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Reassessing Roman ceramic building materials: economics, logistics and social factors in the supply of tile to Dorchester on Thames, Oxfordshire

Reconsideraciones sobre materiales cerámicos romanos de construcción: economía, logística y factores sociales en el suministro de tejas a Dorchester en el Támesis, Oxfordshire

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ABSTRACT
This research explores the supply of Roman ceramic building materials to Dorchester on Thames, Oxfordshire. Mineralogy and bulk chemistry of tile fabrics were analysed by thin-section and scanning electron microscopy. The assemblage from this Roman 'small town' has shown, besides the existence of local manufacture, that *tegulae* were on occasion transported c. 50 km by road to the site. The 'pink grog-tempered ware' fabric in which some *tegulae* were made is analogous to a fabric used to produce large storage jars in the vicinity of Stowe Park, Buckinghamshire. Analysis and discussion of the mechanisms and logistics which facilitated the production and long-distance transport of these tiles and jars is undertaken. Social and economic factors involved in their production and purchase are proposed. This study demonstrates the importance of greater levels of analysis of building materials, with the potential to inform us about social strata beneath those most visible in the historical and archaeological record, and a significant, often neglected aspect of the Roman economy.

Keywords: Roman Britain; Ceramic building materials (CBM); Tegulae; Pink grog-tempered ware; Trade; Road transport; Scanning electron microscopy (SEM); Thin-section; Petrography.

RESUMEN
Este trabajo analiza el suministro de materiales constructivos cerámicos de época romana de Dorchester-on-Thames, Oxfordshire. La mineralogía y la composición química del material latericio se han analizado con láminas delgadas y microscopía electrónica de barrido. En el caso de esta "pequeña ciudad" romana se ha demostrado la presencia de una producción local de *tegulae* que, en ocasiones, se transportaban a 50 Km de distancia por carretera. La composición del material empleado para la fabricación de algunas *tegulae* es análoga a la utilizada en la producción de grandes jarras de almacenamiento en las cercanías del parque de Stowe, Buckinghamshire. En este sentido, se analizan los mecanismos y la logística que permitieron la producción y el transporte a larga distancia de estos materiales y se discuten los factores sociales y económicos que intervinieron en su proceso de producción y adquisición. El estudio demuestra, además, la importancia de la investigación de estos elementos constructivos sencillos que ofrecen para registro arqueológico informaciones y visibilidad a los estratos sociales más bajos.

Palabras clave: Bretaña romana; Materiales de construcción cerámicos (CBM); *Tegulae*; cerámica de color rosa-templado; Comercio; Transporte por carretera; Microscopía electrónica de barrido (SEM); Lámina delgada; Petrografía.

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INTRODUCTION

Research into Roman architecture and construction has in the past tended to focus on the grandest cities, buildings, and materials in the empire. Rather than a city like Rome, in this paper a small town in Roman Britain is studied: the relatively modest remains of presumably domestic and commercial buildings are investigated in order to explore what can be learnt about Roman building habits in an environment far from the Imperial building projects of the Mediterranean. Instead of expensive marbles, ceramic building materials are the particular material under scrutiny. The study of ceramic building materials has been shown to offer a great deal of information about the social and economic environment in which they were made and used (e.g. Bukowiecki 2012). In this paper the fact that this is true not just for big cities like Rome will be shown: ceramic building material from the Romano-British small town at Dorchester on Thames, Oxfordshire, has been analysed with the aim of gaining new insights into the social strata well beneath those most visible in the historical and archaeological record. Here the methodology and a brief summary of results are presented, followed by the analysis and discussion of one particular finding.[1]

APPROACHES TO THE 'CINDERELLA ARTEFACT'. CERAMIC BUILDING MATERIAL

Ceramic building material (hereafter CBM) presents a number of deterrents and obstructions to a researcher. Firstly, if the material is collected at all in excavation (certainly not a given) it is often not preserved, undergoing simple quantification before being re-deposited on site. Being bulky and thus expensive and difficult to handle, transport, process, and in particular store, it makes an unattractive investment for comprehensive analysis by archaeological projects.

Secondly, ceramic building materials are difficult to study. In the intervening centuries since the end of use of many Roman buildings highly significant proportions of the total material involved in their construction has been lost, presumably mainly to robbing and recycling (Parsons and Sutherland 2013). Unlike pottery, CBM follows a very limited range of different forms, and thus broad analyses of shape or style offer far less information than for many artefacts. Those few morphologically-interesting parts of the material, such as *tegula* 'cutaways,' are relatively rarely preserved in the archaeological record. Thus gathering large enough sample sizes for statistically significant analysis of these features can be difficult (Warry 2006, 2010, 2012; *cf.* Mills 2013). In some regions the presence of brick- and tile-stamps, sometimes containing highly detailed information, is common, particularly in Rome (Bruun 2005). However in much of the empire they are rare, and thus in such regions those which are found denote a particular or peculiar case (e.g. military production, or involvement of the Imperial administration or estate). It must be questioned whether conclusions drawn from this evidence are more broadly applicable to civilian society and the building trade in those areas (for Britain *cf.* Wright 1976, 1978, 1985).

With morphological and stamp studies difficult to carry out, dependent on highly favourable assemblage conditions, fabric analysis remains a final option. Just as with pottery however, analyses of CBM fabrics require investment in expertise and analytical tools, and offer many problems to the researcher. With regard to traditional ceramic petrography by thin-section microscopy, it is difficult to judge the objectivity of the study: all practitioners will have varying degrees of experience and approaches to the material, possibly leading to divergent conclusions in fabric characterisation (*cf.* Graham 2006: 31-34). The degree of precision with which provenance can be attributed is highly variable with each case study, dependent on the breadth of variation in local geology and the uncovering of kiln sites to provide material baselines against which to compare samples.

