Sourcing Scottish White Gritty Ware

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SUMMARY

Following on from the successful pilot study funded by Historic Scotland which assessed the previous work and analyses carried out on Scottish White Gritty Ware pottery, a major investigation of the Scottish White Gritty Ware industry was initiated by Glasgow University Archaeological Research Division and funded by Historic Scotland. The project set out to examine the range and type of vessels, the production areas and chemical composition of the clays used in the production of Scottish White Gritty Ware. The chemical and petrographic analyses aimed to identify the source or sources of the pottery and its distribution within Scotland.

Over six hundred sherds of pottery from over forty Scottish archaeological sites were evaluated by chemical analysis using ICP, combined with the petrographic examination of a selection of thin sections. Also undertaken as part of the project were the construction of a Scottish White Gritty Ware vessel typology, a limited programme of clay prospection, a review of past scientific work, glaze analysis, chemical comparisons with English and Continental material and a geophysical survey of the Scottish White Gritty Ware kiln site at Colstoun in East Lothian. The petrographic analyses were carried out on the existing thin section collection housed in the National Museum of Scotland and newly prepared examples from sherds especially selected for the study.

The results of the analyses have pointed to the production of White Gritty ware in several areas of Scotland from the Scottish Borders to the Moray Firth and have identified those geographic areas that require further research and excavation.

This study has put together the largest and one of the most significant datasets for any Medieval European ceramic industry and has created a major platform for any future work on Scottish ceramics.

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INTRODUCTION

In 1998, one of the authors (GH) examined all the previous chemical, petrological and typological studies carried out over the last twenty years on Scottish Medieval White Gritty Ware (hereafter SWGW) pottery (Will *et al.* 2003). This work showed that of the large number of resulting datasets, only two had any long-term validity or had produced results that could be verified. The time was right therefore for a more systematic effort which began with a pilot study (funded by a grant from the Russell Trust) consisting of chemical analysis by inductively-coupled plasma spectrometry (ICPS) of a selection of SWGW from around Scotland (Chenery 1998). The results taken together with a review of the existing thin-section database revealed that there were differences between White Gritty Wares from the various findspots, many of which could be distinguished by the chemical and petrographic compositions. But because of the limits of the pilot study (Will *et al.* 2003) and difficulties in tracing pottery samples from previous scientific studies it was not possible to compare directly the pottery sherds with the scientific data. Therefore the present project concentrated on creating a sherd typology linked directly with the new chemical and petrographic work with the aim of producing a secure vessel typology and terminology to describe it. From the beginning its main aim was to determine if the small fabric variations in many of the sherds, which could sometimes be detected by a simple visual examination, were significant chemically and petrographically in terms of multiple origins. If this were achievable, it was hoped to create a field guide to identifying and sourcing SWGW visually without recourse to chemical analysis

What is Scottish White Gritty Ware?

The term 'Scottish White Gritty Ware' is a general term that covers a wide range of visually similar pottery fabrics recovered from excavation throughout large areas of Scotland, dating from at least the mid 12th through to the late 15th century. The fabrics are usually hard with a quite finely grained matrix often encompassing a range of rock fragments and inclusions which makes them gritty to the touch. In colour the vessels range, when oxidised, from the very common white or cream to the occasional buff or pink. Under reduction they are generally a light to medium grey but can on occasions be almost black. The main vessels types are jars/cooking pots and jugs although a limited range of other vessel types have been recorded. The Historic Scotland funded ICP-ES pilot study suggested that there were a great many undiscovered production centres awaiting discovery; however, at present only two have been identified with any confidence: Colstoun (Brooks 1980; Hall forthcoming c) and Ceres (see Fife section below). In the areas of Fife, Lothian and the Borders, from the 12th to the 15th centuries, SWGW are the dominant fabric groups, often representing over ninety percent of the medieval pottery recovered.

Pilot study – conclusions

The main conclusion of the pilot study (Will *et al.* 2003) was that some perceived/potential regional differences within SWGW fabrics could be identified by both petrographic and chemical analysis. This was demonstrated by the examination and assessment of the existing petrographic thin-section database on the one hand, and on the other, chemical data resulting from new ICPS analyses and from earlier neutron activation analyses (the latter data was not fully accessible during the pilot study). The task of data collection proved to be much more difficult than anticipated due in part to the haphazard approach to the archiving of medieval pottery assemblages in the past, with the result that the desired information was often not available. This observation highlights the need in Scotland as elsewhere for a 'minimum standards' procedure for the archiving and publication of all pottery assemblages.

Project and aims

In recent years archaeological excavations have produced large amounts of White Gritty sherds from both rural and urban sites throughout Scotland. As a number of these new stratified assemblages originated from outside what had traditionally thought the core area of production – the east coast south of the river Tay – it became imperative to address the old unanswered problems of origin, typology, chronology and demise.

To tackle these issues, the present authors, who combine expertise in Scottish medieval pottery and archaeological sciences, devised what they regarded to be a realistic research strategy building on the results of the pilot study. ICP-ES was deemed at the outset to be a proven and cost-effective technique of chemical analysis (Thompson and Walsh 2003) capable of tackling the problems of origin and distribution. The related technique of ICP-MS had been successful when used in a Historic Scotland-funded trial on the sourcing of Scottish redware (Chenery, Phillips and Haggarty 2001).

- Our primary aim was to apply analytical scientific techniques to groups of SWGW pottery. The combination of chemical sourcing by ICP-ES and petrographic examination of thin sections would, we hoped, allow us to characterise a range of sub-fabrics which in turn would be the basis of a nationally held SWGW fabric reference collection.
- To develop a recognised and agreed terminology for the description of SWGW pottery, which would be flexible enough to be adapted and developed as required in the future.
- To produce if possible, a workable field guide to SWGW based on visual characteristics, supported by thin section work and ICP-ES.
- To produce a provisional vessel typology for the SWGW industry.

Sampling

Five hundred and seventy-two samples in addition to the 50 samples used in the pilot study were collected from forty Scottish rural and urban sites. The county town of Elgin was the most northerly, and Buittle Bailey castle in Dumfries and Galloway the most southerly. However, as might be expected, the main concentration was from the Borders, Lothian and Fife, areas where SWGW has traditionally been found in greatest quantity. Figure 2 shows the locations of the sites mentioned and those from which samples were taken.

Samples were selected from either complete vessels or sherds for which vessel profiles were available, where a good range of vessel forms were present or where there was external dating or evidence and security of stratification. In this way we hoped to bring together existing information concerning vessel shape, form, distribution and dating. In a few cases small body sherds were the only ones available and these were included if the site was particularly important in terms of geographic position. For the larger towns and cities samples were often selected from more than one site.

HISTORICAL BACKGROUND

The first serious attempt to classify what at present is known as the SWGW pottery industry was carried out by Lloyd Laing in the early 1970s and exemplified by him in a paper entitled 'Cooking pots and the origins of the Scottish medieval pottery industry' (1973, 183–216). Using rim morphology, Lloyd examined a large number of what were mainly unstratified White Gritty sherds and tried, we believe with no success, to relate these to similar archaeologically derived examples from the south of the border.

The first attempt at analysing SWGW pottery from a purely Scottish perspective was when George Haggarty coined the term 'Scottish East Coast White Gritty Ware' and suggested, on the evidence from excavations at Kelso Abbey and a number of east-coast Burghs, that it may have been introduced into Scotland along with monasticism in the second quarter of the 12th century (Haggarty 1984, 396). This hypothesis has never been disputed, while the dating has subsequently been borne out by a sherd of similar pottery from Roberts Haven in Caithness, which comes from a deposit radiocarbon dated to 1172–1266 (Hall forthcoming e). Haggarty also went on to suggest that it might be possible to study and categorize the SWGW industry using diagnostic regional variations and more particularly vessel forms (Haggarty 1984).

At present we have no real idea how long the SWGW industry lasted or its geographical spread at different dates, but excavations carried out in the port of Leith and just across the River Forth in Inverkeithing show conclusively that a white pottery industry of sorts was still manufacturing crude large jugs at least into the 15th century (MacAskill 1985, 416; 1983, 535–542).

REGIONS

Borders

In the 1980s Eion Cox began his important programme of petrographic analyses using the 12th-century pottery from the large excavated pit below the infirmary range at Kelso Abbey (Types 1 1a & 1b) and material of a similar date from Jedburgh Abbey. He compared this pottery with similar looking material from a number of other Scottish east-coast sites. The published results showed that most of the Kelso pottery had been made locally; however it also demonstrated that it was impossible to sub-divide the variants of the White Gritty industry by eye (Cox 1984a, 381–395; Haggarty and Will 1995, 99). Cox also went on to show that the straight-sided 12th century pottery from Aberdeen, Duffus, the Hirsel, Berwick and Hawick probably all shared a common geological parentage with the material from Kelso and Jedburgh Abbeys, while the more rounded 13th and 14th-century pottery from Elgin, Inverness, Edinburgh and Eyemouth was geologically different (Cox 1984b, 4). The 12th- century Kelso pit also included a very small rounded vessel (Type 1g) which may indicate a need for different capacities (Haggarty 1984, 383–384). Of similar date from Jedburgh Abbey there is a rare and well-made white gritty ceramic lamp (Type 26).

Later cooking pots/jars are represented in the Border typology by examples from excavations at Springwood Park, Kelso. These are of a more rounded shape with a pronounced sagging base (Type 2), and were found in deposits dating to the 13th or 14th centuries.

Borders jug forms are represented by four 12th-century examples from Kelso Abbey: Type 10 has a strap handle, slightly rilled external surface and a fairly upright form, Type 11 is a much narrower straight-sided form, while Type 12 is small and rounded, and Type 13 is distinguished by its 'baluster' shape. The slightly splayed rims of these jugs may be a distinctive early Border trait.

Lothians

The study of the SWGW industry and its possible regionalisation continued with the publication of a magnetometer survey and collection of largely unstratified pottery from the multi-phase kiln site at Colstoun in East Lothian (Brooks 1980, 364–403). Subsequent work has given an archaeomagnetic *terminus ante quem* of 1350 for a Type 3 kiln at Colstoun (Hall forthcoming c). The majority of Colstoun vessels (82%) were in rounded jar/cooking pot form and many have cordons on the shoulders (Types 4); 10% were in straight-sided jar/cooking pot forms, also thought on present evidence to date from the 13th or 14th century (Types 3, 3a, 3b and 4y).

The Lothian 13th and 14th-century jug forms from Colstoun (Brooks 1980, 376–379; Hall forthcoming c, 19a) are rounded in shape with a slight variation in neck profile and pinched spouts (Types 14 and 15). From the Musty type 2 kilns there were also a number of anthropomorphic (Type 16), tubular spouted (Type 17) and bridge spouted jugs (Type 18).

Following limited investigation on the large unpublished Ronaldson's Wharf assemblage at Leith, George Haggarty and Alan Vince suggested that the earliest SWGW pottery from the site was straight-sided Borders jars (Type 1c). These vessels, which are associated with 12th century Developed Stamford wares, are also securely stratified below the locally-made Lothian rounded jars (Type 4). Evidence that these thin-walled, straight-sided forms are the earliest type in the Lothian's sequence seems to be have been confirmed by a small excavation in Market Street, Haddington where a group of 12th century sherds included the more complete profile of a small straight-sided, flat-based vessel with the usual pronounced rilling (Type 1f).

Later jar forms recovered from the Lothians include rounded vessels (Type 3–3b), squat straight-sided vessels (Type 4), vessels with frilled rims (Type 5 and 5a) and a rounded vessel with two (?) handles (Type 6). This is an intriguing mixture of forms, most of which are also present in Fife and the Scottish Borders. Archaeology would suggest that the rounded jar, often with a shoulder cordon, (Types 3 and 3a) be considered as the main Lothian form for the 13th and 14th centuries, as there are now a good number of restored examples from excavations in Leith. Sherds from tripod pipkins, handled skillets and a small handled ladle (Type 27) have also been recovered at Colstoun, but it has not been possible to reconstruct profiles of the other vessels (Brooks 1980, 380, Figs 206–10).

Fife

The medieval pottery recovered from the area around St Andrews in Fife was the backbone of Laing's early paper 'Cooking-Pots and the Origins of the Scottish Medieval Pottery Industry' (1973, 183–216). An interim vessel typology was later published by Hall (1997, 40–63), and a year earlier in a paper on the medieval pottery from St Andrews castle Haggarty and Will (1996, 667) suggested that St Andrews may have been the site of one of the earliest medieval potteries industries in Scotland). This hypothesis was based on the lacuna of English imported coarse sandy and shell-tempered wares which are not uncommon in other large Scottish east-coast ports. Haggarty and Will proposed that there was a local ceramic industry strong and dynamic enough to hold its own. At various times, claims have been put forward for three White Gritty kiln sites in Fife:

Balchrystie, Tentsmuir and Ceres. While we are confident that excavation will confirm Ceres as a production site, this is unlikely to be the case at Balchrystie.

It was also Laing who first suggested that cooking pot/jars with frilled bifid rims, (Type 7) might be a specific Fife form, and recent work on material from Tentsmuir Forest and Ceres would seem to confirm this (Hall 2002, 7; Colin Martin pers. comm.). These rim forms also occur in ceramic assemblages in ports around the River Tay such as Perth with several published examples (MacAskill *et al.* 1987, Fig nos 244 and 294) and the River Forth such as Leith, where a number have been recovered (Haggarty pers. comm.), and Cramond (Will pers. comm.), suggesting that these vessels were being traded. Following a series of excavations in the medieval burgh of St Andrews it has been postulated that the distinguishing characteristic of at least some cooking vessels from that area is that they have two opposed handles (Types 8, 8a & 8b). Indeed one of the forms included in the Fife typology combines both the (Type 7) frilled bifid rim and opposed handles (Type 8c). It is ironic however that, despite all the excavations carried out in St Andrews, it has not been possible to develop a chronological sequence. There is, nevertheless, a large published group of standard rounded White Gritty jars/cooking pots (Type 9) from a site adjacent to the castle (Haggarty and Will 1996, 648–669).

The standard Fife jug form is rounded with a pulled spout and strap handle (Type 19), but there are also local copies of Yorkshire forms (Type 20, 24 and 25) and one sizeable example with three strap handles (Type 20a). There is slightly more evidence from Fife for the production of a wider range of vessel forms including bowls (Type 30), aquamaniles (Type 31), ladles (Type 29) and dripping pans (Type 34). Owing to the lack of well-stratified ceramic assemblages in the area, we still have no firm chronology. We would suggest that both the arrival of the white ware industry and possibly its disappearance may be connected with the foundation and dissolution of the major monastic houses of St Andrews and Dunfermline, a hypothesis which has long been suggested for the Scottish Borders industry (Haggarty 1984, 383–384).

Dumfries and Galloway

Given the dearth of long stratified ceramic sequences from the west and south west of the country and the conflicting nature of the published material, we are presently in no position either to suggest geographical or chronological limits for the production of White Gritty Ware or to create meaningful vessel typologies. For example, in the 12th century quasi-independent principality area of Galloway it is always possible that there was no indigenous White Gritty Ware industry as excavations at the important multi-period site of Whithorn produced not one sherd (Clark 1996, 510–518). Archaeology along the Solway coast at the main castle of Caerlaverock also suggest that the local red firing clay was being used (Laing 1999, 198) and excavations at the important castle of Threave produced only two small sherds (Haggarty 1981, 129). A number of other important castles in the area including Cruggleton in the far west (Haggarty 1985) and Buittle (D Hall pers. comm.) have produced some White Gritty material, but at present it is not possible to suggest its origin. Further east in Dumfriesshire major castles such as Lochkmaben have produced White Gritty material, but there is much work to be done in the region before any real understanding of its medieval ceramic history can be gained.

Strathclyde and Central

From an excavated midden at Kidsneuk in Ayrshire (Curle 1918, 66, Fig. 1), in an off-white sandy fabric, there is a small rounded jar/cooking pot which seems to have affinities with the earlier medieval pottery from areas like Chester (Haggarty pers. comm.) and which may be one of the diagnostic forms in the area in the 12th/13th centuries. A number of these small vessels from various locations were published in the Kirkcudbright Castle pottery report (Dunning *et al.* 1958, 136). Excavations carried out in Dumbarton and Ayr suggests that at some period jug forms on the Scottish west coast may have been influenced by imported French vessels (Franklin and Hall forthcoming).

It is imperative that the huge assemblages of pottery from the old Manpower Services Commission-sponsored excavations in Glasgow be published soon. Without this information the distribution of SWGW will always be skewed.

A SCOTTISH WHITE GRITTY WARE VESSEL TYPOLOGY

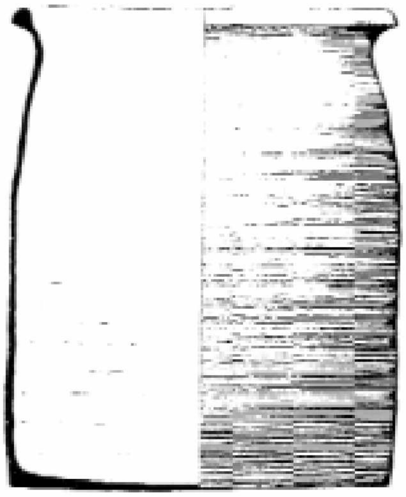
Jars

Type 1 (MPRG Guide to Classification ref. 4.1.3a) (Fig. 1a, b)
Tall straight-sided or cylindrical thin-walled vessel with flat base, undecorated with pronounced rilling marks (Kelso Abbey BY)

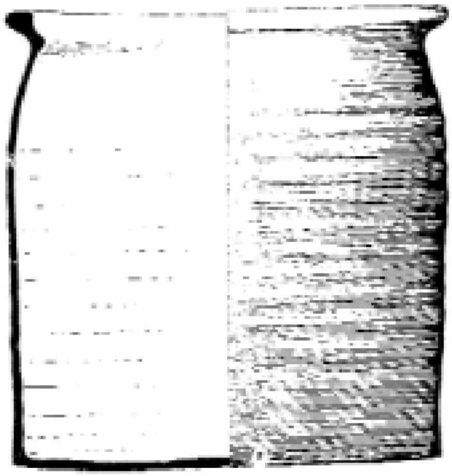
Type 1a
Squat straight-sided thin-walled vessel with flat base undecorated with pronounced riling marks (Kelso AbbeyBY)

Type 1b
Narrow straight-sided thin-walled vessel with flat base, undecorated with pronounced rilling marks (Kelso AbbeyBY)

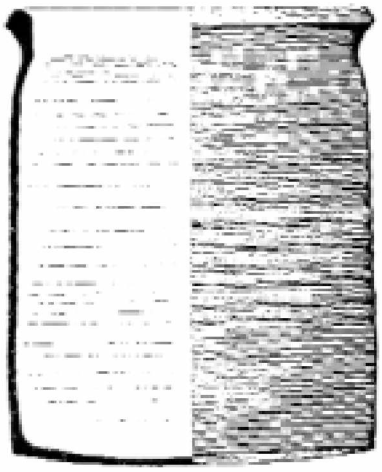
Type 1c
Straight-sided vessel with flat base and a slightly everted rim, undecorated with pronounced rilling marks (Ronaldson’s Wharf, Leith 2951)



1
Kelso Abbey BY

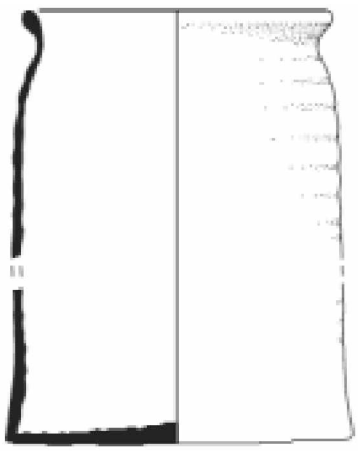


1a
Kelso Abbey BY



1b
Kelso Abbey BY

1c
Ronaldson's Wharf, Leith 2951



1d
Nicholson's Garage, High Street, Elgin

1e
Castlecliffe, St Andrews

Fig. 1a Jars, Types 1a–1e (scale 1:4)

