattered isolated patches viz at 34.90 m and 35.65 m.	1	78	36	08
c/forward	36	08		

	Thickness		Depth from Surface	
	Metres		Metres	
b/forward	36	08		
CHLORITE-QUARTZ-SERICITE-SCHIST. Much darker than above due to increase in chlorite content, some minor variation in chlorite/mica along length produces more quartz -rich areas. Foliation strongly buckled and folded into both tight and relatively open folds. Pyrite variable along length but generally sparse 0.5%, occurs in isolated patches, trails and veinlets, and small anhedral crystals viz 37.00 m and 37.22 m. Locally concentrated approaching 1%, and appears to be associated with cross-cutting pink quartz-feldspar vein at 36.60 m. Strong red-brown (?) haematite staining and associated pyrite at 37.65 m.	1	57	37	65
(Laminated) MICACEOUS QUARTZITE, with variable chlorite/sericite mica content along length, in places becomes highly micaceous with isolated bands of almost pure dark green (?) chlorite developed viz at 39.00 m. Foliation constant typically at 45°. Increase in micaceous partings in lower 30 cm of unit. Pyrite is widely scattered dominantly as small patches, with occasional trails, along unit < 0.5%, locally richer areas viz 39.28 m - 39.30 m but never exceeding 1%. Cross-cutting reddish quartz-feldspar (?) carbonate veins at 40.78 m and 40.91 m which carry pyrite.	3	33	40	98
CHLORITE-SERICITE-QUARTZ-SCHIST, with strong foliation which is often highly folded and buckled particularly in uppermost 10-20 cm. Foliation variable due to general folding, approximately 40° at 41.64 m. Some patches of almost pure quartz with minor chlorite at 41.40 m but generally fairly uniform unit. Pyrite (< 0.5%) occurs generally as small sporadic patches but some trails/veinlets in more chloritic zones.	1	09	42	07
HIGHLY MICACEOUS QUARTZITE distinctly more quartz-rich unit, with prominant foliation inclined at 45°. Trace of pyrite.	-	26	42	33
CHLORITE-SERICITE-QUARTZ-SCHIST identical to previous schist unit, with rare pyrite.	-	31	42	64
MICACEOUS QUARTZITE. Laminated quartzite with consistent foliation at approximately 45°. Indications of incipient micro-lithon development indicating "polyphase" deformation. Pyrite generally absent to very rare but coarse patches in cross-cutting quartz-feldspar vein at 43.43 m.	-	88	43	52
CHLORITE-SERICITE-QUARTZ-SCHIST with strong foliation due to high chlorite content. Foliation affected by buckle folding. Minor quartzitic bands. Pyrite sparse, widely distributed in small patches ≲ 0.5%.	1	08	44	60
BOREHOLE COMPLETE	44	60		

SECTION OF Meall Mor

Borehole No 5

Inclined at 50° from the horizontal towards 300° M

Surface Level 240 m O.D.

Communicated May 1977 by IGS Highlands and Islands Unit

Date of boring or sinking 1977 Borer IGS Geochemical Division

One-inch Map 58 Six-inch Map Argyll 191 NE

958116 4M 2/75 J.F.&S. 275

	Thickness		Depth from Surface	
	Metres		Metres	
Overburden/No recovery	5	50	5	50
CHLORITE-SERICITE-QUARTZ-SCHIST. Foliation strongly buckled/folded. Pyrite distributed along length of unit in small patches < 0.5%, pyrite increases slightly downwards with relatively rich zone (0.5-1.00%) at 5.87 m.	-	48	5	98
EPIDIORITE. Distinct foliation more evident in upper 5-10 cm, inclined at 45-50°. Several thin cross-cutting calcite veins. Trace pyrite.	1	02	7	00
CHLORITE-SERICITE-SCHIST, with sparse pyrite.	-	10	7	10
QUARTZITE. Upper 30 cm sparsely micaceous (chlorite and (?) biotite) with no pronounced foliation. 11.0 cm-thick chlorite rich unit at 7.91-8.02m with strong foliation. Below this the quartzite is relatively enriched in mica. Pyrite sparse to absent, minor scattered patches in general area of quartz-feldspar-(?)carbonate veins at 7.31 m and 7.35 m. Further pyrite at 7.74 m.	1	02	8	12
EPIDIORITE minor variations in fabric; small pyritous veinlet at 8.25 m. Quartz segregations at 8.20 m and 9.41 m.	1	34	9	46
CHLORITE-QUARTZ-SCHIST strong foliation which shows evidence of minor folding/buckling. Distinctly more mafic/speckled unit at 9.61 m, 14 cm thick. Small scattered patches of pyrite distributed along units.	-	28	9	74
LAMINATED QUARTZITE with fairly regular laminations picked out by chlorite/mica, becoming more closely spaced towards lower end of unit. Isolated pyrite trail/veinlet at 9.92 m - 10.02 m.	-	34	10	08
EPIDIORITE with sporadic isolated anhedral patches of pyrite.	-	16	10	24
CHLORITE-QUARTZ-SCHIST. Uppermost 9 cm laminated quartzite passes down into chlorite-schist unit. In latter foliation highly contorted/crumpled. Sporadic pyrite patches scattered throughout, with relative enrichment in lowest 8 cm. Overall probably 0.5%.	-	37	10	61
c/f			10	61

	Thickness		Depth from Surface	
	Metres		Metres	
b/f			10	61
QUARTZITE. Finely 'laminated' with micaceous wisps inclined 15-20°. Sulphide dominantly pyrite with trace of (?) chalcopyrite. Present throughout in general but usually concentrated along the micaceous wisps in small trails, together with some coarser isolated patches. Pyrite 0.5% over the unit but locally may reach 1% within the micaceous wisps (eg 11.30 m).	1	02	11	63
CHLORITE-QUARTZ-SCHIST. Chlorite-rich, with locally more quartzitic lenses, strong foliation showing limited buckling and kinking. Sulphide present as small isolated patches of pyrite less than 0.5%.	-	18	11	81
MICACEOUS QUARTZITE. Very finely laminated in uppermost 5 cm, inclined 25°. Chlorite/mica content variable over length of section with locally well laminated units viz 12.25 m, and more chlorite-rich zone at 12.10 m. Below approximately 12.45 m quartzite takes on greenish colouration which is persistent until the end of the hole. Sulphide absent from upper 8-10 cm, below relatively rich zone with scattered patches of pyrite making up 0.5%. Chlorite-dark mica zone at 12.10 m (above) carries pyrite and (?) chalcopyrite in coarse patches and small trails 0.5-1.0%. Pyrite veinlet at 12.22 m sub-parallel to foliation. Chalcopyrite recorded at 12.62 m and rich coarse zone at 12.81 m with associated pyrite, sulphide content 8-10% here. Further pyrite and chalcopyrite noted 13.02 m with associated haematite and specular haematite and mineralised quartz-feldspar ?carbonate vein with pyrite, chalcopyrite, haematite and (?) stibnite at 13.17-13.25 m. Small patch chalcopyrite at 13.65 m. Several small cross-cutting veins, dominantly of quartz with minor calcite, vary in thickness 1 mm up to 8 cm.	1	89	13	70

END OF BH

Lower half of core notably enriched in pyrite with additional patchy chalcopyrite in lowest metre. The sulphides are concentrated in veins which are preferentially developed in the quartzites.

SECTION OF Meall Mor BH 5A

Inclined at 50° from the horizontal towards 300° M

Surface Level 240 m O.D.

Communicated 1977 by IGS Highlands and Islands Unit

Date of boring or sinking May 1977 Borer IGS Geochemical Division

One-inch Map 58 Six-inch Map Argyll 191 NE

958116 4M 2/75 J.F.&S. 275

	Thickness Metres		Depth from Surface Metres	
Overburden/No recovery	1	05	1	05
QUARTZITE. Distinct greenish colour (?) epidotised. Upper 16-20 cm broken, with quartz vein material, pyrite and minor malachite present. Chlorite knots in small striped unit between 2.00 m and 2.10 m. Chalcopyrite and pyrite present in small veinlets sub-parallel to and cross-cutting foliation. Former dominant locally up to 1% but overall <0.5%.	1	30	2	35
QUARTZ-CHLORITE ROCK. Essentially a quartzite with dark green chlorite knots and, more rarely bands (eg 2.83-3.20 m) which resemble 'green beds'. Chloritic units decrease below 5.10 m leaving greenish quartzite with micaceous laminations. Sulphide occurs as patches and occasional veinlets, dominantly chalcopyrite, locally reaching 1%, and minor pyrite. Several shatter zones noted one at 5.09 m containing pyrite, chalcopyrite and ?bornite. Very coarse chalcopyrite patch at 3.27-3.32 m.	3	18	5	53
QUARTZITE, greenish, (?) epidotised, with mica-chlorite bands which vary in density along length of unit. Highly micaceous portion between 6.27-6.47 m. Foliation inclined 40° in uppermost 30 cm. Sulphide content variable with highest concentration in upper 40 cm, comprises chalcopyrite and pyrite in small trails and scattered patches. Locally may reach 1% but overall much less than 0.5%. Chalcopyrite dominant. Small calcite-quartz veinlets recorded at 7.70 m and 9.22-9.31 m, latter with associated feldspar and carrying pyrite.	4	07	9	60
CHLORITE-SERICITE-SCHIST with coarse light and dark banding in lowermost 10-20 cm. Foliation inclined mostly at 40° but small folds/buckles present which produce variation. Pyrite rare, present as irregularly distributed isolated patches.	-	89	10	49
QUARTZITE, greenish, (?) epidotised, with local mica-chlorite units viz 11.30-11.68 m. Pyrite sparse to absent throughout, quartz vein with associated pyrite between 10.80-11.17 m.	1	46	11	95
CHLORITE-SERICITE-SCHIST, with strong foliation which shows crumpling and folding. 6 cm quartz vein in uppermost portion which carries unidentified grey black mineral. Pyrite sparse though a small veinlet is present at 12.25 m.	-	39	12	34
c/f			12	34

	Thickness Metres		Depth from Surface Metres	
b/f			12	34
QUARTZITE, with green colouration, and bands of laminated micaceous quartzite locally (eg 12.73-12.90 m). Pyrite sparse forming small isolated patches with relatively coarse patch at 12.90 m approximately, possibly related to increased chlorite content. Small cross-cutting red veinlet at 13.07 m.	-	94	13	28
CHLORITE-QUARTZ-SERICITE-SCHIST, with strongly developed foliation affected by buckle folding which locally (eg 13.60-13.70 m) may produce intense deformation. Pyrite sparse, veinlet at 13.59 m, with further quite coarse patch, and thin vein, at 13.70 m along chlorite band. Pinkish quartz-feldspar-(?)carbonate vein at 13.52 m, also noted red-brown (?) haematite staining.	-	65	13	93
QUARTZITE, with minor chlorite/mica "wisps" which give crude foliation inclined at approximately 45°. Cross cut by several thin veinlets, purplish colour, some of which carry small crystals of pyrite viz at 14.39 m. Apart from these isolated veinlets sulphide absent from the quartzite.	-	87	14	80
CHLORITE-SERICITE-QUARTZ-SCHIST. Typical foliated chlorite-schist unit, with strong crumpling and folding locally. More quartzitic unit between 15.22 and 15.37 m with typical colouration. Quartzite content increases in lower 20-30 cm of unit and distinct banding with essentially no crumpling/folding is the norm; foliation/banding inclined 40-50°. Very minor pyrite, as small isolated patches over length of unit, with brown staining at 15.14 m. Quartz-carbonate-feldspar vein (4.0 cm) at 15.02.	1	77	16	57
QUARTZITE, greenish with thin chlorite and mica wisps throughout imparting crude foliation. Pyrite very sparse with small isolated widely scattered patches recorded viz at 17.2 m. Small thin pink quartz-feldspar-carbonate veinlets cross cut unit at 16.65 m, 17.17 m, 17.78 m and 18.43 m with associated minor pyrite.	2	22	18	79
QUARTZITE, grey-white with irregularly spaced mica-chlorite laminae giving crude foliation inclined 50°. Unit becomes darker below 19.40 m and foliation less obvious as a result. Pyrite and chalcopyrite sparse, present as both small patches and trails with chalcopyrite dominant. Coarse 3-4 mm veinlet of chalcopyrite noted at 19.56 m and small patch associated with quartz-feldspar veinlet at 19.67 m. Isolated patch of brown unidentified sulphide at 19.56 m. Small quartz-feldspar veinlets at 19.36 m, 19.40 m and 19.67 m.	-	98	19	77
EPIDIORITE, dark green garnetiferous rock with distinct mottled appearance and poorly defined foliation inclined at 30-35°. Pyrite sparse and sporadically distributed, overall very much less than 0.5%; coarse pyrite patch at 22.08 m. Several irregularly spaced quartz-feldspar and carbonate veinlets noted viz 23.28-23.57 m and 24.60-24.90 m some with minor pyrite. Light green (?) epidote veinlet with pyrite at 21.0 m; reddish ?haematite veins in uppermost 10 cm of unit again with pyrite.	6	06	25	83
c/f			25	83

(249/1589) D. No. 248420 5,000 7/72 M. & St., Ltd. G249

SECTION OF MEALL MOR BOREHOLE NO.5A (Cont.)

Six-inch Map (County and Quarter Sheet) ARGYLL 191 NE

	Thickness Metres		Depth from Surface Metres	
b/forward	25	83		
QUARTZITE, initially identical to previous quartzite, below 26.15 m however takes on greenish colouration, (?) epidote, and also shows an increase in "purple ?chlorite/mica bands", which may be due to secondary alteration. Distinct increase in chlorite content below 27.00 m, present as well defined bands and irregular patches. Pyrite sparse, present as small cubes at 26.59 m and 26.64 m, possibly associated with carbonate veinlets, and isolated patches below 27.0 m. Several veinlets of quartz and carbonate throughout, some of which carry pyrite, viz 26.10 m and 26.19 m. Coarse (2-3 mm) pink carbonate veinlet carrying coarse patches of pyrite at 27.00 m.	1	54	27	37
MICACEOUS QUARTZITE, fine grained, with 'salt and pepper' appearance due to numerous small biotite flakes. Transitional with above unit and along length variable mica content results in true quartzite patches. Vein quartz in lowest section below 28.39 m, and pale green (?) epidote patches at 28.18 m and 28.30 m. Pyrite very sparse, present as small isolated patches, and associated with quartz-feldspar-(?)carbonate veinlet at 27.56 m and 28.48 m. Chalcopyrite recorded at 28.06 m. Thin pink quartz-feldspar-(?)carbonate veinlets at 27.56 m. 28.48 m, and 28.50 m, former carrying grey unidentified sulphide. (? arsenopyrite as deduced from assay results)	1	74	29	11
BANDED QUARTZ-CHLORITE-SCHIST, variable unit with both greenish quartzite and chlorite-rich schistose areas. The schist shows evidence of folding, outwith these bands, foliation inclined approximately 45°. Pyrite absent apart from minor amounts in quartz at 29.24 m and 30.15m.	1	61	30	72
MICACEOUS QUARTZITE, with very variable chlorite/mica content. Greenish quartzite between 31.34 and 31.51 m and immediately below this chlorite-rich schist followed by further dominantly quartzite. Strong foliation picked out by mafic minerals inclined at 45° with limited crumpling/folding in more schistose units. Pyrite very rare, present as trails at 31.72 and 32.00 m, small patches along chlorite rich veinlet at 30.96 m and associated with pink quartz-feldspar vein at 31.08 m. Overall very much less than 0.5%	1	32	32	04
c/forward	32	04		

	Thickness		Depth from Surface	
	Metres		Metres	
b/forward	32	04		
CHLORITE-QUARTZ-SERICITE-SCHIST. Strongly schistose and highly folded unit, schistosity picked out by 'mica/chlorite' bands. Sporadic pyrite as small veinlets/trails and patches distributed throughout unit. Overall less than 0.5%.	-	68	32	72
BOREHOLE COMPLETE	32	72		

