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Stratabound barium and base-metal mineralisation in Middle Dalradian metasediments near Braemar, Scotland

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B J Chacksfield, N J Fortey and P H A Nancarrow

BRITISH GEOLOGICAL SURVEY

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Mineral Resources Series

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Geology
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Cover illustration

A banded carbonate/sphalerite/marcasite/galena vein from the Gwynfynydd Gold Mine, near Dolgellau in North Wales

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DATA PACKAGE:

A detailed information package is available at a current (1989) cost of £350 (plus VAT). This includes:

A) Consultation with available staff who carried out the work.

B) Examination of drillcores.

C) A detailed data package containing the items listed below.

1. Geological-mineralogical Data

1.1 List of surface rock samples taken for geochemical analysis and/or mineralogical investigation.

1.2 Lithological logs.

1.3 Mineralogy and Petrology Report No. 87/25.

1.4 Mineralogy and Petrology Report No. WG/88/4C.

1.5 1:10 000 partial geological maps (sheets No. 18SE, 17NE, 17SE, 17SW).

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2.5 Cairn of Claise : computer listings of sample locations and geochemical analyses of 995 shallow overburden samples.*

2.6 Allt an Loch : computer listings of sample locations and geochemical analyses of 39 deep overburden samples and 39 panned basal till samples.*

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*Available on 5¼" or 3½" floppy disks or magnetic tape.

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All the data except the Glen Brighty area are available in the form of computer generated paper plots and listings on 5¼" floppy magnetic disks.

Enquiries concerning this Data Package should be made to Dr D J Fettes, British Geological Survey, Murchison House, West Mains Road Edinburgh EH9 3LA or Mr J H Bateson, British Geological Survey, Keyworth, Nottingham NG12 5GG.

SUMMARY

Stratabound mineralisation comprising baryte, barium silicates, sphalerite, galena and other sulphides has been discovered in the upper part of the Ben Eagach Schist Formation 11-13 km SSE of Braemar. This Formation forms part of the Middle Dalradian (late Precambrian to Cambrian) sequence of metasedimentary and meta-igneous rocks. The new mineralisation occurs at the same stratigraphical position as the Aberfeldy and Loch Lyon deposits, 45 km and 90 km SW respectively along the regional strike in the Grampian Highlands. One of the Aberfeldy deposits is presently being worked for baryte at Foss Mine by M-I Great Britain Ltd. Up to 10% Zn+Pb is present in Coire Loch Kander in quartzite which also contains hyalophane and armenite, the rare hydrated barium-calcium aluminosilicate. Bedded quartz-baryte rock is exposed in the headwaters of Allt an Loch, 1-2 km south of Loch Kander where it is some 5 m thick. A barium anomaly in the overburden extends over 1.6 km along the strike of the bed. The mineralisation was found as a result of integrated geochemical-geophysical-geological investigations northeastwards along the presumed strike of the Ben Eagach Schist from the Glenshee district. Overburden sampling and geophysical (VLF-EM, magnetics, IP and SP in part) measurements were conducted along 40 km of across-strike lines running for 11 km from Glen Brighty in the south, across the mountains of Glas Maol and Cairn of Claise to the Allt an Loch district and Coire Loch Kander.

Host-rocks are graphitic schists and quartzites regionally metamorphosed to amphibolite grade lying at or within a few tens of metres of the top of the Ben Eagach Schist against a thick, sill-like amphibolite body incorporated into the Ben Lawers Schist Formation. Sharp variation in the thickness of the Graphitic Schist Member from 0 m to 300 m may be partly attributable to folding but along-strike facies variation is probably of greater significance. Younger igneous rocks include a stock-like diorite body which has contact metamorphosed both the bedded sulphide mineralisation and a thin baryte-galena vein unaffected by the regional metamorphism. The geochemical and geophysical information provides an excellent guide to the bedrock geology which is very poorly exposed except in Coire Loch Kander.

The zinc-lead sulphide enrichment in quartzite is accompanied by pyrite, actinolite and diopside as well as by armenite, hyalophane and traces of baryte, while the massive fine-grained quartz component of this rock is rich in fluid inclusions. The precursor assemblage may have been a hydrothermally altered sediment or a chemical exhalite. The sulphidic quartzite is interdigitated with 15 m of highly pyritic graphitic quartz-schist, regarded as a distal exhalative iron-sulphur concentration in carbonaceous mud, and banded calc-silicate schist. In contrast, the bedded, quartz-baryte rock occurs in a gossanous clastic quartzitic sequence containing very little graphitic schist 1 km to the south along strike.

SCOPE OF PRESENT INVESTIGATION

The integrated geochemical, geophysical, geological and mineralogical investigations described in this report cover some 11 km of strike-length of the Ben Eagach Schist equivalents and adjacent Middle Dalradian formations between the headwaters of Allt an Daimh [NO 150 730] in the SSW and the northern cliffs of Coire Loch Kander in the NNE. The work was prompted by previous discoveries of stratabound baryte and zinc-lead mineralisation at north of Aberfeldy and at Loch Lyon (see Fig. 1) and by the identification of low-anomalous base-metal concentrations in graphitic schist and quartzite forming the Ben Eagach Schist in the valley of Allt an Daimh, Glenshee (Coats et al, 1988). Investigations northwards of the head of Allt an Daimh commenced in 1985, extending for 4 km through Glen Brighty [NO 165 745] to the head of Glas Maol Burn [NO 163 761], some 0.5 km SW of the summit of Glas Maol (1068 m) [NO 167 766]. Geophysical methods utilised were VLF-EM and magnetics in order to trace conductive graphitic schist through the very poorly exposed ground of Glen Brighty. Whereas few geochemical anomalies of significance resulted from the sampling of Glen Brighty, very high overburden values for barium, lead and zinc were recorded over the inferred contact of the Ben Eagach Schist with the Ben Lawers Schist and associated amphibolite near Allt an Loch [NO 197 796] on the Carn an Tuirc megatraverse (see Geochemistry section). A block of high-grade (10% Zn + Pb) stratabound sulphidic quartzite was found in Coire Loch Kander and fragments of baryte in screes traced to a small trial on a thin baryte-galena vein [NO 189 807].

Table 1. **Middle Dalradian formations near Braemar**

This report			Upton (1986) and Sheet 65W	
Subgroup	Formation	Lithology	Formation	Subgroup
Crinan	Ben Lui Schist	Quartz-mica schist, gneiss	Caenlochan Schist	Crinan
Easdale	Ben Lawers Schist	Calc schist, variably calcareous, quartzite , quartz-mica schist, incorporating a thick amphibolite sill at or near base	Glen Lochsie Schist	Easdale
Easdale	Ben Eagach Schist			
	Graphitic Schist Member	Graphitic schist, calc-silicate schist, bedded baryte, sulphidic barian chert	Glas Maol Schist	Easdale
	Laminated Member	Laminite (laminated graphitic schist and quartzite), laminated quartzite and rather massive quartzite	Cairn of Claise Transition	Islay
Easdale	Carn Mairg Quartzite	Massive quartzite, pebbly	Creag Leacach Quartzite	Islay

Table 2

Incidence and orientation of Ben Eagach Schist lithologies, Allt an Loch district, near Braemar

	[1]Outcrop measurements %	Average strike, degrees Grid	[2]Average dip, degrees
Graphitic Schist Member			
Graphitic schist	5	066	66
Bedded baryte	3	133	51
Quartz-(mica) schist	5.5	063	76
Laminated Member			
Laminite	52	046	60
Laminated quartzite	28	087	66
Quartzite	5.5	125	70
Overall strike and dip		067	63

[1] Total 106

[2] All dips are to the west or south

In 1986, a systematic survey of the 5 km strike-length of Ben Eagach Schist between the northern limit of the Glen Brighty survey and Coire Loch Kander was completed, involving some 25 km of across-strike lines at 200 m intervals. Measurements and sampling were conducted at 25 m intervals along each line and the available surface outcrops mapped at 1:10 000 scale (see Data Package). A very coherent, narrow geochemical anomaly (Ba, Pb and Zn), paralleled by a down-dip VLF-EM anomaly, was detected over 1.6 km of strike-length between the eastern margin of Coire Loch Kander and ground to the south of Allt an Loch. Here, outcropping bedded quartz-baryte rock and a thick gossan were recorded, while exposures of stratabound zinc-lead mineralisation were located in the corrie (see Fig. 2).

Geophysical measurements (with emphasis on IP) and overburden sampling were carried out at 100 m line spacings in the mineralised area in 1987. The ground centred on the headwater of Allt an Loch (950-1000 m OD) was surveyed tacheometrically and a 1:2000 scale geological-topographic map developed (see Table 2 and Data Package). The sites of shallow sampling boreholes representing 43 m of drilling (Table 3) were completed; the main sites are shown on Fig. 2. The accessible parts of the cliffs of Coire Loch Kander were mapped, using a 1:5000 enlargement of the existing 1:10 000 map, and a final geochemical-geophysical traverse was made on the western spur of Coire Loch Kander to explore an unexposed contact between schists and amphibolite. The Data Package contains analyses of the drillcores and 74 outcrop samples. together with two reports giving comprehensive petrographical descriptions of the cores and rocks.

