Natural Environment Research Council

Institute of Geological Sciences

Mineral Reconnaissance Programme Report

A report prepared for the Department of Industry

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

No. 18

A mineral reconnaissance survey of the Doon-Glenkens area, south-west Scotland.

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A mineral reconnaissance survey of the Doon–Glenkens area, south-west Scotland

South Lowlands Unit

J. Dawson, BSc

J. D. Floyd, BSc

P. R. Philip, BSc

Applied Geophysics Unit

A. J. Burley, BSc, PhD

Mrs J. M. Allsop, BSc

J. R. P. Bennett, BSc

G. R. Marsden, BSc

Radioactive and Metalliferous Minerals Unit

R. C. Leake, BSc, PhD

M. J. Brown, BSc

Edinburgh 1977

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17 Lead, zinc and copper mineralisation in basal Carboniferous rocks at Westwater, south Scotland

18 A mineral reconnaissance survey of the Doon–Glenkens area, south-west Scotland

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CONTENTS

ILLUSTRATIONS

Summary

An integrated reconnaissance survey was carried out over 600 km^2 of Lower Palaeozoic sediments and Caledonian granites in south-west Scotland.

Airborne electromagnetic (EM), magnetic, and radiometric surveys were made over three sectors of the project area considered on available geological evidence to offer environments favourable to mineralisation. The EM and magnetic surveys showed prominent anomalies associated with belts of black shales and a number of these are currently under examination. No significant anomalies were indicated by the radiometric survey and no important radioactive mineralisation was found in ground survey follow-up. The gravity survey has improved the knowledge of the spatial relationships of the major granite plutons.

Field and geochemical surveys led to the discovery of many new mineral prospects. Gold, not previously reported in the project area, was shown by panning to have a wide distribution and several interesting copper, lead, zinc, molybdenum and tungsten occurrences have been found.

1.3 Physical Description of Project Area

The area is covered by one-inch to one-mile Ordnance Survey Sheets 67 and 73 and one-inch to one-mile Geological Survey Sheets 4, 8, 9, 14 and 15.

The region is dominated by the ring of high ground formed by the metamorphic aureole of the Loch Doon intrusion. The western aureole includes the Merrick (840 m), the highest peak in the south of Scotland, while the eastern aureole forms the prominent ridge of the Rhinns of Kells. The Carsphairn granitic complex, in contrast with the Loch Doon intrusion, rises above its aureole to form the large rounded mass to the north-east of Carsphairn village.

The main watercourses of the area are the Doon, Cree, Ken and Dee; the Doon flowing northward into the Firth of Clyde and the others south to the Solway. The Doon and Dee drain the northern and southern halves respectively of the Loch Doon intrusion, while the Ken and Cree drain most of the remaining ground. The main watersheds and drainage pattern are shown in Fig. 1.3 (back pocket).

A large part of the area is covered by young forest. This hindrance to free movement is more than offset by the access provided by the useful network of new forest roads.

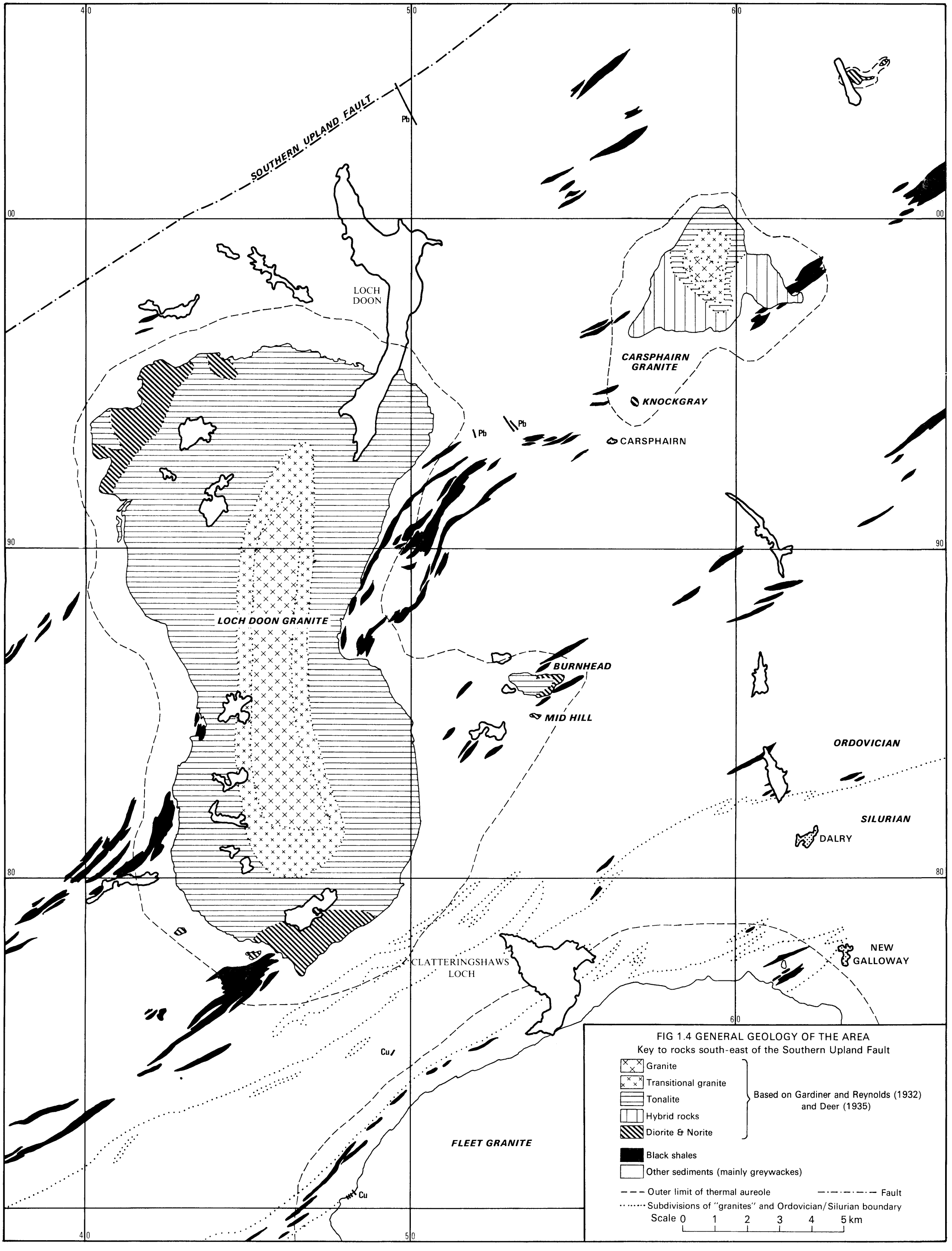
1.4 Geological Description of the Area

The early concept of the geology of the Southern Uplands was of a relatively thin, strongly folded sequence of greywackes, siltstones and shales. A revival of interest in the greywackes of this Lower Palaeozoic succession, begun in the 1950's, soon cast doubt on the earlier interpretation. The modern view envisages a thick succession, dominated by greywackes, laid down rapidly in an Ordovician-Silurian trench environment. This pile was subsequently subjected to strong

NW-SE compressional movements which, eventually, produced fault-bounded blocks of near-vertical beds. The stratigraphical sequences within blocks can be traced for considerable distances along strike (NE-SW) but are difficult to correlate across strike (NW-SE).

The culmination of the main period of orogenic movement was accompanied in Lower Old Red Sandstone times by the emplacement of granite plutons into the folded sedimentary pile. The principal intrusions of Loch Doon and Carsphairn are broadly similar in that they both have a central acid phase encompassed by a variety of more basic rocks which, in turn, are in contact with the country rock. Geological opinion is divided as to whether substantial portions of the basic facies rocks have a magmatic origin or are derived from the melting of sedimentary formations. The granitic intrusions were subsequently unroofed and now form important physical and geological features of the Southern Uplands. The general geology of the area is shown in Fig. 1.4.

The Southern Uplands have long been known to contain both noble-metal and base-metal mineralisation and in some areas intermittent prospecting and mining has been carried on for centuries. Historically the most productive district was Leadhills - Wanlockhead, which yielded lead-silver and zinc ores from near-vertical veins with WNW to NW and NNW to NNE trends. Significant amounts of base-metal ores have been produced, mainly in the 19th century, from veins in the Newton Stewart district and from Woodhead near Carsphairn village.


SOUTHERN UPLAND FAULT
Pb
LOCH DOON
CARSPHAIRN GRANITE
KNOCKGRAY
CARSPHAIRN
LOCH DOON GRANITE
BURNHEAD
MID HILL
ORDOVICIAN
SILURIAN
DALRY
NEW GALLOWAY
CLATTERINGSHAWS LOCH
FLEET GRANITE
Cu
40
50
60
80
90
FIG 1.4 GENERAL GEOLOGY OF THE AREA
Key to rocks south-east of the Southern Upland Fault
Granite
Transitional granite
Tonalite
Hybrid rocks
Diorite & Norite
Based on Gardiner and Reynolds (1932) and Deer (1935)
Black shales
Other sediments (mainly greywackes)
Outer limit of thermal aureole
Fault
Subdivisions of "granites" and Ordovician/Silurian boundary
Scale 0 1 2 3 4 5 km

2. GEOPHYSICAL SURVEYS

2.1 Introduction

2.1.1 Aims and Objectives of Surveys

The geophysical reconnaissance methods used fall into three categories:

1) The gravity survey
2) The airborne surveys, comprising electromagnetic (EM), magnetic and radiometric measurements
3) Ground follow up of anomalies measured in airborne surveys

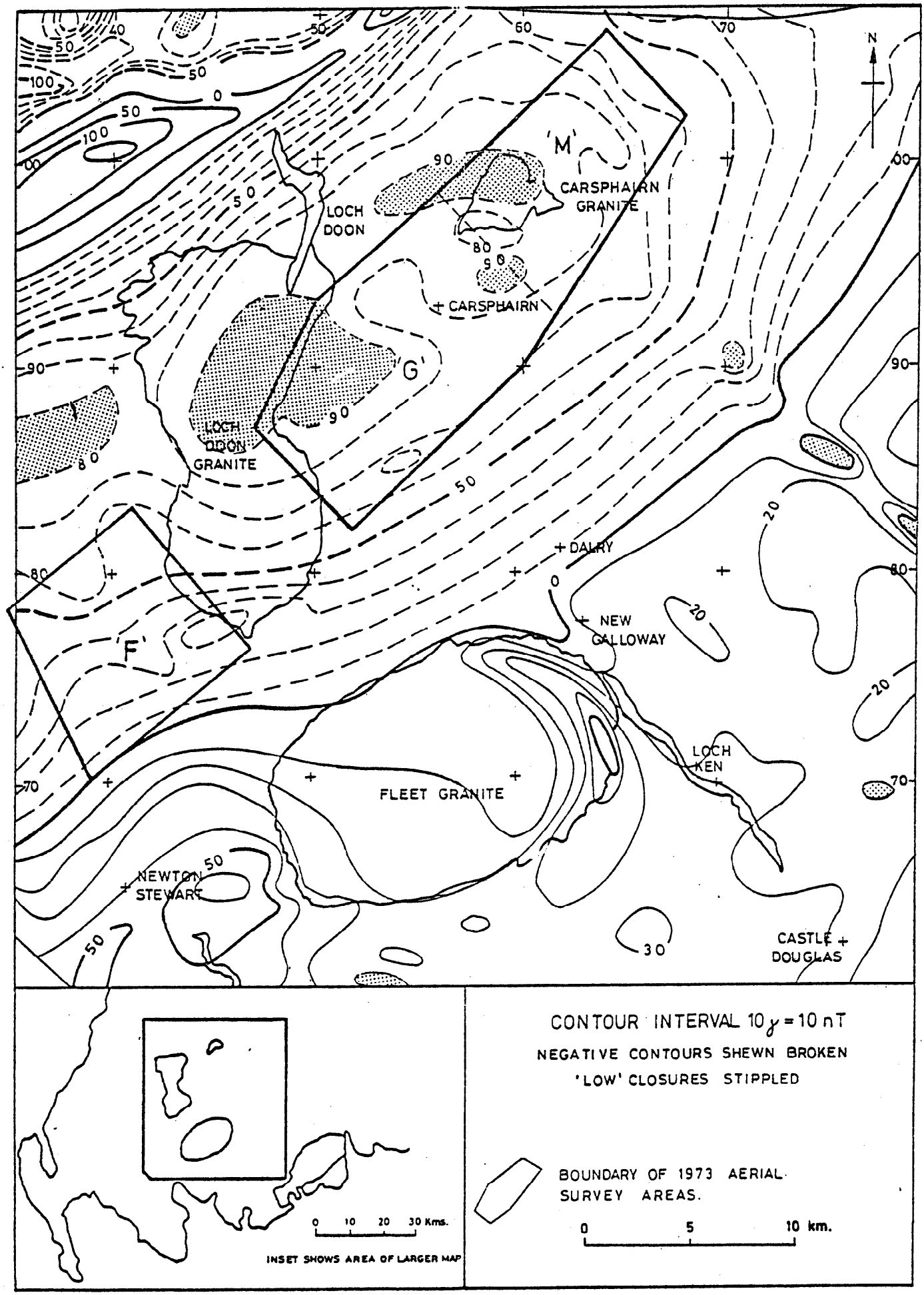
The objective of the gravity survey was to define the distribution of granitic rocks below the present erosion surface. Significant negative residual Bouger anomalies coincide with the granitic complexes and it is therefore possible that other similar anomalies may reflect the presence of buried granitic intrusions which represent possible controls of mineralisation.

The airborne surveys were carried out over a limited area to test their ability to detect ore bodies, with a view to extending coverage if successful. Ground follow up of interesting aerial anomalies is necessary in order to establish their position, size and shape more accurately.

2.1.2 Previous Work : the 1959 Aeromagnetic Survey

An aeromagnetic survey of south-west Scotland was made during 1959 and the results published as a map (IGS, 1972). Fig. 2.1 shows the results for the Doon-Fleet district and surrounding area. Over the Southern Uplands the magnetic field is relatively smooth and must reflect the variation in depth or composition of a deep magnetic basement. Independent calculations by various authors based on different kinds of geophysical evidence (magneto-telluric, seismic and

FIG 2.1 AEROMAGNETIC MAP (1972) OF DOON-FLEET DISTRICT.



magnetic) indicate that this basement lies at a depth of about 12 kilometres. There is no clear relationship between the magnetic field and the distribution of granitic complexes though the parts of them which contain higher proportions of magnetite are responsible for some of the small-scale features. The linear negative anomaly trending NW-SE on the east side of Fig. 2.1 is almost certainly caused by a reversely magnetised Tertiary dyke. It can be traced south-east across England to the Cleveland-Armathwaite dyke and at Troston Hill (NX 7091) it coincides with a dyke outcrop which may link with the Caponcraig-Coylton dyke of Ayrshire.

2.2 Gravity Survey

2.2.1 Area Examined

The survey was carried out in the Doon-Fleet district over the area covered by the map in Fig.2.2. The information obtained was supplemented by the results of previous surveys in areas to the south and east by Bott and Masson Smith (1960) over the Criffell complex and by Parslow and Randall (1973) over the Fleet granite.

2.2.2 Technique and Data Reduction

The instruments used were a La Coste and a Worden gravimeter. Where possible measurements were taken at bench marks or spot heights, but in areas where these were sparse stations were levelled to the nearest bench mark, and a series of levelled traverses were made to improve the definition of some steep gravity gradients. Observations were related to the IGSN 71 network and reduced using the 1967 International Gravity Formula and a density of 2.70 $g.cm^{-3}$. Complete terrain corrections were applied and the results presented as a 1:50 000 Bouger anomaly map contoured at 1 milligal (10 gravity units) intervals. In Fig. 2.2 this map is shown reduced to a scale of 1:100 000.

2.2.3 Results

The figure shows a regional decrease in the value of the Bouguer anomaly from west to east across the whole of the area: this is probably caused by a change in crustal thickness from the Scottish mainland to the Irish Sea. By inspection of profiles extending for about 100 kilometres around the area surveyed (derived mainly from other gravity surveys carried out by IGS) the regional gradient was evaluated at 0.2 milligal per kilometre decreasing in an easterly direction. For the purpose of interpretation a 'residual' Bouguer anomaly map was prepared at the same scale (1:50 000) with this regional gradient removed.

Apart from the regional gradient, the most prominent features are the 'lows' coinciding with the granite of the Loch Doon igneous complex and the Fleet granite. There is clearly an extension of low density material to the east and north of these exposures. Between the two igneous complexes lies an axis of relatively weaker 'highs', corresponding to material denser than the country rock, trending approximately NE-SW but with a change in direction where the complexes are closest to each other.

2.2.4 Interpretation in Terms of Geology

The following list of average rock densities is based on a large number of laboratory measurements on rocks from the area, most of them given in previously published material and some carried out by the Engineering Geology Unit of IGS:-

Granite	2.62 $g.cm^{-3}$
Norite	2.82 $g.cm^{-3}$
Sediments	2.72 $g.cm^{-3}$
Tonalite	2.71 $g.cm^{-3}$

For the purpose of interpretation the small difference between the sediment and tonalite densities was ignored. The density contrasts are thus:-

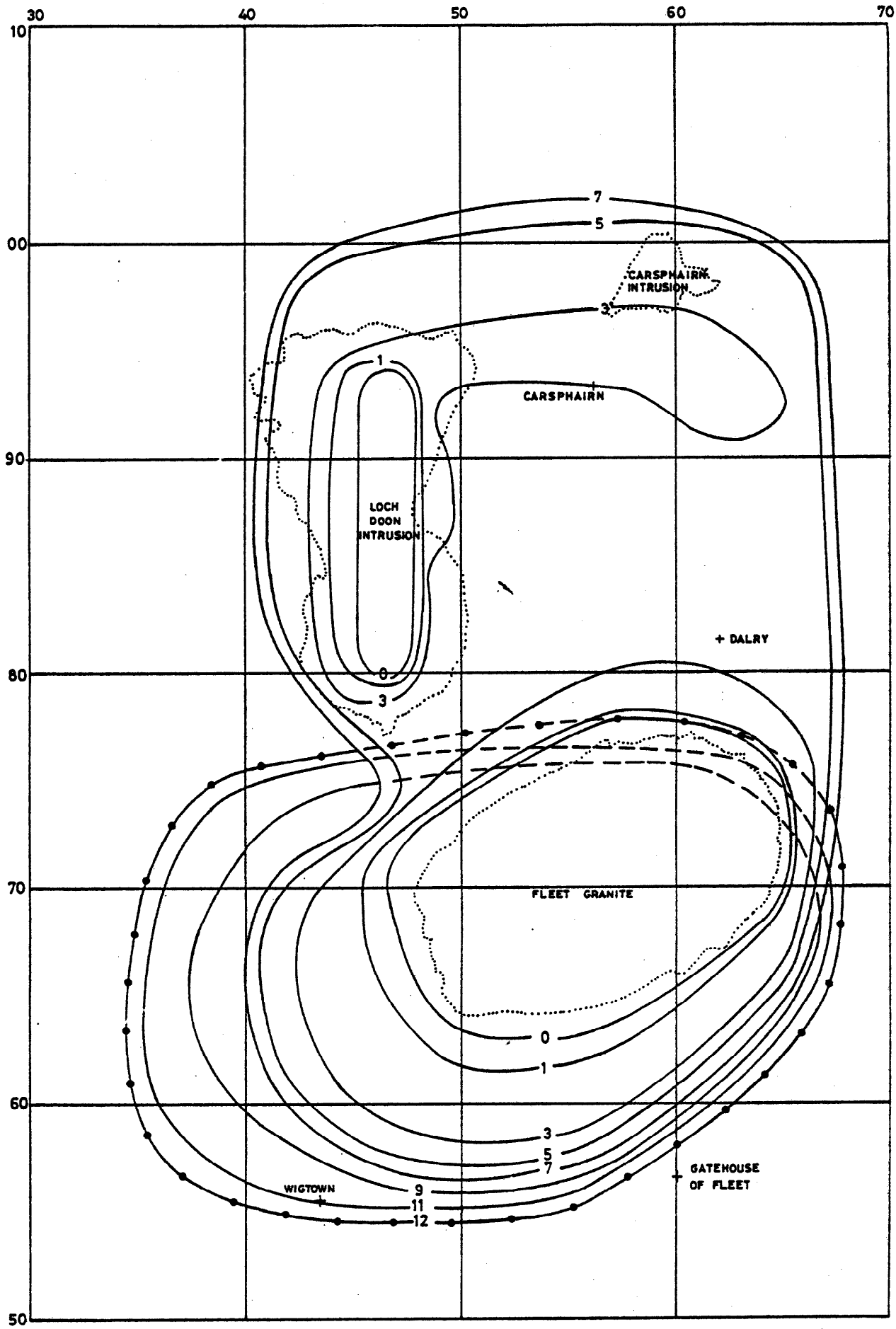


FIG 2.3 GRANITE-SEDIMENT MODEL OF DOON-FLEET DISTRICT

CONTOURS SHOW DEPTH TO GRANITE IN KILOMETRES BELOW A DATUM 0·35 Km ABOVE SEA LEVEL. BASE OF GRANITE IS 7 Km. BELOW DATUM EXCEPT WHERE INDICATED BY ⟷ (12 Km)

DENSITY CONTRAST : 0·1 g cm^{-3}

Detailed traverses across the complex revealed a residual gravity 'low' of amplitude 3 milligals and width approximately 3 kilometres centred a little to the north-east of the granite exposure (Fig. 2.3a). A gravity model of the structure indicates that the granite/acid hybrid part of it has a diameter increasing to about 3 kilometres not far below outcrop, suggesting a gently dipping roof extending towards the north. The sides of the structure are near vertical, except towards the north-west, and it is joined to the granite platform postulated above.

The model does not account for a residual ridge of positive anomalies having a maximum amplitude of 5 milligals south-west of the Loch Doon complex, decreasing between the Loch Doon and Fleet complexes to about 2 milligals towards the Burnhead intrusion. Interpretation of this feature is speculative, but attempts have been made to explain it in terms of either norite, or of denser sediments which do not feature in the density measurements because the samples on which they have been made were not collected from this part of the area. The two models are shown in Figs. 2.4 and 2.5. In the norite model (Fig. 2.4) the exposed norite corresponds with that at the southern end of the Loch Doon complex. In both models the shapes of the structures, particularly their variation with depth, should be treated only as a guide to a possible model explaining the observed gravity results. The station spacing itself is less than one per square kilometre so the effects of masses with dimensions of the order of a kilometre may not be revealed and will not therefore be included in the models. The norite outcrop in the Burnhead complex, for instance, has dimensions smaller than this.

The model based on sediments of a higher density is perhaps geologically more satisfactory: a cross-section of the model is shown in Fig. 2.6 in which the density contrast with the surrounding sediments has been taken as 0.03 $g.cm^{-3}$. It is of course quite possible that a combination of the two models is the true explanation of the gravity results.

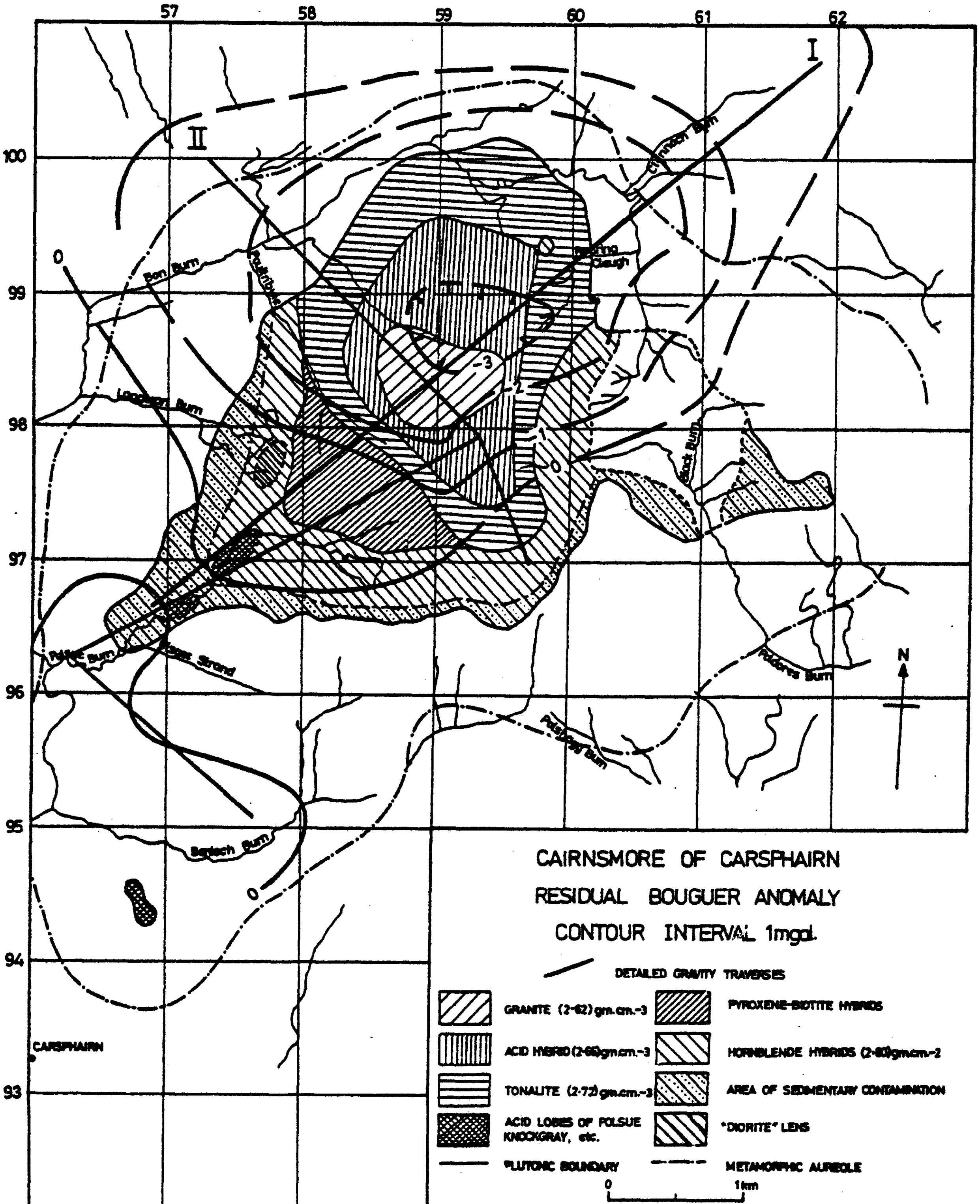


Fig. 2.3a Residual Bouguer Anomaly map of the Carsphairn intrusion.