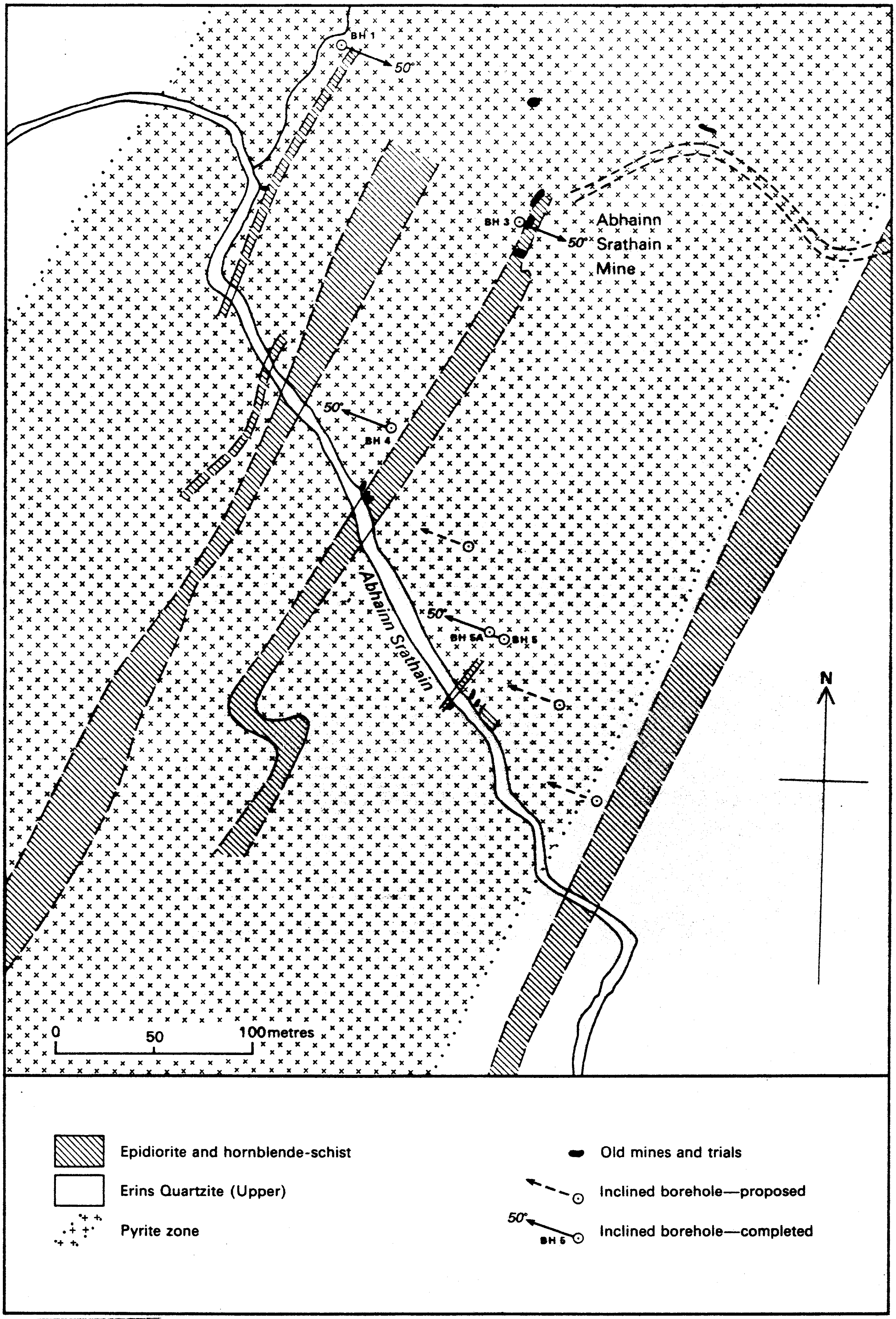
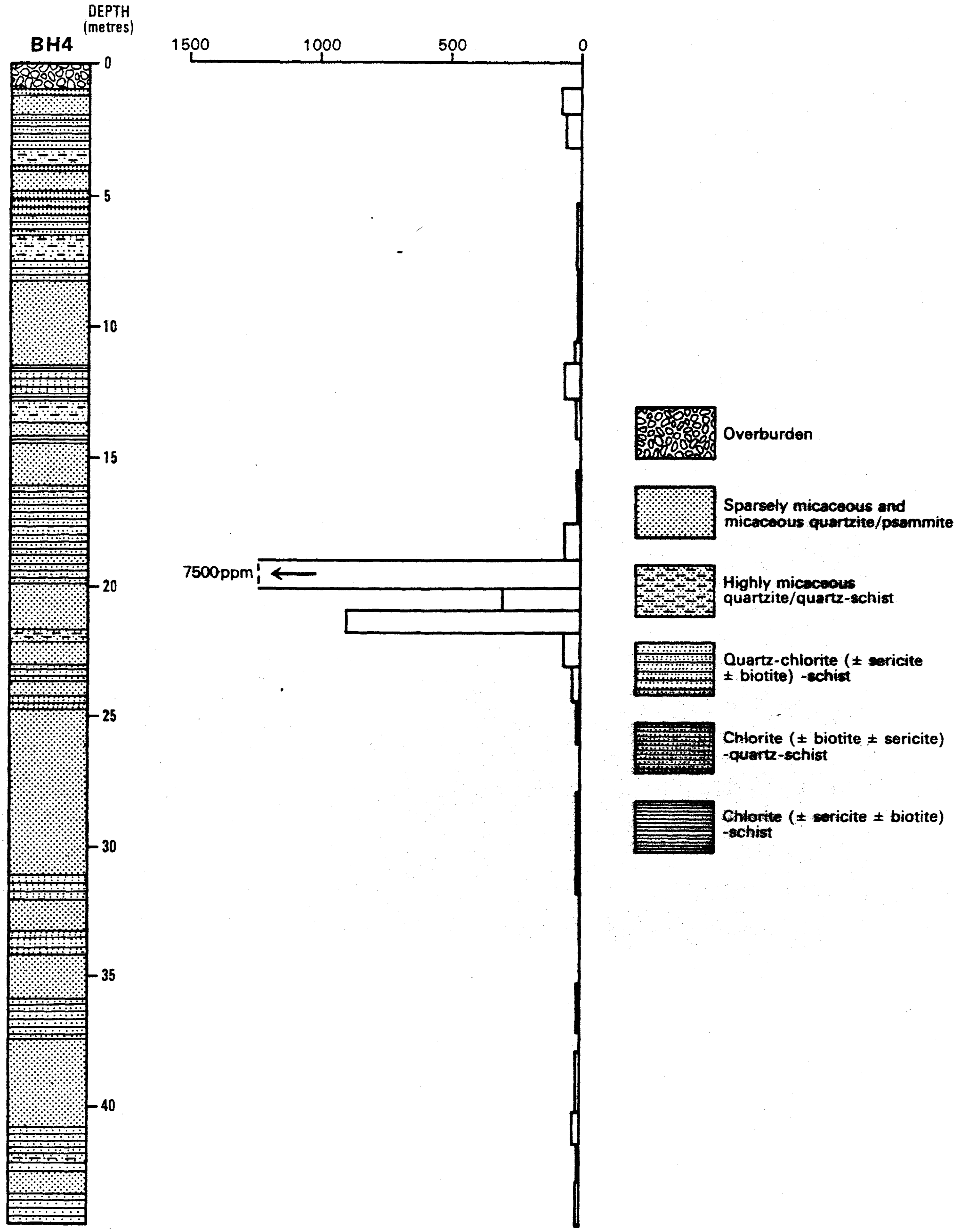


Fig. A3.1 **Abhainn Srathain: General geology and borehole sites**

Fig. A3.2 Graphic Log of Borehole 4



Geological summary log

Histogram for Cu in ppm (Based on sample assays)

Fig. A3.3 **Graphic Log of Borehole 5**

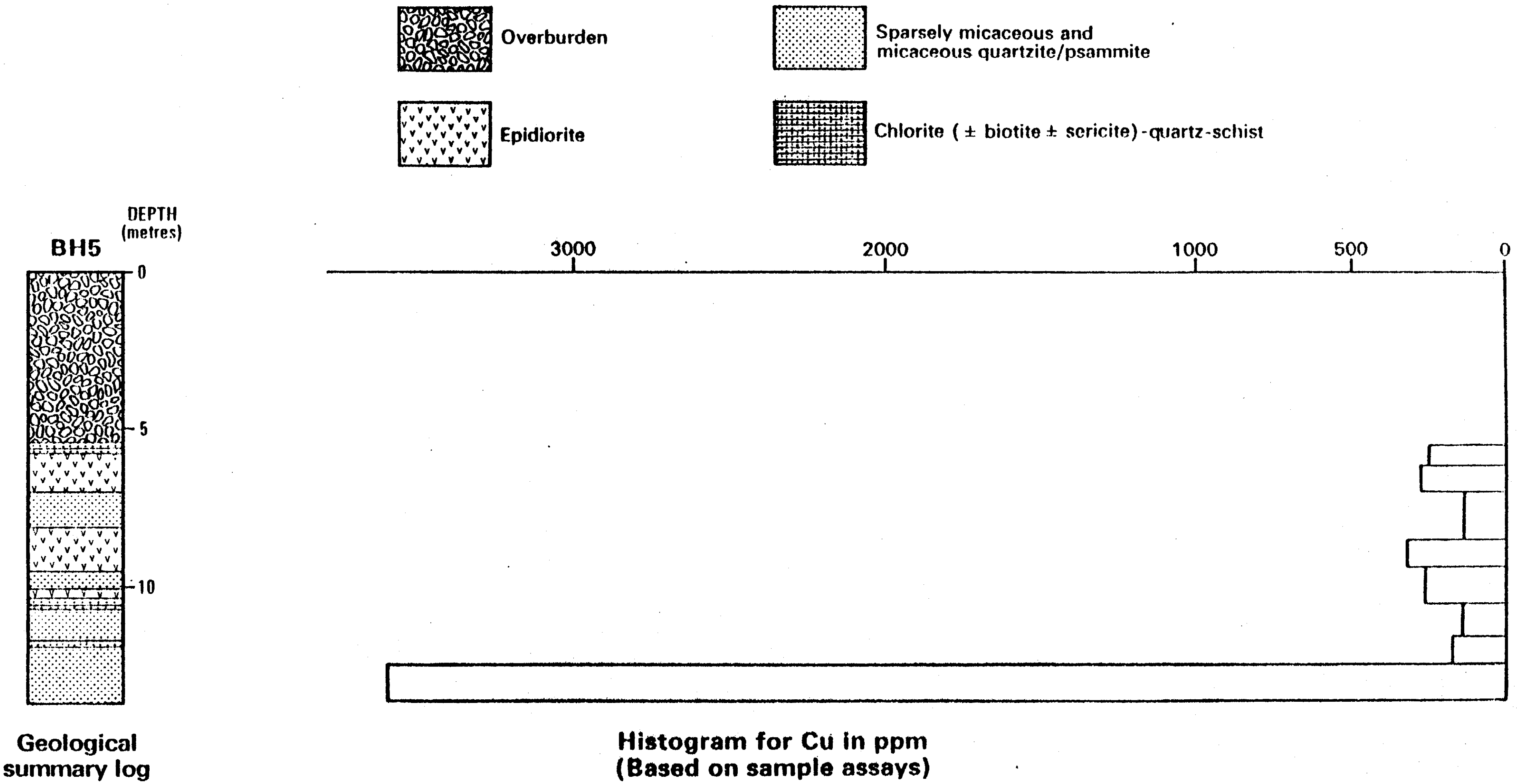
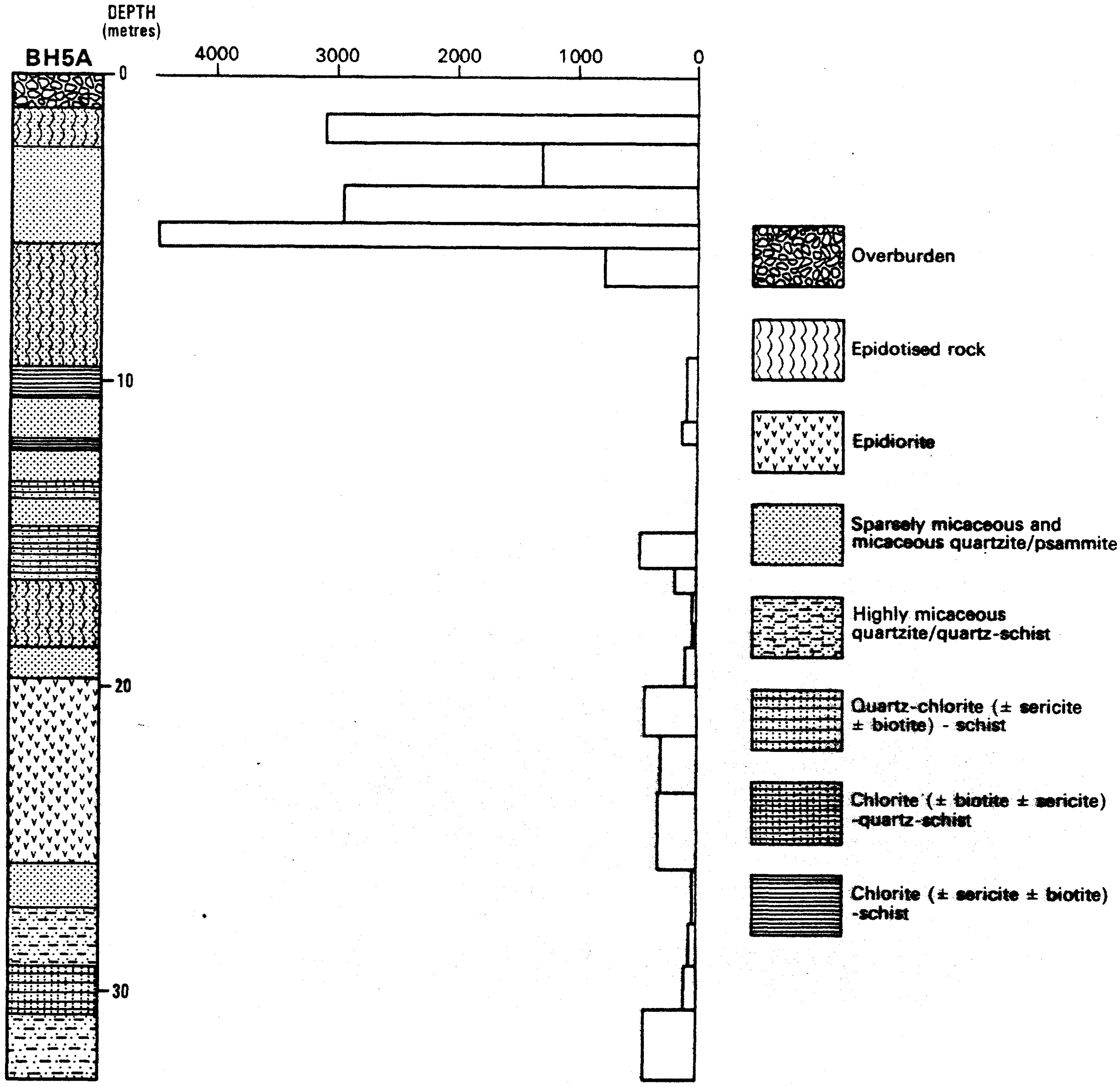


Fig. A3.4 **Graphic Log of Borehole 5A**



Geological summary log

Histogram for Cu in ppm (Based on sample assays)

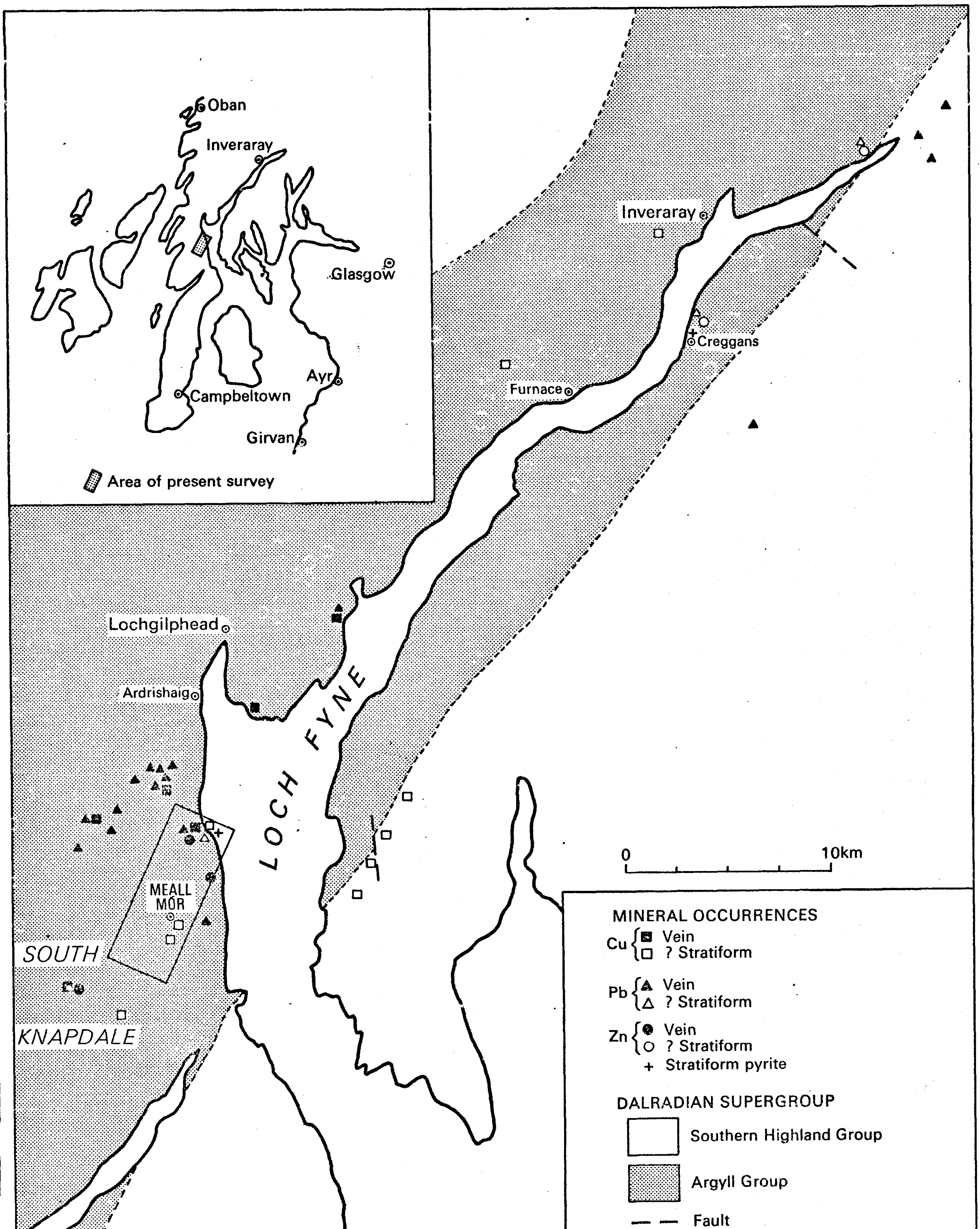


Fig1 Loch Fyne Area, General Geology, Mineral Occurrences and Location of Present Survey

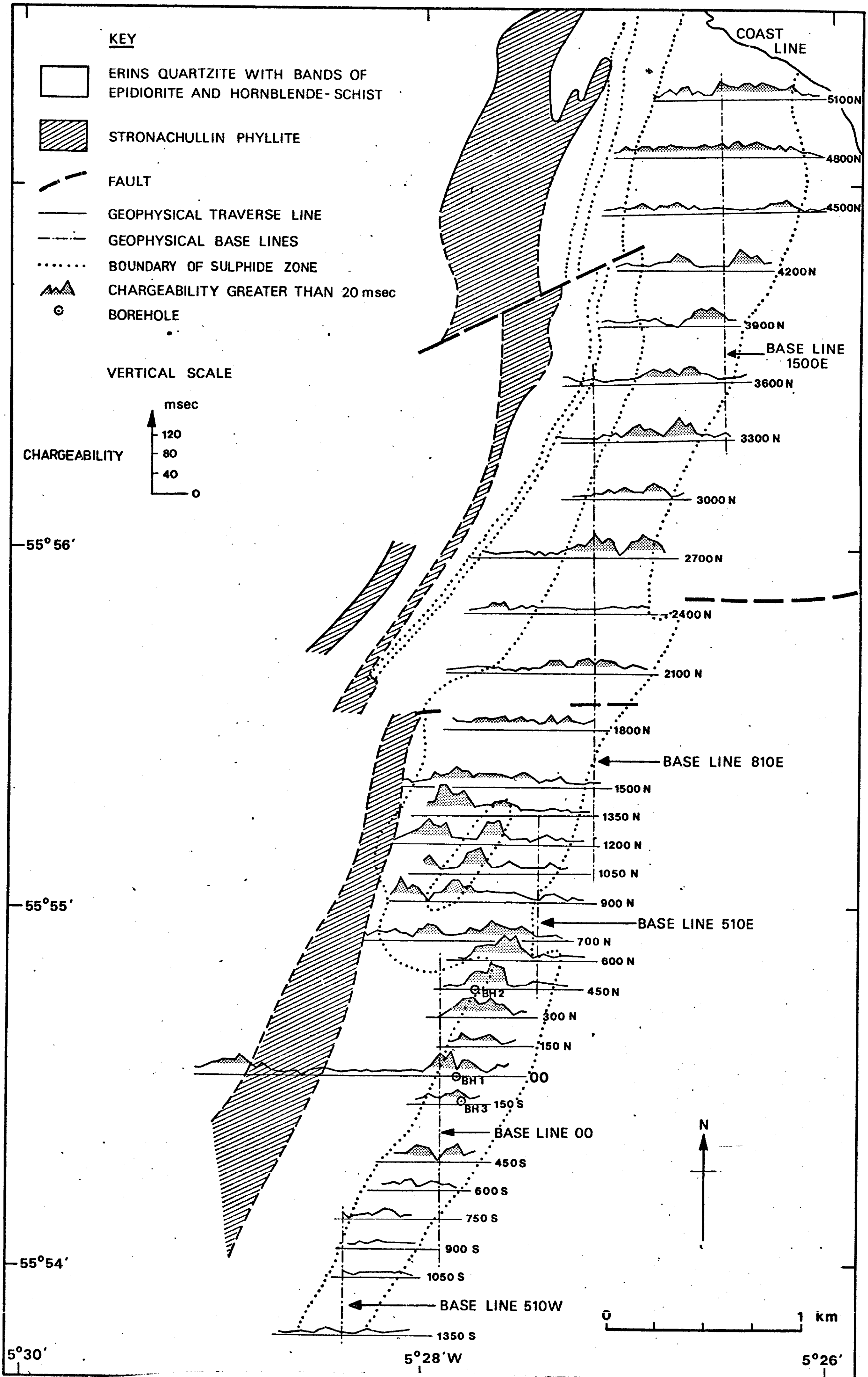


Fig. 3. Chargeability profiles for n 3 traverses.

