

Mineral Statistics of the U.K.

Cornish Mineral Production

Cornwall was the most important metal mining county in the United Kingdom. It probably had the longest history of continuous production and a total value of output that dwarfed its nearest rivals. Together with associated districts just to the east of the Tamar, it produced nearly all of the country's tin and arsenic and most of its copper. Lead and silver deposits, which dominated the non-ferrous mining of the Pennines and Wales, were less plentiful but the county briefly claimed the country's largest single lead mine -- East Wheal Rose -- in the mid-1840s. Cornwall produced a wider range of minerals than any other district (it was the only source of some of the rarest minerals) and was the only one to see large-scale mining continuing down to recent times. The only important mineral that the county did not possess in commercial quantities was coal. Although this prevented it from maximising the benefits of its mineral wealth by developing processing and manufacturing industries, the county nevertheless became a leader in the early stages of British industrialisation. During the eighteenth and early nineteenth centuries Cornwall pioneered deep mining and steam pumping technology and its miners and managers were eagerly welcomed in mining districts throughout the world.

The position of Cornwall within the British non-ferrous mining industry in the late nineteenth and early twentieth centuries is shown in Table 1. Estimates of the average annual value of output of the principal non-ferrous ores and associated minerals by decade 1850-1909 suggest that the county was responsible for around half of U.K. production for most of that period. From around 53 per cent of national output in the 1850s, Cornwall's contribution dropped slightly to just over 40 per cent during the third quarter of the century as a rapid decline in its copper and lead output failed to be compensated by rising sales of tin. Thereafter, an increasing concentration on tin and arsenic production began to restore its earlier position. The markets for those metals held up better than for lead/silver, on which most other districts were primarily dependent, and by the beginning of the new century Cornwall was again producing more than half of the country's non-ferrous minerals. In 1900 tin revenues accounted for over 90 per cent of the county's income from metal mining, which was a marked reversal of the situation at the mid-century when copper was dominant and tin accounted for just over a third of the total. The *copper* county had become a *tin* county as mines responded to changing market conditions and exploited new tin deposits encountered at depth in old copper mines. The common progression from copper to tin at depth in the mineralisation of large parts of Cornwall and its commercial demonstration in the mid-nineteenth century, was the critical factor in the survival of Cornish mining during the next hundred years. Lead/silver output was of no real significance in the county after the third quarter of the nineteenth century and zinc, barytes, and fluorspar production, which had provided a brief salvation for lead mining districts in other parts of the U.K., never became of any real importance in Cornwall. Table 1 also clearly shows the very dominant position of Cornwall within the south

western mining region as a whole. Somerset had ceased to be a major producer of non-ferrous ores by the end of the eighteenth century and although Devon still counted many important mines -- including Devon Great Consols, for sometime the largest copper producer in the world -- Cornwall contributed around 87 per cent of the region's total estimated value of output during the third quarter of the nineteenth century. By the 1900s this had increased to over 96 per cent. In quantitative terms, the story of the south west from the mid-nineteenth century is synonymous with the story of Cornwall. It is worth noticing, however, that the considerable additional output from Devon mines during the 1850s increased the region's overall value of output to almost two thirds of the national total, asserting its leading role in the industry even more convincingly.

From the published annual returns, it would appear that there were over fifteen hundred separate mining ventures producing ore of various types in Cornwall between 1845 and 1913. It is important to stress, however, that this does not necessarily mean that there were a similar number of mining sites. Many of the separate commercial ventures worked the same ground over again, as independent mines and as consolidated holdings with other areas of mineralised ground. Mining sets were constantly being given up and re-let. They were redefined, divided and amalgamated. A simple count of mine names or mining companies does not give a reliable figure of separate 'holes in the ground' or areas of independent working. A glance at a geological map of Cornwall shows large areas of intensively mineralised ground, complex vein systems and other deposits, which have been variously worked by different companies, in different combinations, at different times. In general, the changes and improvements in mining techniques which took place during the eighteenth and nineteenth centuries favoured activity on an increasingly large-scale. The multitudinous small and shallow workings of groups of independent miners which had still been very important in the early eighteenth century -- each partnership working just one part of one lode -- gave way to larger, deeper enterprises, organised by groups of capitalists from inside and outside of the region, to work several vein systems in combination. Increasing returns to scale at many sites, offered by improved pumping, mining and dressing machinery, encouraged further combinations of capital and enterprise in the late nineteenth century, so that whole areas of mineralised ground were worked as a single operation. At the same time, some "exhausted" sections of large workings were sold off and reverted to small independent ventures which might still scrape a living, conduct further exploration, and possibly discover new deposits. Together with other new prospects and discoveries, this had the effect of keeping up the total number of ventures in operation.

In the twentieth century the process of amalgamation has continued unabated, though the smaller marginal ventures have become less common. The history of South Crofty mine, which still operates between Camborne and Redruth, clearly illustrates the continuous process of consolidation and growing scale of operations. Today's mine is a very different enterprise from that which started operations under that name in 1854. It now works an area of ground many times larger than its original leases and includes the sets of many of its once famous and far more illustrious neighbours. Formed in 1854 from three previously independent mines (viz. Longclose, Dudnance and Penhellick), it had a troubled and chequered history down to the beginning of the twentieth century, expanding its operations only slightly. It then began a period of more rapid

expansion, mainly at the expense of its neighbours, which gave up operations in the difficult inter-war years. By the late 1960s it controlled a set measuring nearly 6 square miles which included what had been the most productive mines in Cornwall -- viz. all of the Carn Breas, Cooks Kitchens, Croftys, Dolcoaths, Pools, Roskears, Setons and Tincrofts, as well as Agar, Harriet, Tehidy and others. The total recorded output of all of the mines in its current set between 1845 and 1913 was well over 800,000 tons of copper concentrate and nearly a quarter of a million tons of tin. This amounts to over a fifth of Cornwall's total recorded output of copper and well over a third of its total tin production. The production of those metals was usefully supported by the sale of a wide range of associated minerals, particularly arsenic. In a similar way, today's Geevor mine has expanded far beyond its nineteenth century boundaries, to include the once highly productive sets of the Boscasswells and Levants, as well as Botallack, Carne, Carnyorth and Pendeen Consols. In both cases, the scale of the modern mining venture is hardly hinted at by the comparatively puny returns listed under South Crofty and Geevor in the nineteenth century. They inherited some of the most productive mineral ground in Cornwall and clearly showed how apparently exhausted lodes could be reworked to a profit given new, more efficient techniques and a buoyant metal market.

The process of steady amalgamation and consolidation of mines working the richer deposits gave the economic structure of the industry two important characteristics. Firstly, different metals tended to be produced in combination from the same mines, particularly the larger producers. The original process of mineralisation had created a mixture of minerals in many of the lodes and large-scale integrated production often meant raising and processing varying combinations of ores through the same shafts and dressing procedures. The economics of the Cornish mining industry can only be understood in terms of the production of changing "cocktails" of minerals which were sold in different and often diverging metal markets. The income of many mines was rather like that of the mixed farmer -- many and various, with perhaps some specialisation within the mixture. Of around 1,530 mines producing metalliferous minerals in the county between the mid-nineteenth century and the First World War, about 380 derived income from the sale of more than one mineral, or approximately a quarter of the total. These multi-mineral producers included all of the major mines and accounted for more than four-fifths of the county's total output. Of the multiple producers, over 260 mines sold both copper and tin ores in varying combinations, frequently in association with arsenic. About 100 mines sold lead ores in association with other minerals, usually silver, zinc, copper and/or tin and occasionally iron or manganese. In general, the only mines that depended for the whole of their income on the production of just one mineral were small developing workings, those that had long-since passed their best, or those that held very small leases of ground. Almost everywhere, large-scale consolidated working of multiple lodes resulted in the production of several different ores, though usually the minerals were not produced in equal proportions and frequently the secondary minerals played only a minor supporting role.