Most of the area covered by this report lies within either a Site of Special Scientific Interest or a Nature Reserve. All of the mineralisation described here falls into the Loch Kander SSSI. The higher cliffs of Coire Loch Kander, not examined in this investigation, are continually subject to rock falls because of grazing sheep as well as frost action. In the corrie and in gullies such as the headwater of Allt an Loch, snowdrifts persist into June, while after July access is difficult because of sporting activities. All of the observed mineralisation lies in Grampian Region (Aberdeenshire) on part of Invercauld Estate. The regional boundary against Tayside (Perthshire) runs through Cairn of Claise to the southeast of which is Tulchan Estate.

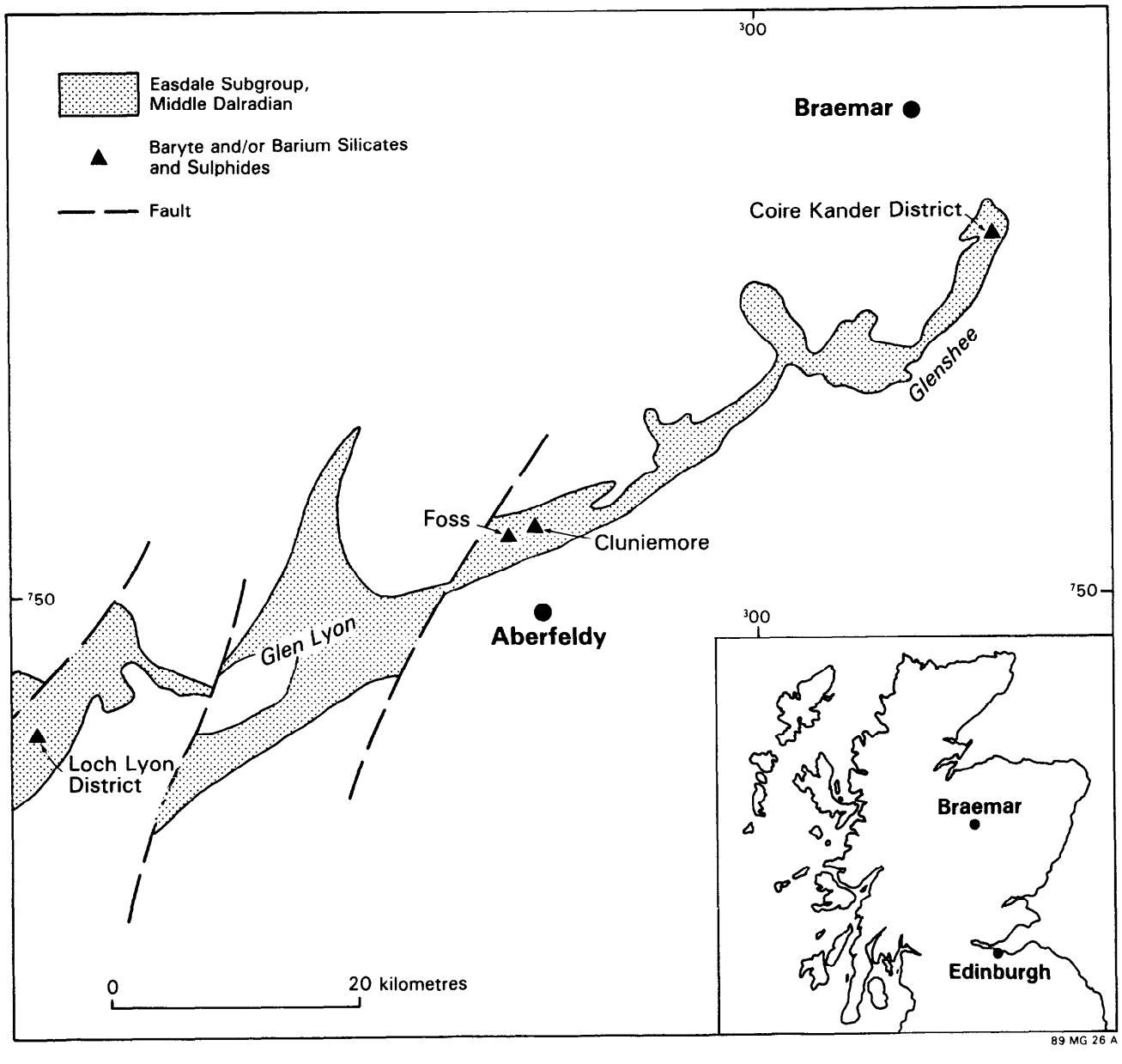

Figure 1 Location of the new stratabound and base metal mineralisation near Loch Kander, SSE of Braemar, relative to other Middle Dalradian mineralisation in the Grampian Highlands.

Table 3

Location and general features of sampling boreholes, Allt an Loch district, near Braemar

Borehole No.	Nat. Grid. Ref. (NO)		Depth, m	Notes
1	19640	79640	7.75	
2	19636	79639	5.75	No recovery
3	19632	79636	11.75	
4	19644	79640	7.00	No recovery
5	19654	79640	5.00	
6	19432	79254	5.75	
7	19392	79254	7.00	
8	19378	79262	5.00	

GEOLOGY AND MINERALISATION

The area of investigation lies in Middle Dalradian (Argyll Group) metasedimentary and in places metabasic igneous rocks intruded by post-tectonic granitic rocks probably of late Silurian to early Devonian age.

1. Lithostratigraphy

The bedded baryte and associated stratabound base metal deposits discovered near Braemar provide a key to the Middle Dalradian stratigraphy of the Grampian Highlands because of their equivalence, in lithostratigraphic position as well as in composition, to the deposits near Aberfeldy (Coats and others, 1980; Coats, Smith and others, 1981) and Loch Lyon (Coats and others, 1984), respectively 45 km and 90 km southwestwards along the regional strike (Fig. 1). Consequently, for comparative purposes, the Middle Dalradian lithostratigraphy of central Perthshire is used in this report, in the same way as in the report on the Glenshee district (Coats and others, 1988). The adopted correlations with the local stratigraphy (Upton 1986, BGS 1:50 000 Sheet 65W (Braemar) are shown in Table 1.

The Carn Mairg Quartzite is erroneously included in the Islay Subgroup by Upton (1986, Table 1). Neither Smith and Harris (1976) nor Treagus and King (1978), to whom Upton refers, discuss Middle Dalradian rocks. The equivalent in the Braemar area of the Carn Mairg Quartzite is more probably the Creag Leacach Quartzite than the Cairn of Claise (Laminated) Transition. The latter is regarded here as a Laminated Member of the Ben Eagach Schist Formation on the basis that stratabound zinc-lead mineralisation is associated with these rocks in the Allt an Daimh district (Coats and others, 1988).

2. Structure

In the most recent review of the structure of the Dalradian rocks south of Braemar, Upton (1986) concludes that the rocks lie on the lower inverted limb of the Tay nappe. Although there are sharp variations in strike within the investigated area due to minor folding, dips are principally to the south and west at moderately steep angles whereas the rocks young northeastwards. Minor fold axes measurable in the Laminated Member on the Cairn of Claise plateau plunge at shallow angles to the northeast and east. Thus the entire outcrop of the Ben Eagach Schist between Cairn of Claise and Coire Loch Kander represents a major NE-plunging fold which alters the lithological strike from N-S to E-W (Fig. 2).

Significant NE-SW and NW-SE faults are expressed in the cliffs of Coire Loch Kander. In the Allt an Loch district, a series of narrow linear topographic features generally of NE trend are interpreted as minor faults (Fig. 2). At the detailed scale (see 1:2000 map in Data Package) local sinistral offsets in the trend of the baryte bed are observable from plotting the distribution of eluvial baryte blocks.

