PETROLOGICAL ANALYSIS OF THE ANGLO-SAXON AND ANGLO-NORMAN STONE WORK OF ST PETER'S, WEARMOUTH AND ST PAUL'S, JARROW

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SUMMARY

Since the monastic churches of Wearmouth and Jarrow were built and consecrated some 1,300 years ago (St Peter's, Wearmouth AD 674 and St Paul's, Jarrow AD 684-5) the built fabric of both has undergone considerable modification. In the early Middle Ages the buildings suffered successive periods of damage (probably by the Norse and later by the Scots), and were later refurbished by the Benedictines following the Norman Conquest. In more recent times large sections of both churches have been completely removed and rebuilt during phases of restoration. In the period between the Conquest and the present day, changes in liturgy and building style are reflected in interior and exterior modifications including the placement of doors, windows, altars and other features, as well as, architectural details.

As part of the 'One Monastery in Two Places' project, a new appraisal of the remaining early medieval stonework was undertaken in 2011-12. It has long been recognised that the builders of both monasteries drew on cut stone from existing and nearby Roman sites, abandoned some 300 years earlier (e.g. Cramp 2005, 23-7). The stone obtained in this way was largely good quality. It was often used without alteration but good examples exist of recut and remodelled Roman stones (Cramp 2006, Fig. 28.2.1, AS1a and b; see Fig 3b below). In addition, new stone was extracted and prepared for both sites. At Wearmouth it was used to build the walls, and at both Wearmouth and Jarrow small quantities were cut from more distant quarries to embellish windows and doors.

An examination of the stone types used in the construction of the standing fabric at both structures was undertaken with the aim of providing additional evidence for the sources of the stonework, in order to understand more fully the relationships between these structures and the wider Roman and post-Roman landscape. The results were integrated with laser scans of the churches to create 3-dimensional models of the early fabric allowing a new perspective on how the recycled Roman stone was used and integrated within the surviving early medieval phases.

The tradition of ashlar stone recycling continued throughout the following centuries.As the buildings at Wearmouth and Jarrow changed, the cut Roman stone was recycled on site or as they expanded more cut stone was obtained from the former Roman sites. This reuse of former Roman ashlar is highlighted in the 18th century rebuilding of the nave at Jarrow where many Anglo-Saxon sculptural pieces and Roman dressed stones (including several Roman dedication pieces; Breeze 2006,130) were incorporated into the wall fabric and foundations. Only in the 19th century did the recycling of existing ashlar partially cease, with newly quarried and cut stone from nearby locations giving at least the exterior of the churches — the nave at Jarrow and most of the nave and chancel at Wearmouth — a more uniform appearance.

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1. INTRODUCTION

> 'In no more than the space of one year after the foundation of the monastery, Benedict, after crossing the sea, made for the kingdom of Gaul and asked for the masons to build him a stone church in the manner of the Romans, which he always loved' *Hist. Abb*. 5.

Since the monastic churches of Wearmouth and Jarrow were built and consecrated some 1,300 years ago (St Peter's at Wearmouth in AD 674 and St Paul's at Jarrow in AD 684-5), the built fabric of both has undergone considerable modification. The buildings have suffered successive periods of damage, neglect and refurbishment and have been heavily restored in more recent times. In the period between the Conquest and the present day, liturgical and building style changes are reflected in interior and exterior modifications, door and window placement, architectural style, positioning of seating and altars etc. Each, however, remains a remarkable survival, preserving some of the very first masonry architecture of the post-Roman era in northern England. The surviving Roman stonework of the northern frontier — forts, bridges, monuments, roads and defences, etc — must have been a prominent, if decaying, heritage in the contemporary landscape. In the centuries following Roman military withdrawal, communities in the region relied entirely on timber building traditions for the construction of their halls and ancillary structures. The arrival of Christianity resulted in the re-introduction of stone-building techniques. The written accounts, including the excerpt above from Bede's writings, describe how the first Roman missionaries sought out Roman towns and buildings, and how Benedict Biscop in the north sought skilled masons from the continent of Europe to build his new churches in stone.

It has long been accepted that this first phase of early medieval stone technology in England relied on the reuse of existing cut stone from Roman sites and structures (see Eaton 2000 for summary). Roman structures were ideal quarries providing building materials and architectural features (Stocker and Everson 1990; Eaton 2000). The first stone 'Anglo-Saxon' churches, with their distinctive use of Roman stonework, Roman ceramic building materials (CBM), megalithic quoins, small single-splayed windows and tall and high doorways and arches, owe much in terms of style and form to the Roman buildings which provided the source for much of their construction material (Cramp 2005, 359). St Peter's and St Paul's, along with a number of other churches along the rivers Tyne and Wear such as Escomb, Corbridge, Hexham and the two churches at Bywell survive from this pre-Conquest era, and their earliest fabric attests to the use of significant amounts of recycled Roman cut stone. Few have seen any intense study of the proportions of Roman versus fresh stone used in the pre-Conquest structures or of the sources of the recycled and freshly quarried stone. As part of the 'One Monastery in Two Places' project, a new appraisal of the remaining early medieval and medieval stonework at both sites was undertaken in 2011-12. The aim was to explore the petrology of the standing fabric, if possible identify the proportions of fresh and reworked Roman stone in the pre-Conquest churches, and source the origins of both groups of building material. In this way the project could establish more fully how these structures drew upon, and were created from, the resources of the locality, and how the 'imported' ideas of Biscop impacted upon the regional and local scene.

2. THE SURVEY

The form and fabric of the pre-Conquest churches at Wearmouth and Jarrow were explored in the publication of the excavations and recording undertaken by Rosemary Cramp (Cramp 2005, 56-9, 147-54). In her programme of work at both churches, the pre-Conquest stonework of St Peter's and St. Paul's was recorded using photography and manual measurements, and photogrammetry (Cramp 2005, Figs. 5.8, 5.9, 5.10, 5.11 and 13.1). These surveys were used as a basis for the published discussions on the shape and form of the original monastic layouts and buildings (Cramp 2005, 43-72, 139-68). The use of Roman cut stone was recognised as an integral element of the design and technological accomplishment of each pre-Conquest church, but especially at St Paul's, Jarrow (Cramp 2005, 359). Excavations also demonstrated that cut Roman stone was reused in the foundations of Building D (Bidwell 2006, 1). 'One Monastery in Two Places' employed laser scanning to record the surviving internal and external pre-conquest standing fabric at St Peter's and St Paul's. In addition, in collaboration with a team from Conservation Technologies, National Museum of Liverpool, the project undertook high resolution laser scanning of the porch sculptures at St Peter's. The petrological survey was undertaken by the first author of this report, using the original stone-by-stone records of the pre-conquest fabric published in Cramp 2005 as a basis. The results were integrated with the 3D-models of the early fabric produced from laser scanning, both phases of work executed by the Project Officer Alex Turner (Newcastle University). This process allowed us to create and visualise a 3D-view of how recycled and freshly quarried stone had been deployed within each construction. The initial results of the laser scanning and modelling, including the integration of the petrological results with the 3-D models, can be found in the project monograph (Turner, Semple and Turner 2013).

The process of on-site survey was carried out using an hydraulic lift, which gave access to the upper fabric. The stone types were identified by examination with a hand-lens and colour coded using a standard Munsell colour chart. Stone types were coded according to geological type, with some classified as groups. All were colour coded on the field drawings and this colour coding was translated to the digitised elevations and 3D modelling. Identification in this way is not infallible. Weathering and staining through pollution were inhibiting factors at both sites. Where possible, stone identifications were tested by means of minute rock samples which were thin-sectioned at Durham University and assessed by the first author. For example, samples were taken for assessment as a by-product of sampling stone and mortar at both churches for the purpose of Optically Stimulated Luminescence dating (Bailiff 2014). All pre-conquest fabric in the interior and exterior of each church was examined in detail and coded. In addition the excavated and retrieved architectural fragments such as the balusters were included in the study. The Norman phases of stonework at Wearmouth and Jarrow fell within the remit of this strand of analysis, but the later medieval to modern phases of build and restoration were not examined in detail. Significant amounts of burned stone were recognised during the survey and were also recorded.

In order to test the source of the fresh and recycled cut stone at both sites, the first author also made extensive explorations of nearby Roman ruins and sites, for example at Segedunum, Arbeia and along eastern sections of Hadrian's Wall. Stone types were examined in the same way and close attention was paid to surviving architectural features

and fragments and to the size and form of the cut Roman building stone. Alongside this, a survey of available and accessible fresh stone sources was undertaken. Old Roman quarries were assessed as potential sources for fresh cut stone. This too has limitations. The urbanisation of the landscape between the rivers Tyne and Wear means that potential stone exposures that could have been utilised as quarry sites are now lost beneath extensive modern developments. However, our survey paid close attention to historic accounts of stone quarries and to the types and the shape, form and size of reused and fresh cut stone at Wearmouth and Jarrow, and considered issues of access and transportation. We cannot be totally certain, but the outcomes of this programme of work suggest that locally available stone — fresh and reused —provided the bulk of the building material, with some evidence for the occasional exploitation of fresh and recycled material for specific purposes from more distant sites.

3. BUILDING STONE

It is evident from our work that the earliest builders reused cut stone from existing nearby Roman sites, abandoned some 300 years earlier. These provided most of the material in the case of St Paul's, Jarrow, and part of it at St Peter's, Wearmouth. The stone obtained in this way was largely good quality and often used with little or no modification. At Wearmouth a significant proportion of fresh stone was sourced from the immediate locality. At St Paul's, no building stone sources were locally available as the underlying Upper Carboniferous Coal Measure sediments are masked by substantial deposits of Quaternary tillites and fluviatile deposits and St Paul's is built almost wholly from reused Roman cut stone. Where appropriate, for special building purposes, the extraction and specialist working of small quantities of new stone from more distant quarry sites including former Roman extraction sites is evident. The tradition of ashlar stone recycling continued throughout the following centuries, and as the buildings at Wearmouth and Jarrow changed, the cut Roman stone was either recycled on site or more was obtained from the former Roman sites. This reuse of former Roman ashlar is highlighted in the 18th-century rebuilding of the nave at Jarrow where many Anglo-Saxon sculptural pieces and Roman dressed stones were incorporated into the wall fabric and foundations (including several Roman dedication pieces; Breeze 2006,130). Only in the 19th century did the recycling of existing ashlar partially cease, with newly quarried and cut stone from nearby locations giving at least the exterior of the churches (the nave at Jarrow and most of the nave and chancel at Wearmouth) a uniform appearance.

3.1 St Peter's, Wearmouth

At St Peter's the surviving pre-Conquest fabric is largely confined to the western façade and the lower levels of the original porch which survive today as the lower portions of the tower (Figs 1a-c). Stone-by-stone recording of the surviving pre-Conquest fabric, once the western church of the early monastic complex, indicates that the majority of the cut and shaped ashlar was sourced from an abandoned Roman site or sites. The round-headed door and window frames (Fig 2), the additional door apertures of the porch (Fig 3a) and the original quoins (Fig 4), all comprise imported Roman cut and dressed stonework. Other finds have provided good evidence for the sourcing and alteration of Roman stone monuments (e.g. Cramp 2006, Fig. 28.2.1, AS1a and b; see Fig 3b).

However it is significant that the bulk of the original Anglo-Saxon building of St Peter's was constructed from locally quarried Upper Permian Magnesian Limestone. This largely undressed stone was used to compose randomly built rubble walls. In addition, more exotic glacial erratics, likely collected during field clearance, were also incorporated into the wall fabric. An exception is provided in the case of the sophisticated baluster shafts that still adorn the exterior porch entrance of the minster church (Fig 5) and which once also formed an integral part of the interior design (Cramp 2006, 164). These were lathe-cut from very good quality new 'green' stone, also locally quarried. In addition some poorer quality soft sandstone was quarried at North Hylton on the north bank of the River Wear (Smith 1994, 21), cut and dressed and used in some upper door and window frames (Fig 6).

The basilica church at Wearmouth has a complex history (Taylor and Taylor 1980, 432-5; Pevsner 1985, 465-7). Most of the monastic buildings were extended after the consecration in 674 AD and have been damaged, partly demolished and rebuilt at various times as a result of damage, fire and neglect.

3.2 St Paul's, Jarrow

At Jarrow much of the original pre-Conquest church complex survived more or less intact until 1782 (Taylor and Taylor 1980, 338). At this point the western church was rebuilt as a nave. This 18th-century structure was demolished less than a hundred years later, in 1866, when Sir G. G. Scott created the current larger nave. It is during this 19th-century rebuilding that many of the important Anglo-Saxon architectural artefacts were discovered, built into the 18th-century nave fabric and foundations. However, the early eastern chapel, now the chancel, remains in part intact. The eastern chapel was originally separated from its western counterpart (Taylor and Taylor 1980, 340) but at some point later in the life of the eastern and western churches, the western wall was largely removed, the external large quoin stones were sheared off and a 'junction building' was constructed that joined the churches together (Figs 7a and b). This had an upper storey and perhaps supported a tower. It is considered pre-Conquest by Cramp, who suggests construction of this joining structure around the year AD 800 (Cramp 2006, 167-8), although others have postulated a late Saxon and late 11th century date (Gilbert 1951-6 and Taylor and Taylor 1965; Radford 1954). This now forms the base of the current tower. The tower was raised and developed in the 12th century (Cramp 2006, 252-3; Cambridge 1977, 34).

Much of the eastern wall of the chancel has been rebuilt or restored over the years owing to foundation problems and the insertion of the large east window. However there are tantalising architectural features, possibly original, at the base of the exterior eastern wall, now partly obscured by more recent buttressing (Cramp 2005, 147-8, 167-8) (Fig 8).

The walls of the eastern chapel have been considerably altered over time as a result of liturgical demands or fenestration. The sequencing of these changes has been carefully analysed by Taylor and Taylor (1980, 339-349). Much of the original stone used by Biscop's late 7th-century building was later used and reused when subsequent changes were made to the structure. Only limited quantities of newly quarried stone were added to the fabric of this chapel — for example during the replacement of the windows.

Stone-by-stone analysis of the extant early medieval fabric indicates that virtually all the cut and shaped stone used in these early structures was obtained from Roman sites and buildings in the near vicinity. The lack of quality building stone in close proximity to the site of St Paul's may have concentrated the attention of the masons on the good quality and

already well-dressed stone available from the nearby sections of the Roman wall and the fort at Wallsend (Segedunum) across the Tyne to the north-west and the remains of the substantial supply fort at South Shields (Arbeia) to the east.

The only new stone used at St Paul's was again sourced for the creation of the ornamental baluster shafts (Fig 9). These are similar in design and to those used at St Peter's church and the stone was newly quarried, dressed and lathe turned while still 'green' in a similar fashion. The stone source for the Jarrow balusters was totally different, however, from that used for the St Peter's balusters. This use of two different quarry sources is informative, not least as both quarries were broadly equidistant from Jarrow. These turned items of stone are relatively small and rather easily portable. The use of different stone sources implies some kind of strategic decision led to the choice of a different quarry for the Jarrow fittings *c.* 10 years on from the work at Wearmouth – a decision that did not relate to issues of distance or carriage.

All in all, the use of Roman ashlar and squared stone at Jarrow is remarkably consistent, from the original early medieval construction, through the 11th century and the medieval expansion of the monastic site. Even during the rebuilding work of the 18th century, the Roman dressed stone seemed to have been reused again. Only Scott in the 19th century diverged from this building tradition using a new, but local, quarry source to produce the uniform exterior of the nave seen today.

4. THE REUSE OF ROMAN CUT STONE AT ST PETER'S AND ST PAUL'S

The reuse of Roman stone at both sites is well recognised (see for example Taylor and Taylor 1980; Pevsner 1985; and Cramp 2005). However, the current stone by stone survey of the extant Anglo-Saxon and Anglo-Norman parts of both buildings, using ladders and a hydraulic extendable platform, has revealed the extent to which Roman stone has been reused, particularly at St Paul's Jarrow.

4.1 The physical and architectural evidence for the Roman origins of cut stones

At both sites large blocks of Roman ashlar are frequently encountered showing cut holes for use with a Lewis lifting device (Hill 2006, 83), a common Roman method of moving and placing large pieces of heavy masonry (Figs 10a and b). These holes are not in context on the monastic sites and the ashlar blocks have been placed in positions that do not reflect the use of a Lewis lifting system. Also visible and frequently completely out of context, are mouldings and moulding fragments (Figs 11a and b), ornamentation (Fig 12a), frieze string courses (Fig 12b) and even a piece of *opus signinum* flooring.

The survey reveals that door frames and window surrounds may have been removed in their entirety from their Roman context and reused on both sites, sometimes modified by masons to fit the new buildings. These can be envisaged as features obtained from the derelict Roman structures 'to order' and in some quantity. When reused on site, some door frames for example have not been rebuilt in the original order. As Figure 13 demonstrates, sometimes the voussoirs and frames were mixed up when architectural features were reconstituted on the monastic sites (Fig 13).

