The Glass Industry in the Woodland Economy of the Weald

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Thesis for the degree of PhD

University of Sheffield, School of Education

November 2006

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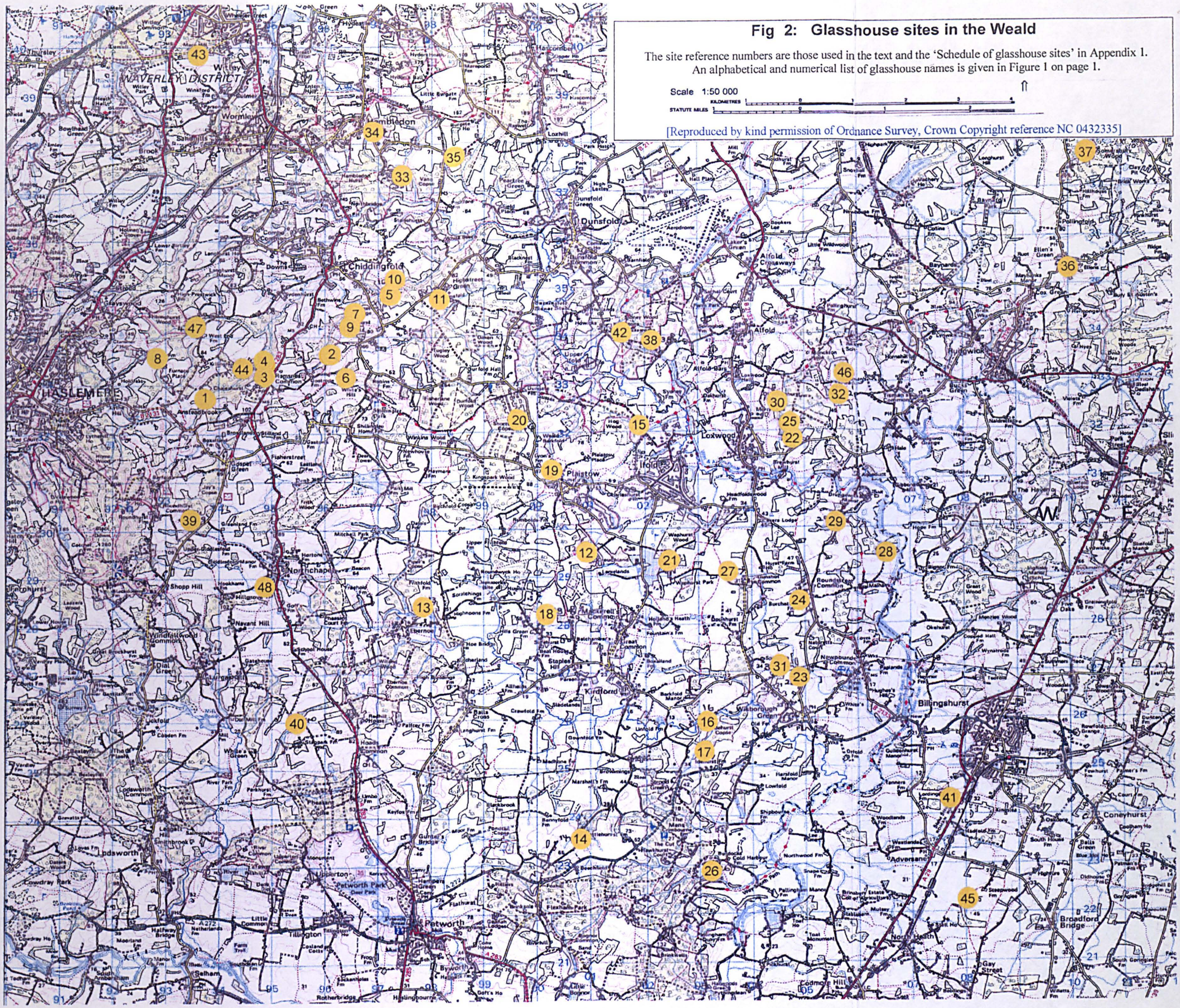

Fig 2: Glasshouse sites in the Weald

The site reference numbers are those used in the text and the 'Schedule of glasshouse sites' in Appendix 1. An alphabetical and numerical list of glasshouse names is given in Figure 1 on page 1.

Scale 1:50 000

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1: Introduction: the objectives of the research

It is now 40 years since Kenyon published his book *The Glass Industry of the Weald* and during the intervening years new information has emerged about forest glass making suggesting a reassessment is due. This was recognised by David Crossley in the early 1990s when he carried out a field assessment of Wealden glasshouse sites for the Monuments Protection Programme (English Heritage). In the course of this enquiry it became apparent that there were gaps in the record occasioned by recent discoveries and that there were areas that would benefit from new research (Crossley 1996). This thesis aims to update the record and to consider the industry in the wider context of the woodland landscape within which it operated.

In this chapter, the research objectives will be outlined, setting out the questions to be examined in later chapters of the thesis. However, in the next chapter, the comparatively small district within the Wealden region in which glassmaking took place and which forms the geographical focus of this study is defined, and sections about the geology of the region and a description of its main geographical and landscape features are offered by way of background and to explain why the Weald contained such extensive woodlands that were so vital to the local economy.

The availability of wood fuel was a primary factor in the location of the glass industry in the Weald and the particular requirements of the industry will be examined. However, wood and timber were resources used for a variety of purposes, and in chapter 3, the research will investigate the character and significance of other wood users that formed the 'woodland economy' of which the glass industry was a part. It will aim to find out about the industries that operated in this 'woodland economy', what its main products were, where were their markets and how they were manned and managed? This is an area of study that has not so far been examined in relation to the western Weald and is relevant to a study of the glass industry as the context within which it operated and significantly as a potential competitor for fuel. Reference will be made to the records of manors adjoining the area under study, such as Loseley, Petworth and Shillinglee, and a search will also be made of national records.

Glassmaking is central to this thesis and is an example of an industry dependent on woodlands for its fuel. Chapter 4 will form a background to the examination of the more specialised aspects of glassmaking that follow in succeeding chapters, and will contain a review of the existing literature, in which mid-20th century research is prominent (Winbolt 1933; Kenyon 1967; Wood 1965, 1982). This chapter contains an historical summary, tracing the development of glassmaking in the Weald from its origins in the thirteenth century, through years of apparent decline in the fifteenth century, the renaissance of the industry following the introduction of immigrant workers in the 1570s, and finally, the closure of the industry following the ban on the use of wood fuel imposed in 1615.

The term 'Wealden glass' is used widely to describe glass of forest glass type manufactured in the Weald during the Middle Ages and the post-medieval period, and includes window and vessel glass, both of which were manufactured throughout the period under study. Window glass was manufactured using both the 'crown' and the 'broad' glass methods, and the research will compare the merits of these two processes: it will also consider to what extent window glass was in use during the period under discussion and where its main markets were. An attempt will be made to assess the importance of vessel glass at this time and the extent to which it was in general use. The research will also aim to find out what main vessel types were in use, and where they were sold. The relative importance of window glass to vessel in terms of overall glass manufacturing volume will be considered. Reference will be made to documentary sources and museum examples of glass finds to examine these questions.

It is now approaching 40 years since Eric Wood excavated Knightons glasshouse, the last archaeological examination of any note to be carried out in the Weald. However, in the intervening years, significant excavations of contemporary glasshouses have taken place in other parts of the country, such as those in Staffordshire (Crossley 1967; Welch 1997) and North Yorkshire (Crossley & Aberg 1972); and important studies of the same tradition of forest glass making have been carried out on the Continent (Rose-Villequey 1971; Ladaique 1973; Phillipe 1998). The research aims to find out how these more recent studies can contribute a greater understanding of the Wealden industry: for example, is it possible to identify features in design and layout that indicate a progression towards a more efficient furnace operation? How were furnaces built and what construction materials were used? A particular problem has been the origin of the clay used in the manufacture of crucibles. This has for a long time been a difficulty for researchers, which still has not been resolved. Here the research will look at possible sources of clay used, and will include the selection of crucible samples for laboratory analysis. The subject of furnaces and crucibles will be considered in chapter 6.

The constituents of forest glasses have been the subject of several studies in recent years: these have included the laboratory analysis of glass samples and experiments with batch materials (Mortimer in Welch 1997; Merchant 1998; Welham 2001). Chapter 7 will aim to identify the sources of materials available to the Wealden industry, and to establish whether these were to be found nearby or were transported to the glasshouse, perhaps from outside the region. Both Winbolt and Kenyon (1933, 53; 1967, 46) considered beechwood ash an essential constituent in the batch, but preliminary observation suggests that the great majority of glasshouses are not situated in beech woods today. Does this indicate changes in wood species over the centuries or was access to beech ash of less importance than previously thought? The significance of beech ash in the manufacture of Wealden glass will be investigated.

The laboratory analysis of Wealden glass has generally been carried out using samples taken from museum collections, with the possibility that some of these may have been cullet brought in from elsewhere. It is an objective in this research to select samples of glass during field-work that represent manufacturing waste and that can be identified with local manufacture with reasonable certainty. These will be analysed to demonstrate the difference in the constituents of glass made during the medieval period from that of post-immigrant manufacture.

The glassmakers were significant users of wood fuel, a never-failing supply of which was fundamental to their success. Chapter 8 investigates the wood species available in the Weald, how it was obtained by the glassmakers and how it was prepared for use. It is well known that the iron industry developed sustainable sources of fuel by the use of managed coppicing methods; however, a subject that has not so far been examined is whether managed coppice was used by glassmakers in the Weald. This will be investigated using local records, including surveys of local landed estates, and the published works of contemporary observers.

A question that has not so far been adequately considered is why the ban on the use of wood fuel (1615) was directed against the glass industry, allowing other significant users of wood to be exempted. In chapter 9, national records and the writings of contemporary observers will be used to examine the legislative measures adopted for the preservation of the woods, with particular reference to its impact on the Weald and its effect on the glass industry.

Finally, to assess the field evidence for the Wealden glass industry, all known Wealden glasshouses, and areas where evidence of glassmaking has been noted, will be examined. Since Eric Wood's excavation of Knightons in the 1970s, the glass industry has been a neglected topic in the archaeology of the region and many of the sites discovered by Winbolt and Kenyon have become largely overgrown or forgotten. However, many of these sites have a potential for future investigation and remain an important source of glass and crucible fragments for laboratory examination.

A further reason for field work is that the Wealden region has been undergoing considerable change in recent years, adjusting to new agricultural practice and forestry policy, and new patterns of land-ownership, all of which pose a threat to known glasshouse sites, but also present opportunities for new discoveries. The research will involve field-work visits to known glasshouses and locations where evidence of glassmaking has been discovered to note present condition and to note the potential for further exploration. A schedule of glasshouses will form an appendix to this thesis, as a point of reference for future researchers, providing information about location, literature, present condition, the potential for future exploration and the whereabouts of any finds. Of the material deposited in museums, some is known to have an unreliable provenance, for example items in the Cooper Collection at Haslemere Museum, and some deposited items do not appear to have survived. The research will aim to identify what excavated material has survived and its whereabouts.

Note: in the text, glasshouses are identified by a reference number (in brackets).

See: Figure 1 'Glasshouse site names and reference numbers', and

Figure 2 'Map of Wealden glasshouse sites'.

2: Geology and geographical features of the Weald

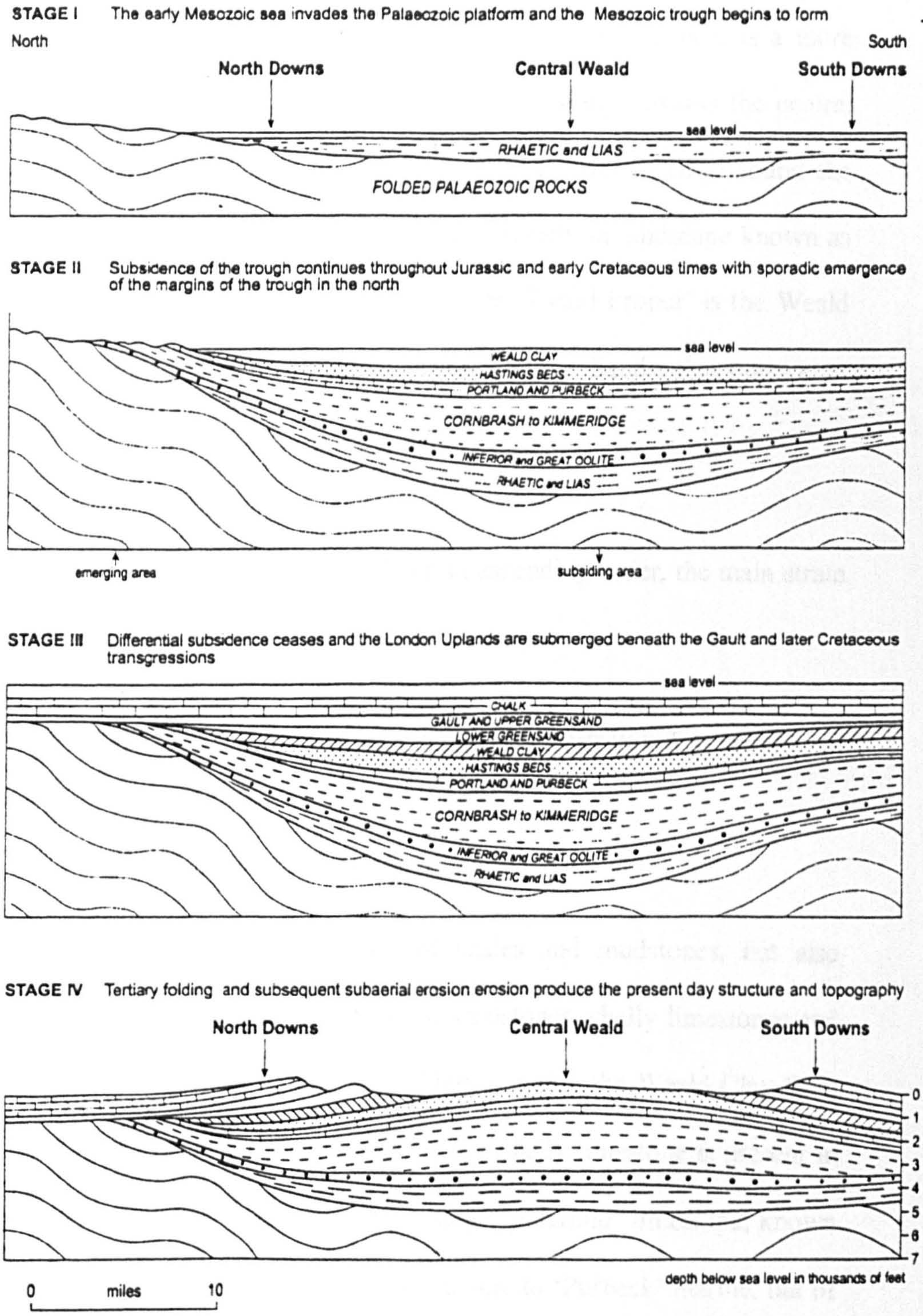
The geology of the Weald

Geographically the Weald is the area bounded by the North and South Downs which includes substantial parts of the counties of Kent and Sussex and lesser proportions of Surrey and Hampshire. The Weald is a clearly defined and recognised geological district although the historical origin of the term 'Weald' derives from the heavily wooded nature of the region in pre-conquest times, and is related to the German word *Wald* meaning wood or forest (Brandon 2003, 13).

The Wealden District is characterised by rocks and soils notable for their wide-ranging variety and quality contained within a comparatively small area. Since these conditions have been influential in shaping human settlement and occupation over the centuries it is relevant to provide an overview of the underlying geological structure that has formed them. For a more detailed account, reference may be made to Thurrell, Worssam & Edmonds 1968, Gallois 1992, and the Geological Survey of Great Britain (Sheet 301).

All the rocks in the Wealden District are of sedimentary origin and comprise a series of deposits laid down mainly in the Cretaceous period and Mesozoic era. During the Tertiary period which followed, uplifting and folding of these strata produced an anticline, known as the Wealden dome, oval in plan and having an axis which runs across the district from East South East to West North West. The dome has since been eroded, revealing a succession of rock types that outcrop in a series of concentric rings. How this process of sedimentation, folding and erosion may have evolved is illustrated in Fig. 3 (p. 10).

Fig. 3: The geological evolution of the Weald



(from: Brandon 2003)

The outermost of these rings is the prominent rim of the North and South Downs which encircles the 'Weald Proper'. From the crest of this rim, the escarpment falls away steeply on the inward side, whilst on the dip slope there is a more gentle slope outwards. Within the chalk rim, and moving towards the centre, successive strata of varying rocks outcrop to form a series of rings round the centre: this formation has produced a comparable variety in landscape known as 'scarp-and-vale' topography. At the centre of the 'Weald Proper' is the Weald Clay overlaying a series of strata known as the Hastings Sands, that outcrop at the eastern end of the District.

Moving out from the centre of the Weald and in ascending order, the main strata are as follows (see also Fig. 4, p. 12):

Weald Clay
Lower Greensand - (Atherfield Clay, Hythe Beds, Sandgate Beds, Folkestone Beds)
Gault Clay
Upper Greensand
Chalk - (Lower Chalk, Middle Chalk, Upper Chalk)

The Weald Clay consists predominantly of shales and mudstones, but also contains less significant deposits of siltstones, sandstones, shelly limestones and clay iron stones. Ironstone exists at several levels within the Weald Clay from which it has been extracted for the iron industry. Shelly limestone is present in different consistencies, the best known being large '*paludina*' limestone, known as 'Sussex' or 'Petworth' marble, similar in structure to 'Purbeck' marble, but of inferior quality. Sussex marble was mined to the north of Petworth, near Kirdford, and is commonly found in local churches where it has been used for bases, shafts, capitals, tomb slabs, memorial tablets and fonts. Shelly limestone

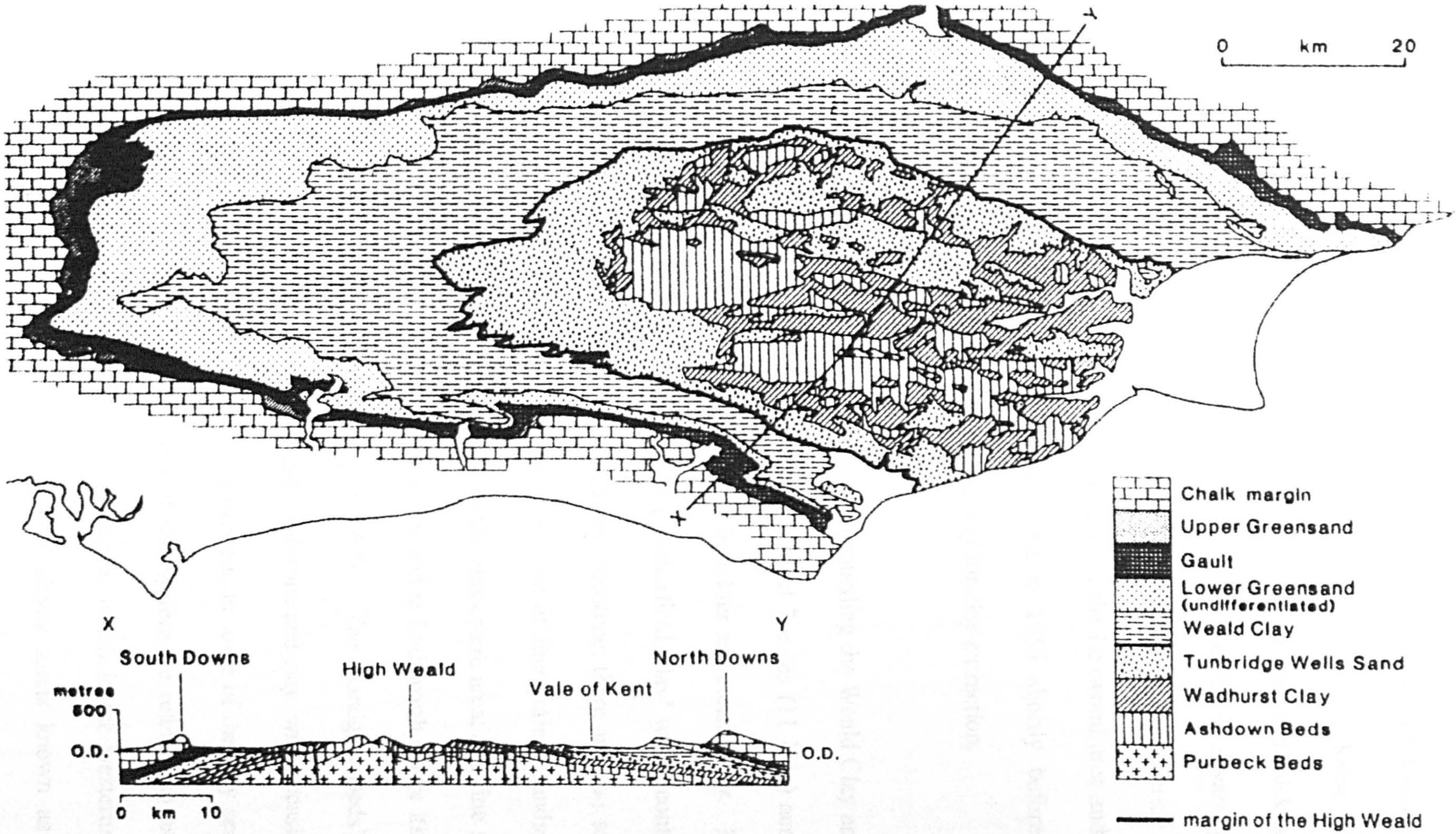


Fig. 4: The geology of the Weald

(from Robinson & Williams 1984)

has also been found sufficiently often at iron working sites to suggest that it may have been of value, possibly as a flux (Cleere & Crossley 1985, 13). The arenaceous divisions in the Weald Clay are manifest in a variety of forms from compact, fine-grained, quartzose sandstones, to deposits of loose sand. 'Horsham stone' is a hard wearing sandstone that was extracted in thick slabs from the Weald Clay, making it suitable as a roofing material in a variety of buildings, including Kirdford church. The clay itself was suitable for brick and tile making, and for pottery. Bricks were made in the Loxwood area and the glasshouse at Blunden's Wood was discovered in 1959 shortly before its destruction by a local brick company to make way for clay extraction.

The Lower Greensand forms part of an ellipse surrounding the Weald Clay and is at its broadest in the west where it extends to around 7 miles (11 Km.) across. It is of interest for its sand deposits which vary in colour and consistency. Four main sub-divisions have been identified. The 'Atherfield Clay' which contains shales and mudstones with concretions of clayey ironstone: there are also sands and silts in this division. The 'Hythe Beds' consist of fine grained sandstone which has been used as a building material in the Haslemere area; and fine sand which outcrops between Witley and Hambledon, and at Lodsworth where its use by the glassmakers is recorded on a map of 1629. The 'Sandgate Beds' are more variable and contain sandy clays, sandy ironstone and clay, with occasional deposits of fuller's earth used in the fulling process, in some of the clay seams. To the west of the region, the lower beds of this system are referred to as the 'Bargate Beds', characterised by pebbly sandstone, which in the westernmost part of the area are overlain with ferruginous clayey sands known as the

'Puttenham Beds'. The 'Folkestone Beds' are the most consistent of the Lower Greensand series and comprise coarse sands, pebbles, clay and lumps of ferruginous sandstone known as 'carstone'. Carstone could easily be cleaved into flat pieces and was used for paving and building walls. The sands are generally fine to medium grade and stained yellow to reddish brown, although silver sand occasionally occurs.

The Gault Clay is characteristically bluish-black formed by mud being deposited over the Lower Greensand layer. Since it lies between the chalk and the Lower Greensand it is usually wet and often waterlogged, giving rise to a heavy, sticky clay soil. The Gault forms a narrow outcrop at the foot of the chalk escarpment where it is often obscured by downwash.

The Upper Greensand generally appears as a very thin layer between the Lower Chalk and Gault Clay: it is more apparent to the west of the region and where the Arun cuts through the South Downs. It is not consistent and contains beds of sandstone and clay.

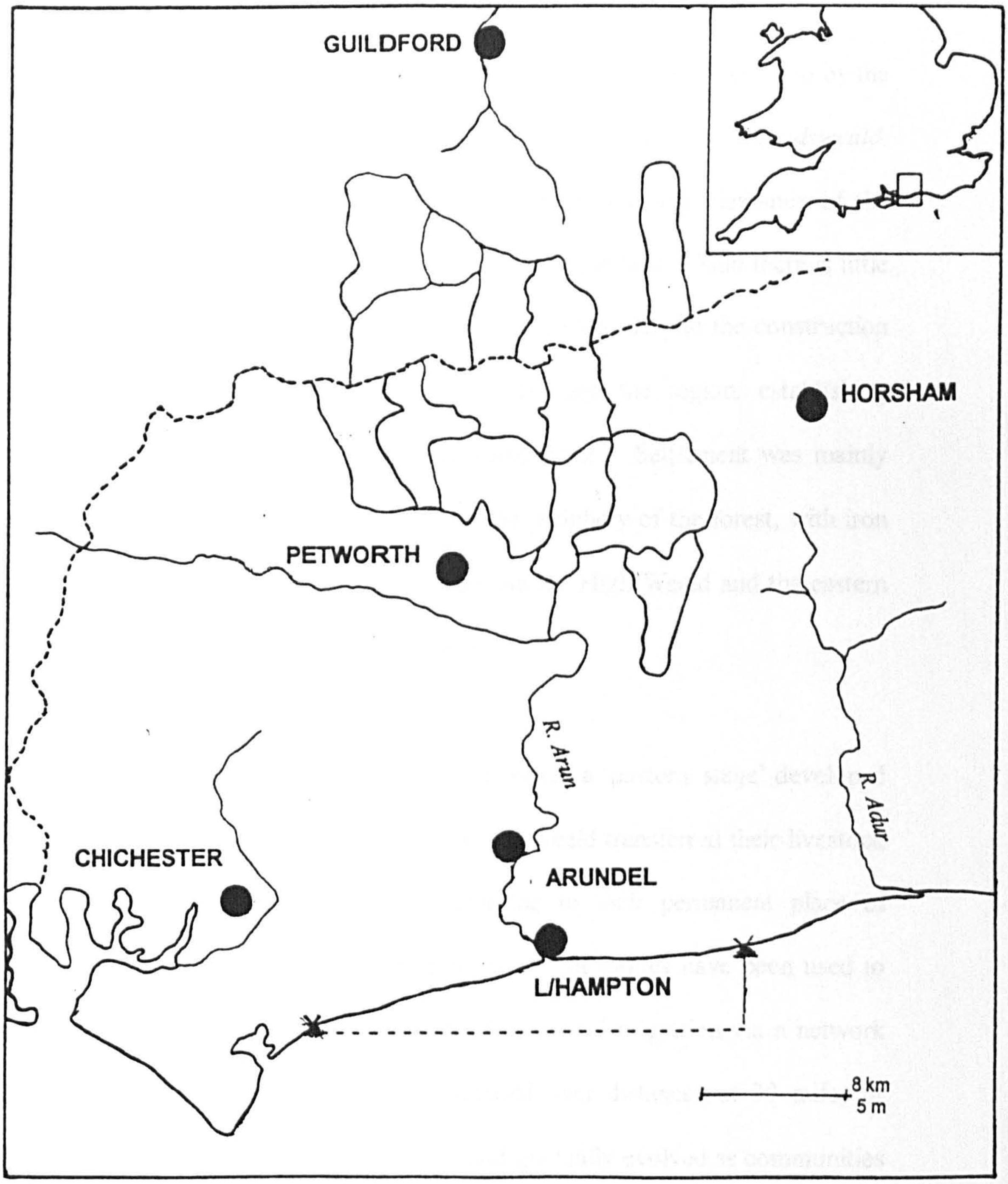
In the chalk rim encircling the Weald, there are three distinct chalk layers. The 'Lower Chalk' is an impure chalk, containing up to 50% of non calcareous material or marl, greyish in colour and has been referred to as 'chalk marl'. Marl was used as a soil dressing to remedy the deficiency of lime in the Wealden soil. The 'Middle Chalk' is visible on the steep scarp slope of the South Downs. It is free of flints and contains a higher proportion of calcium carbonate, making it a relatively pure limestone. The 'Upper Chalk' is exposed over a large area of the Downs and is noted for the large quantities of flints it contains, and is often referred to as 'chalk with flints'. Flint was used as a building material on both sides of the Downs for the walls of churches, farmhouses and barns. On its south side, the chalk rim has been cut through by the rivers Arun, Adur, Cuckmere and Ouse. Where this has happened, deposits of river gravel can be found on terraces left by the rivers as they cut deeper into lower strata.

Geographical and landscape features of the Weald

The district within the Wealden region that is the subject of this thesis lies to the north west, straddling the borders of Surrey and West Sussex where the glass industry was most in evidence (see Fig. 5, p. 16). This is a comparatively small area, approximately 10 miles in diameter and is defined by the following co-ordinates:

SU 92 22 / TQ 12 22 x SU 92 40 / TQ 12 40. However, it should be noted that there is evidence of glassmaking elsewhere in the Wealden region where glasshouses appear to have operated in isolation: at Sevenoaks (*c.* TQ 529 524), Northiam (TQ 842 250), Graffham (SU 996 182) and at Buriton (SU 739 169) just over the Hampshire border. The district under study is part of the Low Weald, a low-lying area that runs around the High Weald and bounded by the Wealden Greensand. As mentioned above, the underlying geology is mainly Wealden Clay resulting in heavy, sticky soils that have made cultivation laborious and a hazard for transport. Deposits of sandstone form gentle ridges that cross the area in an east-west direction and here the soil is lighter and more suitable for agriculture. These geological features give rise to a topography of

Fig. 5: The glassmaking region



The glassmaking parishes on both sides of the Surrey/ Sussex border.

I- - - - - - - - - - -I the coastal sector for which the port of Arundel/Littlehampton had responsibility for collecting customs duties.

gently undulating hills intersected by small streams that drain into the river Arun to the south.

From prehistoric times the Weald was densely wooded and was referred to by the Romans as *Sylva Anderida*, later amended by the Saxons to *Andredsweald*. Recent archaeological research suggests that occupation and clearance of the woodlands began in prehistoric times. However, in the Low Weald there is little evidence of colonisation during the Roman occupation, despite the construction of roads such as Stane Street that passed through the region, establishing communication between London and the south coast. Settlement was mainly confined to the North and South Downs on the periphery of the forest, with iron production concentrated in areas to the east, on the High Weald and the eastern coastal plain of Sussex (Brandon 2003, 36-8).

During the Saxon period, what Brandon describes as a 'pastoral stage' developed in which communities living on the edge of the Weald transferred their livestock into the Weald for summer pasture, returning to their permanent place of habitation for the winter. Saxon charters and place-names have been used to demonstrate how communities undertook this seasonal migration via a network of tracks and droveways which often extended over distances of 30 miles or more (ibid., 45-8). Colonisation of the Weald gradually evolved as communities made clearings in the forest at their customary place of summer pasture and took up permanent occupation there. During the early Middle Ages clearance of the woodlands proceeded in an intermittent and fragmentary manner, firstly with the formation of scattered farmsteads and later with the combination of a number of these into small village communities. The origins of village development in the Weald have been the subject of study over several years (Hoskins 1955; Taylor 2000; Chapman & Seeliger 2000).

It was found that woodland clearance gave access to land that was unsuited to cultivation because of the nature of the heavy clay soil, a problem that has persisted into modern times. This led to the development of farming that was predominantly pastoral in character occupying small fields and closes within the surrounding woodlands. Since pastoral farming was less labour intensive than that based on working the land, there was a surplus of labour available that could be taken up with other occupations related to forestry and the production of a range of wood products. Thus the coincidence of land economically marginal for farming and the resources of the surrounding woodlands combined to produce a local economy heavily dependent on timber and wood products.
Remarkably, the Weald remained well-wooded, and even today is among the most densely wooded regions in England. Paradoxically this is due in great part to the woodland industry itself that developed techniques of planting and coppicing to conserve supplies of its most essential material. Another factor that has been important in the survival of the woodlands was the great difficulty of transport through miles of Wealden clay which, in the absence of proper roads, made the extraction of timber to distant markets a laborious business. The problem of transport is well illustrated by the following concession given by the bishop of Chichester in the fifteenth century allowing the building of a chapel at Loxwood, situated on the Sussex/Surrey border, to save the local people undergoing the arduous journey to Wisborough Green to attend church:

'...distant from their parish church by three long miles deepe and miery and full of moorish woods so that in rainy and winter seasons accesse to their parish church by difficultie of the waies is too tiresome and long so they are forced to go out of the Diocese of Chichester to hear Masse and receive Divine Sacraments. And therefore for these and other causes us thereto to consent of the Vicar and inhabitants to build and make one certayne Chapell in some meete and convenient place in Loxwood' (Buckwell 1912, 176-7).

It is likely that the Navy Board had in mind the problems of extricating timber from the Low Weald when, in 1611, they requisitioned 6,000 loads of timber to be taken from a list of wooded regions in England which did not include the Weald (PRO. HMC Salisbury (Cecil) MS Vol.XXI HMC, 1970, London, 307). The problem of transport persisted with roads, or lack of them, being the subject of complaint by travellers such as Defoe, Walpole and Cobbett well into the nineteenth century (Brandon 2003, 177-80).

The Lower Weald lack the advantage of navigable rivers although it is heavily dissected by river flood-plains containing many streams and small tributaries, often in hedgerows or bordering woodland. Water was in demand by a number of local industries for use in processes such as tanning and fulling, and to provide power for iron furnaces and forges, milling and gun-powder manufacture. The glass industry used water for washing, cooling and mixing clay, and it is significant that glasshouses are invariably to be found close to a supply of water.

3: The woodland economy of the western Weald

Introduction

This chapter investigates the reasons for the emergence of industry in the Weald and in particular the wood industry, how it was manned and managed, its products and markets.

Documentary sources about the wood industry and its organisation are fragmentary. The archives of local estates such as Shillinglee and Petworth contain surveys indicating the extent of woodlands, but contain little information to show how the woods were managed or to whom wood and timber were sold and for what purpose. At Petworth, for example, annual accounts provide global figures relating to wood sales but details of individual transactions are lacking. It is also questionable to what extent records of this kind ever existed in circumstances where transactions were often carried out orally.

As well as examining local records, the research involved an exploration of the Port Books (National Archives, Kew PRO. E190 series), a source that proved to be productive as an indicator of the range of wood and timber products that were transported seawards from the Weald to other English ports as well as across the Channel. Early port records were in the form of Customs Rolls and Bundles, but after 1565, Port Books were used to record in-coming and out-going goods and particulars of applicable duty paid. For administrative purposes, the head port of Chichester, which covered the entire Sussex coast from Kent to the Hampshire border, was divided into five subdivisions, each having its own Port Books. The subdivision that is of particular interest in the context of this thesis is the port of 'Arundel with Littlehampton' that included the coast between Heene (Worthing) and Felpham and would have been the most easily accessible port for goods passing from the western Weald (Fig. 5, p. 16).

The terms 'timber' and 'wood' used here conform to definitions described by Rackham: 'timber' being wood with a girth of more than two feet, and 'wood' being of smaller girth obtained from the branches of large trees, or underwood including coppice-wood and seedlings. Bark, used in tanning was obtained from each of these sources (Rackham 1995, 10).

Reasons for the development of industry in the Weald

As mentioned in chapter 2, poor conditions for cultivation resulted in a farming system that concentrated on animal husbandry with small-scale arable produce for subsistence, resulting in farms and smallholdings composed of small fields and closes suited to stock farming rather than tillage. Ralph Treswell's survey of the Petworth estate (1610) well illustrates this pattern of settlement in the locality of Northchapel and Lurgashall, an area of 1,692 acres divided into 33 copyholds each having an average of 51 acres. The total area was divided into 402 divisions indicating that each copyholder held an average of 12 fields or closes of just over 4 acres. The largest holding was farmed by John Stint, containing 148 acres in 42 divisions, of which 43 acres (29%) are shown as arable and 105 acres (71%)

pasture. All copyholders held variable amounts of both arable and pasture/meadow, with the exception of William Goodier, who farmed 8 acres of arable and John Goodier who had 17 acres of pasture: the common family name here suggests they worked together. Of the total 1,692 acres, 41% was arable land, with the rest given over to pasture and meadow. This compares with Zell's estimate that Wealden farms in Kent 'have twice as many pastoral acres as arable' (1994, 231), and illustrates how farming was concentrated on rearing livestock rather than arable. Further evidence of the predominance of livestock farming is the reference in manorial customaries, such as Shillinglee, to the rights of tenants to a 'layne of ferne' (usually ferns or bracken) used for animal bedding in regions where arable crops were insufficient to produce straw (WSRO. MF77, 154); and in an indenture between Anne Stanley and Henry Warter (1616) it is stated that land containing 'ferne' used for cattle litter should not be broken up (WSRO. Add. Ms. 3820).

Despite woodland clearance during the early medieval period and before, the Weald remained relatively thickly wooded, particularly at the western end of the region and, by the beginning of the 16th century, was still among the most heavily wooded areas in England. Elsewhere there were many parts of the country that were becoming short of wood and timber, giving rise to the legislation to 'preserve the woods' (discussed in chapter 9); but whereas these areas became subject to regulation to prevent further loss, the 'Wealds of Surrey, Sussex and Kent' were largely exempt. Norden compared the thickly wooded areas of the Weald and other places, including Derbyshire, Cheshire and Shropshire, with areas of deprivation and great shortage, such as Wiltshire and Lincolnshire where there was insufficient wood for fuel or construction (Norden 1618, 214-6).

The emphasis on stock farming, less labour intensive than arable, enabled local people to engage in by-employment for much of the year to supplement earnings. The role of rural communities in the development of industry has been recognised in several studies in the Weald (Mendels 1972; Zell 1994) and in other parts of the country such as south Yorkshire (Hey 1972) and the west Midlands (Rowlands 1975). The availability of labour combined with the rich natural stocks of wood and timber to become the basis of a flourishing wood industry, and these resources were complimented by the presence of iron and an abundance of water used for a variety of industrial processes and for power. Continental expertise was close at hand and was an important factor in the advancement of the technology of industries such as iron founding and glassmaking: the immigration of skilled workers was encouraged by a forward looking government whose mercantilist inclinations allowed the settlement of immigrants able to contribute new skills.

The development and growth of industry was led by expanding demand, particularly by metropolitan centres of which London was pre-eminent. Important among market forces was a steady growth in population throughout the sixteenth century and an increase in prosperity arising from improvements in agriculture and from expansion in trade. It has been estimated that the population of England more than doubled between 1500 and 1650, from around 2.5 to 5.2 millions (Wrigley & Schofield 1981, 208-9). This increase was accompanied by greater urbanisation, which Corfield suggests, from her study of towns having a population in excess of 5,000, grew from 4% of total population in the 1520s to about 11% by 1650 (Corfield 1976, 217, 223, 229). Of greatest significance was the growth in the size of London from an estimated 70,000 to 400,000 between 1550 and 1660 (Brandon & Short 1990, 152). Despite the problems of transport within the Weald, there must have been significant advantages in being near to the London market. The sustained growth in the population of the capital throughout the period created greater demands for foodstuffs, raw materials and manufactured goods upon surrounding counties. The county of Sussex and the western Weald were among those regions that responded to these opportunities, developing a highly capitalised agriculture along the coastal plain, combined with a trade in products based on the Wealden wood industry to bring prosperity to the region.

A significant area of market growth during the 16th century was the navy, particularly in the shipbuilding and victualling yards of the Medway and the Thames estuary. It was during this period that the western Weald became established as a major supplier to the navy, not only of timber but of iron products and ordnance. Trade outside the region, enhanced by the increasing demands of the military and the navy, also had the effect of stimulating demand in the local economy (Brandon 1974, 144).

Manpower and management of the woodlands

Those employed in the woodland industry possessed a variety of trades and crafts: wood-cutters and sawyers were involved in extracting wood and timber from the woodlands; carpenters, wood-turners, coopers and wheelwrights used timber to manufacture a wide range of products from timber-framed buildings to agricultural equipment and household utensils; while others produced wood for fuel (including charcoal), burned wood for ash and stripped bark for tanning. However, local records, such as Parish Registers, Wills and Probate Records, do not provide an accurate picture of the numbers employed in different occupations where only the main or primary occupation is given: secondary occupations on a part-time basis or for certain seasons of the year are not recorded. This is a problem that has confronted researchers in other areas where 'dual employment' or 'by-employment' was customary, such as the Sheffield area and the West Midlands (Hey 1972, 5: Rowlands 1975, 20).

The occupations of 'yeoman', 'husbandman' or labourer are commonly found in records, but it is evident that in many instances a secondary occupation was involved giving rise to a class of 'husbandman/artificers'. Typical examples include Matthew Napper, yeoman, who entered into a bond with Robert Trower of Wisborough Green, yeoman, to 'fell, cutt, corde, cole, sawe, cleave, convert, worke out and carry away all woods and timber' and to make 'coal pits and saw pits' on his land (WSRO. MP23 Misc I). Richard Otway, referred to in his probate inventory (1614) as 'yeoman', had a 'fowerthe parte of certaine iron workes in

Sussex' (WSRO. MP23 Inv. 1). In another example, Henry Strudwick, a member of a large family of yeoman farmers, was in possession of a 'smithes forge' and a 'glasse house' (WSRO. EpI/11/9 f.120). The terms 'glassmaker' or 'glasscarrier' appear only to have been used where this was a prime occupation, and others who worked in or for a glasshouse on a casual basis are likely to have been designated 'yeoman', husbandman' or 'labourer'. Many craftsmen were also smallholders who were able to engage in other occupations during the winter months when husbandry was less demanding and when the woodland industry was at its busiest (Brent 1977, 47). The records of the large numbers of those who worked in unskilled occupations, in transport and as labourers have not survived. These factors make it impossible to estimate the numbers involved in the woodland industry, but it is clear that there were many more people involved than suggested by their recorded occupations.

An important figure in linking the woodland industry of the Weald with more distant markets was the woodbroker, or woodmonger, who acted as an agent in seeking new outlets and in procuring materials from the producers. In the Weald, woodbrokers such as John English of Horsham and John Irelande of Wisborough Green would have organised the supply of wood and timber to order, and arranged carriage to the customer, often another woodbroker acting as an agent elsewhere (WSRO. Ep.I. 11/12; Rice 1941, 378). In London, the trade of woodbroker had evolved in the early Middle Ages with formation of wharves for the importing, storage and sale of wood and timber, and the development of a transport system throughout the capital (BL. Harl. MS 6838 f. 144). The high prices charged by the woodbrokers were a cause for complaint in 1593 and resulted from the many hands through which timber passed on its way to the London consumer. It is also probable that an element of profiteering had crept into the market, a problem that had been prevalent in the 1560s when woodmongers were accused of restricting supply in order to raise prices (CPR 7th March 1560). A lack of regulation over the dimensions and quantities of timber offered for sale created a confusing situation in which customers were '...greatly deceaved and abused...', and in one instance it was said that '...all lathes are so insufficient in breadth and thickness that tilers and labourers are in great danger to stand uppon them on the roofes of houses' (BL. Lansd MS 162 f. 184).

By the second half of the sixteenth century landowners were becoming increasingly aware of the value of wood and timber. The medieval concept of the forest as a reserve for the hunting of deer had vanished, and a new class of landowner who had acquired land after the Reformation was adopting a more commercial approach to its use. In many parts of the country stocks were becoming scarce at a time of rapidly increasing demand. The emergence of the professional surveyor is a feature of this period, and large estates, such as Loseley, Petworth and Shillinglee employed the services of a surveyor to record land-use, including the extent of wood and timber stocks. A comparison of the surveys of the Petworth estate, carried out in 1557, 1576-7 and 1610, shows a significant increase in the amount of detailed information recorded that could be used in the management of the estate, the last by Ralph Treswell being a particularly fine example (WSRO. PHA. 1409; 1414; 1451). The advance in surveying techniques is well illustrated by methods introduced by the King's Surveyor, Rooke Churche, by which the timber content of individual trees as well as whole areas of woodland could be accurately estimated using a brass instrument, rather like a sextant, in conjunction with mathematical tables. He also devised formulae for calculating the volume of loads of timber which took into account the tapering effect of logs, a process which he describes as '...both facile and pleasant...' (Churche 1612, 74). Contemporary writers such as Fitzherbert and Norden comment on the importance of conserving supplies of wood and timber and offer advice about techniques for the propagation of trees and the cultivation of woodlands (Fitzherbert 1598; Norden 1607).

Timber for construction

The greatest use of timber was in the construction of buildings, including houses, barns and workshops. Gulley has concluded that 'there are in the Weald many more houses built between 1570 and 1640 than in any other period of comparable length before or afterwards' (Gulley 1961, 127, 132); and points to a period of prosperity and rising population.

Oak was the primary timber used for construction, though other species such as elm or chestnut were also used. Beech was not highly thought of as a timber for construction as suggested by an extract from the 'proclamation for Buildings, in and about London' (1605):

'...they are daily driven to builde with Beech, and other like kinde of Timber, being of small continuance which in time will be (if the same be not prevented) the notorious peril and decay of the same cittie...' (Larkin & Hughes 1973, 111-112).

Evelyn considered beech to be '...good only for shade and the fire...': he also noted that it was not tithable, because '...in counties where it abounds...tis not accounted timber...' (Evelyn 1662, 47, 253). Whereas oak had been traditionally reserved for buildings of distinction, by the second half of the 16th century, it was in more general demand as standards of living improved. Harrison noted a growing preference for oak:

'...in times past men were contented to dwell in houses, builded of sallow, willow, plumtree, hardbeame and elme, so that the use of oke was in manner dedicated wholly unto churches, religious houses, princes palaces, noblemens lodgings and to navigation, but now all these are rejected and nothing but oke any whit regarded...' (Harrison 1577, 91; see also Salzman 1952, 241, 250).

Norden found that '...oke is of most request [for building] a timber most firme and most durable ...', and Evelyn extolled the merits of English oak, finding it '...infinitely preferable to the French...' which, in his experience, was '...wanting that native spring and toughness which our English oak is indued withal...' (1662, 34). Albion attributes the special suitability of Sussex oak for shipbuilding to a moderate, humid climate combined with the clayey soil of the Weald (Albion 1926, 17; Norden 1607, 210; Evelyn 1662, 34).

During the 16th century there were stylistic changes and developments in constructional method of timber-framed buildings which had a bearing on timber use. From the second half of the 15th century there had been a reduction in the size of timbers used: this may have been for reasons of economy, for aesthetic appearance or possibly as a result of a realisation on the part of the builders that the use of such substantial timbers was structurally unnecessary (Barnwell & Adams 1994, 75). However, a study of timber-framed houses in Kent suggests that the size of timbers should not be used in isolation to determine date (Pearson 1994, 155).

More wood was used to enhance the appearance of a building, where close studding was adopted in place of square panelling, the former a style adopted largely for aesthetic reasons and regarded as a sign of wealth. It was costly because of the extra timber and labour involved, and was often confined to the front elevation and to distinguish other high status parts of a building (Barnwell & Adams 1994, 80, 82).

The incorporation of chimneys into houses during the 16th century was an important development in design which not only provided better heating but enabled open halls to be lofted over to provide more living space and better communication at first-floor level (Pearson 1994, 60). Harrison noted the increase in chimneys in his lifetime as this practice spread (Harrison 1577, 90). It became usual to construct chimneys of brick, but in the early stages of their introduction, in the early 16th century, a smoke bay was sometimes introduced, as at King Post, Elham (Kent). And late in the 16th century at Black Pig Inn, Staple (Kent), the flooring over of the hall was achieved by the insertion of a timber chimney, later replaced by one of brick (Pearson, Barnwell & Adams 1994, 59, 120). The introduction of the chimney led to a greater use of timber in houses for partitions, floors and staircases.

Since the definitive article by Hoskins, in which the term 'the Great Rebuilding' was formulated (Hoskins 1955), research has increasingly revealed that the reconstruction of medieval buildings took place to a considerable extent, adapting existing dwellings to provide additional facilities to meet the expectations of a more prosperous age. This process was noted by a contemporary observer: '...then down with old houses, and new set in their places: for the houses where the fathers dwelt could not content their children...' (PRO. SP12/156, cited in Platt 1994, 4). Houses were frequently enlarged by the addition of a further wing, often incorporating facilities such as kitchens or brew houses that hitherto had existed in separate buildings adjacent to the main house. Instances have been found of whole bays of a house having been replaced, perhaps because of dilapidation but also to improve or 'modernise' the property. Surveys of 234 timber-framed buildings in the Rape of Hastings (East Sussex), suggest that between 29% and 40% were enlarged or altered in this way (Martin D & Martin B 1999, 121-132). A modification found characteristically in the western Weald, was the substitution of Horsham stone for thatch as a roofing material. This was usually confined to larger houses and involved the replacement of roof timbers with more substantial members, set at a lower pitch, to withstand the weight of the stone slabs (Gulley 1961, 137; Brandon 1974, 39).

Before the 16th century, the mansions of the aristocracy and greater gentry were usually built of stone, and the use of brick was uncommon in Sussex before 1500, despite the vast expanse of continental brickwork that went into the construction of Herstmonceux Castle in the 1440s. Initially, brick and clay tiles were imported from the Low Countries, Twineham church being an early Tudor example. At first, brick was used in small amounts in house building, for example for the chimney piece, and was only used on a large scale by the most wealthy, such as Sir Thomas Shirley, who built Wiston House of brick between 1578-85. However, as the century progressed, the demand for bricks and tiles increased, leading to the emergence of a thriving home industry in the Weald by 1600 (Brandon & Short 1990. 136, 197). By this date even comparatively modest structures made use of brick, including glass furnaces such as that at Sidney Wood (Kenyon 1967, 203). The use of stone or brick in house building, although reducing the need for a timber frame, by no means eliminated the use of timber in buildings, and large quantities were needed for panelling, flooring, staircases and roofing: wood fuel was also needed for brick and tile manufacture.

An example of the amount of timber required for a substantial mansion is given in a 'Book of Computations' prepared for the ninth Earl of Northumberland when he was planning a replacement for his house at Petworth between 1615 and 1625. The main structure was to have been of stone and brick, with timber estimated as follows:

Item	Loads of timber (of approx. 1 ton)
Main beams (somers)	29
Joists	111
Main beams and joists	193
Wall plates	27
Roofing timber	514
Boards for lofting	142
Rafters	176
Ballisters and stairs	36
Planks	20
Boards	10
Total:	1,258

(from Batho 1958, 108-34)

The above were all items to be used for structural purposes, mainly for roofs and flooring, but timber would also have been needed for items such as doors, door frames and panelling for fitting out the house; and in addition, there would have been a requirement for wood for scaffolding and access platforms during construction. In total, this amounts to a huge quantity of timber, which in this instance would have come from the Lord's woodlands. In the event, this particular project did not go ahead and a programme of repairs and extensions to the existing house was substituted (Batho 1958, 108-134).

Attempts have been made to calculate the number and size-distribution of trees required to build houses of more modest proportions. In house building, timber was selected, often by the carpenter himself, from the smallest tree capable of serving its particular purpose in order to minimize the amount of cutting and wastage. Rackham has estimated that a house at Swaffham Prior (Cambs.) with an overall ground plan measuring 40ft x 16ft (12.3m x 4.9m), needed 79 trees of sizes varying from 6½ - 8½in (0.16-0.21m) in basal diameter to 13 - 17½in (0.33-

0.44m). A larger house at Stanton (West Suffolk), 67ft (20.6m) long and 20ft (6.1m) wide used 332½ trees, within the range 4½ - 6in (0.11-0.15m) in diameter to 18 - 25½in (0.46-0.65m) (Rackham 1980, 146).

References appear in the port records of Littlehampton/Arundel to loads of timber being exported, mainly to London, much of which was clearly intended for use in house building. Between October 1590 and June 1591, 76 loads of 'framed timber' passed through the port, of which 56 loads were destined for the capital. It is not clear whether the description 'framed timber' means that complete timber frames had been prepared or whether timber had been cut and squared to make it suitable for constructing timber frames on site. However, there are also references in the port records to 'one frame for a house' and 'one frame for a barn' indicating that timber frames were being pre-fabricated in the Weald and marked before being dismantled for transport to their destination for re-assembly. This practice had the advantages of allowing a greater choice of materials and adding value at the point of manufacture as well as savings in transport costs (PRO. E190/ 746/24; 749/21; 750/11). Other timber items mentioned in port records and clearly intended for use in building construction include joists, lathes, wattles, shingles and rafters and appear with other wood and timber products found among the Port Records of Arundel/Littlehampton indicating that their origin was the western Weald (see Fig. 5, p. 35)

Fig. 6: Wealden wood and timber products

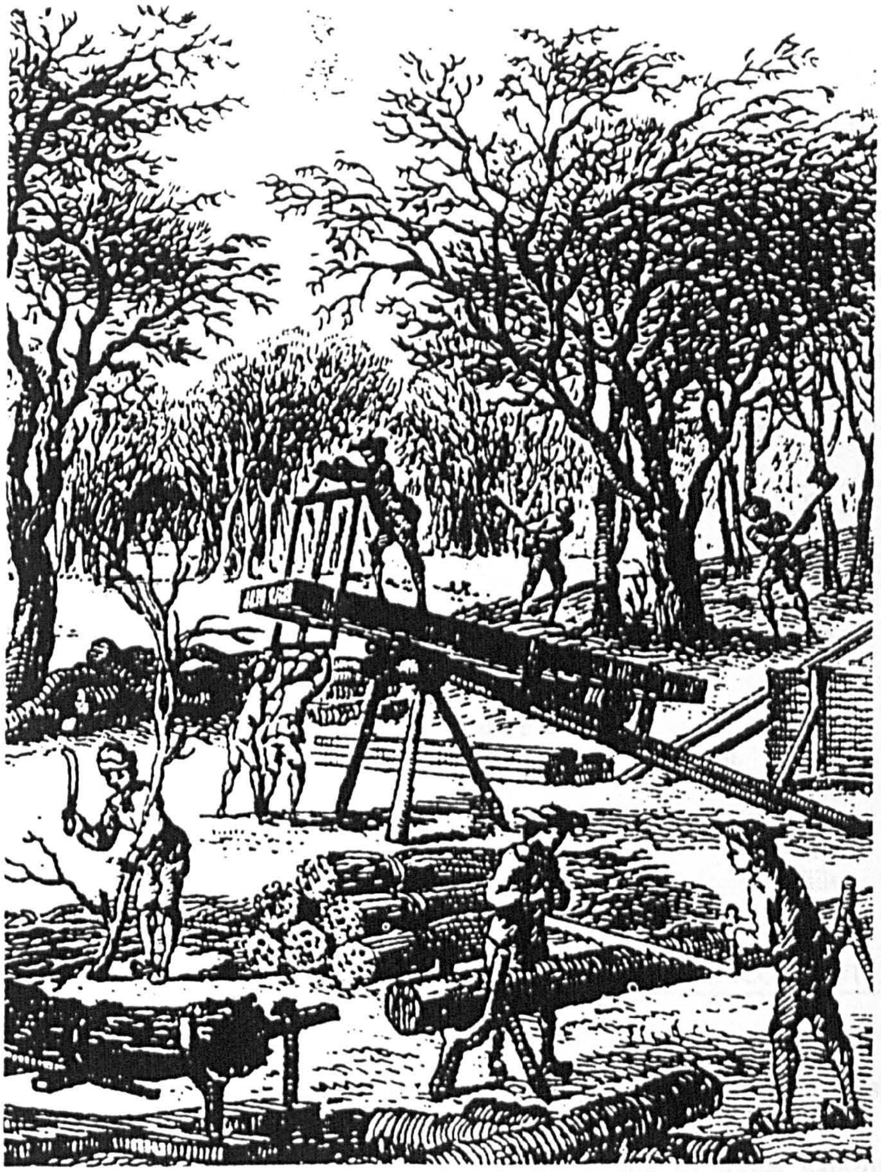
The variety of wood and timber products from the Weald is illustrated by the following list of items that appear in the port records of Arundel and Littlehampton between 1566 and 1610 (PRO E 190 series):

Barrel boards
Base boards
Beddsydes
Bedstaffs
Beech timber
Boards (various thichnesses)
Billets
Bundles of wood for burning
Crooks
Dutch boards
Elm pieces for ships
Elm timber
Felloes
Featheredge boards
Firkin boards
Framed timber
Frame for house/barn
Garde boards
Horsede boards
House timber
Inch boards
Joists
Kildikin boards
Knees
Lathes
Planks (various thicknesses)
Posts
Quarter boards
Rafters
Sawn boards
Sawn timber
Shingles
Shipboards
Small timber
Staves
Sugar chests
Tallwood
Timber
Timber frame
Trenchers
Trennells
Vishinboards
Wattles
Wheel timber
Wood

Timber for most construction purposes was worked 'in the green' which was far easier in terms of labour and wear on tools than timber that had been seasoned. Value could be added by processing it in the Weald at the point of felling, for example by the sawing of planks and boards in a range of dimensions and thicknesses. This was not only a means of increasing income through the sale of a higher-value product, but must also have made handling easier and reduced transport costs.

Timber was sawn either over a sawpit or with the use of a frame. Sawpits could easily and cheaply be dug in woodlands where felling was taking place: the household accounts of Sir William More for the year 1582 includes the item, 'for a sawpit makinge 11*d*', and at Upper Beeding in 1588 two sawpits were made for 2*s* (SHC. LM1087/6; MCO. 2523/143/67). Sawing frames were used on construction sites and in the shipyards, but were transportable and could also be used at the site of felling (Fig. 7, p. 37). There is no evidence that mechanised sawmills were in use in the Weald at this time although there are records of their use in the Low Countries in 1596, and elsewhere on the continent in the second half of the 16th century (Holland 1971, 45). In England, a licence for the making of '...a machine for cutting wood powered by wind or water...' was granted in 1565, but this proposal does not seem to have materialised (PRO. CPR Eliz., 7th Sept. 1565). Besides the substantial capital investment involved in setting up a powered sawmill, it lacked the flexibility of the sawpit or the frame, necessitating the transport of timber from the site of felling: the difficulties of transportation in the

Fig. 7: Work in the woods



A team of eight men involved in various forestry activities in winter: tree-felling, sawing planks using a frame-saw, cross-cutting, and trimming branch loppings. The products include planks, logs, bundles of rods and brush-wood. A stand on which the rods are tied into bundles can be seen in the bottom left-hand corner. (print *c.* 1600, in James 1981, 120).

Weald made it easier to carry finished goods rather than whole trees. A lack of water in the summer months is also likely to have rendered sawmills inoperable in the same way that many iron works were out of action during the 'dry' season.

