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by
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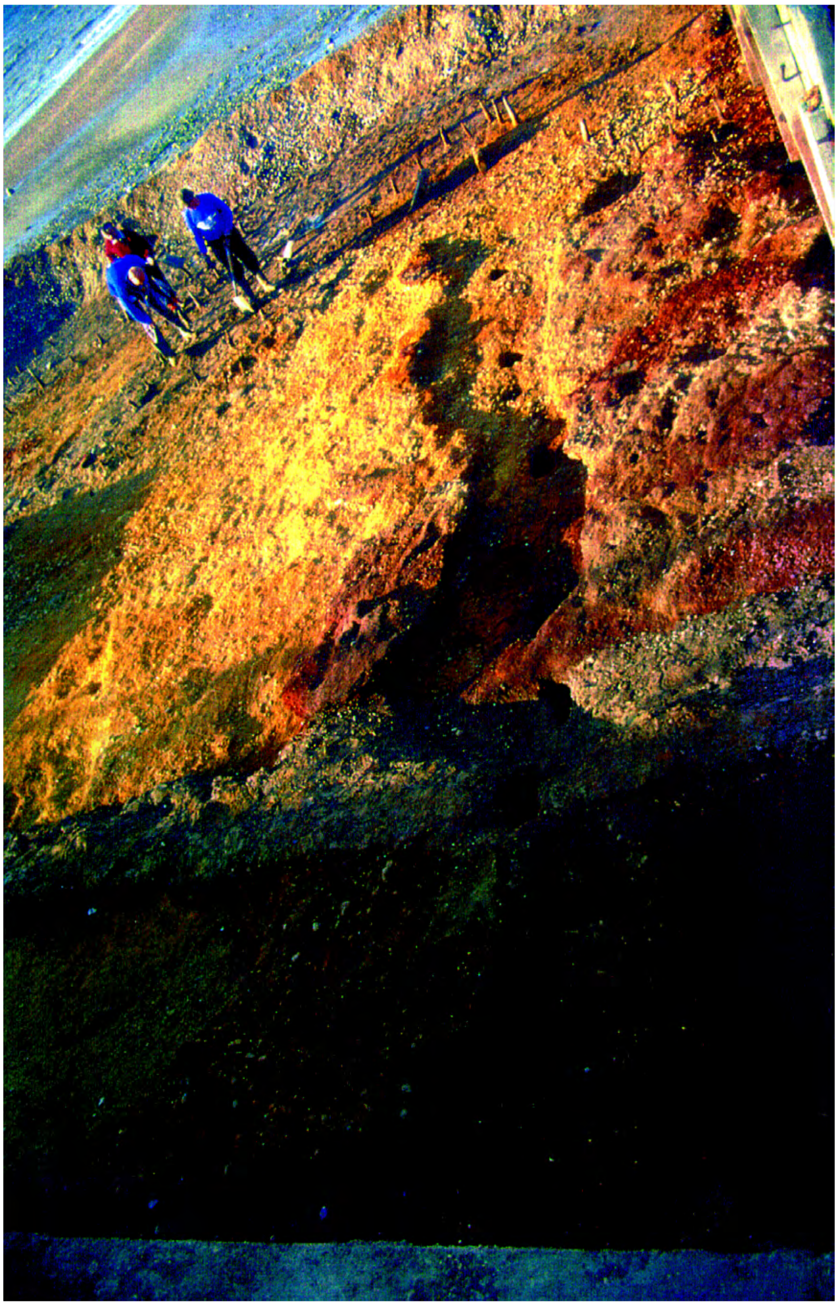

Frontispiece: Part of the buried industrial landscape associated with the copperas works is exposed on Tankerson forehsore in 1998.

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Tim Allen, Mike Cotterill and Geoffrey Pike
November 2002

1
Introduction

General introduction

In 1995 members of the Oyster Coast Fossil Society observed that marine erosion had exposed a great number and variety of timber structures and a substantial poured mortar floor along the length of the upper foreshore on the western part of Tankerton Bay, immediately east of Whitstable and west of Swalecliffe, on the North Kent Coast, some 5.6 miles (9 km.) north of Canterbury (**Fig. 1**) Amongst these remains was an extensive complex of wooden posts laid out in a predominantly zigzag pattern and set in an expanse of yellow-orange poured mortar, forming what appeared to be a man-made surface. The zigzag-shaped structures came to be called 'copperas pits' because of their position beneath the Tankerton Slopes, where eighteenth- and early nineteenth-century maps show the presence of a group of buildings usually marked as 'copperas houses' (**Figs 2, 26 and 27**).

In their exposed state both the mortar surface and timber structures were subject to continued erosion and in danger of complete destruction in the event of severe wave action. The remains were also considered to be threatened by collateral damage from coastal protection works, a scheme for which had been submitted to the then Ministry of Agriculture, Fisheries and Food by Canterbury City Council and accepted. Prior to the commencement of the protection work, Canterbury Archaeological Trust was commissioned by English Heritage to undertake an archaeological evaluation in order to expose, record and ascertain the significance of the remains before they were destroyed or reburied. The evaluation took place in March 1997. On the basis of the results and the recommendation of Ted Edwards, Principal Engineer of the City Council's Sea Defences Department, a further programme of excavation, funded by the Council via the Ministry of Agriculture, Fisheries and Food, was undertaken between 20 May and 12 June 1998.[1]

Iron pyrites (ferrous disulphide/FeS_2, also commonly known as fool's gold or gold stone), occurs in certain Eocene bands of London Clay in Essex and Kent and is ubiquitous in the Thames Basin, where it occurs in the form of spherical nodules (defined mineralogically as 'marcasite') and as thin twig-like fossils. The pyritic nodules occur in profusion on the Whitstable foreshore, where they used to be known as 'copperas stones' or 'gold stones', the latter name deriving from the brown oxidised crust surrounding a radiating core of yellow fibres, which makes up the structure of each nodule. Crystals of copperas or ferrous sulphate heptahydrate can be produced from iron pyrites and an industry therefore developed at Whitstable and at various other sites on the Greater Thames estuary. The majority were on the Essex and north Kent coast, where the London Clay is exposed and eroded by the action of the sea. Other centres were established on the coastal margins of the Isle of Wight, Hampshire and Dorset, where iron pyrites occurs in Jurassic, Cretaceous and Eocene deposits. In Hampshire and Dorset the industry was focused on the Bournemouth area, where large quantities of the raw material were first extracted from surface deposits of the Bagshot and Bracklesham Beds. Later the centre of copperas production shifted to the northern coalfields of Tyneside and Yorkshire and to Scotland.

It has been proposed that the name 'copperas' derives from the German *Kupferwasse* (copperwater) on the basis that the first North European copperas producers eventually used iron pyrites as a replacement for copper pyrites because it was a richer source of copperas, but they retained the old name (Pearce undated). A more commonly held view is that the word derives from the Latin '*cupri rosa*' (rose, figuratively 'flower' of copper) via the French *couperose* (George 1991, Donald undated). As pure copperas contains no copper, this name may have arisen due to a mistaking of the substance's chemical identity in antiquity.

1 This is probably the first time that archaeological mitigation work has formed part of a coastal protection scheme. It is hoped that a precedent has now been established for future work.

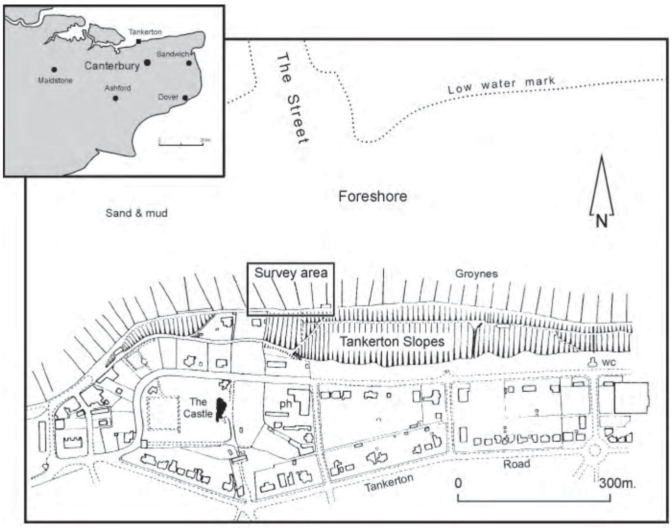


Fig. 1. Location plan

Copperas, the end product of a long and noxious process, was also known as 'green vitriol' (hence sulphuric acid, which was produced from it, was known as 'oil of vitriol') and occasionally as brimstone, although the latter was sometimes also used as a generic term for sulphur or any sulphur-rich substance. It should be noted that copperas is often referred to in association with alum, a term denoting a range of dye fixatives that are more versatile than copperas but more difficult to produce. Copperas can be produced as a by-product of alum production and it is probable that the first copperas production in England resulted initially from failed attempts to make alum, which was the more valuable product. However, copperas quickly came to make up the bulk of the early trade in home-produced dye fixatives, presumably because it was easier and more cost effective to produce.

With its origins in prehistory and its world-wide importance in the textile industries over a long period, it is surprising that copperas production has received scant individual attention in studies of the development of the chemical industry and, in the broader perspective, Industrial Revolution studies. In particular, a comprehensive history of the early copperas industry in England has never been published, although several researchers have compiled detailed notes on, or written in-depth accounts of, various aspects of the industry (Cotterill 1991; Donald undated; George 1975; Goodsall 1956; Pearce undated). This contrasts starkly with the several detailed and authoritative accounts which exist for alum[2] production (Jenkins 1936; Singer 1948; Bettey 1982). The role of the chemical industry in general (and the copperas industry in particular) has been poorly served in studies of the Industrial Revolution, largely because of an over-emphasis on the metal industries. Indeed, as Spence states: '... the equally significant extraction and application of substances we should now call 'chemical', which have led to many changes in the lives of men and to many new activities, have not been so well recognised or given the importance they merit' (1948, v–vi).

Historical background

The origins of copperas production lie in prehistory. The industry is thought to have existed in ancient Babylon (Singer 1948), although it is unlikely that the Babylonians differentiated between the various sulphur-based mordants. At this period, the production process would have been highly unpredictable and was probably considered a quasi-magical affair. The industry was certainly well-established in the Classical period; a substance (*alumen*) discussed by Pliny in about A.D. 70[3] has been identified as designating both ferrous sulphate and the other common vitriols, copper sulphate, zinc sulphate and aluminium sulphate (Agricola 1556). Indeed, Herodotus, some 500 years earlier than Pliny, refers to a substance called *stypteria*, and later Roman authors equate this Greek term with the Latin *alumen* without qualification.

Pliny describes the use of *alumen* for dying cloth in some detail, lists the places from which it came and also describes its varied appearance and properties. A clearer identification of copperas was made by the Spanish Moor Jabir-ibn-Hayyan[4] of Cordova (A.D. 721–815), who was known in Europe as 'Geber' (Williams 1969, 52). Unlike the classical authors, Jabir-ibn-Hayyan drew a distinction between ferrous sulphate (green vitriol or copperas) and copper sulphate (blue vitriol). Later, in Northern Europe, Theophilus (*c.* 1100) mentions several uses of green vitriol (Presbyter 1979, 15, 115, 152), and Albert Groot, the great theologian with scientific interests and better known as Albertus Magnus (1193–1282), gave what is probably the earliest account of the production process for green vitriol (Best and Brightman 1973, 128). In the thirteenth century Raymond Lull from Majorca is known to have prepared copperas from pyrites (Partington 1962; Guttman 1901, 5; Thorpe 1909, 31).

By the fourteenth century, vitriol production was centred in Asia Minor, principally in the Constantinople and Smyrna areas, where a Genoese syndicate controlled the trade. The Italians appear to have acted first as middlemen and then to have settled down as copperas producers, dyers and cloth merchants (Hoover 1950, 569). The initiating stimulus for the European industry came with the fall of Constantinople

2 'Alum', technically a double sulphate of aluminium and not a vitriol, appears sometimes to have been used in antiquity in its Latin form '*alumen*' as a generic term referring to all kinds of vitriols, of which copperas was one. Copperas, however, is never used to designate alum.

3 *Historia Naturalis* (*c.* A.D. 70), XXXV, 52.

4 Many Arabic texts attributed to Jabir were however compiled in the tenth century by the Ism'iliya religious sect (Brock 1992, 20).

to the Turks in 1453, when many of the Italian producers fled back to Italy. Following this, the Turks imposed prohibitive export duties on vitriols, posing a serious threat to the European cloth industry (Brooks 1946, 222).

One of the Italian refugees was a dyer called John de Castro who, using his knowledge of vitriol production in Constantinople (in this case zinc sulphate, known as 'white vitriol'), re-founded the industry on papal territory under the auspices of the Apostolic Chamber.[5] De Castro discovered that the ore used as raw material in Asia Minor also occurred at Tolfa, near Civita Vecchia, where production began. A papal monopoly was established and enforced, often by threat of excommunication, in Spain, the Netherlands (in particular Brabant), Denmark and Germany, in which countries blue and green vitriol were produced from native pyrites under papal licence. An Italian decree of 1480 prohibited Master Dyers from keeping green vitriol, here called 'vitriolum', and other tanning agents in their workshops. This was apparently an attempt to protect the native woad industry and followed similar injunctions against indigo, another supposedly corrosive and 'diabolical' dye from the east, in England, France and Germany (Brunello 1973, 190–1). The prejudice against new and exotic dyestuffs was clearly deep and long-lasting. A manuscript from Ferrara dated 1550 warns: 'Dyers tell merchants that vitriol darkens cloth and produces a better result and does not harm the cloth. They do not tell the truth and use it to destroy cloth, using only a little woad and then covering it with vitriol later' (Zanazzo 1914, 191).

During the period of the papal monopoly vitriol production was effectively controlled by a ring of Italian financiers resident in Antwerp. The ring was headed by Augostino Sauli and included the Genoese Battista Spinola and Nicolo Palavicino, with Palavicino controlling the English market. Between 1550 and 1560 the price of vitriols doubled under the control of this ring, although William Tipper, a London merchant, wrote: 'When Palavicino had the whole trade and contract for alum he served the Realm better cheap than long before it had been' (Stone 1956, 48). It was in Antwerp that the overland route for white vitriol and potash alum from Italy terminated. At that time England was importing 10,000 quintals of vitriol per annum at a cost of £15,000 (Stone 1956, 52), equivalent to many millions of pounds in present-day terms (in this context one quintal was usually equal to a 'short' hundred weight of 100 lbs). Antwerp was at that time the centre of both the wool trade and the associated vitriol trade and was therefore the great textile *entrepôt* of Northern Europe 'such as the world had never seen' (Rowse 1950, 142). Given the massive scale of the English wool industry (75 per cent of all export earnings), the papal monopoly and Spanish trade contraints threatened economic disaster. The stimulus had therefore been provided to initiate a search for a source of vitriol in England. One of those sources was to be at Whitstable, where the recent archaeological discoveries have precipitated an in-depth study of this hitherto neglected industry which was of great national economic importance for over two and a half centuries.

The uses of copperas

The principal use of copperas was as a dye fixative for woollens. Another important use, when used in combination with oak-gall, was as a black dye (V.C.H. 1907, 411). By the sixteenth century the production of woollen cloth had become the largest of the domestic manufacturing industries, forming about three-quarters of the country's total export and ranking second after agriculture in overall importance. Later, copperas was used to produce the nitric acid ('*aqua fortis*') required by gilders and brass founders and, more importantly, to manufacture sulphuric acid, known as oil of vitriol, which was used extensively in metallurgy. It was also increasingly demanded by dyers as an alternative to copperas for use as dye and dye fixative, for example, Prussian Blue and Saxony Blue, the latter made by dissolving indigo in strong sulphuric acid (Haber 1958, 2; Aikin and Aikin 1807, 375).

England had achieved a European reputation for the production of sulphuric acid from domestic supplies of copperas by the late seventeenth century (Cotterill 1991, 16). The copperas industry was closely linked to the major Kentish centres of cloth production, located for the most part around Cranbrook in the Weald of Kent. In a Cranbrook clothier's inventory dated 1567, we find that the clothier was in possession of 'a c[wt] of copparasse and 5 li of allam, 20s' (Melling 1961, 110). Unlike their West Country counterparts, the Kentish clothiers dyed their yarn before weaving, rather than dying the cloth afterwards. Whilst copperas was at first used chiefly for dying, and later for the manufacture of sulphuric acid, it was also widely used to colour leather goods black after tanning, and for a great many other purposes as discussed below.

A report in the State Papers of Elizabeth I (January 1584) records that a large proportion (one third) of 'Brimstone' went for the 'Tryminge and Dressinge of shippes and other vessels'.[6] The significance of 'Tryminge and Dressinge ...' etc, is not yet understood, although it was possibly related to the stripping and tarring of ship's timbers known as 'blacking' (Goodsall 1956, 154; Traill 1981, 371). It has been suggested that tar impregnated with sulphur, which has toxic properties, might constitute an effective anti-fouling agent and this may explain the extensive use of the material in this way (I. MacKenzie, National Maritime Museum, pers. comm.)

The same report records that another third of the annual consumption of 'Brimstone' was used to manufacture gunpowder. Gunpowder was made using saltpetre, charcoal and sulphur. Sulphur was imported from Sicily at great cost to the Crown, a fact which may explain the urgent search for a domestic supply. It is possible that the 'Brimstone' referred to in the report here denotes sulphur rather than copperas,

5 The Commentaries of Pius II, 1614, 185.

6 State Papers Dom. Eliz. [12] 167, No. 56, Public Record Office, Kew.

Fig. 2. Detail from Mudge's map, 1801, © Harry Margary, Lympne Castle, Kent.

with the sulphur being produced as a residue when copperas stones were heated up in 'firnaces'. The report goes on to say that 'Brimstone' was 'Drawen out by force of the fyre of suche stones as here we psent to yr honrs wherof we fynd sufficient quantytie upon the Coastes of the Isle of Sheppey Whitstable and other Coasts therabouts.' Presumably, the stones presented to their honours were copperas stones. In 1579 Lambarde made a distinction between sulphur and copperas production on the Isle of Sheppey in his *Perambulations*. A 'Brabanter' called Matthias Falconer is described as trying to 'drawe very good Brimstone and Copperas out of a certein stone...' (Lambarde 1826, 228).

In 1570 a method of producing sulphur probably specifically for the manufacture of gunpowder was discovered by Christopher Saunders (Chaptal 1807, 270–2). Layers of copperas stones were built around a chimney channel, above a wood fuel base. The whole was then covered by earth and wet ashes to make a pyamid-like structure rather like a charcoal-burner's mound. The wood was ignited and, following the roasting process, the copperas stones yielded condensed deposits of sulphur along with a residue suitable for making copperas. Lesser quantities of copperas stone ('the brightest of these Stones'), were also required for the production of 'wheel-lock pistols and fuses' (Colwall 1677, 1057). As sulphur is a prerequisite of gunpowder production, it is not clear how copperas stones alone could be used in this way. However, it is possible that the stones were ground up before being mixed with gunpowder to produce a sparking chemical, perhaps similar to the chemical used to make modern sparklers.

The possible early use of copperas stones in the manufacture of gunpowder is not well understood and presents a fascinating research topic in its own right, especially regarding the relationship of the Whitstable copperas industry with the Faversham gunpowder works, some 10 miles to the west. The first gunpowder works at Faversham appears to have been established some time before 1573, when a Thomas Gyll is referred to in a muster roll as a gunpowder maker (Crocker *et al*. 1999, 36). This reference confirms the assertion made in 1774 by Faversham's first historian Edward Jacob that there was a '... Powder Maker in Faversham in the sixteenth century'. It is therefore possible that this early phase of gunpowder manufacture in Faversham was based on the extraction of sulphur from copperas stone as described above, and that a gunpowder industry was originally established in Faversham because of its proximity to the Whitstable and Queenborough copperas stone beds.[7] It is likely that the copperas industry received a significant boost during the English Civil War (1640–60), when there was a massive increase in the demand for uniforms, gunpowder, saddles, harnesses, etc.

During the medieval period, copperas mixed with thornwood extract had been used as scribe's ink ('*incaustrum*', also '*atramentum*'), to colour gold and in *repoussé* work. Earlier still, during the Classical period, copperas appears to have been used as shoe-maker's black under the name '*atramentum sutorium*' (Presbyter 1979, 15, 115, 152). Copperas, along with tannin-rich oak galls, was also used in the production of ink (Watson 1787, 228; Aikin and Aikin 1807, 566). The seventeenth century saw a marked increase in literacy and consequently a vast increase in the numbers of hand-written letters, records and general documentation, and this too must have acted to boost the copperas industry. To make writing ink the copperas/oak gall solution was reduced by fire to an easily transportable black powder, which could then be reconstituted as a solution when required.

In the late seventeenth century Dr Robert Plot, a noted antiquary of Kentish origin, attributed the scarcity of rats and moles on the island of Sheppey to the toxic property of copperas stones,[8] and that this property also allowed copperas to be used as a dressing for scab in sheep (V.C.H. 1892, 397). An account dated 1464 makes mention of '... a cure for sore eyes using white coperose' (Hudson-Williams 1841, 280), white copperas being zinc sulphate. The medicinal use of the substance for humans continued into and beyond the eighteenth century, at which period it was used (presumably in very small quantities) as a laxative. It later became the basis for many pharmaceutical products, especially the fashionable tonic and purgative known as Glauber's 'Sal Mirabile', thus establishing a clear link between copperas and the emergent pharmaceutical industries. The Royal Navy used 'elixir' of vitriol (ineffectively) to treat scurvy (Carpenter 1986, 17) and John White (in Page 1763, 14–15) described 'Cleanest Copperas' as the principal ingredient in the preparation of Joshua Ward's highly popular patent medicine marketed as 'White Drop'. Watson (1787, 228) stated that copperas of a quality suitable for export was not produced until the late seventeenth century and this may explain the beginning of the export trade in sulphuric acid, the production of which required high quality copperas. Watson also showed that between the 1680s and the 1780s, an annual importation of 500 tons of copperas was transformed into an annual exportation of 2000 tons. By the middle of the eighteenth century, the principal use of copperas was its part in the production of sulphuric acid, the use and importance of which had increased so rapidly that by 1843 it was famously stated that '… we may fairly judge of the commercial prosperity of a country from the amount of sulphuric acid it consumes' (Leibig 1843, 30).

By the late eighteenth century sulphuric acid was not only needed by dyers but was also used for other processes, such as the manufacture of soda (Clapham 1869, 36–7), bleaching cotton (Aikin and Aikin 1807, 144), refining sugar from sugar beet (Hogben 1946, 436) and the manufacture of nitric and hydrochloric acid, both used extensively in the metal trade (Cotterill 1991, 38). It was also used to bleach manuscript paper prior to recycling (Ure 1821, under bleach). The importance of sulphuric acid was further increased by the discovery in 1774 of chlorine, first called oxymuriatic acid, by C.W. Scheele at Uppsala, Sweden (Thorpe 1909, 31; Guttman 1901, 5; Partington 1962). Chlorine, which was made using sulphuric acid, common salt and manganese dioxide (Cotterill 1991, 91–2), came to be used for a short period in the late eighteenth/early nineteenth century as a textile bleach, although not in its highly toxic gas form (Aikin and Aikin 1807, 144). This represented another link between the copperas industry and cloth producers because initially the sulphuric acid appears to have been made from copperas (Macquer 1777, 608; Nicholson 1795, 65).

However, from the late eighteenth century onwards, sulphuric acid for this purpose was increasingly made using imported mineral sulphur (Chaptal 1807, 273–5). The traditional bleaching agent for wool and silk (and also, curiously, straw) is reported to have been the gas sulphur dioxide (SO_2), because these more delicate materials would have been damaged by chlorine (Aikin and Aikin 1807, 145–6; Hicks 1963, 458; Kingzett 1877, 180; Tomlinson 1854, 799). This raises the intriguing possibility that some *ad hoc* textile bleaching may have taken place within the copperas works themselves because SO_2 can be produced as a by-product of copperas production (see p. 27).

Whilst the south-eastern copperas industry in general declined gradually throughout the late eighteenth and early nineteenth century, the works at Queenborough, on the Isle of Sheppey, continued to diversify and flourish. Copperas and 'brimstone' are known to have been produced there in 1579 (see p. 29) and Stevens Sons and Company were still producing copperas at the Queenborough Chemical and Copperas Works as late as 1882. In 1886 the same company

7 It should be noted that in contrast to the dry condensation process represented by the Saunders method, the 'wet process' as discovered here used for copperas production practised in Whitstable and elsewhere was not suitable as a means of producing sulphur (Frank Panton, pers. comm; Mellor 1930, 2, 255-5).

8 Plot's *Natural History of Staffordshire* (1686) is an important source of data on early Midland industries and is extensively quoted in Court's classic text on economic history (1938).

had begun manufacturing the fertilisers Sulphate of Ammonia and Superphosphate, the latter also called 'vitriolised bones', using sulphuric acid produced from copperas stones. The company, which is still owned by the Stevens family and now known as Sheppy Fertilisers Ltd, continues to produce inorganic and semi-organic compound fertilisers and superphosphates, thus demonstrating a 400-year long period of development between the ancient copperas works and the modern chemical industry.

It is clear that during the seventeenth and eighteenth centuries copperas increased greatly in economic importance and, following the founding of the domestic industry, eventually became a major English export under the name of 'English Green Vitriol'. Indeed, in 1764 it was claimed that England was the principal European producer (Croker *et al.* 1764), making the domestic copperas industry a major economic asset in terms of export earnings. Eventually, copperas came to be used in a range of products related to the paint industry, including the production of the important pigment, Venetian Red. This later use, however, falls outside the scope of the present study.

2
The Archaeological Excavation

Introduction

The archaeological site was immediately adjacent to and seaward of the concrete sea wall/promenade, which is of twentieth-century construction. The origin of the cliff at Tankerton, to the east of Whitstable harbour, has been ascribed to marine erosion (Holmes 1981, 101–5). However, a large body of evidence is now available, including the archaeological evidence discussed below, which clearly refutes this hypothesis (see p. 19).

The remains were concentrated within the area of six groyne-enclosed 'bays' designated as the 'study area'. The poured mortar floor extended discontinuously for more than 60 m. between Groynes 19/19 to 19/21, and the complex of timbers extended for approximately 156 m. from west of Groyne 19/17 to Groyne 19/21 (**Fig. 3**). Prior to the beginning of the first programme of excavation it was proposed, on the basis of achievability in an inter-tidal environment, to evaluate two smaller areas (Areas 1 and 2) within the study area by means of non-destructive excavation, in which no archaeologically significant remains would be disturbed. The same strategy was also adopted for the second programme of work during which another such area (Area 3) was excavated. Prior to excavation and by courtesy of Canterbury City Council, all erosion-exposed timbers within the study area were recorded in plan by Electronic Distance Measuring (EDM) (see **Fig. 3**). The siting of the three evaluation areas was based on the results of this work, each being located where concentrations of timber structures and well-preserved poured mortar occurred. Due to the vagaries of the inter-tidal environment, the EDM survey of the study area is not considered to be comprehensive. For example, when the remains within the eastern parts of the groyne-enclosed bays were exposed by the marine erosion of shingle, the remains in the western parts of each bay were thickly covered by the transported shingle and vice-versa. Furthermore, access to the site was limited to periods of low tide.

Evaluation Areas 1 and 2 were situated adjacent to the eastern groyne and the sea wall in the eastern parts of Bays G19/19–19/20 and G19/18–19/19, respectively. Area 1, in Bay G19/19–19/20 was 297 m.^{2}, Area 2, in Bay G19/18–19/19 was 53 m.^{2} and Area 3, exposed during the second programme of excavation in Bay G19/17–19/18, was 182 m.^{2}. The study area measured 5250 m.^{2}. The total evaluated area (532 m.^{2}) was therefore 10 per cent of the whole. Areas 1 and 2 lay immediately south and landward of the long shingle-covered London Clay bank ('the Street') which extends north for a considerable distance from the foreshore into the sea (**Fig. 4**). During exceptionally high seas, this natural feature no doubt afforded some protection to the excavated wood and stone structures described below.

Initial excavation was undertaken by mechanical digger. During this phase most of the overburden of shingle and sand was removed and used in conjunction with the sea wall to form a rectangular dam around each evaluation area in order to reduce the destructive effects of wave action. However, because shingle is fully permeable, each area was inundated at high tide. The lower part of the shingle and sand was removed by hand in order not to damage the archaeological remains.

