

Minerals in Britain

Past production . . .
Future potential

Gold

Gold in Britain

Gold has been worked intermittently in Britain since pre-Roman times. Production peaked between 1860 and 1909 when over 3500 kg were recovered: 90% came from the Dolgellau gold belt in North Wales while the remainder was produced from the Ogofau mine in mid-Wales and the Helmsdale area of northern Scotland. Prior to this, Devon and the Leadhills district of the Southern Uplands of Scotland were the most important centres of gold production. Since 1938 there has only been intermittent minor production from the Clogau and Gwynfynydd mines in Wales.

During the last 20 years new gold deposit models and improved analytical methods have led to a better understanding of the distribution of gold in Britain, the identification of new exploration targets, and new mine development.

Gold deposits and prospects in Britain are now known to occur in rocks ranging in age from Proterozoic to Permian. Most are of mesothermal lode type although several examples of other styles are also present. Terranes prospective for gold now include the Dalradian (Neoproterozoic) of the Scottish Highlands, the Lower Palaeozoic rocks of southern Scotland, the English Lake District and Wales, Devonian volcanic rocks of Scotland and northern England, and the Variscan and overlying Permo-Triassic rocks of south-west England.

Much of the exploration work carried out by private- and public-sector organisations since the 1960s is either published in summary form or held on open file at the BGS. Most of the public-sector work was carried out by the BGS under the DTI-funded Mineral Reconnaissance Programme (MRP). The results from this work are contained in the MRP Report Series and much of the data collected is available in digital form. Some of the private-sector exploration work was carried out under the terms of the Mineral Exploration Investment Grants Act 1972 (MEIGA) in the 1970s, and most of these data are now available on open file.

Mesothermal lode deposits

This type of mineralisation is widespread in the Lower Palaeozoic and older rocks of Britain. In the **Scottish Highlands** several prospects have been found in rocks of the Dalradian Supergroup. The most important deposit so far identified is at *Cononish* in the historic Tyndrum lead-mining district, close to the major north-east-trending Tyndrum Fault. The deposit comprises a steeply dipping quartz vein, up to 6 m wide, cutting

psammites. Underground exploration has defined a resource of 483 000 t at 15.9 g/t Au. Caledonia Mining Corporation has planning permission to develop an underground mine.

There are many recorded occurrences of gold in the area between Aberfeldy and Comrie. At *Calliachar Burn*, 4 km south-west of Aberfeldy, gold-bearing quartz-carbonate veins occur in quartzites and amphibolites of the Upper Dalradian. Gold grades in



Cononish mine development.

