Coal, evaporite and metallic mineral resources are located on or beneath the sea bed and these have been worked from onshore deep mines which extend for limited distances under the sea. Coal and evaporite minerals are an important national asset and adequate and steady supplies are needed to maintain current and future economic development. The UK metallic minerals industry has declined over recent years but substantial resources remain.

Coal and evaporite mineral resources have been inferred from geological mapping data and the interpretation of boreholes. These resources have not been evaluated on any systematic basis by drilling or by other sampling methods for the purpose of mineral exploration. The map depicting the distribution of geological formations hosting coal resources is included in Appendix 1 - Map of coal resources and the map depicting the extent of sub-sea evaporite-bearing geological formations (salt-bearing halite resources) is included in Appendix 2 - Map of evaporite resources. Data on offshore metallic minerals is sparse and the location and properties of resources are poorly known. The presence of these resources is inferred from geochemical data, geological sampling and explorative actives by the extractive industry. The map depicting metallic mineral occurrences is included in Appendix 3 - Map of metallic mineral occurrences.

Coal resources

Coal is a combustible carbonaceous sedimentary rock derived from lithified plant remains. It was formed by the alteration of dead plant material that initially formed as a superficial deposit of peat and has been buried by subsequent layers of younger sediments. As temperatures rose underground, due to increasing depth of burial, the initial superficial peat deposits were altered by the process of coalification forming first brown coals, including lignite and sub-bituminous coal, to black or hard coals that encompass bituminous coal, semi-anthracite and anthracite (Kendall et al., 2010[1]). The process of coalification involves the loss of water and volatiles leading to an increase in carbon content, from about 60 per cent in peat to greater than 95 per cent in anthracite. The calorific value of coal also increases from about 15 megajoules per kilogram in peat, to about 35 megajoules per kilogram in bituminous coals and anthracite (Kendall et al., 2010[2]).

Coals are commonly defined by their content of moisture, volatiles, ash and fixed carbon. These properties together determine a coal's rank, or degree of coalification. For example, anthracite is classed as a high rank coal whereas lignite is classed as low rank.

There are several sedimentary basins containing coal resources within this map area, the northernmost part of the Southern North Sea Basin, the mid North Sea Basin and the Forth Approaches Basin. These coal resources often occur near the sea bed and at depths below 1000 metres so in the past have been worked offshore from onshore shafts around the north-east coast of England and in the Firth of Forth.

The Southern North Sea Basin hosts extensive coal-bearing deposits of Late Carboniferous age. The majority of this basin is in the East Inshore and East Offshore map area however the northernmost
part of the basin extends into the Scottish and central North Sea map area. Coal seams have been proved offshore between 2000 to 3000 metres below sea level and between 450–750 metres in thickness.

The Mid North Sea Basin, offshore east of Newcastle Upon Tyne, hosts coal deposits of Carboniferous age represented predominantly by the Caister Coal Formation. The onshore expression of these coal measures are represented by the Lower (Westphalian A) and Middle (Westphalian B) Carboniferous Coal Measures. Dinantian and Namurian aged coal units are also observed offshore in the Scremerston and Yoredale Formations. Within the Cleveland Basin the Caister Coal Formation occurs at a depth of approximately sea level to 1000 metres below sea level in the west, deepening to a maximum 2000 metres towards the east (BGS, 1999[2]). Individual coal seams may reach three metres in thickness and constitute up to five per cent of the formation. The Caister Coal Formation has a maximum thickness of 750 metres (Cameron, 1993a). Data relating to the quality of Dinantian and Namurian coals is sparse; however, they are considered to be generally of low quality. The Scremerston Coal Formation has a total maximum thickness of about 266 metres; coal seams are typically about 1.5 metres thick and comprise less than five per cent of the total formation volume (Cameron, 1993a[3]).

The Forth Approaches Basin contains Carboniferous aged coal-bearing strata, which are hosted by a series of synclinal structures. One of these structures is known to occur underneath the Firth of Forth where onshore coals are known to extend offshore. Coal seams range in thickness between three and nine metres; however, the thickness of individual seams can be variable due to synsedimentary faulting and folding (Gatilff et al., 1994[4]). Within the Forth Approaches Basin Carboniferous coals occur at a depth of approximately sea level to 1000 metres below sea level at the edges of the coalfield, deepening to a maximum 2000 metres towards the centre (BGS, 1999[2]). Coals of Jurassic age are also present in central and northern North Sea. Typically these coals are thin and occur at significant depths (over 1500 m). The highest concentrations of coals from Jurassic sediments occur around the Inner and Outer Moray Firth where coal seams are recorded in the Beatrice Formation, Brora Coal Formation and Pendland Formation. These occur at variable depths, between 1400–3600 m, and are typically no greater then 1 m thick, although seams up to 6 m thick have been recorded in the Pentland Formation. These coals have not been shown on the map as they are much thinner and comprise much smaller proportions of the total formation then Carboniferous coal resources.

