Chapter 2

PIPEMAKERS AND THEIR WORKSHOPS

The use of geochemical analysis in the study of the clay tobacco pipe industry

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Abstract: The smoking of tobacco was introduced into the British Isles in the late sixteenth century and the production of the clay pipes in which it was smoked was initially a London monopoly. However, in less than a century, clay tobacco pipes were being produced in a network of centers spread across the whole country. These centers range from major cities down to small market towns and rural settlements. Our interest in this paper is to consider the supply of pipeclay. We describe the natural occurrence of pipeclay in the British Isles, some of the evidence for its exploitation and distribution, and the two main analytical techniques used to characterize it. Eventually, we hope to investigate the use of clay on a macro-scale, to reconstruct the routes over which pipeclay was supplied to this network, and on a micro-scale, to help reconstruct the way in which pipemakers worked. At present, however, we have shown the viability of our methodology and produced some initial results. We use as our main example the Pipe Aston Project, run by Allan Peacey in northeast Herefordshire. Finally, we discuss ways in which this study could progress.

Key words: Clay tobacco pipes; chemical analysis; Pipe Aston, Herefordshire, United Kingdom.

1. THE INTRODUCTION OF TOBACCO PIPES TO ENGLAND

Before contact with the Americas in the late fifteenth century, there was no tradition of smoking in Europe. There was not even a concept of "smoking" and initially the term used was to "drink" tobacco. During the sixteenth century, however, tobacco was imported and grown in Europe and the habit of smoking in a clay pipe was well established. To understand something of the background of the use of the pipe, we should consider the social context of its spread.

The first Europeans to smoke tobacco were sailors and adventurers who had observed and then adopted smoking. Subsequently, there were probably three main forces at play: its novelty and exotic nature; the medicinal benefits of tobacco (it was noted as an appetite suppressor); and, the social status of its earliest users (courtiers).

The progress of tobacco into England, as with the rest of Europe, is shrouded in uncertainty. At best, the documents only provide cameos on which to form a judgment. English sailors under the command of Hawkins in 1565 observed the native Floridians taking smoke through a pipe consisting of a cane and earthen cup, and recorded that the French, who had already established a colony there, also practiced the smoking habit (Hakluyt, 1589:47). In the face of this experience, it seems unlikely that some of the English sailors did not experiment also. Only six years later, in 1571, attempts were being made to cultivate tobacco in England (MacInnes, 1926:75, quoting Lobelius, 1576). If Hawkins' men brought pipes into England, they would have been of the stub-stemmed type that they observed in Florida. The pipe from Cambridge Backs illustrated by Oswald, conforming to this general type is atypical (Oswald, 1975:35). From the outset, English pipes had a bowl and stem formed as one.

After an initial expedition in 1584, Sir Walter Raleigh sponsored his second voyage to Virginia in 1585 with the intention of founding a permanent settlement. Thomas Hariot, mathematician, astronomer and tutor to Sir Walter Raleigh (Stephen and Lee, 1917:1321-1323), was a member of this expedition. In his *Briefe and true report of the new found land of Virginia,* he provides a reliable description of native tobacco culture and smoking habits (Hariot, 1588). Significantly, he writes "they use to take the fume or smoke thereof by sucking it through pipes made of claie ... We our selves during the time we were there used to suck it after their maner, as also since our returne" (Ibid.). An engraving by De Bry after a watercolor by White (the recording artist of the expedition) shows two Native Americans sitting on a mat surrounded by various foodstuffs and artifacts. Amongst these artifacts is a tobacco pipe of the angular elbow form still popular in the second half of the seventeenth century and forming a significant part of the production of Emmanuel Drue of Swancove, Maryland, whose production site has been investigated by Luckenbach et al. (2002:46-63). Pipes of this form are likely to have been the model for subsequent British clay tobacco pipe production.

By 1598, Paul Hentzner (1598:4), a visitor to England, records the constant custom of smoking in public places and notes that:

> The English – have pipes on purpose made of clay into the farther end of which they put the herb, and putting fire to it draw the smoak into their mouthe.

The first suggestion that these English pipes were modeled on American examples appeared in 1605. De l'Ecluse (1605) added a footnote to his abridged translation of Monardes' *Las Indias Occidentales,* based on Hariot's account (Mackenzie, 1957:81):

> In the year 1586 ... they found that the Inhabitants did frequently use some Pipes made of clay, to draw forth the fume of Tobacco leaves set on fire; which grew amongst them in great quantity, or rather to drink it down, to preserve their health. The English returning from thence (Virginy), brought the like pipes with them, to drink the smoke of Tobacco; and since that time the use of drinking Tobacco hath so much prevailed all England over, especially amongst the Courtiers, that they have caused many such like Pipes to be made to drink Tobacco with.

In England, it seems probable that pipes were being made in quantity by 1590, a supposition supported by Oswald's statement that pipes from deposits dating to the last decade of the sixteenth century are mold made (Oswald, 1975:5). The basic form of the pipe, exclusive use of white clay and the use of a two-piece mold to produce it in enormous quantities, were established at this time and both were retained with only minor alteration into the twentieth century.

2. PIPECLAY

In England, the term "pipeclay" has become synonymous with the white-firing, Tertiary ball clays of southern England and clays with similar characteristics. As luck would have it, all English-made clay pipes, from the late sixteenth century to the nineteenth century, were made from such clays. However, in northern America and the Caribbean, this was not the case, since some were made from red-firing clays, leading to the confusing but true statement that not all clay pipes are made of pipeclay. In what follows, we use the term pipeclay in its potting/geological sense.

