

コンウォール地方の陶土産業

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梗 概

コンウォール地方は今日、風光明媚な土地として多くの観光客を集めている。夏は涼しく、冬は暖かで、多くの都会人は退職後この地で暮らすことを夢見ている。しかし、この地方がかつて産業革命期に、活発な産業活動を行っていたことを知る人は少ない。歴史的には約3千年もの昔から錫の採掘を行っており、最盛期（1830年から1860年）には、この地方だけで6百台以上の蒸気エンジンが稼働していたほどである。しかしながら、ヨーロッパで唯一この地方のキャンボーンで、この錫を採掘していた South Crofty 鉱山が本年（1997年）8月9日に閉山を通告され、その歴史を閉じることになった。

筆者はその前日の8月8日にこの鉱山の最深部470ファゾムズ（1ファゾム＝1.83メートル）まで降りて、つぶさに採掘現場を見学する幸運に恵まれた。おそらく筆者がこの鉱山を訪れた最後の見学者であろう。

他方、今日コンウォール地方が英国で石油に次ぎ、第2位の産物を輸出していることは意外に知られていない。それは陶土（china clay）である。世界的にはアメリカ合衆国のジョージア州と、サウスカロライナ州の2州で6万トンの陶土が生産されている。このコンウォール地方はデボン地方と合わせて約3万トンであるから、その生産量は比較的大きな数量である。

本稿で筆者は、この陶土産業についてその地質学的背景を「第1章」で、また歴史的背景を「第2章」で解説した。「第3章」では世界的な陶器製造業者ジョサイア・ウエッジウッドと、コンウォール地方の陶土との関係について、「第4章」では陶土採掘技術、「第5章」では現代のコンウォール地方の陶土産業の現状について述べた。「結論」では「電子革命期」と言われている現代に陶土産業が直面する諸問題を論究し、併せて産業考古学の視点から The Wheal Martyn China Clay Heritage Centre の重要性について考察した。

A General Survey of the China Clay Industry in Cornwall

Yoshio Oro

Introduction

Cornwall is now a famous sightseeing county situated in the farthest peninsula of southwest England. This district is surrounded by the sea so that the climate is warm in winter, and cool in summer. In particular, the whole area of the southern coast is praised as a good resort by many tourists. Its beautiful scenery is a canvas for many painters. This district is also a Utopia for workers who, spending their lives in noisy, large cities, dream to reside here after their retirement.

However, those who now buy their houses or cottages, on a headland, in a valley or near an estuary, little realize that Cornwall was industrialised from 1760 onwards just like the Midlands and the North of England. It is stated in the *Industrial Archeology in Cornwall* that for almost two hundred years Cornwall was one of the most important metal-mining areas in the world and the setting for tremendous enterprises in the world of engineering, its blue skies shrouded by the smoke from a thousand chimney-stacks, and its wildlife in the fields, moors and lanes disturbed by the roar and clatter of machines.¹ It attracted many workers from other parts of England. The population nearly doubled from 192,000 to 369,000 between 1801 and 1861. It is ironic that people today try to move from contaminated cities to this once very polluted county which is now clean, quiet and smogless.

In spite of industrial activity in former days, Cornwall, once a center of the mining world, is now a very different county. In his famous book *La Grande-Bretagne* Mr. Cazamian already gave us such a devastated scene as "big scars left on mines, a huge accumulation of waste, the dereliction everywhere

extending halfway up the sides of hills, and stairs cut in the rocks show us how the activity lasted for several centuries.”² He also described the cone-shaped mysterious ventilations of mine shafts, the refuge huts having no roofs, scrap iron, the wreckage of rusted machines are an original side of scenery in this county. Today there are innumerable mines and derelict engine houses dotted here and there in this district. When copper and tin mining was its main economic activity from 1830 to 1860, over 600 steam engines were at work. Now those give an aspect which can be called ‘a graveyard of the mines’.

The dynamic growth of its mining industry was enormous between 1801 and 1861. Then it was followed by an equally dynamic fall caused by a mining collapse between 1861 and 1901. The reason for the sharp decline was the pinching-out of copper ores and the discovery of larger and more easily worked deposits overseas, especially in South-east Asia and the U.S.A. Tin mining once looked as if it might have been experiencing a revival, but the closure of the tin mine at South Crofty, the last in western Europe, was announced by the owner this year, 1997.

However, there is an exception to this decline. Not all mining is in decline. The china clay industry maintains its supremacy producing about 2.5 million tons a year in this county. Although china clay is the second most valuable mineral export next to petroleum, the industry itself is not much known. Does this industry have its own history? What is the main cause of its survival? The purpose of this article is to solve these questions mainly from the viewpoint of British industrial archaeology.

Chapter I. Geological Background

Cornwall is a peninsula which projects into the Atlantic and is situated in the most south-western corner of England. The shoreline is rugged and deeply indented, and the oldest rocks forming the Lizard Peninsula are resistant to erosion.

Geologically the Lizard represents part of the Paleozoic ocean floor thrust onto the continental crust. Apart from carboniferous sandstones in the north, the rocks mainly belong to the Devonian strata; granite intruded into this layer approximately three hundred million years ago, and big igneous rock lumps were exposed by erosion. Moorland where this granite is exposed forms the backbone of this district. The highest point is 423 meters (1375 feet) at Brown Willy on Bodmin Moor. This plateau is exposed to gales; therefore, it is treeless, and spreads out to the beach.

The granite is thought to have been generated by the process (anatexis) by which lower crustal igneous rock remelts into magma at depths of 17 to 19 kilometers at a

temperature of around 800°C. This molten rock rose up as great cylindrical masses and began to crystallise. As crystallisation proceeded a watery residue rich in ore metals accumulated near the top of the granite. As the rock cooled it formed cracks, along which the watery residue streamed out of the granite. This cooling process resulted in a variety of ore minerals being deposited in lodes. The melt contains a variety of elements including Li (Lithium), Cl (Chroline), U (Uranium), Th (Thorium), Sn (Stannum = tin), W (Wolfram = Tungsten), F (Fluorine), Cu (Cuprum = Copper), and REE's (Rare Earth Elements). As the granite cooled slowly, there was enough time for it to grow large crystals more than 2 mm long and so produced coarse-grained granite.