Where circumstances permit, certain coal seams may be a source for alternative fossil fuels. Sometimes known as ‘unconventional hydrocarbons’, alternative fossil fuels may present a viable replacement for natural gas. Obtaining alternative fossil fuels requires extraction technologies which are very different to those used to extract conventional hydrocarbons. Of relevance to offshore coal resources is methane recovered from undisturbed or ‘virgin’ coal seams (usually known as coalbed methane (CBM)) and underground coal gasification (UCG).

The prime requirements for CBM prospects are unworked coal seams thicker than 0.4 metres at depths of between 200 and 1200 metres. Low permeability and high drilling costs currently make deeper targets unattractive.

‘Underground coal gasification’ (UCG) involves combustion of underground coal seams in situ to produce synthetic gas (‘syngas’). Coals located at depths in excess of 1200 metres are considered unsuitable for Underground Coal Gasification (UCG), with ideal depths being between 600 and 1200 metres (Holloway et al., 2005[5]). Coal occurs at shallow depths, often below 1000 metres in this map area, there may be potential for both CBM and UCG in the future.

The potential to exploit offshore coal resources is uncertain. Any attempt to extract coal using conventional deep mining techniques from onshore would incur significant development costs given the depths and distances involved, therefore conventional extraction is currently unlikely. Likewise,
it is unlikely that offshore coal resources will be exploited more than a few kilometres from shore by any of the above new technologies (CBM and UCG) in the near future. Research is required to obtain a better indication of their potential. Further information on the UK’s coal resources can be found in the BGS Mineral Planning Factsheet on coal (http://www.bgs.ac.uk/downloads/start.cfm?id=1354).

**Evaporite resources**

Evaporite minerals, including gypsum and anhydrite, halite (rock salt) and, more rarely, potash and magnesium salts, are precipitated during the evaporation of seawater. The arid conditions that existed during Permian and Triassic times across Britain resulted in several cycles of evaporite deposition, represented by numerous halite sequences. These resources have the potential to be extracted at depth via brine pumping, and the resulting cavities have potential for underground gas storage.

There are several basins in the map area which host evaporite deposits are present in this map area; The Southern, Central and Northern North Sea Basins, the Moray Firth Basin, the Forth Approaches Basin and North Channel Basin. In the deeper parts of these basins, the salt is prone to halokinesis causing it to migrate and be concentrated in salt domes. The northernmost extent of the Southern North Sea Basin is within this map area; however the majority of the mineral resource lies within the East Inshore and East Offshore Map (Bide *et al.*, 2011[6]). The most significant evaporite formations in the Southern North Sea Basin are the Billingham Anhydrite Formation and the overlying Boulby Halite Formation which, along with the Boulby Potash Member, are known offshore as the Leine Halite.

The Central North Sea Basin, Northern North Sea Basin, Moray Firth Basin and Forth Approaches Basin consist of the Upper Permian evaporite deposits of the Zechstein Group. The most significant evaporite formations are the Shearwater Salt Formation and the Halibut Anhydrite Formation. The Shearwater Salt Formation includes the thick Upper Permian evaporites that occur across the centre of the Northern Permian Basin. The formation is dominated by halite but includes significant components of sulphate minerals (particularly anhydrite and polyhalite) and chlorides (sylvite and carnallite). These minerals are concentrated into discrete intervals in some places which vary from a few metres to several tens of metres thick. However, these intervals, cannot be correlated between boreholes due to the regional halokinetic deformation.

Few wells have drilled to the base of the Shearwater Salt Formation but of those that have, the maximum thickness recorded is 2142 metres and in most other wells the thickness is between 500 and 1000 metres (Cameron, 1993b[7]). The Upper Permian Halibut Anhydrite Formation occurs below the Shearwater Salt Formation. It is predominantly anhydrite but contains an argillaceous unit and local developments of carbonate. Thicknesses vary but it is generally between 20 and 120 metres thick throughout the Northern Permian Basin (Cameron, 1993b[7]). Evaporite units from within the North Channel Basin have been identified by boreholes but their extents and properties are poorly constrained.

Although there are extensive offshore evaporite resources on the UKCS, their extraction may not always be economically viable. Feasibility of mining these resources depends on factors such as the commodity prices, geology, available technology, depth of deposits, distance to shore and other factors.

