

# British Geological Survey

## BGS databases for mineral exploration: status in 2000



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# **BGS databases for mineral exploration: status in 2000**

S F Hobbs, S F Kimbell, J S Coats and N J Fortey

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Keyworth, Nottingham British Geological Survey 2000

## BRITISH GEOLOGICAL SURVEY

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*The British Geological Survey is a component body of the Natural Environment Research Council.*

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## SUMMARY

The Minerals Programme and its predecessor, the Mineral Reconnaissance Programme (MRP), have been funded by the Department of Trade and Industry (DTI) since 1972. During the course of these programmes a large body of multidisciplinary geoscientific data relating to the potential for economic mineral deposits in Britain has been collected. This report documents the status of the BGS databases that hold this data and other information relevant to the current Minerals Programme.

Three Oracle databases that hold most of the information are considered: geochemistry, geophysics and mineralogy. Geochemical data, which is normally generated in digital form, were the first to be incorporated into a BGS database. Loading of data commenced in 1985 and at present the Geochemistry Database contains more than 2 million element determinations. The data are derived from various sample media, mainly stream sediments, panned concentrates, overburden, rocks and drillcore. The sample points are distributed widely in Britain but are concentrated in areas known to contain, or prospective for, metalliferous mineralisation.

Metadata describing geophysical survey data for regional-scale national surveys and for small-scale surveys related to mineral exploration are also held on databases. The Local Surveys Database contains information on about 650 geophysical surveys including many over terrain prospective for mineral deposits. These surveys comprise approximately 9 600 survey, lines and points, many of which were surveyed with more than one geophysical technique. The Airborne Geophysical Surveys Database holds data from both regional and detailed airborne surveys. Low-resolution aeromagnetic data for the whole of Britain, is supplemented by data from uranium exploration programmes in south-west England to provide improved resolution suitable for mineral exploration purposes. Data for many other high-resolution airborne surveys are also available. These include the 1998 High resolution airborne Resource and Environmental Survey (HiRES) which covered 14 000 km<sup>2</sup> of the English Midlands. Other smaller surveys were mostly carried out in support of mineral exploration projects using a combination of magnetic, electromagnetic and radiometric sensors. Gravity data are held in the Regional Land Gravity Database which contains almost 168 000 records over Britain at a density of about 1 station per 1–2 km<sup>2</sup>.

Information on more than 155 000 samples from the BGS petrological reference collection is held on the Britrocks Database. Registration of mineralogical samples and thin sections collected by the MRP is in progress and will be incorporated into the database shortly. A large number of unpublished mineralogical reports describing work carried out for the MRP is available to interested parties.

Recent developments have improved accessibility to mineral exploration data held in BGS databases. The Geoscience Data Index (GDI) allows Internet access to BGS data holdings, enabling potential investors to see index data from the databases, to view project areas and to identify potentially useful datasets.

The data in these databases is a major strategic resource to underpin mineral exploration and development activities in Britain. The databases facilitate integration of multivariate datasets and thus provide the foundation for studies related to metallogenesis and mineral prospectivity mapping. A large part of the accessible data has already been captured in digital format but there remains a significant quantity of potentially valuable information from many surveys, mostly carried out during the early part of the MRP, that should be added to the databases. Future developments will lead to greater accessibility to an increased range of information over the Internet, including on-line data delivery. Improved links between BGS databases and better methods for the integration and display of multidisciplinary data will yield significant benefits to mineral exploration in Britain.

## INTRODUCTION

The Minerals Programme and its predecessor, the Mineral Reconnaissance Programme (MRP), have collected a large body of information during investigations on the potential for economic mineral deposits in Britain. The MRP was initiated to carry out baseline mineral exploration studies for the promotion of metal mining in Britain and to encourage inward investment. The work undertaken included geochemical sampling of a variety of media, airborne and ground geophysical surveys, drilling and mineralogical studies. The aims of the Minerals Programme include provision of a sound information-base to aid policy formulation and decision making and the promotion of commercial exploration in Britain.

The information gathered during these programmes comprises data on the geochemistry, geophysics, mineralogy and geology of mineralised areas in Britain and much of this has been stored in BGS corporate databases. The purpose of this report is to provide information on the status of these databases:

- what data they hold
- where it is located
- what is still to be loaded

Data collected by one project can be used for several different purposes. For example, detailed geochemical studies in an old mining area with the primary aim of locating new prospects can be used for environmental purposes, such as identifying old mines and trials that are a potential hazard. Similarly, data collected during earlier surveys for nickel or chromium may be re-used in later exploration for platinum-group metals. Geophysical data, such as airborne surveys, is potentially useful in mineral exploration, natural radioactivity hazard identification and petroleum exploration.

Re-examination and re-interpretation of existing data have become increasingly important parts of projects carried out by the Minerals Programme and under the Science Budget. New GIS techniques of multi-dataset integration together with new mineral deposit models have underpinned recent studies of gold in the Lower Devonian volcanic rocks of Northern Britain (Gunn and Rollin, 2000) and of gold and base-metals in the Welsh Basin (Cooper et al., 2000)

Data of potential use in mineral exploration is stored in several BGS corporate databases:

- Geochemistry Database – geochemistry holdings for the landmass of Britain from the Minerals Programme, Geochemical Baseline Survey of the Environment (G-BASE), and various litho-geochemistry projects.
- Geophysics Databases – Local Surveys Database of ground geophysical surveys, and the Airborne Surveys Database, which includes high resolution airborne surveys flown for the Mineral Reconnaissance Programme
- Britrocks Database – database of the BGS corporate petrological collections

Information on these three databases is available to the wider user community via the Internet on the BGS website ([bgs.ac.uk](http://bgs.ac.uk)). There are two ways to locate this data: (i) via an interactive map-based interface (the GeoScience Data Index, or GDI, at <http://www.bgs.ac.uk/geoindex/home.html>); or (ii) via a text-based interface, the BGS Discovery Metadata Index.

The Geoscience Data Index (GDI) allows maps of the datasets held by BGS in Britain and UK Continental Shelf to be viewed and interrogated. The data points or areas can be listed and maps printed to show their distribution.

## **DISCOVERY METADATA**

Metadata is 'data about data' and can be used at two levels: a discovery level, which describes the whole dataset, and a technical level, which describes in more detail how the data are organised. At present Discovery metadata is available for most Minerals Programme datasets and Technical metadata for some datasets such as the Geochemistry Database. Information on Discovery metadata is presented in the following tables (Tables 1–4).

Further information on these tables and other metadata tables can be seen on the BGS website at <http://www.bgs.ac.uk/discoverymetadata/home.html>.

Technical metadata is currently not publicly available on the BGS website but the information given in this report provides the reader with a similar level of detail. Other BGS reports (Harris and Coats, 1992 and Smith and Royles, 1989) give more information at the technical metadata level for the geophysical and geochemical databases. The structure of the Local Surveys Database, which holds metadata describing ground geophysical surveys in Britain, is shown in Figure 1 and a description of the main tables is given in Table 5.

## **Reports**

In some cases metadata is also held in reports, which usually contain a description of the work carried out over the survey area. The list of MRP and Minerals Programme reports (Appendix 1) and accompanying map (Figure 2) shows the data coverage. The GDI (<http://www.bgs.ac.uk/geoindex.htm>) shows each of the MRP report areas and by clicking on an area the report number and title are displayed in a box beneath the map (Figure 3). A locality index to each report area is also given on the minerals UK website at: <http://www.mineralsUK.com/mrpnet/mrpindex.htm>.



**Table 1** Discovery metadata for the Minerals Programme data in the BGS Geochemistry Database

<b>Identifier</b>	MRPGEOCHEM		
<b>Description</b>	Minerals Programme Geochemistry Database.		
<b>Abstract</b>			
The "Mineral Reconnaissance Programme (MRP), funded by the DTI carried out baseline mineral exploration in Great Britain between 1972 and 1997. Its main aim was to stimulate private-sector exploration and the development of indigenous mineral resources. It has been subsumed into the new BGS Minerals Programme, also funded by the DTI. The Programme provides information and advice to industry, enables technology transfer and promotes wealth creation through the effective sustainable development of Britain's mineral resources. The database contains information from the MRP together with some from earlier programmes and the new Minerals Programme. Information from the early 1970's was largely concerned with the search for uranium and base-metals, while since the 1980's gold and PGEs have dominated. A range of pathfinder elements has also been determined. Data is held on the geochemistry of drainage stream sediments, panned concentrates, soil, deep overburden, rock and drillcore samples.			
<b>Start Date Comment</b>	The Mineral Reconnaissance Programme started in 1972 following earlier work on uranium exploration. It was succeeded by the Minerals Programme in 1997.		
<b>Start Date</b>	1972-01-01 00:00:00	<b>End Date</b>	
<b>End Date Comment</b>	On-going.		
<b>Update Frequency Comment</b>	Updated as data is received.		
<b>Completeness</b>	Data collected on a project basis covering many of the mineralised areas of the UK.		
<b>Level of Spatial Detail</b>	Varies from regional drainage samples collected at 1 sample per square kilometre to soil samples at 1 sample per 10 m spacing		
<b>Logical Consistency</b>	Data validated by collector and analytical laboratory.		
<b>Lineage</b>	Project was a successor to uranium exploration for UKAEA and has been funded by the DTI as the MRP and Minerals Programme since 1972.		
<b>Metadata Entered</b>	1999-11-03 14:52:29	<b>Metadata Updated</b>	1999-12-02 09:58:44
<b>Access Constraints</b>	Data sold under licence.		
<b>Use Constraints</b>	Copyright control.		
<b>Spatial Reference System</b>	BRITISH NATIONAL GRID		
<b>Bounding Coordinates</b>			
<b>West</b>	38000	<b>East</b>	646000
<b>North</b>	1215000	<b>South</b>	18000
<b>Areal Extent</b>	ENGLAND	<b>Areal Extent Type</b>	COUNTRY
<b>Areal Extent</b>	SCOTLAND	<b>Areal Extent Type</b>	COUNTRY
<b>Areal Extent</b>	WALES	<b>Areal Extent Type</b>	COUNTRY
<b>Areal Extent</b>	UNITED KINGDOM	<b>Areal Extent Type</b>	KINGDOM
<b>Storage Format</b>	RELATIONAL DATABASE		
<b>Delivery Format</b>	REPORT		
<b>Delivery Format</b>	DIGITAL		
<b>Language</b>	ENGLISH		
<b>Supplier</b>	BRITISH GEOLOGICAL SURVEY		
<b>Postal Address</b>	KINGSLEY DUNHAM CENTRE KEYWORTH		
<b>Town</b>	NOTTINGHAM		
<b>Post Code</b>	NG12 5GG		
<b>Contact Telephone</b>	0115 9363100	<b>Contact Fax</b>	0115 9363200
<b>Metadata Originator</b>	STAN (JS) COATS		
<b>Metadata Originator</b>	SUSAN HOBBS		
<b>Authority for Reliability of the Datasets</b>	STAN (JS) COATS		

**Table 2** Discovery metadata for the Geochemical Baseline Survey of the Environment (G-BASE) data

<b>Identifier</b>	GBASEGEOCHEM		
<b>Description</b>	Geochemical Baseline Survey of the Environment (G-BASE) for the UK.		
<b>Abstract</b>	<p>The G-BASE programme involves systematic sampling and the determination of chemical elements in samples of stream sediment, stream water and, locally, soil, to build up a picture of the surface chemistry of the UK. The average sample density for stream sediments is about one site per 1 km square, and for stream waters one site per 1.5 km square. Analytical precision is high with strict quality control to ensure countrywide consistency. The data provide baseline information on the natural abundance's of elements, against which anomalous values due to such factors as mineralisation and industrial contamination may be compared. Analytical data for the 150 microns fraction of soil and stream sediment samples are available for some or all of: Ag, As, B, Ba, Bi, Be, Ca, Ce, Cd, Co, Cr, Cs, Cu, Fe, Ga, K, La, Li, Mg, Mn, Mo, Nb, Ni, P, Pb, Rb, Sb, Se, Sn, Sr, Th, Ti, U, V, Y, Zn, and Zr. Most water samples have been analysed for alkalinity, pH, conductivity, F and U and some for multi-element analyses including Al, Cl, Na, Si, SO4, NO4, and TOC.</p>		
<b>Start Date Comment</b>	Regional geochemical Mapping commenced in the Caithness and South Orkney area carried out by the Institute of Geological Sciences (IGS -now BGS).		
<b>Start Date</b>	1968-01-01 00:00:00	<b>End Date</b>	
<b>End Date Comment</b>	Projected completion 2010		
<b>Update Frequency Comment</b>	Updated on a yearly basis.		
<b>Completeness</b>	Completed for Scotland, Wales, Northern England and Humber-Trent. Central and Eastern England ongoing. Southern England yet to be started.		
<b>Level of Spatial Detail</b>	Samples av. 1 per 1 km square collected using 1:50 000 OS base maps.		
<b>Logical Consistency</b>	Geochemical mapping carried out according to International Geochemical Sampling methods described by IGCP 259.		
<b>Lineage</b>	Project initially called Regional Geochemical Reconnaissance Programme (RGRP) and subsequently Geochemical Survey Project (GSP).		
<b>Metadata Entered</b>	1999-04-19 13:01:26	<b>Metadata Updated</b>	1999-12-02 09:58:43
<b>Access Constraints</b>	Data sold under licence.		
<b>Use Constraints</b>	Copyright control.		
<b>Spatial Reference System</b>	BRITISH NATIONAL GRID		
<b>Bounding Coordinates</b>			
<b>West</b>	50000	<b>East</b>	550000
<b>North</b>	1220000	<b>South</b>	160000
<b>Areal Extent</b>	ENGLAND	<b>Areal Extent Type</b>	COUNTRY
<b>Areal Extent</b>	SCOTLAND	<b>Areal Extent Type</b>	COUNTRY
<b>Areal Extent</b>	WALES	<b>Areal Extent Type</b>	COUNTRY
<b>Areal Extent</b>	UNITED KINGDOM	<b>Areal Extent Type</b>	KINGDOM
<b>Storage Format</b>	ORACLE		
<b>Delivery Format</b>	ATLAS		
<b>Language</b>	ENGLISH		
<b>Supplier</b>	BRITISH GEOLOGICAL SURVEY		
<b>Postal Address</b>	KINGSLEY DUNHAM CENTRE KEYWORD		
<b>Town</b>	NOTTINGHAM		
<b>Post Code</b>	NG12 5GG		
<b>Contact Telephone</b>	0115 9363100	<b>Contact Fax</b>	0115 9363200
<b>Metadata Originator</b>	CHRISTOPHER JOHNSON		
<b>Metadata Originator</b>	ROBERT (TR) LISTER		
<b>Authority for Reliability of the Datasets</b>	CHRISTOPHER JOHNSON		

**Table 3** Discovery metadata for the Ground Geophysical Surveys

<b>Identifier</b>	GEOP_SURVEY_UK		
<b>Description</b>	Ground geophysical surveys in the UK done for specific projects.		
<b>Abstract</b>	The database contains an index to over 600 ground geophysical surveys carried out in the UK for a variety of projects. A large number of these surveys were done for the DTI Mineral Reconnaissance Programme in the 1970's and 80's, many other s were done at the request of BGS field mapping groups. Information held describes the survey objective, location of measurements, geophysical methods and equipment used, reports and publications, storage locations of data and results (for analogue and digital data), dates and personnel.		
<b>Start Date Comment</b>	Date of first documented geophysical survey carried out by BGS.		
<b>Start Date</b>	1952-01-01 00:00:00	<b>End Date</b>	
<b>End Date Comment</b>	Geophysical surveying still being done.		
<b>Update Frequency Comment</b>	Data input as and when surveys are undertaken.		
<b>Completeness</b>	Dataset about 70% complete. Data missing comes from a backlog of older surveys and some of the most recent surveys.		
<b>Level of Spatial Detail</b>	Irregular, depending on detail required for each survey.		
<b>Logical Consistency</b>	Very inconsistent depending on objectives of survey.		
<b>Lineage</b>	Data collated from records held by RG which include maps, text and geophysical data.		
<b>Metadata Entered</b>	1999-10-04 09:48:57	<b>Metadata Updated</b>	1999-12-02 09:58:44
<b>Access Constraints</b>	In principle no restrictions to index information. No charges for index level information, standard BGS charges for geophysical data.		
<b>Use Constraints</b>	None.		
<b>Spatial Reference System</b>	BRITISH NATIONAL GRID		
<b>Bounding Coordinates</b>			
<b>West</b>	50000	<b>East</b>	660000
<b>North</b>	1220000	<b>South</b>	0
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<b>Storage Format</b>	ORACLE		
<b>Storage Format</b>	RELATIONAL DATABASE		
<b>Delivery Format</b>	MAP		
<b>Delivery Format</b>	TEXT		
<b>Language</b>	ENGLISH		
<b>Supplier</b>	BRITISH GEOLOGICAL SURVEY		
<b>Postal Address</b>	KINGSLEY DUNHAM CENTRE KEYWORTH		
<b>Town</b>	NOTTINGHAM		
<b>Post Code</b>	NG12 5GG		
<b>Contact Telephone</b>	0115 9363100	<b>Contact Fax</b>	0115 9363200
<b>Metadata Originator</b>	SARAH KIMBELL		
<b>Metadata Originator</b>	BGS KEYWORTH SITE		
<b>Authority for Reliability of the Datasets</b>	SARAH KIMBELL		

**Table 4** Discovery metadata for the Airborne Geophysical Surveys

<b>Identifier</b>	GEOP_AIR_UK		
<b>Description</b>	Airborne Geophysical Surveys of United Kingdom and Adjacent Areas.		
<b>Abstract</b>	Analogue aeromagnetic surveys of Great Britain for the Geological Survey (GSGB), subsequently digitised. Commercial Analogue survey of North Sea by Areasurveys Inc, subsequently digitised by BGS. Commercial digital (+ one analogue) surveys off NW/N/NE of Britain by Huntings Geology and Geophysics, purchased outright by BGS. Local surveys, digital and analogue aeromagnetic (+ other methods) surveys for BGS and commercial companies.		
<b>Start Date Comment</b>			
<b>Start Date</b>	1955-01-01 00:00:00	<b>End Date</b>	
<b>End Date Comment</b>	Additional surveys as data acquired.		
<b>Update Frequency Comment</b>	HiRES 1 will be loaded when data processing is completed.		
<b>Completeness</b>	Approximately 75% of bounding rectangle covered by regional surveys. Complete coverage of UK land area and adjacent waters.		
<b>Level of Spatial Detail</b>	Line spacing typically 2km over UK but 0.4km over Devon/Cornwall. Aerosurveys/Huntings surveys vary between 6.4 to 15 km. Detailed surveys at various resolutions. Along line spacing: Analogue data digitised from 1:63 360 and 1:253 440 scale map sheets. Digital surveys: Decca navigation, 350m asl. Local helicopter surveys: Analogue and digital recordings. Various survey heights. HiRES survey: Full digital data capture at 0.1 sec intervals. GPS navigation. 90m survey height.		
<b>Logical Consistency</b>	Earlier surveys (1955-65): Analogue recording. Line fixing by fiducial camera (land) and Decca navigation over sea. Typically survey height 305m ground clearance/barometric elevation/constant elevation. Analogue data digitised from 1:63 360 and 1:253 440 scale map sheets. Digital surveys: Decca navigation, 305m asl. Local helicopter surveys: Analogue and digital recordings. Various survey heights. HiRES survey: Full digital data capture at 0.1 sec intervals. GPS navigation. 90m survey height		
<b>Lineage</b>	Details of data acquisition available in Contractors reports for each survey. Conversion of analogue data to digital format detailed in Smith and Royles 1989.		
<b>Metadata Entered</b>	1999-10-13 09:02:01	<b>Metadata Updated</b>	2000-07-04 10:04:00
<b>Access Constraints</b>	BGS has only part ownership of some surveys and acts as agent for others.		
<b>Use Constraints</b>	Different conditions apply to each survey.		
<b>Spatial Reference System</b>	LATITUDE/LONGITUDE		
<b>Bounding Coordinates</b>			
<b>West</b>	-16.	<b>East</b>	10.
<b>North</b>	64.	<b>South</b>	49.
<b>Areal Extent</b>	UK CONTINENTAL SHELF	<b>Areal Extent Type</b>	CONTINENTAL SHELF
<b>Areal Extent</b>	UNITED KINGDOM	<b>Areal Extent Type</b>	KINGDOM
<b>Areal Extent</b>	NORTH SEA	<b>Areal Extent Type</b>	SEA
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<b>Storage Format</b>	ANALOGUE		
<b>Delivery Format</b>	MAP		
<b>Delivery Format</b>	NUMBER		
<b>Delivery Format</b>	CHART		
<b>Language</b>	ENGLISH		
<b>Supplier</b>	BRITISH GEOLOGICAL SURVEY		
<b>Postal Address</b>	KINGSLEY DUNHAM CENTRE KEYWORTH		
<b>Town</b>	NOTTINGHAM		
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<b>Metadata Originator</b>	CHRIS ROYLES		
<b>Authority for Reliability of the Datasets</b>	CHRIS ROYLES		

