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MINERAL INVESTIGATIONS IN THE NORTHUMBERLAND TROUGH: PART 4, THE BEWCASTLE AREA

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This data package relates to work carried out by the British Geological Survey on behalf of the Department of Trade and Industry

CONTENTS

TABLES

FIGURES

INTRODUCTION

Background

Broad similarities between the tectonosedimentary setting of the Northumberland-Solway Basin and the extensively mineralised rocks of the Irish Midlands (Plant and Jones, 1991; Andrew,1993) prompted the MRP to carry out exploration surveys for carbonate-hosted base-metals along a 70 km strike-parallel zone at the northern margin of the Solway-Northumberland Basin (Colman et al., 1995). This report describes the results of geochemical reconnaissance and limited follow-up sampling over the Lower Carboniferous rocks of the Bewcastle Anticline undertaken as part of these investigations.

Situated only about 10 km south-east of the basin margin, the Bewcastle Anticline is considered to be a favourable environment for stratabound base-metal mineralisation because of the presence there of early Dinantian intrabasinal growth faults active during deposition of Lower Border Group (Courceyan-Chadian) carbonates and siliciclastics. By analogy with Irish-style SEDEX mineralisation these synextensional faults are the most likely sites for metalliferous fluids expelled from deeper structural levels within the basin. Mafic lavas, which mark an early period of extensional fracturing at the basin margin, and are locally associated with mineralising hydrothermal activity, are of minor occurrence in the Bewcastle district, but may be more extensive at shallow depth in the core of the anticline or in the hanging wall block of growth faults.

Previous research and selection of survey area

Encouraging indications of base metal mineralisation, close to the faulted basin-margin in the Northumberland Trough, were originally discovered by the MRP in 1976 following reconnaissance geochemical surveys near Langholm, Dumfriesshire. Anomalous concentrations of Pb and Zn extend intermittently over about 20 km of strike, broadly coincident with the Lower Carboniferous-Lower Palaeozoic boundary (Gallagher et al., 1977). Subsequent shallow diamond drilling (13 holes to depths of 20 to 60 m) revealed the presence of sporadic Pb-Zn-Cu mineralisation (0.1-0.3 % combined grade) over 1-2 m thickness in a varied cementstone-sandstone-siltstone sequence (Lower Border Group), developed over a strike length of 4 km. In the immediately underlying Birrenswark Lavas, mineralised breccia zones carrying chalcopyrite and pyrite (0.35 % Cu over 1.7 m) were discovered, both styles of mineralisation showing a close spatial association with north-easterly trending normal faults and cross faults.

A multidisciplinary study involving the analysis of spatially-related digital (geochemical, geophysical and geological) datasets and mineral deposit modelling for carbonate-hosted mineral deposits in northern England (Plant and Jones, 1991; Jones et al., 1994) also emphasised the high base-metal prospectivity of the Solway-Northumberland basin. The work suggested that particularly favourable sites for mineralisation occur where the northern basin-margin synsedimentary faults cut Courceyan-Chadian rocks at <0.5 km depth.

Based on an evaluation of all available geochemical, geological and geophysical data, five prospective areas were selected close to the northern basin margin by the MRP for more detailed examination. From the south-west these were the Kirkbean area on the north Solway coast (Open File MRP Report No 22), the Ecclefechan-Waterbeck area (Open File MRP Report No 21), the Newcastleton area (Open File MRP Report No 20), the Bewcastle Anticline (this report) and the Arnton Fell area (Open File MRP Report No 18). The principal targets in each area were the Lower Carboniferous rocks of

Courceyan-Chadian age cut by major syn-depositional basin margin, or in the case of the Bewcastle area, intra-basinal faults.

Field work was carried out in the Bewcastle area during 1994 and 1995. The objective in the first year was to confirm and investigate the cause of geochemical anomalies over Lower Border Group rocks discovered during MRP and G-BASE surveys in the late 1970's and early 1980's respectively. The results indicated several zones of very high Zn associated with modest base-metal and Ba anomalies in close proximity to major east-north-east trending faults. Consequently, further work was carried out in 1995 to cover areas of Lower Border Group outcrop not adequately sampled in previous surveys and to follow-up the most promising anomalous zones found in 1994 by detailed inspection of outcrop and lithogeochemical sampling.

Location and physiography of the survey area

The Bewcastle Anticline is situated at the northern tip of Cumberland about 25 km north-east of Carlisle and 65 km north-west of Newcastle (Figure 1). The England-Scotland border defines the north-west boundary and the Kielder Water reservoir, the north-eastern limit of the 460 km^2 project area. Much of the area lies within Ordnance Survey 1:50,000 map sheet 86 (Haltwhistle and Bewcastle) with smaller parts included in sheets 85 (Carlisle & Solway Firth), 80 (The Cheviot Hills), and 79 (Hawick & Eskdale). Geology of the district is covered by British Geological Survey One-inch Sheet 12 (Bewcastle). The results of systematic stream sediment sampling by BGS are described in the Regional Geochemical atlas of southern Scotland and part of northern England (BGS, 1993).

Most of the southern part of the area lies on the northern fringe of the Carlisle Plain and is typically gently undulating, drift-covered low ground averaging a little over 100 m above OD. To the north and east, near the Cumberland - Northumberland boundary, the land rises steadily to a maximum of just over 500 m on the high peaty moorlands of Glendhu Hill, Black Knowe and the Bewcastle Fells (Figure 1). This line of hills forms the primary watershed between the River North Tyne which flows eastwards to the North Sea, and the Cumbrian and Scottish Border rivers, including the Liddel Water-Kershope Burn catchment and the Black and White Lyne rivers, which discharge southwards into the Solway Firth.

The district is predominantly agricultural, with arable crops on the lowest sheltered ground passing northwards into more poorly drained land used as rough grazing for sheep and cattle. Widespread afforestation of the moorland areas in the 1960's and 70's has given rise to broad expanses of coniferous plantation which now cover over half of the project area in a virtually continuous tract (The Border Forest). Because of the high density of trees the approaches to some stream sections are difficult although an extensive system of forest tracks has created many new exposures and provides good general access. In the southern half of the area an extensive network of minor tarmac roads link the small villages of Catlowdy, Roadhead, Bewcastle and Stapleton with the market town of Brampton and the main east-west A69 trunk road joining Carlisle and Newcastle. Apart from these villages most of the sparse population reside in farms in the southern part of the district. There is a large military establishment, totally enclosed by Wark Forest, situated to the south-east of Bewcastle at Spadeadam Camp.

PLANNING AND DEVELOPMENT FRAMEWORK

There are no known conservation areas likely to effect mineral extraction either within or in close proximity to the study area. Because of the broad expanse of coniferous forests, low population density and ease of access to major towns via good road and intercity rail communications, the area is

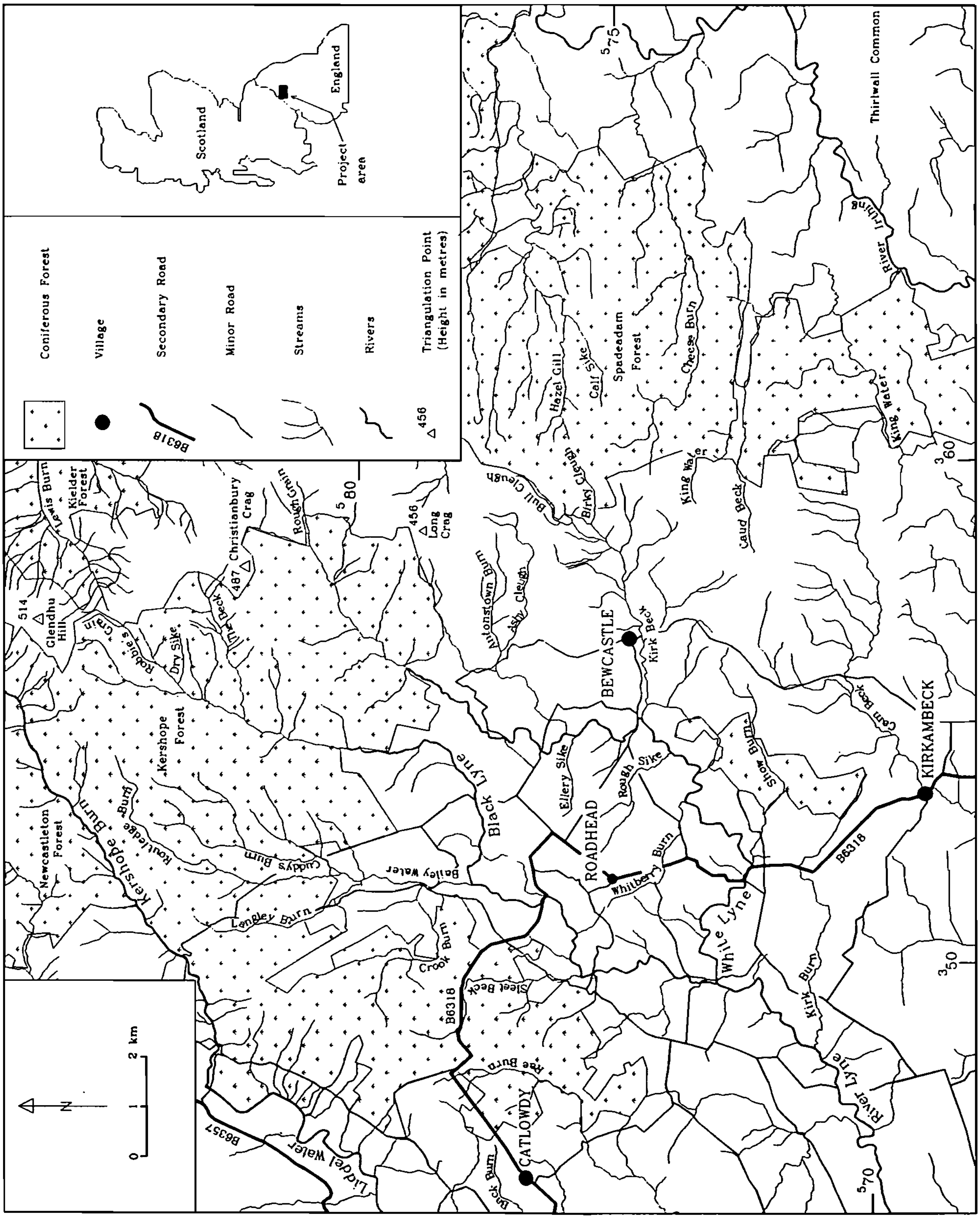

Figure 1 Locational and drainage network map of the survey area

considered particularly favourable for new mining and quarrying operations. A number of thin coals have been exploited on a small scale in various parts of the district, but no working pits remain. Numerous small-scale workings of sand, gravel and sandstone for road metal are present in Kielder and Wark forests in the east and north-east parts of the district. Limestone has been extracted from several small quarries in the Bewcastle Beds and Main Algal Beds to the north and north-west of Bewcastle village. A new quarry, situated in Newcastleton Forest about 4 km north of the project area, has recently commenced production of sandstone (Larriston Sandstone) for use as dimension stone.

GEOLOGY

The area is composed principally of Dinantian (Lower Carboniferous) sedimentary rocks overlain by extensive Pleistocene and recent unconsolidated deposits. Nothing is known of the pre-Carboniferous history of the district since the lowest rocks exposed in the core of the Bewcastle Anticline, a major north-east trending inversion structure associated with Variscan deformation, belong to the Lower Border Group. Rapid deposition of the Lower Border Group, preceded and accompanied by localised eruption of basaltic lavas, followed basin initiation caused by fault-controlled subsidence during Courceyan to Chadian times. Sedimentation occurred mainly in alternating shallow marine, coastal and fluviodeltaic environments (Chadwick et. al., 1995). Younger synextensional strata (Middle and Upper Border groups) , of Arundian to Holkerian age, gradually spread more widely around the flanks of the Bewcastle Anticline as the extensional phase gave way to a period of regional thermal relaxation subsidence characterised by only limited normal faulting

In the Langholm and Bewcastle areas, Lumsden et al. (1967) and Day (1970) divided the Lower Carboniferous into a tripartite (Lower, Middle and Upper) Border Group and a bipartite (Lower and Upper) Liddesdale Group. These were primarily distinguished on biostratigraphical grounds with unit tops and bases defined by marker horizons. However, there is continuing uncertainty about correlation over large areas, due in part to restricted faunal development in marginal marine areas, and the occurrence of facies-dependant faunas. Lithostratigraphical sub-division is equally difficult because of rapidly alternating lithologies, major lateral facies changes and lack of easily recognisable markers (Leeder, 1974).

A simplified geological map is presented in Figure 2 and the stratigraphical succession summarised in Table 1. No attempt has been made to show sub-divisions of strata younger than the Lower Border Group and the basal part of the Middle Border Group (Cambeck Beds). Only a brief account of the geology and structure is given here. More detailed descriptions of the sedimentary and tectonic evolution of the Northumberland-Solway Basin are available in Day (1970), Armstrong and Purnell (1987), Kimbell et al. (1989), Leeder et al. (1989), Chadwick et al. (1993) and Chadwick et al. (1995).

Lower Border Group (Courceyan-Chadian)

Lynebank Beds

The Lynebank Beds occupy the core of the Bewcastle Anticline forming an oval tract of low-lying land flanked by the higher ground of the Bewcastle Fells to the east and north, but open to the south (Figure 2).

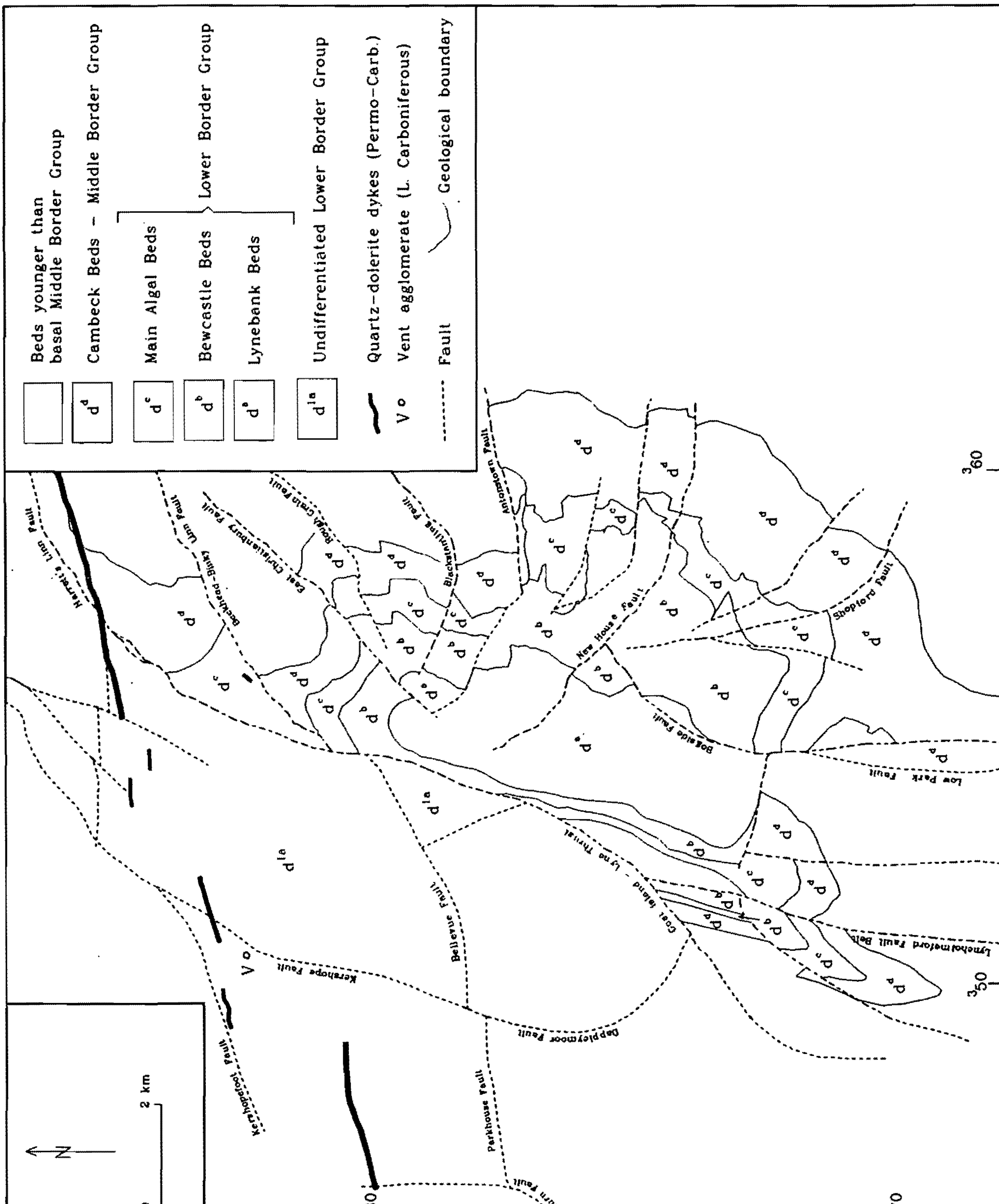

Figure 2 Simplified geological map of the survey area

Table 1 Stratigraphical succession

MAJOR DIVISIONS		MAPPED SUBDIVISIONS	THICKNESS
	RECENT	Peat	0.2 - 4 m
		Alluvium	<5 m
	PLEISTOCENE	Glacial sand and gravel	<3 m
		Till	1.5 - 10 m
	CARBONIFEROUS		
D	LIDDESDALE GROUP	Undivided in project area	c. 500 m
I	UPPER BORDER GROUP	Oakshaw Tuff (near base)	c. 650 m
N	MIDDLE BORDER GROUP	Kershopefoot Basalt (near top)	c. 600 m
A		Cambeck Beds (at base)	
N	LOWER BORDER GROUP	Main Algal Beds	c. 90 m
T		Bewcastle Beds	c. 100 m
I		Lynebank Beds	c. 180 m
A			
N			

Notes: This table mainly follows the lithostratigraphical groups of the Dinantian succession as defined by Day (1970) and subsequently modified by Armstrong and Purnell (1987) (see section on Cambeck Beds below).

In the lower part of the sequence (Lower Lynebank Beds) rhythmic alternations of 'Yoredale' type limestone, shale, and sandstone predominate, contrasting with the almost complete absence of sandstone in the upper part (Upper Lynebank Beds) which is dominated by limestones and calcareous shales. Beds of brecciated mudstone up to 60 cm thick interpreted as desiccation breccias are characteristic, but not confined to, the Lynebank Beds. These are seen in Banks Quarry [35558 57490] and in stream sections near Bewcastle. Their presence may mark the former sites of evaporite beds removed by groundwater dissolution since thick sequences of anhydrite were intersected in beds of the same age in a deep oil exploration borehole drilled at Easton [344124 571694] (Chadwick et al., 1995).

Bewcastle Beds

The Bewcastle Beds are more arenaceous than the underlying measures, but less fossiliferous. Yoredale-type facies again predominate although the sandstones are variable in thickness and many of the limestones are dolomitic and approach 'cementstone' in lithology. These are concentrated in the lower part of the succession in the Bogside, Holmehead, Righead and Ashy Cleugh limestones with a cumulative thickness of about 40 m. The best exposures are on the east side of the anticline (Figure 2) in the River White Lyne catchment where they give rise to the low-lying ground around Bewcastle village and also to the lower slopes of the fells to the north, rising to more than 300 m on Grey Hill, south of Ashy Cleugh. Horizons fairly high in the Bewcastle Beds crop out in the headwaters of the River Black Lyne and in Bailey Burn and its tributaries Langley Burn, Routledge Burn and Crook Burn.