2.1 Formation

Pipeclays are composed mainly of silica, kaolinite and muscovite. These three minerals also occur in china clay, but there is no evidence that this clay, which outcrops on the granite batholiths of southwestern England, was ever used for pipe making except when blended with other clays. Indeed, there are documentary references to the importation to Cornwall of ball clay from the Isle of Wight (Douch 1970:33-34). The main compositional differences between china clay and pipeclay are that the former is of a coarser texture, being poorly sorted, and that the clay requires sieving and crushing before it can be used, whereas most pipeclays are plastic when dug and could be used by potters and pipemakers without further treatment. Chemical analyses of china clays and ball clays show that the latter have a higher titanium content.

Pipeclays were formed by the in situ modification of fine-grained muds contemporary or immediately following their deposition. They formed in sub-tropical deltaic conditions where the sea level fluctuated seasonally. In these conditions, leaching of various elements took place, together with chemical modification of the clay minerals, leading to the formation of authigenic kaolinite and the redeposition of iron and associated minerals in a B horizon underlying the pipeclay, which is sometimes overlain by an organic deposit, such as coal or lignite. This gives rise to the alternative name for these clays, seatearth. This term simply implies "the clay/mudstone layer immediately underlying a coal," and does not necessarily imply that the clay is a pipeclay, in most cases it will be, in the other cases it might be a siltstone. Such conditions recurred several times in the geological past of the British Isles, from the Carboniferous Period (c.330 MY BP) to the Tertiary (c.55 MY BP). In some cases, the coal is absent, either because conditions did not allow it to form, or because of subsequent erosion. Because of the deltaic environment, it is not uncommon to find that the lithology of the strata is variable, with silt- and coal/lignite- filled channels cutting down through the earlier pipeclay. Furthermore, in many cases, the basins in which these deposits were forming were subject to cyclic variations in relative sea level, so that the coal is succeeded by sandstone.

2.2 Occurrence

Coal and pipeclay first occur in the early Upper Carboniferous, for example in the Millstone Grit Series. They become more widespread in the subsequent coal measures, outcropping in the coalfields of Scotland, Lancashire, Yorkshire, Leicestershire and South Derbyshire, Staffordshire, East Shropshire, and North Somerset. In addition, there were probably pipeclays in the Forest of Dean and in several other small outcrops not large enough to be exploited for coal extraction (Figure 2-1).

Figure 2-1. Location map showing places mentioned in the text.

These Carboniferous deposits are now often masked by later deposits, and are heavily faulted and indurated, all of which would have hindered their use. For the seventeenth and early eighteenth centuries, we can assume that only deposits outcropping at the surface would have been exploited.

Suitable conditions for pipeclay deposition did not recur until the Middle Jurassic Period. Two periods of coal deposition occurred in North Yorkshire, outcropping around the fringes of the North Yorkshire Moors and associated with seatearths. South of the Humber, now often exposed on the scarp slope of the Jurassic ridge, pipeclay is particularly well-developed and exposed in south Lincolnshire and Northamptonshire but not associated with a coal.

The next period in which pipeclays probably formed is the earlier part of the Lower Cretaceous, where deltaic conditions existed in the southeastern part of England, including patchy outcrops along the Oxfordshire/Buckinghamshire border and a more extensive, but poorly exposed, area in the center of the Weald.

Finally, the most important deposits of pipeclay, as far as pipe making is concerned, are those which were deposited in southern England during the Tertiary Period. These deposits have been subject to folding since deposition and now outcrop in isolated patches and basins. Outcrops exist in Devon to the north and south of Dartmoor (Peter's Marland and Bovey Tracey); in Dorset at Portland (especially at Arne, Povington and East Holme); and through Dorset, Wiltshire, Hampshire and Sussex (the Reading Beds, including the West Wellow clay, exported for pipe making and pottery). The Reading Beds in the Thames basin outcrop as a thin band from Surrey westwards into Berkshire then eastwards along the dip slope of the Chilterns and are exposed intermittently as far east as southern Suffolk. In the London basin, there are at least two periods of pipeclay deposition, the earlier being the Reading Beds and the later outcropping as part of the Bagshot Beds. In most of these outcrops, only a small proportion of the deposits consist of usable pipeclay and the only beds which are still worked today are Bovey Tracey, Peter's Marland, and the Isle of Purbeck. These clays are known as ball clays, initially because they were transported as large balls of clay.

3. THE PIPECLAY TRADE IN THE BRITISH ISLES

In 1619, James I granted a monopoly of pipe production to the pipemakers of Westminster, replacing and consolidating previous monopolies which had conflicting privileges. Although the 1619 charter covered the whole of England and Wales, it was openly flouted within the year at Bristol and prosecutions for infringement took place at Portsmouth (1622) and Reading (1623). This monopoly was closely linked to Philip Foote who, in 1618, was granted a 21-year monopoly to supply pipeclay to pipemakers (Atkinson and Oswald, 1969). Within a year, the monopoly was being broken and a lease dated 1619 between Swithen Bonham, one of the pipemakers who signed the 1619 Charter, Sir John Webb and Thomas Brundell, Knight and Baronet, records their agreement that the said Swithen Bonham "shall and may have and take any earth or shale for the making of tobacco pipes" from waste ground at Poole (Cooksey, 1980:338).

From the beginning, the London pipe making industry was supplied exclusively with clay from Poole and the Isle of Wight. There are many documented references for the coastal trade in tobacco pipeclay from these sources to ports as far west as the Helford estuary in Cornwall and as far north as Newcastle (Douch, 1970:33-34; Cooksey, 1980:337-347).

Ball clays from Peter's Marland, near Barnstaple in North Devon, were shipped up the channel to Bristol and Gloucester (Grant, 1983:40) and around the Welsh coast to Chester (Rutter and Davey, 1980:47). Some of this clay was taken by shipmasters acting as their own merchants, but 62 tons were shipped by a single individual, Peter Bewes (Grant, 1983:40).

