13.2 The Archaeology of Cobalt Mining

13.2.1 Introduction

Cobalt is found as a component in mineralisation across the British Isles (Andrews 1962, 64; Tindle 2008). However, it has only been recovered at a few localities, principally in Cornwall, Cumbria and Cheshire, but also in north Shropshire, and the Ochil Hills, Scotland (Andrews 1962, 65). Once separated, cobalt minerals were used primarily in the manufacture of smalt, a pulverised glass produced by fusing cobalt oxide with powdered flint and potash, which was used for colouring in china and glass manufacture, and as a 'blue whitener' in paper making and in the linen industry. Ores could be smelted to produce the metal; this was usually carried out by specialist smelters remote from the mines but in one case, in Cumbria, it appears to have been attempted on site.

13.2.2 Geology

In Cornwall cobalt minerals include smaltite (a variety of the arsenide skutterudite), the hydrated arsenate erythrite, the sulpharsenide cobaltite, and the oxyhydroxide asbolane (Tindle 2008), and are found in association with nickel and bismuth ores (Dines 1956, 30). The association in Cumbria is with copper-lead-zinc mineralization and barite, with the former mineral grouping being linked to the Borrowdale granite intrusion (Stanley & Vaughan 1982). In Triassic sandstones of the Cheshire Basin cobalt is associated with barite mineralisation and localised occurrences of low grade, copper-dominated, sediment-hosted ore deposits, of which those in the Alderley Edge Geological Site of Special Scientific Interest are cited as a classic example (Warrington 2010).

13.2.3 Historical Context

Saxony was, from at least the 17th century, a principal European source of cobalt but export of the ore was prohibited and it was roasted there to produce *zaffre* for export; the Duke of Saxony thus monopolised the source material and that product, from which *smalt* was prepared. The cost of importing smalt into England in the mid-18th century stimulated a search for indigenous sources of cobalt ore. Some was already known from Cornish mines, and smalt production had been attempted there. In 1754 the Royal Society of Arts offered a premium of £30 for the best English ore sample and this was awarded in 1755 for ore from a mine near Truro. In the same year the Society offered a

premium of £30 for the manufacture of zaffre and smalt from indigenous ore; this was not awarded until 1764 (Watney 1963). The Napoleonic Wars resulted in further impetus to the discovery of indigenous supplies amongst which were those in Cheshire (Warrington 1981, in press).

Only a few mines in England produced cobalt ores or concentrates. In Cornwall, East Pool, Great Dowgas, and St Austell Consols have recorded outputs, in the latter case mixed with nickel ore (Dines 1956, 333, 545-46). Ore was raised from Trugo (Beer 1988, x) and parts of South Crofty (Dines 1956, 318), and possibly also from Dolcoath (Dines 1956, 30). Wheal Sparnon in Redruth was an important source of cobalt ore from at least 1808. Work there ceased in late 1810 but had resumed by 1814 when 'superior quality' ore was being produced; two tons, valued at £1200, were sent to London. Later, around 80 tons were raised in about one year from a 'large and valuable cobalt lode'. Mining at the 'Wheal Sparnon and Corner Stone Cobalt Mines' stopped while accumulated ore was smelted to produce pure oxide. A separate company was formed for that purpose and about £4000 worth of oxide was sold to potters between mid-1816 and mid-1817. In 1819 the 'cobalt lode' was worked down to 60 fathoms, and eventually down to 70 fathoms (below adit). In 1826 a 'cobalt works' was completed at the mine which was then unique in Cornwall in being worked *solely* for cobalt ore. Sales of the product to Staffordshire were anticipated and £600 worth of cobalt was prepared by January 1827, but the mine closed soon afterwards (Hamilton Jenkin 1979a, 19-23). Before 1817 some ore from this mine was apparently refined by the British Cobalt Smelting Company at Hanley (Watney 1963, 8). Cobalt ore was evidently worked at the Wherry Mine in Mounts Bay (Russell 1949; Hamilton Jenkin 1979b) in the late 18th century; Williams (1810, 488 cited by Timberlake 2010) referred to the mineral worked as 'pure cobalt ore'; erythrite and skutterudite have been recorded (Tindle 2008, 200). Some ore was produced at Wheal Owles and Boscawen before 1893, and at Polgooth, Wheal Huckworthy and Wheal Unity (Andrews 1962, 65). Cobalt ores were recorded from the Botallack, Levant, Hawkes Point, Rosewarne and Herland, and South Terras mines (Dines 1956), and cobalt minerals are recorded from many others in Cornwall (Tindle 2008).

