Appendix 1: Petrographic analysis, by P.S. Quinn

Background

As part of an English Heritage-funded project aimed at characterising the medieval Hedingham Ware pottery industry of North Essex, thin-section petrographic analysis has been conducted on a selection of coarse and fineware sherds. This analysis compliments hand-specimen fabric classification of material from the various Hedingham production sites, as well as answering specific questions about the raw materials and technology of this regionally important pottery industry. Details of the samples analysed and the aims of the analysis are given below.

Sample materials

A total of fifty sherds were submitted for analysis. These include both fine, glazed wares and coarsewares. The material comes from several of the production sites that have been discovered around Sible Hedingham, Gosfield and Halstead, including Hole Farm, Southey Green and Holy Trinity. The samples were chosen by Helen Walker based upon the hand-specimen fabric classification of a large corpus of Hedingham Ware pottery. A total of thirteen different fabrics are represented, with in most cases, five sherds from each (Tables 10 and 11). The samples were numbered 1–50 and have been given the prefix HD for the purpose of this analysis.

Aims of analysis

Petrographic analysis of the Hedingham pottery samples in this study was intended to compliment the hand-specimen fabric classification of the same material and contribute towards the establishment of a typology for this medieval ware in line with project research aims (see Chapter 1). Analysis was conducted within the confines of the already-established hand-specimen fabrics in order to characterise them in more detail, check their validity and examine their relationships to one another and other pottery wares. In this respect, specific questions were asked of many of the fabrics, in communication with Helen Walker (HW). These can be found in the discussion of the appropriate fabrics below.

In addition to complimenting and extending the fabric analysis of the ceramics, petrographic analysis was used to interpret the raw materials and technology of the Hedingham samples. Geological interpretation of the raw materials used in the potting industry and comparison with the surface geology of North Essex was aimed at identifying the specific deposits used by the Hedingham production centres. This contributes towards the interpretation of the place of the Hedingham industry within its geographical and environmental setting. Lastly, the investigation of micromorphological and textural features in thin-section was used to address aspects of the production sequence of the Hedingham pottery. These include paste preparation, vessel forming methods and firing.

Methodology

Sub-samples of all fifty artefacts were impregnated and prepared as standard petrographic thin-sections at University of Sheffield, Department of Archaeology. These were studied at magnifications of 25-400x under the polarising light microscope. Petrographic analysis was conducted within the confines of the already-established hand-specimen fabric classification (Tables 10 and 11). Each fabric was characterised in detail under the microscope and interpreted fully in terms of its constituent raw materials and pottery technology. An assessment was made of the validity of each hand-specimen fabric, answering specific questions about their relationships between one another as well as with pottery from the site of Frogs Hall (Vince 2006). Identification of the likely source(s) of raw materials used for the Hedingham pottery was made by comparison with geological maps and reports of the North Essex area.

Results

Fabric 1

(Samples HD1, 2, 3, 4, 5)

A homogeneous fabric characterised by equant-elongate, rounded to well-rounded medium sand-sized inclusions in a non-calcareous light coloured fine silty clay matrix. The rounded sand inclusions which range up to 1.8 mm (sample HD1) and have a modal size of *c.*0.48 mm (medium sand) are mainly composed of monocrystalline quartz with undulose extinction and polycrystalline quartz. The polycrystalline quartz varies in grain size and can have foliation, suggesting that some of it is of metamorphic origin. Rarer sand-sized inclusions include chert, altered untwined feldspars (HD5), phyllite (HD4), siltstone (HD2), cataclasite (HD5) and hornblende (HD1). The rounded sand inclusions form a separate mode and appear to have been added as temper, perhaps in the form of a loose, well-sorted sand. This has been added to fine homogeneous clay with fine, sub-angular, silt-sized quartz, muscovite mica and ferruginous inclusions. Clay textural features (TFs) in several samples (e.g. HD3, 4, 5) appear to represent lumps of the base clay used to produce these ceramics. These indicate that there was some variability in the texture and composition of this clay, for example HD4 contains finer TFs and an overall finer base clay, whereas HD3 is coarser. The clay TFs generally have neutral optical density and blend into the matrix, but can have a more conspicuous darker, reddish colour (e.g. HD4, 5). The samples contain meso and macro elongate voids and vughs (e.g. HD1). They can exhibit a preferred alignment parallel to each other and the margins of the sections (e.g. HD1, 2), which might be related to drying or firing or could be due to forming. The largely equant sand inclusions do not show any preferred alignment. The clay matrix of the samples is highly to moderately optically active, suggesting that they were fired below 800-850°C. Most Fabric 1 samples analysed were fired in an oxidising atmosphere. Samples HD2 and HD5 have oxidised margins and dark cores, suggesting that they were incompletely oxidised due to a short firing duration, or were reduced and rapidly cooled in air.

Fabric 6

(Sample HD6)

As suspected by HW, this sample is very similar to Fabric 1. It is almost identical in terms of composition and texture to the previous fabric (compare with samples HD2, 3), being composed of rounded medium sand-sized inclusions of quartz and polycrystalline quartz in non-calcareous clay with silt-sized quartz and muscovite mica. Like Fabric 1 it appears to have been made by adding sand temper to fine clay, it has elongate voids that are aligned to the vessel margins and it was fired below 800–850°C in an oxidising atmosphere. One difference between this sample and the Fabric 1 sherds is the absence of clay TFs, but this could be explained by more thorough hydration of the base clay during paste preparation. Two possible relic coil structures can be picked out by the distribution and orientation of the sand inclusions, suggesting that the pot was formed by coiling.

Fabric 2

(Samples HD7, 8, 9, 10, 11)

A relatively homogeneous fabric, characterised by the presence of equant to elongate, rounded to well-rounded medium sand-sized inclusions (max 1.12 mm) of monocrystalline quartz with undulose extinction, foliated polycrystalline quartz, altered feldspar, cataclasite (HD9), chert, untwined feldspar (HD10) and possible phyllite (HD10), in a non-calcareous light coloured clay matrix with abundant elongate-equant, silt-sized quartz and muscovite mica and ferruginous inclusions. The bimodal grain-size distribution of the inclusions in the samples suggests that the rounded sand inclusions were added as temper in the form of a well-sorted sand deposit. Evidence for the nature of the base clay can be found in the form of inconspicuous clay TFs in some samples (e.g. HD11), which represent lumps that were not sufficiently hydrated during paste preparation. Elongate voids occur in sample HD9 and especially in HD11, where they are parallel to the vessel margins. Samples HD7 and HD8 do not contain many voids, but seem to have possible relic coils picked out by the orientation of the sand inclusions. The clay matrices of the samples are moderately-highly optically active and therefore suggest a firing temperature below 800-850°C. Most samples were fired in a neutral to reducing atmosphere, with the exception of sample HD7, which has an oxidised margin. Sample HD10 stands out from the other samples in that it has slightly finer sand inclusions. Samples HD7 and HD8 have rather sparse sand inclusion and less voids compared to the other samples in the fabric. The five Fabric 2 samples are compositionally and texturally very similar to the samples in Fabric 1, with the exception that the majority of the Fabric 2 samples are reduction fired, whereas most of the Fabric 1 samples are oxidised. This confirms the suspicion of HW that Fabric 1 is an oxidised version of Fabric 2, or that Fabric 2 is a reduced version of Fabric 1. The same can be said for Fabric 6.