Another source of pipeclay, presumably an outlying pocket of Tertiary ball clay, was being exploited at Chitterne in Wiltshire in the seventeenth century. Although the earliest reference dated 1646 recording pits upon the Cowedowne of Chitterne does not specify the type of clay being extracted, that it was tobacco pipeclay becomes clear in a later document since a license was issued in July 1651 by Henry Powlett to Edward Ffripp and Christopher Merriwether to dig "thirtie loades of clay to make tobacco pipes out of upon the downe of Chittern Mary" (Lewcun, 1987).

Documentary sources make it clear that Tertiary ball clays were favored by pipemakers from the early seventeenth century (and probably before) to the effective end of the industry at the turn of the twentieth century. Areas close to the coast were favored and the clay distributed around the coast in two main networks, one supplying the west coast and the other the south and east. Inland, other sources of ball clay were utilized, as at Chitterne, but probably only to supply pipemakers in their immediate neighborhood.

Coal measure pipeclays were inferior in quality but much more widely distributed in nature. This is confirmed by Plott (1686) when writing about the pipeclays of Staffordshire:

> As for tobacco pipe clays they are found all over the county, near Wrottesley House, and stile cop in Cannock Wood, whereof they make pipes at Armitage and Lichfield, both which though they are greyish clays yet burn very white. There is tobacco pipe clay also found at Darleston near Wednesbury, but of late disused, because of better and cheaper found in moreway field betwixt Wednesbury and Willingforth, which is of a whitish colour, and makes excellent pipes as doth also another of the same colour dug near the salt water pool in Pensnet chase, about a mile and a half south of Dudley. And Charles Rigge of Newcastle makes very good pipes of three sorts of clay, a white and a blew which he has from between Shelton and Hanley Green, whereof the blew clay burns the whitest, but not so full as the white, i.e. it shrinks more; but the best sort he has from Grubbers Ash, being whitish mixed with yellow, it is a short brittle sort of clay, but burns full and white, yet he sometimes mixes it with the blew before mentioned. But the clay that compasses all others of this county, is that of Amblecote, on the bank of the Stour, in the parish of Old Swinford yet in Staffordshire.

The use of coal measure clays is also documented in Shropshire. From Caynham in south Shropshire, there is a document from 1680 recording the sale of the manor with the exception of certain mineral rights amongst which tobacco pipeclay is specifically mentioned. There are documented pipemakers at Caynham in the late seventeenth century, but presumably the clay was also supplied to workers in Ludlow and Cleobury Mortimer, both known from documentary and archaeological evidence. Caynham is the nearest possible source of clay for the Pipe Aston industry.

The use of the middle Jurassic pipeclays is less well documented than either the Tertiary ball clays or the coal measure clays although the pipeclay at Northampton was said to be amongst the best in the land and was supplied to pipemakers in Northamptonshire and neighboring counties (Morton, 1712). At some point in the late eighteenth century, this clay source was exhausted and pipemakers instead used imported ball clay (Moore, 1975).

These quoted documents give a varied picture of the extraction and use of pipeclays, from the direct involvement of the pipemaker Swithen Bonham with the clay pits at Poole to merchant handlers and ship owners of both Poole and North Devon acting as middle men between the clay diggers and the pipemakers.

4. THE PIPE ASTON PROJECT

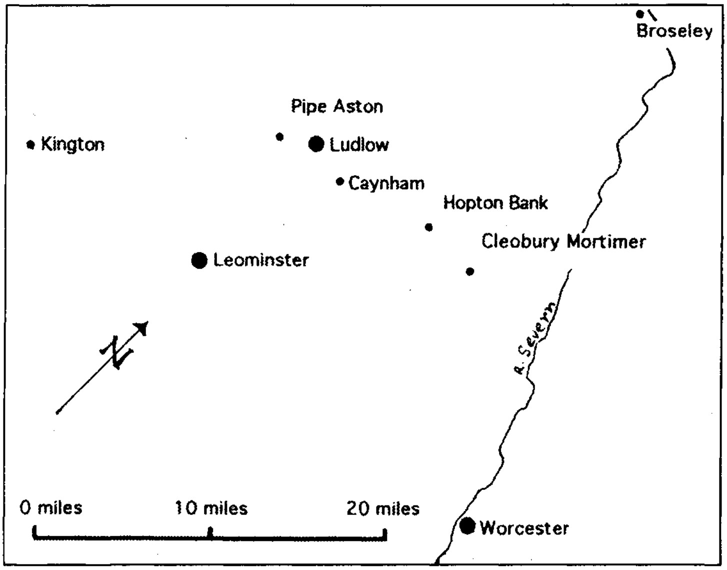

Figure 2-2. Map of North Herefordshire and South Shropshire showing places mentioned in the text.

Pipe Aston is situated in a predominantly wooded rural area of North Herefordshire, four miles to the west of the town of Ludlow (Figure 2-2). Although officially only known as Pipe Aston from the 1841 census onwards, pipemakers were active in the parish from the early seventeenth to the mid eighteenth centuries. Pipemakers had left the village a century before the place name was first recorded. To date, eight production sites have been located in the parish and at one of these, Roy's Orchard, at least eight makers were operating, although only one of these is known as a pipe-maker from written records. For a short period of time, little more than a century, a large number of pipemakers were working in this parish, and a study of the distribution of stamped pipes (mostly later than c.1650) shows that they had a limited market.

The Pipe Aston Project was set up to investigate developments in kiln design in the late seventeenth and early eighteenth centuries. The quality of the data recovered led to new avenues of research. Excavations in Roy's Orchard showed that pipemakers in this remote region of North Herefordshire worked in an extended family based, co-operative manner, sharing both workspace and molds, but using their own personal stamps to mark their products. Intermarriage between the pipe making families ensured a tight knit community with links extending from Cleobury Mortimer, 16 miles to the east, to Kington, 19 miles to the southwest. From this one production site, where up to seven makers were working at any one time, a total of 63 stamps were used, ranging from full names to initials to enigmatic symbols. That this array of stamps can be matched to as many as 36 identifiable molds shows clearly that the type of stamp had a market significance in many instances rather than simply maker identification. This diversity makes the products of this site ideal for further investigation by chemical analysis of their clay composition. Could different batches of clay be limited to product status, maker preference, or temporal factors? Initial work has shown identifiable patterns, the meanings of which remain somewhat enigmatic. Further work targeted at specific questions is anticipated.