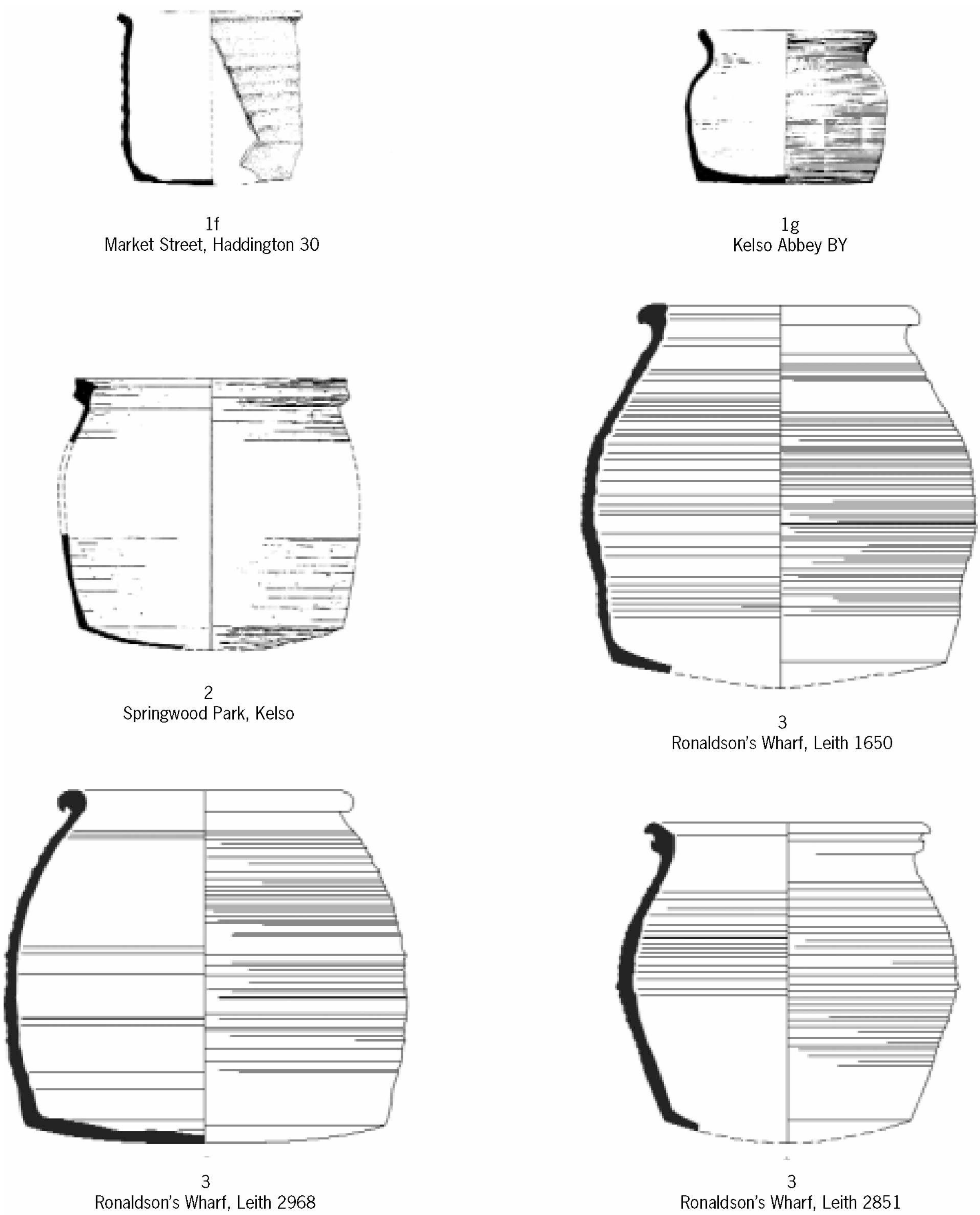


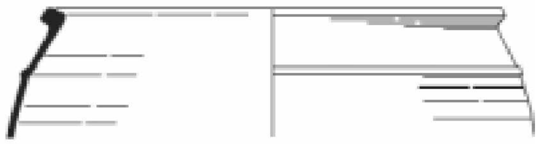
Fig. 1b Jars, Types 1f–3 (scale 1:4)

Type 1d
Straight-sided thin-walled vessel with slightly splayed flat base, undecorated with pronounced rilling marks (Nicholson's Garage, High Street, Elgin 124)

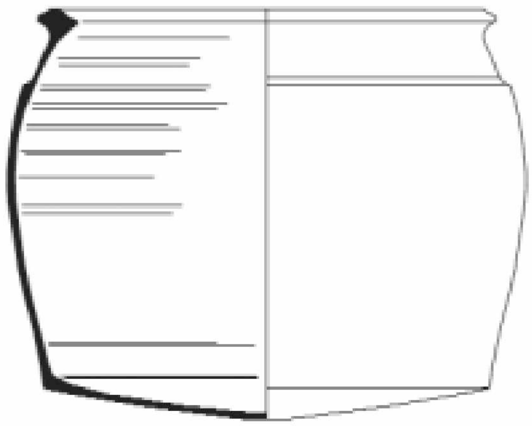
Type 1e
Straight-sided thin-walled vessel with slightly concave flat base, undecorated with pronounced rilling marks (Castlecliffe, St Andrews nineteenth/twentieth century deposit)

Type 1f
Small straight-sided thin-walled vessel with a flat base, undecorated with pronounced rilling marks (Market Street, Haddington 30)

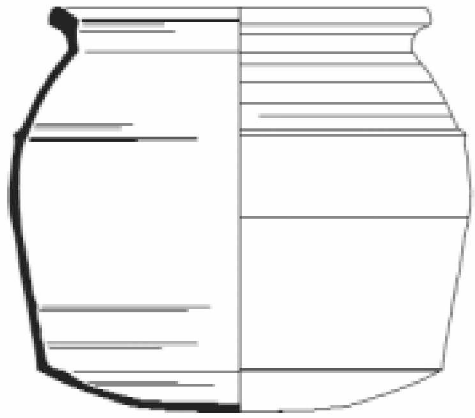
3
Coulstoun



3a
Coulstoun



3a
Burgess Street, Leith 6640



3a
Burgess Street, Leith 6505

3a
Ronaldson's Wharf, Leith 1324

Fig. 1c Jars, Types 3a (scale 1:4)

Type 1g
Small rounded thin-walled vessel with flat base, undecorated (Kelso Abbey BY)

Type 2 (MPRG Guide to Classification ref. 4.1.7d) (Fig. 1b)
Slightly rounded thin-walled vessel with sagging base, undecorated (Springwood Park, Kelso)

Type 3 (MPRG Guide to Classification ref. 4.1.7d) (Fig. 1b–d)
Rounded cooking vessel with slightly everted rim, sagging base, undecorated with pronounced rilling marks (Ronaldson's Wharf, Leith 1650)
Rounded cooking vessel with hooked rim, sagging base, undecorated with pronounced rilling marks (Ronaldson's Wharf, Leith 2968)
Rounded cooking vessel with bifid rim, sagging base, undecorated with pronounced rilling marks (Ronaldson's Wharf, Leith 2851)
Rounded cooking vessel with square rim and sagging base, undecorated (Colstoun)

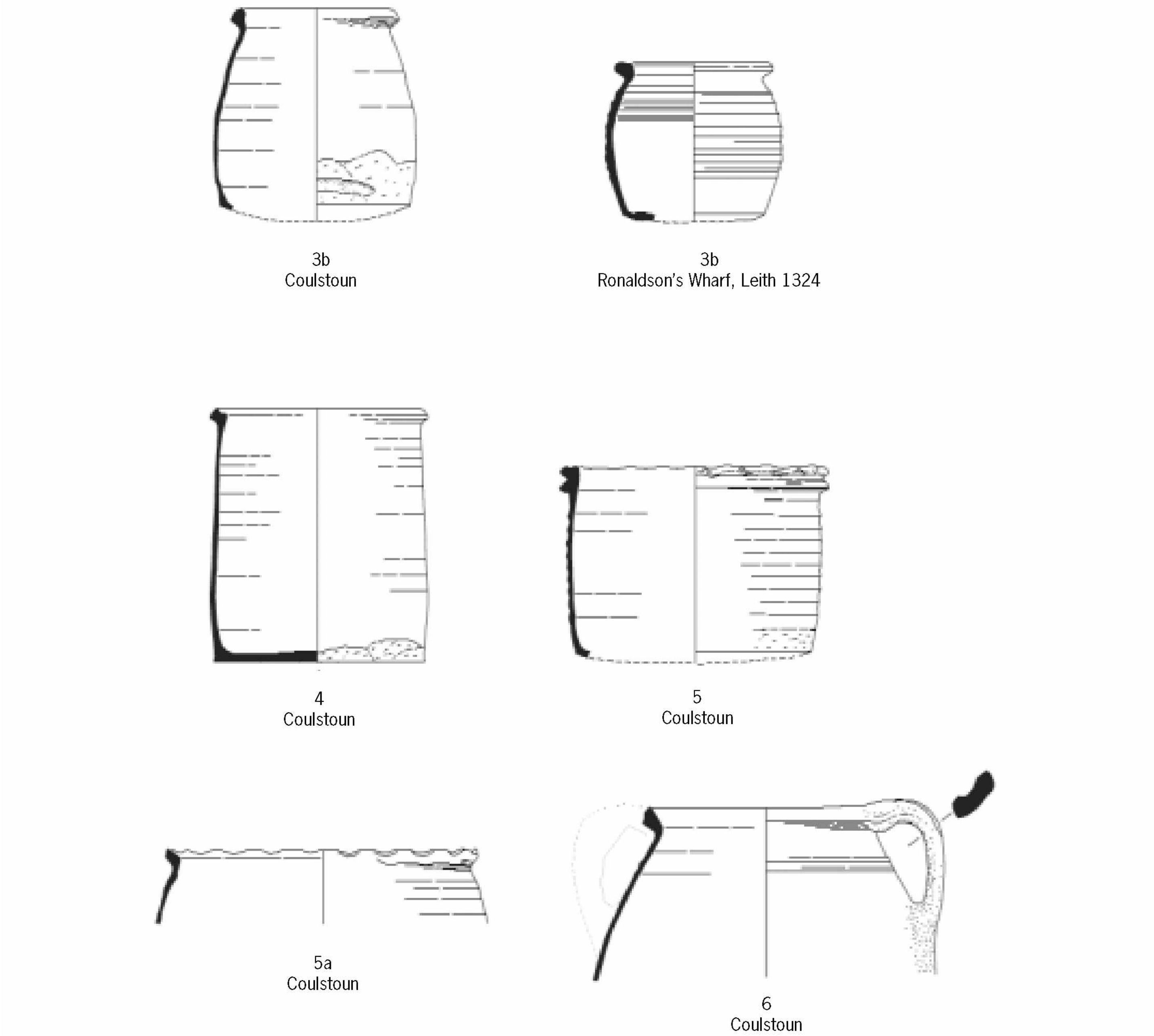


Fig. 1d Jars, Types 3b–6 (scale 1:4)

Type 3a

Large rounded cooking vessel with pronounced cordon below rim, undecorated (Colstoun)
Rounded cooking vessel with sagging base and pronounced cordon below rim, undecorated (Burgess Street, Leith 6640)
Rounded cooking vessel with sagging base and pronounced cordon below rim, undecorated (Burgess Street, Leith 6505)
Rounded cooking vessel with sagging base, rounded rim and pronounced cordon, undecorated with pronounced rilling marks (Ronaldson's Wharf, Leith 1324)

Type 3b

Small rounded cooking vessel with sagging base, undecorated (Colstoun)
Small rounded cooking vessel with slightly everted rim, sagging base and pronounced rilling marks, undecorated (Ronaldson's Wharf, Leith 1324)

Type 4 (MPRG Guide to Classification ref. 4.1.3a) (Fig. 1d)

Straight-sided vessel with flat base, undecorated (Colstoun)

Type 5 (MPRG Guide to Classification ref. 4.1.3a) (Fig. 1e)

Squat straight-sided vessel with flat base and a frilled bifid rim, undecorated (Colstoun)

Type 5a

Cooking vessel with frilled rim (not bifid) (Colstoun)

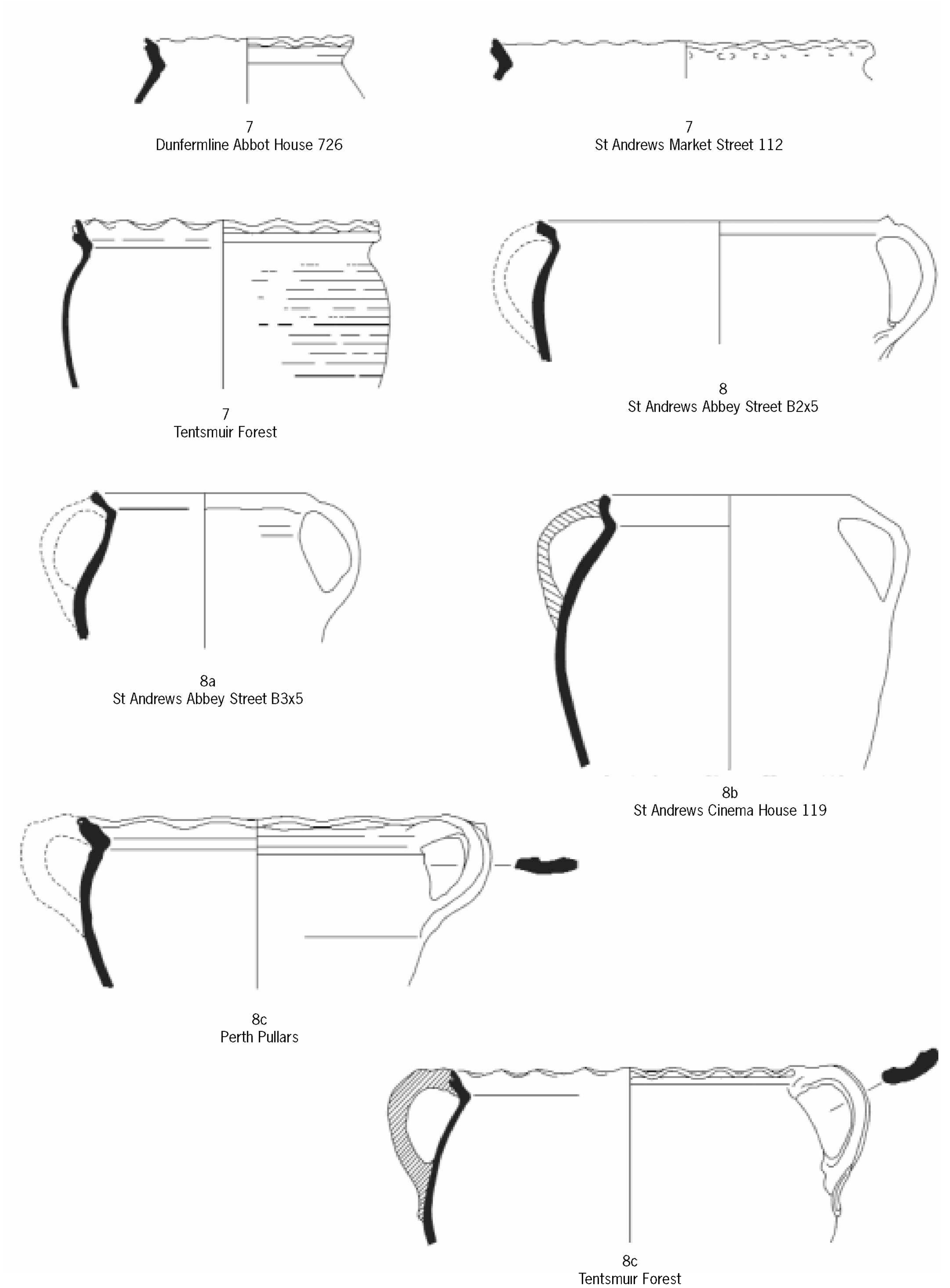


Fig. 1e Jars, Types 7–8c (scale 1:4)

Type 6 (MPRG Guide to Classification ref. 4.2.3a) (Fig. 1d)

Rounded vessel with two grooved strap handles attached to the rim with cordon, undecorated (Colstoun)

Type 7 (Fig. 1e)

Frilled rims, one with decoration below the rim and the others undecorated (Abbots House, Dunfermline 726, 134 Market Street, St Andrews 112, Tentsmuir Forest)

Type 8 (MPRG Guide to Classification ref. 4.2.3a) (Fig. 1e, f)

Note, due to the fragmentary nature of many of these vessels or vessel profiles it cannot be stated definitively that each vessel had two handles although there is strong evidence to suggest that they did.
Rounded vessel with two strap handles attached to the rim, undecorated (Abbey Street, St Andrews B2X5)

Type 8a

Small rounded vessel with two strap handles attached to the rim, undecorated (Abbey Street, St Andrews B3X5)

Type 8b

Rounded vessel with frilled rim and two strap handles with stabbed decoration attached to the rim, undecorated (Cinema House, North Street, St Andrews 119)

Type 8c

Rounded vessel with frilled rim and two strap handles attached to the rim, undecorated (Curfew Row, Perth 249, Tentsmuir Forest)

Type 8d

Rounded vessel with two handles attached below the rim, undecorated but copy of metal vessel (Murraygate, Dundee 197, 228)

Type 9 (MPRG Guide to Classification ref. 4.1.7d) (Fig. 1f)

Rounded vessel with flat base, undecorated (Logies Lane, St Andrews 218, St Andrews Castlecliff Pit B)

Type 9a

Small rounded vessel with flat base, undecorated (St Andrews Castlecliff Pit B)

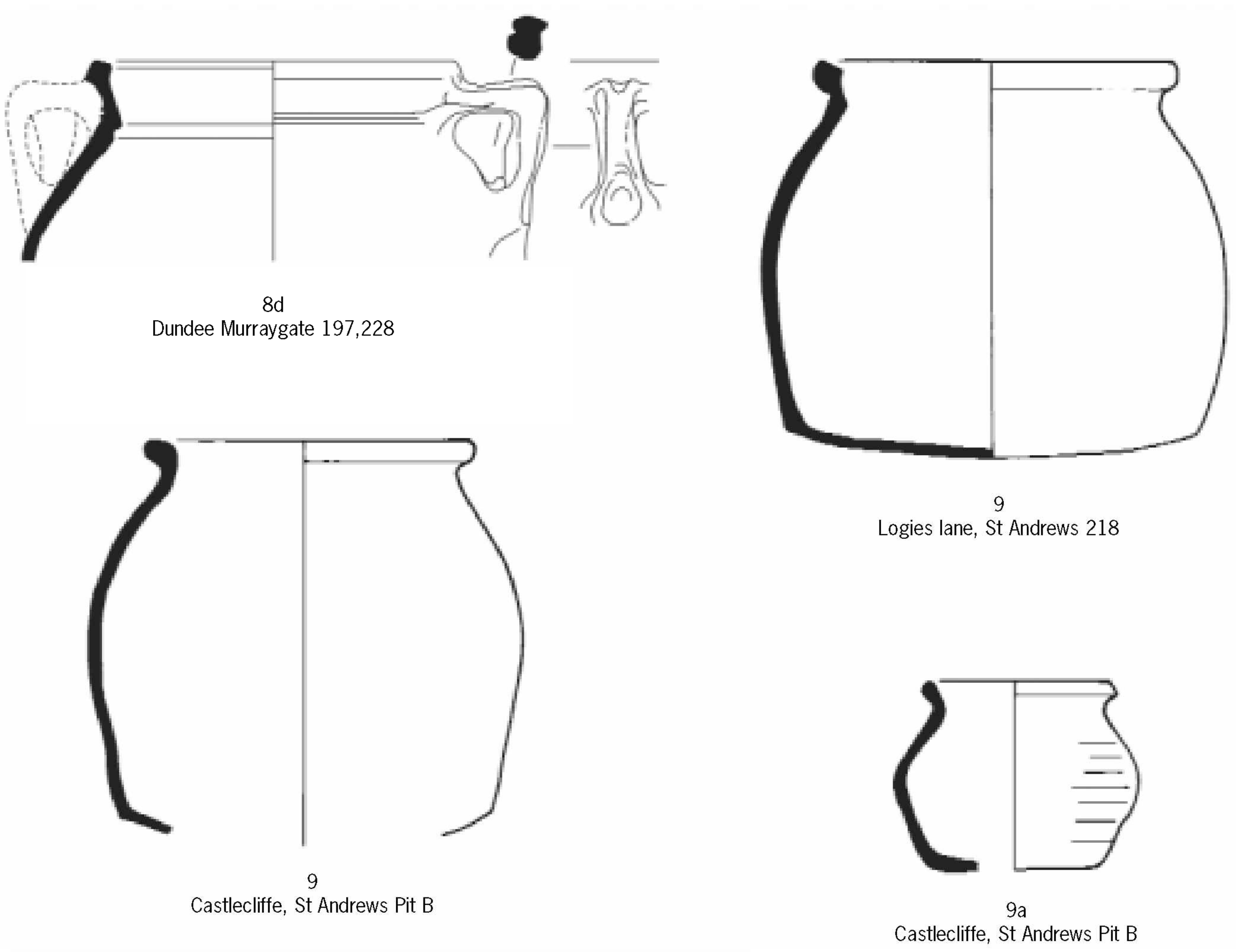


Fig. 1f Jars, Types 8d–9a (scale 1:4)

Jugs

Type 10 (MPRG Guide to Classification ref. 3.1.9) (Fig. 1g)
Cylindrical straight-sided vessel with flat base and a grooved strap handle attached below the rim, glazed on upper body and pronounced rilling marks (Kelso Abbey BY)