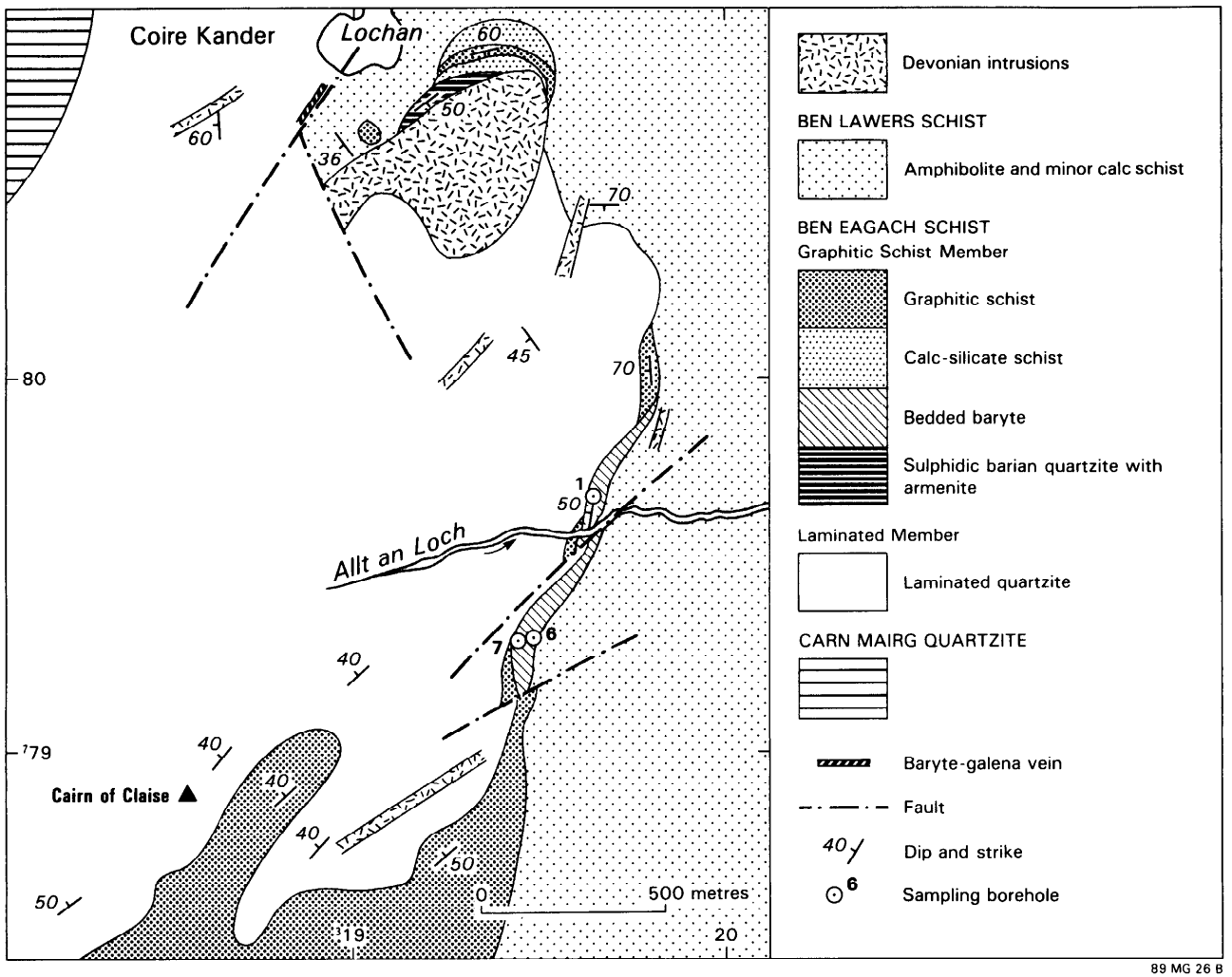

Figure 2 Sketch-map of the geology of the Loch Kander district showing the location of sulphidic chert and bedded baryte in the Middle Dalradian Ben Eagach Schist.

3. Glaciation and degree of exposure

The area has been intensely glaciated and evidence of periglacial activity is widespread. Coire Loch Kander is a classical glacial corrie up to 250 m deep and 1 km wide. Cliffs rising above screes are the most impressive outcrops in the study area; elsewhere the degree of exposure is of the order of 0.1% so that geophysical and geochemical investigations are essential. On the rolling plateau running southwards from the corrie to the watershed at the head of Caenlochan Glen, thin till or residual mineral soil, covered in grass and mosses, is interspersed by tracts of thin peat and exposure is lacking over wide areas, notably between Cairn of Claise and Coire Loch Kander. The narrow watershed between Cairn of Claise and Glas Maol is underlain by soft graphitic schists which also outcrop in the headwaters of drainage southwards from Glas Maol into Glen Brighty. The western side of this glen is obscured by talus from the quartzite ridge of Creag Leacach and graphitic schist remains unexposed over a strike-length of 2.3 km up to the watershed between Glen Brighty and Allt an Daimh near the south-southwest limit of the area investigated.

Periglacial features such as block fields, stone polygons and stripes are commonly developed on mountain summits. On lower slopes, solifluction deposits formed by downslope till transportation are widespread yielding poorly stratified soil. Similar features are described from the Glenshee district (Pease, Coats and Fortey, 1986). The only true moraine is that at the outlet of Loch Kander and in Caenlochan Glen.

4. Mineralisation near Loch Kander

Sphalerite, galena and barium minerals occur in a 15 m thick band of hard quartzite exposed in cliff faces SE of Loch Kander. The discovery scree block assayed 5.5% Zn, 4.6% Pb, 20 ppb Ag (by AAS) and material containing up to 30% of galena and sphalerite has since been located *in situ*. The sulphidic barian quartzite is interdigitated with calc-silicate schists and a 15 m thick band of sulphidic graphitic schist over some 300 m of strike-length within about 50 m of the top of the Ben Eagach Schist Formation (Fig. 2). This sequence, referred to as the Graphitic Schist Member, is inverted, dipping southeastwards at 50-60°. The sulphidic barian quartzite is an extremely hard, cherty rock difficult to sample from the lichen covered cliff ledges. Channel sampling proved impossible and grades of spot samples taken at bedding planes or joints proved very erratic. In the highly folded rock conformable mm-scale bands of sphalerite, galena, pyrite and pyrrhotite are definable, confirming the stratabound nature of the mineralisation. Most spectacular are sulphide bands up to 3 cm thick dominated by coarse-grained galena which appears to have formed by local remobilisation. Among the associated minerals of the quartzite are the barium silicates armenite, new to the UK, and hyalophane; baryte, salitic pyroxene and tremolite-actinotite also occur. Full locational, chemical and mineralogical details of the rock samples from Coire Loch Kander are given in the Data Package.

The associated calc-silicate schist contains tremolite-actinolite, hedenbergite, scapolite and bands of microgranlular feldspar, and is itself interlaminated with quartz-muscovite schist. The associated graphitic schist is a fine-grained quartzose rock with bands containing up to 50% of fine-grained pyrite, which resembles "vasskis", a distal exhalative iron and sulphur-rich deposit in carbonaceous mud (Sand, 1986).

To the northwest, lying conformably and structurally beneath the Graphitic Schist Member, are amphibolite and calc schist assigned to the Ben Lawers Schist Formation which extend westwards to a junction of NE-and NW-trending faults. A small inlier of pyritic, graphitic schist some 20 m x 30 m in area outcrops within shallow-dipping calc schists 400 m to the southwest of the main graphitic schist outcrop, and the sulphidic barian quartzite horizon may be present beneath it.

Westwards of the NW-trending fault are mainly laminated quartzite and quartz-mica schists of the lower Laminated Member of the Ben Eagach Schist Formation. Within them, close to the main NE-trending fault, occurs a sub-parallel baryte-galena vein 10-40 cm thick. Although somewhat annealed, the baryte grains retain a bladed habit suggesting that the vein post-dates regional metamorphism but has been affected by contact metamorphism related to the nearby early-Devonian diorite stock. An ancient trial of a few cubic metres extent is located on the vein which lies in the foliation of the schists. Most of the upper cliffs of southern Coire Loch Kander are inaccessible and the geology poorly known. The general dip is westwards so the rocks are inverted, lying structurally

Table 4

Thickness of the Ben Eagach Schist between Loch Kander and Glenshee

Locality (see Table 4a)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Along-strike separation, km (approx)	0	1.2	2.2	2.6	3.1	3.6	4.7	5.8	7.8	8.2	10.5	11.8	13.2	14.9	17.1	20.8
Outcrop thickness, m																
Graphitic Schist Member	20+	35	15+	30+	(?)140	(?)280	c400	c700	c220	c220	c280	-	-	c500	c1000	c50
Laminated Member	500+	c1000	c1500	c1800	c2000	c1700	c1200	c600	c150	c200	c300	c250	c200	(?)500	c400	c100
True thickness, m																
Graphitic Schist Member	20+	35	15+	30+	(?)	(?)	(?)300	(?)300	(?)150	(?)150	(?)150	c35	c100	c300	(?)500	(?)40
Laminated Member	300+	(?)700	(?)1000	(?)1200	(?)1400	(?)1100	(?)800	(?)600	(?)100	(?)140	(?)200	(?)200	(?)150	(?)	(?)300	(?)70
Total, km	0.3+	0.7	1.0	1.2	1.4	1.1	1.1	0.9	0.25	0.29	0.35	0.24	0.25	0.3	0.8	0.11

Borehole data at localities 12-13 and descriptions of localities 14-16 in Coats and others (1988)

Table 4 (contd)