With regards to more modern chemical analysis methods there is no single infallible methodology for the analysis of ceramic materials, and the various tools which are available all have their own strengths and weaknesses. The integration of archaeological science into more traditional archaeological practice, particularly with regards to the Roman world, has been somewhat slow, with effective engagement between archaeological scientists and archaeologists often still lacking, resulting in something of an "us" and "them" divide (Pollard 2012; Killick 2015). Details of archaeometric methodologies and findings are often difficult for non-scientists to follow or critique, whilst archaeological science has recently

[1] This study represents preliminary results from doctoral research at the University of Oxford, for a thesis entitled "The supply of building materials to construction projects in Roman Oxfordshire: logistics, economics, and social significance," funded by an AHRC Doctoral Studentship.

been described as being in "awkward adolescence," not yet a mature, rigorous science, with problems of poorly conceived, flawed, or trivial studies (Killick 2015: 243).

With CBM having been studied comparatively rarely, no rigid, well-tested research framework exists. In sum, if building material is even collected at all during an excavation, as Warry remarks in the preface to his work on *tegulae* in Roman Britain, it often "languishes as a Cinderella artefact, unavoidably assigned to the darkest and least accessible parts of a curator's store and, by some immutable law, always with the heaviest boxes on the highest shelves" (Warry 2006 *Acknowledgements*). It is clear then that the subject needs more work.

STUDY AREA

This paper uses as its case study the Romano-British small town of Dorchester on Thames, situated in the Upper Thames Valley in the south east of the Roman province of Britannia (Fig. 1). Dorchester lay on the main road running north from Silchester, *Calleva Atrebatum*, to Towcester, *Lactodurum*, and was the meeting point of several other minor roads. Situated less than one kilometre from the confluence of the Rivers Thame and Thames, and c. three kilometres from the crossing point of the Silchester-Towcester road over the Thames at Shillingford, Dorchester was well positioned to exploit these routeways. We still lack detailed evidence for the internal arrangement of the town, but we do know that it grew up in the later first century, that it was enclosed by earthen ramparts in the 2nd century (reinforced with a stone town wall in the 3rd), and that it conformed broadly to a traditional Roman 'playing-card' shape, with a main road, akin to a *cardo maximus*, running north-south through the centre of the town (Stevens and Keeney 1935; Booth, Dodd, Robinson and Smith 2007: 70-73). The remains of several stone-footed buildings have been uncovered (Frere 1962, 1984).

The wider region around Dorchester has seen extensive archaeological prospection, through aerial photographic surveys, research excavation, and development-led excavation, in particular at the sites of large open area gravel quarries (e.g. Benson and Miles 1974; Miles,

