

## CHAPTER 3

# THE MINING OF COPPER 1760 – 1820

The aim of this chapter is to examine the performance of the copper mining industry for the years between 1760 and 1820. Many factors impinged on this performance, a number of which are considered in the following sections. The chapter opens with a brief outline of the constitution and management practices common in the Cornish mines. It continues with an analysis of the productivity and profitability of the Cornish copper industry, coupled with its interdependence with the production of tin. Recognising that the mines of Cornwall were not the sole source of copper ore over these years, an overview of the other major source, the Anglesey copper mines, concludes the chapter.

## CORNISH COPPER MINING

### EARLY HISTORY

It is difficult for visitors to Cornwall today to appreciate the extent to which the county was industrialised in the eighteenth and nineteenth centuries. Mineral output was

not restricted to copper and tin, but included lead, iron, tungsten, silver, and arsenic. China clay was quarried extensively in the eastern half of the county, close to St Austell. The ports of Looe, Polperro, Porthleven, Newlyn, Mousehole, and St Ives were amongst some of the more important fishing stations in the country. Falmouth became a major packet port, serving Europe and the Americas, as well as being the first port of call for many ships following an Atlantic crossing, captains being directed by owners to 'call at Falmouth for orders'. Even a superficial observation of the landscape will reveal the relics of industrialisation, dominated by the remnants of the engine houses, with their substantial walls and high chimneys, prominent on skyline, cliff, moor, and in field and valley alike. Less obvious, yet no less evident, are the remains of the surface works, which even after a hundred years or more lack significant vegetation, polluted as the land was with the detritus of mineral processing, and littered with derelict buildings and open shafts.

The early history of copper mining in Cornwall can be traced through the work of contemporary topographic writers. Amongst the earliest to recognise the worth of copper was Norden. Writing in about 1580, he made passing reference to the existence of copper ore, but left it to a final postscript in which to recognise the potential value of copper deposits in the county, directing his address to King James I:

Touching your Majesties Mineralls in Cornwall ... copper, a metall whose qualitie and quantity would so farr excede the former (tin), as were the Workes affirm'd into your Majesties own hands, duly searched, trulie managed, and effectually followed, would raise a greater yearlie profite then the value of your Majesties Land Revenues: So riche are the Workes, especially some lately founde, as by the Opinion of the Skilfull in that Misterie, the like have not been elsewhere found.<sup>1</sup>

Richard Carew in 1620 provided the first glimpse into the operation of the copper trade:

Touching Metalls: Copper is found in sundrie places, but with what gaine to the searchers, I have not beene curious to enquire, nor they hastie to reveale. For at one Mine (of which I took view) the Owre was shipped to be refined in Wales, either to save cost in the fewell, or to conceal the

profit.<sup>2</sup>

It was most likely this brief insight resulted from his friendship with William Carnsew, who could rightly be called Cornwall's first mineral agent. His correspondence contained the earliest indication of output for the county, illustrated in this letter addressed to him by the manager of the St Just mines, John Otes:

At the present time, God be thanked for his goodness, the mines in St Just were never better than they are now. I would to God we had a dozen such mines as St Just. For we have gotten of the said two mines, from 6 of July last until the last day of October, 50 ton and better.<sup>3</sup>

Little is known of the operations in the county after Carnsew's death in 1588, and it is probable that like the copper mines around Keswick they stumbled on until the Civil War brought all activity to a halt.

The next reference to the mining of copper is not to be found until 1695, when Celia Fiennes rode through England on her side saddle. Her narrative was the first to recognise the renewed interest in the operation of the copper mines. Whilst staying at Tregothnan, the residence of Lord Falmouth, she wrote: 'Six miles from this place westward was to Truro, and the north to the hills full of copper mines.' And a couple of sentences later:

The next day, ... I ... went for the Land's End by Redruth, 18 miles, mostly over heath and downs, which were very bleak and full of mines. Here I came by copper mines ... They do not melt it here, but ship it off to Bristol by the North Sea, ... which supplies them with coals for their fuel at easier rates than the other side. ... Indeed, at St Ives they do melt a little, but nothing that is considerable.<sup>4</sup>

From the beginning of the eighteenth century, accounts of copper mining, written by both travellers in the county and indigenous topographers become more commonplace and comprehensive, as to be beyond the scope of this thesis to reproduce in any part.<sup>5</sup> However, they firmly establish the existence of an active copper mining industry in

Cornwall by the beginning of the eighteenth century.

Acts of Parliament in 1689 and 1693 abolished the restrictive rights of the Company of Mines Royal and the Mineral and Battery Company, enabling anyone prepared to risk their capital to search freely for copper ore previously the monopoly of the two companies. Copper ore deposits in Cornwall were not so readily accessible as those of tin, the latter being found on or close to the surface in both fluvial and detrital deposits, as well as in shallow mines. It was not until the tin mines had been worked down to depths of the order of 50 fathoms or more that copper ore in economic quantities was discovered, raised and shipped to Bristol and the Forest of Dean for smelting.

By the first decade of the eighteenth century copper ore was being raised from a number of mines, mainly in the central mining district of Cornwall, that area bounded by Camborne, Redruth, and Gwennap (Plate III), including those at:

Chace–water in the parish of Kenwyn; North Downs, in Reddruth;  
Huel–Rôs, in St Agnes; Roskear and Huel–kitty in Camborn;  
Huel–fortune in Ludgvan; the Pool, in Illogan; Dalcooth, Bullen–garden,  
Entral, Longclose, in Camborn; Metal Works, in Gwenap; Trejeuvan, in  
Gwenap; Binner Downs and Clowance Downs, in Crowan; Huel–cock  
and Rosmoran in St Just; and Herland mine, in Gwinnear...<sup>6</sup>

Notwithstanding the difficulties experienced in developing new ore deposits, the industry progressed, and output rose significantly. Between 1726 and 1775, the average annual tonnage increased by over 400 per cent, with an annual income in the latter year of £200,000 approximately (figure 3.6).



## ORGANISATION AND MANAGEMENT

The organisation of the copper mines differed from that of the tin mines in that they were not subject to the stringent legislation of the Stannary authorities. The most significant differences were the lack of restrictions on the location of copper smelting, and arrangements for setting a mine to work did not require the prior approval of the Stannary courts.

Negotiations for the formation of a company were between the owner of the mineral rights and the new investors who were prepared to risk their capital in a speculative venture.<sup>7</sup> Where it was proposed to reopen a mine the previous leaseholders would also be approached if their lease was still in effect. Typically, the lord would grant a lease for twenty one years, with the right to foreclose, if in his opinion, the mine was worked ineffectually. He was entitled to inspect the mine at any time to ensure it was being maintained in good working order as regards the state of the shafts, levels, adits, etc. He could demand the construction of new shafts and adits, the installation of equipment, direct development to certain regions of the mine, and stipulate the effort applied to exploration to establish reserves. In return for permission to work the sett<sup>8</sup> the adventurers delivered to the lord a proportion of the ore raised, or more usually a monetary equivalent. The amount paid, the lord's dues, was based on the expectations for the mine and could vary widely. Where large profits appeared likely, or at those times when the copper market was buoyant, the dues could be set as high as one eighth, whereas when attempting to reopen an old deep mine, with high costs of draining old workings and putting the mine back into good order, dues could be as low as a one twenty-fourth part of the gross receipts from the sale of ore. This archaic method of setting the amount of the dues greatly favoured the mineral lord. He was assured of his income, and it was not unusual for the dues levied to turn a profit into a loss.

Notwithstanding this inequality, this system of leasing mineral rights was to remain in existence throughout the eighteenth century and most of the nineteenth. Lower dues could be agreed for the early years of operation when major expenditure was most likely, perhaps for as long as the mine operated at a loss. Also, dues could be renegotiated if significant losses were incurred, or the industry went into a period of recession. Ultimately dues became based on net profit, although for the period under discussion this more equitable approach was very much in the future. There was little doubt the payment of dues was a major burden for many adventurers, and a source of easy income for the lords, the eighteenth century 'fat cats' of Cornwall.<sup>9</sup>

Contemporaneously with the negotiation of the lease, the adventurers agreed the constitution of the company. Throughout the eighteenth and most of the nineteenth centuries the mining ventures in Cornwall were constituted on the cost book principle. The cost book originated with the early small scale tin operations, when adventurers were small family units, or associations of close friends. It became the universal system of company structure until the introduction of the limited liability company in 1862. Even then the cost book company survived for many years thereafter. One definition of a cost-book company was:

A company, constituted upon the cost book system, is in effect an extended partnership; rules being substituted for the partnership deed, which rules bind all the shareholders together and give them a joint interest and liability.<sup>10</sup>

The cost book was the single binding book of accounts, in which all disbursements and reimbursements were entered and periodically balanced. During the company's formation the sett was surveyed, and initial costs determined, with the

adventurers agreeing a proportionate share of the financial responsibility each was prepared to bear. The total estimated outlay was typically divided into 64 shares, or multiples thereof. Details of the adventurers, with their respective share holding, and the regulations for the mine's management, became the opening entries in the cost book. Each adventurer was called upon to deposit an amount proportional to his registered shareholding to meet the initial outlay. At routine intervals, such as every two or three months, the cost book would be closed, and the account balanced. Shortly thereafter the adventurers would meet, endorse the balance entered in the cost book, review the past performance, and determine the future progress of the mine. Liabilities and operating costs for the next two or three months, that is up to the next settlement day, would be determined, and offset against the previous period's balance. If a profit had been made, this would be divided amongst the adventurers in proportion to their holdings. In the event of a loss, they were called upon to contribute in proportion to their holding the amount to cancel out the loss and provide for continued operation. Such 'calls' would continue as long as losses were made without limit to their respective liability. The only release for an adventurer was to sell his share, or relinquish it to the company without compensation. In the latter event, the adventurer still retained liability for any further losses sustained during that accounting period. Liability for any outstanding calls remained the responsibility of the remaining adventurers. Those unable to attend these meetings were bound by the resolutions determined by those present.<sup>11</sup>

As the eighteenth century progressed so the Cornish copper mines became deep hard rock operations, resulting in escalating costs associated with the nature of the ground, and the continuous threat of flooding. Improved bucket and plunger pumps, and the power of the steam engine ultimately proved effective in minimising the latter. It was these machines that heralded the essential need for capital investment in the mines. No



longer was it possible to provide for them out of profits or calls, particularly when a mine might require five or more such engines to drain the extensive workings, and raise ever increasing quantities of ore. With the capital cost of a Watt engine of 45 inch cylinder diameter, typical of the size employed in operating pumps in the deep mines, in excess of £1,500, there was probably little alternative for the adventurers other than resorting to some credit arrangement to finance these engines.<sup>12</sup> This cost could well exclude the cost of the boiler, and the engine house. From the middle of the eighteenth century banking facilities slowly emerged in the county, and it was not unusual to find that one or more of the adventurers in a particular mining company were bankers, and thus in a position to advance the capital needed.

Mines frequently closed in times of recession, only to be opened under new management when demand for copper once again exceeded supply. In restarting a mine, the new company would either have to refurbish any existing machinery, such as the water wheels and steam engines, or buy new, or frequently secondhand equipment, and pump out the flooded levels below the adit. In some fortunate situations viable mineral deposits above adit could contribute to the reopening costs, but again an injection of capital could well be required before the mine would become fully functional. In copper mines such injections of capital were almost always concerned with the provision of engines for pumping or raising ore. Surface works required minimal capital investment, with dressing of ore being mainly accomplished by manual and very simple water driven machines. Underground, the vast amount of work was accomplished by manual labour, coupled with reliance on gunpowder for breaking ground. Thus, throughout most of the life of the Cornish copper industry, and with the exception of the provision of steam power, the demands for capital were tolerably reasonable, thereby encouraging the growth of a small mine culture in the county. As the industry moved into the nineteenth century the 'Cash

versus credit' philosophy, whilst a worthy aim, became less feasible.

Thus the concept of the working adventurer gave way to the capitalist adventurer, no longer needing to be a dedicated miner, but an investor drawn from a widely divergent social background. By the middle of the eighteenth century the adventurers could range from a member of the land owning class to the tradesman hoping for employment, as well as a return on his investment, merchants were conspicuous by their presence. A list of mines with the names of their adventurers was submitted in evidence to the 1799 Parliamentary Inquiry. It included all social classes, peers and knights of the realm, lawyers, clerics, bankers, merchants, engineers, landowners, farmers, tradesmen and others.<sup>13</sup> Some would be directly involved in the day to day operation of the mine as its principal captain or purser,<sup>14</sup> others in supplying material or services, the in-adventurers, and those whose interest lay simply in looking for a return on investment, the out-adventurers.

