Characterisation Studies of Medieval Pottery from Dursley, Gloucestershire

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Following an assessment of the medieval pottery from the Victoria Works, Dursley, it was recommended that samples of the pottery were studied using thin section and chemical analysis since they did not appear to fit into the author's classification of the medieval pottery of the Severn Valley (Vince 1984) and were potentially of local manufacture.

Consequently, samples of medieval wares which were visually separated into 11 fabric groups were analysed, together with samples of fired clay (as an example of the characteristics of the locally-available clay) and vessels which could not be positively identified by eye (Table 1). A full list of the samples is given in App 1. Following analysis it was recognised that there were five 'new; fabric groups, here termed Dursley Fabrics A to E, whilst examples of eight previously-identified fabric groups were identified. All are described here. In the initial sampling, about 10 samples were chosen from each of the wares under investigation, of which all were analysed using Inductively-coupled Plasma Spectroscopy (ICP-AES) and half were thin-sectioned (except for Gloucester TF41B, which has been extensively analysed in thin section but for which no chemical analyses were previously available).Table 1 shows the breakdown of samples per fabric group after analysis.

Table 1

cname	ICPS	TS;ICPS	Grand Total
BATHA	3	1	4
BR		2	2
DURSLEY A	2	5	7
DURSLEY B	11	11	22
DURSLEY C	5	10	15
DURSLEY D	8	7	15
DURSLEY E		1	1
FCLAY		1	1
GLOS110		1	1
GLOS41B	7	1	8
MEDX		1	1
MINETY	10	5	15
NBYB		1	1

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SANDY MINETY		1	1
SEW		1	1
SNTG/CITG		1	1
WORCS		1	1
Grand Total	46	51	97

Thin Section Analysis

Thin sections were prepared by Steve Caldwell, at the Department of Earth Sciences, University of Manchester, and were stained using Dickson's method (Dickson 1965). This staining distinguishes ferroan (stained blue) and non-ferroan calcite (stained red) whilst dolomite is unstained. The thin sections have been retained in the AVAC reference collection where they can be consulted by appointment.

Fired Clay

A sample of fired clay was thin-sectioned (V2891). The fabric contains few inclusions over 0.2mm across, all rounded quartz grains, ranging from c.0.2mm to 0.4mm across and a single opaque tabular fragment, probably hammerscale.

The groundmass consists of optically isotropic baked clay minerals with abundant angular quartz ranging from less than 0.05mm to 0.2mm across and sparse muscovite laths up to 0.2mm long.

One face of the sample has been vitrified and consists of isolated areas of groundmass set within a vesicular opaque to dark brown glass. Fuel ash slags normally contain clear glass and the dark colour of the glass either suggests that the clay was involved in iron working or is a function of a high iron content in the fabric. The possible presence of hammerscale in the clay suggests the former.

The high quantity of fine quartz/muscovite silt in the groundmass suggests that this clay is derived from the Upper Lias which in the Dursley area is noted for its high quartz content (1948, most of the other clays outcropping close to Dursley are much finer in texture, with few visible inclusions, even in thin section).

Dursley Fabric A

The distinguishing features of this fabric at x20 magnification are the presence of abundant limestone sand grains in a silty groundmass. In thin section, the samples of this fabric could be grouped into two subfabrics on the basis of the character of the limestone. A1 contains a mixed limestone whilst A2 contains solely oolitic limestone fragments, similar to those found in Gloucester Fabric 41B. However, if the inclusions are leached then it would be impossible to distinguish these two subfabrics.

The following inclusion types were noted in thin section in Fabric A1.

- Oolitic limestone. Moderate sub-rounded fragments consisting of non-ferroan calcite ooliths c.0.2mm across, in a groundmass of ferroan calcite. The ooliths mainly have a micrite core but a minority have an angular quartz grain as their core.

- Bioclastic limestone. Moderate to abundant sub-rounded fragments consisting of non-ferroan bivalve shell and ferroan calcite echinoid shell fragments in a groundmass of ferroan calcite.

- Organics. Sparse elongated voids up to 1.0mm long and 0.2mm wide surrounded by a black halo.

- Iron/clay nodules. Moderate rounded dark brown to opaque inclusionless grains up to 1.0mm across.

The groundmass consists of optically anisotropic baked clay minerals, abundant angular quartz grains c.0.05-0.20mm across, sparse muscovite laths up to 0.3mm long, echinoid spines(?) c.0.15mm in diameter and amorphous ferroan calcite specks up to 0.2mm across.

The following inclusion types were noted in thin section in Fabric A2.

- Oolitic limestone. As in Fabric A1

The groundmass is identical to that of Fabric A1.

The silty micaceous groundmass can be paralleled locally by the groundmass of the fired clay sample, which presumably was made from a clay outcrop close to Dursley. Bioclastic limestone similar to that in Fabric A1 could occur in the Rhaetic or Lias within the valley but the oolitic limestone is more likely to come from the middle Jurassic limestones which outcrop along the Jurassic scarp and dipslope. Quaternary sands in the Severn valley, if calcareous, normally contain a mixture of quartzose and limestone inclusions. Limestone sand with no quartz grains can be paralleled in talus and colluvial deposits in valleys cutting through Jurassic limestones along the Cotswolds scarp but the mixed nature of the limestones distinguishes this fabric from that produced at Haresfield and is in fact much more similar to the limestone sand found in Minety ware.

Dursley Fabric B

At x20 magnification, the distinguishing features of this fabric group are the presence of a mixed limestone/quartz sand with moderate rounded iron/clay grains. The following inclusion types were noted in thin section:

- Oolitic limestone. As in Dursley Fabric A but perhaps more rounded.
- Bioclastic limestone. As in Dursley Fabric A but perhaps more rounded and with no echinoid shell fragments.
- Calcareous algae. Rounded fragments composed of purple-stained calcite with numerous tubes.
- Bivalve shell. Sparse to moderate thin-walled shell fragments, probably derived from the bioclastic limestone, up to 1.0mm long and c.0.2mm wide.
- Iron/Clay nodules. Rounded fragments of dark brown to opaque inclusionless clay/iron compounds up to 2.0mm across.
- Rounded quartz. Sparse to moderate rounded quartz grains up to 1.0mm across. Mostly monocrystalline and unstrained but strained grains and polycrystalline grains with incipient mosaic quartz formation also occur.
- Siltstone. Sparse rounded fragments of siltstone, containing quartz and muscovite laths up to 0.2mm long. Some of these have a ferroan calcite cement and others have a dark brown clay cement.
- Chert. Sparse/rare rounded chert fragments up to 1.5mm across.

The groundmass consists of optically anisotropic baked clay minerals with sparse angular quartz, dark brown/opaque grains and muscovite laths up to 0.1mm long.

The rock and mineral clasts in this fabric are distinctive and indicate that the inclusions are a detrital sand. The groundmass is typical of Jurassic clays, both in the lower Jurassic (i.e. outcropping within the Severn Valley)and in the Upper Jurassic (i.e. outcropping on the dip slope of the Cotswolds). The similarity of the limestone sand to that found in Fabric A (and D, see below) suggests a similar origin.

Dursley Fabric C

At x20 magnification, the distinguishing features of this fabric are an abundant quartz sand in which some of the grains are well-rounded with a high sphericity, typical of Permo-Triassic sand grains deposited under desert conditions.

In thin section, the following inclusion types were noted:

- Quartz. Abundant grains ranging from c.0.2mm to 1.0mm across. Most are monocrystalline and unstrained. Some are well-rounded with high sphericity but subangular grains are also present.

- Sandstones. Moderate fragments ranging from c.0.2mm to 1.5mm across. Most are sub-angular to sub-rounded in outline. The fragments vary in texture but most contain sub-angular fragments of quartz, sandstones, metamorphic rock fragments and acid igneous rock fragments in a matrix of brown-stained silica.

- Opaques. Moderate rounded and angular fragments ranging from c.0.2mm to 1.5mm across.

- Siltstone. Sparse sub-angular fragments up0 to 1.0mm across, possibly derived from the sandstone.

The groundmass consists of optically anisotropic baked clay minerals, sparse angular quartz and muscovite up to 0.1mm long and subangular opaque/dark brown grains up to 0.1mm across.

The sandstone is probably the source of most, but not all of the other inclusions in this fabric. The exceptions are the well-rounded, spherical quartz grains and the opaque grains.

Similar sandstones have been observed in the Old Red Sandstone of South Wales and similar Palaeozoic sandstones in the South-West of England. In particular, the Quartz Conglomerate which forms the lower part of the Upper Old Red Sandstone has a similar description to the rock in this fabric. Locally, there are outcrops of Quartz Conglomerate in the Severn Valley between Tortworth and Sharpness (1948, 15). The Triassic Dolomitic Conglomerate is also a possible source of this rock, but does not outcrop close to Dursley (Kellaway & Welch 1948, 39-40). However, the well-rounded quartz grains are indeed likely to be of Triassic origin. Such grains are very common in Severn Valley terrace sands, where they are derived from the Triassic sandstones of the West Midlands. The groundmass is finer in texture than those associated with the Old Red Sandstone or Triassic deposits and is likely to be of Jurassic age. Thus, the source of this fabric should be sought to the west of Dursley, in an area of Jurassic clays bordering outcrops of the Quartz Conglomerate.

Dursley Fabric D

At x20 magnification, the distinguishing characteristics of this fabric are moderate calcareous inclusions (or voids), some of which are definitely bivalve shell, in a silty, micaceous groundmass. Only the shell and the lower quantity of calcareous inclusions separate this fabric from Dursley Fabric A.

In thin section, the following inclusions were noted:

- Bivalve shell. Moderate fragments up to 1.0mm long and c.0.2mm wide. Typically, they consist of a central non-ferroan calcite core with layers of prismatic ferroan calcite on either side. At least one of these shells is from a punctate brachiopod and the ferroan calcite is therefore either cement from a bioclastic limestone or deposited by calcareous worms, often noted on Jurassic fossils.

- Echinoid shell. Moderate fragments composed of ferroan calcite, up to 1.0mm long.

- Oolitic limestone. As in Fabric A and up to 1.0mm long.

- Bioclastic limestone. As is Fabrics A and B. The clasts included iron-replaced echinoid shells in a ferroan calcite cement.

- Calcareous algae. As in Fabric B. In one case the algae have grown around an oolitic limestone core.

- Quartz. Moderate sub-rounded grains up to 0.5mm across.