The second major characteristic of the Cornish mining industry was the pronounced pyramidal structure of its production. The process of amalgamation and consolidation of the mines working the richer deposits meant that the bulk of the county's output was derived from a handful of big

mines, supported by a larger number of medium-sized producers and a plethora of small workings which came and went on the margins of the industry. This can be demonstrated for the whole of the late nineteenth and twentieth centuries taken together or for shorter sub-periods or individual years. There was clearly a tendency for the number of medium and smaller mines to decline in absolute numbers over the years as metal prices fell and marginal producers found it more difficult to make a living, but the general structure of the industry remained unchanged. In 1855, for example, there were 133 mines producing tin in Cornwall, of which 17 produced over 200 tons of dressed ore, 30 produced 50-199 tons, and 84 produced less than 50 tons. The largest mines were therefore responsible for just over 52 per cent of the total, the medium mines nearly 36 per cent and the small mines just 12 per cent. By 1913 the total number of tin producers in Cornwall had fallen to 60. The effective measure of a large mine had now risen to a production of more than 500 tons of dressed ore and a medium mine to between 100 and 500 tons. The first category included six mines and was responsible for 67 per cent of total output. The medium category included eight mines and was responsible for 25 per cent of output, leaving 46 mines with a production of less than 100 tons, which were responsible for just eight per cent of output. The only noticeable trend was towards an even greater domination of a few large producers with a relatively larger number of small producers within the total. Similar patterns may be shown for the production of other metals but the more rapid decline of their total output tends to distort the general trend. For example, the 97 copper producing mines of 1855 had been reduced to just five by 1913. In 1855 there were six very large producers, with an output of over 5,000 tons of dressed ore and they accounted for nearly 29 per cent of total output. By 1913 there was just one "large" mine, with an output of 383 tons, and that accounted for 91 per cent of output. Similar structural patterns can be shown for the combined mineral output of mines -- viz. the total value of the output of tin, copper and other minerals year-by-year -- with the largest percentage being derived from a few major producers.

The structure of the industry can also be examined taking the period as a whole, from the mid-nineteenth century to the First World War. This enables the identification of the mines with the largest overall production record. It can be done either by looking at individual metals or by taking the total value of the mines' output of all ores. Returns of the value of tin production began in 1853 and by 1913 well over £39 million of dressed ore had been sold by nearly 700 mines in the county. Of this total, three quarters was derived from just 33 mines, all of which had a tin output in excess of £250,000. Just less than two thirds of the total was produced from 17 mines with an aggregate tin output of over £500,000. The value of copper output was returned from 1845 and provides the longest continuous series. By 1913 the total value of the output of dressed copper ore amounted to nearly £21 million. Of nearly 450 mines responsible for this total, just ten, with an output of over £500,000, accounted for more than a third and 24 mines, each with an aggregate value of production over £250,000 accounted for two thirds. Because some mines were large producers of both copper and tin -- viz. Basset, West Basset, and Carn Brea and Tincroft appeared in both lists -- the number of producers dominating the two industries together was less than the aggregate number suggested above. Just 24 mines, with a joint output of copper and tin ore valued in excess of £500,000, were responsible for over half of the total output of those metals in Cornwall during the period.

A similar picture is presented if the total value of the mines' output of all minerals is taken. There are some problems here because the value of the output of some metals, eg. lead, were not regularly returned until the last quarter of the century. However, by simply taking those that are available for lead, arsenic, manganese and other associated minerals and adding them together with those for copper and tin, the number of large mines, producing over £500,000 of saleable ore during the period, is increased to 28. See Appendix A. Taken together, these large mines were responsible for nearly two thirds of the entire mineral output of Cornwall, which had a declared market value of just over £60 million. Just ten of these mines -- classifiable as very large producers, with an aggregate output of over 1 million -- contributed more than 40 per cent of the total. The medium-sized mines, with a total declared value of output between £100,000 and £500,000, numbered 73 and were responsible for just over a quarter of the county's output. Again, the largest contribution was made by the largest producers in this group. The small mines, with a value of output of all minerals that was less than £100,000, numbered over 1,420. However, they produced only 14 per cent of the total. Figure 1 illustrates the broadly based structure of the industry, both in terms of the number of mines within each production category and, inversely, the contribution of each group to Cornwall's total output.

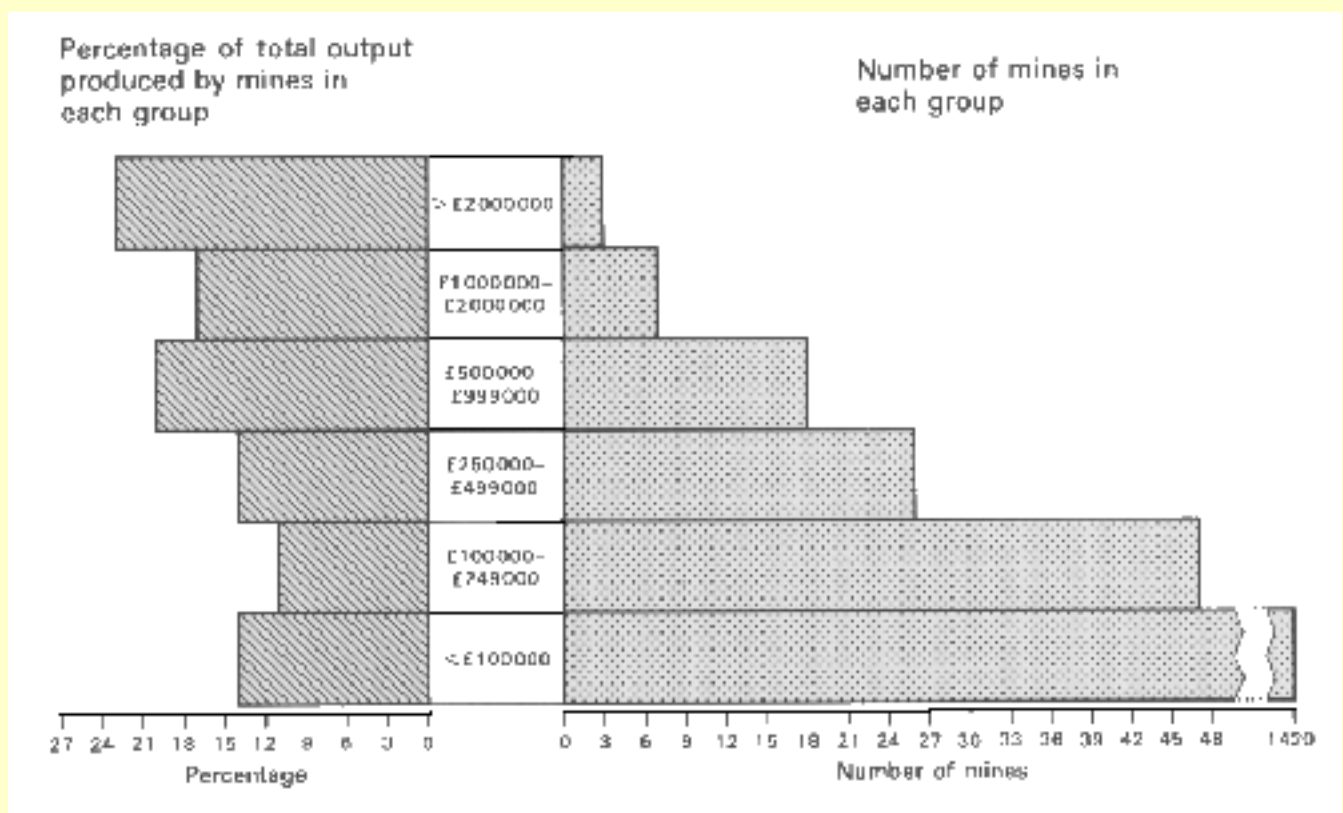


Figure 1: The structure of output from Cornish mines, taking the value of all metals produced 1845-1913