Fabric 3

(Samples HD12, 13, 14, 15, 16)

The five samples analysed of Fabric 3 are compositionally very similar but can be divided into two groups based upon their texture. All samples appear to have been made from a similar recipe to Fabric 1, Fabric 6 and Fabric 2 of loose rounded quartz and polycrystalline quartz sand added to fine silty, micaceous non-calcareous clay. Samples HD13, 15 and 16 are compositionally as well as texturally very similar to Fabric 1, Fabric 6 and Fabric 2 and could therefore be placed in the same fabric. Samples HD12 and HD14 differ from the other three in that their sand temper is of a smaller grain size (fine sand). This agrees with the interpretation of HW of Fabric 3 as a finer version of Fabric 2 (at least for these two samples). One fine sand tempered sample (HD10) occurs in Fabric 2 and is very similar to HD12 and HD14. As with Fabrics 1 and 2, unmixed lumps of the base clay occur in some samples (HD13, 15). Several samples (HD12, 13, 14, 15) also exhibit elongate voids with alignment parallel to one another and the vessel margins. The moderate-high optical activity of the matrices of the samples indicates that they were below 800-850°C. Most samples in this fabric were oxidised, although sample HD15 may have been incompletely oxidised due to a short firing duration and sample HD12 may have been reduced and rapidly cooled in air. Possible relic coils, picked out by the distribution and orientation of the sand inclusions occur in all samples, particularly samples HD13, 15 and 16.

Fabric 5

(Samples HD17, 18, 19, 20, 21)

This fabric is characterised by abundant, fine inclusions in a non-calcareous clay matrix. The five samples analysed can be split into two groups. Samples HD17 and HD19 contain very abundant, well-packed, well-sorted, elongate and equant, sub-angular to rounded very fine sand-sized inclusions of quartz, muscovite mica, polycrystalline quartz, plagioclase feldspar, microcline feldspar, untwined feldspar and ferruginous inclusions. These inclusions have a general preferred orientation parallel to the vessel margins in sample HD17. Both samples contain abundant meso-elongate voids that are also aligned parallel to the vessel walls. Samples HD17 and HD19 both have non-calcareous clay matrices that exhibit slight optical activity, indicating that these samples were probably fired at around 800–850°C. Both samples were fired under reducing conditions. Sample HD19 contains some sparse larger (fine-medium quartz) equant, rounded to well-rounded quartz and polycrystalline quartz inclusions that stand out from the finer well-sorted inclusions that dominate this sample. Samples HD18, 20 and 21 are related to samples HD 17 and HD19, but have generally coarser, less well-sorted and less well-packed inclusions (max = 0.64 mm, mode = fine). They appear to contain less fine muscovite mica and more coarse rounded quartz grains. Due to the wide unimodal grain-size distribution of the inclusions in samples HD18, 20 and 21, it is not possible to determine whether the larger inclusions represent temper added to fine silty/sandy clay, though the roundness of these inclusions may set them apart from the finer more angular inclusions in the ceramics. As with samples HD17 and HD19, the other three samples have meso-elongate voids that are orientated parallel to the vessel margins. The generally moderate activity of the non-calcareous clay matrix in samples HD18, 20 and 21 indicate that the ceramics were fired below 800–850°C. Samples HD18 and HD21 were oxidised, whereas sample HD20 was reduction fired. The samples of Fabric 5 submitted for analysis are easily distinguishable from fineware Fabrics 1, 6, 2 and 3 by their finer, but more inclusion-rich nature. This confirms the suggestion of HW.

Sandy orange ware fabric (hedsao)
(Samples HD22, 23, 24, 25)
Three of the analysed samples from this fabric are characterised by abundant equant to elongate, well-rounded to sub-angular quartz inclusions in a non-calcareous clay matrix. The inclusions have a wide, unimodal grain-size distribution. However, there is a difference in the roundness, and in some respects the composition, between the larger more rounded sand-sized inclusions of quartz, polycrystalline quartz, chert, plagioclase feldspar, weathered untwined feldspar, fine sandstone, phyllite and cataclasite, and the more angular, finer silt-sized inclusions of quartz, muscovite mica, chert, feldspar, amorphous orange weathered inclusions and biotite. It is possible that the larger, more rounded inclusions represent temper and the finer inclusions were a natural component of the silty base clay to which this was added. A rather inconspicuous textural feature in sample HD25 may represent a poorly mixed fragment of the base clay used for these ceramics. This sample also contains dark red to black iron-rich or organic-rich TFs and inclusions of different sizes. It is not clear whether these are natural or the result of paste preparation. Sample HD25 also contains a single distinctive grey argillaceous inclusion that is rich in angular quartz, feldspar and muscovite mica. This may also be a lump of dried clay, but its relationship to the mix of the ceramics is not clear. One possibility is that it represents the source of the fine sub-angular inclusions in this fabric, suggesting that the paste of these ceramics was made from three separate components. This cannot be confirmed with certainty without seeing other samples of this fabric. Sample HD24 contains abundant elongate meso- and macro-voids that are aligned parallel to the vessel margins. Sample HD22 contains many macro-vughs that may be due to the thin-section preparation process. Sample HD25 does not contain many voids. Possible relic coils exist in sample HD24. The clay matrices of the analysed samples range from moderately optically active (HD25) to optically inactive (HD22), suggesting that they were fired at or above 800–850°C. Sample HD25 was well oxidised giving it an orange-red colour, whereas sample HD24 was fired in a less oxidising environment. Sample HD22 has an oxidised, red-orange margin, which is sharply contrasted with a grey, reduced or incompletely oxidised core. This may be due to reduction firing, then rapid cooling in air. Sample HD23 differs from the other three samples analysed from this fabric. It has a bimodal grain-size distribution, with a more distinctive sandy temper fraction and a finer base clay. This sample bears closer resemblance to Fabric 2 (e.g. sample HD9) and Fabric 3 (e.g. sample HD13). HW commented that the sandy orange fabric looks close to Fabrics 1–3. Whilst this is true for sample HD22, the other three samples are texturally