Main Algal Beds
The Main Algal Beds include at least 14 distinctive algal, algoolitic or serpulid bands. Lithologically they differ from the beds above and below mainly in the number of well-developed algal horizons disposed in rhythmic alternations with thin bands of shale. Individual limestones are commonly 1 to 3.5 m thick, but the Birky Clough Limestone attains a total thickness of about 6 m and the cumulative thickness of limestone over the 90 m vertical interval of the Main Algal Beds is of the order of 25 m. The complete sequence is exposed in Birky Clough, and nearby, in Bull Clough [35872 57575] and Stack Clough [35888 57464] quite extensive, but discontinuous sections occur. Short sections exposing the top 6 bands or so are also apparent in the River White Lyne north-east of Kaysbank [35110 87280] and in Whitberry Burn [35229 57398]. The three most notable areas of exposure to the west of the Hole of Line Fault are in Crook Burn [35040 57841], Cuddy's Burn [35204 58088], and in the headwaters of the River Black Lyne in Lancy's Cleugh [3557 5846] and Robbie's Grain [35596 58402].

Middle Border Group (?Arundian-Holkerian)

Cambeck Beds
The original classification by Day (1970) placed the Cambeck Beds in the upper part of the Lower Border Group. Recent palynological investigations (Armstrong and Purnell, 1987) however, suggest a somewhat younger, Arundian-Holkerian age. Lithologically there is little to differentiate the Cambeck Beds from Lower Border Group rocks, but their fauna contrasts with that of the underlying succession in being dominantly shelly. Algal limestones occur at intervals throughout the sequence, but they are impersistent and relatively thin, few exceeding 1 m in thickness. The Cambeck Beds are well exposed in the southern part of the district in the headwaters of Cam Beck, although the most complete section is exposed in Whitberry Burn on the steeply dipping western limb of the Bewcastle Anticline.

The rocks overlying the Cambeck Beds (middle and upper part of the Middle Border Group) crop out in a continuous 3 to 4 km wide tract around the east and south east sides of the Bewcastle Anticline (Figure 2), capping the fells east of Bewcastle and forming a gentle dip slopes inclined to the east. Here they comprises about 400 m or more of undifferentiated rhythmically deposited limestones, shales, and sandstones with subordinate seatearths and thin coals.

In the west, the beds are dominantly marine with only limited fluvio-deltaic input, but northwards there is evidence of a marked facies change, the beds becoming progressively more arenaceous and reflecting an increase in clastic sediment supply from the north-east. In the absence of distinct marker horizons the boundaries of the group are poorly defined.

At the northern margin of the basin in Kershope Burn, up to 40 m of olivine basalt, represented by the Kershopefoot Basalt (see below), occur near the top of the Middle Border Group possibly suggesting localised extensional fault movement (Chadwick et al., 1993).

Upper Border Group (Asbian)

Marine influence throughout deposition of the Upper Border Group was greater than in the Middle Border Group although rock-forming algae are insignificant, thick limestones rare and dolomitisation uncommon. The cyclical nature of the deposits, in which sandstone predominates, are thought to reflect marine incursions from the west and south-west and fluvio-deltaic input from the east and north-east (Chadwick et al., 1993). Rocks of this group are present over large areas between the Goat Island-Lyne Thrust and the Back Burn Fault, along the east side of Kershope Burn and extensively on the gently dipping eastern limb of the Bewcastle Anticline and around Spadeadam. Exposure is very poor in the latter area due to thick spreads of boulder clay, whereas along the topographic divide formed by the ridge running between Long Crag and Glendhu Hill, many of the crags including those of Christianbury (Figure 1), are formed from thick sandstones at the base of the group.

Liddesdale Group (Asbian-Brigantian)

These beds are typically of Yoredale facies and comprise the repeated lithological sequence: limestone, shale, sandstone, coal. The most distinctive feature of these cyclothems are their greater thickness and occurrence of thick laterally-persistent, relatively pure limestones with well-developed, open marine faunas. Overall the Liddesdale Group shows a marked change from a higher proportion of deltaic shales and massive sandstones in the lower part to a preponderance of thick marine limestone in the upper. Their distribution in the survey area is restricted to the ground immediately west of the Back Burn Fault in the Liddel catchment, a small faulted outlier west of the River Lyne [3480 5720], and the south-east corner of the project area around Thirlwall Common [3670 5690].

Igneous rocks

Compared to the northern basin margin where tensional fracturing resulted in the eruption of basaltic lavas along a strike length of at least 80 km, igneous rocks are of minor occurrence in the Bewcastle district. They are represented by;

1. Small exposures of thin brecciated calcareous tuff (the Rawney Tuff) containing banded microcrystalline calcite extensively replaced by coarser calcite matrix and scattered pyrite grains in the Lower Border Group Lynebank Beds at [355000 576450].

2. More substantial outcrops of olivine-basalt (the Kershopefoot Basalt, Table 1) near the top of the Middle Border Group. An arcuate outcrop more than 3 km long with a maximum thickness of about 40 m, terminated at each end by faults, straddles the England-Scotland border in the lower reaches of Kershope Burn. The lava is locally vesicular with infillings of chlorite, carbonate and chalcedony. Locally the effects of late magmatic alteration are evident from the variable replacement of groundmass ferromagnesian minerals by chlorite, calcite, quartz and hematite.

3. A tuffaceous bed (the Oakshaw Tuff, Table 1) lying close to the base of the Upper Border Group. The tuff is equated with the Glencartholm Volcanic Beds on the Scottish side of the border which were proved in the Archerbeck Borehole (Lumsden and Wilson, 1961). It achieves maximum thickness of about 1 m in the River Black Lyne [350490 575780] and is present as a thin (30 cm) bed in a disused quarry at Oakshaw Bridge [357230 576060]. In thin section the rock shows abundant lithic fragments of mugearite-trachyte and clastic dolomite in a matrix of iron oxides, clay minerals and carbonate

4. A small vent agglomerate exposed in Harry's Sike, a tributary of Langley Burn [350560 582380]. The outcrop is now inaccessible due to dense forestry, but according to the geological memoir (Day, 1970), fragments of the agglomerate consist of altered sediments containing carbonaceous inclusions set in a matrix of highly altered carbonated, pyritised and ferruginised felsitic lava.

5. Several dykes of quartz-dolerite and tholeiitic compositions (the Lewis Burn-Troughend Dyke-echelon) with east-north-easterly alignment exposed in stream sections in the north and north-west of the area. They are part of a more extensive suite of minor intrusions of late Carboniferous or early Permian age which extend eastwards to the Northumberland coast and are probably genetically associated with the Whin Sill. Good exposures are seen in the headwaters of Routledge Burn [353640 584530], Lancy's Cleugh [355530 584790], the River Black Lyne [356330 585020]. Typically the dykes are 10-20 m wide and give rise to quite extensive dispersion trains of distinctive dark, rounded dolerite boulders. Groundmass pyroxene is occasionally altered and replaced by chlorite, but otherwise these rocks show little evidence of hydrothermal alteration. However, sedimentary rocks at their margins are often baked to a whitish or greenish colour due to chloritisation and carbonatisation. In Lancy's Cleugh for example metasomitised sandstones contain anastomosing streaks, patches of chlorite and secondary silicification.

Structure

Basement influence

The structural pattern, which is largely the result of deformation during the end-Carboniferous to early Permian, Variscan Orogeny, probably reflects reactivation of older Caledonian structures within the underlying basement (Chadwick and Holliday, 1991). Two deformational phases effecting the Lower Border Group rocks are recognised in the Bewcastle area (Sheills, 1964), an earlier north-south compression resulting in the formation of a broad east-west trending dome, and a later, dominantly east-west compression, which was superimposed on the earlier dome and resulted in the asymmetric Bewcastle Anticline overthrust to the west. The thrusting was accompanied by small scale, approximately east-west faulting, normal to and east of the main thrust-plane. Most of the major north-easterly trending faults (Figure 2) probably followed the main phase of compression since several of them displace the east-west faults.

Depositional growth faults

Recent seismic interpretation and outcrop studies (Chadwick et al., 1993; 1995) in the Solway Basin have indicated that normal faulting, near the basin margins was the result of rapid extensional subsidence during the early Dinantian, and that continuing movement on these syn-depositional faults accompanied deposition of the Lower and Middle Border groups. South-east of the basin margin a set of subsidiary north-east trending intrabasinal Dinantian growth faults cut the Bewcastle Anticline. The most important of these are the Goat Island-Lyne Thrust, the Back Burn Fault and a parallel structure, the major Brackenhill Thrust concealed beneath the Permo-Triassic cover of the Carlisle Basin. Both the Goat Island-Lyne Thrust and the Back Burn Fault show normal down-to-the-south-east growth, by at least 1000 m, during deposition of the Lower Border Group and were strongly inverted during the Variscan orogeny.

Inversion- compression structures

Other major fault structures associated with the main period of compression include 1) the Kershope-Dappleymoor Fault which runs parallel to the Scottish Border, 2) the Lyneholmeford Fault-belt; a steeply dipping reversed fault consisting of five separate fractures which enclose narrow tilt blocks of Main Algal or Bewcastle beds, 3) the Hole of Lyne Fault; the northward extension of the Goat Island-Lyne Thrust continues into Northumberland as the Harrett's Linn Fault with a northerly downthrow. The amount of throw is small, but the fault is marked by a wide zone of disturbance, 4) the Antonstown Fault; one of a set of rotational shear faults, radially disposed with respect to the Bewcastle Anticline. The latter display arcuate traces, concave northwards, and both branch- and cross-faults are common. The Black Stantling Fault follows a sinuous course sub-parallel to the

Antonstown Fault and has a similar northern downthrow, 5) Farther north, three major faults, the Rough Grain, East Christianbury and Beckhead-Binky Linn faults all have substantial throws of between 100 and 400 m.

Glacial and Recent deposits

Glaciation during the Pleistocene produced extensive tracts of boulder clay (till) and retreat-stage sands and gravels. These deposits together with alluvium in the river and stream valleys, and peat which is most extensive over the upland areas particularly to the east of the River White Lyne, effectively mask all, but a very small proportion (<0.1%) of the outcrop. Glacial deposits are notably thinner and more patchy above 300 m OD and virtually absent from the high fells (>450 m OD) in the headwaters of the rivers White and Black Lyne. Their thickness, as observed from stream and river sections, is very variable but commonly ranges from 2–10 m, although records from boreholes drilled near Spadeadam indicate far greater overburden depths locally exceeding 30 m.

Mostly the deposits are dominated by grey, chocolate-brown or reddish till characterised by unsorted, internally structureless material containing abundant clasts of locally derived pale sandstone with lesser amounts of siltstone, limestone, shale, and basalt lava supported by a sandy or sandy-silt matrix. Glacial stratigraphy is relatively simple, the evidence being consistent with a single till unit deposited during the latest glaciation.

Erratics of well rounded Criffel-Dalbeattie granodiorite are commonly found at all elevations indicating, together with the dominant east-west trend of rare striae and the easterly alignment of drumlins, a generally eastwards ice movement. Although the distribution of red tills, which occur mainly over the lower ground in the River Lyne catchment, indicates a possible component of transport from areas underlain by Permo-Triassic rocks to the south, Day (1970) suggests that their colour is inherited from underlying reddened Carboniferous rocks.

Sand and gravel in the form of kames, eskers and indeterminate mounds are widely distributed throughout most of the southern part of the district. Around Kirkambeck ice-wastage features form a very conspicuous train of east-west aligned kames (the Gilsland-Kirkambeck kame-train) associated with several deep, peat- and alluvium-filled lakes and a number of glacial drainage and overflow channels, the latter caused by ice-damming of pre-glacial drainage courses.

All of the larger and some of the smaller rivers within the district are flanked by modern alluvium and river terrace deposits. The composition and morphology of the alluvium varies widely from boulder dominated torrent deposits characteristic of the immature upland streams to terrace deposits of graded silts, sands and cobbles of the mature rivers.

DRAINAGE GEOCHEMISTRY

All available BGS geochemical data for panned concentrates from the Bewcastle area have been integrated into a single data set (Table 2) for plotting and interpretation. They comprise information from: 1) earlier MRP reconnaissance surveys of the Solway-Northumberland Basin conducted in 1976 and 1979 (61 samples), 2) the BGS Geochemical Baseline Survey of the Environment (G-BASE) in 1981 (157 samples), 3) follow-up and fill-in sampling in 1994 and 1995 to trace the source of anomalies and improve sample density (241 samples).

Sampling and analysis

Heavy mineral concentrates were obtained by wet screening stream sediment to produce about 4 litres of -2 mm sand and silt fraction for panning to a final volume of 25-35 ml. Analysis for Cu, Zn, Pb, Ba, Ni, Fe, Mn*, Sn, Sb and As* was performed on a 12 g split of milled sample by X-ray Fluorescence Spectrometry (XRF) at the BGS, Geochemical Division laboratories in London (pre 1994 samples) and Keyworth (1994/95 samples). Mineralogical examination, based on grains separated from the -500 and +500 μm unground excess panned concentrate, was carried out on a selection of anomalous samples to assist in the identification of ore minerals and contaminants. The results of optical examination/semi-quantitative XRF and of confirmatory phase identification using a Cambridge Microscan Electron Microprobe are given in Tables 5 and 6 respectively.

Distribution of panned concentrate anomalies

Geochemical plots for Cu, Pb, Zn, Ba and Sn are shown in Figures 3-7. In each plot solid circles of continuously variable diameter proportional to element concentration have been used, except for the highest values (Cu and Pb >98.5%, Zn and Sn >97.5% and Ba >95%), which are indicated by hatched circles of fixed diameter. The area occupied by rocks of the Lower Border Group is shown in grey stipple.

Copper

Copper values in panned concentrates show quite a wide range of concentration (0-479 ppm) (Table 2; Figure 3); although levels over much of the central and western parts of Lower Border Group are low (< 30 ppm) and comparable with average levels over the Newcastleton (Smith and Walker, 1996) and Arnton Fell areas (Smith et al., 1996). The highest Cu values (>60 ppm) occur in several distinct clusters around the eastern and western sides of the Bewcastle Anticline, mostly associated with either the Cambeck Beds or the underlying Main Algal Beds. The most prominent anomalous groups are located in the headwaters of the Black Lyne (Robbie's Grain, Dry Sike and The Beck) and the White Lyne (Rough Grain) rivers, the Antonstown Burn-Ashy Cleugh-Crew Burn catchment, Crook Burn and Sleet Beck.

Near the junction of Robbie's Grain and Dry Sike (Figure 1), outcrops and numerous boulders of ochreous weathered calcite-veined limestone of the Main Algal Beds were noted in a 50-100 m wide zone extensively disrupted by the Hole of Line Fault (Figure 3). Moderately anomalous Cu values (up to 140 ppm in BFP 7229 at [355600 583580]) are associated with high Pb, Zn and Ba values and the observation of abundant fine-grained oxidised pyrite in several samples, although geochemical dispersion trains are relatively short, possibly indicating several small mineralised sources. To the south, in The Beck, the second highest value of the dataset (470 ppm in sample BFP 8011 at [357440 583080]), coincident with high Zn and Ba, is located near the head of the stream which follows the major east-north-east trending Beckhead-Binky Linn Fault. Abundant coarse hematite and baryte fragments are notable constituents of the panned concentrate and carbonate veining was also noted in float boulders at the sample site suggesting that vein mineralisation may be present nearby.

The highest recorded Cu value (479 ppm) occurs together with very high Zn (7100 ppm) and Ba (63100 ppm) in a sample (BFP 8057 at [359300 581100]) collected from the headwaters of Rough Grain. Abundant fresh, coarse-grained cupriferous pyrite (and ?minor chalcopyrite), sphalerite and baryte were recorded in the pan and subsequently mineralogically confirmed (Table 5). The source of

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* Not determined in all samples

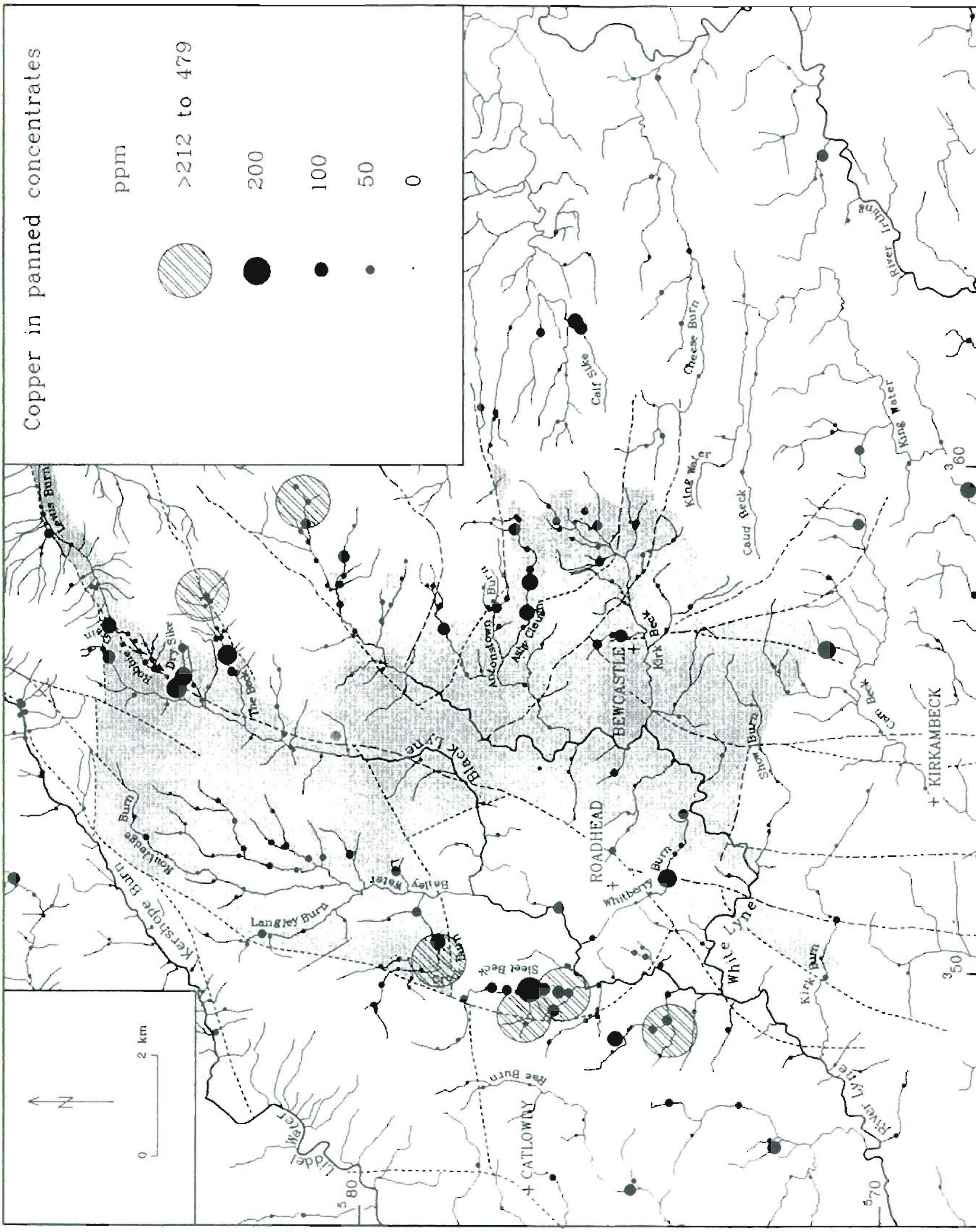

Figure 3 Copper in panned concentrate samples

the mineralisation is most probably fracture controlled since a major structure, the Rough Grain Fault, runs sub-parallel to the stream course causing disruption of Middle Border Group strata. A few metres upstream of the sample site, an iron-stained fault gouge associated with localised alteration (chloritisation) of sandstone bedrock was observed adjacent to a 10 m wide quartz-dolerite dyke.