Routine management depended on the size of the undertaking. In the smaller mines a single manager might well oversee all operations, becoming greatly extended in the larger mines. Overall control was entrusted to the principal captain.<sup>15</sup> In the financial and administrative management of the mine, he would be assisted by the purser, who had responsibility for the maintenance of the cost book, and control of the budget. His ultimate responsibility was to balance the cost book and prepare the accounts which would be presented at the regular meetings of the adventurers, as well as handling all routine payments and receipts ensuring agreed financial limits were not exceeded.<sup>16</sup>

Where the overall operational management would exceed the capacity of the principal captain assistance was forthcoming from one or more underground and grass

captains. Their routine tasks would be the supervision of operations, both below and above ground; ensuring the extraction and sorting of ore was proceeding as agreed, that shafts were being sunk, adits driven and levels advanced as proposed. Similarly, at the surface, the grass captains were responsible for the dressing of the ore, and its preparation for sale. But, perhaps, the prime responsibility of the captains was the determination of future activities on the mine. In particular, the captains had the responsibility for determining the extent of the various developments to be undertaken in the next accounting period, and estimating the likely return. Arriving at the most effective programme for future operations required considerable experience on the part of the mine captains, all of whom had risen through the ranks of labouring miners. They were universally recognised as men of considerable ability, although with limited formal education. Yet they were required to be skilful in surveying, ensuring that levels and shafts progressed on the desired alignment, and bounds were not crossed. Whilst entirely ignorant of the science of geology, they were able to judge the nature of the ground in which the mine was situated, the rate, and thus the cost, of breaking through it, and also the worth of the mineral in the lode. A vital role was ensuring that the working miner was performing for the benefit of the adventurers.

The grass captain was responsible for ensuring that the material raised from the mine was dressed such as to obtain the most cost-effective extraction of the embedded ore. In addition, he assisted the purser in organising the preparation of the ore for sale. In this he was required to clearly identify each parcel of ore raised by each group of miners, from which a sample would be taken for later assay, and on which payment to the miner would be based. He ensured the ore was prepared for sale by parcelling it into suitable parcels or doles, and following completion of the sale liaised with the purchaser for its collection.

Depending on the size of the mine, the adventurers may have employed an engineer for the maintenance of the steam engines, engine men and boiler men for their operation; carpenters and timber men for the installation and maintenance of surface works and underground pit work; store men; and clerical assistance to the purser. These employees, captains and purser represented the directly employed work force in the mine. The remainder, the miners and surface workers, were employed on various contract terms.

## LABOUR

Contracted labour was divided into three categories; the tutworkers, tributers, and dressers.<sup>17</sup> Tutworkers and tributers were employed below ground, the dressers were surface workers. Broadly, tutworkers were deployed in the development of the mine, whereas the tributers were concerned with the winning of the ore. All three categories were employed on contracts awarded by auction. There were significant benefits in this employment pattern for the adventurers, it ensured the minimum size of labour force for the task in hand, and thus the minimum labour cost. Payment was made by results, the income to the miner being determined by his zeal and enterprise. Payment was not made until the contract had been completed, and in the case of the tributer not until the ore had been sold, for only then was its value fully realised. Its one significant disadvantage was the possibility of fraud, the holding back of rich material for a later contract in the expectation of achieving a better price, or the transfer of rich ore to those tributers working a lean pitch receiving a high return. Prevention of such frauds relied on the integrity and diligence of the underground captains. Overall, the system served the adventurers better than it did the miner, connivance between the miners was difficult.

Tutwork was mainly concerned with the development of the mine, including the

driving of levels and adits, and the sinking of shafts. In some situations it could also include the stoping of ground, or the stepwise removal of mineralised material on a lode adjacent to a level.<sup>18</sup> Driving and sinking were paid on the basis of a linear fathom, the former in length, the latter in depth. Stopping was paid by the cubic fathom. The amount the tutworkers could earn would depend on the nature of the ground, and the volume of material to be removed. What was considered achievable in the course of a particular contract was left to the judgement and experience of the captains. The total amount of tutwork for the upcoming period was subdivided into bargains. The manpower required to complete each bargain was known as a 'pare', the number in the pare depending on the nature of the work. For a level a pare may have been six men, whereas for a shaft perhaps as many as twelve. Each pare would be subdivided to enable three shifts each of eight hour duration to be undertaken daily for a six day week.<sup>19</sup> The tutworkers would receive payment for any ore raised in the fulfilment of their bargain.

Tribute work was concerned with the excavation, and initial dressing of the mineral, rendering it fit to be raised to the surface. Contracts were let on the basis of the likely yield of the ore after dressing, and the nature of the ground. In tribute work the level or stope to be worked was known as a 'pitch'. It was let at so much in the pound sterling, the richer the ground, coupled with its ease of working, the lower the price set.<sup>20</sup> Again the pare would be expected to work the same hours as tutworkers.

Dressing included all the tasks required to prepare the ore for sale. Whilst a certain amount of waste would have been removed underground, ore raised to the surface would still require further dressing. In this case, however, instead of the contract being awarded to a group of labourers, the contract would be awarded to a single person, the 'taker', to render a fixed quantity fit for marketing. The hiring of additional labour, usually women

and children, to undertake this work was the responsibility of the taker.

The day set aside for the award of the contracts was known as the setting day. Immediately prior to it, the captains would have determined and apportioned the quantity of work to be accomplished in the coming two months, or whatever other period had been determined between the accounts being made up and closed. On the setting day the miners and other labour would attend, not just the ones previously employed but all seeking employment. Following a reading of the contract conditions, the principal captain would offer the various packages to the assembled work force. In the first instance the tutwork bargains were put up, to be followed by the tribute pitches, and finally the dressing bargains.

In all three instances bids were invited, the first to make an offer usually being the leader of a pare previously employed on the mine. Others would join in the bidding offering progressively lower bids, until no other bid was forthcoming. The lowest bid would then be accepted by the captain if he considered it satisfactory, otherwise he would put up his own lower estimate of the value of the work. By the captain's refusal to accept the lowest bid, any combination amongst the labour force was avoided, yet the captain's reserve had to be realistic if it was to be accepted. In the award of the tribute pitches, or tutwork bargains, acceptance was speculative. Whether the miner or the captain was the gainer in this process came down to their respective knowledge and skill. Though there were occasions when a rich parcel of ore was struck in what was considered to be a much poorer pitch, the opposite was more often the case.

At the completion of the bidding process, accounts were opened by the purser for each pare of tutworkers and tributers, and the takers of the dressing bargains. Into each

account was entered the materials issued to the various parties. For all miners this would include any new tools, candles, fuse and gunpowder, plus in the case of the tributers the cost of raising the ore and waste to the surface, and its subsequent dressing. In addition, debits included the costs associated with the sharpening and other maintenance of tools, subsist,<sup>21</sup> the doctor<sup>22</sup> and barber's subscriptions. Takers of dressing bargains would be debited in similar fashion. Calculation of the amount due to tutworkers and takers of the dressing bargains was relatively straightforward. The quantity of work accomplished by the tutworkers was measured at the end of the accounting period, the advances deducted from the respective totals, and the balance paid to the bargain taker. The amount due to the taker of a dressing bargain was based on assay, resulting in a balance being realised between waste on the one hand, and excessive labour on the other. Thus it was again possible to turn the work undertaken into a monetary value, deduct debts incurred by the taker, achieve a balance and make the necessary payment.

The calculation of the amount due to the tributers was more complicated, for it was determined by the yield, and the quantity of the ore raised. It was for this reason that the quantity raised by each pare had to be kept segregated from all other, thus enabling a sample to be taken, and assayed to determine the metal content. The quantity of copper, or yield, in the ore raised and dressed would be determined, and following its sale the value determined. It was therefore incumbent upon the tributers to maximise their efforts below ground to ensure only the richest ore was raised. Whilst the ores of copper were frequently found in concentrated masses, and readily visible underground, lower yielding ores could be rejected, or overlooked in the dismal light of a candle as waste with the aim of reducing subsequent costs. In this way both the hauling and dressing charges for which they were liable were kept to a minimum. These sums were debited to their account, and a balance arrived at and paid as appropriate.

## BOULTON & WATT AND THE ENGINE BUSINESS

Keeping the underground workings free of water was the greatest cost that the Cornish adventurers had to meet. During 1814 the three pumping engines at the United Mines in Gwennap raised an average of 1,180 gallons of water per minute to adit level from depths of 136, 152 and 110 fathoms. In so doing they consumed 11,010 tons of coal at a cost of between £9,000 and £9,500.<sup>23</sup> These engines were at the very least three or four times more efficient than some of the best of Newcomen's atmospheric engines. It was, therefore, little wonder that the Newcomen engine found little favour in the county, and the introduction of the greatly improved Watt engine was greeted with enthusiasm.

In 1763, whilst employed as an instrument maker in Glasgow University, James Watt (1736 – 1819) repaired a model of a Newcomen engine, during which he became aware of the engine's deficiencies, particularly the thermal inefficiency. He quickly realised that it was essential to minimize heat loss, particularly in the cylinder. By 1765 he had arrived at a solution. He conserved the cylinder's high temperature by enclosing it within a steam jacket, whilst the steam injected below the piston was carried off to be condensed in a separate vessel, appropriately named the condenser. During these early years he was assisted by Dr John Roebuck, the Scottish industrialist, and founder of the Carron Ironworks, with whom he entered into partnership in 1769. Through him Watt was introduced in 1768 to Matthew Boulton. In 1773 Roebuck became bankrupt, which enabled Boulton, as a creditor, to take over Roebuck's share in the patent. By 1775 Boulton had entered into partnership with Watt, the latter now removed to Birmingham.<sup>24</sup>

Matthew Boulton (1728 – 1842) was by this time well established in Birmingham. At the age of 14 he had entered into his father's employment, a toymaker.<sup>25</sup>



On coming of age Boulton was invited by his father to become a partner. Following his father's death in 1759 he assumed sole control of the company. In 1762 he opened a new factory, the Soho Manufactory, in partnership with John Fothergill, a Birmingham merchant. The partners rapidly extended their stock-in-trade to include buttons, steel jewellery and, most importantly, Sheffield and silver plate, and ultimately solid silver wares. At the age of 45 Boulton was an established and much respected Birmingham business man, but ambitious, always seeking to expand into new enterprises.<sup>26</sup>

One such was his partnership with Watt. From early on in their relationship Boulton appreciated the potential of Watt's modification to Newcomen's engine, and in 1775 Boulton negotiated an extension of the patent for a further 25 years, and immediately commenced a search for customers. Watt was more cautious, wanting time for further development. Boulton ignored these pleas, supplying the partnership's first pumping engine to Bloomfield Colliery near Tipton in 1776, followed by a blowing engine for John Wilkinson's blast furnaces at Broseley in the same year.<sup>27</sup>

The greatly improved efficiency brought about by the separate condenser was of little significance at the coalfields where coal was cheap, and the inefficiencies of the much cheaper Newcomen engine tolerated. The colliery owners were therefore unlikely to be customers for the Watt engine. This was not so in Cornwall, where the cost of coal brought in by sea was inflated by both a customs duty and carriage.<sup>28</sup> By 1776, although the efficiency of the Newcomen engine had been greatly improved by the local engineers, it fell far short of that of the new Watt design. And efficiency was vital, not only to enable exploration to greater depths in the mines, but also as a counter to the competition from Thomas Williams and the emergent mines of Anglesey.