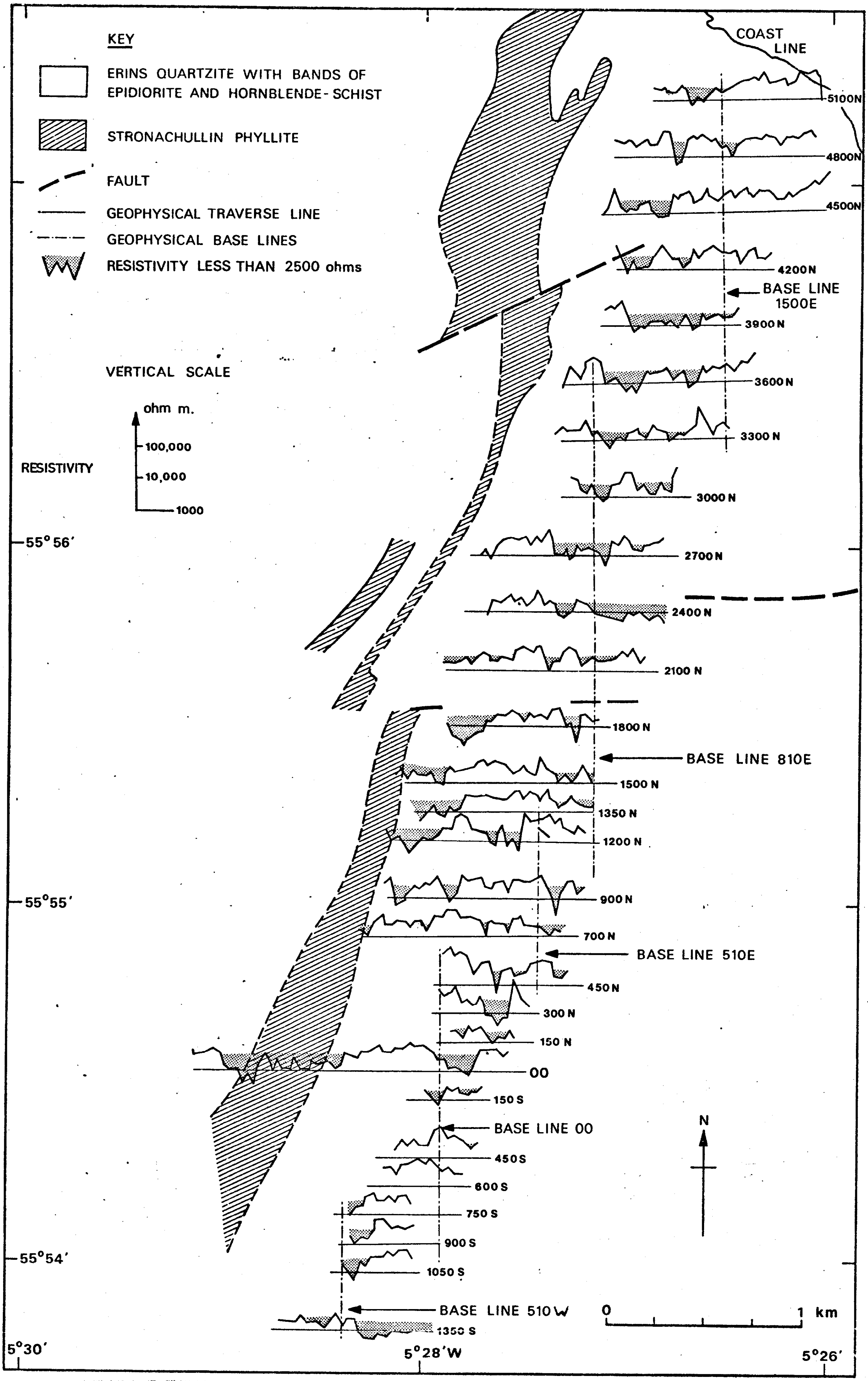


Fig. 4. Resistivity profiles for n 3 traverses.

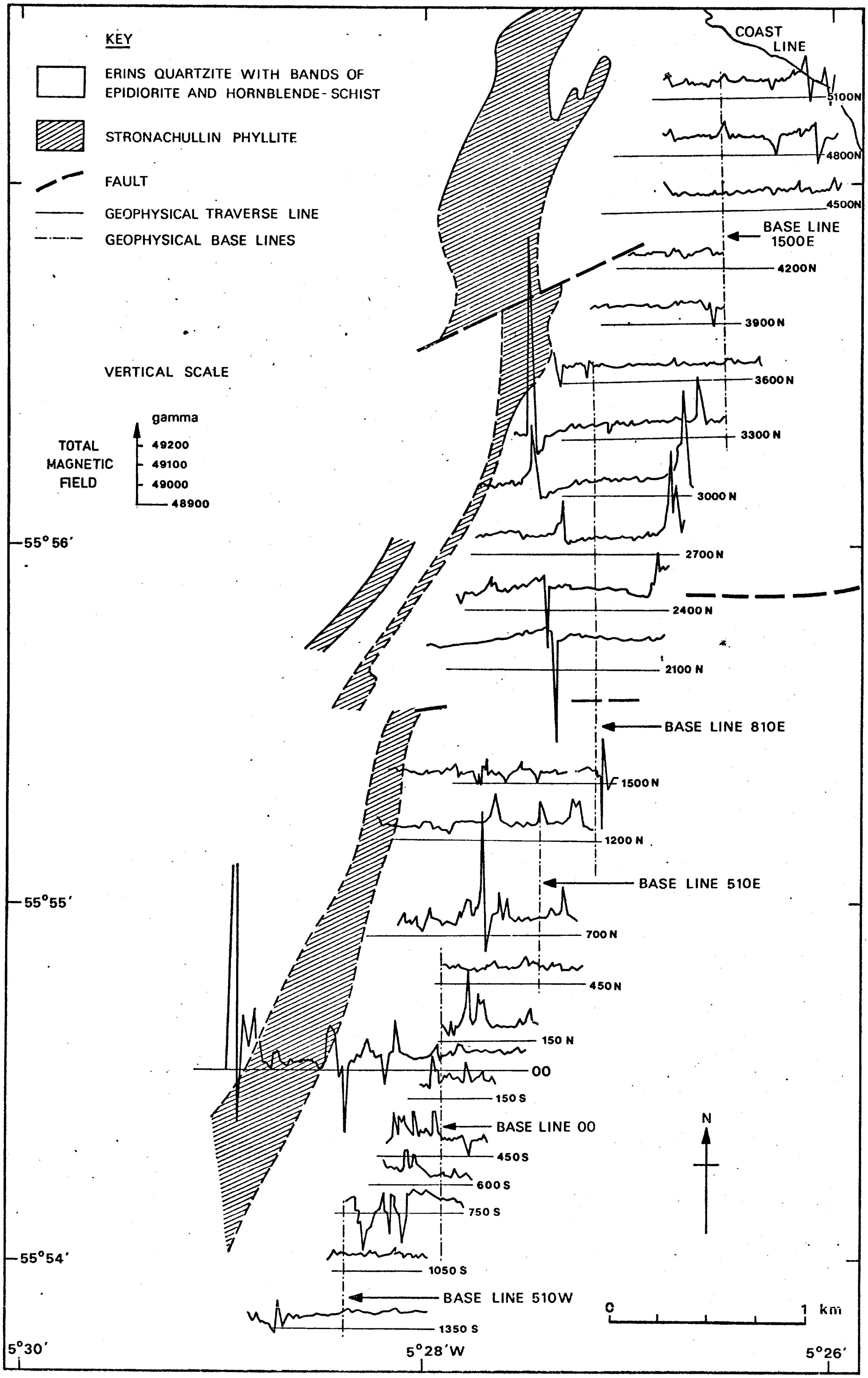


Fig. 5. Total field magnetic profiles.

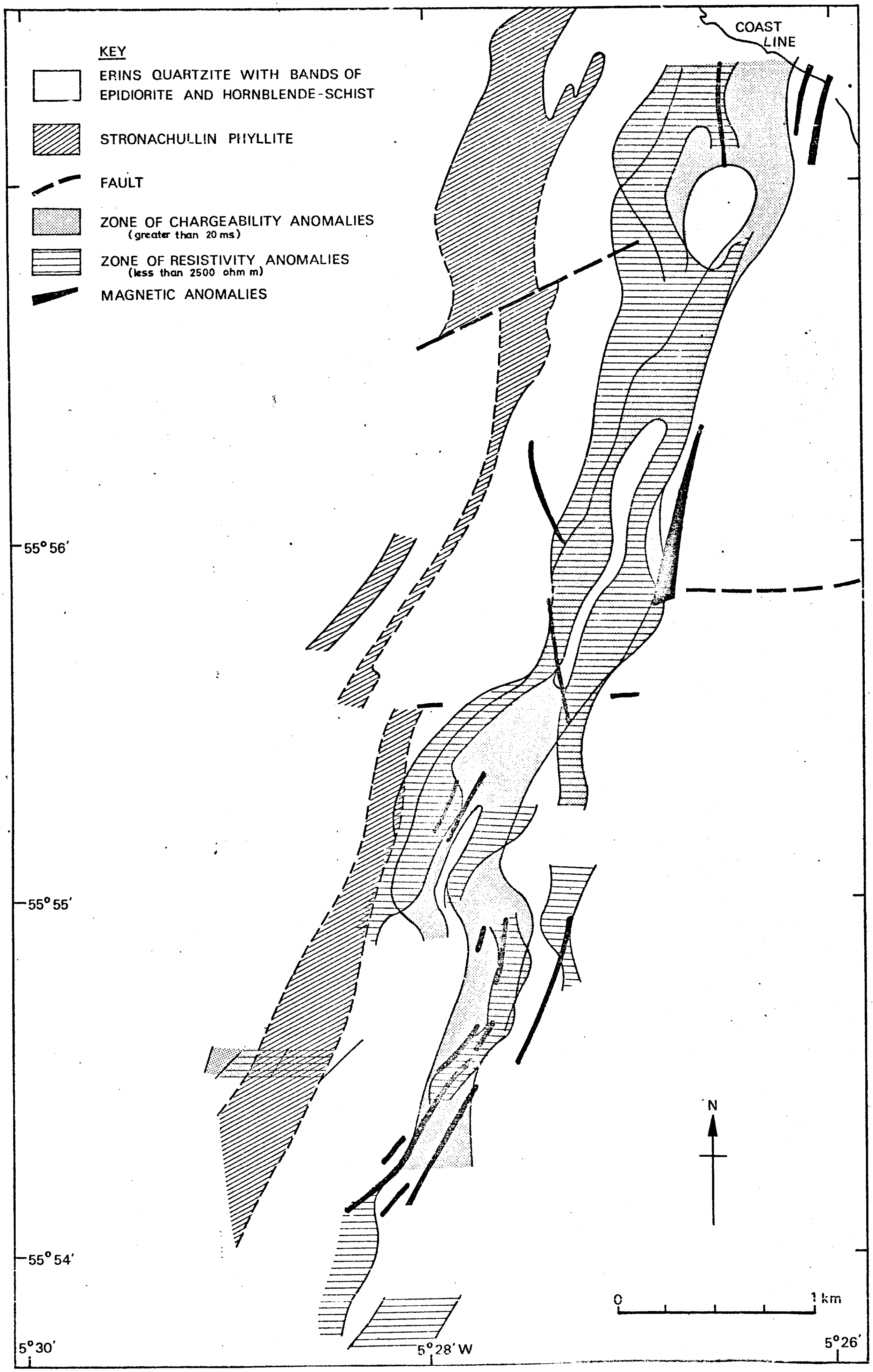


Fig. 6. Chargeability, resistivity, and magnetic anomaly trends.

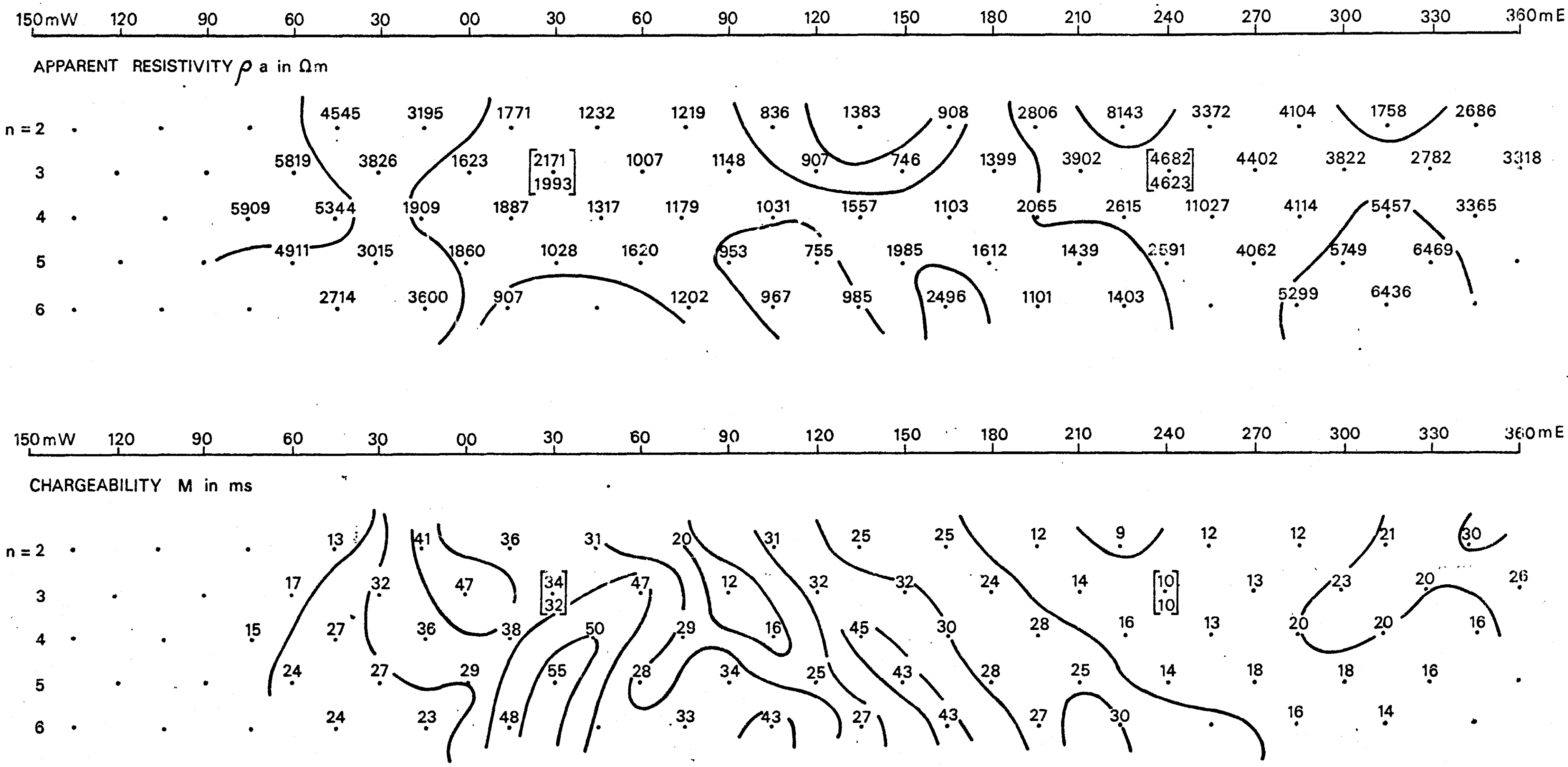


Fig. 7. IP pseudo sections for line 00.

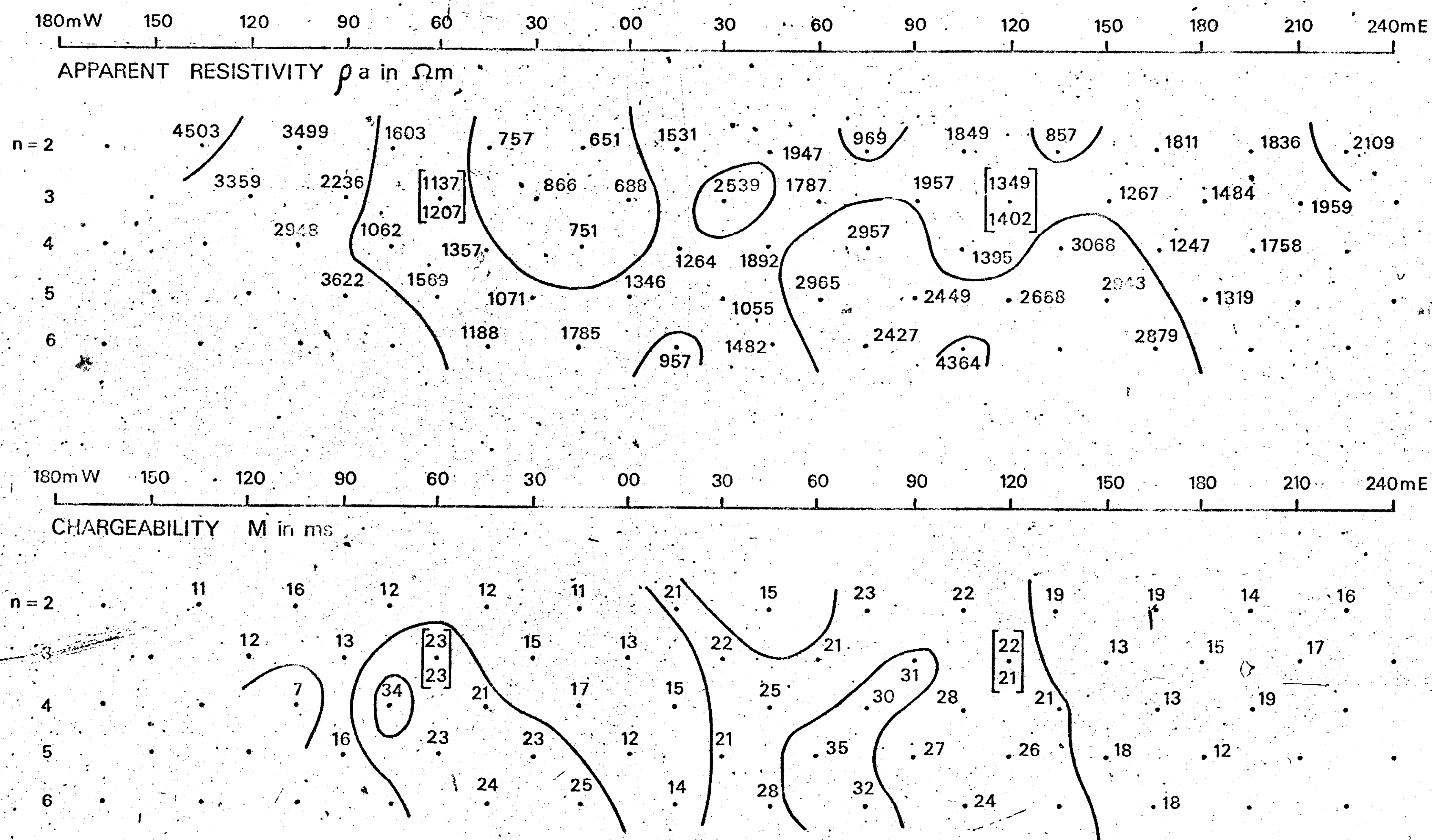


Fig. 8. IP pseudo sections for line 150S.