- Chert. Sparse sub-rounded grains up to 0.5mm across.

- Clay/iron nodules. Moderate rounded fragments, some probably oolitic and others with sparse quartz and muscovite silt up to 0.1mm across.

The groundmass is identical to that of Fabric A and consists of optically anisotropic baked clay minerals, abundant angular quartz grains c.0.05-0.20mm across, sparse muscovite laths up to 0.3mm long, echinoid spines(?) c.0.15mm in diameter and amorphous ferroan calcite specks up to 0.2mm across.

The quartz and chert are probably detrital grains of Triassic origin. The calcareous algae and limestone fragments are also detrital but it is possible that the shell fragments were naturally present in the clay, although it is more likely that they too are detrital, perhaps derived from a shell bed within a clay or a shelly bioclastic limestone.

Dursley Fabric E

A single example of Dursley Fabric E was recognised. It combines the sandstone temper of Dursley Fabric C, the mixed calcareous sand of Fabrics A, B and D and the clean groundmass of Fabrics B, C and D. It suggests that fabrics B,C and D could have been made in the same locality.

In thin section the following inclusion types were noted:

- Quartz. Abundant subangular fragments 0.1mm to 0.5mm across. Mainly unstrained monocrystalline grains.
- Microcline feldspar. Sparse subangular fragments up to 0.5mm across.
- Altered feldspar. Sparse subangular fragments up to 0.5mm across.
- Muscovite. Sparse laths up to 0.3mm long.
- Opaques. Sparse rounded grains up to 0.3mm across.
- Sandstone. Sparse angular fragments of sandstones of varying grain sizes, all with a brown-stained silica cement, up to 1.5mm across.
- Clay. Moderate rounded fragments composed of dark brown clay, some with a concentric structure and some with sparse angular quartz inclusions up to 0.1mm across.
- Calcareous sandstone. Sparse rounded grains consisting of angular quartz grains up to 0.2mm across in a ferroan calcite matrix.
- Limestone. Two different lithologies are present, but both are sparse. The first consists of sparry non-ferroan calcite, with grains up to 0.4mm across, and the second consists of bioclastic limestone fragments up to 0.5mm long often consisting of non-ferroan shell fragments with prismatic ferroan calcite coating or either side. Also angular ferroan calcite fragments, up to 0.3mm across.
- Organics. Sparse rounded voids up to 0.2mm across surrounded by a blackened halo (probably rootlets).

The groundmass consists of optically anisotropic baked clay minerals with few visible inclusions

The quartzose inclusions (quartz, feldspar and sandstones) are similar to those in Fabric C whilst some of the calcareous inclusions are similar to those in Fabrics A, B and D. However, the sparry non-ferroan calcite does not occur in those fabrics. The fine-textured groundmass is similar to those in Fabrics B, C and D.

South-East Wiltshire ware

A single thin section of a South-East Wiltshire tripod pitcher was prepared. At x20 magnification, the distinguishing characteristics of this ware are the presence of sparse angular flint fragments, a quartz sand and a clean, light-coloured groundmass.

In thin section, the following inclusion types were noted:

- Quartz. Abundant sub-rounded grains ranging from c.0.1mm to 0.4mm across. Sparse well-rounded grains ranging up to 1.5mm across with iron-rich veins and low sphericity.
- Opaques. Moderate well-rounded grains up to 0.4mm across.
- Flint. Moderate sub-angular grains, mostly with dark brown staining, up to 1.5mm across.
- Ferruginous sandstone. Sparse subangular fragments up to 1.5mm across containing ill-sorted subangular quartz grains up to 0.3mm across in an opaque groundmass.

The groundmass consists of optically anisotropic light-coloured baked clay with few visible inclusions.

The presence of stained flints suggests the use of a Tertiary or later sand whilst the larger quartz grains probably originated in a Cretaceous or Tertiary sand with iron panning. Such sands occur in the Hampshire/Surrey border and in Bedfordshire (the Woburn Sands). Furthermore, the quantity of opaque grains is higher than normal for Southeast Wiltshire products and a source further west, perhaps in the Hampshire Basin, is also possible.

Gloucester TF41B

One thin section was identified as being of Gloucester Fabric 41B.

The following inclusion types were noted:

- Oolitic limestone. It contains abundant rounded fragments of oolitic limestone up to 2.0mm

The groundmass consists of inclusionless optically anisotropic baked clay.

The ooliths in the limestone inclusions are about twice as large as those in Fabrics A, B and D, including those in Fabric A1, where a single rock type dominates the limestone sand inclusions.

Minety Ware

Five thin sections of Minety ware were made. They include samples from two wheelthrown vessels but no difference was noted in thin section between the handmade and wheelthrown samples.

In thin section, the following inclusion types were noted:

- Oolitic limestone and ooliths. Moderate rounded fragment up to 1.0mm across. The matrix consists of ferroan calcite and the ooliths are up to 0.5mm across with multiple layers of non-ferroan calcite and usually a clay or ferroan calcite core.

- Bioclastic limestone. Moderate rounded fragments up to 1.0mm across. The clasts consist of ferroan calcite echinoid shell, nacreous non-ferroan calcite bivalve shell, bryozoans and gastropod shell and the cement consists of ferroan calcite.

- Calcareous sandstone. Sparse rounded fragments up to 1.0mm across. The fragments contain well-sorted angular quartz grains, c.0.1=0.2mm across and have a ferroan calcite matrix.

- Quartz. Sparse rounded grains up to 1.0mm across.

- Mudstone. Sparse laminated fragments ranging from a similar colour to the groundmass to a dark brown. Probably relict clay.

The groundmass consists of optically anisotropic, light-coloured baked clay minerals, with few quartz or muscovite inclusions and sparse to moderate dark brown or opaque grains, less than 0.1mm across.

The limestone sand in this ware is similar to that in Fabrics A, B and D although the groundmass is different.

Sandy Minety Ware

A single thin section of Sandy Minety ware was prepared.

The following inclusion types were noted:

- Quartz. Abundant, well-sorted angular grains ranging from c.0.1mm to 0.3mm across. Sparse rounded grains c.0.3mm across are also present

- Oolitic limestone. Sparse rounded fragments as in Minety ware.

- Bioclastic limestone. Sparse rounded fragments as in Minety ware.

- Opaques. Sparse dark brown/opaque grains c.0.3mm across.

The groundmass is similar to that of Minety ware.

This section indicates that the sandy Minety fabric was produced from the same clay as the earlier Minety ware rather than the red-firing clay used in Ashton Keynes, the adjoining parish to the south.

Newbury B Ware

A single thin section of Newbury B ware was prepared. By eye, the distinctive features of this fabric are the angular flint fragments, rounded quartz sand and calcareous algae fragments (usually leached, leaving pock-marks).

The following inclusions were noted in thin section:

- Quartz. Abundant rounded grains up to 1.0mm across. Most are well-rounded, including grains with a high sphericity, but some are strained metamorphic, or re-crystallised mosaic quartz.

- Calcareous algae. Moderate rounded fragments of calcareous algae up to 2.0mm across, stained purple by Dickson's method.

- Flint. Moderate angular or sub-angular grains up to 2.0mm across. The flint is either unstained or has a faint light brown stain and has some microfossils filled with slightly coarser-grained silica.

- Clay. Sparse fragments of relict clay with no signs of bedding, varying from dark brown to the colour of the groundmass.

- Limestone. A single rounded fragment of ferroan calcite, 0.8mm across containing one angular quartz grain 0.2mm across.

The groundmass consists of optically anisotropic baked clay minerals with few quartz or muscovite inclusions but moderate dark brown to opaque clay/iron pellets ranging from less than 0.05mm to 0.3mm across.

Gloucester TF110

A single thin section of Gloucester TF110 was prepared. By eye, this fabric is characterised by moderate inclusions of a sandstone with calcite cement and a silty, micaceous groundmass.

The following inclusions were noted in thin section:

- Quartz. Moderate angular and rounded, highly spherical grains up to 1.0mm across.

- Chert. Sparse rounded fragments up to 1.0mm across.

- Calcareous sandstone. Moderate subangular fragments consisting of angular quartz grains up to c.0.5mm across with a non-ferroan calcite cement (stained strong red).

- Organics. Sparse organic inclusions, c.0.1-0.2mm across surrounded by blackened haloes.

- Clay. Sparse rounded fragments up to 1.0mm across, similar in colour and texture to the groundmass. Also some of darker brown colour of similar size.

The groundmass consists of optically anisotropic baked clay minerals, moderate angular quartz grains up to 0.1mm across and sparse muscovite laths up to 0.1mm long.

The spherical quartz and the chert inclusions indicate the presence of quartz sand of Triassic origin. This conflicts with the supposed origin of Gloucester TF110, in the middle Wye valley (most likely in the area between Ross on Wye and Monmouth).

Bristol Medieval Glazed ware

Two samples of vessels with a fabric which was visually distinguished from Bristol Medieval ware by the lack of quartz sand inclusions were thin sectioned. The thin sections indicate that they were made from a Coal Measures whiteware clay and are probably a variant Bristol product.

In thin section the following inclusion types were noted:

- Quartz. Moderate sub-rounded grains c.0.1mm to 0.3mm across.

- Sandstone. Sparse rounded fragments up to 0.3mm across containing angular quartz grains up to 0.2mm across in a matrix of silica and brown amorphous matter.

- Mudstone. Moderate rounded pellets up to 1.0mm across. These vary in texture (most contain no visible inclusions, but some contain abundant quartz and muscovite up to 0.05mm long) and in colour, ranging from off-white to grey.

- Calcite. A single angular fragment of fine-textured non-ferroan calcite 0.5mm across.

- Phosphate. Sparse brown angular fragments up to 0.2mm across.

The groundmass consists of optically anisotropic baked clay minerals with abundant quartz and muscovite up to 0.05mm long.

The groundmass and clay pellets are typical of Coal Measures whiteware clays, being formed from weathered mudstones with a low iron content. It is uncertain whether the phosphate inclusions were part of the original clay/sand or are secondary infilling of pores.

Bath Fabric A

A single thin section of Bath Fabric A was prepared. At x20 magnification, the distinctive features of this fabric are: polished, rounded quartz grains, either flint or lower Cretaceous chert and a silty, micaceous groundmass.