Sample	*Fabric*	*Context*	*Record No.*	*Description (and illustration No.)*
1	Fabric 1	Hole Farm kiln 2 east stokehole	r.11586	unglazed collared jug rim
2	Fabric 1	Hole Farm Ditch	r.11605	abraded body sherd with traces of yellow glaze and red slip
3	Fabric 1	Hole Farm kiln 2 oven	r.11888	small sherd ?from shoulder of jug
4	Fabric 1	Hole Farm Ditch	r.11707	jug handle
5	Fabric 1	Hole Farm Ditch	r.11522	sherd with thumbed applied strip and red pellet
6	Fabric 1/6	Hole Farm Ditch/kiln 2 east	r.11591	sherd from shoulder of jug (Fig. 14.3)
7	Fabric 2	stokehole	r.11588	abraded sherd with intersecting red slip stripes
8	Fabric 2	Hole Farm Ditch	r.11685	sherd with brown slip stripe
9	Fabric 2	Hole Farm Ditch	r.11606	body sherd with splashes of matt glaze
10	Fabric 2	Hole Farm Ditch	r.11684	lower handle attachment with incised decoration
11	Fabric 2	Hole Farm kiln 2 US	r.11878	jug rim
12	Fabric 3	Hole Farm Ditch	r.11693	red slip stripes and pale greenish glaze
13	Fabric 3	Hole Farm non-kiln feature	r.11983	sherd with reduced surface and dark greenish glaze
14	Fabric 3	Hole Farm kiln east stokehole	r.11590	sherd with matt glaze and clay adhesion
15	Fabric 3	Hole Farm Ditch	r.11755	sherd from shoulder of jug, rilled with pale greenish glaze
16	Fabric 3	Hole Farm Ditch	r.11756	unglazed sherd with brown stripe
17	Fabric 5	Hole Farm unstratified	r.11991	reduced, abraded sherd with applied strips and pads
18	Fabric 5	Hole Farm Ditch	r.11611	unglazed abraded base sherd
19	Fabric 5	Hole Farm Ditch	r.11760	reduced sherd with Rouen-style decoration
20	Fabric 5	Hole Farm kiln 2 oven	r.11885	sherd with intersecting brown stripes
21	Fabric 5	Hole Farm US	r.11990	sherd from stamp strip jug
22	Sandy orange (hedsao)	Starlings Hill Ditch (2)	r.13175	pierced jug handle
23	Sandy orange (hedsao)	Starlings Hill Ditch (1)	r.13184	body sherd with greenish glaze and attachment scar
24	Sandy orange (hedsao)	Starlings Hill Ditch (2)	r.13161	glazed body sherd with faint combing
25	Sandy orange (hedsao)	Starlings Hill Ditch (2)	r.13167	lower handle attachment, green-glazed

Table 10 Fineware ceramics from the Hedingham pottery industry submitted for thin-section analysis, with hand-specimen fabric classification and other information

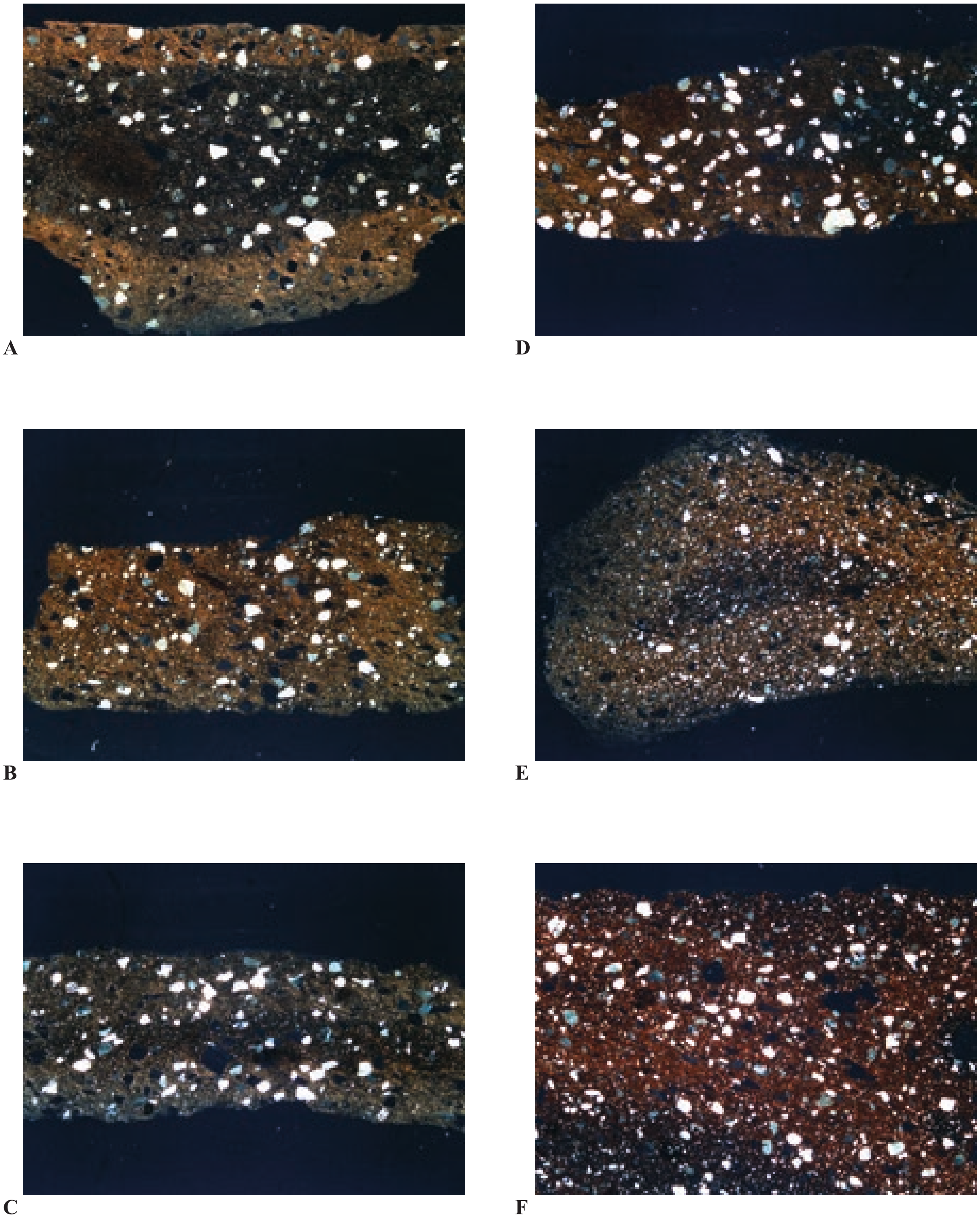

Plate 45 Thin-section photomicrographs of medieval fineware ceramics from the Hedingham pottery industry. A. Fabric 1 Sample HD5, B. Fabric 1/6 Sample 6, C. Fabric 2 Sample 9, D. Fabric 3 Sample 15, E. Fabric 5 Sample 18, F. Sandy orange fabric Sample HD25. All images taken in XP. Image width = 1.25 cm

distinguishable from these fineware fabrics and appear to have been made using a different base clay.

Fabric hedcwem

(Samples HD26, 27, 28, 29)

The four samples analysed from this fabric are characterised by the presence of equant and elongate, rounded to well-rounded, medium-coarse sand-sized inclusions (max 2.0 mm – HD28) of quartz with undulose extinction, polycrystalline quartz which is sometimes foliated (e.g. HD27, 29), chert (e.g. HD27), metaquartzite (e.g. HD26) and phyllite (e.g. HD27), in a non-calcareous clay matrix with fine sub-angular, elongate and equant muscovite mica, biotite, chert (e.g. HD29), amorphous orange weathered inclusions and ferruginous inclusions. The rounded sand appears to have been added as temper to fine silty clay. Voids are not common in the samples, with the exception of some mega-vughs in HD27 and HD28. Sample HD27 contains argillaceous TFs, which may represent insufficiently mixed areas of the base clay. Sample HD27 and possibly sample HD26 contain relic coils from the pottery manufacturing process. The clay matrices of the samples are optically slightly (HD26, 28, 29) to moderately active (HD27) indicating that they were perhaps fired in the temperature range of 800-850°C. Samples HD26, 27 and 29 were oxidised, whereas sample HD28 was either incompletely oxidised due to a short firing duration or fired in an oxygen-poor atmosphere then rapidly cooled in air. The four samples analysed from coarseware fabric hedcwem bear similarities to the fineware sandy orange fabric (hedsao).

