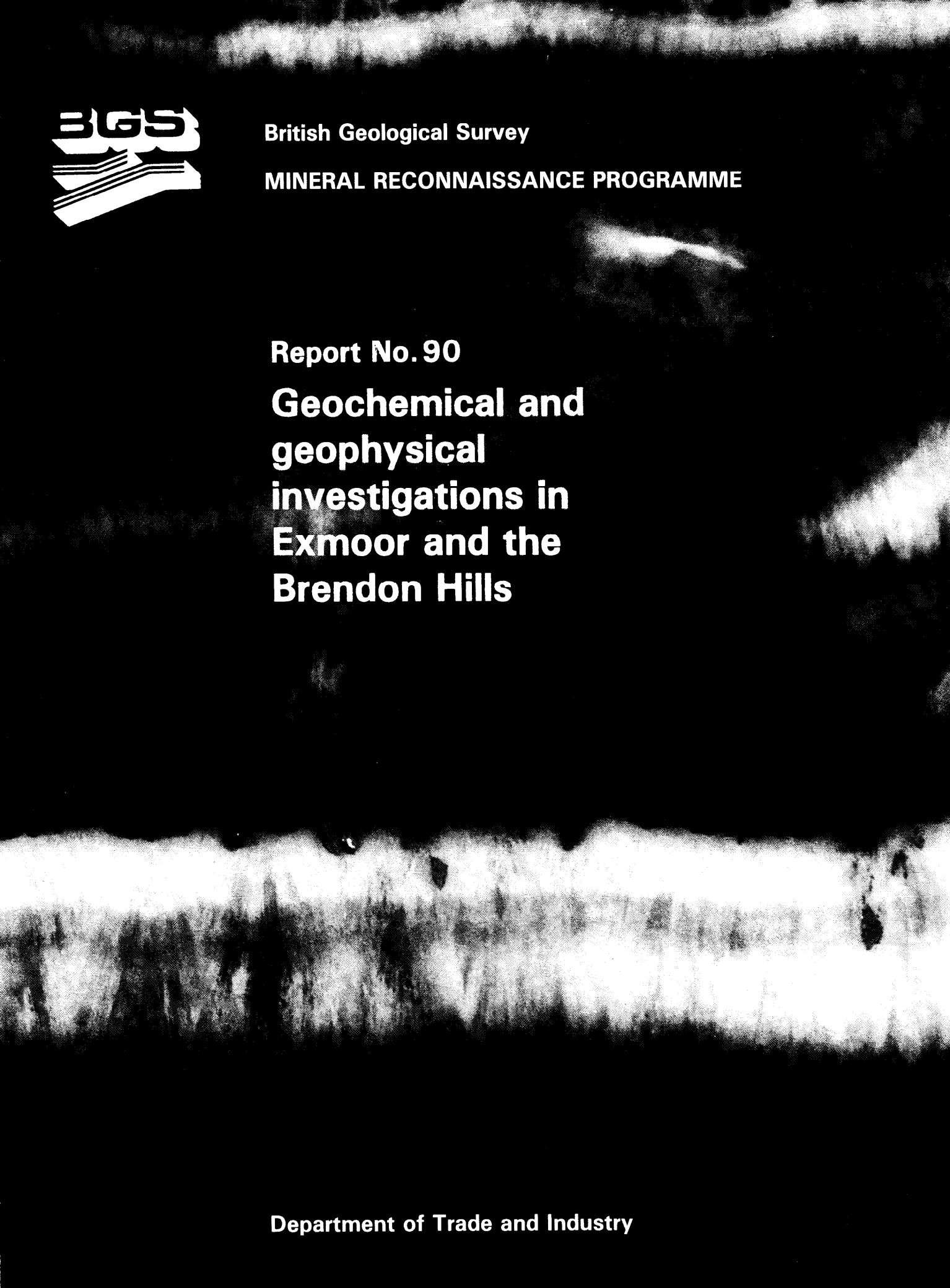

British Geological Survey

MINERAL RECONNAISSANCE PROGRAMME

Report No. 90

Geochemical and geophysical investigations in Exmoor and the Brendon Hills

Department of Trade and Industry

BRITISH GEOLOGICAL SURVEY
Natural Environment Research Council

Mineral Reconnaissance Programme

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Geochemical and geophysical investigations in Exmoor and the Brendon Hills

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A report prepared for the Department of Trade and Industry

Keyworth, Nottinghamshire 1987

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DEPARTMENT OF TRADE AND INDUSTRY

Mineral Reconnaissance Report No. 90.