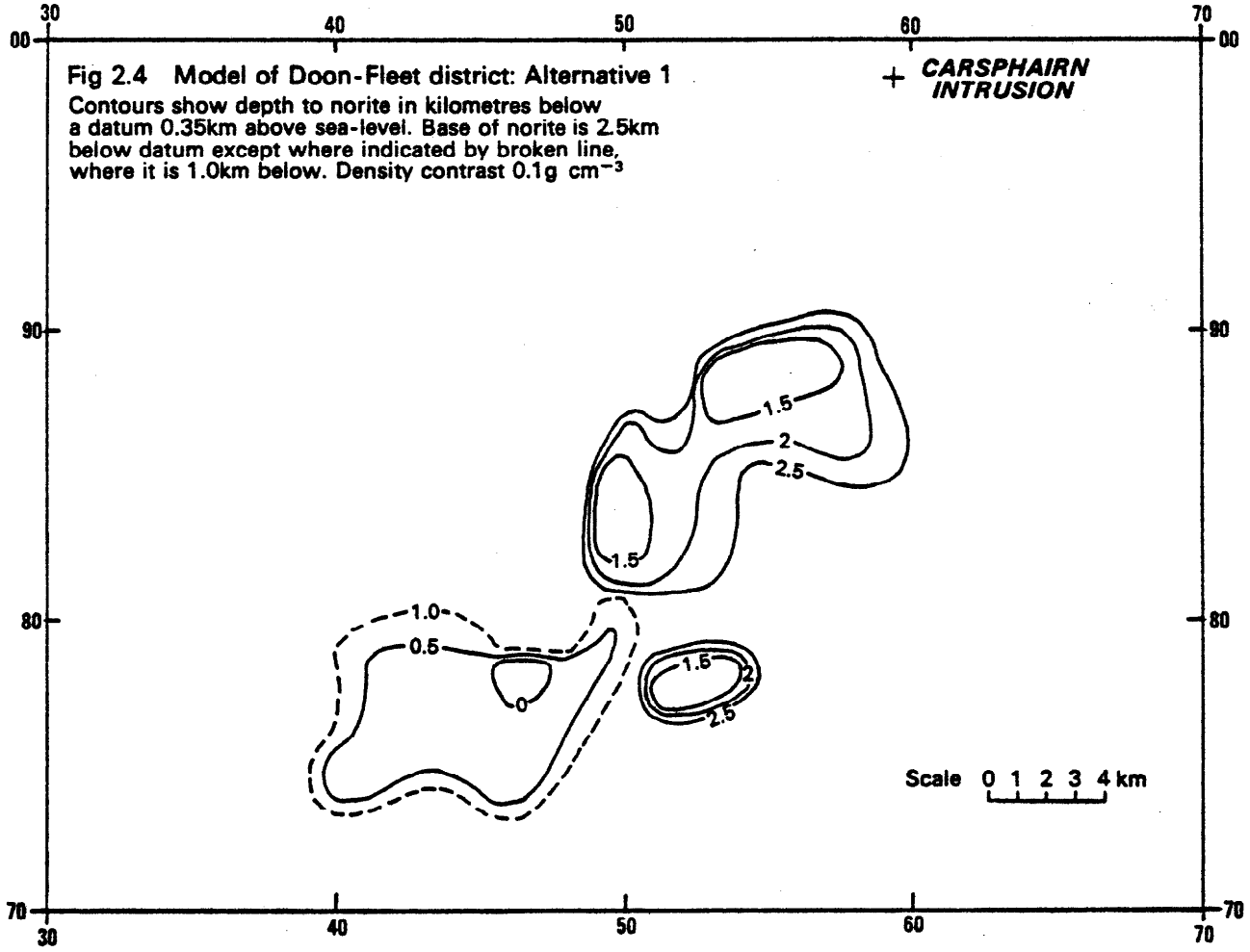


Fig 2.4 Model of Doon-Fleet district: Alternative 1

Contours show depth to norite in kilometres below a datum 0.35km above sea-level. Base of norite is 2.5km below datum except where indicated by broken line, where it is 1.0km below. Density contrast 0.1g cm^{-3}

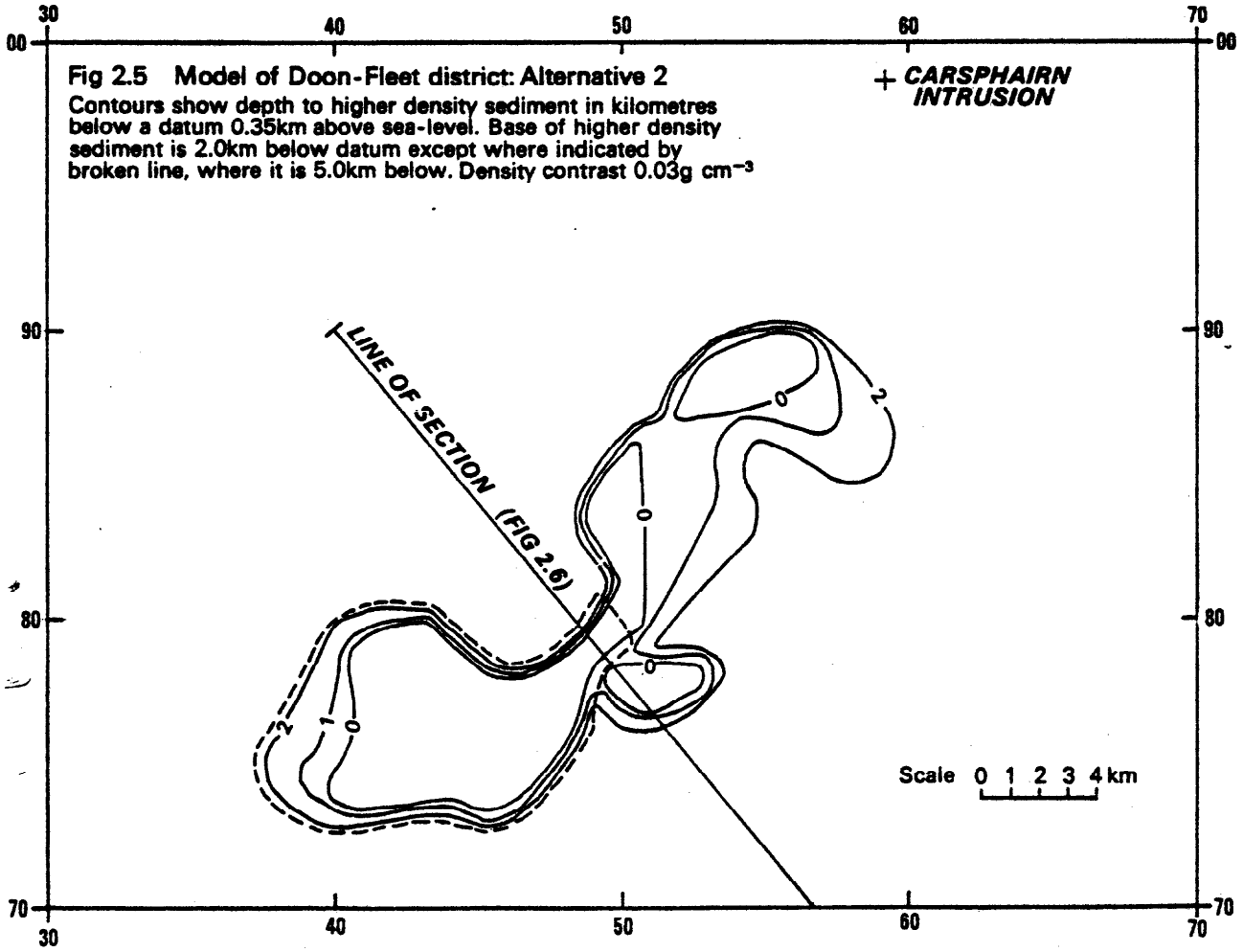


Fig 2.5 Model of Doon-Fleet district: Alternative 2

Contours show depth to higher density sediment in kilometres below a datum 0.35km above sea-level. Base of higher density sediment is 2.0km below datum except where indicated by broken line, where it is 5.0km below. Density contrast 0.03g cm^{-3}

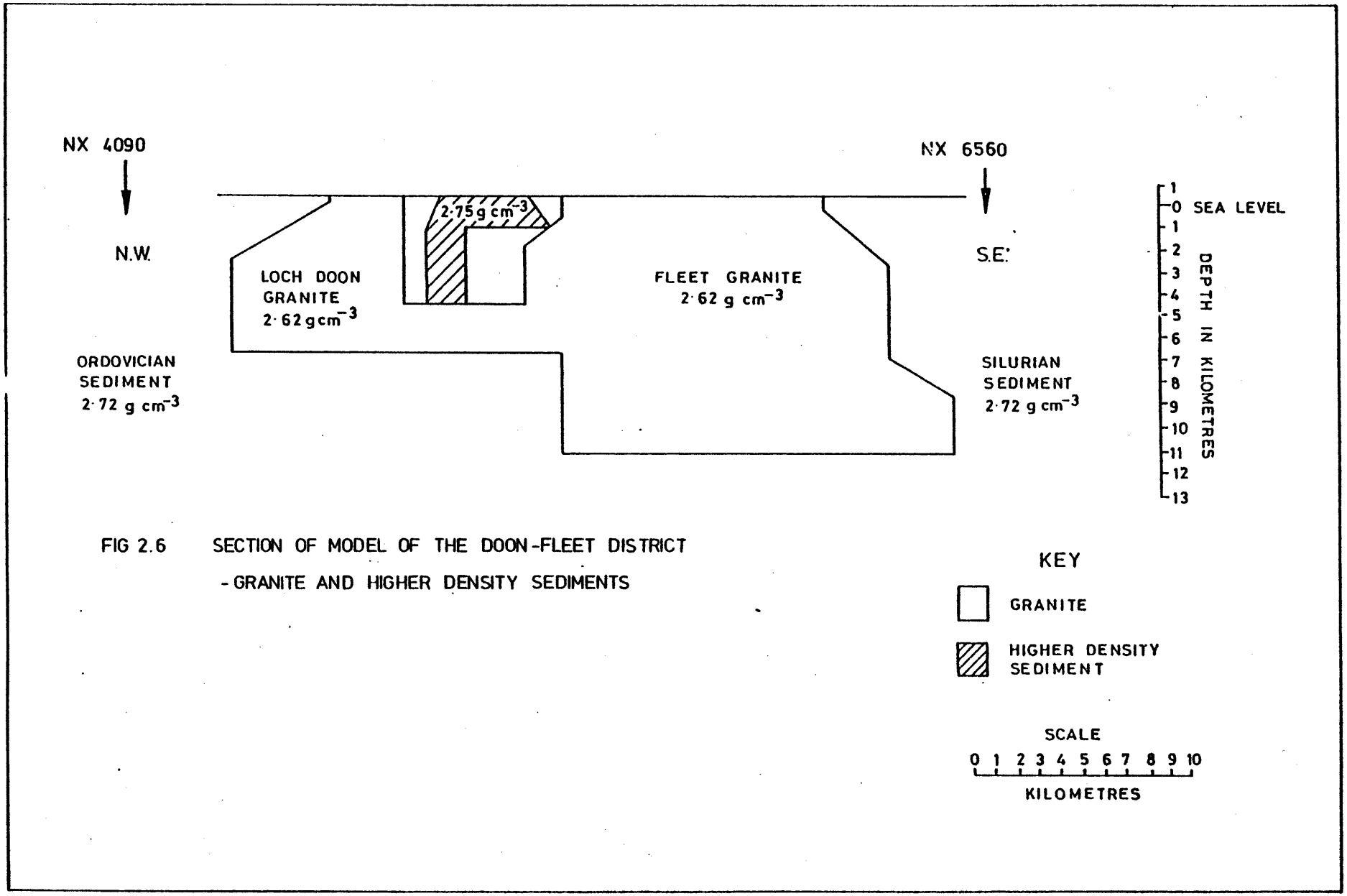


FIG 2.6 SECTION OF MODEL OF THE DOON-FLEET DISTRICT - GRANITE AND HIGHER DENSITY SEDIMENTS

The existence of more basic material between the Doon and Fleet complexes is supported by the geochemical reconnaissance data obtained by the Radioactive and Metalliferous Minerals Unit. The data show a clearly defined zone of enrichment in such elements as Mg, Ca, Ti, Fe and Ni stretching from the middle reaches of Penkiln Burn, NNE towards the most basic part of the southern section of the Doon complex. The main minerals accommodating these elements are ilmenite, orthopyroxene and clinopyroxene which are typical of more basic rocks. The zone does not appear to extend beyond the Doon complex towards the Burnhead intrusion, though the residual gravity anomaly persists with a reduced amplitude.

The remaining residual anomalies not accounted for by the granite model together with either the norite or higher density sediment models, are all less than 1.3 milligal except in the extreme east of the area (centred around NX 65 78) where there is a residual negative anomaly of just over 2 milligal.

2.3 Airborne Surveys

2.3.1 Areas Examined

Two areas (Fig. 2.1) were selected on geological grounds as favourable environments for the occurrence of economic mineralisation and where the terrain and absence of man-made interference rendered them suitable for this type of survey. Total area surveyed was approximately 275 km^2 and total length of line flown 1416 km.

2.3.2 Techniques Employed

(a) Equipment: The airborne surveys were carried out during July 1973 by Hunting Geology and Geophysics Ltd under contract to NERC. Continuous measurements of electromagnetic (EM), magnetic and radiometric response were made from a helicopter at a mean ground clearance of 61 metres along NW-SE flight lines 200 m apart.

The EM equipment (Scintrex HEM-701) uses a single frequency of 1600 Hz with transmitter and receiver coils mounted vertically and coaxially 9 m apart in a rigid boom which is towed below and behind the

aircraft at the end of a 30 m cable. The receiver measures the in-phase and out-of-phase components of the resultant field which are recorded as parts per million (ppm) of the primary field.

A proton precession magnetometer was used to measure the earth's total magnetic field, the sensing head being on the towing cable 12 m below the helicopter (approximately 49 m above the ground).

Continuous recordings of gamma radiation were made in the energy bands corresponding to potassium, uranium and thorium emissions, as well as of the total gamma radiation.

(b) Sources of anomalies: EM anomalies are produced by electrically conducting materials and by man-made sources of interference such as power lines and radio transmitters. Conduction in the most near-surface rocks is largely electrolytic, taking place through ionised fluid in pore spaces and is normally insufficient to give aerial EM anomalies. There are however some naturally occurring minerals which are good electronic conductors and therefore permit conduction through the mass of the rock if their grains are sufficiently concentrated and interconnected. The most important of these are graphite and most of the base metal sulphides, the latter being the prime target of EM surveys. Most clay minerals have high conductivities resulting from the ionised absorbed water they contain and represent another important cause of EM anomalies, particularly in areas containing shales.

The naturally occurring sources of magnetic anomalies are principally iron and titanium oxides, and pyrrhotite, an iron sulphide. Magnetite is the commonest cause, followed by pyrrhotite, ilmenite and some forms of hematite. Magnetite is not a significant constituent of rocks in the project area so most of the magnetic anomalies are attributed to ilmenite with possible important contributions from the minerals pyrrhotite and hematite in certain areas.

2.3.3 Results

(a) EM results: These were presented by the contractor in the form of maps at a scale of 1:10 560 of the in-phase component contoured at intervals of 25 ppm, and diagrammatic maps at the same scale showing the position and in-phase : out-of-phase ratio of the anomalies. The coil arrangement used in this survey produces a mainly positive anomaly over a conductive body and many of these were recorded. Areas of in-phase anomaly exceeding 50 ppm are shown in Fig. 2.7. They have a dominant NE-SW trend and generally correspond to mapped inliers of shale which occur in belts in this area. The "herring bone" pattern on many of these anomalies which are perpendicular to the direction of flight results from the fact that alternate lines are flown in opposite directions and over hilly areas, inaccuracies in position tend to be along the flight direction. Anomalies over the shales vary considerably, from less than 25 ppm to over 600 ppm (the highest value which could be recorded on the equipment used). The most probable reason for the high shale conductivity is the absorbed water which they contain in clay minerals; however some of them also contain graphite, pyrite or pyrrhotite which would also contribute to their conductivity. The large variations in conductivity may be explained by the variation in water content according to the degree of compaction of the shales, and/or in the percentage of other conductive minerals present. Within the aureoles of the igneous complexes the shales are generally non-conductive which could be a result of the removal of water by baking.

Outside the shale belts the more prominent EM anomalies are caused by man-made features; this applies for instance to the chain of negative anomalies trending approximately SSE from Craig of Knockgray between NX 54 96 and 59 89 which are due to a power transmission line. The rest are of relatively small extent and almost certainly reflect

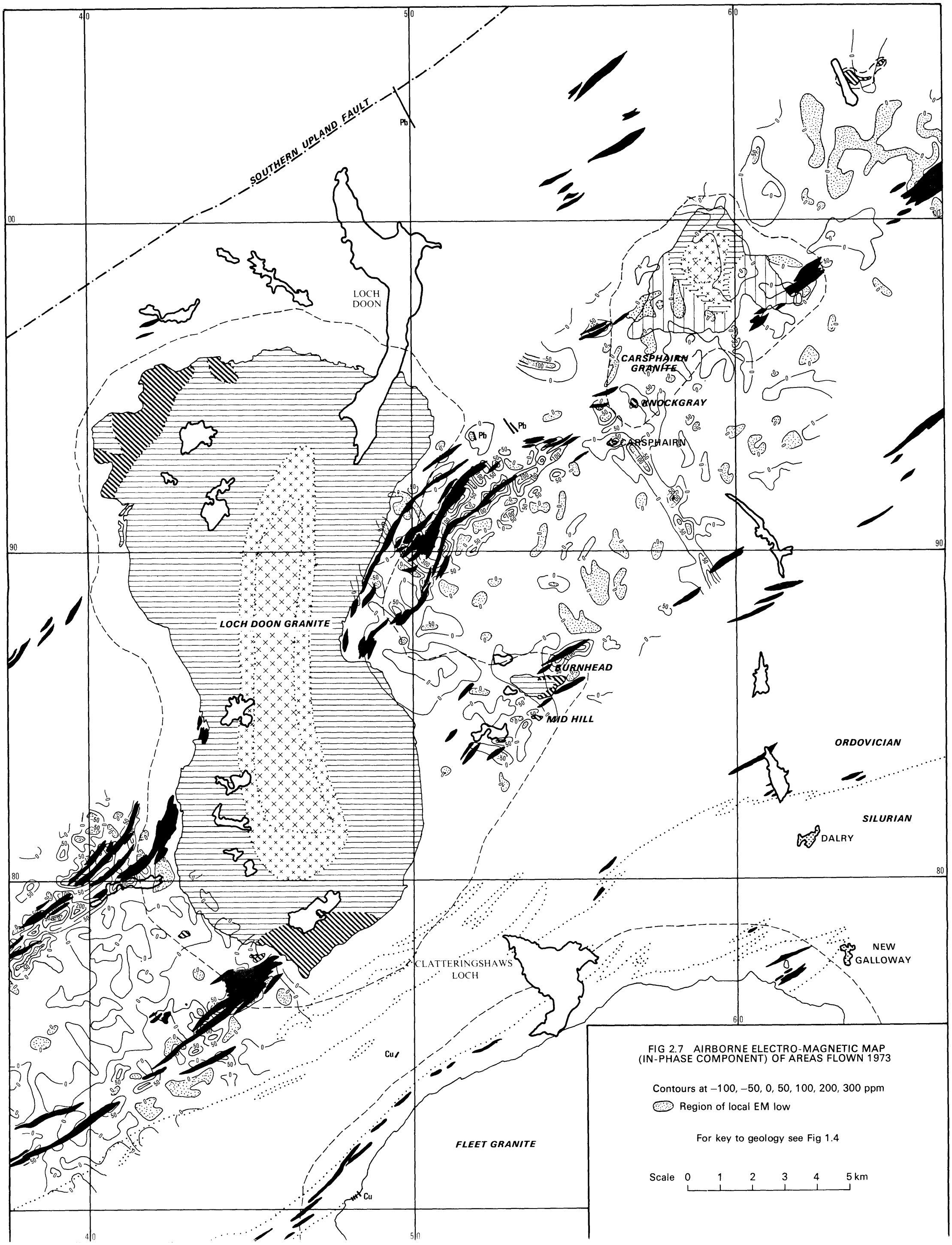


FIG 2.7 AIRBORNE ELECTRO-MAGNETIC MAP (IN-PHASE COMPONENT) OF AREAS FLOWN 1973

Contours at −100, −50, 0, 50, 100, 200, 300 ppm

Region of local EM low

For key to geology see Fig 1.4

Scale 0 1 2 3 4 5 km

small unmapped shale inliers; none have significant magnetic anomalies associated with them.

(b) Aeromagnetic results: Results were presented by the contractors as contoured maps on a scale of 1:10 560. Fig. 2.8 shows these results reduced to a scale of 1:100 000. There is no dominant NE-SW trend of the type indicated on the EM map. Although most of the stronger magnetic anomalies occur in the same areas as the main EM anomalies, that is over the shale belts, they are often not coincident and are not of the same shape. This suggests that the magnetic material is not necessarily in the shale itself but may be associated with it. One possibility is that lavas which underlie the shales cause the anomalies, although there is some evidence against this (section 2.4.3.). Some of the anomalies over shales were investigated in more detail on the ground.

A strong magnetic anomaly was measured over the Burnhead - Mid Hill intrusions, and a smaller one over the Craig of Knockgray [NX 570 944] intrusion.

In the NE part of the area flown the character of the aeromagnetic map changes. To the NE of Carsphairn village the predominant trend is NW-SE though the anomalies are not large. In areas of weak magnetic anomaly this trend should be treated with suspicion as it is exactly parallel to, and probably therefore is a consequence of, the direction of the flight lines. However some of the anomalies with this trend are 30 gamma or more above or below the background and it is unlikely that these could be spurious. The anomalies immediately to the north-east of the Carsphairn igneous complex are on strike with a much more prominent negative anomaly revealed in the 1959 Aeromagnetic survey (Fig. 2.1) and attributed to a reversely magnetised Tertiary dyke.

2.3.4 Aeroradiometric results: Not available for this report

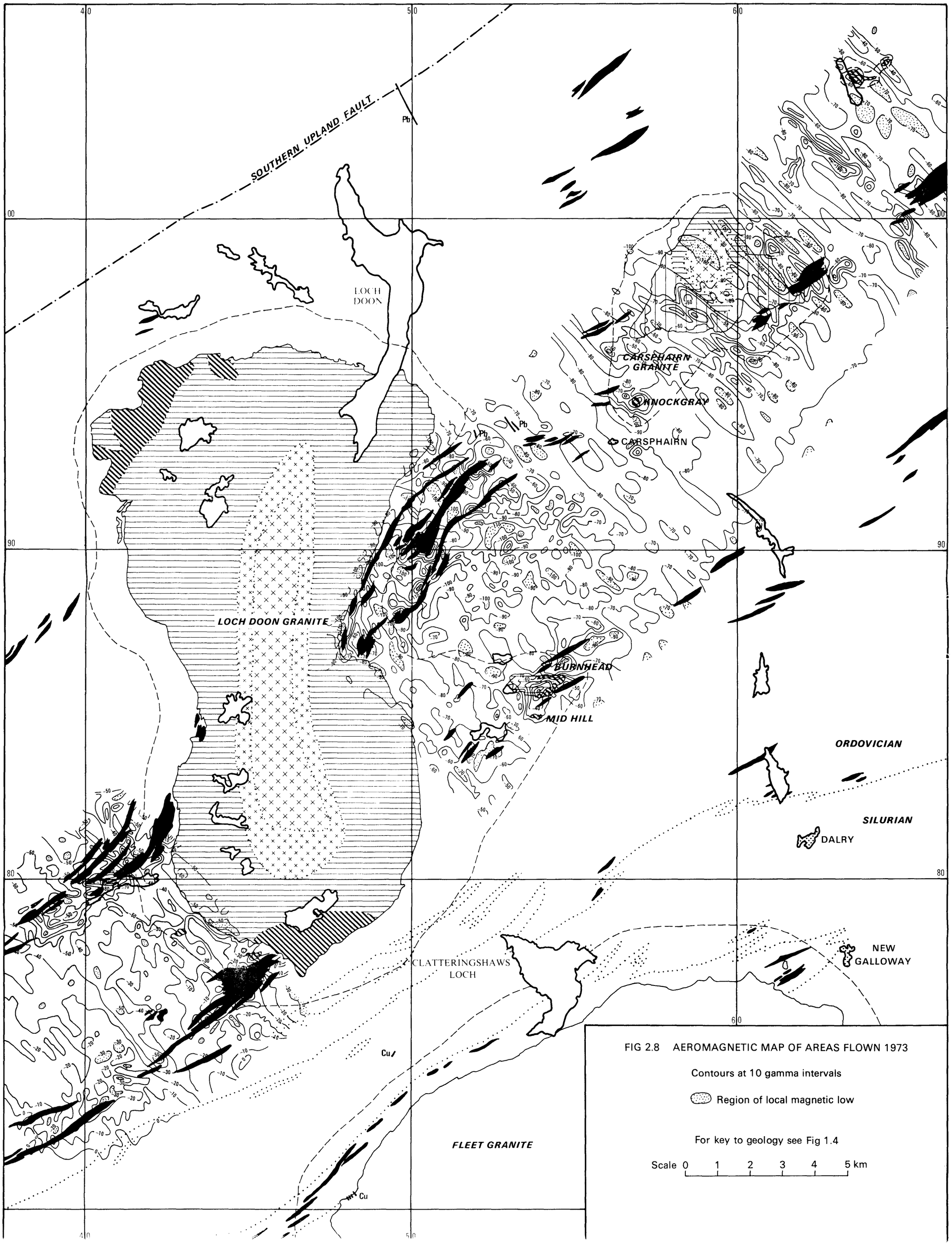


FIG 2.8 AEROMAGNETIC MAP OF AREAS FLOWN 1973

Contours at 10 gamma intervals

Region of local magnetic low

For key to geology see Fig 1.4

2.4 Ground Follow-up of Airborne Surveys

2.4.1 Areas Examined

At Craig of Knockgray magnetic measurements were made to determine whether the magnetic material indicated by the aerial anomalies is contained within the igneous intrusion there or in the surrounding greywackes. Ground EM and magnetic surveys were carried out in the Cairnsgarroch area (Fig. 1.3) where large EM anomalies, some with apparently associated magnetic anomalies, were measured in the aerial survey over the belt of shales. At Bush Farm [NX 545 867] aerial EM anomalies lying over an inlier of black shales and lavas were investigated. At Penkiln Burn [NX 445 765], where there are good aerial EM and magnetic anomalies, ground measurements were made primarily to find out whether the sources of lead observed in stream sediments by the Radioactive and Metalliferous Minerals Unit could be detected. In addition the position and nature of most of the small isolated EM anomalies was established by ground measurement.