Most of the quoins at both locations are of Roman origin, many with Lewis holes (Fig 14), and a few that seem to resemble modified commemoration or altar stones (Fig 15).

What is most noteworthy is the reuse of cut and squared stone blocks or *saxa quadrata* particularly at St Paul's Jarrow for the general building of walls (Figs 7a and 16). The Romans were efficient organisers with regard to building stone production – especially in military contexts. They had set standards for arch and window sizes and for general building purposes, stone blocks with squared fronts and sides or *saxa quadrata*. These were often standardised with a 24 cm lift height, often with *c.* 24 x 24 cm squared rubble faces; Fig 17a). Of the Roman sites along the Tyne and Wear, Segedunum seems exceptional in this respect: the evidence is limited but here a *c.* 15 cm lift height seems to have been the norm (Fig 17b). These stone building blocks seem to have been produced at various conveniently placed quarry sites in large numbers and distributed to the building sites around the Roman North East in finished form, so avoiding the costly transport of stone waste. Although squared off at the front, the sides were left roughly tapering at the back to add building strength to the rubble cored walls (Fig 18). *Saxa quadrata* could be lifted easily by wall builders and rapid construction was possible. Most of the Anglo-Saxon and Anglo-Norman interior and exterior walls at St Paul's have been constructed using these standard Roman building units. At St Peter's Wearmouth, there is some use of squared stone blocks in the Anglo-Saxon walls, but the bulk is constructed using newly quarried Magnesian Limestone (Roker Dolomite) rubble. By contrast, there is considerable use of squared Roman ashlar in the Anglo-Norman upper lifts of the tower/porch at St Peter's (Figs 1 and 19).

4.2 Roman installations in the vicinity of Wearmouth and Jarrow

The recognition of selective use and recycling of cut Roman stone at Wearmouth and the large quantity of similar material reused at Jarrow, raises the question of where the Roman cut stone was being sourced for each church. Although there has been a strong local oral tradition of Roman structures in the vicinity of Wearmouth, the evidence is sparse. The River Wear is unlikely to have been overlooked by the Romans. There may have been piers or quays near the river's mouth, (as suggested for the River Tyne; Bidwell in Cramp 2006, 1). Much further up the Wear, the Roman fort at Binchester is thought to have been exploited for cut stone during the construction of the nearby early medieval church at Escomb (Cambridge 1984). On the Tyne, the Roman bridge at Corbridge is thought to be a source for the stone used to construct the early crypt at Hexham – located some 2 km west along the River Tyne (Bidwell 2010), and the pre-Conquest church at Corbridge itself is thought to have been built using stone from the bridge and the nearby Roman town. While there is no question that cut Roman stone was used at St Peter's in the first construction, its source until now has remained unknown.

In the case of Jarrow, the fort at Arbeia has long been posited as a possible quarry for the cut stone, given its close proximity to the monastery and to the river which could have provided a suitable means of transport (Birley 1961, 157-8). The presence of Roman stone and Roman inscriptions on the site of St Paul's at Jarrow has also provoked speculation about the presence of a Roman fort or signal station on the site itself (Hodgson 1840, 230; Dobson 1970, 197). Excavations and more recently several geophysical surveys have failed to identify any evidence for the presence of substantial Roman-period structures at the site (see Cramp 2006, 25 for short summary). The more extensive geo-prospection undertaken

during the 'As One Monastery in Two Places' project (using ground penetrating radar, resistivity and fluxgate gradiometry), immediately around St Paul's and in Drewett's Park to the north of the complex, has failed to produce any indicators of major sub-surface masonry features (Turner *et al* 2013; Turner 2014). Paul Bidwell examined the building stone at both sites, and noted in particular that the reused stone present in the foundations of Building D at Jarrow displayed details consistent with 'blocks which came from what is loosely termed "*opus quadratum*", a form of construction employing large blocks laid in regular courses and joined together with dowels and clamps of wood, lead or iron encased in lead' (Bidwell 2006, 1, citing Bidwell and Holbrook 1989, 117-33). This kind of construction is argued by Bidwell to be indicative of large road bridges in the northern military zone, evident for example at Piercebridge in Co Durham or Corbridge in Northumberland (Bidwell 2006, 1). Bidwell argues that the stonework from the foundations of Building D at least may have derived from the eastern terminus of Hadrian's Wall at Wallsend, where the wall 'extended beyond the low-water mark of the river' (ibid.).

Detailed studies of Brixworth, Northamptonshire, an historic church constructed in several phases in the 8th and 9th centuries, has revealed that the earliest phases of fabric were constructed from a mix of stone and ceramic building materials (CBM), drawing on recycled Roman building stone of varied rock types, with the use of Roman CBM to define and outline key architectural features such as doorways and windows (Sutherland 2013, 147-58). The reused Roman material is thought to derive from several Roman structures, with the possibility that some of the recycled stone was transported from as far away as the Roman Leicester (Sutherland 2013, 152-3, 153-4). Brixworth remains one of the few sites where petrology and examination of the surrounding geology and has allowed the researchers to establish some of the sources of stone and spolia exploitation underpinning the creation of the new church structure. The stone composition of the forts along the Tyne near Jarrow is considered in the following section.

4.2.1 Arbeia

Richmond (1953, 1) suggested that Arbeia, the supply fort on a low knoll by the mouth of the River Tyne ('The Lawe'), may have been constructed in timber around the early first century, and replaced slightly later in stone. The site proved to be an important strategic Roman fort, with an extensive plan including at least 22 granaries (Breeze 2006, 118), a notable contrast to the usual two per fort. Richmond (1953) noted just how important and strategic the site was, with a protected maritime frontage, ready access to the North Sea, and sheltered anchorage on the River Tyne, a tidal river with tributaries navigable with shallow draft barges well upstream to the west. This supply depot played a crucial part in Roman supply and defence for the Northern frontier. It may be significant that some of the last troops stationed at the fort were the *Numerus Barcari Tigrisiensis*, Tigris bargemen from Iraq. In addition the fort was well served by the road network linking the Tyne military corridor with areas south of the River Tees, and military bases to the west of the Pennines.

The fort at Arbeia has been extensively robbed of its building stone since its abandonment and despite recent extensive excavations the history of the site is still only partially known.

Although the Romans chose an excellent strategic and logistical site for the supply fort, quality building stone was not near to hand (Fig 20a). Arbeia is sited on glacial tillite (Boulder Clay) and fluviatile sediments covering Coal Measure sediments (Westphalian B,

Upper Carboniferous) with the Magnesian Limestones (Upper Permian) Cleadon uplands to the south (Fig 20b). The earliest building phase in stone (Richmond 1953), utilized Magnesian Limestone (Upper Permian) both ashlar and rubble in the building programme. Examination of the remaining *in situ* material suggests that this was obtained from the eastern margins of the Cleadon Hills around the Marsden quarry area (NZ 359644), south-east of the Arbeia site. This Roker Dolomite (Fig 21a) continued to be exploited in this area until the 20th century for building and rubble stone, but also importantly for lime-burning. Contemporary with the use of Magnesian Limestone for general building purposes at Arbeia, a coarse-grained Millstone Grit (Westphalian, Upper Carboniferous) was also imported from some distance. This was used for special quality masonry on site and for special dedications and altar stones.

The Romans civil engineers developed a tradition of using coarse grained sandstones and Millstone Grits for special building purposes. For example at York (Eboracum), Millstone Grit formed the foundations and footings of many walls and buildings, since it is durable and resistant to damp. The use of this material at Arbeia and elsewhere is not surprising: it was used contemporaneously with the Magnesian Limestone (used for the granaries), in the colonnades of the Headquarters building (Figs 22a and b), the drains and the huge strong-room blocks beneath the *Sacellum* (Fig 22c) and elsewhere. This stone was brought to the site along the River Tyne probably from the Heddon-on-the-Wall area where it was also used extensively to construct the Roman Wall (Fig 23). The quarries (NZ 130668) exploited the 'Third Grit' on the north side of the Tyne valley (Mills and Holliday 1988) and lay very close to the river which would have been navigable to shallow draft craft. There is some indication that these ashlar pieces, some of which were very large (Fig 22c) would have been cut and finished at the quarry site (to avoid the cost in time and effort transporting waste stone) and then transported to the place of use. Some of the ashlar units show a standard square-faced pattern and may have been produced in bulk for use at various fort sites and construction of the Wall (Fig 24).

In the Antonine period (c AD 162) another very local stone from Dean Quarry (NZ 364 652) was exploited for building purposes. This is a pink to reddish micaceous sandstone of Upper Carboniferous, Middle Coal Measures (Westphalian C) age and the unusual colouration is due to a natural geological phenomenon. In the late Carboniferous and very early Permian periods this area of North East England was part of a much larger desert region (Smith 1994) stretching over much of Europe and the reddening of these Late Carboniferous strata is the direct result of desertification, when oxidised iron rich ground waters contained in near-surface rocks resulted in reddish colouration (Anderson and Dunham 1953). Much of this rather inferior quality sandstone exhibits a pinkish hue (Munsell 6/4 – 6/6) but particularly the clay minerals and micaceous fraction have a rich dark red colour (Munsell 10R 4/6) due to the development of hematite. These hematised Upper Carboniferous sediments were later covered by dolomitised Upper Permian Calcareous deposits (subsequently de-dolomitised in part) of the invading Zechstein Sea (Smith 1994). Although of quite poor quality and susceptible to weathering and erosion, these reddened Upper Carboniferous Dean Quarry sandstones are important because they are visually distinctive and a good source indicator stone (Figs 25a and b).

The use of newly quarried Magnesian Limestone and reddened sandstones from Dean Quarry were a feature of the second stage of the fort construction (Richmond 1925) and were superseded by the use of quality sandstone extracted from Gateshead Fell to the

west. These very pale brown sandstones (Munsell 10YR7/4) are medium grained. Relatively well-sorted sandstone was quarried just to the south of the Wrekendyke Roman Road (809) at Wrekenton (NZ 280590), close to the junction of the Roman Road (80b) to Pons Aeilus (the bridge and fort on the Tyne; Fig 20a). This very good quality sandstone was obtained from a very thick Middle Coal Measure (Westphalian B, Upper Carboniferous) unit – the 70 fathom Post that underlies large areas of Gateshead Fell and the area between Newcastle and Wallsend on the north bank of the River Tyne. There is also evidence that the Romans extracted smaller quantities of a favoured reddish brown sandstone (Munsell 7.5YR 6/6 – 7/6) from the upper beds of the 70 fathom Post in the Wrekenton – Springwell area for use in the manufacture of memorial and altar stones. Similarly a paler brown variety (Munsell 10YR 7/4 – 7/6) of the 70 fathom Post sandstone was extracted at Heworth (NZ 285651) for use in monument and artefact production.

The distinctive monument to 'Victor the Moor' found at Arbeia is executed in a fine-grained light brown-grey sandstone (Munsell 10YR 6/2), suggesting that the Romans were also exploiting, perhaps in a small specialised way, the Grindstone Post (Middle Coal Measures, Westphalian C, Upper Carboniferous) of Gateshead Fell. These quarries, chief of which was at Windy Nook (NZ 277605), became the very important centre of grindstone manufacture in the 18th and 19th centuries (Hughes 1969).

4.2.2 Segedunum Garrison Fort, Wallsend

Such is the degree to which this Roman Fort has been robbed of stone over the centuries that sadly little of the excavated walls are now visible on site. The subsurface area of this part of Wallsend has also been considerably destroyed, often at depth, by urban and industrial development such as coalmining and shipbuilding. What remains is still helpful in identifying some of the stone types used for the buildings and for artefacts and the probable quarry sources; it also offers detail on the building style.

A detailed summary of the fort architecture and its building chronology from the earliest Hadrianic period to the 4th century has been made by Breeze (2006, 131-8), including the nearby excavated section of the Roman Wall and the wall (or quay) that apparently continued to the low tide level of the River Tyne. Breeze (2006, 130) has also considered the important question of the presence or absence of additional military features along the Tyne between Arbeia and Segedunum. One important difference between the sites at Segedunum and Arbeia relates to the dimensions of the common building unit used for walling purposes. The lift height of square masonry at Arbeia (Fig 17a) seems to be predominantly *c*. 24 cm in thickness whereas at Segedunum (Fig 17b) by contrast, the surviving remains indicate a lift height of 15 cm (2 palmus). This may be a function of the bed thickness in the supply quarries or the tradition of use at the Wallsend fort.It is an important indicator in this consideration of the likely source of cut Roman stone used for St Paul's, Jarrow.

At Segedunum, as at Arbeia, coarse-grained feldspathic grits ('Millstone Grit'), probably from Heddon-on-the-Wall (but also from the Bearl Quarries), were in common use. These include very large, squared blocks, e.g. forming the base of the East Gate, (Fig 26a) and the well-dressed bases of the granary portico (Fig 26b). In addition this coarse grit was used for door frames, steps and the manufacture of altars and other artefacts (i.e. quern stones).

There is some evidence for its use in squared rubble walling, but with a lift thickness of *c.* 15 cm (6 Roman inches or 2 palmus).

The application of this thinner, lift walling was also practised with good quality, locally obtained, sandstone. This medium-grained sandstone was quarried in the 70 Fathom Post (Westphalian B, Upper Carboniferous) that underlies the Quaternary drift in a large area of Byker, Walker and Wallsend. Local quarries may have been exploited in this area during the Roman period that have since been back-filled and built over. This excellent quality sandstone was apparently used for wall construction in the cavalry barracks, the granaries and currently exposed sections of the Wall adjacent to the fort. The well-constructed drainage culverts on the fort site (Fig 27a), also utilised this stone type, as did the the washing mortaria and latrine of the hospital (Fig 27b). Culvert linings and roofing on site seem to have been constructed using the flaggy upper parts of the 70 Fathom Post sandstone.

Other stone types used at Segedunum are now found in museum exhibits. The distinctive orange brown upper beds of the 70 Fathom Post sandstone, from the Wrekenton-Springwell area (Gateshead Fell), were used in the manufacture of special memorial plaques and altar stones. Pale brown sandstone from the Heworth quarries (Felling) just across the river, also part of the extensive 70 Fathom Post sandstone unit, was also used for the same purposes.

It is significant that, from the available evidence, there appears to be no contemporary use of Permian Magnesian Limestone or the reddened Carboniferous sandstones from Dean Quarry on this site. At Arbeia these stone types were important parts of the building chronology. The recently constructed section of wall containing the 19th and 20th century commemoration plaques now seen at Segedunum (Fig 28) does contain these stone types but seems to have been built using imported Roman stone from another source, probably Arbeia, and is therefore discounted here as evidence for the use of this stone on the Wallsend site.

4.3 Stone types and building materials at Wearmouth and Jarrow

During the detailed stone-by-stone survey at Wearmouth and Jarrow, twelve distinct stone types were recognised in the Anglo-Saxon and Anglo-Norman walling. Much of the stone could be identified as recycled cut Roman stone. With this in mind, the stone used for building purposes and artefact manufacture at the Roman sites of Arbeia (South Shields), Segedunum (Wallsend) and eastern sections of Hadrian's Wall was examined and compared with the stone types recorded at the St Peter's and St Paul's monastic sites.

In addition the occurrence and therefore reuse of Roman man-made materials (tiles, bricks and portions of *opus signinum* flooring) was also recorded. Table 1 shows the building materials recognised at St Peter's Wearmouth and St Paul's Jarrow, compares them with similar materials on nearby Roman sites, and analyses the incidence of use. Throughout this section, a Munsell colour chart (Munsell 1975) is used to describe the colours of the stone types under consideration e.g. very pale brown (Munsell) 10YR 8/4.

4.3.1 Hand list of stone types and their use (see also Table 1)

Type A: **Sandstone**

Recorded: This stone type has been used in the fabric of St Peter's, Wearmouth (and St Paul's, Jarrow in the pre-Conquest and Anglo-Norman fabric. It is extensively used at Arbeia, South Shields in 4th and 5th century contexts (Fig 19a) and at Segedunum , but here taken from local Wallsend area quarry sources.

Hand specimen: Medium grained, poorly sorted, micaceous, yellow (2.5YR 7/6-8) to light yellowish brown (10YR 6/4) in colour, often with small sporadic limonitic patches brownish yellow (10YR 6/6) in colour. Some of the stone exhibits brown limonitic liesegang markings (Fig 30)

Thin Section: Grains are *c*. 0.50 – 0.70 mm in size, sub-rounded to sub-angular in appearance, quite tightly packed, but not well sorted. Largely consisting of quartz grains from metamorphic rock sources (strained extinction features); also composite meta-quartzite grains; alkali feldspar (usually microcline with polysynthetic twinning) degrading to clay minerals; a little plagioclase feldspar (? oligoclase) and occasional zircon and sphene grains. Clay minerals partly fill the interstitial pore space. Annelid worm bioturbation has partly resulted organisation of some patches of grains.

Source Location: This stone came from the older quarries at Wrekenton (Fig 31a; NZ 280590) near the Wrekendyke Roman road (Fig 31b). A very pale brown (10YR 8/4) sandstone from the deeper most recent quarries (also now backfilled) in the same formation at Springwell (NZ 282593) have been used for replacement quoins at St Peter's, Wearmouth.