The following inclusions were noted in thin section:

- Quartz. Moderate well-rounded grains, some containing veins with slight iron-staining, ranging from 0.2mm to 1.0mm across. Some of the larger grains have the low sphericity characteristic of lower Cretaceous quartz grains.

- Opaques. Sparse rounded grains ranging from c.0.2mm to 0.5mm across.

- Chert. Sparse angular fragments of lower Greensand quartz up to 1.0mm across containing pores up to 0.2mm across partially filled with chalcedony.

- Organics. Sparse rounded voids up to 0.3mm across surrounded by blackened haloes.

The groundmass consists of optically anisotropic baked clay containing abundant angular quartz grains up to 0.2mm across, moderate muscovite laths up to 0.3mm long and moderate sub-rounded glauconite grains up to 0.2mm across.

Tin-Glazed Import

A single thin section was made of a tin-glazed plate of Italo-Netherlandish character.

In thin section, the fabric is almost devoid of visible inclusions and has a groundmass consisting partly of optically anisotropic calcareous clay and partly of optically isotropic ceramic, the result of firing at a temperature sufficient to bring about a reaction between the clay minerals and calcium carbonate in the presence of brine.

The lack of inclusions is unusual in Netherlandish or British tin-glazed wares but is more typical of Italian maiolica. Nevertheless, on the basis of the thin section alone no statement can be made about the origin of the vessel.

Unsourced Wares

A thin section was made of a sherd from a glazed, wheelthrown bowl with an internal plain lead glaze, appearing yellow.

In thin section the following inclusion types were noted:

- Quartz. Abundant sub-rounded, rounded and well-rounded grains, including several near-spherical grains, up to 1.0mm across. Mostly unstrained monocrystalline grains but with a sizable minority of strained polycrystalline grains of metamorphic origin.

- Chert. Sparse rounded and well-rounded grains, up to 1.0mm across.

- Calcareous inclusions. Moderate sub-angular fragments up to 1.5mm across. Probably heat-altered and replaced by amorphous non-ferroan calcite.

- Sandstone. Sparse fine-grained sandstones up to 0.5mm across, composed mainly of quartz grains with some light green chlorite grains.

The groundmass consists of optically anisotropic baked clay minerals with few visible inclusions (sparse angular quartz grains ranging from c.0.05mm to 0.2mm).

The quartzose inclusions (all the quartz, plus the chert and sandstone) in this sample indicate the use of a sand of Permo-Triassic origin. The calcareous inclusions, because of their condition, cannot be characterised and the clay matrix is probably of Jurassic or Tertiary origin. Unfortunately, fine-textured Tertiary and Jurassic clays outcrop in the vicinity of Permo-Triassic sands over a large part of midland and southern England, from the Severn Valley through to the Thames Basin. Visually, the fabric is reminiscent of Brill/Boarstall ware (1994, OXAW2) and a source in that area is consistent with the petrology. However, calcareous inclusions have not been recorded in Brill/Boarstall products and it must remain unsourced using the thin section evidence alone.

A single thin section of a glazed vessel with a thumbed frill base was prepared. In general the vessel was similar in appearance and fabric to Worcester Glazed ware. The sample was taken because the fabric contains sparse calcareous inclusions, not a feature of that ware.

In thin section the following inclusion types were noted:

- Quartz. abundant sub-rounded, rounded and well-rounded grains ranging from c.0.2mm to 1.0mm across. Some grains have a high sphericity. The grains are mostly unstrained and monocrystalline but include a high proportion of strained polycrystalline grains, some of metamorphic origin.

- Chert. Sparse well-rounded grains up to 0.5mm across. Some are brown stained.

- Sandstone. Moderate rounded fragments of varying texture and lithology. They include fine-grained sandstones with amorphous brown material in the silicious matrix, micaceous siltstones, fragments containing interlocking quartz grains up to 0.3mm across and no visible cement, orthoquartzite with overgrown quartz grains and kaolinite cement/pore infilling/heavily altered feldspar.

- Limestone. Sparse subangular fragments of heat-altered limestone up to 1.0mm across. The limestone is amorphous and non-ferroan.

- Ferruginous sandstone. Sparse fragments up to 1.0mm across.

The groundmass consists of optically anisotropic baked clay (except for the reduced core, which is isotropic), sparse angular quartz and muscovite laths, up to 0.1mm long. A single fragment of ferroan calcite, c.0.2mm across, is present but may be post-burial filling of a pore.

The quartzose inclusions indicate the use of a detrital sand, a large component of which is derived from Permo-Triassic sandstones. Similar sands occur throughout the Severn Valley terraces as well as further east. The groundmass, is similar to those of Jurassic clays but contains fewer inclusions than Worcester Glazed ware. Unfortunately, the alteration of the limestone inclusions means that it is not possible to identify them or their source.

Chemical Analysis

A total of 95 samples were analysed using Inductively-Coupled Plasma Spectroscopy (ICP-AES). The analyses were carried out under the supervision of Dr J N Walsh at Royal Holloway College, London. A series of major elements and minor and trace elements were measured. The major elements were measured as percent oxides (App 2) and the remainder as parts per million (App 3).

Because pottery fabrics are often tempered with quartz sand, and silica is not measured by this method, the data were normalised by dividing the measured values by that of the Aluminium oxide.

Silica Content

An estimate of the silica content was obtained by subtracting the total measured oxides from 100%. Fig 1 shows the mean estimated silica content and the ranges for each of the wares examined. Bath Fabric A has a much higher silica content than the remainder and the tin-glazed import (marked SNTG/CITG) has the least. The remainder have overlapping silica values, with sandy wares having between 65% and 75% and limestone-tempered wares having between 55% and 68% silica.

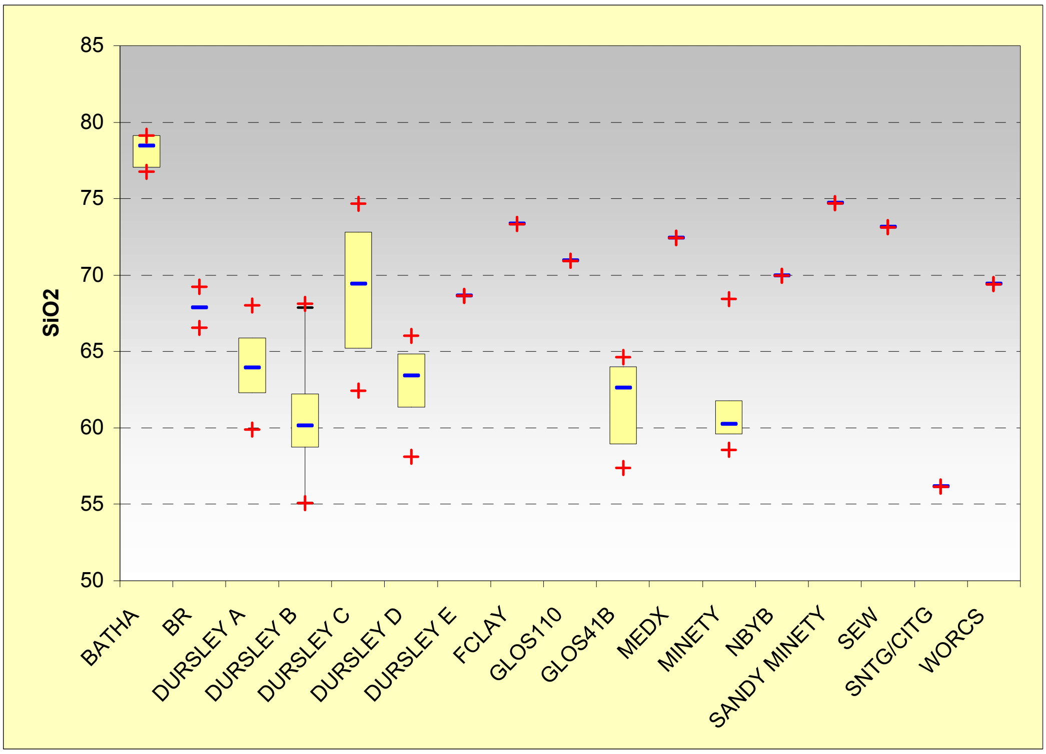

Figure 1

Factor Analysis

The normalised data were analysed using factor analysis (Fitch 2001). This analysis found six factors in the data. In total these account for 68% of the variability in the dataset. A –plot of F1 values against F2 values (Fig 2) indicates a large cluster, containing most of the samples, with a smaller cluster distinguished by higher F2 values. The unsourced jar is an outlier (marked MEDX JAR). The smaller cluster consists of the fired clay sample, four of the Dursley A samples, three of the Gloucester TF41B samples, one Dursley C sample and one Dursley B sample. The main elements contributing to F2 scores are Calcium and Strontium, both present in the calcareous inclusions and both affected by post-burial alteration (both leaching and infilling of pores). Thus, this separation has no significance for the source of the raw materials used in the samples.

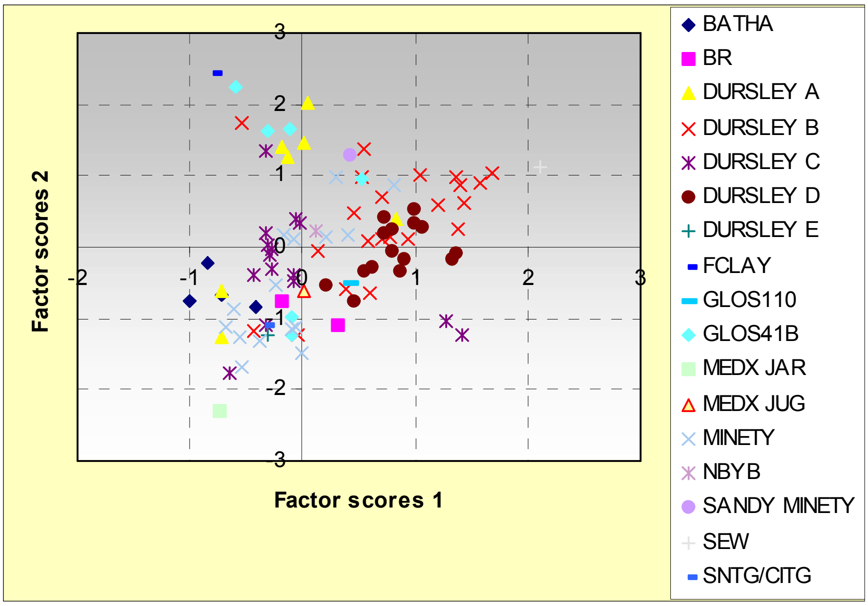

Figure 2

However, neither of these elements plays a major part in the calculation of the F1 scores, which may therefore be more useful and the Southeast Wiltshire sample has a higher F1 score than any of the remaining samples. A plot of F3 against F4 scores (Fig 3) separates most of the Minety samples from the remainder, and most of the Dursley C samples. The tin-glazed import, the fired clay, the Gloucester TF110, and the Bristol Medieval ware samples are all separated clearly from the remainder. Within the main cluster, there is an overlap between most of the fabric groups, and in particular Dursley B and Dursley D fabrics, confirming the petrological analysis, which suggests that the two fabrics are very similar.