**Table 5** Description of Oracle tables used in Local Surveys Database

<b>TABLE NAME</b>	<b>INFORMATION HELD IN TABLE</b>
GEOP_SURVEY	Index information on all geophysical surveys. Includes country, survey name, survey objective, survey target or project, start year, data owner and survey company, and survey shape (polygon, line or point) and co-ordinate system (eg BNG, UTM, Lat/Long).
GEOP_SURVEY_OUTLINE	Grid co-ordinates for the polygon outlining each survey. In the UK this information is held as British National Grid easting and northing, and as latitude/longitude.
GEOP_LOCATION	Names of individual datasets within each survey, like sites/lines/points, where data were measured.
GEOP_LOCATION_ENDS_BENDS	Grid references for the sites/lines etc specified in GEOP_LOCATION. In the case of survey lines, grid references area held for the end points and where bends occur along a line.
GEOP_ACTIVITY	Describes all measurements made at every location. Includes information on each geophysical method, technique, and instrument used, with personnel and dates.
GEOP_DIGITAL_FILE	Table giving details and storage location of any digital data held for a survey.
GEOP_AREA_RECORD	Table to link survey to analogue records.
GEOP_RECORD	Information on analogue records for each survey, like item type (notebooks, folders, maps etc) and where the records are stored.
GEOP_AREA_REPORT	Table to link survey to any relevant BGS reports (published or unpublished).
GEOP_REPORT	Bibliographical reference for each report.
GEOP_AREA_PUBLICATION	Table to link survey to any relevant publications.
GEOP_PUBLICATION	Bibliographical reference for any external publications relating to a survey.
GEOP_METHOD	Glossary of geophysical methods used in GEOP_ACTIVITY
GEOP_TECHNIQUE	Glossary of geophysical techniques used in GEOP_ACTIVITY
GEOP_FORMAT	Table describing format of digital data in GEOP_DIGITAL_FILE.

## GEOCHEMISTRY DATABASES

### Introduction and operations

The Geochemistry Database is a relational database comprising thirty-four tables (Table 6). The design of the database and a detailed description of the tables are presented in MRP report 125 (Coats and Harris, 1992). Since this publication there have been only minor changes to the database.

Because the database contains data collected over a long period of time by a variety of exploration geologists, standards of data collection and validation have varied considerably. For this reason the information recorded about geochemical samples varies from a complete description (most drainage samples) to rather sketchy details of texture and colour (soil samples).

**Table 6** Number of MRP records in each of the Geochemistry Database tables

<b>Table name</b>	<b>Number of records</b>
Alterations	16
Analysis	7809*
Analyte Determinations	2375836
Analytes	56964*
Batches	4553*
Bore Sites	709*
Clasts	6049
Contaminants	2271
Core Positions	7157
Drainage Sites	39453
Drifts	12630
Drillcores	8074
Drillmuds	0
Gases	23
Geological Features	2129
Geologys	22712
Horizons	16419
Landuses	9676
Mineralisation Types	523
Minerals	5901
Normal Rocks	8577
Normal Sites	67013
Overburdens	57713
Panneds	33714
Project Batches	3176
Rock Types	8678
Sample List	153603
Sediment ppt	6152
Sediments	28739
Site List	114564
Vegetations	53
Waters	16630
<b>Total</b>	<b>3077519</b>

\* Figures are for all records on the Database not just the MRP.

New data are routinely added to the database as it is acquired. However a large part of the data was collected prior to the development of databases and consequently occurs in several formats. Some of the data are in digital format and simply requires loading to the database. However, a significant part of the digital data lacks sufficient 'identification' to allow quality control. It cannot therefore be loaded to the database until it has been correctly identified and matched with the appropriate fields. Where the data are present in paper form only, as field cards, noted on maps, recorded in notebooks or in reports, considerable effort is needed to capture and validate it.

For many samples only the analytical data and grid references were routinely entered into the database from the outset. Other more detailed information such as weather, stream order, drainage type, contamination and geology was not normally entered into the database.

When samples were submitted to the BGS laboratories for analysis details of the number of samples and the sample type were recorded in a numbered series and the batch of samples given a Laboratory Number (LABNO). This data has been systematically entered into the database and gives the best indication as to the complete numbers of samples and sites. For this reason the tables associated with the chemical analysis such as the Analysis Table and the Project Batch Table, have been used as the benchmark for an analysis, aimed at locating 'missing' data and thus to quantify how many samples and analyses have not yet been loaded to the database.

#### **Current status of database as at 01 January 2000**

The number of distinct sample analyses in the Database are shown in Table 7 for each of the different sample types. It can be seen that for some sample types, such as marine sediments, little analytical data are held on the database. The majority of the samples collected and analysed were stream sediments, drill cores, rocks, soils, tills and waters. There are also significant numbers of panned concentrate and panned overburden samples that have been processed by panning to increase the concentration of minerals to aid identification of mineralised anomalies.

**Table 7** Number of analysed samples in the database

<b>Sample type</b>	<b>No. of samples</b>
C – Stream sediments	29046
D – Drill cores	14684
E – Minerals	3
F – Float sediments	856
J – Marine sediments	36
M – Drill mud	253
N – Panned drill mud	16
P – Panned concentrates	33594
R – Rocks	11570
S – Soils	75599
T – Tills	3193
U – Panned overburdens	2736
V – Vegetation	445
W – Water	9639
<b>Total</b>	<b>181670</b>

Table 8 shows the best estimate of the total number of samples of each type submitted to the laboratories. In some instances this figure was derived from the difference between the maximum sample number and

minimum sample number. This is not the actual number of samples where the number series is incomplete, and consequently can only be used as a guide to the total number of samples. This derived figure will tend to over-estimate the number of samples submitted. There may also have been some samples collected during the early part of the MRP that were only submitted to outside laboratories and were never entered into the BGS laboratory's batch numbering system. In this case the estimates given in Table 8 will be underestimates of the true number of samples.

**Table 8** Number of samples submitted for analysis to the BGS laboratories

<b>Sample type</b>	<b>Number of samples</b>
C – Stream sediments	59459
D – Drill core	26353
E – Mineral	4
F – Float sediments	1466
J – Marine sediments	107
M – Drill mud	1259
N – Panned sludge	16
P – Panned concentrate	56871
R – Rock	18574
S – Soil	109357
T – Till	4554
U – Panned overburden	3318
V – Vegetation	1094
W – Water	42826
<b>Total</b>	<b>325258</b>

For various projects site locations are held in the database as local grid co-ordinates rather than in terms of Britain national grid (Table 9). Work is in progress to convert these local co-ordinates to National Grid co-ordinates.

**Table 9** Project codes for which only local grids are present

<b>Project code</b>	<b>Minimum site No.</b>	<b>Maximum site No.</b>	<b>Number of sites</b>
AZ	8201	8723	316
BS	2701	11728	680
BT	2001	2372	354
BW	10001	10246	198
CV	10501	10979	476
CY	1	226	221
CZ	14001	15133	286
DD	10001	10456	446
DG	10001	10169	168
DH	1	292	290
DJ	10101	10527	427
GL	2001	3543	225
GS	2501	2690	190
KK	7601	7718	117
WC	2337	2725	11
<b>Total</b>	<b>-</b>	<b>-</b>	<b>4408</b>



Figure 4 shows the progress of data loading, on a daily and cumulative basis. The initial steep curve reflects well maintained data while subsequent flattening relates to more problematic data that required greater effort for capture and validation.

Table 10 shows the number of element determinations in each sample type. For instance, some analytes were only determined on certain sample types, e.g. dysprosium (Dy), erbium (Er) and europium (Eu) have only been determined for on drill cores (D) and rocks (R), whereas copper (Cu), lead (Pb) and zinc (Zn) have been determined on most sample types.

**Table 10** Number of element determination for each sample type (C-W)

Analyte	Total	C	D	E	F	J	M	N	P	R	S	T	U	V	W
Ag	64791	18495	5787		479	31	155	1	6086	4859	25400	1829	1389	280	
Al	11344	1957	4113	3	62				495	3593	343	49	497	232	
As	73409	10212	9824		425	31	148	16	12043	7805	27484	2286		280	696
Au	13610	1140	3095		172	36			2906	3116	1237	969	424	515	
B	18863	10958	1222		51				452	921	4908	52	67	232	
Ba	133775	24571	12175		641	31	253	16	32151	9945	48352	3030	2330	280	
Be	12619	8748	367						22	723	2707	52			
Bi	28187	4943	3459		256	31	98	16	4095	3659	9319	922	1157	232	
Br	48													48	
C	13									13					
Ca	91197	6133	11725	3	502	31	253	16	27701	10141	29959	2358	1933	442	
Cd	1805	178	597		51				277	289	66		67	280	
Ce	64306	3254	9126		440	30	227	1	27473	5415	15273	1780	1239	48	
Cl	1393		629							764					
Co	63458	19363	9199		346	31			2577	5770	23572	1359	961	280	
Cr	65323	16665	8924		362	31		15	3893	6937	25001	1726	1327	442	
Cs	208									208					
Cu	171922	28684	14364		804	31	227	16	33300	10819	71998	3037	2612	232	5798
Dy	21		3							18					
Er	21		3							18					
Eu	21		3							18					
F	1950		851				57			171	169				702
Fe	133467	23465	13652	3	811	31	253	16	31824	10727	46373	3263	2607	442	
Ga	6762	2796	322		51				199	1495	1872		27		
Gd	21		3							18					
Ge	1765	1457	101							167			40		
Hf	47									47					
Hg	1729	295			51			15	491	145	25	548	111	48	
Ho	21		3							18					
Ir	198		3							147				48	
K	14219	3066	3771	3	62				564	3648	2380	10	435	280	
La	18255	3856	4578		346	31			1580	3524	3018	733	309	280	
Li	5709	2847	322							667	1873				
LOI1050	2033		139	3						1732			159		
LOI450	14703	4205	62							253	10105	78			
Lu	21		3							18					
Mg	16694	3079	4350	3	253	31		15	913	3913	3123	47	573	394	
Mn	124697	22051	11729	3	808	31	253	16	29744	9970	44572	3251	2037	232	
Mo	61423	21566	8833		482		197	1	6655	5296	16596	1303	214	280	
Na	8241	197	3317	3	62				260	3354	507	10	251	280	
Nb	25698	3297	6578		103		243	1	2974	5433	5848	859	362		
Nd	135		3							132					
Ni	133205	23263	13248		807	31	253	16	31534	9666	48428	3203	2476	280	
Os	40		3							37					
P	8394	229	3152	3	62				707	3357	426		226	232	

**Table 10** Number of element determination for each sample type (C-W) continued

Analyte	Total	C	D	E	F	J	M	N	P	R	S	T	U	V	W
Pb	164540	29614	13903		667	31	227	16	33449	10777	68868	2879	2366	232	1511
Pd	5139	254	2125		13	36			317	1350	4	419	389	232	
Pr	21		3							18					
Pt	5137	254	2122		13	36			317	1349	4	419	391	232	
Rb	40550	4336	9067		429	31	243	15	3193	6171	15303	1061	653	48	
Re	15		3							12					
Rh	4533	254	2110		13	36			222	1063	4	394	205	232	
Ru	150		3							147					
S	6185	30	2405		11			15	699	1897	810	47	271		
Sb	74935	4124	7903		637	31	211	16	28595	5831	23407	1836	2064	280	
Sc	1504		629							827				48	
Se	1064	198	101		62				398	190			67	48	
Si	10132	1784	3706	3	11				394	3564	193	47	430		
Sm	69		3							18				48	
Sn	88826	19976	7405		476		253	16	32187	3380	22315	1040	1778		
Sr	52451	5378	10939		346	31	243		7476	7348	18038	1544	876	232	
Ta	95									47				48	
Te	969	192	101		62				305	242			67		
Th	23858	1567	5195		152		243		3591	5016	6598	880	336	280	
Ti	100693	6958	11758	3	502	31	253	16	30099	9824	36386	2336	2133	394	
Tl	523	192			62				199	43			27		
U	52244	12163	6080		489		243	1	7374	6072	14261	1139	460	280	3682
V	58409	15381	7758		346	31		1	3416	6453	22565	1334	730	394	
W	24997	2038	4806		248		98	16	3620	1560	11294	519	518	280	
Y	35196	6682	8556		295		243	1	3387	5640	8589	1064	739		
Yb	21		3							18					
Zn	168377	28851	13799		833	31	227	16	33266	10748	65612	3223	2612	280	8879
Zr	66071	15451	9663		295	31	243	16	8815	7291	21168	1704	1394		

Notes:

1. Sample type codes (C-W) are defined in Table 8
2. LOI1050 and LOI450 are Loss-on-ignition figures in ppm by weight at 1050° and 450°C respectively

Comparison of the number of samples submitted for analysis (Table 8) with the number of samples that have already been loaded to the Analyte Determinations Table (Table 7) allows the number of samples remaining to be loaded to the Geochemistry Database to be estimated (Table 11). These figures are not precise as the number of samples submitted for analysis was not always accurately recorded.

The majority of the analytical data loaded to the database was analysed by XRF. For this method there was a standard procedure to transfer the data to database. However, no such procedure existed for many of the other analytical methods and, therefore, it relied on individual geologists sending the data to the data administrator to be loaded.

Taking the figures from Table 11 and obtaining the number of samples for which the analyses and locations have been entered onto the database, the percentage 'analysed' and 'analysed and located' can be calculated (Table 12).

**Table 11** Number of samples to be loaded

Sample type	No. of samples submitted to laboratory (Table 8)	No. of samples loaded to database (Table 7)	No. samples to be loaded (column 2 minus column 3)
C – Stream sediments	59459	29046	30413
D – Drill cores	26353	14684	11669
E – Minerals	4	3	1
F – Float sediments	1466	856	610
J – Marine sediments	107	36	71
M – Drill mud	1259	253	1006
N – Panned sludge	16	16	0
P – Panned concentrate	56871	33594	23277
R – Rocks	18574	11570	7004
S – Soils	109357	75599	33758
T – Tills	4554	3193	1361
U – Panned overburdens	3318	2736	582
V – Vegetation	1094	445	649
W – Water	42826	9639	33187
<b>Total</b>	<b>325258</b>	<b>181670</b>	<b>143588</b>

**Table 12** Summary of MRP geochemical data held on the Geochemical Database

Sample type	No of samples	Total analysis	Analysis with locations	% analysed	% analysed & located
C – Stream sediments	59459	29046	26870	48.9	45.2
D – Drill cores	26353	14684	6297	55.7	23.9
F – Float sediments	1466	856	630	58.4	43.0
M – Drill mud	1259	253	57	20.1	4.5
P – Panned concentrates	56871	33594	29811	59.1	52.4
R – Rocks	18574	11570	6699	62.3	36.1
S – Soils	109357	75599	43632	69.1	39.9
T – Tills	4554	3193	1735	70.1	38.1
U – Panned overburdens	3318	2736	1495	82.5	45.1
V – Vegetation	1094	445	47	40.7	4.3
W – Water	42826	9639	9485	22.5	22.1

This data are also presented in graphical form (Figures 5 and 6). Figure 5 shows the percentage of each sample type loaded to the database and Figure 6 shows the total number of each type which have been analysed and located.

The distribution of samples that have both analyses and locations loaded to the database have been plotted for each sample type (Figures 7–13).

## **GEOPHYSICAL SURVEYS DATABASES**

### **Introduction**

Since the 1950s a large number of geophysical surveys have been carried out by BGS for a variety of projects and customers, both national and international. These have included regional-scale national

surveys and small-scale surveys to address particular problems, including surveys carried out to aid geological mapping or to solve specific geological problems, and surveys for mineral exploration. Many of the latter were carried out for the DTI-funded Mineral Reconnaissance Programme in the 1970s and 1980s.

The majority of geophysical surveys carried out by the former Regional Geophysics Group of BGS are now held in Oracle databases, which consist of sets of tables containing metadata and data on each survey undertaken. The top tables in the database hierarchy, GEOP\_SURVEY, GEOP\_SURVEY\_OUTLINE and the reports & publications tables, hold information on all geophysical surveys, whether regional, local, overseas or airborne. Beneath these the survey data are divided into groups as described below.

### **Local Surveys Database**

The Local Surveys Database consists of a series of Oracle tables that hold metadata describing ground geophysical surveys in Britain. A brief description of the Oracle tables is given in Table 5, and the relationship between tables is shown in Figure 1.

The reasons for creating this database were:

1. With the large number of surveys involved; many of which were never fully published, it was essential to record what work has been done and where, and for this information to be available easily for everyone.
2. The standard methods for recording work were started in the late 1960s, so many of the earlier surveys were not properly documented.
3. With the development of digital geophysical equipment the old analogue system of record-keeping started to become redundant in the 1980s. However as no new central system was introduced, results from many surveys were at risk of being lost.
4. Most surveys were set out and recorded using a local grid system, with a base point as the origin and distances measured in yards/metres relative to this known point. Consequently it was difficult to merge adjacent surveys and to combine with other datasets.
5. When starting new projects or carrying out further surveys it is useful to know what work has already been done in an area, or to find out if surveys have been carried out in similar environments elsewhere. With a properly structured database this should be achievable.

For each geophysical survey the Local Survey Database holds information on:

- the location of the survey,
- the survey objective and target,
- the position of individual lines/points, along with methods, techniques and instruments used on each line,
- dates and personnel,
- the storage location of data acquired (digital and analogue), and
- details of any BGS reports and publications on the survey work (a list of unpublished geophysics reports is given in Appendix 2).

The majority of the data held in the database comes from surveys carried out by the former Regional Geophysics Group for various projects and programmes since the 1950s. The Local Surveys Database at

present holds details of about 650 geophysical surveys, comprising some 96000 survey lines and points. Many of these lines were surveyed with a number of geophysical methods, giving a total of just over 14000 datasets, spread across Britain (Figure 14).

There are about 70 surveys to be added to this database: mainly older surveys for which complete records may be difficult to trace, and some of the most recent ones that have yet to be forwarded to the database manager. At present only 26 of the 650 surveys in the database have centrally-stored digital records. A further 70–100 surveys are likely to have digital data associated with them. These are mainly surveys done since the early 1980s or older surveys that have been re-worked as part of recent projects. These will be entered into the system on receipt. The remaining surveys are in analogue form only, and digitisation of these data would take place in support of BGS projects or if requested by external customers.

### **Airborne Geophysical Surveys Database**

This database contains both regional and detailed surveys as described below. The metadata are held in the same Oracle tables as the Local Surveys Database, with additional tables holding the digital data and survey flight parameters.

