

BOW PORCELAIN: GLAZE COMPOSITIONS ASSOCIATED WITH THE PHOSPHATIC WARES ~1742–1774

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Glaze compositions associated with 23 Bow phosphatic porcelain wares are presented. These compositions represent a transect through the manufactory's bone ash production, stretching from the mid 1740s through to the closure of the concern in the mid 1770s. The glaze employed was essentially a three component SiO₂-PbO-K₂O glaze with PbO > 40 wt%. CaO is a small but persistent additive. These glazes show a cryptic compositional drift over time with a minor increase in K₂O relative to SiO₂ and PbO. Likewise SiO₂ increases through time relative to PbO.

Key words: Bow porcelain, glaze, composition, bone ash.

BY 1750 east of London on the Essex boundary with Middlesex, a porcelain manufactory known widely as 'New Canton' or more simply as 'Bow' was operating and this concern had by 1755 a turn-over in china sold to the value of £18,115 8s 9d (Adams and Redstone, 1981). The proprietors listed on the first extant insurance policy for the Bow China Manufactory with the Sun Assurance Company and dated July 7th, 1749 were Thomas Frye, a portrait painter and mezzotint artist, Edward Heylyn, a member of the Saddlers' Company and an active merchant with the New World, and John Weatherby and John Crowther —both glass sellers with a wholesale pottery business at St Catherine's-by-the-Tower. A fifth member of the group has generally been assumed to be Alderman George Arnold, a wealthy linen-draper, alderman of the City of London, and an apparent land speculator in the Carolinas. The first documentary evidence that at least two of these proprietors were interested in the manufacture of porcelain relates to the so-called 1744 patent of Heylyn and Frye, which was filed in December 1744 and entered or 'inrolled' in April of the following year, though see Daniels and Ramsay (2009) who demonstrate, using the letter by John Campbell, that Bow was in existence most likely by the 1730's. This patent specifies the use of white clay known as *unekā*¹ the produce of the Cherokee na-

¹ Here the Cherokee Indian spelling of the word is used rather than the Anglicised version *unaker*

tion in America, and a glass, assumed to represent a lime-alkali glass, used in various proportions for both the porcelain body and the glaze. This detailed specification has for various reasons over the last 100 years been both marginalised and underestimated by numerous workers and Ramsay et al. (2006) review the various reasons as to why these misconceptions and confusion have arisen. Moreover the Si-Al-Ca porcelains, products of this patent, have now been identified (Ramsay and Ramsay 2007b; Ramsay et al. 2003). The site of manufacture of these Bow first patent wares is uncertain but was likely to have been in the vicinity of Bow village, located on or close to the Middlesex-Essex boundary.

Subsequently Thomas Frye filed a second patent in 1749 known variously as the Bow second patent, the 1749 patent, or the 1749 patent of Thomas Frye. This patent stipulates the use of crushed silica, pipe clay, and a substance referred to as 'virgin earth'. It has now been demonstrated that virgin earth comprised variable mixtures of bone ash, glass cullet, and gypsum (Ramsay and Ramsay 2007b). It is widely regarded that it was this recipe or paste specification, dominated by bone ash, which sustained the factory through to closure in 1774 and became the subsequent basis for the English bone china industry. Numerous detailed accounts and/or exhibitions of the Bow factory and its output have appeared commencing with Hurlbutt (1926), followed by Tait (1959),

and then more recently by Adams and Redstone (1981), Gabszewicz and Freeman (1982), Bradshaw (1992), Gabszewicz (2000a), and Begg and Taylor (2000). Current and recent research (Daniels 2007; Daniels and Ramsay 2009; Ramsay and Ramsay 2005, 2007a, 2007b, 2008; Ramsay et al. 2003, 2004a, 2004b, 2011) demonstrates that this ceramic concern has been considerably underestimated by previous workers at several levels - compositionally, technically, artistically, and chronologically. Ramsay and Ramsay (2007b) argue that the confluence demonstrated by the Bow porcelain manufactory in intellect, technological development, entrepreneurial drive, financial acumen, and the linkages with the best in the English artistic world including painting, engraving, and sculpture all contained within a few years, is possibly unparalleled in the entire history of British decorative arts.