It has been suggested that the emergence of a few large mines to dominate the Cornish industry was the result of a combination of mineralisation and production characteristics that offered important returns to scale. Richer, more easily worked lodes, economies in pumping, hauling and dressing operations, particularly as mining increased in depth, would suggest that the productivity

of the largest mines was greater than that of the medium producers and their's was greater again than the smaller mines. Unfortunately, this is difficult to prove. It is not possible to assemble comprehensive figures of capital investment and for much of the early part of the period there are no reliable figures of employment. However, from 1878 the Mine Inspectors began to publish regular details of employment at all active mines and it is possible to estimate some crude figures of output per employee. This can be done on the basis of either the tonnage of ore produced or its value. Unfortunately, the tonnage figures are of little real value. As already noticed, most mines produced a mixture of different ores and the employment figures are not divided by metal. Dressed copper ore was easier to produce than black tin and considerably higher tonnages per employee could be achieved. Since different mines produced different tonnages of copper in their total output, tonnage output could vary considerably without reflecting real differences in the efficiency of working. The only meaningful and comparable measure of output per employee is therefore derived by taking the total value of output, aggregated for all of the minerals produced.

Estimates of the value of output per employee for all large and medium-sized mines listed in Appendix A have been calculated for the years 1880, 1890, 1900, and 1910. They have been divided into three groups; Group 1 is very large producers, with a total value of output of more than £1 million; Group 2 is large producers, with a total value of output of between £500,000 and £1 million; and Group 3 is medium-sized producers, with a total value of output of between £250,000 and £500,000. See Table 2. Only returns for mines that were still working on a significant scale during the survey years (viz. employing more than 50 people) were included, since productivity varied wildly as they were coming into or going out of production. Within each group productivity varied considerably between mines, but some clear patterns do emerge. At the largest mines, the value of output per employee appears to have fallen off noticeably during the difficult years of low tin prices in the 1880s and early 1890s but to have recovered to new high levels by 1900, following reorganisation, rationalisation, and a revival of the market. The first decade of the new century saw a further strengthening of productivity, with the annual value of output per employee standing well above £100 at many mines by 1910. This represented an increase of nearly a third on the levels of 1880, at current prices. In the Group 2 mines, the average value of output per worker also seems to have declined slightly during the 1880s and possibly the early 1890s but to have been recovering by 1900. In 1910 it stood markedly above any earlier figures at about £90 per worker per annum but this may be a statistical aberration, produced by a very small sample. The medium-sized mines in Group 3 saw remarkably little change in the average value of output per worker during the period. The levels of 1880 still applied in 1890 and were hardly changed by 1910. Although these figures are at best only rough approximations, it does seem fairly clear that the value of output per employee was highest in the larger mines and diminished with the scale of operations. In this context it might be noted that it was the gradual concentration of the industry into the hands of larger producers, together with the general process of technological change and increased investment, that was largely responsible for the doubling of average productivity per worker during the period. Taking all types of Cornish metal mining together in 1854, around 36,500 men, women and children achieved a total output valued at around £1.5 million -- or just over £40 per worker. In 1910, slightly more than 7,200 workers, now almost entirely adult males, produced metalliferous minerals to a value of

about £636,000 -- or around £88 per employee.

It is interesting to note, that while productivity per worker varied between mines of different size in Cornwall, there were at least some similarities with mines of the same size in other districts. An earlier volume in this series considered output per employee in Cardiganshire. It was noticed that the production of that county was not so heavily dominated by a few large producers as many other mining fields but was derived from a relatively large number of medium-sized ventures. They were all primarily lead/silver/zinc producers, unlike the copper/tin producers of Cornwall, but in most of the technical aspects of their operation they were very similar to the Cornish mines. Unfortunately, it is not possible to divide them into production categories that are comparable with those for Cornwall, because the value of lead output was not regularly returned until the mid-1870s, which was after their most productive years. However, comparing like with like in terms of the level of employment for spot years after that date produces some very similar levels of value of output per employee. In 1880, for example, productivity per person at Frongoch, the largest Cardiganshire producer, with a labour force of 294 working in a deep shaft and fairly highly capitalised operation, averaged £42.6. This compares closely with the £41.9 averaged at Cooks Kitchin in that same year and the £48.8 at Wheal Owles and £48.5 at Wheal Seton. All three of these medium-large Cornish mines employed similar numbers in similar workings. At Cwmystwyth, a shallow deposit worked through short shafts and adits without much expensive equipment, working was maintained in 1880 and 1890 with an average output per employee of around £30. This was not unlike the £29 average achieved at Pednandrea in 1880 or the £24 average at the Prince of Wales in 1890, both Cornish mines operating with a comparable labour force. Similarly, comparing Cornish mines with those in other parts of the U. K., the high £100 per employee achieved at the immensely productive Dolcoath in 1880, was closely matched by the £103 achieved at the highly capitalised Laxey mines in the Isle of Man in the same year. Equally, the £107 averaged at Greenside mine in Westmorland in 1900 was only a little less than the figure at East Pool and Agar at the turn of the century. The geographical flexibility of investment seems to have had some effect in evening out regional variations in the productivity of labour, but the degree of similarity achieved has yet to be estimated.

It is important, however, not to push these comparisons too far. They may simply be odd coincidence in a wide range of very divergent performances. Average productivity in the mines mentioned above often varied greatly in other years and there were clearly important differences in the productivity of many similar sized mines at any given point in time. It is also important to note that nothing that has been said should be taken to indicate differences in the profitability of different sized mines. Large workings employed more capital than small mines -- in the form of underground equipment, steam engines, dressing machinery etc. as well as larger outlays on sinking deep shafts and driving long exploratory levels. The cost of all this investment needed to be paid for in addition to current labour charges and could sometimes be very high. It was therefore not unusual when some smaller mines, with a low value of output per employee, nevertheless returned higher profits on total outlays than some of the larger workings.