2.4.2 Techniques Employed

For EM measurements an ABEM Demigun equipment was used. This is a slingram horizontal loop EM system operating on two frequencies. Normally the transmitter-receiver separation was 60 metres and measurements were taken every 20 metres along pegged lines. This was supplemented by a Geonics EM 16 equipment which measures distortions of the VLF field from distant transmitting stations.

Magnetic measurements of the total field were made along the same traverse lines with an Elsec proton magnetometer. At the Penkiln Burn IP measurements were made as well using a Geoscience frequency domain IP equipment.

2.4.3 Results

(a) Craig of Knockgray: Intense elongated magnetic anomalies of up to 3000 gamma amplitude, striking NW-SE, were measured on the ground within

the area of the intrusion, but mainly close to its margins. Outside the intrusion the anomalies are small, so that the possibility that significant quantities of magnetic minerals have been concentrated by the intrusion in the surrounding greywackes must be rejected. The one significant anomaly which does occur outside the intrusion is probably caused by a dyke.

(b) Cairnsgarroch: Very strong, well defined EM anomalies were measured; they extend across the SE slopes of Cairnsgarroch and correspond closely with mapped shale horizons. They are almost certainly produced by shale bands dipping steeply to the north-west. They are highly conductive, with resistivities of the order of 0.1 ohm metre. Within the anomalous area there is a relatively resistive band coinciding with an outcrop of pillow spilite lava, and laboratory measurements on a specimen showed that it is indeed non-conductive. In an area of shales where the main EM anomaly bifurcates and shows a flexure in its trend there is a band of magnetic anomalies (up to 500 gamma). It is possible that the change of trend indicates a fault around which magnetic material has concentrated. However over much of the area surveyed EM and magnetic anomalies are not clearly associated and therefore do not arise from the same source. Laboratory measurements of the magnetic susceptibility of a pillow lava specimen showed that it is only weakly magnetic (10^{-5}CGS units) and therefore unlikely to be the source of the magnetic anomalies, which would need to have a susceptibility of around 10^{-3}CGS units. Since magnetite is not common in the area the most likely cause is ilmenite with minor contributions from hematite and pyrrhotite.

Results from the analysis of soil samples along four of the geophysical traverses by the Radioactive and Metalliferous Minerals Unit indicate only weak anomalies, insufficient to suggest the presence of any significant quantity of copper, lead or zinc mineralisation. Copper appears to show the best defined pattern of anomalies and zinc the least.

There is no clear correlation with the EM or magnetic results, though the direction of the trend is similar and the better geochemical anomalies occur downslope from the geophysical anomalies.

(c) Bush Farm: As at Cairnsgarroch the EM anomalies correspond very closely to the shale inlier, but the material is not as conductive (resistivity about 5 ohm metre). There are no appreciable associated magnetic anomalies though small anomalies do occur over parts of the surrounding greywackes which have been shown by the South Lowlands Unit to contain traces of pyrrhotite. Traverses were made across the Polharrow Burn section and laboratory measurements on a lava sample taken from that section show the lava to be only weakly magnetic (7.5×10^{-5} CGS units).

(d) Penkiln Burn: This area was investigated in some detail using the induced polarisation method as well as EM and magnetic methods to determine whether information from geophysical measurements would be of use in tracing the source of lead mineralisation indicated from analyses of stream sediment and soil samples collected by the Radioactive and Metalliferous Minerals Unit. As is the case elsewhere, certain shale bands have been clearly defined by strong EM anomalies, and large IP anomalies were measured.

In contrast to Cairnsgarroch, the correlation between the EM and geochemical soil results is quite good. Copper, zinc and particularly lead levels are appreciably higher and the anomalies are much better defined; moreover lead, zinc and some copper mineralisation have been discovered in situ. Within the Penkiln soil grid there are three anomalous zones, one very well defined, another moderately well defined and the third less distinct. The most obvious anomalous zone correlates clearly with a belt of low EM values, that is with a zone of low conductivity rock. A similar correlation, though less clearly defined, is apparent for the other two geochemically anomalous zones; none of these

zones lie over rocks of high conductivity, suggesting that the more conductive shales are not the ones which are mineralised. There is no correlation between magnetic material and any geochemical patterns.

If the relationships at Penkiln apply elsewhere, then the EM method could be useful in delineating zones of poorly conducting rocks in the mineralised areas of the black shale belt.

2.5 Conclusions

2.5.1 The Gravity Survey

The validity of the space form deduced for the Doon-Fleet granite complex depends essentially on the correctness of the assumption of a uniform density contrast between the two major rock types, but, on geological grounds, the densities could be expected to be uniform. Confidence in the interpretation is strengthened by the absence at outcrop of any other rock type of different density, other than norite, and the close coincidence of the actual and model outcrops of the granite. Except for the relatively minor residual anomaly between the Doon and Fleet granites the Bouguer anomaly fluctuations can be explained satisfactorily by a downward extrapolation of known surface geology. There is evidence to suggest that the residual anomaly arises from more basic material.

The most significant feature of the model is the granite platform which appears to connect the Fleet, Doon and Carsphairn cupolas at a depth of 3-5 kilometres. No major unexposed cupola rises from this platform although cupolas of the order of 1 kilometre in diameter or less would not be detected. It is unlikely therefore that unexposed granite of greater extent occurs at a depth of less than 3 km below surface anywhere in the area. Geochemical and geological evidence indicate that there is no enhancement of mineralisation in the greywackes over the area of the granite platform.

2.5.2 Aerial Surveys and Ground Follow-Up

It is almost certain that none of the major EM anomalies measured arise directly from ore bodies. Virtually all of them are caused by black shales of no intrinsic economic value. However the geochemical reconnaissance drainage survey has indicated that there is a connection between mineralisation and the belt of black shales, so the geophysical anomalies cannot yet be dismissed as of no economic significance. At Penkiln the relation between the lead mineralisation and the shales is not known, but a good correlation has been demonstrated between lead concentrations in soils and the non-conductive parts of the shale belt; at Cairnsgarroch, where concentrations are relatively low, there is no such correlation however. A few isolated EM anomalies which have not been investigated in detail lie on strike with the shale belt and are very probably caused by shales themselves.

Measurements on the ground have confirmed that the EM and magnetic anomalies do not have the same origin; the latter are probably caused by the presence of ilmenite with minor magnetite and pyrrhotite in the shale belts. An interesting aspect of the aeromagnetic survey is the NW-SE trend of the anomalies in the NE part of the area flown (ie to the NE of Carsphairn) which corresponds to the trend of a major Tertiary dyke revealed on the regional aeromagnetic map for the area.

3. FIELD SURVEYS

3.1 Introduction

This section reports on the results of the field investigations and the consequent laboratory work completed in the period 1973 - 1975 by the South Lowlands Unit, IGS.

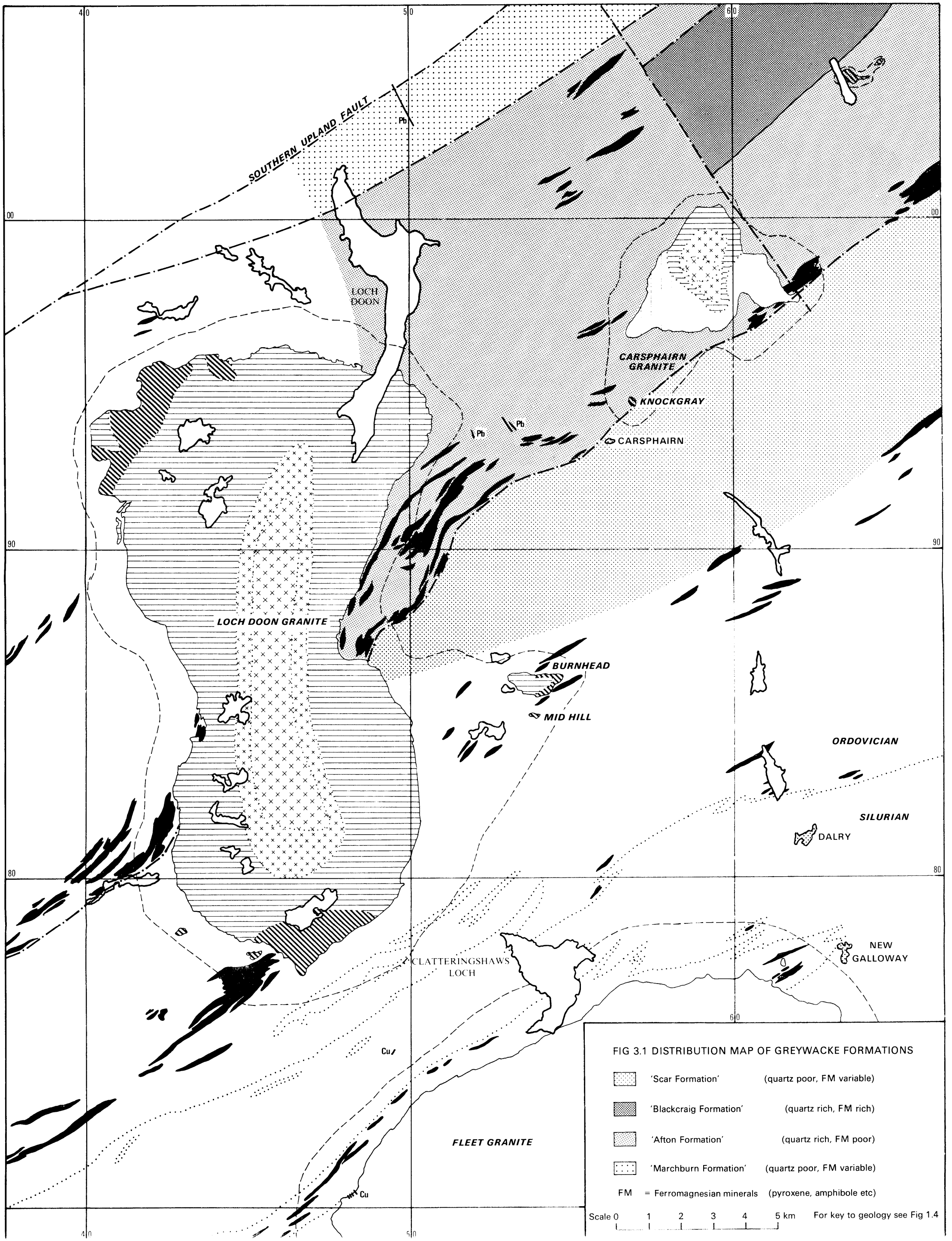
3.2 Field Investigations

Reconnaissance field investigations carried out involved the examination and selective sampling of rocks, with particular attention being directed to promising areas suggested by an inspection of existing IGS maps and records. Outcrop inspection was supplemented by panning, a useful support technique in searching for ore minerals in areas of poor exposure. Revision field mapping was carried out in a few areas to assist the interpretation of recognised mineralisation.

3.2.1 Advances in Geological Information

Since the 1950's increasing attention has been paid to the greywackes in the Southern Uplands and recent work has been carried out in areas along strike to the south-west and north-east from the Doon - Glenkens area. During the present investigations the opportunity was taken to study the greywackes and other sediments in order to attempt a correlation with these other areas and to assist in a structural analysis of the region.

Laboratory work has confirmed that the greywackes of the present area can be subdivided into 'formations' which have a similar petrology and distribution pattern to those formations described from flanking areas. Fig. 3.1 is a map showing the distribution of greywacke formations in the northern part of the area. The situation in the southern part


40
50
60
00
00
90
90
80
80
40
50
60
SOUTHERN UPLAND FAULT
Pb
LOCH DOON
CARSPHAIRN GRANITE
KNOCKGRAY
CARSPHAIRN
Pb
Pb
LOCH DOON GRANITE
BURNHEAD
MID HILL
ORDOVICIAN
SILURIAN
DALRY
NEW GALLOWAY
CLATTERINGSHAWS LOCH
Cu
Cu
FLEET GRANITE
FIG 3.1 DISTRIBUTION MAP OF GREYWACKE FORMATIONS
'Scar Formation' (quartz poor, FM variable)
'Blackcraig Formation' (quartz rich, FM rich)
'Afton Formation' (quartz rich, FM poor)
'Marchburn Formation' (quartz poor, FM variable)
FM = Ferromagnesian minerals (pyroxene, amphibole etc)
Scale 0 1 2 3 4 5 km
For key to geology see Fig 1.4

is more complex and will require further work.

The structural pattern also appears to show a remarkable degree of similarity throughout, at least, the northern belt of the Southern Uplands, with the dominant control being exercised by large strike-faults, probably of reverse type. NW-SE trending wrench-faults also occur and tend to control the vein-type mineralisation in the area.

Existing knowledge of the important pyrrhotite-nickel mineralisation association at Talnotry emphasised the need to determine the distribution and composition of pyrrhotite in the project area. Of the small number of minor occurrences identified, some by the aeromagnetic survey, only those found within the aureole of the Fleet granite gave any indication of associated nickel mineralisation.

3.2.2 Mineralisation

Mineralised rock samples taken for laboratory study were examined microscopically for economic minerals, with confirmation by X-ray powder diffraction (XRD) where considered necessary. Selected samples were analysed to determine their economic element content.

These investigations established the existence of several previously unknown examples of exposed mineralisation. These are described and located in some detail in the appendix to this section but are summarised here as follows:-

(a) Burnhead - Mid Hill

Tonalite-diorite intrusions : disseminated marcasite, arsenopyrite, pyrrhotite, pyrite, chalcopyrite and molybdenite.

(b) Kirreoch Burn, Loch Doon

Marginal tonalite facies : disseminated marcasite, pyrite, pyrrhotite, and arsenopyrite.

(c) Knockgray, Carsphairn

Acid hybrid intrusion : disseminated marcasite, pyrite and pyrrhotite.

(d) Milldown, Loch Dungeon

Black shales : Pb-Zn mineralisation in belts of crushed shales.

(e) Kirshinnoch Burn

Altered 'dyke' rock : mineralised breccia with major Fe, Ti and minor As and W.

(f) Gairland Burn tributary, Doon Granite

Doon complex tonalite : lode with significant amounts of Fe, W, Co, As and (?)Ni.

(g) Step of Trool

Greywacke and shale : mineralised breccia with pyrite, arsenopyrite and traces of spalerite and galena.

Lead-zinc mineralisation with traces of nickel minerals was found in the new Forestry Commission quarry on the west side of Clatteringshaws Loch. Mineralisation was also identified at a number of trials discovered in the Craigshinnie Burn (Pb), the Pulran Burn (Pb, Zn), the Grey Mare's Tail Burn (Pb), and the Clennoch Burn (Pb) areas.

The search for mineralisation was supported by the collection of panned heavy mineral concentrates from streams. Tributaries, rather than main streams, were selected in an attempt to narrow down sources of supply. It was anticipated that panning would supplement other geological information in areas of poor exposure and assist in revealing the presence of finely disseminated or altered mineralisation not readily identifiable from outcrop inspection. Streams supplying sediment to large

tracts of alluvium (notable examples being present within the Loch Doon pluton) were also panned to determine whether the level of concentration of any ore minerals found would warrant alluvial exploitation. The distribution of panning sites is shown in Fig. 1.3.

A Malayan style 'dulang', a circular dish 50 cm in diameter and 10 cm deep, was the form of pan used in this exercise. The technique at each site involved the extraction by sieving of the -5 mm size fraction from poorly sorted stream sediment and the subsequent removal, by washing, of the light minerals (ie quartz, feldspar, mica etc) to leave a residue of heavy minerals. The 'dulang' can accommodate workable amounts of sediment up to 8 kg, this amount usually being obtained from approximately 20 kg of unsorted stream debris.

Residual light fraction minerals were removed from each sample in the laboratory using heavy liquid separation. The heavy fractions were then further divided into 5 or 6 portions by passing through a 'Cooke' isodynamic separator. This technique groups the minerals according to their magnetic susceptibilities and so provides a useful additional identification guide prior to microscope examination. Microscope determination, with XRD identifications where necessary, gave an estimate of the proportion of both economic and non-economic minerals present.

Many new occurrences of economic minerals were identified from pan concentrates and are listed in APPENDIX I. The mineral assemblages and concentrations recorded at any site are influenced by variable and unquantifiable factors and consequently give little guidance as to the number, size or distance of any contributory source of mineralisation.

The mineral information derived from the field and geochemical surveys is collated in section 5 to show the geographical distribution of the several economic elements and in section 6 the mineralisation pattern in different parts of the area surveyed. The two sections are closely linked to each other and to APPENDIX I.

4. GEOCHEMICAL SURVEYS

4.1 Introduction

Geochemical surveys have been carried out extensively in SW Scotland at both reconnaissance and follow-up levels but only the results of reconnaissance drainage surveys of the Doon - Glenkens area are described in this report. It must be emphasised that the geochemical results and interpretation presented in section 5 are preliminary and incomplete by virtue of some unresolved uncertainties of analytical accuracy in some of the data (Optical Emission Spectroscopy analyses of stream sediment data eg for Mo) and because analytical data for a significant number of samples from the area have yet to be received.

4.2 Methods of sample collection and analysis

Reconnaissance drainage geochemical exploration has been carried out in the area using a combination of sample types from each site. At the majority of sites a panned heavy mineral concentrate was collected by the classical gold panning technique so as to obtain about 25 g of concentrate. Details of the method of collection, preparation and analysis for the elements Ca, Ti, Mn, Fe, Ni, Cu, Zn, Sn, Sb, Ba, Ce and Pb are given in Leake and Aucott (1973), and Leake and Smith (1975). In addition a -100 mesh sieved sediment was collected from most sites in the manner described in Plant (1971) though with the use of a minimum of water in wet-sieving through $^{1}/_{10}$" mesh in the field so as to avoid uncontrollable loss of the finest sediment fraction as suspension in the excess water. The sieved sediments have been analysed for the elements Li, Be, B, V, Cr, Mn, Fe, Co, Ni, Cu, Ga, Rb, Sr, Y, Zr, Mo, Ag, Sn, Ba, La, Pb by Direct Reader Optical Emission Spectrograph, for Cu, Zn and Pb by Atomic Absorption Spectrophotometry and for U by delayed neutron activation.

At several sites, particularly in the smaller streams where the amount of sediment was low, a water-suspended fraction sediment (effectively -240 mesh sediment) was collected as described in Leake and Smith (1975). These samples were analysed for Mn, Fe, Ni, Cu, Zn, Pb and U by XRF and selected samples of water-suspended and -100 mesh sediment were also analysed for As, either colourimetrically or by XRF.

4.3 Methods of data interpretation

The object of the collection of two or more different samples at one site was to detect dispersion of elements of interest with maximum efficiency in as much of the sediment size spectrum as possible. Using a combination of panned heavy mineral concentrate and sieved or suspended fraction sediment achieves an effective coverage of heavy metal dispersion within the grain size range 1000 um to 2 um. Detection of dispersion of heavy detrital grains is best achieved with the panned concentrate but this sample is unable to detect hydromorphic dispersion of the more soluble elements as concentrations occur adsorbed onto clay grade material and on grain coatings which form a significant proportion of the sediment only at fine grain sizes. Hydromorphic dispersion, though less pronounced than detrital dispersion from mineralisation in the area as a whole, is the best means by which heavily leached and gossan type surface expression of mineralisation can be detected.

Comparison of concentrations of elements of interest in the various sample types from one site collected at the reconnaissance stage can lead to an understanding of the predominant dispersion mechanism from mineralisation and therefore the probable nature of surface expression of the ore, and can give indications of the most efficient methods for further delineation of the anomaly in the early stages of follow-up.

The panned concentrate has the further advantage that if dispersion is predominantly detrital, the ore mineral can often be identified easily after microscopic examination of the concentrate sub-sample not consumed by preparation for analysis. Furthermore ore minerals can often be

identified in the field at the panning stage, which can be especially useful in initial follow-up work.

The most important early step in the analysis and interpretation of the reconnaissance drainage data for mineral exploration is the determination of which samples contain anomalous metal concentrations ultimately derived from mineralisation. Though this procedure can often be carried out easily by inspection, in many cases significant anomalies can be of low amplitude and statistical data handling, often multivariate, is necessary to detect them. This aspect of the present work is as yet far from complete for reasons mentioned above. Nevertheless several clearly anomalous sites have been recognised by a combination of the analysis of cumulative frequency diagrams for each element in each sample type and by comparison with data from other parts of SW Scotland where the interpretation of the drainage data has been carried further.

Concentrate data sets often show a clearly defined background and anomalous population, with a marked discontinuity between, by virtue of the presence or absence of ore minerals. Such is the case for Pb where the content of this element in the common rock-forming minerals which make up the bulk of the concentrates is low, and a higher concentration in the sample indicates the presence of an ore mineral in a significant amount. Mineralogical examination of selected background and anomalous concentrates from the area have shown a close correlation between the statistically chosen threshold and the presence of a significant amount of a lead mineral. For other elements eg Zn this does not apply, as some common rock-forming minerals can contain a significant amount of Zn eg orthopyroxene. Though the highly anomalous samples can be recognised easily, low amplitude anomalies can best be distinguished from local enrichments in the background due to a different rock type by study of the element association in the samples. Sieved or suspended fraction sediment data sets often also do not exhibit well defined divisions into anomalous and background populations

for single elements as environmental effects, eg Mn content, greatly influence many element contents, eg Zn. In such cases multivariate statistical methods, eg multiple linear regression, factor analysis, and discriminant analysis, have to be used to distinguish a mineralised population from background samples. Nevertheless single element data can be used effectively in conjunction with the concentrate data, and using the convention that the anomalous population is equivalent to the samples with concentrations greater than either Mean $+\sigma$ or M + 2σ levels of the log transformed total population.

As a large number of anomalous sites have been found during the reconnaissance drainage survey of SW Scotland, these have been ranked in order of possible significance so that the limited amount of follow-up work possible within the time and resources available can be expended towards the most promising targets. In addition to geological consideration as to the environment of mineralisation, the anomalies have been classified in terms of length of dispersion train and also degree of dispersion within the stream sediment, ie the proportion of the size spectrum within which dispersion is significant. In this report geochemical data on the distribution of the elements Cu, Zn, Ba and Pb in concentrates, and Cu, Zn and Mo in drainage sediment are discussed. The anomalous sites are in some cases tentative as they have been chosen without detailed statistical analysis of the data.

5. RESULTS OF INTEGRATED SURVEYS

5.1 Introduction

In the following paragraphs the evidence of mineralisation derived from the integrated surveys is described under geographical headings, for convenience of reference and consideration of the general pattern. A National Grid Reference is given where necessary to assist in the initial localisation of an area. Numbers in brackets refer to the pan concentrates listed in APPENDIX I.

5.2 Details

5.2.1 Pulran Burn [NX 530 752]

A small abandoned trial level has been driven into the north bank of the burn at NX 52277494 for over 5 m on a quartz vein trending N10°E. Traces of pyrite, arsenopyrite and chalcopyrite with some malachite staining can be seen on a vein fragment at the adit portal. Hematite, pyrite, arsenopyrite, chalcopyrite and galena have been identified from the small area of waste debris a few metres upstream (2). Nearby, traces of pyrite and chalcopyrite were recorded in thin quartz stringers trending N85°E, dipping 20° to 355° in a metre-high waterfall feature in brecciated phyllite.

Traces of copper minerals (123) and relatively large quantities of sphalerite have been obtained in concentrates from a tributary a few metres above an outcrop of faulted black shales forming a waterfall feature in which traces of lead-zinc mineralisation were seen. Further upstream, the sphalerite disappears but the zinc content of the stream sediment is still relatively high. Both copper and zinc minerals are present in another north tributary (124). A high content of zinc (in stream sediment) was also recorded from a tributary flowing north into Pulran Burn [NX 520 746] but this is at least partly due to environmental enrichment.

Further east, in a small quarry [NX 5387 7585] an irregular quartz vein, intruding shattered, indurated silty shales, has been shown to contain pyrrhotite (with traces of pentlandite : XRD identification), pyrite, galena and sphalerite. Along the Clatteringshaws Loch shore to the ENE there are several quartz veins containing occasional traces of pyrite, chalcopyrite and sphalerite.

