THE PROVENANCE OF CHALK TESSERAE FROM SELECTED SITES IN ROMAN BRITAIN

Thesis submitted for the degree of

Doctor of Philosophy

at the University of Leicester

by

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2015

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ABSTRACT

Microfossil analysis of chalk tesserae from mosaics at five sites in Roman Britain (Caerleon, Colchester, the Isle of Wight, Leicester and London) was undertaken in order to ascertain the biostratigraphical age of the chalk used and thereby to determine its lithostratigraphical position within the Chalk Group. This information was then used to determine its most likely geographical provenance.

The foraminiferal evidence presented in this thesis strongly suggests that the source of the chalk used to manufacture the tesserae within the Roman province varied with time. Comparison of the results obtained with previous micropalaeontological analyses of chalk tesserae from Silchester, Norden (Dorset) and elsewhere in London suggest that Dorset may have acted as a regional source of chalk tesserae supply for mosaics dating to the first or early second century AD. This confirms previous suggestions that a 'geomaterials complex' was operating in the Poole-Purbeck area of south-east Dorset at this time.

Chalk tesserae dating to later periods did not display this same pattern of supply and appear to have been derived from elsewhere in the province. Kent and Sussex are suggested as possible sources for chalk tesserae dating to the second and third centuries AD, whereas Baldock in Hertfordshire emerges as a possible source in the fourth. The geological evidence also shows that harder members of the Chalk Group do not seem to have been preferentially selected for use in tesserae manufacture.

The results obtained confirm the value of the 'microfossil approach' to the problem of provenance in archaeological studies. It is suggested that the extension of this technique to chalk tesserae from other sites might enable some wider aspects of mosaic manufacture in Roman Britain to be investigated and two areas are put forward for future consideration.

ACKNOWLEDGEMENTS

One of the most consistent pieces of advice given to prospective doctoral students is to avoid undertaking a cross-disciplinary project. This advice is offered because (work load apart) such projects are extraordinarily difficult to complete without the willing collaboration of experts in different disciplines. It is therefore with considerable gratitude, as well as with great pleasure, that I acknowledge the help and support I have received from friends and colleagues in the fields of geology, palaeontology and archaeology during the course of this PhD.

My deepest thanks go to my supervisors, Professor Mark Williams of the Department of Geology at the University of Leicester, Dr Ian Wilkinson of the British Geological Survey and Professor Michael Fulford of the School of Archaeology, Geography and Environmental Science at the University of Reading, all of whom have provided invaluable help and guidance. Supervision is an undervalued art, but Mark, Ian and Mike have all excelled at it, generously giving their time and willingly sharing their expertise whenever it was needed. Their patient blending of information, practical support and gentle direction has not only taught me a great deal, but also saved me from many errors. I am most grateful for their help, and can only hope that they consider the completion of this thesis a suitable recompense.

It is also a great pleasure to offer my thanks to those in the archaeological community who provided tesserae for this research project so generously: Ms Laura Pooley for tesserae from Brading Roman Villa; Ms Corina Westwood of the Isle of Wight District Council, for tesserae from Combley and Newport Roman Villas; Mr Nick Cooper of ULAS (University of Leicester Archaeology Services) for tesserae from the Vine Street Town House in Leicester; Dr Mark Lewis of the National Roman Legion Museum, Caerleon for tesserae from the Backhall Street mosaic and August Villa Garden in Caerleon; Dr Dan Nesbitt and Dr Ian Betts of MOLA (Museum of London Archaeology) for tesserae from six sites in London; and Mr Philip Crummy of the Colchester

Archaeological Trust for tesserae from Gosbecks Park Temple Complex in Colchester. I hope the results obtained justify the confidence they placed in my research.

It has been a great help also to have had supportive colleagues. I should like to thank in particular Dr Haydon Bailey of Network Stratigraphic Consultancy Limited, for his thoughtful loan of literature to a new researcher and his generous help later with identifying several problem microfossils; and Professor David Siveter of the University of Leicester and Dr Samantha Cook of the University of Reading, who both kindly offered to 'stand by' as additional supervisors if the project moved into the more refined realms of taxonomy or geochemistry. I should also like to thank Nick Cooper of ULAS for his unfailing support for this project and for many valuable discussions on the finer points of archaeology. Lastly (but not leastly) I should like to thank the technical staff at the University of Leicester for their assistance with using the Scanning Electron Microscope (Rob Wilson, Lin Marvin) and with making thin sections (Colin Cunningham), not to mention a series of challenging discussions on the Romans and Roman Britain (Dave York). My research would have been much harder and far less rewarding without their help and interest.

No-one works in a vacuum and other postgraduates have also been immensely supportive during my time at Leicester. My personal thanks go in particular to Jennifer (now Dr) Graham, with whom I shared a room cheerfully for a number of years, and who has now gone on to greater things with Chemostrat in Houston, Texas; and also to Dave Riley, Steve Grebby and Laurent Darras (also now all Drs) for their help and friendship. I can say in complete honesty that my experience as a student would have been much poorer without their fellowship.

Finally, I should like to put on record the immense amount of support provided by my family during the last seven years. It was through their encouragement that I embarked on this PhD and it has been their enthusiasm that has enabled me to finish it. This thesis is therefore as much their achievement as it is mine.

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ACRONYMS and ABBREVIATIONS

Acronyms

ADS	Archaeology Data Service
BGS	British Geological Survey
CADW	Historic Environment Division of the Welsh Government
CBA	Council for British Archaeology
EH	English Heritage
FBZ(s)	Foraminiferal Biozone(s)
HER(s)	Historic Environment Record(s)
LAARC	London Archaeology Archive and Research Centre
LPRIA	Late Pre-Roman Iron Age
Ma	Millions of years ago
MOLA	Museum of London Archaeology
MOLAS	Museum of London Archaeology Service
NGR	National Grid Reference
NMR(s)	National Monuments Record(s)
RCHME	Royal Commission on Historic Monuments in England
SMR(s)	Sites and Monuments Record(s)
ULAS	University of Leicester Archaeological Services
UK	United Kingdom

Abbreviations (including Latin terms)

AD	*anno Domini* (= CE: Common Era)
aff.	*affinis* (having affinity with)
BC	Before Christ (= BCE: Before Common Era)
cf.	*confer* (bring together; hence, compare)
c.	*circa* (about)
e.g.	*exempli gratia* (for example)
ibid.	*ibidem* (in the same place)
i.e.	*id est* (that is)
op. cit.	*opere citato* (in the work cited)
passim	frequently; in several places
sp., spp.	species (singular), species (plural)

Note that all dates cited in the text are AD unless otherwise specified.

Chapter 1

Introduction

ABSTRACT

The rationale and methodology of the 'microfossil approach' to the determination of chalk tesserae provenance is introduced through the concept of biostratigraphy. Chalk tesserae from Silchester (*Calleva Atrebatum*) and Norden in Dorset are used as a case study to demonstrate the effectiveness of the technique. Questions arising from the results of the case study are used to frame the aim and objectives of the project. The outline of the thesis is explained.

1.1 Introduction

Excavations of urban and rural sites across Britain dating to the Roman occupation (AD 43-410) have revealed many mosaics of high quality, as a recently-completed corpus of mosaics from Britain illustrates (Neal and Cosh 2002, 2009; Cosh and Neal 2006, 2010). The wealth of abstract pattern and figurative detail contained in these mosaics has excited considerable discussion about their iconographic interpretation (*e.g.*, Rainey 1973; Johnson 1995; Ling 1997; Scott 2000; Witts 2005) and also speculation as to the existence of groups of mosaicists based on the identification of regional shared stylistic characteristics (Smith 1969, 1984; Johnson 1982, 1995).

However, there are still many practical questions concerning the manufacture of the mosaics that remain unanswered. In particular, we have little knowledge about the sources of the tesserae (the small cut stones used to fabricate mosaics) or the routes used to transport them. Determination of the provenance of mosaic materials is therefore of fundamental importance in addressing both these questions. As a result, the application of scientific techniques from adjoining disciplines to tesserae and other artefacts found on excavation sites in an effort to determine their provenance is a growing area of interest among archaeologists (Quinn 2008). Recent studies on stone materials dating to the Roman period, including tesserae, have been carried out using microfacies classification (Flügel and Flügel 1997; Flügel 1999, 2004), petrology (Allen and Fulford 2004, Allen *et al*. 2007), an integrated approach including geochemistry (Hayward 2009), and microfossil analysis (Wilkinson *et al*. 2008; Tasker *et al.* 2011; 2013). The results have been informative. We know now, for example, that boulders and pebbles of Mesozoic carbonates and sandstones found locally in Pleistocene and Holocene glacial deposits provided the raw material for mosaic tesserae from two villas close to Augsburg (*Augusta Vindelicum*) in Bavaria (Flügel 1999); that dolomitic cementstone and burned clay sourced from the Upper Jurassic Kimmeridge Clay Formation in Dorset contributed the raw material for mosaics found at Silchester (Allen and Fulford 2004); and that Caen limestone and similar freestones from Jurassic, Upper Cretaceous and Tertiary strata were imported into *Britannia* from widely separate outcrops in northern and central France during the first century AD (Hayward 2009).

This thesis is concerned with the way in which one such approach – that of biostratigraphy – can be applied to the question of materials provenance. The first part of this chapter introduces the concept of biostratigraphy and this is then followed by a case study illustrating the application of the biostratigraphical approach to chalk tesserae from Silchester. The questions raised by the results that were obtained from the Silchester study form the basis for the research described in the rest of the thesis.

1.2 Biostratigraphy and the 'microfossil approach'

1.2.1 Chalk

Chalk was widely used in Roman mosaics found in Britain. It is familiar from the bichrome patterns typical of mosaics dating to the first and second century AD, where its extreme whiteness was utilised deliberately to contrast with a darker lithology, but it was also commonly used to provide a neutral background to figured or complex geometric polychrome designs, or to highlight a detail within them, such as a line of drapery or a strand of guilloche. As a result, chalk tesserae are often recovered from any excavation in which mosaics are uncovered, making this lithology a good choice with which to investigate the provenance of mosaic materials.

Chalk is perhaps the most instantly recognisable of all the various lithologies found in the British Isles. In composition, it is a very white, pure, extremely fine-grained sedimentary limestone formed from the dead or discarded calcareous tests (shells) of minute marine fauna. In hand specimen, it appears almost homogeneous, but under a microscope it can be seen that it contains a mixture of fine and coarse material. The coarse fraction typically comprises between 10-25% of the chalk and is composed of the fossil remains of marine fauna and flora such as foraminifera (<1mm in size), calcispheres (algal spheres such as pithonellids, also <1mm) and fragments of bivalves or bryozoa, which may be several millimetres in length. Ostracod carapaces (tests) of 1-2mm are also occasionally found (Figure 1.1).

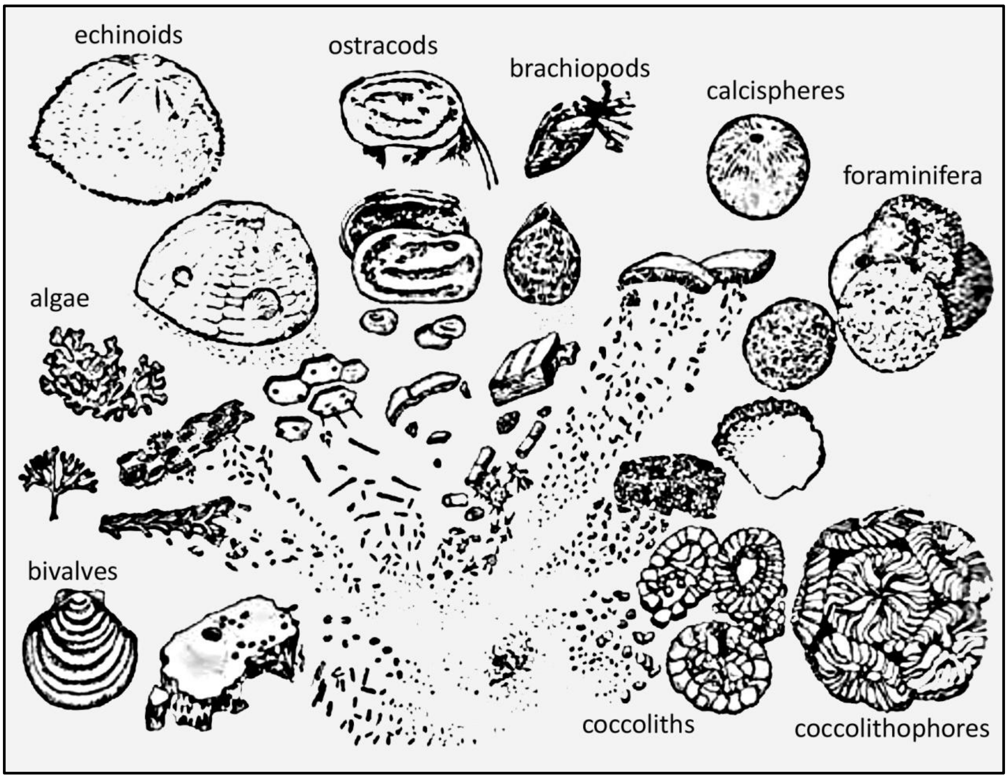


Figure 1.1. Faunal and floral components of chalk. After Woodcock and Strachan 2006, 358, Figure 19.1. The fine fraction of Upper Cretaceous chalks consists mainly of coccoliths and coccolith debris and the coarse fraction of whole or fragmentary foraminiferal tests. Other occasional material includes bivalve, brachiopod and echinoid shell or spinal debris, ostracod carapaces and bryozoan (algal) fragments.

In contrast, the fine fraction, which forms the bulk of the chalk (75-90%), is almost entirely formed from coccoliths - the minute calcite plates secreted by unicellular marine algae called coccolithophores that surround and enclose the organism in life but rapidly disaggregate upon its death. Coccoliths are measured in microns (typically, 5-15µm), but the carbonate ooze they form on the sea bed is an important rock-forming material; a pure chalk may be formed almost entirely from coccolith debris.

Chalk was deposited widely over several continents in a largely shallow marine shelf environment in the Late Cretaceous Period (*c*. 100-65 Ma) at a time when temperatures and sea levels were much higher than they are today. Regionally, this has meant that rocks similar to those of the Chalk Group - the collective name for the chalk formations found in the UK - are found also in northern and central Europe and extend well into the North Sea basin. However, the depositional history of the Chalk Group in the north and south of England is not the same (although there are many similarities) and both a Northern and Southern Chalk Province can be identified on the basis of differences in their fossil record. A simplified chalk stratigraphy diagram for the UK Chalk Group is shown below in Figure 1.2.

Chalk is surprisingly porous. The 'average' chalk has porosity of about 35%, although this can be reduced considerably in chalks that have been compressed during tectonic events or whose pore spaces have become filled with calcareous or siliceous cements during their post-depositional history. A reduction in porosity due to either physical (tectonic) or chemical (secondary cementation) events has the effect of hardening the chalk. This means that the hardness of natural chalk varies considerably. The more porous chalks are generally softer, more friable and less suitable for use as building stone. In contrast, the chalks affected by tectonic movements (such as those found on the Isle of Wight) or by condensation and/or erosion of existing sediments (such as the Totternhoe Stone, the Melbourn Rock and the Chalk Rock, three distinctive members of the Chalk Group in southern England) are recognised as being particularly hard. The hardness of some chalks can present a problem when processing chalk tesserae, as Chapter 2 shows. The petrology of Cretaceous chalk is reviewed in Hancock (1975) and further information on the faunal constituents of chalk can be found in Armstrong and Brasier (2005).

<table>
<tr><th rowspan="2">STAGE</th><th rowspan="2">GROUP</th><th rowspan="2">SUBGROUP</th><th colspan="2">FORMATIONS</th></tr>
<tr><th>SOUTHERN ENGLAND</th><th>NORTHERN ENGLAND</th></tr>
<tr><td>MAASTRICHTIAN
(part)</td><td rowspan="18">CHALK</td><td rowspan="16">WHITE CHALK</td><td rowspan="2"></td><td>‘Trimingham Chalk’
(only found in Norfolk)</td></tr>
<tr><td rowspan="5">CAMPANIAN</td><td>‘Norwich Chalk’
(only found in Norfolk)</td></tr>
<tr><td>Portsdown Chalk</td><td rowspan="3">top of exposed chalk in Yorkshire</td></tr>
<tr><td>Culver Chalk</td></tr>
<tr><td rowspan="3">Newhaven Chalk</td></tr>
<tr><td rowspan="3">Flamborough Chalk</td></tr>
<tr><td rowspan="3">SANTONIAN</td></tr>
<tr><td rowspan="3">Seaford Chalk</td></tr>
<tr><td rowspan="4">Burnham Chalk</td></tr>
<tr><td rowspan="2">CONIACIAN</td></tr>
<tr><td rowspan="3">Lewes Nodular Chalk</td></tr>
<tr><td rowspan="4">TURONIAN</td></tr>
<tr><td rowspan="4">Welton Chalk</td></tr>
<tr><td>New Pit Chalk</td></tr>
<tr><td rowspan="2">Holywell Nodular Chalk</td></tr>
<tr><td rowspan="3">CENOMANIAN</td></tr>
<tr><td rowspan="2">GREY CHALK</td><td>Zig Zag Chalk</td><td rowspan="2">Ferriby Chalk</td></tr>
<tr><td>West Melbury Marly Chalk</td></tr>
</table>

Figure 1.2. Chalk stratigraphy diagram for the Upper Cretaceous in the UK, illustrating the relationship between the various stages of the Upper Cretaceous (Cenomanian, Turonian, *etc*.) and the Chalk Group formations (Holywell Nodular Chalk, Burnham Chalk, *etc.*) found in southern and northern England. The timeline runs from bottom to top of the chart and covers the period 100-65 Ma (approximately). The Upper Campanian and Maastrichtian stages are only represented in the UK by a small number of outcrops in Norfolk. Stratigraphy after Wood and Smith, 1978; Rawson *et al*., 2001; Mortimore *et al*., 2001; Hopson, 2005.

1.2.2 Foraminifera and biostratigraphy

Foraminifera are single-celled marine rhizarians (formerly classified as Protista) whose small size, generally rapid rates of evolution and relative ubiquity have made them very useful to geologists for characterising sedimentary rocks. The correlation of particular fossil species or assemblages over distance has proved a useful means of dating rocks relative to one another, as rocks containing the same fossil species must necessarily have been laid down at the same time. This is the conceptual basis underpinning the science of biostratigraphy, which enables rock successions characterised on the basis of their faunal content to be placed into a relative chronological framework comprising a series of successive stages. However, although the fossilised remains of foraminifera are found in a wide variety of sedimentary rocks, they are not evenly distributed either in space or in time within the host material. This means that some rock samples may be barren, a point of particular relevance to small items such as tesserae (this is discussed further in Chapter 2). Also, to place a rock unit within an absolute chronological framework (one based purely on age) it is necessary to refer to material that can be dated radiometrically, such as the mineral inclusions found in layers of volcanic ash within the rock succession.

Foraminiferal sampling has enabled the complete chalk succession for the Upper Cretaceous to be categorised by the British Geological Survey (BGS) into a series of 25 contiguous foraminiferal biozones (FBZs) based on differences in the faunal content of the chalk (Wilkinson 2011a). A number of these are further divided into subzones (*e.g.*, BGS FBZ 20iii). This detailed categorisation enables the foraminifera identified in any particular chalk tessera to be compared with those found in each of the BGS biozones. A foraminiferal ‘match’ between the two provides a biostratigraphical age for the chalk (*e.g*. BGS FBZ 20) and the Chalk Group formation relating to this biozone can then be identified and its exposure determined from a geological map. This enables possible geographical sources for the chalk tessera to be identified. The above stages form the basis of the ‘microfossil approach’ used to undertake the work described in this thesis. A diagram illustrating this process in relation to the analysis of chalk tesserae, using data from the Silchester Case Study (section 1.3) is shown in Figure 1.3.

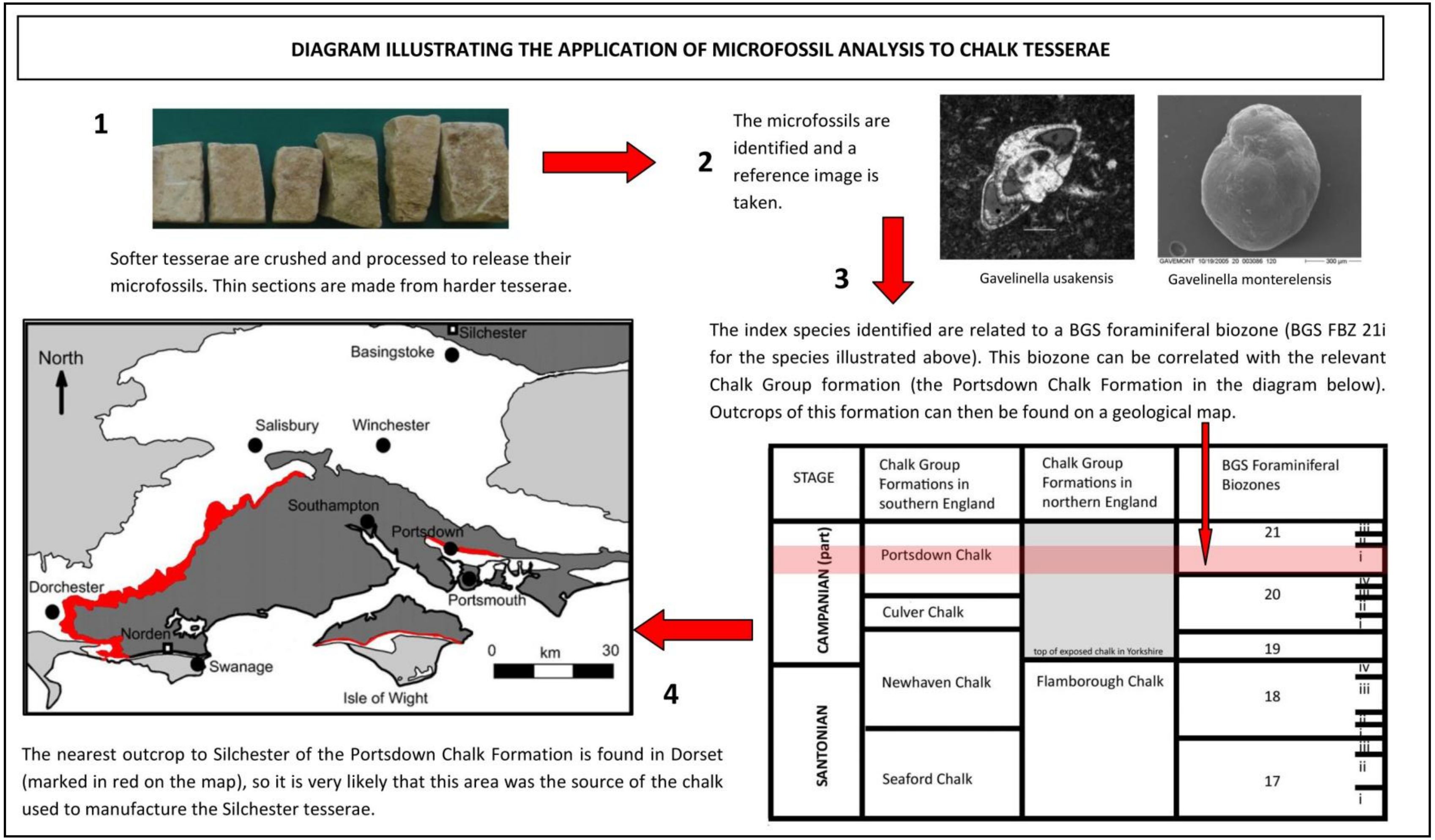


Figure 1.3. Diagram illustrating the ‘microfossil approach’ and its application to chalk tesserae (using data from the Silchester Case Study). The chalk stratigraphy diagram shown in step 3 above is similar to Figure 1.2 but with the addition of BGS Foraminiferal Biozones. Colours other than red on the inset map indicate other Chalk Group (white) or non-Chalk Group (shades of grey) members. BGS Foraminiferal Biozones after Wilkinson 2011*a*. Map data @NERC 2015.

1.3 The Silchester Case Study

In 2007, five loose chalk tesserae obtained from the University of Reading's excavation of Insula IX of the Roman town of Silchester (*Calleva Atrebatum*) in Hampshire were subjected to microfossil analysis. The idea behind this experiment was to find out whether or not a biostratigraphical analysis of the microfossils present in the chalk would be able to determine, or at least to suggest, possible sources for the chalk used to manufacture the tesserae. A biostratigraphical approach was thought to be particularly promising because of biostratigraphy's long and successful contribution to the categorisation and correlation of sedimentary rock strata in the British Isles (described above, section 1.2) and its consequent potential for identifying source areas for any artefacts manufactured from these materials. However, it was not known whether this approach would be viable for samples as small as individual tesserae, which are typically cubes with sides of the order 10-15mm and sometimes smaller.

1.3.1 The Silchester Case Study: geological results

Application of the 'microfossil approach' resulted in foraminifera being obtained from three of the five Silchester tesserae. The species identified are listed in Table 1.1 of Appendix A. The two chalk tesserae that were barren of foraminifera highlight the fact that the generally small size of tesserae and the limited number usually available for study from any one site means that there is always a possibility that results cannot be delivered because of a succession of poor or barren samples.

This result validated the physical process, but the palaeontological results were not as expected. Silchester is sited on gravel and overlooks sediments of sand and clay, but it is within easy reach of chalk outcrops, found some 10km to the north around Reading and 8km to the south around Basingstoke. It was expected therefore that one or both of these chalk sources would have been utilised for mosaic manufacture in the town. However, the palaeontological results showed that the chalk from one of the Silchester tesserae (MPA 54160) could be dated biostratigraphically to BGS FBZ 20, and that the chalk from two others (MPA 54161 and MPA 54162) could be dated to the contiguous, but slightly younger, BGS FBZ 21i. [Note that the 'MPA' numbers referred to above and throughout the text and also the 'MPK' numbers encountered below (in Figure 1.6 and elsewhere) are the BGS reference numbers given to the tesserae or thin sections (MPA) or to the samples or images derived from them (MPK) that either have been, or will be deposited with the BGS for research and reference purposes].

Both BGS FBZ 20 and 21i represent chalk which is much higher in the stratigraphical succession (and so younger) than the chalk from the locations closer to Silchester. Significantly, therefore, the local chalk was too old to have supplied the material for the Silchester tesserae and it was necessary to look elsewhere for a source. Chalk associated with BGS FBZ 20 is found relatively widely over the south of England and so could have been sourced from a number of areas, but chalk from the slightly younger BGS FBZ 21i outcrops only rarely in the south of England, as the vast majority of the original deposit, the Portsdown Chalk Formation, has been removed by later erosion. However, limited exposures do occur in the Salisbury-Dorchester-Swanage area of Dorset, some 90km to the south of Silchester (marked in red on the inset map in Figure 1.3). It was considered therefore that these areas were the most likely source for the two Silchester tesserae, a finding that was later published (Wilkinson *et al.* 2008).

By way of illustration, the results for MPA 54161 are charted on a foraminiferal range chart in Figure 1.4. This chart is a key component of the 'microfossil technique', in that it relates the evolutionary age ranges of index foraminifera in the Upper Cretaceous to the BGS foraminiferal biozones introduced in section 1.2.2. The ranges of the index foraminifera are shown by grey horizontal lines and the BGS biozones (*sensu* Wilkinson 2011a) by blue vertical ones. The value of the foraminiferal range chart becomes clear when the age ranges of the foraminifera identified in tessera MPA 54161 are plotted on it as red horizontal lines (Figure 1.4). These show that there is only a narrow overlap in time between the first appearance in the record of the index species *Gavelinella monterelensis* and the last appearance of the index species *G. usakensis.* The only biozone therefore in which these foraminifera could have coexisted is BGS FBZ 21 (in the subzone BGS FBZ 21i) and it assumed therefore that this is the biostratigraphical age of the chalk.

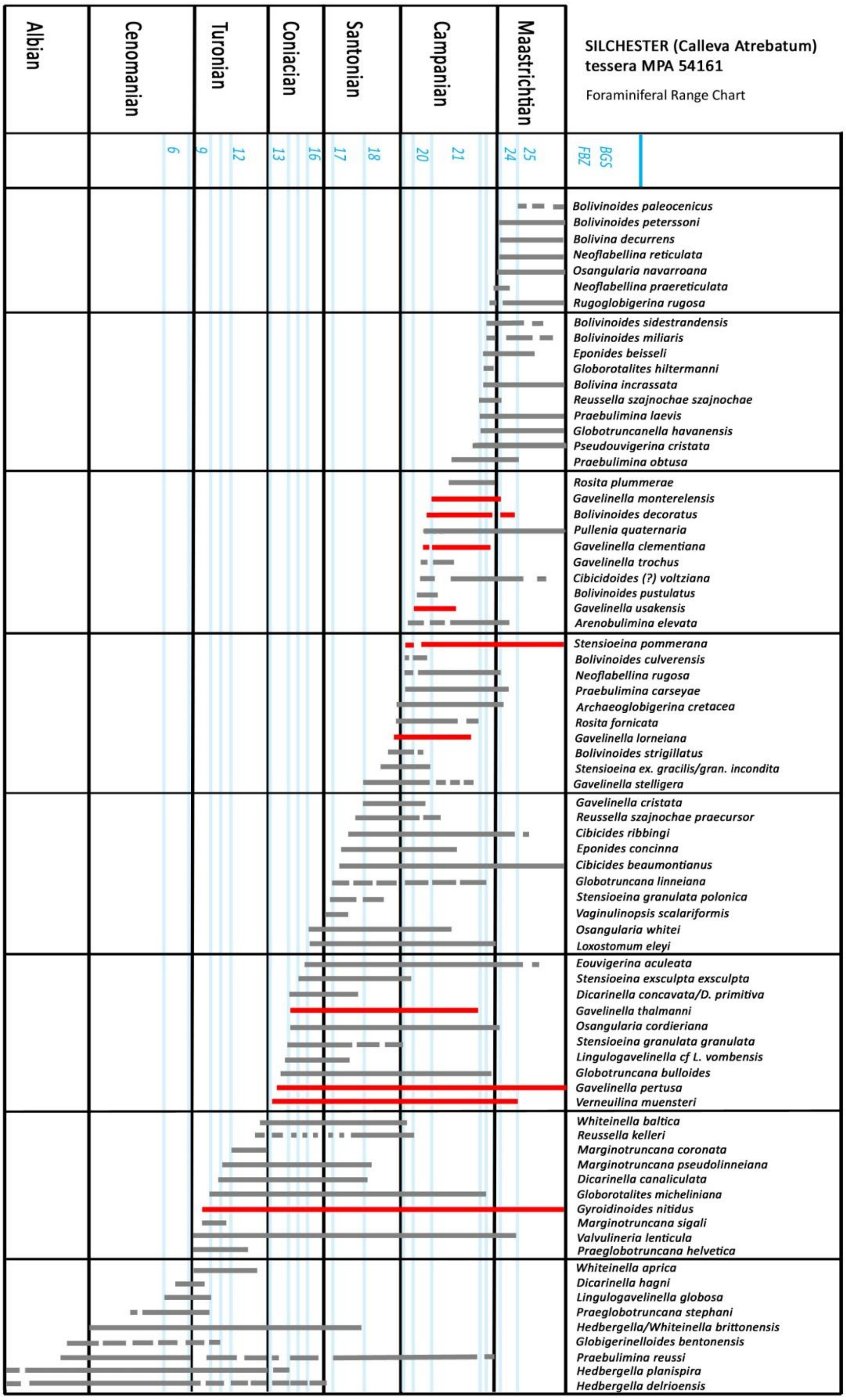


Figure 1.4. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tessera MPA 54161 from Silchester. Chart data are derived from Hart *et al*. 1989 298-301 (amended to show First Appearance Data) with additions (based on Hart. *op. cit.* and Swiecicki 1980). BGS Foraminiferal Biozones after Wilkinson 2011*a*.

The foraminiferal range chart is a very useful tool for determining the biostratigraphical age of chalks and similar charts will be used to display and compare the biostratigraphical results obtained for tesserae from each of the sites investigated in this project.

The Silchester Case Study illustrates the value of the 'microfossil approach' to determining chalk provenance. It shows that two of the five Silchester tesserae did not originate locally but were (most probably) imported into Silchester from a geologically limited area of Dorset. Here, then, was confirmation that mosaicists did not always use the nearest source of chalk for their raw material and that mosaic materials could be, and were, transported for considerable distances around the province. It now remained to be seen whether archaeology could build on this geological finding.

1.3.2 The Silchester Case Study: archaeological results

The Silchester chalk tesserae that were analysed for microfossils were found amid demolition layers and consequently their original context is not known. However, they can be placed within a broad chronological framework. The largest number of chalk tesserae recovered from Insula IX was found in contexts associated with the demolition of two masonry houses (Fulford and Clarke 2011, 214 and Figure 95). These two buildings were constructed around AD 125 and replaced earlier first-century timber ones. At some time in the second century these masonry houses were succeeded by a larger building; this was itself demolished about AD 200, and a smaller quantity of tesserae was found associated with its demolition also (Allen and Fulford 2004, 11; Fulford and Clarke *op. cit*., 217).

The constructional history of these buildings and their predecessors is complex, but Fulford and Clarke make it clear that the demolition layers from which the mass of tesserae were recovered accumulated over a considerable period of time and that some of the material almost certainly relates to a much earlier period of construction. The inclusion within this material of fragments of decorative stone inlay (including some imported stone), calcite crystals (for the manufacture of wall-plaster), a mosaic fragment and a mass of tesserae waste suggests that they originated from a building of considerably higher status than either of the two second-century houses appear to have been. The authors (*op. cit.,* 329) suggest this 'high status' material might represent residual debris from the demolition of a major first-century building that was probably located near to the forum-basilica to the south-east of Insula IX; evidence from other archaeological contexts in Silchester in favour of such a high-status building dating to the AD 60s or 70s was put forward earlier by Fulford (2008).

The archaeological evidence therefore suggests that the earliest of the tesserae recovered from Insula IX in Silchester probably date to mosaics laid in the later first century AD and that the remainder date to contexts not later than about AD 200. As most of the chalk tesserae were found in contexts associated with the 'high status' debris, it is possible that all the Silchester chalk tesserae analysed relate to the earlier period. However, it is not possible to state this for certain.

Wilkinson *et al.* (2008) speculated that a possible manufacturing location for the Silchester tesserae might have been the Romano-British industrial site at Norden, near to Corfe Castle in the Isle of Purbeck in Dorset. The site at Norden is known to have been manufacturing chalk tesserae in considerable quantities in the late first century AD, as more than 1500 hard white chalk tesserae and associated chalk chippings were found in a layer dating to just after AD 70 (Sunter and Woodward 1987). Although a number of sawn slabs of chalk dating to the late third century were also found at Norden, the authors state that very few of the chalk tesserae found there date to this time. It has been suggested that this earlier large-scale manufacture of chalk tesserae may have been intended to meet demand outside Dorset, as there are few mosaic floors dating to the first century in the county (White *et al.* 2012); the Flavian palace at Fishbourne is an obvious late first century candidate, but it is possible that Silchester might also have been a destination. Interestingly, there is evidence at Norden for the long-term (late first or early second to fourth century AD) manufacture of tesserae and *opus sectile* (thin-cut stone pieces) from non-chalk material, specifically dolomitic cementstone (Allen and Fulford 2004).

In order to test the 'Norden origin' hypothesis, Wilkinson *et al.* (2008, 2420) conducted a microfossil analysis of six hard white chalk tesserae found at Norden and also a loose block of chalk rock found at the same site (Tables 1.2 and 1.3 respectively in Appendix A). The authors found that one of the Norden tesserae (MPA 54216) could be assigned to BGS FBZ 21i and that three others (MPA 54217, MPA 54218 and MPA 54220) could be assigned to BGS FBZs 20-21i. These are the same two biostratigraphical horizons as the three Silchester tesserae. The remaining two tesserae from Norden, like the remaining two from Silchester, could not be closely assigned to a particular biozone due to lack of faunal evidence. The chalk tesserae found at Norden were therefore a very good biostratigraphical match to the Silchester tesserae. The same analysis also revealed that the loose chalk block sample found at Norden (MPA 54222, Table 1.3 in Appendix A) could also be assigned to BGS FBZs 20-21i, showing that this was also a good match to the Silchester tesserae.

The loose block of chalk rock found at Norden was found to be a calcrete (a chemically hardened chalk mass, produced by post-depositional secondary calcification (calcareous cementation) of an existing chalk deposit). Sunter and Woodward found no evidence that chalk was actually quarried at Norden, so the site does not appear to have been the actual source of the sample. This led Wilkinson *et al.* (*op. cit.*, 2420) to speculate that the hard white chalk tesserae discovered at Norden might have been manufactured there from large blocks of similarly calcretised chalk obtained locally as field brash. However, an alternative hypothesis put forward by White *et al*. (*op. cit*., 125) was that the Norden tesserae were quarried from outcrops along the chalk ridge on which the site lies. This ridge forms the northern limb of the Purbeck Monocline and as such the chalk would have been subject to tectonic (*i.e*., physical, rather than chemical) hardening, which would account for the hardness of the tesserae found at Norden. This latter is perhaps the more likely explanation, given the large-scale nature of the Norden manufacturing process. But whatever the actual source of the chalk, the authors agree that Norden is the most likely site of manufacture.

Biostratigraphic analysis, therefore, has enabled the Purbeck area to be identified as the most likely source of the chalk used for the Silchester tesserae and archaeological evidence supports the suggestion that Norden should be identified as their most likely place of manufacture. Circumstantial confirmation for this latter hypothesis is found in the evidence for the long-term manufacturing of raw geological materials in the Isle of Purbeck, which appears to have constituted a ‘geomaterials complex’ or series of small industrial units utilising local materials (chalk, Kimmeridge Shale, Kimmeridge Clay, dolomitic cementstone and Purbeck Marble) to manufacture a range of goods for either home consumption or export during the first to the fourth centuries AD (Allen *et al.* 2007; Allen and Todd 2010). Indeed, the known distribution of Late Pre-Roman Iron Age and Romano-British production sites on the Isle of Purbeck is widespread; a recent map identifies some sixty-odd sites (White *et al*. *op. cit*., 124, Figure 5).

1.3.3 The Silchester Case Study: the Early Wall

The discovery that mosaic materials had been transported some considerable distance to Silchester begs the question as to why the local sources of chalk were being ignored. This question became particularly pertinent when an investigation into the source of the chalk used to construct the foundations for the Roman ‘Early Wall’ at Silchester (dated *c*. AD 80-125/50; Amanda Clarke, personal communication 22.10.15) was undertaken as part of this thesis. The foraminifera identified in thin sections cut from a sample of Early Wall chalk are itemised in Table 1.4 in Appendix A and plotted onto a foraminiferal range chart in Figure 1.5. Selected images obtained from thin sections SIL_EW_D01 and D02 are shown in Figure 1.6.

Figure 1.5 shows that the species identified in the Early Wall thin sections were mostly long-ranging, but included the index foraminifer *Plectina cenomana,* whose range extends across BGS FBZs 4-7 (Mid to Late Cenomanian). However, the common occurrence in all the Early Wall thin sections of the algal sphere *Pithonella sphaerica* suggests that this biostratigraphical age can probably be narrowed to the Late Cenomanian, as *P. sphaerica* begins to be found in increasing numbers in BGS FBZ 6 and appears in abundance in BGS FBZ 7-9 (Wilkinson 2011b; see also Figure 3.4 in Chapter 3). A thin section image showing *P. sphaerica* in considerable abundance appears in Figure 1.6 (2). The probably identification of *Arenobulimina preslii* supports

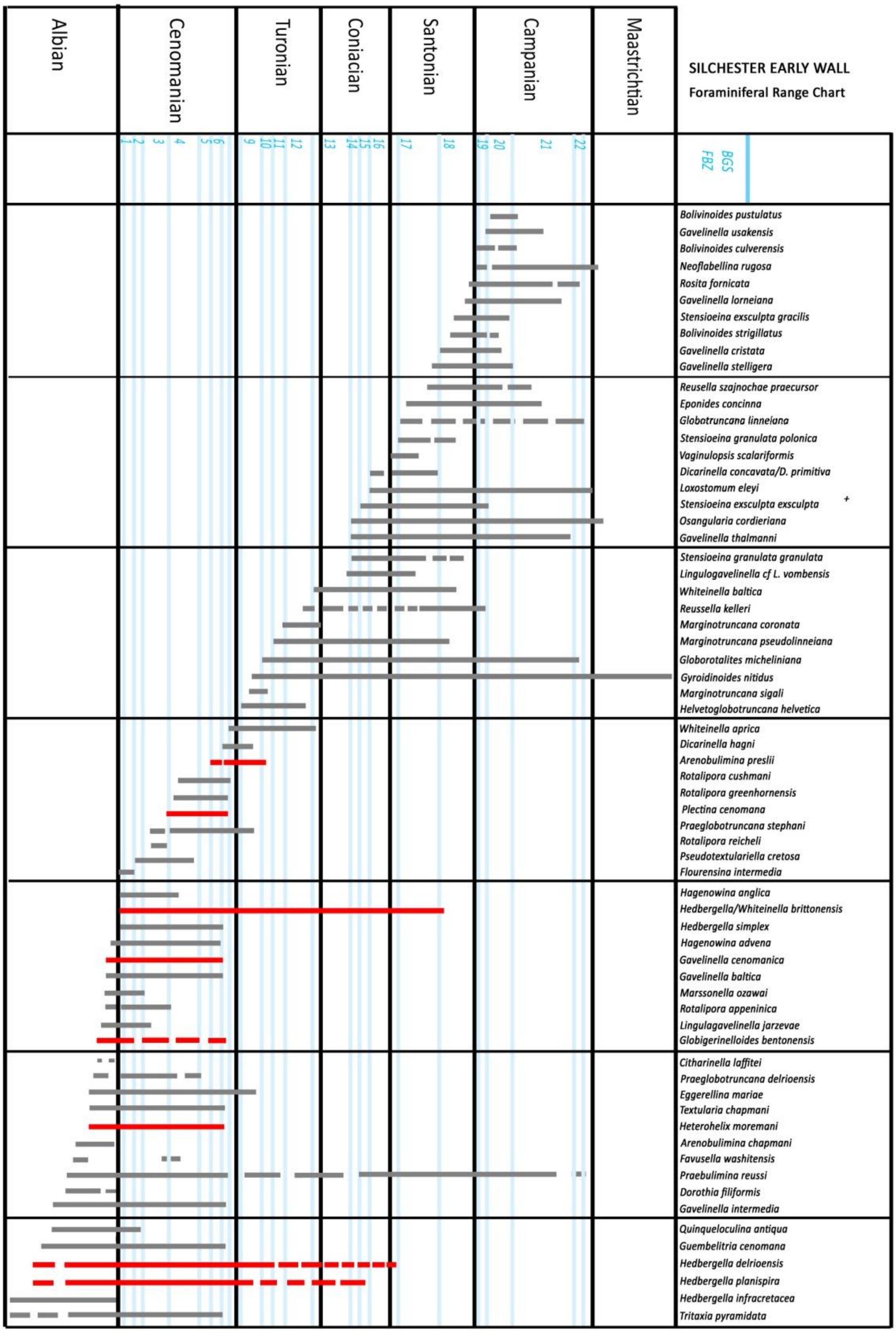


Figure 1.5. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for the chalk sample taken from the foundations of the Early Wall at Silchester. Chart data are derived from Hart *et al*. 1989 298-301 (amended to show First Appearance Data) with additions (based on Hart. *op. cit.* and Swiecicki 1980). BGS Foraminiferal Biozones after Wilkinson 2011*a*.

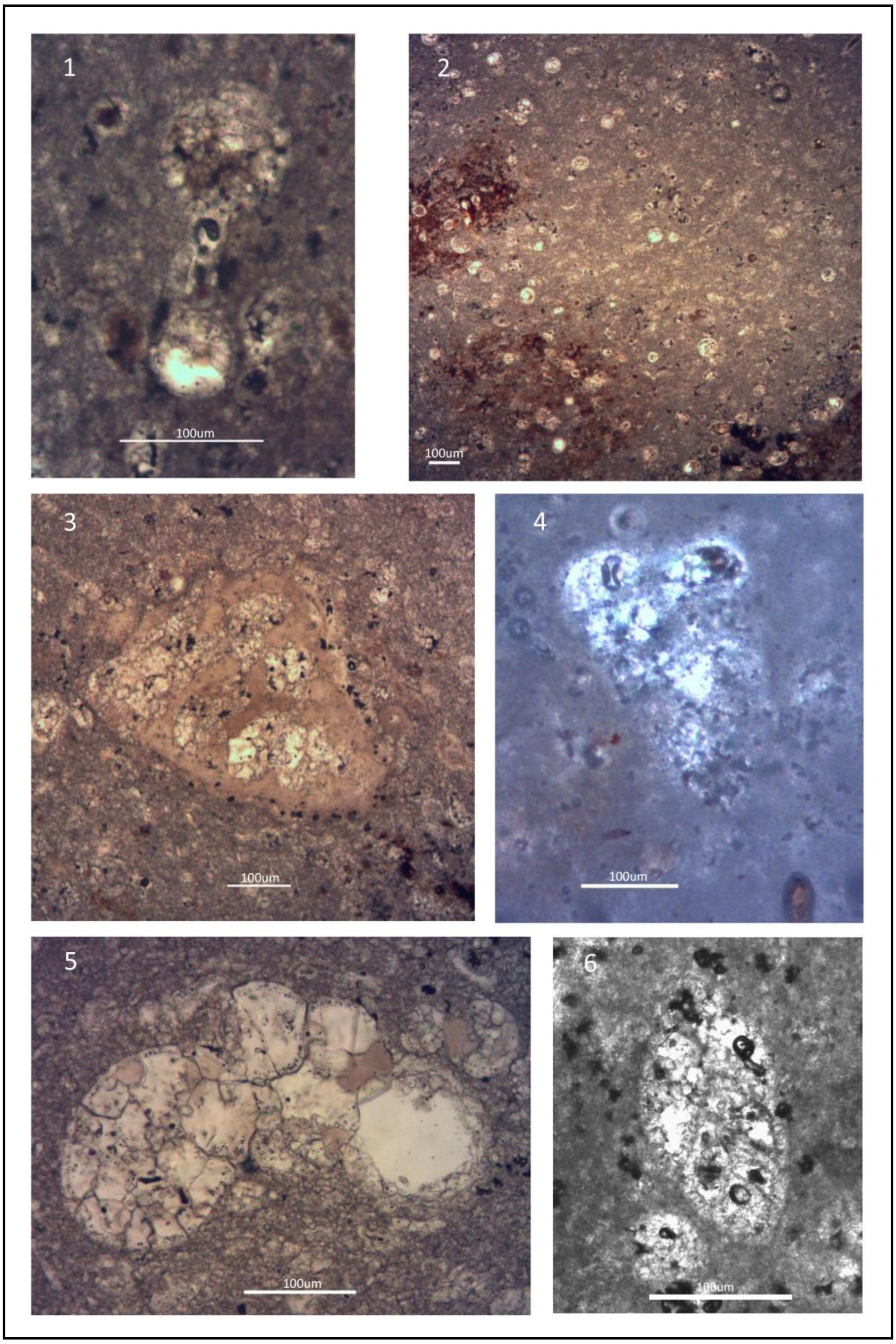


Figure 1.6. Thin section images of foraminifera identified in a chalk sample taken from the Early Wall, Silchester, UK. All scale bars are 100µm. 1*: Globigerinelloides bentonensis* (SIL_EW_D01_03); 2: Common *Pithonella sphaerica* in thin section (SIL_EW_D01_09); 3: *Marssonella trochus* (note the flat top) (SIL_EW_D01_07); 4: *Plectina cenomana* (similar morphology, but note the more rounded top with a central depression) (SIL_EW_D02_07); 5: *Hedbergella brittonensis* (SIL_EW_D01_08); 6: *Arenobulimina* sp. cf. *preslii* (SIL_EW_D02_15).

this, as the foraminifer does not appear in the stratigraphical record much before BGS FBZ 7 (Hart 1970). The biostratigraphical age of the Early Wall chalk can therefore be narrowed to the Late Cenomanian and probably lies within BGS FBZs 6-7. Comparison with Figure 1.4 shows that this is a considerably older biostratigraphical age than that of the Silchester tesserae and so the chalk source cannot be the same. However, Chalk Group exposures relating to BGS FBZs 4-7 (upper West Melbury Marly Chalk, Zig Zag Chalk and lower Holywell Nodular Chalk formations) are found some 12-15km to the south west of Silchester, with easy access to the town (Figure 1.7). It seems likely therefore that this local source provided the chalk used to build the foundations of the Early Wall. So this finding showed that although local exposures of chalk were both known about and being used at the time of Early Wall (*c.* AD 80-125/50), they were not used to manufacture the Silchester tesserae; an interesting finding, as the two uses may well have been coeval. This point will be taken up in Chapter 8 (Conclusions).

1.3.4 Silchester Case Study: conclusions

Several conclusions can be drawn from the Silchester Case Study:

a) The 'microfossil approach' worked with small chalk samples, such as tesserae;
b) A biostratigraphical approach to determining chalk provenance could not only suggest possible source areas, but also eliminate others;
c) The nearest source of chalk was not always used by mosaicists;
d) The long distance transport of chalk was a reality;
e) The use of archaeological information to generate a context in which to place geological data was a potentially successful method in provenance studies;
f) Investigating the provenance of chalk tesserae from other sites in order to compare the results with those obtained for Silchester would be fruitful.

1.4. A new project

The conclusions listed above were useful, but it was clear that they did not answer all the questions raised by the Silchester Case Study. For example: why were some outcrops of chalk selected and others ignored? Was Silchester an isolated occurrence

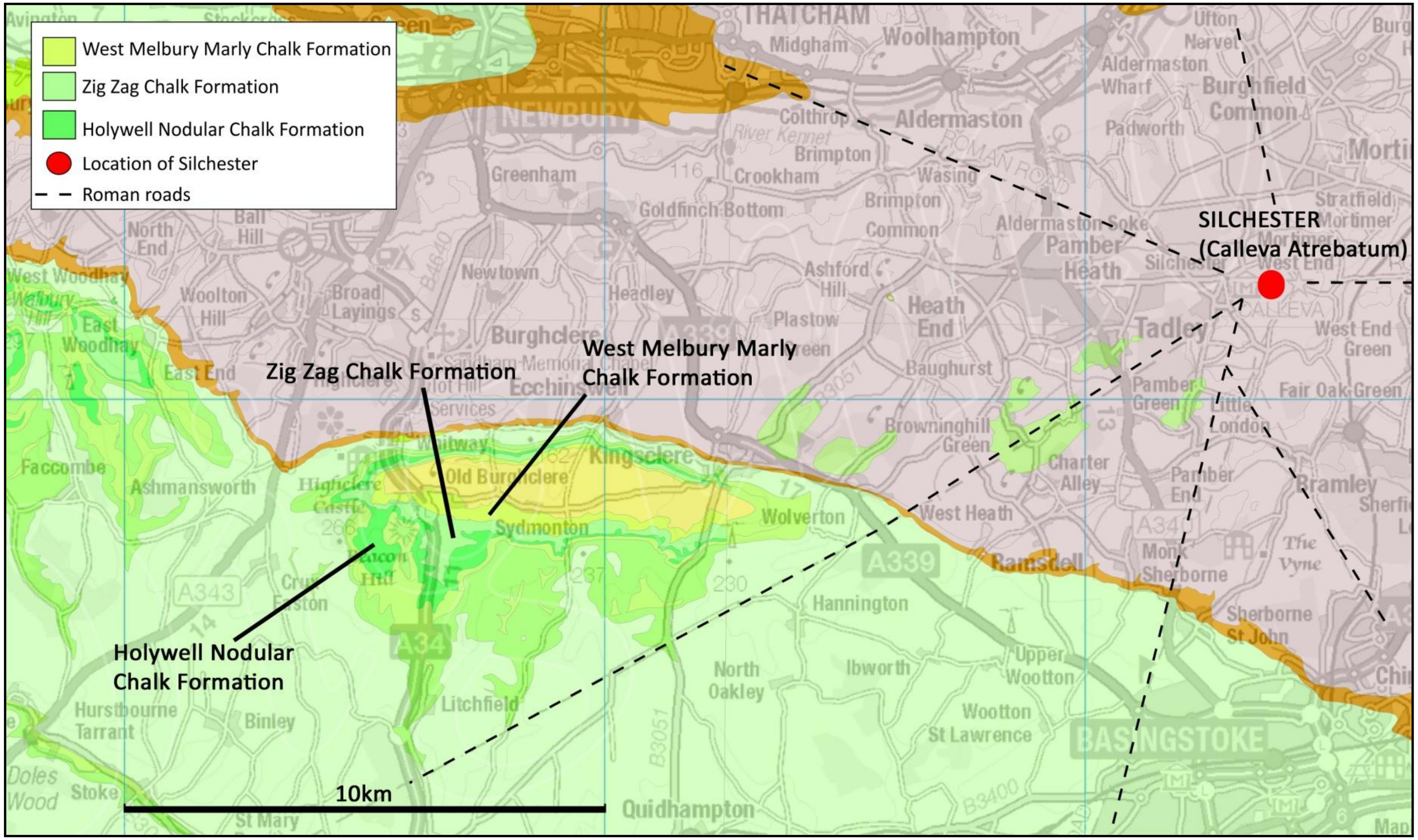


Figure 1.7. Sketch map showing the position of Silchester (*Calleva Atrebatum*) in relation to exposures of the West Melbury Marly Chalk, Zig Zag Chalk and Holywell Nodular Chalk formations. The main Roman roads into Silchester are also indicated. Geological Map Data © NERC 2013. The Roman road data are based on the Ordnance Survey map of *Roman Britain* 5th edition (2001).

or was the long-distance transportation of chalk commonplace in *Britannia*? If so, where was the chalk quarried and how did it travel? Were any of the harder strata of chalk specifically selected for the manufacture of tesserae? Were the same sources of chalk used throughout the Roman occupation or did these vary with time? Might the microfossil approach be able to tell us anything about the sources of materials used by the various 'schools' of mosaicists that were thought to have operated in the province at different times and in different locations?

The difficulty of answering these questions without further information led to the suggestion that the biostratigraphical approach to materials provenance that had proved so successful for the Silchester tesserae should be extended to the study of chalk material from other sites. A cross-disciplinary project (this PhD) was therefore set up in order to try to address the questions posed above.

1.4.1 Aim and objectives of the project

The aim of the project was to use the medium of biostratigraphy (the 'microfossil approach') to determine the provenance of chalk mosaic materials from selected sites in Roman Britain and to use the results obtained to shed light on the changes in supply and the movement of materials that might have taken place in the province over time.

The objectives of the project are listed below and some are discussed further in the following section.

a) To further validate the 'microfossil approach' and its usefulness to archaeology;

b) To analyse chalk tesserae from a selection of sites in Roman Britain selected on the basis of (i) geographical locus and (ii) historical date of the tesserae in order to determine the biostratigraphical age of the chalk used in their manufacture;

c) To use the biostratigraphical data found from (a) as a basis for determining possible source areas for the chalk used to manufacture the tesserae;

d) To determine from (a) and (b) whether there was any evidence for the harder strata of chalk being targeted for tesserae manufacture during the Roman occupation;

e) To use the source area data determined from (b) to investigate whether the sources of chalk used for tesserae in Roman Britain varied through time;

f) To see whether any conclusions could be drawn from the results obtained about the use and transport of chalk mosaic material around the Roman province.

1.4.2 Discussion of the above objectives

It was stated above in (b) that the sites for investigation for this project should be selected as far as possible according to two criteria: geographical locus and historical date of the tesserae. Proximity to known Chalk Group outcrops was a main consideration for the first criterion. It was decided, firstly, to analyse chalk samples from at least two other sites bordering Chalk Group outcrops. This was because it was necessary to find out whether chalk always travelled (as might be suggested by the Silchester Case Study) or whether in any instances local chalk appeared to have been used. However, it was also clearly important to investigate material from sites distant from Chalk Group outcrops; this was because in such instances the chalk *must* have travelled to reach the site and microfossil analysis offered the possibility of ascertaining where it had come from and how far it had travelled.

It was also recognised early on that it would be desirable to obtain material from sites that were geographically remote from one another, as this would offer the best opportunity for shedding light on the movement of materials around the Roman province. This was therefore a secondary consideration. However, although this always remained an intention, in practice it was only partially achieved because of the difficulties of obtaining suitable tesserae material (described below, in Chapter 2).

The second criterion was that of date (objectives (b) and (e)). It was clearly important to try to obtain tesserae from buildings dating from the first to the fourth centuries AD, to see whether there appeared to be any change in the sources of chalk used during the time span of the Roman occupation. However, this also presented difficulties because the tesserae obtained did not always come from a firmly dated context. Some tesserae were sourced from an unstratified context (as at August Villa Garden, Caerleon, Chapter 5), and of those that were stratified, some (as at Leicester, Chapter 4) were found in a context suggestive of re-deposited material, which meant that the date provided by the excavation context did not necessarily match that of the mosaic from which the tesserae originated. However, it proved possible in most cases to constrain the dates provided by using other criteria: for instance, using other archaeological context data (as at Leicester) or stylistic criteria (as at Combley, Chapter 3) to limit the range of possible dates for the relevant mosaic and thereby narrow down its date of construction.

The question of chalk selection was raised in the fourth objective (d). Chalk is a biogenic material and as such its hardness is not uniform; as mentioned in section 1.2.1, within the Chalk Group there are three strata in particular that are recognised for their hardness. It was a possibility that these strata might have been targeted deliberately for mosaic raw material due to their natural hardness.

1.4.3 Outline of the thesis

With the above objectives in place, the project went ahead. The results obtained form the basis for this thesis and are discussed in the following chapters.

Chapter 1 has already introduced the concept of biostratigraphy and highlighted a number of questions arising from the Silchester Case Study. Chapter 2 describes the research methods employed and the rationale behind them, examines some of the difficulties encountered during the course of the work, explains how these were overcome or otherwise obviated, and considers the limitations of the data acquired. In the chapters following, the work undertaken on chalk tesserae from 13 sites in five locations is described in a series of case studies (the Isle of Wight, Leicester, Caerleon, London and Colchester respectively) and the results obtained in relation to each site are discussed. The final chapter (Chapter 8) examines the totality of these results and considers whether some general conclusions as to chalk provenance and the movement of materials can be drawn from them, before suggesting areas for future work. Various appendices then formally tabulate the palaeontological results or contain ancillary material of interest.

Chapter 2

Methodology

ABSTRACT

The subject matter of this thesis is by nature cross-disciplinary and its investigation has involved developing methodologies for both its palaeontological and archaeological components. The first section (2.1) deals with the palaeontology component and describes the laboratory procedures involved in processing the chalk tesserae, the rationale for using these, the difficulties encountered and the solutions adopted. The second section (2.2) is concerned with the archaeological methodology. This comprises a description of the main primary and secondary sources of archaeological data used and a short discussion on the reliability that can be placed on them for the purposes of this thesis.

2.1 Palaeontology methodology

2.1.1. Problems of extraction

It is generally recognised that the extraction of foraminifera from chalk and limestone presents some difficulties for the researcher. The main problem is that both the foraminifera and the matrix in which they are encased have the same chemical composition ($CaCO_3$, calcium carbonate). This means that it is not possible to remove the matrix using the standard chemical method (dissolution, using an acid) as this is liable to damage or destroy the microfossil as well. Laboratory approaches have therefore concentrated on developing physical rather than chemical means for disaggregating the microfossils from their matrix. These methods vary from gentle crushing of the chalk under water (the simplest, quickest and easiest method) to more complex laboratory processes, but all aim to compromise the physical integrity of the matrix without damaging the fragile structure of the microfossil.

A secondary problem is that members of the Chalk Group vary considerably in their degree of hardness. Members that are softer (more porous) or more marly (having a higher clay content) respond reasonably well to these physical approaches, but this is not the case with those that have been indurated (made harder) through post-depositional tectonic movements and secondary cementation processes. The harder chalks, therefore, are not easy to process, and in fact a comprehensive review of the methods available caused one researcher to conclude that, although some techniques were more effective than others, none was entirely satisfactory (Slipper 1997). However, there is considerable advantage to the researcher in extracting clean specimens of foraminifera from chalk tesserae if at all possible, as whole specimens are generally easier to identify than those found in thin section because of their ability to be examined in the round. It was therefore considered worthwhile to attempt to extract microfossils from at least a few of the chalk tesserae obtained from each of the sites examined in this study.

The extraction methods deployed were the two techniques that were used with most success on chalks by Slipper (*op. cit*.); namely, the white spirit method and the freeze-thaw process. It was found that the white spirit method (Figure B1 in Appendix B) took time to implement, required the use of a laboratory with a fume cupboard and was no more effective in releasing microfossils from the harder chalk tesserae than the freeze-thaw technique. However, it was reasonably successful on the softer chalk tesserae, and with a few of these (for example, one or two of the tesserae from Leicester) the technique delivered a large number of clean foraminiferal samples. But in practice the method proved to be time consuming, and so after processing some of the tesserae from Leicester and a chalk sample from Silchester, it was eventually abandoned in favour of the freeze-thaw method (Figure B2 in Appendix B), which was quicker and easier to use, as effective on softer chalks and also had some success on harder ones.

2.1.2. The freeze-thaw process

The freeze-thaw process involved drying out the chalk sample, soaking it in a saturated solution of Glauber's salt ($NaSO_4.10H_2O$, sodium sulphate decahydrate) and then freezing it as quickly as possible. The fluid infiltrates the pore spaces in the chalk during the soaking phase and is then frozen rapidly during the freezing phase. Rapid freezing encourages high nucleation (crystal formation) but small crystal growth, whereas slow freezing would encourage the formation of larger crystals which might damage the microfossils. The expansion of the fluid as it freezes generates pressure in the pore spaces of the matrix and so causes the chalk to break up along existing lines of weakness (principally grain boundaries, such as those between the microfossil test and its matrix), thereby releasing the microfossils.

In theory, the freeze-thaw process should work well. Recent investigations into the nature of physical weathering on heritage stone buildings, particularly that caused by salt crystallization in pore spaces in limestones, have demonstrated that this process can be extremely destructive (for example, Smith and Viles 2006; Angeli *et al*. 2007; Angeli *et al*. 2010; and references therein). These investigations were aimed at understanding, and so potentially reducing, the impact of external (atmospheric pollution, acid rain) and internal (iron leaching, salt crystallization) factors on the fabric of historic buildings, but their findings are of interest because the most serious mechanism identified for causing catastrophic decay in limestones was the ingress and subsequent crystallization of soluble sodium sulphate salts into the pore spaces of the fabric. The physical expansion caused by the crystallization of these salts increased the internal pressure in the pore spaces and caused the limestone either to spall or to crack - exactly the same physical mechanism as that utilised in the laboratory by the freeze-thaw process, although in the natural environment, the ingress of salts and their subsequent crystallization occurred during repeated wetting and drying cycles at the masonry face.

Smith and Viles (*op. cit*.) found that differences in the limestone's physical parameters, such as its fossil content, hardness and porosity, determined the stone's susceptibility to decay and suggested that these differences determined why some limestones were better able to resist weathering and the effects of atmospheric pollution than others. Angeli *et al*. (2010) found that the most damage appeared to be caused if the sodium sulphate crystallised in its decahydrate form (as the mineral mirabilite) and if the limestone exhibited a large number of small but interconnected pore spaces (*i.e.* it was permeable as well as porous). This is understandable, as a lack of permeability would mean that any fluid in the pore spaces would remain relatively immobile. The latter's series of laboratory experiments also found that both the concentration of the soluble salt and its temperature affected the type and degree of damage caused, the maximum amount of damage being caused by a high salt concentration operating within close temperature parameters. In particular, it was found that an operating temperature above 50^{o}C caused the salt to migrate from its hydrous (mirabilite) to its anhydrous (thenardite) form, which nullified its destructive tendencies during the crystallization phase. These last findings enabled Slipper's technique to be modified so as to specify maximum temperatures for the salt solution during the freeze-thaw process in order to promote the most likely conditions for matrix disaggregation.

Results from the above research implied that in normal circumstances, chalk rock (essentially, a permeable and microporous limestone) should be susceptible to considerable damage from the freeze-thaw process. However, the dependence of its success on the deep penetration of the salt solution into interlinked pore spaces also suggested why the reduced porosity of a harder chalk might still present a problem. In fact, despite the refinement of Slipper's technique in the light of the above research, it still proved difficult to extract foraminifera from the harder chalks with any degree of reliability, and so recourse was had eventually to thin section analysis for all the sites investigated in this study.

2.1.3. Availability of material

The decision to move to thin section analysis was supported by a second difficulty, namely, a general shortage of material. The methods used to process tesserae for microfossils are destructive and the process itself is a relatively new technique within archaeology, so unless many tesserae are made readily available, it is understandably only possible to obtain a relatively small number for analysis. Typically only about a dozen or fewer tesserae would be provided by the museum and it was clearly not possible to experiment with too many processing methods when the material was limited. This led eventually to the decision to use the freeze-thaw method on approximately one third of the tesserae provided and to make thin sections from another third. This allowed the possibility of obtaining complete foraminiferal specimens from the chalk, whilst also providing thin sections as an alternative or supplementary form of identification. The remaining third of the tesserae could then be either processed or thin sectioned as necessary. This approach was adopted for the majority of the sites examined in this study.

The thin sections were photographed using a Nikon petrological microscope equipped with a JVC KYF55B digital camera (later upgraded to a Leica DMLP microscope fitted with a GXCAM-5MP CMOS Imaging Camera). However, the foraminiferal samples and a number of thin sections were also examined under a Hitachi 3200N scanning electron microscope.

2.1.4 Using thin sections

It was mentioned above that the value of extracting whole foraminifera from the chalk matrix is considerable. Unless damaged, foraminifera are far easier to identify in hand specimen as opposed to thin section. This is because the identification of individual species relies upon the ability to observe the range of morphological and ornamentational characteristics found on the spiral, umbilical and lateral profile of the test (in common parlance, the back, front and side of the fossil shell: see Armstrong and Brasier (2005) for an explanation of terminology), which can only be achieved with satisfaction if the specimen can be turned over and examined on both sides.

In comparison, a thin section suffers from two drawbacks. Firstly, it can only provide a two-dimensional image, from which a three-dimensional one has to be mentally constructed. The difficulty involved in doing this largely depends on the angle at which the test has been cut in the thin section. It is easier to construct a mental image of a test from an axial or transverse section than from an oblique one, which can be particularly challenging to visualise in three dimensions. Secondly, even when a suitable section is presented, it may show few or none of the morphological features necessary for an absolute identification of the test to species level, although it may allow the researcher to identify the genus with some certainty. Fortunately, many genera are limited to specific stages of the stratigraphical column, and identifying a number of these with reasonable certainty will often suggest a 'ball park' age for the chalk, placing it broadly within (say) either the Cenomanian or Campanian stage of the Upper Cretaceous, even if a specific BGS foraminiferal biozone cannot be identified. However, although the identification of microfossils might be harder in thin section than in the round, thin section analysis does offer two advantages. Firstly, it allows assemblages of microfossils to be examined. This compensates to a certain degree for the difficulty of identifying actual species in thin section, as the assemblage of micro-fauna and -flora present in the thin section will itself be typical of a particular stage in the stratigraphic succession and thereby suggest an age for the chalk. For example, the identification of large numbers of the algal cyst *Pithonella sphaerica* in a thin section would constrain the age of the chalk to those periods of time in which this species was known to appear in flood proportions. The assemblage might also include juvenile or small species which are less likely to survive the processing methods because of their physical vulnerability and therefore might only be identified in thin section.