Following a visit to the Midlands by a group of Cornish adventurers in 1776, an order was placed for an engine to be installed at the Ting Tang mine in Gwennap. This was shortly followed by a second order for another engine for the same mine. The first was delayed, resulting in the second order being fulfilled in 1777, and the former in 1778. Orders followed rapidly; a further one in 1778, three in 1779, five in 1780, one in 1781, nine in 1782, one in 1783, four in 1784, two in 1785, eight in 1786, and four in 1787. A further twelve were commissioned over the next 13 years, that is to the expiry of the patent, making a total of 52 engines in all. An example of the benefits of the new technology is provided with the replacement of seven Newcomen engines installed at Great Consols in Gwennap by five of Watt's design, resulting in savings of £9,097 per annum.<sup>29</sup>

Boulton and Watt did not sell their engines, nor did they manufacture them in their entirety, restricting themselves to design, manufacturing of the smaller components such as the valve gear, and supervision of the engine's erection. Their profit was gained from dues, initially calculated on the basis of the savings in coal when compared to an equivalent Newcomen engine. Boulton and Watt claimed one third of such saving. Rarely was there a directly equivalent Newcomen engine, and the idea of a hypothetical engine was not attractive to the Cornish adventurers, notwithstanding Watt's even handedness in calculating dues (Appendix 1). Watt was forced to revise the method of calculating these dues, such that it ultimately became a fixed annual sum agreed at the time of contract for a new engine.<sup>30</sup>

This revised approach was initially accepted by the adventurers, but as the threat from Anglesey gained in intensity, and the ever-falling ore price forced mines to close or cut back operations, adventurers became more and more disillusioned with the

requirement to pay the ongoing engine royalties. Coupled with the initial cost of purchase, and the perceived increasing obsolescence, adventurers felt encouraged to look to other sources for the supply of new engines. Boulton and Watt, however, were diligent in the protection of their patent rights. Thus, as new engines were designed and installed, by engineers like the Hornblower brothers and Edward Bull, so Boulton and Watt sought protection from the courts, for all these new engines employed the separate condenser. Following on from the erection of the first of the 'pirate' engines by Jonathan Hornblower in 1791 at Tincroft mine, to the end of the century and of Watt's patent, Boulton and Watt pursued these engine builders, and the adventurers who employed them through the courts, not so much to stop their construction, as to secure their dues. In this they achieved a degree of success in limiting the spread of such designs, without any challenge to the validity of their patent rights, a matter they were keen to avoid. Ultimately, this question was brought before the courts, and their rights upheld by a judgement awarded in 1799, just months before the end of the patent award. During this period 30 engines had been built by the pirate engineers.<sup>31</sup>

Boulton and Watt found themselves in a dilemma as the adventurers became more and more disgruntled with the demand for dues. Up to the development of the rotary engine in 1781, they were to a great extent dependent upon the Cornish market. To this end Boulton invested in the mines in which their engines were installed, as well as encouraging other Midland manufacturers, such as Josiah Wedgwood and the iron founder, John Wilkinson, to do likewise.<sup>32</sup> However, following the introduction of the rotary engine in 1783, Boulton and Watt shifted their interest towards other industries where rotary power was in demand.<sup>33</sup> No longer were such industries tied to a water supply to drive waterwheels, the sole source of rotary motion up to the closing decades of the eighteenth century. Boulton was also losing interest in the engine business, following his enthusiasm

for the minting of copper medals, tokens and coins.<sup>34</sup> By the 1790s Boulton had become a consumer of copper, and was no longer seeking to protect the high price of the metal. After 1800 Boulton and Watt secured only one further order in Cornwall, that for a rotary whim, or winding engine.

The great improvement in efficiency of Watt's design over that of the Newcomen engine enabled the Cornish adventurers to meet in part the challenge from the Anglesey mines. But as economic conditions worsened the payment of dues became a substantial burden, particularly for a technology that was approaching obsolescence in the Cornish mines. Unable to install legitimately the improved engines introduced by a new generation of engine designers, and faced with continuous litigation in the closing decade of the eighteenth century from Boulton and Watt, rejection of Watt's engine became universal by the Cornish adventurers. In those final years of the patent, Watt's conservative attitude delayed the introduction of new technology in the unwatering of the copper mines of Cornwall, the largest financial burden faced by the adventurers. Notwithstanding the loss of the Cornish market, the Soho Manufactory went on to build a total of 496 engines during the life time of the partnership.

## PRODUCTIVITY

Between 1760 and 1820 copper ore in economic quantities was found at three locations. First and foremost was the county of Cornwall. Its success, however, was threatened between 1775 and 1790 by the two big opencast Anglesey mines, producers of low cost ore, and to a lesser extent by the Ecton mine in Staffordshire.<sup>35</sup> In this section the productivity achieved in these mines will be examined.

Scrutinizing the events which occurred during the sixty years from 1760, it is clear

that great importance was placed on productivity in the Cornish mines, exemplified by the routine calculation of standard, the hypothetical value of the copper contained in the ore prior to smelting,<sup>36</sup> and yield. Statistics relating to productivity have been published by a number of authorities,<sup>37</sup> yet examination indicates they derive mainly from two sources, William Pryce for the years between 1726 and 1775 (Table 3.1),<sup>38</sup> and Sir William Lemon for the years between 1771 and 1837.<sup>39</sup> This data is not without its limitations. Pryce only provides data for quantity of ore raised, and Lemon fails to disclose his source, although most likely it would have been obtained from the published results of the fortnightly copper sales. It is also assumed that all the output of the Cornish mines was offered at these sales, but there was no reason why a mine should not seek a private sale. It is also regrettable that there are gaps in the data during the most contentious years, the late 1780s and early 90s, in addition to the 1760s. As will be seen from the notes to the tables of Appendix 2 a number of these gaps can be filled from other sources, otherwise interpolation has been resorted to.

Output from the Cornish copper mines rose rapidly in the years from 1760 to 1820, due to improved performance of individual mines, and the opening up of new reserves. In 1760, 15,780 tons of ore (each of 21 cwt, one hundredweight being allowed for wastage) were raised, yielding 1,894 tons of metallic copper.<sup>40</sup> By 1820, output had risen to 91,473 tons of ore, and 7,508 tons of metal, representing an almost six fold increase in ore and a fourfold increase in metal content (Figure 3.1).<sup>41</sup>

The initial increase in the 1760s and early years of the 1770s, was followed by a period of decline in the closing years of the decade, as supply began to exceed demand. Furthermore the Cornish mine owners began to experience the adverse impact of the rapidly increasing productivity of the Anglesey mines, resulting from their low production

costs, associated with what was essentially an open cast operation, and the aggressive marketing methods of the managing partner, Thomas Williams. Output rose during the 1780s with increases in the early years rising by as much as 60 per cent. This was an attempt to maintain income levels through increased production as a means of countering falling receipts. The result was over-production and stockpiles of unwanted ore. The end of the decade witnessed a decline as the Cornish mines came under ever increasing competition from Anglesey. During the years, 1784 to 1792, the CMCo attempted to rescue the industry buying all copper ore raised, having it converted to copper and attempting to market it, but with little success. By the late 1780s, with the output from the Anglesey mines having passed its peak, Williams's need for copper led him to assume responsibility for the disposal of the CMCo's surplus stock. Following the disposal of these embarrassing surpluses the Cornish mine owners entered a prolonged period of expansion. Numerous new mines were opened, as well as the reopening of older ones, closed during the 1780s and 90s. By 1800 Williams had ceased to present any significant threat to Cornish mining, with output from Anglesey reduced to approximately 1,000 tons of copper from an estimated high of 3,000 tons in 1789 (Figure 3.12). Throughout the next 50 years output rose steadily to such an extent that the Cornish copper mines expanded to become the world's major producer of copper ore.

The receipts for the labour of the adventurers also increased significantly during the period (Figure 3.2), notwithstanding the closing decades of the eighteenth century being a period of great economic difficulty. By 1785, the price the adventurers were receiving for a ton of ore fell below £5, with the standard at £71. The low point was 1788, with the standard falling to £58, with the price of ore at approximately £4 per ton. Mines were forced to close, and large numbers of miners and surface workers were laid off. Shortly thereafter the commencement of the decline in the output of the Anglesey mines resulted

in considerable relief in Cornwall. By the end of the century demand from new markets, in part stimulated by the enterprise of Thomas Williams, resulted in demand outstripping supply, and a marked improvement in prices, a situation which was sustained until prices peaked in 1805 when the value of a ton of ore reached £10.99 (Figure 3.2 and App 2, Table 2.6).

Once again the all too common feature of the Cornish industry prevailed, production outstripping demand with the inevitable fall in price with values by 1820 more typical of the eighteenth century than those that had been experienced in the opening decade of the nineteenth century. Comparing the opening and closing decades of the period under discussion, the equivalent average price received by the Cornish mine adventurers for a ton of copper ore was £6.20 in the 1770s with the standard at £75.75. In the decade up to 1820 these values rose to £7.45 and £118.66, an increase of 21 per cent and 57 per cent respectively. Superficially this would appear to represent progress, but it takes no account of rising costs, both material and labour, due to rising prices. In strictly inflationary terms, in 1820 the value of the pound sterling had fallen to 53 per cent of its value in 1760.<sup>42</sup> Thus in 1760 terms the Cornish adventurer was receiving £4.56 for his ton of ore, a loss of £1.64 per ton. It is hard not to draw the conclusion that copper mining in Cornwall was in general a rather unprofitable proposition, and it had to be the speculative nature of the industry which preserved the ongoing commitment of the adventurers.

One aspect of the increase in the output of the mines should not be overlooked, that being the difference of greater than 100 per cent between the increase in ore and the increase in metal, clearly indicating a reduction in the yield (Figure 3.3). The yield for the early years for which data is available, 1770 to 1785, remained exceedingly stable at 12 per cent, the variation being no more than one two hundredth of a percentage point, notwithstanding significant variation in the quantity of copper ore raised from the mine.<sup>43</sup>

This is assumed to be an agreed value, not the actual yield. There may be a number of contributory factors for the decline after 1785. With ever improving skill and technology, the smelting companies of South Wales were able to convert lower grade ores. In periods of boom, the Cornish mine adventurers were encouraged to raise lower grade material, in the sure knowledge it would find a market. Or, with improvements in the drainage of mines, the mines could be explored to ever greater depths, with the upper zone of enriched ores being replaced by the lower yielding primary ores. Whilst there would be a cumulative effect from the three factors, it is impossible to state what proportion each contributed, and it is most likely each varied over the period under discussion, and from mine to mine.

Notwithstanding the ever increasing output of copper ore, the production of tin continued to influence the economy of Cornwall. Up to the middle of the eighteenth century tin was the principal output from the mines, and only as the mines went deeper, and exploration was extended laterally did copper ore replace tin ore as the predominant mineral. By 1770, the quantity of copper ore raised was in excess of that of tin, a feature of the copper industry which was to prevail until the second half of the nineteenth century. Nevertheless, the output of tin continued to make a substantial contribution to the economy of the mining industry and Cornwall as a whole. Figure 3.4 illustrates the contributions of the two metals. Whilst overall the output of copper rose unceasingly, the output from the tin mines remained reasonably constant, averaging close on 3,000 tons of metal per annum. In the period of depression in the last quarter of the eighteenth century, the output from tin mining rose, a likely indication of a shift in emphasis towards working those mines rich in that ore. Similarly the boom in copper output in the early nineteenth century was accompanied by a fall in the output of tin. Thus each industry may well have tended to compensate for the respective good and bad times experienced by the other, a not surprising outcome. This was of benefit to those mines where both ores were present,



but could also possibly result in a redistribution of labour as miners moved from one mine or district to another, although there is no concrete evidence to substantiate this.<sup>44</sup> Figure 3.5 illustrates the difference in price received for the two metals and except for the year 1805, tin always attracted the higher price per ton.<sup>45</sup> However, the greater quantity of ore raised from the copper mines ensured a significantly higher annual revenue received from those mines as the nineteenth century progressed (Figure 3.6), although there was little to separate them until the closing years of the eighteenth century.

Thus at the routine account meetings, the adventurers could determine development on their understanding of the prospective movement in tin and copper prices. Where the mine's output was only one of these two ores, this choice was unavailable. However, some flexibility of operation could be achieved, where adventurers participated in a number of mines, and thus perhaps had some scope for directing labour. The two mining industries were inextricably linked to the point of complementing each other. The mining of both ores was identical, requiring the same consumables: gunpowder, timber, candles, rope, leather, etc. Both required coal, supplied from the coal fields of South Wales, primarily for the working of the steam engines, but additionally in the case of tin, for its smelting.

## PROFITABILITY

Vivian in evidence to the 1799 enquiry presented statistics detailing the performance of the Cornish mines for the six months ending either in January, or in February, 1799.<sup>46</sup> Out of a total of 60 mines, he classified ten as old deep mines, costly to operate, producing in excess of 50 per cent of copper ore raised in the county, and operating at an overall loss. The second group of seven, producing approximately 40 per cent, returned a profit. The remaining 43, whose output was not much over 5 per cent, operated at a loss with only 13

raising any ore. Overall, only 13 mines made a profit in those six months, a performance that does not appear to hold out much prospect of a profit for the adventurers.