Fieldwork over the ten year period of the project has identified eight production sites within a one mile radius of Roy's Orchard. They range in date from c.1620/30 to c.1740. Two of these sites, pre-dating the English Civil War, offer the opportunity to examine kiln structures of a significantly earlier date than any so far studied. That pipes were being made as early as the1620s in this seemingly remote region can probably be explained by the presence in Ludlow of the Council of the Marches, which was at this period the government of Wales. Even before the Pipe Aston Project began, the Ludlow area was noted for its high frequency of early seventeenth-century pipes. In Ludlow, there would have been a ready market conversant with London tastes and fashions.

5. THE ORGANIZATION OF PIPE MANUFACTURE

In urban areas, tobacco pipe making, as with other trades, was controlled by burgesses through the apprenticeship and freedom system. This ensured a continuity of ideas and practices handed down from master to apprentice over a period of training lasting generally seven years. In rural settings, such as Pipe Aston, it is likely that less formal methods were followed, such as the kin relationships previously noted. Although no such relationships with Broseley have yet been discovered in contemporary documents, the evolving pipe forms of Aston, which follow closely those of Broseley, suggest powerful links between the two communities. In either case, formal or informal apprenticeship, knowledge of the methods and practices of the trade were handed down from the master. The influence of the master would greatly impact the source of clay used as well as its preparation.

Clay was generally transported as dry balls of about 56 pounds in weight. Before use, these balls had to be rendered plastic and of even consistency. Two methods were commonly used to bring this about: levigation; and, kneading or beating. In order for the dry clay to take on water, it must first be broken down into small particles. Levigation can be used to separate stones and grit, which sink to the bottom, and organic material, such as roots, which float to the top. In 1998, excavations of a series of nineteenth-century clay pipe making sites at Francis Street, Dublin, revealed two clay settlement tanks lined with thin slabs of stone, saddle jointed at the corners.

Beating clay is well documented throughout the history of tobacco pipe manufacture (Peacey, 1996:189-90). One example will suffice here:

> It must be dried before it can be worked, and in so doing it looses about a sixth part. Then water is strewn upon it which it greedily sucks in, till, 'tis like a past, after which 'tis very well beaten, till all parts be alike and it seems like a piece of dough (Houghton, 1694).

6. CHARACTERIZATION OF PIPECLAY ARTIFACTS

There are several methods which can be used to determine the source of the clay used to make pipeclay artifacts. The simplest of these is examination of a freshly-broken edge at 20x magnification using a stereo microscope. This simple technique can be sufficient to identify coal measure seatearths from other pipeclays, because the former usually contain rounded pellets of clay, which are so hard that they have survived whatever preparation processes were carried out on the clay (such as beating or levigation). Such pellets are rare in more recent pipeclays. At the seventeenth-century pipe making community at Pipe Aston, the earliest group of pipe making waste found to date (dating to the mid seventeenth century) contains these pellets, which distinguishes it from the later seventeenth- and early eighteenth-century pipe waste found on other sites. Similar pellets can be seen in some of the mid seventeenth-century products of Broseley. Therefore, with very little effort, it is possible to distinguish most pipes made from coal measure clays from the remainder. However, it is not possible using this technique to distinguish pipes made from one outcrop of coal measure clay from another.

Thin section analysis is a second approach that has been used with some success. Davidson and Davey (1982) took samples of pipes from seven sites: Norton and Chester in Cheshire; Buckley in Flintshire; Hull in East Yorkshire; Rainford and Liverpool in Merseyside; and, Broseley in Shropshire. By the systematic recording of each inclusion type present in the section, they demonstrated that the Hull pipes were made from different clay from the remainder, which were probably made from different outcrops of coal measure clay. However, because the range of inclusion types is so limited and because the technique depends to a great extent on being able to compare sections side-by-side, looking at roundness, grain size distribution, and the character of the grains (mostly quartz), it is a method which is: 1) only suitable for the coarser textured coal measure clays; and, 2) best used to answer simple questions, such as comparing two or three groups of pipes, perhaps where other evidence suggests the same pipemaker was operating at two separate sites, or where a group of distinctive pipes might be made by the same maker or in the same center. In these cases, the answer to the question "is this group of pipes made from the same clay as that group of pipes" might be meaningful. It is not possible to use the technique to identify the clay source of a pipe for which there is no way of narrowing down the possible sources since the section would need to be compared under the microscope with each of the comparative groups.

The third approach is to use chemical analysis, which is our method of choice. Various techniques of chemical analysis have been carried out on archaeological ceramics, such as Atomic Adsorption Spectroscopy and Neutron Activation Analysis. In several fields of study, there is a large body of analyses which make the continued use of a specific technique sensible. However, for clay pipes and other pipeclay artifacts, there is no such database, which means that we chose a method based on price and suitability rather than the need to ensure compatibility with earlier work. We therefore use Inductively-Coupled Plasma Spectroscopy (specifically, ICP-AES) which, although destructive, uses small samples and measures major elements, such as Aluminum, Potassium and Sodium, and minor elements, such as Barium, Chromium and the Rare Earth elements.