Secondly, thin section analysis allows the structure of the matrix (the groundmass and any inclusions) to be examined petrologically. This has already proved a valuable technique in archaeology: for example, the petrographical analysis of ceramics in thin section has enabled deductions to be drawn about the provenance of the raw materials used (clays, tempering agents), the method of production (paste preparation, vessel forming) and the temperature at which the pots were fired, all based on differences observable in the microstructure of the ceramic groundmass and its inclusions (shell fragments, grog, mineral crystals) (Quinn 2009). Petrographical analysis has also been applied to the question of provenance of tesserae, with some interesting results: some recent examples have been cited in Chapter 1 (section 1.1).

However, petrographical analysis has the disadvantage that it is not able to confirm a link between an artefact and its potential source of raw material with the same confidence as it can dismiss one. The particular physical and chemical parameters determining the environment in which sediments are laid down are specific, but they are also repeatable, and so might occur (and probably have done so) at more than one time or place in the stratigraphic succession. It is difficult therefore to state with certainty from petrography alone that microstructures which are apparently identical in thin section are actually from the same source. Biostratigraphical analysis, on the other hand, has the advantage that it enables an artefact to be linked with possible source material in terms of an evolutionary component (its faunal make-up); if the species identified in the artefact and those found in the potential source material are the same or coeval, then the two are linked together in time. This makes the identification of a material source based on biostratigraphical similarities more secure than one based on microstructure alone. As we have seen with the foraminifera recovered from the chalk tesserae from Silchester, this assignment can sometimes be extremely specific in terms of geography as well as geology.

2.2 Archaeology methodology

2.2.1 Choice of sites

It was decided from the outset of this project that in order to obtain some idea of the long-distance (or otherwise) transport of chalk in Roman Britain, it would be necessary to obtain chalk tesserae from at least two sites that were well removed from any outcrops of Chalk Group rocks. The sites from which such tesserae were obtained were the legionary baths at Caerleon (South Wales) and a town house in Leicester (East Midlands). These sites were chosen for the obvious reason that any chalk tesserae found at them must have travelled to get there. Material was also obtained from sites that were sited close to Chalk Group outcrops, as it was necessary to ascertain whether or not local chalks were used to manufacture tesserae or whether long-distance transport was always the norm (as at Silchester). Tesserae were therefore examined from three villas on the Isle of Wight (Brading, Combley and Newport) and also from the temple complex at Gosbecks Park, close to Colchester in Essex. Finally, the opportunity arose to examine tesserae recovered from six excavation sites in the City of London. This offered the possibility of discovering whether an important port and trading centre such as London might have imported chalk tesserae.

It was thought useful to superimpose a map of Roman roads in the province over one showing the known outcrops of Chalk Group rocks in order to identify overland routes along which tesserae might have travelled from potential source areas to final sites (Figure 2.1). This map proved particularly useful in discussing a possible provenance for the chalk tesserae found at Leicester (Chapter 4), as it showed not only which areas of chalk outcrop were easily accessible by road, but also those which were not (the chalk outcrops in Lincolnshire and Yorkshire being prime examples of the latter). This raised the question of whether these more remote chalks might have been less attractive to exploit commercially, a point which will be taken up in various sections of the thesis.

The Silchester Case Study described in Chapter 1 showed that complementing the geological information obtained from foraminiferal analysis with archaeological information on possible chalk quarry or manufacturing centres could be successful in narrowing down possible geographical source areas for raw materials. This approach appeared to be particularly useful when the source area identified was geologically constrained but geographically extensive.

2.2.2 Sources of information

Information relating to possible sites of chalk quarrying in Roman Britain has been obtained from three main sources. The first of these is the mass of published data. This includes books; papers and reports in academic journals, including those published by local archaeological and geological societies; site excavation reports; county council minutes; and relevant articles in newspapers, geological and archaeological magazines, developers' newsletters and in one instance, Hansard.

The second source of information is the archive material held in national or local datasets. These include Sites and Monuments Records (SMRs) and Historic Environment Records (HERs) maintained by all county and unitary authorities in England. The SMRs were originally set up to act as a source of information to planners after government guidance required local authorities to take archaeology into account as a material consideration when determining planning applications. However, many SMRs have now broadened into HERs, which take historic landscapes and buildings as

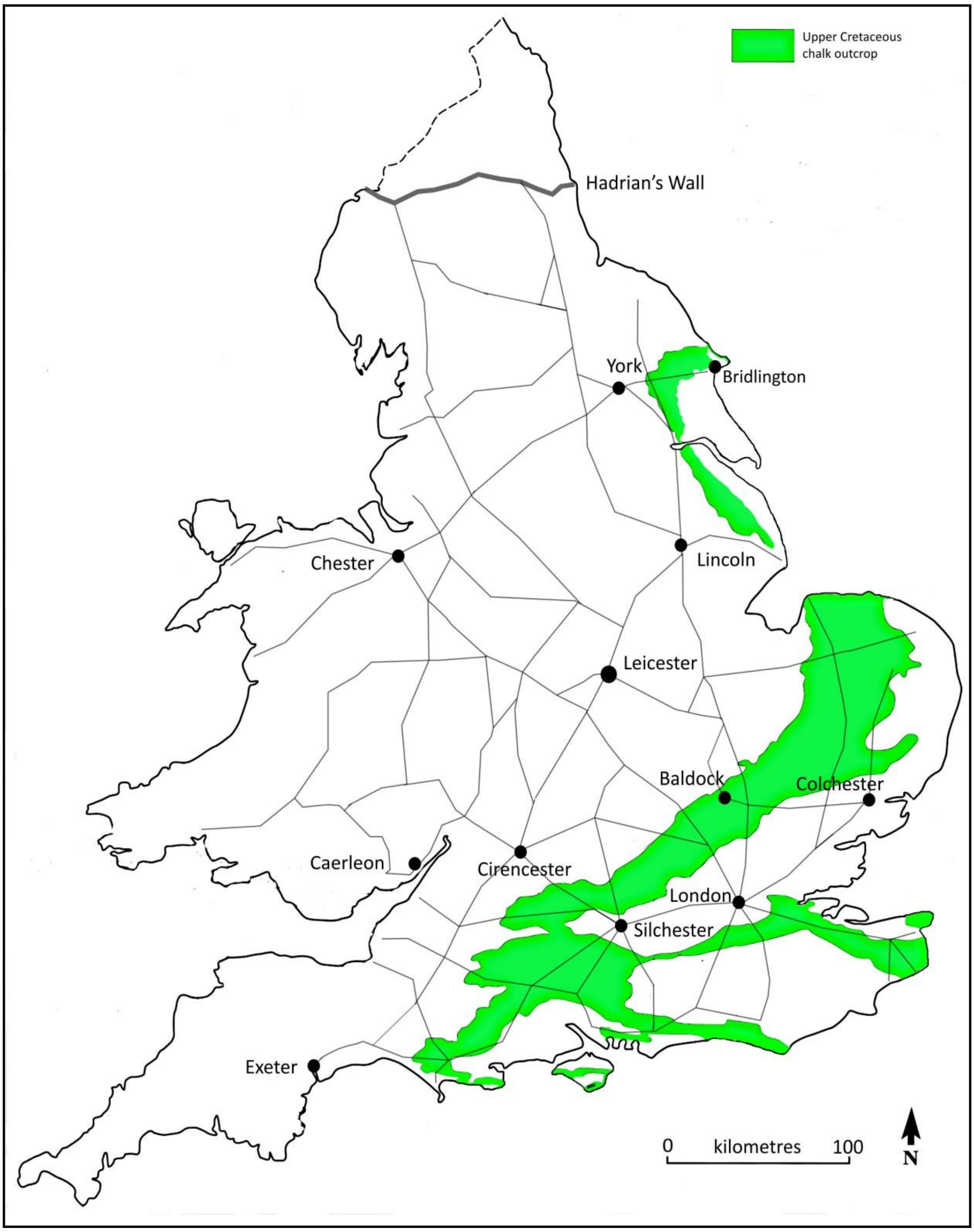


Figure 2.1 Sketch map of England and Wales, showing the distribution of Upper Cretaceous Chalk Group outcrops (in green) and their intersection with Roman roads. The main towns mentioned in the thesis appear with modern placenames. Cretaceous Chalk data taken from Geological Conservation Review volume 12 (1997) *Karst and Caves of Great Britain*, Chapter 7 and Figure 1. Geological Map Data© NERC 2011. The Roman road data are based on the Ordnance Survey map of *Roman Britain* 5th edition (2001).

well as archaeological sites into consideration. Both sets of records include basic information on archaeological sites (name, type, location, period and description) and if available, more detailed information (location maps, excavation reports, field survey results and miscellaneous correspondence). This information includes sites for chalk pits and quarries revealed by excavation. Many SMRs and HERs are now accessible digitally through Heritage Gateway, a portal maintained by English Heritage (EH) and its partners. The EH historic environment database for England, which includes information on archaeological sites, is accessible through its Pastscape portal (found at: http://www.pastscape.org.uk/default.aspx) and includes links to maps and photographs, where available, as well as to archaeological records.

The third main source of information is the Archaeology Data Service (ADS). This is an open-access digital archive set up in 1996 by a group of eight university archaeology departments and the Council for British Archaeology. It was originally intended for use only in Higher Education Archaeology, but it is now available to researchers and the wider archaeological community. In addition to hosting a number of national and local government archives datasets and engaging in its own research, the ADS has become the main repository for what is known as 'grey literature': the mass of archaeological reports, local investigations, field surveys and watching briefs that have been produced for developers and contractors over the years in response to the regulatory framework. Until the ADS was formed, these remained unpublished and so largely inaccessible, but many of the commercial archaeology reports now reside in the ADS *Library of Unpublished Fieldwork* and can be accessed via its ArchSearch search engine (found at: http://archaeologydataservice.ac.uk).

This 'grey literature' is important because, although not peer reviewed, it comprises an archive of information which academics recognise as being significantly underused and whose inaccessibility is a growing concern (Bradley 2006). Recently, however, significant steps forward have been taken to improve this situation through the Roman Grey Literature Project (Fulford and Holbrook 2011).

2.2.3 Potential difficulties

It is necessary to recognise that number of tesserae sampled from each of the sites was very small. A mosaic with a surface area of 25m^2 would contain over 100,000 tesserae (based on a tessera size of 1.5 x 1.5cm^2) of which only five might have been analysed. It is therefore possible that the analysis of other tesserae taken from the same mosaic might have revealed different biostratigraphical results. However, all the tesserae supplied were loose, which in itself implies a degree of random selection; the biostratigraphical results obtained from these inherently casual samples were very similar for the same site at the same context level (suggesting that a range of different sources was not involved); and biostratigraphical results are valid, even at the level of a single tessera. So whereas the smallness of the sample sizes must be borne in mind, this does not of itself invalidate the conclusions drawn.

Secondly, there are also potential difficulties with utilising the databases described above. SMRs and HERs only record ancient quarries exposed through excavation; as this is largely confined to urban areas, it is probable that the evidence for ancient quarries in rural areas is less systematically recorded and that this may represent a significant gap in knowledge. Also, not all SMR and HER information is on line. Some SMR datasets, for instance, have not yet been digitised and can only be consulted through a query service or a personal visit and the same is true for about half of the HERs. This means that, however thorough the search, there are likely to be gaps in the information available and this must be taken into account when drawing conclusions. In addition, not all the information available has been formally published and so little has been subjected to peer review. This need not necessarily negate the quality of the report, but it is a point that has to be borne in mind when relying on the data presented.

There are also some problems with interrogating the various datasets. Information is categorised under various headings and it is necessary to become familiar with all of these in order not to miss any data. Finally, it is as well to be aware that the archaeological site in question may have more than one reference number (some of which may be obsolete) and finding it again using the above search engines may not always be straightforward.

Some problems have also arisen when using the BGS map data. The geological maps published by the BGS through their website are an excellent source of information, but they are necessarily based on observations made in the field. In some cases it has not been possible for the map compilers to differentiate between two adjacent Chalk Group formations because the boundary between the two was not discernible on the ground. Where this is the case, it has made it difficult to determine the exact geographical extent of the relevant exposure on the ground and so to plot it accurately on a map. This has made it harder to limit the area of possible chalk provenance under discussion. However, in a number of instances, it has been possible to use palaeontological analyses (usually published as BGS Internal Reports) to clarify or otherwise supplement observations made in the field. These reports have been particularly useful for the palaeontological discussion in Chapter 5 (section 5.6).

2.3. Conclusions

a) There are difficulties with processing the harder chalks and even refining the freeze-thaw method failed to release microfossils from many samples;

b) Foraminifera are harder to identify in thin section, but this is partly compensated for by the insight provided into the microfossil assemblage and its matrix;

c) The tesserae sample size analysed for each site was small;

d) Information on archaeological sites and excavations is stored in a number of different datasets. These are likely to be incomplete; they are not yet centrally coordinated, so access can be confusing; and not all of these are on line, so internet access is patchy;

e) A significant amount of information is only available as ‘grey literature’; this is often extremely valuable but requires care in using;

f) Information on BGS large-scale maps may need supplementing from other sources to help determine the boundaries between adjacent Chalk Group formations where this is missing on the maps.

Chapter 3

The Isle of Wight

ABSTRACT

Thin section foraminiferal analysis of chalk tesserae from Brading Roman Villa in the Isle of Wight identifies a range of planktonic foraminifera and the calcareous algal cyst *Pithonella* typical of microfossils found in BGS Foraminiferal Biozone 4iii, indicating a biostratigraphical age in the Late Cenomanian for this chalk. Similar analysis of chalk tesserae from Combley and Newport Roman Villas, also from the Isle of Wight, identifies foraminifera from BGS Foraminiferal Biozones 20-21i, which suggests for the chalk a (younger) biostratigraphical age in the Mid Campanian. The local chalk, which outcrops to the north of the villa at Brading and to the south of the villas at Combley and Newport, includes rocks of both biostratigraphical ages, suggesting that the chalk for the tesserae in each case was sourced locally rather than at long distance.

3.1 Introduction

The successful identification of Dorset as a likely provenance and Norden as a possible manufacturing site for the chalk tesserae from Silchester in Chapter 1 suggested that a project investigating the provenance of chalk tesserae found at other locations in Britannia might shed light on the movement of mosaic materials around the province. This chapter focuses on an investigation into the sources of chalk tesserae used at three Roman villas on the Isle of Wight: Brading, Combley and Newport. Results from the microfossil analysis of the chalk tesserae from Brading Roman Villa have already been published (Tasker *et al*. 2011). This chapter is an extended and updated version of the original paper, which was published in the *Proceedings of the Geological Association.*

3.2 Archaeological background

Archaeological evidence suggests that the Isle of Wight was well populated during the Roman occupation (Lyne 2007; Tomalin 1987). Farm and villa sites, domestic artefacts, coin hoards and evidence of industrial activity all point to a relatively prosperous community on the island. Industrial activities included iron, lead and copper working at Yaverland; stone quarrying for Bembridge Limestone and 'Quarr Stone' at Quarr; and salt production at Barnes Chine, Grange Chine, Fishbourne and Redcliff (Pearson 2006; Tomalin 1990; Trott 2002). Local industries included the production of Vectis Ware during the second and third centuries AD, which does not seem ever to have become large scale; tile manufacture at Combley; and a possible winery at Rock, suggesting that viticulture as well as agriculture may have been practised at the villas and farmsteads (Lyne, *op. cit*.).

Between AD 250 and 270 a phase of newly built or expanded villas and farmsteads reflects a period of increased prosperity on the island. Substantial Roman stone-built farmsteads or villas are known at Bowcombe (Sydenham 1945); Brading (Price and Price 1881; 1890); Carisbrooke (Rigold 1969; Spickernell 1859); Clatterford (Busby *et al.* 2001; Kell 1856); Combley (Sydenham 1945; Fennelly 1969, 1971); Gurnard (Kell 1866); Rock (Goodburn *et al.* 1976, 367-8; Tomalin 2006) and Shide, at Newport (Sherwin 1929; Stone 1929).

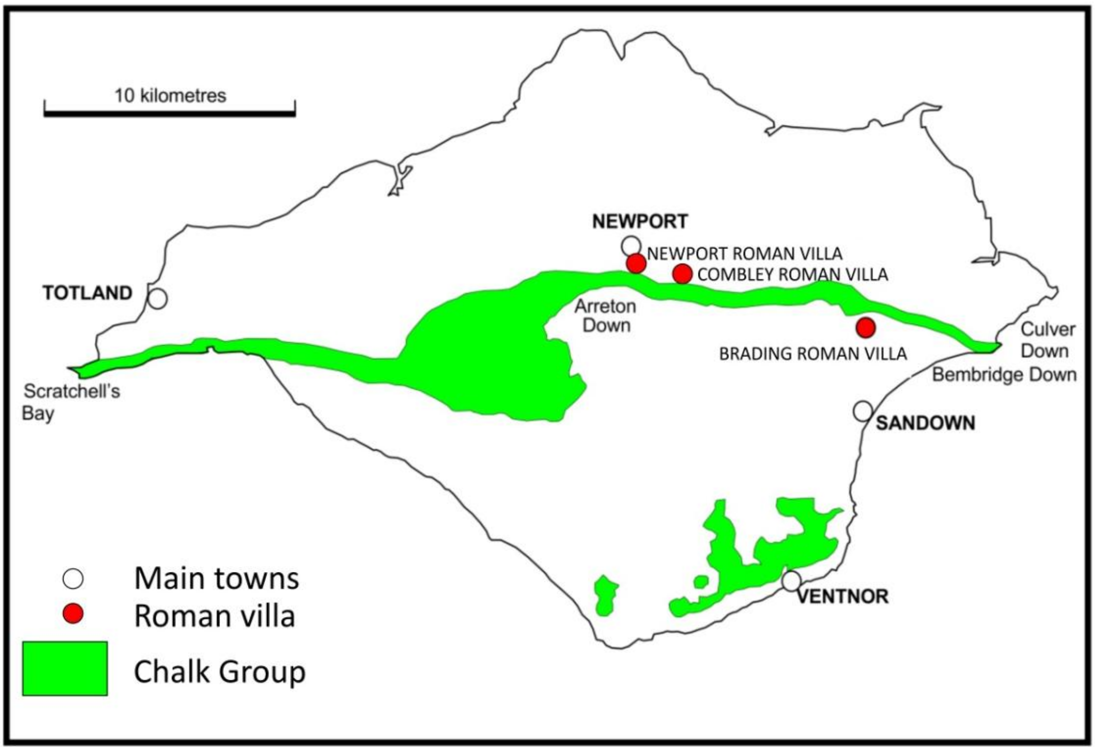


Figure 3.1. Sketch map of the Isle of Wight, showing the position of Newport, Combley and Brading Roman Villas in relation to Chalk Group outcrops (in green) and main towns.

3.2.1 Brading Roman Villa

Brading Roman villa is sited on the Ferruginous Sandstone Formation (part of the Lower Greensand Group) a few hundred metres south of Brading Down, the local section of the chalk ridge that runs across the island from Scratchell's Bay and The Needles in the west to Culver Down in the east (Figure 3.1). Although first excavated in the late nineteenth century, the site was poorly understood and a definitive history was never determined. However, a series of fresh excavations on the villa and new research into its development is currently being undertaken by Professor Sir Barry Cunliffe, Emeritus Professor of European Archaeology at the Institute of Archaeology in Oxford, in order to establish an accurate building sequence. A report on the first three seasons' work has recently been published (Cunliffe 2013).

Brading is one of four Roman villas on the island known to have installed mosaics. The figured mosaics in the West Range of the villa are normally dated to around the mid-fourth century AD, but a recent excavation by Kevin Trott (now Regional Manager (Midlands) at Pre-Construct Archaeology Limited) put forward the possibility of a late third century date (Neal and Cosh 2009, 262-280, especially 263). However, the date of the mosaics is likely to be re-evaluated in the light of the new excavations.

It is known that local materials were used in the construction of the villa at Brading. Recent analysis of the materials found on site has identified Bembridge Limestone, Ventnor Stone (a glauconitic sandstone) and Binstead Stone (a cream-coloured limestone), as well as a (possibly local, but since eroded) Holocene tufa (Gale 2011). Rounded clasts of Bembridge Limestone, apparently collected from the beach, were used extensively in some interior walls, whilst higher quality blocks were used to manufacture the cornerstones of buildings and chalk and flint utilised for wall infill. In addition, considerable quantities of fissile Purbeck Limestone were imported from the Swanage area on the east Dorset coast for use as roofing tiles. These appear to have been quarried rather than beach collected, as only one sample shows evidence of marine worm boring (Gale, *op.cit*). Black and grey tesserae have also been found. The black tesserae have been identified as Kimmeridge Clay Blackstone, an oil shale widely used in the Iron Age for personal ornamentation, whose nearest source is in Dorset, but the grey tesserae are currently unattributed to any source.

The range of constructional materials used at Brading suggests not only a good working knowledge of local island stone, but also the ability to import materials for specific purposes if none existed locally. It seems likely that the imported materials (Purbeck Limestone and Kimmeridge Clay) originated from Dorset, as the nearest outcrop of both lithologies is found there. Burned Kimmeridge Clay has already been mentioned in Chapter 1 as a source of first-century tesserae from Silchester (Allen *et al.* 2007).

3.2.2 Combley Roman Villa

Combley Roman Villa lies about 0.5km north of the east-west chalk ridge bisecting the island and about 6km east-north-east of Brading (Figure 3.1, above). Excavations at the site (Sydenham 1945; Fennelly 1969, 1971) revealed an aisled building linked by a corridor to an adjacent bath-house and facing a large courtyard. The few coins that were found suggest a *floruit* of AD 250-350. The north wall of the bath-house had been cut into the slope of the hillside and both it and the corresponding wall of the aisled building had been set on oak piles to counteract the instability of the subsoil. It is possible that the villa was abandoned in the mid fourth century because of water logging, although there was some evidence that the main building remained in use longer than the bath-house (Goodburn *et al*. 1976, 364-366; villa plan in Fig. 23).

Both the bath-house and the aisled buildings contained tessellated floors and mosaics: a geometric mosaic in the aisled building and a figurative (dolphin) mosaic in the *frigidarium* (cold plunge room) of the bath-house (Neal and Cosh 2009, 284-6). The geometric mosaic, now deformed due to floor distortion owing to the poor underlying drainage, was originally dated to the late third century AD, but Neal and Cosh (*op. cit*., 285) have revised this to the early fourth on stylistic grounds. Excavation showed that the bath-house had been modified at least three times and that the dolphin mosaic dated to the latest phase of development, so this is also likely to be a fourth century pavement.

The Combley chalk tesserae examined were small and evenly sized, with a top surface of approximately 15mm square. There was one triangular sample that had sharp angles (all approximately 60^{o}) implying that it had been cut specifically to shape, rather than simply being a half tessera. This suggests that it may have originated from a mosaic of quality. It is not known whether the chalk tesserae were derived from the geometric or the figurative mosaic, as Neal and Cosh report that both mosaics contained white material. However, if the mosaics are of similar date (early fourth century), it is possible that they both utilised the same source of stone.

3.2.3 Newport Roman Villa

The winged corridor villa at Newport was excavated in the late 1920s after Roman tiles were discovered when digging foundations for a garage on a housing development in the suburbs of the modern town (Sherwin 1929; Stone 1929; Taylor and Collingwood 1926). The villa was constructed in the AD 270s above an earlier first or second century building, but seems to have fallen into disuse by about AD 330.

The fine bath house found in one of the villa wings contained window glass and painted plaster and had patterned mosaics in two of its rooms and a large central panel of red and white squares in a third (Newport Villa Museum, no date). Descriptions of the mosaics show that those in the *apodyterium* (changing room) and *frigidarium* were of high quality (Neal and Cosh 2009, 287-8). However, it is not known in which rooms the chalk tesserae examined were discovered.

3.3 Palaeontological analysis

3.3.1 Brading Roman Villa

Six unstratified tesserae were chosen initially for processing (IOW_BRV_A01 to A06: MPA 61045-61050). The chalk in these samples was very hard and neither of the methods described by Slipper (1997) succeeded in disaggregating the chalk. Five stratified tesserae were therefore thin sectioned (IOW_BRV_B01 to B05; MPA 61051-65055) with two thin sections being cut from each tessera. Eight of the thin sections revealed foraminifera. The results are summarised in Table 3.1 of Appendix A. Selected images of the microfossils found are illustrated in Figure 3.2.

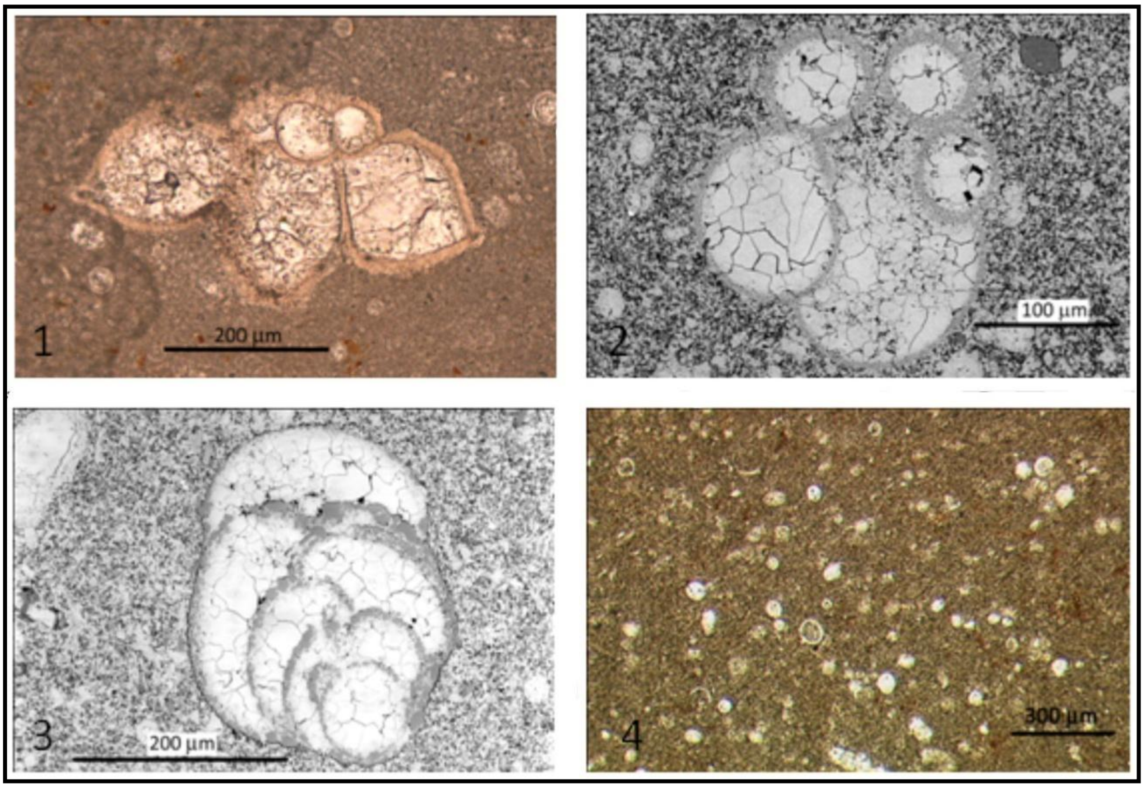


Fig. 3.2. Selected thin section images of microfossils found in chalk tesserae from Brading Roman Villa, Isle of Wight, UK. 1: *Rotalipora cushmani* (MPK 14107); 2: *Hedbergella* sp. (MPK 14108); 3: *Arenobulimina* (now *Hagenowina*) sp. (MPK 14109); 4: overview of thin section MPA 61053, showing low-porosity chalk containing planktonic foraminifera and large numbers of the calcareous algal cyst *Pithonella sphaerica* (MPK 14110). All images ex MPA 65053/1.

Figure 3.3 plots the ranges of the key foraminifera identified in all the Brading thin sections onto a foraminiferal range chart. As shown previously for the Silchester tesserae (section 1.3.1), this chart relates the evolutionary ranges of the foraminifera identified to the BGS FBZs identified by Wilkinson (2011a). The biostratigraphical age of the chalk is determined by the width of the biozone(s) in which all the foraminifera are coeval. Figure 3.3 shows that for the Brading thin sections, there is only a very narrow overlap in range between the first appearance in the stratigraphical column of the index species *Rotalipora cushmani* and the last appearance of the index species *Praeglobotruncana delrioensis* during which all the species identified could have co-existed. This constrains the biostratigraphical age of the chalk used to BGS FBZ 4iii (the upper part of BGS FBZ 4) in the Mid Cenomanian.

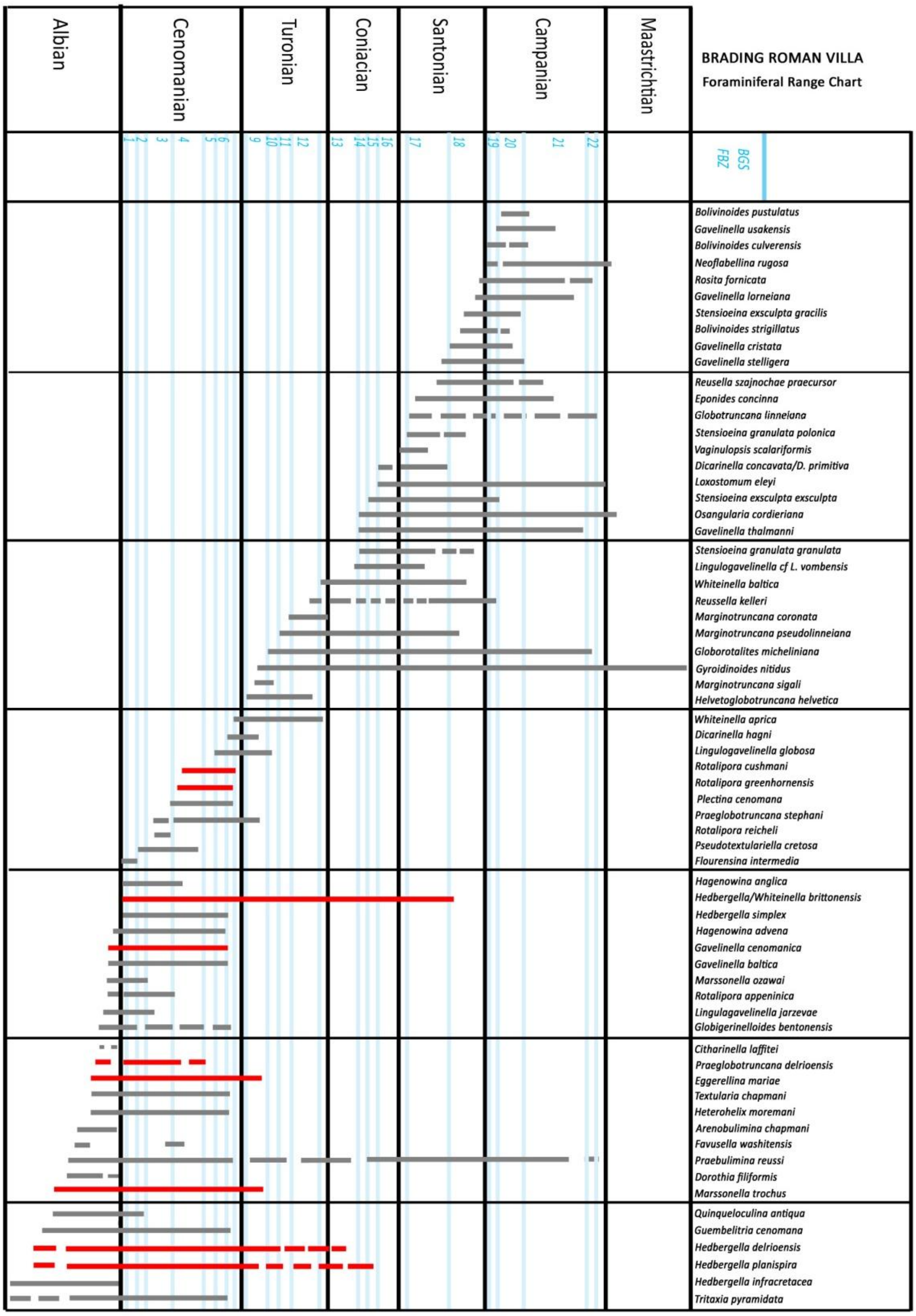


Figure 3.3. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from Brading Roman Villa, Isle of Wight, UK. Chart data are derived from Hart *et al*. 1989 298-301 (amended to show First Appearance Data) with additions (based on Hart. *op. cit*. and Swiecicki 1980). BGS Foraminiferal Biozones after Wilkinson 2011*a*.

Figure 3.4 takes the provenance process a step further, by correlating the biostratigraphical age of the chalk identified on the foraminiferal range chart (for example, BGS FBZ 17) to its lithostratigraphical expression in a particular rock formation within the Chalk Group (the Seaford or Flamborough Chalk formation). From Figure 3.4, it can be seen that a biostratigraphical age in the Late Cenomanian (BGS FBZ 4iii) has its lithostratigraphical expression in the lower part of the Zig Zag Chalk Formation in the south of England (S) and the middle of the Ferriby Chalk Formation in the north (N). As these formations have been mapped geologically, it is possible from this information to identify possible provenances for the chalk used for the Brading Roman Villa tesserae. This is discussed in section 3.4, below.

Note that Column 6 of Figure 3.4 also includes data on the frequency and abundance of the 'blooms' (high abundances) of the calcareous algal cyst (*Pithonella* spp.) recorded in Upper Cretaceous strata. The blooms recorded in southern England appear to the left of the midline in the column and those recorded only in the Isle of Wight appear to the right (Wilkinson 2011b). It can be seen from this figure that a very extensive pithonellid bloom occurred in both locations in the Late Cenomanian and Early Turonian. The abundance of *Pithonella sphaerica* and the occasional appearance of *P. ovalis* in several of the Brading thin sections therefore also strongly support a biostratigraphical age in the Late Cenomanian for the Brading tesserae. Figure 3.2 illustrates the algal sphere *Pithonella sphaerica* in flood proportions in one of the chalk tesserae thin sections (Figure 3.2:4).

Figure 3.4 is an extremely useful chart and it will be referred to frequently throughout this thesis to illustrate the relationship between the biostratigraphical age of the chalk as determined by foraminiferal analysis and its lithostratigraphical expression in particular Chalk Group formations. The figure has the advantage of showing the BGS foraminiferal subzones (*e.g*. BGS FBZ 20iii) as well as the biozones. It was unfortunately not possible to indicate the subzones on the foraminiferal range chart itself due to lack of space.

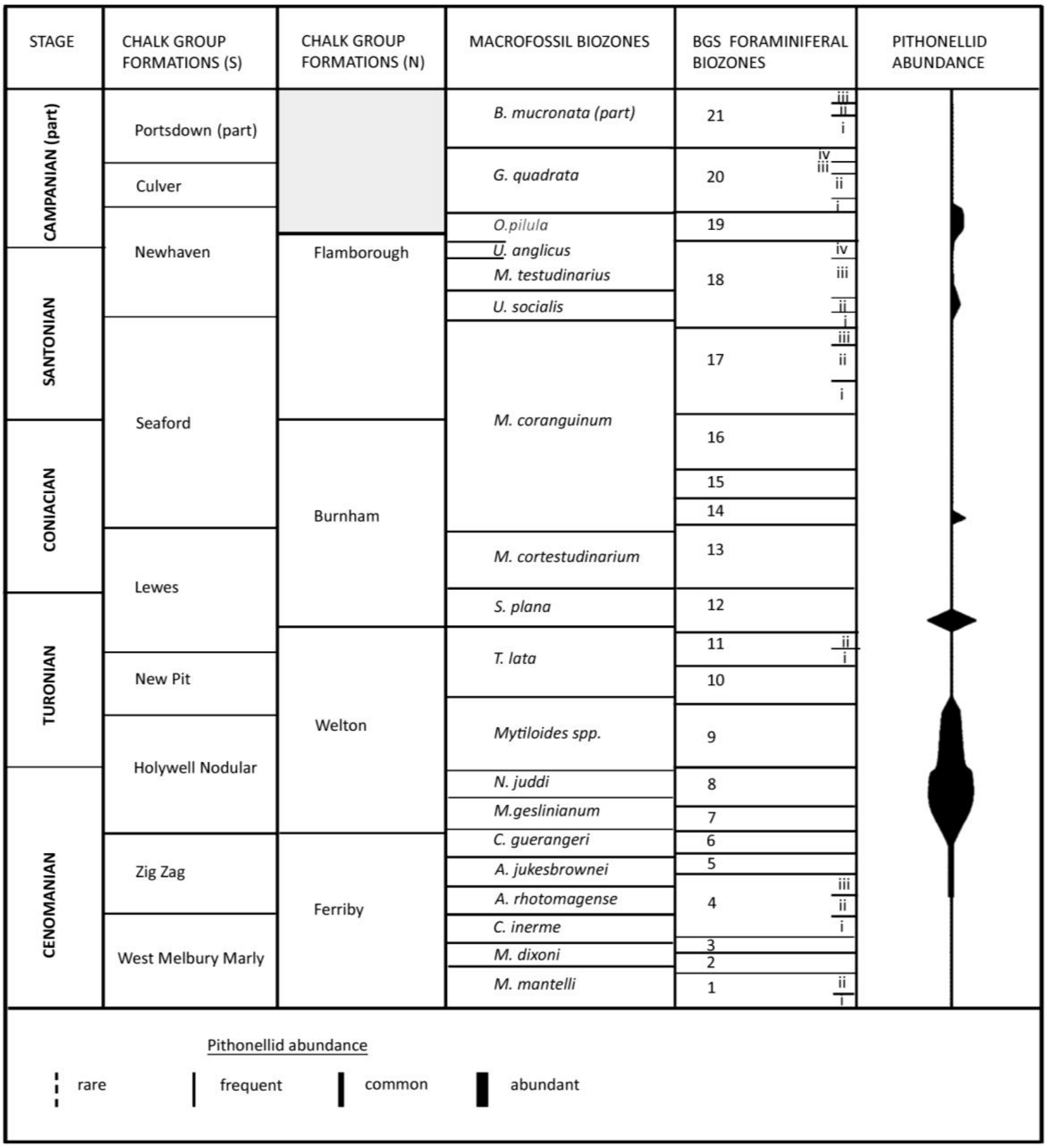


Figure 3.4. Diagram illustrating the relationship between BGS Foraminiferal Biozones, Chalk Group formations in the north (N) and south (S) of England and 'blooms' (high abundances) of the genus *Pithonella* in the south of England. For BGS Foraminiferal Biozones and pithonellid data, see Wilkinson 2011*a*, *b.* The standard Macrofossil Biozones (column 4) are included for comparison and reference.

Note that the left side of the pithonellid bloom mid-line in Column 6 shows blooms recorded in southern England and the right side of the mid-line shows blooms recognised in the Isle of Wight.

3.3.2 Combley Roman Villa

The chalk from which the Combley Roman Villa tesserae were cut was less hard than that used at Brading and around thirty microfossil specimens were recovered from processing six of the chalk tesserae (IOW_CRV_A01 to A06). However, thin sections were also made from two other Combley tesserae (IOW_CRV_A07 to A08) in order to provide a comparison with those cut from the tesserae found at Brading and Newport Roman Villas. Table 3.2 in Appendix A lists the foraminifera identified in the tesserae from Combley and Figure 3.5 plots the ranges of these on a foraminiferal range chart.

From Figure 3.5, it can be seen that the first appearance of the index foraminifer *Gavelinella clementiana* and the last appearance of the index foraminifer *G. usakensis* constrain the biostratigraphical age of the chalk to the upper part of BGS Foraminiferal Biozone 20 and the lower half of BGS FBZ 21 (*i.e*. to the subzones BGS FBZs 20iii-21i). Other foraminifera identified in the Combley chalk tesserae were all longer ranging than either *G. clementiana* or *G. usakensis*, so this is the only period of time in which all the species identified could have co-existed. The identification of BGS FBZs 20iii-21i places the biostratigraphical age of the Combley chalk source in the Mid to Late Campanian Stage. This is supported by the general absence of *Pithonella* species in the Combley thin sections, as there was no bloom recorded at this time (Figure 3.4). Figure 3.4 also shows that the inferred lithology corresponding to these biozones in the south of England is the Culver Chalk and lower part of the Portsdown Chalk formations.

3.3.3 Newport Roman Villa

The chalk tesserae obtained from Newport Roman Villa were harder than those obtained from Combley Roman Villa, and although six chalk tesserae (IOW_NRV_A01 to A06) were processed using the freeze-thaw technique described in Chapter 2, the few microfossil samples recovered were of too poor a quality to enable identification. Genera and species identifications were therefore made from thin sections cut from two additional tesserae (IOW_NRV_A07 to A08). Table 3.3 in Appendix A lists the microfossils identified in the two thin sections and Figure 3.6 plots the ranges of these on a foraminiferal distribution chart.

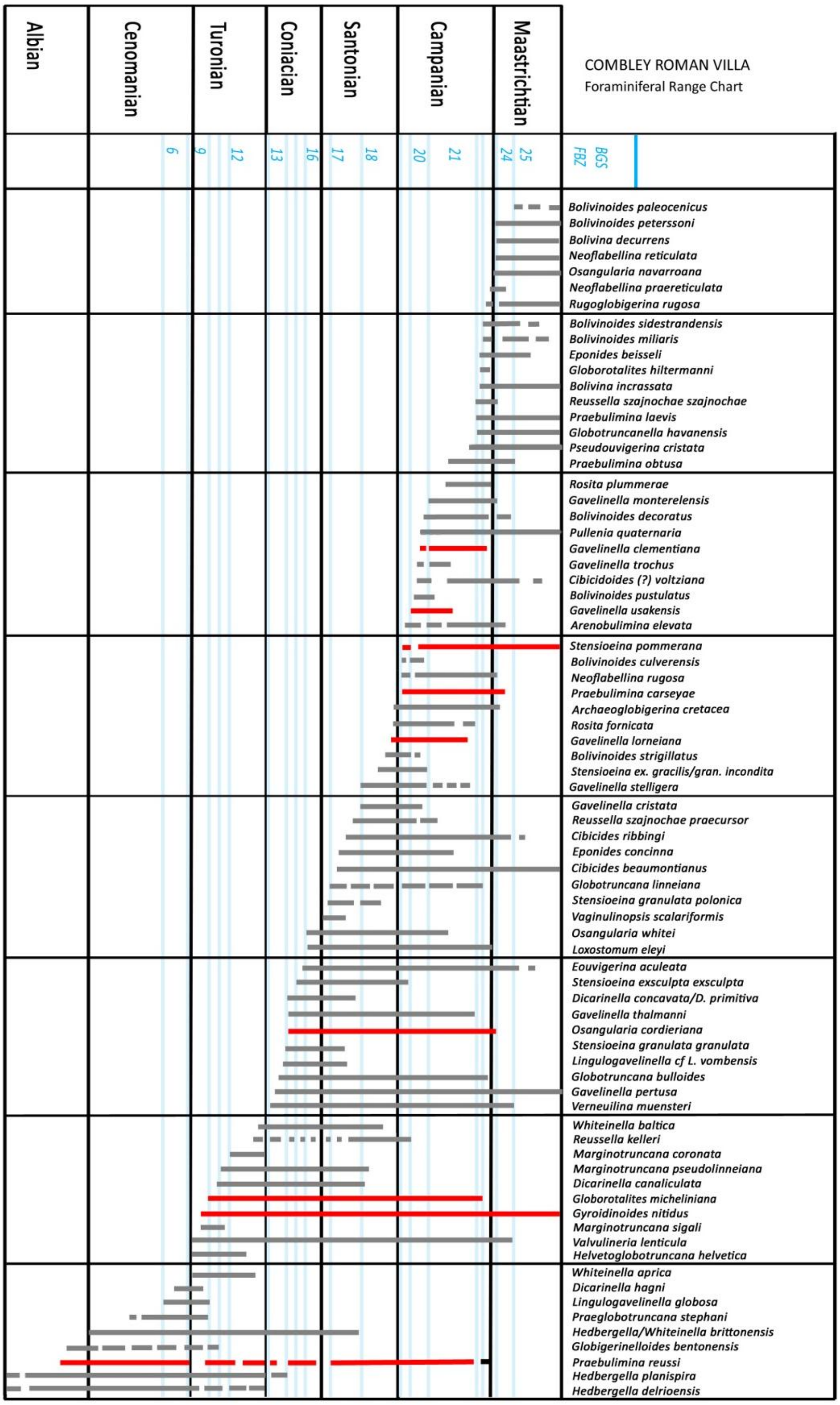


Figure 3.5. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from Combley Roman Villa, Isle of Wight, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

Although foraminifera were found sparsely in the Newport thin sections, it was possible to identify the index foraminifera *Gavelinella usakensis* and *Stensioeina granulata incondita*. Both these microfossils are useful in provenance studies as they have limited ranges and therefore closely constrain the age of the chalk in which they are found. The presence of *G. usakensis* would suggest that the chalk source relates to BGS Foraminiferal Biozones 20-21i, but the last appearance of *S. granulata incondita* in the stratigraphic record restricts this to BGS FBZ 20 alone.

In addition, the appearance of the algal sphere *Pithonella sphaerica* – found rarely or not at all in the thin sections from Combley, but appearing commonly within the thin sections cut from the Newport chalk tesserae, along with occasional *P. ovalis* - suggests that the biostratigraphical age of the chalk source for the Newport tesserae can be narrowed further, to the basal part of BGS FBZ 20 (20i-ii). This is because a bloom of *P. sphaerica* is known to have occurred in the Isle of Wight at this time (Figure 3.4).

This combination of factors provides a Late Cretaceous (Mid Campanian) age for the chalk from which the Newport tesserae were cut and places their chalk source firmly within the Culver Chalk Formation.

3.4 Discussion

Thirteen samples of chalk collected by the BGS during a recent re-surveying of the island were studied in order to compare the local chalk with that used to manufacture the tesserae found at Brading, Combley and Newport Roman Villas. The BGS samples were collected from the chalk ridge that crosses the Isle of Wight and passes close to all three villas (Figure 3.1). The ridge represents the near-vertical northern limb of the Sandown Monocline and the tectonic movements involved in its formation resulted in structural induration of the chalk. This prevented physical disaggregation of the BGS samples and microfossil identification was done through thin section analysis.

The map locations of the chalk samples taken by the BGS are shown in Figure 3.7. Table 3.4 in Appendix A lists the National Grid references for each of the BGS sampling points and lists the key microfossils identified in each of them.

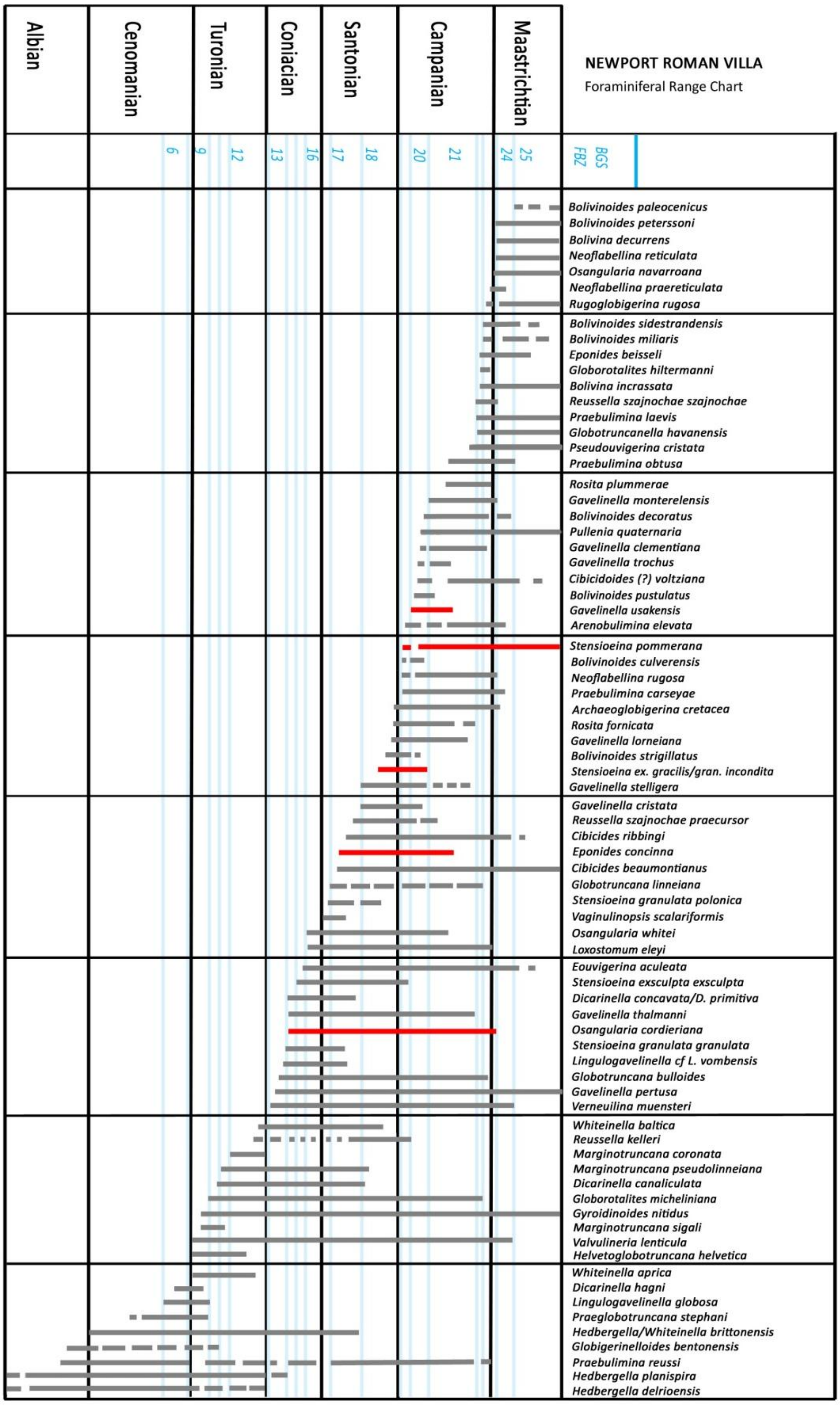


Figure 3.6. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from Newport Roman Villa, Isle of Wight, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

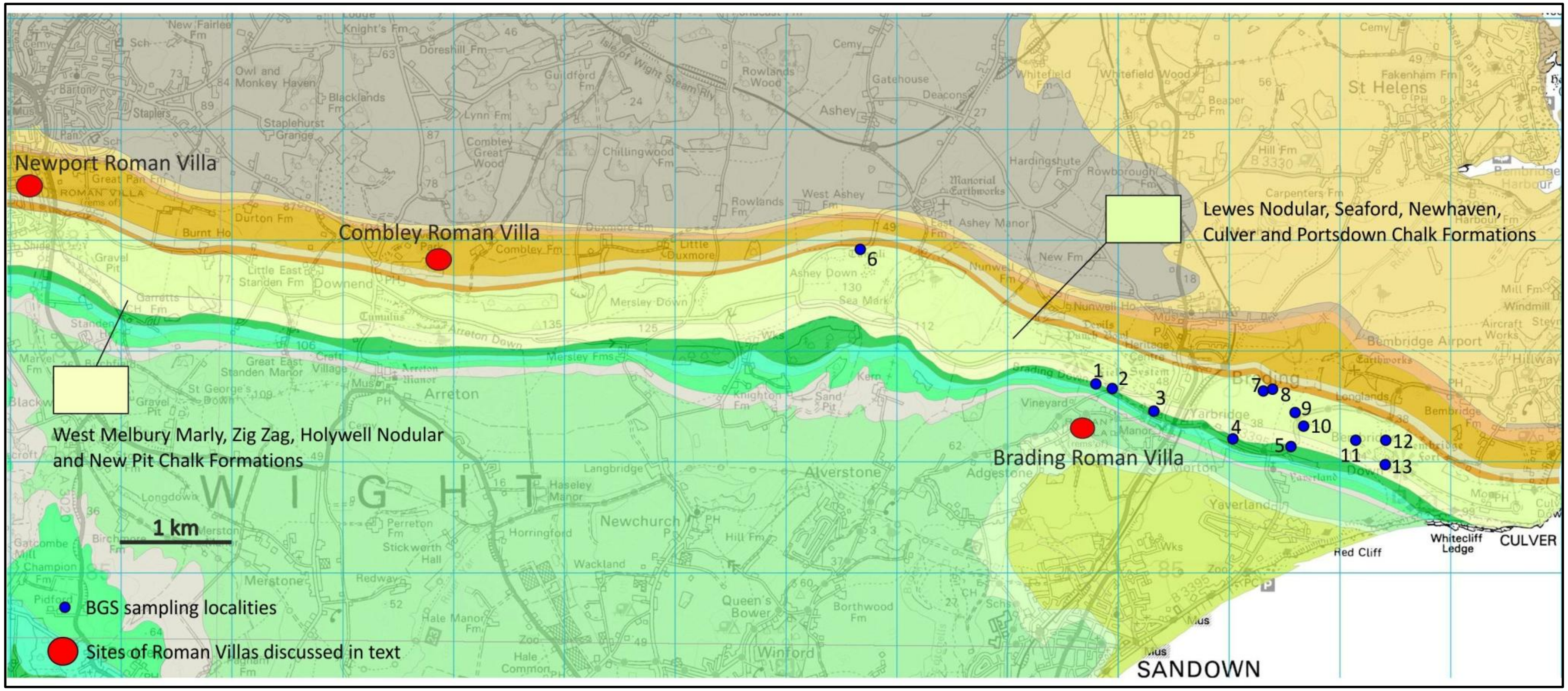


Figure 3.7. Map of the eastern half of the east-west chalk ridge of the Isle of Wight, showing the locations of Newport, Combley and Brading Roman Villas and the positions of 13 BGS sample points in relation to the local geology. Scale is 1:50000. Geological Map Data © NERC 2013. National Grid references and microfossil analyses for the BGS sampling localities marked on the map (1-13) are found in Table 3.4, Appendix A.

The Silchester Case Study in Chapter 1 (section 1.3) showed that the chalk used for the Silchester tesserae had probably been transported from Dorset, some 90km to the south west (Wilkinson *et al.* 2008). Proximity to the sea for the Isle of Wight in general and Brading Roman Villa in particular (via the adjacent harbour at Brading Haven) suggested that importation of chalk from nearby south coastal areas (Dorset, Sussex) might also have been a possibility for the three villas discussed above.

However, this appears not to have been the case. Foraminiferal analysis of the BGS chalk samples taken from Localities 1-5 on the southern margin of the chalk ridge found that they all dated to the Cenomanian or Early Turonian Stage of the Upper Cretaceous and so were similar in age to the chalk used to manufacture the tesserae found at Brading (BGS FBZ 4iii). This a particularly true for the chalk sampled at Locality 3, which had a biostratigraphical age of BGS FBZ 4i-ii, just slightly older than the chalk from Brading. A parsimonious interpretation of this evidence, therefore, is that the most likely source of the chalk used to manufacture the tesserae found at Brading Roman Villa was local.

Analysis of three other chalk samples taken by the BGS (at Localities 6, 7 and 8 on Figure 3.7, close to the northern margin of the chalk ridge) showed that the chalk sampled at these locations could be assigned biostratigraphically to the much later foraminiferal biozone BGS FBZ 20. Thin section analysis of all three BGS samples, for example, revealed the foraminifer *G. usakensis,* with specimens closely resembling *Bolivinoides culverensis* also being identified in BGS sample 6. The finding of the index foraminifer *G. usakensis* confirmed that the chalk in these three BGS samples had the same biostratigraphical age as the chalk from which the Combley and Newport tesserae were cut (BGS FBZ 20). Figure 3.8 compares images of *G. usakensis* found in two of the BGS chalk sample thin sections (from Localities 6 and 7) with those found in the Combley and Newport chalk tesserae.

It can be seen from Figure 3.7 that the outcrop of Campanian chalk from which BGS samples 6, 7 and 8 were taken extends westwards along the northern margin of the chalk ridge to come within a kilometre of both Combley and Newport Roman Villas. This makes chalk of this biostratigraphical age (BGS FBZ 20) the closest outcrop to both sites. So although the Culver Chalk Formation also outcrops widely over southern England (for example, in Dorset), the parsimonious suggestion, as with Brading, is that the chalk for the mosaics found at both Combley and Newport Roman Villas was collected locally.

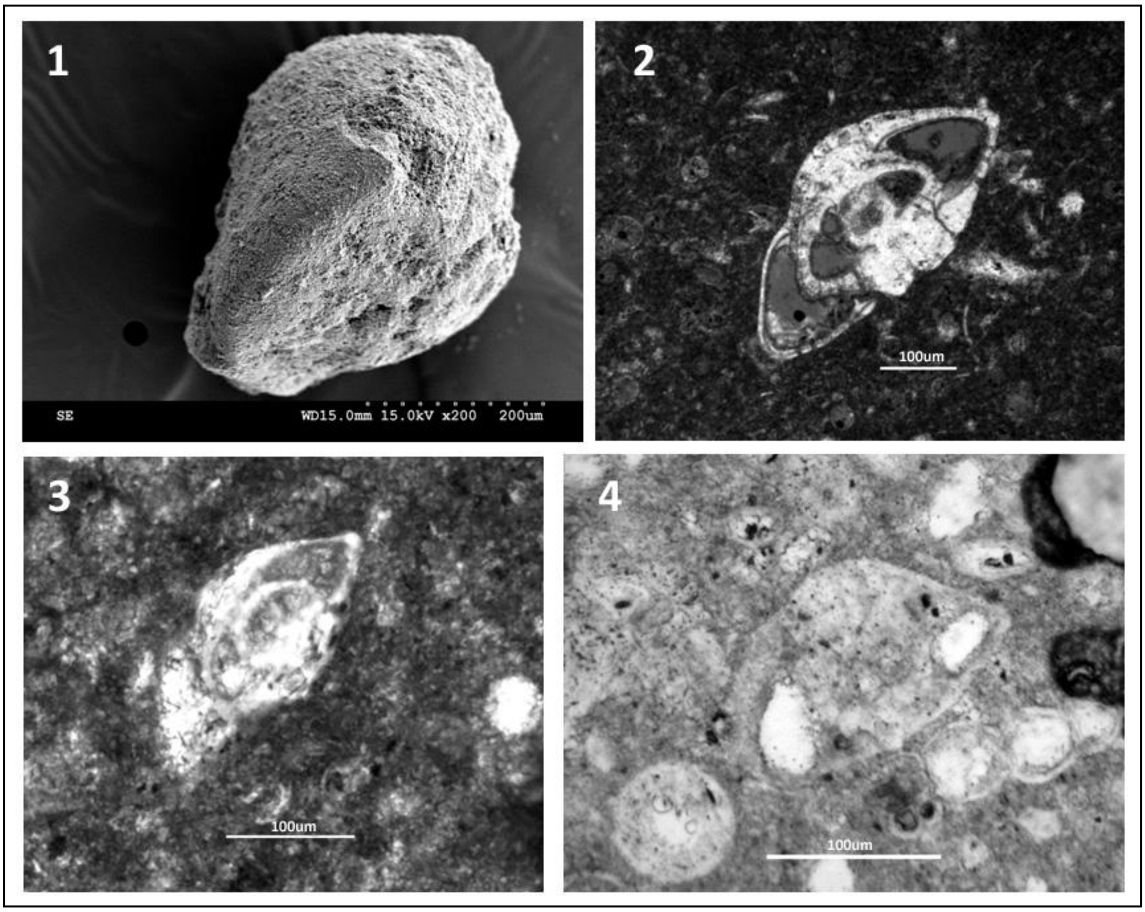


Figure 3.8. Images of the foraminifer *Gavelinella usakensis* identified in Campanian chalk samples taken from locations in the Isle of Wight, UK. *Gavelinella usakensis* is an index foraminifer for BGS FBZs 20-21i and chalk containing this microfossil can be dated biostratigraphically to the Campanian Stage of the Upper Cretaceous.

1: SEM image of *Gavelinella usakensis* obtained from a chalk tessera from Combley Roman Villa (IOW_CRV_A02_20); 2: thin section image of *G. usakensis* from chalk sampled at BGS point 6 on Figure 3.7 (ex MPA 57080); 3: thin section image of *G. usakensis* from chalk sampled at BGS point 7 on Figure 3.7 (ex MPA 57088); 4: thin section image of *G. usakensis* obtained from a chalk tessera from Newport Roman Villa (IOW_NRV_A08_26). Note that image 2 provides an excellent axial cross-section of the foraminifer, showing clearly the proloculus (initial chamber) in its centre.

Two further conclusions can be drawn. Firstly, it is interesting to note that the two villas sited to the north of the chalk ridge (Combley and Newport) and the one sited to the south of it (Brading) all appear to have utilised chalk from their nearest outcrops. Thus the chalk tesserae from Brading betray a Cenomanian age, whilst those from Combley and Newport reveal a (biostratigraphically much later) Campanian one. The chalk used therefore appears not only to have been local, but to have been *very* local.

Secondly, given the approximate contemporaneity of date for construction of the mosaics in all three villas (late third to early fourth centuries AD), the evidence does not support the view that the chalk used for tesserae by each of the three villas was obtained from a central source, as the geological age of the chalk used at Brading is different from that used at Combley and Newport. Rather, it implies that casual chalk quarrying connected with each villa was already in existence, perhaps for liming or building purposes, and was simply utilised *ad hoc* for the manufacture of tesserae.

3.5 Conclusions

Thin-section microfossil analysis of chalk tesserae from Brading, Combley and Newport Roman Villas in the Isle of Wight:

a) identifies a range of foraminifera and the calcareous algal cyst *Pithonella;*

b) provides a biostratigraphical age of BGS FBZs 4iii (Late Cenomanian) for the chalk tesserae from Brading Roman Villa;

c) provides a biostratigraphical age of BGS FBZ 20iii-21i (Mid to Late Campanian) for the chalk tesserae from Combley Roman Villa;

d) provides a biostratigraphical age of BGS FBZ 20i-ii (Mid Campanian) for the chalk tesserae from Newport Roman Villa.

In addition:

e) Comparison with local chalk samples taken by the BGS shows that chalk of these biostratigraphical ages is found close to the sites of the villas;

f) The parsimonious conclusion therefore is that local chalk was used to manufacture the tesserae from all three sites, the local source being the chalk ridge to the north (of Brading) or south (of Combley and Newport) Roman Villas.

This is a different conclusion from that reached for the Silchester tesserae, in which the chalk was shown to have been sourced remotely from Dorset;

g) The biostratigraphical evidence does not support the idea that chalk for the villa mosaics was being supplied from a single source, as the geological age of the chalk used at Brading and at Combley/Newport is different.

These conclusions further demonstrate that microfossils provide a powerful ‘forensic tool’ that can be applied to the identification of building material provenance in Roman Britain.

Chapter 4

Leicester

ABSTRACT

Fourth century AD chalk tesserae from Roman Leicester (*Ratae Corieltavorum)* yield rich microfossil assemblages that identify a biostratigraphical age in the Late Cenomanian to Early Turonian stages of the Upper Cretaceous. The nearest Chalk Group outcrops to Leicester lie in Hertfordshire, Lincolnshire, Yorkshire and north Norfolk, indicating that the material for the tesserae must have been sourced remotely and transported to *Ratae*. Superimposing the Roman road network onto a map of the relevant Chalk Group distribution provides a guide to possible sources. A process of evaluation identifies Baldock in Hertfordshire and Bridlington in Yorkshire as the most likely sources for the Leicester tesserae.

4.1 Introduction

In 2010, the opportunity arose to contribute to the post-excavation analysis of the first complete Town House to be uncovered in Leicester by examining chalk tesserae from several different excavation levels from the site. Leicester was considered to be a good location for investigation because there are no Chalk Group outcrops within about 90km of the town, which meant that any chalk artefacts recovered from excavation must have been transported. The town had had good road and river communications with the rest of the province and it was thought that this would enable some light to be shed on the movement of mosaic materials. The results of this analysis were eventually published (Tasker *et al.* 2013), and this chapter is a reorganised, condensed and updated version of the original paper published in *Britannia.*

4.2 Geological background

The underlying solid geology of the Roman town of *Ratae Corieltavorum* comprises the Triassic Mercian Mudstone Group sedimentary deposits, which to the east of the modern city are succeeded by younger Jurassic limestones and mudstones that form a series of rolling hills stretching towards the town of Peterborough in Cambridgeshire. Unlike at Brading on the Isle of Wight (Tasker *et al.* 2011) or at Roman Silchester (Wilkinson *et al.* 2008) there is no immediate source of rock from the Cretaceous Chalk Group in or around Leicester, nor are Chalk Group erratics reported from the Quaternary till deposits of Leicestershire. Small fragments of chalk do occur locally in the glacial till of the Oadby Member (Figure 4.1), but the taxa identified in them relate to the Coniacian to Santonian Stages (Wilkinson and Riding 2006) and the taxa identified in the Vine Street tesserae have an older biostratigraphical age, as will be shown (see section 4.4.5, below). Figure 4.1 also shows that the chalk fragments themselves are almost certainly too small and too few to have been used systematically as a source for tesserae. These two factors strongly suggest that the chalk used to manufacture the Vine Street mosaics had a remote source.

Figure 4.1. Till of the Oadby Member (Quaternary) at outcrop, showing entrained chalk fragments. Picture courtesy of Mr Keith Ambrose, British Geological Survey.

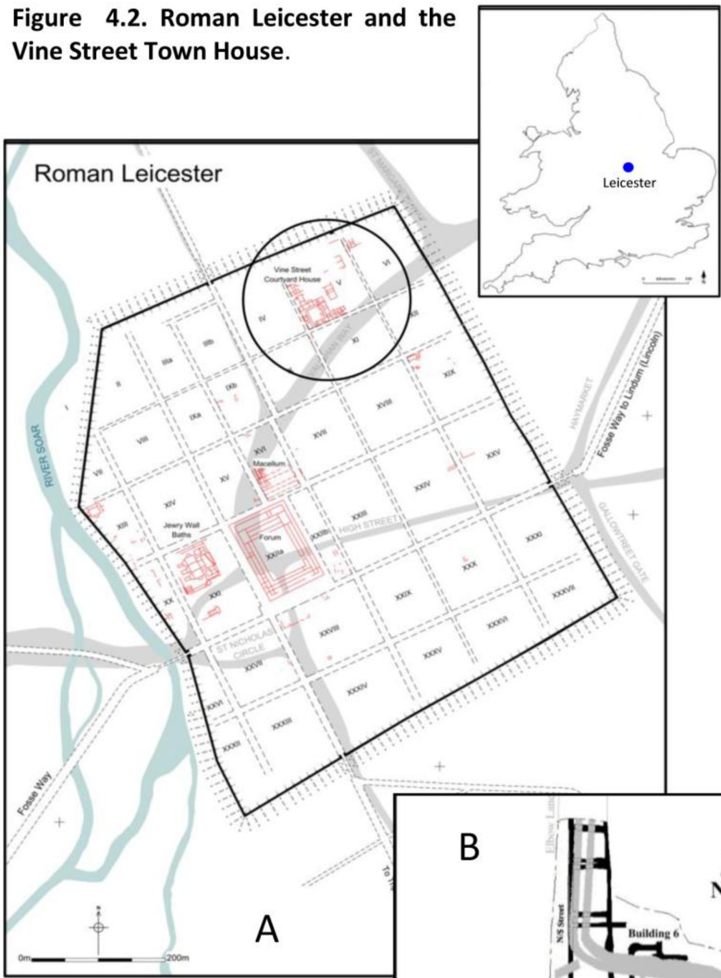
The Chalk Group outcrops nearest to Leicester are found in the Hertfordshire Chilterns, about 95km to the south east; in the Lincolnshire Wolds, about 110km to the north east; in north Norfolk, some 120km almost due east; and on the West Berkshire Downs, around 140km to the south. Although proximity does not necessarily equate with accessibility, it makes sense to focus on these areas as possible chalk sources, after examining the archaeological background to the tesserae.

