BRITISH
GEOLOGICAL
SURVEY

OR/10/034

Project: Prehistoric Pottery Production
in Charnwood Forest, Stage 1.
(Project Leader, D. Knight
Trent & Peak Archaeology)

Comparative petrography of pottery sherds and potential geological source materials in the East Midlands

J N Carney

Comprising petrographic descriptions of pottery sherds from various locations, and comparisons with possible geological source materials

Exposure of Mountsorrel Complex granodiorite at Castle Rock, Mountsorrel. The crags overlook the River Soar floodplain, forming the low ground behind

Bibliographic reference:
Carney, J N, 2010. Comparative petrography of pottery sherds and potential geological source materials in the East Midlands. *Open Report of the British Geological Survey,* OR/10/034

Contents

Figures

Tables

1. Background

This report forms part of the Prehistoric Pottery Project, which is aimed at investigating by means of petrographic and electron microprobe analyses the production and distribution of later prehistoric granodiorite-tempered pottery from the East Midlands. Earlier petrographic studies have identified potential production sources in rocks cropping out in the Mountsorrel area of Charnwood Forest (Knight et al., 2003) and it is intended to test this hypothesis by the application of electron microprobe analyses, combined with additional thin section petrography. This is envisaged as the first stage of a 2-phase project, which in the second stage will examine the potential of isotope analysis for refining our knowledge of sources of potting clays and temper.

2. Methodology

Fifty one samples of pottery sherds, and six lab-fired clay brickettes were submitted by Dr E Faber, on behalf of Trent and Peak Archaeology, for thin section preparation and petrographical examination at the BGS. The samples were initially impregnated by immersion in a pot containing Epo-tek resin, mixed with blue dye powder. The addition of blue dye ensures that any fracturing or porosity inherent to the sample (as opposed to damage caused by slide preparation) is preserved on the thin section. The pots containing the samples were then subjected to repeated vacuum treatment in order to dispel air bubbles in the resin mixture. After hardening overnight, the samples were placed on a lapper for preliminary grinding. They were then bonded to a glass slide and ground down to an optimum thickness for petrographical examination, which is approximately 30 microns. Details of these samples, and their locations, are provided by E Faber in another report of Stage 1. In the account that follows, the locations of pottery sherd samples are indicated by codes. The index to these is as follows:

ACS	Aston upon Trent	Trent valley
CRI	Crick	Northamptonshire
GAM	Gamston	Trent valley
GBR	Holme Pierrepont (Great Briggs)	Trent valley
EKE	Eye Kettleby	south of Wreake valley
HLF	Hallam Fields, Birstall	Soar valley
MNF	Manor Farm, Humberstone	Leicester, east side of Soar valley
SWL	Swarkestone Lowes	Trent valley
WAN	Wanlip	Soar valley
WIL	Willington*	Trent valley

*Submitted as already prepared thin sections, not resin or dye-impregnated

Simplified geological maps showing the distribution of the local bedrock units and superficial (Quaternary) deposits considered in this study are given in Figs. 1a and b. Details of the in-situ geological source materials that were used to provide comparison with the pottery inclusions and pottery clay matrix are given in Table 1. This listing includes 6 new samples of potential local bedrock geological source materials (ROW 1 and 2; JNC 927-930). The other 14 bedrock samples in Table 1 were obtained from the BGS thin section collection.

A further 5 samples of alluvium, and one of Mercia Mudstone, all collected by hand-auger, were made into pottery clay brickettes by E Faber before being thin sectioned at BGS; their locality details are given in Table 1. Dr Faber gave the following details of the technique used to do this:

“The six clays were formed into brickettes by hand and left to dry at room temperature for a week. All six were fired at the same time in the furnace in an oxidising atmosphere. The temperature was increased using a heating rate of 3 degrees C per minute up to 100 degrees C and held there for 20 minutes to ensure they were dry. The temperature was then increased again at 3 degrees C per minute up to 750^{o} C, which was then held for 60 minutes. After this the furnace was turned off and left to cool back to room temperature.

The Mountsorrel, Enderby and Kingston-upon-Soar alluvial deposits all fired with a dark core and a red surface, suggesting the presence of a large amount of organic matter that did not have time to burn out. The Swarkestone and Rowhele depositis fired with a light core, suggesting that the centre of the brickette did not fully oxidise. The Shelford deposit fired to a uniform colour throughout. I do not think that the presence of the grey core is related to the variation in size/thickness of the brickettes as the Swarkestone brickette was the same size as the Mountsorrel and Kingston-upon-Soar brickettes.The Enderby brickete split in the furnace, probably due to a fault in the forming. I suspect that two pieces of clay were inadequately joined together’.

The pottery sherds, brickettes and rock samples were subjected to a rapid petrographical examination, and the results for the pottery samples are summarised in Table 2, which is also supplied as an xls spreadsheet for sorting and integration with other databases. Photomicrographs have been prepared for all of the pottery and some of the rock samples. Selected images illustrate the report that follows.

This report is divided into descriptions of a) pottery sherd matrix clays and b) silicate inclusions; the latter comprising the larger part of the study. Potential in-situ source rocks (locations in Table 1) are also discussed and their petrography illustrated in selected photomicrographs.

3. Pottery clay matrixes

In thin sections, most pottery sherd matrixes consist (in lithological terminology) of red-brown to black, silty clay. The exceptions are many of the WIL samples, which have very few silt-size inclusions. Many samples show interlayering between pale red-brown (or pale brownish green) and very dark red-brown to black clay types (e.g. EKE0902). Most samples also show a certain degree of matrix heterogeneity, caused by the presence of rounded to ellipsoidal, somewhat shadowy inclusions of silty clay that is of a slightly different colour (in terms of the red-brown spectrum) to the surrounding matrix. These shadowy inclusions could represent incompletely incorporated relicts of the original pottery clay source-rock, or they could be pre-existing pottery fragments. Although this pottery clay is compared (below) with possible geological red clay sources (Mercia Mudstone and Thrussington Till), it is realised that the firing process will contribute to the redness of the final pottery product.

A significant proportion of pottery samples contain rounded, petrographically opaque aggregates of black silty clay or black, non-silty material (Fig. 2a). In these aggregates silty, silicate inclusions are mainly arranged at random, but there are some examples showing a concentric arrangement (e.g. MNF0908). These opaque aggregates (and probably also the black layering referred to above) might be iron oxide-rich, or they could represent incompletely burned-out organic material. The latter alternative is suggested by experimental fabrication of the alluvium brickettes, a process which, as noted by Dr Faber (above), does not completely burn off the included organic material, even when the clay was fired to 750^{o} C. On the other hand, the opaque aggregates also resemble those described by Beck and Neupert (2009), who noted that in some clayey soil profiles iron oxide can precipitate along plant rootlets, before being dispersed as small rounded aggregates when the clay is processed for pottery making. The examples of opaque masses with concentrically arranged silicate inclusions may suggest an original pedogenic origin.

The silt to fine-sand inclusions[1] in the pottery clay matrix are very important as they are virtually ubiquitous. They show up well in thin sections; typical examples are illustrated in Figures 2a and 2b, and in many other photomicrographs. Some consist of angular crystal fragments, such as quartz, plagioclase and K-feldspar, which match the crystal constituents of the larger inclusions described and thus are probably their more finely pulverised equivalents. Others may have been integral components of the source material that provided the pottery clay, or be ‘natural’ sand or silt contaminants, introduced during the pottery-making process. They are dominated by quartz, which commonly has strained extinction or occurs in granoblastic aggregates, some with a strong foliation (probably meta-quartzite). Other very common silty or sandy inclusions consist of foliated quartzose meta-siltstone. These inclusions indicate an ultimate derivation from metamorphic sources not present in the region. Local sources are still possible, however, as such lithologies are common in local Triassic conglomerates and Quaternary deposits, as discussed in Sections 3.1 and 5.3.

Fracture systems in the clay matrix are shown up by areas of blue dye. They are therefore shrinkage features attributed to the original pottery making process, rather than to any breakages during thin sectioning. The fractures are extremely narrow and discontinuous. Most show a preferred orientation (Fig. 2b), which is generally parallel with the edges of the sherd samples.

[1] In geological terms, silt is represented by grains of c. 63 µm, fine sand by grains between 63 and 250 µm and sand between 250 and 2000 µm

Other fractures are more arcuate, and some follow the edges of larger inclusions, as around the black silty clay inclusion in Fig. 2a.

3.1 Possible geological sources of pottery clays

In this region, the principal clay-yielding geological units (Figs 1a, b) are:

a) Triassic mudstone (Mercia Mudstone Group); red to brown silty mudstone which retains its colour when weathered. Widely distributed.
b) Carboniferous mudstone (Coal Measures); dark grey mudstone and silty mudstone, weathering to yellow clay at surface. Local outcrops around Thringstone-Swadlincote.
c) Carboniferous mudstone, Etruria Formation; red-brown silty mudstone with thin limestone beds. Crops out only in Warwickshire & Staffordshire.
d) Jurassic mudstone; dark blue-grey mudstone weathering to yellow-brown, plastic clay at surface. Crops out in SE of area shown in Fig. 1a.
e) Quaternary clays and tills (boulder clay), the latter dominantly consisting of Thrussington Till and Oadby Till. All tills are commonly weathered to yellow silty clay within about 0.5 m of the surface. Wide outcrops.
f) Alluvial clay and silty clay. Found in alluvium of Soar and Trent floodplain and tributaries.

Of these, a), e) and f) are ubiquitous throughout the East Midlands, and are therefore considered to have the best potential for pottery clay source material.

3.1.1. Mercia Mudstone

These Triassic strata are widely distributed (Fig 1a), and thus available for pottery making at many localities. They typically consist of red to brown, rarely green-grey, silty mudstone weathering to sticky clay that is usually red when dry and red-brown or brown when wet. In thin section (Fig. 2c), typical Mercia Mudstone contains abundant, dispersed silt to fine sand size crystal fragments, which represent aeolian grains that mixed with fine dust in Triassic desert conditions. These fragments show a wide variation in distribution throughout the mudstone, resembling the varying proportions of silt to fine sand silicate inclusions in the pottery clays (Table 2). They are commonly angular to subangular and mainly consist of metamorphic quartz, showing strained extinction and sutured grain boundaries, but can also include K-feldspar and plagioclase.

Many workers have noted that Mercia Mudstone cropping out in the Mountsorrel area contains grains, such as plagioclase, K-feldspar and biotite mica, which were probably derived from the local granodioritic rocks. The extent of this local influence was tested by the collection by hand-auger of a sample of Mercia Mudstone located about 300 m north-east of the

Mountsorrel granodiorite outcrops at Rowhele Hill and Buddon Wood. The brickette made out of this sample (Fig. 2d) contains silty quartz inclusions, similar to those in the Mercia Mudstone sample described above. In addition, there are common grains of perthitic K-feldspar and altered mica (possibly original biotite). There are also, however, common laths of muscovitic mica, which is not found in the Mountsorrel granodiorite or the South Leicestershire diorites. Muscovite mica laths are, however, common in beds of dolomitic siltstone that are intercalated within the Mercia Mudstone. Fragments of this dolomitic siltstone are shown in Fig. 2d, and possibly reflect the abundance of such beds in the local Mercia Mudstone succession. In this respect, this local variety of Mercia Mudstone is very similar to Thrussington Till (Fig. 2e).

3.1.2. Thrussington Till

This Quaternary deposit represents part of an extensive superficial sequence formed during the Anglian glaciation c. 430 000 years ago. It can be found in most parts of the generalized till outcrop shown in Fig 1b, underlying the Oadby Till. Thrussington Till was deposited by ice-sheets originating in the Pennines uplands and travelling south-south-eastwards across the East Midlands. It incorporated much weathered Mercia Mudstone bedrock, which is thus the dominant constituent of the red-brown silty or sandy clay matrix that characterizes this till. A sample of Thrussington Till (Fig. 2e) resembles Mercia Mudstone (Fig. 2c,d) petrographically, in that its matrix is pale red to red-brown, with abundant silt to sand-size grains; the latter include crystal fragments of the type found in Mercia Mudstone and there are also fragments of Triassic dolomitic siltstone. Other constituents, not found in Mercia Mudstone, include ‘Bunter’ quartzitic pebbles, the latter typically found in Triassic conglomerates, together with Carboniferous lithologies such as coal and various types of sandstone and limestone. It should be noted that, because of the prevailing ice transport direction, Thrussington Till cropping out to the south of Mountsorrel and Charnwood Forest contains additional erratics of Mountsorrel granodiorite and Charnian rock types, and its matrix will include material incorporated from local Triassic mudstones containing aeolian grains derived from these rocks.

It is concluded that the Thrussington Till shown in Fig. 2e does resemble many of the pottery clays, such as featured in Figures 2a and b and elsewhere in this report. However, fragments of Triassic dolomitic siltstone, which are very common in Thrussington Till (Fig. 2e), and in Mercia Mudstone from close to the Mountsorrel outcrop (Fig. 2d), have not been identified in the pottery thin sections.

3.1.3. Oadby Till

The Oadby Till generally forms the uppermost layer of till shown on Fig. 1b, and therefore has more extensive outcrops than Thrussington Till. It is also of Anglian age, but was deposited from ice-sheets travelling from the east. It has a dark blue-grey clay matrix, derived from Jurassic mudstones, and its erratic suite includes chalk, flint and various types of Jurassic limestone or fossil remains. In Fig. 2f, Oadby Till typically has a grey matrix with red mottles and silt- to fine sand-size crystal fragments. It contains abundant fragments of carbonate-rock and shelly material, which have never been found in the pottery clay samples.

3.1.4. Alluvial clay

LiDAR and ground surveys of alluvial tracts, such as the Trent floodplain, indicate that alluvium represents a complex of deposits. These include sand and gravel, which appears as arcuate point-bars, and also laminated muds, silts and sands that comprise gently sloping levees. The low-lying backswamp areas tend to accumulate the purest clays, primarily through the deposition of suspended material in overbank swamps and water bodies during flood events, or as fills to abandoned channels. These alluvial clay provinces probably occupy less than about 30% of an average floodplain. Most alluvial clays contain silt or fine-sand grade particles in varying proportions, as described below. Alluvial clays are also, very commonly, rich in organic material and may even contain layers of peat.

To test the possibility that alluvial clay may have formed convenient local resources of pottery material, five samples were collected at shallow depths (c. 0.5-0.7 m) by hand-auger, at localities on the Trent and Soar floodplains indicated in Table 1. In order to facilitate thin sectioning of these samples, and to compare them with the pottery sherd material, they were first of all converted into pottery brickettes by the method described in Section 2.

Swarkestone Clay brickette, from the Trent floodplain upstream of the Soar confluence, has a dark maroon to pale red, very silty clay matrix. Embedded in this are relatively large entities consisting of rounded, silty aggregates that are conspicuously black, and opaque under the microscope (Fig. 3a). Also in the matrix, but more sporadic in the opaque silty aggregates, are about 30% of evenly disseminated, silt to sand-size silicate inclusions. These mainly consist of angular to subrounded grains of quartz; many show internal sutured crystal boundaries and strained extinction, and some have a granoblastic, shape-orientated texture defining a metamorphic foliation. Less common are silicate inclusions of K-feldspar, including microcline and perthite. Other grains include microcrystalline quartz (possibly flint) and mica-rich meta-sediment. One silicate inclusion, a fine-grained K-feldspar mosaic, may be of igneous origin.