#### *The National Aeromagnetic Survey of the UK*

The aeromagnetic data for the UK were collected on 15 different surveys between 1955 and 1956. The bulk of the surveys were flown with a line spacing of 2 km and a flying height of 1000 ft (305 m) above ground. The maps were digitised in the 1980s to produce the digital aeromagnetic data set of Britain, comprising some 530648 data points (Smith and Royles, 1989). In general the resolution of the data are too low to be of use in mineral exploration. However improved resolution is available over south-west England, where the regional aeromagnetic survey was combined with the UK Atomic Energy Authority's uranium exploration programme. For this survey the flight line spacing was reduced to 400 m, terrain clearance was 150 m, and an airborne scintillation counter was installed in the aircraft. This survey is classed as one of the BGS high-resolution airborne surveys (see below).

#### *High Resolution Airborne Surveys*

The BGS holds data for 27 high resolution surveys (Figure 15), flown with a terrain clearance of less than 150 m and flight line spacing between 50 and 400 m. The majority of these surveys were carried out in support of mineral exploration projects using a combination of magnetic, EM and radiometric sensors. Table 8 outlines the main parameters for each of these surveys. Much of the data was originally recorded in analogue form, but the larger surveys and others of particular interest for mineral exploration have now been converted to digital form. The largest survey is the 1998 High resolution airborne Resource and Environmental Survey (HiRES) which covers 14000 km<sup>2</sup> of the Midlands (Area 26 on Figure 15). It is hoped that this survey will be extended to cover the whole UK and replace the old National Aeromagnetic Survey.

### **Regional Land Gravity Database**

This database contains nearly 168,000 gravity records covering the entire onshore UK at an average density of 1 station per 1–2 square km. It also includes data collected in near-shore areas by hovercraft or from sea-bottom stations. The data were collected in a number of surveys carried out by the BGS, oil companies and universities commencing in the 1950s. New data acquired is routinely added to this database.

**Table 13** Details of high-resolution airborne surveys in the UK for which BGS hold data

Survey Area	Client	Contractor	Year	Target	Line Spacing (m)	Terrain Clearance (m)		
						magnetics	em	radiometrics
<b>1. Cornwall</b>	UKAEA/BGS	Hunting G & G Ltd	1957	Mineral exploration	400	150	100	150
<b>2. Devon &amp; Somerset</b>	UKAEA/BGS	Hunting G & G Ltd	1958/9	Mineral exploration	400	150	not flown	150
3. Argyllshire	BGS	Fairey Air Surveys	1961	Mineral exploration	300	not flown	not flown	150
<b>4. Aberdeenshire</b>	EVL	Barringer Research	1970	Mineral exploration	320	49	30	not flown
<b>5. Anglesey</b>	DTI	Hunting G & G Ltd	1972	Mineral exploration	100 & 200	30	30	61
<b>6. Harlech Dome</b>	DTI	Hunting G & G Ltd	1972/3	Mineral exploration	100 & 200	30 & 46	30	61
<b>7. Bodmin</b>	DTI	Hunting G & G Ltd	1973	Mineral exploration	200	46	30	61
8. Dent	DTI	Hunting G & G Ltd	1973	Mineral exploration	100	46	30	61
9. Augill	DTI	Hunting G & G Ltd	1973	Mineral exploration	100	46	30	61
<b>10. Doon–Glenkens</b>	DTI	Hunting G & G Ltd	1973	Mineral exploration	200	46	30	61
<b>11. Lunedale</b>	DTI	Hunting G & G Ltd	1973	Mineral exploration	200	46	30	61
12. Stockdale	DTI	Hunting G & G Ltd	1973	Mineral exploration	200	46	30	61
<b>13. Craven</b>	DTI	Hunting G & G Ltd	1973	Mineral exploration	200	46	30	61
14. Lothersdale	DTI	Hunting G & G Ltd	1973	Mineral exploration	200	46	30	61
<b>15. Blair Atholl</b>	DTI	Sander Geophysics Ltd	1974	Mineral exploration	200	35	45	61
<b>16. S Northumberland</b>	DTI	Sander Geophysics Ltd	1978	Mineral exploration	250	60	75	75
<b>17. Girvan–Ballantrae</b>	DTI	Sander Geophysics Ltd	1978	Mineral exploration	250	60	75	75
<b>18. S W Dyfed</b>	DTI	Sander Geophysics Ltd	1978	Mineral exploration	250	60	75	75
<b>19. Dalradian</b>	EXXON	Dighem Ltd	1983	Mineral exploration	200	50	35	not flown
20. Witham - Tiptree	BGS	Barringer Research	1973	Sand and Gravel	161	not flown	70	not flown
21. Garstang	WRB	Barringer Research	1973	Sand and Gravel	161	not flown	70	not flown
<b>22. Formby</b>	BGS	Global Earth Sciences	1987	Hydrocarbons	200	100	not flown	not flown
<b>23. Fylde</b>	BGS	Global Earth Sciences	1987	Hydrocarbons	200	100	not flown	not flown
<b>24. Sellafield</b>	NIREX	Aerodat ltd	1990/91	Waste Disposal	200	100	115	130
<b>25. Dounraey</b>	NIREX	Global Earth Sciences	1991	Waste Disposal	200	100	not flown	130
<b>26. Midlands HIREs</b>	BGS	World Geoscience	1998	Research	400	90	90	90
<b>27. East Midlands</b>	DETR/EA	Finnish Geological Survey	1999	Research	50	50	50	50

(in column 1, numbers refer to areas in Figure 15 and surveys areas in **bold** indicate those for which digital data are available)

## MINERALOGY

By its essence, mineralogy is concerned with the microscopic features of carefully selected samples. Most mineralogical tests are to a large extent non-destructive, so that the samples can be routinely archived after analysis and made available for further investigation. Unfortunately, prior to the 1990s there was only limited curation of mineralogical samples from the Mineral Reconnaissance Programme (MRP).

During the 1960s and early 1970s mineral analysis and characterisation was carried out by the Applied Mineralogy Group of the Geochemical Division of the British Geological Survey (then the Institution of Geological Sciences) under the Uranium Survey programme carried out by the Atomic Energy Division. Details of the several thousand samples and thin sections, known as the UG (Uranium Geology) Collection, were held in a set of loose-leaf paper registers, which, despite deteriorating condition, remain in the mineralogy laboratories of the BGS at Keyworth. In addition, many of the samples and thin sections are also present. These represent localities in Britain and overseas. However, there is no modern database of these samples and the data derived from them, nor any precise assessment of which samples remain accessible.

During the 1970s and 1980s, further mineralogical work was carried out by the Applied Mineralogy Group and, post-1987, by its successor the Mineralogy & Petrology Group, in support the MRP. This work was undertaken on samples submitted by the field survey teams. In general, panned concentrates, rock samples and drillcore samples were prepared and described by optical microscopy, augmented where necessary by electron-probe microanalysis. Observations derived from these were provided in the form of a series of technical reports. These reports remain available in paper form and are listed in Appendix 3. In addition, a card index was maintained by the thin section laboratory, in which samples were registered along with their field collection and thin section numbers. However, this index was not rigorously kept to a consistent quality standard, nor were the samples and thin sections assembled into a single collection. As a result, only a proportion of the sample and thin-section collection is currently available at the Keyworth office. Similarly, only a part of the card index has been retained.

Work is currently in progress to register the immediately accessible parts of the MRP thin-section collection into the main BGS petrological reference collection and simultaneously capture index information for these samples into the database (Britrocks) that has been developed to manage this collection. When completed, some hundreds of sections will have been placed in secure storage. There is little prospect of rescuing much more of the MRP material in this way.

Britrocks was established in the early 1990s to replace the earlier PetMin Databank, a single Oracle table that held an index of the BGS Land Survey collection of samples. Britrocks is a relational database established in Oracle DBMS and held on the Keyworth database server KWDBASE. As such it is available to BGS staff and work is in progress to make it available to the public via the Internet, using the interactive Geoscience Data Index GIS interface. The design of this database was described, in 1996, by Killen, although the report was not issued and remains in a provisional status. Britrocks differs in several ways from PetMin, one being the capability of recording samples from diverse sample collections including the MRP material or, potentially, the Uranium Geology material. Figure 16 reproduces the entity diagram for Britrocks as given by Killen.

The coverage of the Britrocks database is extensive with over 155000 samples stored in the main Sample table (Figure 17). There is some bias towards the western and northern 'hard rock' areas of Britain, but

most major formations are represented. The site location metadata is not currently available on the GDI but incorporation of this is planned for the future.

## **DISCUSSION AND CONCLUSIONS**

A large volume of multidisciplinary data useful in mineral exploration has been entered in the Minerals Programme databases in recent years. The trend in data loading to the Geochemistry Database is steady as data are continually added from paper records (Figure 4). The initial rapid progress was due to the loading of existing digital records. Nearly all geophysical data has now been indexed and the map of geophysical ground surveys shows the comprehensive nature of this metadata. The Britrocks mineralogical database is comprehensive in its UK coverage but, as yet, does not contain all MRP data. Much of the mineralogical information is already incorporated into the MP and MRP report series and a list of unpublished reports is given in Appendix 3.

The biggest development in making geoscience information for Britain accessible to potential investors, whether they are based in Britain, Canada or Australia, is the improvement in web technology which allows the investor to see what data are available for mineral exploration in Britain. Through the Minerals Programme the BGS has been an active participant in these developments: a website ([mineralsUK.com](http://mineralsUK.com)) has been set up for publishing minerals data; database information has been made available on the BGS GDI site; and technical publications are sold on the BGS e-commerce website. All these developments depend on the availability of data held in the underlying databases described in this report.

Whilst there has been considerable progress in populating the BGS Geochemical, Geophysical and Mineralogical databases there is still a significant volume of data that remains to be incorporated which has potential value in mineral exploration and other fields. The value of this data are illustrated by the example of airborne geophysical data from south west England, which was flown between 1956–9 to search for domestic uranium deposits. The data remained in analogue form until 1999, when students funded by the EU Leonardo Programme digitised the data from the flight lines and entered the spatial information into a database. The resultant digital data, once checked and validated, is more useful and for a variety of applications in mineral exploration, heavy metal pollution studies, radon hazard identification, and alteration mapping around china clay deposits.

The MRP and GBASE programmes carried out by BGS are the largest surveys conducted in Britain, which provide data for mineral exploration. Commercial companies, such as BP, Rio Tinto (formerly RTZ) and Consolidated Goldfields, have spent considerable funds exploring particular detailed areas, but generally have not carried out widespread or comprehensive field surveys collecting baseline regional data. Some of this data was collected under the terms of the Mineral Exploration and Investment Grants Act 1972 between 1971 and 1984 and is now available on open file. However little of this data was in digital form and with the exception of a major airborne geophysical survey of part of Aberdeenshire none has been converted to digital form. Other data has been lost due to the lack of a formal mineral licensing system in Britain. The situation is different in Northern Ireland where much information from grassroots mining company exploration is now in the public domain. This has helped considerably in promoting Northern Ireland as a prime exploration target. It is therefore specially important that all BGS data should be made available in a modern and easily-accessible format in order to promote Britain as an area with potential for mineral deposits.

Developments in information technology and the growth of the Internet allow the retrieval of data from databases sourced anywhere in the world. To ensure that Britain does not fall behind in developing its



inherent mineral potential, BGS should ensure that all the available data are made accessible to potential investors not just in Britain but throughout the world. The first and most essential stage is to convert it from analogue to digital format and store in a database. Paper records or points marked on maps do not yield much value in the new information age. Changing exploration models (e.g. Voisey's Bay) and demand for metals (such as platinum and nickel) can result in a revitalisation of mineral exploration in an area previously discarded as lacking the potential for economic ore deposits. Prior to the discovery of the Aberfeldy SEDEX baryte deposits (Coats et al., 1980) the Dalradian of Scotland was not considered to have any economic mineral potential.

Synergy between geoscientific disciplines is also becoming increasingly important. This has been recognised in mineral exploration, where the integration of geological, geophysical and geochemical data are of prime importance. The discovery by the MRP of the Aberfeldy baryte deposits illustrates this very clearly. Here initial geochemical anomalies were confirmed by detailed geophysics and geological mapping, and further developed by drilling into a world-class deposit. Improvements in computing such as increased processor speed, storage capacity, better displays and superior programs now allow vastly improved multidisciplinary visualisation and sophisticated modelling of data. A DTI-funded Technology Transfer project to produce 3D models of the Parys Mountain VMS deposit on Anglesey, north Wales is but one example (Colman and Cooper, 1998). Various prospectivity-mapping projects carried out by the Minerals Programme depend on this increased power (Gunn and Rollin, 2000, Cooper et al., 2000). However, the use of these sophisticated models and advanced applications are wholly dependent on the availability of relevant, high quality data. For example, without high resolution airborne geophysical survey data you cannot detect features on the ground which may be related to a VMS or lode gold deposit. Similarly, if geochemical drainage survey data are not held in a database it cannot be used in prospectivity analysis.

In a country like Britain, new challenges appear as falling mineral prices and exhaustion of deposits cause social and economic problems and the environmental legacy of mining becomes more important. Mineral exploration data and interpretation are very helpful to identifying these problems. Baseline geochemical data and knowledge of background and 'natural' anomalies are important in setting thresholds and action levels for remediation. Maintenance of such information, data collection, data entry, validation and management are therefore crucially important in this new information age to a wide range of applications.

There will always be a need in mineral exploration for the collection of new data and re-interpretation of existing data can only form part of a new exploration programme. Demand for previously unwanted metals or minerals may change in response to industrial or technological advances, while new metallogenic models may open up previously unconsidered regions for other mineral commodities. For example, much of the British Isles was thought to lack any potential for the occurrence of diamond deposits, but recent discoveries in Canada, Greenland, Norway and Russia have increased interest in Britain and Ireland. The search for diamond deposits demands more sophisticated exploration methods than base-metal deposits, including detailed aeromagnetic surveys and mineralogical analysis of large heavy-mineral concentrates. Such data are not, however, available in potentially favourable areas of Britain, such as the Lewisian terrain of north-west Scotland. New surveys are therefore essential to explore for diamonds in Britain.

There is an onus or duty on the holders of exploration data to maintain it properly. Database technology changes and evolves, and data must be periodically archived, moved, converted and reorganised to meet the challenge of new technology. Databases, like the humans that created them, are never perfect and errors will nearly always be present so that data validation and checking is an on-going process: only a

redundant or unused database is not updated. Even maintaining metadata is difficult without knowledge of the subject and the nature of the original sampling methods.

Two recent developments have improved the accessibility of BGS data. The first is the development of the Geoscience Data Index (GDI), which allows Internet access to index-level data on BGS data holdings. It is therefore possible for any interested investor to see index data from the Minerals Programme databases. The locations of, and elements determined in, a range of MRP geochemical samples are now available worldwide. Areas covered by MP and MRP reports are also easily accessible. Development of the user interface is continuing, with delivery of data over the Internet a planned future enhancement.

The second development is the closer integration of BGS's diverse and extensive data holdings. Until recently, much of BGS data were held in stand-alone databases, which were not easily interrogated or integrated. Several initiatives have improved this situation and made more data available within the corporate databases. Common standards of data recording have also improved the ability to link between data derived from different sources. The better links between databases allow improved integration of multi-disciplinary data for mineral exploration. For example Figure 18 shows the area covered by an airborne survey of Dyfed, Wales and the location of ground survey traverses. A digital geological map can be added to allow further interpretation. Figure 19 shows airborne radiometric data as a coloured map with superimposed geological line work and known occurrences of uranium mineralisation as points derived from the Mineral Occurrence Database. These simple examples clearly demonstrate the superiority of digital data in comparison with separate analogue records (geophysics), paper maps (geology) and reports (U occurrences).

## **RECOMMENDATIONS**

Recommendations for future work fall into two categories:

1. continuation of existing work to ensure that all Minerals Programme and MRP data are incorporated into databases.
2. further development of methods to improve data accessibility, both to users in BGS and externally.

Detailed recommendations are:

- Continue capturing geochemical, geophysical and mineralogical data in digital format.
- Continue management of data in modern corporate databases.
- Keep pace with developments in database methodology and IT technology.
- Develop improved accessibility to data over the Internet, including on-line delivery.
- Develop better methods for integration and display of geoscientific data for mineral exploration.

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SMITH, I F and ROYLES, C P. 1989. The digital aeromagnetic survey of the United Kingdom. *British Geological Survey Technical Report WK/89/05*.

## APPENDIX 1 List of Mineral Reconnaissance Programme (MRP) Reports and Data Releases

<b>Report Number</b>	<b>MRP Report Title</b>
1	The concealed granite roof in south-west Cornwall.
2	Geochemical and geophysical investigations around Garras Mine, near Truro, Cornwall.
3	Molybdenite mineralisation in Precambrian rocks near Lairg, Scotland.
4	Investigation of copper mineralisation at Vidlin, Shetland.
5	Preliminary mineral reconnaissance of Central Wales.
6	Report on geophysical surveys at Struy, Invernesshire.
7	Investigation of tungsten and other mineralisation associated with the Skiddaw Granite near Carrock Mine, Cumbria.
8	Investigation of stratiform sulphide mineralisation in parts of central Perthshire.
9	Investigation of disseminated copper mineralisation near Kilmelford, Argyllshire, Scotland.
10	Geophysical surveys around Talnotry Mine, Kirkcudbrightshire, Scotland.
11	A study of the space form of the Cornubian granite batholith and its application to detailed gravity surveys in Cornwall.
12	Mineral investigations in the Teign Valley, Devon. Part 1 - Barytes.
13	Investigation of stratiform sulphide mineralisation at McPhun's Cairn, Argyllshire.
14	Mineral investigations at Woodhall and Longlands in north Cumbria.
15	Investigation of stratiform sulphide mineralisation at Meall Mor, South Knapdale, Argyll.
16	Report on geophysical and geological surveys at Blackmount, Argyllshire.
17	Lead, zinc and copper mineralisation in basal Carboniferous rocks at Westwater, south Scotland.
18	A mineral reconnaissance survey of the Doon–Glenkens area, south-west Scotland.
19	A reconnaissance geochemical drainage survey of the Criffel–Dalbeattie granodiorite complex and its environs.
20	Geophysical field techniques for mineral exploration.
21	A geochemical drainage survey of the Fleet granitic complex and its environs.
22	Geochemical and geophysical investigations north-west of Llanrwst, North Wales.
23	Disseminated sulphide mineralisation at Garbh Achadh, Argyllshire, Scotland.
24	Geophysical investigations along parts of the Dent and Augill Faults.
25	Mineral investigations near Bodmin, Cornwall. Part 1 - airborne and ground geophysical surveys.
26	Stratabound barium-zinc mineralisation in Dalradian schist near Aberfeldy, Scotland: preliminary report.
27	Airborne geophysical survey of part of Anglesey, North Wales.
28	A mineral reconnaissance survey of the Abington–Biggar–Moffat area, south-central Scotland.
29	Mineral exploration in the Harlech Dome, North Wales.
30	Porphyry-style copper mineralisation at Black Stockarton Moor, south-west Scotland.
31	Geophysical investigations in the Closehouse–Lunedale area.
32	Investigations at Polyphant, near Launceston, Cornwall.
33	Mineral investigations at Carrock Fell, Cumbria. Part 1 - Geophysical survey.
34	Results of a gravity survey of the south-west margin of Dartmoor, Devon.
35	Geophysical investigation of chromite-bearing ultrabasic rocks in the Baltasound–Hagdale area, Unst, Shetland Islands.
36	An appraisal of the VLF ground resistivity technique as an aid to mineral exploration.
37	Compilation of stratabound mineralisation in the Scottish Caledonides.
38	Geophysical evidence for a concealed eastern extension of the Tanygrisiau microgranite and its possible relationship to mineralisation.
39	Copper-bearing intrusive rocks at Cairngarroch Bay, south-west Scotland.