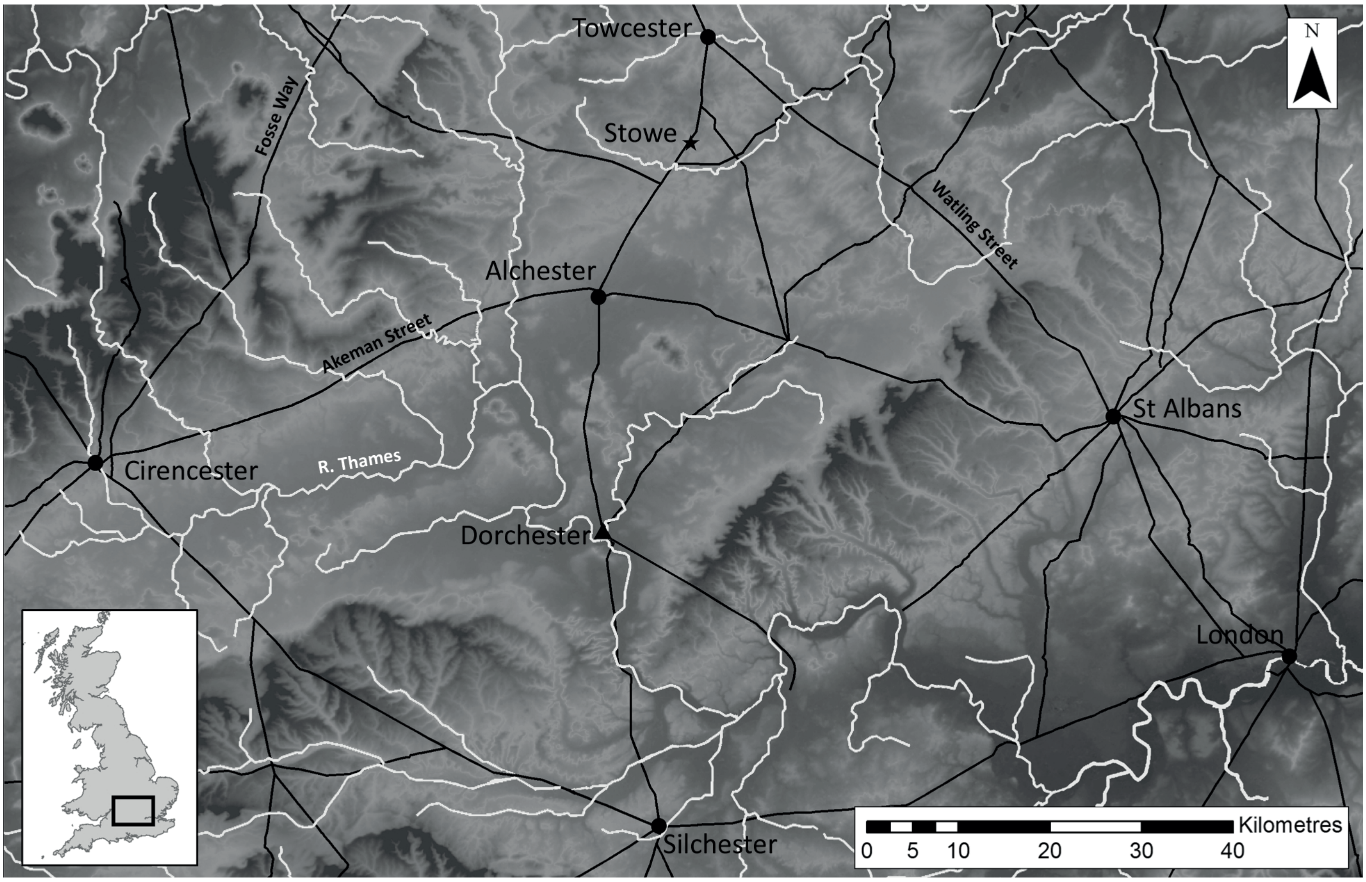

Fig. 1. A map of the study region, with towns mentioned in the text, major Roman roads, and rivers marked. Contains Ordnance Survey data © Crown Copyright and Database Right (2016). Road data provided by the Oxfordshire Historic Environment Record.

Allen, Lorimer and Lorimer 2007). This prospection has revealed the broader settlement patterns in the landscape (Booth, Dodd, Robinson and Smith 2007). Within the boundaries of the modern county of Oxfordshire the two most significant Roman urban sites, classified as small towns or *agglomérations secondaires*, are Dorchester itself and Alchester, which lies at the crossroads of Akeman Street (joining Cirencester with St Albans, *Verulamium*), and the north-south road running from Silchester, through Dorchester, to Towcester (*cf*. Sauer 2007).

Given our evidence from Dorchester and an understanding of the regularly settled Roman landscape of south eastern Britain we would expect a settlement of its kind to have few official civic or administrative functions, and thus no need for the infrastructure associated with those, such as basilicas or formal *fora*. However, we would expect to discover at Dorchester a certain degree of economic specialisation and corresponding social diversity, the town serving as a market centre for the surrounding landscape, for it perhaps to be home to a local 'elite' of land owners, and for it to possess some productive facilities (*cf*. Whittaker 1990). As such we expect to find a range of building types, including various qualities of domestic structures, commercial structures, workshops, and stores (Burnham and Wacher 1990).

In terms of building materials, Dorchester sits in an interesting location: no brick or tile kilns have been found in the vicinity of the town, despite the density of excavation and survey in the region (Fig. 2). Nevertheless, large quantities of CBM have been found on the site; this study was therefore in part motivated by the aim of discovering the sources of CBM exploited by the settlement. Was material produced locally at an undiscovered kiln site, or was it imported from further afield?