Cu (and Zn, Ba) anomalies in Antonstown Burn, Ashy Cleugh, Crew Burn and Crook Burn (Figures 3, 5 and 6) are all associated faulted and intensely carbonate-veined limestones within the Main Algal Beds. No chalcopyrite was identified in the samples, but in all cases abundant fine-grained pyrite, sometimes accounting for several percent of the heavy mineral assemblage, is the likely source of Cu anomalies. Many of the panned concentrates examined from these streams contained several morphologically different types of pyrite including cubic, framboidal and microfossil replacements in various stages of oxidation.

In Sleet Beck and its western tributary, Giller Beck, seven high Cu values ranging from 60 to 244 ppm occur within a relatively small area. Anomalous levels of other base metals and barium together with high concentrations of detrital iron oxides, abundant sphalerite, small amounts of pyrite and a few grains of cinnabar (Tables 5 and 6), suggests a mineralised source close by. However, from the cluster of high Sn values (several exceeding 200 ppm) in Sleet Beck and in the unnamed streams near Mallsgate [34850 57400] (Figure 7), some contribution to the high Cu_p values from metallic contamination, possibly arising from farming and/or recent forestry activities is likely. However, with the exception of fence wire there was little direct evidence recorded at sample sites and no contaminant phases, other than one or two inderterminate rusty anhedral grains, were mineralogically identified. Some particularly high Cu_p, Sn_p and Pb_p values (e.g. 261 ppm Cu, 708 ppm Sn and 463 ppm Pb at [348900 573990]) are undoubtedly the result of heavy metal contamination, but in other cases, high Cu_p values associated with Zn_p and Ba_p show no correlation with Sn_p, and are most probably caused by mineralisation concealed by drift.

Lead

The distribution of Pb_p is broadly similar to Cu_p and Zn_p with mainly low values (<60 ppm) over much of the Lower Border Group especially the Lynebank Beds, the lowermost formations of the Bewcastle Beds and the area of undifferentiated rocks west of the Hole of Line Fault (Figure 4). Higher values, mostly in the range 70-200 ppm, are frequently associated with elevated levels of Cu, Zn and Ba and are clustered in the headwaters of 1) the River Black Lyne, 2) the Antonstown Burn-Ashy Cleugh-Kirk Burn catchments, 3) Sleet Beck and 4) the King Water catchment suggesting that metalliferous mineralisation is the principal cause of the anomalies in each of these areas. In contrast to areas of comparable lithostratigraphy close to the basin margin where minor fracture-bound galena occurrences are relatively common (Gallagher et al., 1977; Smith and Walker, 1996; Smith and McMillan, 1996), no galena or other lead minerals were seen either in outcrop, float or, with one notable exception (see description of sample BFP 8177 below), in the panned concentrates.

One cluster of moderately high Pb_p values (222 ppm at [356200 584920], 120 ppm at [355650 584600] and 94 ppm at [355410 583830]) (Table 2) are worthy of note since they occur at consecutive sample sites in the westernmost headwaters of the River Black Lyne and are associated with modest Cu and Zn enrichment. A 10-20 m wide quartz-dolerite dyke, part of the Lewis Burn-Troughend Dyke-echelon, intersects the stream course just above the sample site with highest Pb_p value. Evidence of localised fluid movement, possibly aided by small scale faults, is apparent from alteration (carbonatisation and chloritisation) of sedimentary rocks at the margins of the dyke (Day, 1970). In the Westwater district, near Langholm, similar alteration and minor Pb-Cu-Zn mineralisation at the

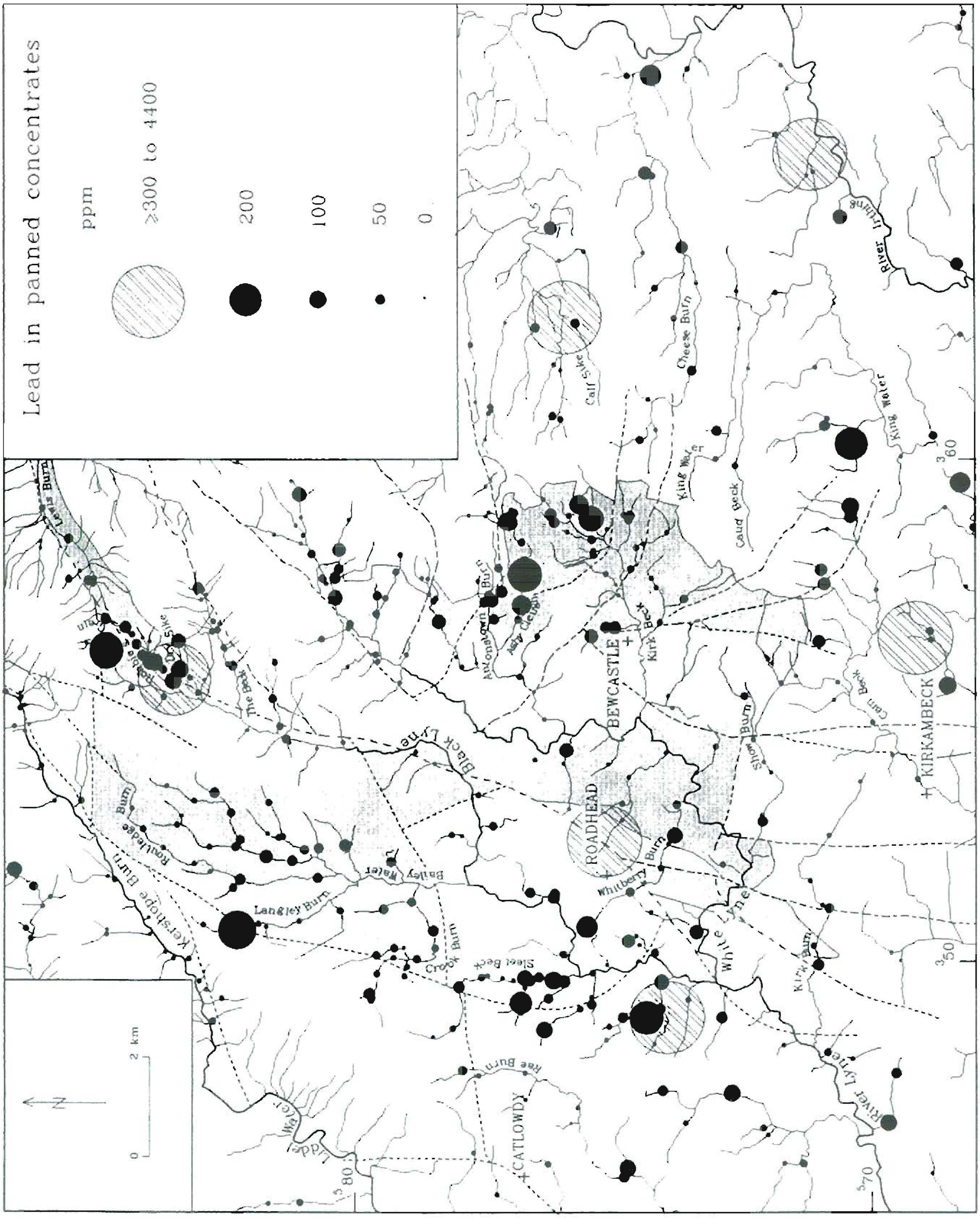

Figure 4 Lead in panned concentrates

Birrenswark Lava-Cementstone Group contact accounts for panned concentrate anomalies of similar magnitude.

Although there is no clear lithostratigraphic control, many of the moderately anomalous Pb values (90-150 ppm) correspond to the presence of limestone outcrops either within the Main Algal Beds (areas 1 and 2 above), or within the uppermost part of Middle Border Group and the Upper Border Group (areas 3 and 4 above). Intense carbonate veining, usually associated with fracturing in fault zones, was commonly observed in each of these areas, although detailed inspection of available outcrop and stream clasts revealed no evidence of Pb-mineralisation. The anomalies are therefore presumed to be caused by isolated rare grains of galena probably located within or at the margins of carbonate veins and comparable in style to the more widespread fracture-bound galena mineralisation associated with veined limestones and cementstones along the faulted northern basin margin near Langholm and Newcastleton (Gallagher et al., 1977; Smith and Walker, 1996).

The maximum Pb_p value of the dataset (4400 ppm) was recorded over Middle Border Group rocks in Calf Beck at [362830 575820], together with very high Zn_p (6600 ppm) and Ba_p (10400 ppm) in a sample containing abundant relatively coarse, galena, sphalerite and baryte. Strongly anomalous Sn_p (275 ppm) in the same sample indicates a possible source of some metals from contamination, possibly derived from the nearby military training area at Spadeadam. However, none was seen in the vicinity of the sample site and mineralogical examination of the panned concentrate (Tables 5 and 6) confirmed a strongly mineralised assemblage comprising abundant fresh galena, sphalerite, pyrite, baryte, and minor cinnabar. In the absence of bedrock a detailed examination of the dominantly bioclastic limestone float was carried out, but failed to identify any signs of sulphide mineralisation or carbonate veining. From the lack of oxidation and relative coarseness of the ore mineral grains a local mineralised source obscured by glacial drift is the most likely explanation.

Several very high Pb_p values (Figure 4) are attributable, at least in part, to metallic contamination frequently encountered in streams in the low lying agricultural areas. Even where visible metallic contamination was not recorded at a sample site the association of high Pb_p with high levels of Sn_p (Figure 7) (15 to >200 ppm) and Sb_p (>5 ppm) often suggests its presence. Thus, in the unnamed tributary of the Black Lyne to the south of Sleet Beck, the close correlation between high Pb and Sn (up to 463 ppm Pb, 708 ppm Sn and 8 ppm Sb at [348900 573990]) is almost certainly caused by contamination, probably from battery lead or solder. Similarly, the major Pb_p anomaly in Rough Sike (936 ppm at [352420 575110]) is related to high Sn_p (72 ppm) and Sb_p (8 ppm), and may also be due solder. In both instances however, some contribution to the high Pb contents from metalliferous mineralisation cannot be excluded since anomalous Zn_p and Ba_p levels are also present due to relatively abundant coarse sphalerite and baryte in the panned concentrates. Glass, another major Pb-bearing contaminant, has an even wider distribution than anthropogenic metals, and was recorded in up to 20% of sample sites. It occurs either as large fragments distributed through the sediment profile or less frequently, as rounded, sub-millimetre-size grains in panned concentrates, accounting for scattered Pb_p values ranging from 80 to >200 ppm generally unrelated to other base-metals anomalies. For example, in sample BFP 8173 ([350630 582320]), containing 239 ppm Pb, fragments of brown glass was identified in the coarse (>2 mm) fraction and also mineralogically confirmed in the excess panned -2 mm material (Table 5).

In other cases the cause of anomalous Pb_p values is less easily ascertained, for example a high Pb_p value of 564 ppm at [356470 569080], approximately 3 km east of Kirkambeck is unrelated to anomalous levels Cu_p, Zn_p, Ba_p. Galena was not seen in the panned minerals and the presence of slightly elevated Sn_p (14 ppm), together with the location of the site in the headwaters of a minor

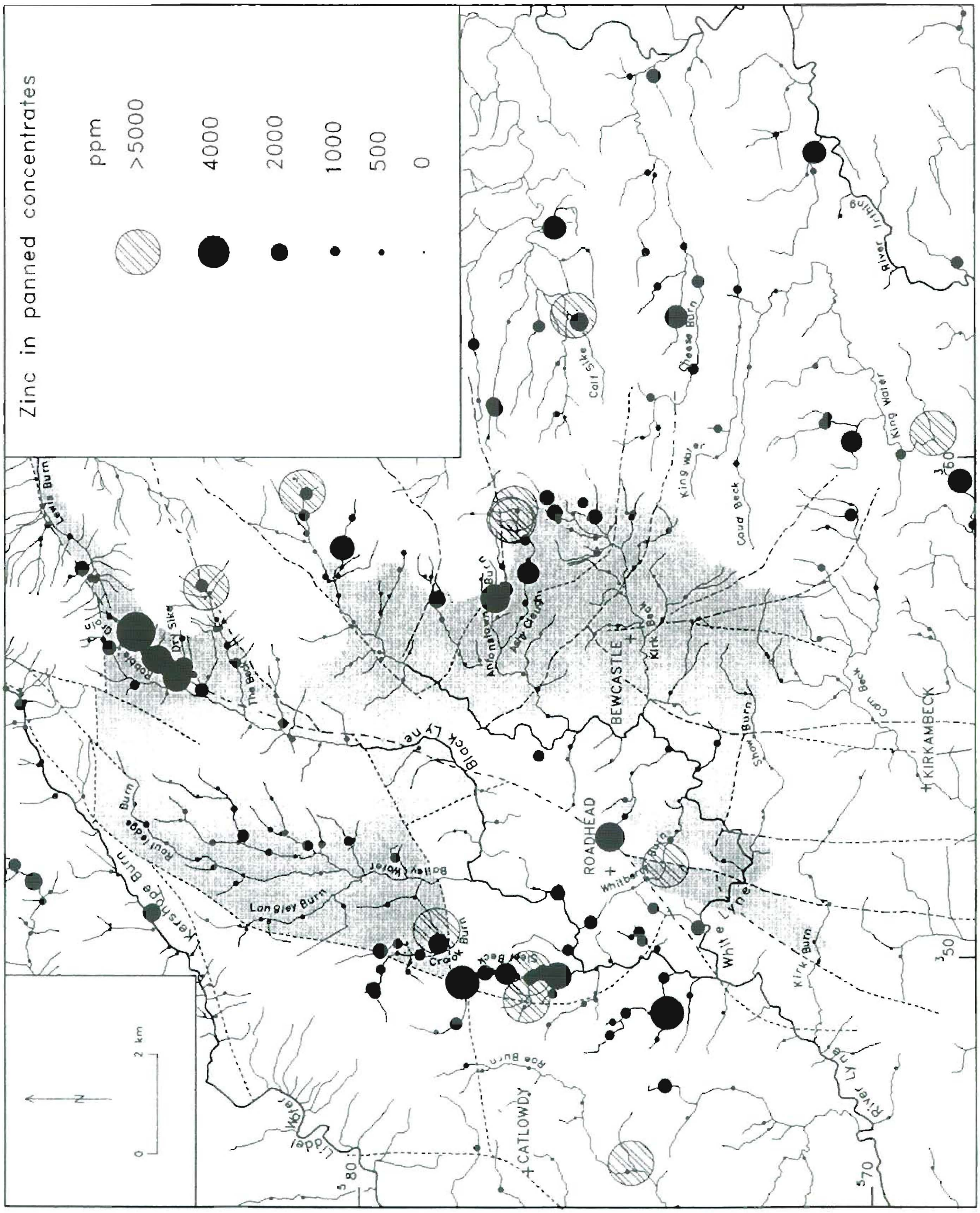

Figure 5 Zinc in panned concentrates

stream 50 m above a farm track, suggests that the anomaly is due to contamination, probably from metallic lead.

Zinc

High concentrations of Zn are a characteristic feature of the panned concentrate data over much of the project area (Table 2, Figure 5) with the exception of dominantly low values in the central and southern parts of the Bewcastle Anticline underlain by the Lynebank and Bewcastle beds. Average Zn_p levels are considerably higher than reported elsewhere from the Lower Carboniferous of northern Britain (Bateson et al., 1983; Cooper et al., 1991), but comparable to those recorded in other parts of the Solway-Northumberland basin (Colman et al., 1995; Smith and Walker, 1996). Mineralogical examination, based on a small selection of anomalous samples (Table 5), identified the principal source of the Zn as relatively coarse euhedra of resinous, glassy sphalerite varying in colour from yellow to brown or occasionally orange-red. Almost 20% of the sample population (87 samples) contains >1000 ppm Zn and, in the majority of these, sphalerite, often accompanied by abundant fresh framboidal and cubic pyrite, spherulitic marcasite and minor amounts of baryte, was recognised as a prominent constituent of the heavy mineral assemblage accounting for several tens or even hundreds grains.

Like Cu_p and Pb_p, high Zn values (>1000 ppm) tend to occur in distinct groups in catchments along the eastern and western limbs of the Bewcastle Anticline (Figure 5). In the headwaters of the Black Lyne (Robbie's Grain and Dry Sike), the Antonstown Burn-Ashy Cleugh catchment and in Crook Burn, the main anomalies are located over faulted and veined limestones of the Main Algal Beds. In Ashy Cleugh, several major Zn (and minor Cu and Ba) anomalies (up to 9680 ppm Zn at [358760 577050]) are closely related to a 50 m wide zone of intense calcite (minor baryte) veining and carbonate cemented breccia associated with the east-north-east trending Antonstown Fault. Minor coarse-grained sphalerite occurs as scattered dark brown to black, euhedral crystals close to the margins of some veins, and pyrite is present both as fine disseminations in the host limestone and as coarse aggregates within the veins. Evidence of old exploratory adits and abundant debris of veined limestone were seen on the hillside nearby [35960 57734], but no sulphides were observed.

Though the degree of exposure is poor, the source of the high Zn_p (and other metal) values in the Robbie's Grain-Dry Sike catchment is likely to be caused by faulting since the major Hole of Lyne Fault-Harrett's Linn Fault follows the main valley over a distance of several hundred metres. The fault is responsible for considerable disruption of the Main Algal Beds and the development locally of intense calcite veining in limestone. Two adjacent sample sites (BFP7229 and 8036) on Dry Sike, lying either side of the main fault (Figure 2), contain high coincident Zn, Pb, Cu, and Ba values (Table 2) and abundant sphalerite, pyrite and baryte (Tables 5 and 6). The only evidence of mineralisation was traced to a 0.5 m thick outcrop of dolomitised, reticulate-veined, orange-yellow fossiliferous limestone a few metres upstream of sample BFP7229 (see section on Mineral Occurrences and Rock Geochemistry below). Visible sulphide was restricted to finely disseminated pyrite in the groundmass and occasional patches of coarse pyrite-marcasite in the veins, but chemical data for the limestone and the immediately underlying mudstone (Table 3b, samples BFR8279 and 8281) indicate weak enhancement of Zn, Pb and Ba.