Timber was in demand for other construction projects, such as repairs to the bridge at 'Bodyng' (Upper Beeding, Sussex) in 1588, which had been within the Sussex estates of Magdalen College, Oxford since 1474. The 'Account of the Bailiff's Expenses' for the repair work carried out is of interest in that it provides a record of the stages involved from the felling of the timber to fix it in place:

Item		**Cost**	
for felling tymbaz		vis.	viiid.
for carying of tymbaz to ye sawpytt			
and from ye sawpytt unto ye watazs syd		xiiis.	viiid.
unto ye sawyers for sawing of timbaz and planks		xls.	
for making of ii sawpytts		iis.	
unto the carymen for carrying of tymbaz and plank		xxs.	
unto ye carpenters for ther work about ye sayd bridge	iiil.	iis.	viiid.
for iii ton of timbaz		xxiiis.	
unto iii laborazs for ther work		xxiiis.	
for carrying of chawk unto ye sayd bridge		iis.	viiid.
for forme worke about ye sayd bridge		iiis.	vid.
for a hundred of planks		viiis.	

(MCO. 2523/143/67)

This account shows that approximately 20% was spent on materials, 23% on transport and the remainder on labour for the felling of trees, making sawpits, sawing planks, form work and other work by carpenters and labourers.

During the late Middle Ages, timber had been used extensively in church building. Churches, founded in Saxon times, were often rebuilt, enlarged or restyled to conform with changing liturgical custom and the needs of a growing population.

New buildings were also required where new parishes were established, or where local communities had grown sufficiently to justify their own place of worship. There are many examples, as at Northchapel, where a chapel-of-ease was founded at some time in the 14th century to save the inhabitants a ten-mile round journey to their parish church at Petworth; also the new chapel at Loxwood referred to in chapter 2. Wealden churches were often of timber-framed construction, as might be expected in a region short of good building stone but having an abundance of fine timber. The first 'chapel' at Northchapel is likely to have been of timber construction, as was the chapel at Plaistow, probably the last of the 'timber' churches to be replaced by a stone building in 1851 (Brandon & Short 1990, 45, Bruce P 2000, 11). A feature of the rather modest Wealden and Downland churches of this period was a squat spire, usually clad in shingles made from cleft oak heartwood, as at Alfold (Surrey) and the broach spire at Wisborough Green (West Sussex). Shingles had the advantage of being light in weight, requiring a less substantial support, were easily shaped and could be used on steep surfaces, unlike tile or stone which were too heavy. Disadvantages were high labour costs in manufacture and in fixing with wooden pegs, and lack of durability (Gulley 1961, 137-8).

After the Reformation, although there was a general decline in new church building, there was a continuing need for alterations and repairs. The Ashworth Churchwarden's Accounts for 1540-1, show that a new bell frame was installed and is an example of the kind of work that was going on in most parishes from time to time (WSRO. MF 978. PAR11/9/1). A fire at South Harting in 1576 caused extensive damage, necessitating an entirely new oak roof over the nave, chancel and central transepts. Recent research has revealed a greater degree of building activity associated with churches, particularly in refurbishment and repairs, than was previously thought (pers. com. J Barham). In addition there would have been a requirement for timber for pulpits, pews, communion tables and reading desks to accommodate the needs of the reformed church.

Timber for shipbuilding

Oak timber was in demand for shipbuilding by the local industry along the coast as well as by the new shipyards that were being developed in the Medway and the Thames estuary. The navy of the Middle Ages had been a modest affair with a few dedicated naval vessels and reliance on the commandeering of ships from the merchant fleet when required, a practice that continued well into the Elizabethan period. For example, in July 1570, the Council ordered William More, Vice Admiral of Sussex, to detain for the Queen's service all ships of 30 tons burthen or more and all mariners within his jurisdiction (SHC. LM/COR. 12/35). Henry VII inherited just four naval ships and added only six others to the fleet during his entire reign, including the *Regent*, a vessel of 600 tons built on the river Rother (Sussex). After the papal Bull of Excommunication (1535) raised fears that England would be invaded by forces from the continent intent on restoring the Catholic cause. Henry VIII took the precaution of strengthening south coast defences and developing the navy: a process that was continued by successive monarchs throughout the century. In the 50 years from 1539 to the Armada, 131 vessels were added to the Royal Navy, including ships bought in from foreign yards and those appropriated from alien fleets as a 'prize' (Mackie 1966, 210, 371; Glasgow 1970). In 1559, a prohibition was placed on the selling of 'any seaworthy vessels' to foreigners, though the stated purpose of this was 'on account of the scarcity of timber' rather than for strategic reasons (PRO. CPR Eliz., 23rd August 1559).

Shipbuilding for the navy had been carried out in a variety of ports during the Middle Ages. In 1495, Portsmouth was established as a naval dockyard and, although used extensively during the reign of Henry VIII for the building of ships such as the *Mary Rose* (1509-10), fell into disuse in preference to ports in the Thames estuary until its revival at the time of the Civil War. Nearer to London and the seat of government, the Thames ports became the centre for naval shipbuilding during the 16th century, with the founding of Woolwich (1512), followed by Deptford (1513) and Chatham (1567): the latter being the leading dockyard in the realm before the Civil War (Catalogues, National Maritime Museum; Brandon & Short 1990, 159).

The port records of Littlehampton/Arundel contain frequent entries relating to timber and include products, such as 'sawn' timber, 'shipsboards', 'trennells' and planks in various substances destined for these ports, clearly for use in shipbuilding (PRO. E190 series, passim). Timber was ideally obtained from oak of 80 to 120 years growth having a diameter of between 2 and 3 feet and from which substantial sizes could be obtained: heartwood was used in preference to sapwood which was prone to rot (Dodds & Moore 1984, 14).

Although it was clearly preferable to select timber that was easily accessible to water transport, there is evidence that timber was being earmarked for naval use deep in the western Weald as early as 1574. In that year, 116 oaks at Kirdford are referred to in a bargain of sale as being '...already marked with an anchor...' by Christopher Baker, '...one of the assistants of the admiralty...' (HMC. (Salisbury MS) xiii., 1915, 122). In 1609, sufficient horses were ordered by the Privy Council for '...the land carriage of 500 loads of timber and trynailes...' from His Majesty's Sussex manors '...to the waterside to be brought to His Majesty's yards at Deptford and Woolwich for the building of His Majesty's ships there...' (BL. Add. Ms. 5702/33, Burrell Collection, 244).

Essential for shipbuilding was a supply of curved pieces of oak from which shaped pieces such as 'knees' and 'futtocks' could be made. The most suitable timber for this purpose was obtained from hedgerow trees which had unrestricted growth and were able to develop more in a horizontal than an upwards direction producing large, spreading crowns. Timber of this kind is referred to in the port books as 'crooks' or 'crooks and knees' (PRO. E190/741/21; 44/26), although later in the 17^{th} century it was known as 'compass timber'. Demand for 'crooks and knees' was in the ratio of around 4 loads to every 100 loads of standard timber (James

1981, 149). In 1611, a warrant was issued for the felling of the large quantity of 2,000 loads of 'crooked timber' for the Royal Navy, to be obtained from several English counties, including Sussex (PRO. SP14/67/13).

It is noted that 58 loads of '...timber of crooks...' were exported to Flushing in October 1579 and a further entry for '...6 loads crooks...' for Dieppe in June 1580 (PRO. E190/741/12; 742/2), suggesting that timber for shipbuilding was still being exported to foreign yards despite the ban on the sale of shipping to foreigners mentioned above (p. 41).

Unlike timber used in house building and construction, ships timber had to be seasoned before use and it was usual for it to be delivered to the dockyards where it would be stored until it had thoroughly dried out. This meant that much of the sawing and working of the timber took place in the dockyard rather than at the point of felling in the Weald. The amount of timber used in the construction of naval vessels has been estimated at 1½ to 2, or more, loads per one ton of ship: thus an average-sized Elizabethan warship of 400 tons would consume in the region of up to 800 loads. One load was equal to 50 cubic feet, the size of an average tree, and weighed 1 ton (Dodds & Moore 1984, 14). As shipbuilding became more complex, with the installation of more cannon and the addition of further decks, the use of timber increased. A tendency for a larger average size of vessels brought about a demand for greater sizes of timber for extra strength (ibid., 13; Holland 1971, 30; James 1981, 145).

As well as the demands of the navy, merchant shipping became increasingly important with the growth of coastal and overseas trade. In the Middle Ages, it was the East Sussex ports such as Rye and Winchelsea that developed strong commercial links with the ports of northern France and the Low Countries. By the early 1500s, these ports thrived through the handling of imports of wine and a variety of other products, including glass, which together with the produce of the local fishing industry were transported overland to London. In exchange, exports mainly consisted of timber, firewood and other wooden products from the eastern Weald. The intensity of this trade has led Hipkin to describe Rye in the early 16th century as 'a medieval boom town' (Hipkin 1995, 241; Brent 1977, 46). The port records of Rye indicate that most of this trade was in the hands of overseas shipping in the 1560s, the home fleet being preoccupied with a flourishing fishing industry. The Rev Arthur Young, writing at the end of the 18th century, noted that:

'...in the reign of our sixth Edward the 'hoys' [small, general-purpose cargo boats] that were laden with timber went out of Rye harbour to the number of thirty seven one tide, and never an English mariner among them...' (Young 1813, 85).

However, during the second half of the 16th century, there was a general and sustained increase in merchant shipbuilding around the English coast, particularly in the South and East. This was brought about mainly by the need to supply growing urban populations, particularly London, with food, fuel and consumer goods, and was encouraged by the withdrawal of foreign shipping as a result of political uncertainty and the war with Spain.

Merchant ships were generally not customised and were consequently capable of handling a variety of cargoes and often carried passengers; boats primarily built for the fishing trade were also used for freight transport when the fishing season permitted (Farrant & Farrant 1980, 335; Dulley 1969, 46). The most frequent and bulky merchandise passing from the South Coast ports included grain (mainly wheat), wood, timber and iron. Most merchant shipping consisted of small boats of less than 50 tons, which required timber of small scantling, but the cutting of timber trees for that purpose would have prevented them maturing to a size suitable for use in the naval dockyards. Simpler construction and smaller vessel size meant that merchant shipbuilding needed in the region of only 1 load of timber to 1 ton of shipping (Albion 1926, 115). The size of the entire merchant fleet in 1629 has been estimated at 115.000 tons (Rackham 1980, 154) representing perhaps 3,500 to 4,500 vessels.

The exploits of merchant adventurers, such as Drake, Hawkins and Frobisher encouraged greater enterprise in developing trade with the Americas and the Far East. The vessels that plied these routes were considerably larger than those engaged in coastal and cross-channel trade and were often armed. Merchant ships with a carrying capacity of 100 tons or over increased tenfold between 1545 and 1629, as follows:

Year	Merchant ships of over 100 tons burthen	
1545	35	
1577	135	
1582	177	
1588	183	
1629	350	(Nef 1966. 172 n.4)

Few docks were capable of servicing large ships of this kind and this meant that there was a need for lighters and barges to carry goods to and from shore. Large quantities of timber were also used in the construction of the docks and shipyards themselves (Holland 1971, 30).

Ships, both merchantmen and naval vessels, had a short life: repairs and replacement were frequent and represented a significant proportion of the workload in most shipyards. Albion estimates that timber for repairs represented half that used in new shipping each year (Albion 1926, 115). Dulley observed that of the 58 vessels belonging to the port of Rye in 1565, the majority of which were fishing boats, '...at most, 6 were included among the 32 'Ryers' [boats operating out of that port] in Thomas Colshill's list of coasting trades in 1571-1572' (Dulley 1969, 47). Ships of the Royal Navy rebuilt during the 30 years between 1558 and the Armada, numbered 12 having an overall tonnage of 4,560 tons, compared with 31 new commissions with a tonnage of 8,540 tons (Glasgow 1970, 304-7).

Other timber products

Frequent references appear in the port records to barrel boards, firkin boards and kilderkin boards, not only bound for use by the London coopers, but also to south coast ports between Dover to Plymouth. Consignments for destinations such as Sandwich, Gravesend and Margate suggest use in victualling the navy (PRO. E190/741/21; 744/26; 750/23). Barrel boards would also have been in demand locally for the transport and storage of beer, fish and other products such as ashes.

The 'wet' cooper was discriminating in the type of wood used in barrel making: the timber selected had to be hard-wearing and having a close grain making it impervious to liquid, be capable of bending when heated without cracking, and having neutrality of taste. Wealden oak possessed all of these qualities and after being cut to length, was cleft radially to the centre of the log (Kilby 1971, 70-74). The removal of the sapwood and the heartwood from the sides of the boards to leave timber with consistent grain involved considerable waste. Elkington estimates that no more than 300 cubic feet of barrel staves could be obtained from 1,000 cubic feet of timber (1933, 276-7). In November 1604, John Launder entered into an agreement with Sir George More to take sufficient timber from his woodlands at Witley to make 800,000 barrel, firkin or kildikin boards for the sum of £500. Just five years later, in November 1609, he entered into a further agreement to take '...trees of oke, standing, growing...' in the same woods to make 67,000 boards (SHC. LM 349/8; LM 349/68). Barrel making also required a strong, flexible wood for hoops to secure the boards in place: coopers used mainly cleft hazel rods for this purpose, but Fitzherbert suggests small ash trees as an alternative (Fitzherbert 1598, 97).

Barrel boards were also exported to continental ports, including Bruges, St Valery and Dieppe, but this trade was brought to a halt during 1592-3 when an Act of Parliament '...for bringinge in of Clapboarde...' was passed as one of the measures to limit the export of timber. The Act required exporters to import barrel boards in proportion to the volume of exported goods: for example, '...for every 6 tonnes of Beere, 200 clap-boards fytt to make Caske of length 3ft 2in at least...': aliens were not allowed to export fish unless they had already imported sufficient clap-boards (Eyre 1820-29, iv. 860).

In addition to these major outlets, timber had numerous smaller-scale uses, for example, during 1599, '...1,000 felloes...' and '...20 loads of wheele timber...' were dispatched to London (PRO. E190/750/11; 750/29); and between April and May 1592, 41 loads of '...sugar chests...' were sent to London followed by a further consignments in 1596, perhaps an indication of growing trade with the Caribbean (PRO. E190/748/3; 749/21).

Timber was used in the manufacture of a number of smaller items including furniture, household utensils, agricultural equipment, gates and fencing, which, when taken together, must have added considerably to the total volume of timber consumed. Reference to the port books provide an indication of the variety of timber and wood items produced in the Weald that were exported to markets outside the area, mainly London, and these are listed in Fig. 6 (p. 35).

Firewood

The greatest demand for firewood came from domestic needs. Local people were generally able to obtain supplies from their own lands, by agreement with their employer or by manorial custom such as 'firebote', which gave rights to take wood from the commons for fuel. An example of this kind of agreement is to be found in the 1581 customary of the Manor of Shillinglee (WSRO. MF 77, copy of the Burrell MSS, BL. Add MS. 5701). The demand for fuel for urban areas, especially London, led to the development of an extensive wood fuel industry. Since firewood was bulky and of low value, it was more easily transported by sea than overland, and in the early Middle Ages an extensive trade developed transporting wood from the eastern Weald of Sussex via the ports of Rye and Winchelsea. Large quantities of wood billets passed through these ports mainly to London, but also to cross-channel ports such as Antwerp, Dunkirk and Dieppe, to supply the poorly-wooded coastal regions there (Pelham 1928, 171). Licences were granted for the shipment of firewood, such as that to George Joyner in 1526 to export 8,000,000 billets from Sussex within a period of four years: a further licence for a similar quantity was granted to him in the following year (PRO. Letters & Papers of Henry VIII, iv, 2132, 2927).

Towards the end of the 16th century, a notable change in the pattern of the firewood trade developed in which the centre of activity moved from East Sussex ports westwards: firewood drawn from the western Weald was shipped from the port of Littlehampton/Arundel, which assumed greater importance. The main reason for this change was the incapacity of the ports of Rye and Winchelsea due to the silting up of their harbours. Ironically the timber industry itself has been cited as a cause of this process since topsoil from areas of deforestation found its way into rivers and was borne downstream to be deposited in the harbour entrances. This effect was compounded by alien shipping shedding their ballast before entering harbour to take on their cargos of wood, and also as a consequence of marshland drainage after the 1560s (Pelham 1928, 181-2; Hipkin 1995, 244). Other factors giving rise to the decline of the port were the loss of Calais in 1558, which had accounted for up to 75% of exports earlier in the century; and the disruption to shipping that followed the occupation of Rouen by the Catholic League in 1558 (Hipkin 1995, 242). The outcome of these events was the inability of these ports to operate effectively, resulting in a decline in trade and loss of prestige and importance. Between the 1570s and 1660, the population of Rye fell from over 3,500 to fewer than 1,300 (ibid. 241).

During the 1570s, Henry Fitzalan, (12th Earl of Arundel) widened and cleared the channel between Arundel and the sea enabling ships to be loaded at the inland port of Arundel rather than their cargoes having to be transported a further five miles to the sea at Littlehampton (Eustace 1922, 118). These developments to the port facilities at Littlehampton/Arundel were significant in opening up the hinterland, including the western Weald, to greater trade outside the region. The decline of the firewood trade passing out of the port of Rye to continental destinations and the rise of that carried out through Littlehampton/Arundel, can be seen by the following comparison of firewood shipments:

Period	Rye	Littlehampton/Arundel
Dec.1566 – Sept. 1567 (10 mths.)	36	17
Jun. 1580 – Aug. 1580 (3 mths.)	17	82
Oct. 1589 – Mar. 1590 (6 mths.)	4	25

(PRO. E190/737/24; 737/15; 742/12; 742/3; 745/27; 745/20)

An overall decline in the export trade during the 1589-1590 period reflects the general restrictions on trade imposed by the Catholic League after 1588.

In early records the term 'billet' is used to describe firewood, but by the 1570s the term 'tallwood' is invariably used, suggesting that larger limbs of wood were involved that would have been easier to handle during transportation. The extent of the firewood industry can be gauged from records of the five months between Easter and Michelmas 1580 when the overseas trade was probably at its peak. During this period, there were 86 shipments from Littlehampton/Arundel containing 113,000 units of 'tallwood'. Assuming an average cargo size of 20 tons, this represents around 1,720 loads of wood which would have been delivered to the wharf at a rate of something like thirteen loads each working day (PRO. E190/742/3).

Wood-burning industries

Large quantities of firewood were used by wood-burning industries in the Weald, operating as near as possible to the sources of fuel, to minimize transport costs. The particular needs of the glass industry are discussed in chapter 8, but there were numerous others that depended on wood fuel, the prime user being the iron industry, which had been present in the Weald since Roman times. Up to late in the 15th century, it had operated on a comparatively small scale, based on simple technology using the bloomery process, but with the introduction towards the end of the 15th century of new methods from northern France, in the hands of a skilled immigrant workforce, the industry was transformed enabling substantial growth in output. At the heart of the new technology, was a larger, more permanent furnace receiving a forced draught from water-powered bellows. The greater heat and higher carbon content achievable in the blast furnace resulted not only in the faster melting of the ore but a lowering of the melting temperature, allowing liquid iron to be cast in moulds. Probably the most important feature of the new technology was the possibility of continuity of production with campaigns lasting 30 to 35 weeks at a time (Hammersley 1973, 599).

The iron industry underwent considerable expansion in the Weald of East and Central Sussex during the 16th century, due to the rise in demand for iron, and particularly for ordnance, which became an important product of the Sussex industry. The industry expanded westwards with a furnace being established at Chiddingfold (1570), a furnace and forge at Northchapel (1574) and a furnace and forge at Kirdford (1574) (Cleere & Crossley, 1995). By 1574, there were three furnaces operating in the neighbourhood of the western Weald, and a further six had been set up by the end of the century (ibid.). Expansion westwards was due to the need for wood fuel, which was becoming difficult to obtain in some areas: during the 1560s, the master of the furnace at Framfield (East Sussex) found it necessary to instruct his steward to call on all tenants within a 3 mile radius of the ironworks and to '...inquire and learne by all [means] as you ride up and downe the woode...if they have sufficient fuell both for themselves and to sell...'; the master had gone to great lengths in preparing lists of all likely tenants and neighbouring landowners, with space for the steward to add information and comments about his findings (ESRO. SRL13/1). Legislation for the preservation of the woods after 1581 became increasingly directed against the expansion of iron works and probably encouraged this movement westwards. The measures taken to regulate the use of wood fuel are discussed in chapter 9.

The iron industry used charcoal in several stages of the manufacturing process: smelting, fining and forging. Charcoal was ideally made from underwood of up to 0.05-0.06m in diameter, representing 7-12 years growth, and because of its friability, was ideally manufactured within a 3 to 5 mile radius of the point of use (Cleere & Crossley 1995, 131,133). A licence granted to Henry Sidney in 1568 allowed him to use '...apse, hazel, hawthorn, blackthorn, sallow, beech birch and any other kind of wood except oak, elm or ash...' (PRO. CPR 16th July 1568). Areas of woodland containing a variety of wood species would have been cut over to provide wood for charcoal-making and then left to regenerate. Later in the century, the use of woodlands became more methodical when ironmasters such as Christopher Darrell developed managed coppices to maximise outputs and to provide a sustainable source of supply. There was also a move towards cultivating a single fast-growing species so that consistent quality of charcoal could be produced. Analysis of pollens found in hammer ponds in the western Weald show that hazel was a widespread underwood species at this time, and since this species thrives in open conditions without shade, coppice plantations started to be cultivated without a canopy of standard trees (Evans 1991, 351-7).

It has been estimated that a load of charcoal (a cartload of 12 sacks and weighing around 17cwt) needed 3½ cords of wood and that 7 loads of charcoal were required to produce 1 ton of iron bar. Assuming an average annual output per furnace of 200 tons of iron bar, the volume of wood consumed would be in the region of 4,900 cords per furnace. In terms of 'illkempt' standing coppice, rated at 30 cords per acre by the crown surveyors in 1610, this would represent an annual usage of approximately 160 acres of woodland by each furnace (Hammersley 1973, 603-5).

Continuity of supply was essential and it was necessary to secure supplies well in advance to ensure that there was no interruption during a campaign. To avoid this possibility, buffer stocks, sometimes amounting to a year's supply, were held at the furnace. The probate inventory of Richard Otway of Rudgwick, dated 16th March 1615, refers to '...his fowerth parte of all the cole beinge three hundred loades lyinge at the furnace and hammer of Deddysham...', valued at £210, equal to 14*s* per load (WSRO. MP1261). This implies a total stock of 1,200 loads, which compares with Hammersley's estimate of 1,400 loads required by a furnace to produce 200 tons of bar iron in a year (Hammersley 1973, 602, 605). The Commission given to Sir Thomas Carden and others in 1548 to examine the operation of iron mills, mainly in east Sussex, reported that:

'...the iron mills and furnaces do spend yearly by estimation one with another above 500 loads of coals, allowing to every load of coals at the least three loads of wood, that is every iron mill spendeth at the least yearly 1,500 loads of great wood made into coals...' (HMC, Salisbury (Cecil) XIII, 19-24).

The annual output of iron from the mills surveyed is not recorded and it is possible that manufacture at this date was less efficient than later on.

In addition, charcoal was used by forges for 'fining' (the decarbonising of pig (cast) iron) into bar iron, and to fashion a variety of artefacts (Hammersley 1973, 603-6). An agreement for the supply of cordwood for coaling at the Forges of Bayham and Tollesley involved the supply of 16,800 cords over 21 years, and would have produced an average of approximately 230 loads of charcoal per year (Jack 1981, 9-10).

In the middle of the 16th century charcoal production associated with iron smelting appears to have been largely carried out by immigrant workers. Awty found that, at the Sydney's Robertsbridge Ironworks between 1540-50 '...the new method of iron smelting brought with it charcoal specifications that could not be met by native charcoal burners' (Awty 1981, 526). The Westminster Denization Roll of 1544 lists 3 colliers and 29 ironworkers among enrolments that were consistently understated (Awty 1978, 17-19). By the end of the century, immigrant workers still seem to have been in demand, as in the case of Nicholas Fowle 'late of France and now in the Parish of Wadhurst', who entered into an agreement to buy 6,000 cords of wood for coaling (PRO. C3/26/77).

Iron-masters such as John Pelham and Christopher Darrell are noted for having coppiced their own woodlands, and would either have employed their own colliers or contracted with a collier to make charcoal in their own woods. It was also customary for a landowner to sell wood on his land, allowing the purchaser to make charcoal on site as in the case of Thomas Knight and Thomas Greenfield, who entered into a series of agreements with Henry West of Petworth to fell timber trees on his lands at Billingshurst. The conditions of these agreements allowed him to make sawpits and 'colepitts', suggesting that timber was sawn on site and the cordwood used for charcoal (PRO. C2/JAS I/W21/22). However, there is evidence that colliers also operated independently, as in the case of John Alderton of Northchapel who would have been a supplier to the furnace at the Frith nearby and whose will contains no hint that he was employed by the iron industry or had any share in it (WSRO. STC 111/K f. 51).

Despite its friability, charcoal was often transported long distances to the consumer. In October 1596, 20 loads passed through the port of Littlehampton/Arundel on its way to London, and this was followed by a further 30 loads two years later (PRO. E190/749/21; 750/11). In 1605-6 the county of Sussex was evidently in arrears in its contribution of 405 loads towards the King's 'service of coals', since stern reminders had to be issued for its prompt delivery. The 'service of coals' was an annual levy of charcoal for use by the royal household, demanded of counties having trade links with London. In apportioning the contribution due, an assessment appears to have been based on the circumstances of each county and their ability to carry out the order. In this instance, the order refers to 26 hundreds in Sussex, each responsible for a certain number of loads for which they received the sum of 11*d* per quarter from the crown, being the estimated cost of production: the cost of transport to Hampton Court or Richmond was to be born by the whole shire. The organisation needed to meet this order, together with the costs to the community in implementing it, must have made it unpopular (WSRO. MF77 f. 31).

Other outlets for charcoal included gunpowder, not made in England on a commercial scale before the first half of the 16th century. However the establishment of a home industry became increasingly important as the threat of hostilities caused the government to seek independence from continental sources. The first gunpowder mill was established at Rotherhithe (Surrey) in *c.* 1543, and between 1579 and the end of the century, manufacture was started at the Surrey mills of Wotton, Abinger and Shere, using water-power from a tributary of the river Wey (Crocker & Crocker 1990, 134; Nef 1966, 185).

Another wood-fuel led industry that grew steadily in importance was brick and tile making. Bricks and tiles were at first imported from the Netherlands, but by the middle of the 16th century, as these building materials became more popular, a native industry developed in the Weald using local clay and sand. By 1611, the greater use of brick in London '...which is safer [less of a fire hazard] and reduces use of timber which needs to be preserved...', was being actively promoted (Larkin & Hughes 1973, 120-1). Locally, bricks and tiles were being used in the rebuilding of Petworth House in 1574 and the 1590s (Batho 1957, 13). The wood fuel used to fire the brick and tile kilns was usually in the form of faggots (Beswick

1993, 7), but, in the early 1600s, John Baker was using cord wood at the rate of 50 cords for the production of 70,000 bricks and tiles in his kiln at Witley (PRO. C2/JAS1/P2/4). The firing of bricks and tiles was not a continuous process and the relatively small quantities of wood consumed cannot have provided serious competition to other users. It is also to be noted that, although the home industry was expanding, bricks were still being imported from the continent at this time: in February 1605, 16,000 'brickstones' were shipped into the port of Littlehampton/Arundel from the Netherlands (PRO. E190/754/5).

The use of bricks in building required lime for mortar, and manufacture of these products sometimes existed side by side. In 1587, John Robynett was granted 3 acres on Bepton common on which to build a mansion, furnace and kiln for making bricks, tiles and lime (WSRO. Cowdray MS. 285 f. 13v). Lime was also in demand as a fertiliser and was manufactured for that purpose in separate lime kilns, usually sited at point of use:

'...and now latelie in some parts of Sussex the industrious people are at more extraordinarie charge and toyle for the poore Husbandmen and Farmers doe buy, digge and fetch limestones 2, 3, 4 miles off and in their fields build lime-kilns, burn it and cart it on their fields to their great advantage...' (Norden 1607, 224).

Other products of the wood industry

Two other products of the 'wood industry' were important in providing materials for other industries carried on in the Weald and further afield: oak bark and wood ash. Oak bark was used in the tanning process and must have been in constant demand considering the size and importance of the leather industry. A late 16th century record states that:

'...in most villages in the realm there is some one dresser or worker of leather, and for the supplies of such as have not, there are in most market towns ten or twenty and in London and its suburbs nearly two hundred...' (BL. Lansdowne MS. 74/154, cited in Blair & Ramsey 1991, 301).

The tanners themselves were situated in regional centres such as Ashington, Pulborough, and Chichester supplying leather workers in the surrounding area (VCH Sx, ii, 259); and Nicholas Alderton of Petworth is described as a 'tanner' in an indenture of 1615 (WSRO, Cowdray 4467). Bark was ideally taken from trees felled in the Spring when the sap was rising and it could most easily be stripped. Tusser recommends selling bark to the tanners before felling took place in April, whilst Churche suggests that felling timber for bark was best carried out between 1st April and no later than 30th June, thereby allowing sufficient time for the new growth to become established before winter (Tusser 1577, 45; Churche 1612, 54, 57). The stripped bark would then have been delivered to the tanners for preparation before use. This involved crushing, which at some tanneries was carried out in a tanning mill using water power, the earliest known example in England being in use in 1217: a bark mill was also used in a tannery attached to Battle Abbey ((Harvey 1975, 99; Blair & Ramsey 1991, 302). Tanning was a closely regulated process, controlled by the municipal authorities and the trade guild, who ruled that only oak bark must be used (Harvey 1975, 66; Evelyn 1662, 33). However, Harrison complains about the poor quality of shoe leather made from '...ashe barke...which doth prove in the end to be very hollow and not able to holde out water...' (Harrison 1577, 91).

Wood ash was an important source of alkali used in the manufacturing of products such as soap, cloth, saltpetre and glass. With the possible exception of glassmaking, wood species was unimportant and the ash burners would have burned whatever they could get hold of. A puzzling item appears in the annals of Shillinglee manor (n.d. *c.*1600), which records '...there were sold about 3 years past to the ashburners, 100 oaks...', which suggests an extravagant use of timber trees: however this could relate to old trees, the 'offal' of timber trees, or immature trees on land to be used for another purpose (WSRO. MF. 77; BL. Add. Ms. 5701, Burrell Collection, 146). Ashes, contained in sacks or barrels, were shipped to English ports such as Dover and Sandwich, and, despite an Act of 1548, '...againste the carriage of White Ashes out of this Realm...', to continental destinations such as Dieppe, St Valery and Fecham, (2 and 3 Edward VI, c. xxvi; PRO. E190 series, passim).

4: Glassmaking in the Weald

Introduction

Glassmaking, as a considerable user of wood fuel is examined in this thesis as an example of an industry that operated as part of the woodland economy. This chapter summarises the record of earlier research and outlines the history of the industry in the region.

Glass was manufactured in the Surrey/Sussex Weald from the 13th century until 1618. Evidence of glassmaking has been found at over forty locations, making the Wealden group one of the most important concentrations of glasshouses in Britain during the medieval and post-medieval periods. The method of manufacture conformed to the 'forest glass' type (*verre de fougère, waldglas*) that developed in central and northern Europe during the Middle Ages using potash as the main flux to produce window glass, and simple vessel types. Two distinct phases in glassmaking have been noted: the first started with the introduction of glassmaking in the 13th century, through the medieval period to the middle of the 16th century; and the second after 1567 when the industry was re-vitalised by immigrants who introduced new methods.

Previous studies

Interest in the local glass industry began with the Cooper family who carried out documentary and archaeological investigations about the parish of Chiddingfold between the 1880s and the 1920s. The Revd. T S Cooper, who lived in Chiddingfold from 1875 until his death in 1918, concentrated his studies on documentary research, in which he drew extensively on the Sadler Papers, now in the Surrey History Centre, and Tithe Maps of local parishes. Cooper's research resulted in his 'History of Chiddingfold', a substantial work of 730 pages in two volumes which has never been published, and which remained in manuscript form until 1957, when it was typed by a member of the family and deposited in the archives room of the Haslemere Museum. During his study of the history of the parish, Cooper came across references to glassmaking which led him to develop a 27 page appendix entitled 'Glass'. Although he had been involved in the excavation of a Roman house in Chiddingfold, Cooper, perhaps surprisingly, did not personally uncover any of the glasshouses he had identified from documentary research. It was not until 1911, after he had become ill, that members of his family discovered the first glasshouse and went on to find three more before his death in 1918. Loose notes found amongst his papers suggest that these were Broomfield Hanger, Chaleshurst Upper and Lower, and Hazelbridge Hanger, all within a short distance of Cooper's home. Ill-health prevented Cooper from taking an active part in these explorations, but he was able to visit some sites and to examine glass finds, many of which are labelled in his own hand in Haslemere Museum.

Cooper's contribution includes his account of the industry in the Chiddingfold area, which contains much carefully presented historical detail, but lacks references to information sources. His map, showing the location of suspected glasshouse sites, although confined to the parish of Chiddingfold, pointed the way to the use of tithe maps as a source for place names. His collection of glass fragments, part of the 'Cooper Collection' in Haslemere Museum, is problematical since much of the glass has been poorly labelled and is of questionable provenance. Cooper's main contribution was that his pioneering work created an awareness of a long-forgotten local industry and established a continuing interest in its rediscovery.

After Cooper's death, the family interest in the glass industry was continued, particularly by one of his daughters, Mrs B Halahan, who discovered a glasshouse at Fromes Copse in 1921. She added to the Cooper collection of glass finds at Haslemere Museum and wrote and lectured on the subject of glassmaking in the Middle Ages (Halahan 1921 and 1925).

During the 1920s, S E Winbolt became interested in the work carried out by the Cooper family and started to make archaeological explorations of glasshouses in the area. Winbolt was a classicist who, during his working life as a teacher at Christ's Hospital, Horsham, used his leisure to develop an interest in archaeology and became well known for his explorations of Roman and pre-historic Sussex. By the early 1930s he had examined over 20 glasshouse sites, extending the area of investigation beyond Chiddingfold into surrounding parishes. His book, *Wealden Glass*, appeared in 1933 and was the first published account of the industry. It includes a brief account of the history of glassmaking from the earliest times, a chronological account of the Wealden industry for which he acknowledged the benefit of Cooper's research, and a list of 27 glasshouses with descriptions and notes about finds. Twenty of these had been 'proved' by physical examination and seven were noted as 'reputed' as a result of documentary evidence or place names. Limited resources resulted in Winbolt's examinations being mainly superficial, establishing the presence of a glass furnace and extracting samples of glass and crucible, but at Vann Copse and Fernfold he proceeded with more extensive excavations and produced sketch plans and a few photographs. Appendices to *Wealden Glass* contain useful translations of early accounts of glassmaking by Theophilus, Månnson and Agricola. Winbolt went on to add to his list of glasshouses and published particulars of a further 15, mainly in Sussex, making a total of 42 (Winbolt 1935 and 1940). A criticism of Winbolt's writing, however, is his lack of references to sources. Assemblages of glass and crucible fragments, and furnace material from Winbolt's excavations have been deposited in national museums and several local museum collections, the most important being at Haslemere and Guildford.

From 1931 onwards, Winbolt was assisted in many of his explorations by G H Kenyon, who had settled in Kirdford in 1927 and became his pupil. Further work was halted by the war and by Winbolt's death (1944), but in 1959 Kenyon was persuaded by Dr D B Harden to embark on a re-assessment of the Wealden glass industry (Kenyon 1967, 11). Kenyon re-visited all the glasshouse sites, including those claimed by Cooper, and carried out a thorough re-examination of all the available material, questioning many of Winbolt's ideas. His own research, using local archives at the West Sussex Record Office and the Guildford Muniment Room, provided more material and enabled him to check unsubstantiated material used by others. Kenyon acknowledged the assistance of Mr W S Taylor of Horsham, an amateur archaeologist, who as an employee of the Ministry of Agriculture had access to the local countryside during the course of his work (Kenyon 1967, 23). He was able to benefit from some of the documentary research carried out by E S Godfrey in her unpublished doctoral thesis, 'The Development of English Glassmaking, 1560-1640' (University of Chicago, 1957), later published (Godfrey 1975). He was also acquainted with the excavation of the Blunden's Wood glasshouse carried out by E S Wood in 1960 (Wood 1965). Kenyon's book, *The Glass Industry of the Weald*, published in 1967, became recognised as the standard work on the subject. This book contains sections on all aspects of glassmaking, the families who manned the industry and a catalogue of 42 glasshouse sites in which he provides a critical account of Winbolt's earlier descriptions. His book includes good references to source material.

E S Wood's excavation of Blunden's Wood, referred to above, was followed by his excavation of a glasshouse at Knightons between 1965 and 1973. This site was known to Kenyon (1967, 208) but the excavation had produced little before the publication of his book and the full site report did not appear until after Kenyon's death (1977). Whereas Blunden's Wood had been a 'rescue' excavation, at Knightons, Wood was able to work over several seasons, assisted by members of the Surrey Archaeological Society, to explore extensively and develop a full report (Wood, 1982).

Documentary sources

There are few documentary references to glassmakers in the Weald in the early period, and it is only after the arrival of the immigrants in the 1560s that records of glassmaking families are to be found to any notable extent. Whilst a lack of written evidence may in part be due to the non-survival of records, it is likely that few records were ever made about the proceedings of the glass industry. There are two main reasons for this. Firstly, the industry operated remotely in the backwoods of the Weald where details of transactions for consumables, such as wood fuel and other raw materials, may either have gone unrecorded or were considered unworthy of preservation. Secondly, with few exceptions, the industry was controlled by aliens, particularly in the late period, who were not entitled to own land: there is therefore an absence of records relating to land or property ownership, which also makes it difficult to relate the names of known glassmakers to the occupation of specific glassmaking sites.

The names of glassmakers in the 13th and 14th centuries appear in a few isolated documents, after which there is a gap in the written record during the entire 15th century. During the 16th century, details contained in the wills of two local farming families, the Peytowes and the Strudwicks, link them with glassmaking. However, after the arrival of the immigrants in the 1560s, references appear locally in Parish Records and more widely in State Papers, court proceedings and correspondence.

The Early period

It is probable that glassmaking in the Weald was started by immigrants from across the Channel. Glassmaking had been carried out in the Forêt de Lyons area of Normandy for the Paris market from the beginning of the 12th century (Le Vaillant de la Fieffe 1873, 5). The technique of manufacturing window glass by the 'crown' method was developed there and has been attributed to Philippe de Cacqueray in a document dated 1330 referring to him as *'premier inventeur du plast de verre, appelé verre de France'* (ibid. 3), though it has recently been shown that examples of crown glass are to be found in windows dating from at least 50 years earlier (Lafond 1969, 37), suggesting that de Cacqueray's 'invention' was perhaps an improvement of a method already in use (Chambon 1963, 167).

Following the Norman conquest, large numbers of French and Norman families crossed the Channel to settle in the southern counties, and the county of Sussex at that time has been referred to as 'a bridge connecting the estates of the Norman nobility in England and Normandy' (Armstrong 1974, 48). Settlement penetrated deep into the Weald, as demonstrated by the number of Norman names that feature in Cooper's *History of Chiddingfold* (1911). The church, as an important landowner and user of glass on both sides of the Channel, may have provided the motivation for the industry to expand into southern England. The Benedictine Abbey of Seez in Normandy became the mother house of Arundel Priory which held extensive lands in Sussex, including property in Wisborough Green and Kirdford (Elvins 1981, 2-6). A deed of 1385 links the Abbey of Seez with glassmakers in the Weald (SHC. G 105/1/119), but so far it has not been possible to establish a connection between the Abbey and the glassmakers of the Forêt de Lyons region. There is also archaeological evidence of crown glass production at Blunden's Wood (Surrey) in the second quarter of the 14th century (Wood 1965, 79).

The earliest record containing a name suggesting a connection with glass is a deed, dating from *c.*1240, granting Laurence Vitrearius 20 acres of land in the parish of Chiddingfold (SHC. G 105/1/30). Winbolt, no doubt influenced by Cooper's study of the Sadler Papers, which includes this document, took this as firm evidence that glass was being made in Chiddingfold at that time (Winbolt 1933, 7). Kenyon took a more circumspect view, pointing out that 'Vitrearius' could mean 'glazier' as well as 'glassmaker' at this date. The interchangeable use of terms is confusing, and there is an instance of the term 'glazier' being used to denote 'glassmaking' much later on, in the agreement dated April 1568 between John Carré and John Chevalier, and the Lorraine glassmakers (BL. Lansd. 59/76).

A Quitclaim dated 1300 refers to William le Verir of Chiddingfold, whom Cooper suggests was a son of Laurence, but apart from the name, no useful information is given (SHC. G 105/1/31). Records show that in 1351 white glass was bought from John Alemayne of Chiddingfold and transported by William Holmere to London for use in the glazing of St Stephen's, Westminster. Further consignments were obtained from Alemayne between 1355 and 1378 for the Royal Chapels at Windsor and Woodstock (Salzman 1927, 188-9). The archaeological investigations by Winbolt and Kenyon of sites such as Fromes Copse and Hazelbridge Hanger provide evidence that glass was being made in the Weald at that time; and this is supported by Eric Wood's use of archaeomagnetic dating methods at Blunden's Wood which produced a date of *c.*1330 (Wood 1965, 77-8). It has been suggested that Alemayne was also a merchant, working with Holmere in the purchase of foreign coloured glass for the same contracts (Lowe 1962, 499), but Alemayne was a local man, his name appearing as a witness in several documents between 1330 and 1364 (SHC. G 105/1/72; 105/1/109). An indication that he was involved in manufacture appears in a conveyance of 1367, in which he leases his property at Hazelbridge to John Schurterre, 'glazier' (SHC. G 105/1/110).

The Schurterre family is referred to in deeds that firmly connect them with glassmaking in the Weald. The first of these, dated 1380, gives particulars of an agreement between Joan Schurterre, the widow of John who had died a year earlier, and John Glaswryth of Staffordshire, to manage the glasshouse on her behalf for a term of six years (SHC. G 105/1/117, translated in Winbolt 1933, 45). The need to bring in assistance from outside the area suggests the death of John left his Chiddingfold glasshouse lacking the necessary expertise to carry on the business of glassmaking, and also supports the evidence, given elsewhere (Crossley 1967, 44-5), that Staffordshire was a centre of glassmaking in the 14th century. Glassmaking is again referred to in a deed of 1385, renewing an agreement between between the bailiff of Atherington, acting for the abbot and convent of Séez, and Robert Pikeboussh and John Shertere [junior] enabling them to continue to operate a glasshouse and to cut underwood for fuel (SHC. G 105/1/119, translated in Winbolt 1933, 45). It is not clear how long the Schurterre family kept up its association with glassmaking, but further references indicate a continuing interest and confirm that glassmaking was still in progress in the Weald. In 1391, John Schurter, and Peter Schurtere, his nephew, are both referred to in a deed as 'glasiers' (SHC. G 105/1/121), and in 1400 there is a record of a payment to Peter Shorter (? Schurterre) for five loads of glass delivered to Westminster (Kenyon 1967, 116). As mentioned above. there is an absence of records during the 16th century, but the name Shorter reappears in Chiddingfold in a document of 1495 transferring property to Henry Ropley. 'glassecaryour' (SHC. G 105/1/140): this shows that glass was being produced in sufficient quantity to justify the employment of a glasscarrier, but does not confirm that the Shorters were still engaged in manufacture.

The sixteenth century

During the 16th century, glassmaking passed into the hands of two yeoman families: the Peytowes, based in the parish of Chiddingfold and the Strudwicks of Kirdford. The Peytowes had settled in Chiddingfold *c.*1440 (Kenyon 1967, 117) and a record of 1475 shows that the family were related to the Schurterres by marriage (SHC. G 105/2/9), but there is no confirmation that the Peytowes were engaged in glassmaking at this time. They were primarily employed in farming, and by the 16th century owned around 1500 acres concentrated on two agricultural estates, Pickhurst and Combe. Records starting in 1536 show that the following members of the family used the occupation of 'glassmaker':

1536	John (Will)	(Kenyon 1967, 117)
	John (son of the above)	
1563	Thomas (will)	(PRO. C 3/10/101)
1576	William (burial)	(SHC. Chiddingfold PR)
1580	Stephen (conveyance)	(WSRO. Shillinglee MS 13/1/1)
1610	John (burial)	(SHC. Chiddingfold PR)
1613	John (burial)	(SHC. Chiddingfold PR)
1614	William (burial)	(SHC Chiddingfold PR)

The Strudwicks also settled in the area during the 15th century, and by the early 17th century owned a similar acreage spread between 20 farms, mainly in the parish of Kirdford. The extent of the Strudwick family is illustrated by the frequency of marriage of both male and female members of the family between 1560 and 1614. During this period, the combined Parish Registers of Kirdford and Wisborough Green record 56 marriages despite a gap in the records of Kirdford between 1575 and 1584. Between 1557 and 1614, nine members of the family are recorded as having worked in the industry either as 'glassmaker' or 'glasscarrier'.

Glassmakers:		
1557	Henry (will)	(Rice 1938, 72-3)
	Robert	
	William	
1575	Gilbert	(WSRO. Ep. I/11/1 f. 84)
1576	Thomas	(Cockburn 1975, 614)
1586	Robert	(BL. Add. MS. 39,437)
1595 & 1597	William	(WSRO. Kirdford PR)
Glasscarriers:		
1575	George	(BL. Add. MS. 39,437)
1614	Henry	(WSRO. Ep. I/29//116)

The evidence of Nicholas Naldrett, a witness to the Probate hearing of Henry Strudwick before the Chichester Consistory Court in 1601-2, refers to a 'glass house where the testator [Henry Strudwick] in former time did worke' (WSRO. Ep. II /11/9/f. 120). No occupation is given for Henry Strudwick in this document, which also mentions that he had been the owner of a 'smithes forge in Kirdford', but it is an example of a family, primarily involved with farming, entering into by-employment as a way of supplementing income. (see chap 3).

The state of the industry before the arrival of the immigrants

The Wealden industry in the years before the arrival of the immigrants, has been portrayed as being limited in capability and small in scale (Kenyon 1967, 85; Godfrey 1975, 11-12). Godfrey cites documentary sources to suggest that glassmaking had fallen to a 'low ebb' by the middle of the 16th century, with a discontinuation of window glass manufacture and production limited to the simplest of vessels and apothecaries ware. In 1565, Armigail Waade reported to Queen Elizabeth's Principal Minister, Sir William Cecil, that Cornelius Lannoy had found that 'all our glassmakers cannot facyon him one glasse tho' he stoode by to teach them', and the 'the potters cannot make him one pot to content him' (PRO. SP

12/37/3). Lannoy himself was probably not a reliable witness, since a year later he was imprisoned in the Tower for having 'greatly abused the Queen', by failing to produce '50,000 marks of pure gold yearly' out of base metal (PRO. SP 12/36/12; 12/40/32). However, there are other indications of the limited scale of the industry at that time. The Communar's accounts of Chichester cathedral for the year 1560 include an item for the carriage of a box containing 300 lbs of glass from London to Chichester, and also show that glass stocks amounting to 22 'bonches' [bunches] were held at the cathedral (WSRO. Cap. I/23/4 f. 36; f. 82). This suggests that window glass was not available from the Weald (only 20 miles away) at this time, and that it was imported from the Continent via London.

Jean Carré

Jean Carré was responsible for introducing enduring improvements to the Wealden industry. Of his achievements, Kenyon comments: 'owing to the enterprise of Jean Carré, this undistinguished forest industry grew into something four or five times its former size' (1967, 13). His main accomplishments were in recognising the potential for regenerating glass manufacture in England, in introducing skilled craftsmen familiar with the latest production techniques and in negotiating a patent which would provide the industry with some degree of protection whilst it was becoming established.

Carré was born in Arras (Low Countries), but had lived in Antwerp for some years before moving to London in May 1567. The Returns of Aliens Dwelling in the City of London record that he 'came hither for religion' (Godfrey 1975, 17), which is probably true since Protestantism in the Low Countries was undergoing persecution at that time at the hands of Philip II of Spain. There are indications that religious tensions were damaging to trade, as suggested by George Longe in his petition to Lord Burghley (October 1589) which records that '...troubles began in France and the Lowe Countries so that glasse could not be conveniently brought from Lorraine into England...' (BL. Lansd. MS. 59/72; 59/75). There were also personal reasons that must have encouraged Carré to move to England: his daughter, Mary, had married a Flemish cloth merchant, Peter Appel, and had settled in London in 1561 (Godfrey 1975, 17).

It is uncertain how and when Carré became associated with the glass industry. Godfrey has suggested that he may have been a maker of vessel glass (ibid.), but George Longe, in the petition referred to above, stated that 'Cary [Carré] and Dollyne, having themselves no knowledge, were driven to lease of the benefit of their patent to the Frenchmen' (BL. Lansd. MS. 59/72; 59/75). It seems clear that Longe's comment refers to the practical skills of glassmaking, however it is probable that Carré acquired considerable knowledge of the industry, its markets and sources of supply, whilst working as a merchant in Antwerp. Here he is likely to have had dealings with manufacturers in Lorraine as well as outlets in northern Europe, which included the English market. There is no record of Carré having visited England before 1567, but he must surely have done so, perhaps to see his family. This would have given him the opportunity to assess the opportunities for developing the English market, and would explain why he was able to implement his plans speedily after his arrival in England in around May 1567. This date is arrived at from an entry in the Returns of Aliens Dwelling in the City and suburbs of London, showing that, by 10 November 1571, 'John Carr, howseholder, and Jane his wife, hath been here iiii yeres and di' (Kirk & Kirk 1900-08, X, ii, 39-40, quoted in Engle 1977, 1).

By the summer of 1567, Carré claimed in a letter to Cecil to have already built two furnaces, under licence from the Queen, for making window glass on land in Fernfold Wood, near Alfold (PRO. SP11/13/89): the land, and presumably the wood fuel on it, was leased for £35 a year (BL. Add. MS. 5071/150). Carré formed a company, or 'fellowship', to operate and to help finance the business: he also applied for a monopoly to preserve his investment and to safeguard the business during its formative years. A monopoly was granted, for 21 years, on 8th September 1567 for the manufacture of window glass '...such as is made in ffrance, Lorayne and Burgundy...' (Godfrey 1975, 18-21). Essential to the success of the enterprise was the recruitment of skilled labour to operate the furnaces. Carré initially relied on workers from Normandy who had probably been making window glass in the Weald, at Knightons, as recently as the 1550s (Wood 1982), but it became necessary to increase the labour force and operatives were recruited from Lorraine.

Among Carré's other achievements were interests in the merchanting of window glass in London and a glasshouse to produce *cristillo* at Crutched Friars (Godfrey 1975, 22). He had also intended to set up a 'furnace of ye small glasse', for the production of green glass vessels, in the Weald but this project did not materialise (PRO. PCC Daper 39, 11 May 1572; Godfrey 1975, 26). Although some of Carré's projects were not fully realised, his achievements were significant. He had introduced the essential requirements for the renewal of the industry; successfully obtained a patent for window glass manufacture, which gave the industry some protection against competition; and had convinced the government that the development of a native industry was not only desirable but achievable.

The new Immigrants

As mentioned above, the introduction of skilled immigrant labour was a crucial element in the renewal of the glass industry in England. Skilled workers came from two sources, Normandy and Lorraine.

Glassmakers from Normandy were the first on the scene. Their forbears had settled in the Weald during the Early period and, as mentioned above, it seems clear from evidence found at Knightons that this glasshouse had been operated by workers from Normandy as recently as the 1550s. (Wood 1982). Knowledge of conditions in the Weald and an awareness of the opportunities for cultivating an increasingly buoyant English market would have encouraged their return; and, as Protestants, they would have been attracted to a more favourable religious regime in England (Black 1952, 53). There is no record of a contract or agreement between Carré and the Normans, but they were producing glass by 1568 (BL. Lansd. MS. 59/76), and in 1569 Peter and John Bungar are referred to as makers of 'brode glass' (SHC. LM. COR/3/108). Of the Normandy glassmaking families, only two appear in local records, Cackeray and Bungar (Wisborough Green P Rs.).

There is no record of glassmakers from Lorraine working in the Weald before the arrival of Carré, although they were among the main suppliers of glass to the English market, following a route via the Low Countries to the Port of London. As mentioned above, this was a market with which Carré was familiar and the Lorraine glasshouses must have been his first choice when looking for experienced labour. Carré's partner, John Chevallier, who had a close association with the glassmakers of the Darney region of Lorraine, played a crucial role in the negotiations, acting as guarantor in a form of agreement (April 1568) by which Thomas and Belthazar were invited to England '...as soon as possible...' (BL. Lansd. MS 59/76).

The readiness of the Lorrainers to move to the Weald at this time was prompted more by economic considerations than fears of religious persecution. Although not directly affected by religious oppression, the Lorraine glass industry suffered indirectly as a result of disruption to transport and its markets elsewhere in Europe where religious wars and persecution were taking place. Coinciding with this contraction in the market, and following a period of prosperity and expansion, the glassmakers were now producing more glass than the market could absorb. Over-production caused prices to fall, and profit margins were further eroded by the removal of some of the time-honoured privileges that had been afforded to the glassmakers, and by the imposition of taxes. The authorities attempted to tackle the problem by controlling production, and in 1557, regulations were introduced limiting the output from each furnace to 30 bundles of glass a day. Reduced margins and restricted output encouraged the glassmakers to move into areas where demand was healthy but where local production facilities were poor or lacking altogether. By the second half of the 16^{th} century, migration was taking place not only to England but to other parts of Europe, such as the Low Countries and Switzerland (Rose-Villequey 1971, 433).

Early troubles resulted in some of the Lorraine immigrants returning home and there was delay in achieving full-scale production until after Carré's untimely death in May 1572. Several years seem to have elapsed before the Lorraine workers had become fully established in the Weald. The earliest reference to members of known Lorraine glassmaking families is in the Ewhurst Muster Rolls for 1583-4 where the names of Tysack, Tyttery and Hensey appear. The absence of entries in Sussex Parish Registers before 1588 may be due to a lack of care in the registration of aliens, but may indicate that families were exercising caution before committing themselves to emigrating. This is supported by local records in Lorraine which show that glassmaking members of the Hennezel family emigrated in significant numbers only after 1575 (Ladaique 1973, 138). The following are referred to in Sussex Parish Registers between 1588 and 1620:

Kirdford:	Tysack 1588, 1590
Wisborough Green:	Tyttery 1599:
	Hensey 1599,1603,1616
Billingshurst:	Hensey 1616, 1617, 1618
Petworth:	Hensey 1592

Ananias Hensey of Northchapel appears in the Lay Subsidy Returns between 1590 and 1595 (PRO. E179/186/334).

By the mid-1580s, Lorraine glassmakers were working in other parts of the country: in 1585, Ambrose Hensey was making glass at Bagot's Park (Staffs) and was joined by Richard Hensey who had moved there from Eccleshall (Staffs) (Crossley 1967, 47). The Parish Registers of Eccleshall contain the names of several members of the Hensey and Tysack families, the first reference to a Henzey appearing in 1586 (Pape 1934, 90). In his history of the Stourbridge glass industry, Guttery refers to Ambrose Henzey making glass at Blithfield (Staffs) in 1585, and to Edward and Peregrine Henzey working in the Stourbridge area soon after 1615 (Guttery 1956, 13-4).

The government had abandoned its policy of limiting the inflow of alien workmen that threatened employment in native industries, adopting a more pragmatic approach which encouraged the settlement of alien workmen possessing particular skills of benefit to the economy. The employment of foreign labour was by no means the preserve of the glass industry and significant numbers came to work in other Wealden industries. Foremost was the iron industry in which between 500-600 immigrants, mainly from Normandy, were employed throughout Sussex during the Tudor period, with not less than 300 engaged in the industry in around 1550 (Awty 1981, 526, 529).

The Anglicising of immigrant family names took place, and the variation in spellings that appear in documents has caused some confusion:

de Bongard:	Bongard, Bonngard, Bougard, Bongars, BUNGAR
de Hennezell:	Henneze, Henzey, HENSEY
de Thysac:	Thysac, Tisick, Teswick, TYZACK
de Thietry:	Theatrye, Thietry, Tttery, TITTERY

In addition to the known Normandy and Lorraine glassmaking families referred to above, a number of other immigrant families appear in Parish Records, with Wisborough Green having the largest number of such entries (Kenyon (1967, 137).

Glassmaking in the Weald reached its height at the beginning of the seventeenth century, by which time the volume of window glass imported from the Continent had fallen considerably, despite increasing demand, indicating that the needs of the home market were being satisfied by native production. This is illustrated by records of window glass imported into the Port of London for the year 1615 which show that only 26 cases of Normandy glass were brought in, the equivalent of around 15 days output from one furnace (PRO. E190/18/6). Most of this came from the Weald, though glasshouses such as those at Bagots Park and Wolseley (Staffs), and St Weonards (Hereford), also operated by immigrant labour, were also contributing to overall production (Crossley 1967; Welch 1997; Bridgewater 1963).

The development of coal fuel

The introduction of coal fuel in the early years of the century had a significant effect on the English glass industry as a whole, and particularly on glassmaking in the Weald. As wood fuel became more scarce and expensive in many parts of the country, coal became an increasingly attractive alternative as more productive mining techniques and improved sea transport to the main centres of population enabled prices to remain stable. For many industries such as brewing, dyeing, salt-boiling and lime-burning, conversion to coal was a relatively simple matter, but for glassmaking there were technical difficulties in converting to the new fuel. Firstly, the coal fire, having a shorter flame did not burn with sufficient heat in the conventional wood-burning furnaces, which depended on a vigorous fire to create a reverberatory effect. Secondly, coal smoke polluted the molten glass metal in open pots, usually turning it black; and the obnoxious fumes of the smoke also created difficult and unpleasant working conditions for the operatives. These problems were overcome by the redesign of the furnace to position the fire at the centre of the furnace, between the sieges, and the provision of draught assistance through passages under the hearth (Charleston 1978, 30-1; Newton & Davison 1996, 130).

The pollution of the glass by sulphurous coal fumes was largely resolved by the use of 'hard coal' from Newcastle that produced less harmful smoke than Scottish coal (Godfrey 1975, 105, 109).

The inventors of this new process, led by Sir Edward Zouch, were at first (1611) granted a patent exclusively concerned with '...the making of glass with Seacoles...' (PRO. PR9 Jac. I, pt. 29, m. 19). This patent protected the coal process but did not ban the use of wood and had no direct effect on the Wealden manufacturers: indeed the purchase of woodlands near Crawley by Isaac Bungar as late as 1614 suggests that the coal process was not perceived as a threat (PRO. STAC 8/111/10). However, further patents were introduced between 1614 and 1615 prohibiting the use of wood fuel in glassmaking anywhere in England and also banning the import of glass of all types (PRO. PR11 Jac.I, pt.16, No 4; E101/471/6)). At the same time, new partners were incorporated into Zouch's company, introducing investment capital and fresh management expertise. Sir Robert Mansell, one of the new proprietors of the Company, rapidly emerged as the dominant partner showing considerable management ability and entrepreneurial skills in advancing the industry into a new stage of development.