ERRATUM SHEET

Please replace

DATA PACKAGE: DETAILED INFORMATION AVAILABLE FOR THE EXMOOR AND THE BRENDON HILLS AREA

The contents of an information package are itemised below, comprising geological, geochemical and geophysical maps, data listings and written accounts. The geochemical data may be available in computer compatible format as well as in the form of printouts.

A current, 1987, charge, of £1000 will be made for a copy of this information, consultation with staff, examination of drillcores and for the time of staff required to make a short field visit to the area.

1. Locations and analyses of stream sediment samples.
2. Log probability plots for stream sediment analyses.
3. 'A geochemical reconnaissance of Exmoor and the Brendon Hills' by R C Jones. A full assessment of the stream sediment geochemistry.
4. 'Investigation of an aeromagnetic anomaly at Exmoor, North Devon' by J M C Tombs, K E Beer and R C Jones (includes soil and analyses, borehole geological logs, geochemistry and geophysical interpretations).
5. 'Magnetic susceptibility determination on 56 samples from the Honeymead boreholes, Exmoor' by A Forster.
6. Listing of Kappameter readings on drill cores from Honeymead boreholes 1 and 2.
7. Location maps of geophysical observations at 6" scale.
8. Ground magnetic survey data.

For further information apply to Dr D J Fettes, British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA (Tel: 031-667-1000) or to Mr J H Bateson, British Geological Survey, Keyworth, Nottingham NG12 5GG (Tel: 06077-6111).

Other relevant data sets, obtainable from the Chief Geophysicist, British Geological Survey, Keyworth, Nottingham NG12 5GG.

1. Aeromagnetic raw data.
2. Aircraft flight lines.
3. Aircraft height data.

SUMMARY

A programme of geochemical and geophysical study was started in 1971 to assess the mineral potential of the Exmoor area. Drainage geochemistry over both Exmoor and the Brendon Hills indicated areas of anomalous metal concentrations in stream sediments which call for further investigation. Some of these anomalies undoubtedly relate to vein style mineralisation, but others probably reflect a stratiform distribution of ore metals. Barium anomalies have also been recognised and these are presumed to indicate previously unrecorded veins of barite.

Investigation of an aeromagnetic anomaly which trends WNW–ESE over the upland areas resolves it into shallow and deep components. The source of the more deep-seated magnetic anomaly remains uncertain but two diamond drill holes showed the shallow source to be pyrrhotite mineralisation in the form of disseminations and veinlets. Detailed soil geochemistry was carried out over some of the aeromagnetic anomalies.

Raw geophysical and geochemical data, location plots, borehole logs and all pertinent reports (see p.8 for details) can be purchased as a comprehensive package at a cost of £1000. For further information apply to Dr D. J. Fettes, British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA (Tel. 031-667-1000) or to Mr J. H. Bateson, British Geological Survey, Keyworth, Nottingham NG12 5GG (Tel. 06077-6111).

INTRODUCTION

The somewhat scattered nature of the mineralisation in North Devon and West Somerset is not a hopeful augury in the search for new metalliferous deposits. On the other hand it must be recognised that this part of the peninsula was sufficiently remote from the active mining areas of Cornwall to have been largely overlooked by the successful miners and entrepreneurs of years gone by. The localisation of base metal ore bodies around Combe Martin (Pb) and Heasley Mill (Cu) offers some hope of further resources in these districts, with the presence of noble metals adding to the interest.

As a preliminary phase in the examination of that potential, geochemical and geophysical studies were initiated as part of the Mineral Reconnaissance Programme (MRP) undertaken by the British Geological Survey (BGS) and funded by the Department of Trade and Industry (DTI).