In the Lake District cobalt ore was obtained from mines near Coniston (Andrews 1962, 65) and near Borrowdale. From about 1848 the Keswick Mining Company attempted to work cobalt at a mine high on the fells between Sail and Scar Crags, to the west of Borrowdale. The intention appears to have been to produce metallic cobalt. Dressing floors were erected and a smelt mill adapted for the purpose but the working failed

without producing anything of value (LDNPA HER 11654; Postlethwaite 1987, 109; Adams 1988, 47-48).

In Cheshire, mines at Alderley Edge were leased to the Alderley Mine Company in 1805. Cobalt minerals, predominantly asbolane (a mineral of variable composition but usually including nickel, cobalt and manganese or 'wad'), were recognised there in 1806, after probably being first identified at nearby Mottram St Andrew. In 1808 the Alderley cobalt ore was let to Tomlinson, Plowes & Co. of the Ferrybridge Pottery, in Yorkshire. However, this agreement was terminated after little more than one year although ore continued to be produced at Alderley and a treatment works was established at Wallasey, operated by the Seacombe Cobalt Company. That was dissolved around 1814 and succeeded by the Seacombe Smalt Company. However, the Alderley Mine Company had been dissolved before 1812 and the source of ore treated at Wallasey following that date is unknown. The Seacombe Smalt Company was dissolved in 1817 in the face of competition following resumption of imports from Europe after the Napoleonic Wars (Warrington 1981, in press). Cobalt was recovered at Alderley Edge later in the 19th century as a by-product of an acid-leaching process introduced there in 1857 to treat copper ore. It was also mentioned as having been sold from the nearby Mottram St Andrew mine between 1860 and 1865 (Warrington 1981, 65).

Cobalt minerals have also been recorded from Bickerton, west Cheshire (Carlon 1981) and from mines in north Shropshire, at Eardiston, Pim Hill and Clive; some ore was produced from the last (Dewey & Eastwood 1925; Shaw 2009). These occurrences are in deposits similar to but smaller than those at Alderley.

13.2.4 Techniques and Technology

There are few techniques or any technology specific to the extraction and production of cobalt minerals or the metal. During exploration of the Cobalt Mine at Alderley Edge tools were found which had evidently designed for extracting asoblane from joints in the sandstone (Timberlake & Mills 2003). The ore, described as blue-black grains, similar to gunpowder, disseminated in red sandstone or lying in thin seams, was 'got out in thin pieces, and separated afterwards as much as possible from the stone; it is then packed into tubs and sent near Pontefract, where it is manufactured into smalt' (Bakewell 1911). Otherwise the techniques of mining were no different from other mining activity of the period. Ore preparation would have relied initially on manual separation and grinding,

with gravity separation employed in the large dressing floors treating polymetallic deposits, as in Cornwall. Unfortunately little is known regarding the attempt to smelt cobalt on site in Cumbria.