Professor Colin Bristow says that, "although it is hard compared with most rocks, it is, in fact, slightly lighter in density, so it tends to rise in relation to the slightly denser rocks around it. It is the buoyancy of the granite which keeps the Cornish peninsula above sea level, so we can truthfully say that Cornwall is a peninsula of hardened mud held up by granite."¹ A long period of erosion wore down the land before the granite was exposed at the surface to form the beautiful landscape we are now familiar with.

Etymologically, 'granite' derives from the Italian 'granito', which means 'grained' in English. The original Italian word has been adopted in most of the European languages; for example, 'granito' in Spanish and Portuguese, 'granit' in German, Swedish, Danish and 'Graniet' in Dutch. Granite is a granular crystalline rock consisting essentially of quartz, feldspar, and mica. Again, in Professor Colin Bristow's words, "granite has a high silica (SiO₂) content, traditionally referred to as an 'acidic' igneous rock because it was visualised as containing a high content of (insoluble) silicic acid."² Quartz is silica which is usually grey in colour and has a greasy lustre. Feldspar is a name given to a group of minerals, usually creamy off-white in colour, in some cases, pink or flesh-red in colour, occurring in crystals or in crystalline masses. According to Colin Bristow, it sometimes shows angular cleavages due to the crystal structure having preferred lines of weakness along which to break. It has a more complicated composition—KAlSi₃O₈ is the composition for orthoclase, which is a potassium feldspar, and NaAlSi₃O₈ is the composition for albite, a sodium feldspar. The third mineral is a flaky mica, which comes in two common forms: biotite, which is an iron-bearing mica, usually black in colour, and muscovite, which is a transparent flaky potassium-rich mica.³ Briefly, the mica is a small plate of talc, selenite, or other glistening crystalline substance found in the

structure of a rock.

China clay is decomposed granite. To be more precise, it is the granite where the feldspar crystals have changed to kaolin, a fine white clay, leaving the quartz and mica in the rock unchanged. This process happened a long time ago in geological time. Dr. Philip Payton describes it as follows: "Rainwater soaked into the granite and over those millions of years was circulated convectively by the residual heat of the rocks (a function of their radioactivity), leading to a significant decomposition of the granite into kaolin or china clay. This process was accelerated by periods of intense earthquake activity, when old faults created during the Variscan orogeny were reactivated to form new cracks through which water might be further circulated and the phenomenon of 'kaolinisation' thus extended."⁴ Briefly, kaolinisation is a process of the earth producing a fine white clay by decomposition of feldspar. This very fine grained mineral is called kaolinite and is the main constituent of china clay. A feature of china clay is its extreme fineness. Even the coarser grades of china clay are finer than most talcum powders. Soft decomposed granite is called 'growan' in Cornish, which is a gravel-like deposit of quartz sand mixed with mica and china-clay.

The question of how feldspar was altered to china clay was debated for two centuries among geologists. Two theories were proposed from each opposing standpoint. One was the hydrothermal theory that kaolinisation took place as a result of hot, chemical laden gases and fluids rising from subterranean ground through the granite soon after it was formed. The other theory was supported by those who believed the clay had been formed as a result of weathering from ground level during a geological time when the climate was hot and humid. After much geological research, professor Colin Bristow concludes that, "it is now clear, a whole sequence of events was needed, the earliest of which would have been under hydrothermal conditions and the latest of which was probably a form of deep weathering."⁵ He also gives us his opinion that it is likely that much china clay would have formed under conditions which are on the borderline between 'weathering' and 'hydrothermal', so it is a rather futile semantic argument to try and decide which is the more important process.⁶

Chapter II. Historical Background

One of the oldest uses to which clay was put was that of making pottery or earthenware. Clays are the most common materials, easily available in nature.

Usually it was coarse, unrefined and by mineral staining it was variously coloured black, red, buff, yellow or grey, etc. They are plastic when mixed with water and can be formed into various shapes. The technology of pottery has also kept its primitiveness and has changed less than that of almost any other craft over a period of several millennia. The hand-forming of plastic clay and changing it by heating into a hard utensil which does not permeate water is a technique that goes back to the dawn of civilisation, that is, to before 6000 BC.

Three principal operations are employed in primitive potting: (1) getting and preparing the clay, (2) shaping the pot, and (3) leaving it to dry in the sun or heating it in an open fire, later in a kiln. When left to dry in the sun, the clay is not perfectly dried up and lacks mechanical strength. When firing at 450–750°C, the water is dispelled; the clay can no longer combine with water and it becomes moderately hard stone. When firing at higher temperatures, the clay vitrifies and fuses. But primitive man could rarely achieve this last stage. During the early civilisation of Egypt, Mesopotamia, and the Indus, the technology of potting gradually developed. It is impossible to date the technical advances, but the art of throwing pots on the potter's wheel evolved at this time. The ware was fired in kilns, fueled with wood or charcoal, in place of an open fire. Conspicuously the method of glazing was improved from a coarse porous ware to a non-porous one by burnishing, that is, smoothing the unbaked surface by rubbing, by dipping the ware in a 'slip' or a slurry of fine clay and firing, or by glazing, namely, painting on to the surface a substance which would turn into a thin layer of glass when it was fired.

It is said that in about 700 BC the Assyrians made an important discovery of lead oxide-based glazes, an important development as this was the first glaze that would stick to a clay base. They could obtain a yellow colour by roasting antimony sulphide with lead oxide, and get blue and red from copper compounds. The Greeks and Romans made progress in fine workmanship and artistic design rather than in technology. However, the Greeks, from about 600 BC, developed the technique of black and red ware achieved by using reducing and oxidizing conditions to produce two different states of iron oxide in the red clay.

In England Romano-British potters made full use of the wheel in moulding their pots, but when they withdrew at the end of the fourth century the wheel seems to have been forgotten until its reintroduction in about the ninth century. In the Middle Ages, it is found from the excavated kilns that some of them have wall stones heavily burned and marked with green glaze which has run over them. This, and a

greenish-yellow glaze, were very typical of the thirteenth and fourteenth centuries. This effect was caused by sprinkling the pot with powdered galena (lead sulphide). The usual lead glaze was yellow. Some of the brighter green glazes contain a small proportion of a copper ore. Salt was also commonly used as a glaze for centuries, which potters threw into the kiln at the proper stage. Then the fumes or vapour of the salt settled on the surface of the pots producing a fine transparent glaze.

