UK Critical Minerals Intelligence Centre

MINERALS FOR THE UK'S NET ZERO TRANSITION

# The potential for cobalt in the UK

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## Introduction

Cobalt is a lustrous, silvery-grey metal with many physical and chemical properties that make it useful in a wide variety of chemical and metallurgical applications. In the UK, cobalt is used in high-performance alloys for the aerospace sector and in the cemented carbide, magnet and special steel industries. Cobalt chemicals are used in the manufacture of batteries, glass and ceramics (Petavratzi et al., 2019). An area of significant demand growth for cobalt, and as such a driving force in the search for new cobalt deposits worldwide, is its use as a cathode material in electric vehicle batteries.

Between 1993 and 2020, world mine production of cobalt increased at a compound annual growth rate of about six per cent (BGS World Mineral Statistics Database). Despite the challenges faced by the mining industry during the COVID-19 pandemic, the production of cobalt increased in 2020 relative to 2019, with global production amounting to nearly 126 000 tonnes (metal content from mine production of cobalt) (Idoine et al., 2022). Thirteen per cent of cobalt mined globally is derived from artisanal

*This profile provides an overview of the geological potential for cobalt in the UK. It forms part of a series on the minerals the UK requires to transition its economy in the coming decades to net-zero emissions. It was produced by the British Geological Survey for the Department for Business, Energy and Industrial Strategy as part of the UK Critical Minerals Intelligence Centre.*

British Geological Survey

and small scale mining (Cobalt Institute, 2021). The Democratic Republic of Congo dominates world cobalt production with a share of 68 per cent of the total in 2020. Other significant cobalt producers include Russia, Australia, and Cuba, each of whom account for about five per cent of total world cobalt production (Idoine et al., 2022). Other notable cobalt producers include Canada, China, and New Caledonia. Cobalt is typically a by-product of copper or nickel extraction and is only produced as the primary commodity from one operating mine, which is located at Bou Azzer in Morocco (Bouabdellah et al., 2016; Ikenne et al., 2021).

Globally, battery manufacturing was the largest consumer of cobalt in 2020, at 57 percent. The cobalt is used in the production of nickel-manganese-cobalt battery cathodes, which have a cobalt content of between 10–20 per cent. Ongoing developments in battery cathode chemistry are likely to influence future cobalt demand. 13 per cent of cobalt was used to manufacture nickel-based alloys, with the remaining thirty per cent split across end use applications such as tool materials, pigments, catalysts, magnets and others (Cobalt Institute, 2021). The UK imports cobalt in several forms, chiefly scrap. In 2020 the total apparent consumption of cobalt in the UK was about 3000 tonnes of contained cobalt metal (Bide et al., 2022), double the amount used in 2017 (Bide et al., 2019). UK imports of cobalt in all forms were valued at £123 million in 2020, with a corresponding export value of cobalt in all forms of £113 million (Bide et al., 2022).

Global demand for cobalt in clean energy technologies is expected to increase by as much as 21 times in 2040. However, this projection will be influenced by the rate of uptake of electric vehicles and future battery chemistries (IEA, 2021). Cobalt is on the UK's critical minerals list (Lusty et al., 2021).

Cobalt can be found in economic concentrations in three principal deposit types: stratiform sediment-hosted copper-cobalt deposits; magmatic nickel-copper (-cobalt-platinum-group element) sulfide deposits; and nickel-cobalt laterite deposits typically formed by tropical weathering of magmatic deposits (Mudd et al., 2013; Naldrett, 2013). Cobalt can also be concentrated in a variety of other geological settings and deposit types, some of which were historical sources of cobalt (Horn et al., 2021; Slack et al., 2017). Significant concentrations of cobalt also occur on the seafloor in iron-manganese-rich nodules and crusts, although to date no cobalt has been extracted from these on a commercial-scale (Lusty and Murton, 2018).

## UK mineral occurrences, exploration and production

There is currently no mine production of cobalt in the UK, and there are no deposits that have cobalt resources and reserves, which are compliant with international reporting standards. Cobalt occurs as a minor constituent of base metal ores in several parts of the UK (Figure 1). However, where these ores were mined in the past, copper, lead and zinc, and locally silver and nickel, were the main metals of interest. At a few abandoned mines in south-west England, north Wales, central Scotland and Cheshire, polymetallic ores including cobalt were mined, mainly in the eighteenth and nineteenth centuries.