Shelford Clay brickette, from the Trent floodplain downstream of the Soar confluence, is strictly speaking a silt. It has abundant (c. 50-60%) silt to very fine sand-size, angular to subrounded or well-rounded silicate inclusions in a dark maroon clay matrix. The silicate inclusions mainly consist of quartz with strained extinction and sutured internal boundaries; there are also minor amounts of perthitic K-feldspar and plagioclase. Sporadic grains of microcrystalline quartz, probably flint (see below), are also present, as shown at bottom left of centre in Fig. 3b).

Kingston Clay brickette, from the Soar just south of its confluence with the Trent, is composed of silty clay. It contains c. 40-50% of silt to very fine sand silicate inclusions in a black to dark maroon clay matrix. The latter contains sporadic, small, rounded opaque silty aggregates, similar to those described for the Swarkestone clay sample. The silicate inclusions mainly comprise the same types of metamorphic quartz (strained extinction, sutured grain boundaries, locally foliated) as the above two samples, together with very minor proportions of microcline. There are also very common, subangular fragments of microcrystalline quartz (Fig. 3c). The latter show margin-related zonation, probably resulting from weathering, and contain small chalcedonic segregations comparable to petrographic textures associated with flint.

Mountsorrel Clay brickette represents the purest clay sample, with only c. 10% of silt to fine sand size silicate inclusions. These dominantly consist of the same quartz varieties noted in the above three samples, together with minor K-feldspar. One small granodioritic aggregate was seen, however (Fig. 3d), suggesting detritus contributed from the nearby outcrop of Mountsorrel granodiorite.

Enderby Clay brickette, like that of Mountsorrel, is a fairly pure clay, with only about 10% of mainly silt-size silicate inclusions. The clay matrix is black to pale red, the latter showing conspicuous rounded to elongate, opaque silty aggregates (Fig. 3e). The silicate inclusions mainly consist of the quartz- rich types noted above, and there is also a small aggregate with a mineralogy consistent with quartz diorite or granodiorite.

3.2 Conclusions: provenance of the pottery clays

These conclusions are summarized in Section 6 and Table 3b. The three most likely potential geological sources of clay material described above (Mercia Mudstone, Thrussington Till and alluvium) all have one feature in common: they contain abundant silt to fine sand-size silicate inclusions, in which quartzose metamorphic assemblages are very common. Those inclusions found in Thrussington Till and alluvium almost certainly were derived through the weathering and erosion of Mercia Mudstone bedrock, and this common origin explains the similarity of petrographical type between silt/fine sand inclusions in all three potential clay resources. The inclusions are identical to the silt/fine sand silicate inclusions found embedded within, and obviously integral to, the pottery sherds described in Table 2. It follows, therefore, that they will be non-diagnostic of any of the three potential geological sources mentioned above.

Also found in the alluvium, however, are small fragments that have been identified as flint. Flint is a Cretaceous lithology, which was transported to the East Midlands during the Anglian glaciation and forms an important erratic component of the Oadby Till (Section 3.1). Other components of Oadby Till, such as limestone and fossil shell fragments, have not been found in the pottery sherds; therefore, Oadby Till was not a source of pottery clay. Due to subsequent erosion, however, flint is noticeably concentrated within the Trent and Soar river terraces and floodplain alluvium, forming up to 50% of the pebbles in gravelly deposits. Small flint fragments have also been identified as part of the silt/sand detrital component in the Swarkestone, Shelford and Kingston clay brickettes. The presence of flint may therefore be used as an indicator of clay provenance (Table 3b) and on this basis, flint-bearing sherds from the sample sets WAN, MNF, HLF and GAM (Table 2) could have been made from alluvial clay. It should be noted that so sporadic are these flint fragments that their absence in thin sections does not necessarily preclude an alluvial source for any of the pottery clays, but this could be tested by isotope studies of (apparent) flint-bearing and non-flint-bearing samples. An alluvial source is also in keeping with conclusions drawn from the petrography of certain of the larger inclusions (below), particularly those of assemblages A, C and E which, as suggested in Section 5.3, may represent temper hand-picked from larger pebbles in gravelly alluvium.

A further feature of many sherds, and of the alluvial clay brickettes, is the presence of rounded black opaque aggregates. The possible origin of these is discussed at the beginning of Section 3. If such aggregates consist of organic/pedogenic material, they could be a further indicator of an alluvial source for the pottery clay, although it is possible that organic material, such as wood or charcoal, could have been incorporated during the clay-making process.

4. Pottery inclusion assemblages

Here the term ‘inclusion’ covers any component that is not clay. It therefore encompasses the silt to fine sand inclusions within the pottery clay matrix, discussed above. *Emphasis will, however, be placed on descriptions of the larger inclusions*. These are aggregations of silicate minerals, the composition and texture of which provide evidence of the rock types from which they were derived. Comparisons between these inclusions and likely source rocks are given in the next section (5).

Brief petrographic details of the inclusions are given in Table 2, and the distribution of these assemblages throughout the sample set is summarised in Table 3a. During the survey it was found that the same types of inclusion, or assemblage of inclusions, kept appearing among the various pottery sherd samples. Therefore to rationalise this distribution, and the descriptions that follow, several categories of inclusion assemblage have been delimited, and are lettered A-E in the right-hand column of Table 2. It is accepted that these assemblages may not necessarily represent pottery of radically different provenances. For example, a given pottery factory might have used a variety of rocks, or even broken stone implements, that were conveniently close at hand, so that different rocks could be used for different pots or even for the same batch of pots. In the case of landscapes developed on alluvium or glacial deposits, a wide variety of rock-types would have been available as cobbles and boulders strewn about on the surface or extracted by shallow excavation. Conclusions regarding provenance, based on inclusion assemblage type, are discussed in Section 5.

Assemblage A – granodiorite

Pottery sherds with granodiorite inclusions are widely distributed among the samples submitted. Together with the related assemblage A1, they constitute all of the WAN samples and 50% of the EKE, HLF, and MNF suites. They are also represented in 2 out of the 3 ACS samples, 1 out of 3 of the GAM and GBR samples and as single samples in SWL and CR. Obviously the smaller the number of samples in a given batch, the less meaningful these proportionate comparisons become. Assemblage A is unique in that it does not contain significant amounts of sedimentary or metasedimentary rock inclusions.

Typical granodiorite inclusions consist of granular aggregates of quartz, plagioclase and K-feldspar, the latter commonly with perthitic intergrowths seen as vein or rod-like streaks of albite plagioclase in a K-feldspar host (Figs 4a and b). Textures are typically inequigranular, demonstrated by inclusions containing oscillatory-zoned plagioclase feldspar that is euhedral (shows good crystal form) and is appreciably larger than the crystals of the surrounding granular aggregates. Biotite with strong red-brown pleochroism[2] is a common accessory mafic mineral, as shown in Fig. 4a. Hornblende with pale green to brown or almost colourless pleochroic scheme is also common (e.g. in WAN 0902). Smaller inclusions in Assemblage A mainly represent fragments of the granular quartz-feldspar aggregates, some with biotite, together with fragments of individual zoned plagioclase (e.g. EKE0906, WAN0908). The latter indicates that upon crushing, the rock may have separated along the edges of these larger crystals. The matrix of many Assemblage A and A1 (below) sherds also contains very small individual laths of red-brown biotite (e.g. WAN0902, 0904, and Fig. 4d). Biotite is a sheet-silicate, and would readily have formed such flakes upon crushing.

Assemblage A1 – granodiorite and metasediment

This is a variant of Assemblage A, characterised by a slightly more diverse suite of inclusions, in which the granodiorite variety is accompanied by various types of sedimentary and metasedimentary rock fragments. These include chert, flint (Fig. 4c), foliated quartz-rich meta-siltstone and various types of quartzite and metaquartzititic sandstone. The latter commonly have granoblastic textures and/or sutured grain boundaries; a variety with a strong foliation is shown in Fig. 4d.

Assemblage A2 – granite or syenite

This assemblage was recognised in EKE 0912 and three of the WIL samples. In EKE 0912 it consists of aggregates of large plates of K-feldspar with

[2] Pleochroism is a property whereby a mineral changes colour upon rotation of the microscope stage under plane polarized light

perthitic texture, together with smaller crystal fragments of the same mineral (Fig. 4e). This mineralogy appears to represent fragments of coarse-grained rock with a dominance of K-feldspar over plagioclase, such as might be found in granitic or syenitic rock-types. More intact inclusions, in WIL 0901 and 0902 consist of large, perthitic K-feldspar enclosing smaller euhedral plagioclase (Fig. 4f). In addition to granular quartz aggregates, there are small laths of muscovite mica, indicating a different type of mineralogy to the Mountsorrel granodiorites with their characteristic red-brown biotites. These inclusions therefore differ from the granodioritic inclusions in the other Assemblage A examples.

Assemblage B – quartz diorite with green hornblende

These inclusions occur in the MNF, HLF, CR and WIL sample batches. They mostly consist of medium- to fine-grained granular to hypidiomorphic-granular aggregates of heavily altered plagioclase (e.g. Fig. 5a), together with abundant laths of hornblende. The latter is pervasively altered to oxides and chlorite in most cases, but in less-altered samples (e.g. Fig. 5b), has a pale green to green-brown pleochroism. Other constituents include primary Fe-Ti oxides and interstitial quartz aggregates. One textural variant, in HLF 0904, shows subordinate granophyric intergrowths. Large inclusions of inequigranular granodiorite, with pale green hornblende and red-brown biotite are additionally present in HLF 0905 and WIL 0904. In the latter, green hornblende is abundant, suggesting that the parent quartz-diorite may be heterogeneous, with ‘mafic clumps’ (Fig. 5d), a feature typical of many dioritic and granodioritic rocks in the East Midlands. WIL 0904 contains other unusual quartz diorite inclusions, in which green hornblende is accompanied by red-brown biotite. Other inclusions in Assemblage B consist of metasandstone, chloritised ?metavolcanic rock, chert, flint, siltstone and metasiltstone, and individual crystal fragments and grains of quartz, plagioclase, microcline and pale green hornblende.

Assemblage B1 – quartz diorite with green/brown hornblende

This assemblage has been found only in CR 0905 and 0906. In these samples, quartz diorite inclusions appear to be mineralogically similar to Assemblage B, with plagioclases typically heavily altered (Fig. 5c). They are, however, distinctive in that they contain hornblende with a dark brown or red-brown to green pleochroic scheme.

Assemblage C – metasandstone and sandstone

Metasandstone forms a minor inclusion component in many assemblages (Table 2), but is dominant in Assemblage C, which has been recognised in the EKE, MNF, HLF, ACS and GBR sample batches. These inclusions are both quartzitic and subarkosic (ie containing minor feldspar, which includes microcline). Textures in most metasandstone inclusions are granoblastic, indicative of derivation from metamorphic rock. Related to this, a possible example of mortar texture (large, strained crystals surrounded by mosaics of smaller less-strained crystals) is shown by the large inclusion at the bottom of Fig. 5e, which also contains smaller fragments with sutured grain boundaries, again indicative of recrystallisation during metamorphism. Undeformed to mildly deformed, fine-grained quartzitic or subarkosic sandstone forms a minority of smaller inclusions in Assemblage C, but is dominant in GAM 0903 and HLF0906. In the latter (Fig. 5f) overgrowth textures, of original diagenetic origin, are preserved around many quartz grains. Silt to sand-size inclusions in Assemblage C mainly represent the finely comminuted debris of larger fragments, but also include chert, flint, metasiltstone, schist/phyllite and silicified-rock, together with clinopyroxene, biotite and K-feldspar crystal fragments.

Assemblage D – basalt and microgabbro, with metasediment

This distinctive inclusion suite forms a minority of the pottery sherds in the EKE and MNF sample suites. Microgabbro inclusions consist of fresh, fine-grained aggregates of lath-shaped plagioclase, which is sub-ophitically enclosed by plates of clinopyroxene. Orthopyroxene is sparsely present as early-crystallising euhedra that do not enclose plagioclase. Fe-Ti oxides and minor interstitial quartz aggregates are the other constituents. The occurrence of quartz together with orthopyroxene indicates derivation of the rock from oversaturated, tholeiitic magmas. Textures are microgranular, verging to sub-ophitic in Figure 5a. Basalt inclusions have essentially the same mineralogy, but are finer grained with intergranular textures, this being where clinopyroxene and orthopyroxene occur as granules rather than plates (Fig. 6b). Other inclusion types in Assemblage D consist of subarkosic sandstone (Fig. 6a) and green, fine-grained chlorite-rich fragments interpreted to be of metavolcanic rock (Fig. 6b); EKE0904 also contains small fragments of quartz and perthitic K-feldspar suggesting a granite or granodioritic inclusion component.

Assemblage E – silicified rock

Rare inclusions consisting of silicified-rock have been encountered in the HLF and GBR sample suites. Because the textures produced by these are so unusual and distinctive, they have been recognised as a separate assemblage, although they may in reality form small parts of other inclusion assemblages. Convincing sections through a silicified plant fossil are shown in Fig. 6c. In Fig. 6d, an angular fragment of silicified rock probably has a similar provenance, although does not show any obvious organic features. The latter inclusion type co-exists with large granodiorite fragments, suggesting an affinity to assemblage A; however in GBR0902 (Fig. 6c) the co-existing inclusions are mainly small fragments of metasandstone, suggesting affinity to Assemblage C.

5. Geological sources of the larger pottery inclusions

Only the large-size inclusions (>c.3 mm) are considered here. Most of the smaller, silt to sand-size inclusions may be intrinsic to the pottery clay matrix, the source(s) of which are discussed in Section 3.2. It should be noted, however, that fine crushing of rock materials used as temper would also produce angular sand or silt-size material that will have been dispersed within the pottery clay.

In the study by Knight et al. (2003) on the petrography of granodioritic inclusions in East Midlands prehistoric pottery, it was suggested that a local source utilising Mountsorrel granodiorite was possible, based on comparisons of mineralogy and texture between inclusions and samples of potential source rocks. There were, however, reservations when assigning the very small inclusions to a particular source using petrographical methods alone, since small inclusions with only a few crystals may not be representative of the texture and mineralogy of the source rock.

For the present study, the much larger sample subset has shown a greater diversity of inclusion types, which is reflected by the several assemblage categories shown in Table 2. There are also many particularly large inclusions (up to 5 mm size), which are amenable to comparison with potential source rocks, either local or from farther afield. For these comparisons, photomicrographs of selected rock types are illustrated in Figs. 7 and 8. Their locations are given in Table 1 and (for local rock types) Fig. 1a.