In both Areas 1 and 2 a small number of individual timbers which could not be identified with larger structures and whose functions remain unknown are not discussed, but are shown on plan (**Figs 5** and **6**).

Evaluation Area 1

Area 1 contained a modern pit (3) which cut into a sequence of red/brown-stained poured mortar layers, and bright yellow powder, sand and shingle (see **Figs 5** and **7**). These deposits appeared to represent a series of floors, floor beddings and levellings laid down over a protracted period of time. The pit extended down 0.74 m. into, but did not reach the base of, the sequence, which contained at least three consolidated surfaces with embedded occupation detritus mostly comprising scrap iron fragments and iron and copper nails.

The overall depth of the deposit sequence was not completely exposed by the pit, but severe erosion to the west

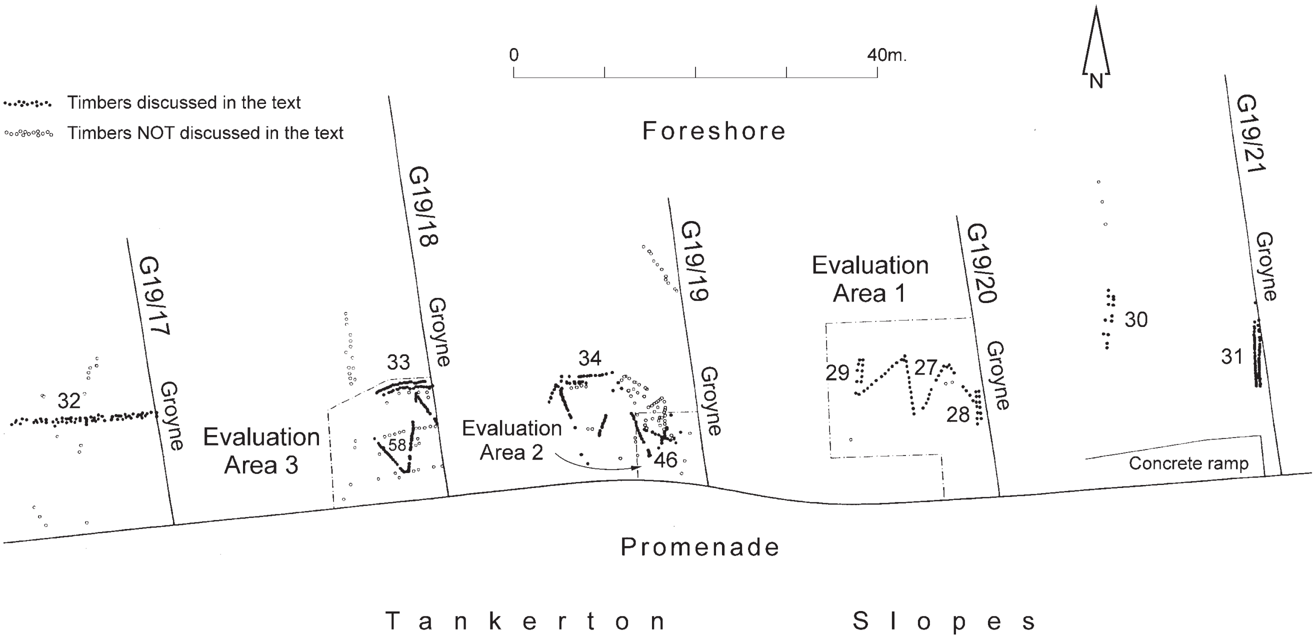


Fig. 3. The results of the survey of exposed timber remains and the three evaluation areas on the Tankerton foreshore.

and north-west showed its full depth to be approximately 0.95 m., although the eroded exposures were at a very acute angle to the horizontal. The uppermost of the consolidated surfaces (20) was also the uppermost layer within the sequence and probably represented the floor in use when the site was abandoned. Like the underlying poured-mortar layers (6, which was also exposed as a surface deposit to the south and north, and 12), it took the form of a compacted fine-grained, red-brown material with an apparently deliberately-smoothed upper surface, the whole having an even thickness of 30 mm.. The red-brown colour of layer 20 appeared to be the result of staining which had also affected an underlying band of fine shingle (19). This in turn overlay an earlier red/brown-stained poured mortar surface (6) bedded on a layer of yellow powdery material (7), presumably waste product from the copperas works.

The mortar floors, floor beddings and levellings extended down to a depth of 0.52 m. where a basal sequence comprising (possibly sulphurous) yellow powdery deposits of uneven thickness occurred (sulphur is the main constituent of iron pyrites). These deposits (18, 17, 16, 15 and 14) were interpreted as the dumped by-products of copperas production. The depth of the basal layer (18) varied greatly and its uneven thickness (maximum 0.16 m.) was considered to be not wholly the result of erosion. The four overlying and similarly yellow, powdery deposits were also of uneven thickness and appeared to have resulted from dumping in the area. The presence in the upper part of the sequence of three layers of yellow powdery material (7, 11, 13), each underlying a poured mortar surface or a mortar bedding, suggested that this by-product was used as levelling at a later period. The uppermost surface (20) within the floor sequence survived only in patches and did not have an obvious stratigraphic relationship with any of the many timbers exposed in Area 1. However, an earlier poured mortar layer (6) clearly post-dated an upright timber as it had been moulded around it.

The upright timber comprised part of a north–south aligned double row of similar timbers (28) interpreted as a jetty or wharf support (see p. 25). This was parallel to three other such similarly-interpreted structures exposed in the study area. One (29) lay 13 m. to the west, one (30) lay 14 m. to the east and another (31) lay 30 m. to the east (**Fig. 3**). As each was approximately equidistant to the next, it was thought that they were contemporary.

A series of timber posts (27) arranged in four lines forming a zigzag was bounded by two of these structures (28, 29, **Fig. 5**). As these extended exactly between two double-row timber structures they too were considered contemporary. The uppermost poured mortar layer (20) was cut by a roughly 1 m. wide east–west aligned strip trench (22, fill 21), the function of which could not identified. This feature apparently pre-dated the use of mechanical diggers as its edges were irregular and its mixed clay and sand backfill comprised compacted spade-sized blocks.

Trench 22 was in turn cut by a north–south aligned clay- and shingle-filled linear trench (24) which was between 0.70 to 0.90 m. wide. Excavation showed this feature to be approximately 0.50 m. deep against the sea wall and to be punctuated at approximately 2 metre intervals by post-pits, one of which still contained a post. The trench became progressively shallower as it extended seaward and was completely eroded away at a distance of 12 m.. This feature was interpreted as the remains of an earlier groyne, as was a rectilinear pit (26) situated some 0.10 m. to its west. The backfill (25) of this pit surrounded a sea-blackened truncated timber set diagonally to the vertical with the upper part pointing in the direction of trench 24. The timber was interpreted as the base of a diagonal support for the earlier groyne.

The modern pit (3) excavated in the south-west corner of Bay G19/19–19/20 was identified to be modern by cellophane confectionary wrappers found within its shingle and clay fills. This, along with its position and shape, suggested it was a machine-excavated test pit associated with the construction of the existing groyne system. A surrounding spread of puddled clay some 0.08 m. thick was interpreted as associated spoil. Both the puddled clay and the pit fill were sealed by a recent shingle deposit (1), which extended across the entire study area up to a depth of 1.50 m..

All the timbers described above were between 50 mm. and 0.12 m. in diameter.

Evaluation Area 2

Area 2 (the south-eastern part of Bay G19/18–19/19) contained a more complex and concentrated arrangement of archaeological features, suggesting that activity associated with the copperas industry had been more intense or protracted on this part of the foreshore. Following the removal of shingle, a test pit measuring 0.90 m. north–south and 0.70 m. east–west was cut into the surface of the London Clay (41) in order to establish whether or not the clay was *in situ.* The test pit exposed a 20–50 mm. thick peat layer (42) at a depth of 50 mm., proving that the surface 'London Clay' was in fact eroded clay redeposited as alluvium in this area. The peat contained two fragments of Kent peg tile, indicating that it had accumulated at least partly during the late medieval or post-medieval period. Also recovered was part of a redeposited perforated Late Neolithic/Early Bronze Age stone mace head (Wilson 1996–7, 37–8), the second such implement to be recovered from the Tankerton foreshore (Kelly 1964, 225).

Further excavation exposed an elongated, roughly rectilinear spread of chalk rubble and limestone blocks (35) extending from Groyne 19/19 for a distance of 5 metres (**Figs 6 and 8**). A 0.90 m. long iron bar was embedded in its surface at right-angles to its south-west alignment. The north-west edge of the chalk and limestone spread abutted a row of twelve upright timbers (40). The feature as a whole, which was 0.70 m. wide, had the appearance of a rough foundation. It was probably contemporary with a row of upright timbers (36) which intersected it diagonally at its exposed end on a south-east to north-east alignment. The area defined by these two linear features was covered by fine-to-medium aggregate flint cobbling (37) which was stained to a depth of at least 50 mm. by a deep red-brown substance (38). The staining was interpreted as the residue from oxidised copperas stones and it was therefore proposed that the stained area marked the approximate site of a copperas bed or a copperas works.

Numerous fragments of brick and a large quantity of iron nails, along with some lead fragments and other metal

Fig. 4. 'The Street' showing part of the expanse of yellow industrial waste.

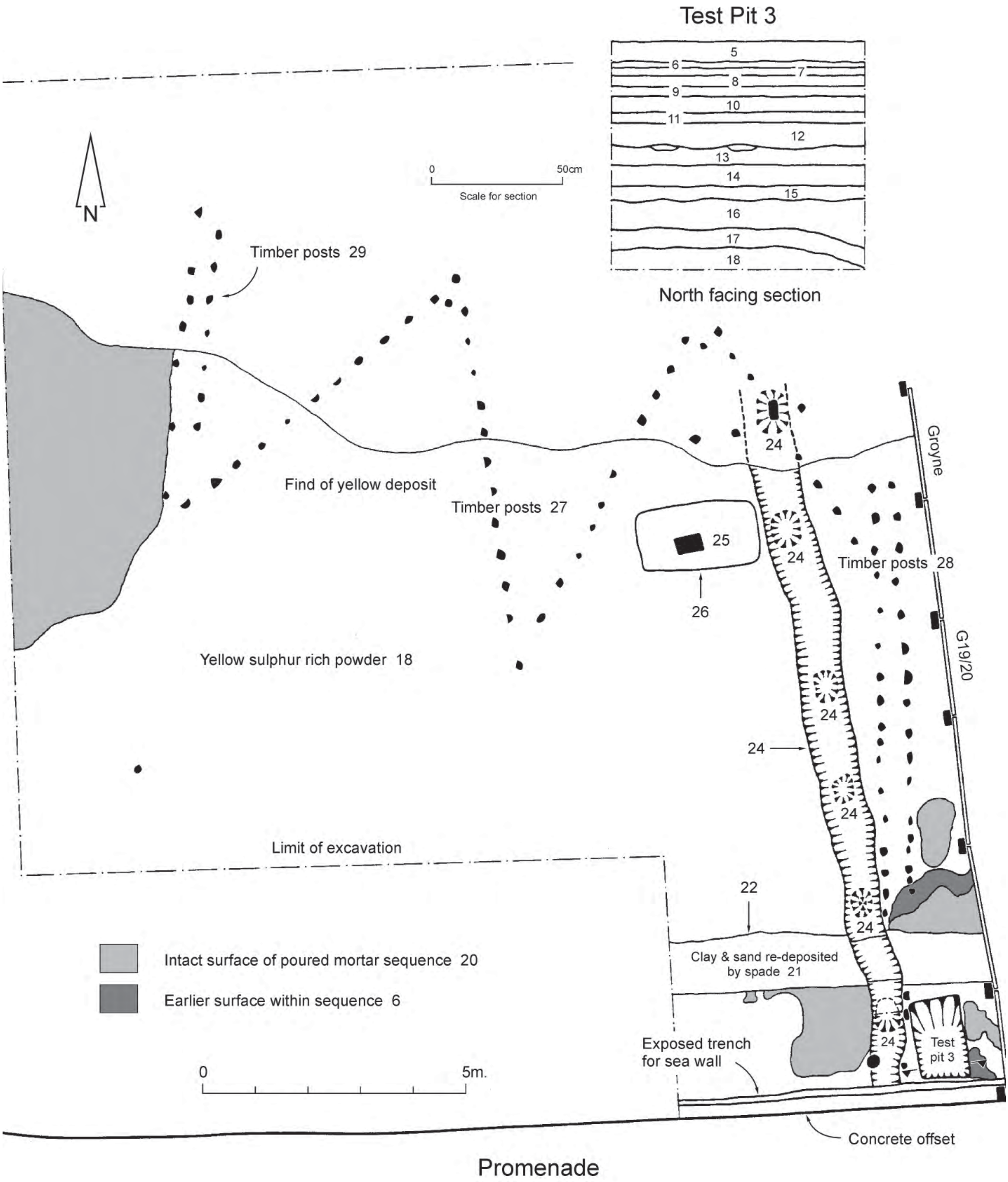


Fig. 5. Excavation plan of Evaluation Area 1.

artefacts, notably early post-medieval lead tokens and cloth seals (see p. 17–18), were recovered from the surface of the flint cobbling (37).

Two rows of upright timbers (46) arranged in a zigzag pattern were exposed which appeared to be part of the same triangularly-arranged pattern of timbers exposed in Area 1. The overall plan of posts and other timbers exposed on the Tankerton Foreshore (**Fig. 3**) showed this arrangement to occupy at least the three bays between Groynes 19/17 to 19/20.

The chalk and limestone spread (35) and the stained cobbling (37/38) underlay a dense scatter of medium and large water-rounded greensand blocks (39), which contained a 0.90 m. long iron bar identical to that in the underlying chalk and limestone spread (35). A thin layer of fine shingle separated the stones from 35/37/38, indicating that the overlying stones were redeposited. Consequently their position roughly within the triangular area defined by post-lines 36 and 40 was thought to result from them having been trapped within the timber posts before the posts were truncated by erosion. This was also thought to be the case in Area 3 (see below and **Fig. 9**). Such stones were exposed and redeposited in large quantities throughout the study area although they do not occur naturally in this area. They were identified as 'dogger' stones from the Upper Thanet Beds and may have represented examples of the 'Stones fitted in' by Sarah Parker around 1775 to consolidate the beach (Goodsall 1956, 159, see p. 26).

Immediately adjacent to and north of the present sea wall was a line of upright timber posts (44) and two sections of edge-set 10 mm. thick planking (43). These formed an approximately east–west aligned linear structure which cut redeposited London Clay (41) to the north and was abutted by a mixture of redeposited shingle and London Clay (45) to the south. In the light of the more extensive evidence for similar structures exposed in Evaluation Area 3 (see below), this was interpreted as the remains of a 'copperas bed', as described by Colwall in 1677 (see p. 19).

Evaluation Area 3

The same method of excavation was adopted as in Areas 1 and 2. The removal of shingle revealed the western side of Evaluation Area 3 (Bay G19/17–19/18) to be severely eroded by the sea. It had also been subject to later disturbance by man as indicated by a backfilled pit of unknown function (47/fill 48), containing concrete fragments. It should be noted that the effects of marine erosion had probably been aggravated in this area by the construction and eventual removal/decay of an earlier groyne, as suggested by the presence of a linear scar sharing the same alignment as a number of timber stumps (see 50 and 51, **Fig. 9**).

Two east–west aligned edge-set planked structures (52, 54) with adjacent upright timber supports, along with a north–south aligned structure (53) comprising six end-set planks appeared to represent the oldest formal remains exposed in this area. The six end-set planks had the appearance of a partition or similar. All the Area 3 remains described above protruded through the poured mortar/levelling sequence discussed below, but where the uppermost layer of the sequence (poured mortar 49) survived, it was moulded around or overlay them, indicating that the planked structures were of earlier date.

Too little of these structures survived for their overall design or function to be identified. However, in the case of 52 and 54, a similarity in construction and alignment with a 10 m. long section of a well-preserved plank and post structure 5 m. to the south (56/57), along with two abutting clay strips (59/67) suggested, on the basis of Colwall description (1677, 1057), that these were parts of copperas beds (see p. 19). This complex of linear features (recorded as 59/57:67/56) consisted of two roughly parallel rows of edge-set timbers (56 and 57), each with a clay lining (respectively 67 and 59) on its southern side. The whole was interpreted on the basis of Colwall's description as comprising the remains of a repaired or rebuilt copperas bed (**Figs 10** and **11**).

Many of the truncated uprights, presumably supports, associated with the four sets of edge-set timbers (52, 54, 56, 57) were of considerable size and one upright (55) consisted of two timbers skilfully joined by mortise and tenon (**Fig. 11**). Two sections (A and B) were cut adjacent to edge-set timber row 57 in order to ascertain its depth and manner of construction (**Fig. 9**).

Section A exposed a composite timber wall extending down to a depth of 1.10 m. at an angle of 60 degrees to the

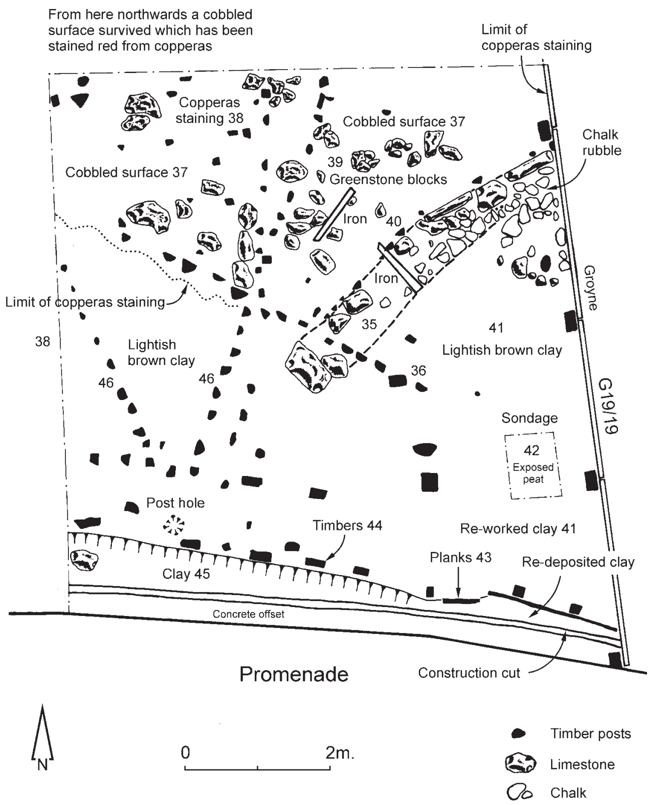


Fig. 6. Excavation plan of Evaluation Area 2.

Fig. 7. The test pit in Area 1.

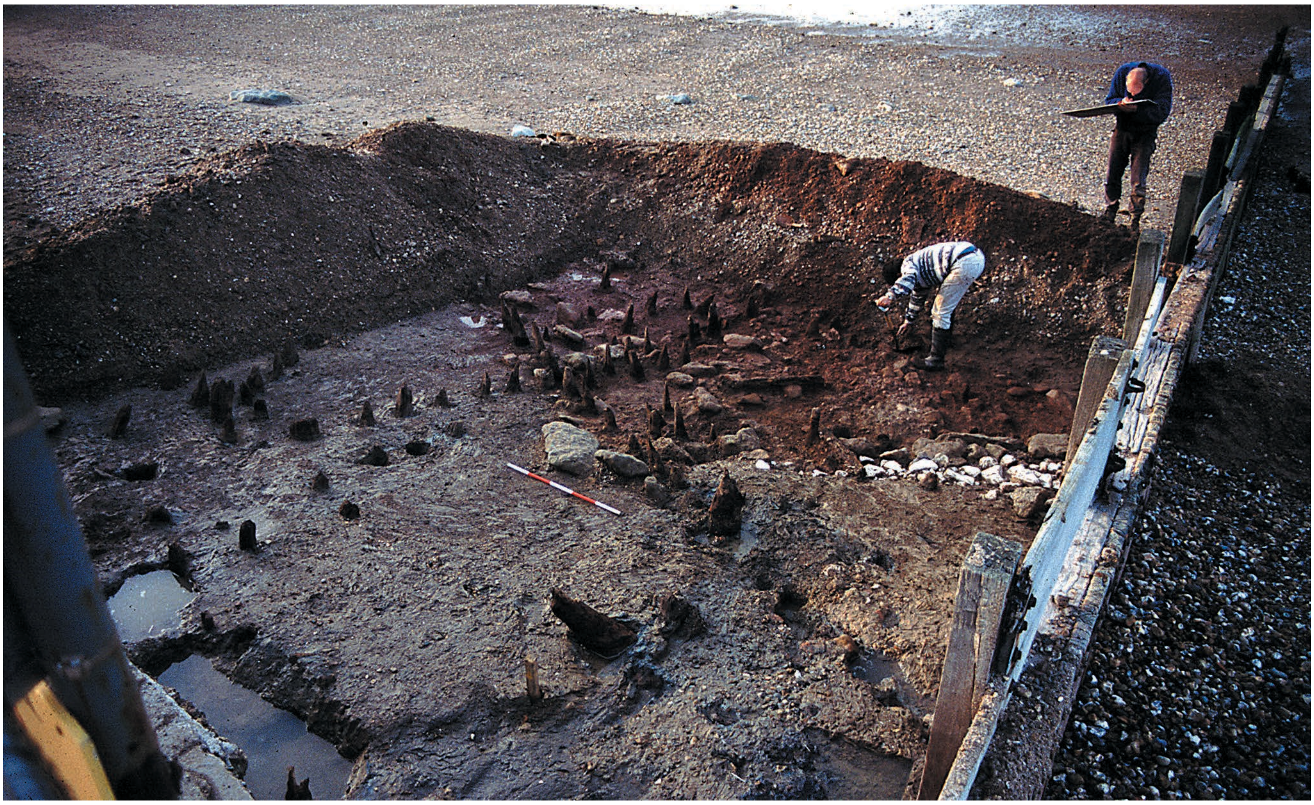


Fig. 8. Evaluation Area 2.

Fig. 9. Excavation plan of Evaluation Area 3.

Fig. 10. Part of a rebuilt or repaired copperas bed.

Fig. 11. A copperas bed support showing mortise-and-tenon work.

horizontal (**Fig. 12**). The construction was shown to be of tenoned upright timbers set into a basal horizontal sleeper beam. Attached to the lower part of the tenoned uprights were vertically-arranged fine-sawn planks of regular size. These underlay three horizontally-arranged split-log or rough-sawn planks. A series of approximately 0.20 m. wide split-log supports (not exposed in section) appeared to have been driven down the outside of the wall. It is more likely, however, that they were driven into the ground at the appropriate angle before the other timbers were attached to them. All visible joins were by mortise and tenon.

Section B extended down to a depth of 0.40 m. and confirmed the construction and angle of the upper part of the timber wall, while an approximate consistency of depth was confirmed following the removal of shingle from a post-hole which had originally contained one of the outer supports. This indicated that the post and the adjoining timber wall extended down to a depth exceeding 0.80 m.. The large size of the timber supports coupled with their deep penetration into the ground and, where visible, the quality of their mortise and tenon joints, suggested that the structures which they supported were originally of considerable height.

Excavation of the eastern part of the bay exposed six *in situ* patches of a consolidated surface layer consisting of red/brown-stained poured mortar (49), which either abutted or was abutted by edge-set timber wall 56 (the outer section of the postulated repaired copperas bed) and was therefore contemporary with it at some stage. The originally large extent of the consolidated surface within Bay G19/17–19/18 was indicated by the widely-scattered nature of the patches. It was observed where marine erosion had taken place that poured mortar 49, like layer 20 in Evaluation Area 1, was the uppermost of a deposit sequence comprising other such mortars occurring within layers of, variously, bright yellow powder, sand and shingle, the sequence as a whole being horizontally well-stratified (see **Fig. 5 inset**). As in Area 1, an aggraded surface of made ground consisting of levelled industrial waste or beach materials underlying poured mortar working surfaces was indicated. On this basis, and because poured mortars 20 and 49 were identical in appearance, they were interpreted as the remains of the same extensive made floor; probably the last to be laid prior to the abandonment of the site in the face of progressive marine encroachment.

Also exposed in Evaluation Area 3 was a series of timber posts (58) arranged in four rows, the whole having a zigzag form similar to the arrangements exposed in Areas 1 and 2. As in the case of Area 1, at least the upper part of the sequence of poured-mortar floor and levellings was formed around the timber posts, suggesting that the posts pre-dated the mortar. However, the insertion of a post into wet mortar may have had the same effect. As one of the more deeply buried mortar floors (layer 6 in Evaluation Area 1) was also observed to be moulded around one of the timber posts, it was assumed that the mortar floor sequence had been relaid several times around the structures represented by the zigzag arrangement of timbers.

The southern apex of the zigzag timber arrangement (58) either respected or was cut by structure 56 (the outer timber wall of the postulated copperas bed, see **Figs 9 and 13**). However, a concentration of three upright timbers along the line of apparent cut at the apex suggested that the former was more likely. In either event the zigzag-arranged timbers (58) and the rebuilt or repaired copperas bed (57/59; 56/67) were apparently used contemporaneously at some point. Features 43, 44 and 46 exposed in Area 2 appeared to betray a similar relationship, although their poor preservation meant that the relationship was suggested rather than certain.

The remains of a well-preserved double row of upright timbers (33) extended east–west across the northern part of the area (**Figs 9** and **14**) Two edge-set planks (65) lay flush with the outer edge of the southernmost row, the two rows being approximately 0.6 mm. apart and set into an intensely red-stained cobbled surface (68) consisting mostly of large water-rounded ‘doggers’ (greensand blocks) set into clay-silt. The cobbles terminated with the southernmost row of timbers but extended northward beyond the limit of excavation. This suggested that a wall-like structure (of which the double row of timbers were remains) and the cobbled surface, were contemporary.

Fig. 12. An exposed part of the shelving timber wall of a copperas bed

Fig. 13. Evaluation Area 3 from the south.

Fig. 14. Evaluation Area 3 from the north.

The finds

The finds assemblage is of mixed date, presumably as a result of the continual shifting of the overlying shingle by the sea. Smaller objects seem to have descended through the shingle throughout the post-medieval period and eventually come to rest on the intact surface exposed in Evaluation Area 2 or on the partly eroded surfaces exposed in Evaluation Area 1. However, it is also clear from the unabraded condition and postulated date of manufacture of many of the artefacts that the intact consolidated surfaces below the shingle contained materials which were contemporary with those surfaces. Also, many of the artefacts were embedded within the surfaces and were therefore clearly *in situ*. Only finds considered to be from intact archaeological contexts had context numbers ascribed to them.

Lead

The lead objects include two complete cloth seals. One, stamped with a floral mark, was recovered in unabraded condition from the cobbled surface (37) in Area 2, the other came from the surface of intact surface layer 49 in Area 3. A lead disc in similar unabraded condition and which had lost its attachment but appeared to have been a small weight with convex, dished sides was also recovered from this context. Also recovered from apparently *in situ* contexts were five unifacial lead tokens bearing rough devices. Four fragments of lead waste in the form of narrow strips, were also recovered. These could relate to the manufacture and repair of copperas boilers and other fittings associated with the industry, as could the small number of lead nails also recovered.

The lead cloth seals and tokens[9]

Regulatory lead seals were attached to individual lengths of cloth to identify the maker and to show that they had been inspected and conformed to the legal requirements of the time (Egan 1995a; Endrei and Egan 1982). Both examples found on the foreshore site are of the two-disc form. One is of 21 mm. diameter (both discs) and bears the scratched initials *SD* with the number *23¼* underneath and, on the other disc, the rough depiction of a crown over a double rose with an *A* and a *G* on either side, below the double rose. The numerals *24¼* are scratched below the rose (**Fig. 15, No. 1**). The presence of the scratched number *23¼* on one disc and *24¼* on the other may result from a correction or amendment. If so, it is odd that no attempt was made to obliterate the original number.