Thickness of the Ben Eagach Schist between Loch Kander and Glenshee

	Locality	Nat. Grid Ref. (NO)	Graphitic Schist Member Comments	Adjoining Laminated Member Comments
1	Cliffs north of Corrie Loch Kander	187 819	Measured outcrop	Inferred from outcrops
2	Upper eastern face, Corrie Loch Kander	193 808	Measured section	ditto
3	North of Allt an Loch	198 800	Single outcrop	ditto
4	Northern side of Allt an Loch	197 796	Borehole data	Inferred from scattered outcrops
5	Southern side of Allt an Loch	194 793	Blocks only	ditto
6	South of Allt an Loch	192 787	Single outcrop	ditto
7	Northern headwater, Glassalt Burn	183 780	Faulted outcrops	ditto
8	Watershead, head of Caenlochan Glen	171 775	Outcrops include amphibolite sills and felsite dykes	ditto
9	Batheacbeg Burn	168 755	Isolated outcrops	ditto
10	Sron Riabhach	167 750	Debris only but agrees closely with No. 9	ditto
11	Watershed NW of Mallrenskein	149 733	Debris only	ditto
12	Upper Allt an Daimh	145 721	Borehole intersection	ditto
13	SE side,Carn an Daimh	138 709	Borehole data	Close outcrop control
14	Bad an Loin	122 708	Isolated outcrops	Inferred from scattered outcrops
15	South side of Gulabin	100 710	Scarce outcrops	Scarce outcrops
16	Coire Buidhe Mór, Glen Lochsie	064 714	Debris only	ditto

beneath the Carn Mairg Quartzite (Fig. 2). The Laminated Quartzite Member is considered to extend southwards to Cairn of Claise in virtually unexposed ground, a view supported by the geophysical and geochemical surveys.

The outcrop of sulphidic barian quartzite in eastern Coire Loch Kander is cut out by the Lower Devonian diorite, which has contact metamorphosed the mineralised horizon. Numerous felsite and microdiorite dykes are also present in the district (see Fig. 2).

5. Mineralisation near Allt an Loch

Bedded baryte-quartz rock outcrops near the head of Allt an Loch and is traceable by eluvial blocks over 700 m of strike-length at or very near to the top of the Ben Eagach Schist Formation. The junction of this Formation with amphibolite of the Ben Lawers Schist Formation runs southeastwards from the eastern edge of Coire Loch Kander then south-southwestwards to the ground south of Allt an Loch, describing a NE-plunging fold (Fig. 2). The overburden geochemical data illustrate that barium enrichment occurs at this junction for about 0.5 km north and south of the observed baryte distribution.

The Graphitic Schist Member is only only 15-30 m thick on the north side of Allt an Loch (Table 4) and the graphitic lithology is itself poorly developed - none was located in the shallow boreholes on and around number 1 site. The inferred outcrop thickness of this Member nevertheless appears to increase sharply southwards from sites 5-6 (see Fig. 2 and Table 4). In contrast, the Laminated Quartzite Member appears to be 1-1.5 km thick in the Allt an Loch district.

The baryte horizon is approximately 4.5 m thick at the principal outcrop, as measured from a shallow diamond drillhole (no. 1 in Table 3). The horizon dips conformably westwards at 50° within quartz-muscovite schists assigned to the Graphitic Schist Member. Although the presence of barium silicates has not been specifically investigated chemical analyses (see Data Package) show that the schists are enriched in barium. Drilling proved that amphibolite occurs some 10 m eastwards of the baryte bed. Eluvial baryte blocks extend some 200 m northwards from the outcrop but are absent over 400 m to the south before a conspicious cluster occurs at the site of borehole no. 6 (Fig. 2), some 80 m from the inferred base of amphibolite. A cluster of large blocks of gossanous breccia containing baryte-quartz patches, and blocks of graphitic schist occur around borehole no. 7, 30-50 m westwards of this site, the blocks extending for 100 m along the strike. A little graphitic mica-schist was intersected westwards of the gossanous zone suggesting that the total thickness of the Graphitic Schist Member at this location (no. 5 in Table 4; see also Fig. 3) is some 140 m. However, deeper drilling will be necessary to determine true thickness and the relationships of the lithologies observed in sparse eluvium.

GEOCHEMISTRY

1. Introduction

The 1985 soil surveys were undertaken in the Glen Brighty area and detailed stream sediment sampling carried out over most streams from Glen Brighty to Loch Callater, north of Loch Kander (Fig. 5). In the same year a reconnaissance "megatraverse" was extended eastwards from Carn an Tuirc to Allt an Loch using the techniques described by Coats, Pease and Gallagher (1984). In 1986 three lines of evidence led to this survey being considerably extended linking the Glen Brighty area via Glas Maol to Loch Kander in 1986-7.

These were the recognition of high Ba, Pb and Zn anomalies on the megatraverse line, high Zn and Pb values in streams draining Loch Kander and the adjacent stream to the east, and a prospector's report of baryte and galena in Coire Loch Kander. The area covered by the geochemical and geophysical surveys is irregular in shape because of the difficulty in accessing the steep corrie walls of Loch Kander, Garbh-choire and Caenlochan Glen.

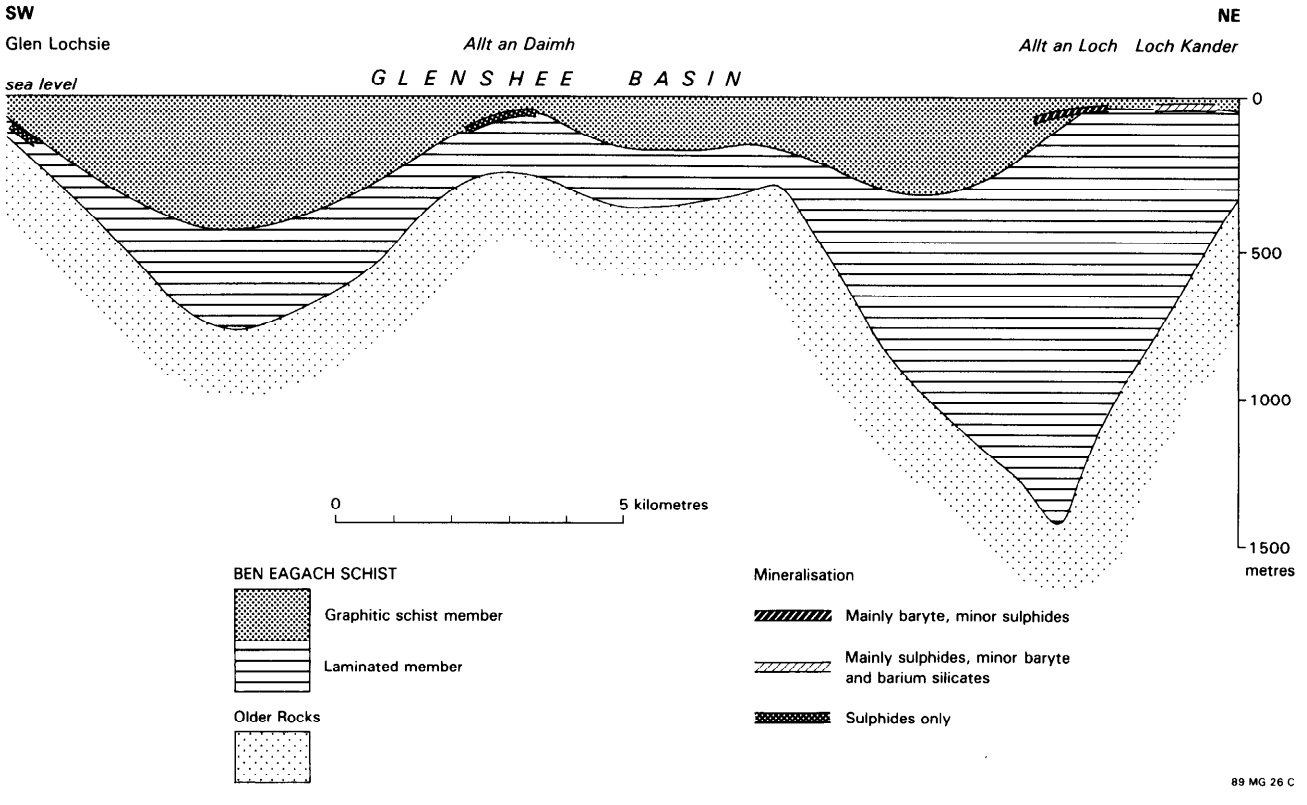

Figure 3 Schematic section of the proposed Glenshee Basin showing position of observed stratabound mineralisation within the Ben Eagach Schist.