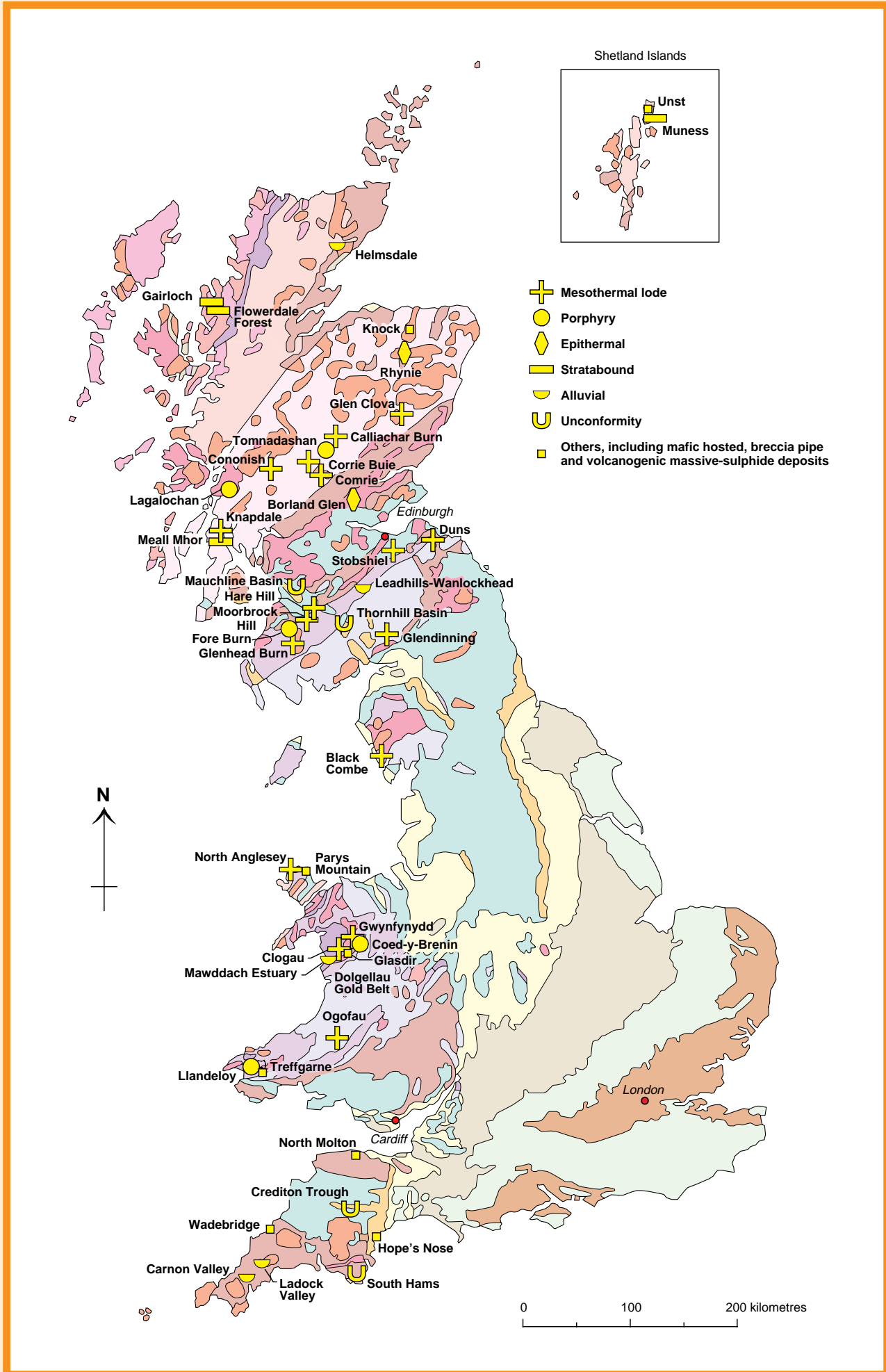
one structure average 8–9 g/t over a strike length of 87 m, and the overlying gossan is reported to contain up to 400 g/t Au and 230 g/t Ag.

Recent studies by the BGS have indicated the potential for lode gold mineralisation in Dalradian metasediments of the *Knapdale* area, where quartz-carbonate veins, some previously worked on a small scale for base metals, locally contain ppm levels of gold.

In the *Glen Clova* district of the central Highlands, drainage geochemical data and observations of gold in panned concentrates have indicated several targets, and grades of up to 6.8 ppm Au have been recorded in mineralised bedrock.

Other minor occurrences of probable mesothermal type occur in a stockwork of galena-bearing quartz veins at *Corrie Buie* and in a shear zone cutting the southern margin of the *Comrie* diorite complex.

The **Southern Uplands** of Scotland have a long history of gold production, principally from alluvial sources (see below). Recent exploration by the BGS and companies has identified several new mesothermal gold occurrences, many associated with late-Caledonian granitic intrusions and major strike-slip faults.



Gold mineralisation at *Moorbrock Hill* is associated with quartz veins in a zone of brecciation, hydrothermal alteration and iron-oxide development along a north-east-trending splay of the Leadhills Fault system. The host rocks comprise Ordovician hornfelsed pelagic shale and chert at the margin of the post-tectonic Cairnsmore of Carsphairn granitic intrusion.

At *Hare Hill*, the site of a former antimony mine, gold occurs in fractures and shears in a small late-Caledonian granodiorite hosted by Ordovician greywackes, shales and basalts. Early arsenic-copper mineralisation with gold enrichment is overprinted by a late arsenic-lead-zinc stage in the core of the intrusion.

Mesothermal gold-arsenic mineralisation has been found also at *Glenhead Burn* close to the contact of the late-Caledonian Loch Doon pluton with its host of Ordovician greywackes. The highest gold concentrations, up to 8.8 ppm, occur in quartz veins up to 30 cm wide within a stockwork of thicker veins.

In the north-eastern Southern Uplands gold, is recorded in fracture-controlled veins and breccias associated with small late-Caledonian intrusions at *Stobshiel*. In the *Duns* area, follow-up by the BGS of regional geochemical surveys identified gold in stream sediments and bedrock associated with major structural features and small late-Caledonian intrusions.

In the southern part of the Southern Uplands, minor antimony-arsenic-gold mineralisation of mesothermal origin has been documented at a former antimony mine in Silurian greywackes at *Glendinning*.