There is some evidence to suggest that experimentation in the use of coal took place in the Weald during the years leading up to 1615. The Wealden glassmakers must have been aware of experiments in the use of coal going on elsewhere, and signs of coal burning were found by Winbolt during his examination of the glasshouses at Somersbury Wood (37), Sidney Wood (38) and Petworth Park (40), but he did not note any modifications to furnace design to accommodate coal (Winbolt 1933, 40-

1, 50, 24). Later on, Sir Robert Mansell, during his protracted lawsuit with Isaac Bungar (1624), suggested he had unsuccessfully experimented with coal:

'...Bungar...attempted the making of glasse with cole, but finding no likely-hood of perfection and the difficulties, hazard and charge too great for him to undergo, desisted, when he had spent much money therin...' (PRO. SP14/162/231b).

One of the problems facing Bungar was that there was no local source of coal within easy reach of the Weald to make its use economically viable. There is little evidence of the use of coal in the region during the medieval period. A shipment of 'seacole' is noted in the records of the port of Winchelsea for 1323 (Pelham 1929, 107), and traces of coal have been found in archaeological contexts of the 13th and 15th centuries (Holden 1963, 179; 1980, 292). By the early 1600s, small amounts of coal were being imported to the port of Littlehampton/Arundel (from Newcastle) by the Earl of Northumberland, presumably for domestic use at Petworth House (PRO. E190/738/14; 746/9). However, this source of supply would have been impracticable for industrial use in an area where wood and charcoal were readily available

The end of glassmaking in the Weald

The second patent (4th March 1614) awarded to Sir Edward Zouch, banning the use of wood in glass manufacture, signalled the end of glassmaking in the Weald. In these circumstances most the of the glassmakers accepted the inevitability of the closure of the Wealden industry and moved to Newcastle where Sir Robert Mansell had settled upon establishing new glasshouses in an area where there was plentiful coal, refractory clay and easy sea-transport to London. The names of known glassmaking families such as Hensey, Tysack and Tittery, familiar in the Weald, are to be found in Parish Registers in the area.

However, there were those, notably Isaac Bungar, Edward Hensey and Paul Vinion, who were defiant in their opposition to the monopoly and entered into a series of legal encounters with Sir Robert Mansell in an attempt to restore their rights to continue their time-honoured craft. They pleaded with the Privy Council that, either they be given time to use up the fuel and glass making materials they had already prepared and paid for, or that the patentees be ordered to pay them compensation '...at reasonable...' prices. The Council responded by ordering Bungar and Hensey to cease glassmaking and appointed arbitrators to assess the value of their materials for compensation purposes. By April 1616 the committee of inspectors had made little progress with their valuation, the reason given to the Council being '...an overflowing of waters, and afterwardes faylinge to proceede therin...' (PRO. APC xxxiv, 283). Bungar and Hensey renewed their plea to work out their materials, proposing that they supply their total output to Mansell at the price of 18*s*. per case. Mansell was disposed to agree with these proposals since his new coal-fired furnaces were still in the process of developing sufficient productive capacity and the London glaziers were complaining about the '...scarcytie of windowe glasse...' (PRO. SP14/105/18). He also welcomed an alternative to paying compensation at a time when he was having to invest in the development of a business that, as yet, was producing little return. The Privy Council ruled that Bungar should be allowed to manufacture glass for 60 weeks and Hensey for 30 weeks from 15th April 1616: all glass was to be supplied to Sir Robert Mansell, or his agents, at the price of 18*s*. a case delivered to Broken Wharf, London, or 16*s*. a case collected from the glasshouse. Only existing stocks of wood and materials were to be used, and Bungar and Hensey were not permitted to

'...buy or provide any more woode than is already in their yeardes...' (PRO. PC2/28/213). The difference in time allowed to the two glassmakers presumably reflected the stocks of materials each had available, but it also provided Mansell with a phased approach to assuming sole production.

A year later, the glaziers of the city of London were still experiencing difficulties in supplies, complaining to the Council that the prohibition on foreign imports had led to an '...exceedinge scarcity...' of glass (PRO. APC xxxiv, 232-3). A committee of enquiry appointed by the Council to assess and report the situation recommended an extension to the arrangement with Isaac Bungar '...for the better supplie of the kingdome...', and it was agreed that he should be allowed to continue to operate two furnaces until 20th August 1617 and thereafter one furnace until April 1618. There is no evidence of glass being made after this latter date and it may be assumed that this marks the conclusion of three centuries of glass making in the Weald.

Closure of the Wealden glasshouses not only deprived Isaac Bungar of profits from glass manufacture, but also those he derived from the merchanting of glass to the London market. For the next few years Bungar is found engaged in a series of law suits and other activities, including sabotage, aimed at disrupting the operation of Sir Robert Mansell's monopoly. These proceedings have been well chronicled by Godfrey from an extensive series of original documents, and show how discussion about the glass industry developed within the wider context of the debate that was taking place about monopolies and patents generally (Godfrey 1975, 110-126).

Although Isaac Bungar continued his crusade against the monopoly, nothing was achieved towards the resumption of glassmaking in the Weald, where manufacture had ceased in 1618. He died in comparative poverty at Pulborough in 1643: the £1,000 he had earned at the height of his career and about which he had boasted had disappeared, and the sum total of the legacies left to members of his family in his will of 12th November 1642, amounted to £57 7*s* 6*d* (PRO. SP14/162/231b; PROB 10/633).

5: Glass types found in Wealden contexts

Introduction

The examination of Wealden glasshouse sites by earlier researchers has shown that window and vessel glasses were manufactured in both the early and post-immigrant periods of the industry. In this research, local documents have been used to investigate the uses and markets for window glass, including the role of the glazier. The convergence of two different traditions of window glass making in the Weald, 'broad' and 'crown', have been noted and the growing preference for broad glass in the post-immigrant period is commented on. Examples of vessel glass found in the Weald are generally disappointing, there being few surviving fragments of sufficient size from which to reconstruct the outline of vessel form, but it is clear that the great majority of items produced were simple items for domestic use. Glass samples deposited in museums have been examined, and a schedule has been compiled to indicate where surviving examples from different glasshouses may be found. This forms appendix 4.

Description of Wealden glass

Typically, glass fragments found at Wealden furnace sites have a predominantly greenish tint that can vary from yellow-green to blue-green, and show differing signs of corrosion. Kenyon describes the typical condition of medieval Wealden glass as '...usually soft with no sharp fracture, semi-opaque, and milky-green to blue-green with a, now, rough and often corroded surface' (Kenyon 1967, 17). At Blunden's Wood, where glass was being made in the 1330s, Wood found all the glass more or less weathered:

'...mostly with the sandy flecking typical of Wealden glass. But about a quarter had passed beyond this stage. That is, it was opaque, dark green, some almost black, as against the translucent pale green of the rest. Thick pieces had often developed three layers, one in the middle covered with surface-pitting...those outside breaking up along tiny vertical cracks. Some was flaky; some quite 'rotten', or soft and crumbly' (Wood 1965, 67).

It was the degradation of glass found at Fromes Copse (5) into flakes, or layers, that led some early observers to describe it as 'flashed' (Halahan 1921, 24-31). In the most extreme instances, Wealden glass would have totally disintegrated and disappeared altogether. Since one of the main causes of corrosion in glass is water, the siting of glasshouses near to streams or ponds and the general wet conditions of the Weald have not been conducive to its survival.

In contrast, Kenyon found that glass from post-1567 sites was:

'...at its best indistinguishable from modern glass, was mostly hard with a sharp fracture, fairly clear, dark blue-green with a burnished surface which is seldom corroded, and much more uniform in appearance than the earlier, poorer glass' (Kenyon 1967, 17).

The quality and durability of glass is dependent on the ingredients used and on manufacturing technique. But it has also been shown that the deterioration of glass is attributable to the environment in which it has been buried or stored as well as its composition (Newton & Davison 1989, 135).

Window glass manufacture

Two methods of manufacturing flat glass were employed, both involving the use of blown glass, and originating from two distinct traditions of continental glassmaking that came together to operate side by side in the Weald. Despite the confusion caused by cullet and the difficulty in identifying the two types from small corroded fragments, both techniques appear to have been in use in the medieval and the post-1567 periods of the industry (Kenyon 1967, 86).

The 'broad' glass method, also known as 'cylinder' or 'muff', was the technique most widely adopted by the forest glass industry in northern Europe. Contemporary documents also use the terms 'Burgundy' and 'Lorraine' (*verre en tables*) to describe this type of glass, even when made in England (PRO. E190/746/9; SP15/13, no. 89). This method of manufacture is described in detail by Theophilus writing in the 12th century (Dodwell 1961, 40-2). He explains how, after blowing an elongated bulb of glass, an opening was made in the end opposite the blowpipe. This opening was then pinched together so that a pontil could be attached and the blowpipe was then broken off and the other end opened up. The resulting cylinder was then detached from the pontil, annealed and, after cooling, split longitudinally. The cylinder was then reheated and spread out into a flat, rectangular shaped sheet on a 'marver' stone before again being annealed.

A broken piece of Purbeck marble, measuring approximately 10 in x 4 in and 2 in thick (0.25m x 0.10m x 0.05m), smoothed and flattened on one side, found at Idehurst Copse N (16) is thought to be the remains of a marvering slab (Kenyon 1967, 176). Stone slabs of this kind were used by the forest glass industry, though later on, a cast iron sheet, polished on one side, was used for this purpose (Newton & Davison 1989, 280). Harden refers to the probability that, at some stage, the process was speeded up by cutting the cylinder with shears while still hot, thereby eliminating the first annealing process with consequent savings in handling (Harden 1961, 41). Examples of broad glass from Fromes Copse (5) and Somersbury (37) are to be found in Haslemere Museum (Ref. HA.7.82; 56).

The second method of manufacture, 'crown' also known as 'spun' or 'disc', is not mentioned in Theophilus's account. Examples of small 'crowns' have been found in 4th century contexts in the Near East and it is thought that the technique spread to Europe during the early medieval period, with evidence of its use in Rouen by the 13^{th} century (Harden 1961, 40; Lafond 1969, 37). Normandy became the centre for this technique, and the product is sometimes found referred to as 'Normandy' glass (PRO. E190/737/15), and is known as *verre en plats* in France. This method involved blowing a globular shape, transferring it to a pontil on the opposite side to the blowpipe, snapping off the blowpipe and enlarging the resulting hole. Then, after re-heating, the glass was manipulated on the pontil by spinning until centrifugal force caused it to flatten and to spread out into a flat disc shape. The circular sheets, or discs of glass were then annealed in a separate furnace. An example of crown glass from Wephurst (14) is to be found at Haslemere Museum (Ref. HA.7.80).

The sizes of finished glass sheets, made by either method, were variable, depending on materials and technique, although no doubt attempts were made at consistency. It was probably for this reason that glass was sold by weight by medieval glassmakers, as shown by documented examples (SHC. 105/1/117; Salzman 1927, 188-92). However, later on, sales by the case or bundle containing a number of sheets amounting to a recognised overall footage became the practice (see Fig. 8, p. 89). But even here there were inconsistencies leading to complaints from the London glaziers that they were being over-charged by the manufacturers (PRO. SP14/120/89).

Fig. 8: Measures of window glass

Early Medieval period:

1 WEY[1] (or PONDER)	= 5 lbs.
24 WEYS[1]	= 1 SEAM (120 LBS.)

15[TH] and 16[th] Centuries:

1 WISP[2]	= 5 lbs.
1 CASE/CHEST/CRADLE[2]	= 120 lbs.
1 LODE[3]	= 2 HUNDREDS/CASES/ CRADLES or SEAMS

Post-immigrant period:

Crown glass[4] – sold in TABLES averaging 30 ins. in diameter.
A CASE or CRADLE contained 24 TABLES (approx. 120 ft^2)

Broad glass[4] – sold by the BUNCH or BUNDLE, comprising 3 sheets, averaging 3 ft^2.

A CASE or CRADLE contained 20 BUNCHES or BUNDLES (approx. 180 ft^2)

CHEST[5] = 2 CASES
WEY[5] = 2 ½ CASES

1 Salzman 1952, 184.
2 Blair & Ramsey 1991, 266.
3 Kenyon 1967, 29.
4 BL. Lansd. MS. 21/68; 22/6; Godfrey 1975, 200-1.
5 Godfrey 1975, 210.

Broad glass was produced in rectangular sheets of approximately three square feet (Godfrey 1975, 200-1). However, the average size of a sheet produced in Lorraine in the second half of the 16th century was 0.84m x 0.42m ('*3 pieds de long sur 1 pied ½ de large*') (Rose-Villequey 1971, 170), amounting to an area of 0.35 m^2 (3.78 ft^2). The finished sizes of crown sheets increased from the Early to the Late period as technique developed. Crown made in the Forêt d'Eu (Normandy) in the 15th century had a diameter of 0.50m, but by 1624, manufacturers in France were producing crowns of up to 0.81-0.86m in diameter, having a superficial area of 0.50-0.58 m^2 (Philippe 1998, 178). In the Weald, crown sheets made at Knightons (42) in the 1550s have been estimated to have measured between 34½ ins (0.88m) and 35½ ins (0.90m) in diameter, producing an overall area of around 6.66 square feet (0.62 m^2) (Wood 1982, 34).

In appearance, broad glass differs from crown in several details though these are largely theoretical since, in practice, it is difficult to distinguish one from the other when examining fragments that are small, and in a corroded state. The manufactured edge of broad glass is straight, and since the glass has been subjected to heat after the cylinder has been cut, the outside edges on all sides are smooth; the glass is of more uniform thickness throughout the sheet, and impurities and bubbles in the glass tend to form in straight, parallel lines. The manufactured edge of crown glass on the other hand is curved, and the impurities and bubbles in the glass follow a concentric formation, as do any ripples or striations on the surface. Thickness is variable according to where in the disc the sample comes from, starting with thinner glass towards the edge and graduating to the thickest area forming the characteristic 'bull's eye' or pontil mark at the centre. Broad glass, being roughly rectangular in shape, had the advantage of a greater usable area with less loss in cutting. The circular crown glass discs generally meant greater waste in cutting, and a limited maximum size that could be obtained from one sheet. The boss at the centre, or 'bull's eye', where the pontil had been attached was usually discarded. During excavations at Lewes (Sussex), a 'bull's eye' was discovered measuring 84 x 87mm and varying from 2 – 10mm in thickness. All edges were broken with no signs of 'grozing' (the process by which glass was shaped by nibbling the edges with pliers or a specially made 'grozing iron'), suggesting it was too thick and heavy to glaze (Rudling 1983, 73). However, crown glass could be spun thinner, and possessed a fire polish on both surfaces giving it a brighter and more transparent appearance than broad glass, one surface of which was dulled as a result of manipulation during the process of spreading and flattening the cylinder on the marver. Later on, the surface of broad glass was greatly improved by the introduction of polished cast iron sheeting on which to spread out the cylinders, but not in this period (Harden 1961, 42-3; Kenyon 1967, 85; Rose-Villequey 1971, 170).

The thickness of window glass varied considerably with a trend towards producing thinner substances after 1567 (Kenyon 1967, 30). This development was intentional, enabling the manufacturers to obtain a greater sheet area from a given volume of glass metal, and contributed to containing prices below the rate of inflation, thereby encouraging the greater use of glazed areas in buildings. Thinner glass had the desirable qualities of admitting more light and having greater transparency, making it more acceptable to the ultimate user, but was inclined to break more easily, a fault that glaziers '...seemed not desirous to have reformed...' for the extra repair business that came their way (PRO. SP113/53). Some of the thinnest glass manufactured in the Weald was broad glass found by Kenyon at Glasshouse Lane (No. 14) measuring '...from 3/32 in. to less than 1/32 in...' thick: unfortunately these examples do not appear to have survived (Kenyon 1967, 174).

At this Late site, the main product of which was broad glass, quantities of quarry fragments were also found, giving rise to the suggestion that glass was cut to size at the glasshouse before delivery to the glazier, a procedure that would have created more added value for the manufacturer, made transportation easier and would have allowed the off-cuts to be retained for use as cullet. However, this would have been to the disadvantage of the glaziers, who would not only have lost flexibility over the way glass was cut, but would also have had to pay more for their glass and bear a loss of profit on the cutting. It is not surprising to find that when, in 1621, the manufacturers using Mansell's patent attempted to sell glass pre-cut into quarries, they encountered stiff opposition from the glaziers (BL. Harl. MS. 6847/273-4). It is likely, therefore, that quarry fragments found at Wealden glasshouses were brought in for use as cullet.

Both broad glass and crown glass were manufactured in the Weald, but despite the presence of glassmakers of the Normandy tradition, there appears to have been a distinct move towards broad glass as the favoured method of manufacture during the Late period. Unfortunately, archaeology is not helpful in confirming this point since glasshouses of the Late period have not been systematically excavated and glass samples removed for examination may be cullet: however there is documentary evidence for the predominance of broad glass. In contemporary documents the glassmakers are invariably referred to as 'broad glass' makers, for example, in 1569 Peter and John Bongard are '...makyng of brode glasse...', and in 1616, Isaak Bungard and Edward Henzey are '...broade glasse makers...' (SHC. LM/COR/3/108; PRO. PC2/28/213). The Port Records of Arundel/Littlehampton show that before the immigrant revival, glass is referred to as Normandy (ie crown) glass (PRO. E190 737/15), whereas later on when Wealden glass started to be exported, mainly to the west country, the terms used are 'English Glass' Burgundy Glass' and 'Broad Burgundy Glass' (PRO. E190 745/20; 746/9; 744/26).

By the time Sir Robert Mansell started to make glass after 1615, only broad glass was being made. It was said he had '...caused to be erected 9 broad-glasse Furnaces in the several and most remote places in the Kingdome...' (PRO. SP14/162/231b), and in 1621 it was said that crown (Normandy) was no longer available:

'Whereas churches. his majesty's palaces, noblemen's houses and other buildings of account have ever been glased with Normandy glasse it being not possible to make so good in England by reason of the patent that kinde of glasse in respecte of restraynte is not to be had in the kingdome to supply those uses' (BL. Harl. MS. 6847/269-274).

The predominance of broad glass was no doubt partly due to the influx of immigrants from Lorraine after 1567 who were skilled in this method, but there were other reasons. Crown glass, although generally considered to be of superior quality, was more expensive: in 1505, glass for the glazing of Croydon

Manor (Surrey) cost 4*d* per square foot using Rhenish (broad) glass, but Normandy (crown) glass used in the same contract cost 5*d* per square foot (Marks 1993, 31). And 100 years later, Normandy glass was evidently still more costly, '...the materialls of which cost more than ordinary glasse, and therefore to be sold dearer...' (PRO. SP14/162/231a). No explanation is available as to why this was so and is a question that has not so far been answered by the comparative analysis of the constituents of crown and broad glass. From the glaziers' point of view it was not only that crown was inherently more costly, but that having bought it they would have to bear greater loss in cutting than when using broad glass.

As to the matter of quality, it was a period in which increased prosperity and population contributed to a building boom, with higher standards of accommodation and comfort being demanded. Many people had access to window glass for the first time, and would have been satisfied with a product that admitted light and excluded the weather, attaching less importance to transparency. Later on, towards the end of the 17th century, as technology developed and the public became more discriminating, broad glass was gradually replaced by crown glass of better quality. A change of fashion to crown glass at the beginning of the 18th century caused manufacturers of broad glass to convert to making crown or go out of business (Ellis 2002, 74-5, 102).

Despite finds of coloured glass fragments at some glasshouses, for example Fromes Copse (5), there is little evidence that coloured glass was made in the Weald (see Chapter 7). There had been an attempt to introduce the making of coloured glass into England in 1449 when a monopoly was granted to John Utyman to make coloured glass for Eton College and King's College, Cambridge: '...because the said art has never been used in England...' (PRO. CPR. 1446-1452, 255, cited in Marks 1991, 165; Knowles 1926, 157). However, this proposal did not materialise, and in 1621 it is recorded in evidence presented to the House of Commons Committee on Grievances appointed to debate the glass monopoly, that coloured glass '...was never made in England...' (BL. Harl. MS. 6847/274).

The market for window glass

During the period of the Wealden industry, demand for window glass was always greater in volume terms than that for vessel. Earlier alternatives to the use of glass in window openings, such as oiled cloth or parchment and various types of wooden shutter were markedly less satisfactory, whereas for vessels and containers there were suitable alternative materials to glass, including metal, wood and pottery (Salzman 1952, 173-5; Knowles 1926, 158).

The main demand for glazing came with the huge amount of church building that took place after the Norman Conquest as a result of agrarian prosperity and population growth and followed the pattern of ecclesiastical building in France where it has been estimated that 80 cathedrals and 500 churches of cathedral size were built between 1170 and 1270 (Cowen 1979, 12). The more severe climate in England made it even more desirable for buildings to be enclosed. Although churches were not always fully glazed at the outset, it is thought that by the second quarter of the 12th century, the glazing of church windows was customary

(Salzman 1952, 175). Demand for window glass increased with the development of architectural styles incorporating larger glazed areas and this trend was in turn encouraged by the greater availability of glass. Older church buildings were 'updated' by the introduction of new windows that greatly enlarged the area of glazing. For example, in Chichester cathedral (Sussex), the superficial area of glass in the standard window of the nave aisles in the Norman period measured approximately 56 ft^2, but after side chapels were added in the 13th century, enclosing the nave aisles, the new windows were considerably larger containing an overall glazed area of around 120 ft^2, an increase of 214%.

Most of the glass for ecclesiastical buildings, a high proportion of which was coloured, was imported. Knowles gives this as a reason for the main centres of stained glass production to have been situated in centres such as Norwich, York and London all of which possessed ports that were easily accessible from the continent (Knowles 1926, 158-9). However, there is evidence to suggest that, from the end of the 13th century, glassmaking was being carried on in association with religious houses in England, although the extent of this is unknown, and it is uncertain whether production was confined to in-house use or the needs of a wider market. Between 1284 and 1309, glass was being made at the Cistercian abbey of Vale Royal (Cheshire) and a 'glashous' is referred to in the 15th century accounts of Salisbury cathedral (Salzman 1952, 182). Winbolt, in his personally annotated copy of *Wealden Glass* (1933, 7), refers to a possible connection between Salisbury and the Weald from around 1274 when the bishops of Salisbury became Lord of the manor of Godalming, in which Hundred Chiddingfold was situated (Haslemere Museum Archives).

By the 14^{th} century, glassmakers are found to have established permanent sites for the manufacture of window glass in the heavily-wooded areas of the Weald and Staffordshire, where they were able to enter into agreements for renting land with access to wood fuel (Kenyon 1967, 13; Crossley 1967, 45). An indenture of 1380 links these two places of manufacture, suggesting they were well established by this date and refers specifically to the making of 'brodeglas' (SHC. G105/1/117).

A rare survival of glazing accounts covering the period from 1351 to 1378 shows that 1,890 lbs of white glass was transported from the Weald for use in the chapels of the royal palaces at Windsor, Westminster and Woodstock (Salzman 1927, 35-41; 1928, 188-92). These accounts also indicate that coloured glass was imported from the continent for use in making the same windows, and costing more than twice the price of white glass (see also Kenyon 1967, 30). The lower cost of white glass, combined with the discovery at the beginning of the 14^{th} century, of silver stain, which enabled glass to be tinted yellow (Newton & Davison 1989, 30), led to the greater use of white glass in ecclesiastical contexts. It was found that a simple design or motif painted on white glass, often with the use of shading and enhanced by the use of silver stain, could be used to good effect in stained glass as a background, in canopies and in *grisaille*. A study of ornamental glazing by A W Franks (1849), illustrates the versatility of this mode in secular as well as ecclesiastical settings. Towards the end of the medieval period, white glass also became fashionable as a means of admitting more light to church interiors. However, with far less church building and alteration taking place, even in the century before the Reformation, ecclesiastical demand for window glass declined, and was replaced by greater secular use (Marks 1991, 229).

During the early Middle Ages, secular glazing was confined to palaces and other high status buildings. The introduction of window glass into more humble domestic buildings was a gradual process that developed in line with the rise in real incomes and expectations of higher living standards. Contemporary records and archaeological evidence suggest that the use of window glass extended to manor houses and domestic buildings of quality during the 15th century, and according to Harden, 'by the 16th century glass must have been normal, not only in palaces but in most houses of any pretension, including town dwelling-houses' (1961, 56-7; 1969, 99-100). However in more humble dwellings the use of glass was not universally adopted until the later 17th century. A local example is a house of the mid-17th century built with unglazed windows at Holloway Hill, Godalming, which has been dismantled and is currently held in store at the Weald and Downland Museum (Singleton, West Sussex) (Chatwin 1996, 68).

In recent years, there has been much research into domestic buildings, nationally by the Vernacular Architecture Group and locally by organisations such as the Wealden Study Group. It has been found that, despite the wealth of timber-framed buildings in the Weald that have survived since the Middle Ages, details about the extent of glazing and the methods used are often lacking due to their removal during later alterations. However, a recent study of domestic buildings in the High Weald of East Sussex suggests that it was common for buildings to be only partially glazed, initially concentrating on the more prestigious rooms of the house with additional glazing being added later. This study also illustrates how the introduction of glazing started in the more prestigious dwellings but only devolved slowly to cottage level. Whereas 80% of mansions and large houses contained some glazed windows by the middle of the 16th century, it was not until the beginning of the 18th century that a similar extent of glazing was to be found in cottages (Martin & Martin 1991, 84-5). The rate at which glazing was adopted would have varied in different parts of the country, and in 1678 John Aubrey noted that there were still regions where the poor could not afford glass in windows (cited in Louw 1991, 47). However, the use of glass in domestic buildings appears to have advanced at a faster rate than in many continental countries, including parts of France, where it is noted that oiled paper and cloth were still in common use until the end of the 18th century, even in Paris (Sauzay 1870, 54). The importance of weather in extending glazing to poorer buildings in England has been suggested as one of the reasons why the French manufacturers were anxious to develop the English market (Rose-Villequey 1971, 430).

A survey of the hamlet of Etchingham (East Sussex) in 1597, demonstrates how the extent of domestic glazing related to socio-economic status. The 'Parsonage and Rectory' house, contained '...five lower Rowmes and Fower Chambers, Twoe garretts, twoe double Chymneys of Bricke with glasse wyndowes...', suggesting the building was fully glazed, at least in the main rooms. The house of Stephen Bennett, a substantial yeoman farmer with arable and pasture amounting to 149 acres, had similar accommodation, containing '...five windowes glased...'. The home of Edward Standen, who farmed 21 acres including '...1 little house for calves...', is described as a cottage having only '...one glasse windowe...' (Vivian 1953, 143-4, 153).

Until the 16th century, glazed windows were a rarity and considered a luxury. They were treated as tenant's fixtures and glass was often fitted in casements that enabled easy removal, along with other furnishings, when a tenant moved on. This practice led to disputes between the heir and executors (and landlord and tenant), remedied in 1505 when it was ruled that glass was the property of the executors and might be taken away (Salzman 1952, 185; Grazebrook 1877 192; Ashdown 1919, 13). It was not until 1599 that this judgement was withdrawn and it was ruled that '...glass annexed to windows by nails, or in other manner, by the lessor or by the lessee, could not be removed by the lessee, for without glass it is not perfect house...' (Wilson 1776, 64). However, despite this judgement, John Lickfold of Lurgashall (West Sussex), evidently felt it necessary in his will of 1615 to state that the '...glass in the windows and the wainscott about the house...' were not to be considered among his chattells to be divided between members of his family (WSRO. M Dean 28).

By the early 1600s, glazing in larger houses had become something of a status symbol with larger windows to admit more light. A 'computation' for the rebuilding of Petworth House, dated 1615, shows the extent of glazed areas in a country mansion of the period. In this example, a total of 9,732 square feet of glass was allowed for glazing 242 windows, and although this building did not go ahead, it illustrates the growing importance of glazing in secular buildings in both the overall area of glass and increase in individual window size (Batho 1958, 113-129).

At the upper end of the market architects were also experimenting with new ideas to satisfy a more discerning public with sufficient wealth to satisfy a desire for individuality. In 1615, Walter Gedde published a book of designs for leaded lights which he describes as '...principaly serving for glaziers...' (Gedde 1615). This work contains 103 designs for leaded windows ranging from simple layouts of squares and triangles to elaborate geometric patterns, and the author goes on to describe how the designs can be further 'beautified' by the addition of shading or stippling painted on the glass. This decoration could be added in black or colour, and instructions are given for building a kiln for firing.

Early window glass had been effective in admitting light and keeping out the weather, but lacked transparency because of poor quality. With the improvements introduced by the immigrants after 1567, early glazing was up-graded with new glass of better transparency and clarity. This happened at Knole House (Kent) following a survey carried out in 1570 which revealed that the building was in '...meetlie good repaire savinge the glass...' (CKS. U269/E336/3), and records of the early 1580s show that glass was made at Knole for use in refurbishing the house (ERO. D/DL E77; CKS. U442 P102). At Petworth (Sussex) a similar situation was found in 1576-7 when it was noted that '...the greatest charge in repare of the hall is in the yron and glasse for windowes...' (WSRO. PHA 1413). It is probable that new glass was also made at a glasshouse on the estate, Petworth Park (40), or nearby at Northchapel.

Old glass removed from buildings to make way for new may have found its way back to the manufacturer for use as cullet, but there are also instances of re-use in locations of less importance. At Kingston-on Thames (Surrey), the Churchwardens accounts of 1566-7 show that glass removed from windows in the Free School was used to repair windows in the local church (*VCH. Surrey* 2, 161). And a painting by Pieter Breughel the Younger, well illustrates how discarded panels of glazing were re-used in positions where light and weathering were important, but the transparency of the glass less so: temporary repairs using parchment are also shown (Fig. 9, p. 103).

In the 1560s, the development of glassmaking had become part of Government policy to encourage new industries and in particular, the manufacture of window glass that was practically all imported at that time. The granting of the first licence to Anthony Becku and Jean Carré, for 21 years, clearly states this priority: '...to erect in any place in England, furnaces, buildings and machinery for the making of glass for glazing...' (PRO. CPR. 8th Sept. 1567). And when there were early difficulties with the immigrant workers, the resolve of the Government to overcome them in the interests of establishing an independent, native industry was expressed by its concern that if the matter was not settled, '...her majesties intentions to have the science of the making of that kynde of glass [ie window glass] to remayn here within her realme is likely to be frustrated' (SHC. LM/COR/12/34).

Fig. 9: Glazed panels

Panels containing different designs of leaded glazing, using square and diamond panes, have been used in an apparently arbitrary way suggesting they were removed from another location and passed down for use in a lower status context. Repairs have been carried out using sheets of parchment, a traditional glazing material. (From: *Rent Day* – Peter Breughel the younger, early 16th century, Burghley House, Stamford).

Glaziers

There appears to have been a clear demarcation between the role of the glassmaker and the glazier, at least from the mid-13th century, but the use of the term *vitrearius*, which can mean either glassmaker or glazier must be interpreted with caution (Marks 1993 28; Godfrey 1975, 9). An entry in the Pipe Rolls for 1172, referring to Chichester cathedral makes it clear that a glazier was being employed at that time: '*...Eugoni vitrearis 1 marcam, pro custedia vitrearum ecclesiae...*' (PRO. Pipe Rolls 18 Hen. II. P. 133, cited in Round 1921, 203). The 14th-century records referred to above show how glaziers working on the royal palaces were able to obtain white glass from the Weald and coloured from the continent, using merchants such as William Holmere to procure the glass for them. Glaziers designing and producing stained glass for the church became established in centres such as London, York and Norwich, but by the 14th century, most major towns had a resident glazier. The techniques used in the manufacture of stained glass, the organisation of the craft, and the commissioning of windows in England, have been described in detail by Marks (1993).

As demand for domestic glazing increased, glaziers capable of carrying out repairs, and cutting and leading clear glass became established in small towns. In 1608, a Guild representing craftsmen working in the city of Chichester contained four glaziers, but by 1650 their numbers had risen to 21. This reflects a significant increase in the importance of the trade at a time when the population rose from around 1,800 (in 1610) to approximately 2,400 (in 1648), (Morgan 1992, 11, 42, 47). The earliest reference to a Guild, or 'Company of Glaziers', in London is 1328 when a petition was raised mainly to protect the interests of its members against competition by foreigners and unskilled labour (Ashdown 1919, 16), but by the early 1600s, the Company had increased in size and influence and felt sufficiently confident to challenge the onerous conditions being imposed by the manufacturers at that time: their various complaints are summarised in a petition of 1621, signed by 46 glaziers (PRO. SP14/120/89). The Glaziers' Company was awarded a Charter of Incorporation in 1638, but a coat of arms had been in use before then, the first known reference being in an Heraldic Visitation in 1588 (Ashdown 1919, 34, 47). The blazon of arms quoted by Ashdown is: 'Argent, two glazing irons in saltire sable between four closing nails of the last, on a chief gules a lion passant guardant or' (ibid. 47).

There were several ways by which glaziers obtained their glass from the manufacturer. The local glazier would no doubt have bought glass at the glasshouse door, and cut and leaded it on his own or his customer's premises before fixing. The large London market was serviced by glass carriers who transported glass by the case to warehouses in London, owned and managed by merchants, who then sold on to glaziers by the case or even the sheet. Isaac Bungar combined his activity as a Wealden manufacturer with that of an agent for other Wealden manufacturers to sell glass to the London glaziers. An indenture of 1595 refers to a contract between the Bungars and the London merchant, Thomas Lawrence, for the supply of 500 cases of Normandy glass (Guildhall MS. 5758/5). It was as a result of his activities, combining the interests of manufacturer and merchant, that '...in around 1605...', Bungar gained notoriety among the London glaziers for '...the sole ingrossinge of all the glasse made in Sussex...' (PRO. SP14/120/89). The substance of their accusation being that merchants such as Bungar:

'... for theire owne private gaine, for the inhancinge of the prices of glasse, doe often forbidd the bringing of yt into the cittie and other places of great concourse, untill such tyme as they fynde great scarcitie, and then they raise the prices at their pleasure...' (Bodl. North MS. a. 2, fol.145).

Glaziers generally held small stocks sufficient for their immediate needs, but they did not always obtain glass for a sizeable contract themselves. The accounts relating to the building of Loseley House (Surrey) by Sir William More between 1561 and 1569 show that he himself bought glass by the case and employed glaziers, paid by the hour, to cut, lead and fix it. In this example, eleven cases of glass were bought at a cost of 29*s* per case, including delivery, and glaziers were paid at the rate of 6*d* a day plus an allowance of 5*d* for '...meate and drynke...' (Evans 1855, 309). In another, more modest example, Thomas Bennett, a draper of Arundel, contracted (1602) to buy a load of broad glass, '...of the best...', from Thomas Phillips and Thomas Baker, brickmakers, to be delivered and paid for, in two consignments (WSRO. Lavington MS. 657). Stocks of glass and glazing materials were also held at large buildings, presumably so that repairs could be carried out expeditiously. In 1565, the 'plumbery' at Chichester cathedral held 316 lbs of lead and 22 bunches of glass, worth 2s. 1d. per 'bunch' (WSRO. Cap. 1/23/3 f. 82, cited in Peckham 1973, 25).

The method of casting lead into cames used by glaziers to join together pieces of glass and described by Theophilus (Dodwell 1961, 53-60) remained substantially the same until the introduction of milled lead, in the middle of the 16th century (Knight 1983-4, 49). Glaziers appear to have fabricated their own lead cames and this is perhaps supported by a record of the indictment of a glazier, William Wynne of Hastings (Sussex) in 1582 for the theft of several items, including a vice, a soldering iron and two sheets of lead (Cockburn 1975, 167). Lead was obtained from a variety of sources including recycled material stripped from old glazing, usually by glaziers before selling the old glass back to the glasshouse for use as cullet, and this probably explains why lead is rarely found in association with cullet. New lead was not available from natural sources in the Weald and would have had to be imported from outside the region. A possible source is the west country, suggested by an entry in the Littlehampton/Arundel Port Records for March 1591 recording the delivery of one ton of lead from Plymouth (PRO. E190/746/9).

The survival of Wealden window glass

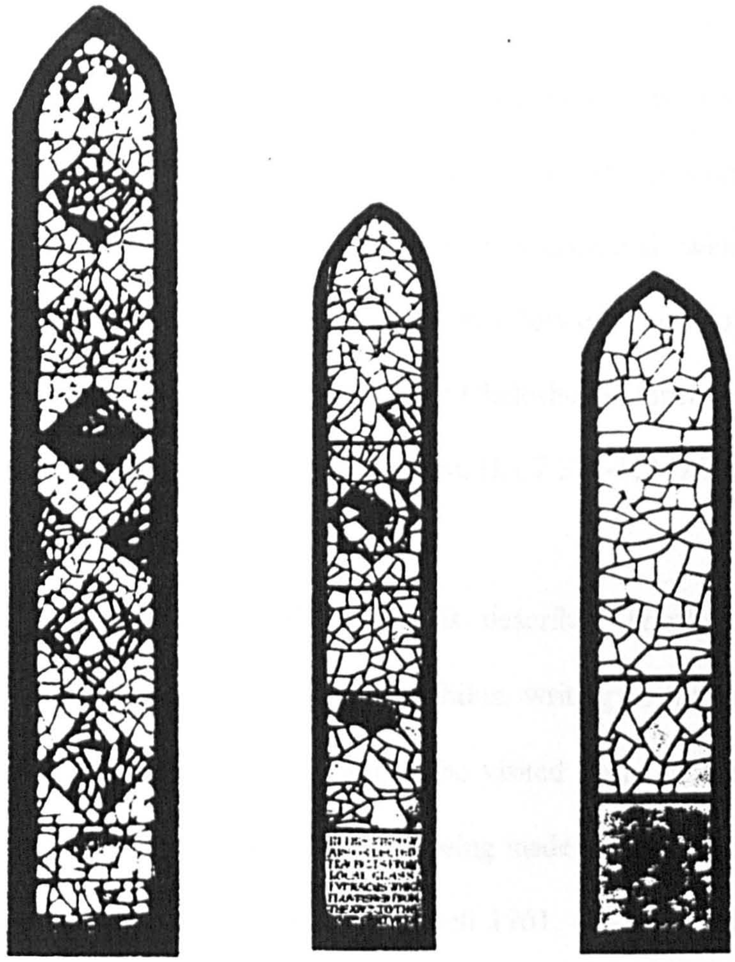
The main outlet for Wealden window glass was London, but since glass was also being imported from the continent during the medieval and post-medieval periods, it is impossible to identify with any certainty the origin of window glass fragments discovered at archaeological sites there. In these circumstances, glass is usually described by the generic term 'forest glass type'. There are similar difficulties of identification for glass found in the Weald, including the problem of cullet at manufacturing sites. however, it would be reasonable to suggest that at least a higher proportion of glass used in the Weald at this time was of local manufacture. Kenyon discovered glass fragments of thin glass 'Below the 15th century wall and east window of Kirdford church...', which he considered as '...probably of local manufacture...' from earlier glazing (Kenyon 1967, 44). Excavations in Sussex at Cliffe and Old Buxted Place produced fragments of window glass, mostly broad glass, that may have been manufactured in the Weald (Rudling 1991, 171-3; Tebbutt 1975, 52). Although there has been greater attention to the recovery of glass discovered during excavation in recent years, assemblages are usually very small and this may be due to the salvaging of glass by glaziers who were able to sell it back to the manufacturer for use as cullet.

It is unlikely that any locally produced glass has survived *in situ*, having been replaced at some stage either because of breakage, decomposition due to poor quality of manufacture, or, later on, because of the availability of better quality, more transparent glass. However, there is no shortage of unsubstantiated claims by local residents that windows in their houses contain locally produced glass. Examples of window glass taken from Wealden sites by Cooper, Winbolt and Kenyon are to be found in churches at Chiddingfold, Kirdford and Wisborough Green, where they were glazed during the last century to form memorial windows, dedicated to those who made glass in the area. Although these windows contain some imported cullet, including coloured, they are worthy of examination as examples of how Wealden window glass may have appeared at the turn of the 17th century (Fig. 10, p. 109).

Vessel glass manufacture

Vessels were manufactured from the same potash glass metal as that used in the making of window glass. This resulted in glassware having a pale green or bluish green tint and containing similar impurities to those found in window glass. The terms 'green glass' and 'forest glass' have been used to distinguish

Fig. 10: Glazed examples of Wealden window glass



A B C

A: (approx. 9 x 48 in), made from 427 pieces of glass, 224 of them coloured, collected by Cooper and installed at the West end of Chiddingfold church in 1916. The following inscription is nearby:

> 'This window filled in with ancient glass found near the sites of local glass furnaces is dedicated to the memory of Chiddingfold Glassmakers and others connected locally with the industry for a period of at least 400 years, including Laurence the Glassmaker, William de Franceis & William le Verier in the 13th Century: John Alemayn, William Holmere, John Schutere & John his son, Richard & Peter Schutere in the 14th Century: Peter Frenssheman, Richard Sherter, Henry Ropley, and the Peytowes of Picard atte Bridge, & of Pound at Combe in the 15th & 16th Centuries and William Peyto, Glassmaker who was buried at Chiddingfold on 30th January 1614'.

B: (approx. 8 x 42 in), made from fragments of glass, approximately 15% of which are coloured, collected by Kenyon and placed in a window at the north east end of Kirdford church in 1933. Inscribed:

> 'In this window are collected fragments from local glass furnaces which flourished from the XIVth Century'.

C: (approx. 8 x 36 in), made from local glass collected by Kenyon and installed in the South aisle of Wisborough Green church in 1968. Inscribed:

> 'This glass made locally *c.*1600, commemorates the principal glassmakers then working in the Parish: the Bongars & Caquerays from Normandy and the Hennezels & Thiertys from Lorraine'. (photographs by C Clark)

this type of glass from the better quality glassware made from soda glass and produced at specialist manufacturing centres (described below). Winbolt and Kenyon found vessel glass made in the Early period was not only poor in quality, but generally cruder in appearance, whereas glass from the post-immigrant period, at its best at Sidney Wood, was 'completely uncorroded' with a shiny burnished finish (Kenyon 1967, 203). The contrast between the two types is apparent when comparing museum examples from Chaleshurst Upper (medieval) and Sidney Wood (post-1567) (Haslemere Museum, HA.7.374-5; 1426-9).

The procedure for making a simple vessel is described briefly in three contemporary accounts. Firstly, that by Theophilus, writing in the early 12th century; secondly by Peder Månsson, a Swede who visited Rome between 1508 and 1525 and recorded his observations of glass being made there; and thirdly by Christopher Merrett writing in the 1660s (Dodwell 1961, 43-4; for Månsson's account, see the translation by Winbolt 1933, 79; Merrett 1662, 247-8).

Despite an interval of five hundred years between these accounts, the basic methods are similar. Firstly, a sufficient amount of molten glass was gathered on a blowpipe and shaped into an even globular form on the 'marver', a specially prepared flat surface of stone or marble. After re-heating, the glass was blown and shaped by swinging and the use of pincers to the desired form and size. With the blowpipe still attached, the opposite end was then shaped to form the base, usually by pushing the end of the bulb into the underside of the vessel to form a kicked base. Next, a pontil was attached to the base and the blowpipe could then be broken off, enabling control of the vessel to be passed to the pontil.

The rim of the vessel could then be formed by widening the opening left by the blowpipe with a piece of wood, and shaping it with the use of pincers and shears. The finished vessel could then be separated from the pontil and transferred to the annealing kiln. In this simple example, the vessel was formed from only one gather of glass, but more complicated forms necessitated separate gathers as additional components of the vessel were added, for example, the bowl, stem and foot of a goblet.

Decoration took various forms and could be added at different stages during manufacture. A comprehensive summary of the most common techniques used on glass of the period is given by Willmott (2002, 15-18) but only the simplest of these can be related to vessels made in the Weald. First are what he refers to as 'early stage techniques', which were carried out while the vessel was still attached to the blowpipe. These include optic-blowing in which the gathering is blown into a single-piece patterned mould followed by further inflation and manipulation, perhaps twisting the vessel to form a wrythen pattern. Moulds made in two or more pieces were also used enabling the glass to be withdrawn after blowing, and made it possible to produce vessels of a standard size and shape as well as introducing a decorative pattern. Excavated examples of patterned glass suggest that moulds were in use in the Weald in both the medieval and post-immigrant periods, and is confirmed by a reference in the will of John Peytowe (proved 4 April 1536) in which he bequeathed to his son John '...10*s* of suche things as shall come and be made of the glasshowse and all my toyles and moulds as belongeth to the glasshowse...' (London Metropolitan Archives, DW/PA/7/4 f. 150v., cited in Webb 1990, 63). No remains of moulds have been discovered in the Weald or at forest glass sites elsewhere, and the materials used and how they were made remains a problem. It has been suggested that a refractory clay would have been unsuitable since degradation of the surface would result from the corrosive effects of molten glass (Willmott 2002, 15). It is probable that a metal, such as copper, was used as suggested by a reference in Månsson's contemporary account (*c.* 1530) to '...a variety of copper moulds, ornamented inside...', and in Agricola, to the use of a '...hollow copper mould...' (Winbolt 1933, 79; Agricola 1556, 591-2). It is also possible that wood, cheap and easily renewable, was used. Despite the presence of a local iron industry, there is no evidence that iron was used for moulds at this date, although iron moulds became usual in bottle making by the mid-18th century (Morgan 1976, 27).

Further decoration could be added after the vessel form was completed but still held on the pontil, and is referred to by Willmott as 'late-stage techniques' (2002, 16). These include the application of trails of white or coloured glass to form patterns on the surface which could be left to stand proud, or flattened on the marver. Examples of this type of decoration have been found in the Weald at Horsebridge (26) and at Sidney Wood (38) where 'lengths of threading or veining used for ornamenting' were discovered. However, a piece of white glass decorated with a thread of blue found at Sidney Wood is likely to be cullet, since, as mentioned above, coloured glass was not manufactured in the Weald. Glass tubes found at the same site were probably used for decoration, though Winbolt ingeniously suggests these may have been applied around bottle necks as a means of providing a method of securing a stopper (Winbolt 1933, 39-40).

Another form of decoration involved the application of blobs of glass, or 'prunts', that could be impressed with a design or drawn to a point (Tyson 2000, 15), and examples of this technique have been found at Vann Copse (35) (Winbolt 1933, 31). Other decorative techniques applied after completion of the vessel, such as enamelling, gilding and engraving, that appear on the finest imported glass of the period, do not appear to have been carried out and were beyond the level of sophistication of the local product.

During the forming of a vessel it was necessary to maintain an even temperature, hot enough to enable the glass to be manipulated, but sufficiently cool to prevent sagging. This meant constant re-heating and is referred to by Merrett in his description of a Master workman at work: 'And thus with *blowing, pressing, scalding* (which must be repeated as often as the Glass cools) *amplifying, cutting,* &c. [he] frames it into the shape preconceived in his mind' (Merrett 1662, 248).

Simple tools were used to shape and fashion the glass such as those illustrated in Agricola. Månsson mentions the use of 'iron pincers' for shaping and smoothing, and Merrett describes how 'shears cuts off what is superfluous' (Winbolt 1933, 79; Merrett 1662, 247). The only remains of glassmakers tools to have been found in the Weald are fragments of iron blowpipes such as those found at Fromes Copse (5), Hog Wood (15) and Knightons (42), and a piece of pontil rod discovered at Wephurst (21).

Charleston has considered the use of the glassmakers' chair (Charleston 1962) in connection with medieval and post-medieval vessel making, and reaches the conclusion that it would not have been used in the forest glass industry, but suggests that glass workers may have rolled their irons on wood bound on the thigh, as described by Månsson (Winbolt 1933, 79).

The market for vessel glass

The availability of alternative materials, including wood, metal or pottery, from which vessels could be satisfactorily formed, was a principal reason for the hesitant development of a glass vessel industry. Some of the inherent properties of glass, such as its fragility and lack of ability to withstand heat, put it at a disadvantage when compared with other materials, whereas its unique qualities of transparency and clean appearance made it particularly suitable for some objects such as hanging lamps and urinals.

In England, two distinct types of vessel product developed, based on different traditions of glass manufacture, one using soda as the main alkali in the batch, and the other, potash. The use of soda had been the practice since the earliest times and had been used throughout the Roman world. By the Middle Ages, this method was in use in regions around the Mediterranean and in southern Europe. The glass itself, referred to as *cristallo*, was characteristically pure and clear, and its soft, ductile quality enabled it to be blown very thin and decorated with fine ornamental detail. The manufacturing centre of excellence has been traditionally regarded as Venice, but recent research indicates there were other centres in Italy, southern France and possibly Spain that also specialised in fine quality vessels in *façon de Venise* (Tyson 2000, 11). The quality of the product is attributable to technique and the careful selection and preparation of the finest materials, which in some instances were imported from other parts of the Mediterranean (ibid.). The high cost of ingredients and the method of manufacture meant that the resulting product, decorative, luxury tableware, was expensive and only affordable by the wealthy. During the medieval period, this exclusive tableware was imported, usually via the Low Countries, to the English market, mainly the seats of the aristocracy and urban centres. The establishment of crystal manufacture in England was one of Jean Carré's enterprises that only started shortly before his death (1572), when he encouraged skilled craftsmen to set up a furnace in Crutched Friars (London) exclusively for making crystal wares (Godfrey 1975, 25). Following Carré's death, control of the Crutched Friars glasshouse passed to Jacob Verzelini who obtained a patent, for the manufacture of drinking glasses in the Venetian style, for 21 years from 15 December 1574, and which included protection from competition by the banning of imports of similar wares. For the next forty years, production remained in London with new glasshouses established at Blackfriars and Southwark, under the care of a succession of new owners and the protection of renewed patents (ibid., 29, 38-41; Willmott 2002, 10-11). The manufacture of crystal continued in London, independently of glassmaking elsewhere in England, with a distinctive range of vessels, produced by specialist craftsmen using their own techniques and supplying an exclusive, luxury market.

Glass manufacture using potash developed in northern Europe primarily for glazing purposes but the same glass metal was also used for making a variety of vessels, though of inferior quality compared to soda glass. Although soda glass might possess a tint caused by impurities in the raw materials, in potash glass a pronounced greenish tint was usual and resulted in it being referred to as 'green glass'. But perhaps the most important difference between the two types of glass was in its durability, potash glass being far more prone to decay and total breakdown. In the production of fine glassware, not only were the makers of green glass at a disadvantage in having the use of poorer quality materials, but as makers of window as well as vessel glass, they were lacking in specialist skills. Green glass manufacture was therefore directed towards the production of household vessels such as drinking glasses, bottles, flasks, and jars, and other utilitarian wares such as urinals, hanging lamps and chemical wares.

A distinction between the two types, the luxury *cristallo* wares and the more mundane products of the green glass manufacturers, was well understood by contemporary commentators such as Harrison writing in 1587:

'...the poorest also will have glass if they may; but sith the Venetian is somewhat too deer for them, they content themselves with such that are made at home of fern and burned stone...' (Harrison 1587, 128).

And Camden, commenting on the product of the Sussex glasshouses in 1610, says:

'Neither want there glasse-houses, but the glasse there made, by reason of the matter or working, I wot not whether, is likewise nothing so pure and cleare, and therefore used of the common sort only' (Camden 1610, 306).

Archaeological evidence obtained from Wealden manufacturing sites is confused by the presence of imported cullet, but nevertheless suggests that both vessel and window glass was made at the great majority of glasshouses there from the 14th century until 1618 (Kenyon 1967, 90). This is supported by an indenture of 1380, referring to a glasshouse, possibly in the vicinity of Hog Wood (15), which mentions payment for 'brodeglas' and 'vessel' (SHC, 105/1/117; Kenyon 1967, 33). Whilst window glass manufacture may have ceased for a time during the middle of the 16^{th} century, vessel making appears to have been continuous, albeit at a modest level, as suggested by the reference to glass blowing in Charnock's *Breviary of Natural Philosophy* of 1557 and contemporary records to glassmaking members of the Peytowe and Strudwick families (Kenyon 1967, 83, 117-9). However, by the 1600s it is clear that some glasshouses were specialising in vessel glass. This is confirmed in Sir Robert Mansell's response to Paul Vinion's petition that he be allowed to continue making glass using wood fuel, thereby infringing the terms of Mansell's monopoly, and in which Vinion is referred to as a maker of '...green drinking glasses...' (PRO. SP14/105/18). Specialisation in either window or vessel manufacture appears to be a feature of glassmaking during the post-1567 period, following the example of some sectors of the industry in France 50 years earlier. In Lorraine, before 1500, there was versatility of production in which glasshouses produced both window and vessel, but manufacturing became more specialised during the first part of the 16^{th} century. As the trend towards specialisation developed, certain glassmaking families concentrated on a particular product sector of the market establishing contacts with merchants and tradesmen with access to that particular market (Rose-Villequey 1971, 165).

The market for Wealden vessel glass is extremely difficult to determine. The quality of the glass itself has nothing to distinguish it from forest glass made on the Continent or elsewhere in England, and insufficient remains have survived to denote a local 'style'. Just how far from the Weald vessel glass was transported for sale is not known, and fragments of forest glass type found in urban excavations cannot be positively identified as having their origins in the Weald. In the Weald itself, where it would be reasonable to expect the local product to have been in use, the lack of documentary references to glass is puzzling. Inventories, Wills and Books of Accounts relating to households and individuals in the area, including neighbouring towns, such as Guildford and Petworth, mention glass only rarely, often in such a way that type or purpose cannot be identified. However, part of an inventory has survived belonging to a prominent member of the county gentry, William More of Loseley, dated 1566, which includes items of glassware. Although this document is incomplete, it provides an insight into the range of glass vessels available at the time, and includes coloured and crystal ware of high quality as well as forest glass vessels. Glass items have been extracted from the inventory as follows:

Item:	Value:	
'xxv. glassys for waters	v s.	
j. great bottell glasse	vj d.	
an ewrynall	j d.	
a glasse botell w^t^ wycker	ij d.	
a glass w^t^ a cover to drink bere in	iij d.	
a glasse ewere gilt	iij d.	
a lyttle blewe bereglasse	ij d.	
a lyttle bereglasse of whyte and grene	vj d.	
ij. glasses for conserves	iiij d.	
ij. other lyttle glasses	j d.	
a bere glasse	ij d.	
an howreglasse	ij d.	
a lyttle bottell for sweete water	j d.	
a lyttle glasse for water	j d.	
iij. glasses lyk chalisys	xij d.	
ij. bole glasses	xvj d.	
a glasse bottell coloured	ij s.	
a glasse ewere	viij d.	
a great glasse ewere to keepe oyle in	xx d.	
a lyttle glasse for aqua composita	j d.	
ij. bere glasses	iiij d.	
a bere glase wt a cover	xij d.	
a ewere of glasse brode	vj d.	
a bottell glasse	vj d.	
a bere glasse wt ij handles	iiij d.	
ij. glasses for waters	iiij d.	(Evans 1855, 292-3)

Considering the pre-immigrant date, it is likely that most, if not all of these items, were imported. The Port Records of Littlehampton/Arundel show that bottles were being imported from Dieppe, 18 dozen during 1567 and a further 12 dozen in the following year, suggesting that local production was unable to satisfy demand (PRO. E190/737/26; 738/1). However, by the late 1580s there are signs that the Wealden industry had been rejuvenated by the immigrants, since drinking glasses were being exported from the same port: '40 groze small glasses' are recorded in 1588 and a further 15 gross in 1591 (PRO. E190/744/26; 746/24). These exports were all to the west of England, and it is likely that, as in the case of window glass, consignments for the London market were transported overland. The import of 'drinking glasses' again features in the Littlehampton/Arundel Port Records for 1604 and may suggest faltering native supply, but more probably indicates a rise in demand as the use of glass vessels became more popular. The rise in popularity of glassware in the early 1600s placed great demands on the manufacturers that could not be satisfied by native production until after 1630 (Godfrey 1975, 222). Despite the development of high quality glassware at the London glasshouses, there remained a demand for the best Continental products. In 1620 the Earl of Arundel imported '...6 chests of Venice drinking glasses...', and two years later the Earl of Northumberland took delivery of '...4 firkins of cutt glasse...'. (PRO. APC xxxvj, p. 201; E190/760/11).

The absence of documentary references to vessel glass has been taken to indicate its general lack of use in ordinary households until the early 17th century (Kenyon 1967, 99; Godfrey 1975, 219). Even in the parishes in which the glassmakers lived and worked, the use of glass does not appear to have been widespread. For example, in 1623, John Driver of Rudgwick left 'glasses' in an inventory totalling only £12 6*s* 6*d*, whereas William Young, a substantial yeoman of Wisborough Green, leaving £869 12*s* 0*d*, appears to have owned no glass whatsoever; and Henry Strudwick, who might be expected to have acquired some items of glassware during his employment as a 'glasse carryer', left no items of glass in an inventory dated 20 April 1614 (WSRO. EpI/29/160; 29/210; 29/116). The absence of references to glassware in wills and similar documents should be interpreted with caution as items of this kind were often combined with similar articles and listed, for example, as 'other wares' or 'other items in the kitchen'. However, it is clear that some households persisted in the use of traditional alternatives to glass, as in the inventory of James Butcher of Petworth (1612) which contained no items of glass, but which included 'three wooden tankerdes' (WSRO. EpI/29/149).

Vessel types found in the Weald

Glass found at furnace sites may be either manufacturing waste, including breakages during manufacture, or imported cullet which may not be of local origin. In the Weald, glass finds have generally been unrewarding because of their 'remarkable fragmentation', making it extremely difficult to identify the type of vessel it was from and practically impossible to reconstruct vessel form. In the Weald, only two complete vessels have been discovered, both are small unguent bottles, one, faulty but complete, found by Winbolt at Brookland (Winbolt 1940, 158), and now in Haslemere Museum (Ref. HA.7.1433), and the other in a private collection. Kenyon, referring to the lack of meaningful fragments found by himself and Winbolt, commented 'the poverty of evidence is great', and particularly mentions the glass at Sidney Wood as having been 'fragmented into insignificance'. Kenyon's suggestion was that fragmentation may be the result of glass being blown too thin and becoming crushed by earlier investigators (Kenyon 1967, 89, 203). However, this is not a satisfactory explanation: it is possible that this characteristic is to do with the management of cullet and that glass assembled for re-use was either deliberately broken down at point of collection for ease of transport, or on arrival at the glasshouse. Fragmentation of glass appears to be a feature of the Weald and does not occur to the same degree at contemporary glasshouses elsewhere. Excavations at locations such as Hutton and Rosedale (North Riding) and Woodchester (Gloucestershire), have been more rewarding in producing vessel remains that are larger in size, enabling more detailed interpretation. At Hutton and Rosedale, for example, it was even possible to compare the inherent quality of the glass, vessel form and decoration and to distinguish the work of different teams of craftsmen. And the Woodchester glasshouse produced sufficiently large fragments to enable James Powell & Sons to make full-scale reconstructions of a range of drinking glasses, now in the City Museum, Gloucester (Crossley & Aberg 1972, 128-9; Daniels 1950, 20; Kenyon 1967, 218, Pl. XVIII, XIX).