The principal area of anomalous Zn_p over rocks of the Middle Border Group occurs in the Sleet Beck catchment. Here, Zn levels commonly exceed 1000 ppm rising to a maximum of 9500 ppm in a minor west bank tributary, and are associated with one or more metalliferous elements at concentrations suggesting a local source(s) of mineralisation. A major north trending structure, the Dappleymoor Fault (Figure 2), which further north forms the western faulted margin of the Bewcastle Anticline,

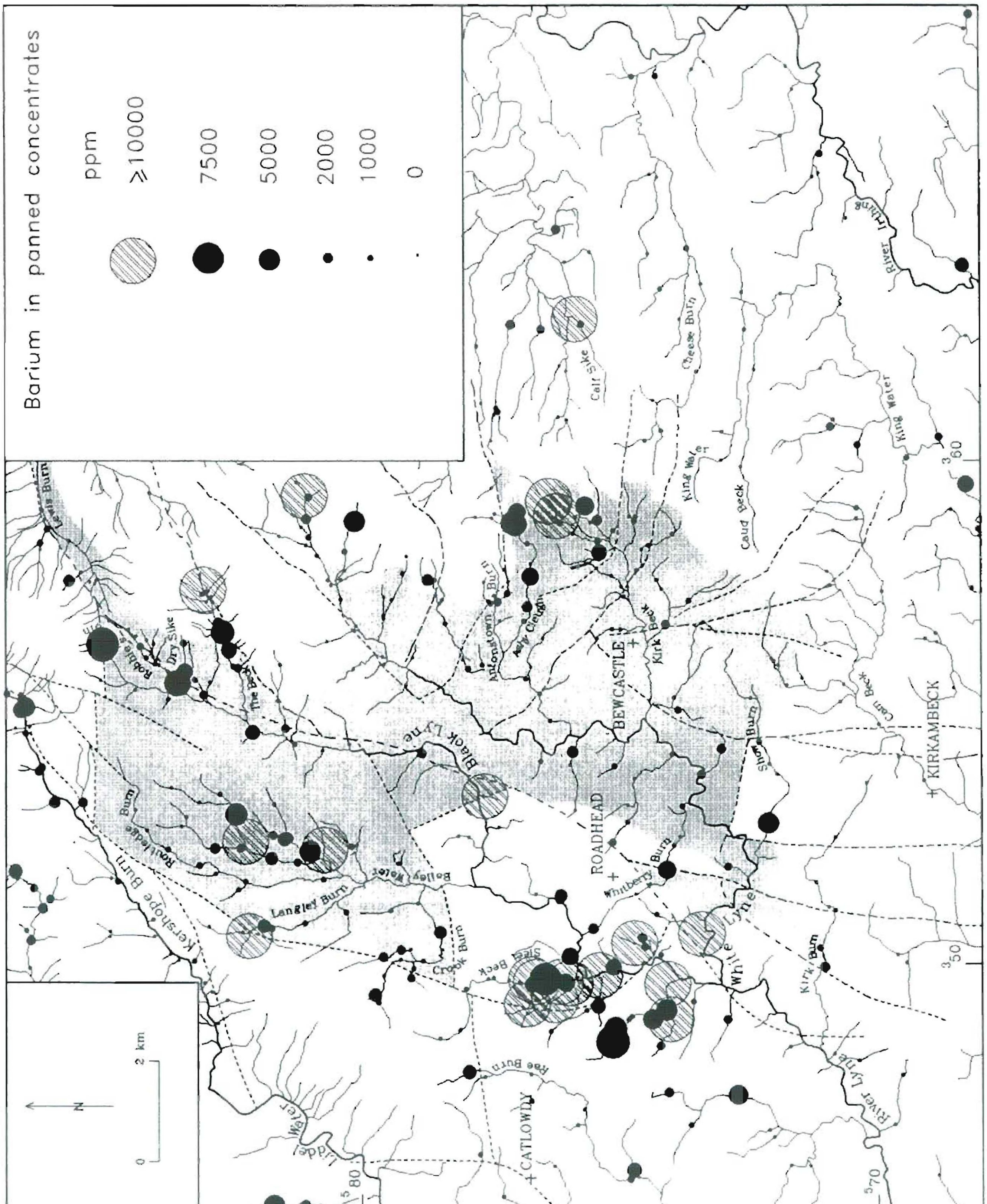

Figure 6 Barium in panned concentrates

passes very close to the sites with the highest Zn values. Upstream and uphill of the fault all sites contain only background metal values. Deep drift on the valley sides completely obscures bedrock, outcrop being limited to apparently unmineralised exposures in the most deeply incised part of the main stream [349640 576940 to 349670 577310]. Detailed examination of float material revealed only two mineralised boulders, one of heavily veined (calcite-hematite-baryte) sandstone (BFR 7041), and the other a bituminous limestone (BFR7042) containing abundant pyrite in thin ?dolomitic veins. Analytical data (Table 3b) however, suggests that base-metal mineralisation in these samples is negligible and the source of the anomalies therefore remains unresolved.

The broad scatter of high Zn_p values (>1000 ppm) accompanied in some instances by modest enrichment of Ba and Pb in the south-east quadrant of the project area (Figures 4, 5 and 6), occurs over rocks of the Middle and Upper Border groups. Many anomalies appear to be spatially related to faulted limestones, particularly the Cumcrook and Kingsbridge Limestones, but no follow-up was undertaken since they fall well outside of the target Lower Border Group rocks effected by synextensional faulting.

Barium

High levels of Ba in the panned concentrate samples (>5000 ppm) are caused by the presence of relatively coarse (>300 μm) grains of white and pink baryte frequently displaying well developed cleavage surfaces (Tables 5 and 6). The Ba-anomaly pattern (Figure 6) shows many similarities with the distribution of Zn_p and to a lesser extent Pb_p and Cu_p, suggesting a common source of the metals. However, several notable differences are also apparent including the magnitude and extent of the north-west trending zone of very high concentrations recorded in the Sleet Beck catchment; the presence of high Ba_p values unrelated to base-metal anomalies in Cuddy's Burn and Langley Burn headwaters in the north-western part of the Bewcastle Anticline, and the generally low levels of Ba over Middle and Upper Border group rocks in the south-east quadrant of the project area. Generally though, in comparison with panned concentrate data over Lower Border Group rocks close to the basin margin (Gallagher et al., 1977; Smith and Walker, 1996; Smith and MacMillan, 1996), which show Ba levels commonly in the range 1-10%, those in the Bewcastle area are substantially lower. This is particularly evident over the oldest exposed rocks in the central part of the Bewcastle Anticline where Ba_p levels over the Lynebank Beds, for example, rarely exceed 1000 ppm.

With few exceptions the highest Ba_p values are located within 500 m of major intrabasinal faults (Figures 2 and 6), many of which are associated with extensive carbonate veining in limestones, and to a lesser extent in sandstones and mudstones. Baryte, intergrown with carbonate, forms a minor, but widespread constituent of faulted limestones of the Main Algal Beds along the eastern limb of the Bewcastle Anticline (Dry Sike and the headwaters of Antonstown Burn), and in Crook Burn on the western limb (see section on Mineral Occurrences and Rock Geochemistry). Similar weak baryte mineralisation, associated with the Cuddy's Fault and a complex of subsidiary faults, is likely to account for the spread of high Ba_p values in the Cuddy's Burn catchment where the Main Algal Beds are represented by outcrops of crinoidal limestone and interbedded shales containing extensive reticulate veining and vertical slickensides (Day, 1970). Although some samples here contain in excess 1% Ba (e.g. 14115 ppm Ba in BFP7260 at [352440 582260]) there is no evidence of corresponding base-metal enrichment which characterises faulted limestones of the Main Algal Beds elsewhere.

The pattern of high Ba_p values associated with major Cu_p, Zn_p and minor Pb_p anomalies in the Sleetbeck catchment is exceptional in showing a particularly close spatial relationship with the Dappleymoor Fault and a parallel minor structure to the south-west passing close to Troughfoot

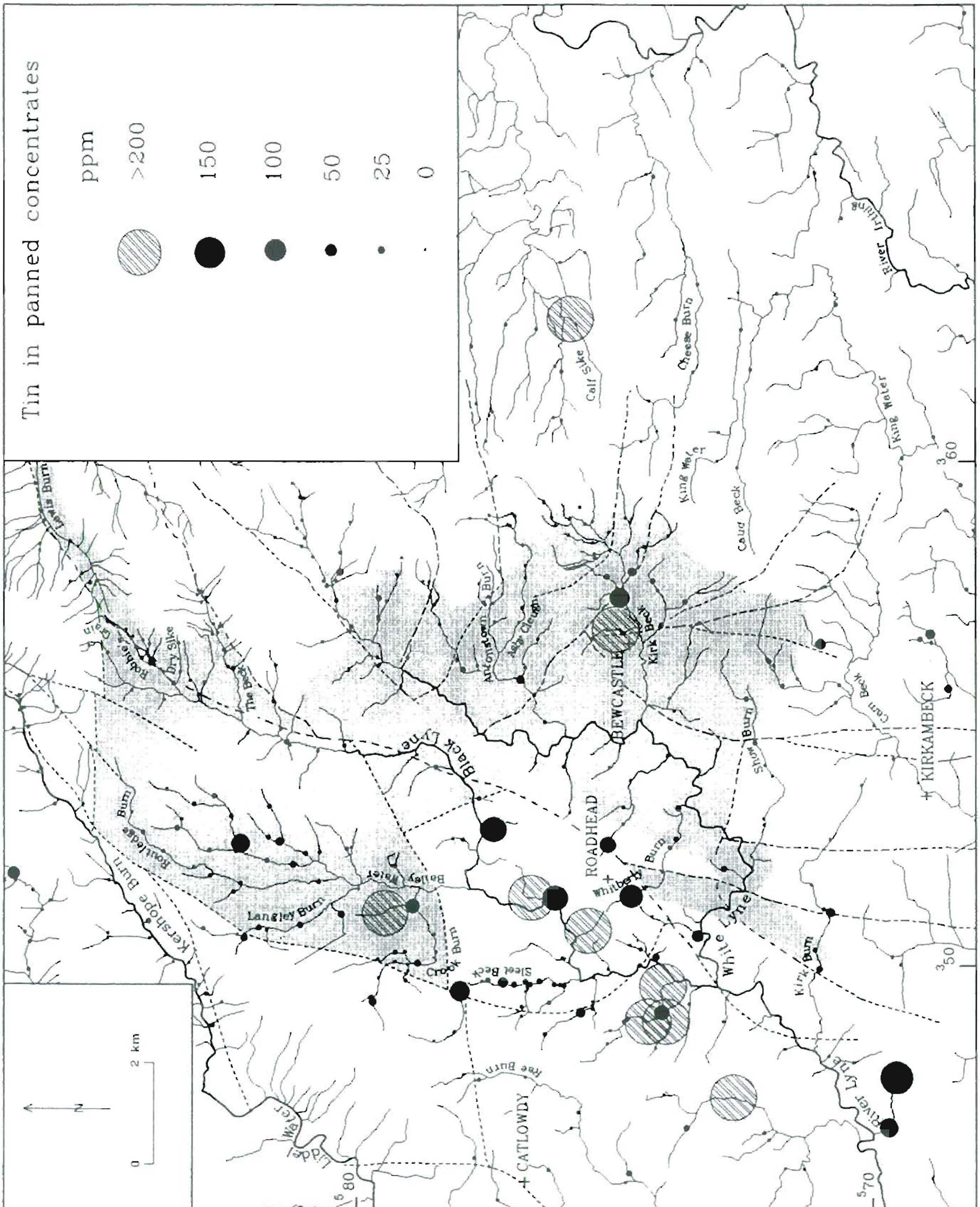

Figure 7 Tin in panned concentrates

[34900 57450]. More than 50% of the very high Ba_p values (>1%) of the dataset are located in Sleetbeck or its west bank tributaries, but exposure is very poor, the only evidence of possible sources of mineralisation being float boulders of basic igneous material and calcite-baryte veined sandstone in the main stream (Tables 3a and 3b). The possibility of basic igneous rocks lying proximal to a major structure invites comparison with the mineralisation style in the Westwater, Newcastleton and Langholm areas (Gallagher et al., 1977; Smith and Walker, 1996) where baryte vein mineralisation is widely developed in the Birrenswark Lavas close to faulted contacts with Lower Border Group sedimentary rocks. Although rocks around Sleetbeck are somewhat higher in the stratigraphic sequence (Middle and Upper Border groups), basalts of the Glencartholm Volcanic Beds, which are associated with major Ba_p anomalies to the south of Langholm (Colman et al., 1995), may occur in the drift-covered ground near the inferred surface trace of the Dappleymoor Fault.

Gold observations

Visible gold grains were recorded in panned concentrates from 10 sites (Table 4). Most grains were quite coarse (0.3-0.5 mm), flattened, and irregular or subrounded in shape suggesting transport over a relatively short distance . The distribution of eight of the ten samples indicates a possible source area in Routledge Burn or immediately adjacent catchments, the other two being located well to the south (Kirk Burn) or east (The Beck). Although not apparently associated with other metalliferous elements, the gold-bearing samples all contain varying amounts of coarse-grained, dark red hematite, sometimes in quite high abundance (a few tens to several hundreds of grains). A similar association with hematite was noted in the Ecclefechan area (Smith and McMillan, 1996), where visible gold occurs in several streams draining the Birrenswark lava outcrop. In the Bewcastle area, quartz-dolerite dykes of the Permo-Carboniferous Lewis Burn-Troughend Dyke-echelon, intersect the majority of the gold-bearing catchments giving rise to a southerly-directed clastic dispersion train of float boulders observed in drift and alluvium several kilometres from source. The hematite may be an alteration product from the weathering (or late hydrothermal alteration) of iron ores such as titanomagnetite which is a common accessory mineral in the dyke rocks.

Optical examination revealed only one inclusion in a gold grain extracted from a panned concentrate from lower Routledge Burn (BFP7222 at [351680 580740]). Electron microprobe analysis of the inclusion and the bulk grain indicated the principal component to be galena (Tables 6 and 7), but the presence of other unidentified phases/elements is indicated from the anomalously low 'totals'values (Table 7). From such limited geochemical and mineralogical data a genetic association between gold and the basaltic rocks cannot be demonstrated although it is interesting to note that localised hydrothermal alteration of sandstones, resulting in silicification, carbonate veining and chloritisation, has been recorded adjacent to the Lewis Burn-Troughend Dyke-echelon about 6 km to the east-north-east of Routledge Burn (Day, 1970).

Only one site in the project area yielded more than one grain of gold. In Kirk Beck, in the south of the area (BFP8035 [349940 571030]), three grains of gold were recorded together with very abundant coarse hematite and the highest total Fe-content (29.96%) of the data set. A considerable thickness of glacial overburden obscures bedrock on the valley sides but, in the stream bed 200 m upstream of the sample site, there are outcrops of the Main Algal and Cambeck beds. There are no mapped basic igneous rocks anywhere in the catchment, and no evidence of float material was seen which might indicate their presence.

Mineralogical examination of panned concentrates containing major base-metal anomalies from Sleetbeck (Tables 5 and 6) revealed abundant pyrite, hematite and, in two samples, cinnabar (BFP7238 at [349690 576700] and BFP7241 at [349640 576140]). Gold was not recorded here, but several As_p values in the Sleet Beck catchment, although not strongly anomalous, are amongst the highest in the data set (Table 2) indicating the possibility of undiscovered precious metal mineralisation obscured by thick drift to the west of the main stream. Interestingly a local landowner claims to have discovered an unusually dense, gold-coloured metallic fragment whilst ploughing a field adjacent to Sleet Beck.

MINERAL OCCURRENCES AND ROCK GEOCHEMISTRY

Sampling and analysis

Inspection of available outcrop and float material was routinely undertaken during the drainage sampling together with follow-up rock sampling in anomalous catchments and visits to old trials and the only recorded mineral occurrence in the area. This resulted in the collection of 123 rock samples (90 outcrop and 33 float boulders) which showed evidence of veining, alteration or other indications of mineralisation. The samples were analysed by X-ray fluorescence (XRF) for the same range of elements as the drainage samples (see Sampling and Analysis, p 8). Lithological and locational information is presented in Table 3a and geochemical data in Table 3b .

Reconnaissance rock sampling

The analytical data confirm the field observation of widespread, but economically insignificant amounts of sphalerite ± pyrite (± marcasite) ± baryte mineralisation in fractured and carbonate veined limestones and cementstones mainly within, but not restricted to, the Main Algal Beds and the underlying Bewcastle Beds. Most of the mineralised occurrences are in areas containing major north or north-east trending intrabasinal growth faults including the Dappleymoor-Kershope and Hole of Lyne-Harrett's Linn fault systems on the west side of the Bewcastle Anticline, and the Antonstown and Rough Grain faults on the eastern limb. With very few exceptions, the levels of Pb and Cu in the rock samples are very low and fall within the background range expected for unmineralised sedimentary rocks. This is in marked contrast to the northern basin margin where Pb, Cu, and Zn sulphides are recorded intermittently over a total strike length of some 40 km associated with dolomitic veining in basal Dinantian sediments and underlying Birrenswark Lavas (Gallagher et al., 1977; Smith and Walker, 1996; Smith and McMillan, 1996). No comparable lavas outcrop in the project area, but sampling of limestones close to Permo-Carboniferous quartz dolerite dykes exposed in the headwaters of Routledge Burn (BFR8287 and 8288) and Rough Grain (BFR8226-8230), where substantial base-metal anomalies in drainage panned concentrates are reported, revealed high concentrations of disseminated and vein-pyrite. In Sleet Beck the discovery of several fine-grained dolerite boulders in a section of stream in which major coincident base-metal and Ba anomalies exist, suggested proximity to a basic igneous dyke. Other than fine disseminated pyrite, the dolerite boulders contained no sulphides and trace element data (BFR8290, Table 3b) are typical of unmineralised basic igneous rocks.

Old trials

There is no history of metalliferous mining in the Bewcastle district and only one recorded occurrence of metalliferous mineralisation. This is located just outside the north-eastern corner of the project area in Kielder Forest [362185 582475]. The information, presented in the geological memoir for sheet 12, suggests that this is a relatively trivial occurrence, being represented by a 2 cm wide, north-north-west trending calcite vein cutting limestones and shales of Upper Border Group age and containing scattered crystals of coarse sphalerite. A visit to the site revealed a 0.5 m thick exposure of muddy siltstone overlain by thin shales in the south bank of a small stream. Numerous calcite veins were seen in the siltstone, two or three of which carried rare sphalerite crystals; analytical data for sample BFR 7083 indicated only modest Zn concentration (435 ppm) confirming the low tenor of the sphalerite and the absence of other base-metals. A short distance upstream a few sandstone float boulders, bearing conspicuous slickensides and a few barren carbonate veins, indicated that a small unmapped fault may be responsible for the mineralisation. Sphalerite may have been discovered here long ago since the stream is named 'Black Jack Sike'; the term 'Black Jack' originally being used by 19th century miners to describe black sphalerite in the North Pennine Ore Field.

The Geological Survey memoir describes the remains of an old (*c.* 1848) exploratory adit situated close to the Antonstown Fault, just to the north of the headwaters of Ashy Cleugh, and about 2.5 km north-east of Bewcastle (Day 1970). Numerous loose blocks of heavily calcite-veined algal limestone now mark the site [359100 577200], but no other trace of mineralisation was seen here. Similar trial workings are also recorded immediately to the west on the line of the same fault at [359600 577340] and [358900 577190], the latter indicated by a small mound of calcite-veined limestone and shale.

Follow-up rock sampling

Ashy Cleugh-Hill Cleugh

Detailed inspection of outcrop and float in this area, which contains some of the highest Zn_p values (see section on Zinc in panned concentrates above), revealed an east-west zone of calcite veining, up to 150 m wide and traceable in stream outcrops (Ashy Cleugh and Hill Cleugh) along the fault line for at least 1350 m ([359000 577100] to 357640 577140]). The old trials lie at the eastern end of this zone, which is clearly associated with the Antonstown Fault and a parallel branch fault (the White Preston Fault) about 200 m to the south. Veining is most strongly developed in a small horst block lying between the margins of the two structures. Minor amounts of coarse dark sphalerite crystals occur as clusters and scattered grains in a small proportion of the veins, the latter mainly cutting dark limestones and, to a lesser extent, thin interbedded sandstones. Average Zn concentrations in 12 samples from Ashy Cleugh (BFR7026-7032, 7059-7063, and 8209, 8210; Table), and 6 samples from Hill Cleugh (BFR7064-7069), are consequently of the order of a few hundred ppm (maximum 4001 ppm in a sample of locally derived float, BFR7026). Apart from minor baryte, either intergrown with the calcite or occassionally infilling small cavities, the only other ore mineral observed was pyrite, forming fine-grained disseminations in the limestone matrix.

