# FABRIC *of the* FRONTIER

*Prospection, Use, and Re-Use of Stone from Hadrian's Wall*

Rob Collins, Ian Kille & Kathleen O'Donnell

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# Glossary

The glossary brings together terminology associated with geology, masonry, and quarrying for ease of reference and understanding of the reader, anticipating that most readers are not experts in all these fields.

| | |
|---|---|
| Abrasion | The process of wearing away rock surfaces by the scouring action of sedimentary particles in air, water, or ice. |
| Aeolian | of wind/air. Aeolian sediments are those which have been transported in air by wind and then deposited. Common to deserts but can also be found in foreshore and neighbouring environments. |
| Arch ring | Each course of voussoirs. In the north of England, the Romans used only a single ring of voussoirs. |
| Arris | The distinct line or edge formed by the meeting of two surfaces. |
| Back Filling | The use of spoil (soil, stones, or other waste) to fill in a hole, trench, or quarry pit. At quarry sites, back filling is often done to make a pit level with surrounding ground, and often to reduce risk or danger. |
| Bed | 1. (masonry usage) The upper and lower faces or surfaces of a building stone, top and bottom bed.<br>2. (geological usage) A distinct stone formation deposit in a larger volume of geological material, usually bedrock. Beds may be thick or thin and are divided from one another by other material, such as clay. Apparently solid beds of rock may have fine divisions where softer material was deposited. Bedding is often seen in exposed geological faces, within quarries, or even on the faces of weathered stone. Layers of bedding also mark the orientation of the land-surface on which they are being laid down.<br>3. (combined masonry and geology) The upper and lower beds of a worked block of stone are expected to be parallel to the plan of the natural geological bedding, except in a few special circumstances. |
| Boulder | A type of sedimentary *clast* which is greater than 256 mm in diameter. |
| Calcite | A mineral composed of calcium carbonate ($CaCO_3$), a major component of *limestones*, and a common *cement* for *clastic* sedimentary rocks. A key component of shells, corals, and other skeletons. Its crystals have trigonal symmetry commonly forming elongate pyramid-shaped crystals giving its common name of dog-tooth spar. It has a hardness 3 on the Mohs Scale. |
| Cement | Mineral material precipitated between the grains of clastic sedimentary rocks after the clastic material was laid down, which hold the rock together in much the same way that cement (in common parlance) holds bricks together. Calcite, iron oxides, and quartz are common cements in sandstones. |
| Centre | A light wooden framework which rested on the capitals and upon which the arch was built. |
| Chamfer | The angle of a stone cut away to a flat surface, often at 45°. See also *splay*. |
| Clast | A piece of mineral or rock which has been deposited as a discreet sedimentary particle which can be of any size from micron to many metres. Also referred to as a grain. |
| Clastic | A rock made up of clasts (or grains), for example sandstones, shales, and conglomerates. Most sedimentary rocks are clastic excluding *evaporates* and some *limestones*. |
| Clay (minerals) | A suite of mica-like minerals found in clays. In the presence of water, they are the breakdown products of a range of silicate minerals (such as feldspars, pyroxenes, and amphiboles) found in metamorphic and igneous rocks. They invariably occur in extremely fine grains. The minerals include kaolin, montmorillonite, illite, and chlorite. |
| Cleavage | Planes of weakness found in minerals and some rocks, along which they break more easily. In minerals such as feldspar and calcite, which have strong cleavage planes, they easily fracture along the cleave planes producing flat, shiny surfaces. |
| Cobble | A type of sedimentary *clast* which is between 64–256 mm in diameter. |
| Concretion | Rounded nodules found in (principally) sedimentary rocks from a few mmm to many m in diameter. They are formed by the preferential precipitation of minerals from groundwater after sedimentary material is deposited. They are formed of the same minerals as *cement* – calcite, iron oxide, and quartz – and can be thought of as a sort of differential cementation. |
| Crenellations | A parapet of upstanding parts, or *merlons*, and openings, or *embrasures*. |

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| Cross-lamination | Lamination found between sedimentary *bedding* planes which are at an angle to the *bedding* planes. Also known as cross-stratification. |
| Cross-stratification | See *cross-lamination*. |
| Diagenesis | From the Greek 'across generations'. The process that happens after sediments are laid down where water circulating through the sediment precipitates minerals onto the grains. |
| Distal | A generalised description for a rock in which the material included in it has travelled a long distance from its source. The opposite of *proximal*. |
| Dressing | The process of preparing stone with tools by masons once the stone has been extracted from the quarry. |
| Edge bedded | Laid so that the *beds* are vertical and at right angles to the face, like a book on a bookshelf. |
| Embrasure | The opening in a *crenellated* parapet. |
| Erosion | The process by which rocks are broken down and removed as sedimentary material. |
| Exposure | An area of visible stone that is not covered by any vegetation or soil deposits, which can be naturally occurring or man-made. |
| Extrados | 1. The outer curve of an arch.<br>2. The outer line of an arch. |
| Face | The exposed, often worked or dressed, surface of a stone, either at the quarry or of a smaller worked stone. Faces can have different surface treatments and textures. For example, quarry faces may be high, vertical, low, stepped, or irregular. |
| Face bedded | Where the stone is laid so that the *beds* are vertical and parallel to the face. As the stone weathers the face is liable to fall off in a series of laminations. |
| Fault | A fracture that runs through multiple beds of rock and moves these relative to each other so that *bedding* planes no longer align. |
| Feldspar | A framework silicate mineral made of varying proportions of silica, aluminium, sodium, potassium, and calcium. There are two major groups of feldspars – alkali and plagioclase. Feldspars have a hardness of between 6–6.5 on the Mohs scale. |
| Fluvial | Of rivers. Fluvial sediments are those which have been transported by rivers and then deposited. Other water-based sedimentation occurs in marine and lacustrine environments. |
| Grain | A piece of mineral or rock which has been deposited as a discreet sedimentary particle that can be of any size from micron to many metres. Also known as a *clast*. |
| Grit | A very coarse grain of sand. It does not form part of the Wentworth classification of grain size, so it is not precisely defined. |
| Gravel | A type of sedimentary *clast* that is between 2–64 mm in diameter. |
| Hardness | A measure of how resistant a mineral or rock is to abrasion. Mohs scale of hardness uses scratching as a qualitative test of this resistance. |
| Iconography | Images or symbols carved into or added to an object or location. |
| Immature | Used to describe sedimentary material which has spent a short time in the sedimentary lifecycle, so that there has been little time for physical and chemical breakdown and *sorting*. |
| Intrados | The inner curve of an arch; it is the line of the arch, not the under surface *(soffit)*. |
| Joints | Natural breaks or fractures in rock confined and running perpendicular to beds. They are caused by contraction of the rock (particularly *igneous* rock) or by flexing of the rock through *tectonic* activity. Not to be confused with *faults*. |
| Keystone | The central stone in a semicircular arch, often more prominent than the others. In structural terms it has no more value than any other voussoir. |
| Lamination | A sequence of fine layering found between *bedding* surfaces in *sedimentary* rocks. See also *cross-lamination*. |
| Laminar | A description of flow in steady parallel streamlines, as if in layers. |
| Lewis | A lifting device used by masons and quarrymen to move large stones into place with a crane or winch. It is inserted into a specially prepared hole in the stone face. |
| Limestone | A sedimentary rock composed mostly of carbonate, usually calcium carbonate (lime). |
| Lithic fragments | *Clasts* found in sedimentary and sometimes in volcanic igneous rocks that are fragments of pre-existing rock with more than one mineral grain. |
| Margin | A strip of stone usually about 25 mm wide around the face of a stone, used where the face is other than a flat finish. In the best work it is dead straight and at right angles to the *bed*. |
| Mature | Used to describe sedimentary material that has spent a long time in the sedimentary lifecycle, such that there has been plenty of time for physical and chemical breakdown and *sorting*. Mature sediments will have a *distal* source. |
| Merlon | The upstanding part of a *crenellation*. |
| Mica | A family of sheet silicate minerals that have a strong basal cleavage, which means they appear in sedimentary rocks as fine, shiny flakes. Most common micas are muscovite (silvery gold in colour) and biotite (dark brown or black in colour). Micas have a hardness of between 2–3 on the Mohs scale. |
| Moulding | The profile formed by working stone to a set contour. |
| Mud flakes | Partially consolidated mud ripped up in *fluvial* environments and redeposited within another sedimentary layer. |

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| Outcrop | A rock formation or bedrock that appears above the surface of surrounding land, exposed through natural processes like erosion, weathering, or landslip. |
| Overburden | Waste stone, soil or other material covering a deposit of stone that must be removed to gain access to the desired stone. |
| Period | (Geological) One of a series of geological units of time. Period denotes 10–100 million years of time. Within the chronological scale used in geology (from largest to smallest), period is in the middle: Eon; Era; Period; Epoch; and Age. |
| Pores | Those parts of a sedimentary rock which are neither grain nor cement, but either air or fluid filled. |
| Provenance | (Geology) The source of sedimentary material including the journey it has made between its source and the location in which it is deposited. |
| Proximal | A generalised description for a rock where the material included in it has travelled a short distance from its source. Opposite of *distal*. |
| Pyroxene | A single chain silicate mineral made of varying proportions of silica, calcium, sodium, iron, or magnesium. They are a common component of basic to intermediate igneous rocks and have a hardness between 5–7 on the Mohs scale. |
| Quartz | A mineral made of silicon dioxide ($SiO_2$), which occurs in granites and almost all *clastic sedimentary* rocks. It is also a common vein mineral as it is readily dissolved in hydrothermal fluids. Quartz has a hardness of 7 on the Mohs scale. |
| Quoin | The corner of a building. Also a stone forming the corner. |
| Return | Any wall or *moulding* which changes direction, usually at 90°, either horizontally or vertically. |
| Rock-faced | Limestone or sandstone with a projecting natural face. Rock-faced ashlar will have a carefully worked *marginal* draft. |
| Sandstone | A *clastic* rock composed of grains of sand between 62.5 micrometres and 2 mm in diameter. |
| Silt | A *clastic* rock composed of grains between 3.9–62.5 micrometres in diameter. |
| Sorting | A description of how diverse the range of sizes and shapes are in a *clastic* sedimentary rock. A small variation is classed as well sorted, and a wide variation is poorly sorted. |
| Square | Two wooden arms set at right angles, used for checking external angles on a stone. |
| Spoil Heap | A pile of waste stone, rubble or soil that is created as the by-product of excavation and/or quarrying. |
| Straight edge | A length of thin wood planed to give a perfectly straight edge, used for checking the accuracy of working on good quality work. |
| Stratigraphy | (Geology and Archaeology) The study of the relationship between layers of rock and/or soil, with particular emphasis on what this reveals about the relative chronology of the layers. |
| Soffit | The under-surface of an arch. |
| Splay | A vertical run of masonry set at an angle, as in the jambs of a window. Often used for any angled surface. |
| Springer | The lowest voussoir in an arch. |
| Springing line | The horizontal line from which the arch springs; this is normally the top *bed* of the capital. |
| String course | A horizontal *moulded* course running across the face of a wall. |
| Till | Material deposited directly by glaciers, which is poorly *sorted*. Often referred to as boulder clay. |
| Transport | The mechanism by which sedimentary material is moved from its source to its depositional destination. Transport will be by water, air, or ice. |
| Twinning | Where crystals of a single mineral grow back-to-back but in different orientations. This is common in feldspars. In plagioclase feldspars twinning commonly happens multiple times, creating a distinctive striped appearance just visible with a magnifying glass. |
| Weathering | Processes acting on a rock at or near to the surface where the rock is *in situ*. |
| Wedge | A wedge-shaped tool used to split stone. The wedge is placed at points of weakness in a stone, often between beds. Iron wedges are hammered into position to split stone, while wooden wedges were often placed in pre-made holes and soaked with water so that the resultant expansion would fracture the rock. |
| Wall line | The point on the stone marking the transition from face to *bed*. The better the quality of work, the more clearly this line is marked. |
| Zircon | A mineral composed of zirconium silicate ($ZrSiO_4$). It forms as a secondary mineral in some igneous and metamorphic rocks. Its physical and chemical durability means it is also found in *clastic* sedimentary rocks. It is also used as a gemstone. Zircon has a hardness of 7.5 on the Mohs scale. |

# Abbreviations

CSIR *Corpus Signorum Imperii Romani: Great Britain, Vol. 1.x*, with the x indicating the specific fascicule of the series

RIB *Roman Inscriptions of Britain*, typically followed by a number referring to a specific stone. This is accessible online at https://romaninscriptionsofbritain.org.