At Knightons (42), Wood found 61.5kg of glass in the cullet heap, estimated to contain 12,000 pieces, of which only some 320 fragments, or 2.7%, were considered 'diagnostic or significant' (Wood 1982, 19). Although this glasshouse was a producer of crown window glass, the cullet heap included a good deal of vessel glass, most of which was identified by Wood as 'clearly of local manufacture', only 46 pieces of the 320 being 'unquestionably' brought in from elsewhere (ibid., 19). The fragments from this site therefore provide an indication of the range of vessel types in use and being produced in the Weald in the mid-16th century, although in most instances the fragments are too small to suggest details of shape, size and decoration, and all are weathered. The glass finds recovered from Knightons are described and illustrated by Wood (ibid., 19-38) and are deposited at Guildford Museum (Ref. AS4796). The most frequently occurring items being drinking glasses (beakers and goblets) and container vessels (bottles and flasks) of which fragments of bases, necks and rims are identifiable, and come in different shapes and sizes suggesting a variety of forms and styles. Willmott's 'classifcation of vessel glass' (2002) is useful in attempting to reconstruct the overall appearance of a vessel from isolated fragments. For example, a complete beaker base having remains of the walls and with milling around the base, described and illustrated by Wood (1982, Fig 10:12, 24), is suggestive of Willmott's 'plain cylindrical beaker' (Willmott 2002, 37). However, the great majority of fragments are small, making comparisons of this kind tantalizingly speculative.

Other fragments of interest include handles from jugs or tankards. Handles were also found at other sites such as Redwood and Gostrode, and a good example was found at Brookland Farm (Haslemere Museum Ref. HA.7.590). Uroscopy was used in medical diagnosis at least from the 13th century, and urinals, used for this purpose, were blown thin to facilitate visual examination (Tyson 2000, 150-3). An unusually large number of urinal fragments were discovered in the

Knightons assemblage, representing eighteen vessels in all, and were of two distinct types. The first, having a 'wide and heavy flaring rim and elongated round based body of oval profile', and the second, with a flat brim with the edge turned up vertically and having a globular body with a straight neck (Wood 1982, 31).

Among other finds at Knightons were fragments of a plate and bowl, part of a linen smoother and two rims of hour-glasses, the only examples found in the Weald, and of local manufacture (ibid., 27-8). A number of parts of distilling apparatus were discovered, including fragments of alembics, cucurbits and receivers, all made locally (ibid., 32-3): evidence of local use of such equipment is implied from an inventory dated April 1614 belonging to Henry Alleynt of Petworth, a 'Practicioner of Phisike' who owned 'divers glasses of waters and apothycarey stuffe' (WSRO. Ep I/29/149).

From the remains found in the Weald, it is clear that the form and style of vessels made there was simple and functional, underlining their utilitarian purpose, and correspond with forest glass ware made elsewhere. Decoration is used sparingly and is unpretentious. At Sidney Wood, ornamental bottles or vases were decorated with threads applied to the surface (Haslemere Museum Ref. HA.7.161). Simple moulded patterns were also used, the commonest found at Knightons being vertical or horizontal ribbing, and wrythen in which the moulding was rounded and not sharply defined. Sometimes these treatments were combined with wrythen overlying fluting or ribbing (Wood 1982, 25).

Specimens of soda glass have been found at Wealden furnace sites, clearly brought in as cullet. Examples of these are a moulded 'bird's wing', found at Fernfold (25) and now in the Barbican House Museum, Lewes (Winbolt 1935, 790-1), and a fragment of 'syrian blue' from Brookland Farm (23) (Haslemere Museum, Ref. HA.7.069).

The other source of vessel remains is from archaeological sites at point of use, usually in urban contexts, however, there are clearly difficulties in establishing the origin of glass which, although of 'forest glass' type, may have come from one of several manufacturing centres. This was the case when Kenyon examined glass taken from bombed sites in London in 1962 and declared that he was not satisfied that any of it came from the Weald (Kenyon 1967, 97). In recent years, more medieval glass has been recovered from excavations in London at Old Broad Street, Aldgate, Moorgate and the Royal Mint, now in the Museum of London, but again it is speculative to attribute manufacture to the Weald. Excavations closer to the Weald such as those at the medieval hall-house at Brook Lane, near Horsham and in the north-east quadrant, Chichester, are more likely to produce glass made locally (Shepherd 1989, 128-9; Charleston 1981, 221-8). Both of these sites have yielded glass of Wealden type, and of the Chichester glass, Charleston writes:

'It may be taken as axiomatic that such glasses would be obtained from the nearest accessible furnace, and since throughout the period covered by the Chichester finds the Weald of Surrey/Sussex was the most important glass-manufacturing area in the country, it may reasonably be assumed that the Chichester green glasses were made there' (Charleston 1981, 222).

The Chichester glass is noticeably less fragmented than glass found at furnace sites, enabling more accurate identification and classification of vessel type: this underlines the importance of preserving glass finds for further study. Happily, over the past 30 years, there has been an increasing awareness of the importance of glass finds, with 'glass' receiving independent comment in archaeological reports. It has also become an established feature of archaeological reporting that a specialist is consulted to examine and comment on glass finds. Recently, two important works have been published that will serve as points of reference for the classification of the entire range of vessel types for the medieval and post-medieval periods (Tyson 2000; Willmott 2002).

Packaging and transport

Even in the early period of the industry, glass was transported considerable distances, as in the examples of glass being conveyed from the Weald to Westminster during the fourteenth century cited by Salzman (1927, 188). Glass is a fragile, heavy and awkward product and can only be transported safely when carefully packaged. Early accounts refer to the use of cases and cradles in which the glass was packed using a suitable insulation material such as hay, straw or bracken (ibid.). In Lorraine in the sixteenth century, window glass was bound with reeds into 'bundles' of three sheets and placed in baskets woven from willow (Rose-Villequey 1973, 195; Ladaique 1973, 73). The crown sheets made by the Normandy glassmakers were packed into wooden cases or cradles, containing 24 crown sheets (BL. Lansd. MS. 21/68). This method was still in use towards the end of the eighteenth century, as illustrated by Diderot (1772, Verrerie en Bois, Planche I). Vessel glass was packed into baskets that could be carried on the backs of salesmen or pedlars who hawked these wares from door to door (Kenyon 1967, 112; BL. Add. MS 24189), or in larger panniers for use with packhorses such as were used in the ceramics industry until late in the eighteenth century.

Window glass would have been sold from the glasshouse for local needs, but the main market was the London glaziers who usually bought their supplies from merchants who had obtained supplies from the manufacturers (Godfrey 1975, 200). Before the arrival of the immigrants, practically all glass was imported from Normandy and the Low Countries, most of it shipped direct to the Port of London where the merchants had established wharves. As early as 1295 the trade of 'glassecaryour' is referred in a conveyance between Thomas Shorter and Thomas Ropley, but no further particulars are given (SHC. G. 105/1/140). But from around 1570 onwards, as output from the Wealden furnaces increased, a transport system developed to convey glass to London. It has been suggested that glass from the Weald was transported, probably by packhorse, to the nearest port (Arundel/Littlehampton) for shipping to London (Godfrey 1975, 182). However, there is documentary evidence to challenge this idea suggesting that an overland route was used between the Weald and the London market. Port Records show that very few consignments of glass were exported from Arundel/Littlehampton towards London, although there are several references to west of England destinations such as Weymouth, Dartmouth and Plymouth (PRO. E. 190 passim). Secondly, there are records of glasscarriers living between the area in which the glass was produced and London, suggesting an overland route. In the Parish Registers for Horsham, the names of four glasscarriers are recorded between 1590 and 1614.

Despite the difficult terrain referred to in chapter I, overland transport between Petworth and London appears to have been commonplace as confirmed by Thomas Stanley's Book of Accounts for 1589-1590 which contains frequent entries for conveying goods and letters on behalf of the earl of Northumberland (WSRO. PHA 5724). The Lorraine glassmakers had been accustomed to using hauliers with large wagons for long distance transport across the Continent (Rose-Villequey 1971, 189), but in the Weald, conditions were unsuitable for wheeled traffic. The will of Henry Strudwick, 'glassecarryer' of Kirdford, dated 1614, suggests that packhorses were the likely means of transport since he left '...six small nags or mares...', but only one cart and harness (WSRO. Ep I/29/116).

6: Glassmaking: furnaces and crucibles

Introduction

Apart from the two excavations carried out by Eric Wood, Blunden's Wood (33) and Knightons (42), the examination of Wealden glasshouses has generally been superficial, usually confined to confirming the existence of a furnace floor and to recovering examples of glass, crucible and other small finds. Records of the work carried out by Winbolt and Kenyon are mainly descriptive and include only two diagrams of furnace floor plans, Fernfold (25) and Vann Copse (35). Stone robbing has clearly been a problem in an area in which stone was not commonplace, and ploughing and general decomposition has also meant that little remains of furnace structures, making it difficult to reconstruct details of furnace design and construction above ground. This research has involved the examination of more recent glasshouse excavations, elsewhere in England and on the Continent, enabling comparisons in points of detail that can increase our understanding of furnaces in the Weald. The process of crucible manufacture is examined and suggestions are made about the possible sources of refractory clay used.

Medieval-type furnaces

In northern Europe, where the 'forest glass' industry developed, furnaces assumed a rectangular plan, having wood-burning fires using natural draught, at both ends of a central flue that passed between siege platforms on which the crucibles rested: above the crucibles, a superstructure was constructed to produce a reverberatory effect. Separate furnaces were constructed for the subsidiary processes of fritting, pot-arching and annealing. This general description applies to furnaces found in the Weald and is supported by excavations of medieval glasshouses elsewhere in England, for example in Staffordshire at Bagot's Park and Wolseley (Crossley 1967; Welch 1997).

Although separated by an interval of over 200 years, the furnaces at Blunden's Wood (*c.*1330) and Knightons (*c.*1550), possess common characteristics in design, the use of separate subsidiary furnaces and type of building materials suggesting little innovation in the Wealden industry. There are however points of detail that require comment. One is the development, at Knightons, of an annealing furnace of unusual design, used for annealing crown glass sheets and apparently having been specially designed for this purpose. It consisted of two chambers, back to back, with a gap in the common wall to allow heat to pass from one chamber to the other. The chambers measured 1.92m by 1.17m and 2.15m by 1.53m internally, with a gap in the party wall between the two 0.6m wide. Signs of burning in both chambers of the furnace suggest alternating use to provide a continuous operation (Wood 1982, 9-10, MP 39). This feature was not found at the Staffordshire sites mentioned above although they were in operation at approximately the same time and were also producing crown glass. However, it is thought that a similar arrangement may have existed at a glasshouse in Jamestown (Virginia) in use in *c.*1608 (Harrington 1953, 49).

At Knightons, it was found that the melting furnace partially overlaid the remains of an earlier melting furnace that had been dismantled. The layout was similar to the one it replaced, but there had been a significant reduction in the width of the flue from 0.76m to 0.6m wide. This is clearly a deliberate adjustment to the design and must be regarded as an improvement rather than for experimental purposes. The earlier furnace had an internal fire chamber area, represented by the central flue and the sieges, of 7.73m^2 compared with 6.22m^2 for the later furnace. This reduction in superficial area suggests, assuming a similar furnace height, implies a smaller internal cubic capacity in the second furnace, requiring either less heat with savings in fuel, or enabling higher temperatures to be achieved. The trend towards smaller, more compact furnaces is discussed in more detail below in connection with post-immigrant furnaces.

A further, puzzling feature of the Knightons melting furnace was the discovery that there had been a wall at the west end allowing for a fire only at the east end, and representing a departure from the usual layout of hearths for fires at both ends. This detail is not found in excavated examples elsewhere and raises the question of the necessity to have a fire at both ends. Provision for a single fire may suggest economy in fuel use, but there would appear to be several advantages, at least for having the facility for a second fire. even if this was not in continuous use. A fire at both ends of the furnace would provide greater flexibility, produce greater heat distributed more evenly within the furnace, and facilitate the clearing of ash. The use of two hearths in furnaces elsewhere appears to have been customary and the example of a single hearth at Knightons is unusual.

In his excavation report of Blunden's Wood, Eric Wood speculates that the roof of the melting furnace may have been constructed '...of rough stones embedded in thick clay...supported on a timber frame which burnt away...' (Wood 1965, 58-9). This idea is supported by evidence of this type of construction found at Bagot's Park (Staffs), where '...lumps of clay originally stiffened by twigs...' were found lying in the central flue suggesting that 'the roof had been shaped with a stiffening of twigs, burnt out as the clay hardened after the fires were lit' (Crossley 1967, 53, 57). A similar method may also have been used at Wolseley (Staffs) (Welch 1997, 26). However, Wood's suggestion that one of the subsidiary furnaces at the same site used a forced draught system is not supported by findings elsewhere, and indeed is unlikely in the context of a small furnace used for one of the low-temperature processes (Wood 1965, 59).

Immigrant period furnaces

One of the most significant features of the glassmaking techniques introduced by the immigrants after 1567 was a different formula, using more lime and less alkali than previously (see chapter 7 below). This change in the mix enabled a better quality glass, harder and more durable, but required a higher melting temperature: higher temperatures also enabled faster melting, better dispersal of seeds in the molten glass and a need for less alkali in the batch (Cable 1998, 319). It was therefore essential that there should be improvements in furnace performance to achieve and maintain higher temperature operation. This was brought about by a combination of several factors, rather than by a fundamental change in furnace design.

A comparison of the plan dimensions of furnaces suggests a progressive reduction in the cubic content of the fire chamber in later furnaces, assuming that furnace heights stayed much the same. The following table shows a reduction in the superficial area of the fire chamber, defined as the space occupied by the two siege platforms and the flue between them, in later furnaces.

A comparison of the superficial area of fire chambers in furnaces:

Site	Date	Area m^2	Comments
Blunden's Wood[1]	1330	4.83	window glass - 4 crucibles
Knightons F2[2]	1550	6.22	window glass - 6 crucibles
Fernfold[3]	1567	4.64	window glass - 6 crucibles
Lichcourt (Lorraine)[4]	1600-18	2.25	window glass - 4 crucibles

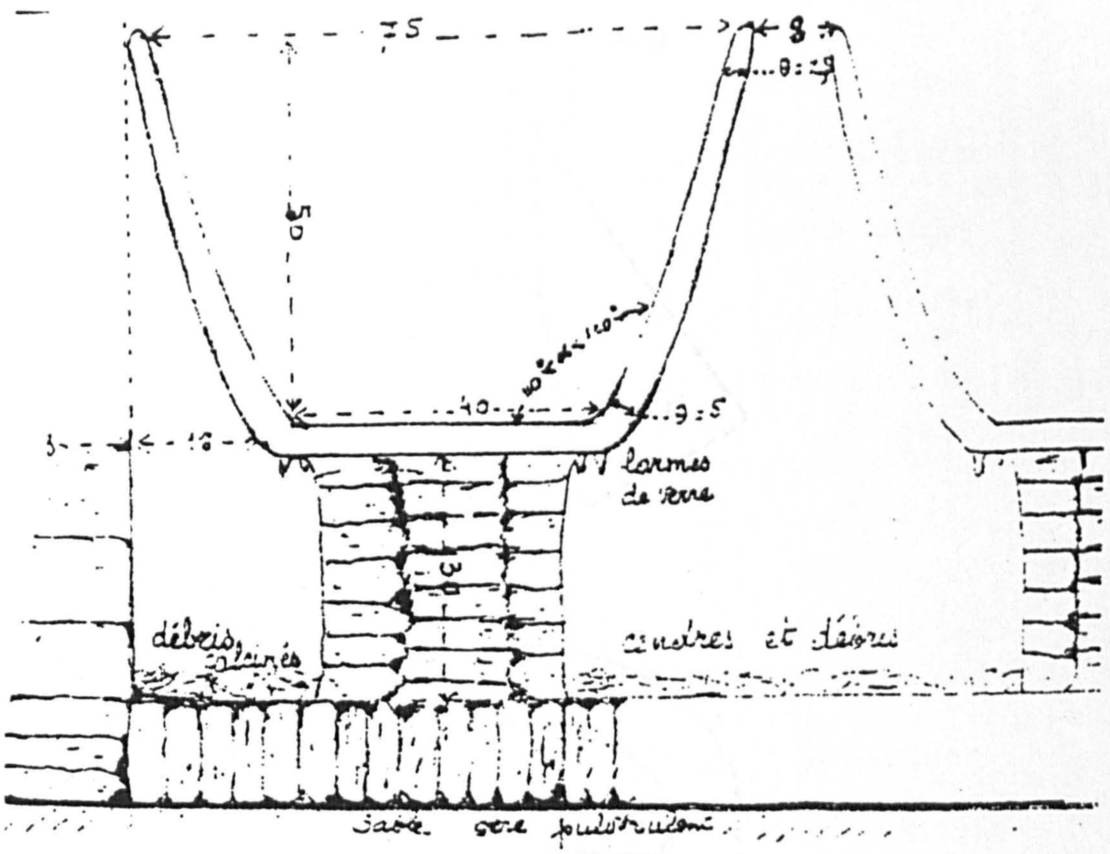
([1] Wood 1965, 57-8; [2] Wood 1982, 8; [3] Winbolt 1935, 790; [4] Ladaique 1973, 80)

This suggests a deliberate development towards a more compact furnace layout that would have resulted in less heat being dissipated in heating furnace fabric and a greater concentration of heat applied to the crucibles. Excavated examples of post-immigrant glass furnaces are sadly lacking in the Weald, but the trend towards smaller, more compact furnaces in window glass manufacture is well illustrated by the instance from Lichcourt (Lorraine) quoted in the table above which had a capacity for four large crucibles with a rim diameter of 0.75m. A reduction in the number of crucibles from six to four is likely to have been made possible by higher operating temperatures, resulting in faster melting and enabling smaller furnace size.

Another feature of the Lichcourt furnace is that the crucibles were placed on columns instead of sieges, as illustrated on page 134, making it possible for the flames to envelop the base of the crucible. No such example of this arrangement has so far been found in England and it is possible that it was experimental: certainly the columns would have been vulnerable to corrosion and crucible replacement would have been difficult.

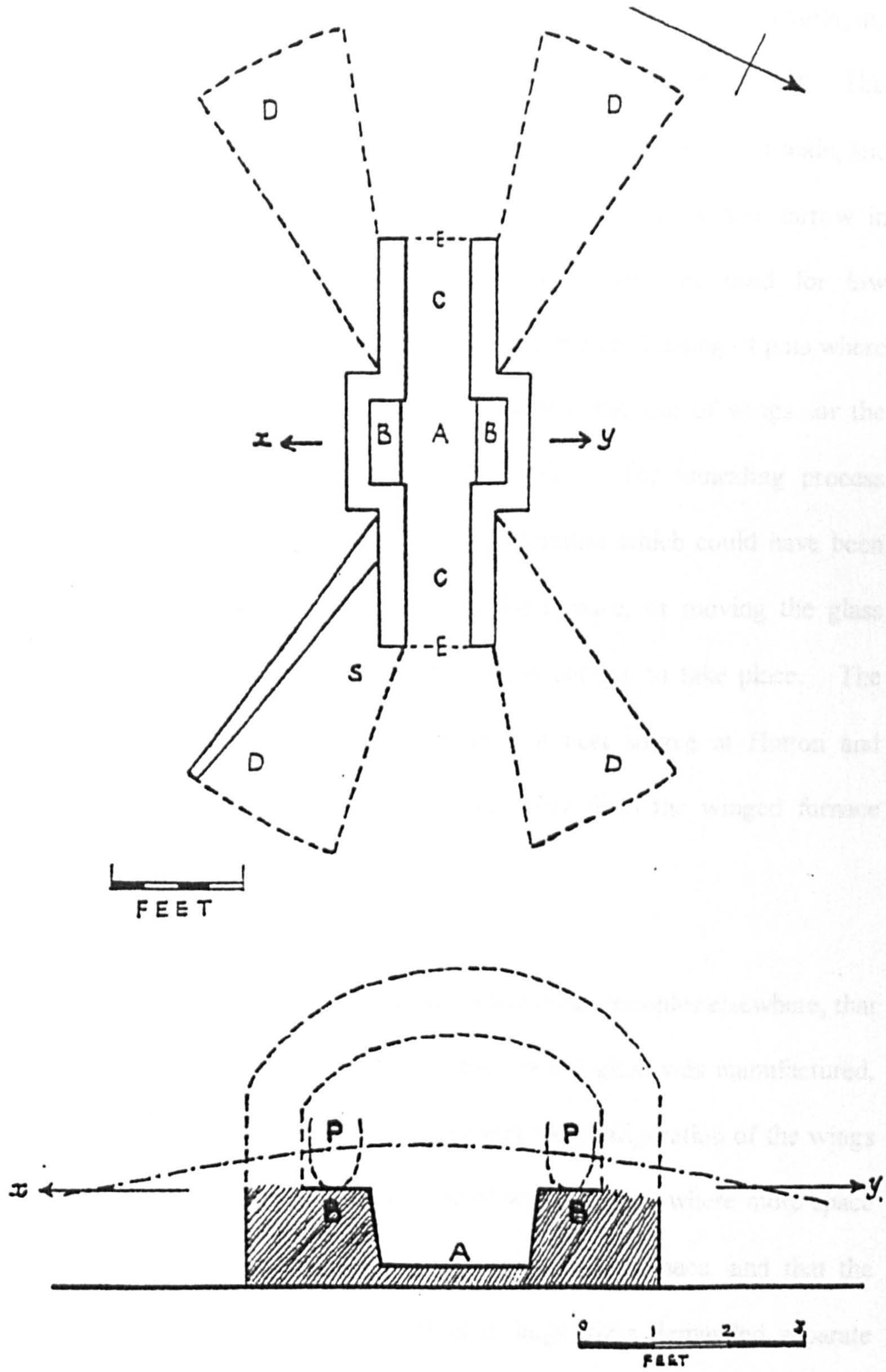
An important innovation was the introduction of multi-chamber or 'winged' furnaces that enabled heat from a melting furnace at the centre, to be transferred to chambers or 'wings' in which the low-temperature processes could be carried out. Heat taken from one central source in this way would have brought about savings in fuel and labour, and the compact layout of these furnaces would also have enabled a saving in space within the glasshouse. The only known example of this kind of furnace to be found in the Weald is Vann Copse (35). Although discovered in 1931 by Winbolt and Mr Caroe, it was not until 30 years later that Kenyon attempted to interpret Winbolt's notes and photographs to provide a reconstruction (p. 135). However, there remain doubts about the accuracy of this reconstruction, for example, in the dimensions and position of the wings in relation to the main furnace. Following the excavation of winged furnaces at Rosedale, N Riding (Crossley &

Fig. 11: Furnace, Lichcourt (Lorraine)



Sectional drawing of a crucible resting on supporting columns, Lichcourt (Lorraine).
(Ladaique 1973, 81)

Fig. 12: Vann Copse furnace



Furnace reconstruction, plan and section:

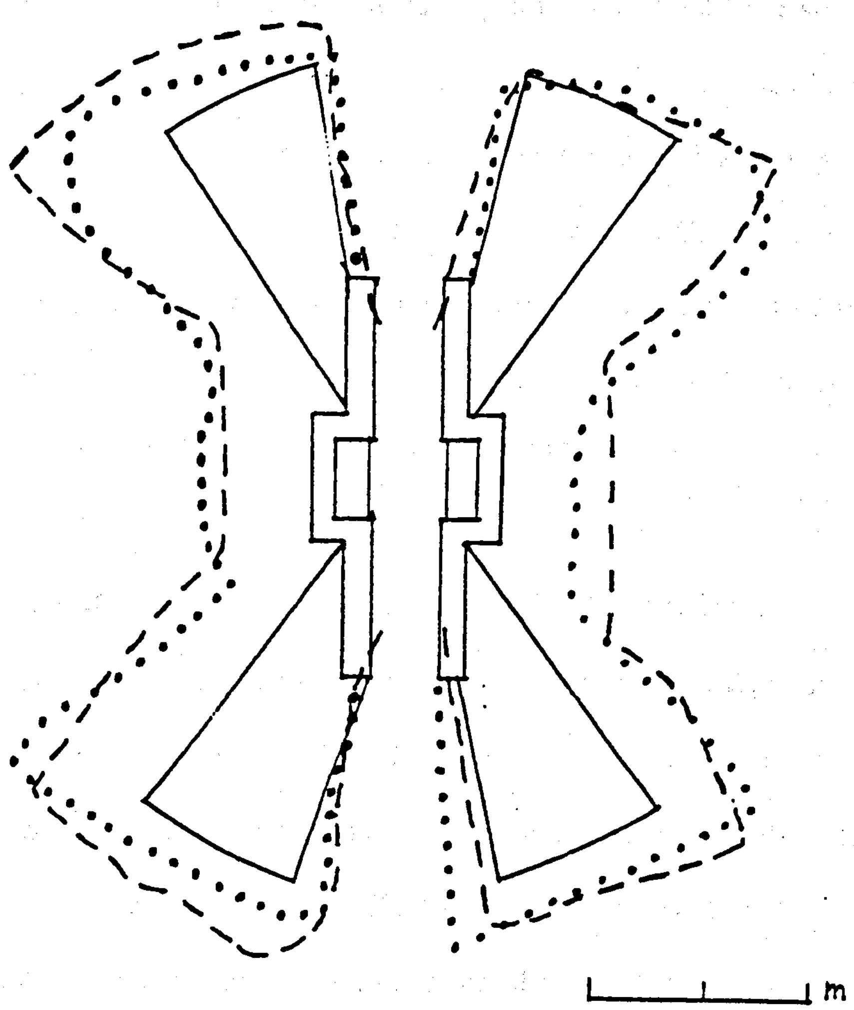
A	Fire chamber
B	Siege shelves
C	Hearth tunnels
D	Wings
E	Hearth lip
P	Crucibles

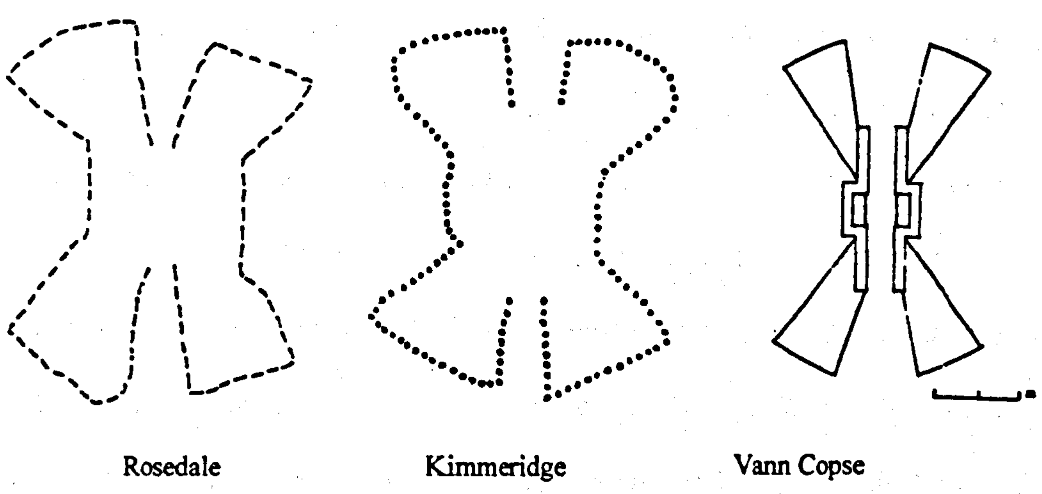
(Kenyon 1967, 196-7)

Aberg 1972) and Kimmeridge, Dorset, (Crossley 1988) it is possible by overlaying the furnace plans to make a comparison with the Vann Copse (see p. 137). This reveals that Rosedale and Kimmeridge are of strikingly similar profile and scale, and suggest that the wings in the Vann Copse plan are shown to be too narrow in Kenyon's drawing. The wing chambers could effectively be used for low temperature processes such as fritting, and the making and pre-heating of pots where delivery of a consistent heat was required. However, the use of wings for the annealing of finished glass products, is questionable. The annealing process required heat, followed by a steadily reducing temperature which could have been achieved by cutting off the flow of heat from the furnace, or moving the glass progressively away from the source of heat to allow cooling to take place. The discovery of separate furnaces with an independent heat source at Hutton and Rosedale suggest that annealing was carried out away from the winged furnace complex (Crossley & Aberg 1972, 115, 120-1).

It is apparent from the illustration of Vann Copse and from examples elsewhere, that winged furnaces are only found at locations where vessel glass was manufactured. The reason for this is not clear, but it is possible that the configuration of the wings was found to be unsuitable for the manufacture of window glass where more space was needed to work large gatherings of glass close to the furnace, and that the annealing of large quantities of window glass in large sizes demanded separate facilities. The introduction of specialist features to cater for the particular needs of window or vessel glassmakers would appear to mark an important stage in the

Fig. 13: Vann Copse furnace





Overlay of four-winged furnaces:
Rosedale (N Riding), Kimmeridge (Dorset) and Vann Copse (Weald)

(Crossley & Aberg 1972, 119; Crossley 1988, 349; Kenyon 1967, 196) development of furnace design, representing a move away from the all-purpose furnace used for making both products. Window-glass makers used large volumes of glass, needing a spacious working area and an annealing facility capable of taking large sheets. Vessel-glass manufacturers, on the other hand, used less glass and could manage with a smaller, more compact furnace. At Vann Copse, the sieges measured only 30in by 10½in (0.76 x 0.27m) allowing space for only two small crucibles on each side and at Rosedale, the sieges accommodated only one pot on each side (Kenyon 1967, 197; Crossley & Aberg 1972, 117).

With the exception of the two excavations carried out by Wood referred to above, we have little knowledge of subsidiary furnaces or the layout of a typical glasshouse. This is in part due to the technique adopted by early researchers of concentrating their limited resources on exploring the melting furnace. But it may also be, as suggested by findings at Bagot's Park (Staffs), that subsidiary furnaces were '...more vulnerable to robbing and decay, unprotected by the layer of fused glass which coats melting-furnace sieges' (Crossley 1967, 61; Welch 1997, 27-8). The arrangements for annealing window glass in the post-immigrant period remain a particular problem: so far, there has been no excavation of such a furnace in the Weald, and excavations elsewhere have not revealed a solution. If the annealing process used heat ducted from the melting furnace, as in the winged-furnaces described above, one might expect to find evidence of chambers linked horizontally at ground level to the melting furnace. However, at Bishops Wood (Staffs), a window-glass furnace in operation between 1580 and around 1600, no indication of such an arrangement was noted, suggesting the use either of chambers above the furnace, or altogether separate furnaces (Pape 1934, 90-1).

Furnace superstructures

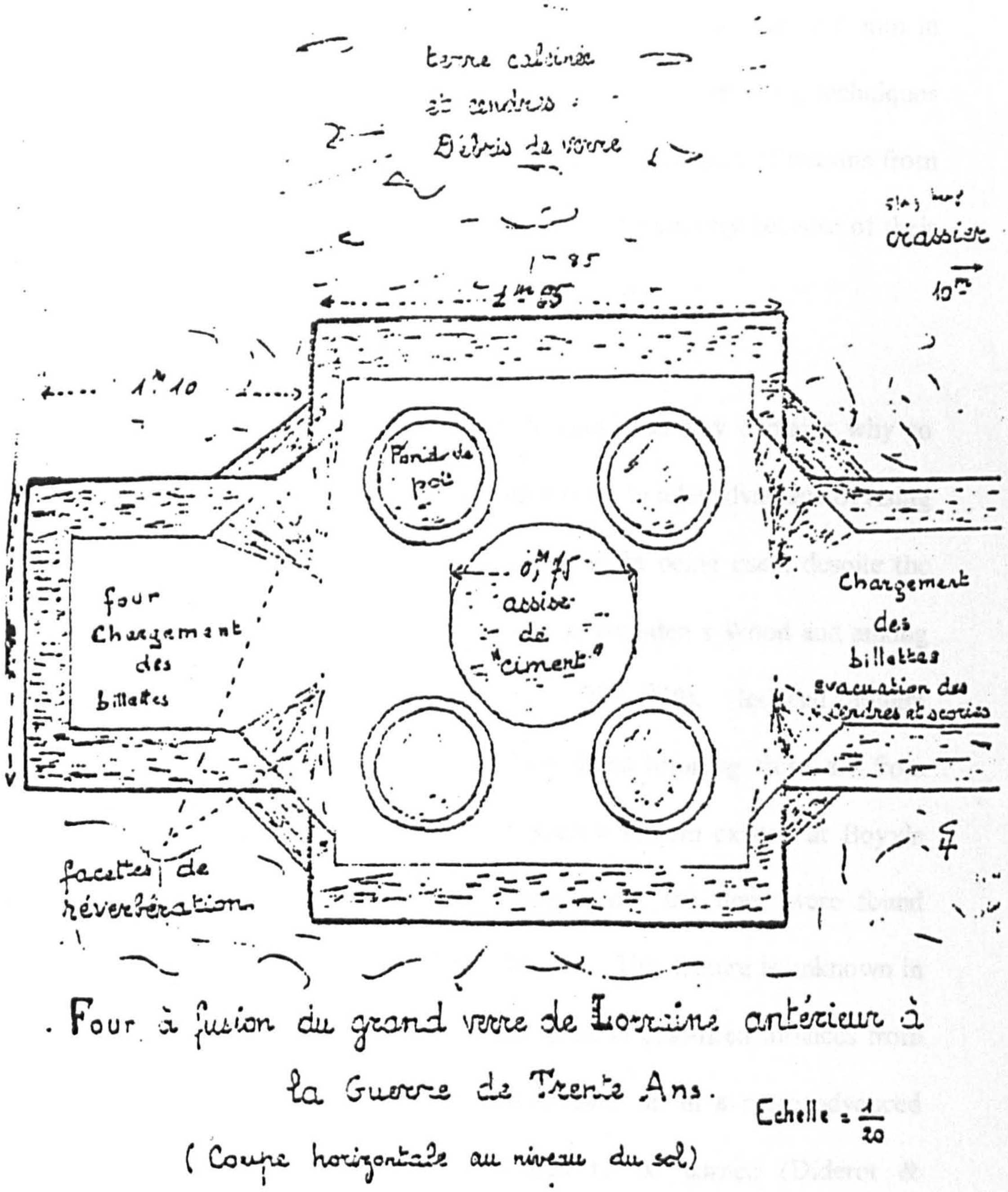
As mentioned above, the absence of surviving superstructures has left a serious gap in our understanding of Wealden furnaces. The design of the vault over the crucibles was crucial in producing the most efficient reverberatory effect and eliminating harmful hot and cold spots. The principle of the reverberatory furnace

being, '...one in which the material under treatment and the solid fuel are kept apart, and the flame and hot gases from the burning fuel enter the furnace proper at one end and are deflected or beaten down on to the material on the hearth by the roof of the furnace' (Jenkins 1933, 67).

In its simplest form, this effect could be achieved by the use of a barrel vault, but such a basic design would have left scope for improvement and fine-tuning to improve efficiency. A great deal of care was taken to improve performance, and this is illustrated by an example found in Lorraine, where the top corners of the fire chamber were specially shaped (*'facettes de réverbération'*) to reflect the heat evenly onto the crucibles (Fig 14, p.140). It would be reasonable to assume that small improvements of this kind would have been introduced routinely as they were found to be effective.

The use of higher temperatures was a potential cause of wear to the furnace fabric, and builders were continually seeking new materials and methods of construction to prevent failure. Better construction techniques were used at Fernfold (25) where Winbolt found '...alternate courses of shaped sandstones and excellently made fire

Fig. 14 Plan of a Lorraine furnace



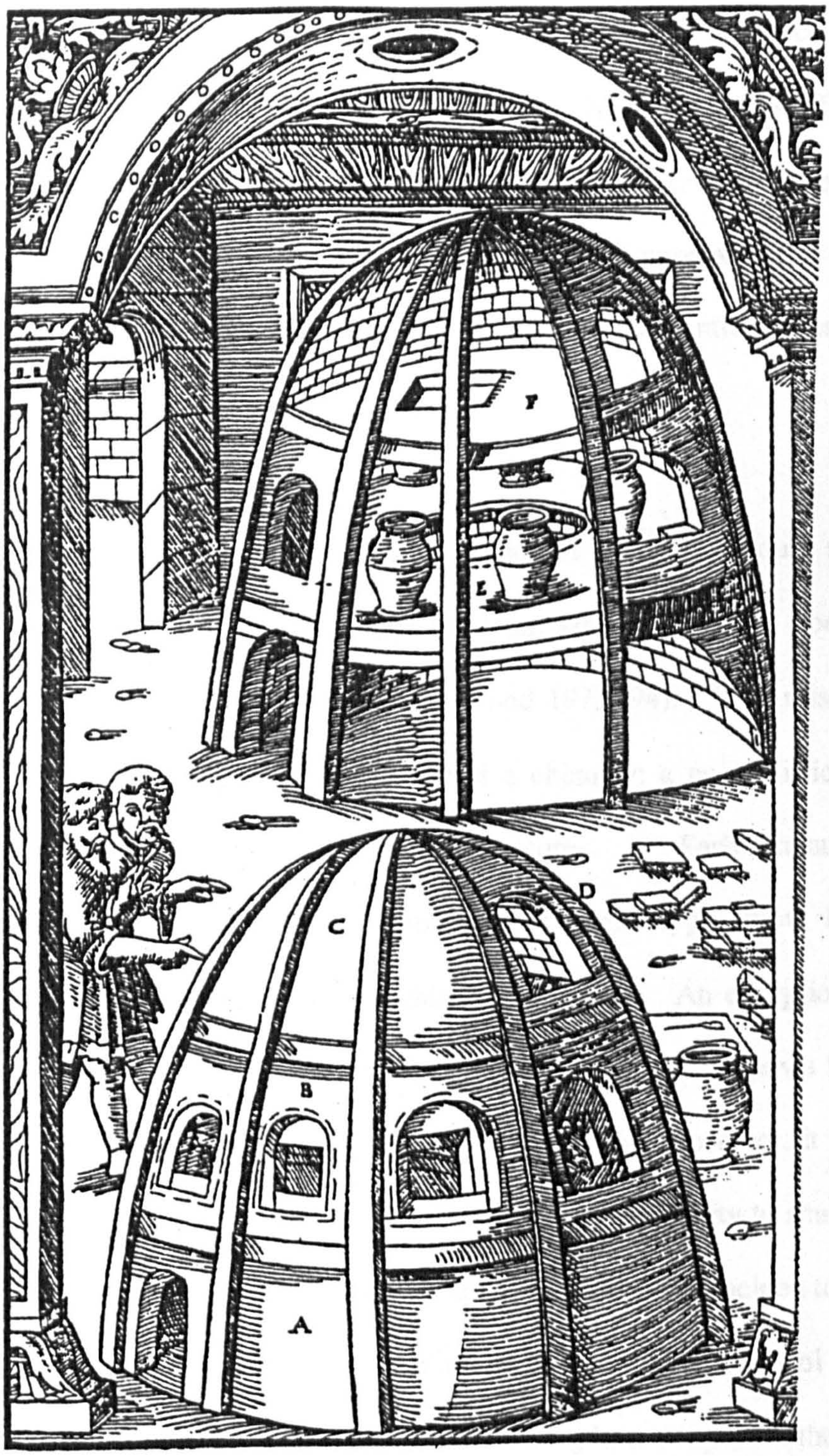
Plan of Lichcourt furnace, Lorraine, drawn by Ladaique (1973, 80).

bricks...' (1935, 790). Similar materials have been found at other late sites such as Hutton (N Riding); and at Buriton (Hants) where bricks were used, made from 'coarse cream coloured, sandy fabric', which contained inclusions up to 3 mm in size and (Crossley & Aberg 1972, 113; Fox & Lewis 1982, 9). Building techniques were also becoming more advanced, and Ladaique quotes examples of masons from Lorraine being hired to build furnaces in other parts of the country because of their specialist skills in furnace construction (Ladaique 1973, 76).

Wealden furnaces were dependent on induced draught, and may explains why so many glasshouses were sited on a shelf on sloping ground to take advantage of rising air currents. There is no firm evidence of forced draught being used, despite the discovery of a tuyere in one of the smaller furnaces at Blunden's Wood and among glass waste at Graffham (Wood 1965, 59; Kenyon 1967, 209). Induced draught could be improved by the addition of under-floor ducts bringing fresh air from outside the glasshouse to the furnace hearth. Such a system existed at Boyvin (Lorraine) where the remains of channels passing under the floor were found clogged with ash and charcoal (Ladaique 1973, 74, 84). This feature is unknown in wood-fired furnaces in England, but was generally used in coal-fired furnaces from the early 17th century onwards. It is also found later on in a more advanced formation in France where wood fuel continued to be burned (Diderot & D'Alembert 1772, *Verrerie en bois, Grande Verrerie à vitres*, Planche III), Evidence of channels or ducts designed to improve draught should be looked for in future furnace excavations.

The absence of furnace superstructures makes it necessary to resort to conjecture, supported by contemporary illustrations, such as those by John Mandeville and Agricola, in order to try to understand some aspects of the upper part of a furnace. In the walls, immediately above the crucible placements, there would have been holes through which the glass could be gathered and through which heat could pass for reheating the glass as it was worked. To replace a crucible, it would have been necessary to enlarge the opening around the working hole to provide access. Since this would have considerably weakened the furnace structure, the furnace wall was constructed with reinforcing arches around the area of the working holes (Fig. 15, p. 143). After the crucible had been inserted, the hole would have been reduced to a size sufficient for a gathering of glass to pass through: a second small hole may have been left for heating the blow-pipes and pontils (Charleston 1978, 15). One method of achieving this was to seal the opening with clay through which a gathering hole was cut. This procedure is illustrated by Diderot & D'Alembert, and involved building up a layer of clay over a wattle frame which was then fixed in position over the hole, allowing the clay to harden in the heat of the furnace as the supporting wood reinforcing was burned away (1772, *Verrerie en bois*, Pl. XIII, Fig. 2). An alternative method is suggested by Charleston, in which a pre-fired slab of clay, with a working hole in the centre was used as a cover, and was evidently the method used at Jamestown (Charleston 1978, 15; Harrington 1953, 23-25). Removable covers were used to cover the working hole when not in use to conserve heat. At Bagot's Park (Staffs), a working hole cover was found measuring 10in (0.25m) square and

Fig. 15: The 'southern' style furnace



The 'southern' style furnace as illustrated in Agricola's *De Re Metallica.*
(Agricola 1556, 589)

having a central 'lifting hole' to assist in handling. This was made from a slab of clay 1½ -2in (0.035 – 0.050m) thick, revealing signs that it had been reinforced with fine twigs during manufacture (Crossley 1967, 59, 75). At Wolseley (Staffs), 14 fragments of working hole covers were recovered from the waste tips, suggesting they were frequently broken and expendable: these measured approximately 0.22-0.23m square and, as at Bagot's Park, contained a hole in the centre for ease of handling (Welch 1997, 26).

Eric Wood's original reconstruction drawing of Blunden's Wood glasshouse shows a hole or short chimney in the roof, though his later, amended version does not include this detail (Wood 1965, 60; Ashurst & Wood 1973, 94). This raises the question whether or not furnaces would have had a chimney: a point difficult to resolve in the absence of surviving furnace structures. Early manuscript illustrations of furnaces, mainly of the 'southern' European type, show flames emerging from the gathering holes and no chimney is shown. An exception is a furnace illustrated in *Tractus de Herbis* by Dioscorides (1458), which shows flames issuing from a hole in the roof (cited in Foy 1989, Plate IV). However, it would seem that a chimney, or even a hole in the furnace roof, with the ability to shut it off when not required, would have had several advantages: it would have helped to draw the fire, assist in the disposal of harmful smoke and provide greater control of the furnace atmosphere. It would also be a means of diverting heat away from the glory holes during the hazardous operation of replacing a damaged crucible.

At Shinrone (Republic of Ireland), the rare survival of part of a barrel-vaulted furnace roof, constructed from sandstone, contains two holes approximately 0.30m in diameter situated side by side and above the stoking tunnel at one end of the furnace. Their purpose is not clear, but they are in the wrong position in relation to the sieges to be glory holes: it is possible their purpose was to convey hot air to subsidiary furnace chambers adjacent to the main furnace, but no meaningful remains were discovered on excavation. The other possibility is that they were venting holes, used for controlling temperature and the furnace atmosphere as suggested above (the glasshouse at Shinrone was excavated by Caimin O'Brien and Jean Farrelly in 1999 and the final excavation report is awaited).

Measuring furnace temperature

No accurate method of measuring temperature was available to the glassmakers, but they were accustomed to working with fire and would have had the benefit of experience gained from observing changes in the tint of crucibles and furnace fabric, and the behaviour of the materials being heated.

Fritting was a preliminary 'cooking' process in which the materials (sand and ash) were heated until they started to melt and become fused together in small lumps: a process that could be monitored by practised observation. Research has demonstrated that clearly observable changes in colour occur with increasing temperature as the process develops, ranging from brown at room temperature through black/purple at 900° C., to red/pink at 1,051° C. (Smedley *et al.* 1998, 154-

5;). Experiments with what was thought to be frit, taken from Blunden's Wood, confirm a temperature of around 900° C. (Merchant 1998, 168).

Melting furnaces appear to have operated at a maximum achievable temperature, up to around 1,350° C., in order to produce rapid melting and better quality glass. Research carried out by Prof Cable on samples of late sixteenth century glass from Hutton and Rosedale has demonstrated that furnaces, particularly in the post-immigrant, period were capable of operating at temperatures between 1,275 – 1,350° C., far higher than Turner's earlier estimate of around 1,200° C. (Cable 1987, 97; Turner 1956, 295). Here it was the quality of the melt that was important, with sufficient heat being necessary to remove impurities and to allow air bubbles to dissipate.

In the annealing process, the estimation of temperature was more critical: insufficient heat resulted in poor annealing, making the glass liable to shatter or break irregularly when cut, whilst too high a temperature risked distortion of the finished product. Ideally the glass would have been heated to around 600° C. and then allowed to cool gradually. It is not clear how this temperature was gauged but it is possible that a method was devised similar to that described by Walter Gedde in his account of the firing of painted and enamelled glass by glaziers in stained glass manufacture (Gedde 1615, R1-3). In the performance of this process the temperature was all-important: sufficient heat was necessary for the paint or enamel to become fused into the surface of the glass, but too high a temperature could result in the paint being burned away. Gedde explains how the correct temperature could be determined by the use of 'proofe peeces', small pieces of painted glass, which could be accessed and monitored during firing through a 'proofe hole' in the side of the furnace (Fig. 16, p. 148). It is possible that a similar method was used to gauge the optimum temperature range for annealing glass, for example, by using slips of glass that would bend indicating that the temperature was too high.

Crucibles

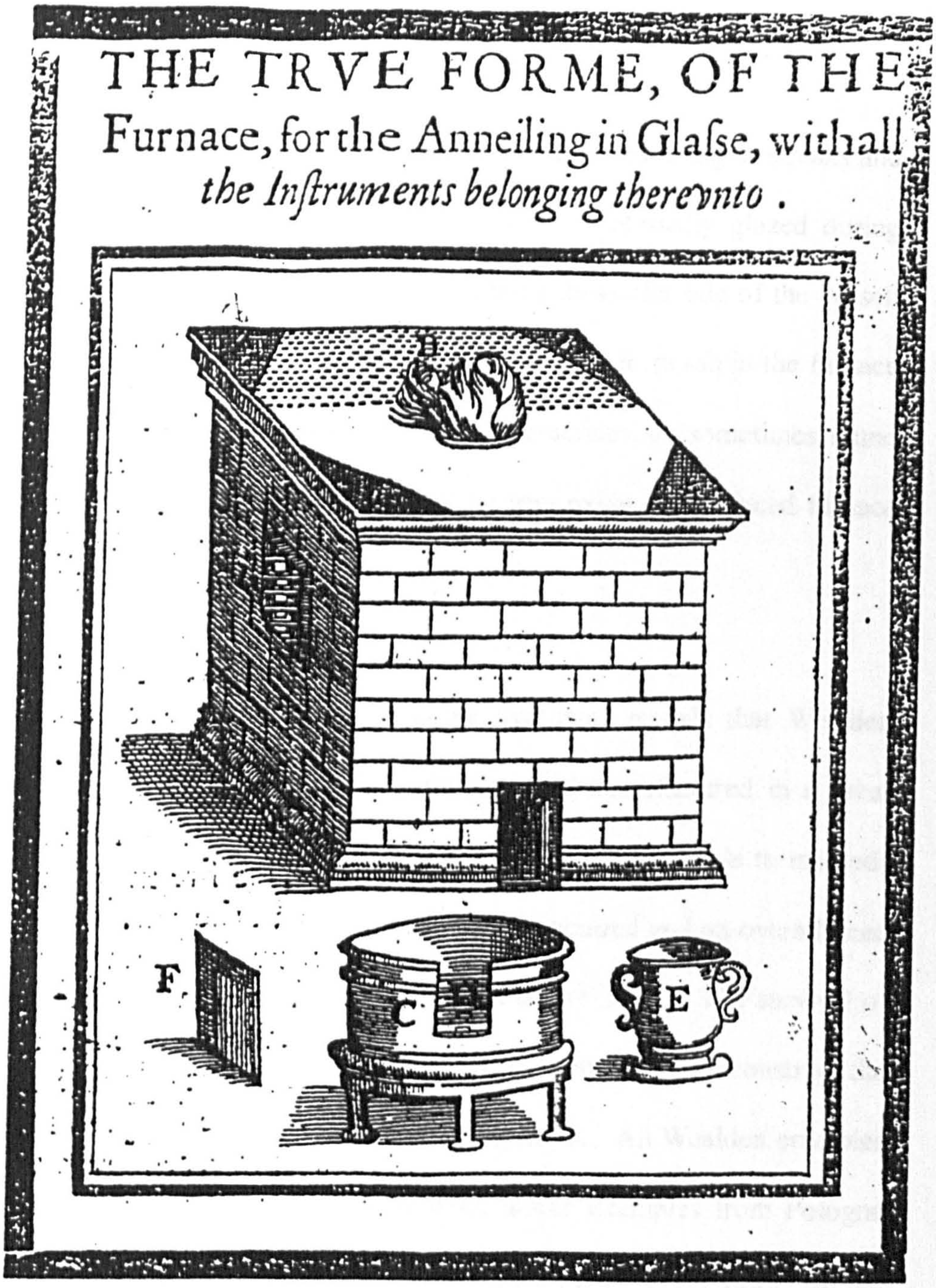
The use of crucibles, in which the ingredients were melted, had significant advantages over the 'tank' furnaces of ancient times: several crucibles could be in use at one time, containing ingredients at different stages in the melting process, allowing greater flexibility and the possibility of continuous operation; glass could be gathered more easily; and the breakage of a crucible allowed for replacement with a minimum of disruption without the necessity to shut down the furnace.

Crucible fragments are very distinctive, having a coarse stone-like texture, and are unlike any other pottery found in the Weald: Winbolt gives the following description:

'the pots look sometimes like limestone, sometimes like blue lias, and occasionally are brown or dark red: all types are hard to break with a hammer and sharp mason's chisel' (Winbolt 1933, 53).

Typically, the colour is cream/buff or grey: the 'dark red' referred to by Winbolt was found at Crouchland (ibid., 49) and is unusual, though examples of pieces having a

Fig. 16 Annealing kiln



A kiln for use by glaziers to fire glass after painting. Glass is placed in the pan which is positioned in the kiln so that the opening in the side corresponds with the opening in the side of the kiln. The progress of the firing process can be monitored using 'proof pieces' that can be moved in and out of the opening for examination whilst firing is taking place. (Gede 1615).

pink tint have been found elsewhere, as at Blunden's Wood and Buriton (Hants) (Wood 1965, 68; Portsmouth City Museum Collection. Ref. E4 b).

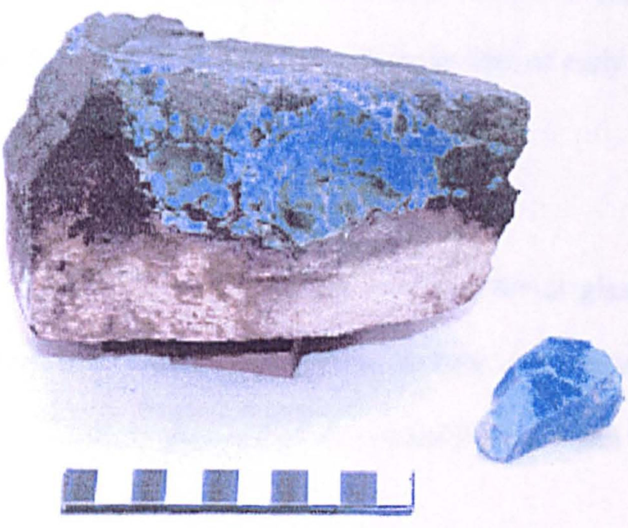
Interior and exterior surfaces are frequently found with glass adhering in streaks and patches: this is not an indication that the vessel was intentionally glazed during manufacture, but is the result of molten glass dribbling down the side of the vessel, or the interaction between silica in the clay matrix and alkali from ash in the furnace atmosphere (Marson 1932, 74). Base fragments of crucibles are sometimes found with an opaque, glassy sediment, coloured blue by iron oxide in a reduced furnace atmosphere (Fig. 17 p. 150).

The examination of a large number of crucible fragments reveals that Wealden crucibles, in common with those found elsewhere, were manufactured in a great variety of size, shape and thickness. These differences are attributable to methods of manufacture, ease of handling, the volumes of glass required and an overall need to make a durable product rather than for reasons of artistic style. The survival of complete crucibles is rare and caution is needed when attempting to reconstruct the shape and dimensions of a complete vessel from fragments. All Wealden crucibles appear to have been modelled on a circular base, unlike examples from Pologne (Argonne) where an oval shape was occasionally adopted (Foy 1989, 100). In the majority of instances, crucibles appear to have been made without the use of moulds or the potters wheel, leading to irregularities in shape and thickness which make it difficult to recreate the appearance and true dimensions of a complete vessel.

Fig. 17 Crucible fragments

Inside of crucible showing a coating of glass from the last melt.

Exterior of crucible showing, on the left, streaks where molten glass has run down the vessel, and on the right, glassy patches formed as a result of ash from the fire reacting with the fabric of the vessel body.



Fragment of crucible base. The blue, opaque, glassy substance is the remains or 'dregs' of the melt. The brown stains on the pottery are the result of prolonged contact with ferruginous soil conditions. (photographs by Colin Clark)

The largest crucible fragment found in the Weald, from Malham Ashfold, and now displayed in the Haslemere museum, has a base diameter of 11in (0.28m) and may have been over 13in (0.33m) high (ibid., 49, 52), but Kenyon estimates that a typical crucible had a base diameter of 10-12in (0.25-0.30m) and was approximately the same height, holding a capacity of around 2-3 gallons (9-13 li).

In the Weald, the largest crucibles tend to be associated with glasshouses operating in the post-immigrant period, and this is supported by a similar trend elsewhere, for example at Little Birches (Staffs). Here it was possible to compare crucible fragments from the earlier (14th century) and the later period (mid-16th century) on the same site, and it was found that those from the late period were notably thicker, indicating larger size, and suggesting improved technology (Welch 1997, 16, 18). Crucibles continued to increase in size, and a 17th century example from the glasshouse at Martagny (Normandy) was found to measure 0.40m high and to have a maximum diameter of 0.75m (Philippe 1998, 151). A tendency towards larger crucible size may be noted as a general trend, but there are clearly exceptions to this progression, as in the examples of crucibles of large size, of early 16th C., date found at Bagot's Park (Staffs) (Crossley 1967, 74).

There is evidence to suggest that crucibles were smaller at glasshouses producing mainly vessel glass, where a smaller working volume of glass was needed than at sites manufacturing window glass. The siege platforms at Vann Copse (35), a late, vessel producing glasshouse, are noticeably small, being only 30in (0.76m) long by 10½in (0.26m) wide and would only be capable of accommodating crucibles of small size (Kenyon 1967, 197).

Crucible manufacture

The technology of crucible making was highly important, demanding the selection of the best materials and exacting standards of workmanship. Crucible fabric had to be sufficiently strong to support the weight of the contents, resistant to the corrosive effects of molten glass and sufficiently refractory to withstand temperatures of around 1,400° C.. High standards were important since crucible failure during the melting process could result in wastage of materials and loss of production time. Serious damage to the sieges and furnace could result from spillages of molten glass combining with the fluxing action of ashes from the fuel (Marson 1932, 46).

Crucible-making was a specialised branch of pottery requiring unique skills developed specifically to satisfy the needs of the glassmakers. For this reason, potters worked at the glasshouse, operating as members of the glassmaking team, although there were probably instances where a potter was shared with another glasshouse (Foy 1989, 93). There is documentary evidence of clay being delivered to the glasshouse at Knole (Kent), in 1585, 'for makyng xii pots' (ERO. D/DL E77), and at la Sybille (Lorraine), it is recorded that in 1546, the glasshouse had a separate room where the potters prepared and worked their clay (Ladaique 1973, 83). There are also examples of specialist potters working alongside craftsmen engaged in other industrial processes (Fig. 18 p. 154).

The clay used was a fire-clay, creamy white in colour, having a high silica/alumina ratio and a low iron content. The analysis of a typical sample of fire-clay from Stourbridge (Worcs.) revealed a content of 65% silica and 22% Alumina (Winbolt 1933, 53), but the analyses of 14 samples of 'Stourbridge' clay has demonstrated that there could be wide variations (Bridgewater 1963, 309). Selection by trial and error would have been an on-going process to obtain the best quality, involving transport from sources outside the Weald: possible sources for clay used in the Wealden crucibles are discussed below.

Preparation of the clay is recorded by Theophilus (Dodwell 1961, 40), but he makes no mention of other substances being added. However, recent analysis indicates that sand (quartz) granules were added to Wealden crucible clay: these were of regular size, below 0.30 mm in diameter, suggesting grading by sieving (Williams 2000, 3). There is little evidence that grog was added, although the analysis of crucible fragments from Lower Roundhurst revealed '...a number of distinctive argillaceous inclusions...' which may point to the presence of grog or may be naturally-occuring clay pellets (ibid., 5). Grog has not been found in contemporary examples elsewhere, though there are records showing that it was used in Lorraine in 1690 (Ladaique 1973, 83), and, by the middle of the 18th century, its use had become

Fig. 18 A potter at work

An example of a potter using his specialist skills in the context of a manufacturing process, in this instance the extraction of sulphur and bitumen from metal ores. (Agricola 1556, 277).

a routine ingredient in crucibles of French manufacture (Diderot & D'Alemebert 1772, Planche VII).

After water had been added to the clay, various methods were used to mix it thoroughly and to remove bubbles, including beating it vigorously with a piece of wood, and pummelling and trampling with bare feet (Dodwell 1961, 40; Ladaique 1973, 83; Merrett 1662, 245). Crucibles were hand-moulded using the coil method (*le procédé au colombin*) in which the vessel was gradually built up using thick sausages of clay, without the use of a wheel (Foy 1989, 83; Philippe 1998, 149). Because of the weight of the clay it would have been necessary to raise the pot in stages, allowing time for the clay to dry out between each stage, so as to prevent slumping. This lengthy process could be reduced if the vessel was supported during fabrication by moulds, and although there is no evidence of these having been used in the Weald, there are documentary references to the purchase and use of moulds (*des moules pour les pots*) in Lorraine in the 1690s. A reference to iron hoops (*cercles de fert pour un moule à pot*), suggests moulds were in sections held together during fabrication (Ladaique 1973, 83).