The area covered by these surveys (Fig. 1) measures some 65 km by 20 km and lies within North Devon and West Somerset. To the north and west it is defined by the coast, to the south by the A361 Taunton to Barnstaple road, and to the east by the valley between Watchet and Taunton which separates Exmoor from the Quantock Hills. That portion lying to the east of the A396 Tiverton to Minehead road is known as the Brendon Hills.

Most of the area is upland, much of it moor, with a deeply incised drainage which flows mainly east and south forming the head waters of the rivers Exe and Taw. Shorter, steeper streams flow northwards into the Bristol Channel. Agriculture and tourism are the major industries of the region but a little forestry and quarrying is practised locally in the south. About half the study area falls within the Exmoor National Park.

GEOLOGY

Almost all the study area is underlain by Devonian sediments which, for the most part, form the southward dipping limb of a broad major anticline the axis of which trends WNW–ESE and passes through Lynton (Fig. 2). The A361 road approximates to the southern margin of the Pilton Beds, a transitional series containing the palaeontological boundary between the Devonian and Carboniferous strata; to the south lies a thin succession of shales, cherts and limestones of Visean age, in turn overlain by Namurian shales and thin turbiditic sandstones of the Crackington Formation. All these Palaeozoic sediments have been regionally metamorphosed to greenschist facies grade.

In the east both Devonian and Carboniferous strata are overstepped by varying Mesozoic sediments.

Recent geological re-mapping of the Barnstaple (293), Bideford and Lundy Island (292), Ilfracombe (277) and Taunton (295) Sheets has improved our understanding of the stratigraphy and structure of the Palaeozoic rocks but has affected only slightly the boundaries shown in Figure 2.

MINERALISATION AND FORMER MINING

Significant expressions of mineralisation are recorded from about a hundred locations throughout Exmoor and of these some 52 have been explored by mining (Rottenbury, 1974). The main productive mines (Dines, 1956) can be readily grouped into four areas. These are:

1 In the Brendon Hills there are two parallel structures within which are sporadically developed lensoid bodies of hematite ore which, in depth, passes into siderite. The main production period was from 1850 to about 1883 during which time some 750 000 tonnes were sold; a few mines were tried again early this century (Groves, 1952). Some mines reported up to 0.5% Cu in the form of finely scattered chalco-pyrite or malachite.

2 The iron mines of central Exmoor were sunk on structures similar to the hematite veins of the Brendon Hills but the workings were generally smaller and less productive. Some may be much older mines, perhaps even Roman in origin. The ore is again of hematite, some clearly secondary after siderite but some apparently primary in a mamillary form or as a fine-grained assemblage with quartz. Copper may be present in these ores; at Wheal Eliza it reputedly reached 1% and the mine sought that metal.

3 Around Combe Martin argentiferous galena has been reported commonly in veinlets exposed in the cliffs. It was worked in several local mines, some of which date back to the 13th Century (Dines, 1956). In addition to galena the mines contained sphalerite, copper sulphides, copper carbonates and native silver together with traces of antimony. The veins here trended roughly NW–SE, occupying transverse fault fractures.