Geological Horizon: The upper part of the 70 Fathom Post, Middle Coal Measures, Westphalian B, Upper Carboniferous.

Type B**: Reddened inferior quality sandstone**

Recorded: Used extensively in the construction of the supply fort at Arbeia (Fig 32), stone reused on site during later periods of remodelling and rebuilding. Not seen at all in the verifiable, Roman-constructed walls as Segedunum. Very small quantities found in the standing Anglo-Saxon fabric at St Paul's Jarrow (Fig 25b) in the form of built rubble and more consistently as cut ashlar in the porch interior (Fig 1). Found sporadically throughout the Anglo-Saxon and Anglo-Norman walls at St Peter's, Wearmouth.

Hand specimen: Fine-grained, poorly sorted, cross-bedded soft sandstone with a pink body colour (5YR 7/3), the micaceous and clay matrix fractions are reddened by hematite to a stronger red colour (10R 3/2). This poor quality sandstone is part of the Upper Carboniferous Coal Measure strata reddened by percolating ground waters beneath the late Carboniferous – Lower Permian desert unconformity (Anderson and Dunham, 1953).

Thin-sections: Fine grained (less than 0.1 5 mm) and poorly sorted, the grains are largely sub-rounded and in a randomly formed matrix. Most of the quartz grains (including those of a composite metaquartzite type), show a metamorphic strained extinction feature. Also seen are muscovite mica plates, quartz – alkali feldspar graphic intergrowths and alkali feldspar, the latter degrading to clay minerals. The pore space of this stone is largely filled with clay minerals coloured red with hematite, giving the pink body colour to this stone.

Source location: Dean Quarry (now back-filled and restored as West Park), South Shields (NZ 364652).

Geological Horizon: Sandstone below the Dean Coal, Middle Coal Measures, Westphalian C, Upper Carboniferous.

Illustrations: Photomicrographs (Figs 44a, b, c); Arbeia (Fig 42); St Peter's, Wearmouth (Fig 25a); St Paul's, Jarrow (Fig 25b).

Type C: **Coarse feldspathic sandstone 'Millstone Grit'**

Recorded: Substantial use at Arbeia and Segedunum, as well as at Heddon-on-the-Wall. Also frequently observed as part of the pre-Conquest fabric at St Paul's Jarrow and to a much lesser extent at St Peter's Wearmouth.

Hand specimen: A coarsely grained rock with substantial quantities of quartz and weathered alkali feldspar visible to the naked eye. Very pale brown (10YR 7/3) in colour.

Thin-section: Grains 0.8 – 1.00 mm in general size, tightly packed, quartz minerals generally showing metamorphic strained extinction, and include grains of a composite nature, (metaquartzite with opaque iron oxide inclusions) and quartz/alkali feldspar graphic intergrowths. The commonly occurring alkali feldspar fraction of this rock is degraded to secondary micas and clay minerals. Little primary muscovite mica is present. Clay minerals fill much of the available pore space.

Source locality: This stone was quarried by the Romans for the wall construction at Heddon-on-the-Wall (NZ 130667). These quarries are now back filled and built over. This stone is almost identical with that used at Segedunum and Arbeia and reused at in Anglo-Saxon and Anglo-Norman contexts at St. Paul's, Jarrow. Lesser quantities of this stone were also reused at St Peter's' Wearmouth.

Geological horizon: The strata above the Quarterburn Marine Band, Lower Coal Measures, Westphalian A, Upper Carboniferous.

Illustrations: Photomicrographs Fig 45a (Heddon-on-the-Wall), 45b (St Paul's, Jarrow), 45c (Roman Strongroom), Arbeia; Arbeia (Fig 22); Heddon-on-the-Wall (Fig 23); St Paul's, Jarrow (Fig 42a-c); St Peter's, Wearmouth (Fig 1).

Type D1: **Upper Magnesian Limestone, Concretionary Limestone**

Recorded: Used extensively at Arbeia, occasionally used in the pre-Conquest and Anglo-Norman fabric at St. Paul's, Jarrow. Not apparently used at Segedunum.

Hand specimen: Coarsely crystalline, un-laminated dolomitic limestone (Fig 33a), very pale brown in colour (10YR 8/3). Not concretionary in nature, sometimes thinly bedded and used as packing during building work (Fig 33b; also see Figs 13a and b).

*Thin-section: C*omposed of large individual dolomite crystals (up to 2 mm in size) randomly arranged with much open pore space.

Source locality: Identical material can be seen in Marsden Hall Quarry and Marsden Old Quarries (NZ 396646; Fig 21), inter-bedded with very coarse concretionary and spherulitic dolomitic limestones. There can be no doubt that this type of dolomitic limestone

building stone came from the Cleadon Hills, either from the area of the above quarry complex or from a series of small quarries, now partly in-filled, between Westoe and Cleadon (Smith 1994).

Geological horizon: Concretionary Limestone Formation (part of EZ2Ca), Upper Permian.

Illustrations: Photomicrographs (Fig 46a and 46b Arbeia); St Paul's, Jarrow (Figs 33a and); Marsden Old Quarries (Fig 21).

Type : **Upper Magnesian Limestone, Concretionary Limestone and Roker Dolomite**

Recorded: Used extensively at St Peter's, Wearmouth, particularly in the pre-Conquest fabric and present in the Anglo-Norman extensions.

Hand specimens: A variety of different forms of concretionary limestone can be seen in the walls of St Peters, including Cannonball Limestone so characteristic of the Roker Dolomite (Fig 34a), calcite spherulite limestone (Fig 34b) and various forms of dolomitic limestone with coarse radial structures (Fig 35). The colour of these dolomitic limestone is usually very pale brown (10YR 8/3-8/4) but sometimes yellow in colour (10YR 7/6) with slightly more iron content.

Thin-sections: Not available.

Source Locations: These distinctive forms of Upper Magnesian Limestone (Concretionary Limestone) are unique to the Sunderland area. Any quarries located in the vicinity of St. Peter's have been covered by the expanding Sunderland conurbation, but this strata with the characteristic structures can still be seen close by at Carley Hill (NZ 384597) and the famous Fulwell Quarries (NZ 382598). The Roker Dolomite, the unique cannonball limestone upper part of the Concretionary Limestone Formation can be viewed on the foreshore at Roker (NZ 407596).

Geological horizon: The Upper Magnesian Limestone (EZ2Ca) includes the lower Concretionary Limestone and the upper Roker Dolomite Formations, the Cannonball Limestone usually delineates to boundary between these two Formations.

Illustrations: St Peter's, Wearmouth (Figs 34 and 35).

Type D3: **Oolitic Limestone, Roker Dolomite**

Recorded: St Peter's, Wearmouth. Used for all accessible baluster shafts (Fig 5). Also occasionally used in the stone-walling (Fig 47a).

Hand specimen: A well sorted, clean, medium grained oolitic limestone. Usually a uniform very pale brown colour (10YR 8/4). When subject to flash burning, this stone assumes a slightly pinkish colouration (5YR 7/4).

Thin-section: Well sorted calcitic ooliths (0.75-1.00 mm in size), variable in shape and size. There is apparently no detrital or organic material in the interstitial micritic matrix which suggests that this rock has undergone at least partial dolomitization (Fig 47b).

Source location: There are exposures of Permian Oolites at Mere Knoll Road, Seaburn (NZ 403598) within 2.5 km of the St. Peter's Anglo-Saxon site which compare well with the stone used at the Wearmouth site.

Geological horizon: Part of the Roker Dolomite Formation (EZ2Ca), Upper Magnesian Limestone, Upper Permian.

Illustrations: Thin-section (Fig 47b); Baluster shafts, St. Peter's (Fig 5); Building stone, St. Peter's (Fig 47a).

Type E: **Brown sandstone**

Recorded: Commonly found at Arbeia and Segedunum usually as artefacts, commemoration slabs and altars. Reused Roman pieces, used out of context in the built fabric of St Paul's Jarrow and to a much lesser extent, at St Peter's, Wearmouth.

Hand specimen: As Type A sandstone except that the stone is a strong brown colour (7.5YR 5/6).

Thin-section: As Type A except that the quartz and other grains have limonitic coatings and the clay content is a limonite brown colour.

Source location: There are no exposures of this stone type in the hinterland of the Roman fort sites, however loose material built into the walls around Springwell village and Eighton Bank (NZ 278584) suggest that this may have been the source location.

Geological horizon: Probably the upper beds of the 70 Fathom Post, Westphalian B, Middle Coal Measures, Upper Carboniferous.

Illustrations: Photomicrograph (Fig 48b); St. Paul's, Jarrow (Fig 48a); St. Peter's, Wearmouth (Fig 48c).

Type F: **Medium to coarse feldspathic sandstone ('Millstone Grit')**

Recorded: This stone has had considerable use as squared rubble in the Roman Wall in the vicinity of Heddon on the Wall and occasional used at Segedunum for ashlar and squared rubble. Rarely used at St Peter's, Wearmouth and St Paul's Jarrow in either Anglo-Saxon or an Anglo-Norman wall fabric context.

Hand specimen: A compact well sorted feldspathic sandstone, grain size up to 1.0 mm in dimension.

Thin-section: Tightly packed granular texture with little sign of grain alignment, grains sub-angular to sub-rounded in appearance. Largely composed of quartz (usually with metamorphic strained extinction) and alkali feldspar (including microcline with polysynthetic twinning) and some plagioclase feldspar. A little muscovite mica and some opaque oxide grains and brown limonite. The matrix is very clean with little signs of clay minerals in the pore space.

Source location: This type of feldspathic sandstone can be found in a number of quarries in the vicinity of Bearl on the north side of the Tyne valley (NZ 055655), but quite close to the River Tyne.

Geological horizon: This feldspathic sandstone is the 'Third Grit', from the strata between the Quarterburn Marine Bed and the Ganister Clay Coal, Lower Coal Measures, Westphalian A, Upper Carboniferous.

Illustration: Photomicrographs (Fig 49a and c).

Type G: **Grindstone Post sandstone**

Recorded: This stone type has been used for the manufacture of the turned, baluster shafts at St Paul's, Jarrow and is also occasionally evident in the walls. It has also been recognised in small quantities in the wall fabric at St Peter's, Wearmouth. The Romans were exploiting these quarries for fine sculptural pieces such as the memorial to 'Victor the Moor' at Arbeia.

Hand specimen: A fine-grained, hard and uniform sandstone, grey in colour (10YR 5/1)

Thin-section: A tightly-packed, fine sandstone with angular to sub-angular grains, largely quartz but with occasional muscovite mica flakes and very little clay mineral content in the pore spaces. Very little alignment texture to this rock, only the occasional worm burrow can be seen.

Source location: This stone came from the famous grindstone quarries of Gateshead Fell, centred on Windy Nook Quarry (NZ 277605). These quarries provided grindstone for national and international use up to the early 20th century.

Geological horizon: The Grindstone Post, Middle Coal Measures, Westphalian C, Upper Carboniferous.

Illustrations: Photomicrograph (Fig 49b); St. Paul's Jarrow (Fig 9).

Type H**: 'Heworth Brown' sandstone**

Recorded: Used for the manufacture of memorials at Segedunum and Arbeia and only rarely evident as reused squared-rubble and as quoins at St Paul's, Jarrow.

Hand specimen: A good quality, medium-grained sandstone with little signs of cross-bedding, light yellowish brown in colour (10YR 6/4) sometimes with darker ferruginous speckles (dark yellowish brown 10YR 4/4). An excellent freestone for specialist memorial and ashlar production.

Thin-section: None available.

Source Location: This stone type seems to resemble that quarried at Heworth, Felling (NZ 285651) until the early 20th century and known as 'Heworth Brown'. This is the near surface weathered variety, whereas the unweathered stone from the more recent deeper quarries was marketed as 'Heworth Blue'.

Geological horizon: This is part of the 70 Fathom Post sandstone that underlies so much of Gateshead Fell and eastern Tyneside, Middle Coal Measures, Westphalian B, Upper Carboniferous.

Illustrations: Stone type (Fig 50).

Type S: **A very fine-grained, soft, inferior sandstone**

Recorded: Used at St Peter's, Wearmouth, largely in a pre-Conquest context, for door and window jambs (Figs 36a and b). Also occasionally used as built rubble in the walling.

Hand specimen: A very soft inferior sandstone, usually dark greyish brown in colour (2.5Y 4/2), but also can be very pale brown (10YR 8/3) to brown (10YR 5/3). A very fine-grained and poorly sorted rock with prominent bedding features.

Thin-section: Fine-grained, largely very angular quartz grains (up to 0.3 mm in size). Poorly sorted with considerable clay mineral content (estimated as up to 15% of the whole rock). This contributes to the weakness of this rock. Considerable amounts of secondary mica occur with some primary muscovite mica flakes. Limonite stains the clay content and concentrates in patches. Trace fossils in the form of burrow structures punctuate the rock texture.

Source location: Sandstones exposed on the north bank of the River Wear in the North Hylton area (NZ 353575), resemble these stone types used in the pre-Conquest fabric of St. Peter's, Wearmouth.

Geological horizon: Upper Coal Measures, Westphalian C of the Boldon Syncline, Upper Carboniferous.

Illustrations: Photomicrograph (Figs 51a and b); St Peter's, Wearmouth (Figs 36a and b).

Type J: **Glacial erratics**

Recorded: Sporadically used as a building material in the walls at St Peter's, Wearmouth and very occasionally in the walls at St Paul's, Jarrow.

Hand specimens: Variable materials but all glacially rounded cobbles and boulders. Those recognised include dolerite (black), andesitic lavas (green-grey) and rhomb-porphyry (yellow brown).

Thin-sections: None available.

Source locations: Probably found as a result of ploughing and field clearance in the local area. These erratics have been in Boulder Clay (Tillite) which has been ice transported some distance into this area during the last, Devensian Glaciation. The dolerite is probably from North Northumberland, the andesitic lava from the Cheviot area and the rhomb-porphyry is probably from Southern Norway.

Geological horizon: Not available.

Type M: ***Opus Signinum* flooring**

Recorded: One piece was found in the south-west wall inside the porch at St Peter's Wearmouth.

Hand specimen: Roman hydraulic cement flooring with red tile/pottery inclusions.

Thin section: Not available

Source location: Flooring of the better quality Roman buildings, for example the houses and the Headquarters on Roman forts. It was probably bought onto this site with Roman building stone but a precise source is unknown.

Geological horizon: Not applicable.

Type T: **Tiles and bricks**

Recorded: A common feature at the Roman sites of Segedunum and Arbeia, but rarely seen in the built fabric at either and St Peter's, Wearmouth or St. Paul's, Jarrow (Fig 35a).

Manufactured: Very commonly produced inside or close to Roman forts and other settlements.

4.4 Evidence for burning at both monastic sites

Burnt stone is a common occurrence in the built fabric at both monastic sites; however the interpretation of this feature can be complicated. Most sedimentary rocks commonly used for building purposes contain small amounts of iron, usually in the form of ferrous hydroxides (limonite, goethite, etc). Some rock types often contain only minor traces of iron (i.e. some 'pure' limestones), others including sandstones may contain appreciable amounts and some calcareous and siliceous rocks can contain enough iron minerals to constitute low grade iron ores. This ferrous iron creates the earthy yellow/brown – dark brown colouration (Munsell 2.5YR, 10YR and 2.5Y colours) in building stones, depending on the quantity of iron minerals contained in the rock (Fig 30).

When stone is subject to accidental or deliberate burning the effect is to change its appearance. Ferrous iron is converted to ferric iron (e.g. limonite - iron hydroxide to hematite – iron oxide) and the rock colour changes from the normal earthy yellows and browns to bright earth red colours (Munsell 10R and 2.5YR colours; Fig 29).

However caution should be exercised as one of the original Roman stone types local to South Shields and reused at both monastic sites, is naturally reddened due to hematite content. Distinguishing the natural reddened stone from burnt stone is a key part in the understanding of the building development history of both sites.

Isolated burnt stones. Examples of reused burnt material are common to both sites (Fig 29). This suggests that the original, dismantled Roman buildings had been subject to fire damage: intentional (close proximity to domestic or industrial processes) or accidental fires or deliberate burning during raids and wars. This stone was taken away and reused out of context at St Peter's and St Paul's.

Evidence of in situ fires. The is strong evidence of extensive flash burning of walls at both monastic sites affecting lower parts of exterior and interior walls and doorways and created by falling burning timbers (Figs 38-39). High window apertures also bear witness to fire damage, as at St Peter's where the upper Anglo-Saxon window apertures have been considerably reddened and damaged by exiting flames (Figs 40 and 41a and b). At both sites fire damage has been recorded at various times in the history of the buildings from the documented Viking raids around AD 794 to the fire at Monkwearmouth in 1984.

Evidence of multi-phase fire damage to stone work. At both sites there is evidence that some sections of walling have undergone several phases of fire damage. The clearest examples involve architectural features (e.g. door frames) and wall sections with isolated

fire damaged stone units, presumably resulting from exposure to flames in the context of the original dismantled building. Later these features can be seen to have undergone a later episode of conflagration damage in the context of their current situation (Fig 37).