TV *Tabulae Vindolandenses*, typically followed by a number referring to a specific tablet. This is accessible online at https://romaninscriptionsofbritain.org/tabvindol

# Preface

This monograph is the result of research and activity undertaken as part of the Hadrian's Wall Community Archaeology Project (WallCAP), funded by the UK National Lottery Heritage Fund. The funding from Lottery supported the salaries of project staff, paid for the expenses accrued by staff and project volunteers, and supported costs for training of volunteers and undertaking of fieldwork and subsequent analysis. The bespoke illustrations in this volume, too, were made possible with Lottery's support.

WallCAP was a complex project with many aims and worked with various audiences and stakeholders. Broadly speaking, the project sought to: increase our knowledge and understanding of Hadrian's Wall; better understand and reduce the risks facing various parts of Hadrian's Wall; and ensure that local communities and the public were more engaged with the monument. WallCAP organised and hosted more than 310 activities during the course of the project (2019–2022) to meet these aims, with two strands in particular contributing to this volume.

The work of the Stone Sourcing & Dispersal (SSD) strand was focused on the geology of the Wall, its host region, and attempted to identify and/or confirm links between the Wall and post-Roman structures. This strand (detailed in various chapters of this volume) established a framework to complete the research and the methodologies that would be required.

The Heritage At Risk (HAR) strand was not primarily focused on the geological aspects reported on in this volume, but the fieldwork undertaken during the strand provided access to new and primary data that supported the geological research. For example, samples of both natural geological material and Roman building fabric were obtained, and measurements of Roman building materials could be taken where the fabric was normally inaccessible.

All information and data necessary to understanding the geological fabric of Hadrian's Wall from the project can be found in this volume, but further information about WallCAP and digital data from the project is also available in other sources.

A synthetic report of WallCAP can be found in *Community Archaeology on Hadrian's Wall 2019–2022* (Collins *et al*. 2023), which provides an overview of the project, its structure and aims, and a summary of results of both the HAR and SSD strands of work, as well as statistics on volunteer participation and community engagement.

Full fieldwork reports are published in Collins and Harrison (2023), *Excavations along Hadrian's Wall 2019–2021: Structures, Their Uses and Afterlives* (Oxbow).

Further archived data and reports can be found at data.Ncl, the official archive of Newcastle University, and also with the Archaeology Data Service (ADS).

- data.Ncl: https://doi.org/10.25405/data.ncl.c.4893762.v1
- ADS: https://doi.org/10.5284/1100068

# Acknowledgements

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Just as important as the Lottery, the many dozens of volunteers that participated in the training, data-gathering, data-entry, and interpretation that all make up a citizen-science project are to be thanked and congratulated. Thank you to everyone that worked as part of the Stone Sourcing and Dispersal strand of the project, and which this monograph presents the results of.

In addition, we also wish to thank English Heritage, Historic England, the National Trust, and the Northumberland National Park Authority, and the many individual landowners that provided access to the sites, archives, and geological outcroppings on their lands and allowed us to gather the data for the research presented here. The Vindolanda Trust provided access to the Charles Anderson archive.

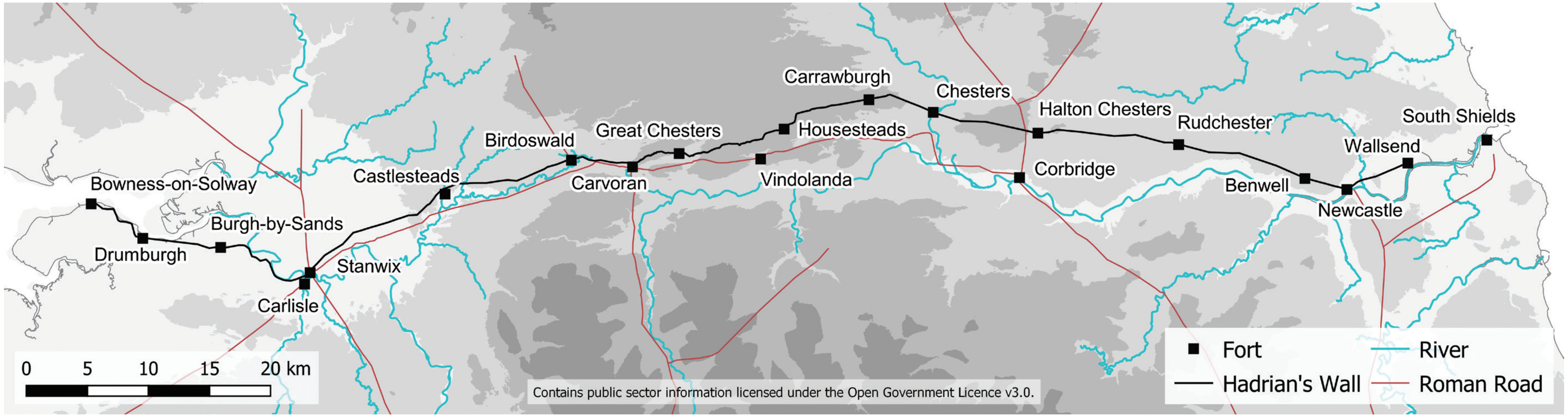
We would also like to thank the late Peter Hill, who was able to contribute to the project in its early stages prior to his passing. His volunteer guide to Roman masonry was a key document in the training of project volunteers, and through conversation, he was able to pass on his decades of practical experience in masonry that enriched everyone he spoke to.

Rob Collins would like to thank Ian and Katy and the rest of the WallCAP team for their hard work and dedication to see this project to its fruition – we have broken new ground with this volume, and the open-mindedness and creative thinking that accompanied the work was greatly appreciated. Sam Turner provided guidance and goodwill throughout the project (even if we didn't examine as many churches as he would have liked), and Fiona Watson was an essential member of the team, liaising and assisting with Lottery when adjustments needed to be made. Lastly, I would like to thank my family, Sarah, Mara, and Hudson, who were occasionally drafted in or held as bored captives when I needed to quickly visit a site, verify some measurements (providing an extra pair of hands), or wait while I had an unexpected meeting.

Ian Kille would like to add his thanks to the WallCAP team, Rob for his support, insights, knowledge and drive to make this happen, to Katy for so generously sharing her knowledge of Roman quarrying, to Kerry for being brilliant with the volunteers and making things happen, and to Kathryn and Jane for their skill and enthusiasm to share knowledge. The volunteers have been a particular pleasure to work with and have my thanks for their enthusiasm, dedication, and interest. Cumbrian Stone graciously provided samples of St Bees (Birkham's Quarry) and Lazonby sandstones for analysis. I would also like to thank Stuart Jones of Durham University Earth Sciences department and Sanem Acikilin and Cees van der Land of Newcastle University Earth Sciences Department for their professional advice in helping to understand the geology and petrology of the Wall stones, as well as Eline Van Asperen and Diana Blumberg of Newcastle University and Mike Dobby, formerly of Brucker, for their help in trying to wrestle something useful out the pXRF and other technical help. Finally, I would like to thank my partner Rachael for her patience and support throughout this project, reading and commenting on many texts and presentations, and keeping me calm when I had been looking at one sandstone too many.

Kathleen O'Donnell would like to thank Rob for being so accommodating in helping her get involved with this project as an early career researcher, and for his feedback and mentorship. She would also like to thank Ian for his support and expertise which helped provide new perspectives on the quarries. She would like to thank Kerry for organising the quarry walks with the volunteers, and the volunteers themselves for their enthusiasm and commitment, even on the rainiest of days. Many thanks also to Matilde and Kathryn for their illustrations that bring the research to life. Finally, I would like to thank my family for their support throughout the process, especially my husband Paul for being patient about many late nights writing after work, and to my father-in-law, Gunther, for every time he fixed my car after many bumps on the long drives down from Edinburgh.

Finally, maps have been made (by Kathryn Murphy) containing public sector information licensed under the Open Government Licence v3.0 (available at: https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/) and OpenStreetMap basemap for images containing lidar (https://www.openstreetmap.org/copyright).




*Map 1: Hadrian's Wall, locating the forts and towns along its length, Roman roads, and sites in its hinterland relative to topography.*

# 1

# Introduction

The history of Hadrian's Wall traditionally begins in AD 122, when the emperor Hadrian visited the province of *Britannia*, and it is assumed to have ended in AD 410, when Britain was permanently lost to the Roman Empire. This is a reasonable *precis* of the *Roman* history of the Wall, but the monument has a much longer and more complex life. The origins of the monument extend hundreds of millions of years into the past with the formation of the rock quarried and worked to build the Wall. And to date, the Wall has not 'ended'. Following its use as a Roman military work, sites along the Wall continued to provide homes and shelters to different communities through the ages, with houses and farms built directly on top of the Wall and occupied to this very day. Alternatively, the Wall was also a source of convenient stone, from which new structures were built. There are many locations where the Wall is no longer visible or has been entirely dismantled, but there are also substantial lengths where its survival attracts visitors, tourists, and researchers (Fig. 1.1). In short, the Wall has a rich and complex life beyond the 300 years it served as a Roman frontier monument (Hingley 2012).

There is a vast body of scholarship on Hadrian's Wall, with focused research and interpretation of its remains and ruins beginning in the 16th century, consisting largely of descriptions of sites, inscriptions, and objects. A narrative history of the monument emerged in the 18th century, and the advent of archaeology and the use of excavations to recover information in the 19th century resulted in a fundamental shift in the approach to the Wall and its understanding through the 20th century (Breeze 2014). Archaeological analysis has underpinned interpretation of the monument and its constituent elements, its chronology, the operation and practices of the Roman army, and aspects of the daily lives of the people that lived along its length. Dozens of papers can be found in journals such as *Archaeologia Aeliana*, the *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, and *Britannia*, supplemented by detailed excavation reports of specific sites. The first comprehensive synthesis and interpretation of the Wall appeared nearly 50 years ago (Breeze and Dobson 1976), and new discoveries have since refined understanding and sparked further debate as captured in the handbooks that have accompanied the decennial Pilgrimages along Hadrian's Wall (Bidwell 1999; Hodgson 2009; Collins and Symonds 2019).

Excellent recent syntheses (Hodgson 2017; Symonds 2020) are available that provide a good starting point for understanding the Roman history and archaeology of the Wall. More focused research has considered the conception of the Wall (Breeze 2009), its construction (Hill 2004; 2006), and its use in the final years of the Roman Empire in Britain (Collins 2012). Other studies have examined the way that the Wall has been physically incorporated into post-Roman structures (Whitworth 2000) and its reception and presentation in more recent centuries (Hingley 2012). More recently, the Wall has contributed to research in the fields of heritage and management, as the complexities and priorities of managing a large World Heritage Site and its relationships with local communities and stakeholders have become more widely appreciated (Stone and Brough 2014; Alberti and Mountain 2022). All of these studies draw on a substantial amount of data accumulated through excavation and detailed research, as seen in the bibliographies of all the works referenced above and in the 14 editions of the *Handbook to the Roman Wall* (most recently Breeze 2006).

With such a substantial corpus of scholarship, it is reasonable to ask why another volume is necessary. Put bluntly, despite the impressive quantity of data available for Hadrian's Wall, there is much that is still not known or understood about the Wall (Symonds and Mason 2009). This volume takes a biographical approach to the Wall, with particular focus on the stone fabric of the monument. It takes a much wider arc of time as its reference,

*Figure 1.1: The stone curtain of Hadrian's Wall at Walltown Crags, looking west as the line of the Wall follows the forward line of the crags. This stretch of Wall survives in very good condition, often exceeding 2 m in height.*

exploring the stone fabrics of the Wall not only as man-made artefacts but as naturally formed geological material. This takes us into deep time, the geological history of the Wall extending over many hundreds of millennia. The rocks and strata that underpin the landscape of Hadrian's Wall are the very materials used in its construction. Understanding the natural history of these rocks and the processes by which they were formed provides a potential method to characterise Wall-stones, relate them to their sources and explain the limits of our ability to do so. Exploring geological history also gives an insight into the nature of the landscape within which the Romans had to make decisions about where to place the Wall and how to construct it. Altogether, this provides a way to explore the intimate relationship between the geology and archaeology of the Wall. This rationale also extends into the post-Roman centuries, providing an opportunity to understand in greater detail how the peoples living in the former Roman frontier made use of the Wall in the centuries after the demise of the Roman Empire, living amongst its ruined buildings, or borrowing the dressed stone for new structures.