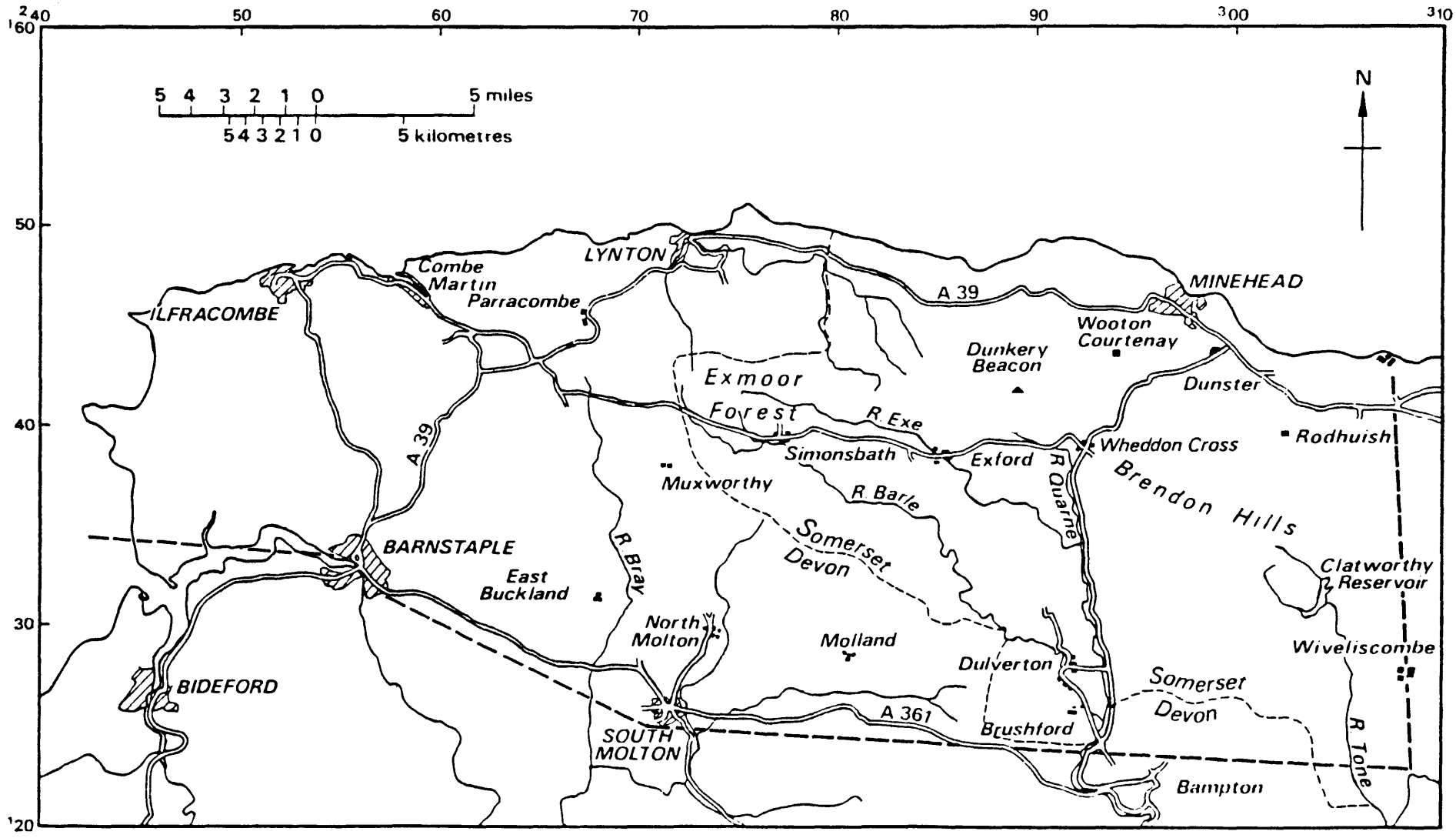

Figure 1 Exmoor and the Brendon Hills

4 In the North Molton area there are a group of veins parallel to the strike of the cleavage; these are concentrated close to the axes of a large anticline and its complimentary syncline. The productive veins carry copper ores, galena, sphalerite, siderite or hematite, sometimes with barite, and are usually contained within the Upcott Slates. Traces of gold are associated with the veins at Poltimore (Bampfylde) Mine and nearby Britannia Mine (Rottenbury, 1974).

By Cornish standards none of the mines is very large, nor did any have a long, continuous production history. Many of the workings are believed to be very old but have had a chequered record of closure and reopening. Exmoor produced only a small proportion of the total metal output of South-west England; figures are woefully incomplete but it is estimated (Rottenbury, 1974) that over 1 million tonnes of iron ores, 20 000 tonnes of copper ores, and a similar amount of lead ore were raised and more than 1500 kilogrammes of silver produced.

PREVIOUS GEOCHEMISTRY AND GEOPHYSICS

The earliest geochemistry seems to have been a stream sediment sampling programme in the southern foothills of Exmoor by Rastall (1969). He records a relatively uniform distribution of copper levels but differences in lead and zinc levels which he considered characteristic for the various stratigraphic lithologies he sampled. In 1971–72 the British Geological Survey (at that time the Institute of Geological Sciences) conducted a hydrogeochemical survey of Exmoor for uranium and this was supplemented by a car-borne scintillation counter survey along most of the minor roads. No evidence was found for uranium mineralisation.