The royal device of the crown on this seal shows it to be an alnage seal, the word ‘alnage’ deriving from the late Latin *alena* via the Old French *aunage*. The Latin word relates to the word *ulna* and, like a yard, denoted a measurement of cloth using the arm. The same measurement was termed an ‘ell’ in Middle and early modern English (one English ell equals 45 inches). The English word is derived from the Old Teutonic *alina* via the Anglo-Saxon ‘*eln*’ and is cognate with the Latin words *alena* and *ulna*. By the early sixteenth century the word ‘alnage’ had came to signify both an official quality-control seal and the fee charged by the ‘alnager’ (official cloth inspector) for the inspection of the cloth. The scratched initials *SD* on the specimen described above are likely to be those of the ‘alnager’ or the member of his staff who carried out such an inspection.

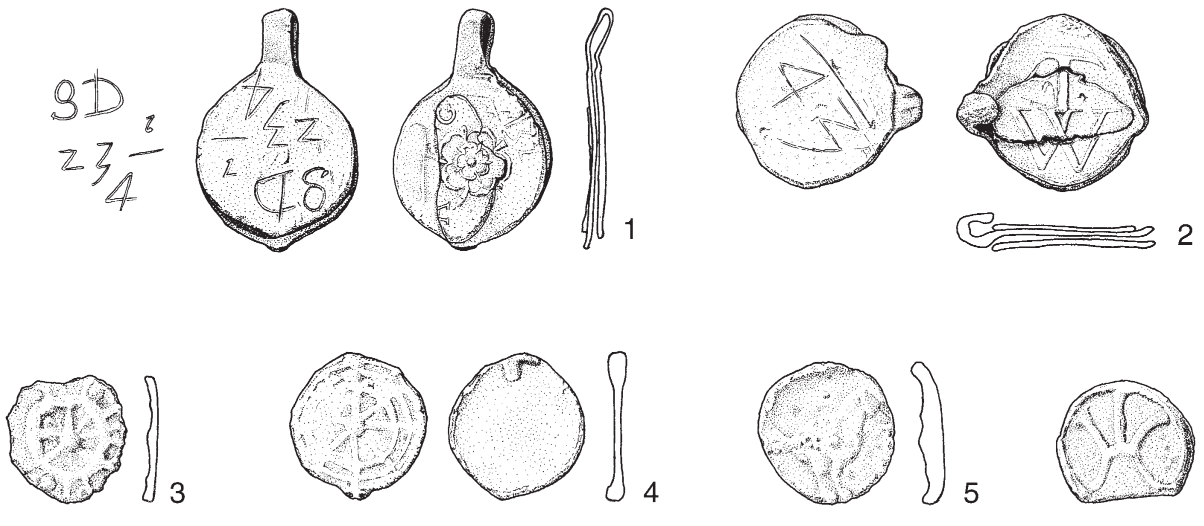


Fig. 15. The lead seals and tokens. Scale 1:1.

9 The seals and tokens were examined by Geoff Egan and the seals conserved by Kirsten Suenson-Taylor both of the Museum of London; the discussion is based on the notes supplied by Mr Egan.

The Tudor appearance of the seal is belied by the presence of arabic numerals, which probably indicate the length of the cloth in yards. The use of such numerals is not known in earlier, sixteenth-century Kentish seals, which have edge legends and Lombardic lettering. The numerals therefore probably indicate an early seventeenth-century date for this piece. However, the presence of a crown over a double rose with initials places the seal within a uniquely Kentish series originating in the Tudor period and probably associated with the early Kentish broadcloth industry. The series appears to date from *c.*1520 onwards, with the crown-and-rose motif apparently being copied from the gold half crowns first issued by Henry VIII in that year. The comparatively late use of the crown-and-rose motif for these seals in Kent is not paralleled elsewhere, although stylistically-earlier crowns are used on uninitialled, late medieval seals from other counties (Egan 1995a; 1995b, 1099). However, an alternative date for the establishment of the Kentish alnage seal sequence may be 1517, when an order was placed for twenty-two dies of suitably hard metal for stamping the lead alnage seals attached to bales of cloth to be made and delivered to Sir Edward Guldeford, supervisor of cloth in Kent (Jessup 1974, 404). The second seal recovered from the foreshore site has one disc of 20 mm. diameter and one of 21 mm. (**Fig. 15, No. 2**). One disc bears the scratched number 43 under a horizontal line and the other bears the joined (ligature) letters TW and what appears to be some half-hearted doodling in the form of a few scratched lines. This seal is an eighteenth-/early nineteenth-century weaver's or clothier's seal with scratched specifications, probably for a length of cloth measured in yards.

Given the established relationship between the copperas industry and wool production, it is possible that the cloth seals point to *ad hoc* bleaching or dying having taken place within the copperas works themselves. Alternatively, they may represent random examples of recycled lead which were used, along with other lead scraps, for mending the various types of lead container used in the copperas industry.

The five lead tokens are of possible eighteenth-century date. The devices represented on the assemblage are: a spider's web, another spider's web (different mould), a bird standing and a fleur-de-lis (**Fig. 15, Nos 3–6**). One device is too corroded to be interpreted and is not illustrated here. Such tokens were common and widespread throughout the seventeenth and eighteenth centuries and may have circulated locally as currency for very small purchases, each token being worth a fraction of a penny (Dean 1977). However, as halfpennies and farthings were in plentiful supply in the eighteenth century, such use might suggest a slightly earlier, seventeenth-century date for these examples.[10]

Iron

The majority (sixteen) of the iron finds were large nails with six other object types making up the remainder. The latter include a wool comb tooth, a small hooked fitting, a 0.20 m. long strip pierced by a bolt or similar and a large stake. The stake occurred in the lower part of shingle layer 1 and probably derived from the adjacent modern groyne.

The scrap iron objects and large iron nails concentrated largely in Evaluation Area 2 probably relate to the production of copperas itself. Scrap iron in large quantities was required for the process and nails would undoubtedly form one of the most readily available forms of iron scrap.

Copper alloy

Most (forty-seven) of the metal finds were of copper alloy. These include several fragments of discs and studs, all of which are conventional post-medieval forms. Although they are generally undiagnostic, some are clearly of modern manufacture. The group as a whole is dominated by a series of twenty-one nails, all but one of which have flat circular or subcircular heads and square shafts. The relatively large quantity of nails of this type may be significant as they are of variable sizes but are, with the one exception, very similar. Although nearly all are oxidised they have generally survived in excellent condition and show little sign of use/wear. The purpose of the nails cannot be determined. Although it is possible that they relate to the copperas industry, they are not securely dated and similar assemblages have come from other post-medieval contexts on East Kent sites.

A copper alloy hook was recovered from the cobbled surface in Area 2. It was unbarbed but may have been a fishhook.

Wood

Organic materials tended to survive, albeit in an abraded state, in this sea water environment. These include a small fragment of a shallow wooden vessel and several pieces of abraded fossilised wood.

10 It should be noted that these are not examples of the copperas tokens mentioned on p. 37.

3
Interpretation and the Industrial Process

There are several contemporary accounts of the early copperas industry in Europe and southern England including Agricola (1556); Brereton (1844, written in *c.* 1634); Colwall (1677), Fiennes (1982, written in *c.* 1682) and Ray (1674). Using these and the often comprehensive inventories of tools and equipment surviving from copperas works (for instance George 1975, 44–5; Goodsall 1956, 152) it is possible to provide a relatively detailed description of the copperas manufacturing process. More specifically, a number of sixteenth-, seventeenth- and eighteenth-century documents, including a series of maps and charts, assisted in the interpretation of the structures exposed on the Whitstable foreshore, as did the observations of some later commentators. Amongst the most important of these is the following: 'In 1639 it was said that the first works in the Whitstable district had been erected fifty years before. Another had been set up about 1610, but both had since disappeared with the encroachment of the sea'.[11] This statement strongly suggests that the present foreshore was both dry land and the site of copperas works until the early seventeenth century and therefore raises the possibility that some of the remains exposed during the evaluation were part of the earliest copperas works. It also represents strong evidence refuting the conventional explanation for the origin of the Tankerton Slopes as marine eroded cliffs (Allen 2000).

Copperas beds

The copperas stones were collected from the seashore and transported to 'beds', which were outdoor sites where weathering and bacterial activity converted the iron pyrites to ferrous sulphate and sulphuric acid: 'in time, these stones turn into a kind of Vitriolick Earth, which will swell and ferment like Leven'd Dough' (Anon 1704, no pagination). This contemporary comparison with organic processes is of interest as the beds appear to have been managed in a way which encouraged bacterial activity, including that of thermophilic species. The report states that new beds needed to be 'seeded': 'When they make a new Bed, they take a good quantity of the old fermented Earth, and mingle [it] with new Stones'. It is stated in a later account that, following this preparatory stage 'in half a year, a year, two years, sooner or later, according to its quality, the pyrites acquires a spontaneous heat' (Watson 1787, 224).

Colwall (1677, 1057) describes beds at Deptford in detail:

> Out of the aforesaid Cistern the liquor is pumped into a Boyler of Lead, about eight feet square, containing about twelve Tuns, which is thus ordered. They make Beds according as the Ground will permit. Those at Debtford [*sic*], are about an hundred feet long, fifteen feet broad at the top, and twelve feet deep [approx. 30.50 by 4.60 by 3.70 m.], shelving all the way to the bottom. They ram the Bed very well, first with strong Clay, and then with the Rubbish of Chalk, whereby the Liquor, which drains out of the Dissolution of the Stones, is conveighed into a Wooden shallow Trough, laid in the middle of the Bed, and covered with a Board; being also boarded on all sides, and laid lower at one end than the other, whereby the liquor is conveyed into a Cistern under the Boyling House.

Seven such beds are reported to have been attached to the combined 'Old' and 'New Mascall' works at Tankerton in Whitstable.[12] When the bedding material was 'indifferently well dryed', the copperas stones were piled in the beds to a height of 2 feet (0.60 m.) or so and then left for between four

11 E. 134/15 Chas. 1, East 7, Public Record Office, Kew.

12 Deeds of the Pearson Estate, U905, T1-7, Centre for Kentish Studies, Maidstone.

Fig. 16. A sixteenth-century copperas factory showing sunken barrels, boiler and cistern (Agricola 1556).

and six years, although Agricola (1556, 576), in his description of the sixteenth-century continental industry, claims that a year or so was sufficient:

> Such ore is at first carried and heaped up, and is then left for five or six months exposed to the rain of spring and autumn, to the heat of summer, and to the rime and frost of winter. It must be turned over several times with shovels, so that the part at the bottom may be brought to the top, and it is thus ventilated and cooled; by this means the earth crumbles up and loosens, and the stone changes from hard to soft. Then the ore is covered with a roof, or else it is taken away and placed under a roof, and remains in that place six, seven, or eight months.

Agricola's description of the continental production process is broadly comparable with the English accounts, with the exception of the use of roofed beds and the piling up of copperas stones to 'weather' before their introduction into the beds (**Fig. 16**).

On Brownsea Island in Dorset, copperas stones were reported to have been placed on raised beds 'like the beds in gardens' (Fiennes 1982, 39). Within the beds, each stone '… by degrees begins to swell and burst, and shoot out in salts, ... in a downy efflorescence on the surfaces', at which point workmen turned the stones in order to expose more of their surface to the air (Croker *et al.* 1764).

Colwall's description provides a convincing identification for the edge-set timbers (43), post supports (44) and abutting clay layer (45), in Evaluation Area 2, as part of a copperas bed and also for the foundation-like chalk and limestone spread ('the rubbish of Chalk'). Similarly, in Area 3, structures 52, 54 and especially 56/67 and 57/59 can be interpreted with confidence as the remains of copperas beds on the basis of their overall conformity with Colwall's description. Clay layer 59 was particularly evocative in the light of the Colwall's description, because it covered the shelving timbers of structure 57 like a thick layer of rendering ('... shelving all the way to the bottom. They ram the Bed very well, first with strong Clay …').

Section A in Area 3 showed that the copperas beds were skilfully constructed using mortise and tenon joints, presumably because any iron or copper bolts or nails would have eventually dissolved in the acid within the beds. It also appeared, from the great number and large size of the erosion-truncated supporting posts exposed in plan that, consistent with Colwall's description, the beds were originally of considerable height.

The upper part of the thick poured mortar/levelling sequence extending across most of the exposed areas appeared to post-date two of the planked structures interpreted as copperas beds (52 and 54 in Area 3) as it occurred on either side of the edge-set planks, thereby sealing whichever side was the site of the bed, which must therefore have been previously filled in. However, the mortar/levelling sequence either abutted or was abutted by the well-preserved section of rebuilt or repaired copperas bed (56/67; 57/59 in Area 3), but was not present in the area immediately south of clay lining 59, which clearly, in the light of Colwall's description, represented the internal part of the bed. This suggested that the deliberate consolidation of the ground surface using poured mortar did not take place following the use and eventual abandonment of this bed because, if it had, a poured mortar surface would be expected to have occurred on either side of the copperas bed wall, as was the case with the other two examples (52 and 54). It was therefore thought that the rebuilt/repaired bed (56/67; 57/59) post-dated the other two and was probably contemporary with the upper part of the poured mortar/levelling sequence. This in turn suggested that the upper poured mortar layers lying to the north of that bed represented the last of such consolidations.

Contemporaneity was also postulated for the later bed and the zigzag arrangement of timbers because the southern apex of each triangle was located immediately adjacent to the outer edge-set timber (56). It was therefore proposed that the shelving sides of the bed may originally have extended upwards to the top of wharfing or jetties which the zigzag arrangement of timbers appears to have supported (see below).

Cisterns and boilers

Towards the end of the 'weathering' period the stones began to produce a large quantity of 'liquor', which was collected, via a planked channel at the base of the bed. The channel was enclosed but its covering board was perforated to allow the liquor to drain into it and to be conducted to a 'cistern' or tank within a boiler house (see **Fig. 16** for an outdoor example). Agricola (1556, 576–7) describes a two-stage process in which two cisterns, termed 'vats', were used:

> Afterwards as large a portion [of weathered ore] as is required is thrown into a vat, which is half-filled with water; this vat is one hundred feet long, twenty-four feet wide, eight feet deep [30.50 x 7.30 x 2.40 m.]. It has an opening at the bottom, so that when it is opened the dregs of the ore from which the vitriol comes may be drawn off, and it has, at the height of one foot from the bottom, three or four little holes, so that, when closed, the water may be retained, and when opened the solution flows out. Thus the ore is mixed with water, stirred with poles and left in the tank until the earthly portions sink to the bottom and the water absorbs the juices. Then the little holes are opened and the solution flows out of the vat, and is caught in a vat below it; this vat is of the same length as the other, but twelve feet wide and four feet deep [3.70 by 1.20 m.]. If the solution is not sufficiently vitriolous it is mixed with fresh ore; but if it contains enough vitriol, and yet has not exhausted all of the ore rich in vitriol, it is well to dissolve the ore again with fresh water.

The single cistern at Deptford (described above by Colwall) is said to have been made of strong chalk-caulked oak boards, to have been subdivided to reduce loss in the event of a leak, and to have had a capacity of 700 tons. At Whitstable, one cistern shared by the combined 'New' and 'Old Mascall Houses' measured 15 feet by 6 feet (approx. 4.60 by 1.80 m.) and two others measured 80 feet by 9 feet (approx. 24.40 by 2.70 m.) and 60 feet by 9 feet (approx. 18.30 by 2.70 m.) respectively.[13] However, in the first copperas works to be established at Whitstable, in about 1588, the liquor was held in '18 greate butts that stand in the grounde to receyve the liquer from the goulde stones'.[14] Here, the liquor was pumped from the channel into the butts, which, as described by Agricola, were probably sunk into the ground (**Fig. 16**). Similarly, at Queenborough, the liquor was conveyed from the beds via a wooden channel to old barrels and then to 'a great tub' or cistern (Brereton 1844, 244–5). The liquor was then pumped from the cistern into a lead boiler which at Deptford was about 8 feet square (5.95 $m.^2$) and had a capacity of 12 tons (Colwall 1677, 1058), these figures suggesting a depth of about 2 metres for the boiler. An illustration of the copperas production process in Agricola's *De Re Metallica* shows a boiler of similar proportions (**Fig. 17**).

Fig. 17. A sixteenth-century outdoor copperas factory showing boiler ('caldron') and copperas 'cakes' being moulded (Agricola 1556)

However, at Whitstable, the Mascall deeds[15] describe a boiler belonging to the Old Mascall House as 12 feet square (13.40 $m.^2$). Assuming a similarity in depth, this suggests the capacity of the Mascall Works was over twice as much as that of the Deptford works. As six copperas houses were in operation at Whitstable during this period (the late seventeenth and early eighteenth century), the total capacity of the Whitstable industry was clearly very much greater than that of Deptford. Indeed, a document dating to between 1759 and 1765 (**Figs 21 and 22**) shows the combined annual output of the Whitstable works to have been 970 tons, as opposed to 296 tons for Deptford.

13 *Ibid.*

14 Exchequer Deposition, East 42 Eliz. No. 14, Public Record Office, Kew.

15 *Op. cit.* note 12.

Colwall (1677, 1058) describes the copperas boiler at Deptford as being positioned over a furnace comprising a grid made of flat iron bars set at right-angles over 12 inch thick (305 mm.) cast-iron bars, the whole being supported on brick walls and the grid being positioned 2 feet (0.60 m.) above the fire:

> .... the liquor is pumped into a Boyler of Lead, about eight feet square, containing about twelve Tuns, which is thus ordered. First they lay long pieces of Cast Iron, twelve inches square, as long as the breadth of the Boyler, about twelve inches one from another, and twenty four inches above the surface of the fire. Then crosswise they lay ordinary flat Iron Barrs, as close as they can lye, the sides being made up with Brick-Work. In the middle of the bottom of this Boyler is laid a trough of lead, wherin they put at first a hundred pound weight [approx. 45.4 kg.] of Old Iron.

The phrase ' ... the liquor is pumped ... ' perhaps provides an explanation for the red-brown staining evident in Areas 2 (38) and 3 (65) as the residue of spilt 'liquor', while the associated presence of two 0.90 m. long iron bars and the many fragments of lead and red brick is consistent with the rest of the account. This is also true of the pieces of scrap iron, chiefly nails, which were present in large quantities. In Fiennes's account of the Brownsea copperas works, she states 'they do add old iron and nailes to the Copperass Stones' (Fiennes 1982, 39).

During the ensuing boiling process, which lasted for up to twenty days, another 1500 pounds (680 kg.) of scrap iron was added. This was supposedly to prevent the liquor from 'thickening', in which case the thickened liquid would 'gather to the bottom of the Boyler and Melt' (Colwall 1677, 1059). Agricola (1556, 577) describes a similar process as practised on the Continent:

> As soon as the solution becomes clear, it is poured into the rectangular leaden caldron through launders, and is boiled until the water is evaporated. Afterwards as many thin strips of iron as the nature of the solution requires are thrown in, and then it is boiled again until it is thick enough, when cold, to congeal into vitriol. Then it is poured in to tanks or vats, or any other receptacle, in which all of it, apt to congeal, does so within two or three days. The solution which does not congeal is either poured back into the caldron to be boiled again, or it is put aside for dissolving the new ore, for it is far preferable to fresh water.

The furnace was fuelled with Newcastle or Sunderland coal. If, as in the case of Whitstable and Queenborough (Brereton 1844, 244–5; Clow and Clow 1952, 244), the tank was larger, it was heated by a number of furnaces, five being used at Queenborough.

The boiling process for copperas was highly dangerous as it involved hundreds of gallons of boiling liquid with an appreciable sulphuric acid content. In 1788 it was reported that: ' ... as John Wellard, one of the men who work at the copperas houses at Whitstable, was assisting in running the copperas ink coolers [see below], he unfortunately slipped in up to the breast. Every assistance was given but in 24 hours a mortification ensued and in two hours after, he expired'.[16]

Colwall suggests that Sir Nicholas Crispe of Deptford initiated the only major modification to the production process during the first century or so after the founding of the English industry. Crispe's modification acted to improve the efficiency of the furnace so that more of the boiler was exposed to the heat. Crispe also introduced the use of a secondary boiler ('the heater'), which was positioned above the main boiler and took heat from the furnace. The cold, fresh liquor, which had previously been poured directly into the boiler, thus reducing the temperature and dramatically retarding the manufacturing process, was now pre-heated before its introduction. The effect was to reduce the copperas boiling process from twenty days to less than a week.

The crystallisation process

As the liquor was thickened and reduced by evaporation more unprocessed liquor was added. The test to see if the liquor was sufficiently concentrated to produce an acceptable quantity of copperas was to observe how long it took to 'gather and crust about the sides thereof' when poured in small amounts into a shallow earthen pan (Colwall 1677, 1058). When it was judged to be sufficiently strong, the liquor was conducted into a cooling tank (the 'cooler'), where it remained for fourteen or fifteen days. The two coolers at the Old Mascall House at Whitstable were made of lead but at Deptford the single cooler was made of 'tarras', a cement of consolidated volcanic ash which did not dissolve in the acidic copperas solution. This cooler was 20 feet long (6.10 m.), 5 ft deep (1.52 m.) and was 9 ft wide (2.74 m.) at the top but narrower at the base (Colwall 1677, 1059). The two Mascall coolers are described as being 29 ft long by 6 ft and 6 ins wide (8.14 m. by 1.98 m.) but their depths are not given.[17]

In Deptford,[18] 'bushes' or bundles of twigs appear not to have been placed in the cooler but this was common practice at Brownsea Island (Fiennes 1982, 39), at Queenborough (Brereton 1844, 245), on the Continent, where ropes or lathes were also used (Agricola 1556, 575 and **Fig. 20**), and also probably at Whitstable. As the solution cooled, the copperas 'congealed' (crystallized) on the base and sides of the cooler to a depth of 5 inches (0.13 m.) or so, and also accumulated around the ropes or twig bundles where these were used. The remaining solution was then drained into a second cooler

16 *The Kentish Gazette*, 8 February, 1788.

17 *Op. cit.* note 12.

18 For contemporary accounts of the Deptford works see Anon 1704 and Lewis 1773, Vol.1, 270.

to be reboiled after the addition of fresh liquor. The solidified copperas remaining in the first cooler as a residue or shaken off the twig bundles was then shovelled onto a board which also drained into the second cooler so that any remaining liquid would not be lost. A graphic description is provided by Celia Fiennes in *c*. 1682:

> ... they place iron spikes in the panns full of branches and so as the liquid boyles to a candy it hangs on these branches: I saw some taken up it look't like a vast bunch of grapes, the coulleur of the copperace not being much differing, it lookes cleare like sugar-candy, so when the water is boyled to a candy they take it out and replenish the panns with more liquor ...

Agricola (1556, 578) reports that to achieve greater purity the solidified copperas could be reheated until it liquified and then poured into moulds where it solidified to make easily transportable pale green cakes (**Fig. 17**):

> The solidified vitriol is hewn out, and having once more been thrown into the caldron, is reheated until it liquefies; when liquid, it is poured into moulds that it may be made into cakes. If the solution first poured out is not satisfactorily thickened, it is condensed two or three times, and each time liquefied in the caldron and re-poured into the moulds, in which manner, pure cakes, beautiful to look at are made from it.

The finished product was shipped out in barrels or casks, often containing a previously agreed quantity of copperas (see p. 47). A contract drawn up between Sarah Parker, a Whitstable copperas producer, and two London customers in 1775 stated that each cask would contain between 9 and 14 hundredweight of copperas (Goodsall 1956, 157). A typical cargo perhaps weighed between 8 tons, the amount carried by the '*Content*' to London in February 1688, and 11.5 tons, the average amount carried by the '*Gift of Whitstable*' and the '*Thomas of Whitstable*' in 1629 (Harvey 1993, 20).

The early Whitstable industry

The identification of the remains of at least three copperas beds on the foreshore is significant in terms of locating an important part of the early Whitstable industry because a detailed description of the Stevenson/Gauntlett house dated 1600[19] refers to '... the workhouse and coolinge house with a cisterne in the same workhouse … three beddes or raucks of goulde stones or sulphure stones to make coppres, that lie in a feilde wherein the workhouse nowstandeth, with 18 greate butts that stande in the the grounde to receyve the liquer from the goulde stones …' (see p. 43). From the mid seventeenth century, the cisterns and seven copperas beds associated with the combined Old and New Mascall works are repeatedly described in the Mascall deeds:[20]

> And also without and near adjoining to the said Copperas house within the said small Parcell of Land Three Bedds or Pannells made of Gold Stones, Sulpher Stones, Marquesette Copperas Stones or Stones whereof Copperas is made, each Bedd being Seaven Roods [35 m.] in length and One Rodd and an halfe [8.50 m.] in breadth, being separated from four other Bedds belonging to the aforesaid New Copperas house by a Clay wall Cap[t] or headed with Brick. And also one other Cisterne without the said house being Eightie foot [24.40 m.] in length and nine foot and four inches [2.80 m.] in breadth being separated from a Cisterne belonging to the aforesaid New Copperas house by a particon of Clay or a Clay wall. And also one other Cisterne conteining by estimacon Sixtye foot [18.3 m.] in length and Nine foot [2.70 m.] in breadth lyeing neare the said Cisterne herinbefore menconed to conteyne Eightye foot in length and Nine foot and Four inches in breadth. And also one Cole Yard as is now severed and parted from the other Coleyard now belonging to the New Copperas house by a particon of Timber and Deale boards. And also one Pump of Leade and Small Furnace of Kettle for melting of Leade.

The Old Mascall House itself is described in the same document as:

> ... the first Copperas house which he the said Thomas Mascall made or built and being the lesser (is) separated from the New Copperas house by a particon of Timber and Deale Boards (both the said Copperas houses being under one roof) the said Old Copperas house containing in it One Furnace of Leade being Twelve foot and Two inches Square [13.40 m.^{2}] or thereabouts, Two Coolers of Leade each of them being nine and Twentye foot in length and Six foot and Six inches in breadth [each 17.50 m.^{2}]. One Cisterne being fifteen foot in length more or less and about Six foot in breadth [8.40 m.^{2}] being severed and parted from the Cisterne which did then belong to the New Copperas house by a particon of Clay or a Clay wall. Also one Binn over the said first menconed Cisterne of the same length and breadth [8.40 m.^{2}]. The Cisterne and Binn both made of Timber and Deale boards.

We are told that the Old Mascall works occupied 'a small parcell of land lying and being at a certain place called

19 *Op. cit.* note 14.

20 *Op. cit.* note 12. These descriptions of buildings and equipment are transcribed by Goodall (1956, 152–3).

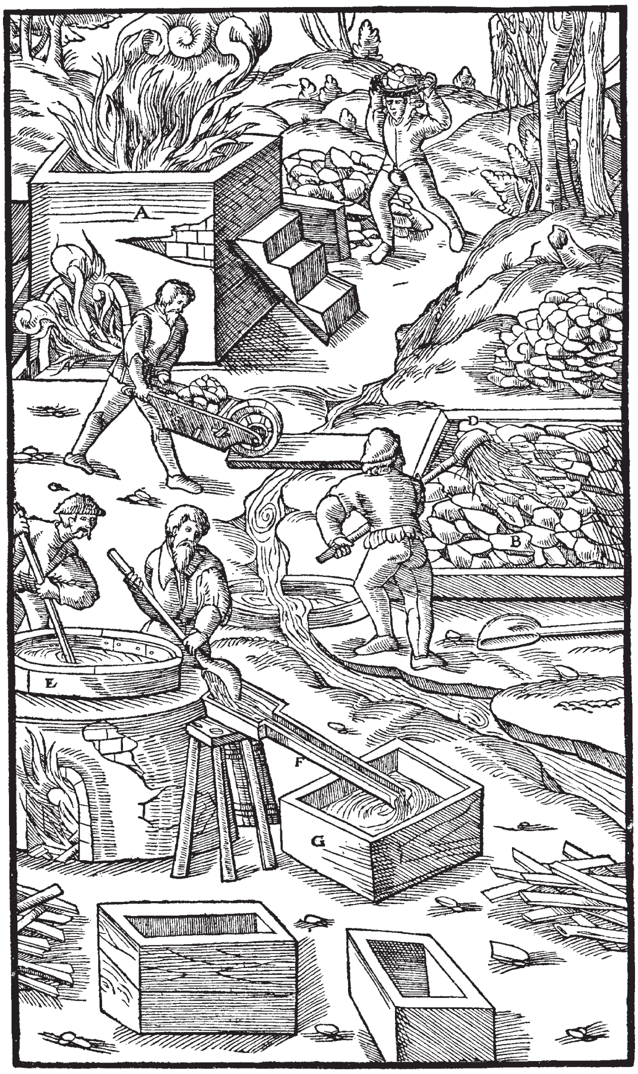


Fig. 18. A sixteenth-century alum factory with 'beds' (Agricola 1556).