<b>Report Number</b>	<b>MRP Report Title</b>
40	Stratabound barium-zinc mineralisation in Dalradian schist near Aberfeldy, Scotland: Final report.
41	Metalliferous mineralisation near Lutton, Ivybridge, Devon.
42	Mineral exploration in the area around Culvennan Fell, Kirkcowan, south-western Scotland.
43	Disseminated copper-molybdenum mineralisation near Ballachulish, Highland Region.
44	Reconnaissance geochemical maps of parts of south Devon and Cornwall.
45	Mineral investigations near Bodmin, Cornwall. Part 2 - New uranium, tin and copper occurrences in the Tremayne area of St Columb Major.
46	Gold mineralisation at the southern margin of the Loch Doon granitoid complex, south-west Scotland.
47	An airborne geophysical survey of the Whin Sill between Haltwhistle and Scots' Gap, south Northumberland.
48	Mineral investigations near Bodmin, Cornwall. Part 3 - The Mulberry and Wheal Prosper area.
49	Seismic and gravity surveys over the concealed granite ridge at Bosworgy, Cornwall.
50	Geochemical drainage survey of central Argyll, Scotland.
51	A reconnaissance geochemical survey of Anglesey.
52	Miscellaneous investigations on mineralisation in sedimentary rocks.
52	Geochemical reconnaissance in the Cheshire Basin.
52	Titanium dioxide in the Ayrshire Bauxitic Clay.
52	The Marl Slate (Kupferschiefer) in the Southern North Sea Basin.
53	Investigation of polymetallic mineralisation in Lower Devonian volcanics near Alva, central Scotland.
54	Copper mineralisation near Middleton Tyas, North Yorkshire.
55	Mineral exploration in the area of the Fore Burn igneous complex, south-western Scotland.
56	Geophysical and geochemical investigations over the Long Rake, Haddon Fields, Derbyshire.
57	Mineral exploration in the Ravenstonedale area, Cumbria.
58	Investigations of small intrusions in Southern Scotland.
59	Stratabound arsenic and vein antimony mineralisation in Silurian greywackes at Glendinning, south Scotland.
60	Mineral investigations at Carrock Fell, Cumbria. Part 2 - Geochemical investigations.
61	Mineral reconnaissance at the Highland Boundary with special reference to the Loch Lomond and Aberfoyle areas.
62	Mineral reconnaissance in the Northumberland Trough.
63	Exploration for volcanogenic sulphide mineralisation at Benglog, North Wales.
64	A mineral reconnaissance of the Dent–Ingletton area of the Askrigg Block, northern England.
65	Geophysical investigations in Swaledale, North Yorkshire.
66	Mineral reconnaissance surveys in the Craven Basin.
67	Baryte and copper mineralisation in the Renfrewshire Hills, central Scotland.
68	Polymetallic mineralisation in Carboniferous rocks at Hilderston, near Bathgate, central Scotland.
69	Base metal mineralisation associated with Ordovician shales in south-west Scotland.
70	Regional geochemical and geophysical surveys in the Berwyn Dome and adjacent areas, North Wales.
71	A regional geochemical soil investigation of the Carboniferous Limestone areas south of Kendal (south Cumbria and north Lancashire).
72	A geochemical drainage survey of the Preseli Hills, south-west Dyfed, Wales.
73	Platinum-group element mineralisation in the Unst ophiolite, Shetland.
74	A reconnaissance geochemical drainage survey of the Harlech Dome, North Wales.
75	Geophysical surveys in part of the Halkyn–Minera mining district, north-east Wales.

<b>Report Number</b>	<b>MRP Report Title</b>
76	Disseminated molybdenum mineralisation in the Etive plutonic complex in the western Highlands of Scotland.
77	Follow-up mineral reconnaissance investigations in the Northumberland Trough.
78	Exploration for porphyry-style copper mineralisation near Llandeloy, south-west Dyfed.
79	Volcanogenic and exhalative mineralisation within Devonian rocks of the South Hams district of Devon.
80	Mineral investigations in the Ben Nevis and Ballachulish areas of the Scottish Highlands.
81	Investigations for tin around Wheal Reeth, Godolphin, Cornwall.
82	Mineral investigations near Bodmin, Cornwall. Part 4 - Drilling at Royalton Farm.
83	Mineral investigations near Bodmin, Cornwall. Part 5 - The Castle-an-Dinas wolfram lode.
84	An airborne geophysical survey of part of west Dyfed, South Wales, and some related ground surveys.
85	Geophysical surveys near Strontian, Highland Region.
86	Volcanogenic mineralisation in the Treffgarne area, south-west Dyfed, Wales.
87	Exploration for stratabound mineralisation in Middle Dalradian rocks near Huntly, Grampian Region, Scotland.
88	Mineral exploration for zinc, lead, zinc and baryte in Middle Dalradian rocks of the Glenshee area, Grampian Highlands.
89	Geochemical and geophysical investigations of the Permian (Littleham Mudstone) sediments of part of Devon.
91	A geochemical survey of part of the Cheviot Hills and investigations of drainage anomalies in the Kingsseat area.
92	A mineral reconnaissance survey of the Llandrindod Wells/Builth Wells Ordovician inlier, Powys.
93	Stratabound base-metal mineralisation in Dalradian rocks near Tyndrum, Scotland.
94	Geochemistry of some heavy mineral concentrates from the island of Arran.
95	Mineral reconnaissance at Menear, St Austell, Cornwall.
96	Geochemistry of sediments from the Lui drainage, Braemar, Grampian.
97	Magnetic and geochemical surveys in the area between Geltsdale, Cumbria, and Glendue Fell, Northumberland.
98	Exploration for gold between the lower valleys of the Erme and Avon in the South Hams district of Devon.
99	Base-metal and gold mineralisation in north-west Anglesey, North Wales.
100	Molybdenum mineralisation near Chapel of Garioch, Inverurie, Aberdeenshire.
101	Skarn-type copper mineralisation in the vicinity of Belstone Consols Mine, Okehampton, Devon.
102	Geophysical and geochemical investigations of the manganese deposits of Rhiw, western Llyn, North Wales.
103	Exploration for volcanogenic mineralisation in the Devonian rocks north of Wadebridge, Cornwall.
104	Stratabound barium and base-metal mineralisation in Middle Dalradian metasediments near Braemar, Scotland.
105	Investigations at Lambriggan Mine, near St Agnes, Cornwall.
106	Marine deposits of chromite and olivine, Inner Hebrides of Scotland.
107	Mineral investigations near Bodmin, Cornwall. Part 6 - The Belowda area.
108	Geochemical investigations around Trewalder, near Camelford, Cornwall.
109	Copper and molybdenum distribution at Shap, Cumbria.
110	Mineral investigations near Bodmin, Cornwall. Part 7 - New uranium occurrences at Quoit and Higher Trenoweth.
111	Gold and platinum group elements in drainage between the River Erme and Plymouth Sound, South Devon.

<b>Report Number</b>	<b>MRP Report Title</b>
112	Geophysical and geochemical investigations on Anglesey, North Wales.
113	Mineral investigations at Tredaule, near Launceston, Cornwall.
114	The Mineral Reconnaissance Programme 1990.
115	Platinum-group elements in the ultramafic rocks of the Upper Deveron Valley, near Huntly, Aberdeenshire.
116	Gold in the Ochil Hills, Scotland.
117	Exploration for vanadiferous magnetite and ilmenite in the Lizard Complex, Cornwall.
118	Mineral exploration in the Cockermouth area, Cumbria. Part 1 - regional surveys.
119	Investigations for Cu - Ni and PGE in the Hill of Barra area, near Oldmeldrum, Aberdeenshire.
120	A gravity investigation of the Middleton Granite, near Inverurie, Aberdeenshire.
121	Exploration for gold in the South Hams district of Devon.
122	Mineral exploration in the Cockermouth area, Cumbria. Part 2: follow up surveys.
123	Mineral investigations in the Teign Valley, Devon. Part 2: base metals.
124	Platinum-group elements in the Huntly intrusion, Aberdeenshire, north-east Scotland.
125	Geochemistry database: data analysis and proposed design.
126	Mineral exploration in the Pitlochry to Glen Clova area, Tayside Region, Scotland.
127	The metalliferous mineral potential of the basic rocks of the Penmynydd Zone, south-east Anglesey.
128	Mineralisation in the Lower Palaeozoic rocks of south-west Cumbria. Part 1: regional surveys.
129	Mineralisation in the Middle Devonian volcanic belt and associated rocks of South Devon.
130	The occurrence and economic potential of nodular monazite in south-central Wales.
131	Platinum-group element mineralisation in the Loch Ailsh alkaline igneous complex, NW Scotland.
132	Reconnaissance drainage survey for base-metal mineralisation in the Llyn peninsula, North Wales.
133	Exploration for gold in the Crediton Trough, Devon. Part 1: regional surveys.
134	Exploration for gold in the Crediton Trough, Devon. Part 2: detailed surveys.
135	The potential for diamonds in Britain.
136	A review of detailed airborne geophysical surveys in Great Britain.
137	Exploration for volcanogenic mineralisation in south-west Wales.
138	Gold exploration in the Duns area, Southern Uplands, Scotland.
139	Exploration for carbonate-hosted base-metal mineralisation near Ashbourne, Derbyshire.
140	Mineral exploration for gold and base-metals in the Lewisian and associated rocks of the Glenelg area, north-west Scotland.
141	Assessment of the potential for gold mineralisation in the Southern Uplands of Scotland using multiple geological, geophysical and geochemical datasets.
142	Industrial mineral potential of andalusite and garnet in the Scottish Highlands.
143	Gold mineralisation in the Dalradian rocks of Knapdale-Kintyre, south-west Highlands, Scotland.
144	The potential for gold mineralisation in the British Permian and Triassic red-beds and their contacts with underlying rocks.
145	Exploration for stratabound mineralisation in the Argyll Group (Dalradian) of north-east Scotland.
146	Mineral exploration in Lewisian supracrustal and basic rocks of the Scottish Highlands and Islands.

**Number MRP Data Release title**

- 1 Data arising from investigations of mineralisation in Dalradian rocks, Tyndrum, Scotland.
- 2 Geochemical till sampling in the Middleton area, Peebles, Scotland.
- 3 Drill core from investigations around Chillaton, Devon.
- 4 Geochemical reconnaissance of the north-east Scottish Borders.
- 5 Data arising from investigations of the Lizard Complex, Cornwall.
- 6 Data arising from investigations in the Shelve area, Shropshire.
- 7 Data arising from drilling and overburden investigation at Brownstone Farm, Holbeton, South Hams, Devon.
- 8 Data arising from drilling investigations in the Loch Borrallan intrusion, Sutherland, Scotland.
- 9 Data arising from investigations of the Knock intrusion at Claymires, Aberdeenshire.
- 10 Data arising from investigations into the distribution of platinum group elements, South Harris, Isle of Lewis, Scotland.
- 11 Rare earth elements in alkaline intrusions, north-west Scotland.
- 12 Mineral investigations in the Scardroy area, Highland Region, Scotland.
- 13 Exploration for gold in Central Wales.
- 14 Geochemical Surveys for gold in the Berwyn Hills.
- 15 An appraisal of the gold potential of mine dumps in the North Molton area, North Devon.
- 16 Exploration for stratabound mineralisation around Chillaton, Devon.
- 17 Regional appraisal of the potential for stratabound base-metal mineralisation in the Solway Basin.
- 18 Mineral investigations in the Northumberland Trough: Part 1, Arnton Fell area, Borders, Scotland.
- 19 Exploration for gold in the Thornhill Basin, Southern Scotland.
- 20 Mineral investigations in the Northumberland Trough: Part 2, Newcastleton area, Borders, Scotland.
- 21 Mineral investigations in the Northumberland Trough: Part 3, The Ecclefechan - Waterbeck area.
- 22 Mineral investigations in the Northumberland Trough: Part 4, the Bewcastle area.
- 23 Mineral investigations in the Northumberland Trough: Part 5, The Kirkbean area, south-west Scotland.



## APPENDIX 2 Geophysics Reports

### Unpublished reports on geophysical surveys in the UK.

- CORNWELL, J D & SMITH, I F. 1973. Geophysical surveys on the Dent, Augill and Lunedale Faults, 1973: Preliminary report. AGU-MRP 1
- CORNWELL, J D. 1973. Geophysical surveys on the Stockdale Monocline, 1973:Preliminary Results. AGU-MRP 2
- SMITH, I F.1973. Interim Report of geophysical fieldwork, Anglesey, N Wales (summer 1973). AGU-MRP 3
- SMITH, I F. 1973.Interim Report of geophysical fieldwork, Harlech, N Wales (summer 1973). AGU-MRP 4.
- BENNETT, J R. 1974. Airborne Geophysical surveys and ground follow-up investigations in S W Scotland (March 1974) AGU-MRP 5.
- SMITH, I F.1974. Interim Report of geophysical fieldwork, Anglesey, N Wales (summer 1974).AGU-MRP 6.
- SMITH, I F. 1974. Interim Report on geophysical fieldwork, Harlech, N Wales (1974). AGU-MRP 7.
- HOWARD, S H D & BENNETT, J R P. 1974. Geophysical investigations of mineralised areas in Sutherland and Caithness, N Scotland (November 1974). AGU-MRP 8.
- HOWARD, S H D .1974. Geophysical investigations of a sulphide occurrence at Mcphun's Cairn, Loch Fyne, Argyll (November 1974). AGU-MRP 9.
- BURLEY, A J. 1974. Report on Geophysical surveys at Struy, Inverness-shire in August 1974. AGU-MRP 10.
- BURLEY, A J & PARKER, M E.1974. Report on Geophysical surveys in Shetland, October 1974. AGU-MRP 11.
- TOMBS, J M C & ROLLIN, K E. 974. Report on Geophysical survey in S W England, 1974. AGU-MRP 12
- EVANS, A D. 1974. Geophysical surveys in the Swaledale (Stockdale Monocline) area, 1974: Preliminary Results and recommendations (January 1975). AGU-MRP 13.
- HOWARD, S H D & BURLEY, A J. 1975. Induced polarisation and magnetic traverses across a mineralised metamorphic intrusion in N Benbecula (January 1975). AGU-MRP 14.
- HOWARD, S H D & PARKER, M E. 1975. Geophysical exploration for sulphide deposits in the Dalradian rocks Central Perthshire (January 1975). AGU-MRP 15.
- PATRICK, D J. 1975. Geophysical surveys in the Lunedale Fault area 1974: Preliminary results and recommendations (January 1975). AGU-MRP 16.
- PATRICK, D J & EVANS, A D. 1975. Geophysical surveys in the Craven Fault area 1974: Preliminary results and recommendations (January 1975). AGU-MRP 17.
- PATRICK, D J. 1975. Geophysical surveys in the Dent/Augill area, 1974: Preliminary results and recommendations (February 1975). AGU-MRP 18.
- TOMBS, J M C & ROLLIN, K E. 1975. Geophysical surveys in the Teign Valley area, Devon, 1974 and 1975. AGU-MRP 19.

ALLSOP, J M. 1975. Gravity survey of the Doon-Fleet granite district, Scotland (May 1975). AGU-MRP 20

SMITH, I F. 1975 Abstract of gradient array IP survey, Anglesey, N Wales (summer 1975). AGU-MRP 21

DAWSON, J, FLOYD, J D, PHILIP, I P, BURLEY, A J, ALLSOP, J M & BENNETT, J P R. 1975. A mineral reconnaissance survey of the Doon-Glenkens area: Interim Report (August 1975). AGU-MRP 22

ROLLIN, K E. 1975. Geophysical surveys at Godolphin, Cornwall, July 1975, and Bere Alston, Devon, August 1975. AGU-MRP 23

ANDREW, E M & COLLAR, F A. 1976. Seismic investigations in the Craven Basin. AGU-MRP 24

BURLEY, A J & HOWARD, S H D. 1976. The airborne geophysical survey of the Blair Atholl/Glenshee area, June 1974. AGU-MRP 25

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### APPENDIX 3 Mineralogy and Petrology Reports

#### Pre-1985

- No.20 Identification of mineral grains selected from panning concentrates from the Invershin area of Sutherland, Scotland. M.6463/264. August 1968
- No.25 Identification of mineral grains selected from panning concentrates from the Helmsdale, Ben Loyal, and Blackwater areas of North Scotland. M.6463/266, 269 and 270. November 1968.
- No.26 X-ray fluorescence and mineralogical examination of panning concentrates from the Invershin Area of Sutherland, Scotland. M.6463/264. November 1968
- No.30 X-ray fluorescence and mineralogical examination of panning concentrates from the Ben Loyal Area of Sutherland, Scotland. M.6463/269. February 1969.
- No.32 X-ray fluorescence and mineralogical examination of panning concentrates from the Helmsdale area of Sutherland, Scotland M.6463/266. February 1969
- No.33 X-ray fluorescence and mineralogical examination of panning concentrates from the Blackwater area of Sutherland, Scotland. M.6463/270 March 1969
- No.34 A mineralogical and geochemical examination of peat/granite rubble soils from Allt na Muic radiometric anomaly, Helmsdale district, Sutherland, Scotland. M.3481/32. March 1969
- No.36 Galena-fluorite-baryte mineralisation in thirty-two specimens from the Grudie granite and its country rocks, Invershin district, Sutherland, Scotland. M.6743/102. March 1969.
- No.55 Mineralogical examination of heavy mineral concentrates from nine stream sediment samples, Ratagain area, Wester Ross, Scotland. M.7086/1. September 1969.
- No.63 Mineral beneficiation trials on a talc-carbonate rock from Cunningsburgh, Shetland. M.5194/101. November 1969.
- No.82 Mineralogical examination of phyllites from Loch Fyne, Scotland, M6743/111 October 1970.
- No.83 Investigation of further samples of talc-carbonate rocks from Cunningsburgh, Shetland. M5194/101 November 1970
- No.103 The mineralogy and geochemistry of some rocks from S E Shetlands M.6743/112 February 1972.
- No.119 Mineralogical studies of radioactive specimens from Orkney GD.11.25/1.
- No.121 Mineralogical studies of the ophiolite belt in Unst, Shetland GD.11.32/1 January 1973
- No.125 The ore mineralogy of some rocks from the Loch Shin Area GD 01.42/8/7/M March 1973.
- No.133 New Lead-Zinc mineralisation at Port An Righ, Easter Ross, Scotland. M.6354/48 October 1973
- No.135 Mineralogical assessment of geochemical drainage anomalies at Bail Hill, Dumfriesshire. GD 19.03/1
- No.140 The petrography and mineralogy of some rocks from the Loch Shin Area GD 01.42/8/7M April 1974.
- No.141 Notes on the petrography of selected samples of diamond drill cores from the Loch Shin area. GD 01.42/8/7M May 1974

- No.142 The identification of heavy minerals derived from tin-bearing rocks in the Cairngorms. GD May 1974.
- No.146 Heavy mineral assemblages in concentrates from panning efficiency trials, N W Scotland. August 1974. GD 04.51/1
- No.147 Location of metal anomalies in mineral constituents of panning concentrate from S W Scotland. September 1974 GD 19.03/1
- No.148 Uranium mineralisation at Rogie Falls, Ross-shire. December 1974 GD 99.70/6.
- No.149 Second interlaboratory survey of the accuracy of ore analysis GD 99.23/2 Feb.1975.
- No.151 Notes on the ore mineralogy of the Port Quinn area, North Cornwall GD 27.21/2 Feb.1975
- No.153 Petrographic examination of mineralised sediments from the Lower Carboniferous of Dumfries-shire GD 18.03/1 Mar. 1975
- No.155 Uranium mineralisation in rock samples obtained by drilling at Tremayne, Cornwall. GD 27.03/4M March 1975
- No.156 The location of molybdenum in samples of till from the Grudie Area, Sutherland. GD 12.16/1M April 1975
- No.157 Mineralogical examination of panning concentrates from Anglesey with respect to metal contamination. GD 37.03/3M April 1975.
- No.161 Determination of secondary lead minerals from Penkiln Burn, Galloway. GD19.03/2. June 1975
- No.164 Uranium abundancies in some granitic rocks of the British Isles. Various file nos. Sept. 1975.
- No.165 Aegirine of probable authigenic origin in sediments of Middle Devonian age from the Halkirk District, Caithness. GD 16.03/M. Oct. 1975
- No.167 Mineralised samples from Vidlin Ness, Shetland. GD 11.03/3M Nov. 1975.
- No.168 Some notes on the copper sulphide mineralisation of a magnetite skarn from Strath, Isle of Skye. GD.13.21/1 Nov. 1975.
- No.170 Metalliferous mineralisation in core samples from Penkiln burn, Galloway GD 19.03/1 Feb. 1976
- No.171 Mineralogical investigation of porphyrites and associated rocks from Garbh Achad, Central Argyllshire GD 16.03/4M April 1976.
- No.172 Mineralogical investigations of porphyrites and associated rocks from Kilmelford, Central Argyllshire GD 16.03/4M April.1976.
- No.175 Mineralogical investigations of chromite bearing rocks from the Corriecharmaig serpentinite, Central Perthshire, GD 15.67/1 July 1976.
- No.177 Mineralogical investigations of geochemical anomalies from panned concentrates, Mid-Cornwall reconnaissance survey. GD 27.03/4M Aug.1976.
- No.178 Petrographic examination of rock specimens from outcrops in the Pokeskine Syke area, Dumfries-shire GD 18.03/1 July 1976.