Later in the 19th century the Alderley Edge Mining Company Limited produced cobalt-rich residues between 1857 and 1864 as a by-product of an acid leaching process for the extraction of copper. Solutions remaining after precipitation of the copper by scrap iron were concentrated by boiling in wrought iron pans, then sprayed over sand-covered tiles heated from below, in a furnace at dull red heat. Metallic oxides accumulated in the sand, and acid vapour and steam were conducted to a condensing tower. The resulting acid was recycled, but to little financial advantage and this procedure was suspended until cobalt present in the sand could be recovered profitably. According to Timberlake and Prag (2005, 140) a cobalt and nickel precipitate was subsequently partially smelted in reverberatory furnaces. A company report (*Mining Journal* 1864, 153) mentions furnaces at the 'cobalt works' being stopped after 357 tons of precipitate that yielded 10 tons 11 cwts and 2 qrs of 'speiss' with an estimated value of £650 to £700 had been processed (Warrington 1981, in press). There is no record of further production of those materials and the works referred to were clearly ancillary to that for recovering copper. 'Cobalt Treatment Works' and a 'Cobalt Tower' are alluded to in Timberlake & Prag (2005), suggesting the existence of a plant dedicated solely to cobalt production; these were a part of a much larger operation to recover copper ore.

13.2.5 Transport and infrastructure

The transport of cobalt ores presented little difficulty. They were relatively small in quantity and could be expected to utilise the existing infrastructure. For example, the quantity of 'cobalt-bearing wad' (i.e. asbolane) produced at Alderley in the early 19th century has been estimated as between 50 and 300 tons (Timberlake & Prag 2005, 144). This would have been carried by packhorse or horse-drawn cart to a suitable point for transfer by canal or river to the works at Ferrybridge or Wallasey. In the 1860's Alderley produce may have been transferred from carts to railway wagons in nearby sidings. Treatment was attempted on site in the Lake District, and was carried out at Wheal Sparnon from where, in the early 18th Century, transport of the product to customers in, for example, the Staffordshire Potteries, would have been largely water-borne, by sea to river and canal systems.

The extraction and processing of the minerals did not continue on any one site for sufficient time for the establishment of dedicated settlements.

13.2.6 The archaeology of cobalt mining

Workings connected with cobalt mineral extraction at Alderley Edge and in Cumbria have been explored and recorded (Johnson 1984; Adams 1988, 47-48; Timberlake & Mills 2003; DCC 2007; Norgate 2012; Carlon & Dibben 2012, 103-09). The Ferrybridge Pottery site was interpreted by Bidgood (1978).

At Alderley evidence for a 'Cobalt Treatment Works', particularly an interpretation of soil geochemistry, is alluded to in the work by Timberlake and Prag (2005). The site of the 'Wood Mine cobalt works and associated mines' is now a scheduled ancient monument (Number 1020181) and the description of this site alludes to 'buried remains of metal ore processing works' and states that features related to cobalt production that will survive include 'remains of wooden tanks, … the bases of furnaces for heating the cobalt bearing solutions, the foundations of the cooling tower for evaporating the heated mixture and the beds for the steam engines which powered the entire process'.

Traces of some structures have been noted in this area (in Timberlake & Prag, 2005) but none are unequivocally related to cobalt production which ended in 1864. Many, if not all, the structures erected by the Alderley Edge Mining Company Limited were removed after the company wound-up and its effects were auctioned in 1878 (Warrington 1981, in press). A small processing plant that would have overprinted vestiges of structures from earlier periods was erected on the site, and removed, in the early 20th Century (Warrington 1981, in press). Some buildings contemporary with and possibly connected with the early 19th Century cobalt mining are extant (Warrington in press), but lie outside the area of the scheduled ancient monument.

13.2.7 Notes on associated minerals

Nickel - Mainly produced in Scotland, the only Cornish mines to market this mineral were Fowey Consols and St Austell Consols. During the 1850s and 1860s, they had a combined output of 17.6 tons of ore valued at £653. (Burt et al, in prep. Two tons of 50-60% nickel ore were raised from Pengelly mine (Beer 1988, xiii). Precipitates containing

nickel were smelted at Alderley Edge for a short period (see above: Techniques and Technology).

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