Granodiorite *sensu stricto* has been mapped at a variety of British locations, principally in Scotland. It is a relatively rare lithology in England and Wales; however, in the East Midlands granodiorites of the Mountsorrel Complex (Carney et al., 2009) form the easternmost, and most extensive, exposures of a series of intrusions of Ordovician age (*c.*445 million years before present). The rocks in the relatively smaller exposures to the west and south of the Mountsorrel Complex (Fig. 1a) are quartz diorites, containing less quartz and greater proportions of ferromagnesian minerals (mainly pale green hornblende) than Mountsorrel granodiorites. These rocks, exposed at Croft, Enderby, The Yennards and Sapcote-Stoney Stanton, are collectively known as the ‘South Leicestershire Diorites’ (Worssam and Old 1988). They are related to each other and to the Mountsorrel Complex by a common trend of geochemical evolution (Le Bas, 1972; 1981).

5.1. Assemblage A: granodiorite inclusions

For this type of inclusion, a local source in the granodiorite exposures (Front cover) of the Mountsorrel Complex was considered possible (e.g. Knight et al., 2003). In situ specimens of typical Mountsorrel granodiorite, from the outcrops shown in Fig. 1a, have a coarsely inequigranular appearance on weathered or fresh faces (e.g. Carney et al., 2009; Carney and Pharaoh, 1999). This texture is caused by the presence of large (c.10-15 mm) rectangular to oblong-shaped, pink or white, concentrically zoned crystals of plagioclase, which are set in granular (medium- to coarse-grained) aggregates of zoned plagioclase, quartz and untwinned perthitic K-feldspar, as shown in Figs. 7a and 7b. In thin sections feldspars are somewhat clouded and grainy, due to partial secondary alteration that has resulted in the development of sericite, and minute, oxide–rich inclusions. The mafic or ferromagnesian minerals appear as dark speckles on fresh surfaces of the rock, and include biotite, with red-brown to pale greenish brown pleochroism, and hornblende, with pale yellow to pale green pleochroism. The biotite is generally altered along its margins and cleavage to chlorite and Fe-Ti oxides.

The selected examples of Assemblage A granodiorite inclusions illustrated in Figs. 4a and 4b compare well with the Mountsorrel granodiorite described above, and featured in Figs. 7a and 7b, in terms of mineralogy and their inequigranular texture. The latter texture features euhedra of zoned plagioclase feldspar of various sizes, which are significantly larger and better-formed (more euhedral) than the surrounding granular crystalline aggregates. The particularly large plagioclase feldspars would probably have fallen out upon crushing, resulting in their incorporation as single crystal fragments in the inclusions and there are many examples of this; e.g. EKE0906 and WAN0908 (Table 2). Thus the granodiorite inclusions tend to contain only the smaller of these euhedral plagioclase crystals.

In their discussion about methods of prehistoric exploitation of Mountsorrel granodiorite, Knight et al (2003) suggested that as the most readily extractable material would have been from naturally weathered exposures it is those, rather than fresh samples from the active or disused quarries, that would be more appropriate for provenancing. Samples were therefore also collected from small craggy exposures at the summit of Rowhele Wood, immediately north of Buddon Wood Quarry (Table 1). It was noted that a) these rocks gave a rather dull sound when hit with a hammer, b) the large feldspars appeared unusually white and thus possibly were altered, and c) when hit, the rock crumbled easily along a centimetre-scale anastomosing fracture system that was obviously related to weathering. Surprisingly, a thin section of one of these weathered samples (ROW-1; Fig. 7b) appears remarkably fresh and, apart from the microfractures noted earlier (not shown in Fig. 7b), is indistinguishable petrographically from newly quarried material (Fig. 7a). This suggests that natural weathering of the granodiorite mainly involved mechanical rather than chemical agencies (the latter would produce a soft, clay-rich weathering profile). Mechanical weathering would render the granodiorite amenable to extraction and crushing while retaining its original lithological character.

Other inclusion types include flint, siltstone and deformed sedimentary rocks consisting of metasiltstone and fine-grained metaquartzite in ***Assemblage A1*** (Figs. 4c and 4d). Metamorphosed sedimentary rocks are not represented at outcrop in the Midlands region; however, the derivation of these inclusions could still have involved local sources, such as the pebbles in Triassic conglomeratic sandstones, or the same pebbles subsequently concentrated within alluvial gravels, as discussed below in section 5.3.

The granitic or syenitic inclusions of ***Assemblage A2*** (Figs. 4e, 4f) are not obviously comparable to the East Midlands parental granitoid rocks shown in Fig. 1. In particular, they contain muscovite mica as opposed to the red-brown biotite typical of the Mountsorrel Complex.

Conclusions:

1) The larger Assemblage A inclusions could be derived from Mountsorrel Complex granodiorite.

2) The sedimentary and metasedimentary inclusions (Assemblages A1 and A2) could have been added in from local bedrock or alluvial sources (Section 5.3.).

3) Assemblage A2 contains granitic material with a mineralogy that is atypical of East Midlands granodiorites or quartz diorite

5.2. Assemblage B: quartz diorite

These inclusions are typically finer-grained, and more equigranular (even-grained) than the granodiorite inclusions of Assemblage A. A range of types may be present, dependent upon the degree of alteration of the feldspars and ferromagnesian minerals and the abundance of hornblende.

Quartz diorite inclusions with highly altered, grainy feldspars (e.g. Fig. 5a) and partially to completely altered hornblende are comparable in appearance to rocks from the small outcrops of South Leicestershire Diorites, such as found at Stoney Cove and The Yennards (e.g. Fig. 7e and 7f). There are also smaller inclusions (not illustrated) of relatively less altered, inequigranular quartz diorite (in MNF0905), similar to the rocks at Croft (Fig. 7d). The relatively less altered quartz diorite inclusion (Fig. 5b), with abundant green hornblende, appears similar to the quartz diorite found within the Mountsorrel Complex at Brazil Wood, Swithland Reservoir (Fig. 7c), although it could also represent a particularly fresh example of South Leicestershire Diorite.

Local sources of quartz diorite that can be ruled out are the Precambrian intrusions of the North Charnwood Diorite and South Charnwood Diorite, the latter also known as ‘markfieldite’. In these diorites, granophyric textures are widely developed (Figs 8a and 8b) and would be expected to show, even within the confines of a small pottery inclusion.

Assemblage B1 quartz diorites, known only from the CR samples, contain hornblende with a dark brown or red-brown to green pleochroic scheme and are therefore probably not sourced from either the Mountsorrel Complex or South Leicestershire Diorites.

Conclusions:

1) Assemblage B quartz diorite inclusions could all have been derived locally, from the South Leicestershire Diorites and possibly the Mountsorrel Complex.

2) Assemblage B1 quartz diorite inclusions were not derived from local in situ rock types.

5.3. Assemblage C: metasandstone and sandstone

It is important to note that as well as forming the large inclusions which define Assemblage C, sandstone and metasandstone (e.g. metaquartzite) also accompanies the igneous rock inclusions in all of the other assemblages, with the exception of Assemblage A. Most of these inclusions are quartz-rich, either quartzites or, where possessing deformational textures, metaquartzites. There are also subarkosic types, characterised by minor proportions of K-feldspar, such as microcline. These sedimentary inclusions are also generally fine-grained, as shown in Fig. 5f.

Quartzite and subarkosic sandstone forms small exposures in the Midlands region; for example in Charnwood Forest, at Nuneaton, and farther west in the Lickey Hills of Worcestershire and at the Stiperstones, in the Welsh Borders. All of these sandstones are undeformed and are characterised by a quartz cement, which forms overgrowths around the original grains. This diagenetic texture is seen in several Assemblage C sandstone inclusions.

Inclusions consisting of deformed sandstones (metaquartzite and subarkosic metasandstone), together with large quartz crystals possessing strained extinction, suggest derivation from metamorphic parental rocks that do not crop out in the Midlands region. Possibilities are:

a) The pottery was manufactured outside the region
b) The inclusions represent fragments of pebbles derived from a source in coarse-grained Carboniferous sandstones and conglomeratic Triassic sandstones found in the region.
c) The inclusions were collected from alluvial gravels containing an abundance of such pebbles.

In the case of b), a wide range of sandstone pebble-types, including foliated metaquartzite, has been found within East Midlands Triassic conglomerates (e.g. Lott, 2006; Strong, 1979). Particularly high concentrations of quartz pebbles, some of relatively large (cobble) size, characterise the Nottingham Castle Sandstone Formation (also known as the Polesworth Formation and formerly known as the ‘Bunter Pebble Beds’). These strata have extensive local outcrops bordering the Trent valley; for example, around Nottingham and the Foremark Reservoir in South Derbyshire. An investigation of pebbles from Triassic conglomerates near Swadlincote, South Derbyshire, found that some had flakes of mica and sutured grain boundaries (Strong, 1979), suggesting that they are of metamorphic origin. In a further study of 66 Triassic pebbles from the Lichfield area (Lott, 2006), meta-quartzite, quartzose sandstone, volcaniclastic sandstone, volcanic rocks and various igneous rocks were all found as pebbles. The meta-quartzites are described as being 'fine-grained' and 'welded', and a photomicrograph is included of a sample possessing sutured grain boundaries and a weak foliation. Metaquartzite and various types of sandstone have also been found as pebbles in strata of the Carboniferous-age Millstone Grit, which crop out in the East Midlands. The Millstone Grit, however, contains particularly abundant pebbles of granitic material, such as granophyre and pegmatite (e.g. Gilligan, 1919), which have not been encountered during the present study.

Given the location of these pottery sites on or close to major floodplains, further sources to be considered are alluvial gravels and river terrace deposits (option c) above). Quartz-rich pebbles and cobbles are preferentially concentrated within these deposits, due to their resistance to abrasion and dissolution. Their ultimate derivation, however, is most likely to be from the erosion of Triassic conglomerates. The studies of Strong (1979) and Lott (2006), detailed above, suggest that although dominantly quartz-rich, Triassic pebbles are diverse in type, perhaps accounting for the occurrence of possible metavolcanic (Fig. 6b) inclusions. The sedimentary inclusions studied here, however, mainly consist of quartzite and meta-quartzite suggesting that these types of pebbles were especially selected for use as temper. This could be because of their hardness, or their ability to flake and split easily along foliation planes, or they may have certain features (e.g. colour, coarse banding) to easily distinguish them from the many other types of pebbles. Selection would be greatly facilitated by searching through loosely-bound deposits, such as alluvium or river terrace gravels, in which pebbles are already naturally concentrated. Selection based on lithology and mode of occurrence may also explain why granodiorite and quartz diorite temper material appears to be little represented in Assemblage C. Flint is also not represented among the larger inclusions, but is a sporadic constituent of the silt to fine-sand size inclusion component, again suggesting an alluvial influence (Section 3.1.4).

Conclusions:

1) Assemblage C inclusion lithologies are 'exotic' to this region, but could have been derived from pebbles in local Triassic sandstones and conglomerates.

2) Such pebbles are naturally concentrated in alluvium or floodplain deposits, from which they could easily have been picked out.

5.4. Assemblage D: basalt and microgabbro inclusions

These inclusions (Figs. 6a and 6b) contain microgabbro with the assemblage plagioclase-clinopyroxene-orthopyroxene-Fe/Ti oxides-quartz. They belong to a quartz-oversaturated, tholeiitic basic magmatic suite, and in this important respect they are unlike any of the Carboniferous gabbroic or basaltic rocks exposed in the East Midlands. The principal feature of East Midlands basalts and gabbros is that they contain olivine, have no quartz, and belong to an alkaline basic magmatic suite.

The time constraints of this study did not allow for detailed research into the provenance of these inclusions. It is noted, however, that the Carboniferous-age Whin Sill of northern England consists of quartz dolerite (dolerite is a textural variant of microgabbro), with the mineralogy: clinopyroxene, orthopyroxene and quartz, commonly with sub-ophitic texture (Fig. 8c). It therefore has considerable similarities to Assemblage D microgabbro (cf Figs 6a and 8c). In Fig. 8c, however, the interstitial quartz is commonly expressed as myrmekite rather than the granular to ophitic pools found in the Assemblage D microgabbros. Myrmekite is, however, sparsely distributed in Whin Sill rocks and thus might not always occur within the limited confines of a pottery inclusion. The basaltic inclusion (Fig. 6b) probably represents a finer grained variant of the same magma that produced the microgabbro of Fig. 6a; rocks with basaltic textures typically occur in the outer, chilled margins of gabbroic intrusions.

The Whin Sill is a well-known archaeological resource in central and eastern England, albeit of prehistoric tools (Group XVIII) as opposed to pottery material (Williams-Thorpe et al., 2003). The latter authors attributed the distribution of Whin Sill artefacts to the ‘opportunistic use of glacial erratics rather than trade from the primary source’. In the case of the pottery material discussed here, however, this is highly unlikely as the local East Midlands glacial succession contains few, if any, erratics of this type.

Other possible sources of gabbroic material in the UK can be ruled out. For example, gabbro from the Lizard peninsula, Cornwall (Fig. 8d), does not have ophitic textures and the mafic minerals consist of hornblende, as opposed to the abundant fresh clinopyroxene in Fig. 6a. Other Cornish gabbro samples are extremely coarse-grained (pegmatitic), unlike the texture of assemblage D inclusions.

Conclusions:

1) Assemblage D-type pottery contains inclusions ultimately derived from rocks exotic to the Midlands, but strongly resembling microgabbros of the Whin Sill

2) It may have been therefore have been manufactured outside of the East Midlands, or

3) It was manufactured locally but with imported basalt and microgabbro used as temper. There is a possibility of opportunistic use of discarded stone implements of this type, which evidently furnished an important archaeological resource, particularly in south/central and eastern England.

5.5. Assemblage E: silicified rock

As noted above, the inclusion content of this assemblage is essentially similar to that of Assemblage C, but with the additional presence of sporadic silicified rock fragments, some preserving fossil plant remains (Fig. 6c). This mode of preservation is highly unusual, but has been described from Carboniferous Limestone strata in West Lothian, Scotland (Brown et al., 1994). Chert nodules do occur in the Carboniferous Limestone of Derbyshire, but these preserve shelly fossils, such as crinoids, rather than plantae.

Conclusion: The silicified rock inclusions appear to be from a source, possibly of Carboniferous age, that is exotic to this region. They nevertheless occur as part of Assemblage C, the origins of which are discussed above.

6. Summary

Tables 3a and 3b summarise the conclusions that can be drawn regarding the likely sources of, respectively, pottery temper and pottery clay. The petrographic investigation has confirmed that Mountsorrel granodiorite and the South Leicestershire Diorites formed major pottery temper resources. It is unlikely that these lithologies would have been present in alluvium or superficial deposits of the River Trent west of the Soar confluence, since this would be against the natural, erosional transport paths. It is also unlikely that these materials would be present to any great extent in alluvial deposits elsewhere, since the gravelly component of such deposits is known to mainly contain flint and Triassic-derived, quartzose pebbles. It is therefore concluded that this granodioritic and dioritic material was locally quarried, from the various outcrops shown in Fig. 1a.