In a previous contribution (Ramsay and Ramsay, 2007b) the compositional range of the first patent Si-Al-Ca porcelains and the second patent phosphatic wares produced by Bow, ranging from the *Developmental period*² (~1742–1743) through to the *Tidswell period* (1770–1774) was presented. This compositional stratigraphy was erected based on results obtained from the sampling of dated porcelain items and the dated specifications of the first and second patents. In addition a record by Josiah Wedgwood of the composition used by Bow by the mid-late 1750's was also integrated with this compositional stratigraphy (Table 1).

This new contribution documents the composition of the lead-dominated glazes associated with the Bow phosphatic wares. The key objective of this work is the need to elucidate the variability of the glaze compositions used on phosphatic wares at Bow through time and to determine whether there are, if any, distinct changes in glaze composition coinciding with the documented changes in porcelain composition. The glaze compositions arrived at have been grouped according to the compositional classification of their host porcelain bodies as given by Ramsay and Ramsay (2007b).

METHODS AND RESULTS

Micro samples of glaze from a range of Bow phosphatic porcelains covering the bulk of the bone ash output from ~1742–1774 were collected, mounted in epoxy blocks, polished, and subjected to analysis using a JEOL 840A scanning electron microscope equipped with an Oxford Instruments ATW X-ray Energy Dispersive Spectrometer. Operating and detection levels are as specified in Ramsay and Ramsay (2007b: Appendix 1). Major components of the glazes comprise SiO₂, PbO, and K₂O, which collectively comprise some 93wt % or more of each glaze. Other minor constituents often include Na₂O, Al₂O₃, MgO, and persistent CaO. Average analyses for each of the four groups are given in Table 2. In the case of the *Tidswell period* one analysis only is available.

Three analyses are presented for the *Developmental period* and these are characterised by low K₂O relative to the other three groups. Average K₂O is 1.4 wt% whilst PbO is high at 52% and CaO is prominent at an average of 2.9%. Twelve analyses are available for the *Defoe-New Canton period*. PbO averages 48.7%, SiO₂ 44.5%, and K₂O 2.4%. CaO is still a minor component averaging 1.9%. During the *Bowcock period* PbO declines and for the seven samples averages 41.9% whilst SiO₂ surpasses PbO at 50.2%. K₂O likewise increases relative to both PbO and SiO₂ and averages 3.7%. CaO remains essentially static at an average of 1.65%. One glaze sample for the *Tidswell period* is available and this compares with the average for the *Bowcock period* with SiO₂ 51.4%, PbO 40.1%, K₂O 4.1%, and CaO 1.7 wt%. For all groups, sulphur as SO₂ looks to be a little high in some instances, possibly reflecting interference with Pb peaks.

These results demonstrate that the Bow glaze composition used on the phosphatic wares was broadly constant over a thirty year period from c. 1742–1774. The glaze type is high-lead glaze with PbO >40% and K₂O varying from 0.8–4.9%. CaO is a small but ubiquitous component, which ranges from 0.3–4.4%. Whilst there is a general homogeneity in the high-lead glaze used at Bow, when broken down into groups based on the porcelain body recipes a subtle cryptic drift in glaze composition can be discerned with both an absolute and relative increase in K₂O when compared to both SiO₂ and PbO and a concomitant decline in PbO (Table 2, Fig. 1). The highest absolute levels of PbO (~58 wt%) are to be found in glazes used during the *Developmental* and

² Ramsay and Ramsay (2007b) dated the onset of the *Developmental period* to ~1746. Current research strongly suggests that a range of experimental Bow phosphatic bodies most likely dates back to the 1730s. For this contribution the base of the *Developmental period* is placed at ~1742 and the base of the *Defoe-New Canton period* (formerly *New Canton period*) at ~1744.

Table 1. Compositional classification of body and glaze of Bow phosphatic porcelains through time, modified after Ramsay and Ramsay (2007a, b). The date ranges for the *Developmental period* and the *Experimental period* have been modified as discussed in the text. Likewise the *New Canton* period has been renamed the *Defoe-New Canton period*. # values given are wt%.