In those days, however, a very different kind of manufacture, porcelain, had already been produced in China. It was originally produced in about 700 AD. Two materials were used in the manufacture of this hard white ware, a refined white china-clay named 'kao-ling' (or kaolin as it passed into the English language), and a ground china-stone or petuntse (as it was called in China). The petuntse is granite that has been only partially altered by the process of kaolinisation, and quarried like any other rock. Kaolin is the soft, refractory clay and petuntse is the hard fusible stone. The mixture of these two materials was fired at the correct high temperature, that is, around 1400°C, when the ground stone vitrified and gave great strength. The resulting porcelain could be very hard, thin, white, resonant, translucent, and delicate in appearance. It is probable that the Venetian explorer Marco Polo brought back the first specimens of this porcelain from China to Italy in the thirteenth century. This new product was about to make an impact on European taste and fashion. In order to make the porcelain, the exact proportion of kaolin and petuntse, along with the exact temperature, were so important that China had kept the recipe a strict secret. Therefore, it did not leak out into Europe for a long time. China had been justly proud of its long history of manufacturing porcelain until the Dutch and British East India Companies were established early in the seventeenth century. Since trade in these wares became very active, this fine white ware was imported in quantity.

In the early 18th century, European pottery was by contrast somewhat coarse, even if potters made progress in elaborate glazing and decoration. They carried out intensive, energetic research to discover the constituents of Chinese porcelain and the closely guarded secret of its manufacture. One of their achievements was the first successful imitation produced by Dutch potters centred on Delft. They used carefully prepared clay and a tin-enamel glaze. By the end of the seventeenth century delftware had spread to England and was being manufactured at Lambeth, Bristol, and Liverpool. But the first true porcelain, using china clay, was achieved by the German Johann Friedrich Boetger (1719). He began working on research to discover its constituent in 1701 in the royal laboratory of Friedrich August II, Elector of

Saxony, in the town of Meissen. It is interesting that after ten years he came across kaolin, being sold as a wig powder, and feldspar, which often occurs with it. With these he obtained a true porcelain in 1710. In spite of strict precautions, the knowledge spread with wares to other countries such as France, Vienna, and Venice; for example, in France the Sevres works was founded at Vincennes in 1738, but only produced a true hard porcelain from 1768.

However, the secret eluded England. In this country several porcelain works were established at Stratford-le-Bow in east London after 1740, followed by Chelsea, Derby, Lowestoft, Longton Hill in Staffordshire and Worcester. They repeated the pattern and produced only artificial porcelain, using powdered glass with white clay. As potters in England used a poorer quality of clay in its domestic industry, ceramic manufacture was more coarse, and England was inferior to its rival countries in Europe.

We had to wait for the appearance of William Cookworthy (1705–80), a Quaker chemist and Doctor of Kingsbridge in South Devon, for china clay in England to be established as an industry. In the 1740s, when a traveller returned from Virginia, one of Britain's North American colonies, he brought back a sample of china clay with him. He showed this to William Cookworthy, who already knew the secret of Chinese ceramic production which had been superior to any other countries in the Western World. He was well versed in the fact that granite weathered into china clay and chinastone is feldspathic kaolin and also that kneaded kaolin can bear an extremely high temperature of 1,350 degrees. As the temperature needed to burn high quality stoneware is usually 1,150 degrees, it fuses the ingredients more effectively, and is able to make a characteristic type of ceramic. In her assiduous, laborious research, *A History of the Cornish China-Clay*, R. M. Barton pointed out that "he (Cookworthy) gained this considerable theoretical knowledge of the methods and materials used in China from two essays or letters, dated 1712 and 1722 and written by Pere d'Entrecolles, the superior-general of the French Jesuits in China. These gave a detailed account, often difficult to follow, of the materials Cookworthy sought and of the manufacture of true porcelain as it took place in the vast Imperial Factory of Ching-te Chen near Nanking, where some three thousand kilns turned the night skies red for miles around."¹

The exact year is not known, but writing about 1767, he records that it was at Tregonning Hill near Germoe in Cornwall about twenty years previously that he found the stone containing the special and peculiar properties of 'kaolin'. He wrote

as follows: "I first discovered it [the petuntse] in the parish of Germo, in a hill called Tregonnin Hill. That whole country in depth is of this stone. It reaches east and west, from Breag to Germo, and, north and south, from Tregonning Hill to the sea. From the cliffs some of this stone hath been brought to Plymouth where it was used in the casemates of the garrison; but I think the best quarried are in Tregonnin. The stone is a compound of small pellucid gravel [quartz] and a whitish matter, which indeed is caulin petrified [feldspar], and as the caulin of Tregonnin Hill hath abundance of micae in it, this stone hath them also. If the stone is taken a fathom or two from the surface, where the rock is quite solid, it is stained with an abundance of greenish spots, which are very apparent when it is melted. This is the circumstance noted by the Jesuits, who observe that the stones which have most of this quality are the most proper for the preparation of glaze."² At that time, according to Cookworthy, the use it was commonly put to was in mending tin furnaces and fireplaces of the fire [steam] engines, for which purpose it was very poor.³ The traditional place is Wheal Grey, situated on the north side of the A394 road (Penzance-Helston) about a mile west of Aston, which became an active clay works in later years, even as late as the 1920s.

On a later journey, he discovered better china clay at Carloggas Quarry near St. Stephens-in-Brannel than that of Tregonning Hill. He described it as having "much whiter body, and do not shrink so much by far in baking, nor take stains so readily from the fire . . ."⁴ In his record he used two words for the stone he had discovered, 'petuntse' which is Chinese for feldspar, and 'caulin' for 'kaolin'. The former was ground in mills to fine powder which was then mixed with the latter. In 1765 he succeeded in the first real experiment in the firing of hard porcelain. He took out his patent for making porcelain in 1768 and established a china factory in Plymouth that year with the help of Hon. Thomas Pitt. This Plymouth China Factory employed between fifty and sixty persons and was highly successful because the demand at home and abroad, particularly in America, for its articles was so large that they could hardly make the wares fast enough.

Furthermore, Cookworthy and Pitt ran into financial difficulties due to the fact that there were "many imperfections in the wares . . . mis-shapen pieces, unsatisfactory glazes, bad colour, fire cracks, etc. . . . which absorbed the profits made on the saleable remainder."⁵

The fuel used in firing was wood, although after some two hundred and fifty years of deforestation in the area this was difficult to obtain. This was brought about

by inconsistent quality of the raw materials which came from various places. The Plymouth Factory was finally closed down as a result at the end of 1770.