5.2.2 Darnaw Burn [NX 530 767]

The site of the former Craignell copper-zinc trial was located on the north bank of the stream [NX 5308 7679]. The vein, reported to be about 45 cm wide and trending N20°E contained sphalerite and chalcopyrite in a quartz calcite gangue. Only quartz-calcite stringers with mineral traces can be seen in bedrock at the bottom of the burn at this point. Locally both sediment and concentrate samples are anomalous in copper and zinc.

An unusual sequence of green, silty and possibly tuffaceous mudstones are well exposed along the stream course for over 100 metres from NX 5300 7665 with a diorite lamprophyre intrusion at NX 5293 7662. Both sedimentary and igneous rocks are locally enriched in disseminated pyrite and (?) chalcopyrite with grains of sphalerite lining some sedimentary inclusions in the lamprophyre.

Both copper and zinc minerals have been identified in panned concentrates further upstream (3 and 4).

5.2.3 Tonderghie Glen [NX 497 740]

The panned concentrate (356) taken at the foot of the Glen, below a belt of dark shales, contains significant amounts of sphalerite, galena, pyrite and chalcopyrite. This may be related to similar mineralisation recorded at the Grey Mare's Tail waterfall about 1 km along strike to the south-west. Malachite, sphalerite and galena have been found in a concentrate from a small stream draining north into

Black Loch [NX 496 727] and was subsequently traced to a small strike-trending structure in shales.

The anomalous amounts of copper and zinc in a concentrate from a tributary of Corse Burn [NX 495 746] are probably derived from a nearby quartz vein [NX 4953 7471], around 30 cm wide, trending N20°E and containing scattered pyrite and chalcopyrite. An altered porphyrite dyke (with a northerly trend) outcropping a short distance downstream contains some finely disseminated pyrite and (?) chalcopyrite. The copper-zinc anomalies persist downstream into Tonderghie Burn [NX 498 743].

Stream sediment samples showing a marked enrichment in zinc were collected from an area extending from east of Corse Burn [NX 495 750] across Clatteringshaws Loch to Benbrack Burn [NX 562 809]. A few concentrates from the area show some enrichment in zinc though no zinc minerals have so far been identified in these samples. Further work is being done in this area but it seems likely that the zinc, together with manganese, is derived from dispersed sources in the greywackes.

5.2.4 Grey Mare's Tail Burn [NX 491 720]

On the east side of the burn just below the Grey Mare's Tail waterfall there is an abandoned trial on a fault breccia trending E30°N and over a metre wide. The breccia here is composed of crushed black shale with abundant disseminated pyrite traversed by thin irregular stringers of pyrite, quartz and dolomite. Traces of galena were recorded on the footwall of the structure and abundant galena, some pyrite, and traces of sphalerite were identified from the pan concentrate (357) taken a few metres downstream. There have been several trials on this mineralised breccia both to the north-east and to the south-west of the waterfall at the base of an escarpment. There are two trial levels into the structure within a distance of 250 m south-west from the burn, but access is barred by iron grilles at the their portals. Traces of pyrite and

sphalerite were recorded in a small stream (403) flowing over the escarpment. There is a short accessible trial level into the base of the escarpment some 200 m further south-west, near the point where the scarp feature loses identity. Here only brecciated, iron-stained phyllite with traces of pyrite was intersected. Low levels of radio-activity, in the range 25-40 μr/hr, were recorded in scintillometer traverses along the line of this mineralised structure. North-east from the waterfall there is evidence of trial investigations as far as the shaft site at NX 4980 7292, and perhaps, as indicated in the previous section, the mineralisation may extend to Tonderghie Glen.

A short tributary flowing north-east off the Fell of Talnotry shows significant amounts of pyrite, marcasite and some arsenopyrite in the pan concentrate (400). Still further upstream, in contact-metamorphosed greywackes, there are quartz veins with pyrrhotite and chalcopyrite, and follow-up work is still in progress in connection with this occurrence.

There are at least three known abandoned shafts and several trial pits on the south and south-east flanks of the Fell of Talnotry, and a pan concentrate collected nearby [NX 485 722] contained appreciable amounts of sphalerite.

The Grey Mare's Tail Burn was panned (345) above its junction with the Black Dubs Burn and just below a belt of black shales. The sample contained a composite fragment composed of granular quartz, chlorite and gold. Sphalerite and pyromorphite were identified in the Black Dubs Burn concentrate (344).

Stream sediment samples with characteristics similar to those collected between Corse Burn and Benbrack Burn (see 5.2.3 above) were obtained from the headwaters of Black Burn [NX 482 748].

5.2.5 Talnotry area [NX 480 710]

In the drainage basin of the Palmure Burn anomalous amounts of

copper and zinc occur in concentrates and sediments, with sphalerite and chalcopyrite identified in the pan. Some of this material may however be derived from old workings near the lower part of the stream at Talnotry.

Anomalous amounts of zinc, and to a lesser extent copper, occur in sediment and concentrate samples from a small stream draining Black Craig and Craighandle south-west of Talnotry [NX 481 710] and further work has been carried out in this area. Anomalous levels of zinc occur in sediments, and to a lesser extent in concentrates, from small streams in the vicinity of the Talnotry nickel trials [NX 477 701-3].

Magnetic and EM measurements were made in the vicinity of the Talnotry mine ore body (pyrrhotite and niccolite) to determine whether or not it is an isolated occurrence. Detailed measurements showed that the ore itself has a high susceptibility and gives a small but prominent magnetic anomaly where it is still in situ. No comparable magnetic anomalies were measured elsewhere in the area and no significant EM anomalies were recorded.

5.2.6 Pulnee Burn [NX 460 724]

There is encouraging evidence of base metal mineralisation in the panned concentrates from both the source branches of the burn draining the complex geological area of the Red Gairy. The sedimentary sequence of strongly folded and fractured silty shales, flags and greywackes is intruded by numerous and often altered lamprophyre and porphyrite dykes. The southerly stream concentrate (395) contains significant amounts of galena, sphalerite, pyrite and (?) chalcopyrite and the northern one (396) pyrite with some sphalerite.

5.2.7 Penkiln Burn [NX 450 726]

A very prominent broad belt of strongly folded and contorted black shales forms the north to north-east sector of Lamachan Hill, the source area of the Penkiln Burn. Pyrite with traces of gold was recorded in the panned concentrate (365) from the principal source branch of the burn and

again from the smaller branch to the east (367). The latter sample however contained important amounts of the lead mineral plumbogummite (XRD identification). Several other concentrate and stream sediment samples from the same area contain anomalous amounts of lead (present as plumbogummite, beudantite and pyromorphite) and to a lesser extend copper (as malachite) and zinc. Mineralisation containing these minerals has been found and is presently under investigation. Another tributary with possible mineralisation on Sheet NX 47 NW is the west one (369) which was panned downstream from three narrow belts of black shale and yielded, in addition to pyrite, some arsenopyrite, sphalerite and molybdenite.

The next major tributary to the south gave a concentrate (370) rich in pyrite with some pyrrhotite and chalcopyrite. The west tributary flowing off the Nick of Sheuchan was panned (372), again below a belt of black shales and cherts, and yielded a concentrate with a predictably large amount of pyrite but also containing traces of galena and sphalerite. The concentrate (373) from the Benroach Burn further south-east however only contained some pyrite and a trace of sphalerite. Much further south the small west tributary concentrate (377) contained traces of the lead minerals galena and pyromorphite.

The source of the anomalous amounts of zinc in some of the concentrate and stream sediment samples from the Penkiln Burn drainage basin has been traced to orthopyroxene, which together with ilmenite makes up the bulk of the heavy minerals derived from the area. As no significant volume of basic igneous rocks is known to occur in the area, it is thought that the minerals are derived from the local greywacke type which is enriched in these minerals. This belt of sedimentary rocks which also show slightly anomalous levels of copper, can be traced along the regional strike from tributaries of Penkiln Burn [NX 435 741] north-east to White Laggan Burn [NX 767 775].

5.2.8 Cordorcan Burn [NX 390 717]

Several belts of black shales intersect the course of this burn but only in one instance has any tributary concentrate indicated the presence of base-metal mineralisation. Pyrite is present in all concentrates but some sphalerite was identified in the sample from the eastern stream off Benailsa (335). In the lower reaches of the burn, the north tributary, the Pulhowan Burn, was panned (352) downstream from a prominent fault and yielded interesting amounts of the titanium mineral anatase. A short distance to the south anatase was again found to be common in the concentrate from the Washing Burn (351).

5.2.9 Coldstream Burn [NX 400 703]

Two lead-zinc veins were formerly worked in the area just east from the River Cree (just off Fig. 1.3); one crossing the Coldstream Burn east of Cruive End Bridge trends northward, while the other, trending N20°W is found to the south of the burn and crosses the west flank of Mill Hill and the top of Smithy Hill. A concentrate (354) from the Straminnon Burn tributary yielded significant amounts of sphalerite with some galena and (?) chalcopyrite. This indicates that the lead-zinc mineralisation persists upstream but probably not beyond the Nappers Cottage area where results were negative (353).

5.2.10 Silver Rig and Laggairy Howe [NX 378 729]

The former Silver Ridge mine [NX 3776 7290] is located near the Lagbaes Burn about 1 km from the River Cree. The vein containing lead, zinc, and copper ore, trends W10°N and is up to 1.5 m in width. The lead ore is reported to be rich in silver (Wilson 1921). The mineralisation was confirmed by panning mine debris (338).

There are further indications of base-metal mineralisation both to the north and to the south of the mine. The eastern tributary of the Lagbaes Burn, panned south of Silver Rig (339), showed the presence of sphalerite, secondary lead minerals and pyrrhotite, as well as common

pyrite and arsenopyrite. The concentrate (340) taken near the source of the Lagbaes Burn, south of Laggairy Howe contained traces of galena and gangue mineral dolomite. Gold was also present.

5.2.11 Pulniskie Burn [NX 400 753]

Gold has been recorded from Strife Land (317), the source area of the Burn; from the south tributary off Larg Fell (348), and also from the north branch of the Thorny Burn (349) also off Larg Fell.

Anatase (TiO_2) is common in concentrates derived from the Pulniskie (318 and 348), Thorny (349 and 350) and Ferrach Burns (321).

5.2.12 Caldons Burn [NX 420 773]

Both galena and sphalerite were identified in the concentrate from the main branch of the stream (323) as well as the more common pyrite, marcasite and (?) chalcopyrite. Gold is present in the south tributary, the Mulmein Burn, along with traces of sphalerite (324) and significant amounts of lead [NX 415 775] in the concentrates.

5.2.13 Step of Trool Burn [NX 420 797]

A poorly mineralised breccia, trending N30°W and up to 30 cm wide, can be traced for over 10 m up the east side of a small stream above the Forest Trail at NX 4202 7974 on the south side of Loch Trool. Traces of sphalerite and galena were identified along with more common pyrite and arsenopyrite in the quartz-dolomite gangue and in the stream concentrate (309).

5.2.14 Glen Trool Lodge [NX 406 801]

A broad belt of black shales intercalated with coarse, often pebbly greywackes forms the ground north and north-west from the Lodge on the north side of Loch Trool. Traces of lead and zinc minerals were found in the concentrates derived from the two small streams (305 and 306) immediately north of the Lodge. Gold was recorded in one of these (305) as well as in two of the tributaries of the Pulnabrick Burn further to the north-west (300 and 301).

5.2.15 Buchan Burn [NX 430 835]

The Buchan Burn and its tributaries drain a large part of the south-west sector of the aureole of the Loch Doon pluton. This is a structurally complex area containing a prominent belt of strongly folded and indurated black shales and invaded by intrusions of diorite, lamprophyre and porphyrite.

A branch of the Kirn Burn tributary panned (295) below a belt of dark shales yielded a concentrate with significant amounts of the lead mineral pyromorphite (XRD identification) and traces of sphalerite. Stream sediments collected from the same area contain anomalous amounts of copper and to a lesser extent lead, but the absence of copper anomalies in the corresponding concentrates suggests that dispersion is hydromorphic, probably from a relatively dispersed source. The concentrate from the Eldrick Burn (297) contained sphalerite, as did that from a small stream (298) flowing off Buchan Hill.

Gold, recorded from the Whiteland Burn tributary (303), will find its way into the large alluvial flat from Culsharg down to the Buchan Burn.

5.2.16 Kirshinnoch Burn [NX 400 864] - Shalloch Burn [NX 376 900]

An altered, mineralised 'dyke', trending N33°E and over 1 m wide, is exposed on the north bank of the Kirshinnoch Burn at NX 4172 8611. A few centimetres of undisturbed rock can be seen at the west side of the outcrop passing eastward into a zone of rock breccia, 20 cm wide, composed of altered 'dyke' fragments veined and impregnated with pyrite (sample A). This is succeeded by a zone, 70 cm wide, consisting mainly of soft clay gouge rich in disseminated pyrite (sample B). The east margin, 15 cm wide, consists of brecciated, fine-grained greywacke veined with stringers of pyrite and arsenopyrite (sample C). Kilogram samples were crushed and representative material analysed by the neutron activation method at

AWRE Aldermaston.

The following results were obtained:

Sample	%	ppm								
	Fe	As	Ti	Cr	W	Mn	Cu	Zn	Ba	Au
A	25	459	3333	139	307	158	< 800	< 160	< 300	< 0.02
B	11	314	5570	172	258	182	< 800	< 120	< 300	< 0.02
C	11	550	3500	142	173	280	< 1000	< 150	< 500	< 0.04

The mineralised structure is characterised by high iron and titanium and also has an interesting level of tungsten (W). Though no significant zinc mineralisation was detected here, the concentrate from the Red Glen tributary (283) yielded traces of sphalerite. Gold recorded in the tributary (281) flowing out of the Black Gairy on the north side of the Merrick will find its way into the large alluvial tract known as the Bog of the Gairy.

Significant lead anomalies were found in sieved sediments in Cross Burn [NX 385 871] while anomalous concentrations of zinc and smaller-scale lead anomalies occur in sediments in the headwaters of the same stream [NX 408 880]. The source of the large zinc anomaly in a concentrate from Shalloch Burn [NX 376 900] is thought to be small and local as the corresponding sediment shows no enrichment.

5.2.17 Loch Doon Granite Complex

The few indications of base-metal mineralisation within the intrusion are mostly confined to the marginal tonalite and nortie facies. In the northern sector the concentrates from the Double Strand (241) and Sheil (242) Burns contain traces of sphalerite. The relatively high zinc anomalies in sediments from the north-west part of the intrusion are probably environmentally enhanced from a dispersed source as the corresponding concentrates contain very little zinc.

In the southern sector traces of lead mineralisation occur in the concentrate from the Cooran Lane tributary (260) with zinc mineralisation from the Green Strand (259), Minnaul Burn (255), and Hazelbush Burn (254). In the extreme south, traces of sphalerite are present in the concentrates of the White Laggan (8 and 52) and Well Burns (55). Perhaps the most encouraging evidence is the occurrence of sphalerite and gold in the pan sample from the unnamed stream (326) which flows into the west end of Loch Neldricken. Traces of galena were identified in the concentrate from the Long Loch Burn (265), a tributary of the Glenhead Burn.

Some of the copper anomalies in concentrates correspond to the most basic (norite) part of the Doon Granite and probably reflect the normal enrichment in copper shown by basic igneous rocks. A persistent copper anomaly was found in the southern margins of the intrusion [NX 449 785] in the area of quartz-arsenopyrite veins which are still being investigated.

The only example of lode mineralisation discovered occurs at NX 4332 8212 in the bed of a tributary of the Gairland Burn, over 1 km south-west of Loch Neldricken. This structure trends N40°W and can be traced for nearly 10 metres, increasing in width downstream from 10 to 50 cm. It contains abundant disseminated pyrite and minor amounts of other minerals in a gangue of red jasperiod quartz. A representative sample, taken from a 1 kg crush, was sent to AWRE Aldermaston, for neutron activation analysis with the following results:

%	ppm									
Fe	As	W	Co	Cr	Mn	Ti	Cu	Zn	Ba	Au
3.5	431	992	510	55	132	1200	800	120	300	0.02

These figures suggest that minerals of tungsten, cobalt and possibly nickel (though Ni is not directly determinable by this analytical

technique) are present. The occurrence of tungsten minerals is confirmed by the identification of scheelite (XRD) in a concentrate taken from a drainage furrow on the east side of Craigmawhannal (239) in the northern sector.

Molybdenum is enriched in the Doon Granite relative to the surrounding sedimentary rocks and is present in the form of the sulphide (molybdenite). The incidence of this mineral is widespread but there is a notable increase in frequency of occurrence and of concentration levels in pan samples from the northern sector around Loch Macaterick (231 and 230); both sides of the Eglin Lane on the flanks of Craigfionn (237) and Craigmawhannal (233, 236 and 239); the northern flanks of Hoodens Hill (238 and 240) and east of the Gala Lane on the flank of Dinnins (243 and 244). The other notable area is around Loch Neldricken (325, 328 and 330) and the mineral has been identified in the shore sands (329).

As there are extensive alluvial areas within the granitic complex, a careful search was made for tin minerals but with negative results. However significant amounts of the thorium mineral monazite (XRD identification) are present in the pan samples from the Dungeon Burn (385) and the Dow Burn (389) which drain from the central granite area of Craignaw. The mineral is concentrated to some degree in the large alluvial area incorporating the Round Loch of the Dungeon (386), Long Loch of the Dungeon and the Brishie Burn which drains from the loch down to the Cooran Lane. Monazite constitutes nearly 3% by weight of the heavy mineral concentrate taken from the Brishie Burn (387) at a point some 400 m above its junction with the Cooran Lane. Only traces of the mineral were recorded in pan samples derived from streams draining the west side of Craignaw into Loch Neldricken. No other important radioactive minerals have been identified but scintillometer radiometric levels in the range 30 - 60 μr/hr recorded in traverses over the central granite area are similar to those

encountered over the SW England granites.

Gold has been recorded from only three streams: in the north (199), where the pan sample was taken downstream from a large metamorphosed sedimentary 'raft' in tonalite from which the gold might have been derived; in the Eglin Lane (232); and in the previously mentioned stream (326) flowing into the west side of Loch Neldricken. Gold was found in the Kirreoch Burn (100) and in the March Burn (97) in the eastern aureole of the complex but both streams drain into the granite complex.

Erratics with disseminated mineralisation similar to that encountered in the small Mid Hill and Burnhead intrusions, occur around the margin of the Doon mass where it is cut by the Kirreoch Burn. Pieces of altered 'tonalite' were found to be enriched in pyrite, marcasite, arsenopyrite and pyrrhotite.

5.2.18 The area south of the Southern Upland Fault

Several low amplitude anomalies, particularly for copper, occur in this area. The source of copper anomalies in concentrates from around Glenmuck [NS 51 02] has not yet been traced, but their spatial distribution suggests a dispersed source. In relatively subdued topography north of the Doon Granite, especially around Loch Finlas [NX 46 98], there are a series of zinc anomalies in sediments without enrichment in the corresponding concentrates. It is probable that these anomalies represent a local enhancement influenced by topographical and environmental factors, though the source has not been identified.

Several anomalies in both concentrate and sediment samples occur along, and immediately south of the Southern Upland Fault, notably for copper and zinc in the Laggan and Corrn Roy drainage basins [NX 31 92 and 34 93]. Veins with sphalerite have been found nearby at Nick of the Balloch [NX 345 928].

5.2.19 Woodhead [NX 530 940]

A greywacke breccia, up to 12 m wide and trending between N50°W and N70°W, contains the main ore shoot, the Woodhead Vein. The vein, up to 1 m wide, bifurcates southward with several intervening ore stringers. The eastern branch is now identified as the Garryhorn Vein and runs parallel to the Woodhead Vein about 90 m to the north-east. The principal ore is galena with subordinate zinc and copper minerals contained in a quartz-dolomite gangue. To the west of the mine there is a small trial level at NX 5194 9340 which is reported to have been driven on a thin lead vein. However only sphalerite was identified in the pan sample (116) taken from the stream above this trial. Further to the south-west a branch of this Garryhorn Burn tributary (117) was panned along strike from a prominent band of black shales and was shown to contain some pyromorphite with traces of sphalerite and chalcopyrite. Prominent lead anomalies recorded in concentrates from Lumps Burn [NX 512 920] are the subject of follow-up work in progress in the area.

There is an exploratory level high up on the north-east flank of Black Craig at NX 5257 9250. Important amounts of pyromorphite with traces of sphalerite and chalcopyrite were identified in the pan sample of the tributary (121) draining the ground between Black Craig and Craighit.

Some 1.3 km south-east in the Halfmark Burn at NX 5420 9170 there is a broad zone of brecciation with minor quartz veining on a NW trend. Though no significant mineralisation was detected here, the pan sample from the tributary (115) further to the south-east yielded some pyromorphite with traces of chalcopyrite. Gold was also found in this stream.

The identification of lead, zinc and copper minerals in pan samples from the Green Burn (127) and the Lamloch Burn (128) near Woodhead farm indicate possible northward extensions of economic mineralisation. Significant amounts of galena, sphalerite and chalcopyrite were recorded

from both streams.

5.2.20 Cairnsgarroch [NX 516 914]

The aeromagnetic survey (Fig. 2.8) indicated a prominent anomaly high up on the SE flank of Cairnsgarroch Hill. Ground investigations show this anomaly to coincide with a thrust or fault zone made up of strongly folded and brecciated black shales, cherts and spilite lavas. Unfortunately exposures are very limited in the area of the anomaly but those that do occur show disseminated pyrite with occasional pyrrhotite. Gold was found in the headwaters of the Halfmark Burn (108) just downstream from the anomaly.

5.2.21 Polmaddy Burn [NX 530 899]

A broad belt of strongly folded black shales and cherts extends south-west from the NW flank of Cairnsgarroch to Goat Craigs, with sub-parallel bands crossing the upper reaches of the Polmaddy Burn and over Carlin's Cairn to the Kirreoch Burn. Gold was found in both the major north tributaries of the Polmaddy Burn, Goat Burn (111) and Blaree Burn (112) which drain from the principal shale belt. Sphalerite is present in the pan samples derived from the Goat and Blaree Burns, the Polmaddy Burn (93) and one south tributary (90) draining from Craignelder, while suspended fraction sediments collected from small streams nearby [NX 516 886] are noticeably enriched in lead.

Quartz veining with sporadic pyrite and chalcopyrite invades greywackes in the Polmaddy Burn at NX 5099 8944, and there is some carbonate veining with traces of mineralisation in an outcrop of disturbed black shales and cherts near NX 5042 8856. The high proportion of hematite in the concentrate from the upper reaches of the Polmaddy Burn (92), indicates the presence of a vein or veins of iron ore.

5.2.22 Loch Harrow [NX 530 867]

The small burns descending the steep NE slope of Craigbrock into

Loch Harrow contain traces of chalcopyrite, arsenopyrite and gold (74 and 75). Relatively coarse-particle gold and significant amounts of sphalerite were found in the pan sample from the Folk Burn (83), where the burn flows round the northern end of Craigbrock scarp. Attempts to trace the mineralisation upstream by panning the two principal source branches of the burn were unsuccessful, although anomalous amounts of zinc in a concentrate and lead in a suspended fraction sediment were recorded a short distance upstream [NX 522 873].

5.2.23 Polharrow Burn [NX 560 863]

This burn flows eastward out of Loch Harrow and is joined by the Lumpford Burn about 400 m below the loch. Along the stream bed of the Lumpford Burn at NX 5320 8720 there is a fault breccia up to 1.5 m wide trending N20°W, with interstitial hematite and ferruginous gouge set in a greywacke matrix. There is some quartz veining in the median zone. Gold seen in the pan sample (84) just downstream was not confirmed by subsequent laboratory examination. Not far above the confluence with the Polharrow Burn another breccia structure is exposed in the burn, trending N50°W, showing interstitial pink calcite and traces of sulphides.

The aeromagnetic survey detected an anomaly on the Polharrow Burn at Bush Farm [NX 5445 8667]. Ground investigations showed this to coincide with a belt of black shales and cherts with a small 'core' of spilite lava. The shales and some dark chert bands are enriched in finely disseminated pyrite and coarser, sparsely disseminated pyrite was identified in contiguous beds of greywacke. Though only pyrite was identified (XRD) from a selection of grains from shales, cherts, greywackes and lava, some grains were observed to possess weak magnetic properties.

A concentrate from the headwaters of Crummy Burn [NX 567 837] contains an anomalous amount of copper, but dispersion is limited downstream. Anomalous values of lead and copper were obtained in a concentrate from

McAdams Burn [NX 542 841] but as the corresponding stream sediment is only slightly anomalous in copper, and not anomalous in lead, the source is likely to be of small scale.

5.2.24 Burnhead and Mid Hill [NX 540 860 and 539 849]

The small hybrid diorite intrusion on the NE side of Mid Hill contains sporadic disseminated sulphides, particularly towards the east margin of the mass. Samples collected from NX 5397 8490 contain from 3-5% pyrrhotite and about 0.2% of chalcopyrite and pyrite. The pyrrhotite does not contain significant Ni-Co values.

The larger Burnhead intrusion, some 600 m further north, forms White Hill and the south side of Bennan Hill above Loch Minnoch. The main part of White Hill is composed of fine- to medium-grained diorite and hybrid diorite showing little evidence of mineralisation. The western sector, however, is composed of coarser grained, altered hybrid tonalite containing up to 1% of disseminated mineralisation, with richer material located near the diorite contact in the Mid Burn at NX 5363 8560. The following minerals have been identified (XRD) from in-situ samples of altered tonalite:- marcasite, arsenopyrite, pyrrhotite, pyrite and molybdenite. Gold and molybdenite were found in pan samples (29 and 73) taken in the west sector of the intrusion. Concentrates from a small stream draining southwards from the intrusion contain anomalous amounts of molybdenum and arsenic, but on the basis of a reconnaissance soil traverse in the area, the source appears to be relatively dispersed.