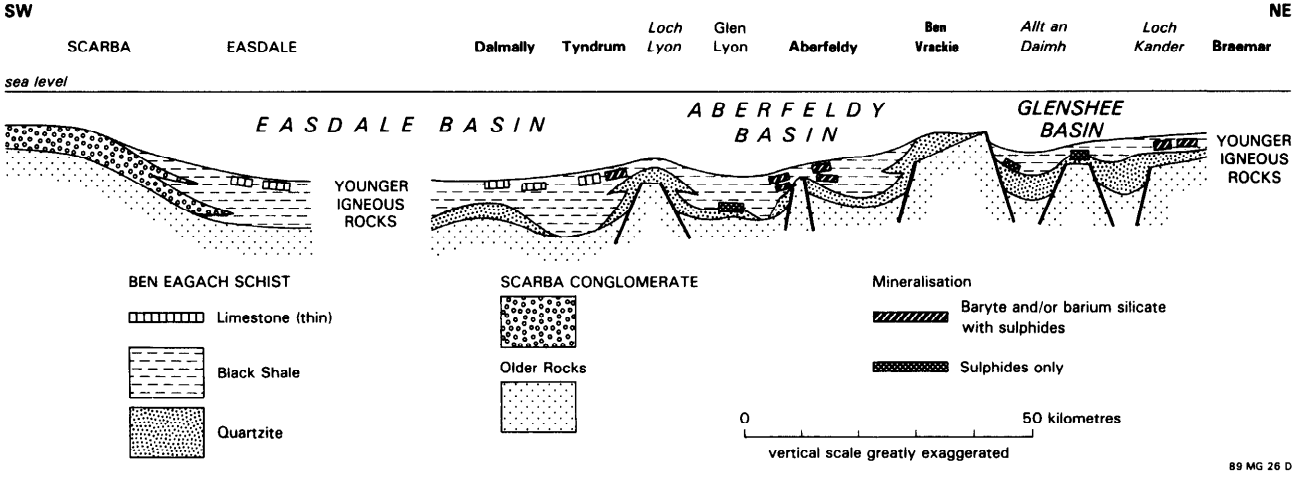

Figure 4 Schematic section of the Dalradian basin at the time of Ben Eagach Schist deposition showing location of stratabound mineralisation.

2. Drainage sampling

As the area has been covered by the Geochemical Survey Programme, the regional geochemistry is not presented here. Two streams sampled as part of that work were anomalous in zinc and lead. Follow-up detailed sampling of these streams and those cutting the Ben Eagach Schist Formation was carried out in 1985. The Data Package gives details of the analyses and the sample locations. Thresholds of 300 ppm Zn, 80 ppm Pb and 1300 ppm Ba in the <150 mesh fraction of the stream sediment have been shown to have general application in the Scottish Dalradian (Smith and others, 1984).

Anomalous samples with high lead and zinc were identified from the stream draining Loch Kander and the adjacent stream; also from Allt an Loch, Claise Burn and Glasallt Burn draining into Caenlochan Glen. These anomalous streams all drain the outcrop of the Ben Eagach Schist Formation, but this Formation is only anomalous in the section between Loch Kander and Caenlochan Glen. Further south to Allt an Daimh the values are at background levels. Barium is significantly enriched only in Allt an Loch and in the Loch Kander streams. Levels in Allt an Loch are not very high, for example in stream sediment Ba is 963 ppm and in panned concentrate it is 1010 ppm, even though the stream directly drains the baryte mineralisation.

3. Carn an Tuirc megatraverse

Detailed investigation elsewhere in the Middle Dalradian has shown that the techniques of using across-strike geochemical and geophysical traverses is effective in the search for stratabound mineralisation and in elucidating the basinal structure of the Dalradian (Coats and others, 1984; see also Fig. 4). A traverse was completed in September 1985, running 2.5 km ESE from Carn an Tuirc, and the shallow overburden samples were analysed by XRF for Ti, Fe, Mg, Ca, Mn, As, Ba, Cr, Cu, Ni, Pb, Rb, Sr, Th, U, V, Y, Zn and Zr. Listings of the geochemical data are presented in the data package but the significant elements for mineralisation are Ba, Pb and Zn. Barium reaches 3104 ppm, lead 1859 ppm and zinc 1213 ppm, which are exceptionally high levels for the Middle Dalradian. Surface pitting on this anomaly in 1986 confirmed the presence of significant stratabound mineralisation.

4. Glen Brighty shallow overburden survey

4.1 Methods

Shallow overburden samples were collected along lines 200 m apart with a 25 m sample interval covering the NW side of Glen Brighty (Fig. 5). A hand auger reaching a maximum depth of 1.3 m was employed but in bouldery terrain a trowel was used to scrape up the interstitial material. The survey lines were terminated to the northwest by the steep precipitous scree of the Creag Leacach ridge which is composed of the Carn Mairg Quartzite Formation. Below this blocky scree there are a number of solifluction or mass debris flow deposits which can be recognised by the lobate fronts on the lower ground near the Glen Brighty Burn. The outcrop of the Ben Eagach Schist Formation is largely covered by these deposits or by peat in the bottom of the valley. Only on the ridges leading to Mallrenheskein, Sron Riabhach and Little Glas Maol it is better exposed. The 536 samples collected were dried, sieved and analysed by XRF for Ca, Ti, Mn, Fe, V, Cr, Ni, Cu, Zn, Zr, Ba, Ce and Pb.

4.2 Results

Summary statistics are presented in Table 5 and can be compared with those for the Cairn of Claise survey (Table 7). Background levels can best be compared using the medians, and most resistate elements such as Ti, Cr, Zr and Ce show similar levels in the two survey areas. More mobile elements such as Fe, Zn, Mn and V are lower and this may be due to leaching of the soils of the Glen Brighty area, the presence of solifluction deposits covering the Ben Eagach Schist or a lower primary value in the rock in this area. Calcium is the only element that shows a higher median level in the Glen Brighty soils, probably a primary feature.

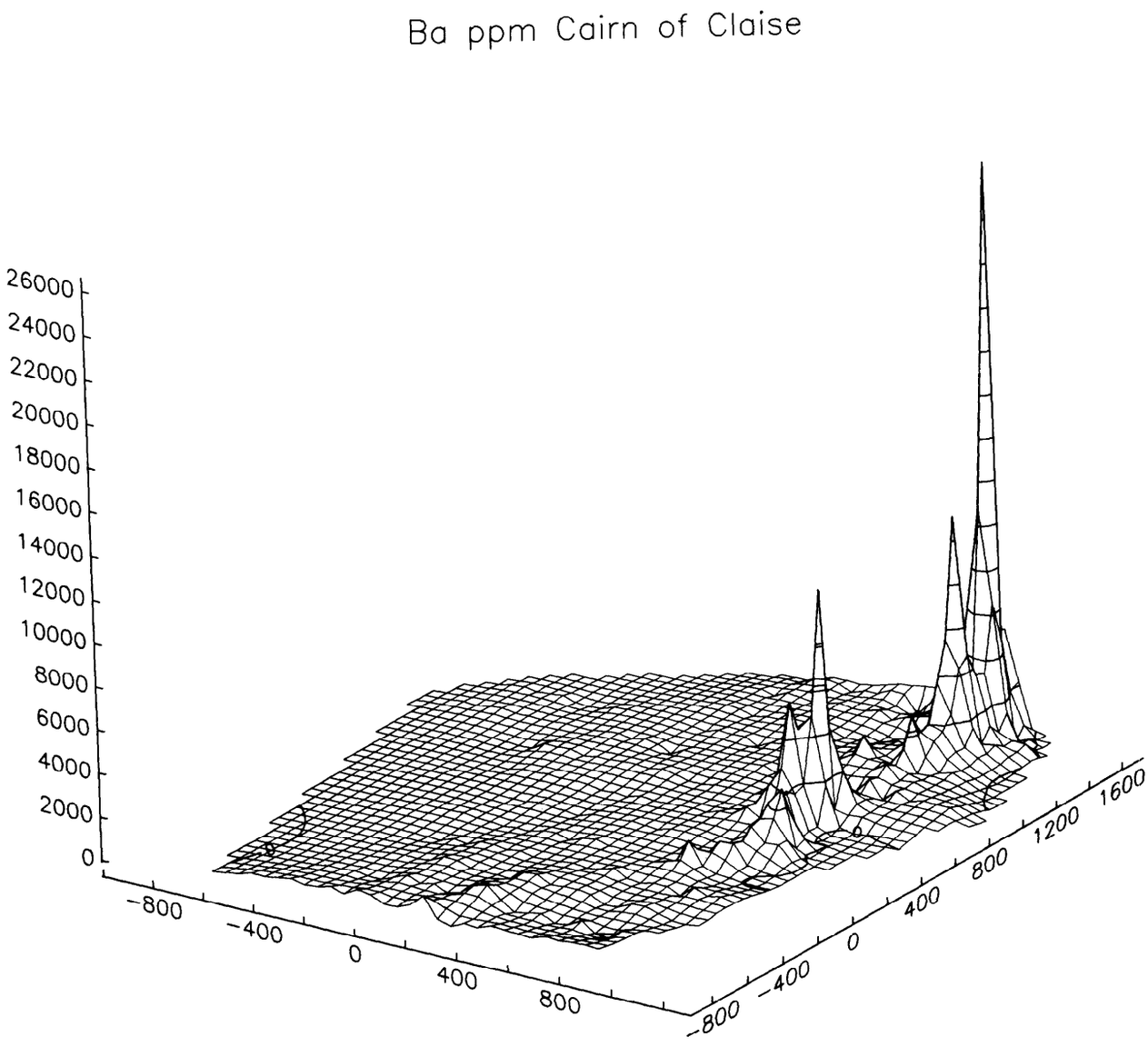

Figure 5 Ba ppm (Cairn of Claise): an isometric view from the southeast illustrating barium distribution in 995 samples.