Temper composed of quartzose material, such as quartzitic sandstone and meta-quartzite, is geologically ‘exotic’, but found in abundance as pebbles in alluvial gravels of the Trent and Soar floodplains, which are therefore considered to have formed major resources for this material. Alluvial sources are, to some extent, confirmed by the appearance of small flint fragments in the pottery clay matrix; these are evidently ‘accidental’ contaminants from a possible alluvial clay resource. It appears, however, that flint was never used as temper.

Other temper material, such as microgabbro of possible Whin Sill origin, and granitic or dioritic fragments with mineralogies atypical of either the Mountsorrel or South Leicestershire rocks, appear to be ‘exotic’ and may have been introduced to the region by human agencies.

The source of pottery clay remains debateable; however, the occurrence of small flint fragments points to a possible use of alluvial clays and silts, which are abundant on the floodplains of the Trent and Soar. The other matrix constituents – abundant silty silicate grains, are non-diagnostic of origin as they occur in Triassic mudstones, glacial deposits and alluvium. The common presence of black, opaque, silty masses in the pottery clay is intriguing – if it is organic, it may point towards an alluvial source. Contamination of the clay by woody material during fabrication cannot be entirely ruled out, although such contaminants would form elongate, not rounded, masses in thin sections. Finally, some of the pottery material appears to have incorporated fragments of pre-existing pottery.

References:

Beck, E., and Neupert, M.A. 2009. Identifying pottery clay from rice fields: an example from southern Luzon, the Philippines *Journal of Archaeological Science, 36, 843–849*

Brown, R.E, Scott, A.C., and Jones, T.P. 1994. Taphonomy of plant fossils from the Visean of East kirkton, West Lothian, Scotland. *Transactions of the Royal Society of Edinburgh: Earth* Sciences, 84, 267-274.

Carney, J N, Ambrose, K, Cheney, C S, and Hobbs, P R N. 2009. Geology of the Leicester district. *Sheet description of the British Geological Survey*, 1:50 000 Series Sheet 156 (England and Wales).

Carney, J. N. and Pharaoh, T. C. 1999. Buddon Hill. In *Caledonian Igneous Rocks of Great Britain*, Geological Conservation Review Series No. 17, Joint Nature Conservation Committee, Peterborough, 224-227.

Gilligan, A. 1919. The petrography of the Millstone Grit of Yorkshire. *Quarterly Journal of the Geological* Society, 75, 251-294.

Knight, D., Marsden, P., and Carney, J. N. 2003. Local or non-local? Prehistoric granodiorite-tempered pottery in the East Midlands. In: *Prehistoric Pottery: People, pattern,and purpose* (Ed. A. Gibson). Prehistoric Ceramics Research Group; Occasional Publication No. 4. 111-125.

Le Bas, M. J. 1972. Caledonian igneous rocks beneath Central and Eastern England. *Proceedings Yorkshire Geological Society*, 39, 71-86.

Le Bas, M J. 1981. The igneous basement of Southern Britain with particular reference to the geochemistry of the pre-Devonian rocks of Leicestershire. *Transactions of the Leicester Literary and Philosophical Society*, Vol. 75, 41-57.

Lott, G. K. 2006. Petrographic description and identification of pebble samples from the Permian –Triassic (?Hopwas Breccia Formation), Lichfield Sheet (154). *British Geological Survey Research Report*, IR/06/141, 17pp.

Strong, G.E. 1979. Petrographical descriptions of Polesworth Formation pebbles (Triassic) from the Netherseal and Warton areas, near Swadlincote, Derbyshire. *Institute of Geological Sciences, Petrology Unit Report* No. 177, 2pp.

Williams-Thorpe, O., Webb, P.C., and Jones, M.C. 2002. Non-destructive geochemical and magnetic characterisation of Group XVIII dolerite stone axes and shaft-hole implements from England. *Journal of Archaeological Science*, 30, 1237-1267.

Worssam, R.A. and Old, R.A. 1988. Geology of the Country around Coalville. *Memoir of the British Geological Survey*, Sheet 155 (England and Wales).

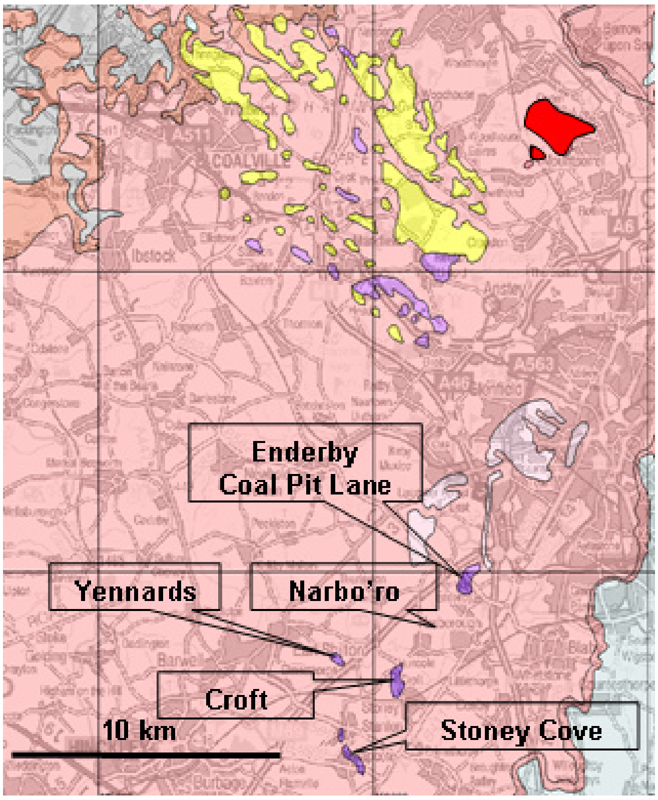

Fig. 1a. Simplified bedrock geology

Jurassic

Triassic:
Mercia Mudstone
Sherwood Sandstone

Carboniferous
(Coal Measures)

Ordovician:
Mountsorrel Complex
South Leics. Diorites
(only the named outcrops)

Precambrian:
N & S Charnwood Diorites
Charnian Supergroup

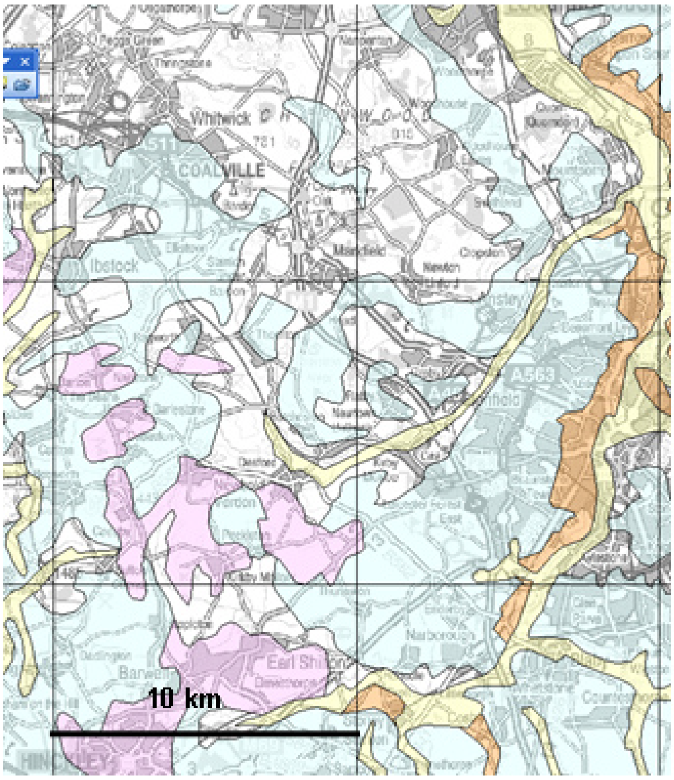

Fig. 1b. Simplified Quaternary geology

Floodplain alluvium
River terrace deposits

Glacial till*
Glacial sand and gravel*

* Anglian Stage deposits

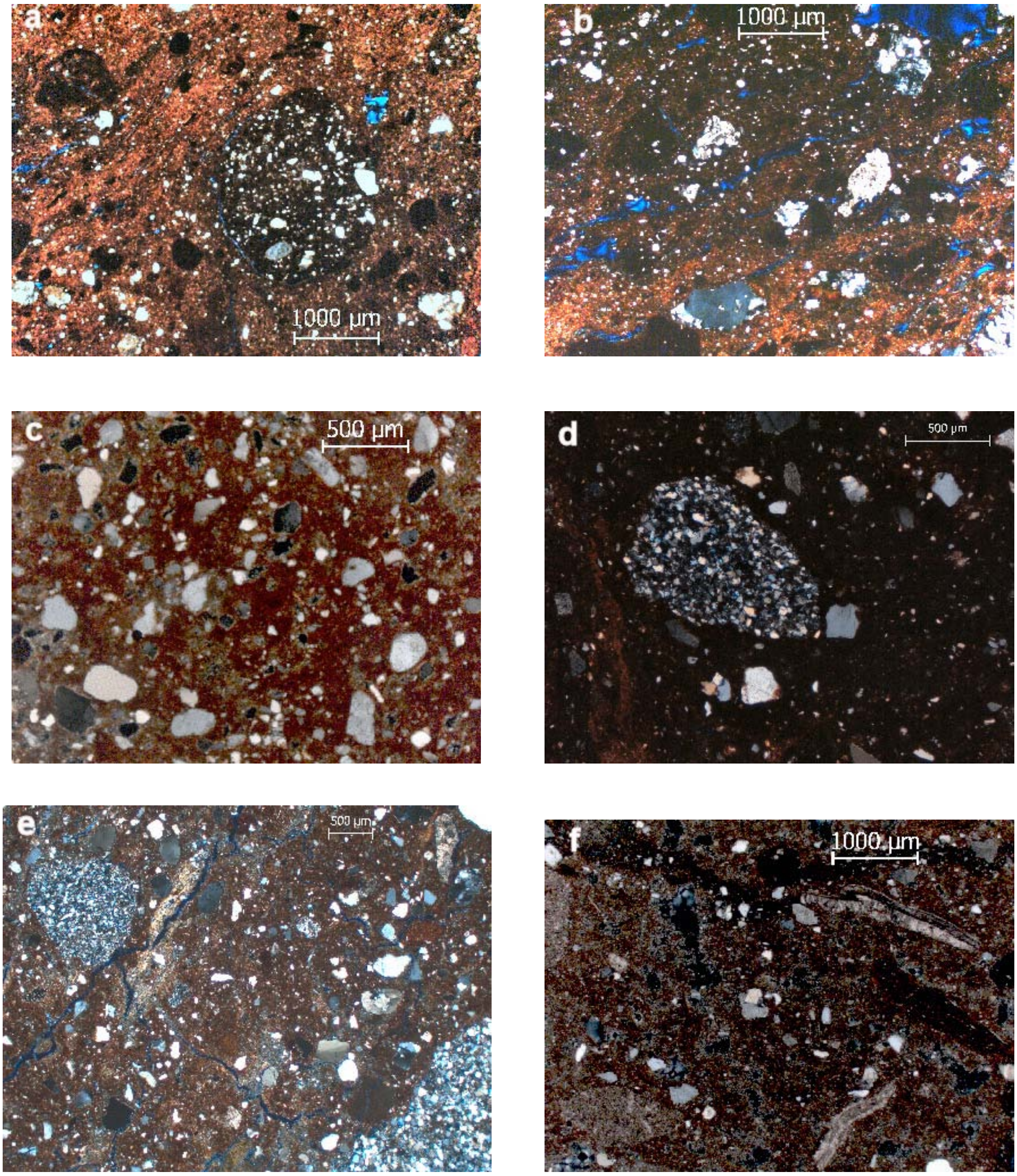

Fig. 2. a) Typical red pottery clay matrix, with rounded inclusions of black silty clay and black non-silty ?iron oxide rich material; WAN 0901 (ppl). b) Discontinuous parallel fractures in pottery clay, shown by blue dye in WAN 0902 (x-nicols). c) Mercia Mudstone, with angular to subrounded silt/fine sand inclusions; JNC 927 (x-nicols). d) Auger sample of Mercia Mudstone 'ROWHELE CLAY' from c. 300 m north-east of Buddon Wood granodiorite outcrop, showing dolomitic siltstone fragment (x-nicols). e) Thrussington Till, with fragments of dolomitic siltstone (e.g. lower right corner); JNC 930 (x-nicols). f) Oadby Till, showing carbonate shell debris (elongated inclusions); JNC 929 (x-nicols).

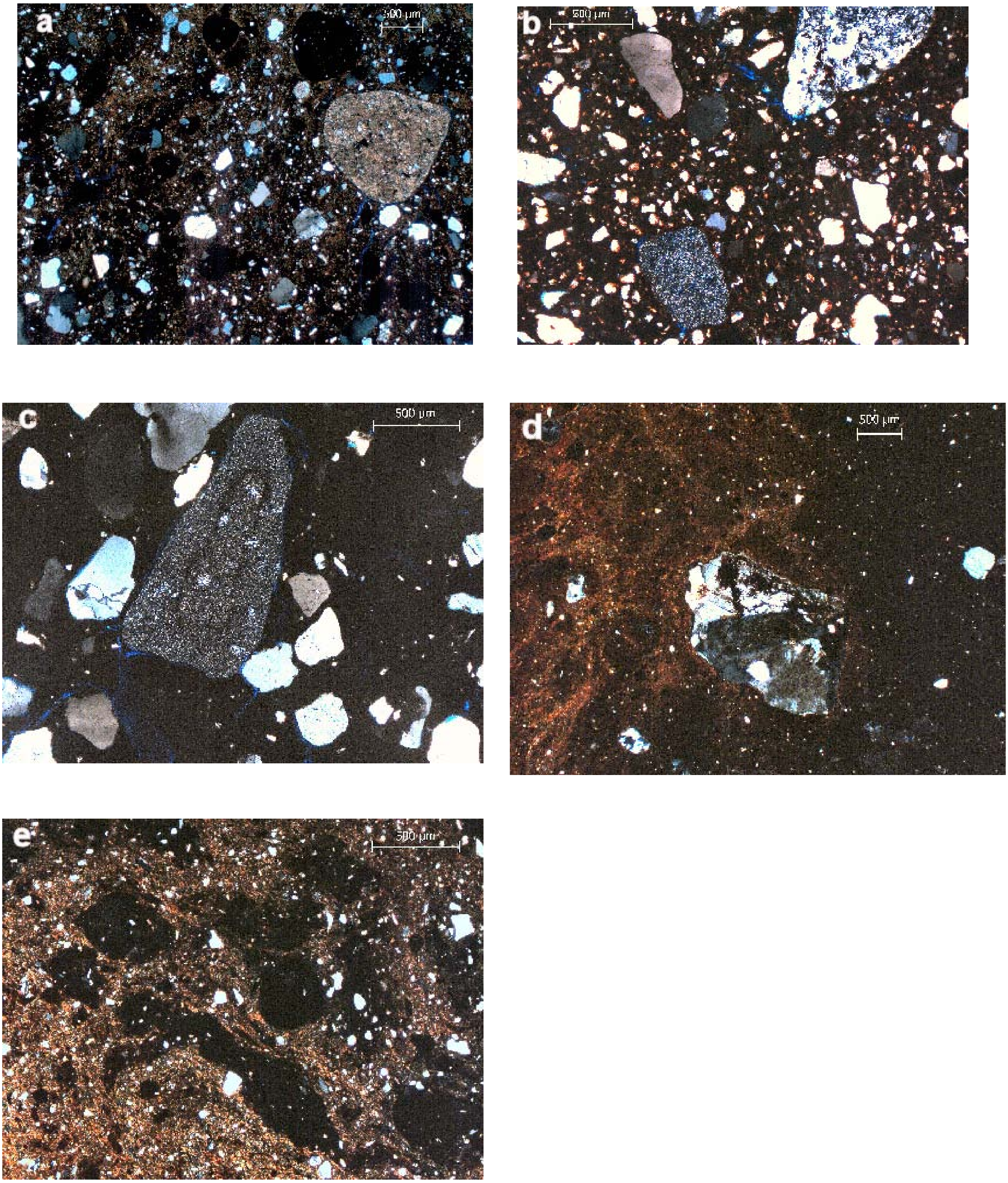

Fig. 3 Alluvial clay brickettes. a) Swarkestone Clay, showing rounded black opaque aggregates (x-nicols). b) Shelford Clay, showing microcrystalline quartz fragment, interpreted as flint, in lower part of view (x-nicols). c) Kingston Clay, showing microcrystalline quartz fragment with chalcedonic segregations, interpreted as flint; other grains include quartz with sutured boundaries and strained extinction (x-nicols). d) Mountsorrel Clay, showing small granodioritic fragment (x-nicols). e) Enderby Clay, showing common rounded to elongate, black opaque silty aggregates (ppl).