It was important that the completed crucible was allowed to dry thoroughly before firing at low-temperature to stabilise the pot: glassmaking materials were not added at this stage, to minimise wastage in the event of pot failure. New crucibles may have been used initially for the low-temperature fritting process, which enabled them to undergo further 'testing' before being submitted to the full heat of the melting furnace (Wood 1982, M 60). Pre-heating the crucible (pot arching) in one of the subsidiary furnaces, to avoid thermal shock, was essential before entry into the melting furnace, where it remained in use until it showed signs of failure.

Some crucible fragments have been found with marks or decoration incised in them. At Knightons, Wood found a few pieces ornamented with decorative lines just below the rim (ibid., 39-40), and at Kimmeridge (Dorset), fragments of two fired, but unused crucibles were discovered marked 'XXXX' and 'XXXI' (Crossley 1988, 371). These marks clearly have no decorative value, but may have been used to identify individual crucibles, perhaps so they could be used in order of manufacture and identified at different stages during their working life. It may be significant that in both instances these crucibles have been marked near the top so they could be recognised when in the furnace, however, once placed in the furnace, any marks around the rim would soon become obscured by molten glass or corrosion.

Crucible clay

The local Wealden clay, although used in furnace construction, was not used for making crucibles because of its inability to withstand the combined stresses of high temperature and the corrosive effects of molten glass (Wood 1965, 70-1; Williams 2000).

Experiments carried out by Ian Merchant into the behaviour of Wealden crucible samples taken from Blunden's Wood, Knightons and Sidney Wood and subjected to heat, show that firing temperatures of between 1,200-1,400° C. were achieved: the degradation of crucible fabric above 1,400° C. indicates that firing would not have been possible above this temperature. This temperature range was confirmed by the presence of mullite and cristobalite formations in the samples. In these experiments, it was also noted that the samples from Sidney Wood, a post-immigrant glasshouse, were of better quality, enabling a higher firing temperature (Merchant 1998). These findings are supported by research carried out by David Williams on samples from the same glasshouses and from Lower Roundhurst (Williams 2000). The examples from Lower Roundhurst, another post-immigrant glasshouse, contained more frequent formations of mullite crystals indicating exposure to higher temperature.

Williams discovered argillaceous inclusions in the Lower Roundhurst samples, suggesting the possibility of grog being added, but this could not be confirmed and may be attributed to naturally occurring clay pellets. All the samples were found to contain quartz grains that may have been added to the clay to enable it to withstand higher temperatures. They are of similar size, below 0.30 mm. in diameter, suggesting the possibility of a grading process. This practice seems to have been followed elsewhere, for example at Bagot's Park (Crossley 1967, 74). The coarser appearance of the samples from Blunden's Wood and Sidney Wood was attributed to a smaller average grain size in the Knightons samples, and a lower density of grains in the Lower Roundhurst samples. Quartzite inclusions in the clay base are important, in that they perform an interlocking function that helps to bind the matrix under intense heat. However, they have a different coefficient of expansion from the clay base, and over a period of time, with fluctuations in temperature, contribute to the matrix breaking down.

Pinpointing the origin of crucible clay has been a problem for researchers over many years and has still not been resolved (Welch 1997, 45-6; Williams 1999, 134-5). The task of identification is undoubtedly made more difficult where the character of the clay has become altered by the addition of grog or sand. Further complications occur where fire-clay may have become corrupted by mixing with local clay in an attempt to eke out supplies. The mixing of different clays, whether for reasons of economy or for greater effectiveness, appears to have been a regular practice in Merrett's time, and he noted that pots '...for green glass are made of Non-such clay, mixed with another clay brought from Worcestershire' (1662, 246). It has also been demonstrated that the relative proportions of the constituents of fire-clays actually vary within the districts in which they are found (Bridgewater 1963, 305, 309).

Fire-clay is often present in association with coal seams not found in the Weald and would have had to be brought in from elsewhere. Different circumstances existed at other glassmaking centres such as Worcestershire, Staffordshire and the North Riding, where it was possible to obtain refractory clay from nearby (ibid., 304; Welch 1997, 45; Crossley & Aberg 1972, 157). It is not inconceivable that clay could have been transported from the Midlands to the Weald though this would have been difficult and expensive, particularly in the medieval period of the industry. Sources nearer and more convenient for the Weald must therefore be considered.

Merrett refers to 'the melting-pots...made of clay fetched from Perbeck in the Isle of Wight' (1662, 245). Merrett is here referring to the highly refractory pipe-clay to be found within the Bagshot Beds which is derived from decomposed feldspars of the Dartmoor and Cornish granites. These deposits are mainly to be found in the Isle of Purbeck area of Dorset, but they also outcrop on the Isle of Wight in a narrow seam that crosses the island running east from Alum Bay (Osborne-White 1990, 87-93). Although Merrett was writing in the early 1660s, at a time when pipe-clay production had developed as an important industry of the region with a thriving trade to other parts of the country, there is evidence to show that this trade was already in being at an earlier date. From around 1300, the clay pits at Morden (Dorset) were being worked (Kerr 1988, 31) and by the beginning of the 17th century agreements relating to the working of clay in the area, mainly for tobacco pipe production, were being formally entered into (DRO. TN/PO8/I/4). The earliest record of this kind of transaction to have survived is dated 1618 and relates to clay to be taken from 'the waste grounds of Canford or Poole' (DRO. D/WIM 45), but it is probable that a trade in clay was already flourishing by that date. The export of finished articles made from pipe-clay is suggested by references in the Port Records (Poole) of the 1590s to 'stone potte' (PRO. E190/866/16; 866/18). Pipe-clay from Dorset is also likely to have been used at the nearby glasshouse at Kimmeridge (Crossley 1988, 371). Deposits of refractory clay that might have been suitable for crucible manufacture are rare in the south east, but there are records of a trade in the supply of clay for pipe-making at Kemsing (Kent) in the 1620s (PRO. C2JAS I/F6/23).

The possibility that clay was imported from the Continent must not be overlooked. Although Isaac Bungar, in his response to Sir Robert Mansell's case for upholding his glass patent, states that the glassmakers '...never found any want, but had it [clay] upon reasonable termes within the Kingdome' (PRO. SP14/162/231a), it is reasonable to suggest that when the glassmakers first settled in the Weald, they would have brought their own clay with them, along with other glassmaking materials, with which they were familiar, and could trust. The practice of importing clay from Normandy no doubt continued from time to time, involving little extra cost than buying in supplies from native sources such as Staffordshire or Purbeck. The source of clay used by the Normandy glassmakers is thought to have been Bellière, near Forges-les-Eaux (Philippe 1998, 147), from where it could easily have been shipped from Rouen or Dieppe across the Channel to the Sussex coast . This was a source used by Sir Robert Mansell when he was experiencing difficulties in obtaining clay for his glassworks in Newcastle, and was '...forced to his farre greater charge to send for Clay from beyond Roan [Rouen] in France...' (PRO. SP14/162/231a). Two intriguing entries appear in the Port Records for Littlehampton/Arundel: the first appears in May 1605 for 26 barrels of 'French clay' from Rouen, and the second is in July 1611 for a further 100 barrels, also from Rouen (PRO. E190/754/5; 755/22). The import of clay to the port of

Littlehampton/Arundel is surprising, considering there was already a flourishing clay industry in the Weald, supplying the needs of local potters and tile and brick manufacturers. Special earths, such as 'red oker' (also described as 'redd earth') were also being shipped from Littlehampton/Arundel at this time, for example in June 1605, '...xx hundred of redd earth toward Dieppe'. 'French clay' was valued at 4*s* 0*d* per barrel, campared with 4*s* 2*d* per ton for 'redd earth' (PRO. E190/758/5; 754/5). These records suggest that what was being imported was unobtainable in the Weald and was of comparatively high value, and it is tempting to think that these consignments of 'French clay' were destined for use in crucible manufacture.

7: Glassmaking: batch ingredients

Introduction

This research examines the constituents used in making 'forest glass' and the sources of supply available in the Weald. Recent laboratory analysis has demonstrated significant differences in the constituents used in medieval or 'early' glass compared with that produced by the immigrants after 1567. These differences can be used in dating glasshouse operation to medieval or post-immigrant type and in this research have been related to historical evidence to demonstrate that, after the arrival of the immigrants, local native glassmakers continued to manufacture glass using their traditional formula and techniques.

Silica

The source of silica was almost certainly sand, found in great variety in the Wealden region. Despite the presence of flint in the chalk of the South Downs just 15 miles to the south, there is no evidence of the use of flint or pebbles as at Wolseley (Staffs) (Welch 1997, 22, 34). The immigrant glassmakers were evidently accustomed to using sand, and it has been shown that in Lorraine the preferred source was sand from riverbeds where it was 'washed and naturally graded, with the larger grains being deposited first on the bends in rivers'. Sand was also quarried from old riverbeds in the valley floors (Rose-Villequey 1971, 73). During the excavation of the glasshouse at Boyvin (Lorraine), abandoned in 1574, a pile of fine, white sand was found which closely corresponded with sand found in the riverbeds nearby (Ladaique 1973, 87, 94). And in Normandy, a fine, white sand was quarried, especially in the region of the Forêt d'Othe (Philippe 1998, 112).

There is little guidance to be found in contemporary literature or records to indicate how the materials for glassmaking were selected and prepared. Merrett provides only a brief description of the type of sand required: a 'fine soft and white sand' is needed to make crystal, whereas green glass requires 'that which is harder and more gritty' (Merrett 1662, 260). This does however, suggest two properties, colour and grain type and size which could be identified from visual inspection.

The first of these criteria, colour, would have been important in selecting sand having low iron contamination. In certain parts of the Weald the iron content is low, but typically, the Greensands are notably ferruginous, colouring the sand from off-white through to a deep yellow/brown, and capable of tinting the glass when only minute traces are present. Sand having an iron content of as little as 0.5% of iron oxide can create a green tint in glass, and in modern glassmaking, an iron content of as little as 0.1% requires a de-colouriser to produce clear glass suitable for glazing (Boswell 1918, 37; Charleston 1991, 238). By comparison, the Lorrainers would have been accustomed to the availability of sand having a low iron content of no more than 150 ppm. (0.015%) (Rose-Villequey 1971, 73, n. 5). The selection of sand having a pale or white colour, indicating a low iron content, would therefore have been important in producing clear glass. The second criterion, grain type, would also have been of importance since sand having a regular grain size assists in even melting.

The Tithe maps of the glassmaking parishes contain field names such as 'Sandpit Field' and 'Sandhole Plat', marking some of the places where sand has been quarried in the past. Recent observation on the ground by the writer has revealed that most of these workings are no longer in use, suggesting they have either been worked out or abandoned as demand ceased or could be more efficiently satisfied from elsewhere. It should be noted that sand has been in demand for a variety of purposes over the years, including iron founding, brick and tile manufacture, and construction, and it is not suggested that these sites were necessarily used by glassmakers.

As aliens, the immigrant glassworkers were not permitted to own land, and had to rely on renting woodlands with permission to set up a glasshouse (PRO. STAC8/179/9). The main benefit of such an arrangement was in siting furnaces in close proximity to the large volumes of wood fuel required. It would have been a fortunate coincidence if they had also been able to combine these facilities with a source of good quality glassmaking sand nearby. An examination on the ground of glasshouse sites suggests that only a few, such as Barnfold (22) and Woodhouse Farm (32) have sand within a quarter of a mile, and that this is of questionable suitability for glassmaking. It is possible that early sand-pits may have been worked out, but there are no obvious signs of earlier extraction. It is probable, therefore, that sand was brought to the glasshouse, possibly involving carriage over several miles, or even from outside the region, which would have been preferable to having to transport wood fuel over long distances, and points to access to woodlands rather than sand as the main attraction for the glassmakers.

There are indications that sand was imported by glassmakers elsewhere, where it was either unsuitable or non-existent. Rose-Villequey refers to instances on the Continent, and in England, Bridgewater found that the nearest source of suitable sand was 10 miles from the glasshouse, at St Weonards, Herefordshire (Rose-Villequey 1971, 74; Bridgewater 1963, 306). The only known documentary reference to sand in connection with glassmaking in the Weald is from an inscription on a map of Fitzlee Common (parish of Lodsworth) dated 1629, which refers to '...diging of sand and the sellinge therof to ye glasse makers...' (WSRO. Mitford MS. 998). Whilst this particular record may refer to supplying the nearby glasshouse at Graffham, it is also feasible that sand could have been transported to other glasshouses in the Weald only 10 miles away. This reference is also interesting in that it implies the existence of a trade in sand. Sand from the Fitzlee Common source was examined by Prof W E S Turner who commented that:

'...although it cannot be said to be a first quality sand, or even a second quality judged by our present standards, it could, I think, have furnished material for making glass of a pale colour' (Kenyon 1967, 35).

Samples taken from nearby at (SU 928 188) by the writer were analysed and found to have a high silica content, and an iron content that would have produced glass having a significant tint unless corrected by a decolouriser, such as manganese oxide:

Sand extracted at SU 928 188

SiO_2	97.30
Fe_2O_3	0.84
K_2O	0.02
CaO	0.02
Total:	98.18 wt. %

Analysis by Weeks Laboratories, Glasgow (2004)

At Knightons (42), '...a 1.5 cm. thick layer of unburnt sand, some 1.5 m. by 4.5 m., which appears to represent a sand store...' was found. There is no record of this sand having been analysed and none appears to have survived in museum collections, but Wood notes that it was of low iron content and unlike anything found nearby (Wood 1982, M46).

Sand was a relatively cheap commodity, the greatest cost of which was in transport. In 1546, sand was carried the five miles from 'Pannyngrydge' to the iron forge at Robertsbridge '...at xvi*d* the lode' (Lower 1849, 186). And Sir William More's Household Accounts for 1576 and 1582, show that sand for use on his estates at Loseley (Surrey), and probably only transported a short distance, cost 12*d* per load (SHC. LM. 1087/6/1). Contemporary entries in the Port Books for Littlehampton/ Arundel show that sand was exported across the Channel to St Valery (PRO. E190/748/10).

In 1994 a sandpit was excavated at Roundabout Farm (West Chiltington) where old workings were found for the extraction of a shallow deposit of 'silver' sand, dated by pottery as having been in use in the early 17th century (Kenny 1994, 3). This sandpit appears to have been worked out and abandoned, but within 100 m. to the east, sand of pale colour and good quality was recently found by the writer less than 1m below a topsoil of leaf-mould in old woodlands. This location is within ten miles of the Wealden glasshouses and within a reasonable distance for daily delivery by a contractor or collection by the glassmakers themselves. Another possible source is referred to in a Survey of the Manor of Reigate of 1623, in which there is mention of '...a great quantity of speciall white sand...', but it is not stated what this was used for or to whom it was sold (SHC. 3537/1/21 f. 162). It is likely that the glassmakers experimented with sand from different sources to achieve the most satisfactory results, and it is likely that obtaining the 'right' sand entailed transport for some distance.

Having obtained the sand, it could be improved by washing and sieving as instructed by Theophilus (Dodwell 1961, 39). Merrett also refers to the washing of sand: '...it must be white and small and well washed before used, which is all the preparation of it...' (Merrett 1662, 260): he makes no mention of sieving, but this would be beneficial in producing a narrow range of grain size. Sand of small and even grain size has been found to be important in reducing melting time and enabling more even melting (Welham 2001, 35, 40). The presence of large grains would not only prolong melting time, but would increase the possibility of incompletely melted grains appearing as opaque lumps or 'stones' in the finished glass (Segrove 1976, 41-2). Glass fragments from Wealden sites have been found to contain opaque inclusions or 'stones' which might suggest a lack of sieving, but this fault can also occur as a result of pieces of the crucible breaking off into the molten glass, or the accidental inclusion of foreign matter such as earth or stone (Newton & Davison 1989, 189). The discovery of glass with this defect, in finds from archaeological sites elsewhere, suggests this type of fault was not necessarily a reason for rejection at the time of manufacture.

Alkali

An alkali was added to the silica and acted as a flux to lower melting temperature and to lengthen working time while the glass was still hot. Wealden glass was of the northern European 'forest' type in which the alkali was potassium oxide (K_2O) obtained from the ash of inland plants and trees. Glass of this type is often referred to as 'potash glass' because of the importance of this ingredient in the batch, but it has been shown that ash from different plant sources contain a large number of different chemical constituents (Turner 1956 c, 289T). It has also been demonstrated that, not only is there great variability in the chemical constituents of ash from different plant species, but that variability is influenced by the part of the plant from which the sample is taken, the soil in which it was grown and the time of year it was harvested (Smedley *et al.*, 1998, 148; Welham 2001, 39). This research has helped to explain the high degree of variation in the range of elemental concentrations found in 'forest glass', for example in 486 samples of glass mainly from urban archaeological contexts in France analysed by Barrera & Velde (1989, 50). Modern laboratory techniques are able to identify chemical constituents in glasses by type and volume with great accuracy, but the source of vegetable ash used is more difficult to pinpoint.

The accounts of both Theophilus and Agricola state that the quantity of ashes required for the batch was twice that of sand (Dodwell 1961, 39; Agricola 1556, 586). It has been demonstrated that these proportions were measured by weight rather than volume, and considering the ash yield from wood-burning is in the region of only approximately 2% wt., must have represented a considerable quantity of burnt wood and vegetable material (Smedley *et al.* 1998, 148, 152; Cable 1998, 324).

Two main sources of ash were used: that obtained by burning selected inland plants such as ferns or bracken, and wood-ash from the furnace fires. It is likely that both types were used together, but the few surviving accounts of glassmaking provide little information about what was used and how it was prepared. However, it has been pointed out that the ash of a wood type readily available and best suited for heating the furnaces was not necessarily ideal for use in the batch (Cable 1998, 319). The wide variety of plant ash used suggests experimentation, using what was locally available, to discover the most effective formulation.

No documentary evidence has survived for the use of ash from plant species, such as ferns and bracken, in the Wealden industry, but the widespread use of such plants containing a high potash content elsewhere suggests this was the practice in the Weald. In Lorraine, a variety of plants were used including ferns, heather, broom and the shoots of young trees, and the glassmakers enjoyed special rights to the free collection of '...ferns and all other herbs favourable and suitable to glass making...'. The plants were cut between the end of May and mid June and transported to the glasshouse where they were burned and dried in a trench (Ladaique 1973, 45, 84, 89; Rose-Villequey 1971, 75). Ferns and other plants were also used in Normandy (Foy 1989, 35-6). And at Wolseley (Staffs), it is recorded that ferns were sold to the glassmakers in 1479 for 5*s* (Crossley 1967, 47; Welch 1997, 2).

In the Weald, plants such as bracken and heather would have been available from common land, where they were encouraged to grow for use as litter for stock animals in an area where there was a shortage of straw on small farms (Brandon 2003, 62). The Customary of Shillinglee Manor (1581) refers to the rights of an individual to his '...layne of ferne as much as groweth...' in a defined area of the estate (WSRO. Burrell MSS. MF 77/154).

Wood ash from the furnace fires was clearly a source of alkali, but it is unclear to what extent it was a primary or a secondary source. If ash was not produced on site, either from the furnaces or through separate burning, wood ash could be bought in. Alkali in the form of potash was in demand by a number of industries including soapmaking, saltpetre, textiles and as a fertiliser in agriculture, besides glassmaking. The Weald was a centre for ashburning and the trade of 'ashburner' is referred to in local contemporary documents and in the Statute of Artificers of 1563 (WSRO. MF 77; Statutes of the Realm, 5 Eliz. Cap. iv, 23). Ashes were transported surprisingly long distances in sacks or barrels, and despite there being an 'Act againste the carriage of white ashes out of this Realme', which had been in place since 1548, ash was exported across the Channel to ports such as Dieppe, St Valery and Rouen (PRO. E190 series). A trade in ashes also existed in Lorraine and Normandy (Rose-Villequey 659; Philippe 1998, 116).

Ash was obtainable from many sources and the ash-burners would probably have burned anything they could get hold of. Wherever trees were felled for timber or hedges cut, there would have been small wood to burn. Agricola describes the making of ashes from old trees, whereby '...the trunk at a height of six feet is hollowed out and fire is put in, and thus the whole tree is consumed and converted into ashes...' (Agricola 1556, 586). In Lorraine, it was the practice of the glassmakers to produce ashes by setting fire to a part of the forest each year, and ashes were also systematically collected from domestic hearths (Ladaique 1973, 89-90). At Shillinglee Manor in the Weald it is recorded that '...there were sold about 3 years past to the ashburners, 100 oaks...' (WSRO. MF. 77/146): this, however, would not have been a legitimate use for timber trees and was probably an exception.

It was clearly in the interests of the glassmakers to be as self-sufficient as possible in producing their own supply of ashes, since costs were in the region of 6s per bushel, or 17% of total production costs (Godfrey 1975, 197). There was also a need to control the quality of a product easily polluted by dirt or stones.

Before ashes could be added to the batch, they would have undergone some form of basic preparation. This would have been straightforward and did not involve the complicated and experimental processes of multiple distillation and filtration described by Merrett later on (1662, 2-5). Ash would have been crushed and sieved to remove large particles, mainly of carbon, the remaining smaller carbon particles being left to be burned off in the fritting process. It would have been important for the prepared ash to be stored in a dry place, possibly in barrels, to prevent leaching.

The literature about the Wealden glass industry has placed emphasis on the use of beech both as a fuel and a source of alkali (Winbolt 1933, 53; Kenyon 1967, 46), but this idea must be questioned as a result of more recent research.

Winbolt and Kenyon are likely to have formed their view as a result of Theophilus's dissertation in which he recommends the burning of beech logs (*ligna fagina*) (Dodwell 1961, 39); and by a reference in the will of the Wealden glassmaker, Henry Strudwick, to '...the beches I have bought and half the beches in and upon Idehurst and Crofts...' (Rice 1938, 72). A general preference for beech has been portrayed as the practice in many glassmaking areas on the Continent such as Lorraine and Normandy, noted for their beech forests (Rose-Villequey 1971, 79; Philippe 1998, 116; Ladaique 1973, 23). And attention has also been drawn to the tendency for Continental glasshouses to be located in areas of beech forest, suggesting that it was the availability of beech that determined where the glassmakers settled (Newton 1985, 101).

Turner has commented on the 'extraordinary occurrence of manganese in beechwood ash' as an explanation of Theophilus's methods for producing a wide range of colours, depending on the time the glass was allowed to stand in the crucible (Turner 1956c, 289T). Newton has further explained how the design of the northern European furnace also had a bearing on the tint of the glass produced, demonstrating that colour was in part determined by the furnace atmosphere and the degree of oxidation introduced to the glass. He maintained that the design of the northern furnace produced a stronger draught, enabling greater opportunities for its control, and hence the state of oxidation of the melt (Newton 1985, 99-102; Dodwell 1961, 41-2). This technology, combined with the special properties of beech wood, made it possible to produce the enormous amounts of coloured glass needed for the ecclesiastical buildings of the Middle Ages. It seems clear that Theophilus had in mind the manufacture of coloured glass, techniques for which are described in his account, when recommending the use of beech.

However, there is no evidence that coloured glass was made in the Weald. The 14th-century accounts relating to glass for the Royal Chapels at Westminster and Windsor show that coloured glass was obtained from the Continent and that it was only 'white' glass that was supplied from the Weald (Salzman 1928, 188-9). By the 15th century, demand for coloured window glass was in decline, and by the end of the 16th century, when the Wealden industry was at its height, demand had dwindled still further. Wood records that the cullet heap at Knightons, operating in the 1550s, yielded 'less than a dozen' pieces of coloured glass from a total of around 12,000 fragments (Wood 1982, M48).

In the Weald, beech grew on the lighter soils of the greensand and particularly on the chalk scarp slopes bordering the region. The reference to beech in Henry Strudwick's will of 1557, referred to above, may be misleading in suggesting a general use of beech, since it is clear that the majority of Wealden glasshouses are situated in oak growing areas where the conditions of wet, clay soil are unsuitable for beech. Oak has been continuously predominant in the region since post-glacial times, and it has been suggested it is unlikely that soil conditions have changed over the past few hundred years (Wooldridge & Goldring 1953, 134-7). It therefore seems unlikely that the glassmakers had beech immediately available to them and that they would have relied on other wood species, mainly oak, for fuel and consequently for ash.

It is also significant that glassmaking was established in other parts of Britain where beech was not present, and where the product was white glass rather than coloured. At Hutton and Rosedale (North Riding) a number of different wood species was used for fuel, including oak, birch and willow, whilst at Wolseley (Staffs) the fuel was almost entirely birch (Crossley & Aberg 1972, 158; Welch 1997, 33). This supports the view that, whereas beech ash was of importance in making coloured glass, its special properties were of less importance in the manufacture of white glass. It is therefore suggested that, so far as the Wealden industry is concerned, the availability of beechwood was not an essential factor, and that its importance has been exaggerated.

Lime

Lime was an important ingredient of the batch, acting as a stabiliser to prevent decomposition through contact with water and for durability. Its importance in early glassmaking does not, however, appear to have been understood and its introduction to the batch appears to have been as a chance contaminant in the sand or ash components rather than as a separate constituent deliberately added to the batch. It was not until the end of the 17th century after extensive refining of materials in the quest to improve quality led to the elimination of lime, that it was found necessary to introduce it deliberately (Merrett 1662; Turner 1956a, 40).

The source of lime could be sand, as found in some Mediterranean glass making regions, where the sand used was notably calciferous. (Newton & Davison 1989, 57). But in most northern European glassmaking regions sand has been found to contain low levels of lime. Analysis of the sand found at Boyvin (Lorraine) indicated a lime content of 0.2% (Ladaique 1973, 94). In the Weald, a sample of sand from Ashurst Wood (East Grinstead) contained 0.43% wt. (Merchant 1998, 20) and samples taken from Loxwood, Lodsworth, Balls Cross and Graffham by the writer contained a lime content ranging from between 0.05% and 0.20% (pers. com. Dr K Watson, University of Portsmouth). This suggests that in forest glass, including that made in the Weald, lime originated from ash rather than sand, and is supported by experiments carried out by Merchant (1998, 192).

Analysis of the composition of ash from a range of burnt wood and plant sources referred to above (Turner 1956 c, 289T), indicates a wide variation in lime content. This seemingly random addition of lime has contributed to the diverse amounts found in forest glass, for example in the 486 samples of glass analysed by Barrera & Velde, and referred to above, lime concentrations varied from between 4.0 and 29.5% wt. (1989, 50). The optimum lime content was in the region of 10% wt., above which lowered resistance to weathering, and lack of control over this element was a significant cause of the poor quality of much early glass (Newton & Davison 1989, 143).

Recent research has drawn a distinction between 'medieval' and 'post-immigrant' glass based on the analysis of its chemical constituents, a characteristic of the later glass being that it has a higher lime content ('high lime, low alkali' type). It is not clear how a greater volume of lime was introduced without a corresponding rise in alkali concentrations, and raises the question of whether this was achieved by the introduction of a different ash source, or a lime product such as chalk or limestone, available locally from the Downs. This is a matter requiring research into lime-bearing sources available to the glassmakers and their behaviour when combined with other glassmaking ingredients at different operating temperatures.

Frit and fritting

Fritting was the first of the heat processes and involved heating the raw materials (sand and ashes) to a temperature of around 850° C. until they fused together in lumps (Newton & Davison 1989, 61). Stirring the raw materials during this process enabled the formation of more regular granules and facilitating a faster reaction during melting (Welham 2001, 48, 142). During this process waste organic material was burned off and physical and chemical reactions between the constituents were initiated.

Recent experimental research has sought to understand the function of fritting in the glassmaking process and to assess its advantages (Smedley *et al.* 1998; Welham 2101). It was found that fritting led to a decrease in batch volume, which meant that the number of times the crucible had to be re-charged during melting could be reduced. A change in colour of the batch during the frit process enabled progress to be monitored by practised observation. The material produced by fritting was denser, less volatile than ash, and consequently less likely to combine with furnace materials to cause corrosion to furnace fabric and possible contamination of the molten glass. Frit will heat up faster than basic batch materials to form a glass that is more homogeneous. Another advantage of the fritting process was that it could be made in advance and stored until needed.

The fritting process is described by Theophilus (Dodwell 1961, 40) and frit is frequently referred to by Merrett (1662, passim). A list of items needed for glassmaking at Knole (Kent) in 1585 included, '...iii busshels of fretyng glas...' ERO. D/DL E. 77), but little archaeological evidence for fritting has been found in the Weald. Wood comments that Furnace 3 at Knightons, was '...liberally scattered with lump glass, frit and scum from fritting...' (1982, 9), though, from an inspection of some of this material in Guildford Museum, it is possible that some could be scum or weathered furnace material. Nor has frit been found at sites outside the Weald, for example at Bagot's Park (Staffs) where Crossley suggests that, if left on site, it would soon cease to be recognisable (Crossley 1967, 62). However, it has been assumed that one of the purposes of the subsidiary furnaces found at glasshouses such as Blunden's Wood (33), Knightons (42) and Vann Copse (35), was the preparation of frit.

The grinding, or pulverising of frit, when cool and before being placed in the crucibles for melting, is not mentioned by Theophilus, but it has been suggested that this would have provided a more homogeneous mix (Welham 2001, 48). The mixing of frit and cullet in a long wooden box is illustrated by Diderot & D'Alembert (1772, 10, Planche XVII).

Cullet

Cullet was obtainable either as manufacturing waste in the form of shearings, knock-offs, drippings and breakages; or as recyclable scrap, such as glaziers' off-cuts or broken vessels, brought in from elsewhere. This last category may be identified as glass having signs of previous use, such as traces of paint or grozed edges, or as glass having a distinctly different appearance from that produced on site, when compared with manufacturing waste and glass found on crucible and furnace fragments. It is particularly important to distinguish between these two sources of cullet when selecting samples for analysis.

The addition of cullet to the batch assisted in the melting process by reducing the melting point and by forming a nucleus around which the new glass was formed (Marson 1932, 12; Newton & Davison 1989, 54). Cullet was also used for reasons of economy to add bulk to the volume of the batch, and there is no theoretical limit to the amount that could be used.

The demand for cullet led to the development of a small trade in the collection of offcuts and unwanted glass from glaziers' workshops for sale back to the manufacturers. It is probable that glass-carriers brought glaziers' cullet back to the Weald on their return journeys after delivering new glass to the London market. An indication of the value of cullet can be gauged by the price quoted in 1620 by the London glaziers to Sir Robert Mansell of 11*s* per barrel (PRO. SP14/113 n. 50). Mansell attempted to increase the supply of cullet from his glasshouses in Newcastle by supplying window glass cut to size in quarries rather than in the usual stock sheet form. This caused a reaction from the glaziers who complained of having to pay higher prices, suffering delay and loss of profit by not cutting the glass themselves (BL. Harl. MS. 6847/269-74). The value of cullet is further illustrated by the fact it was found worthwhile to export it across the Channel for use by glasshouses in Normandy. In 1611, nine barrels of 'broken glasse', valued at 12*s*, were exported from Littlehampton/Arundel to Rouen, and between May and September 1613, 12 barrels were sent from the port of Meaching/Lewes to Dieppe (PRO. E190 755/22; 756/21).

The volumes of glass found at Wealden sites are not large, an exception being Knightons (42), where, as mentioned above, 12,000 glass fragments were found possibly because the site was abandoned at short notice, or forced to shut down (Wood 1982, M9-10). Coloured glass found in the Weald is invariably cullet and appears more commonly in association with medieval sites such as Fromes Copse (5) and Malham Ashfold (29), in operation at a time when coloured glass was more commonly in use. But it is possible that it was found that the addition of coloured cullet to the batch adversely affected the quality of glass in some way and was therefore rejected by the glassmakers.

Kenyon has commented on the fragmentation of glass found at Wealden glasshouses, suggesting that this may be partly explained by the glass being blown too thin and some being crushed by early investigators (Kenyon 1967, 89). However, the writer suggests an alternative explanation relating to the collection and preparation of cullet. Cullet was transported in barrels and it would have been possible for a greater volume of glass to be contained in a barrel if it had first been broken down into small pieces; this would have been particularly so in the case of vessel glass. Before being used in the manufacturing process, it would have been reduced to small pieces to facilitate mixing with frit, a process illustrated by Diderot in the 18th century (1772, Planche XVII). However, the fragmentation of glass found at Wealden sites does not appear to be a characteristic found elsewhere, for example at Woodchester (Gloucestershire) and Hutton and Rosedale (N Riding) (Daniels 1950, 20; Crossley & Aberg 1972, 129), and may indicate different circumstances in cullet collection. Whereas the Wealden glasshouses relied on their supplies from the London market, involving large quantities from one main area, at Woodchester and at Hutton and Rosedale, cullet retrieval is likely to have been on a smaller scale from a wider area entailing smaller loads.

Coloured Glass

Apart from examples of coloured cullet, only two instances of possible coloured glass manufacture have come to light in the Weald. The first of these is a piece of crudely flashed ruby glass found at the medieval site of Malham Ashfold (29): here, a lump of copper was also discovered and it has been suggested that this represents an attempt at window glass manufacture. The other example comes from the post-1567 site at Lower Chaleshurst (4) and is a small crucible, approximately 0.22m in diameter, containing a deposit of ruby glass in the base. Glass fragments with applied ruby decoration were also found at this site and it is probable that the ruby was experimentally manufactured for this purpose (Kenyon 1967, 88, 161, 190). Winbolt's reference to copper clinker and flashed ruby at Idehurst Copse South (17) is not confirmed by Kenyon who assisted him in examining the site (Winbolt 1940, 156; Kenyon 1967, 178). There is no further evidence of coloured glass manufacture in the Weald, and included in a list of twenty 'Articles of obieccons...', dated 1621, to Sir Robert Mansell's patent, is the statement '...coloured glass which was never made in England...' (BL. Harl. MS. 6847/274).

Analysis of main constituents

The analyses of Wealden glass carried out under the auspices of Kenyon and Wood some 40 years ago, aimed at determining whether chemical differences in glass samples taken from apparently medieval and post-immigrant contexts could be used for dating purposes. The results of glass sample analyses undertaken at that time are reproduced in Table 1, as follows:

Table 1: The composition of Wealden glass (% wt.)

Glasshouse site	date	Na_2O	MgO	SiO_2	K_2O	CaO	Fe_2O_3
Malham Ashfold[1]	early	2.3	6.7	56.0	11.1	15.0	0.5
Blunden's Wood[2]	early	3.4	6.9	57.0	9.0	17.5	1.3
Wephurst Copse[1]	early	2.2	3.6	56.7	6.3	23.0	0.4
Knightons[3]	early	1.7	5.8	56.9	10.0	15.7	0.8
Glasshouse Lane[1]	late	0.4	2.6	64.7	4.7	20.8	0.7
Sidney Wood[1]	late	1.2	2.7	59.5	4.4	24.9	1.0

([1]Kenyon 1967, 39; [2]Wood 1965, 67; [3]Wood 1982, M44).

Table 2 illustrates the wide variation in proportions of the various constituents given in Table 1:

Table 2: Range of concentration of constituents in Table 1

	Na_2O	MgO	SiO_2	K_2O	CaO	Fe_2O_3
Minimum	0.4	2.6	56.0	4.4	15.0	0.4
Maximun	3.4	6.9	64.7	11.1	24.9	1.3
Variance %	750	165	15.5	152	66	225

Kenyon, who had noted the superior quality of glass of the post-immigrant period, expected the improvement to be attributable to the use of soda as an alkali. This idea was based on the knowledge that soda was used in the manufacture of the finest contemporary glass, and on the evidence of Carré's stated intention that he was '...sending for soda from Spain...' (PRO. SP15/13 n. 89). The above analyses did not show the expected result, and demonstrated that it was not soda that had brought about the improvement in quality. Furthermore, it was noted that the post-immigrant glasses contained considerably less total alkali (K_2O + Na_2O) and significantly more calcium than the early glass, signalling a marked change in composition.

Recent research has helped to explain the difference between early forest glass and post-immigrant glass in terms of its chemical structure. Analysis carried out by Mortimer (1991) of glass samples from the City of London and Little Birches (Staffs) are discussed in Welch (1997, 38-43). These analyses show that towards the end of the 16th century a major change took place in the composition of forest glass, characterised by a significant increase in lime content, accompanied by a decrease in total-alkali, including potash. High-lime, low-alkali (HLLA) glasses of this kind also have visually distinctive features noted by Kenyon in his description of glass he found at Sidney Wood: '...the shiny burnished glass was largely fine quality thin vessel, usually a dark olive or blue-green, completely uncorroded and showing no weathering...' (Kenyon 1967, 203).

Referring to Table 1, the samples from Wephurst Copse, Glasshouse Lane and Sidney Wood are all of the HLLA type, indicating a post-1567 date. This challenges Kenyon's dating of the Wephurst Copse glasshouse which he refers to as 'unmistakably early', based on the quality of the glass found there (Kenyon 1967, 181). A post-immigrant date for the site is also supported by pottery dated *c.* 1610 found by Kenyon and which puzzled him (ibid.).

In 2004, David Dungworth of the English Heritage Centre for Archaeology, kindly undertook to analyse examples of glass taken from Wealden sites by the writer. The sites from which samples were selected were Idehurst Copse North (16), Idehurst Copse South (17) and Tanland Copse (48), the first two having been discovered and examined by Kenyon and the third being a more recent discovery (1998). The Idehurst Copse North furnace is located in woodland and is likely to be in a well-preserved state, having been until recently protected beneath the roots of an oak tree. Idehurst Copse South, also in woodland, was described by Kenyon when it was found in 1938 as '...much dug about...', but there are still concentrations of material to be found on the slope that runs down from the furnace remains to the stream. Tanland Copse is in a shaw, and although undercut and eroded by a small stream has not been disturbed by excavation.

A significant reason for selecting samples from these glasshouses was that all three are mentioned in contemporary documents and can be linked to known glassmaking families. The Idehurst glasshouses are on land farmed by the Strudwicks from the middle of the 16th century. Henry Strudwick's will of

1557, referred to in chapter 3, associates him with Idehurst and with glassmaking. The family appears to have continued its involvement with the glass industry until the early 1600s when William, son of Henry Strudwick '...was pleased to worke in the glasse house where he the testator [Henry Strudwick] in former times did worke...' (WSRO. EpI/11/9 f. 120). Tanland Copse is the only glasshouse to have been discovered in the parish of Northchapel and is likely to be that operated during the last years of the industry by the Lorrainers Edward Hensey and Timothy and Thomas Tysack (PRO. APC.xxxiii, 658).

It is not known how samples were selected by the earlier researchers for the analyses referred to in Table 1, and only one sample appears to have been tested for each glasshouse. At the Idehurst sites and Tanland Copse, particular care was taken to select samples that could be identified as far as possible to be of Wealden manufacture rather than imported cullet. Samples were collected of 'working waste', such as lumps, drips and shearings, that could reasonably be attributed to site manufacture, as well as 'artefact fragments' that might either be of site manufacture or imported cullet. A summary of the samples selected by site, type and quantity are given in Table 3:

Table 3: Samples selected for analysis.

Glasshouse	Working waste	Artefact fragments	Total
Idehurst Copse (North)	5	8	13
Idehurst Copse (South)	8	3	11
Tanland Copse	10	7	17
Total:	23	18	41

(Dungworth & Clark 2004)

Examples of glass adhering to crucible fragments and furnace material, although probably manufactured on site, were excluded, since it has been shown they can be contaminated by reactions between the glass and the crucible ceramic or furnace brick/stone (Merchant 1998, 143; Dungworth 2003). All 41 samples were analysed, full details of which appear in Appendix 3. The most significant results are those relating to the 'working waste' samples which can be attributed to local manufacture with reasonable certainty: these were 23 in number and analysis of their main constituents appear in Table 4, below:

Table 4: The composition of the glassworking waste (% wt.)

Glasshouse		Na_2O	MgO	Al_2O	SiO_2	P_2O_5	K_2O	CaO	MnO	Fe_2O_3
Idehurst North	mean	2.1	7.2	1.1	55.3	3.2	11.6	17.0	1.1	0.6
(5 samples)	s.d	±0.2	±0.2	± 0.1	±1.8	±0.5	±0.6	±0.3	±0.1	±0.1
Idehurst South	mean	3.0	8.7	1.4	53.3	3.9	10.8	16.6	1.0	0.6
(8 samples)	s.d	±0.3	±0.2	± 0.2	±0.8	±0.1	±0.8	±0.5	±0.1	±0.1
Tanland Copse	mean	1.5	2.8	2.2	61.2	2.2	3.8	24.2	0.7	1.2
(10 samples)	s.d	±0.5	±0.2	±0.2	±1.1	±0.2	±0.8	±1.0	±0.1	±0.1

(Dungworth & Clark 2004)

The results in Table 4 above show a distinct difference between the composition of the Idehurst glasses and the glass from Tanland Copse: glass from both the Idehurst sites being of the medieval (forest glass) type and Tanland Copse of the post-immigrant high-lime, low-alkali (HLLA) type. At least one of the Idehurst sites is likely to have been in operation in the 1550s, and one, or even both may have continued to operate after the arrival of the Lorraine immigrants who worked the Tanland Copse glasshouse. The change in chemical structure of the post-immigrant glass supports the theory that the Lorrainers brought a new formula with them. The 'new' formula also substantiates the evidence relating to furnace design and crucibles, referred to in chapter 6, to suggest that a higher firing temperature in the region of 1,300° C. was used.

Whilst at Tanland Copse analysis of the artefact fragments and the working waste proved to be indistinguishable, suggesting all were manufactured there, at both Idehurst sites there were found to be inconsistencies. At Idehurst South, three artefact fragments (Table 5: IDS 9, 10 and 11) are of forest glass type but do not have the same chemical composition as the glassmaking waste samples and are probably cullet, possibly manufactured at another Wealden glasshouse. At Idehurst North, five of the artefact samples (Table 5: IDN 6, 7, 8, 11 and 13) are of HLLA type and are probably cullet brought in. They vary in detail from the Tanland Copse samples and are unlikely to have been made there, although it is possible they were manufactured at another post-1567 Wealden glasshouse nearby. The presence of these post-1567 artefact fragments suggests that Idehurst North was still producing glass during the immigrant period, while the working waste samples indicate that the old forest glass formula was still in use. This supports the documentary evidence, referred to above, that the Strudwicks continued to manufacture glass contemporaneously with the immigrants. It also suggests they operated in ignorance of the 'new' formula and supports the traditionally held view that the immigrant glassmakers operated under conditions of extreme secrecy and were reluctant to train Englishmen in their art (see chapter 4).

These analyses also question Kenyon's interpretation of glass found at his 'transitional' sites. There were three sites, Frithfold Copse (13) and the two Idehurst glasshouses (16 and 17), that he referred to as 'transitional' and he provides a definition of this term in his description of glass found at Frithfold Copse:

'There are some undoubted Late blue-green fragments, but there are some less good fragments, not yet typically early, which may be cullet but perhaps were made there. The glass is therefore difficult to classify and it does not fit neatly into either Early or Late dating, so I have taken refuge in 'Transitional' (Kenyon 1967, 172).

The above research suggests that glass made at the 'transitional' sites may have been manufactured by native workmen, using traditional forest glass methods, who continued to operate after the establishment of immigrant glasshouses, but who used cullet that originated from neighbouring immigrant glasshouses.

These examples have demonstrated the value of laboratory analysis in identifying different glass types and thereby assisting archaeology in the dating of glasshouse sites. Should the opportunity arise, it would be reassuring to establish firm dates for the three sites used in this study, applying archaeological methods on the ground.

8: Glassmaking: wood fuel

Introduction

Early researchers thought that charcoal was used in glassmaking (Pape 1934, 79), and even Kenyon, in an early article, considered '...the evidence in favour of charcoal is abundant...', a view he quickly corrected in a subsequent article (Kenyon 1939, 172). The mistake is easily made since charcoal is commonly found in and around glass furnaces, and is the remains of a fierce wood fire burning in a confined space. Charcoal would not have been suitable for use in a reverberatory furnace designed to direct long flames around and down on to crucibles containing the glass mix. There is no doubt from contemporary records and a study of glass furnace design that the fuel used was wood. Following the invention of a coal-fired process in England at the beginning of the seventeenth century, wood-fired furnaces continued to be used on the continent, particularly in France, into the nineteenth century (Cable 1998, 323).

The large volume of wood consumed by the furnaces was the main reason for locating them in thickly wooded areas such as the Weald and Staffordshire. Wood was a major item in the cost of production, and handling it through the various stages between cutting and burning was the most labour-intensive activity associated with a glasshouse. Selection of the most suitable wood from what was available, securing a sufficient amount for a forthcoming campaign, and its preparation, were all essential.

This chapter considers the fuel requirements of the industry, drying, the available sources of wood and examines the question of whether fuel for glassmaking was obtained from managed coppices.

Fuel requirements

Wood fuel took various forms depending on the particular circumstances of its use. Faggots and bavyns were used where heat was required for a comparatively short period, such as in firing pottery, brick making or the baking of bread. Wood billets were commonly used where a more sustained heat was needed, such as in the salt and dyeing industries, and for domestic heating and cooking.

The term 'billet' was used to describe wood of a particular type and size suitable for fuel. It could be of round wood or cleft timber and had to conform to overall standard dimensions. In 1601, 'an Acte concerning the Assize of Fewell' was introduced to formalise dimensions. The length of a billet was to be 3ft 4in and there were to be three categories depending on the circumference ('greatness') of the wood: 'single' having a circumference of 7½in, 'caste' 10in and 'two caste' 14in; all to be measured within one foot of the centre (Eyre 1811-29, iv, 981-2, 43 Eliz., c. 14). These regulations were presumably considered necessary to safeguard consumers where wood was being sold through merchants and suppliers. The glassmakers used wood of this general type, but would have used dimensions suitable to their particular needs and availability. The length of the billet is referred to by Månsson (*c.* 1530) : '...the furnace should be 1ft 8in [51cm] broad. You should stoke it with dry wood, the length of which corresponds to the inner breadth of the furnace...' (Winbolt 1933, 78). The method of feeding the furnace is not described by Månsson, so it is not clear why he stresses this relationship, but it could mean that it was intended that billets would be laid horizontally across the hearth. If this is so, it is of interest to note the internal width measurements of other furnaces. For example, at Blunden's Wood (33), an early site, the melting furnace measured 0.6m across. Later furnaces were wider: Fernfold (25) being 0.74m, and Knightons (42) 0.76m (Wood 1965, 58; Kenyon 1967, 188; Wood 1982, 8). In Lorraine, Ladaique states that the length of billet was 22in long, '*...billettes de 22 pouces de long...*', (0.56m) (Ladaique 1973, 86). Billet length was clearly important in relation to the type and size of furnace, since it enabled the operative to feed the fire in such a way as to burn with the greatest efficiency. This point is made by Diderot, and although writing in a later period and about a furnace of very different design, seems relevant. He states that length of the billet should vary according to the size of the furnace, and should be of sufficient length so that when fed into the stoke-hole, it would rest at an angle between the stoke-hole and the hearth floor. It was in this sloping position that optimum combustion would take place (Diderot & D'Alembert 1765, 136).

These dimensions suggest that cord wood of 4 feet in length (1.22m) could be used when cut in half. The use of cord wood is recorded at Knole (Kent) where the woodcutters delivered to the glasshouse '...cords of log wood..' and '...clefte cords...' (ERO. D/DL E77). Sir Robert Mansell's statement against the petition of Isaac Bungar (1622) refers to '...no wood fit to make Glasse, under 20 yeares groath...', suggesting that wood of around 4in (0.10m) in diameter was used (PRO. SP16/62/231b). However, Diderot recommends a thinner substance of wood of between 0.10 and 0.15m in circumference (*quatre ou six pouces de tour*) (Diderot & D'Alembert 1765, 136). Wood of small diameter such as this was preferable to thicker logs that would not combust so quickly.

Drying

Accounts of glassmaking from medieval times to the 19th century all stress the importance of using 'dry' wood. This was necessary for several reasons. In the melting furnace it was essential for fuel to burn with the hottest flame, in order to achieve and maintain the high temperatures necessary to melt glass, usually between 1,100 – 1,400° C. This called for a strong and vigorous flame completely engulfing the crucible to provide an even and constant distribution of heat to the glass. It would not be possible to achieve these temperatures and to maintain them consistently if damp wood were used. The introduction of damp wood into a furnace at working heat, would lower the temperature sufficiently to render the mix temporarily unusable, causing delays in production. Fluctuations in temperature would have been harmful to the crucibles and structure of the furnace, and Cable has concluded that a drop in temperature by more than 200-300° C. could seriously affect the working life of a furnace (1998, 317). Damp wood was also likely to 'spit', leading to possible ash contamination of the glass and furnace. The smoke produced by damp wood could also affect the quality of the glass itself, and Turner has indicated that in some situations wood burned when green, can produce sufficient carbonaceous material to act as a reducing agent and cause discolouration of the glass (Turner 1956c, 293-4 T). Smoke would also have been a hindrance to the operatives.

Wood cut during the winter cutting season and dried under natural atmospheric conditions would not be ready for use until at least the Autumn, despite having the benefit of the summer months for drying. It is likely that soon after cutting, wood would have been moved to the glasshouse, where it could be stored under the supervision of the glassmakers, since it was necessary to ensure that there was a sufficient supply of fuel well in advance of the start of a campaign. When Albert Hensey was preparing to make glass near Wisborough Green (1606), he '...did to his greate costes and charges provide and bringe to the saide glasshouse greate store of wood and other commodityes used for the makinge of glasse...' (PRO. STAC8/179/7). And after the prohibition of wood fuel, the glassmakers pleaded that '...either they be given time to use their materials already prepared [including wood], or the patentees be ordered to pay reasonable prices for them...' (PRO. APC.xxxiii, 668-71). Paul Vinion stated that he had stocks of wood and other materials to the value of £250 which he reckoned was sufficient for 14 months production (PRO. SP14/105/16).

There is some evidence to suggest that logs and poles were split, creating a larger surface area exposed to the air, to accelerate drying. The indenture of 1385 between the bailff of Atheryngton and Robert Pikeboussh and John Shertere, refers to permission to cut down and 'cleave' underwood (SHC. 105/1/117). And at Knole, in 1587, '...clefte cords...' were delivered to the glasshouse (ERO. D/DL E77). However, there is no record of wood being de-barked at this period, although it became customary to do so later on. Diderot comments that bark conserves humidity, prevents instant combustion and gives off smoke, and goes on to emphasise the need for wood that is dry and most favourable for immediate and perfect combustion (Diderot & D'Alembert 1765, 136).

The use of dead wood was not favoured because it does not burn so vigorously and has a tendency to absorb moisture, although had it been suitable, it would have helped to preserve stocks of live wood. In Lorraine, in the late 1500s, steps were taken by the authorities to encourage the use of old and dead wood in glassmaking, but these attempts were strongly resisted by the glassamkers who preferred 'live wood from the largest trees in the forest' (Ladaique 1973, 86).

It seems clear from several sources that wood was brought into the heat of the glasshouse for a final drying perhaps 24 hours before use. Theophilus refers to making a fire of '...beechwood logs, thoroughly dried in smoke...' , suggesting that wood was placed over a fire to dry out (Dodwell 1961, 39), and the early fifteenth century John Mandeville drawing illustrates how wooden billets were stacked on racking above the furnace to dry (Fig. 19, p. 194). Ladaique refers to a sixteenth century document describing the glasshouse at Saint Vaubert (Lorraine) in which an area seven metres long between two workstations was set aside to stack wood (1973, 74, 86). Wood billets drying in racks under the roof of a glasshouse is illustrated by Diderot & D'Alembert (1772, Tom 10, Pl. I). During the early 19th century, when wood-fired furnaces acquired their greatest degree of sophistication, purpose-made kilns with independent heating systems were constructed adjacent to the glass furnace to thoroughly dry wood so that it would combust instantly when placed in the furnace. During the 1830s a detailed description of wood-drying at the Royal Würtemburg glasshouse

Fig. 19 Medieval forest glasshouse

Drawing of an early fifteenth-century forest glasshouse (probably in Bohemia) illustrating the processes involved in making glass vessels: collecting and preparing materials, drying wood on a rack to the right of the furnace, blowing glass, annealing, inspecting the finished product and packing.

(from Sir John Mandeville's *Travels*, BL Add. Ms. 24189 f. 16)

(Germany), was recorded by Kirn together with details of his experiments into the preparation of wood fuel (pers. com. Prof M Cable).

Archaeological excavations of glasshouses in the Weald have so far failed to produce evidence about methods of drying wood, but excavations elsewhere have provided clues about how this may have been done. During the excavation of Little Birches (Staff), pairs of post pits were discovered at both ends of furnace 1, south site, (Welch 1997, 7-10, 11), and at Bagot's Park (Staffs) post-holes capable of taking substantial posts, 15in. (0.38m.) in diameter, were found (Crossley 1967, 59). These features have been interpreted as placements for posts to support the glasshouse roof, however, it is questionable, from the evidence of contemporary timber-framed buildings, whether supports for roof-trusses would have been necessary in structures of this size. It is also likely that posts positioned in the centre of a glasshouse would have caused obstruction to the operatives. It is therefore suggested that these posts were supports for racking that extended above and over the furnace for the purpose of drying wood.

Fuel consumption

Very little is known about how much fuel was used by a Wealden glasshouse. Clearly usage would depend on the number and size of furnaces in use and on the length of a campaign. As mentioned in chapter 6, furnace design and layout evolved, making furnaces of the post-immigrant period more fuel-efficient. The medieval glasshouse at Blunden's Wood had a melting furnace with a hearth at each end and two subsidiary furnaces for the low temperature processes. By comparison, the later glasshouse at Vann Copse (*c.* 1580s), although not typical of Wealden glasshouses, had one central furnace with 'wings' in which the subsidiary processes were carried out, probably using heat drawn from the main furnace. Such an arrangement must have led to savings in fuel as well as labour in stoking and handling wood. However, some winged-furnaces appear to have had self-contained fires within the 'winged' area. An example being Hutton (N Riding), where the excavated floor of the north-east wing had a surface of 'hard baked red clay' which may be an indication that a fire had burned there (Crossley & Aberg 1972, 126). Merrett also comments on the use of winged-furnaces: '... the Green Glass furnaces are made square...having at each angle an arch...' and '...they make fires in the arches, to anneal their vessels, so that they make all their process in one furnace onely...' (Merrett 1662, 243-4).

For an indication of rates of fuel consumption by a Wealden glasshouse, reliance has been placed on a reference in the Lennard papers to the glasshouse operating at Knole (Kent), between 1585-87 (CKS. D/DL E77; Lennard 1905, 127). This document provides details of wood, in cords, delivered to the glasshouse between 7th June 1585 and 19th February 1586, and has been used by Godfrey to suggest a weekly consumption of 18 cords per week (1975, 191). However, these figures must be used with caution. Firstly, they refer to wood '...carted to ye glasshouse...' with no indication that it was for immediate use. Around half (231) of the 452 cords used in Godfrey's calculation were delivered between 7th June and 3rd September, a period when it is most unlikely glassmaking would have been in progress since this was the time of year when the furnaces were shut down for repairs: '...at certain times of the year as at the height of summer, the furnaces will be out for 8 or 10 weeks because during the great heat...' (PRO.

SPDom. 12/43, No. 104; Kenyon 1967, 47). It is not clear whether the wood referred to was newly cut or whether it had been cut, perhaps during the previous spring, and stored elsewhere before being delivered to the glasshouse. The latter alternative is more likely since most forestry work took place during the winter, and it would have been necessary to allow time for the wood to dry out during the summer months. A further entry in the Lennard papers, dated 17th November 1587, in which Pulston, the steward, complains that the woodcutters '...do not sett upp the cords halfe so fast as they are caryed away...', suggests the wood was newly cut, in which case an interval of several weeks would have been needed to allow the wood to dry out before it could be used (Lennard 1905, 129).

No details are provided about the type of furnace in use at Knole, though Kenyon has suggested that window glass was being made for Knole house itself (Kenyon 1967, 47), an idea that is supported by the 1570 survey of Knole in which the poor condition of the window glass is mentioned: '...the capitall house of Knole is in meetlie good repaire savinge for glasse...' (CKS. U269/E336/3).

Information about the amount of wood used by forest glass furnaces in England and on the Continent is sadly lacking. In her account of the glass industry in France, Foy comments on the absence of facts about this important aspect of glassmaking, and refers to a master glassmaker in Catalonia who used the equivalent of 328 tonnes of wood in six or seven months (Foy 1989, 42). Assuming that one tonne of wood is approximately equal to one cord, this would mean a daily usage of $1^2/_3$ cords a day. However, the absence of details about other factors needed to interpret this information, such as the size and number of furnaces at work, make the value of such calculations questionable.

Godfrey ventured to estimate the annual consumption of wood by a glasshouse at between 900 and 1,000 cords, based on a usage of 18 cords per week deduced from the Knole house accounts referred to above, multiplied by an estimated number of weeks worked during the year (Godfrey 1975, 191). If it is accepted that the Knole figures are approximately correct, then it is necessary to amend Godfrey's estimate for the number of weeks worked downwards to account for the glasshouse being shut down for several months for repairs and rebuilding during the 'great heat'. Perhaps a more realistic estimate would be a rate of between 500 and 600 cords a year, representing operation of the furnace over a period of 30 weeks. This compares with approximately 4,900 cords used by an average Wealden iron furnace producing 200 tons of iron bar a year (Hammersley 1973, 603).

Wood type

Norden refers to the Weald of Surrey, Sussex and Kent as the 'grand nursery' of timber trees, '...especially Oake and Beech...' (1607, 214). Oak was the predominant species from around 7,000 BC onwards thriving on the damp, heavy clay soils of the Weald. It was not until about 2000 BC, when the climate became drier, that beech appeared and began to colonise the slopes of the north and south Downs where soils were lighter (Wooldridge & Goldring 1953, 131). Beech made incursions into the drier zones of the Weald, but was not able to cope with the wet and water-logged soils common in areas of heavy clay.

Research by Watt has demonstrated how the spread of beech woods into the Weald has been restricted because of the adverse affect on this species of poorly oxygenated conditions on germination (Watt 1923, 28). Oak, on the other hand, is more at home in wetter soils where it predominates over beech. Recent analysis of pollen samples taken from hammer ponds operating in the area during the 16th century confirms the dominance of oak, though the site at Burton Mill contained a significant presence of beech, possibly reflecting close proximity to the chalky soils of the south Downs (Evans 1991, 340). The same overall pattern of distribution exists today, with oak predominating on the wet clay soils of the Weald and beech prevailing on the drier soils of the north and south Downs (Manning 1974, 100).

During the medieval and post-medieval periods, the species of oak growing in the Weald were *Quercus robur* and *Quercus petraea* (Evelyn 1662, 22, uses the term '*Quercus Urbana*', which Allen Coombes of the International Oak Society confirms is the species now referred to as '*Quercus petraea*'). Both of these species are present today, but the woodlands now also contain other oak species such as *Quercus cerris*, introduced in the 18th century. Most of these more recently introduced varieties have the advantage of comparatively fast growth, but lack the strength and enduring qualities of the traditional 'English oak' varieties. The variety of beech in the Weald is *Fagus sylvatica*, the only beech species ever to have been native to the United Kingdom.