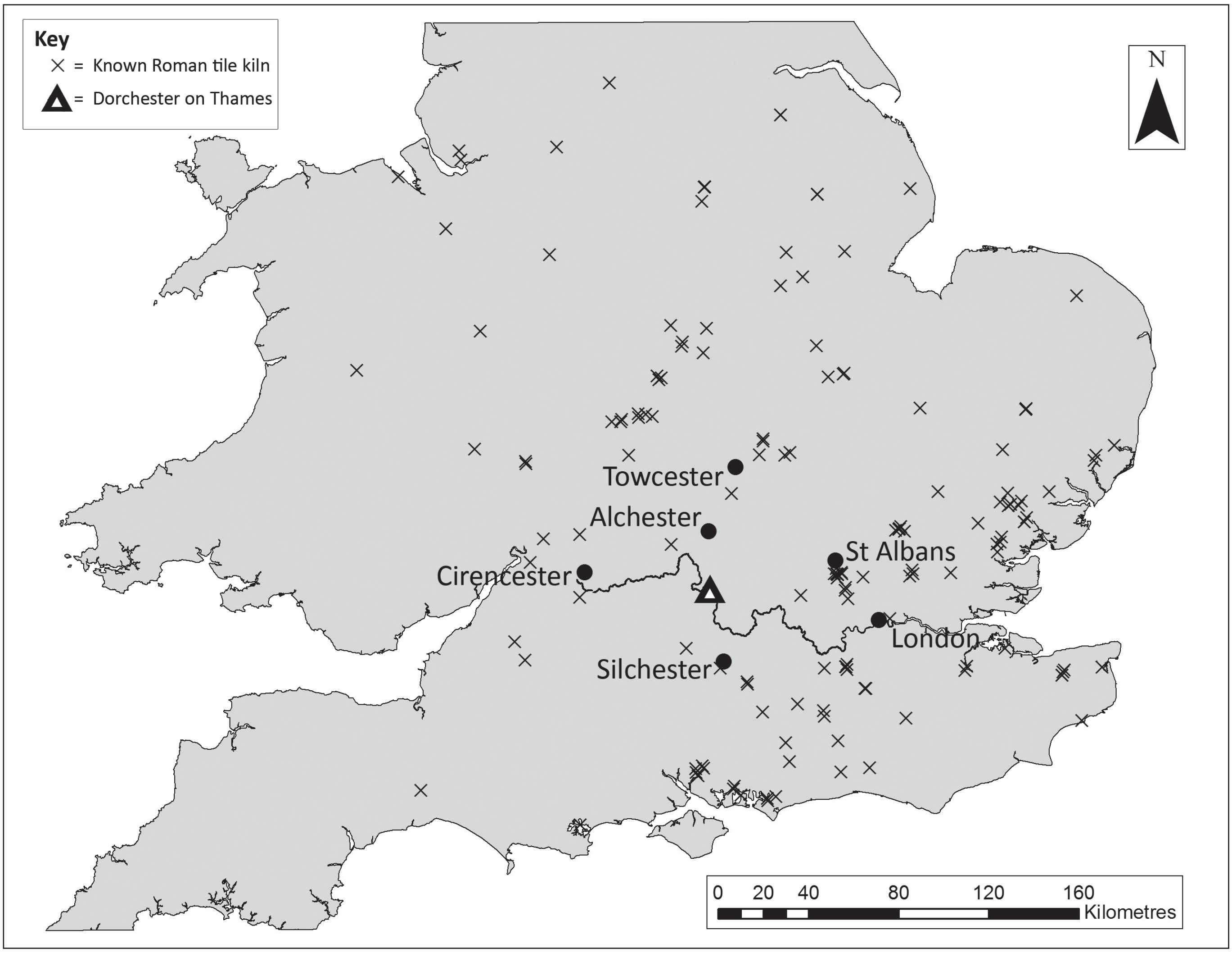

Fig. 2. A map of known Roman tile kilns in southern Britain; note the lack of evidence in the Upper Thames Valley. Adapted from Mills: http://www.archaeologicalceramics.com/tile-kilns.html. (Accessed 08/06/15)

The material for this study has been collected in the course of the ongoing excavations conducted as part of the *Discovering Dorchester Research Project*, run jointly by the University of Oxford School of Archaeology, Oxford Archaeology, and the local people of Dorchester. At the time this study was conducted material was available from the 2008 – 2012 seasons of excavation, in theory representing 100% retention of finds, although it is inevitable that some will have been mistakenly discarded. The assemblage surveyed came to 323.6 kg, in c. 6000 sherds. Fragments of *tegulae* and *imbrices* made up most of this assemblage, with lesser quantities of box-flue tile and brick.

APPROACH

The Dorchester on Thames assemblage did not allow the use of morphology, metrology, or stamp analysis for CBM investigation, as not a single stamp was observed, and the total number of complete dimensions and intact *tegula* cutaways was very small. Therefore fabric analysis was selected as being the most appropriate approach with the view to exploring questions of the origins of the CBM found at Dorchester, the nature of its production and marketing, and following this the social and economic factors involved in its use.

SAMPLING STRATEGY AND ANALYTICAL METHODOLOGY

It should be noted here that no CBM was found in a primary deposit, all pieces having come from secondary deposits within the Roman layers of the town. The assemblage is highly fragmentary, and represents only a very small proportion of the original quantities of CBM used in Roman Dorchester: the roof of a single small building would require multiple tonnes of CBM. A large quantity is missing presumably on account of historical recycling. Because of this, quantitative analyses of frequency of CBM types, forms, or fabrics were not undertaken, as the excavated assemblage will be unrepresentative, the product of the complex processes of selective reuse over long periods.

Initial fabric groupings were formed based on visual assessment alone, on an appraisal of colour, texture grade, relative frequency, shape, and size of pores, and frequency, size, and type of visible inclusions. Following this stage a subsample of the main fabric types was selected for more detailed scientific analysis, with the aim of verifying, precisely characterising, and exploring further the origin and nature of production of these major fabric groups. This took the form of both compositional (mineralogical and chemical) and microtextural analysis, utilising thin-section microscopy and scanning electron microscopy (SEM) with an energy dispersive spectroscopy system (EDS). This combination of techniques is ideal for ceramic analysis, as it brings the power of plane- and cross-polarised light microscopy for identifying solid phases within their textural network together with the ability of SEM to visualise and analyse the mineralogy of the material at a high spatial resolution, to determine the chemistry of the clay body and inclusions, and to easily facilitate digital image analysis through the output of greyscale and false-colour imagery (Tite, Freestone, Meeks and Bimson 1982; Olsen 1988; Freestone and Middleton 1987; Ravishankar and Barry Carter 1999).

Twenty and forty-four samples of archaeological CBM were respectively chosen for this pilot study of thin-section and SEM analysis with the aim of understanding the variation in the assemblage, seeking a broad range of different fabric types. Standard thin-sections were prepared by the Open University Petrological Thin-Section Laboratory, and were analysed using a Nikon Optihot 2 microscope. SEM analysis was carried out on samples prepared in-house by setting in epoxy resin; these were studied using a Jeol JSM 5910 scanning electron microscope.

In addition to the analysis of archaeological ceramic material, samples of clay from various local sources were also analysed, including wind-blown ‘loess’ or ‘brickearth’ subsoil which underlies the town itself, the bedrock Gault Clay formation which outcrops in the direct vicinity of the town, alluvial clay from the Thames extracted less than one km from the town, and Kimmeridge Clay bedrock which outcrops *c.* five km north of the town. These samples were analysed using both optical microscopy and SEM, in a raw state and following firing into test briquettes.

RESULTS

At least seven different fabrics have been identified thus far based on significant differences in mineralogy, chemistry, and micro-texture. Several fabrics showed a mineralogy that was consonant with that which we might expect from a fired ceramic made from the local bedrock Gault Clay. Several fabrics diverge significantly from this however, suggesting that the town was supplied by a range of CBM sources from further afield. Full results of the analyses conducted in this experiment will be presented elsewhere, with further work continuing. However, one of these divergent fabrics, 'Fabric J,' will be discussed in more detail here.