Crook Burn area

Geologically and structurally there are many similarities between Crook Burn and the Ashy Cleugh-Hill Cleugh catchment. A more or less complete sequence of the Main Algal Beds and the uppermost part of the Bewcastle Beds (Rigghead and Ashy Cleugh limestones) are exposed in the lower reaches of Crook Burn and, although no major fault is evident in the immediate vicinity, there are several small north-south trending structures causing disruption of the beds and carbonate veining which decreases in intensity away from the faults. Geochemical data for 17 rock samples (BFR7006-7017 and 7023-7025) (Table 3b) collected over a 380 m long section from [350220 578450] to [350490 578460] are also comparable to the Ashy Cleugh-Hill Cleugh catchment in terms of their modest Zn contents and low concentrations of other base-metals. Apart from rare, irregular grains and patches of marcasite and pyrite, sphalerite constitutes the only sulphide mineralisation identified in the carbonate veins. It forms scattered, but conspicuous clusters of dark to honey-coloured crystals often concentrating near the vein margins. Pyrite also occurs as fine disseminations and dispersed blebs throughout the matrix of the darker limestones suggesting a syngenetic or diagenetic origin. One unusual feature of the lower part of this stream is the presence of high Cu in several panned concentrate samples (see section on Copper above) at levels not explained by the uniformly low concentrations in the veined limestones (<12 ppm). Evidence that the Cu_p anomalies might originate higher in the catchment was provided by the discovery of three heavily oxidised stream boulders of veined, sandy, carbonaceous limestone (BFR7056, Tables 3a and 3b) containing 201 ppm Cu. The Cu may be present either adsorbed onto secondary iron oxides, which are dispersed through the rock matrix, or contained within a network of thin carbonate-siderite-pyrite veinlets. Thick drift obscures bedrock in the vicinity of the sample site, but the most likely source of the mineralised float is the major north--north-east trending Kershope Fault, mapped less than 200 m upstream of the sample site.

A short distance to the north, in an identical structural setting relative to the Kershope Fault, more substantial carbonate veins (up to 2 cm wide) containing coarse aggregates of pale and dark sphalerite were discovered in large grey limestone float blocks in the upper reaches of Langley Burn (BFR8213, Tables 3a and 3b). The relatively low concentration of Zn (1030 ppm) and other base-metals suggests however, that despite the presence of intense brecciation and net veining, sulphide mineralisation is only weakly developed.

CONCLUSIONS AND RECOMMENDATIONS

1. The results of the drainage panned concentrate surveys indicate distinct groups of very high Zn values (>1000 ppm), frequently associated with modest enrichment of Cu, Pb and Ba, over Lower, Middle and Upper Border Group rocks along the eastern and western limbs of the Bewcastle Anticline. Much lower levels of all the metalliferous elements characterise the oldest Carboniferous rocks exposed in the core of the anticline, although relief here is low and outcrop largely obscured by glacial drift.

2 In the headwaters of the Black Lyne, the Antonstown Burn-Ashy Cleugh catchment and in Crook Burn, the principal panned concentrate anomalies are located close to major intra-basinal faults over the Main Algal Beds, and to a lesser extent the underlying Bewcastle Beds. Mineralogical examination identified the cause of high Zn and Ba values in panned concentrates as due to relatively abundant coarse grains of sphalerite and baryte.

3. Follow-up investigations in the anomalous catchments led to the discovery of quite widespread, but weak epigenetic sphalerite±baryte±pyrite mineralisation in intensely carbonate-veined limestones and cementstones (Main Algal Beds). All of the new occurrences are situated within a few hundred metres of major intrabasinal faults, the most important structures being the north-east end of the Hole of Lyne-Harrett's Linn Fault, the Beckhead-Binky Linn Fault, the Rough Grain Fault, the Antonstown Fault and the Kershope Fault. Apart from pyrite, which is present in both vein and disseminated form, no evidence of economically more attractive syndiagenetic mineralisation was seen. The combined base-metal concentrations, of a few hundreds of ppm on average, in rocks carrying vein-style mineralisation, are not sufficient to encourage further work.

4. The cause of the high lead and copper in panned concentrates is more difficult to establish especially over the lower agricultural ground where extensive contamination has contributed variably to total base-metal concentrations. This problem is particularly acute in Sleet Beck and adjacent catchments where major coincident copper, lead, zinc, barium (and to a lesser extent arsenic) anomalies are partly related to a suite of ore minerals including sphalerite, pyrite, baryte, cinnabar and hematite and also to contamination evident from the very high levels of tin. The anomaly pattern appears to be truncated on the west side of Sleet Beck in an area of thick drift close to the inferred position of the Dappleymoor Fault. Because of the possibility of both precious- and base-metal mineralisation, further work involving deep overburden sampling and geophysics is recommended in

the area around the fault to investigate the source of the geochemical drainage anomalies and basic igneous float boulders.

5. The highest Pb_p value of the dataset, from a site over the Middle Border Group limestones east of Bewcastle, is caused by abundant coarse fresh galena, accompanied by other sulphides and baryte, at concentrations indicative of a substantial local source of mineralisation probably obscured by drift. Although epigenetic mineralisation is suspected from the coarse-grained nature of the panned sulphides, a limited programme of deep overburden sampling is recommended to confirm this and investigate the possible extent of geochemical dispersion adjacent to the stream site.

6. Relatively coarse particles of gold were panned from 10 sites in the project area, of which eight are clustered in the Routledge Burn catchment. The only geological feature which distinguishes this area from adjacent catchments in which gold is absent is the presence, in several of the headwater tributaries, of Permo-Carboniferous quartz-dolerite dykes displaying localised wall rock alteration. In this context it is interesting to note that the MRP recently discovered high levels of gold in altered, evolved basaltic lavas of Permian age from Devon (Cameron et al., 1994; Leake et al., 1994). More detailed drainage and rock sampling is thus merited to establish whether a primary association between gold and basic igneous rocks exists in Routledge Burn, or whether the gold is derived from more distant sources such as the Lower Palaeozoic rocks of the Southern Uplands.

7. Although no firm evidence of "Irish-Style" mineralisation was found, the widespread occurrence of weak base-metal mineralisation suggests that its presence at depth, adjacent to one or more of the major fault structures, cannot be discounted, but is not easily tested without major expenditure.

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BRITISH GEOLOGICAL SURVEY
Mineral Reconnaissance Programme

Table 2 Panned concentrate data for the Bewcastle area (34P1801-34P2100, 1981/2; HBP 735-2795, 1979/80 ; BFP2281-5516, 1976; BFP7203-7278, 1994; BFP7284-8179, 1995)

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Mn ppm	Sn ppm	Sb ppm
34P1801	347110	575670	0	14	77	343	5	16340	150	5	7
34P1803	355060	573840	6	10	123	1204	7	28050	120	0	2
34P1804	351390	576600	1	53	93	108	8	28530	160	210	5
34P1805	358890	574770	9	29	131	234	16	36700	340	0	4
34P1806	356380	571010	123	67	375	92	5	15460	160	41	0
34P1808	356870	579570	4	10	31	121	6	20810	200	0	3
34P1809	355310	573920	2	7	174	473	4	18080	90	0	0
34P1810	352810	572110	12	52	59	4845	21	184320	840	2	0
34P1811	349700	577540	7	34	1674	176	10	31330	160	3	0
34P1812	349910	578990	6	24	169	640	20	46870	480	0	0
34P1813	348900	574800	9	53	1092	653	14	81940	300	9	0
34P1814	356750	574080	8	25	54	1649	10	57010	230	11	7
34P1815	356820	577300	20	52	52	121	23	80660	400	1	0
34P1816	357230	578430	24	21	1209	122	22	46970	570	0	7
34P1817	348660	576320	13	93	300	603	8	30520	290	7	6
34P1819	345790	568850	3	8	31	119	9	28160	130	0	1
34P1821	349250	573550	13	20	502	707	13	108870	500	2	5
34P1823	350420	574690	24	72	435	12900	40	123370	620	0	3
34P1825	347800	576700	1	14	81	180	8	29190	330	0	1
34P1826	350290	579050	0	8	30	117	3	15340	80	4	6
34P1827	347750	577600	9	17	182	219	8	30520	380	5	4
34P1828	358320	574410	4	7	26	422	5	14950	220	1	0
34P1829	356650	574950	78	69	217	371	19	42820	130	262	6
34P1830	346700	572100	19	30	57	140	19	120660	460	5	6
34P1831	357370	577150	26	65	1711	1088	33	42510	570	0	3
34P1832	348210	570850	5	35	47	149	12	79630	500	2	0
34P1833	353160	574810	4	21	354	122	11	66230	500	3	0
34P1835	354300	573010	11	22	610	1815	8	55600	180	0	2
34P1836	356110	579000	4	14	59	134	8	23830	260	4	6
34P1837	358930	576910	21	41	309	508	35	56010	640	3	0
34P1838	358760	577050	35	101	9680	5461	38	55800	830	0	0
34P1839	349600	574050	28	84	1185	17300	24	148470	880	239	19
34P1841	357300	574880	1	7	37	359	5	26190	160	88	2
34P1842	358880	574650	33	45	516	500	22	48320	280	0	0
34P1844	353960	578450	4	8	30	164	5	13760	110	9	4
34P1848	357320	578560	4	11	60	104	6	23860	170	5	5
34P1849	357310	577400	16	39	180	244	18	34190	180	0	0
34P1850	350520	574540	10	11	1167	1880	13	45050	250	0	0
34P1851	347450	574030	45	55	1605	1888	34	112990	810	2	5
34P1852	349240	579690	4	24	322	1007	9	55190	340	0	0
34P1853	354230	575890	7	77	299	2416	18	93760	630	0	0
34P1854	350090	579250	4	20	286	239	11	55360	350	0	0
34P1855	347790	569540	12	53	100	420	22	99110	410	159	1
34P1856	350990	574260	4	15	1173	696	10	53380	360	0	4
34P1857	351940	572880	12	24	210	1375	17	113260	600	18	6
34P1858	355560	579130	2	14	181	116	5	19860	170	0	4
34P1859	350170	575990	13	14	345	1010	8	29750	190	2	4
34P1860	347270	576690	1	10	105	669	4	17110	110	2	5

Table 2 (continued)

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Mn ppm	Sn ppm	Sb ppm
34P1862	353700	574680	0	9	64	61	3	15170	110	0	2
34P1863	347850	577910	5	46	447	3035	9	39660	280	0	0
34P1864	346800	575800	0	1	17	336	2	11280	50	1	0
34P1865	349380	579750	18	52	1361	2947	21	109750	790	7	6
34P1866	345980	571320	2	35	85	130	11	29830	130	3	2
34P1867	346560	572010	87	15	19	175	9	39720	270	4	6
34P1869	349630	576030	331	29	886	4081	22	82250	560	8	4
34P1870	348350	571700	10	14	51	246	10	27780	160	4	4
34P1871	350630	578480	101	55	5947	2657	30	96070	620	0	3
34P1872	353990	572090	1	9	29	148	5	19050	270	1	4
34P1873	346800	569690	17	92	63	198	12	53760	210	86	0
34P1874	350710	575490	29	129	1502	2145	28	116670	310	210	8
34P1875	358900	576190	42	60	1749	25200	31	42930	470	0	0
34P1876	358400	575390	17	36	318	1019	22	33660	540	1	7
34P1877	358880	575830	6	15	156	130	6	19680	210	3	12
34P1878	351590	574380	0	4	10	193	0	2970	30	0	3
34P1879	357500	574930	0	2	23	132	1	8390	60	1	0
34P1880	345990	571690	2	14	46	205	13	67150	290	0	0
34P1881	357210	577530	9	11	122	240	11	16170	280	1	0
34P1882	350600	573390	14	80	1601	12400	29	245820	1710	47	1
34P1883	352530	573800	21	86	136	131	5	33180	170	12	7
34P1884	348080	570370	2	15	22	275	6	17150	90	2	0
34P1885	349300	575400	8	20	156	1090	21	43810	410	0	3
34P1886	348900	573990	261	463	4117	28100	39	205620	1150	708	8
34P1887	346800	573600	5	18	128	757	7	47780	150	18	2
34P1888	355880	577920	10	16	101	938	14	56130	240	15	1
34P1889	358610	575090	0	10	37	524	3	12510	150	3	5
34P1890	354200	578820	6	13	204	1787	9	32170	500	0	0
34P1891	357450	574150	1	15	40	109	4	25620	180	0	0
34P1892	358090	575320	7	16	164	689	7	25880	140	0	1
34P1893	349500	576700	8	16	266	698	12	45770	430	0	0
34P1894	347400	572700	37	97	238	4465	30	273910	1770	270	6
34P1895	358820	575400	55	151	1618	2091	26	59410	250	1	0
34P1896	357700	576700	111	210	2549	3978	99	152910	570	0	0
34P1897	356810	576830	15	33	93	640	24	31520	350	0	0
34P1900	348900	572900	25	60	63	1606	26	203930	1150	0	2
34P2001	365660	574360	16	71	581	85	16	38880	130	4	0
34P2002	363400	574170	17	31	727	575	14	57210	220	0	0
34P2003	361830	571080	0	13	412	73	2	14120	100	4	2
34P2004	360010	573010	0	22	158	85	0	10930	140	0	19
34P2005	346200	577700	17	15	566	633	12	38890	320	6	5
34P2006	357400	569910	4	13	335	228	6	17350	230	1	1
34P2007	361810	572370	4	8	235	189	6	17550	210	4	6
34P2008	358850	570400	69	65	1352	273	23	43000	310	2	1
34P2011	348700	578080	7	15	872	131	9	32440	190	6	11
34P2012	362700	577080	10	6	124	1831	5	26530	150	5	9
34P2013	360680	570900	15	56	1279	1478	19	95170	450	0	2
34P2014	350180	569630	1	7	18	137	4	10400	60	6	0
34P2015	365620	571230	1	8	119	105	2	14980	90	0	3

Table 2 (continued)

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Mn ppm	Sn ppm	Sb ppm
34P2016	356570	568880	6	36	205	202	13	106140	560	38	0
34P2017	345970	576250	36	27	65	110	10	94710	630	5	0
34P2018	357520	570910	6	69	111	114	9	28910	180	1	1
34P2019	351200	578900	54	40	138	160	10	36860	270	61	0
34P2020	356090	572050	0	0	38	93	4	22090	120	0	3
34P2021	363340	572600	7	12	821	76	3	8100	40	0	2
34P2022	362800	573800	16	24	2686	156	6	28190	180	4	17
34P2023	365610	574220	3	33	341	115	5	13790	180	7	10
34P2024	358610	570850	9	10	284	85	9	20720	140	0	0
34P2025	354120	569600	0	12	25	166	5	18770	120	3	1
34P2026	364090	574400	7	10	735	150	4	38560	240	1	0
34P2027	359060	570400	0	101	137	668	3	21410	300	3	8
34P2028	360820	570850	8	20	874	447	6	22610	180	0	0
34P2029	363930	576020	2	9	54	79	3	10040	70	0	0
34P2030	361050	577370	29	25	1800	666	10	25410	170	0	0
34P2034	361770	573470	7	47	1093	317	8	33240	260	0	0
34P2035	352520	577920	2	12	38	77	6	24260	210	8	5
34P2036	363310	571850	4	19	257	139	11	29810	640	3	3
34P2037	367600	574240	27	124	1555	926	26	103110	420	2	1
34P2038	355220	570720	1	9	94	246	4	19910	110	4	4
34P2039	354770	569980	4	17	62	155	12	61960	390	2	1
34P2040	353650	569120	6	20	64	229	14	61380	310	0	0
34P2043	360600	574160	19	14	448	436	5	16540	250	0	0
34P2044	362700	575710	82	45	2119	1211	20	53590	270	0	0
34P2045	364120	575540	3	10	221	125	2	8430	60	0	0
34P2046	350020	569460	2	2	47	162	7	13350	110	5	0
34P2047	367340	571610	3	8	88	135	6	13830	120	3	5
34P2049	367590	574700	7	25	531	793	14	53230	220	1	3
34P2050	362600	572550	2	6	50	423	4	12410	110	4	3
34P2051	355300	572450	4	34	34	204	5	13260	90	13	5
34P2052	361200	574310	2	15	773	113	5	17180	100	0	0
34P2053	367800	571730	6	12	150	123	7	29090	160	6	7
34P2055	345900	574700	21	93	6140	3240	25	200740	1080	17	12
34P2058	360580	572990	5	52	803	268	7	24450	200	1	4
34P2059	355700	571460	4	11	153	154	6	24480	130	2	0
34P2061	345720	574770	72	56	253	1278	11	56220	260	1	0
34P2063	345360	577240	7	18	398	458	14	47010	310	3	4
34P2064	361780	576000	3	10	33	67	4	15910	230	8	6
34P2066	359880	572630	12	27	540	213	10	32440	170	0	0
34P2067	355500	568540	4	100	66	151	10	101470	420	29	1
34P2070	367730	573540	4	19	149	263	8	30660	150	2	0
34P2072	366430	571840	7	22	482	125	9	24540	110	5	7
34P2073	355570	570650	4	12	69	136	7	44920	160	5	5
34P2075	363500	573380	8	11	1326	164	5	22370	100	3	0
34P2079	363100	570700	1	1	40	81	3	8890	60	6	16
34P2080	364570	576190	17	70	2757	1719	15	49500	130	1	2
34P2082	367890	573300	0	2	19	80	4	9520	50	0	0
34P2083	360400	574470	6	37	252	392	8	46370	500	0	
34P2085	349900	571040	5	14	29	236	11	61630	240	3	1

Table 2 (continued)