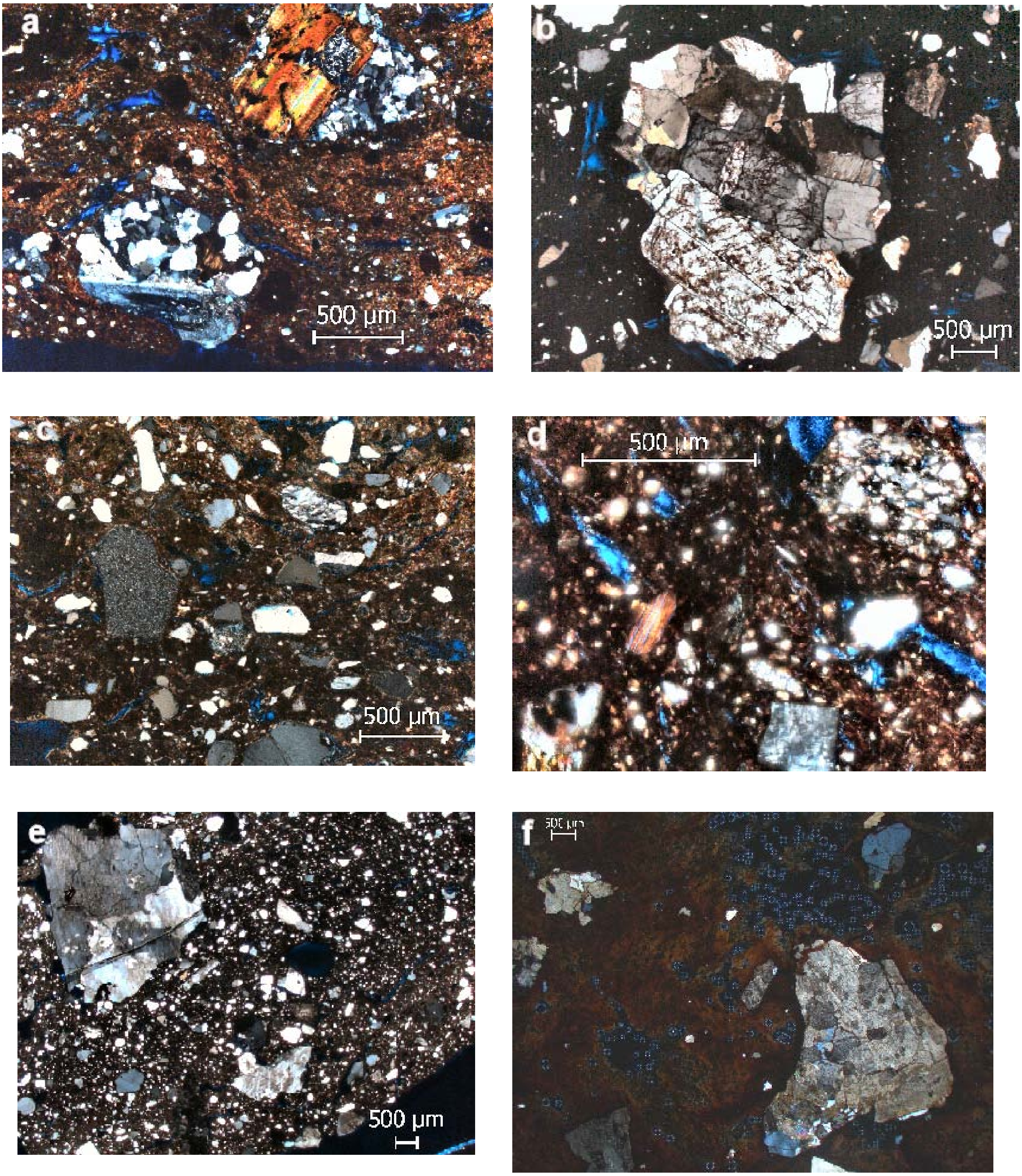

Fig. 4 a) Assemblage A-type granodiorite inclusions. Note inequigranular texture caused by large zoned plagioclase feldspar in lower inclusion. Red-brown biotite is seen in upper inclusion; sample WAN 0902 (x-nicols). b) Granodiorite inclusion of Assemblage A, showing large plagioclase (lower part of inclusion) enclosed by granular aggregate of quartz, plagioclase and perthitic K-feldspar; sample EKE0909 (x-nicols). c) Assemblage A1 inclusions, showing flint fragment (left of centre) and foliated metaquartzite or crushed vein quartz (ovoid inclusion at upper right of centre); MNF0908 (x-nicols). d) Assemblage A1 showing fine-grained metasandstone inclusion with mica foliation at top right. Note also, individual biotite lath in matrix at lower left; sample HLF0903 (x-nicols). e) Assemblage A2 inclusions consisting of aggregates and smaller fragments of perthitic K-feldspar; EKE0912 (x-nicols) f) Assemblage A2 inclusions, consisting of coarse aggregates of grainy, altered K-feldspar and brightly coloured scraps of muscovite; sample WIL 0902 (x-nicols).

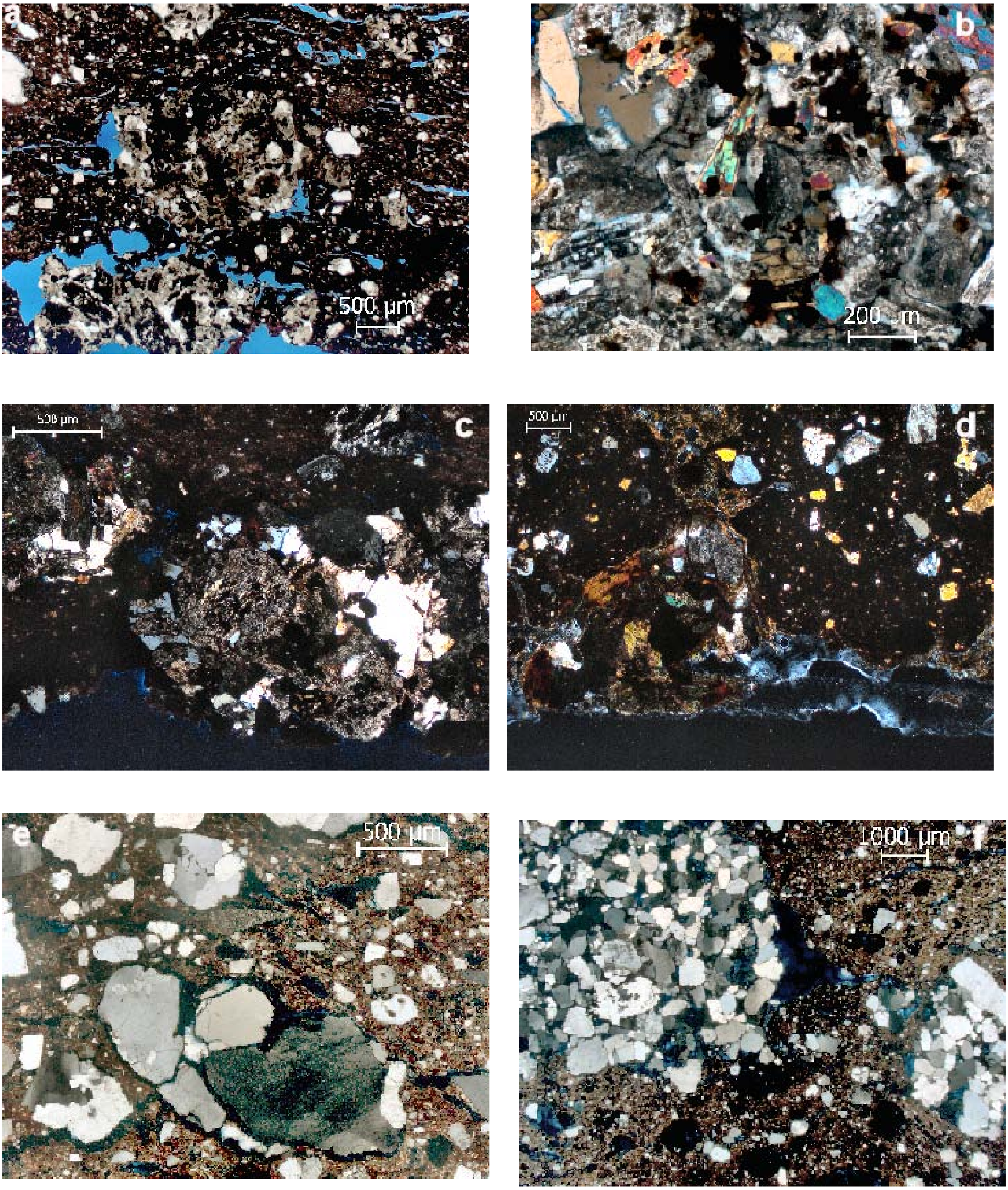

Fig. 5 a) Assemblage B quartz microdiorite inclusions (centre and lower part of picture); MNF 0902 (ppl). b) Close-up of assemblage B microdiorite in HLF 0904, showing fresh hornblende laths (bright blue-green-orange colours). c) Assemblage B1 quartz diorite variant with green/red-brown pleochroic hornblende; CR 0906 (x-nicols). d) Assemblage B quartz diorite (lower edge of sherd) with 'mafic clump' of abundant green pleochroic hornblende; WIL 0904 (x-nicols). e) Assemblage C metasandstone inclusions; MNF 0901 (x-nicols). f) Assemblage C fine-grained subarkosic sandstone inclusions; HLF 0906 (x-nicols).

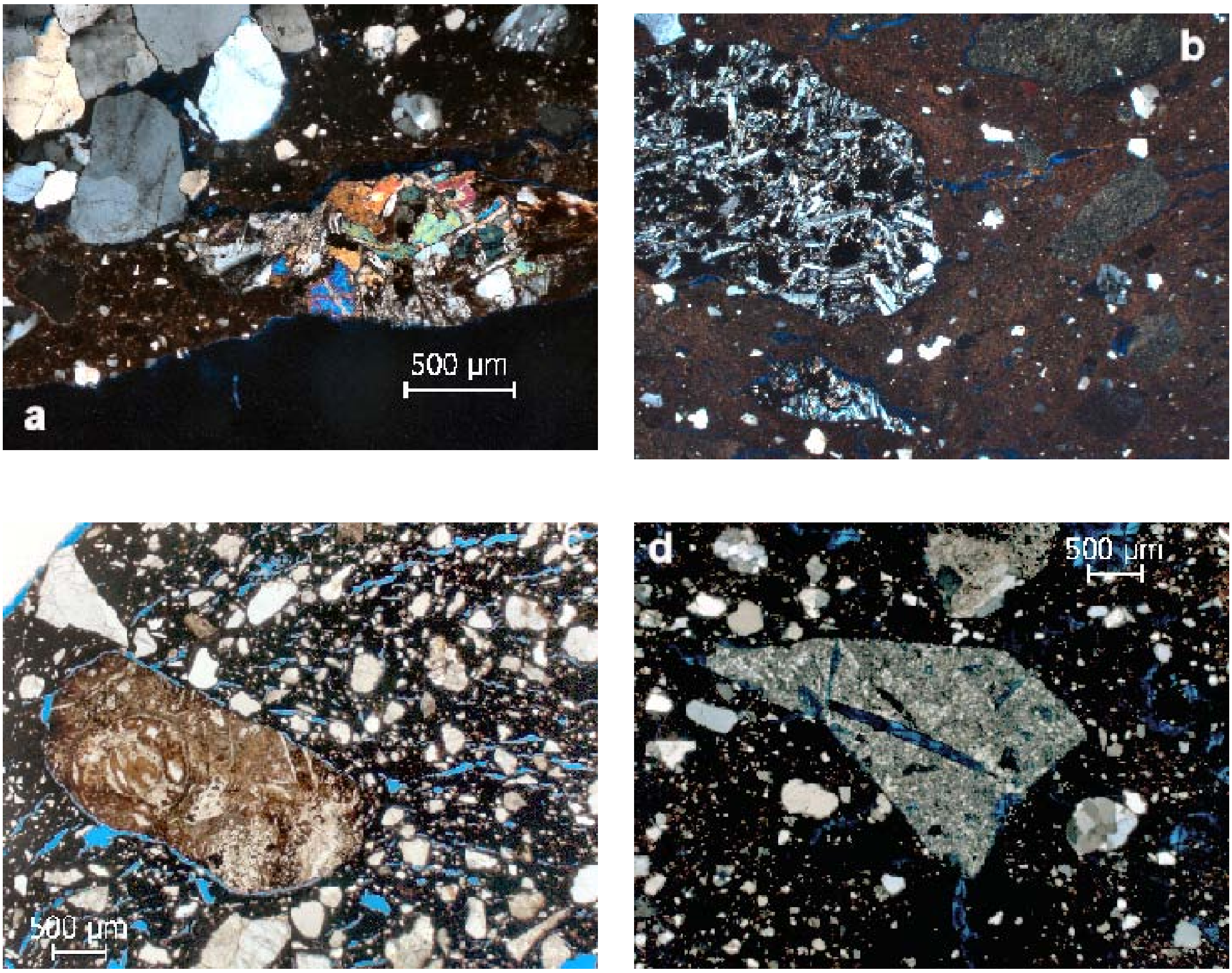

Fig. 6 a) Assemblage D microgabbro inclusion (lower right), with a subarkosic sandstone forming the large quartz-rich inclusion at top left; MNF 0906 (x-nicols). b) Assemblage D basalt inclusion, at left; note also green inclusions of chloritised ?metavolcanic rock; EKE0904 (x-nicols). c) Assemblage E inclusion, consisting of a section through a silicified plant stem, and other silicified organic material; GBR 0902 (ppl). d) Assemblage E silicified rock fragment; HLF 0908 (x-nicols)

