

Minerals in Britain

Past production . . .
Future potential

Copper



British
Geological
Survey

dti

**Stratabound copper mineralisation
at Gairloch**

Copper in Britain

Britain has been an important centre of copper production since pre-Roman times. There is evidence for copper mining in south-west England and north-west Wales as far back as the Bronze age. In Cornwall, trade in copper and tin was carried on with the Phoenicians as early as 1500 BC. The Parys Mountain mine in north-west Wales, from which copper may have been obtained in Roman times, became the world's largest copper producer for a period in the eighteenth century. Returns for the whole of the nineteenth century show Britain to be the world's fourth largest copper producer, accounting for nearly 10% of total production. Extraction fell rapidly towards the end of the century, and today there are no copper mines active in Britain.

Past mining focused on small-tonnage, high-grade deposits, mostly of vein-style, exposed at the surface. Increased geological understanding has resulted in the discovery of other types of deposit which can be mined more profitably with present-day technology: porphyry-type copper deposits, with very large tonnages but relatively low grade, are a pre-eminent example. Consequently, recent exploration has focused on different geological environments and found mineralisation in different parts of the country to former mining fields.

Exploration work carried out from the late 1960s, using new tectonic and mineralisation models, has led to the discovery of many new deposits. So far, none of these have been considered to be economic, but the potential for finding new mineralisation is high. The most attractive targets are likely to be relatively small high-grade polymetallic base- and precious-metal deposits.

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 are available in digital form. Much 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 the data are now available on open file for inspection. Some, particularly airborne geophysical data, have been converted to digital form and can be purchased in user-specified formats.