Further information on the UK’s salt resources can be found in the BGS Mineral Planning Factsheet on salt (http://www.bgs.ac.uk/downloads/start.cfm?id=1368).
Metallic minerals

Marine processes can lead to the concentration of metallic minerals in sea bed sediments. Currently there are no workings on the UKCS for metallic minerals. However, several types of mineral have been recorded in potentially economic concentrations and the working of some deposits has been considered in the past.

One of the most common types of metallic marine mineral resources are dense (or ‘heavy’) minerals such as cassiterite and zircon. These are commonly concentrated in placer-type deposits. The formation of placer deposits is fundamentally a process of sorting heavy minerals from those of a lower density during sediment deposition.

In marine environments, chemical precipitation is also an important potential process in concentrating certain metals. For example, manganese nodules form by the precipitation from sea water of an array of metals, such as manganese, nickel, copper, molybdenum and cobalt. The processes by which manganese nodules form are numerous and complex, and may include bacterial oxidation, authigenic reactions during sedimentation, and direct precipitation on to a suitable substrate (Robb, 2005[8]).

Titanium (rutile; ilmenite)

Significant accumulations of rutile and ilmenite are not known on the UKCS. However, where heavy-mineral sands have been identified offshore, for example offshore areas of north-east Scotland and the Sea of the Hebrides, it is likely these sediments will also contain titanium minerals such as rutile and ilmenite (Colman, 1994[9]).

Zircon

The majority of zircon occurrences are confined to onshore beach sands or shallow near-shore sands. Sea bed exposures of Tertiary sediments in the north-western North Sea have yielded elevated concentrations of zircon; sediments offshore from Alnmouth, Northumbria, and sediments on the Dogger Bank have zircon concentrations of 0.043 per cent and 0.1 per cent respectively (Hardisty, 1990[10]).

Other heavy minerals (chromite; magnetite; haematite; garnet; olivine)

Placer-type deposits of heavy minerals are known to occur in the vicinity of Shetland, where they are restricted to the near-shore areas off Unst on the eastern side, and in St Magnus Bay to the west. Heavy minerals comprise up to 5 per cent of the total fine-sand fraction and consist mostly of garnet, haematite, magnetite, and chromite (Stoker et al., 1993[11]). The mineral assemblage comprises about 20–50 per cent garnet; about 10–20 per cent magnetite; up to 15 per cent chromite; and about five per cent staurolite (Johnson et al., 1993[12]). In the vicinity of the eastern Outer Hebrides, high concentrations of heavy minerals are known to occur in the near shore of The Minch. High concentrations of these minerals may also exist in the near shore west of the Outer Hebrides (Stoker et al., 1993[11]).

Sediments from Loch Scridain, Mull, and the Sea of the Hebrides have yielded magnetite concentrations between 1–2 per cent; however, in exceptional cases samples containing about 5.6 per cent magnetite have been collected (Fyfe et al., 1993[13]).

Marine sands offshore Rum and south-west Skye contain considerable quantities of olivine and
chromite, probably derived from the Tertiary igneous complexes of Rum and the Cullins of Skye. The upper metre of sand in submerged deltaic areas south of Rum contains approximately 70 000 tonnes of chrome spinel with an average Cr$_2$O$_3$ content of 32 per cent. Approximately 1.5–2 million tonnes of forsterite-rich olivine is also present with an average MgO content of 47 per cent. Other minerals likely to be present in the sediments are ilmenite and vanadiferous magnetite (Gallagher et al., 1989).

**Manganese nodules**

Manganese nodules are known to occur in small patches in many of the sea lochs around the Firth of Clyde, for example Lochs Fyne, Goil, and Striven (Evans, 1986). In Loch Fyne the nodules are confined to the upper 10–15 centimetres of surface sediments in water depths of about 180–200 metres. The nodules are spherical and range from a few millimetres to about three centimetres in diameter. The nodules contain about 30 per cent manganese and four per cent iron; barium, cobalt, molybdenum, nickel and zinc are also variably concentrated in the nodules (Calvert and Price, 1970).

Manganese carbonate concretions also occur in the surface sediments of Loch Fyne. The concretions are irregularly shaped and are typically between 0.5–8 centimetres in size. They have lower concentrations of both manganese and iron, about 19 and 1.5 per cent respectively, but are typically more widespread (Calvert and Price, 1970).

**References**

2. BGS. 1999. Coal Resources Map of Britain, 1:1 500 000. NERC and the Coal Authority.
10. HARDISTY, J. 1990. The British seas: an introduction to the oceanography and resources of
the north-west European continental shelf. *Routledge.*


Category:

- OR/13/013 The mineral resources of Scottish waters and the Central North Sea

Navigation menu

Personal tools

- Not logged in
- Talk
- Contributions
- Log in
- Request account

Namespaces

- Page
- Discussion

Variant

Views

- Read
- Edit
- View history