The more relevant data were the returns detailing the state of the copper mines for the years 1792 to 1798.<sup>47</sup> The number of mines operating in each of the seven years, ranged from a minimum of 64 mines in 1792 to a maximum of 76 in each of the three years to 1798. A total of 107 mines were named by Vivian, reflecting closures and new ventures. These totals correlate well with those given by Richard Trevithick Snr. in 1777, who in his account books lists 86,<sup>48</sup> and Richard Thomas in 1819, who lists 95.<sup>49</sup> The industry was clearly turbulent, with 33 of the 107 mines in operation for the whole of the seven year period, and of which only 17 were in profit.

Of the 16 mines for which Vivian supplied the names of the adventurers, eight were included in the list of the old deep and well established mines, four were from the group of seven profitable mines, and the remaining four from the group of 43 new losing mines. Of this last group, Wheal Hope and West Wheal Jewell were shown to be in existence from 1792 and could hardly be viewed as recent propositions. The other two were later arrivals, Treskow in 1796 and Penberthy Croft in 1797. Figure 3.7 illustrates the performance of these 16 mines. Only in the final year were all 16 in operation.<sup>50</sup> In the seven years, only in 1792 (ten out of a total of 14) and 1796 (11 out of a total of 15) was there a majority operating profitably.

Figure 3.8 illustrates the financial performance of these mines, and presents an entirely different, and more optimistic picture of the profitability of this group of mines. An overall profit was realised in each of the seven years, albeit marginal in 1793, regardless of the ratio of losing to gaining operations. In no single year was the overall profit less than

£10,000. Over the seven years eight mines returned a profit, with the other eight making a loss. The eight working profitably achieved a total profit for the period of £265,221, against a total loss for the seven years of £50,174. Performance, however, amongst these 16 mines was still very patchy as can be seen in figure 3.9. One mine achieved a profit in all seven years, and that was Wheal Unity. Wheal Jewell remained in profit for six of the seven, no figure being available for 1794. All the others made a loss in one or more years. Wheal Hope reported a loss in every year, as did West Wheal Jewell, except, for 1797 for which no data was supplied. It is also clear from figure 3.8 that the bulk of the profits were contributed by just three mines: Cook's Kitchen (£57,750), Tin Croft (£52,635), and Wheal Unity (£102,206).

In his evidence to the inquiry Vivian identified the adventurers, their share in each mine, and whether they were merchants supplying the mine in which they had an interest.<sup>51</sup> In the report it is stated: "The Witness produces lists of adventurers in the Mines of Cornwall, which, he says, are made of recollection, but believes to be sufficiently accurate:..."<sup>52</sup> Vivian must have had a superb memory for he lists a total of 311 holdings in the 16 mines. Eliminating the duplication resulting from multiple holdings there still remained ambiguity, adjustments still had to be made before a judgement as to the final total could be arrived at. Further reductions were made by assuming for example that J and James Kevill were the same person, or Col Rodd and Francis Rodd were Col. Francis Rodd of Trebartha Hall situated at North Hill. In other cases such assumptions were not possible, as illustrated by the inability to distinguish J Vivian as James, John, Johnson or Joseph Vivian.

As a result of this consolidation a final total of 191 adventurers was arrived at. There was no indication in Vivian's evidence as to the length of time the adventurers had

held their shares. Many could well have held them for at least the period for which data relating to the performance of the mines was available. For 14 of the 16 mines Vivian supplied financial data for these years, suggesting these had been in operation for at least the seven years; the other two commenced sometime during this period. Thirdly, many of the adventurers had been involved in the mining industry for a period significantly longer than the years covered by the data. A number of them were directors of the CMCo, following its foundation in 1784. They were also found on the subscribers' list to John Provis' *Copper Tables*,<sup>53</sup> and as signatories to a pamphlet of the Cornish Miners Committee, dated 23 Aug 1810.<sup>54</sup> It is assumed, therefore that the adventurers named by Vivian had held their investments for at least these seven years, or from the commencement of the two mines which were opened during this period. The holdings reflect the sort of division that may be expected if made at the outset of the venture, ie:  $\frac{1}{16}$ ,  $\frac{1}{24}$ ,  $\frac{1}{64}$ , whilst others were not so obvious. For example, Mr Hole and John Williams each held  $\frac{1}{32}$ nd of the whole, and  $\frac{1}{64}$ th and  $\frac{1}{256}$ th of  $\frac{15}{16}$ ths of the shares in Wheal Gorland. This would suggest the initial fraction was an original commitment, whereas the complex fractional holdings were procured as and when shares became available.

Of the 191 adventurers named, 65 remain unidentified. In a number of other cases, identification was tentative. An examination of the names would suggest that the majority were of Cornish origin. In part this was supported by the small number of out of county adventurers identified including three who were resident in London; two the partners in the Soho Foundry, Matthew Boulton and James Watt; the Birmingham representative of the Birmingham Copper Company; and Lord Arundell of Wardour Castle, Sussex. The remainder represented a very broad cross section of Cornish society:

Bankers	9	Cornish and London
Clergy	13	
Engineers	6	

Landowners	13	
Legal	9	
Merchants	33	
Mine Management	12	2 pursers, 6 agents and 3 captains
Mineral lords	6	
MPs	11	
Peers & knights	7	
Sheriff	4	
Smelter owners	6	3 copper and 3 tin

In addition 11 women were listed as holding shares. It was impossible to determine whether they were investing in their own right, or in partnership with their husbands, or other family members. Some, no doubt, came by their holdings through inheritance.

A number of miscellaneous trades and professions were identified: John Cole, a hatter from Redruth; Collan Harvey of St Day, cooper, draper, grocer, ironmonger and mathematical instrument maker; Robert Hichens, a London stock and insurance broker; J Holman, the Camborne boilermaker and iron founder; Gen. James Macarmick, one time governor of Cape Breton, and subsequently a Truro wine merchant, and finally, William Pearce, a hotelier in Redruth. Of the merchants the best known were probably the Foxes of Falmouth.

The list included a number of well known landowners: Sir Francis Bassett (Lord de Dunstanville) of Tehidy, Sir Christopher Hawkins of Trewinnard and Trewithen, George Hunt of Lanhydrock, Sir William Lemon of Carclew, Sir Michael Noell of Penwarne, Col. Francis Rodd of Trebartha Hall, Sir John St Aubyn of Clowance, Rev. Henry Hawkins Tremayne of Heligan, and James Willyams of Carnarton.

An observation regarding the adventurers was the belief that adventurers spread their investments across a number of mines with the aim of off-setting losses against

profit. Phillips and Darlington wrote:

The radical principal to be observed by a capitalist, when about to invest money in profitable or established mines, is to distribute his means over a considerable number of them; since to adventure in any single concern is with the best advice a matter of considerable risk.<sup>55</sup>

This could not be substantiated, as can be seen in figure 3.10.

Given the individual holdings, it was possible to determine the profit or loss realised by each adventurer for each of the seven years from 1792 for each mine in which he had a share. This was achieved by multiplying the return for each mine in each year by the adventurer's fractional share in that mine. This resulted in 106 adventurers out of a total of 191 sharing a profit of £216,548 over the 7 years. The average gain was £2,043, with Sir William Lemon attaining the highest profit of £26,430.26. Sir William's achievement was due to his good fortune in having a quarter share in the most profitable of all the Cornish mines at this time, Wheal Unity. The remaining 85 shared a loss of £37,317. The average loss was £439.22, with the merchants Messrs Geo C Fox and Sons suffering the greatest loss of £4,142.23. Messrs Fox held shares in seven mines, Consolidated, Herland, North Downs, Tresavean, Wheal Gorland, Wheal Hope and Wheal Jewell. Of these only Consolidated Mines (£126.53), and Wheal Jewell (£1,338.10) achieved a profit during the seven year period. Figure 3.11 illustrates the gains and losses realised by the individual adventurers and it is no surprise that the majority achieved gains or losses of less than £1,000. The greatest gains are indicated below:

<u>Adventurer</u>	<u>Profit</u>	<u>Remarks</u>
Lemon, Bart, Sir William	£26,430.26	Of Carclew. Land and mineral lord. Banker. MP for Cornwall – 1774/80/84/90/96. 1802/06/07/12 and 1818.
Vivian, Rev John	£23,541.58	Of Pencalenick.
Richards, Executors of P	£15,622.66	Adventurer in Dolcoath, Tin Croft mines, etc. Merchant. Partner in Messrs Lubbocks, bankers, London.

Walker, Rev Mr	£9,764.29	Vicar of St. Winnow
Vivian, Executors of Rev T	£8,517.17	–

and losses:

<u>Adventurer</u>	<u>Loss</u>	<u>Remarks</u>
Fox and Sons, Messrs Geo C	£4,142.23	Falmouth merchants & bankers
Birmingham Company	£3,782.55	Birmingham Mining & Copper Co.
Carne, William	£1,778.20	Of Penzance. Merchant, Purser of Relistian Mine. Mine agent & Broker. Partner Cornish Copper Co. Banker.
Oxnam, Richard	£1,497.19	Merchant. Partner in Chyandour Smelter. Penzance banker.
Buller, Mr	£1,303.38	Landowner & Quaker. MP for Cornwall

The commonly held assumption that a proportion of the merchants involved in mining invested for the purpose of securing profits on sales to the mine regardless of that mine's performance is not clearly demonstrated in this analysis, notwithstanding that three of the five largest losers were merchants. Vivian identified a total of 25 merchants who supplied the mines in which they were adventurers. Of these 16 shared a combined profit of £47,598.25, whilst the remainder incurred a loss of £8,245.00. This is remarkably similar to the proportion of profit-takers to the total number of adventurers, as indicated below:

	<u>Profit</u>		<u>Loss</u>		<u>Total</u>
	No.	%	No.	%	
Adventurers	106	55	85	45	191
Merchants	16	64	9	36	25

	<u>Profit</u>		<u>Loss</u>		<u>Total</u>
	Amount	%	Amount	%	
Adventurers	£216,548	85	£37,317	15	£253,865
Merchants	£47,598	85	£8,245	15	£55,843

The figures above suggest that the merchants supplying those mines in which they were

adventurers were not reliant on profits from sales to them overcoming losses made in them. This notwithstanding the poor performance of the Fox's investments and the others in the list of biggest losers. This would suggest that Vivian was correct in his assertion, contradicting that which had been written both at the time and since. From these statistics it is concluded merchants did not rely on sales to the mines in which they were adventurers to cover their losses.<sup>56</sup>

One group who were unlikely to lose as a result of their involvement in the industry were the mineral lords, or the lords of the soil (Table 3.2). Their income was assured as long as the mine was producing and selling ore. As noted earlier, payments made to them by the adventurers were a proportionate part of the gross income regardless of profit or loss. Information linking mine with mineral lord, and output is sketchy at best, particularly direct evidence. One indicator of accruing wealth, however, was the improvements made to property, a feature of many Cornish estates in the seventeenth and eighteenth centuries. The St Aubyn family of Clowance and St Micheal's Mount are a case in point, building a harbour at the Mount for the export of pilchards, copper and tin, and 53 houses around the small harbour between 1700 and 1811. On the death of John St Aubyn in 1836 the auction of his art collection took 17 days to complete.<sup>57</sup> A further example was the Bassett's estate, perhaps the foremost family amongst the mineral lords in the county. In 1734 John Pendarves Bassett commenced rebuilding the family seat at Tehidy. He died five years later at the early age of 25, bequeathing to his widow the sum of £100,000, and leaving the completion of the house to his son, Francis. The bulk of this fortune would almost certainly have derived from mining dues, as the Bassetts owned a large part of the central mining district around Carn Brea, between Camborne and Redruth. As well as completing the house and furnishing it in the highest of style, Francis Bassett developed the harbour of Portreath for the ore and coal traffic between Cornwall and South Wales.



A further instance of how these mineral lords amassed their fortunes was the inclusion in mining leases on Bassett property of the requirement that ore raised from these mines had to be shipped through Portreath. Thus Francis Bassett received double dues from the industry.<sup>58</sup> The Bassetts continued to receive dues through to the twentieth century.