*Figure 1.2: WallCAP volunteers recording stone fabric at Thirlwall Castle, taking note of morphological and metric aspects of the stone for its use as a building material, and geological attributes of the stone that help to identify its origins and sourcing.*

The work to achieve this was carried out as part of the Hadrian's Wall Community Archaeology Project (WallCAP) which ran between March 2018 and September 2022 and was funded by the National Lottery Heritage Fund. The project was large and multifaceted, undertaking work with various stakeholders and audiences to better understand, interpret, and protect Hadrian's Wall. As such, much of the work of WallCAP was undertaken with volunteers and local communities. The aims and engagements undertaken by WallCAP are detailed elsewhere (Collins *et al*. 2023), but the data contributing to this volume are derived from the Heritage at Risk (HAR) and Stone Sourcing and Dispersal (SSD) strands of the project. Across these two strands, fieldwork was undertaken by the project team and in collaboration with volunteers and local communities to collect data pertaining to geology, Roman archaeology, and post-Roman archaeology (Fig. 1.2). The large dataset produced in consequence of this mass-science project is used in conjunction with modern analytical methods and presented here. In that regard, this volume complements the existing scholarship associated with the Wall and provides further data to enhance our understanding not only of the monument, but also of the broader natural and cultural environments that it sits within.

It is hoped that the 'stone biographies' offered in this volume provide an enhanced understanding of the monument as a whole, but also underscore the rich details and histories of specific locations along the Wall. Subsequent chapters will cover the geology of the Wall corridor and its formation, the use of stone in building the Wall, the sourcing and quarries for this stone, and post-Roman use of Wall stone. However, good understanding of these issues requires a suitable foundation in the so-called Wall basics.

## Wall basics

There are a number of aspects of Hadrian's Wall that need to be understood to better appreciate the data and interpretations offered in this volume. Firstly, this includes an overview of the different landscapes the Wall ran through. Secondly, it is necessary to reiterate the basic terminology and anatomy of the Wall as a monument. Thirdly, the chronology and sequence of how the Wall was built in the 2nd century AD very directly relates to the 'stone biographies' offered here.

### *Landscapes of the Wall corridor*

The Wall runs from Wallsend in the east, positioned on the north bank of the River Tyne, to Bowness-on-Solway in the west, positioned on the southern shore of the Solway Firth (Fig. 1.3). Between its eastern and western terminals, the specific local conditions and elevations vary considerably. For convenience, the Wall is often broken up into three discrete sectors, east, central, and west. The east and

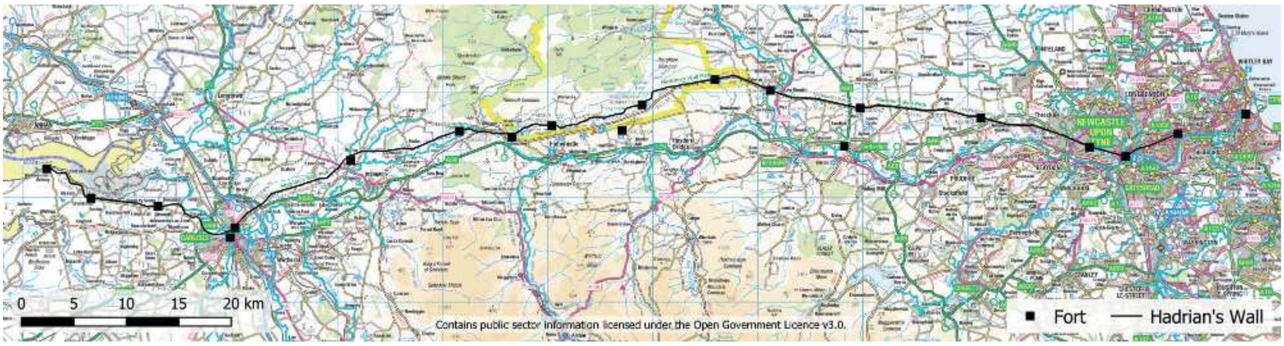



*Figure 1.3: A map of Hadrian's Wall and its immediate vicinity, showing the line of the monument and the key Roman forts and sites along its length, relative to contemporary settlement.*

*Figure 1.4: Looking east along the Solway coast at Bowness, at the approximate location of the Wall's western terminus. Note the flat, low-lying, and marshy ground.*

*Figure 1.5: (Top) The Wall as it runs atop the crags in Wallmile 37, west of Housesteads fort, as viewed from the air to the north. (Bottom) The same stretch of Wall, looking west, from the ground. Note the changing elevation of the crags, which are not a uniform height.*

west sectors tend to be lowland, while the central sector, lying between the North Tyne and Irthing rivers, consists of uplands. Though broadly accurate, within each sector there is a regular changing of elevation along the Wall, and its position relative to slopes, crags, mossy moors, and boggy marshes lends a distinct local character to each and every location along the Wall. For example, the western miles of the Wall sit atop relatively flat land averaging only 15–20 m above sea level; centuries of improvement have introduced good drainage and flood management to the area, but in the Roman era there would have been regular flooding and much of the land immediately north of the Wall could be fairly characterised as salt marsh (Fig. 1.4). In contrast, there are approximately 20 km in the central sector where the Wall is built on the north face of a steep, rocky crag or cliff, with the natural topography 200–325 m above sea level (Fig. 1.5). Here the elevation and the crags expose the Wall to more wind and rain, and the lands around the Wall can be characterised as upland moor. Flanking the central sector, however, are picturesque wooded river valleys as at Cam Beck/Castlesteads and Chesters (Fig. 1.6). Recent history, too, has also dramatically changed the environment of the Wall, particularly at its east end where the urban conurbation of Newcastle (Tyneside) has expanded through the 19th and 20th centuries. The Wall in Tyneside is typically invisible, though some consolidated curtain can be seen at Wallsend and Denton; for those 'in the know', different pavements mark the course of the Wall, but the urban environment has almost completely destroyed or submerged the visible aspects of the Roman landscape (Fig. 1.7).

These different environments have had important impacts on the Wall, including not only the survival of

*Figure 1.6: The gently rolling hills that flank the upland central sector of the Wall are visible at Black Carts, looking east from the north side of the curtain.*

*Figure 1.7: The Wall can be seen as a short, consolidated stretch at Denton (right side of the image), with the A69 and West Road generally following the line of the Wall up the hill to Benwell and further east into Newcastle. Note all the urban development visible in the image.*

the archaeology, but also access to surviving fabric. Given that the research presented here attempts to connect the monument to source geology, as well as post-Roman structures that have borrowed from it, direct access to the Wall has been essential.

### *Anatomy and terminology*

Hadrian's Wall is more than a very high and very long wall; it should be understood as a monumental complex consisting of several discrete elements and/or features. These interrelated features can be framed as anatomical, with each constituent element clearly defined in its own terms but also fundamental to the make-up of the Wall as a whole. These are separated into linear features and

*Figure 1.8: The ditch and berm north of the Wall at Carvoran, looking east. Here the ditch has a V-shaped profile, with the base of the ditch indicated by the taller grasses and reeds. The land immediately to the right of the ditch formed the berm. The stone curtain is not visible to any surviving height at this location.*

site-based structures (Breeze 2006, 53–90 provides more extensive discussion of each element).

The central or most fundamental feature of the Wall monument is the element built as a wall, known as the curtain (as seen in Figs 1.1, 1.6). All other features relate to the curtain, either directly attached to it, or positioned and aligned to it. The curtain is a linear feature, built primarily of stone, but there was a phase in which a portion of the Wall curtain was built in turf. This will be detailed below relative to the building sequence, but it introduces a distinction between the Stone Wall (SW) and Turf Wall (TW). Use of Stone Wall or Turf Wall is limited to the early phases of construction and occupation of the Wall, and applied either more generally or in conjunction with a specific site. The curtain always refers to the stone-built Wall, regardless of a specific date. In this way, it can be distinguished from the walls of other structures, like milecastles or turrets.

In addition to the curtain, there are three other linear features of the monument: the ditch, the berm, and the Vallum. The ditch and the berm are located to the north of the curtain. The berm is the strip of land 4–6-m wide that separates the curtain from the ditch. At locations in the eastern sector of Hadrian's Wall, between Wallsend and Heddon-on-the-Wall, evidence has been found along the berm for pits and postholes. This has been interpreted as evidence for a series of obstacles, such as upward-pointed sharpened stakes, located on the berm to increase the defensiveness of the curtain (Bidwell 2005). The ditch was typically dug by the Romans in a V-shape in clay and soil conditions, though when excavated from bedrock it takes on a U-shape (Fig. 1.8). Where the Wall runs along the forward edge of crags or cliff-faces, there is no ditch or well-defined berm. South of the curtain is the Vallum,

*Figure 1.9: The Vallum at Down Hill, looking east. The V-shaped ditch of the Vallum has a mound to its north and south. The Vallum survives in variable condition, with it being completely destroyed at some locations.*

*Figure 1.10: Turret 48b, east of Willowford Farm, looking into the low surviving courses of the structure from the southeast.*

a monumental feature in its own right consisting of a central ditch flanked by large earthen mounds (Fig. 1.9).

One further linear feature should be noted, the Military Way. This was a paved road that ran immediately south of the curtain. In the upland central sector, the Military Way is a visible feature of raised, flattened ground; in more lowland locations the Military Way has been known to run along the top of the north mound of the Vallum. Its exact course is not fully known, and based on very limited evidence, it appears to have been built or at least paved in the later 2nd century. In other words, it does not appear to be part of the initial construction of the Wall, but was an important element for most of the Roman period.

Along the line of the curtain was a series of distinct structures: turrets, milecastles, and forts. Turrets are towers, built to a square or sub-square plan, and found every one-third of a Roman mile along the curtain (Fig. 1.10). Their function seems to have been simple – to act as elevated observation platforms for the immediate vicinity of the Wall (ideally for a *c*. 500–1000-m radius, depending on terrain), and possibly to also provide platforms for signalling (Woolliscroft 1989; Foglia 2014). Milecastles, as the name suggests, were small rectangular fortlets positioned every Roman mile along the curtain, consisting of an outer wall integrally joined to the curtain with a gate through the curtain surmounted by a tower; along with a south gate through its perimeter, a milecastle had the potential to provide access through the Wall every Roman mile, though the true extent of such accessibility is debated (Fig. 1.11). Forts are the largest of the structures found in the Wall corridor (Fig. 1.12). These were the primary bases for the units of the Roman army that garrisoned the Wall, and each fort consisted of a number of buildings to house and support the unit(s) in residence. All forts also had four primary gates and two secondary gates; the primary north gate provided access through the curtain. The use and accessibility of milecastle and fort gates changed over time.

There are other features that are also part of the Wall complex, though they are less numerous and/or not as well understood. There are, for example, at least three independent gates that provided access through the Wall curtain distinct from those at forts and milecastles. These have been found and excavated at Portgate, located where the Roman road known as Dere Street intersects with the Wall north of Corbridge, and at the Knag Burn, immediately east of Housesteads fort. A third gate is expected to be positioned on the Roman road running north of Carlisle and to the west of Stanwix, but to date it has not been found. There were also considerable bridgeworks that carried the Wall across major and minor rivers; these have been confirmed by excavation at Chesters across the North Tyne, at Willowford across the Irthing and at Castlesteads across the Cam Beck.

Specific local placenames can be used to specify and locate sites along the Wall, such as Denton or Halton Chesters, but a simple scheme that makes use of the built features of the Wall also provides a framework for convenient location and discussion. Given that the Wall is 80 Roman miles in length, and a milecastle can be found each mile, the Wall is often discussed in detail in reference to Wall-miles, and this designation is also extended to the features within such a mile. For example, Poltross Burn is the local placename applied to a milecastle, which can also be named as milecastle 48. It is followed by turrets 48a and 48b, and the Wall-mile ends with milecastle 49 (Harrow's Scar).