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Mn ppm	Sn ppm	Sb ppm
34P2088	357800	570970	24	67	666	143	38	51350	500	0	0
34P2090	360320	570380	53	200	2530	1229	19	72300	510	6	0
34P2091	361880	576130	3	18	280	88	5	21680	230	0	6
34P2092	364200	573650	22	63	677	940	18	76400	400	0	0
34P2093	351130	570950	4	16	50	128	8	19500	150	7	4
34P2094	365690	571110	2	12	520	106	4	12180	70	5	0
34P2095	362610	576490	50	45	1257	1519	17	47340	280	2	2
34P2096	362260	577750	3	15	1209	110	5	17510	110	0	1
34P2097	356470	569080	8	564	24	124	5	32550	180	14	0
34P2098	360870	576160	8	36	594	226	11	53820	320	1	4
34P2100	360810	576000	1	26	106	182	8	35150	1210	3	4
HBP735	368540	568290	0	27	365	342	10	67910	500	1	4
HBP754	368830	568200	19	25	413	1618	13	66500	540	7	7
HBP918	357460	568180	39	10	32	584	2	13030	100	8	0
HBP926	358640	568050	5	30	802	888	8	37700	260	0	9
HBP936	360060	569430	15	8	1051	784	12	19080	150	5	3
HBP946	366070	571090	72	603	2776	1280	28	83960	370	3	0
HBP947	359530	568290	107	120	2928	3711	33	144730	960	7	35
HBP957	356400	568860	0	23	151	125	4	33110	220	6	11
HBP961	364800	570590	11	79	168	99	13	74600	340	4	4
HBP962	359030	568580	0	10	27	133	4	18980	140	5	0
HBP963	363870	568340	0	66	1287	3044	26	142830	1100	0	2
HBP983	362470	568280	28	19	62	109	2	12900	120	2	0
HBP987	360480	568810	11	38	7462	1440	18	60740	170	4	1
HBP2704	358420	585720	9	46	406	92	14	68860	700	5	1
HBP2705	359620	584750	1	0	113	29	2	5850	40	0	0
HBP2710	359560	586380	3	12	69	174	7	16590	90	1	0
HBP2715	357620	585180	5	30	173	84	11	54670	440	0	0
HBP2734	358240	586300	0	4	21	60	4	6480	30	0	0
HBP2741	358370	586300	7	7	281	1077	7	14600	70	0	2
HBP2743	359360	584120	8	8	21	270	4	14960	120	5	0
HBP2777	358830	586220	2	4	25	87	6	12060	60	2	3
HBP2782	359020	586260	11	29	321	294	13	45610	450	0	0
HBP2792	358640	586160	52	3	434	1044	6	12480	70	0	2
HBP2795	357640	585140	1	9	46	63	5	24000	210	1	1
BFP2281	354740	586520	2	4	0	107	4	9700	100	1	0
BFP2286	353220	585450	6	29	170	1963	28	66800	300	1	0
BFP2287	351650	584740	2	23	167	1111	13	61300	200	3	0
BFP2288	350550	584040	1	9	59	148	5	35900	200	2	1
BFP2290	354700	586810	7	16	253	97	23	44400	100	2	4
BFP2292	353920	586280	18	20	330	1544	14	55600	200	5	0
BFP2293	355270	586670	41	13	193	1972	13	33500	700	0	3
BFP2294	355360	586700	4	4	211	645	8	16000	200	4	1
BFP2295	353850	586340	4	0	275	1671	10	45900	200	0	0
BFP2296	355120	586600	21	8	258	4428	8	25100	100	1	7
BFP2297	353220	586020	5	13	418	2391	18	43300	200	3	1
BFP2298	351710	584880	0	10	132	192	8	53100	200	2	0
BFP2299	350890	584060	4	7	2071	442	6	35200	100	14	0
BFP2908	351110	586260	13	13	638	1999	24	66300	300	0	0

Table 2 (continued)

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Mn ppm	Sn ppm	Sb ppm	As ppm
BFP2911	350670	586590	0	27	110	634	19	49400	500	3	0	
BFP2912	350470	586500	5	21	186	1861	12	51900	300	3	0	
BFP2913	351300	586110	0	14	196	1484	12	49900	200	3	5	
BFP2914	351510	586440	7	42	2036	1445	13	49900	200	1	0	
BFP2915	351690	586770	2	10	22	270	5	23900	100	0	0	
BFP2929	350070	583570	0	15	79	90	9	35900	300	0	1	
BFP2930	350200	583730	1	12	75	175	5	25000	200	0	0	
BFP2998	348440	583420	3	3	159	76	7	34500	200	0	0	
BFP2999	348210	583790	3	41	646	144	8	23400	100	2	4	
BFP3000	348490	584100	4	0	15	104	4	15400	100	1	2	
BFP4010	348470	586450	20	62	273	687	29	162300	800	5	3	
BFP4011	348840	586500	9	17	52	205	11	47400	200	2	0	
BFP4013	349920	586520	5	1	49	237	3	18100	100	3	0	
BFP4014	349610	586410	3	10	47	357	5	32800	100	4	4	
BFP4098	355380	586980	7	27	521	1160	8	22700	200	1	2	
BFP4099	355060	586700	19	21	1128	3644	20	56700	200	0	2	
BFP4100	354600	586600	14	10	376	1036	11	40700	100	0	3	
BFP4138	351840	586810	74	84	1328	3158	22	74500	200	54	5	
BFP4169	345200	581090	16	30	87	1835	18	76000	500	9	1	
BFP4170	345180	581710	6	15	75	5167	13	64600	400	0	0	
BFP5426	350650	584900	3	8	21	124	5	15700	100	3	9	
BFP5427	350550	584910	3	17	61	129	10	39000	3200	2	3	
BFP7203	350280	578440	212	34	2316	140	25	51196		2	0	9
BFP7204	350140	579590	12	36	1705	1860	21	82040		4	0	15
BFP7205	349770	579580	30	33	915	402	15	63855		1	0	12
BFP7206	352660	584170	27	29	485	180	26	96517		8	2	10
BFP7207	352920	583410	3	8	326	130	6	20143		4	1	5
BFP7208	351960	583160	6	17	283	1037	12	45531		5	1	8
BFP7209	353380	582760	19	52	186	626	31	158974		12	9	46
BFP7210	353220	583160	7	22	45	102	15	75116		10	0	13
BFP7211	352300	582860	6	19	476	2077	15	57421		9	1	17
BFP7212	358980	576960	20	21	6874	3995	14	17135		0	0	3
BFP7213	358740	577000	73	90	<10000	5591	48	56512		0	0	11
BFP7214	358350	576760	24	34	1066	623	23	38957		1	0	7
BFP7215	357620	578580	21	12	206	683	7	9652		1	2	2
BFP7216	357630	578700	10	14	147	2443	12	21472		0	1	4
BFP7217	357170	578470	11	20	1880	111	8	11820		1	0	3
BFP7218	356770	578370	77	79	321	549	50	62596		4	1	13
BFP7219	356070	578030	4	9	50	191	7	18045		7	0	4
BFP7220	351030	580300	7	29	225	725	10	32592		23	1	8
BFP7221	352500	581430	34	27	353	2239	23	56092		6	0	15
BFP7222	351680	580740	11	48	151	723	20	112813		9	6	36
BFP7223	352330	580200	44	64	921	1085	23	87075		7	2	26
BFP7225	355660	583240	19	23	571	826	13	41894		4	2	9
BFP7226	355360	583080	11	24	1468	1482	12	35879		4	3	8
BFP7227	355620	582960	2	7	48	95	5	10351		4	4	3
BFP7228	355660	585090	5	7	26	37	4	6574		3	4	1
BFP7229	355600	583580	140	306	3078	6279	73	98545		4	1	22

Table 2 (continued)

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Sn ppm	Sb ppm	As ppm
BFP7230	355600	583570	28	93	3326	806	35	122465	8	2	23
BFP7231	356040	584000	4	14	274	71	6	20143	25	1	10
BFP7232	355980	584020	31	92	2823	446	35	96727	5	3	15
BFP7233	357580	577610	7	13	134	91	7	13428	2	2	2
BFP7234	357830	577210	13	38	509	213	15	18045	1	1	4
BFP7235	357190	577340	62	73	3447	1539	44	57701	2	0	12
BFP7236	357160	577480	17	52	82	724	10	17695	4	2	4
BFP7237	349680	577140	60	13	2494	156	11	23500	39	0	4
BFP7238	349690	576700	179	87	5078	28136	80	128340	17	4	44
BFP7239	349590	576670	39	31	1405	3574	24	62317	3	0	19
BFP7240	349200	576780	244	132	<10000	34159	98	111974	6	3	32
BFP7241	349640	576140	77	100	3265	53281	41	146734	12	2	44
BFP7242	350760	581900	47	25	235	2800	16	52805	15	3	16
BFP7243	353180	581700	12	30	74	246	17	92531	12	2	26
BFP7244	352480	581500	9	30	292	3063	16	61827	30	8	17
BFP7245	352100	581750	31	72	647	2677	39	163730	12	5	56
BFP7251	350060	578800	16	38	1085	490	19	76794	22	0	13
BFP7252	349720	579040	9	24	420	1550	14	46021	6	1	12
BFP7253	350280	579240	16	37	955	1758	21	96237	5	1	20
BFP7254	349300	579690	15	42	1241	689	17	68891	28	2	11
BFP7255	349390	579710	18	53	1369	1004	24	97986	8	1	18
BFP7256	352280	583770	7	18	134	797	13	44202	5	2	10
BFP7257	352740	583500	3	22	29	114	6	18534	15	4	10
BFP7258	351800	582850	5	14	375	397	11	31403	6	2	12
BFP7259	352980	582440	20	38	567	5264	26	82180	9	1	19
BFP7260	352440	582260	27	44	1271	14115	30	96447	85	0	20
BFP7261	352300	582350	13	43	212	1440	25	126521	12	4	36
BFP7262	352020	581240	16	53	188	1384	31	162680	22	5	29
BFP7263	352240	581000	35	44	1061	4925	31	100294	11	1	25
BFP7264	352270	580720	33	50	670	15763	37	104770	8	5	33
BFP7265	357950	576700	42	61	319	85	24	36159	1	2	12
BFP7266	357100	576760	102	113	461	2104	78	85187	5	0	24
BFP7267	356570	582800	28	28	489	298	11	48538	1	0	7
BFP7268	356600	582700	17	31	234	5614	13	22731	1	0	8
BFP7269	356220	582550	4	13	100	67	6	14967	3	1	3
BFP7270	356250	582580	134	25	535	3549	14	37068	4	2	6
BFP7271	355900	582400	23	46	957	1539	28	84208	8	0	14
BFP7272	355930	582500	47	20	223	877	9	31123	3	0	4
BFP7273	356200	584920	87	222	1615	1565	29	126312	5	0	10
BFP7274	355650	584600	48	120	1046	505	36	145252	6	0	15
BFP7275	355410	583830	45	94	2085	1213	53	152941	8	3	10
BFP7276	358250	577310	19	50	8240	18209	12	15728	1	-5	5
BFP7277	357240	577400	19	21	393	583	24	32434	3	3	7
BFP7278	356760	577380	41	12	47	199	11	21389	9	1	6
BFP8001	358320	581065	4	10	64	198	6	14329	<5	<5	<5
BFP8002	358500	581595	4	9	39	83	7	10974	<5	<5	7
BFP8003	358680	581165	19	8	15	<5	4	8953	<5	<5	<5
BFP8004	358795	580130	8	9	632	4827	3	7554	<5	<5	8
BFP8005	358195	580320	77	73	2931	762	36	57984	6	<5	7

Table 2 (continued)

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Sn ppm	Sb ppm	As ppm
BFP8006	357815	580325	24	47	93	<5	32	213399	24	<5	59
BFP8007	357640	580400	40	60	326	142	31	71273	<5	<5	6
BFP8008	357625	580645	18	36	459	122	26	69315	<5	<5	9
BFP8009	358115	580860	20	38	182	445	18	40917	<5	<5	10
BFP8010	357345	583100	4	16	148	636	7	17696	<5	<5	<5
BFP8011	357440	583080	470	58	1369	14400	35	56515	<5	<5	13
BFP8012	357400	582995	35	22	5200	176	15	31335	<5	<5	<5
BFP8013	357300	582920	23	10	29	33	8	9163	<5	<5	27
BFP8014	357200	583020	12	12	85	50	5	11051	<5	<5	<5
BFP8015	356770	582785	12	20	245	2439	8	17206	<5	<5	<5
BFP8016	356720	582660	5	12	88	19	8	14548	<5	<5	<5
BFP8017	352420	575110	38	936	3607	1298	13	39798	72	8	6
BFP8018	352830	574815	5	7	450	577	3	17766	<5	<5	<5
BFP8019	353950	575075	42	10	106	885	11	34622	<5	<5	6
BFP8020	353060	575840	3	9	89	66	5	12520	<5	<5	<5
BFP8021	353970	575950	6	7	167	31	6	15947	6	<5	<5
BFP8022	354040	576505	8	13	1211	510	7	21613	<5	<5	<5
BFP8023	358555	575870	11	13	215	270	8	12450	<5	<5	<5
BFP8024	358400	575395	4	7	226	191	4	8953	<5	<5	<5
BFP8025	358180	575360	13	25	53	3443	12	32874	<5	<5	7
BFP8026	358095	575360	45	30	572	1637	19	50989	<5	<5	9
BFP8027	357720	575120	8	17	92	280	10	17766	17	<5	<5
BFP8028	356480	575400	55	74	37	95	35	64348	<5	<5	<5
BFP8029	356660	575115	29	59	21	409	23	34832	<5	<5	8
BFP8030	353600	570220	5	10	24	163	10	24900	<5	<5	<5
BFP8031	352520	570825	6	15	35	172	4	12240	<5	<5	8
BFP8032	351620	571190	6	16	34	283	7	26019	<5	<5	6
BFP8033	351070	570820	37	48	117	443	20	75050	33	<5	12
BFP8034	350320	571120	7	24	47	1089	13	75260	9	<5	8
BFP8035	349940	571030	22	58	100	1921	42	299640	20	6	20
BFP8036	355825	583440	120	101	2102	3635	68	113659	<5	<5	24
BFP8037	356385	583465	48	80	488	1229	62	155625	<5	<5	7
BFP8038	356375	584040	3	11	26	149	6	9582	<5	<5	5
BFP8039	356445	584175	5	5	14	56	<3	3637	<5	<5	<5
BFP8040	356825	584920	108	56	485	<5	29	145693	7	<5	12
BFP8041	356360	585050	32	10	401	8200	7	20983	<5	<5	<5
BFP8042	356345	585330	19	8	108	44	3	13989	<5	<5	<5
BFP8043	357290	579570	20	43	110	23	23	112960	15	<5	19
BFP8044	357235	579410	14	25	64	151	13	40428	<5	<5	10
BFP8045	355980	579560	7	16	180	96	12	36860	<5	<5	<5
BFP8046	356120	579600	9	27	185	44	13	69874	<5	<5	10
BFP8047	356920	579590	18	34	78	156	20	62320	<5	<5	<5
BFP8048	357760	579200	10	28	302	491	15	30566	<5	<5	<5
BFP8049	358100	579120	8	19	369	91	10	24131	<5	<5	<5
BFP8050	358940	577400	<3	10	105	141	4	2728	<5	<5	<5
BFP8051	358860	577460	3	10	63	66	<3	1539	<5	<5	<5
BFP8052	358880	577780	3	6	84	108	4	6575	<5	<5	<5
BFP8053	359460	577460	<3	7	58	67	<3	1888	<5	<5	<5
BFP8054	349015	576780	17	28	164	37	6	9372	<5	<5	<5

Table 2 continued

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Sn ppm	Sb ppm	As ppm
BFP8055	348655	576340	<3	8	47	130	6	6715	<5	<5	<5
BFP8056	358840	581065	61	6	1145	1944	5	11401	<5	<5	<5
BFP8057	359300	581100	479	83	7100	63100	35	57354	8	<5	6
BFP8058	359570	581260	17	<3	10	124	<3	2728	<5	<5	<5
BFP8059	356660	584520	16	63	1090	<5	14	86171	<5	<5	8
BFP8060	356520	584380	15	20	4900	64	15	29726	<5	<5	<5
BFP8061	356320	584300	15	51	418	1220	18	54696	<5	<5	6
BFP8062	356100	584185	25	55	895	509	22	73371	<5	<5	6
BFP8063	356130	584060	4	13	440	80	6	23921	<5	<5	5
BFP8064	355965	583940	29	96	3385	238	32	136601	<5	<5	18
BFP8065	355825	583765	10	37	2220	475	15	58333	<5	<5	9
BFP8066	351400	574660	<3	43	32	88	<3	5875	109	<5	<5
BFP8067	351880	574060	126	25	6000	4168	12	30845	<5	<5	6
BFP8068	352360	573920	16	13	531	484	3	8253	9	<5	<5
BFP8069	353140	573760	59	36	81	809	16	93445	19	<5	<5
BFP8070	353780	573390	9	11	402	1554	5	33853	<5	<5	<5
BFP8071	354180	573960	4	12	608	575	8	27698	5	<5	<5
BFP8072	359100	575640	37	110	1144	4337	35	48471	<5	<5	7
BFP8073	358770	575540	8	17	63	275	9	18955	<5	<5	<5
BFP8074	358875	575840	8	19	139	269	9	18115	<5	<5	<5
BFP8075	358740	576120	16	53	407	506	16	26789	<5	<5	<5
BFP8076	359200	576340	17	12	1652	39600	18	19165	6	<5	<5
BFP8077	351060	579445	10	48	347	451	10	37280	242	<5	6
BFP8078	358800	574680	25	41	424	862	28	49590	<5	<5	<5
BFP8079	350060	583265	8	20	103	628	14	75959	<5	<5	15
BFP8080	349620	583060	5	15	83	280	13	73931	<5	<5	11
BFP8081	349445	582925	4	15	32	142	11	49870	7	<5	7
BFP8082	349280	582620	7	20	78	280	16	43365	<5	<5	7
BFP8083	348820	582800	29	34	99	54	73	124850	10	7	16
BFP8084	352000	579300	57	48	943	349	40	103307	<5	<5	17
BFP8085	352000	579240	3	11	261	148	8	34133	5	<5	<5
BFP8086	352540	578120	4	26	21	87	4	10002	<5	<5	<5
BFP8087	353340	577600	12	24	17	60200	<3	6505	10	<5	<5
BFP8088	352720	577320	12	40	213	109	13	67636	120	<5	8
BFP8089	354380	581300	7	13	554	661	5	27278	<5	<5	7
BFP8090	354260	580760	<3	6	38	120	5	8253	<5	<5	<5
BFP8091	354620	582120	6	8	99	3225	3	13359	<5	<5	6
BFP8092	353180	581700	7	22	65	114	10	70294	9	7	13
BFP8093	352560	581720	26	11	337	1553	35	67496	13	5	<5
BFP8094	352360	580100	7	17	190	93	9	47912	<5	<5	5
BFP8095	355960	577640	3	4	114	591	7	14269	<5	<5	<5
BFP8096	355920	576700	<3	8	24	103	7	11611	<5	<5	<5
BFP8097	355685	576800	15	26	178	575	13	53997	29	<5	12
BFP8098	355380	576520	4	7	358	446	8	20354	<5	<5	<5
BFP8099	354840	576320	7	13	159	281	9	22942	6	<5	6
BFP8100	356480	576460	<3	22	26	102	7	15318	<5	<5	5
BFP8101	350180	574185	26	39	638	776	8	35671	24	<5	<5
BFP8102	350340	574480	30	11	1121	1372	10	30076	7	<5	<5
BFP8103	349940	575100	8	9	243	3520	8	21823	<5	<5	<5

Table 2 (continued)