Period	Date	Porcelain recipe [#]	Glaze composition [#]
<i>Experimental</i>	pre-1742	Not included in this study but see Tait (1960), Ramsay & Ramsay (2007b)	
<i>Developmental</i>	c. 1742–1743	ball clay 25%, crushed silica 25%, bone ash 40%, glass cullet 7%, gypsum or alum ~3%	High lead sub-group >1.25 wt% PbO c. 1742–1753 SiO ₂ ~ 40%, PbO 44–58%, K ₂ O 0.8–2 %
<i>Defoe-New Canton</i>	c. 1744–1753	ball clay 25%, crushed silica 25%, bone ash 45%, glass cullet 5%	SiO ₂ 36–51%, PbO 41–58%, K ₂ O 0.6–3.8%
<i>Target or Transitional</i>	1754	ball clay 25%, crushed silica 25% bone ash 44%, glass cullet 5%, gypsum 1%	Not included in this study
<i>Bowcock</i>	1755– c. 1769	ball clay 15%, crushed silica 44%, bone ash 35%, gypsum 6%	SiO ₂ 46–53%, PbO 35–44% K ₂ O 2–4%
<i>Tidswell</i>	c. 1770–1774	ball clay 15%, crushed silica 40%, bone ash 33%, glass cullet 6%, gypsum 6%	SiO ₂ 51%, PbO 40%, K ₂ O 4.1%

Table 2. Representative analyses of glaze compositions used on Bow phosphatic bodies. 1. B30, single shell-salt. 2. B3, moulded sauce boat in underglaze blue. 3. B41, waster decorated in underglaze blue. 4. B18, leaf dish in underglaze blue. 5. Average analysis for the *Developmental period* (n = 3). 6. Average analysis for the *Defoe-New Canton period* (n = 12). 7. Average analysis for the *Bowcock period* (n = 7).

	1	2	3	4	5	6	7
SiO ₂	38.51	44.35	50.99	51.36	39.83	44.54	50.18
TiO ₂	0.13	0.07	0.18	0.15	0.08	0.07	0.11
Al ₂ O ₃	0.16	0.31	1.19	0.46	0.19	0.58	0.75
FeO	0.11	0.13	0.07	0.21	0.06	0.18	0.21
MgO	0.00	0.08	0.48	0.16	0.37	0.15	0.22
CaO	3.27	1.66	0.5	1.68	2.87	1.92	1.65
Na ₂ O	0.26	0.26	0.81	0.40	0.63	0.31	0.62
K ₂ O	1.29	2.94	4.43	4.14	1.37	2.37	3.71
P ₂ O ₅	2.21	0.00	0.00	0.00	0.89	0.27	0.07
PbO	53.03	50.02	41.39	40.11	52.00	48.72	41.91
SO ₂	1.07	0.22	0.00	1.38	1.73	0.92	0.59
Total	100.04	100.04	100.04	100.05	100.02	100.03	100.02

Defoe-New Canton periods. The glaze employed during the *Defoe - New Canton period* shows the greatest compositional variation (Fig. 1) whilst compositional variation of glazes and porcelain body compositions during the *Bowcock period* show a much more restricted compositional spread when compared with both body and glaze compositions from the preceding periods (Fig. 1; Ramsay and Ramsay 2007b, fig. 8 & table 13).

What does emerge is that with time, relative and absolute PbO levels tend to decline and K₂O levels increase. During both the *Developmental* and *Defoe-New Canton periods* PbO > SiO₂ but for the *Bowcock* and *Tidswell periods* this is reversed with PbO < SiO₂. CaO remains a minor but persistent component of the glazes used during the approximate 30 year period phosphatic wares were being produced. Images

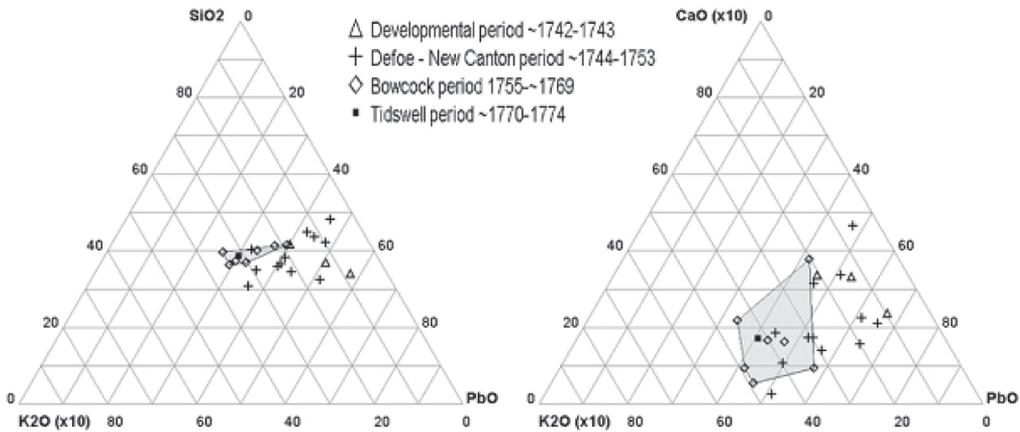


Fig. 1. Bow glazes plotted on $\text{SiO}_2\text{-K}_2\text{O}(\times 10)\text{-PbO}$ and $\text{CaO}(\times 10)\text{-K}_2\text{O}(\times 10)\text{-PbO}$ triangular diagrams. The shaded areas represent the compositional extent of the *Bowcock period*, 1755–c. 1769. The groupings are *Developmental period* (~1742–1743), *Defoe–New Canton period* (~1744–1753), *Bowcock period* (1755–1769), and the *Tidswell period* (1770–~1774). The *Target or Transitional period* (1754) is not shown.