A recent BGS multi-dataset analysis of the Southern Uplands, applying mineralisation-model criteria to integrated digital geological, geochemical, mineral-occurrence,

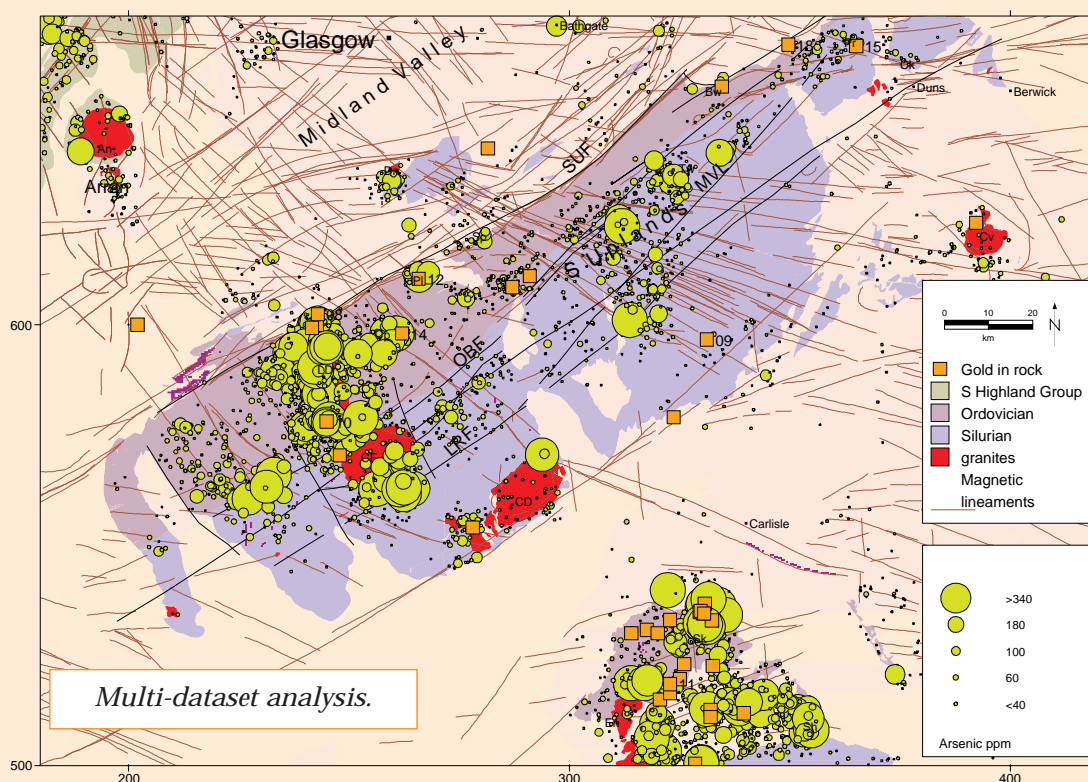
geophysical, and structural datasets, identified several new areas favourable for gold mineralisation. Test field sampling in some of these revealed new indications of gold mineralisation, and further assessment is merited.

In **north-west England**, vein-style, turbidite-hosted gold-bearing polymetallic mineralisation has been found at *Black Combe*. It is hosted by Ordovician siltstones and mudstones of the Skiddaw Group and lies in the Westmorland Monocline, a major Caledonian structure at the south-east margin of the Lake District batholith.

Mines in **Wales** have dominated gold production in the British Isles for as long as reliable records have been kept. With the exception of *Ogofau*, all the producing mines were in the *Dolgellau Gold Belt*, where the two largest and most famous mines were *Clogau* and *Gwynfynydd*. The mineralisation is typical of turbidite-hosted vein-style deposits. Gold occurs in fault-controlled polymetallic quartz-sulphide veins cutting clastic sedimentary rocks of Cambro-Ordovician age. Usually the veins only contain appreciable gold where they intersect graphitic horizons, notably the black mudstones of the *Clogau Formation*.

In the *Ogofau* deposit, gold occurs in pyritic shales, quartz veins and reefs in a tightly folded and sheared clastic sedimentary succession close to the Ordovician-Silurian boundary. Recent regional geochemical surveys suggest that undiscovered deposits of the same style may exist elsewhere in the Welsh Basin.

Gold occurs locally in *north Anglesey*, notably in quartz veined structures developed along fault and thrust boundaries in late-Precambrian and Lower Palaeozoic clastic sedimentary rocks.