### *South-west England*

In south-west England, cobalt was recovered from nine mines from the mid-eighteenth century to the nineteenth century, with a total production of a few hundred tons of ore (Rollinson et al., 2018). The mines with known production are Wheal Sparnon near Redruth; Pelyn Wood Mine near Lostwithiel; Tretoil Wood Mine near Lanlivet; Trugo Mine near St Columb; Dolcoath and East Pool near Camborne; Great Dowgas and St Austell Consols near St Stephen; and Pengreep, near Gwennap. Wheal Sparnon had the most significant production, from a so-called 'cobalt lode', which was mined solely for cobalt. The ore was mainly roasted to produce cobalt oxides for use in the pottery industry (Jenkin, 1979; Rollinson et al., 2018). Cobalt at these mines in Cornwall is associated with lead, zinc, silver, uranium, antimony, manganese, iron, bismuth and nickel in late mineralised fractures, which cut across the main copper and tin orebodies (Rollinson et al., 2018). Cobalt-rich mineralisation has also been reported in copper-lead-zinc-silver ores associated with the Wheal Lushington mines

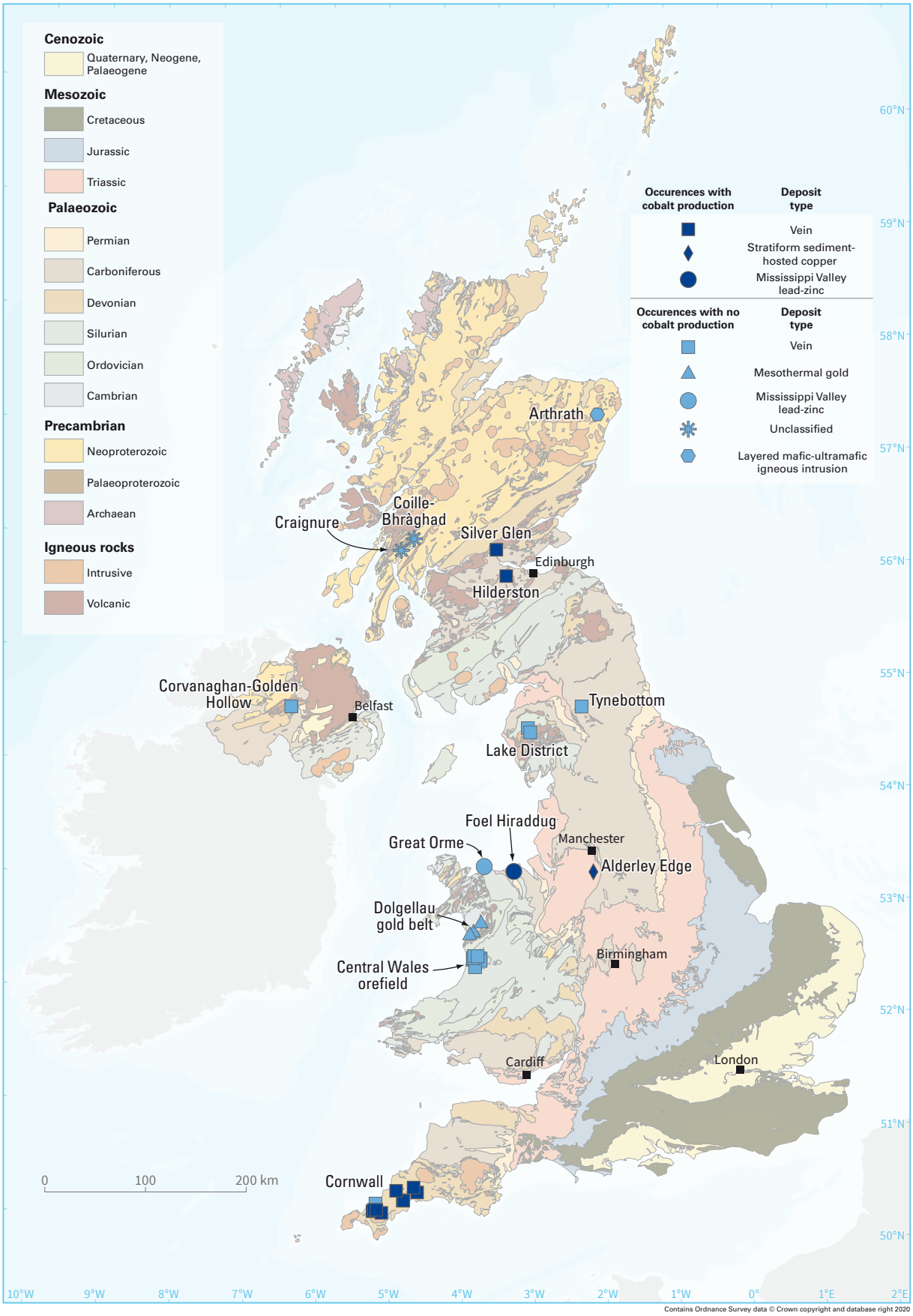


Figure 1 Location of the principal cobalt occurrences in the United Kingdom.

at Porthtowan near St Agnes (Rollinson et al., 2018).

## North-west England

In the Lake District, ores from Scar Crag and Dale Head North have high reported cobalt contents (Ixer et al., 1979; Stanley and Vaughan, 1980, 1982). Cobalt extraction was attempted in the mid-nineteenth century at Scar Crag, which was also called the 'cobalt mine', but this was never successful (Postlethwaite, 1913). The cobalt is incorporated in a range of minerals, in association with a chalcopyrite-pyrite-arsenopyrite assemblage (Ixer et al., 1979; Stanley and Vaughan, 1982). Recent research on vein-hosted mineralisation in the Scar Crags area in the Lake District confirms that cobalt is consistently hosted in arsenopyrite (up to 4.2 wt.%) with associated nickel (Solferino et al., 2021; Stanley and Vaughan, 1982). It has been suggested that the mineralogy and paragenesis at Scar Crags is similar to the Bou Azzer cobalt deposit in Morocco (Solferino et al., 2021). Silver-nickel-cobalt mineralisation has been described from the disused lead mine at Tynebottom, Garrigill, near Alston in the North Pennine Orefield (Ixer and Stanley, 1987). Small amounts of nickel-cobalt mineralisation have been recorded with copper ores in the Bonser vein and in the Paddy End section of the mines near Coniston in the Lake District (Russell, 1925; Young, 1987).