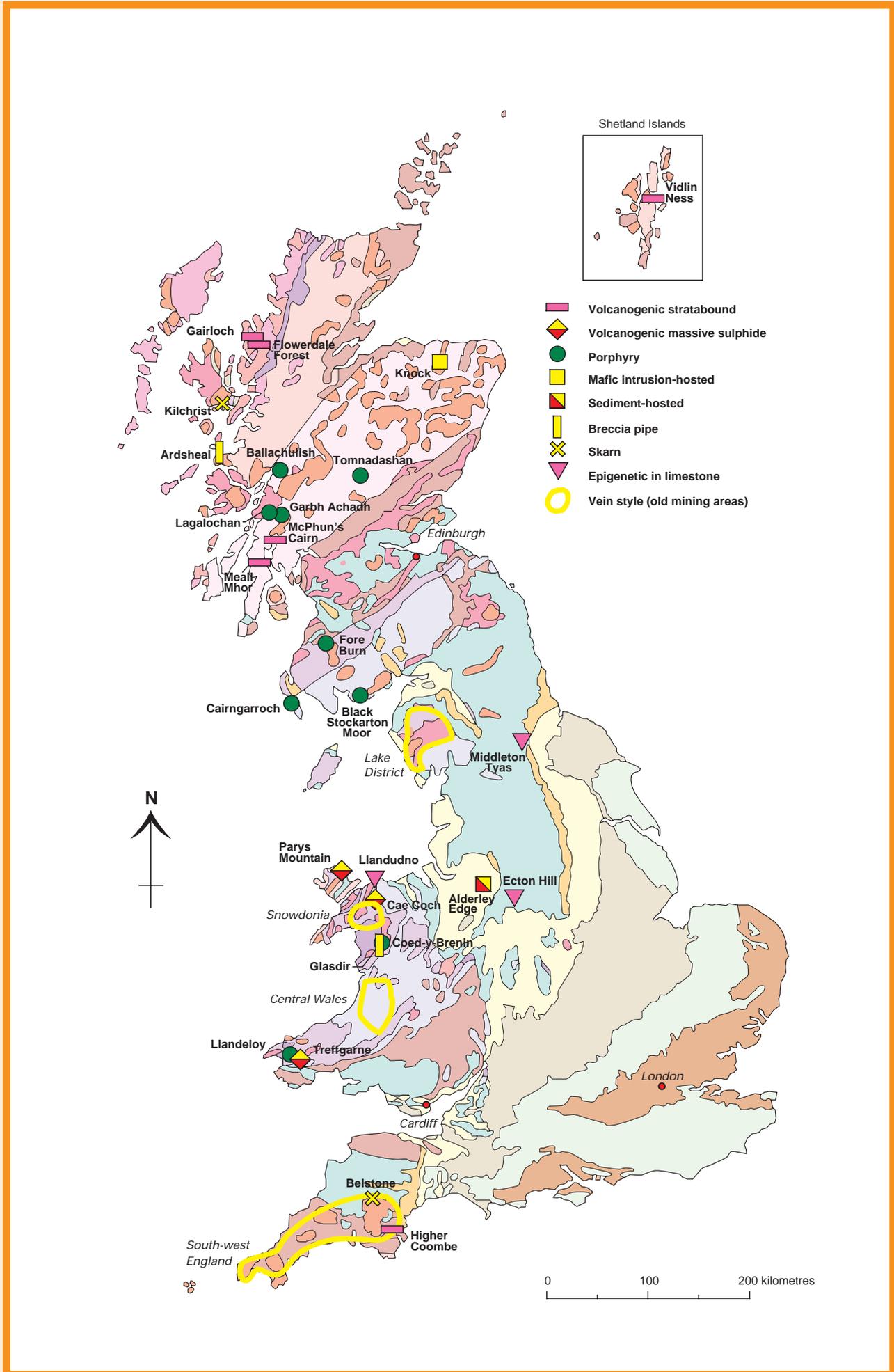
Volcanogenic stratabound deposits

Besshi-style copper-zinc-gold mineralisation occurs within deformed metabasic supracrustal Lewisian rocks near *Gairloch* in north-west Scotland. Two laterally extensive sulphide horizons were located within the Loch Maree Group. One of these horizons was traced intermittently for over 6 km and consists mainly of iron sulphides. The other, which has a strike length of at least 1 km, comprises a 4-m-thick quartz-carbonate schist with pyrite, pyrrhotite, chalcopyrite, sphalerite and gold. The footwall is chlorite-hornblende schist and the hanging wall contains quartz-magnetite schist (banded iron formation). Extensive



Slump breccia containing copper-lead-zinc massive sulphide mineralisation from the 275 m level at Parys Mountain mine, Anglesey.

drilling by Consolidated Goldfields Ltd proved a sub-economic deposit in this horizon, known as the Kerry Road sulphide deposit. The deposit grades c. 1% Cu, 0.5% Zn and 1 g/t Au. Recent work by the MRP discovered gold mineralisation (up to 4g/t) along strike from this deposit, in *Flowerdale Forest*, and also traced iron-rich exhalites with variable base-metal enrichment elsewhere within the outcrop of the Lewisian supracrustal rocks.





Meall Mhor: Stratabound mineralisation (chalcopyrite and pyrite) in Dalradian quartzite.

Stratabound disseminated and massive sulphides have also been found at various stratigraphical levels in the Dalradian rocks of Scotland. The richest occurs at *Vidlin Ness* in the Shetland Islands, where drilling by the MRP revealed stratabound sulphides reaching 10 m in thickness and grading up to 1.19% Cu and 1.27% Zn. Further drilling was carried out under the MEIGA scheme. No mining has yet taken place, but the mineralisation is similar in style to several small deposits exploited in Scandinavia.

In much of the central Highlands, stratabound mineralisation in the Dalradian is dominated by pyrite and/or pyrrhotite, but in the south-west, around Loch Fyne, appreciable Cu contents have been recorded (e.g. at *McPhun's Cairn*). These, historically, supported mining on a small scale, for example at *Meall Mhor*, and recent work has indicated the potential for associated gold mineralisation.

In south-west England stratabound base-metal mineralisation occurs locally in the Devonian-Carboniferous succession of sedimentary and volcanic rocks. In general, its distribution is poorly known and is much disrupted by folding and faulting. Drilling of IP anomalies by the MRP intersected low-grade disseminated and veinlet mineralisation of this type close to the Lower–Upper Carboniferous boundary near *Higher Coombe* in south Devon. There have also been similar discoveries by companies, but to date no economic deposit has been identified. There appears, however, to be potential for Sedex mineralisation similar to that found in Germany (Meggen, Rammelsberg).

Volcanogenic massive sulphide (VMS) deposits

The most important deposit of this type known in Britain is at *Parys Mountain* on the island of Anglesey, North Wales. The deposit has been extensively mined by open pit and underground methods, and recent exploration work by Anglesey Mining plc has shown that additional resources are present at depth. In its 1997

Annual Report the company gave an identified geological resource of about 6.5 Mt grading 5.3% Zn, 2.7% Pb, 2.3% Cu, 39 g/t Ag and 0.32 g/t Au. The company has since revised its geological model and is carrying out further work with the aim of increasing the reserves. Mineralisation is associated with a succession of highly altered volcanic rocks

and mudstones. The precise age of the volcanism is in doubt, as it is only constrained by overlying Silurian (Llandovery) shales and underlying Ordovician mudstones of possible Llanvirn age.