Chapter III Josiah Wedgwood and China Clay

Josiah Wedgwood was a great pioneer of English china and porcelain. He was born into a pottery manufacturing family at Burslem in Staffordshire in 1730. He experienced apprenticeship from fourteen to nineteen years of age. By the time he entered into a partnership with Thomas Whieldon in 1754, a highly successful local manufacturer of pottery, he had already gained a thorough grounding in the scientific knowledge of clay for his day. By 1759 he accumulated sufficient capital to set up his own business at the Ivy House Works. Superficially the business was far from promising for this young master-potter. Richard Tames gives us a comment in his *Josiah Wedgwood 1730-1795* that, "The local industry was primitive and without reputation and the country was so isolated by the badness of its road that it seemed it would never be possible to break out into a wider market."¹ However, he was born under a lucky star. At the time of his birth the Industrial Revolution had just begun. As he grew older, it was also proceeding to its highest point. Steam-power, turnpike roads and canals were making their impact on industry and commerce. Besides, the population of Britain began to increase rapidly as never before.

Such household utensils as plates and pots were coarse and fragile. Therefore, the way was open for him to produce tough, cheap, durable earthenware pot. On top of that, changing tastes among people were also favourable to him. In order to respond to the demand for tea which had already become popular in those days, he succeeded in manufacturing a great quantity of cheap mugs at his factory and sold them loose. He not only made an effort to develop raw materials, but also displayed talent as a manager. Wedgwood perfected a cream coloured earthenware in about 1750. The ingredients of this ware were Cornish china clay, china stone, ground flint and Devon ball clay. It was then covered with a tough lead glaze. This new whiter ware (known as cream-ware or, after 1765, Queen's ware) was the foundation of Wedgwood's success.

Later, he introduced the turning lathe for moulding some of his precision wares, and used transfer printing. As a master potter, he improved the working conditions of his laborers, made much of the quality control of products, and tried to improve transportation conditions. The great difficulties of transport due to the geographical situation of the Staffordshire potteries turned Wedgwood to taking an interest in

promoting first turnpikes and then canals. Because of improvements in transportation systems, Wedgwood wares spread over the whole country in the course of a very few years; in his phrase, "spread almost over the whole globe."² In 1763 he was chosen by his fellow potters to act as their spokesman before Parliament in promoting a new local turnpike and it is probable that he helped to draw up a new official petition. On 13th June 1769 he opened a factory in the open country west of Hanley, with a house for himself, and a village for his workers. The new settlement was named Etruria (so named from the imitation Etruscan style adopted for his quality wares).

As stated above, when Cookworthy's Plymouth Factory was closed down, he disposed of the patent to Richard Champion. From February 1775, when Champion tried to renew the patent, he found it difficult because the Staffordshire potters including Josiah Wedgwood were against the renewal of his patent. Eventually he was granted the extension, but with the important modification that, "although he retained the exclusive right to manufacture transparent or hard porcelain from the Cornish materials according to his specification, all other potters were at liberty henceforward to use these in the manufacture of opaque wares."³ Champion lost his monopoly over the Cornish materials and from then on all the potters were free to make their bargains with landowners and to lease their own setts. This prolonged legal battle came to an end successfully in favour of the Staffordshire potters, and it caused Champion financial embarrassment. His manufacturing in Bristol had become sluggish by 1778, and was closed finally in 1782.

In the meantime, "fashion was pressing hard for the production of a whiter body than that of Queen's ware, and Wedgwood himself was searching diligently for materials to this end."⁴ Even if he was handicapped physically, he visited Cornwall by chaise to see if the raw materials could be had in sufficient quantities. When he arrived at Tregonning Hill where Cookworthy had first discovered china clay, he found the chinastone too iron-stained for his purpose. Instead, he found china-clay and china-stone were plentiful at Gew Graze and Carloggas. He used Cornish clay in the making of his Jasper wares. According to Richard Tames, "they were a type of vitrified 'stoneware' although when such things as cups were made very thinly they had a slight translucency."⁵ Another feature of this ware was its imperviousness to water. Glazing was not necessary and it could be cut and polished on a wheel. With this invention of Jasper his experiment came to fruition in 1774.

Wedgwood had seen a Newcomen engine at work when visiting clay sites in Cornwall. In 1782 he experimented with the first improved Watt engine, "a further

step towards mass production by the use of steam for crushing china-stone, preparing clay and grinding flints.”⁶ He was the first potter to order this engine for his works from Boulton and Watt. He pioneered the application of steam power in the pottery industry and mechanization resulted in raising output.

Chapter IV Technology of Winning China Clay

By 1800 several china clay pits and quarries were very active on Hensbarrow (St. Austell). Compared with today’s workings, they were rather small and shallow. Pits and Quarries were usually several acres in extent, three or four hundred feet deep. One of the largest contemporary works, Trethosa, produced 300 tons per annum (tpa). However, this smallness and shallowness had merits for the small-scale enterprises. They did not need to install costly pumping apparatus, fixed equipment or permanent structures. John R. Smith observed that, “There was very little mechanization of china-clay processing until the later part of the 19th century, as the profits to be made from clay were small compared with the riches that might be gained from metal ores. The canny entrepreneurs of St. Austell were quick to realise that, although profits might be less spectacular, they were steady; and an assured income from clay was often preferable to an uncertain one from copper.”¹

The method of producing china clay remained almost unchanged from the eighteenth century to the early twentieth century. According to Charles Thurlow, the process consists of: (1) removing the overburden, (2) breaking up the clay face using water, (3) separating the clay slurry from sands by gradual refinement in a series of settling processes, (4) thickening and drying the clay and (5) then shipping it.²

(1) Removing the overburden

The clay ground often lay in water-logged depressions (slads) on the surface of the moor. Mrs. Barton told us that these hollows, known then as ‘bottoms’ or ‘sladdy bottoms’ were the result of the relatively rapid erosion of soft, kaolinesic granite that formed the hills. The surface is covered with soil and vegetation which discoloured the upper level of the china clay, usually stained with iron. The meatearth, (top soil) and overburden or oberburthen (sub-soil) had to be removed and discarded with barrows. In the early nineteenth century, teams of men worked together to remove all the waste materials, including discoloured clay or ‘weed’ using picks and shovels, or ‘shammelled’ from step to step to the surface where they disposed of it. The selected clay was then carried in wheelbarrows to the washing place or strake.