In Cheshire, small amounts of cobalt were recovered from copper deposits in Triassic sandstones at Alderley Edge in the early nineteenth century and at Clive in Shropshire (Bateson et al., 1982; Warrington, 2012). There is no information on the amount of ore extracted or metal produced from the mines in this district prior to 1857 (Warrington, 1981).

## Scotland

In the eighteenth century cobalt ores were mined on a small scale with silver at Silver Glen, near Alva, in Perthshire, Scotland. The mineralisation occurs in veins related to Permo-Carboniferous east–west-trending faults in late Devonian volcanic rocks (Hall et al., 1982; Moreton, 1996). Cobalt is also reported from the Hilderston mine, near Linlithgow in West Lothian, central Scotland, where it is also associated with silver and nickel. As at Silver Glen, mineralisation occurs in Carboniferous east–west trending faults, but here it is hosted by Lower Carboniferous sedimentary rocks (Stephenson et al., 1983). The British Geological Survey has undertaken diamond drilling to investigate these cobalt-bearing silver ores (Hall et al., 1982; Stephenson et al., 1983). The Coille-bhràghad and Craignure copper mines, near Inverary in western Scotland, are reported to have produced nickel-bearing minerals, which contained trace levels of cobalt (Coats et al., 1982). Ongoing commercial exploration for nickel-copper mineralisation in the Arthrath mafic-ultramafic intrusion, north-east Scotland highlights the potential for associated cobalt (Aberdeen Minerals Limited, 2022).

## Wales

In the Central Wales Orefield cobalt is a minor component of polymetallic vein mineralisation (Mason, 1997). The main mining activity here focussed on lead, zinc, copper and silver, and cobalt occurs in various cobalt-nickel minerals. Cobalt, hosted in an iron nickel sulfide mineral, has been recorded at several mines including: Erglodd, Brynyrarian, Loveden, Ystrad Einion, Esgairhir, Esgairfraith and Nantycagl (National Museum Wales, 2019a). In north Wales cobalt and nickel sulfides occur in the copper ores at the Great Orme Mine, near Llandudno (Ixer and Stanley, 1996; National Museum of Wales, 2019b). Cobalt production in Wales is only known from Foel Hiraddug (also known as Moel Hiraddug) near Dyserth, located about 30 kilometres east of Llandudno. Production of cobalt ore is estimated to have been 264 tons between 1878 and 1880 (Foster, 1882; North, 1962). The orebody had a length of about 23 metres and an average width of about 0.3 metres (with a maximum of 3 metres). It was worked to a depth of about 73 metres and a second 'vein' was trialled to about 30 metres. Foster (1882) reported assays of ore parcels containing 1.0–1.8% Co and 0.4–1.1% Ni. Minor cobalt mineralisation is also present in several disused gold mines in the Dolgellau gold belt in north Wales (Mason et al., 2002).

## Northern Ireland

During the last five years, commercial exploration for precious and base metal mineralisation in the Tyrone Igneous Complex in Northern Ireland has highlighted some potential for associated cobalt. Quartz-sulfide veins in a quarry in the

Corvanaghan-Golden Hollow area were reported to contain up to 0.13% Co, 1.27% Cu and 50.3 grams per tonne Ag (Walkabout Resources, 2018).

## Resource potential

Based on the widespread occurrence of cobalt minerals in a variety of deposit types there is potential for undiscovered cobalt resources in several areas of the UK. These include the Lake District, north Pennines, Silver Glen (Alva) Clackmannanshire and Coille-bhràghad, Argyll and Bute, Scotland, Cheshire and north Wales. Elsewhere historic mining of cobalt in the UK has demonstrated limited economic potential, either because of the small size of the orebodies or because the cobalt grade was low.

The most attractive targets for cobalt exploration, as a by-product of nickel mineralisation, are located in Caledonian layered mafic-ultramafic intrusions in north-east Scotland (Fletcher, 1989; Fletcher et al., 1997; Gunn, 2007). Although the geology of the north-east Grampians is complex and bedrock exposure is sparse, experience from past commercial exploration has demonstrated the efficacy of soil geochemistry (Hashmi et al., 2022; Hashmi et al., 2021) and electromagnetic (King, 2007) surveys for locating deposits of this type in the region (Gunn, 2007). The application of these or similar techniques based on modern conceptual models for deposits of this type provide a sound basis for undertaking further exploration.

It is important to stress that no systematic modern exploration for cobalt has been undertaken in the UK and modern research aimed at assessing the abundance and distribution of cobalt has not been carried out. Further research is required to understand the UK's cobalt prospectivity.

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