Beech has traditionally been regarded as the favoured wood species for glassmaking: not only did it burn well, but it possessed properties that made it particularly suitable as a source of alkali for the batch. Reasons for the choice of beech as a source of ash are discussed above in the context of glassmaking, rather than as a fuel which is the subject of the present chapter (see chapter 7). As a fuel, beech wood was considered among the best for use in a glass furnace. According to Diderot '...of all species, that which produces most flame and the greatest heat is undoubtedly beech and ash, particularly the former...': oak, he says, '...cannot be compared with beech for glassmaking since it tends to carbonise and produces little flame and therefore little heat...' Diderot & D'Alembert 1765,136).

The 1557 survey of the Petworth estates carried out by Richard Hogynson, John Dudley and Theo Wiseman, gives particulars of large quantities of oak and beech growing together in the same woodland area (WSRO. PHA1409; 1410). Oak and beech appear to have grown happily together in 'The Mens', an area of ancient woodland lying to the south of Kirdford that has undergone little change since pre-medieval times (Tittensor 1978, 357). These two species are found together on lighter soils where conditions are favourable to beech, but it is notable that oak predominates in the vicinity of the great majority of glasshouses located in the damper areas of the Low Weald. Wooldridge & Goldring have indicated that it is most unlikely that soil conditions have changed over the past few hundred years, suggesting that oak has been continuously predominant in the region since post-glacial times (1953, 134-7). This casts some doubt on the traditionally-held view that the glassmakers used beech wood for fuel (Kenyon 1967, 45-6), since it would be uneconomic to transport large volumes of wood long distances.

Some tree species are more responsive to coppicing (discussed below) than others. Oak produces good results and can withstand repeated cutting into biological old age. Coppiced oak had a wide range of uses depending on age and size from the smaller timbers in house construction, fencing, wood fuel and charcoal: oak bark was much in demand for tanning. Beech is not a species that coppices vigorously and only has the ability to do so in young trees when the stump is small (Buckley 1992, 18, 25).

Landownership

One of the main reasons for the establishment of the glass industry in the Weald was the presence of extensive woodlands as a source of fuel. A glasshouse could be set up at relatively little cost, making it possible to move to a different location after fuel in the immediate area had been used up, but access to a continuing supply of wood cannot have been easy. During the Middle Ages, land tenure became based on a tradition of gavelkind and partible inheritance in which partitioned holdings became the subject of a variety of leasehold and partnership agreements. It was not uncommon for the rights to underwood in an area of woodland to be leased to one party, whilst rights to timber were retained by the owner and rights to other uses such as pannage being let to yet another party.

The two 14th-century deeds referred to in chapter 3 illustrate the dependence of a glasshouse on its woodlands. The first (1380), records the appointment by John Schurterre's wife Joan of John Glasewryth of Staffordshire to help operate the glasshouse in which he was to receive half a share in the enterprise, including '...the underwood growing or being in the aforesaid place called Shuerewode and Strowykeswode...' (SHC. G105/1/117: Kenyon 1967, 31). The word used here for underwood is *suboscus,* the term used for all forms of growing wood that is not timber, and includes 'tops' and 'lops' from mature trees, coppice wood, thinnings and smaller species such as holly, alder and hazel (Rackham 1995, 10). The second is dated 1385:

'...indenture between Richard Suzonne, bailiff of Atheryngton, procurator of the abbot and convent of Séez, of the one part, and Robert Pikeboussh and John Shertere, of the other part: witnessing that previously the said bailiff had granted to the said Robert all the underwood of Souzwoude and Stroudwikeswoude, with free ingress and egress to make of the said underwood in the said wood a 'Glashous' and to use it as the office of 'Glasiere' requires, for a certain term, now expired: and that the said Bailiff hereby grants to the said Robert and John all the tenement of the said underwood in the wood aforesaid not cut down or expended, to have, cut down, cleave and expend it ...'.

Here, the glassmakers appear to have had permission to set up a glasshouse with rights to the underwood in the surrounding woodlands. It is interesting to note that the terms of the agreement included an extension to the contract period, for an additional sum, if all the available underwood had not been used up (SHC. G105/1/119: Kenyon 1967, 31-2).

By the middle of the 16th century, glassmaking was in the hands of two local yeoman families, the Peytowes of Chiddingfold and the Strudwicks of Kirdford, referred to in chapter 2. Both families were substantial landowners, principally engaged in farming, but with interests in other pursuits including iron forging and glassmaking. It is probable they would have had access to wood from woodlands on their own lands giving them an advantage over those who had to rent woodlands or buy wood from others. Kenyon estimated that in 1627, 26%

of the acreage of the average Kirdford farm contained woodlands (Kenyon 1955, 101). This would mean that of the 350 acres farmed by the Idehurst Strudwicks, where there is known to have been at least two glasshouses (Idehurst Copse North and Idehurst Copse South), around 90 acres would have been wooded.

The immigrants that arrived after 1567 were not permitted to purchase land and had to rely on obtaining supplies of wood from the landowner on whose land they had set up their glasshouse, or to purchase on the open market from other owners of woods and possibly from the woodmongers. The woodmongers acted as merchants, procuring wood and timber to provision the urban market, mainly London. It is not clear what role they performed locally, other than as buyers, and it is probable that local consumers would have sought to bypass them to trade direct with local suppliers rather than pay a merchant's commission.

Ideally, wood from an area adjacent to the glasshouse was purchased from the landlord, as in the instance of John Shertere quoted above, and this appears to have been the practice at Bagot's Park (Staffs) (Crossley 1967, 45-8). However in circumstances where wood in the surrounding area had been used up, or was earmarked for another purpose, it would have been necessary to buy in wood from elsewhere. This seems to have been the case in the example of Albert Hensey, who entered into an agreement (1606) for three years, in payment of a rent of £3 a year, for land on which he had a glasshouse. No reference is made to rights to wood, which he probably had to obtain from elsewhere: '...and beinge soe therof possessed did to his greate costes and charges provide and bringe to the said glasshouse greate store of wood and other commodityes used for the makinge of glasse' (PRO. STAC8/179/7). Another indication that glassmakers were having to buy wood from suppliers other than their landlords is found in the will of Samsonn Coulstocke, yeoman of Kirdford, who refers to £25 owed to him for wood by 'Mr Bonngard' [Bungar] (PRO. PCC 67 Dixy).

The need to buy wood fuel from others was a distinct disadvantage requiring forward planning to ensure continuity of supply. Wood had to be purchased well in advance of a campaign, incurring liability for payment before glassmaking had started. This problem is well illustrated in the case of Paul Vinion who had bought wood and other materials just before the introduction of the ban on making glass with wood fuel:

'...before your Majesty's proclamacon of restrainte from the saide trade your petitioner had provided and laid to the value of £250 in a stock of wood and other materialls to be imploied and used in his trade of glasse making for the which stock hee standeth still indebted unto divers of his friends to whome he is no waies able to make payment or satisfacon nor keepe and maintaine him selfe from [insolvency] and out of prison..' (PRO. SP14/105/16).

Isaac Bungar, as a native born Englishman, was able to buy land and entered into a number of transactions involving woodlands. In 1612, he bought '...certayne woode or trees...' in partnership with Thomas Knight and Edmunde Freeman for the sum of £174 6*s*. of which Bungar's share was £79 1*s* 6*d*. The partnership was later joined by William Martin, who contributed £20. In a further transaction, in 1614, Bungar, in partnership with Knight and Martin, bought more woodlands for £105, his contribution being £53 11*s* 8*d*. In 1620, a case was heard in Chancery in which Bungar pleaded that Martin, who had assumed responsibility for managing the woodlands, had sold '...plankes, bordes, lathes and timber...' and failed to pass on to Bungar his share of the profits. These sales appear to have taken place after the prohibition of wood fuel and suggest that Bungar was endeavouring to derive an income from wood sales while at the same time keeping possession of his woodlands. In so doing, he may have hoped that his long drawn out legal battle over the question of wood fired furnaces might eventually go in his favour and he would once again be able to use his woods for glassmaking (PRO. C5/593/19). The total purchases of woodlands by Bungar must have been extensive, since he sold woodland valued at £500 to Lionell Bennett in 1615 (PRO. C54/2277; Godfrey 1975, 56). Undoubtedly the main motive for Bungar's purchases was to secure supplies of fuel for his glassmaking interests, but landownership was also an outward display of his success, and in the legal proceedings of 1620, Bungar is referred to as 'Gentleman'.

Coppicing

Coppicing is the process by which broad-leaved, underwood trees are cut near ground level so that they can grow again, producing several stems from the stools or suckers which can be cut again after an interval of years, depending on the species and the thickness of wood required. This is an on-going process in which woodlands may continue to provide repeated cuttings over many years (Mutch 1998, 139; Rackham 1995, 222).

The principles of coppicing were understood in ancient times and became widely practised in the Middle Ages. Rackham considers most woodlands in the medieval period to have been of the 'coppice-with-standards' model in which the underwood was cut from time to time to provide an income while the timber trees were retained as a longer term capital investment (Rackham 1995, 61-4). The attraction of a quick cash return derived from coppicing, combined with the conversion of woodlands to agriculture, came to be regarded as a threat to timber production. An Act for the Preservation of the Woods (1543) was an attempt to overcome this problem by requiring that at least twelve timber trees, or standards ('standels'), were to be left on each acre of woodland cut over (Eyre, 1811-29, iii 977-80, 35 Henry VIII, c. 17). This Act recognised both wood and timber as valuable natural resources, and was the first of a series of statutes aimed at the 'preservation of the woods' through better management.

The 'coppice with standards' model favoured the cultivation of timber trees since the growth of vigorous underwood suppressed the development of lower branches causing them to strive upwards to produce tall, straight trunks, ideal for timber. Coppiced underwood also thrived under these conditions, growing rapidly and producing straight poles as they strove towards openings in the canopy above (Rackham 1995, 70).

Essential to coppicing was the enclosure of an area after cutting to protect the new growth from browsing animals. Fitzhertbert advises:

'...before you fell your wood...you must make a good sure hedge that no manner of cattell may get in, and as soone as it is felde, let it be carried away before the spring come up, or else the cattell that doth carry the wood will eat the spring and when the top is eaten or broken, it is a great hurt and hindrance with the goodness of the spring...' Fitzherbert 1598, 98).

It was common for leasing agreements to contain clauses requiring an area of woodland to be enclosed after cutting to protect the new growth from browsing animals (PRO. PRC66/1032/76), and the mention of 'enclosure' in documents about woodlands is often a sign that coppicing was being carried out or intended in the future. The Customary of the Manor of Shillinglee allowed tenants to '...fence and keep out deer upon their copyholds...' (WSRO. Burrell MSS. MF 77/146). And in 1613 the Earl of Northumberland enclosed a parcel of land at Petworth '...for making a new Springe for the better preservacon of woodes there...' (WSRO. PHA5668). Failure to provide adequate enclosure, or the misuse of enclosed woodlands, could lead to disputes such as that entered into between Sir Thomas Leedes and Thomas Ingram in 1612. Sir Thomas accused his tenant, Thomas Ingram, of having '...putt his cattell into the said places where the Copses grew and did utterly destroye the growth and springe of the said copses...' (PRO. C2 Jas. I, L18//43).

Woodland in which coppicing was carried out usually contained underwood of several species and of variable growth and it is probable that woodlands were cut over periodically, at irregular intervals, depending on when the woods were considered 'ready'. The 'right' time to cut was a matter of judgement by the owner who needed to balance the possible output of his woodland in relation to the available outlets at the time. and took into account his need for income and opportunities for obtaining the most favourable prices. After cutting, the area was left to regenerate for an undetermined period until circumstances were favourable for a further cutting to take place.

Managed Coppice

Coppicing, as described above, produced wood of variable size, shape and species. This was generally satisfactory where most wood was used for domestic fuel or products such as fencing. However, enlightened landowners came to realise that with planning and more careful husbandry, coppice yields could be improved, and generate a more consistent output. The type and size of wood produced could also be more in keeping with the needs of a particular use, such as charcoal for the iron mills.

There were two main areas of development. Firstly, was the determining of a period of rotation depending on the wood species to be grown and the size of wood required. If, for example, there was a demand for oak of 15 years growth, the coppice woodland would be divided into 15 areas, or 'coupes': one coupe being cut each year in rotation to provide a continuous annual supply. Secondly, the use of one main wood species enabled greater consistency in size and product quality, a factor that was becoming increasingly important to specialist consumers such as the iron mills. Consistency in size and volume of yield was also beneficial to the wood producer who could handle his 'crop' more efficiently, and more easily plan labour requirements in advance (Mutch 1998; Rackham 1995, 63-6). The process of applying a systematic approach to coppicing represents a significant advance over traditional methods and is referred to as 'managed coppicing'.

It is uncertain when 'managed coppicing' was introduced, but in the following example from Cambridgeshire, dated 1356, it is clear that a planned system of rotation was in use, producing sustainable crops of wood:

'...a certain wood called Heylewode. which contains eighty acres by estimate. Of the underwood of which there can be sold every year without causing waste or destruction. eleven acres of underwood which are worth 55*s* at 5*s* an acre...a certain other wood called Liteond which contains 26 acres by estimate. Whose underwood can be sold every seventh year. And it is then worth in all £6 10*s* at 5*s* an acre...' (PRO. E143/9/2; Rackham 1995, 59).

In the second half of the 16th century, the coppices owned by Sir John Pelham in East Sussex appear to have been managed in an efficient and productive manner, producing regular supplies of wood suitable for coaling in connection with his iron mills:

'...I have certain iron mills and divers young and copised woods the which young woods I will that my wife for the better augmenting of her living shall take with ore and mine yearly during her life for the necessary making of sowes and iron within the said iron mills provided that she not take nor employ any of my great woods within any of my said manors and lands that is to say nay such of my woods there as have not been heretofore cut down within this forty years last past; also I will that my wife shall see all such woods as she shall cut down and employ to that use that the places where the wood stands to be incopsed for the preservation of the spring of that woodland for the better continuance of wood there' (Rice 1906, 146).

This describes a system of rotation producing wood fuel 'yearly' for the iron mills, and also indicates that coppices dedicated to underwood were apart from the 'great woods' where timber was grown separately and was to be left undisturbed as a long-term investment.

The available evidence suggests that 'managed coppices' were developed in association with iron mills. It was essential that iron mills had continuity of supply and for that reason, iron masters such as Pelham invested in woodlands from which they took a sustainable annual yield. Consistency in the size of wood was important for providing good charcoal, the optimum being up to 0.05-0.06m in diameter, from coppice of between 7-12 years growth (Cleere & Crossley 1995, 133). It was also desirable for the source of supply to be in the vicinity of the iron mills to limit transport costs and so that friable charcoal was delivered in good condition. These were prudent commercial reasons which encouraged iron masters to develop their wood fuel resources to the highest degree, and in which coppice management was most important. A system aimed at renewal of woodlands rather than their destruction appealed to a government concerned to promote a policy of 'preservation of the woods'. The enterprise shown by another iron master, Christopher Darrell, in the management of his coppices in Surrey was recognised in the Statutes of 1558 and 1581 in which an exception was made for an iron master whose '...woods have been preserved and copysed for the use of his iron works...' (Eyre, 1811-29, iv, 337; iv, 667). The example made of Darrell in the context of legislation, must have been intended as a clear signal for others to follow his best practice for producing sustainable supplies: but it is also an indication that coppice management was not widely practised at this time.

In his study of the Wealden iron industry, Straker found charcoal from several species of wood at iron making sites, mainly in the eastern Weald, and listed them in order of frequency of occurrence as follows: birch, oak, beech, hornbeam, ash. hazel, poplar, maple, plum (1931, 109-111). This diverse assemblage of species suggests little selection was taking place and that use was being made of whatever happened to be locally available from mixed woodlands. It is likely that by the second half of the 16th century, as the management of coppice woodlands developed, selection of wood species was taking place to produce consistency and fast regeneration. Pollen analysis carried out at 6 hammer ponds in the western Weald has shown that hazel (*corylus*) was the predominant underwood species from the 1570s when the iron mills were in operation, suggesting that selection and specialisation was taking place in the species used (Evans 1991, 357).

A move away from the traditional 'coppice with standards' model in which the cultivation of underwood and timber trees was separated, and as described by Sir John Pelham above, became a characteristic of managed coppicing. This was not only for organisational reasons but also due the fact that many underwood species grow better on their own. For example, hazel coppices vigorously but does not like shade which reduces the rate of growth, a problem that could be overcome by reducing the amount of shade from the tree canopy either by thinning out the standard trees or establishing separate coppice plantations. Contemporaries such as Arthur Standish understood the difficulty:

'...and whereas it is required by lawe that there should be certaine number of trees preserved, for timber, which is by few men performed, the reason is, that the dropping and shadow of them will destroy the underwood...': [he recommended] '...that rather the number of timber trees might be preserved in some corner of the spring, where they may be preserved from many dangers which they are subject to, as they are left in the spring...' (Standish 1613, 18).

The success of the iron industry in developing a sustainable supply of wood fuel of consistent quality was the means by which the industry was able to survive in the Weald and in other areas, such as the Forest of Dean, until the 18th C.. The industry became no longer regarded as a 'destroyer' of woodlands but rather as a 'preserver': John Evelyn 'no advocate of iron works', conceded that:

'...a Forge and some other Mills, to which he [Evelyn's father] furnish'd much fuel, were a means of maintaining and improving his woods; I suppose, by increasing the industry of Planting and Care...' (Evelyn 1662, 252).

This view was shared by Yarranton writing in the 1670s:

'...[it is said that] iron works destroy the woods and timber. I affirm the contrary; and that iron works are so far from destroying woods and timber, that they are the occasion of the increase there' (Yarranton 1677, 149).

The importance of wood fuel in iron making has been comprehensively discussed in recent times (Hammersley 1973; Cleere & Crossley, 1995). The recognition and understanding of the role of coppice management in the context of the iron industry has given rise to speculation as to whether such a system was used to provide fuel for the glass industry (Crossley 1994, 72). To answer this question it is necessary to examine the available information about woodland management in the western Weald at around the turn of the 16th century. Use has been made of local archive material and reference has been made to contemporary writers.

The most complete archive of an estate in the area is that of the Petworth estate of the earl of Northumberland, which had at least two glasshouses on its land. Three surveys of the estate have survived, for the years 1557, 1576-7 and 1610 (WSRO. PHA1409; 1413; 1451). A later review of the estate entitled 'a view of my business at Petworth in Christmas 1615' is among papers relating to the estates in Sussex in the Archive of the Duke of Northumberland at Alnwick Castle (ALN. X. II. 10 Box 2 h).

The survey of 1557 includes six areas of woodland on the Lord's Demesne covering a total area of 603 acres. All of these contain timber trees of oak and beech, valued by the acre according to number, age and condition: there is however no reference to underwood or coppice. Twenty years later, the survey of 1576-7 gives similar details but notes that in the Frith, an area of 160 acres,

'...the woods therin have been lately fallen and cutte downe...the springe therof cometh again verie hardlie by reason the same is also not preserved from cattall. The herbage thereof is lette for a yearlie rent as in the saide booke of survey it doth appeare' (WSRO. PHA1413).

This clearly indicates that coppicing was not intended and that a regular income from herbage was customary. The letting of woodland areas for herbage appears to have been a general practice on the estate, often with agreements of 21 years making it difficult to end the custom (WSRO. PHA5670). Herbage, providing a regular annual income, may have been considered preferable to the cost of enclosure and an interval of several years before saleable wood had developed. It is apparent that the forestry policy of the estate was directed towards raising timber trees as a long-term investment, with an annual income from lettings for herbage. This policy is still evident from Ralph Treswell's survey of 1610, and can be clearly seen on his map of the estate (WSRO. PHA1451; 5417) where areas of timber trees are marked, recording their stage of development in terms of 'years growth'. A close of four and a half acres in North Parkhurst 'sowed with akorns' is shown, indicating that timber trees were intended. There is no mention in these surveys of copse or coppicing.

Underwood, the result of natural regeneration, was presumably taken from these timber woodlands from time to time for use within the estate or sold on to others. The Petworth accounts show that 3,430 cords of wood were sold to John Mose in 1606 and were paid for over a number of years. No other large sales are recorded and a list of 'wood cutt and corded at Petworth' during a period of ten years between 1607 and 1618, records a total of only 1,155½ cords, and variations in the yearly amounts suggest there was no regular outlet (ALN. X. II. Box 2 h). This apparently modest total for wood sales may be the result of unrecorded transactions or ones that have become lost, but there is no evidence of systematic management, or coppicing, of the underwood being carried out by the estate.

The 'Survey of Christmas 1615' (ALN. X. II 10 Box 2 h) is a broad-brush review of the estate lacking the detail recorded in Treswell's account, but it is clear that a change in direction is taking place in how the estate manages its woodlands, with references to enclosure and coppicing:

'...the underwood at Fryth sould is letten unto Sir Edward Francis [seneschal of the Manor of Petworth between 1595 and 1620] which he will noe doubte incopse upon the cutting to preserve it from browsing beasts untill it be of reasonable groweth...').

The following suggests that enclosure was recognised as a worthwhile investment rather than agreements for herbage:

'...The wood at Rattfallinge cont. about 13 acres to be cleane cutt downe for copce will beare about 36/40 lods of an acre worth in the whole £80 whereof must be deducted the charge of felling and fencinge...' (ibid.).

Plans for the introduction of managed coppices are also suggested:

'... Cole Hook groweth in patches especially nearest comon passage [in 1610, Cole Hook wood was in four parts, totalling 108 acres] wherefor I thinke it most convenient to devide it into severall coppces suffering no more waies than needs and them to be formed with quicksett otherwise there will be noe expectacon of wood...' (ibid.).

This appears to be the start of coppicing on the Petworth estate and came far too late to be of any potential benefit to the glassmakers. Reference to coppicing on other estates in the area is also lacking at the beginning of the 17th C., although within a period of thirty years references are frequent, for example in the records of the Cowdray estate and Shillinglee Park (WSRO. MS 1630; 1635; Shillinglee

MS 3/6), indicating that this method of woodland management was by then in fashion.

At the end of the 16th century, there was no lack of authors who wrote condemning the 'destruction of the woodlands', and adding their proposals for remedying the situation, but there is little information given about the culture of coppices. Advice is given about preserving the spring from animals after cutting, as for example by Fitzherbert (1598, 98-9), but there is an absence of instruction about coppice rotation and selection of the most suitable wood species. Even Norden, who was familiar with Sussex having toured and produced a map of the county, offers no description of managed coppicing (Norden 1595, (map); WSRO. MP1242; 1768). If 'managed coppicing' was evident and significant in the woodland economy, it is surprising that no description or explanation appears in the woodland section of his well respected *Surveyor's Dialogue* (1607): even the 1618 edition of this work does not include a discussion of the subject. It was not until Evelyn published his definitive work on woodland management, *Sylva* in 1662, that coppice management was fully expounded and discussed (Evelyn 1662, 176-180).

For the reasons given above, it appears that 'managed coppicing' was the invention of the iron masters who found this source of fuel most effective in producing sustainable supplies of consistent quality, as well as enabling them to meet the requirements of the law to 'preserve the woods'. There is no evidence that the glassmakers relied on this source of fuel which arrived too late in the western Weald to be of advantage to them.

Two other important points should be noted. Firstly, the iron masters tended to be owners of land, either as individuals or in partnership with others, giving them control over fuel production and continuity of supply. The glassmakers on the other hand lacked capital and, as aliens, were not normally landowners. The only exception being Isaac Bungar, who, as a native born Englishman was entitled to buy land, and who had accumulated sufficient funds to purchase several parcels of woodland between 1612 and 1614 (PRO. C5/593/19). However, there is no evidence that Bungar attempted to develop coppices in his woodlands, and in the legal action brought by Bungar against his partner, William Martin, in 1620, it is revealed that Martin had been selling '...planks, bordes, lathes and timber...', the products of timber trees rather than underwood (ibid.).

The second point is that the needs of the two industries were notably different. The iron industry demanded poles of 0.05-0.06m in diameter, and the glass industry poles of larger diameter, perhaps between 0.10-0.15m, requiring a further 7-10 years growth, a circumstance that would have enabled the wood suppliers to have demanded a considerable premium to grow the coppice for this further period.

Sources of fuel

As stated above, the ideal dimensions of billet wood for burning in a glass furnace was around 0.60m long (cord wood cut in half) and between 0.05m and 0.10m diameter. The billet could be split lengthways to assist in drying and it was preferable for the wood to be straight to enable easy stoking. Wood of this specification could be obtained from several different sources, although there is no evidence of mature timber trees being felled to provide fuel for glassmaking. By the second half of the 16th century, measures had been introduced to preserve mature trees for use as timber, and legislation was being directed against the wasteful use of timber trees for fuel in iron mills (see chapter 9). During 1591, the Exchequer authorities carried out a local commission of enquiry into the destruction of woodlands contrary to the Statute of 27 Eliz. (1585), involving woodland in Harting Combe and Nyewood (Sussex) where, according to an informant, Hugh Alley, 2,000 oaks of above one foot in diameter had been felled and coaled for fuel in the iron mills at Rogate. One of the woodmen, William Marche, who gave evidence in the case, stated that:

'...he thinketh in his conscience [he] would have made some cleftwares or sawing timber if the same had not been torne in pieces converted and imployed to cordeworke for the making of iron...' (PRO. E178/2305).

Examples of this kind of abuse are rare in the Weald, but it seems likely that, had the glassmakers been using timber to fuel their furnaces, that some record would have survived.

However, trees felled for 'timber' produced by-products such as branches, brushwood and bark that could be used for a variety of purposes in the woodland economy, including cordwood for fuel.

Branches and brushwood were not only taken from trees after felling. The cutting back of branches from the sides and the crown of living trees, a procedure known as 'top and lop', produced a variety of wood from substantial limbs to smallwood and brushwood and allowed the tree to produce new growth for use in the future. An advantage of this method was that it could be applied to large trees where coppicing was inappropriate, whilst at the same time maintaining a potential for timber from the mature tree. This process is described by Fitzherbert:

'...if they be great old trees, if ye fel them by the earth, there wyl never come any spring of them up agayne except they many smale pumples and sprynges about the rotes. And therefore suche old trees would be topped and cropped to beare more wode styll...' (Fitzherbert 1560, Cap. XXX).

This practice was also beneficial to the landowner in enabling him to obtain saleable wood from his timber trees whilst keeping on the right side of the law in preserving the required number of timber trees per acre on his land:

'...if a tree be headed and used to be lopt and cropt at every twelve or one and twenty years, and or thereabout, it will beare much more wood in processe of time than if it were not cropped, and much more profit to the owner...' (Fitzherbert 1598, 96).

The process of 'top and lop' was clearly widespread in Fitzherbert's time and he provides a detailed explanation of how the work should be carried out and the best time of year for doing it (Fitzherbert 1598, 96-7). A lease granted to Richard Kinge in 1585 entitled him to take 300 cartloads of wood yearly form Loxwood Wood states that this should be from '...le loppes and toppes...' of the trees growing there (WSRO, Add. MS. 37159). And it was a condition of the Customary of the Manors of Shillinglee, Hibernoe and Pallingham (1581):

'...that if the Lord do take any trees for tymber or pale in any mans copyhold, that then ye tenants of ye saide copyholde ought shd have 10 'loppes' of ye said trees, and if he felleth any in ye common woode, then the tenants to have the 'loppes' for their fuel' (Burrell MSS, WSRO. MF77).

There are two recorded examples where the glassmakers state their preference for 'top and lop' as a source of fuel. In 1567, in his application to set up glasshouses in the Weald, Jean Carré assures Cecil that 'tops' and 'lops' would be used rather than timber (PRO. SP12/43 No 104). And Isaac Bungar, in his appeal to the House of Commons against the continuance of Sir Robert Mansell's monopoly (1622), maintained that: '...the wood which the Glasse-makers use, being lops of trees...' (PRO. SP16/162/231a). The fact that this type of wood is specified indicates that it was suitable for the job, even if it was not the only source.

Wood growing in the hedgerow could be an important source of fuel. As enclosure progressed and the number of small fields and closes proliferated, hedgerows became a valuable source of wood and fuel for the tenants. Leasing arrangements often allowed tenants to use the 'smallwood' from hedges, the rights to the use of timber trees growing there usually being retained by the landlord. The importance of the hedgerow as a store of wood and timber is well illustrated in the 1557 survey of the Petworth estate which included:

'...in the hedgerows of all the copyholds belonging to the same manor, and in the common woods not measurable because they stand here and there, is 1,680 old oaks and beeches some of 300 yrs. growth and some of 200 yrs. growth whereof there is 2,000 of fair timber trees of oak...' (WSRO. PHA1409).

And Standish recognised the value of hedgerows as a renewable source of wood:

'...which will approvedly make as good char-cole for all uses as any other wood, which may be continued so long as it shall please God the kingdom shall endure...' (Standish 1613, 4).

A distinctive feature of the Wealden countryside that has survived from the Middle Ages to the present day, is the 'shaw', also referred to as a 'row' or 'rew'. This is a broad boundary containing trees and underwood between fields and closes, frequently following the course of a stream or land drainage ditches.

Arthur Young commented on 'the singular custom of shaws' as a source of timber and wood:

'...broad belts of underwoods, and trees, two, three, and four rods wide, around every petty enclosure. The landlord is tenacious in preserving them, because they afford protection to a quantity of timber; and the tenant is allowed the underwood at the regular period of cutting.
(Young 1813, 181).

At one time thought to be the remnants of ancient woodlands that have survived the incursions of arable or pastoral enclosures (ibid.), the origin of the shaw is now considered to be a feature that was created deliberately. Brandon has suggested it was a woody boundary, capable of enlargement or being reduced in size as the need for wood or agricultural land changed: 'the shaw should be seen not as a static but as a dynamic feature, expanding or contracting over time in response to economic or other considerations' (Brandon 2003, 67-8). Whatever the origin of the shaw, it is a feature that clearly illustrates the integration of agriculture and forestry.

Hedgerow trees were often pollarded, creating another regenerative source of fuel. Wood from pollards was not only used for fuel: an indenture of 1616 specifies that '...competent stake timber...' was to be taken '...of pollards only growinge in the hedgerowes...' (WSRO. Add. Ms. 3820). The pollarding of a mature or old tree stimulated further growth enabling it to continue producing useful cuttings, often out-living timber trees, and was also done to create distinctive, long-lived trees to act as boundaries in fields or woodlands. Pollarding normally took place above 8ft from the ground, which meant that the spring was out of the reach of browsing animals. This had the advantage of making enclosure unnecessary and pollards could safely be cultivated in the hedgerows of fields and closes containing cattle. However, a disadvantage compared with coppicing, was that cutting was a more labour intensive operation involving the use of ladders, and saws for cutting rather than an axe or bill- hook.

Old trees, sometimes referred to as *dotards*, past their best for prime timber, were accordingly written down in value by surveyors, but retained some value as a source of wood for fuel or fencing.

One of the problems facing landowners who cultivated trees for timber was in deciding the best time to fell a tree. Oak was considered to be at its best for timber, and was usually felled, when it was between 80 and 120 years old, measuring approximately 24-36in (0.60-0.90m) in diameter. There was an increasing requirement for larger sizes of timber (great timber), particularly for shipbuilding, obtained from trees of around 180 years old. Since beyond the age of around 120 years oak is liable to decay at the heart, it was a matter of judgement whether to cut the tree at an age when it was likely to be sound, or to risk growing it on for a further 60 years or so in the hope that it would produce sound 'great timber' which would command a higher price (Dodds & Moore 1984, 140).

Hammersley has drawn attention to the large amount of old and decayed timber referred to in surveys of the crown estates between 1604-12, where he found 'almost as much timber decayed by age as sound' (Hammersley 1957, 152-3). The county survey of timber and wood in the royal forests, parks and chases of 1608 did not include the county of Sussex, which had little property in the possession of the crown at that time, but the point is well illustrated by reference to the adjacent counties of Surrey and Hampshire (Southampton com.). In Surrey, the survey records a total of 10,913 sound timber trees and 12,918 'decaying' trees, the average values of which were 9*s* and 6*s* 9*d* respectively. In Hampshire, which included the extensive area of the New Forest, there were recorded 151,753 timber trees valued at an average of 8*s* 10*d* each, and 154,252 'decaying' trees valued at only 2*s* 8*d* each. The commentary accompanying the survey for Hampshire states that 'the trees are for the most part oakes and some small quantities of beach and ashe' (PRO. SP14/42). This pattern of decaying trees was repeated fairly consistently throughout the country and indicates poor management and even neglect of timber resources. As Hammersley points out, it also suggests that 'had there been a genuine timber shortage, trees would have been cut and used or sold as they reached maturity' (Hammersley 1957, 152-3).

There is no clear evidence in the form of timber surveys to produce a comparable picture about the extent of decaying trees on the estates of lesser landowners. Estate records occasionally refer to old trees, as in the series of surveys of the Petworth estate between 1557 and 1610. The survey of 1557 makes reference to Colehoke wood, a 76 acre area of woodland described as being '...of old shrugged oaks and beeches of 300 yrs growth, thin set...'. This wood is referred to again in the survey of 1576-77 as having been enlarged to 115 acres by the addition of the adjacent Chawfold wood '...well sette with oke and beeches...'. By the time of the 1610 survey, the wood had been further extended to a total of 145 acres, but Treswell's map which accompanies his survey, indicates a 53 acre area of the original wood as being still covered by 'scrubed trees': this area of the map is also illustrated with grazing cattle suggesting that little had been done over the previous 50 years to improve timber and wood stocks in this part of the estate (WSRO. PHA1409; 1413; 1414; 1451; 5417). As mentioned above, the 1610 survey shows that within the estate as a whole, extensive regular replanting had been taking place and that woodland areas described as containing old trees extended to no more than around 15% of the whole: a far lower proportion than that found in the contemporary surveys of the crown woods. It is not clear to what extent this was typical, but there are other examples of woodland management which suggest that private landowners were seeking to maximise profits from their estates, and it is likely that woodlands in private hands were generally better managed. The increase in wood and timber prices acted as an incentive for greater efficiency, and land containing decaying trees was of greater value if cut and replanted, or even converted to arable. Old trees, although suspect as a source of timber were still of value for their tops and lops for use as fuel or small timber (WSRO. Add. MSS, 3820). In Bradhurste Park, Arundel, (n.d. Jas.I), there were '...woods standing very thin being in effect all old trees of Beech and Oak meet for fuel and maintenance of the pale...' (BL. Add. Ms. 5701; WSRO. MF 77).

We do not know precisely how the glassmakers obtained their fuel: the lack of ownership of woodlands must have been a distinct disadvantage to them. A variety of sources were available, as described above, and it seems likely that an opportunistic and even predatory approach was taken in pursuing all possible sources as they arose. Both Carré and Bungar maintained that the industry used the 'tops and lops' of trees which would have been available from standing trees in woodlands and hedgerows, as well as a by product of felled timber. Underwood, comprising coppice wood, seedlings and thinnings from mixed woodland would also have been available, however, there is no evidence for the use of managed coppices in the Weald.

9: The preservation of the woods

Introduction

The use of wood fuel for industrial purposes became an increasingly emotive issue as supplies in some parts of the country became scarce in the face of intensifying demand. This chapter examines the views of contemporary writers and the legislative measures adopted by government to 'preserve the woods' in the context of circumstances in the Weald. Consideration is given as to why it was that the glass industry alone, among all other users, was prohibited from the use of wood fuel.

'Want of wood and timber feared'

Concern for the nation's stocks of wood and timber began to be expressed in the first half of the 16th century. Anxiety about the availability of timber for shipbuilding and the need to maintain adequate stocks for the future developed as the century progressed and the threat of war with Spain became more apparent. At the same time, an increase in the demand for wood fuel for industrial use added to that of a rapidly growing domestic market, caused prices to rise sharply.

The cause of the problem in its most visible and dramatic form was the cutting down of the woodlands to fuel local industries, an activity Norden found widespread in the Weald:

'...such a heat issueth out of the many forges and furnaces, for the making of iron, and out of the glass kilnes, as have devoured many famous woods within the Welds...' (Norden 1607, 214);

he makes particular mention of several places in the western Weald, where glasshouses and iron mills would have been in operation at close quarters: '...Lopwood [Loxwood], Greene [Wisborough Green], the Minns [Mens], Kirdford, Petworth Park and Ebernoe...';

and goes on to estimate the amount of wood consumed by the activities of the iron mills:

'...I have heard there are or lately were in Sussex, neere 140 hammers and furnaces for iron, and in it and Surrey adjoining, 3 or 4 glass houses: the hammers and furnaces spend each of them in every 24 hours 2, 3 or four loades of charcoale...' (ibid., 215).

The number of 'hammers and furnaces' referred to by Norden must have included forges, since the number of furnaces in operation between 1600 and 1609, when the industry was at its peak in Sussex, has been estimated at 52 (Hammersley 1973, 595). It has been estimated that a Wealden furnace would have required in the region of 2,500 acres of sustainable coppice to produce 250 tons of pig iron, and a further 1,500 acres for the fining process : an annual consumption of 330 acres of woodland for each furnace (Cleere & Crossley 1995, 135; Hammersley 1973, 607).

Norden goes on to warn that if the wood fuel industries were to continue to 'devour' the woods unchecked, severe shortages would soon occur:

'...the Welds of Surrey, Sussex and Kent, the grand nursery of those kinds of trees, especially Oake and Beech shall find such an alteration within less that 30 yeres as may well strike feare, lest few yeres more, as persistent as the former, will leave few good trees standing in those Welds...' (Norden 1607, 214-5;).

John Speed, in company with numerous other commentators, drew attention to the threat to future supplies if destruction of the woodlands was not brought under control:

'...the commodities of this Province [Sussex]are many and divers, both Corne, Cattle, Woods, Iron & Glasse; which two last, as they bring great gaine to their Possessors, so doe they impoverish the Countrie of Woods, whose want will be found in ages to come, if not at this present in some sort felt...' (Speed, 1610).

The shortage of wood and timber was perceived as a national problem, though there were clearly regional differences in both supply and demand. Norden refers to shortages in parts of Wiltshire, where '...peats, turffe, heath, furze, broome and such like fuel for firing,...yea and neats dung...' were in use as substitutes for wood (Norden 1607, 216): and in the 1618 edition of his *The Surveyor's Dialogue*, he adds Lincolnshire and the Isle of Portland as being similarly affected, suggesting the situation was worsening. In areas '...wel wooded...', such as parts of Derbyshire, Cheshire and Shropshire, and the Weald of Kent, Sussex and Surrey, Norden's Surveyor instructs his Bailiff to use discretion in valuing wood and timber according to local supply and demand, '...else he may deceive himself and his lord much, if he prize wood in the Wield of Sussex, as it is worth about Salisbury plaine...' (ibid., 140).

Agriculture was also a threat to woodlands as more land was given over to arable and pasture to feed an increasing and more prosperous population. Poor management of woodlands producing low cash returns per acre encouraged conversion to agriculture where a higher return could be obtained. Hammersley has drawn attention to inefficiencies in the way the royal forests were administered and has demonstrated how the Crown was slow to develop the wood sales potential of its 53,000 acres of woodland during the 16th century. His calculations indicate that an annual income of £3,000 represented a return of only 1*s* 3*d* per acre: an amount less than might be expected from the rent of farmland (Hammersley 1957, 142). Roger Taverner, the deputy surveyor of woods, suggested measures for improving the management and preservation of the woods, but his proposals for enclosure and plantation were not implemented resulting in deforested land being converted to agriculture (Jack 1997, 241-247).

The shortage of wood and timber as a commodity was not the only concern: it was also looked upon as a threat to employment. Arthur Standish considered that a shortage of wood, particularly timber, would lead to unemployment among those who depended on it for a living such as '...the carpenters, shippewrights, the plough and cart-makers, the joyners, the cowpers and the coach maker...' (Standish 1613, 4).

These were the concerns of contemporary observers who sought to create awareness of the destruction that was going on and to influence government and landowners to have a mind for the future by exercising restraint and better husbandry.

Legislation to preserve the woods.

Early legislation relating to forests and woodlands was primarily concerned with the administration and maintenance of the forests for the royal hunt, the main object being to protect the beasts of the forest, the vert and cover in which they thrived, and to ensure that a favourable environment was preserved. The forest laws were administered by courts who were responsible for establishing and regulating the rights of tenants, punishing miscreants and appointing officials to act as overseers. During the Middle Ages, the revenue derived by the Crown from its forests came mainly from the fines imposed by the forest courts: income from sales of wood at this time was negligible (Hammersley 1957, 137-8). The destruction or waste of woodlands was viewed in terms of harm to this environment as described in the following early definition: '...if a man standing on the stump of a felled tree could see the stumps of five other felled trees, then waste had taken place...' (fitz Nigel R, 1179, *Dialogus de Scaccario*, cited in James 1981, 14).

Among the earliest Statutes for preserving the woods was that introduced in 1482, for '...the inclosing of woods in forests, closes and purlieus...' (Statutes of the Realm, Vol 2, 1816, 22 Edw. IV, c. 7), which enabled tenants licensed to fell woods within a forest or chase, to enclose the area after felling had taken place for a period of seven years to allow the woodland to regenerate. This was primarily to preserve the forest for the benefit of deer and other game, but also acknowledged that destruction by browsing cattle caused hindrance to tenants.

During the first half of the 16th century, circumstances changed, as forests became less significant as reserves for hunting and more important as a source of income from wood and timber. The royal hunt became less fashionable, and the forest laws began to be more relaxed resulting in a reduction of income from fines: at the same time, the Crown became increasingly in need of money to finance various projects, not least the wars with Spain. The process of the exploitation of the Crown Woods, described by Hammersley, developed slowly, initially producing a low return. The commercial development of the royal forests was dogged by an inefficient and out-dated administration accompanied by the lack of a coherent policy, and was further aggravated by corruption and the petty theft of wood and timber. Greater progress was being made in the 'private sector' which included landowners, many of whom had benefited from the dissolution of the monasteries in the 1540s, who were eager to obtain a profitable return from their estates and investments in industry and agriculture. This was particularly so in the Weald where there were few estates under the control of the Crown. From now on, policy and legislation concerning woodlands would be directed towards preserving and developing the nation's resources of wood and timber (Hammersley 1957; James 1981).

Legislation introduced in 1543-4 (Eyre, 1811-29, iii. 977-80, 35 Henry VIII c. 17) was in response to a general anxiety about the increased use of timber and wood, and was a turning point in that it was the first attempt to establish a system of woodland management. The preamble to the Act referred to:

'...the greate decay of Tymber and Woodes universally within this Realme of Englande to be suche that unlesse speedy remedy in that behalfe be provided there is great and manifest likelyhood of scarcity and lacke as well of Tymber for building, making, repayringe and maynteyninge of Houses and Shippes, as also for fewell and fyrewood...'.

This highlighted the problem of wood, and particularly timber, being consumed at a greater rate than it could be replaced, but at this stage it was articulated as a generality with no particular consumer section being singled out for mention. The proposed remedy was to preserve timber trees by requiring at least 12 'standills' (standards) to be left on every acre of woodland cut over. In the case of underwoods and coppices at or under 24 years growth, where there were no mature trees, 12 young trees were to be left and preserved until they were 10 inches square. Since it would take in the region of 60 years for an oak to reach this stage of maturity, the intention was that these trees should be preserved and allowed to develop, although the surrounding underwood might be cut two or three times during this period. Where woods containing mature trees exceeding 24 years growth were to be felled, 12 'great trees' were to be left. Twelve trees to the acre was in fact a low density that would have allowed up to approximately 60 ft between each tree, but this was, of course, a statutory minimum number. A lease for 21 years of woods in Gillingham (Kent) in 1567 provided for two cuttings of the woods, with enclosure, and stipulated that 60 'staddels' must be left on each acre cut (PRO. C66/1032/76). As noted above in chapter 8, too great a density of staddels could reduce the productivity of the coppice below, where some species such as hazel are adversely affected by shade. John Evelyn, writing in the 1660s, recommended the cultivation of up to 37 or 38 trees per acre in different stages of development which he considered would cause no harm to the underlying coppice:

'...it is very ordinary copse which will not afford three Firsts, that is Bests, fourteen seconds, twelve thirds, 8 wavers according to which proportion the sizes of young trees in copsing are to succeed one another...' (Evelyn 1662, 178).

The Statute of 1543 also required the enclosing of woodlands after cutting for a given period to protect the 'spring' from browsing deer, and there were additional regulations about the introduction of domestic animals for grazing purposes and damage to fencing during the prescribed enclosure period. The conversion of woodlands into tillage or pasture was also prohibited. The '...Wealds of Kent, Surrey and Sussex...', presumably because they were still heavily wooded and relatively inaccessible at this time, were exempt from this legislation, and consequently wood-burning industries there were not affected. However, this did not mean that all the provisions of the Act were ignored. In the Weald, where wood pasture farming had been widely adopted from early medieval times, enclosure after coppicing was usual, but this had been in keeping with common sense and good practice rather than as a result of the force of law.

In 1558, the first Elizabethan Statute (Eyre, 1811-29, iv. 377, 1 Eliz., c.15) supplemented the Henrician Statute, forbidding the felling of timber more than '...one foot square at the stubbe...' within fourteen miles of the sea or any navigable '...ryver, crecke or streame...' for the purpose of making '...coale or other fewell...' for iron making: timber trees of '...oke, beeche and ashe...' being expressly mentioned. Certain areas were exempt from this legislation, notably the county of Sussex, the Weald of Kent and the parishes of Charlwood, Newdigate and Leigh in the Weald of Surrey.

One of the objectives of this Statute was to exercise some measure of control over the development of the iron industry that was undergoing considerable growth at this time. Sir Thomas Carden's Commission of 1548 (HMC, Salisbury, Cecil, XIII, 19-24) had reported 53 iron mills and furnaces in Sussex, mainly situated in the eastern Weald. Straker has estimated that each consumed 500 loads of charcoal, which, allowing for three loads of wood for each load of charcoal, amounted to 1500 loads per annum yearly for each iron mill (Straker 1931, 114, 121). With a total estimated annual consumption of around 75-80,000 loads it is not surprising that the iron industry attracted so much attention. The intention was not to limit expansion of the industry, which was assuming increasing national importance, particularly as a producer of ordnance, but to confine it to areas at a distance from the environs of London and where there would be the least threat to timber having easy access to sea transport.

Of particular interest in the 1558 Act is the exemption from the regulations of the nominated Surrey parishes referred to above. It is clear from a later Statute, of 23 Elizabeth (1581), that this was a reference to the sustainable coppice woodlands of Christopher Darrell, where he was founding iron at Ewood Furnace and Forge, and Leigh Hammer Forge. The specific reference to Darrell's estates indicates that sustainable coppice woodlands were not in general use by the iron makers at this time and suggests that the legislators sought to promote the 'best practice' aspects of Darrell's enterprise as an example to other iron makers. It is also of interest to note that this bill has been attributed to a 'Mr Sackvill' (D'Ewes 1693, 44). It is likely this is Sir Richard Sackville whose family acquired considerable wealth and influence during the Tudor period, Richard Sackville himself having served as a Steward to the Earl of Arundel, and had held several important positions of state in the counties of Kent, Sussex and Surrey.

A further Statute appeared in 1570 as it was considered the intervals for enclosure following the cutting of woodlands as laid down in the Statute of 1543 were insufficient for full regeneration to take place. The new Act extended the periods of enclosure by two years (Statutes of the Realm, Vol 4, 1819, 13 Eliz., c. 35).

By the 1580s. the existing legislation was evidently considered insufficiently effective, and again it was the activities of the iron mills which attracted the attention of the legislators, who were concerned about the '...late erection of sondrye Iron Milles...not farre distaunte from the Cittye of London and the Suburbs...the Downes and the Sea Costes of Sussex...'. The Statute of 1581 (Eyre 1820-29, iv. 667, 23 Eliz., c.5) commented on the availability of wood and timber from these areas which '...dothe daylie decaye and become scant, and will in tyme to come muche more scarcer...yf some remedye bee not provided...'. The growing scarcity of wood was cited as the cause of increases in prices '...growen to bee verye greate and unreasonable...'.

The remedy was to prohibit the use of '...any manner of wood or underwood...' growing within 22 miles of London and the Thames, four miles of the Sussex Downs or three of the coast, from being used as fuel in any form of iron making. In addition, no new iron works were to be erected within these areas. The Weald was again exempt from the regulations insofar as it did not extend to within 18 miles of London or 8 miles of the Thames. As in the Act of 1558, exemption was expressly given to land in the parish of Newdigate belonging to Christopher Darrell where '...woods have heretofore ben and be by him preserved and copysed for the use of his iron works...'. but the parishes of Charlwood and Leigh were not mentioned.

The first attempt at legislation directly affecting the glass industry appeared in February 1584-5, in the form of a bill '...against the making of glasses by straungers and outlandyshe men within the realm and for the preserving of tymber and wood spoyled by glasshouses...' (HLRO. Main Papers. 16 Feb 1584-5). This bill required immigrant glass workers to employ one Englishman for every two foreigners employed, and to '...teach and instruct [them] in the trade, arte and mysterye of making glasse...'. In addition, no one was to be engaged in the trade nor cut timber, wood or underwood for glassmaking within 22 miles of London, 7 miles of Guildford and 4 miles of Winchelsea, Rye, Pevensey and the South Downs. In an earlier (manuscript) draft of the bill, dated 9th Dec. 1584 (ibid.), it is clear that the words '...tymber and wood spoyled by glasshouses...' were added to the title of the bill as an afterthought. This suggests that the prime purpose of the bill was to rule against the growth in trade carried out by foreigners that was taking place, particularly in London and the South East, and that the reference to the destruction of the woods was added to strengthen the argument for action. This was not the only bill which articulated feelings of antagonism towards foreigners working in England, for in the same Parliament, another bill was presented '...an Acte against retailing of Linen cloth by aliens...' (HLRO. Main Papers, 25 Feb 1584-5).

The immigrant glassmakers were still bound by the agreement in the letters patent granted to Carré in 1567, that they were '...to instruct fully in the art a convenient number of Englishmen apprenticed to them according to the custom of the City of London...', but clearly little or nothing had been done to satisfy this condition (CPR. 8th Sept 1567). The apparent addition to the bill of a denouncement of the use of wood by the glass makers which '...would otherwise have been used in households in London and neighbouring counties...', is likely to have strengthened opinion in favour of the bill. However, in the event, the bill in its revised form, although approved by both the Lords and the Commons, failed to gain the support of the Crown (HMC, Third Report, 5).

The importance of this bill so far as the glass industry is concerned is that it represents the first attempt to regulate the use of wood fuel by the industry. It is therefore surprising that the Statute which followed, in 1585, '...for the preservacion of Tymber in the Wildes of the Counties of Sussex, Surrey and Kent...' made no reference to glassmaking at all, but continued to concentrate on the activities of the iron industry. The fact that the glass industry is not mentioned suggests that the addition of clauses about '...tymber and wood spoyled by glasshouses...' in the bill of 1584-5, and referred to above, was indeed a stratagem to intensify opinion against foreigners, and may also indicate that the use of wood fuel for making glass was still insignificant compared with that used by the iron mills.

The new Statute of 1585 (Eyre, 1820-29, iv. 726-7, 27 Eliz., c.19) aimed to preserve wood and timber in the Weald itself. No iron mill was to be established other than on an existing site, or on land where the owner '...shall continuously furnish same with sufficient supplie of his...owne proper woodes...', which was not to include timber trees exceeding one foot at the stub. This clause in the Act must have caused the glassmakers to consider how they could acquire woodlands of their own. Nationality, and probably a lack of access to investment capital, meant they were unable to make purchases until the early 1600s, when Isaac Bungar bought several parcels of woodland. These regulations were clearly intended to encourage the iron masters to follow the example of Christopher Darrell in developing managed coppice woodlands yielding sustainable supplies of fuel, and the ownership of woodlands became increasingly desirable for the iron masters who had seen prices of charcoal quadruple between 1540 and 1600.

Cleere & Crossley (1995, 137,) have suggested that this Act encouraged expansion of the iron industry westwards to sites where owners could supply sufficient wood from their own woodlands. This resulted in iron furnaces being established at Imbhams (Chiddingfold), Frith (Northchapel), Shillinglee (Kirdford) and Ebernoe (Ebernoe) from the mid-1970s onwards, in the neighbourhood of the glasshouses and must have provided further competition for the glassmakers in their search for fuel.

It is clear from references in the Journals of the House of Commons and the Lords that, between 1607 and 1614, the question of the 'woodlands' was regularly debated, although little has survived about the issues discussed (HC and HL Journals). A reference to a bill entitled 'an Act for the better Breeding, Increasing and Preserving of timber and underwoods' suggests that consideration was being given to improving productivity in woodland management, to complement regulations which hitherto had been mainly proscriptive. During May of 1614, both Houses were engaged in discussing bills: in the Commons, '... an Act for Increase of Timber in future times...', and in the Lords, '...an Act for the preservation of Wood and Timber...'. It is not clear whether this was one and the same bill or whether two separate bills were involved, perhaps one to introduce regulations to encourage better productivity and the other to implement further prohibitions, however all official debate was brought to an end by the prorogation of Parliament on the 6th June, which continued until 16th Jan 1620.

As referred to in chapter 4 above, experiments had been taking place in the development of glassmaking using coal, resulting in a patent being granted to Sir

Edward Zouch in 1611 (PRO. PR9 Jac. I, pt. 29, m. 19). This provided commercial protection to those developing the coal process, but did not amount to a ban on the use of wood. However, the development of a coal-fired process had advanced sufficiently for a second patent to be awarded to Sir Edward Zouch on 4th March 1614 prohibiting the use of wood fuel in glassmaking (PRO. PR11 Jac. I, pt. 16, No 4). This monopoly was followed on 19th January 1615 with a third patent, but more significantly by 'A Proclamation Touching Glasses' dated 23rd May 1615 (PRO. E101/471/6) which further reinforced the ban on wood fuel. The preamble to the Proclamation declared that '...the waste of wood and timber hath been exceeding great and intollerable by Glasse-houses and Glasse-workes of late in divers parts erected...', and its terms were to apply to all parts of the country, including the Weald which had been largely excluded from the effects of previous legislation. The message was clear: '...no person or persons whatsoever shall melt, make...any kind, forme or fashion of Glasse or Glasses whatsoever, with timber, or wood, or any fewell made of timber or wood...'; and banned the construction of '...any furnaces, structures, engines or devises for the melting or making of any kind or sort of Glasse or Glasses with Timber or Wood' (ibid.).

Difficulties in administering the law

By the 1580s, legislation was in place to limit the use of wood and timber and to encourage greater efficiency in woodland management, but it was not fully effective for several reasons. Firstly, there was a general lack of information about the nation's timber and wood resources with the result that the government had little idea of its whereabouts, extent and ownership. There had been attempts to reform control of the royal forests during the 16th century (Hammersley 1957, 137-8), and numerous surveys of manorial estates had been carried out by private landlords, such as those carried out at Petworth in 1557, 1576 and 1610 (WSRO. PHA1409; 1414; 1451), but no attempt had been made to co-ordinate the results, with the consequence that government lacked an overall picture, making planning and the formation of policy difficult.

Secondly, the Statutes themselves contained exceptions and exclusions providing opportunities for liberal interpretation: for example, the requirement in the Statute of 1543 for the maintenance of 12 'staddells' in every acre of woodland, Norden commented:

'...I have seen in many places at the fals, where indeed they leave the number of standils and more; but instead they cut downe them that were preferred before, and at the next fall, them that were left to answere the Statute, and yong left againe in their stands...' (Norden 1607, 213).

Arthur Standish also noted that this regulation was '...by few men performed...' (Standish 1613, 18).

Thirdly, there was the problem of enforcement. Breaches of the regulations were generally punishable by fines administered by the Justices of the Peace, 50% of which went to the crown and the other 50% to the individual or party who brought the complaint to court. This system depended largely on individuals informing on their neighbours and must have been difficult to operate consistently in small rural communities such as the Weald, and it is perhaps not surprising that there is little evidence of prosecutions taking place. There is however a record of one flagrant case of abuse that took place at Harting, on the Sussex/Hampshire border, in 1589 when it was found that oak trees had been felled to make charcoal for the iron works and forge nearby. Hugh Alley, an informer, had alerted the authorities to quantities of oak timber trees that had been felled and corded for charcoal. One of the witnesses questioned by the commissioners, William Marche, testified that:

'...he hath cutt tymber trees of oke...for to use of the iron workes...[which] he thinketh in his conscience would have made some cleftwares or sawing timber if the same had not been torne in pieces, converted and imployed to cordeworke for the making of iron...' (PRO. E178/2305).

The quality and integrity of those responsible for enforcement was brought into question by contemporary writers such as Rooke Churche who commented that, although he considered the laws on the Statute Book were good, he felt they were ineffective because they were not being implemented properly: '...there do want peculiar officers that should carefully looke thereunto, those lawes, as many other be, are little respected...' (Churche 1612, 68). This view is supported by the case of John Taverner, who was refused a patent '...to survey and examyne such offences as are committed in spoyle and not preservinge woods...', because it was considered '...that he might compound with those spoiling the woods to his own benefit...' (BL. Lansd. MS 106/29). And William Harrison observed that the laws of the preservation of the woods were not fulfilling their purpose either because they were being manipulated to further a particular interest, or because they were being disregarded altogether: he noted that there were those who devised some '...crooked construction thereof [the laws] to the encrease of their private gaine...', and that '...as many laws are made, so they wil kepe none...' (Harrison 1577, 91). As in every age, there were also those who failed to adopt the spirit of the law, and Churche readily condemns the wasteful attitude of 'responsible' members of society towards the preservation of the woods;

'...if we looke upon the clergie, we may then see their church land to be rather champaigne than reasonably woodie, and their wood and copies cut downe, wasted and sold by them, not upon necessity, but of covetessness, want of charity and due care of churche posteritie. If we look upon foundations and donations of Colledges, Schooles and Hospitals, every man we see is for himself, wasting and devastating all, as though they expected never to have successors at all...' (Churche 1612, 71).

Other proposals for the preservation of the woods

The 'preservation of the woods' continued to be a cause for concern and further remedies were proposed, though many of these failed to gain official recognition. In 1589, George Longe, who claimed he was the only Englishman skilled in the art of making glass, put forward a plan for moving the industry to Ireland where wood was plentiful and labour readily available. He proposed retaining just four glasshouses in England and supplying the mainland from new glasshouses to be established under his control in Ireland. Accordingly, a bill to Parliament sought to suppress the operation of glasshouses in England and to grant him the monopoly over production in Ireland. Longe presented an attractive case, suggesting '...wood in England will be preserved...', and that the crown would benefit by customs paid on '...glass being transported from Ireland to England...': and in Ireland he undertook to '...fynde 20 men at every glasshouse sufficiently furnished to serve her...majestie...' in the event of rebellion, and '... many poore folke shalbe sett in worke...'. He also offered a bribe to Burghley which included the pledge '...to repaire your Lordship's building from tyme to tyme with the best glasse during the terme of the saide patent...' (BL. Lansd. MS. 59/75). Burghley's response was to refer the matter to a committee where it appears to have foundered. In commenting on this outcome, Longe maintained that although '...the House well liked it...' the '...committyes chosen beinge suche as soulde woodes to the frenchmen for that purpose kept the bill and never sate theron, and so it rested undetermined...' (Lansdowne MS. 59/72, 59/75). This conclusion is probably correct since the committee appointed to discuss the bill included the Mores of Loseley who owned extensive estates in the vicinity of land occupied by the glass makers. It is also noted that in 1609 Sir George More was selling large quantities of oak timber from his estate in Witley to the coopers of London (SHC. LM349/68; 349/8). The interest of owners of woodlands was one of the potential obstacles facing Sir Edward Zouch in the promotion of his patent for the use of coal fuel, and he took care to try and placate '...Gentlemen well wooded hindered in the sale of their woode...' (Bodl. North MS a. 2, f. 145).