4.3 Archaeological background

Leicester (*Ratae Corieltavorum*) is sited at a crossing point of the River Soar and this geographical advantage is likely to have contributed to its early development as an important Late Iron Age settlement. By the end of the first century BC, the community was prosperous enough to be importing pottery from Gaul and the Mediterranean (Liddle 1982, 26; Clay 2001, 11, 14 and Figure 7). The settlement appears to have been a local centre for the Corieltavi, whose coins are found here, most recently amongst a series of hoards found in a shrine context some 15km to the south east at Hallaton (Score 2006; Hargrave 2009). It is possible that the strategic importance of the settlement and its river crossing point made Leicester an early military objective for the invading Roman army, as a small Roman fort appears to have been established on the west bank of the river to control the crossing (Clay and Pollard 1994, 46), and one explanation for the series of Corieltavian coin hoards found in Yorkshire may be that these were taken there by refugees from the Roman advance (Mattingly 2006, 140-1).

Figure 4.2(A) shows the location of Leicester in the UK and the town plan of *Ratae*. The gridded town plan was laid out early in the second century AD, probably coincident with the town becoming a *civitas* capital, and several phases of civic building followed: a stone forum and basilica were built under Hadrian (117-138 AD), the Jewry Wall public baths under Antoninus Pius (138-161 AD) and the market hall or *macellum* towards the end of the second century (Cooper 2006, 147; Higgins *et al*. 2009, 3). Mosaics dating from the second to the fourth century AD, some of very high quality, have been recorded, the greatest density being found in the west of the town (Johnson 1980) from houses overlooking the river. This may indicate that the western half of the town was more prosperous than the east (Connor and Buckley 1999, 57).

Figure 4.2. Roman Leicester and the Vine Street Town House.



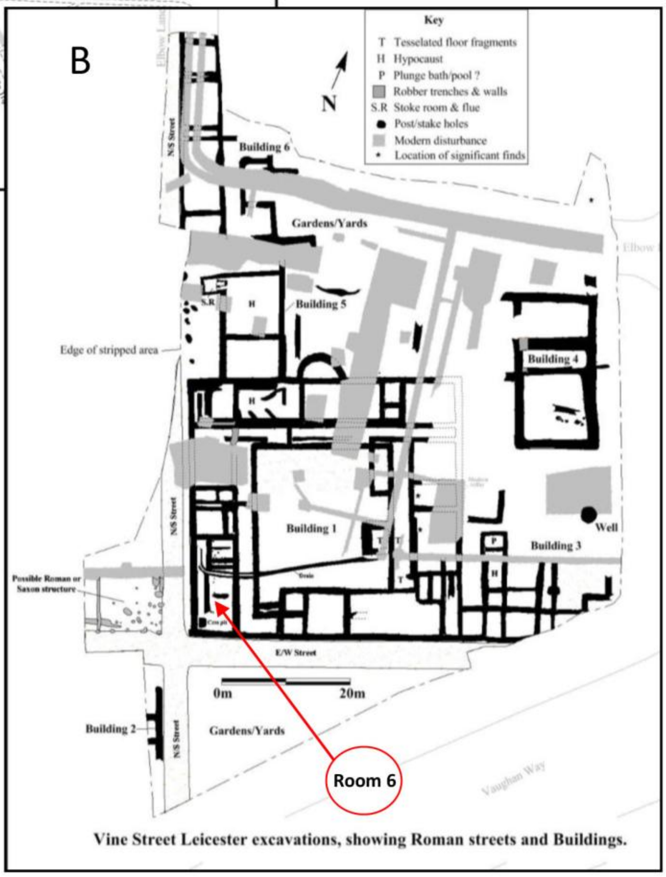


Figure 4.2.

A: Plan of Roman Leicester showing position of the Vine Street Town House (inset: UK location map for Leicester); B: Plan of the Vine Street Town House, showing location of Room 6. Both plans courtesy of ULAS

In 2004-6, the University of Leicester Archaeological Services (ULAS) carried out the largest excavation ever undertaken in Leicester as part of the new Highcross retail development (Higgins *et al.* 2009). Ten Roman buildings, dating from the late first to the late fourth centuries AD, were excavated in one of the peripheral *insulae* in the north-east corner of the settlement. Tesserae and decorated wall plaster containing cinnabar was found among debris associated with one of the second century buildings, so it is possible that this building may have been the source of the second-century geometric mosaic found in 1839 (Johnson 1980, 2-4 and Plate 3; Neal and Cosh 2002, 95-6; Higgins *et al. op. cit*., 7 and Figure 5, 65-6) and which is now housed in the Jewry Wall Museum in Leicester. Renewed construction at the beginning of the third century AD led to the above building and two others on the same site being remodelled into a single structure by the addition of a north range. The new north range was partially provided with a hypocaust system and contained a central apsidal room, suggestive of a formal reception room, which was set opposite a possible entrance hall in the southern range across the courtyard. This remodelling created a substantial courtyard-style town house some 39m x 40m square (the Vine Street Town House). A plan of the Town House is shown in Figure 4.2(B) and an artist's reconstruction in Figure 4.3.

4.3.1 *The Vine Street Town House*

The Vine Street Town House occupied the south-east corner of the *insula*, which provided the building with two road frontages. Successive resurfacing of its floors indicates that it was occupied continuously for around 150 years until its abandonment as a dwelling in the mid-fourth century AD. There is no evidence of sumptuous decoration, but fragments of coarse mosaic flooring were found *in situ* in the peristyle corridor of the eastern range. These are contextually dated to the early fourth century AD. Enough tessellation remains to show that the simple design consisted of red tile tesserae set into a background of blue-grey sandstone ones, either in multiple stripes or in a grid pattern. The red-on-blue grid pattern is similar to other geometric mosaics found in Leicester dating to the same period, such as those found at the Norfolk Street (Cherry Orchard) Villa, sited about 1km outside the Roman town on the west bank of

Figure 4.3. Reconstructed drawing of the Vine Street Town House, Leicester. Image provided by ULAS (Credit: Mike Codd).

the river (Neal and Cosh 2002, 110-115), and the design is similar to other fourth-century mosaics found at Tixover and Thistleton Dyer in Rutland (*ibid*., 123-5, 126-7), although in these villas the red grid is laid on a buff background. Enough quantities of residual blue-grey and red tesserae were recovered from elsewhere in the Town House to suggest that the north range suite of rooms and its associated corridor may have been similarly tessellated, although a Small Find (SF) of intact mosaic, consisting of several rows of smaller tesserae (SF 1084, discussed below) indicates that the building may have housed a finer quality mosaic in at least one room. Unfortunately the north range appears to have been deliberately demolished in the mid-fourth century AD, thereby removing any evidence for mosaics from the rooms most likely to have housed them. The Town House also appears to have been abandoned as a private dwelling around this time. There is evidence that some rooms continued to be used as workshops for a short time longer, but the building seems to have become derelict by the end of the fourth century (Higgins *op. cit.*).

4.3.2 *The Vine Street Town House tesserae*

The tesserae examined in this study came from four levels of redeposited and unsorted material found in Room 6 in the far south-western corner of the Town House (Room 6 is marked in red on Figure 4.2(B); in Figure 4.3, it lies on the extreme left of the image). The four levels were categorised as Vine Street A, B, C and D respectively.

As the tesserae represent redeposited material, it is not possible to know with certainty either when or where the mosaics from which they were salvaged were laid. However, it is possible to make some assumptions. The simple tessellated design of the surviving peristyle mosaic appeared to use only blue-grey and red tesserae, so the white chalk tesserae analysed in this study probably came from elsewhere in the Town House. Also, the tesserae examined included some finer material, the thin triangular tesserae of the Vine Street A and C material in particular suggesting detailed tessellation; these may therefore have been laid originally in one of the principal rooms in the north range and were salvaged for re-use when this was demolished in the mid-fourth century. If this was the case, the cemented tesserae of the Vine Street D Small Find may be a fragment of a mosaic that was laid originally in one of the formal rooms.

Unfortunately, it was not possible to ascertain from the archaeological evidence a precise date at which any such finer-quality mosaics might have been laid. The north range was demolished in the mid-fourth century and post-Roman truncation removed levels to below that of the Roman floor. However, the date can be modestly constrained by recognising that any mosaics laid at the time of the construction of the north range would date to the early third century AD, whilst any contemporaneous with the tessellation of the peristyle corridor would date to the early fourth. Arguments for the later date might include the reasonable assumption that the tessellation in the north range and its associated corridors was laid at the same time, and that the tesserae found in Room 6 had been carefully salvaged and collected; any mosaics in the north range laid in the early fourth century would not have been in place for longer than about 20 or 30 years before the range was demolished and the material might therefore have been thought particularly worth saving.

4.4 Palaeontological analysis

Thirty-six tesserae, sampled from four levels of the Vine Street excavation (Vine Street A, B, C and D) were either processed using the white spirit method (Appendix B, Figure B1) or thin sectioned. A table is given below (Figure 4.4). The results obtained are discussed in sections 4.4.1 to 4.4.4 and the results summarised in Section 4.4.5.

Level name	Archaeological context	Number of tesserae			Total
		Unprocessed	Processed	Thin sectioned	
Vine Street A	A24.2003.5751.740	2	13	2	17
Vine Street B	A24.2003.5886	1	4	1	6
Vine Street C	A24.2003.5266.626	-	6	1	7
Vine Street D	A24.2003.5265.1084	-	-	6	6
TOTAL		3	23	10	36

Figure 4.4. Number of tesserae examined from each of the Vine Street Town House levels. All the tesserae were provided by ULAS. The archaeological context numbers are provided for reference.

4.4.1 *Vine Street A*

There was considerable variation in size among the Vine Street tesserae. The greatest variation occurred in the Vine Street Level A tesserae, in which some of the small triangular and rectangular tesserae were only approximately 4.0 x 10mm, whilst the largest were approximately 25 x 30mm. The Vine Street A tesserae were also generally softer than those obtained from any of the other three levels, so two of them (LE_VS_A09 and A10) were experimentally crushed and examined without being processed in order to see ascertain whether microfossils could be extracted in this way. However, this technique was not successful and so thirteen further tesserae (LE_VS_A01 to A06, and A11 to A17) were processed using the white spirit method and an additional two (LE_VS_A07 and 08) were thin sectioned. The foraminifera identified in sample and thin section are listed in Table 4.1 in Appendix A and plotted on a foraminiferal range chart in Figure 4.5. Selected images are shown in Figure 4.6.

Four of the Vine Street A tesserae were barren and several of the species identified were long ranging. However, Figure 4.5 shows that the identification of both *Helvetoglobotruncana helvetica* and *Lingulogavelinella globosa* suggests that the fauna can be dated biostratigraphically to the Late Cenomanian or Early Turonian (BGS FBZs 8-9) (Figure 4.6: 8, 5). This conclusion is supported by the low numbers of benthonic specimens identified, as the fauna in the UK is known to have been dominated by planktonic taxa in the Early Turonian (Hart *et al*. 1989, 310); the frequent identification in the thin sections of the algal sphere *Pithonella sphaerica*, whose numbers are known to have to reached flood proportions in the Late Cenomanian-Early Turonian (Figure 3.4) (Wilkinson 2011b); and the tentative identifications of the species *Dicarinella canaliculata* and *Marginotruncana marginata,* which do not appear in the chalk stratigraphic record until BGS FBZ 8 (Wilkinson 2011a).

4.4.2 *Vine Street B*

The Vine Street Level B tesserae had been re-used to provide the substrate for a new floor in Room 6 during a major phase of resurfacing in the early to mid fourth century AD. They were largely square, with sides typically 15-20mm in length. Although chalky in outward appearance, they broke into hard and splintery grey fragments when crushed and also released a very strong smell of bitumen. However, the fragments reacted positively ('fizzed') when tested with cold dilute hydrochloric acid, the standard test for the presence of chalk or limestone (*i.e*. calcium carbonate) in the field (the action of acid on carbonate releases water and carbon dioxide gas, resulting in a 'fizz' of foam on the rock surface). These tesserae were therefore identified as a calcareous mudstone. Processing five of them (LE_VS_B01 to 05) recovered a very few microfossils that could not be positively identified. A thin section (LE_VS_B06) was similarly uninformative. Details of the tesserae (LE_VS_B01 to 06) appear as Table 4.2 in Appendix A, but as the material was not a chalk and no foraminifera were identified by analysis or revealed in thin section, this material was not considered further.

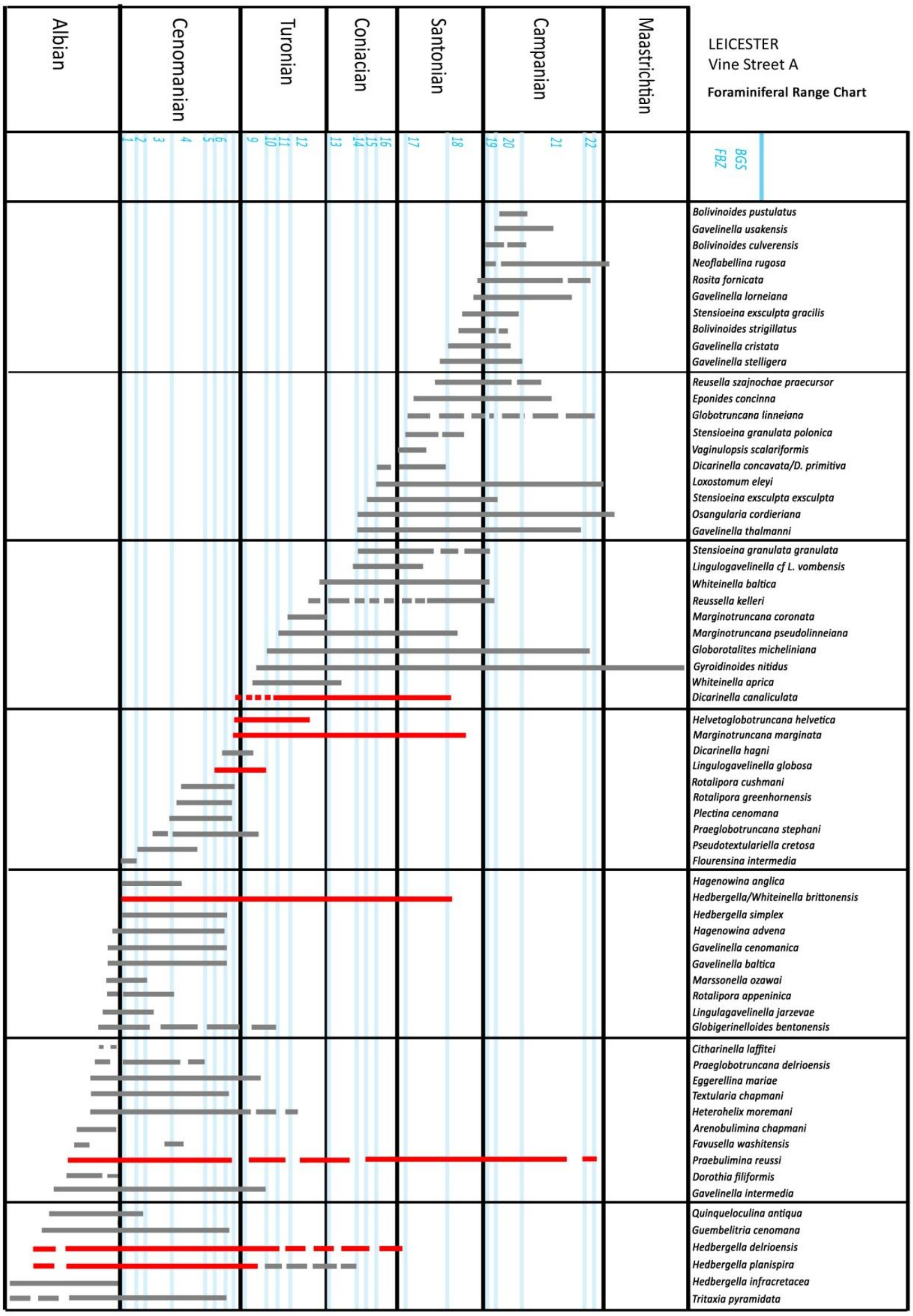


Figure 4.5. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from Level A in the Vine Street Town House, Leicester, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

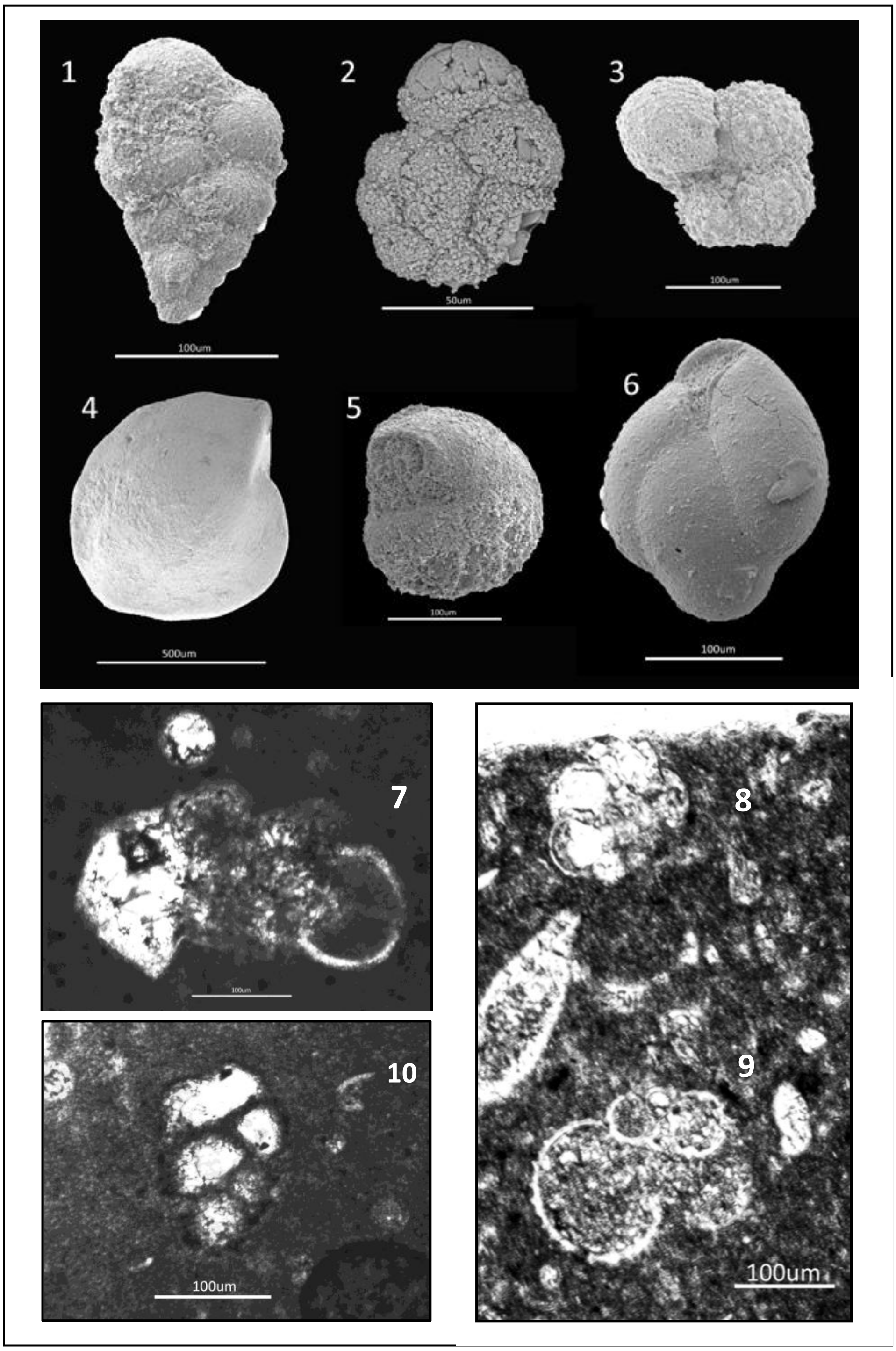


Figure 4.6. Selected specimens (1-6) and thin section images (7-10) of foraminifera identified in chalk tesserae from Level A in the Vine Street Town House, Leicester, UK. 1: *Heterohelix reussi* (LE_VS_A02_01); 2: *Hedbergella planispira* (LE_VS_A04_01); 3: *Whiteinella baltica* (LE_VS_A02_02); 4: *Lenticulina rotula* (LE_VS_A01_01); 5: *Lingulogavelinella globosa* (LE_VS_A05_02); 6: *Praebulimina reussi* (LE_VS_A01_03); 7: ?*Marginotruncana marginata* (LE_VS_A07_27); 8: *Helvetoglobotruncana helvetica* and 9: *Hedbergella brittonensis* (both LE_VS_A08_01); 10*: Arenobulimina preslii* (LE_VS_A07_05). All scalebars are 100um except for *Hedbergella planispira* (no. 2) which is 50um.

4.4.3 *Vine Street C*

The Vine Street C tesserae also varied in size. The surface area of the largest was 17 x 17mm, but that of about half of the remaining samples was closer to 10 x 10mm. Two of the tesserae were thin and triangular, and a further two were either rounded or shaped like a half-cylinder, suggesting that they may have been used for fine tessellation. Six of the tesserae (LE_VS_C01 to 06) were processed using the white spirit method, during which five (LE_VS_C01 and C03 to 05), although superficially chalky due to a surface covering of lime mortar, were discovered to be a dark blue-grey limestone; these splintered on processing and no foraminifera were recovered either from them or from their mortar.

The remaining tessera (LE_VS_C02) was soft, creamy-white chalk from which several foraminifera were recovered. Unfortunately the foraminifera were poor in quality and few could be identified with certainty, except for two specimens of the benthonic foraminifer *Gavelinella intermedia* and one of a possible *G. berthelini.* However, a thin section cut from a second, harder chalk tessera (LE_VS_C07) did reveal a number of microfossils. The species identified in the Vine Street C material are listed in Table 4.3 in Appendix A and plotted on a foraminiferal range chart in Figure 4.7. Selected images are shown in Figure 4.8.

Many of the foraminifera identified in the thin section were non-keeled and long ranging planktonic species, such as *Hedbergella delrioensis*, *H. brittonensis* and *Heterohelix reussi.* However, a number of keeled planktonic species were also identified; these included the index species *Dicarinella hagni*, whose biostratigraphic range is limited to BGS FBZs 6-9, and also the species *Marginotruncana marginata* and *Dicarinella canaliculata*, which do not appear in the stratigraphic record until BGS FBZ 8 (Wilkinson 2011a). The thin section also revealed the algal sphere *Pithonella sphaerica* in flood proportions (Figure 4.8, no. 2). As mentioned previously (above and in section 3.3.1), pithonellid blooms are characteristic of several stages in the Late Cretaceous, the earliest of which occurs in the Late Cenomanian-Early Turonian (Wilkinson 2011b).

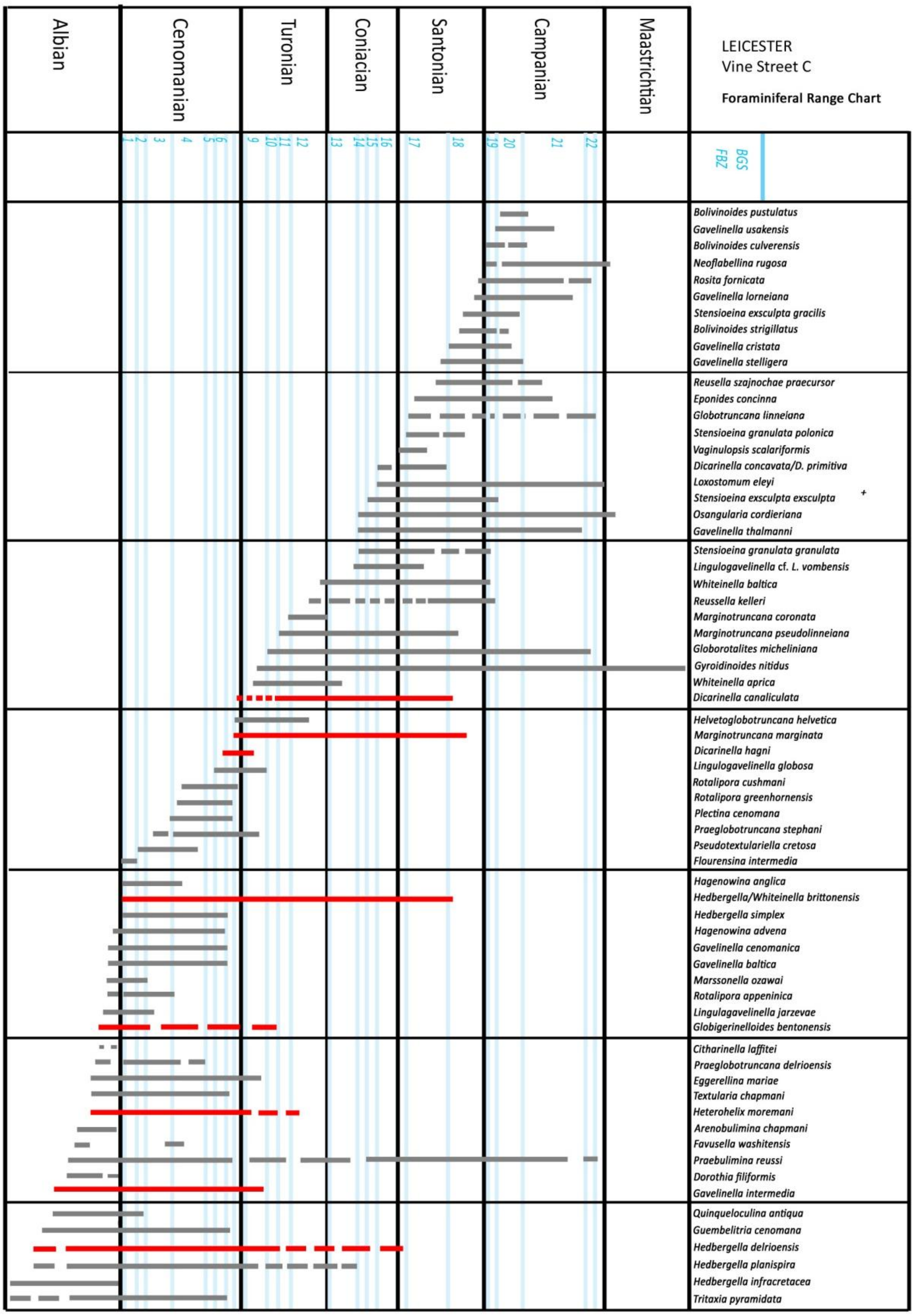


Figure 4.7. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from Level C in the Vine Street Town House, Leicester, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

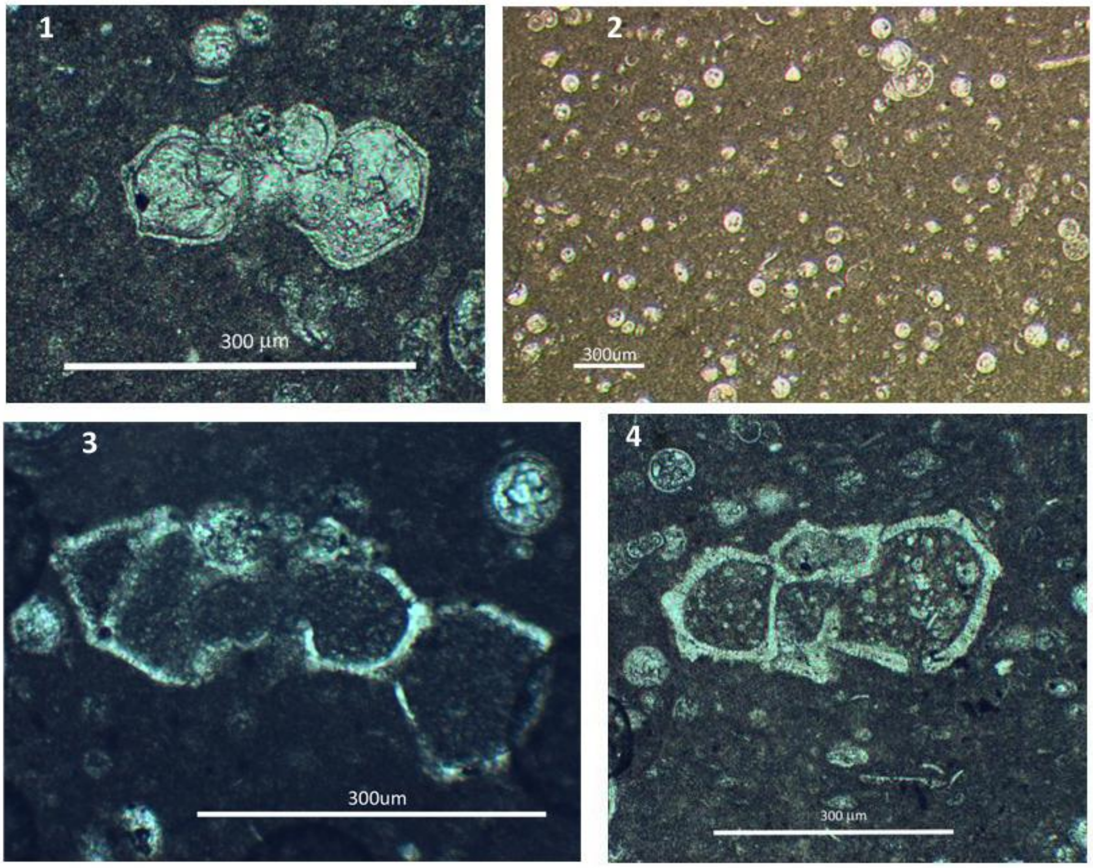


Figure 4.8. Thin section images of foraminifera (1, 3-4) and algal spheres (2) identified in chalk tesserae from Level C in the Vine Street Town House, Leicester, UK. 1: *Dicarinella hagni* (MPK 14370 ex MPA 62491); 2: *Pithonella sphaerica* in flood proportions (LE_VS_C07a_04); 3: *Marginotruncana marginata* (LE_VS_C07b_16); 4: *Dicarinella canaliculata* (MPK 14372 ex MPA 62491). All scalebars are 300um.

The pithonellid and planktonic foraminiferal evidence combined therefore suggest that the chalk from which the Vine Street C tesserae were cut dates to the late Cenomanian or Early Turonian (BGS FBZ 8-9). This is supported by evidence from the few benthonic foraminifera recovered, which include, as stated above, a possible specimen of the benthonic foraminifer *Gavelinella* sp. cf. *berthelini*, which is found particularly in the Cenomanian and Turonian stages of the Upper Cretaceous (Paul *et al*. 1990, 92).

4.4.4. *Vine Street D*

The Vine Street Level D tesserae were sampled from Small Find (SF) 1084. This was a mosaic fragment that had been picked off the floor of Room 6. It consisted of three rows of small white chalk tesserae and one row of small dark blue-grey limestone tesserae, all typically having sides of 10-13mm. It is noticeable that white chalk and blue limestone are the same two lithologies as those found in the Vine Street C material (discussed above), which suggests that SF 1084 might have been salvaged from the same mosaic.

Five tesserae of white chalk (LE_VS_D01 to 06) and one of blue limestone (LE_VS_D07) were removed from SF1084 for thin sectioning. Only bivalve fragments were seen in the limestone sample and so this was not considered further. The foraminifera identified in the thin sections (LE_VS_D02 to D06) are listed in Table 4.3 in Appendix A and plotted on a foraminiferal range chart in Figure 4.9. Selected images of these are shown in Figure 4.10. The species included keeled and unkeeled planktonic foraminifera and variable numbers (rare to flood proportions) of the algal sphere *Pithonella sphaerica*. The unkeeled foraminifera were all long-ranging species, but the keeled ones included the index species *Marginotruncana marginata,* which first appears at the base of BGS FBZ 8. The range of this species, together with that of *Heterohelix moremani*, constrains the biostratigraphic age of this particular tessera (LE_VS_D01) to the Late Cenomanian to Mid Turonian (BGS FBZs 8-12).

However, a date in the Early Turonian for this material seems more likely, because of the possible identification of the index foraminifer *Dicarinella hagni* in one of the Vine Street D thin sections (LE_VS_D02) and the almost total absence of benthonic foraminifera in all of them. *D. hagni* last appears in the chalk succession in BGS FBZ 9, so if its identification is correct, the biostratigraphical age of the Vine Street D chalk tesserae would be constrained to BGS FBZs 8-9, rather than to BGS FBZs 8-12. This would accord well with the absence of benthonic species in the thin sections, as the Early Turonian is known to be dominated by planktonic taxa at this time (Hart *et al*. 1989, 310). A date in the Early Turonian is also supported by the occurrence of the algal sphere *Pithonella sphaerica*, which is found in abundance at this time; this was found rarely in one thin section (LE_VS_D02), but occurred commonly or in flood proportions in two others (LE_VS_D04 and D03) (Wilkinson 2011b).

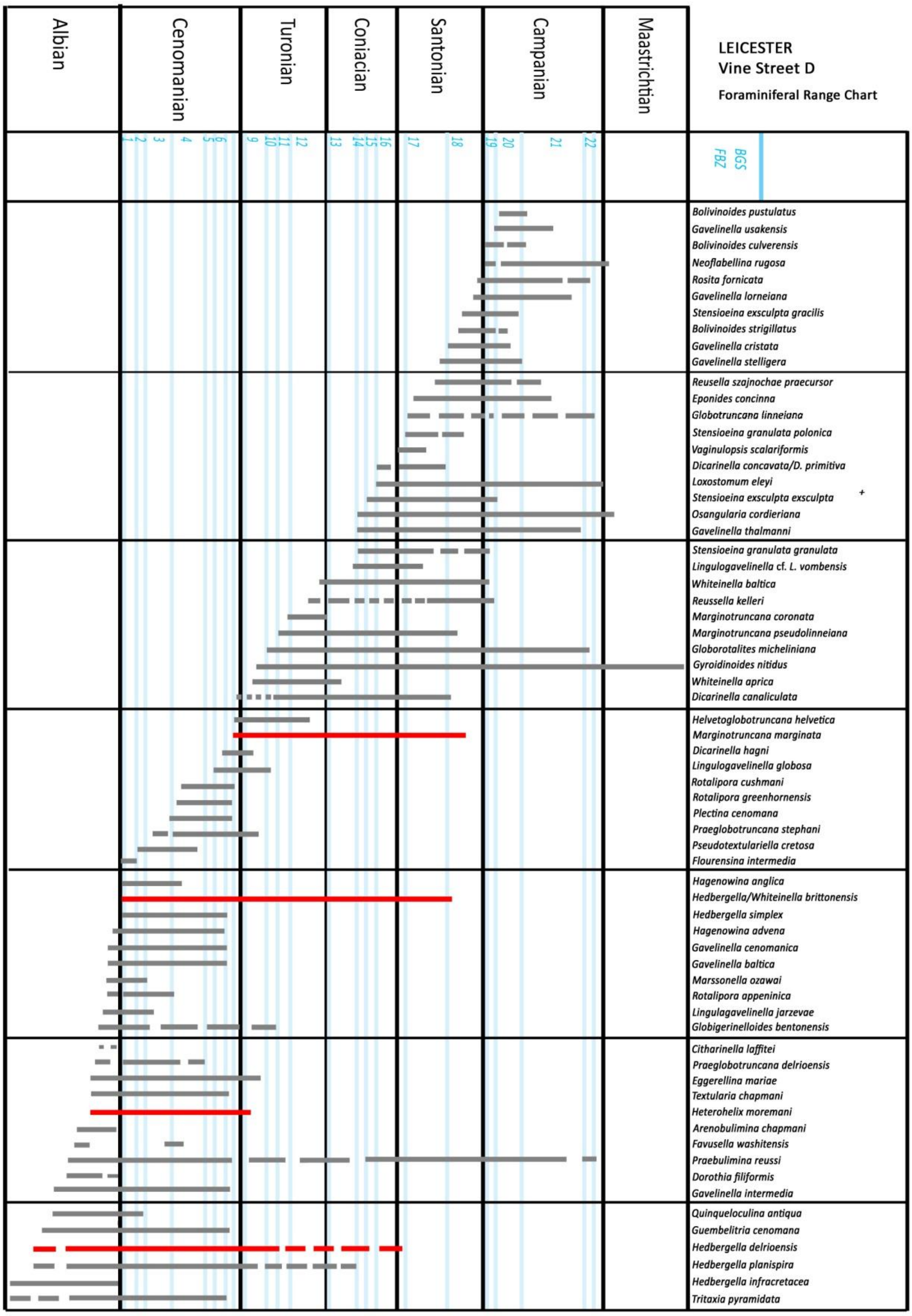


Figure 4.9. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae recovered from Small Find 1084 (Vine Street Level D) in the Vine Street Town House, Leicester, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

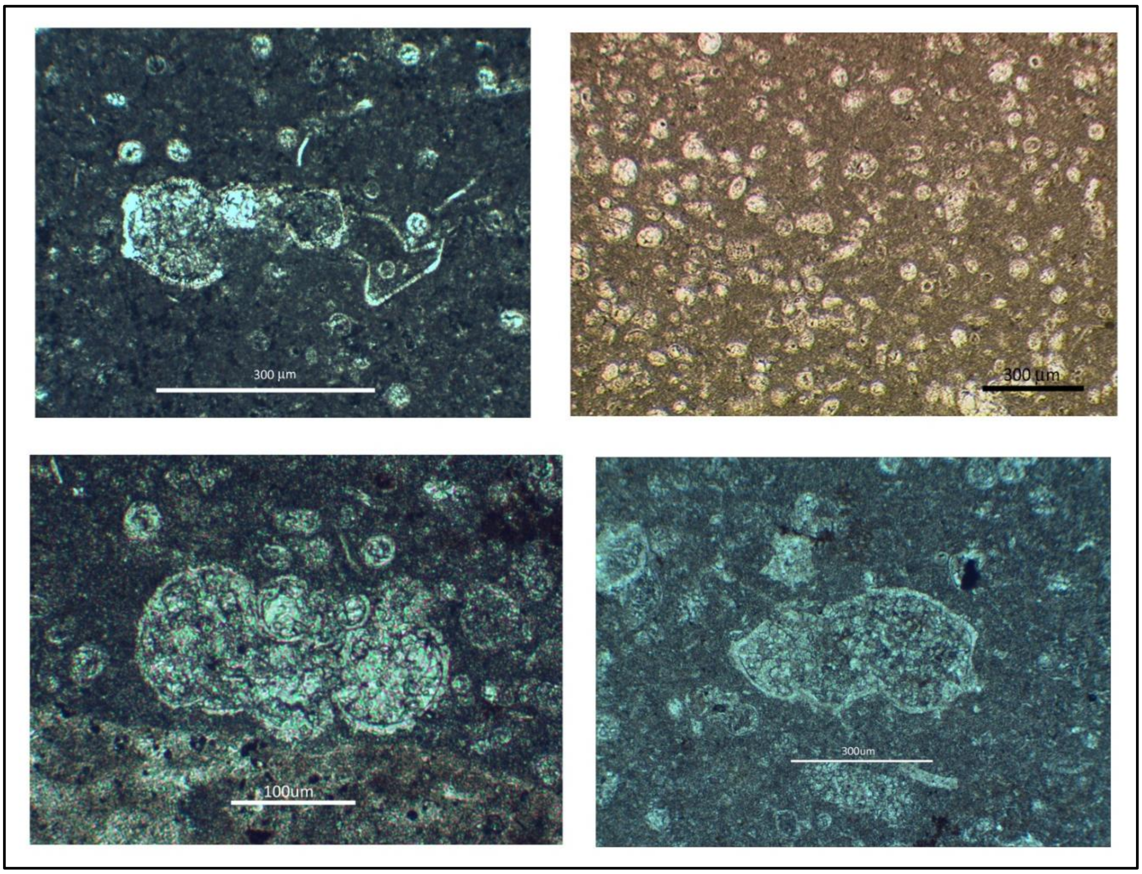


Figure 4.10. Thin section images of foraminifera (1, 3-4) and algal spheres (2) identified in chalk tesserae from Small Find 1084 (Vine Street Level D) from the Vine Street Town House, Leicester, UK. 1: *Marginotruncana marginata* (MPK 14373 ex MPA 62492); 2: *Pithonella sphaerica* in flood proportions (MPK 14371 ex MPA 64294); 3: *Hedbergella delrioensis* (LE_VS_D01_14); 4: *?Dicarinella hagni* (LE_VS_D02_01). All scalebars are 300um except for image no. 3. Note that the majority of specimens in image no. 2 are *Pithonella sphaerica,* but that *P. ovalis* also occurs in small numbers.

4.4.5 *Summary of section 4.4*

The palaeontological analyses described above show that all Vine Street Town House tesserae were provenanced from chalks with a biostratigraphical age in the Late Cenomanian or Early Turonian (BGS FBZs 8-9). The inclusion of additional data (pithonellid evidence and the preponderance of planktonic taxa) supports this date. Figure 3.4 shows that chalk of this biostratigraphical age has its lithostratigraphical equivalent in the Holywell Nodular Chalk Formation in the south of England, and in the Welton Chalk Formation in the north.

4.5 Discussion

It is important to note that Chalk Group outcrops relating to a particular formation need not necessarily be extensive. The actual width of the outcrop depends on the dip of the chalk strata. It can be seen from Figure 4.11, for example, that a quarry based on the Holywell Nodular Chalk Formation could easily have supplied chalk from all of the biozones found within it. This means that it would not have been difficult for the chalk for all the Vine Street tesserae (Levels A, C and D) to have been supplied from a single quarry.

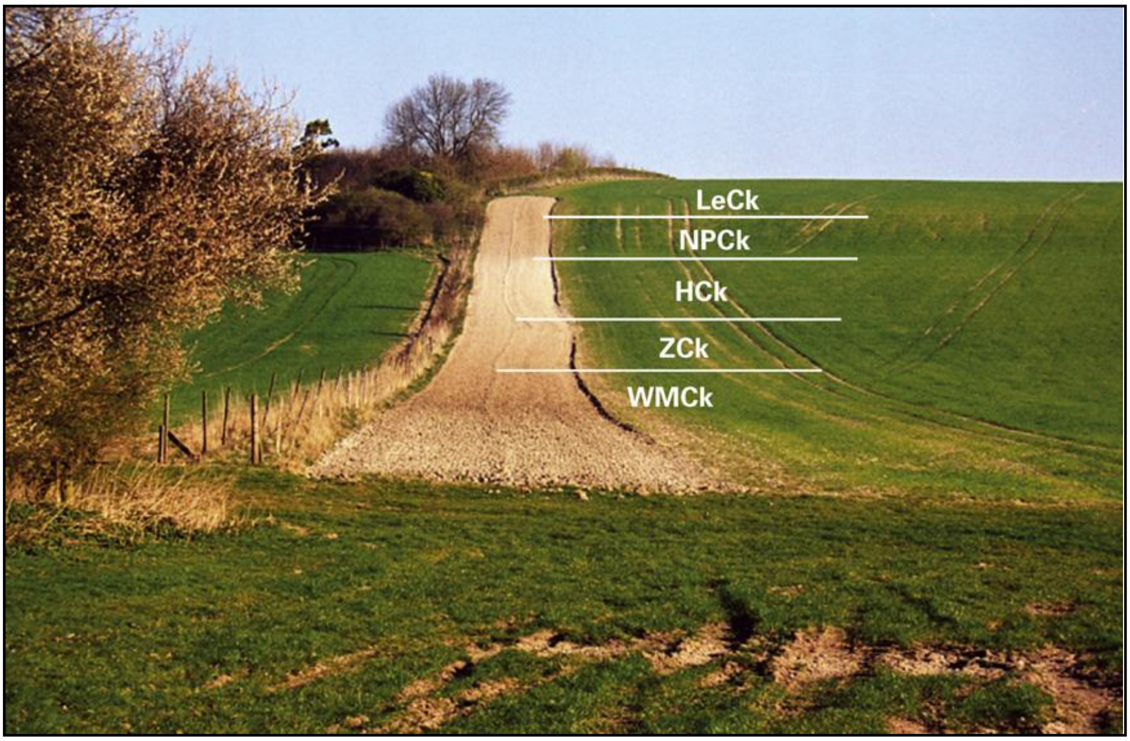


Figure 4.11. Chalk outcrops in farmland, about 5km south of Hungerford, West Berkshire. After Aldiss *et al*. 2012, 735 Figure 5. The Chalk is dipping away from the camera, causing the width of the outcrops to be reduced. It can be seen from this photograph that the exposure of the Holywell Nodular Chalk Formation would not be extensive in this location. Key: WMCk = West Melbury Marly Chalk Formation; ZCk = ZigZag Chalk Formation; HCk = Holywell Nodular Chalk Formation; NPCk= New Pit Chalk Formation; LeCK = Lewes Nodular Chalk Formation.

The above finding (of a likely biostratigraphical age in the Late Cenomanian or Early Turonian for all the Vine Street chalk tesserae) is a good result for the microfossil approach. However, superimposing the approximate position of the relevant biozones onto a map of the Chalk Group (Figure 4.12) shows that although the relevant chalk outcrops may be well constrained geologically, they are not particularly well constrained geographically. The nearest Late Cenomanian and Early Turonian chalk outcrops to Leicester are found at some considerable distance from the town: in the Lincolnshire Wolds, about 110km to the north-east; in north Norfolk, some 120km almost due east; in the Hertfordshire Chilterns, about 95km to the south-east; and on the West Berkshire Downs, around 140km to the south. Other chalk outcrops of the same age are also widely found along the south coast of England, for example at Beer (south-east Devon), around Seaford Head (Sussex) and at Dover and Folkestone (Kent). These last locations are obviously at greater distances from Leicester (>300km), but as we have seen already, transport over such distances is not impossible.

From a geographical perspective, therefore, the potential source areas for the Vine Street chalk tesserae are widely spread. However, although it is clear from the mass of archaeological reports, watching-briefs, field-walking surveys and Historic Environment Records (HERs) comprising the grey literature of Romano-British archaeology that the casual digging of pits for the local extraction of chalk around settlements was a common practice, there are places in which the archaeological evidence appears to show that the extraction of chalk was deliberate and systematic and on a large enough scale to suggest that actual quarrying was taking place. We need to see, therefore, whether we can use archaeological data to narrow down the geographical possibilities.

The following section therefore combines archaeological and geological data to evaluate the relative likelihood of any of the geographical areas covered by the relevant Chalk Group outcrops being a provenance for the chalk used to construct the Vine Street Town House mosaic floors.

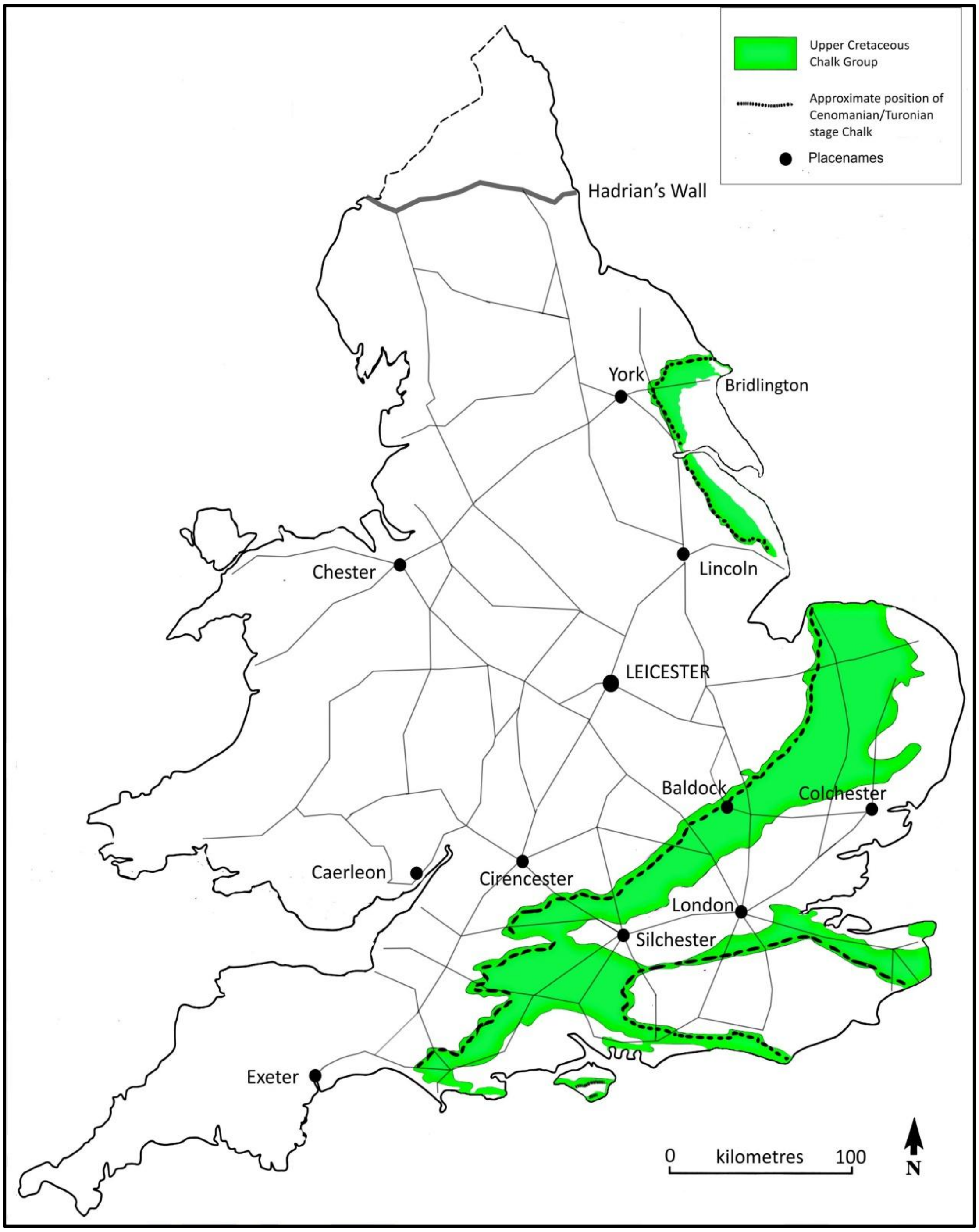


Figure 4.12. Sketch map of England and Wales, showing the distribution of the Upper Cretaceous Chalk Group (in green), the approximate position of Late Cenomanian-Early Turonian (BGS FBZ 8-9) chalk outcrops (black dotted line), the Roman road scheme and the main towns mentioned in the text (modern placenames). Cretaceous Chalk data taken from Geological Conservation Review volume 12 (1997) *Karst and Caves of Great Britain*, Chapter 7 and Figure 1. Geological Map Data© NERC 2011. The Roman road data are based on the Ordnance Survey map of *Roman Britain* 5th edition (2001).

4.6 Possible chalk sources for the Vine Street tesserae

4.6.1. *Norfolk*

Chalk Group rocks form the bedrock of much of north and central Norfolk, but their exposure is limited due to a much later deposition of Pleistocene sediments. However, Cenomanian and Turonian stage chalks are exposed in a long narrow ribbon running broadly inland north-south from the coast at Hunstanton along the East Anglian Heights (the chalk ridge separating the flat Fens to the west from the flat Broads to the east). The section most easily accessed through the Roman road network is found around Swaffham and Thetford.

There is small concentration of villas about 12-15km to the north-west of Swaffham, but the plain mosaics found in them appear to date to the second century AD, suggesting the buildings were early foundations. If the villas were still occupied in the fourth century, they do not seem to have installed any mosaics dating to this period (Cosh and Neal 2005, 211-219). Cosh and Neal note that no fine mosaics of any period have yet come to light in Norfolk and that plain red tessellated pavements are the norm, even in villas where excavation has revealed the presence of bath-houses and painted plaster (*ibid.* 213). Indeed, with the exception of the large cluster found in Colchester and its environs, the authors record very few mosaics from East Anglia as a whole.

This surprising absence of display of wealth in an area of generally rich farmland has been interpreted by Jones and Mattingly (1990, 224) as evidence for retarded development among the Icenian elite as a long-term legacy of the Boudican revolt, and also possibly for the establishment of large imperial estates on confiscated land. The number of hoards of silver and gold coin and plate dating from the first to the fifth centuries found throughout Norfolk show that local wealth did exist (Abdy 2002, 67-9), but perhaps its owners preferred to keep it portable rather than to translate it into something more permanent. It is possible therefore that tessellation was regarded locally as more a functional than a decorative practice; and although this may, and probably did, involve the utilisation of local chalks, it does not suggest that these were exploited on a large enough scale or for a long enough period to have acted as a source of tesserae for Leicester, some 120km distant.

4.6.2. *The Chiltern Escarpment*

Chalk with a biostratigraphical age in the Late Cenomanian and Early Turonian has its lithostratigraphical equivalent, in the south of England, in the Holywell Nodular Chalk Formation (Hopson 2005, 18-22). Exposures of this Chalk Group formation are found along the northern edge of the Chiltern escarpment from Cambridgeshire to Wiltshire. Although outcrops are nowhere large in scale and are occasionally very patchy, nevertheless the geographical area under consideration is extensive.

Here it is instructive to consider the Roman road network shown in Figure 4.12. The routes south from Leicester cross the Holywell Nodular Chalk Formation in three places: in Hertfordshire, at Royston and Baldock (near to Stevenage); in Bedfordshire, around Dunstable; and on the Berkshire Downs, in the vicinity of Lambourn. It seems sensible therefore to look in these areas for evidence of the quarrying of chalk that could have been used to manufacture the Vine Street tesserae.

4.6.2.1. Local use of chalk in the Chiltern escarpment

It is known that chalk from the Chiltern escarpment was utilised in Roman times. The second-century villa at Totternhoe in Bedfordshire utilised dressed blocks of Totternhoe Stone, the local 'clunch' (hard building stone), in the construction of foundations and hypocausts (Matthews *et al*. 1992, 46, 48-9, 53), and a block of the same stone was found paving Watling Street under the Edgware Road in London (Wood 1902, 239; Coddrington 1903, 68). Chalk blocks were also used in the construction of two early villas at Alfred's Castle (Gosden and Lock 2003, 73) and nearby Maddle Farm (NMR 1029200), both sited on the Berkshire Downs close to Lambourn. There is also evidence of chalk quarrying in the escarpment. Chalk quarries or pits dating to the Roman period have been identified at Barrington, about 16km south west of Cambridge (Collins and Knight 2007); at a site close to Todd's Green, about 3km west of the A1(M) at Stevenage in Hertfordshire (Hertfordshire Heritage Environment Record (HHER) 11534); at Datchworth, also in Hertfordshire, a few kilometres south of Stevenage (HHER 1898); about 10km south-west of Avebury in Wiltshire (Small 1999, 21-2); and possibly also at *Verulamium* (modern St Albans), both to the north (HHER 14329) and south (HHER 6205) of the Roman town.

All of the above quarrying sites are within reach of Leicester on the Roman road system, but none of them appears to have been the source of the chalk used for the Leicester tesserae. Totternhoe Stone, used at the eponymous villa and also excavated at Barrington, has a biostratigraphic age in mid-Cenomanian and so is slightly too old, and the quarries west and south of Stevenage and those at *Verulamium* expose chalks which are too young. The series of shallow pits south-west of Avebury might expose chalk of the relevant age, depending on their exact location, but the layout of the pits, dug parallel to the Roman road from Bath to Marlborough, suggests localised quarrying for hardcore rather than large-scale extraction. Other evidence for chalk quarrying in the same Morgan's Hill and Cherhill Down area, which interestingly centres on linear extraction of the hard bed of Chalk Rock found locally, has been dated to the post-mediaeval period (Small 1999, 21-2 and Figures 13-14).

There is, however, evidence that chalk of the correct age was quarried in the Roman period at Baldock in Hertfordshire.

4.6.2.2. <u>Baldock</u>

Baldock was an important settlement in the Late Iron Age that developed into a small town in the Roman period (Burleigh 1995, 179). Excavation of a site in the north west of the town was carried out by North Hertfordshire District Council's Field Archaeology Section (Atkinson *et al*. 1992). This site (The Stationmaster's House) lies at the junction of the Icknield Way and the Roman road leading north from Baldock to Godmanchester and thence either to Lincoln or Leicester. Trial trenching exposed the remains of a quarry in excess of 20 x 15m in area and about 2.5m in depth. This had been cut into the side of the chalk ridge and the chalk extracted using a series of smaller stepped cuts that had left angular faces. Contextual evidence suggests that the quarry came into use during the third century AD and continued in use into the mid fourth.

It is not possible to ascertain the use for the extracted chalk. Chalk was used for agriculture as well as building and it is possible that even a large quarry may have served only Baldock and its environs. However, as the quarry lies directly on chalk dating to the Late Cenomanian-Early Turonian, and appears to have been operating at the time the Vine Street Town House was being refurbished, and also has good road access to Leicester, there is at least the possibility that it may have provided chalk for the Vine Street tesserae.

The Stationmaster's House quarry is not the only evidence for chalk extraction in Baldock. A large pit dug into the Holywell Nodular Chalk Formation discovered during excavation in advance of development in the town was also interpreted as a chalk quarry dating to the Roman period (Fenton *et al*. 2003, 9, 25-26, 50). However, fill from this pit comprised a series of deposits of silty clay and redeposited chalk containing pottery dating from the second to the late third century AD. This would limit the quarrying activity to the first or early second centuries AD, which is too early a date to suggest that material from here might have been used in the production of the Vine Street tesserae. But it will be interesting to see whether further excavation in the Baldock area uncovers additional evidence for chalk extraction and whether examination of chalk tesserae from elsewhere suggests that their material might have been supplied from the town.

4.6.2.3. Chalk selection

The use of Totternhoe Stone raises the interesting question of chalk selection. This is discussed more fully in the Conclusions (section 8.4), but in passing it is worth noting that the Chalk Group rocks exposed at three of the above quarry locations contains a bed of hard white chalk (the Totternhoe Stone at Totternhoe and Barrington, and the Chalk Rock at Todd's Green west of the A1(M) at Stevenage). It would make sense if these particular horizons had been deliberately sought out for the production of tesserae, as hard chalks should be considerably harder wearing underfoot than softer ones. However, no evidence has yet emerged to support the view that any of these beds of chalk was being deliberately and systematically exploited. For instance, the

Melbourn Rock Member - a condensed bed of hard, off-white, blocky fractured chalk that might have been considered a suitably hard medium for the manufacture of tesserae – is found within the Holywell Nodular Chalk Formation and outcrops only about 250m east of the Stationmaster's House site, but there is no evidence that it was targeted for Roman quarrying activity at Baldock.

4.6.2.4. Summary of section 4.6.2

It is not possible to form a judgement as to whether chalk from the Chiltern escarpment travelled to Leicestershire. We know that Totternhoe stone travelled from Bedfordshire to London (above, section 4.6.2.1). Burleigh *et al.* (1990, 12, 18 and Figure 8.3, 21 and Figure 9) state that chalk tesserae were found at Little Wymondley villa in Hertfordshire, but as this villa is within a few kilometres of potential sources at both Baldock and Stevenage, this does not constitute much of a movement of material. However, there is some evidence that stone material from Leicestershire was travelling in the opposite direction. Swithland slate from Charnwood in north-west Leicestershire has been identified in roof tiles from one of the buildings at Bancroft in Buckinghamshire (Neal and Cosh 2002, 24) and also in dark blue-grey tesserae occurring in mosaics found at the villa (Neal 1981, 43; Williams and Zeepvat 1994, 259 'probably'; Neal and Cosh 2009, 51). Other possible identifications of Swithland slate have been made in fourth-century villa mosaics from nearby Foscott in Buckinghamshire and Thenford near Banbury in Northamptonshire (*ibid.*, 56). McWhirr injects a cautious note concerning the identification of 'Swithland' slate, but nevertheless his records indicate that the material has been found at sites as far as 60-80km from Leicester (McWhirr 1988, 3-4 (for reservations) and Figure 2 (for map of Swithland Slate distribution)).

Assuming that the above identifications are correct, this evidence, although slight, suggests a movement of Swithland slate southwards from Leicestershire during the mid-fourth century AD. This is perhaps not unconnected with the proposed Midlands Group of mosaicists active at the same time (Neal *op. cit*., 43; Neal and Cosh 2002, 24). Neal and Cosh point out that mosaics at Bancroft Roman Villa, located in the suburbs of Milton Keynes in Buckinghamshire and dating to around AD 350, show strong stylistic similarities to coeval mosaics from villas at Drayton in Leicestershire and to the slightly later mosaics at Great Casterton in Rutland (2002, 24; 2009, 49). Although any such movement of material (and possibly in the case of Bancroft, also mosaicists) is later than the suggested early fourth century AD date for the Vine Street Town House mosaics, there is a possibility that it was a continuation of an earlier trend. If this was so, it may not be implausible that chalk material from Baldock in Hertfordshire was moving northwards in a reciprocal movement. Indeed, the nearest source for the chalk tesserae found at the late third to early fourth century villa at Whitehall Farm on Watling Street, some 13km north of Towcester, would be the Chiltern escarpment around Dunstable to the south (Young 2006, in section on The Lower Slope Building).

4.6.3. *The North East*

Late Cenomanian and Early Turonian stage chalk also has a lithostratigraphical equivalent in Lincolnshire and north-east Yorkshire, where it comprises the middle and lower part of the Welton Chalk Formation (Hopson 2005, 36-8). Much of the solid geology in this area is obscured by Pleistocene sedimentary deposits, but the relevant outcrops run in a narrow band which curves inland from the Yorkshire coast at Bempton before turning south east towards the Humber estuary and continuing along the western edge of the Lincolnshire Wolds to reach lower ground close to Skegness. As with the Chiltern escarpment, therefore, the relevant Chalk Group outcrops in Yorkshire and Lincolnshire are geologically constrained, but geographically extensive, and it is necessary to see if potential source areas can be identified through archaeological considerations.

About half of the thirty-odd Roman villa sites in Yorkshire are found on the western edge of the Yorkshire Wolds (Halkon 2010, 32 and Figure 5). This is in contrast to Lincolnshire, where most of the villas are sited along or in proximity to Ermine Street and relatively few are sited on the Wolds themselves (Neal and Cosh 2002, 132-4). The majority of the mosaics found in these north-eastern villas date to the third or fourth centuries AD. They are remarkable in that very few are figured; Neal and Cosh speculate that this might be a cultural rather than an economic phenomenon (*ibid.*). The rising prosperity of Yorkshire and the North East during the third and fourth centuries AD, and possible reasons for the comparative lack of villas in the area, are discussed succinctly in Wilson *et. al*. (1984).

4.6.3.1 Transport and communication in the North East

The main overland north-south movement of men and materials in the North East bypassed the chalk outcrops of Yorkshire and Lincolnshire. Traffic moved north along Ermine Street from Lincoln to the Humber crossing at Winteringham-Brough and thence towards York and the northern frontier. An alternative route bypassed the Humber crossing by running inland to the Trent at Littlethorpe and then to York; this may have become the preferred route north by the third century AD. Both routes north from Lincoln therefore passed to the west of the chalk escarpment. However, Ermine Street was connected with potential chalk sources in the Wolds by a series of secondary routes. Two of these linked the main highway to ports on the east coast, at Bridlington in Yorkshire and Skegness in Lincolnshire, whilst a third ran north from the Humber to Malton in the Vale of Pickering. Other routes, linking Ermine Street to its eastern hinterland (to Caistor, for instance) and linking Horncastle to the Humber estuary at South Ferriby, have been suggested; practical considerations suggest that such routes must have existed, but definite evidence for them is lacking (for a discussion of the evidence for the above routes, see Whitwell 1992, 53 and map 4).

Data on riverine transport of stone materials in Roman Britain are limited. Pearson (2006, 90-107) makes an economic case for the movement of bulky materials by water and cites interesting evidence for the combined road and river transport of Lens Limestone in France (*ibid*., 92-4). This is similar to that envisaged below for Caerleon (see sections 5.7.2-3). Water transportation routes to Leicester from the north east were generally good. The town was connected via the rivers Soar and Trent to the Humber estuary and thereby to York, and Lincoln was accessible through the Foss Dyke which connected the Trent with the Witham. It is possible that the Soar-Trent-Humber route could have transported chalk (as blocks or tesserae) to Leicester from quarries in the North East, although none of these have as yet been positively identified.

4.6.3.2. Local use of chalk in the North East

It is difficult to quantify the Roman use of chalk in the North East. The use of stone in York during the occupation has been well studied (Buckland 1988; Gaunt and Buckland 2002; Pearson 2006, 120-8) but there is little mention of chalk being used as a building material. Gaunt and Buckland (*op. cit.,* 141) state that chalk was used for sill walls on several Roman villa sites in East Yorkshire, but do not provide details of specific locations. Whitwell provides some information on quarrying activity around Lincoln and also states that chalk was used for foundations for the putative Roman villa at Worlaby, about 7km south east of Winteringham (*op. cit*., 39, 116).

A few sources provide information on the use of chalk for tesserae. Gaunt and Buckland (*op. cit.,* 141) state that chalk was used extensively for the manufacture of white tesserae and that examples of such tesserae have been found in York, but without providing further details. Price and Wilson, however (1988, 266, citing Smith in Brinklow *et al*. 1986, 41, 60) state that chalk tesserae were found in pavements from Aldwark and Clementhorpe. Neal and Cosh record about ten mosaics from York, over thirty from the *colonia* at Lincoln and a further ten from the nearby villa at Greetwell, but unfortunately without being able to confirm the use of chalk tesserae in any of them (2002, 368-378 (York); 163-183 (Lincoln and Greetwell)). However, they do record the presence of chalk tesserae in pavements from Haceby in Lincolnshire and from Aldborough, Harpham, Langton and Wharram Grange in Yorkshire, all of which have either an early, or a probable, fourth century AD date (*ibid*., 144, 318, 339, 342 and 367 respectively). Chalk tesserae were also used in pavements at the Roman villa at Winterton (sited about 10km north of Scunthorpe) and chalk tesserae chippings were found above a floor in one of its rooms (Room 21); the suggestion being that the latter were probably the residue from patching work undertaken on some of the mosaics at the other end of the building (Stead 1976, 272, 46-7). Pragmatism also suggests that some of the 'white tesserae' described by Neal and Cosh as making up the background, borders or fine detail of the (largely) geometric patterned pavements found elsewhere in Yorkshire and Lincolnshire were also manufactured from local chalks, but in the absence of positive identification, this has to remain a conjecture.