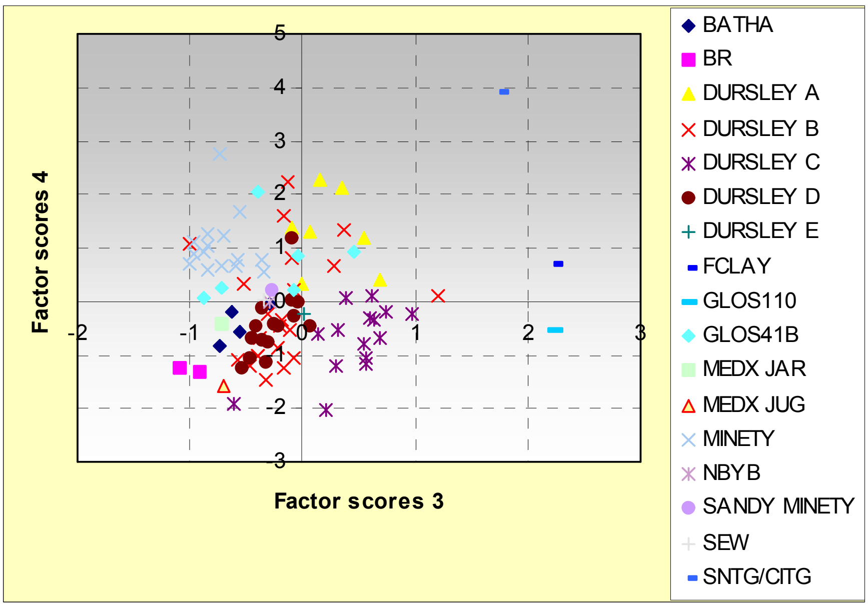

Figure 3

A plot of F5 against F6 separates the unsourced jar, the Bristol Medieval samples and the tin-glazed import from the remainder, all having high F6 scores. High F5 scores distinguish the Bath Fabric A samples but also separates the fired clay, two Dursley A samples and a Gloucester TF41B sample from the remainder, all of which form a single cluster.

It is therefore possible to distinguish several of these wares from each other and the remainder of the samples by the use of factor analysis. The distinguished samples include the fired clay, the South-east Wiltshire sample, the Minety ware, Gloucester TF110, the Bristol Medieval ware, the Bath Fabric A samples, the tin-glazed import and the unsourced jar. The analysis fails to distinguish the Newbury B sample, the Sandy Minety ware and the unsourced jug. In the first two of these cases, the petrological evidence is clear and there is no doubt that these are non-local vessels but in the third, the unsourced jug, the chemical data suggests that the sample may be locally-produced. The fact that the fired clay could be easily distinguished from all of the samples suggested that none of these local fabrics was produced from the same clay, discounting production in Dursley itself.

The analysis was then repeated, omitting the non-local and imported vessels distinguished in the first factor analysis and omitting the Calcium and Strontium values. Since several thin sections indicate phosphate deposition in the pores of the vessels post-burial, Phosphorus was also omitted. This analysis found four factors, accounting for % of the variability in the dataset.

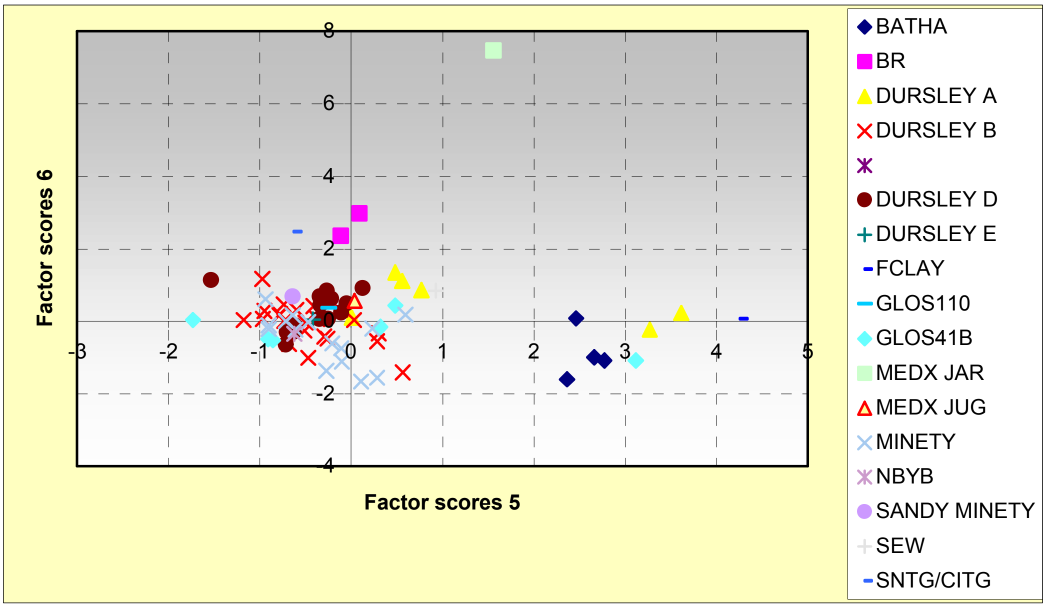

Figure 4

A plot of F1 against F2 in this second analysis (Fig 5) distinguished the Minety and Sandy Minety samples from the remainder whilst showing that the F2 scores for Gloucester TF41B are lower than those of the local Dursley fabrics but higher than the Minety/Sandy Minety samples.

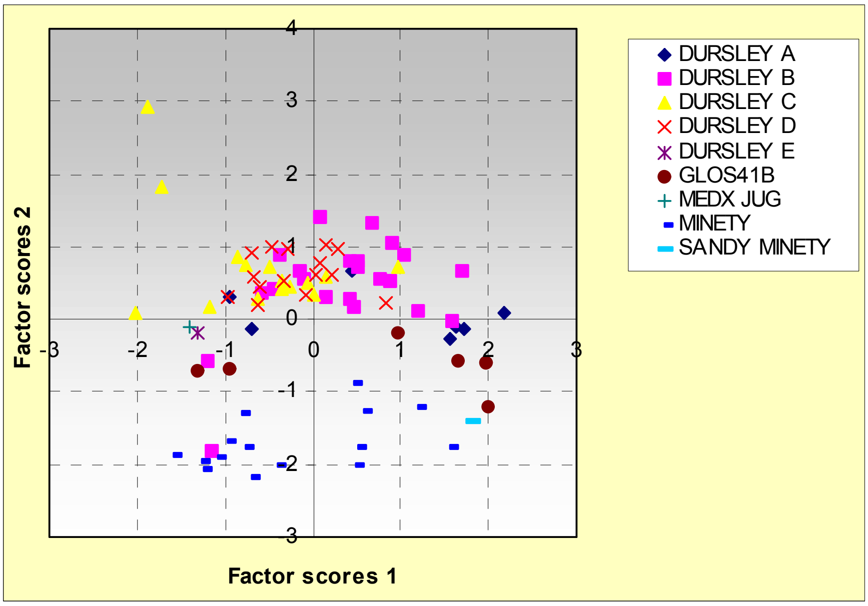

Figure 5

A plot of F3 against F4 scores shows that F3 scores separate the Dursley C and Dursley E samples from the remainder (bar two) and F4 scores separate the Dursley A samples from most of the remainder. High F3 scores are due mainly to Chromium and Vanadium and low F3 scores are due to high Potassium values. High F4 scores are due to high Zirconium values, which indicates that the silt inclusions in Dursley A ware include Zircon grains.

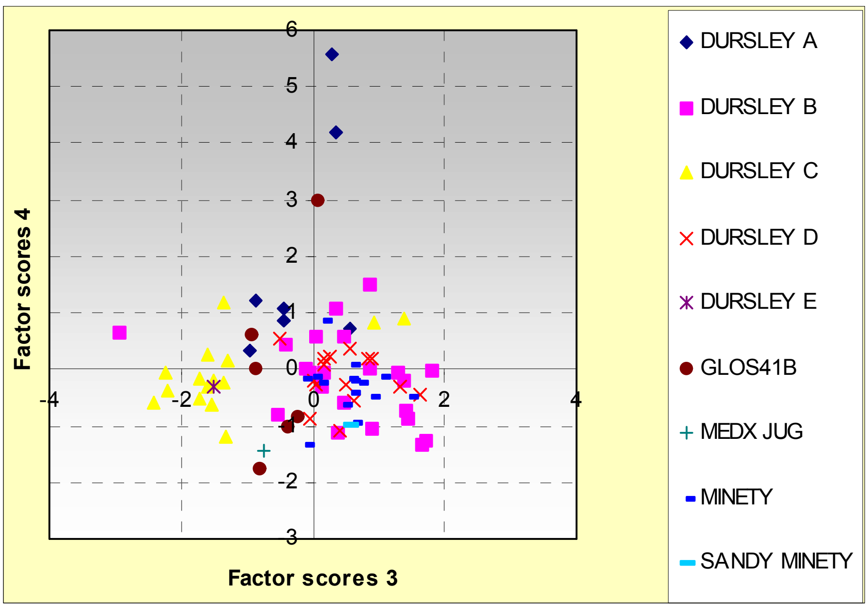

Figure 6

The results of this second analysis can be summarised by plotting F2 against F3 scores (Fig 7). This shows that Minety wares can be clearly distinguished from local fabrics (with one exception, which may well be a Minety product mis-identified as Dursley Fabric B. Most of the sandy Dursley Fabric C samples form a discrete cluster, with two exceptions which form a separate group distinguished by both their F2 and F3 scores. The Gloucester TF412B samples overlap with the Dursley A samples but have lower F2 scores and there is very little difference at all between Dursley B and Dursley D samples. The unsourced jug plots in Fig 7 close to the Gloucester TF41B and Dursley A samples, and this may suggest a local origin.