When taken together, the terminology applied to the various elements and features of the Wall helps to communicate its monumentality and provide specificity. For example, the Wall's existence as a monumental complex is made abundantly clear if you consider approaching it from the north. First, one would encounter the ditch, then

*Figure 1.11: Milecastle 39, looking west. Note the breaks in the north and south walls of the structure, which provided gateway access through the line of the curtain.*

the berm (and possibly its obstacles), followed by the curtain, and subsequently the mound-ditch-mound construct known as the Vallum. When crossing the curtain, one would be observed from the top of a turret or the north tower of a milecastle, and may have required traversing through the internal walls of a fort, full of Roman soldiers.

### *The building sequence of the Wall*

The Wall had a complex building sequence that began under the emperor Hadrian, and was not fully completed until later in the 2nd century, though the exact date is unknown. The building sequence is particularly important to understand in reference to this volume, focused as it is on stone biographies, because the identification of quarries for sourcing rock and the preparation and building in stone relates to the primary planning and construction of the Wall as well as subsequent repairs and refurbishments. Therefore, the detail of the geology and stone relates directly to the building sequence, and understanding this process in the planning and building of the Wall frames the data and interpretations offered in subsequent chapters.

However, it is also important to remember that the Roman army had been operating in the regions of Central and Northern Britain for at least 40 years prior to the construction of Hadrian's Wall. Indeed, following the withdrawal from highland Scotland (or Caledonia, as the Romans called it), a linear cordon of forts across the Tyne-Solway isthmus was established by Trajan, supplementing the existing forts at Corbridge, Vindolanda, and Carlisle, and subsequently connected by a paved road. This is known as the Stanegate system, and highlights that the Roman army had already identified the Tyne-Solway isthmus as a strategic east–west corridor in the landscape of Central Britain. In that regard, the landscape where the Wall was built was not 'new' to the Romans, but one in which they were already intimately familiar with the topography, which will have further informed and influenced the process of planning and constructing the Wall. Indeed, in addition to the permanent forts located on the Stanegate, there are numerous camps located in the Tyne-Solway isthmus positioned to access and presumably monitor key locations and routeways both east–west and north–south, for example the series of camps of varying size on Haltwhistle Common (Welfare and Swan 1995).

Highly detailed accounts of the interpretation and supporting evidence for the planning and building sequence of the Wall are available (most recently Poulter 2009; Graafstal 2012; 2018; Symonds and Breeze 2016; Hodgson 2017; Breeze 2018; Symonds 2019a; 2019b; 2020), but these can be summarised in brief. In essence, the building sequence consists of eight steps, though only the final steps are attested archaeologically.

1. The initial conception of the Wall, perhaps by Hadrian himself.
2. Initial scouting and survey of the course of the Wall by army surveyors.
3. Planning the work and supporting logistics for construction.
4. Gathering the labour and necessary materials to begin construction.
5. Initial construction, including foundations and possible completion for some lengths of the curtain and some milecastles and turrets.
6. Alterations to the building plan, including:
   a. The decision to build forts on the line of the Wall;
   b. Construction of the Vallum;
   c. Narrowing the width (thickness) of the stone curtain.
7. Completion of the building work.
8. Replacement of the Turf Wall with stone.

The initial plan or concept for the Wall (step 1) seems to have consisted of a rather uniform monumental barrier consisting of the curtain with very regularly spaced milecastles and turrets, probably also consisting of the ditch in front of the curtain. There were no forts planned, as the Stanegate and its garrisons could act as the main bases for military units. Initial surveys for the course of the Wall and the planning of and assembly of soldiers and tools for construction (steps 2, 3, and 4) were undertaken to execute this initial plan. Though it cannot be proven, it seems likely that during these phases identification of quarries for sourcing building stone (almost exclusively sandstones) was also undertaken, though at present identification of definite Hadrianic quarries is speculative (see Chapter 4).

The initial construction of the Wall (step 5) was undertaken in stone at various locations between Newcastle and the River Irthing. West of the Irthing, construction of turrets was completed in stone but the curtain and milecastles were built in turf and timber (Fig. 1.13). This first-phase construction in stone is identifiable on the ground as any structures built to a 'Broad Wall' gauge or thickness of curtain, 2.7–3.2 m wide in the foundations

*Figure 1.12: An aerial view of the fort at Housesteads, viewed from the south.*

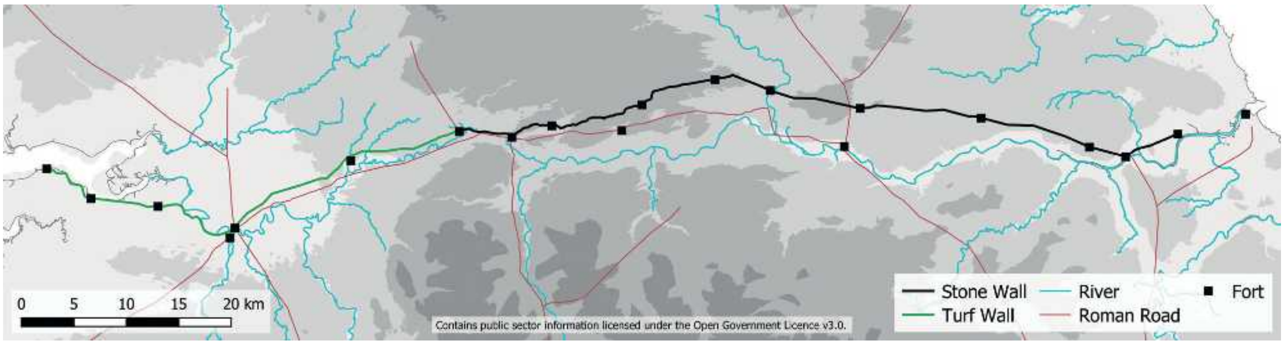



*Figure 1.13: A map showing the extent of the Stone Wall and Turf Wall executed in the initial construction of Hadrian's Wall.*

and 2.7–3 m wide above the foundations. The presence of Broad Wall dimensions with associated wingwalls of turrets and milecastles, along with other morphological features, have also allowed for identification of structures built first, for example, at milecastles 47 and 48. These first-built structures have been argued to be priority constructions (Symonds 2005; 2019b; Graafstal 2012; Hunneysett 2017), highlighting the Roman army's sensitivity to local landscape issues. Priority construction will also have required associated quarrying. It is assumed that construction of the Turf Wall began at the same time, and it has been argued that the Turf Wall could have been completed in one season of building work (Graafstal 2012, 137–138; Hodgson 2017, 66–69).

At some point during the construction of the Wall, the initial plan was altered (step 6). Three important changes were introduced to the Wall and are frequently clustered together under the notion of nominal 'fort decision'. First, it was decided that forts would now be built in the line of the Wall curtain. Second, after the positions of the forts were decided and laid out (though probably not built), the Vallum was constructed. Significantly, the Vallum seems to have been completed in its entirety before the rest of the Wall. Third, the thickness of the Stone Wall curtain was reduced from Broad Wall to Narrow Wall (2.4–2.7 m foundations, 2.1–2.4 m above the foundations). These decisions made and implemented, work was eventually completed on the Wall (step 7).

It is uncertain how long it took for the Wall to be built, or at exactly what date various changes were made. Graafstal (2012) resurrected a suggestion made some decades ago by Stevens (1966, 39) that building work for the Wall commenced *c*. AD 120, with the fort decision made or approved by Hadrian during his visit in 122, and with the entire building project completed by 127. Hodgson (2017, 63) notes the possibility that with enough labour and resource directed toward the project, the Wall complex could have been completely built in 4–5 years. There is evidence, however, for breaks in the building program, and RIB 1736 from Great Chesters names Hadrian as *Pater Patriae*, a title he did not take until 128 and indicating completion of the fort no earlier than that year. It is feasible that the Wall was not completed by the end of Hadrian's reign in 137 (Breeze 2019, 90), though there is no specific evidence that demonstrates this.

Subsequently, the Turf Wall and its milecastles were sleighted (destroyed), and then rebuilt in stone. From the River Irthing to Wall-mile 54, this replacement seems to have occurred in the AD 130s, during the final years of

Hadrian's reign, and was built to a Narrow Wall gauge. The stone replacement of Wall-miles 54–80 was completed in a different fashion, the curtain being built to the Intermediate gauge (2.6–3.3 m at the foundations; 2.4–2.9 m above the foundations). The construction of the Intermediate Wall is often dated to the 160s on the basis of the small amount of pottery associated with the work, but the pottery could date from the 120s–190s.

The building sequence is important as it provides a simple order for the events in the construction of the Wall. For the more general purposes of better interpreting the monument, this helps to elucidate how the Roman builders prioritised aspects of construction and infer significance of particular structures to localised aspects of the landscape or the otherwise unattested socio-political conditions of the frontier region. However, there are limits to the knowledge and insight the building sequence provides. First and foremost, it is a relative chronology. That is to say, there are almost no unambiguous calendrical dates to correlate to particular events or activities; each step in the building sequence is positioned relative to the others, deduced through vertical and horizontal stratigraphic relationships. Second, the underlying motivation for much of the research on the building sequence has been focused on achieving a deeper understanding of the intended purpose and function of the Wall. Given the subsequent changes to the Wall and its long-term use and occupation by the Roman army, such insights are limited to a narrow chronological band, and it has been observed that more academic fixation on separating functional use of the Wall for defence or control is a false dichotomy (McCluskey 2018).

For the purposes of this volume, however, the building sequence and associated dating is useful in correlating changes in the stone fabric with different phases of activity. When assessed relative to detailed geological analysis, either physical or chemical, it also yields insights into Roman interactions with and exploitation of local landscapes.

### *Significant changes to the Wall after Hadrian*

Further phases of change can be identified along the Wall after its Hadrianic construction, though the dating of these changes is rather general. For example, a number of turrets were blocked up and subsequently demolished in the later 2nd century, sometime after the recommissioning of Hadrian's Wall following its temporary abandonment during the construction and occupation of the Antonine Wall (Breeze 2006, 105–107). However, the full extent of turrets that were demolished is uncertain, given the number of turrets that remain unexcavated. It is presumed that the turrets were abandoned and demolished as they were no longer deemed essential to the operation of the Wall. This underscores that changes to the monument were made in respect to changing socio-political circumstances on the ground.

Another major period of construction work is associated with ceramics of the very late 2nd–early 3rd century, in which substantial lengths of the Wall curtain were rebuilt using a very hard white mortar. These rebuilt lengths of curtain were reduced in thickness, given the name Extra-narrow Wall (1.5–1.9 m thick). This phase of rebuilding is typically correlated to direct imperial attention from Septimius Severus, either in advance of or concurrent with his British campaigns in the early 3rd century and appears to be the last Wall-wide construction programme. Significantly, a date for stone quarrying in 207 is provided by an inscription at the Written Rock of Gelt (RIB 1009). This quarry was located 6 km south of the Wall and produced a fine-grained red-brown sandstone, though there is no certain evidence that the stone was used in the Wall curtain. Further east, this period is likely to be the date that a new fort was added to the Wall at Newcastle (Snape and Bidwell 2002).

However, it should be noted that sites and discrete structures throughout the entire Wall corridor continued to be refurbished, demolished, replaced, or simply repaired throughout the Roman period. The continued need for building stone, therefore, can be observed throughout the entire length of Roman occupation of Hadrian's Wall, whether freshly quarried or repurposed from demolished structures.

## Current understandings of the geology and fabric of Hadrian's Wall

Work on the fabric of Hadrian's Wall has taken several different forms, though these have primarily focused on the construction of the Wall (see above). It is only recently that more comprehensive research into Roman quarrying that built the Wall has been initiated (O'Donnell 2021). Significantly, there is a considerable body of research on the geology of Central Britain, including Hadrian's Wall, but this has been undertaken almost entirely independent of the archaeology and history of the Wall (Smith 1817; Mckerrow and Cocks 1976; Cleal and Thomas 1995; Hallsworth and Chisholm 2000; Cossey 2004; Clarkson and Upton 2009; Stone *et al*. 2010; Waters 2011; Burt and Tucker 2020; Nauton-Fourteu *et al*. 2021).