The products of Ordovician submarine volcanism are common in Wales, but, with the exception of the *Cae Coch* massive pyrite deposit of Ordovician (Caradocian) age in Snowdonia, no other VMS deposits are known. MRP and company work has identified several targets across Wales, from *Treffgarne* in the south-west to Snowdonia and parts of Anglesey in the north, but none of these has been investigated beyond the scout drilling stage.

Porphyry-type deposits

Several deposits of this type have been identified in Britain during the last 30 years. All occur associated with high-level intermediate to acid intrusive rocks of Caledonian age and comprise disseminated copper and minor gold mineralisation in characteristically altered lithologies. The first deposit to be discovered, and the best known, is situated in *Coed-y-Brenin* forest, near Dolgellau in North Wales. This deposit, containing 200 Mt grading 0.3% Cu, with trace gold, lies within the Snowdonia National Park and proposals to mine it in the early 1970s met considerable opposition. A deposit believed to occur in rocks of similar age and tectonic setting was found by the MRP near *Llandeloy* in south-west Wales. The rocks in this area are very poorly exposed, but scout drilling revealed disseminated copper mineralisation with trace gold in altered (propylitic and potassic) tonalites and diorites. Interpretation of the limited data suggested that the basal part of the deposit coincided with the present land surface and that much of the mineralisation may have been eroded away. The discovery of fluvial sands and clays of Tertiary or Quaternary age containing anomalous levels of copper close to the deposit added weight to this interpretation.

In the south-west Highlands of Scotland, disseminated polymetallic mineralisation of epithermal-porphyry style is found at *Lagalochan*, associated with the last phase of the Kilmelford calc-alkaline dioritic-grano-dioritic intrusive suite. Three phases of base- and precious-metal mineralisation have been identified, accompanied by multiple hydrothermal alteration events. Copper, molybdenum and gold mineralisation in veinlets and disseminations was followed by shear-related lead-zinc-silver-gold-arsenic-antimony mineralisation and, lastly, by lead-zinc-silver carbonate veins. Mineralisation of porphyry type is also recorded in association with high-level intrusions elsewhere in the Dalradian belt (e.g. *Ballachulish*, *Garbh Achadh* and *Tomnadashan*) and small intrusions into the Lower Palaeozoic low-grade metasediments of the Southern Uplands of Scotland (e.g. *Fore Burn*, *Cairngarroch* and *Black Stockarton Moor*). They are thought to be of late-Caledonian age.

Mafic-intrusion-hosted deposits

Poorly exposed, layered mafic-ultramafic intrusions of late-Caledonian (490 Ma) age underlying large areas in north-east Scotland have been the subject of exploration for nickel-copper and PGE mineralisation. Drilling of the *Knock* intrusion by Exploration Ventures Ltd outlined a 'geological reserve' of 3 Mt grading 0.52% Ni and 0.27% Cu in two sub-parallel near-conformable zones. More recently, it has become clear through BGS, MRP and university-based work that this and other intrusions have suffered from shearing deformation and that, in part due to poor exposure, the internal structure of the intrusions and their relationships to each other remain poorly understood, leaving the potential for mineralisation open to reassessment.

Sediment-hosted copper deposits (SCDs)

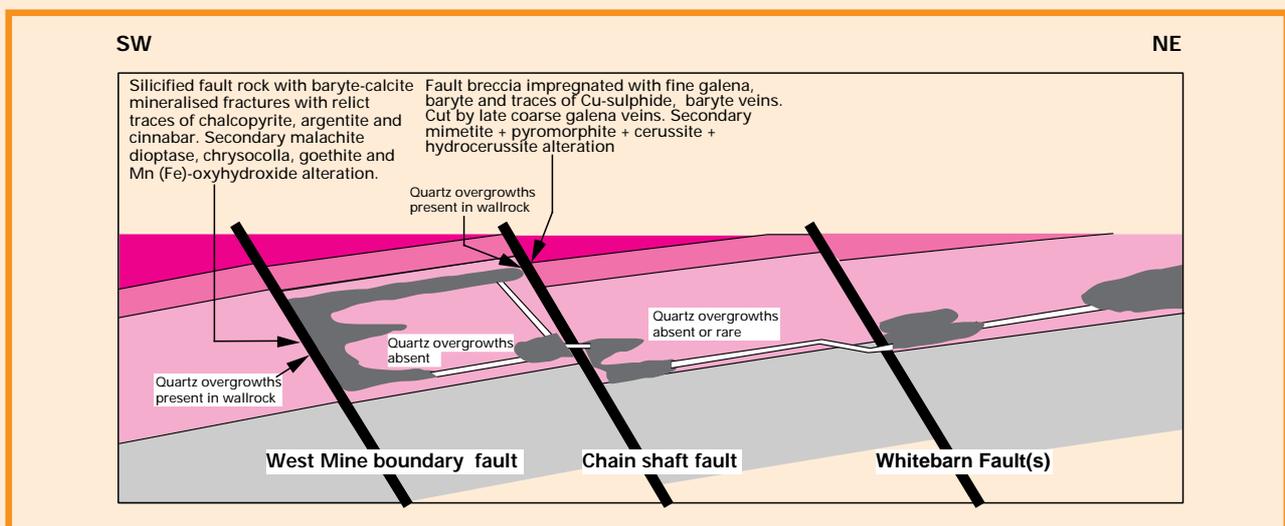
Red beds of Triassic age in the English Midlands contain copper-dominated polymetallic deposits of this type. The most productive mineralisation occurs in flu-