Table 5

Summary Statistics: Glen Brighty Shallow Overburden Samples (N=536)

	Median	Mean	Std.Dev^n	Minimum	Maximum	Q_3-Q_1
Ca	1900	3263	3496	0	27100	4100
Ti	5395	5354	2514	430	22630	2348
Mn	220	353	942	40	20530	210
Fe	19350	21582	17448	1100	236700	21375
V	60	58	30	10	240	30
Cr	60	57	28	10	190	30
Ni	5	8	10	0	91	10
Cu	0	4	7	0	84	4
Zn	44	56	41	4	234	42
Sr	49	61	45	11	425	27
Zr	367	353	159	4	862	176
Ba	330	370	420	0	5380	368
Ce	40	43	24	0	120	40
Pb	42	70	74	1	448	48

Notes
1. All values in ppm
2. Q_3-Q_1 is the interquartile range

Compared to the Cairn of Claise survey the anomalous results are not very high reaching peak levels of 5380 ppm Ba, 448 ppm Pb and 234 ppm Zn. Barium is enriched only in the north western corner of the grid. This may be the continuation of a barium anomaly from the Allt an Daimh area but there is no corresponding lead or zinc anomaly. A feldspar porphyry dyke which outcrops in the area or baryte veins associated with it, may have enhanced the barium levels.

Lead is anomalous at the northern end of several lines at the base of the Carn Mairg Quartzite scree and this is thought to represent minor lead enrichment in the lower part of the Laminated Quartzite Member such as that seen in the Allt an Daimh area (Coats and others, 1988). Zinc follows lead very closely (Spearman rank correlation coefficient(r)=0.61) but levels are much lower than at Cairn of Claise with only 1% of samples exceeding 200ppm Zn as compared to 10% in the latter survey area. Apart from this minor enrichment in Pb and Zn in the soils over the lower part of the laminated quartzite, the Glen Brighty area is not thought to contain significant baryte or base metal mineralisation.

5. Glas Maol shallow overburden survey

A survey of the Glas Maol area in 1986 involved 197 samples. A 1750 m long line connecting this survey with the Cairn of Claise grid was also sampled and the results are included with the statistics of the Glas Maol survey. As the lines do not extend to cover the Ben Lawers Schist Formation or the associated amphibolite body it is not surprising that the Glas Maol soils have lower Ca, Ni, Cu, Mn, Fe and Sr than those from the Cairn of Claise survey. Only one sample exceeds 1000ppm Ba and none contain more than 200 ppm Zn (Table 6). There are a few anomalous lead values greater than 200 ppm but all are in samples of very organic-rich peats with little or no clastic material. There is no indication from the soil geochemistry of any significant baryte or base metal mineralisation.

6. Cairn of Claise shallow overburden survey

Similar sampling methods were used to those at Glen Brighty but there are significant differences in physiography between the two areas. The summit of Cairn of Claise forms the top of a broad plateau which slopes gently to the north and east. This plateau is cut by the steep corries of Garbh-choire

Table 6

Summary Statistics: Glas Maol Shallow Overburden Samples (N=268)

	Median	Mean	Std.Dev^n	Minimum	Maximum	Q_3-Q_1
Ca	400	903	1885	0	21700	700
Ti	4895	4974	1362	780	11330	1463
Mn	240	278	187	40	1030	220
Fe	38150	37489	16322	7900	113500	23375
V	70	70	23	16	155	31
Cr	56	57	22	11	147	29
Ni	6	8	6	0	37	8
Cu	4	5	12	0	47	8
Zn	22	31	25	4	145	24
Sr	44	51	35	20	322	16
Zr	393	390	125	15	812	139
Ba	346	344	122	0	1008	102
Ce	51	50	17	10	115	23
Pb	29	44	47	7	316	31

Notes 1. All values in ppm
2. Q_3-Q_1 is the interquartile range

and Loch Kander where sampling is impossible and further south is dissected by Caenlochan Glen. Upon the plateau, the soils are predominantly residual with active periglacial features such as stone polygons and blockfields. Vegetation is fairly sparse and often artic-montane in character. The lower flanks particularly to the east are more peaty and once the feature formed by the Graphitic Schist Member of the Ben Eagach Schist Formation is crossed the soils are predominantly peats on top of boulders or roche moutonne of amphibolite. The results are presented as detailed listings and plots in the Data Package and summary statistics are given in Table 7.

Ca and Sr peak over amphibolite bodies. Later igneous dykes are marked by narrow Ca, Sr, Ti and V anomalies and these correlate well with the magnetic anomalies. Ti, V, Ni, Cr and Cu show similar patterns with a broad anomaly over the main amphibolite body and narrow isolated peaks over the igneous dykes. Occasional high Cr values may be related to thin heavy mineral bands in the Carn Mairg Quartzite.

High Ce values are also found over the outcrop of the Carn Mairg Quartzite and the Laminated Quartzite Member. A similar pattern is seen in the Allt an Daimh area and is probably due to heavy mineral bands in the quartzite lithologies (Pease, Coats and Fortey, 1986).

Zinc has high correlations with lead (r=+0.51) and also copper (r=+0.52) and is high over the mineralised horizon *and* the adjacent amphibolite. Zinc is probably higher in basic rocks than in unmineralised graphitic schist but the observed pattern is probably more related to hydromorphic dispersion of the zinc.

Table 7

Summary Statistics: Cairn of Claise Shallow Overburden Samples (N=995)

	Median	Mean	Std.Dev^n	Minimum	Maximum	Q_3-Q_1
Ca	1500	4237	6723	0	47100	3800
Ti	5240	5684	2365	250	22170	1920
Mn	380	434	285	50	3420	280
Fe	40700	40906	17538	5100	125800	22800
V	79	84	37	13	416	37
Cr	63	68	37	3	390	35
Ni	11	17	20	0	238	17
Cu	11	17	21	0	184	20
Zn	97	165	194	5	1645	138
Sr	58	85	73	13	458	53
Zr	339	335	113	2	1037	127
Ba	433	888	2381	0	58344	427
Ce	44	46	22	3	125	29
Pb	68	161	319	0	3879	95

Notes
1. All values in ppm
2. Q_3-Q_1 is the interquartile range
3. Ag not included as below the detection limit of 3ppm

Lead and barium show a very coherent pattern with a large anomaly over the mineralised band (Figure 2). Both elements show a similar low mobility in the secondary environment and values greater than 200ppm Pb and 1000ppm Ba form a nearly continuous zone 25-100 m wide over 1600 m, with the peak anomaly adjacent to outcrops of the baryte-rich band. The gossanous breccia at [NO 194 793] is also high in barium indicating that the mineralised zone is thickest in this section. Major barium anomalies are absent south of line 00 (Fig. 6) peaks up to 1293ppm Ba and 1135ppm Ba show that there is a minor barium enrichment at the *top* of the Graphitic Schist Member of the Ben Eagach Schist Formation, not at its base. The graphitic schist thickens to the south so that the baryte mineralisation is situated where graphitic schist thins to almost zero. Further north there is a large barium in soil anomaly extending over outcrops of laminated quartzite lithologies (this peak is probably overemphasized in Figure 6 by the large area of the anomaly on line 1600N where the strike swings from N-S to E-W). These rocks probably contain barium in a feldspar or mica phase.

From the overburden anomaly it can be deduced that there is a central zone of baryte deposition developed at the chronostratigraphic top of the Ben Eagach Schist Formation. Marginal to this central zone there is cryptic barium enrichment in graphitic schist to the south and laminated quartzite to the north.

Minor lead anomalies are also found about 200 m west of the main mineralised zone and these can be interpreted as a thin band which can be traced around the Cairn of Claise summit. This may represent a lead-rich feldspathic layer or a slightly earlier mineralisation pulse, such as seen at Allt an Daimh where the lead-zinc mineralisation occurs in the Laminated Quartzite Member (Pease, Coats and Fortey, 1986).