The cost to the adventurers is indicated in the Table 3.2, and illustrating the ease with which a profit could be turned into a loss by the imposition of dues. United Mines, Wheal Treasury and Tresavean posted a loss as a result of the payment of dues. Whilst these were not significant losses it was not exceptional for a mine to cease working as a result of the enforcement of dues.

Profits were there to be made, but those of any significance were restricted to very few mines, and highly variable on a year by year basis. Perhaps it is not inappropriate to conclude with two of the many dictums offered to speculators:<sup>59</sup>

To determine the number of shares you will take in a very promising mine, first consult your wife, then count your children, and lastly, calculate your household expenses.

It is far easier to put tin into a mine, than to get tin out of a mine; and it is more likely that you will lose £100 than gain £10.

The data presented in this section needs to be treated with some caution. Reliance has been placed on the evidence of John Vivian. In litigation there is always cause for suspicion regarding the precision of evidence, but as he states that the data relating to the performance of the mines is taken from the individual company's cost books it is accepted as reliable. On the other hand, the data relating to the adventurers comes with no such pedigree, further aggravated when it is recollected that Vivian recalled the lists from memory.

## THE COPPER MINES OF ANGLESEY

Parys Mountain,<sup>60</sup> the location of the Anglesey mines, is situated in the parish of Amlwch at the north end of the island. In the mid-eighteenth century it was divided into two parcels of some 3,500 acres of poor grazing. The larger, of some 3,000 acres, was owned by Sir Nicholas Bayly of Plas Newydd, with the remainder held by him in partnership with William Lewis of Llys Dulas. There was no recognised boundary between the two properties. Following Lewis' death in 1762, his title to Parys Farm passed via his wife and her sister to Rev Edward Hughes.

With demand for copper rising, and with the discovery of old workings, Bayly engaged his mineral agent, John Cartwright to survey the area. As a result of which, in 1762, Bayly elected to lease the workings for a period of 21 years to Roe and Company, of Macclesfield. Initially the company had little success, and abandonment appeared likely. But like all good mining ventures, a rich discovery was made 'at the last minute'. On 2 March 1768 a large deposit of copper ore was discovered at the pitch known as Golden Venture. Problems arose when it was discovered that the deposit extended into the Parys Farm property. In 1769 Hughes also began to take an interest in mining on his property, and refused Bayly access to his land for the purpose of mining. Bayly took the matter to court, resulting in seven years of litigation, during which Hughes was represented by a local lawyer, Thomas Williams (1737 – 1802). In this Hughes met with some success, further encouraging his interest in mining. In due course Williams became his partner, and manager of the Parys Mine Co.

In 1785, Henry Paget, the Earl of Uxbridge succeeded to the Plas Newydd estates, and invited Williams to enter into partnership as the manager of a new Mona Mine Company, resulting in Williams gaining control of both mines. From this base he went on to develop a network of integrated companies, achieving control of all the manufacturing processes from mining to the marketing of finished copper. By the 1780s, Williams controlled, in addition to the Anglesey mines, smelters in Lancashire and South Wales, copper and brass manufactories in Flintshire and the Thames Valley, warehouses and sales offices in London, Liverpool and Birmingham, chemical works in Liverpool, and banking facilities in Chester, Bangor and Caernarfon.<sup>61</sup> Little wonder he was able to gain total control of the copper industry in the late 1780s and early 1790s.

In the period of their greatest prosperity between 1775 and 1800 the Parys Mountain mines were worked by opencast methods, resulting in the extensive excavation known as the Great Opencast (Plates IV and V). Mining in the accepted sense did not commence until the nineteenth century, by which time the vast bulk of the ore deposit had been worked out. The ore was of low yield, about six per cent copper content, but was so freely available and cheaply worked as to make extraction and conversion highly cost-effective.

As a result of the highly integrated structure of William's business, he was able to sell copper direct, and had no need to resort to the public sale of ore. This has resulted in a dearth of data regarding his operations, and rendered satisfactory analysis of the impact of the productivity of the Anglesey mines on the Cornish industry very difficult. Until a comprehensive record of the output from the two Anglesey mines can be located, it is only possible to fall back on the few sources that have been published. Hamilton suggests that output had fallen '...from 3,000 tons in 1784 to about half that quantity in 1796', whilst



*Open working at Parys mine, Julia Cesar Ibbetson, 1785*



*One of the copper mines at Parys mountain, John Warwick Smith, 1790*



*Open working at Parys mine, 'The Great Opencast'.*  
The author, 2002

Hunt places the output at 1,900 tons in 1799. Jones tabulates data for the Mona Mine only, with output of 452 tons in 1800, down from 809 tons in 1797. Assuming Parys Mountain made a similar contribution then 1,000 tons in 1800 is not unreasonable. These figures provide a far from complete picture of the performance of the two mines. An attempt to overcome this shortcoming was made by interpolating the data that was available, as illustrated in Figure 3.12. It broadly agrees with expectations, rising rapidly to peak in the late 1780s. Thereafter decline sets in as the readily accessible deposits were exhausted. The estimate in the decade 1810 to 1820 is probably more representative than the initial decline after 1790. The literature suggests this fall should be much sharper, perhaps falling to approximately 1,000 tons by 1800 and flattening out at under 500 tons by 1820.<sup>62</sup> Nevertheless the peak years, the years in which Cornish adventurers faced their greatest problems from these mines, the vertical integration of Thomas Williams' enterprises, and his monopoly of the trade in copper, are considered representative of the

productivity of the Anglesey mines.

To summarise this section the total copper output from the two counties (Figure 3.13) was estimated. The initial impact of the rapidly rising output from the Anglesey mines was to cause a sharp fall in Cornish output. Cornish output remained depressed until 1782. The recovery was quite sharp up to 1786. For the next seven years little data were available, and the output for these years is estimated. From 1795 the trend in output was again generally registering an increase. The combined output of the two counties rose sharply in the early years, but fell off slightly after 1790 due to the decline in the output from Anglesey. This was compensated by the rise in the output from Cornwall, accelerating as more mines were brought back into production. In Anglesey output continued to decline, until it reached the bottom of its slide in 1820. Following a peak combined output in excess of 8,500 tons in 1813, output falls for the five years to 1820 to an average of 7,500 tons approximately, resulting from a marked reduction in demand following the conclusion of the Napoleonic War. As to other sources, gross estimate of the output from Ecton<sup>63</sup> combined with the imports from Ireland<sup>64</sup> would probably add something in the order of 200 tons per annum in the closing years of the eighteenth century.

## CONCLUSION

This chapter has provided a broad overview of the operation and productivity of the copper mining industry for the years 1760 to 1820. The speculative nature of the industry was recognised in the examination of the profit and loss incurred in the Cornish mines, and the impact on this performance of the dues levied by the mineral lords and Boulton and Watt, whose methods in calculating engine dues were scrutinized. No evidence could be found to substantiate the widely held belief that mines were operated for the benefit of

those merchants who were both adventurers and suppliers. The difficulties faced by the Cornish adventurers were examined following the opening of the Anglesey mines, with the latter's ability to bring to market significant quantities of copper at much lower prices.

The 20 years from 1775 clearly imposed considerable strain on the mining industry in Cornwall, to the point where many mines could not compete. Nevertheless, from 1790 onwards Cornwall benefited from both the decline in output from the Anglesey mines and the new markets generated by Williams. By 1820 the output of copper ore from the Cornish mines had risen such that copper produced had increased by over 350 per cent from approximately 2,000 tons from 16,500 tons of ore in 1760 to in excess of 7,500 tons from 91,500 tons of ore by 1820. The process of conversion, the function of the smelters, will be examined in the next chapter.

Table 3.1.(1). An Account of all Copper Ores sold in Cornwall the last fifty Years; their Tonnage, Amount, Price and Value

<u>Date</u>	<u>Ten Years Tonnage</u>	<u>ditto Average Price per Ton</u>	<u>Amount</u>	<u>Average Annual Tonnage</u>	<u>Average Annual Amount</u>
1726 – 35	64,800	£7 – 15 – 10	£473,500	6,480	£47,350
1736 – 45	75,520	£7 – 8 – 6	£560,106	7,552	£56,010
1746 – 55	98,790	£7 – 8 – 0	£731,457	9,879	£73,145
1756 – 65	169,699	£7 – 6 – 6	£1,243,045	16,970	£124,304
1766 – 75	264,273	£6 – 14 – 6	£1,778,337	26,427	£177,833

Table 3.1.(2)

<u>Date</u>	<u>Annual Tonnage</u>	<u>Date</u>	<u>Annual Tonnage</u>	<u>Date</u>	<u>Annual Tonnage</u>
1726	5,000 Tons	1743	7,040 Tons	1760	15,780 Tons
27	6,700	44	7,230	61	17,004
28	6,800	45	6,700	62	16,054
29	6,870	46	7,000	63	17,898
30	6,900	47	4,900	64	21,489
31	7,000	48	6,000	65	16,774
32	7,290	49	7,200	66	21,251
33	7,000	50	9,400	67	18,502
34	6,000	51	11,000	68	23,671
35	5,240	52	12,050	69	26,655
36	8,000	53	13,000	70	30,776
37	9,000	54	14,000	71	27,896
38	10,000	55	14,240	72	27,654
39	11,000	56	16,000	73	27,765
40	5,000	57	17,000	74	30,253
41	5,500	58	15,000	75	29,950
42	6,050	59	16,700		

(Pryce, W. (1777), xv)



Table 3.2. Accounts for the Six Months to end of December, 1799

<u>Mine</u>	Income from		Dues		<u>Profit</u>	<u>Loss</u>
	<u>Ore Sales</u>	<u>Fraction</u>	<u>Amount</u>			
North Downs	£ 25,689	1/18	£ 1,427	—	—	£ 1,353
United Mines	£ 26,184	1/30	£ 873	—	—	£ 360
Herland	£ 15,342	1/18	£ 852	£ 556	—	—
Crenver & Oatfield	£ 9,547	1/12	£ 796	—	—	£ 2,912
Wheal Jewell	£ 8,789	1/10	£ 879	£ 745	—	—
Wheal Treasury	£ 7,626	1/9	£ 847	—	—	£ 47
Consolidated	£ 19,718	1/24	£ 822	£ 3,237	—	—
Tresavean	£ 5,157	1/13	£ 397	—	—	£ 27
Wheal Gorland	£ 2,870	1/15	£ 344	—	—	£ 981
Wheal Godolphin	£ 2,609	1/8	£ 359	—	—	£ 990
Stray Park & W Gons	£ 5,339	1/10	£ 261	—	—	£ 2,613

(NLW, Vivian, E61)