Today the process is modernized as shovel loaders with a twelve cubic metre

bucket fill dumpers with up to fifty tons of overburden. Even larger loaders and dumpers are now coming into use for this purpose.

(2) Breaking up the clay face using water

Work contained one or more slow moving streams whose pure waters were ideally suited for the purpose of washing clay. Usually they were diverted across the moorland to the works. The water was directed over small heaps of clay, washing the kaolinised material away. The integration of soft clay rock was aided by workers (called breakers). They used long-handled shovels and picks 'which were a local type with a single chisel point, known as dubbars.'³ They stood in the clay stream and broke up the decomposed granite. By the end of the nineteenth century, as pits deepened, water was piped from the surface through hoses with narrow nozzles to wash the clay. This was operated by a hoseman who directed a jet of water onto the clay face. Owing to the introduction of the hoses, the number of breakers was gradually diminished.

Today when you look down from the top of a china clay pit, you can see a special water cannon called a 'monitor', from which a jet of water is gushing onto the hillside to break up the decomposed granite. The monitor is remotely controlled by an operator from a cabin. Over the past twenty years, the washing process and most subsequent operations have been performed twenty-four hours continuously. This increases the output of china clay considerably.

(3) Separating the clay

Minerals are mixed up in water in the process of washing. The minerals are called a suspension, like mud in a muddy stream is 'in suspension'. While water carries this suspension, china-clay is separated from larger particles of quartz sand, and mica. Originally three rectangular catch-pits were used. They were walled and floored with granite blocks set in mortar. When clay slurry containing fine particles in suspension was conducted through wooden launders and flowed through these pits successively, the heaviest particles of its load were deposited in the first pit. These materials were finer quartz sand and coarse mica. Next, the clay stream overflowed through launders (long wooden troughs for carrying liquid) into the second pit, where the fine mica settled. In the third pit, the water contained only the finest particles, most of which were of china clay. Then the stream flowed to settling pits for thickening. The clay stream was allowed to flow into rectangular or circular settling pits which were lined with granite blocks set in mortar. These were called drags. The object was to sift out fine sands from the china clay.

As this process was very simple and inefficient, the refining of slurry was improved in the mid-nineteenth century. According to Charles Thurlow, "One drag pit was retained, but a set of long narrow channels replaced the other drags. These channels were only a few inches deep and fine sands in the slurry were settled out. Because the fine sand contained a good deal of a flaky material called mica, these channels were called micas."⁴ A man called a 'mica man' used a large hoe, shaped to fit the channels to clear the fine sands out of them. The hoe is called a 'shiver' or 'shyver'.

There was a system of drains underneath the channels of the mica drags. When the drains were in use, they were plugged. Again, in Charles Thurlow's phrase, "To clear the channels the plugs were removed and fine sand was discharged down the drains into the local rivers, which used to be known as 'white rivers' because the residue contained some china clay."⁵ This resulted in serious damage to the environment: the destruction of all aquatic life in the river, and the silting-up of ports and harbours such as Pentewan.

Today, the sand or mica is treated within the china clay area itself. To contain this material, lagoons are formed, with walls built of sand and rock. These lagoons are called 'mica lagoons'. The sand (mica) settles here in the lagoons leaving a layer of clear water on the surface. This water is then pumped away for re-use, not discharged into rivers. The flat surface of lagoons can be restored to agriculture by seeding and careful management. Furthermore, for environmental reasons, new refining methods are being developed. Early mica settling pits are often reworked to recover clay which was lost in the less efficient, old processing. In this way it is possible to reprocess the debris and extract second-grade clay.

(4) Thicking and Drying the clay

At the refining stage of the third pit, a milky white clay stream flowed into large rectangular or circular pits up to ten feet in depth, built with stone walls and floors. The clay slowly settled and the clear surface water was drawn off through pin-hole launders. These were square wooden pipes with vertical lines of holes in a wooded board fixed in the side of the pits. They were called 'pin-hole launders' because they had holes plugged with wooden 'pins'. To adjust the water level, the plugs in the holes would be removed one by one by a man able to reach the far side of the board by means of a ladder.

When the creamy thick clay deposit had reached a certain level, it was discharged or barrowed into large, shallow drying tanks called 'sun pans' where

thickening would take place. The drying process was carried out in open sheds called 'air dries'.

In the early days the shallow drying pans were dug on the open moors, and dried out gradually in the open air. The method of air-drying, used in places until the 1920s, was inevitably slow and required much heavy labour. Also, the weather restricted production. It took four months in a cool summer, and during the wet Cornish winters twice as long. Later, the method was improved. A pipe was laid underneath the pit, and through this pipe creamy clay flowed out to a second set of tanks where further thickening took place.

When the clay was sufficiently dry and stiff to be cut and handled, it was cut into blocks with large knives and stacked on the shelves of a drying houses (shed) open on three sides. This air-dried clay was probably low grade and in irregularly shaped lumps. The better grades of china clay from air dries were scraped clean after drying to remove sand and any surface sand. This task was done by women using triangular-bladed scrapers. After being scraped, the blocks of clay were stacked on one side of the kiln or dry (shed for drying).

In the mid-nineteenth century, deeper thickening tanks and drying on long floors heated by coal fires replaced this method of air drying. The 'lardy-clay' was deposited in outer tanks adjacent to the dry (a long single-storey building), which was a characteristic of this district. The outer tanks were filled with china clay from settling pits, where the clay was thickened to the level of butter. The dries were roofed and built next to settling tanks. As soon as the clay had reached a certain thickness, it was dug out with a shovel and loaded into wagons, and was taken into the dry. The dry had long floors heated by coal fires. On these long floors a wagon of clay was run onto a bridge, which moved on rails set along the whole length of the dry. The floors or pans of the dry were composed of large bricks or fire-clay tiles, on which the clay was spread out evenly. The heat from coal fires was conducted through long brick flues covered with special tiles, and passed into a typically tall Cornish engine-house chimney stack at one far end.

When the clay had been dried here, it was cut into lumps while it was still damp. Usually it took from one to five days to dry the clay lumps. The number of drying days depended on the place where the clay was: that is, whether it was at the hot end close to the fires or at the chimney end which was cooler.