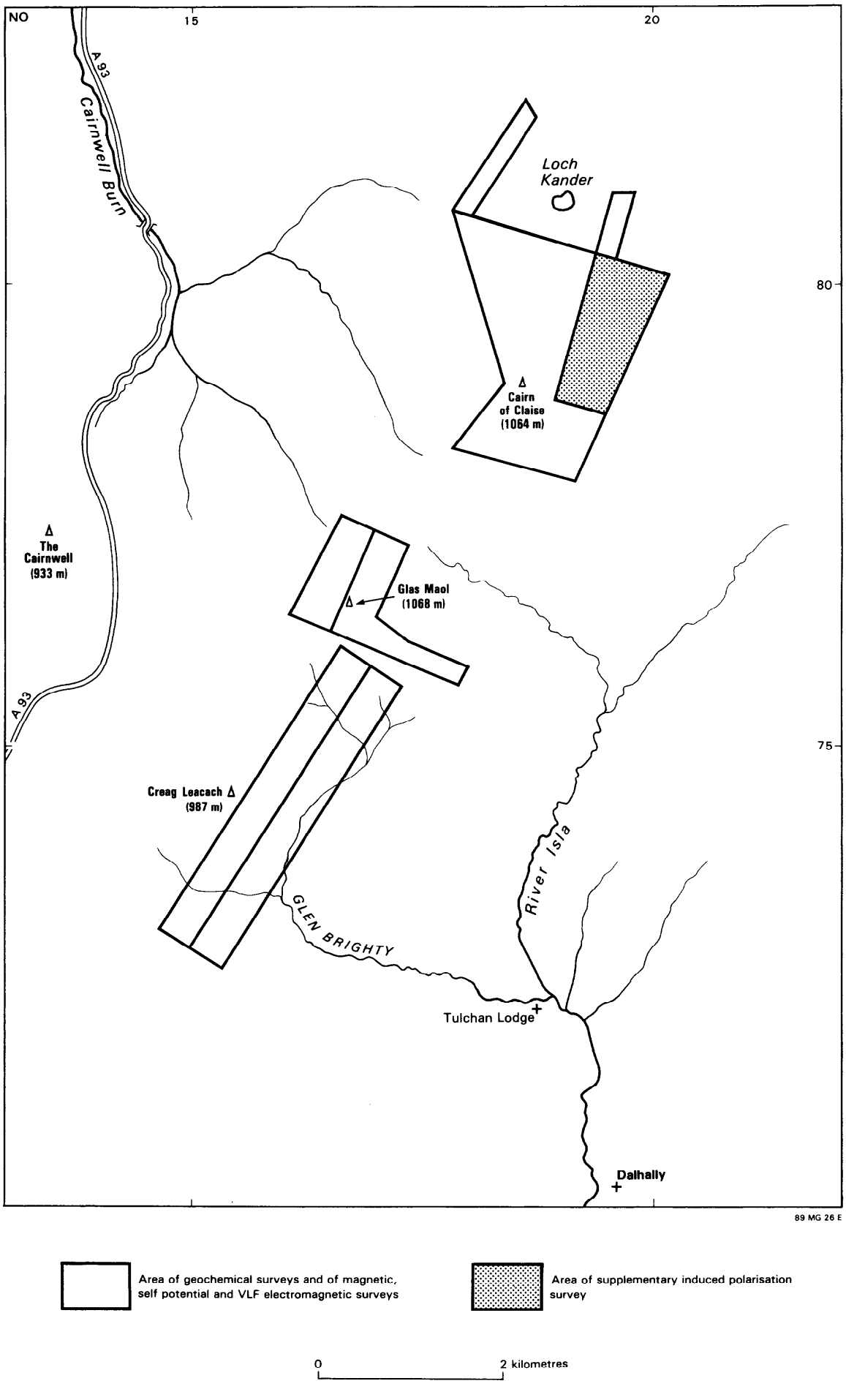

Figure 6 Areas of geophysical surveying between Glen Brighty in the SSW and Coire Loch Kander in the north. These areas correspond closely with those where geochemical overburden sampling was carried out.

Table 8

Median levels of elements in rocks from the Allt an Loch District compared to Allt an Daimh drillcore and the average shale

	This Area Median N=74	Allt an Daimh Drillcore Median * N=240	Average Shale (Taylor & MacLennan 1985)
Ca	1200	7650	9300
Ti	3150	4375	6000
Mn	335	825	850
Fe	36900	38250	51000
V	59	60	150
Cr	45	65	110
Ni	11	25	55
Cu	35	28	50
Zn	152	95	85
Sr	56	58	200
Zr	210	-	210
Ag	3	-	-
Ba	987	730	650
Pb	55	27	20
As	3	7	-

*Coats and others, 1988.

7. Allt an Loch deep overburden survey

Three deep overburden traverses were completed using a power auger to improve the depth coverage over the mineralised zone. At Aberfeldy it was possible to distinguish baryte-bearing from celsian-bearing rocks by panning the deep overburden (Coats and others, 1980). The traverses were sampled at 10 m intervals and the basal overburden and the panned till analysed for Ca, Ti, Mn, Fe, V, Cr, Ni, Cu, Zn, Sr, Zr, Ag, Ba, Ce and Pb. The detailed results are presented in the Data Package. Generally the overburden was relatively shallow but reached 6.0 m at one location. The peak barium level was 1.18% Ba. The panned overburden 10 m away had a similar level of 1.02% Ba. The levels in the panned till are significantly lower than those at Aberfeldy and may be due to increased leaching at Allt an Loch.

Lead behaved similarly to barium but the anomaly is wider indicating that lead is enriched in the host rocks on either side of the baryte. Peak levels were 0.61% Pb and 0.49% Pb in the panned basal overburden at the same site. Some secondary dispersion may also be present because of the higher value in the basal till compared to the panned till. Zinc reached a maximum of 0.19% Zn in the basal overburden and 0.25% in the panned till but this anomaly was displaced 40 m to the east from the barium and lead anomalies.

8. Geochemistry of the drill cores

The borehole cores were analysed for Ca, Ti, Mn, Fe, V, Cr, Ni, Cu, Zn, Sr, Zr, Ag, Ba and Pb; the analyses (25 in number) are presented in the Data Package.

The boreholes were drilled to intersect the visible baryte-rock and associated gossans so nearly all the drillcore is enriched in barium. Borehole 1 intersected 7.3 m of siliceous baryte-rock but no attempt was made to give a complete cross section of the mineralised zone. Barium levels reach a peak of 37% Ba in the first borehole and there is a clear group of samples, mainly from boreholes 1 and 2, with 27-37% Ba. The median of this group is 33% Ba and these samples are dominantly composed of quartz and baryte, with a calculated baryte content by weight of 56% $BaSO_4$. This can be compared to Aberfeldy, where the median barium content of the baryte rock is 50% Ba (equivalent to 85% Ba SO_4), and to Loch Lyon, where the median content of the baryte-bearing calc-schist is about 6%

Ba (equivalent to 10% Ba SO_4) (Coats and others, 1984). However, nearly all the drillcore from Allt an Loch is leached so that formerly baryte may have been more abundant.

There are three samples with baryte concentrations in the range 7-14% Ba which are gossans, partly after quartz-baryte rock, or in one case (described as quart-mica schist) with minor baryte veining. The remainder of the samples contain between 0.9 and 4.2% Ba, which is highly anomalous for normal sediments. Most are described as metasedimentary rocks ranging from quartzite to quartz-mica schists but all must have an exhalative component. The barium is probably present in a feldspar phase such as celsian or hyalophane but no microprobe determinations were carried out on the drillcore samples. The presence of micas and heavy mineral grains such as zircon indicates that they are predominantly detrital sediments with an exhalative component added during sedimentation or diagenesis. There is evidence from borehole 3 of syndepositional brecciation and recementation by, probably, hyalophane indicating that active faulting was taking place during deposition.

Base metal levels are not very high with median levels of 88 ppm Zn, 836 ppm Pb and 39 ppm Cu. The low zinc-lead ratio is attributable to the high degree of leaching of the core with the highest zinc and copper levels occurring in the iron-rich gossans. Lead levels are higher reflecting the insolubility of secondary lead minerals and reach a maximum of 0.23% Pb in a micaceous quartzite breccia. Silver contents of the borehole samples are high (up to 40 ppm) but the possibility of interference by barium in the XRF method cannot be ruled out. Compared to Aberfeldy, base metal levels are low but given the degree of leaching and the bias in drilling towards the baryte-rock, levels at Allt an Loch are not unpromising. As discussed in the next section base metal levels in the rock samples from Loch Kander are higher.

9. Geochemistry of the rock samples

Seventy-four rock samples were collected from the Glas Maol to Coire Loch Kander area and were analysed for Ca, Ti, Mn, Fe, V, Cr, Ni, Cu, Zn, Sr, Zr, Ag, Ba, Pb and As. The analyses are reported in the Data Package and a summary is presented here.

Calcium is commonly at low levels in these rock samples but there are several samples, including most of the igneous rocks analysed, with greater than 1% Ca. High titanium levels (>0.7% Ti) are also characteristic of metabasaltic igneous rocks and five samples exceed this threshold. Some rocks described as metasediments contains high Ti, Fe, V, Cr (440 and 321 ppm), Ni, Cu and Zn which would seem to indicate an igneous component. One rock described as a possible microdiorite sill has low levels of Ti and may be a later acid intrusion as shown by its low levels of V, Cr, Ni and Cu but high Zr (942 ppm).

Manganese, nickel and strontium are closely correlated. Manganese is below detection limit in the iron-rich gossanous rocks and is probably removed from these during leaching. Nickel is similarly very low in these samples. Manganese is also low in the quartz-baryte rocks and the pyritiferous graphitic schist ("vasskis" facies), and is probably not deposited in this part of the exhalative system. There is no counterpart to the highly manganiferous carbonate rock seen at Aberfeldy (Coats and others, 1980).