Fig 3.1: Output from the Cornish Copper Mines

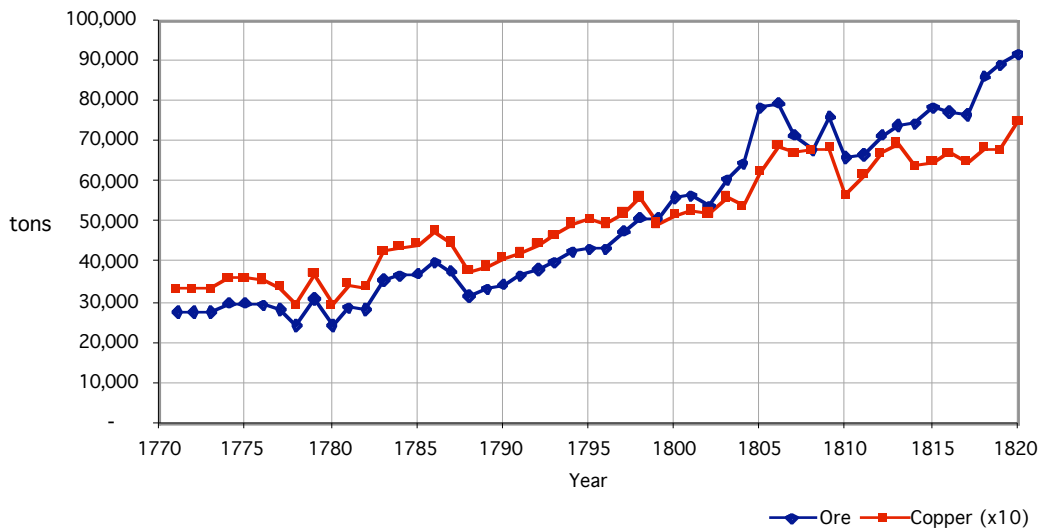


Fig 3.2: Copper Output: Standard & Market Price

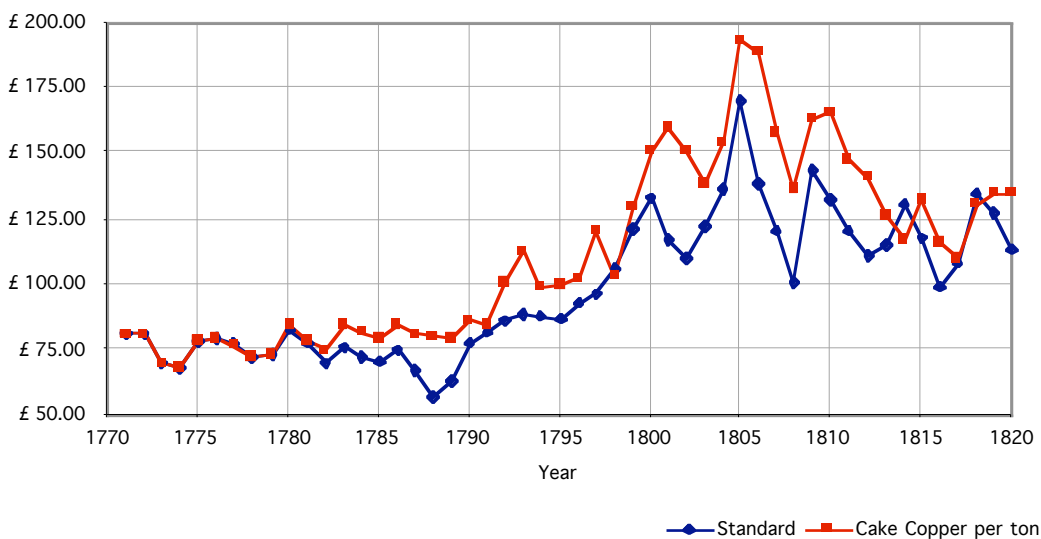


Fig 3.3: Yield

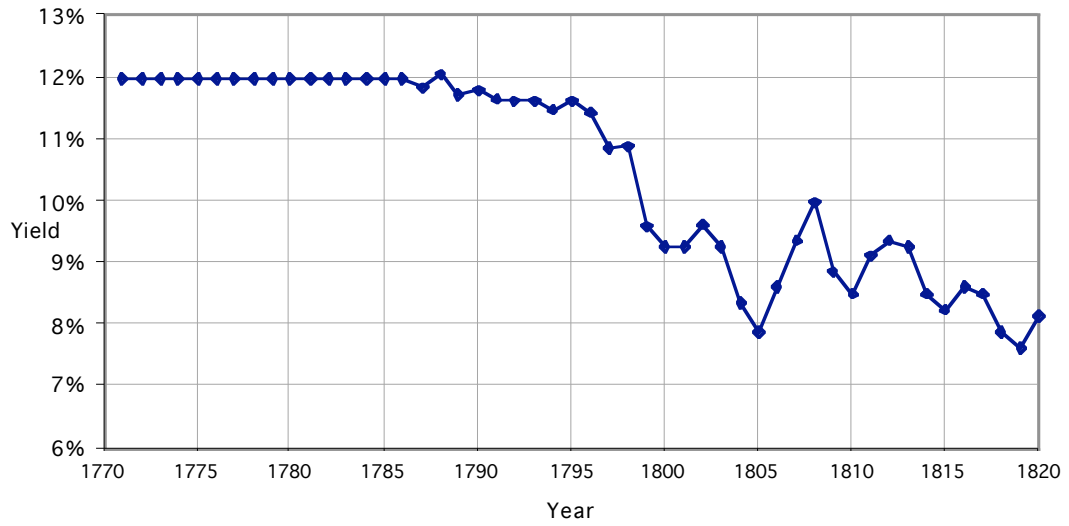


Fig 3.4: Output – Copper & Tin

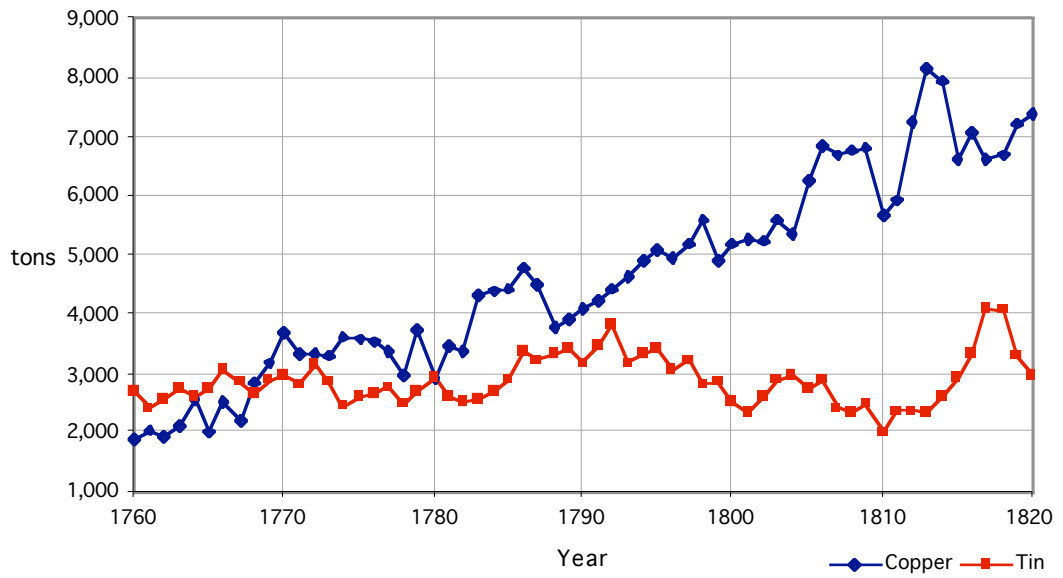


Figure 3.5: Cornish Mines – Prices Realised for Copper and Tin .

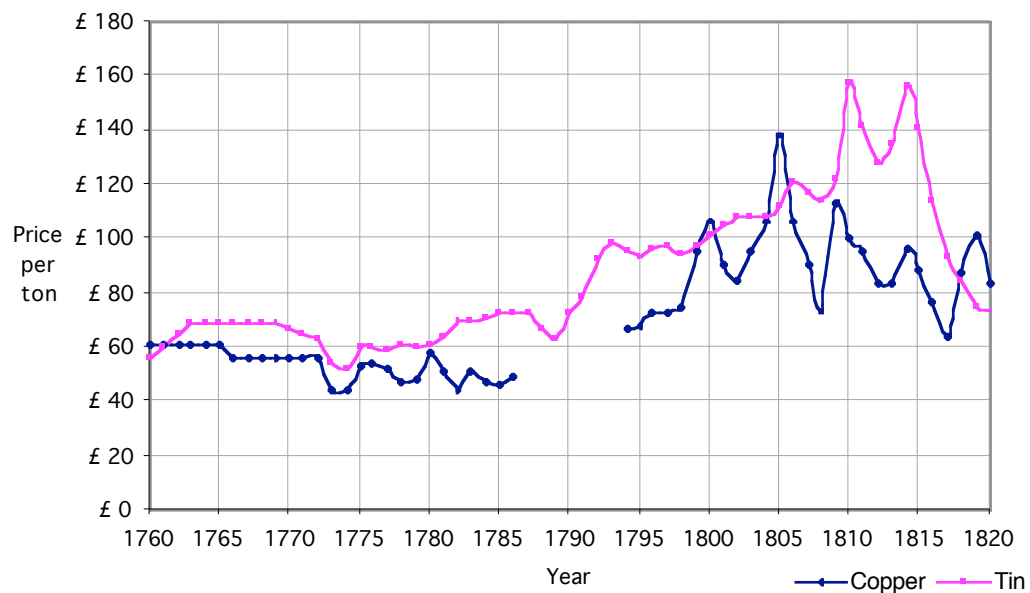


Figure 3.6: Cornish Mines - Total Receipts for Copper and Tin .

