

Minerals in Britain

Past production . . .
Future potential

Gemstones

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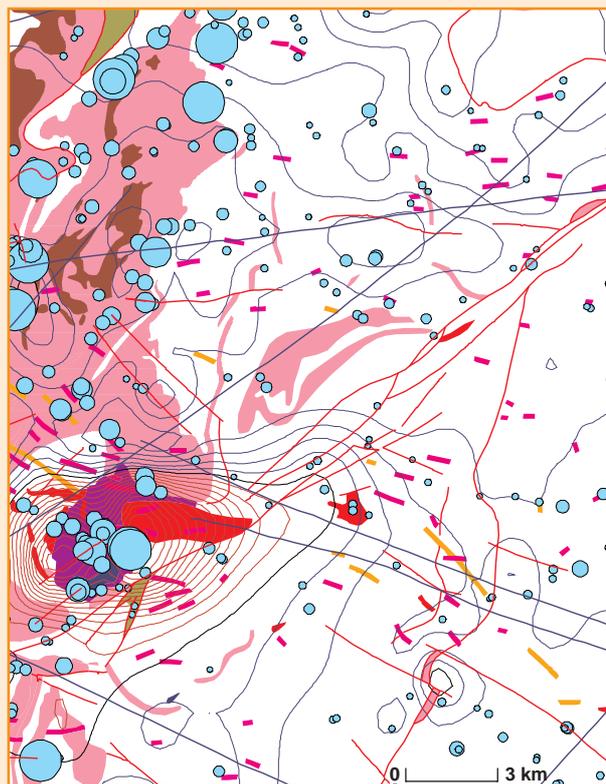
Although Britain is a major gemstone trader, it currently produces little from indigenous sources. There are, however, records of a wide variety of gem material, particularly in Scotland. In addition to sapphire, ruby and possible diamond, the country has yielded topaz, beryl, and many varieties of semi-precious stones including cairngorm, amethyst, garnet, tourmaline, agate, zircon, 'Blue John' fluorite and jet. There is also an unconfirmed report of Scottish emerald. Most of these gemstones were found by amateur geologists and gemologists but recent discoveries, particularly of diamond indicator minerals in Scandinavia and Ireland, have raised commercial interest in the potential of Britain as a source of precious stones.

Systematic exploration based on historical records, new datasets and a modern understanding of the geological processes which control the formation of gemstones can lead to the identification of new prospects. Exploration can be assisted by computer-based decision-support systems, using integrated multidataset analysis of regional digital parameters, identified and weighted by the application of the appropriate geological model. Follow-up field-survey verification of prospective areas can be assisted by rapid in-field qualitative analysis of heavy-mineral concentrates, prior to detailed laboratory analysis of mineral suites.

The success of the modern approach to gemstone exploration is illustrated by the results from recent commercial surveys in Ireland. Little attention was given to prospecting for gemstones in Ireland until a few years ago, but recent surveys have established the presence of hitherto unrecorded alluvial sapphires in County Donegal and kimberlite indicator minerals in County Fermanagh, close to where an alluvial diamond was discovered in the nineteenth century. Except for a DTI-sponsored Mineral Reconnaissance Programme report on the diamond potential of Britain, little has been published on gemstone exploration in Britain, but baseline digital geological, geochemical and geophysical datasets are available for study.

Diamond

The eminent Scottish mineralogist Professor M F Heddle, on returning from a visit to the Kimberley diamond fields of South Africa in the 1870s, undertook a search for diamonds in Scotland, and it is recorded that he found a small diamond in northern Scotland, 4.5 km north-east of *Ben Hope*. Three supposed diamond crystals are reported to have been discovered at the same locality more recently (1958) although, like Heddle's claim, this has not been substantiated. In the 1890s, crystalline material, thought to be diamond