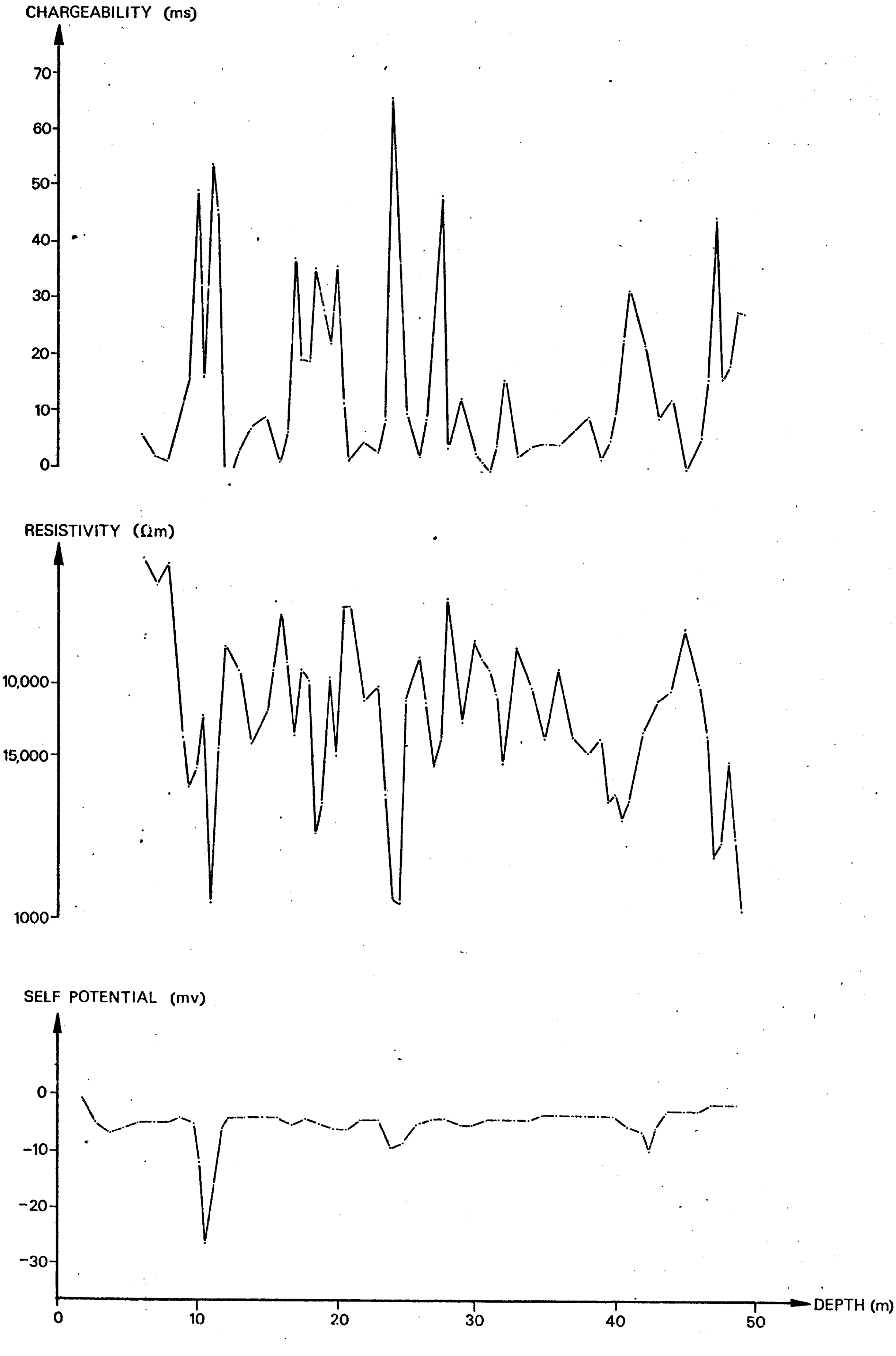


Fig. 9. IP and SP logs for borehole 1.

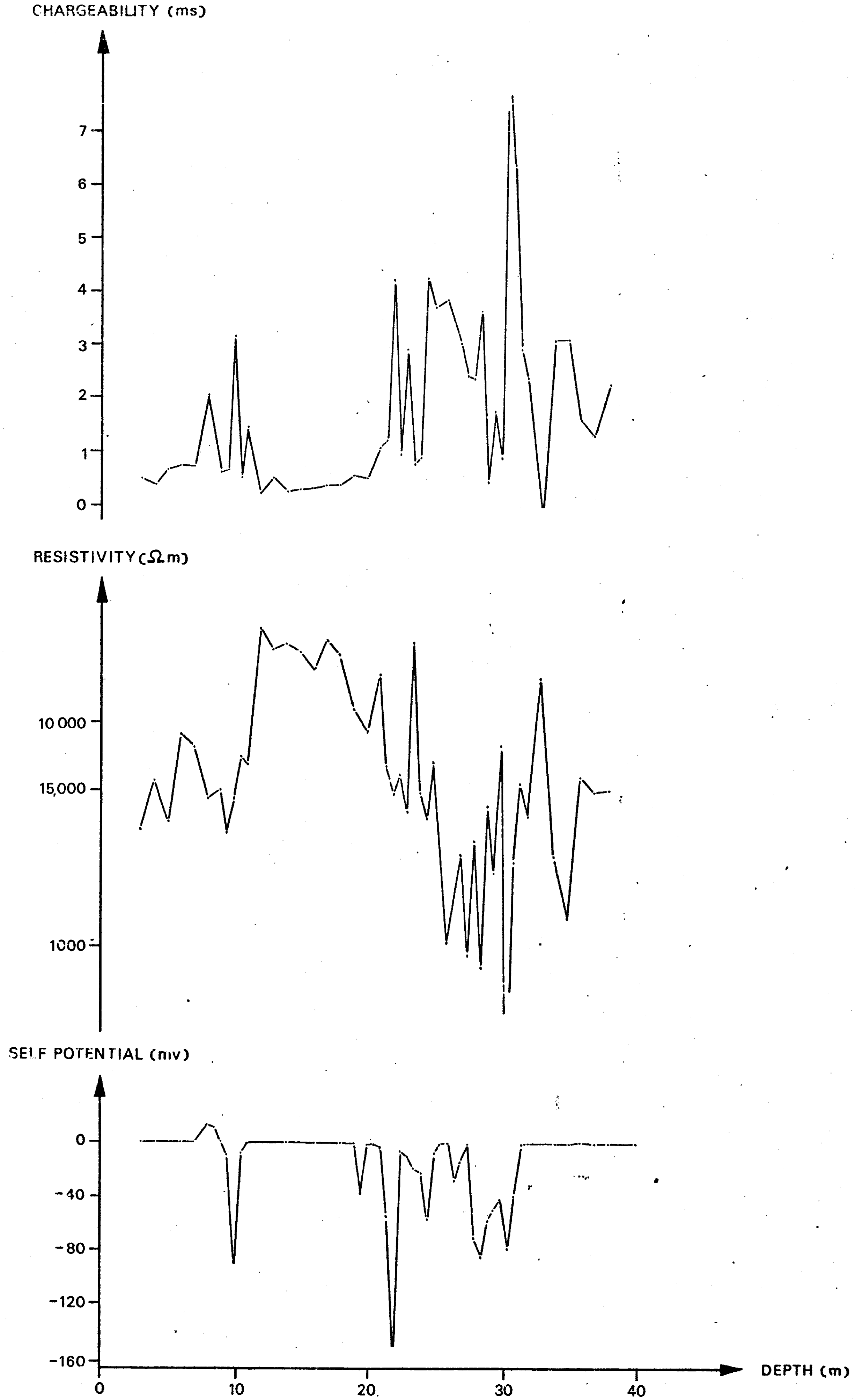


Fig. 10. IP and SP logs for borehole 2.

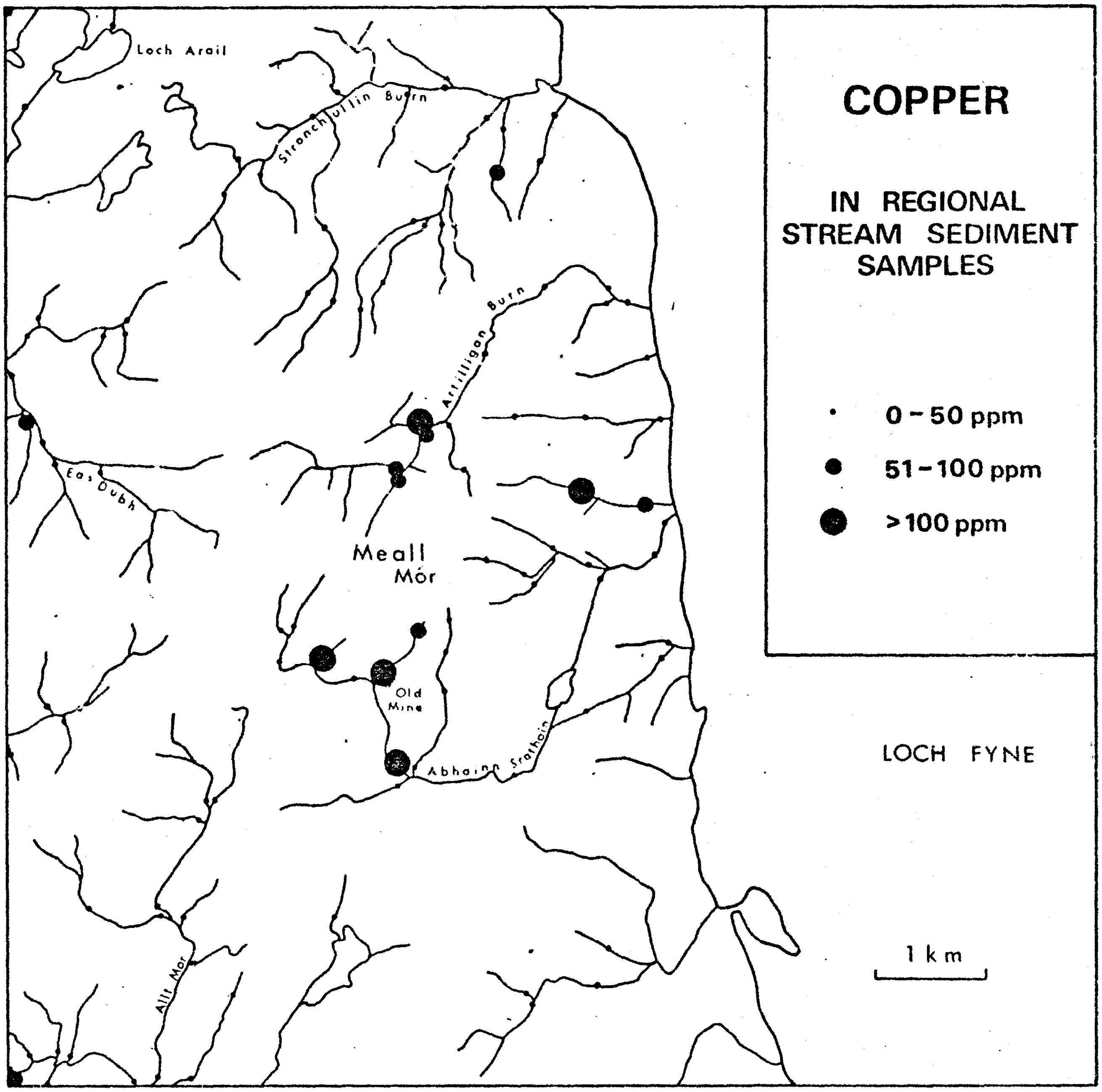


Fig. 11. Distribution of copper in stream sediment samples.

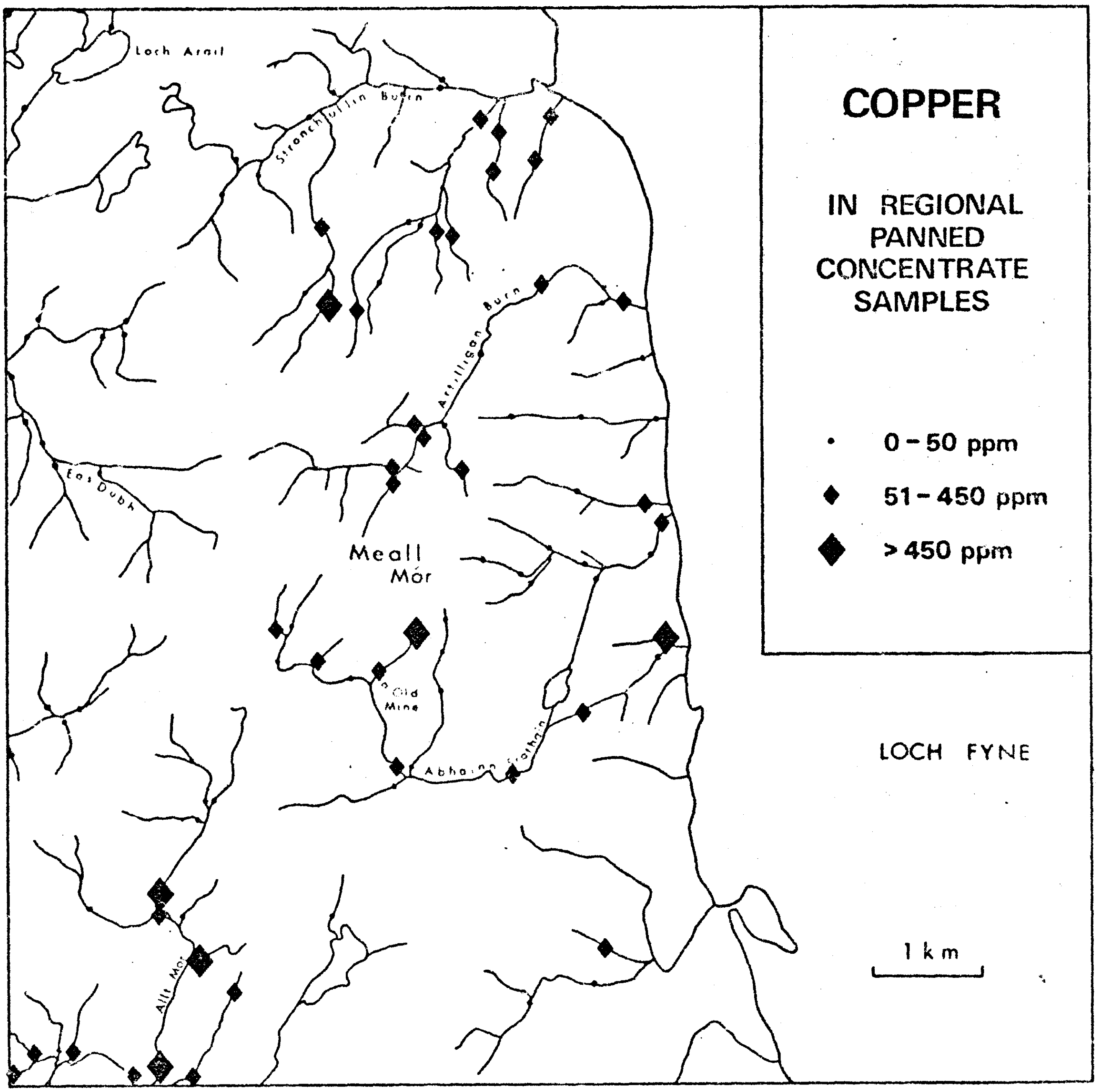


Fig. 12. Distribution of copper in panned concentrate samples.