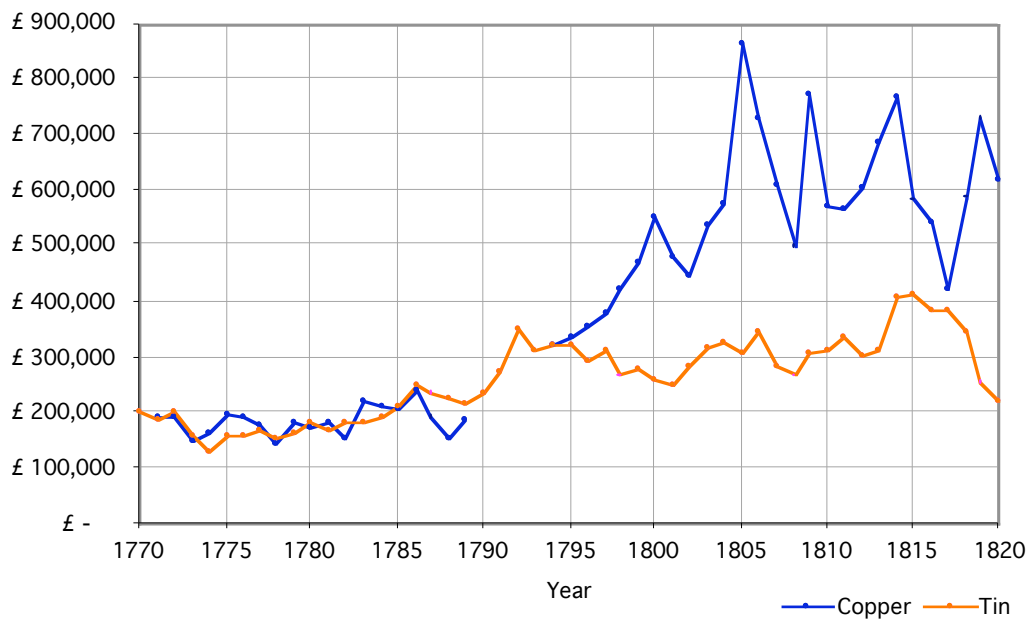


Fig 3.7: Performance where Identity of Adventurers known

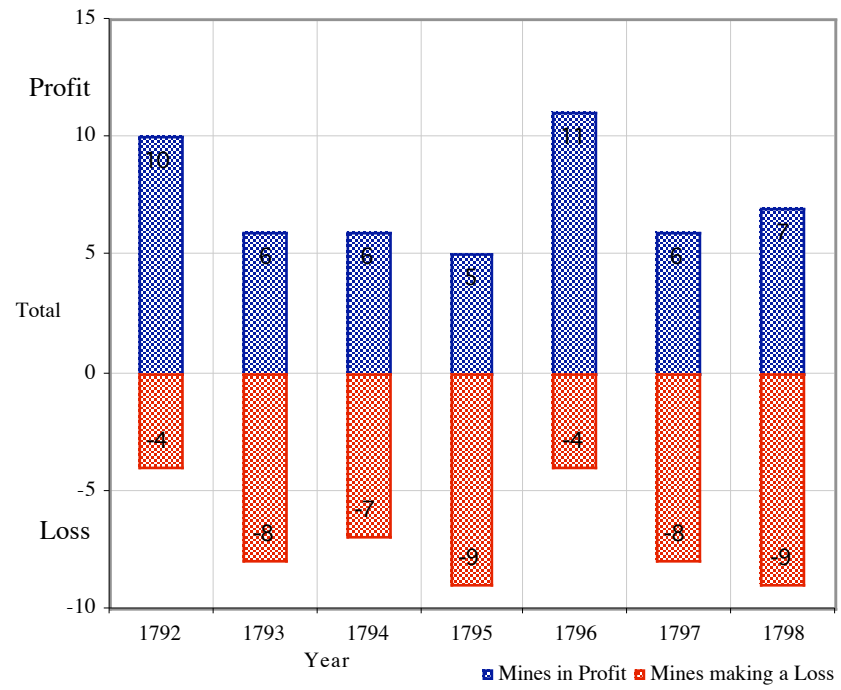


Fig 3.8: Performance where Identity of Adventurers known

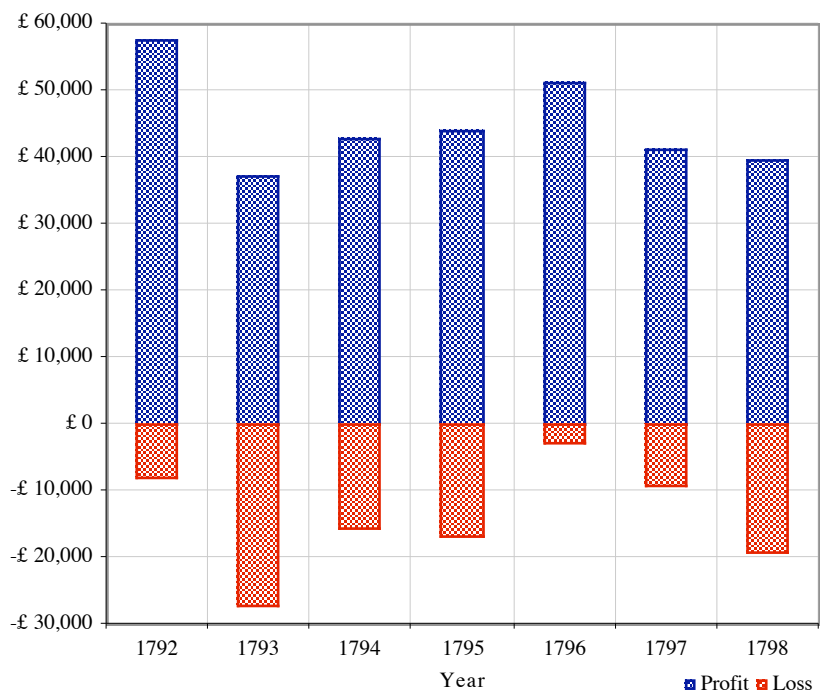


Fig. 3.9: Profit and Loss in those Mines where the Adventurers are Known

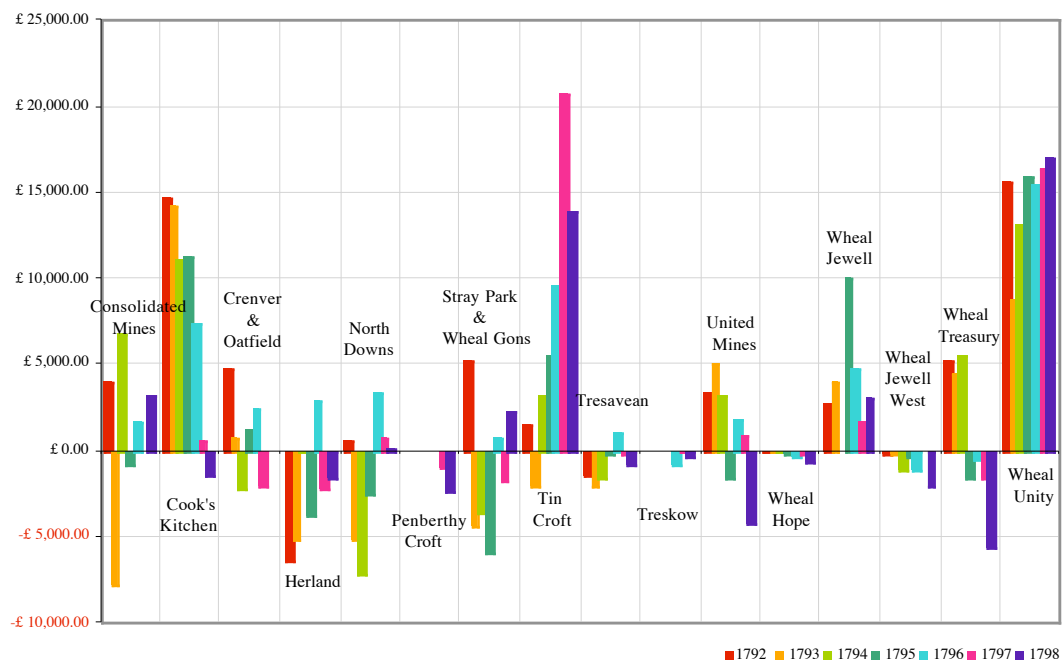


Fig. 3.10: Adventurers' Holding – 1792 to 1798

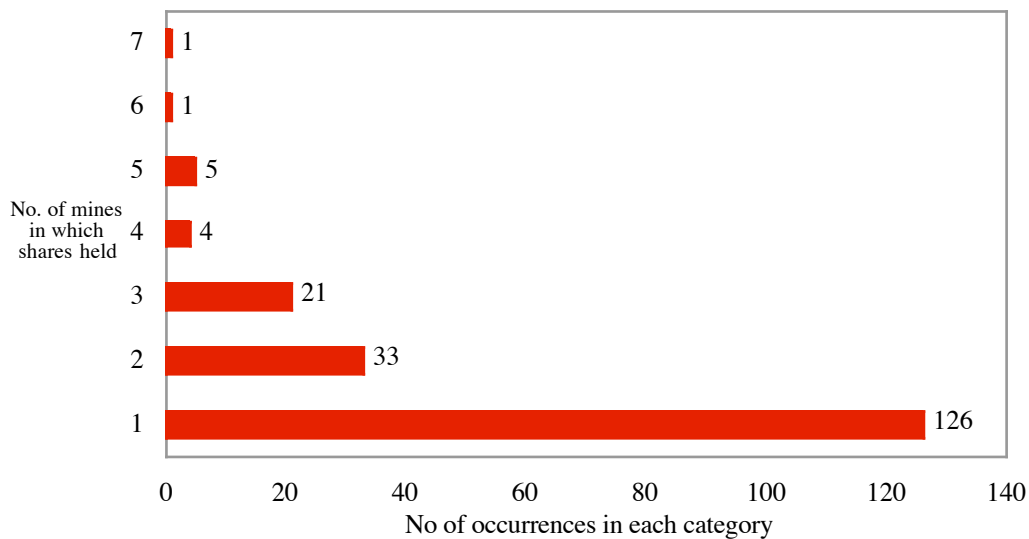


Fig 3.11: Profit and Loss – 1792 to 1798

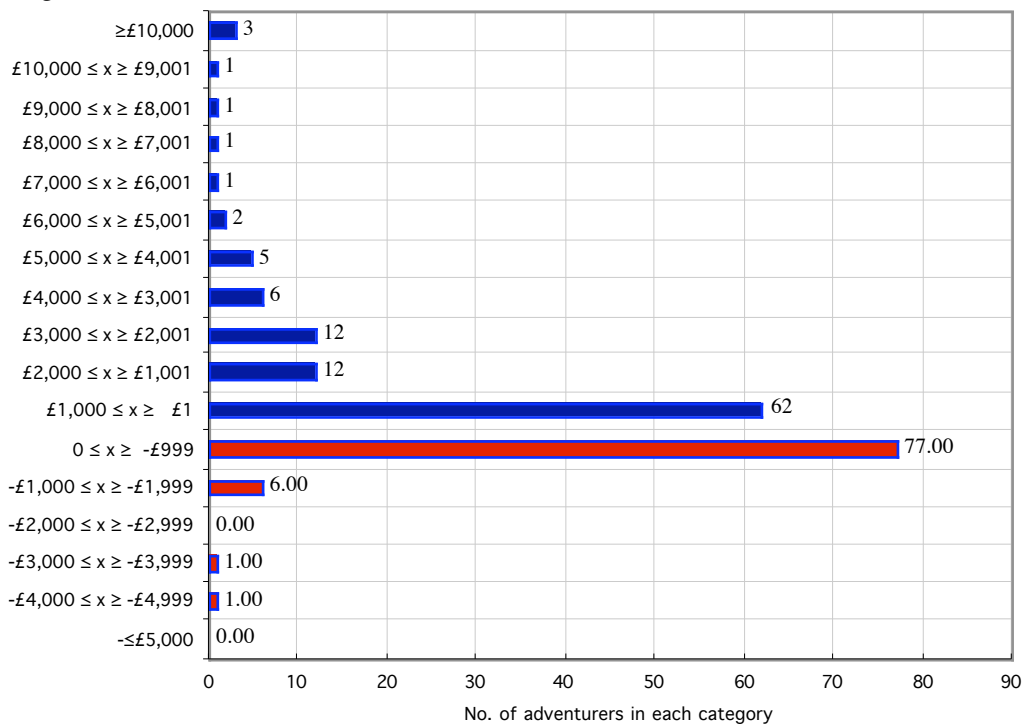


Figure 3.12: Combined output of the Mona and Parys Mountain Mines

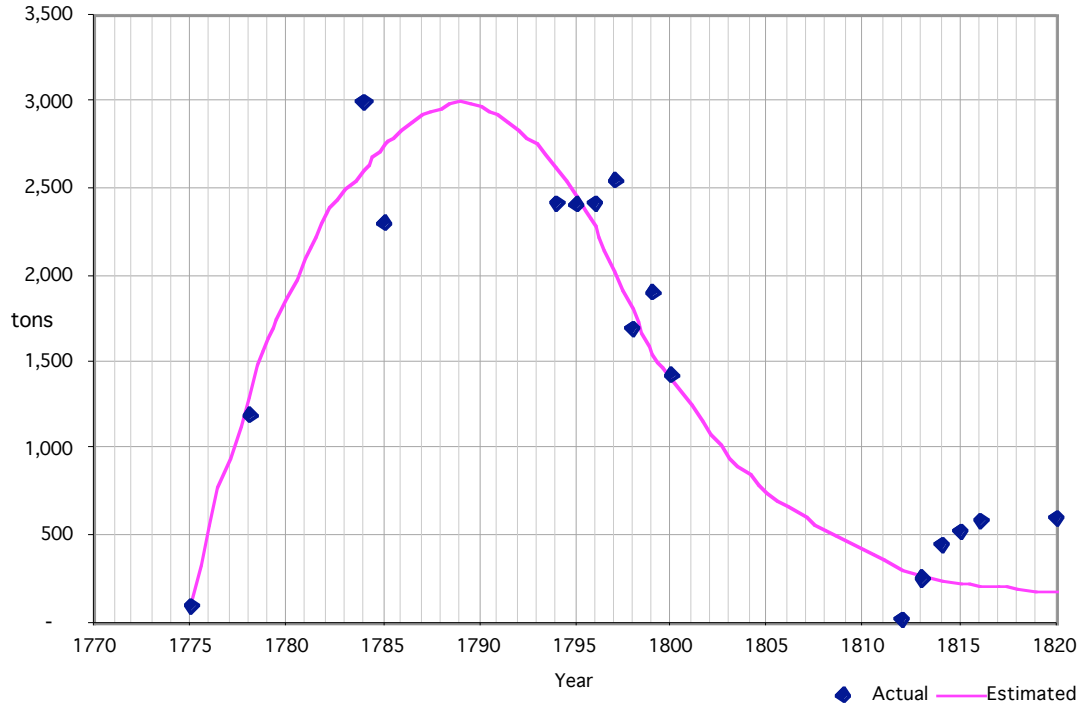
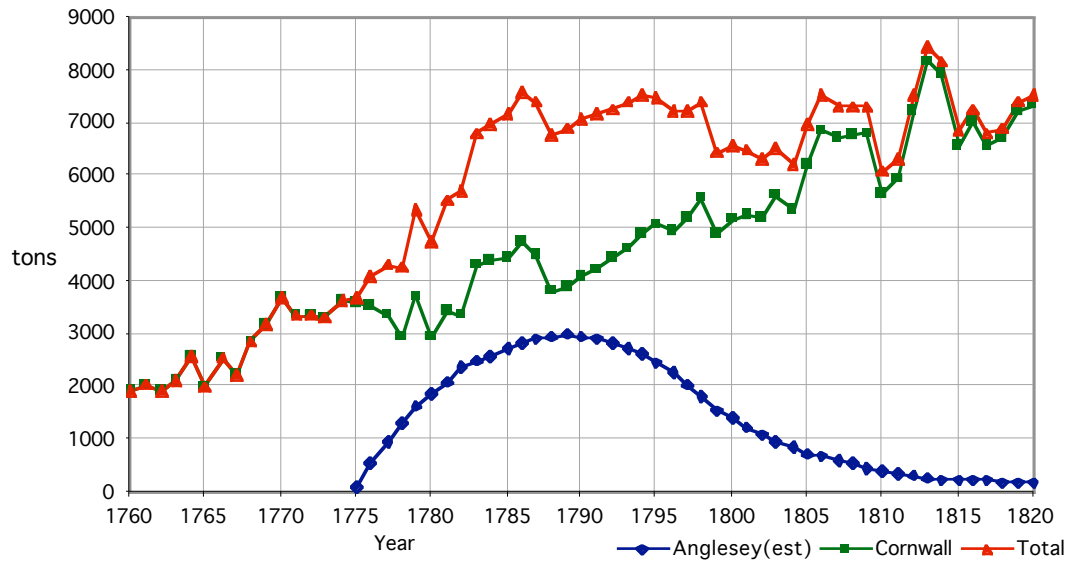




