

Consequences of environmental contamination by lead mining in Wales

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Abstract

Lead mining in Wales originated before the Roman Occupation. The main active period was from 1750–1900 when zinc and copper were also mined and during this period only simple and inefficient ore processing methods were available. Consequently large amounts of copper, lead and zinc compounds were lost to the environment and have since become incorporated in sediments and soils. Locally, pollution may still occur from drainage from abandoned mines and by mobilization of mine tailings. This paper describes the present state of Welsh rivers and reviews the distribution of contaminants in sediments and soils. The uptake of heavy metals by plants and the consequences for human health are also discussed.

Introduction

The British Isles were once among the major producers of non-ferrous metal ores but after 1880 the industry declined in the face of foreign competition and, except for tin, British ore output is now negligible (Richardson, 1974). Evidence of this once prosperous industry can be seen in many parts of Great Britain especially Wales. In every county in Wales there are abandoned workings with their attendant waste heaps most of which are still bare of vegetation. In addition to the visible reminders of past industrialization there is also an invisible inheritance in the form of widespread contamination of soils, sediments and biota by toxic metals which were released to the environment when the mines were working. This paper presents an overview of research on heavy metal pollution in Wales.

Heavy metals may be defined as those having a metallic density $>6 \text{ g}\cdot\text{cm}^{-3}$. Chief concern focuses on Cu and Zn, which are essential micro-nutrients but may be harmful when present in large concentrations and on Cd, Hg and Pb, which have no known beneficial metabolic role but are known toxins. These metals are ordinarily present in rocks, sediments and soils but locally may become concentrated in rocks as ore bodies and generally in the environment through pollution as a consequence of mining the ores.

Lead and zinc ores in Wales normally occur as veins or lodes associated with faulting in the host rocks (Imm, 1959). The main carriers of the veins are Ordovician and Silurian sediments and Carboniferous limestone. Associated with these ores are the gangue minerals quartz, calcite and barite. Galena (PbS) and sphalerite (ZnS) were mined extensively in Wales, whereas chalcopyrite (CuFeS_2) was less common and the most notable mine was at Parys Mountain, Anglesey. Gold was mined at a number of localities which form a broad belt north of Dolgellau. Further south an isolated mine at Pumpsaint, Dyfed was an important producer during the Roman Occupation.

The major elements in the ore minerals are invariably accompanied by minor or trace amounts of other metals. It has been known since prehistoric times that silver can be extracted from lead after galena has been smelted and many of the mines in Wales were opened primarily to obtain silver. Other important constituents are antimony, arsenic, bismuth, cadmium, gallium and germanium. Davies (1983) has provided fuller accounts of the accessory metals in ore minerals. The important point is that these 'guest' metals are also potential contaminants when ores are milled and smelted.

Mining in Wales predates the Roman invasion in AD 43. It virtually ceased during the Dark Ages (5th to 11th centuries) and became economically

important again after the 15th century when there was a growing demand for silver for coinage and lead for armaments (Richardson, 1974). The industry peaked in the middle decades of the nineteenth century and only a few mines were still worked during this century. Some 313 base metal mines are recorded in Wales and adjacent areas of England. Figure 1 illustrates the main mining areas of England and Wales. Figure 2 illustrates the distribution of lead mines in the Principality.

The techniques for separating ore from rock remained broadly the same throughout the whole mining period and entailed total reliance on the use of water. Water wheels drove the ore crushing machinery in most Welsh mines (Trevithick's Cornish steam engine never became popular in Wales) and the lighter rock was separated from the denser ore by hydraulic action in jigs and buddles. The waste water from the processing machinery carried both dissolved metal compounds and suspended ore particles and was released into rivers without pretreatment.

At first, smelting took place near the mines but diminishing supplies of wood for charcoal in the

eighteenth century led to the development of specialised smelting centres near the coalfields of north and south Wales. There were 20 major smelters just outside Swansea in the Tawe valley and 11 smelters near Holywell along the Dee estuary. Thus, Wales was one of the major metallurgical areas of the world a hundred years ago. Its smelters handled ore not only from other British mining fields but also from abroad; e.g., the mines around Fredericktown in south eastern Missouri sent their copper concentrates to Swansea (Richardson, 1974; Beynon & Betteridge, 1979; Chadwick, 1981).

Although the ore dressing and smelting process improved with time they were always inefficient. In the middle of the nineteenth century, farmers living in the Aberystwyth area complained that mine waste was deposited on fields in valley bottoms when local rivers flooded and was ruining their land. The consequence was an enquiry by the Rivers Pollution Commissioners. In their report (Frankland & Morton, 1873) they remarked that 'Lead mining is, in many instances carried on in an extremely slovenly and wasteful manner... we cannot doubt that reckless waste of valuable materials is permitted in many mines'. They analysed waste from jigs and concluded that 6.8 tons of ore were lost in every 100 tons of waste and calculations from their data lead to the conclusion that approximately 35% of the ore raised to the surface was lost to the environment during ore dressing. The subsequent smelting process was also inefficient. Overall, it can be estimated that for every ton of silver-free lead which was produced as much as 2 tons may have been lost to the environment (Davies, 1980).

The toxic nature of lead compounds was well understood and there was a wide variety of local names in Great Britain for lead poisoning: potter's rot, Devonshire colic, painters' colic, lead palsy, belland (Derbyshire) and *y ballan* or *y belen* (Wales). Yet the mining industry was entirely unregulated until 1876 when the Rivers Pollution Prevention act (39 & 40 Vict.) passed into law. But it came too late to be effective in Wales since the industry was then in a state of rapid decline. The environmental damage had been done.

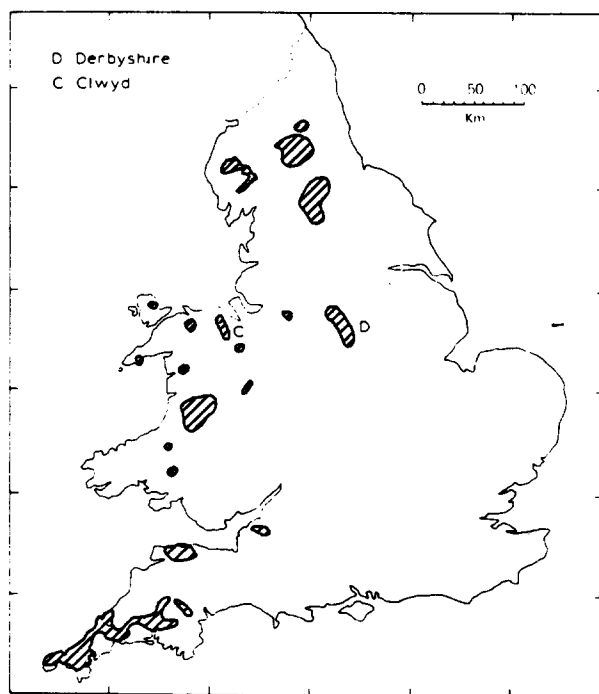


Fig. 1. Generalized locations of lead-zinc-copper mining fields in England and Wales.