- No.181 Petrographic examination of rock specimens from the Kilmelford intrusion centre, Argyllshire. GD 16.03/7 Oct. 1976.
- No.183 Petrographic notes on sulphide-bearing quartzites and schists from the Ben Eagach Schist mineralised horizon, Perthshire, Scotland. GD 1603/4M Oct. 1976
- No.186 Mineralogical investigation of drill-core from Borehole 7, Black Stockarton Moor: Part 1, mineralogical log of specimens. GD 19.03/1 Oct. 1976.
- No.189 Mineralogical investigations of drill-core from Borehole 7, Black Stockarton Moor: Part2, General description and discussion. GD 19.03/1 Oct. 1976.
- No.190 Petrographic notes on rock specimens from Garbh Achadh, Argyllshire. GD 16.03/7. Nov.1976.
- No.192 Mineralogical investigation of drill-core from Borehole 1, Kilmelford, Argyllshire. GD 16.03/7. Jan 1977.
- No.193 Mineralogical examination of specimens from drill hole 2, Kilmelford, Argyllshire, GD 16.03/7. Feb.1977.
- No.195 Mineralogical examination of panning concentrates for the Borders Carboniferous Project. GD 18.03.1M. March 1977.
- No.196 Mineralogical investigation of anomalous basalt till concentrates for the Borders Carboniferous Project. GD 18.03/1M. 1977.
- No.197 Petrographic examination of rock specimens from the Borders Region of Scotland. GD 18.03/1M. April 1977.
- No.198 Petrographic examination of rock specimens from Meall Mhor, Argyllshire GD 16.03/4M. May 1977.
- No.201 Petrographic examination of drill core from Meall Mhor, Argyllshire. GD.16.03/1M. May 1977.
- No.202 Mineralogical studies of stream sediments from Orkney and Helmsdale. GD 11.03/7. June 1977.
- No.205 Uranium mineralisation; Killeganogue and Quoit. GD 27.60/2 July 1977.
- No.207 Mineralogical examination of drill core from Borehole 8, Black Stockarton Moor, S.W. Scotland. GD 19.03/1 July 1977.
- No.208 Mineralogical examination of drill core from Borehole 9, Black Stockarton Moor, S.W. Scotland. GD 19.03/1 July 1977.
- No.210 Investigations into the causes of electromagnetic anomalies in Cambrian and Ordovician sediments of the Harlech Dome, Gd 37.03/4M. Aug. 1977.
- No.212 Lead and arsenic determinations on 1748 panning concentrates from Cornwall and Devon by X-ray fluorescence analysis. GD 27.03/4M. Oct 1977.
- No.213 Mineralogical examination of borehole cores from Carmel Head, Anglesey. GD 37.03/3M Oct.1977.
- No.214 Mineralogical examination of miscellaneous specimens from the Harlech Dome. GD 37.03/4M. Nov 1977.

- No.215 Mineralogical and petrological investigation of rocks for the Dalradian Sulphide Project. GD 16.03.4M Jan. 1978.
- No.216 Mineralogical investigation of contaminated panning concentrates from the Borders Region. GD 18.03/1M March 1978.
- No.220 Mineralogical examination of Unst drill core. GD 11.02/2M. April 1978.
- No.221 Mineralogical examination of further borehole cores from Carmel Head, Anglesey. April 1978.
- No.223 Mineralogical examination of boreholes one to five, Ben Eagach, Perthshire: Part 1. Mineralogical logs. June 1978. GD 16.03/4M.
- No.224 Mineralogical and petrological investigation of rocks from Middle Mill Quarry, St. Davids, Pembrokeshire. July 1978 GD 38/21/1.
- No.226 Mineralogical and petrological investigations of mineralized rocks from the Fore Burn Complex and Broadlaw Granite. August 1978. GD 38/21/1.
- No.227 Petrographic notes for specimens of drillcore from Ben Eagach boreholes one to five. September 1978. GD 15.02/1M.
- No.229 Mineralogical examination of samples from Foel Ddu and Penaran Forest Areas of Harlech Dome. October 1978. GD 37.03/4M.
- No.231 Mineralogical and petrological examination of further samples from Middle Mill Quarry, Pembrokeshire. November 1978. GD 38/21/1.
- No.244 Petrographic examination of rock specimens from Balmaha, Central Scotland. GD 16.02/2 August 1979
- No.246 Drill-core specimens from Alva, Central Scotland; boreholes 1,2, and 3. GD 16.03/7 October 1979
- No.247 Rock specimens from the Bryn Mawr area of the Harlech Dome GD 37.03/4M October 1979
- No.248 Au/Ag ratios in gold grains from the Helmsdale placer deposit, Sutherland. File M6743/98 October 1979.
- No.259 Preparation of high-grade baryte concentrates from the bedded-baryte deposit. Ben Eagach, Perthshire. D.A.Briggs, D.A.W.Bernard, D.J.Bland and J.A.Bain. File GD 15.02/1M 1 May 1980.
- No.262 Petrographic examination of rock specimens from the ophiolite complex of Girvan/Ballantrae, Ayrshire with particular reference to opaque mineral constituents. J.L.M.Lambert. File GD 17.32/1 29 August 1980.
- No.265 Petrography, mineralogy and petrogenesis of Silurian sediments, Glendinning, S.W.Scotland; Boreholes 1-4. B.R.H.Skilton. File GD 19.03/1 November 1980.
- No.292 Petrographic examination of rock specimens from the ophiolite complex of Girvan/Ballantrae, Ayrshire: Part 1. J.L.M.Lambert File GD 17.32/1 16 March 1982.
- No.299 Petrographic examination of rock specimens from the ophiolite complex of Girvan/Ballantrae, Ayrshire: Part 2. J.L.M.Lambert File GD 17.32/1 November 1982



- No.311 N.J.Forthey. Petrography of outcrop specimens from the Dericampus area of Glen Lyon, Tayside Region, Scotland. 1984.
- No.312 N.J.Forthey. Petrography of outcrop specimens from the Glen Shee area of Scotland – preliminary report. 1984.
- No.319 N.J.Forthey & P.H.A.Nancarrow. Mineralogical examination of drillcore specimens from the Lecht manganese mineralization, NE Scotland. 1984.
- No.323 N.J.Forthey. Petrographic notes on drillcore specimens from the Lecht manganese mineralisation, NE Scotland. 1984.

### 1985

- WG/85/12 P N A Nancarrow. Vanadiferous nodules from Permian strata near Budleigh Salterton, Devon.
- WG/85/22C A J Bloodworth & D A W Bernard. Quantitative mineralogy and beneficiation trails of talc-bearing rocks from the Shetland Isles.
- WG/85/38R N J Forthey. Texture and mineralogy of Fe-Mn-Zn-Ba rich oxide rock from Lecht Borehole 6, NE Scotland.

### 1986

- WG/86/16R D J Bland. Panned concentrates from Wasdale, Lake District.

### 1987

- WG/87/4C N J Forthey. Petrography of specimens of diamond drill core from Wellheads, Grampian Region, Scotland.
- WG/87/5C N J Forthey. Petrography of diamond drill core and outcrop specimens from Allt an Daimh and other areas in Glen Shee, Tayside Region, Scotland.
- WG/87/6C P H A Nancarrow. Mn-minerals from Mynydd Rhiw, North Wales.
- WG/87/23C D J Bland. An examination of gold and accompanying minerals from the South Hams, Devon.
- WG/87/25C N J Forthey & P H A Nancarrow. Petrographic examination of rocks from Loch Kander, Aberdeenshire.

### 1988

- WG/88/4C N J Forthey. Petrographic examination of rocks from the Loch Kander area of the Grampian Highlands: second report.
- WG/88/7C D J Bland. An occurrence of silver and gold in Wasdale, Lake District.
- WG/88/15 M T Stytes. Petrology of borehole cores from the South Hams area, Devon.

### 1989

- WG/89/2C I R Basham, B Beddoe-Stephens & A McDonald. Mineralogical assessment of submarine heavy mineral sands, S Rhum.

WG/89/7C N J Fortey. Mineralogical investigation of rock specimens from the Black Combe area, SW Lake District.

WG/89/21C D J Bland. Examination of some panned concentrates for the Cockermouth area, Lake District.

**1990**

WG/90/7R N J Fortey. Mineralogy and petrography of rock samples and drillcore from the Borland Glen area, Ochil Hill, Scotland.

**1993**

WG/93/7R M T Styles. A mineralogical study of Platinum Group Element Mineralisation in the Loch Ailsh complex, Sutherland, Scotland.

WG/93/14C N J Fortey. Petrography and mineralogy of Lewisian rocks from the Loch Maree and Loch Duich areas.

**1995**

WG/95/5C N J Fortey. Mineralogy and petrology of rocks from the Duns Area, S E Scotland.

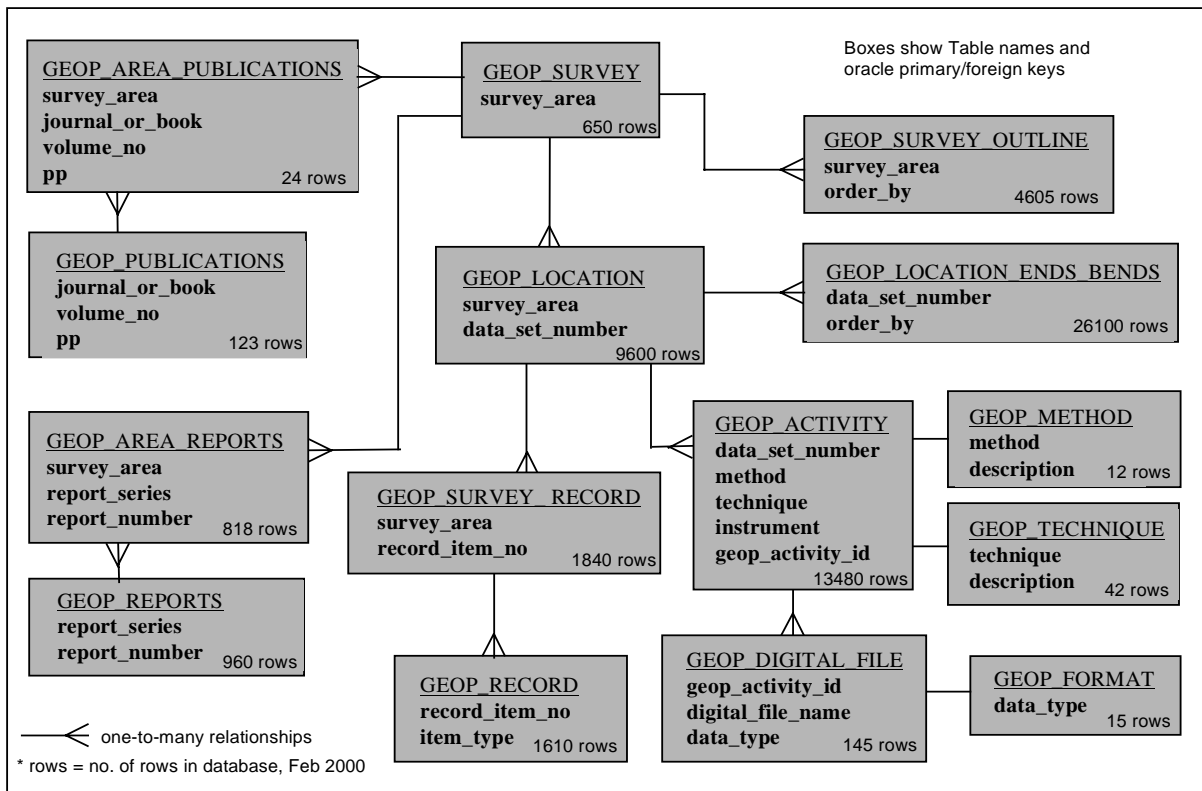
WG/95/28C N J Fortey. An assessment of Au, Pt and Pd potential in magnetite-rich Lewisian gneiss from Tiree, Scotland.

WG/95/29C N J Fortey & M T Styles. Mineralogy and petrography of rock samples from the Flowerdale area, N W Scotland.

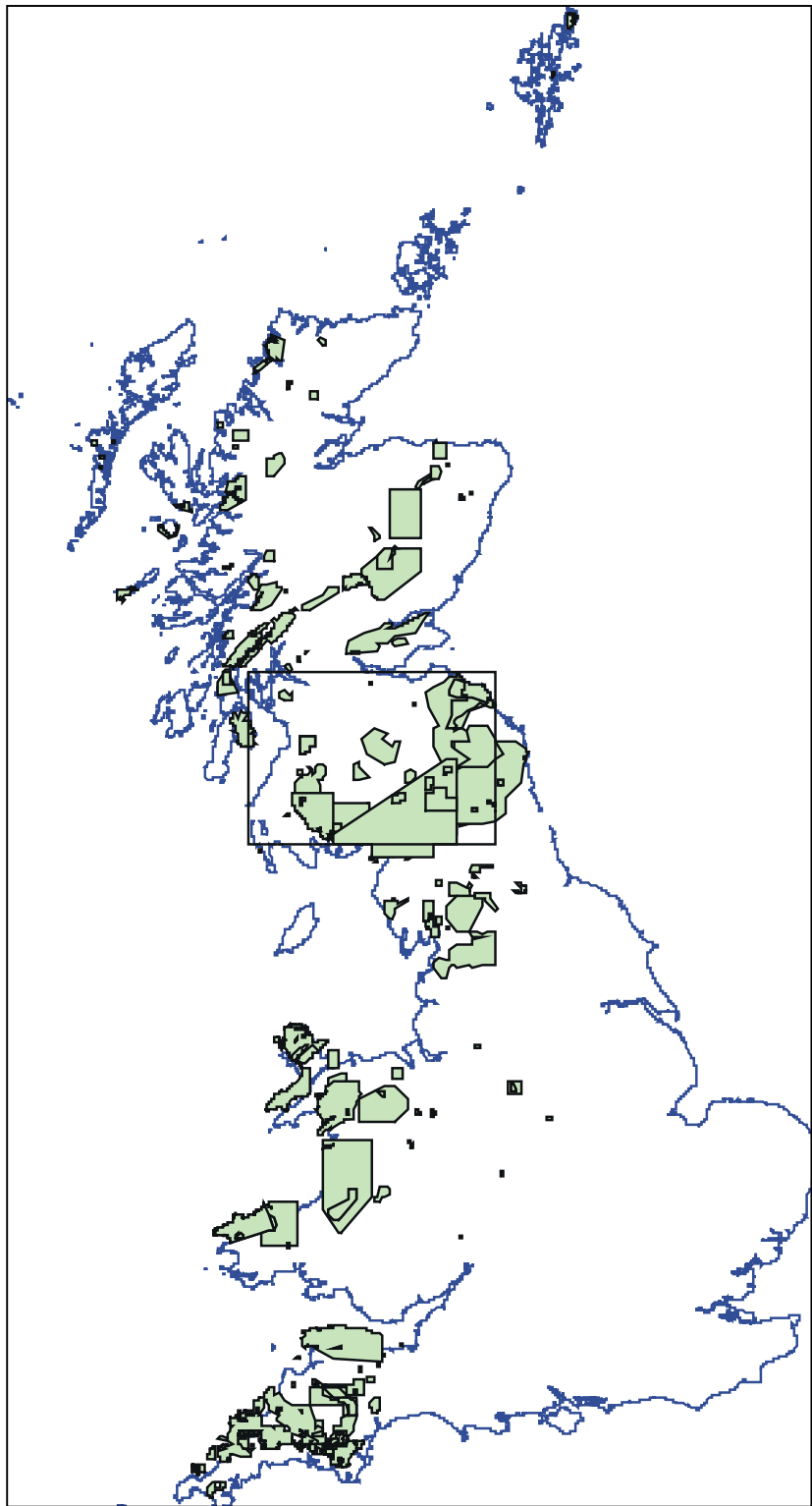
**1996**

WG/96/23R M T Styles. A mineralogical study of possible gold mineralisation from the Knapdale area, Kintyre, Scotland.

WG/96/44C M T Styles, R C Leake, D J Bland & E J Evans. Characterisation of gold from N Ireland.