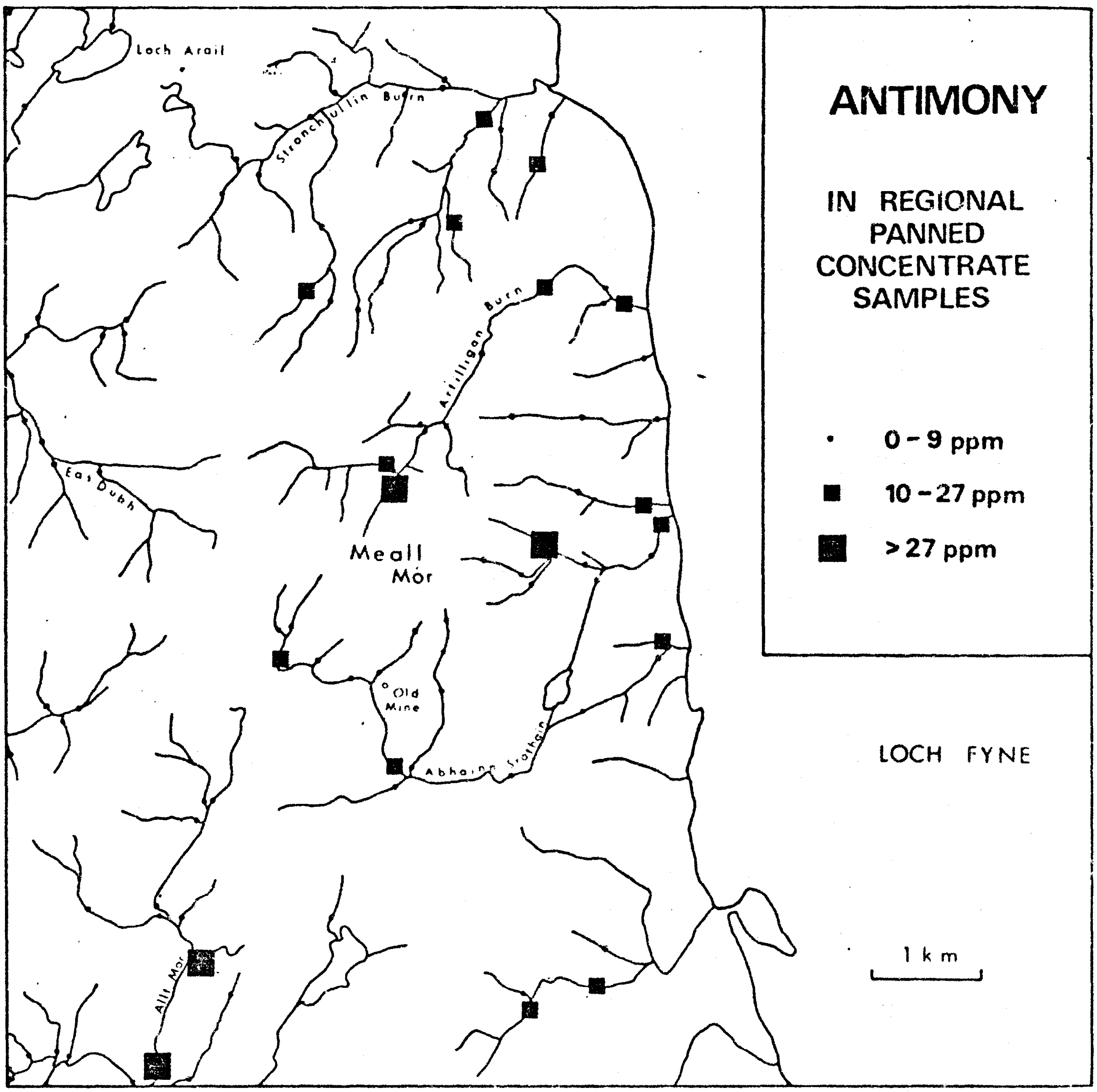


Fig. 13. Distribution of antimony in panned concentrate samples.

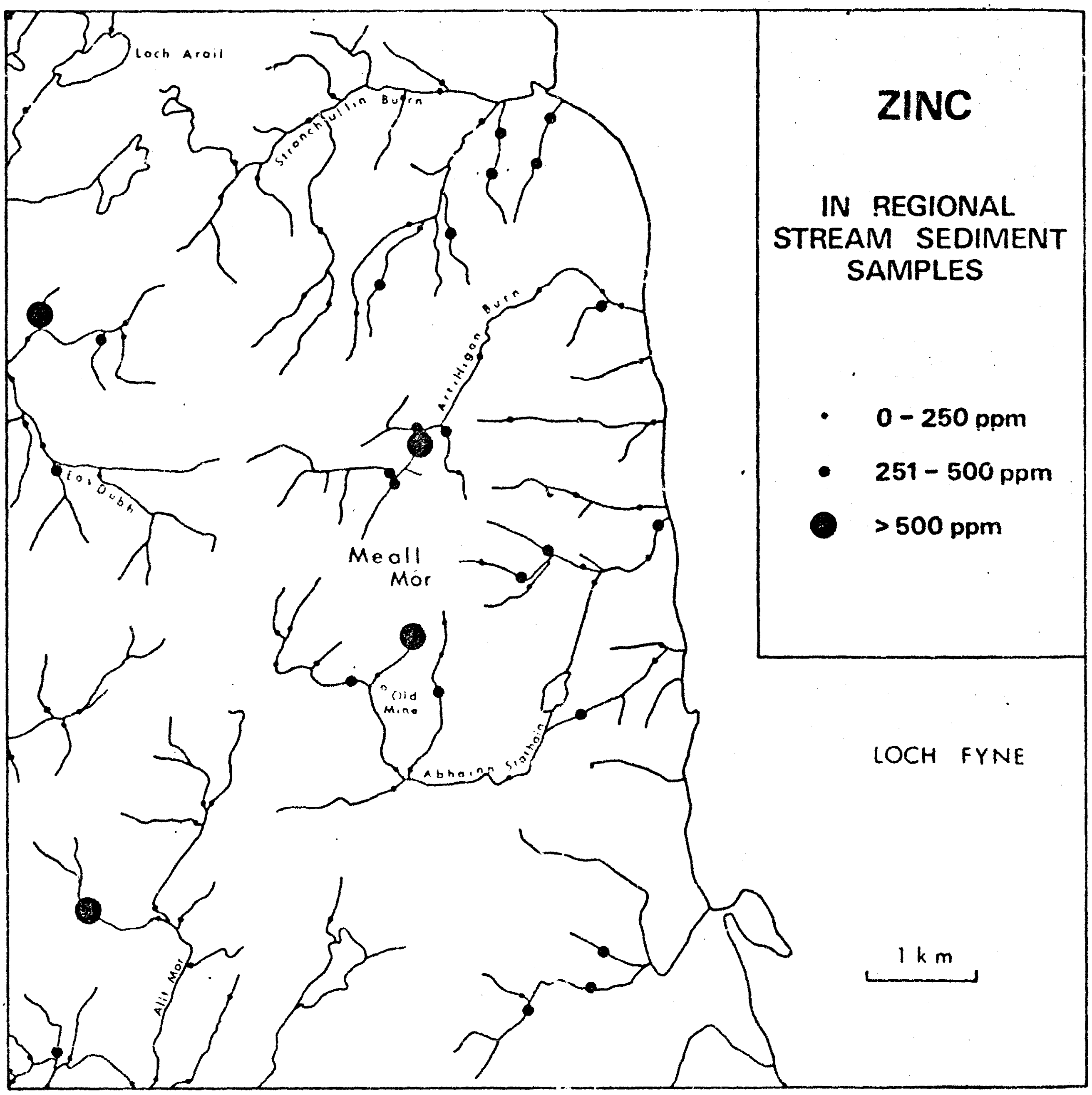


Fig. 14. Distribution of zinc in stream sediment samples.

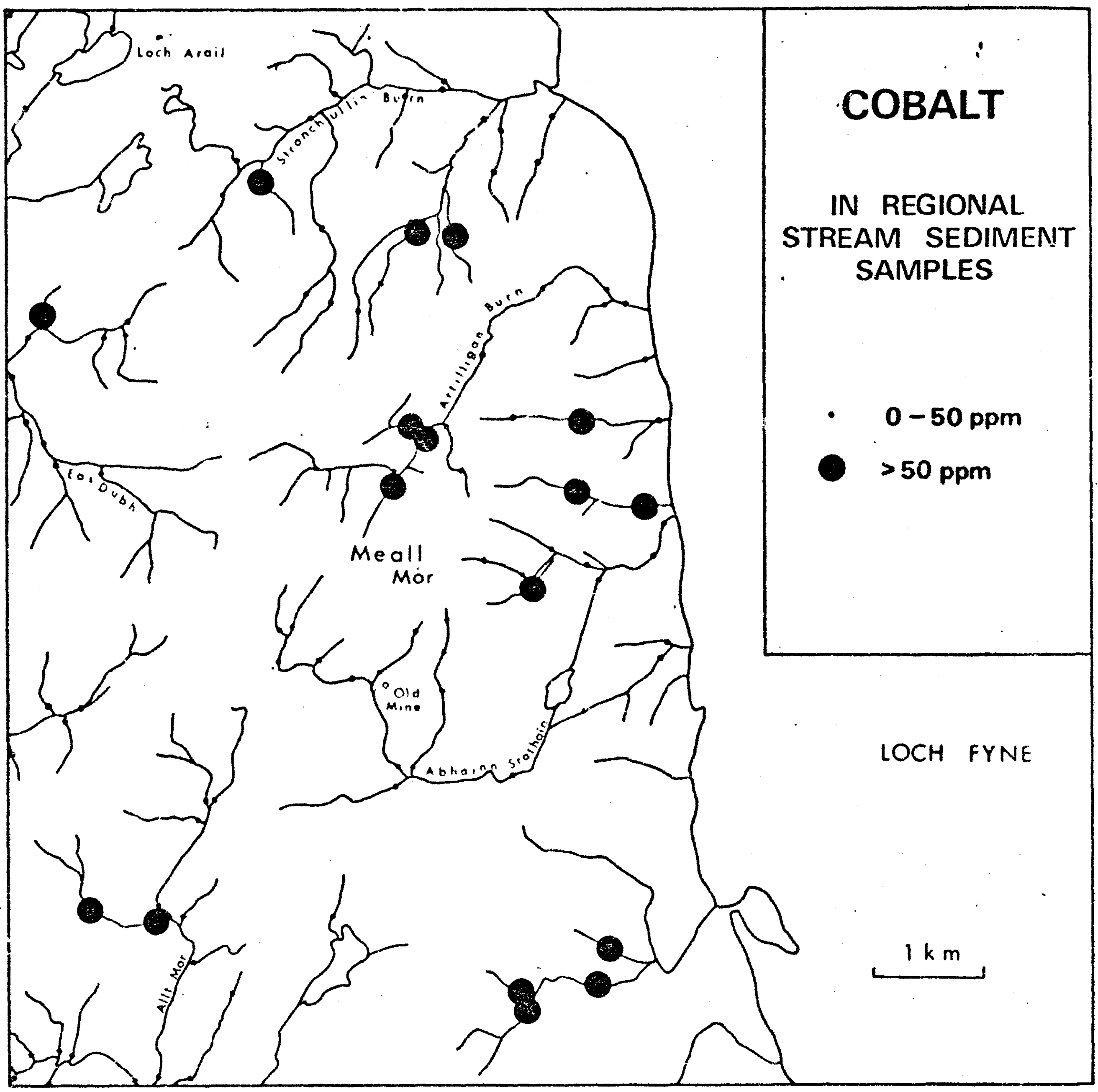


Fig. 15. Distribution of cobalt in stream sediment samples.

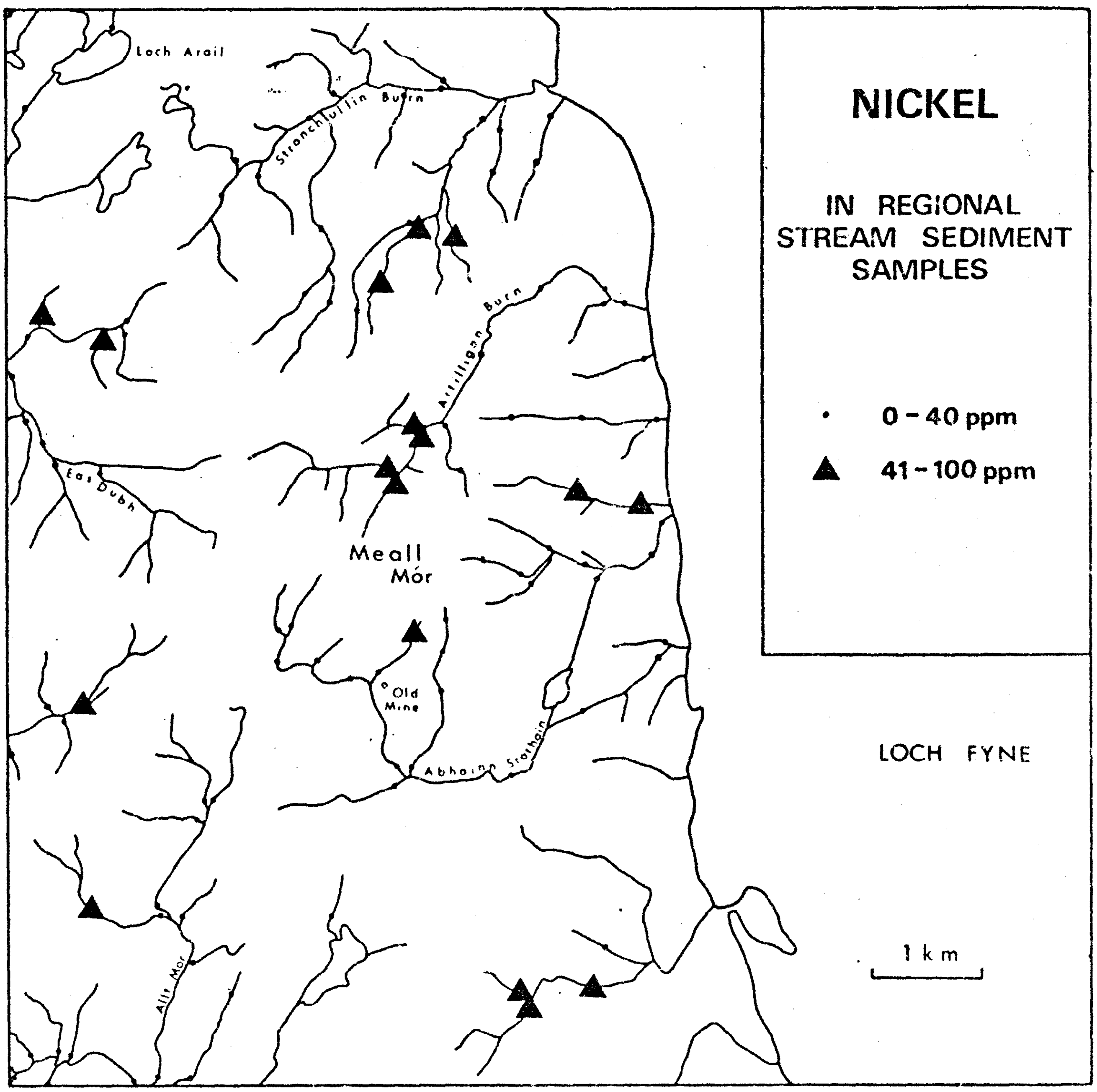


Fig. 16. Distribution of nickel in stream sediment samples.

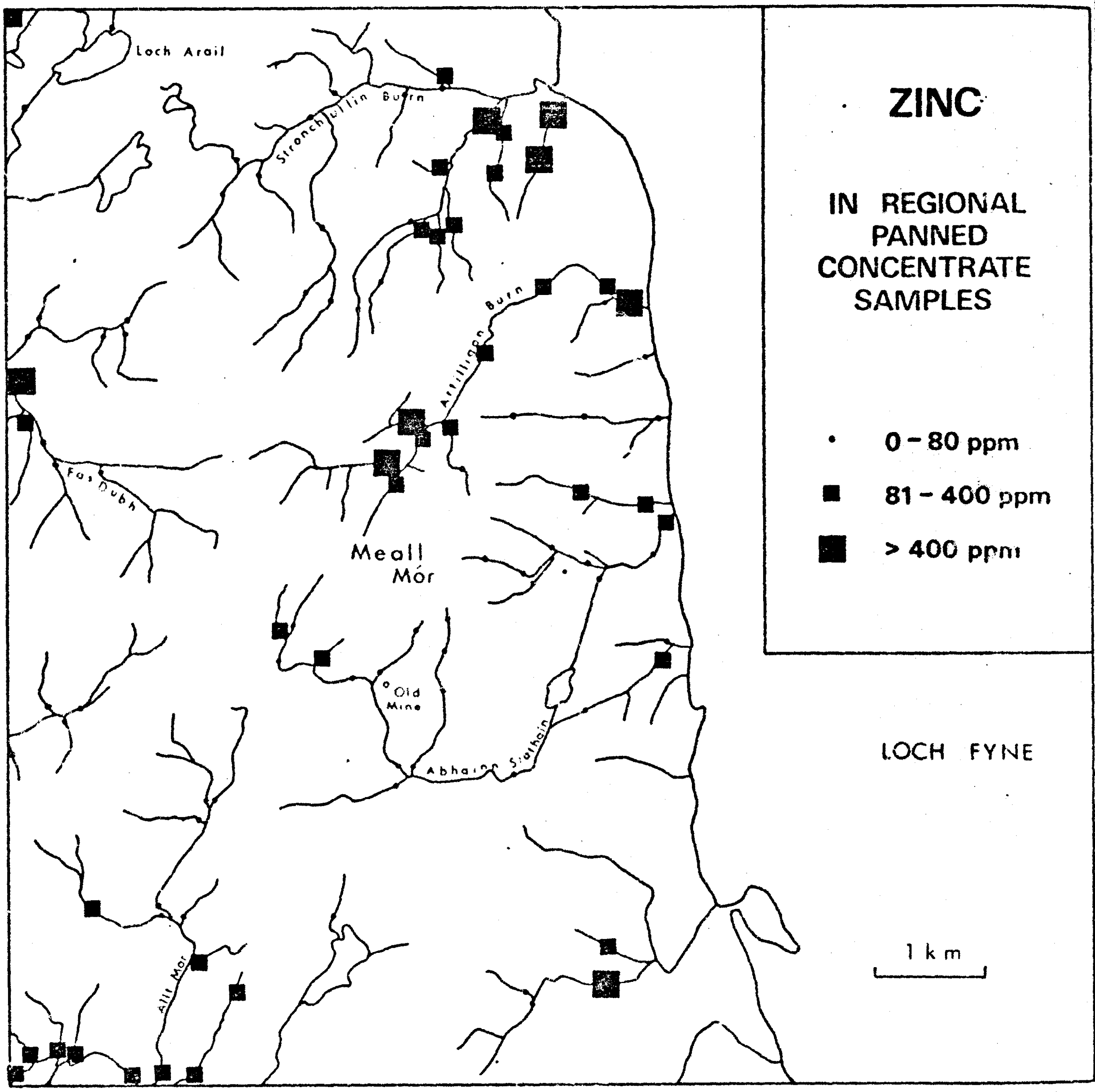


Fig. 17. Distribution of zinc in panned concentrate samples.