To date, we have analyzed 59 pipeclay artifacts, mostly clay pipes and a small number of wig curlers, made by the Pipe Aston pipemakers (Peacey and Vince, 2003). These samples were mainly obtained from groups of pipe making waste from sites in the Severn Valley and Welsh Borderland (Gloucester, Broseley, Pipe Aston), together with samples of coal measure pipeclays from outcrops at Ironbridge Gorge (close to Broseley) and Hopton Bank (between Caynham and Cleobury Mortimer). Three separate outcrops at Hopton Bank, between a quarter and half mile apart, were sampled. Tertiary ball clay from Peter's Marland in North Devon was also sampled. As an indication of the similarity in composition of pipeclays worldwide, two samples of clay pipes from a kiln in Maryland (USA) were analyzed together with one sample of pipeclay from the same area, which was thought to be the raw material used for making these pipes.

Table 2-1 shows the mean and standard deviation of the measured major elements, expressed as percent oxides. Silica, which was not measured, probably accounts for the majority of the sample. Subtracting the total measured oxides from 100% suggests that silica accounts for between 58% and 80% of the samples by weight.

Table 2-1. Mean and standard deviations for major elements measured in pipeclay samples from the Severn Valley and Welsh Borderland.

Element	Mean	Standard Deviation
Al_2O_3	25.76	4.558823373
Fe_2O_3	2.09	1.513243852
K_2O	1.39	0.751260464
TiO_2	1.22	0.163886177
MgO	0.52	0.28241724
CaO	0.20	0.110270376
Na_2O	0.17	0.077027825
P_2O_5	0.07	0.097411561
MnO	0.02	0.012949572

The mean and standard deviation of the estimated silica content (Table 2-2) suggests that the Devon Ball Clay from Peter's Marland has a higher silica content than any of the sampled pipes or coal measure clay samples. However, until we have more data for the Devon Ball Clay, and preferably from other sources of pipeclay as well, we cannot say for certain that none of our pipes were made from this clay.

Table 2-2. Estimated silica content in pipeclay samples from the Severn Valley and Welsh Borderland.

Site	N	Mean	Standard Deviation
PA00/1	6	60.35	1.917527053
Ironbridge Gorge	1	63.05	----
BR00	6	64.10	1.748310613
Easthorpe Wood	1	64.41	----
Broseley 7583	2	66.35	0.270821897
PA02/1	6	67.26	1.614633085
28/79	6	68.23	2.897298167
PA95/2	23	70.03	2.08808036
Hopton Bank 1	1	73.79	----
Hopton Bank 6	1	74.44	----
Maryland	2	75.63	0.05939697
Hopton Bank 3	1	75.84	----
Maryland S. River	1	79.52	----
Peters Marland	2	79.90	1.209152596
Entire sample	59	68.55923729	4.948602326

Multivariate analysis of the oxide data, using the factor analysis module from Winstat for Excel (Fitch, 2001), shows that there are two major factors in the dataset. Factor 1 (F1) has high weightings for Iron and Manganese while Factor 2 (F2) has high weightings for Potassium. The full list of weightings is given in Table 2-3. A plot of the F1 against F2 scores for the 59 samples shows that individual waste groups tend to have oxide compositions more similar to themselves than to other groups. Furthermore, the Ironbridge Gorge clay sample has similar scores to those of one of the groups of waste from Broseley, and all of the Broseley samples plot in the same area of the diagram, together with one of the Pipe Aston waste groups. The latter group is the earliest analyzed from Pipe Aston and visually has the abundant clay pellets which typify some coal measure clays. It seems, therefore, that the earliest pipemakers at Pipe Aston, in the mid seventeenth century, obtained their clay from Ironbridge Gorge/Broseley, a distance of about 25 miles as the crow flies.

The three clay samples from Hopton Bank, a much closer source to Pipe Aston, do not match with any of the sampled pipes, nor do the Peter's Marland or Maryland samples. However, as a side observation, both samples are not that dissimilar, a measure of how the weathering processes involved in the production of pipeclay homogenize raw materials from differing sources.

Table 2-3. Factor analysis weightings for major elements in a set of pipeclay analyses from the Severn Valley and Welsh Borderland.

Element	Factor 1	Factor 2
Al_2O_3	-0.059703779	0.206505249
CaO	0.543639077	0.025184575
Fe_2O_3	0.945668632	-0.016342298
K_2O	0.146884037	0.77955969
MgO	0.639281363	0.440353857
MnO	0.915408785	0.040159826
Na_2O	0.145216787	0.646013648
P_2O_5	0.11452253	-0.031132997
TiO_2	-0.078914736	0.553789068

As Figure 2-3 shows, F1 is poor at discriminating between different pipe groups and indicates that some samples have much higher Iron and Manganese samples than others from the same group. This is probably due to both the inclusion of Iron/Manganese-rich fragments in the clay and the contamination of the samples after burial by groundwater, often indicated in the field by a visible brown to black staining. However, F2 is much more effective in distinguishing groups and this probably reflects variations in the frequency of micas and feldspars. Those groups with higher F2 scores tend to be those with a less silty texture and a low estimated silica content. Yet, as Figure 2-4 shows, the differences in F2 scores are not simply due to fluctuations in estimated silica content. The Gloucester samples, for example, have a similar estimated silica content to those from Roy's Orchard, Pipe Aston (PA95/2) but have much higher F2 scores.

Figure 2-5 shows the results of factor analysis of the minor element data, where three major factors were found. Individual groups can be distinguished in this diagram, particularly the Gloucester samples. However, there is even less sign of any underlying patterning which might reflect differences in composition by source. For example, the Maryland samples plot in the same part of the diagram as the Pipe Aston and Broseley pieces. The third factor distinguishes the Ironbridge Gorge, Broseley and mid-seventeenth-century Pipe Aston samples from the remainder, mainly through a high Scandium weighting. This is therefore a reflection of the lower estimated silica content of these pipes, as Scandium is concentrated in clay minerals.