Fabric hedcwefi

(Sample HD30)

This sample bears a strong resemblance to coarseware fabric hedcwem and also the glazed sandy orange fabric hedsao. It is particularly similar to the latter (e.g. sample HD25) in terms of its composition and texture. It has a well-packed red-firing, silty, base clay, to which rounded sand temper has been added. The sample contains several large conspicuous dark red to black iron- or organic-rich TFs. HW commented that sample HD30 is relatively fine and micaceous. The thin-section prepared from this sample has medium sand-sized temper inclusions with a maximum size of 0.68 mm. It is finer than several coarseware fabrics such as hedcwem, hcwoxcor, hcwcor and hcwstor. In thin-section sample HD30 does indeed have much fine muscovite mica, though this is also a feature of many other samples and fabrics analysed from the Hedingham pottery industry.

Fabric hcwoxcor

(Sample HD31)

This coarse sample has a fabric characterised by abundant, equant and elongate, rounded to well-rounded, coarse sand-sized inclusions of quartz, polycrystalline quartz, untwined feldspar, siltstone and chert in fine silty clay with sub-angular quartz, muscovite mica and chert. It contains several dark red iron-rich clayey TFs and possible unmixed traces of the silty base clay. Numerous large vughs are probably the result of the thin-section making process. The clay matrix of this sample is moderately optically active, suggesting that it was not highly fired. It was fired in an oxidising atmosphere. This sample bears similarities to coarseware fabric hedcwem among others. It differs from this fabric in that it contains a greater proportion of coarse sand temper.

Fabric hcwcor

(Samples 32, 33, 34, 35, 36)

This fabric is characterised by sparse, elongate and equant, rounded to well rounded, coarse sand-sized inclusions of quartz, polycrystalline quartz, chert (e.g. sample HD32) and breccia (sample HD35) in non-calcareous clay containing abundant silt-sized equant and elongate, angular to sub-rounded quartz, muscovite mica, ferruginous inclusions, biotite (HD36), hornblende (HD34) and epidote (HD36). It is clear from the strongly bimodal grain-size distribution of the inclusions and the differences in the roundness of the two modes that the coarse sand was added as temper. This loose sandy material appears to have been well-sorted (e.g. HD34), but also contained some finer sand particles (e.g. sample HD35). The fine, angular silt-sized inclusions were likely to have been present in the base clay that was used to produce these ceramics. Elongate meso- and macro-voids are present in many of the samples analysed (e.g. HD35) and are generally aligned to the vessel margins. Sample HD36 contains mego-elongate voids and mega-vughs. Relic coils are picked out by the orientation of the coarse sand temper in samples HD32, 34, and 36. All analysed samples were reduction-fired and have very dark brown to black clay matrices. Due to its dark colour, it is not possible to determine the optical activity of the clay in the samples. However, there appears to be some slight birefringence, suggesting that the samples were not fired above 800–850°C. HW commented that this fabric is from a different site than the other coarseware samples analysed here and that it is much coarser than the standard Hedingham coarseware. In thin-section the fabric bears strong similarities to many of the previous coarseware fabrics in terms of its composition and technology, including hedcw below. However, the sand temper added to hcwcor is slightly coarser than all other samples, setting it apart.

HW asked specifically about the similarity between coarseware fabric hcwcor and medieval pottery analysed by Vince (2006) from Frogs Hall, near Takeley, Essex. Although it has not been possible to access the thin-sections from this site for direct comparison, the description of the Frogs Hall ceramics and fired clay artefacts suggests strong similarities with hcwcor and indeed other Hedingham coarseware fabrics. Vince (2006) classified all of the Frogs Hall samples in his fabric 1, which is composed of rounded sand grains of quartz, metamorphic quartz, flint, chert and sandstone in a silty clay with abundant angular quartz and moderate muscovite. As in the Hedingham pottery analysed here, he appears to interpret the rounded sand inclusions in the Frogs Hall material as temper added to a base clay.

Fabric hedcw

(Samples 37, 38, 39, 40, 41, 42)

This fabric is compositionally and texturally very similar to the samples analysed from coarseware fabrics hedcwem and hedcwefi. The six samples analysed are related, though samples HD37 and HD38 are slightly coarser than the other four and sample HD41 is finer and contains less temper. Notable compositional features include the common chert in the fine fraction (e.g. sample

HD38), the high proportion of ferruginous inclusions in sample HD42 and the high proportion of foliated polycrystalline quartz in sample HD37. Sample HD38 contains a TF that may represent an unmixed lump of the base clay used to manufacture these ceramics. The slight optical activity of the matrices in samples HD37 and HD38 indicate that the samples were moderately fired in the region of 800–850°C. The firing atmosphere of the samples varies from oxidising (sample HD41) to reduced (samples HD39, 40, 42). Sample HD37 has a reduced core and margin, between which the clay was oxidised. This complex layered structure may suggest that the sample was reduced, cooled rapidly in air, then reduced again, or that the sample was incompletely oxidised, then reduced for a short duration. HW asked whether there is any difference between the reduction fired and oxidised hedcw samples. In thin-section these look compositionally and texturally the same.

Fabric hcwfi

(Samples 43, 44, 45, 46, 47)

The samples analysed from this fabric are characterised by the presence of equant and elongate, rounded to sub-rounded, fine- to medium-sand sized inclusions of quartz, polycrystalline quartz, in some cases with foliation (e.g. sample HD46), chert (e.g. samples HD43, 47), siltstone (sample HD43) and untwined feldspar (sample HD45), in a non-calcareous clay matrix with abundant, well-packed, equant and elongate, sub-angular to sub-rounded silt-sized inclusions of quartz, polycrystalline quartz, muscovite mica, biotite (e.g. sample HD47), plagioclase (e.g. sample HD43), chert (e.g. sample HD47), microcline (sample HD45), amorphous orange weathered inclusions and ferruginous inclusions. The sand inclusions, which may represent temper, have a wide grain size distribution in sample HD45, 46 and 47 and thus may have been added as a loose, poorly-sorted sand deposit. Sample HD44 has less sand temper, which was better sorted, leading to a more bimodal grain-size distribution. Sample HD43 stands out in that it is finer than the other four and appears to have had some very fine sand added. Inconspicuous clayey TFs in samples HD44, 45 and 47 may be remnants of the paste preparation process and represent the nature of the base clay. Dark, iron-rich TFs occur frequently in samples HD46 and 47. Samples HD45 and 47 may contain small pieces of crushed pottery or 'grog', though their identification is not positive. Meso-elongate voids permeate all samples, except HD44. These can be aligned with the margins of the samples. The clay matrices of the samples are moderately optically active (sample HD45), slightly active (samples HD43, 48) and optically inactive (samples HD46, 47), suggesting a range in the degree of firing. Sample HD46 contains much less fine muscovite mica than the other samples, which might suggest that it was high-fired, leading to the decomposition of these small inclusions. Firing took place in an oxidised (sample 45), weakly oxidised (samples HD43, 44), neutral (sample HD47), reduced (sample HD46) atmosphere. HW commented that hcwfi is a fine version of the standard coarseware, with much less sand. In thin-section the samples are generally finer than hedcw and are compositionally and texturally similar to hedcwefi and