5.2.25 Loch Dungeon [NX 520 845]

In the headwaters of the Hawse Burn, as in the Polmaddy Burn some 2 km to the north, the pan sample (78) contained a high proportion of hematite. A breccia in the Hawse Burn at NX 5062 8602, trends N5°W, is up to 3 m wide, and is veined with quartz. Interstitial areas are impregnated with hematite. Another, probably larger structure with hematite is thought to

occur to the east of the burn and be intersected by the Altibrick Strand whose concentrate (76) contains appreciable amounts of hematite. Gold was also found in this Hawse Burn tributary.

Several thin quartz veins, trending N5°E and containing traces of arsenopyrite, occur in greywacke on the flank of Millfire at NX 5082 8534.

Narrow belts of crumpled and brecciated black shales occupy gullies on the steep scarp of Milldown, west of Loch Dungeon. The stream draining the most northerly gully forms a tributary of the Hawse Burn while those in the other two flow directly into Loch Dungeon. The black shales in the most northerly gully have the highest range of radiometric activity .. 24 to 28 μr/hr, as against a range of 18 to 22 μr/hr for the other two shale belts. The stream concentrate however contained little evidence of mineralisation beyond pyrite and a trace of arsenopyrite (79). By contrast the pan sample from the Garinner Strand shale belt (81) contained significant amounts of sphalerite, chalcopyrite and pyrite with traces of arsenopyrite. Traces of galena were observed, in situ, in crumpled, anthracitic black shale exposures on the flanks of the most southerly gully at NX 5199 8396. The pan sample (82) confirmed the presence of important amounts of sphalerite, some pyrite, chalcopyrite, and arsenopyrite and traces of galena.

The source has not so far been established for the anomalous amounts of zinc and chromium in the concentrate and stream sediment samples respectively collected from a small stream flowing into the east side of Loch Dungeon [NX 530 846].

5.2.26 Garroch Burn [NX 560 826]

Traces of the secondary lead mineral pyromorphite were identified in the pan sample from the headwaters branch of the stream (44). Two sites nearby were anomalous in copper and lead-zinc respectively, but dispersion from both was found to be limited.

5.2.27 Glenlee Burn [NX 570 808]

The Lochspraig Burn tributary was panned at the foot of Fumart Glen (35), downstream from a narrow belt of black shales. The concentrate contained traces of galena and gold. The main Glenlee Burn was panned downstream from a well exposed sequence of greywackes (37) veined with quartz, and five particles of gold were found in the resulting concentrate.

5.2.28 Maggot Hill [NX 595 788]

At the beginning of the reconnaissance fine-particle gold was discovered when panning the Knocknairling Burn just above Darsalloch (11) and an attempt was made at that time to determine a provenance for the gold. It was established from 25 pannings of small streams and drainage ditches that gold is present on the north and south flanks of Maggot Hill, on Will's Hill, just west of Maggot Hill, and on the north side of the Craigshinnie Burn (19 and 21). Negative results were obtained on Rig of Airie, 1 km ESE from Maggot Hill and on the south side of the Knocknairling Burn.

The Maggot Hill area presents some geological features which distinguish it from the rest of the project area:-

a. Quartz veins are more common, frequently broader, and have structural affinities with pegmatites.

b. The sediments which form Maggot Hill are between 0.5 and 1.5 km from the Fleet Granite contact but the degree of metamorphism and alteration observed is greater than normally found at this distance. Shaly and silty sediments have been converted to low grade mica-schists and phyllites, and shearing is common in greywacke exposures. Alteration and weathering frequently impart a rotted appearance to schists and phyllites.

c. The sedimentary sequence is invaded by a group of minor diorite intrusions which have been foliated and altered in the structural

deformation and metamorphism of the area.

Most of the quartz veins and the foliated diorite bodies show a Caledonoid trend between east and north-east. Patchy pyrite, pyrrhotite, and arsenopyrite mineralisation (XRD) is present in many quartz veins and along the margins of the diorite intrusions. Gold was not observed in any quartz vein and the element was detected (0.03 ppm) in only one of several samples sent for gold assay to AWRE Aldermaston. This sample was taken from the south margin of a quartz vein, trending E-W and over 6 m wide, exposed in the Knocknairling Burn at NX 5935 7735. The patchy mineralisation in quartz veins generally forms aggregates with rosettes of mica towards the vein margins and finely disseminated with mica in the vein wall rock. Impersistent 'gash' veins and stringers of quartz are common in greywacke but examination showed only occasional traces of pyrite.

The debris forming small galcial drift mounds along the course of the Knocknairling Burn was panned (103 and 32) to check whether gold might have been introduced into the area as a result of the Pleistocene glaciation but no gold was found.

A low scarp of black shales extends WSW from Achie Hill, 1.5 km west of New Galloway, across the A 712 at Darsalloch road end before pinching out in the Knocknairling Burn. Pan samples from the Knocknairling Burn (33 and 11) and two tributaries (12 and 31) near this shale belt contain traces of lead, zinc and copper minerals, but as both dispersion trains and concentration levels in the corresponding stream sediments are relatively low, it is concluded that the sources of mineralisation are probably local and of small scale. The pan sample taken from the Knocknairling Burn tributary (30) below the next prominent black shale belt downstream at Waukmill contained traces of pyromorphite. Traces of galena and gold were found in the concentrate from a tributary of the

Knocknairling Burn (27) intersecting a belt of dark shales on the SE side of Will's Hill.

Two very poorly exposed quartz 'veins' of indeterminate width and some 100 m apart occur just to the west of Rig of Airie and Gallows Knowe, trending around N20°W. Only the west margin of the easterly 'vein' can be seen, at two points, but the 'vein' is thought to extend eastward across a persistent shallow depression feature several metres wide. Indications of base metal mineralisation were sought but none obtained.

On the north side of the Craigshinnie Burn at NX 5857 7939, two unrecorded trial adits, one a few metres above the other, have been driven on a thin breccia structure trending N10°W. Both levels are located on the course of a small burn with the upper level driven a distance of 4 m and the lower around 20 m into the hillside. Traces of galena were identified in greywacke breccia at the east side of the lower adit portal and the stream concentrate taken immediately downstream contained important amounts of the lead minerals mimetite ($Pb_5Cl(AsO_4)_3$) (XRD) and galena. Again dispersion trains and lead levels in the corresponding sediments from the area indicate a local and small-scale source.

Weakly radioactive mineralisation (scintillometer readings up to 80 μr/hr) were recorded over thin fractures in fine-grained greywacke on the east bank of the Darsalloch Burn at NX 6086 7716.

A so-far unexplained copper anomaly in sediments, but not concentrates, occurs in the Pultarson Burn at the margin of the Fleet Granite [NX 624 762].

5.2.29 East side of Clatteringshaws Loch

Several sites with highly anomalous zinc contents in sediments occur at the edge of the aureole of the Fleet Granite just east of Clatteringshaws Loch.

Carsphairn District

5.2.30 Green Hill and Moorbrock Hill [NX 616 973 and 621 984]

Gold has been found in all streams panned which drain the Green Hill and Moorbrock Hill area on the east to south-east margin of the Carsphairn Granite complex. A broad belt of strongly folded, faulted and indurated black shales and cherts, trending ENE, forms most of the ground of these two hills. The aureole rocks on Green Hill and, to a lesser extent on Moorbrock Hill, have been intruded by a suite of porphyrite and lamprophyre dykes. Quartz veining is not common, and, where present, is thin and impersistent, rarely containing more than a trace of pyrite. Gold was found in the Poldores Burn and its tributaries (140, 141, 142, 143 and 150) and in the Poltie Burn (151), the White Burn (139) and the Knotty Burn (138), all tributaries of the Polifferie Burn. Gold from the source region may find its way into alluvial tracts along the course of the Polifferie Burn. Further to the south-west gold was also recorded in the Polshagg Burn (146) which drains from Beninner and Knockwhirn.

In the black shale belt to the east of the Carsphairn Granite, two concentrate samples are anomalous in lead and lead-copper respectively. The corresponding sediment samples contain anomalous amounts of copper.

Several small-scale copper anomalies are a feature of concentrates, but not the corresponding sediment samples, from the area of greywackes south of the black shale belt. The source of the relatively large zinc anomaly in a concentrate from Dry Burn [NX 629 916] has not yet been traced.

5.2.31 Clennoch Burn [NS 610 007]

In the metamorphic aureole on the northern margin of the Carsphairn granite complex traces of lead mineralisation (most commonly pyromorphite) have been identified in the pan samples from the source branch of the Shalloch Burn (153) draining from the Nick of the Sware, the source branch

of the Polwhat Burn (173) off Dugland, and east of Dugland in the four headwaters branches of the Clennoch Burn (160, 161, 163 and 164). A mineral trial (Pb) is reported to be located in the Claygrane Burn at NS 6200 0063. There is a track down to the stream at this point but no evidence of former workings was seen.

Gold was found in the Red Cleugh (163), Fox Yird Burn (164) and the source branch of the Polwhat Burn (173).

5.2.32 The Carsphairn Granite complex

Tin, molybdenum and base-metal mineralisation have not been found and there are few other indications of economic mineralisation within the complex. Traces of disseminated marcasite, pyrite, and pyrrhotite were occasionally found in the hornblende hybrid and diorite facies. Some concentration of these minerals was recorded near the margin of the outlying 'diorite' mass of Craig of Knockgray, north of Carsphairn village. Tonalite-breccia impregnated with hematite is exposed in the Poultriebuie Burn at NX 5801 9822 and the pan sample from Disgee Strand (184) contains hematite, probably however, derived from a structure in the aureole.

Scintillometer radiometric traversing was carried out over the granite complex and levels in the range 30 - 60 μr/hr were recorded over the central granite and surrounding finer-grained 'acid hybrid' facies. The Polchiffer Burn is the only stream of any consequence to drain from the central granite. Traces of the thorium mineral monazite were identified in this (189) and some other stream concentrates. Of particular interest was the discovery of two groups of radon emitting springs within the granite area. The first group, comprising two springs, lie on a NE bearing near the boundary wall above Gold Wells at NX 5907 9784 and NX 5909 9787 respectively. The lower spring has a maximum radiometric level of 35 μr/hr and the higher one a maximum level of 80 μr/hr. The

second group, comprising at least three springs on an approximate E-W bearing, are located just south from the source of the Polchiffer Burn between NX 5894 9877 and NX 5905 9878. The springs on either side of the larger central spring gave maximum radiometric readings of 60 μr/hr while the central one gave the unusually high maximum reading of 150 μr/hr.

6. DISTRIBUTION OF ECONOMIC ELEMENTS

6.1 Introduction

This section describes the distribution of the minerals of each element and shows how this is related to the known geology. The economic potential of each element is considered and, where relevant, its association with other elements.

6.2 Distribution of Elements

The maps which accompany the text show the distribution of the minerals of each element, both primary and secondary. These are constructed mainly from the information given in APPENDIX I (stream concentrates) and from Section 5 which contains details of stream sediment and 'in situ' mineral occurrences. No attempt is made in the distribution maps to distinguish between concentration levels at sites. The elements in this section are discussed in the following order:

Copper	Antimony
Lead	Titanium
Zinc	Chromium
Molybdenum	Manganese
Iron	Cobalt-Nickel
Gold	Arsenic
Tungsten	Uranium-Thorium
Tin	Barium

6.2.1 Distribution of Copper Mineralisation (Fig. 6.1)

Copper mineralisation is widespread in and around parts of the granite plutons but the level of concentration in mineralised outcrops and in pannings is generally too low to encourage consideration of any occurrence as a primary copper prospect. Nevertheless copper mineralisation could be an important economic factor in any assessment of

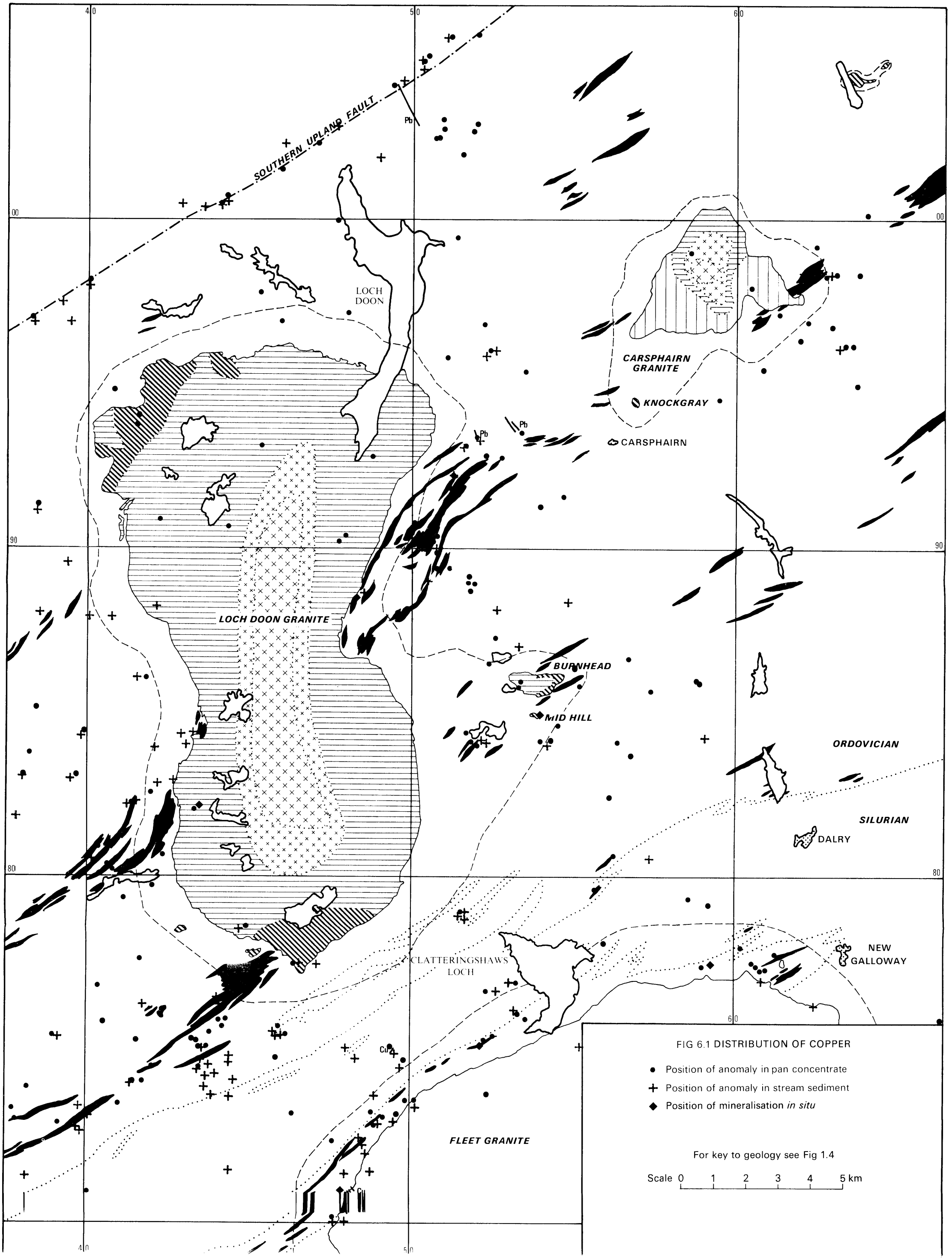


FIG 6.1 DISTRIBUTION OF COPPER

- Position of anomaly in pan concentrate
- Position of anomaly in stream sediment
- Position of mineralisation *in situ*

For key to geology see Fig 1.4

Scale 0 1 2 3 4 5 km

other ores with associated copper minerals.

The principal primary mineral is chalcopyrite accompanied at some localities by minor amounts of secondary minerals malachite and azurite. Chalcopyrite commonly forms a small percentage of the proportion of disseminated pyrite present in sedimentary rocks. Notable examples occur in the Brownhill Burn, tributary of the Water of Deugh (132); on the flanks of Cairnsgarroch and in the nearby Lumps (119) and Blaree Burns (112); on Lamachan Hill and in Penkiln Burn (365, 367 and 369); and in the Glenlee Burn (35).

In the aureole of the Fleet granite, simple veins composed mainly of chalcopyrite, pyrite and occasional (?) bornite in a quartz gangue, are quite common. A vein with copper minerals occurs in the Corse Burn at the head of Tonderghie Glen [NX 4953 7471], several have been identified at or near the granite contact in the catchments of the Palnure and Knocknairling Burns, and there is a small trial on one such vein in the Pulran Burn [NX 5227 7494]. Minor amounts of copper minerals occur disseminated in porphyrite, lamprophyre and foliated diorite intrusions in the Maggot Hill [NX 595 788] - Rig of Airie [NX 606 780] area and around Clatteringshaws Loch. Veins and fractures in and marginal to these intrusions may also carry copper minerals. Several streams in the Talnotry area contain copper minerals, while ore samples from the Talnotry nickel mine [NX 4810 7018] have been shown to contain interesting percentages of copper ranging from 0.84 to 2.41% in three analyses.

Minor amounts of disseminated copper mineralisation were found at several localities in the norite and tonalite facies of the Loch Doon pluton, the tonalite facies of the Carsphairn pluton, in the smaller intrusions of Mid Hill and Burnhead and in association with quartz-arsenopyrite veins on the southern margin of the Loch Doon pluton. The

aureole rocks of these intrusions also contain copper mineralisation, but this is generally of small scale.

Copper mineralisation occurs in association with lead-zinc mineralisation in veins at the former mines at Woodhead (104) and Silver Ridge (338) and also has been identified with galena and sphalerite on Milldown (81 and 82), south-west of Loch Dungeon. Copper anomalies near Glenmuck [NS 51 02] have not yet been traced to a source.

6.2.2 Distribution of Lead Mineralisation (Fig. 6.2)

Lead mineralisation considered to have economic potential is closely associated with those sectors of the aureole of the granite plutons composed essentially of shales and finer sediments or to vein systems transverse to the Caledonoid trend. Few indications of lead minerals have been found within the Doon or Carsphairn granite complexes. The most common minerals identified are galena and pyromorphite, with plumbogummite-beudantite and mimetite present in significant amounts in pan samples from the Penkiln and Craigshinnie Burns respectively.

Lead (and usually zinc) minerals have been found in veins, fractures, faults and shear zones both parallel and transverse to the Caledonoid trend, in the structurally complex sector of the northern metamorphic aureole of the Fleet granite which extends nearly 20 km from Talnotry Hill [NX 478 709] almost to New Galloway. A number of trial shafts and adits have been driven at several points on a NE-SW Caledonoid trending fault zone which can be traced along the base of a scarp feature for 1.5 km from the foot of Tonderghie Glen, through the base of the Grey Mare's Tail waterfall at NX 4912 7262, before losing identity some 600 m to the south-west. Further trials have been made on sub-parallel mineralised structures above the Grey Mare's Tail waterfall at NX 4897 7265, at Garmel [NX 4833 7215] and at Craighandle [NX 4820 7168], and pan samples confirm the continued presence of lead minerals further

FIG 6.2 DISTRIBUTION OF LEAD

- Position of anomaly in pan concentrate
- Position of mineralisation *in situ*

For key to geology see Fig 1.4

Scale 0 1 2 3 4 5 km

afield in the Black Dubs Burn (344) and in the vicinity of the Talnotry nickel mine (399). Lead mineralisation, possibly related to a NE extension of the Grey Mare's Tail fault zone, occurs at the Pulran trial (2); in the Forestry Commission quarry on the west side of Clatteringshaws Loch [NX 5387 7585] and again below the scarp of Glenlee Hill in the Craigshinnie trial (46). Traces of lead minerals also occur in pan samples (11, 27, 31 and 42) from the Knocknairling Burn and its tributaries which drain the NE aureole of the Fleet granite. Indications in the concentrate (30) on the north side of Birch Hill are in the same area as occurrences reported near Kenmure Castle and Marchwell (about 3 km further north) in the 'Statistical Account of Scotland'. Anomalous amounts of lead were detected in pan samples collected near Hen Craig [NX 558 825] and from McAdams Burn [NX 542 841].

Lead mineralisation associated with belts of dark shales occurs in the Penkiln Burn (367) and Caldons Burn (323), with both streams draining the broad belt of strongly folded black shales which form the main part of Lamachan Hill. Similar lead-shale relationships occur in the structurally complex area of the Red Gairy (395) 2 km to the east, in Buchan Burn [NX 432 842], in Cross Burn [NX 385 871], and again on Milldown (82), south-west of Loch Dungeon. The marked grouping of lead (but not zinc) mineralisation in the north-east aureole of the Carsphairn complex, particularly in the source branches of the Glennoch Burn (160, 161, 163 and 164), is not obviously related to shale belts and requires further investigation. Similar occurrences in areas remote from shale belts were recorded from Mulmein Burn [NX 415 775], Folk Burn [NX 522 873] and tributaries of Polmaddy Burn [NX 516 886].

Groups of veins and vein breccias containing lead, zinc and minor copper ores, with a trend generally transverse to the regional strike, have been worked at the Silver Ridge and Coldstream Burn Mines in the

Newton Stewart district and at the Woodhead Mine near Carsphairn. Lead (with zinc and copper) minerals have been identified in pan samples derived from streams up to 1 km north (340) and south (339) of Silver Ridge and in the catchment of the Coldstream Burn (354), 1.5 km above the Coldstream Burn Mine. These mineral associations also occur in the pan samples collected up to 2 km to the south of the Woodhead Mine at Craigenwallie (121), to the north in the Green Burn (127) and Lamloch Burn (128), and to the west in tributaries of the Garryhorn Burn (116 and 117). The results suggest the presence of further undiscovered lodes in both the Woodhead and the Silver Ridge - Coldstream Burn areas.

6.2.3 Distribution of Zinc Mineralisation (Fig. 6.3)

Zinc minerals are more widely distributed than those of lead and occur at nearly twice as many localities. This is mainly attributable to the superior detrital survival potential of the principal mineral sphalerite compared with the equivalent common lead minerals galena and pyromorphite. The distribution map thus shows a more marked relationship of zinc mineralisation to major shale belts than is apparent in the corresponding map for lead.

As brought out in the foregoing section many of the more significant zinc occurrences are associated with lead mineralisation. There are, however, a few examples of mineralisation related to shale belts where important amounts of sphalerite occur in pan concentrates without associated lead minerals. A notable example is the Brown Hill Burn (132), a tributary of the Water of Deugh.

Zinc mineralisation, considered to have economic potential but not obviously connected with major shale belts, occurs on the west side of Clatteringshaws Loch in the Darnaw Burn (3, 4 and 105). A vein carrying copper-zinc ores in a quartz-carbonate gangue is reported at the Craignell trial on the north bank of the Darnaw Burn. More widespread mineralisation is indicated by the continued presence of sphalerite in

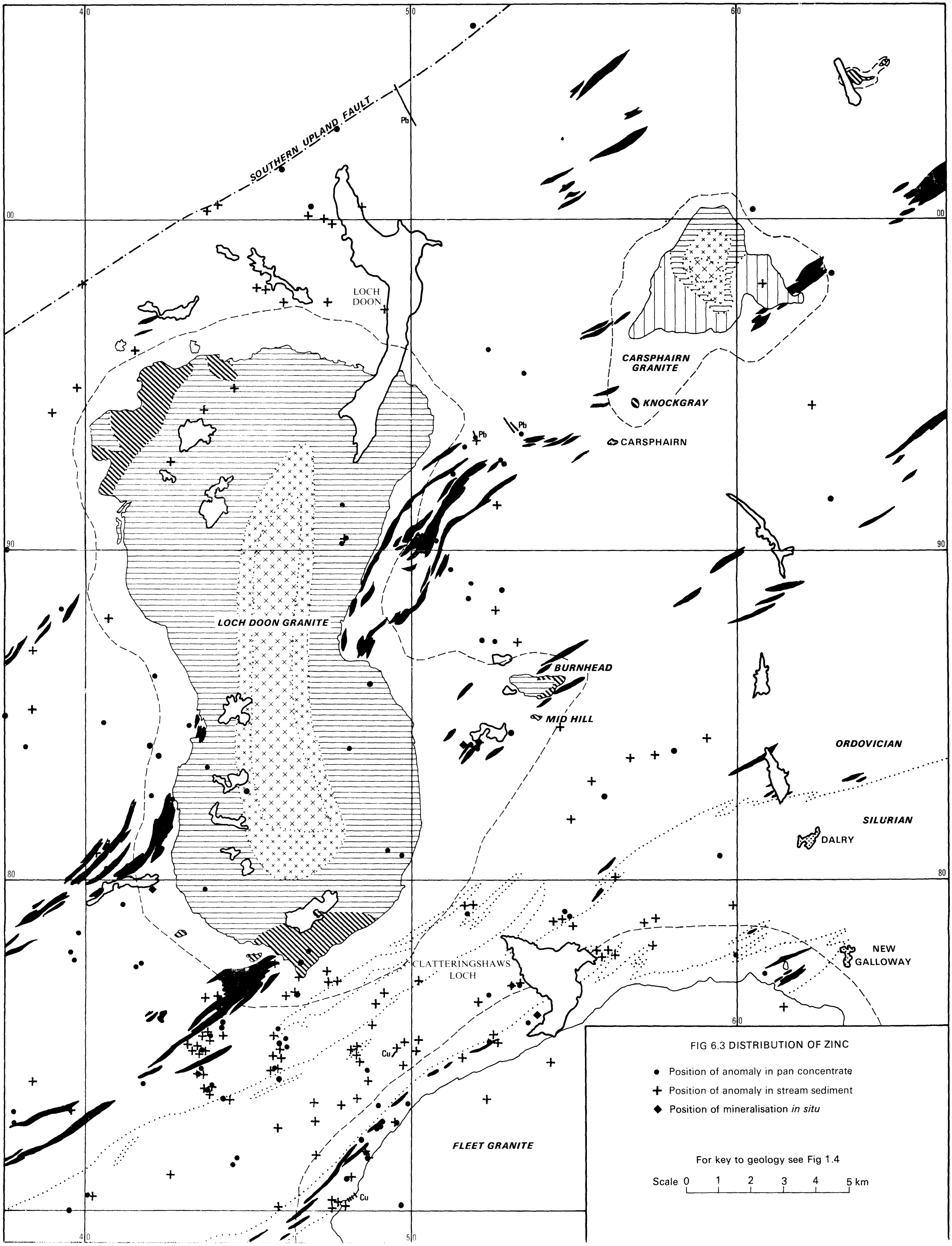


FIG 6.3 DISTRIBUTION OF ZINC

- Position of anomaly in pan concentrate
- Position of anomaly in stream sediment
- Position of mineralisation *in situ*

For key to geology see Fig 1.4

Scale 0 1 2 3 4 5 km

pan samples (3 and 4) nearly 1 km upstream from the mine site.