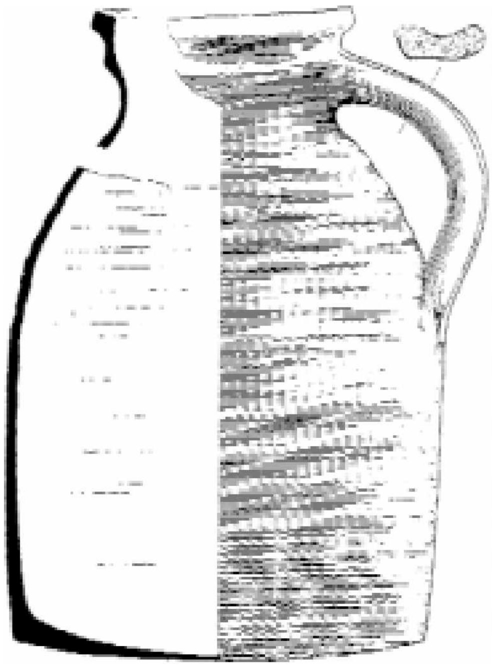
Type 11 (MPRG Guide to Classification ref. 3.1.9) (Fig. 1g)
Narrow cylindrical straight-sided vessel with flat base with pronounced rilling marks, partially glazed with some fuming (Kelso Abbey BY)

Type 12 (MPRG Guide to Classification ref. 3.1.9) (Fig. 1g)
Small rounded vessel with slightly sagging base and a grooved strap handle attached below the rim, partially glazed (Kelso Abbey BY)

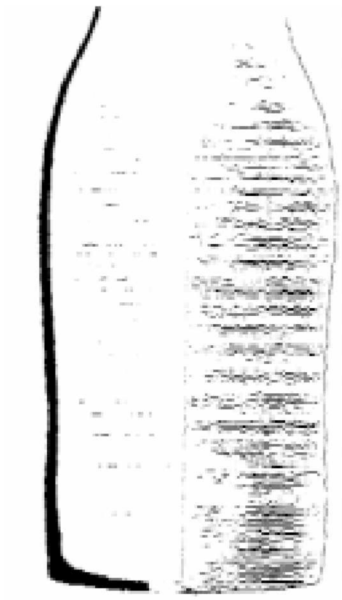
Type 13 (MPRG Guide to Classification ref. 3.1.1a) (Fig. 1g)
Baluster jug with flat base, partially glazed (Kelso Abbey BY)

Type 14 (MPRG Guide to Classification ref. 3.1.9) (Fig. 1h)
Slightly rounded shouldered jug with distinctive rim profile, a grooved strap handle attached below the rim and sagging base (note base variation, sometimes thumbed occasionally flat) (Colstoun Kiln B)

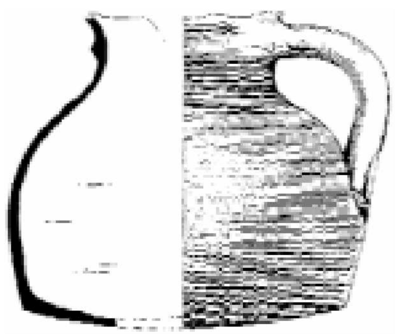
Type 15 (MPRG Guide to Classification ref. 3.1.9) (Fig. 1h)
Rounded shouldered jug with upright rim and neck, pulled spout, grooved strap handle attached below the rim and slightly sagging base (Colstoun Kiln C)



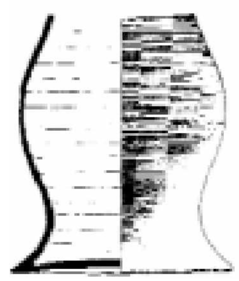
10
Kelso Abbey BY



11
Kelso Abbey BY



12
Kelso Abbey BY



13
Kelso Abbey BY

Fig. 1g Jugs, Types 101–3 (scale 1:4)

Type 15a (MPRG Guide to Classification ref. 3.1.11b)
Jug with anthropomorphic decoration on either side of the vessel (note common decorative variation is twisted rods at base of beard on facemask, good parallels for this from Stenhouse) (Colstoun)

Type 15b (MPRG Guide to Classification ref. 3.1.9 with bridge spout 11.8b)
Jugs with tubular spouts (Colstoun)

Type 15c
Jugs with bridge spouts (Colstoun)

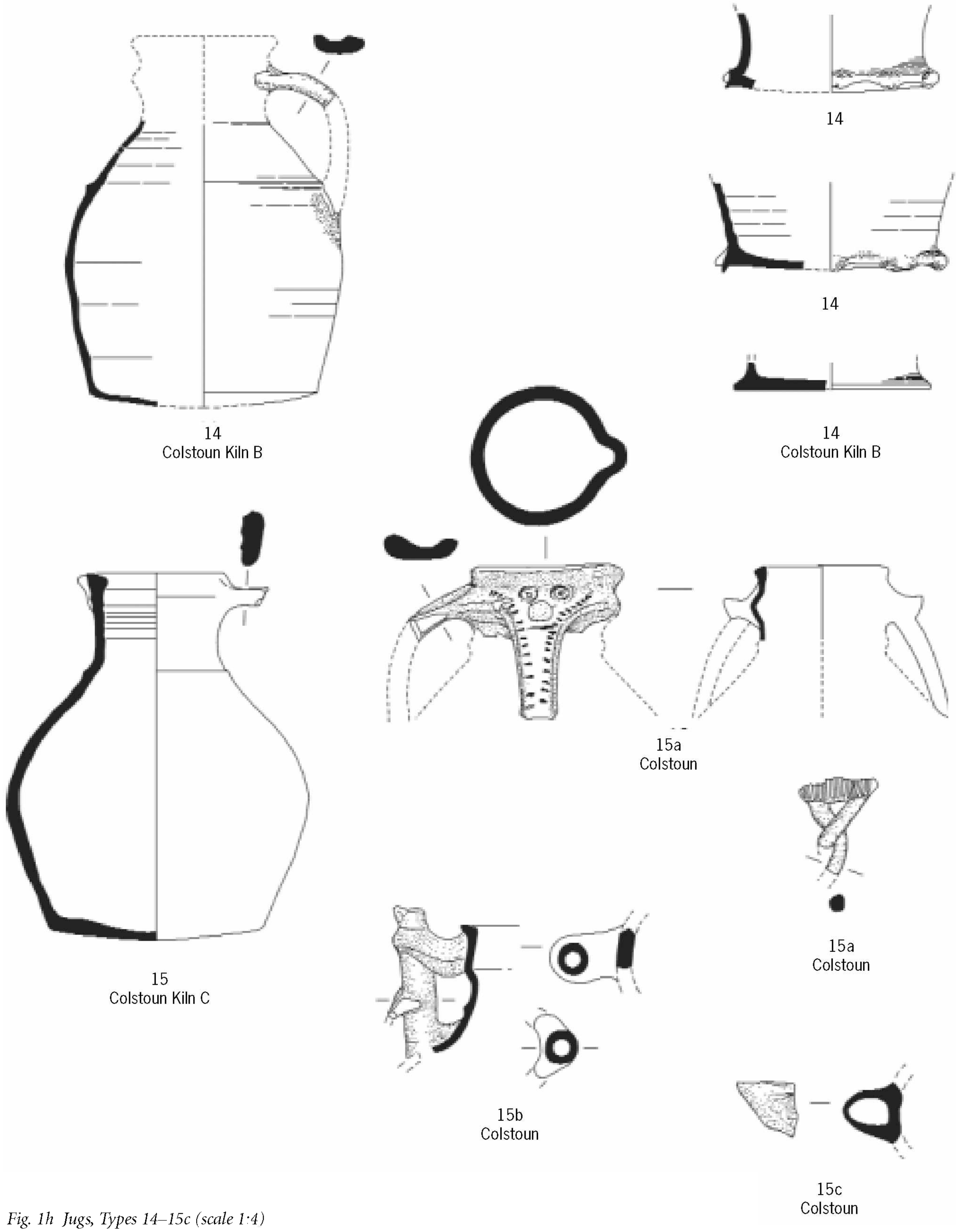


Fig. 1h Jugs, Types 14–15c (scale 1:4)

Type 16 (MPRG Guide to Classification ref. 3.1.8b) (Fig. 1i)
Rounded-shouldered jug with a splayed rim and pulled spout and a grooved strap handle attached below the rim with stabbed decoration and a flat base (Cinema House, North Street, St Andrews 119)

Type 17 (MPRG Guide to Classification ref. 3.1.9) (Fig. 1i)
Jug with three handles and a tubular spout, highly decorated with full green glaze (St Andrews, Castlecliff Pit B)

Type 18 (Fig. 1i)
Jug with two grooved strap handles with stabbed decoration

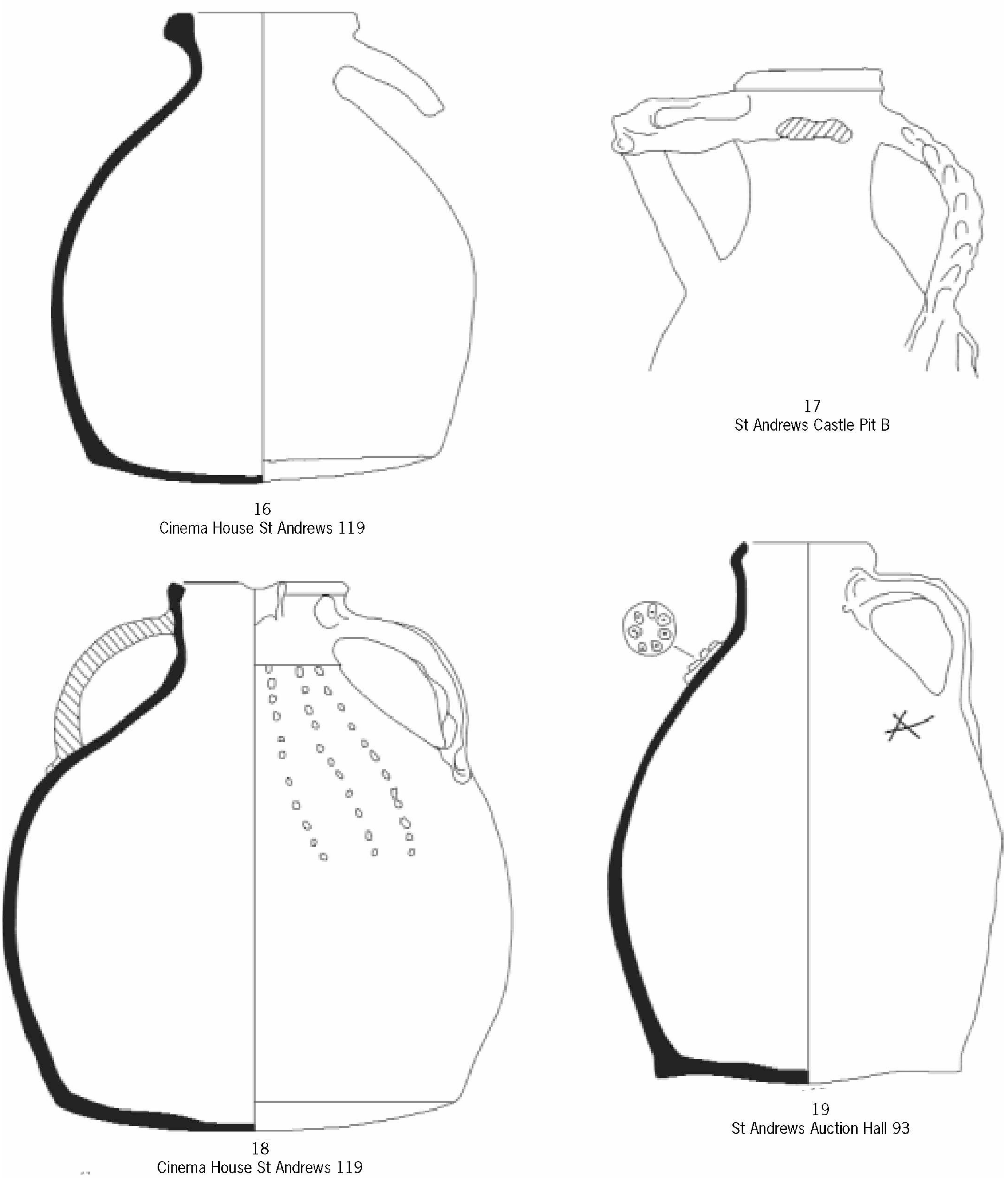


Fig. 1i Jugs, Types16–19 (scale 1:4)

attached below the rim with two opposing pulled spouts and a flat base. This jug is decorated with combed lines and applied scale pattern (Cinema House, North Street, St Andrews 119)

Type 19 (MPRG Guide to Classification ref. 3.1.8b) (Fig. 1i)
Rounded-shouldered jug with a grooved strap handle attached below the rim. Decorated with a stamped pad on the front and an incised triangle by the handle (Auction Hall, St Andrews 93)

Type 20 (MPRG Guide to Classification ref. 3.1.11c) (Fig. 1j)
Vessel with applied anthropomorphic/face mask on rim (120 Market Street, St Andrews 509)

Type 21 (MPRG Guide to Classification ref. 3.1.8b) (Fig. 1j)
Rounded jug with grooves strap handle attached below the rim and a narrow neck with a slightly sagging base and denuded glaze (St Andrews, Castlecliff Pit B)

Type 22 (MPRG Guide to Classification ref. 3.1.9 with bridge spout 11c) (Fig. 1j)
Rounded-shouldered jug with a grooved strap handle attached below the rim with a bridge spout and distinctive cordon below neck, full green glaze (Byre Theatre, Abbey Street, St Andrews 5)

Type 22a (MPRG Guide to Classification ref. 3.1.9)
Rounded-shouldered jug with a single twisted rod handle and full green glaze (Byre Theatre, Abbey Street, St Andrews 9)

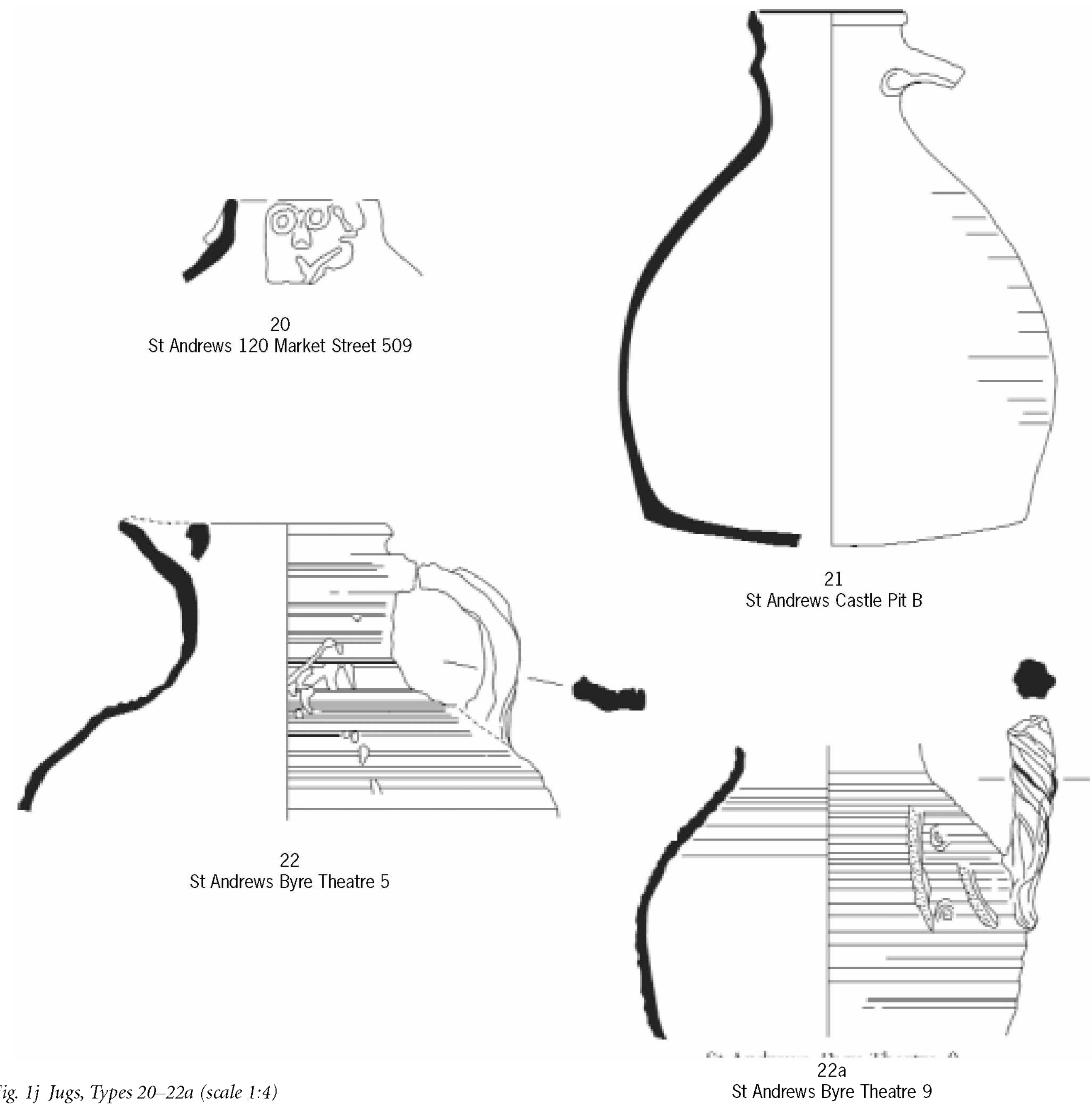


Fig. 1j Jugs, Types 20–22a (scale 1:4)

Other Vessel Forms

Type 23 Lamp (MPRG Guide to Classification ref. 8.2.6) (Fig. 1k)
Spike or cresset lamp, undecorated (Jedburgh Abbey 928)

Type 24 Ladle (MPRG Guide to Classification ref. Pipkin 4.3e) (Fig. 1k)
Small rounded ladle with a pulled spout and a flat base with a curving handle attached below the rim at right angles to the spout, undecorated (Colstoun)

Type 25 Curfew (MPRG Guide to Classification ref. 8.5.1) (Fig. 1k)
Curfew with spots of green glaze (Abbots House, Dunfermline 774)
Curfews were used to cover domestic fires and in their simplest form consist of inverted bowls with a loop handles added to the top and one or more holes in the top and/or walls.

Type 26 Ladle (MPRG Guide to Classification ref. Pipkin 4 3e) (Fig. 1k)
Handled ladle, globular jar with a pulled spout and a straight handle attached to the rim at right angles to the spout, undecorated (St Andrews Castlecliff Pit C)

Type 27 Bowl (MPRG Guide to Classification ref. 5.1.4) (Fig. 1k)
Bowl (St Nicholas Farm, St Andrews 1013, 1044)

Type 28 Aquamanile (MPRG Guide to Classification ref. 10.2) (Fig. 1k)
Fragment of a spout (Cinema House, North Street, St Andrews 190)
These vessels were made in a zoomorphic form, sometimes combined with human Figures. The best-known examples represent horses with riders. The vessel is filled through a hole or device in the top of the body and liquid is poured out through

Type 29 Storage vessel (MPRG Guide to Classification ref. 4.1.7d) (Fig. 1k)
Rounded storage vessel, undecorated (St Andrews Castlecliff Pit C)

Type 30 Side-handled urinal (MPRG Guide to Classification ref. 10.28.2) (Fig. 1k)
A rounded jar with a narrow mouth and a single looped strap handle attached beside the rim (Burgess Street, Leith)

Type 31 Oil Jar (MPRG Guide to Classification ref. 4.1) (Fig. 1k)
Small globular glazed jar with tubular spout, central filling spout and narrow looped strap handle (75 High Street, Perth 6137). This small vessel is presumably for decanting oil or some other liquid and is a copy of a so far unprovenanced import

Type 32 Lid (MPRG Guide to Classification ref. 7.1.8a) (Fig. 1k)
Lid from a jug, green glaze (Abbots House, Dunfermline Unstratified)

Type 33 Dripping pan (MPRG Guide to Classification ref. 5.3.6c) (Fig. 1k)
Dripping pan, rim with handle junction, undecorated (Abbots House, Dunfermline 724)
Dripping pans are a type of dish specifically designed to catch the juices from roasting meat. The dish can be oval, semi-circular, rectangular or wedge shaped. There are generally one or two handles located on one long side and a lip on one or both short ends.

Newly Identified Forms

When other types of vessels are identified in this fabric they can be added to the vessel typology.