Tankerton in the parish of Whitstable' measuring 'three-quarters of an acre and five perches [3162 m.^{2}]'. Assuming that the new works were built on the same plot of land, and that its 'Bedds' and 'Cisterne' were the same size as the others, the combined area of the 'Bedds' and 'Cisternes' totals 2294 m.^{2}, with 868 m.^{2} left over. If the new works were built on separate land, we are left with approximately 2140 m.^{2}.

The equipment within the house as described above covers a total area of approximately 65 m.^{2}. If we subtract this from the 868 m.^{2} not occupied by 'Bedds' and 'Cisternes' we are left with 803 m.^{2} (the equivalent of an area measuring 28 m. by 28 m.) for the adjoining copperas house, workspace, paths and roadways, stables, fencing, the two coal yards, open ground, the walls of the building, etc. Again, this assumes, as the description suggests, that the New Mascall house was built on the same 'three-quarters of an acre and five perches' as the Old Mascall house, with which it shared a roof. If not, an area of 2075 m.^{2} (equivalent to about 45 m. by 45 m.) is indicated. In either case, the area appears too small to have extended as far south as the top of the Tankerton Slopes unless an extremely narrow and elongated parcel of land is envisaged (at present the northernmost edge of the top of the Slopes is 80 m. south of the foreshore). The area would, however, have been sufficient to extend as far south as the present tea gardens, once the public 'Pleasance', suggesting that this may have been the site of the Mascall works. Indeed, a lead sheet identified as part of a 'copperas panell' is reported to have been found there by workmen in 1947 (Goodsall 1956, 158–9).

It would therefore appear that the two copperas works established in the late sixteenth and early seventeenth century were situated on what is now foreshore in or near the area where the copperas beds were exposed. It also seems likely that later works were established southward on and above the Tankerton Slopes as the sea encroached on earlier works. Most of the remains on the lower part of the Slopes would have been destroyed when the present sea wall/promenade was built during during the later twentieth century. Initially, parts of the later works may have been established on terraces cut progressively higher up on the Slopes, possibly in areas now occupied by the coastguard's house and its western neighbour and, as discussed above, the area which eventually became the 'Pleasance'.

A now unnamed and truncated road is shown on the 1933 Ordnance Survey to have originally skirted the cliff top before descending towards the coastal flats near Beach Walk. This appears to represent all that is left of the original coastal trackway depicted faintly as a dotted line on a chart dated 1725 (**Fig. 26**) and more clearly as two closely-placed parallel lines extending down the cliff and on to the foreshore on a chart of 1770 (**Fig. 27**). Probably once known as 'Bolders Lane' (Goodsall 1956, 153), the trackway seems to have provided access from the copperas works down the Slopes to ships standing off the Horsebridge. The copperas houses on these charts are shown to lie south (landward) of the trackway, but the less schematic Mudge Map of 1801 (**Fig. 2**) shows them to lie seaward of a road, presumably Tower Hill, set further to the south (see below). The original trackway is not shown on the Mudge Map but appears, albeit very faintly, on the Ordnance Survey of 1819 as a narrow strip skirting the clifftop to the north of a group of houses labelled 'copperas works', some of which appear to occupy the site of the later 'Pleasance'.

The identification of Bolders Lane with the above trackway can be made with some confidence as the only other track shown in the area is clearly the predecessor of the driveway to the Castle, now a road called Tower Hill. When taken in conjunction with the documentary and archaeological evidence discussed above, this supplies strong supporting evidence for copperas works having been established in two phases to the south following the abandonment of the two works on the coastal flats. It is possible that the first phase (the Old Mascall Works) was sited on terraces cut low down on the Slopes, adjacent to its associated copperas beds, these apparently being located on the then much-diminished (and diminishing) flats. The second phase, the 'New Works', appear to have been built on adjacent land to the south, higher on the Slopes. Indeed, a parcel of Mascall land is described in a late seventeenth-century schedule as 'bordering upon the land of Mary Godfrey, widow towards the east, to lands now or late of Sir Thomas Allen towards the west and towards and bordering upon a certain lane there called Bolders Lane [therefore, by elimination, south] and towards the Sea north' (Goodsall 1956, 153).

In 1693 Sir Thomas Allen was the owner and co-administrator of another copperas works on land to the west formerly owned by Robert Knight (see p. 43). It would appear from the above description that, like the adjoining Mascall land, the Knight/Allen works were located somewhere between the sea and 'Bolders Lane', which descended to the foreshore at an acute angle to the edge of the Slopes, with the beds and cisterns perhaps being located below the Slopes on the coastal flats. However, as the Knight/Allen holding originally comprised 28 acres, it probably extended as far west as, and included, the marshy 'Outletts', an area that comprised sixteen acres in 1779, but was accounted as 28 during the sixteenth century (Bowler 1983, 42).

The archaeological evidence for parts of the later copperas works, possibly the Mascall Works, to have been sited low down on the Tankerton Slopes is also consistent with information in the 1783 Sewer Commissioners' report, where it is stated that a John Blackman was permitted to take up to '100 cart loads of Beach from without the Old Sea Wall' (presumably the original 1583 wall) to make a road from the Street. The road is described as '... a Way or Passage from the Copperas Houses ... by, through and near the Outletts and over the end of the New Insett Wall [built in 1780, one year after a great storm] near Whitstable' (Bowler 1983, 42).

Fig. 19. A sixteenth-century outdoor copperas manufactory (Agricola 1556).

It is therefore reasonable to propose that the excavation uncovered parts of one of the two earliest copperas works and, probably, parts of the later Old Mascall Works. The site, on what would have been a dry coastal flat, would initially have offered level ground and ample space in a sheltered position between the Slopes and 'the Street'; an ideal venue for the massive copperas beds, cisterns, etc, and the adjoining houses. Furthermore, the works would have been close to the source of the copperas stones and would have had easy access along the sea wall or along the 'Way or Passage', built in 1783, to ships standing off the Horsebridge or thereabouts. It is likely that this was achieved by loading the copperas onto smaller boats (lighters) at the quay adjoining to the 'Copperas Sluice' (see p. 43). The lighters would have then have carried the copperas out to the ships standing offshore.

The 1725 chart provides a *terminus ante quem* for the remains of the two earlier copperas beds and associated deposits exposed on the foreshore (**Fig. 26**). This shows four triangular structures, each divided into between nine and seventeen rectilinear compartments. The zigzag arrangement of timbers exposed in Areas 1, 2 and 3 is consistent in appearance with these triangular structures and it is difficult to see this as coincidence. Where exposed, these timbers were either superimposed over or appeared to respect the remains of the copperas beds and so to postdate or be contemporary with them. On this basis it can be assumed that two of the copperas beds (52 and 54) were built well before 1725 and predated the triangular structures shown on the 1725 chart. It can also be assumed that the later, rebuilt or repaired bed (59/67; 56/67) was used at the same time as the triangular structures, if only for a short period.

The zigzag arrangement of timbers was set into the extensive poured mortar/levelling sequence and therefore appeared to be a dry-land structure, as the sequence was not firm enough to survive protracted wave action. The timbers themselves probably represent what survives of a raised wharf or series of jetties built behind a well-built wall (33), the remains consisting of a double row of timbers with some *in situ* edge-set planks (59). A substantial red-stained cobbled surface of large water-rounded greenstone blocks (68), presumably derived from the Upper Thanet Greensand Beds, extended seawards from the base of the wall, showing that intact archaeological remains survived beyond the northern limit of the excavation.

It should be noted that during the survey of exposed timbers, three parts of this wall were identified, one (32) being west of Groyne 19/17, one (33) being in Area 3 and one (34) being in Area 2 (see **Fig. 3**). The wall can be identified with some confidence as an irregular, fence-like linear structure shown to skirt the foot of the foreshore on the 1770 map, where it probably marked the northern limit of the wharfing, land piling, etc as described in the Parker survey discussed below. However, as previously discussed, the excavation in Area 3 showed this wall consistently to abut or be abutted by the northern apexes of the zigzag timber arrangement, suggesting that the wall was contemporary with the timber arrangement and therefore already in existence in 1725. Despite being well-made, it is improbable that this structure would have been strong enough to withstand heavy seas, but it may have provided protection from occasional, exceptionally high tides. It should be noted that none of the above-described structures could have been built in or have survived a permanent high-energy tidal environment and they must therefore predate the sustained marine encroachment onto the upper foreshore indicated by Mudge's map of 1801 (**Fig. 2**).

Three double-rows of upright timbers recorded during the EDM survey (**Fig. 3,** contexts 28, 29, 30) are not shown on the 1725 chart, but appear to contain the triangular structures and therefore be contemporary with them. It is possible that these rows were not particularly noticeable within what would have been an impressive triangular raised jetty, wharf or similar structure and therefore did not catch the eye of the compiler of the chart, which is in any event highly schematic in style.

The zigzag-shaped timbers seem to have disappeared by 1770, as a map of that date (**Fig. 27**) shows the area to be occupied by thirteen rack-like structures, probably 'land ties' (see below). Each of these is shown as three upright posts connected by a single cross-post and all are located south and landward of the fence-like structure identified as representing the timber wall exposed in three sections (32/33/34) in the study area (**Fig. 3**). The map's date corresponds approximately with a survey of around 1775 quoted by Goodsall (1956, 159) which makes mention of large-scale structural works previously carried out on the Tankerton foreshore during the time that Sarah Parker owned two of the copperas works:

> By the Sea-side, Eight large Jetties [groynes] and five small ditto, with long Wharfing and a great quantity of Stones fitted in, with land-ties and ironwork to all the same. Long land-piles, land-ties and planking to keep the upper ground secure; the whole having been done within these few years at a great expence.

It is likely that many of the unidentified timbers and the large number of redeposited water-rounded greenstone blocks exposed throughout the study area derive from this 'great quantity of Stones'. Both the large scale and 'great expence' of Sarah Parker's work suggest that marine encroachment had made considerable inroads by this time and that a last-ditch attempt was being made to halt it. However, given the constant and gradual nature of sea level rise, the enterprise may have seemed rather more viable than we, with the benefit of hindsight, know it to have been. It is with some sadness that we find only three groynes and a fish weir shown on the foreshore area on the Ordnance Survey of 1819.

The chemistry of copperas production

During the industrial process copperas stones, otherwise iron pyrites (ferrous disulphide/FeS_2) were oxidised and hydrated to form a weak solution of copperas, otherwise hydrated ferrous sulphate ($FeSO_4{\cdot}7H_20$), and sulphuric acid (H_2SO_4). Spontaneous oxidation was first initiated by protracted exposure of the pyrites to the elements. Initial oxidation by this process was very slow but was subsequently greatly hastened by the action of acidophilic bacteria such as *Thiobacillus ferrooxidans* and *Sulfolobus acidocaldarious* when the material had become sufficiently acidic (Cotterill 1991, 18; Brock *et al.* 1984, 436). The resulting dilute solution of hydrated ferrous sulphate and sulphuric acid was collected and, following evaporation by boiling and the addition of iron (which combined with the sulphuric acid to make more ferrous sulphate), a richer solution of ferrous sulphate was produced. The addition of iron acted to reduce the concentration of the sulphuric acid by converting it to ferrous sulphate. If this was neglected and the sulphuric acid was allowed to become too strong, it thickened as its specific gravity increased, raising the boiling point of the solution as a whole to the point where the lead boiler would melt. However, a certain degree of acidity had to be maintained to prevent atmospheric oxygen converting the ferrous ions into ferric ions (see below). If the pyrites contained copper as an impurity, the addition of iron is also thought to have prevented the formation of undesirable copper sulphate.

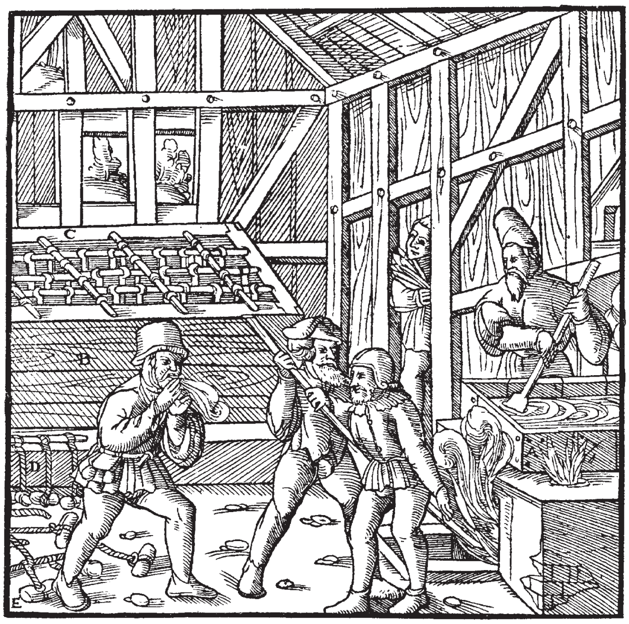


Fig. 20. A sixteenth-century copperas factory showing the boiler and ropes being used in the same way as twigs in the copperas cooler (Agricola 1556).

An additional need for iron derived from the fact that each molecule of copperas stone (FeS_2) contains twice as much sulphur as a molecule of green vitriol ($FeSO_4.7H_20$). Therefore, to change an iron-to-sulphur ratio from 1:2 in favour of sulphur to 1:1 (the ratio in which iron and sulphur occur in copperas) extra iron had to be added. This also had the clear advantage of substantially increasing the volume of the copperas finally produced. The addition of iron also acted to reduce any ferric ions (Fe^{3+}) back to the ferrous state (Fe^{2+}), thus turning ferric sulphate back into ferrous sulphate. Ferric sulphate [$Fe_2(SO_4)_3$] is more soluble and therefore could quickly form a thicker solution capable of retaining more heat. A hot, dense solution containing ferric sulphate would trap more heat near the base of the lead boiler and threaten to melt the lead. Luckily, the addition of iron allowed the following reaction, which is energetically very favourable: $2Fe^{3+} + Fe$ (metal) $\rightarrow 3Fe^{2+}$ (Dr John Danilewicz, pers. comm.).

When the solution had achieved the required concentration and was left to cool, pale green crystals of hydrated ferrous sulphate formed as a residue, although the ferrous sulphate content of the material at this stage was still only about 50 per cent. In order to increase the purity, the residue could be reheated until it liquified and then poured into moulds where it congealed into cakes of crystallized ferrous sulphate. The end product was a mordant or dye fixative, in this case comprising a compound containing an atom of metal in the form of iron. During the dyeing process the mordant molecules impregnated the cloth fibre and then bonded with the dye molecules, thereby fixing the dye.

The above-described process assumes pure chemicals and is, to that extent, idealised. In reality, the presence of ferric sulphate and of impurities within the copperas stones such as arsenic and copper would make the chemical reactions described above rather more hit-and-miss, certainly more complex, and it is likely that much of the final product contained impurities and was unpredictable in its effects.

Copperas as a mordant

The documentary evidence suggests that, from the founding of the industry in the late sixteenth century to the early eighteenth century, most of the copperas produced in England was used by the domestic dyeing industry, which dealt almost exclusively with home-produced woollens. However, from the early eighteenth century onwards, increasing quantities of sulphuric acid produced from copperas went for export, largely for use by continental dyers (Haber 1958, 2), and high quality copperas, probably mostly produced in Yorkshire, Tyneside and Scotland, was also exported for the same purpose.

Having converted the crystallized copperas back into a solution, the dyers could then use it as a mordant (from the Latin *mordere* meaning to bite). The use of this word shows how copperas was originally thought to bite into textile fibres and then bond with the dye, thus fixing it (Freemantle 1987, 541). In reality, the process is rather different. Having impregnated the textile fibre, each molecule of copperas (hydrated ferrous sulphate) then forms a covalent bond with a dye molecule to form a much larger and chemically more stable molecule, called a chelate or a metal complex, which is large enough to be physically and virtually permanently trapped within the fibres (T.W.J. Apperley pers. comm.).

Dyers played an essential role in maintaining the quality and marketability of woollens, and they clearly had to exercise considerable expertise in their trade in order to succeed. Hence we read: 'Colouring is one of the most delightful arts, also a most responsible branch of manufacture; and a good dyer makes a manufacturer wealthy, happy and renowned, while a poor one brings ruin, bankruptcy and misery; and not considering the fineness of the cloth or the faultless weaver, the colour sells the cloth' (Haserick 1869).

Therefore, it is not surprising that successful dyers were highly secretive about their methods and the consequent lack of documentary evidence may explain the apparent neglect of their art by historians of the textile industry. However, Ponting (1971, 36) examined extant eighteenth-century pattern books and their associated cloth samples along with dyers' personal manuscript dye-recipe books in the south-west of England. There, wool was dyed in large vats and a wider range of dyes was used than in previous centuries, with dyes being fixed using many different mordants. Textile colour reflected both the dye and the mordant used.

A modern account of wool dyeing using copperas at the Colour Chemistry Department of Leeds University perhaps provides a clue as to how the dyers of the sixteenth, seventeenth and eighteenth centuries operated.

> At about 100:1 liquor ratio, wool hank, piece, loosestock (in a stainless steel wire basket) for example, well wetted out, would be entered into a cold bath containing 6% hydrated ferrous sulphate [copperas] and 4% oxalic acid (a natural substance obtained from plants such as rhubarb) on weight of fibre (owf). The temperature was then raised to the boil in 45 minutes, and boiling continued for one hour with continuous agitation. The wool was rinsed and dyed from cold in a dye bath containing 10% Alizarin Paste (a natural red dye obtained from madder) owf and raising to the boil in 45 minutes and boiling for 45 minutes with continuous agitation.

Copperas (hydrated ferrous sulphate/$FeSO_4{\cdot}7H_20$ containing Fe^{2+}) is suitable in solution for immediate use as a mordant. Some, however, may have been processed to give ferric sulphate ($Fe_2[SO_4]_3$ containing Fe^{3+}) as a solid, plus the gases sulphur dioxide (SO_2) and sulphur trioxide (SO_3). The ferric sulphate is suitable for making a variety of mordants, while the trioxide in water gives sulphuric acid (H_2SO_4), used to dissolve certain dyes.

In the absence of extensive documentation for the domestic industry, it is conjectured that dyers or their suppliers may have processed copperas with simple apparatus made of fireclay using methods employed in mainland Europe as described by Foucroy (1804, 260). At the copperas works at Nordhausen in Saxony, copperas was strongly heated in a clay retort to produce fumes of sulphur dioxide (SO_2) and sulphur trioxide (SO_3) along with water vapour. The fumes condensed directly into acid in specially cooled stoneware bottles or 'condensers':

> The very strong sulphuric acid is expelled in the form of heavy vapours which condense in the cold into an oily-looking fluid. The latter portions when received in a separate refrigerator, frequently concrete in to a crystalline mass, formerly called glacial oil of vitriol. About 64 pounds of strong acid may be obtained from 600 pounds of copperas (Ure 1839, 1218).

Dyers, even if they made rather weaker acid, would have been able to heat copperas with 'glacial oil of vitriol' to create ferric sulphate, which in turn would react readily with ammonia (present in stale urine; Derry and Williams 1970, 268). This reaction produced ammonium iron alum ($[NH_4]_2SO_4 \cdot Fe_2[SO_4]_3 \cdot 24H_2O$), a mordant superior to copperas. Alternatively, the dyer could use ferric sulphate to make other chemicals such as the mordant potash iron alum ($K_2SO_4 \cdot Fe_2[SO_4]_3 \cdot 24\ H_20$), using wood ash (Hicks 1963, 542). By reacting sulphuric acid with common salt, hydrochloric acid could be made, and subsequently (as a very hot gas) made to react with ammonia to make ammonium chloride (NH_4Cl), also known as Sal Ammoniac, a special mordant. In France it was observed in 1777 that sulphuric acid was employed in the production of both Glauber's Secret Sal Ammoniac (used medicinally and marketed as 'Glauber's Sal Mirabile') and Nitrous Sal Ammoniac (Macquer 1777, 608) and the acid was probably used similarly in England around this time (see, for example, J. White's desciption of Joshua Ward's process for 'The true and genuine Method of preparing the WHITE DROP' in Page 1763, 13–15).

Saxony Blue, also known as 'sulphat of indigo' and '*Bleu de Saxe*', also required sulphuric acid in its production. This dye, first made in 1744 by Bergrat Barth of Freiberg by treating indigo with fuming sulphuric acid, was popular with French dyers from the 1760s onwards and is credited by Haber (1958, 2) for the greatly increased demand for sulphuric acid, and hence copperas, from England. The necessary fuming acid or '*oleum*' was made by dissolving sulphur trioxide in concentrated sulphuric acid, a highly dangerous procedure for the dyer.

The high purity of the acid necessary for dyeing favoured acid produced in the traditional way from copperas rather than from lead chambers, a later technique pioneered by John Roebuck in the mid eighteenth century whereby pure Sicilian sulphur was burned with nitre, otherwise saltpetre/potassium nitrate (Cotterill 1991, 16). Although the Roebuck lead-chamber technique was an improvement on a process invented by Joshua Ward in 1740, it still produced acid containing variable quantities of lead sulphate and nitrous acid, both of which could turn the bright blue of indigo into unmarketable green. Aikin and Aikin (1807, 371) observed that European dyers willingly paid extra for sulphuric acid (they called it 'vitriolic acid') known to be produced from copperas in order to avoid this problem. However, it may be assumed that, where this refers to English Green Vitriol, it means the superior product of the northern industry because the annual output of the southern industry had fallen drastically by this time and what was produced probably supplied its traditional London market.

The link with fertiliser manufacturing

At Queenborough, the sulphuric acid used in the manufacture of industrially-produced fertilisers was first made with copperas stones (iron pyrites) using a horizontal lead chamber method, this being an adaptation of Roebuck's chambers. There and elsewhere it appears that the pioneers of the fertiliser industry took over the plant, the chemical expertise and some of the chemical processes associated with the production of sulphuric acid from copperas. Indeed, the first of the new industrial-scale fertiliser factories was built on the site of the old copperas works at Deptford. The preliminary sketch plan of the site made by Sir John Bennet Lawes for his new fertiliser works built at Deptford in 1842, clearly shows the old 'vitriol tanks' and the redundant copperas house (Dyke 1993, 14–17). Similarly, another fertiliser factory was built at Ipswich on the site of a copperas works. Other elements of the developmental links between the copperas and subsequent chemical industries are discussed in Chapter 4 (pages 38–39).

The first industrially-manufactured fertilisers were sulphate of ammonia, phosphate of ammonia, potash sulphate and superphosphate, a later development of the latter being triple superphosphate. All these were used to restore nitrogen, phosphorus, and potassium to the soil on a continuous basis, a process which Sir James Murray (1788–1871), Sir John Bennet Lawes (1814–1900) and other agricultural scientists recognised would greatly increase crop yields, although it should be noted that the way in which plants took up nitrogen was imperfectly understood at this period and experimentation was carried out largely on a trial-and-error basis (Dyke 1993, 27–36, 50–51). Given the enormous increase in the population of Great Britain between 1750 and 1850, mass starvation had been predicted as inevitable by philosophers such as Malthus, but the soil scientists' discoveries meant that such a catastrophe did not occur (Windridge 1998, 849).

4
The Industry in the South of England

The founding of the industry

In 1545 and again in 1551, unsuccessful attempts were made, initially in Ireland, to find 'domestic' reserves of pyrite (Singer 1948; Donald 1961, 12). In 1553 William Cholmeley published a pamphlet *A Project for Dying Cloth in England*, in which he stated that he had: 'sent to Antwerpe, and there procured for wages a man verye expert in the feate of dyinge, and willing to serve in England'. Cholmeley's pamphlet highlighted the problem faced by the domestic cloth industry but nothing seems to have come of his efforts. In 1562 a patent was granted to a William Kendall of Launceston to find suitable ores for the manufacture of vitriol in the coastal counties from Surrey to Cornwall (*Calendar of Patent Rolls* 1939–86, 465). Again, the enterprise appears to have come to nothing and the high price of imported vitriol continued to damage the English economy.

The urgency of the situation is evident in a letter to Sir William Cecil, the Queen's Secretary, dated 1565 (Donald 1961, 10–11. This states:

> There is an art in Germany [referring to copper refining] which is not above five years old and the artificial place watched day and night, like a town of war, to keep the art secret to the first finders (of which house my Almain is) ... This man is of many other singular knowledges and, if he may know of state of perpetuity, he will become an Englishman never to depart this realm, except it be in service thereof ... He is singular in all dry materials such as alum, copperas, sulpher and the like.

Fortunately for the English Crown, by this time the papal monopoly was beginning to crumble as the Reformation and nascent nationalism weakened the Pope's power on the Continent. Also in 1565, Elizabeth I was able to attract 'certain foreign chymistes and mineral masters', 'Dutch Mynerall men' and 'Germans experienced in mines' to England by granting lucrative privileges of mining which granted 'patents which gave monopoly rights over both the production of the ore and its processing' (Hoover and Hoover 1950, 282–3; Turton 1938, 6–8). This concerted campaign to attract foreign expertise to England and to encourage the domestic industry was clearly successful. We find the following, referring to Queenborough Castle, Sheppey, in Lambarde's *Perambulations* (1826, 227–8). The passage has been described as 'probably the oldest known record of a chemical factory in Britain' (Stevens 1987, 1).

> Being at this Castle (in the yere 1579) I found there, one Mathias Falconer (a Brabander) who did (in a furnesse that he had erected) trie and drawe very good Brimstone and Copperas, out of a certein stone that is gathered in great plenty upon the Shoare neare unto Minster in this Ile.

Nor did the attempt to acquire the necessary expertise end with the arrival of the 'Dutch Mynerall men' and others. In 1582 an English cloth factor in Turkey was instructed to 'learn to know all the materials and substances that the Turks use in dyeing' in order 'to amend the dyeing of England' (Rowse 1950, 175).

As an intrinsic part of the woollen industry, the domestic copperas industry received substantial state support during this embryonic period and beyond. In 1565 an Act of Parliament stipulated that hats could only be dyed black using copperas (Campbell 1971, 91); the date coincides approximately with the first recorded production of copperas in England. Later, the industry was to receive more substantial state support as progressively tighter restrictions were placed on the export of unfinished, and therefore undyed, cloth at the behest of clothiers. In 1614, as part of Alderman William Cockayne's disastrous attempt to reorganise the cloth export trade, a royal proclamation was issued which totally banned the export of unfinished cloth (Ashley 1967, 14) and a similar ban was re-imposed in 1675 (V.C.H. 1892, 352).

A report in the State Papers of Elizabeth I written in January 1584[21] provides fascinating details about the quantities of copperas, copperas stones and sulphur imported (all apparently called 'Brimstone') and the uses to which they were put. High expectations clearly preceded the establishment of the Kentish industry:

> Briefe Notes for the makinge of brimstone wherby may appeare what benifite is lickly therbie to growe to her ma^{tie} this her Comonwealthe and to her highnes patentees warrantede by the triall and experience latelie had in the painefull and costlie folowinge and searchinge oute of the same.
>
> firste for the use of Brimstone it is greate wthin this Comonwealthe and growethe dailie more by reason that the same hathe of late been much Emploiede and occupiede about the Tryminge and Dressinge of shippes and other small vessels. The same is lickwise good m^{ch}andize at Rochells Flaunders and other neare parts to this Realme; what quantitye this realme will conscume yerelie we knoweth not certainlie but we gesse that 300000 will be the Leaste makinge the proportion thus C^{r} 100000 for the makinge of Gonepowder, a 100000 about the Shipps and 100000 solde by Retaile throughe the whole lande, for div^{r}se other purposes and I doubte not but a 100000 may be ventede abroade to her ma^{ties} friends w^{ch} is all this 400000.[22]
>
> Concerninge the makinge of the same yt is Drawen out by force of the fyre of suche stones as here we p^{sent} to y^{r} hon^{rs} wherof we fynd sufficient quantytie upon the Coastes of the Isle of Sheppey Whitstable and other Coasts therabouts to o^{r} Jugm^{t} to make the said quantytie of Brymston yerlie duringe the yers Conteinede in the pattente the w^{ch} we p^{r}esume because we find the stone supliede in shorte tyme wher we have gathered before all away and that by the workinge and benefyte of the sea.