**Figure 1** Data model for the Local Surveys Database



**Figure 2** Coverage of Mineral Reconnaissance Programme Reports

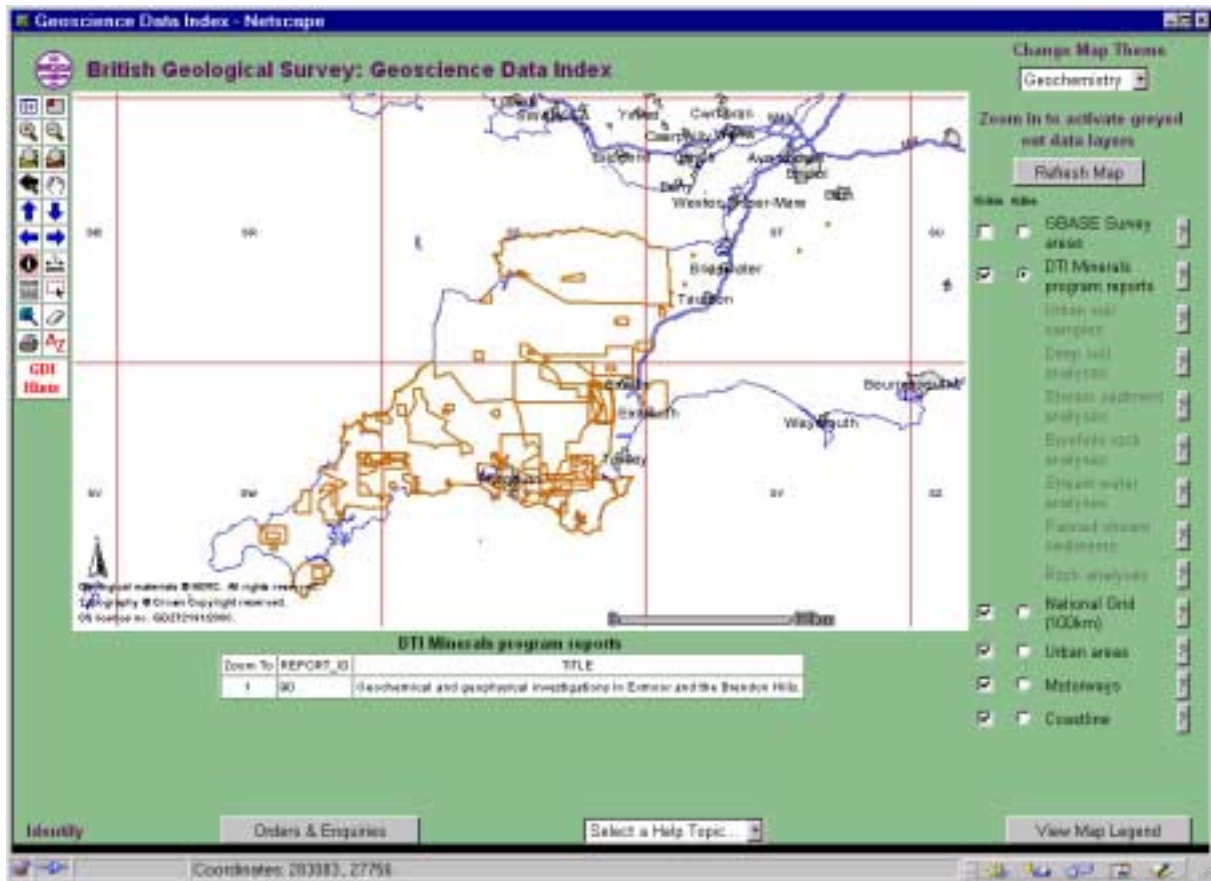
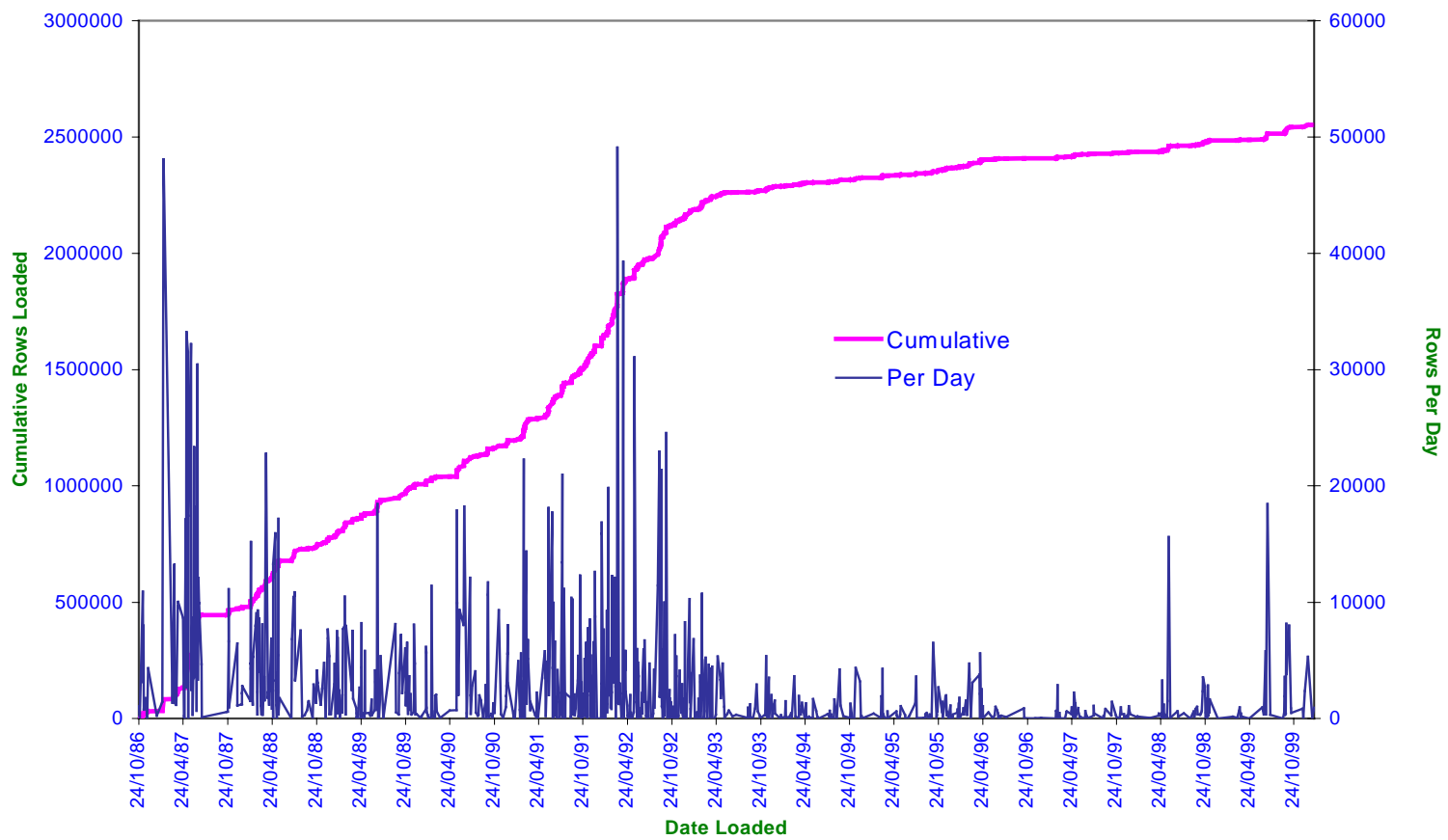
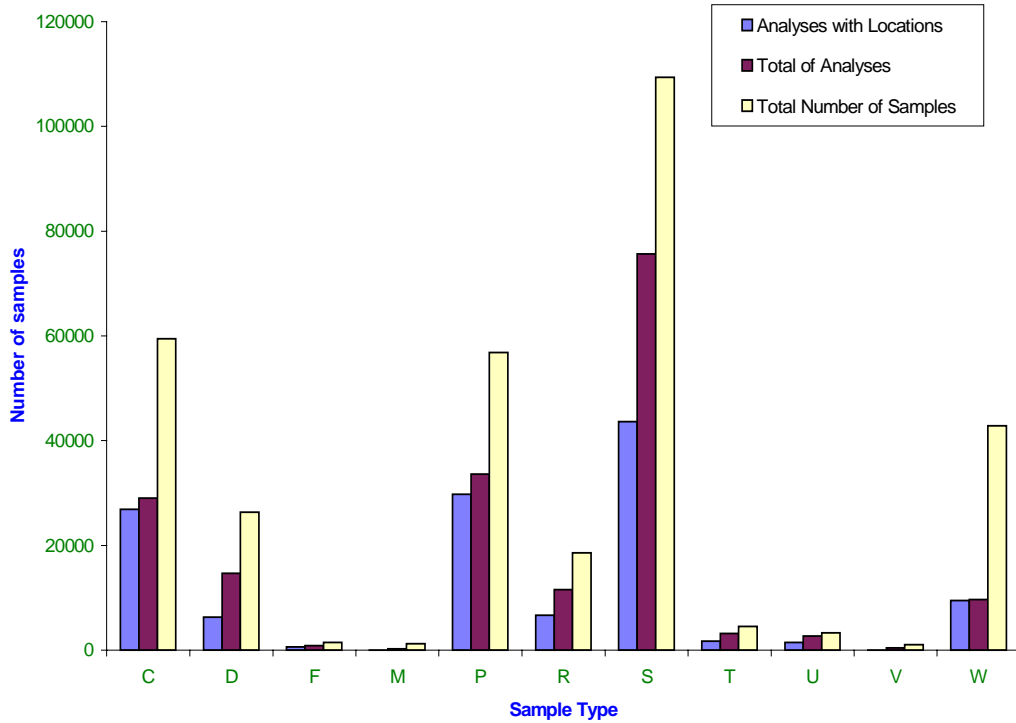


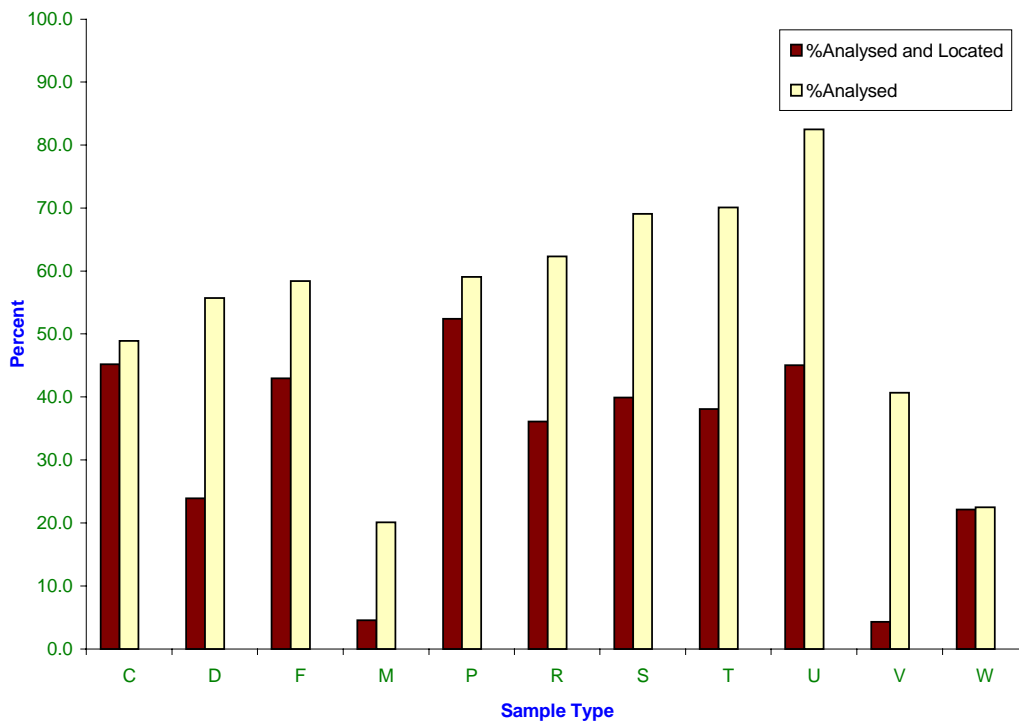
Figure 3 Internet Geoscience Data Index identifying the report areas and title of selected report



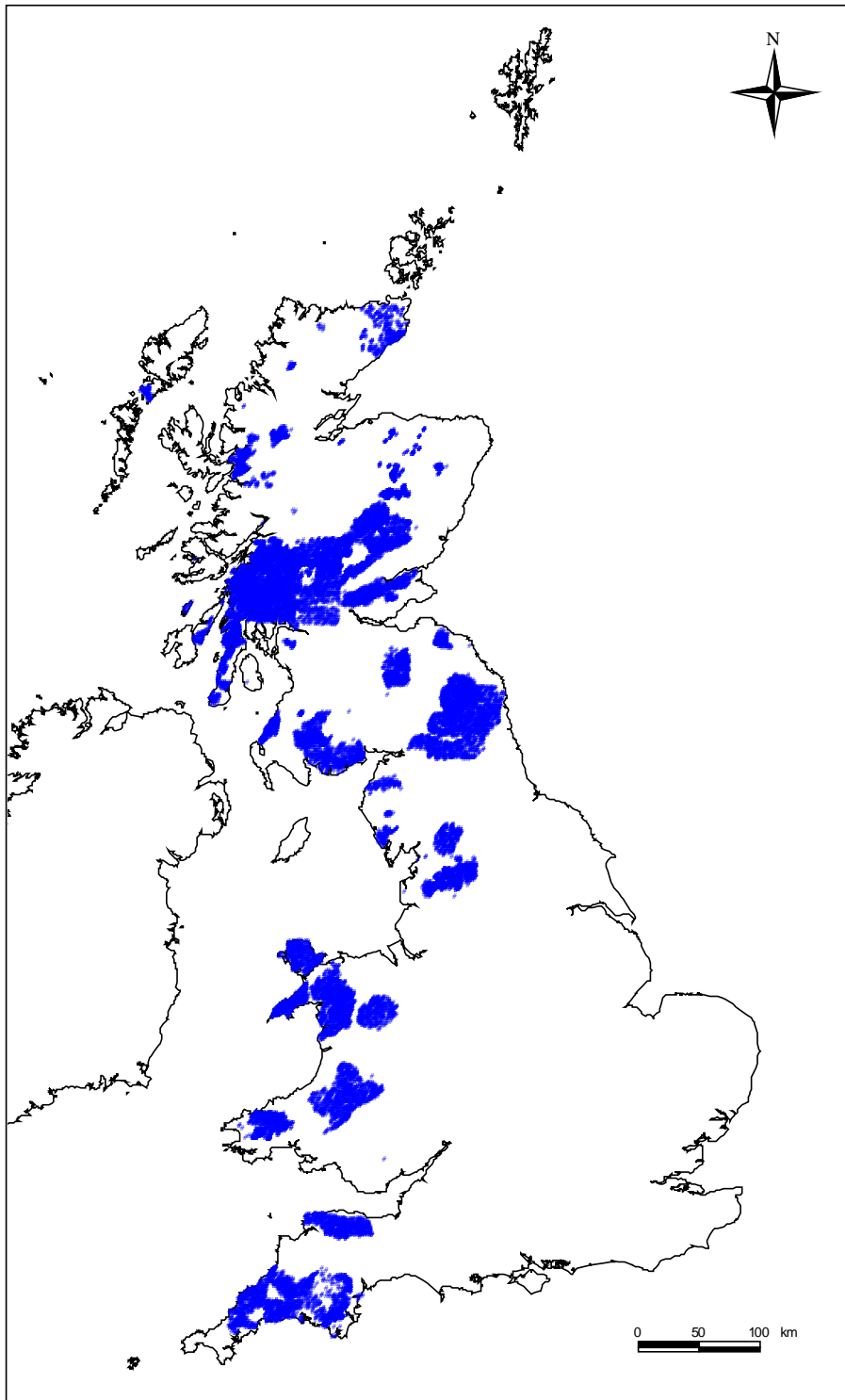
**Figure 4** Loading of records to the Geochemistry Database on a daily and cumulative basis