TECHNOLOGICAL CHARACTERISATION

White clays

From the end of the second decade of the 17th century there are a number of extant documents and letters which refer to the search for Scottish white clays (Register of the Privy Council of Scotland X1 1619, Commissions Fol. 81a, 81b & 82a). There is no evidence that these clays, which were in demand for the manufacturing of crucibles to be used in the glass industry, clay pipe manufacture, and for the production of white earthenwares, were found in any quantity. One example of such a search can be found in a letter sent by the polymath Dr Black, in which he states that the Count de Lauraguais, a famous and well connected French porcelain maker who had been granted the rights to produce hard paste porcelain in Scotland, for 14 years from 1766 "had on his trip to the granite area [Aberdeenshire?] found no clays that were suitable for making hard paste porcelain" (Haggarty and Forbes 2002, 9). What is also indisputable is that from the middle of the 18th century Scotland's industrial potteries, apart from Delftfield in Glasgow that obtained the majority of its calcareous clay for the production of tin glazed earthenware from Carrickfergus, were totally dependent, as were most English potteries, on the white clays of Devon and Cornwell. In the later 19th century the potential of Scotland's vast refractory fireclay beds, which although coarser than that used for the production of 'typical' Medieval white gritty ware (and which indeed are not true potters clays) were used in vast

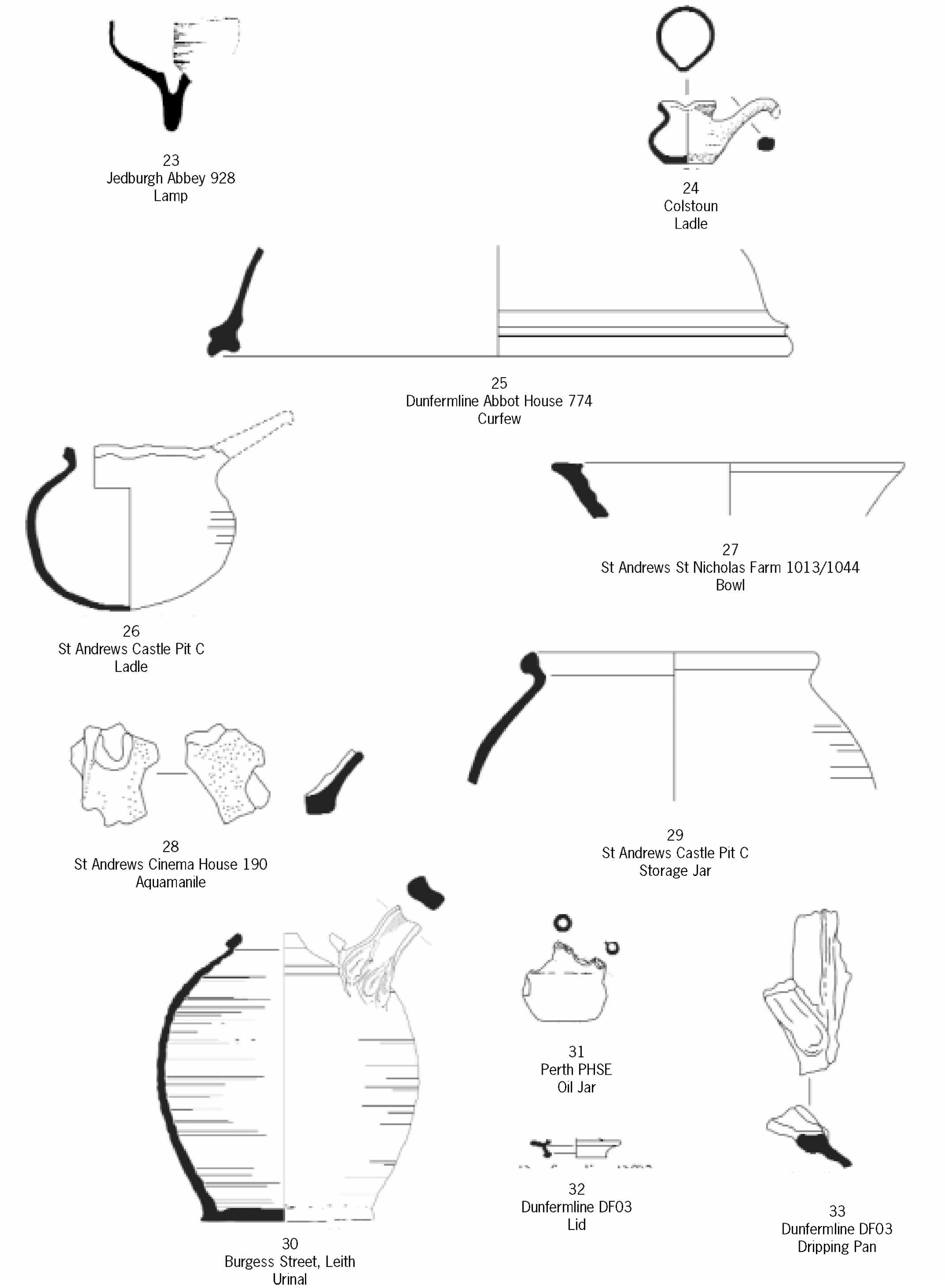


Fig. 1k Other forms, Types 23–33 (scale 1:4)

quantities for the production of garden furniture (Quail 1985). These clays, which are quartz-rich and frequently pale-coloured, are commonly associated with carboniferous coal measures in central Scotland and Ayrshire (Douglas and Oglethorpe 1993, 19).

These remarks are in keeping with the limited attempts and failure of the project to locate white-firing clays. This may also suggest that it may have been in part the lack of resources which brought about the demise of the SWGW industry and which in the late 15th and 16th centuries heralded the introduction of the Scottish Post-Medieval Oxidised and Reduced Ware industries (Haggarty 1980, 38).

Glaze

It is reasonably supposed that the glaze on SWGW is lead based, yet very little has been done to investigate this, nor has there been any attempt to determine the sources of the lead. The glaze could have been applied in a number of ways (Newell 1995; Hughes 2000; Griffiths and Redknap 1991; Henderson 2000, 126), but in any case glaze was no doubt precious and so used sparingly. In this study it is estimated that some 20% of the SWGW had extant glaze; it was frequently thin and abraded. In view of the paucity of data on Scottish glazes, some fifteen glazed sherds were selected for two pilot investigations: scanning electron microscopy with energy-dispersive X-ray analyser carried out by Dr E Photos-Jones (Scottish Analytical Services for Art & Archaeology) to examine the morphology and elemental composition of the glaze, and lead isotope analysis performed by Dr R Ellam (Scottish Universities Environmental Research Centre) to provide information on the possible sources of the lead. The results of both investigations will be published together at a later date.

Firing

The direct evidence for manufacture and firing of SWGW comes from the research carried out at the only relevant excavated kiln site, that at Colstoun in East Lothian (Brooks 1980), now supplemented by the work reported here (see section on Colstoun) and by Hall (forthcoming c). Two of the three kilns excavated at Colstoun were examples of Musty's type 2 (double flued), the third a Musty type 3 multi-flue; however, it is not clear if this difference represents a chronological development of the Colstoun industry or a specific intent to fire different vessel types in different types of kiln (Musty 1974; Hall forthcoming c). Colstoun has also produced evidence for the methods of stacking and separating the vessels in the kiln during firing (Hall forthcoming c). Objectively determined firing temperature of SWGW ranges are very few, but Thomas' results for St Andrews (using pottery shrinkage estimates; see Will *et al* www.guard.arts.gla.ac.uk/project 481: section 5.1.5) suggest they are *c*.850–1050 °C, and observations from the present study on the nature of the microstructure point to temperatures not exceeding 900 °C. The evidence presented here for variable firing conditions will need to be considered in the light of results obtained from experimental firings carried out in England (Bryant 1977; Newell 1998–99). With so few production sites excavated the assumption that wood was the main fuel used for firing the kilns needs to be tempered by the fact that coal is also a readily available fuel resource. This is particularly true in those parts of Scotland where it outcrops close to the surface such as Lothian and Fife. Chemical analysis of potsherds from the Colstoun kilns failed to confirm that coal was used to fire them (Chenery forthcoming).

PETROGRAPHIC AND CHEMICAL CHARACTERISATION

Introduction and background

PREVIOUS LABORATORY-BASED WORK ON SWGW

From the 1970s onwards the study of SWGW has incorporated laboratory-based work directed towards origin determination and technological enquiry, and this has been summarised by Will *et al.* (2000). The petrographic component was dominant in this early phase, yet some of its output appeared disappointing with the result that its potential was not fully realised. As a first stage of the present project, it was decided to re-examine that resource for some ten sites; its results (obtained by Ann Marchand) which are summarised below encouraged further petrographic work in the present study. The most recent contribution has been the pilot chemical study using ICP-MS on SWGW from eight sites (Chenery 1998), whose results showed that these sites could to varying degrees be discriminated from each other.

AIMS AND OBJECTIVES

The present project comprises several components, the main one being laboratory-based work dealing with fabric characterisation and with technological issues. The prime hypothesis to be tested was whether SWGW was produced at many different centres in Scotland. A smaller, field-based component involved clay prospection and geophysical prospection at a single site, Colstoun.

Owing to the availability of reliable multi-element analysis in the form of ICP spectroscopy together with the good results obtained using ICP-MS on SWGW, as mentioned above, and also on Scottish Red wares by Chenery, Phillips and Haggarty (2004), it was decided at the outset of the project that the principal characterisation should be chemical and that this would be supplemented by petrographic analysis. In the event, however, the first phase of the project saw the adoption of the more desirable approach of analysing both chemically and petrographically a set of typologically-controlled material from sites in Fife and Tayside. Thereafter the strategy reverted more towards selecting for petrographic analysis small groups of SWGW from a wide geographical range of findspots, with less emphasis on encompassing all/most vessel types at each site, but more emphasis on covering those sites that had not received previous attention. All samples were analysed chemically by ICP-ES which measures the major and minor elements and a large suite of trace elements; furthermore, a comparable study of English gritty wares has employed this same technique, and in the same laboratory (A Vince pers. comm.). As shown below, the elements common to both ICP-ES and ICP-MS have been determined with satisfactory agreement.

SAMPLING STRATEGY

The main criteria were a wide geographical distribution of SWGW findspots, and the availability of a minimum of ten sherds of SWGW, typologically recognisable where possible, from each findspot. The sherds varied considerably in size; the majority of them were sufficiently large for chemical, petrographic and technological analysis.

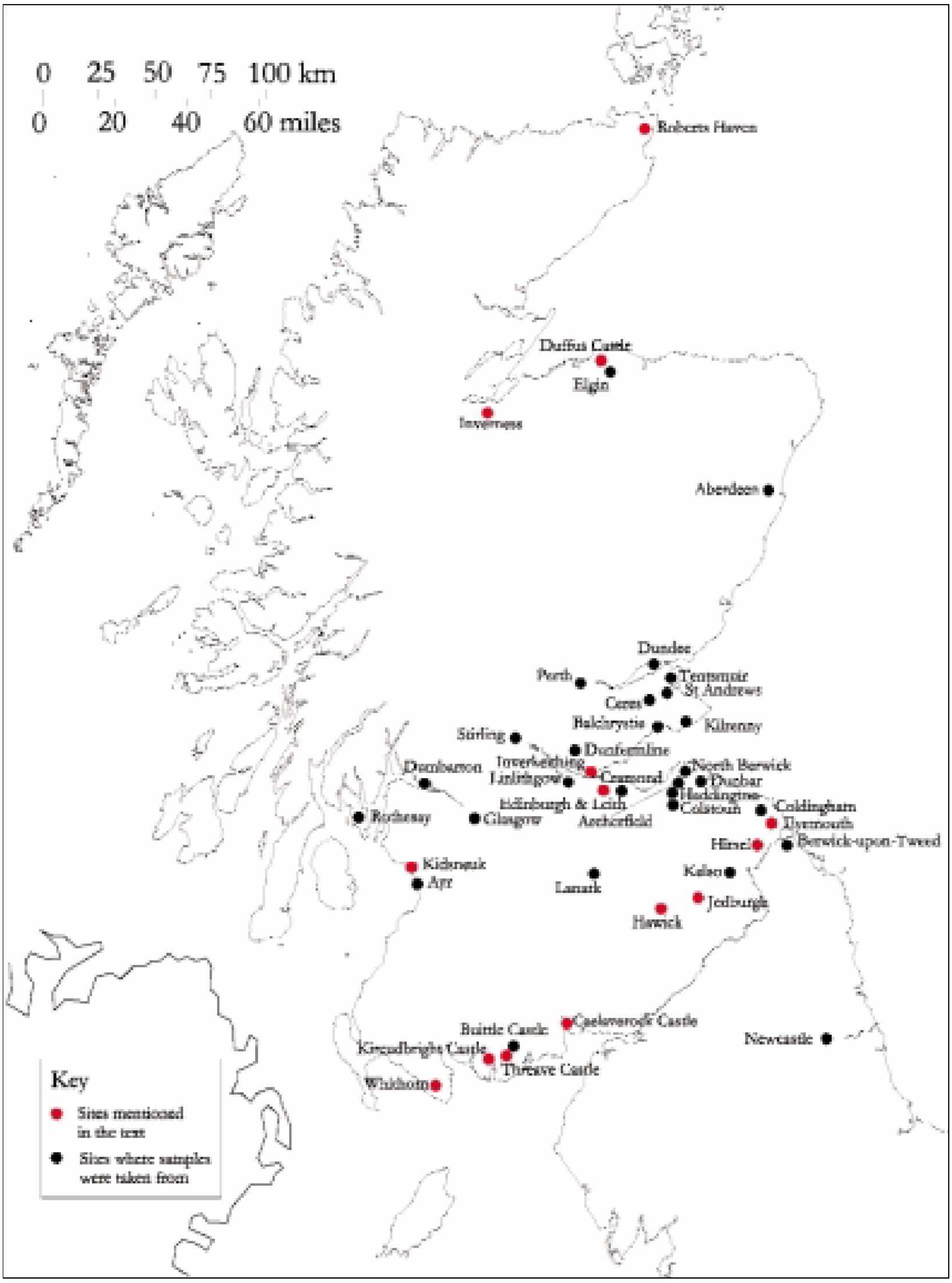


Fig. 2 Map of Scotland showing the sites mentioned in the text and those where samples have been taken from

SITES (Fig. 1) AND SAMPLES

Aberdeen: Urban
Excavations: Broad Street and 42 St Paul Street (Murray 1982) and published fabric types: Cooking pots and jugs.

Archerfield: Rural
Excavation: (Leslie 1991): Jar/cooking pots, bowl.

Ayr: Urban/Port
Excavations: Ayr, New Bridge Street and St Johns Tower (Hall and Franklin forthcoming): Cooking pots, jugs, thumbed base, bowl.

Balchrystie: Rural
Fieldwalking: Jugs and cooking pots (Moira Greig, pers. comm.).

Berwick Upon Tweed: Urban/Port
Excavation: Cooking pots, bowl.

Buittle Bailey: Castle/Estate Centre
Excavation: (Hall forthcoming d): Jugs.

Coldingham: Monastic/Rural
Excavation: (Laing 1974): Jar/cooking pot, jugs.

Colstoun: Rural Kiln Site
Excavation: (Brooks 1980) and (Hall forthcoming c): Cooking pots straight-sided and rounded, jugs with cordon, bridge spouts, tubular spouts, various decoration, twisted handle, face mask, frilled rims, bifid rim, skillet handle, ladle, pipkins.

Dumbarton: Urban/Port
Excavation: (Coleman 2004): Jugs.

Dunfermline: Urban/Religious
Excavation: (Hall 1996): Handled cooking pots, curfew, frilled rim, bifid rim, lid, dripping pan, jugs, cooking pots.

Dunbar: Urban/Port
Excavation: (Hall 2000a): Cooking pots, jugs.

Dundee: Urban/Port
Excavation: Murraygate (Hall 2000b): Cooking pots, jars.

Edinburgh/Leith: Urban/Port
Excavations: Scottish Parliament (Hall forthcoming a), Canongate (Gooder 2001), Leith Ronaldsons Wharf (Reed and Lawson 1999) and Leith Burgess Street (Collard and Reed 1994): Storage jars, cooking pots, straight-sided, rounded, handled cooking pots, jugs, twisted handles, cordons, bowls.

Elgin: Urban
Excavations: (Hall 1998): Cooking pots including straight-sided, frilled rims, jugs.

Glasgow: Urban
Excavations: Cathedral, College Goods Yard (Kerr 1984), Saracens Head: Cooking pots, jugs, thumbed base, balaster jug.

Haddington: Urban (Addyman 1998)
Excavation: Straight-sided cooking pot.

Kelso Abbey: Rural/Monastic
Excavation: (Cox and Haggarty 1984): Straight-sided cooking pots, jugs.

Kelso, Springwood Park: Rural
Excavation: (Brown 1998): Cooking pots straight-sided and rounded some with cordon, ladles, jugs with cordons, tubular spout, bifid rim and cordon.

Kilrenny: Rural
Fieldwalking: (James 2000): Cooking pots, jugs.

Lanark: Urban
Excavation: Greyfriars (Archer and Archibald 1999): Cooking pots, jugs.

Linlithgow: Urban
Excavation: High Street (Brooks 1974) and Carmelite Friary (Lindsay 1987): Cooking pots, jugs.

North Berwick: Urban/Port
Excavation: (Cromwell 1993): Cooking pots, jugs, cordon and straight sided.

Perth: Urban
Excavations: 75 High Street (Hall forthcoming b) and King Edward Street (Hall 1995): Jugs tubular spout, barrel shaped cp, frilled rims, cooking pot with applied vertical strip decoration, large pipkin represented by a tubular handle and a leg, also a skillet handle.

Rothesay: Urban/Port
Excavation: Speller (1999): Jugs.

St Andrews: Urban/Port
Excavations: Castle (Haggarty and Will 1996), Market Place and Auction Hall (Hall 1987) and Cinema House (Hall 1987): Jugs, cooking pots, ladles, curfews, skillets, frilled rims, bifid rims, storage jar, dripping dish, bowl, twisted handle.

Stirling: Urban
Excavations: Baker Street (Will 1998) and Tolbooth (Will 2000): Cooking pots, jugs, bifid rim.

Tenstsmuir: Rural
Antiquarian excavation: (Hall 2002): Cooking pots, frilled rims.

Table 1 Summary of the petrographic analysis of White Gritty ware (AM, Ann Marchand; AM-PS, AM in Pilot Study; JW, Joan Walsh)

Site	Fabric group (number of samples)	C:f:v	Matrix: its colour (in PPL), and its nature	Voids	Mineral inclusions
Aberdeen (JW)	1 (9)	3:96:1 to 20:65:15	Orange brown- dark brown. Coarse to fine grained	Few to common	Abundant quartz. Clasts predominantly quartz and occasional feldspar. Mica frequent in matrix. Absence of burnt clasts. Rare rock frags. 14-3 is different
Ayr (AM-PS)	1 (27)	19:76:5 to 23:69:9	Green brown. V common to abundant silt-sized minerals	Few to rare	Quartz/opaque minerals/oxidized biotite/Fe-oxide/ biotite/feldspar/sandstone Clasts/matrix muscovite
Balchristie (AM-PS)	1 (14)	19:83:7 to 20:70:10	Green-brown. V common silt-sized minerals	Few to abundant	Typically quartz/opaque minerals/oxidized biotite/Fe-oxide conc./feldspar/sandstone clasts
Berwick-u-Tweed (AM-PS)	1 (18)	10:83:7 to 20:67:13	Green- brown. Abundant silt-sized minerals	Few to common	Typically quartz/opaque minerals/feldspar/muscovite/ oxidized biotite/Fe-oxide
Ceres (JW)	1 (6)	15:82:3 to 25:72:3	Yellow brown. Varied texture	Few	Common quartz, rare opaques and rock fragments
Colstoun (AM-PS)	1 (8)	20:65:15	Brown/opaque. No silt-sized minerals	Abundant	Quartz/opaque minerals/chert and sandstone clasts/muscovite/feldspar
Colstoun (AM-PS)	2 (8)	9:90:1 to 20:74:6	Brown. V. common to abundant silt-sized minerals	Rare to abundant	Quartz/metamorphic quartz/opaque minerals/chert and sandstone clasts/altered grains/oxidized biotite/feldspar
Colstoun clays (JW)	(3)	20:75:5 to 45:45:10	Orange-green to brown. Fine to coarse matrix	Few	Abundant quartz, common opaques, rare rock frags
Dundee (AM)	1 (2)		Green. Some silt-sized minerals		V common silt-sized quartz; large inclusions of sedimentary rock frags. Similar to Dunfermline 1
Dunfermline (AM)	1 (5)		Green. Some silt-sized minerals		Quartz/opaque minerals/Fe-oxide stains/feldspar/ oxidized biotite/ muscovite
Dunfermline (AM)	2 (3)		Brown. Coarse matrix		V common silt-sized quartz; large inclusions of quartz clasts
Edinburgh WM (AM-PS)	1 (4)	6:68:26 to 10:68:22	Green. V common silt-sized minerals	Abundant	Quartz/opaque minerals/sandstone clasts/feldspar/ Muscovite
Edinburgh (JW)	1 (4)	7:90:3 to 25:65:10	Brown. Varied matrix	Few	Abundant quartz, common-abundant opaques; siltstone/mudstone frags; oxidised material present as brown streaks; some mica in matrix
Elgin (JW)	1 (1)	25:65:10	Grey	Channels aligned	Common quartz and feldspar, the latter up to 2mm; common rock fragments (containing large polycrystalline quartz) and common feldspar clasts
Eyemouth (AM-PS)	1 (27)	17:75:8 to 22:74:4	Green brown. Abundant silt-sized minerals	Few to rare	Typically quartz/opaque minerals/muscovite/ biotite/oxidized biotite/sandstone clasts and chert/ Fe-oxide stains
Glasgow (JW)	1 (6)	15:70:15 to 30:60:10	Brown. Varied matrix	Common; aligned channels	Common quartz which is often micro-crystalline; rare feldspar
Inveresk (AM-PS)	1 (4)	13:76:11	Green-brown. Abundant silt-sized minerals	Common	Quartz/opaque mineral/sandstone clasts/Fe-oxide stains/feldspar/oxidized biotite/matrix muscovite
Kelso (AM-PS)	1 (63)	9:79:12 to 30:64:6	Typically green/opaque. V common to abundant silt-sized minerals	Few to abundant	Quartz/opaque minerals/ biotite/muscovite/altered grains/Fe-oxide stains/oxidized biotite/sandstone clasts/feldspar
Kilrenny (JW)	1 (4)	3:95:2 to 25:60:15	Varied matrix	Few to common; present as channels	Common quartz clasts (probably igneous) and rock frags. Common opaques.
Lanark (JW)	1 (5)	7:88:5 to 25:50:25	Typically dark brown. Varied matrix	Few to common; present as channels	Common quartz clasts (probably igneous) and rock frags. Common opaques. Quartz has undulose extinction. Mica in the matrix.