Geological research of Central Britain, the area lying between the Humber estuary and the Firth of Forth, goes back to the beginnings of geology as a science and includes early debates about the nature of the Whin Sill. Much of this geology with a good description can be found in Stone *et al*. (2010), and it is clear that the dynamic environments of the Carboniferous, Permian, and Triassic epochs *c.* 359–200 million years ago were responsible for much of the geology as understood in the present day. Notably, the ubiquitous presence of hydrocarbons in the sedimentary strata of the region – coal, gas, and oil – was a driver that fuelled a detailed understanding of the geological sequence and history of Central Britain. As a result, geological maps and understanding of the region are excellent. This high level of geological knowledge, however, has not yet been realized by Wall scholars. Descriptions of the geology within archaeological publications have often been limited and, in some instances, contain geological ambiguities (Dobson and Breeze 2000; Hill 2006). Johnson (1997) provides a complete description of each of the geological units across which the Wall traverses. When combined, Johnson (1997) and Stone *et al*. (2010) provide a firm foundation to understand the geology underpinning the Wall, with the latter also providing the appropriate terminology for geological information. These issues are explored in detail in Chapter 2, which frames both the quality and locations of rock available for exploitation by the Roman builders through its formation history.

Generations of archaeologists have contributed data and research to understanding the construction of the Wall, but a leading figure emerged in Peter Hill, who brought his skills and experience as a stonemason to bear to examine the methods, techniques, and operations required to build the Wall (Hill and David 1995; Hill 2004; 2006). Hill's works, including many shorter and site-specific contributions, often highlight the difference between an archaeologist's understanding of the Wall's fabric and that of someone intimately familiar in working directly with stone (Hill 1981; 1991; 2009; 2013). He provided quantified estimates of the volume of stone required to build the Wall, methods and timings to quarry, dress, and build, and even the supporting logistics to ensure construction occurred, and these have provided baselines to better understand the monumentality of the Wall project. Hill's research has also further highlighted distinctive traits by which to confidently identify Roman masonry, for example via specific types of dressing and/or use of tools. However, Hill has also cautioned about the limits to identifying Roman masonry, as the tools and techniques employed by Roman builders were also used in subsequent centuries largely unchanged until the advent of modern industrial techniques and tools. For these reasons, the presence of inscriptions or carvings which not only allow for a much firmer identification of these individual pieces as Roman stonework are still important, and further imply a Roman origin for adjacent stones. A clear conclusion of Hill's research, however, is that the quality of stone used in building the Wall and the degree of skill in its masons was highly variable. Furthermore, there is a greater amount of low-level masonry found at the surviving sites and lengths of the Wall than highly skilled masonry. The variation of the size of stones employed in building the Wall, particularly the curtain, has been highlighted in recent years (Breeze *et al*. 2020), further underscoring the variation observed along the Wall that relates not only to the builders and their skill, but also the attributes of the stones used. These variables also change across the *c*. 300 years of the Wall's occupation by the Roman army. These issues are explored in more detail in Chapter 3.

It has long been known that the local sandstone geology was employed to build Hadrian's Wall. The quarry site and inscriptions at Gelt, for example, were discussed by Camden (1607, 106). The ready availability of stone for building in combination with the defendable crags provided by the Whin Sill have often been invoked to explain certain features of the Wall, as well as the seeming absence of building stone in the western sector where the Wall was originally executed in turf. But while the 'facts' were known, the direct connection between quarries and the Wall itself has been largely ignored in the course of research. Hill (2004; 2006) explores the processes and tools employed for quarrying, but again rarely connects specific quarry sites to the monument or its fabric. In this regard, the Wall is in stark contrast to other large Roman monuments in the Mediterranean where the use of marble can often be sourced to a particular area, if not an exact quarry; it also contrasts with Roman quarries known from other locations in the former empire, where extractions of 1000s of cubic-meters can be attested (Russell 2013). In a ground-breaking study, O'Donnell (2021) developed a method to assess the probability of 153 potential Roman quarry sites in the Wall corridor, and employed petrography, geochemistry, and statistical analysis to identify direct links between Wall fabric and source geological beds. She highlighted the challenges and limitations of identifying unique characteristics in the sandstones used in the Wall's fabric. This topic is given more attention in Chapter 4.

In the centuries following the end of the Roman Empire, its monuments, buildings, and structures became a convenient source of dressed stone for subsequent communities. The robbing and re-use of Roman fabric happened across the entirety of the former province of *Britannia*. The re-use of Roman fabric, rather than fresh quarrying and preparation of stone, could introduce considerable savings in skilled labour and time for medieval and later builders (Eaton 2000), and integration of Roman stone or structures into buildings and communities often had ideological benefits (Fafinski 2021), though caution must be applied against projecting ideological motivations onto the past. The fact that in no location does Hadrian's Wall survive to its full height and that no fort or other settlement is perfectly preserved provides some indication not only of the extent of collapse and ruin of the Roman structures, but also the extent to which they were robbed for building materials. Roman inscriptions and sculptures built into structures provide a direct testimony, whether it is the use of decorated stones from Corbridge integrated into the 7th-century crypt at Hexham Abbey, or a centurial stone last seen in 1732 incorporated into a farmhouse doorjamb at Willowford (RIB 1864). The way in which the Wall was incorporated into post-Roman communities was the focus of Whitworth's (2000) work. Moreover, his research provides an excellent starting point in mapping, quantifying, and qualifying the extent of fabric re-used from the Wall from the Middle Ages to the modern period. Specific sites are known to have extensively re-used Roman fabric from the Wall, such as 14th-century Thirlwall Castle (Young *et al*. 2001) and the 7th-century monastery of Jarrow (Turner *et al*. 2013). Through a combination of broader survey and site-specific case studies, it is possible to gain a fuller appreciation of how much of the Wall has dispersed and directly affected the establishment of post-Roman communities, explored further in Chapter 5.

## Aims, objectives, and methods

Through the course of research, it has also become clear that the range of stone and other geologically sourced materials used to construct the Wall is more diverse than has been previously described and understood. With some notable exceptions (Johnson 1997), there is also an absence in the literature of comprehensive documentation of the geology of the Wall's landscape directly relating it to the fabric of the monument. It is, therefore, a key aim of this publication to provide a comprehensive description of the geodiversity of the Wall, from its geological history to the relationship between the landscape and the geological materials incorporated into the monument.

The Stone Sourcing and Dispersal (SSD) strand of WallCAP was designed and implemented with a series of four objectives to identify and collate the data necessary to meet the aim above:

1. To compile a large dataset of combined geological and archaeological information about Wall-stones located in their original setting, focused principally on facing-stones of the curtain, but also on other buildings associated with the Wall including forts, milecastles, turrets, and bridges.
2. To compile a large dataset of combined geological and archaeological information about stones located in post-Roman buildings which are thought to have been re-used and taken from Hadrian's Wall.
3. To add to data about possible sources for stone used in constructing the Wall and the routes between these sources and the Wall.
4. To carry out petrological and geochemical analysis of the rocks from a range of possible stone sources as well as some material from the Wall and post-Roman buildings, where feasible.

The undertaking of these objectives and the data gathered from them allowed WallCAP research:

A. To illuminate our understanding of the Roman approach to quarrying and transport of stone to the Wall.
B. To explore and test these methodologies as a way of being able to refine our ability to associate Wall-stones with their source and to better recognise Wall-stones re-used in post-Roman structures.
C. To further illuminate our understanding of the way that stone from the Wall has been re-used, including chronological parameters and thresholds of re-use, the volumes of stone incorporated into post-Roman structures, and where it was re-used and why.

At the heart of this work is the ability to uniquely characterise pieces of sandstone. If this can be achieved then it becomes possible to identify, to a higher degree of accuracy, where the fabric of the Wall came from and to be able to trace where that material has been re-used. This identification has two parts. The first is to be able to uniquely recognise the geological fabric of the stone to link it to its source rock (in this monograph, the word 'rock' is used to refer to hard geologically formed material, and the word 'stone' is used to refer to rock which has been shaped by human hand). The second is to be able to characterise stones used in Wall construction in such a way that they can be demonstrably shown to have been shaped in Roman times.

Achieving both these parts is challenging. To trace Wall stone to a particular geological source requires obtaining any data (or a combination of data) about the geochemistry or the fabric (petrography) of the stone from the Wall and appropriate geological horizons. At the outset of this study, it was anticipated that finding these characteristics would be unlikely to give a definitive answer for every stone encountered in the Wall or in post-Roman structures. However, while definitive answers for each sector of the Wall remain elusive, the use of complementary methods, combining archaeological and geological data, has progressed our ability to link Wall-stone to source geology and to sites of re-use, as explained in the following chapters of this volume.

To this end, two principal approaches were taken across a range of archaeological and geological sites (Fig. 1.14). The first approach was as an exercise in mass-science that engaged people residing in communities throughout the Wall corridor. As well as having the potential to deliver large amounts of data across the whole length of the Wall, an additional advantage was being able to draw on local knowledge and expertise. The second approach was to carry out more intensive analytical research to produce more detailed geochemical and petrological datasets on a limited number of Wall-stones and possible stone sources. This had the advantage of producing more detailed and reliable data which in turn could be used to calibrate the more extensive data set captured by volunteers. Each of these methods are fully described in Appendix 1: Methods Employed for the Research.

Throughout the course of research, a considerable volume of archaeological and geological data was accumulated. Data pertaining to individual sites has been collated in a site-based gazetteer in Appendix 2, allowing each chapter to offer a more thematic and comprehensive interpretation or overview. Chapter 2 explores the deep

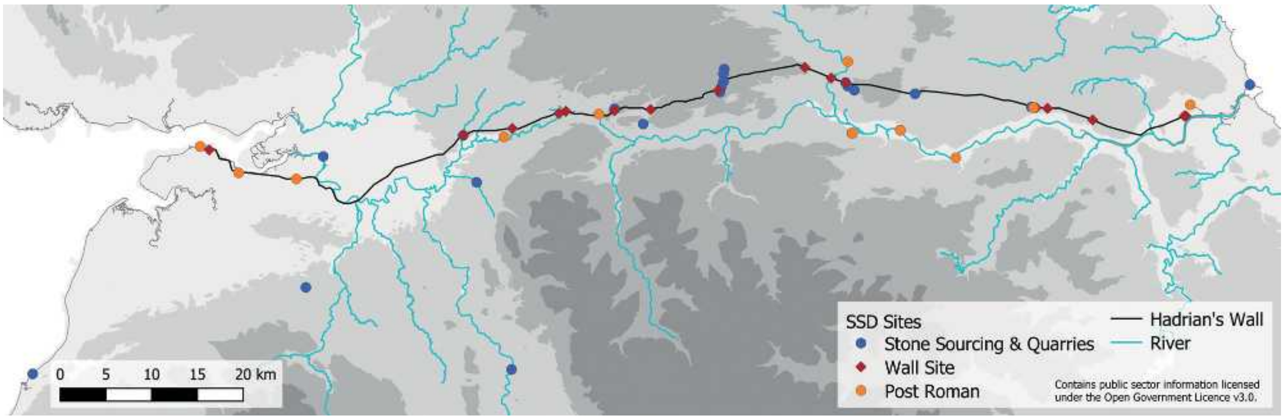



*Figure 1.14: A map locating key sites of investigation by WallCAP within this study, separated by site type.*

geological history of Central Britain across hundreds of millions of years. Not only does this help explain the shape of the landscape as we understand it today, it further elucidates the geological diversity of the regions and offers insights into the sandstones that made up the Wall. Chapter 3 then examines the building and fabric of Hadrian's Wall, highlighting the tools used in its construction, but more importantly looking in detail at the physical and geological attributions of the fabric of the Wall and the different building techniques used during initial construction and over the intervening centuries of Roman military occupation. Chapter 4 then steps away from the Wall to assess and expand upon current understandings of Roman quarrying related to the monument. The chapter offers a system by which to identify and assess the probability of a Roman quarry, as well as extraction methods and distribution of quarries relating to the Wall. Chapter 5 turns to the post-Roman centuries, considering the extent to which construction in stone was common in different periods and the implications this had for the Wall. In addition to a series of case studies of varying scale that explore re-used Wall-fabric. Chapter 6 is the conclusion to the volume, drawing the themes together to highlight the importance of local resourcing and needs to the Wall throughout its history, and presenting a loose phasing for the Wall's ruin and destruction over the past 1500 years.