5. CONCLUSIONS

There can be no doubt that the first early medieval builders at these monastic sites reused large quantities of former Roman building material when constructing the 7th Century Anglo-Saxon Monasteries of St Peter's, Wearmouth and St Paul's, Jarrow. This tradition of reusing Roman stone continued into the 11th century and beyond.

5.1 The available Roman building sources

The nearest Roman sites, Arbeia (South Shields), Segedunum (Wallsend) and the Roman Wall have been extensively robbed of stone since *c.* AD 400 and comparatively little is now left to be seen. The remains of the stone walls at Arbeia are still the best guide to the types of stone available and the methods of Roman construction (Richmond 1952). Segedunum at the eastern end of Hadrian's Wall has been almost completely destroyed and most of its stone reused elsewhere, but the remains of Roman buildings at Segedunum still supply enough evidence of stone sourcing to compare that site with Arbeia and the monastic sites at Wearmouth and Jarrow.

The work of Richmond (1954) at Arbeia and archaeological evidence obtained in the subsequent 60 years shows that during the life of this supply fort (1st – 5th century AD) the Romans exploited a number of quarry sites in north-east England for stone. The observed spectrum of stone use, though still incomplete, can be seen in Table 1. For general building purposes at Arbeia, the Roman use of stone with a lift height of approximately 24 cm is a distinctive feature also present at other Roman sites, e.g. Heddon-on-the-Wall. At these sites, variations of *c.* 24 x 24 cm faced squared rubble can be found, but also cut and finished ashlar. At Segedunum, little is left on site and any attempt to extract information on the changing use of stone over time is very difficult, but it should be noted that the squared rubble walling on this site, where it survives, provides evidence for the use of a *c*. 15 cm lift height, bothin the fort and also on the foundation section of Roman Wall nearby. Figs 17, 18, 24 and 30 illustrate the differences in height and proportion of squared rubble walling stone at various sites.

The evidence for the likely Roman harbour and quay developments at Segedunum, Arbeia and Jarrow has been discussed by Bidwell (2006, 1-2), but any such featuers have been so completely destroyed and/or obscured by coastal development that to date 'no Roman military installation has been discovered between South Shields and Wallsend on either side of the River Tyne. The discovery of pottery and coins at Jarrow has led to the suggestion that a military structure may have been located there, though no physical remains have been found' (Breeze 2006, 130). The extensive geophysical survey undertaken during the 'As One Monastery in Two Places' project, although not conclusive, has not produced any evidence for Roman installations or structures (Turner 2014). The few Roman finds from Jarrow and antiquarian traditions of a Roman structure (summarised by Cramp 2005, 24-7), alongside the discussion of antiquarian observations that appear to suggest a Branch Wall

beyond the low-water mark at Wallsend Bidwell (2006, 1-2), remain the only evidence of additional Roman constructions along this stretch of the Tyne.

The construction of the Roman road system was instrumental to the development and pattern of stone quarrying in the area. The spur road (809 of Margery 1938) to the supply fort at Arbeia was developed from the north-south arterial road (80b, Margery 1938) from Gateshead Fell at Wrekenton. These roads meant that stone could be transported easily to Pons Aelius (Newcastle) and Arbeia from the Wrekenton-Springwell quarries.

5.2 Sources of the building stone used at St Peter's Church, Monkwearmouth

Most of the cut, dressed stone used in the church of St Peter is s of Roman origin. The use of Dean Sandstone and Millstone Grit in particular in the pre-Conquest fabric and Wrekenton Sandstone in the upper sections of the Anglo-Norman tower, suggest Arbeia as a source. Arbeia lay at some distance, *c.* 9.9 km by land, and transporting building stone over this distance, by land or coast, would have been a labour-intensive exercise. This may account for the construction of the overwhelming bulk of the remaining walls at St Peter's, Wearmouth, in local Roker Dolomite rubble. Other local stone, the poor quality Upper Carboniferous sandstones from North Hylton (Fig 36), was occasionally used for door surrounds and general building, and the excellent quality Permian Oolite from the Seaburn area was exploited for the turned baluster shafts (Fig 5).

Sourcing the architectural stone from Arbeia must have presented a challenge in terms of transport. At other sites, such as Hexham or Escomb, the cut Roman stone appears to have been sourced at Roman sites a short distance up-river, meaning transportation by river or land would have been less cumbersome. Transportation of stone by river on flat barges is certainly a possibility but using the river and coast to move cut stone from Arbeia to Wearmouth would have involved loading and unloading heavy loads of stone several times. Transport by road would have required the use of heavy oxen carts. The journeys would be slow but the stone would be delivered to the site and handled only twice, in the loading and unloading of the cart. Ox carts comparable with the Roman 'Angaria' cart (Hill 2006, 92) or the 14th century 'Plaustrorum' (Salzmann 1952, 349), would be capable of slowly transporting heavy loads up to 24 tonnes (Salzmann 1952). The presence of a Roman Road from Arbeia to St Peter's is not documented, but a possible route can be suggested (Fig 30). A section of road exists on the South side of Arbeia, from the south gate on a line nearly parallel with Baring Street where it could have joined the old South Shields to Sunderland road documented by Ogilby (1675), or it could have simply joined the Wrekendyke Roman spur road (Fig 29). A putative route could have run from the Old Sunderland Road (Ogilby HER2331) and Salters Trod (HER11813) from Westoe to Cleadon; the path way (Cut Throat Lane) through Moor Farm and the Academy of Light Football Centre (NZ 392610), Dene Lane (NZ 396600) and Fulwell Road (NZ 398590) (Fig 20a). St Peter's Monastery lies directly at the southern end and this route passes over very gentle terrain (Fig 20b). Roman pottery has been found at Carly Hill near to Fulwell quarry (NZ 382598) about 1 km west of Fulwell Road, implying this route may have provided access to varied local stone sources in the Roman period. This road would have facilitated the movement of stone by cart from Arbeia to St Peter's at Wearmouth. It would also have connected St Peter's to the sources of local stone used at the monastery, to Roker, Seaburn and the Carley/ Fulwell quarry complex, and

lime could also have been sourced at the latter location, for use in the construction at St Peter's.

5.3 Sources of the building stone at St Paul's, Jarrow

This survey indicates that virtually all the surviving pre-Conquest structure has been constructed using recycled Roman stone (Figs 42a, b and c), even the dedication plaque, now set into the east wall of the nave and dated 25 April 685 is a recut and reused piece of Roman ashlar. Only the fine baluster shafts (Fig 5) utilised newly quarried stone.

The origin of this reused Roman stone is of considerable debate (Cramp 2005, 26-7; Bidwell 2006, 1-2).

Arbeia and Segedunum, the nearest Roman sites, each have evidence for the use of a spectrum of stone types. The types of stone used in the fort at Arbeia are clearer because the archaeological evidence is partly still present; at Segedunum the site has been extensively robbed over time so less remains on site. Table 1 compared the stone types observed at Arbeia and Segedunum (and sections of Hadrian's Wall) with those recorded at St Peter's Wearmouth and St. Paul's, Jarrow. In addition Table 1 indicates in what form these stone types were used and notes the observed frequency of use. Two of the key rock types used at Arbeia, the Magnesian Limestone from the Cleadon Hills and the naturally reddened sandstone from Dean Quarry, South Shields, were not, as far as this survey could determine, used at Segedunum. One of these indicator stone types, the Dean sandstone, was found in sufficient quantity at St Peter's, Wearmouth, to suggest that Arbeia was the source of Roman stone for this Anglo-Saxon structure and certainly for the Anglo-Norman phases. Although Permian dolomitic ashlar was also found in the pre-Conquest fabric at St Peter's, it was impossible to ascertain, without considerable sampling, whether it was 'new' local stone or imported material from Arbeia.

With regard to St. Paul's, Jarrow, the source is less clear. The two indicator stone types from Arbeia are present in the standing pre-Conquest structure, but only in very small quantities and were used more or less as built rubble only. Figs 33 and b show the Magnesian Limestone used as contemporary packing and in Fig 25 fragments of Dean Quarry sandstone are present as part of the built-rubble walling. The Anglo-Norman fabric at St. Paul's was less ambiguous, with substantive reuse of Dean Quarry sandstone.

Another strand of evidence, however, is the dimensions of the squared rubble building stone used throughout the pre-Conquest and late Saxon/Norman phases. This regular sized building stone, easily picked out in the surviving elevations and representing the bulk of the building stone in the pre-Conquest structure, is reused from a Roman site and has a standard lift height of *c.* 24 cm, equating to a *c.* 24 x 24 cm squared face. As discussed above (p24), the squared rubble blocks at Arbeia have a matching lift height of *c.* 24 cm (10 Roman inches or 3 palmus) and a 24 x24 cm face. By contrast at Segedunum (though it is important to remember much less material remains on site), the surviving stonework indicates a lift height of *c.* 15 cm (2 palmus). It is of course possible that the Roman stone was brought to St. Paul's from another local site, the remains of which have been lost. The possible sourcing of the foundation stonework for Building D at Jarrow, from a now lost bridge or more likely, a Branch Wall at Wallsend, shows the need for caution (Bidwell 2006, 1-2). However, given the rich array of nearby Roman structures, there is no reason why the cut stone at Jarrow

needs to have been sourced from one location. Indeed, it seems unusual that Arbeia should be selected as a source for the architectural stonework at St Peter's in *c*. AD 674, only to be abandoned in favour of other Roman structures during the completion of St Paul's some 10 years later. Logistics could have been an issue, if other Roman structures were perhaps just a little closer. However *on balance* this detailed examination of the built fabric at St Paul's, suggests that much of the Roman stone extensively used in the Eastern Church at Jarrow, *probably* came from Arbeia.

The late Saxon/Norman fabric at St Paul's tells a different story. The unmistakeable Roman ashlar and squared rubble blocks include significant examples of Dean Quarry Sandstone and Magnesian Limestone as well as Wrekenton Sandstones and Heddon stone, and therefore indicate Arbeia as a source. The same can be argued for the eleventh-century tower extension at St Peter's Wearmouth. This presents two possibilities: that early pre-Conquest buildings were being demolished and the recycled cut Roman stone was being reused again in these later extensions, or that Arbeia was being heavily exploited once again for Roman cut stone in the late Saxon/Norman transition.

The site of St Paul's lies 1.5 km to the north of Roman branch road 809 Wrekendyke of Margery (1938, 172-3) which links the Durham – Gateshead – Newcastle Road (80b of Margery 1938, 171) with the supply fort at Arbeia (Fig 20a). The site was thus well connected by land to Arbeia and to other Roman sites. The situation of St. Paul's on the Slake which opens onto the River Tyne, however, means water transport may have been a more likely means of delivering Roman cut stone to Jarrow.

5.4 Summary

Although much of the pre-Conquest standing fabric at Wearmouth and Jarrow has been removed over time, enough is left to be certain that the Middle Saxon builders obtained significant quantities of building stone from the abandoned Roman sites on the southern bank of the River Tyne.

Analysis of the stone types exploited by the Romans for their supply fort at Arbeia (South Shields) and Segedunum at Wallsend, and comparison with the stone types used at St Peter's (Wearmouth) and St Paul's (Jarrow), suggest that Arbeia supplied good quality building stone, and in some quantity, for the construction of both monasteries at various times. Specialised Roman ashlar was apparently used in the construction of the late 7th century church at Wearmouth and later, general squared building stone was used in quantity for the 11th century tower (Table 1).

The source of the large quantities of Roman, squared building stone used in the construction of the late 7th century Eastern Church at St Paul's, Jarrow, remains less certain. The key stone types (Wrekenton Sandstones, Millstone Grit, Heworth Sandstone etc.) used in the Eastern Chapel are present at Arbeia (Table 1), but the two key stone types, the reddened Dean Sandstone and Magnesian Limestone, such key parts of some areas of construction at Arbeia, are only marginally present in the surviving standing structure. The consistent lift height of *c.* 24 cm for the standard stone building blocks used in the Eastern Church, does suggest however, that Arbeia, rather than Segedunum, might be the source of building stone for the surviving church. It is possible that stone supplies were obtained from Arbeia, from parts that did not include the two key indicator stone types. The suggestion by

Bidwell (2006, 1-2), that the stone may have been obtained from a now lost Branch Wall at Wallsend or a lost bridge, although not well evidenced, remains relevant and plausible. Bidwell argued that the foundation stonework from Building D at Jarrow demonstrated details that might suggest just such a source. The first monastic complex at Jarrow may have been constructed from cut Roman stone from a variety of nearby sites, but this survey reveals that Arbeia is a definite candidate once again for at least some of the massive quantity of recycled Roman stone used here. The late Saxon/Norman phases at St Paul's did make extensive use of building stone from Arbeia, indicating perhaps the demolition and recycling of Anglo-Saxon buildings constructed using Roman cut stone, or that other areas of the fort at South Shields were again being exploited around the time of the Norman Conquest for new phases of construction at both monastic sites.

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7. ILLUSTRATIONS

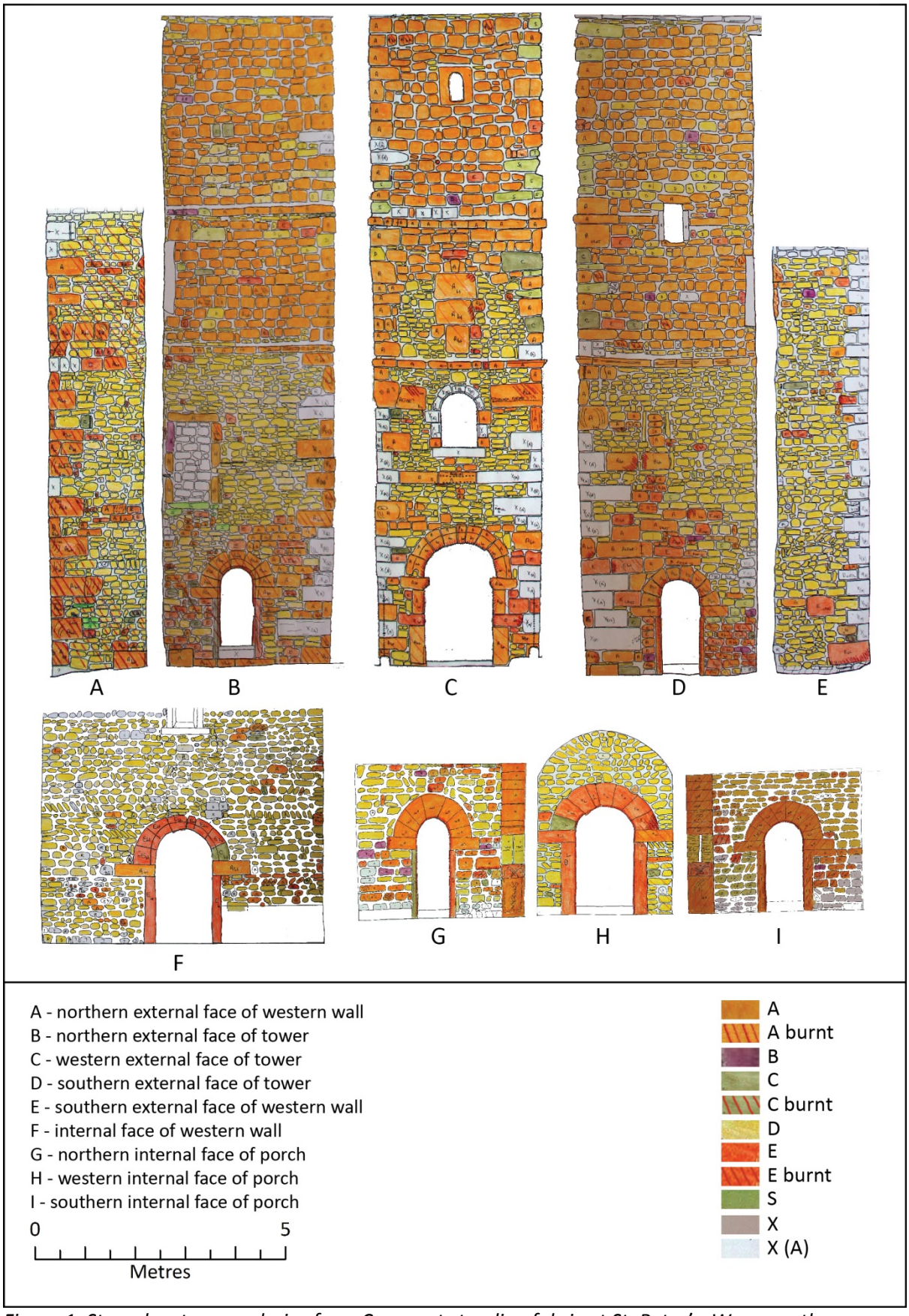

Figure 1: Stone-by-stone analysis of pre-Conquest standing fabric at St. Peter's, Wearmouth.

Figure 2: Western porch entrance, St. Peter's, Wearmouth. Showing original roof line.