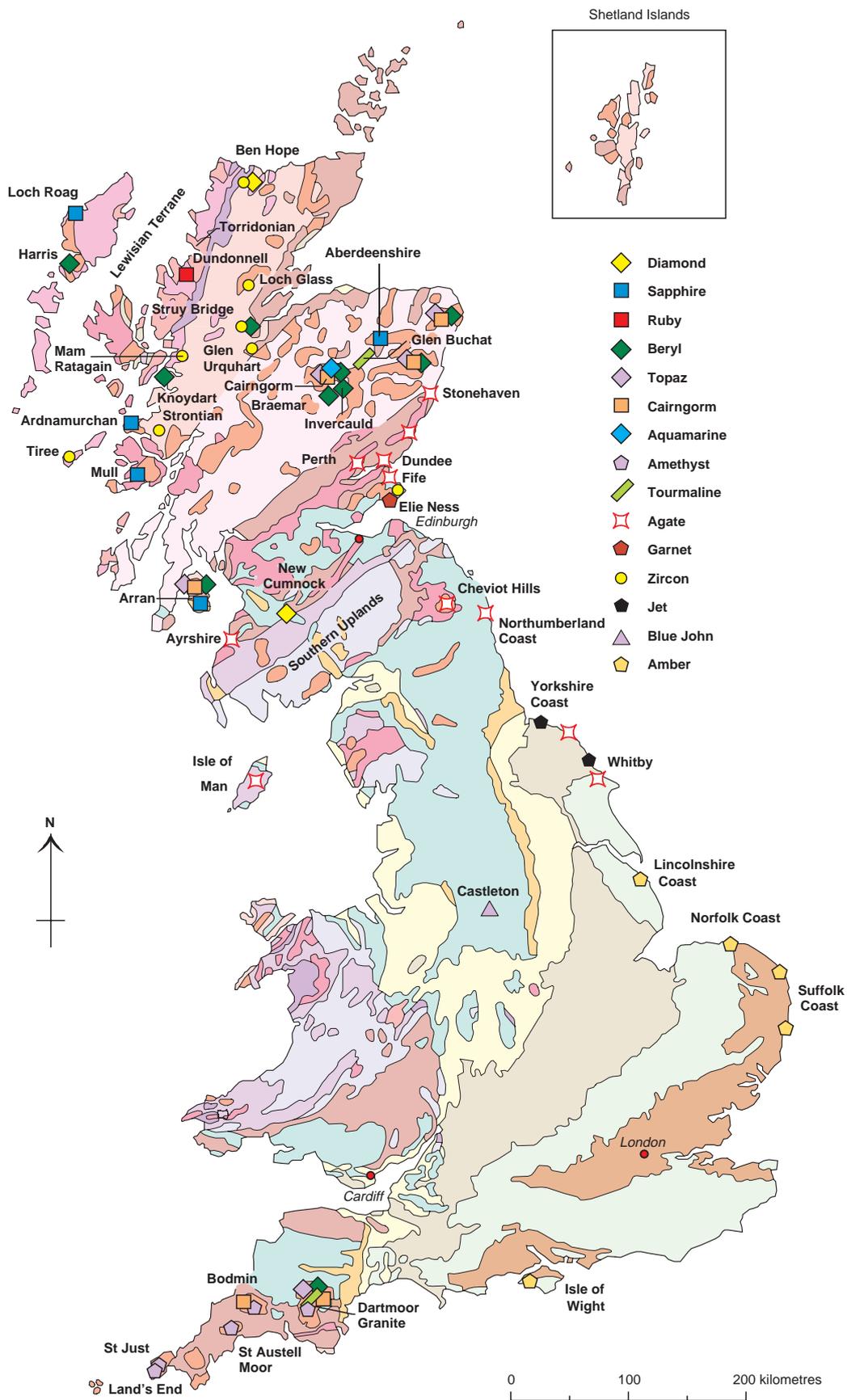


Integrated multidataset analysis of regional geological, geochemical and geophysical data.

because it was hard enough to scratch quartz, was reported from near *New Cumnock* in southern Scotland. The mineral occurred as minute crystals in a seam of graphite, formed by thermal metamorphism of coal.