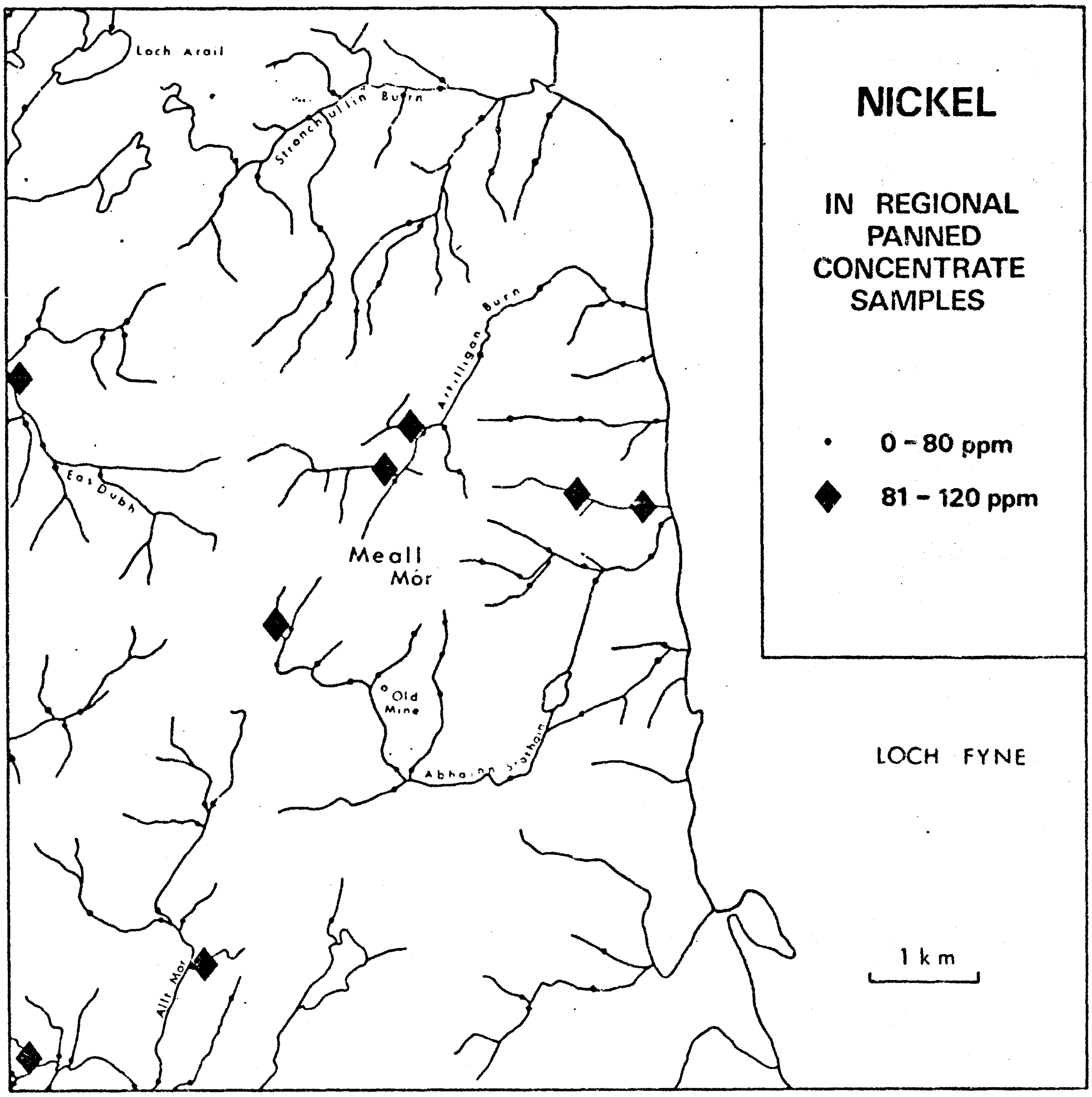


Fig. 18. Distribution on nickel in panned concentrate samples.

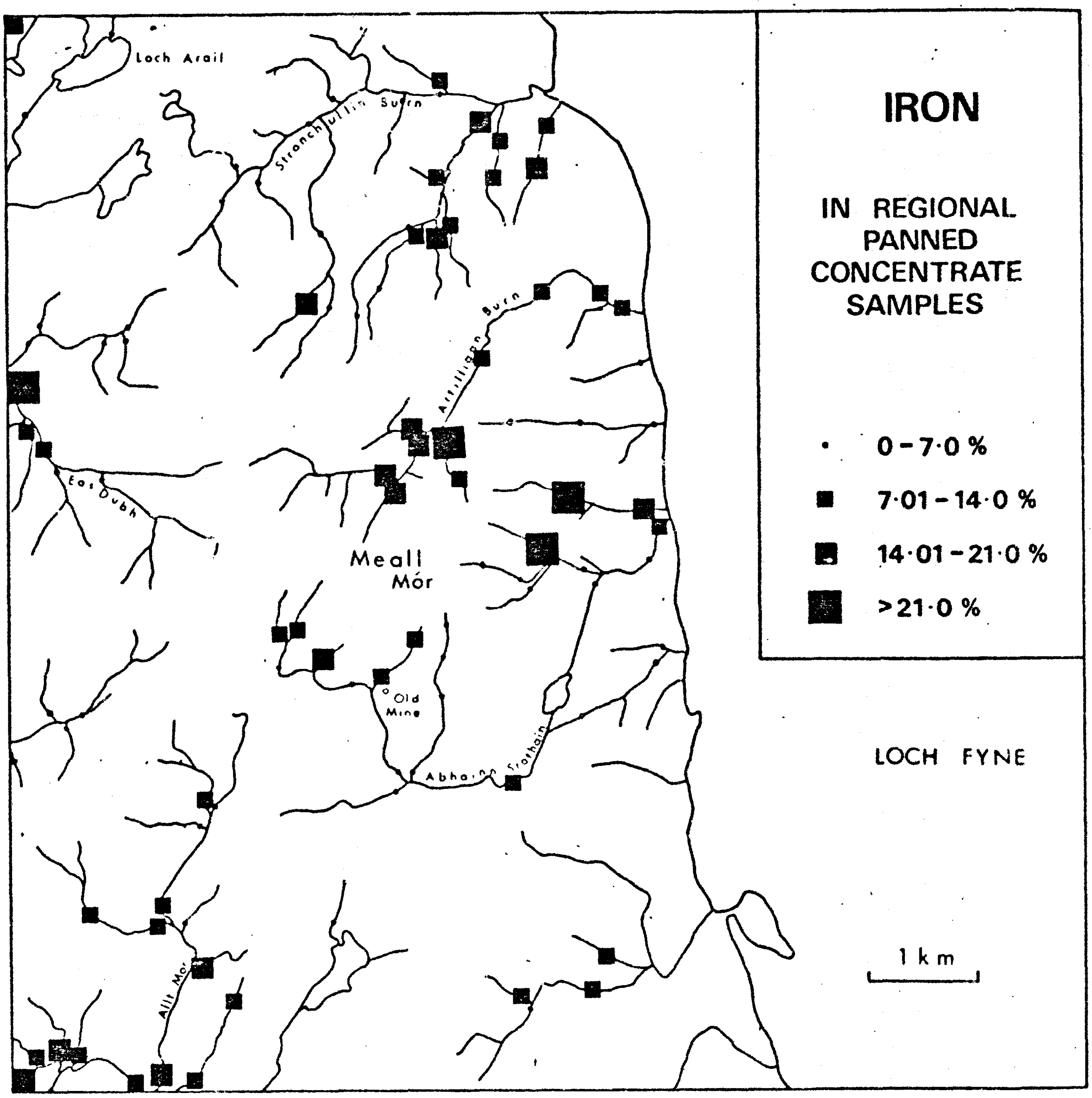


Fig. 19. Distribution of iron in panned concentrate samples.

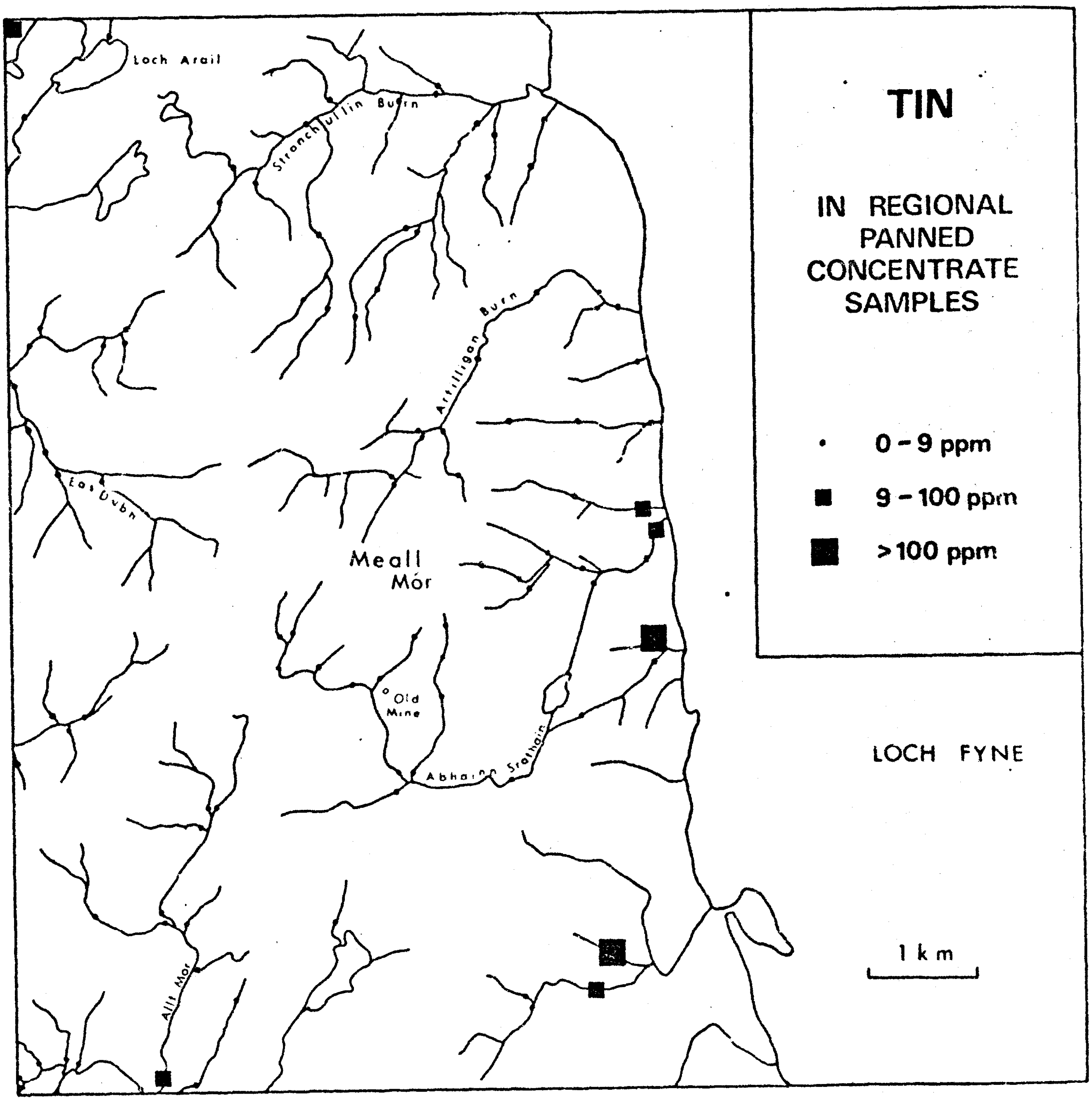


Fig. 20. Distribution of tin in panned concentrate samples.

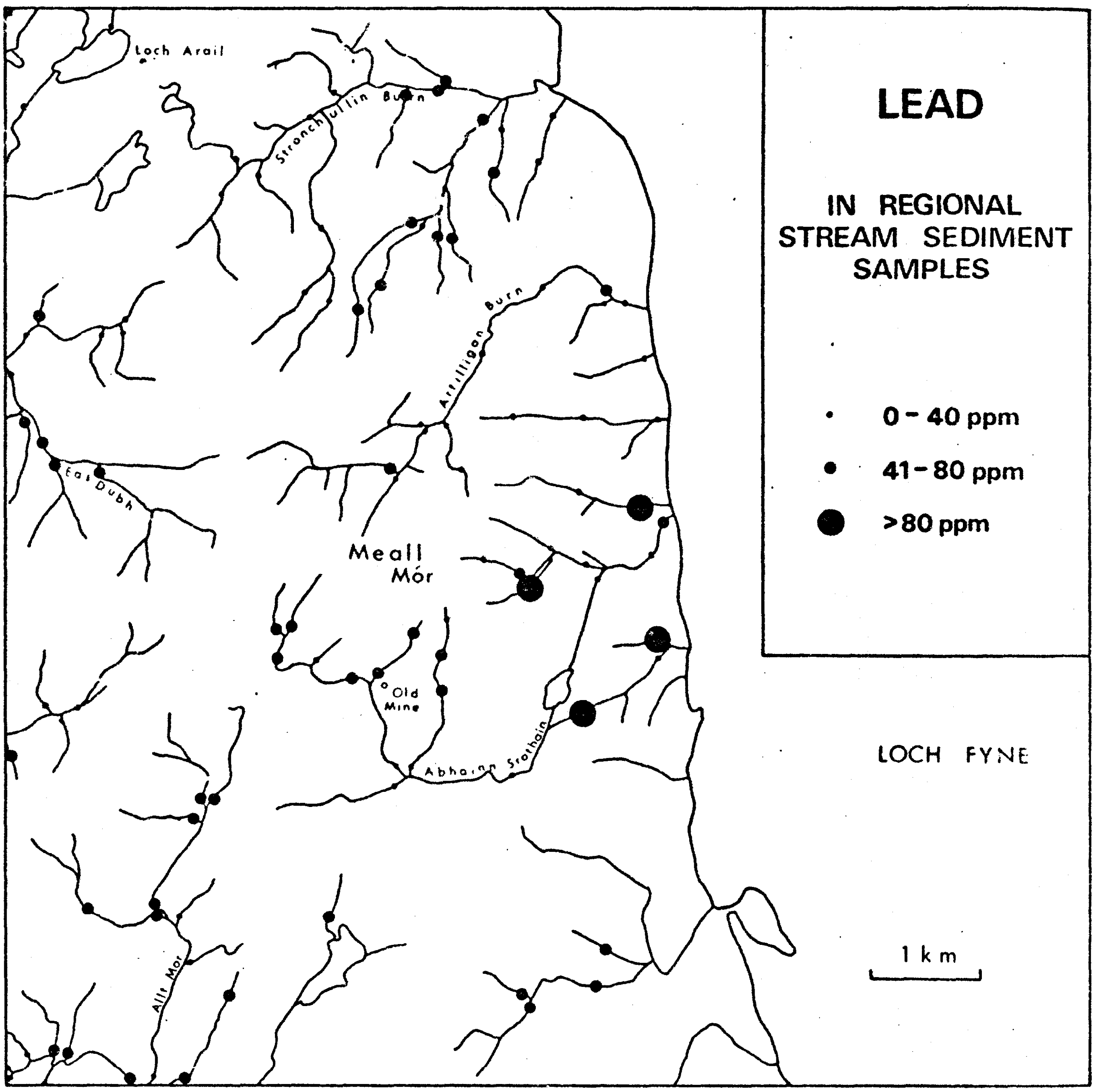


Fig. 21. Distribution of lead in stream sediment samples.

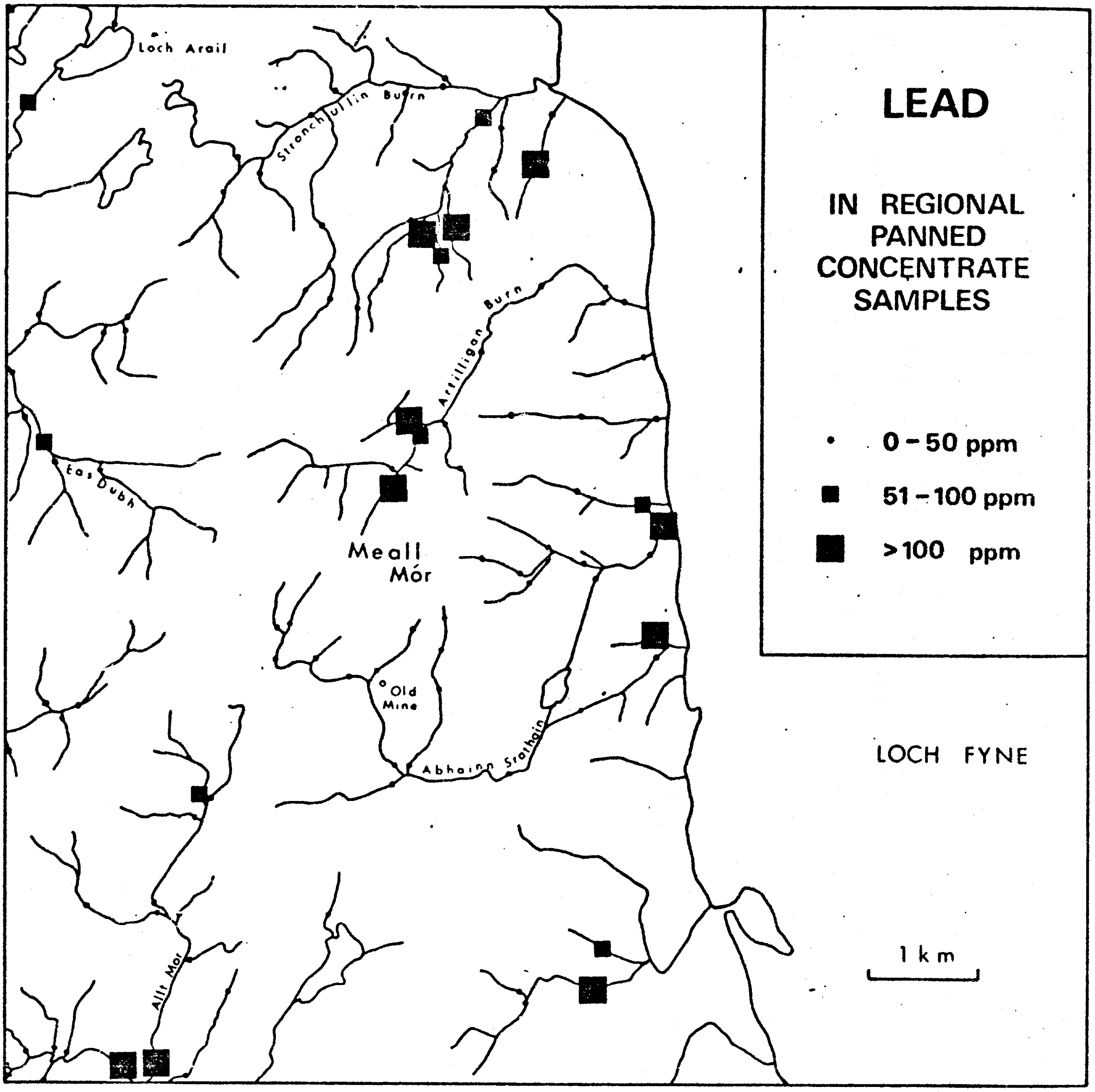


Fig. 22. Distribution of lead in panned concentrate samples.