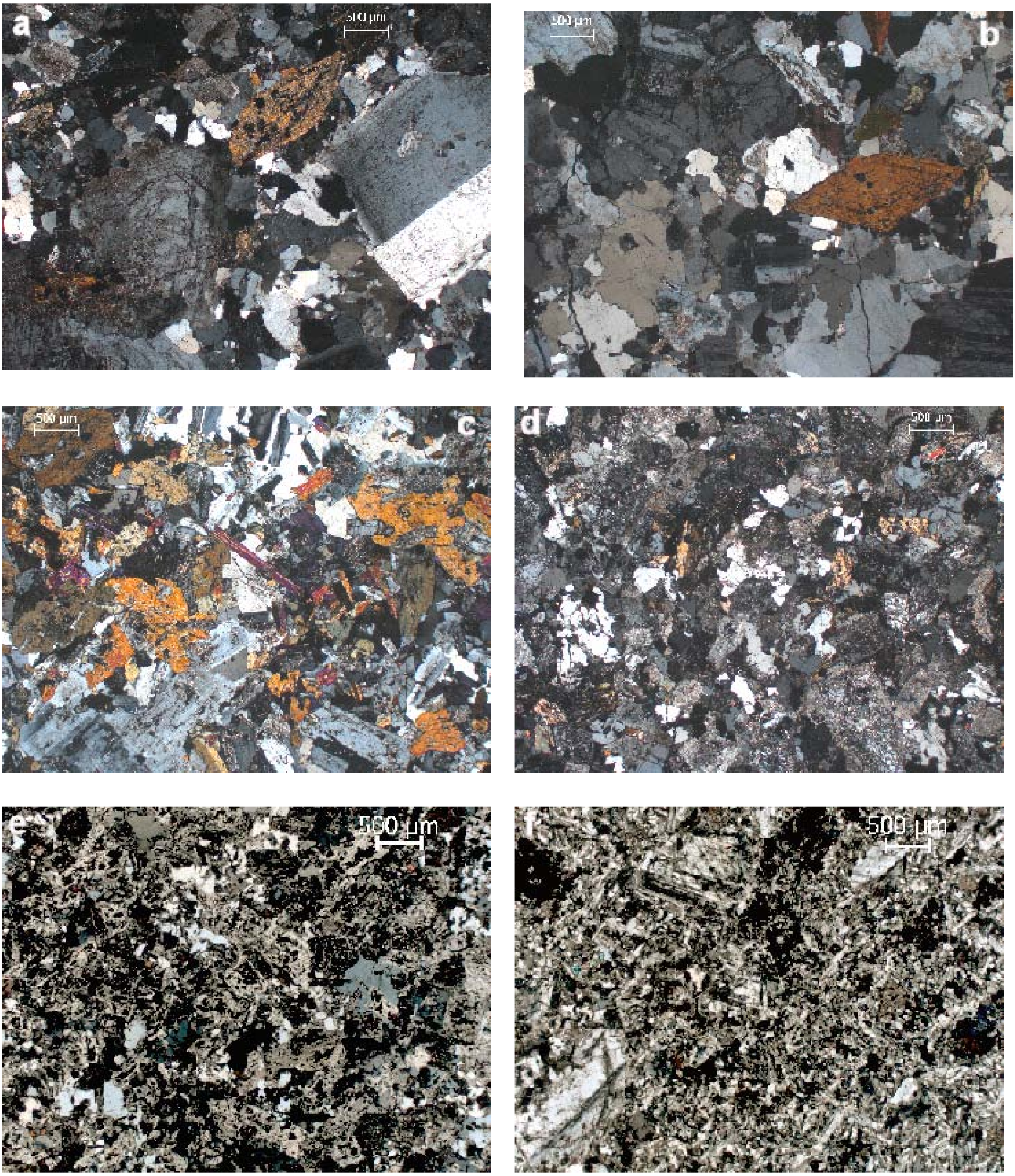

Fig. 7. Potential local inclusion source rocks (see Table 2 for location details). a) Mountsorrel Complex granodiorite. Note inequigranular texture and diamond-shaped section of hornblende; sample JNC870 (x-nicols). b) Mountsorrel Complex granodiorite. The brown diamond-shaped crystal is fresh hornblende, with red-brown biotite just above it; sample ROW-1 (x-nicols). c) Mountsorrel Complex quartz diorite; note abundant hornblende (red-orange-brown laths and diamond-shaped crystals); sample JNC882 (x-nicols). d) Quartz diorite, Croft Quarry. Note extensive sericitic alteration of the plagioclase, and the presence of laths and diamond-shaped euhedra of hornblende; sample JNC796. e) Quartz diorite, Stoney Cove Quarry. Note equigranular texture, pervasive sericite alteration of feldspars and oxides replacement of ferromagnesian minerals; sample E43871 (ppl). f) Quartz diorite from The Yennards Quarry. Texture is fine-grained inequigranular. Note pervasive sericite alteration of plagioclase and oxides replacement of ferromagnesian minerals; sample E43881 (ppl).

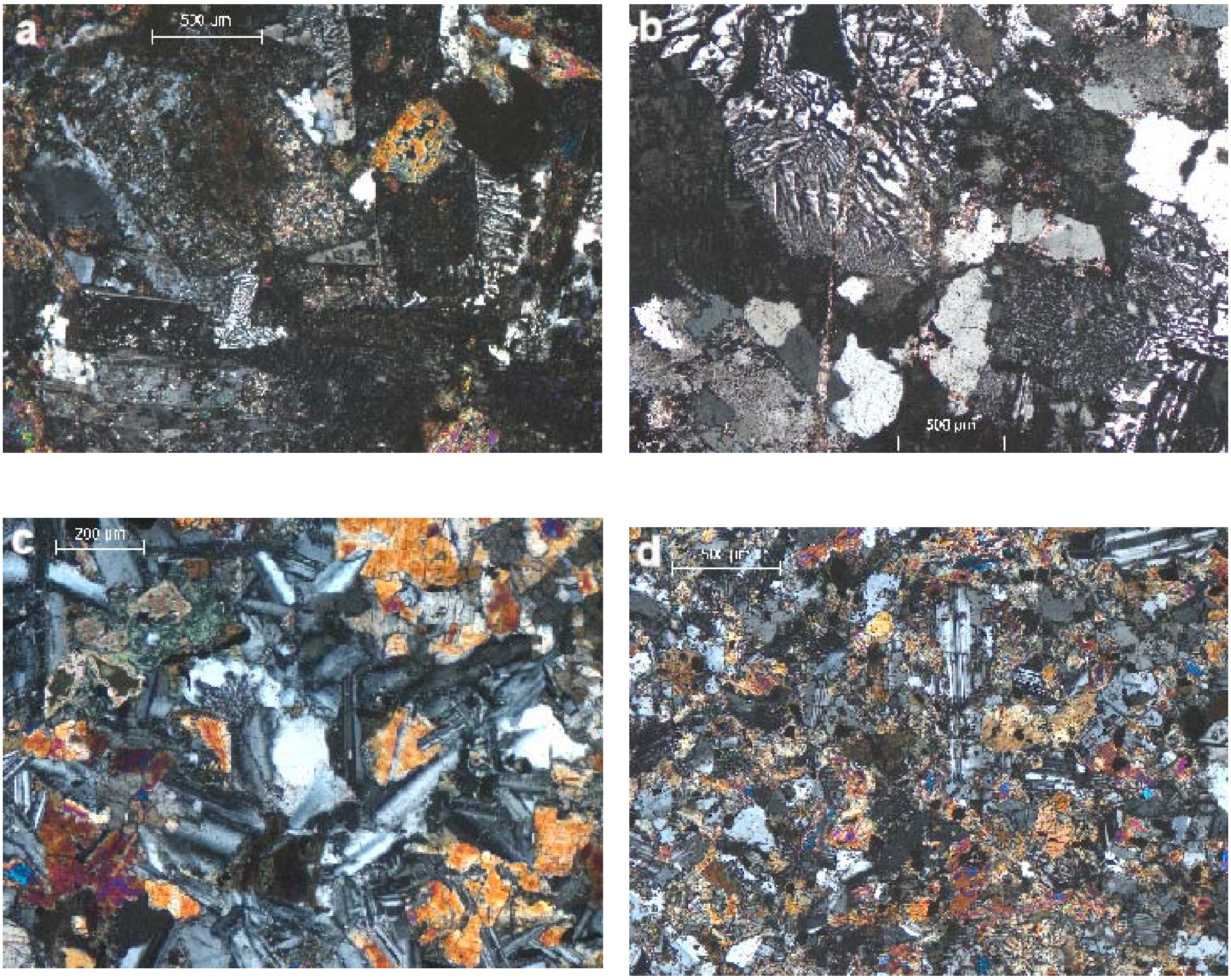

Fig. 8. Potential diorite and gabbro source rocks (see Table 2 for location details). a) North Charnwood Diorite, showing localised granophyric texture; sample JNC 421 (x-nicols). b) South Charnwood Diorite, showing typical coarse granophyre; sample JNC 874 (x-nicols). c) Whin Sill gabbro, from Northumberland. Note well developed subophitic texture between plagioclase (grey laths) and clinopyroxene. The presence of quartz is indicated by interstitial myrmekite at upper left of centre; sample E1740 (x-nicols). d) Gabbro from the Lizard, Cornwall. The bright coloured minerals all consist of hornblende; sample E6703 (x-nicols).

Table 1. PREHISTORIC POTTERY PROJECT 2009: SOURCE ROCK SAMPLE LIST OF THIN SECTIONS

UNIT	Thin section Registration Number/Name.	Rock sample Field No.	NGR	Locality details	Description
Mountsorrel Complex	E73857	JNC 870	SK 5770 1440	Halstead Road Field Wildlife Area	Main phase granodiorite
Mountsorrel Complex	E 72433	JNC 874A	SK 5633 1565	Old Quarry on W. side of Rowhele Wood	Main phase granodiorite
Mountsorrel Complex	E 72435	JNC 851	SK 5583 1556	Gravel Pit' N. of Swithland Resr. dam	Basified' granodiorite
Mountsorrel Complex	E 73866	JNC 882	SK 5579 1364	Summit of Brazil Wood, Swithland Resr.	Diorite
Mountsorrel Complex	ROW-1	ROW-1	SK 5641 1567	Summit of Rowhele Wood	Weathered granodiorite
Mountsorrel Complex	ROW-2	ROW-2	SK 5641 1568	Summit of Rowhele Wood	Weathered granodiorite
S Leicestershire Diorites	E 71077	JNC 796	SP 5110 9670	Croft Quarry, N. face	Main phase quartz diorite
S Leicestershire Diorites	E 71078	JNC 797	SP 5110 9670	Croft Quarry, N. face	Synplutonic diorite sheet
S Leicestershire Diorites	E 43871	23	SP 495 941	Stoney Cove Quarry	Quartz diorite
S Leicestershire Diorites	E 47546	4	SP 524 975	New Narborough Quarry	Quartz diorite
S Leicestershire Diorites	E 43881	29A	SP 489 970	The Yennards Quarry	Quartz diorite
S Leicestershire Diorites	E 62188	JNC 28	SK 5413 0007	Enderby Warren Quarry	Quartz diorite (Sheet 126)
North Charnwood Diorite	E67492	JNC 421`	SK 4941 1685	Longcliffe Quarry	Quartz diorite
South Charnwood Diorite	E73861	JNC 874	SP 5140 0912	Bradgate Granite Quarry, Groby	Quartz diorite, abundant granophyre
Whin Sill	E1740	RB 1471		Belford, Northumberland	Sub-ophitic quartz microgabbro
Gabbro	E6703	635		Lizard Peninsula, Cornwall	Hornblende gabbro, medium grained
Alluvium,Trent	Swarkestone Clay	E Faber brickette	SK 3496 2757	Swarkestone, field S.of Le Farge gravel pit	Silty clay floodplain alluvium
Alluvium,Trent	Shelford Clay	E Faber brickette	SK 6581 4246	Shelford, field	Silty clay floodplain alluvium
Alluvium, Soar	Kingston Clay	E Faber brickette	SK 4968 2759	Field E. of Kegworth,	Clay-rich floodplain alluvium
Alluvium, Soar	Mountsorrel Clay	E Faber brickette	SK 5818 1539	Field E of Mountsorrel Lock	Clay-rich floodplain alluvium
Alluvium, Soar	Enderby Clay	E Faber brickette	SP 5519 9863	Floodplain at Jubilee Park, Enderby	Silty clay floodplain alluvium
Mercia Mudstone	Rowhele Clay	E Faber brickette	SK 5692 1579	Field W of Woodside Farm, Mtsorrel	Red Mercia Mudstone, weathered, with siltstone fragments, from auger sample
Mercia Mudstone	JNC 927	JNC 927	SK 7252 2061	233.6 m depth in Asfordby Hydro Bh	Mercia Mudstone; Edwalton Fm
Mercia Mudstone, dolomitic siltstone bed	JNC 928	JNC 928	SK 6600 3934	Radcliffe on Trent	Dolomitic siltstone in Gunthorpe Formation
Oadby Till	JNC 929	JNC 929	SK 565 147	S. face of Buddon Wood Quarry, Mountsorrel	Chalk/flint till with blue-grey clay matrix
Thrussington Till	JNC 930	JNC 930	SP 5902 9811	Excavation in Wigston, S. Leicester	Red, silty matrix with fragments of Triassic siltstone, ?Carboniferous chert and quartzite pebbles

Note: 'E' numbers refer to slides registered with the BGS Thin Section collection

Table 2. PETROGRAPHIC DESCRIPTIONS OF THE POTTERY SAMPLES, PREHISTORIC POTTERY PROJECT 2009

Sample No.	Sample descn	Matrix	Inclusions	Comments/ category
ACS0901	c. 20% inclusions; very few of sand-size; several large inclusions up to 3 mm	Dark red-brown with paler red-brown areas, a few arcuate, discont fractures. V. common masses of black/red-brown, opaque silty clay.	1) Most large inclusions are of **granodiorite,** with large zoned plag, K-feldspar (perthite), qutz and red-brown partly chloritised biotite. 2) Sporadic inclusions of **meta-quartzite** with fine-grained, equigranular granoblastic texture. Relict qutz overgrowths seen. 3) Anhedral, angular qutz frags prob. derived from fragmentation of granodiorite. 4) Silt-to fine sand-size qutz, metaqutzite & feldsp grains.	**A1**
ACS0902	c. 30-40% inclusions, mainly silt/fine sand size. 6 larger inclusions up to 3.5 mm	Medium red-brown; well-developed parallel discont fracture fabric	1) Larger inclusions mainly quartz with strained extinction and ? melt textures. Rare enclosures of red-brown biotite. Subordinate perthitic K-feldspar fragments. 2) One large rounded inclusion is of **metaquartzite** with poss. foliation. Smaller rounded inclusions are mainly **quartzite** with sutured grain boundaries; one consists of clay-rich **metasiltstone**, poss. a turbidite. 3) Silt/sand size inclusions are of angular qutz, strained qutz, meta-qutzite & perthitic K-feldspar.	**C**
ACS0903	c. 30-40% inclusions, mainly silt/fine sand size. 6 larger inclusions up to 3 mm	Dark/medium red-brown. Strong parallel fabric of pale and dark areas, which is followed by discont fractures	1) Large inclusions mainly **granodiorite**, with zoned plag, perthitic K-feldsp, qutz and partly chloritised red-brown biotite. 2) One smaller inclusion contains abundant partly chloritised red-brown biotite (mafic clump?) . 2) Small inclusions of granoblastic **metaquartzite** with sporadic muscovite laths. 3) Silt/sand inclusions derived by fragmentation of larger ones	**A1**