For comparison, the most abundant fabric type (Fabric A) exhibits moderately abundant quartz silt and sand, common iron oxides, moderately common potassium feldspar, and rare anatase, ilmenite, and zircon, and a fairly open, slightly platey micro-texture with frequent longitudinal pores. The clay is non-calcareous, and is generally fully oxidised to a consistent mid or pale orange colour. Fabric J is characterised by a very different texture, showing very few discrete inclusions, abundant small sub-rounded pores, the presence of what appears to be grog temper, i.e. broken fragments of ceramic added to the unfired clay during production, and a very different bulk chemistry to the most frequent fabric groups, having a very high calcium content. CBM in this fabric is often only partially oxidised, having a pale pink outer and a reduced dark grey core (Fig. 3).

PINK GROG-TEMPERED WARE

Fabric J, on the basis of the petrographic and chemical results, can be equated with a fabric known as 'pink grog-tempered ware,' a pottery fabric characterised in the British *National Roman Fabric Reference Collection* (Tomber and Dore 1998: 'PNK GT'). Amongst other forms, distinctive large storage jars were produced in this fabric in the late 3rd and 4th centuries AD (Booth and Green 1989). On account of the fact that Roman pottery has seen a far greater degree of study than CBM, the distribution of these storage jars has been mapped demonstrating a fairly wide trade in these vessels, presumably

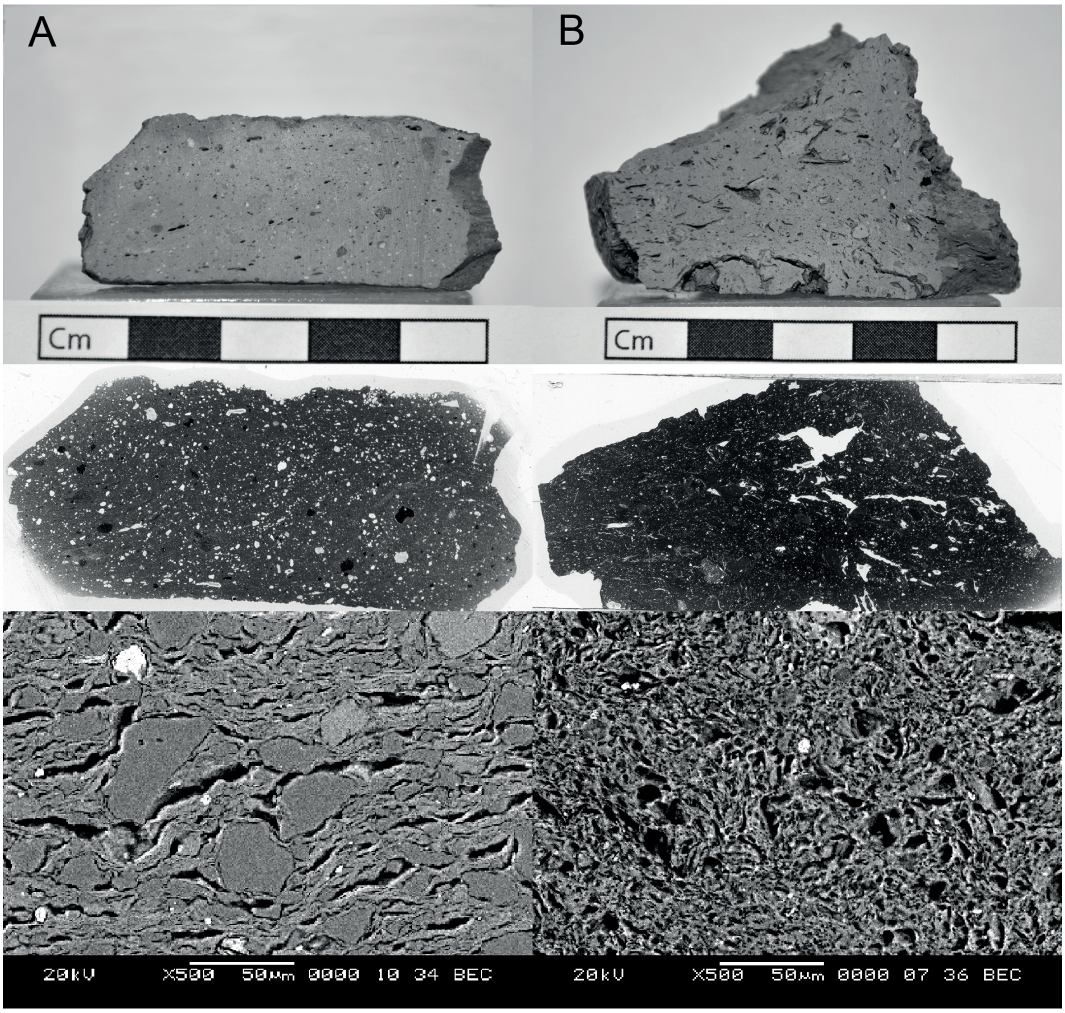

Fig. 3. A photograph, scanned thin-section, and SEM image at x500 magnification of an example of Fabric A (A) and Fabric J (B).

filled with an agricultural product (Taylor 2004: 61). Kiln sites where these jars were made lie within Stowe Park, Buckinghamshire (Booth 1999; Northamptonshire Archaeology 2003). It has been recognised for some time that CBM (*tegulae*, *imbrices*, and flue tiles) was also made from this fabric, with this manufacture assumed to date to roughly the same period (Booth and Green 1989: 82; Mills 2013: 445); however, it is only relatively recently that the picture of just how far the building materials seem to have travelled has begun to emerge. Mills gives a summary of some of the locations at which it has been identified, including Alcester, Worcester, and Alchester (Mills 2013: 451). The distribution zone of the CBM seems thus far to map onto that of the large storage jars, with Dorchester being one of the most southerly sites in this zone. The implications of the discovery of this CBM type at Dorchester are significant, and raise several interesting areas of questioning.