Table 1 (continued)

Site	Fabric group (number of samples)	C:f:v	Matrix: its colour (in PPL), and its nature	Voids	Mineral inclusions
Linlithgow (JW)	1 (6)	8:86:6 to 35:45:20	Brown. Varied matrix	Varied in form and quantity	Fine to coarse matrix; common burnt clasts; abundant opaques; common rock frags. Feldspar observed in some
Perth (AM)	1 (2)		Green. Medium frequency of silt-sized minerals		V common silt-sized quartz; large inclusions of sedimentary rock frags. Similar to Dunfermline 1
Perth (AM)	2 (3)		Brown. Medium coarse		Varying silt-sized quartz, large quartz clasts & sedimentary rock frags
Perth (JW)	1 (6)	15:78:7 to 30:60:10	Brown. Medium coarse	<10%, usually channels	Abundant quartz and opaques, common burnt clasts. Rock frags range from rare to common (feldspar in P9 and quartz arkose in P10); . one example of basalt
St Andrews (AM-PS)	1 (2)	19:64:17	Green. Abundant silt-sized minerals	Abundant	Quartz/opaque minerals/Fe-oxide stains/feldspar/ oxidized biotite/ muscovite
St Andrews (AM)	2 (3)		Green. Coarse		V common silt-sized quartz; large inclusions of sedimentary rock frags Similar to Dunfermline 1
St Andrews (AM)	3 (2)		Green-brown. Medium textured matrix		V common silt-sized quartz; large inclusions of quartz clasts. Similar to Dunfermline 2
St Andrews (AM)	4 (2)		Green. Fine matrix		Silt-sized quartz & sedimentary rock frags are rare. Common large quartz clasts
St Andrews (AM)	5 (7)		Variable		Magmatic (probably igneous) rock fragments
Soutra (AM-PS)	1 (12)	22:74:4 to 27:65:5	Green brown. Abundant silt-sized minerals	Few to rare	Typically quartz/opaque minerals/altered grains/chert and sandstone clasts/feldspar/ Matrix muscovite
Stirling (Bakers St & Tolbooth)	1 (11)	5:92:3 to 30:60:10	Yellow to dark brown. Varied matrix		Common quartz and rock fragments. Latter are partially burnt blurring distinction between them & burnt clasts. Frequent mica in matrix

Petrographic analysis

For each selected sherd, a 3 cm fragment was cut, usually at right angles to the rim or base or vertically through a body sherd. Standard thin sections were then prepared and examined with a polarising microscope; their descriptions follow the scheme outlined by Whitbread (1995: Appendix 3).

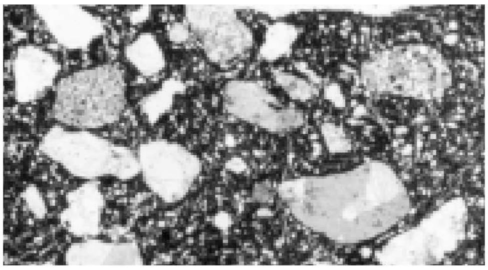
The summary table (Table 1) presents the results from the present study combined with those obtained from re-examination of previous work (presented in the pilot study, Will *et al.* 2000). The full petrographic descriptions are available on request from the authors.

There is a measure of similarity in the nature and identity of the inclusions present in the matrix, yet this can be balanced against variability in the texture and fabric colour. The latter should be ascribed largely to firing conditions (see the technology section below), while variability in the former is a reflection of the amount of quartz present in the fabric. As discussed below, potters were able to select their clays with the appropriate quartz content naturally present, although that is not to negate the possibility of deliberate tempering.

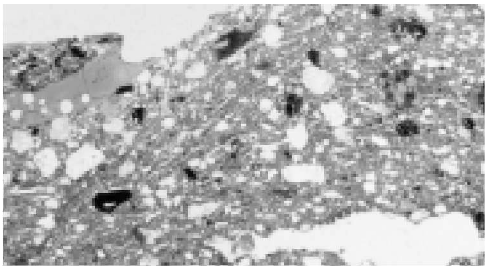
Plate 1 illustrates a range of SWGW fabrics from several of the sites represented in this study. Photomicrographs of other examples of SWGW including those from Colstoun appear in the Appendix in www.guard.arts.gla.ac.uk/project 481.

Examination of Table 1 points to the limited presence of diagnostic or unusual inclusions among the thin sections examined. Most encouraging is the occurrence of igneous rock fragments in some of the material from St Andrews (fabric 4), as well as in most or all of the samples from Lanark (Plate 1) and Kilrenny, and in singletons from Perth and Colstoun (Pilot Study samples). Inspection of geological maps reveals first that small areas of basaltic type rocks are found to the SW of St Andrews and east of Cupar, the closest being less than 10 km from St Andrews. No such rocks occur to the north of St Andrews towards Tentsmuir. Second, there is the broad band of andesitic lavas running NE–SW that lies immediately north of Cupar. At Kilrenny the closest areas of basalt lie 8 km NW and further to the west forming a band north of Largo Bay. Small areas of intrusive igneous rocks occur near Lanark: 5 km west is a small area of felsite, trachyte and porphyrite, and perhaps more important is the area near Carstairs, a few kilometres east of Lanark. No such intrusive rocks seem to be associated with either Perth (and its vicinity) or Colstoun; instead there are the lavas and volcanic ash associated with the Lower Old Red Sandstone in the Sidlaw Hills to the east of Perth, and extrusive rocks from North Berwick extending just to the south of Haddington. For the rest, attention is drawn to the apparent frequency of chert and sandstone clasts at Soutra, and of muscovite and sandstone at Berwick-on-Tweed.

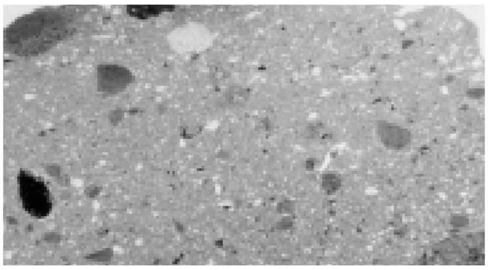
Table 2 sets out the main or diagnostic petrographic features at each site, alongside the corresponding summary chemical characteristics.



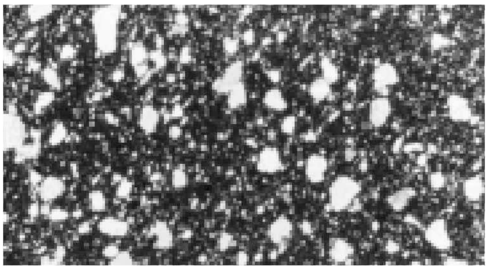
a Elgin 4



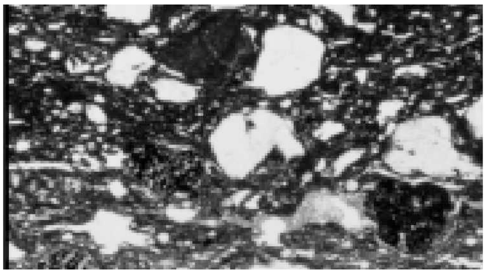
b St Andrews BYR 98 110



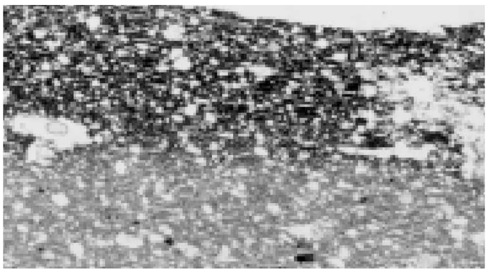
c Edinburgh Parliament 2



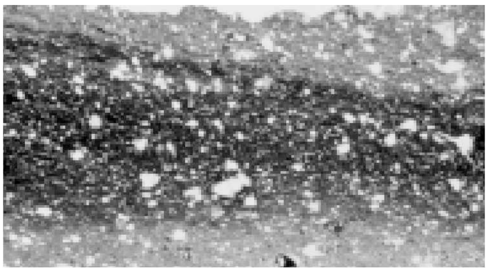
d Kelso 20/78



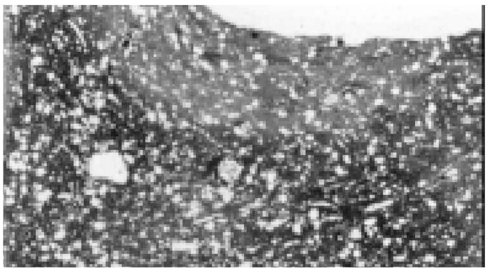
e Lanark Greyfriars 8



f Stirling Tolbooth 5



g Glasgow Cathedral 13



h Ayr 86/25

Plate 1 Photomicrographs of thin sections of White Gritty ware (all taken with parallel polars): a. Elgin 4 x10; b. St Andrews BYR 98 110 x6; c. Edinburgh Parliament 2 x5; d. Kelso 20/78 x10; e. Lanark Greyfriars 8 x21 – note the igneous fragments arrowed; f. Stirling Tolbooth 5 x5; g. Glasgow Cathedral 13 x5; h. Ayr 86/25 x5

Table 2 Main or diagnostic petrographic features at each site, with the corresponding summary chemical characteristics

Site	Region	Petrographic characteristics	Chemical characteristics
Kelso Abbey	Tweed	See Table 1	
Colstoun	East Lothian	*Pottery*: two equal-sized fabrics, one with, and the other without metamorphic quartz and oxidised biotite (Table 1). *Clays*: Fabric heterogeneous, large proportions of which are oxidised; voids not easily seen; clasts are generally rounded to sub-rounded quartz; rounded rock fragments with diffuse boundaries; rare feldspar (identified by its albite)	Low Al; low Ba; Cr <100ppm; low Sc; low V; low Zr
Haddington	East Lothian	No thin sections examined	Low Co
Edinburgh (Parliament)	Lothian	Voids are very insignificant: <5%, usually vughs; oxidised material present as brown streaks is morecommon; some optical activity observed; feldspar is less common; some mica observed in the matrix	Low Zr
Leith, Burgess Street	Lothian	No thin sections examined	High Y; low Zr; low Sr
Stirling, Bakers Street		Non-pleochroic fabric and optically active; frequent mica observed in the matrix; the clasts predominantly quartz and rock fragments. The latter are usually partially burnt, blurring the distinction between them and burnt clasts. Rare feldspar	Low Co; high Sr
Linlithgow	W Lothian	Voids are significant: 20% forming channels parallel to the surface and anatomising around the clasts. Coarse-grained matrix with quartz, white mica and feldspar. Quartz is generally mono-, occasionally polycrystalline with undulose extinction. Feldspar twinning observed in all except L13	Low Y
St Andrews	Fife	Four fabrics: 1 silt-sized quartz; large sedimentary rock fragments (cf Dunfermline 1); 2 silt-sized quartz, quartz clasts (cf Dunfermline 2); 3 silt-sized quartz, large quartz clasts; 4 magmatic rock fragments	High K
Ceres	Fife	Common, often round mono-crystalline quartz; rock fragments generally rare, feldspar common	
Tentsmuir	Fife	No thin sections examined	High K; low Cu
Dunfermline	Fife	Two fabrics, both encountered at St Andrews (*qv*); see Table 1	
Kilrenny	Fife	Voids present as channels. Common quartz clasts; common rock fragments. Microcrystalline quartz present in most samples. Rare feldspar (identified by its albite or microcline twinning). Perthitic texture in most samples. Source of clasts probably igneous	
Perth	Tay	Two fabrics (Table 1), one similar to Dunfermline 1 (*qv*). Voids <10%, usually irregular channels. Clasts vary 15-35%. Feldspar twinning observed in all. Quartz generally mono- occasionally polycrystalline, undulose extinction. Burnt clasts/rock fragments, mudstone part-burnt, leaving quartz grains; one example of basalt.	
Aberdeen	NE Scotland	Non-pleochroic fabric, and, if optically active, only slightly so. Frequent mica in the matrix. Clasts are predominantly quartz and occasionally feldspar. Absence of burnt clasts.	
Elgin	NE Scotland	Rock fragments containing large polychrystalline quartz; large feldspar clasts	High Fe, K, Ba, Sr, Rb; low Al, Li, Zn, Zr, REE
Lanark	Clyde Valley	Voids present as channels. Mica present in the matrix. Non-pleochroic matrix, and about half samples are optically active. Common quartz clasts, and rock fragments. Microcrystalline quartz in all samples. Rare feldspar (identified by its albite twinning). Source of clasts is probably igneous.	High K; high but wide ranging Mn; high Sr
Glasgow Cathedral	Clyde	Voids present as aligned channels. Clasts generally rounded to sub-rounded quartz. Rock fragments rounded with diffuse boundaries. Microcrystalline quartz in two samples. Rare feldspar (identified by its albite)	Low Al; high but wide ranging Mn; <100ppm Cr; low Cu; low Rb; low Zr
Dumbarton	Clyde	No thin sections examined	High Ti; low Ni; low Rb, low Y; high Zr, very low Sr
Rothesay, Bute	West Scotland	No thin sections examined	Low Al; high P; high but wide ranging Mn; low Cu; low Ni; low Rb; low La, low Y; low V
Ayr	West Scotland	No thin sections examined	High but wide ranging Mn; low Ni; high Zr

Chemical analysis

SAMPLE PREPARATION AND ANALYSIS

Samples were prepared using a diamond-tipped saw to give a fragment free of glaze and weathered surface, commonly a few grams in weight. The cleaned fragment was thoroughly dried before grinding to fine powder in an agate mortar. The powder was then transferred to a small crucible and placed in batches of ten in a furnace to be heated to 550 C for 3 hours. The heated sample was stored in a plastic vial. Batches of samples which included at least two standards (Edinburgh Standard clay and British Museum Pottery standard) were sent to the Geosciences Department, Royal Holloway College, London University for analysis by ICP-ES. The powdered samples were acid-dissolved before analysis. The concentrations of 29 elements were determined: four major elements (Al (expand for each element), Fe, Ca and Mg), five minor elements (Na, K, Ti, P and Ba), thirteen trace elements (Mn, Co, Cr, Cu, Li, Ni, Sc, Sr, V, Y, Zn, Zr and Rb) and seven rare earth elements (La, Ce, Nd, Sm, Eu, Dy and Yb). The samples were analysed in eleven batches between autumn 1999 and autumn 2002. Long-term reproducibility of data was paramount: it was monitored by including at least two ceramic standards – Edinburgh Standard clay and the British Museum Standard Pottery in each batch, coupled with Royal Holloway's own internal standards. A dozen samples selected at random from the first ten batches were re-analysed in the last batch (11), and as a further check two whole batches were re-analysed to check on the reproducibility of elements, notably chromium, that are problematic from an analytical point of view, yet very important as geochemical discriminators.

ICP-ES AND ICP-MS COMPARISON

This exercise in 1999 involved three laboratories – Geosciences, Royal Holloway College (ICP-ES), BGS Keyworth (ICP-MS) and SUERC (ICP-MS) – which each analysed six samples of SWGW from Ayr and Edinburgh (and two of Shelly ware from Perth). The results from the first two of these laboratories were generally good: agreement to within 10% for Li, Sc, Ti, Co, Ni, Cu, Zn, Sr, Y, Ba, La, Ce, Sm and Eu and to within 25% for Cr, Zr and Dy; for Nb it was greater than 25%. The ICP-ES determinations were lower than the corresponding ICP-MS ones for all elements except Li, Cr, Ni, Nb, Ba, Nd and Sm which were higher.

DATA TREATMENT

The procedure for treating the chemical data began with visual inspection of the individual compositions. Distributions of individual elements especially the major and minor elements, Cr, Rb, Sr and Zr were plotted, and these were followed by bi-variate plots (commonly Al vs K/Rb ratio) with a view to identifying atypical samples at a given findspot and hence judging the uniformity or otherwise of the compositions at each findspot.

Extensive use was made of multivariate methods of data analysis on the full complement of elements except for Pb whose content was found to vary widely depending on whether the vessel had been glazed and for the highly-correlated rare earth elements Ce to Dy. Elements that may be sensitive to post-depositional effects such as Na, K, Ba and P were included in the data treatment but were treated with caution. The form of the data for multivariate analysis was either natural or standardised, not log transformed. Principal Components Analysis (abbreviated PCA, and run on SPSS v. 11.5 and Minitab v. 11) of the compositions helped to look for structure in a given data set, more specifically to look for potential groupings among samples and for outliers, as well as to identify which combination of elements was responsible for that structure. The results of this operation are presented below in the form of conventional plots of the first two principal components (PC1 and PC2); useful though they are, most of them suffer from the disadvantage of only accounting for about half the total variance in composition.

Having defined which samples from a given findspot formed a coherent group and having removed the anomalous samples, Discriminant Analysis (abbreviated DA, and run on SPSS v. 11.5) was well suited and indeed was extensively used to assess how well or otherwise that group could be discriminated from other similarly defined site groups. Thus, the DA plots presented below optimise the usually small distinctions in composition existing *between groups*. DA was run on the same suite of elements as for PCA. The stepwise method of DA was employed. The first two discriminant functions (DF1 and DF2) were normally plotted, but as in some of the PCAs it proved useful to adopt the first and third discriminant functions (DF1 and DF3) in some instances. In all cases, those elements loading the discriminant functions are included in the plots.

In summary, PCA gives a fair representation of the relationship between individual *samples* without any preconceptions/bias as to which site or group they belong, while DA is more structured and discriminates between pre-established *groups*. The scatter of samples within each group in a DA plot gives a direct indication of how uniform or otherwise it is; a uniform set of compositions will appear in the DA plot as a 'tight' group. Since DA assumes great importance in visualising many of the chemical results, it is emphasised here that only where groups are graphically well separated in the two-dimensional DA plots (ie there is no overlap between the groups) can they be regarded as having a meaningful difference in composition. More common is the situation where the scatter of samples within one group is such that the separation from that of a neighbouring group is more tenuous, in which case the difference in composition between the two groups is correspondingly less significant. Lastly, an important issue which is treated in the

Discussion is to check the validity of what constitutes a 'good discrimination' between two groups in DA by comparing the summary statistics of the two groups. Only in this way can the process of identifying credibly distinguishable chemical groups become rigorous.

The individual chemical compositions are available on request from the authors.

Results

GENERAL PICTURE

The overwhelming impression gained from visual inspection of the total chemical data set is one of uniformity. The chemical compositions are with few exceptions all of low calcium and low iron type; what variations there are occur in several elements but they are relatively small. This should cause little surprise, reflecting the common materials – essentially a white firing, gritty clay – and common technology used in the production of SWGW. The distributions of most individual element concentrations in the *total data set* are unimodal and as such bear out this picture of uniformity; calcium, magnesium, europium, cobalt and lanthanum belong to this class. However, the presence of bi-modal distributions (for example, iron and chromium) as well as more complex ones (aluminium, and, significantly, alkali and alkali earth elements (potassium, rubidium and strontium) and zirconium) emphasises that, below the broad single group encompassing all the samples, subtle sub-groups can be detected.

SITE AND REGIONAL LEVEL

The results for each site are presented by region, according to river system (Fig. 3). The uniformity of the compositions of each site was first examined with a view to identifying the presence of any anomalous compositions; the typology (and therefore indirectly also the date) of those sherds with such compositions was then carefully checked. The usual procedure was to remove those anomalous compositions from further consideration. The next step was to treat the remaining compositions for a given site as a group and to compare that group with groups from other sites, whether in the same region or further afield.

Fig. 3 Map of Scotland showing the Regions and main rivers

Table 3 Samples selected for chemical analysis from sites in the Tweed Valley

Location	Chemical analysis	Anomalous typologically (T) or chemically (C)
Coldingham	COLD 1-7	COLD 4, 6 and 7 (C) COLD 3 & 8 (red wares)
Kelso Abbey	KA 1-14	KA 6 & 14 (C, T)
Kelso Abbey	ICP-MS Kelso 1-6 (Chenery 1998)	
Kelso Springwood	KSP 1-8	KSP 8 (C,T)
Berwick-on-Tweed	BERHXA 1-6	BERHXA 6 (C, T)
Jedburgh clay	JED	
W Morrison clay	WM	

The Kelso Abbey group is quite uniform chemically but for KA 6 and 14 which are possibly from the same vessel and may be examples of early Red ware KA 2, 5, 8 and 10, which have a very fine fabric and probably all from jugs, relate to each other having low Rb. There is little systematic difference between the Abbey and Springwood compositions. KSP8, which may typologically be French, differs from the remainder on the basis of Al, K and Rb. The two modern clays, although superficially resembling the pottery in composition, are significantly more iron-rich and have lower Al contents. The Berwick samples form a good group chemically, except for BERHXA 6 which is later in date.