The gradual concentration of the Cornish mining industry into the hands of a diminishing number

of large enterprises appears to have been achieved without a major change in the methods of ownership and management, at least until the very last years of the century. The cost book form of organisation, developed in the eighteenth century and earlier, proved very flexible and well equal to the task of financing and operating the largest enterprises through the heyday of the industry. As early as the mid-1830s, Sir Charles Lemon had listed five cost book mines that employed over 1,000 men, women and children, with Consolidated and United each employing well in excess of 3,000. They all involved capital investment of tens of thousands of pounds and were among the largest enterprises of the world's leading industrial nation. When a major change did finally take place, with a general shift to joint stock organisation following the tin crisis of the early 1890s, it was precipitated not by the inherent needs of large-scale finance and organisation but by a desire to limit liability and to increase security for an investing public that had become pessimistic about the future of the industry. The change resulted from the new requirements of investors rather than the operating conditions of the mines themselves.

The changing pattern of ownership is clearly documented in the mine returns. There is some problem for the third quarter of the nineteenth century as, unlike other counties, the *List of Mines* inexplicably furnished details only of mine managers and agents. However, from the mid-1870s details of the ownership of most mines in progress began to appear regularly. At that time many mines, particularly the minor producers, appear to have been in the hands of individuals or small partnerships, frequently referred to by their own names. They, like the adventurers adopting a more formal company name, may have been organised on the cost book principal, but this was not made clear. From 1891, however, the *List of Mines* began specifically to identify cost book companies and we have used the initials C.B. in the ownership sections to signify where this was done. Again it is not clear whether all cost book companies were properly identified from that date, but the great majority probably were. The ownership entries for Wheal Owles illustrate these points. The increasing importance of joint stock companies, identifiable by the abbreviation Ltd at the end of the company name, is noticeable from the 1870s. Until the 1890s this form of organisation was largely confined to the smaller, progressive mines and was almost entirely ignored by the larger established producers. Thereafter most of the surviving mines took advantage of the security of limited liability and registered as joint stock companies. There was no inevitable progression, however, with some ventures, such as Park of Mines, going in the other direction and other small workings remaining in private or partnership hands. It should be noticed that the original ownership returns also often included brief comments on the suspension, abandonment of workings etc. These have been included in the mine tables under the ownership comments section, as has necessary cross referencing material.

The management section of the Mine Tables lists in order the main officers of the mining companies, viz. manager, chief agent, and secretary. For Cornwall, the original *List of Mines* also sometimes listed the companies' pursers. In the returns individuals were frequently moved between categories and it would appear that for many mines, particularly the smaller ventures, one person might perform the functions of several offices. By contrast, for some larger ventures, multiple names were returned for the various offices. These have been allocated under the standard headings, with pursers and secretaries sometimes being identified with the abbreviations

(P) and (S). Using this name information it is possible to follow the developing careers of managers and agents: to trace their progress from mine to mine: and to examine the wide range of interests that some individuals and families established at given points in time. The sorting facility provided with the computer data base is particularly useful for this work. The family management and promotional partnership of John Taylor and Sons, for example, can be shown to have had a direct involvement with almost 30 Cornish mines during the period, including such well known ventures as Balleswiddan, Polberro, Drakewalls and the Tolguses. From these mines they produced a wide range of different minerals, including copper, tin, lead, iron and arsenic, and they established an important position in the markets for most of them. Thus in the early 1860s, the combined output of mines in which the Taylors held a managerial interest placed them within the top five tin and copper producers in the county. In the 1870s their involvement in the great Herodsfoot mine made them the second largest Cornish lead producer and their control of Restormel Royal made them the county's main iron producers. However, there are limitations to this technique of analysis. The Taylors undoubtedly controlled other mines in the county through a network of agents but without careful information on their names, derived by other research, these mines cannot be readily identified. A similar problem presents itself for the analysis of family involvement in the industry. Were managers of the same surname all members of the same family? A search on the name Hosking, for example, identifies at least eight different individuals of that name involved in the management of 35 different mines. William Henry Hosking, widely known in several other mining districts up and down the country, was connected with ten of those mines. His possible family connection with others of that name must be established from other records as must be the possible degree of family cooperation and collaboration in the operation of their business interests. Nevertheless, the material presented here clearly has important uses in genealogical and business history.

Notwithstanding the growing level of concentration in the Cornish mining industry and the extended ownership and managerial control developed by some individuals and family partnerships, there is no evidence of any group of mines or investors developing an influence over market supply and prices. This was undoubtedly because of the rapid increase of imports from the third quarter of the nineteenth century and the sharply declining market share of domestic producers. Table 3 shows estimates of the total U.K. production, imports and exports of tin and lead at ten yearly intervals 1850 1913 and indicates the quantities available for domestic consumption. The diminishing role of home output is apparent in both sectors. Similar trends can be shown for copper, manganese, zinc and the other non-ferrous metals but it is difficult to calculate accurately the quantities of actual metal in trade from the available official statistics. As indicated above, differences in the timing and scale of the import invasion, as well as variations in the expansion of the industrial demand for the metals, and differences in the geological availability and costs of working the minerals, caused the structure of output to change significantly during the period. Table 1 showed how the relative balance of copper, tin and lead production in Cornwall at the mid-century had been turned into a near total domination of tin output by the beginning of the twentieth century as a result of the more rapid decline of copper and lead. These changes in the production of different minerals may now be taken in turn.

In the middle of the nineteenth century, as during the previous hundred years or more, *copper* was the most important mineral by quantity and value produced in Cornwall. See Table 1. The figures use here were those given in the ticketing returns 1845 1876, distinguishing the mines selling at the Swansea ticketings by (S) and ore sold by private contract by (P). From 1877 to 1881, the returns were compiled by the Mining Record Office from a combination of the Inspectors of Mines' returns and their own calculations of metal and value. From 1882, the figures are those produced by the Mine Inspectors only. In the 1840s and 1850s Cornwall was responsible for well over 80 per cent of British copper production and was probably the most important mining district in the world, accounting for nearly a quarter of total recorded output. Thereafter, however, the district went into dramatic, irreversible decline as its aging mines were unable to compete with rapidly increasing production from the rich, low cost workings of North America, Chile and Spain. Cornish copper production was halved between 1860 and 1870 and halved again during the next decade. Output fell more rapidly than in other parts of the U.K. and by the late 1880s its share of national production stood at only just over 40 per cent. See Table 4. Leadership in the small remaining rump of the industry was now shared almost equally with the mines on the other side of the Tamar, dominated by Devon Great Consols. By the 1890s and 1900s, the long decline had almost levelled off and Cornwall's share again began to climb gradually. This was mainly because its few remaining producers derived the bulk of their income from the production of other minerals, particularly tin, and were able to survive better than mines in other parts of the country. Nevertheless, in the years immediately preceding the First World War copper production in the county stopped almost entirely.