Evidence from the major diamond-producing areas of the world indicates that most diamonds formed in sub-cratonic roots during the early history of the earth. In addition, it is now recognised that diamond could theoretically form in regions where cold crust is being subducted, particularly where the down-going slab contains carbonaceous sediments. The main requirements for a primary diamond deposit are therefore:

- A suitable upper-mantle root within the stability field of diamond.
- A host magma formed deep enough to be able to pick up fragments of the mantle source region on its way to the surface.
- A structural and tectonic regime for the development of pipes.
- A rapid transit to the surface in a suitable (kimberlite, lamproite) medium.



The 1995 Mineral Reconnaissance Programme evaluation of the diamond potential of Britain identified the *Lewisian Terrane* of north-west Scotland as the most prospective area, principally because it is a fragment of the ancient Laurentian craton with a lithospheric mantle root and is cut by major shear zones, which seismic data suggest reach the upper mantle. Gem diamond is only known to occur in kimberlites and lamproites, neither of which has been recorded in this part of Scotland, but exposure is poor over large areas in north-west Scotland, so it is possible that pipes have escaped detection.

Fresh kimberlite can contain up to 10% iron oxides, so intrusions may generate distinctive magnetic anomalies, frequently of the order of 200 nT. Most of the existing aeromagnetic cover of north-west Scotland is too widely spaced to give an adequate indication of whether any diatremes are present, but a notable and, as yet, unexplained magnetic anomaly with magnitude c. 600 nT above background occurs less than 8 km north-north-west of Heddle's diamond site and, coincidentally, in an area where alkaline lamprophyre dykes are known to outcrop.

It has recently been shown by isotopic studies of mineral inclusions that diamonds do not crystallise from kimberlite or lamproite melts; rather, they occur as mantle-derived xenocrysts and xenoliths, the ultimate source being garnet lherzolite and/or eclogite forming the wall rocks through which the magma passed. It is thus possible that other types of intrusions originating in the mantle, such as lamprophyres (which have chemical similarities with kimberlites and lamproites), could also bring diamonds to the surface. If this is so, the late-Palaeozoic alkaline lamprophyres which occur widely throughout north-west Scotland offer an additional target for diamond exploration.

Diamonds could also occur in palaeoplacers within the undeformed and unmetamorphosed Proterozoic *Torridonian* sedimentary rocks of north-west Scotland, which are sourced from an Archaean craton to the west of the Lewisian terrane.

The hypothesis that diamonds could form in regions of subducted cold crust offers other possible targets for diamond exploration, principally in south-west England and the Southern Uplands of Scotland where some doubt surrounds the nature of the basement. Rocks which fit into the lamproite class are found in the post-Variscan Exeter volcanic rocks (late Carboniferous to early Permian) of south-west England and lamprophyres in the same region approach lamproite chemistry. In addition, aeromagnetic data for this region, which is more closely spaced than for the rest of Britain, contains features which may be related to the presence of unexposed pipe-like intrusions. In the *Southern Uplands* of

Scotland some potential exists in lamprophyres, alkali basalts or nephelinites which locally contain evidence of mantle origin.

Sapphire and ruby

These gem-quality varieties of corundum occur in more types of geological environment than diamond. They are found in acid pegmatites and basic rocks such as lamprophyres, and may be associated with included material. They also form by regional and contact metamorphism of sedimentary rocks, particularly limestone, and are commonly re-worked into placer deposits.

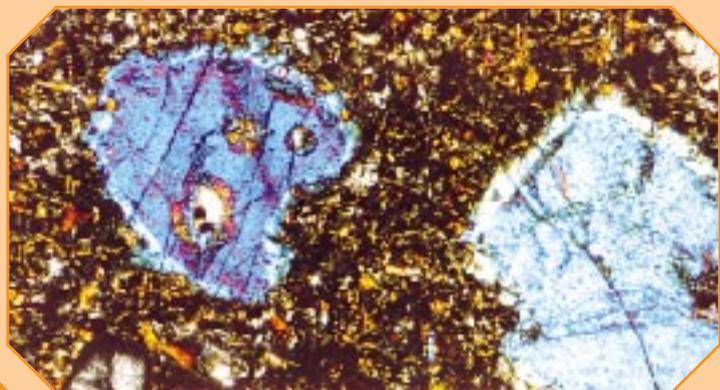
All of these environments are known in the Scottish Highlands, and the gemstone prospectivity of the region was confirmed in 1984 when sapphire megacrysts 10–30 mm in size were discovered in a monchiquite dyke at *Loch Roag* on the Isle of Lewis. A 9.6 carat cut stone from this locality was valued at about £60 000 in 1995. The dyke is up to 1.5 m wide, cuts Archaean gneisses and contains xenoliths of mantle-derived spinel-lherzolite. Although a Tertiary age has been obtained by K/Ar dating, the dyke is now believed to be part of the late-Palaeozoic mantle-xenolith-bearing alkaline lamprophyre suite and has potential for both diamonds and sapphires.