The first discriminant analysis (DA) plot compares the five chronologically early groups of SWGW around Scotland, comprising straight-sided cooking pots (Fig. 4). Here the Kelso Abbey group is poorly discriminated, overlapping extensively with Leith and to a lesser extent with Aberdeen. Drawing on DF2 and DF3 does not improve the picture. Either some of these groups may have a common origin or the differences between them are very small. There is a much more optimistic situation in the second DA which looks specifically at inter-regional differences (Fig. 5a): Kelso Abbey is clearly discriminated from all sites except the Edinburgh Parliament group, but these two sites may be well separated in the plot of DF2 and DF3 (Fig. 5b). The Coldingham compositions are not uniform, COLD 4 and 6 (the latter a red ware) being different from each other and standing well apart from the remainder. COLD 7 is also atypical owing to a very high Al content.

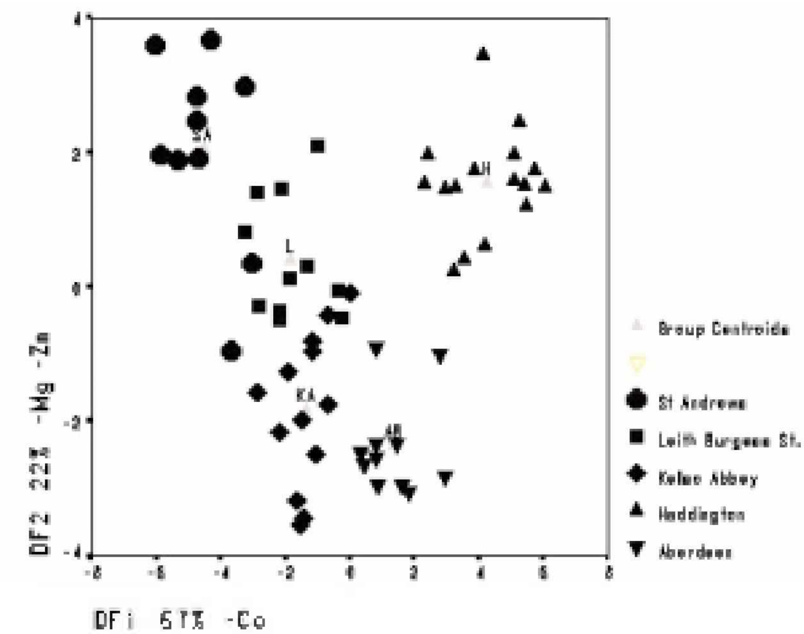


Fig. 4 Discriminant Analysis (DA) plot of the five chronologically early SWGW groups: Kelso Abbey (KA blue), Aberdeen (AB red), Haddington (H green), Leith Burgess Street (L crimson) and St Andrews (Logies Lane) (SA black)

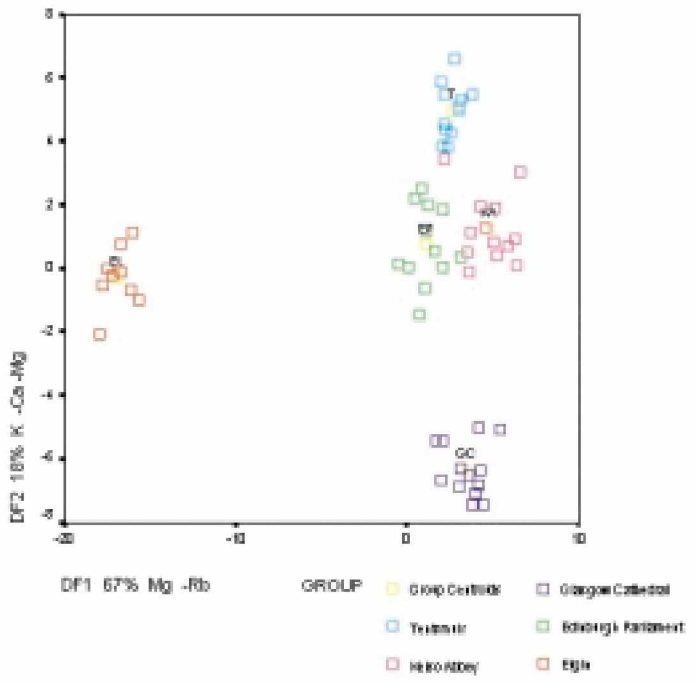


Fig. 5a DA of WG groups from five dispersed geographical locations: Kelso Abbey (KA crimson), Edinburgh (Parliament site) (EP green), Tentsmuir (T black), Elgin (E red) and Glasgow (Cathedral site) (GC blue)

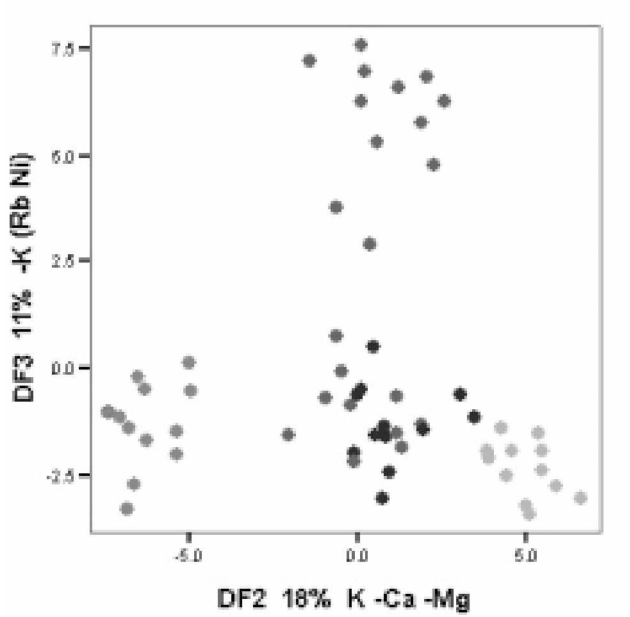


Fig. 5b

This section begins with Colstoun whose importance in this study has been recognised by the combination of systematic prospection and sampling of clay, magnetic prospection in the area of the known kilns and beyond (Millican in press), as well as chemical analysis of SWGW and red wares from the site. Pale-coloured gritty clays were taken from the sides of the burn 200 m west of the kiln site (Fig. 6a). Although their texture varied considerably laterally, more so than vertically (a section no more than 0.5 m deep was cut), they worked well on the wheel and fired well at 850°C (as well as higher temperatures) for six hours to give a light orange colour. The red plastic clays from Duddie Bonnets (1.5 km SE of the kiln site) used at the 19th century brick/tile works (Hall forthcoming c) nearby were also sampled. All the clays were fired into briquettes before analysis.

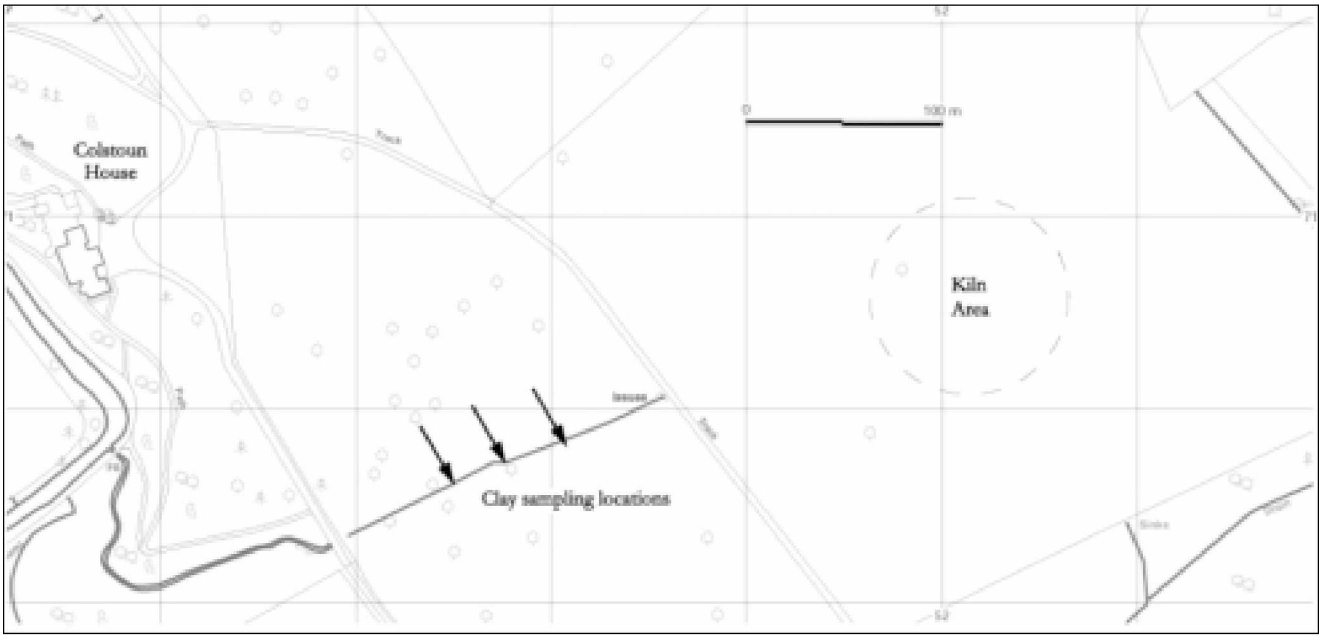


Fig. 6a Map of Colstoun showing the general area of the kilns and to the west the burn from which the clay samples were taken. The dotted line shows the course of the burn across the field with the kilns where the burn is now culverted

Table 4 Samples selected for chemical analysis from sites in East Lothian

Location	Chemical analysis	Anomalous typologically (T) or chemically (C)
Archerfield	AED 1-7	AED 5 (C), AED 1-7 (T)
Colstoun	SWGW	C 1-14
Colstoun Red ware	COLR 1-6	-
Colstoun clays	2a, 1a, 1b, 1c and DD1, DD2	
Colstoun SWGW	ICP-MS: Colstoun 1-10 (Chenery1998)	
Dunbar	D 1-10	
Haddington, Market Street	HMS 1-16	
North Berwick	B 1-12	B7 (C) and B2 (T)

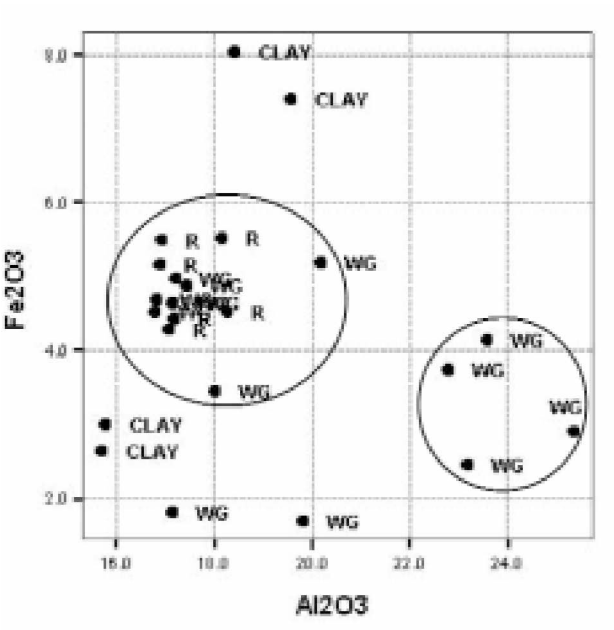


Fig. 6b Plot of iron oxide versus aluminium oxide contents in the SWGW and Red ware (R) and clays from Colstoun Burn and Duddie Bonnets. The red clays from Duddie Bonnets have high iron contents

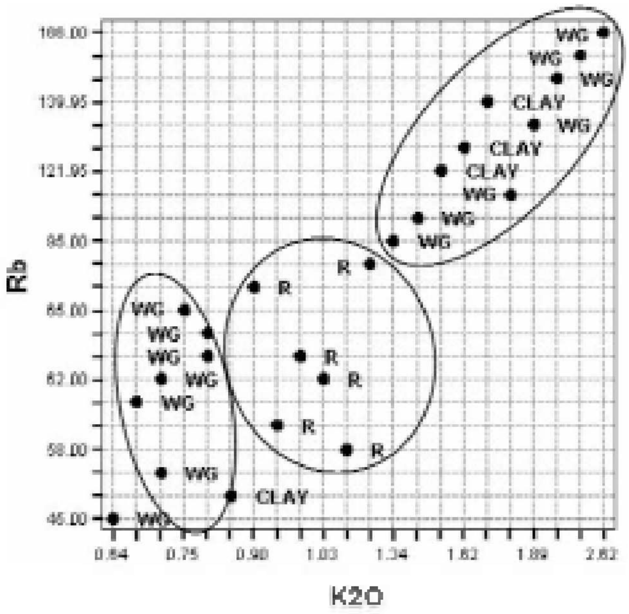


Fig. 6c Plot of rubidium versus potassium oxide contents in the SWGW and Red ware (R) and clays from Colstoun. One of the Colstoun burn clays has a low Rb and K contents in contrast to the other clays

Turning to the pottery from Colstoun, the first point to make is that the SWGW jugs are not chemically uniform, probably reflecting the relative fabric variability: thus, in the three bi-variate plots in Figs. 6b–d involving alumina, iron oxide, potassium oxide, Rb and Sr the SWGW, rather than forming a single group, classifies into at least two group. The high level of correlation between Rb and K contents in Fig. 6c is notable. The second and unexpected observation is that the differences in terms of the major/minor elements between Red ware and SWGW are not large: the former, for example, forming a tight grouping with some of the SWGW in the Al-Fe

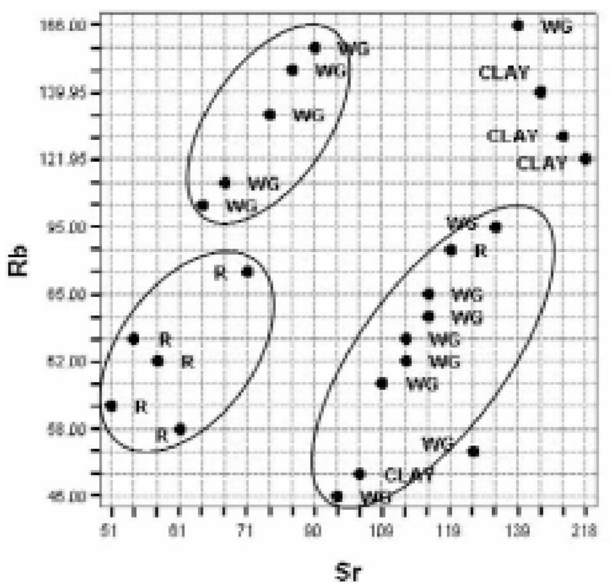


Fig. 6d Plot of the rubidium and strontium contents in the SWGW and Red ware (R) and clays from Colstoun. One of the Colstoun burn clays has a low Rb content in contrast to the other clays

oxides plot (Fig. 6b). However, a differentiation between the two wares is apparent in the Rb-K oxide plot (Fig. 6c) and the Rb-Sr plot (Fig. 6d). As for the modern clays, those from the burn adjacent to the main site have a fair resemblance with SWGW especially with one of the groups in the Rb-K oxide plot, while not unexpectedly the red clays stand apart having a significantly higher iron content than the Red ware (Fig. 6b).

The present data for SWGW at Colstoun can now be usefully compared with the datasets obtained by A Vince and S Chenery (the latter from cooking pots, jugs and face masks), using the *common* elements, that is the trace and rare earth elements. Examination of the PC plot in Fig. 6e reveals a broad central clustering of samples from all three datasets, a tight clustering of the present samples (PS) on the left hand side of the plot (that is with negative values on PC1) and some Vince and Chenery samples on the right hand side (with high positive PC1 scores). In summary, it seems reasonable to see the three groups of SWGW analysed as broadly similar, yet having quite wide concentration ranges. This again reinforces the observation that SWGW has (much) wider concentration ranges than Red ware, which in petrographic terms is manifested by the presence of two fabric groups at Colstoun, differing essentially in texture and in metamorphic character (Tables 1 and 2). The modern clays (Tables 1 and 2) do not shed light on this issue, rather their value is to show (1) the presence of pale, *naturally* gritty clays at Colstoun, a significant finding which is returned to in the Discussion, and (2) an absence of metamorphic quartz and biotite.

At Archerfield the compositions are uniform except for AED 5. In light of the hand-specimen examination which revealed a decidedly atypical SWGW fabric having large dark inclusions, petrographic analysis of the Archerfield sherds is now desirable. The Dunbar compositions are quite uniform despite their mixed typology and late date. Haddington resembles Colstoun in the way its compositions fall into two groupings, one with high, the other with low Al and Rb. At North Berwick B2 stands out chemically (high Al and Ti) and typologically. The remaining samples form a reasonable group.

Taking a more general view of the sites in East Lothian, PCA indicates little or no obvious site-based groupings. In DA there is a broad similarity in composition within the region, only Haddington and to a much lesser extent Archerfield showing some measure of discrimination (Fig. 7). Colstoun overlaps overlaps entirely with North Berwick and Dunbar. Using Colstoun as a 'marker' for East Lothian in an inter-regional view, there is excellent discrimination (employing DF1-3) with Tentsmuir, Elgin and Kelso Abbey (Fig. 8a-b). Haddington can be discriminated, albeit imperfectly, from the four other early SWGW groups – Kelso Abbey, Leith Burgess Street, St Andrews and Aberdeen – in DA (Fig. 4).

At the Canongate site three samples (1, 2 and 11) stand somewhat apart from the remainder owing to low Zr and Rb and high Al and Cr. The chronologically later Parliament site samples form a reasonable group, while noting that 1, 4, 5 and 7 have higher Fe but lower Rb contents. At Leith itself, 3, 5, 8 and 11 from the Burgess Street site have higher Cr than the

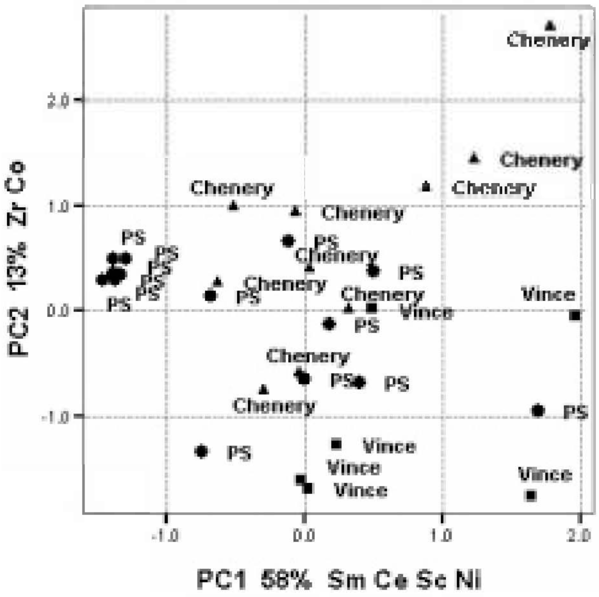


Fig. 6e PC plot of SWGW samples analysed in the present study (PS), by A Vince (with ICP-ES) and by S Chenery (with ICP-MS), using the trace element and rare earth element contents

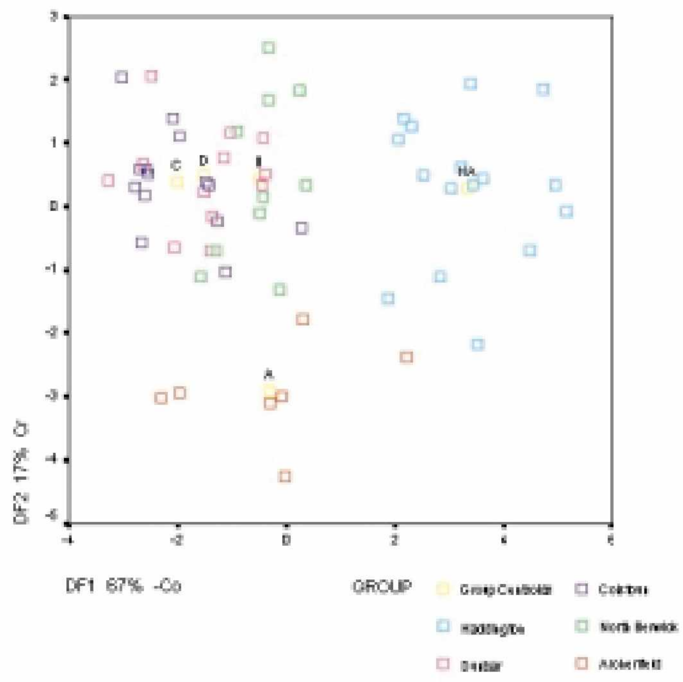


Fig. 7 DA of the SWGW groups from sites in E Lothian: Haddington (H black), Dunbar (D crimson), Colstoun (C blue), North Berwick (B yellow) and Archerfield (A red)

remainder of the group, and at Ronaldson's Wharf LR 9 stands apart chemically and to the eye. A group of samples from the Kirkgate site at Linlithgow differs from the remainder at Linlithgow having lower Fe and higher Cr, Zr and Rb. The compositions at the two sites at Stirling overlap with each other, but there are at least three atypical samples (SB 2, 3 and ST 10). The Stirling Bakers Street group is the best if imperfectly discriminated site among the Forth sites (Fig. 9).