4.6.3.3 Chalk provenances in the North East

With regard to provenance, the chalk tesserae found at Winterton in north Lincolnshire are described as local (Stead *op. cit.* 272) and indeed the villa is less than 10km from the foot of the chalk escarpment of the Lincolnshire Wolds. However, Neal and Cosh report (2002, 339; see also Sheppard 1940) that the white tesserae found in Hull and East Riding Museum and attributed to the fourth-century villa at Harpham were found by the museum to have originated from sea-worn rock chalk pebbles, which may have come from the chalk shore source closest to the villa, which is the bay at Bridlington, about 10km to the east. This is interesting, because the excavation report for the much earlier baths at Well in Yorkshire - sited north of Ripon and about 5km west of Ermine Street on its alternative inland route - gives a probable geological provenance of ‘the beach area north of Bridlington’ for the hard white chalk tesserae found at the site (Versey, in Gilyard-Beer 1951, 68). As Well is over 100km from Bridlington, this would imply that chalk from the coast was already travelling a considerable distance inland by about the mid-second century AD.

It is possible that Bridlington may have been a source of chalk for tesserae. The regional dip of the Chalk Group rocks to the north and south of Flamborough Head exposes a succession of strata around the coastal cliffs, which includes an exposure of Late Cenomanian and Early Turonian chalk around Bempton Cliffs to the north of Bridlington. However, several sections of these coastal chalk exposures, particularly those around Bempton Cliffs themselves, are today noticeably difficult or even impossible to access (Mortimore *et al*. 2001, 408-11 and Figure 5.19). It is possible that coastal erosion may have resulted in the current cliff morphology bearing little resemblance to that of Roman times. Nevertheless, if the cliffs presented similar difficulties to the Romans, it is not clear whether the Late Cenomanian or Early Turonian chalk exposed at Bempton Cliffs would have been sufficiently accessible to have supported tesserae production on a large enough scale to have supplied mosaicists in Leicester. The more accessible of the Bridlington exposures, though, might have provided chalk for the tesserae found at Harpham and at Well, and may also have supplied material to other villas in the region. In this context, it is perhaps worth noting the piles of tesserae found during excavation at Rudston Roman Villa, some 7km west of Bridlington. Those found in Building 3 at Rudston were sorted by size and colour, whilst those found in Building 7 were unsorted but numbered around 1500 (Stead 1980, 13, 17-18). This was thought by Smith (1980) to constitute evidence for the manufacture of tesserae at the villa, either for domestic use or as a cottage industry. It is interesting to note that, of the material found in Building 3 at Rudston, the largest pile was of small white tesserae. If these were cut from chalk, it is possible that they may have been sourced from the Bridlington area.

4.6.3.4 Summary of section 4.6.3

Given the above information, it would not be surprising to find that chalk for the local production of tesserae was quarried in the North East, even though evidence for quarrying on the scale of the excavations described above at Baldock has not been found. However, it is harder to prove that any such material might have moved to Leicester. Neal and Cosh identify stylistic affinities with two mosaics in Leicester in a second-century mosaic from Well (2002, 364, 366), suggesting that they might be the product of the same craftsmen; the authors also identify similarities in a fourth-century mosaic from Haceby (2002, 144); and the use of Leicestershire Swithland Slate roof tiles at the settlement of Haceby is also attested (McWhirr 1988, 5, Figure 2, 6). But this does not constitute robust enough evidence to demonstrate a strong link between the two locations.

However, accessible chalk of the same age as that used to manufacture the Vine Street tesserae is found in the North East, including around Bridlington; many of the mosaics laid in the North East date to the fourth century and so were utilising chalk tesserae at the same time as the Vine Street mosaics are thought to have been laid; and the piles of tesserae at Rudston might possibly be evidence of a tesserae workshop, if only a local one. This means that a source of chalk in the North East for the Vine Street tesserae is still a tantalising possibility.

4.6.4 *The South*

Much of the Chalk Group responsible for the familiar chalk landscapes of southern England is younger than the chalk used to manufacture the Vine Street tesserae. Outcrops with Late Cenomanian-Early Turonian biostratigraphical age are limited to the scarp faces of the North and South Downs, a narrow outcrop in the Isle of Wight and an Early Turonian exposure at beach level in Beer in south Devon. The Downs exposures run north-east (for around 190km) and south-east (for around 140km) from the vicinity of Petersfield in Hampshire to culminate in cliffs at Folkestone and Dover, and at Eastbourne and Beachy Head, respectively. The relevant Chalk Group outcrops are crossed by a series of Roman roads running from London to the south and east coasts (Figure 4.12). All of these routes provide good communications with Leicester.

Both south-east and south-central England were occupied and settled earlier than the rest of *Britannia* and experienced earlier prosperity. However, the continual uneasiness and sporadic instability of the political situation at home and on the continental mainland during the third century AD may have effected a later downturn in the economic prosperity of the region, particularly in the south east. This would explain the comparatively large number of mosaics in this region that can be dated to the second century and the comparatively few that can be dated to the fourth (Neal and Cosh 2009, 3, 19). This economic situation is very different to the one found in the South West and also in the North East: in these areas, villas were being established or developed during much of the fourth century and a considerable number of mosaics and several mosaic workshops date to this period (Cosh and Neal 2005, 5, 21-30 and references therein).

4.6.4.1 Use of chalk tesserae in the South

Neal and Cosh record the use of chalk tesserae in mosaics from Hampshire, at West Meon (2009, 250); West Sussex, at Chilgrove, Fishbourne, Pulborough and Southwick (*ibid*., 520, 532, 555 and 557 respectively); East Sussex at Preston (*ibid*., 555); Kent, at

Boxted and Folkestone (*ibid*., 359 and 377); and Surrey, at Walton-on-the-Hill and Worpleston (*ibid*., 477 and 478). Chalk tesserae have also been found in Ilchester in Somerset (Somerset HER 55896; Cosh and Neal 2005, 216, 220 and 225); in Dorset, at Halstock villa near to Ilchester (*ibid.*, 142) and at the Applegates site in Dorchester (Jones 1989); and in Wiltshire, at Badbury and Tockenham (Cosh and Neal *op. cit*., 318, 365 respectively). However, of the mosaics that are dated, only those from sites further west (Ilchester, West Meon, Chilgrove, Badbury and Halstock) are fourth century; the other sites either flourished earlier or are of unknown date. It is likely that this reflects the greater stability and affluence of the west of the province at this time, as evinced by the groups of mosaicists thought to have been operating out of Dorchester and the Cirencester area in the fourth century (*ibid*., 21-30).

In five instances the provenance of the chalk used to manufacture tesserae in the south is either known, or strongly suspected. The chalk tesserae workshop at Norden, Corfe Castle, in the Isle of Purbeck (Sunter and Woodward 1987, 36, 43) seems to have utilised chalk from a local source (Wilkinson *et al*. 2008, 2420), as noted in Chapter 1 of this thesis; chalk from Dorset was used to manufacture tesserae for mosaics from Silchester (*ibid*.); the mosaicists at Brading Roman Villa on the Isle of Wight probably utilised a local source, as noted in Chapter 3 (Tasker *et al.* 2011, 937); chalk from Stonehill Down, Purbeck, was used for tesserae from the Applegates site in Dorchester (Jones 1989); and chalk from the Marlborough Downs has been identified from Tockenham (Cosh and Neal 2006, 365, citing Harding and Lewis 1997). Chalk tesserae at Norden were being produced as early as AD 70, but the evidence suggests that activity at the site declined after the mid second century. It would appear therefore that chalk tesserae manufacture at Norden was confined almost entirely to the earlier period, and as Sunter points out (*op. cit*., 43), it might not be a coincidence that this coincided with the construction of floors for the Flavian villa at Fishbourne.

4.6.4.2 Possible chalk provenances in the South

The possibility of supplying chalk to Leicester from the south of the province is an interesting one, given its technical feasibility and the fact that other lithologies are known to have travelled considerable distances. However, the archaeological evidence for any actual quarrying of chalk in the south in Roman times is limited. Chalk quarries dating to the Roman period have been identified in locations in Dorset, Wiltshire, Greater London, Kent and Essex (see Appendix D for the relevant locations), but the main period of operation for all but one of these quarrying activities appears to have been before the mid-third century AD. So if these quarries were supplying chalk to a wider hinterland than their immediate neighbourhood, it does not seem that any of them was still in production at the time of the laying of the Vine Street mosaics. The exception is the chalk quarry on the Dartford District site, which from excavation evidence appears to have been considerable in size and also operational beyond the mid third century. However, neither the Dartford District nor any of the above quarries appears to have been sited on the rather limited outcrops of Late Cenomanian or Early Turonian chalk and so none could have acted as a source for the Vine Street tesserae.

4.6.4.3 Summary of section 4.6.4

The lack of evidence for chalk quarrying in the South of England after the mid-third century, coupled with the paucity of later mosaics from the South-East, does not suggest a thriving mosaic industry in this part of the province. It is worth noting that a number of mid-fourth century AD mosaics from Silchester and London show stylistic affinities with the Saltire Group of mosaicists working out of Cirencester (*Corinium Dobbunorum*): in the case of London, Neal and Cosh speculate that this might be because the London-based Acanthus workshop may have ceased to operate by the late third or early fourth century AD and so expertise had to be imported from the West (Neal and Cosh 2009, 191, 400-1, 437). Probably, this makes it unlikely that the chalk for the Vine Street tesserae was sourced from anywhere in the South-East, although it does not eliminate possible sources further south and west. This begs the question of where the chalk for the many fourth-century mosaics being laid by the Corinium and Durnovarian Groups in the West and South-West *was* being sourced, and also whether the mosaic 'workshops' operating out of the region at this time were using the same or different sources of chalk. A microfossil analysis of chalk tesserae from a selection of such mosaics might provide some interesting answers.

4.7 Overall summary

It is clear from the above discussion that it is not possible to draw a definite conclusion as to the provenance of the chalk tesserae used to manufacture the mosaics in the Vine Street Town House, although it has been possible to suggest two possible source locations, both of which satisfy the geological and the archaeological criteria. These are Baldock in Hertfordshire and Bridlington in Yorkshire. Baldock is the nearer of the two and the easier of access, given the road network, and therefore on these grounds, the more convincing suggestion. However, we should not discount the possibility of a northern source. The slower rise to prosperity in the north east meant that mosaics were being laid there well into the fourth century AD, which must have created a demand for materials, if only a local one. Further investigation into the provenance of chalk tesserae from mosaics in Yorkshire might yet produce surprises.

4.8 Conclusions

Microfossil analysis of chalk tesserae from the Vine Street Town House in Leicester has shown that:

a) The chalk tesserae from the Vine Street Town House have a biostratigraphical age of BGS FBZs 8–9. Pithonellid data supports this conclusion. These biozones identify the stratigraphical interval of the Holywell Nodular Chalk Formation in the south of England and the Welton Chalk Formation in the north of England;
b) The relevant Chalk Group outcrops are geologically constrained, but geographically extensive;
c) Consideration of the archaeological evidence suggests that the chalk source for the tesserae is most likely to lie either in the Chiltern escarpment or in the North East, rather than in Norfolk or in the South;
d) A process of elimination suggests either Baldock in Hertfordshire or Bridlington in Yorkshire as the most likely chalk source areas for the Vine Street tesserae.

Chapter 5

Caerleon

ABSTRACT

Thin section analysis of chalk tesserae from two sites in Caerleon (Backhall Street and August Villa Garden) identifies foraminifera with a Late Cretaceous (Campanian Stage) biostratigraphical age. The Backhall Street mosaic formed part of the Baths complex of the legionary fortress and is dated to the 80s AD; the August Villa Garden tesserae were found close to Barrack Buildings IX and X and may have been laid about AD 200. Chalk Group outcrops are not found close to Caerleon, so the chalk used in both instances must have been transported to the site. The foraminiferal analyses suggest a possible source in the Dorset area. A transport route from Dorset to the legionary fortress via either Crandon Bridge or Sea Mills on the Severn estuary is suggested.

5.1 The archaeological background

The conquest and pacification of the Silures in south west Wales took nearly three decades (from *c*. AD 49-78: for concise summaries of the military engagements, see Millett 1990, 51-54; Salway 1997, 77-81; Mattingly 2006, 97-98 (Table 2), 101-106, 116, 143-146). The legion most actively engaged in these campaigns was the Second Augustan Legion (*Legio II Augusta*), which is thought to have been stationed in Exeter (*c*. AD 55-65) and then in Gloucester (*c*. AD 65-74) before finally moving to Caerleon in AD 74-5. An overview of the deployment of *II Augusta* and its contribution to the control and development of the province of *Britannia* can be found in Brewer (2002). Figure 5.1 shows the localities in the west of the province mentioned in this chapter.

In support of campaigns against the Silures, *II Augusta* established an operational base at Usk in South Wales during the mid-50s AD. However in AD 74-5 the legion began to construct a new fortress at Caerleon (*Isca*), several miles to the south of Usk and with the practical advantage of a sea connection to the Bristol channel via the Severn estuary. Caerleon was to remain the legion's base for the next two centuries, although it is clear that from the time of Hadrian (*c*. AD 120) that detachments of *II Augusta* operated elsewhere, most noticeably in the north, where the legion was much involved with the construction of Hadrian's Wall and, later, the Antonine Wall (Breeze 2002; Fulford 2002, 95-6). Caerleon was to become one of only three permanent legionary fortresses in *Britannia*, the other two being at Chester (*Deva*) and York (*Eboracum).* There is evidence that the site continued to be occupied into the fourth century AD, although how much of this was a military rather than a civilian presence is not clear; Fulford suggests that *II Augusta* may have relocated to a new coastal fort at Cardiff in the late third century AD before moving to Richborough (*Rutupiae*) in Kent in the late fourth (Fulford *op.cit*., 98-99).

5.1.1 *The legionary fortress and canabae at Caerleon*

The fortress itself is sited on a terrace that overlooks the floodplains of the River Usk (to the south and east) and the Afon Lwyd (to the north). It lies at the lowest crossing point of the Usk, about 14km upstream from where the river flows into the Severn estuary at Newport. The strategic assumption has always been that the site was tidally navigable, this being the main advantage it offered over the previous fort at Usk. However, estimations of changing sea levels at Caerleon during Roman times now suggest that the third-century 'quayside' excavated by Boon (1978) was probably a riverside dock rather than a tidal structure (Toft 1992, 254). Recent excavation, though, has shown that the lack of archaeological evidence for a Roman quayside is almost certainly due to its loss from erosion caused by the westwards migration of the Usk over its floodplain since Roman times (Guest *et al*. 2012). This suggests that definitive archaeological evidence for port facilities may never be found.

The complex of buildings comprising the southern *canabae* (the civilian complex of buildings outside a fortress) (Figure 5.2) was almost certainly constructed at the same time as the fortress. This is based on the fact that there are no occurrences within it of tiles stamped *II Augusta,* a legionary practice known to have been introduced around 80-90 AD (*ibid.,* 91-2), which suggests that the complex was already constructed by this time. This is consistent with its main function being that of a port, supplying docking and warehouse facilities to house the necessary mass of constructional and military

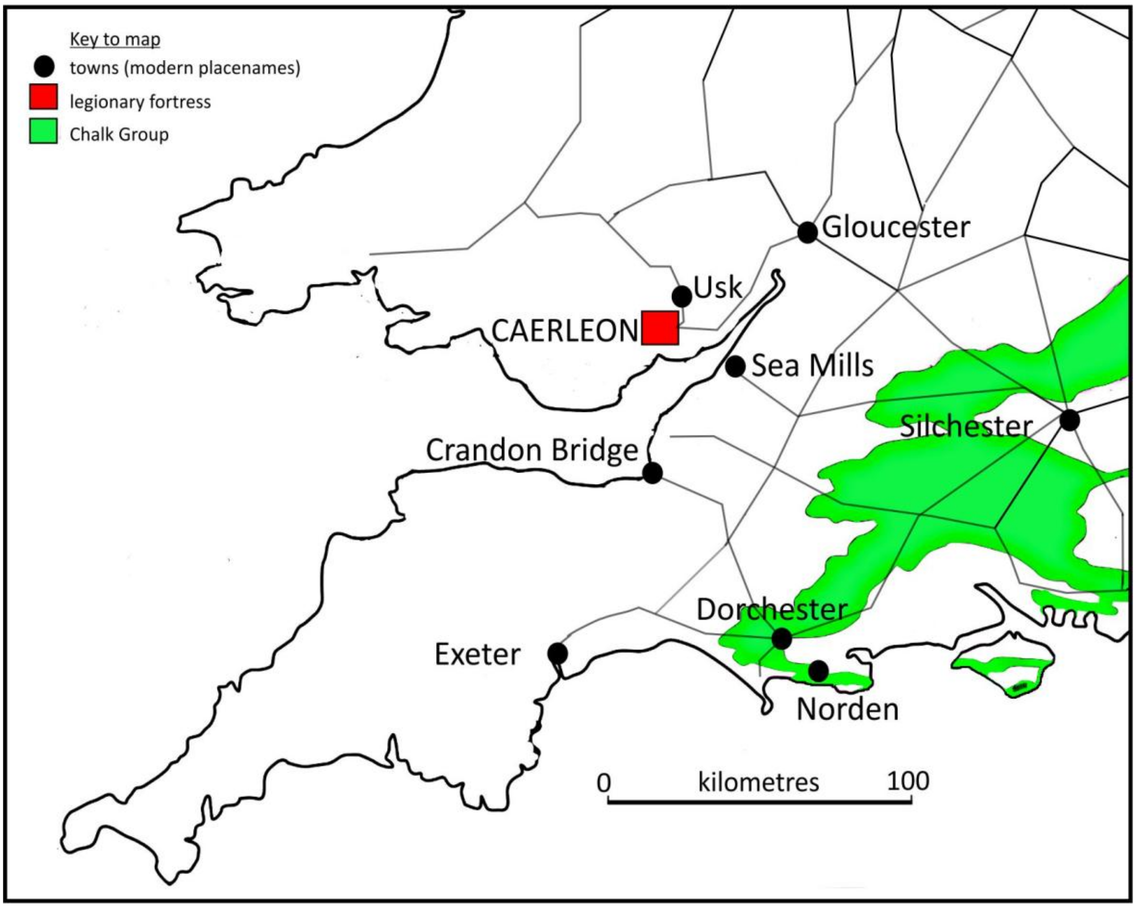


Figure 5.1. Sketch map of the south-west portion of *Britannia*, showing the main locations discussed in Chapter 5 and their proximity to Chalk Group outcrops (in green). Geological Map Data © NERC 2013. Roman roads taken from OS Roman Britain map, 5th edition (2001).

Figure 5.2. Reconstruction of the Caerleon fortress in the Roman period. The fortress appears in the top right of the image and the southern *canabae* occupies the middle and bottom left. The amphitheatre lies between the two. Photograph: 7reasons. Source: www.theguardian.com. Thursday 12 August 2010.

supplies arriving by sea. Guest *et. al*. note that one advantage of using a shipping route for supplies might have been that it was thought safer than using an overland one that would pass through newly conquered and possibly hazardous territory (*ibid*., 95).

The history of excavation at Caerleon is long. Boon (1972) records some twenty-nine excavations carried out prior to his, of which only a handful had been published in any detail, principally by Nash-Williams (1929; 1931; 1932a; 1932b) and Murray Threipland (Murray Thriepland and Davies 1959; Murray Thriepland 1965; 1967; 1969). However, a recent survey of this earlier excavation work commissioned by CADW (the Welsh Government's historic advisory service) concluded that its quality was very variable and its publication record poor (Glamorgan-Gwent Archaeological Trust 2004). Results from more recent excavations, conducted on the Fortress Baths (Zienkiewicz 1986a; 1986b), the north-west *canabae* (Evans 2000) and the interior of the fortress and the southern *canabae* by Cardiff University and the Institute of Archaeology at University College, London (Guest and Young 2006, 2009; Gardner and Guest 2010) are now producing results that are clarifying and in some cases, challenging the established chronology and interpretation of the site. In particular, the use of geophysical survey methods allied to selective excavation has led to a re-evaluation of the interior organisation and function of the fortress (Guest and Young 2009, 107-9) and excavation in the southern *canabae* is expected to continue for several more years.

5.2 The geological background

Wales has experienced a long and complex geological history, whose legacy can be found in the rich and varied landscape visible above ground and in the mineral wealth found below it (Woodcock and Strachan 2012). An overview of the geological background to the site at Caerleon is included here in order to provide a context for the movement of raw materials taking place in the west of the province during the later first century AD. These movements will then be used to generate possible contexts for the transportation of chalk to Caerleon.

The legionary fortress at Caerleon is sited on a bluff that forms part of the St Maughan's Formation, a series of Early Devonian alluvial sedimentary deposits consisting largely of interbedded sandstones and mudstones. These provided the 'Old Red Sandstone' used predominantly in the construction of the first-century Fortress Baths and second-century barrack buildings (Zienkiewicz, 1986a, 341-2). Further inland, the geology is dominated by older Ordovician and Silurian strata, mostly marine sedimentary deposits (shales, sandstones, mudstones and slates) which were deposited in a subsiding basin over a long period of time during which they were much folded and faulted as a result of tectonic activity.

In the south of Wales, these older sedimentary strata were overlain by Carboniferous alluvial and coastal plain deposits, responsible for the outcrops of limestone, coal (the South Wales Coal Measures Group) and sandstone (the overlying Pennant Sandstone Formation) found there today. In turn, these Carboniferous deposits were overlaid in places by much later Jurassic sedimentary deposits containing thin beds of muddy limestones, some of which outcrop at Goldcliff, about 8km to the south of Caerleon. Downstream from Caerleon, the modern town of Newport sits on Triassic sedimentary deposits (mainly mudstones and siltstones) of the Mercia Mudstone Group.

Despite this varied geology, it is important to note that there are no deposits of Cretaceous chalk either in the vicinity of the fortress or in its hinterland.

5.2.1 *Roman exploitation of regional and local geology*

There is considerable evidence that minerals in the province were exploited by the Romans from the early years of the occupation: for example, a dated ingot of lead (a lead 'pig') in the British Museum attests to lead mining in the Mendips in Somerset as early as AD 49 (Elkington 1976; Todd 1996). In Wales, a range of minerals was exploited from the later first century AD onwards (Jones and Mattingly 1990, esp. Chapter 6; Arnold and Davies 2000, Chapter 9 and Figure 9.1). Mineral rights were invested in the emperor and usually exploited through the military, although Arnold and Davies review the career of a possible lessee of lead mining operations in Flintshire (now Clwyd, north east Wales), which were in operation from AD 74 (*op. cit*., 101). The aqueducts, reservoirs and sluicing systems related to the gold-mining operation at Dolaucothi illustrate the sophisticated engineering capability of the army (Jones and Mattingley *op.cit*., 180-184 and Map 6.4).

Mineral resources close to Caerleon were also exploited. Legionary stamped tiles and bricks and deposits of lead ore and slag provide evidence for late first century AD lead mining at sites at Lower Machen, Risca and Draethen, some 10-15km to the west of the legionary fortress (Arnold and Davies *op. cit*., 98). No lead pigs are known from south east Wales, but the authors speculate that this may have been due to the absorption of locally-produced lead by legionary demand or may just reflect an accident of survival (*ibid*).

There is evidence also for the early use of coal at the legionary base. Small fragments of unburned residue of mineral coal recovered from the mortar of the wall-core of the earliest buildings of the Fortress Baths suggest that this might have been used as a fuel to burn lime to produce mortar (Zienkiewicz 1986a, 343). Zienkiewicz pointed out (*ibid*.) that if this coal had been sourced locally from the South Wales coalfield, its use would not only demonstrate an early awareness of the mineral wealth of the area but also represent some of the earliest known use of coal in the province. A later analysis has now shown that nearly all of the coal found at Caerleon does appear to have been sourced from the south-eastern outcrop of the South Wales coalfield and that the more distant Forest of Dean coalfield was not exploited until the second and third centuries AD (Smith 1996).

Potential iron sources in Glamorgan do not seem to have been worked extensively in the Roman period. The Forest of Dean iron industry, centred on *Ariconium* and with its chief market at Gloucester (*Glevum*), appears to have been on a very modest scale until the second century AD (Cleere 1981, 85-69).

5.2.2 *Exploitation of stone*

Local sources of stone around Caerleon were exploited from an early date. The main constructional material used for building both the first-century Fortress Baths and the second-century barracks at the legionary fortress was the Early Devonian ('Old Red') sandstone of the local St Maughan's Formation (Zienkiewicz *op. cit.*, 341-2; Allen 2005, 26). Sudbrook Sandstone (s*ensu* Allen, *op. cit*.), part of the much younger Triassic Mercia Mudstone Group, was also utilised. This unit outcrops both inland and on the coast of the Severn Estuary in a series of limited exposures, some of which are only accessible at low tide. Sudbrook Sandstone was used extensively in the *civitas* capital of Caerwent (*Venta Silurum*) from the early second to the fourth century AD. In Caerleon, the stone was used earlier than this, but in more limited contexts, being generally confined to situations in which large blocks supportive of infrastructure were required, such as the *voussoirs* and piers of the amphitheatre, constructed around AD 90 (Allen *op. cit*.; Pearson 2006, 116-120) .

There is some evidence for the longer-distance transhipment of stone in the materials used in the construction of the legionary fortress. Zienkiewicz records the use of 'Liassic [= Lower Jurassic] limestone' in the Fortress Baths, particularly for paving, and suggests that this stone may also have been the source of the lime burned to provide the mortar used in construction (1986a, 71 and 341-2). Lower Jurassic limestones outcrop in the Vale of Glamorgan, to the south of Caerleon, but it is not clear from the report whether or not the limestone described by Zienkiewicz was quarried locally or imported from exposures in Somerset. However, Bath Stone (a Middle Jurassic oolitic limestone, which outcrops on the eastern side of the Severn estuary at Combe Down, just south of Bath) was used for construction and paving in the Fortress Baths and elsewhere (Zienkiewicz *ibid.,* 71; Allen *op. cit*., 30; Pearson *op. cit.,* 117-118) and this must have been transported from Somerset to Caerleon.

Pearson suggests that the use of Bath Stone in Caerleon might reflect the relative ease with which different stone types could be imported into the legionary base, although he also admits that the admixture of Sudbrook Sandstone and other lithologies at Caerleon might simply indicate a slightly haphazard approach to stone procurement in Roman building projects (*ibid*., 118). Evidence supporting the latter suggestion is perhaps provided by the use of mixed constructional materials in the buildings of the southern *canabae* (Guest et al. 2012: see 17, Figure 14, for an example of *tegulae* and riverside cobbles used to construct a wall, suggesting something of an *ad hoc* approach to the obtaining of building materials).

Purbeck 'marble' (a hard Early Cretaceous freshwater limestone from Dorset) is also found at Caerleon, where it was used as a decorative veneer in the Fortress Baths (Zienkiewicz, *op. cit*., 342). Exposures of Purbeck marble are very limited and occur only as a thin outcrop running east-west across the Isle of Purbeck in Dorset, so clearly the stone travelled from there to Caerleon. This may not be totally unexpected: the overview of the use of Purbeck marble in Roman times by Pearson (*op. cit*., 109-116 and Figure 41) makes it clear that that the stone was exploited from early in the occupation and was used widely during the first century AD in contexts from Colchester to Chester.

There is little evidence of the use of exotic stones at Caerleon. The one known example is a slab of Luna Marble, imported from Carrara in north west Italy, its use dated to AD 99-100 by the inscription incised on it (Pearson *op. cit*., 85 and Colour Plate 3). Zienkiewicz also mentions the use of a calcareous tufa, although it is not known where this may have originated (*op. cit*., 342).

It can be seen from this overview that most of the building material for the legionary fortress was sourced locally, but that transport routes for the movement of constructional raw material to Caerleon from Somerset (Bath Stone) and Dorset (Purbeck marble) did exist from its earliest years. This will be seen to have a bearing on the availability of chalk for the tesserae found in the mosaics of the Fortress Baths.

5.2.3 *Availability of chalk*

Chalk Group formations in the UK are almost entirely confined to the south and east of the mainland, although small and isolated outcrops can be found in the Inner Hebrides of Scotland and along the Antrim coast in Northern Ireland, and limited outcrops also appear in County Kerry in the Republic of Ireland. All of the Chalk Group, therefore, is situated at a considerable distance from Caerleon. Figure 5.1, above, shows that the nearest Chalk Group exposures, as the crow flies, are on the Salisbury Plain, some 75km or more to the south east, and that outcrops on the Marlborough or Wiltshire Downs to the east, or in Dorset further to the south west, are over 100km distant.

As the local geology around Caerleon does not include chalk, any chalk used for the manufacture of mosaic floors or for building purposes at Caerleon must have been brought to the site from elsewhere. Microfossil analysis of the chalk tesserae from the Backhall Street mosaic and the August Villa Garden site therefore has the potential to be particularly informative with regard to ascertaining the movement of mosaic materials in this part of the province.

5.3 The Caerleon sites

5.3.1 *The Fortress Baths and the Backhall Street mosaic*

The Backhall Street chalk tesserae examined for this thesis were obtained through the generosity of The Museum of Wales in Cardiff. They originate from a mosaic discovered in 1877 during the installation of drains in the eponymous street in Caerleon (Morgan 1878, 1882; Zienkiewicz 1986a, 33 and 272 (Plate XCIV); Boon 1986; see also Cosh and Neal 2005, 334-337 (Mosaic 482.3); and references therein).

Backhall Street is now known to overlay part of the Fortress Baths, one of the first buildings to have been constructed at Caerleon after its founding (Zienkiewicz 1986a; 1986b). The bath suite was substantial, forming one side of an exercise yard which also contained a long swimming pool. The mosaic itself appears to date from Phase II of the construction, carried out in the early 80s AD (*id*. 1986a, 339); it is therefore one of the earliest mosaics to have been laid in Roman Britain. Detailed plans of the Baths showing the location of the mosaic in what was probably the changing room (*apodyterium*) appear in Zienkiewicz (1986a, 165-8; see also the Frontispiece (an artist's reconstruction) and Figures 1 and 2); a simplified version of the plan showing the position of the mosaic also appears in Cosh and Neal (*op. cit.,* 334, Figure 338). The pool, the bath suite and a remnant of the mosaic are all now housed in the Roman Baths and Fortress Museum which is in the care of CADW. Previous lack of care meant that the mosaic required extensive conservation before it could be placed in the museum (O'Sullivan 1987).

The Backhall Street mosaic is known variously as the Fortress Bath House mosaic, because of its location, or as the Thyrsus mosaic, from the Bacchanal symbol allegedly featured in its iconography (Boon 1986). In passing, it is perhaps worth noting that the exact iconography of the 'thyrsus' is debated: see Neal (2006) and Ling (2008) for two recent alternative interpretations and Cosh and Neal *op. cit.,* 336-337, for further comment.

5.3.2 *Tesserae from the Backhall Street mosaic*

The Backhall Street mosaic appears to have been one of several pavements laid in the Fortress Baths suite (Zienkiewicz, 1986a, 174, 339-340 for evidence of loose tesserae indicating the presence of others). Flakes of waste chalk, presumably from larger blocks brought to the baths and knapped on site, were found in the earliest sediments, indicating that the Baths had been decoratively paved from the start (*ibid*., 339). Cosh and Neal (*op. cit.,* 337) record a second mosaic in the *frigidarium* (Mosaic 482.4) and state that it is likely that other rooms in the bath suite were similarly paved. It is possible that some of the very small tesserae represent debris from a wall or vault mosaic (Zienkiewicz, *op. cit*., 339).

In 2004, samples of loose tesserae relating to these mosaics and now in the National Roman Legion Museum in Caerleon were examined and compared with the tesserae visible on the Backhall Street surviving fragment (Allen and Fulford 2004, 27-28). The authors reported that the loose tesserae they examined contained several colours other than black and white and that all of these colours appeared to be present in the Backhall Street fragment. They also stated that the coloured tesserae appeared to be made from materials very similar to the mudrocks or dolomitic cementstones sourced from the Jurassic Kimmeridge Clay Formation in Dorset that had been used to manufacture tesserae for several early Roman mosaics from Silchester (*ibid*., 13-16, 30-34). The white tesserae, by contrast, were identified as a hard chalk (*ibid*., 28). The Backhall Street tesserae examined for this thesis conform to this last description, being composed of a hard, white, very fine-grained chalk which splintered into sharp fragments on crushing.

An interesting feature of the Fortress Baths tesserae noted by Allen and Fulford (*ibid.,* 28) and previously by Boon (1986*,* 273) is their large size, double-sized tesserae of 25-35mm in length being not uncommon. The Backhall Street tesserae examined for this thesis also shared this characteristic, with five of the twelve tesserae examined measuring a robust 15 x 30mm and the smallest three measuring 12 x 25mm. Allen and Fulford (*op. cit*., 34) suggest that double-tesserae set on end might be employed as a remedy against seeping damp; they also note (*ibid*., 28) that the Fortress Baths tesserae they examined were much larger than those used to floor the legionary bath suite at Exeter, built some fifteen years earlier by *II Augusta.* The latter observation is picked up by Cosh and Neal (*op. cit*., 331, 337), who also remark that the Backhall Street mosaic appears crudely laid in comparison with the Exeter legionary baths mosaics and so may not be the work of professional mosaicists. If this analysis is correct, perhaps the Caerleon Fortress Baths mosaics represent either the legion's attempt to lay its own mosaics or the employment of out-source workers offering a skill still in the early stages of development.

5.3.3 *Tesserae from the August Villa Garden site*

Twelve chalk tesserae were also obtained from a second site in Caerleon (August Villa Garden). Five of the August Villa Garden tesserae were broadly square (20 x 20mm) and seven were broadly rectangular. The rectangular samples varied between 15 x 25mm and 15 x 30mm. The larger double-sized tesserae were similar in size to those obtained from the Backhall Street mosaic described above. The chalk used to manufacture the August Villa Garden tesserae was also similar in appearance, being a hard, white, fine-grained chalk.

August Villa was built in 1985 as infill development in the grounds of a house called Sandygate on Cold Bath Road. The land on which Sandygate had been built originally formed part of Barrack Blocks IX and X in the Prysg series (Evans *et al*. 1991). The tesserae were found in the garden topsoil of August Villa in 2004, but no further details of the find were provided other than its National Grid reference (ST 3372 9073), which is plotted on Figure 5.3 below.

The August Villa Garden tesserae were a casual find and as such have no proper archaeological context. It is possible, though, that their location (in close proximity to the north-western corner of the barrack buildings) may suggest a rationale and a possible date for the tesserae. Nash-Williams (1931, 131-3 and Figure 28) records the presence of a substantial number of loose 'white tesserae' among the remains of a pavement excavated in Room 42-4 in Prysg Field. This room appears to have been part

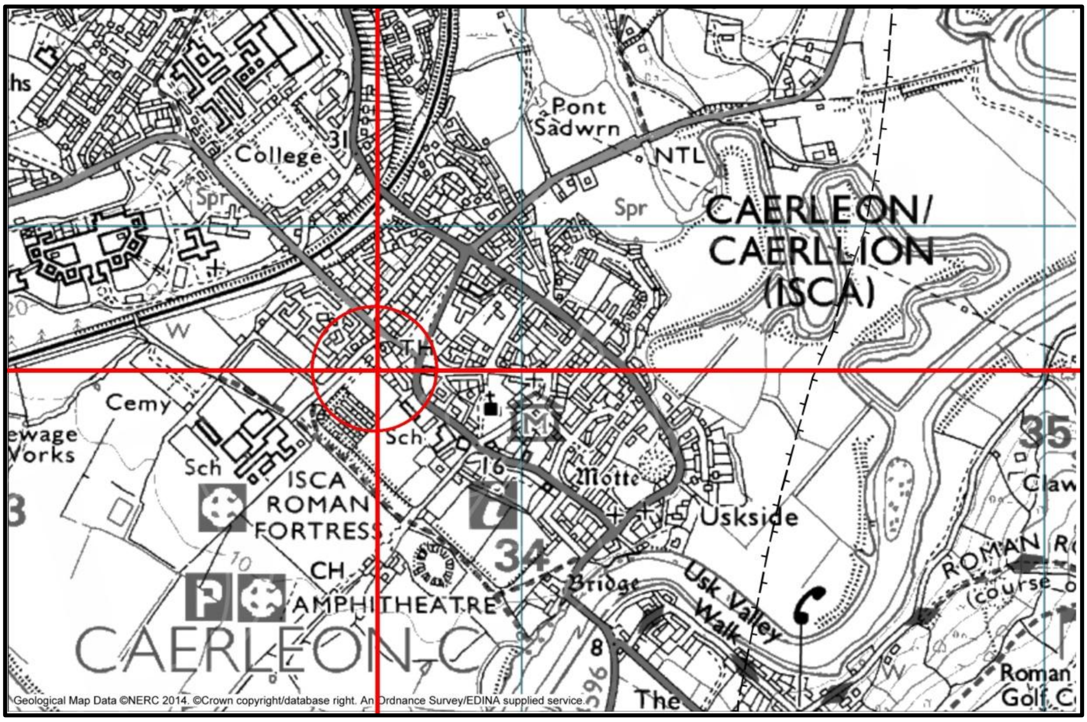


Figure 5.3. Approximate find spot of the August Villa Garden tesserae (ST 3372 9073) (circled at the junction of the red grid lines) at the north western corner of the Barrack Blocks of the legionary fortress at Caerleon, Gwent, UK. Geological Map Data © NERC 2014. The excavated section of the Barrack Blocks can be seen in the bottom left quadrant of the red circle.

of a storehouse built around AD 200 in the *intervallum* (the space between the barrack ramparts and the fortress's outer defensives) and lay close to the top of Barrack Block X in the Prysg series. The storehouse pavement is catalogued as Mosaic 482.6 by Cosh and Neal (*op. cit*., 337).

It is possible that the proximity of this pavement to Barrack Block X may be related to the find of the tesserae in August Villa Garden. It has previously been suggested that a number of other 'white tesserae' found in 1997 during small-scale excavation for a double garage at Sandygate might relate to floors laid in buildings erected in the *intervallum* (Glamorgan-Gwent Archaeological Trust 1997). As stated above, Sandygate was built over the remains of Barrack Blocks IX and X (Evans *et al.* 1991) and is the same house in whose garden August Villa was later erected (see Figure 5.3). Assuming therefore that the 'white tesserae' excavated by Nash Williams in Room 42-4 are actually manufactured from chalk, this suggests that a mosaic in an *intervallum* building might represent a 'best guess' origin for the chalk tesserae found in the garden of August Villa also. If this interpretation is correct, the mosaic from which the August Villa Garden tesserae originate could perhaps be dated, albeit very tentatively, to the same period as Nash-Williams' storehouse (around AD 200).

5.4 Evidence for the use of chalk in Caerleon

5.4.1 *Chalk and other 'white' tesserae*

Evidence for the use of chalk tesserae in Caerleon is not extensive. The knapping waste recovered from the Fortress Baths has already been mentioned in connection with the early mosaics found there (above, section 5.3.2), as have the 'white tesserae' discovered in Room 42-4 of the *intervallum* and those found in the garage foundations at Sandygate (section 5.3.3).

However, recent excavation in the southern *canabae* has uncovered the remnant of an early black and white mosaic floor in the room of one of the central buildings (Guest *et al*. 2012, 75 and Fig. 54) and scattered black and white tesserae were recovered from three of the excavation trenches (Trenches 4, 5 and 6), suggesting the possibility of similar mosaics in adjacent buildings (*ibid.*, 75 and Fig. 54). The southern *canabae* buildings have been dated to the later first century AD (*ibid*., 91-2), so it seems likely that these fragments represent mosaics contemporaneous with those found in the Fortress Baths. The white tesserae are not specifically identified as chalk, although it is clear that in a bichrome scheme, the bright whiteness of chalk would have offered the best contrast to a darker lithology such as slate or a black limestone.

Murray Threipland (1967, 55) also cites the discovery of chalk tesserae by Nash-Williams in the hypocaust of Room 27 of a strip-house in Bear House Field (part of the southern *canabae*). Nash-Williams excavated Bear House Field in 1954; his results were unpublished, but Murray Threipland had access to his notes. Summaries of the same Bear House Field excavations appear in Wright (1955, 121-122 and Figure 6; 1956, 119-122 and Figures 20 and 21) and in Evans (2000, 508-510); these do not mention chalk tesserae specifically, but record the mosaic floor found in the strip-house and two other pavements found in a well appointed courtyard house (catalogued by Cosh and Neal (*op. cit*., 338-9 and Figures 344-5) as Mosaics 482.8 and

482.9-10 respectively). Evans (*op. cit*., 509) describes the strip-house mosaic as 'probably Hadrianic' (AD 117-138) and suggests that the two courtyard house mosaics should be dated to the third century AD (*ibid.,* 510). This would make all of the Bear House Field mosaics later in date than the Backhall Street mosaic.

It is also possible that the paler tesserae visible in the 'Labyrinth' mosaic, which was found in the north-east corner of the churchyard in Caerleon in 1865 and is dated on stylistic grounds by Cosh and Neal (2010, 332-3) to the early second century AD, may also be of chalk, as these are described by O'Sullivan as a 'chalky limestone' (*op. cit.,* 15). However, this has not been confirmed.

5.4.2 *Chalk as building material*

Chalk is also found at Caerleon in another guise. Murray Threipland (1967) found that blocks of chalk had been used occasionally for constructional purposes. A rescue excavation carried out in the grounds of The Croft in 1966 revealed that 'chalk lumps' had been used to build the foundations of the east-west internal partition walls of Barracks 4 and 9 in the Prysg Field series in Period 2 (late first to mid-second century) and Period 4 (early to mid-third century), and that similar 'lumps' were found to have been used in the refurbishment of Barrack 9, also in Period 4 (*ibid.,* 55). This was in contrast to the other barrack buildings, which appear to have used medium-sized square sandstone blocks for wall foundations (*ibid*.). Two of the chalk 'lumps' were described by Murray Threipland as 'probably belonging to the Grey of the Lower Chalk', which, if correct, would suggest a stratigraphical age in the Early to Mid Cenomanian (BGS FBZs 1-6) (see Figures 1.1 and 3.4) However, this observation has not been corroborated biostratigraphically.

5.5 Palaeontological analysis

5.5.1 *The Backhall Street tesserae*

Four chalk tesserae obtained from the Backhall Street mosaic (CAER_BS_03 to 06) were crushed and processed using the freeze-thaw method described in Chapter 2. However, the results were disappointing and so five further tesserae (CAER_BS_01 to 02, and 07 to 09) were analysed in thin section. This method was much more successful and a large number of species were identified from the thin sections. These are listed in Table 5.1 in Appendix A and are plotted on a foraminiferal range chart in Figure 5.4. Selected images of the foraminifera identified appear in Figure 5.5.

It is difficult to be precise about the age of the chalk from which the Backhall Street tesserae were cut because of uncertainties in the identification of three foraminifera: *Stensioeina exsculpta* cf. *gracilis* (Figure 5.5: 3), *Gavelinella* sp. cf. *clementiana* (Figure 5.5: 4) and *G.* sp. cf. *cristata* (Figure 5.5: 6). In each case, the identification is not absolutely certain because of the cut of the thin section. However, identifying the sub-species *gracilis* for the *S. exsculpta* image is probably correct, although the trochospire (the raised coil) is lower than would normally be expected for this species. The identification of *G.* sp. cf. *clementiana* is also fairly certain, although the species usually has a flatter base than that shown in the image. It is possible, though, that the foraminifer identified as *G.* sp. cf. *cristata* is in fact another specimen of *G. clementiana.* Although the *cristata* identification seems the more likely, discrimination between the two species in thin section relies on being able to examine the specimen in profile, which means that a clean axial cut is necessary (compare the images for these two foraminifera to those in Figure 5.7 for the August Villa Garden tesserae).

Assuming that the identifications of *S. exsculpta gracilis, G. cristata* and *G. clementiana* are correct, it would mean that foraminifera found in four of the five Backhall Street tesserae (CAER_BS_01, 02, 08 and 09) could have coexisted in the interval of time delineated in Figure 5.4 by the overlap in evolutionary range between the first appearance of *Gavelinella clementiana* (in BGS FBZ 20iii) and the last appearance of *Stensioeina exsculpta gracilis* (in BGS FBZ 20iv). However, the fifth tessera (CAER_BS_07, in which *G. cristata* was identified) must have originated from an horizon immediately lower in the chalk succession, as *G. cristata* last appears in BGS FBZ 20i and so is not coeval with *S. exsculpta gracilis* (or other species identified in the other four tesserae). This tessera would therefore have a slightly earlier biostratigraphic age of BGS FBZs 19-21i, based on the first appearance of *Arenobulimina footei* towards the top of BGS FBZ 19 and the disappearance from the stratigraphic record of *G. cristata* slightly later in BGS FBZ 20i.

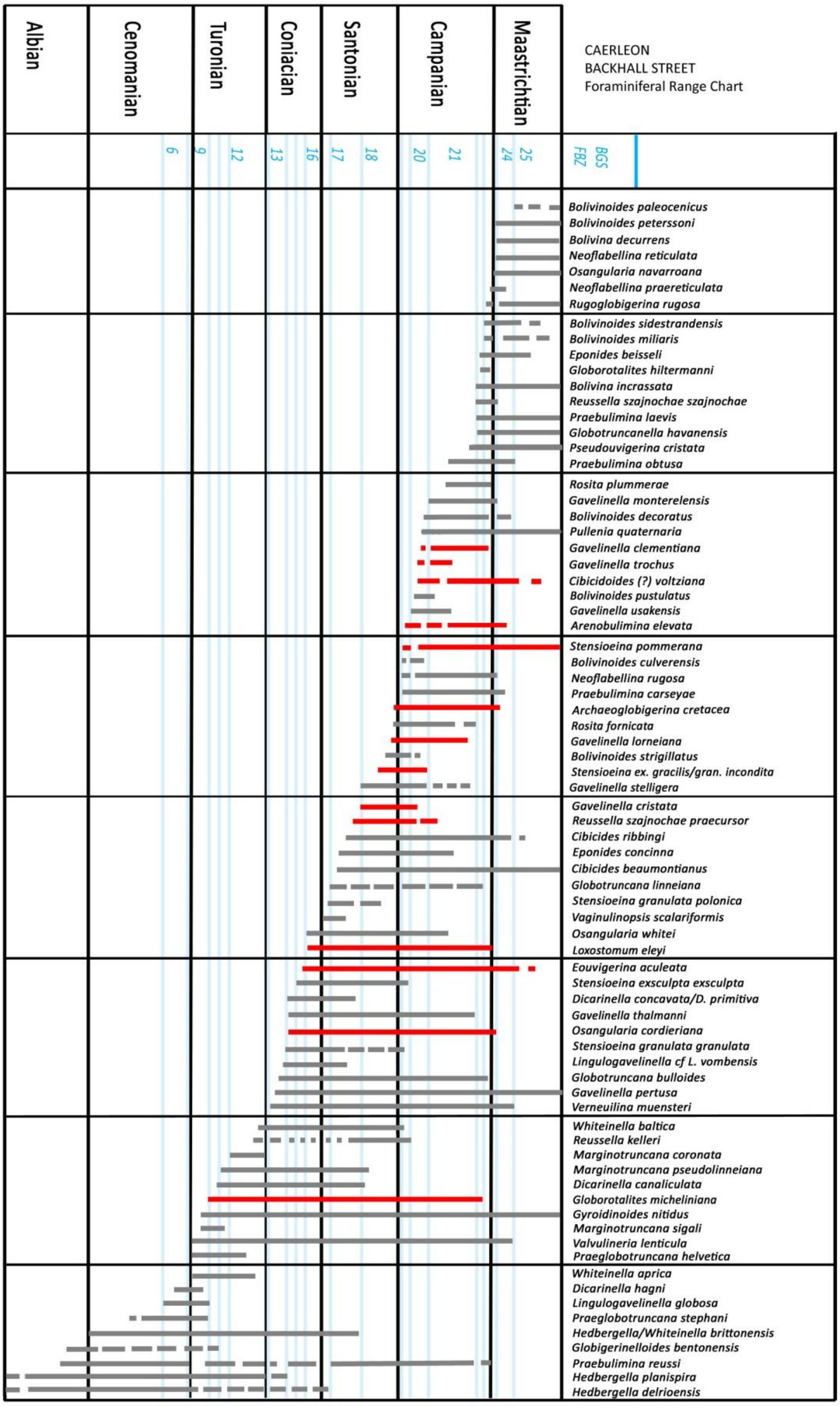


Figure 5.4. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from the Backhall Street mosaic, Caerleon, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

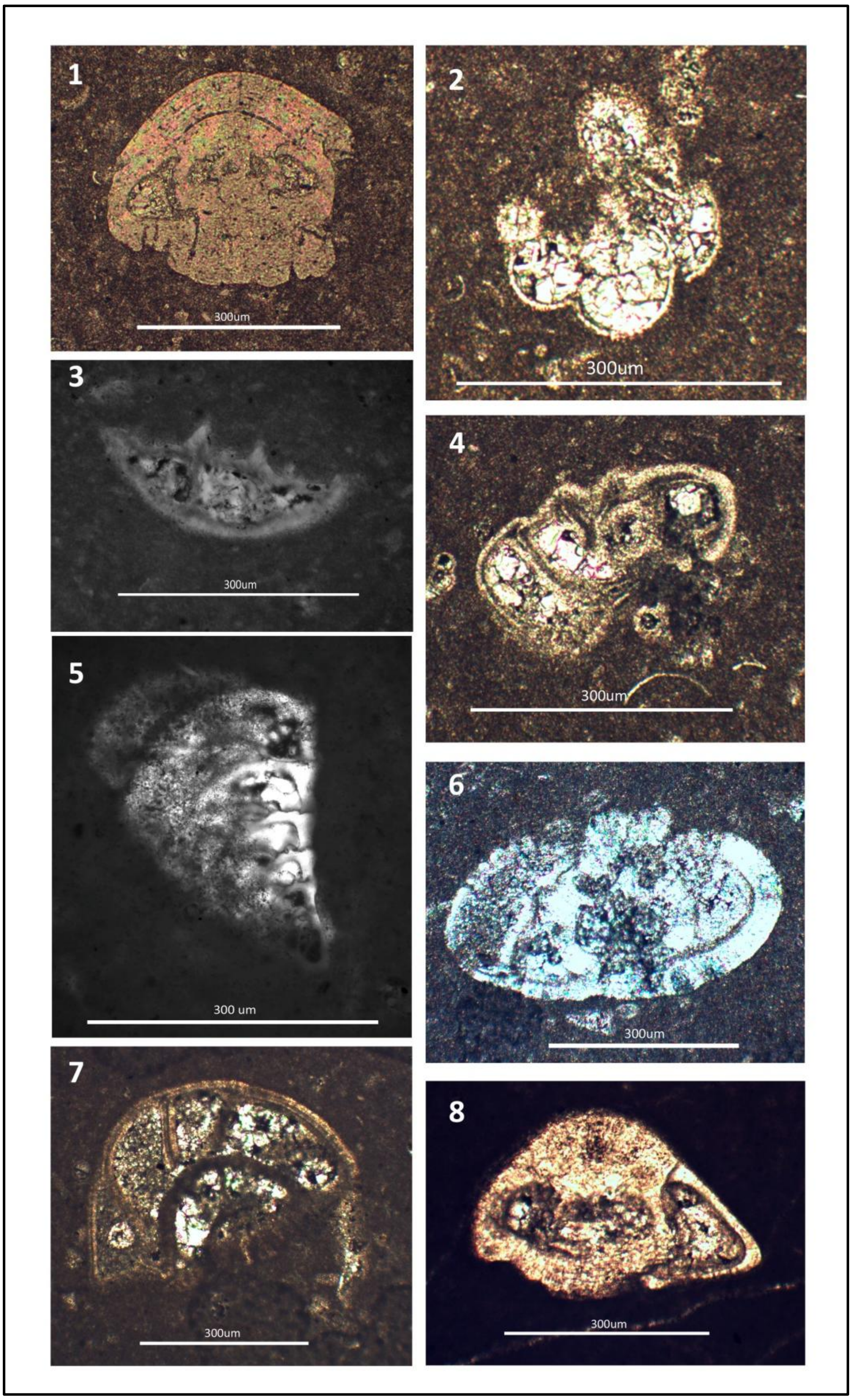


Figure 5.5. Selected images of foraminifera identified in chalk tesserae from the Backhall Street mosaic, Caerleon, Gwent, UK. All scalebars are 300um.

1: *Gavelinella trochus* (CAER_BS_01_29); 2: *Archaeoglobigerina cretacea* (CAER_BS_01_19); 3: *Stensioeina exsculpta* cf. *gracilis* (CAER_BS_02_09); 4: *Gavelinella* sp. cf. *clementiana* (CAER_BS_02_11); *5: Reussella szajnochae praecursor* (CAER_BS_09_17); 6: *Gavelinella* sp. cf. *cristata* (CAER_BS_07_06); 7: *Stensioeina pommerana* (CAER_BS_02_12); 8: *Cibicidoides* (?) *voltziana* (CAER_BS_09_21). [Note that the question mark after *Cibicidoides* indicates taxonomic uncertainty in the attribution of this species to a particular genus and not to uncertainty in its identification in this study].

The above data would give the Backhall Street tesserae a biostratigraphical age in the Late Cretaceous (Campanian) of BGS FBZs 19-20i (for tessera CAER_BS_07) and BGS FBZs 20iii-iv (for the other four tesserae), assuming the identification of *G. cristata* in CAER_BS_07 is correct (if it is not, all the tesserae would be coeval within BGS FBZs 20ii-iv). But as these biozones are very nearly contiguous and might easily have been exposed in the same quarry face, this need not imply that two different chalk sources were involved.

5.5.2 *The August Villa Garden tesserae*

Four of the chalk tesserae found in August Villa Garden (CAER_AV_03-06) were also resistant to the freeze-thaw process and so, as with the Backhall Street tesserae, five further tesserae (CAER_AV_01 and 02, and 07 to 09) were thin sectioned and subjected to foraminiferal analysis. The results are tabulated in Table 5.2 of Appendix A and the foraminifera identified are plotted on a foraminiferal range chart in Figure 5.6. Selected images of the foraminifera identified appear in Figure 5.7.

Figure 5.6 shows that the species identified in the August Villa Garden thin sections are similar to those identified from Backhall Street. As before, the foraminifera identified in four of the five thin sections are coeval within BGS FBZs 20iii-iv (defined in Figure 5.6 by the interval between the first appearance of *Gavelinella clementiana* in BGS FBZ 20iii and the last appearance of *Stensioeina granulata* cf. *incondita* in BGS FBZ 20iv).

However, the fifth tessera (CAER_AV_01) is constrained to the slightly earlier BGS FBZs 19-20i by the first appearance of *Stensioeina pommerana* (in BGS FBZ mid-19) and the last appearance of *G. cristata* (in the sub-zone BGS FBZ 20i). But as stated above in connection with the tesserae from the Backhall Street mosaic, the sub-zones BGS FBZs 20i and 20iii are very nearly contiguous and it is quite possible that the same quarry face could have exposed both horizons. So, again, it is not necessary to postulate two different chalk sources for the tesserae.

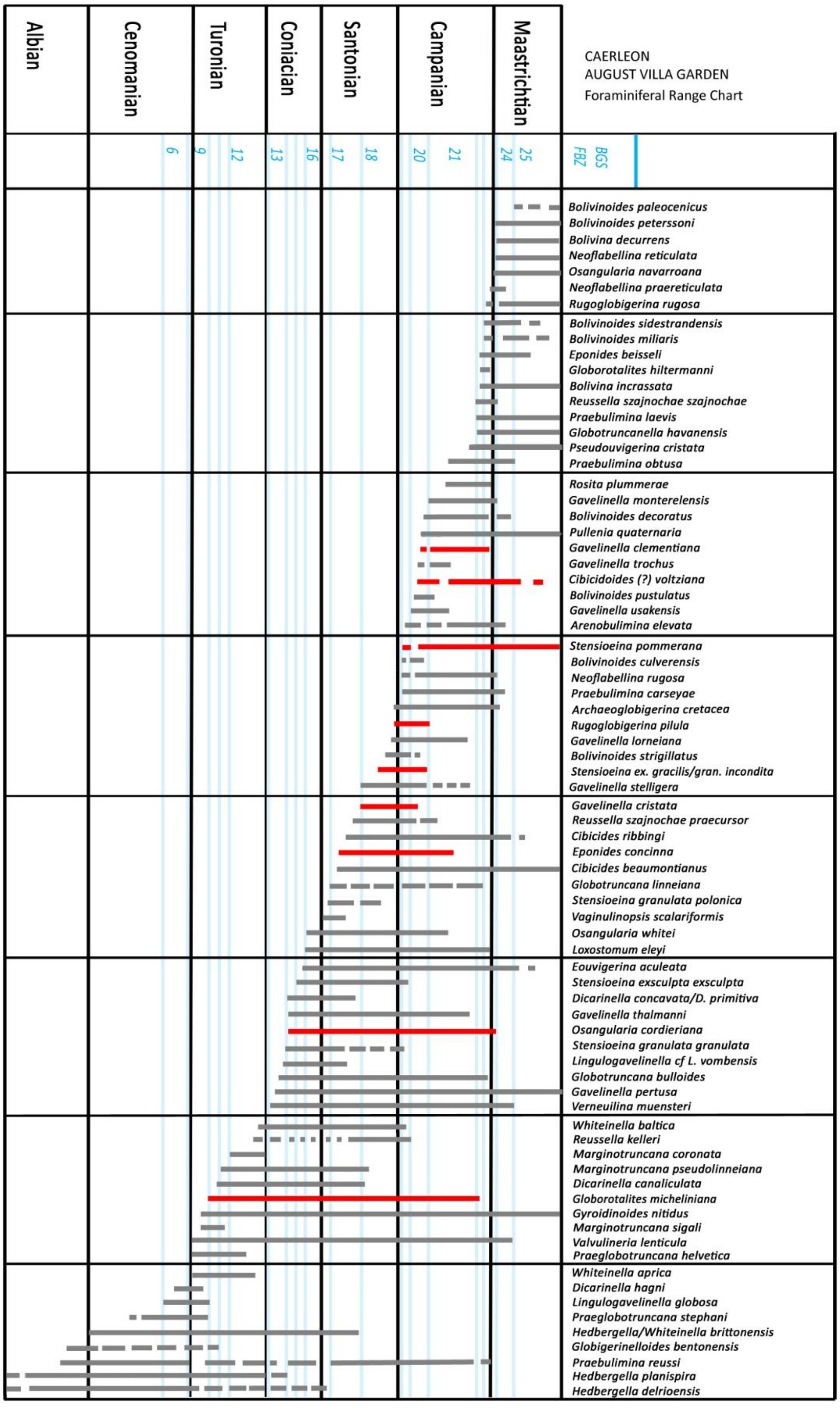


Figure 5.6. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from August Villa Garden, Caerleon, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

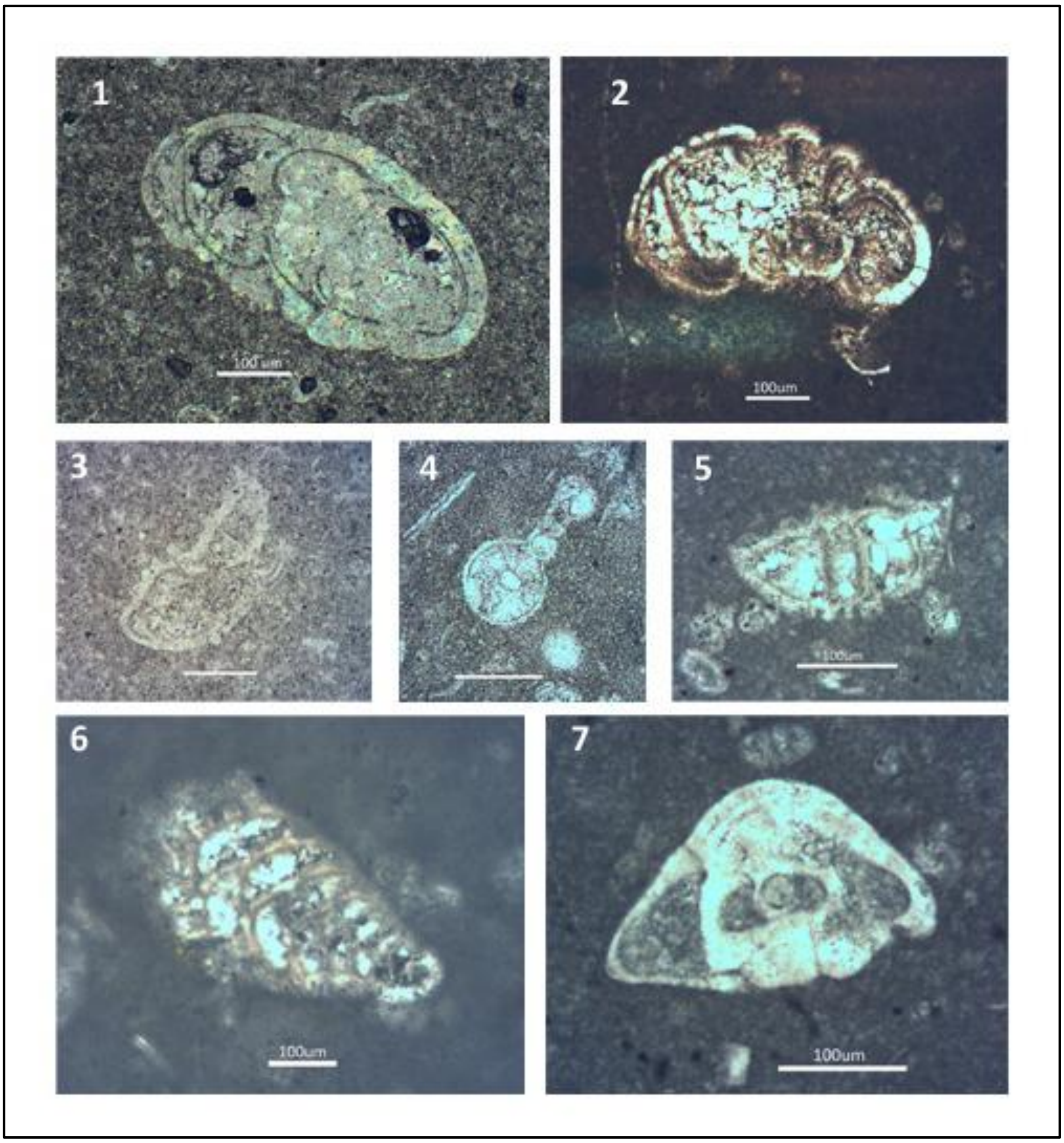


Figure 5.7. Selected images of foraminifera identified in chalk tesserae from the site at August Villa Garden, Caerleon, Gwent, UK. All scalebars are 100um.

1: *Gavelinella cristata* (CAER_AV_01_08); 2: *Gavelinella clementiana* (CAER_AV_09_27); 3: *Stensioeina granulata* cf*. incondita* (CAER_AV_02_15); 4: *Globigerinelloides aspera* (CAER_AV_08_24); 5: *Stensioeina pommerana* (CAER_AV_08_17); 6: *Spiroplectammina* sp. (CAER_AV_09_26); 7: *Cibicidoides* (?) *voltziana* (CAER_AV_08_16).

There are some noticeable similarities between the Backhall Street and August Villa Garden tesserae. They are both hard white chalk; they both include double-sized tesserae; they both have similar biostratigraphical ages in the Late Cretaceous (Campanian); and in both, the micropalaeontological analysis shows that the chalk from one of the tesserae (certainly in the case of August Villa Garden, and probably in that of Backhall Street) has a slightly older biostratigraphical age than that of the other four, suggesting that in both cases the chalk source spanned more than one biozone.

In different circumstances, these similarities might suggest that the Caerleon tesserae were sourced from the same quarry. However, the date of construction of the two mosaics appears to differ by at least a century, and although the foraminiferal assemblages are very similar, they are not identical (*Gavelinella trochus*, for example, was only identified in the Backhall Street tesserae). So it seems unlikely that the chalk used for these two mosaics was sourced at the same time or from exactly the same place. It is clear, though, that chalk of a very similar biostratigraphical age was utilised in both cases.

5.6 Possible chalk sources for the Caerleon tesserae

Analysis of the Backhall Street and the August Villa Garden tesserae above shows that the chalk from which they were cut had a broad biostratigraphical age of BGS FBZ 20. From Figure 3.4 (above), it can be seen that chalk with this biostratigraphical age has its lithostratigraphical expression in the Culver Chalk Formation (for BGS FBZs 20i-iii) and the basal section of the Portsdown Chalk Formation (for BGS FBZs 20iv).

Figure 5.8 shows the main exposure of these two formations in the south of England. The Portsdown Chalk Formation outcrops principally in parts of Dorset, Hampshire and the Isle of Wight, as discussed in Chapter 1 (section 1.3.1). The Culver Chalk Formation outcrops more widely, running south-east from Salisbury along the southern edge of the South Downs to Beachy Head; exposures are also found around Newmarket, but much of the Culver Chalk Formation in the Chiltern Hills and Cambridgeshire is either buried beneath later sedimentary cover or else very patchily exposed.

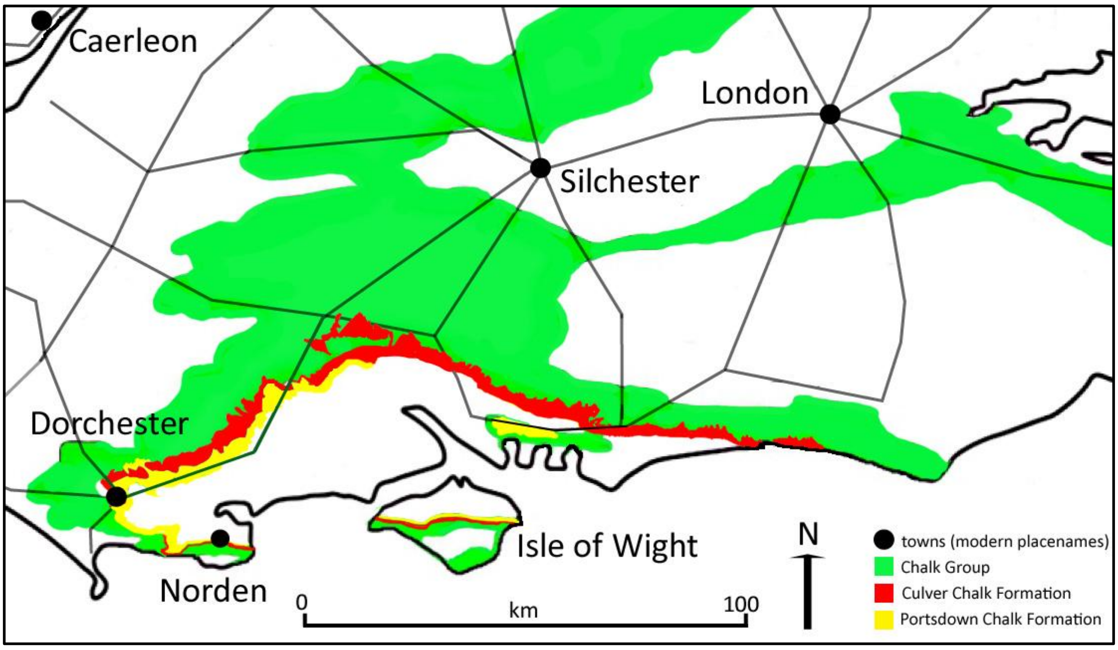


Figure 5.8. Sketch map showing the main exposures of the Culver Chalk Formation (in red) and the Portsdown Chalk Formation (in yellow) in the south of England. The remainder of the Chalk Group is shown in green. The main towns mentioned in the text are marked (modern placenames). The Culver Chalk Formation is also patchily exposed in Cambridgeshire and a few outcrops of BGS FBZ 20 chalk are also found in Norfolk. Geological Map Data © NERC 2013. Roman road data are taken from the Ordnance Survey map of *Roman Britain*, 5th edition (2001).