Figure 3a: Entrance on north side of the porch, St. Peter's, Wearmouth. Shows burned ashlar in situ.

Figure 3b: A door jamb reshaped from a Roman altar, executed in sandstone (Cramp 2006, Fig. 28.2.1, AS1a and b). Reproduced with permission of the Corpus of Anglo-Saxon Stone Sculpture.

Figure 4: Original quoins at north-west corner of the original nave at St. Peter's, Wearmouth. Note the burned stonework

Figure 5: Baluster shafts situated in the porch entrance at St. Peter's, Wearmouth.

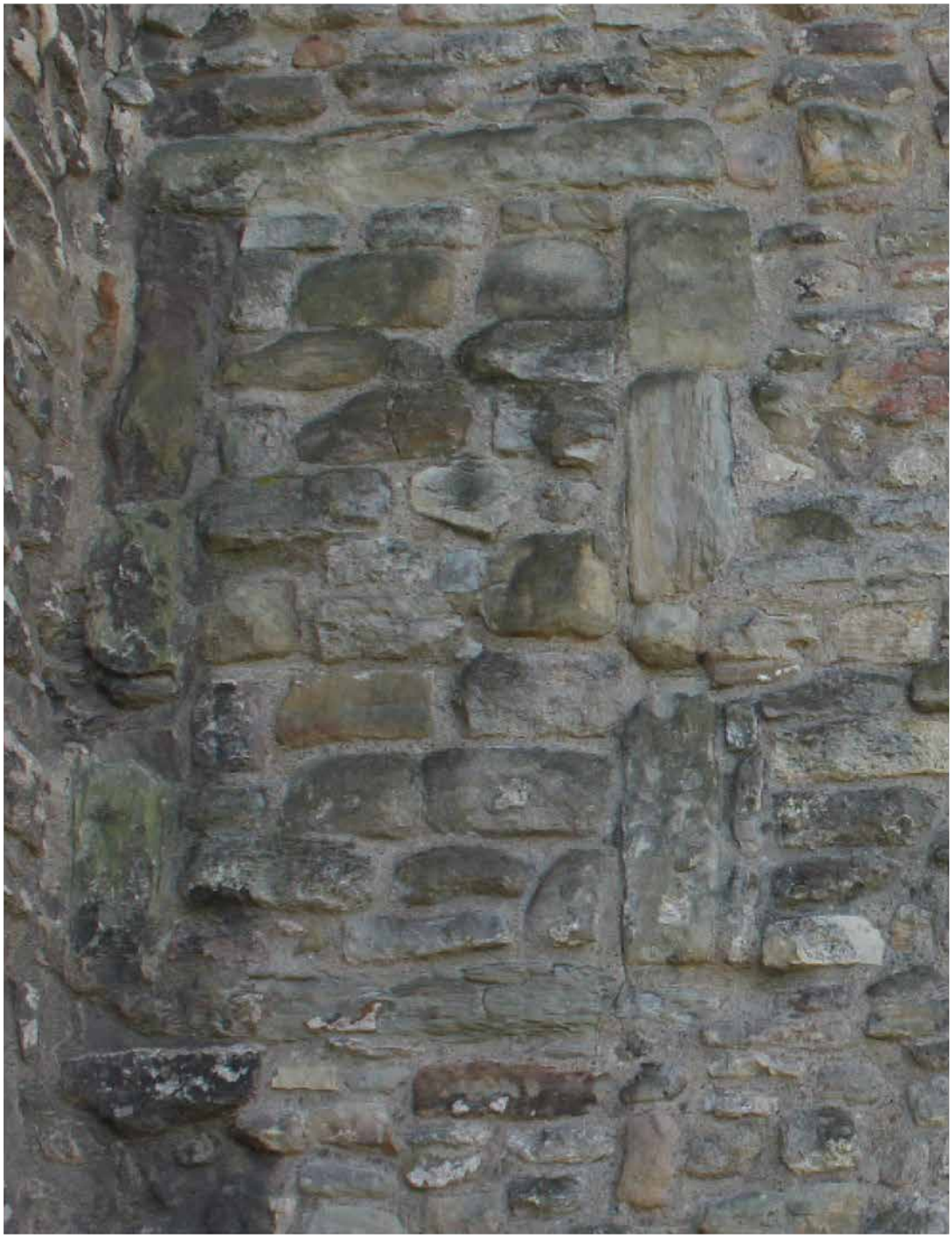

Figure 6: Infilled door with frame on north side of porch/tower, executed in soft sandstone from North Hylton

Figure 7a: The south external elevation of the Eastern Church – and the joining tower

Figure 7b: North western interior corner of the Eastern Church, showing sheared quoins.

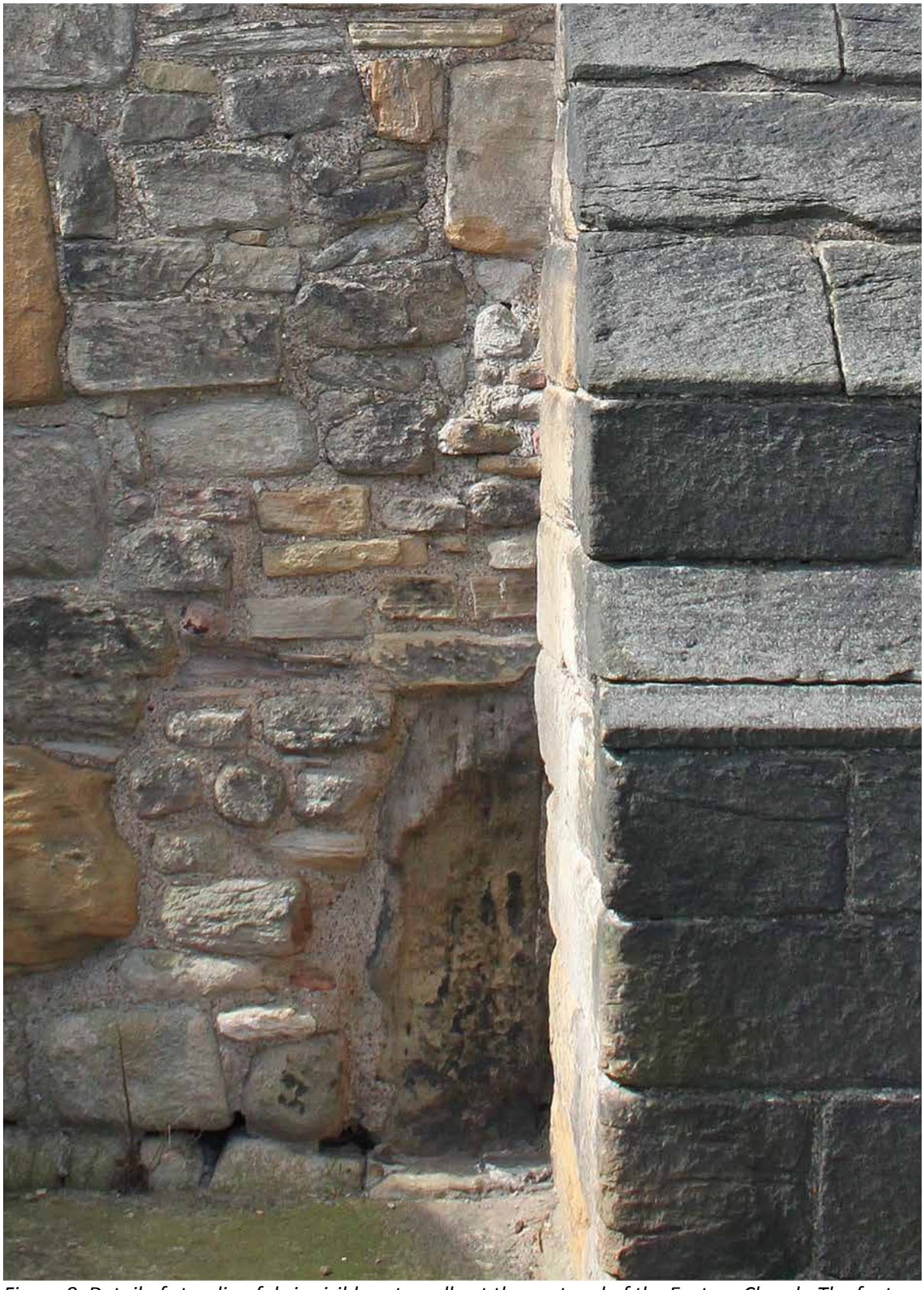

Figure 8: Detail of standing fabric visible externally at the east end of the Eastern Church. The feature is yet to be interpreted. The Type A sandstone is scorched at the base.

Figure 9: Baluster shafts, St. Paul's, Jarrow. Executed in fine-grained sandstone.

Figure 10: Left: Lewis lifting hole in reused Roman ashlar: quoin at south-east corner of the eastern chapel at Jarrow. Right: Lewis lifting hole in reused Roman ashlar: voussoir on southern side of the western porch entrance at Wearmouth.

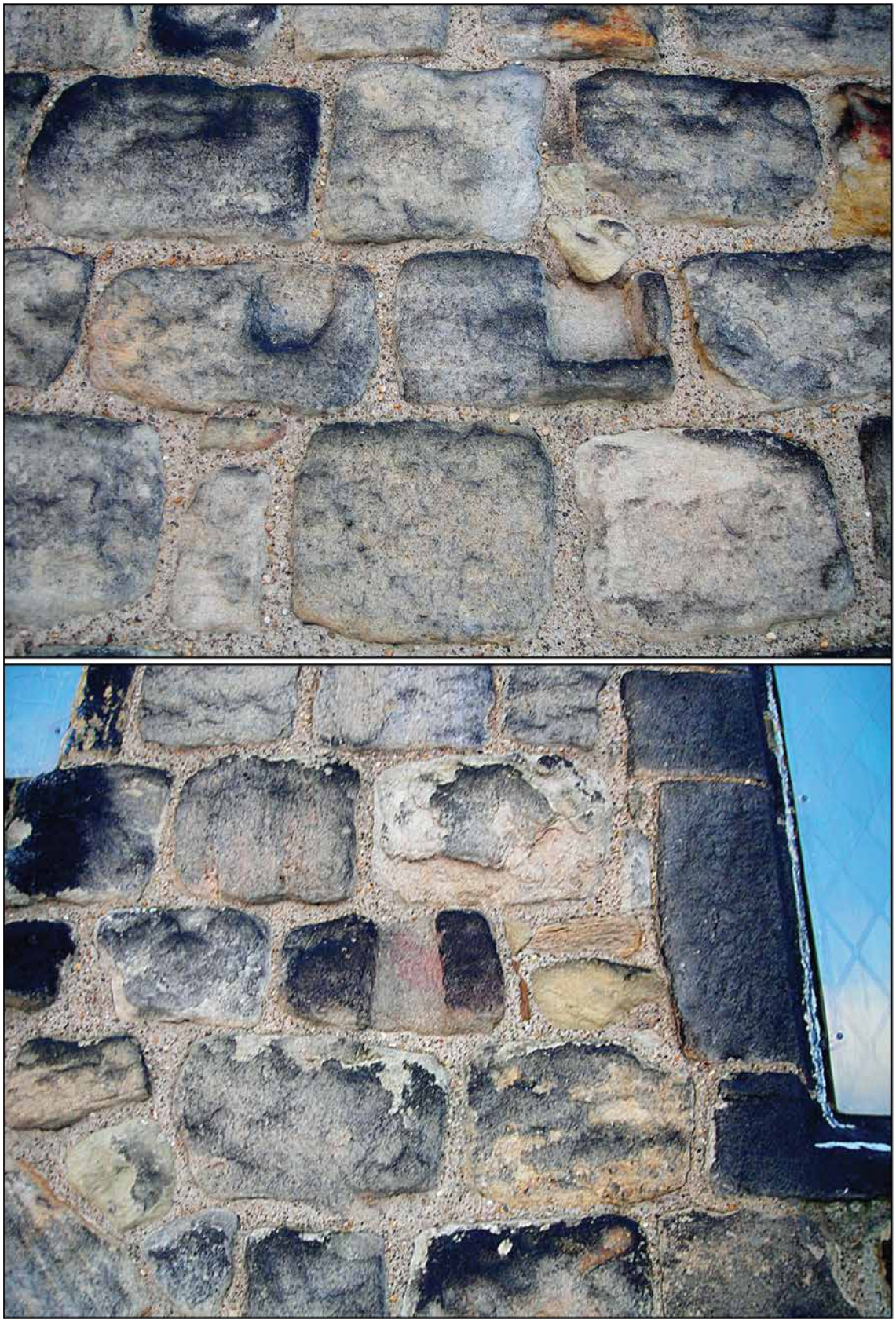

Figure 11: Roman cut mouldings, visible on north external elevation of the Eastern Church at Jarrow.

Figure 12a: Roman decorated stone, visible on north external face of Eastern Church, Jarrow.

Figure 12b: Roman frieze: strong coursing, west face of porch at St. Peter's, Wearmouth.

Figure 13:. Roman stonework evident in the surround of the blocked doorway on the north side of the Eastern Church at Jarrow.

Figure 14: Lewis holes visible in quoin used at the north-west corner of the west external face of the porch at St. Peter's, Wearmouth. The block has been split in two for use in the early medieval building.

Figure 15: One example of several quoins at both churches, whose shape resembles modified Roman altar stones. This lies at the external south-east corner of the east end St. Paul's, Jarrow.

Figure 16: Roman squared building stone – saxa quadrata – west end of the exterior north wall at Jarrow.

Figure 17: Top: Arbeia: standard 25 x 25 x 25cm squared ashlar executed in Wrekenton Sandstone. Bottom: Segedumum: squared rubble walling executed in Millstone Grit with a lift height of c. 15 cm

Figure 18: Arbeia: example of squared rubble blocks executed in Wrekenton Sandstone with a c. 25 cm lift height and tapered backs.

Figure 19: The 11th-century tower at St. Peter's, Wearmouth: not the extensive use of Roman squared stone, largely executed in Wrekenton sandstone.

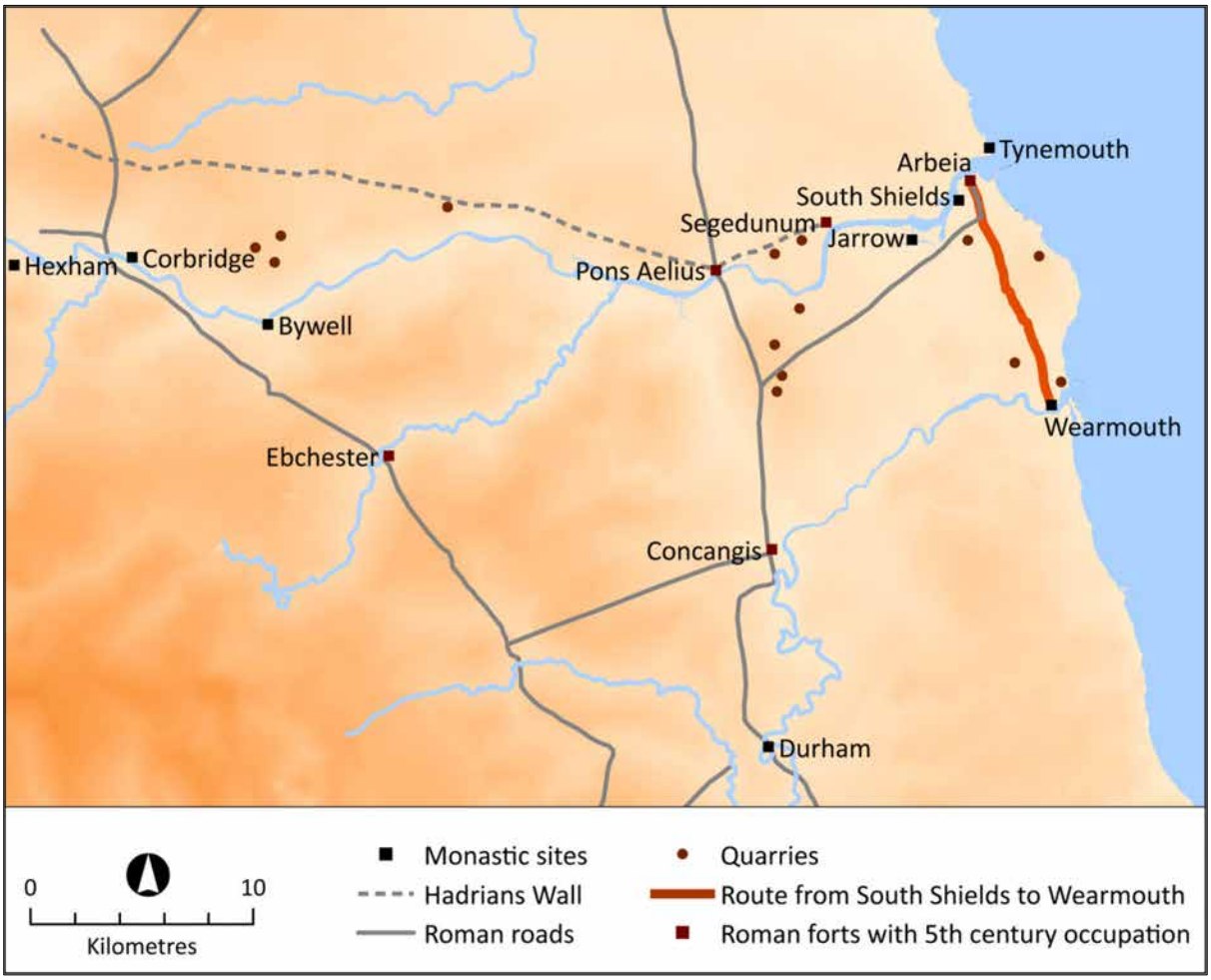

Figure 20: Roman and Anglo-Saxon monastic sites sites along the River Tyne corridor with possible communication routes including the putative land route connecting Arbeia to St. Peter's, Wearmouth.