Fig 3.13: Total Output of Copper – Cornwall & Anglesey



## NOTES

- <sup>1</sup> This was not contemporary with the main text, written most likely in the early seventeenth century. Norden, J. *Speculi Britannie Pars: A Topographical and Historical Description of Cornwall*, (London; 1728).
- <sup>2</sup> Carew, R. *The Survey of Cornwall*, 3rd ed, (London; 1769), 6.
- <sup>3</sup> This amount of ore would probably yield 5 to 6 tons of copper. Otes to Carnsew, (October 1586). PRO SP/12/155/39 and in Donald, M B. (1989), 348. Carnsew's correspondence also contains the first references to the shipment of copper ore from Cornish port of St Ives to Neath, South Wales, where a smelter had been established a year earlier.
- <sup>4</sup> Fiennes, C. *Through England on a Side Saddle*, (1695). reprinted in Pearse Choep R (ed.), *Early Tours in Devon and Cornwall*, (David & Charles, Newton Abbott; 1967), 127.
- <sup>5</sup> Brooke, J, (trans), *The Kalmeter Journal 1724 – 1725*, (Twelvehead Press, Truro; 2001). Berg, T and P, (trans), *R R Angerstein's Illustrated Travels 1753 – 1755*, ( Science Museum, London; 2001). Borlase, W. (1758). Pryce, W, (1778).
- <sup>6</sup> Borlase, W. (1758), 206.
- <sup>7</sup> respectively the lord of the soil or the mineral lord, and the adventurers.
- <sup>8</sup> Sett A lease defining the boundaries of the area in which the adventurers may explore for mineral deposits, combined with the terms under which they may do so.
- <sup>9</sup> Burt, R (ed.), *Cornish Mining – Essays on the Organisation of Cornish Mines and the Cornish Mining Economy*, (Augustus M Kelly, New York; 1969). 17 – 18. Pryce, W. (1778), 137 – 41.
- <sup>10</sup> Mining Journal, 5 Sep 1846, 386. Burt, R., 'The Adaptability of the Cornish Cost Book System', *Business History*, vol 25, no. 1, (1983), 30.
- <sup>11</sup> Burt, R (ed), (1969), 18 – 19. Phillips, J.A and Darlington, J. *Records of Mining and Metallurgy*, (E & F N Spon, London; 1857, Reprinted in facsimile by Mining Facsimiles, Worksop; nd), 221 – 234.
- <sup>12</sup> Tann, J. (ed), (1981), 16.
- <sup>13</sup> 1799 Report, apps 25–31.
- <sup>14</sup> Purser: the mine's principal administrator.
- <sup>15</sup> For detail of the duties of captains see Burt, R. (ed), (1981), 18 – 19.
- <sup>16</sup> Earl, B., *Cornish Mining*, (D Bradford Barton, Truro; 1968), 11. For a specific example, see Barton, D.B., *Essays in Cornish Mining History*, vol. 1, (D Bradford Barton, Truro; 1968), 117.
- <sup>17</sup> Burt, R. (ed), (1981), 20 – 25, and 133 – 152. Liefchild, J R. *Cornwall: Its Mines and Miners*, (Longman, Brown, Green and Longmans, London; 1855), 143 – 148. Pryce, W. (1778), 188 – 194. Rowe, J. (1953), 26 – 28.
- <sup>18</sup> Pryce, W. (1778), 328.
- <sup>19</sup> Miners on each shift were know as a core.
- <sup>20</sup> The following is a typical example of a tribute contract awarded at the Briggan mine on 8 June, 1793:  
A Pitch from Nancarrow's shaft so far east as to join Amos Nicholl's Pitch from the 55 fathom level as deep as the 61 fathom level.  
2 men Thos. Cocking (Taker) till August Sampling, 13s 4d.  
Jenkin, A K H. (1927), 136.
- A tutwork bargain would be similar, except the payment would be per fathom rather than so much in the pound sterling.
- <sup>21</sup> Subsist: the monetary advance made to the miners prior to settlement day.

<sup>22</sup> Doctor: payments made to the adventurers for the provision of medical services in the event of accident, but may also include some payment usually one off, to a widow in the event of a miner's death. Amounts were entirely dependent on the wealth of the mine.

<sup>23</sup> Lean, T. *On the Steam Engines in Cornwall*, (First published 1839. Reprinted by D Bradford Barton, Truro; 1969), 28 – 29. Coal is assumed to have cost 17/- a ton approximately.

<sup>24</sup> Watt moved to Birmingham in May, 1774. Dickinson, H W. and Jenkins, R. *James Watt and the Steam Engine*, (First published 1927, reprinted by Encore Editions, London; 1981), 41. Smiles, S. (1874), 145.

<sup>25</sup> toymaker: a manufacturer of small metal objects such as seals, snuffboxes, buckles, buttons and corkscrews.

<sup>26</sup> Smiles, S. *Lives of the Engineers. The Steam Engine, Boulton and Watt*. (John Murray, London; 1874), 113 – 129

<sup>27</sup> Dickinson, H W. and Jenkins, R. (1981), 111. Smiles, S. (1874), 161.

<sup>28</sup> 'The duty seems to have been initiated in 1698 by Act of Parliament (9 & 10 William III) ... imposed a duty on coal carried by sea from any English or Welsh port and landed at any other place in England or Wales.' Howard, B. 'The Duty on Coal 1698 – 1831', *Journal of the Trevithick Society*, vol 26, (1999), 30– 35.

<sup>29</sup> Barton, D B. (1965), 22 – 23.

<sup>30</sup> Rowe, J. (1953), 79 – 82. Tann, J. (ed). *The Selected Papers of Boulton and Watt*, (MIT, Cambridge, Massachusetts, USA; 1981), 15, 277 – 286.

<sup>31</sup> Dickinson, H W. and Jenkins, R. (1981), 298 – 327. Barton, D B. (1965), 23 –27.

<sup>32</sup> Hamilton, H. (1967), 167 – 68. Smiles, S. (1874), 214.

<sup>33</sup> The first rotary engine was erected for John Wilkinson at Bradley in March 1783. Dickinson, H W. and Jenkins, R. (1981), 159. Barton, D B. (1965), 26.

<sup>34</sup> Smiles, S. (1784), 292 – 309.

<sup>35</sup> Copper ore was found elsewhere in England and Wales. In the middle of the eighteenth century Charles Roe explored deposits in Cheshire at Alderley Edge, but abandoned the site following the discovery of copper ore on Parys Mountain. Small amounts were raised elsewhere, in the North Pennines at Alston Moor and in Mid- and North Wales. Devon, particularly the southern boundary of Dartmoor became particularly productive in the second half of the nineteenth century. Bick, D. *The Old Metal Mines of Mid-Wales*, (published in 6 parts by The Pound House, Newent, Glos; 1974 – 1991). Dodd, A H. *The Industrial Revolution of North Wales*, (University Of Wales Press; 1933). Jenkin, A K H. *Mines of Devon*, vol 1, (David and Charles, Newton Abbot; 1974). Jenkin, A K H. *Mines of Devon*, vol 2, (Devon Library services, Exeter; 1981). Hunt, R. (1887). Metcalfe, J E. *British Mining Fields*, (Institute of Mining and Metallurgy, London; 1969).

<sup>36</sup> A detailed treatment of the standard is included in Chapter 5.

<sup>37</sup> de la Beche, H. (1839), 606. Hunt, R. (1887), 892. Rowe, J. (1953), 331. Mitchell, B R, (1962), Table 2. Pryce, W. (1778).

<sup>38</sup> Pryce, W. (1778), xv. Pryce listed output of ore only, and a constant yield of 12 per cent was assumed to calculate the metal content, the same yield assumed by Lemon for the years from 1771 to 1785.

<sup>39</sup> Lemon, Sir Charles. 'The Statistics of the Copper Mines of Cornwall', *The Journal of the Statistical Society of London*, volume 1, (1838), 65 – 84. Data for the years 1787 to 1797 is missing. Wherever deemed feasible the gaps have been filled by linear interpolation. Sir Charles Lemon was born in London on 30 Sep 1784 and died in Cornwall 12 Feb 1868. He was MP for Penryn, and West Cornwall. Fellow of the Royal Society and President of the Royal Statistical Society, 1836 – 38. Also a mine adventurer, mineral lord, landowner and banker, Jenkin, A K H. *Mines and Miners of Cornwall*, vols. vii, 59; viii, 60; ix, 25 and xiii, 44. Boase, G C and Courtney, W P, *Bibliotheca Cornubiensis*, vol. 1, (Longmans, Green, Reader and Dyer, London; 1874), 314 –5. Elvins, B, 'The Lemon Family Interest in Cornish Politics', *Cornish Studies*, vol. 7, (1999), 49 – 73. The table reproduced in Burt, R (ed.), (1969).

<sup>40</sup> Pryce, W. (1778), xv.

- <sup>41</sup> The data from which this figure, and those that follow, are plotted is contained in Appendix 2.
- <sup>42</sup> *Inflation: The Value of the Pound*, Research Paper 99/20, House of Commons Library, 23 Feb 1999. *How Much is Money worth Today*, Economic History Services, EHNet, University of Miami, <www.eh.net>,[7 Jul 2001].
- <sup>43</sup> This will be examined in Chapter 5.
- <sup>44</sup> Lewis, G R. *The Stannaries: A Study of the English Tin Miner*, (Archibald Constable & Co Ltd, London; 1908), 252 – 58.
- <sup>45</sup> Hunt, R. (1887), 887 – 88
- <sup>46</sup> 1799 Report, App 6.
- <sup>47</sup> 1799 Report, Apps 17 – 24
- <sup>48</sup> Titley, A. 'Cornish Mining – Account Books of Richard Trevithick, Snr', *TNS*, (1930–31), 26 – 41.
- <sup>49</sup> Thomas, R.(1819)
- <sup>50</sup> The 16 mines were: Consolidated Mines, Cook's Kitchen, Crenver & Oatfield, Herland, North Downs, Penberthy Croft, Stray Park & Wheal Gons, Tin Croft, Tresavean, Treskow, United Mines, Wheal Hope, Wheal Jewell, Wheal Jewell West, Wheal Treasury and Wheal Unity.
- <sup>51</sup> 1799 Report, Apps 25 – 31.
- <sup>52</sup> 1799 Report, 664.
- <sup>53</sup> Provis, J. *Tables of the most useful kind, to facilitate business in the copper trade,...*, (Truro; 1801), prelims not paginated.
- <sup>54</sup> NLW Vivian E66.
- <sup>55</sup> Phillips, J A and Darlington, J.(1857), 199. See also Rowe, J.(1953), 65
- <sup>56</sup> Jenkin, A K J. *The Cornish Miner*, (George Allen & Unwin Ltd, London; 1927), 132. Pryce, W. (1778), 174.
- <sup>57</sup> Gill, C. *Great Cornish Families*, (Cornwall Books, Tiverton; 1995), 76 – 81.
- <sup>58</sup> Gill, C. (1995), 7 – 10.
- <sup>59</sup> Leifchild, J R. (1855), 262.
- <sup>60</sup> Much of the material in this section has been drawn from Dodd, A H. (1933), Harris, J R. (1964), and Rowlands, J. (1966).
- <sup>61</sup> Harris, J R. (1964), 140.
- <sup>62</sup> Hamilton, H, (1967), 180 and 209. Hunt, R, (1887), 448 and 896 – 897. Jones, H, *Accounting, Costing and Cost Estimation*, (University of Wales Press, Cardiff; 1985), 171. Rowlands, J, (1966), 55 – 59.
- <sup>63</sup> Robey, J A and Porter, L. *The Copper & Lead Mines of Ecton Hill, Staffordshire*. (Moorland Publishing, Leek, Staffs; 1972), 75 – 79.
- <sup>64</sup> 1799 Report, App 37.