Strontium generally follows calcium but high levels up to 1719 ppm are found in the baryte-quartz rock where strontium substitutes for barium in the baryte. Vanadium behaves like chromium and titanium and is high in the rocks with basaltic character. Unusually it is also high in the quartz-baryte rocks (171-353 ppm V) but this may be due to an XRF interference.

Zirconium is a good indicator element for the ratio of the clastic relative to the exhalative components. The exhalatives, such as the baryte-quartz rocks, have very low zirconium levels between 21 and 35 ppm. The only rocks with lower levels than these are the gossans (0-23 ppm) and the very sulphide-rich rocks. In rocks with between 35-150 ppm Zr, the detrital component is diluted substantially by exhalative material and low zirconium is associated with high levels of base metals, typically greater than 0.5% Pb+Zn. For example, two sulphidic cherty quartzites from Loch Kander have high Ba (1.49% and 1.21%), high Pb (0.45% and 0.86%) but only 72 and 42 ppm Zr respectively. There is clearly an addition of exhalative material such as barium, lead and probably

silica to this sediment which has diluted the clastic minerals.

Silver can reach 45 ppm in lead-rich rocks and it is also enriched in the gossans (1-14 ppm) and the baryte-quartz rock (12-28 ppm). Lead and zinc are most enriched in the sulphidic banded lithologies in Coire Loch Kander (this may due to the higher degree of exposure in the cliffs) but the Ba-enriched schist from Allt an Loch can also have high base metal values. The sulphidic graphitic schist ("vasskis") is enriched in base metals (511-4177 ppm Zn, 247-4111 ppm Pb) relative to the type examples from Norway (Sand, 1986) despite having less iron sulphide.

Barium is, as expected, highest in the four samples of baryte-quartz rock which have a median concentration similar to that in the boreholes (33% Ba). Most of the other rock samples are enriched in barium to some degree with the median of 987 ppm clearly higher than the average shale. Rocks with greater than 0.5% Ba on optical examination have an alkali feldspar phase which is probably hyalophane or celsian. Rocks originally described in the field as quartz-celsian rock have high levels of barium (up to 7995 ppm) but commonly rocks without visible mineralisation such as the laminites and laminated quartzites have anomalous levels of barium (up to 1883 ppm). This cryptic barium enrichment in the rocks from this area demonstrates that the exhalative system was extensive over a regional (1 km) scale rather than confined to particular lithologies.

The unusual lithologies present in Coire Loch Kander include highly calcareous lithologies, metabasic rocks and also highly sulphidic, banded rocks and graphitic schist. The calcareous rocks could be interpreted as evaporitic with minerals such as scapolite formed during metamorphism but equally these could be examples of extremely hydrothermally altered tuffaceous rocks interbanded with exhalites. Their complex chemistry and mineralogy is clearly worthy of further study.

GEOPHYSICS

1. Introduction

Figure 6 illustrates the areas over which the geophysical surveys were undertaken. These areas are of irregular shape and non-continuous nature because of the logistic constraints incurred by the very rugged topography. Geophysical measurements were conducted along 50 km of cross-strike lines running from Glen Brighty in the south to Corrie Loch Kander in the north. They comprised magnetic, VLF electromagnetic and self potential traverses along all 50 line kilometers, with an additional 5 line kilometers of induced polarisation traverses in the Allt an Loch area immediately south of Corrie Loch Kander. All the detailed geophysical data are in the Data Package (q.v.).

2. Geophysical methods

The Scintrex digital equipment used for the survey comprised the IPR-11 induced polarisation receiver and the IGS-2 MP4/VLF4 magnetometer and VLF receiver. Both systems have solid state memories for data capture and are off-loaded onto a computer at the end of a day's fieldwork for subsequent data reduction and plotting. The geophysical diagrams for the Data Package were thus generated from these data sets.

Using the MP4 portion of the IGS-2 system, measurements of the magnetic total field were made at 10 m intervals along the traverse lines. The VLF (magnetic field) measurements of the in and out of phase components of the resultant field were also taken at 10 m intervals using the VLF portion of the Scintrex IGS-2 system. The source of the VLF primary field was BGR, Rugby, transmitting at 16.0Khz.

Data from a digital voltmeter used for the self potential survey was recorded manually and entered into a computer for plotting. One of the two non-polarising electrodes used remained static as a reference whilst the other traversed away in 10 m intervals and the self potential between them thus recorded. Every 500 m the static electrode was brought to the moving electrode and the process repeated until the end of the traverse was reached.

The induced polarisation method utilised the colinear dipole array with 25 m dipoles whose separation

varied from 2 to 7 units of dipole length. The severe logistic problems imposed by the rugged terrain and the non-availability of any form of vehicle over the survey grid prevented the use of a motor generator set for use with the induced polarisation transmitter. The induced polarisation survey was thus confined to the use of a battery powered Huntec Lopo transmitter. The average transmitted current was 150 mA.

3. Results of the geophysical surveys

The VLF method worked well given the thin and relatively uniform thickness of overburden (till/glacial moraine) and allowed the conductive horizons within the Middle Dalradian sequence to be mapped. Thus the Ben Eagach Schist Formation was clearly identified as was the Graphitic Schist Member and Laminated Member of the Formation.

The self potential method also gave good correlatable data over the Graphitic Schist Member with self potential values in excess of -900 millivolts.

The magnetic method was of less value in differentiating between the Ben Lawers Schist, the Ben Eagach Schist and the Carn Mairg Quartzite than the VLF electromagnetic method. However, the more magnetic diorite was readily detected and many dykes were thus mapped throughout the survey area in addition to the intrusives in the NE and in the SE of the area.

The induced polarisation survey was limited to the Allt an Loch district and like the VLF survey indicated the Graphitic Schist Member. Both the induced polarisation (chargeability) and apparent resistivity pseudo-sections show good responses to the graphitic schists within the Ben Eagach Schist Formation. However, the narrow band of mineralisation within the graphitic schists near the top of the Ben Eagach Schist Formation could not easily be identified because of the masking effect of the good response from the extensive zones of graphitic schists.

The VLF was likewise unsuccessful because the large VLF anomaly caused by the nearby contact of the Ben Eagach Schist and Ben Lawers Schist Formations tends to mask that caused by the mineralised horizon.

4. Summary

In the search for stratabound minealisation in the Braemar area the induced polarisation and VLF electromagnetic methods have proved to be the most useful geophysical techniques. The geological mapping of the largely concealed lithostratigraphy has been greatly assisted by the VLF electromagnetic and self potential surveys. The most useful feature of the magnetic survey has been the identification and mapping of the numerous dykes and other intrusive rocks that occur; the lack of any significant magnetic minerals within the Ben Eagach Schist and adjacent formations preclude the magnetic technique as a prime geophysical method in the area.

CONCLUSIONS

Bedded baryte-quartz rock 4.5 m thick and with approximately 50% baryte has been discovered over at least 0.7 km of strike length at Allt an Loch on Cairn of Claise, indicating that a considerable quantity of baryte is present. Zinc-lead concentrations in sulphidic quartzite at Coire Loch Kander are of exploration significance. No evidence of mineralisation was found SSW of Allt an Loch in the intervening strike length of Ben Eagach Schist to Allt an Daimh where base metal mineralisation was previusly recorded (Coats and others, 1988; see Fig. 3).

The mineralisation near Braemar resembles that at Aberfeldy and is interpreted in similar manner as the result of sea-floor exhalative activity related to subsidence and lateral basin extension during deposition of the Middle Dalradian (Fig. 4). The attenuated thickness of the Ben Eagach Schist north of Allt an Loch and at Coire Loch Kander (Fig. 3) suggests deposition in a local third-order basin probably less than 2 km wide related to listric growth faults at the margins of an uplifted block. Another small basin is represented by the stratabound zinc-lead mineralisation in graphitic schist and quartzite of the Allt an Daimh district, Glenshee (Coats and others, 1988), and both developed during

deposition of the Ben Eagach Schist in a second-order Glenshee basin (Fig. 4). The baryte-galena vein in Coire Loch Kander indicates a component of epigenetic mineralisation following Grampian regional metamorphism and folding and possibly involving remobilisation of metals from the Ben Eagach Schist, but the subsequent contact metamorphism and skarn alteration appears not to have contributed to the mineralisation.

Stratabound baryte and/or base metal mineralisation is now known at intervals over some 100 km of Middle Dalradian strike length between Tyndrum and Loch Kander. North of Loch Kander the Dalradian outcrop is interrupted by large early Devonian granitic intrusions but resumes northwards from the River Avon for 70 km to the Moray Firth coast. The East Grampians section of the Middle Dalradian outcrop, currently undergoing mapping and geophysical investigation, is regarded as highly favourable for exploration on the basis of the new evidence of baryte and base metal mineralisation near Braemar reported here.

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