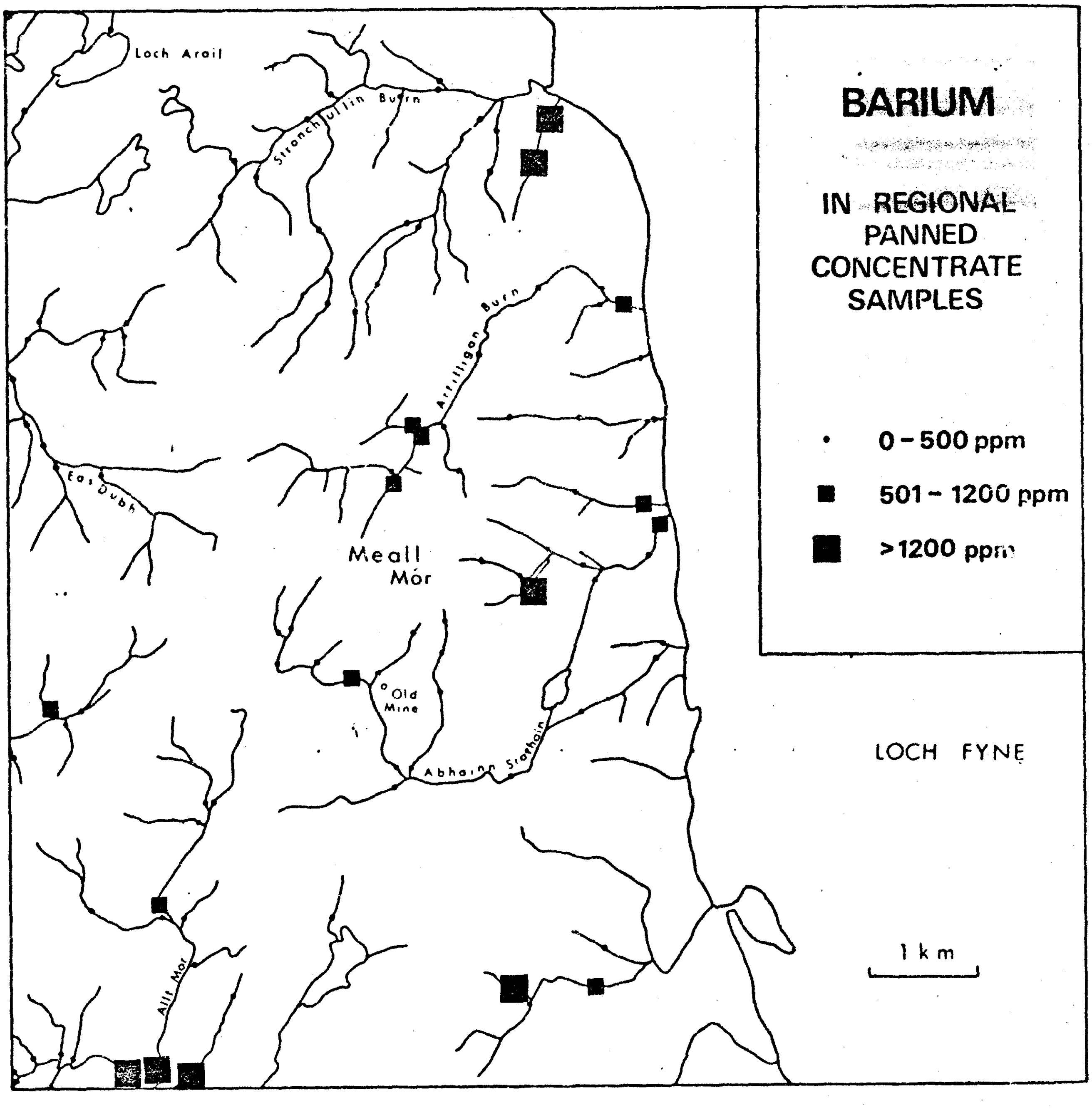


Fig. 23. Distribution of barium in panned concentrate samples.

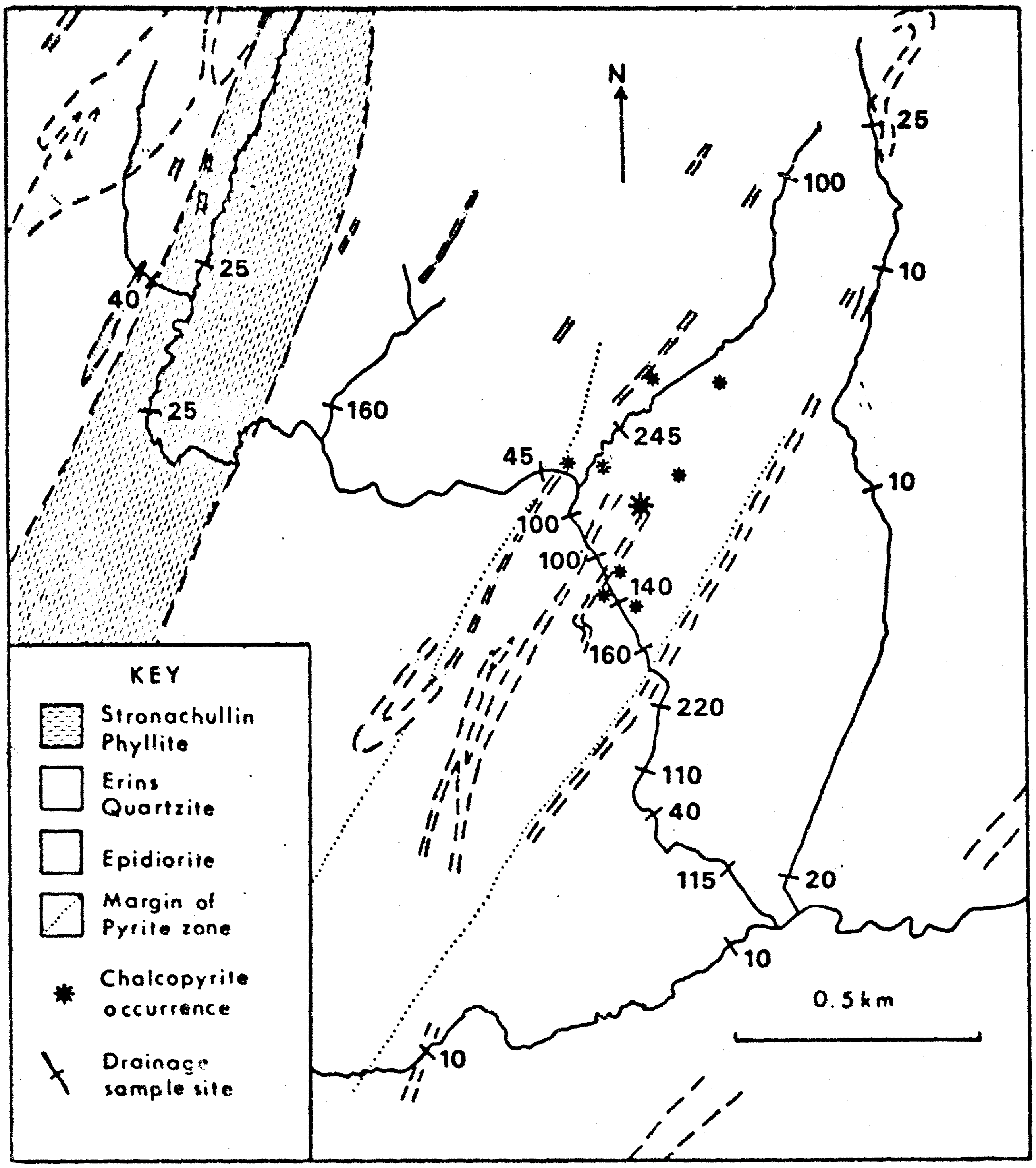


Fig. 24. Cu (ppm) in stream sediment samples, Abhainn Srathain.

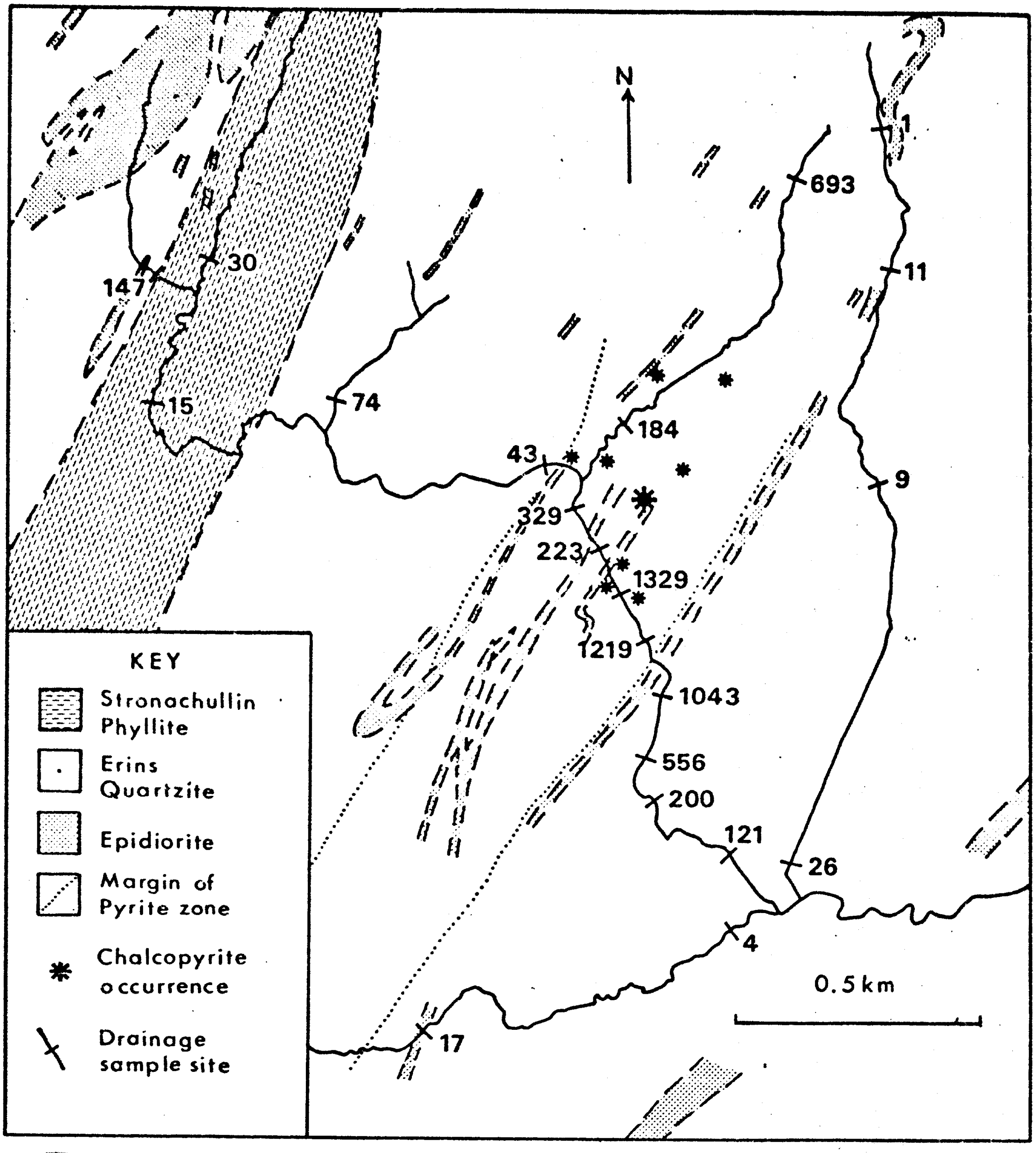


Fig. 25. Cu (ppm) in panned concentrate samples, Abhainn Srathain.

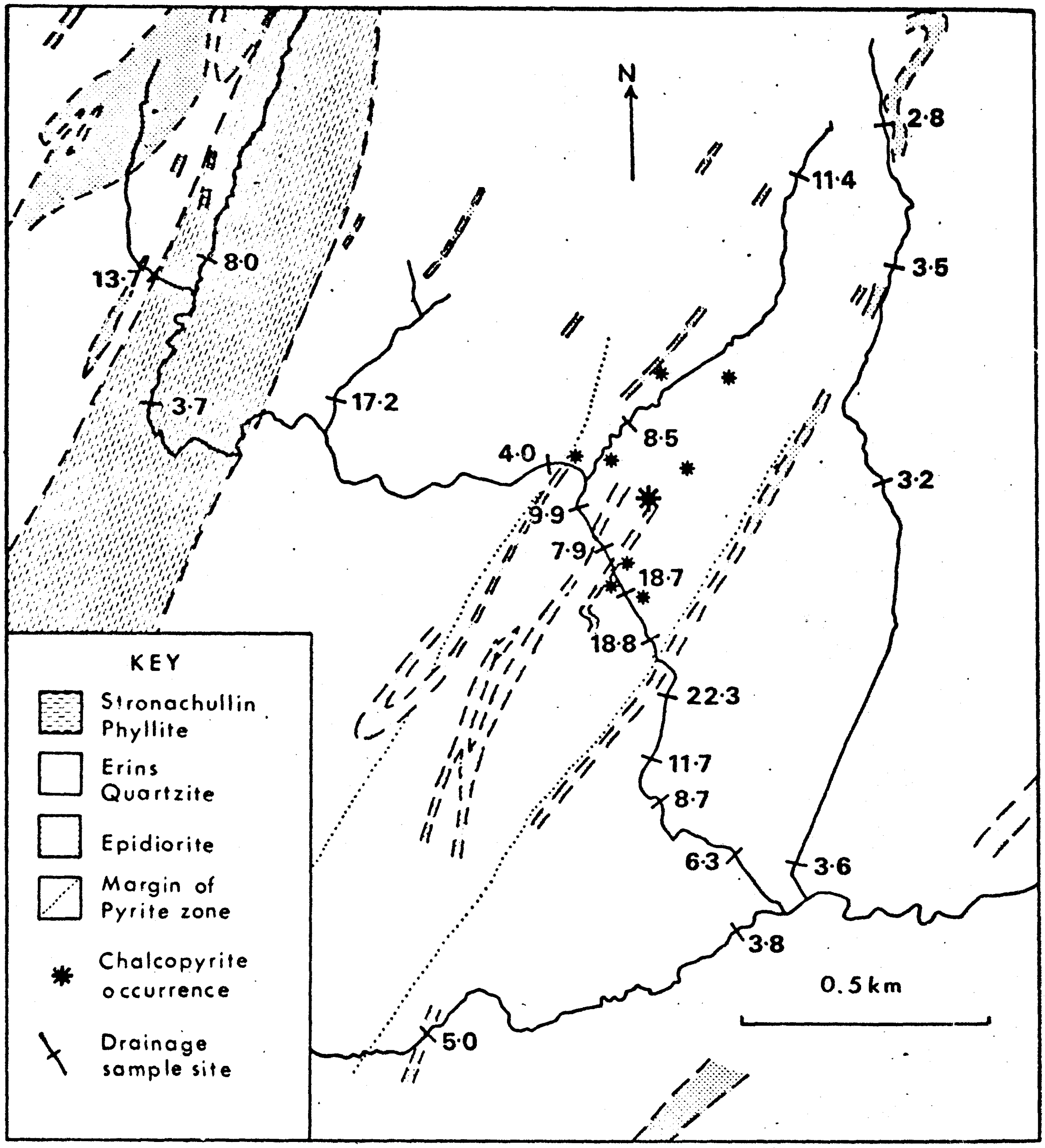


Fig. 26. Fe (%) in panned concentrate samples, Abhainn Srathain.

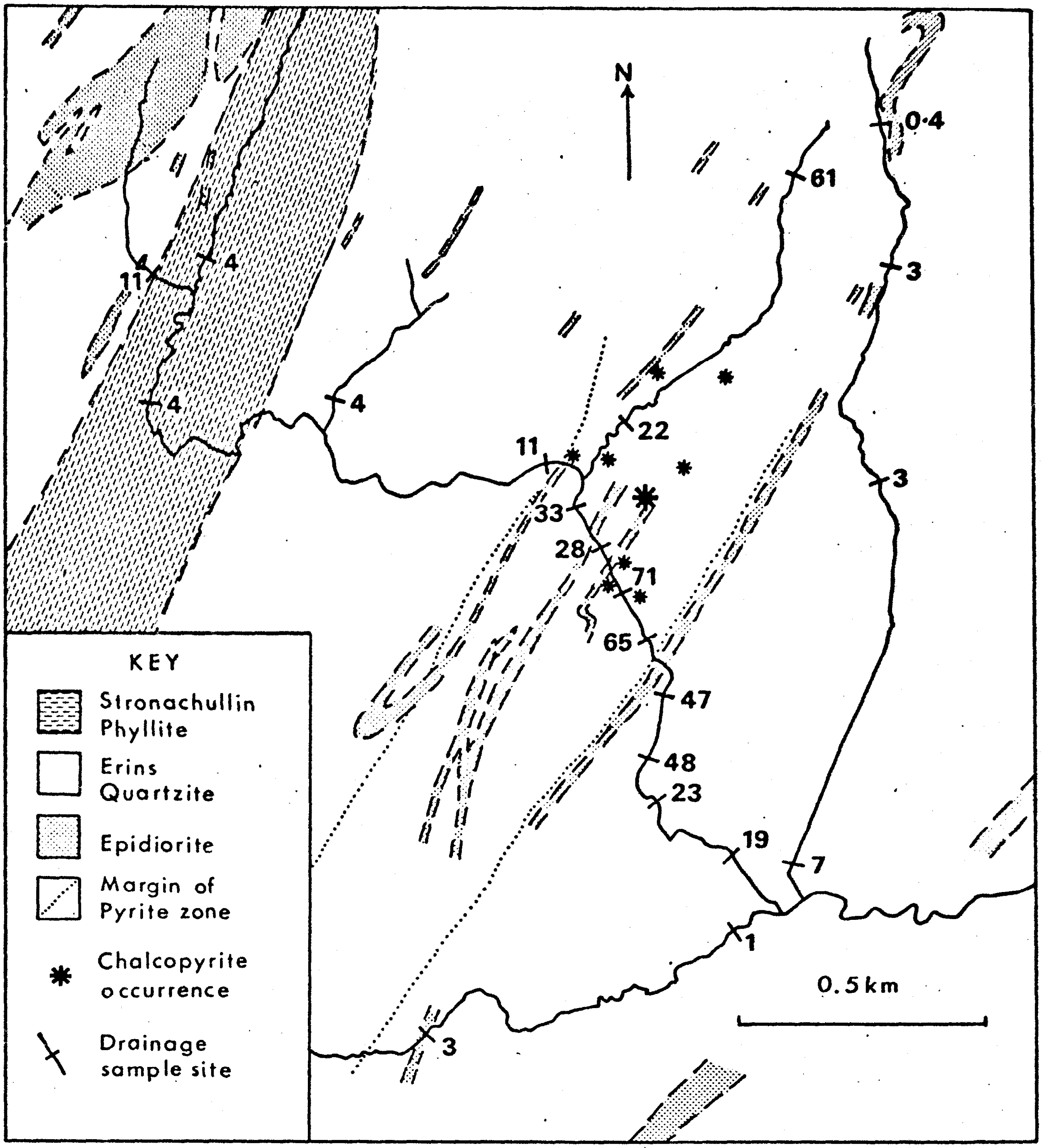


Fig. 27. Cu/Fe x 10^4 in panned concentrate samples, Abhainn Srathain.