The changing level of copper production in Cornwall was accompanied by important changes in the geographical distribution of output within the county. During the second half of the nineteenth century this amounted to a dramatic decline in the output of the mines in the western districts of the county, with a rising, but not fully compensating, output from the eastern districts. The old traditional centre of the industry was declining while newly discovered eastern deposits were being seriously exploited for the first time. The 1840s and 1850s saw the peak of production from the western workings, which were mainly concentrated in a heavily mineralised area between Bissoe and Camborne. Mines like Consolidated and United, Buller and the Bassets, Carn Brea and Tincroft, that had dominated the county through the early part of the century, still played the leading role. They were powerfully supported by other neighbouring mines, such as East Crofty, North Pool, Seton and North Roskear. The only other important producers, such as Par and Fowey Consols, were to be found in the centre of the county, near St Austell. The mines in the eastern district, clustered mainly around Caradon Hill, were already beginning to make their presence felt but had not yet come fully into their own. Their star was soon to rise, however, paralleling that of Devon Great Consols just across the Devon border. By the end of the 1850s, the western mines still held the lead in output but South and West Caradon and neighbouring Phoenix were now well established among the top ten copper producers. While the output of United Mines of Gwennap, long Cornwall's most important copper producer, had fallen by nearly 20 per cent between 1848 and 1858, that of South Caradon achieved the highest value of copper output in the county in 1858 -- a position which it held for the next three years. In the early 1860s the reorganisation of the United, Consolidated and Clifford workings into Clifford Amalgamated

again gave west Cornwall the county's largest copper producer but the eastern mines continued to increase their relative importance, with East Caradon and Mark Valley also taking their place among the top ten producers. A revival of Seton and West Seton during the late 1860s also helped to keep up the traditional role of west Cornwall but with sharply falling prices the older mines were rapidly being forced to curtail production. East Cornwall's convenient topography for relatively low cost adit working enabled its mines to compete more effectively and by the early 1870s it had become the main source of output. In 1873, for example, Phoenix, the Caradons, Glasgow Caradon, Marke Valley, Hingston Downs, Prince of Wales, Gunnislake Clitters and Craddock Moor, out of a total of 68 working Cornish copper mines, were responsible for just over half of the county's surviving output. They retained something like this for the remainder of the decade, just ahead of the western district which increasingly relied on West Tolgus, West Seton, Crenver and Abraham, East Pool and particularly a revitalised Mellanear, located away from the main mining area, near Hayle on the north coast. With total output now down to less than a quarter of its mid-century level by volume, Mellanear took over from South Caradon as the largest copper producer in the county in 1879 and gradually consolidated and increased its lead during the 1880s as production elsewhere continued to fall off. In 1883 the east Cornwall mines still accounted for over 40 per cent of output but five years later they had all virtually disappeared. The new mining district that had given so much during the mid-century had ceased to exist as a force in the Cornish mining industry. To the west Mellanear gave way to Levant as the largest single producer in 1889. Sustained mainly by its revenues from tin and arsenic production, Levant continued as the largest copper producer down to the First World War and was responsible for more than two thirds of the county's total output 1890 1913. The far west had completely eclipsed the east as the last bastion of the county's copper production.

Whereas Cornish copper output declined rapidly from the mid-1850s, *tin* production increased until the early 1870s and held fairly steady at a high level until the early 1890s. See Table 5. The figures used here are the Stannary returns 1852 1872; a combination of Stannary and Mine Inspectors' returns collated by the Mining Record Office 1873 1881; and the Mine Inspectors' returns only after 1882. During this period Cornwall became, and remained, primarily a tin mining district. As already suggested this was mainly because many erstwhile copper mines encountered tin mineralisation at depth and switched to the production of the metal. The change was encouraged and facilitated by the relative firmness of tin prices. While both metals saw a major loss of overseas and domestic markets to foreign suppliers, the tin market generally remained stronger, sustained by the expanding tin plate industry. The price of tin actually increased by over 50 per cent during the third quarter of the century, from an average £84 per ton 1846 1850 to £130 per ton 1870 1874. During the same period copper prices remained relatively stable, dropping by a marginal five per cent from an average £87 per ton 1846 1850 to £82 per ton 1870 1874. The production switch which started as a simple response to the increasing profitability of tin became a rout for copper as sharply rising imports caused copper prices to collapse during the next two decades. By the end of the 1880s the price of copper had fallen by nearly a third to an average of £56 per ton 1886 1890, while tin prices held up above £100 and were still 25 per cent above their mid-century level. In 1854 the value of Cornish copper production stood around £1 annually and tin output was only a third of that, at just over

£330,000. By 1890 the value of the county's copper production had slumped to just £10,000 while tin output had more than doubled to almost £750,000. Copper mining had become hopelessly uneconomic while tin production still sustained over 70 mines.

The fortunes of the tin industry changed dramatically in the mid-1890s and it too began a dramatic decline. Difficulties in the tin market caused prices to slump by nearly a third between 1890 and 1896 and output was suddenly halved. At one point, at the depths of the crisis, production was suspended in nearly all of the county's mines. Some were reorganised but many never recovered. In 1893 there were 67 mines in Cornwall producing tin but by 1897 only 31 were still making returns. Prices and production remained depressed for the next few years and when the market began to pick up again at the end of the decade, there was no perceptible surge in output. In 1900 tin prices were more than twice their level in 1895 and in the years immediately preceding the First World War they had rocketed to more than £200 per ton but production remained persistently low and unresponsive. See Table 5. By the late 1900s there was again a similar number of mines making returns annually but the output from the larger producers, and particularly the medium-sized mines, failed to pick up. For some reason that sector of the industry that was traditionally the most productive had suddenly lost its sensitivity to price changes. A comparison of tin production in 1892 and 1910 illustrates the change. In both years just over 60 mines made returns and output was dominated by a few large producers. However, in 1892 the seven largest mines, all producing over 500 tons of black tin, achieved a combined output of more than 8,000 tons. In 1910 the six mines in this category had a combined output of only just over 5,000 tons. The decline was even more pronounced in the medium production range. In 1892 there were 15 mines producing between 100 and 500 tons of black tin while in 1910 there were only three. In 1892 the combined output of mines in this production range was over 4,000 tons while in 1910 it was only just over 700 tons. The consequence of the tin crisis of the mid-1890s had been a permanent reduction in the output from Cornwall's largest mines and an almost complete disappearance of its medium-sized producers. This was partly because of the merger of some medium producers into new large consolidated ventures; partly because of the exhaustion of some tin deposits, particularly after their eyes had been picked during the crisis years of the mid-1890s; and partly because of capital starvation resulting from the increasing fascination of mine investors with more profitable foreign ventures. The relative importance of these and other factors has long been debated and undoubtedly varied considerably between different mines. However, the particularly poor performance of the medium-sized mines strongly points towards the paramountcy of the deficiency of capital and enterprise argument. Not all were swallowed up by larger neighbours and it is unlikely that so many deposits should have approached exhaustion at the same time. Rising prices should have given commercial viability to some previously underworked deposits. Here at least Cornwall appears to have been clearly lacking in promotional drive, resources for development and expansion and, possibly, skilled management and labour. All were haemorrhaging to other mining districts worldwide and depriving the Cornish industry of its previous health and vigour.

Of the several leading Cornish tin producers, one mine, Dolcoath, consistently led the field as the standard bearer for the industry. It was the largest single producer in every year throughout the

period. Dolcoath's output grew progressively until the late 1880s; levelled off and remained fairly steady during the difficult 1890s; and, though gradually contracting, continued at a high level through to the First World War. The trebling of its production during the 1850s and 1860s was significant in carrying Cornish tin output to its all-time peak in 1871. In that year Dolcoath produced just less than ten per cent of Cornwall's tin output. In the mid-1880s, with production again more than doubled and at its own peak of output, it was responsible for more than 20 per cent of the county's total. This share rose to well over a third in the mid-1890s as other mines faltered and closed but Dolcoath's production hardly hiccuped from peak levels. In the years before 1914 its tin output was still above that achieved in the prosperous 1870s and notwithstanding increasing depth and production problems, it was still accounting for around a quarter of the tin produced in the U.K.