**Figure 5** Proportion of each sample type loaded to the Geochemistry Database

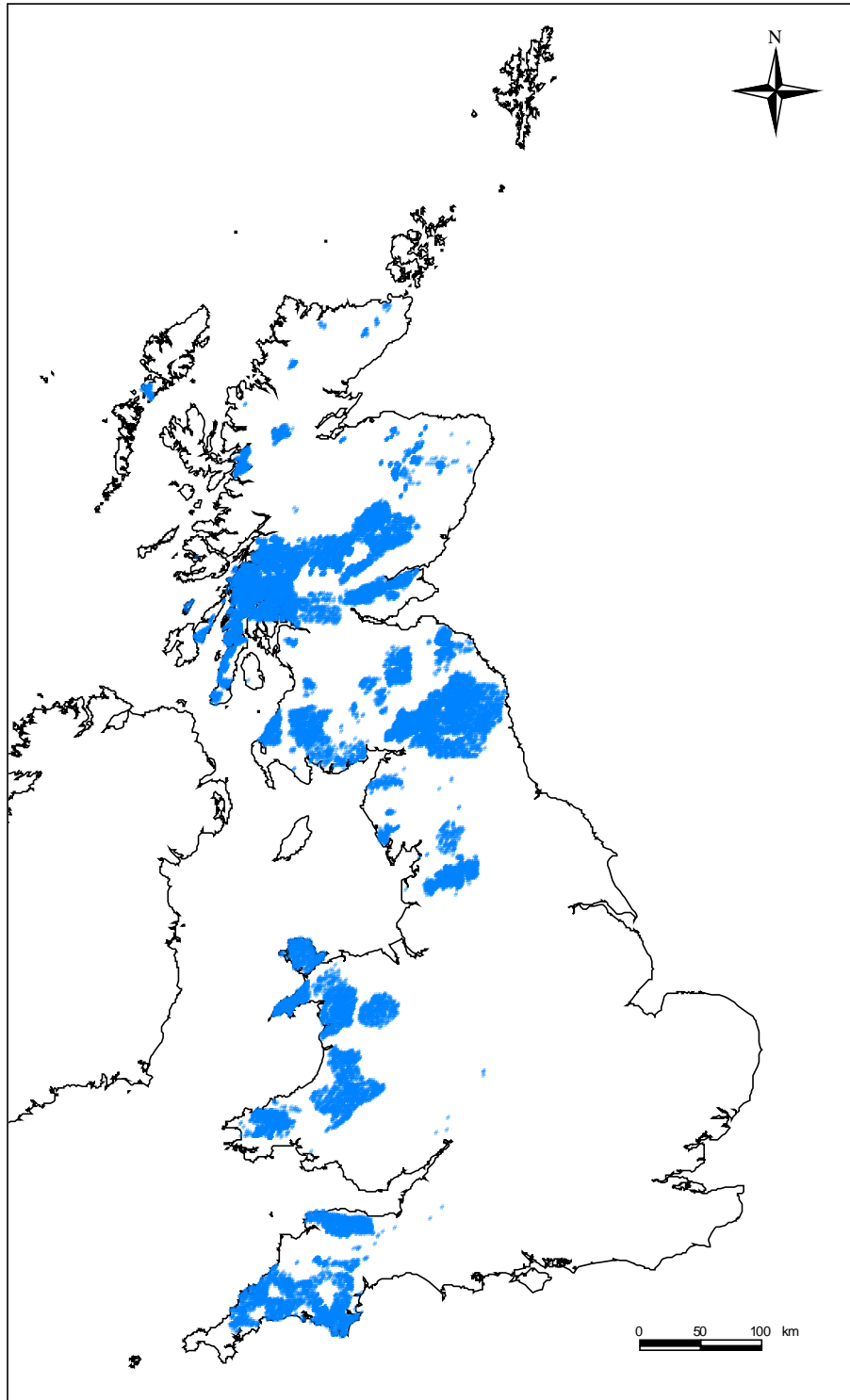


**Figure 6** Number of samples for each sample type loaded to the Geochemistry Database

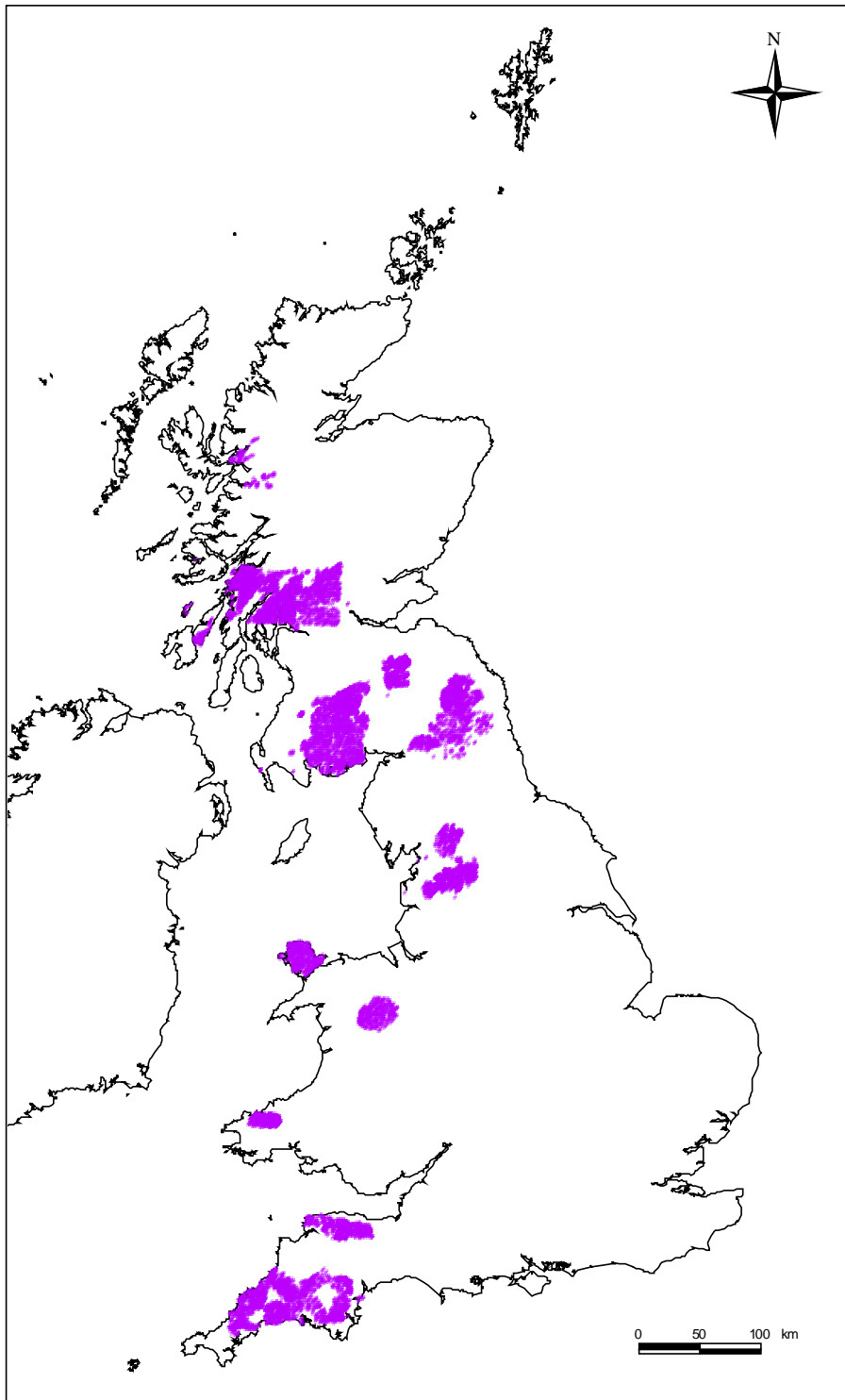


**Figure 7** Distribution of stream-sediment samples (26870 samples)

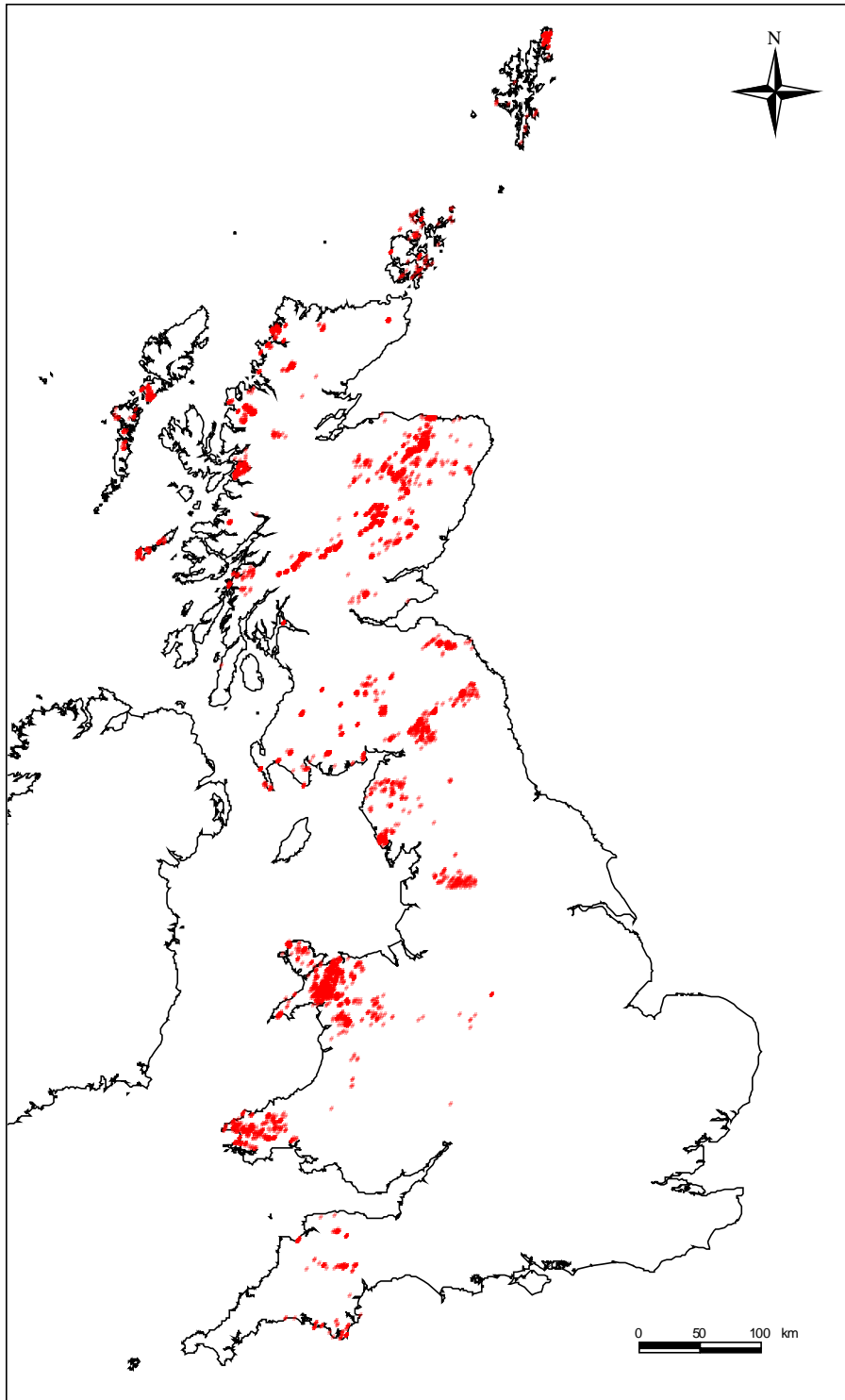




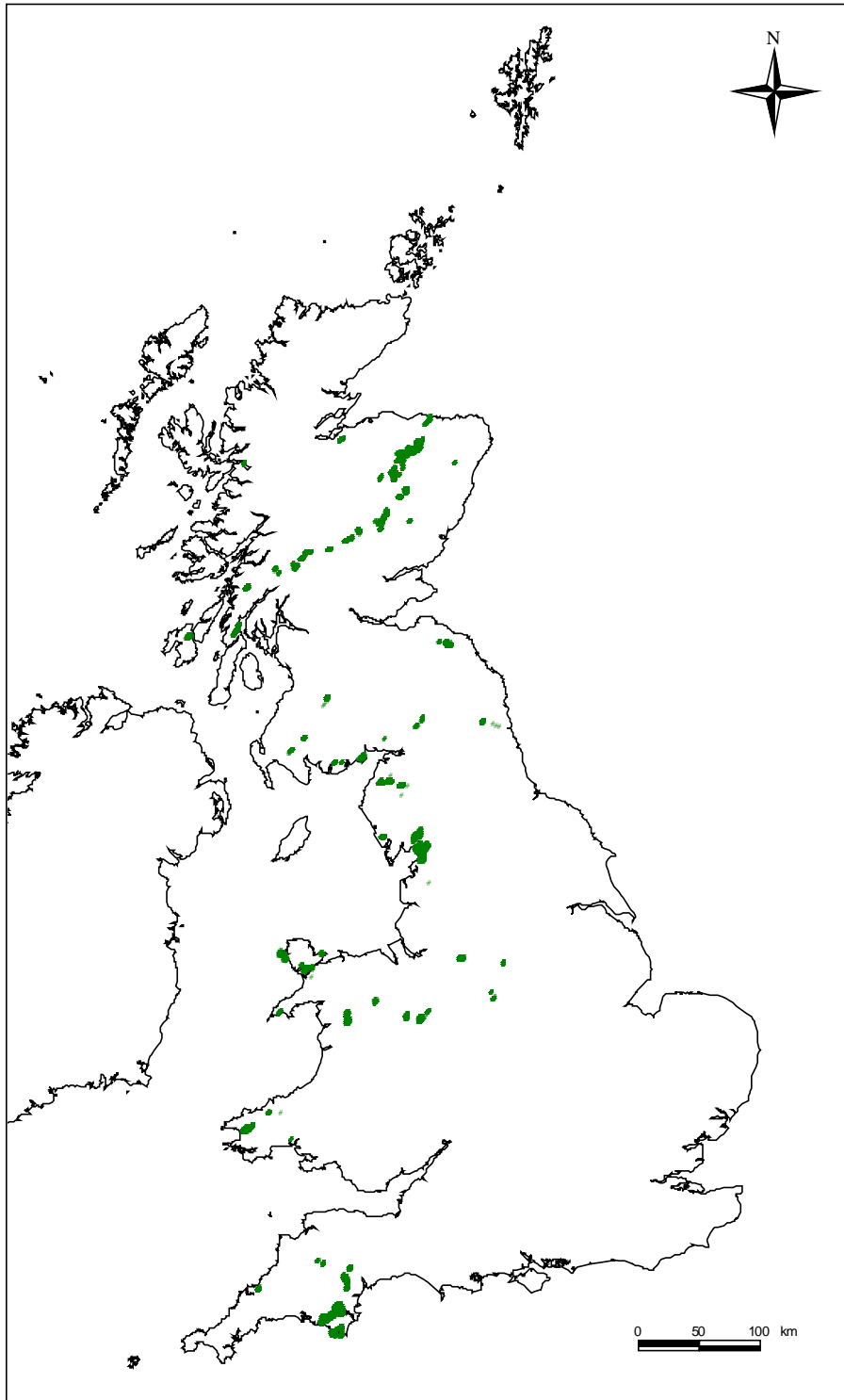
**Figure 8** Distribution of panned-concentrate samples (29811 samples)



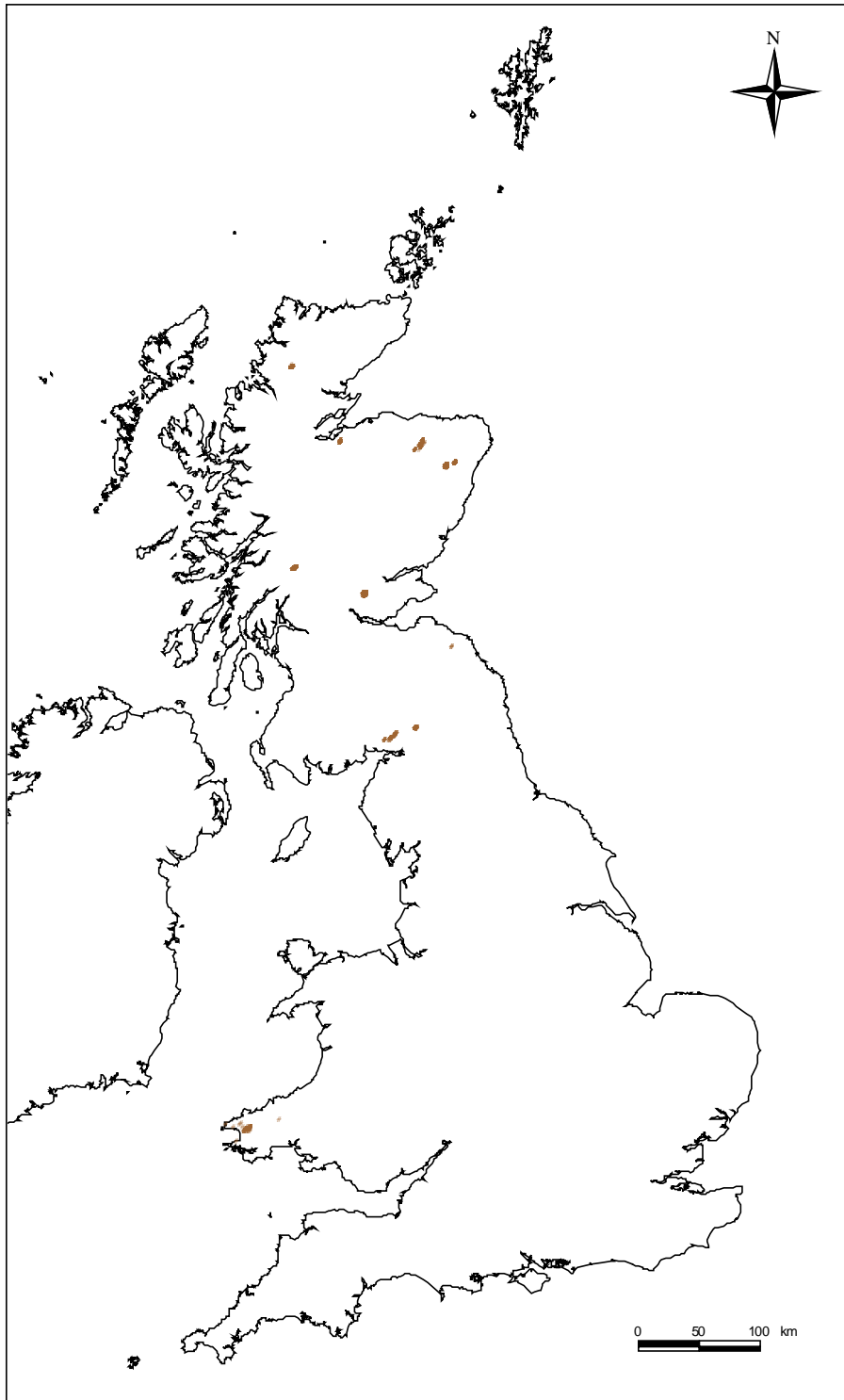
**Figure 9** Distribution of water samples (9484 samples)



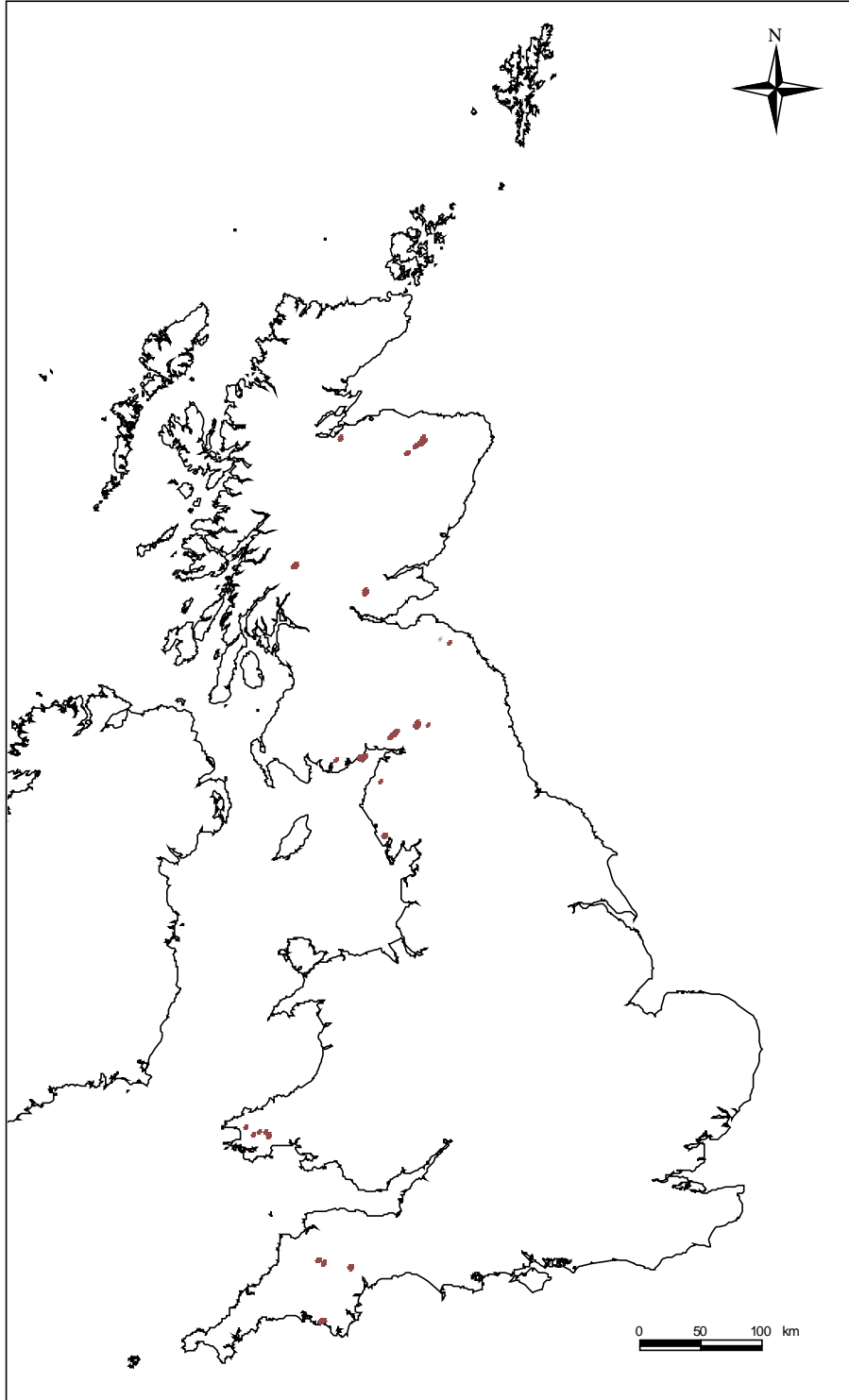
**Figure 10** Distribution of rock samples (6699 samples)



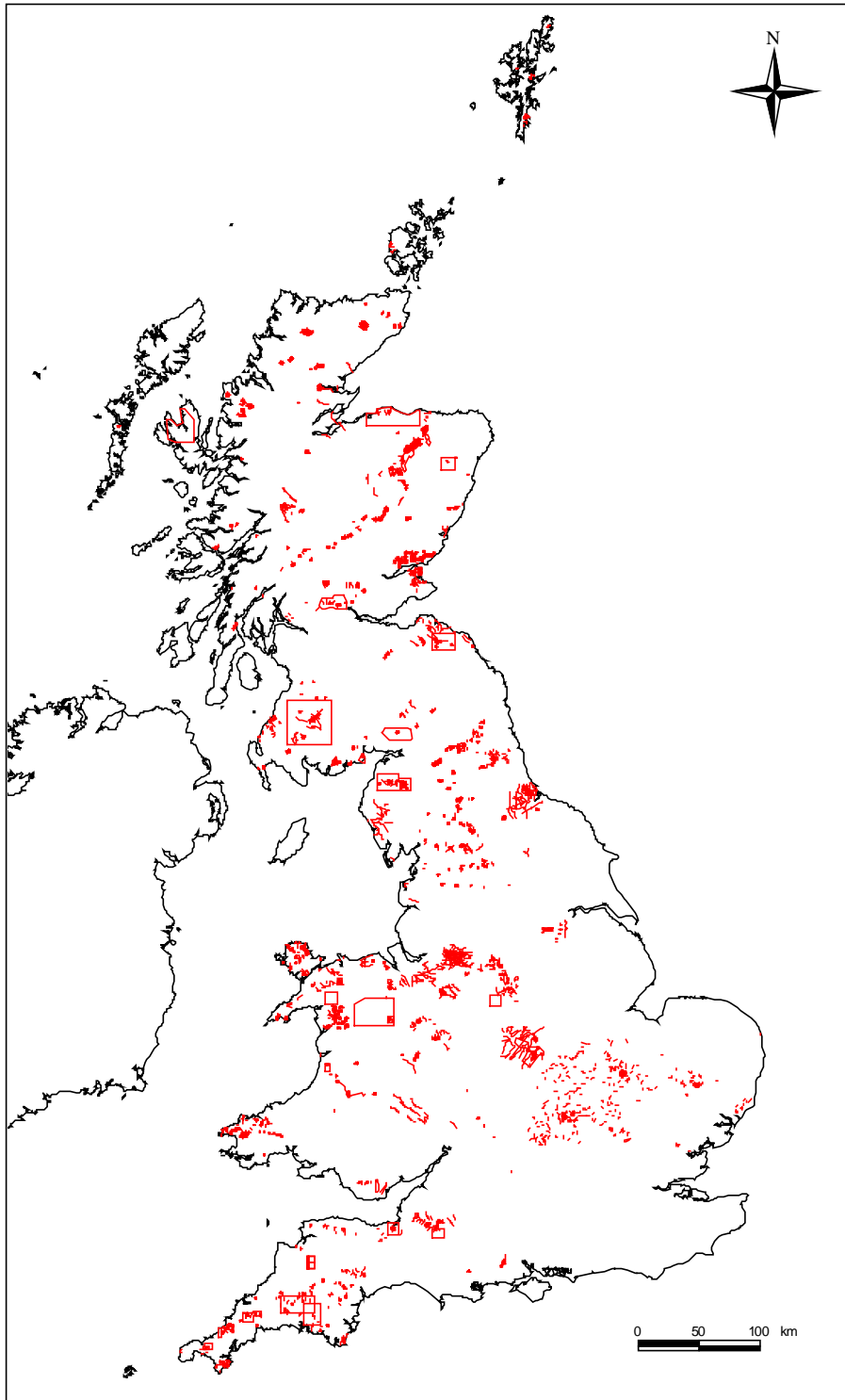
**Figure 11** Distribution of soil samples (43632 samples)