# 2

# Geology of the Wall

Hadrian's Wall, while an archaeological monument, is also a geological entity. To understand the monument, it must be considered in two interrelated geological questions. First and most directly, which types of geological materials can be found used in the Roman monument? Second, how does the monument and its landscape relate to the underlying geology of Central Britain? Answering these two questions not only better relates the Wall to its host environment, but also contributes to a greater understanding of the monument itself. Understanding the geology of Central Britain explains the origins of rock formations and their location, which in turn provided the Romans and other occupants of Central Britain with the opportunity to quarry, build, and otherwise exploit geological materials. Furthermore, detailed examination of the geological materials used in Hadrian's Wall allows specific locations along the Wall to be linked with specific geological formations, and further narrows down prospective quarrying locations. Similar examination can also link post-Roman structures back to the Wall, or source quarries. This chapter provides a foundation for the geological understanding of Hadrian's Wall and its landscape. Fundamental to achieving such an understanding is the acknowledgement of geological diversity that contributes to both the landscape and the monument (Fig. 2.1). This chapter explains that diversity and its significance to the Wall, the long-term formation of Central Britain over millions of years, and the location and relationships of geodiversity relative to the Wall.

## The Wall and sandstone

The geological materials of the Wall may be categorised as facing stones, foundations stones, core, and bonding. In turn each of these may be categorised in terms of their rock type and their mineralogical and geochemical content. The facing stones of the Wall consist almost exclusively of sandstones. More rare are facing stones made of dolerite. Foundations, when not set upon exposed bedrock, can make use of sandstones or dolerite. The core of the curtain, however, is where the greatest diversity of geological materials can be found. Core materials not only include sandstones, limestones, and dolerite, but other mixed stones resulting from glacial deposits, soils, sands, and clays. Bonding materials, sometimes clay and sometimes mortar derived from limestone, can also be found in the core or between facing stones.

Sandstones, which contribute the greatest volume of material to the Wall, are particularly significant and typically derive from one of three geological periods: the Carboniferous, the Permian, and the Triassic. The Carboniferous sandstones are the most diverse in colours and textures. They range in colour through white, yellows, buff, browns, and purples and in grain size and sorting from fine well-sorted sandstones to coarse gritty poorly sorted sandstones (Fig. 2.2) The Carboniferous sandstones also incorporate a wide range of sedimentary textures both from their fluvial depositional setting (*e.g.*, cross-bedding, rip up clasts) and their diagenesis (*e.g.*, concretions and iron oxide banding (Fig. 2.3). Permian sandstones, of which the Penrith Sandstones are the most prevalent, are typically salmon pink in colour, fine to coarse grained and well sorted. Sedimentary structures when present reflect their aeolian origin (*e.g.*, low angle, large scale dune-bedding). The Triassic sandstones, of which the St Bees Sandstone is most prevalent, are more purple in colour than the Penrith sandstones and less dusty looking (Fig. 2.4). The St Bees sandstones have sedimentary textures reflecting their fluvial origin and commonly have fine laminar bedding (Fig. 2.5). Diagenetic textures in both the Permian and Triassic sandstones are less common. These descriptions highlight the visible diversity amongst sandstones, but there are other attributes that are variable due to differential formation conditions and which results in varied weathering, erosion, and overall appearance over time.

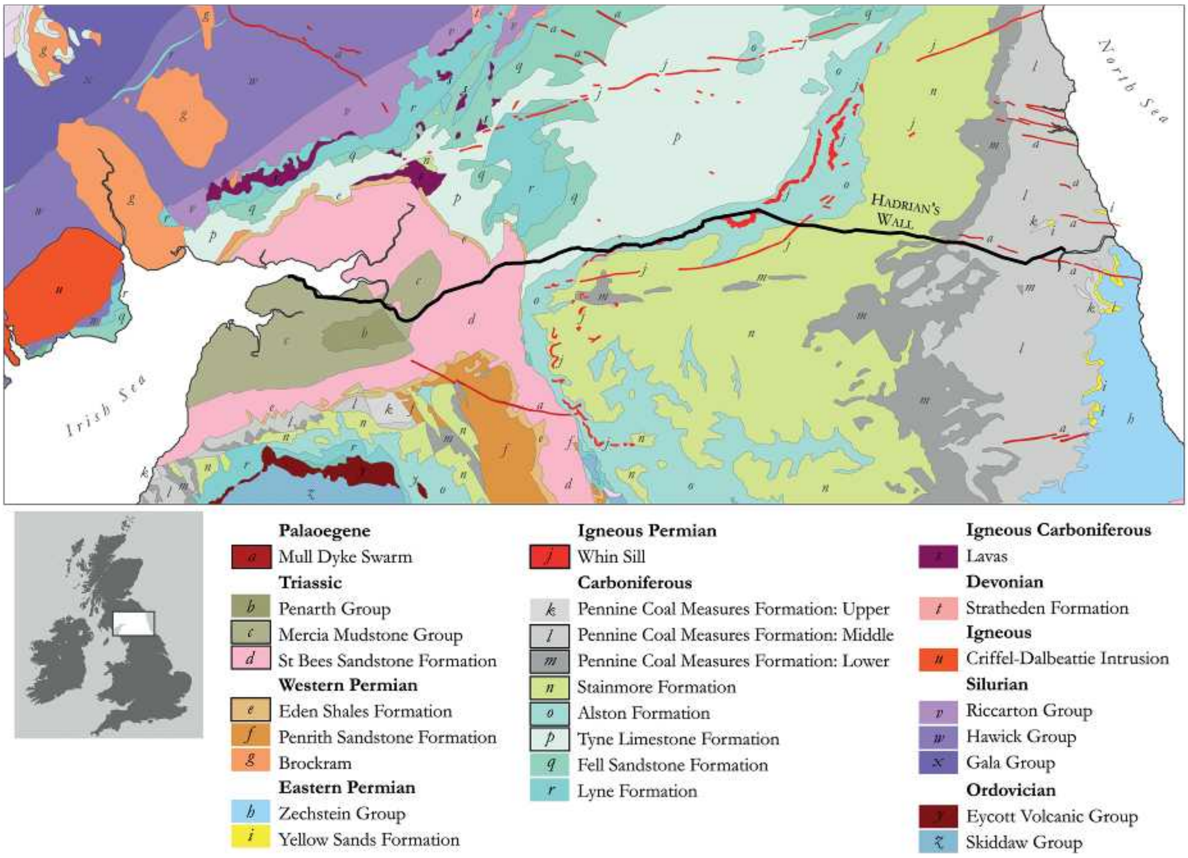



*Figure 2.1: A geological map of the wider landscape of Hadrian's Wall. Illustration by Matilde Grimalde.*

*Figure 2.2: Examples of the range of colours and textures in Wall-stones from the Carboniferous strata.*

The detailed character of a sandstone is a product of a series of geological processes. These operate from the source location of its mineral components to its place of deposition and in cementing and altering the sandstone after it has been laid down, this latter process known as diagenesis. These processes are in turn controlled by the configuration of land and sea (the palaeogeography) and by climate. Examination of the paleogeography of each of the major periods gives a greater understanding of why the sandstones have their character and ties groups of sandstones to a particular paleogeography and a particular period of time. This characterisation is also true of other geological materials, so that a good understanding of the nature of a particular geological period provides a good starting point for recognising rock from that period when it has been used within stone structures.

The detailed operation and interaction of these processes leads to complex variation in sandstone bodies within a given location. By comparing this local variation to variation between locations and over geological age it is possible to determine to what degree of precision source locations maybe deduced. This approach gives the principal focus of this study; that is as a mechanism to uniquely categorise the sandstones used to make facing stones, such that they may be linked to a precise or more generalised geological source, which would in turn enable

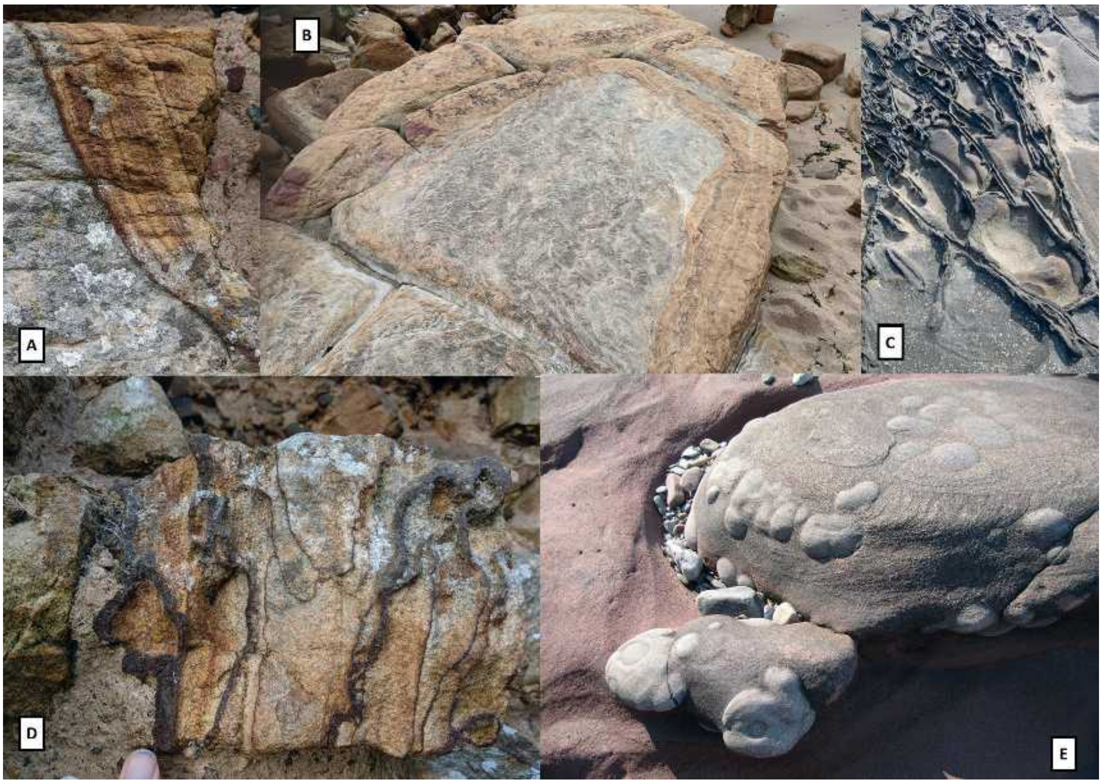



*Figure 2.3: Examples of diagenetic patterns. (A) Re-used Wall-stone at Thirlwall Castle with Liesegang iron patterns. (B) Liesegang iron-oxide patterns adjacent to joints in a sandstone at King Edward's Bay, Tynemouth in the Pennine Middle Coal Measures. (C) Iron oxide veins in sandstone at Rumbling Kern near Howick in the Stainmore Formation. (D) Re-used Wall-stone at Thirlwall Castle with iron-oxide veins. (E) Eroding concretions of calcium carbonate in a sandstone at Cocklawburn Beach near Berwick-upon-Tweed in the Alston Formation.*

*Figure 2.4: Examples of the range of colours and textures in Wall-stones from the St Bees Sandstone Formation in the Triassic strata.*

facing stones re-used in post-Roman structures to be linked to the Wall.

This chapter will therefore first summarise the processes that create variation in sandstones, then consider how geological stratigraphy is applied to this study. It then maps out the major geological periods. This will include a look at how the rocks are disposed in relation to the Wall, the formal stratigraphic naming of the component rock series, the characteristics of each of the time periods, an exploration of how they progress through time and the major tectonic episodes which have contributed to their character. This will allow comparison of the contrasting sedimentary environments in which each of the sedimentary (and other) rocks were formed.

This includes a more detailed exploration of the nature of sandstone bodies, particularly within the Carboniferous Period. This will allow for a comparison of cyclic versus progressive change in sedimentation, which directly impacts on the limits to characterising specific sandstone units.