Next to Dolcoath, the largest tin producers were Carn Brea and Tincroft, East Pool and Agar, Grenville, Basset and Levant. Most of these mines were found leading the production tables in every year during the period. However, they were joined and even surpassed in some years by a number of other large producers which also briefly appeared high in the reckoning. In the 1850s and 1860s, for example, Drakewalls, Great Wheal Vor and Providence mines consistently produced large quantities of tin. Similarly, in the 1870s and 1880s Botallack, South Condurrow, Eliza Consols and Phoenix made important contributions. South and West Francis also rose to prominence in the 1880s and 1890s and West Kitty (St Agnes), which saw a surge in its output from the mid-1880s, continued as one of the few very large producers well into the new century. The late 1890s also saw the emergence of South Crofty and it became well established as a future leader of the industry in the years preceding the First World War. Nearly all of these mines were located in west Cornwall, particularly around the central Camborne -- Redruth area and the neighbouring St Agnes and Lelant districts on the north coast. There was no significant eastward shift of production in the county on the pattern of copper mining. However, the occasional importance of Eliza Consols, Charlestown United, Par Consols and Great Polgooth in the St Austell area, as well as Phoenix, Drakewalls, Hingston Downs, Prince of Wales, Clitters United and others in the Calstock/Gunnislake area clearly indicates that the mineralisation of that part of the county was not unimportant.

The main by-product of Cornish copper and tin mining -- rising to the status of primary material at some mines by the end of the century -- was *arsenic*. In 1855 the production of refined white arsenic, which was used in the manufacture of pigments, dyes, glass, etc., was already well established. Total output was estimated by the Mining Record Office to be around 1,400 tons per annum. Recorded production was near that level in the late 1860s but then began to expand rapidly, mainly to supply a new export demand for use as a pesticide. The value of output peaked in the early 1880s, fell off, and then recovered to a second, lesser peak in the early 1890s. See Table 6. The increasing income that it produced usefully compensated for the sharp fall in copper revenues during these years and the levelling off in the growth of tin production from the early 1870s. The cushioning effect rapidly began to disappear from the mid-1890s, however, as production and the value of output plummeted. By 1903 production had fallen to less than a quarter of its 1890 level and only two mines received any significant benefit from its sale.

Arsenic production had lived in a mutually supporting relationship with tin mining -- the revenues from one helping to keep open mines that would also produce the other. When the markets for both products began to be severely undercut by low cost foreign competition at the end of the century, a mutual downward spiral was inevitable. By the early 1900s only a rump of the old industry was left. When both tin and arsenic prices revived in the middle of that decade there were not enough mines still operating to produce a significant increase in the output of either mineral. The downward decline was checked and arsenic production returned to just over 2,000 tons in 1907 but the great days of the industry were finished.

Over the period 1854-1913, nearly 140 mines marketed crude and refined arsenic and/or unprocessed arsenical pyrite. Most of the mines calcined the ore themselves but a few sold the ore to other mines and manufacturers. These were usually small producers or mines with an output that temporarily exceeded the capacity of their own processing plant. Thus around 110 mines marketed white arsenic during the period and just over 60 sold arsenical pyrites. Only a small proportion of these producers were in operation at any one time. In 1873 nearly 30 mines sold arsenic but through the peak years of production in the 1880s the number was always less than 20. The number of mines selling arsenical pyrite was usually less than ten until the 1890s. There was then a sudden increase in this section of the industry as mines everywhere desperately tried to maximise income from any source during the crisis years of the middle of the decade.

Most arsenic production in Cornwall took place in the central western district, between Camborne and Redruth, and in the east of the county, near Callington. These were the principal copper and tin districts and offered the widest facilities for by-product production. In the 1850s and early 1860s, when arsenic production was still at a low level, most output was derived from East Pool, Carn Brea and the Setons in the west and Okel Tor in the east. Prosper United, near Penzance, had a brief period of importance in the mid-1860s but it was the rise of New Great Consols, near Callington, that was primarily responsible for the sudden surge of output in the early 1870s. In the peak production year of 1873, New Great Consols was responsible for nearly a third of total output. East Pool resumed the leadership in production in the mid-1870s to be overtaken by the newcomer to the industry, Holmbush, and an expanded Okel Tor in the early 1880s. Agar and Levant also began to achieve some prominence in this period and by 1887, Agar and its neighbour East Pool were producing almost half of the total output. The last years of the 1880s also saw the rapid rise of arsenic production at Callington United and Drakewalls, and by 1890 the eastern half of the county was contributing well over half of the county total. This was short-lived, however, and by the latter part of that decade control of production was firmly back in the hands of the now amalgamated East Pool and Agar and Carn Brea and Tincroft, usefully supported by Levant. This situation continued down to the First World War, though South Crofty also became of importance in the early years of the new century.

The sale of arsenical pyrites was generally on a much smaller scale than refined arsenic and it was not separately recorded until 1875. The great majority of the pyrite producers were in the eastern district of the county and were led in the late 1870s and early 1880s by New Great Consols, Holmbush and Okel Tor, all three of which also sold refined arsenic. In the 1880s

Calstock and Danescombe entered the market on a fairly large scale and were joined briefly at the end of the decade by Queen, located near Calstock. In the 1890s and 1900s Danescombe, Prince of Wales and Trelawney in the east and Great Busy in the west were the main producers, to be superseded by Tamar Consolidated in the years immediately preceding the War.

All-in-all a large number of Cornwall's copper and tin mines derived a useful additional income from the sale of arsenical by-products. It is important to emphasise, however, that the great majority of mines never found these products of lasting significance. They were consequential at some mines in some years and may even have kept a few going during crisis periods which would otherwise have seen their suspension or closure. However, it never succeeded in checking the general decline in the industry precipitated by the fall in tin prices. It must also be stressed that the majority of copper and tin producers never found arsenic in commercially viable quantities. Even some of the largest and otherwise highly diversified producers, such as the Bassets, Phoenix and Grenville, failed to find any commercially viable ore. The great Dolcoath rarely succeeded in producing arsenical products valued at more than a few hundred pounds per year.

The production of *lead* in Cornwall was taking place on a very large scale during the first half of the nineteenth century but collapsed during the third quarter and had dwindled to nothing by the late 1880s. See Table 7. The figures used here were those collected by the Mining Record Office, together with the Stannary returns and, from 1872, the Inspectors of Mines' returns. In 1850 the production of lead in Cornwall was equal to that of Cumberland and second in England only to that of Durham and Northumberland. By the late 1870s, however, it had fallen to the third smallest producer in England, ahead only of its southwestern neighbours, Devon and Somerset. As Table 1 shows, in the 1850s and 1860s, the value of lead and its associated silver, accounted for around one tenth of the total value of all metals sold in Cornwall and it was the third most valuable mineral in production. By the 1880s, with an output down to a few hundred tons per year, lead and silver contributed less than one per cent of the value of all metals and were in fifth position, behind tin, copper, arsenic and zinc. The demise of lead production in Cornwall and the south west appears to have been more the result of exhaustion than adverse price movements. Elsewhere in the U.K. relatively high and buoyant prices encouraged an expansion of production and produced record levels of output in the early 1870s. Nationally lead production only began to decline significantly during the last quarter of the century.