Besides the pan, there was a shed consisting of a roof resting on a wall at the back, and supported in front by pillars. It was called a 'linhay' or storage area, where

dried china clay was stacked and stored till ready for sale. This type of pan-kiln, known as dries, quickly developed into a standard form during the 1860s and 1870s and became a familiar and integrated feature of the landscape in the St. Austell district. They were usually situated in the vicinity of clay pits connected by pipelines. John R. Smith explained it as follows: "The asymmetric roof covering a squat profile, the use of natural stone and slate, and the punctuating stack made them a truly vernacular feature of the clay district."⁶

(5) Shipping

Shipping (or transportation) was another big problem in the early days of the china clay industry. By the mid-nineteenth century the demand for the product had been rapidly increasing mainly due to the expansion of the pottery industry. In the early nineteenth century two thousand tons of clay was produced per annum (approximately seven hundred wagonloads). There was no home market in the county for china clay, and so it had to be shipped out to customers all over Britain as well as abroad. Wagons drawn by horses carried three or four tons of clay put into casks to the local ports. There were no sufficient harbour facilities. Along the south coast of Cornwall, ships ran up to the beach at high tide, clay casks were loaded at ebb tide, and the ship sailed off on the next flood. This practice was subject to weather conditions. Therefore, it was inconvenient and often dangerous.

It was in 1791 that Charles Rashleigh built Charlestown harbour on the site of West Polmear south of St. Austell Bay to make loading and unloading of this clay easier. According to Mrs. Barton, "Between 1791 to 1798 he had excavated outer and inner basins to which were fitted lock gates, and had constructed a dry dock, warehouses, a number of dwellings, and facilities for ship-building."⁷

Incidentally Wedgwood tried to establish pot works in this town, but he had to give up the idea because the coal needed to fire the kilns had to be imported from such a remote coalfield as Swansea and this was more expensive than transporting the Cornish raw material to Staffordshire. If Wedgwood had been able to establish a pottery industry in Cornwall, it would have made a great difference to the economic situation of today's Cornwall. But it was not to be.

When Phillip Ball, co-lessee of Charlestown harbour from Charles Rashleigh, forfeited the lease of the Charleston estate including the harbour, because of bankruptcy, no leasee for the harbour was forthcoming. Therefore, the management of harbour was in a somewhat disorganized state in 1825. By this time the traffic transporting china clay had increased at Charlestown, and it was creating a demand to

build a second harbour at the most sheltered point of the coast nearest to the clay-producing area.

Since the sixteenth century, at least, Pentewan had been used as a haven for fishing vessels and in 1744 a harbour had been built there by the Hawkins family. But it had been in a bad state and was out of repair by 1800. It seems that before the building of Charlestown a number of small vessels were merely beached on the open shore to load with clay and stone for Staffordshire. Sir Christopher Hawkins of Trewithen had the idea of excavating a basin at Pentewan. From 1817 to 1824, he erected his own harbour and a pier at the site of the old harbour. The site was ideal, and many clay works were opening up in that area. However, they poured large quantities of waste sand and mica into the streams which made its way down to the sea. This debris caused the silting of the harbour. In 1827 the construction of a railway from the port to St. Austell was proposed and this horse tramway was completed two years later when the access to the harbour was seriously blocked by silting in the entrance channel. In Mrs. Barton's phrase, "it served the china clay works well, and the heavy wooden wagon each carrying four tons of clay, being a familiar sight along the new harbour wharves."⁸

However, both Charlestown and Pentewan harbours were limited in their capacity. Even if the former was a small-scale harbour, scores of lumbering china clay wains had to travel there via the rutted, narrow and steeply twisting streets of St. Austell, while the latter suffered constantly from silting problems. Furthermore, gales stopped the port's activity for days on end. Another effort was made to search for a suitable port available to the shippers of china clay. Another harbour was to be built on the more sheltered south coast. This was an entirely artificial harbour, Par, which had been started in October in 1829 on an open beach to the east of Pentewan. It came into use in 1833. It was not primarily intended for the export of china clay, but of granite and copper ore. The merit of this harbour was that it was connected by canal to granite quarries and from the canal terminus to the china clay district by a horse-drawn tramway.

To be exact, by 1850 three horse-drawn tramways served the clay producers of Hensbarrow (St. Austell). They were the Pentewan Railway, the Par to Bugle tramway and the Hendra to Newquay tramway. In those days the traffic to the coast led by teams of horse drawing wagons was so busy that the roads were almost choked. The tramways played a part in supplementing them, but their capacity and speed was little better than the horse-drawing wagons on the roads.

The qualities of Fowey as a deep water harbour had long been known. However, there was no good transport links to this port, so that it had previously played no part in the shipping of china clay. In 1874 a line from Par to Fowey was built by the Cornwall Minerals Railway Company (CMR). Thus the line brought the Fowey harbour into direct contact with the china clay area for the first time. Fowey developed rapidly as a major deep-water china clay port. Pentewan finally succumbed to silting, and the railway closed; Charlestown closed about five years ago, and is now only used by pleasure craft. Par and Fowey are still in use as the principal china clay harbours. The industry exports two million tons of china clay each year through these ports to all parts of the world.

Chapter V. Modern China Clay Industry

When Cookworthy discovered kaolin, the china clay industry was only a local and small scale industry, producing less than 2,000 tons per annum (tpa) in the 1800s. According to Professor Bristow's investigation, the output was about 30,000 tpa by the mid-1830s and by 1912 it had reached a peak of about 900,000 tpa. 'During the first World War and the Depression of the 1930s, the industry declined to half that of its best days. Furthermore, during the Second World War, it was obliged to recede to less than 200,000 tpa. In the post-war period, the output of this industry has greatly revived and 'since 1970 total output has fluctuated between 2.5 and just over 3 million tpa.'¹

Technology and the organization of the industry had to change in order to meet the demand of a china clay trade that has now become worldwide. As already mentioned, a high pressure hose was developed to wash the clay and to break up the decomposed granite from the stopes and pits, in place of the old stream and strake working method. Special water cannons called 'monitors' are used now, which are remote-controlled by an operator from a cabin. The mechanization of this washing process has enabled operations to continue throughout the day, night and at weekends. This increases the tonnage of clay output remarkably. Incidentally, jet water is provided by large centrifugal pumps, which pump water that is recovered later on in the process. Electricity was developed for industrial use in St. Austell during the 1880s and from then pumps also provided sufficient centrifugal force to lift the clay slurry itself. In the mid-nineteenth century coal-fired drying kilns were built. These kilns were a great success and other producers quickly followed suit. They were very small, but could dry a charge of clay in three days. It drastically

accelerated the production from 13,440 tpa in 1838 to 65,600 tpa in 1858. Today various drying methods have been developed; for example, using a rotary dryer which is the first type of mechanical dryer to be used on a large scale in the china clay industry. This rotary consists of a long rotating cylinder about 2 metres in diameter and 12 metres in length. In this rotating cylinder there is an inner cylindrical tube. Hot air from a furnace chamber burning oil or gas is passed through this tube. Clay is fed into the space around the inner tube and inside the outer tube to be dried. The second drying method uses a Buell tray dryer which consists of a stack of trays in a round tower, rotated in a current of hot air, drawn into the dryer by fans. Clay is fed into the top of the dryer. Another method has recently been introduced. It uses a dryer in which the hot air for drying in a horizontal cylindrical chamber is introduced under slight pressure through a perforated floor. These dryers use gas or electricity instead of coal and the drying speed is very quick and uniform.