Chalk with a biostratigraphical age of BGS FBZ 20 is also found in Norfolk, although only close to Wells-next-the-Sea (Swiecicki 1980, Volume 2, 55 and Figure 7.26: BGS FBZ 20 correlates with his B2 zone in column 5). However, chalk of this age is not exposed in the North East (Lincolnshire and Yorkshire) or in the North Downs (Surrey and Kent), so these areas can be eliminated as possible chalk sources for the Caerleon tesserae.

The above evidence suggests that Dorset and the South Downs probably represent the most likely areas in which to find a chalk source for the Caerleon tesserae, as both the Culver Chalk and Portsdown Chalk formations are relatively well exposed in these areas. Unfortunately, though, there is one difficulty with this suggestion. This concerns the fact that the foraminifer *Gavelinella usakensis,* which is a key identifier for BGS FBZ 20 chalks in the south of England, has not been identified in any of the thin sections from either of the Caerleon sites.

It is not known whether the absence of this microfossil in the Caerleon thin sections is significant in determining a possible source for the tesserae. The following three sub-sections (5.6.1-5.6.3) therefore constitute a short digression examining this possibility. These can also be used as a 'case study' to illustrate some of the difficulties encountered in applied microfossil analysis.

5.6.1 *Gavelinella usakensis and the concept of biostratigraphical provinces*

The first appearance of *Gavelinella usakensis* in the chalk record of southern England is taken by biostratigraphers to be the 'key indicator' for the base (start) of foraminiferal biozone BGS FBZ 20. This means that its identification in a chalk thin section is sufficient to assign that chalk biostratigraphically to BGS FBZ 20 or to the succeeding subzone BGS FBZ 21i (the biozones which together encompass the age range of the foraminifer). For example, *G. usakensis* has been identified in chalk tesserae from Silchester and Norden in Chapter 1 (Tables 1.1 and 1.2 in Appendix A); in those from Combley and Newport Roman Villas in the Isle of Wight in Chapter 3 (Tables 3.2 and 3.3 in Appendix A; illustrations are found in Figure 3.8); in the loose chalk block found at Norden (Table 1.3 in Appendix A) and in the Campanian Stage thin section chalk samples taken by the BGS in the Isle of Wight (Table 3.4 in Appendix A). It is therefore surprising that the foraminifer has not been identified in the tesserae from Caerleon, which the palaeontological evidence suggests should be assigned to this biozone.

The absence of *G. usakensis* in the Caerleon thin sections may be significant because it may relate to the concept of Cretaceous biostratigraphical 'provinces'. These are geographical areas of chalk that for geological and/or environmental reasons have experienced different depositional (and hence, faunal) histories. The three provinces found in England – the Northern, Southern and Transitional Provinces – broadly relate to Chalk Group outcrops found in Yorkshire, Lincolnshire and Norfolk (the Northern Province); the Chiltern Hills, the Berkshire Downs and the Marlborough Downs (the Transitional Province); and Dorset, Salisbury Plain and the North and South Downs (the Southern Province) (Mortimore *et al*. 2001, Chapter 1 and Figure 1.15; Hopson 2005, Chapter 1 and Figure 1). The Transitional Province, as its name implies, lies between the North and South Provinces and retains faunal characteristics of both (Figure 5.9).

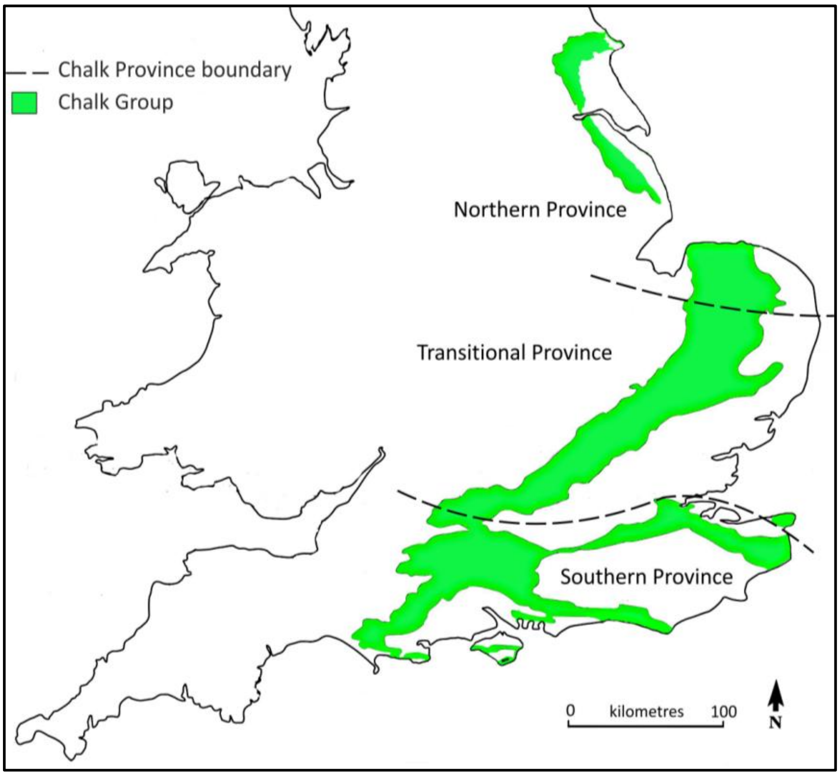


Figure 5.9. Sketch map of England and Wales, showing Chalk Group outcrops (in green) and indicating the position and extent of the Northern, Transitional and Southern Chalk Provinces (dotted lines). Geological Map Data © NERC 2013. Provinces after Hopson (2005), Figure 1.

The significance of these provinces lies in the fact that their different faunal histories mean that taxa found in one province may not appear in another. *Gavelinella usakensis,* for example*,* although very commonly identified in Campanian chalks in the Southern Province, is found extremely rarely in chalks of the same biostratigraphical age in the Northern and Transitional Provinces. Only two recordings in these provinces are known to the author. The first, cited in an unpublished report (Wilkinson 2004) was found at Stiffkey, in northern Norfolk in the Northern Province; the second was found at Claydon in the Gipping Valley, near Ipswich in Suffolk, in the Transitional Province (Woods *et al*. 2007). But in both records, the identification is uncertain.

The virtual absence of *G. usakensis* in Campanian chalks of the Northern and Transitional Provinces suggests that these areas might have supplied the chalk for the Caerleon tesserae. However, two of the five Backhall Street thin sections also contained the foraminifer *Gavelinella trochus* (*see* Appendix A, Table 5.1). This species has not been recorded in Norfolk by Swiecicki (1980) and only once there (tentatively) by Wilkinson (2004). This makes it unlikely that the Backhall Street tesserae were sourced from a Northern Province chalk. But a Northern Province source is a technical possibility for the August Villa Garden tesserae, which did not reveal *G. trochus*, and a source in the Transitional Province might be possible for either site.

Unfortunately, at this point it becomes difficult to pursue the 'Transitional Province' line of enquiry with respect to the Backhall Street and August Villa Garden tesserae, for several reasons. Firstly, exposures of Chalk Group formations in the Transitional Province with a biostratigraphical age of BGS FBZ 20 are uncommon (there are virtually no exposures of this biostratigraphical age between Hampshire and Cambridgeshire, for instance), which means that there are not many potential locations for a possible chalk source for these tesserae. Secondly, large scale geological maps do not always record the boundaries between Chalk Group formations in the Transitional Province because geologists working in the field have not been able to distinguish between (say) the Culver Chalk and Portsdown Chalk formations on the ground. Thirdly, few of the outcrops that are known to exist have been subject to systematic microfossil analysis; in most cases, therefore, we do not know whether or not there are instances in which *G. trochus* but not *G. usakensis* is recorded. The result of these uncertainties is that the question of whether the Transitional Province might be a potential chalk source area for the Backhall Street tesserae has to remain unresolved.

It is to be hoped that future research will clarify these areas of biostratigraphical uncertainty. However, the fact remains that Chalk Group exposures with a biostratigraphical age of BGS FBZ 20 are patchy in the Transitional Province and limited to a few locations in north Norfolk in the Northern Province. It is therefore worth considering whether there might be grounds for considering the more numerous BGS FBZ 20 Chalk Group exposures in the Southern Province as potential source areas for the Caerleon tesserae.

5.6.2 *Possible explanations for the absence of Gavelinella usakensis in thin section*

There are two explanations that could account for the absence of *Gavelinella usakensis* in the thin sections cut from the Backhall Street and August Villa Garden tesserae. The first would put this down to an accident of sampling. Tesserae are very small, and thousands of them may have been used in a mosaic. This means that thin sections cut from other tesserae taken from the same Backhall Street or August Villa Garden mosaic might reveal the 'missing' index microfossil. Against this hypothesis, it could be argued that a total of ten thin sections, representing five tesserae from each site, could be considered a reasonable dataset (comparing well with the number of tesserae investigated from the sites mentioned above – Silchester, Norden, Combley and Newport - that did reveal *G. usakensis*), and that it is something of a coincidence for the chalk tesserae from *both* the Caerleon sites to lack the index microfossil.

A second explanation for the absence of *G. usakensis* in the Caerleon thin sections is that it reflects an accident of environment. Microfossils are not evenly spread throughout chalk facies, and even fauna predicted to be abundant within a particular biozone may be represented patchily in parts of the biostratigraphical record as a result of variation in local environmental conditions. It is possible, therefore, that parts of the Southern Province contain chalks with a biostratigraphical age of BHS FBZ 20 but whose foraminiferal make-up, due to variations in one or more local environmental parameters, does not include *G. usakensis*. One example of this has been found in the Ringwood area of Hampshire, south of Salisbury, in which *G. trochus* but not *G. usakensis* was identified in a chalk sample MPA 49650 (NGR SU 1261 1695) (Wilkinson 2000d, 3). Although this is the only example known to the author, it does prove that local variations in fauna do occur, as all the other samples of chalk of the same biostratigraphical age taken by Wilkinson at the same general location revealed either both or neither of these key foraminifera. It is possible therefore that a similar accident of environment might explain the absence of *G. usakensis* in the Caerleon thin sections.

5.6.3 *Summary of discussion*

It is difficult to decide how much importance should be placed on the absence of *Gavelinella usakensis* in the Caerleon thin sections. Accepting the microfossil's absence as significant would have the advantage that potential chalk source areas could be greatly narrowed down on palaeontological grounds (they would be limited to the few outcrops of the Culver Chalk Formation in the Transitional Province for the Backhall

Street tesserae, and to this area and to coastal north Norfolk for the August Villa Garden tesserae). However, it is clear that there are also possible explanations for the absence of *G. usakensis* in the Caerleon thin sections. So, as it is not yet known whether the absence of *G. usakensis* in chalks of BGS FBZ 20 is significant enough to be correlated to specific geographical locations, it is probably incautious to rely entirely on this finding in determining possible provenances for the Backhall Street tesserae.

In the absence of definitive information, therefore, it seems wisest to adopt a conservative approach and conclude that the Backhall Street and August Villa Garden tesserae originate from a chalk source in the Southern Province whose foraminiferal make-up, for some reason, does not include *G. usakensis*. The identification in their thin sections of secondary indices (*i.e.*, other foraminifera that are important, but not zonal, biostratigraphical indicators) suggests that outcrops of Southern Province chalks having a biostratigraphical age of BGS FBZ 20 (the Culver Chalk and basal Portsdown Chalk formations) represent the most likely source areas for the chalk used to manufacture the tesserae from both sites. We must now consider whether, as with the tesserae from the Vine Street Town House in Leicester (Tasker *et al*. 2013), it is possible to narrow down these potential chalk source areas using archaeological data.

5.7 Archaeological analysis

It is necessary to address firstly the question of how the chalk to manufacture the Caerleon tesserae might have arrived in South Wales, as this should shed light on the availability and degree of use of different transport routes and thereby indicate (or eliminate) some of the possible source areas for the raw material.

5.7.1 *Casual transport by sea*

Murray Threipland (1967, 55) makes the interesting suggestion that the chalk used to construct the barrack walls and that used for the Bear House Field tesserae may have originated in chalk blocks used as ballast, with construction and tesserae-knapping acting as useful secondary activities once the ballast was no longer required. This would imply a one-way trip for the ballast, and Murray Threipland suggested that perhaps it was being replaced by lead pigs or a similar trading commodity from the Caerleon hinterland as the ships travelled in the opposite direction (*ibid*.).

This is an attractive hypothesis that would explain the presence of chalk at Caerleon. It is true that a transhipment of low-density goods such as pottery might require the addition of heavier material as ballast to stabilise the ship and there is little doubt that this practice was utilised in Roman times (see Pearson (2006, 104-5) for a short discourse with examples on the use of ballast in Roman shipping). It is also true that chalk blocks do appear to have been used to knap tesserae for the Fortress Baths mosaics, as waste flakes of chalk were found there in the earliest sediments (see section 5.3.2). However, it is not easy to substantiate this hypothesis from other archaeological evidence.

The first difficulty is that there is no evidence that lead pigs originating from mining activities in the Caerleon hinterland were being shipped southwards (or indeed, in any direction) during the later first century, although considerable evidence survives for the movement of lead pigs originating elsewhere in the province. The best example of the latter activity is perhaps the lead pig produced in the Mendips by *II Augusta* during the reign of Nero (during the period AD 54-68, so before the legion was based at Caerleon) which was found at St Valéry sur Somme in northern Gaul (RIB II.l. 2404.24). However, more than sixty other pigs from various mining localities have been found elsewhere in Britain (*ibid*. 2404, *passim*) and none of these appears to have originated in South Wales. It does not seem likely therefore that either lead pigs or other reasonably high density items, such as iron ore or coal (see section 5.2.1) were being shipped southwards from Caerleon.

A second and more serious objection is the lack of evidence for the use of chalk in construction. It might be expected that the repeated off-loading of ballast associated with a consistent commercial practice would result in large quantities of unwanted (and presumably, therefore, either free or low-cost) material being available for re-use at the point of deposition. However, reports of the most recent excavations carried out in the barracks and southern *canabae* of Caerleon (Guest *et al*. 2012) do not record the widespread use of chalk lumps or blocks for constructional purposes - something that might be expected if this material were freely available during the first century AD, and particularly if the ‘slightly haphazard’ approach to materials procurement suggested earlier by Pearson (*op. cit*., 118) sometimes necessitated an element of constructional opportunism. Similarly, excavation of buildings dating to the second and third centuries have shown the use of chalk in only two of them (the barracks blocks of Murray Threipland’s excavation) as the excavations carried out in Bear House Field (section 5.4.1) do not record chalk being used as a constructional material in either the strip-houses or the courtyard house. This lack of evidence for the casual use of chalk in construction at Caerleon does not suggest that there was a large quantity of chalk ballast freely available at any given time that might have provided a regular source of material for either building or mosaic-making.

It is therefore hard to argue from the above that there was a clear and demonstrable use of chalk ballast at Caerleon. This does not mean that ballast was not being used, or that chalk ballast was not used occasionally, but it does not seem that chalk was arriving in Caerleon in such regular and sufficient quantities that it was being utilised freely for constructional or other purposes. This in turn implies that the chalk needed for the manufacture of tesserae was being obtained through a different and perhaps a more organised and reliable route.

5.7.2 *Transport facilitated by II Augusta*

Fulford has made a convincing argument for the involvement of *II Augusta* in the general supply of goods and materials to the north and west of the province during the second and early third centuries AD and for the likelihood of a Roman fleet operating under its control in the Severn estuary during this time (Fulford 2002, 93-101, esp. Figure 5.13). This conclusion was based primarily on the skewed distribution pattern of South-East Dorset Black Burnished Ware Category 1 (SEDBB1) pottery in the west, a detailed analysis of which had been published in an earlier paper (Allen and Fulford 1996). From the latter, it was clear that the main distribution route for SEDBB1 pottery, which originated in the Poole area of Dorset, was via Ilchester to Crandon Bridge on the north Somerset coast; from here, the pottery might travel either north up the Severn or south via the Bristol Channel to supply the military forces on the northern frontier (*ibid*., 255-60 for discussion and Figure 13 for map of inferred routes). The location of Crandon Bridge is shown on Figure 5.1, above.

Fulford argues (*op.cit*., 94-5) that a direct military involvement by *II Augusta* in the northwards transportation of goods made economic sense because of the need of the army for other products that could be supplied from the same geographical Poole-Purbeck area. These were principally salt, but also shellfish and shale products. Salt in particular was a necessary and highly valued commodity in the ancient world (Gerrard 2008a, and references therein) and would have been a particular need at Caerleon, as it is probable that the ambient estuary water was of too reduced a salinity to develop salterns (Rippon, 2008, 136). Although salt may have been produced in the Somerset Levels close to Crandon Bridge (*ibid*.), its production in the Poole Harbour area is well attested, making it likely that SEDBB1 pottery distribution pattern actually reflects the movement of salt rather than the desire for pottery *per se* (Gerrard, *op. cit*., 121-123). It is also worth recalling the possibility that some of the Backhall Street tesserae may have been made from mudrocks sourced from the Kimmeridge Clay Formation in Dorset (Allen and Fulford 2004, 13-16, 30-34), as we saw above in section 5.3.2.

Fulford's hypothesis concerning the involvement of *II Augusta* in the west coast transportation of goods and supplies could form the basis for an explanation of the origin of the chalk found at Caerleon. We have seen that Chalk Group rocks with a biostratigraphical age of BGS FBZ 20 (the Culver Chalk and basal Portsdown Chalk formations) are widely but relatively thinly spread over Dorset and Hampshire in the south of England. Figure 5.8 shows that the most westerly occurrence of Chalk Group rocks assignable to this biozone is found around and to the north of Dorchester in Dorset. Dorset has already been suggested as a likely source area for the chalk tesserae found at Silchester (see Chapter 1, section 1.3.2) and the industrial site at Norden close by has been recognised as a possible centre for their fabrication during the later first century AD. There are therefore good archaeological reasons for considering Dorset as a possible chalk source for the production of tesserae during the first century AD. However, samples taken from the loose chalk block found at Norden contained the foraminifer *Gavelinella usakensis,* which, as noted earlier, was not found in any of the Caerleon thin sections (section 5.6). If this chalk block was sourced from the locality of Norden – and it may not have been – this would suggest that the chalk local to the Norden ridge may not have been the source for the Caerleon tesserae. We need therefore to consider other possible provenances within the region.

5.7.3 *Dorchester*

One possible alternative source area to Norden might be Dorchester (*Durnovaria*) itself. The town is sited on a chalk plateau bordered to the north and east by the River Frome. Its proximity to Chalk Group outcrops with a biostratigraphical age of BGS FBZ 20 (the Culver Chalk and Portsdown Chalk formations; see Figure 5.10) raises the possibility that chalk for either the Backhall Street or August Villa Garden tesserae could have been quarried from within the town or its vicinity. There is evidence of chalk quarrying in and around Dorchester relating to the later first century AD, as well as to later periods (Table 1 in Appendix D). Some of this activity may represent the causal quarrying of chalk for agricultural or general constructional purposes. However, the extent of local quarrying in and around the town would seem to suggest that a chalk source in Dorchester or its vicinity is at least a possibility.

Alternatively, Dorchester might also have acted as a collection and supply point for chalk products originating in the local area. Dorchester to Ilchester is identified by Allen and Fulford (1996, 257-8) as the second leg of the route taken by SEDBB1 pottery from its source in Poole Harbour to Crandon Bridge (the first leg involving either a sea route to Weymouth or a land route directly to Dorchester). However, the Poole Harbour-Dorchester-Crandon Bridge route does not appear to have been fully in operation until a market developed on the province's northern frontier with the construction of Hadrian's Wall. Excavation at Crandon Bridge, for instance, considered to be a significant staging post on the journey, has not provided any hard evidence for buildings dating before the early second century AD (Rippon 2008), and an analysis by Allen of eight unused, double-sized, hard white chalk tesserae found at the Crandon Bridge site revealed that the four stratified tesserae appeared to relate to either second or third century contexts (*ibid.,* 125-6).

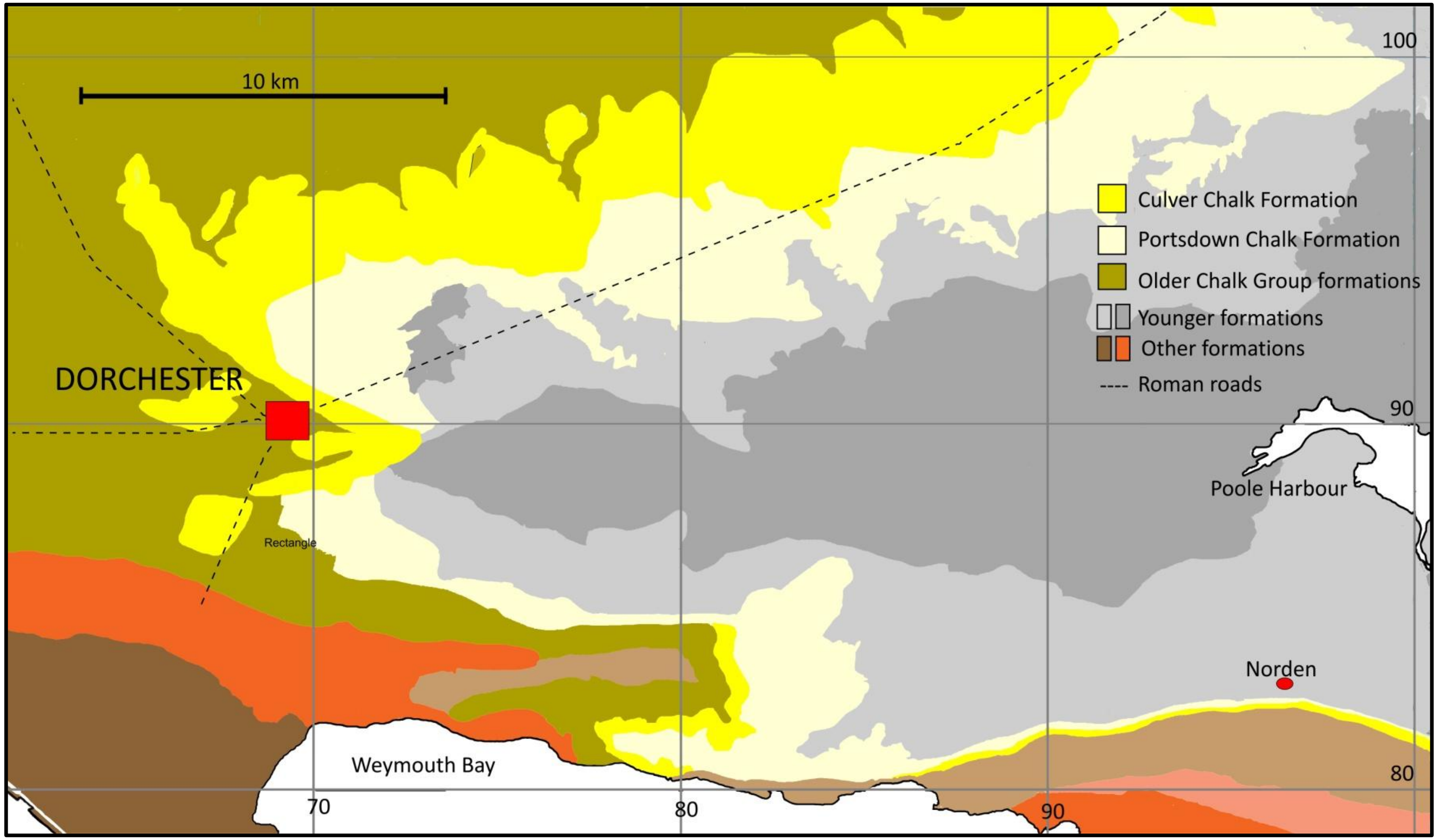


Figure 5.10. Sketch map showing the location of the Culver Chalk Formation, Portsdown Chalk Formation, older Chalk Group formations and other non-Chalk Group formations in the vicinity of Dorchester, Dorset, UK. The Culver Chalk Formation marked on the map includes both the Tarrant and Spetisbury Members. BGS FBZ 20 comprises the Culver Chalk Formation and the base of the Portsdown Chalk Formation. Geological Map Data © NERC 2013. Roman road data data taken from Ordnance Survey map of *Roman Britain* 5th edition (2001).

It is possible that the Crandon Bridge tesserae relate to a (postulated, but as yet undiscovered) higher status building on the site, as painted wall-plaster was also found there (*ibid*., 132). However, their occurrence, as Allen suggests (*ibid*., 126), supports the idea of the settlement at Crandon Bridge acting as a second-to-third century transhipment port. If, as postulated earlier (section 5.5.1), the August Villa Garden tesserae do represent the remains of a mosaic laid in a building constructed around AD 200 in the *intervallum* of the fortress at Caerleon, these dates would fit together rather well. But the Backhall Street mosaic was laid around AD 80, which is significantly earlier than either the main flux of SEDBB1 pottery northwards or the Crandon Bridge archaeological evidence mentioned above. We need to know, therefore, whether this route was in existence any earlier than the second century AD.

There is some evidence that it was. Samples of SEDBB1 pottery have been found in Neronian (AD 54-68) contexts at Usk (Manning, 1993, 64-5, 265) and Purbeck marble decorated the Fortress Baths in the earliest phase, around AD 75 (Zienkiewicz, 1986a, 303-6); both these commodities travelled to South Wales from Dorset. Moreover, it could be argued that the size and complexity of the buildings comprising the southern *canabae* at Caerleon*,* which was contemporaneous with the construction of the fortress, imply that significant quantities of goods and foodstuffs were being transported to the legionary base from the time of its foundation in the mid-70s AD. This suggests that the transportation of chalk tesserae from Dorset to Caerleon for the construction of mosaics for the Fortress Baths (and also, maybe, for pavements in the *canabae:* see section 5.4.1) was indeed a possibility.

The lack of first-century archaeological evidence from Crandon Bridge might be explained by postulating that during the earlier period, goods crossed the Severn estuary from the alternative port of Sea Mills. The harbour at Sea Mills (*Abona*), close to Bristol, which had access to the Severn via the River Trym and faced Caerwent across the estuary, appears to have operated as a military supply port, ferry crossing and trading centre from the 60s AD (or possibly even earlier), so the site was certainly active during the period of construction of the legionary base at Caerleon (Ellis 1987) and either raw chalk or fashioned tesserae for the Fortress Baths mosaics could have been shipped to Caerleon from there.

5.7.4 *Other possible chalk sources*

There remains the possibility that the chalk for the Caerleon tesserae was not sourced from Dorset but from further afield. Figure 5.8 shows that exposures of chalk with a biostratigraphical age of BGS FBZ 20 are found elsewhere in the Southern Province. Exposures of the Culver Chalk Formation are found in the Salisbury-Winchester-South Downs areas of Hampshire and West Sussex and the Portsdown Chalk Formation is exposed at Portsdown, north of Portsmouth. Strong evidence for Roman activity in this area from earliest times is shown by the remains of military installations at Fishbourne and Chichester, which appeared to act as principal supply centres for bases further west at Hamworthy in Poole Harbour and Topsham near Exeter (Cunliffe 1998, 28-31); the area is also well known for its early and elaborate villas, such as Fishbourne (Neal and Cosh 2009, 527-553) and Angmering (*ibid*., 485-6). The one identification of a Southern Province chalk containing *G. trochus* but not *G. usakensis*, as we have seen, occurs in the Ringwood area of Hampshire (section 5.6.2), making this location a possibility for the Backhall Street tesserae in particular. It would have been easy for chalk sourced in Hampshire or West Sussex to have travelled by sea to Dorset for onward shipment to Caerleon. The Isle of Wight is also a possible Southern Province source, as the chalk used to manufacture tesserae for the villas at Newport and Combley (which also had a biostratigraphical age of BGS FBZ 20) was probably local (see Chapter 3). However, the Newport and Combley mosaics are almost certainly early fourth century (so much later than the Caerleon mosaics) and there is no evidence of any large scale chalk quarrying activity on the Isle of Wight at any time, so this is perhaps less likely.

As discussed earlier, a source in the Transitional Province for either the Backhall Street or August Villa Garden tesserae is also not impossible, although it has proved difficult to pursue this possibility due to the reasons given (see sections 5.6.1 - 5.6.3). Finally, Norfolk is also a possible chalk source for the August Villa Garden tesserae. Two inland sites, at Stiffkey and Warham St Mary, near to Wells-next-the-Sea in north Norfolk, expose chalk of the same biostratigraphical age (BGS FBZ 20iii) as that used for the August Villa Garden tesserae (Wilkinson 2004). However, the relevant exposures are too few and too small to have been exploited economically, there is no evidence for chalk quarry operations in this area in Roman times and the area is fairly remote from the Roman road system (and considerably remote from Caerleon). This therefore does not therefore seem to be a very likely possibility.

5.8 Summary

In terms of a source area for the chalk tesserae from Backhall Street and August Villa Garden, it would seem that the Dorchester area of Dorset is capable of satisfying both the geological and the archaeological criteria. The town itself lies both on and close to outcrops of chalk with a biostratigraphical age of BGS FBZ 20 and could have provided chalk for both the Backhall Street and August Villa Garden tesserae; it appears to have acted as a conduit for the movement of SEDBB1 pottery to Caerleon in the second and third centuries AD, and probably for other materials to Usk and Caerleon at an earlier date; and it is also the nearest BGS FBZ 20 chalk source to South Wales. The town and its hinterland therefore represent a ‘best guess’ location for the chalk sources of the Caerleon tesserae. However, this identification would be firmer if it were known that there were some areas of chalk close to Dorchester that contained a sparser-than-expected population of *Gavelinella usakensis*.

Although the proposed ‘army assisted’ mode of delivery is speculative, it is clear that such a system would have considerable advantages for the mosaicists over a chalk source whose availability was determined by the casual arrival of ballast. Both small and large quantities of tesserae could be added to goods already in transit; goods would be travelling from their source along an established, regular and army-maintained route; and transportation costs would be diluted by the volume of goods moving in the same direction, in so far as costs were relevant to the needs of the army. Such a system, therefore, would offer flexibility, security, reliability, convenience and cost effectiveness. So there is perhaps an additional argument for a chalk source in Dorset to be made here on the grounds of practicality.

5.9 Conclusions

Microfossil analysis of chalk tesserae from the Backhall Street and August Villa Garden sites in Caerleon has shown that:

a) The chalk from both sites has a broad Late Cretaceous (Campanian) biostratigraphical age of BGS Foraminiferal Biozone 20. This biozone was identified on the basis of secondary indices, as the index foraminifer (*Gavelinella usakensis*) was not identified in the Caerleon thin sections;

b) BGS FBZ 20 identifies the stratigraphical interval of the Culver Chalk and basal Portsdown Chalk formations of southern England. Chalk of this biostratigraphical age is not found in the North East or in the North Downs, so a chalk source for the Caerleon tesserae in Yorkshire, Lincolnshire, Surrey or Kent is highly unlikely;

c) The identification of *Gavelinella trochus* in the Backhall Street thin sections suggests that Norfolk is an unlikely source area for these tesserae;

d) It is not known whether the absence of *G. usakensis* in chalks having a biostratigraphical age of BGS FBZ 20 is significant in terms of source location. If it is, the most likely source for the Backhall Street tesserae may lie within the Transitional Province and that for the August Villa Garden tesserae within either this Province or Norfolk. If it is not (probably the correct interpretation) the most likely source of the tesserae found at both the Caerleon sites is Dorset;

e) There are difficulties in identifying possible chalk source areas in the Transitional Province due to a lack of geological and palaeontological data;

f) Dorchester or its vicinity is identified as a likely source for the August Villa Garden tesserae, because (i) chalk of biostratigraphical age BGS FBZ 20 outcrops at and close to the town and (ii) Dorchester was on the proposed SEDBB1 pottery Poole Harbour-Severn Estuary 'transport route' operating under the control of *II Augusta* from the second century AD;

g) Dorchester is also identified as a likely source area for the Backhall Street tesserae, because an earlier version of the above route could have supplied chalk tesserae from the local area to the legionary base at Caerleon for use in the Fortress Baths in the later first century AD.

Chapter 6

London

ABSTRACT

Chalk tesserae from six sites in Roman London (*Londinium*) dating to the first and second centuries AD are analysed biostratigraphically and possible provenances for the chalk used are discussed on the basis of the data obtained. Possible correlations between the chalk source and the date of mosaic construction are considered. A Dorset provenance is suggested for tesserae dating to the first century AD and a provenance in Kent (Birchington) or Sussex (Seaford Head) for those dating to the second century.

6.1 Introduction

Roman London (*Londinium*) is a study in its own right. A concise account of the history of the settlement is found in Perring (1991); more recent summaries can be found in *e.g*. Schofield and Maloney (1998) 6-8 and Mattingly (2006) 273-276, but the pace of excavation in London is fast moving. Recent redevelopment in the City has offered significant opportunities to conduct large-scale excavation, for example at One Poultry (Hill and Rowsome 2011) and Bloomberg Place (Symonds 2013), both of which have revealed new data with regard to the early history of the settlement.

The brief historical overview that follows (section 6.2) is therefore provided only in order to set the six sites investigated within a chronology. However, information on the latest excavations is posted on the website of The Museum of London Archaeology Service (MOLAS) (http://www.museumoflondonarchaeology.org.uk) and summaries of current or previous excavations relating to particular sites can be found on the website of the London Archaeological Archive and Research Centre (LAARC) (http://archive.museumoflondon.org.uk/laarc/catalogue) using the Catalogue of Sites tab and either the site name or its LAARC site code. The LAARC site code (*e.g*. WAT78) for the main sites mentioned in the text is given.

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6.2 Historical overview

6.2.1 *Early history*

Londinium appears to be a Roman foundation, although how early the settlement was established is not yet clear. There is no evidence that a settlement existed at the time of the invasion in AD 43, but neither does it seem that the town developed around a military fort established at that time (Wallace 2013). However, a crossing over the River Thames was needed in order to move troops from the main bridgehead and port at Richborough in Kent to other parts of the province, and the site lay at the lowest crossing point of the Thames that also offered the possibility of developing port facilities (Watson *et al*. 2001). The site therefore possessed the twin advantages of intrinsic strategic importance and significant commercial potential, and it seems likely that the combination of these factors provided the driving force for the establishment of the settlement that was to become the provincial capital.

By about AD 50-55, a bridge across the river had been established and it is likely that a settlement was starting to develop by this time. The earliest buildings on the north bank were centred on Cornhill, but the settlement soon expanded westwards across the marshy valley of the Walbrook onto Ludgate Hill. By about AD 60 there was considerable ribbon development along Watling Street towards the west (although, interestingly, less towards the capital at Colchester in the east). The early decision, either planned or pragmatic, to make *Londinium* the administrative and fiscal centre of the province established its importance as a centre for business and commerce (Perring *op. cit.;* Rowsome 2008).

A systematic programme of new building was instituted under the Flavian emperors (AD 69-96) in the decades following the sacking and burning of the settlement in the Boudican revolt of AD 60-1. The new building transformed the town: public baths and the first forum-basilica were built and an extensive waterfront with mass storage facilities was constructed along the north bank of the Thames; a second waterfront at Southwark reflected the growth of trade and settlement on the south bank. Further development took place in the early second century (*c.* 100-130 AD), during which time the forum-basilica was remodelled to become the largest building in Roman

Britain and the marshy Walbrook valley was drained and reclaimed for industrial development (Perring *op. cit.;* Rowsome *op. cit*). However, not all of this development was well executed. Excavation of the second forum-basilica and its associated buildings at Leadenhall Court (LCT84) in 1984-6, for example, showed that some of the underpinning of the basilica was poorly done and that several of the buildings were later affected by subsidence and required a succession of repairs (Brigham 1990; see, for example, 66-7).

6.2.2 *The second and third centuries AD*

The early vigour of the settlement seems not to have lasted much beyond the middle of the second century. The reasons for this are debated, but a contributing factor must have been the serious fire that swept through the settlement during the reign of Hadrian (AD 117-138), probably at some time between AD 120 and 130. This was not the first fire to affect *Londinium*; the Leadenhall Court excavation, for example, found evidence for three separate episodes of burning, none of which appears to have been the actual Hadrianic fire (Brigham *op. cit.,* 81-3). Also, not all of the settlement was affected; the administrative complex, suburbs and workshops in both Southwark and the Walbrook industrial quarter seem to have escaped the blaze. Nevertheless, the town's earlier vitality does not seem to have reasserted itself after the conflagration. Excavation of the second forum-basilica, for instance, has showed that although the building had been restored by the end of the second century, it appeared to have become neglected by the early third, and by the late third or early fourth century it had been demolished and its site levelled (*ibid*. 72-3, 81-2). As Brigham points out (*ibid*. 92-4), this degree of neglect of the central business area raises some serious questions about the economic health of the settlement.

Perring (*op. cit.*) proposed that this apparent loss of vibrancy may have been due to a reduction in commercial demand by the military. Not only were the garrison's material needs being met locally from a stable and settled province, but its disposable income was becoming progressively reduced because of devaluation of the coinage by the imperial treasury. A probable reduction in the numbers of military stationed in the province during the early third century AD also may have contributed to the decline in regional and long-distance trade in the province (Fulford 1991, 44). If this analysis is correct, it is not difficult to believe that it might seriously have undermined the commercial basis for the prosperity of *Londinium.*

Nevertheless, some prosperity remained: stone city walls were constructed in the late second century and during the third, many of the clay-walled houses that had replaced the earlier first-century timber buildings were themselves replaced with larger houses built in stone. Some of these larger houses included mosaics laid by the London 'Acanthus' *officina* (workshop), which was operating in the town at this time (Johnson 1993, 159). But despite this modest revival, *Londinium* does not seem to have regained its former prominence, and the later archaeological record suggests a slow but persistent depopulation. Towards the end of the fourth century, many of the houses in the settlement appeared to have been abandoned and much of the town was apparently being used for agricultural purposes, and by the fifth century there was little evidence of occupation (Perring *op. cit.,* chapters 6-8).

6.2.3 *The six sites and their tesserae*

The tesserae examined for this thesis were obtained from six sites in London: 41 Eastcheap, 5-12 Fenchurch Street, Harp Lane, 60 London Wall, 1 New Change and The Pinnacle (Crosby Square). Tesserae from the six sites were made available through the generosity of the Museum of London Archaeological Service. Figure 6.1 shows the locations of the six sites; a summary of their details appears in Figure 6.14. LAARC code numbers for these sites and for others discussed are given in the text.

The earliest tesserae are those from Fenchurch Street, which have a probable context date of AD 80-91. This makes the mosaic from which they derive broadly contemporaneous with the Backhall Street mosaic laid in the Fortress Baths at Caerleon (discussed in the previous chapter). Tessellation at such an early date is not unusual for London: Neal and Cosh (2009) record a number of mosaics from sites dating to the later first century, including those from the extensive public baths at Huggin Hill (DMT88) and the complex of buildings (the so-called 'palace') underlying Cannon Street Station (LYD88), both of which date to the Flavian period (AD 69-96) (*ibid.* 419-420 and 408-410 respectively). However, the earliest evidence for

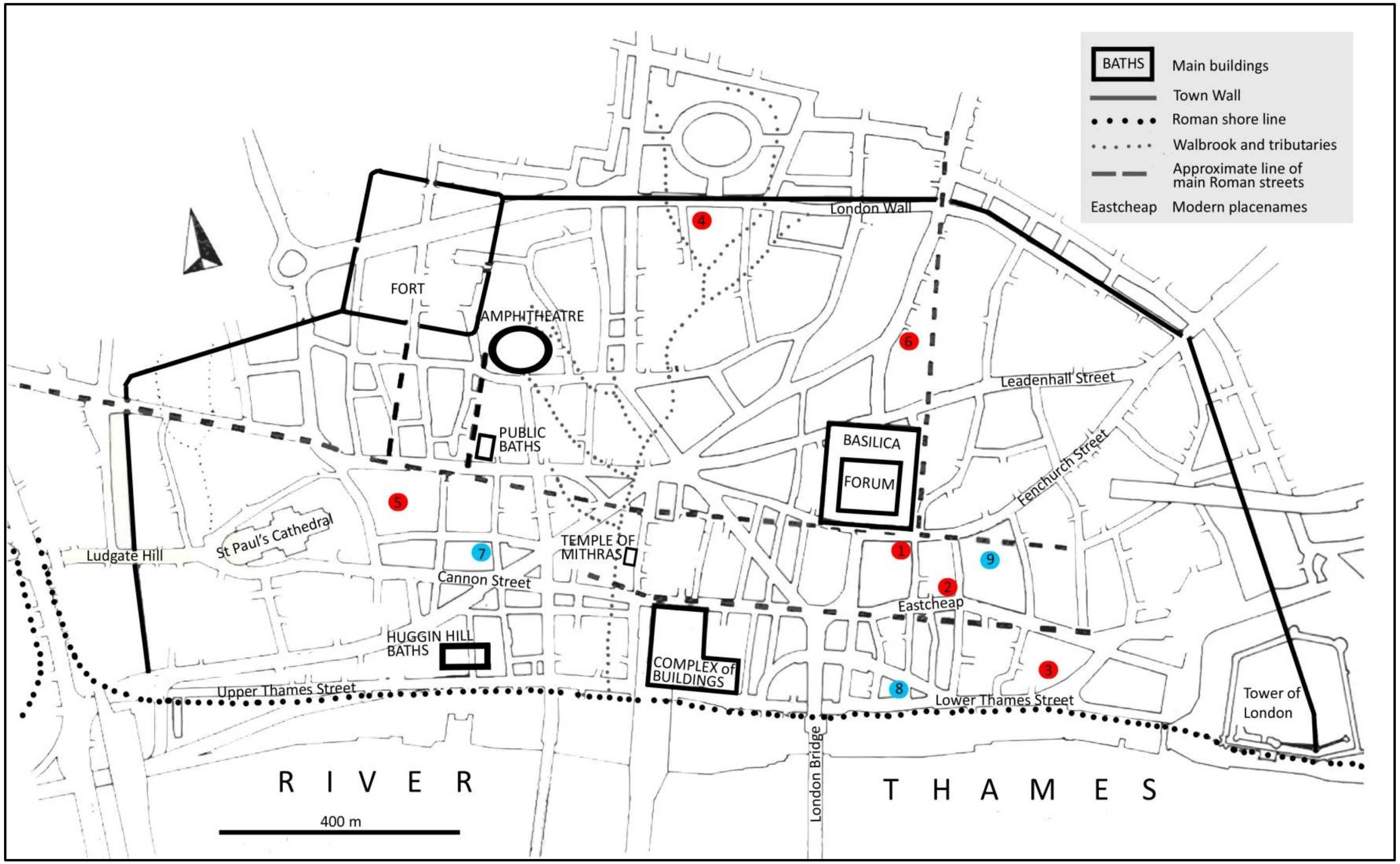


Figure 6.1. Sketch map of Roman London, showing the position of the six sites investigated for this thesis (in red) and other sites mentioned in the text (in blue).. 1: Fenchurch Street; 2: Eastcheap; 3: Harp Lane; 4: London Wall; 5: New Change; 6: The Pinnacle; 7: Watling Court; 8: Peninsula House; 9: Plantation Place. Map based on that found at http://followthecreativepath.blogspot.co.uk/2011/01/roman-london.html (permission requested) and updated using information supplied by MOLAS.

tessellation comes from a series of town houses at Watling Court, west of the Walbrook (WAT78) (*ibid.* 399, 449-452), which date to before AD 85. Excavation at Watling Court revealed mosaics in seven out of the eleven rooms and also found fragments of painted plaster showing traces of Egyptian Blue (Perring and Roskams 1991, 85-7 (wall plaster) and 88-94 (mosaics)). Finds such as these attest not only to the availability of tessellation in *Londinium* at this time, but also to a considerable degree of private prosperity during the later first century AD. Indeed, stylistic elements in the Watling Court mosaics suggest that continental mosaicists, possibly from Rheims, may have been employed in their construction (Neal and Cosh *op. cit.,* 399).

Tesserae from three of the other sites investigated in this study (Harp Lane, London Wall and New Change) appear to date to the mid second century AD, although those from Harp Lane might possibly be earlier (see section 6.5). The tesserae from the fifth and sixth sites (The Pinnacle (Crosby Square) and Eastcheap) cannot be more closely dated than to AD 70-200 because of the lack of context, but are probably also second century. Neal and Cosh record mosaics from a number of other second century sites, such as those at Gresham Street, Birchin Lane and Milk Street *(ibid.* 417-418, 405-406 and 431-432 respectively). However, surprisingly little evidence for tessellation was found during excavation of the second-century second forum-basilica at Leadenhall Court (LCT84), even though the uncovering of considerable amounts of painted plaster suggested a building of quality (Brigham 1990).

In the following sections (6.3 – 6.8), a description of each site and information on the context in which the tesserae were found is given, followed in each case by the results of the palaeontological analysis carried out on the chalk and illustrations of the key foraminifera identified. A short summary section then follows (section 6.9). Possible provenances for the chalks identified are then discussed in section 6.10.

6.3 5-12 Fenchurch Street (FEN83)

The earliest of the six sites (5-12 Fenchurch Street) dates to the period of revival of the settlement after its destruction by Boudica in AD 60-61. The site lies close to the centre of *Londinium*, immediately south of the main east-west road through the Roman city and opposite the south-east corner of the forum (Site 1 on Figure 6.1). It comprises a series of some thirty buildings whose ages span nearly the whole period of the Roman occupation to around AD 350 (Schofield and Maloney 1998). The earliest, pre-Boudican timber buildings date to the time of Nero (AD 54-68) and are associated with high-class ceramic imports. The site then appears to have been carefully cleared after the Boudican fire and a large aisled building, nearly 20m long and at least 11m wide, was erected on pile foundations as part of the Flavian building programme. The aisled building was attached to a series of smaller rooms, which were developed and redeveloped over the years and show signs of having been used as shops or workshops; one of them, a kitchen, appears to have been decorated with a considerable amount of painted wall plaster (Rhodes 1987). The site was destroyed by the Hadrianic fire (*c*. AD 120-130), but there is evidence of later residential occupation in the mid third century AD and then sporadic usage afterwards.

6.3.1 *The Fenchurch Street tesserae*

The Fenchurch Street chalk tesserae were found in a dump deposit outside and to the west of the aisled building (Building 12a) (Hammer 1987). The context level (1651) consisted of hard white chalk and mud-brick tesserae, large fragments of flint and medium to coarse pebbles. White chalk tesserae were also recorded in the adjoining levels. The tesserae are described as rectangular (approximately 25 x 15 x 15mm in size), a description closely matching those analysed for this study, and are contextually dated to the late first century AD. The mostly likely date is *c.* AD 80-91, but an earlier date (AD 61-74) is also a possibility; a later one (AD 119-149) is less probable (*ibid*.). The excavation report states that the tesserae appeared to be unused and lay within the make-up layer either as wasters or as a pebble-like consolidation of the ground. No trace of a floor to which they might relate was found within Building 12a or elsewhere on the site, causing them to be described as ‘something of a puzzle’ by the excavator.

There are two possible explanations for the ‘puzzle’ of these unused tesserae. The first hinges on the fact that the site lies very close to the south-east corner of both the first forum basilica and its later (remodelled and extended) namesake. On the assumption that the floors of the main public building in the settlement were tessellated, if only simply, it is tempting to suggest that perhaps unwanted or otherwise loose tesserae were made available (or salvaged or, indeed, purloined) and subsequently used as part of the make-up for the foundation of the Fenchurch Street aisled building. Indeed, similar 'purloining' has been suggested with regard to the calcite component of the mortar and the cinnabar component of the paint found in the fragments of painted wall plaster recovered from the kitchen on the Fenchurch Street site (Morgan 1992, 85, 258-9), which were also something of a surprise find in a relatively humble context.

Unfortunately there are some difficulties with this suggestion. The first is the question of dating. The first forum-basilica is thought to have been constructed *c*. AD 70, and work on the second, much larger, one was not started until *c*. AD 90-100 and not completed until about thirty years later. This places the constructional date of the first forum-basilica a little too early, and that of the second a little too late, for any direct 'purloining' to have been an obvious source of material for the Fenchurch Street building (although it must be noted that this problem disappears if either the earlier (AD 61-74) or the later (AD 119-149) alternative context date for the tesserae is adopted).

There is also a problem with considering the second forum-basilica as a potential source of unused tesserae. Excavation on the Leadenhall Court site (LCT84) did not reveal any direct evidence for tessellation, although the considerable amounts of painted wall plaster discovered suggest a high-status building (Brigham 1990, 70-3). Brigham suggests that this may be because some of the floors recorded as *opus signinum* may originally have been the base for tesserae that were removed when the floors were replaced. Loose red and white tesserae were found in most phases of the excavation, but it was not possible to state with certainty that that these were not accidental introductions (*ibid.* 73). Although it is difficult to believe that the main floors of such an important public building were not tessellated, the ambiguity of the evidence is not helpful in determining whether unused tesserae might have been available for re-use elsewhere.

However, a later excavation on the same Leadenhall Court site did uncover hard, white chalk and grey shale tesserae, as well as fragments of imported marble wall veneer, in deposits associated with a series of relatively humble clay and timber buildings that pre-dated the second forum-basilica (Milne and Wardle 1993, 44-5, 57). As there was no evidence for tessellation in these buildings, it appeared that the chalk tesserae and marble veneer fragments had originated elsewhere. The authors suggest that the source of this high-status material may have been waste material obtained either from a known (but undated) major reconstruction of the first basilica, or from the demolition or refurbishment of an undiscovered building nearby (*ibid.* 59, 151). Either of these interpretations could fit with the AD 80-91 context date for the Fenchurch Street material and explain the puzzle of the unused tesserae.

The excavation at Plantation Place (FER97) illustrates the sort of high-status building that could have been a source of material (Brigham 2001). The site (31-35 Fenchurch Street; Site 9 on Figure 6.1) is about 200m east of the site at 5-12 Fenchurch Street. Excavation produced quantities of loose and consolidated tesserae, suggesting the presence of two mosaics dating to the late first or early second century AD. There was also evidence for chalk tesserae knapping on site, in the form of loose chalk blocks from which tesserae had been cut and waste stone material embedded in white lime mortar that appeared to have acted as a foundation for the mosaics (Neal and Cosh 2009, 415-6 and Figures 385-7). Further excavation on the same site in 2000 produced evidence for timber-framed buildings dating from *c*. AD 70 and also high quality painted wall plaster and mixing boxes for paint (Brigham *op. cit.*). Mudstone tesserae with a source in the Kimmeridge Clay Formation of Dorset were also identified at two different levels from the site (Allen and Fulford 2004, 27).

However, although it is clear that constructional activity of this kind could have been a source of unused or discarded tesserae, there is no evidence that the tesserae found at 5-12 Fenchurch Street were obtained from the site at Plantation Place. Proximity to the first forum-basilica therefore suggests that this known, but undated, first century major reconstruction is the most likely source of material.

6.3.2 *Fenchurch Street palaeontology*

Seven tesserae from the Fenchurch Street site were examined for microfossils. Four of these (LON_FS_01, 02, 09 and 10) were thin sectioned and three others (LON_FS_03 to

05) were processed using the freeze-thaw technique (see section 2.2.2). A few poor-quality microfossil samples were recovered from the processed chalk tesserae, but these could not be identified. Species identification was therefore carried out using images from the four thin sections. The species identified are listed in Table 6.1 in Appendix A and plotted on a foraminiferal range chart in Figure 6.2. Selected images of the foraminifera identified are illustrated in Figure 6.3.

Figure 6.2 shows that the foraminifera identified included several species typical of the Mid Campanian Stage of the Upper Cretaceous (*Gavelinella usakensis, G. clementiana, Bolivinoides* sp. cf. *decoratus* and *Eponides biconvexa)*, and two less common species, *Reussella szajnochae praecursor* and *Pseudouvigerina* sp. cf. *plummerae*. Other longer ranging species included *Arenobulimina footei, Gavelinella pertusa* and *Gyroidinoides nitidus.* The identification of both *Reussella szajnochae praecursor* and *Bolivinoides* sp. cf*. decoratus* constrains the biostratigraphical age of the chalk to the foraminiferal subzones BGS FBZ 20iv-21i, within which all the species identified could have been coeval.

Figure 3.4 shows that chalk of this biostratigraphical age in the UK (BGS FBZs 20iv- 21i) has its lithostratigraphical equivalent in the lower Portsdown Chalk Formation. Exposures of this formation in the UK are limited (Figure 5.8). However, the Portsdown Chalk Formation is found in Dorset, the Isle of Wight and in parts of Hampshire, and there are a few outcrops in Wiltshire and Sussex. Possible source areas for the Fenchurch Street tesserae based on this information are discussed in section 6.10.

6.4 41 Eastcheap (EAE01)

The earliest occupation on this site comprised several Early Roman quarry pits and timber buildings whose remains had been sealed by a layer of fire debris, probably representing the Boudican fire of AD 60-1 (Greater London Archaeology Advisory Service Quarterly Report 2005). The first or early second century buildings built over the debris had also been destroyed by fire, probably the Hadrianic fire of AD 120 to 130. In the later Roman period (third century AD), a masonry building (Building 29) was constructed on the site. The location of 41 Eastcheap is shown as Site 2 on Figure 6.1.

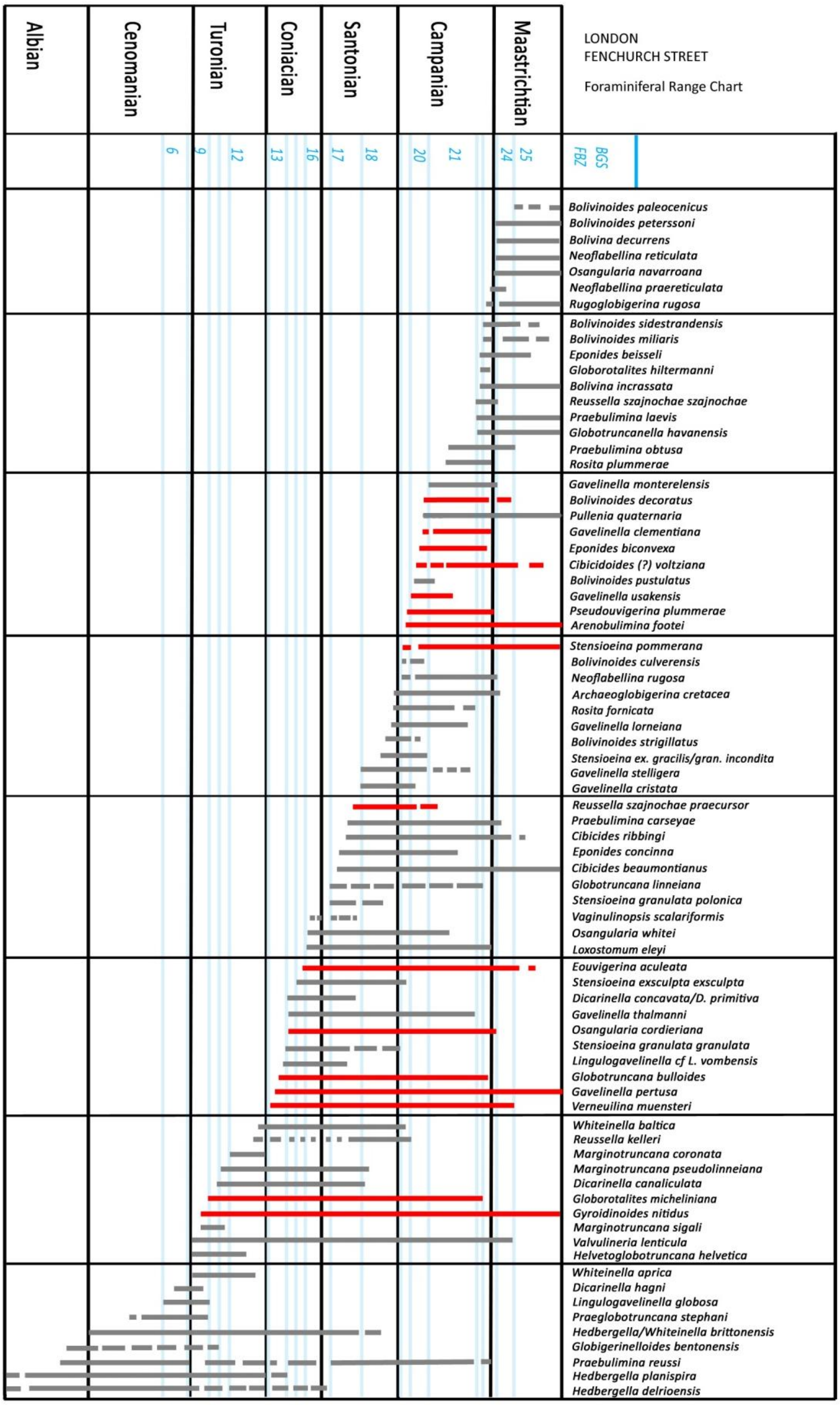


Figure 6.2. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from the site at 5-12 Fenchurch Street, London, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

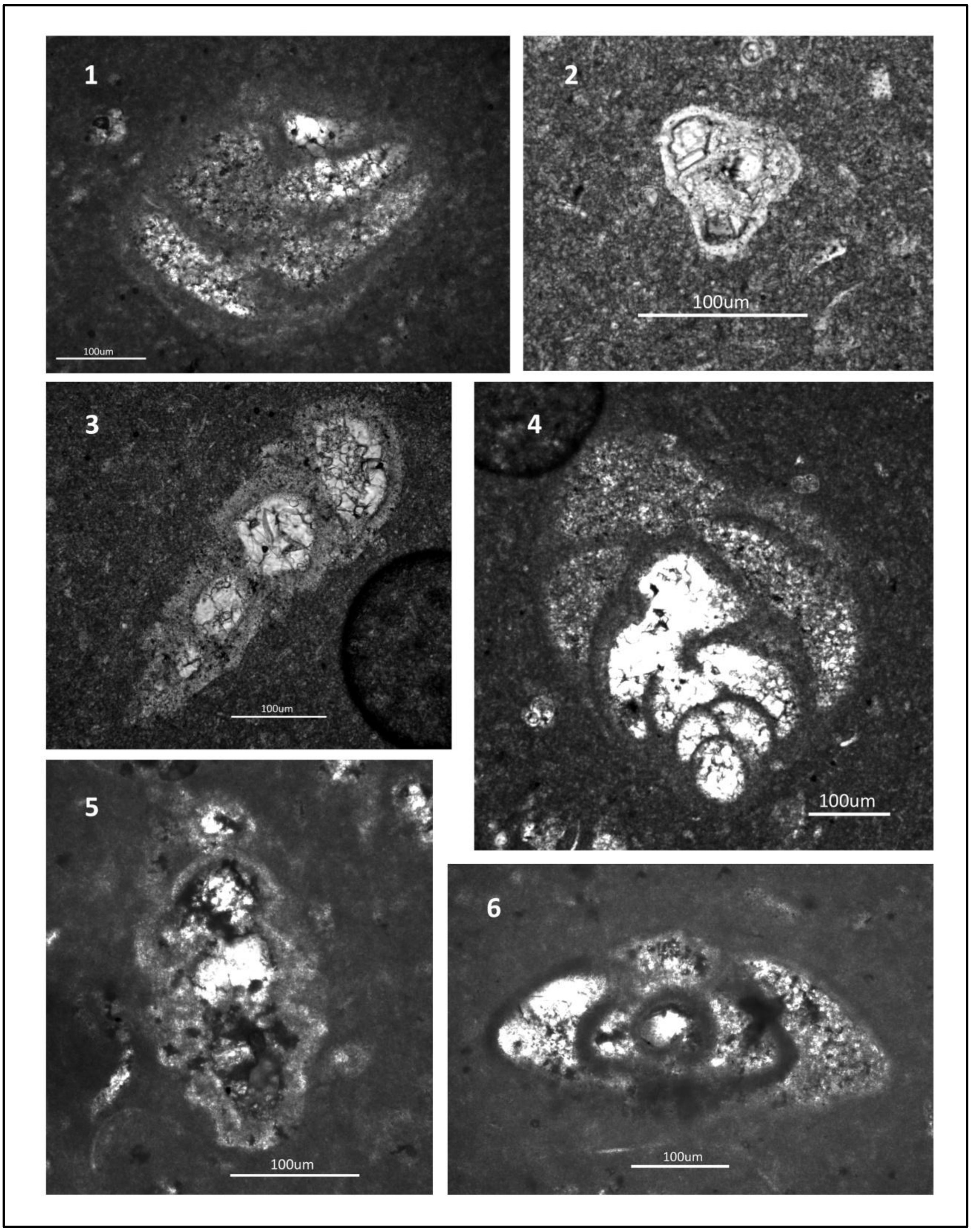


Figure 6.3. Selected thin section images of foraminifera identified in chalk tesserae from Fenchurch Street, London, UK. All scalebars are 100um.
1: *Verneuilina muensteri* (LON_FS_01_15); 2: *Pseudouvigerina* sp. cf. *plummerae* (LON_FS_01_22); 3: *Bolivinoides* sp. cf. *decoratus* (LON_FS_01_23); 4: *Arenobulimina* sp. cf. *obliqua* (LON_FS_01_27); 5: *Eouvigerina aculeata* (LON_FS_09_02); 6: *Gavelinella usakensis* (LON_FS_09_23).

6.4.1 *The Eastcheap tesserae*

The tesserae obtained from the Eastcheap site were found in demolition debris associated with the construction of the third-century masonry building (Ian Betts, MOLAS, pers. comm.). The debris included over 100 pieces of stone and tile, as well as very large numbers of tesserae, suggesting that they had been derived from a building of quality and substance. The archaeological context (184) suggested that the tesserae represented the remains of a floor that pre-dated the masonry building and which was probably laid at some time between AD 70 and AD 200. However, a more precise date for the parent mosaic cannot be determined with any certainty.

6.4.2 *Eastcheap palaeontology*

Ten tesserae were obtained from the Eastcheap site, of which three (LON_EC_01, 02 and 03) were thin sectioned and a further three (LON_EC_04, 05 and 06) were processed using the freeze-thaw technique. The chalk used for the tesserae splintered easily. Microfossil recovery from the processed material was poor and no genera could be identified with certainty. However, two of the three thin sections (LON_EC_01 and LON_EC_02) revealed a number of identifiable species. The species identified are listed in Table 6.2 in Appendix A and plotted on a foraminiferal range chart in Figure 6.4. Selected images of the foraminifera identified are illustrated in Figure 6.5.

Figure 6.4 shows that the species of foraminifera identified were mostly long-ranging. However, the overlap in range between the first appearance of *Eponides* sp. cf. *concinna* and the last appearance of *Hedbergella brittonensis* constrains the chalk used for the Eastcheap tesserae to the foraminiferal biozones BGS FBZs 17ii-18ii (the only time-period in which all the species could have coexisted). This dates the chalk source biostratigraphically to the Mid Santonian Stage of the Upper Cretaceous.

From Figure 3.4, it can be seen that chalk of this biostratigraphical age is represented lithostratigraphically by the highest Seaford and lowest Newhaven Chalk Formations in southern England, and by the Flamborough Chalk Formation in the North. The Santonian chalk outcrops of the Flamborough Chalk Formation are limited to coastal cliff exposures around and to the south of Flamborough Head (Mortimore *et al*. 2001,

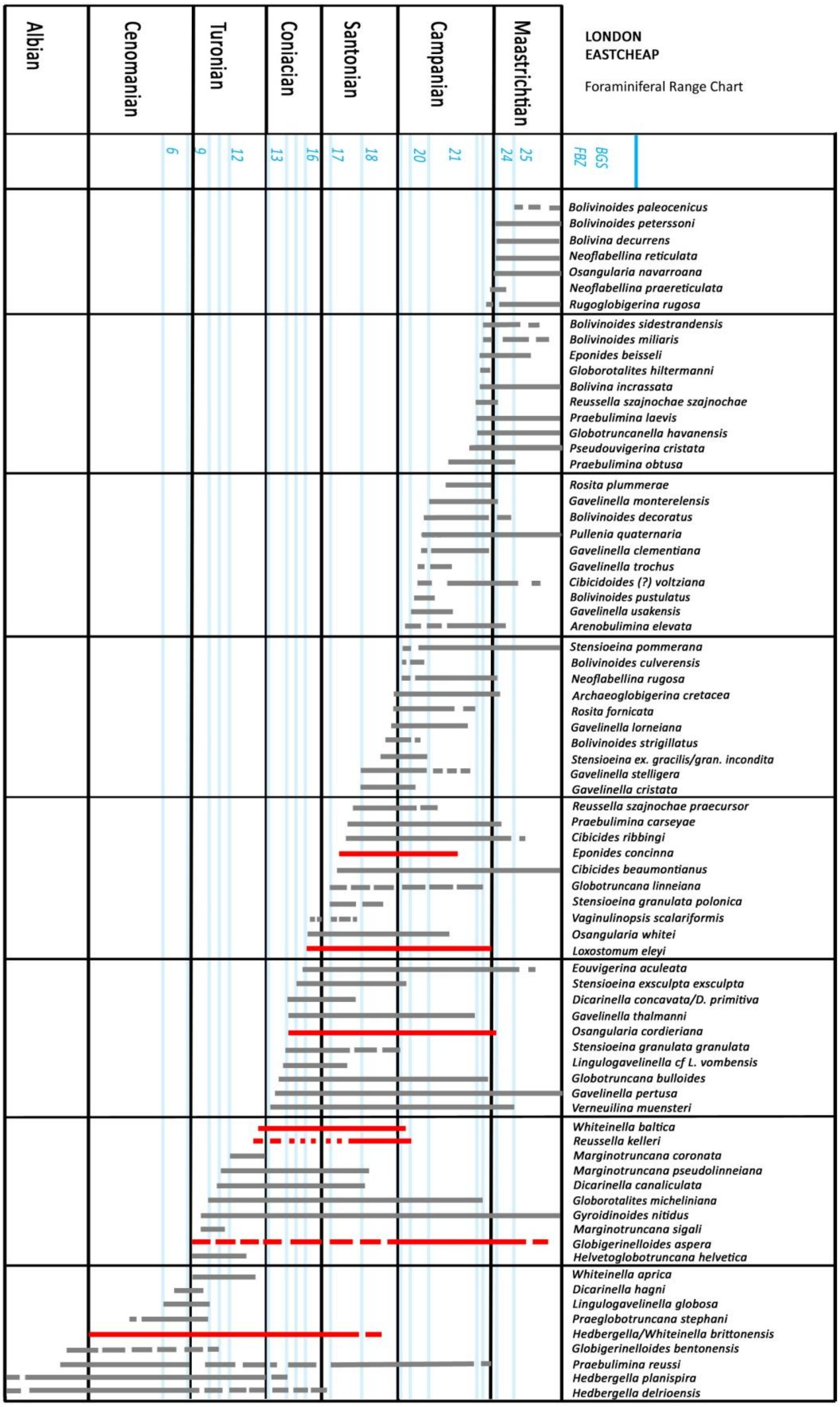


Figure 6.4. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from the site at 41 Eastcheap, London, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki (1980). BGS Foraminiferal Biozones after Wilkinson 2011*a.*

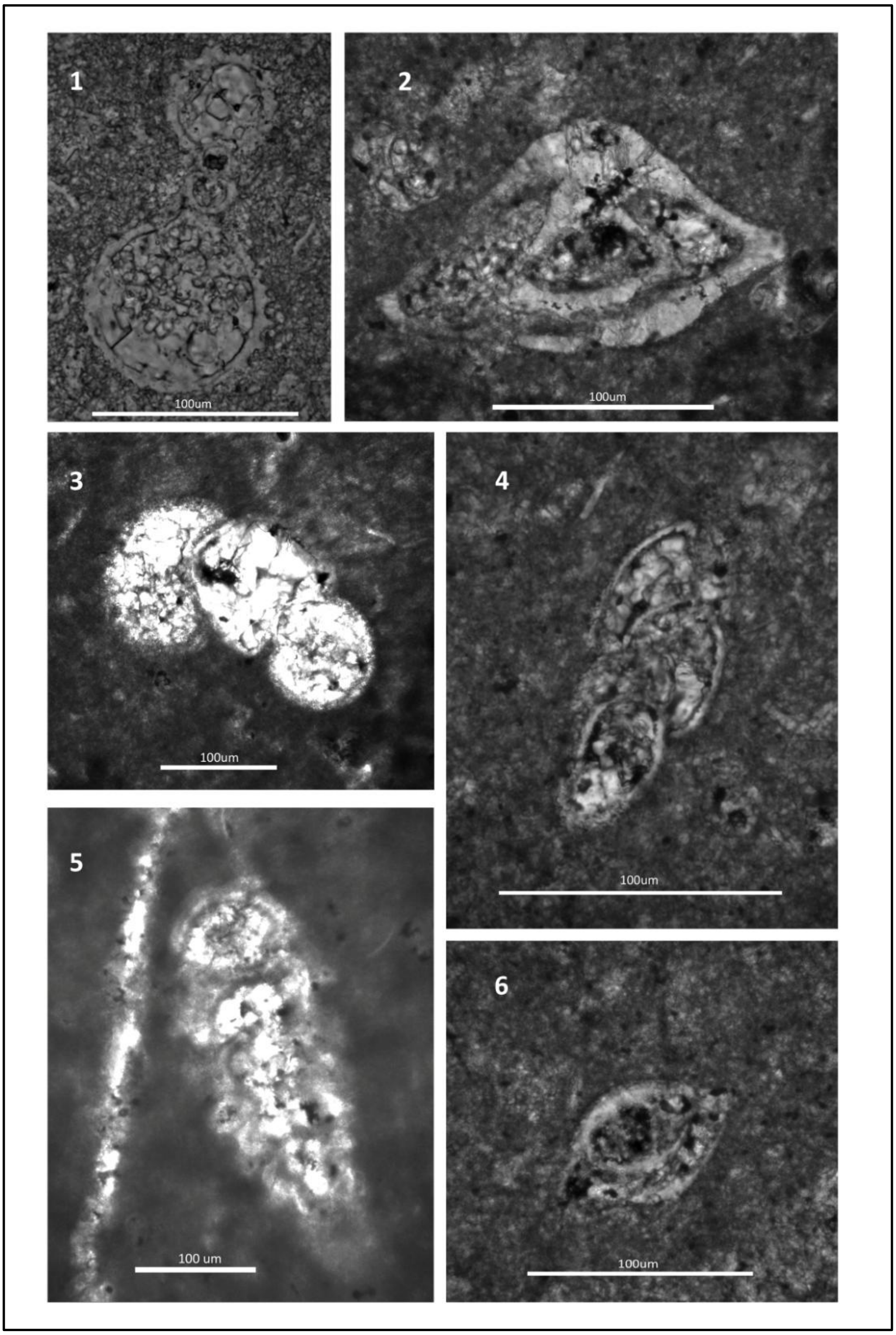


Figure 6.5. Selected thin section images of foraminifera identified in chalk tesserae from 41 Eastcheap, London, UK. All scale bars are 100µm.