of representative items of Bow phosphatic porcelains analysed in this contribution are shown in Figure 2.

There have been numerous reports in the literature that various additives were included in glazes on early English porcelains. In the case of underglaze blue porcelains the most commonly reported is cobalt, which can be traced back to the Thomas Frye patent of 1749. In the specification Frye records that a small portion of smalt (diluted cobalt ore fused with potassium carbonate and finely ground) is added to the glaze mixture to clean the colour. Dossie (1758: 88) records that smalt is;

zaffe vitrified with proper additions; which are generally fixt alkaline salts and sand, or calcined flints.

We see no reason to doubt Thomas Frye, but as yet our analyses have not been able to record any measurable level of Co in the glaze. This inability by us to detect cobalt in the glaze is understandable because as commented on by one of the reviewers of this paper just 0.1% Co would be enough to impart a blue colour to the glaze. Likewise, Hurlbutt (1926: 36) records that owing to the large amount of lead employed in the glaze, considerable tinting by the addition of smalts was required to ‘clear’ the glaze. Strangely, he continues that some pieces such as part of the white glazed sprigged wares and the red, green, blue, yellow, and gold Imari patterns, were not so tinted, and have a rich creamy body and glaze yet, based on our work, still apparently having a high lead content. Tite and Bimson (1991) report considerable

levels of tin oxide as SnO_2 in three Bow glaze compositions analysed by them (E12, 2.7 wt%; E14, 2.3 wt%; and 745, 2.7 wt%). We have reanalysed 745 and confirm a trace level of tin being present.

An important body of work, which has just come to hand (Owen et al. 2011), provides the composition of eight porcelain sherds recovered from various historical sites in Charleston, South Carolina. Five of these sherds are of the sulphurous phosphatic type (Owen 2007) and based on both chemistry and decorative idioms are attributed to Bow, most likely from the *Bowcock period* (1755–c. 1769). In each case, glaze compositions have distinct SnO_2 levels (1.0–1.85 wt% SnO_2) and very low but discernible cobalt levels (0.04–0.39 wt% CoO). Further work by us, in relation to the additives, Co and Sn, is continuing and it is interesting to speculate whether SnO_2 was a feature of glaze compositions during the *Bowcock* and *Tidswell periods*.

DISCUSSION

The nature of the glaze employed by Bow on its phosphatic wares has caused considerable discussion when compared with that for other 18th century English porcelain concerns, with the Bow ‘drab glaze’ group or the ‘mushroom-grey glaze’ group receiving particular attention. The problem in attempting to characterise the ‘drab glaze’ group based on subjective observation alone has caused considerable con-

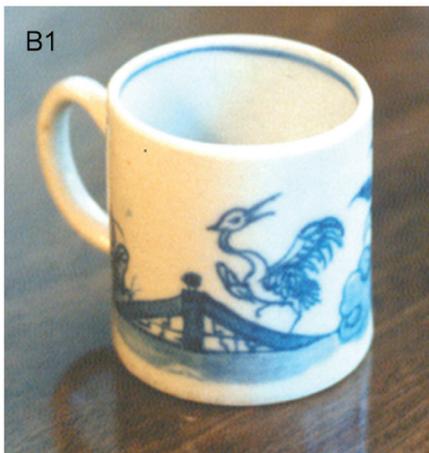
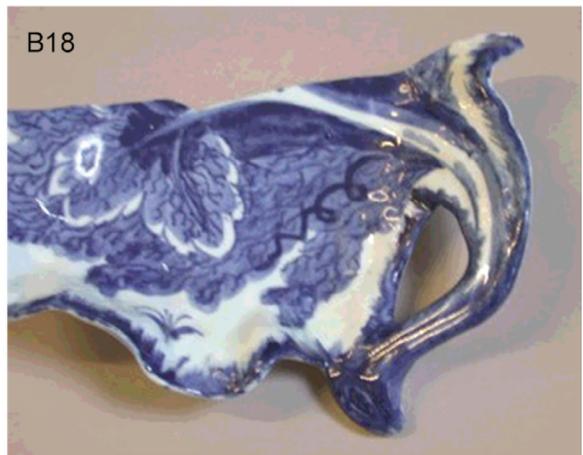


Fig. 2. For caption see pg. 166.