Zinc mineralisation has been detected in pan and/or sediment samples from the Pulran Burn [NX 525 751], a stream near Black Loch [NX 496 727], the Grey Mare's Tail Burn [NX 491 727] and other sites westwards to Talnotry [NX 481 710] and Penkiln Burn [NX 440 737]. The greywackes lying in a belt from the middle reaches of Penkiln Burn northeastwards through the headwaters catchment of Pulnee Burn to the edge of the Loch Doon intrusion have been shown to be enriched in zinc contained within detrital orthopyroxene grains in the rock. The zinc in the sieved stream sediment N and NE of Clatteringshaws Loch is not accommodated in orthopyroxene but is present in the adsorbed form ie it has been dispersed hydromorphically from an as yet unknown source. Sphalerite is also present in pan concentrates taken from the Folk Burn (83) and a tributary of the Polmaddy Burn (90) draining Craigrine. The strongly folded sequence of shales, flags and greywackes forming this hill are intruded by an unusually dense swarm of porphyrite and lamprophyre dykes with a north to north-east trend.

Evidence for zinc mineralisation in the Carsphairn granite complex and its aureole is markedly absent but a number of occurrences have been identified in the marginal facies and aureole of the Loch Doon intrusion.

6.2.4 Distribution of Molybdenum Minerals (Fig. 6.4)

The distribution of molybdenum mineralisation, as represented by the mineral molybdenite (MoS_2), is restricted, with few exceptions, to the Loch Doon, Fleet and Burnhead intrusions.

The Doon occurrences are grouped into two main areas, one in and around the northern part of the central ridge of more acid facies granite and the other in the south around Loch Neldricken and just west of the central ridge. In the latter area the mineral was found in the loch

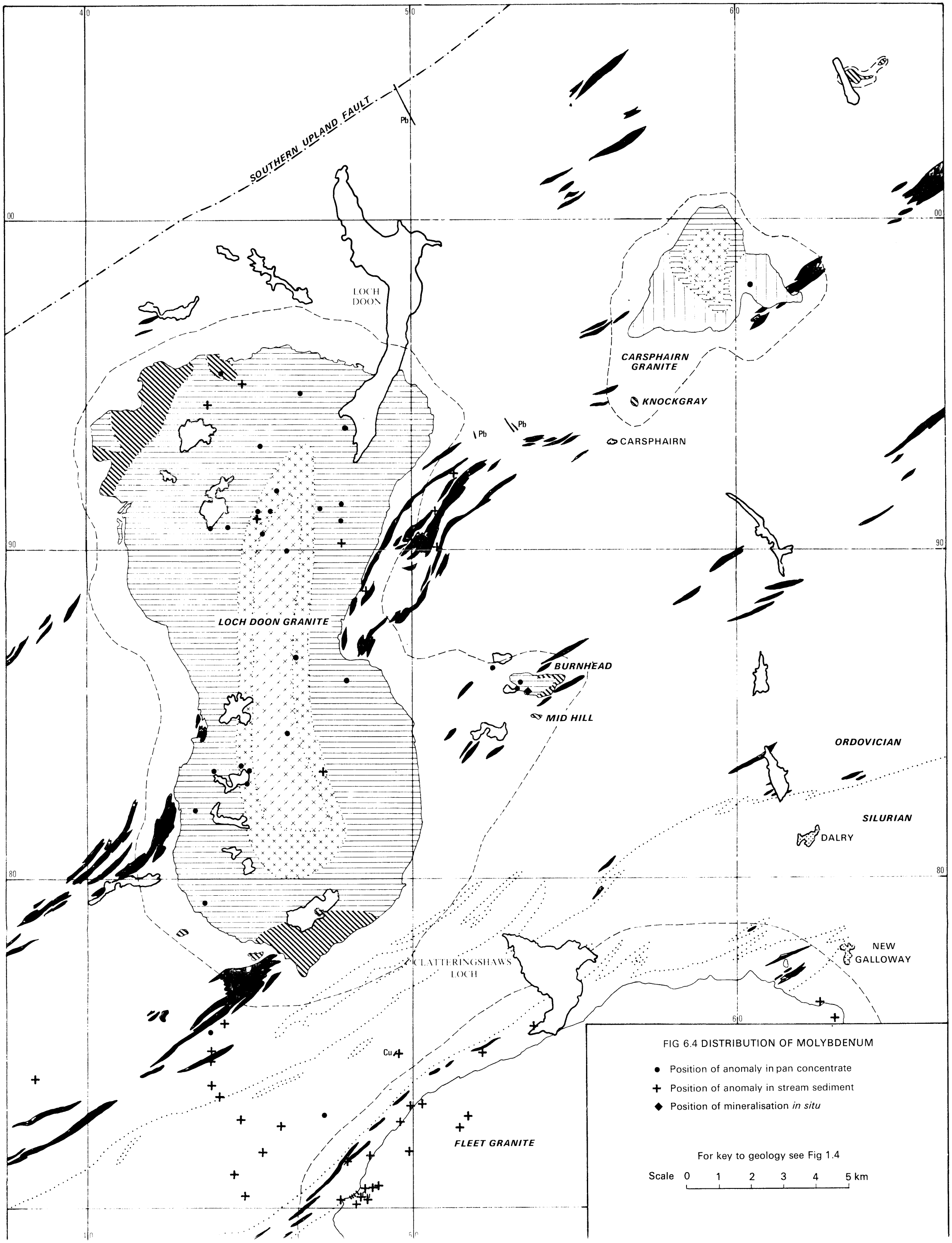


FIG 6.4 DISTRIBUTION OF MOLYBDENUM

- ● Position of anomaly in pan concentrate
- \+ Position of anomaly in stream sediment
- ◆ Position of mineralisation *in situ*

For key to geology see Fig 1.4

Scale 0 1 2 3 4 5 km

shore sand where it is present at a very low level of concentration.

In the Burnhead mass, flakes of molybdenite occur sparsely disseminated in the hybrid tonalite facies and are also present in pan samples (29 and 73) collected from streams draining that part of the intrusion.

With examples of molybdenum mineralisation already known from both the Fleet and Criffell plutons, the results of the current investigation confirm the continued association of the element with the major Southern Uplands granites.

6.2.5 Distribution of Iron Minerals (Fig. 6.5)

Magnetite is a rare constituent of pan samples taken within the granite complexes of Loch Doon and Carsphairn or from sedimentary catchment areas.

Hematite, in contrast, has a very wide distribution throughout the project area. However, if emphasis is restricted to occurrences where the mineral is common to abundant, as is shown on the accompanying distribution map for the mineral, it can be seen that within the granite intrusions significant indications occur only in some eastern marginal parts of the Doon complex. The most important hematite 'lode' known is that structure which can be traced for nearly 3 km from Coran of Portmark in the marginal tonalite facies of the Doon intrusion, passing into the aureole 1 km south and terminating in the source area of the Blaree Burn, 1 km west of Cairnsgarroch. This occurrence attracted mining interest in the past and unsuccessful attempts were made to work the ore. Possible southerly extensions of this or sub-parallel structures are indicated by the prevalence of hematite in pan samples from the Blaree Burn, the Polmaddy Burn, the Hawse Burn, the Altibrick Strand and some streams around Loch Dungeon. A breccia with hematite is exposed in the Hawse Burn [NX 5062 86C2]. Westward, closer to the granite contact, hematite

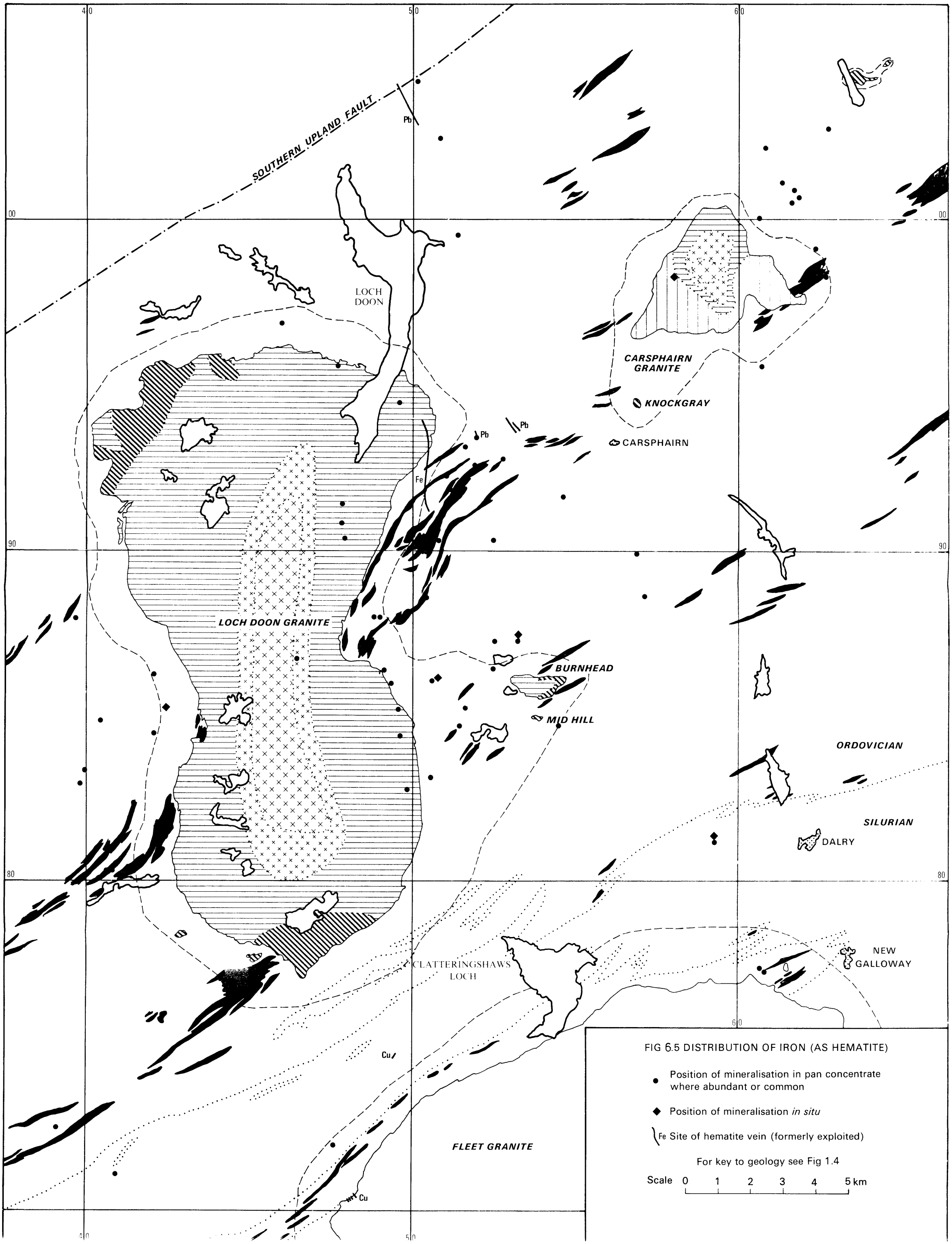


FIG 6.5 DISTRIBUTION OF IRON (AS HEMATITE)

- Position of mineralisation in pan concentrate where abundant or common
- Position of mineralisation *in situ*
- Fe Site of hematite vein (formerly exploited)

For key to geology see Fig 1.4

Scale 0 1 2 3 4 5 km

veins have been found in the Kirreoch and March Burn catchments. Hematite is notably common in pan samples from the Clennoch Burn catchment on the north side of the Carsphairn complex.

Pyrite has been listed in APPENDIX I as it is recognised to have a limited role as a possible indicator of associated sulphides of other economic elements. The mineral is widely distributed in finer sediments, particularly black shales. It is commonly found finely disseminated in lavas, dykes and other minor intrusions in the metamorphic aureoles of the major plutons. Marcasite, the 'white' pyrite variety, has been identified in the Maggot Hill area and also in a more unusual genetic association with the hybrid tonalite facies of the Burnhead intrusion. The magnetic iron sulphide pyrrhotite forms a major component of the ore at the Talnotry nickel mine. Analyses indicate nickel contents up to 3%. Minor amounts of the mineral have been detected in quartz veins in the Maggot Hill - Rig of Airie area. Pyrrhotite with traces of the nickel mineral pentlandite (XRD) has been identified in mineralised vein samples from the Forestry Commission quarry on the west side of Clatteringshaws Loch and from other sites in the vicinity. Disseminations of pyrrhotite occur in parts of the Mid Hill and Burnhead intrusions and also in the small hybrid diorite mass of Knockgray above Carsphairn village. Pyrrhotite has also been recorded in rocks from the middle and lower reaches of Penkiln Burn. It occurs together with chalcopyrite in thin veins to the NE of the Talnotry workings as far as the Grey Mare's Tail waterfall. Traces have been recorded in pan concentrates from some streams draining shale belts in the catchments of the Penkiln and Polmaddy Burns and also on Milldown, near Loch Dungeon.

6.2.6 Distribution of Gold (Fig. 6.6)

Although there is no previous record of gold in the project area,

FIG 6.6 DISTRIBUTION OF GOLD

● Position of mineralisation in pan concentrate

For key to geology see Fig 1.4

Scale 0 1 2 3 4 5 km

the metal has been shown by panning to have a wide distribution.

In only three areas is the incidence of the element common enough to warrant further attention. Gold has been found in an area extending from the Knocknairling Burn, over the Maggot Hill - Will's Hill ridge, to the Craigshinnie catchment and thence over the Back Hill of Glenlee to the Glenlee Burn. It has also been identified from all the streams draining Green Hill and Moorbrock Hill on the eastern margin of the Carsphairn granite, with further occurrences in and around the Clennoch Burn catchment on the north side of the intrusion. Gold was found in the two pan samples taken from a small stream draining the hybrid tonalite facies of the Burnhead mass into Loch Minnoch. Other occurrences may be significant although not more than two particles of gold were found in any one panning.

The majority of particles are sub-angular or angular in form, indicative of a fairly local source. Most grains have a size range of 0.1 - 0.5 mm diameter and a weight range of 0.1 - 0.25 mg.

Strips of alluvium along the courses of the Knocknairling and Craigshinnie Burns are too small for placer exploitation even if payable values were to be proved. This also applies to limited thin eluvial placer areas on the flanks of the Maggot Hill - Will's Hill ridge. The gentle grades of both the Knocknairling and Craigshinnie Burns make it unlikely that much gold from these sources will find its way into the large areas of alluvium in the valley of the Water of Ken. Gold from the streams draining the Green Hill and Moorbrock Hill areas may reach alluvial tracts along the course of the Polifferie Burn. Gold present in stream concentrates from the headwaters of the Glenhead Burn [NX 4492 7855] was traced to thin quartz-arsenopyrite veins still under investigation in the contact aureole [NX 4473 7814] of the Doon intrusion.

There is a relationship between the distribution of particle gold and shale belts, this being more evident near the granite intrusions. An attempt to trace the provenance of the gold in the Maggot Hill area yielded inconclusive results. Samples of quartz veins containing minor sulphide minerals, specimens of sparsely mineralised, foliated diorite, and samples of indurated pyritous, carbonaceous shale have been analysed but in only one instance has the gold tenor been proved to be above the minimum analytical detection level of 0.02 ppm. It may be that the gold is held in the basic volcanic detritus and/or vein quartz components of greywackes and that the element is mobilised by solutions developed from effects of folding and metamorphism, before being finally precipitated as visible particles within and around structures in host rocks containing reducing agents such as organic matter and/or sulphides (eg pyrite).

6.2.7 Distribution of Tungsten Mineralisation

There is evidence of minor tungsten mineralisation in both the Doon and Fleet plutons.

In the southern sector of the Loch Doon complex an analysis of a sample from a lode occurring in the Gairland Burn tributary [NX 4332 8212] shows it to contain approximately 0.1% of the element, and in the north a trace of scheelite was identified (XRD) in the pan sample (239) collected from the east flank of Craigmawhannal.

Three analyses of 'arsenopyrite' ore from the Palnure Burn trial [NX 4810 7018] at the margin of the Fleet granite in the Talnotry area gave tungsten values of up to 0.07%.

6.2.8 Distribution of Tin Minerals

The principal mineral cassiterite has not been found. A single grain of the wood tin variety, Toad's Eye tin, was identified in the concentrate from the Glenowrie Burn (6) in the southern aureole of the

Loch Doon complex. The geochemical reconnaissance data indicate that there is no significant tin mineralisation within the Doon granite or its surroundings.

6.2.9 Distribution of Antimony Mineralisation

No antimony minerals have been found. Geochemical evidence indicates that Sb is only a minor component of mineralisation in the area. It is present in a concentrate from the stream draining the old working at Craigshinnie at the 25 ppm level and elsewhere in a few samples at similar levels. It is also a minor constituent (40 ppm level) in the base metal mineralisation at Penkiln Burn. A sample of 'niccolite-cobaltite' ore from the Talnotry nickel trial [NX 4791 7036] contained just over 0.03% of the element and no values over 50 ppm were recorded in any other analyses of mineralised samples.

6.2.10 Distribution of Titanium Minerals

The highest geochemical titanium concentrations in stream sediments are to be found in the most basic parts of the Doon complex and with a group of the sediments extending from the southern margin of the intrusion to the middle reaches of Penkiln Burn. Relatively high titanium levels are also present in samples derived from the tonalite facies of the Carsphairn granite and the sediments to the SE of the intrusion. An isolated very titanium-rich sample is derived from the western side of Mid Hill.

Ilmenite is present in all pan samples. Notable alluvial concentrations, derived from the norite and diorite of the Loch Doon complex, occur in the Balloch Lane in the north-west part of the intrusion (208) and again in the south in the shore sands of Loch Dee (61). Coarser detrital ilmenite is recognised in many stream concentrates from the area between the Loch Doon and Fleet plutons. In some sedimentary catchment areas patchy to amorphous alteration products of

ilmenite are as common as ilmenite and occasionally traces of (?) pseudobrookite are present.

Minor amounts of rutile and its polymorph anatase are usually present in pan samples collected from sedimentary catchment areas, but both minerals, particularly anatase, are much less common in the granite complexes. Unusually coarse anatase is common in several stream concentrates in the sector between the two major shale belts of the Glen Trool and Penkiln Burn areas. Its abundance in the branch of the Ferrach Burn (321) merits an investigation to establish the mineral's provenance.

Sphene (titanite), the calcium-titanium silicate, is present in many pan concentrates and is particularly common in parts of the Loch Doon and Carsphairn complexes.

6.2.11 Distribution of Chromium Minerals

The highest chromium stream sediment values are located in a zone of sediments surrounding the Burnhead and Mid Hill intrusions. Comparatively high levels also occur in a zone within the tonalite facies of the Doon granite to the west of Loch Dungeon within sediments SE of the Carsphairn granite and in an area north of Loch Doon adjacent to the Southern Upland Fault. Lesser concentrations appear to be associated with the thrust slice of black shales and greywackes located along the NW contact of the Fleet granite as far as Clatteringshaws Loch.

Chromium spinel (chromite) occurs in most stream concentrates collected from sedimentary rock catchments but is rarely present in pan samples taken within the granite plutons. Chromium spinel can range as high as 20% by weight of the heavy mineral fraction. Analyses of several grains show variations in the Cr_2O_3 content from 30 to 56%. The incidence of chromium spinel appears to bear some relation to the

proportion of basic igneous fragments present in greywackes.

6.2.12 Distribution of Manganese Mineralisation

Manganese minerals have not been found in other than trace amounts. The low tenor (0.1%) of the element in all analysed ore samples makes it unlikely that significant mineral concentrations occur in the area.

6.2.13 Distribution of Cobalt-Nickel Mineralisation

Weathering and alteration of the diorite and norite rocks in the Black Laggan Ward area on the southern margin of the Loch Doon complex to depths up to 4 m has been observed in new forestry road sections. A sample collected from the road to Loch Dee at [NX 4700 7795] was analysed but the result of 55 ppm Co and 90 ppm Ni shows no concentration compared to unaltered rocks.

The most important occurrence of cobalt-nickel mineralisation is at the Talnotry Mine [NX 4791 7036] where cobaltite (CoAsS) and niccolite (NiAs) are associated with pyrrhotite and chalcopyrite at the margin of a diorite intrusion. Three analysed samples of mixed ore from the mine dump gave cobalt values ranging from 0.07% in pyrrhotite-dominant material to 1.2% in a sample rich in cobalt-nickel minerals. Neutron activation analysis is not a suitable technique for the determination of nickel. Analyses quoted in the IGS Special Reports Series (Wilson 1921) show nickel values up to 3% in pyrrhotite and up to 12% in niccolite. Disseminated pyrrhotite was found in a diorite outcrop in the nearby Glen of the Bar and traces occur in pan samples from streams just west of the mine.

Present results indicate that pyrrhotite found in the intrusions of Burnhead, Mid Hill and Craig of Knockgray does not contain significant amounts of nickel. Minor amounts of cobalt-nickel minerals may be present in the lode structure exposed in the Gairland Burn Tributary at [NX 4332 8212] as a sample analysis gave 0.05% Co.

6.2.14 Distribution of Arsenic Mineralisation

The principal mineral arsenopyrite has been identified in several different associations. It is common in the tonalite facies of the Burnhead mass (but not Mid Hill), it is present in quartz veins in the Maggot Hill area and in the southern marginal facies of the Loch Doon intrusion, particularly in the upper reaches of the Glenhead Burn, and has also been identified in some streams concentrates from the Moorbrock Hill area. Gold has been proven to occur in all these areas. However at the Palmure Burn trial [NX 4810 7018], where the dominant ore mineral is arsenopyrite, analysed samples showed no gold values, though up to 2 ppm was recorded in analyses of ore samples from the nearby Talnotry nickel mine.

Arsenopyrite has not been recorded in other than trace amounts from the majority of pan samples. In the few instances where the mineral is relatively common, other important economic minerals are also present.

6.2.15 Distribution of Uranium-Thorium Mineralisation

Widely scattered traces of radioactive mineralisation, giving scintillometer readings ranging up to 80μr/hr, occur in the aureole of the Fleet granite. Examples are to be found in the Knocknairling Burn tributary below Darsalloch, in the west bank of the stream below the Grey Mare's Tail waterfall, and in the crags on the east side of Buckdas of Cairnbaber [NX 4880 7625].

The occurrence of two groups of radon-emitting springs in and around the central granite facies of the Carsphairn complex is an unusual feature. One spring, near the source of the Polchiffer Burn at NX 5900 9877, gives the uncommonly high scintillometer reading for such a spring of 150 μr/hr.

Traces of the thorium mineral monazite occur in pan samples from

several streams draining the Carsphairn pluton, including the Polchiffer Burn. Monazite is a much more common accessory mineral in the central granite facies of the Loch Doon complex, particularly in the area around Craignaw. There is some concentration of the mineral in the large alluvial tract west of the Cooran Lane.

6.2.16 Distribution of Barium Mineralisation

Unexpectedly few instances of barium mineralisation were found in the project area considering that the principal mineral barytes has a wide occurrence in mineralised structures in many parts of Scotland. Apart from several localities along the line of the Southern Upland Fault, mineralisation appears to be largely restricted to the area west of the Loch Doon complex, with examples at the Silver Ridge mine, on the flank of Benmore [NX 3808 8405] 1 km east of the Water of Minnoch, and as traces in some stream concentrates.

6.2.17 Distribution of Phosphate Rock

Crushed phosphate rock from North Africa has been extensively used as a fertiliser by the Forestry Commission and other private groups. As forested areas comprise the greater part of the project area, pan samples are usually contaminated by minor amounts of small, rounded, white to brown, translucent phosphate grains.

7. CONCLUSIONS AND RECOMMENDATIONS

Diverse noble- and base-metal mineralisation has been found in the area between the Doon and Fleet granites from Maggot Hill to Talnotry and also in the Silver Rig to Glen Trool area.

More detailed investigations in selected areas are required and some of these are now at an advanced stage.