1: *Globigerinelloides aspera* (LON_EC_01_06); 2: *Eponides* sp. cf. *concinna* (LON_EC_01_29); 3: *Whiteinella baltica* (LON_EC_02_03); 4: *Loxostomum eleyi* (LON_EC_01_31); 4: *Reussella kelleri* (northern form: see Swiecicki 1980, 317) (LON_EC_01_11); 6: *Osangularia* sp. cf. *cordieriana* (LON_EC_01_30).

427-429 and Figure 5.19), but the Seaford and Newhaven Chalk Formations in the south of England are widespread, comprising large parts of the South Downs, the Marlborough Downs and the Chilterns. The nearest source to London, however, is in the North Downs, some 20km to the south and east. Discussion of potential chalk sources for the Eastcheap tesserae based on this information is found in section 6.10.

6.5 Harp Lane (HL74)

The Harp Lane site (Site 3 on Figure 6.1) lay on terraces overlooking the Roman waterfront in London, the line of which is thought to have run broadly along the modern Lower Thames Street, about 100m or so inland from the present shoreline (Bateman and Milne 1983). The earliest structures on the Harp Lane site were replaced in the late second or early third century by two stone buildings (Buildings A and B), both of which had tessellated floors and one of which (Building B) had a hypocaust. Between these two buildings lay a terraced courtyard or passage which terminated against a revetment wall to the south (Boddington and Jones 1982). The two buildings appear to have been residential; if so, they would have had an excellent view across the Thames toward Southwark.

The floor in Building A consisted of plain red tesserae, laid on a roughly mortared floor which overlay a clay make-up layer containing pottery sherds and many small tesserae. Building B had a fine red tessellated floor in a hypocaust room; fragments of Purbeck marble and imported marble inlays were noted amongst the rubble associated with its collapse, suggesting a building of some quality. Contextual evidence suggests that the construction date of Building A was no earlier than AD 180-200 and may have been as late as AD 220-230. Building B is assumed to be either contemporaneous or slightly later. The buildings were used throughout the third century AD, but by the later fourth both were disused and had been robbed of their constructional material (*ibid*.).

6.5.1 *The Harp Lane tesserae*

The tesserae examined for this study were found in the clay make-up layer of Building A (Context 135). This contained 149 very small tesserae of various materials: dark grey shale (69), hard white chalk (68), grey Kentish Ragstone (7) and red ceramic building material (CBM) (5), as well as a mosaic fragment consisting of three red and two white CBM tesserae of normal size (Pringle 1990a). Redeposited pottery sherds contained in the clay layer dated from around AD 50 to about AD 150, suggesting that the tesserae probably represented the residue of floors laid at some time between these dates. The smallness of the Harp Lane tesserae examined (four were about 13 x 15mm and six were about 10 x 10mm) suggests fine tessellation in the parent mosaic.

There was no evidence on the Harp Lane site for a paved floor dating to this time from which the tesserae might have come (Boddington and Jones *op. cit*.). However, it is possible to put forward a suggestion. In 1979, a large (40 x 30cm) mosaic fragment was recovered from an excavation on the nearby site at Peninsula House (Neal and Cosh 2009, 429-30 and Figure 404). Peninsula House (PEN79; Site 8 on Figure 6.1) is about 200m west of the Harp Lane site. The mosaic fragment in question contained a banded pattern of fine (12mm) dark grey and white tesserae set into a thick base of *opus signinum.* It was a stray find within dumped material and gave no clue as to its origin. Neal and Cosh consider that it was originally part of a very large apsidal or circular room within a public bath house, as a thick *opus signinum* base layer is typical of bath house flooring, but as no evidence for a bath house was found on the site, the authors conclude that the fragment probably derived from a large public building such as the baths at Huggin Hill (*ibid.* 420), some 800m to the west (Figure 6.1). As a dark grey and white scheme is common on later first-century geometric pavements in London, the authors tentatively date the Peninsula House fragment to this time (*ibid.* 430).

It is possible that Neal and Cosh's 'bath house' explanation for the origin of the Peninsula House mosaic fragment might also be applied to the Harp Lane tesserae. The similarities are suggestive. The two sites (HL74 and PEN79) are geographically close; the tesserae found are, in both cases, small and almost exclusively dark grey and white; both sets of tesserae were found in a make-up layer dating to the late first or early second century AD; neither set appears to have originated on the site on which they were found. It seems possible, therefore, that the tesserae in both cases may have originated from the same third source. If this hypothesis is correct, it suggests that the Harp Lane tesserae may also represent the residue of a fine quality geometric floor laid in the late first century AD. Interestingly, excavation on the site of the Huggin Hill baths has produced evidence of dark grey and white tessellation from a mosaic dating to the late first century that was destroyed by the mid second century (*ibid.* 419-20). However, this does not prove that the Harp Lane tesserae were derived from this source, which lies almost a kilometre to the west, but the suggestion remains an interesting possibility.

6.5.2 *Harp Lane palaeontology*

Six chalk tesserae from the Harp Lane site were processed using the freeze-thaw technique (LON_HL_03 to 08) but no microfossils were obtained. Thin sections were therefore cut from two of the remaining tesserae (LON_HL_01 and 02) and species identification was made from these. The species identified are listed in Table 6.3 of Appendix A and plotted on a foraminiferal range chart in Figure 6.6. Selected images of the foraminifera identified in the Harp Lane thin sections are shown in Figure 6.7. The foraminifera identified included *Stensioeina* sp. cf. *exsculpta gracilis,* the planktonic species *Whiteinella baltica* and several longer-ranging species such as *Eouvigerina* sp. cf. *aculeata* and *Gyroidinoides nitidus*. The first appearance of *Stensioeina exsculpta gracilis* and the last appearance of *Whiteinella baltica* constrain the chalk to the upper part of BGS FBZ 18 and the basal part of BGS FBZ 19 and date it biostratigraphically to the Upper Santonian and Lower Campanian Stages of the Upper Cretaceous. The identification of *Globotruncana* sp. cf. *arca* (if correct) would restrict this range to BGS FBZ 19 (in the Lower Campanian), as this species does not appear in the stratigraphic record until then. However, *G. arca* is known to be rare in its initial appearances (Wilkinson 2011, 847) and its identification in this thin section is not absolutely certain. The more cautious interpretation is therefore to retain the range of BGS FBZs 18iii-19.

As Figure 3.4 shows, a biostratigraphic age of BGS FBZs 18iii-19 gives the chalk a lithostratigraphical position in the Newhaven or Flamborough Chalk formations. Chalk relating to this formation is found widely over the south of England and coastal exposures are found in the North East. However, as with the tesserae from the Eastcheap site, above, which relate to similar biozones (BGS FBZs 17ii-18ii), possible local sources also exist. These will be discussed in section 6.10.

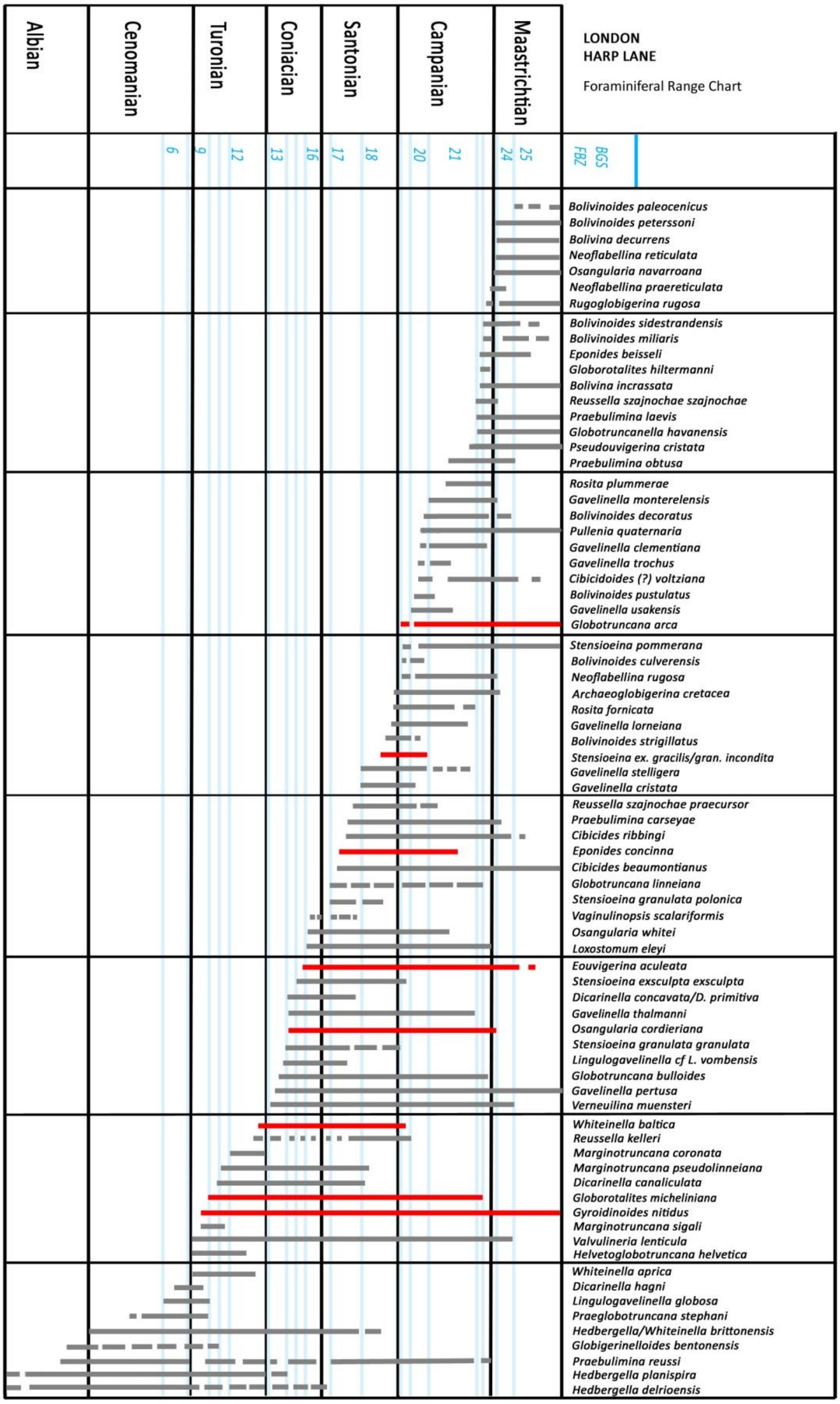


Figure 6.6. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from the site at Harp Lane, London, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

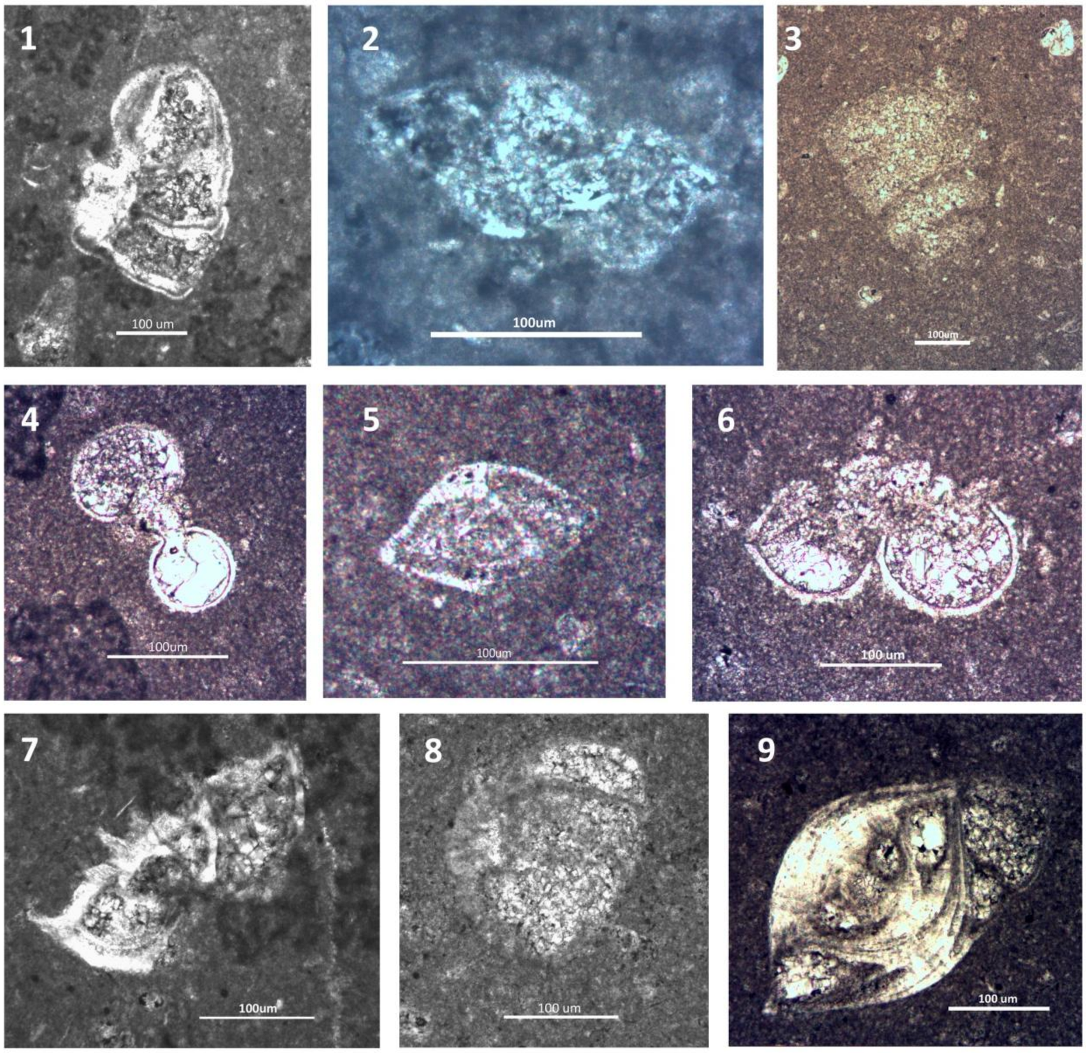


Figure 6.7. Selected thin section images of foraminifera identified in chalk tesserae from Harp Lane, London, UK. All scale bars are 100µm.

1: *Globorotalites micheliniana* (LON_HL_01_13); 2: *Globotruncana* sp. cf. *arca* (LON_HL_01_11); 3: *Marssonella* sp. cf. *trochus* (LON_HL_02_06); 4: *Globigerinelloides aspera* (LON_HL_02_03); 5: *Osangularia cordieriana* (LON_HL_02_08); 6: *Whiteinella baltica* (LON_HL_02_04); 7: *Stensioeina exsculpta* cf. *gracilis** (LON_HL_01_03): 8: *Gyroidinoides nitidus* (LON_HL_01_12); 9: *Eponides* sp. cf. *concinna* (LON_HL_02_02).

*It is possible that this image represents *Stensioeina exsculpta exsculpta* and not *S. exsculpta gracilis.* This is because the *gracilis* sub-species normally has a higher spire. It is considered that the lack of this is due to the cut of the thin section. However, an identification of *S. exsculpta exsculpta* would make no difference to the biostratigraphical age calculated above for the Harp Lane chalk tesserae, as the last appearance of this species in the stratigraphical record is in BGS FBZ 19 (see Figure 6.6).

6.6 60 London Wall (LOW88)

The site at 60 London Wall was excavated in 1988 (Site 4 in Figure 6.1). It is situated in the north-west part of the upper Walbrook valley, an area that was drained and reclaimed for industrial and residential purposes by the Romans in the early second century AD (Maloney 1990). Industrial activity in the Walbrook valley appears to have focussed on trades such as leatherworking, ironmongery and glass foundries (Woodger and Orton 1989), creating considerable down-stream debris; this is now being revealed in the finds from the large-scale excavation currently taking place at Bloomberg Place in the lower Walbrook valley (Symonds 2013).

The earliest activity on the London Wall site appeared to be land reclamation alongside a tributary of the Walbrook. Second-century strip-buildings backed onto the tributary and fronted onto gravel roads running across the site. The buildings had clay walls with painted wall plaster. Most of the pottery found on the site dated to the mid second century AD and the majority of finds were related to commercial activities, particularly leatherworking (Schofield and Maloney 1998; Woodger and Lees 1989).

6.6.1 *The London Wall tesserae*

Excavation on the site recovered 55 tesserae of hard chalk, 5 of shale, 3 of Kentish Ragstone and several of reused brick or tile. The loose tesserae were associated with a well-compacted make-up layer (Context 1249) underlying a clean and undisturbed floor in the earliest phase of one of the buildings (Structure 8). The make-up layer included, apart from tesserae, pieces of chalk, fragments of tile and mortar, silt, sand, and occasional oyster shells. Fragments of painted wall plaster were also recovered. The pottery assemblage suggested a Hadrianic-Antonine date for the tesserae (*c*. AD 120-160) (Pringle 1990b).

6.6.2. *London Wall palaeontology*

All except one of the chalk tesserae obtained from the London Wall site were coarsely rectangular (typically, about 15 x 25mm). Their larger size enabled two thin sections to be cut from one of them (LON_LW_01a and 01b). A second tessera (LON_LW_02) was also thin sectioned. All three thin sections revealed foraminifera. Three further tesserae (LON_LW_03 to 05) were processed using the freeze-thaw method, but only a few indeterminate foraminifera were obtained. The foraminifera identified in the thin sections are listed in Table 6.4 in Appendix A and plotted onto a range chart in Figure 6.8. Images of several of the key species appear in Figure 6.9 (a) and (b).

Foraminiferal analysis revealed that the biostratigraphical age of the two chalk tesserae that were thin sectioned was not the same. In the first thin section (LON_LW_01), the species identified are long-ranging, but the coexistence of both *Stensioeina pommerana* and *Whiteinella baltica* restricts the biozone in which they are found to the basal part of BGS FBZ 19. This gives the chalk a biostratigraphical age in the Early Campanian Stage of the Upper Cretaceous. However, the second thin section (LON_LW_02) contains the index species *Cibicidoides* (?) *voltziana* and *Globorotalites micheliniana,* which gives this chalk a later biostratigraphical age of BGS FBZs 20ii-22. It is not possible to assign the two thin sections to the same biostratigraphical age because the evolutionary ranges of *Whiteinella baltica* and *Cibicidoides* (?) *voltziana* do not overlap. This is clear from Figure 6.8, in which the evolutionary ranges of the foraminifera identified in the two thin sections LON_LW_01 and LON_LW_02 are shown in red and blue respectively.

In theory, it is possible that the quarry face from which the chalk was obtained spanned both biozones. This would account for the difference in biostratigraphical age of the chalks. However, although chalk of basal BGS FBZ 19 is represented lithostratigraphically by the upper part of the Newhaven Chalk Formation, which forms much of the chalk downlands of southern England, outcrops of BGS FBZ 20ii-22 are represented only by the Culver and Portsdown Chalk formations, which have a much more limited exposure (Figure 5.8). Possible quarry locations spanning both biozones are therefore few in number. It seems more likely therefore that the difference in biostratigraphical age between the London Wall tesserae is the result of their being obtained from unrelated chalk sources. Chalk tesserae found in a make-up layer might well have been obtained from different (demolished) buildings and so have different sources, and this would account for the difference in biostratigraphical age found.

Possible provenances for the London Wall tesserae are discussed in section 6.10.

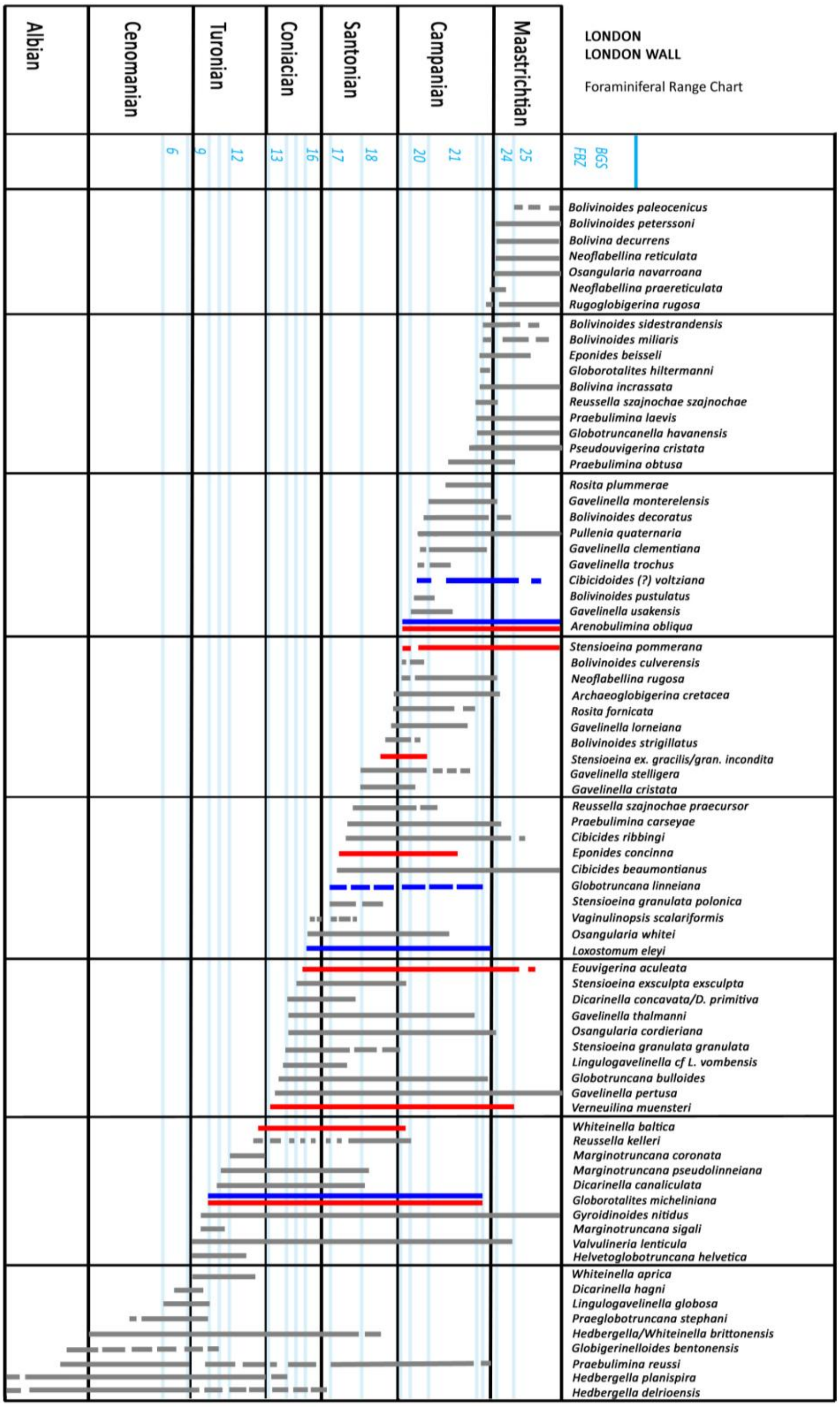


Figure 6.8. Foraminiferal Range Chart (red, deep blue) and BGS Foraminiferal Biozones (blue) for chalk tesserae from the site at 60 London Wall, London, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.* Note that the foraminifera identified in tessera LON_LW_01 are marked in red, whilst those identified in tessera LON_LW_02 are marked in blue.

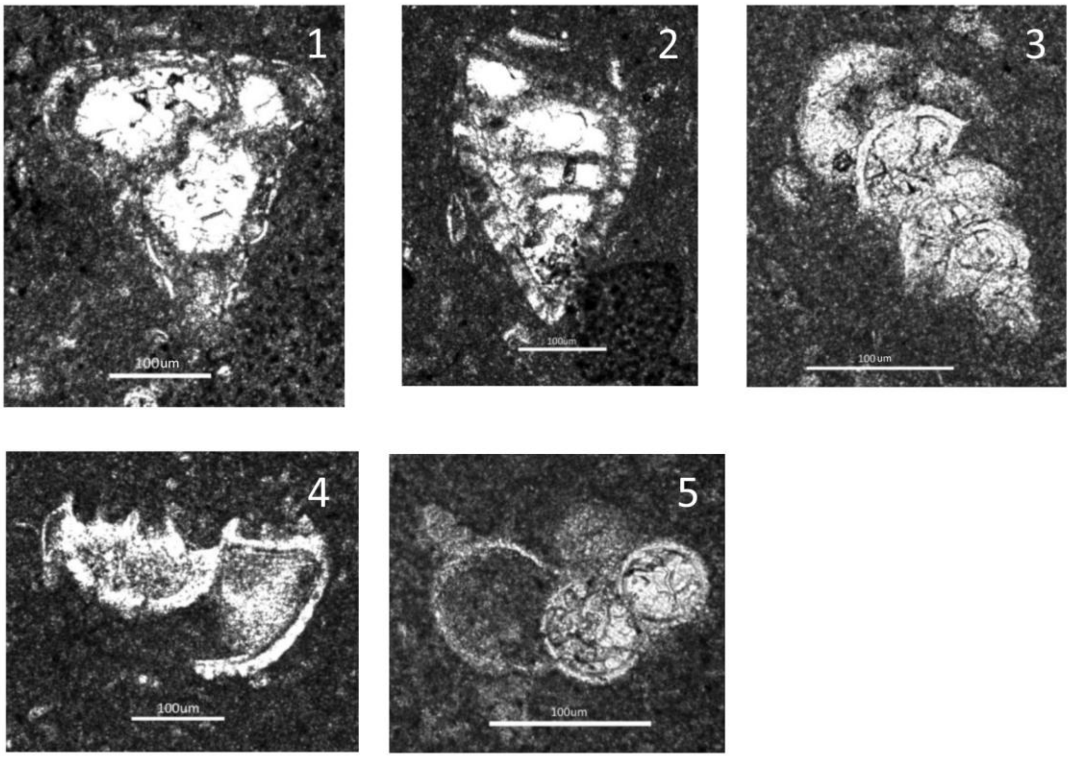
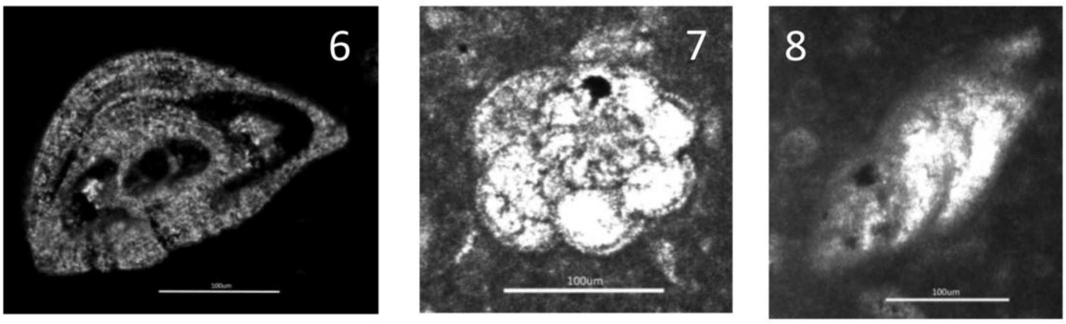


Figure 6.9 (a). Selected thin section images of foraminifera identified in chalk tessera LON_LW_01 from 60 London Wall, London, UK. All scale bars are 100µm.
1: *Verneuilina* sp. cf. *muensteri* (cross section) (LON_LW_01a_10); 2: *Verneuilina muensteri* (axial cut) (LON_LW_01b_04); 3: *Eouvigerina aculeata* (LON_LW_01b_03); 4: *Stensioeina pommerana* (LON_LW_01b_07); 5: *Whiteinella baltica* (LON_LW_01b_08).



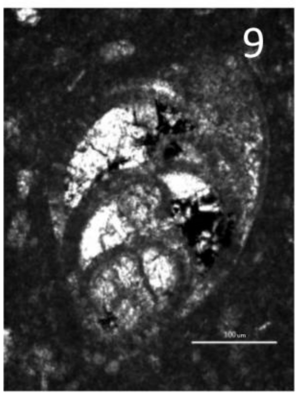


Figure 6.9 (b). Selected thin section images of foraminifera identified in chalk tessera LON_LW_02 from 60 London Wall, London, UK. All scale bars are 100 µm.
6: *Cibicidoides* (?) *voltziana* (LON_LW_02_11); 7: *Globotruncana* sp. cf. *linneiana* (LON_LW_02_15); 8: *Loxostomum eleyi* (LON_LW_02_04); 9: *Arenobulimina* sp. cf. *obliqua* (LON_LW_02_13).

6.7 1 New Change (NCZ07)

The site at 1 New Change comprises a series of buildings located to the east of the present-day St Paul's Cathedral (Site 5 in Figure 6.1). The earliest buildings date to the first century AD. One of these revealed a floor constructed of variously shaped mosaic pieces surrounded by a black and white border. A pottery kiln dating to *c*. AD 60-70 was found in one of the yards situated behind the buildings and a first-century cremation pit was found below one of the buildings (Maloney 2007, 63).

6.7.1 *The New Change tesserae*

The tesserae were found associated with a Late Roman building on the site, Building 32. They were found in the fill of a robber cut (a trench or hole dug for the purposes of robbing the original building material), which makes them difficult to relate to the context of the building. However, the pottery sherds in the same fill have been dated to *c*. AD 120-170, so it seems likely that the tesserae also date to this period (Ian Betts, pers. comm.).

6.7.2 *New Change palaeontology*

Three chalk tesserae (LON_NC_04 to 06) obtained from the site at New Change were processed using the freeze-thaw method, but only a few indeterminate microfossils were recovered. Three further tesserae were therefore thin sectioned (LON_NC_01 to 03). The foraminifera identified in the thin sections are listed in Table 6.5 in Appendix A and plotted onto a range chart in Figure 6.10. Images of several of the key species identified appear in Figure 6.11.

Relatively few of the foraminifera in the thin sections could be identified to species level. However, Figure 6.10 shows that all the species identified are coeval within foraminiferal biozone BGS FBZ 19. The biostratigraphy is constrained by the first appearance of *Stensioeina pommerana* (in tessera LON_NC_03) and the last appearances of *S.* sp. cf. *exsculpta exsculpta* (in LON_NC_02) and *Whiteinella baltica* (in LON_NC_01). Chalk of BGS FBZ 19 has its stratigraphical equivalent in the Newhaven Chalk Formation, which is widespread over southern England, and in the Flamborough Chalk Formation in the North East. Possible chalk sources for the New Change tesserae are discussed in section 6.10.

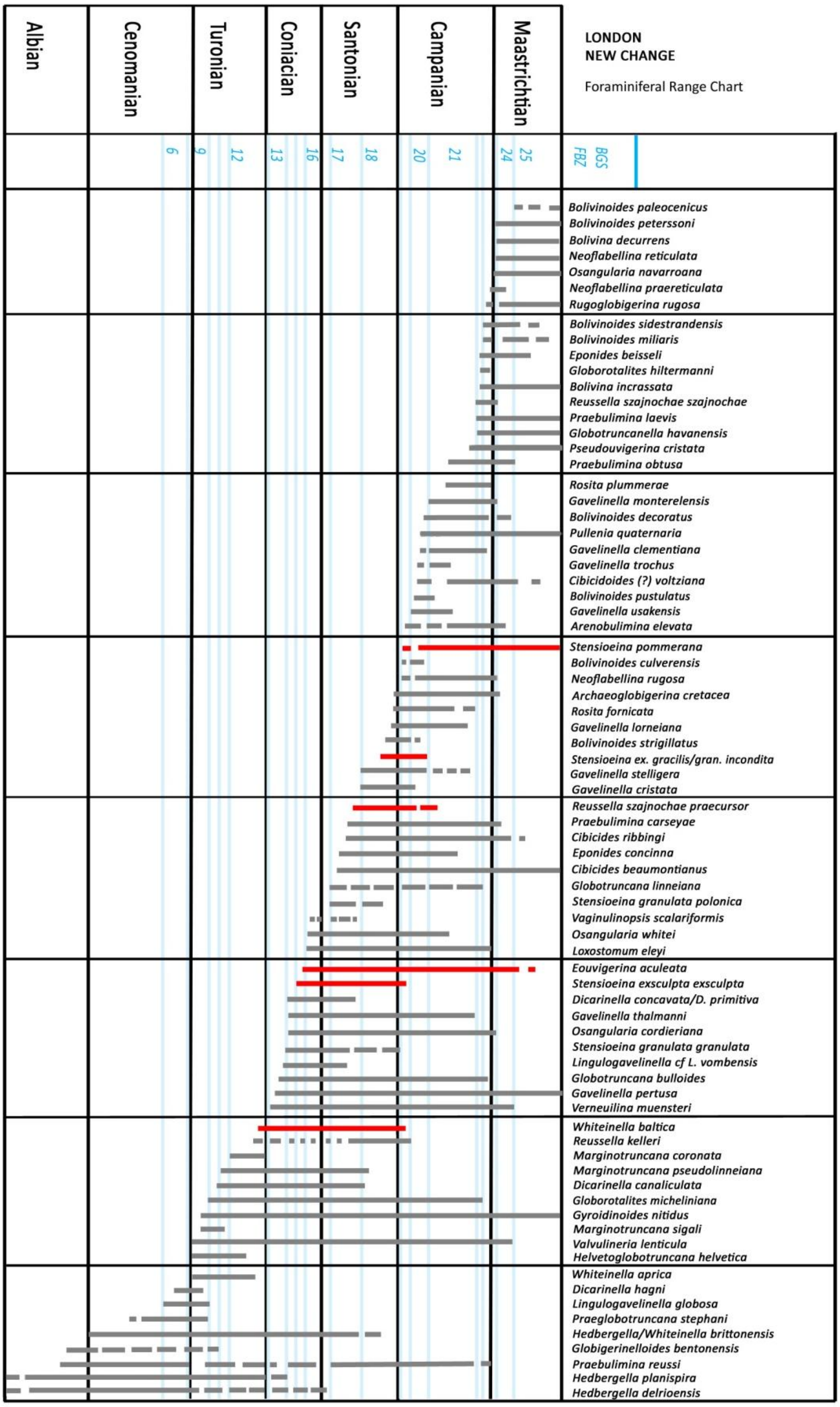


Figure 6.10. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from the site at 1 New Change, London, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.*

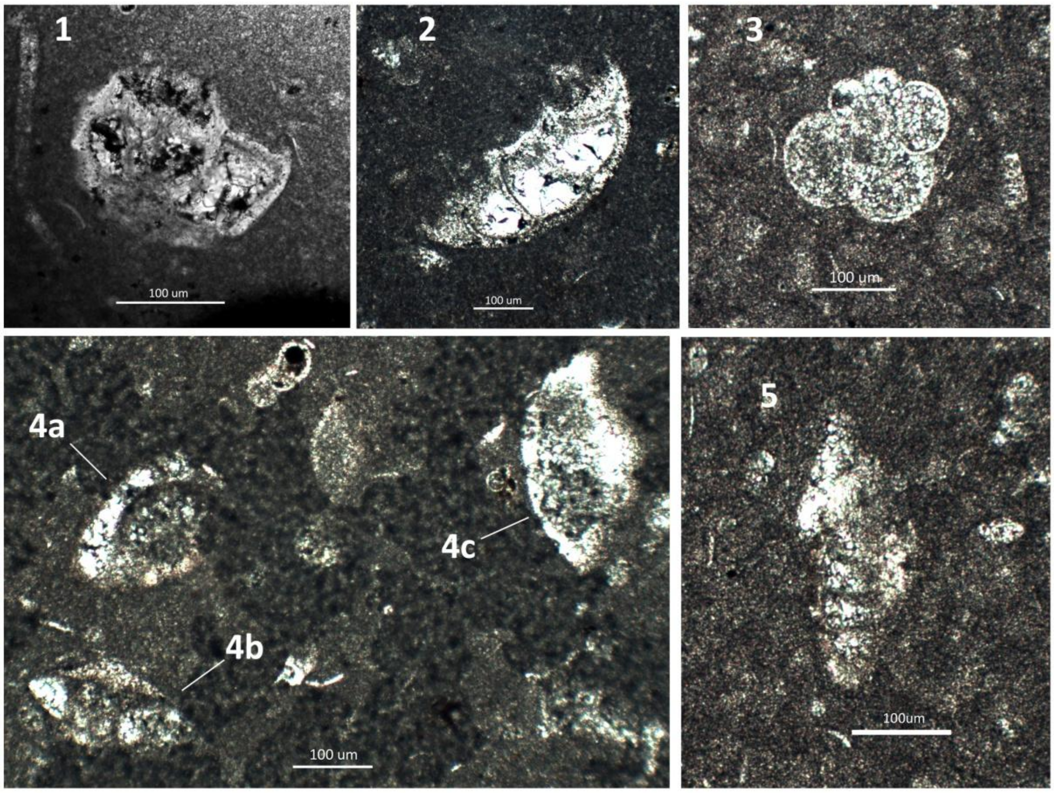


Figure 6.11. Selected thin section images of foraminifera identified in chalk tesserae from New Change, London, UK. All scale bars are 100µm.
1: *Stensioeina pommerana* (LON_NC_03_02); 2: *Stensioeina exsculpta exsculpta* (LON_NC_02_05); 3: *Whiteinella baltica* (LON_NC_01_09); 4: (4a) *Eponides* sp.; (4b) *Osangularia* sp.; (4c) *Stensioeina* sp. cf. *exsculpta gracilis* (LON_NC_02_16); 5: *Eouvigerina aculeata* (LON_NC_01_14).

6.8 The Pinnacle (Crosby Square) (CYQ05)

A series of evaluations, watching briefs and excavations on this and adjacent sites in 2005 revealed a complex sequence of Roman buildings and dumped deposits spanning the period from AD 70 to about AD 200. Excavation revealed a series of *opus signinum* floors and one floor with a border of plain white fine tesserae; some painted wall-plaster was also found. A plunge pool allied to one of the buildings was constructed at some point. There was evidence of fire debris in several places. The remains of these buildings were overlaid by dumped soil horizons cut into by later pits and mediaeval burials (Chapman *et al*. 2009, 258; 2010, 388-9).

6.8.1 *The Pinnacle tesserae*

Tesserae were obtained from two contexts on this site. The first (570) relates to Building 3 and was found close to the site of an *opus signinum* floor. These tesserae were very small (8 x 8mm) and may have come from Building 3. The second (858) was a fill found in a cut made to rob the foundations of Building 10. These tesserae were larger (15 x 15mm) and appear to have come from Building 10, even though they were found in dumped material. It is not possible to date the context for either set of tesserae more closely than to AD 70-200 (Ian Betts, pers. comm.).

6.8.2 *The Pinnacle (Crosby Square) palaeontology*

Two tesserae were obtained from Context 858 and eight tesserae from Context 570. The two Context 858 tesserae (LON_TP_01 and 02) were both thin sectioned. Three of the eight Context 570 tesserae (LON_TP_04 to 06) were unsuccessfully processed using the freeze-thaw method and so one tessera from this context was also thin sectioned (LON_TP_03). The foraminifera identified in the tesserae from both Contexts are listed in Table 6.6 in Appendix A and plotted onto a foraminiferal range chart in Figure 6.11. Images of several of the key species identified appear in Figure 6.12.

The species identified from the two contexts are plotted on Figure 6.11 (Context 858 in red and Context 510 in blue). Those identified from Context 858 were all capable of coexistence within BGS FBZ 17ii (the interval between the first appearance of *Eponides* sp. cf*. concinna* and the last appearance of *Vaginulinopsis scalariformis*). Those identified from Context 510 are coeval in the interval between the appearance of

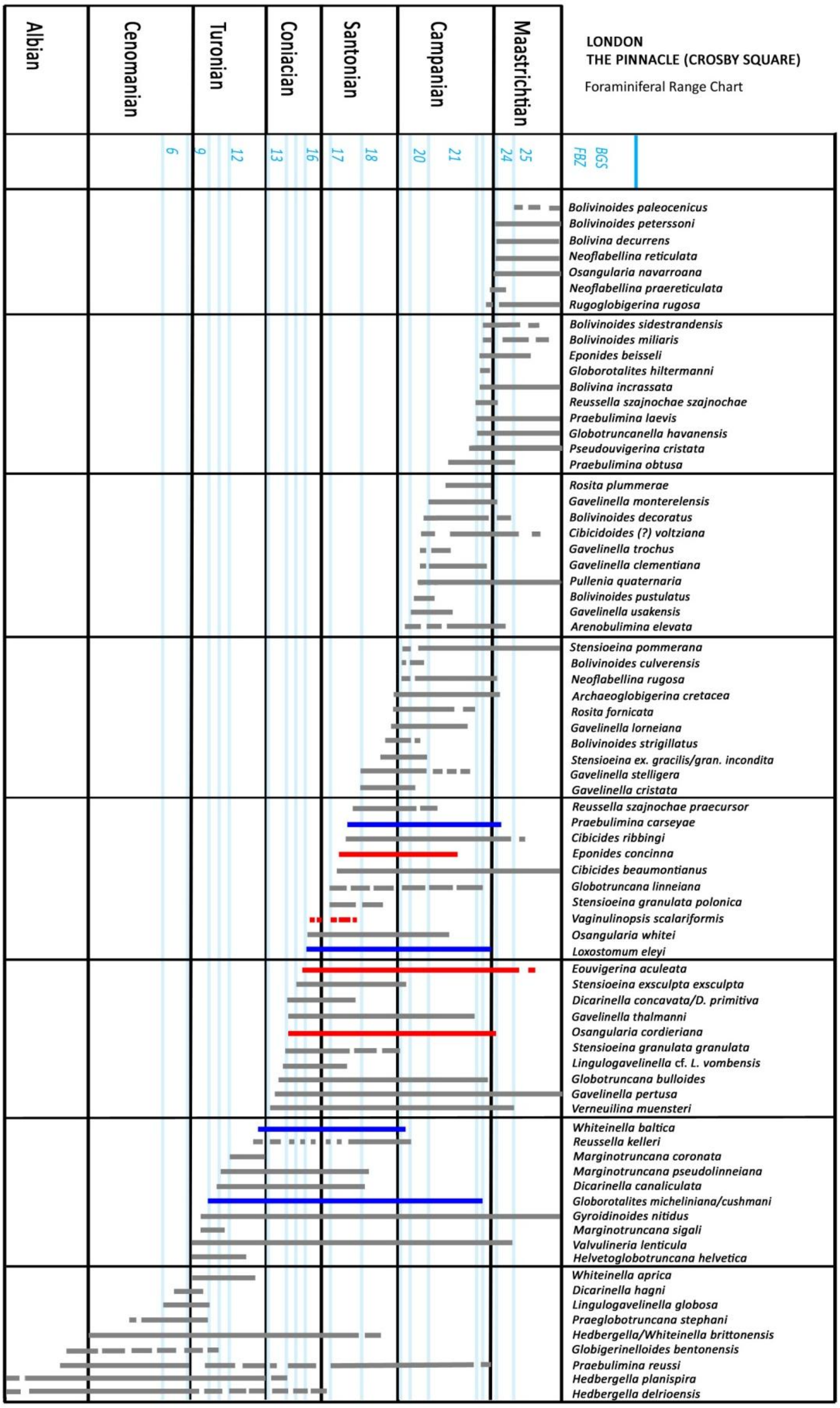


Figure 6.12. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from the site at The Pinnacle, London, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki 1980. BGS Foraminiferal Biozones after Wilkinson 2011*a.* Note that the foraminifera identified from Context 858 are shown in red and those identified from Context 510 are shown in blue. .

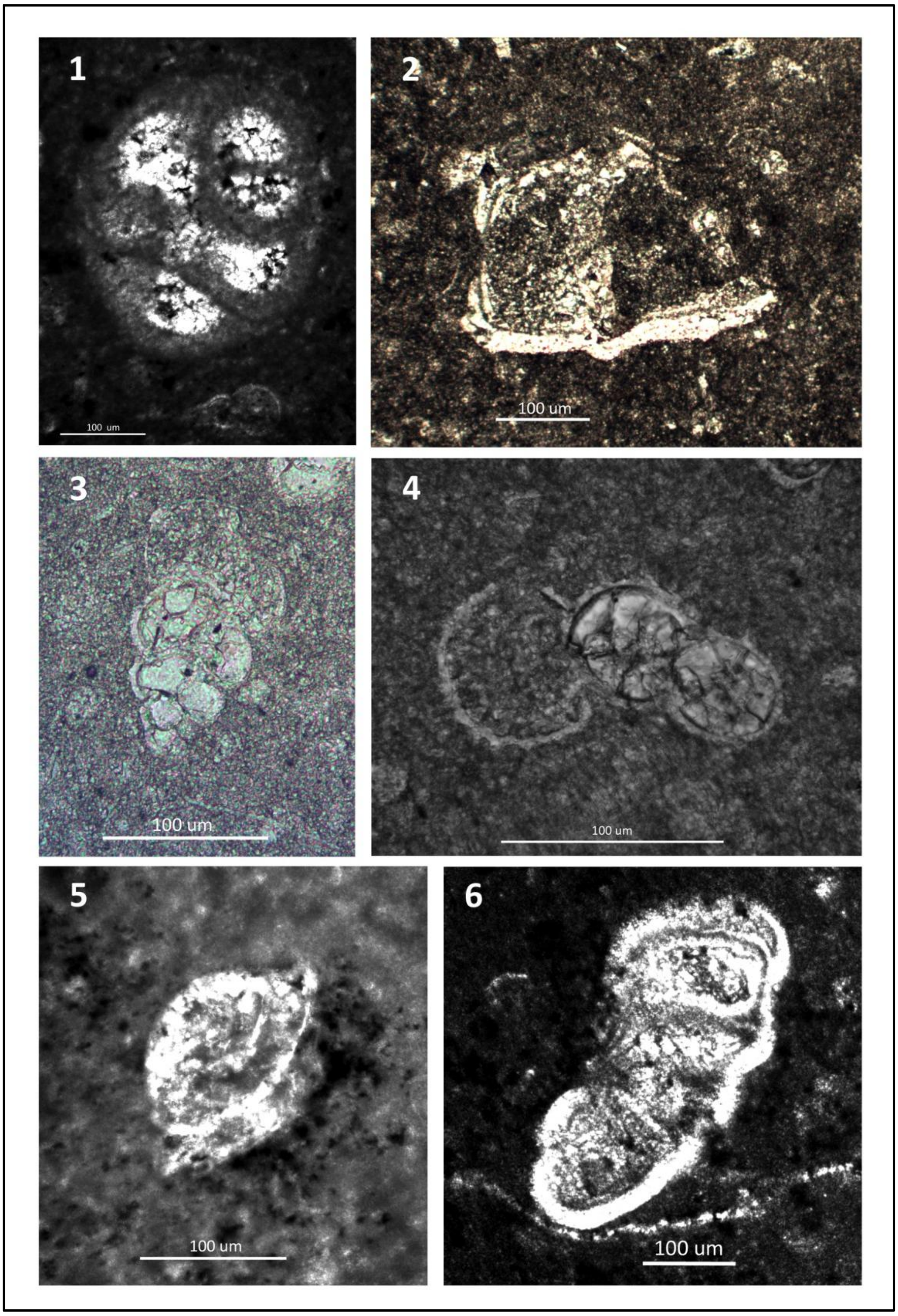


Figure 6.13. Selected thin section images of foraminifera identified in chalk tesserae from The Pinnacle, London, UK. All scale bars are 100um.
1: *Arenobulimina* sp. cf. *obliqua* (LON_TP_02_04); 2: *Globorotalites cushmani* (LON_TP_03_12); 3: *Praebulimina* sp. cf. *carseyae* (LON_TP_03_17); 4: *Whiteinella baltica* (LON_TP_03_06); 5: *Eponides* sp. cf. *concinna* (LON_TP_02_08); 6: *Vaginulinopsis scalariformis* (LON_TP_02_06).

Praebulimina carseyae in BGS FBZ 17ii and the disappearance of *Whiteinella baltica* in BGS FBZ 19. All the foraminifera identified are therefore capable of coexistence within BGS FBZ 17ii. This biozone relates to the Santonian Stage of the Upper Cretaceous.

6.8.3 *Vaginulinopsis scalariformis and the question of chalk provenance*

There are three interesting points of information concerning the foraminifer *Vaginulinopsis scalariformis,* identified in tessera LON_TP_02 from Context 858, which are relevant to the question of chalk provenance. The first concerns its geographical distribution. Hart *et al.* (1989, 312, 364) state that *V. scalariformis* appears to be confined almost entirely to the south east of England. The species is not recorded in Devon (Bailey 1978, 255), and is found only intermittently in chalks of the Isle of Wight and Wiltshire (*ibid.* 241, 252 respectively) and at only one site in Norfolk (*ibid.* 247). The Wiltshire samples were taken from a working quarry at Quidhampton, about 4km north-west of Salisbury, from strata well below the current ground level (*ibid.* 250); this site can therefore almost certainly be discounted as a provenance for the present purposes. In contrast, *V. scalariformis* has been reliably recorded in chalk from Thanet and south east Kent (*ibid.* 231) and the species has recently been found in chalk from Sussex (Hampton *et. al.* 2007).

The second point concerns the evolutionary range of the species. Until recently, *V. scalariformis* had been recorded reliably only in chalks dating to the Early Santonian Stage of the Upper Cretaceous (Hart *et al*. *op. cit*., 364), although Bailey (*op. cit*., 120-1) states that the species probably appeared in the Coniacian. However, in 2007 the foraminifer was recorded at Seaford Head in Sussex in chalks dating to the Campanian Stage (Hampton *et al*. *op. cit*., 52 and Figure 9), thus extending its Last Appearance Datum from BGS FBZ 17 in the Mid Santonian to BGS FBZ 19 in the Lower Campanian. This appears to be the only recording of this species in chalk of such a young age, so it is possible that this biostratigraphic event is confined to the chalk of Sussex. Nevertheless, this finding suggests that a chalk source for The Pinnacle Context 858 tessera which contained *V. scalariformis* should be sought in chalk relating to BGS FBZ 17ii in Thanet and Kent, but to BGS FBZ 17ii-19 in Sussex.

The third point of interest to note is that *V. scalariformis* has also been recorded in one non-UK location: the south east of France (Hart *et. al*. *op. cit.,* 364). Possible palaeogeographical reasons for the restriction of this species to the south of France and the south east of England were put forward earlier by Bailey (*op. cit*., 271-7). However, whilst a provenance in France for tesserae from London is a possibility, the other foraminifera identified from The Pinnacle Context 858 are all commonly found in UK chalks. This makes the likelihood of a chalk source in the UK the more realistic assumption.

For the single tessera from Context 510, the range of possible provenance is wider. The species identified are longer-ranging and the chalk is dated biostratigraphically to BGS FBZs 17ii-19; these biozones relate to the upper Seaford and Newhaven Chalk formations, both of which are widespread over southern England.

The evolutionary ranges of the foraminifera plotted in Figure 6.11 show that all the species identified in The Pinnacle tesserae are capable of coexistence within the same biozone (either BGS FBZ 17ii in Thanet or Kent, or BGS FBZ 17ii-19 in Sussex). There is therefore the possibility that the chalk for both Context 858 and 510 might have been derived from the same source. This is a slightly surprising finding. The tesserae are from different contexts; they are of different sizes; and they are associated with different buildings. There is therefore no reason why their parent mosaics could not have been laid at different times and by different people. However, the above data suggests that, even if this were the case, the chalk source for both sets of tesserae might have been the same. One explanation for this might be that the two buildings concerned (Buildings 3 and 10) were tessellated at the same time, either by the same firm, or by different firms using the same source of chalk. Alternatively, the buildings may have been tessellated at different times, in which case the quarry supplying the chalk must have been active for at least the period of time between the construction of the two buildings. This is an interesting line of thought, as the constructional date for the two buildings might have been very different. However, the dating evidence for the two buildings is not very firm and the above suggestions probably represent an over-interpretation of the available evidence.

6.9 Summary

A table summary of the six sites investigated and their principal characteristics is given in Figure 6.14. Context dates for the tesserae are given where this is known, or where the information given above in sections 6.3 to 6.8 has enabled a suggestion to be made with reasonable certainty. The foraminiferal biozone(s) or subzone(s) identified for the chalk source of the tesserae are also given.

The sites themselves fall broadly within two categories: those relating to the early growth of the settlement (Fenchurch Street and (probably) Harp Lane) and those relating to the post-Hadrianic period (Eastcheap, London Wall and New Change). Tesserae from The Pinnacle were difficult to place from the archaeology context and so could relate to either of these time periods.

6.9.1 *Preliminary conclusions from the biostratigraphy*

Figure 6.14 shows that the foraminiferal biozones identified for the chalk tesserae from the six London sites range from BGS FBZ 17ii, in the Early to Mid Santonian Stage of the Upper Cretaceous (Eastcheap, The Pinnacle) to BGS FBZ 21iii, in the Late Campanian Stage (London Wall). This information enables several deductions to be drawn.

Firstly, it is clear that although the chalk tesserae from the six sites were all found in London, they do not share the same microfossil signature; indeed, their parent chalks display a considerable spread in biostratigraphical age. This makes it very unlikely that the tesserae originated from a single, large, quarry supplying chalk tesserae to London during the late first and second centuries AD.

Secondly, the biostratigraphical age ranges of the foraminifera mean that some potential chalk source areas can be eliminated. For example, the chalks used to manufacture the tesserae for Brading Roman Villa in the Isle of Wight and those used for the Vine Street Town House in Leicester are both too old to have been used for the London tesserae.

Thirdly, a chalk source in the North East can be eliminated for any tessera with a foraminiferal biozone signature above (*i.e.*, younger than) BFS FBZ 19. This is because chalk of this biostratigraphical age is not exposed in Lincolnshire or Yorkshire. Outcrops of this biostratigraphical age are also patchy in Transitional Province areas (the Berkshire Downs and Chiltern Hills), so these areas too are less likely sources for such tesserae.

Site Name and LAARC code	Greater London SMR	NGR (TQ)	Description of tesserae	Date of tesserae	BGS FBZ
41 Eastcheap EAE01	-	3310 8083	10 regular-sized tesserae 10-15mm square, no double-sized samples.	Not possible to date more closely than AD 70-200.	17ii – 18ii
5-12 Fenchurch Street FEN83	043255-61	3303 8092	8 tesserae, approx. 15 x 25mm. One triangular specimen appeared to be half a rectangular cut diagonally.	AD 80-91 suggested by context. An earlier date (AD 61-74) is also possible. A later date (AD 119-149 AD) is less likely.	20iv-21i
Harp Lane HL74	042153-4	3319 8068	4 tesserae about 13 x 15mm and 6 smaller square ones were about 10 x 10mm.	Possibly late first century AD (from the demolition of a bath house (?)), but no later than AD 150 on pottery evidence.	18iii – 19
60 London Wall LOW88	041636-49	3282 8147	7 large, coarse tesserae, 15 x 25mm and one square 15 x 15mm sample.	Found in make-up layer dated to mid second century AD.	Basal 19 (LON_LW_01); 20ii-22 (LON_LW_02)
1 New Change NCZ07	-	3220 8120	5 small (approx. 10 x 10mm) and 5 large (20 x 20mm) tesserae.	Probably mid-second century AD. Pottery context dates from AD 120-170.	19
The Pinnacle (Crosby Square) CYQ05	-	3315 8127	Context 858 (2 tesserae 15 x 15mm). Context 570 (8 tesserae 8 x 8mm).	Not possible to date more closely than AD 70-200.	Context 858: 17ii (or 17ii-19 in Sussex). Context 510:17ii-19

Figure 6.14. Tesserae from the six London sites (summary). The tesserae were generously provided by the Museum of London Archaeological Service (MOLAS). All site information (including Greater London Sites and Monument Records (SMRs) and National Grid References (NGRs)) was obtained from archaeological reports supplied by MOLAS (references are cited in the text). SMR = Sites and Monuments Record; BGS FBZ = British Geological Survey Foraminiferal Biozones (and subzones).

6.10 Possible chalk sources for the London tesserae

Figure 6.14 shows that all the London tesserae analysed for this thesis, with the exception of those from Fenchurch Street and one tessera from London Wall (LON_LW_02), have a biostratigraphical age of BGS FBZs 17ii-19. These foraminiferal biozones and sub-zones have their lithological equivalents in the Flamborough Chalk Formation of north eastern England and in the upper Seaford and Newhaven Chalk formations of southern England. The last two Chalk Group formations are particularly widespread: the North and South Downs, much of Dorset, parts of Norfolk and considerable areas in the Transitional Province either consist of, or expose, chalks of this biostratigraphical age. This means, as with the chalk tesserae from the Vine Street Town House in Leicester (Chapter 4), it is difficult to suggest possible provenances without the help of archaeological evidence.

Unfortunately, the available archaeological evidence has not been as helpful in narrowing down potential chalk sources for these first and second century London tesserae as it was for the fourth-century Vine Street Town House site in Leicester. Evidence for large scale chalk extraction dating to the first or second century AD, of the sort discovered at Baldock, has not been forthcoming. Nevertheless, in the following sections, the biostratigraphical data obtained from the microfossil analysis of the London chalk tesserae is allied as far as possible to the information available on chalk quarries thought to have been operating during the Roman occupation in order to suggest possible source areas for the London chalk tesserae.

The possible provenances are considered on a geographical basis, and additional data from other sites in London are used to support some of the conclusions drawn.

6.10.1 *The North East*

It is possible to make a case that chalk tesserae having a biostratigraphical age below (*i.e.*, older than) BGS FBZ 19 are unlikely to have been obtained from the North East during the later first and early-to-mid second centuries AD. The Roman occupation of *Britannia* did not begin to establish a firm grip on the north of England until the later first century AD (the military fortress at York was not founded until AD 71, as a base for campaigns against the Brigantes). The subjugation of the North may have been particularly brutal (Mattingly 2006, 115-119) and much of the area remained under permanent military occupation for most of its history; in comparison with the South, development was slow and relatively impoverished (*ibid.* 418-422).

This did not prevent some stone quarrying from taking place in the North East. Military tombstones from the legionary base and later *colonia* at Lincoln show that the local shelly limestone (the Middle Jurassic Lincolnshire Limestone) was being used from the AD 70s and possibly earlier (Hayward 2009, 52, 100-102), and an inscription from York dated to AD 107 (RIB 665) inscribed on the local 'Magnesian Limestone' (the Permian Cadeby Formation) shows that this stone was being quarried at that time, probably from around Tadcaster (Pearson 2006, 125), However, it is doubtful whether this activity extended to any systematic quarrying of chalk for tesserae. Analysis of potential chalk sources for the Vine Street tesserae from Leicester in Chapter 4 (section 4.6.3) uncovered only one definite instance for the early use of chalk tesserae in the North East, in the mid-second century baths excavated at Well in Yorkshire (Gilyard-Beer 1951, 68). The chalk in this case appears to have come from the beach at Bridlington, suggesting perhaps an *ad hoc* approach to collection. But the *floruit* of villas with mosaics in the North East, which might have encouraged the development and sustained the use of local chalk quarries, did not occur until much later, in the fourth century AD.

There are also geological reasons for proposing that chalk having a biostratigraphical age of BGS FBZs 17-18 in particular might not have been sourced from the North East. The Santonian and Lower Campanian Stage exposures of the Flamborough Chalk Formation, which comprise these biozones, are limited to coastal cliffs to the south of Flamborough Head (Witham 1993; Mortimore *et al*. 2001, 427-429 and Figure 5.19) and to a few (modern) inland quarry pits. There does not seem to be any evidence of inland quarrying activity in the Roman period, and the cliff exposures are awkward to access, occur at a considerable distance from London and are remote from the main land route south (Ermine Street: see the discussion in section 4.6.3.1). But sea transport of stone to London and elsewhere at this time was certainly not unknown (see Williams 1971, 173-4 for the local transport of Kentish Ragstone, for example) and it is possible that Santonian or Campanian Stage chalk was being quarried inland or culled from coastal rock-falls and then transported via the sea to London. The casual collection of coastal chalk would not have left any trace in the archaeological record, so it is difficult to ascertain whether or not this might have occurred.

However, there seems to be little hard evidence to suggest that chalk was being systematically quarried in the North East during the later first and early second centuries AD. So, although lack of data is not conclusive (it is important to remember that 'absence of evidence is not evidence of absence'), it does seem on balance that a chalk provenance in the south of England is more likely for the tesserae from the London sites.

6.10.2 *The London area*

There are a number of potential chalk sources that have been found relatively close to London. Three possible Roman quarries have been identified. The first was discovered in a modern chalk quarry at Coulsdon, in the London borough of Croydon, in 1923 (MN 403828; NMR TQ 35 NW 15). The pit was identified as a quarry as the sides may have been stepped and pick marks were evident, but it is not known for how long it was in use.

The geology of this part of London is difficult to categorise and the large-scale geological maps of this area are not able to differentiate between the Lewes Nodular, Seaford and Newhaven Chalk formations. This means that, despite a grid reference, it is not possible to know with precision on which chalk formation the Coulsdon quarry was sited. It is possible, though, to make an assumption. The Chalk Group succession in the North Downs runs from south to north; this means that the upper Seaford and Newhaven Chalk formations, being the youngest strata in the succession, would be expected to lie closest to the northern edge of the Downs. The Coulsdon quarry site, though, lies close to the geographical centre of the Downs, and so is almost certainly sited on formations lower in the succession, probably on either the Lewes Nodular or lower Seaford Chalk formations. This would mean that chalk quarried from this site would relate to BGS FBZs 12-16 and so would have been too old to have supplied any of the chalk tesserae for the London sites.

The second and third London area quarry sites are found on the banks of the River Thames close to the Blackwell Tunnel. The second site lies on the chalk above the north foreshore of the River Thames and was identified during an archaeological assessment of development land at Church Hollow in Purfleet in Essex (Essex HER 45478) (Tindall 2010, 11 and Table 1). Late Roman pottery was recovered from the fill, suggesting its period of activity might be too late to have supplied material to any of the six London sites, and the size of the quarry (only 2.6m wide) suggests small-scale development.

The third site is a pit found at Stone Castle Quarry at Greenhithe (NMR TQ 57 SE 54) on the south bank of the Thames estuary (so technically in Kent) about 300m north of the line of Watling Street. The site appears to have been reoccupied around AD 75; its chalk quarry probably dates to the early second century AD, but appears to have been filled in within a few decades. There is evidence that the chalk was extracted for use as bricks; several chalk bricks were found on the site, showing signs of tooling, but no tesserae were discovered. This suggests that the main use of the quarry was for local construction projects (Detsicas 1966, 142-147 and Plate 1).

Both the Purfleet and Greenhithe quarry sites lie on the Seaford Chalk and Newhaven Chalk formations (these formations are undifferentiated on the geological maps). Geologically, therefore, the two sites are possible chalk provenances for all of the London tesserae except for Fenchurch Street and London Wall. However, it seems that the Purfleet site may not have been operating as early as the later first and second centuries AD, and there is no evidence that the Greenhithe site was involved with anything other than the manufacture of chalk bricks. From the archaeological evidence, therefore, it is not clear that either site is a particularly convincing chalk source for the London tesserae.

6.10.3 *Kent and the North Downs*

Kent was one of the earliest areas settled after the invasion (for a history, see Millett 2007). About 11 villas date to the later first century AD. Some of these are very early; the villa at Eccles, for instance, appears to have been started around AD 55 and rebuilt *c*. AD 65, and another at Thurnham, also overlooking the Medway, was built around AD 70. Most of the villa settlement was in west Kent, in the Medway and Darent valleys, with less either around Canterbury or in east Kent, and none in The Weald (*ibid*.). This may have been because the *civitas* of the *Cantiaci* was limited to northern Kent, and The Weald was under some form of Roman control (Mattingly 2006, 386).