### *What causes variation in sandstones?*

Before looking at the history and range of materials on offer in the Wall's landscape, it is necessary to consider the major processes in the formation of a sandstone that cause

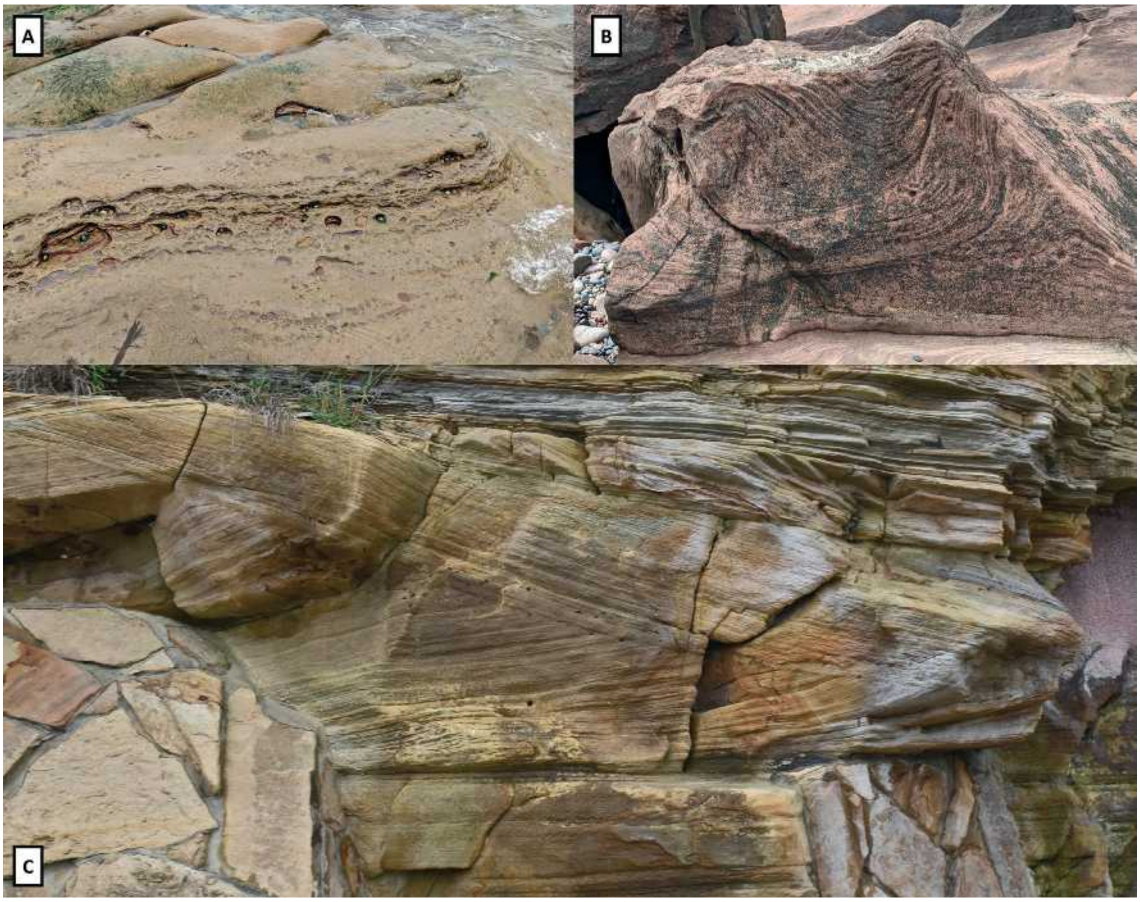



*Figure 2.5: Examples of sedimentary textures. (A) Rip-up clasts of mud-flakes in a layer of sandstone by Tynemouth Pier in the Pennine Middle Coal Measures Formation. (B) Water escape patterns caused by excess water escaping from and disrupting sedimentary lamination. St Bees, in the St Bees Sandstone Formation. (C) Trough cross-bedding in a sandstone at Brown's Point near Whitley Bay in the Pennine Lower Coal Measures Formation.*

variation. By doing this, the combined history (including tectonic history, palaeogeography (including sources and transport routes), depositional environment and global environment) mapped out below can be related to the characteristics of specific sandstone bodies.

Each of the following has an impact on the type of sandstone formed (see sandstone classification in Appendix 1: methodology):

- Source
- Weathering
- Erosion and transport
- Depositional environment
- Diagenesis

The most important control on a sandstone's content is its depositional environment. The energy of the depositional environment controls grain size – for example, the faster a river flows the larger the grain size it can transport. The nature of the environment controls grain shape and degree of sorting and also produces of a range of sedimentary textures including cross-bedding and water escape structures (Fig. 2.5). This means that a sandstone's petrology may be used to help diagnose its depositional environment. For example, a dune-bedded sandstone with rounded and patinated grains is readily distinguishable as having formed in an aeolian environment. The source rocks define the range of mineral types available and their starting condition. For example, a sandstone source would provide quartz grains which have already been through a cycle of abrasion and rounding. In contrast igneous and metamorphic sources would provide a much richer range of minerals, each entering the sedimentary cycle as unabraded grains. The way that the source rock(s) were weathered and eroded – in a hot or cold climate, and at what speed – affects the way that less physically and chemically durable components survive. This is compounded by how far and in what conditions the mineral components are transported. For example, a distal source gives more time for mineral components to be broken down or abraded into rounder forms.

Post-deposition is the time at which unconsolidated clastic material is turned into stone through the addition of mineral cement introduced by precipitation from

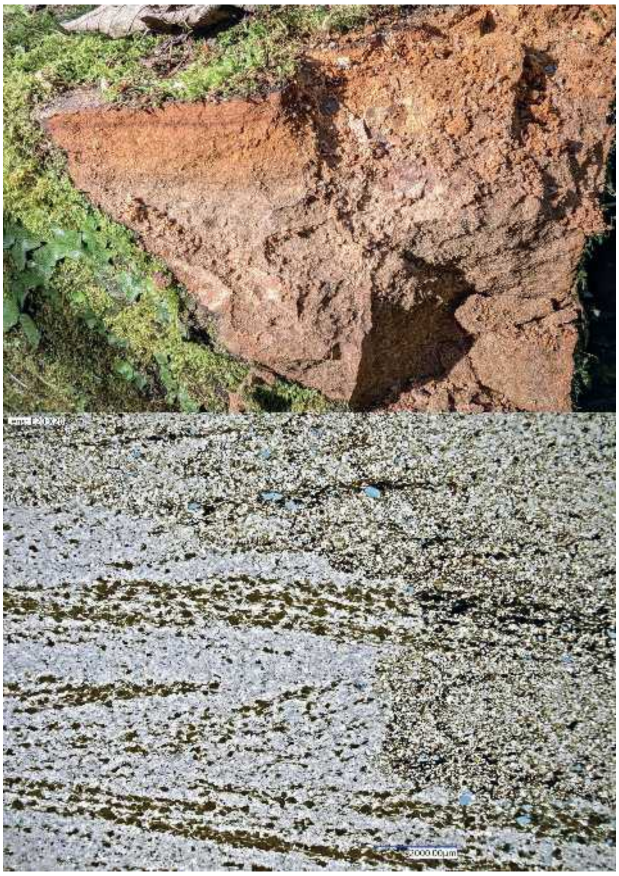


*Figure 2.6: Top: Weathered stone in stream bed at Shawk, with fresh stone at the bottom and darker bands of weathered stone toward the top. Bottom: thin section across weathering profile of sandstone from Hartley Bay (HB002) with fresh stone bottom left and the darker more iron rich weathered stone across the top of the image and down the right-hand side.*

intergranular water. This affects the porosity and strength of sandstones as well as creating distinctive textures. For example, the quartz overgrowths commonly seen in many of the samples observed in thin section for this study. These diagenetic processes are also responsible for creating macroscopic features which include concretions, notably of calcium carbonate and iron, as well as banding and Liesegang rings formed from iron oxides (Fig. 2.3).

All of the features described above may be found in sandstones used in the Wall, in post-Roman buildings, and potential sources for Wall stone. Each feature may help provide a way of characterising individual rock units.

Finally, in examining the petrology of sandstones, the effects of weathering also need to be considered. In the possible source rock locations, samples of rock which are as fresh as possible have been collected. In some samples, the effects of weathering may be seen, with alteration penetrating many centimetres into the stone (Fig. 2.6). Weathering alters sandstones by breaking down sandstone's cement and less chemically durable minerals, such as feldspar and iron oxides. The surface of weathered sandstone may also have the less durable minerals washed out so that just a framework of quartz is left at the surface.

## The geological history of Central Britain

The components that make up the geology of Central Britain are a product of a series of major tectonic events over a period of more than 400 million years. This begins with the Ordovician, Silurian, and early Devonian Periods (approximately 485–400 MYA) in which a series of dramatic events resulted in the formation of a Himalayan-scale mountain range composed largely of metamorphic and igneous materials.

In the following Carboniferous Period (359–299 MYA) a large basin developed over Central and Southern Britain into which many kilometres of sedimentary rocks were deposited. These are characterised by a hot but wet tropical climate within which coal swamps periodically flourished.

Late in the Carboniferous and into the early Permian Period, major tectonic events to the south of the UK created a gap in the geological record and significantly changed the orientation of sedimentary basins. Many kilometres more of sedimentary rock were deposited in these basins east and west of the Pennines through the mid to late Permian, Triassic, and early Jurassic Periods. In contrast to the Carboniferous, these were laid down in a hot dry intra-continental climate and the reds of oxidising iron are a feature of the sediments.

Jurassic and Cretaceous sediments may well have been deposited in the area but have since been eroded away during later regional uplift associated with the opening of the Atlantic Ocean. The Palaeogene Period (66–23 MYA) saw the intrusion of dykes from the distant Mull volcano.

The finale in creating the landscape we see today was the action of ice on the landscape as ice-sheets repeatedly advanced and retreated during the Quaternary Period (2.48 MYA to the present).

Over the course of approximately 500 million years, the formation of mountains; their erosion and replacement with seas and inland deserts; the upward thrust of new lands linked to newly formed oceans through river systems; and eventually, the carving of the topography through repeated cycles of glacial expansion and retreat, all contributed distinct sequences and cycles of geological formation, ultimately resulting in geological strata producing faults and formations that are the foundations of environmental geology, and from that humanity's relationship with stone.

### *Geological concepts and terminology*

When describing any given sequence of rock strata – its stratigraphy – two approaches can be used to categorise the sequence. The first, chronostratigraphy, names geological units according to the time of formation, for example the Visean Stage lasted from 346.7 (±0.4) to 330.9 (±0.2)

MYA within the Carboniferous Period. These chronostratigraphic units are internationally agreed so that events at a given geological time maybe compared anywhere in the world. The second, lithostratigraphy, is principally concerned with describing rock-types (lithologies) and rock-assemblages (containing related rock-types) for a given geographical area. The Tyne Limestone Formation, for example, is approximately in the middle of the Visean Stage. The precise time at which rocks within this formation were laid down varies across Central Britain, and in some places the formation is absent.

To understand where stone has been sourced, it is necessary to understand its lithology and its place within the lithological sequence. There is no requirement to know its precise time of formation. Therefore, in this monograph the outcrops and underlying geology will be referred to by their lithostratigraphic names. This has most resonance with the geographical area of northern England and the Scottish Borders and provides a consistent frame of reference for this study. The lithostratigraphic scheme used here is simplified from that used (and kept updated) by the British Geological Survey and is described in Stone *et al*. (2010).

This lithostratigraphy is presented as the key to Figure 2.1, while Table 2.1 highlights the relationship between the lithostratigraphic framework and conventional chronostratigraphic periods (Stone *et al*. 2010). Whilst this simplified scheme is sufficient to provide a practical framework for this study, it is acknowledged that details of lateral variation and nomenclature are lost in the process. Where necessary, additional detail is found within the text.

During the course of geological history and within the specific time periods relevant to this project, there are progressive changes which may be recorded within the rocks. The most obvious is that of evolution. Different assemblages of fossils are characteristic of the time period in which they live with measurable progression from single celled organisms through to whales, octopuses, and orangutans. There are other progressive changes, for example in global climate, atmospheric chemistry, latitude, growth and decay of mountains, and the configuration of sedimentary basins that may also be recorded as specific characteristics in the rocks. These characteristics, unique to their location in the rock sequence, are required to relocate stone back into the context of the rock sequence from which it has been removed.