The existence of sapphires in Scottish rocks has been known since the nineteenth century. Small platy crystals have been collected from thermally altered aluminous sedimentary rocks in Tertiary basaltic and gabbroic rocks on *Arran*, *Mull* and *Ardnamurchan*, and from the Dalradian rocks of *Aberdeenshire*. None of these sapphires are of gem quality, but they provide evidence of potential by indicating the presence of aluminium-enriched crust favourable for the formation of corundum.



Left: A 9.6 carat cut sapphire from a lamprophyre (monchiquite) dyke, Loch Roag, Isle of Lewis.

Below: Thin section of the same dyke, showing reaction rims around xenocrysts of pyroxene.



Rubies may be present near *Dundonnell* in the Lewisian terrane of north-west Scotland, according to an unconfirmed nineteenth century report and to more recent claims.

Beryl and topaz

Beryl and topaz are typically late-stage products of granite magmatism, forming at moderate depths in pegmatites, veins and cavities. They are recorded in several Scottish granites, notably *Arran* and *Cairngorm* where topaz is generally associated with cairngorm. The largest topaz crystals, including some weighing more than 0.5 kg, have come from Beinn a' Bhuird in the Cairngorm mountains.

Beryl crystals up to 7 cm long occur in pegmatites at *Struy Bridge*, and other occurrences are known in pegmatites from *Harris* and *Knoydart*. Alluvial occurrences are reported from *Braemar* and *Invercauld*. In south-west England, minor topaz and possibly beryl have been recorded from the Meldon Aplite at the margin of the *Dartmoor Granite*.

Semi-precious stones

Historically, the Cairngorm mountains have been Britain's most prolific source of gem material and the search for stones formed a locally important industry in the nineteenth century. The stones occur in late-stage pegmatites and drusy cavities in the *Cairngorm Granite* and consist principally of yellow to black cairngorm (a variety of quartz), which may be accompanied by topaz, aquamarine and beryl. No production figures survive, but it is recorded that single cairngorm crystals weighing more than 22 kg were found. Cairngorm also occurs, with beryl and topaz,

in other granites in north-east Scotland and on *Arran*.

In south-west England, minor occurrences of cairngorm, amethyst and gem-quality tourmaline are known in the *Dartmoor Granite*. Cairngorm and amethyst are also recorded from the southern and eastern margin of the *Bodmin Granite* but, reputedly, the best of the Cornish amethysts come from *St Austell Moor* and near *St Just* and *Land's End*.