Chalk tesserae appear to have been used in mosaics in Kent from an early date. White tesserae (assumed to be of chalk, since they were used for contrast in dark grey or black-and-white schemes) appear in late first century mosaics at Eccles, Little Chart and Wingham and possibly also at Teynham (Neal and Cosh 2009, 369-373 (Eccles); 378 (Little Chart); 391 (Teynham); 391-2 (Wingham); for a map of mosaic sites in Kent, see *ibid*. 356, Figure 328). Some of the 'hard white' chalk tesserae from the baths at Eccles were examined by Allen and Fulford (2004, 24-5). These tesserae had a *terminus ante quem* of AD 120, but most likely date to the later first century AD. The authors' analysis of other tesserae from the same context made from cementstone and burned mudrock concluded that these were probably sourced from coastal exposures of the Kimmeridge Clay Formation of Dorset and may have been manufactured either at Norden or elsewhere in Dorset (*ibid.* 30-32). However, the Eccles chalk tesserae were not subjected to microfossil evaluation, so it is not known whether or not these also might have come from Dorset, or whether a local source should be implicated.

Evidence for chalk quarrying in Roman times has been obtained for four sites in Kent: Darent District, Chartham, Birchington and Kingsdown. A fifth site at Greenhithe on the Thames estuary has already been mentioned (section 6.9.4). A possible sixth site, north of Pegwell Bay, has been eliminated as it appears to be a Roman pit-shrine (Baker 2011).

The first of the Kent sites can probably be discounted. This was a large quarry exposed during the A2/A282/M25 Improvement Scheme road works close to Darenth. Chalk appears to have been extracted here on an almost industrial scale, but the quarry does not seem to have been in operation much before the later third century AD. A series of smaller pits and two dene holes on the same site suggest that small-scale excavation of chalk took place here from the Late Iron Age onwards, but the main phase of activity is too late to have supplied chalk for the London sites examined for this thesis (Simmonds *et al*. 2011, 196-7).

A second Kent chalk quarry active in Roman times has been located at an Iron Age/Romano-British farmstead at Kingsdown, Deal (Parfitt 2011), close to the top of the cliffs forming the northern end of the White Cliffs of Dover. This site seems to have been in use from the mid first to the mid third century AD, but the quarrying activity is difficult to date and may not have extended over the whole of this time. The full extent of the quarry was not revealed, but a pit some 17 x 5.9m and up to 1.25m deep was excavated; it had sloping sides and an undulating base and had been used as a rubbish tip after extraction ceased *(ibid.* 402 and Figure 2).

It is not clear whether the quarrying activity at Kingsdown was consistent enough to have supplied mosaic materials commercially to a London market, but it is a possibility for The Pinnacle tesserae. The farmstead is sited on the Seaford Chalk Formation and the chalk quarried would have a biostratigraphical age of BGS FBZs 16-17, which would include the sub-zone BGS FBZ 17ii of the Eastcheap and The Pinnacle tesserae. This site is also close to St Margaret's Bay, one of the sections of south east Kent where the species *Vagulinopsis scalariformis* was reliably recorded by Bailey (*op. cit.,* 231). Upper sections of the chalk cliffs at Kingsdown also expose at their highest points a small capping of the slightly younger Margate Chalk Member (Mortimore *et al*. 2001, 276); if the quarry accessed this, it could have supplied chalk of a slightly younger biostratigraphical age as well (from the subzone BGS FBZ 18i). This means that chalk from here might also have supplied the site at Eastcheap, whose tesserae have a biostratigraphical age between BGS FBZs 17ii – 18ii. But the other four London sites would require a younger provenance higher up in the chalk succession.

The third site in Kent is a large (20 x 17m) Romano-British chalk quarry that was uncovered during excavation prior to residential development of the St Augustine's Hospital (East Kent Asylum) site at Chartham, about 6km south west of Canterbury (HER TR 15 SW 59). A chronology for the quarry is hard to establish, but the initial feature appears to have been developed in the late first century AD; a second (smaller) phase of development appears to cross-cut this and is dated to the early second century by a single cremation. After this, the quarry appears to have been abandoned before being re-opened later, probably in the later second century and remaining in sporadic use until the late third or early fourth (Burnham *et al.* 1997; Rady 1996). A plan of the quarry showing the phases of development appears in Rady (*op. cit.,* 10). Chartham lies on chalk of the Seaford Chalk Formation and so could have provided chalk for the Eastcheap tesserae and also for those from The Pinnacle, assuming the inland chalk included the foraminifer *Vaginulinopsis scalariformis.* The tesserae from these two sites cannot be more closely dated than between AD 70-200. However, the Chartham quarry appears to have been active during the later first century and also during the later second century, so, like Kingsdown, it can be considered as a potential source for these tesserae.

The fourth site is a coastal chalk quarry on the foreshore at Grenham Bay, Birchington, in the Isle of Thanet. The site lies on the coast between Herne Bay and Margate, about 7km east of the Roman site and Saxon Shore Fort at Reculver (Perkins 2001). It is thought to be Belgic or Roman in date; if so, it could have been active from the first century AD (HER TR 27 SE 2). The remains of the quarry were exposed by coastal erosion, which has unfortunately removed many of its features and which makes precise dating difficult. Perkins calculates that up to 600m of coastline may have been lost since Roman times and suggests that much relevant evidence may have been destroyed as a result (*ibid.* 50). This makes it difficult to estimate the scale of the quarrying operation, although a coastal site, which presumably offered easy sea access to London, might well have supported a thriving enterprise.

The Birchington quarry is sited on the Margate Chalk Member, which is coeval with the topmost Seaford and lower half of the Newhaven Chalk Formations and represents the highest chalk (*i.e*. the top of the Chalk Group succession) found in Kent and the North Downs (Mortimore *et al*. 2001, 282, Figure 3.125). It has a biostratigraphical age in the Late Santonian and Early Campanian stages of the Upper Cretaceous and comprises the upper part of BGS FBZ 17, the whole of BGS FBZ 18 and the basal part of BGS FBZ 19. Thanet is also one of the Kent locations in which Bailey (*op. cit.,* 231) recorded *Vaginulinopsis scalariformis*, which makes it a potential chalk source for tesserae from The Pinnacle. This means that a quarry in this area - assuming its period of activity lasted into the second century AD - could have supplied chalk for The Pinnacle, Eastcheap, Harp Lane, New Change and London Wall (01) sites (the contiguous biozones BGS FBZs 17ii, 17ii-18ii, 8iii-19, 19 and 19 respectively).

Kent is therefore a possible provenance for chalk tesserae found at five of the six London sites. Tesserae from the sites at Eastcheap, Harp Lane, London Wall (01), New Change and The Pinnacle could have been quarried at Birchington; those from Eastcheap and The Pinnacle could also have been quarried at either Chartham or Kingsdown. However, Kent could not have supplied chalk for the Fenchurch Street or London Wall (02) tesserae, as these require a source of chalk that lies higher up in the Chalk Group succession.

Birchington, Chartham and Kingsdown all had good access by road (Watling Street) to *Londinium,* although Kingsdown was considerably further distant from the capital than the other two sites. Birchington, being a coastal quarry, also had good sea access to *Londinium* via the Thames estuary. The quarrying of chalk at either Birchington or Chartham would fit in with the region's early villa development, as there was clearly constructional activity taking place in the nearby Darenth and Medway valleys from the later first century AD; it may have been that both quarries were in operation at the same time. However, a chalk source at Birchington, assuming it was active at the time, could potentially have supplied tesserae to all five London sites, including The Pinnacle. This seems therefore a more likely chalk source for the London tesserae than Chartham.

6.10.4 *The South Downs*

The chalk ridge of the South Downs runs eastwards from the Petersfield area in Hampshire towards Newhaven and Eastbourne in Sussex. It connects with the Wiltshire Downs (to the west) and the Berkshire Downs (to the north); in the east, it ends in cliffs at Seaford and Beachy Head. These rolling downlands are formed largely by the Seaford and Newhaven Chalk Formations. Much of this landscape could have provided chalk for the five London sites whose tesserae have biostratigraphical ages between BGS FBZ 17-19: Eastcheap, Harp Lane, London Wall (01), New Change and The Pinnacle (although Context 858 would be limited to the South East: see section 6.8.1). The cliffs at Seaford Head, for example, expose accessible chalk from the Coniacian, Santonian and Early Campanian Stages (BGS FBZ 14-20) (Hampton *et al*. 2007).

Unfortunately, very little archaeological evidence of quarrying activity during the first and second centuries has come to light to help narrow down the field of possibilities. It is clear, though, that chalk was being used in the South from an early date. Mosaics found at the Flavian palace at Fishbourne (Cunliffe 1971, 41-2) and the Neronian-early Flavian villa at Angmering (Allen and Fulford 2004, 25-6) show that chalk tesserae were common in both places. They were also used as building blocks at Angmering. White chalk tesserae are also recorded in many of the first-century mosaics found in Sussex (for examples, see Neal and Cosh 2009, 479-558). However, the source for these materials is not known. It seems likely that the chalk tesserae for both Fishbourne and Angmering were obtained from the industrial site at Norden, as the sheer number of chalk tesserae found at Norden suggest manufacture for large, rather than purely local, projects; but there is no evidence on the site at Norden for actual quarrying (Sunter and Woodward 1987, 36, 43; White *et al.* 2012, 127).

It is possible that coastal rock-falls provided a source of material. A coastal source on the Isle of Purbeck is suggested for tesserae manufactured at Norden from the Kimmeridge Clay Formation (Allen and Fulford 2004, 29, 32) and this may be true for the chalk also. It would not have been difficult to transport raw chalk or cut tesserae from Sussex to *Londinium* by either land or sea. Foreshore activity at this time is not unknown; some of the chalk blocks used at Angmering may in fact have come from the foreshore near Ferring (Williams 1971, 170). It is known that a fine-grained glauconitic sandstone, probably from the Church Rocks Reef at West Wittering, was used in the proto-palace at Fishbourne in the AD 60s, and that a foraminiferal limestone from Mixon Shoal, off Selsey Bill in West Sussex (and now underwater), was quarried for use in the later Flavian palace *c*. AD 85 (Cunliffe *op. cit.,* 1-3). We only know the source of these two stones because their particular lithologies have geological characteristics that make them readily identifiable. However, this evidence makes it possible to speculate that the coastal harvesting of chalk from rock-falls at (say) Seaford Head might have provided material for the chalk tesserae found at the London sites mentioned above (particularly for tesserae from The Pinnacle, as the foraminifer *Vaginulinopsis scalariformis* was found in chalk of BGS FBZ 19 at Seaford Head); it could also have supplied chalk for the first century villas in Sussex. A coastal source would explain the lack of specific site evidence for chalk quarrying in the South Downs during the later first or early second centuries AD, at a time when chalk was obviously being quarried from somewhere in reasonably large quantities.

The 'coastal rock-fall' hypothesis remains speculative, but it could be tested by subjecting chalk tesserae from sites such as Fishbourne and Angmering to foraminiferal examination, in order to ascertain whether or not the chalk could have come from Seaford Head and also to eliminate any potential chalk sources that did not comply with the data obtained. As the Chalk Group formations found around Seaford Head have a different (older) biostratigraphical age from the Portsdown Chalk Formation found close to Norden, this could be an interesting project for future research.

6.10.5 *Dorset*

The Isle of Purbeck in Dorset has already been discussed as a probable chalk source for tesserae from Norden and Silchester (section 1.3.2), and Dorchester or its vicinity a possible one for tesserae from the legionary fortress at Caerleon (section 5.7.3). It seems sensible therefore to investigate the possibility that the area might have supplied material to early *Londinium* as well.

An interesting slant on this possibility is provided by research undertaken on non-chalk tesserae from other early London sites. Allen and Fulford (2004) examined samples of loose tesserae made from cementstone (a calcareous mudstone: technically, one containing more than 50% calcite) from three early Roman sites in London: Watling Court, west of the Walbrook; Plantation Place, south west of the forum-basilica; and Winchester Palace in Southwark. Watling Court (Site 7 in Figure 6.1) has already been mentioned above in the introduction to this chapter (section 6.2.2), and Plantation Place in connection with the Fenchurch Street site (section 6.3). The authors found that the source of the cementstone used to manufacture tesserae from all three of these sites was the Jurassic Kimmeridge Clay Formation of Dorset.

6.10.5.1 Chalk tesserae from Watling Court

Allen and Fulford (*op. cit*.) also examined some white chalk tesserae from Watling Court. These were described as a 'hard chalk' and appear to have originated from a bichrome mosaic (or mosaics). The tesserae were not subjected to a palaeontological examination, so it was not possible to confirm whether or not the chalk might have originated in the Dorset area as well. However, a foraminiferal analysis on six different chalk tesserae from Watling Court (WAT78, context 161) was undertaken at a later date (Ian Wilkinson, pers. comm. 10.7.13). This did result in the recovery of a number of poorly-preserved specimens.

The palaeontological results from Wilkinson's analysis are listed in Table 6.7 in Appendix A. The microfauna identified included the index foraminifera *Gavelinella* sp. cf. *usakensis* and *Verneuilinoides* sp. cf. *muensteri.* These identifications indicate a biostratigraphical age for the chalk of BGS FBZs 20-21i (in the Campanian Stage of the Upper Cretaceous) and infer a lithological source in outcrops of the Culver Chalk or basal Portsdown Chalk Formations of the south of England.

It is not known whether the Watling Court chalk tesserae from context 161 analysed by Wilkinson were derived from exactly the same archaeological context as those examined by Allen and Fulford, but it seems that it would have been similar. The Watling Court buildings in which the mosaics were found are dated to earlier than AD 85 and were presumably of some quality, as seven of their eleven rooms were tessellated (Perring and Roskams 1991). The archaeological evidence seems clear that all but one (or, possibly, two) of these mosaics date to the same period as the buildings (Smith 1991, 88-94). This makes it a reasonable assumption that the chalk tesserae examined by Wilkinson and by Allen and Fulford were laid at approximately the same time, even though they may have been derived from different mosaics. Six of the mosaic fragments found at the site are catalogued by Neal and Cosh (2009, 449-452).

Chalk with a biostratigraphical age of BGS FBZs 20-21i has a limited and somewhat patchy distribution over the south of England, but one of the areas in which it is exposed in reasonable quantities is in Dorset (see Figure 5.8). The tesserae found at the first-century manufacturing site at Norden in Dorset and the loose chalk block picked from its floor both had a biostratigraphical signature of BGS FBZs 20-21i, and the (probable) first century tesserae found at Silchester appear to have originated there (see the discussion in section 1.3.2). As the chalk tesserae from Watling Court share the same biostratigraphical signature, this makes the site at Norden a potential manufacturing source for these tesserae also. This suggestion is supported by the context dates for the tesserae concerned. Tesserae were being manufactured at Norden from around AD 70; all the Watling Court mosaics except one (or possibly, two) appear to have been laid before AD 85; and the Silchester tesserae are also likely to date to the later first century, possibly as early as AD 60-70 (section 1.3.2). It is possible that the chalk for the Backhall Street mosaic (dated to the mid-80s AD) also originated here (see section 5.6) and Norden is thought to have supplied chalk for the proto-palace at Fishbourne (White *et al*. *op. cit*., 127). So Dorset in general and the Norden area in particular seem very likely chalk sources for the first century tesserae found at Watling Court.

6.10.5.2 <u>Chalk tesserae from other London sites</u>

If this deduction is correct, it suggests that Dorset may also be the source of other first century chalk tesserae found at London. Cautious support for this hypothesis is available on the basis of the foraminiferal evidence obtained from the first century site at Fenchurch Street. The chalk tesserae found there (section 6.3 and Figure 6.2) have a narrow biostratigraphical age of BGS FBZ 20iv-21i, which lies within the wider BGS FBZ 20-21i biostratigraphical interval identified for the chalk block and tesserae found at Norden. The archaeological context date of the Fenchurch Street tesserae (AD 80-91) and their biostratigraphical signature therefore both suggest that they could have been supplied by the 'tesserae factory' at Norden.

However, the foraminiferal analysis of chalk from the second London site whose tesserae possibly derive from first-century mosaics – Harp Lane – reveals chalk of a much older biostratigraphical age (BGS FBZs 18iii-19). These subzones have their lithostratigraphical equivalent in the Newhaven Chalk Formation, which, although widespread over the south of England (including Dorset), is not actually found at Norden. It is possible that this is an indication that the Harp Lane tesserae date to the second, rather than to the first, century AD; this would bring their microfossil signature in line with those of the other known second century London sites (Eastcheap, New Change and The Pinnacle).

One other tessera – LON_LW_02, from the London Wall site – also has an age commensurate with that of chalk found at Norden. However, this was found in a mid second century context. It is therefore difficult to confidently relate this tessera to the known period of activity at Norden, unless this extended further into the second century than is currently thought. But all the London Wall tesserae were found in a make-up layer, so this particular tessera may simply represent waste material from an earlier building that was demolished and used for land reclamation; in which case, it is possible that it was originally sourced from the Norden area and simply become reused.

The above analytical results suggest that possible differences may be emerging between the sources of chalk utilised in the province to manufacture mosaics dating to the first and the second centuries AD. This question of change in chalk provenance over these periods is reviewed and explored further in Chapter 8.

It has already been noted that chalk of BGS FBZ 21 has its lithostratigraphical equivalent in the Portsdown Chalk Formation and that outcrops of this formation in southern England are limited to Dorset, Hampshire, Wiltshire, the Isle of Wight and Sussex (see Figure 5.8). The chalk ridge close to Norden is therefore not the only possible site from which chalk tesserae recording this biostratigraphical age (Fenchurch Street, Watling Court, Caerleon (Backhall Street) and Silchester) could have been quarried. For example, a long and thin exposure of the Portsdown Chalk Formation is found to the east and north-east of Dorchester in Dorset (this might have been the source area for the Caerleon Backhall Street tesserae (section 5.7.3)). An even thinner exposure is found around Portsdown to the north of Chichester in West Sussex. The same formation also outcrops thinly along the northern edge of the chalk ridge that runs east-west across the Isle of Wight, and there are patchy exposures also in Hampshire and Wiltshire.

However, none of these alternative source areas is extensive geographically and none has produced evidence of first-century chalk quarrying activity, or of tesserae manufacture, similar to that found at Norden. Consideration of the above evidence therefore suggests that chalk exposures on the Isle of Purbeck close to Norden still appear to be the most rational choice for the source of the Fenchurch Street tesserae.

6.10.6 *Imported chalk*

One last possibility for the source of chalk tesserae found in such a major importation centre as *Londinium* is a provenance outside the UK. Continental trade with northern Gaul and the Rhineland would allow the possibility of importation of material from European sources. Inscriptions and votive sculpture to the sea-goddess Nehalennia found both in Kent and in the Mosel area, for example, suggest regular contact between the province and northern Europe during the second and later centuries AD (Jenkins 1956). However, despite the proximity of Kent to Gaul and the Rhine Provinces, Neal and Cosh could find no obvious continental influences in the Kent mosaics, even at the second-century villa at Folkestone, located within sight of the Gallic coast at Boulogne (Neal and Cosh *op. cit.,* 357, 376-7).

The identification of imported chalk material in terms of microfossil analysis is not impossible. It would be difficult to identify chalk imported from the Paris Basin of northern France on biostratigraphical grounds, as the geology and palaeontology of the area is very similar to that of southern England. However, chalk that contained obviously 'foreign' material, such as Late Cretaceous (Late Maastrichtian) or Palaeogene (Danian) foraminifera, might indicate that chalk was being imported from (say) the Rhine Provinces, and the consistent identification of Tethyan species would suggest a Mediterranean origin such as Libya, Tethyan sediments being deposited in seas warmer than those covering the British Isles landmass in the Late Cretaceous. But none of the tesserae examined contained either Danian or Tethyan material.

6.10.6.1 Chalk tessera from Leadenhall Court

Interestingly, a petrological examination of a tessera (LCT84.4386) from the second forum-basilica site at Leadenhall Court described it as 'an exceptionally hard Upper Cretaceous chalk of possible Tethyan origin' (Sanderson 1991). This tessera is one of those discovered by Milne and Wardle during their excavation of the Leadenhall Court site and suggested might have been derived from the known (but undated) reconstruction of the first forum-basilica (Milne and Wardle 1993, 44-5, 56). Sanderson's description implies that the tessera may have been imported, but the author admits that this description is only a subjective impression and that further sampling would be necessary to confirm it; the micropalaeontological (nannoplankton) assessment undertaken only confirmed the biostratigraphical age of the source as Coniacian–Maastrichtian (identifying the very wide interval of BGS FBZs 13-25). In theory, a foraminiferal analysis of this tessera might be able to determine whether or not it was Tethyan (on the basis of species identified) and whether it had the same biostratigraphic age as the Fenchurch Street tesserae (*i.e.*, BGS FBZ 21i); this evidence combined should be able to indicate whether or not it might have originated in Dorset.

Imported material was not unusual in London in the first century AD: mixed marble fragments found at the Union Street site in Southwark, for instance, appear to be the residue of first-century buildings demolished in the early second century, perhaps as a result of the Hadrianic fire (Gerrard 2008b). However, there is no evidence that any of the tesserae from the six London sites fall into this category.

6.11 Conclusions

Microfossil analysis of chalk tesserae from six sites in London has shown that:

a) Chalk from the first century AD site at Fenchurch Street has a biostratigraphical age of Late Cretaceous (Mid Campanian) BGS Foraminiferal Biozone 20iv-21i. This biozone identifies the stratigraphical interval of the Portsdown Chalk Formation of the south of England;

b) The Fenchurch Street tesserae share a biostratigraphical signature with other first-century chalk tesserae from London (Watling Court), Silchester, Norden and Caerleon (Backhall Street). This suggests that they may all have been derived from the same provenance (the ‘tesserae factory’ at Norden), which was active at this time;

c) One tessera from a second-century context at London Wall (LON_LW_02) also has a biostratigraphical age in the Mid Campanian Stage of the Late Cretaceous (BGS FBZs 20ii-22). However, this tessera was found in a floor make-up layer and may have been derived from an earlier building. If so, the chalk may also have originated from the same area of Dorset;

d) Chalk tesserae from five London sites (Eastcheap, Harp Lane, London Wall (except for LON_LW_02), New Change and The Pinnacle) have biostratigraphical ages in the Santonian and Early Campanian stages of the Late Cretaceous (within

BGS FBZs 17ii-19). These biozones identify the stratigraphical interval of the Seaford and Newhaven Chalk Formations, which are widespread over the south of England;

e) Chalk tesserae from Context 858 from The Pinnacle revealed the species *Vagulinopsis scalariformis*, which is recorded only in the South East, most reliably in Thanet and in south east Kent, and in Sussex at Seaford Head. This suggests that these two locations are the most likely sources for these tesserae;

f) Birchington in Kent (Isle of Thanet) is sited on the Margate Member and is a possible coastal chalk source for the tesserae from five of the six London sites: Eastcheap, Harp Lane, London Wall (except for LON_LW_02), New Change and The Pinnacle. Chartham in Kent is sited on the (slightly older) Seaford Chalk Formation and is a possible alternative inland source for the tesserae from Eastcheap and The Pinnacle;

g) The species identified in The Pinnacle Context 570 and 858 chalk tesserae could all have coexisted in BGS FBZ 17ii. This means that they may have been obtained from the same chalk source, even though they derive from different (possibly time-separated) contexts. This may reflect the same chalk source operating over a (possibly long) period of time;

h) Imported chalk does not appear to have been used to manufacture the London tesserae.

Additional information also suggests that:

i) The Fenchurch Street tesserae may have been derived from a late first century reconstruction of the first forum-basilica;

j) The Watling Court chalk tesserae may have derived from the Norden area.

Chapter 7

Colchester

ABSTRACT

Foraminiferal analysis of chalk tesserae obtained from the site of the late first or early second century AD Romano-Celtic temple complex at Gosbecks Park close to Colchester (*Colonia Claudia Victricensis*) reveals a biostratigraphical date for the chalk in the Mid Campanian Stage of the Upper Cretaceous. The equivalent lithostratigraphical position is found in the uppermost Culver or lower Portsdown Chalk Formations of southern England. Consideration of the biostratigraphical and archaeological evidence makes a source in Dorset the most likely provenance for the chalk tesserae. This identification is the same as that made for previously examined chalk tesserae of similar date and suggests that Dorset might have acted as a regional source for chalk tesserae production in the later first century AD.

7.1 The archaeological background

A concise account of Iron Age and Roman Colchester can be found in Crummy (1997) and the following overview is provided only to place the site at Gosbecks Park within an historical context.

7.1.1. *Gosbecks Park, Camulodunum and Colchester*

Gosbecks Park lies about 4km to the south west of modern-day Colchester. Figure 7.1 shows the geographical situation of Colchester with regard to Chalk Group outcrops and the main roads and towns of Roman Britain.

In the Late Pre-Roman Iron Age (LPRIA) Gosbecks Park formed part of the *oppidum* (a large, defended settlement) of the *Trinovantes*, the Belgic tribe native to Essex and south Suffolk. In addition to Gosbecks Park, the *oppidum* included an industrial site at Sheepen on the River Colne and a considerable part of present-day Colchester, an extensive area that was protected to the south and west by a series of substantial dyke systems. The *oppidum* was known to the Romans as *Camulodunum* and was probably the tribal meeting place of the *Trinovantes* before they became absorbed into a more powerful eastern kingdom dominated by the neighbouring *Catuvellauni* in the early part of the first century AD. A full account of the early history and archaeology of *Camulodunum* can be found in Hawkes and Crummy (1995).

The eastern kingdom was a prime target for the invading Roman forces and the strategic importance of *Camulodunum* made its capture a priority (Mattingly 2006, 58-9). A strong military presence was established there through the construction of a fort at Gosbecks Park and a much larger legionary fortress some 4km to the north east, close to Sheepen. However, within about six years of the invasion (*i.e., c*. AD 49), the legion occupying the fortress (the Twentieth Legion) was strategically relocated to a new base at Gloucester and the now-redundant fortress was converted into a civilian settlement for discharged veterans and native *Trinovantes* (*ibid*., 271-2). This civilian settlement now underlies modern Colchester. Figure 7.2 shows its location in relation to Gosbecks Park and Sheepen.

The newly founded civilian settlement (*Colonia [Claudia] Victricensis;* the '*Claudia*' is probable but not attested*)* possessed privileged legal status as a *colonia* and immense prestige as the first planned town of the new province. As the erstwhile 'First City' of *Britannia*, it appeared the natural choice to become its capital. However, the enforced obligation of the native community to engage with (and also to contribute financially towards) the new programme of urbanisation was considerably resented and the *colonia* was burned to the ground in the Boudican revolt of AD 60-1 (*ibid*., 271). The settlement itself was quickly re-established, but its site proved to have drawbacks: it lacked a good natural harbour and the River Colne offered poor access to the sea. Practical considerations therefore ensured that within a few decades the commercial and administrative importance of the new *colonia* had been usurped by the more conveniently-placed *Londinium* (Crummy *op. cit*., 72).

7.1.2 *The Gosbecks Park site*

The LPRIA Gosbecks Park site consisted of a large farmhouse and an adjoining sacred space (an area enclosed by a ditch). It is possible that the farmhouse was the home of

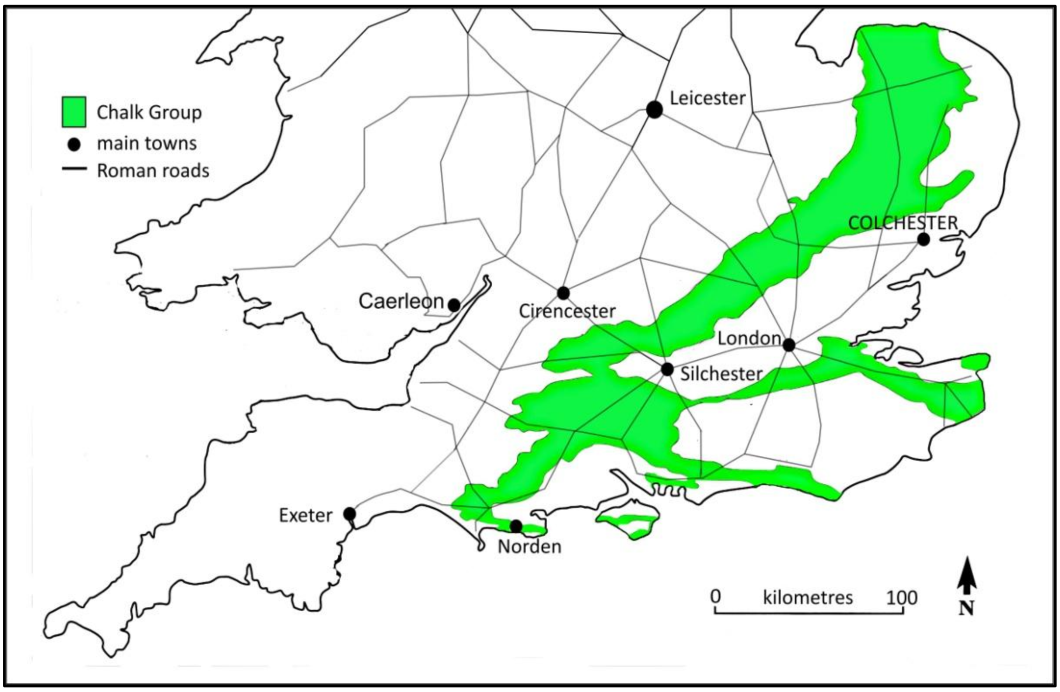


Figure 7.1. Sketch map showing the position of Colchester in relation to the Chalk Group (in green), Roman roads and main towns mentioned in the text (modern placenames). Cretaceous Chalk data taken from Geological Conservation Review volume 12 (1997) *Karst and Caves of Great Britain*, Chapter 7 and Figure 1. Roman road data based on the Ordnance Survey map of *Roman Britain* 5th edition (2001).

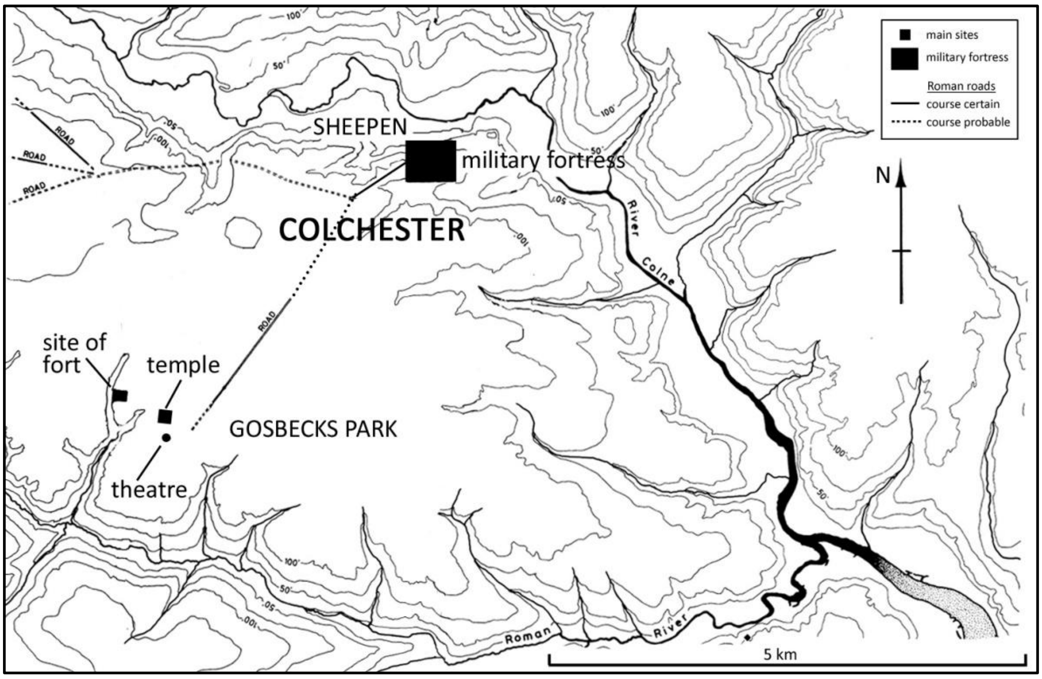


Figure 7.2. Location of Gosbecks Park and the Temple Complex in relation to Sheepen and Colchester. The military fortress (large black square) was redeveloped as *Colonia Claudia Victricensis* (Colchester). The sites of the early Roman fort and the Roman temple and theatre at Gosbecks Park are marked. After Crummy 1977, Figure 14 (adapted).

Cunebelin, the tribal leader of the eastern kingdom in the decades preceding the Roman invasion and that the sacred space was the site of his funerary pyre or burial ground (Hawkes and Crummy *op. cit*., 97-98, 104-105; Crummy *op. cit*., 12, 17-18, 27-28). The site appears to have been of considerable tribal religious significance, which would explain why the Romans thought it necessary to build a fort there (Wilson 1977, Hawkes and Crummy *op. cit*., 104-105) and to retain its religious function.

7.2 The Gosbecks Park Temple Complex

The Romans built two large and impressive structures on the Gosbecks Park site: a temple and a theatre (Crummy *op. cit*., 102-107). The theatre appears to have been built firstly in wood, possibly as early as *c*. AD 100, as the later stone building probably dates to the middle of the second century (Dunnett and Reece 1971). It was over-large for the local population and so may have served as a place of assembly, perhaps at times of festivals associated with the temple (*ibid*.).

The Gosbecks Park temple was erected in one corner of the sacred space in the Romano-Celtic 'square within a square' style. A substantial double *porticus* (covered walkway) constructed around the outside of the existing ditch effectively converted the sacred space into the precinct of the new temple. An entrance in the east wall of the *porticus* led across the ditch to the sacred space and the new building. Figure 7.3 shows a reconstruction of the Gosbecks Park Temple Complex after completion.

7.2.1 *Excavation on the site*

Excavation on the Temple Complex site has been very limited. The temple itself appears to have been demolished some time after AD 337 (Crummy *op. cit.*, 120), but the date of its construction and that of the surrounding *porticus* is unknown. However, a trench dug in 1995 across the site in order to establish its ground plan recovered a considerable amount of building debris from the backfill of the adjoining ditch. This included pieces of column from the temple (or possibly from the *porticus*), fragments of Purbeck marble (from wall sheathing), red ceramic roof tiles, some painted plaster and a quantity of black and white tesserae (Crummy *op. cit*., 106-107; Neal and Cosh 2009, 139).

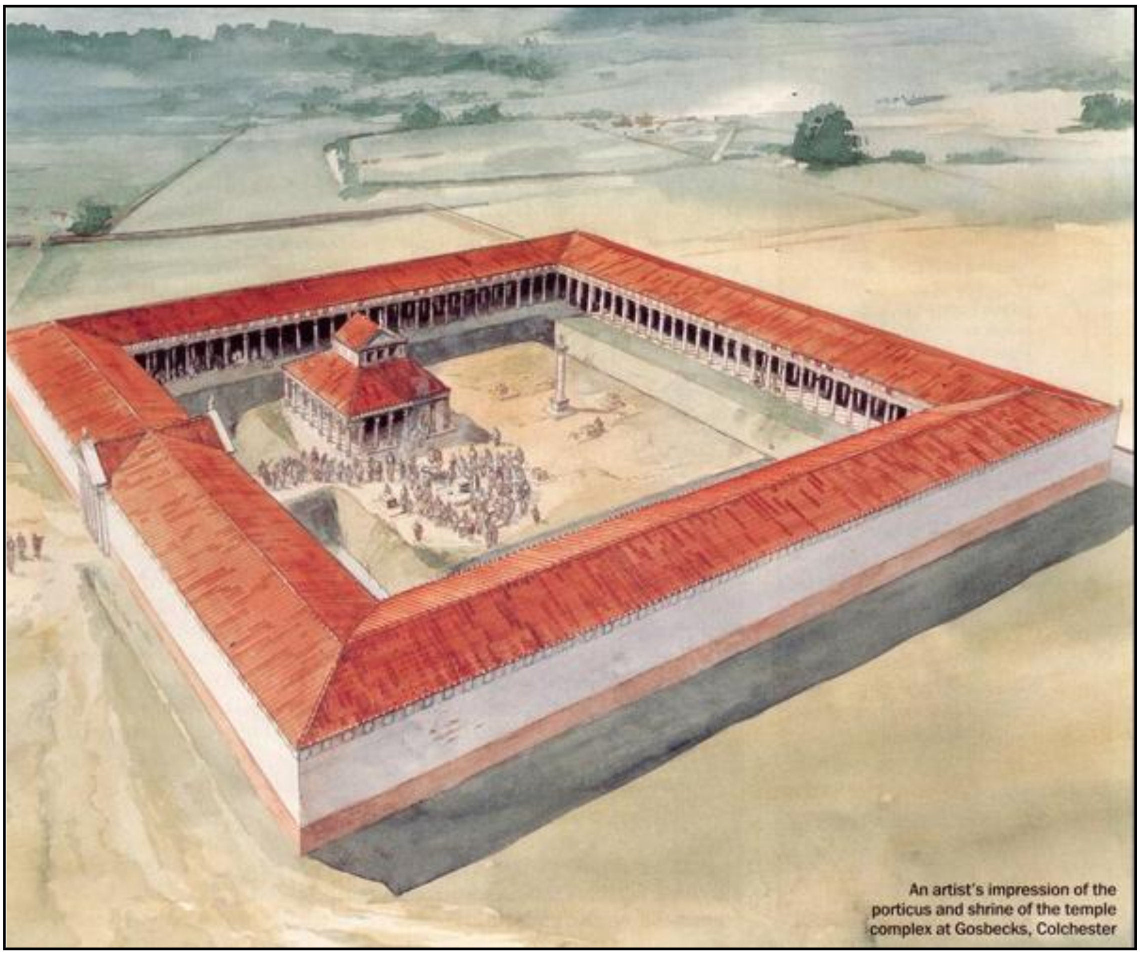


Figure 7.3. A reconstruction of the Roman Temple Complex at Gosbecks Park. Image taken from: http://www.camulos.com/gosbecks.htm.

It seems likely that the tesserae found in the 1995 excavation derive from a black and white temple floor mosaic laid at some time in the later first or early second century AD. Black and white mosaics dating to this time appear to be a feature of early temples found in Essex. For example, large numbers of black and white tesserae have been found at the Temple of Claudius in Colchester (possibly the remnants of the earliest mosaic laid in Roman Britain) and also at temples in Sheepen and Harlow (Neal and Cosh *op. cit*., 80, 84 (Temple of Claudius); 144 (Harlow); 139 (Sheepen)). Similar black and white late first or early second century mosaics have also been found in non-religious buildings in other locations in Essex: for instance, at Chelmsford, Colchester and the early villa at Rivenhall (*ibid*., 81-2 (Chelmsford); 105, 130-1 (Colchester); 146 (Rivenhall)). It seems likely therefore that the tesserae from the Gosbecks Park Temple

Complex site also date to this time. If so, it would make the construction of the Romano-Celtic temple and its *porticus* either slightly earlier or approximately contemporaneous with the construction of the wooden theatre on the same site.

7.2.2 *The Gosbecks Park tesserae*

A number of chalk tesserae from the Temple Complex site at Gosbecks Park were made available for analysis through the generosity of the Colchester Archaeological Trust. All the tesserae derived from the same site (the Temple Ditch) and had the same context (95.40) and level (F1.446.L8) number. It is presumed from the context number that the tesserae were recovered during the 1995 trench excavation mentioned above.

The tesserae comprised large and small samples cut from both 'softer' and 'harder' chalks (the terms being relative only to these tesserae). The larger tesserae were typically harder, cut from white or creamy-coloured chalk and mostly around 25 x 15mm in surface area, although several were irregularly shaped. The smaller tesserae were typically softer, cut from white chalk and had a surface area of around 12 x 12mm, although the smallest of these was only 10 x 10mm.

Eight tesserae (COL_GP_A01 to A08) were selected on the basis of size and relative hardness and processed using the white spirit method (Figure B1 in Appendix B). Three of the tesserae were soft and large (COL_GP_A01 to A03), one was soft and small (COL_GP_04), three others were hard and large (COL_GP_A05 to A07) and a final tessera was hard and small (COL_GP_08). The relative softness of several of these tesserae enabled a number of foraminifera and ostracods to be physically extracted and examined in three dimensions: most of these were recovered from one of the larger and softer samples (COL_GP_A01). Thin sections were also cut from a further three tesserae (COL_GP_A17 to 19).

A further six tesserae (COL_GP_A09 to A16) were crushed but not processed; this was because a sufficient number of index foraminifera had been already identified from the above tesserae and thin sections. A list of the species identified can be found in Table 7.1 of Appendix A. The foraminifera identified are plotted on a range chart in Figure 7.4 and selected images are shown in Figure 7.5**.**

7.2.3 *Palaeontological analysis*

A specimen of the index foraminifer *Gavelinella usakensis* recovered from tessera COL_GP_A07 provided an initial biostratigraphical age for the Gosbecks Park chalk of BGS FBZs 20-21i (in the Mid Campanian Stage of the Upper Cretaceous). However, the additional identification of the foraminifera *Rugoglobigerina pilula* (from COL_GP_A01) and *Gavelinella* sp. cf. *clementiana* (also from COL_GP_A01) suggested that this biostratigraphical age could be narrowed further, as *G. clementiana* does not appear in the stratigraphical record until the middle of the biozone (at BGS FBZ 20iii) and *R. pilula* becomes extinct at the top of it (in BGS FBZ 20iv). All the foraminifera identified in the remaining Gosbecks Park tesserae were capable of coexistence within these narrow sub-zones (BGS FBZs 20iii-iv) (Figure 7.3).

Identification of this biostratigraphical age is supported by the fact that several examples of the foraminifer *Gavelinella stelligera* were identified in the samples recovered from the Gosbecks Park tesserae. This microfossil is common in chalk of the upper part of BGS FBZ 20 (Wilkinson 2011a, 847). The ostracod species identified are also typically found in chalk of the Late Cretaceous, but are long ranging (Pyne 2001).

The differences in size, colour and relative hardness of the tesserae from the Gosbecks Park Temple Complex initially suggested that more than one provenance for the chalk might be involved. However, as Figure 7.4 shows, all of the foraminifera recovered from the Gosbecks Park tesserae have a concurrent range within the short time-span represented by the biostratigraphical subzones BGS FBZs 20iii-iv. It seems more likely therefore that the tesserae were derived from a single chalk source, rather than from a number of different ones, as chalk provenanced from several different geographical areas might be expected to reveal foraminifera exhibiting a wider variety of biostratigraphical age. This means that the relative softness observed in some of the tesserae probably reflects either natural variability within a particular chalk stratum or a degree of post-constructional degradation after the mosaic was laid, rather than a different source of chalk.

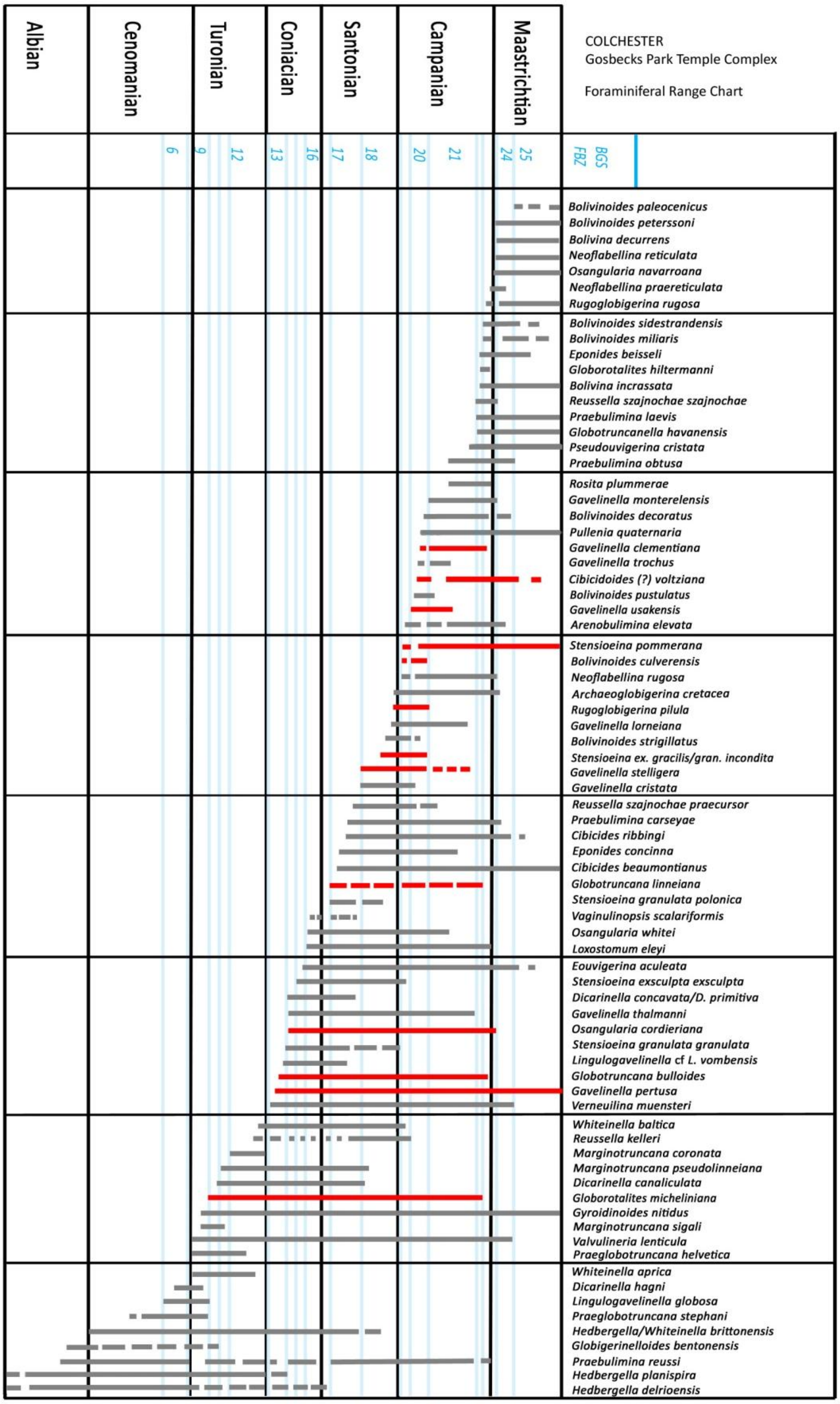


Figure 7.4. Foraminiferal Range Chart (red) and BGS Foraminiferal Biozones (blue) for chalk tesserae from the site at Gosbecks Park Temple Complex, Colchester, Essex, UK. Chart data are derived from Hart *et.al*. (1989) 298-301 (rearranged to show First Appearance Data) with additions based on Swiecicki (1980). BGS Foraminiferal Biozones after Wilkinson 2011*a.*

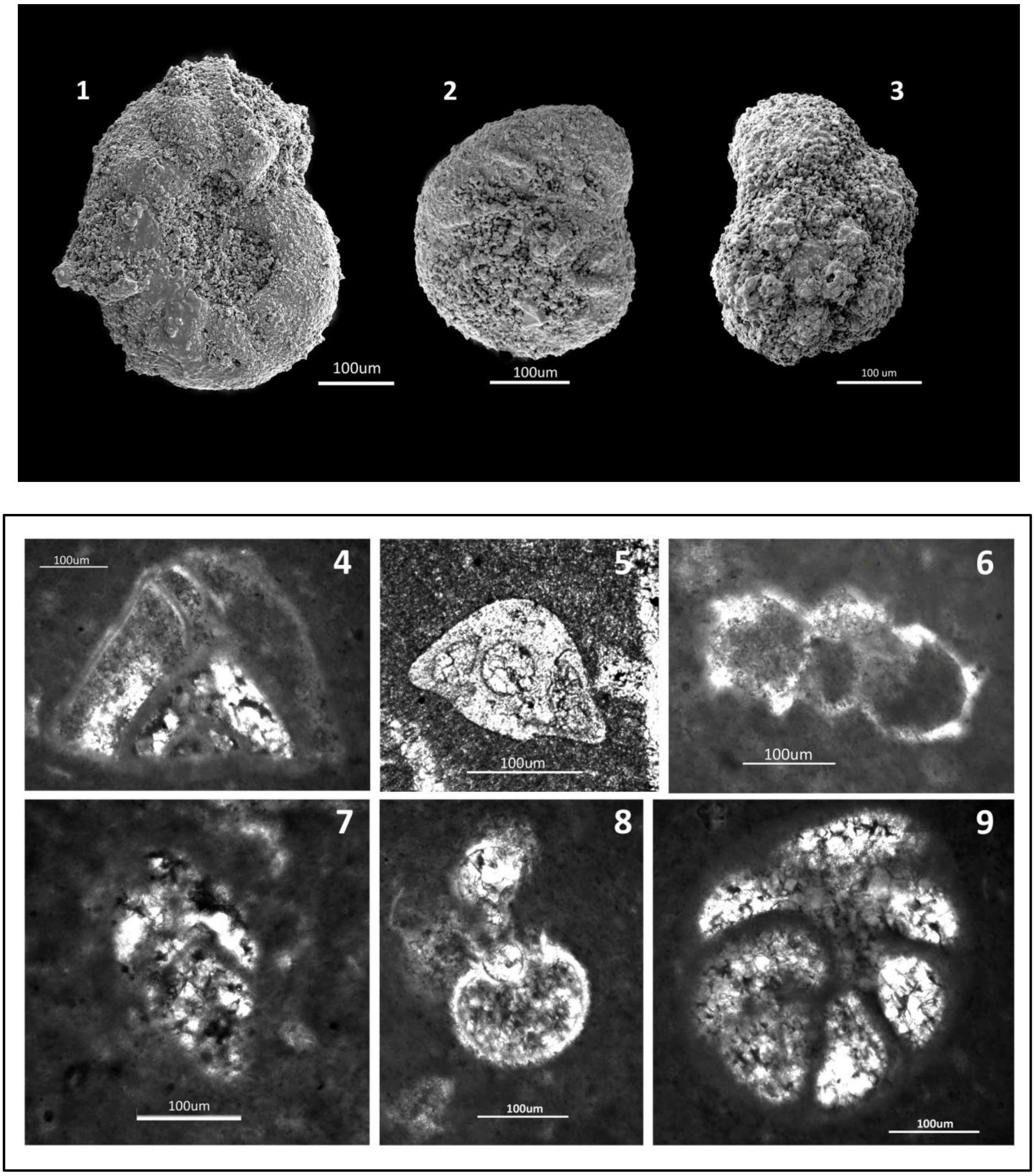


Figure 7.5. Selected SEM (1-3) and thin section (4-9) images of foraminifera identified in chalk tesserae from Gosbecks Park Temple Complex, Colchester, Essex, UK. All scalebars are 100um.
1: *Gavelinella pertusa* (COL_GP_A01_01); 2: *Gavelinella clementiana* (COL_GP_A01_22); 3: *Rugoglobigerina pilula* (COL_GP_A01_27); 4: *Globorotalites micheliniana* (COL_GP_A17_27); 5: *Cibicidoides (?) voltziana* (COL_GP_A18_11); 6: *Globotruncana linneiana* (COL_GP_A17_25); 7: *Bolivinoides* sp. cf. *culverensis* (COL_GP_A17_13); 8: *Globigerinelloides aspera* (COL_GP_A17_19); 9: *Ataxophragmium* sp. cf. *variabile* (COL_GP_A17_28).

7.3 Possible chalk sources for the Gosbecks Park tesserae

Figure 3.4 shows that the subzones BGS FBZs 20iii-iv are lithostratigraphically confined to the uppermost Culver Chalk and lowermost Portsdown Chalk Formations. Exposures of these two Chalk Group formations are almost entirely confined to southern England, although there are also a few isolated exposures in Norfolk of chalk of the same biostratigraphical age (these are not shown on Figure 7.6).

Figure 7.6 shows the main exposures found in Dorset and in parts of Wiltshire, Hampshire, Sussex and the Isle of Wight. The Dorset exposures have already been mentioned in connection with the tesserae from Silchester and Norden in Chapter 1, the tesserae from Caerleon in Chapter 5 and the Fenchurch and Watling Court tesserae from London in Chapter 6. All of these potential source areas are discussed below.

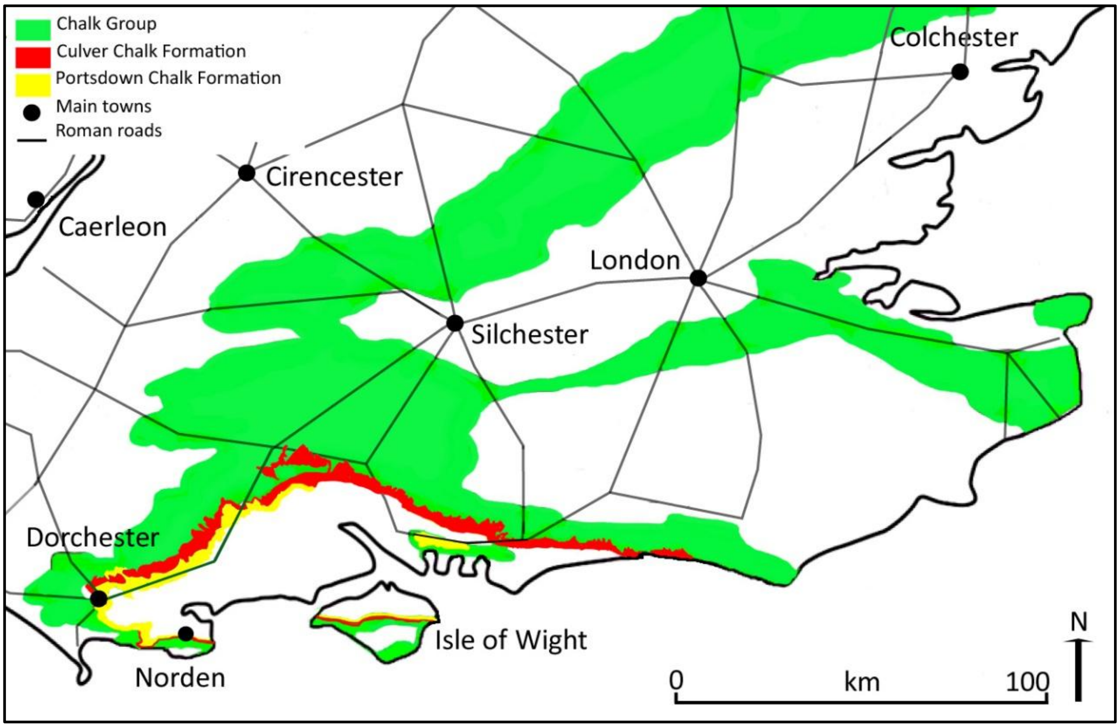


Figure 7.6. Sketch map of southern England, showing the approximate extent of outcrops of the Culver Chalk Formation (in red) and the Portsdown Chalk Formation (in yellow). Note the limited exposure of both formations. The main Chalk Group outcrop in southern England appears in green. The Roman road system and towns mentioned in the text (modern placenames) are also shown. Geological Map Data © NERC 2013. Cretaceous Chalk data taken from Geological Conservation Review volume 12 (1997) *Karst and Caves of Great Britain*, Chapter 7 and Figure 1. Roman road data based on the Ordnance Survey map of *Roman Britain* 5th edition (2001).

Rather surprisingly, given the proximity of Colchester to north east Kent, the Margate Chalk Member of Thanet, discussed in the previous chapter in connection with the London tesserae (section 6.10.2), can be eliminated as a possible chalk source. Macrofossil analysis shows that the highest Chalk Group exposures recorded in Kent and on the North Downs (in Thanet, on the coast around North Foreland and inland at Broadstairs) do not extend beyond the basal beds of the *Offaster pilula* biozone, in the very earliest Campanian Stage (Mortimore *et al.* 2001, 289, 292). As Figure 3.4 shows, this would place the top of the Margate Chalk Member (*i.e.*, the youngest exposure) within BGS FBZ 19, giving this stratum too old a biostratigraphical age to have supplied chalk for the Gosbecks Park tesserae. This means that the chalk quarry at Birchington in Thanet, discussed in the previous chapter (section 6.10.2) as a possible chalk source for the tesserae found at all of the London sites except Fenchurch Street, could not have supplied chalk for the mosaics at Gosbecks Park Temple Complex.

Chalk of this biostratigraphical age (BGS FBZ 20iii-iv) does not outcrop in Yorkshire, Lincolnshire or the Humberside area, so these areas can be eliminated as possible sources for the Gosbecks Park tesserae. However, a few isolated outcrops occur in Norfolk and as these are relatively close to Colchester, they need to be considered.

7.3.1 *Norfolk*

Much of the chalk of Norfolk is buried beneath later Palaeogene and Quaternary drift deposits, but a number of Late Campanian and Maastrichtian exposures are found on the Norfolk coast and patchy outcrops of older (Early and Mid Campanian) chalks are found in a few places inland. The coastal exposures, found largely between Trimingham and Overstrand, are too young to be source candidates for the Gosbecks Park tesserae (Wilkinson 2011a), but two of the inland sites - at Stiffkey and Warham St Mary, 6km and 5km to the east and south east respectively of Wells-next-the-Sea in north Norfolk - expose chalk of the same biostratigraphical age (BGS FBZ 20iii) as that used for the Gosbecks Park tesserae (Wilkinson 2004). However, Norfolk does not seem to be a likely source of chalk for the Gosbecks Park tesserae. The relevant exposures at Stiffkey and Warham St. Mary are too small to have been exploited economically and there is no record of a quarry dating to Roman times in the area.

These sites are also remote from the Roman road system, although it is possible that a coastal route to Colchester might have existed via the River Stiffkey. More significantly, it is known that the foraminifer *Gavelinella usakensis* is found extremely rarely in Norfolk. Wilkinson (2004, 7) did not find it at Warham St Mary; its identification at Stiffkey is tentative (*ibid*.); and Swiecicki (*op. cit*., 343) did not find it in any of his eighteen samples from Norfolk (which also included one from Stiffkey). Only one other recording of this species is known from East Anglia - a single, poorly-preserved specimen recovered from Early Campanian chalk at a site in Claydon in the Gipping Valley in Suffolk – but this is also a tentative identification, and other foraminiferal evidence from this outcrop and others nearby suggests that this chalk is slightly too old to be considered as a source for the Gosbecks Park tesserae (Woods 2004, Woods *et al.* 2007). The foraminiferal evidence therefore suggests strongly that the Gosbecks Park chalk tesserae were not sourced from East Anglia.

7.3.2 *The Isle of Wight, Sussex and Hampshire*

In contrast, *Gavelinella usakensis* is found in moderate abundance in chalk of the same biostratigraphical age from the Isle of Wight (Swiecicki 1980; Hopson *et al.* 2011), Sussex (Hampton *et al*. 2007), Hampshire (Wilkinson 2000a, b, c (Winchester district) and d (Ringwood district)) and Dorset (Bristow *et al.* 2002, Wilkinson *et al.* 2008). It seems considerably more likely, therefore, that the source of the chalk used for the Gosbecks Park tesserae is to be found in south central England than in East Anglia.

Figure 7.6 showed that outcrops of the Culver and Portsdown Chalk Formations can be found in the Isle of Wight, Sussex, Hampshire and Dorset. These areas are all therefore potential provenances for the Gosbecks Park tesserae. It seems likely that the Isle of Wight villas (Brading, Combley and Newport) (section 3.3) sourced the chalk for their tesserae from the chalk ridge that lay a few kilometres above their sites. Foraminiferal analysis showed that the three villas did not obtain their chalk from a single quarry, as the biostratigraphic ages of their chalk tesserae differed (section 3.4). However, the mosaics at these villas were most probably laid in the early fourth century, considerably post-dating any from the Gosbecks Park Temple Complex, and there is no evidence for a chalk quarry dating to the earlier Roman period on the island. It does not seem likely, therefore, that the Isle of Wight was acting as a source of chalk at the time when the Gosbecks Park tesserae were being laid.

It is difficult to ascertain whether any potential chalk source areas for the Gosbecks Park tesserae might be found in Sussex or Hampshire. Chalk with a biostratigraphical age in the Early Campanian (BGS FBZ 20) can be found at Seaford Head in Sussex (section 6.10.3) and the possibility that chalk from this area might have supplied tesserae to some of the London sites or to the early Roman villas, such as Fishbourne or Angmering, has also been considered (also in section 6.10.3). However, it is not clear from the microfossil analysis of the chalk exposed at Seaford Head whether or not the Campanian outcrops found there are young enough to have supplied chalk to the Gosbecks Park tesserae. This is because the zonal indices found were too few to clarify how far into BGS FBZ 20 the biostratigraphical age of the youngest chalk extended (Hampton *et al.* 2007). However, assuming that the biostratigraphical age of this chalk does extend into BGS FBZ 20iii-iv, Seaford Head might be a provenance for the tesserae at Gosbecks Park. If so, a sea route to Colchester seems the most likely form of transportation.

In Hampshire, the areas around Ringwood (Fordingbridge) and Winchester (Broughton, Over Wallop and Saddler's Down) are possible provenances, as outcrops of both the Culver and Portsdown Chalk formations are found in these parts of the county (Wilkinson 2000a, b, c, d). A land route to Colchester via Silchester and London would seem the most likely mode of transport: a possible route can be seen in Figure 7.6. The distance might seem considerable, but monumental and inscriptional evidence shows that Painswick stone (a Jurassic oolitic limestone) was being quarried and transported from its source in the Gloucester area to Silchester, London and Colchester during the later first century AD, probably with the assistance of the army (Hayward 2009, 98-99), so such long distant transport of stone materials is a possibility.

7.3.3 *Dorset*

It can be argued, though, that the most likely source for the chalk tesserae found at the Gosbecks Park Temple Complex lies in Dorset. Chapter 6 (section 6.4.10) reviewed the foraminiferal evidence obtained from chalk tesserae dating to five other known or probable first century tesserae from Silchester, Norden, London (Watling Court and Fenchurch Street) and Caerleon (Backhall Street). The similarity of the foraminiferal signatures identified in these chalk tesserae suggested that their source was also to be sought in the uppermost Culver or lower Portsdown Chalk formations of southern England. The early dates of these sites – either confirmed (Caerleon (Backhall Street), Fenchurch Street, Norden) or proposed (Silchester, Watling Court) – also strengthened the case for a Dorset source, because of the known activity of the 'tesserae manufacturing' site identified at Norden during the later first century AD (Sunter and Woodward 1987, 36, 43).

It now appears possible that the Gosbecks Park Temple Complex tesserae might be added to this list. The chalk tesserae found there have two factors in common with those mentioned above: the microfossil signatures of their chalk and the early date of the construction of their parent mosaic. The foraminiferal signature of all the early material is very similar (BGS FBZs 20iii-iv in the case of Gosbecks Park, and BGS FBZs 20-21i in the case of the other early examples) and it seems likely that the black and white Gosbecks Park Temple mosaic was constructed at a similar date (either during the late first or early second century AD). This suggests that the Dorset area might have provided chalk for the Gosbecks Park tesserae and that Norden might be a candidate site for their processing. If this hypothesis is correct, it would suggest that the Dorset area might have acted as a *regional* source for chalk tesserae production in the later first century AD. This would strengthen the case for the existence of a geomaterials industrial complex in the Poole-Purbeck area at this time (Allen *et al.* 2007). This point will be developed in the following chapter (Chapter 8).

7.4 Conclusions

Microfossil analysis of chalk tesserae from the Gosbecks Park Temple Complex site in Essex has shown that:

a) Chalk from the site has a biostratigraphical age in the Late Cretaceous (Mid Campanian). Its microfossil signature can be identified specifically with BGS FBZs

20iii-iv. These biozones identify the stratigraphical interval of the uppermost Culver Chalk and lowermost Portsdown Chalk formations of southern England;

b) Chalk Group formations in the North East can be eliminated as chalk sources for these tesserae as chalk of this age does not outcrop in Yorkshire, Lincolnshire or the Humberside area;

c) It is almost certain that Norfolk can also be eliminated as a possible chalk source for the Gosbecks Park tesserae as there are very few recordings of the index foraminifer *Gavelinella usakensis* in East Anglia. Also, the relevant exposures are few, small and isolated and no evidence has been found for Roman chalk quarrying in the area;

d) The coastal chalk quarry at Birchington in Kent (Isle of Thanet), which lies within easy reach of Colchester by sea and may have supplied chalk for five of the six London sites discussed in Chapter 6, could not have supplied chalk for the tesserae found at the Gosbecks Park Temple Complex. This is because the Margate Member, on which it is sited, has a different (older) microfossil signature from that identified in the chalk from the Gosbecks Park tesserae.

In addition, it can be suggested that:

e) Tesserae obtained from the Gosbecks Park Temple Complex probably represent a first or early second century AD black and white mosaic laid on the temple site. This is because similar bichrome mosaics of this age are found at early temple sites elsewhere in Essex;

f) It is noticeable that the chalk used to manufacture the tesserae found at the Gosbecks Park Temple Complex has a biostratigraphical signature (BGS FBZs 20iii-iv) similar to that found in other first-century AD chalk tesserae from London (Watling Court and Fenchurch Street), Silchester, Norden and Caerleon (Backhall Street). This suggests that the Gosbecks Park tesserae may derive from the same source area proposed for the Silchester and other first century tesserae (Dorset) and may also have been processed at the ‘tesserae factory’ at Norden, which was active at this time.

Chapter 8

Conclusions

The aim of this project as stated in the Introduction (section 1.4.1) was to use the medium of biostratigraphy (the 'microfossil approach') to determine the provenance of chalk tesserae from selected sites in Roman Britain in order to see whether any changes in the supply or movement of chalk mosaic materials had taken place during the four centuries of Roman occupation. This final chapter looks at the results obtained and considers how well these relate to the initial aim and objectives of the project and whether any conclusions can be drawn from them.

8.1 Assessing the value of the 'microfossil approach' to archaeology

The foraminiferal analyses undertaken for this thesis have clearly validated the 'microfossil approach' described in the Introduction (section 1.2) as a useful technique in the determination of provenance for archaeological artefacts. Despite the limitations of the methodology and the *caveats* that need to be borne in mind when interpreting the results (discussed in Chapter 2), it has been shown that this analytical technique offers a reliable method of determining potential source areas for archaeological materials manufactured from fossiliferous sedimentary deposits (in the case of this thesis, of chalk tesserae). Even in instances where it has not been possible to narrow down potential source areas to a particular locality, the technique has produced results that have allowed areas of the country to be eliminated on biostratigraphical grounds, by showing that a possible source within the Chalk Group in certain localities would be the 'wrong' age for the tesserae.

From the work carried out for this thesis, for example, we now know that the chalk used to build the Early Wall at Silchester was not obtained from the same source as that used to manufacture the tesserae found in Insula IX (section 1.3.2); that the chalk tesserae used to pave the floor of the Gosbecks Park Roman Temple at Colchester were sourced from Chalk Group formations in south central England, rather than from much closer outcrops in Kent (section 7.4); and that the results obtained from foraminiferal analysis of chalk tesserae from Silchester, London (Fenchurch Street), Caerleon (Backhall Street) and Colchester has enabled a chalk source within Dorset to be identified with some confidence. All of these findings represent valuable information for the archaeologist.

However, the work undertaken has also shown that the technique does depend on the opportunity to identify foraminifera to genus and preferably to species level, which is not always possible in thin section, and that clearly it will not work for those tesserae that are found to be barren of microfossils. So although the 'microfossil approach' is a valuable scientific tool in the armoury of the archaeologist, its usefulness for determining provenance is necessarily subject to the technical and practical factors discussed in Chapter 2.