Another significant change was the introduction of 'filter presses' in 1911. This process was carried out by pumping the clay under pressure, into a series of chambers lined with a fine mesh cloth (nylon today), which water permeated, but not clay particles. The process removed most of the water from the clay before it was placed on the pan, effecting great savings in coal.² It might well be left unsaid that the building of local railways and improvements to road and port facilities contributed their shares to the thriving of the china clay industry.

The more potters made use of china clay, the more the demand grew. By the early nineteenth century the kaolin industry had become highly successful. At that time there were many potters who set up their own small companies owning rights to mine the material for themselves. Early in the twentieth century, the industry was made up of some seventy or so individual producers, each competing on price without regard for marketing. There was almost no capital investment or product development and over-production was a serious problem. Besides, wages were low and working conditions were poor. In spite of this fact, "by 1910 production was approaching a million tpa and paper had completely overtaken ceramics as the prime user of china clay. Over 75% output was exported, with North America and Europe being major markets. The china clay industry in Cornwall and Devonshire held a virtual monopoly on the supply of that mineral to the world market."³ It had become obvious that the multitude of these small companies was now a barrier to the efficient working of the clay ground. In 1919 just after the First World War three large companies, Matin Brothers, the West of England China Clay Co., and the North

Cornwall China Clay Company were brought together to form English China Clays, Ltd. or ECC. In 1932 ECC acquired its major competitors, John Lovering and H. D. Pochin, forming a new company ECLP & Co. It was renamed ECC International Ltd. in 1986 and in 1988 reached this century's highest level of production, viz: 3,277,000 tpa. There still survive such major independent producers as Goonvean & Restowrack, Steetley, and some other minor producers. However, one company, ECC International Ltd., controls almost 50% of the industry's production.

It cannot be disregarded that there are between seven and eight tons of waste produced for every one ton of china clay. The waste is usually made up of the over-burden that covers the deposit, mica, coarse-grained sand and rocks or unkaolinised granite known as 'stent'. This waste has to be removed from working pits. It used to be shoveled into wagons and wagon loads of stent were pushed to a point where they could be transferred into a skip on the incline railway. In order to pull up skips to the top of an incline a waterwheel was once used. Later it was superseded by a Cornish beam engine. The waste was tipped directly onto the top of the incline, which gradually extended as the tip grew. These dumps piled up into pyramids were soon nicknamed 'the Cornish Alps'. For 200 years the waste has been dumped on surrounding land. Many of the early pits had their sand tips beside them on clay bearing ground. They "created a unique 'lunar-landscape' of deep pits and white conical tips, blue lagoons and wasteland clad in gorse and heather."⁴ Any industry including the extractive industries that live off the land produces environmental problems. In order to solve these problems, old pits which have been worked out are used for depositing waste materials. Wherever this practice was done, many previously unsightly areas have been transformed into attractive, productive pastures. Among them there are some pits which have been flooded to provide the huge quantities of water necessary each day for the mining process.

Various attempts have been made to restore a balanced ecosystem in Cornwall. The waste materials such as sand, mica, or soil and stone are badly deficient of nutritious substances, especially nitrogen. They make it difficult to sustain wildlife and plants. If we do not start vegetation quickly, a sand tip will remain barren for about thirty years before ling and heathers begin to grow. Ten years after that small shrubs will appear. In further ten years plants such as willow and rhododendron will follow, but a hundred years can pass before the tip will become completely colonised by trees.

On steep sand tips the surface causes water to flow down very easily and water

is often a cause of erosion, the problems of which are very severe. Added nutrients are soon lost, making all the programs of reclamation and regeneration unsuccessful. "The extensive research over many years has resulted in the selection of special blends of grass seed with nitrogen-fixing legumes, most frequently clover. Clover accelerates the rate of nutrient build-up and enables the sward to become established."⁵ Today tree lupines, gorse and other shrubs have been found to grow particularly well on the steep waste materials and they can be interplanted. "If they are planned as eventual woodland, trees can be planted once the scrubland has become established to provide a sufficient nutrient level and shelter for the saplings."⁶

Over the last few years such significant improvements have already been made with many acres landscaped and planted with trees, shrubs, and grass. Rivers have been cleaned, and smoke emitted from chimney stacks into the atmosphere has become much less. Therefore, "the results of much of this recent improvement are there to be seen although the full benefit of some planting schemes will not be evident for several decades. The process of regeneration is now well under way."⁷

Originally china clay was exploited for ceramic manufacture, but since about 1807, it had increasingly been used for other purposes. According to Charles Thurlow, the percentage of UK Clay used by different industries today is: 48% for paper coating, 32% for paper filling, 12% for ceramics and 8% for other industries.⁸

China clay is used dominantly in the paper industry for two main purposes:

- (1) Relatively coarse clay is used as a filler in the manufacture of paper, to give a smooth texture and whiteness to the sheet. It also helps the paper take printing ink without the ink spreading. Blotting would occur on paper which contains no filler.
- (2) Fine clays are mixed with such adhesives as latex, starch or casein in order to coat paper. Paper already filled with china clay is coated with fine clay to give a smoother, brighter and glossier surface for high quality colour printing.