A similarly early interest in developing the copperas industry, this time specifically in Whitstable, is recorded in a letter written in 1569 to Sir William Cecil (Goodsall 1956, 144). Matthew Parker, Archbishop of Canterbury, wrote:

> This poor man cometh to me and signifieth that by the councel of a stranger whom he hath kept in his house, and by his own cost and industry, he hath found out the making of brimstone ... and saith further that the stuff where he gathereth it on the shore of Whitstable is so fat, that it will yield so well that it will rise to a good comodity, and nothing so chargeable as hath been elsewhere proved to be.

It is probable that the 'stranger whom he hath kept in his house' refers to one of the 'foreign chymistes and mineral masters' invited to this country by Elizabeth. If so, a likely candidate is Cornelius Stevenson, probably a native of Liège in Brabant, who received a patent to produce copperas at Whitstable in 1565,[23] though he apparently did not begin production at that time. Turton (1938, 38–9) identified Cornelius Stevenson, also known as Cornelius Stevens, as a man 'formerly under the allegiance of Spain, and therefore a native of the Low Countries, who, in company with others from Liège and neighbouring states, was naturalised on 3rd June, 1562'. He is also named as one of the first leaseholders at the Alum Chine works in Dorset (see below).

From the very beginning of the industry, links existed between copperas works in different parts of the country. This and the industry's seemingly endemic dishonest practice are well illustrated by the activities of Edward Lane. In 1597, Lane was charged in the Court of Star Chamber with theft from the copperas works at Whitstable in Kent (see p. 42) and is also known to have molested a leaseholder of one of the works in Dorset, to have stolen his licence to produce copperas and to have eventually installed himself in the lessee's house.[24] In the latter case, Lane acted 'by colour of the Earl's title', i.e. as a hired intimidator. Perhaps aptly in view of Lane's activities, two early inventories for the Walton and Brightlingsea works in Essex list muskets, swords and bayonets as part of the equipment within the copperas works (George 1975, 44–5).

Early production centres

The early centres of copperas production were established on or near the coast in southern England, with a general bias to the south-east (Chalklin 1965, 113). The major sites were in the Isle of Wight, Dorset (Alum Chine and Okeman's Close in Canford, and Brownsea Island) and Essex (Harwich, Ramsey near Walton-on-the-Naze and Brightlingsea). In Kent the main production sites were at Whitstable, Deptford and Queenborough in Sheppey. At Rotherhithe a copperas works was founded at an early date adjacent to the Deptford works.

A document dating to between 1759 and 1765 (**Figs 21** and **22**)[25] comprises 'A LIST of all the Copperas Works in Great Brittain Divided into 3 Divisions, With an Account of the Quantity of Copperas that Each Work Used to make in a Year, Upon an Average of 7 & 10 Years, With the quantity Each Work

21 *Op. cit.* note 6.

22 C^{r} probably means 'chaldron' which is a measurement of volume equal to 288 gallons. See note 70 below for a weight equivalent.

23 *Op. cit.* note 14.

24 Acts of Privy Council, 12 225/261/265, Public Record Office, Kew.

25 From the Pearson family archive by kind permission of Mrs Butterworth.

is to Make Now in a Year, With the Superficial Square feet Each Bed Contains'. Within the list are 'The 14 Old Standard Works Near London'. These were located at Deptford, Greenwich, Gillingham, Queenborough and Whitstable (six works) in Kent; at Brightlingsea and Walton-on-the-Naze in Essex, at Blackwall in Middlesex and at Rotherhithe in Surrey. Smaller works established on the Isle of Dogs, at Bromley, at Greenwich in South London, at Rochester, Grange and Milton, on the Lower Medway (Pearce undated, 95–6), at Folkestone and elsewhere in Kent and Middlesex had probably disappeared by the time the list was compiled.

The Dorset industry

The Dorset works were the first well-documented attempt to establish an English copperas industry and it is likely that they were the first large-scale works in the country, given the lack of documentary evidence for production elsewhere.

It appears that initially a different process was attempted in Dorset in which mined pyritic shale was roasted as part of a process for producing alum, in this case ammonia iron alum. Copperas could also be produced using this method (Colwall 1677, 1056), and in 1564 it was claimed that both alum and copperas would be produced at Canford in equal quantities.[26] However, alum was at first the favoured product because it was a better dye fixative, hence the names 'Alum Chine' (also 'Alumenchine'), 'Alum Bay', etc. Pyritic shale for alum production was extracted at Kimmeridge and Alum Chine (Bournemouth) and pyritic clays at Alum Bay on the Isle of Wight, with the latter supplying an alum works in Parkhurst Forest in 1579 (Singer 1948; Worsely 1781).

Despite its favoured status, alum production in Dorset was soon superceded by copperas production, probably because the lengthy alum production was not cost-effective. Colwall describes a complicated process requiring the admixture of kelp and urine, of which the best was 'that which comes from poor labouring People, who drink little strong Drink' (Colwall 1677, 1055). The speedy demise of the southern alum industry is consistent with further details in Colwall's account, in which he locates the alum mines '... in most of the Hills between Scarborough and the River of Tees in the County of York. As also near Preston in Lankashire.'. He then states that the sources of copperas stones are '... found on the Sea-shore in Essex, Hampshire, and so Westward' (Colwall 1677, 1056). This is in turn consistent with Fiennes's late seventeenth-century account of 'the Copperice Workes' at Brownsea Island, which were associated with the Canford works (Turton 1938, 330). Fiennes states that copperas stones formed the raw material, that no preliminary roasting took place (as required for alum production) and that only copperas was produced (Fiennes 1982, 39). She goes on to describe a production process at Brownsea similar to those described later at Deptford and Queenborough (pp. 19–21). Judging from an inventory of equipment for one of the Dorset works, the later part of the process for alum production was similar to that described above for the Kentish and Essex copperas industries.[27]

In 1564, Cornelius de Vos, 'of London marchaunte and our liege made subjecte' had been granted the patent previously held by William Kendall to 'work and trye out … the oures of allome coperas and other mineralles'[28] in the Isle of Wight, but evidence is lacking for the production of copperas there. It would appear that de Vos originally intended to produce alum and copperas at Canford in his own right but lack of capital meant that he could only begin production under the aegis of John Blount, 6th Lord Mountjoy, with whom he compounded his patent in 1566.[29] Thus we read, in a private statute pased in 1566, that de Vos ' ... was of no sufficient wealth and ability to bring these ores to such perfection as was requisite ...' and so ' ... Lord Mountjoy by his great charge has composed with him and attained the interest of his letters patent.'[30] Mountjoy had recently inherited a two-thirds share of the extensive manor of Canford but was nonetheless in great financial difficulties and, as he declared in his submission to the Queen, expected de Vos's enterprise 'to deliver him from his miseries' and also 'to be of benefit to the realm and the annoyance of the pope' (Gough 1969, 177–5).

The shadiness of character and the reliance on social connections which typified many of the early copperas producers is well illustrated by the subsequent dealings of Cornelius de Vos, effectively the industry's founder in England. Following his rather quick departure from Dorset in 1565, we hear a complaint against him in 1573 by his wife Helen, claiming that he had deserted her eight years previously and returned to Liège, a claim supported by Lionel Duckett, the Lord Mayor of London and one of de Vos's business colleagues.[31] However, we know that around the time of his supposed desertion, de Vos was in fact involved in the embryonic mining industries of Scotland and the north of England, where it was said that merchants '... very much fear the true dealing of Cornelius therein least he should make it richer by deceit than it is in deed' (Donald 1955, 86). Duckett, a Governor of the monopoly Company of Mines Royal, of which de Vos was a shareholder, almost certainly knew that de Vos was not in Liège at that time because he received a letter from Scotland in 1568 stating that this was '... where the said Cornelius is now, and has gotten privileges in that place, and others for gold, silver, copper and lead' (Donald 1955, 87–8).

26 State Papers 12/40/50, Public Record Office, Kew.

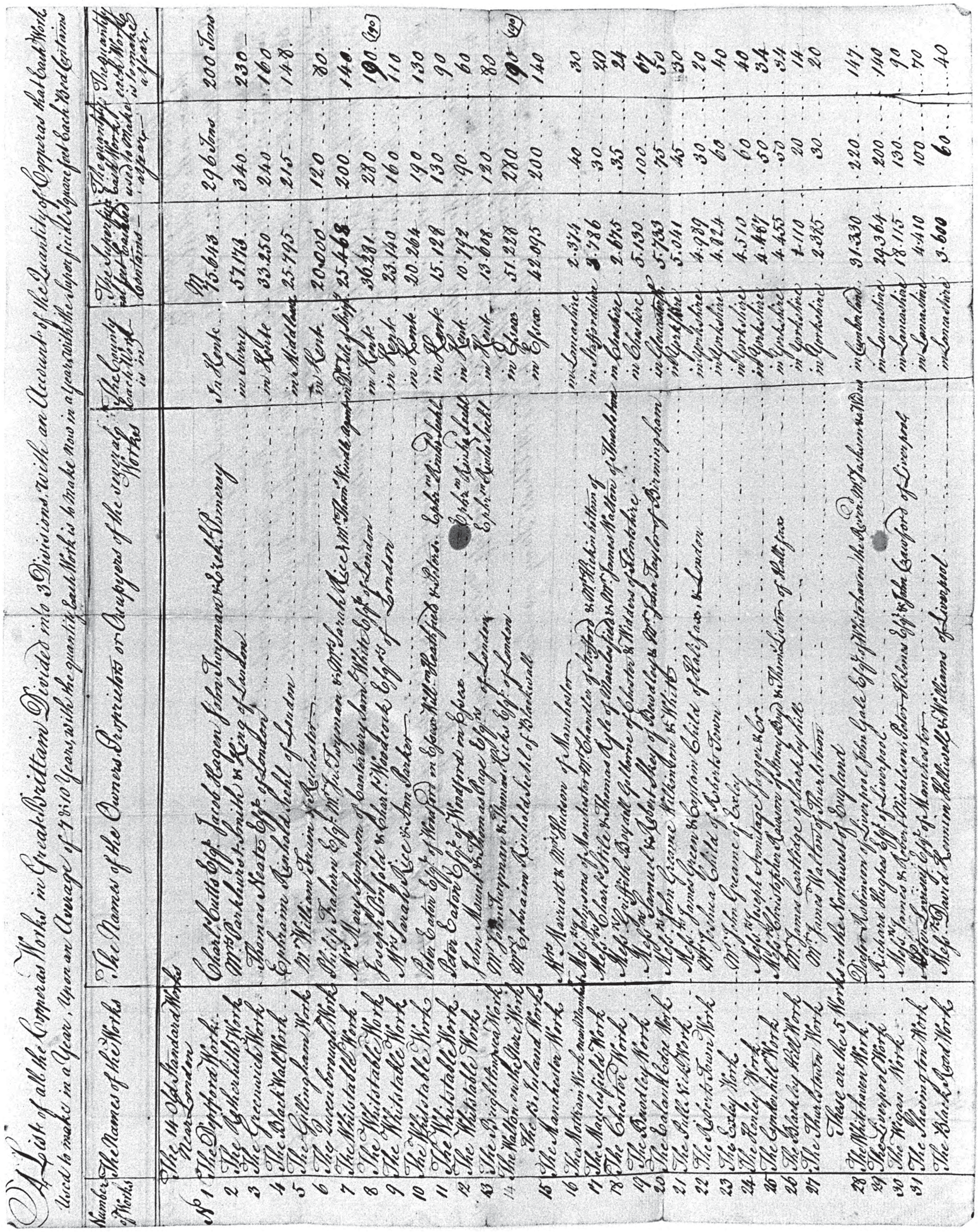
27 State Papers 12/163/56 (Inventory for Okeman's House, 1583, Public Record Office, Kew.

28 State Papers, Dom. 1547–80 and Patent Rolls 1563–66, C. 119, Public Record Office, Kew.

29 Patent Rolls 1563—66, C. 119, Public Record Office, Kew.

30 C.8. Eliz. c. 21, Public Record Office, Kew.

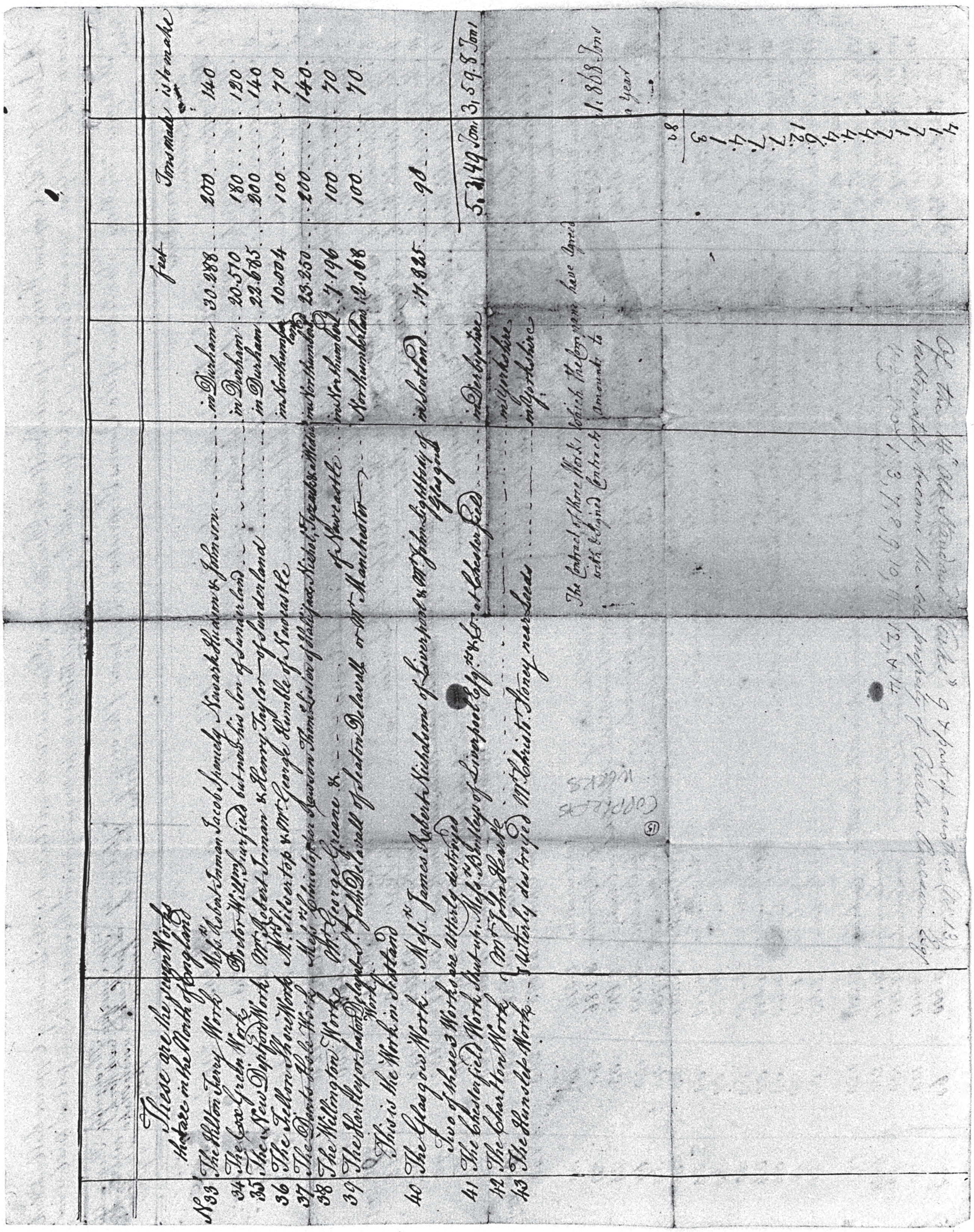
31 Court of Requests, Eliz. 28/60, 134/4, Public Record Office, Kew.



A List of all the Copperas Works in Great Brittain Divided into 3 Divisions, with an Account of the Quantity of Copperas that Each Work Used to make in a Year, Upon an Average of 7 & 10 Years, with the quantity Each Work is to make now in a Year, with the Superficial Square feet Each Bed Contains

Number of Works	The Names of the Works	The Names of the Owners, Proprietors or Occupyers of the several Works	The County Each Work is in	The Superficial feet Each Bed Contains	The quantity each Work used to Make a year	The quantity each Work is to make a Year
	The 14 Old Standard Works near London					
No 1	The Deptford Work	Charl. Cutts Esqr. Jacob Hagen John Twyman & Ezek. Pomeroy	In Kent	ft 75.643	296 Tons	200 Tons
2	The Rotherhith Work	Mrs Parkhurst Smith & King of London	in Surry	57.173	340	230
3	The Greenwich Work	Thomas Neate Esqr. of London	in Kent	33.250	240	160
4	The Black Wall Work	Ephraim Rinhold Sechl of London	in Middlesex	25.795	215	148
5	The Gillingham Work	Mr William Fruin of Rochester	in Kent	20.000	120	80
6	The Queenborough Work	Philip Fraherin Esqr. Mr Jn. Twyman & Mrs Sarah Rice & Mr Thos. Windle agent	in the Isle of Sheppy	25.468	200	140
7	The Whitstable Work	Mrs Mary Sympson of Canterbury Saml. White Esqr. of London	in Kent	36.281	280	190 (190)
8	The Whitstable Work	Joseph Pinfold & Charl. Woodcock Esqrs. of London	in Kent	23.140	160	110
9	The Whitstable Work	Mrs Sarah Rice & Ann Parker	in Kent	20.264	190	130
10	The Whitstable Work	Peter Eaton Esqr. of Woodford in Essex Willm. Heathfield & Peters. Ephrm. Rinhd. Sechl	in Kent	15.128	130	90
11	The Whitstable Work	Peter Eaton Esqr. of Woodford in Essex Ephrm. Rinhd. Sechl	in Kent	10.792	90	60
12	The Whitstable Work	John Mount & Thomas Page Esqrs. of London Ephrm. Rinhd. Sechl	in Kent	13.608	120	80
13	The Brightlingsea Work	Mr John Twyman & Thomas Ricks Esqr. of London	in Essex	51.228	280	190 (190)
14	The Walton on the Naze Work	Mr Ephraim Rinhold Sechl of Blackwall	in Essex	42.095	200	140
	The 13 Inland Works					
15	The Manchester Work	Mrs Marriott & Mr Hudson of Manchester				
16	The Mottram Work near Manchester	Messrs Johnsons of Manchester Mr Chandler of Stafford & Mr Hickinbottom of	in Lancashire	2.374	40	30
17	The Macclesfield Work	Messrs Charl. Stile & Thomas Ryle of Macclesfield & Mr James Walton of Thurlstone	in Staffordshire	3.786	30	20
18	The Chester Work	Messrs Griffith Boydell Golborne of Chester & Widders of Flintshire	in Cheshire	2.675	35	24
19	The Bowdley Work	Messrs Samuel & Robert Shey of Bewdley & Mr John Taylor of Birmingham	in Cheshire	5.130	100	67
20	The Ealand Edge Work	Messrs John Greame Wilkinson & White	in Gloucestersh.	5.733	75	50
21	The Pull Nick Work	Messrs James Green & Captain Child of Halifax, & London	in Yorkshire	5.041	45	30
22	The Roberts Town Work	Mr Joshua Child of Roberts Town	in Yorkshire	4.989	30	20
23	The Exley Work	Mr John Greame of Exley	in Yorkshire	4.824	60	40
24	The Henley Work	Messrs Joseph Armitage Jagger & Co	in Yorkshire	4.510	60	40
25	The Cinderhill Work	Messrs Christopher Rawson of Stoney Royd & Thoms. Lister of Hallifax	in Yorkshire	4.487	50	34
26	The Blackley Hill Work	Mr James Cartlidge of Blackley hill	in Yorkshire	4.455	50	34
27	The Thurlstown Work	Mr James Walton of Thurlstown	in Yorkshire	4.110	20	14
			in Yorkshire	2.385	30	20
	These are the 5 Works in the Northwest of England					
28	The Whitehaven Work	Doctor Robinson of Liverpool John Gale Esqr. of Whitehaven the Revd. Mr Jackson & Widow	in Cumberland	31.330	220	147
29	The Liverpool Work	Richard Hughes Esqr. of Liverpool	in Lancashire	29.364	200	140
30	The Wigan Work	Messrs James & Robert Nicholson, Peter Holmes Esqr. & John Crawford of Liverpool	in Lancashire	18.115	130	90
31	The Shevington Work	Peter Livesey Esqr. of Manchester	in Lancashire	4.410	100	70
	The Black Rood Work	Messrs David Kennion Holliwell & Williams of Liverpool	in Lancashire	3.600	60	40

Fig. 21. 1759–1765 list of copperas works, their owners and quantities of copperas produced, past and projected (Pearson family archive).



These are the seven Works that are in the North of England

No	Work	Owners		feet	Tons made	is to make
33	The Hilton Ferry Work	Mess.rs Robert Inman Jacob Spenely Newark Hudson & Johnson	in Durham	30.288	200	140
34	The Cox Green Work	Doctor Will.m Surfield but now his Son of Sunderland	in Durham	20.510	180	120
35	The New Deptford Work	Mr Robert Inman & Henry Taylor of Sunderland	in Durham	22.685	200	140
36	The Fellon Shore Work	Mrs Silvertop & Mr George Humble of Newcastle	in Northumberland	10.004	100	70
37	The Dents Hole Work	Mess.rs Christopher Rawson Thos Lister of Hallifax, Nichol, Tyzack & Midd..	in Northumberland	23.250	200	140
38	The Willington Work	Mr George Greane & ... of Newcastle	in Northumberland	7.196	100	70
39	The Hartley or Seaton Delavel Work	Sr John Delavall of Seaton Delavall or Mr Manchester	Northumberland	12.068	100	70
	This is the Work in Scotland					
40	The Glasgow Work	Mess.rs James Robert Nicholsons of Liverpool & Mr John Lightbody of Glasgow	in Scotland	17.825	98	
	Two of these 3 Works are Utterly destroyed				5.3149 Tons	3,598 Tons
41	The Chesterfield Work Shut up	Mess.rs Bentleys of Liverpool Esq.rs & Co at Chesterfield	in Derbyshire			
42	The Charlton Work	Mr John Heart	in Yorkshire			
43	The Hunslet Work	Utterly destroyed Mr Christ.r Stoney near Leeds	in Yorkshire			

The Contract of these Works which the Company have Agreed with & Signed Contracts amounts to 1.868 Tons a Year

COPPERAS WORKS

Fig. 22. 1759–1765 list of copperas works, their owners and quantities of copperas produced, past and projected (Pearson family archive).

The importance of influence and favour in gaining monopolies is illustrated by a letter written by Mountjoy in 1566 to Sir William Cecil, stating that: ' ... touching the success of the minerals, the copperas is wrought with weekly gain over and beside all expenses'.[32] In another letter of the same year he claimed he would be able to make: ' ... in two years 150 tons of alum as good as the Romish sort and 150 tons of copperas as good as the Danske sort'[33] (but as previously discussed, alum was only produced for a short period). Mountjoy made this claim despite the fact that difficulties had arisen which hampered the initiation of production, probably as a result of the inexperience of the locals employed in the works. To remedy this, de Vos had brought in supposedly skilled workmen from Italy at the expense to Mountjoy of £300, but Mountjoy later claimed that these too were incompetent. In 1567, Mountjoy was granted the patent for twenty-one years (Jenkins 1936, 199) and took over the management of the enterprise. Finding himself in the unaccustomed role of tradesman, the aristocratic Mountjoy is reported to have exclaimed 'Some saie that I verrye from my vocation to become a myner' (Gough 1969, 178). In 1572, Mountjoy granted the lease of a second works (Okeman's House) to Cornelius Stevenson (Turton 1938, 40–41) and later a third Dorset house was established on Brownsea Island, also called 'the Isle of Branksea,' and another established at Boscombe.[34]

The expected profitability of the Dorset works is apparent from Mountjoy's letters to Sir William Cecil. That this expectation was realised is evident from a complaint made against the Dorset works in 1571 by a group of Bristol merchants, whose trade in Spanish alum had been hard hit by this new and cheap source of vitriol (Thirsk 1978). The industry clearly continued to be highly profitable, as is indicated by the increase in the cost of the original Alum Chine lease from £5 in 1566 to over £1000 in the 1580s when it was eventually re-leased. It is also evident from the 3rd Earl of Huntingdon's determined and eventually successful attempts to take possession of the Dorset works (the Earl of Huntingdon was the landlord and principal creditor of the near-insolvent Mountjoy). The high profitability is indicated by the £6,000 which the Privy Council required Huntingdon to pay over a five-year period in order to acquire the business (Gough 1968, 178). This followed a complicated and far-reaching legal judgement passed in 1586 in which mining rights were separated from manorial rights.[35]

The dishonest practises which appear to have been such a part of the early industry (see also p. 42) were clearly the result of the large amount of money which could be made. Following the Earl of Huntingdon's acquisition of the Dorset works, profitable production continued despite complicated legal wrangles revolving around a claim by Mountjoy's two sons to the estate and the mines. In 1586, after six years of litigation, the dispute was eventually settled to Huntingdon's advantage, albeit at a cost to him which he estimated at £20,000 (Gough 1969, 179–80).

Various financial transactions illustrate the great value of the Canford mines during this early period. For example, Huntingdon raised mortgages on the mines to help settle his debts and was able to borrow £1,200 on the security of a twelve year lease to produce 200 tons of copperas a year. The burgeoning profitability of the business was also indicated by the increase in value of the lease for a mine from £5 in 1566, £100 in 1579, £1,500 in 1585 and £1,300 in 1588 (Cross 1966, 94–5; Gough 1969, 180–1). In 1586, Huntingdon claimed to be making £400 per annum from the mines (Bettey 1982, 93) and Poole harbour prospered on the back of the copperas trade. A cargo of 100 tons bound for London in 1584 realised the huge sum for a single cargo of £1,200 or £12 a ton (Willan 1976, 36). Bettey (1982, 93) published a typical inventory for a copperas house, in this case for Okeman's House in 1583:

> 25 hogsheads of copperas made and in casks ... another 30 made but not in casks ... 50 pittes of oar full without doors ... Lycore lefte in the howse, boyled and congealed ... to the quantity of 14 hogsheads, and Oare reddy digged and cast upp in great heapes about a hundred in number, some bigger than some to lye a seasoninge before they come to the workinge.

Huntingdon's duties at Court eventually led him to lease all the mines to Philip Smith in 1587 at an annual rental of £1,300, around which time Cornelius Stevenson appears to have decamped to begin copperas production at Whitstable. The Canford monopoly was not renewed in 1591 but this appears not to have immediately affected the working of the mines. However, it is clear that production had ceased by 1608, when Smith's lease expired, because the new 5th Earl of Huntingdon attempted to re-open the works and, in order to ensure a supply of fuel, enclosed a peat-rich tract of Canford waste. This was strongly opposed by the locals, who claimed rights of common on the land and, in support of their case, stated that the two copperas houses on the land in question 'for many years ... had both been suffered to fall into decay' (Gough 1969, 179–80). This situation was confirmed when the 5th Earl sued Smith for arrears of rent and was awarded £800 as the estimated profit due if the works had continued in production, and a further £1,050 as compensation from Smith for having demolished one house and allowing the other to fall into disrepair (Cross 1966, 96).

Copperas production was not resumed on the Canford site. Clearly the Dorset industry was in drastic decline at this time. A few years earlier, in 1603, Richard Laycolt, an associate of de Vos and a co-lessee of the Alum Chine works at Canford, had left to test some promising ores in the grounds

32 State Papers 12, 39 77, Public Record Office, Kew.

33 State Papers 3, Case 1721, Constantine 7, Public Record Office, Kew.

34 Exchequer Bills and Depositions E 178/710, Public Record Office, Kew.

35 *Op. cit.* note 33.

of John Atherton Esq. at Skelton, near Guisborough, Yorkshire (see p. 49). These ores proved suitable for the economic production of alum and copperas and provided the basis for the embryonic northern industry (Gough 1969, 183–4; Turton 1938, 65).