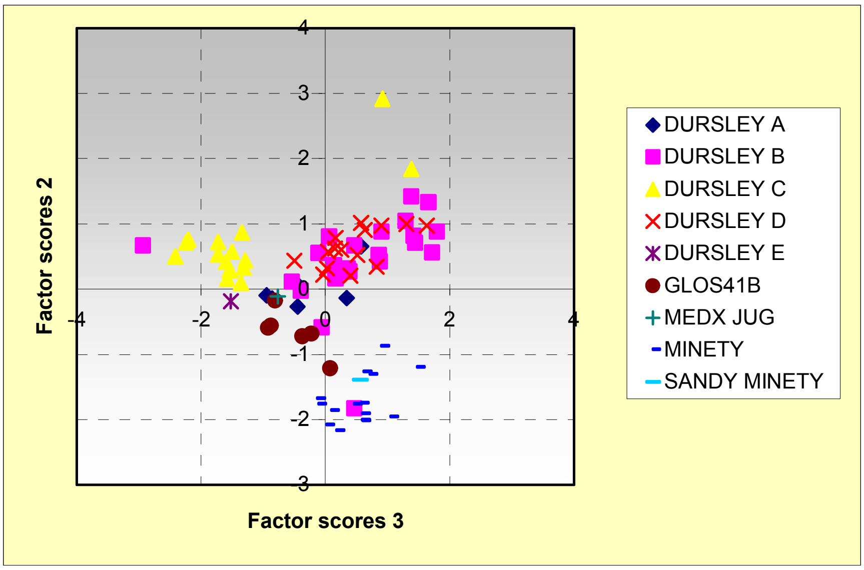

Figure 7

Tin-Glazed Import

The data from the ICP analysis of the tin-glazed vessel was compared with that from the British Museum's study of maiolica from sites in north-west Europe (Hughes and Gaimster 1999), which was undertaken using Neutron Activation Analysis. Only a small number of elements were common to both methods of analysis and the oxides had to be converted to element values. Nevertheless, a Factor Analysis of this data, together with a small number of ICP analyses of British finds revealed two factors. A plot of F1 against F2 for this data separated samples of Norwich tin-glazed ware from the remainder and separated most examples of Italian maiolicas (CITG) from the rest. This left a large cluster containing mainly samples of Low Countries and British origin (Antwerp, Amsterdam, Utrecht, Haarlem and London). The Dursley sample plotted with the Low Countries vessels (Fig 8). On this evidence, it would appear to be a Low Countries product.

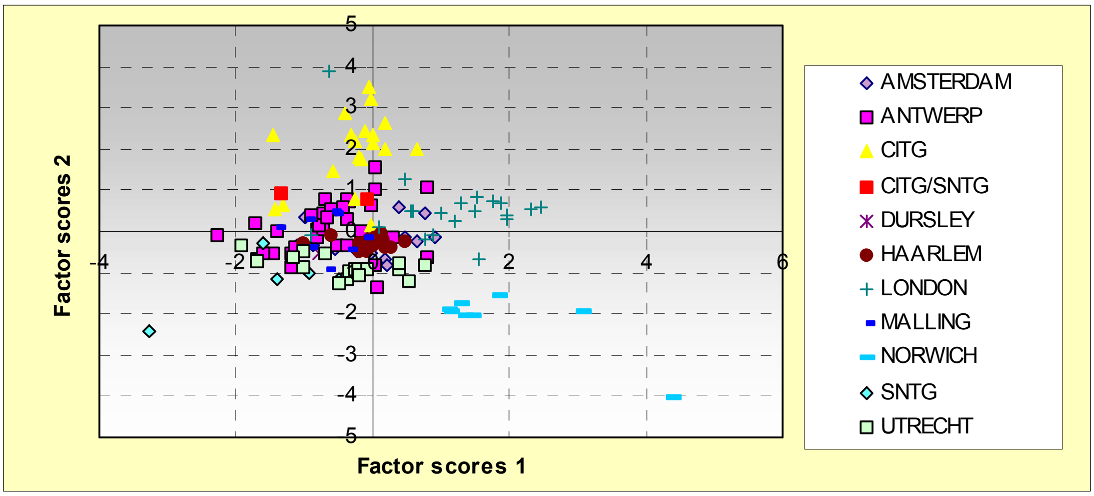

Figure 8

The analysis was then repeated, omitting the Italian and London samples and a plot of F1 against F2 for this data shows that there is a large amount of overlap in composition between the groups but that the Dursley sample is most similar to Amsterdam maiolica (Fig 8).

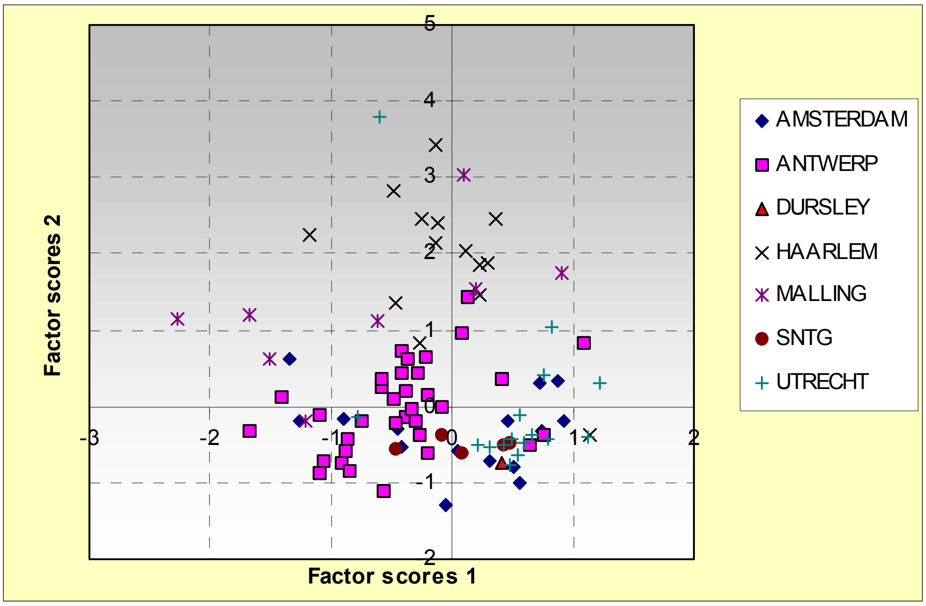

Figure 9

Conclusions

The thin section and chemical analyses indicate that the there are a series of wares present at Dursley which can be distinguished from Gloucester TF41B and Minety wares both in thin section and by their chemical composition. They consist of two fabrics with mixed limestone sand temper and silty groundmasses: Dursley A and Dursley D wares. The chemical composition of these two groups distinguishes them from each other. This distinction is due in part to the presence of higher Zircon in Fabric A. There are also two local fabrics made from clays with few inclusions in the groundmass. Fabric C contains a sandstone-derived quartz sand, probably coming from a source close to the outcrop of the Old Red Sandstone Quartz Conglomerate whilst Fabric B contains a mixed limestone sand, identical to that in Fabric A. The chemical analysis clearly separates these two groups from each other, but the Fabric B and Fabric D samples are similar in chemical composition. In this case, therefore, the additional quartz silt found in Fabric D does not seem to have any effect on the composition, since the dilution effect of the silica has been countered by normalising the data. The one Fabric E sample has characteristics which combine features found in Fabric C and the mixed limestone sand-tempered fabrics whilst its chemical composition places it closer to Fabric C, but still separate from that group.

Whether Dursley Fabrics A to E come from five separate localities, exploiting similar raw materials, or come from few centres which were using clays and sands of different origin (as the Fabric E evidence might suggest) cannot be determined without either carrying out geological fieldwork in the area or finding archaeological evidence for production. It would certainly be worthwhile to examine samples of local superficial calcareous sands and Jurassic clays but even without this evidence we can say that Dursley was indeed supplied with pottery from local sources which did not supply the major centres in the area (such as Bristol, Gloucester or Cirencester).

The tin-glazed import was shown in thin section to be rather different in fabric from samples made in Antwerp and London, pointing to an Italian origin. However, the ICP analysis shows that it is probably not Italian and suggests instead that it may be a product of the Amsterdam industry, whose wares have not been studied in thin section.

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Appendix 1

TSNO	Sitecode	Context	REFNO	cname	Form	Action	Description
V2891	STGCM 2003.19	4672		FCLAY	HEARTH LINING	TS;ICPS	BLACK FUEL ASH GLAZE ON SURFACE
V2892	STGCM 2003.19	4570		GLOS110	JAR	TS;ICPS	HM
V2893	STGCM 2003.19	4205		GLOS41B	JAR	ICPS	EVERTED ROUNDED RIM
V2894	STGCM 2003.19	4261		GLOS41B	JAR	TS;ICPS	EVERTED RIM
V2896	STGCM 2003.19	4441		GLOS41B	WCV	ICPS	
V2898	STGCM 2003.19	4556		GLOS41B	JAR	ICPS	EVERTED FLAT-TOPPED EXT THICKENED RIM
V2899	STGCM 2003.19	4244		DURSLEY B	JAR	ICPS	SAGGING BASE;GLOB BODY
V2900	STGCM 2003.19	4354		DURSLEY B	JAR	ICPS	
V2901	STGCM 2003.19	4460		DURSLEY A	JAR	ICPS	
V2902	STGCM 2003.19	4476		DURSLEY A	JAR	TS;ICPS	
V2903	STGCM 2003.19	4489		DURSLEY B	JAR	DR;TS;ICPS	ROLLED OUT TRIANGULAR RIM
V2904	STGCM 2003.19	4570		DURSLEY A	JAR	TS;ICPS	
V2905	STGCM 2003.19	4603		DURSLEY A	JAR	ICPS	
V2906	STGCM 2003.19	4603		DURSLEY B	JAR	TS;ICPS	
V2907	STGCM 2003.19	4661		DURSLEY B	JAR	TS;ICPS	WT
V2908	STGCM 2003.19	4684		DURSLEY B	JAR	ICPS	
V2909	STGCM 2003.19	4261		DURSLEY B	JAR	DR; TS; ICPS	EVERTED RIM WITH TWO THUMB IMPRESSIONS SIDE-BY-SIDE
V2910	STGCM 2003.19	4262		DURSLEY B	JAR	ICPS	HM
V2911	STGCM 2003.19	4298		DURSLEY B	RIDGE	TS;ICPS	
V2912	STGCM 2003.19	4332		DURSLEY B	RIDGE?	ICPS	SINGLE GROOVE DEC
V2913	STGCM 2003.19	4353		DURSLEY B	JAR/BOWL	ICPS	HM;INT PLAIN GL
V2914	STGCM 2003.19	4430		DURSLEY B	JAR	DR;ICPS	EVERTED BEADED RIM
V2915	STGCM 2003.19	4430		MINETY	JAR	ICPS	EXT GL