CRI0901	c. 40-50%, mainly silt/fine sand size but several larger angular ones, up to 3.5 mm	Pale red-brown to dark red-brown; strong fabric outlined by colour-banding. A discont. fracture system is parallel with this fabric. A few small rounded black, opaque silty clay masses are present.	1) Larger inclusions are of fine- to medium-grained inequigranular **quartz-diorite** with aggregates of colourless to green-brown ?epidote. Plagioclases show extensive grainy alteration, with epidote and ?oxides also developed, producing a 'skeletal' appearance. 2) Silt and sand-size inclusions seem mainly derived from the diorite, but there are sporadic fragments of **chert** & **micaceous siltstone**. **Mica** (muscovite) also occurs as sporadic small laths.	**B**
CRI0902	c. 30-40%, mainly fine sand-size but c.12 larger angular ones, up to 4 mm.	As for CRI0901; strong parallel fabric.	1) Larger inclusions are of fine-to medium-grained, inequigranular **quartz-diorite** with aggregates of colourless to pale green clinopyroxene. Latter shows alteration to pale green hornblende (actinolite), which also forms discrete euhedra. Plagioclases show extensive grainy alteration, with epidote and ?oxides also developed, as in CRI0901. 2) Silt and sand-size inclusions seem mainly derived from the diorite. **Mica** (muscovite) also occurs as sporadic small laths.	**B**

CRI0903	50-60%, mainly silt/fine sand size but several larger angular ones, up to 3 mm	As for CRI0901; strong parallel fabric. sporadic black, opaque silty clay inclusions + large shadowy masses, possibly of earlier pottery.	1) Larger inclusions are of fine-to medium-grained, inequigranular **quartz-diorite**, some with relict colourless clinopyroxene and green-brown hornblende. Some also contain fresh, pale green hornblende (actinolite), which also forms discrete euhedra. Plagioclases show extensive grainy alteration, with epidote and ?oxides also developed, as in CRIACS, 0901. 2) Sporadic angular fragments of **micaceous feldspathic siltstone**. 3) Silt and sand-size inclusions seem mainly derived from the diorite, but fragments of **perthitic K-feldspar** also present. **Mica** (muscovite) also occurs as sporadic small laths.	**B1**
CRI0904	c.40-50%, range from silt/fine sand size up to coarse sand/granule size, latter very common.	Red-brown to pale red-brown; discont fractures in parallel orientation.	1) Most of the larger inclusions are angular fragments of zoned plagioclase and highly anhedral quartz; sporadic green-brown hornblende also present.. 2) Subordinate inclusions consist of medium-grained hypidiomorphic granular **granodiorite** (Plag+perthitic K-feldsp+granular interstitial quartz aggregates+pale green-brown hornblende+red-brown biotite alt. to chlorite). 3) V. sporadic **siltstone** fragments 40 Silt/sand incls mainly of quartz and feldspar.	**A**
CRI0905	c.50-60%, range from silt/fine sand size up to coarse sand/granule size, latter very common. C. 6 inclusions up to 3 mm size	Mainly dark red-brown. Strong discont parallel fracture system	1) Larger inclusions are of fine-to medium-grained, inequigranular **quartz-diorite**, some with green-brown hornblende. Some also contain fresh, pale green hornblende (actinolite), which also forms discrete euhedra. Plagioclases show extensive grainy alteration, with epidote and ?oxides also developed, as in CR10901. 2) Sporadic angular fragments of **micaceous feldspathic siltstone**. 3) Silt and	**B1**

			sand-size inclusions seem mainly derived from the diorite. **Mica** (muscovite) also occurs as sporadic small laths.	
CRI0906	c. 40%, range from silt/fine sand size up to coarse sand/granule size, latter very common.	Dark to pale red-brown; strong discont parallel fracture system. Sporadic small masses of black, opaque silty clay.	1) Larger inclusions are of fine- to medium-grained inequigranular **quartz-diorite**. Plagioclases show extensive grainy alteration, with epidote and ?oxides also developed, producing a 'skeletal' appearance. Some inclusions contain relict laths of red-brown to pale green pleochroic hornblende. 2) Silt and sand-size inclusions mainly derived from the diorite, but there are sporadic fragments of chloritised ?**volcanic rock. Mica** (muscovite) also occurs as sporadic small laths.	**B1**
EKE0902	c. 40% inclusions, inc. 4 large ones (c. 3.5 mm) with highly angular outlines	Dark red/black with paler red-green layers. Arcuate fractures tending to be parallel to sides of sherd. Some cavities. Silt-size fragments of qutz, feldsp. and mafics, evidently derived from larger inclusions.	1) Large & small angular frags. of fresh **microgabbro** (plag+cpx+Fe-Ti oxides+ minor opx+minor interstit qtz; microgranular textures. Some show altn to iddingstite/sericite. 2) Large & small angular frags of fine-grained **subarkosic sandstone**, with granoblastic/sutured/polygonal textures; no obvious foliation	**D**
EKE0903	c. 20-30% inclusions, mainly fine sand/silt size; 4 are 2 mm across	Dark red/brown; common fine silt size qutz & feldsp grains. Some darker red-brown silty clay masses around which matrix fabric is deflected.	1) Aggregates of inequigranular qutz **?meta-quartzite** - large grains show strained extn; interspersed between sutured microgranular qutz aggs, some with poor foliation. Minor K-feldsp also present. 2) Small single-xtal grains include qtz, plag & K-feldsp. 3) Silt/fine sand size incls. of quartz 7 meta-quartzite.	**C**

EKE0904	c. 40% inclusions. Mainly fine sand/silt size but one is 4 mm across	Dark red/brown to pale russet. Abundant silt-fine sand size grains, many derived from larger inclusions. Discont fractures parallel to side of sherd.	1) Large inclusions are of **basalt,** with intergranular texture of plag. laths, cpx and Fe-Ti oxides. 2) Subordinate large inclusions of undeformed fine grained **qutzitic sandstone**. 3) Small inclusions are aggregates of quartz and perthitic K-feldspar (**'granitic'**). 3) Several small angular fragments of green, fine-grained chloritic rock with faint foliation - prob. **basic meta volcanic rock.**	**D**
EKE0906	c. 50-60% inclusions, mainly silt to fine sand size but 5 larger ones up to 2.5 mm	Dark red/brown to black; discont fracture system parallel to side of sherd. Sporadic rounded to ellipsoidal masses of black, opaque silty clay.	1) Larger inclusions are of **granodiorite**, with qutz, K felsp (locally perthitic) and plag. Some chloritised mafic minerals & relict red biotite also present. One large inclusion is a single zoned plagioclase, indicating an inequigranular texture for the parent rock. 2) Smaller (sand/silt) angular inclusions are of qutz, perthitic K-feldsp and plag derived by granulation of larger inclusions.	**A**
EKE0907	c. 40% inclusions. Mainly fine sand/silt size but one is 3 mm across	Dark red/brown to black; interlayered with russet/pale red brown; discont fracture system parallel to side of slide	Essentially as for EKE0906; large inclusion is of quartz enclosing small euhedral plag & K-feldspar aggregates.	**A**
EKE0909	c. 50-60% inclusions, mainly silt to fine sand size but c. 15-20 larger ones up to 4 mm	V dark red/brown to black. Abundant silt & sand size inclusions	1) Large incls are **granodiorite,** inequigranular, with lrge zoned plag & granular areas of qutz+plag+K-feldsp (locally perthitic). 2) Smaller inclusions are angular & consist of frags derived from larger ones. Some with red-brown biotite. 3) Silt/fine sand inclusions are of strained quartz, meta-quartzite, K-feldspar & meta-siltstone.	**A**

EKE0911	c. 50-60% inclusions, mainly fine sand/silt size but c. 15-20 larger ones up to 3 mm.	Pale brown, discont fractures show poor preferred orientation parallel to side of slide. V. sporadic rounded masses of black, opaque silty clay.	1) Larger **granodiorite** incls with plag+K-feldsp (perthitic) + qutz +red-brown to brown biotite+pale brown hornblende. 2) Smaller (sand/silt) inclusions are angular & consist of frags derived from larger ones, some with scraps of red-brown biotite.	**A**
EKE0912	c. 40-50% inclusions, mainly silt to fine sand size but 5-6 larger ones up to 5mm	Dark red-brown to black. Discont parallel fracture system. V. sporadic rounded masses of black, opaque silty clay.	1) Large inclusion consists of large poss **?granite** or syenite; perthitic K-feldspar as interlocking grains, with minor oxidised biotite & zoned plag. 2) Smaller inclusions also of K-feldspar but some consist of plag.	**A2**
GAM0902	c. 40-50%, mainly of large size, up to 4 mm	Dark red-brown; discont parallel fracture system. Silt/sand size inclusions not abundant.	1) Larger inclusions entirely of **inequigranular granodiorite** with large zoned plag, plates of perthitic K-feldspar, quartz aggregates, partially chloritised red-brown biotite & largely chloritised pale green hornblende.	**A**
GAM0903	c. 60% mainly fine sand-size inclusions; c. 5 larger ones, up to 5 mm	Dark red-brown, very few fractures but some small holes. Abundant silt/sand size inclusions.	1) Larger inclusions are of fine-grained qutz-rich **sandstone** - extensive quartz overgrowth textures. More sporadic grains are of granoblastic **metaquartzite** with poss foliation; some have marked sliver-like outlines. 2) Sand-size grains mainly derived from 1), but also small rounded **flint** grains + one grain of **silicified rock** + some frags of K-feldsp with perthitic texture	**C**

GBR0901	c. 40%, dominant fine sand/silt mode but several larger ones, up to 3.5 mm	Medium red-brown; discont parallel fracture system.	1) Larger inclusions: strained quartz w. some subgrain devel; sporadic frags of K-feldsp perthite. Also inclusions of fine-grained **schistose rock** - granoblastic qutz with foliae defined by small aligned red-brown biotite. Poss **chert** frag also seen.2) Sand-size inclusions mainly qutz but include granoblastic **meta-quartzite.**	**C**
GBR0902	c. 40% inclusions, mainly fine sand size with several larger ones up to 2mm	Dark red-brown; parallel discont fractures. Abundant silt/fine sand inclusions.	1) One large inclusion of ?**silicified plant material**. 2) Smaller inclusions of strained qutz & qutz aggregates with granoblastic textures + some with sutured grain boundaries-prob **meta-sandstone**. Sporadic anhedral K-feldsp xtal frags. 3) Silt/sand incls. include strained quartz & meta-quartzite.	**E**
GBR0903	c. 60-70%, mainly silt/fine sand size. Largest c. 1 mm	Dark red-brown; parallel discont fractures. Abundant silt/fine sand inclusions.	1) Larger inclusions mainly frags of qutz+large zoned plag+small **granodioritic** aggs with qutz+ plag+red-brown biotite. 2) Sand-silt size inclusions mainly frags of qutz, meta-qutzite and feldsp, but some rounded grains of **meta-siltstone** & **chert**	**A1**
HLF0901	c. 40% inclusions; mainly silt/fine sand size; c. 8 larger ones, up to 4mm.	Dark red-brown. Abundant silt-fine sand size grains. Discont. fracture fabric, with parallel relationship to side of sherd. Sporadic small, rounded, black, opaque silty clay masses.	1) Larger inclusions are **granodioritic** aggs of quartz+zoned plag. with minor partially chloritised red-brown biotite. Also some plag & K-feldsp aggregates. 2) Smaller (silt/sand) inclusions are more finely granulated equivalents of these, but also include strained quartz, meta-quartzite & K-feldspar.	**A**

HLF0902	c. 20-30% inclusions, mainly fine sand/silt size but c. 10 are up to 2 mm across.	Dark red-brown, with paler brown areas, latter with fewer silty inclusions. Abundant silt/fine sand size grains. Discont parallel fracture fabric. Prominent small, black, opaque silty clay masses.	1) Larger inclusions comprise qutz with perthitic K-feldsp; some zoned plag also present. 2) Smaller inclusions mainly quartz and K-feldspar, commonly perthitic. 3) Rare small rounded grains of **granophyre** & grains with sutured quartz aggs (**?metasandstone**). 4) Silt/sand size incls of quartz, meta-quartzite & K-feldspar.	**A?**
HLF0903	c. 50% mainly silt/fine sand size inclusions. 2 larger ones up to 3 mm.	Dark red-brown. Abundant silt/fine sand size grains. Discont fracture fabric parallel to side of sherd.	1) Largest inclusion is of zoned plag with much sericite altn. 2) smaller inclusions are angular frags of plag, perthitic K-feldsp, quartz & red-brown biotite; prob fragmented **granodiorite**. 3) Small rounded grains of **subarkosic (?meta-) sandstone** with weak foliation defined by aligned micas. 4) Silt/sand size incls of quartz, meta-quartzite & K-feldspar.	**A1**
HLF0904	c. 40-50% inclusions; silt/fine sand size. c. 10 larger ones, up to 3mm	Mainly black; abundant silt/fine sand size inclusions. Discont parallel fracture fabric.	1) V. common rounded/angular frags of inequigranular **quartz-diorite**: Ext. sericitised plag+quartz anhedral pools+pale green/green-brown hornblende+Fe-Ti oxides. One cluster showed minor *granophyric* intergrowths. 2) Sporadic rounded grains of **?metasiltstone**, some with weakly anastomising foliae picked out by oxides. 3) V. common small single xtal frags of qutz, plag, hornblende, microcline.	**B**