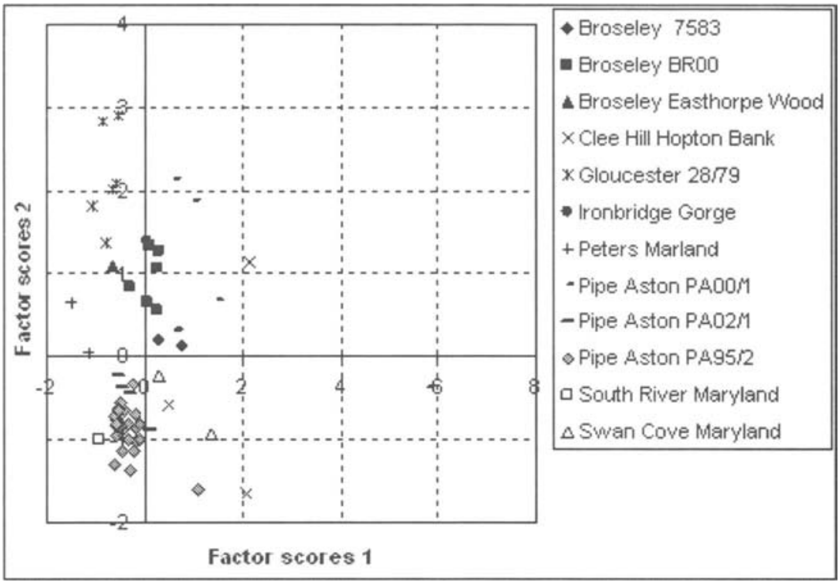

Figure 2-3. A plot of Factor 1 against Factor 2 scores in a set of pipeclay analyses from the Severn Valley and Welsh Borderland (major elements).

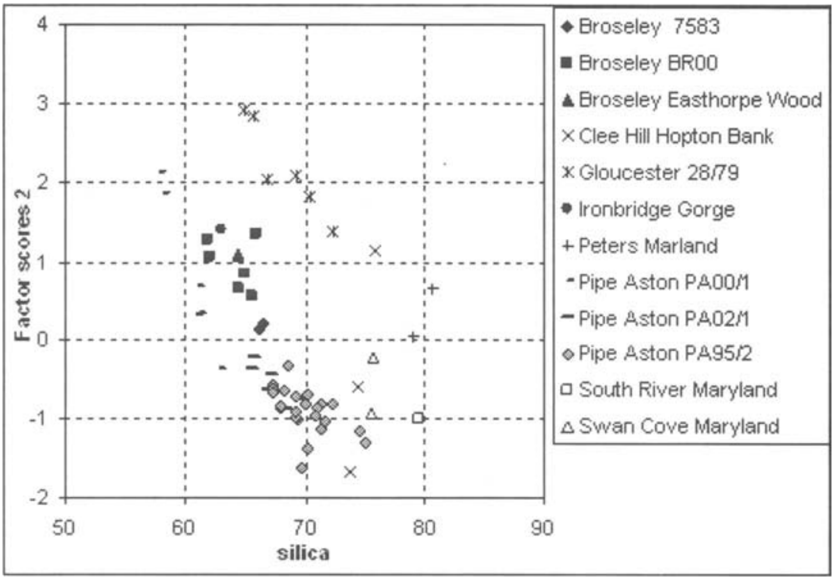

Figure 2-4. A plot of estimated silica content against Factor 2 scores in a set of pipeclay analyses from the Severn Valley and Welsh Borderland.

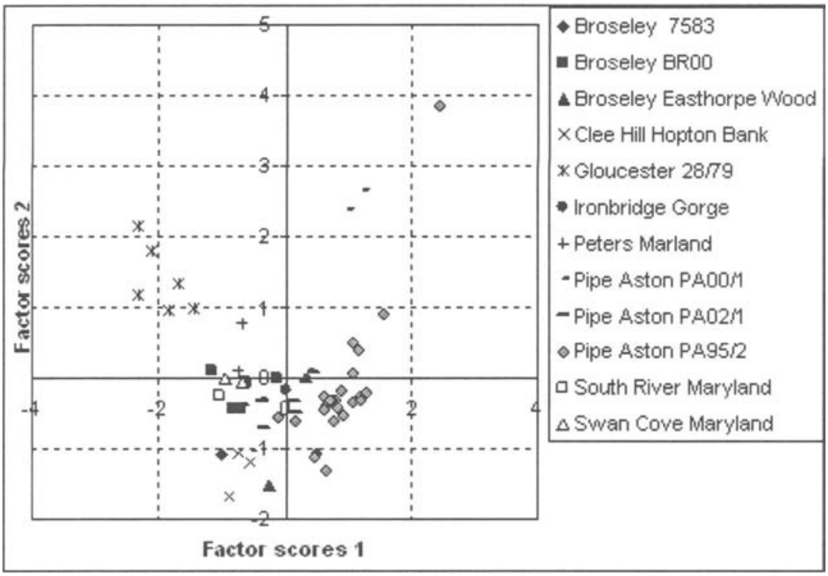

Figure 2-5. A plot of Factor 1 against Factor 2 scores in a set of pipeclay analyses from the Severn Valley and Welsh Borderland (minor elements).

As a tool to characterize pipeclays, chemical analysis (or at least this particular technique) suffers from the same problem as the others – the process of pipeclay formation leads to the removal of distinguishing features present in the original sediments which were themselves determined by the source of the mineral component of the clay. This is shown most clearly by the fact that the Maryland pipes and clay sample are not dramatically distinguished from the English samples. Even elements, such as Titanium and Zirconium, which occur in resistant minerals and which therefore survived this pedogenesis best, fail to differ markedly in their frequency in these pipeclay samples.

However, the failure to find marked differences in the composition of pipeclays of different geological age or from outcrops in different parts of the world, does not mean that chemical composition contains no interesting patterning. Because of the homogeneity of pipeclays, the pipes made in a single batch of clay tend to be similar to each other. We have used this fact to demonstrate that the unmarked wig curlers found on the Roy's Orchard Site at Pipe Aston were made from two batches of clay and that pipes with stamps of different makers tend to have different compositions. We hope to use these differences to help reconstruct the work practices employed at the Roy's Orchard Site.