In Dorset, Sir William Clavell made a belated and unsuccessful attempt in the early seventeenth century to establish four copperas houses on a site some 12 miles to the west of Canford at Kimmeridge on the Isle of Purbeck (Bettey 1982, 94–5). It is also known from contemporary accounts that the works at Brownsea Island, 'where there is much copperice made' (Fiennes 1982, 39) remained productive at least until the end of the seventeenth century and that copperas stones continued to be collected along the coast of the Isle of Wight and dispatched to Deptford via the Thames throughout the eighteenth century (Worsely 1781, 271). In 1739, an agreement is recorded between John Rice of Deptford, 'copperas maker' and two Isle of Wight locals for the collection of copperas stones from the beach and delivery at £1 5s. 0d. a ton.[36] Large-scale export of copperas stones from the Isle of Wight continued well into the eighteenth century because we are told in 1773 that pyrites was delivered to the Deptford works 'by water, chiefly from the Isle of Wight, under the name of copperas stones' (Lewis 1773, 270). Pyrites was also shipped north to the newly-founded New Deptford works in County Durham during the late eighteenth century (Morris and Russell 1988, 151). Nevertheless, the greater distance of Dorset and the Isle of Wight from the London markets relative to the Essex and Kent industries certainly favoured the latter.

The Essex and Thames estuary industries

The Essex and Thames estuary industries appear to have developed similarly to each other, but differed from the Dorset industry in that no sustained attempt was made to produce alum. The pyritic ore within the London Clay of the Thames Basin was unsuitable for that purpose.

Records for the early development of the Essex and Thames estuary industries (other than Whitstable) are rare, but there is some slight evidence for the gathering of copperas stones on the Essex coast in the early part of the sixteenth century and this may suggest small-scale copperas production associated with the local textile industry (Shenstone 1907, 411–13; Thirsk 1978, 36–7). However, as Lambarde's observations of 1579 (p. 29) make clear, the industry at Queenborough, on the west coast of Sheppey in Kent, soon developed, initially under the direction of a Brabant immigrant. The substantial works and production process at Queenborough were described in some detail by Sir William Brereton in 1634 and were reported at that time to use 300 tons of coal per year (Brereton 1844; Neff 1934–5, 3). Brereton states that the copperas ore came to Sheppey from the Essex coast, which suggests that Essex ore was of better quality than that available at Sheppey (George 1975, 35). From Sheppey it was transported to the 'landing place of the copperas houses either at Blackwell or at Deptford',[37] both of which were owned by the Crispe family (p. 37).

A series of later leases confirm that much of the copperas ore collected in Essex was for processing elsewhere, with most going to the Blackwall and Deptford works. George (1975) provides examples of quantities delivered and prices paid for copperas stones collected in Brightlingsea. Thus, we read an account of copperas stones delivered to 'Charles Crispe Esquire or to his order from the 9th of Aprill 1715 to Midsummer 1720,' in which a total of 1,158 tons 13 hundredweight, 2 quarters and 21 pounds were dispatched to Crispe's London works for a price of £4,948 15s. 3d. (about £4 6s. 7d. a ton), including a refund of £66 10s. 0d. for 'copperas pretended to be had.'[38] The total sum is approximately four times greater than that paid for a similar quantity from Sheppey (George 1975, 13), again suggesting that the Essex copperas was of higher quality.

Two inventories dated 1702, one for a copperas works at Walton and one for a works at Brightlingsea, list the many and expensive items of equipment required for on-site copperas production, indicating local copperas production (George 1975, 44–5). Copperas production at 'Bricklesey' (now Brightlingsea) was described by John Ray (1674), and Samuel Dale (1730) referred to similar works at Copperas Bay, Ramsey, near Walton-on-the-Naze. Documentary evidence confirms that the area continued as a substantial copperas producing centre into the early nineteenth century (Anon 1829, 20–21).

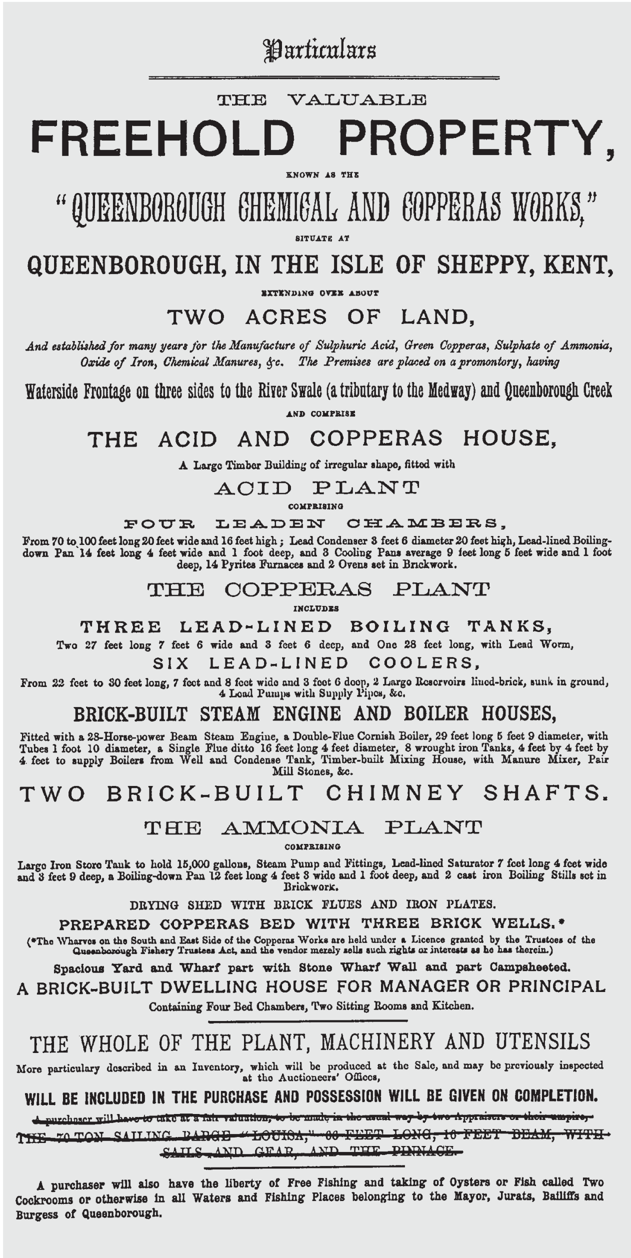
In Essex early in the twentieth century 'The fragments of copperas were gathered on the beach by the wives and children of the fishermen who obtained their richest harvest after severe storms, which washed the fragments out of the cliffs' (Shenstone 1907, 402). Copperas production was therefore located at various points along the Essex coast where the raw material was most easily obtainable, probably in response to the demands for the product by cloth and leather manufacturers.

Smaller-scale copperas production appears to have taken place in the Medway estuary. Here, pyritic nodules in the London Clay (possibly redeposited as alluvium) were collected at low tide and supplied at least two copperas houses, one at Grange, by the suggestively named Copperhouse Marshes, and one at Horrid Hill (Pearce undated, 95–6). The name of the latter may derive from the foul smell which accompanied copperas production. In Kent, as in other copperas-producing areas, a number of smaller copperas houses were established, for example at Milton Regis and Folkestone.

36 Bd/323, Isle of Wight Record Office.

37 Centre for Kentish Studies, Maidstone, U487 E1.

38 D/DM Z12, Essex Record Office.



Particulars

THE VALUABLE

FREEHOLD PROPERTY,

KNOWN AS THE

"QUEENBOROUGH CHEMICAL AND COPPERAS WORKS,"

SITUATE AT

QUEENBOROUGH, IN THE ISLE OF SHEPPY, KENT,

EXTENDING OVER ABOUT

TWO ACRES OF LAND,

And established for many years for the Manufacture of Sulphuric Acid, Green Copperas, Sulphate of Ammonia, Oxide of Iron, Chemical Manures, &c. The Premises are placed on a promontory, having

Waterside Frontage on three sides to the River Swale (a tributary to the Medway) and Queenborough Creek

AND COMPRISE

THE ACID AND COPPERAS HOUSE,

A Large Timber Building of irregular shape, fitted with

ACID PLANT

COMPRISING

FOUR LEADEN CHAMBERS,

From 70 to 100 feet long 20 feet wide and 16 feet high; Lead Condenser 3 feet 6 diameter 20 feet high, Lead-lined Boiling-down Pan 14 feet long 4 feet wide and 1 foot deep, and 3 Cooling Pans average 9 feet long 5 feet wide and 1 foot deep, 14 Pyrites Furnaces and 2 Ovens set in Brickwork.

THE COPPERAS PLANT

INCLUDES

THREE LEAD-LINED BOILING TANKS,

Two 27 feet long 7 feet 6 wide and 3 feet 6 deep, and One 28 feet long, with Lead Worm,

SIX LEAD-LINED COOLERS,

From 22 feet to 30 feet long, 7 feet and 8 feet wide and 3 feet 6 deep, 2 Large Reservoirs lined-brick, sunk in ground, 4 Lead Pumps with Supply Pipes, &c.

BRICK-BUILT STEAM ENGINE AND BOILER HOUSES,

Fitted with a 28-Horse-power Beam Steam Engine, a Double-Flue Cornish Boiler, 29 feet long 5 feet 9 diameter, with Tubes 1 foot 10 diameter, a Single Flue ditto 16 feet long 4 feet diameter, 8 wrought iron Tanks, 4 feet by 4 feet by 4 feet to supply Boilers from Well and Condense Tank, Timber-built Mixing House, with Manure Mixer, Pair Mill Stones, &c.

TWO BRICK-BUILT CHIMNEY SHAFTS.

THE AMMONIA PLANT

COMPRISING

Large Iron Store Tank to hold 15,000 gallons, Steam Pump and Fittings, Lead-lined Saturator 7 feet long 4 feet wide and 3 feet 9 deep, a Boiling-down Pan 12 feet long 4 feet 3 wide and 1 foot deep, and 2 cast iron Boiling Stills set in Brickwork.

DRYING SHED WITH BRICK FLUES AND IRON PLATES.

PREPARED COPPERAS BED WITH THREE BRICK WELLS.*

(*The Wharves on the South and East Side of the Copperas Works are held under a Licence granted by the Trustees of the Queenborough Fishery Trustees Act, and the vendor merely sells such rights or interests as he has therein.)

Spacious Yard and Wharf part with Stone Wharf Wall and part Campsheeted.

A BRICK-BUILT DWELLING HOUSE FOR MANAGER OR PRINCIPAL

Containing Four Bed Chambers, Two Sitting Rooms and Kitchen.

THE WHOLE OF THE PLANT, MACHINERY AND UTENSILS

More particulary described in an Inventory, which will be produced at the Sale, and may be previously inspected at the Auctioneers' Offices,

WILL BE INCLUDED IN THE PURCHASE AND POSSESSION WILL BE GIVEN ON COMPLETION.

~~A purchaser will have to take at a fair valuation, to be made in the usual way by two Appraisers or their umpire,~~

~~THE 70 TON SAILING BARGE "LOUISA," 66 FEET LONG, 16 FEET BEAM, WITH SAILS AND GEAR, AND THE PINNACE.~~

A purchaser will also have the liberty of Free Fishing and taking of Oysters or Fish called Two Cockrooms or otherwise in all Waters and Fishing Places belonging to the Mayor, Jurats, Bailiffs and Burgess of Queenborough.

Fig. 23. Detailed bill of sale with list of equipment, 1882.

Four important copperas houses were established by the Thames near London, one at Deptford Creek, one at Greenwich, one alongside the River Lee at Blackwall and one at Rotherhithe. These houses, along with a number of others, clearly benefited from their position on the river (the chief means of transport) and close to the capital (the chief market for their product).

The Deptford works would appear to have been the most important of these works. Commenting on the close relationship between the Kentish industry, Deptford and the London markets, Chalklin (1965, 114–5) states:

> The London market took a large share of the product and London capital played its part in the growth of the Whitstable works. A factory at Tankerton was sold in 1636 for £1,000 to John Eldred, citizen and merchant of London, and next year he resold it to William Aleyn, a London grocer. In 1702 Aleyn's grandson mortgaged it to a London doctor, John Lawson. The direct influence of the city market may be seen in the buildings of the works at Deptford drawing on supplies in the Isle of Sheppey: the factory was in the vicinity of its chief market instead of the source of its raw material.

It may be that Chalklin was unaware of the great size and productive capacity of the Whitstable industry when he drew this conclusion. Judged on the basis of the six Whitstable works, their greater overall size, the amount of their associated equipment and their greater total annual output, the Whitstable industry clearly surpassed both the Deptford and Queenborough works by a considerable margin. Yet the Whitstable industry was established next to the source of its raw material, rather than its principal market, with a direct and relatively short shipping route to the London market via the Thames compensating for the greater distance.

Occasional references in trade and port records provide evidence for the great quantities of pyritic ore and processed copperas destined for the London markets. For example: in 1638 from Colchester, 55 tons (Willan 1976, 75); in 1656 from Whitstable, 225 tons and from Faversham 27 tons (Andrews 1955, 129–30; Chalklin 1965, 179); in 1685 from Ipswich, 430 tons in two cargoes (Willan 1976, 75). From 1656 to 1701, the combined copperas exports from Faversham, which included those from Whitstable, were 375 tons per annum falling to 181 tons by 1741 (Andrews 1955, 129–30; Chalklin 1965, 179).

Inventories and detailed descriptions of the Deptford and Essex works (Colwall 1677, 1056–9)[39] show them to have been large in scale, but other sources indicate that the production process itself was not labour intensive with, for example, only two or three people being employed at the Deptford works in 1748 (Kalm 1892, 79). At a Whitstable works we are told that the workforce, (copperas pickers apart), consisted of ten men: 'a man in charge of the pickers who earned £30 a year or 12s. 6d. a week, a Master Workman who earned £32 a year or 13s. 4d. a week, a Master Labourer, payed 6d. a day, three ordinary labourers payed 1d. each a day, and a Lead Burner, a Salesman, a Blacksmith and a Shipman, wages unknown' (Donald undated). Much larger numbers of people were employed in collecting copperas stones and the transportation of these and the refined product must have employed many more. In addition, we are told of 'old iron, picked up by the poor people about our streets to sell to the copperas makers' (Croker *et al.* 1764).

39 Also D/DB T608, Essex Record Office.

Ownership

It has been shown that a complex network of common part-ownership, shared leases and family interest came to connect most of the copperas works in south-east England (Goodsall 1956; George 1975). This is clear from the indenture of 1702 to which the Walton and Brightlingsea inventories are attached, where it is stated that Steven Ashton leased from one Richard Hopkins:

> All that his third part in Queenborough copperas work ... also all that share of all warehouses,edifices, buildings, beams, scales, cranes and superstructure on the East Side of St Saviour's Dock in the parish of St Mary Bermondsey Surrey ... and all that his full third part of … copperas works in Walton and Brightlingsea.[40]

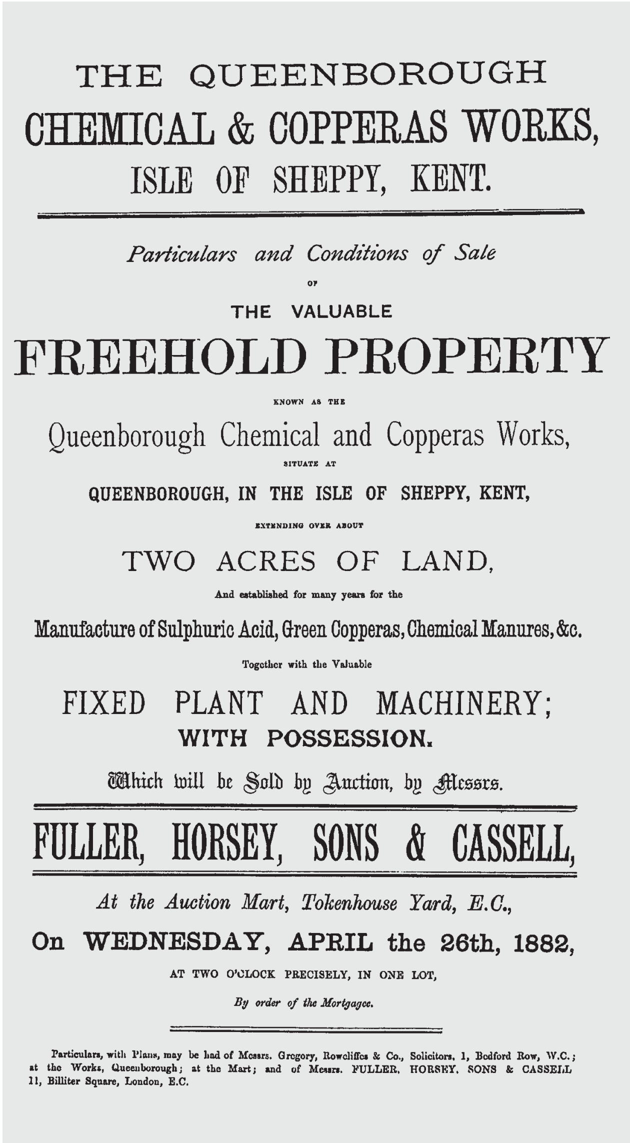
Extensive documentary research (Goodsall 1956) has revealed that holdings and leases in the industry were largely passed down through a group of families with strong social links. The following account demonstrates this phenomenon and illustrates how the later Whitstable industry was thereby linked to the Essex, Queenborough and Deptford industries as part of a labyrinthine social and familial network.

In 1780, Charles Pearson married Elizabeth Radford who had inherited two copperas works in Whitstable from her uncle and who later bought two Whitstable copperas houses from Sarah Parker. Sarah Parker had inherited the two copperas houses from her nephew, Charles Crispe Rice, who had in turn inherited them from John Rice of St Paul, Deptford. As suggested by Charles's middle name, the Rice family was linked with the Crispe family who owned the Deptford copperas works from the mid seventeenth to the late eighteenth century.[41]

The Crispes were a powerful family whose involvement with the southern copperas industry lasted for more than a century, during much of which they appear to have dominated the industry. The name appears in many extant leases[42] and Nicholas and Ellis Crispe are also known to have been involved in the Yorkshire alum and copperas industries in 1610 (Turton 1938, 73–4). In 1575, a Nicholas Crispe resided at '*Grimgill* [Grimshill Manor], in Whitstaple' (Hasted 1798, 297–302). A branch of the family also lived at Quex Hall, Birchington, on the Isle of Thanet, Kent (Hussey 1915, 26, 51).

The Crispes were also established as wealthy merchants in Guinea and both Nicholas and Ellis were members of the East India Company and Merchant Adventurers. The latter in effect constituted a capitalist monopoly engaged primarily in the export of finished cloth, hence the connection with the alum and copperas industries. Like the first domestic copperas producers, the Merchant Adventurers represented the vanguard of state-backed entrepreneurialism, the net effect of which 'won English trade from the foreigner and laid for Englishmen the basis for their later commercial supremacy' (Rowse 1950, 177). However, as we have seen, in the case of the copperas producers, this was achieved by turning foreigners into Englishmen. The Crispes' association with the copperas industry lasted at least until 1723, when Sir John Crispe's will refers to 'my share in both companies at Deptford and Blackwell' (Crisp 1882, 73).

John Rice is also known to have issued copperas tokens in Essex and Kent for paying copperas pickers in about 1785



THE QUEENBOROUGH
CHEMICAL & COPPERAS WORKS,
ISLE OF SHEPPY, KENT.

Particulars and Conditions of Sale
OF
THE VALUABLE
FREEHOLD PROPERTY
KNOWN AS THE
Queenborough Chemical and Copperas Works,
SITUATE AT
QUEENBOROUGH, IN THE ISLE OF SHEPPY, KENT,
EXTENDING OVER ABOUT
TWO ACRES OF LAND,
And established for many years for the
Manufacture of Sulphuric Acid, Green Copperas, Chemical Manures, &c.
Together with the Valuable
FIXED PLANT AND MACHINERY;
WITH POSSESSION.
Which will be Sold by Auction, by Messrs.

FULLER, HORSEY, SONS & CASSELL,

At the Auction Mart, Tokenhouse Yard, E.C.,
On WEDNESDAY, APRIL the 26th, 1882,
AT TWO O'CLOCK PRECISELY, IN ONE LOT,
By order of the Mortgagee.

Particulars, with Plans, may be had of Messrs. Gregory, Rowcliffes & Co., Solicitors, 1, Bedford Row, W.C.; at the Works, Queenborough; at the Mart; and of Messrs. FULLER, HORSEY, SONS & CASSELL 11, Billiter Square, London, E.C.

Fig. 24. Bill of sale for the Queenborough works, 1882.

40 D/DbT608, Essex Record Office.

41 The parish register of St Mary St Leonards, Bromley-by-Bow, records a Thomas Rice living in 'the Copperas House' there in 1701.

42 For example, U 487 E. 17, Centre for Kentish Studies, Maidstone.

(George 1991, 15–17) and is thought to be descended from a Mr Rice who took delivery of copperas from Queenborough on behalf of Sir Nicholas Crispe from 1715 to 1720 (George 1975, 34–7). The document listing the domestic copperas works (**Figs 21** and **22**) described in detail on p. 48 also indicates that a Mrs Sarah Rice had part-ownership of the Queenborough works and one of the Whitstable works in about 1760. When Charles Pearson married Elizabeth Radford he had been engaged in negotiations to buy the Deptford copperas works for four years and had bought the associated residence, known as 'Copperas House', which had been built by the Crispe family.

Nineteenth-century chemical works

The Deptford works ceased production in about 1828 at about the same time as those at Whitstable (Anon 1704). This was ostensibly the result of the financial difficulties besetting their common owner Charles Pearson (see below, p. 48), but the technological and other changes discussed above meant that ultimately closure was inevitable. A technical innovation, presumably a belated attempt to revive the London industry, had in fact been attempted in 1818 by Thomas Hills of Bromley-by-Bow and Uriah Haddock. Haddock and Hills patented a method[43] for preparing sulphuric acid from iron pyrite (copperas stones) by roasting it over coal and condensing the resulting acid gas (Dickinson 1937, 56). Copperas stones delivered to the two London works from the Isle of Sheppey were considered ideal for this purpose because they were free from arsenic. Elsewhere, other works had to import arsenic-free iron pyrite from Wicklow in Ireland at a cost of £1 7s. a ton. Contamination of the acid by soot from the coal quickly led to abandonment of the Haddock/Hills process. But high sulphur prices later promoted successful innovations elsewhere. Roast pyrites techniques were introduced by Messrs Peret in France (1835) and Thomas Farmer in London (1839) (Dickinson 1937, 56).

In 1882, William Carr Stevens bought the Queenborough works on the Isle of Sheppey, from the Queenborough Chemical Company Ltd, which had acquired them from Josiah Hall in 1871. Stevens Sons and Company continued to use local copperas stones to produce sulphuric acid via a horizontal lead-chamber process (a development of Roebuck's lead chamber method) using plant previously installed by the Queenborough Chemical Company. By 1886, Stevens Sons and Company was using this process to produce the fertiliser Sulphate of Ammonia (made using sulphuric acid and ammonia from gasworks), along with a wide range of other chemicals including organic manures, superphosphates, bone glue, tallow and degelatised bone. Eventually, the use of copperas stones was discontinued in favour of the sulphur-rich waste from gasworks, this marking the end of the 300 year-old copperas industry at Queenborough (Stevens 1987, 2).

Deeds and schedules in the possession of the company's now-retired co-chairman, Mr Michael Stevens, show that copperas was still being produced in 1892 and that copperas stones were being crushed to make sulphuric acid using a '15 inch Stone Crusher'. The company, still owned by the Stevens family and now known as Sheppy Fertilisers Ltd, continues to produce fertilisers at Queenborough to the present day. Thus, this modern and successful chemical factory can be shown to be the direct descendent of the Falconer works as observed by Lambarde in 1579.

The link between the early copperas works and the modern chemical industry is also evident in an inspection of the Queenborough Chemical and Copperas Works by a Mr Packard, who accompanied Mr William Carr Stevens, prior to the latter's purchase of the works in 1882. Mr Packard was an Ipswich sulphuric acid manufacturer, the Ipswich industry having been established to take advantage of the rich supplies of high-quality copperas stones available at Harwich and Walton-on-the-Naze. Packard eventually joined with other chemical manufacturers to form Fisons, Prentis and Packard, later to become the major agricultural chemical company Fisons Ltd (Stevens 1987, 2), now Hydro Agri (UK) Ltd.

In the 1860s the Queenborough works were still sufficiently prominent for a claim to be made that they were 'the most ancient copperas manufactury, being the first established in England' (Post Office 1866, 1118), a claim also made for the Rotherhithe works, near Deptford (Manning and Bray 1804, 228). The 1869 Ordnance Survey (compiled 1864/5) shows and names the copperas house and bed at Queenborough and the same works were named, mapped and described in detail in a bill of sale and related documents dated 1882 (see **Figs 23–25**).[44] The Ordnance Survey of 1892 does not show the copperas works to have survived as a separate entity at that time, although the documentary evidence discussed above indicates that some small-scale copperas production still took place at that time.

The Deptford copperas works similarly demonstrate a developmental link between the copperas industry and the modern chemical industry. Seven years after the bankruptcy of their owner Charles Pearson Junior in 1835, they were acquired by John Lawes, who is reported to have chosen the site as he took a trip down the Thames looking for a suitable location for a new factory.[45] Lawes is famous for inventing and patenting the manufacturing process for the fertilisers now called superphosphates, and other fertilisers called variously 'Sulphate of Ammonia', 'Phosphate of Ammonia' and 'Super Phosphate of Lime'. Thus we read on page 442 in the *Gardener's Chronicle* of 1 July, 1843:

43 Patent number 4263.

44 Documents held at Queenborough Public Library, Isle of Sheppey.

45 An insight into Lawes' general outlook is perhaps evident in the fact that he combined this task with his honeymoon (Dyke 1993, 14–17).

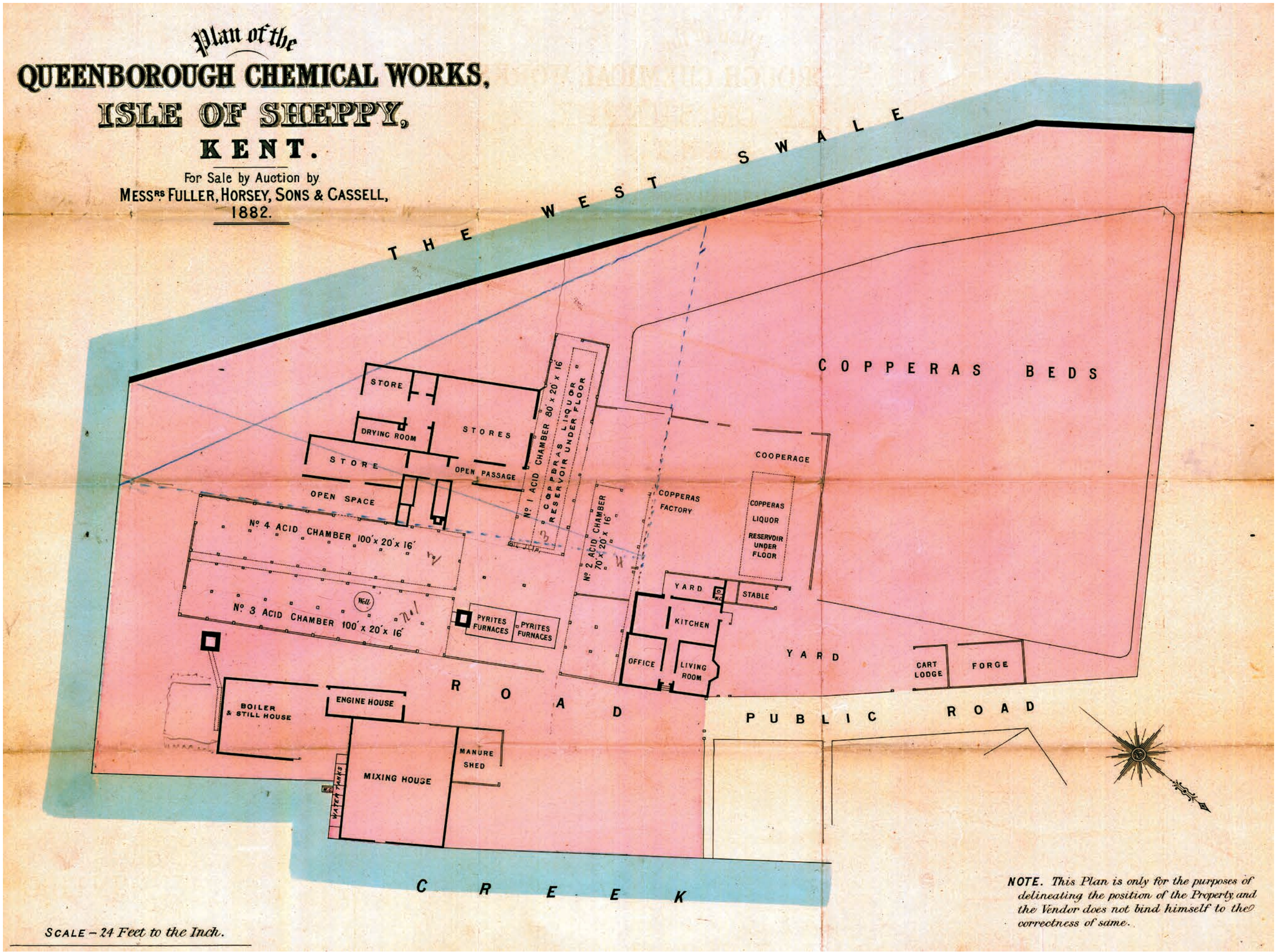


Fig. 25. Plan of the Queenborough Chemical Works, for sale in1882.