ACKNOWLEDGEMENTS

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APPENDIX I

APPENDIX I Mineralisation in Pan Concentrates

No.	Type*	Locality	6" Sheet*	Grid ref.*	Cu	Pb	Zn	Mo	FeO	FeS	As	Au	*
1	S	Pulran Burn	NX 57 SW	5226 7493	●	-	-	-	-	●	-	-	
2	T	Pulran Burn trial	NX 57 SW	5227 7494	●	●	-	-	-	●	●	-	
3	S	Darnaw Burn	NX 57 NW	5235 7650	●	-	•	-	-	-	-	-	
4	S	Darnaw Burn	NX 57 NW	5235 7650	•	-	●	-	-	-	-	-	
5	S	Fore Burn	NX 47 NE	4894 7634	-	-	-	-	-	-	-	-	
6	S	Craigencallie Lane	NX 57 NW	5026 7615	-	-	-	-	-	-	-	-	
7	S	Nr. Black Laggan	NX 47 NE	4700 7795	-	-	-	-	-	-	-	-	
8	S	White Laggan Burn	NX 47 NE	4683 7782	-	-	●	-	-	-	-	-	
9	S	Knocknairling Burn	NX 57 NE	5899 7728	●	-	-	-	-	-	-	-	
10	S	Knocknairling Burn trib*	NX 67 NW	6060 7732	•	-	-	-	-	●	•	-	
11	S	Knocknairling Burn	NX 67 NW	6069 7727	•	•	-	-	●	•	-	●	
12	S	Darsallooh Burn	NX 67 NW	6085 7718	•	-	●	-	●	-	•	-	
13	S	Craigshinnie Burn trib	NX 67 NW	6010 7896	-	-	-	-	-	-	-	-	
14	S	Maggot Hill	NX 67 NW	6002 7910	-	-	-	-	●	-	-	-	
15	S	Craigshinnie Burn	NX 67 NW	6006 7938	-	-	-	-	-	-	-	-	
16	S	Craigshinnie Burn trib	NX 57 NE	5989 7936	-	-	-	-	-	-	-	•	
17	S	Craigshinnie Burn trib	NX 57 NE	5986 7927	-	-	-	-	-	-	-	•	
18	S	Maggot Hill	NX 57 NE	5909 7915	-	-	-	-	-	-	-	●	
19	S	Craigshinnie Burn trib	NX 57 NE	5886 7941	-	-	-	-	-	●	•	•	
20	S	Airie Bennan Hill	NX 57 NE	5868 7860	-	-	-	-	-	●	-	-	
21	S	Craigshinnie Burn trib	NX 57 NE	5823 7930	-	-	-	-	-	●	-	•	
22	S	Craigshinnie Burn trib	NX 57 NE	5814 7870	-	-	-	-	-	-	-	•	
23	S	Craigshinnie Burn trib	NX 57 NE	5823 7871	-	-	-	-	-	-	-	-	
24	S	East point of Clatteringshaws Loch	NX 57 NE	5663 7743	-	-	-	-	-	●	-	-	
25	S	East point of Clatteringshaws Loch	NX 57 NE	5595 7787	-	-	-	-	-	●	-	-	

26	S	Glenlee Burn trib.	NX	57	NE	5570	7967	●	-	-	-	-	●	-	-
27	S	Knocknairling Burn trib.	NX	57	NE	5880	7760	-	•	-	-	-	-	-	•
28	S	Knocknairling Burn trib.	NX	57	NE	5974	7766	-	-	-	-	-	-	-	•
29	S	Off Bennan Hill,Loch Minnoch.	NX	58	NW	5335	8591	•	-	-	•	-	-	-	•
30	S	Knocknairling Burn trib.	NX	67	NW	6208	7713	-	•	-	-	-	-	-	-
31	S	Knocknairling Burn trib.	NX	67	NW	6145	7743	-	•	-	-	-	-	-	-
32	D	Boulder clay bank beside Knocknairling Burn.	NX	67	NW	6144	7736	-	-	-	-	-	●	-	-
33	S	Knocknairling Burn trib.	NX	67	NW	6096	7723	●	-	-	-	-	●	-	•
34	S	Off Gallows Knowe,	NX	67	NW	6165	7827	-	-	-	-	-	●	-	-
35	S	Glenlee Burn trib.	NX	58	SE	5624	8063	●	-	-	-	-	●	-	•
36	S	Glenlee Burn trib.	NX	58	SE	5711	8062	-	-	-	-	-	-	-	-
37	S	Glenlee Burn.	NX	58	SE	5677	8080	-	-	-	-	-	●	-	●
38	S	Glenlee Burn trib.	NX	58	SE	5567	8067	-	-	-	-	-	-	-	-
39	S	Glenlee Burn trib.	NX	58	SE	5543	8126	-	-	-	-	-	-	-	-
40	S	Glenlee Burn trib.	NX	58	SE	5930	8116	-	-	-	-	●	-	-	-
41	S	Minnigall Lane.	NX	58	SW	5299	8246	-	•	-	-	-	-	•	-
42	S	Knocknairling Burn.	NX	57	NE	5938	7737	-	•	-	-	-	-	-	-
43	S	Minnigall Lane.	NX	58	SW	5316	8192	-	-	-	-	-	-	-	-
44	S	Garrooch Burn head-water.	NX	58	SW	5414	8192	-	•	-	-	-	●	-	-
45	S	Black Burn.	NX	58	SE	5537	8300	-	-	-	-	-	-	-	-
46	S	Craigshinnie Burn trib.	NX	57	NE	5858	7937	●	●	-	-	-	●	-	-
47	S	Knocknairling Burn trib.	NX	67	NW	6001	7790	-	-	-	-	-	-	-	-
48	S	Knocknairling Burn trib.	NX	57	NE	5989	7774	-	-	•	-	-	-	-	•
49	S	Knocknairling Burn trib.	NX	67	NW	6020	7793	●	-	-	-	-	●	-	-
50	S	Crummy Burn trib.	NX	58	SE	5659	8364	-	-	-	-	-	-	-	-

* For explanation refer to end of Table.

APPENDIX I (cont) Mineralisation in Pan Concentrates

No.	Type	Locality	6" Sheet	Grid ref.	Cu	Pb	Zn	Mo	FeO	FeS	As	Au	*
51	S	Crummy Burn trib.	NX 58 SE	5616 8415	-	-	-	-	-	-	•	•	
52	S	White Laggan Burn	NX 47 NE	4671 7710	-	-	-	-	-	-	-	-	
53	S	Crummy Burn trib.	NX 58 SE	5774 8430	-	-	-	-	-	-	•	-	
54	S	Crummy Burn trib.	NX 58 SE	5629 8402	•	-	-	-	-	-	•	-	
55	S	White Laggan Burn trib.	NX 47 NE	4644 7737	●	-	-	-	-	●	•	-	
56	S	Maggot Hill	NX 67 NW	6133 7758	●	-	-	-	-	●	-	-	
57	S	Maggot Hill	NX 67 NW	6121 7747	-	-	-	-	-	-	-	-	
58	S	Pulcagrie Burn	NX 57 NW	5399 7899	-	-	-	-	-	●	-	-	
59	S	Pulcagrie Burn trib.	NX 57 NW	5451 7882	-	-	-	-	-	-	-	-	
60	S	Nr. Upper Craigenbay	NX 57 NW	5496 7857	-	-	-	-	-	-	-	-	
61	S	Loch Dee beach sand	NX 47 NE	4733 7884	-	-	-	-	-	-	-	-	
62	S	McAdam's Burn	NX 58 SW	5403 8353	-	-	-	-	-	-	-	-	
63	S	McAdam's Burn trib.	NX 58 SW	5379 8379	-	-	-	-	-	-	-	-	
64	S	Polmaddy Burn trib.	NX 58 NE	5710 8859	-	-	-	-	●	-	-	-	
65	S	Polmaddy Burn trib.	NX 58 NE	5691 8990	-	-	-	-	●	-	-	-	
66	S	Polmaddy Burn trib.	NX 58 NE	5880 8768	-	-	-	-	-	-	-	-	
67	S	Polharrow Burn trib.	NX 58 NE	5738 8564	●	-	-	-	-	●	-	-	
68	S	Polharrow Burn trib.	NX 58 NE	5667 6561	●	-	-	-	-	-	•	-	
69	S	McAdam's Burn trib.	NX 58 SW	5441 8377	-	-	-	-	-	●	-	-	
70	S	McAdam's Burn trib.	NX 58 SW	5397 8418	●	-	-	-	-	-	-	-	
71	S	Stream draining Loch Dungeon	NX 58 NW	5276 8522	-	-	-	-	-	-	-	-	
72	S	McAdam's Burn trib.	NX 58 NW	5366 8559	-	-	-	-	-	●	●	-	
73	S	Bennan Hill, Loch Minnoch	NX 58 NW	5327 8577	•	-	-	•	-	-	•	●	
74	S	South-west of Loch Harrow	NX 58 NW	5248 8632	-	-	-	-	●	-	•	-	
75	S	South-west of Loch Narrow	NX 58 NW	5235 8644	●	-	-	-	-	●	•	•	

76	S	Hawse Burn trib	NX	58	NW	5163	8519	-	-	-	-	●	-	-	●				
77	S	Hawse Burn trib	NX	58	NW	5055	8597	-	-	-	-	●	-	-	-				
78	S	Hawse Burn trib	NX	58	NW	5060	8605	-	-	-	-	●	●	-	-				
79	S	Hawse Burn trib	NX	58	SW	5146	8462	-	-	-	-	●	-	●	-				
80	S	Hawse Burn trib	NX	58	SW	5170	8435	●	-	-	-	●	-	-	-				
81	S	South of Loch Dungeon	NX	58	SW	5184	8408	●	-	●	-	-	●	●	-				
82	S	South of Loch Dungeon	NX	58	SW	5199	8396	●	●	●	-	●	●	●	-				
83	S	Folk Burn	NX	58	NW	5254	8723	●	-	●	-	●	-	-	●				
84	S	Lumford Burn	NX	58	NW	5325	8717	-	-	-	-	●	-	-	-				
85	S	McAdam's Burn trib	NX	58	SW	5450	8459	●	-	-	-	●	-	-	-				
86	S	McAdam's Burn trib	NX	58	NW	5493	8554	-	-	-	-	-	-	-	-				
87	S	McAdam's Burn trib	NX	58	NE	5512	6580	●	-	-	-	-	-	-	-				
88	S	Folk Burn trib	NX	58	NW	5168	8754	-	-	-	-	-	-	-	-				
89	S	Folk Burn	NX	58	NW	5139	8703	-	-	-	-	●	-	-	-				
90	S	Off Craigrine	NX	58	NW	5177	8893	●	-	●	-	●	-	-	-				
91	S	Off Craigrine	NX	58	NW	5185	8891	●	-	-	-	●	-	●	-				
92	S	Polmaddy Burn head-waters	NX	58	NW	5042	8856	-	-	-	-	●	-	-	-				
93	S	Polmaddy Burn	NX	58	NW	5118	8941	●	-	●	-	-	●	-	-				
94	S	March Burn trib	NX	48	NE	4802	8595	-	-	-	-	-	-	-	-				
95	S	March Burn	NX	48	NE	4850	8583	-	-	-	-	●	-	-	●				
96	S	Kirreoch Burn trib	NX	48	NE	4839	8842	-	-	-	-	-	-	-	-				
97	S	March Burn trib	NX	48	NE	4934	8595	-	-	-	-	●	-	-	●				
98	S	March Burn trib	NX	48	NE	4916	8637	-	-	-	-	●	-	-	-				
99	S	Kirreoch Burn	NX	48	NE	4882	8804	-	-	-	-	●	-	-	-				
100	S	Kirreoch Burn	NX	48	NE	4887	8796	-	-	-	-	-	-	-	●				

APPENDIX I (cont) Mineralisation in Pan Concentrates

No.	Type	Locality	6" Sheet	Grid ref.	Cu	Pb	Zn	Mo	FeO	FeS	As	Au	*
101	S	Kirreoch Burn	NX 48 NE	4851 8885	-	-	-	-	●	-	-	-	
102	R	West slope of Rhinns of Kells	NX 48 NE	4800 8800	-	-	-	-	-	-	-	-	
103	D	Boulder clay bank beside Knocknairling Burn	NX 57 NE	5978 7759	-	-	-	-	-	-	-	-	
104	T	Stream running through Woodhead mine dumps	NX 59 SW	5335 9351	●	●	●	-	-	-	-	-	
105	S	Darnaw Burn	NX 57 NW	5324 7680	●	-	●	-	-	-	-	-	
106	S	Kirreoch Burn	NX 48 NE	4882 8794	-	-	-	-	●	-	-	-	
107	S	Kirreoch Burn	NX 48 NE	4887 8796	-	-	-	-	-	-	-	-	
108	S	Halfmark Burn	NX 59 SW	5284 9147	-	-	-	-	●	-	-	•	
109	S	Halfmark Burn	NX 59 SW	5374 9121	-	-	-	-	-	●	-	-	
110	R	Above Halfmark Burn	NX 59 SW	5404 9133	-	-	-	-	●	-	-	-	
111	S	Polmaddy Burn trib	NX 59 SW	5012 9018	•	-	•	-	○	-	-	•	
112	S	Polmaddy Burn trib	NX 59 SW	5075 9030	●	-	•	-	●	-	•	•	
113	S	Polmaddy Burn trib	NX 59 SW	5063 9021	●	-	-	-	●	●	•	-	
114	S	Polmaddy Burn trib	NX 59 SW	5241 9028	-	-	-	-	●	-	-	-	
115	S	Halfmark Burn trib	NX 59 SW	5465 9160	●	•	-	-	●	●	-	•	
116	S	Garryhorn Burn trib	NX 59 SW	5196 9344	•	•	•	-	●	-	-	-	
117	S	Garryhorn Burn trib	NX 59 SW	5161 9315	•	-	•	-	●	-	-	-	
118	S	Garryhorn Burn	NX 59 SW	5104 9223	-	-	-	-	●	●	-	-	
119	S	Garryhorn Burn trib	NX 59 SW	5116 9187	●	-	-	-	●	-	●	-	
120	S	Garryhorn Burn trib	NX 59 SW	5192 9260	-	-	-	-	●	-	-	-	
121	S	Garryhorn Burn trib	NX 59 SW	5277 9275	•	●	•	-	●	-	-	-	
122	S	Craigshinnie Burn trib	NX 57 NE	5938 7951	-	-	-	-	●	-	-	-	
123	S	Pulran Burn trib	NX 57 NW	5252 7514	●	-	-	-	-	-	-	-	
124	S	Stream flowing into south-west Clatteringshaws L.	NX 57 NW	5355 7565	●	-	●	-	-	●	•	-	
125	S	Muck Water	NX 50 SW	5027 0275	-	•	-	-	-	-	-	-	

126	S	Garrary Burn trib.	NX	58	SW	5376	8004	-	-	-	-	-	-	-	-				
127	S	Carsphairn Lane trib.	NX	59	NW	5349	9538	●	•	●	-	-	●	-	-				
128	S	Carsphairn Lane trib.	NX	59	NW	5237	9606	•	●	●	-	●	●	-	-				
129	S	Shalloch Burn trib.	NS	50	SE	5668	0047	-	-	-	-	-	-	-	-				
130	S	Shalloch Burn trib.	NS	50	SE	5696	0051	-	-	-	-	-	-	-	-				
131	S	Shalloch Burn trib.	NS	50	SE	5748	0071	-	-	-	-	-	-	-	-				
132	S	Brownhill Burn.	NS	50	SW	5465	0095	●	-	●	-	-	●	-	•				
133	S	Bow Burn trib.	NX	59	NE	5664	9814	-	-	-	-	-	-	-	-				
134	S	Marbrack Burn trib.	NX	59	SE	5963	9386	-	-	-	-	-	-	-	-				
135	S	Marbrack Burn trib.	NX	59	SE	5948	9455	●	-	-	-	-	●	-	-				
136	S	Marbrack Burn trib.	NX	69	SW	6088	9418	-	-	-	-	-	-	-	-				
137	S	Polifferie Burn trib.	NX	69	NW	6245	9926	●	-	-	-	●	●	-	-				
138	S	Polifferie Burn trib.	NX	69	NW	6235	9911	-	-	-	-	●	●	•	•				
139	S	Polifferie Burn trib.	NX	69	NW	6268	9830	●	-	-	-	●	●	-	•				
140	S	Poldores Burn trib.	NX	69	NW	6125	9747	-	-	-	-	-	-	-	•				
141	S	Poldores Burn trib.	NX	69	NW	6108	9816	-	-	-	-	-	-	-	•				
142	S	Poldores Burn trib.	NX	69	NW	6045	9797	•	-	-	-	-	-	-	-				
143	S	Poldores Burn trib.	NX	69	NW	6131	9719	•	-	-	-	-	-	-	●				
144	S	Poldores Burn trib.	NX	69	NW	6115	9715	-	-	-	-	-	-	-	-				
145	S	Marbrack Burn trib.	NX	69	NW	6145	9612	-	-	-	-	-	●	-	-				
146	S	Marbrack Burn trib.	NX	69	NW	6061	9554	-	-	-	-	●	-	-	•				
147	S	Bow Burn trib.	NX	69	NW	6084	9860	-	-	-	-	-	-	-	-				
148	S	Bow Burn trib.	NX	69	NW	6042	9933	-	-	-	-	-	-	-	-				
149	S	Bow Burn trib.	NX	69	NW	6060	9866	-	-	-	-	-	-	-	-				
150	S	Poldores Burn trib.	NX	69	NW	6212	9693	●	-	-	-	-	●	-	•				

APPENDIX I (cont) Mineralisation in Pan Concentrates

No.	Type	Locality	6" Sheet	Grid ref.	Cu	Pb	Zn	Mo	FeO	FeS	As	Au	*
151	S	Polifferie Burn trib.....	NX 69 NW	6230 9733	-	-	-	-	-	-	-	•	
152	S	Shalloch Burn trib.....	NS 50 SE	5888 0121	-	-	-	-	-	●	-	-	
153	S	Shalloch Burn trib.....	NS 50 SE	5868 0113	-	-	-	-	-	-	-	-	
154	S	Water of Deugh trib.....	NX 59 NE	5618 9664	-	-	-	-	-	-	-	-	
155	S	Water of Deugh trib.....	NX 59 NE	5595 9686	-	-	-	-	-	-	-	-	
156	S	Carsphairn Lane trib.....	NX 59 NW	5237 9893	-	-	-	-	-	-	-	-	
157	S	Bow Burn trib.....	NS 50 SE	5971 0069	-	-	-	-	-	-	-	•	
158	S	Bow Burn trib.....	NX 59 NE	5958 9993	-	-	-	-	-	-	-	-	
159	S	Bow Burn trib.....	NS 60 SW	6059 0002	-	-	-	-	●	●	-	•	
160	S	Clennoch Burn trib.....	NS 60 SW	6166 0052	-	•	-	-	●	●	-	-	
161	S	Clennoch Burn trib.....	NS 60 SW	6185 0066	-	•	-	-	●	-	-	-	
162	S	Clennoch Burn trib.....	NS 60 SW	6164 0087	-	-	-	-	●	-	-	-	
163	S	Clennoch Burn trib.....	NS 60 SW	6137 0105	-	●	-	-	●	-	-	•	
164	S	Clennoch Burn trib.....	NS 60 SW	6081 0086	-	•	-	-	●	-	-	•	
165	S	Water of Deugh trib.....	NS 60 SW	6260 0276	-	-	-	-	●	-	-	-	
166	S	Water of Deugh trib.....	NS 60 SW	6235 0206	-	-	-	-	-	-	-	-	
167	S	Water of Deugh trib.....	NS 60 SW	6234 0185	-	-	-	-	-	-	-	-	
168	S	Fingland Burn trib.....	NS 60 SW	6080 0211	-	-	-	-	●	-	-	-	
169	S	Fingland Burn trib.....	NS 60 SW	6118 0213	-	-	-	-	-	-	-	-	
170	S	Loch Doon east side.....	NX 49 SE	4866 9257	-	-	-	-	-	-	-	-	
171	S	Muck Water.....	NS 50 SW	5155 0235	-	-	-	-	-	●	-	-	
172	S	Carsphairn Lane trib.....	NX 59 NW	5102 9581	●	-	-	-	-	●	-	-	
173	S	Water of Deugh trib.....	NS 50 SE	5996 0170	-	•	-	-	-	●	-	•	
174	S	Water of Deugh trib.....	NS 50 SE	5602 0423	-	-	-	-	-	-	-	-	
175	S	Stream draining Loch Muck.....	NX 59 NW	5136 9950	●	-	-	-	●	●	-	-	

176	S	Muck Water trib.....	NS	50	SW	5010	0425	-	-	-	-	●	●	-	•				
177	S	Muck Water trib.....	NS	50	SW	5075	0255	●	-	-	-	●	●	-	-				
178	S	Carsphairn Lane trib.....	NX	59	NW	5214	9688	●	-	-	-	-	●	-	•				
179	S	Bow Burn trib.....	NX	59	NE	5666	9927	-	-	-	-	-	-	-	-				
180	R	Polsue Burn.....	NX	59	NE	5773	9724	-	-	-	-	-	-	-	-				
181	S	Polsue Burn trib.....	NX	59	NE	5803	9723	-	-	-	-	-	-	-	-				
182	S	Polsue Burn trib.....	NX	59	NE	5841	9694	-	-	-	-	-	●	-	-				
183	S	Polsue Burn trib.....	NX	59	NE	5857	9715	-	-	-	-	-	-	-	-				
184	S	Polsue Burn trib.....	NX	59	NE	5728	9616	-	-	-	-	-	●	-	-				
185	R	Polsue Burn.....	NX	59	NE	5684	9642	-	-	-	-	-	-	-	-				
186	R	Above Bow Burn.....	NX	59	NE	5781	9878	-	-	-	-	-	-	-	-				
187	S	Bow Burn trib.....	NX	59	NE	5807	9822	-	-	-	-	-	-	-	-				
188	S	Bow Burn trib.....	NX	59	NE	5803	9809	-	-	-	-	-	-	-	-				
189	S	Bow Burn trib.....	NX	59	NE	5852	9902	●	-	-	-	-	●	-	-				
190	S	Loch Finlas, south side.....	NX	49	NE	4527	9773	●	-	-	-	-	●	-	-				
191	S	Loch Finlas, south side.....	NX	49	NE	4545	9760	-	-	-	-	-	-	-	-				
192	S	Loch Finlas, south side.....	NX	49	NE	4596	9689	•	•	-	-	●	●	-	-				
193	S	Loch Finlas, south side.....	NX	49	NE	4685	9690	-	-	-	-	-	●	-	-				
194	S	Loch Finlas, south side.....	NX	49	NE	4766	9720	-	-	-	-	●	-	-	-				
195	S	Garpel Burn trib.....	NX	49	NE	4800	9718	●	-	-	-	●	●	-	-				
196	S	Loch Doon, west side.....	NX	49	NE	4822	9665	-	-	-	-	-	●	-	-				
197	S	Loch Doon, west side.....	NX	49	NE	4822	9527	-	-	-	-	●	-	-	-				
198	S	Loch Doon, west side.....	NX	49	NE	4764	9551	-	-	-	-	●	-	-	-				
199	S	Loch Doon, west side.....	NX	49	NE	4735	9540	-	-	-	-	-	-	-	•				
200	S	Carrick Lane trib.....	NX	49	SE	4705	9448	-	-	-	-	-	-	-	-				

APPENDIX I (cont) Mineralisation in Pan Concentrates

No.	Type	Locality	6" Sheet	Grid ref.	Cu	Pb	Zn	Mo	FeO	FeS	As	Au	*
201	S	Carrick Lane trib.	NX 49 SE	4657 9478	-	-	-	●	-	-	-	-	
202	S	Stream into Balloch ling Loch.	NX 49 NE	4612 9580	-	-	-	-	-	-	-	-	
203	S	Whitespout Lane trib.	NX 49 NW	4420 9532	-	-	-	•	-	-	-	-	
204	S	Whitespout Lane trib.	NX 49 SW	4407 9391	-	-	-	-	-	-	-	-	
205	S	Whitespout Lane trib.	NX 49 NW	4497 9524	-	-	-	-	-	-	-	-	
206	S	Loch Riecawr,north side.	NX 49 SW	4374 9417	-	-	-	-	-	-	-	-	
207	S	Whitespout Lane trib.	NX 49 SW	4313 9480	-	-	-	-	-	-	-	-	
208	S	Balloch Lane.	NX 49 SW	4281 9471	-	-	-	-	-	-	-	-	
209	S	Balloch Lane.	NX 49 NW	4191 9528	-	-	-	-	-	-	-	-	
210	S	Cornish Loch,south side.	NX 49 SW	4101 9282	-	-	-	-	-	-	-	-	
211	S	Cornish Loch,south side.	NX 49 SW	4046 9305	-	-	-	-	-	-	-	-	
212	S	Cornish Loch,east side.	NX 49 SW	4166 9363	-	-	-	-	-	-	-	-	
213	S	Loch Riecawr,west side.	NX 49 SW	4192 9171	-	-	-	-	-	-	-	-	
214	S	Loch Riecawr,west side.	NX 49 SW	4186 9205	-	-	-	-	-	-	-	-	
215	S	Loch Riecawr,west side.	NX 49 SW	4227 9294	-	-	-	-	-	●	-	-	
216	S	Loch Riecawr,west side.	NX 49 SW	4236 9363	-	-	-	-	-	-	-	-	
217	S	Loch Doon,east side.	NX 49 SE	4929 9410	-	-	-	-	-	-	-	-	
218	S	Loch Doon,east side.	NX 49 SE	4960 9445	-	-	-	-	●	-	-	-	
219	S	Loch Doon,east side.	NX 49 NE	4960 9517	-	-	-	-	-	●	-	-	
220	S	Loch Doon,east side.	NX 49 SE	4871 9281	•	-	-	-	-	●	-	-	
221	S	Whitespout Lane trib.	NX 49 SE	4576 9308	-	-	-	-	-	-	-	-	
222	S	Whitespout Lane trib.	NX 49 SE	4533 9313	•	-	-	•	●	●	-	-	
223	S	Loch Riecawr,south side.	NX 49 SW	4224 9087	•	-	-	-	●	●	-	-	
224	S	Loch Riecawr,south side.	NX 49 SW	4223 9068	-	-	-	-	-	-	-	-	
225	S	Loch Riecawr,south side.	NX 49 SW	4235 9058	-	-	-	-	-	-	-	-	