Other measures were proposed, but were unsuccessful probably because of the vested interest of landowners who were receiving higher prices for wood sales. In 1592, an unsuccessful attempt was made to extend the application of the Act of 1534-5 to Lords of manors and owners of woods in the county of Sussex (HMC., 1872, Third Report, 7). A bill introduced in April 1593 '...touching iron mills and glasshouses near unto any navigable or portable river...', proposed the prohibition of the use of wood growing within 8 miles of a navigable river for the making of iron, steel or glass, and also the erection of new iron, steel or glass works in these areas. This bill failed to progress beyond its first reading, but it conveys the continuing concern for what was perceived as the dwindling stocks of timber, especially near readily accessible water ways, which would have been required for the enlargement of the navy at this time.

Those genuinely concerned about declining timber stocks sought opportunities for controlling its use and reducing waste. An example of this is the Statute of 1592-3 '...an Acte for bringinge in of Clapborde...' (Eyre, 1820-29, iv. 860). This required exporters of goods in barrels to import the equivalent timber content of the barrels involved for the manufacture of new barrels: for example, '...for every 6 Tonnes of Beere, 200 clap-boards fytt to make caske of, length 3 foot 2 inches at least...' were to be imported, and aliens were not permitted to export fish unless they had first imported sufficient clapboards. Since clapboards were made from oak timber this was a justifiable provision, but one which must have been difficult to implement.

There were suggestions for preserving the woodlands by introducing an alternative source of fuel, and as early as 1574, Jeremy Neuner and George Zolcher, citizens of Strasburg, were granted a patent for 5 years to exercise a new invention whereby the '...excessive use of wood fuel may be spared...' (CPR. 27th August 1574). In October 1589, letters patent were granted to Mr T Proctor and others for making iron and lead with pit-coal instead of wood: and in the same year, Edward Gage petitioned Burghley to investigate a method of making iron using peat fuel, the invention of a Mr Topcliffe (BL. Lansd. MS. 59/73; 59/74). However, none of these proposals appear to have come to fruition.

The conversion of woodlands into agricultural land had been prohibited by the Statute of 1543-4, but the introduction in 1604 of a bill '...against the Turning of Coppices and Underwoods into Pasture and Tillage...' suggests this practice was still going on. The bill was discussed on several occasions in the Commons between April and July 1604, but then appears to have been set aside (House of Commons Journals, 21, 28 April, 4 July 1604).

In the Weald, disparking was taking place, making more land available for agriculture: between 1582-1618, Shillinglee Park, an area of 1,700 acres, was enclosed and let on leases of 21 and 60 years to 14 tenants (WSRO. MP1058). The same process was taking place at Petworth around the turn of the century as shown by the patchwork of closes on Treswell's map (1610). The copyholders of Northchapel, occupying land to the north of the manor, excluding the cottagers who had only small plots of land, numbered 37 and together occupied a total of 1,692 acres divided into 402 divisions (WSRO. PHA1451; 5417. See also Brandon & Short 1990, 174).

In London, concern was mounting over the difficulties of governing a city which had grown in population from an estimated 70,000 to 200,000 in just fifty years between 1550 and 1600: food and fuel prices had increased significantly and there were hazards to health arising from uncontrolled urban expansion. In 1611, a 'Proclamation for Restraint of Building in and about London' introduced regulations aimed to deal with some of these problems including a direction for the greater use of brick in building '...which is safer and reduces use of timber, which needs to be preserved...' (Larkin & Hughes 1973, 267-269).

It is evident from entries in the House of Lords and the House of Commons Journals between 1607 and 1614 that the 'preservation of the woods' was a matter frequently debated, though it is unfortunate that details of the issues discussed have not survived. The tabling of a bill entitled '...an Act for the better Breeding, Increasing and Preserving of timber and underwoods...' (House of Commons Journals, 17th Feb.1609) suggests that the government was seeking to complement its policy of prohibition by adopting measures to encourage the better management of woodlands. In another example, the draft of an 'Act for the increase of timber for ensuing times' under discussion in May 1614, includes the suggestion that owners of land above a certain acreage should be obliged to plant a portion with acorns (RCHM Third Report, 1872, 14).

The ban on the use of wood fuel in glassmaking

The invention of the coal-fired process, referred to in chapter 4, introduced coal as a viable alternative fuel, but it was not the intention of its inventors to prohibit the use of wood-burning, as seems clear from a paper dated 1610, 'Notes Touching Sir Edward Zouche his sute for making of glass with seacoles' (Bodl. North MS. a. 2, fol. 145). This document discusses some of the possible consequences of the use of coal and includes the statement, '...we purpose not to restrayne them [the glassmakers] from makinge yt [glass]as now they do with woode'. Instead they proposed to leave the matter to market forces: '...for the excessive price of woode would in tyme make all glass makers learne our invencon and use our fuell by reason that it is cheaper than the other...'. It is clear from the following extract that Zouch and his colleagues had in mind glassmakers in the Weald:

'...wee doe not intende to sett up any glasse house in any place where woode is plentifull for ...the cheapness thereof wilbe a meanes that the glasse makers sell yt cheaper, than we can possiblie can doe there, in respecte of our carriage for the wayes in those places are fowle and very deepe...'.

This represents the point of view of the parties to the monopoly granted to Sir Edward Zouch in 1611.

The granting of this patent started a struggle for the control of the glass industry as a whole, including the manufacture of crystal, and has been described in detail by Godfrey (1975, 65-74). During this debate, Zouch and his company added demands for a total ban on the use of wood fuel and the prohibition of imports, considered essential to protect their investment during the early stages of development of the new process, particularly the building and perfecting of new furnaces.

The main argument concerned the savings in wood that could be made by the introduction of coal-fuel. Conversion to coal was adopted by some industries, such as brewing and dyeing, but for some industrial processes, such as iron-making, this was not feasible. The iron mills, the largest industrial user of wood, had been the main target of legislation up to this point, but to some extant criticism of the industry had moderated as the industry moved towards the adoption of sustainable sources of wood fuel, a move probably attributable as much to commercial good practice as to legislative measures. In any case, iron was of such national importance, particularly for the manufacture of ordnance, that its protection would have been necessary for strategic reasons. The prospect of banning the use of wood by a major user such as the glass industry must therefore have been viewed by the authorities as an attractive opportunity.

Zouch made an appeal to the King who was persuaded of the benefits of the coal process as a means of conserving the woodlands. The outcome was the granting, on 4th March 1614, of a second patent to Zouch which revoked all other glass patents, forbidding the use of wood fuel in all types of glass manufacture and also protecting the patentees with a ban on glass imports (PRO. PR11 Jac. I, pt. 16, No 4). Before granting this patent, the King and Council had taken measures to ensure that the new coal fired process had indeed been 'perfected' and that the patentees were capable of delivering glass of a suitable quality and in sufficient quantity to satisfy the market. The responsibility for this was entrusted to Sir George More, who was apparently satisfied with outcome of his enquiries. The monopoly was further reinforced on 23rd May 1615, by 'A Proclamation Touching Glasses', the preamble of which cites, '...the waste of wood and timber hath been exceeding great and intollerable by Glasse-houses and Glasse-workes of late in divers parts erected...' (PRO. E101/471/6).

It is said that James I had a genuine concern for the preservation of the woods. That it was a matter dear to his heart appears to have been well known, as recorded in a letter from Lord Chancellor Ellesmere to Lake dated 12 October 1614, in which he refers to '...his majesties great cause for preserving of woods...' (PRO. SP14/76/31). This view is also supported by the opinion of the Lord Chief Justice in a letter to Lord Salisbury, that the '...King might suppress all glass houses provided their inconvenience exceeded their profit...' (HMC Salisbury (Cecil) MSs. Vol. XXI (1609-1612), 1970, London). The King accordingly seized on the discovery of '...a way and meanes to make Glasse with

Sea-cole and Pit-cole...' as an opportunity to demonstrate his resolve that something must be done to further this cause.

The absence of any mention of the iron industry in the Proclamation, which had figured so prominently in previous legislation, may indicate that the measures already in place were having the desired effect of encouraging dependence on sustainable coppicing. At least action had been taken to reduce the use of wood and the uncompromising terms of the Proclamation would have sent a signal to other industrial users of wood fuel about the government's determination to deal with the problem.

Another factor in favour of the monopoly was that it involved a complete reorganisation of the industry, bringing absolute control into the hands of English owners. Traditionally the industry had been operated by aliens who, although having made great progress in advancing the industry, did not have a favourable record with the government because of their failure to pay duty on the glass they produced and their unwillingness to teach native Englishmen the art of making glass (PRO. C66/1040).

Details of the debates that took place leading up to the banning of wood fuel are sadly lacking, but it is likely that the King and Council were influenced by the opinions of those who stood to gain from the granting of a monopoly, and particularly those who were considering investment in the industry. From the end of the sixteenth century, greater prosperity had encouraged investment in a wide range of projects in trade, industry and exploration, as illustrated by the large number of patents that were applied for at this time. The glass industry, with expansion in demand for window glass and a growing fashion for vessel, must have appeared an attractive area for investment, particularly with the added potential of the new coal-fired process. During the period 1611-15, Zouch's company was joined by several new members, attracted to investing in the industry as a commercial venture without involvement in its day to day management. By the time the third patent had been awarded to Zouch (19th January 1615), the Earl of Montgomery and Sir Thomas Howard, both familiar at court and advisers to the King, had joined the company. Sir Robert Mansell, an MP, treasurer to the navy, and later to become Vice-Admiral of England, also joined the company at this time and quickly assumed control of the business providing managerial experience and great energy to carry the industry forward into a new phase. Men of such importance in public life and in favour with the King would certainly have used their influence to promote the cause of the monopoly, and would have had great a considerable advantage over alien glassmakers operating in the backwoods of the Weald. By comparison, the Wealden glassmakers had been slow to recognise the possible consequences of the development of the coal process and in any case lacked the capital needed for investment in any new major project (PRO. SP14/216/No 231 b). As aliens, they had little influence at Court or with the government, and their record over the matter of paying duty and teaching Englishmen the art of glassmaking, was not favourable.

The survival of the Weald as a predominantly wooded area was due only in part to the legislation introduced to 'preserve the woods'. Much of the regulation introduced in the 16th century was not applicable to the Weald, and that aimed at curbing the activities of the iron mills served only to encourage practices, such coppicing, which had already been found to have commercial advantages in providing a continuing supply of fuel. Whereas woodlands in other parts of the country had become seriously depleted by conversion to agriculture, in the western Weald this did not take place because of unsuitable conditions there. However, these very conditions of wet clayey soils that were unfavourable for agriculture, were beneficial to the cultivation of wood and timber upon which the local economy had become so dependent. It became vital for the local community to preserve the woodlands on which they were so dependent, and to this end they were resourceful in developing methods of coppicing and planting to ensure survival. It is tempting to speculate that had the glassmakers not been prevented from using wood fuel that they would have developed sustainable sources from pollarding or managed coppicing in the way the iron industry had been so successful in doing.

During the seventeenth century, management of the Wealden woodlands developed to a high degree with greater areas devoted to coppices and more judicious planting of timber trees. Evelyn noted a paradox in which the iron mills, the 'destroyer of woodlands', became the cause of their preservation since they stimulated demand and encouraged the 'industry of planting and care' (Evelyn 1662, 252).

10: The Wealden glasshouses

Introduction

A significant part of the research involved fieldwork visits to glasshouse sites resulting in the production of the 'schedule of glassmaking sites' to be found in Appendix 1. In the forty years since the publication of Kenyon's schedule, (Kenyon 1967, 158-208), new information has emerged to add to the record. For example, during the period of research (1999 – 2005), a new glasshouse was discovered at Northchapel, Tanland Copse (48): this has turned out to be a significant find since records of a glasshouse here directly associate it with the immigrant family of Hensey (Rice 1906, 43; PRO. APC xxxiii, 658). And during 2004, new discoveries of glass, crucible and furnace material were found at June Hill (44), one of Cooper's sites (Ovenhouse Field) omitted from Kenyon's listing because he could find nothing and was unconvinced by Cooper's evidence.

The new schedule contains an assessment of current site conditions, noting changes in land use, as at Burchetts (24), where deep ploughing to re-seed old pasture has revealed a scatter of crucible fragments and glass manufacturing waste. One of the objectives in producing a new schedule has been to present information in a format that will provide an easily accessible point of reference, giving the essential details of all significant Wealden glassmaking finds. It is considered this information will be of use in identifying sites suitable for taking samples of glasshouse material for laboratory analysis, and for possible future glasshouse excavation. The fieldwork also provided the opportunity to select samples of glass, sand and crucible for the analysis described in chapter 7.

Visits have also been made to museums, both local and national, to inspect their collections of Wealden glass, and these are summarised in the schedule and in Appendix 4.

Discovery of the glasshouses

There was little knowledge of there having been a glass industry in the Weald, even to local inhabitants, until the end of the 19th century, when Rev T S Cooper embarked on research into the history of Chiddingfold. However, whilst there was little appreciation of the scale and significance of the industry, there was a vague awareness that glass had been made in the locality in the past. Evidence of an oral tradition, among local people, is illustrated by the following quotation:

'I was told by a farmer, who had spent all his life in Ewhurst, that the road referred to passed near the site of some ancient glassworks in a clearing in the above named wood [Somersbury], which, it appeared, is styled Glass-house Field in the Tithe Apportion Book. It is supposed they were in operation in the reign of Elizabeth' (Harrison 1874, 2).

Field names must have helped reinforce this oral tradition, and it was their discovery in Tithe Maps and Apportionment Schedules that attracted Cooper's attention and led to his interest in glass. Later on, field names were a considerable help to Winbolt and Kenyon in finding glasshouses on the ground (Kenyon 1967, 147). Field names bearing the name 'glass', or a variant, occur in the Tithe Apportionment Schedules of eight parishes, with a total of 36 field names relating to 20 sites. They also occur in deeds, as at Little Slifehurst (18), and maps, such as a late-18th-century map of Frithfold Copse (13).

The 'glasshouses' marked on John Norden's maps of 1595 cannot be accurately identified: that marked on his map of Sussex may be Songhurst (30) or Woodhouse Farm (32), and that shown on his map of Surrey may be Sidney Wood (38). These two maps were reproduced and 'augmented' by John Speede in 1610 and show the positions of the glasshouses exactly as indicated by Norden. Despite the cessation of glassmaking in the area by 1618, these glasshouses continue to appear in the county maps of cartographers such as John Blaeu (*c.* 1645) and Schenk & Valk (*c.* 1695), suggesting that maps were copied by successive map makers with little reference to features on the ground.

As mentioned above, the recording of possible locations of glasshouses was first carried out by Revd T S Cooper, working from documentary sources, and plotting his findings on his map of Chiddingfold along with other places of archaeological and historical interest around the village. Cooper had become a semi-invalid before the discovery of the first glass furnace (*c.* 1909), which explains the absence of detailed plans (Kenyon 1967, 154). He recorded 14 'sites of glass kilns' and eight 'Glasshouse Fields' on his map (reproduced in Kenyon 1967, Pl. XX). In the 1930s, Winbolt compiled a schedule of the 27 'Glasshouse sites' he had examined, and listed in the order in which he found them in his main work *Wealden Glass*

(Winbolt 1933). As further discoveries were made, he increased the list to 36 (Winbolt 1935), and finally to 42 (Winbolt 1940).

G H Kenyon's 'Description and Schedule of Glasshouse sites', included in his *The Glass Industry of the Weald* (1967), also contains 42, but arranged alphabetically by Parish. Kenyon, having closely studied Winbolt's schedule, found that the evidence for some of his sites was unsatisfactory. He omitted these, but added others found after Winbolt's death. The fact that both schedules contain 42 sites is coincidental, but can be confusing.

In addition to the sites mentioned in the schedule in Appendix 1, there are a number of locations where finds have been made, but where there is insufficient evidence of glassmaking to warrant inclusion in the main schedule. The majority of these consist of chance finds of small quantities of glass, crucible or manufacturing waste, possibly originating from sites nearby and which have become disseminated with other rubbish. Discoveries of this kind may become more significant if there are further finds in the vicinity, and locations that have produced finds of this kind have been recorded separately in the 'supplementary' list in Appendix 2.

Of these, eight are referred to in Cooper's material, seven being marked on his map, and one, Furnace Place, is mentioned in a note by one of his daughters found with his papers. Those referred to by Winbolt are indicated using Winbolt's numbering. None of these are included in Kenyon's schedule since he was not convinced they demonstrated sufficient evidence of glassmaking, but his brief comments are of interest. Where finds have been notified, they have been recorded in the appropriate HER and the NMR.

Archaeology

This section of the schedule summarises the results of excavations that have been carried out to date, mainly by Winbolt, Kenyon and Wood, and provides an indication of their findings. A separate section, 'Present Condition' (see below), describes the circumstances of the site as found by the writer during field visits carried out during 2003/5.

Kenyon classified the sites listed in his schedule as 'proven', 'probable' or 'possible' according to standards which he defined (Kenyon 1967, 149). A total of 26 are listed as 'proven', 16 of which were found to have the convincing evidence of the remains of a furnace floor: four had some structural remains in place. The other ten produced 'satisfactory evidence that a furnace existed at or very close to the map reference given'. Ten sites have been defined as 'probable' and have been identified by field-names combined with finds of glass and crucible within a small area. Of the six others, listed 'possibles', two are associated with field-names but having no other finds, and the remaining four have yielded only a few fragments of glass and crucible but no other significant finds. A summary of this 'evidence criteria' is shown in Appendix 5.

Since Kenyon produced his schedule, six further sites have been identified as worthy of record. One of these, Tanland Copse (48), contains the evidence of a furnace, largely destroyed by tree roots and eroded by a stream, together with glass and crucible fragments. The remaining five (Nos. 43-7), have all produced small assemblages of glass and crucible indicating the possibility of a site nearby. Two of these (44 and 47), known to Cooper, but rejected by Kenyon because of a lack of surviving evidence, have produced further finds in recent years. The remaining three (43, 45 and 46) are new discoveries.

Considering the large number of glasshouses on record, few have been examined in any great detail. Winbolt had some archaeological experience, and had excavated at Silchester and other Roman sites in Surrey and Sussex. However, working on his own in the Weald, until joined later on by Kenyon, he was limited through lack of resources to the examination of a site rather than full archaeological exploration. Kenyon acknowledged this superficial approach in stating that their objective had been to 'find and prove' the presence of a glasshouse and that their method was 'with the spade rather than the trowel' (Kenyon 1967, 10, 150). Sites that received particular attention by Winbolt are Vann Copse (35), discovered in 1931, and Fernfold (25) found in 1934. In both instances he was able to expose the whole furnace area and record a brief description of what he found, illustrated by a plan, and in the case of Vann Copse, with photographs of the work in progress (Winbolt 1933, 29-31; 1935, 788-90). During the early 1960s, Kenyon, who had assisted Winbolt with the examination of Vann Copse, carried out a reappraisal of Winbolt's notes and was able to present a fuller interpretation of their finds, making use of his experience of other sites (Kenyon 1967, 193-200).

The first complete archaeological examination of a Wealden glasshouse was carried out by E S Wood, at Blunden's Wood (33), a site discovered in 1959 and therefore unknown to Winbolt (Wood 1965). Although this was a rescue dig on the site of a brickworks, Wood was able to use the resources of the Surrey Archaeological Society to thoroughly examine the site and to produce a proficient report, a pioneering work of its kind. The discovery of a further site, at Knightons (42) in 1965, enabled Wood to build on the experience gained at Blundens' Wood, and this time with more time available, to take a more analytical and critical approach to his excavation (Wood 1982).

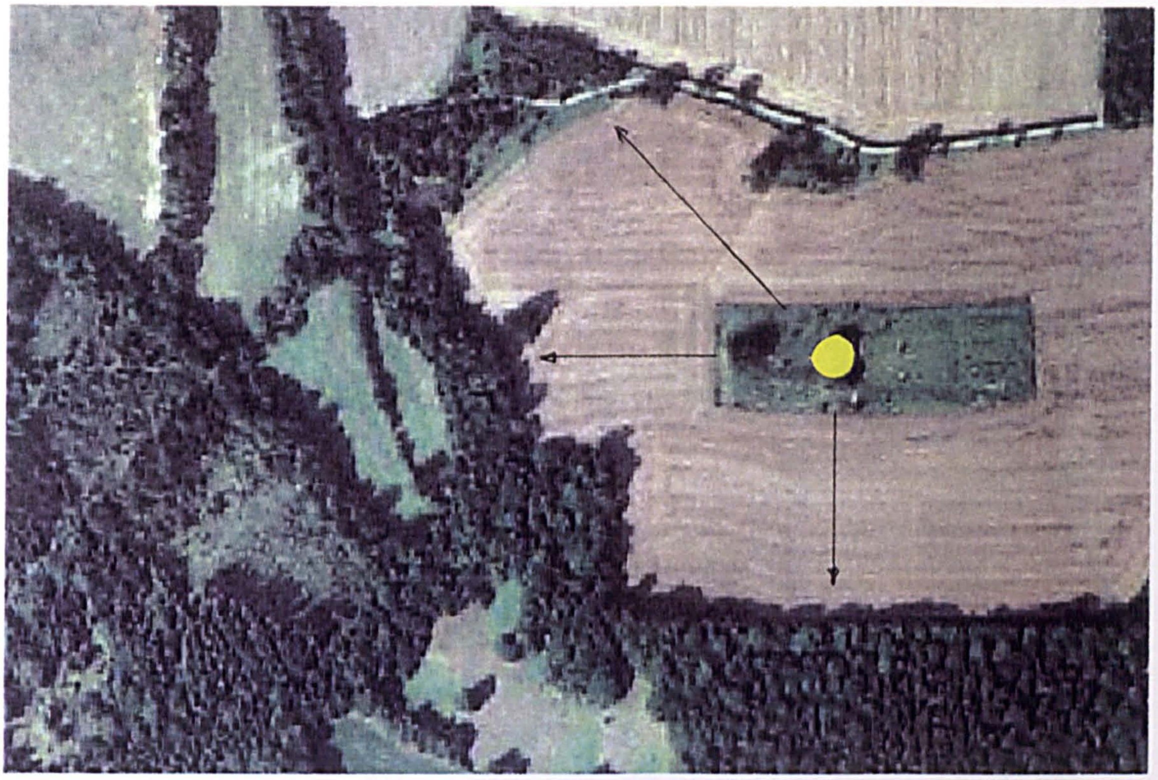
Wealden glasshouses have suffered destruction over the years, leaving little in the way of structural remains. Some, such as Broomfield Hanger (2), were found to have been entirely robbed of all structural material, only the area of the furnace being marked by a patch of reddened, baked clay. Others, including Fernfold (25), Blunden's Wood (33), Vann Copse (35) and Knightons (42) were discovered with sufficient brick or stone structure to outline the plan of the furnace, indicating fire chamber, hearths and sieges, and which provide some information about the building materials used. No examples of furnace superstructure remain. There is evidence of stone having been removed for building purposes (Kenyon 1967, 179), and many sites have been destroyed following the conversion of woodlands to agriculture. Of

20 sites having appropriate field names in the Tithe Apportionment Schedules of the 1830s and 40s, 16 are shown as having been in arable use at that date, suggesting that by then, fields had been cleared of obstructions that would be a hindrance to agricultural equipment. Winbolt observed that sites on arable land, although more evident than those in old woodlands, are more vulnerable to damage: 'ploughed fields are our good allies but woods and copses are the best preservers' (Winbolt 1935, 791). Artefacts from glasshouse sites located in land that has been ploughed frequently can become distributed over a wide area compared with those from woodland sites that have been comparatively undisturbed where the scatter is more confined (Fig. 20, p. 259).

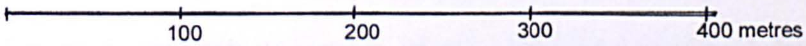
Apart from Vann Copse (35), a vessel-producing furnace, there has been little examination of post-immigrant sites. It is uncertain what changes in furnace design were introduced by the immigrants, for example in the arrangement of the annealing furnace for window glass manufacture, and whether there were differences of detail between the Norman and Lorraine traditions.

With the exception of the excavations carried out by Wood, both of pre-immigrant glasshouses, the early excavations were confined to examinations of melting furnaces. Little attention has been given to exploring other important elements of the glasshouse, such as the layout and relationship of subsidiary furnaces, the areas in which materials were prepared and stored, and the arrangements for assembling

Fig. 20: Scatter of glasshouse material



Woodhouse Farm (32): showing wide scatter of material as a result of repeated ploughing.



Idehurst Copse North (16): the furnace is in woodlands where it has been relatively undisturbed and the scatter of material is localised.

fuel. This information would be of particular interest in relation to a post-immigrant, window producing, glasshouse.

Museum collections

Finds from Wealden sites have found their way into national and local museum collections, the largest and most important being at Haslemere and Guildford, where there are also permanent displays about the glass industry. A summary of museums containing material from Wealden glasshouses is given in Appendix 4.

Haslemere contains Cooper's collection, mainly of early glass fragments, many of which are coloured and probably cullet, still housed in the two wooden cabinets that were his personal property. Unfortunately, few items have been individually marked, Cooper having relied on using labelled drawers or boxes to denote the place of origin of their contents: the provenance of the greater part of this collection is therefore unreliable. The museum's general collection contains mainly fragments of window and vessel glass, pieces of crucible and furnace material from 25 Wealden sites, the largest number represented in any of the museum collections. The museum library contains a typed copy of Cooper's unpublished work, 'The History of Chiddingfold', in which there is an Appendix about 'Glassmaking' (Volume II, 47-73).

At Guildford, there are extensive collections of items from the excavations carried out by Wood, of the medieval site at Blunden's Wood (33) and from the mid-16^{th}-

century site at Knightons (42): the excavation archives are also deposited there. The other major deposit is from Winbolt and Kenyon's excavations of the 'late' site at Sidney Wood (38), which includes particularly good quality glass and a small but complete crucible. Also at Guildford is a selection of finds from other glasshouses, including three boxes of items from Cooper's collection.

Modest deposits are to be found in the museums at Godalming, Worthing, Horsham, Lewes, and Littlehampton, but some of the items in these collections have no reliable provenance. There are also small assemblages at the British Museum and the Science Museum in London. It is unfortunate that the collection left by Winbolt to the museum at Christ's Hospital, where he was classics master, has been lost and there appear to be no records of its content. There are 17 sites for which finds have either been lost, incorrectly catalogued or perhaps never were deposited in museum collections.

Over the years, items of glass, crucible, and pottery have been collected by local residents, found through gardening, construction work or agriculture, and remain in private hands. It would be advisable for these to be brought together and deposited with a local museum while there is still some knowledge of their origin.

Dating

The absence of reliable dating material has meant that the dates attributed to sites has been approximate and in many instances only provisional. Generally, it has only been possible to indicate whether a site belongs to an 'early' or 'late' period, defined as before or after the arrival of the immigrant workers in around 1567. This broad definition has given rise to use of the terms 'pre-immigrant' and 'post-immigrant'. Kenyon relied heavily on the appearance of glass finds for dating purposes; 'two usually unmistakable types of glass; pre- and post-mid-sixteenth century – the primitive and the modern – which may be called Early and Late' (Kenyon 1967, 16). As mentioned in chapter 5, Kenyon describes Early glass as 'usually soft with no sharp fracture, semi-opaque, and pale milky-green with a, now, rough and often corroded surface'; Late glass he found 'at its best indistinguishable from modern glass, was mostly hard with a sharp fracture, fairly clear dark blue-green with a burnished surface which is seldom corroded' (ibid., 17). However, caution is necessary in attempting to date glass based on the observation of its physical condition, since durability, and therefore appearance, is dependent on many factors during manufacture as well as the environment in which it has been buried. There are instances where pottery found in archaeological contexts has been found useful in giving an indication of date, as at Glasshouse Lane (14), Wephurst Copse (21) and Brooklands Farm (23).

Where a furnace floor is found undisturbed, archaeomagnetic dating can be used to determine its last operating date within a decade or so. This method was used to indicate a date of *c.*1330 for Blunden's Wood (33), and *c.*1550 for Knightons (42), and has been used more recently by Chris Welch, with great success, to determine dates for glasshouses in Staffordshire (Crossley 2003, 263).

Of the 35 Wealden sites where it has been possible to suggest a date, despite the reservations over the assessment of date from the visual examination of glass referred to above, 15 belong to the 'early' (pre-immigrant) period and 20 to the 'late' (post-immigrant) period. This suggests a greater degree of activity in the last 50 years of the industry than during the medieval period and lends support to the documentary evidence.

Present condition

This section of the schedule provides a description of the present condition of the site and features of its immediate environment, based on field observation during visits made by the writer during 2003/5. Inspections have included field walking, the examination of adjacent watercourses and use of a trowel to expose surface evidence, but have not involved any actual digging: nor has use been made of archaeomagnetic survey techniques to trace buried features. Where possible, this section also includes an indication of the potential for future archaeological investigation.

English Heritage assessment

Between 1993 and 1996, field surveys of glasshouse sites were carried out under the Monuments Protection Programme (MPP) to determine threats of further destruction and to assess the importance of the site as part of the national archaeological archive (Crossley 1966). In 1999, the MPP Step 4 report was produced confirming the assessments made in Step 3, setting out the process for scheduling, and recommending appropriate action for conservation management (Chitty 1999). The grading criteria used are those described in Appendix 4 of MPP Step 3 (Crossley 1996) as follows:

***	Major national or international importance.
**	Definite national importance.
*	Lesser national importance.
0	Sites not of national importance.

Trends in land use

It is important to recognise the changes that are taking place in the ownership and use of land in the Wealden countryside, since these may have a significant impact on glasshouse remains in the area. The following overview of current trends is made mainly as a result of observation on the ground, but also with reference to the Surrey Structure Plan (2001-2016) and the West Sussex Structure Plan (2001-2016).

In recent years farming has suffered a general loss of profitability brought about by the staged withdrawal of grants under Common Agricultural Policy reform, an increase in competition from abroad where the industry is often in receipt of more generous subsidies, and constant pressure on price margins from major outlets such as supermarkets. These trends have seriously affected farming in the Weald, traditionally a region of small-scale mixed farms, and farmers are currently driven to diversify and experiment with new activities and outlets for their products and use of their resources.

In arable farming there has been a change of emphasis, away from traditional cereal crops, to alternatives such as maize or potatoes. So far, there appears to be little interest in non-food crops (eg rape for bio-fuels), but changing market and grant régimes make this a possible cause of reclamation of marginal land. Livestock farming, although not directly affected by the outbreaks of Foot and Mouth disease in 2000, is being challenged by changes in agricultural subsidy policy that are posing a particular threat to the future of dairy farming. Fruit growing, which at one time covered a large area to the north of Kirdford, and in which Kenyon himself had an interest, has practically disappeared and old orchards, planted between the wars, have been grubbed out.

Although there have been attempts to experiment by the introduction of new enterprises such as market gardening to supply soft fruit and vegetables to farmer's markets and farm shops, these are small scale ventures, and the overall picture is one of decline in agricultural activity and employment. A downturn in traditional farming practice, fuelled by rising property prices, has led to the break-up of farm estates into smaller land holdings of just a few acres, often purchased by incomers with an interest in keeping horses, a process referred to by local planners as 'horsification'. It is significant that Surrey was the first Local Authority to support and fund a 'Horse Pasture and Management Project', to provide an advice line for the county's horse and pony owners.

The house building policy of Local Authorities on both sides of the county boundary is tending to allow modest development in village areas, confined to 'infilling' and property extensions, provided the impact on the local environment is acceptable. However, in order to support the rural economy and for conservation purposes, diversification in the use of farm buildings is being permitted, within the bounds of strict planning constraints, for such purposes as light industrial use, office accommodation for professionals and holiday letting.

The counties of Surrey and West Sussex are among the most densely wooded in England, and over 22% of the 140 square miles within which the Wealden glasshouses are to be found is still covered by woodlands (SU92 22/TQ12 22 x SU92 40/TQ12 40). In recent years there does not appear to have been any reduction in the overall area covered by woodlands, but there have been local changes in how they are stocked and managed. Softwood plantations have become uneconomic since the collapse of the USSR, with the wood pulp industry taking advantage of the easy availability of cheap imports from old USSR satellite countries. Softwood plantations are being replaced by the planting of broadleaf trees, mainly oak, and quality conifers, for timber. There is a revival of interest in coppicing, bringing old coppice woodlands back into rotation as well as the planting of new coppice areas using mainly hazel, supplemented by ash and hornbeam. There has been significant growth in the demand for coppice wood in recent years for hurdle-making, fencing and charcoal. The revival of interest in the development of woodlands has been encouraged by planning policies that promote the conversion of agricultural land to woodland, better management, and the use of woodlands as a recreational resource. These policies are supported by grants from Local Authorities, the Department for Environment, Food and Rural Affairs (Defra) and in some instances are backed by EC funding.

There is generally a greater interest in the conservation of the countryside as an environmental and biodiversity resource and in its use for leisure and recreational purposes. This is a trend that is likely to continue as resources are made available to further these ends. Policies and facilities to encourage walking and cycling are already being implemented by Local Authorities who are being allocated additional funds for conservation purposes, and sporting activities, such as shooting and riding, continue to be promoted within the private sector. The effects on the region of the establishment of the South Downs National Park immediately to the south are yet to be determined.

The changes taking place in land ownership and management, paradoxically, may be viewed as threats to the preservation of archaeological features as well as opportunities for the discovery of new ones. The activities of deep ploughing, hedging and ditching, forestry and construction work that can so easily destroy a glasshouse, may also be the means of uncovering a new one. It is therefore essential that known locations are preserved and monitored, perhaps under a revitalised Monuments Protection Programme, and that the area is kept under continual surveillance for chance discoveries.

11: Conclusions and opportunities for further work

Conclusions

This thesis has followed three main areas of research. Firstly, an examination of the woodland industry of the western Weald from the second half of the sixteenth century to the first two decades of the seventeenth century. Secondly, a reappraisal of the Wealden glass industry as a significant user of wood fuel and part of the woodland economy referring to research carried out elsewhere in England and on the Continent. And thirdly, through field-work, to investigate and record the present condition of known glasshouse sites. The main conclusions are as follows.

The woodland economy of the western Weald (chapter 3)

Poor conditions for agriculture led to a farming system based on animal husbandry, evidence for which was found in local documents and maps which indicated a low ratio of arable land to meadow and pasture. The lesser manpower demands of stock farming compared with agriculture enabled the development of by-employment. drawing on the natural abundance of wood and timber to provide occupation in a variety of woodland trades and crafts. The woodland economy thrived as it sought to satisfy the demands of a rapidly growing population and the desire for higher standards of living arising from greater prosperity. The growing wealth of the region is reflected in the improved quantity and quality of its housing. Use was made of the Port Records of Arundel/Littlehampton in which references to shipments of a variety of wood products was found. providing a useful indication of the wide range of items made in the western Weald. The Port Records also pointed to the growing importance of the western Weald as a source of timber for shipbuilding, mainly in the Thames Estuary, following a decline in its availability from other regions.

It was also noted that the firewood industry, so important to east Sussex ports during the Middle Ages, declined in favour of ports to the west of the county during the late sixteenth century. The magnitude of the firewood industry at this time is evident when it is recognised that the considerable volume exported from the region, mainly to the London domestic market, was in addition to the local demands of the iron and glass industries.

In trying to build up a picture of the manpower employed in the woodland industries, local records proved to be less rewarding. This was due in the first place to their low rate of survival, particularly in the case of wills and inventories, and secondly the non-recording of secondary occupations. However, it is clear that a body of skilled craftsmen such as sawyers and carpenters was permanently employed in the industry, supported by a large, but indeterminate, number of part-time workers. Sales and distribution to places outside the region, particularly London and the emerging shipbuilding ports, were organised by 'woodmongers' or 'woodbrokers' who acted as merchants at both ends of the market.

Glass types found in Wealden contexts (chapter 5)

Here the research concentrated on a search of local and national documents, archaeological reports and the examination of glass in museum collections. Both window and vessel glass were manufactured in the Weald throughout the period, but it is clear that window glass was more important than vessel in terms of the overall volume of glass produced, particularly in the post-immigrant period when native output was approaching the level of national demand. Evidence was found to suggest that, in the post-immigrant period of the industry, glasshouses tended to specialise in either window or vessel production. Although window glass was made using both the crown and broad glass methods of manufacture, it was broad glass that became predominant, probably because it was cheaper, involved less loss in cutting and the majority of the immigrant manufacturers originated from Lorraine where this process was standard.

Kenyon's view that 'late' window glass was of thinner substance is supported by documentary evidence suggesting this was a deliberate move on the part of the manufacturers enabling them to obtain more saleable glass from a given volume of glass metal. Users evidently accepted this change since it enabled production of a more transparent glass and helped to keep costs down. Instances were found of glass in old buildings being replaced with new, presumably of better quality, and examples where 'old' glass was re-used in other glazed areas of less importance.

It has been shown that, by the beginning of the seventeenth century, the numbers of glaziers were growing to cope with increased demand, with most towns of moderate size possessing glaziers who were often affiliated to a local trade guild.

A research objective was to study vessel remains in museum collections, to determine the range of types in use. The surviving vessel glass from the Weald is so fragmented that it is often difficult, if not impossible, to identify individual vessel types. However, it was clear that the output comprised simple, utilitarian vessels; an exception being examples of distilling apparatus found at Knightons. References to glassware in local wills and inventories were found to be infrequent, suggesting that glass vessels were not widely used in the Weald at this time, or perhaps were not sufficiently valued to be listed as separate items. In inventories for the period following the closure of the industry (1620-40), it was found that glass vessels were referred to with greater frequency, suggesting that perhaps their common use came late in the Weald.

An unexpected discovery was that glass, both vessel and window, was transported overland to London, the main market, rather than by sea as was previously thought.

Glassmaking: furnaces and crucibles (chapter 6)

The study of archaeological reports relating to the excavation of glasshouses elswehere in England and on the Continent has been profitable in helping to interpret furnace design and layout in the Weald. As elsewhere, excavated examples of Wealden furnaces show little sign of advance or development during the medieval period. and it was not until the arrival of the French immigrants, after 1567, that new features appear. One of these was a noticeable trend towards smaller, more compact melting furnaces, allowing less heat to be dissipated in heating furnace fabric, with a greater concentration of heat applied to the crucibles. Evidence was found of small modifications, and experimentation in attempts to attain higher firing temperatures, to improve melting and for greater fuel economy. These improvements were dependent on the availability of better materials and building techniques to provide greater durability, and were identified by the use of purpose-made bricks and by the employment of specialist builders.

The introduction of the 'winged furnace', of which only one has so far been found in the Weald, is a particular example of a new approach to furnace design, in which heat taken from a central furnace was used for subsidiary heat processes in the wings. It was notable that winged furnaces only appear to have been used for vessel manufacture, and supports the view that vessel and window glass making were becoming increasingly specialised. This research was not able to discover how window glass was annealed in the post-immigrant period, and this remains an unsolved problem.

It is suggested that the critical temperatures required in the annealing process may have been measured using 'proof pieces' as described in an early seventeenth century account about firing stained glass.

Attempts have been made to identify the source of clay used in crucible manufacture. Petrological analysis using thin sectioning was used on Wealden crucible samples, but was unsuccessful in providing information that could be compared with geological examples of refractory clay, to determine its origin. This problem has been complicated by the effects of prolonged firing and the possibility of other substances, such as inferior local clay, grog and sand being added during manufacture to eke out the use of refractory clay brought form outside the Wealden district. However, the crucible analysis proved useful in supporting the view that higher temperatures were achieved in the later period of manufacture; and some evidence for the use of grog was discovered.

Glassmaking: batch ingredients (chapter 7)

One of the aims of this research was to identify possible sources of batch materials used in the Wealden industry. The source of silica was sand, to be found in great variety, but much of this is ferruginous and unsuitable for glassmaking without the use of a decolouriser. There are, however, scattered deposits of sand of sufficiently good quality from which glass could be made. None of these deposits was found in the immediate vicinity of a glasshouse and it therefore appears likely that the glassmakers had to carry supplies. To obtain sand of the best quality it may have been necessary to transport it some distance from outside the area, but this would have been preferable to establishing a glasshouse near a supply of suitable sand, and transporting the fuel.

An on-going problem is that the diversity of ash, available from plants and from furnaces makes it difficult to establish the precise origin of the alkali used. As elsewhere, it is likely that the ash of plants such as ferns and bracken was used, supplemented by wood ash from the furnaces, and it is evident from contemporary documents that ferns were available in the locality, as they are today, but no reference has been found associating their use with glassmaking. The question of the use of beech ash has been considered, and it is suggested that its importance in connection with glassmaking in the Weald has been exaggerated by earlier researchers.

It has been assumed over many years that lime was not added to the batch as a separate ingredient, and that it was added unknowingly as a constituent of the ash used as an alkali. This seems likely in the case of glass of medieval forest glass type (potash, lime, silica) and is supported by the analysis of local sand which indicated a low lime content. However, in glass of post-immigrant type (high lime, low alkali), in which the lime content is greater, the origin is not clear and points to the possibility of lime being added using plant ash having a high lime content, or the addition of lime as a separate ingredient.

Documentary evidence for the use of fritting was found, and recent research has demonstrated its advantages, but little evidence of frit appears to have been found in conjunction with glasshouse remains, the only known examples being those taken from Knightons glasshouse in Guildford museum.

Cullet was undoubtedly used, and is referred to in contemporary records, including the Port Books. It is considered that the fragmented state of glass found at Wealden sites, and referred to above in connection with vessel glass, is due to the way cullet was collected and prepared in London for transport to the Weald.

Apart from two isolated examples quoted in Kenyon, no evidence of coloured glass having been made in the Weald has come to light, despite the examples of coloured glass taken from early sites by Cooper, which are probably cullet brought in from elsewhere.

The writer was fortunate in being able to have glass samples analysed at the laboratories of English Heritage. As originally intended, samples of manufacturing waste were selected for analysis, but it was also found possible to take samples from glasshouses which are referred to in contemporary documents that provide a date, and were linked to known glassmaking families. As anticipated, analysis confirmed the introduction of high lime, low alkali glass by immigrants after 1557. An unexpected finding was that a glasshouse worked by native glassmakers was still in operation in the post-immigrant period, and was still producing glass using the earlier 'medieval' formula. This supports the traditionally held view that the immigrants worked in isolation, keeping secret formulae and manufacturing methods to themselves. This research also questions Kenyon's interpretation of glass found at what he termed 'transitional' sites, and suggests that these glasshouses were run by native workmen, using traditional methods, who continued to operate after the arrival of the immigrants.

Glassmaking: wood fuel (chapter 8)

One of the main reasons the glassmakers settled in the Weald was the availability of fuel from its extensive woodlands. This research found no evidence for any particular wood species being used, leading to the conclusion that several varieties were used, depending on what was available.

The importance of dry wood has been emphasised by several writers, but precisely how wood was dried has not been made clear. The research concludes that, after cutting, wood was dried in natural conditions and that it was brought into the glasshouse perhaps a few days before use and placed on racks where it could be thoroughly dried by the heat of the furnaces.

It was intended to investigate how alien glassmakers, unable to own land of their own, obtained their wood fuel, and what transactions were involved between them and local landowners. A search of documents has been unproductive in this respect. This may be due to records of individual transactions being destroyed after consolidation into estate accounts, or it may be that such transactions were carried out verbally with no written record. However, suggestions are put forward for the variety of sources of firewood the glassmakers had at their disposal.

A particular objective was to investigate the use of managed coppicing in connection with glassmaking. This question was approached by searching for evidence of coppicing in the records of local estates, but no such evidence was found before the time the industry was closed down. This was a surprising discovery, considering the highly-developed coppicing methods in use by the iron industry, particularly in the eastern Weald at this time. It is reasonable to speculate that, had glassmaking survived managed coppicing would have been adopted to ensure continuity of supplies, and a ban on the use of wood fuel might not have been implemented.

The preservation of the woods (chapter 9)

This research has examined the writings of contemporary commentators on the need to preserve the woods, and has examined the legislation introduced to combat the problem of the vanishing woodlands, a topic that has so far not been investigated in relation to the western Weald.

At first the Wealden region was largely exempt from legislation aimed at controlling the cutting of wood, probably on account of the extensive and adequate supplies there, compared with other parts of the country where stocks were sparse. But as concern mounted over the increasing demands of the iron mills during the second half of the sixteenth century, regulations were introduced to control their activities, including in the Weald. The response of the iron industry, encouraged by the government, was to develop managed coppicing methods.

It was not until later in the debate that the glass industry became referred to as a threat to the woodlands. By the early 1600s the invention of new coal-fired technology offered an alternative to the use of wood.

It is considered here that it was not the shortage, or the fear of shortage, of wood fuel in the western Weald that resulted in the ban on the use of wood, but rather the invention of the coal-fired furnace that enabled influential investors to mount a powerful lobby against the continuing use of wood and, through the use of the monopoly laws, to establish their control over the industry in all its aspects.

The Wealden glassmaking sites (chapter 10)

This research has involved the examination of all known glasshouses in the Weald, including locations where finds of glassmaking materials have been made, but which lack evidence of actual manufacture. An objective was to assemble information about each location to form a schedule that would be readily accessible for reference by future researchers. A particular aim has been to record the present condition and circumstances of each glasshouse and to assess its potential for archaeological excavation or as a source of glassmaking material suitable for laboratory examination in the future. It was during this field-work that samples of glass and crucible were collected for laboratory analysis.

Early in the course of this research, a glasshouse was found at Northchapel by a local resident: this was a new discovery, and the furnace dates from the post-immigrant period, producing window glass. This was rewarding, due to association with dated documentary references, and the furnace site was used as a source of glass for the laboratory analysis discussed in chapter 7.

Chapter 10 provides an introduction and accompanying notes to the 'Schedule of glassmaking sites' which is contained in Appendix 1. In Appendix 2 'Supplementary list of glassmaking sites', there a is further schedule containing information about locations where glass or crucible has been found, but for which there is insufficient evidence of glassmaking to include them in the main schedule. These locations may become more significant if further finds are discovered nearby.

Visits were also made to local and national museums to examine collections of Wealden glass and glassmaking materials, and this was helpful in providing information for use in chapters 5 and 6. Appendix 4 contains a list of 'Wealden glass in museums', indicating where surviving excavated material is to be found.

Opportunities for future work

At many Wealden sites there is a need for surveys to be carried out, using specialist equipment, to establish the precise location of the glasshouse and its furnace. This is necessary at sites such as lower Roundhurst (39) where evidence of glassmaking has been found but the frunace itself has not so far been discovered; and at sites such as Fromes Copse (5), so dug over by by previous researchers as to make the precise location unclear.

Glasshouses will continue to be important resources for samples of glass and crucible fragments for on-going laboratory research: for example, to identify the batch ingredients used by the makers of HLLA type glass, or the combination of materials used in crucible manufacture.

There are still several unanswered questions relating to the design and layout of furnaces which it may be possible to answer through the use of more sophisticated survey equipment or by excavation: for example, was Vann Copse (35) the only winged furnace to be made in the Weald? Little is known about the use of secondary furnaces for the processes of pot-arching, fritting and annealing: were these structures separate and independent of the melting furnace, or were they linked in some way? The absence of any evidence of such structures in the ground may suggest the use of chambers above the melting furnace, using borrowed heat. Excavation would provide an opportunity to look out for such details as draught channels, samples of frit and evidence of post-holes or footings indicating the extent and type of structure of the glasshouse itself.

Whilst carrying out field work, it was found that several local residents had assembled their own collections of glass, crucible and pottery fragments found over the years through gardening, agriculture or construction. It would be advisable for these to be added to local museum collections while there is still knowledge of their origin. This could perhaps be achieved by mounting a campaign through the auspices of a local museum, to encourage the deposit of these finds with a museum where they can be properly cared for.

It will be necessary to continue surveillance of glasshouse remains in the Weald. Seventeen sites have so far been listed under the Monuments Protection Programme, but it remains to be seen what measures will be taken under this scheme for their preservation. At some locations there are signs of neglect that threaten to destroy remains below ground in the long term. An example is at Wephurst Copse (21), the only glasshouse in the Weald scheduled as an Ancient Monument, where young trees are growing on top of the furnace mound and seem likely to cause root damage to the underlying remains.

Undoubtedly there are still new glasshouses to be found in the Weald: Kenyon was aware of this and there have been fresh discoveries in recent years. In chapter 10, current changes in land use and ownership were described under the heading 'trends in land use', suggesting that change can provide opportunities for new discoveries: this, combined with a greater interest by the general public in archaeology, encouraged by the Portable Antiquities Scheme, is likely to lead to further finds.

Appendix 1: Schedule of glassmaking sites

Notes to the schedule:

Site name: Kenyon's site names have been used with Wincolt's alternative in brackets [ ].

Site number: To avoid any confusion that might result from re-numbering, the schedule is based on Kenyon's list of 42 sites, using his numbering, to which has been added a further six. Of these six, two are sites referred to by Cooper and Winbolt, but which were rejected by Kenyon because he was unconvinced by the evidence: they have been placed in the schedule as there have been finds in recent years. The other four are new finds. The equivalent Winbolt reference number is shown in brackets [ ]. Numbers 1-47 have been listed by Crossley in his survey of Wealden glasshouses carried out in the early 1990s (Crossley 1994, 72-3); Tanland Copse (48) was discovered in 1998, and has so far not been published.

Parish: Parishes are those in being at the time of the Tithe Commutation Surveys of the 1830s and 40s. The modern parishes of Loxwood and Plaistow are shown in brackets [ ] where applicable. Northchapel, formerly part of the parish of Petworth, became a parish in its own right in 1717. Vann Copse (35), was included in the parish of Godalming until 1867 when it became part of the newly created parish of Busbridge, and in 1995, as a result of the further reorganisation of parish boundaries, it was transferred to the parish of Hambledon (Pastoral Measure, 1983).

NGR: There are variations in the National Grid Reference quoted in different sources. Generally these variations are minor, but for the sake of consistency, those used in the County Sites and Monuments Records have been used. A significant variation between sources occurs in the reference given for Crouchland (12), but it has been shown that Kenyon's reference is incorrect (SMR. West Sussex/ 3033).

HER: The County HERs of Surrey (held at Surrey County Council, Kingston upon Thames) and West Sussex (held at West Sussex County Council, Chichester) contain a record of each site with a location map (1:10,000 scale). Much of the work for these valuable records was prepared by Mr F G Aldsworth and Mr J Kenny.

NMR: The NMR reference number refers to records held at the National Monuments Record Centre, Swindon.

English Heritage assessment:

***	Major national or international importance
**	Definite national importance.
*	Lesser national importance.
0	Sites not of national importance.

(see pp. 263-4)

Site name: Bowbrooks [Rodgate] **Site No:** 1 [14]

Parish: Chiddingfold, Surrey.
NGR: SU 9375 3257 **HER:** Surrey/1548 **NMR:** SU93 SW9
Field name: Glasse Field (1803, WSRO. PHA OG12/AP)
Discovered: Furnace not found. Field name only, known to Cooper and marked on his map.
Archaeology: -
Product: -
Museum evidence: -
Date: -
Literature: Winbolt 1937, 37.
Kenyon 1967, 158-9.
Present condition: The NGR marks the position of 'Glasse Field'. There have been no finds at this location, but the Field name is evidence of a glasshouse in the vicinity. The field has been under grass for many years and should a furnace be found it could be well preserved.
E H assessment: 0
Additional notes: A possible site not yet discovered.

Site name: Gostrode I [Broomfield Hanger] **Site No:** 2 [15]

Parish: Chiddingfold, Surrey.
NGR: SU 9610 3351 **HER:** Surrey/1574 **NMR:** SU93 SE2
Field name: -
Discovered: 1911 Cooper family;
1931 revisited by Wimbolt/Kenyon.
Archaeology: 1931 excavated by Winbolt/Kenyon. Part of red, clay floor of furnace, crown window fragments.
Product: Crown window and vessel.
Museum evidence: Guildford: box of glass fragments, and a box of fragments labelled 'Cooper'.
Haslemere: Cooper Collection, glass fragments (some coloured), two pieces of blowpipe, one piece of iron pontil, flints.
Date: Early, as suggested by appearance of glass.
Literature: Winbolt 1933,37.
Kenyon 1967,159-60.
Present condition: Since the O/S survey (1966-76), woodland has been thinned and cleared of undergrowth leaving scattered oak standards in rough grass. There are no visible remains. Furnace remains have probably been damaged by earlier explorations and recent woodland clearance: it may be possible to confirm this using geophysical surveying equipment.
E H assessment: 0
Additional notes: This site is referred to by Kenyon as 'Broomfield Hanger (Gostrode I)'.
See also Gostrode II (no 6).
Nearby Gostrode Farm was owned by the Peytowe from early 16th C.

Site name: Chaleshurst, Upper [Chaleshurst Copse, Upper] **Site No:** 3 [10]

Parish: Chiddingfold, Surrey.
NGR: SU 9481 3323 **HER:** Surrey/1545 **NMR:** SU93 SW6
Field name: -
Discovered: 1916, Cooper family.
Archaeology: 1916, excavated by the Cooper family.
1931, excavated by Winbolt.
Two furnaces 40 yds. apart (see No 4)
'Besides bits of vessels, bottles, crucibles, blow-pipes etc, am immense quantity of window', including painted cullet.
Product: window.
Museum evidence: Haslemere: crucible and glass fragments, quarry.
Cooper Collection: crown, muff and vessel.
Date: Early – suggested by appearance of glass.
Literature: Winbolt 1933, 36.
Kenyon 1967, 161-2.
Present condition: Situated in a tree plantation, no visible features survive.
The furnace is likely to have been damaged by earlier excavations and tree-felling/planting.
E H assessment: *
Additional notes: The Peytowe family owned Chaleshurst from *c.*1503.
Glass from this site was used to make the window in Chiddingfold Church, donated by Cooper in 1916.

Site name: Chaleshurst, Lower [Chaleshurst Lower] **Site No:** 4 [11]

Parish: Chiddingfold, Surrey.
NGR: SU 9476 3333 **HER:** Surrey/2201 **NMR:** SU93 SW6
Field name: -
Discovered: 1916, Cooper.
Archaeology: 1916, excavated by the Cooper family: two furnaces 40 yds. apart (see No 3).
Vessel glass of good quality, small crucible containing ruby glass, fragment of large crucible.
1930s, Winbolt noted the site had been destroyed by drainage works.
Product: ? vessel.
Museum evidence: Guildford: small crucible containing ruby glass, fragment of large crucible.
Haslemere: glass and crucible fragments, furnace waste.
Cooper Collection: vessel fragments, some coloured, flashed.
Date: Late, suggested by type of glass, but Early glass also found, probably cullet.
Literature: Winbolt 1933, 36.
Kenyon 1967, 161-2, Fig. 1, Pl. 3.
Present condition: Destroyed by drainage works (? 1930s).
E H assessment: 0
Additional notes: Ruby glass made here was probably experimental ? for vessel decoration.
The Peytowe family owned Chaleshurst from *c.*1503.
The only Chiddingfold furnace proved by the character of its glass to have been in operation after 1550.

Site name: Fromes Copse [Fromes Copse] **Site No:** 5 [7]

Parish: Chiddingfold, Surrey.
NGR: SU 9721 3489 **HER:** Surrey/1575 **NMR:** SU93 SE3
Field name: -
Discovered: 1921, Mrs B Halahan.
Archaeology: 1921, excavated by Mrs B Halahan, window and vessel glass, including coloured cullet.
1931, excavated by Winbolt, the remains of a mound surrounded by slight ditches, red clay floor, brick and rubble furnace. Early window and vessel glass, including coloured cullet. Iron blowpipe fragment.
Product: Vessel, but mainly window.
Museum evidence: Guildford: glass and crucible fragments.
Haslemere: window (muff), vessel fragments, waste.
Littlehampton: glass fragment.
Worthing: glass fragments.
Date: Early from appearance of glass.
Literature: Halahan 1921, 24-31 (map/plan).
Winbolt 1933, 34-5 (map/plan).
Kenyon 1967, 162-3.
Present condition: In mature woodland, there are several low mounds, the furnace probably at the centre. Probably little disturbed since Winbolt's excavation and could still contain features around the central furnace not investigated at that time.
E H assessment: **
Additional notes: Possibly worked by Allemayne and/or Schurterre: bought by Schurterre from Allemayne in 1368.

Site name: Gostrode II [Gostrode Farm] **Site No:** 6 [5]

Parish: Chiddingfold, Surrey.
NGR: SU 9645 3305 **HER:** Surrey/1581 **NMR:** SU93 SE9
Field name: Glasshouse Copse (1842 tithe map, 1127)
2 Glasshouse Fields (1842 tithe map 1126,1128)
Glasshouse Rew (O/S 1916)
Discovered: 1916, Cooper family found glass and crucible fragments only. The furnace has not so far been discovered.
Archaeology: 1931, area examined by Winbolt.
1961, area examined by Kenyon and Mr R S Porter. Furnace fragments, glass and crucible scattered widely. Furnace not discovered.
Product: ?
Museum evidence: Guildford: few small pieces of early glass.
Haslemere: glass fragments.
Glass fragments in Cooper Collection labelled 'Gostrode' may relate to Gostrode II.
Date: Early, based on Kenyon's examination of the Cooper glass finds, but provenance is unreliable.
Literature: Winbolt 1933, 31-2.
Kenyon 1967, 163.
Present condition: The field south of the copse is presently under grass, but has been ploughed in recent years. No recent disturbance in woodland. Crucible and glass recently found in the S E corner of Glasshouse Rew (2002), and supports the evidence of four field names. Kenyon could not find a burnt patch in the field when it was ploughed in 1961, so the site may be in the woodland, and could be well preserved.
E H assessment: 0
Additional notes: See Broomfield Hanger, Gostrode I (No 2).