> J. B. LAWES'S PATENT MANURES, composed of Super Phosphate of Lime, Phosphate of Ammonia, Silicate of Potass, &c., are now for sale at his Factory, Deptford-creek, London, price 4s. 6d. per bushel. These substances can be had separately; the Super Phosphate of Lime alone is recommended for fixing the Ammonia of Dung-heaps, Cesspools, Gas Liquer, &c. Price 4s 6d. per bushel.

Sulphuric acid was used in the production of superphosphates, and it is likely that the presence of plant for sulphuric acid production (originally made from copperas) on the Deptford site, along with its easy access to the Thames, made this the perfect site for Lawes, who soon built a large factory there. However, as at Queenborough, pyritic ore probably replaced copperas as the raw material for the large-scale sulphuric acid production that the times required, with the ore eventually being replaced by 'spent oxide' waste from gas works, the gas being extracted from coal. In this process, sulphur was recovered from hydrogen sulphide impurites filtered out of the coal-gas with iron-oxide purifiers using a technique developed by Richard Laming and F.J. Evans in the 1840s (Stewart 1958, 24; Mills 1999, 131–4). In the case of the Deptford works the spent oxide came from the Phoenix Gasworks across the creek (Mills 1999, 15; Dyke 1993, 14–17). However, an early sketch of the site drawn by Lawes before his massive factory had been built shows two 'vitriol tanks'. These are consistent in appearance and size with the copperas tanks shown on the plan (**Fig. 25**) attached to the 1882 bill of sale and list of saleable equipment for the Queenborough works (**Figs 23** and **24**). It may therefore be suggested that, by siting his fertiliser factory at Deptford in 1842, Lawes inherited a local workforce experienced in working with noxious chemicals, particularly copperas, sulphuric acid and sulphates, as was certainly the case for William Carr Stevens at Queenborough in 1882.

5
The Industry at Whitstable

The industry in Kent was mentioned by writers and historians from the sixteenth to the early nineteenth centuries (for instance Lambarde in 1579, Seymour in 1776 and Hasted in 1798). However, despite its widespread and noxious nature and the great wealth it once generated, the industry was quickly forgotten after technical innovation had rendered it obsolete. Robert Goodsall, in his detailed history of the Whitstable copperas industry written in 1956, states: 'To-day all visible traces of the works have long since disappeared and local memory is unable to recall details of this bygone trade of many generations of Whitstable folk'.

The first manufacturers

Cornelius Stevenson probably received the first patent to manufacture copperas in Whitstable in 1564,[46] but he seems to have remained in Dorset until the termination of the Okeman's House lease in 1587[47] (see p. 34). However, it seems that, as in Essex, a rudimentary copperas industry may have been established in Whitstable before Stevenson's arrival. Evidence suggestive of early copperas production in the area is supplied by the following account, dated 1572:

> the 17th daye of November in the 15 yere of the reygne of our soverigne ladye Elizabethe, one Crosse of merchaunte man of London whyche he seyethe he nowe by syghte, he went aborde of the said Lewes harder hys barke, lyeing at the cryckes mouthe comyng in here to Faversham [some 10 miles to the south-west of Whitstable] and hys men delyveryd and shypped into hym the said Abraham Snothe hys hoye 4 fattes of cooperes ...[48]

It is possible that Stevenson arrived in Whitstable to exploit his patent to produce copperas because he had been forced to leave Dorset, having defrauded the Earl of Huntingdon (see p. 34). In 1593, an objection was made to the Earl's application to renew his Canford patent, the objection being that two others were already making copperas. Huntingdon answered by stating that '… the copperas is bad, and one of the makers [Stevenson?] was a late tenant of the Earl and had defrauded him of much profit'.[49] It may therefore not be a coincidence that Stevenson is first mentioned in the Whitstable lay subsidies in 1588, around the time that his Canford lease ran out.[50]

The copperas industry required considerable and long-term capital outlay due to the large quantity of equipment involved and the length of time before a return could be expected (Colwall 1677, 1056–9; Coleman 1951, 171). Lack of capital may explain the delay in initiating copperas production in Whitstable, though Stevenson appears to have arrived as a prosperous man; in 1589 he was named as a Whitstable Charity Trustee,[51] suggesting that he had profited considerably from his Canford lease. The Parish Register gives the names of his five children, the first being an infant who died in 1589.[52] Stevenson died in 1594 and the

46 *Op. cit.* note 14.

47 King's Remembrancer, Special Commission, 710, Public Record Office, Kew.

48 F/JQE 1. f. 7v, Centre for Kentish Studies, Maidstone.

49 Cal. State Papers, Dom. Elizabeth 1593–94, No. 244, Public Record Office, Kew.

50 List of Lay Subsidies (Class E179), Public Record Office, Kew.

51 Wallace Harvey Archive, Whitstable Museum.

52 All Saints' Parish Register, Whitstable, Canterbury Cathedral Archive.

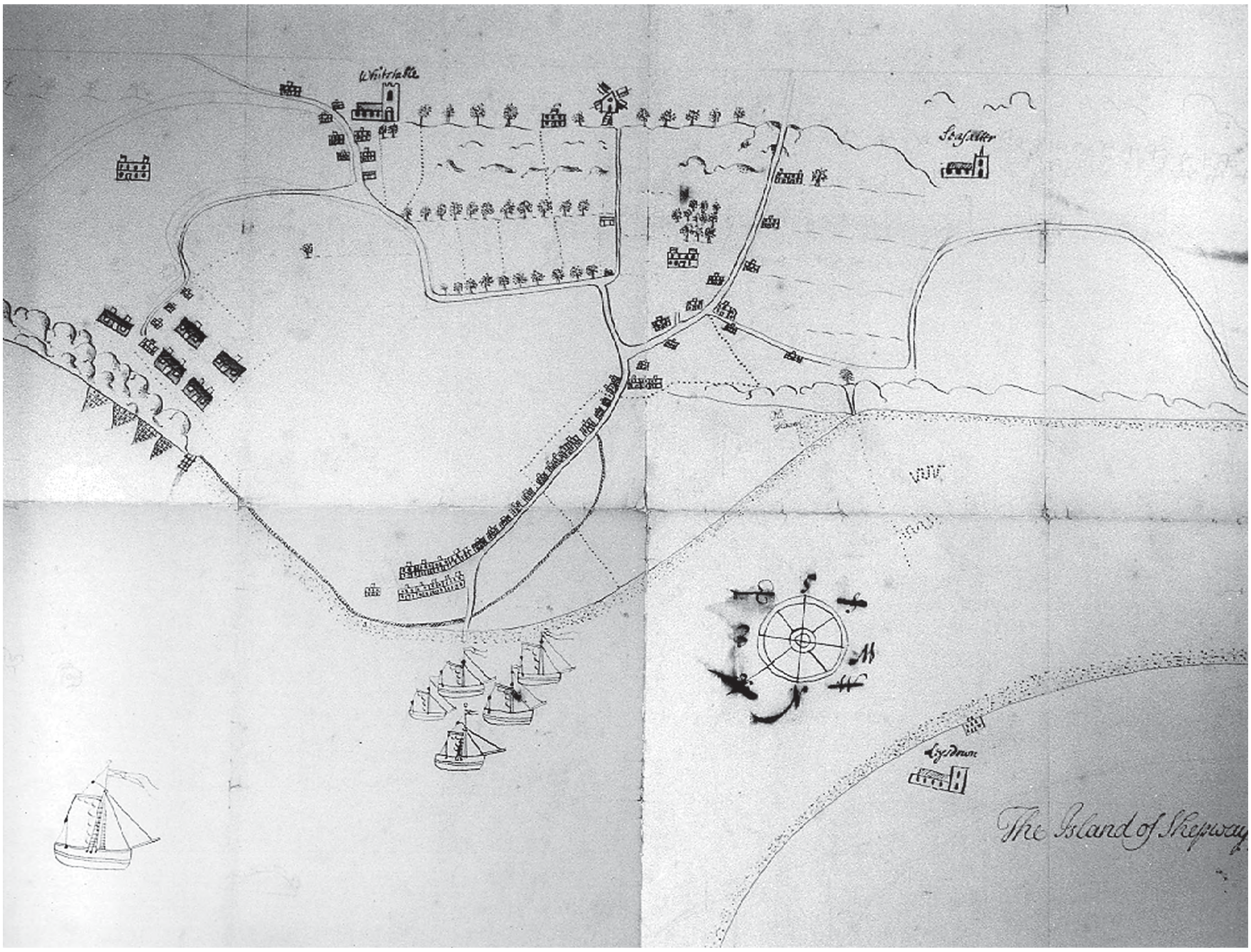


Fig. 26. 1725 chart (Canterbury Cathedral Archives, Seasalter Box BB5/44).

administration of his estate passed to Thomas Eadmeade of Southampton, perhaps confirming a continued link with the south coast (Duncan 1889, 33, 37). Stevenson's wife, Mary, very soon married an associate of her deceased husband called Thomas Gauntlett, who immediately took over the running of the copperas works.

As elsewhere, it appears that once established, the Whitstable industry thrived and consequently became the subject of much wrangling and chicanery. Gauntlett soon became embroiled in two legal suits, both of which illustrate the predatory nature of the business. In 1597, he brought a charge in the Court of Star Chamber against Edward Lane (see p. 30) and James Gibson, under-Sheriff of Kent, who had allegedly: ' ... found divers stones, liquors, coals, iron cisterns, receptacles and furniture for making copperas together with copperas already made and of which they took the greater part'.[53]

An extraordinary charge is recorded in 1600 whereby Gauntlett accused Bidolph, also known as Arthur Bedle, of assuming his name in order to obtain the lease to the Whitstable copperas stone beds.[54] The documents associated with this case represent a rich source of information about the founding of the Whitstable copperas industry, not least because Stevenson is referred to in some detail in respect of precedence of title. However, the documents contradict the evidence of the Parish Register by declaring that he 'set up at Whitstable at his own charge a furnace 7 years ago', i.e. in 1593. However, it should be noted that before production of copperas could begin, the nodules would have to be collected, laid out in the beds, and these could take four to five years to 'ripen'. Making this allowance, Stevenson could have prepared his works *c.* 1588.

Although Gauntlett eventually won this case, his legal expenses compelled him to give up the copperas works '…

53 St. Ch. 5 G33/21, Public Record Office, Kew.

54 *Op. cit.* note 14.

in consideration of divers debts and sums arising which I am indebted and doe owe unto Richard Shepham citizen and merchant taylor of London'.[55] Gauntlett and his wife appear to have left Whitstable within the year leaving Shepham in possession of the works.[56] A document, dated 23 February 1600,[56] by which Gauntlett conveyed his copperas works to Shepham describes the equipment of the works and, to a limited extent, the process that was carried out:

> Inprimis the workhouse and coolinge house with a cesterne in the same workhouse and to bennes to drie the coppres.
> Item a furnes of leade with 13en barres of iron that the same furnes standeth uppon and iron plates that lie betwene the bottome of the furnes and the greate barres with the two iron grates that the fire is made on with the foundacion that the furnes standeth on.
> Item two coolers of leade for the coppres to congeale in, that standeth in the coolinge house.
> Item three beddes or raucks of goulde stones or sulphure stones to make coppres, that lie in a feilde wherein the workhouse now standeth, with 18 greate butts that stande in the the grounde to receyve the liquer from the goulde stones.

Location of the works

The above account, when considered with the archaeological and other documentary evidence (pp. 7–16, 23), suggests that the Stevenson/Gauntlett works were situated on the coastal flat, now the foreshore, immediately north of the Tankerton Slopes, one being established around 1588, the other around 1610, and that both were lost to marine encroachment within fifty years (Chalklin 1965, 154). The evidence also suggests that six more works or 'houses' were established on, above or near the Tankerton Slopes prior to 1693. Of these, one was established in 1604 on four acres of lower ground to the west by Thomas Menfield (sometimes Mendfield), who later became mayor of Faversham (Goodsall 1956, 147). These works appear to have been sited adjacent to the southern part of a marshy area called 'the Outletts', where the Gorrell stream discharged into the sea.

Another house was established by Nicholas Sympson south and some way back from the edge of the Slopes. Deeds for the Mascall Works (see below) describe them as lying 'towards the lands formerly of Mr Sympson but now of (blank) Sympson, widow and Samuel White towards the South' (Goodsall 1956, 154). The Mascall Works (the Old and New, or Combined Mascall Houses) were founded by Thomas Mascall before 1683 and lay between the Sympson property to the south and the sea to the north. Documentary and archaeological evidence discussed in Chapter 3 (pp. 23–25) suggests that the Mascall Works may have extended north from the Sympson holding to the edge of the Slopes and beyond as far as the present foreshore, where the copperas beds were sited.

A further house appears to have been established at a later period on the lower ground north, and probably adjacent to, the Mendfield Works. This house was built on 28 acres of land formerly belonging to Robert Knight of Lowestoft, but the copperas works are first mentioned in a bill of sale dated 1693, when they were administered by a group of people including their owner, Sir Thomas Allen. The documentary evidence for these works is less well preserved than for the others, but the land on which they stood is mentioned in a late seventeenth-century schedule relating to the Mascall lands which adjoined it to the east (Goodsall 1956, 148, 155).

During the construction of the first major sea wall in Whitstable in 1583, a large ditch was cut south and landward of the wall, apparently in order to convey the town's effluent and waste water to the Gorrell stream (Bennett 1996, 19). The chart of 1725 (**Fig. 26**) appears to show the stream as discharging through a sluice, referred to in documentary evidence as the 'Copperas Sluice' and as being adjacent to a quay.[58] Presumably, at high tide, boats could be loaded and unloaded with materials coming from and going to the copperas works at this point. To the west, the chart shows an opening in the sea wall, with a track, probably representing 'Bolders Lane' (see p. 24), passing through the opening. It appears that the Gorrell stream was crossed here, where it flowed through a channel called the 'Copperas Dike'[59] by a bridge referred to in a deed dated 1740 as 'Sir Thomas Allen's Bridge'.[60] A variant of the name Sir Thomas Allen, a baronet of Middlesex, appears as a co-lessee on documents relating to the Sympson works (Goodsall 1956, 148). The significance of this and the multiple appearance of the name Hurlock is discussed in more detail below (p. 45).

Reports issued by the Commissions of Sewers supply invaluable and evocative information about some of the works and their location as we have in references to a 'Copperas Sluice', above. The report of 1583, relating to the first major phase of sea wall construction mentions 'certain houses and grounds lying in the level or valley of Whitstable ...' and proposed a graduated scale of taxes to raise the £100 considered necessary for the 'erection of a proper sea wall and sluice' and, interestingly, names a John Mendfield as one of two 'expenditors' responsible for collecting the tax. We know that Thomas Mendfield, jurat and mayor of Faversham, established a copperas works on the low-lying ground in that area in 1604. We may therefore surmise that

55 State Papers Dom. 1591–94 (1593), 339, V. CCXLIV, Public Record Office, Kew.

56 Visitation of the Archbishop of Canterbury, 1599, Fol. 203, Canterbury Cathedral Archive.

57 Deeds of the Pearson Estate, U905, T1–7, Centre for Kentish Studies, Maidstone.

58 *Report to the Commissions of Sewers*, S/EK/50/5, 92: Centre for Kentish Studies, Maidstone.

59 *Ibid.*

60 *Op. cit*. note 55.

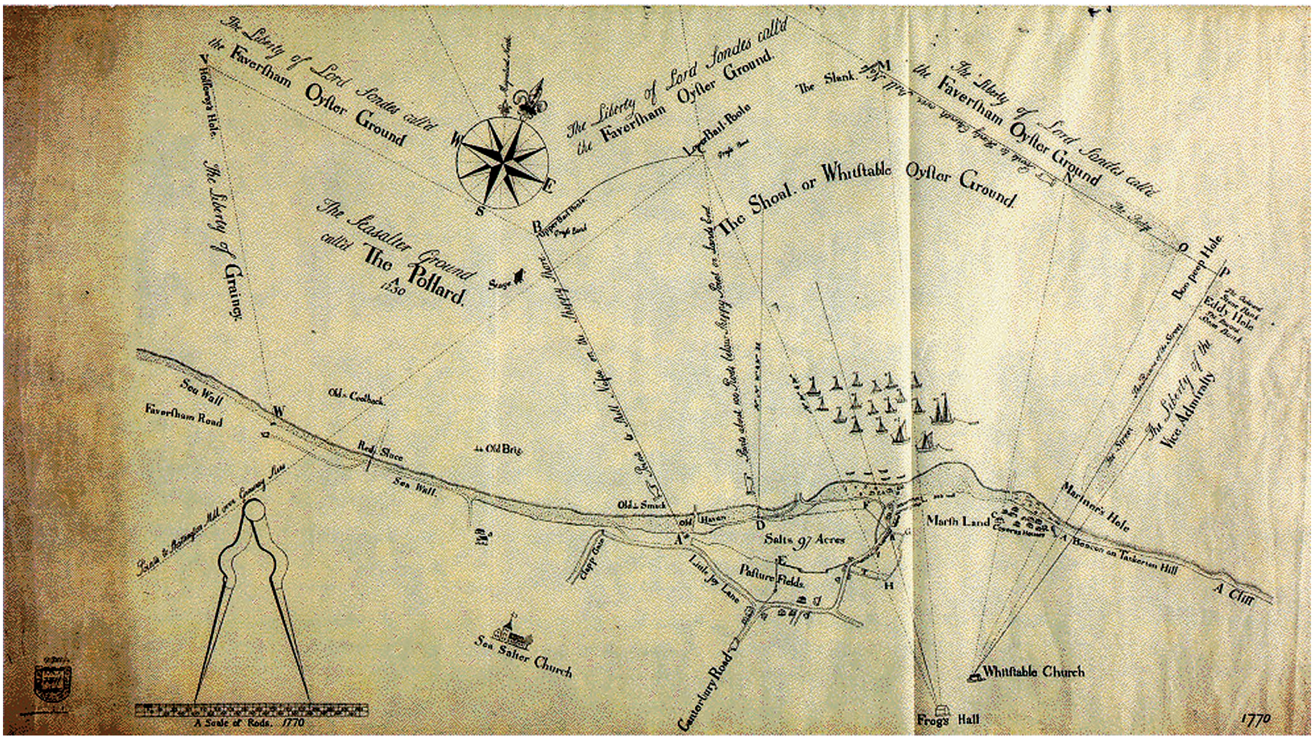


Fig. 27. 1770 map (Centre for Kentish Studies, Maidstone).

family interest made John a particularly assiduous tax collector. The wall was completed, albeit well over budget, in 1588 (interestingly, the same year that Stevenson began copperas production in Whitstable), and a toll was immediately levied on carts and carriages crossing the wall in order to make up the shortfall. Continuous supplies of lead, iron and coal were brought in by ship to maintain copperas production. This was transported by cart the 400 m. eastwards from the Horsebridge or thereabouts to the coppperas houses. This route would have been along the top of the sea wall and the final product would have been carried out by the same route. This practise caused considerable damage to the sea wall and led to further tariffs being imposed to raise money for its repair.

Two later reports, dated 1688 and 1779, indicate that the Knight/Allen Works and the Mendfield Works occupied adjacent plots of land in or near the low-lying, marshy area known as 'the Outletts'. Indeed, it appears that, as a result of marine erosion, the original 28 acres of the Knight holding were eventually reduced to 16 acres and then, in 1769, to less, with the later reduction explained because '... some part thereof hath lately been taken in by the Commissioners of Sewers for the purpose of making Sea Banks'. Following this, in the great flood of 1779, what remained of the 28 acres was 'excluded' when a new sea wall was built 220 yards south of the much repaired 1583 wall (Bowler 1983, 42). Thus, the area occupied by the Knight/Allen works was finally abandoned to the sea in this early example of managed retreat. However, it should be noted that the four acres of the Mendfield Works, which lay south and landward of the Knight/Allen Works, escaped this fate and were eventually bought by Charles Pearson in 1791 (Goodsall 1956, 149).

If, as Hasted claimed (1798, 556), there were six copperas houses at Whitstable in the late eighteenth century, his account comprises the only surviving evidence for a sixth house except for the document shown on **Figs 21** and **22** and a single abstract of title for the Pearson estate dated to around 1830. This describes the estate as 'bounded East by a garden; West and North by the road to Station House occupied by Preventative Men, and South by Public Road'. The garden is further described as comprising 'plantation and garden with stable and coach house', while 'the residue thereof is used as Copperas Works and Copperas Beds'. These works, here called 'the Upper Works', appear to have been sited east of and adjoining the Sympson Works, which are discussed separately in the document, and south-east of the Mascall Works.

Consistent with the locations of the copperas works as proposed above is the cluster of buildings termed 'Copperas Houses' shown schematically on the chart of 1725 (**Fig. 26**). This and other charts also show a sequence of apparently associated structures, presumably jetties and 'land stays' occupying the adjacent coastal flat (**Figs 26** and **27**). Similarly, an unannotated pencil sketch accredited to Paul Sandby (**Fig. 28**), executed in about 1780, shows this part of the Slopes to be occupied by a dense cluster of buildings extending from the foot of the slope to the top and beyond.

A survey dated 1770 (Goodsall 1956, 158) describes what was probably a typical collection of buildings within a copperas works and the associated equipment. The principal structures comprise 'a good dwelling house' for 'the copperas boiler' and 'a large Copperas bed enclosed with a Wall; an extensive Copperas house, Storehouses, Coal warehouse, Stable etc. compleat for the business and in good repair'. By 1835, a map shows only one building in the area, while a description given in the following year states: 'Near the sea shore, the manufacture of copperas (sulphate of iron) or green vitriol, was formerly carried on to a considerable extent; but for some years, the works have been abandoned, and nothing is now remaining but a few ruinous buildings' (Wrightson 1836, 19).

Ownership

Legal documents provide an insight into the complex pattern of ownership and administration which characterised the Whitstable industry. For example, in respect of the Mendfield (sometimes Menfield) Works, it is notable that Joseph Hurlock, a Londoner who owned them in 1791, also owned the Knight/Allen Works in 1770. Along with five other partners, including Ephraim Rinhold Seehl, a Swedish chemical manufacturer also living in London, Hurlock also contracted to buy copperas from Sarah Parker, owner of the Mascall Works in 1775. Seehl, who also owned copperas works at Blackwall (Goodsall 1956, 157; Angerstein 2001, 10), was appointed secretary by the five partners and agreed to sell, presumably in the capacity of a middleman, all the copperas bought under this agreement from Parker's 'Joint House' (Goodsall 1956, 158).

Similarly illustrative of complex patterns of ownership is Sir Thomas Aleyne, owner of the Mendfield works and probably none other than the Sir Thomas Allen, baronet of Middlesex and co-administrator of the Knight works in 1693 (see p. 43). A John Lawson of Middlesex advanced £700 to a Sir Thomas Aleyne on security of the Mendfield property in 1702 (Goodsall 1956, 147–9, 154–5, 157). Sir Thomas Allen/Aleyn/Aleyne was probably a direct descendant of the John Aleyn, who, in 1603, was cited as the former owner of four acres of land leased by a Henry Thompson to Thomas Mendfield (Goodsall 1956, 147). Mendfield built the second Whitstable copperas works for which records exist on the four acre plot (see p. 43). By 1637, it appears that the Mendfield lease had lapsed and that the property was once more held by the Aleyn family in the form of William Allen, a London grocer (Goodsall 1956, 158). It also appears that William Allen's son was later knighted to become the Sir Thomas Allen discussed above. In the light of the above, it is tempting to think that before the Whitstable industries came under common ownership in 1796 a cartel-like system was already in operation.

In 1780 Charles Pearson, a London glover, married Elizabeth Radford and thereby gained control of four of the Whitstable copperas works (see also p. 37), two of which probably comprised the combined Mascall works. He went on to buy the remaining two, paying £655 for the Mendfield works in 1791 and £1,440 for the Sympson works in 1796. Thus, for the first time the Whitstable industry passed into single ownership, with a Canterbury man, Thomas Porter, appointed as manager.[61]

Leaseholders and pickers

Thomas Gauntlett's financial involvement with Richard Shepham (see above, p. 43), represents an early example of the complex links which came to characterise the copperas trade. Shepham was a London businessman associated with the cloth trade. Clearly, the copperas house owners and the London businessmen were the copperas industry's principal beneficiaries, but the first stage of the trade, the collection of the raw material, also benefited the poorer members of society. In legal documents associated with the 1597 Gauntlett/Bidolph case,[62] it is stated that twenty poor people of Whitstable and adjoining parishes were put to work gathering copperas stones, their wages being paid daily. A report of 1584[63] gives an account of the quantities collected and the prices paid in respect of 'the Coastes of the Isle of Sheppey Whitstable and other Coasts therabouts …'

> The stuffe is gatherede by poore men women and Children inhabitants hereabouts. For the gatheringe we give a peny a Bushell men and women may and have gatherede between x and xii Busshells in a Tide and Children of 10 yers may gather iiij busshells a Tide wherby they find good Reliefe to ther Comforte and Contentmente.[64]
>
> C^{f}. w^{h} ye Busshell Conteynethe in waighte 170^{li} wth the more c. wg^{t} yeldethe 10^{li} clere brimstone refinede suche as we here p^{sent} unto y^{r} Hono^{rs}.
>
> The quantitye of Brimstone that may be made wicklie by the firnaces allreadie erected but not in full worke wilbe 2240 weight after this p^{porcon}. The ffurnace is made to conteine xx^{tie} potts, ev^{rie} one of seaven fote in Leynthe, ev^{rie} pott contynethe forty waight of Ewer and dischardgethe his weighte and

61 Documents in the possession Mr Brian Porter, F.R.Hist.S. (a direct descendant of Thomas Porter). Thomas Porter possessed a skill which was a great asset to Pearson in both his Whitstable and Essex works, that being his ability to 'burn' (fuse) lead.

62 *Op. cit*. note 54.

63 *Op. cit*. note 6. The transcript is taken from Goodsall 1956. It has been pointed out (Harold Gough, pers. comm.) that the figures do not add up.

64 1 bushel is a measure of volume equal to 8 gallons, weighing about 170 lbs as copperas stones. A hundredweight (112 lbs) of copperas stones yielded about 10 lbs of 'clerebrimstone'.