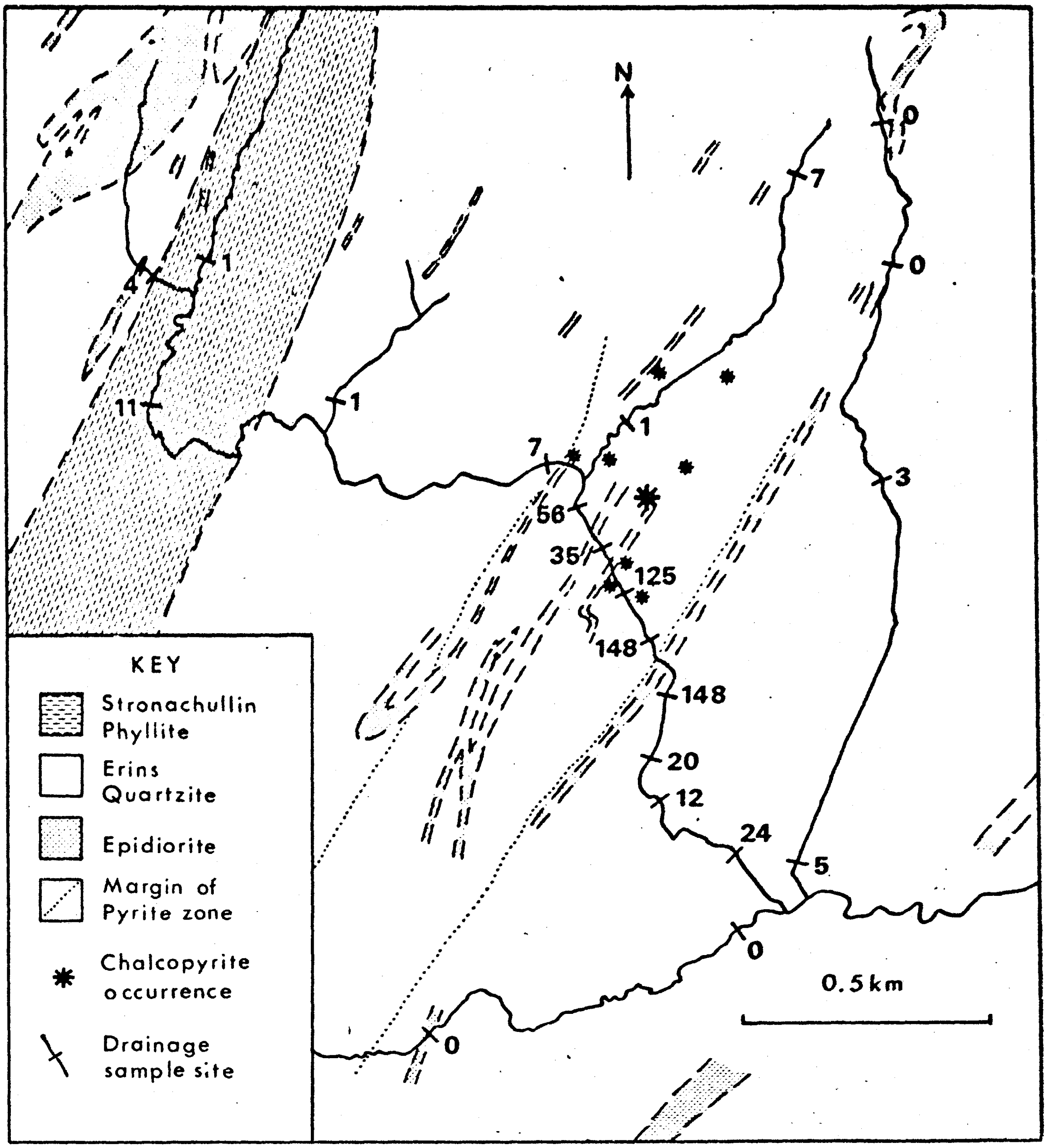


Fig. 28. Sb (ppm) in panned concentrate samples, Abhainn Srathain.

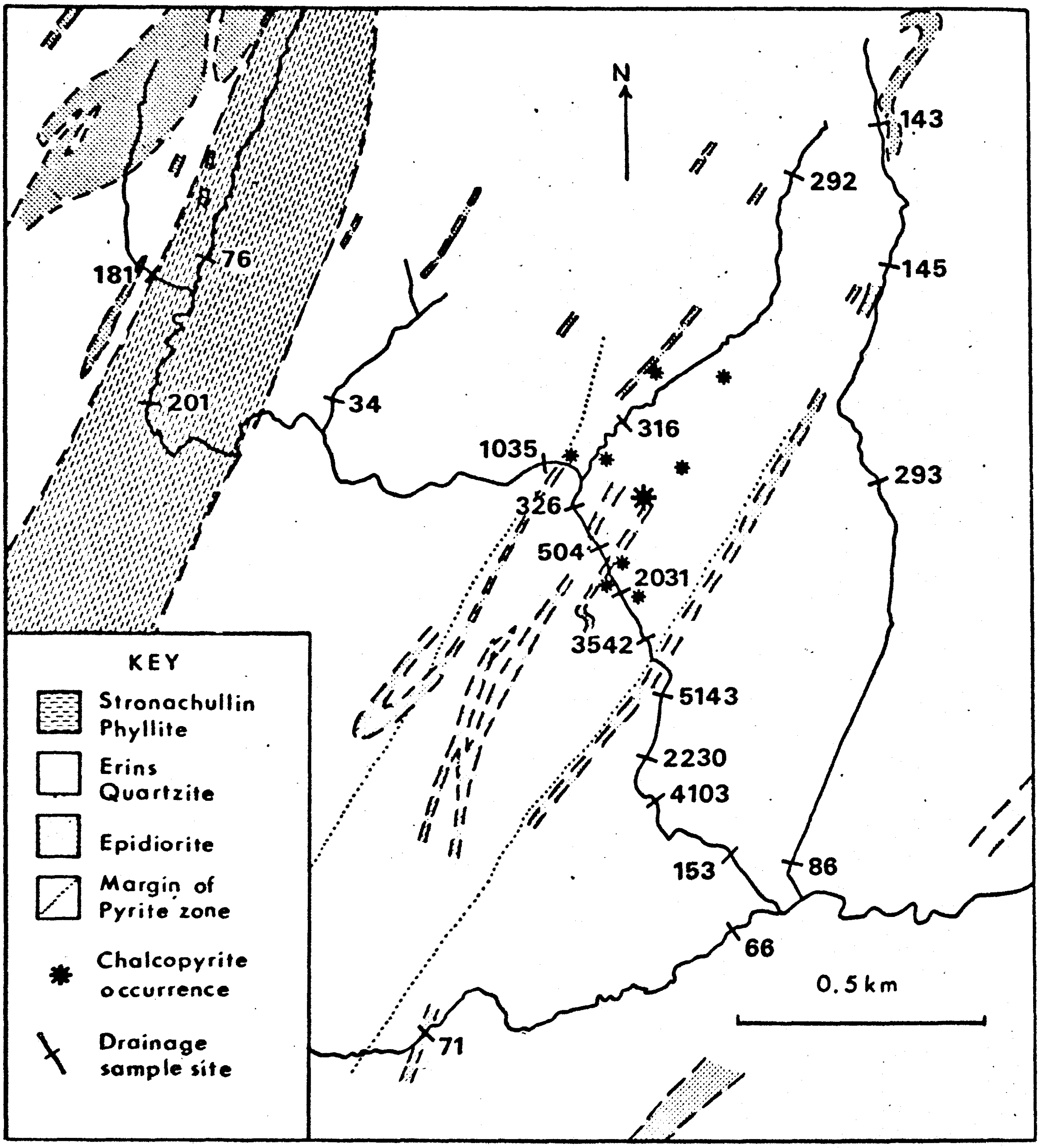
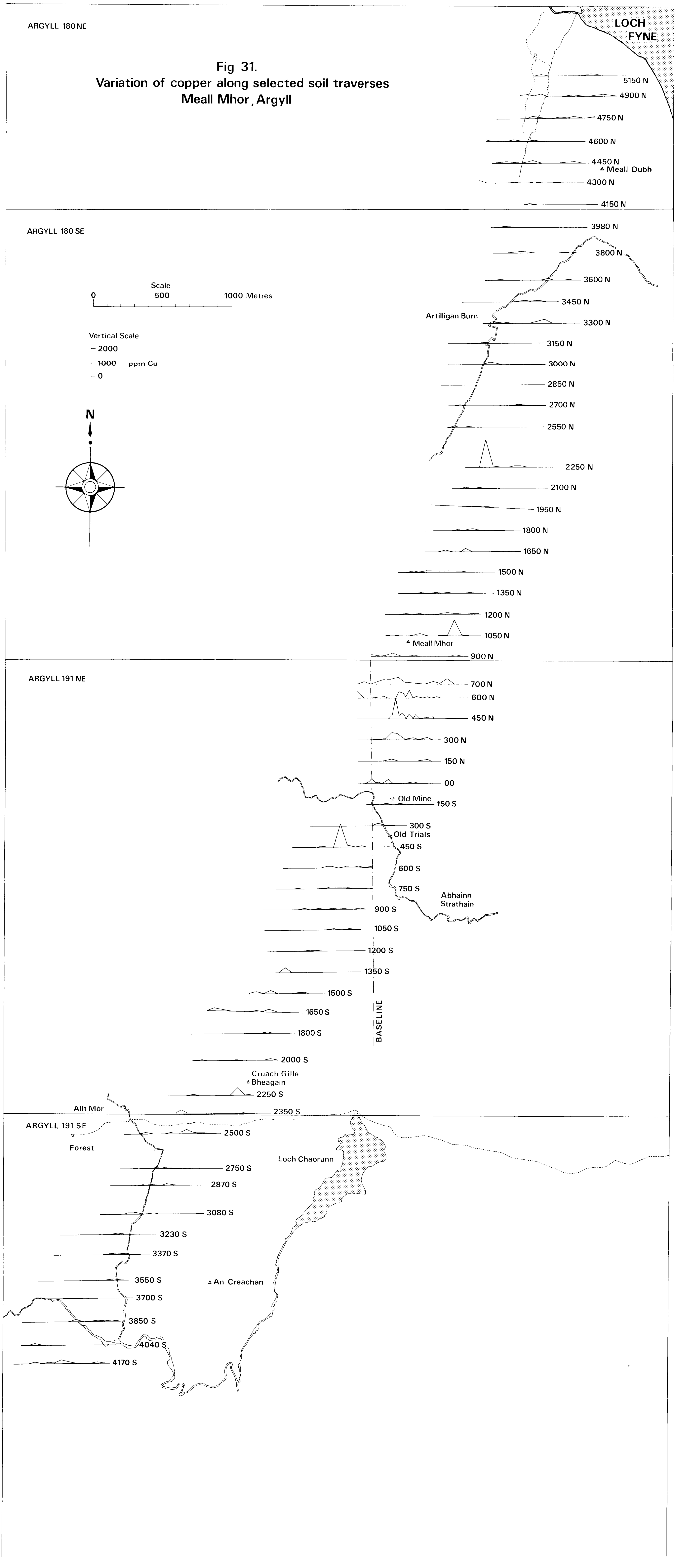


Fig. 29. Ba (ppm) in panned concentrate samples, Abhainn Srathain.

Fig 31.
Variation of copper along selected soil traverses
Meall Mhor, Argyll



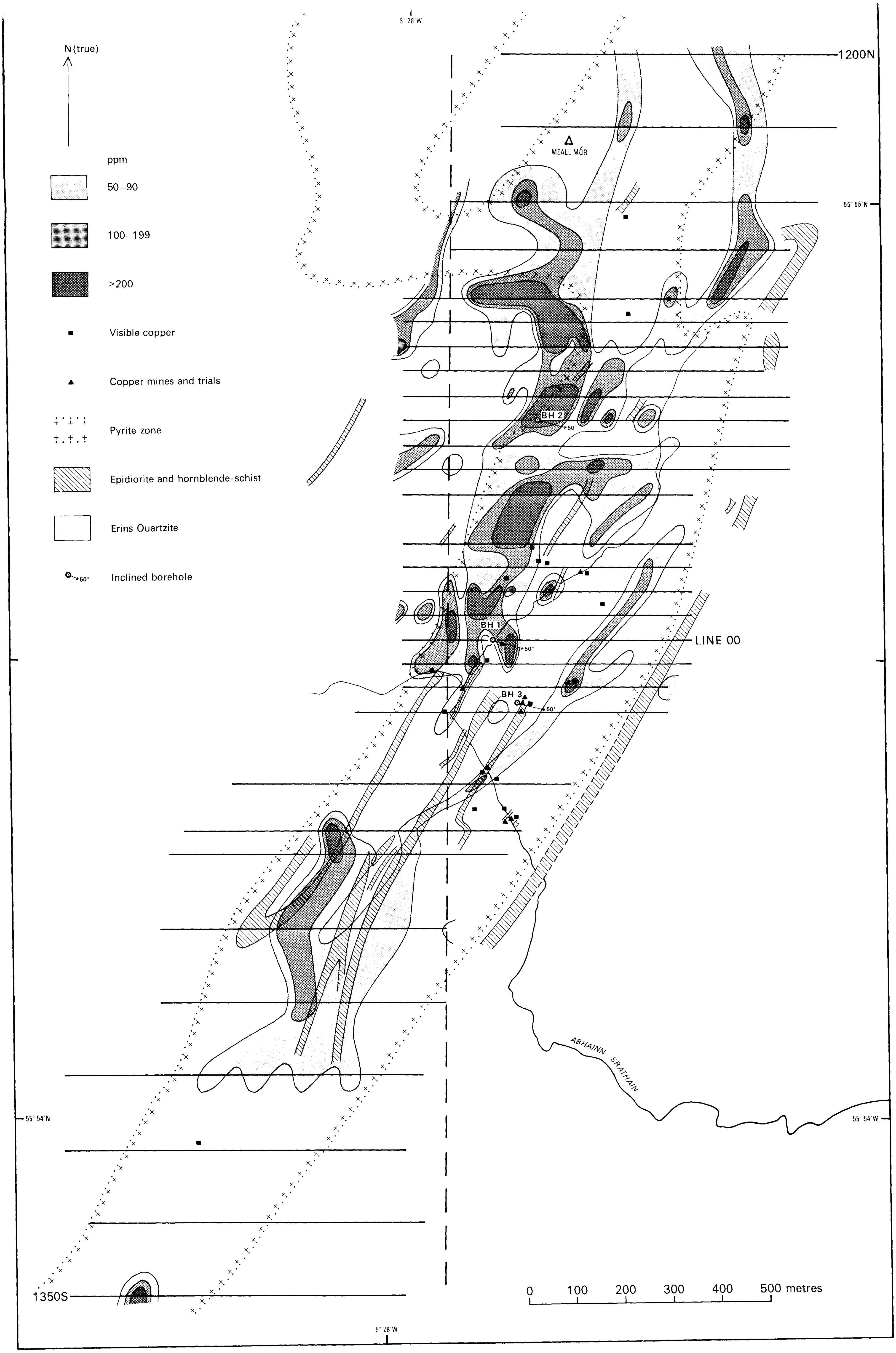


Fig 30 Meall Mór: Copper in Soils

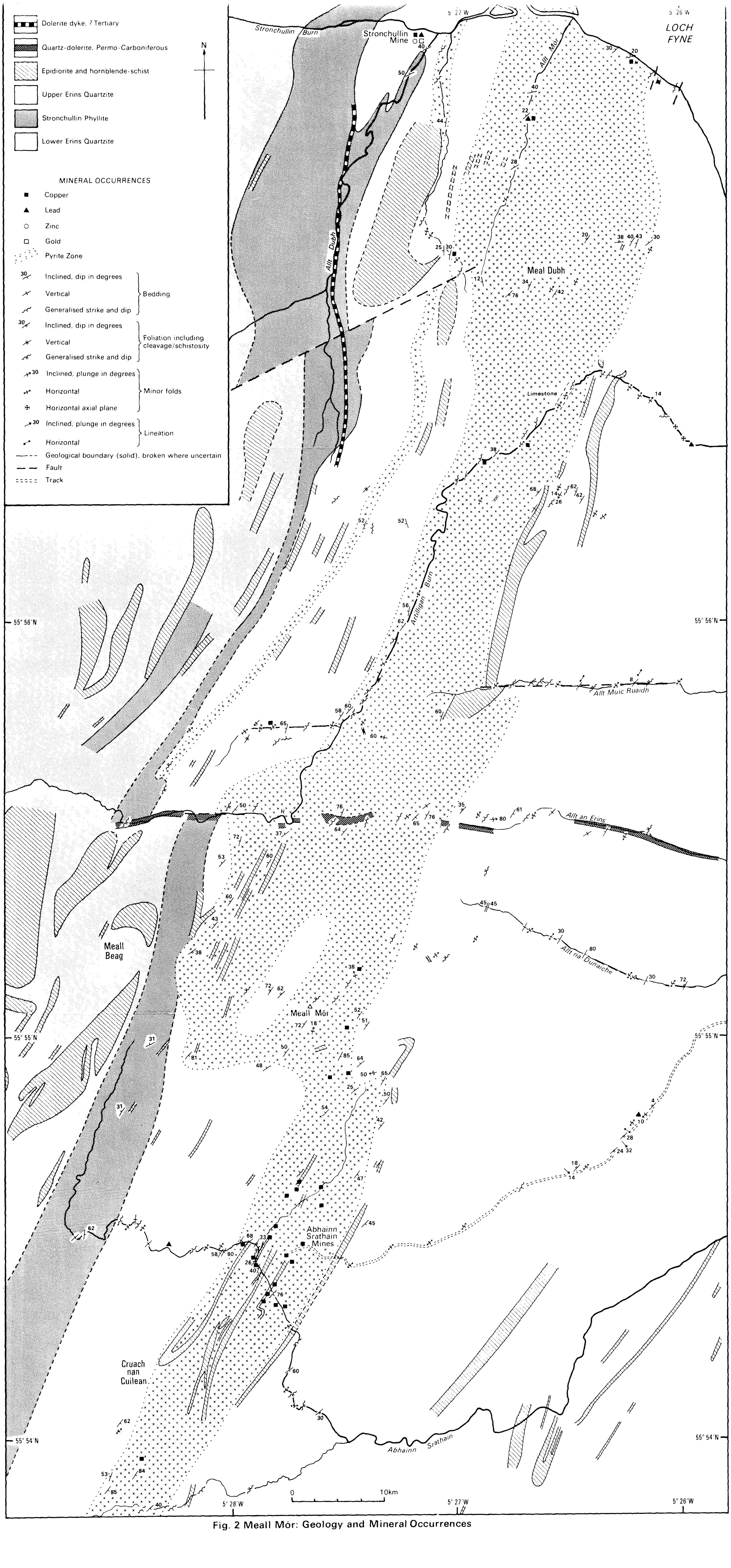


Fig. 2 Meall Mór: Geology and Mineral Occurrences