Porphyry-type deposits

Gold-bearing porphyry-type mineralisation occurs in Caledonian rocks of Scotland and Wales. In the south-west Highlands of Scotland, mineralisation of this type in the *Lagalochan* sub-volcanic complex has attracted commercial interest. The c. 430 Ma complex is thought to reflect a vented diatreme-type structure emplaced in Dalradian rocks. Early copper-molybdenum-gold mineralisation in veinlets and disseminations in a central core of breccias and diorite to granodiorite intrusions was followed by shear-related lead-zinc-silver-gold-arsenic-antimony mineralisation and, finally, by lead-zinc-silver carbonate veins. Carbonate and sericitic alteration are widespread, and K-silicate alteration is locally present.

At *Tomnashan*, gold occurs with porphyry-style copper mineralisation in an altered diorite-granite complex. As well as disseminated pyrite and chalcopyrite, traces of native gold, with galena, bismuthinite, native bismuth and molybdenite, have been reported.

Sub-volcanic porphyry-style copper-gold mineralisation also occurs at the margin of a Lower Devonian volcanic centre and diorite complex at *Fore Burn*, close to the Southern Upland Fault. Detailed exploration in the 1980s identified three styles of auriferous mineralisation: (i) north-west-trending quartz-carbonate veins with up to 50 g/t Au over 90 cm, (ii) north-east-trending aligned quartz-sulphide veins and (iii) a quartz-sulphide stockwork with up to 52 g/t Au over 25 cm.

In Wales, recoverable levels of gold (c. 0.1 ppm) occur in the *Coed-y-Brenin* porphyry copper deposit, which lies within the Dolgellau Gold Belt (see above) and contains 200 Mt of ore, grading 0.3% Cu. To the south, minor gold also accompanies disseminated copper mineralisation at *Llandeloy*.

Epithermal deposits

Evidence for low-sulphidation epithermal gold mineralisation in the Devonian rocks of northern Britain has been accumulating in recent years. In north-east Scotland, mineralisation of this type has been found at *Rhynie* in an outlier of Lower Devonian sedimentary and volcanic rocks. Geochemical, alteration and textural features indicate an origin in a hot-spring setting related to late-Caledonian volcanism. The altered rocks and chert sinters contain gold, arsenic and antimony and are also locally enriched in tungsten, molybdenum and mercury.

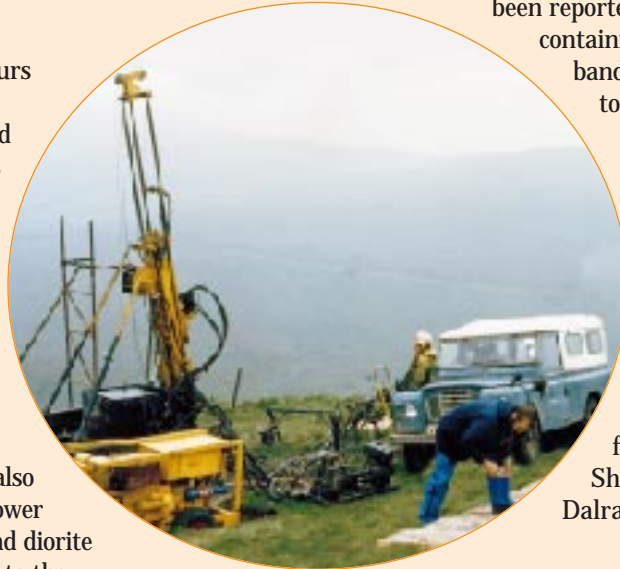
Alluvial gold is widespread in the Ochil Hills of central Scotland. The highest concentrations are in *Borland Glen* where Lower Devonian andesitic lavas and pyro-

clastic rocks are intruded by a dioritic body and porphyry dykes. Argillic hydrothermal alteration and brecciation suggest an epithermal setting, but follow-up investigations have so far failed to identify gold mineralisation in bedrock.

Volcanogenic stratabound deposits

A Besshi-style syngenetic copper-zinc deposit, with minor gold, occurs in Proterozoic supracrustal rocks near *Gairloch* in the north-west Scottish Highlands. The mineralisation comprises stratiform pyrite, pyrrhotite, chalcopyrite and sphalerite in a 4-m-thick quartz-carbonate schist unit with a strike length of at least 1 km. Recently, gold values up to 4 g/t have been reported from a similar succession, containing sulphide-bearing and banded-iron-formation rocks, 10 km to the south-east in *Flowerdale Forest* and it is likely that further mineralisation is present in the area.