THE RELATIONSHIP BETWEEN POTTERY AND CBM MANUFACTURE

In the pink grog-tempered ware we see pottery and CBM produced from very similarly prepared and fired clay, presumably at the same production and kiln sites. There are many reasons which explain a workshop diversifying its output, some of which I will explore here.

In particular it should be noted that both the storage jars and the CBM produced in this fabric might be considered large or bulk goods; the average dimensions for *tegulae* in Britain are c. 43 cm by c. 33 cm, with flanges c. 5 cm high, and a weight of between 5 and 8 kg (Brodribb 1987: 12, 142). The average dimensions for *imbrices* in Britain are c. 43 cm by 17.5 cm, with a thickness of c. 2 cm, and a weight of between 3 and 6 kg (Brodribb 1987: 26). The large pink grog-tempered storage jars are known to have been made in a range of sizes, which makes generalisation difficult: an example in the Ashmolean Museum, Oxford, excavated at Dorchester on Thames, measures c. 45cm in height by c. 50 cm in diameter, whilst sherds excavated at Gill Mill, Ducklington, Oxfordshire, show diameters ranging from 25 to 48 cm (Booth and Simmonds forthcoming).[2] The thickness of the jar walls tends to be c. 3 cm, whilst the weight of the empty jars is estimated to be between 20 and 30 kg (i*bid*.). Explanations for the coincidence of the two productions may therefore lie in this shared characteristic of bulk, and thus the following hypotheses can be made: there was a similar raw material requirement for both products, with the properties of the particular clay used producing consistent and beneficial characteristics for both products; the required equipment, kiln, and transport infrastructure was very similar for both; and markets with demand for each product were coincident. Each of these will be discussed further below.

A GOOD RECIPE?

Beginning with the raw material explanation, the particular properties of the clay used, including its high calcium carbonate content and the added grog temper, might have generated physical properties in a fired product which were beneficial in the creation or use of both the storage vessels and the CBM, making favourable the use of the same recipe for both products. The grog temper conceivably facilitated a more rapid and even drying process with less shrinkage, and a better ability to withstand thermal shock (Tite, Kilikoglou and Vekinis 2001: 310). These properties would have been particularly useful when dealing with the bulky volumes of clay used in these products. A high carbonate content might have allowed for a shorter or cooler firing, reducing the significant firewood cost for firing such large volumes of clay. Finally we might see a technical advantage to the finished product, this particular recipe perhaps making a stronger, more durable object, necessary in such bulky artefacts liable to break under their own weight during transport or in use (Cultrone, Rodriguez-Navarro, Sebastian, Cazalla and De La Torre 2001; Tite, Kilikoglou and Vekinis 2001).

WORKMEN AND TOOLS

Shared infrastructure and production equipment provides a second set of explanations. The tying together of the two productions could reflect the fact that the workshop already had the ability to deal with the large quantities of raw materials coming in, the handling of these through the processing stages, and the movement of the bulky end products going out. Production of either the large jars or CBM, individually, required the manufacturer to possess the expertise and manpower necessary

[2] Ashmolean Museum accession no. AN1886.28

for gathering high volumes of suitable clay and firewood, for bringing it to the workshops, and for storing the clay for maturing and the firewood for drying; they needed to possess expertise and equipment for handling it in the workshop, for forming the unfired vessels and CBM, and for storing them during the essential step of drying; and they needed large kilns and appropriate kiln furniture for efficiently stacking sizeable batches of large products. They needed to understand how to carefully control the kiln conditions in such a way as to reduce the number of failures and produce a consistent firing of effective products. Finally they needed access to the connecting infrastructure to move such bulky goods onwards, including good quality roads capable of handling heavy vehicles, and access to the livestock (oxen or mules) and carts for transporting the materials to their markets.

A HEAVY BURDEN: TRANSPORT CONSIDERATIONS

Clearly transport of these bulky products, either storage jars – presumably full, adding to their weight, although the contents of the pink grog-tempered ware jars is not yet known (Booth and Green 1989: 83; Taylor 2004: 65) – or tiles, posed challenges. The first major point we should make is that from the material source, in the vicinity of Stowe, Buckinghamshire, road transport is the only feasible option for movement of these products over much of their distribution zone, as there are few nearby waterways that could offer an alternative for moving the vessels to the south or west.

As stated above, cart-loads of this material would have been very heavy, and CBM in particular can be stacked very densely on account of its shape. Unfortunately there is scant evidence for the size of the wagons which might have been used in the region for transport. Looking locally, the find of a partial cart-wheel from Gill Mill, Ducklington, Oxfordshire, and a cart side from Dorney Rowing Lake, Buckinghamshire, led Booth *et al*. to attempt a reconstruction, taking into account evidence from the relief from Langres in north-eastern France, which shows two mules pulling a wagon loaded with a large wine barrel (Booth, Dodd, Robinson and Smith 2007: 314; Musées de Langres). This reconstruction gives a notional cart loading space c. 2.5 m long, c. 2 m wide, and c. 1 m deep. Ethnographic and documentary evidence suggests that standard four-wheeled carts pulled by an individual or pair of mules or horses are capable of transporting between 500 kg and 1,000 kg (*Codex Theodosianus* 8, 5; Raepsaet 2009: 598-600).