HLF0906	c. 30-50% inclusions; mainly fine sand/silt size. 2 large ones, largest is well rounded and c. 9 mm across	Pale red-brown; swirling, discont. fracture fabric. Prominent rounded masses of dark red/black silty clay may represent fragments of original original pottery	1) Largest inclusions are of **subarkosic sandstone** mainly consisting of quartz but with a few % microcline. Poorly sorted. qtz grains show strained extn and subgrain/suture development ind. mild deformation - no foliation developed. 2) Smaller inclusions mainly of quartz+microcline derived from sandstone parent represented by larger inclusions. 3) Silt/sand size incls of quartz, meta-quartzite & K-feldspar.	**C**
HLF0907	c. 40-50% densely packed inclusions; mainly fine sand/silt size; some up to c. 0.7 mm.	Dark red-brown; swirling, discont fracture fabric. Common black opaque silty clay masses.	1) Dominantly single xtals of strained qutz + grains of deformed, foliated granoblastic? **meta-qutzite.** 2) Subordinate angular sericitised plag aggs. 3) Rare **flint** grains 4) Rare xtals of clinopyroxene and altered?biotite. 5) Silt/sand size incls of quartz, meta-quartzite & K-feldspar.	**C**
HLF0908	c. 40% inclusions; mainly silt size but 6 large ones up to 4 mm	Mainly dark red-brown. Discont fracture fabric. Common large masses of black, opaque silty clay.	1) Larger fragments include **silicified, cherty rock** with some chloritic vugs and shadowy replaced ?plant material. 2) Large **granodiorite** frags consisting of sericitised plag, minor qutz & altered hornblende ('actinolite' where fresh). 3) Silt/sand size incls of quartz, meta-quartzite & K-feldspar.	**E**
HLF0909	c. 30% inclusions; mainly fine sand/silt size; largest c. 2 mm	Mainly dark red-brown; common rounded masses of black opaque silty clay or ?original pottery clay-rock. Abundant silt/sand grains. Discont fracture fabric parallel to side of sherd	1) Larger inclusions include plag feldsp, qutz, perthitic K-feldsp and ?**granodioritic** aggs of qutz+hypidiomorphic plag feldspar with red-brown biotite. 2) Sporadic granoblastic qutz aggs-**poss meta-qutzite**. 3) Rare rounded grains of **flint**. 4) Small inclusions are fragments derived from 1-3. 5) Silt/sand size incls of quartz, meta-quartzite & K-feldspar.	**A1**

MNF0901	c. 60% densely packed incls; mainly fine sand/silt size; largest c. 1 mm across.	Dark red-brown to black. Abundant silt/sand size frags mainly quartz but also K-feldsp inc. microcline. Discont parallel fracture system.	1) Larger inclusions of **?metaquartzite -** granoblastic/mortar textures. 2) v. small frags of microcrystalline qutz-poss **chert or vein infill**.	**C**
MNF0902	c. 50-60% inclusions; mainly sand size but with c. 10 frags up to 3 mm	Dark red-brown to black. Abundant silt/sand size frags of quartz+ K-feldsp+plag+mafics. Discont parallel fracture system.	1) Large inclusions are of highly altered equigran. fine-grained **quartz diorite**. Abundant sericitised plag. laths + relict, oxidised laths of hornblende (?actinolite). 2) Smaller inclusions are qutz (commonly sutured aggregates), **flint**, plag. feldsp., **siltstone** (rounded clast), pale yellow/green-brown hornblende	**B**
MNF0905	c. 60-70% inclusions densely packed. Mainly sand/silt size but 2 larger ones up to 3.5 mm	Dark red-brown to black. Abundant silt/sand size grains. Discont fracture system parallel to side of sherd. Common rounded masses of black, opaque, silty clay.	1) Larger inclusions are of altered equigran. fine-grained **quartz diorite** sim. to 0902 with qutz+sericitised plag laths+relict green hornblende + poss actinolite. 2) Other large inclusions are of **inequigranular granodiorite**, sim. to 1) but with large zoned plag, quartz+ pale green hornblende+red-brown biotite. Large perthitic K-feldsp also present in one. 3) Smaller silt/sand inclusions include sutured qutz aggregates, foliated quartz (**?metasandstones**), ?hornblende & green chloritised fine-grained rock.	**B**
MNF0906	c. 50%. Mainly sand/silt size but c. 5 larger ones up to 4 mm	Dark red-brown to black. Abundant silt/sand size grains. Discont fracture system parallel to side of sherd	1) Larger inclusions are of **microgabbro** with microgranular verging to subophtic texture of : plag laths partially sericitised+cpx+opx+Fe-Ti oxides.2) **Subarkosic sandstone** and poss **meta-quartzite**, latter with granoblastic /sutured boundaries 3) rare rounded **flint** grains.	**D**

MNF0907	c. 60-70% inclusions, densely packed. Mainly sand/silt size. c. 5 larger ones up to 2 mm.	Dark red-brown to black. Abundant silt/sand size grains. Discont fracture system parallel to side of sherd	1) Fine grained **?granodiorite** with qutz+plag+K-feldsp+red-brown biotite. Many fine-grained with some polyg. grain boundaries. 2) Large xtal frags of zoned plag. + epidotised mafic minerals+qtz. 3) Plag crystal frags + rounded **flint**, **?metasandstone** with granoblastic/sutured grain boundaries + fragment of granular epidote aggregate. 4) Silt-fine sand incls. of strained quartz, meta-siltstonee & K-feldspar	**A1**
MNF0908	c.60-70%, closely packed. Mainly sand/silt size. c. 5 larger ones up to 2 mm.	Dark red-brown to pale red-brown. Abundant silt/sand size grains. Discont fracture system parallel to side of sherd	1) Larger inclusions mainly aggregates of 3-4 qutz xtals with larger zoned plag. 2) Smaller xtal inclusions: strained qutz, K-feldsp (rarely perthite), microcline . 3) Small rounded grains of **siltstone** + foliated **metaquartzite,** granoblastic qutzite + sporadic **flint**	**A1**
MNF0909	c. 30% inclusions, mainly silt/sand size; one large at 3 mm	Dark red-brown, with compression fabric. Discont. fractures parallel to latter and to edge of sherd. Common rounded masses of black, opaque silty clay around which matrix fabric has been deflected.	1) Largest inclusions are of partially/wholly sericitised plag. 2) Smaller inclusions are poss. **'granitic'** fragments of quartz aggregates with minor chloritised mafics and relict red-brown biotite. 3) Small rounded grains of sutured/granoblastic quartz (**?metasandstone**). 4) Silt/fine sand size incls of strained qutz, meta-quartzite & K-feldsp.	**A1**
MNF0910	c. 40% inclusions; mainly fine sand/silt size, but 3-4 larger ones, up to 4mm.	Dark red-brown, with discont fractures parallel to edge of sherd. Common rounded masses of black, opaque silty clay.	1) Large inclusions are of **granodiorite** - aggregates of partially sericitised zoned plag, perthitic K-feldsp and qtz with minor chloritised mafics. 2) Smaller inclusions derived from fragmentation of 1), but also include red-brown biotite laths. 3) Small grains of **meta-quartzite** with sutured grains.	**A1**

SWL0903	c. 40% inclusions; mainly fine sand size but several larger ones, up to 2 mm	Dark red-brown; discont parallel fracture system. Fairly abundant silt/sand size inclusions	1) Larger inclusions all angular & are of strained qutz & K-feldspar perthite 2) Sand-size inclusions mainly angular qutz & feldspar, including plag, derived from larger ones, but also rare rounded grains of meta-qutzite, foliated meta-siltstone & laths of red-brown biotite.	**A?**
WAN0901	c.10-20% inclusions, fine sand size up to 1.7 mm	Dark red-brown; discont fractures parallel to side of sherd. Common silt-size silicate grains. Some black, rounded inclusions of black silty to non-silty clay	1) Larger **granodioritic inclusions** are fine-grained aggregates of granular qutz + larger sericitised feldsp+green hornblende laths 2) Fine sand-size silicate inclusions include plag + qutz + rounded grains of fine grained **metaquartzite**	**A1**
WAN0902	c. 20% inclusions, from fine sand size up to 2 mm	Dark red-brown; discont fractures parallel to side of sherd. Common silt-size silicate grains. Some black, rounded silty clay inclusions may represent fragments of original pottery clay	1) Larger inclusions of **inequigranular fine-grained granodiorite**, with large zoned plag, small granular qutz-K-feldsp aggs, red-brown biotite & pale green hornblende. Also some large frags of zoned plag. 2) Smaller sand size inclusions include frags of qutz, K-feldsp, plag, biotite + fine-grained granodioritic qut/feldsp aggs some with triple point grain bdaries.	**A**
WAN0903	c.50-60% inclusions, fine sand/silt size up to 4mm (c. 6 larger ones)	Red-brown; discont fractures in partial parallel orientation. Common silt/fine sand size silicate grains.	1) Large **granodioritic inclusions** of zoned plag + aggregates of perthitic K-feldspar + anhedral quartz; some with partly chloritised red-brown biotite. 2) Silt/sand size inclusions include frags derived from 1) + strained qutz, meta-quartzite, fine-grained **feldspathic sandstone**. Sporadic small rounded grains of **chert & green meta-siltstone**.	**A1**

WAN0904	c. 30-40% inclusions, from silt to coarse sand size (max. 2 mm)	Dark red-brown, abundant silt-size qtz & felsp grains. Common dark red to black rounded clay lithoclasts. Discont. fracture system parallel to side of sherd.	1) Coarse polycryst quartz ?**meta-sandstone**; 2) **Granodiorite** aggs: qutz, K-feldsp (perthitic, grainy & altered) with red-brown, oxidised biotite. 3) Indiv. angular frags of plagioclase, perthitic K-feldsp., quartz & red-brown biotite.	**A1**
WAN0905	c. 40-50% inclusions, mainly silt to fine sand size	Very dark red-brown, abundant silt-size qtz & felsp frags. Common black rounded opaque clay aggregates. Discont. fracture system parallel to side of sherd.	1) Angular quartz dominant. 2) Feldspar, mainly K-feldsp, locally perthitic. 3) Minor red-brown biotite laths. 4) Silt/fine sand size incls. of strained quartz, **meta-qutzite**, K-feldsp.	**A1**
WAN0908	c.70% inclusions; roughly bimodal size distn. As either silt/fine sand or med/crse sand	Dark red-brown; abundant silt-size qutz, metaqutzite & feldsp. Intense discont. fracture system parallel to side of sherd. Possible shadowy fragments of earlier pottery generation.	1) Larger inclusions of **granodiorite** with red-brown biotite, chloritised mafics, perthitic K-feldsp + zoned plagioclase, latter commonly w. albite veinlets. 2) Indiv. angular quartz, K-feldspar & minor biotite crystal frags. 3) Rare rounded grains of microcryst quartz (**flint**) +**?meta-sandstone** with sutured boundaries & **meta-siltstone**	**A1**
WAN0909	c. 20% inclusions, fine sand size up to 2 mm	Dark red-brown matrix with discont fracture system parallel to side of sherd.	1) Larger **?granodioritic** inclusions: mainly fragments of aggregated quartz + zoned plag + perthitic K-feldsp. Felsps partly sericitised. 2) Smaller inclusions are fragments of 1) + partly chloritised red-brown biotite. Some rare small rounded grains of ?foliated **metadiorite**, green **metavolcanic** rock & **flint.**	**A**

WAN0910	c. 20% inclusions; fine sand up to 3 mm size	Dark red-brown matrix with discont fracture, arcuate in places but broadly parallel to side of sherd. Abundant rounded black opaque silty clay masses.	1) Larger inclusions are **granodioritic** aggs of zoned plag, K-feldsp (perthitic) and quartz with some red-brown biotite. 2) Smaller inclusions mainly derived from 1). 3) Sand/silt size inclusions of strained quartz & meta-quartzite.	**A**
WIL0901	c. 30-40%? Poor preservation, mainly sand-size, with a few larger ones up to 4 mm. V. few inclusions of silt-size.	Dark to pale red-brown; strong parallel fabric shown by colour banding in clay.	1) Larger inclusions consist of: perthitic K-feldspar, commonly enclosing euhedral plagioclase + granular quartz aggregates. These suggest a **granite or granodiorite** parent rock. 2) Also sporadic fragments of metamorphic rock types, mainly **foliated quartz** and quartz partially wrapped by muscovite mica.	**A2**
WIL0902	c. 20-30%? Poor preservation, mainly sand-size, with a few larger ones up to 4 mm. V. few inclusions of silt-size.	Unusual appearance. Mainly pale red-brown. No strong preferred fabric. Cavities present but no obvious fractures	1) Larger inclusions consist of: perthitic K-feldspar, commonly enclosing euhedral plagioclase. Granular quartz aggregates and hypidiomorphic plagioclase aggregates with granular quartz and muscovite mica may also be part of this assemblage. These suggest a **granitic parent rock**. 2) Sporadic fragments of muscovite mica	**A2**
WIL0903	c. 20-30%; mainly sand-size, with a few larger ones up to 4 mm. V. few inclusions of silt-size	Mainly dark red-brown. No strong preferred fabric. Cavities present but no obvious fractures	Essentially similar to WIL0902	**A2**

WIL0904	c. 50-60%; mainly silt to sand-size but several larger fragments up to 6 mm	Mainly dark red-brown. No obvious parallel fracture fabric.	1) Larger inclusions consist of coarse plagioclase aggregates. There are also inclusions of medium-grained, inequigranular **quartz-diorite** comprising: large euhedral plagioclase + granular interstitial quartz aggregates + red-brown partially chloritised biotite + dark green/pale green pleochroic hornblende. In one example hornblende forms aggregates comprising most of the inclusion. 2) Sand/silt size inclusions mainly comprise fragments derived from larger ones + meta-quartzite & laths of partly oxidised red-brown biotite.	**B**

a) LARGER INCLUSIONS			
Assem-blage	**Type**	**Source**	**Sample sets**
A	Granodiorite	Mountsorrel Complex	EKE, GAM, ?HLF, **WAN**
A1	Granodiorite & meta-sediment	Mountsorrel Complex + alluvial gravels?	ACS, GBR, HLF, **MNF**, **WAN**
A2	Granite/syenite	Not known	EKE, **WIL**
B	Quartz diorite with green hornblende	S. Leicestershire Diorites	CRI, MNF, WIL
B1	Quartz diorite with green-brown hornblende	Not known	**CRI**
C	Meta-sandstone & sandstone	Pebbles in alluvial gravels	ACS, EKE, GAM, GBR, HLF
D	Microgabbro & basalt	? Whin Sill	EKE, MNF
E	Silicified rocks & granodiorite	Not known	HLF

b) POTTERY CLAY MATRIX				
Sample sets	**Flint present**	**Opaque masses**	**Pottery fragments**	**Comments**
ACS		x		The presence of flint suggests a possible *alluvial clay source*. Where present in thin sections, however, flint is a very minor constituent so that its absence from other sherd samples need not preclude a similar source for those. The other integral clay components are of wide occurrence and therefore of questionable use *vis a vis* evaluation of Mercia Mudstone, Till or alluvium clay sources. They include mainly quartzose, metamorphic silicate silt/sand grains and black, opaque silty clay aggregates.
CRI		x	x	
EKE		x		
GAM	x			
GBR				
HLF	x	x	x	
MNF	x	x		
SWL				
WAN	x	x	x	
WIL				

Table 3. a) Summary of potential sources for the various assemblages of larger silicate inclusions. Where sample sets show a predominance of certain assemblage types, these are shown by bold lettering. b) Summary of source information for the pottery clay matrixes.