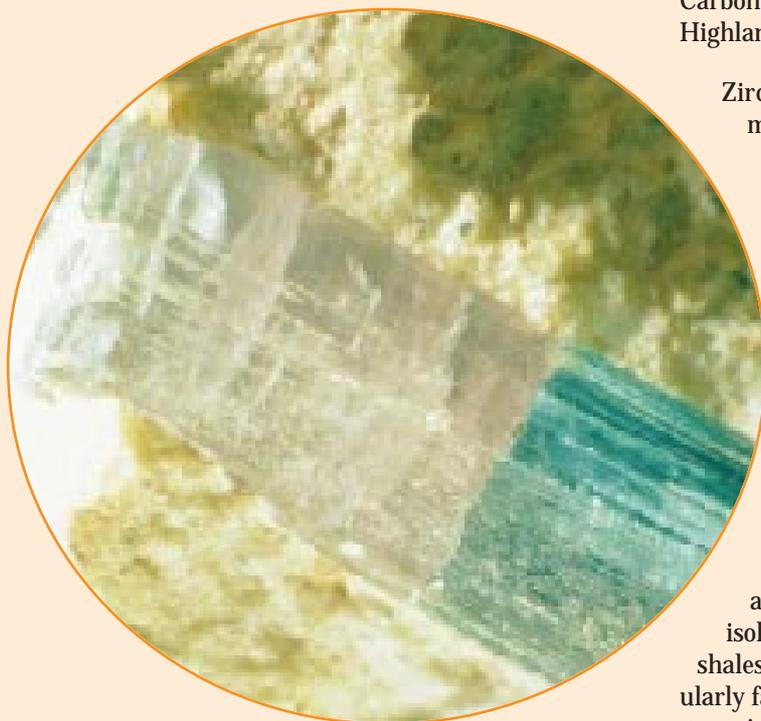
Gem-quality crystals of elbaite tourmaline up to 40 mm long are present in a lithium-enriched granite pegmatite in *Glen Buchat*, Aberdeenshire. The occurrence was first documented in 1982 and since then has produced many small stones with a variety of hues including clear, green, blue green, pink and, rarely, mauve.

Agates are among the most varied and beautiful of British gemstones. They formed in the sites of former gas cavities in andesitic and basaltic lavas or, more rarely, in open cracks and fissures in these rocks. The best quality agates are found on the east coast of Scotland between *Perth* and *Stonehaven*, in north *Fife* and in *Ayrshire*. They also occur in the *Cheviot Hills* and may be found on beaches in several parts of Britain, including the *Isle of Man* and the *Northumberland* and *Yorkshire coasts*.

Garnets occur widely in the metamorphic rocks of the Scottish Highlands, but most are too fractured, too dark in colour and too included for use as gemstones. However, the pyrope garnets from *Elie Ness* in *Fife*, the so called 'Elie rubies', have a delicate port-wine colour and are much sought after. These garnets are contained, along with zircon, in a volcanic vent of Carboniferous age. Similar vents occur in the western Highlands.

Zircon is extremely common as an accessory mineral in granitic and metamorphic rocks but most grains are too small and too impure to be valued as gemstones. However, Heddle noted several localities, besides Elie, where gem-quality material might be obtained, including *Strontian*, *Tiree*, *Glen Urquhart*, *Struy Bridge*, *Loch Glass*, *Mam Ratagain* and *Ben Hope*.

With the exception of south-west England, occurrences of precious and semi-precious stones are rare in England and Wales. The most notable worked occurrences are Whitby Jet and 'Blue John' (a variety of fluorite). *Whitby Jet* comprises diagenetically altered (silicified) araucarian wood occurring as isolated masses in finely laminated dark brown shales exposed on the Yorkshire coast. Jet was particularly fashionable in Victorian times and its extraction gave rise to a significant local industry. Jet ornaments have also been produced from several localities in Scotland. Derbyshire Blue John comprises purple to



Colour-banded elbaite tourmaline, Glen Buchat, Aberdeenshire.

blue banded colourless to yellow flourite occurring in cavities in Lower Carboniferous limestone of the *Castleton* area. It is said to be unique and, like jet, it gave rise to a local industry which persists today.

Amber has been found in situ at only one locality in Britain, on the *Isle of Wight*. It is, however, washed up in small amounts on the east coast of England, mainly on the *Suffolk* and *Norfolk* coasts but also in *Lincolnshire*. It used to be thought that it was derived from Baltic sources, but present evidence suggests that it may be derived from Tertiary deposits under the North Sea.

The potential to exploit precious and semi-precious stones in Britain has been enhanced recently by several new gold discoveries, notably in south-west England and Scotland, as it raises the pos-

sibility of using locally produced gemstones and gold to create jewellery that would command premium pricing due its rarity and local, historical or royal connections.



Whitby Jet jewellery.

(C. Adkin MN28205)

Data Holdings

A substantial amount of minerals-related baseline information for 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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