An airborne geophysical survey flown for the Geological Survey of Great Britain in 1958 included the Exmoor area and completed coverage of the south-west peninsula. This survey employed only magnetic and radiometric techniques and was flown at an intended ground clearance of 500 ft along north-south flight lines nominally 0.4 km apart. A major linear magnetic anomaly was identified, corresponding closely to the mapped outcrop of the upper part of the Ilfracombe Series (the Kentisbury Slates); to the south a parallel but weaker anomaly is related to the overlying Morte Slates (Fig. 2). This data is published in the IGS 1:250 000 Aeromagnetic Anomaly maps, 1980, Bristol Channel and Lundy sheets.

Bouguer anomaly maps prepared from compilations of gravity data collected over a long period have recently been published as provisional sheets for all but the Lundy area; this information was not available in processed form at the time of the MRP study.

Between 1972 and 1976 a programme of geochemical, geophysical and diamond drilling exploration for copper was carried out in the North Molton area by British Kynoch Metals, with financial support from DTI under the Mineral Exploration and Investment Grants Act, 1972. The data generated by that work is now held on open file by BGS. As a result of this commercial interest no follow-up MRP studies were undertaken close to the company's lease areas.

AIMS AND METHODS OF THE STUDY

There is some suggestion in the geological evidence that Devonian stratigraphy and lithology exerts a strong control on the Exmoor mineralisation, even that the metal content may have been syngenetic and is now redistributed (Scrivener and Bennett, 1980). If reflected in the regional geochemistry this would provide a valuable guide to more detailed geochemical prospecting.

The linear magnetic anomalies raised queries about their source which have significance in terms of metalliferous prospects. If the explanation of these anomalies were to be found in magnetic oxides there arises the possibility of hidden igneous associations, volcanic or magnatic, with which may be associated a variety of metals, particularly the ferrous ones. Should the anomalies be found to reflect magnetic sulphides there arises the possible association of bedded or disseminated base metal sulphides, especially copper.

The concept of igneous masses underneath Exmoor has been around for a long time but has been consistently dismissed for lack of supporting evidence; even Bott and others (1958) discount it in explanation of their observed gravity gradients. Strangely, perhaps because of the nearby Cornubian batholith, thoughts have always been of a (Variscan) granite even though there are none of the minor intrusives which typically accompany that batholith. There are, on the other hand, narrow diorite and lamprophyre veins recorded from Hestercombe, north of Taunton, which may point to the hidden presence of a basic igneous cupola (Edmonds and Williams, 1985). It would be tempting to regard such a body as an offshoot of a proposed Tertiary igneous complex west of Lundy (Edmonds and others, 1979). A model of this type poses the possibility of associated sulphide mineralisation and might raise the question whether this could be reflected in the aeromagnetic field.

One of the prime aims of the study, therefore, was to carry out a broad geochemical survey of the Exmoor drainage in order to examine the lithological/stratigraphical distribution of key economic elements, and to look for evidence of significant concentrations of these same elements. Bottom sediment samples were collected from all streams at intervals of about 1 km. Heavy mineral concentrates were produced by hand-panning some 2–3 kg of sediment and at each site two samples of water were taken. The latter were analysed for U and for Cu, Pb and Zn. Concentrates were determined for Ba, Ca, Ce, Cu, Fe, Mn, Ni, Pb, Sb, Sn, Ti and Zn, and the sediments for Ag, Ba, Co, Cr, Cu, Fe, Mn, Mo, Nb, Ni, Pb, Sn, U, V, Zn and Zr. Twenty-four of the heavy mineral concentrates were mineralogically examined to determine the reason for specific geochemical anomalies.