Sample	*Fabric*	*Context*	*Record No.*	*Description (and illustration No.)*
26	hedcwem	Hole Farm kiln 4/5	r.11054	early medieval fabric, lower handle attachment of jug
27	hedcwem	Hole Farm kiln 2 east stokehole	r.12161	early medieval fabric, profile of dish
28	hedcwem	Hole Farm Ditch	r.11076	early medieval fabric, spike lamp (Fig. 16.48)
29	hedcwem	Hole Farm kiln 3	r.12704	early medieval fabric, beaded cooking-pot rim
30	hedcwefi	Hole Farm Ditch	r.10987	fine version of early medieval fabric, body sherd (from cooking-pot) (Fig. 16.49)
31	hcwoxcor	Hole Farm kiln 1 east stokehole	r.11082	transitional fabric (between early medieval and medieval coarseware tradition), pipkin handle (Fig. 33.200)
32	hcwcor	Holy Trinity, Halstead	r.13229	jug handle
33	hcwcor	Holy Trinity, Halstead	r.13227	body sherd from E1 cooking-pot rim
34	hcwcor	Holy Trinity, Halstead	r.13233	base sherd
35	hcwcor	Holy Trinity, Halstead	r.13223	sherd from B4 cooking-pot rim, wavy line decoration.
36	hcwcor	Holy Trinity, Halstead 4	r.13224	sherd from B4 cooking-pot rim
37	hedcw	Hole Farm surface find	r.11027	cooking-pot rim, combed decoration, grey
38	hedcw	Hole Farm kiln 1	r.11022	cooking-pot rim, some oxidation (Fig. 22.104)
39	hedcw	Hole Farm kiln 3	r.11275	cooking-pot rim with rilled sides, grey
40	hedcw	Hole Farm kiln 3	r.11285	jug handle fragment, grey
41	hedcw	Hole Farm kiln 4/5	r.11069	sherd from body of jug, buff coloured (Fig. 31.165)
42	hedcw	Hole Farm kiln 4/5	r.11087	cooking-pot rim with thumbed applied strip, buff
43	hcwfi	Hole Farm kiln 2 oven	r.10963	2 body sherds from socketed dish, buff coloured (Fig. 16.50)
44	hcwfi	Hole Farm kiln 2 oven	r.12568	profile of bowl, buff coloured
45	hcwfi	Hole Farm kiln 2 oven	r.10993	rim sherd from semi-complete cooking-pot, orange-buff
46	hcwfi	Hole Farm kiln 2 oven	r.12499	cooking-pot rim, grey, warped
47	hcwfi	Hole Farm kiln 4/5	r.11007	cooking-pot rim with faint dimpling, pale grey (Fig. 21.98)
48	hcwstor	Hole Farm kiln 1 east stokehole	r.11445	small sherd, oxidised core
49	hcwstor	Hole Farm kiln 1 west stokehole	r.11390	grey sherd
50	hcwstor	Hole Farm kiln 1 oven	r.11032	large fragment

Table 11 Coarseware ceramics from the Hedingham pottery industry submitted for thin-section analysis, with hand-specimen fabric classification and other information

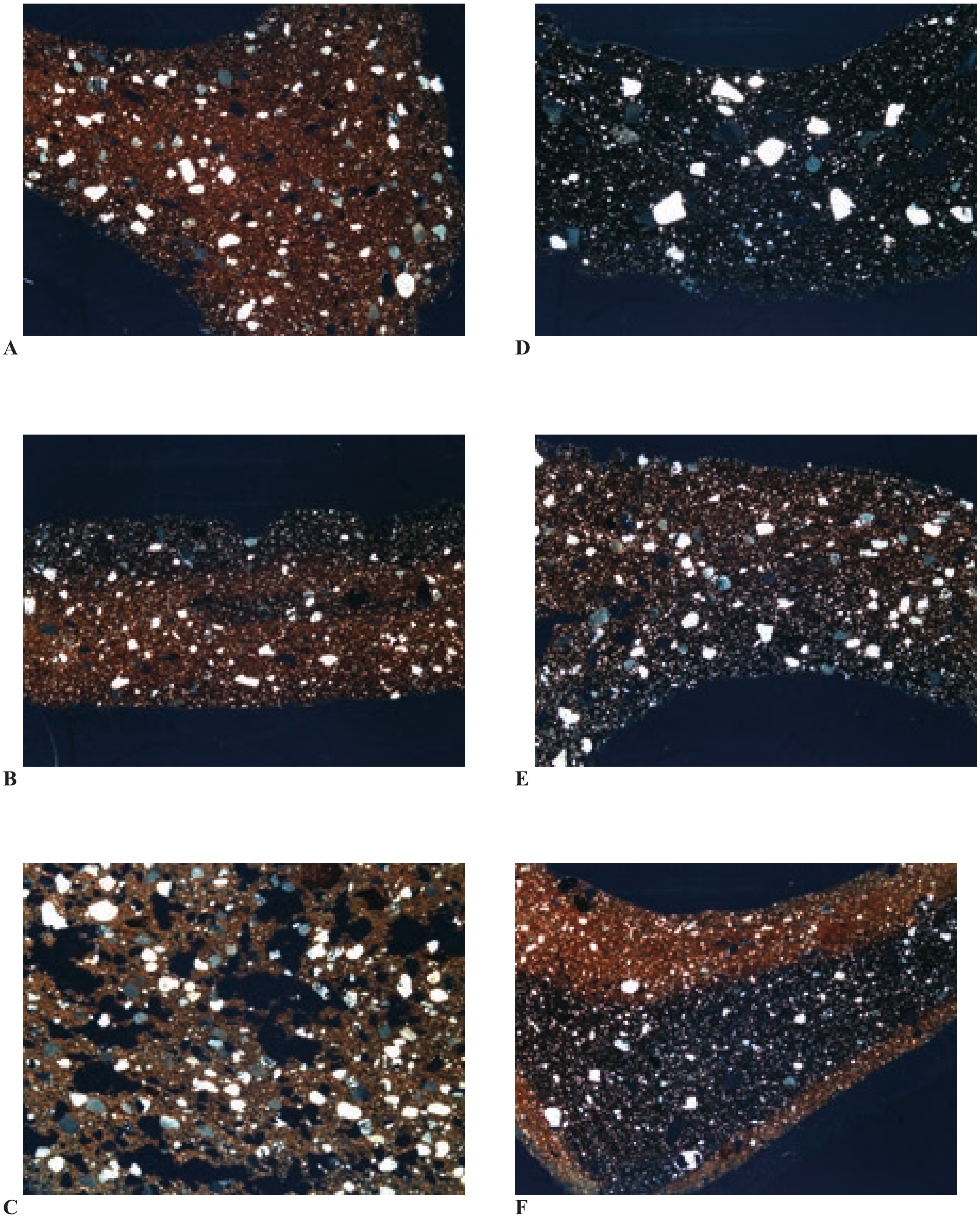

Plate 46 Thin-section photomicrographs of medieval coarseware ceramics from the Hedingham pottery industry. A. Fabric hedcwem Sample HD29, B. Fabric hedcwefi Sample 30, C. Fabric hcwoxcor Sample 31, D. Fabric hcwcor Sample 35, E. Fabric hedcw Sample 38, F. Fabric hcwfi Sample HD45. All images taken in XP. Image width = 1.25cm

hedcwem, but with less temper. Sample HD43, bears similarities to some fineware samples of Fabric 5, however, this fabric group does not contain the small rounded amorphous orange weathered inclusions that occur in HD43. There is some textural and technological variation within the five hcwfi samples analysed here, which might not support the idea of HW that they may be from the same batch. It is not possible to comment on whether the fineness of the hcwfi samples was responsible for them warping, though in thin-section none of them appeared to be over-fired.