It is not just the cart and traction that we have to consider, but also the roads along which they moved. Heavy loads were presumably manageable along the well-surfaced roads of the region such as Watling Street, running from Towcester north-westwards to Wroxeter and south-eastwards to St Albans and London, or the southerly road to Alchester and on to Dorchester. However, poorer quality or unpaved trackways, particularly during and after wet or icy weather, would have been impassable to cart-loads of any significant weight (Booth 2011). This would necessitate highly seasonal transport, and, importantly, the splitting of batches of goods into smaller, more manageable loads.

Based on the average *tegula* dimension cited above of c. 43 cm by c. 33 cm, with flanges c. 5 cm high, around 500 tiles could have fitted in the cart described above. Given that equal numbers of *tegulae* and *imbrices* were required for roofing, one would presumably transport equal numbers of each. However, the weight of 500 *tegulae*, or 250 *tegulae* and 250 *imbrices*, would be in excess of 3000 kg, clearly far beyond the weight capacity of the infrastructure available. The limits imposed by the carts and roads might feasibly have meant loads of just 75 to 150 roof tiles could be moved at once, taking up around a quarter of the space in the cart. Thus transporting cartloads solely of tiles would be inefficient, with significant room wasted.

The large storage jars, at c. 50 cm in diameter and c. 45 cm in height, would have taken up a lot of space, with only 15 fitting in a cart of the size described above, assuming the jars were not stacked one layer on top of the other. Estimating the weight of these jars is problematic, as we do not know what they contained; however, with the largest having a volume of c. 52 litres, using the density of water they might weigh up to c. 80 kg when full.[3] Thus 15 full jars weighed up to c. 1200 kg, again beyond the upper end of the weight capacity of the carts; 12 units provides the theoretical maximum weight. For these jars to have attained such a wide distribution, only moveable in small numbers, the economic conditions of their sale must have been particularly beneficial in order to make such cart-loads profitable.

[3] Volume calculated from the scale drawing of the large pink grog tempered ware storage jar illustrated as Fig. 1 in Booth and Green 1989, using a Right Riemann Sum.

Road transport is widely accepted to have been the most costly of all the transport means available to the Romans, with transport by water far cheaper (Scheidel 2014). With the unavailability of river transport for this particular route from the kilns to Dorchester, some means may well have been sought for making the distribution by road of either the CBM or the large storage jars (and their contents) more economical. Not many storage jars could fit in a cart on account of their size, while transporting CBM on its own (in quantities within the physical limits of the vehicles, draught animals, and roads) would have left a significant space in the cart. Thus both cargoes transported alone might have been fairly economically inefficient; a mixed cart-load, however, of several storage jars with some quantity of CBM, might have increased the profit on each cart-load.

THE DORCHESTER MARKET

The route from the kilns to Dorchester was straight-forward: the location of the production site lay almost directly adjacent to the road between Towcester and Alchester, and thus material simply followed this road southwards through the latter to Dorchester (Booth 1999). This was a relatively well-made, metalled, main road, and so, even in winter, should have presented few difficulties to heavy carts, besides perhaps across the marshy region of Otmoor, and the rise in terrain from Otmoor up to Beckley and on to Headington Hill just north east of modern Oxford (Salzman 1939: 271-281). However, it is the distance these goods are travelling that is somewhat surprising. Regarding the storage jars, perhaps their contents was a particularly specialised commodity, and thus commanded a price to justify and pay for the c. 50 km road journey. The CBM however does not at first glance appear to be a particularly specialised product, and the evidence from the wider study points towards more local CBM having been available at the site, making its transport, and the considerable expense inherent in this, much harder to justify.

It should be noted that the quantities of CBM needed for constructing a roof are not small: a simple pitched roof of a small building measuring 4 m by 8 m, for example, has a surface area of between 34 m^2 and 37 m^2, depending on its precise pitch, here suggested as being of between 20° and 30°. Given the overlap between tiles, each *tegula* on a roof covers c. 0.1 m^2, and thus this roof requires between 340 and 370 *tegulae*, plus the same number again of *imbrices*. This means a total of around 3.7 tonnes of tiles that require transport to the building site. We have to question therefore why there was a market for CBM originating 50 km away, and which presumably had a price tag that reflected the difficulties of transporting such a cargo.

The movement of CBM over relatively long-distances is a phenomenon that has been recognised before in Britain. Betts and Foot have identified a "late Roman calcareous tile group," occurring along the south coast, and possibly produced in the vicinity of Southampton, but reaching both London and Exeter, presumably travelling by boat along the coast (Betts and Foot 1994). Considering road transport, Darvill in his work on stamped tiles from sites in the Cotswolds has shown *tegulae* stamped with the "LHS" stamp, and of his LHS Fabric 1, probably produced at Minety, North Wiltshire, travelling as far as Silchester (c. 70 km by Roman road), Old Sarum (c. 75 km by Roman road), and Kenchester (nearly 90 km by Roman road) (Darvill 1979: 328). Work on the corpus of relief-patterned flue-tiles has shown wide-distributions of tiles stamped with the same roller-stamp dies, tiles impressed with Die 9 for example occurring in London, Surrey, Essex, Kent, Hertfordshire, Nottinghamshire, Suffolk, Leicestershire, and Lincolnshire (Betts, Black and Gower 1997: 31). However, in this case it is not known if all of these represent transport of tiles, or simply an itinerant tile-maker travelling to different tileries with a single stamp, and this highlights the need for more petrographic and chemical characterisation work. In addition, despite these apparent wide-distributions, the explanation for the movement is rarely clear.