The other major aim was to define the source of the northern aeromagnetic anomaly and to determine whether it was associated with any possible base metal mineralisation. Prior to undertaking any ground geophysical surveys the aeromagnetic data derived in 1958 were examined closely and the anomaly form interpreted. Three traverses across the central part of the anomaly were re-interpreted from the raw airborne measurements and possible geophysical models were established. Previous to any MRP investigations three ground magnetic traverses across the most westerly anomalies,

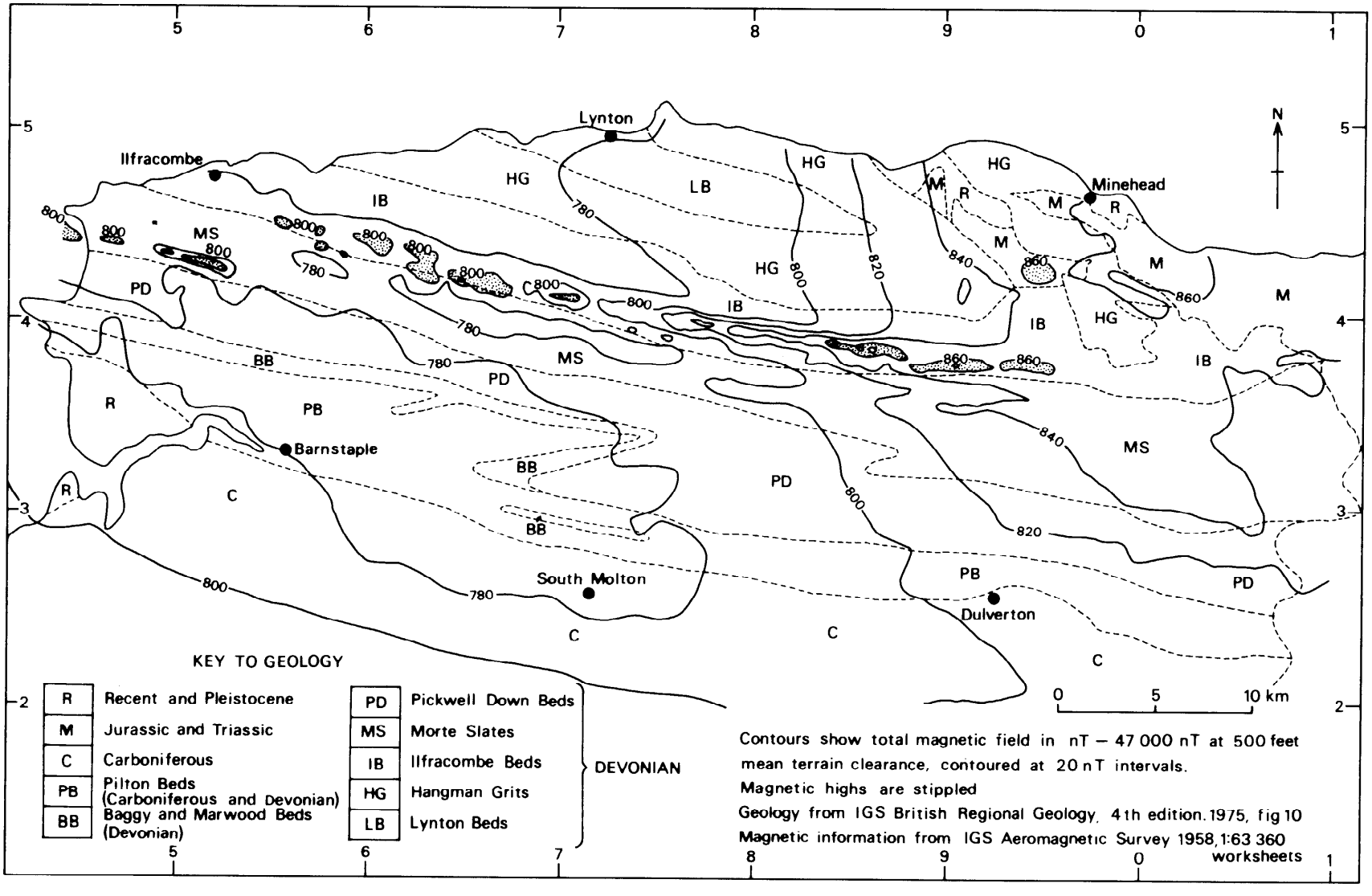

Figure 2 Generalised geology and aeromagnetic anomalies

near West Down, had suggested a causative body some 100 m wide at a depth of only a few tens of metres.