The presence of waste pipes from several different makers, all apparently operating in the same short period of time at the turn of the eighteenth century, can be interpreted in several ways. For example, it may be that certain pipemakers were supplied with pipeclay but produced their pipes at home, bringing the finished pipes back to Roy's Orchard to be fired. However, the detailed analysis of pipe stamps and molds suggests that some pipemakers were working in the same workshop, or at least passing their molds between each other. By the selection and analysis of the appropriate samples, it should be possible to distinguish these two modes of production.

As proof of principle, we have taken samples of pipes from a site situated across the road from Roy's Orchard. Here, two types of pipe were found, one stamped with a rose and crown and the other unmarked. Both appear to be of similar date, but the plain pipes occur mostly in a lower layer than the stamped pipes, and have a texture that is siltier at 20x magnification. However, silt content can be affected by levigation and it might be that the same clay was being used for both types. Six samples were taken for chemical analysis and differences between the two groups were found. However, because of the difference in texture, these do not necessarily show that different clay was used and, in the factor analyses previously described, all six pipes have similar scores, showing that there is more similarity between the two pipe groups than between the pipes from this site and others.

Given the small number of samples from this excavation and the difference in date between these pipes and those from the other sampled sites at Pipe Aston, we cannot produce a single interpretation of the data. Furthermore, if we normalize the data to Aluminum, to take account of the variations in silt content, there are fewer differences between the stamped and unstamped pipes. We might therefore be dealing with a pipe workshop where a single consignment of clay was delivered to the workshop and the difference in texture was introduced by treatment on site. Or, we may be looking at a gradual shift in clay composition from a single clay pit. Or, it may be that sampling errors with such a small sample have produced random differences between the two groups and that a larger sample would show that they are chemically and texturally indistinguishable. Whichever interpretation is correct, our initial study suggests that there is sufficient variability in clay composition for these and similar questions to be posed with some hope of a clear result.

7. INTERNATIONAL COLLABORATION AND ONLINE ARCHIVING

Pipeclays and similar fine-textured, white-firing clays, were used over a wide area of Europe and, it seems at least in some parts of North America. They were used in some parts of Europe in the Roman period and the artifacts made included figurines and pots, which were transported over long distances. There are, therefore, good reasons to try to characterize these clays as a means of studying their trade and use. Furthermore, we have documentary evidence for the long-distance transport of Tertiary ball clays from southern England from the seventeenth century onwards.

Any such studies require comparative data, preferably undertaken using similar methods and calibrated using the same standards. They also require that the data are published in their raw form, not in summary and not left in gray literature in museum and laboratory archives. We have made all of our analyses available online using a map-based interface (Figure 2-6). Copies of the lab reports are also available for several of these analyses in PDF format.

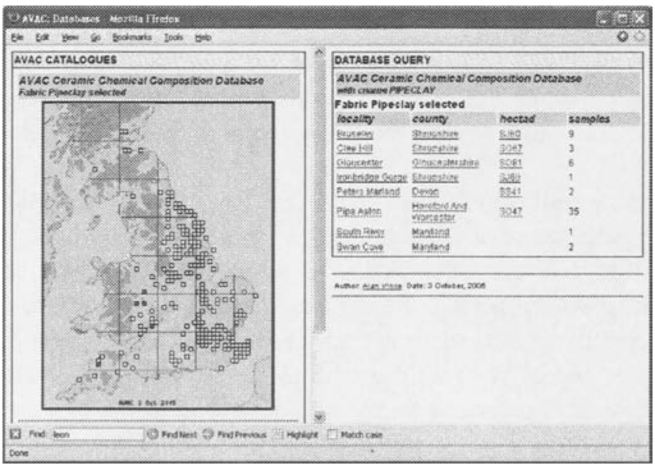

Figure 2-6. Map-based interface for online archiving of chemical analysis of pipeclay (and other ceramic) samples (http://www.avac.uklinux.net/potcat/db.php?db=potcat).

8. DISCUSSION

Our study of the pipeclays used in a small region of England in the seventeenth and eighteenth centuries suggests that it may be more difficult than one might imagine to distinguish pipes made from Devon Ball Clay from those made from locally-available coal measure clays. However, the most likely interpretation at present is that all of the pipes we have examined to date were made from coal measure clays and that the Titanium content is the distinguishing feature of the ball clay samples. We cannot as yet either prove or disprove the hypothesis that in the later seventeenth and early eighteenth centuries, pipes in our study region were made from a mixture of ball clay and local coal measure clay, but our data suggest a gradual shift in composition rather than a sudden one.

However, we have found that there are significant differences in composition between pipes made in different places and can probably conclude that mid-seventeenth-century pipes from Pipe Aston and pipes from three separate groups of waste from Broseley were made using clay from the Broseley area and are indistinguishable from our one clay sample from the area collected at Ironbridge Gorge. This is in itself a useful conclusion in that it discounts one possible reason for the emergence of the Pipe Aston industry – the availability of pipeclay locally. It is also remarkable, if true, in that it would mean that the Pipe Aston pipemakers ignored the closest known supply of white-firing clay, at Caynham, which was only seven miles to the east. Instead, they seem to have used clay which must have been transported about 28 miles, all over land and only accessible by passing within a mile of Caynham.

Our future work will include further testing of this conclusion. First, it is possible that the clay outcrop we sampled at Hopton Bank differs in composition from that at Caynham. The three Hopton Bank samples themselves are distinguishable in chemical composition and it is quite likely that the Caynham clay or other outcrops of pipeclay around Clee Hill are different and more similar to those in the Ironbridge area. The easiest way for us to test this, since no clay from Caynham is available for sampling, is to take products of pipemakers who operated at Ludlow and Cleobury Mortimer, situated to either side of the Caynham clay source and analyze them.