The problem for lead production in Cornwall was that output was heavily concentrated in the hands of a few large producers. When they went into decline there were no others to take their place. In the peak years of production in the county, just one mine reigned supreme. East Wheal Rose, perhaps the most productive mine in England at that time, accounted for 80 per cent of the county's recorded output in 1845. Although its production was already falling off rapidly and had nearly halved by 1850, it still accounted for over 40 per cent of the county's output in that year. East Wheal Rose was supported by a handful of other significant producers, notably Trelawney, Mary Anne, Callington and Herodsfoot. Unlike East Wheal Rose, located near Newlyn in the centre of the county, these other mines were all in the eastern district, close to Callington. In

1850, these four mines had an aggregate output of 4,131 tons of lead ore, which was similar to that of East Wheal Rose and gave the five mines together over 80 per cent of Cornwall's total lead production in that year. The output of Mary Anne and Trelawney held firm during the 1850s and even expanded slightly, whilst that from East Wheal Rose continued its steady decline. By the end of the decade, the reduction in the county's lead production was almost entirely accounted for by the fall-off in the output of East Wheal Rose and that mine had now slipped to third place in the list of major producers. The 1850s also saw the rise of another important producer, Swanpool, while the 1860s saw the emergence of West Chiverton, Cargol and Ludcot, all located in the west of the county. However, these mines could not compensate for the declining fortunes of Mary Anne and Trelawney in the mid-1860s and although there was some overall surge in output at the end of the decade, based on a burst of production from West Chiverton, serious decline was evident from the early 1870s. The fall in lead prices after 1873 greatly increased the industry's difficulties and a further fall in the 1880s virtually finished it off. Taking the period 1845-1913 as a whole, around 170 Cornish mines sold some quantity of lead ore. Just five of these mines -- East Wheal Rose, West Chiverton, Mary Anne, Trelawney and Herodsfoot -- accounted for over two thirds of total production. When their lodes began to run out, none were found to replace them.

One of the principal problems in sustaining Cornish lead mining was a lack of commercially viable secondary minerals. Old Cornish copper mines had been sustained from the 1870s by their ability to produce increasing quantities of tin; the income of many tin mines was bolstered by their ability to produce and market arsenic. Unfortunately, none of these minerals were found in substantial quantities by the major lead producers. Their only hope was provided by the possibilities of refining *silver* from some lead ores and occasionally by developing associated *zinc* deposits. Sometimes these minerals offered a substantial supplement to income from lead sales but they never succeeded in fully offsetting a decline in lead output. In the case of silver, this was because the metal was contained in the lead ore and the exhaustion of lead deposits meant an associated and equal decline in silver output. Of the lead producers, almost three quarters registered a *silver* content in their ores. They were responsible for almost all of the silver output in Cornwall. Over 40 lead mines also recorded some output of zinc, though their role in the total production of that metal was less complete. The assayed silver content of lead ores was reported in the Mineral Statistics from 1852 and its importance to the income of some mines can be seen throughout their productive life. In 1852, for example, the lead ores produced by East Wheal Rose were reported to contain 48,000 oz. of silver which, at around five shillings an oz., increased the total value of the lead by around £12,000. With total receipts from all sales in that year of around £20,000, silver had an almost equal role with lead in the economics of the enterprise. Similarly, at the peak of its output in 1870, West Chiverton produced 3,582 tons of lead which was estimated to contain over 160,000 oz. of silver, eg. 45 oz. to the ton. With refining becoming profitable at anything over 5 oz. per ton, this represented a very considerable extra income to the mine. Again the values of the lead and silver contents of the ores were very similar, at about £40,000 each. However, some caution must be exercised in using these calculations. Although the proportionate importance of the various minerals probably remained the same, it must be emphasised that the mines did not receive the full market values of the ores

that they produced. Clearly allowance was made for transport, reduction, refining and other processing costs. For example, in 1873 West Chiverton sold 2,224 tons of lead ore with an estimated lead content of 1,668 tons of lead and 70,056 oz. of silver. The average price of lead in that year was £15-8-0 per ton and silver stood at about five shillings an ounce. This would suggest a potential market value for the metals of £43,201. However, the mine received only £29,929, with the other third of market value going to the merchants and manufacturers. On this estimate the mines received only just over two thirds of the market value of the metals they produced, the remainder going to the merchants and manufacturers.

Whatever the real return to the individual mining operations, there is no doubt that Cornwall was the most important silver mining county in the U.K. during the third quarter of the nineteenth century. See Table 8. For most of that period it averaged about a third of national production and rose to around 40 per cent in the mid-1850s. With a silver content averaging around 35 oz. per ton during the peak years of lead production in the early 1850s, the richness of its ores was second only to those of its Devonian neighbours, who were working effectively the same ores on the other side of the Tamar. Significantly, the silver content of the ores seems to have increased as lead production declined during the 1850s and 1860s. Silver production in Cornwall rose to a peak of well over 300,000 oz. in 1869, which represented an average of nearly 47 oz. per ton of lead. This was because (a) the silver content of some lodes increased as they were exploited at depth and (b) there was a shift in the centre of lead production towards the more argentiferous districts of the county. However, by the early 1870s the failure of the lead deposits began to precipitate a rapid decline in the output of both metals. Cornwall lost its lead as a silver producer to the Isle of Man in 1872 and within ten years production had fallen to less than 10,000 oz. annually. By 1887 the production of lead and silver in the county had stopped entirely.

It should be noticed that not all of Cornwall's silver came from lead mines. In a few places the lodes were so argentiferous that they supported operations which were primarily silver producing, with little or no associated lead output. At least 11 mines operated on this basis during the late 1870s and early 1880s, of which Newton, Great Crinnis, and the Prince of Wales were the most important. With the single exception of Talnotry in Scotland, they were the only silver mines in the U.K. Production levels were very low, however, and these ventures had no significant effect on the overall level of silver output. Similarly, three operations -- Brothers, Duchy and Peru and New Consols Tin and Arsenic Works -- returned an output of silver from copper and silver precipitate but it never became of any importance.

The production of *zinc* was less significant for Cornwall's lead mines than silver. Only around 45 mines produced the two metals in combination during the period and many of these had very low levels of lead output and made no important contribution to that industry. West Chiverton and Cargol were the only important lead producers to achieve a high level of zinc output and even here the main productive period was comparatively short. However, zinc sales undoubtedly made a very major contribution to Cargol's total income as its lead production fell off in the 1860s and it briefly kept the mine alive and profitable. Similarly, zinc production first grew in importance and then took over as the primary product of West Chiverton in the 1870s and significantly

extended the life of Cornwall's second largest lead producer. In those years it became one of Britain's largest zinc mines. The supportative influence of zinc production was less diffuse than silver and concentrated in a shorter period but it undoubtedly played a crucial role in the lives of some mines.

With the exception of West Chiverton and Cargol, most of Cornwall's zinc came from mines other than lead mines, produced either alone or in association with copper, tin, iron and other minerals. Over 50 mines fell into this category. They included Great Retallack, Pencourse Consols and Budnick Consols, which were the leading producers of the 1850s and early 1860s. During that period they were responsible for up to a third of total U.K. zinc production. However, at the point when the introduction of new galvanising techniques began to expand demand and the producers of other districts began to enter the market, their production began to fall off. By the early 1870s Cornwall's diminished output accounted for only around five per cent of national production. See Table 9. The sudden surge of output from West Chiverton in the late 1870s, powerfully supported by that from Duchy and Peru in the early 1880s, revitalised the industry. It carried Cornish zinc output to an all-time peak during those years and it became the largest single county producer, contributing up to a fifth of total national output. However, new producers in Wales, Cumberland and the Isle of Man were also expanding their operations and soon resumed the lead. With the closure of West Chiverton and Duchy and Peru in the mid-1880s, Cornish zinc production collapsed and rarely again amounted to more than a few hundred tons per year.