Fig. 2 (previous page). Images of representative examples of Bow phosphatic wares whose glazes have been determined chemically.

B1: Coffee can in underglaze blue, decorated with the *Stork, bridge, and banana tree pattern* (private collection), c. 1744–1750, height 60 mm. The body of this coffee can has a calculated recipe comprising ball clay 18 wt%, bone ash 46%, lead glass 3%, lime-alkali glass 5%, and crushed silica 28%. Compositionally it is grouped with the *Defoe-New Canton period*, c. 1744–1753 and is most likely a representative of wares mentioned in the Defoe account in the 1748 edition of *A Tour...*, where it is recorded that,.... *already made large Quantities of Tea-cups. Saucers, &c.*, had been made at Bow. B3: Sauce boat moulded in underglaze blue (private collection), c. 1764–1768, height 100 mm. The body has a calculated recipe comprising ball clay 14 wt%, bone ash 37%, gypsum 7% and crushed silica 42%. Compositionally it is grouped with the *Bowcock period*, 1755–c. 1769. B11: Standing nun in the white (private collection), c. 1750–1752, height 160 mm. The body of this figure has a calculated recipe comprising ball clay 19 wt%, bone ash 46%, lead glass 4%, lime-alkali glass 7%, and crushed silica 24%. Compositionally it is grouped with the *Defoe-New Canton period*, c. 1744–1753. B18: Portion of a leaf dish in underglaze blue marked with pseudo Oriental marks, (Victoria and Albert Museum, C.16-1920), c. 1770–1772, photograph courtesy of A. Gabszewicz. The body has a calculated recipe comprising ball clay 16 wt%, bone ash 37%, lead glass 0.5%, lime-alkali glass 5 %, gypsum 5.5 %, and crushed silica 35 %. Compositionally it is grouped with the *Tidswell period*, c. 1770–1774. B64: Triple shell-salt in polychrome enamels, (Taylor Collection), c. 1742–1743, width 150 mm. The body of this salt has a calculated recipe comprising ball clay 22 wt%, bone ash 40.5%, lead glass 3.5%, lime-alkali glass 4%, gypsum 1%, and crushed silica 29%. Compositionally it is grouped with the *Developmental period*, c. 1742–1743. B68: Plate in underglaze blue, decorated with the *Disconsolate fisherman pattern*, (Taylor Collection), c. 1742–1743, diameter 305 mm. The body of this plate has a calculated recipe comprising ball clay 21.5 wt%, bone ash 33%, lead glass 6.5%, lime-alkali glass 4.5%, gypsum 8.5%, and crushed silica 26%. Compositionally it is grouped with the *Developmental period*, c. 1742–1743.

Table 3. List of samples with analysed glazes.

B1: Coffee can decorated in underglaze blue with the <i>Stork, bridge, and banana tree pattern</i> , private collection - see Ramsay and Ramsay (2007b).
B3: Sauce boat moulded with fruit and decorated in underglaze blue, private collection - see Ramsay and Ramsay (2007b).
B4: Figure of a seated bagpipe player in the white, private collection.
B11: Standing nun in the white, private collection - see Ramsay and Ramsay (2007b).
B16: Cup in the white, moulded with prunus sprays, Victoria and Albert Museum C.673-1919.
B18: Leaf dish decorated in underglaze blue, Victoria and Albert Museum C.16-1920.
B20: Sauceboat moulded in the white with gilding, Victoria and Albert Museum C.673-1920.
B27: Figure of two putti with goat and kid, Newham Borough Council - see Gabszewicz (2000a, No.90).
B30: Single shell-salt in polychrome, Newham Borough Council - see Gabszewicz (2000a, No. 35).
B32: Figure of Kitty Clive in the white, private collection - see Ramsay and Ramsay (2007b).
B33: Teapot in polychrome, private collection.
B41: Waster decorated in underglaze blue from 1969 excavation, courtesy of Dr David Redstone.
B42: Waster decorated in underglaze blue with the <i>Image pattern</i> , courtesy of Dr. David Redstone.
B43: Bowl in underglaze blue, British Museum 32703.
B61: Robert Rich underglaze blue soup plate, Taylor Collection - see Begg and Taylor (2000, No. 150).
B62: Teapot with lobed baluster form in polychrome, Taylor Collection - see Begg and Taylor (2000, No. 34).
B64: Triple shell-salt in polychrome, Taylor Collection - see Begg and Taylor (2000, No. 3).
B66: Sauceboat with flying handle in polychrome, Taylor Collection - see Begg and Taylor (2000, No. 51).
B68: Plate decorated in underglaze blue with the <i>Disconsolate fisherman pattern</i> , Taylor Collection - see Begg and Taylor (2000, No. 2).
B71: Shell sweetmeat stand in the white, private collection - see Begg and Taylor (2000, No. 172).
B73: Tea bowl and saucer 'R'-marked in the white, private collection - see Begg and Taylor (2000, No. 161).
B75: Standing nun in the white - see Begg and Taylor (2000, No. 7).
B77: Fig leaf dish in polychrome, private collection.