Fabric hcwstor
(Samples HD 48, 49, 50)
The three samples analysed of this homogeneous fabric bear strong similarities to numerous coarseware samples, including hedcw, and therefore do not seem to be a separate fabric as suggested by HW. The three samples are indeed homogeneous as commented by HW, being characterised by the presence of rounded medium-sized sand temper of quartz, polycrystalline quartz and chert in a non-calcareous matrix containing angular quartz, muscovite mica, chert, biotite, amorphous orange weathered inclusions and ferruginous inclusions. All three samples are optically inactive and were therefore fired above 800–850°C. Sample HD49 was fired in a reducing atmosphere and samples HD49 and HD50 were fired in a neutral to slightly oxidising atmosphere.

Interpretation

Correspondence between hand-specimen fabrics and composition of Hedingham pottery
In general there is reasonable correspondence between the hand-specimen fabrics and the nature of the samples in thin-section. However, some very close similarities exist between certain fabrics, suggesting that they represent the same recipe. In addition, some hand-specimen fabrics contain internal variation that contradicts their classification.

Fineware Fabrics 1, 6, 2 and 3 are very similar to one another. This was recognised by HW, who commented that Fabric 6 is not much different from Fabric 1 and that Fabric 1 might be an oxidised version of Fabric 2. Some, but not all of the samples analysed from Fabric 3 are finer versions of Fabric 2 (and thus Fabrics 1 and 6). However, three samples are not and would be happy in these previous fabrics. One sample of Fabric 2 has a finer grain-size than the others and is therefore related to the fine Fabric 3 samples.

Fineware Fabric 5 is not related to Fabrics 1, 6, 2 and 3. It appears to be made with different clay and contains far less temper. It is closer to some of the Hedingham Coarseware fabrics, e.g. hcwfi. The samples analysed of Fabric 5 can be split into two groups in terms of the abundance of temper, but are generally related to one another. The sandy orange fabric hedsao also contains some internal variation. One sample appears to be related to Fabrics 2 and 3, whereas the majority of the samples were made with different clay to the more common fineware composition represented by Fabrics 1, 6, 2 and 3. HW notes that the sandy orange fabric samples come from different sites to other finewares analysed.

Coarseware fabric hedcwem bears similarities in composition and texture to the fineware sandy orange fabric, as does hedcwefi. Fabric hcwoxcor is related to coarseware fabric hedcwem among others, but differs in that it contains a greater proportion of coarse sand temper. HW commented that hcwcor is from a different site than the other coarsewares sample analysed here and that it is much coarser than the standard Hedingham Coarseware. In thin-section the fabric bears strong similarities to many of the other coarseware fabrics including hedcw. However, the sand temper added to hcwcor is slightly coarser than all other samples, setting it apart as a homogeneous group.

Fabric hedcw is compositionally and texturally very similar to the samples analysed from hedcwem and hedcwefi. The six samples are related but contain some differences in the grain-size and abundance of temper. HW commented that hcwfi is a fine version of the standard coarseware fabric (hedcw) with much less sand. In thin-section the samples are generally finer than hedcw and are compositionally and texturally similar to hedcwefi and hedcwem, but with less temper. One sample of this fabric stands out in that it is finer than the other four and bears strong similarities to some fineware samples of Fabric 5.

The three samples analysed of coarseware fabric hcwstor are homogeneous but bear strong similarities to numerous coarseware samples, including hedcw, and therefore do not seem to be a separate fabric as suggested by HW. In general, many of the coarseware fabrics are related to one another, with only differences in the grain-size and abundance of sand temper between and within the hand-specimen fabric groups.

Raw materials used in Hedingham pottery industry
Based upon the thin-section analysis in this report, it can be concluded that several types of raw materials appear to have been used in the Hedingham pottery industry. These include loose rounded sand and at least two types of clay. Rounded to sub-rounded and well-rounded, equant and slightly elongate, generally well-sorted, fine to coarse-sand temper was used in the production of nearly all the ceramic samples analysed. This sand is composed of grains of monocrystalline quartz with undulose extinction, which can be cloudy, polycrystalline quartz, that often exhibits a foliated alignment and is likely to be of metamorphic origin, chert and more rarely phyllite, siltstone, cataclasite, breccia, feldspar and hornblende. Despite variation in the grain-size and sorting of the rounded sand the composition of this material is very similar between the fabrics and samples analysed, suggesting a single source. The source of this sand may be the Kesgrave Sands and Gravels, a Quaternary (pre-Anglian) fluvial formation that occurs extensively in Essex (Sumbler *et al*. 1996) and outcrops along the sides of the Colne valley near Castle Hedingham, Sible Hedingham and Halstead, and its nearby tributary. According to British Geological Survey (BGS) 1:50000 Sheet 223, 'this consists of yellow to orange-brown sands and sandy gravels with less than 10% of clay and silt'. The clasts are reported to be 'predominantly rounded and consist mainly of flint, along with about 30% white quartz and brown, purple and bleached quartzites' in addition 'other erratics account for a further 1-4% and these include durable sedimentary rocks such as chert and sandstone, igneous rocks and metamorphic rocks'. The general description of this deposit resembles the sand that

has been added as temper to the Hedingham ceramics, with the exception that flint or chert is much less common and quartz dominates. Variation is noted in this deposit across the region covered by BGS Sheet 22. For example ‘cross-bedded yellow-brown sands with thin green clayey silt beds and muscovite flakes dominate the north-west’ where Hedingham is situated. The map notes state that the deposit is ‘worked extensively for aggregate and building sand’. Certainly it would have represented an abundant locally available source of sand for temper in the wider Hedingham area and is highly likely to be the source of the material observed in thin-section. The grain-size variation in the rounded sand temper added to Hedingham ceramics may represent natural variation in this deposit and possible grading carried out by the potters by sieving or another means. Other available sand deposits in the study area include more recent river terraces and modern alluvium along the Colne.

The rounded sand temper appears to have been added to at least two separate types of base clay that may have come from different clay deposits. The base clay of Fabrics 1, 6, 2 and 3 is light firing and homogeneous, with fine, sub-angular, silt-sized quartz, muscovite mica and ferruginous inclusions. The base clay that was used for the coarseware samples and probably fineware Fabric 5 and the sandy orange fabric, on the other hand is darker, red-firing and contains more inclusions. It too has sub-angular silty clasts of quartz and muscovite mica, but also contains chert or flint and amorphous orange weathered particles. These two base clays may have come from different sources.

The London Clay Formation, which outcrops extensively along the Colne valley near Hedingham is described as being a ‘chocolate-brown, silty clay [that is] micaceous in parts’ (BGS Sheet 223). As such, it is perhaps a good candidate for the source of one or both of the clay deposits used for the Hedingham ceramics. This Eocene occurs extensively across south-east England and was used in the past for ceramic and brick manufacture. In his analysis of medieval pottery and fired clay artefacts from Frogs Hall, Takeley, Vince (2006) suspected the Tertiary Claygate Beds of the London Clay formation to have been exploited. The Claygate Beds or Claygate Member form the youngest part of the London Clay Formation, which has been removed by erosion in North Essex. Whether the basal part of the formation, which remains in this area, was suitable for pottery manufacture is not known. Its description as silty, micaceous clay certainly fits the description of the material used for some of the Hedingham pottery. This could be confirmed by field sampling and analysis of the London Clay outcropping in the Colne valley.