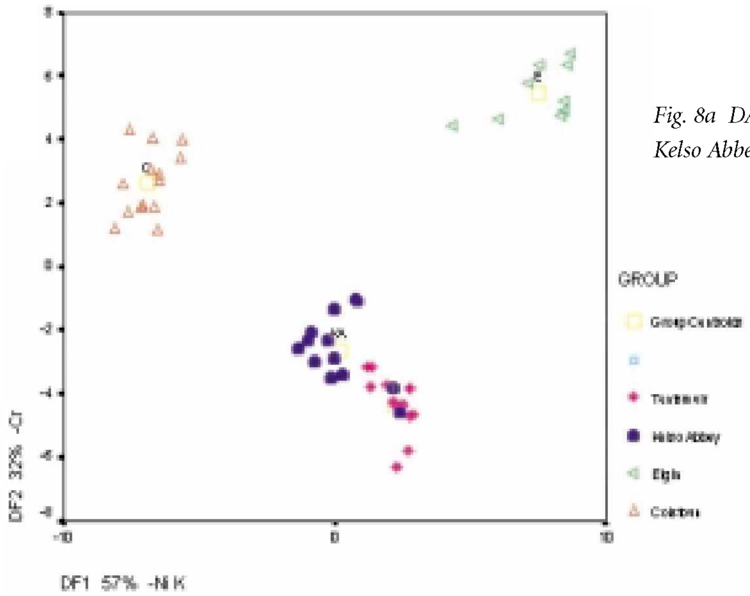


Fig. 8a DA of the SWGW groups from Tentsmuir (T black), Kelso Abbey (KA blue), Elgin (E green) and Colstoun (C red)

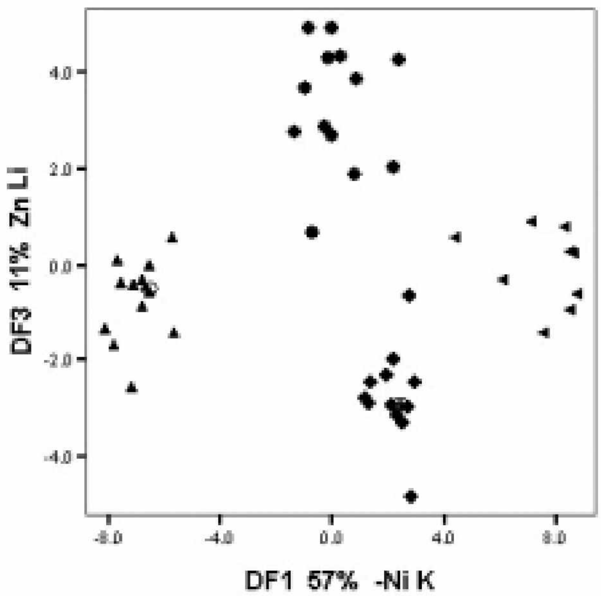


Fig. 8b Same as Fig. 8a but plotting DF1 versus DF3

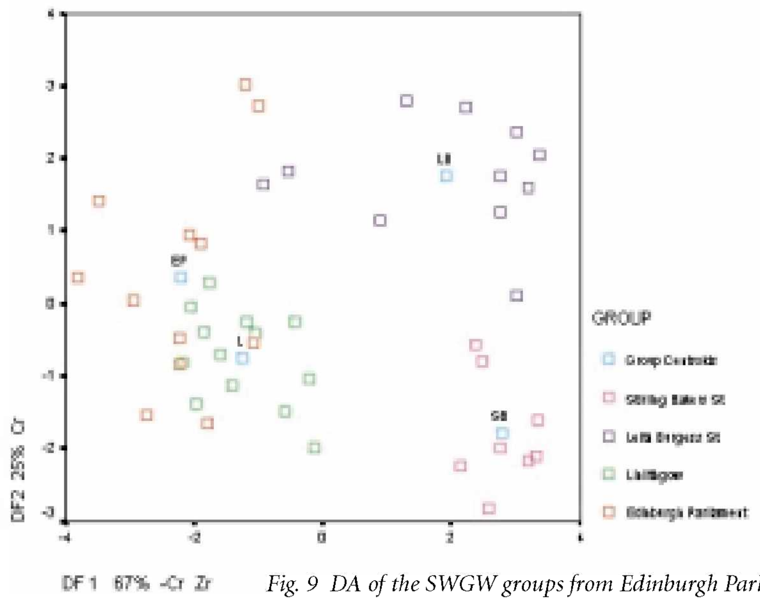


Fig. 9 DA of the SWGW groups from Edinburgh Parliament (EP red), Leith Burgess Street (LB blue)), Linlithgow (L green) and Stirling Bakers Street (SB crimson)

Table 5 Samples selected for chemical analysis from the Forth sites

Location	Chemical analysis	Anomalous typologically (T) or chemically (C)
Edinburgh, Parliament	PAR 1-12	2, 5 (T), 1,4,5,7 (C)
Edinburgh, Canongate	EC 1-12	1, 2, 11 (C)
Edinburgh, Wax Museum	ICP-MS: EWM 1-6 (Chenery 1998)	
Leith, Ronaldson's Wharf	LR 1-10	LR 9 (C & T)
Leith, Burgess Street	LB 1-12	LB 3, 5, 8,11 (C)
Leith	Leith 1-6 ICP-MS Table 4	
Linlithgow, Kirkgate and High Street	LINK 1-9, LIN 10-15	LINK 4 & 6 late or post-Med, LINK 2, 7, 14, 15 (C)
Linlithgow, Carmelite	LC 1-12	LC 6 post-Med
Stirling, Bakers Street	SB 1-10	SB 2, 3 (C)
Stirling, Tolbooth	ST 1-12	ST 10

The material found at St Andrews does not form a homogeneous chemical group. There is notable variation in Al, at least two distributions being visible, and the same applies to Zr and Cr. Restricting attention to the first St Andrews group of 17 samples whose thin sections have been examined, there is a hint in the alumina versus potassium oxide/Rb plot (Fig. 10) that the distinctive fabric group 4 separates by virtue of lower Al content from the other three fabric groups identified at St Andrews, 1-3. That said, there is little or nothing in the hand specimen appearance that differentiates the fabric groups. Both in this first St Andrews group and in the Auction site material, the compositions were scrutinised in relation to typology: for the former group it is apparent that while the two examples of cooking pot Type 7 form a good pair, the same cannot be said of Type 9 cooking pots, and the jugs also admit variation. At the Auction site, SAA 2 and 4, both Type 21 jugs, form a good pair chemically, as do SAA 3 and 5, both thin-walled 'classic' SWGW. SAA 1, a thick Type 19 jug, stands slightly apart chemically. Working on the hypothesis that the heterogeneity of the St Andrews compositions is likely to be a reflection of typological and, more important, chronological diversity, a revised St Andrews group was isolated consisting of ten specimens (from Logies Lane) confidently attributable to an *early* date. Greater uniformity of composition is observable within this revised group, yet the Cr and Sr distributions remain bi-modal and Logie's Lane TS 9 is anomalous. In comparison with the other early groups of SWGW (Fig. 4), this St Andrews group is reasonably discriminated.

The group from Tentsmuir is very well defined chemically, a result which nicely corroborates the visual homogeneity of its fabric. At Perth represented here by a small group of five samples and a separate group of 13th century date from the High Street there are a few samples – PHS 2, 5 and 6 – that stand apart on the basis, as observed frequently at other sites, of lower Al (and Sc and rare earth element) contents. Comparing the three sites in this area, PCA highlighted three anomalous samples (all jugs of typology 16, 19 and 22) at St Andrews which on their removal still showed overlap between St Andrew and Perth. In DA the picture is somewhat clearer (Fig. 11). At the inter-regional level, Tentsmuir is well discriminated

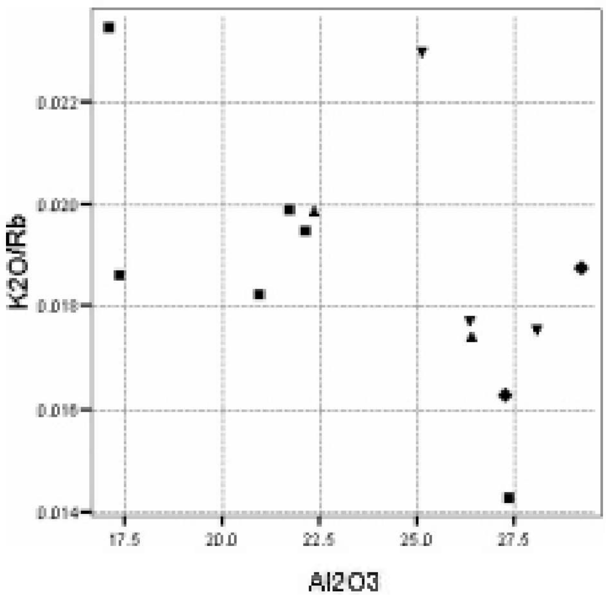
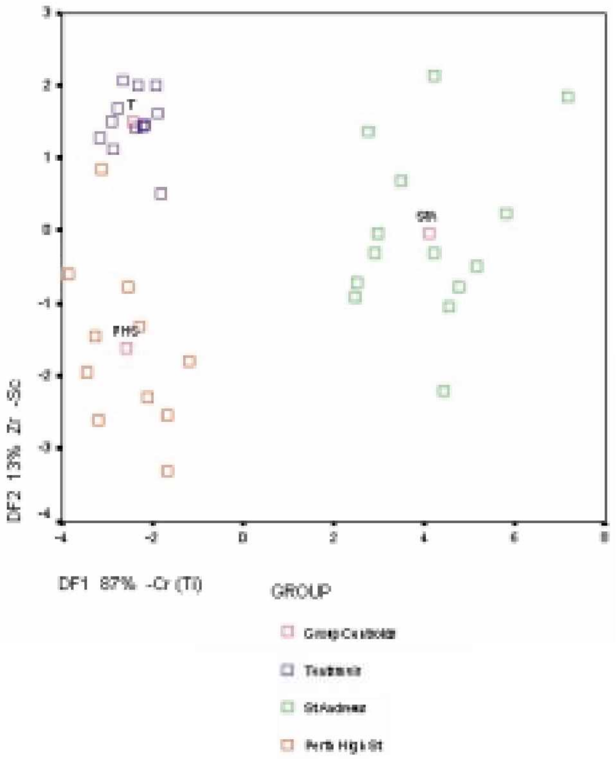


Fig. 10 The aluminium oxide versus potassium oxide/Rubidium ratio for SWGW samples from St Andrews classified petrographically in to Groups 1 (inverted triangle), 2 (triangle), 3 (diamond) and 4 (square)

Table 6 Samples selected for chemical analysis from sites in the Tay Valley and St Andrews

Location	Chemical analysis	Anomalous typologically (T) or chemically (C)
St Andrews	St A 17 samples	St A 23 (jug 10) is not SWGW
St Andrews, Cinema	SAC 1-6	SAC 1 late Med
St Andrews, Auction	SAA 1-6	SAA 1 (C); AY possibly Yorkshire; CD late 15th c
St Andrews, Market	SAM 1-8	
St Andrews, Castle	SACT 1-8	
St Andrews	ICP: StA 1-10:	(Chenery 1998)
Tentsmuir	T 1-12	
Perth	Perth 1-5	
Perth, High Street	PHS 1-11	
Perth, High St & King Edward St	ICP-MS: Perth 1-12: (Chenery1998)	

Fig. 11 DA of the St Andrews (SA yellow), Tentsmuir (T blue) and Perth High Street (PHS red) SWGW groups



from Colstoun, Elgin, Kelso Abbey, Glasgow and Edinburgh (Figs. 5a and 8b). As yet, no chemical data is available for the potential production site at Ceres.

The Dundee group is quite uniform, but four samples (2, 3, 7 and 14) stand apart owing to lower Al (and Sc and rare earth element) contents. The same phenomenon is observed at Dunfermline with respect to Dunfermline 5, 11, 24 and 28. Adding the Dundee and Dunfermline groups to the PCA and DA of the Tayside groups produces a confusing picture, only the Tentsmuir offering any sense of 'individuality'; all the other groups overlap to a greater or lesser extent. Meanwhile, the Balchrystie group is not uniform chemically, but that at nearby Kilrenny is somewhat more so.

Table 7 Samples selected for chemical analysis from sites in North Forth

Location	Chemical analysis	Anomalous typologically (T) or chemically (C)
Dunfermline	DUNF 10 samples	24 (725) and 29 (253) post-Med
Balchrystie	BAL 1-12	BAL3 post-Med
Dundee	Dun 8 and DUN 1-14	
Kilrenny	KR 1-14	K 5, 9

The sherds from Elgin have a distinctive fabric (Table 1 and Plate 1), and this is well reflected chemically (Figs 5a and 8b, Table 2). As for Aberdeen, there are a few anomalous samples (see above Table) but otherwise there are no obvious chemical or petrographic differences between the fabrics (12-15). Their typical SWGW fabric appearance contrasts macroscopically with the red slightly micaceous fabric Aberdeen itself. Aberdeen fabrics 13-14 (9 samples in all) formed a group for comparison by DA with other early SWGW groups (Fig. 4); its similarity with many of these groups is striking.

Table 8 Samples selected for chemical analysis from sites in north-east Scotland

Location	Type	Chemical analysis	Anomalous typologically (T) or chemically (C)
Elgin	SWGW	E 1-9	–
Elgin	SWGW	ICP-MS: Elgin 1-6 (Chenery 1998)	
Aberdeen	SWGW	AB 1-4, 6-17	AB 4 (C)
Aberdeen	Fabric 12	AB12: 1-6	
Aberdeen	Fabric 13	AB 13: 1-6	5 (C)
Aberdeen	Fabric 14	AB 14: 1-5	3, 4 (C)
Aberdeen	Fabric 15	AB 15: 1-6	

Table 9 Samples selected for chemical analysis from sites in the Clyde valley

Location	Chemical analysis	Anomalous typologically (T) or chemically (C)
Dumbarton	DB 1-10	DB 1 (C), 6 (C & T)
Glasgow, Cathedral	GC 1-13	GC 3, 13
Glasgow, College Green	GCG 1-15	GCG 5
Glasgow, Saracen's Head	GS 1-19	GS 1
Lanark, Greyfriars	LGF 1-18	LGF 5, 13 & 15 (C)
Rothesay, Bute	RB 1-10	

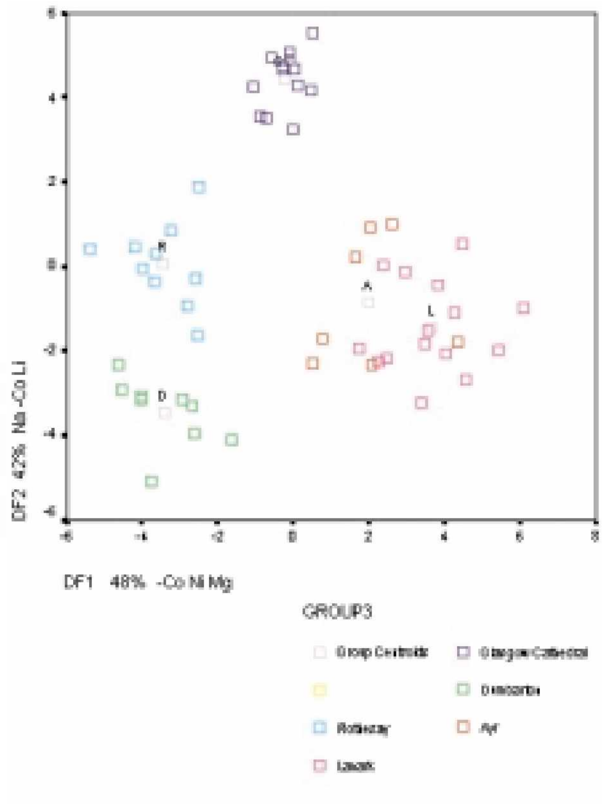


Fig. 12a DA of the Ayr (A red), Dumbarton (D green), Glasgow Cathedral (G blue) and Rothesay (R yellow) and Lanark (L crimson) groups

Chemical results show the Glasgow Cathedral material to be homogeneous, Glasgow Saracen's Head less so and Glasgow College Green least so. The Glasgow material does not exhibit what has been noted repeatedly at sites on the East coast, that is of variation in Al and some other elements. At Lanark, there is notable variation in Fe. In the DA of the groups along the Clyde and western Scotland, Glasgow SWGW (represented by the Cathedral) separates well from the other groups, as it also does on the inter-regional comparison (Fig. 5a).

Table 10 Samples selected for chemical analysis from sites in West Scotland

Location	Chemical analysis	Anomalous typologically (T) or chemically (C)
Ayr, New Bridge	A 1-9	A 3, 5 (visually different)
Ayr, St John	ASJ 1-14	
Ayr	ICP-MS: Ayr 1-6 (Chenery 1998)	
Buittle Bailey	BB 1-4	

In the material from New Bridge at Ayr there are two atypical samples. The remainder and the SWGW from the St John site have uniform compositions. Ayr (represented by the revised New Bridge group) is well discriminated from the other SWGW groups in the west of Scotland. Wherever the SWGW found at Buittle Bailey was made, it was not Ayr (Fig. 12b).

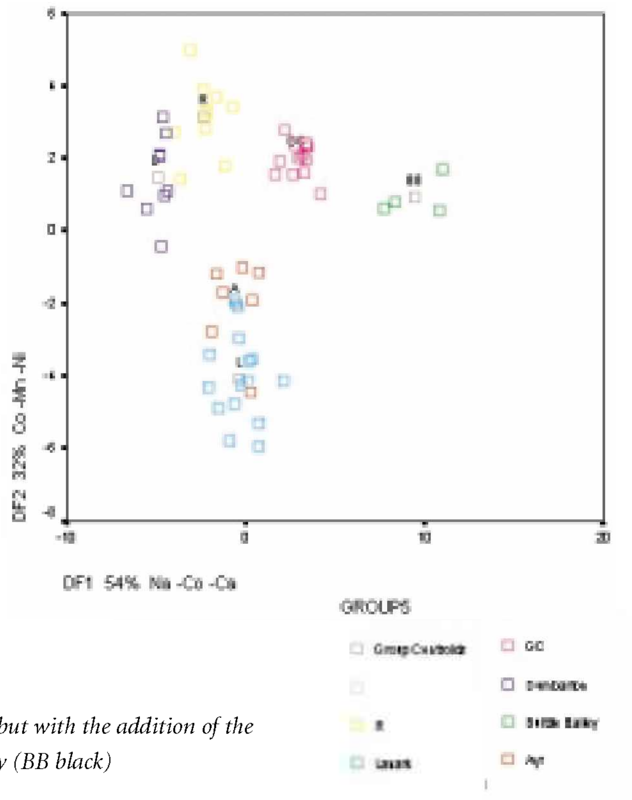


Fig. 12b As for Fig. 12a but with the addition of the group from Buittle Bailey (BB black)

DISCUSSION: FABRIC CHARACTERISATION

Petrography

The petrographic component of the Pilot Study has been able to draw attention to small but definable distinctions between the compositions of SWGW from different findspots in Scotland. Whether these distinctions would stand above the 'continuum' of mineral inclusions and rock fragments to be expected in the white-firing clays of central and eastern Scotland and thereby become potentially indicators of origin was uncertain. Now that the database has been enlarged in terms of sample numbers and geographical span, it has become clear that when combined with the chemical dataset the petrography is consistent with the hypothesis of multiple production centres of SWGW. Nevertheless, ironically but not unexpectedly, the quartz, mica, feldspar, sandstone clasts and other sedimentary and metamorphic-based constituents of SWGW are, in quantity and form, not sufficiently diagnostic in themselves to resolve differences in production locations. Nevertheless, there are a few instances of distinct similarities based on these common constituents of SWGW; the best one is between Dunfermline fabric groups 1 and 2 with St Andrews 1 and 2, and Dundee 1. The results from Ceres, although limited in number, are encouraging in that they differ from those at St Andrews nearby. One difference is the absence at Ceres of igneous inclusions, present in samples from a small number of sites – St Andrews and Kilrenny in Fife, Lanark and Perth; such inclusions are distinctive and therefore informative about origin. At the first of these sites the igneous fabric is dominant, at least in the sample investigated, and the same seems to be the case at Kilrenny and Lanark, whereas at Perth it is represented by a single sample. Although the petrographic detail on the igneous inclusions is as yet limited, it appears likely that, given the occurrence of igneous outcrops in the vicinity of St Andrews, Kilrenny and Lanark, production in each case was probably local rather than in the form of a single centralised location. By contrast, the one example with an igneous rock fragment at Perth may represent an import from Fife.