tradictory comment in the literature. This descriptive feature can be traced back some fifty years to Tait (1959: 17-18) and the *Bow Porcelain Special Exhibition*. Here Tait groups four enamelled shell-salts, a tankard, a sauce boat, and two undecorated wasters recovered in 1921 from the Essex site, all of which (both glazed and unglazed) were described by Tait as

having a markedly (or in one case a less markedly) mushroom-grey or 'drab' appearance. In addition Tait records that no figures are known with a mushroom-grey or 'drab' appearance. Tait refers to Hurlbutt (1926: 95, plate 16b) where Hurlbutt records a pair of single shell-salts displaying what Tait quotes as having a greyish-drab body and glaze. However

Hurlbutt does not elevate this greyish-drab feature to the descriptive or classificatory significance as used by Tait and instead appears to restrict this description to these salts alone. On page 95 Hurlbutt refers to these two items as having a greyish-drab body and glaze, whereas in the caption to plate 16b, he refers to the body alone having this drab appearance. Subsequent workers have followed Tait, with Adams and Redstone (1981) applying this drab appearance to both the body and glaze of a small group of wares. In contrast Gabszewicz and Freeman (1982), Gabszewicz (2000a, 2000b) and Spero (1990, 2001) apply this drab or mushroom-grey feature to the glaze alone. This uncertainty as to what the drab appearance applies to can possibly best be seen in Begg and Taylor (2000) where Begg variously associates the drab appearance to the body, the glaze, and the body and the glaze. To complicate matters further, in the same publication Begg describes the Watney teapot (No. 34), now in the Taylor collection, as having a clear glaze whilst Gabszewicz (2000b) describes the same teapot as being characterised by a mushroom or drab-coloured glaze.

Further possible doubt is added to discussions on Bow glazes where Spero (2008) describes a pair of Bow baluster vases *c.* 1750, as having a soft, tactile, creamy glaze. In the case of a pierced Bow basket *c.* 1750–52 (Spero 2004) the glaze is described as being far less soft and glassy than an almost contemporary pap boat. Yet in contrast Spero (2009, p. 7) ascribes the presence of a durable yet tactile glaze found on a baluster *famille rose* silver-shaped mug (No. 8, *c.* 1748–1750) as indicative of Bow's early period. Spero (2009) then notes that paradoxically a blue and white teapot and a large dish (Nos. 34 and 35), of approximately similar date, are utterly different in their glaze, though these differences are not elucidated. More recently Spero (2010) records that the presence of a smooth shiny glaze and a characteristic texture (Spero 2011) are suggestive of Bow, dating from the early 1750s. Watney (1973), whilst urging caution with regard to scientific investigations into English 18th century porcelains, subject as they are to so much trial and error in their making, points to the importance of the special effects of reflected light on glazed surfaces in combination with the various tints of underglaze blue. In contrast, we suggest that rational and objective science is much more likely to elucidate the subtle changes in both porcelain body and glaze compositions through time. Consequently this account into the glaze types used at Bow places

more emphasis on glaze chemistry and less on the glint reflected from glazed surfaces.

In a study of William Reid porcelains (Hillis 2011) it is observed that there are considerable variations in both body and glaze colour over a relatively short period of time from 1756–1761. At times the wares can look pure white or, occasionally, have a mushroom-like glaze colour but, more often, they appear grey, greenish, or bluish and consequently no single body or glaze can be considered as typical of the William Reid output.