Extensive deposits of boulder clay cover the Tertiary and older rocks in North Essex. This consists of ‘generally pale brown to buff sandy clay with chalk fragments’ (BGS Sheet 223). The presence of chalk fragments is not fitting with the composition of the clay used to produce the Hedingham ceramics. However, the base of this unit, which may be exposed in river valleys, is represented by ‘olive-brown, sandy clay with well-rounded flint and quartz pebbles and but a reduced amount of chalk’. Whether finer, silty clay of the same composition also occurs and in sufficient quantity to be mined for ceramic manufacture is not known. Nevertheless, the presence of fine chert or flint in the base clay that was used for the coarseware ceramics at Hedingham suggests a source in the Quaternary deposits of this area rather than the Tertiary London Clay.

Clearly, extensive local deposits of clay and sand occur along the Colne valley near Castle Hedingham, Sible Hedingham and Halstead. Although analysis of field samples is needed to confidently link these beds to the products of the Hedingham pottery industry, the consideration of the geological literature above suggests that these local deposits may have been utilised for ceramic manufacture in medieval times.

Technology of Hedingham pottery industry

It is possible to interpret several aspects of the ceramic technology of the Hedingham pottery industry from analysis of the samples in thin-section, from paste preparation to firing. The existence in some fabrics (e.g. Fabrics 1, 2, hcwfi) of inconspicuous clay-rich inclusions that have a similar appearance to the surrounding clay matrix appear to indicate that dry, powdered clay was used as a base material for the production of at least some of the Hedingham pottery. These inclusions are interpreted as small particles of crushed clay that were not sufficiently hydrated during the addition of water and soaking of the clay. The absence of these particles in some fabrics and certain samples within fabrics could be due to more thorough hydration, the use of more finely ground dry clay, the use of a wet natural clay, or simply because no such particles were sectioned during sample preparation. It is not possible to choose between these possibilities.

The clay paste of nearly all of the samples analysed from all Hedingham fabrics were made by the addition of rounded sand temper to a finer base clay. The presence of temper can be identified by the grain-size distribution of the ceramics, with the temper forming a separate, larger mode than the fine inclusions that were present naturally in the base clay, as well as differences in the roundness and composition of the natural and added inclusions. The identification of temper is easier in some cases than others. For example, it is not possible to be sure that sand was added to the paste used to produce all of the Fabric 5 samples analysed. However, by comparison with other fabrics, it is clear that sand tempering was a very common practice in the Hedingham pottery industry, being carried out at all of the sites analysed here and being used for the production of both fine and coarsewares.

Two samples of coarseware fabric hcwfi may contain possible fragments of crushed pottery or ‘grog’. The identification of grog can sometimes be difficult, especially when it is not common or when other types of argillaceous inclusions occur in the same thin-section. Should the small inclusions in the two samples be fragments of pottery, their infrequent occurrence and the absence of similar inclusions in other related fabrics is likely to imply that they were incorporated accidentally rather than being an intentional addition.

Evidence for the forming techniques used to shape the Hedingham ceramics is present in several of the analysed samples in thin-section. Despite the generally equant, rounded nature of the sand temper added to the ceramics, the orientation of inclusions in many samples appears to pick out relic coils left from the forming process. These are present in samples from both fineware fabrics (Fabrics 1, 2, 3, sandy orange fabric hedsao) and coarseware fabrics (hedcwem and hcwcor). Many Hedingham pottery

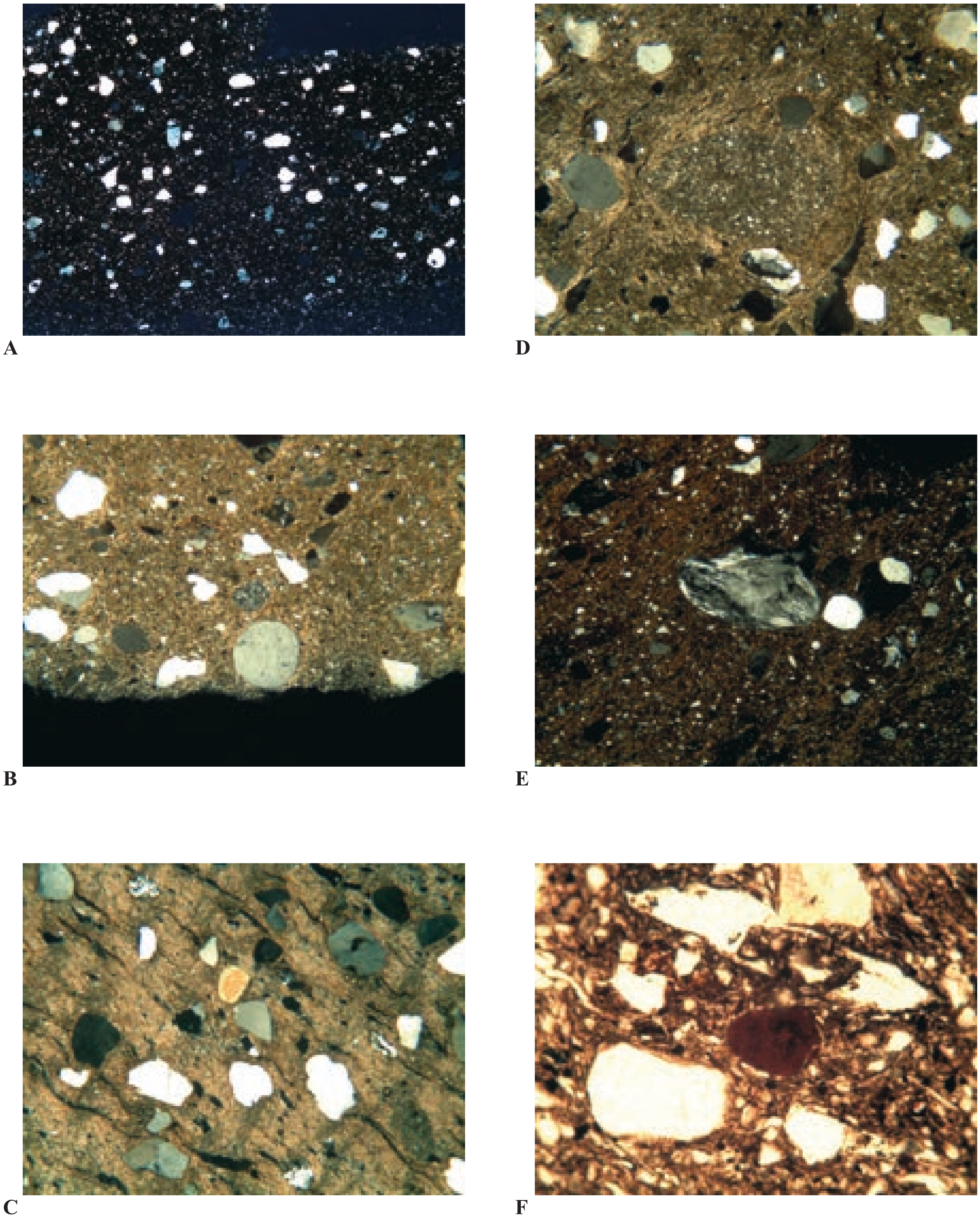

Plate 47 Thin-section photomicrographs of medieval ceramics from the Hedingham pottery industry. A. Coarseware fabric hcwstor. B. Rounded sand temper, C. Rounded sand temper, parallel elongate voids and high optical activity, D. Clay rich textural feature which may be unmixed base clay, E. Foliated, metamorphic polycrystalline quartz, F. Small rounded orange amorphous weathered inclusion. All images taken in XP, except F–PPL. Image width A = 1.25 cm, B–D = 3.8 mm, E = 2.4 mm, F = 1.0 mm