8.2 Variation in chalk provenance over time

Part of the stated aim of this project was to see whether the foraminiferal analyses carried out on the chalk tesserae for this thesis showed that the sources of chalk used for their manufacture varied with time. The results obtained suggest that it did, and the relevant conclusions are discussed in section 8.2.2 and 8.2.3, below. However, there have been some difficulties concerning the dating of material which have made it difficult to investigate this question as well as hoped.

8.2.1 *Difficulties with the dating of material*

With the exception of the Backhall Street mosaic in Caerleon and the Fenchurch Street site in London, few of the tesserae examined derive from well stratified archaeological contexts. This has made dating them difficult. Many tesserae are recovered from re-used contexts, and for these it is not always possible to determine when the parent mosaic may have been laid, although comparison with other archaeological data and known stylistic criteria has often enabled dates to be constrained within a few decades.

Also, the range of dates of the material examined has not been as wide as might be desired. Nearly all of the tesserae obtained for this thesis fell into either the 'earlier' (AD 43 - *c*.150) or 'later' (*c*. AD 270-350) years of the Roman occupation. This is not particularly surprising, as these two periods represent the *floruit* of mosaic manufacture in Roman Britain, but the lack of data relating to the later second and third centuries AD has made it difficult to clarify changes that appear to have taken place in the pattern of chalk supply in the middle years of the occupation.

Nevertheless, the results from the foraminiferal analysis of the relative large number of chalk tesserae dating (probably or certainly) to the earlier period has enabled some conclusions to be drawn about the chalk sources utilised in the later first century, and some indications of change in the sources of supply can be deduced from results relating to the later sites.

8.2.2 *Source areas for the supply of chalk tesserae in the first century AD*

It has been possible to integrate the results obtained for this thesis with those obtained from previous analyses of chalk material from Silchester, Norden and London (Watling Court) to enable an hypothesis to be put forward with regard to the primary source of chalk used to manufacture tesserae in the earlier years of the Roman occupation.

Figure 8.1 compares the results obtained from the foraminiferal analyses of the chalk tesserae investigated for this thesis with similar data from previous researchers. The first seven sites listed date either certainly or very probably to the later first century AD. Figure 8.1 shows that although there are some variances in biostratigraphical age, the data plotted from all seven sites include the biozone BGS FBZ 20iv. This foraminiferal subzone has its lithological expression in the lowermost Portsdown Chalk Formation. Outcrops of this formation, as discussed in the previous chapter (section 7.3), are almost entirely limited to a few areas of southern England. Figure 8.2 shows that these occur principally in Dorset.

Figure 8.1 therefore shows that all the chalk tesserae analysed from the earlier period of the occupation could have originated from one source, and that this source is most likely to be found in Dorset. This finding lends independent support to the case made by Allen *et al*. (2007) and White *et al.* (2012) for the Poole-Purbeck area acting as a 'geomaterials complex' in the later first and early second centuries AD (section 1.3.2).

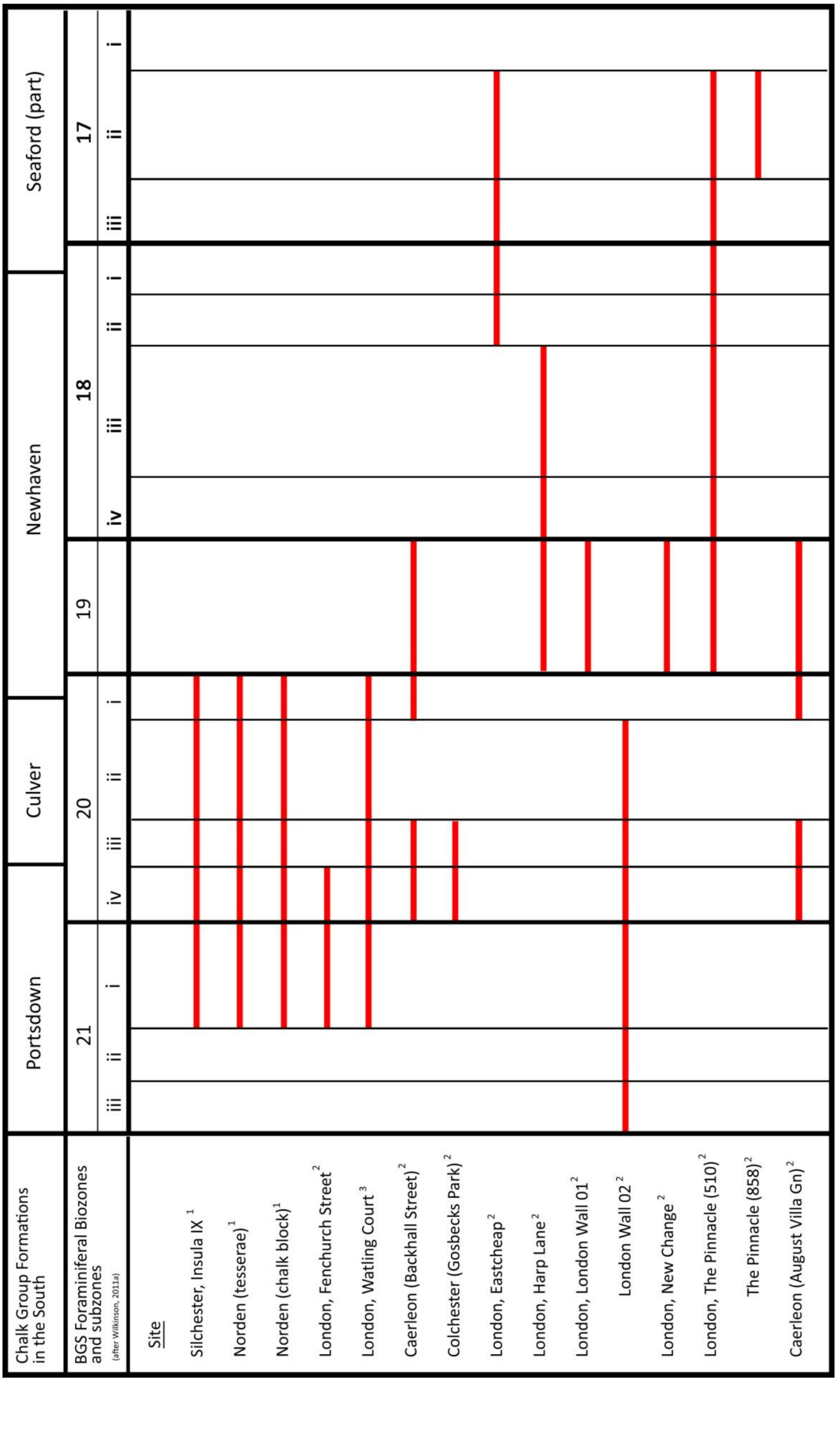


Figure 8.1. Projected stratigraphical range for chalk tesserae from selected sites in Roman Britain. The first seven sites listed date certainly or probably to the later first century AD. The results show that all of their tesserae could have been sourced from chalk with a biostratigraphical age of BGS FBZ 20iv (the lowermost Portsdown Chalk Formation). (Sources: [1]Wilkinson *et al.* 2008; [2]Tasker, this thesis; [3] Wilkinson, unpublished data; Wilkinson 2011a).

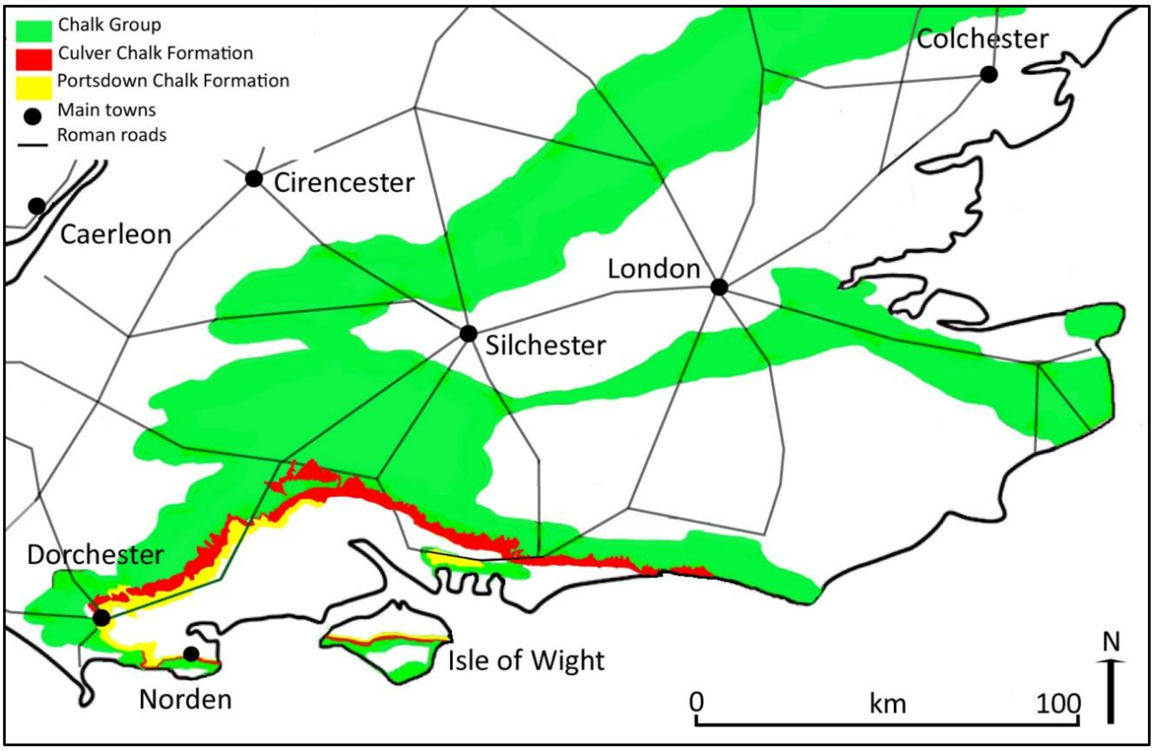


Figure 8.2. Sketch map showing the main exposures of the Portsdown Chalk Formation (in yellow) and the Culver Chalk Formation (in red) in the south of England. The remainder of the Chalk Group is shown in green. Main towns mentioned in the text are marked (modern placenames). Geological Map Data © NERC 2013. Cretaceous Chalk data taken from Geological Conservation Review volume 12 (1997) *Karst and Caves of Great Britain*, Chapter 7 and Figure 1. Roman road data based on the Ordnance Survey map of *Roman Britain* 5th edition (2001).

Moreover, the fact that the early material includes chalk tesserae from as far apart as Caerleon in the west of the province and Colchester in the east suggests that the Dorset area should perhaps be viewed as a *regional* rather than a purely local source for the provision of chalk tesserae during this time.

It is tempting to turn this finding around and use it to state that any chalk tesserae found in London or elsewhere revealing a biostratigraphic signature of BGS FBZs 20-21 in microfossil analysis probably date to the later first century AD. However, although this suggestion is interesting, the data on which it would be based are not yet robust enough to support the conjecture. The samples are too few and there are several possible exceptions to the pattern: the Harp Lane tesserae from London, for instance, are thought to derive from a first century context, but have an older biostratigraphic signature than might be expected for first century material (although of course, this might simply prove that they are *not* first century material). But if a large enough number of known first century chalk tesserae was shown to share the same microfossil signature, it might be possible to ascribe a first century date to material with the same biostratigraphical signature with greater confidence. This is possibly a topic for future research.

8.2.3. *Changes in the pattern of supply during the second century AD*

The data plotted in Figure 8.1 show that this 'early' pattern of supply (of chalk tesserae from the Dorset area during the first century AD) does not seem to have survived beyond the early second century AD. Chalk tesserae from the four London sites dating to around the middle or later second century AD (Eastcheap, London Wall, New Change and The Pinnacle), for instance, all have biostratigraphic ages within the biozones BGS FBZs 17ii-19. These biozones represent a different and earlier microfossil signature to that obtained from (say) the first century Fenchurch Street tesserae, and show that the chalk used to manufacture the tesserae for these second and third century mosaics derives from biostratigraphically older chalk outcrops than those identified for the first century ones. This would suggest that the focus of chalk provision shifted away from Dorset to other sources, such as those found in Birchington in Thanet (Kent) or around Seaford Head in Sussex (section 6.10), at some time during the second century.

However, there are some sites whose tesserae do not fit into these suggested patterns of supply. The first exception concerns the above-mentioned tesserae from Harp Lane. These are thought to derive from a first century mosaic (so it was argued in the text: see section 6.5) but have been shown by foraminiferal analysis to have a 'later' second-century microfossil signature of BGS FBZs 18iii-19. The second exception concerns one of the London Wall tesserae (LON_LW_02), which was discovered in a second-century context, but whose biostratigraphical analysis showed that it had an 'early' microfossil signature of BGS FBZs 20ii-22. The third exception is similar to the second, in that it concerns the chalk tesserae from August Villa Garden in Caerleon, which are thought to date from around AD 200 (assuming they derive from the *intervallum* site discussed in section 5.4.3), but which show a younger 'first century' biostratigraphical signature within BGS FBZ 20.

It is possible to put forward explanations for these three 'anomalous' findings. It could be argued, for instance, that the London Wall (02) tessera was found in a make-up layer and so may represent an example of earlier, re-used material; that the argument for the Harp Lane tesserae being derived from a first-century black and white bath house mosaic (see section 6.5.1) is only conjectural; and that chalk from Dorset might still have been supplying tesserae to the August Villa Garden site in South Wales during the later second century, because Dorset was the nearest source of BGS FBZ 20 chalk to Caerleon. It is also clear (given the relatively small sample sizes examined) that the palaeontological data are as yet insufficient to support the conjecture that the microfossil signature of a chalk tessera is a definite indication of the date of the parent mosaic. However, if – on the basis of the foraminiferal evidence - it were accepted that the Harp Lane tesserae dated to the mid second century and that the London Wall (02) tessera probably dated to the later first, it would suggest that the transition from a Dorset-centred provenance to a more dispersed source pattern which included Kent and Sussex probably occurred during the middle of the second century AD. This is around the time that the 'tesserae factory' at Norden appears to have ceased production, although it is not possible to speculate from the evidence available whether the development of alternative chalk sources, such as those proposed in Kent or Sussex, was a cause or a result of this event, or whether the Norden industry might have suffered a sharp or a gradual decline at this time.

8.2.4 *Source areas for the third and fourth centuries AD*

It is possible that this changing pattern of supply extended to include an increase in the use of local chalks. The conclusion from the analysis of the late third/early fourth-century chalk tesserae from Brading, Combley and Newport Roman Villas on the Isle of Wight was that the chalk used for their mosaics was not only local to the Isle of Wight, but also very local to the villas themselves (section 3.3); the chalks used had different biostratigraphic ages and it was clear that a single quarry did not serve all three villas. However, the chalk found on the island is part of the same geological structure as that in Dorset and similarly indurated, so this usage on the Isle of Wight may simply have been pragmatic and not reflect a general trend across the province.

Did other later 'tesserae manufacturing' centres replace the earlier one at Norden? We have seen that the Vine Street Town House in Leicester was probably obtaining chalk from Baldock in Hertfordshire (section 4.6.2.2); assuming the arguments for the dating of these tesserae are correct, this would have been in the early fourth century, although the Leicester material might possibly be earlier than this (section 4.3.2). Baldock might therefore have been one of the sources of any Late Cenomanian/Early Turonian Stage chalk used in third and fourth century mosaic manufacture. The large quarry found at Darenth District, sited on younger chalk, also appears to have been active at this time (section 6.10.2). However, it is not known whether the many fourth-century mosaics attributed to the Corinium and Durnovarian 'workshops' that were operating in the West and South-West of *Britannia* in the early fourth century were laid using chalk from these or other sources. This suggests that an investigation along these lines would be a promising candidate for future research, as a microfossil analysis of chalk tesserae from a selection of mosaics from these 'workshops' might provide some interesting answers. It was unfortunately not possible to pursue this line of enquiry within the time constraints of this study.

8.3 Movement of chalk materials around the province

It proved possible to conclude very little new concerning the movement of chalk mosaic materials around the province of Britannia from the work carried out for this thesis, although it was not clear that this would be the case at the outset. The results obtained during the present study from the foraminiferal analysis of chalk tesserae from Colchester and Caerleon have shown that it was not unusual for mosaic materials to be transported for long distances in the province of *Britannia* from the early first century AD onwards. However, this was not a particularly surprising conclusion, as previous research had already brought to light the movement of native and imported funerary and architectural stone materials around southern *Britannia* during this time (Hayward 2009) and identified a geomaterials complex in the Poole-Purbeck area capable of supplying mudstone tesserae sourced from the local Kimmeridge Clay Formation to London and other areas during the first century (Allen *et al.* 2007).

Nevertheless, the results obtained add to an emerging pattern of a considerable amount of materials movement in the province during the first and early second centuries AD. The identification of Dorset as the most likely source for the chalk tesserae from the Backhall Street mosaic from Caerleon, in particular, strengthens the case made previously by Fulford for army involvement in the transportation of materials in the south west during the first and early second centuries AD (see section 5.7.2 and references therein). Given the importance of Colchester in the early history of the province, it is possible that a similar involvement was responsible for the transportation of Dorset tesserae to the Gosbecks Park Temple Complex at the same time. However, there is no evidence to support a direct army link with Colchester at this time.

8.4 The targeting of harder chalk strata for the manufacture of tesserae

One of the questions posed in this thesis was whether the harder beds of rock within the Chalk Group might have been preferred for the manufacture of tesserae, on the grounds of hardness of wearing underfoot. However, the foraminiferal analyses carried out on for this thesis on did not suggest that any of the harder units within the Chalk Group – such as the Totternhoe Stone, Melbourn Rock and Chalk Rock Members – were being specifically targeted for tesserae production. This is despite the fact that the Totternhoe Stone had been identified by the Romans as a chalk source, as it was used for walling in the eponymous villa and also for paving in London (section 4.6.2). In contrast, quarrying activities in the mediaeval period appear to have actively sought out such harder rock in some locations; at Avebury, for example, mediaeval excavation of the harder rock deliberately follows the outcrop around the contour on the hillside (Small 1999, 21-2 and Figures 13-14).

It is possible to suggest several reasons why these harder Chalk Group units do not seem to have been targeted for tesserae manufacture. Firstly, the chalk found along the ridge at Norden and in other parts of the Dorchester area may already have been considered hard enough to be used for the production of tesserae. The local exposures include outcrops of the lowermost Portsdown Chalk Formation that were indurated (physically hardened) during the Alpine tectonic movements that caused the formation of the Purbeck Monocline (section 1.3.2). Once this source of very hard chalk had been identified, therefore, other possible sources, at least in the early Roman period, may not have been sought out. This would explain why so many of the earlier chalk tesserae examined for this thesis (and others recorded from previous research) appear to have been sourced from the Dorset area.

A second explanation for the lack of targeting may concern the nature of the strata themselves. A harder chalk bed may be formed by the successive lithification of a series of thin erosion surfaces, which may coalesce to produce a thicker unit; this produces a hard-ground, a series of which comprise the Chalk Rock Member. Others may contain cemented horizons of shelly or gritty material, flints or phosphatised nodules which lend strength to the chalk matrix but may make it more difficult to work. It is possible therefore that prospective quarrying by the army or private individuals may have revealed technical or economic difficulties with the exploitation of these particular rocks that outweighed the practical advantages of using such material. For instance, the physical effort required to knap large quantities of good-quality tesserae from hard, brittle, shelly or nodular strata may have been too great, or taken too much time, or produced too much wastage.

Finally, these strata may have been rejected on aesthetic grounds as not being white enough in colour. Although there is some natural variance, in general Totternhoe Stone is greyish or brownish white, the Melbourn Rock Member is off-white or greyish white and the Chalk Rock Member consists of a number of off-white, grey, pink and green layers. It is understandable that the prospect of enhanced durability might not have compensated for this lack of brilliant whiteness. In contrast, the indurated Chalk Group formations exposed in the Dorset area are almost pure white in colour. This is perhaps the most likely explanation for why so many of the early mosaics of Roman Britain appear to have been supplied with chalk tesserae from the Dorset area.

These twin considerations of hardness and colour may explain why even the early mosaics laid in Silchester used tesserae manufactured from Dorset rather than from local chalk. The Chalk Group formations that were exploited in the construction of the Early Wall at Silchester (the West Melbury Marly and Zig Zag Chalk Formations) are neither hard nor particularly white. This suggests that once the suitability of the chalk at Norden had been assessed and the practical means of organising its transportation to Silchester become available (good roads, burgeoning transport infrastructure, developing economy), there were logical reasons for using the harder, whiter Dorset chalk in preference to the softer and greyer local alternatives.

8.5 Future work

It would be surprising if a work of this nature did not suggest other directions which might be profitable for future research. Two potentially informative lines of enquiry are offered below.

8.5.1 *Shedding light on the operation of 'schools' of mosaicists*

Similarities in design and iconography identified in a significant number of fourth-century mosaics from Roman Britain have led to the suggestion that several 'schools' or groups of mosaicists were operating in the province at this time (principally, Smith 1969, 1982; Johnson 1993, 147-52, 165). It would be interesting to test this hypothesis by using microfossil analysis to provenance chalk tesserae from mosaics assigned to one, or indeed, several of these proposed groups, with the purpose of finding out whether mosaics thought to share similarities in style also shared similarity of source material. A positive finding from such an investigation would suggest considerable organisation within the mosaic trade and could be used to support the hypothesis of organised 'schools'. The lack of any pattern emerging from the results would indicate that raw materials were being sourced in a more *ad hoc* fashion and perhaps suggest that such groups were organised more loosely.

8.5.2 Investigating the change in source of supply over time

It would also be interesting to examine tesserae confidently dated to successive periods of the Roman occupation to see whether changes in the overall pattern of chalk supply could be discerned from their microfossil signatures. This would enable a number of questions to be investigated. Do the provenances of the chalk sources exploited reflect the shift in economic prosperity from the South East to the South West in the later third and early fourth century? Where did the fourth century mosaics laid in London obtain their chalk? Did the fourth century mosaics laid in the North East use local chalks, such as those found at Bridlington, or is it possible that the chalk quarry found at Baldock had a regional remit and supplied tesserae for these also?

It is to be hoped that questions such as these will be taken up and investigated by future researchers. The author looks forward to seeing the results of their work.

Appendices

Appendix A: Palaeontology Tables

Appendix B: Chalk processing methods

Appendix C: List of species cited

Appendix D: Historic Environment Records

Table 1.1 Microfossils identified in chalk tesserae from Silchester (*Calleva Atrebatum*), Hampshire, UK

BGS reference	Archaeological context	NGR (approx.)	Palaeontology	BGS FBZ
MPA 54160	A.1997.25a	SU 639 624	*Gavelinella usakensis, Gyroidinoides nitidus, Globorotalites micheliniana, Heterohelix striata, ?Osangularia cordieriana, Praebulimina* sp., *Stensioeina* sp. cf. *pommerana.* Calcareous nannofossils.	20-21i
MPA 54161	A.1997.25b	SU 639 624	*Bolivinoides decoratus, Gavelinella clementiana, G. lorneiana, G. monterelensis, G.* sp. cf. *pertusa; G. thalmanni, G. usakensis, Gyroidinoides nitidus, Stensioeina pommerana, Verneuilinoides muensteri.* Calcareous nannofossils.	21i
MPA 54162	A.2001.10a	SU 639 624	*Astacolus* sp., *Bolivinoides* sp. aff. *decoratus, Gavelinella clementiana, G. monterelensis, Stensioeina pommerana.* Calcareous nannofossils.	21i
MPA 54163	A.2001.10b	SU 639 624	Calcareous nannofossils.	No FBZ assigned
MPA 54164	A.2002.15	SU 639 624	Barren.	Uncertain

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference.
Data for Table 1.1 taken from Wilkinson *et al*. 2008, Table 1.

Table 1.2 Microfossils identified in chalk tesserae from Norden, near Corfe Castle, Dorset, UK.

BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
MPA 54216	Dorset County Museum, Dorset	SY 956 827	*Gavelinella clementiana, G. lorneiana, G. monterelensis, G. pertusa, G. usakensis, Globorotalites micheliniana, Gyroidinoides nitida, Osangularia cordieriana, Stensioeina pommerana, Verneuilina muensteri.*	21i
MPA 54217	Dorset County Museum, Dorset		*Gavelinella usakensis, Gavelinella* sp., *Verneuilina muensteri.*	20-21i
MPA 54218	Dorset County Museum, Dorset		*Gavelinella stelligera, G. usakensis, Osangularia cordieriana.*	20-21i (although *G. stelligera* not common after 20)
MPA 54219	Dorset County Museum, Dorset		*Gavelinella lorneiana.*	_
MPA 54220	Dorset County Museum, Dorset		*Gavelinella* sp. cf. *involutina, G. lorneiana, G. usakensis, Gyroidinoides nitida, Osangularia cordieriana, Quadrimorphina trochoides.*	20-21i
MPA 54221	Dorset County Museum, Dorset		*Gavelinella* sp., *Stensioeina pommerana.*	_

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Data for Table 1.2 (columns 1-4) taken from Wilkinson *et al*. (2008). Data in column 5 inferred from Wilkinson 2011a,b.

Table 1.3 Microfossils identified in a loose sample of chalk rock from Norden, near Corfe Castle, Dorset, UK.

BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
MPA 54222*	Norden site	SY 956 827	*Arenobulimina* sp., *Hedbergella brittonensis, H. delrioensis,* rare *H. planispira, Gavelinella usakensis, G.* sp. cf. *stelligera, G.* sp., *?Loxostomum eleyi,* very rare *Whiteinella* sp. Poorly preserved radiolarians, ostracods, echinoid spines and bivalve shell.	20-21i

*thin section

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Data for Table 1.3 (columns 1-4) taken from Wilkinson *et al*. (2008). Data in column 5 inferred from Wilkinson 2011a,b.

Table 1.4. Microfossils identified in a sample of chalk from the Early Wall at Silchester (*Calleva Atrebatum)*, Hampshire, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
SIL_EW_A	-	8739	SU 639 624	Microfossils recovered were in poor condition and could not be identified.	-
SIL_EW_B	-			Microfossils recovered were in poor condition and could not be identified.	-
SIL_EW_C	-			Microfossils recovered were in poor condition and could not be identified.	-
SIL_EW_D01*	-			*Globigerinelloides bentonensis, Hedbergella brittonensis, H. delrioensis, Heterohelix* sp., *Marssonella* sp. cf. *trochus.* *Pithonella sphaerica* (common).	1-7
SIL_EW_D02*	-			*Arenobulimina* sp. cf. *preslii, Gyroidinoides* sp. cf. *parva, Plectina* sp. cf. *cenomana, Hedbergella delrioensis, H.* sp. cf. *planispira, Heterohelix moremani, H. s*p. cf. *reussi.*	7
SIL_EW_E*	-			*Hedbergella delrioensis, H.* sp. cf. *planispira.* *Pithonella sphaerica* (common).	-
SIL_EW_F*	-			*Hedbergella brittonensis, H.* sp., *Gavelinella* sp. cf. *cenomanica.* *Pithonella sphaerica* (common); *P. ovalis.*	1-7

* thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 3.1. Microfossils identified in chalk tesserae from Brading Roman Villa, Isle of Wight, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
IOW_BRV_A01 – A06	MPA 61045 - 61050	unstratified	SZ 599 860	No microfossils recovered from these 6 tesserae	-

Sample / BGS reference	TS number	BGS TS number	Archaeological context	NGR	Palaeontology	BGS FBZ
IOW_BRV_B01 MPA 61051	IOW_BRV_B01a*	MPA 61051/1*	BRV.EXO3–Zone 7-785	SZ 599 860	No microfossils could be identified	-
	IOW_BRV_B01b*	MPA 61051/2*			No microfossils could be identified	-
IOW_BRV_B02 MPA 61052	IOW_BRV_B02a*	MPA 61052/1*			No microfossils could be identified	-
	IOW_BRV_B02b*	MPA 61052/2*			No microfossils could be identified	-
IOW_BRV_B03 MPA 61053	IOW_BRV_B03a*	MPA 61053/1*			*Eggerellina* sp. cf. *mariae*, ?*Eoguttulina* sp., *Hagenowina* sp., *Hedbergella brittonensis*, *H. planispira*, *Heterohelix* sp., *Lenticulina rotula, Marssonella* sp. cf. *trochus, Nodosaria* sp., *Rotalipora cushmani, R.* sp. cf. *cushmani*. *Pithonella sphaerica* (abundant), *P. ovalis.*	4-7
	IOW_BRV_B03b*	MPA 61053/2*			*Eggerellina* sp., *Gavelinella* sp. cf. *berthelini, G. cenomanica*, *Hedbergella brittonensis, H. delrioensis, H.* sp., *Heterohelix* sp., *Marginulina* sp. cf. *jonesi, Marssonella trochus.* *Pithonella sphaerica* (abundant).Crinoid ossicle.	1-9
IOW_BRV_B04 MPA 61054	IOW_BRV_B04a*	MPA 61054/1*			No microfossils could be identified	-
	IOW_BRV_B04b*	MPA 61054/2*			*Globigerinelloides aspera, Hedbergella delrioensis*, *H.* sp. cf. *delrioensis*, *H. planispira, H.* sp. cf. *planispira, Heterohelix* sp., *Lenticulina* sp., *Praeglobotruncana delrioensis, Rotalipora* sp. cf. *greenhornensis. Pithonella sphaerica* (abundant).	4iii
IOW_BRV_B05 MPA 61055	IOW_BRV_B05a*	MPA 61055/1*			No microfossils could be identified.	-
	IOW_BRV_B05b*	MPA 61055/2*			No microfossils could be identified.	-

*thin sections BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate); TS: thin section.

Table 3.2. Microfossils identified in chalk tesserae from Combley Roman Villa, Isle of Wight, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
IOW_CRV_A01	-	883.200.447	SZ 5382 8784	*Gavelinella lorneiana, Praebulimina* sp.	
IOW_CRV_A02	-			*Arenobulimina obliqua, Ataxophragmium variabile, Gavelinella clementiana, G. lorneiana, G. usakensis, G.* sp. cf. *usakensis, G.* sp., *Globorotalites micheliniana, Gyroidinoides nitida, Osangularia cordieriana, Praebulimina carseyae, P.* sp. cf. *reussi, Stensioeina pommerana, S.* sp.	20iii-21i
IOW_CRV_A03	-			No microfossils identified.	-
IOW_CRV_A04	-			No microfossils identified.	-
IOW_CRV_A05	-			*Stensioeina pommerana*.	-
IOW_CRV_A06	-			No microfossils recovered.	-
IOW_CRV_A07*	-			No microfossils could be identified.	-
IOW_CRV_A08*	-			*Globigerinelloides aspera, Gyroidinoides nitida, Heterohelix globulosa, Osangularia cordieriana.*	Long ranging species

*thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 3.3. Microfossils identified in chalk tesserae from Newport Roman Villa, Isle of Wight, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
IOW_NRV_A01	-	855.136	SZ 5011 8855	No microfossils found.	-
IOW_NRV_A02	-			No microfossils found.	-
IOW_NRV_A03	-			No microfossils found.	-
IOW_NRV_A04	-			No microfossils found.	-
IOW_NRV_A05	-			No microfossils found.	-
IOW_NRV_A06	-			No microfossils found.	-
IOW_NRV_A07*	-			Thin section too dark and no microfossils could be identified.	-
IOW_NRV_A08*	-			*Eponides* sp. cf. *concinna, Gavelinella usakensis, Hedbergella* sp., *Heterohelix* sp., *Osangularia cordieriana, Stensioeina granulata incondita, S. pommerana.* *Pithonella krasheninnikova; Pithonella sphaerica* (common); *P. ovalis* (rare).	20i-ii

* thin section

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 3.4. Microfossils identified in chalk thin section from samples taken by the British Geological Survey (BGS) in the Isle of Wight, UK.

Sample point on Figure 3.7 (map)	BGS TS reference	NGR	Palaeontology	Biostratigraphy / BGS FBZ
1	MPA 57083*	SZ 59828 86703	Simple planktonics characteristic of the Cenomanian (but not confined to it). Rare benthonic species (*Gavelinella* sp.). *Pithonella ovalis* (abundant), *P. sphaerica.*	Late Cenomanian-Early Turonian
2	MPA 57084*	SZ 59920 86705	*Hedbergella brittonensis, H. delrioensis, Heterohelix moremani* and other simple but long ranging planktonics. Benthonic fauna rare. *Pithonella sphaerica* (common).	Late Cenomanian-Early Turonian
3	MPA 57085*	SZ 60319 86428	*Gavelinella cenomanica, Hagenowina* sp. cf. *anglica, Lenticulina rotula, Plectina* sp. cf. *cenomanica.*	4i-ii
4	MPA 57087*	SZ 61035 86224	*Hagenowina advena, Gyroidinoides praestans, Hedbergella brittonensis, H. delrioensis*, *Marssonella* sp., ?*Spiroloculina papyracea, Tritaxia* sp., *Valvulineria* sp.; plus other long ranging Cenomanian species.	4 (if *S. papyracea* identification correct)
5	MPA 57090 *	SZ 61583 86163	Frequent simple non-keeled planktonic species. Rare benthonic species. *Pithonella sphaerica* (flood).	Late Cenomanian-Early Turonian
6	MPA 57080*	SZ 57700 87929	*Bolivinoides* sp., *Gavelinella usakensis, Globorotalites micheliniana, Globigerinelloides* sp., *Hedbergella* sp., *Heterohelix* sp., *Osangularia cordieriana, Stensioeina pommerana.* *Pithonella sphaerica* (common), *Pithonella krasheninnikova* (rare).	20 -21i
7	MPA 57088*	SZ 61280 86640	?*Bolivina* sp., *Gavelinella usakensis, Globorotalites micheliniana, Heterohelix* sp., *Marssonella* sp., *Stensioeina pommerana*.	20
8	MPA 57089*	SZ 61390 86660	*Bolivinoides* sp. cf. *decoratus, Gavelinella usakensis, Spiroplectammina baudouiniana.*	20 iii-iv
9	MPA 57091*	SZ 61657 86354	*Stensioeina granulata* (but not *S. exsculpta*).	14
10	MPA 57093*	SZ 61609 86446	Long ranging species only found. *Pithonella sphaerica* (common).	unassigned
11	MPA 57094*	SZ 62137 86197	*Osangularia cordieriana, Stensioeina granulata*.	14-17
12	MPA 57097*	SZ 62394 86179	*Gavelinella* sp.cf. *cristata*, *Osangularia cordieriana, Stensioeina* sp. *Pithonella sphaerica* (common)	17-18
13	MPA 57100*	SZ 62409 86009	*Stensioeina exsculpta exsculpta*.	15-19

*thin sections BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate); TS: thin section.

Data in columns 1-4 supplied by IP Wilkinson (BGS); data in column 5 inferred from Wilkinson 2011a,b.

Table 4.1. Vine Street A: microfossils identified in chalk tesserae from the Vine Street Town House, Leicester, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
LE_VS_A01	MPA 62462	A24.2003.5751.740	SK 583 049	*Heterohelix reussi, Lenticulina rotula, Polymorphina* sp., *Praebulimina reussi.*	-
LE_VS_A02	MPA 62463			*Hedbergella delrioensis, Heterohelix reussi, ?Whiteinella baltica.*	-
LE_VS_A03	MPA 62464			*Hedbergella delrioensis, Heterohelix reussi.*	-
LE_VS_A04	MPA 62465			*Hedbergella* sp. cf. *planispira.* *Pithonella sphaerica.*	-
LE_VS_A05	MPA 62466			*Hedbergella delrioensis, Heterohelix* sp., *Lingulogavelinella globosa.*	6-9
LE_VS_A06	MPA 62467			*Heterohelix* sp.	-
LE_VS_A07*	MPA 62468*			*Arenobulimina preslii, Hedbergella brittonensis, H. delrioensis, ?Marginotruncana marginata, Nodosaria* sp., *Praebulimina* sp. *Pithonella ovalis.*	7-13
LE_VS_A08*	MPA 62469*			*Dicarinella canaliculata, Hedbergella brittonensis, H. planispira, H.* sp., *Helvetoglobotruncana helvetica.*	8-12
LE_VS_A09	MPA 62470			*Pithonella sphaerica.*	-
LE_VS_A10	MPA 62471			Barren	-
LE_VS_A11	MPA 62472			*Hedbergella brittonensis, Heterohelix* sp., *Praebulimina reussi.*	-
LE_VS_A12	MPA 62473			Barren	-
LE_VS_A13	MPA 62474			Barren	-
LE_VS_A14	MPA 624775			*Pithonella sphaerica.*	-
LE_VS_A15	MPA 62476			*Pithonella sphaerica.*	-
LE_VS_A16	MPA 62477			*Pithonella sphaerica.*	-
LE_VS_A17	MPA 62478			Barren	-

* thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 4.2. Vine Street B: microfossils identified in chalk tesserae from the Vine Street Town House, Leicester, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	Comments	BGS FBZ
LE_VS_B01	MPA62479	A24.2003.5886	SK 583 049	Only a few microfossils were recovered from these five tesserae and identification of these was not possible. A few echinoid spines were also present.	All six tesserae smelled strongly of bitumen when crushed or thin sectioned. The crushed tesserae material was dirty grey in colour and splintery in texture and was identified as a calcareous mudstone.	-
LE_VS_B02	MPA62480					-
LE_VS_B03	MPA62481					-
LE_VS_B04	MPA62482					-
LE_VS_B05	MPA62483					-
LE_VS_B06*	MPA62484*			Barren		-

*thin section

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 4.3. Vine Street C: microfossils identified in chalk tesserae from the Vine Street Town House, Leicester, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
LE_VS_C01	MPA62485	A24.2003.5266.626	SK 583 049	Barren	-
LE_VS_C02	MPA62486			*Gavelinella intermedia, ?G. berthelini.*	1-9
LE_VS_C03	MPA62487			Barren	-
LE_VS_C04	MPA62488			Barren	-
LE_VS_C05	MPA62489			Barren	-
LE_VS_C06	MPA62490			Barren	-
LE_VS_C07*	MPA62491*			*Arenobulimina* sp., *Dicarinella canaliculata, D. hagni, D.* sp. cf. *hagni, ?Epistomina* sp., *Gavelinella* sp. cf. *intermedia, Globigerinelloides* sp. cf. *bentonensis, Hedbergella brittonensis, H. delrioensis, Heterohelix moremani, H. reussi, Lenticulina rotula, Marginotruncana* sp. cf. *marginata.* *Pithonella sphaerica* (abundant).	8-9

*thin section

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 4.4. Vine Street D: microfossils identified in Small Find (SF) 1084 from the Vine Street Town House, Leicester, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
LE_VS_D01*	MPA62492*	A24.2003.5265.1084	SK 583 049	*Hedbergella brittonensis, H. delrioensis, H. planispira, Heterohelix* sp., *Marginotruncana marginata.* *Pithonella sphaerica.*	8-13
LE_VS_D02*	MPA62493*			*?Dicarinella hagni, Hedbergella* sp. *Pithonella sphaerica* (rare).	7-9
LE_VS_D03*	MPA62494*			*Hedbergella brittonensis, H.* sp., *Heterohelix* sp. *Pithonella ovalis, P. sphaerica* (flood proportions). Bivalve prisms.	8
LE_VS_D04*	MPA62495*			*Hedbergella brittonensis, Heterohelix moremani.* *Pithonella sphaerica* (common). Indeterminate planktonic foraminifera. Bivalve fragment.	7-8
LE_VS_D05*	MPA62496*			*Hedbergella delrioensis, H.* sp., *Gavelinella* sp. *Pithonella ovalis, P. sphaerica.*	-
LE_VS_D06*	MPA62497*			Barren of foraminifera. Bivalve fragments.	-

*thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Figure 5.1. Microfossils identified in chalk tesserae from the Backhall Street mosaic, Fortress Baths, Caerleon, Gwent, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
CAER_BS_01*	-	31.78	ST 340 906	*Archaeoglobigerina cretacea, Arenobulimina elevata, A. obliqua, Eouvigerina* sp., *?Eponides biconvexa, Gavelinella trochus, Globigerinelloides aspera, Globorotalites micheliniana, Hedbergella* sp., *Heterohelix globulosa, H.* sp., *Loxostomum eleyi, Osangularia cordieriana, Stensioeina pommerana, S. exsculpta.* Ostracod sp.	20ii-21i
CAER_BS_02*	-			*Arenobulimina elevata, A.* sp., *Ataxophragmium variabile, ?Epistomina* sp., *Eggerellina brevis, Gavelinella* sp. cf. *clementiana, G. lorneiana, G. trochus, G.* sp., *Globigerinelloides aspera, G.* sp., *Heterohelix* sp., *Osangularia cordieriana, Pleurostomella subnodosa, Stensioeina exsculpta* cf. *gracilis, S. pommerana, Whiteinella* sp. Brachiopod shell fragment, shell debris.	20iii-iv
CAER_BS_03	-			No microfossils recovered.	-
CAER_BS_04	-			No microfossils recovered.	-
CAER_BS_05	-			No microfossils identified.	-
CAER_BS_06	-			No microfossils recovered.	-
CAER_BS_07*	-			*Arenobulimina footei, Gavelinella* sp. cf. *cristata* (or possibly *G.* sp. cf. *clementiana), Globigerinelloides aspera, Globorotalites micheliniana, Hedbergella* sp., *Heterohelix globulosa, H.* sp., *Loxostomum eleyi, Osangularia* sp., *Stensioeina pommerana.* Ostracod sp.	19-20i (19-23 if *G. clementiana* correct)
CAER_BS_08*	-			*Arenobulimina elevata, A.* sp., *?Dentalina* sp., *Gavelinella* sp. cf. *clementiana, G.* sp., *Globigerinelloides aspera, Globorotalites micheliniana, Hedbergella* sp., *Heterohelix* sp., *Osangularia cordieriana, Reussella* sp., *Stensioeina pommerana.*	20iii-23
CAER_BS_09*	-			*Cibicidoides* (?) *voltziana, Gavelinella* sp., *Globigerinelloides aspera, ?Loxostomum eleyi, Marssonella* sp., *Reussella* sp., *Stensioeina exsculpta.*	20ii-iv

*Thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 5.2. Microfossils identified in chalk tesserae from the site at August Villa Garden, Cold Bath Road, Caerleon, Gwent, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
CAER_AV_01*	-	2004.65H	ST 337 907	*Eponides concinna, Gavelinella cristata, G.* sp., *Osangularia* sp., *Rugoglobigerina* sp. cf. *pilula, Stensioeina pommerana.*	19-20i
CAER_AV_02*	-			*Cibicidoides* (?) *voltziana, Eponides* sp., *Gavelinella* sp., *Globigerinelloides aspera, Hedbergella* sp., *Heterohelix* sp., *Osangularia* sp., *Stensioeina granulata* cf. *incondita, S. pommerana.*	20ii-iv
CAER_AV_03	-			A few damaged specimens recovered	-
CAER_AV_04	-			A few damaged specimens recovered	-
CAER_AV_05	-			None recovered	-
CAER_AV_06	-			A few damaged specimens recovered	-
CAER_AV_07*	-			*Globorotalites micheliniana, Osangularia* sp., *Stensioeina pommerana.*	
CAER_AV_08*	-			*Cibicidoides* (?) *voltziana, Globigerinelloides aspera, Heterohelix* sp., *Osangularia* sp., *Stensioeina pommerana, S.* sp.	20ii-24
CAER_AV_09*	-			*Gavelinella clementiana, Globigerinelloides aspera, Hedbergella* sp., *Heterohelix* sp., *Osangularia* sp., *Reussella* sp., *Spiroplectammina* sp., *Stensioeina* sp. cf. *pommerana, S.* sp.	20iii-24

*thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 6.1. Microfossils identified in chalk tesserae from 5-12 Fenchurch Street, London, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
LON_FC_01*	-	FEN83.1651	TQ 3303 8092	*Arenobulimina* sp. cf. *obliqua, A.* sp., *Bolivinoides* sp. cf. *decoratus, Eponides biconvexa, Eouvigerina* sp., *Gavelinella* sp. cf. *clementiana, Globigerinelloides* sp., *Globorotalites micheliniana, G.* sp., *?Globotruncana* sp., *Gyroidinoides* sp. cf. *nitidus, Heterohelix globulosa, Lenticulina* sp., *Pseudouvigerina* sp. cf. *plummerae, Spiroplectammina* sp., *Stensioeina pommerana, S.* sp., *Verneuilina muensteri*. Echinoid plate.	20iv-21i
LON_FC_02*	-			*Arenobulimina footei, A.* sp., *?Gaudryina* sp., *Gavelinella pertusa, Stensioeina* sp.	19-25
LON_FC_03	-			No microfossils identified.	-
LON_FC_04	-			No microfossils identified.	-
LON_FC_05	-			No microfossils identified.	-
LON_FC_09*	-			*Arenobulimina* sp. cf. *courta, A.* sp. cf. *elevata, A.* sp. cf. *obliqua, Cibicidoides (?) voltziana, Eouvigerina aculeata, E.* sp., *Gavelinella usakensis, G.* sp., *Globigerinelloides aspera, G.* sp., *Globotruncana bulloides, Neoconorbina* sp. cf. *scanica, Osangularia* sp. cf. *cordieriana, Pleurostomella* sp. cf. *subnodosa, Reussella szajnochae praecursor, R.* sp. cf. *szajnochae praecursor, Stensioeina* sp. cf. *pommerana, ?Verneuilina muensteri.*	20ii-21i
LON_FC_10*	-			*Arenobulimina* sp. cf. *courta, Gavelinella* sp. cf. *usakensis, Globigerinelloides aspera, Reussella* sp. cf. *szajnochae praecursor.*	20-21i

*thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 6.2. Microfossils identified in chalk tesserae from 41 Eastcheap, London, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
LON_EC_01*	-	EAE01.184	TQ 3310 8083	*Arenobulimina* sp., *Eouvigerina* sp., *Eponides* sp.,?*Gaudryina* sp., *Gavelinella* sp., *Globigerinelloides aspera, Hedbergella brittonensis, Heterohelix reussi, H.* sp. cf. *globulosa*, *H.* sp. cf. *reussi, H.* sp., *Loxostomum eleyi, Osangularia* sp.cf. *cordieriana.* Radiolarian sp., Bryozoan sp.	Long ranging species
LON_EC_02*	-			*Arenobulimina* sp., *Eponides* sp. cf. *concinna, E. sp., Hedbergella brittonensis, H.* sp., *Heterohelix* sp. cf. *reussi, Reussella* sp. cf. *kelleri, Whiteinella* sp. cf. *baltica*. Holothurian sclerite.	17ii-18ii
LON_EC_03*	-			No microfossils identifiable as thin section too cloudy.	-
LON_EC_04	-			No microfossils recovered.	-
LON_EC_05	-			No microfossils identified.	-
LON_EC_06	-			No microfossils recovered.	-

*thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 6.3. Microfossils identified in chalk tesserae from Harp Lane, London, UK.

Sample number	BGS reference	Archaeological reference	NGR	Palaeontology	BGS FBZ
LON_HL_01*	-	HL 74 135	TQ 3319 8068	*Globorotalites micheliniana, Globotruncana* sp. cf. *arca, G.* sp., *Gyroidinoides nitidus, Haplophragmoides* sp., *Heterohelix globulosa, ?Lenticulina* sp., *Stensioeina exsculpta* cf. *gracilis, S.* sp., *?Textularia* sp. Crinoid columnar.	19-20
LON_HL_02*	-			*Arenobulimina* sp., *Eponides concinna, Eouvigerina* sp. cf. *aculeata, Gavelinella* sp., *Globigerinelloides aspera, Heterohelix* sp., *Marssonella* sp. cf. *trochus, Osangularia cordieriana, Stensioeina exsculpta* cf. *gracilis, Whiteinella baltica.*	18iii-19
LON_HL_03	-			No microfossils recovered.	-
LON_HL_04	-			No microfossils recovered.	-
LON_HL_05	-			No microfossils recovered.	-
LON_HL_06	-			No microfossils recovered.	-
LON_HL_07	-			No microfossils recovered.	-
LON_HL_08	-			No microfossils recovered.	-

*thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 6.4. Microfossils identified in chalk tesserae from 60 London Wall, London, UK.

Sample number	BGS reference	Archaeological reference	NGR	Palaeontology	BGS FBZ
LON_LW_01a* and LON_LW_01b*	-	LOW 88 1249	TQ 3319 8068	*Arenobulimina* sp. cf. *obliqua, A.* sp., *Eouvigerina aculeata, Eponides* sp. cf. *concinna, Gaudryina* sp., *Gavelinella* sp., *Globigerinelloides aspera, G.* sp. cf. *aspera, Globorotalites micheliniana, Hedbergella sp., Heterohelix* sp. cf. *globulosa, H.* sp. cf. *reussi, H.* sp., *Nodosaria* sp., *Stensioeina pommerana, S.* sp. cf. *exsculpta gracilis, S.* sp. cf. *pommerana, Verneuilina muensteri, V.* sp. cf. *muensteri, Whiteinella baltica.* Ostracod sp.	Basal 19
LON_LW_02*	-			*Arenobulimina* sp. cf. *obliqua, A.* sp., *Cibicidoides* (?) *voltziana, Eponides* sp., *Globorotalites micheliniana, Globotruncana* sp. cf. *linneiana, Loxostomum eleyi.* ?Ostracod sp.	20ii – 21i
LON_LW_03	-			No microfossils recovered.	-
LON_LW_04	-			No microfossils recovered.	-
LON_LW_05	-			No microfossils recovered.	-
LON_LW_06	-			No microfossils recovered.	-
LON_LW_07	-			No microfossils recovered.	-
LON_LW_08	-			No microfossils recovered.	-

* thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 6.5. Microfossils identified in chalk tesserae from the site at New Change, London, UK

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
LON_NC_01*	-	NCZ02.1699	TQ 322 812	*Eouvigerina aculeata, Gavelinella* sp., *Hedbergella* sp. cf. *reussi, H.* sp., *Heterohelix globulosa, ?Lenticulina sp., Marssonella sp., Osangularia sp., Whiteinella baltica.* Crinoid columnal.	16-19
LON_NC_02*	-			*Eponides* sp., *Hedbergella* sp., *Heterohelix* sp., *Osangularia* sp., *Gavelinella sp., Reussella* sp. cf. *szajnochae praecursor, Stensioeina* sp. cf. *exsculpta exsculpta, S.* sp. cf. *exsculpta gracilis.* Radiolarian. Echinoid plate.	18iii-19
LON_NC_03*	-			*Arenobulimina* sp., ?*Globigerinelloides* sp., *Hedbergella* sp., *Heterohelix* sp., *Osangularia* sp., ?*Praebulimina* sp., *Stensioeina pommerana, Whiteinella* sp. cf. *baltica.* Shell fragments.	19
LON_NC_04	-			No microfossils recovered	-
LON_NC_05	-			No microfossils recovered	-
LON_NC_06	-			No microfossils recovered	-

*thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 6.6. Microfossils identified in chalk tesserae from the site at The Pinnacle (Crosby Square), London, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
LON_TP_01*	-	CYQ05.858	TQ 332 813	*Eouvigerina aculeata, Heterohelix globulosa, H.* sp., ?*Nodosaria* sp. Brachiopod spines. Crinoid columnar.	Species are long-ranging, but coeval with 17
LON_TP_02*	-			*Arenobulimina* sp. cf. *obliqua*, *Eouvigerina aculeata, Eponides* sp. cf. *concinna, Lenticulina* sp., *Marssonella* sp. cf. *trochus (*northern form*), Osangularia* sp. cf. *cordieriana, Vaginulinopsis scalariformis.* Crinoid columnar.	17ii
LON_TP_03*	-	CYQ05.510	TQ 332 813	*Dentalina* sp., ?*Eponides* sp., *Globigerinelloides aspera, Globorotalites* sp. cf. *cushmani, G. micheliniana, Hedbergella* sp., *Heterohelix* sp., *Loxostomum eleyi, Praebulimina* sp. cf. *carseyae*, ?*Reussella* sp., *Whiteinella baltica*. Brachiopod valve. Shell debris.	17ii-19
LON_TP_04	-			No microfossils recovered.	-
LON_TP_05	-			No microfossils recovered.	-
LON_TP_06	-			No microfossils recovered.	-

*thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Table 6.7 Microfossils identified in chalk tesserae from Watling Court, London, UK.

BGS Sample number	Archaeological context	NGR	Palaeontology	BGS FBZ
MPA 54223 (161/1)	WAT78.161	TQ 3235 8104	*Gavelinella* sp. cf. *stelligera, G.* sp.	18-21 (but *G. stelligera* not common above 20)
MPA 54224 (161/2)			*Gavelinella* sp. cf. *usakensis, G.* sp.*, Verneuilina* sp. cf. *muensteri.*	20-21i
MPA 54225 (161/3)			*Gavelinella* sp. cf. *stelligera, Gavelinella* sp.*, Verneuilina* sp. cf. *muensteri.* Indeterminate fragments.	18-21
MPA 54226 (161/4)			*Osangularia cordieriana, ?Stensioeina* sp.	14-23
MPA 54227 (161/5)			Barren.	-
MPA 54228 (161/6)			Indeterminate foraminifera.	-

Data for Table 6.7 (columns 1-4) provided by Dr Ian Wilkinson (pers. comm.). Data in column 5 inferred from Wilkinson 2011a,b.

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

Figure 7.1. Microfossils identified in chalk tesserae from Gosbecks Park Temple Complex, Colchester, UK.

Sample number	BGS reference	Archaeological context	NGR	Palaeontology	BGS FBZ
COL_GP_A01	-			*Gavelinella pertusa, G. stelligera, G.* sp. cf. *clementiana, Globotruncana linneiana, Lenticulina sp., Osangularia sp., Rugoglobigerina pilula, Stensioeina pommerana.* Ostracod *(Neocythere virginea, Cytherelloidea* sp.*).* Bivalve fragment.	20
COL_GP_A02	-			Possibly broken *G. usakensis.*	-
COL_GP_A03	-			*Whiteinella* sp.	-
COL_GP_A04	-			*Gavelinella stelligera.*	18-21
COL_GP_A05	-			*Osangularia cordieriana.*	-
COL_GP_A06	-			?*Lenticulina* sp.	-
COL_GP_A07	-	GOS.95.40 F1.446.L8	TL 968 225	*Gavelinella usakensis, Stensioeina granulata incondita, S. pommerana.*	20
COL_GP_A08	-			*?Gavelinella* fragment.	-
COL_GP_A09-A16	-			Tesserae crushed but not processed, as sufficient data were available from thin sections.	-
COL_GP_A17*	-			*Arenobulimina* sp., *Ataxophagmium* sp., *?Bolivinoides* sp. cf. *culverensis, Gavelinella pertusa, Globigerinelloides aspera, Globorotalites micheliniana, Globotruncana* sp. cf. *bulloides, G. linneiana, Gyroidinoides* sp., *?Lagena ellipsoidalis, Lenticulina* sp., *Marssonella* sp. cf. *trochus (‘oxycona’* form*), Osangularia cordieriana, O.* sp., *Reussella* sp., *Stensioeina pommerana.*	19-20
COL_GP_A18*	-			*Arenobulimina* sp., *?Ataxophragmium* sp., *Cibicidoides (?) voltziana, Gavelinella* sp. cf. *pertusa, G.* sp., *Globigerinelloides aspera, ?Globotruncana* sp., *Heterohelix* sp., *?Nodosaria* sp., *Stensioeina pommerana.*	20ii-25
COL_GP_A19*	-			*Globigerinelloides aspera, ?Pleurostomella* sp.	-

*Thin sections

BGS: British Geological Survey; FBZ: Foraminiferal Biozone; NGR: National Grid Reference (approximate).

APPENDIX B

CHALK PROCESSING METHODS

B1. WHITE SPIRIT METHOD FOR PROCESSING CHALKS

Method obtained from Dr Ian Wilkinson at BGS, adapted for smaller samples.

1. Keep a small piece of the sample unprocessed if possible and put into a labelled bag for reference. Crush the chalk into fragments about 0.5 cm in size. Place crushed chalk in a 250ml bowl and dry at 60^{o}C overnight (or longer) until totally dry.
2. Take bowl out of oven and allow sample to cool to room temperature. Cover sample totally with white spirit and leave for 20 minutes in a fume cupboard. Pour off white spirit into used bottle for disposal (through filter paper if necessary, then flush filter paper into bowl). Cover sample with hot water, add 5ml Teepol (or similar detergent) and leave to soak overnight or preferably for a weekend.
3. Wash sample through a 63µm sieve; place residue into a 250ml container, add 5ml sodium hexametaphosphate flakes and cover with water. Place container in a pan filled with water, bring to the boil and boil for 30 minutes.
4. Wash sample though a 63µm sieve until water runs clear. Wash into clean ceramic 250ml bowl with as little water as possible. Leave to settle and then pour off top water gently through the sieve. Rinse sieve contents back into bowl using a wash bottle. Place bowl in warm oven to dry thoroughly.
5. When dry, pour sample into labelled bag and store appropriately.
6. Label material and all containers with relevant accession numbers throughout the above process. Keep laboratory and other records up to date. Observe all necessary safety protocols.

B2. FREEZE-THAW METHOD FOR PROCESSING CHALKS

Process derived from Slipper (1997)

1. Keep a small piece of the sample unprocessed if possible and put it into a labelled bag for reference. Break the sample into centimetre-sized pieces, spread onto a plate and dry in an oven at 60^{o}C for 24 hours or until totally dry (higher temperatures will bake the chalk). Decant the dried sample into a 250ml beaker.
2. Prepare a supersaturated solution of Glauber's Salt (sodium sulphate decahydrate, $NaSO_4$.10 H_2O) using a 2:1 dilution of salt to water. Heat the solution gently to 25-30^{o}C. Cover the sample with the warm solution and place it in an oven at 25-30^{o}C for 2-3 hours to soak. Top up with warm solution during this process if necessary.
3. After 2-3 hours, remove the sample from the oven and rapidly decant the liquid. Place the sample in a freezer for 3-4 hours or overnight. The rapid chilling of the solution encourages high nucleation with small crystal growth, which is designed to break the rock apart without damaging the microfossils.
4. Remove the beaker from the freezer, cover the sample generously with water and heat until just below boiling point. Wash the processed sediment thoroughly through a 63µm sieve; dry and store.
5. The freeze-thaw section of the process can be repeated if needed.
6. Label all materials, maintain records and observe safety protocols.

Notes

1. Slipper found that one cycle of freeze-thaw was sufficient to break down most chalks and hardgrounds. This method gave a unimodal distribution of material between the coarse and fine chalk fractions, making it a better choice for processing than white spirit, bleach, hydrogen peroxide or simple crushing.
2. White spirit was recommended for marls and marly chalks, but freeze-thaw for white chalk and hardgrounds. Berkshire chalk rock (effectively a limestone) was almost unaffected by every method attempted in the thesis.
3. The poorest results overall were obtained using hydrogen peroxide. This was because some chalks contained small amounts of disseminated pyrite that reacted with H_2O_2 to produce hydrochloric acid. The acid dissolved any microfossils composed of calcium carbonate.

APPENDIX C

LIST OF SPECIES CITED IN TEXT AND TABLES

<u>Foraminifera</u>

Archaeoglobigerina cretacea (d'Orbigny 1840)
Arenobulimina advena (Cushman 1936)
Arenobulimina anglica (Cushman 1936)
Arenobulimina courta (Marie 1941)
Arenobulimina elevata (d'Orbigny 1840)
Arenobulimina footei Jennings 1936
Arenobulimina obliqua (d'Orbigny 1840)
Arenobulimina preslii (Reuss 1846)
Ataxophragmium variabile (d'Orbigny 1840)
Bolivinoides culverensis Barr 1967
Bolivinoides decoratus (Jones 1875)
Cibicidoides (?) voltziana (d'Orbigny 1840)
Dicarinella canaliculata (Reuss 1854)
Dicarinella hagni (Scheibnerova 1962)
Eggerellina brevis (d'Orbigny 1840)
Eggerellina mariae Ten Dam 1950
Eouvigerina aculeata (Ehrenberg 1854)
Eponides biconvexa Marie 1941
Eponides concinna Brotzen 1936
Gavelinella berthelini (Keller 1935)
Gavelinella cenomanica (Brotzen 1942)
Gavelinella clementiana (d'Orbigny 1840)
Gavelinella cristata (Goel 1965)
Gavelinella intermedia (Berthelin 1880)
Gavelinella involutina Hofker 1957
Gavelinella lorneiana (d'Orbigny 1840)
Gavelinella monterelensis (Marie 1941)
Gavelinella pertusa (Marsson 1878)
Gavelinella thalmanni (Brotzen 1936)
Gavelinella stelligera (Marie 1941)
Gavelinella trochus (Goel 1965)
Gavelinella usakensis (Vasilenko 1961)
Globigerinelloides bentonensis (Morrow 1934)
Globigerinelloides aspera (Ehrenberg 1854)

Globorotalites micheliniana (d'Orbigny 1840)
Globorotalites cushmani Goel 1965
Globotruncana arca (Cushman 1926)
Globotruncana bulloides Vogler 1941
Globotruncana linneiana (d'Orbigny 1839)
Gyroidinoides nitida (Reuss 1844)
Gyroidinoides parva (Khan 1950)
Gyroidinoides praestans Magniez-Jannin 1975
Hagenowina anglica (Cushman 1936)
Hagenowina advena (Cushman 1936)
Hedbergella brittonensis Loeblich and Tappan 1961
Hedbergella delrioensis (Carsey 1926)
Hedbergella holmdelensis Olsson 1964
Hedbergella planispira (Tappan 1940)
Helvetoglobotruncana helvetica (Bolli 1945)
Helvetoglobotruncana praehelvetica (Trujillo 1960)
Heterohelix globulosa (Ehrenberg 1840)
Heterohelix reussi (Cushman 1938)
Heterohelix striata (Ehrenberg 1840)
Heterohelix moremani (Cushman 1938)
Lagena ellipsoidalis Schwager 1878
Lenticulina rotula (Lamark 1804)
Lingulogavelinella globosa (Brotzen 1945)
Loxostomum eleyi (Cushman 1927)
Marginotruncana marginata (Reuss 1845)
Marginotruncana pseudolinneiana Pessagno 1967
Marginulina jonesi (Reuss 1862)
Marssonella trochus (d'Orbigny 1840)
Neoconorbina scanica (Brotzen 1936)
Osangularia cordieriana (d'Orbigny 1840)
Plectina cenomana Carter and Hart 1977
Pleurostomella subnodosa Reuss 1860
Praebulimina carseyae (Plummer 1931)
Praebulimina reussi (Morrow 1934)
Praeglobotruncana delrioensis (Plummer 1931)
Praeglobotruncana helvetica (Bolli 1945)
Praeglobotruncana praehelvetica (Trujillo 1960)
Pseudouvigerina plummerae Cushman 1927
Quadrimorphina trochoides (Reuss 1845)
Reussella szajnochae praecursor de Klass and Knipscheer 1954

Reussella kelleri Vasilenko 1961
Rotalipora cushmani (Morrow 1934)
Rotalipora greenhornensis (Morrow 1934)
*Rugoglobigerina pilula (*Belford 1960)
Rugoglobigerina rugosa (Plummer 1927)
Spiroloculina papyracea Burrows, Sherborn and Bailey 1890
Spiroplectammina baudouiniana (d'Orbigny 1840)
Stensioeina exsculpta exsculpta (Reuss 1860)
Stensioeina exsculpta gracilis Brotzen 1945
Stensioeina granulata (Olbertz 1942)
Stensioeina granulata incondita Koch 1977
Stensioeina pommerana Brotzen 1936
Vaginulinopsis scalariformis Porthault 1970
Verneuilina muensteri Reuss 1854
Whiteinella aprica (Loeblich & Tappan 1961)
Whiteinella archaeocretacea Pessagno 1967
Whiteinella baltica Douglas & Rankin 1969
Whiteinella brittonensis (Loeblich & Tappan 1961)

Other species
Neocythere virginea (Jones 1849)
Pithonella krasheninnikova (Bolli, no date)
Pithonella ovalis (Kaufman 1865)
Pithonella sphaerica (Kaufman 1865)

Table D1: Chalk pits or quarries in Dorset and Wiltshire identified in Historic Environment Records (HERs) or other databases.

County	Site	Monument	Date (AD)	NGR	HER	Other ID
Dorset	Dorchester, County Hospital Site A	Chalk quarry pit	Roman	SY 690 903		MDO18950
	Dorchester, County Hospital Site B	Chalk quarry pits	Roman	SY 690 904		MDO18960
	Dorchester, County Hospital Site C	Chalk quarry pit?	75-125	SY 690 903		MDO18953
	Dorchester, Library, Colliton Park	Quarry pit?	50-120?	SY 689 907	1 041 763	
	Dorchester, County Hall, Colliton Park	Chalk quarries	C1-C2	SY 690 909	1 041 748	
	Dorchester, County Hall, Colliton Park	Shallow chalk quarry	75-150?	SY 689 909	1 041 747	
	Dorchester, Fire HQ, Colliton Park	Large chalk quarry pits	150-299	SY 689 909	1 041 758	MDO18640
	Dorchester, Wessex Court	Probable chalk quarry pit	75-200	SY 693 905	1 041 409	MDO18240
	Dorchester, Merchant's Garage,	Large shallow chalk pit	43-99	SY 689 907	1 041 787	MDO18794
	Bradford Peverell, near Dorchester	Pit cluster	LIA-99	SY 666 908		MDO18714
	Middle Farm, near Dorchester	Chalk pits	EIA-Roman	SY 677 901	1 041 534	
	Winterbourne Monkton, W. Dorset	Irregular chalk pits	C2 filled	SY 676 894	1 130 153	
Wiltshire	Tilshead					SU 14 NW 306

NGR = National Grid Reference HER = Historic Environment Record MDO = Mid-Dorset Monuments database identification number

C1, C2 etc = 1st century AD, 2nd century AD etc. EIA = Early Iron Age LIA – Late Iron Age

Source of Dorset data given above: Dorset HER database. This can be accessed through the Heritage Gateway portal at: http://www.heritagegateway.org.uk/gateway/chr/default.aspx.

Table D2: Chalk pits or quarries in Greater London, Kent and Essex identified in Historic Environment Records (HERs) or other databases.

County	Site	Monument	Date (AD)	NGR	HER	Other ID
Greater London	Coulsdon, Croydon	Chalk quarry		TQ 302 592	403828	TQ 35 NW 15
	Greenhithe, Dartford	Chalk quarry and tooled chalk blocks		TQ 583 732		639182
Kent	Birchington, Thanet	Chalk quarry	Belgic/Roman	TR 293 700		TR 27 SE 2 MKE6629
	Chartham, Canterbury	Chalk quarry	Broadly C1-C2, but two stages of development (i) 43-?125 and (ii) ?150-?250.	TR 111 542	*1 131 293*	TR 15 SW 59 1827411
	Darent District	Chalk quarry	Late C3-C4			Simmonds *et al*. 2011*
	Kingsdown	Chalk quarry	Mid C1- mid C3	TR 370 475		
	Keston Roman Villa					Philp *et al*. 1991*
Essex	Purfleet					White 2008

NGR = National Grid Reference HER = Historic Environment Record MKE = Kent Monuments database identification number.

C1, C2 etc = 1st century AD, 2nd century AD etc.

*I am grateful to Dr Martyn Allen of the University of Reading for this information.

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