TSNO	Sitecode	Context	REFNO	cname	Form	Action	Description
V2916	STGCM 2003.19	4437		DURSLEY B	JAR	ICPS	
V2917	STGCM 2003.19	4441		BATHA	JAR	DR;ICPS	EVERTED RIM
V2918	STGCM 2003.19	4441		DURSLEY A	JAR	DR;TS;ICPS	HM;GLOB BODY;EVERTED RIM
V2919	STGCM 2003.19	4544		DURSLEY B	JAR	DR;TS;ICPS	WT;EVERTED TRIANG RIM;GLOB BODY
V2920	STGCM 2003.19	4558		DURSLEY B	JAR	DR;TS;ICPS	WT?;ROLLED-OUT HOOKED RIM
V2921	STGCM 2003.19	4558		DURSLEY A	JUG	DR;TS;ICPS	ROD HANDLE
V2922	STGCM 2003.19	4570		DURSLEY B	JAR	DR;TS;ICPS	HM;EVERTED HOOKED RIM
V2923	STGCM 2003.19	4570		DURSLEY B	JAR	ICPS	HM;GLOB BODY
V2924	STGCM 2003.19	4570		MINETY	JAR	ICPS	HM;INT PLAIN GL
V2925	STGCM 2003.19	4650		DURSLEY B	PANC/CURF	DR;TS;ICPS	HM;V LARGE VESSEL WITH THUMBED EVERTED, THICKENED RIM
V2926	STGCM 2003.19	4650		DURSLEY B	JAR	ICPS	HM;GLOB BODY
V2927	STGCM 2003.19	4205		DURSLEY D	JUG/JAR	TS;ICPS	GLAZE SPOTS EXT
V2928	STGCM 2003.19	4244		DURSLEY B	JAR	TS;ICPS	HM
V2929	STGCM 2003.19	4262		DURSLEY C	JAR	TS;ICPS	HM
V2930	STGCM 2003.19	4262		DURSLEY B	JAR	TS;ICPS	HM;GLOB BODY
V2931	STGCM 2003.19	4280		DURSLEY C	JAR	DR;TS;ICPS	ROLLED OUT SQUARED RIM;HM
V2932	STGCM 2003.19	4558		DURSLEY C	PANC	DR;TS;ICPS	
V2933	STGCM 2003.19	4558		BATHA	JAR	ICPS	
V2934	STGCM 2003.19	4558		DURSLEY C	JAR	ICPS	
V2935	STGCM 2003.19	4650		MEDX	JAR	TS;ICPS	WT;SAGGING BASE WITH INT PLAIN GL;BODY UNGLAZED
V2936	STGCM 2003.19	4650		DURSLEY C	JAR	DR;TS;ICPS	HM;EVERTED INFOLDED RIM
V2937	STGCM 2003.19	4650		DURSLEY C	JAR	ICPS	HM;SAGGING BASE
V2938	STGCM 2003.19	4650		DURSLEY C	JAR	ICPS	HM
V2939	STGCM 2003.19	4650		DURSLEY C	JAR	ICPS	HM
V2940	STGCM	4670		BATHA	JAR	TS;ICPS	

TSNO	Sitecode	Context	REFNO	cname	Form	Action	Description
	2003.19						
V2941	STGCM 2003.19	4298		DURSLEY C	JAR	TS;ICPS	
V2942	STGCM 2003.19	4441		DURSLEY C	JAR	DR;TS;ICPS	EVERTED BEAD RIM
V2943	STGCM 2003.19	4460		DURSLEY C	JAR	DR;TS;ICPS	ROLLED OUT INFOLDED RIM
V2944	STGCM 2003.19	4460		DURSLEY C	JAR	TS;ICPS	
V2945	STGCM 2003.19	4460		DURSLEY C	JAR	ICPS	
V2946	STGCM 2003.19	4467		DURSLEY C	JAR	TS;ICPS	
V2947	STGCM 2003.19	4571		DURSLEY D	JUG	DR;TS;ICPS	PLAIN STRAP;43MM WIDE;EXT WHITE SLIP AND SPLASHED PLAIN GL;HM
V2948	STGCM 2003.19	4406		SANDY MINETY	JUG	TS;ICPS	WT?;HORIZ GROOVES;PLAIN GL EXT
V2949	STGCM 2003.19	4489		DURSLEY D	JUG	DR;TS;ICPS	FLAT TOPPED THICKENED RIM;STRAP HANDLE WITH THUMBING ON EDGE;R/H PLUGGED;UNGLAZED
V2950	STGCM 2003.19	4558		DURSLEY D	JUG	ICPS	WT?;UNGLAZED
V2951	STGCM 2003.19	4558		DURSLEY D	JUG	ICPS	HM;PLAIN SPLASHED GL EXT
V2952	STGCM 2003.19	4558		DURSLEY D	JAR	ICPS	PLAIN INT GL
V2953	STGCM 2003.19	4558		DURSLEY D	JUG	ICPS	HM;EXT PLAIN GL;BROWN PAINTED LINES
V2954	STGCM 2003.19	4570		DURSLEY D	JUG	DR;TS;ICPS	HM;FLAT TOPPED RIM;EXT PLAIN GL;PULLED SPOUT
V2955	STGCM 2003.19	4570		DURSLEY D	JUG	DR;TS;ICPS	HM;FLAT TOPPED RIM;APPLIED THUMBED STIP BELOW RIM;EXT PLAIN GL
V2956	STGCM 2003.19	4570		DURSLEY D	JUG	ICPS	HM;BROWN PAINTED LINES;PLAIN EXT GL
V2957	STGCM 2003.19	4650		DURSLEY D	JUG	ICPS	HM;PLAIN EXT GL
V2958	STGCM 2003.19	4650		DURSLEY D	BOWL/JAR	ICPS	HM;SAGGING BASE;INT PLAIN GL
V2959	STGCM 2003.19	4650		DURSLEY D	JUG	ICPS	HM;GLOB BODIED WITH INTERMITTENT THUMBING;PLAIN EXT GL
V2960	STGCM 2003.19	4650		DURSLEY D	JUG	DR;TS;ICPS	HM;THUMBED, SAGGING BASE;EXT PLAIN GL
V2961	STGCM 2003.19	4670		DURSLEY D	JAR/JUG	DR;TS;ICPS	NARROW STRAP;PLUGGED THROUGH BODY;NO SIGN OF GLAZE

TSNO	Sitecode	Context	REFNO	cname	Form	Action	Description
V2962	STGCM 2003.19	4280		DURSLEY E	JUG	TS;ICPS	LARGE SQUAT?;THUMBED BASE;EXT SPLASHED GL (LEAD GLOBULES)
V2963	STGCM 2003.19	4441		WORCS	JUG	DR;TS;ICPS	APPLIED THUMBED FRILL AROUND BASE;EXT PLAIN GL
V2964	STGCM 2003.19	4566		DURSLEY A	JAR	TS;ICPS	HM
V2965	STGCM 2003.19	4566		DURSLEY C	JAR	TS;ICPS	HM
V2966	STGCM 2003.19	4570		BR	JUG	TS;ICPS	EXT CUGL;STRAP HANDLE
V2967	STGCM 2003.19	4650		BR	JUG	TS;ICPS	WT;EXT CUGL;HORIZ GROOVES
V2968	STGCM 2003.19	4650		SEW	TP	TS;ICPS	HM;PLAIN EXT GL
V2969	STGCM 2003.19	4259		MINETY	FLANGED BOWL	ICPS	PATCHY PLAIN INT GL
V2970	STGCM 2003.19	4430		MINETY	CIST?	ICPS	WIDE EVERTED FLAT-TOPPED RIM;STRAP HANDLE;7 SLASHES AT R/H AND DIAG SLASHES DOWN BACK OF HANDLE;PLAIN GL SPLASHES INT AND EXT
V2971	STGCM 2003.19	4544		MINETY	JAR	DR;TS;ICPS	WT;GLOB BODY;EVERTED RIM THICKENED WITH GROOVE;UNGLAZED
V2972	STGCM 2003.19	4558		MINETY	JAR	DR;TS;ICPS	WT;ROLLED OUT MOULDED RIM;PLAIN GLAZE ON INT RIM ONLY
V2973	STGCM 2003.19	4650		MINETY	JAR	DR;ICPS	HM?;EVERTED HOOKED RIM;DIAG COMBED LINES;PLAIN GL ON INSIDE OF RIM
V2974	STGCM 2003.19	4650		MINETY	JAR	ICPS	HM?;EVERTED HOOKED RIM;DIAG COMBED LINES;PLAIN GL ON INSIDE OF RIM
V2975	STGCM 2003.19	4650		MINETY	TP	DR;TS;ICPS	HORIZ WAVY COMBED LINES WITH VERTICAL COMBED LINES OVER;EXT PLAIN GL
V2976	STGCM 2003.19	4650		MINETY	TP	DR;TS;ICPS	ROLLED-OUT FLAT-TOPPED RIM;GROOVES ON NECK;PULLED SPOUT;CROSSHATCHED COMBING ON BODY;EXT PLAIN GL AND INT GL DRIBBLES
V2977	STGCM 2003.19	4655		MINETY	JUG	ICPS	STRAIGHT WALLED NEAR BASE, CURVING IN AT SHOULDER;PLAIN GL ON UPPER BODY
V2978	STGCM 2003.19	4666		MINETY	JUG	ICPS	STRAP HANDLE;R/H PLUGGED;TWO COLUMNS OF KNIFE