Furthermore, differences in texture between the earlier and later pipes from Pipe Aston suggests that levigation may have been introduced there during the late seventeenth century and this provides an explanation of the change in composition over time in Pipe Aston products. However, there is no similar change in the composition of Broseley pipes, which ranged in date from the 1640s or earlier to c.1680-1700.

All of the pipe making sites in Pipe Aston produced fragments of coal, and coal can outcrop in the same localities as pipeclay (not all seatearths actually have coal seams above them). Coal can be characterized more closely than pipeclay, since there has been considerable work on the paleobotany and mineral composition of coal outcrops. However, such characterization is expensive and has not been attempted at Pipe Aston. It is likely that the coal and pipeclay were obtained from the same source. The discovery that coal was being used for fuel, despite the wooded nature of Pipe Aston removes another possible explanation for why pipe making developed in the parish rather than, say, at Caynham. Furthermore, the local towns, which were most easily accessible from Pipe Aston and which one would imagine to be the main market for its products, have their own pipe making industries at least by end of the seventeenth century. Ludlow pipemakers are documented by 1636 and Leominster (ten miles south of Pipe Aston) had pipemakers by 1662. However, in the 1620/30 period, when the Pipe Aston industry was founded, there was no known competition nearby, Broseley and Bristol being the closest known.

Our investigations have, tentatively, shown the source of at least some of the clay used at Pipe Aston and have inadvertently raised a question: Why did pipemakers move to Pipe Aston in the first place? They did not use local clay and supplemented local wood with coal, which had to be brought to the site. Perhaps in its earliest phase, Pipe Aston makers supplied a much larger market, which was gradually eaten into until, finally, the industry died out in the 1740s. In the later eighteenth century, Herefordshire and South Shropshire were supplied from a few larger industries: Worcester, Gloucester, and Broseley, all, perhaps significantly, located on the River Severn, which was probably used to supply ball clay and distribute the finished pipes. We suggest that proximity to Ludlow was a factor in the emergence of the industry, but cannot find any advantage that Pipe Aston possessed and which other parishes in the area did not. Perhaps, then, Pipe Aston was simply chosen by chance and not for any specific advantage that the locality afforded.

Whether the circumstances of the West Midlands, with its numerous outcrops of coal measure clay and its easy access by water to Devon, will be applicable to other areas and other countries is uncertain, but it is clear that because of the circumstances of formation, pipeclays will always remain difficult to provenance using thin section and chemical analyses. One way for this study to progress would be for all laboratories engaged in the analysis of pipeclays to archive their data online.

REFERENCES

Atkinson, D., and Oswald, A., 1969, London clay tobacco pipes, *J. Archaeol. Assoc.* (3rd series) **32**: 171-227.

Cooksey, A. J. A., 1980, The clay tobacco pipe in the Poole area, in: *The Archaeology of the Clay Tobacco Pipe III*, P. Davey, ed., BAR **78**, Oxford, pp. 337-349.

Davidson, L. S., and Davey, P. J., 1982, Thin section analysis of clay used in five British clay pipe production centres, in: *The Archaeology of the Clay Tobacco Pipe VII*, P. Davey, ed., BAR **100**, Oxford, pp. 311-344.

De l'Ecluse, 1605, quoted in Mackenzie, 1957.

Douch, H. L., 1970, The tobacco trade and the manufacture of clay pipes in Cornwall," *J. Roy. Inst. Cornwall* **6**: 139-153.

Fitch, R. K., 2001, *WinStat for Microsoft® Excel*, http://www.winstat.com.

Grant, A., 1983, *North Devon Pottery in the Seventeenth Century*, University of Exeter, Exeter.

Hakluyt, R., 1589, (1926 ed.), *The Principal Voyages, Traffiques and Discoveries of the English Nation*, J.M. Dent, London.

Hariot, T., 1588, *A Report of the New Found Land of Virginia*, London.

Hentzner, P., 1598, (1757 ed.), *Journey into England*, Strawberry-Hill, England.

Houghton, H., 1694, *Collection for the Improvement of Husbandry and Trade*, London.

Lewcun, M., 1987, Chitterne clay pits, Wiltshire, *Soc. Clay Pipe Res.* **14**: 21-24.

Luckenbach, A., Cox, C., and Kille, J., 2002, *The Clay Tobacco Pipe in Anne Arundel County, Maryland (1650-1730)*, Anne Arundel County's Lost Towns Project, Annapolis, Maryland.

MacInnes, C. M., 1926, *The Early English Tobacco Trade*, Kegan Paul, London.

Mackenzie, C., 1957, *Sublime Tobacco*, Hogarth Press, London.

Moore, W. R. G., 1975, 'Northampton,' *Northamptonshire Archaeology* **10**: 173.

Morton, J., 1712, *The Natural History of Northamptonshire*, Knaplock and Wilton, London.

Oswald, A., 1975, Clay pipes for the archaeologist, *BAR* **14**, Oxford.

Peacey, A., 1996, The development of the clay tobacco pipe kiln in the British Isles, in: *The Archaeology of the Clay Tobacco Pipe XIV*, P. Davey, ed., BAR **246**, Oxford.

Peacey, A., and Vince, A., 2003, Chemical characterization of clay pipes and wig curlers from Roy's Orchard, Pipe Aston, Herefordshire, *Post-Medieval Archaeology* **37**(2): 207-216.

Plott, D. R., 1686, *Natural History of Staffordshire*, Oxford.

Rutter, J., and Davey, P., 1980, Clay pipes from Chester, in: *The Archaeology of the Clay Tobacco Pipe III*, P. Davey, ed., BAR **78**, Oxford, pp. 41-273.

Stephen, L., and Lee, S., 1917, *Dictionary of National Biography*, Oxford.