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Sn ppm	Sb ppm	As ppm
BFP8104	349780	575375	20	29	256	14200	18	48821	<5	<5	<5
BFP8105	349080	575625	16	27	465	640	15	48191	35	<5	8
BFP8106	349620	575945	51	69	303	54200	26	148002	13	<5	49
BFP8107	349280	576240	71	46	880	19200	24	98621	9	<5	26
BFP8108	349700	576425	81	51	1754	7700	32	93725	18	<5	19
BFP8109	349640	576600	57	58	1367	13500	45	137580	13	<5	28
BFP8112	358480	581020	20	13	455	949	8	15318	<5	<5	<5
BFP8113	359275	581020	22	5	1354	1343	6	8393	<5	<5	<5
BFP8114	355885	580155	5	9	41	25	5	26019	<5	11	10
BFP8115	356420	580665	8	30	64	97	14	50430	<5	<5	6
BFP8116	356630	580135	7	15	151	101	9	33363	<5	<5	11
BFP8117	356720	580105	20	35	108	128	21	85332	9	<5	13
BFP8118	357248	580395	37	84	275	391	42	173811	8	8	29
BFP8119	357530	580580	4	15	48	79	11	38189	6	<5	<5
BFP8120	354695	581480	22	33	944	1430	19	90717	<5	<5	7
BFP8121	355245	581620	15	42	123	442	18	142126	7	<5	38
BFP8122	355965	581580	9	29	132	255	13	50849	5	<5	<5
BFP8123	354445	581360	13	42	230	171	25	112120	14	<5	18
BFP8124	354380	580240	<3	15	411	161	12	39728	7	<5	5
BFP8125	355555	571745	7	17	134	82	13	71063	7	<5	7
BFP8126	355960	571920	3	6	39	118	5	9163	<5	<5	<5
BFP8127	356040	572005	9	15	104	315	12	38329	11	<5	5
BFP8128	354430	572285	4	16	124	807	14	57004	11	<5	9
BFP8129	353785	571945	6	9	29	270	8	37140	<5	<5	7
BFP8130	352930	572120	10	14	41	1330	8	54416	<5	<5	<5
BFP8131	356780	574080	5	14	117	287	11	35042	<5	<5	7
BFP8132	357220	573625	18	38	135	816	13	53018	13	<5	5
BFP8133	358540	573945	11	15	461	284	14	23781	<5	<5	<5
BFP8134	357820	574640	6	31	18	181	8	14618	31	<5	<5
BFP8135	358240	574535	17	24	45	102	14	25879	<5	<5	<5
BFP8136	357635	574245	11	15	30	275	9	33014	14	<5	7
BFP8137	348680	578100	5	28	1362	142	17	78967	<5	<5	10
BFP8138	348515	578485	3	10	271	325	4	16996	<5	<5	<5
BFP8139	349505	577980	37	63	4100	454	17	48401	91	<5	7
BFP8140	349725	577430	62	18	701	302	16	43365	13	<5	16
BFP8141	349635	576925	26	15	365	164	9	22242	18	<5	<5
BFP8142	357620	585720	17	36	218	2556	12	29446	<5	<5	46
BFP8143	357780	585480	4	11	1700	138	7	11960	<5	<5	<5
BFP8144	357590	585300	22	47	732	<5	16	108833	7	<5	<5
BFP8145	357555	585200	18	43	510	<5	24	110162	<5	<5	<5
BFP8153	353065	584395	9	17	178	145	17	63229	<5	<5	<5
BFP8154	353520	583700	<3	12	26	82	6	16227	<5	<5	<5
BFP8155	355280	583760	6	25	76	424	12	29796	<5	<5	<5
BFP8156	355460	584400	13	26	974	82	10	38749	<5	<5	<5
BFP8157	362285	577750	3	14	823	104	7	12450	<5	<5	<5
BFP8158	361140	577660	41	4	246	50	4	3497	<5	<5	<5
BFP8159	360980	577340	8	10	1766	1169	3	6015	<5	<5	<5
BFP8160	349165	575395	17	46	345	3203	14	30845	6	<5	<5
BFP8161	348720	575060	103	25	669	5500	22	47632	<5	<5	10

Table 2 (continued)

Sample Ref. No.	Easting	Northing	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	Fe ppm	Sn ppm	Sb ppm	As ppm
BFP8162	348955	574740	8	9	205	676	7	19025	10	<5	<5
BFP8163	348460	575115	6	13	977	8200	11	42246	<5	<5	11
BFP8164	348900	574340	43	205	129	4574	15	53927	205	22	13
BFP8165	349080	574070	57	52	890	4885	20	126669	64	<5	14
BFP8166	348375	574190	5	9	385	1501	11	34482	<5	<5	8
BFP8167	351365	576120	31	56	971	2776	49	107784	120	<5	19
BFP8168	351290	576140	70	64	1649	1846	49	148071	61	<5	21
BFP8169	350155	575945	14	34	1172	3877	17	46793	<5	<5	10
BFP8170	350740	582980	8	21	105	199	15	57984	6	<5	<5
BFP8171	351645	582260	6	57	66	692	9	46093	8	<5	8
BFP8172	351480	582400	13	40	331	633	25	132544	10	<5	15
BFP8173	350630	582320	3	239	70	176	16	54766	<5	<5	<5
BFP8174	350560	582190	14	26	187	70400	19	53087	26	<5	19
BFP8175	350710	581755	7	13	194	1345	6	39169	<5	<5	<5
BFP8176	350815	581100	10	19	227	769	15	48331	15	<5	<5
BFP8177	362830	575820	102	4400	6600	10400	47	90508	275	<5	16
BFP8178	360920	577405	10	16	410	198	6	14688	<5	<5	<5
BFP8179	360400	577470	14	5	136	49	<3	2448	<5	<5	<5

Table 3A Surface Rock Sample Descriptions

SAMP. REF. NO.	EASTING	NORTHING	LOCALITY	COMMENTS
BFR7006	350220	578450	CROOK BURN 580M W OF CROOKBURN FM	GREY ALGAL LIMESTONE
BFR7007	350210	578450	CROOK BURN 560M W OF CROOKBURN FM	MUDDY LMSTN. SOME FOSSILS. VERY THIN CARB. VEIN
BFR7008	350220	578450	CROOK BURN 540M W OF CROOKBURN FM	DENSE LMSTN. VERY FOSSILIFEROUS
BFR7009	350230	578450	CROOK BURN 520M W OF CROOKBURN FM	FOSSILIFEROUS MUDDY LMSTN.WITH SILTY BAND
BFR7010	350240	578450	CROOK BURN 500M W OF CROOKBURN FM	VERY FOSSILIFEROUS
BFR7011	350250	578450	CROOK BURN 480M W OF CROOKBURN FM	THIN VEINS, CARBONATE LINED CAVITIES
BFR7012	350260	578450	CROOK BURN 460M W OF CROOKBURN FM	?FE-OXIDES ON SURFACE OF CARB.VEINS
BFR7013	350270	578450	CROOK BURN 440M W OF CROOKBURN FM	?ZNS IN SCATTERED AGGREGATES
BFR7014	350280	578450	CROOK BURN 420M W OF CROOKBURN FM	IRREGULAR PATCHES OF IRON STAINING, FLOAT SAMPLE
BFR7015	350290	578470	CROOK BURN 400M W OF CROOKBURN FM	COARSE CARB. VEIN WITH ZNS, FLOAT SAMPLE
BFR7016	350300	578450	CROOK BURN 400M W OF CROOKBURN FM	O'CROP 10M E OF FAULT, ABUN VNG WITH CSE ZNS IN LMSTN
BFR7017	350460	568400	CROOK BURN 300M W OF CROOKBURN FM	FLOAT SAMPLE
BFR7018	350120	579580	CROOK BURN 1 KM W OF SAUGHS	FES/MARC IN 0.5CM THICK BAND PAR. TO BEDDING, FLOAT
BFR7020	350140	579510	CROOKBURN 1 KM WSW OF SAUGHS	3CM CARB VEIN WITH? OXID SULPH (NOW 2Y-FEOX.), FLOAT
BFR7021	350140	579520	CROOKBURN 20 M UPSTRM OF BFR 7020	V FINE IRREG FES/MARC AROUND SMALL FOSSILS, FLOAT
BFR7023	350570	578440	CROOKBURN APPROX.200M UPSTRM OF CROOKBURN FM	SANDSTONE WITH 1 OR 2 FINE ?PBS GRAINS (PBS IN HAND SPECIMEN)
BFR7024	350590	578460	10M UPSTRM OF BFR7023 IN CROOKBURN	FLOAT (LOCAL) HEAVILY VEINED (CARB) UPTO 1CM WIDE
BFR7025	350490	578460	10M UPSTRM OF BFR7024 IN CROOKBURN	FINE-GRND DARK LMST WITH SCATTRD. SMALL FES XSTALS
BFR7026	358980	577040	E HDWTR. TRIB ASHY CLEUGH 50M UPSTRM BFP 7212	MUDDY LMST. FLOAT. EXTENSIVE CALC VNING WITH CSE ZNS
BFR7027	358980	577040	E HDWTR. TRIB ASHY CLEUGH 60M UPSTRM BFP 7212	FLOAT FROM NEARBY O'CROP. 1CM CALC VN WITH CSE ZNS
BFR7028	358950	577110	E HDWTR. TRIB OF ASHY CLEUCH 110M UPSTRM BFP 7212	OCCASIONAL SMLL GRNS FES IN LIMESTONE MATRIX
BFR7029	358950	577110	E HDWTR. TRIB OF ASHY CLEUGH 100M UPSTRM BFP 7212	THICK CALC. VN WITH A FEW PINK XTALS BA AND FINE FES
BFR7030	358760	577000	W HDWTR. TRIB ASHY CLEUGH 15M DWNSTRM BFP 7213	A FEW CSE ZNS IN CALC/QTZ VNS (0.5CM) IN ROOTY HARD SST
BFR7031	358760	577000	W HDWTR. TRIB ASHY CLEUGH 15M DWNSTRM BFP 7213	TWO ZNS XTLS IN FAULTED DARK SILTY LMST. SCATTRD FES
BFR7032	358760	577000	W HDWTR. TRIB ASHY CLEUGH (SAME SITE AS BFP 7213)	DARK SCATTERED SMALL XTALS ZNS IN THIN QTZ? VN.
BFR7033	355980	584000	ROBBIE'S GRAIN, 30M UPSTM CONFL WITH SHORTSHANK SIKE	FLOAT BOULDER
BFR7034	349720	583300	400M DWNSTRM KERSHOPE BRIDGE ON N BANK OF BURN	2M WIDE BITUMINOUS DOLOMITIC ORANGE WEATHERED LMST.
BFR7035	357650	578590	STREAM N OF CREW FARM 30M UPSTM OF BFP7215	YELLOW WTHING 0.5M LMST IN STM BED. NO OBS. MINSN.
BFR7036	357190	578460	STREAM SECTION N OF CREW FARM 5M UPSTM OF BF7217	OXIDISED FES AND ?CUFES
BFR7040	355610	582960	1ST W DRNG STM N OF THE BECK 25M UPST FOREST TRK	SCATTERED SMALL XSTALS FES/MARC. ALONG VN MARGINS
BFR7041	349630	576800	SLEET BECK 325M UPST CONFL WITH SE FLWNG TRIB	SANDSTONE FLOAT HEAVILY VEINED WITH HEM AND THIN CALC.
BFR7042	349070	577010	MINOR TRIB. SLEET BECK DRNG E SIDE CHAMOT HILL	ABUN FES IN VEINS/PATCHES IN BITUMIN. CALC-VND LMST.
BFR7045	350750	581900	LANGLEY BURN 500M S OF DOG/GUN INN, SEE BFP 7242	SMALL CLAST AT SITE BFP7242

Table 3A continued

SAMP. REF. NO.	EASTING	NORTHING	LOCALITY	COMMENTS
BFR7046	351680	580740	ROUTLEDGE BURN 100M UPST FOREST TRACK	FES IN CALCITE VEIN IN SILTSTONE STREAM CLAST AT BFP7222
BFR7052	350140	578410	CROOK BURN 600M UPSTRM. CROOKBN FM	LIMESTONE FLOAT BOULDER
BFR7055	350060	578720	FIRST SOUTH DRNG STRM W OF CROOKBURN FARM	VERY FINE DISSEMINATED SULPHIDE ?FES. STREAM CLAST
BFR7056	349950	579000	FIRST SE DRNG STM SE CROOKBURN HILL	FLOAT, V. WTHD. SANDY LMSTN WITH CARBONAC. FRAGS
BFR7057	350300	579140	1ST S DRNG STRM W STONEKNOWE 20M DWNSTRM TRK	LIMESTONE FLOAT BOULDER
BFR7058	350250	579020	CROOK BURN 700M W BUTTERHILL	SMALL CEMENSTONE CLAST
BFR7059	358160	576580	ASHY CLEUGH 79DEG/625M FROM BLACK HILL	FLOAT. THIN CALC AND ?BA VNS UP TO 5 MM, MN/FE STAINED
BFR7061	357750	576700	ASHY CLEUGH 1400M UPSTRM FARM TRACK	IRON STAINING IN CARB. VN AND IN LMST. STREAM CLAST
BFR7063	356820	576830	STRM IN ASHY CLEUGH 400M UPSTRM FARM TRACK	POSS. FAULT BRECCIA. ABUN CALC. VNING AND FE STAINING
BFR7064	358280	577330	HILL CLEUGH 75M UPST 1ST N CONFL	CARBONATE-SULPHIDE VEINING IN STREAM CLAST
BFR7065	357980	577310	HILL CLEUGH 225M UPST W'FALL	LIMESTONE FLOAT. ABUN OUTCROP OF SAME LITHOL. UPSTM
BFR7066	357640	577140	HILL CLEUGH 50M UPST OF 1ST S TRIB	ZNS CRYSTALS IN CALCITE VEINS (UP TO 5 CM WIDE)
BFR7067	357760	577190	STM IN HILL CLEUGH AT WATERFALL, 40M DWNST WALL	FAULT? CALC-BARYTE VEINED SANDY LMST. FLOAT
BFR7068	357640	577140	STM IN HILL CLEUGH 50M UPST OF FIRST S BNK TRIB	PYRITE IN VUGS UP TO 0.5CM DIAMETER IN CALCITE VEIN
BFR7069	357320	577180	STM IN HILL CLEUGH 350M UPSTM ANTONSTOWN BURN	HEAVILY CALC VND FOSSIL LMST FLOAT, WITH OX FES & ?ZNS
BFR7083	362185	582475	HDWTR. TRIB OF BACK BURN 80M E GRAY MARE'S CRAGS	0.5M MUDDY SLTSTN+CARB. VNS (2CM). SLICKENSID SST CLASTS 5M UPSTM
BFR8201	356770	582785	THE BECK 1KM DWNSTM OF BECKHEAD CRAG	SAMPLE FROM BOULDER CLOSE TO OUTCROP
BFR8208	356400	583480	DRY SIKE 250M UPSTM OF QUARRY BY FOREST TRACK	NO OBVIOUS SULPHIDES IN CALCITE VEINS
BFR8209	358750	577200	STM FROM RUSHY CRAG 450M DWNSTM OF WALL	BARYTE PRESENT WITHIN CALCITE VEINS
BFR8210	358750	577100	OLD TRIAL WORKINGS WEST OF RED SKIRTS	SAMPLE TAKEN FROM AREA OF OLD WORKINGS/TRIALS
BFR8213	350710	581755	DIXONS SIKE. 50M UPSTRM OF LANGLEY BURN	LARGE FLOAT BLDR WITH CSE PALE AND DK. ZNS IN 2 CM CAL. VNS.
BFR8215	361100	577650	FOULBOG SIKE. 50M UPSTRM OF FOREST TRACK	HIGHLY VND/BRECC. LMST WITH PINK ?BARITE. FAULT (108DEG)
BFR8216	350620	575790	BLACK LYNE 900M DWNSTM FRM OAKSHAWFORD BDGE.	OUTCROP OF HIGHLY VEINED LIMESTONE
BFR8217	350800	575960	SW DRNG STRM 675M DWNSTM FROM OAKSHAWFORD BRIDGE	OUTCROP OF GREEN-RED TUFF IN RIVER BANK
BFR8226	359300	581100	ROUGH GRAIN 75M UPSTM CONFL. 350M E MIDDLE CRAG	CALC VEIN IN FLOAT, PODS UPTO 15 MM OF COARSE GRN PYRITE
BFR8227	359300	581100	ROUGH GRAIN 75M UPSTM CONFL. 350M E MIDDLE CRAG	DRK MUDDY LMST WITH DISS FINE PYRITE AND CALCITE VN
BFR8228	359480	581180	ROUGH GRAIN APPROX 100M W OF HDWTR TRIB JN	UNUSUAL DARK YELLOW/BROWN ?CALCITE, CHECK FOR ZNS.
BFR8229	359420	581120	ROUGH GRAIN APPROX 200M DWNSTRM OF HDWTR TRIB JN	O'CROP OF CLAY GOUGE+SSTN FRAGS (ROUGH GRAIN FAULT)
BFR8230	359350	581110	ROUGH GRAIN APPROX 130M UPSTM OF N HDWTR TRIB	ISOLATED GNS OF FES DISSEM AND IN JOINTS/FRACTURES
BFR8231	352500	573690	30M N OF RD. 100M UP DRAINAGE DITCH 300M BELOW FORD	DARK LMST FLOAT WITH CALCITE VEINS 2MM-1CM THICK
BFR8232	353780	573390	75M UP JOBS CLEUGH	NO SULPHIDES SEEN. SECONDARY IRON OXIDES ONLY
BFR8233	358800	576060	15M BELOW JUNCTN OF KIRK BURN AND BULL CLEUGH	LMST FLOAT WITH CALCITE VEINS. NEARBY LMST OUTCROP UNVEINED

Table 3A continued

SAMP. REF. NO.	EASTING	NORTHING	LOCALITY	COMMENTS
BFR8234	359240	576380	90M ABOVE W'FALL ON BULL CLEUGH	ALGAL LMST SAMPLE TAKEN FROM O'CROP ABOVE W'FALL
BFR8235	349445	583925	NW FLWG TRIB 400M NE OF THORNY KNOWE	LARGE PYROXENE LATHS VERY DARK COLOUR 1CM LONG. (FLOAT).
BFR8236	348560	582800	250M E OF BRIDGE OVER KERSHOPE BURN BY TOMS SIKE	VERY FOSSILIF SST. FE-OXIDES IN VEINS (HEM. AND FES), FLOAT
BFR8237	359140	576280	50M BELOW W'FALL BY GREEN BRAE ON BULL CLEUGH	ALGAL LMST NODULE FROM OUTCROP
BFR8240	355860	577780	DIRECTLY BELOW UNDERWOOD HOUSE ON CREW BURN	FINE FES IN VNS (3-4MM), O'CROP OF SST AND CALC MDSTN
BFR8241	355880	577710	BELOW UNDERWOOD HOUSE 100M S	CALCITE VEINS BRECCIATED IN PLACES PNK BA? LMST/MDST O'CROP
BFR8252	356720	580105	ON WHITE LYNE, 200M DWN FRM TRIB (SE FLWING)	FLOAT BLDR. INTENSE VEINING, NO SULPHIDES SEEN
BFR8253	354400	572275	N TRIB OFF SHOW BURN, 20M UPSTRM OF SSE FIREBRK	MUDDY LMST, WITH ?DISSEM MINERALISATION.
BFR8254	358540	573945	GREENS BURN ON NW FLOWING SECT 50M S OF CAIRN	THINNLY BEDDED LAMINATED SILTY LMST
BFR8255	349725	577430	SLEET BECK, 100M NW OF BARTLES HILL	FLOAT BOULDER
BFR8256	349635	576975	SLEET BECK, 100M ABOVE EDGE OF FOREST	FLOAT BOULDER
BFR8257	349635	576975	SLEET BECK, 100M ABOVE EDGE OF FOREST	YELLOW-WEATHERING IN-SITU CEMENTSTN OUTCROP
BFR8258	349725	577430	SLEET BECK, 100M NW OF BARTLES HILL	FLOAT BOULDER
BFR8278	355880	583440	DRY SIKE APPROX, 220M DWNSTRM OF QUARRY	CALC-BA VN (2CM)+ SEV. OTHER SMALL CAL VNS. FINE DISSEM FES
BFR8279	355580	583535	DRY SIKE AT JUNCTION WITH SHORTSHANK SIKE	INTENSELY VEINED OR/YELL. FOSSILIF. LMST O'CROP 0.5 M THICK
BFR8280	356055	583430	DRY SIKE 60M DWNSTM QUARRY	2-3M EXPOSURE IN STM BANK, LIMONITIC MUDSTONE, NO SULPHIDES
BFR8281	355580	583535	DRY SIKE 2M UPSTM JN WITH SHORTSHANK SIKE	BLACK MUDSTONE (0.3M) BENEATH HEAVILY VEINED LMST (BFR 8279)
BFR8282	345910	574720	TRIB OF RAE BURN, 80M DWNSTM OF SHAWSTOWN	BLACK SLTSTN IN SMALL FAULT. OVERLIES 5 CM CALC. VN (BFR 8283)
BFR8283	345910	574720	TRIB OF RAE BURN, 80M DWNSTM OF SHAWSTOWN	VEIN LIES IN SMALL FAULT PLANE IN N BANK OF STREAM
BFR8284	345840	574660	W FLOWING TRIB OF RAE BURN APPROX. 100M UPSTM JN	SMALL STM CLMST. V. HARD ORG RICH SST CF.'HARDEN BEDS ZNS'
BFR8286	356080	586920	S'MOST TRIB OF COAL GRAINS APPROX. 100M UPSTM JN	DARK MDSTN, SHALE AND THIN COALS LYING BENEATH 3 M SST
BFR8287	353700	584630	EXPOSURE IN ROUTLEDGE BURN 75M UPSTM FOREST TRK	INTENSLY CARBONATE VND. SILTY LMST WITH V FINE DISSEM FES
BFR8288	353660	584605	HDWATERS ROUTLEDGE BURN, CLASTS FROM 60M SECTN	VARIOUS INTENSELY CARBONATE-VEINED STREAM CLASTS
BFR8290	349620	576850	55M DWNSTM OF FOREST BNDRY ON SLEET BECK	LARGE FINE-GRND BASALT/DOLERITE BOULDER WITH FINE DISSEM FES
BFR8292	349680	576550	SLEET BECK AT JUNCTION WITH MAIN SE DNG TRIB	FLOAT. FINE FES IN MUDDY/SILTY FRAGS WITH RETICULATE CARB VNG