These results are very encouraging, and certainly so for future work. But disappointing though the petrographic results from the other sites may appear at face value, there are in fact several useful findings that should be highlighted. First, the petrographic approach remains the best and obvious way of visualising the SWGW fabric. It demonstrates that SWGW was the product of a distinct pottery-making tradition, while at the same time explaining the not inconsiderable variation within this tradition, from the variation within the raw materials and how these materials were treated by the potters to how the clay was fired. Second, petrographic analysis has independently confirmed or explained observations made on the fabric in hand specimens, for example in corroborating the presence of fine mica in SWGW from several find spots. Third, the petrographic study can effectively characterise and classify material on an *intra*-site basis, as observed best at St Andrews; there, four fabrics were identified, two having parallels with the corresponding material from Dunfermline. More can probably be done by drawing further on the results of the Pilot Study and integrating them with the those of the more recent study specifically for the purpose of *associating* groups/fabrics from different locations, not necessarily for assigning origin. Future work will need to fill some gaps in the geographical coverage, notably in West Scotland where there are already several apparently diagnostic chemical characteristics (Table 2).

Another important line of enquiry for the petrographic approach should be to redress the balance towards technology, the prime question being was SWGW naturally or deliberately tempered? It is likely that both types of tempering were practiced. The results of point counting of quartz grains in the thin sections should be illuminating, but it is already apparent that some of the clays were naturally gritty and moreover they varied in their quartz content (indeed, some SWGW sherds are so smooth that they can be confused with Saintonge ware). Potters therefore may have selected the batch or location of the clay according to the demands of the pottery or component of the vessel they were making. Hand specimen examination of SWGW does suggest that potters were able to vary the amount of quartz (grit) in their clays according to the type or part of the vessel under construction; this scenario could equally well be explained in terms of deliberate tempering. Besides point counting, further work involving experiments with different grades and sources of sand would be worthwhile as much for the petrographic as for the chemical approach.

Chemistry

The chemical approach has undoubtedly been more successful in this study. The promising results obtained by Chenery (1998) on SWGW have been substantiated and greatly extended such that it is now possible to identify the major and unmistakable finding: the existence of small distinctions in the chemical compositions at many of the sites that have been considered. This finding may be interpreted in two main ways: the distinctions are indicative of (a) the different origins of the clays and (b) small differences in the working practises of potters operating at one or more centres. Of these two options, (a) is the more likely to predominate: the SWGW tradition was practised in many different locations in Scotland, employing materials, methods and practices (that we can call the technology) that were essentially uniform and constant but at the same time allowed for small-scale, local variation. This last point is important because the SWGW tradition was a long-lived one which probably diversified or developed to some extent over time. It needs to be borne in mind that the time-depth factor has been included in this study.

White-firing clays of similar geochemical formation have been used to make pottery throughout most of the areas in Scotland studied here, and their general chemical character is remarkably similar, probably more so than the corresponding petrographic compositions. Nevertheless, some small, subtle *inter*-site differences emerge when the chemical data are classified by one of the multi-variate statistical methods, discriminant analysis. The chemical differences apparent on an *inter*-site basis are indicative of differences in origin, but there is little doubt that technological factors are contributing to some of the variation in composition.

The Results section has shown there are in effect site-specific chemical fingerprints for some of the sites considered (*e.g.* Elgin and Dumbarton), and moreover different regions can be discriminated from each other to a greater or lesser extent. That said, the size of each group, as it appears in the discriminant analysis plot which is a direct indicator of how uniform or not the constituent compositions are, varies greatly. There is, on the one hand, the Tentsmuir group which is uniform and compact, and on the other several groups which are much less well defined; they frequently show a tendency to be elongated on the second DF and for two sub-groupings to be apparent. This phenomenon was detected first at Colstoun, where two groupings based on differing Al and other element contents were discerned and at St Andrews, Lanark, Kilrenny, and even Kelso Abbey. The use of related but different clays at these sites is one interpretation of this phenomenon, but other, technological factors could also play a part. This immediately raises the question of the relationship between SWGW and Red ware. At Colstoun (and elsewhere, as Chenery (pers. comm.) has suggested) the latter is made of a uniform clay, and that clay seems to be more related than might be expected to those used for SWGW manufacture. Experimental work based on modern clays collected at Colstoun needs to be pursued to resolve this problem; thus far, it has only been shown that the clays from Colstoun bear a reasonable chemical and petrographic resemblance to SWGW, yet these same clays do not *visually* resemble either SWGW or Red ware on firing in an oxidising atmosphere. This is but one of several issues that encourage the writers of this report to take a more technological, less provenance-oriented approach in future work on SWGW.

Before some summarising remarks can be attempted, it has to be emphasised that this study has encompassed a large of number of sites, some of which are not only important in archaeological terms but also happen to be close in spatial proximity. In this situation and in an area of relative geological uniformity, as is the case for the most part in this study, the discriminatory power of chemical analysis by ICP-ES (as well as ICP-MS) should be kept in perspective. DA of archaeologically meaningful groups from locations close to each other spatially can give the impression of meaningful chemical separation between the groups, but the reality of that chemical separation may be very limited, perhaps reflecting minor textural differences and having little or nothing to do with true origin differences. These remarks apply to the Edinburgh, Leith and Glasgow sites, among others.

Two other methodological issues can be explored here: first, it is clear that distinctions that are potentially informative petrographically – such as the presence of feldspar or mica – are not manifesting themselves chemically. Second, textural differences do not seem to have a direct effect on chemical composition, for instance the presence of quartz giving a straightforward dilution effect on the element concentrations. However, as mentioned above, this is an issue that would be benefit from some experimentation; the effects of different quality sands on chemical composition (from major to trace elements) need to be understood. At least it is gratifying to find that the igneous Group 4 at St Andrews is capable of some measure of chemical resolution from the other petrographic groups identified at that site.

Finally, it is of interest to compare the element concentration ranges in SWGW with those in stream sediments, as determined by BGS' Geochemical Baseline Survey of the Environment (Chenery, Phillips and Haggarty 2001: 52). Different though these materials are, Table 3 takes as an example the stream sediment data from BGS' Regional Geochemistry volumes for the East Grampians and Southern Scotland covering the vicinities of St Andrews, Dunfermline and Perth, Lanark, Kelso, Ayr, Rothesay and East Lothian (BGS 1991; 1993). The Mg, K, Sr and La ranges compare well with the pottery, while the transition elements – Fe, Cr, Co and Ni – are in lower concentration in the pottery, and Rb in higher concentration. Beyond that, this study cannot yet benefit directly from the stream sediment database.

Turning now to an assessment of what sites/regions are capable of discrimination, it is first necessary to place the results of DA in perspective. As explained in the methodology section above, the clear separation of two SWGW site groups in the DA plot, especially along DF1, implies there is a significant chemical difference between the two groups, based often on a combination of elements. In this study those elements frequently include Cr, Co and Ni which are well known more generally as useful discriminators of pottery groups. But to add credence to the picture that DA is giving requires an additional step, that is an inspection of the summary statistics of each group (mean and standard deviation) to identify the presence (if any) of chemical characteristics (or indicators) that may distinguish that group. That process, which has taken the form of a *visual* comparison of the summary statistics, has led to the qualitative statements set out in Table 2 column 4. Some potentially useful observations are apparent, for example the (lower) Clyde sites together with Rothesay have lower Rb than elsewhere and together with Ayr they have lower Ni. While a plausible geological explanation for this is not yet forthcoming, and, as just explained, use of the presently available stream sediment database is still limited, it is

Table 11 Concentration ranges of selected elements in stream sediments in the vicinity of sites or areas of interest

Site/Area	Mg	K	Ca	Fe	Ni	Rb	Sr	La	Cr	Co	Zr
St Andrews	1–2	1.8–2.6	1–2	4–7	50–100	40–100	130–200	30–70	130–275	20–50	600–1500
Dunfermline	1–2	1.8–3.0	0.5–1	5–9	50–100	70–100	100–400?	20–140	130–275	20–70	650–1000
Perth	1.7–4	1.8–2.6	1–2	5–9	50–100	70–100	150–300	50–150	130–400?	10–20	650–1000
Lanark	0.8–3.0	1.5–3	0.5–1.5	6–9.5	50–100	60–100	160–300	20–40	150–300	16–30	500–2000
Rothesay	1–2	1–2	0.5–1.5	5–7.5	20–30	40–80	80–160	30–40	100–150	15–30	500–1500
Kelso	1–3	2.4–4	0.3–2	4–6	20–50	45–100	100–270	15–35	150–200	12–30	700–2000
East Lothian	0.5–1	1–2.5	0.5–3	4–6	16–40	35–50	100–250	45–90	100–280	12–30	700–2000

Taken from BGS Regional Geochemistry volumes for East Grampians and Southern Scotland.
Concentrations are in % oxide for Mg, K, Ca and Fe; the rest in ppm element.

satisfying to note that the compositions at Aberdeen are *not* characterised by high Zr and La, two elements that would be expected to feature prominently in a granitic area such as Aberdeen. The marked chemical similarities between the SWGW pottery at Aberdeen and similarly chronologically early groups at Kelso Abbey, Leith, Haddington and St Andrews may suggest that *some* of these groups have a common source, and that source is unlikely to be Aberdeen. Elsewhere in central and eastern Scotland, Elgin and to a lesser extent Tentsmuir and Colstoun are

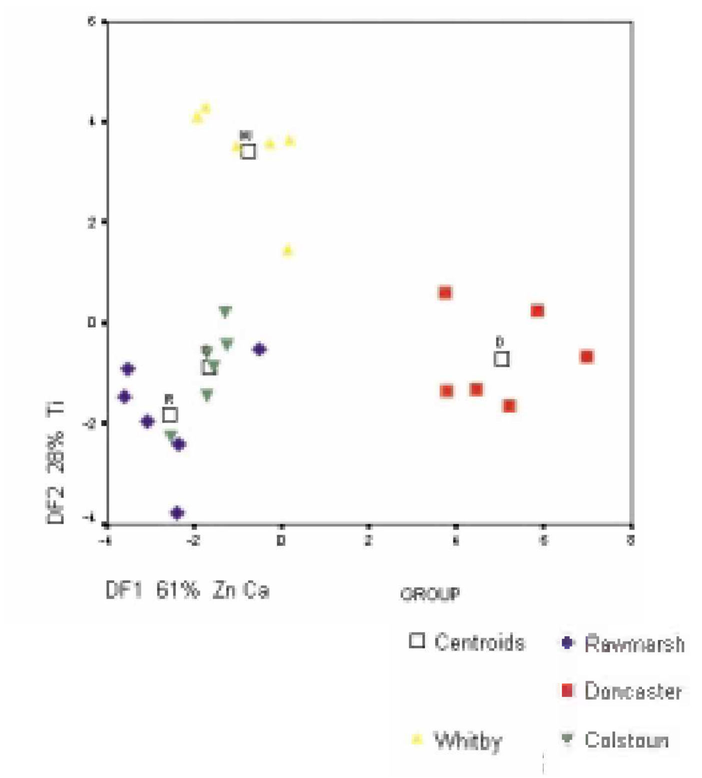


Fig. 13 DA of SWGW groups from Colstoun (C green), and three Yorkshire sites: Whitby (W yellow), Rawmarsh (R blue) and Doncaster (D red). All (ICP-ES) data from A Vince

securely discriminated, and there is a small apparent discrimination between Colstoun and Haddington. But despite the visually encouraging results of the DAs involving site groups in the Forth and Fife (apart from Tentsmuir) and Tay areas, the distinctions are small. They hint no more at the presence of individual production centres, but they are *not* capable of being used to source, for example, a 'blind' sample to an individual centre in these areas.

It remains to establish the extent to which there are compositional differences between the SWGW from the secure Scottish production site, Colstoun, and those in northern England. This was explored using ICP-ES data obtained (for Alan Vince) at the same laboratory (Royal Holloway College, London University) for Colstoun, Doncaster, Whitby and Doncaster. Fig. 13 shows good discrimination between two of Vince's Yorkshire kiln sites and Colstoun, but considerable overlap with Rawmarsh. It is noted that Cr, Co and Ni are on average lower in Yorkshire than in Scotland, and V, Zr and La are higher. Overall, the indications are quite encouraging that the chemical data can contribute to the identification of Northern English products in Scotland.

CONCLUSIONS AND RECOMMENDATIONS

The major outcome of this project is the way it has demonstrated that there are in Scotland many White Gritty Ware production centers awaiting discovery. To the core area of production in the south east and east of Scotland can now be added evidence for production in central and west Scotland and Elgin in the north. An important methodological result of the project is that it confirms what was written in 1984 regarding the examination (with x20 magnification) of the fabric of a selection of white gritty ware from an excavation at Kelso Abbey: "This quantitative technique is suitable as a comparative method of studying a collection of pottery, but with regard to provenance it is not sufficiently controlled to be pursued further" (Cox 1984, 391). We would go further and suggest that such a programme of fabric examination of SWGW must be backed up with additional laboratory-based analysis; on its own, it gives restricted, subjective information which does not provide value for money and is therefore best avoided. For the foreseeable future, we believe the only cost-effective means of characterising SWGW from well-stratified or important pottery assemblages is by chemical analysis (preferably using ICPS), backed up where appropriate with petrographic examination. Since the chemical distinctions between many of our ceramic groups are very small, sourcing of 'blind' samples is almost impossible and again not cost effective.

One of our principal aims was to produce a field guide to SWGW. However, this has proved an almost impossible task largely due to the difficulty already alluded to, namely the difficulty of assigning fabrics using low-power microscopy. We have now taken a major step towards the creation of a comprehensive SWGW vessel typology. In carrying out that task it has been possible to ascribe a number of specific vessel forms on a regional basis. The best example is the 12th century straight-sided jar, which on present evidence, is thought to have been produced in the Scottish Borders, but which has been identified in assemblages from as far north as Caithness. The frilled bifid rim is another distinctive SWGW type, produced in Fife but which has been found in Perth, Leith and Cramond.

Future analysis of SWGW that has been identified from sites in the north east of Scotland, the Northern Isles and Norway (Reed 1994, 61, Fig 2) should determine whether vessels in this ware were coming from a common source or a number of production areas. The identification of a distinctive Gritty Ware fabric from Elgin is important, especially as it cannot be matched with any of the fabric groups from the core production areas. Study of the sherds from northern Scotland although limited in number should help to develop a regional typology for the area around the Moray Firth.

Finally, we draw attention to one feature of the raw material of SWGW, that is the pale or white coloured clay. We have argued here, if indirectly, that potters operating in different areas of Scotland were able to locate sources of this type of clay. Setting that point against two observations – first that our admittedly limited efforts at clay prospection have apparently failed to find significant deposits of such clays today, and second that the production of SWGW probably ended in the late 15th or early 16th centuries to be replaced by the tradition that worked with the widely occurring red clays – raises the distinct possibility that the white clays, perhaps discovered initially in the course of prospection for another material (probably coal), may have been limited in extent. The sources of these clays may have been exhausted in antiquity.

In this report we have opted to use the term Scottish White Gritty Ware as the generic term for the products of this widespread industry, and we recommend that everyone working on groups of Scottish medieval ceramics use this term. However, the issue of fabric/ware terminology and definition arising from the present project deserves to be considered as a matter of high priority. Another urgent issue should be the setting up of minimum standards for the excavating, processing, publishing and archiving of this pottery. Currently, the majority of sherd material entering the Scottish museums system is not marked, and in one case noted by the authors not even washed. There is obviously a need to ensure that when assemblages are deposited in a museum there still remains the potential for their re-analysis and examination in a workable environment.

Looking to the future, the results of the chemical and petrographic analyses presented here have created an important resource and framework which should provide the basis for encourage further field-, museum- and laboratory-based work. One of the tasks of field work should be directed towards locating kiln sites. Although the recent discovery of a kiln site at Ceres in Fife is very welcome, the relative lack of relevant medieval and later pottery production sites in Scotland severely limits our ability to tie down the chemical data from excavations. Colstoun has rightly featured prominently in this study, and yet there is more to be done at this site; the pottery workshops there may be more extensive than initially thought. There is also more to be done in terms of locating and characterising production centres in the west of Scotland, as well as publishing the pottery assemblages from the Manpower Services Commission-sponsored excavations in Glasgow. At the laboratory level, there is scope for integrating the chemical results of English Heritage's pilot study of Northern English Medieval White Ware (Vince 1998). One beneficial outcome would be to investigate those potential production sites supplying both English and Scottish markets that are presently not being identified. It is relevant to point out here that we have no definite evidence that some SWGW was not being imported into Scotland from either England or even Continental Europe.

Of the many science-based studies of SWGW previous to this one, very few had any long-term validity or results that can still be verified. In the light of this we propose that all sherds, samples, and thin sections from the SWGW project should be housed in the National Museums of Scotland as an adjunct to the fabric reference collection.

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Abbreviations

DA Discriminant analysis
DF1-3 Discriminant functions
ICP-ES, Inductively-coupled plasma emission spectrometry
ICP-MS, Inductively-coupled plasma mass spectrometry
MPRG, Medieval Pottery Research Group
PCA, Principal components analysis
SWGW, Scottish White Gritty ware

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Résumé

A la suite du succès des recherches préliminaires financées par Historic Scotland qui ont évalué l'étendue des prospections passées et des analyses sur la poterie de type « Scottish White Gritty Ware », un programme majeur de recherche soutenu financièrement par Historic Scotland a été lancé par Glasgow University Archeological Research Division. Ce projet se proposait d'examiner le répertoire et les types de vaisselles, les zones de production et la composition chimique des argiles utilisées dans la production de la poterie de type « Scottish White Gritty Ware ». Plus de six cents tessons provenant de plus de quarante sites archéologiques écossais ont été analysés chimiquement par ICP et par des analyses pétrographiques de coupes. Le projet a également entrepris la construction d'une typologie des formes, un programme limité de prospection des argiles, un bilan bibliographique des études scientifiques passées, une analyse des vernis, une comparaison avec le matériel anglais et européen des compositions chimiques, ainsi qu' une étude géophysique du site de production de céramiques de type « Scottish White Gritty Ware » à Colstoun en East Lothian. L'analyse pétrographique a été baséee sur les lames minces existant déjà dans les collections du National Museum of Scotland mais aussi sur des tessons spécifiquement sélectionnés pour cette étude.

Les résultats des analyses révèlent l'existence de sites de production de poterie de type « Scottish White Gritty Ware » dans différentes zones allant du Scottish Borders au Moray Firth. Les zones géographiques nécessitant plus de recherches, en particulier des fouilles, ont aussi été identifiées.

Cette étude a rassemblé la plus grande et la plus importante base de données jamais créee sur une industrie céramique médievale européenne et constitue ainsi une base de départ majeure pour les travaux sur la poterie de type « Scottish White Gritty Ware » à venir.

Zusammenfassung

In Weiterführung einer erfolgreichen Pilotstudie, die von Historic Scotland finanziert wurde und die sich mit früheren Arbeiten über und Analysen von schottischer Weißgrobware befaßt, initiierte die Universität Glasgow, Archäologische Forschungsabteilung, eine größere Untersuchung über die schottische Weißgrobwaren Industrie, die wieder von Historic Scotland finanziert wurde. Das Projekt begann mit der Untersuchung des Umfangs und der Typen der Gefäße der Produktionsgegenden und der chemischen Zusammensetzung der Tonerden, die bei der Herstellung der schottischen Weißgrobware verwendet wurden. Chemische und steinkundliche Analysen sollten die Herkunftsorte und die Verteilung innerhalb Schottlands identifizieren.

Über 600 Scherben von über 40 schottischen Fundstätten wurden mit Hilfe chemischer Analysen unter Benutzung von ICP bestimmt und mit einer petrographischen Untersuchung einer Auswahl dünner Stücke verbunden. Ebenso wurden als Teil dieses Projekts eine Gefäßtypologie der schottischen Weißgrobware, wie auch ein beschränktes Programm von Tonerdenuntersuchungen, ein Überblick schon durchgeführter wissenschaftlicher Arbeiten, Glasuranalysen, ein Vergleich mit englischen und kontinentalen Materials, als auch ein geophysikalischer Überblick über den schottischen Weißgrobwarenofen in Colstoun, East Lothian, erstellt. Die petrographischen Analysen wurden an der bestehenden Sammlung dünner Stücke im National Museum of Scotland und einer neuen, besonders für diese Untersuchung zusammengestellten, Gruppe von Scherben durchgeführt.

Die Analysen weisen im Resultat auf die Herstellung von Weißgrobware in mehreren Gegenden Schottlands, von der Border-Region bis zum Moray Firth hin und haben auch die Gebiete kenntlich gemacht, die noch weitere Untersuchungen und Ausgrabungen benötigen.

Die Studie erbrachte die größte und bedeutendste Datensammlung irgendeiner europäischen, mittelalterlichen Keramikindustrie und schuf einen bedeutenden Ausgangspunkt für jegliche zukünftige Arbeiten über schottische Keramik.