viatile sandstones and conglomerates of the Sherwood Sandstone Group in the *Alderley Edge* area of the Cheshire Basin. The ore comprises mixtures of copper carbonates with small amounts of arsenates, oxides and phosphates. In addition to copper, the ore contains small amounts of lead, cobalt, vanadium, zinc, manganese, nickel, arsenic and traces of gold. Baryte is widespread. The deposits show many of the characteristics of continental red-bed SCDs, and the location of the mineralisation is related to traps controlled by faulting and an overlying cover of the Mercia Mudstone Group. The estimated grade of the worked deposits is 2.1% Cu. Recent multidisciplinary research suggests a complex mechanism of formation involving the release of metals by the breakdown of primary minerals in the basin sediments, scavenging of metals from mudstones in the basin by density-driven brines, interaction with reducing fluids from the basement causing precipitation of ores, and alteration of the ore assemblage by meteoric groundwater following basin inversion. These studies indicate the presence of other prospective areas for mineralisation of this type in the Midlands.

In Scotland older sandstones of Devonian (Old Red Sandstone) and Carboniferous age locally contain traces of disseminated and veinlet copper mineralisation of probable similar type.

Vein-style deposits

Vein-style deposits are of three types, associated with (i) granitic intrusions, notably of Hercynian age in *South-west England*, (ii) volcanic rocks (*Snowdonia*, *Lake District*), and (iii) sedimentary basins, such as in *Central Wales*. Hematite veins, worked for iron ore in several parts of Britain and locally containing copper in sufficient abundance to have merited past extraction, probably fall into the latter category. Historically, vein deposits have been important sources of copper in Britain, with those in south-west England yielding over 2 Mt. Currently, however, they are of little economic



Alderley Edge: diagrammatic illustration (not to scale) of the relationship between faults and mineralised sandstone bodies in West Mine. The mined extent of copper mineralisation is shown in dark grey.

interest as sources of copper, though some have potential for other metals.

Breccia pipes

The *Glasdir* mine worked copper with minor gold from a breccia pipe deposit in North Wales close to, and possibly genetically related to, the Coed-y-Brenin porphyry copper deposit. Other pipes have been mapped in the same area, but there is no record of them containing mineralisation at surface. Copper mineralisation has also been reported in appinitic breccia pipes hosted by Dalradian metasediments on the *Ardsheal* peninsula in the Scottish Highlands.

Skarn-type copper deposits

Deposits of this type are rare in Britain, but have been worked near *Belstone* on the northern margin of the Dartmoor Granite. Drilling by the MRP to investigate the extent of the mineralisation indicated that it is more widespread than anticipated but of lower grade. There is accompanying arsenic, bismuth, tungsten and tin, but

the latter is largely held in garnet. Magnetite-chalcopyrite-bearing skarns also occur on the island of Skye, where they are hosted in Cambrian limestone marginal to a granitic intrusion of Tertiary age at Cill Chriost (*Kilchrist*).

Epigenetic deposits in limestones

At *Ecton Hill* in the English Midlands about 100 000 t of ore containing 15% Cu have been extracted from two pipe-like subvertical orebodies and associated veins cutting an anticline of interbedded Viséan limestone and shale. Chalcopyrite with calcite and baryte occur in at least five cavities over a vertical distance of about 400 m. Other small but very high-grade copper deposits have been mined in cavernous limestones of Carboniferous age elsewhere in Britain (e.g. near *Llandudno* in North Wales and *Middleton Tyas* in northern England). These deposits may have formed as a result of the downward migration of copper-rich fluids from the overlying Permo-Triassic red beds.

Data Holdings

A substantial amount of information relating to copper 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 sources are:

- 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.
- Mineral Reconnaissance Programme Reports and Data Releases.
- 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.
- Licensing and legislative matters, planning constraints.
- 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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