Work presented in this paper has been able to demonstrate that the glaze used at Bow on the phosphatic wares from the early to mid 1740s through to the demise of the manufactory on the 1770s (Table 3) was essentially a three component glaze comprising SiO_2 - PbO - K_2O with $\text{PbO} > 40$ wt%. What is of significance is that whilst there were very marked changes through time in the paste recipes used during the Bow phosphatic porcelain production, there is as yet no evidence to demonstrate that these changes in the body recipe were accompanied by changes in the glaze composition.

This broad uniformity in glaze composition found on early Bow phosphatic wares militates against the Bow multiple potworks model as proposed by Spero (1989, 2001, 2006, 2008). In a similar fashion we can as yet find no evidence to support a compositional two-tier level of phosphatic and glaze production at Bow as has been suggested in the literature (Spero 2009). Once a decision was made by the Bow proprietors to change the body composition then it does appear, based on the analyses of some 100 porcelain items, that the resultant recipe change was applied to the entire output be it figures, underglaze blue wares, polychrome items, or porcelain in the white. In contrast the glaze recipe hardly changed during these significant paste transitions. However our research has demonstrated that whilst the broad glaze chemistry remained essentially constant there was a cryptic drift in composition through time. Over the 30+ year output at Bow PbO declined, both in absolute terms and relative terms, with regard to SiO_2 and K_2O , whilst K_2O showed a minor increase in absolute and relative terms. CaO remained a minor but persistent additive during this period.

Very low levels of trace element additives (or the oxidation state of one or more transition elements) may have contributed to reported variations in glaze tints however the detection levels employed by us do not allow for a definitive answer. We note

the recent work by Owen et al. (2011) where both minor amounts of Sn and Co are reported in sherds recovered from archaeological sites in the Carolinas. Reanalysis by us of No. 745 (Tite and Bimson 1991) supports their contention of the addition of SnO₂ to the glaze and one possibility is that members of the *Bowcock* and *Tidswell periods* are characterised by small amounts of tin in their glazes. It has been reported that on some early Bow phosphatic wares there were two glaze layers. The outer or 'top coat' is regarded as being heavily tinted with Co, which in turn, partly or completely, covers a thinner, clear 'undercoat' glaze (Adams and Redstone 1981: 99). Visual observation by us supports this claim with the suggestion that clear glaze coating may constitute the 'top coat'. As yet no chemical work has been undertaken by us to confirm this observation.

Lastly we record that over the last 50 years there has been a slow recognition that there needs to be more comprehensive databases of both glaze and body compositions of early English porcelains. Work in this direction was initiated by Cooper (*vide* De La Beche and Reeks 1855), Church (1881), and was accelerated with the pioneering work of Eccles and Rackham (1922). Following the Eccles and Rackham publication there was a decline in interest in accumulating and publishing comprehensive data sets of complete analyses (rather than spot tests for single elements) published in the public domain, stating the method used, the name of the analyst, the precision, and the detection levels for the various elements and the scientific study of English ceramics entered the *hobby science period*. Possibly the first departure from this trend was work on the Pomona pot works by Paul Bemrose (Bemrose 1973). Over the last 20 years there has been a more positive trend and the final goal should be towards better levels of synergy between the artistic and the scientific approaches to English ceramics.

SUMMARY

The chemical results of glazes obtained from 23 Bow phosphatic porcelain wares, extending through much of the output period, are presented. Collectively, the SiO₂-PbO-K₂O glaze compositions are remarkably uniform with high PbO > 40 wt% and the presence of minor but persistent CaO, MgO, Al₂O₃, and Na₂O all tend to be minor in concentration or below detection level. Over time there was a cryptic drift in composi-

tion with PbO decreasing relative to SiO₂. In most instances our analytical procedure was unable to confirm the presence of possible additive trace elements including Co, As, and Sn. We note that of late there has been considerably more emphasis on full analytical results published in the public domain listing the analyst, methods used, and precision levels.

FINAL COMMENT

In November 1749 Thomas Frye filed a patent for both a porcelain body and its associated glaze. The specification for that glaze 'inrolled' on March 17th, 1750 (Gregorian) was as follows;

Take saltpetre one part, red lead two parts, sand, flint, or other white stones, three parts. To make a glass, melt it well and grind it, to every twenty pounds of which add six pounds of white lead, adding a small portion of smalt to clean the colour; mix it well and glaze the ware,

Based on the formula for red lead (Pb₃O₄), white lead {2PbCO₃.Pb(OH)₂}, and saltpetre (KNO₃), the following patent glaze was calculated (wt%):-

SiO₂ 42.4, K₂O 7.7, PbO 49.8

The SiO₂ and PbO levels compare closely with analysed glazes for both the *Developmental* and *Defoe-New Canton periods* (Table 2) but K₂O is significantly higher, making us suspect that the saltpetre used in the analysed glazes was contaminated with sodium and even calcium salts.