Figure 21a: Most recent part of the Marsden Quarry in the eastern Cleadon Hills (NZ 359 644). The Roker Dolomite (Upper Permian) of this area provided stone for parts of the Arbeia supply fort.

Figure 21b: Coarsely crystalline dolomitic limestone at the Marsden Old Quarry.

Figure 22a-c: The colonnade shafts of the Headquarters Building Missing – new photo needed; b) Footing of colonnade shaft, note the partial burning of the stone; c) Strong-room blocks beneath the Headquarters Building.

Figure 23: Roman Wall section at Heddon-on-the-Wall, constructed with local Millstone Grit ('Third Grit' Lower Carboniferous; NZ 130668).

Figure 24: Heddon-on-the-Wall: squared rubble walling. Note the c. 30 cm lift dimension.

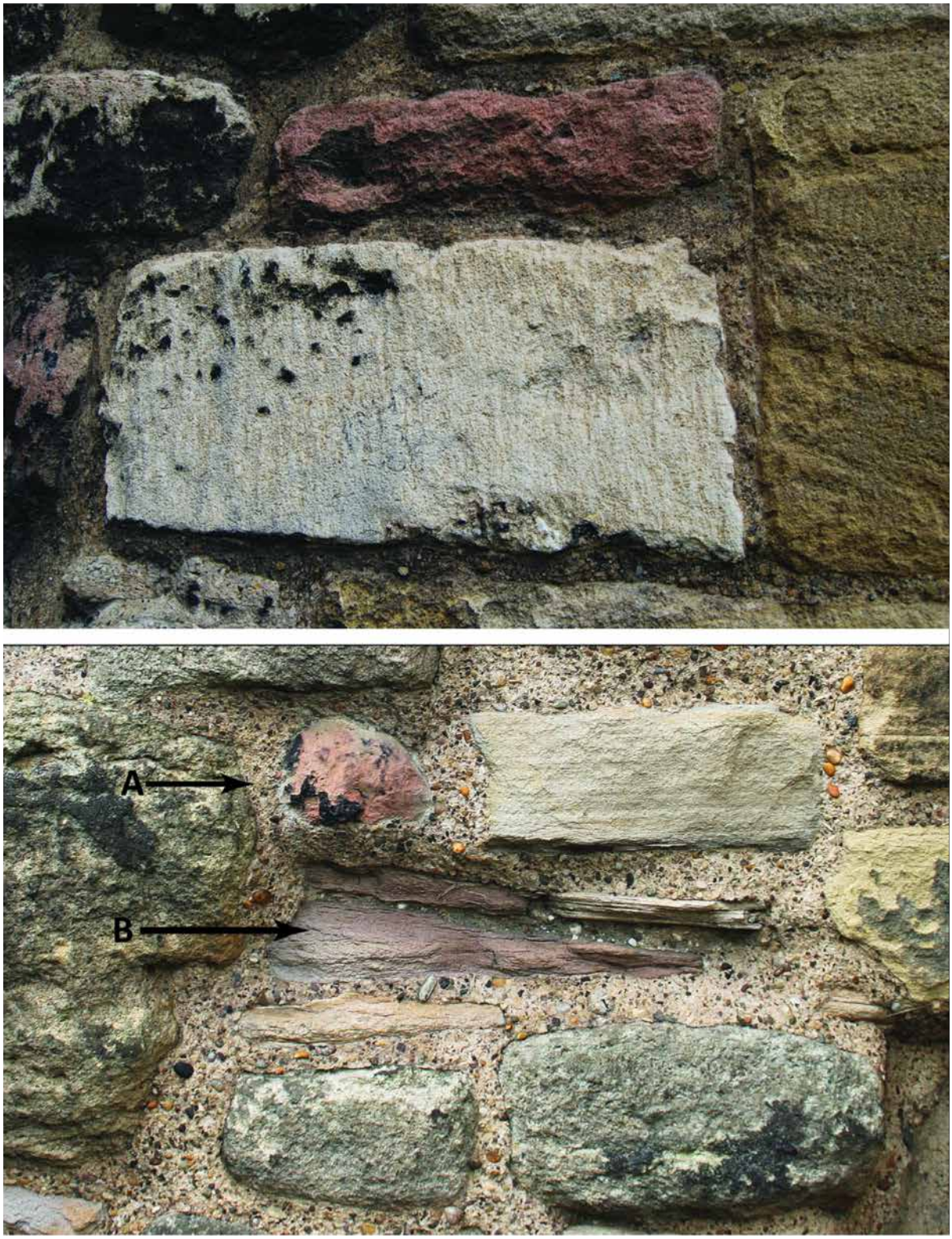

Figure 25: Top: Naturally reddened sandstone from Dean Quarry and Roman stone cut from pale oolitic dolomite. St. Peter's, Wearmouth. Bottom: Reddened sandstone fragment in the Anglo-Saxon fabric of St. Paul's, Jarrow(B) , located in the south-east part of the external east wall. Sitting below a fragment of reddened Roman brick (A).

Figure 26a: Base blocks of Millstone Grit used for the East Gate at Segedunum. Bottom:

Figure26b: Colonnade base, Segedunum.

Figure 27a: Drainage culverts at Segedunum, executed from 70 fathom Post Sandstone.

Figure 27b: Washing mortaria and latrine drains worked from the same stone.

Figure 28: Recently constructed walling supporting 19th and 20th century commemoration slabs. Constructed from Roman squared rubble, probably from Arbeia.

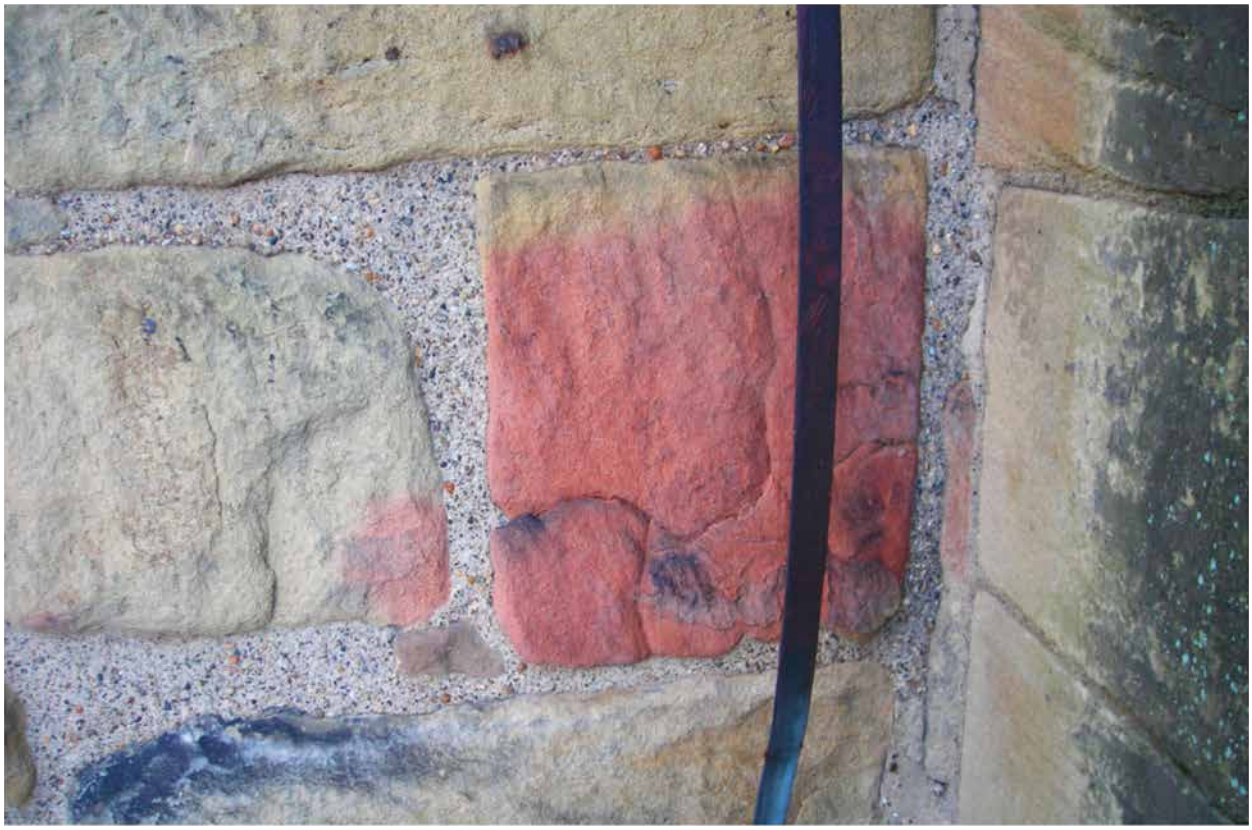

Figure 29: Roman cut stone blocks reused at Jarrow. Exterior, north-west corner of Eastern Church. Stones appear to have been burned prior to their use in the pre-Conquest structure.

Figure 30: Ferruginous liesegang marks in Wrekenton Sandstone. Located in the upper section of the tower of St. Peter's,

Figure 31a: Site of the earliest known quarry, probably the original Roman quarry site, at Wrekenton, once located on the restored fields shown to the left of the road. View looking north to Wrekenton and the Roman Road, Wrekendyke (809) on the sky-line (NZ 280 691).

Figure 31b: View west along the Wrekendyke Roman spur road towards Wrekenton.

Figure 32: Arbeia: squared rubble walling in Dean Sandstone (Type B). Note the pick shade to the body colour of the stone.

Figure 33: Use of Magnesian Limestone in an Anglo-Saxon context at St. Paul's, Jarrow: a) as packing in the frame of the North Doorway; b) As packing at the east end of the church (south-east corner).26

Figure 34a: Types of Permian Roker Dolomite (Lower Magnesian Limestone) present in the standing fabric at St. Peter's , Wearmouth: a) Cannonball Limestone

Figure 34b: Types of Permian Roker Dolomite (Lower Magnesian Limestone) present in the standing fabric at St. Peter's , Wearmouth: b) Spherulite Limestone

Figure 35a: Sample of cellular structures in Concretionary Limestone, Upper Permian present in the standing fabric at St. Peter's, Wearmouth.

Figure 35b: Sample of cellular structures in Concretionary Limestone, Upper Permian present in the standing fabric at St. Peter's, Wearmouth.

Figure 35c: Sample of cellular structures in Concretionary Limestone, Upper Permian present in the standing fabric at St. Peter's, Wearmouth.

Figure 36: Soft Upper Carboniferous sandstone from the North Hylton area of Sunderland, used in the standing fabric of St. Peter's Church, Wearmouth; above) detail of the poor quality of this ashlar

stone; below) weathered ashlar used in the in-filled doorway on north-facing exterior wall of the porch at St. Peter's.

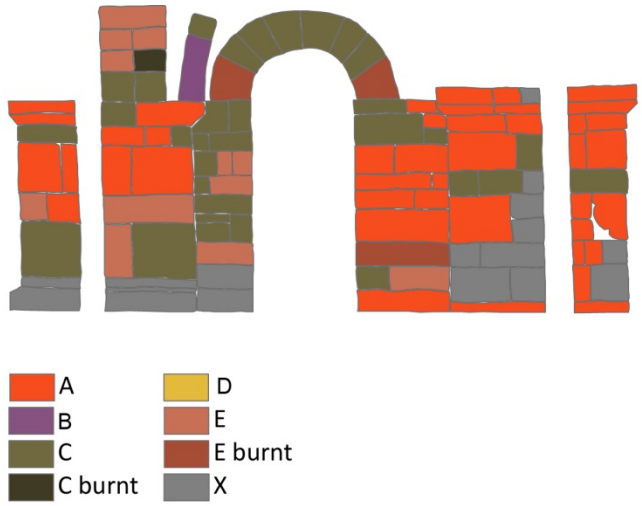

Figure 37: Burned and scorched areas recorded on the interior stonework on the north side of the chancel at St. Paul's church, Jarrow.

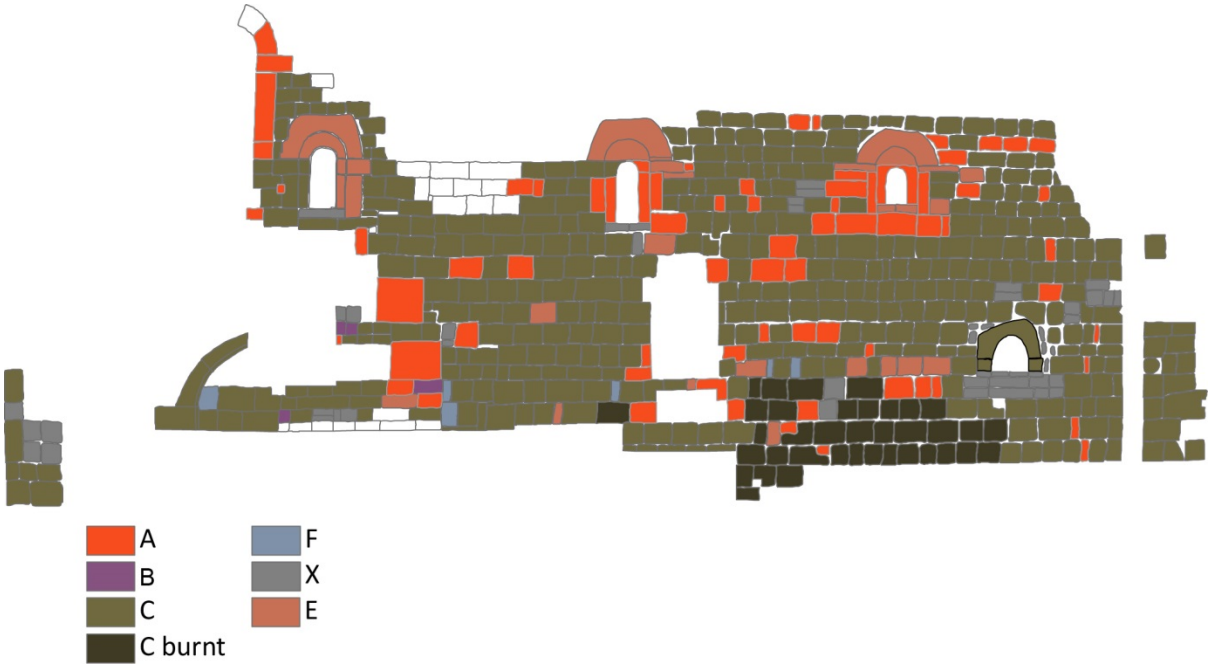

Figure 38: Interior stonework on the south side of the chancel at St. Paul's, Jarrow.

Figure 39: The north doorway of the porch at St. Peter's Church, Wearmouth, showing considerable fire reddening on the stone.

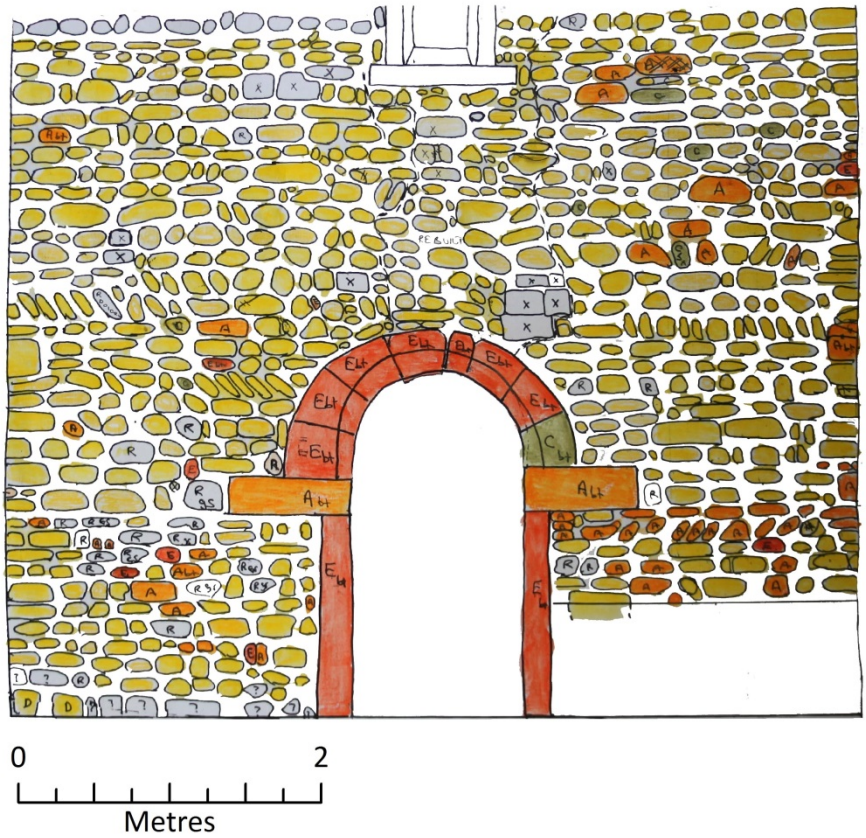

Figure 40: Analysis of the interior stone work on the western end of the nave at St Peter's, Wearmouth.