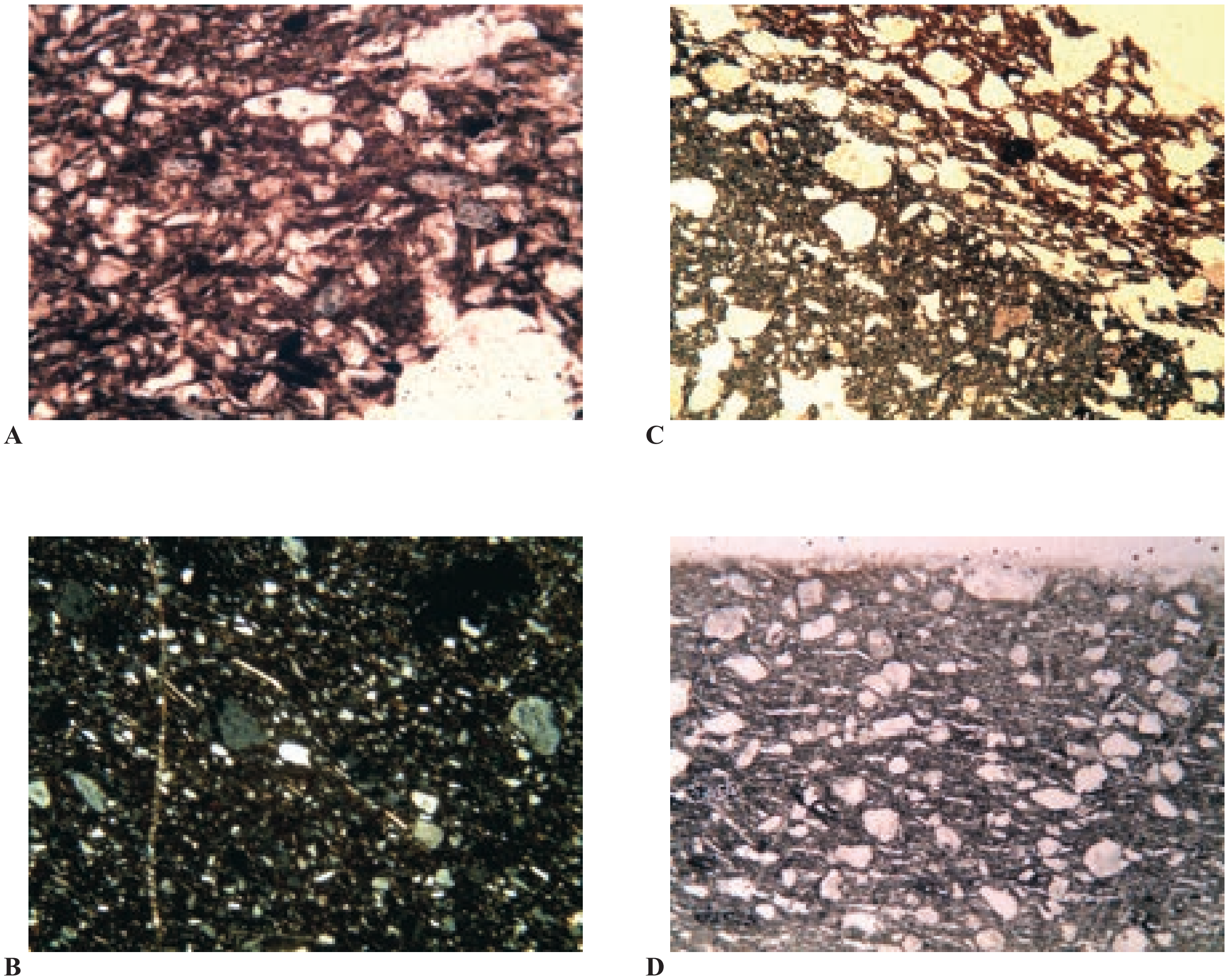

Plate 48 Thin-section photomicrographs of medieval ceramics from the Hedingham pottery industry. A. Fine grey chert/flint inclusions, B. Fine elongate muscovite mica inclusions, C. Oxidised margin and reduced core, D. Elongate voids parallel to vessel margin. All images taken in PPL, except B–XP. Image width A = 1.0 mm, B = 2.4 mm, C-D = 3.8 mm

samples contain small elongate voids in thin-section, which may result from the drying of the paste after forming. Where present, these are usually aligned to the margins of the samples. Strong alignment of voids and inclusions parallel to the vessel margins in ceramics is often taken as evidence for forming on a potter's wheel, where strong forces cause the fabric constituents to align. However, in some Hedingham pottery samples, both strongly aligned elongate voids and relic coils appear. This may suggest that the vessels were coil built and finished on a wheel or turntable.

Aspects of the firing process of the Hedingham pottery samples can be interpreted in thin-section. A rough estimate of the degree of firing can be based on the optical activity of the clay matrix in crossed polars (XP). Variation in this property exists between and with the fabrics analysed from optically highly active samples (e.g. Fabrics 1, 6, 2, 3), through moderately optically active and slightly active samples (e.g. Fabrics 5, hedcwem, hcwoxcor, hedcw) to samples with optically inactive matrices (e.g. hcwstor). It has been suggested that above a temperature of 800–850°C the clay minerals start to break down, giving the matrix an optically inactive, isotropic appearance in thin-section. In this case, some Hedingham pottery samples were fired above this temperature (e.g. hcwstor), some were fired below (e.g. Fabric 1) and others may have been fired around this critical temperature (e.g. Fabric 5). However, firing is a complex process in which other factors in addition to temperature contribute to the degree of firing of ceramics. Furthermore, the clay mineral composition of the matrix also appears to affect its optical activity and the atmosphere of firing may affect the visibility of this property, which is not so apparent in reduced ceramics. In this respect the high optical activity of fineware Fabrics 1, 6, 2 and 3 may be related to the type of clay used for these compositionally related samples as well as their oxidised firing.

The firing atmosphere of the Hedingham pottery samples can be interpreted in thin-section as a result of the relationship between the colour of the clay matrix and the redox conditions during firing. This property can also be interpreted in hand-specimen so need not be discussed in detail here. The samples were fired in a range of conditions from oxidised, through neutral to fully reducing conditions. Several samples exhibit a layered structure with a dark core and a light margin. This pattern can develop as a result of incomplete oxidation of organic matter due to a short firing or reduction firing, followed by a rapid cooling in air. As colour and thus redox conditions appear to have been one of the criteria used to separate the pottery samples into hand-specimen fabrics (e.g. Fabrics 1 and 2), it is not worth commenting on the relationship between atmosphere and fabric. However, it is worth noting that some variation in firing atmosphere exists within some of the fabrics.