TSNO	Sitecode	Context	REFNO	cname	Form	Action	Description
							STAB MARKS
V2979	STGCM 2003.19	4668		MINETY	JAR	ICPS	WT?;EVERTED HOOKED RIM;VERT COMBED LINES;PLAIN GL ON INSIDE OF RIM
V2980	STGCM 2003.19	4692		MINETY	JAR	DR;TS;ICPS	WT;GLOB BODY;EVERTED HOOKED RIM;DIAG COMBING EXT;PLAIN GL EXT AND INT RIM
V2981	STGCM 2003.19	4566		NBYB	BOWL	DR;TS;ICPS	INT RIM
V2982	STGCM 2003.19	4581		SNTG/CITG	PLATE	DR;TS;ICPS	LIGHT AND DARK BLUEFLORAL DEC, PROBABLY PARALLELED IN 16TH-CENTURY ANTWERP
V2983	STGCM 2003.19	4441		GLOS41B	JAR	ICPS	
V2984	STGCM 2003.19	4587		MINETY	JAR	ICPS	EXT PLAIN GL;WT
V2985	STGCM 2003.19	4558		DURSLEY B	JAR	ICPS	GLAZE SPOTS EXT
V2986	STGCM 2003.19	4261		BATHA	JAR	ICPS	
V2987	STGCM 2003.19	4123		GLOS41B	JAR	ICPS	

Appendix 2

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V2891	11.96	6.49	1.06	2.03	0.61	3.43	0.70	0.31	0.06
V2892	12.73	6.50	2.90	1.80	0.28	3.84	0.49	0.39	0.14
V2893	16.14	5.13	1.29	16.39	0.27	2.00	0.67	0.69	0.03
V2894	14.64	4.89	1.17	16.58	0.25	1.79	0.63	0.56	0.04
V2896	13.46	4.87	1.01	12.41	0.24	2.13	0.62	1.43	0.05
V2898	12.70	3.77	0.67	15.25	0.29	1.93	0.67	1.72	0.03
V2899	11.71	5.64	1.04	20.78	0.20	2.29	0.52	0.80	0.05
V2900	15.95	6.11	1.25	13.19	0.38	2.41	0.70	1.28	0.08
V2901	12.69	5.80	0.71	10.80	0.35	1.89	0.67	1.17	0.05
V2902	15.00	5.50	1.14	11.50	0.38	2.39	0.70	0.58	0.11
V2903	17.47	6.14	1.32	12.33	0.29	2.62	0.69	1.89	0.06
V2904	13.24	4.84	1.05	13.82	0.35	2.23	0.64	1.46	0.07
V2905	13.78	5.39	0.90	12.78	0.27	2.09	0.67	4.15	0.10
V2906	11.21	5.23	0.93	23.79	0.23	1.91	0.49	1.09	0.05
V2907	14.75	8.02	1.34	13.95	0.27	2.70	0.62	3.20	0.07

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V2908	13.61	3.22	0.77	16.63	0.19	2.12	0.60	0.61	0.03
V2909	12.30	6.55	1.37	12.86	0.17	2.15	0.53	0.88	0.09
V2910	11.12	5.27	1.18	16.66	0.19	2.05	0.49	0.67	0.06
V2911	15.31	7.62	1.12	5.61	0.28	2.07	0.67	0.65	0.06
V2912	17.47	8.51	1.43	6.45	0.27	2.37	0.76	0.64	0.08
V2913	19.84	9.56	1.58	3.23	0.33	2.68	0.86	0.52	0.12
V2914	20.24	8.30	1.48	4.01	0.41	2.94	0.84	0.94	0.05
V2915	13.34	3.20	0.82	10.38	0.25	2.11	0.57	0.88	0.02
V2916	15.79	6.12	1.78	11.44	0.26	2.87	0.69	0.25	0.06
V2917	11.73	3.47	0.76	1.44	0.14	1.90	0.56	0.85	0.02
V2918	13.00	4.98	1.00	11.70	0.26	2.10	0.62	2.04	0.05
V2919	19.85	10.46	1.39	4.77	0.31	2.54	0.83	0.65	0.12
V2920	19.26	9.40	1.43	5.17	0.31	2.68	0.81	0.89	0.10
V2921	13.51	5.81	1.24	11.02	0.28	2.60	0.61	0.94	0.07
V2922	19.08	9.11	1.39	5.74	0.29	2.45	0.79	0.74	0.09
V2923	16.74	8.63	1.36	8.46	0.30	2.53	0.68	1.62	0.09
V2924	15.81	4.22	1.08	15.83	0.28	2.42	0.69	0.40	0.03
V2925	17.77	8.59	1.47	8.32	0.30	2.68	0.75	0.83	0.12
V2926	19.83	9.20	1.48	5.99	0.41	2.75	0.84	0.46	0.08
V2927	15.82	5.92	1.39	8.13	0.34	3.08	0.67	1.19	0.06
V2928	14.98	7.09	1.17	9.67	0.36	2.58	0.65	0.78	0.06
V2929	15.30	13.24	1.22	1.13	0.32	2.40	0.66	0.48	0.03
V2930	13.34	5.32	1.90	7.51	0.34	2.65	0.55	0.21	0.08
V2931	15.33	5.89	1.73	7.94	0.28	3.36	0.67	0.45	0.10
V2932	12.61	5.17	1.35	7.92	0.33	2.87	0.55	0.43	0.11
V2933	13.21	4.47	0.92	1.25	0.21	2.18	0.62	0.37	0.01
V2934	13.11	5.24	1.48	10.79	0.27	2.93	0.57	0.32	0.12
V2935	17.53	4.22	0.86	1.27	0.21	2.38	0.80	0.29	0.02
V2936	13.32	5.72	1.13	0.95	0.32	2.75	0.67	0.46	0.04
V2937	14.36	6.38	1.62	0.80	0.36	2.76	0.64	0.13	0.09
V2938	13.89	5.79	1.55	2.59	0.33	2.95	0.63	0.31	0.06
V2939	14.35	5.79	1.54	4.00	0.27	3.16	0.62	0.78	0.10
V2940	11.31	3.81	0.79	1.23	0.19	2.08	0.49	1.04	0.02
V2941	13.91	5.50	1.57	6.44	0.40	3.02	0.62	0.34	0.08
V2942	15.82	6.25	1.73	1.09	0.28	3.03	0.71	0.22	0.08
V2943	14.35	5.76	1.51	6.74	0.27	3.04	0.62	1.17	0.08
V2944	12.51	5.07	1.30	5.78	0.36	2.50	0.51	1.02	0.06
V2945	13.75	5.64	1.52	1.43	0.37	2.75	0.59	0.80	0.05
V2946	14.27	5.99	1.80	0.92	0.31	2.91	0.63	0.29	0.07
V2947	14.51	6.41	1.31	9.74	0.29	2.64	0.65	0.56	0.06

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V2948	14.09	3.49	0.85	3.28	0.24	2.20	0.61	0.54	0.02
V2949	14.63	5.61	1.32	10.06	0.35	2.83	0.64	0.77	0.07
V2950	16.84	6.32	1.61	8.92	0.31	3.17	0.72	0.69	0.05
V2951	15.87	7.24	1.62	9.24	0.33	2.97	0.68	0.50	0.07
V2952	19.12	9.84	1.41	7.10	0.40	2.61	0.82	0.49	0.10
V2953	16.69	6.38	1.56	7.81	0.32	3.03	0.74	0.65	0.06
V2954	14.73	5.72	1.40	8.73	0.33	2.76	0.66	0.79	0.05
V2955	17.21	8.26	1.41	5.25	0.33	2.79	0.74	1.48	0.10
V2956	15.49	5.86	1.40	6.51	0.33	2.90	0.66	0.76	0.06
V2957	14.47	6.89	1.22	7.91	0.29	2.78	0.58	1.66	0.08
V2958	18.40	9.44	1.35	5.99	0.37	2.68	0.78	0.72	0.07
V2959	20.08	8.95	1.52	4.76	0.32	2.72	0.87	0.55	0.08
V2960	14.52	5.94	1.29	8.53	0.27	2.60	0.62	1.02	0.06
V2961	11.90	5.04	1.02	11.12	0.25	2.23	0.26	2.62	0.07
V2962	14.16	5.04	1.39	5.49	0.22	3.45	0.59	1.02	0.04
V2963	16.71	6.17	1.14	1.07	0.14	4.14	0.75	0.46	0.02
V2964	10.45	5.18	0.67	11.78	0.35	1.78	0.55	1.17	0.05
V2965	16.37	14.01	1.45	0.99	0.46	3.14	0.73	0.31	0.10
V2966	22.12	3.97	1.34	1.07	0.20	3.42	1.06	0.24	0.03
V2967	19.72	3.88	1.35	0.93	0.21	3.44	1.06	0.17	0.03
V2968	12.08	8.55	0.60	1.50	0.23	2.00	0.55	1.33	0.04
V2969	15.53	4.71	0.99	12.69	0.25	2.14	0.68	0.70	0.06
V2970	17.01	3.89	1.04	13.95	0.24	2.40	0.72	0.48	0.03
V2971	16.25	3.70	0.89	12.91	0.22	2.56	0.71	0.97	0.03
V2972	15.68	4.22	0.86	15.74	0.25	2.29	0.69	0.62	0.03
V2973	14.95	2.79	0.80	16.76	0.20	2.32	0.67	0.49	0.03
V2974	13.78	3.09	0.83	19.19	0.18	2.09	0.61	0.61	0.03
V2975	15.02	3.39	0.86	15.88	0.19	2.31	0.68	0.50	0.03
V2976	14.17	3.02	0.78	15.67	0.17	2.17	0.63	0.95	0.03
V2977	14.24	3.15	0.90	19.16	0.23	2.13	0.60	0.97	0.04
V2978	13.28	3.00	0.85	19.38	0.20	2.02	0.56	0.95	0.04
V2979	14.92	3.38	0.77	14.75	0.21	2.19	0.64	1.36	0.03
V2980	12.83	3.09	0.64	18.96	0.16	2.02	0.58	2.89	0.03
V2981	14.46	4.93	1.18	5.29	0.11	2.68	0.47	0.89	0.02
V2982	12.90	4.56	2.54	20.77	0.58	1.12	0.57	0.68	0.10
V2983	15.00	5.66	1.08	10.92	0.47	2.38	0.35	1.82	0.06
V2984	16.39	3.75	1.13	14.30	0.26	2.66	0.71	0.69	0.03
V2985	18.48	10.18	1.46	6.41	0.56	2.76	0.76	0.51	0.08
V2986	12.86	3.84	0.94	1.02	0.23	2.06	0.62	0.53	0.01
V2987	13.08	4.45	1.00	13.08	0.29	2.19	0.63	0.59	0.06