Table 3B Surface Rock Sample Data

SAMP REF. NO.	EASTING	NORTHING	ROCK TYPE	STYLE	MINERALS	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	As ppm	Sb ppm	Fe_2O_3t %	MnO %
BFR7006	350220	578450	LIMESTONE	VEIN	?ZN, ?CA	2	6	42	15	4	1	5	2.56	ND
BFR7007	350210	578450	LIMESTONE	VEIN	CA, ?ZN	4	6	23	13	5	1	2	1.24	ND
BFR7008	350220	578450	LIMESTONE	VEIN	CA, FE	4	7	238	95	3	0	<1	0.66	ND
BFR7009	350230	578450	LIMESTONE	VEIN	CA, ?ZN	12	23	163	64	24	2	4	3.13	ND
BFR7010	350240	578450	LIMESTONE	VEIN	CA, ?ZN	6	13	407	15	12	1	<1	1.06	ND
BFR7011	350250	578450	LIMESTONE	VEIN	CA, ZN, ?FE	11	18	392	36	18	2	<1	2.38	ND
BFR7012	350260	578450	LIMESTONE	VEIN	CA, ZN	5	8	849	8	6	0	<1	1.42	ND
BFR7013	350270	578450	LIMESTONE	VEIN	CA, ?ZN	6	14	232	5	10	0	<1	2.96	ND
BFR7014	350280	578450	LIMESTONE	VEIN	CA, ?ZN	8	22	197	16	19	1	<1	5.73	ND
BFR7015	350290	578470	LIMESTONE	VEIN	CA	7	9	1657	26	9	0	1	0.97	ND
BFR7016	350300	578450	LIMESTONE	VEIN	CA, ZN	6	7	1756	14	6	1	3	0.58	ND
BFR7017	350460	568400	LIMESTONE	VEIN	CA, ?FE	5	7	485	10	10	0	<1	1.20	ND
BFR7018	350120	579580	SANDSTONE	LENS	FE	2	2	13	64	3	2	<1	2.14	ND
BFR7020	350140	579510	LIMESTONE	VEIN	SID	6	0	6	2747	3	1	<1	1.75	ND
BFR7021	350140	579520	LIMESTONE	DISSEM	FE	4	17	47	1813	16	2	<1	1.19	ND
BFR7023	350570	578440	SANDSTONE	DISSEM	PB	3	7	14	264	6	1	<1	0.65	ND
BFR7024	350590	578460	LIMESTONE	VEIN	CA	12	8	30	32	6	1	<1	4.54	ND
BFR7025	350490	578460	LIMESTONE	DISSEM	FE	8	18	584	43	16	1	1	1.39	ND
BFR7026	358980	577040	LIMESTONE	VEIN	ZN	7	10	4001	224	7	2	<1	0.95	ND
BFR7027	358980	577040	LIMESTONE	VEIN	ZN	9	19	1287	108	10	1	<1	1.06	ND
BFR7028	358950	577110	LIMESTONE	VEIN	FE, CA	7	12	288	46	12	1	<1	0.88	ND
BFR7029	358950	577110	LIMESTONE	VEIN	CA, BA, FE	13	3	26	873	5	1	<1	0.90	ND
BFR7030	358760	577000	SANDSTONE	VEIN	ZN, CA	3	4	399	71	5	0	<1	1.07	ND
BFR7031	358760	577000	LIMESTONE	VEIN	ZN, FE	8	16	408	35	11	0	<1	1.07	ND
BFR7032	358760	577000	SILTSTONE	VEIN	ZN	8	39	810	112	18	2	2	1.67	ND
BFR7033	355980	584000	LIMESTONE	VEIN	CA, BA, ?FE	3	4	19	28	3	1	<1	0.45	ND
BFR7034	349720	583300	LIMESTONE	DISSEM	FE	4	2	25	129	4	3	<1	5.61	ND
BFR7035	357650	578590	LIMESTONE			7	18	13	43	14	2	<1	2.79	ND
BFR7036	357190	578460	LIMESTONE	VEIN	FE, ?CU	11	18	45	71	15	3	3	1.54	ND
BFR7040	355610	582960	CEMENTSTONE	VEIN	BITUMEN	6	38	22	513	16	5	<1	2.29	ND
BFR7041	349630	576800	SANDSTONE	VEIN/POD	HEM, CA	21	12	33	>5000	33	4	<1	3.59	ND
BFR7042	349070	577010	LIMESTONE	VEIN	FE, CA, ?ZN	12	44	101	16	16	3	<1	9.92	ND

Table 3B continued

SAMP REF. NO.	EASTING	NORTHING	ROCK TYPE	STYLE	MINERALS	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	As ppm	Sb ppm	Fe_2O_3t %	MnO %
BFR7045	350750	581900	LIMESTONE	VEIN	?BA, CA	11	2	152	1739	9	1	<1	3.39	ND
BFR7046	351680	580740	SILTSTONE	VEIN	FE, CA, ?BA	7	3	73	436	23	1	<1	9.00	ND
BFR7052	350140	578410	LIMESTONE	VEIN	CA	4	11	82	25	4	0	2	0.82	ND
BFR7055	350060	578720	SANDSTONE	DISSEM	?FE	3	4	11	87	4	2	<1	1.62	ND
BFR7056	349950	579000	LIMESTONE	VEIN	SID, FE, CA	201	12	14	108	13	5	1	7.55	ND
BFR7057	350300	579140	LIMESTONE	VEIN	FE, CA	15	4	67	360	4	1	2	12.90	ND
BFR7058	350250	579020	CEMENTSTO	DISSEM	FE	17	44	18	109	62	28	0	16.57	ND
BFR7059	358160	576580	SANDSTONE	VEIN	CA, ?BA	5	10	171	32	6	2	<1	2.36	ND
BFR7061	357750	576700	LIMESTONE	VEIN/STAINI	CA	7	15	135	31	7	2	1	1.10	ND
BFR7063	356820	576830	?LIMESTONE	VEIN/STAINI	CA	5	9	28	54	8	1	<1	1.25	ND
BFR7064	358280	577330	?SANDSTONE	VEIN	?BA, ?ZN	18	7	1341	>5000	7	4	<1	0.48	ND
BFR7065	357980	577310	LIMESTONE	VEIN	CA, ?ZN	6	24	307	82	13	1	<1	2.98	ND
BFR7066	357640	577140	LIMESTONE	VEIN	CA, ZN	7	5	675	76	5	0	0	1.02	ND
BFR7067	357760	577190	LIMESTONE	VEIN	CA, BA	13	18	353	433	11	2	<1	2.32	ND
BFR7068	357640	577140	SANDSTONE	VEIN	CA, FE	4	1	66	323	3	0	3	0.54	ND
BFR7069	357320	577180	LIMESTONE	POD/VEIN	FE, CA	12	5	3332	278	3	0	1	0.52	ND
BFR7083	362185	582475	MUDSTONE	VEIN	CA, ZN	7	12	435	97	10	<5	<5	2.81	0.170
BFR8201	356770	582785	LIMESTONE	VEIN	CA	6	9	583	80	7	<5	<5	1.10	0.099
BFR8208	356400	583480	CEMENTSTONE	VEIN	CA	6	12	356	143	13	<5	<5	2.96	0.173
BFR8209	358750	577200	CEMENTSTONE	VEIN	CA, BA	5	8	128	123	6	<5	<5	0.68	0.048
BFR8210	358750	577100	LIMESTONE	VEIN	CA	7	16	346	136	14	<5	<5	3.98	0.169
BFR8213	350710	581755	LIMESTONE	VEIN	CA, ZN	4	30	1030	27	20	<5	<5	2.80	0.117
BFR8215	361100	577650	LIMESTONE	VEIN	CA, BA	9	10	76	230	10	<5	<5	1.96	0.111
BFR8216	350620	575790	LIMESTONE	VEIN	CA	6	14	127	245	9	<5	<5	4.16	0.204
BFR8217	350800	575960	TUFF			4	3	16	860	5	<5	<5	2.54	0.119
BFR8226	359300	581100	CARBONATE	VEIN	CA	10	<3	6	21	<3	<5	<5	4.67	0.082
BFR8227	359300	581100	LIMESTONE	DISSEM	CA, FE	5	21	11	42	13	<5	7	0.92	0.113
BFR8228	359480	581180	MICRITE	VEIN	CA, ZN	6	7	16	368	7	<5	<5	3.60	0.420
BFR8229	359420	581120	CLAY	STAINING	LIMONITE	17	42	42	234	43	<5	<5	8.87	0.132
BFR8230	359350	581110	CEMENTSTONE	DISSEM	FE	6	19	12	34	8	<5	<5	1.57	0.150
BFR8231	352500	573690	LIMESTONE	VEIN	CA	16	<3	34	634	62	<5	<5	3.57	0.130
BFR8232	353780	573390	LIMESTONE	VEIN	CA	<3	<3	7	30	5	<5	<5	0.47	0.029

Table 3B continued

SAMP REF. NO.	EASTING	NORTHING	ROCK TYPE	STYLE	MINERALS	Cu ppm	Pb ppm	Zn ppm	Ba ppm	Ni ppm	As ppm	Sb ppm	Fe_2O_3t %	MnO %
BFR8233	358800	576060	LIMESTONE	VEIN	CA	7	5	25	233	6	<5	5	0.59	0.031
BFR8234	359240	576380	LIMESTONE			3	<3	69	48	5	<5	<5	0.52	0.033
BFR8235	349445	583925	BASIC IGN.			4	5	160	40	7	<5	<5	0.89	0.063
BFR8236	348560	582800	SANDSTONE	VEIN	HEM, FE	3	18	13	204	16	<5	<5	3.16	0.030
BFR8237	359140	576280	LIMESTONE			8	13	52	68	7	<5	<5	1.01	0.068
BFR8240	355860	577780	MUDSTONE	DISSEM	MARCASITE	15	12	22	114	30	<5	<5	3.56	0.043
BFR8241	355880	577710	LIMESTONE	VEIN	CA, BA	<3	<3	12	36	3	<5	<5	0.54	0.025
BFR8252	356720	580105	LIMESTONE	VEIN	CA, QTZ	5	5	8	110	3	<5	<5	1.02	0.063
BFR8253	354400	572275	LIMESTONE			7	12	173	45	11	<5	<5	0.57	0.054
BFR8254	358540	573945	LIMESTONE			7	11	94	103	7	<5	<5	0.80	0.050
BFR8255	349725	577430	LIMESTONE	VEIN	CA	6	9	17	55	10	<5	<5	4.92	0.155
BFR8256	349635	576975	LIMESTONE	DISSEM	FE	10	<3	19	73	8	<5	<5	3.49	0.099
BFR8257	349635	576975	CEMENTSTONE	DISSEM	FE	3	4	19	50	3	<5	<5	1.69	0.081
BFR8258	349725	577430	LIMESTONE	VEIN	CA, FE	4	40	316	58	12	<5	<5	4.67	0.158
BFR8278	355880	583440	CEMENTSTONE	VEIN	CA, BA, FE	9	4	35	37	3	<5	<5	2.01	0.191
BFR8279	355580	583535	LIMESTONE	VEIN	CA, BA	3	13	476	>5000	11	<5	<5	3.34	0.375
BFR8280	356055	583430	MUDSTONE			20	26	80	479	57	<5	<5	6.62	0.030
BFR8281	355580	583535	MUDSTONE			14	80	1018	293	26	<5	<5	3.10	0.031
BFR8282	345910	574720	SILTSTONE	VEIN	CA	6	61	8	86	16	<5	<5	3.52	0.091
BFR8283	345910	574720	CARBONATE	VEIN	CA	6	6	3	27	4	<5	<5	0.98	0.096
BFR8284	345840	574660	SANDSTONE	DISSEM	FE	4	9	15	155	4	<5	<5	2.33	0.090
BFR8286	356080	586920	MUDSTONE			27	96	162	208	66	<5	<5	7.08	0.036
BFR8287	353700	584630	LIMESTONE	VEIN	CA, FE	<3	6	43	126	6	<5	<5	0.99	0.059
BFR8288	353660	584605	LIMESTONE	VEIN	CA	<3	12	49	130	4	<5	<5	1.77	0.084
BFR8290	349620	576850	DOLERITE	DISSEM	FE	50	6	100	204	34	<5	<5	12.27	0.131
BFR8292	349680	576550	CEMENTSTONE	VEIN	MARCASITE	4	12	4	94	8	<5	<5	2.67	0.135

ND = Not Determined
CA = Calcite; BA = Baryte; FE = Pyrite
CU = Chalcopyrite; PB = Galena; ZN = Sphalerite
HEM = Hematite; SID = Siderite; QTZ = Quartz

Table 4 Panned Gold Observations

SAMP. REF. NO.	EASTING	NORTHING	LOCALITY	COMMENTS
BFP7206	352660	584170	ROUTLEDGE BURN APPROX. 650M DUE S OF ENGLISH KERSHOPE	HEAVY BLACK PPT, ABUN HEM. 1 GRAIN AU (0.5 MM)
BFP7207	352920	583410	TRIB. OF STRM E OF ROUTLEDGE BN. 1300M W OF SKELTON PIKE	THICK BLDR. CLAY, CSE IRREG GNS FES AND 1 GRAIN AU (0.5 MM)
BFP7210	353220	583160	CALDWELL SIKE 50M UPSTRM OF FOREST TRACK	1 FINE GRAIN AU, HEAVY BLACK PPT ON CLASTS.
BFP7222	351680	580740	ROUTLEDGE BURN 450 M UPSTM JN WITH BAILEY WATER	CLAST (BFR 7046) CONT. FES IN CALC VN., 1 (0.4 MM) GRAIN AU
BFP7256	352280	583770	ROUTLEDGE BURN 1000 M/052 DEG FROM TOMMYS FELL	ONE MOD GRAIN AU (0.3 MM)
BFP7258	351800	582850	TOMMY'S SIKE 75 M UPSTM JN WITH ROUTLEDGE BURN	ONE FINE/MOD AU (0.2 MM)
BFP7269	356220	582550	FOURTH S BANK TRIB OF THE BECK 50M UPSTRM CONFL.	ONE MOD GRAIN AU (0.3 MM), MINOR ZR I
BFP8035	349940	571030	KIRK BURN 350M NE OF FELLEND	V COARSE HEM. IN PAN, 2 MED AND 1 COARSE GRN OF GOLD (0.5 MM)
BFP8170	350740	582980	HEAD'WTR TRIB OF LANGLEY BURN. 100M N OF RD. JN.	1 CSE GRN OF GOLD (0.5 MM)
BFP8174	350560	582190	GOOSE SIKE 75M FRM JN. WITH LANGLEY BURN	1 VERY FINE GRN OF GOLD

Table 5 Mineralogical Examination of -500μm and +500μm superpanned fraction of panned stream sediment

Sample Ref	-500μm						+500μm				
No	Barite	Chalco.	Sphalerite	Galena	Other	Contaminants	Barite	Chalco.	Sphalerite	Galena	Other
BFP7222					1 Gold						
BFP7229	Abun				Abun Pyrite (framboidal)				Few		
BFP7238	Abun		Mod		Abun Pyrite (fram.), 2 Cinnabar						
BFP7240	Mod		Mod		Abun Pyrite and Iron Oxide		Abun		Abun		
BFP7241	Mod		Mod		Mod Pyrite/FeOx, 3 Cinnabar		Abun		Mod		
BFP7273			Few						Few		
BFP8005		?	Abun		Abun Pyrite				Few		Mod Pyrite
BFP8012	Few		Abun		Abun Pyrite				Abun		
BFP8036	Mod		Abun		Abun Pyrite		Mod		Mod		Mod Pyrite
BFP8057	Abun	Few	Abun		Abun Pyrite		Abun		Abun		Mod Pyrite
BFP8173	Few		?			Pb-glass	Abun				
BFP8177	Mod	?	Abun	Abun	Abun Pyrite, 4 Cinnabar				Abun	Abun	Few Pyrite

Estimated number of grains
Abun = >100
Mod = 20-100
Few = up to 20
Several = 3 to 10

Table 6 Electron microprobe identification of selected grains from panned stream sediments

Sample No	1	2	3	4	5	6	7	8	9	10	11
BFP7222	Gold	Sphalerite	Pyrite	Rutile							
BFP7229	Sphalerite	Pyrite	Rutile	Dolomite	Plagioclase	Zircon	Quartz				
BFP7238	Sphalerite	Pyrite	Cinnabar								
BFP7240	Sphalerite	Pyrite									
BFP7241	Sphalerite	Pyrite	Cinnabar								
BFP7273	Sphalerite	Barite	Galena	Rutile	Quartz						
BFP8005	Sphalerite	Sphalerite	Sphalerite	Sphalerite	Sphalerite	Pyrite					
BFP8012	Sphalerite	Sphalerite	Barite	Barite							
BFP8036	Rutile	Sphalerite	Sphalerite	Sphalerite	Pyrite	Barite	Barite				
BFP8057	Sphalerite	Sphalerite	Sphalerite	Pyrite	Barite	Barite	Pyrite	Pyrite			
BFP8173	Quartz	Sphalerite	Quartz	Quartz	Pyroxene	Pyroxene	Pyroxene	Zn+Al+Fe	Pyroxene	Silicate	Quartz
BFP8177	Cinnabar	Cinnabar	Galena	Sphalerite	Sphalerite	Sphalerite	Sphalerite	Pyrite	Pyrite	Barite	Barite

Table 7 Electron microprobe analysis of gold grain

Sample No.	Gold analysis %			Inclusion analysis %				Inclusion analysis (atom. %)	
	Au	Pb	Total	Au	Pb	S	Total	Pb	S
BFP 7222	91.2	3.5	94.7	60.3	38.5	4.9	103.7	54.9	45.1