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Appendix 1. Bow glaze analyses from phosphatic porcelain bodies. # Tite and Bimson (1991)

	<i>Defoe - New Canton period</i>										<i>E10 #</i>					
	<i>B30</i>	<i>B64</i>	<i>B68</i>	<i>B1</i>	<i>B4</i>	<i>B11</i>	<i>B16</i>	<i>B20</i>	<i>B32</i>	<i>B33</i>		<i>B62</i>	<i>B66</i>	<i>B71</i>	<i>B73</i>	<i>B75</i>
SiO ₂	38.51	34.55	46.43	44.35	44.53	45.78	51.3	42.53	47.3	39.33	36.65	43.31	46.08	46.84	46.44	37.2
TiO ₂	0.13	0.11	0	0.07	0.08	0.05	0.11	0.03	0.24	0.04	0	0.03	0.19	0.05	0	0
Al ₂ O ₃	0.16	0.42	0	0.31	0.5	0.12	0.85	0.92	1.69	0.17	0.11	0.44	0.01	1.04	0.84	0.9
FeO	0.11	0.01	0.06	0.13	0.42	0.07	0.15	0.14	0.21	0.08	0.03	0.39	0.15	0.2	0.16	0
MgO	0	0.37	0.75	0.08	0	0	0.06	0.27	0.13	0.32	0.12	0	0.03	0.59	0.24	0
CaO	3.27	2.07	3.29	1.66	1.61	1.03	1.74	0.26	4.44	3.42	1.42	1.58	1.21	2.92	1.74	0.7
Na ₂ O	0.26	0.3	1.34	0.26	0.53	0.12	0.59	0.31	0.17	0.61	0.08	0	0	0.85	0.19	0.6
K ₂ O	1.29	0.84	2	2.94	2.76	3.81	3.51	4.57	0.57	2.44	1.8	1	2.54	1.32	1.24	4.8
P ₂ O ₅	2.21	0.43	0.03	0	0.02	0.14	0	0	0	2.86	0.16	0	0	0	0.12	0
PbO	53.03	58.23	44.74	50.02	49.59	47.56	41.35	50.62	45.27	50.61	58.33	49.5	49.43	44.63	47.72	55.8
SO ₂	1.07	2.73	1.39	0.22	0.02	1.38	0.41	0.39	0	0.16	1.3	3.79	0.41	1.6	1.35	0
	<i>Tidswell period</i>										<i>E14 #</i>	<i>745 #</i>				
	<i>B18</i>	<i>B3</i>	<i>B27</i>	<i>B41</i>	<i>B42</i>	<i>B61</i>	<i>B77</i>	<i>E12 #</i>	<i>E14 #</i>	<i>745 #</i>						
SiO ₂	51.36	48.63	50.85	50.99	53.87	46.67	49.05	43.3	42.2	43						
TiO ₂	0.15	0	0.06	0.18	0.15	0.1	0.21	0	0	0						
Al ₂ O ₃	0.46	0.79	0.79	1.19	0.74	0.6	0.6	1.1	0.6	1.2						
FeO	0.21	0.05	0.13	0.07	0.79	0.15	0.11	0.4	0.5	0						
MgO	0.16	0	0	0.48	0.65	0.04	0.4	0	0	0						
CaO	1.68	1.67	1.47	0.5	2.29	4	0.72	1.1	0.9	0.7						
Na ₂ O	0.4	0.59	0.13	0.81	1.18	0.61	0.32	0.6	0.5	0.9						
K ₂ O	4.14	4	3.33	4.43	4.66	2.13	2.58	4.7	4.1	5						
P ₂ O ₅	0	0.19	0.2	0	0	0.08	0	0	0	0						
PbO	40.11	43.24	42.83	41.39	35.71	44.51	44.23	46.1	48.7	46.5						
SO ₂	1.38	0.9	0.24	0	0	1.16	1.83	0	0	0						
SnO ₂	0	0	0	0	0	0.0	2.7	2.3	2.7	0						