Figure 41a: interior stone work at the western end of the nave at St Peter's, Wearmouth, showing the burnt areas around the upper windows.

Figure 41b: Fire damage evident on the interior stonework in the western end of the nave at St. Peter's, Wearmouth.

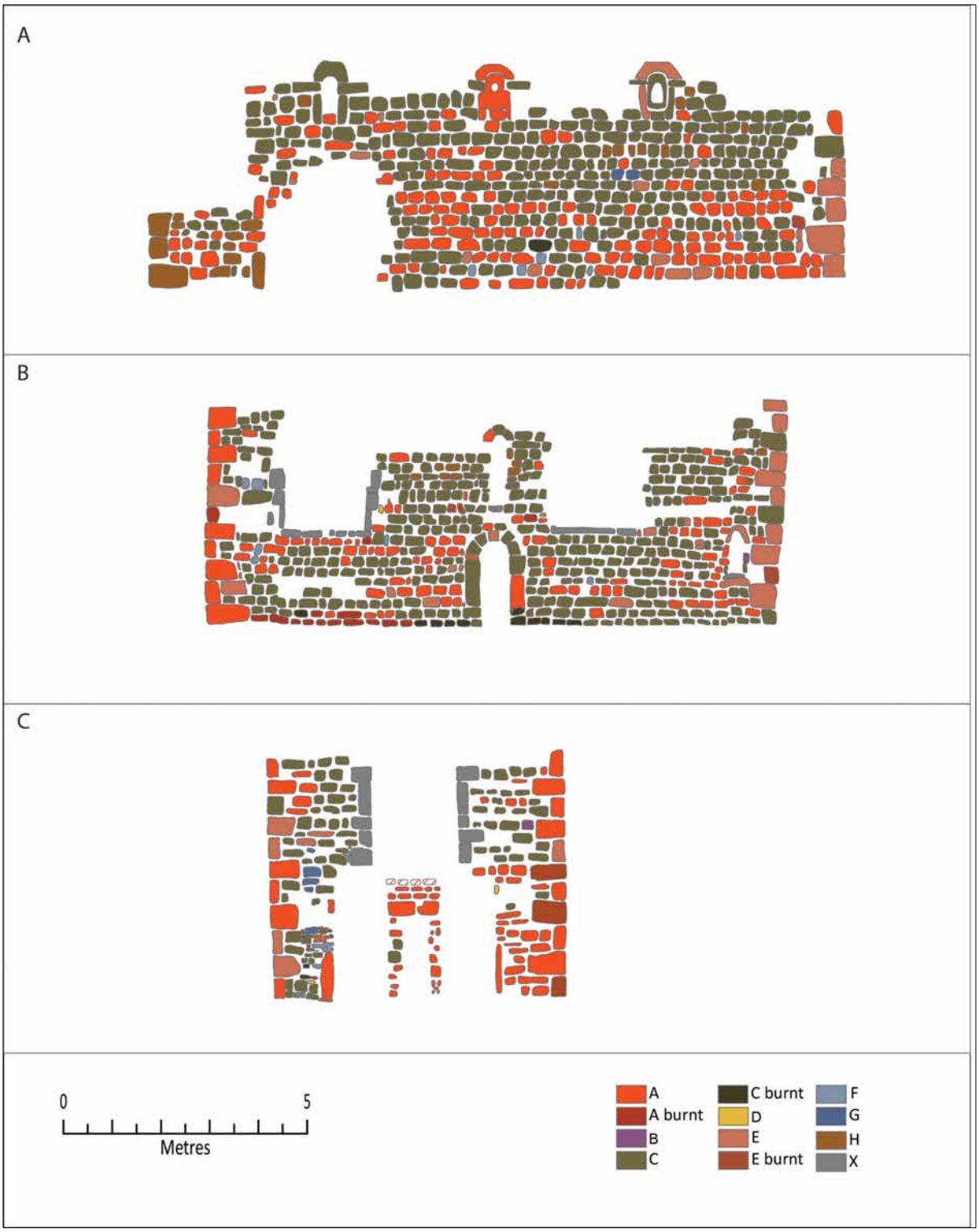

Figure 42 a-c: Stone surveys of the Anglo-Saxon outer walls of St Paul's, Jarrow.

Figure 43 a-b:

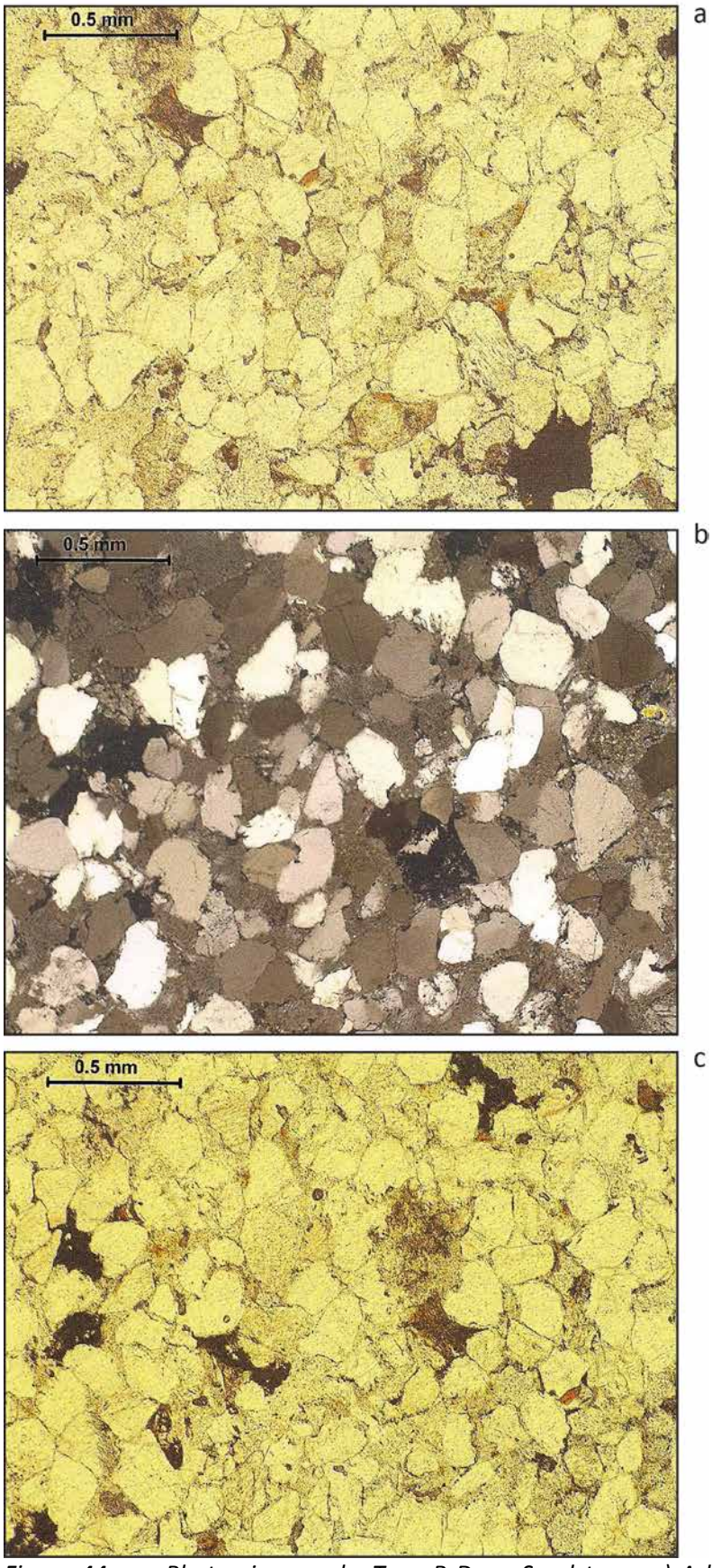

Figure 44 a-c: Photomicrographs Type B Dean Sandstone: a) Arbeia (ordinary light); b) St. Peter's, Wearmouth (ordinary light); Arbeia (polarised light). Note the patches of brown haematite coating to the grains (quartz and otherwise), which produces the pink body colour to the rock.

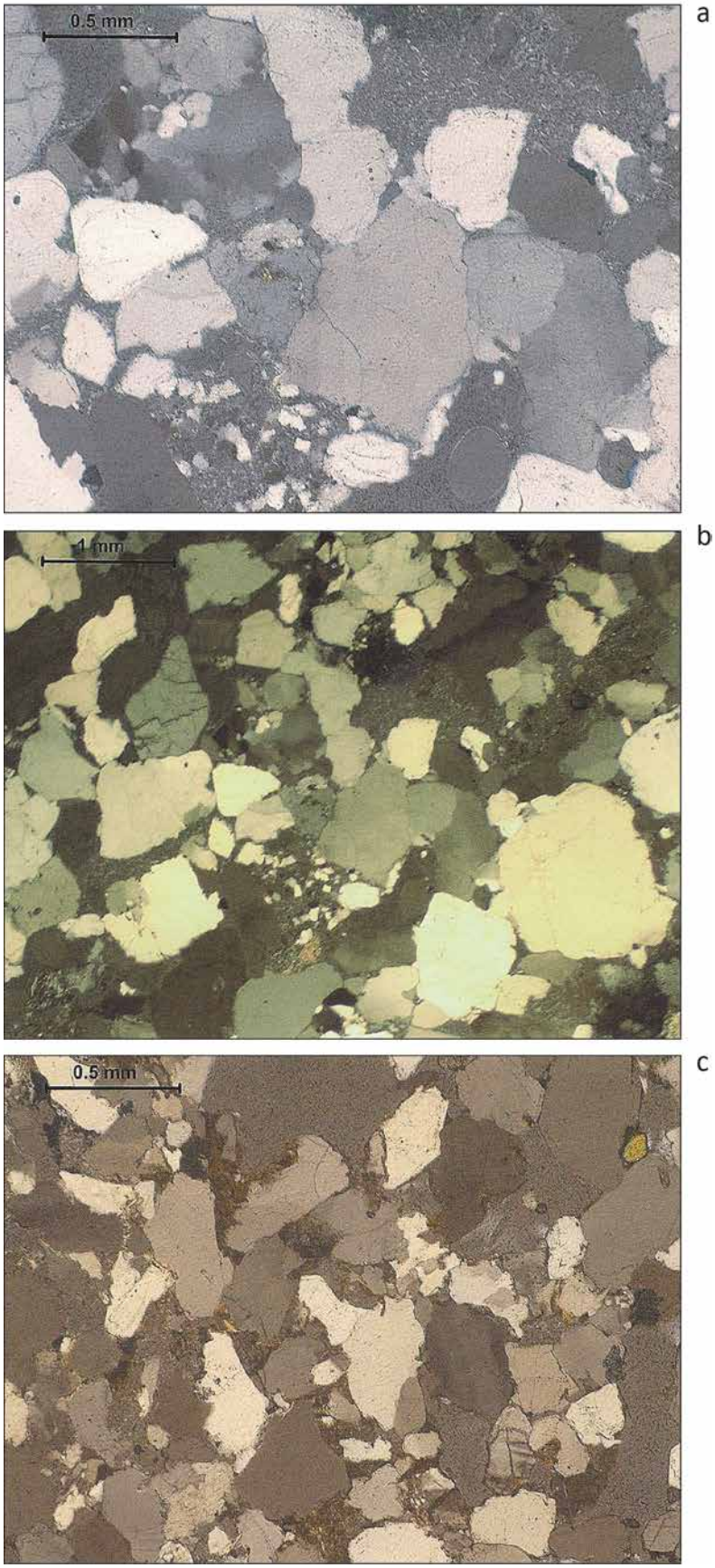

Figure 45 a-c: Photomicrographs 'Millstone Grit', Westphalian A, Upper Carboniferous: a) Heddon-on-the-Wall; b) St. Paul's, Jarrow; c) Strongroom, Arbeia.

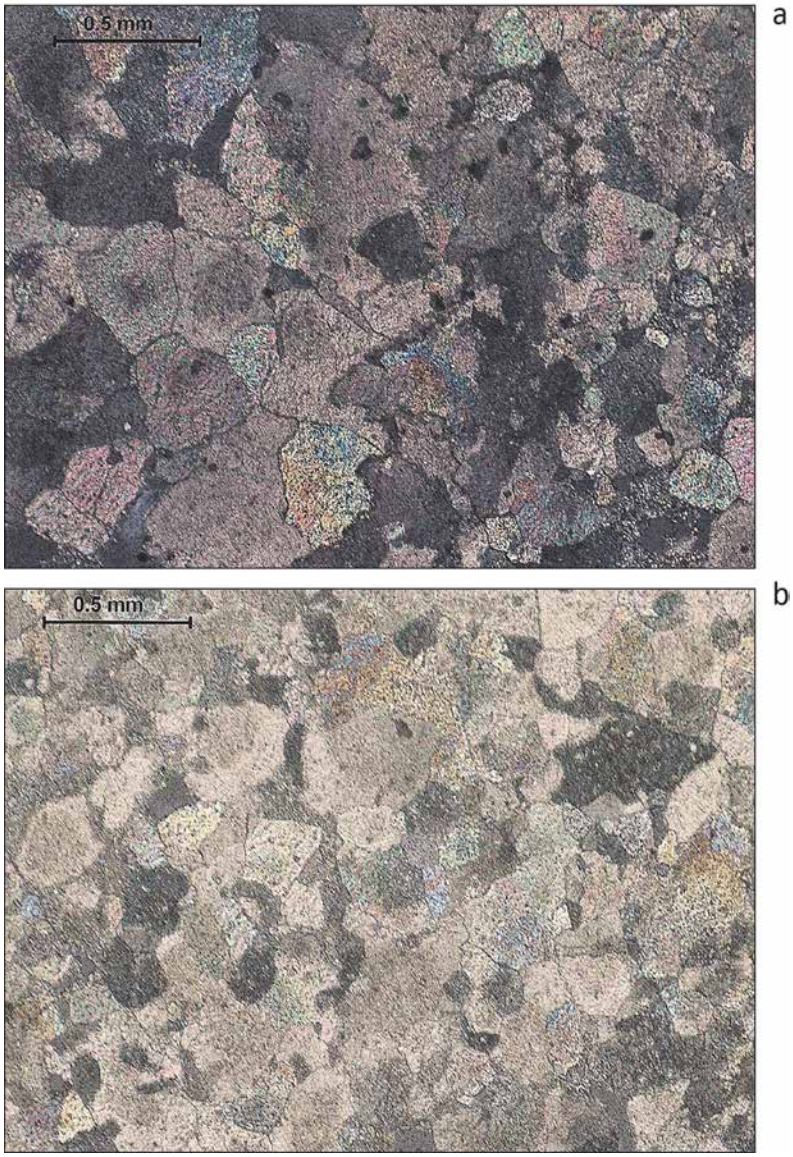

Figure 46 a-b: Photomicrographs coarse Magnesian Limestone both from Arbeia, sourced from the Cleadon Hills. Used in small amounts at St. Paul's, Jarrow in the pre-Conquest and later phases. Also used occasionally in the pre-Conquest fabric at St. Peter's, Wearmouth.