226	S	Tunskeen Lane	NX 49 SW	4306 9066	-	-	-	-	-	-	-	-	
227	S	Tunskeen Lane trib	NX 48 NW	4234 8909	-	-	-	-	-	-	-	-	
228	S	Tunskeen Lane trib	NX 48 NW	4328 8887	-	-	-	-	-	-	-	•	
229	S	Loch Doon, south side	NX 49 SE	4795 9367	-	-	-	-	-	-	-	-	
230	S	Loch Macaterick beach sand	NX 49 SW	4383 9066	-	-	-	•	-	-	-	-	
231	S	Eglin Lane trib	NX 49 SW	4433 9065	•	-	-	●	-	-	-	-	
232	S	Eglin Lane	NX 49 SE	4536 9084	-	-	-	-	-	-	-	•	
233	S	Eglin Lane trib	NX 49 SE	4565 9113	-	-	-	●	-	-	-	-	
234	S	Whitespout Lane trib	NX 49 SW	4445 9319	-	-	-	-	-	-	-	-	
235	S	Eglin Lane trib	NX 49 SE	4566 9166	-	-	-	-	-	-	-	-	
236	S	Eglin Lane trib	NX 49 SE	4582 9182	-	-	-	•	-	-	-	-	
237	S	Eglin Lane trib	NX 49 SE	4526 9118	-	-	-	•	●	-	-	-	
238	S	Eglin Lane trib	NX 49 SE	4540 9043	-	-	-	●	-	-	-	-	
239	S	Gala Lane trib	NX 49 SE	4712 9115	-	-	-	•	-	-	-	-	W
240	S	Gala Lane trib	NX 48 NE	4618 8995	-	-	-	◐	-	-	-	-	
241	S	Gala Lane trib	NX 49 SE	4788 9022	•	-	•	-	●	●	-	-	
242	S	Gala Lane trib	NX 49 SE	4792 9036	•	-	•	-	●	-	-	-	
243	S	Gala Lane trib	NX 49 SE	4786 9086	-	-	-	•	●	-	-	-	
244	S	Gala Lane trib	NX 49 SE	4781 9140	-	-	•	●	●	●	-	-	
245	S	Whitespout Lane trib	NX 49 SE	4566 9360	-	-	-	-	-	-	-	-	
246	S	Gala Lane trib	NX 49 SE	4820 9236	-	-	-	-	-	-	-	-	
247	S	Curnelloch Burn trib	NX 58 SW	5059 8306	-	-	-	-	●	-	-	-	
248	S	Curnelloch Burn trib	NX 48 SE	4963 8303	-	-	-	-	-	-	-	-	
249	S	Curnelloch Burn trib	NX 48 SE	4989 8272	-	-	-	-	●	-	-	-	
250	S	Gala Lane trib	NX 48 NE	4642 8666	-	-	-	-	●	-	-	-	

APPENDIX I (cont) Mineralisation in Pan Concentrates

No.	Type	Locality	6" Sheet	Grid ref.	Cu	Pb	Zn	Mo	FeO	FeS	As	Au	*
251	S	Eglin Lane trib.....	NX 48 NW	4370 8600	-	-	-	-	-	-	-	-	
252	S	Eglin Lane trib.....	NX 48 NW	4346 8689	-	-	-	-	-	-	-	-	
253	S	Curnelloch Burn trib.....	NX 58 SW	5031 8167	-	-	-	-	-	●	-	-	
254	S	Curnelloch Burn trib.....	NX 48 SE	4977 8076	-	-	•	-	-	●	-	-	
255	S	Curnelloch Burn trib.....	NX 48 SE	4921 8098	-	-	•	-	-	-	-	-	
256	S	Downies Burn trib.....	NX 48 NE	4956 8502	-	-	-	-	●	-	-	-	
257	S	Downies Burn trib.....	NX 48 SE	4967 8462	-	-	-	-	-	•	-	-	
258	S	Downies Burn trib.....	NX 48 SE	4957 8435	-	-	-	-	●	-	-	-	
259	S	Downies Burn trib.....	NX 48 SE	4807 8394	-	-	•	-	-	-	-	-	
260	S	Cooran Lane trib.....	NX 48 SE	4799 8301	-	•	-	-	-	-	-	-	
261	S	Cooran Lane trib.....	NX 48 SE	4659 8097	-	-	-	-	-	-	-	-	
262	S	Cooran Lane trib.....	NX 48 SE	4619 8149	-	-	-	-	-	-	-	-	
263	S	Gala Lane trib.....	NX 48 NE	4641 8887	-	-	-	-	-	-	-	-	
264	S	Gala Lane trib.....	NX 48 NE	4619 8774	-	-	-	-	•	-	-	-	
265	S	Glenhead Burn trib.....	NX 47 NW	4364 7971	-	•	•	-	-	-	-	-	
266	S	Glenhead Burn trib.....	NX 47 NW	4393 7942	-	-	-	-	-	•	-	-	
267	S	Glenhead Burn trib.....	NX 47 NW	4363 7920	-	-	-	•	-	-	-	-	
268	S	Minnoch Water trib.....	NX 39 SE	3690 9027	●	-	-	-	-	●	-	-	
269	S	Shalloch Burn trib.....	NX 39 SE	3871 9114	-	-	-	-	-	-	-	-	
270	S	Shalloch Burn trib.....	NX 39 SE	3869 9181	-	-	-	-	-	●	-	-	
271	S	Shalloch Burn trib.....	NX 39 SE	3873 9174	-	-	-	-	-	●	-	-	
272	S	Shalloch Burn trib.....	NX 38 NE	3953 8969	-	-	-	-	●	●	-	-	
273	S	Shalloch Burn trib.....	NX 39 SE	3886 9108	-	-	-	-	-	-	-	-	
274	S	Cross Burn trib.....	NX 38 NE	3924 8817	-	-	•	-	-	●	-	-	
275	S	Cross Burn trib.....	NX 38 NE	3979 8818	-	-	-	-	-	-	-	-	

276	S	Cross Burn trib.	NX	48	NW	4022	8825	-	-	-	-	-	●	-	●						
277	S	Cross Burn trib.	NX	48	NW	4057	8805	-	●	-	-	-	-	-	-						
278	S	Cross Burn trib.	NX	48	NW	4068	8797	-	-	-	-	-	-	-	-						
279	S	Cross Burn trib.	NX	48	NW	4076	8774	-	-	-	-	●	-	-	-						
280	S	Cross Burn trib.	NX	38	NE	3968	8793	-	-	-	-	●	-	-	-						
281	S	Kirshinnoch Burn trib.	NX	48	NW	4182	8604	●	-	-	-	-	●	-	●						
282	S	Kirshinnoch Burn trib.	NX	48	NW	4194	8608	-	-	-	-	●	-	-	-						
283	S	Kirshinnoch Burn trib.	NX	48	NW	4209	8620	-	-	●	-	●	●	-	-						
284	S	Water of Minnoch trib.	NX	38	SE	3808	8405	-	-	●	-	-	-	-	-						
285	S	Water of Minnoch trib.	NX	38	SE	3825	8377	●	-	-	-	-	●	-	-						
286	S	Water of Minnoch trib.	NX	38	SE	3845	8334	-	-	-	-	-	●	-	-						
287	S	Kirkennan Burn trib.	NX	48	SW	4026	8407	-	-	-	-	-	●	-	-						
288	S	Kirkennan Burn trib.	NX	48	SW	4054	8475	-	-	●	-	-	●	-	●						
289	S	Kirkennan Burn trib.	NX	48	SW	4041	8481	-	-	-	-	●	•	-	-						
290	S	Water of Minnoch trib.	NX	38	SE	3956	8178	-	-	-	-	-	-	-	-						
291	S	Water of Minnoch trib.	NX	38	SE	3997	8320	-	-	-	-	●	-	-	-						
292	S	Water of Minnoch trib.	NX	38	SE	3988	8298	-	-	-	-	●	●	-	-						
293	S	Buchan Burn trib.	NX	48	SW	4209	8444	-	-	-	-	●	•	-	-						
294	S	Buchan Burn trib.	NX	48	SW	4283	8472	-	-	-	-	●	-	-	-						
295	S	Buchan Burn trib.	NX	48	SW	4316	8478	-	●	●	-	-	●	-	-						
296	S	Buchan Burn trib.	NX	48	SW	4352	8458	-	-	-	-	-	●	-	-						
297	S	Buchan Burn trib.	NX	48	SW	4200	8256	●	-	●	-	-	●	-	-						
298	S	Buchan Burn trib.	NX	48	SW	4262	8238	-	-	-	-	-	-	-	-						
299	S	Glen Trool, north side.	NX	38	SE	3996	8085	-	-	-	-	-	-	-	-						
300	S	Glen Trool, north side.	NX	38	SE	3986	8086	-	-	-	-	●	●	-	●						

APPENDIX I (cont) Mineralisation in Pan Concentrates

No.	Type	Locality	6" Sheet	Grid ref.	Cu	Pb	Zn	Mo	FeO	FeS	As	Au	*
301	S	Glen Trool, north side	NX 48 SW	4032 8092	●	-	-	-	●	●	-	•	
302	S	Glen Trool, north side	NX 48 SW	4046 8102	-	-	-	-	●	-	-	-	
303	S	Buchan Burn trib	NX 48 SW	4140 8229	●	-	-	-	●	●	-	•	
304	S	Buchan Burn trib	NX 48 SW	4184 8164	-	-	-	-	-	-	-	-	
305	S	Glen Trool, north side	NX 48 SW	4065 8033	•	-	•	-	●	●	-	•	
306	S	Glen Trool, north side	NX 48 SW	4072 8029	●	-	-	-	●	●	-	-	
307	S	Buchan Burn trib	NX 48 SW	4200 8070	-	-	-	-	-	-	-	-	
308	S	Glenhead Burn trib	NX 48 SW	4234 8069	●	-	-	-	-	●	-	-	
309	S	Glen Trool, south side	NX 47 NW	4204 7974	●	-	-	-	-	●	•	-	
310	S	Glen Trool, south side	NX 47 NW	4115 7931	●	-	•	-	-	●	-	-	
311	S	Glen Trool, south side	NX 37 NE	3971 7777	-	-	-	-	-	-	-	-	
312	S	Glen Trool, south side	NX 37 NE	3961 7766	-	-	•	-	-	-	-	-	
313	S	Glen Trool, south side	NX 37 NE	3951 7775	-	-	•	-	-	-	-	-	
314	S	Glen Trool, south side	NX 37 NE	3944 7753	-	-	-	-	-	-	-	-	
315	S	Glen Trool, south side	NX 37 NE	3867 7720	-	-	-	-	-	-	-	-	
316	S	Glen Trool, south side	NX 37 NE	3931 7745	-	-	-	-	-	-	-	-	
317	S	Pulniskie Burn	NX 47 NW	4181 7620	-	-	-	-	-	●	-	•	
318	S	Pulniskie Burn	NX 47 NW	4187 7608	-	-	-	-	-	●	-	-	
319	S	Water of Minnoch trib	NX 47 NW	4029 7644	-	-	-	-	-	●	•	-	
320	S	Water of Minnoch trib	NX 47 NW	4038 7665	●	-	-	-	-	●	-	-	
321	S	Water of Minnoch trib	NX 37 NE	3956 7646	-	-	-	-	-	●	-	-	
322	S	Glen Trool, south side	NX 47 NW	4170 7805	-	-	-	-	-	-	-	-	
323	S	Glen Trool, south side	NX 47 NW	4168 7749	●	●	●	-	-	●	-	-	
324	S	Glen Trool, south side	NX 47 NW	4156 7733	-	-	•	-	-	●	-	•	
325	S	Loch Neldricken, north side	NX 48 SW	4397 8327	-	-	-	•	-	-	-	-	Th

326	S	Loch Neldricken,north side	NX	48	SW	4370	8341	-	-	•	-	-	-	-	•	
327	S	Gairland Burn	NX	48	SW	4334	8209	●	-	-	•	-	●	-	-	
328	S	Loch Neldricken,north side	NX	48	SW	4487	8335	-	-	-	●	-	-	-	-	Th
329	S	Loch Neldricken beach sand	NX	48	SW	4494	8326	-	-	-	●	-	-	-	-	
330	S	Loch Neldricken,south side	NX	48	SW	4499	8289	-	-	-	•	-	-	-	-	Th
331	S	Glen Trool,south side	NX	37	NE	3973	7840	-	-	•	-	-	●	•	-	
332	S	Cordorcan Burn trib	NX	47	SW	4107	7302	●	-	-	-	-	●	-	-	
333	S	Cordorcan Burn trib	NX	47	SW	4198	7416	-	-	-	-	-	●	-	-	
334	S	Cordorcan Burn trib	NX	47	SW	4202	7414	●	-	-	-	-	●	-	-	
335	S	Cordorcan Burn trib	NX	47	SW	4177	7377	●	-	•	-	-	●	-	-	
336	S	Cordorcan Burn trib	NX	47	SW	4063	7383	-	-	-	-	-	●	-	-	Ti
337	S	Pulniskie Burn trib	NX	47	SW	4040	7442	-	•	-	-	-	-	•	-	
338	T	Silver Rig mine dump	NX	37	SE	3776	7290	●	●	●	-	-	●	-	-	
339	S	River Cree trib	NX	37	SE	3782	7264	●	●	●	-	-	●	●	-	
340	S	River Cree trib	NX	37	SE	3820	7359	●	•	-	-	-	●	-	•	Ti
341	S	Tonderghie Burn trib	NX	47	NE	4918	7530	-	-	-	-	-	-	-	-	
342	S	Tonderghie Burn trib	NX	47	NE	4935	7530	-	-	-	-	-	-	-	-	
343	S	Tonderghie Burn trib	NX	57	SW	5006	7494	-	-	-	-	-	-	-	-	
344	S	Grey Mare's Tail Burn trib	NX	47	SE	4865	7419	-	●	•	-	-	-	-	-	
345	S	Grey Mare's Tail Burn trib	NX	47	SE	4830	7339	-	-	-	-	-	-	-	•	
346	S	Tonderghie Burn trib	NX	57	SW	5028	7318	-	-	-	-	-	-	-	•	
347	S	Tonderghie Burn trib	NX	57	SW	5018	7318	●	-	-	-	-	●	-	-	Ti
348	S	River Cree trib	NX	37	NE	3900	7513	●	-	-	-	-	●	-	•	Ti
349	S	River Cree trib	NX	37	SE	3769	7491	-	-	-	-	-	-	-	•	Ti
350	S	River Cree trib	NX	37	SE	3742	7465	-	-	-	-	-	●	-	-	Ti

APPENDIX I (cont) Mineralisation in Pan Concentrates

No.	Type	Locality	6" Sheet	Grid ref.	Cu	Pb	Zn	Mo	FeO	FeS	As	Au	*
351	S	Cordorcan Burn trib.	NX 37 SE	3967 7173	-	-	-	-	-	●	-	-	Ti
352	S	Cordorcan Burn trib.	NX 37 SE	3915 7247	●	-	-	-	●	●	-	-	Ti
353	S	River Cree trib.	NX 47 SW	4101 7095	-	-	-	-	●	●	-	-	
354	S	River Cree trib.	NX 47 SW	4001 7038	•	•	●	-	-	●	-	-	Ti
355	S	Penkiln Burn trib.	NX 47 SE	4767 7192	●	-	-	-	●	●	-	-	
356	S	Tonderghie Burn	NX 47 SE	4990 7317	●	●	●	-	-	●	-	-	
357	S	Grey Mare's Tail Burn	NX 47 SE	4912 7262	●	●	•	-	-	●	-	-	
358	S	Palnure Burn trib.	NX 47 SE	4854 7192	●	-	-	-	-	●	-	-	
359	S	Pulnee Burn trib.	NX 47 SE	4713 7332	-	-	-	-	-	-	-	-	
360	S	Pulnee Burn trib.	NX 47 SE	4710 7336	-	-	-	-	-	-	-	-	
361	S	Pulnee Burn trib.	NX 47 SE	4737 7285	-	-	-	•	-	-	-	-	
362	S	Pulnee Burn trib.	NX 47 SE	4732 7292	-	•	-	-	-	-	-	-	
363	S	Pulnee Burn trib.	NX 47 SE	4708 7218	-	-	-	-	-	●	-	-	Ti
364	S	Pulnee Burn trib.	NX 47 SE	4640 7268	•	-	-	-	-	-	-	-	
365	S	Penkiln Burn trib.	NX 47 NW	4423 7565	●	-	-	-	-	●	-	•	
366	S	Penkiln Burn trib.	NX 47 NW	4428 7566	●	-	-	-	-	●	-	-	
367	S	Penkiln Burn trib.	NX 47 NW	4425 7566	●	●	-	-	-	●	-	•	
368	S	Penkiln Burn trib.	NX 47 NW	4426 7541	•	-	-	-	-	-	-	-	
369	S	Penkiln Burn trib.	NX 47 NW	4386 7525	●	-	•	•	-	●	●	-	
370	S	Penkiln Burn trib.	NX 47 SW	4378 7484	●	-	-	-	-	●	-	-	
371	S	Penkiln Burn trib.	NX 47 SW	4381 7446	-	-	-	-	-	-	-	-	
372	S	Penkiln Burn trib.	NX 47 SW	4354 7420	●	•	•	-	-	●	-	-	
373	S	Penkiln Burn trib.	NX 47 SW	4387 7372	-	-	•	-	-	-	-	-	
374	S	Penkiln Burn trib.	NX 47 SW	4415 7336	-	-	-	-	-	-	-	-	
375	S	Penkiln Burn trib.	NX 47 SW	4473 7268	-	-	-	-	-	-	-	-	

376	S	Penkiln Burn trib.....	NX	47	SW	4455	7335	-	-	-	-	-	-	-	-	
377	S	Penkiln Burn trib.....	NX	47	SW	4457	7104	-	●	-	-	-	-	-	-	
378	S	Penkiln Burn trib.....	NX	47	SW	4439	7034	-	-	-	-	-	-	-	-	
379	S	Penkiln Burn trib.....	NX	47	SW	4454	7137	-	-	•	-	-	-	-	-	
380	S	Penkiln Burn trib.....	NX	47	SW	4466	7159	-	-	•	-	-	-	-	-	
381	S	Penkiln Burn trib.....	NX	47	SW	4298	7170	-	-	-	-	-	-	-	-	
382	S	Penkiln Burn trib.....	NX	47	SW	4290	7126	-	-	-	-	-	-	-	-	Ti
383	S	Penkiln Burn trib.....	NX	47	SW	4260	7130	-	-	-	-	-	●	-	-	Ti
384	S	Penkiln Burn trib.....	NX	47	SW	4257	7155	-	-	-	-	-	-	-	-	Ti
385	S	Cooran Lane trib.....	NX	48	SE	4613	8434	-	-	-	•	-	-	-	-	Th
386	S	Round Loch of the Dungeon beach sand.....	NX	48	SE	4667	8484	-	-	-	-	•	-	-	-	Th
387	S	Cooran Lane trib.....	NX	48	SE	4721	8338	-	-	-	-	-	-	-	-	Th
388	S	Cooran Lane trib.....	NX	48	SE	4745	8394	-	-	-	-	-	-	-	-	
389	S	Cooran Lane trib.....	NX	48	SE	4681	8288	-	-	-	-	-	-	-	-	Th
390	S	Pulnee Burn trib.....	NX	47	SE	4594	7362	-	-	-	-	-	-	-	-	
391	S	Pulnee Burn trib.....	NX	47	SE	4612	7455	-	-	-	-	-	-	-	-	
392	S	Pulnee Burn trib.....	NX	47	SE	4611	7493	-	-	•	-	-	-	-	-	
393	S	Pulnee Burn trib.....	NX	47	SE	4580	7424	-	-	•	-	-	-	-	-	
394	S	Pulnee Burn trib.....	NX	47	SE	4581	7467	-	-	-	-	-	-	-	-	
395	S	Pulnee Burn trib.....	NX	47	NE	4618	7513	●	●	●	-	-	●	-	-	
396	S	Pulnee Burn trib.....	NX	47	NE	4594	7547	●	-	•	-	-	●	-	-	
397	S	Pulnee Burn trib.....	NX	47	NE	4584	7545	-	-	-	-	-	-	-	-	
398	S	Pulnee Burn trib.....	NX	47	NE	4590	7509	-	-	-	-	-	-	-	-	
399	S	Glen of Bar, Talnotry.....	NX	47	SE	4766	7019	●	•	-	-	-	●	-	-	
400	S	Grey Mare's Tail Burn.....	NX	47	SE	4884	7282	●	-	-	-	-	●	●	-	

APPENDIX I (cont) Mineralisation in Pan Concentrates

No.	Type	Locality	6" Sheet	Grid ref.	Cu	Pb	Zn	Mo	FeO	FeS	As	Au	*
401	S	Grey Mare's Tail Burn trib.....	NX 47 SE	4900 7318	-	●	-	-	•	-	●	-	
402	R	Grey Mare's Tail Burn waterfall.....	NX 47 SE	4912 7262	-	●	-	-	•	-	-	-	
403	S	Grey Mare's Tail Burn trib.....	NX 47 SE	4895 7245	-	●	-	-	-	-	●	-	
404	S	Black Water of Dee trib.....	NX 57 NW	5168 7899	-	●	-	-	•	-	-	-	

EXPLANATION

'Type'..... S-Stream Debris; R-Weathered Rock; D-Drift; T-Dump from Mine or Trial

'6" Sheet'.... Designation of Ordnance Survey 1:10 560 map.

'Grid ref.'... National Grid Reference to eight figures.

'trib'..... Indicates the sample was taken from a tributary of the named stream.

Cu Copper

Pb Lead

Zn Zinc

Mo Molybdenum

FeO Iron (as Hematite)

FeS Iron (as Pyrite)

As Arsenic

Au Gold

● Abundant - more than 30% by weight of concentrate.

● Common - more than 5% by weight of concentrate.

● Present - invariably present in small amounts.

• Trace - only one or two grains in any concentrate.

* Entries in this column indicate the presence of additional significant minerals;
'Th'- Thorium (in Monazite) 'Ti'- Titanium (in Anatase, Ilmenite)
'W'- Tungsten (in Scheelite)

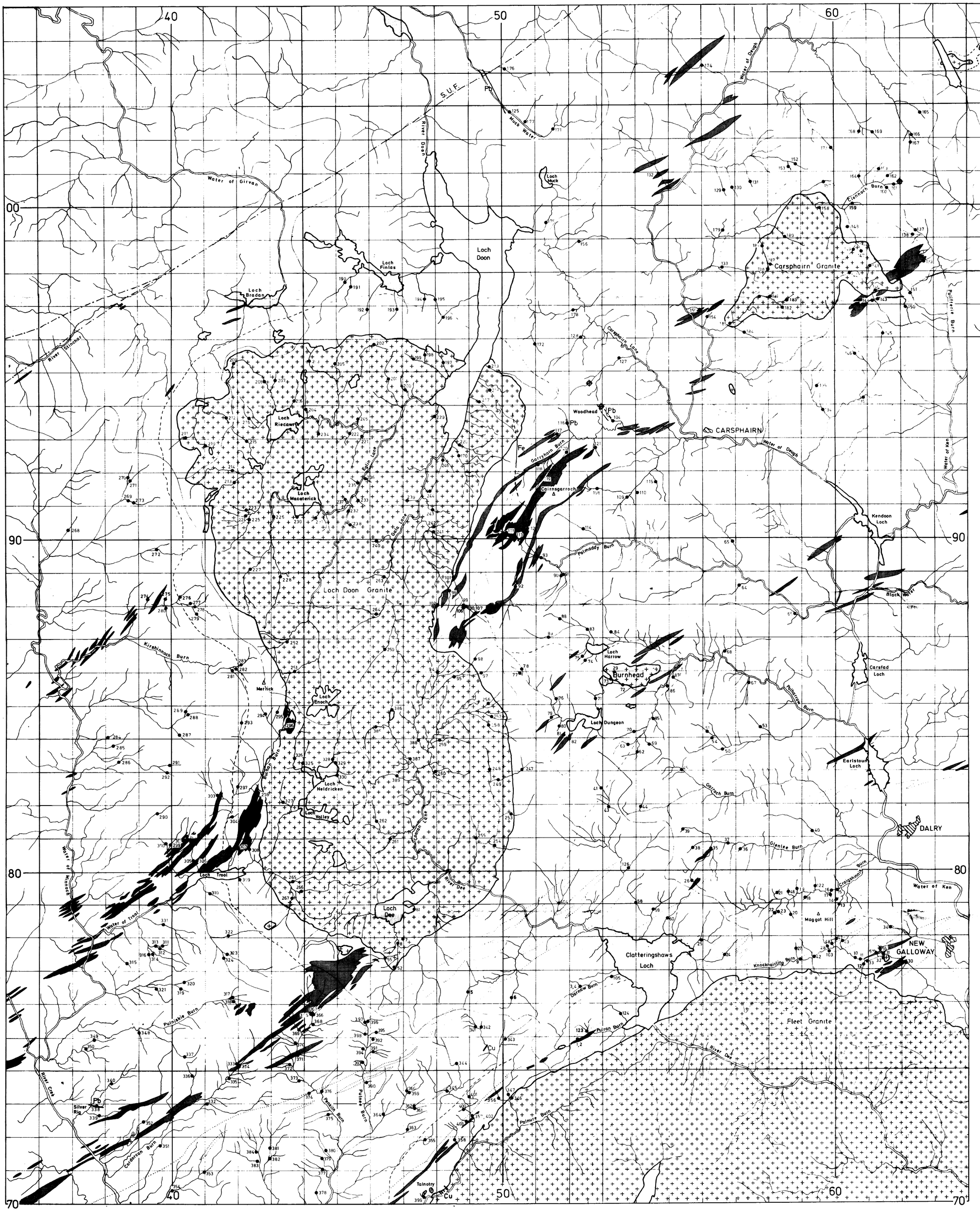

FIG 1.3 MAP OF DRAINAGE AND STREAM SAMPLING POINTS

● 1 - 404 Location and number of pan sample

Main watersheds

For key to geology see Fig 1.4

Scale 0 1 2 3 4 5 km

Fig 2.2 COMPLETE BOUGUER ANOMALY MAP OF DOON-FLEET DISTRICT

- Gravity station

Values based on IGF 1967 and IGSN 71

Density 2.7 g cm^{-3}

For key to geology see Fig 1.4

0 1 2 3 4 5 Kilometres

SOUTHERN UPLAND FAULT

LOCH DOON

LOCH DOON GRANITE

CARSPHAIRN GRANITE

KNOCKGRAY

CARSPHAIRN

BURNHEAD

MID HILL

ORDOVICIAN

SILURIAN

DALRY

NEW GALLOWAY

CLATTERINGSHAWS LOCH

FLEET GRANITE

LOCH KEN

Pb

Cu

+20 +15 +10 +5 0 -5