Appendix 3

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V2891	403	78	17	44	35	10	88	77	27	86	39	72	41	9	1	5	3	138	69	23
V2892	447	88	18	54	46	13	106	114	17	54	30	52	33	6	1	4	2	50	98	19
V2893	285	102	26	99	47	14	284	104	21	61	37	62	39	6	1	4	3	62	102	10
V2894	268	92	23	81	44	13	241	94	20	55	34	64	36	5	1	4	3	28	96	10
V2896	304	86	21	85	43	12	246	78	27	66	43	77	45	8	1	5	3	25	79	12
V2898	262	84	24	26	26	12	262	94	20	94	45	78	46	9	2	4	3	1,358	76	7
V2899	245	84	20	41	41	11	298	110	19	60	31	51	32	4	1	3	2	48	94	9
V2900	285	109	39	91	59	15	231	127	26	65	45	79	47	8	1	6	3	36	90	15
V2901	328	85	26	34	30	12	207	100	14	94	35	59	36	5	1	3	2	32	77	9
V2902	330	90	43	69	59	14	175	91	29	66	46	87	48	9	1	5	3	45	83	18
V2903	355	113	42	57	55	16	244	135	23	72	42	66	43	7	1	4	3	35	91	12
V2904	331	81	43	82	48	12	219	80	26	67	41	73	43	7	1	5	3	27	95	14
V2905	322	86	24	67	47	12	378	85	28	69	43	87	45	9	1	5	3	26	135	15
V2906	236	81	21	48	36	10	395	89	18	52	32	54	33	5	1	3	2	19	98	10
V2907	313	98	37	70	51	14	304	99	23	52	36	58	38	7	1	4	3	32	146	14
V2908	256	105	29	32	27	13	219	101	18	70	34	56	35	5	1	3	2	27	63	4
V2909	266	84	27	55	49	11	199	93	22	57	33	53	35	6	1	4	3	24	113	12
V2910	224	79	35	49	41	10	192	73	23	52	32	55	35	6	1	5	2	20	72	11
V2911	359	123	29	102	58	14	165	120	26	59	45	74	47	9	1	6	3	57	116	15
V2912	402	129	31	139	65	16	228	132	25	59	48	80	49	10	1	5	3	108	126	19
V2913	350	157	29	138	78	19	132	160	27	65	52	94	54	11	2	6	3	2,912	141	25
V2914	370	138	33	131	81	19	159	151	32	74	56	105	59	12	2	7	4	126	151	25
V2915	253	103	34	42	50	13	219	87	19	66	32	54	33	5	1	3	2	124	95	10
V2916	271	103	28	122	54	15	154	114	29	65	49	83	52	10	2	5	3	45	79	15
V2917	273	74	17	46	26	10	127	105	12	65	33	64	34	5	1	3	2	67	61	12
V2918	346	81	21	69	42	12	276	81	25	69	41	69	43	8	1	5	3	26	110	10
V2919	348	171	35	138	90	20	163	152	29	69	56	110	59	12	2	7	4	123	177	44
V2920	365	154	39	121	91	19	162	156	31	76	54	95	57	11	2	6	4	83	161	29
V2921	293	103	29	84	47	13	241	111	22	61	38	63	40	7	1	5	3	180	112	12
V2922	327	161	38	137	90	19	157	153	32	70	57	87	60	12	2	7	4	103	157	23
V2923	338	146	32	116	67	17	223	138	29	74	48	84	51	11	2	6	4	432	146	19
V2924	276	137	40	65	63	16	237	114	32	77	48	71	50	9	2	5	3	498	140	10
V2925	321	149	32	128	70	17	233	149	30	78	52	89	55	11	2	6	4	228	152	24
V2926	343	152	43	159	86	20	137	158	32	75	55	93	58	12	2	7	4	449	168	26
V2927	418	111	32	107	49	14	287	113	22	67	40	61	42	7	1	4	3	289	122	15
V2928	325	100	22	109	49	14	222	103	23	58	40	65	42	8	1	5	3	39	111	13
V2929	328	110	29	134	55	15	119	140	15	57	40	57	41	8	1	3	3	39	86	16
V2930	422	84	24	47	45	11	155	75	24	52	44	64	46	8	1	5	3	38	49	16

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V2931	262	92	29	89	49	14	125	100	22	59	40	61	42	7	1	4	3	29	71	15
V2932	231	75	21	64	42	11	111	77	22	50	40	64	41	7	1	4	2	29	55	16
V2933	263	86	22	48	35	11	91	141	12	67	34	64	35	6	1	3	2	50	60	11
V2934	226	77	25	79	42	11	133	77	21	48	36	55	38	6	1	4	2	30	50	14
V2935	719	99	150	209	42	15	151	91	17	84	44	67	44	4	1	3	2	200	152	10
V2936	298	80	25	67	33	12	86	79	14	63	29	42	30	4	1	3	2	43	64	14
V2937	267	88	26	79	50	13	70	93	18	53	35	62	37	7	1	4	2	41	76	17
V2938	266	89	27	62	48	12	92	88	19	53	37	59	39	7	1	4	2	37	58	18
V2939	305	90	28	67	53	13	145	94	23	58	41	60	43	8	1	4	3	29	69	19
V2940	313	74	25	40	29	10	125	98	11	62	30	54	31	5	1	2	2	40	68	11
V2941	260	81	25	82	45	12	124	86	19	47	36	56	38	6	1	4	2	38	61	17
V2942	295	96	26	101	57	15	85	104	24	54	46	73	47	8	1	5	2	114	63	22
V2943	313	86	25	62	47	13	207	85	20	57	33	49	35	5	1	4	2	31	76	15
V2944	292	78	28	49	45	11	167	76	18	50	32	48	34	6	1	4	2	32	66	14
V2945	315	86	22	53	55	13	126	90	20	60	38	58	39	6	1	4	2	28	60	17
V2946	293	87	22	76	51	13	87	93	19	54	39	60	40	7	1	4	2	45	57	20
V2947	311	110	30	117	47	13	214	117	22	57	40	63	42	8	1	5	3	4,222	105	15
V2948	296	102	38	55	61	14	135	87	33	65	44	73	46	8	1	5	3	227	117	16
V2949	339	108	27	115	47	14	244	111	24	57	41	66	43	8	1	4	3	251	127	13
V2950	322	118	32	110	54	15	238	134	23	67	41	66	43	7	1	5	3	81	140	14
V2951	294	141	29	127	54	16	249	141	23	58	42	67	44	9	1	5	3	706	121	15
V2952	350	142	25	128	73	18	149	146	27	68	48	80	50	10	1	6	3	184	131	22
V2953	334	126	28	135	54	16	224	136	24	64	46	71	48	8	1	5	3	534	134	15
V2954	324	105	27	114	47	14	207	115	22	59	41	66	43	8	1	5	3	3,670	129	13
V2955	409	127	36	105	71	17	205	138	27	71	47	82	49	10	1	6	3	471	156	22
V2956	330	109	26	117	51	14	192	119	21	58	40	65	41	8	1	4	3	187	144	12
V2957	335	122	28	102	49	13	266	117	23	61	39	65	41	8	1	5	3	721	126	15
V2958	344	153	32	124	76	18	155	160	29	67	48	81	50	10	1	6	3	64	148	24
V2959	370	123	30	143	67	20	147	148	29	70	50	88	53	10	2	6	3	101	143	22
V2960	289	109	39	104	48	14	225	119	22	61	39	65	41	7	1	5	3	31,993	122	13
V2961	321	88	27	58	40	11	292	85	21	45	34	58	36	6	1	4	2	378	106	10
V2962	314	86	28	68	43	12	157	87	19	55	32	51	34	5	1	4	2	144	103	11
V2963	396	80	20	185	45	17	286	118	17	52	46	71	46	7	1	4	2	307	122	13
V2964	253	74	27	29	25	10	204	88	14	86	29	42	30	3	1	3	2	44	76	8
V2965	317	111	28	155	63	16	114	148	19	58	36	62	38	8	1	4	3	60	126	26
V2966	451	86	89	161	55	22	145	148	27	80	57	86	58	10	2	5	3	2,948	238	16
V2967	440	118	73	159	57	20	128	143	23	78	46	73	47	9	2	5	3	2,962	266	20
V2968	284	120	36	39	49	12	152	128	25	60	36	54	38	8	1	5	3	2,733	116	18
V2969	331	117	36	63	61	16	243	107	29	71	44	70	46	8	1	5	3	287	114	14
V2970	310	107	40	76	63	16	271	111	39	74	49	74	51	7	1	5	3	186	103	12

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V2971	314	129	39	42	39	17	228	114	24	79	37	62	39	5	1	4	3	91	100	5
V2972	289	105	26	40	35	15	224	105	22	70	41	68	42	6	1	4	2	460	72	7
V2973	257	110	29	35	30	14	224	103	22	72	36	59	37	5	1	4	2	1,463	62	4
V2974	238	100	27	39	32	13	251	92	18	65	32	50	33	4	1	3	2	882	66	4
V2975	258	115	32	40	40	15	233	102	23	72	38	62	39	4	1	4	2	201	82	8
V2976	287	105	38	39	36	14	250	98	26	69	43	68	44	6	1	4	3	2,103	99	7
V2977	269	105	37	56	42	14	265	90	25	67	33	59	34	5	1	3	2	337	94	7
V2978	254	96	34	38	44	13	251	88	28	68	39	70	41	7	1	5	3	1,365	97	6
V2979	300	115	30	40	40	15	238	98	26	70	40	67	41	6	1	4	2	77	87	6
V2980	291	95	38	26	26	12	394	86	20	67	32	57	33	4	1	3	2	209	71	3
V2981	341	88	31	40	58	13	116	101	26	67	40	67	42	7	1	4	3	47	76	19
V2982	360	104	51	41	59	12	665	84	28	83	32	48	34	4	1	4	3	3,383	99	17
V2983	331	92	26	90	54	14	270	89	29	49	45	79	47	9	1	5	3	44	102	11
V2984	329	117	35	76	70	16	287	107	35	77	45	83	46	7	1	5	3	742	157	11
V2985	335	148	32	134	90	18	157	160	30	68	51	85	54	10	1	6	3	14,753	160	20
V2986	308	83	21	47	31	11	117	123	10	64	35	69	35	5	1	2	2	142	63	10
V2987	333	82	34	69	47	12	197	78	29	64	42	77	43	8	1	4	3	56	74	15