Site name: Hazelbridge Hanger [Hazelbridge Hanger] **Site No:** 7 [6]

Parish: Chiddingfold, Surrey.
NGR: SU 9657 3449 **HER:** Surrey/1579 **NMR:** SU93 SE7
Field name: -
Discovered: 1912, Cooper family.
Archaeology: 1912, excavated by Cooper family.
1931, excavated by Winbolt and Kenyon: glasshouse surrounded by a ditch, contained remains of furnace floor and a separate ? 'annealing chamber'. Glass, including cullet with pieces of lead. Crucible fragments, including an in-turned rim.
Product: Window and vessel.
Museum evidence: British Museum: glass, crucible, waste (33 items).
Guildford: glass and crucible.
Haslemere: glass, crucible, waste and trailings.
Cooper Collection: glass fragments, some coloured.
Science Museum: glass (1 item).
Date: Early, from the appearance of glass, particularly that in Cooper' Collection (but ? provenance).
Literature: Winbolt 1933, 32-4 (Plan).
Kenyon 1967, 163-7 (Plan), Plate XIII.
Present condition: In well-maintained, mixed woodland with hazel underwood undisturbed in recent years. Mound with shallow ditches on three sides (N, E & S) still visible. Has been well dug over, but may retain features of interest such as the floor of an annealing chamber referred to in Winbolt's plan.
E H assessment: **
Additional notes: The Peytowe family owned Pickhurst nearby from at least *c.*1440.
This site referred to by Cooper as 'Roaring Pond Copse'.
Glass from this site used in Cooper's window in Haslemere Church. (see p. 109)

Site name: Imbhams [-] **Site No:** 8 [-]

Parish: Chiddingfold, Surrey.
NGR: *c.* SU 9275 3362 **HER:** Surrey/1558 **NMR:** SU93 SW19
Field name: Glasshouse Field (1842 tithe map, 911).
Discovered: 1961, Mr A Stemp.
Archaeology: 1961, excavated by Kenyon: floor of furnace found - a 'red pan of burnt clay'. Scatter of glass and crucible, the glass nearly all unblown lumps.
Product: ?
Museum evidence: Haslemere: glass fragments, waste.
Date: Late.
Literature: Kenyon 1967, 167-8.
Present condition: Under grass, but ploughed in recent years. There are no visible surface remains. Iron slag can be found in the ditch to the south and has also been used to metal the track from the iron works at Furnace Place to Imbhams farm.
E H assessment: -
Additional notes: -

Site name: Pickhurst [-] **Site No:** 9 [-]

Parish: Chiddingfold, Surrey.
NGR: *c.* SU 9660 3435 **HER:** Surrey/2208 **NMR:** SU93 SE6
Field name: Glasshouse Field (1842 tithe map, 841).
Discovered: 1912, tithe map reference noted by Cooper.
1951, Mr J Clegg.
Archaeology: 1951, remains of furnace floor and glass fragments found when a hedge and tree were buldozed.
Product: ?
Museum evidence: Guildford: *glass and crucible in a box labelled 'Cooper. Haslemere: * bottle bases and glass fragments. Cooper Collection, glass and crucible, some labelled 'Pickhurst'.
Date: Late, from appearance of glass.
Literature: Kenyon 1967, 168-9.
Present condition: Field under grass (with new fencing and gates). Site probably completely destroyed in 1951 (see above).
E H assessment: 0
Additional notes: *There is some doubt about the provenance of these items labelled 'Pickhurst' which may have originated from other sites nearby (see Kenyon 1967, 168-9).

Site name: Prestwick Manor [Prestwick] **Site No:** 10 [4]

Parish: Chiddingfold, Surrey.
NGR: SU 9720 3530 **HER:** Surrey/1527 **NMR:** SU93 NE9
Field name: Glasshouse Close (1842 tithe map, 647)
Discovered: Tithe map reference noted by Cooper.
Archaeology: Furnace not discovered, but evidence of Field Name, and glass and crucible found by Cooper.
Product: ?
Museum evidence: Haslemere: Cooper Collection, glass labelled 'Glasshouse Close' and 'High Prestwick'.
Date: Early, from appearance of glass found by Cooper.
Literature: Winbolt 1933, 31.
Kenyon 1967, 169.
Present condition: Furnace not discovered. Field to N of copse ploughed with no visible evidence. Field to W (Glasshouse Close) under grass, but a piece of glass foam was found 3 years ago when the field was ploughed. The copse is bounded to the N and E by bridleways. In the copse, trees have been thinned leaving stumps and the surrounding ground undisturbed. If found, the furnace remains could be well preserved.
E H assessment: *
Additional notes: There are the remains of a lime-kiln in the easternmost corner of the copse and Cooper records that the glasshouse was 'close by' (Cooper 1911, 73).

Site name: Redwood [Redwood] **Site No:** 11 [9]

Parish: Chiddingfold, Surrey.
NGR: *c.* SU 9825 3495 **HER:** Surrey/1585 **NMR:** SU93 SE13
Field name: Glasses Field (1842 tithe map, 606).
Discovered: pre 1914-18 War by Cooper family.
Archaeology: Furnace not discovered. Chance finds of glass and crucible, listed by Cooper and reproduced in Kenyon (1967, 170).
Product: ? vessel, no window found.
Museum evidence: Haslemere: glass fragments and trailings; Cooper Collection, assemblage of mainly vessel fragments, some coloured cullet.
Date: Early, on the appearance of glass.
Literature: Winbolt 1933, 35-6.
Kenyon 1967, 169-70.
Present condition: Farm buildings and stabling have been constructed on what is thought to be the site of Cooper's finds. Further building work in the vicinity may produce new evidence.
E H assessment: 0
Additional notes: -

Site name: Crouchland [Crouchland] **Site No:** 12 [25]

Parish: Kirdford (Plaistow), West Sussex.
NGR: TQ 0086 2959 **HER:** West Sussex/3033 **NMR:** TQ02 NW6
Field name: Glasshouse Mead (1845 tithe map, 528)
Glasshouse Fields (1845 tithe map, 530)
Discovered: 1931, Winbolt.
Archaeology: 1931, excavated by Winbolt and Kenyon. Traces of furnace floor of red burnt clay. Variety of glass fragments, including an 'exceptional' quantity of vessel shearings. Crucible fragments, some with in-turned rims.
Product: Vessel.
Museum evidence: British Museum: glass (13 items).
Guildford: vessel shearings and maufacturing off-cuts.
Haslemere: shearings.
Littlehampton: glass fragments and waste.
Date: Early, but ? some Late by appearance of glass.
Literature: Winbolt 1933, 48-50 (figs. and map, 47)
Kenyon 1967, 170-2)
Present condition: Winbolt had found the furnace at the N end of a rew as it joins the S W corner of Hardnip's Copse. This rew has now been thinned to a line of trees, and the fields on both sides are down to pasture for dairy cattle. There are no visible signs of glassmaking. According to Kenyon, the site was much disturbed.
E H assessment: **
Additional notes: The NGR quoted by Kenyon (TQ 0102 2967) is incorrect (see HER).

Site name: Frithfold Copse [Frithfold] **Site No:** 13 [37]

Parish: Kirdford, West Sussex.
NGR: SU 9791 2848 **HER:** West Sussex/1823 **NMR:** SU92 NE3
Field name: Glasshouse Field (late 18th C., WSRO.PHA. 3347; 1845 tithe map, 722).
Discovered: 1937, Kenyon.
Archaeology: Brick, crucible and glass. Furnace found but not examined.
Product: Window and vessel.
Museum evidence: Haslemere: crucible, glass and waste.
Date: Late. (Kenyon uses the term 'transitional').
Literature: Kenyon 1939, 173.
Winbolt 1940, 156.
Kenyon 1967, 172-3.
Present condition: In coppiced woodland to the E of the rew, the area has been undisturbed for many years, and would be worth further examination.
E H assessment: **
Additional notes: Close to iron furnaces at Ebernoe (SU 976 277) and Shillinglee (SU 972 308).
Possible connection with the Strudwick family (Kenyon 1967, 173).

Site name: Glasshouse Lane [Glasshouse Copse] **Site No:** 14 [24]

Parish: Kirdford, West Sussex.
NGR: TQ 0093 2374 **HER:** West Sussex/2933 **NMR:** TQ02 SW7
Field name: Glasshouse Field x 2 (1845 tithe map, 2160, 2209);
Glasshouse Copse (1845 tithe map, 2164);
Glasshouse Field (1837, Petworth tithe map, 174);
Middle Glasshouse Field (1837, Petworth tithe map, 1730).
Discovered: 1939, Mr A B Nicholls (furnace I).
1948, Mr A B Nicholls (furnace II).
Archaeology: Two furnaces 50 yds apart, the first partly destroyed by hedging and ditching, the second completely dug out.
Brick and glazed stone from furnace remains. Glass, many fragments including glass tubes and quarries. Crucible.
Product: Window (broad).
Glass tubes.
Museum evidence: Haslemere: vessel fragment.
Date: Late, suggested by appearance of glass and use of brick in furnace construction.
Literature: Winbolt 1933, 47-8 (map, 27).
Winbolt 1940, 160-1.
Kenyon 1967, 163-5, 92 (fig. 11).
Present condition: Both sites are recorded as having been destroyed, but pieces of furnace material are to be found in hedgerow ditches on both sides of the lane. Fields on both sides of Glasshouse Lane are now under grass with signs of recent ploughing. The extensive area covered by Field names (*c.* 40 acres) may benefit from field walking when next ploughed.
E H assessment: 0
Additional notes: Fragments of window quarries found here led Kenyon to suggest they were cut at the glasshouse (Kenyon 1967, 174).

Site name: Hog Wood [Strudwick Wood] **Site No:** 15 [22]

Parish: Kirdford (Plaistow), West Sussex.
NGR: *c.* TQ 0195 3207 **HER:** West Sussex/2954 **NMR:** TQ03 SW11
Field name: -
Discovered: 1931, Kenyon.
Archaeology: 1931, exploration by Kenyon. Glass fragment and waste.
Fragment of iron blowpipe..Furnace floor not discovered.
Product: ?
Museum evidence: -
Date: Early, from appearance of glass examined by Kenyon.
Documentary evidence (see below).
Literature: Winbolt 1933, 44-6 (includes map).
Kenyon 1967, 175-6, 31.
Present condition: The NGR is very overgrown in woodland. Winbolt's personal copy of *Wealden Glass* is marked in his own handwriting, 'now a pond' (1938).
E H assessment: 0
Additional notes: Documentary evidence of occupation of the area in the 14th century is discussed by Winbolt (1933, 45) and Kenyon (1967, 31).

Site name: Idehurst Copse, North [-] **Site No:** 16 [-]

Parish: Kirdford, West Sussex.
NGR: TQ 0315 2598 **HER:** West Sussex/4309 **NMR:** TQ02 NW7
Field name: -
Discovered: 1961, Mr W Taylor.
Archaeology: 1962, examined by Kenyon.
Glass fragments and lumps. Crucible, pottery of early 16th C.. Purbeck marble ? part of a marvering slab.
Furnace not found.
Product: Window.
Museum evidence: -
Date: Late 16th C. from analysis of glass.
Literature: Kenyon 1939, 171-3.
Kenyon 1967, 175-6.
Dungworth & Clark 2004.
Present condition: The furnace is probably beneath a decayed oak stump in the S W corner of Idehurst Copse where finds are concentrated. The site seems undisturbed and is worthy of full examination, now that the stump is rotting away. The adjacent field has been under pasture for several years.
E H assessment: ***
Additional notes: Probably a Strudwick site (Rice 1938, 72-3; Kenyon 1967, 171-3). Glass analysis indicates forest glass type, and was probably manufactured by native glassmakers who continued to manufacture into the post-immigrant period (Dungworth & Clark 2004).
See Idehurst Copse, South (No 17).
The site is located in mainly oak with hazel coppice, but there are beeches 100m. to the S W in Standgates Hanger.

Site name: Idehurst Copse, South [Clarke's farm] **Site No:** 17 [39]

Parish: Kirdford, West Sussex.
NGR: TQ 0307 2539 **HER:** West Sussex/4308 **NMR:** TQ02 NW10
Field name: -
Discovered: 1938, Mr Keefe/Winbolt.
Archaeology: 1938, examined by Winbolt and Kenyon. Remains of furnace floor. Glass, window and vessel (thin glass). Crucible, some with 'heavy rounded rims'. Glassy waste. Furnace material.
Product: Window.
Museum evidence: Haslemere: vessel fragments.
Horsham: glass and crucible fragments.
Date: mid 16th C., by analysis of glass.
Literature: Winbolt 1940, 157.
Kenyon 1939, 171-3.
Kenyon 1967, 177-8.
Dungworth & Clark 2004.
Present condition: The site is just inside the copse above a stream. The precise location of the furnace is unclear. The area has been dug over, but there is a scatter of glass, crucible and furnace material on the slope between the furnace remains and the stream.
E H assessment: **
Additional notes: Probably a Strudwick site (Rice 1938, 72-3; Kenyon 1939, 171-3).
Glass analysis indicates forest glass type, similar to Idehurst Copse, North (No 16) (Dungworth & Clark).
Crucible fragments were found in the foundations of 'Hazelhurst', nearby.

Site name: Little Slifehurst [Little Slifehurst] **Site No:** 18 [29]

Parish: Kirdford, West Sussex.
NGR: TQ 0020 2831 **HER:** West Sussex/2870 **NMR:** TQ02 NW4
Field name: Glasshouse Wood (1598, WSRO. Shillinglee MS B4/4).
Discovered: 1934, Winbolt and Kenyon.
Archaeology: 1934, examined by Winbolt and Kenyon. Part of sandstone furnace floor. Glass, a few fragments of window and vessel. Crucible, some 'red-bodied'.
Product: Window and vessel.
Museum evidence: Lewes: glass bottle neck.
Date: Early, from appearance of glass.
Literature: Winbolt 1935, 787-8.
Kenyon 1967, 178-9.
Present condition: The surrounding fruit orchards were grubbed out and the ground ploughed and seeded with grass approximately 15 years ago. The site is well dug over and must be largely destroyed. No visible remains noted in the surrounding grassland.
E H assessment: 0
Additional notes: Due E of the furnace site, where a track passes N/S through woodlands, rubble containing iron slag has been deposited to combat heavy clay. At a point approximately 100 m. S of Accold's Farm glass furnace waste also appears to have been used, probably from Little Slifehurst, but possibly brought in from Crouchland three-quarters of a mile to the N.

Site name: Lyons Farm [Weald Barkfold] **Site No:** 19 [31]

Parish: Kirdford (Plaistow), West Sussex.
NGR: TQ 0034 3143 **HER:** West Sussex/3050 **NMR:** TQ03 SW5
Field name: -
Discovered: 1934, Mr A Baker.
Archaeology: 1934, examined by Winbolt and Kenyon. Furnace not discovered. Glazed sandstone. Glass lumps. Crucible fragments.
Product: ?
Museum evidence: -
Date: ? Early, from appearance of glass.
Literature: Winbolt 1935, 790.
Kenyon 1967, 179-80.
Present condition: Pasture surrounds the NGR which is in a gill trampled by cattle as they drink from a pond. There are no visible remains. Perhaps the items found by Winbolt and Kenyon were taken from elsewhere and dumped there at some time. The surrounding fields should be searched if ploughed.
E H assessment: 0
Additional notes: Drichard Mose, glassmaker of Kirdford bought land in Playstowe in 1547 (Kenyon 1967, 179, n. 80.

Site name: Shortlands Copse [Shortlands Copse] **Site No:** 20 [32]

Parish: Kirdford (Plaistow), West Sussex.
NGR: SU 9960 3235 **HER:** West Sussex/1904 **NMR:** SU93 SE20
Field name: -
Discovered: 1935
Archaeology: 1935, examined by Winbolt and Kenyon. Red burnt clay furnace floor. Glass and crucible fragments.
Product: Window and vessel.
Museum evidence: -
Date: Early, from appearance of glass.
Literature: Winbolt 1935, 791.
Kenyon 1967, 180.
Present condition: The NGR is adjacent to a Water Board pumping station and the furnace has probably been destroyed and there are no visible remains. There has been some house building in the area in recent years.
E H assessment: 0
Additional notes: -

Site name: Wephurst Copse [Glasshouse Copse, Wephurst] **Site No:** 21 [23]

Parish: Kirdford (Plaistow), West Sussex.
NGR: TQ 0244 2936 **HER:** West Sussex/4307 **NMR:** TQ02 NW5
Scheduled Ancient Monument: WS 453
Field name: Upper Glasshouse Croft (1845 tithe map, 1339);
Lower Glasshouse Croft (1845 tithe map, 1338).
Discovered: 1931, Winbolt and Kenyon.
Archaeology: 1931, examined by Winbolt and Kenyon. Clearly defined mound surrounded by ditches. Furnace floor of red-baked clay. Glass, mainly window but some vessel, much of it in poor condition and unusually thick. Piece of iron puntee rod. Pottery of early 17th C..
Product: Window and vessel.
Museum evidence: Haslemere: glass fragments, crown and vessel.
Date: Late, from analysis of glass and pottery.
Literature: Winbolt 1933, 46-7 (map).
Kenyon 1967, 180-2, Pl. XIII.
Aldsworth 1979, 251 (plan).
Dungworth & Clark 2004.
Present condition: The glasshouse is on the edge of woodland beneath overhead power lines maintained by the Electricity Board. Although a Scheduled Monument, the site shows signs of neglect with young trees growing into the furnace remains. Perimeter ditches are clearly visible. Would be worth further examination, including the area around the furnace.
E H assessment: **
Additional notes: The only Wealden glasshouse to be declared an Ancient Monument. Recent analysis of glass suggests a Late date, revising Kenyon's 'transitional' assessment. Overhead electricity power lines.

Site name: Barnfold Farm [-] **Site No:** 22 [-]

Parish: Wisborough Green (Loxwood), West Sussex.
NGR: TQ 0482 3200 **HER:** West Sussex/5195 **NMR:** TQ03 SW12
Field name: -
Discovered: 1961, Mr W S Taylor
Archaeology: 1961, Kenyon explored the area, but no furnace was discovered. Glass waste, blobs and lumps, little blown glass. Crucible pieces.
Product: ?
Museum evidence: Worthing: glass waste pieces of crucible.
Date: ? Late.
Literature: Kenyon 1967, 182.
Barton 1963, 22.
Present condition: The
E H assessment: 0
Additional notes: A doubtful site, and within 400 m. of Fernfold (No 25). Sand of poor quality nearby.

Site name: Brookland Farm I and II [Brookbridge, Brookland (a) and (b)] **Site No:** 23 [33, 40, 41]

Parish: Wisborough Green, West Sussex.
NGR: TQ 0490 2685 **HER:** West Sussex/2869, 3034 **NMR:** TQ02 NW3
Field name: Big Glassy Field (Deeds, Winbolt 1935, 791);
Little Glassy Field (Deeds, Winbolt 1935, 791);
The Glassus (1842 tithe map, 1446)
Discovered: 1938, Winbolt and Kenyon.
Archaeology: Two furnaces have been located 50 yds apart:
(a) as NGR, furnace floor dug out in 1939 by Kenyon. Furnace floor, fire bricks; glass and crucible. Pottery, including Rhenish ware.
(b) 50 yds N W of (a), found in 1938 when an elm tree blew over. Furnace remains (destroyed); fragments of brick, glass and crucible were recovered.
Product: Mainly vessel of good quality.
Museum evidence: Haslemere:window, vessel, threads and lumps, including faulty but complete unguent bottle. Crucible fragments.
Date: Late, dated by pottery of 1570-1600.
Literature: Winbolt 1935, 791; 1939, 186 and 1940, 157-9.
Kenyon 1967, 182-4, Fig. 12, Pl. XVI.
Present condition: (a) dug out and probably destroyed, now under grass, ploughed in recent years to reseed. (b) destroyed when fallen tree was dug out. Items of glass, furnace waste and crucible have been found in ditches 200 m N N W, which may be scatter from the above furnaces or could indicate the presence of another furnace.
E H assessment: 0
Additional notes: Note Winbolt's reference to three furnace sites.

Site name: Burchetts [-] **Site No:** 24 [-]

Parish: Wisborough Green (Loxwood), West Sussex.
NGR: TQ 0497 2853 **HER:** West Sussex/2880 **NMR:** TQ02 NW7
Field name: -
Discovered: 1960s, Mr W S Taylor
Archaeology: 1960s, area explored by Kenyon, but furnace not discovered. Assemblage of glass waste and crucible found in plough soil.
Product: ?
Museum evidence: -
Date: Late, appearance of glass.
Literature: Kenyon 1967, 185.
Present condition: The field has been recently ploughed. There is a sparse scatter of glass and crucible near the E border of the field, but no discolouration of the ploughsoil to denote location of the furnace. Further examination may determine whether there is a furnace floor below plough depth.
E H assessment: 0
Additional notes: -

Site name: -Fernfold [Fernfold Wood] **Site No:** 25 [30]

Parish: Wisborough Green, West Sussex.
NGR: TQ 0477 3209 **HER:** West Sussex/3052 **NMR:** TQ03 SW12
Field name: -
Discovered: 1934, Miss Farmer/Winbolt
Archaeology: 1934, excavated by Winbolt.
Furnace in brick and sandstone, practically all destroyed above floor level.
Large amount of glass (has not survived).
Pieces of crucible.
Product: Window and vessel.
Museum evidence: Haslemere: glass fragment (vessel stem).
Lewes: glass fragments.
Date: 1567 – thought to be Carrè's furnace.
Literature: Winbolt 1935, 788-90 9includes plan of furnace).
Kenyon 1967, 185-8 (plan), Fig. 10,11.
Present condition: Now situated in woodland, though at the time of discovery a clearing had been made at the edge of the wood and ploughed.
The furnace is ? defined by ditches. The soil is heavy and the area of the furnace is usually 'very boggy' as Kenyon found it. However during the summer of 2003 the area completely dried out and it would be possible to re-examine the furnace remains under such conditions.
E H assessment: **
Additional notes: Was probably one of Carrè's furnaces (PRO.SP 15/13 No 89; Hume 1894, 211).

Site name: Horsebridge [Glasshouse, Horsebridge] **Site No:** 26 [21]

Parish: Wisborough Green, West Sussex.
NGR: TQ 0320 2288 **HER:** West Sussex/3043 **NMR:** TQ02 SW15
Field name: Glasshouse Meadow (1842 tithe map, 1872);
Glasshouse Cottage (1842 tithe map, 1873).
Discovered: 1930, Winbolt.
Archaeology: 1930, Winbolt explored the area but failed to find the furnace.
Furnace waste.
Glass, vessel and window, but mainly window.
Crucible pieces. Rhenish pottery.
Product: Window.
Museum evidence: -
Date: late, dated by pottery.
Literature: Winbolt 1933, 44 (map)..
Kenyon 1967, 188-9.
Present condition: There have been new finds, mainly of glass fragments, as a result of increased gardening activity. The furnace is probably under a tree in the garden to the N E side of the cottage. The garden is situated on the edge of ancient woodland and has probably suffered little disturbance over the years.
E H assessment: 0
Additional notes: Part of the cottage probably dates back to the 16th C. and could have provided accommodation for the glassmakers. (See also Songhurst Farm No 30).
The cottage is called 'Glasshouse', and appears under that name in the particulars of the sale of the Stopham estate in 1911 (WSRO. SP16).

Site name: Gunshot [-] **Site No:** 27 [-]

Parish: Wisborough Green, West Sussex.
NGR: TQ 0360 2909 **HER:** West Sussex/2881 **NMR:** TQ02 NW19
Field name: Glassets (tithe map, 660).
Discovered: 1963, Mr W S Taylor.
Archaeology: 1963, Kenyon explored the area and confirmed the discovery of a small concentration of glass and crucible, but the furnace was not found.
Product: ?
Museum evidence: -
Date: Late, suggested by the appearance of glass.
Literature: Kenyon 1967, 189.
Present condition: Under grass at the NGR reference, but has been ploughed in recent years.
Iron slag has been deposited in the area at some time. No finds, but the Field Name remains important evidence of a site nearby.
E H assessment: 0
Additional notes: Gunshot was conveyed to Thomas Jackman in 1603 and in 1606 Jackman was in dispute with Albert Hensey about the lease of his land for the purpose of glassmaking (WSRO. Add. MS 4476; PRO. STAC 8/179/7).

Site name: Malham Farm [Malham Farm] **Site No:** 28 [42]

Parish: Wisborough Green (Loxwood), West Sussex.
NGR: TQ 0650 2955 **HER:** West Sussex/3039 **NMR:** TQ02 NE5
Field name: Glasses Field (1842 tithe map, 847);
Glasses hanger (1842 tithe map, 848).
Discovered: 1939, Winbolt and Kenyon.
Archaeology: 1939, Winbolt and Kenyon explored the area but did not discover the furnace. Burnt sandstone. Glass lumps, badly corroded window glass. Pieces of crucible.
Product: ?
Museum evidence: -
Date: ?
Literature: Winbolt 1940, 159-60.
Kenyon 1967, 189-90.
Present condition: The NGR is under grass, though it has been ploughed in recent years. There are no visible signs of glassmaking in the field or hanger.
E H assessment: 0
Additional notes: The furnace may have been destroyed by woodland clearance or ploughing, or it may be deep under silt washed down from the hanger, in which case it may be well preserved.

Site name: Malham Ashfold [Malham Ashfold] **Site No:** 29 [20]

Parish: Wisborough Green (Loxwood), West Sussex.
NGR: TQ 0560 3010 **HER:** West Sussex/3055 **NMR:** TQ03 SE8
Field name: -
Discovered: 1930, Mr W Priest.
Archaeology: 1931, Winbolt excavated the furnace floor of red, burnt sandstone.
Glass, ruby, 200 fragments of coloured glass.
Glass lumps, vessel and window fragments.
Product: Window and vessel.
Museum evidence: Haslemere: glass lump and fragments, including ruby; Pieces of crucible.
Littlehampton: glass and crucible.
Lewes: glass manufacturing waste.
Date: Early ? *c.*1500.
Literature: Winbolt 1933, 42-4 (map).
Winbolt 1935, 791-2.
Kenyon 1967, 190-1, Fig. 1, Pl. V
Present condition: The precise location of the site is uncertain in overgrown woodland.
E H assessment: *
Additional notes: Probably two furnaces (Winbolt suggests 3).
There is a possibility that flashed ruby glass was made here experimentally.
The only site built on a shelf of outcropping sandstone.

Site name: Songhurst Farm [Loxwood House] **Site No:** 30 [19]

Parish: Wisborough Green (Loxwood), West Sussex.
NGR: TQ 0440 3264 **HER:** West Sussex/3051 **NMR:** TQ03 SW9
Field name: Glasshouse Field (1842 tithe map, 109).
Discovered: 1932, Winbolt and Kenyon.
1996, Mr D Brand found what appears to have been the furnace below floor level in Old Songhurst Farmhouse.
Archaeology: 1932, Winbolt and Kenyon explored the area and found glass, blue/green fragments, lumps, thread and hemmed bases.
1996, Mr D Brand discovered glazed sandstone blocks and pottery.
Product: Window and vessel.
Museum evidence: -
Date: Late, dated by pottery.
Literature: Winbolt 1932, 206.
Winbolt 1933, 42.
Kenyon 1967, 191.
Present condition: Furnace destroyed by building work.
E H assessment: 0
Additional notes: This could be the glasshouse marked on early maps: Norden (1595); Speed (1610); (see also No 32).
Part of Old Songhurst Farmhouse may be of late 16th C. date making it contemporary with glassmaking there; (see also Horsebridge No 26).

Site name: Sparr Farm [-] **Site No:** 31 [-]

Parish: Wisborough Green, West Sussex.
NGR: TQ 0451 2710 **HER:** West Sussex/2868 **NMR:** TQ02 NW2
Field name: Glasshouse Field (referred to in Deeds, Kenyon 1967, 191).
Discovered: 1930s, Winbolt.
Archaeology: 1930s, Winbolt explored the area and found a small assemblage of furnace waste and glazed bricks, but a furnace was not discovered.
Product: ?
Museum evidence: -
Date: ?
Literature: Winbolt 1933, 52.
Kenyon 1967, 191-2.
Present condition: There have been no recent finds. The area around the NGR is under grass and there are no visible signs of glassmaking. Perhaps the furnace was associated with Sparr Farmhouse, nearby, which dates from the 13^{th} C..
E H assessment: 0
Additional notes: John Lutman of 'Sparre' (Wisborough Green PR May 1583).

Site name: Woodhouse Farm [Brick-Kiln-Cottage] **Site No:** 32 [34]

Parish: Wisborough Green (Loxwood), West Sussex.
NGR: TQ 0568 3277 **HER:** West Sussex/3054 **NMR:** TQ03 SE4
Field name: -
Discovered: 1935, by Mr H R Phillips.
1961, Further finds by Mr W Taylor.
Archaeology: Winbolt and Kenyon revealed three possible furnaces, one of which was under the remains of a very large oak, but no attempt was made to dig out the furnace floors. Surface finds included parts of three firebricks, one of which tapers; glass, mainly in lumps, with little blown glass. Crucible pieces.
Product: ?
Museum evidence: Haslemere: glass fragments, trailings, and manufacturing waste. Crucible.
Date: Late, from pottery and appearance of glass.
Literature: Winbolt 1935, 791.
Kenyon 1967, 192-3, Figs. 1 and 2.
Present condition: The field has been cultivated for several years and glass and crucible has become widely scattered. The centres of the scatters could be localised by field walking and further examination may reveal that a furnace floor has survived below plough depth.
E H assessment: *
Additional notes: The only glasshouse to be found on top of a hill.
Possibly three furnaces?
Some crucible fragments have in-turned rims.
Is possibly the glasshouse marked on maps by Norden (1595) and Speed (1610): (see also No 30).

Site name: Blunden's Wood [-] **Site No:** 33 [-]

Parish: Hambledon, Surrey.
NGR: SU 9738 3738 **HER:** Surrey/1535 **NMR:** SU93 NE18
Field name: -
Discovered: 1959, Mr N P Thompson.
Archaeology: 1960, rescue excavation by Mr E S Wood.
Remains of melting furnace and two other furnaces for subsidiary processes.Glass, 400 fragments of window and vessel; crucible. Iron, part of a shovel and horseshoe.
Product: Window and vessel, including crown.
Museum evidence: Guildford: large assemblage of glass, crucible and pottery. Iron, part of a shovel and horseshoe.
Date: *c.* 1330 by archaeomagnetic dating.
Literature: Wood 1965, 54-79 (excavation report).
Kenyon 1967, 193, Figs. 1, 4-7, 10 Pl. XII.
Ashurst & Wood 1973, 92-4.
Merchant 1998.
Williams 2000, 1-7.
Welham 2001.
Present condition: Destroyed by clay extraction for brick-making.
E H assessment: 0
Additional notes: The first systematic excavation of a Wealden glasshouse.

Site name: Gunter's Wood [-] **Site No:** 34 [-]

Parish: Hambledon, Surrey.
NGR: SU 9696 3826 **HER:** Surrey/1536 **NMR:** 0SU93 NE19
Field name: -
Discovered: 1959, Mr W Bolton.
Archaeology: 1959, garden area explored by Kenyon. Furnace not discovered and may be beneath farm buildings.
Glass, piece of crown and fragments of hanging lamp bases; manufacturing waste; pieces of crucible.
Product: ?
Museum evidence: Guildford: glass and crucible.
Date: Early, from appearance of glass.
Literature: Kenyon 1967, 193.
Present condition: Farm buildings constructed recently (1998) over possible site of furnace. There have been no recent finds.
E H assessment: 0
Additional notes: White sand outcrops at Hambledon common nearby.

Site name: Vann Copse [Vann] **Site No:** 35 [2]

Parish: Hambledon, Surrey.
NGR: SU 9842 3771 **HER:** Surrey/1525 **NMR:** SU93 SE7
Field name: Upper Glasshouse Coppice (1842 tithe map, 2072);
Lower Glasshouse Coppice (1842 tithe map, 2075);
Upper Glasshouse Field (1842 tithe map, 2081);
Glasshouse Coppice (1842 tithe map, 2083)
(NB. References are to Godalming tithe map).
Discovered: 1931, Mr A R Caroe and Winbolt.
Archaeology: 1931, excavated by Winbolt and Caroe. Remains of four-winged furnace. Glass, mainly vessel; crucible; Rhenish pottery.
Product: Vessel.
Museum evidence: Lhaslemere: glass (vessel); crucible; glass waste.
Date: Late (1580s) dated by pottery and furnace layout.
Literature: Winbolt 1933, 29-31 (map, plate).
Kenyon 1967, 193-200 (plan, Pls. XXI-II, Fig. 10). .
Present condition: Thin mixed woodland with overgrown hazel coppice. Pieces of manufacturing waste and brick are to be found in the stream. The only winged furnace to be found in the Weald and may be worth further examination, despite extensive excavation in the 1930s.
E H assessment: ***
Additional notes: Possibly Luteri's glasshouse (Beck 1952, 89-91). The only winged furnace so far to be found in the Weald.

Site name: Ellen's Green [Ellen's Green] **Site No:** 36 [38]

Parish: Ewhurst, Surrey.
NGR: TQ 0992 3542 **HER:** Surrey/697 **NMR:** TQ03 NE14
Field name: -
Discovered: 1937, Mr H M Muggeridge.
Archaeology: 1937, Winbolt identified the 'site of at least one furnace' in the vegetable garden to the rear of the cottage, where the soil was 'prolific in glasshouse remains'. Glass fragments, window and vessel. Crucible, yellow, coarse grained.
Product: Window and vessel.
Museum evidence: Haslemere: vessel fragments, lump glass and waste.
Date: Late
Literature: Winbolt 1940,156.
Kenyon 1967, 200-1.
Present condition: There have been no further finds of glass and crucible in recent years. The precise location of the furnace is uncertain.
E H assessment: 0
Additional notes: Possibly related to Somersbury (No 37).

Site name: Somersbury [Somersbury Wood] **Site No:** 37 [18]

Parish: Ewhurst, Surrey.
NGR: TQ 1031 3776 **HER:** Surrey/713 **NMR:** TQ13 NW5
Field name: Glass House Field (1840 tithe map, 742);
Glass House Shaws (1840 tithe map, 743).
Discovered: Known in 1874 (pre Cooper).
1932, Winbolt and Kenyon.
Archaeology: 1932, examined by Winbolt and Kenyon.
Glass, window (thin), and manufacturing waste. Crucible. Coal cinders.
Product: Window.
Museum evidence: British Museum: glass (3 items).
Guildford: glass and crucible.
Haslemere: window fragments, glass waste.
Littlehampton: glass fragments.
Science Museum (London): crucible, brick (2 items).
Date: Late, suggested by appearance of glass.
Literature: Harrison 1874, 2.
Winbolt 1933, 40-2, 23 (map).
Kenyon 1967, 201-3.
Present condition: The site is in a clearing in woodlands in rough grass. Clearance of the area approximately 15 years ago may have destroyed the site and there are no visible remains.
E H assessment: 0
Additional notes: Window glass of 'exceptional thinness'. Coal cinders suggest experimentation in the use of coal fuel.
The glasshouse may have been worked by Lawrence Fryer, 'glasse fownder', and George Gerrat (Kenyon 1967, 202).
There is an area of coppiced beech nearby.

Site name: Sidney Wood [Sidney Wood] **Site No:** 38 [17]

Parish: Alfold, Surrey.
NGR: TQ 0206 3386 **HER:** Surrey/699 **NMR:** TQ03 SW2
Field name: Glasshouse Copse (1895 O/S).
Discovered: 1923, Rev F W Cobb.
Archaeology: 1923, Rev F W Cobb.
1930-1, Winbolt and Kenyon. Firebricks from siege. Glass, vessel of fine quality. Crucible, fragments and one small, complete crucible. Iron puntee rod. Pottery, Bellamine sherds. Coal cinders.
Product: Vessel.
Museum evidence: British Museum: glass, crucible, pottery (39 items).
Guildford: five boxes of material – glass, mainly vessel, crucible, including a small complete crucible, brick, furnace material, part of a glassmaking fork.
Haslemere: vessel glass, some with surface decoration. Crucible.
Pilkington: glass (4 items).
Science Museum (London): glass, crucible, brick (25 items).
Worthing: glass.
Date: Late.
Literature: Winbolt 1933, 37-40 (map, fig.), 71 (fig.).
Kenyon 1967, 203-6, Fig. 1, Pls. IV, XIV and XVI.
Merchant 1998.
Williams 2000, 1-7.
Welham 2001.
Present condition: The site is an area 5m. in dia. Surrounded by closely planted evergreens which screen it from South Path. Spoil heaps from earlier excavations contain glass fragments and pieces of red, baked clay. The area is being invaded by birch and sycamore saplings. In the pond to the S of South Path pieces of brick/tile and baked clay are to be found.
E H assessment: ***
Additional notes: According to Kenyon, 'the finest quality glass' found in the Weald. Possibly the glasshouse shown in Norden (1595) and Speed (1610) maps (see also Nos 32 and 30). Coal cinders suggest experimentation in the use of coal fuel.

Site name: Lower Roundhurst [Lower Roundhurst] **Site No:** 39 [26]

Parish: Lurgashall, West Sussex.
NGR: *c.* SU 9350 3030 **HER:** West Sussex/1891 **NMR:** SU93 SW3
Field name: Glass Piece (1841 tithe map, 135).
Discovered: 1959, Col L F Messel
Archaeology: 1959, chance find by Col Messel after ploughing.
The actual furnace has not been discovered. Glass and crucible fragments.
Product: ?
Museum evidence: Haslemere: glass fragments, manufacturing waste, crucible.
Date: Late, indicated by crucible analysis (see below).
Literature: Winbolt 1933, 49-50.
Kenyon 1967, 206.
Williams 2000, 1-7.
Present condition: Glass Piece is a small area of woodland that has failed to yield any finds despite being dug over by wild boar. Several pieces of crucible were found in 1998 when ditches at the N E corner of Glass Piece were cleared out, suggesting the furnace may in the adjacent field, currently under grass. This supports the evidence of Col Messel's finds when the field was ploughed in 1959.
E H assessment: 0
Additional notes: The quality of crucible suggests late date (Williams 2000).

Site name: Petworth Park [Petworth Park] **Site No:** 40 [27]

Parish: Lurgashall, West Sussex.
NGR: SU 9546 2599 **HER:** West Sussex/1828 **NMR:** SU92 NE8
Field name: Glasshouse Copse (1841 tithe map, 922);
Glasshouse Pond (1841 tithe map, 923);
Glasshouse Pond Plantation (O/S).
Discovered: 1931, Winbolt.
Archaeology: 1931 examined by Winbolt. The burnt floor of the furnace. Glass, blue/green, thin window disc. Crucible. Coal cinders.
Product: Window.
Museum evidence: none.
Date: Late.
Literature: Winbolt 1932, 206.
Winbolt 1933, 50.
Kenyon 1967, 206-7.
Present condition: in woodland, apparently largely destroyed when an ash plantation was laid out, but glass and crucible samples may be recoverable.
E H assessment: ***
Additional notes: Documentary reference to Glasshouse (1604, WSRO. PHA. 5726).
Coal cinders suggest experimentation in the use of coal fuel.

Site name: Lording's Farm [-] **Site No:** 41 [-]

Parish: Billingshurst, West Sussex.
NGR: *c.* TQ 0755 2438 **HER:** West Sussex/3049 **NMR:** TQ02 SE8
Field name: Glass House Field (1841 tithe map, 2396)
Discovered: 1965, Mr W S Taylor.
Archaeology: 1965, finds by Mr Taylor and Kenyon, but furnace not discovered. Glass 'blob'. Crucible.
Product: ? window.
Museum evidence: -
Date: Late.
Literature: Kenyon 1967, 207-8.
Present condition: The field at the NGR has been ploughed frequently in recent years, though currently under grass. There were no visible signs of glassmaking when field walking after ploughing (1999). The furnace may be in Great Lordings Wood to the N of the field.
E H assessment: 0
Additional notes: There is an electric railway nearby.

Site name: Knightons [-] **Site No:** 42 [-]

Parish: Alfold, Surrey.
NGR: TQ 0169 3409 **HER:** Surrey/706 **NMR:** TQ03 SW19
Field name: -
Discovered: 1965, Mr F W Holling.
Archaeology: 1965-73, excavated by Mr E S Wood.
Remains of 2 melting furnaces in sandstone blocks, an annealing furnace, fritting furnace, glasshouse and working floor. Glass, window and vessel, (*c.* 4,000 fragments). Crucible. blowing-iron and pontil pieces. Pottery of the 16th C., coin of Edward VI.
Product: Window, crown.
Museum evidence: Guildford: large assemblage of glass, crucible and pottery fragments. The excavation archive.
Date: *c.* 1550, by archaeometric dating.
Literature: Kenyon 1967, 208.
Wood 1982, 1-47 (excavation report).
Merchant 1998.
Welham 2001.
Present condition: In oak woodland with coppiced hazel, 20 m. W of the canal path. The glasshouse area has been roughly levelled after excavation, with the exception of a spoil heap which contains some glass and crucible fragments. and pieces of red, baked clay. Hazel is growing in the centre of the site and the wooden fencing erected by the Forestry Commission to mark the site has practically rotted away. The glasshouse is referred to in a Surrey Industrial History Group leaflet, but there is no longer any sign to identify the site. The extent of any remains left below ground is not clear from Wood's notes. Glass and crucible samples may be obtained from the spoil heap.
E H assessment: ***
Additional notes: The last of the medieval glasshouses before the arrival of the immigrants.

Site name: Mare Hill **Site No:** 43 (post Kenyon)

Parish: Witley, Surrey.
NGR: SU 9365 3988 **HER:** not listed **NMR:** not listed
Field name: -
Discovered: 1990, Mr P Cripps.
Archaeology: Scatter of furnace material of brick and baked clay on hillside. Glass residue on brick. Crucible pieces.
Product: ?
Museum evidence: -
Date: ?
Literature: -
Present condition: In woodland on steep hillside. The furnace may be on a terraced area above the position of the finds. The location on a steep incline in woodland may mean the furnace has suffered little in the way of damage. A possible source of glass and crucible samples.
E H assessment: *
Additional notes: A power-line is nearby to the N.

Site name: June Hill [Ovenhouse Field] **Site No:** 44 [12]

Parish: Chiddingfold, Surrey.
NGR: SU 9453 3339 **HER:** Surrey/1543 **NMR:** SU93 SW4
Field name: Ovenhouse Field (Cooper).
Discovered: 1915, Cooper, but Winbolt suggests the site was known in the 19th C.
Archaeology: 1915, Cooper records that crucible 'coarsely made', and 'imperfectly fused' glass were found here.
The furnace has not been found.
According to Winbolt, the glasshouse was 'excavated and demolished in the 19th C', but he gives no further information in support of this statement.
In the early 1990s a few glass fragments were found in garden beds.
Product: ?
Museum evidence: -
Date: ? Early
Literature: Winbolt 1933, 36, 51.
Kenyon 1967,155, 157.
Present condition: In 2004 glass, crucible and furnace material was found by new owners in an area to the S W of the house, near the stream. This raises the posibility that the furnace may after all have survived.
E H assessment: 0
Additional notes: This site was known to Cooper, who marked it on his map.

Site name: Steepwood Farm **Site No:** 45 (post Kenyon)

Parish: West Chiltington, West Sussex.
NGR: TQ 0827 2208 **HER:** West Sussex/2944 **NMR:** TQ02 SE10
Field name: -
Discovered: Mr Taylor, *c.*1966.
Archaeology: -1966, glass lumps and waste, and pieces of crucible were found after ploughing. No furnace remains were noted.
Product: ?
Museum evidence: Finds in finder's possession.
Date: ?
Literature: -
Present condition: The field where the finds were discovered has been under pasture for several years. It would be worthwhile to examine the area when next ploughed.
E H assessment: 0
Additional notes: A remote site - over a mile from the nearest 'possible' site (41) and 3 miles from the nearest 'proven' site (26).

Site name: Primrose Copse **Site No:** 46 (post Kenyon)

Parish: Wisborough Green (Loxwood), West Sussex.
NGR: TQ 0570 3330 **HER:** West Sussex/5092 **NMR:** TQ03 SE10
Field name: -
Discovered: *c.* 1960, Mr Taylor.
Archaeology: *c.* 1960, glass lumps, glassmaking wasteand pieces of crucible were found after ploughing.
No furnace remains were discovered.
Product: ?
Museum evidence: Worthing: glass lumps and waste.
Date: Late.
Literature: Barton 1963, 22.
Present condition: The field to the W of Primrose Copse is under grass (?set aside) but has been ploughed in recent years. Crucible fragments have been found (2000) 250 m. to the W where the footpath enters the wood. Mr Taylor suggested the glasshouse might be in Primrose Copse, but no signs have been found. The copse, of oak standards and hazel, is currently overgrown, but would be worth searching the nexr time it is cleared.
E H assessment: 0
Additional notes: -

Site name: Frillinghurst [Wolhook] **Site No:** 47 [13]

Parish: Chiddingfold, Surrey.
NGR: *c.*SU 9350 3350 **HER:** Surrey/1556 **NMR:** SU93 SW17
Field name: -
Discovered: 1915, marked on Cooper's map.
1932, explored by Winbolt and Kenyon.
1966, Mr A C Robinson.
Archaeology: -1932, Winbolt and Kenyon searched but failed to find the glasshouse.
Mr Robinson found glass lumps and crucible fragments in his garden at various times, but there has been no sign of a furnace.
Product: ?
Museum evidence: Haslemere: glass and crucible fragment.
Date: ?
Literature: Winbolt 1933, 36-7.
Kenyon 1967, 155, 158.
Present condition: A woodland garden around a part 16th C. house. There have been no finds in recent years.
E H assessment: 0
Additional notes: Marked on Cooper's map and scheduled by Winbolt, a few finds but no further evidence of a glasshouse.
Part of the house, 'Roppeleghs', is 16th C..

Site name: Tanland Copse **Site No:** 48 (post Kenyon) [-]

Parish: Petworth (Northchapel), West Sussex.
NGR: SU 9485 2880 **HER:** not listed **NMR:** not listed
Field name: -
Discovered: 1998, Mrs P Bruce.
Archaeology: 1998, Mrs P Bruce and C Clark.
Furnace remains of brick and tile. Under oak tree at edge of stream
Glass fragments of window (broad), crucible, glass and furnace waste.
Glass, crucible and furnace remains in the stream below.
Product: Window.
Museum evidence: -
Date: Late.
Literature: Bruce 2000, 36.
Dungworth and Clark 2004.
Present condition: The furnace is in a rew under a mature oak, and is being eroded by a stream as it washes away the ground beneath it. Samples of glass, crucible and furnace material are accessible.
E H assessment: -
Additional notes: The only glasshouse to be found in Northchapel and is likely to have been operated by the Hensey and Tysack families: 'Edward Henzey, and Timothe and Thomas Tiswick...of Northchapel', 1610 (Rice 1906, 43).

Appendix 2: Supplementary list of glassmaking sites

Site name:	NGR:	Notes:
Atte Bridge	*c.* SU 961 353	Marked on Cooper's map. Winbolt's site No 1 (Winbolt 1933, 29). (Kenyon 1967, 156). SMR Surrey/1532.
Coombe House Farm	*c.* SU 943 359	Marked on Cooper's map. Winbolt's site No 3 (Winbolt 1933, 31). (Kenyon 1967, 156). SMR Surrey/1512.
Clemsfold Farm	*c.* TQ 128 332	SMR West Sussex/ 3622. (Barton 1963, 22).
Furnace Place	*c.* SU 931 331	Note in Cooper's papers by his daughter. (Kenyon 1967, 156).
Grayswood	SU 9160 3555	(Graham 2000, 139).
Holloway Hill	SU 969 433	SMR Surrey/1812
Jewsley Farm	SU 9735 3429	Winbolt's site No 8 (Winbolt 1933, 35). (Kenyon 1967, 155). SMR Surrey/1586
Killinghurst, West End	*c.* SU 940 338	Marked on Cooper's map. (Kenyon 1967, 157).
Killinghurst, Wolhook	*c.* SU 936 336	Marked on Cooper's map. Winbolt's site No 13 (Winbolt 1933, 36-7). (Kenyon 1967, 158). SMR Surrey/1556.

Mesells	*c.* SU 986 347	Marked on Cooper's map. (Kenyon 1967, 156). (Winbolt 1933, 50).
Ovenhouse Field	*c.* SU 942 334	Marked on Cooper's map. Winbolt's site No 12 (Winbolt 1933, 36). (Kenyon 1967, 157). SMR Surrey/1544.
Rovehurst	SU 9519 3329	(Kenyon 1967, 155). SMR Surrey/1586
Surreylands	*c.* SU 975 325	Marked on Cooper's map. Winbolt's site No 16 (Winbolt 1933, 37). (Kenyon 1967, 158). SMR Surrey/1584.

Appendix 3: Chemical composition of analysed glass samples

Sample	Description	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_3	SO_3	Cl	K_2O	CaO	TiO_2	MnO	Fe_2O_3	Total
Idehurst North														
IDN 1	Heat distorted neck of small bottle	2.1	7.2	1.1	54.3	3.4	0.3	0.6	11.9	16.6	0.1	1.2	0.6	99.3
IDN 2	Glassworking waste	2.4	6.9	1.3	52.6	4.0	0.2	0.5	12.5	17.2	0.2	1.0	0.7	99.5
IDN 3	Glassworking waste	1.9	7.3	1.1	56.6	2.9	0.4	0.5	11.1	17.3	0.2	1.2	0.5	101.0
IDN 4	Glassworking waste	1.8	7.4	1.1	56.4	3.0	0.3	0.5	11.2	17.2	0.2	1.2	0.5	100.7
IDN 5	Glassworking waste	2.0	7.2	1.1	56.4	2.9	0.3	0.4	11.2	16.8	0.2	1.2	0.6	100.4
IDN 6	Glass artefact fragment	2.5	3.9	1.2	58.4	3.4	0.3	0.6	4.5	23.8	0.2	0.9	0.4	100.1
IDN 7	Glass artefact fragment	3.1	3.8	1.7	57.3	3.4	< 0.2	0.7	6.6	21.5	0.4	1.1	0.6	100.1
IDN 8	Glass artefact fragment	2.6	3.6	2.2	57.3	3.3	0.2	0.6	6.7	21.5	0.3	1.0	0.6	100.1
IDN 9	Glass artefact fragment	2.6	6.9	1.4	53.4	4.0	0.3	0.6	12.0	17.5	0.2	1.0	0.6	100.3
IDN 10	Glass artefact fragment	2.3	7.5	0.8	58.9	2.9	0.2	0.7	11.7	14.2	0.2	1.2	0.7	101.2
IDN 11	Glass artefact fragment	3.0	3.9	1.7	55.8	3.8	0.2	0.7	4.9	25.0	0.3	1.1	0.4	100.6
IDN 12	Glass artefact fragment	2.0	5.3	2.8	53.2	4.6	0.2	0.5	18.2	11.5	0.2	0.7	0.9	100.1
IDN 13	Glass artefact fragment	3.4	4.5	2.8	52.6	4.1	< 0.2	0.6	5.6	24.6	0.3	1.3	0.9	100.9
Idehurst South														
IDS 1	Glassworking waste	3.6	8.7	1.3	51.6	3.8	0.3	0.3	12.8	15.6	0.2	1.0	0.6	99.7
IDS 2	Glassworking waste	2.9	8.7	1.4	53.5	4.1	0.4	0.6	10.4	16.8	0.2	1.0	0.5	100.5
IDS 3	Glassworking waste	2.8	8.4	1.5	53.5	3.9	0.4	0.5	10.5	17.0	0.2	0.9	0.7	100.4
IDS 4	Glassworking waste	2.9	9.1	0.9	54.1	4.0	0.4	0.5	10.6	16.0	0.1	1.1	0.5	100.3
IDS 5	Glassworking waste	3.0	8.8	1.4	53.7	3.8	0.3	0.6	10.4	16.6	0.2	0.9	0.5	100.2
IDS 6	Glassworking waste	2.8	8.8	1.5	53.7	3.9	0.4	0.6	10.4	16.6	0.2	1.0	0.6	100.4
IDS 7	Glassworking waste	2.9	8.6	1.4	53.1	4.1	0.3	0.5	10.5	16.9	0.2	0.9	0.5	99.9
IDS 8	Glassworking waste	2.9	8.3	1.5	53.3	3.9	0.4	0.5	10.5	17.0	0.2	1.0	0.6	100.0
IDS 9	Glass artefact fragment	2.4	6.6	2.3	56.8	3.0	0.4	0.5	9.4	16.9	0.3	1.0	0.8	100.1
IDS 10	Glass artefact fragment	2.3	7.0	2.8	55.2	3.7	0.2	0.4	9.2	16.3	0.3	1.1	1.1	99.7
IDS 11	Glass artefact fargment	2.1	5.2	2.9	56.7	3.3	0.2	0.4	8.9	18.8	0.3	0.9	0.8	100.3

Continued)

Appendix 3: (continued)

Sample	Description	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_3	SO_3	Cl	K_2O	CaO	TiO_2	MnO	Fe_2O_3	Total
Tanland Copse														
TAN 1	Glassworking waste	1.7	2.6	2.1	61.6	2.2	< 0.2	0.5	3.1	24.6	0.2	0.7	1.2	100.8
TAN 2	Glassworking waste	0.7	2.6	2.3	62.0	2.0	0.3	< 0.2	4.1	24.7	0.2	0.7	1.2	100.8
TAN 3	Glassworking waste	1.5	2.6	2.1	60.8	1.9	0.3	0.4	3.3	25.8	0.2	0.6	1.2	100.7
TAN 4	Glassworking waste	1.7	2.8	2.6	60.3	2.2	< 0.2	0.5	3.4	24.4	0.2	0.7	1.4	100.2
TAN 5	Glassworking waste	1.9	2.9	2.1	60.9	2.3	< 0.2	0.5	3.7	23.7	0.3	0.7	1.1	100.2
TAN 6	Glassworking waste	0.9	3.1	2.1	60.3	2.4	0.4	< 0.2	5.3	23.5	0.3	0.8	1.3	100.4
TAN 7	Glassworking waste	0.9	3.0	1.8	60.5	2.2	0.3	< 0.2	4.8	23.9	0.2	0.7	1.2	99.4
TAN 8	Glassworking waste	2.0	3.2	2.5	60.3	2.5	0.3	0.6	4.3	23.0	0.3	0.8	1.3	101.1
TAN 9	Glassworking waste	2.3	2.7	2.1	61.6	2.0	< 0.2	0.8	2.6	25.1	0.3	0.6	1.2	101.2
TAN 10	Glassworking waste	1.6	2.7	1.9	63.7	2.0	0.3	0.4	3.3	22.8	0.3	0.7	1.4	100.9
TAN 11	Glass artefact fragment	1.9	3.0	2.7	61.0	2.0	0.2	0.4	3.7	23.2	0.4	0.8	1.5	100.9
TAN 12	Glass artefact fragment	1.8	2.7	2.1	61.6	2.2	< 0.2	0.4	3.9	22.8	0.3	0.7	1.1	99.7
TAN 13	Glass artefact fragment	0.8	2.9	2.0	59.5	2.3	0.2	< 0.2	4.8	24.8	0.3	0.7	1.3	99.5
TAN 14	Glass artefact fragment	2.0	2.8	2.1	60.9	2.1	< 0.2	0.6	3.2	23.8	0.3	0.6	1.2	99.5
TAN 15	Glass artefact fragment	2.0	2.8	2.1	61.8	2.0	< 0.2	0.5	3.8	22.7	0.3	0.6	1.2	99.7
TAN 16	Glass artefact fragment	0.9	2.9	2.0	61.4	2.0	0.3	< 0.2	4.4	24.0	0.3	0.6	1.4	100.1
TAN 17	Glass artefact fragment	1.8	2.8	2.2	62.4	2.1	0.3	0.5	3.8	23.0	0.3	0.7	1.2	101.0

(Dungworth & Clark 2004)

Appendix 4: Wealden glass in museums - summary of deposits by glasshouse site

	Site	Brit Mus	Cooper	Guildford	Haslemere	Hastings	Horsham	Lewes	L'hampton	Pilkington	Sci Mus	Worthing
1	Bowbrooks											
2	B'Hanger–Gostrode I		*	*	*							
3	Chaleshurst Upper		*		*							
4	Chaleshurst Lower		*	*	*							
5	Fromes Copse			*	*				*			*
6	Gostrode II		*	*	*							
7	Hazelbridge Hanger	*	*	*	*						*	
8	Imbhams				*							
9	Pickhurst		*	*	*							
10	Prestwick Manor				*							
11	Redwood		*		*							
12	Crouchland	*		*	*				*			
13	Frithfold Copse				*							
14	Glasshouse Lane				*							
15	Hog Wood											
16	Idehurst Copse N.											
17	Idehurst Copse S.				*		*					
18	Little Slifehurst							*				
19	Lyons Farm											
20	Shortlands Copse											
21	Wephurst Copse				*							
22	Barnfold Farm											*
23	Brookland I &II				*							
24	Burchetts											
25	Fernfold				*			*				
26	Horsebridge											

Site	Brit Mus	Cooper	Guildford	Haslemere	Hastings	Horsham	Lewes	L'hampton	Pilkington	Sci Mus	Worthing
27 Gunshot											
28 Malham Farm											
29 Malham Ashfold				*			*	*			
30 Songhurst											
31 Sparr Farm											
32 Woodhouse Farm				*							
33 Blunden's Wood			*	*							
34 Gunter's Wood			*								
35 Vann Copse				*							
36 Ellen's Green				*							
37 Somersbury	*		*	*				*		*	
38 Sidney Wood	*		*	*					*	*	*
39 Lower Roundhurst				*							
40 Petworth Park											
41 Lordings Farm											
42 Knightons			*								
43 Mare Hill											
44 June Hill											
45 Steepwood Farm											
46 Primrose Copse											*
47 Frillinghurst				*							
48 Tanland Copse											

Appendix 5: Wealden glasshouse site evidence criteria

Site name	Site number	Furnace floor	Other evidence of furnace	Field name + glass and crucible	Field name, little glass and crucible	No field name, but other evidence	Field name only	No field name, little glass and crucible
Bowbrooks	1						*	
Broomfield Hanger – Gostrode I	2	*						
Chaleshurst Upper	3		*					
Chaleshurst Lower	4		*					
Fromes Copse	5	*						
Gostrode II	6			*				
Hazelbridge Hanger	7	*						
Imbhams	8	*						
Pickhurst	9		*					
Prestwick Manor	10			*				
Redwood	11				*			
Crouchland	12	*						
Frithfold Copse	13		*					
Glasshouse Lane	14	*						
Hog Wood	15					*		
Idehurst Copse North	16					*		
Idehurst Copse South	17		*					
Little Slifehurst	18	*						
Lyons Farm	19							*
Shortlands Copse	20	*						
Wephurst Copse	21	*						
Barnfold Farm	22							*
Brookland I and II	23	*						
Burchetts	24							*
Fernfold	25	*						

Site name	Site number	Furnace floor	Other evidence of furnace	Field name + glass and crucible	Field name, little glass and crucible	No field name, but other evidence	Field name only	No field name, little glass and crucible
Horsebridge	26		*					
Gunshot	27			*				
Malham Farm	28			*				
Malham Ashfold	29	*						
Songhurst	30		*					
Sparr Farm	31						*	
Woodhouse Farm	32		*					
Blunden's Wood	33	*						
Gunter's Wood	34							*
Vann Copse	35	*						
Ellen's Green	36		*					
Somersbury	37		*					
Sidney Wood	38		*					
Lower Roundhurst	39			*				
Petworth Park	40	*						
Lording's Farm	41				*			
Knightons	42	*						
Mare Hill	43		*					
June Hill	44							*
Steepwood Farm	45							*
Primrose Copse	46							*
Frillinghurst	47							*
Tanland Copse	48		*					

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