> yeldeth his Brymstone foure tymes betwene daie and nighte w^{ch} is 16 weighte clere Brymstone a pece and in all is 320. So the same is by wicke 2240 w^{ch} after one C and xij the C comethe unto 1971.
>
> The vallue of Brymestone is sometimes more and sometimes lesse y^{t} hathe of late bene at 30s and 100 and is nowe at xx^{s}. Sometimes in a glutt y^{t} may be at xvi^{S} and at 14^{S} but I doubte not but y^{t} may kepte at an Indifferente pryce between 60 the w^{ch} is xx^{s} after w^{ch} rate the said quantytie of Brymstone will be wicklie worthe 19^{l} 14^{s} 6^{d}.
>
> The chardges wherof wilbe as foloueth

The mr. worckman his wadges beinge 32^{l} a yere Cometh wicklie unto	00—13—04
To one that providethe y^{e} stufe and keepeth y^{e} accomptes 30^{l} a yere, wicklie.	00—12—06
To one laborer after the rate of 6d. a daie	00—09—04
To Thre other laborers at 1^{d} a man by the day	00—01—01
Colles by wicke	0—04—00—00
Cf. men after the rate of 3200 weighte a daie beinge 18 Bushells and by wick 126 bushells at ij^{d} the Bushell amountethe unto	01—01—00
So the wicklie Chardges amounteth unto	vii^{li} vij^{s} ij^{d}
Which beinge deducted out of the said some of	19^{l} 14^{s} 6^{d}
then remaynethe	11—1j—4d
Wherof deducte hir Ma^{te} tenthe parte beinge	01—03—08—06
Then remaynethe clere gaine wicklie	10—13—07—06
Thus one furnace contynually daie and night in workinge clothe make by yere after the rate of 112 the 100 Clere Brymstone	101492 ^{li} wg^{ht}
The vallue wherof after the rate of 20^{d} the greate as before is	1014^{l} 18^{s} 00^{d}
The chardge wherof by yere is	408^{l} 12^{s} 8^{d}
Hir Ma^{ty} xth parte a mountethe unto.	01^{li} 2^{s} 10^{d}
w^{ch} two laste somes deductede out of the said 1014^{l} 18^{s} ther remaynethe clere gayne . .	44^{l} 12^{s} 6^{d}

The rights to gather copperas stones from the beach in the Whitstable area were established by the granting of leases, either to members of the local gentry or to London merchants, from the Archbishop of Canterbury. Copies of many such leases are held at Lambeth Palace Library,[65] and these show a wide variety of London businessmen to have been leaseholders. Examples include a grocer, a doctor, a cooper, a stationer, a goldsmith and a drysalter. Clearly, the copperas industry was considered a sound investment for anyone with money to spare. The leaseholder would usually either employ the copperas gatherers (called 'pickers') directly and sell the stones on to a manufacturer, or sub-let his rights to a manufacturer, who would have contacts in the London copperas trade and the local shippers (Chalklin 1965, 155). In the latter case the manufacturers employed the pickers who were often, if not always, paid in tokens rather than coin (Coleman 1951, 171; George 1975, 21–39). In 1639 we are told that between 600 and 1000 bushels a year were collected, the pickers receiving 5d. a bushel (Chalklin 1965, 155).

Some forty years after the Gauntlett/Bidolph case of 1597, we hear of a sailor's widow from Whitstable called Sarah Jenkins, who, at the age of about sixty, is said to have gathered copperas stones for a living from the age of ten. This would suggest that she had been a copperas picker from around the time of the founding of the industry in 1588 or thereabouts (Chalklin 1965, 154–5). A reference dated 1836, when the manufacturing industry had probably died out, suggests that copperas stones were 'dredged from the extensive flats off Whitstable' (Davidson 1836, 39), implying that the gathering process had become at least partly mechanised towards the end of the industry.

The partners Thomas Gold and Edmund Rouse both owned land in Tankerton and in 1636 both were granted a 21-year lease to collect 'Goldstones, Sulphurstones, Copperas-stones or stones whereof copper [*sic*] is made ... falling out of the cliffs' near Reculver, to the east of Whitstable (Hussey 1904, 126). Gold and Rouse also owned ships in which processed copperas was shipped out on a collaborative basis (see p. 47 below), suggesting that they worked closely with the copperas producers, both as suppliers of raw material and as shippers of the finished product. It was consistent with the spirit of the age that their close working relationship with the producers was mirrored by a close social relationship. For example, we know that Gold's daughter married Thomas Mascall, founder of the Old and New Mascall works, and that Rouse's daughter married Nicholas Sympson, founder of another early copperas works.[66]

Copperas and copperas stones continued to be of great interest to landowners, not least the Dean and Chapter of Canterbury Cathedral, as a means of making money. In 1675, Mr Coppin, after holding court at Seasalter Manor, reported to Dean Bargrave that 'Upon enquiry there are no Gold Stoanes or otherwise called Copperess stoanes cast up or gathered upon the shoares of our Royalty there' (Woodruff 1926, 41).

Little is known of the men engaged in the early production of copperas at Whitstable, as opposed to the patent holders and owners. However, Canterbury marriage licences[67] dated 14 February 1604, 12 May 1610 and 5 June 1616 show men described as 'copperas makers of Whitstable' to have been married on those dates. As their names were, respectively, Owen Jones, William Jones and Howell Evans, it would appear that many of the workmen were Welsh.

65 Lambeth Palace Library, Comm. XII/23/208; TA 657; TA 698/1–8.

66 *Op. cit.* note 52.

67 Canterbury Cathedral Archive.

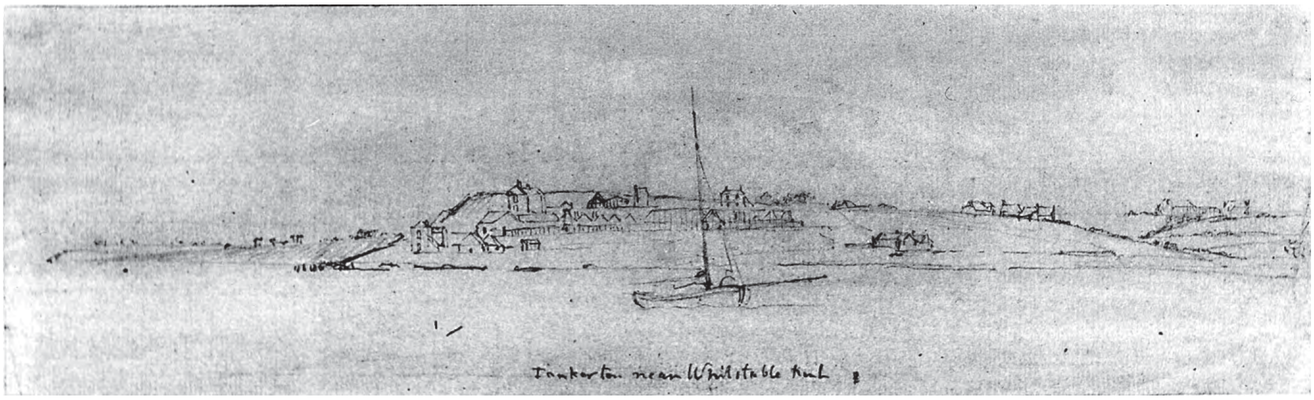


Fig. 28. View of Tankerton Slopes, *c*. 1780, attributed to Paul Sandby, © Canterbury Museums.

Servicing the industry

A listing of manifests (Harvey 1993, 8–47) for seventeenth century Whitstable ships provides details of the large quantities of lead, iron and coal being brought in, while most outward-bound cargoes included up to 20 tons of copperas. A list for 1629 shows that 127 tons of copperas were shipped out on the *Gift of Whitstable* and *Thomas of Whitstable* by the partners Thomas Gold and Edmund Rouse (Harvey 1993, 20), who co-ordinated the shipments so that one exported a cargo on one month, the other the next, presumably in order to ensure continuity of supply and equality in profit. The average monthly tonnage (excepting June when neither producer exported any copperas) was 11.5 tons.[68]

Later records, where they are continuous, as in the case of the *Endeavour* in 1677–78, suggest that the trade was carried on from March to October, presumably in order to avoid stormy seas. The Port Exchequer Book at the Public Record Office, Kew, shows at least ten ships to have been engaged in carrying copperas, with their names given as *Satisfaction, William, Anne, Chance, Christopher & John, Content, Endeavour, Goodwill, Hopewell* and *John*. Whitstable ships are reported to have carried 225 tons of copperas out of Whitstable in the first nine months of 1656. The *Goodwill* carried 147 tons and the *Content* carried 72 tons between 15 March and 30 April 1688. A cargo carried to London on the *John and William of Whitstable* in 1765 comprised the following items: 15 tons of copperas, 20 quarters of wheat, 10 quarters of barley, 5 quarters of oats, 9 butts, 8 backs tanned leather, 1 box wound silk containing 12 pounds and a half load of household goods and apparell. William Philpott.[69]

The lengthy boiling process by which copperas was produced required immense quantities of coal. The Queenborough works in Sheppey are known to have consumed about 300 tons annually up to the year 1640 (Neff 1934–5, 3), and in the late eighteenth century Whitstable is reported to have received 5,000 chaldrons[70] of coal yearly from Sunderland (Hasted 1798, 556; Seymour 1776, 789). The Port Exchequer Book shows that twenty-eight Whitstable ships were engaged in the trade in coal from the North East in the later eighteenth century. It was previously thought that such a vast quantity of coal went mostly to supply the Canterbury market, but is now clear that most was intended for the Whitstable copperas works. Consistent with this, the Mascall deeds of 1683 show two coal yards to have formed part of the combined Mascall works.

A mid to late eighteenth-century Whitstable works manned by a workforce of ten (see p. 36) was able to produce about 126 bushels of copperas a week. As a bushel equals 170 pounds (77 kg.), this is equivalent to a little less than one ton of copperas a week, worth about £4 12s. in 1775. As a ton of copperas is estimated to have cost about £2 to produce, including the 4s. a week required for fuel, Sarah Parker would have expected to make a sum of about £300 per annum profit if maximum production was maintained. Although this was still a significant sum in the 1770s, it may be noticed that a marked decrease in profitability had occurred since 1688. Indeed, in 1584 a ton of Dorset copperas realised £12 (see p. 34), whereas Essex copperas realised £4 6s. 7d. a ton between 1715 and 1720 (see p. 35). In 1584, Kentish copperas pickers received 1d. a bushell for copperas stones,[71] in 1639 they received 5d. a bushel (see p. 46) and in *c*. 1770 they received 1d. a bushel (Donald undated).

68 F/Z17, 7, Centre for Kentish Studies, Maidstone.

69 E190/656/6, Public Record Office, Kew.

70 A 'Newcastle' chaldron was equal to 53 cwt. 5000 chaldrons therefore equals 13,250 tons.

71 *Op. cit.* note 6.

Occasional entries in legal and other documents give some guide to the capital value and profitability of the Whitstable industry. The earliest refers to the Mendfield works in 1636, together with the leases for land and the right to gather 'Goldstones,' being sold to a London merchant for £1,000 (Goodsall 1956, 148). In 1688, the annual profit at the Mascall works was estimated at £400 (Goodsall 1956, 153). In 1687, a third share of the Sympson works raised £410 on mortgage, suggesting a total valuation of £1,230 and in 1694, a twelfth share sold for £130 (Goodsall 1956, 150), suggesting an increased value of £1,560. In 1775, Sarah Parker, then owner of the Mascall works, concluded a contract to sell the output from her works at 4s. 6d. per hundredweight up to a maximum of 120 tons per annum (Goodsall 1956, 157), indicating a projected annual income of £540 and a total income over seven years of £3,780.

The decline of the industry

The collapse of the Whitstable copperas industry, as with the southern industry generally, occurred gradually throughout the mid to late eighteenth and early nineteenth centuries as the centre of production shifted northward, and as technological innovations rendered the southern production process redundant. Surviving inventories suggest that, excepting Sir Nicholas Crispe's late seventeenth-century innovation, the manufacturing process used at Whitstable had changed very little from the sixteenth century until its end in about 1828.

An important contributory factor in the decline of the Whitstable industry was probably progressive marine encroachment, which eventually turned the site of the earlier works on the dry coastal flat, along with the site of the Knight/Allen works on the Outletts, into a tidal foreshore. This meant that the later works were sited further up or above the Tankerton Slopes and consequently copperas stones had to be hauled up the Slopes to the works for processing and the final product transported back the same way and on to the ships anchored off the Horsebridge. This must have resulted in a considerable decrease in the cost efficiency of the operation.

Though the demise of the southern copperas industry was perhaps inevitable, it is clear from the efforts of Charles Pearson, the last principal owner of the Whitstable works, that he was unaware of this. Pearson appears to have seen a great future for the industry and to have intended to become the copperas 'magnate' of the south of England.

He had already acquired the copperas works in Deptford and went on to acquire those of Walton along with the copperas-gathering rights in Kirkby Thorpe and Walton-le-Soken, all in Essex. It has been claimed that by 1808 he owned nine and a half of the forty or so copperas works in and around London and controlled 30 per cent of the total southern output of copperas (Walsh 1995). By 1820, Charles Pearson's son, also called Charles, had taken charge of affairs at Whitstable. Pearson Junior invested in several other ventures and was a minor investor in the building of the Canterbury to Whitstable Railway, built in 1830 to a design by George Stevenson. The line terminated in Whitstable at the Outletts, the site of a new harbour completed in 1832. Although of enormous benefit to the local community, the railway did not make money and meanwhile the market for southern copperas, which was the Pearsons' economic base, continued to contract. Despite this, Charles maintained a high-spending lifestyle in which Whitstable became a summer retreat for himself and his family (Pike 2000, 45). He eventually extended his house, to which his father had already added a fashionable 'gothic' tower, the final result being an impressive residence now popularly known as 'the Castle'. However, in the late 1820s, as his financial position continued to weaken, he was constrained to sell the copperas works and his residence to his wealthy cousin by marriage, Wynn Ellis, and in 1835 he was declared bankrupt. Although Ellis appears not to have continued copperas production, it should be noted that mail was still being addressed to Thomas Porter at the 'Copperas House' as late as 1828.

Although the local manufacturing industry ended with Charles Pearson's withdrawal, the collection of copperas stones continued along the shore for many years. In 1853, Ann Woodcock of Herne Bay was drowned 'in quest of copperas'[72] and probably as late as the early years of the twentieth century, the Whitstable fishermen '... made idle by the gales used to supplement their income by gathering it [copperas stones] and sending it to Germany to be used to make brown dye'.[73]

The copperas works in southern England prospered for about two hundred years and by 1764 it was claimed that England was the biggest producer of copperas in Europe, with the product marketed as 'English Green Vitriol' (Croker *et al.* 1764). The list compiled sometime between 1759 and 1765 (see **Figs 21** and **22**) describes the southern works as 'The 14 Old Standard Works Near London', and gives the locations, owners, proprietors or occupiers, and the past and projected production capacities of these works, along with similar details for the twenty-nine works established later in the north of England and in Scotland. Even at this relatively late date it can be seen that the 'Old Standard Works', with a total annual production capacity of 2,861 tons, far outstripped the total production capacities of 'The 13 Inland Works' (625 tons), the '5 Works in the Northwest of England' (720 tons), the 'seven Works that are in the North of England' (1,080 tons) and the Glasgow works (90 tons). According to the list, the combined annual total output of England and Scotland at that time was 5,366 tons (shown erroneously as 5,349 tons on the document). It is clear that even in the latter part of the eighteenth century, the southern industry still produced over half of the national copperas output and that Whitstable was the largest southern production centre.

The 1759/65 list also documents a proposal by the copperas producers to cut overall domestic annual production

72 *Kentish Gazette*, 8 February, 1853.

73 Reminiscences of Harold Rowden, *Whitstable Times*, 6 January, 1974.

by almost exactly a third (33 per cent) from 5,366 tons to 3,608 tons, the reduction applying equally to all listed works. This may point to a predicted downturn in demand or signal an attempt to drive up or maintain prices. In either event a nationwide cartel was clearly at work at that time. However, if there was a reduction in demand it was probably short-lived. It has been claimed that, by 1776, between 50 and 60 tons of copperas a year was being imported from the Continent because dyers and artisans thought continental copperas contained less copper impurities than even the highest quality English and Scottish product (Clow and Clow 1979, 251). However, the evidence here is not clear and a contradictory view is proposed by several late eighteenth-/ early nineteenth-century commentators. For example, we are told by Lewis (1773, 278) that: 'The English Vitriol is purely ferruginous ... there is scarcely any other Vitriol of Iron without some admixture of Copper', and both Watson (1787, 228) and Aikin and Aikin (1807, 371) make similar assertion.

Towards the end of the eighteenth century the southern industry began to decline. This was partly because of a slump, about which we read in the Essex Victoria County History (1907, 413):

> The causes which led to the decay of the Essex copperas industry are somewhat obscure, but it was discontinued soon after the woollen industry had left the eastern counties and migrated to the north and west of England and the tanning industry had declined greatly also. This suggests that the demand for green copperas came from the local woollen factories and tanneries.

However, the demise of the southern copperas industry was not just a result of its dependence on the local woollen industry (which had virtually disappeared by this time anyway), but was much more a result of the development of more efficient production methods in the north.

We gave already read that in 1603, Richard Laycolt, a former associate of Cornelius de Vos, left the failing Dorset industry, where he had been a co-lessee of the Alum Chine works,[74] to exploit the Jurassic age Upper Lias Shales in the Cleveland Hills. He established an alum and copperas works at Skelton, near Guisborough in East Yorkshire ' ... as well as out of his desire of good doing unto the commonwealth as also to raise unto himself some capital gains and a means of a living' (Gough 1969, 183–4; Turton 1938, 65; Singer 1948, 195).

Over the next 300 years or so the Yorkshire industry prospered greatly, with millions of tons of ore being mined along the coast for dyeing and tanning (Stanisforth 1993, 16). An indication of the speed with which these works grew and how important they had become comes from the behaviour of Sir Thomas Chaloner during the trial of Charles I. Chaloner had been granted a licence in 1603 to produce alum in Yorkshire, presumably in association with Laycolt, but later had his licence revoked by the king. At the time, it was widely believed that Chaloner took his revenge when he strongly supported the execution of the king in 1649 (Wedgewood 1967, 114).

The prosperity of the Yorkshire industry did not rub off on Laycolt, who spent much time in debtors goal and eventually died in a sheriff's goal in London in 1614.[75] It has been suggested (Donald undated) that the financial problems suffered by Laycolt and other investors in the early copperas industry resulted from large-scale losses incurred previously in Dorset, where the industry was clearly in drastic decline at this time, not least because of the establishment of the northern industry and the rapid growth of the south-eastern industries. As mentioned above, the later expansion of the northern industry was also a major causal factor in the contraction of the longer-lived Essex and Thames estuary copperas industries, including that of Whitstable. By the end of the eighteenth century most of the high-quality copperas for export (principally to France and Saxony) was produced by the northern industries, particularly those of Yorkshire and Newcastle-upon-Tyne (Clow and Clow 1945, 44; 1979, 251).

As well as the Yorkshire and Tyneside industries, a coal-based copperas industry developed in the north-west of England (Angerstein 2001, 285–6). Alum and copperas industries were also founded in Scotland (principally at Hurlet, Campsie and Baldernoch: Cotterill 1991, 22; Lunge 1879, 72), thus increasing the competitive pressure on the southern industry (Kingzett 1877, 180).

In addition to the growing northern industry, the invention of an alternative means of producing sulphuric acid using imported sulphur instead of copperas further depressed the southern industry (Watson 1787, 228; Cotterill 1991, 24–42). Roebuck's lead-chamber process, first tried in 1746, superceded Joshua Ward's 'glass globe' method, but both used sulphur rather than copperas. It was stated in respect of the latter that '... this acid [sulphuric acid] can be extracted much more profitably from sulphur than vitriol' (Dossie 1758).

The newer, more efficient and therefore more robust northern industry managed to survive the importation of cheap sulphur although in 1847, the Scottish sulphuric acid manufacturers, along with the alkali and soap makers, were berated for acting to: ' ... annihilate the kelp trade, and nearly to annihilate the native manufacturers of alum and copperas' (Macintosh 1847, 179). However, as previously discussed, at the Queenborough works in south-east England, an adaptation of Roebuck's lead chamber method was eventually devised in which iron pyrites in the form of copperas stones could be used instead of pure sulphur (see p, 28), and this acted to prolong the life of the southern industry, albeit on a much reduced scale.

The death blow to the southern copperas industry perhaps occurred in 1825 when the King of Sicily reduced the export duty on Sicilian sulphur by 96 per cent from £15 a ton to

74 State Papers, 13/Case H. 21, Public Record Office, Kew.

75 St. Ch. 5 L5 89, Public Record Office, Kew.

10s. a ton, reducing the price to £8 a ton at the docks. As was intended, this enormously favoured the production of sulphuric acid using Roebuck's lead chambers and severely reduced the demand for copperas (Clapham 1869, 39), despite the fact that some dyers still thought that purer acid was produced from copperas (Lewis 1773, 278; Watson 1787, 228). Dyers also regarded sulphuric acid produced from sulphur using the Roebuck method as less reliable than that produced from copperas because it contained variable quantities of lead sulphate and nitrous acid, both of which could turn the bright blue of indigo into unmarketable green. Aikin and Aikin (1807, 65, 371) observed that 'The common green vitriol is made use of for this purpose [sulphuric acid production], as it is to be met with at a low price, and the acid is most easily to be extracted from it'. They added that European dyers willingly paid extra for sulphuric acid produced from copperas in order to avoid the problem of impurities. However, neither factor could protect copperas producers from the competion posed by low-priced Sicilian sulphur. Predictably, in 1838, the King of Sicily granted a monopoly on sulphur to Messrs Taix & Co of Marseilles and the price rose, this time to £14 a ton (Statistical Society II 1839, 446). Perhaps equally predictably, there was a renewed demand for domestically produced copperas (Parnell 1844, 381), but by this time the southern industry had all but disappeared and no attempt was made to revive it.

6
Conclusion

The southern copperas industry, which was closely associated with both the immigrations from the Low Countries and the new Elizabethan entrepreneurialism, was the first major inorganic heavily-capitalised chemical industry to be established in England. The industry, which had its roots in the distant past in the Middle East and mainland Europe, was established in England as part of the Crown's deliberate policy to encourage the immigration of 'foreign chymistes and mineral masters'. The policy was successful in its intention to promote domestic production and reduce dependence on other countries, many of which, particularly Spain, had become hostile to English interests as a consequence of the Reformation. The wider effect was to provide an important stimulus towards the capitalisation and industrialisation of the economy.

As such, the industry represented a primitive but robust form of modern capitalism which played an increasingly important part in the English economy from the late sixteenth to the mid eighteenth century. The early stage of the industry also marked the transition from medieval alchemy into modern chemistry, thereby providing the basis for the development of the modern chemical, pharmaceutical, textile-dying and fertiliser industries. The Queenborough works are particularly important in this respect as they represent an example of unbroken development from late sixteenth-century copperas manufacture to on-going superphosphate production on the same site. In the light of the evidence presented here, it can be claimed that the copperas industry played a major role in the industrialisation of the British economy. Until recently, such a role for copperas in Britain's industrial development has been neither fully acknowledged nor well understood.

The documentary research undertaken as part of this review has identified an extensive body of published and unpublished information relating to the early copperas industry in general and the Whitstable copperas works in particular. This information, in conjunction with the results of the archaeological excavations, has provided the basis for a description of the establishment, development and decline of the copperas industry in the south of England, laying a foundation for an informed discussion of the industry's wider role in the establishment of the first major chemical industry and the first industrialised economy.

The archaeological excavations at Whitstable exposed remains consistent in position and design with late sixteenth-/early seventeenth-century descriptions of copperas beds 'without and near adjoining to' their associated works. It is therefore proposed that the exposed structures comprised identifiable parts of the earliest copperas works to have been established in Whitstable, two of which are recorded as being lost to marine encroachment prior to 1639. Parts of a later works, probably the Mascall Works, were similarly exposed. It can therefore be claimed that these structures represent an extremely rare and significantly early example of Industrial Age archaeology.

In its local context, the industry, with its attendant fumes, grime and smoke, transformed many coastal environments: 'On the verge of the shore eastward of Whitstable are extensive vitriol or copperas works, but the black and dismal appearance of the buildings excites disgust rather than curiosity' (Fussell 1818, 71). In addition, the vast quantities of bright yellow industrial waste (see **Fig. 4**), along with the massive 'ripening beds', must have dominated the foreshore. Similarly, the associated presence of copperas traders, manufacturers and pickers toiling on the beach, together with ships and carts loaded with coal, iron, lead, copperas stones or with casks full of 'green vitriol' must have represented a startling development in the small coastal towns which played host to the copperas industry.

Finally, the copperas industries of Whitstable, Deptford and Queenborough must now take their place as part of one of the great endeavours of the industrial age, which was the development of domestic chemical and mineral resources through the introduction of expertise from the European mainland. Nor were these minor, local enterprises. Links in terms of investment, trade, technology and ownership were established with the West Country, London and the Continent from the very beginning of the domestic industry and these links were to characterise the industry throughout its life.

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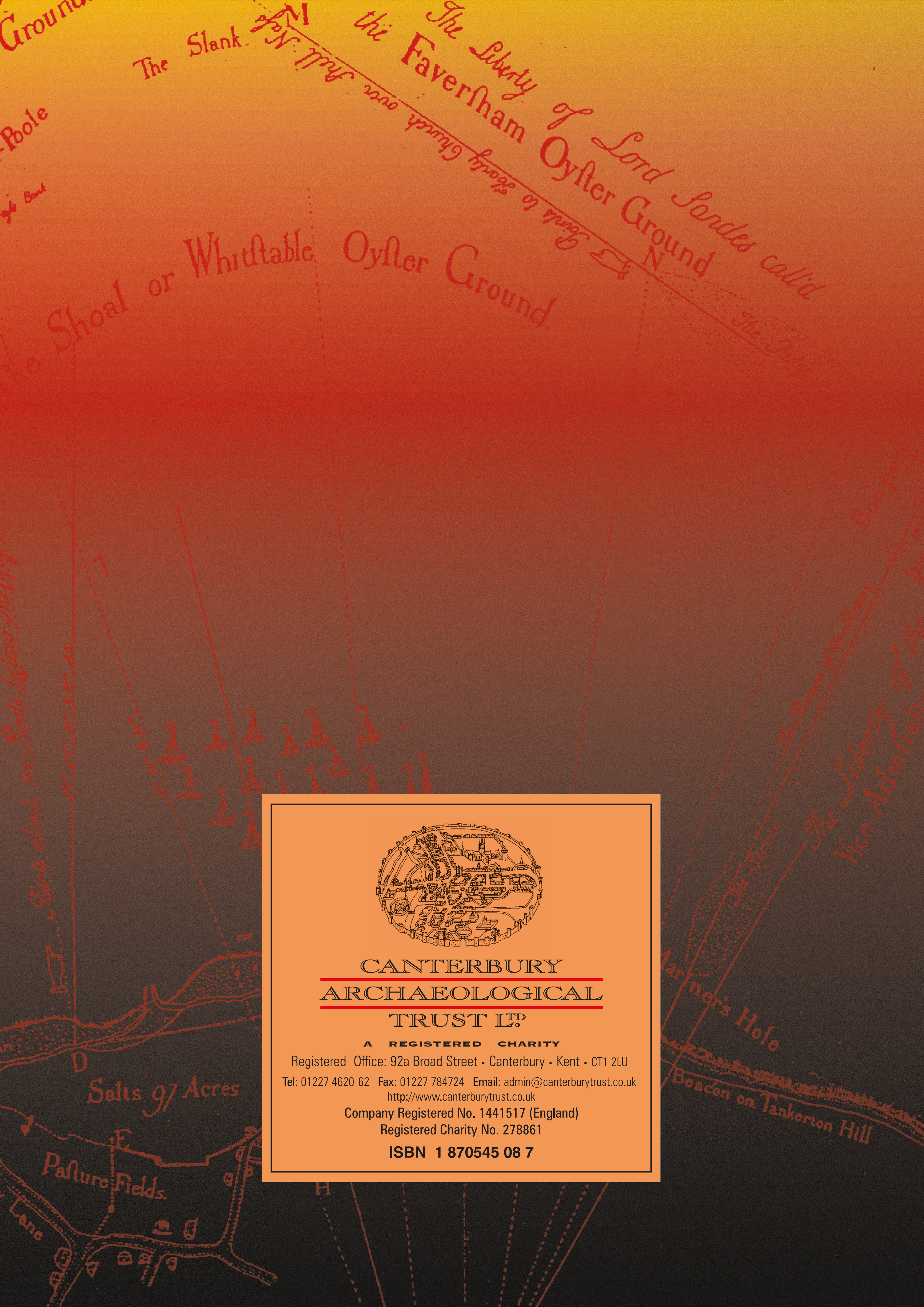

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