Unlike some other metal mining districts, Cornwall produced very little *manganese* and *iron*. Across the county border, Devon mines increased their output of manganese ore to over 8,000 tons a year in the early 1870s but nothing was found in Cornwall with a potential of more than a few hundred tons per year. See Table 10. The only period of significant production in the county was during the 1870s and early 1880s, with a little sporadic output at the end of that decade. Most of the production came from Ruthers, near Newquay, which produced almost half of Cornwall's manganese, mainly in the early 1880s. It was briefly one of the largest producers in the U.K. in 1880, giving the county its only moment of real importance in the industry. The other half of Cornwall's output came from mines in the Launceston area, immediately adjacent to the large Devonian producers, which were located near Marystowe and Chillaton. New Phoenix, Ludcott, West End Down and Greystone Wood were the most important producers in this district, of which New Phoenix was clearly the most productive. In all there were only ten manganese mines in Cornwall, all of which were small operations by the standards of the main producing districts. They usually mined manganese in combination with a little lead, silver or tin but never in sufficient quantities to make a significant difference to the economics of the operations.

In terms of its contribution to national output, *iron* production in Cornwall was even less significant than manganese. The county never produced more than a fraction of one per cent of the U.K. total, even during its best years in the 1850s, early 1860s and early 1870s. See Table 11. It was the smallest producer in the south west, falling behind both Devon and Somerset. Compared with non ferrous mines, the tonnages of ore produced were impressively high but the value of iron output was relatively low. Few mines produced iron ore to a value of more than

£2,000 a year. A comparison of the volume of iron and tin sold over the period 1855-1913 produces very similar results but the value of Cornwall's iron output was only 0.6 per cent of its tin production. Put another way, the value of all of the iron ore raised in the county during this period was roughly equal to the output of just one medium-sized copper and tin mine, such as North Basset.

Over 80 mines marketed iron ore in Cornwall during the period, either alone or in combination with many of the main non-ferrous minerals. Like other types of mining, output was dominated by a few large producers. The 11 mines with a total production in excess of 10,000 tons were responsible for almost three quarters of the county's total output. The four largest of these -- Restormel Royal, Ruby, Pawton, and Trebicken -- accounted for around half of the total. Most of the output came from the eastern part of the county, particularly the St Austell area, though the Perranzabuloe district was also important. With the exception of Restormel Royal, none of the mines produced on a significant scale for more than a few years. Once located, the ores were quickly ripped out and mining was soon abandoned. The most common type of ore produced was brown/red haematite but some of the smaller workings also had a limited output of spathose and magnetite. These are indicated in the mine table by the abbreviations (BH), (SP), and (MO). Iron pyrites were also mined at some mines but like the sometimes associated minerals ochre, umber and redding, they have not been included in this study because of inconsistencies in the original data.

Finally mention must be made of the "rare" and minor, minerals that were sporadically produced by a few mines, usually as a by-product of other operations. The most important of these by volume and value was *wolfram/tungsten*. Like manganese, it was in increasing demand for the manufacture of new specialised hard steels. Between 1859 and 1913, Cornwall produced 4,857 tons of ore, virtually the entire national output, valued at over a quarter of a million pounds. It was more valuable than the output of iron in the county. Of the 20 or more mines recording sales of the ore during these years, four producers -- East Pool, South Crofty, Carn Brea and Tincroft and Clitters United -- dominated the trade. East Pool pioneered production during the 1860s and 1870s, joined briefly by Kit Hill United, and consistently remained the largest producer through to the early 1890s. At that point Carn Brea and Tincroft rapidly expanded production to take the lead but they were eclipsed themselves by Clitters United early in the new century. A revived East Pool was back in the lead by 1906 but was quickly overtaken by South Crofty in the years just before the War. With difficulties in the tin market, the production of this high value by-product could periodically play a strategic role in mine finances. In 1898, for example, the value of tungsten produced at Carn Brea and Tincroft accounted for 28 per cent of total receipts from the sale of all ores. Together with the value of arsenic sales, it produced 38 per cent of the mine's income in that year. Similarly, at South Crofty in 1907, tungsten accounted for over 20 per cent of the receipts from the sale of all ores and together with arsenic provided around 40 per cent of total income. Most of the mines that survived into the twentieth century did so on the production of a very mixed bag of minerals, exploiting all and every opportunity for profit.

The production of *antimony* was never as important as tungsten but three mines -- Bodannon,

Pengenna and Trebullet -- tried to produce it as a single main product. Trevennick also had some production in association with argentiferous lead ore. Total output during the period only amounted to 35 tons, however, with a value of £400. *Bismuth* was produced in even smaller quantities. East Pool, Dolcoath and Wheal Owles were the only producers, with the largest output -- 4 tons, valued at £120 -- being derived from East Pool between 1872 and 1877. *Cobalt* was produced in the 1850s at Great Dowgas and from the 1870s at East Pool. Total recorded production from both mines amounted to only just over 8 tons for the whole period from both mines, with an estimated value of £320. *Uranium* production was also limited for most of the nineteenth century but expanded considerably from the 1890s. Three mines -- Wheal Owles, East Pool and St Austell -- produced very small quantities during the third quarter of the century but their combined output rarely rose much above one ton a year. They all stopped production in the 1880s. In 1890, however, Uranium Mines produced 22 tons in its first year of operation and it dominated production through to 1913 with sales of up to 103 tons per annum. It was supported in the first years of the new century by output from New Crow Hill and Trenwith, where uranium was produced in association with lead and copper and tin. Cornwall dominated the production of all of these rare minerals with one mine, East Pool, standing out as a major supplier of almost the whole range of them. The only exception to this rule was *nickel*. Mainly produced in Scotland, the only Cornish mines to market this mineral were Fowey Consols and St Austell Consols. During the 1850s and 1860s, they had a combined output of 17.6 tons of ore valued at £653. *Plumbago* was said to have been found at several mines in the county but production and sales were never recorded. Although Cornwall was the major domestic source of rare metallic minerals, it was particularly poor in the minor "earthy" products *barytes* and *fluorspar*. These did much to support metal mining in other parts of the U.K. but never made an important contribution to Cornish mines. East Basset was the only venture in the county to record an output of *barytes*, with a small production in the 1870s and early 1880s. It is likely that the "sundries" production of this mineral for 1876 related mainly to Devon. *Fluorspar* production was slightly more common, with nine mines recording some output during the second half of the century. The most important of these was Damsel mine in the St. Day district. The total value of fluorspar production in Cornwall, however, was less than £600.

The greatest *deficiency* in Cornwall's mineral wealth was without doubt its lack of *coal*. This proved to be a near fatal flaw in terms of the county's general industrialisation and long-term economic welfare. The smelting and manufacture of its metallic minerals was generally forced outside of the region to areas where fuel was plentiful and cheap. The secondary industries which developed within the county related only to primary mining and quarrying activity. With the long-term decline of these activities -- which now amount only to the rump of a tin mining industry and large-scale quarrying confined to the St Austell area -- there has been a progressive contraction of the industrial base on which to build a new future.

Last modified .. July 30, 1996