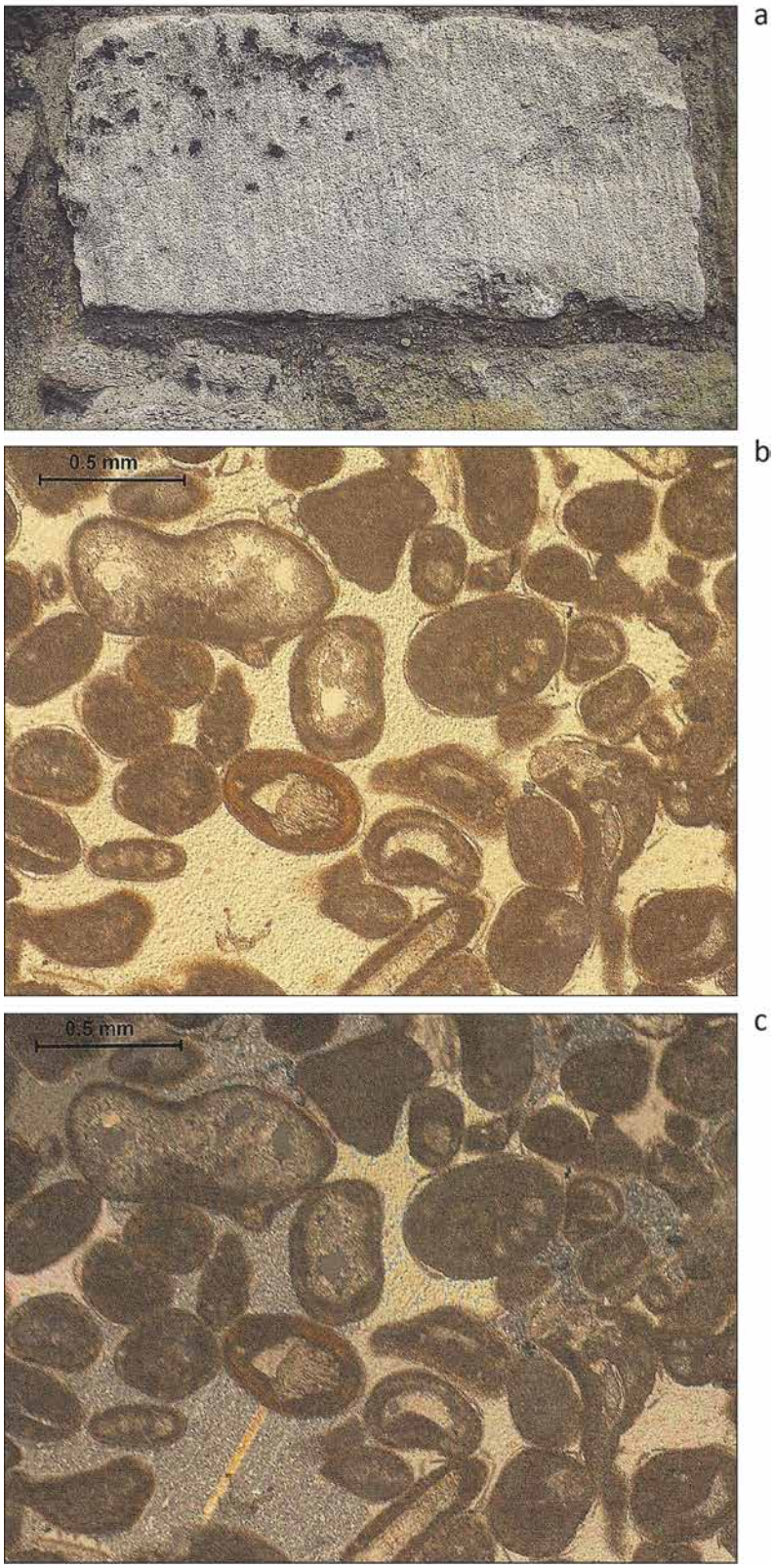

Figure 47 a-c: Roker Dolomite oolitic limestone: a) used as a building stone at St. Peter's, Wearmouth; b) photomicrograph showing the Oolite texture (ordinary light); c) photomicrograph showing the Oolite texture (polarised light).

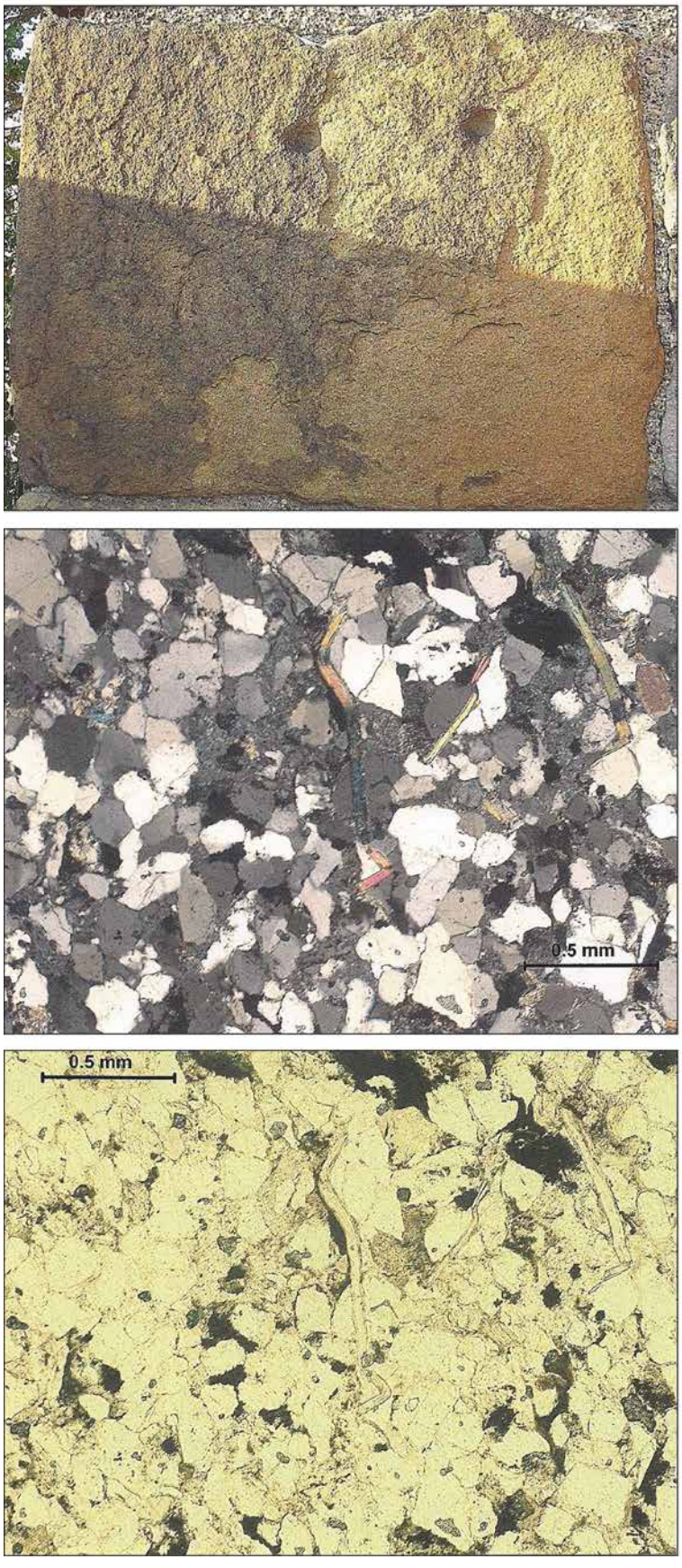
a
b
0.5 mm
c
0.5 mm

Figure 48 a-d: Type E Sandstone (Roman): a) reused as a quoin at the south-east corner of the east wall; b) photomicrograph of sample from Jarrow showing muscovite, mica flakes in typical sandstone matrix (polarised light); c) photomicrograph of sample from Jarrow showing extent of opaque limonite content (ordinary light); d) reused and sculpted stone used as part of the ornate entrance to the porch at St. Peter's, Wearmouth.

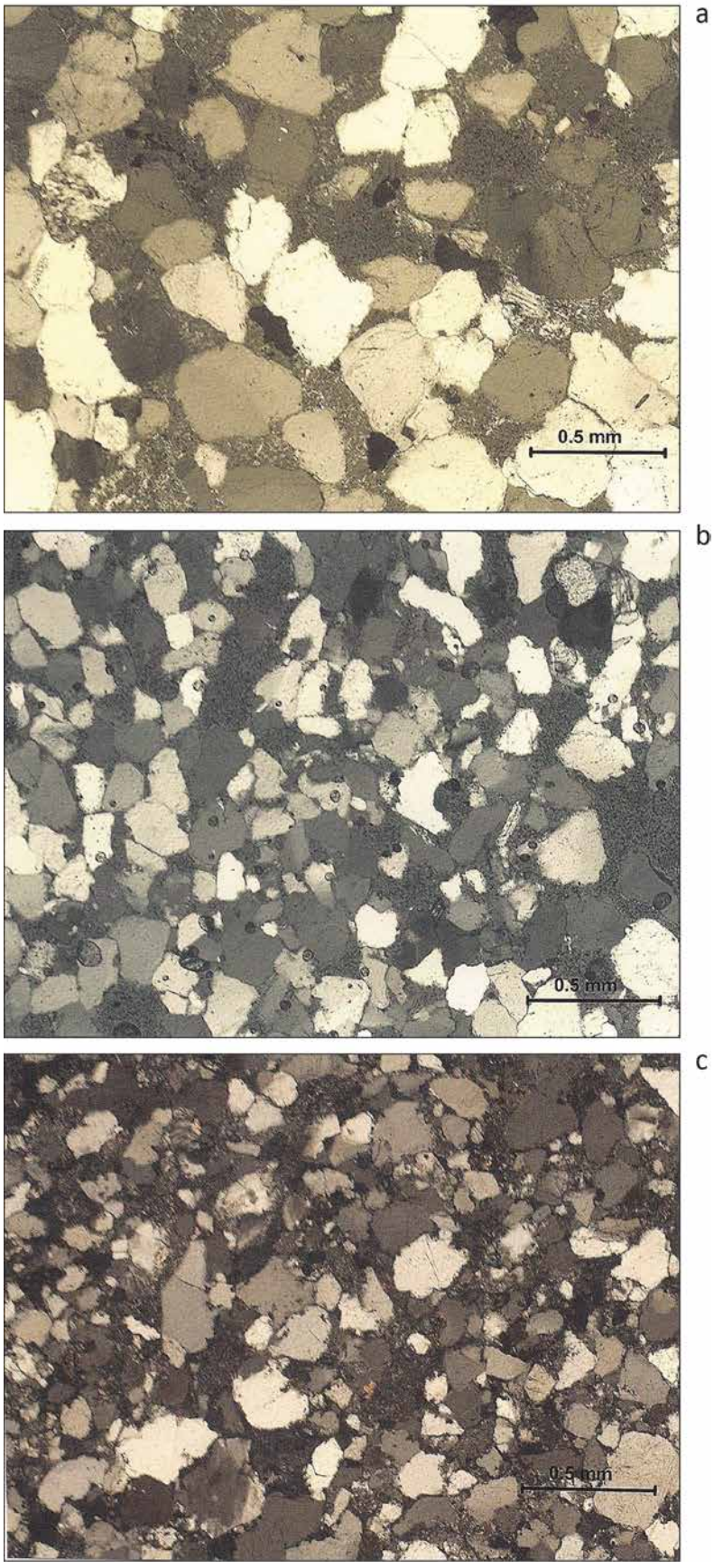

Figure 49 a-c: Sandstones: a) photomicrograph medium grained feldspathic grit from the Bearl area, Northumberland; b) fine-grained, hard sandstone, Grindstone Post, from the Windy Nook area of Gateshead Moor.

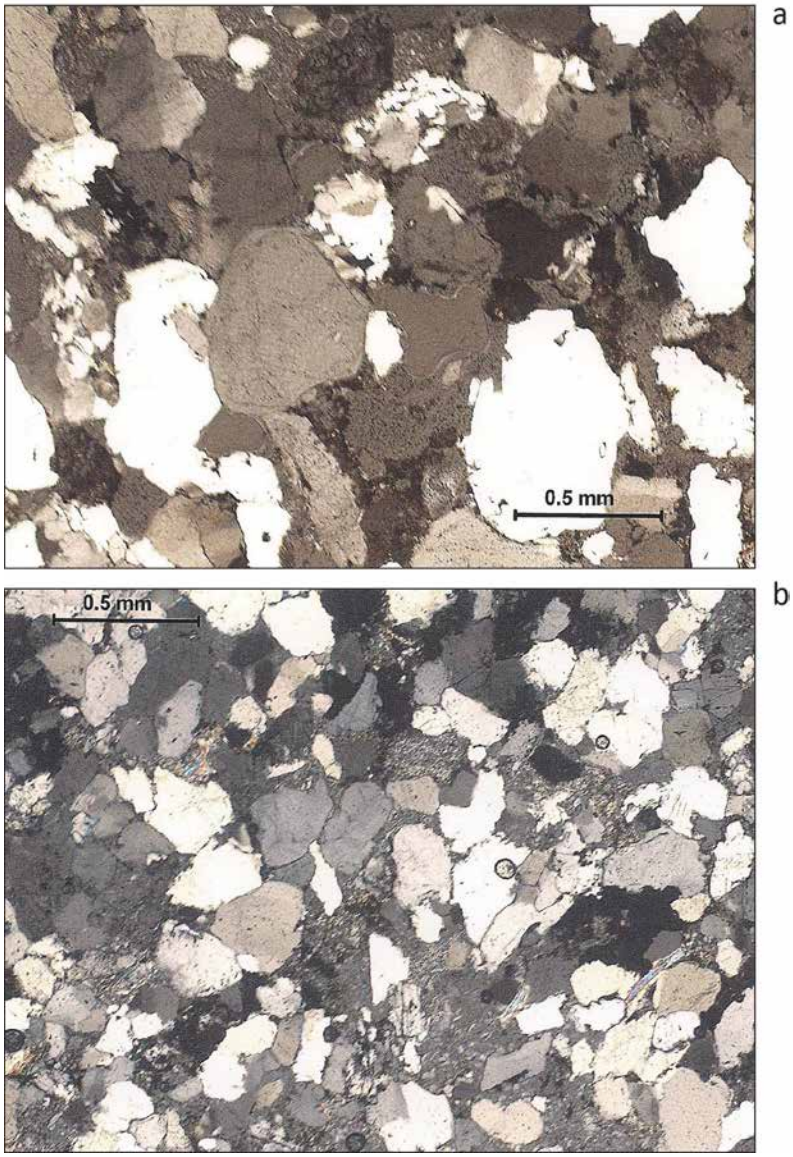

Figure 50 a-b: Sandstones a) photomicrograph burrows in Type F sandstone from St Paul's, Jarrow (polarised light) b) Type H (Heworth) Sandstone (polarised light), St. Paul's, Jarrow.

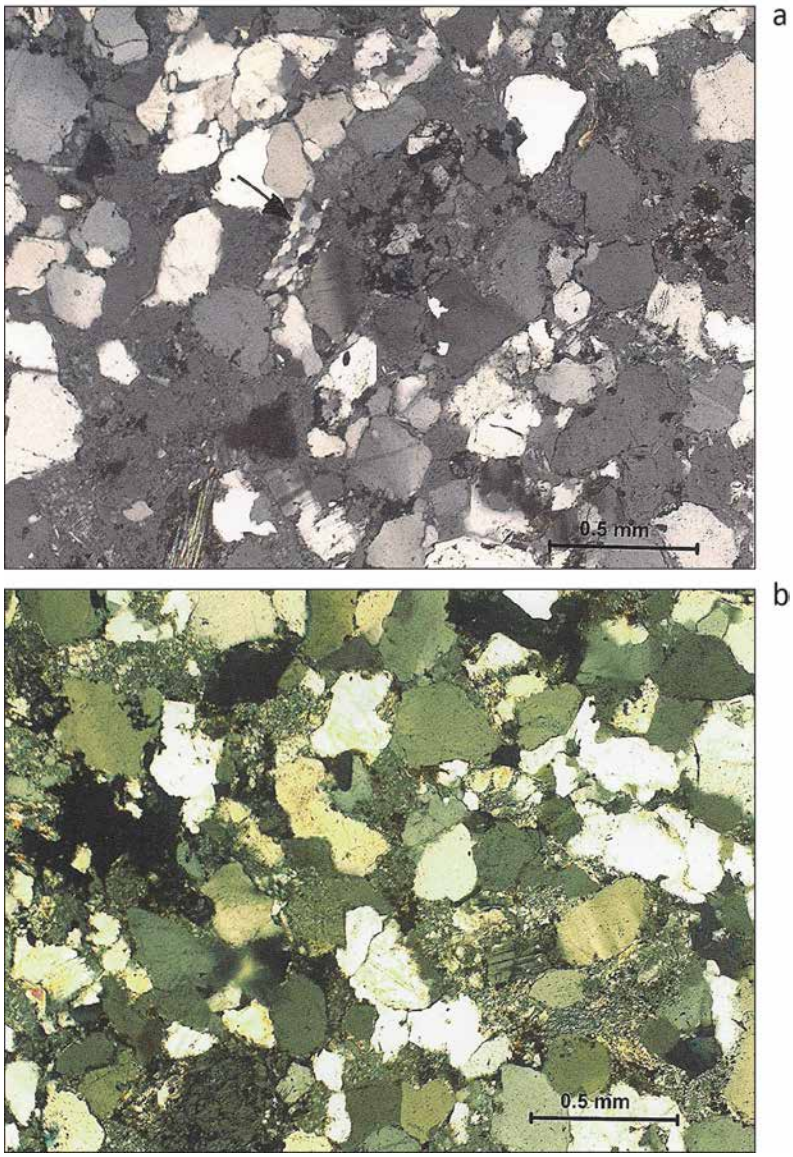

Figure 51 a-b: Photomicrographs Type S Sandstone: a) burrow structure near centre; b) extent of clay mineral content.