Several possible explanations are posited here for the movement of tile to Dorchester. The first is that the coincident manufacture and mixed cargo distribution was highly effective, leading to the cost of pink grog-tempered ware CBM being similar to or less than that of more locally produced material, despite the highly significant road journey involved: the presumably valuable jar contents essentially subsidising the transport of the CBM. Diversifying the products of an estate or workshop was presumably, in the right circumstances, economically beneficial, and is a practice which has been identified elsewhere in the Roman world. For example production of amphorae is noted alongside that of CBM in both Central Italy (Peacock 1977) and in the Guadalquivir valley in Baetica (Chic and García 2004: 320). We might identify a further connection between agricultural production and CBM production, and this is a link that Lancaster has explicitly drawn in suggesting a causal relationship between the appearance of ceramic vaulting tubes ever further inland during the late 2nd and 3rd centuries in *Africa Proconsularis* and the expansion of agricultural production in that region: she proposes that the expansion of the road network to deal with redistribution of agricultural products permitted the spread of other infrastructure and made the production and use of vaulting tubes economically viable (Lancaster 2012).

It is not yet known what the contents of the pink grog-tempered jars was, although Taylor makes the suggestion that they could have contained honey on account of the jar morphology (Taylor 2004: 65). If the jars were produced on the same property as the agricultural product, this may have offered increased profitability. It also led to the development of the production and distribution infrastructure described above, and this in turn may have made the production of CBM a relatively simple, and itself profitable, side venture.

The pink grog-tempered CBM might be particularly competitive at Dorchester if more local material was expensive or difficult to acquire: perhaps there was no tile workshop or kiln in the direct vicinity of the town, and so material could only have been fired in 'clamp kilns,' which would have been more inefficient and only produced material in smaller batches; resources (clay or wood) or expertise could have been harder to source locally, or production might have been kept away from the direct vicinity of the town, on account of its anti-social nature (Darvill 1979: 332, *cf*. Clément 2013: 119-120). All of these explanations might make the purchase of distantly-made material more likely, but do not fit particularly well with the archaeological evidence: the pink grog-tempered ware fabric is far from common, and there clearly was a selection of 'normal' fabrics, presumably more-locally made, which show a high degree of uniformity and are of good quality, and dominate the tile assemblage from the town. It certainly seems unlikely that clay, wood or expertise would have been in short supply, with the extensive Oxford pottery industry directly to the north of Dorchester, and a tile kiln would surely not have seemed particularly anti-social amongst these other productive facilities. There is the possibility that, following a pattern identified elsewhere in the province, local production may have peaked in the mid-Roman period before declining in the 3rd and 4th centuries, leaving a lack of supply (*cf* Betts and Foot 1994: 33-34). This time coincides with the period when the pink grog-tempered ware kilns were active (Mills 2013: 445). However, lacking well-stratified primary deposits, and given the ease of recycling roof tile, it is impossible to verify a drop in local production at this stage.

A final, favoured hypothesis is to conclude that there was a demand at Dorchester for CBM other than the locally produced material. This could result from two explanations, each linked to the other. Firstly, perhaps the pink grog-tempered CBM was functionally superior, and therefore warranted the higher price-tag it must surely have carried; secondly, the imported material may have been 'socially superior,' i.e. more fashionable, broadcasting messages of wealth, particular social values, an ability to control resources, or membership of a certain social group. Such added meaning to the material, an added social value, would have allowed it to command a higher price-tag.

Whilst there do not seem to be obvious advantages in the technical specifications of the pink grog-tempered ware tiles over the more dominant fabrics, they certainly are distinctive. Their colour, being a pink or buff/reddish yellow (Munsell: 5YR7/4 – 5YR7/6), is clearly different to the usual reddish orange or yellowish orange tiles seen on site: possessing a roof with these imported tiles, either covering the whole area or interleaved with different tiles to create patterns, would have been highly visible. Given the high cost of road transport and the difficulty of moving such bulky objects, needed in large quantities, the purchase of these tiles must reflect a significant financial outlay. With no obvious functional advantage over the much more widely available fabrics in the town, the use of pink grog-tempered ware tiles was perhaps motivated by the desire of an individual to impress inhabitants and visitors to the town, and to garner social prestige. This represents a function of architecture that is well-studied in the grandest Roman cities, and with regards to the building projects of elites across the empire. Construction as part of a Roman identity was an act heavily imbued with messages and symbolism, and was enacted as a means of creating or reinforcing political, ideological and economic power, and for displaying membership of certain groups or identities. The imported pink grog-tempered ware tiles seem to demonstrate this same activity. An individual's choice of construction materials was highly visible to any and all in the town, and so the tiles existed as a visually powerful indicator of the significant investment and the command of resources of which this individual was capable. It also spoke to their identity, participating in the overtly elite Roman activity of construction with materials sourced from beyond the local sources.

CONCLUSIONS

In conclusion, it is shown here how the close analysis of building material can be a source of clear insight into the organisation and economics of a particular productive centre in Roman Britain, and further allows investigation of the actions, interactions, and expressions of individuals within the Roman world. The coincident production of both the pink grog-tempered ware jars and tiles suggests a close relationship between agricultural and ceramic production, perhaps undertaken on the same land. The distance of distribution suggests that both the jar contents and the tiles were viewed as luxury products, desirable enough to be worth paying for the significant transport costs. Those responsible for the use of the pink grog-tempered ware tiles at Dorchester must therefore count as local elites, commanding relatively significant resources and harbouring a certain social ambition. Here we see a version of the same well-studied social structures which led to the patronage of the greatest public buildings by the wealthiest citizens of the empire, simply on a different scale, and in a place where we perhaps would not expect to see such activity, in a small town of 6 hectares in Roman Britain.

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