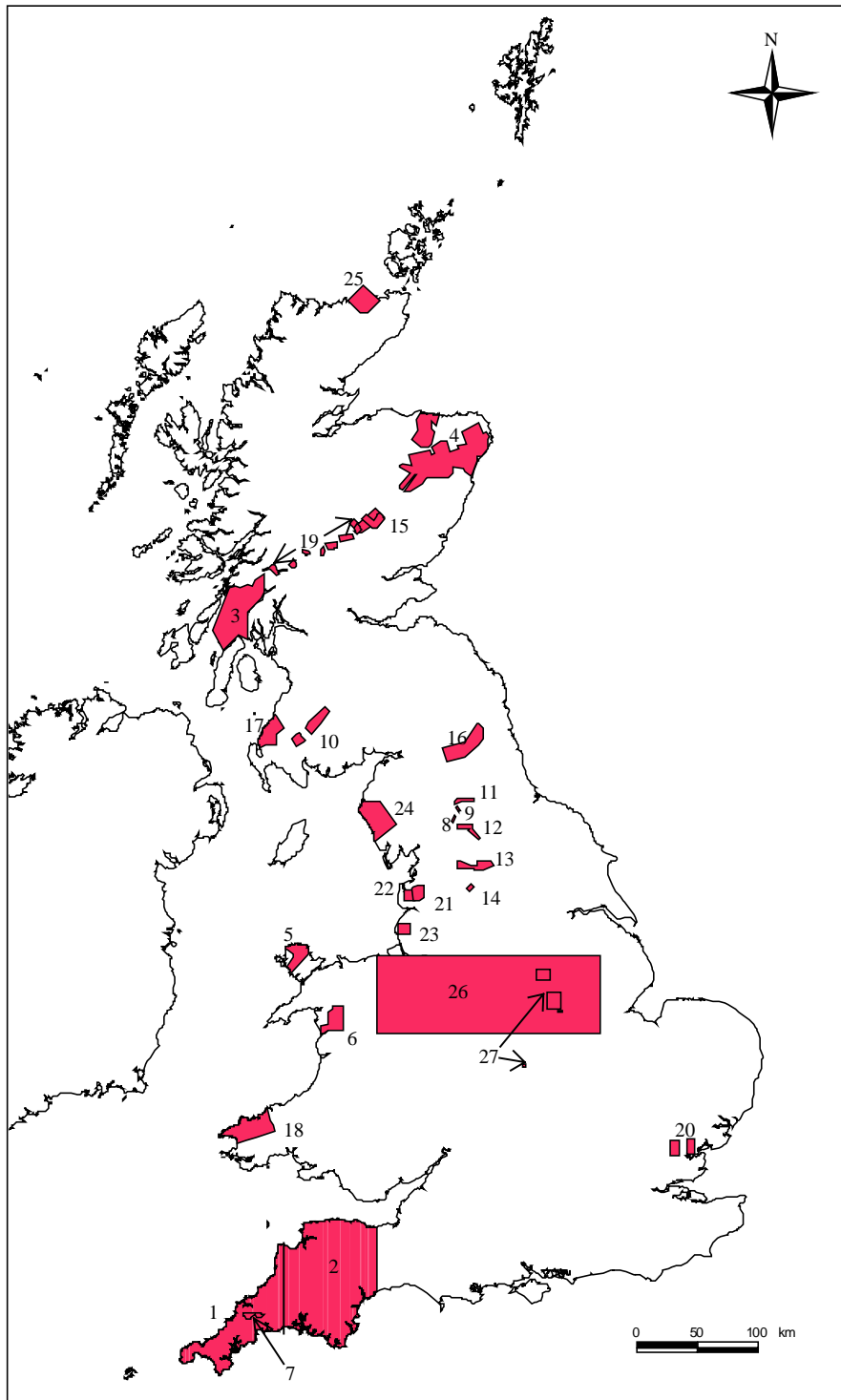
**Figure 12** Distribution of till samples (1735 samples)



**Figure 13** Distribution of panned overburden samples (1495 samples)



**Figure 14** Ground geophysical surveys in Local Surveys database



**Figure 15** High resolution airborne surveys in the UK for which BGS hold data (Survey numbers relate to Table 13)



Petrology and Mineralogy  
Database  
Physical Design.

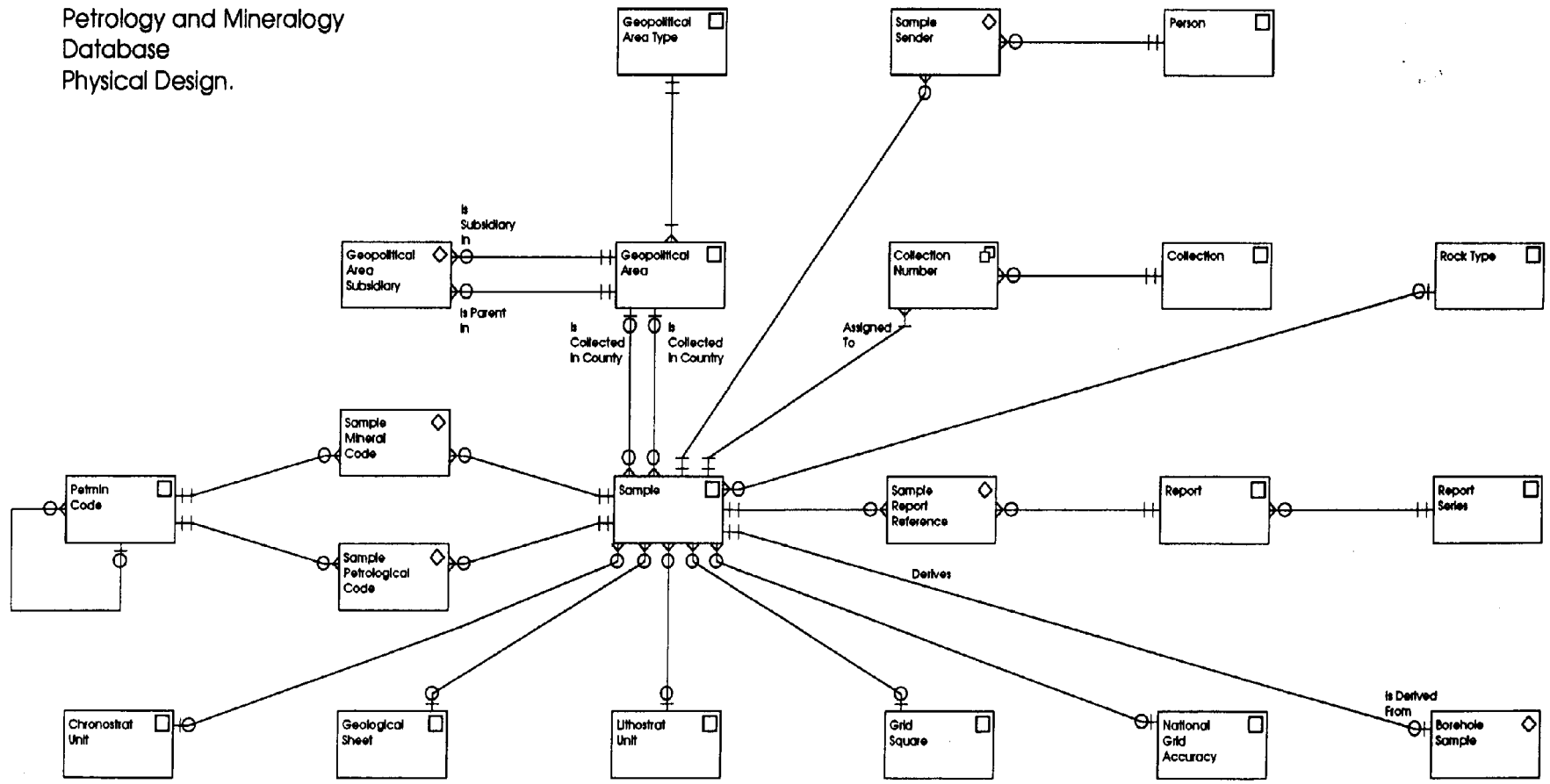
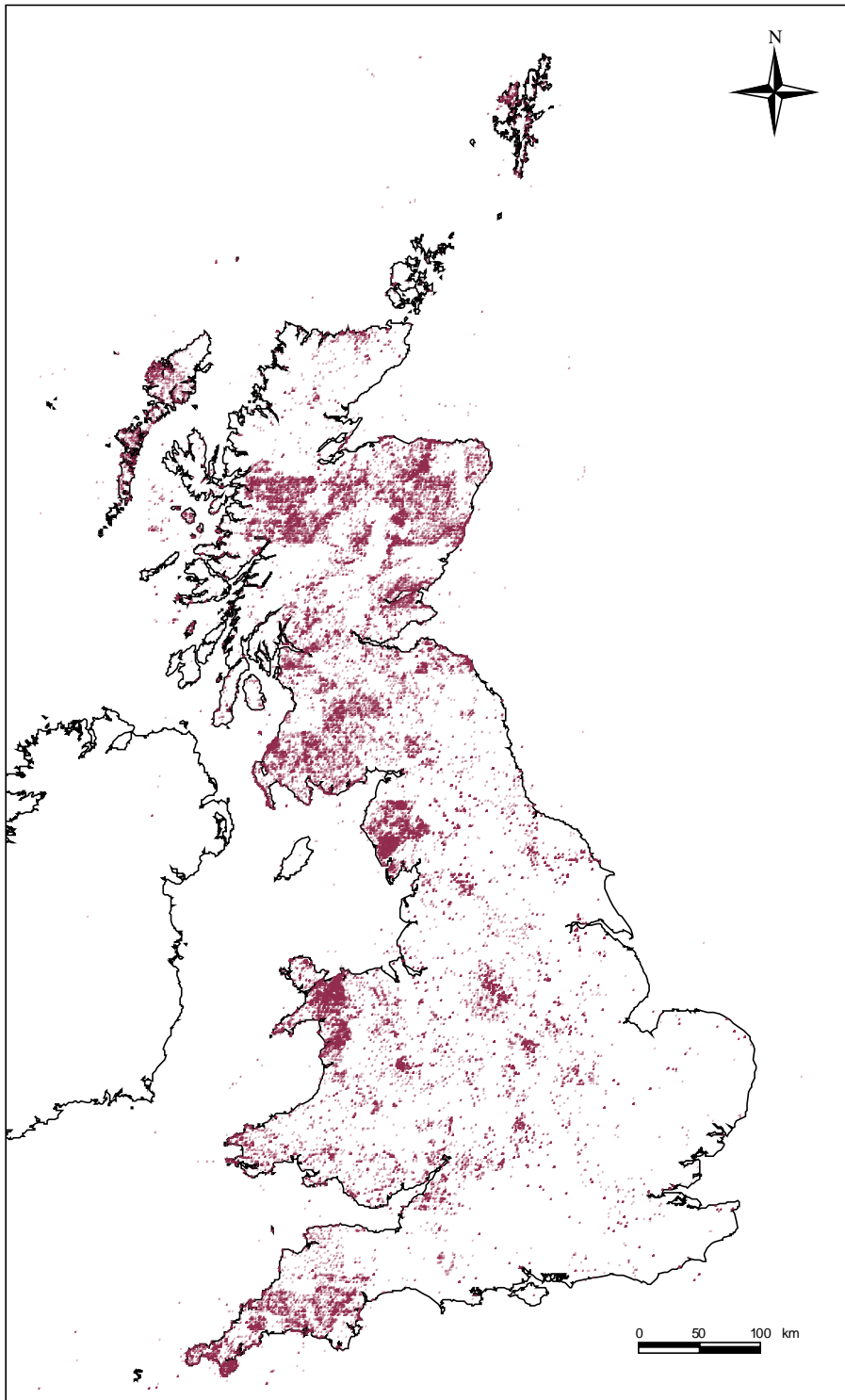
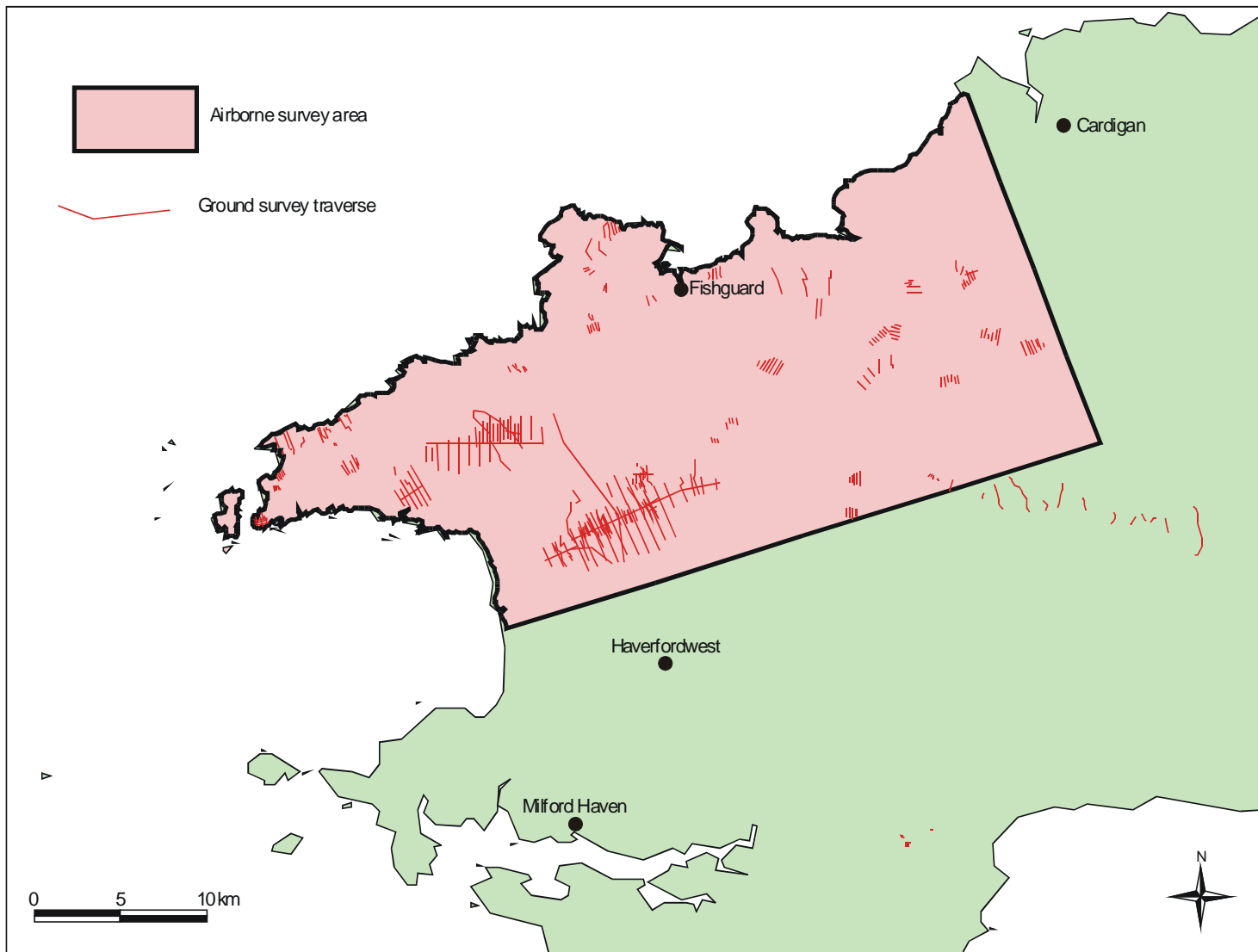


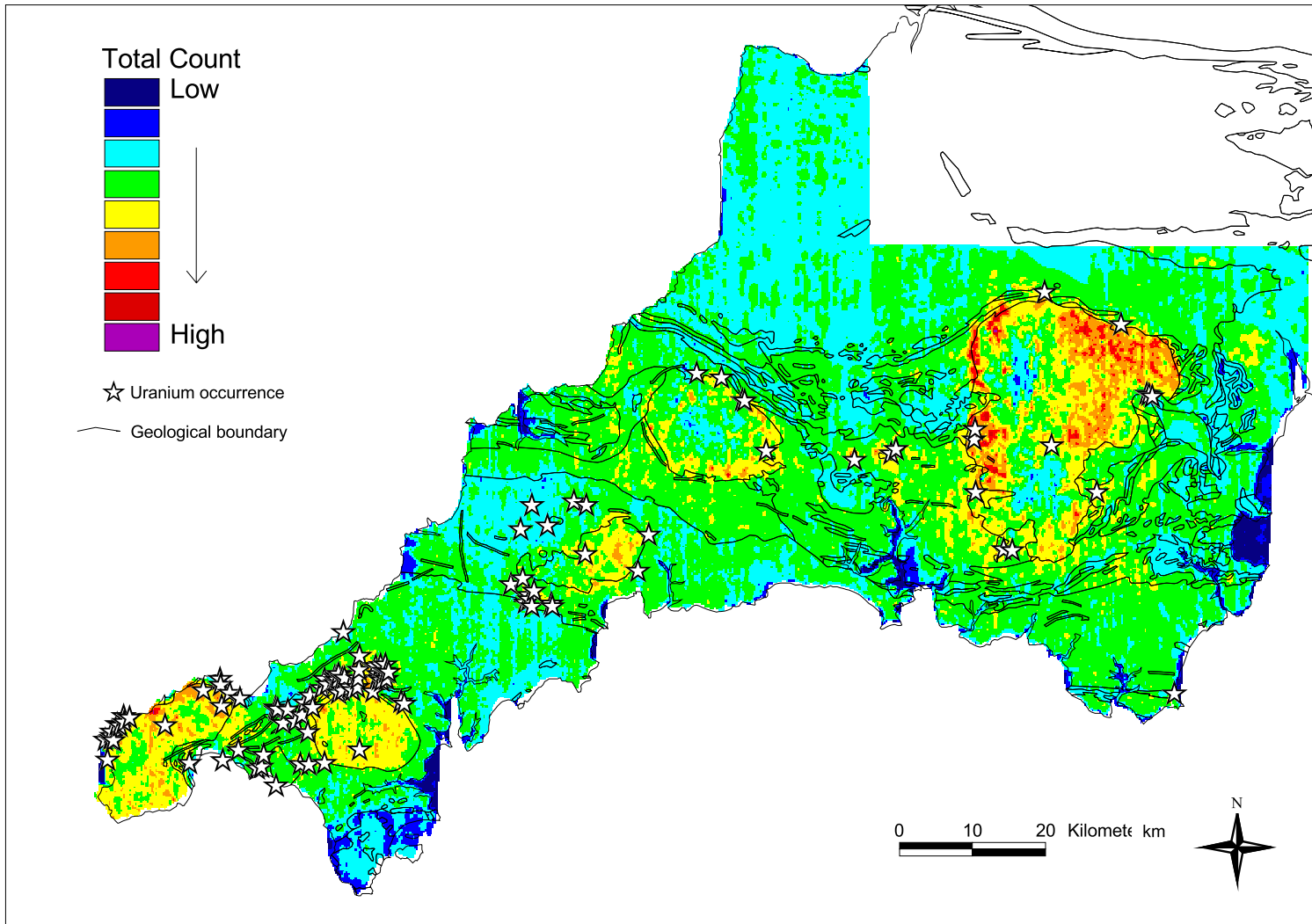
Figure 16 Entity diagram for Britrocks database



**Figure 17** Distribution of UK rock samples in the Britrocks database



**Figure 18** Geophysical surveys in west Dyfed, Wales



**Figure 19** Outline geology and uranium occurrences superimposed on airborne radiometric data from south-west England