Eight north-south ground magnetic traverses varying in length form 1 to 5 km were run across the more interesting or perplexing parts of the linear anomaly and these demonstrated a greater complexity of field than was apparent from the airborne data. Three areas were surveyed in greater detail with lines 50 – 100 m apart and observations 10 m apart. Several near-surface sources were indicated and one of these, to the north of Honeymead Farm, was selected for confirmatory drilling. Some gravity work was undertaken at West Down and along some of the magnetic traverses electromagnetic measurements were made in a search for conductive bodies. Geochemical soil samples were collected along seven of the magnetometer traverse lines and these were analysed for Ba, Co, Cr, Cu, Fe, Mn, Ni, Pb, V, Zn and Zr.

Due to the effects of cleavage attitude it proved impossible to keep the drillstring 'on line' at the Honeymead site and in the event two holes were drilled from the same position. They penetrated fissile slates and interbedded limestones of the Kentisbury Slates. Both holes terminated in a major fault zone which yielded an artesian water flow. Core was geologically logged and its magnetic susceptibility checked with a hand-held Kappermeter which was calibrated from fifty-six samples selected for laboratory measurement of magnetic susceptibility.

RESULTS

Mineralogical examination of the panned concentrates shows there to be widespread contamination of the drainage, in particular by copper wire, galvanised wire, tinplate and, curiously, by a lead-rich glass. As there is no known tin mineralisation on Exmoor the Sn content of the stream sediments can be used as an indicator of contamination. The greatest contamination is found near villages and roads and in the coastal region around Ilfracombe the drainage is heavily polluted with refuse. The base metal mines around North Molton and Molland present a special case with extensive downstream contamination of a magnitude sufficient to mask any natural anomalies.

Log concentration vs. probability graphs produced from the drainage geochemical data for each ore element display distributions suggestive of variations related to lithology. Sub-division according to rock-type permits more meaningful statistical summaries to be derived, this function being improved by removal of the more significantly contaminated samples. The selective elemental distribution thus revealed not only assists in explaining the pattern of mineralisation on Exmoor but can also be used to direct future metalliferous exploration in the area.

Stream sediment geochemistry confirms the widespread lead mineralisation of the Combe Martin area and suggests the possibility of a limited extension. This could be of interest in terms of silver if the Ag:Pb ratio is sufficiently high. Another lead anomaly near the village of Parracombe lies within a built-up area, so that further exploration might be difficult.

Widespread zinc anomalies can be related to a restricted part of the local succession where they seem to be associated with elevated levels of lead, iron and nickel together with antimony and vanadium. The anomalies tend to be clustered into a few stretches of outcrop rather than extending over the full strike length, but the controls on distribution are not apparent. Sphalerite is recorded in some panned concentrates. The form of zinc mineralisation is uncertain; from known occurrences metamorphic hydrothermal veining might appear most probable, but the possibility of stratiform enrichment should not be ruled out.

Local anomalies in copper, in antimony and in uranium remain unexplained and may reflect unrecorded mineralisation. It is pertinent to recall that Gourte Mine at Molland contained antimony minerals and it may be that antimony could be a local indicator of the presence of copper veining. Barium anomalies are presumed to arise from the mechanical breakdown of barite. They are widely scattered, some being associated with former mining and others not, though in some cases the barium is accompanied by moderate concentrations of zinc. Present knowledge suggests vein-form sources though localised barite cement in grit lithologies may also occur.

The short wavelength components of the aeromagnetic anomalies unquestionably arise from the abundance of observed pyrrhotite as cleavage plane coatings, thin veinlets and rare fine disseminations in the silty limestone beds of the Kentisbury Slates at the top of the Ilfracombe Series. Such sulphide distribution correlates well with elevated levels of nickel found in sediments from around the Morte Slates/Ilfracombe Series boundary. Estimates of the pyrrhotite content put this too low to be of commercial interest either for acid production or as a possible source of nickel. Gold has not been determined on these rocks.

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