Low-tenor gold enrichment in association with stratabound copper mineralisation is recorded in Dalradian rocks at *Meall Mhor*; and gold has also been found recently at *Muness*, Shetland, in a sheared pyritic Dalradian phyllite 2 – 12 m wide.



Drilling for epithermal gold mineralisation in the Ochil Hills.

Alluvial deposits

The *Leadhills-Wanlockhead* district used to be the most important centre of gold production in Scotland, but the alluvial gold operations were of secondary importance to lead-zinc mining. Today the area is popular with the amateur prospector and there is potential for slate-belt hosted mesothermal vein deposits in the Lower Palaeozoic bedrocks (see above).

Eastern Sutherland, near *Helmsdale*, is also well known for its historical alluvial gold production. In 1868 a short-lived gold-rush, lasting little over a year, followed the discovery of gold in tributaries of the Helmsdale River, but there has been no significant gold production since then. No bedrock source for the gold has been identified.

Traces of gold have been recorded from many of the former alluvial tin workings around the Variscan granites of south-west England. Noteworthy sites include the *Ladock* and *Carnon* valleys.

In Wales, gold occurs in the extensive alluvial deposits of the *Mawddach Estuary*, which contains the Dolgellau Gold Belt within its catchment.

Unconformity-related (redox) deposits

Work by the BGS over the last ten years has identified several occurrences of this newly described style of mineralisation. It was first recognised when alluvial grains from the *South Hams* area of Devon were found to have a distinctive palladium-rich composition and zoning, with characteristic inclusion assemblages containing selenide minerals. These are believed to have formed by precipitation of gold from oxidising saline fluids at interfaces with more reduced systems. Application of this model to the *Crediton Trough* of central Devon, where red-bed Permian rocks unconformably overlie a Palaeozoic Variscan succession, led to the discovery of gold in drainage and bedrock, which is currently being assessed. Evidence of similar mineralisation has been found at other localities with a comparable geological setting, notably in the *Mauchline* and *Thornhill* basins of southern Scotland.

Other occurrences

In south-west England gold is recorded from several geological environments, notably in hydrothermal quartz veins associated with Devonian basic igneous

rocks (e.g. Treore mine near Wadebridge), in carbonate veins at *Hope's Nose*, and in copper-iron veins at Bampfylde mine near *North Molton*.

High gold values (up to 7g/t), associated with high levels of platinum-group elements, occur in chromite-rich ultramafic rocks of the *Unst* ophiolite complex in Shetland.

Minor gold enrichment, associated with high values for nickel, copper and the platinum-group elements, occurs at the sheared margin of the *Knock* layered mafic-ultramafic intrusion in north-east Scotland.

In North Wales, gold occurs at *Glasdir* in a breccia pipe deposit mined principally for copper, near the Coed-y-Brenin porphyry copper deposit and within the Dolgellau Gold Belt. Recoverable levels of gold also occur in the *Parys Mountain* volcanogenic massive-sulphide (VMS) base-metal deposit in northern Anglesey. In South Wales, gold has been reported from altered pyritic volcanic rocks and mudstones at *Treffgarne*, possibly associated with VMS or epithermal mineralisation.

Data Holdings

A substantial amount of information relating to gold mineralisation in Britain is either published or held on open file at the BGS. Increasingly, the data are held in digital form on databases fronted by a GIS (the BGS MINGOL system) and can be supplied under licence or as hard-copy products, in formats to match the user's requirements. Some of the principal data sets are:

- Mineral Reconnaissance Programme Reports and Data Releases.
- Reports, maps and other data provided under the terms of the Mineral Exploration and Investment Grants Act 1972 (MEIGA). Some, particularly airborne geophysical data, have been converted to digital form and can be purchased in user-specified formats. Hard-copy data and reports may be photocopied.
- Regional and local scale geochemical surveys.
- Regional and local scale ground and airborne geophysical data coverage.
- Geological mapping at various scales.
- Mineral occurrence and mineral workings databases.
- Drillcore and rock samples, thin sections.
- Planning constraints, licensing and legislative information.
- Minerals trade and production statistics in Britain and worldwide.
- Scientific publications on mineral deposits in Britain.

Staff of the BGS Minerals Programme act as a reference point for the supply of advice and information on minerals-related matters in Britain. They can provide detailed information on the above datasets.

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