The making of porcelain is one of the most ancient occupations of mankind, in which man has developed its skills of shaping and firing clay into useful and durable utensils. Today the ceramic industry has spread its traditional roots deep into modern human civilization and grown up to be a sophisticated, giant tree. Modern technology has increased the range of products which includes "whitewares (sanitaryware, tableware, tiles and electrical porcelain), refractories (products resisting high temperatures, such as kiln furniture and furnace linings), glass (including glass fibre and glazes), abrasives, heavy clayware (such as bricks and

sewer pipes) and white cement. Additionally, specific technical and advanced ceramics such as substrates for electronics, medical prostheses and sialons etc. are included in the definition.”⁹ Furthermore, “within each of these broad categories lies a whole range of products of varying complexity and design, from common building bricks to rocket nose-cones, from window glass to gas-fire radiants and from strictly utilitarian sanitaryware to exquisite bone china tableware.”¹⁰

Chapter IV. Conclusion

The declining metal mining industry in Cornwall came to an dead end in 1997 with the close-down of South Crofty, the last tin mine in West Europe. It was a great shock to the people not only in this district but also all over the country. This more than three thousand and a half year history finally gave up the lingering struggle against the severe economic competition of foreign producers.

On the other hand, the china clay industry in Cornwall seems to have maintained a steady pace of production during the second half of the twentieth century. The reason is that, on top of producing ceramics, china clay has a great many uses today; for example, in the manufacture of rubber, plastics, paint, pharmaceuticals, inks and dyes, while the largest proportion goes into papermaking. Due to a widening variety of life styles, the demand for more and more high grade china clay has to be met. However, a serious competitor has emerged since the last World War not only for the UK china clay producers but also for the international china clay market. According to Colin Bristow, “US kaolin exports exceeded US kaolin imports in 1963, and by 1974 three-quarters of a million tonnes of kaolin, mostly paper coating clay, was being exported.”¹ China clay from Cornwall was mainly exported to Europe, to where the US kaolin industry in Georgia has begun now to export its product, calcium carbonate, derived from chalk, limestone or marble deposits. Again in Professor Bristow’s phrase, “In 1970 practically no calcium carbonate based fillers and coatings were used in the European paper industry, but by the early nineties between one third and one half of all the mineral matter used in paper manufacture was composed of calcium carbonate.”² He gives us the data that by 1990 the output of Georgia and South Carolina was 9 million tonnes, as against 3 million tonnes from Cornwall and Devon.³ Furthermore, these days aggressive competitors have successively appeared in the Amazon Basin and in Queensland, Australia, both of whom produce lucrative paper coating kaolins, and they are further intensifying the competition for china clay markets. The Cornish china clay industry is fighting to survive against its

competitors by improving its productivity, changing and rationalizing labour conditions and practices to reduce costs.

As professor Bristow points out, there are some useful possibilities to keep china clay to survive. The main possibility is to recover such useful materials from the waste products of the china clay industry as Lithium, mica, topaz, feldspar, etc. From mica residues lithium is recovered, which is now 'a space age metal', and its range of usage is very wide from "established applications in aluminium production to aerospace, batteries, lubricants, greases, and synthetic rubber production".⁴ Especially because of its predicted potential use in fusion nuclear reactors, the British government has an interest in this metal. The St. Austell resource is very promising, so the Cornish can probably boast having the largest resource of lithium in the European Union. Concerning mica, it has already been recycled in a variety of industrial applications as an important industrial filler in the plastic industry, the automotive industry, and in the paint industry. Another mineral, topaz when calcined, may be a promising possibility as a starting material for synthesising fluorochemicals such as the fluoride used in toothpaste. Feldspar is also recoverable and used in the ceramics industry. If it were economic to do, all the other small quantities of minerals could be technically recovered using well-established mineral processing technology.

The last but not least problem which the present china clay industry has to face is the threat of a modern computerised society. Today people seem to live in the middle of a so-called 'electronic revolution'. There was what is called 'the Agricultural Revolution' which preceded the Industrial Revolution in the 17th/18th centuries in England. Therefore, the present revolution may well be called the third revolution. A variety of publications through the electronic media are sweeping over the whole of traditional publishing in print. It is said that the paperless age is not that far off. Some believe that the use of paper in business for records and correspondence should be declining by 1980 and by 1990, and most record-handling will be electronic. Contrary to this prediction, the drastic reduction of paper has not yet occurred. We may have to wait until next century to see the influence of this electronic revolution upon the Cornish china clay industry.

Despite the present electronic trend in the world, we have to preserve the industrial remains of this china clay industry for our posterity. On the route of the B3274, two miles North of St. Austell, you can see the Wheal Martyn China Clay Heritage Centre. The easiest access for tourists is by bus (bound for Bodmin) from

the St. Austell bus station just in front of the railway station. It takes about 20 minutes.

In the early 1970s action was taken to preserve the industrial history and the heritage of the china clay industry. Because of modern mechanisation in the china clay industry, many traditional methods had disappeared. Production at the present rate has hastened the destruction of the old historic sites and landscapes. But thanks to the china clay workers who served long for the industry, many of its practices and stories still survive. After an action group was formed in 1972 by them, the St. Austell China Clay Museum Limited was founded on January 23, 1974 and the museum was officially opened to the public in March 25, 1975.

Wheal Martyn is probably the most historic example remaining of a small family business. The Martyn family bought the Carthew Estate in 1790, and began china clay production. Their china clay industry was enlarged and was prosperous in 1849. Until it was closed in 1966, this clay works was managed in turn by Eliza, Richard, his widow and finally Miss Ivy Martyn before becoming part of the English China Clays Company.

The method of producing china clay at the Wheal Martyn pit is the same as I have already explained in the earlier chapter. The main feature of this pit is that it had a water engine which provided the power for pumping. A stream coming down the hillside from the west was diverted by launder to operate a large overshot wheel, 25 ft diameter. This wheel drove a flat rod to a distant pump about 100 ft long. This water-engine is a magnificent example of Cornish engineering skill used to harness water-power for a clay-works pump. In the same site there is another waterwheel, 35 ft in diameter, which was used to operate a flat-rod driving another pump 2,000 ft away. This wheel was restored in the late summer of 1968. As the pump sucked up the slurry using the power of a water wheel, it was discharged into a set of micas from which the refined liquid settled down into tanks and finally into kiln tanks located alongside the dry. It took three months for the clay in the kiln tanks to be ready for panning. Besides two working waterwheels, there are mica-drags, and a display housed inside a well restored pan-kiln. Various outdoor exhibits include railway locomotives, carts and a Peerless lorry.

This small intimate works, now a working museum, should be kept as a historic heritage or witness of an industry which has made such a great contribution to the British economy.

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