*Table 2.1: Table showing the relationship between lithostratigraphic units used in this study and the European Chronostratigraphy.*

| *Lithostratigraphy* | | *European chronostratigraphy* | | |
|---|---|---|---|---|
| | | *Substage* | *Stage* | *Subsystem* |
| Pennine Coal Measure Group | | | Autunian | Silesean |
| | | | Stephanian | |
| | Lower Pennine Coal Measures | Westphalian D | Westphalian | |
| | | Bolsovian (Westphalian C) | | |
| | Lower Pennine Coal Measures | Duckmantian (Westphalian B) | | |
| | Lower Pennine Coal Measure | Langsettian (Westphalian A) | | |
| Yoredale Group | Stainmore Formation | Yeadonian | Namurian | |
| | | Marsdenian | | |
| | | Kinderscoutian | | |
| | | Alportian | | |
| | | Chokierian | | |
| | | Arnsbergian | | |
| | | Pendelian | | |
| | Alston Formation | Brignatian | Visean | Dinantian |
| | Tyne Limestone Formation | Asbian | | |
| Border Group | Fell Sandstone Formation | Holkerian | | |
| | | Arundian | | |
| | Lyne Formation | Chadian | | |
| | | | Tournaisian | |
| | | Courceyan | | |

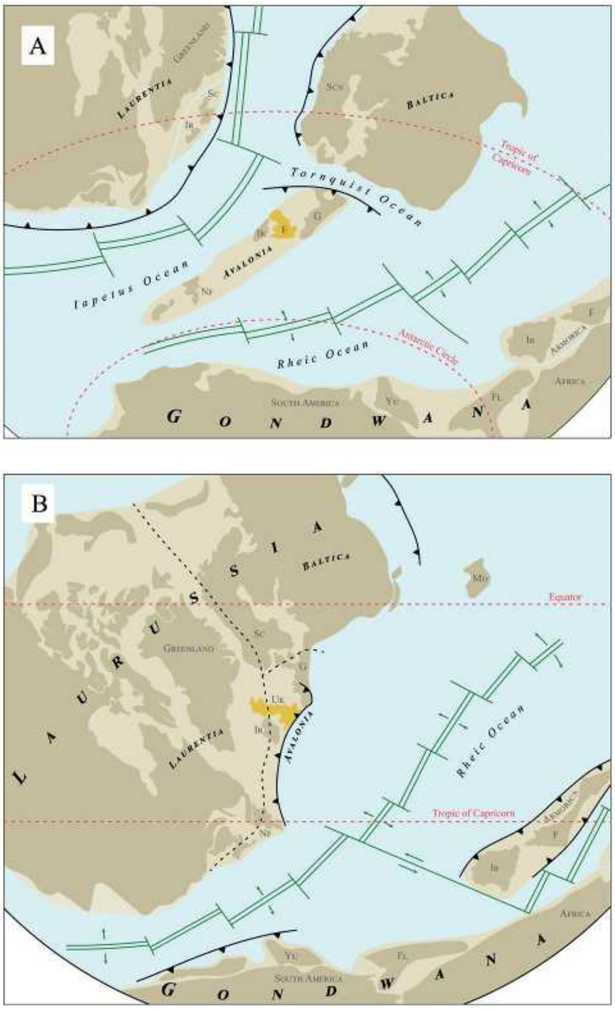



*Figure 2.7: (A) Tectonic map showing the approximate distribution of continents in the Ordovician Period. (B) Tectonic map showing the approximate distribution of continents in the Devonian Period. Diagram after Frisch* et al. *2022. Illustration by Matilde Grimaldi.*

In contrast, many geological processes recur, sometimes cyclically. For example, cross-bedding produced as a stream meanders across a flood plain is a feature that maybe found in all of the Carboniferous formations. If the imprint of this (repeating) palaeoenvironment on the rock formed overwrites any characteristics from progressive changes, then it will not be possible to relocate a stone back into its stratigraphic context.

### The Caledonian Orogeny: setting the scene

The Ordovician, Silurian, and early Devonian Periods occurred approximately 485 to 400 MYA. Within these periods, the Caledonian Orogeny is a complex series of events brought about by subduction and then collision of three major continental masses – Laurentia, Baltica, and Avalonia – to form the super-continent of Laurussia (Fig. 2.7).

During the Ordovician and Silurian Periods, the Iapetus Ocean progressively closed whilst accreting ocean sediments in its subduction zones (Mckerrow and Cocks 1976; McKerrow *et al.* 2000; Stephenson *et al*. 2007; Clarkson and Upton 2009; Stone *et al.* 2012). The three continents collided and sutured from north to south, Baltica joining Laurentia first, followed by Avalonia. In the process these accreted ocean sediments, sandwiched between the continents are further folded and faulted and metamorphosed. Representatives of these Ordovician and Silurian ocean sediments are found both in the Lake District and in the WSW–ENE trending high terrain which stretches from Galloway to East Lothian.

The combination of subduction and collision of these continents created a Himalayan-scale mountain range to the north of the suture. The roots of this mountain range may still be seen in the highlands of Scotland, represented by a wide range of highly metamorphosed, folded, and faulted rocks with a rash of plutonic igneous rocks injected into them (Peach and Horne 1932, Stephenson *et al*. 2007).

Towards the end of the Caledonian Orogeny, in the early Devonian Period there was a final burst of magmatic activity. This resulted in the formation of many igneous intrusions as well as the intrusive and extrusive rocks of the Cheviot volcano. This period of late Caledonian igneous activity is represented in Figure 2.1 by the Criffel-Dalbeattie pluton. The Cairnsmore of Fleet and Loch Doon intrusions in Galloway are also part of this period of igneous activity (Stone *et al.* 2012).

There are three reasons why the Caledonian Orogeny and its associated series of more ancient rocks are relevant to Hadrian's Wall.

The first is the control which they place on the landscape. Highly metamorphosed rocks along with igneous rocks are durable, making them more resistant to erosion and to tectonic action. Highly evolved igneous rocks (for example granites) also tend to be buoyant, and major fault-lines created during the orogeny become long standing lines of weakness. In consequence, the Caledonian Orogeny has a major structural control on the landscape right through to the present day.

The second is that the complex mix of metamorphic and igneous rocks which make up the Caledonian mountain range are a source of clastic material during the late Devonian and Carboniferous Periods (Fig. 2.8). By understanding the mineralogy and chemistry of these derived materials, it may be possible to further characterise the Carboniferous rocks used in construction of the Wall. This is further discussed in the section 'The Wall and its Source Geologies' later in this chapter.

Third and finally, clasts of greywackes and early Devonian plutonic rocks (*e.g.*, granite from the Criffel-Dalbeattie pluton) from Galloway and the Southern Uplands have commonly been deposited across the surface of the Hadrian's Wall landscape by glacial activity dating to the Quaternary Period (Fig. 2.9). Initial

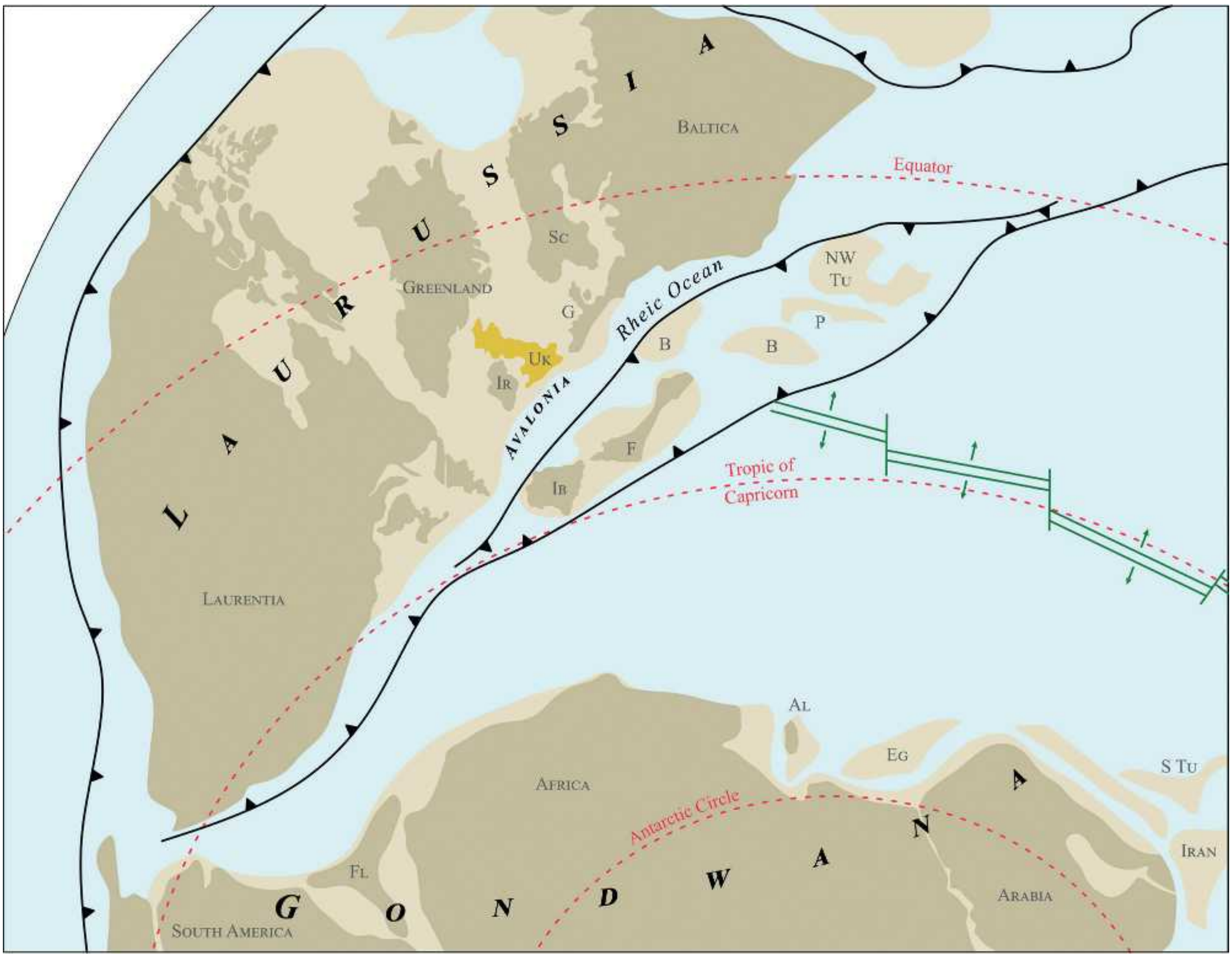



*Figure 2.8: Tectonic map showing the approximate distribution of continents in the Carboniferous Period, diagram after Hoşgör* et al*. 2012. Illustration by Matilde Grimaldi.*

expansion of glaciers fragments, scours, and erodes geological materials that are held within the ice and are subsequently dropped or lost during periods of glacial retreat and/or melt. Cobbles and boulders from these glacial deposits are commonly incorporated within the core of the Wall. This is further discussed below. Both granites and greywackes are highly distinctive in hand specimen and in thin section.

### *The Carboniferous Period (359–299 MYA)*

By the Carboniferous Period, the majority of what is to become the UK was located on the southern margin of the Laurasian super-continent with the Caledonian mountain range to the north and the Rheic ocean to the south (Fig. 2.8). Following the Caledonian Orogeny, the foreland to the south of this newly made mountain range turned from an area of uplift into one of deposition. From the latter part of the Devonian Period, a combination of erosion and crustal stretching and thinning resulted in the formation of a series of fault-bounded sedimentary basins. By the early Carboniferous, these covered an area stretching from the Midland Valley of Scotland down through northern England. Within this basin, areas underpinned by Caledonian granites (the Cheviots, Alston, Askrigg, the Lake District amongst others) behaved as buoyant fault bounded blocks over which sedimentation was initially absent or thinned. Between these blocks – for example, in the Northumberland trough, which encompasses the route of Hadrian's Wall – sedimentation was essentially continuous and during the Carboniferous Period laid down several kilometres of sedimentary rock. As the Carboniferous Period progressed and the basin deepened sedimentary deposition covered and thickened over these blocks (Figs 2.10–2.12).

In the Carboniferous period, the northern UK sedimentary basin progressively deepened and the elevated areas become submerged. In parallel with this, the global climate changed from hot to temperate and was matched by a reduction in the level of atmospheric $CO_2$ and increased $O_2$. It was also marked by a progressive shift in the types of sediments laid down. In the early Carboniferous, the

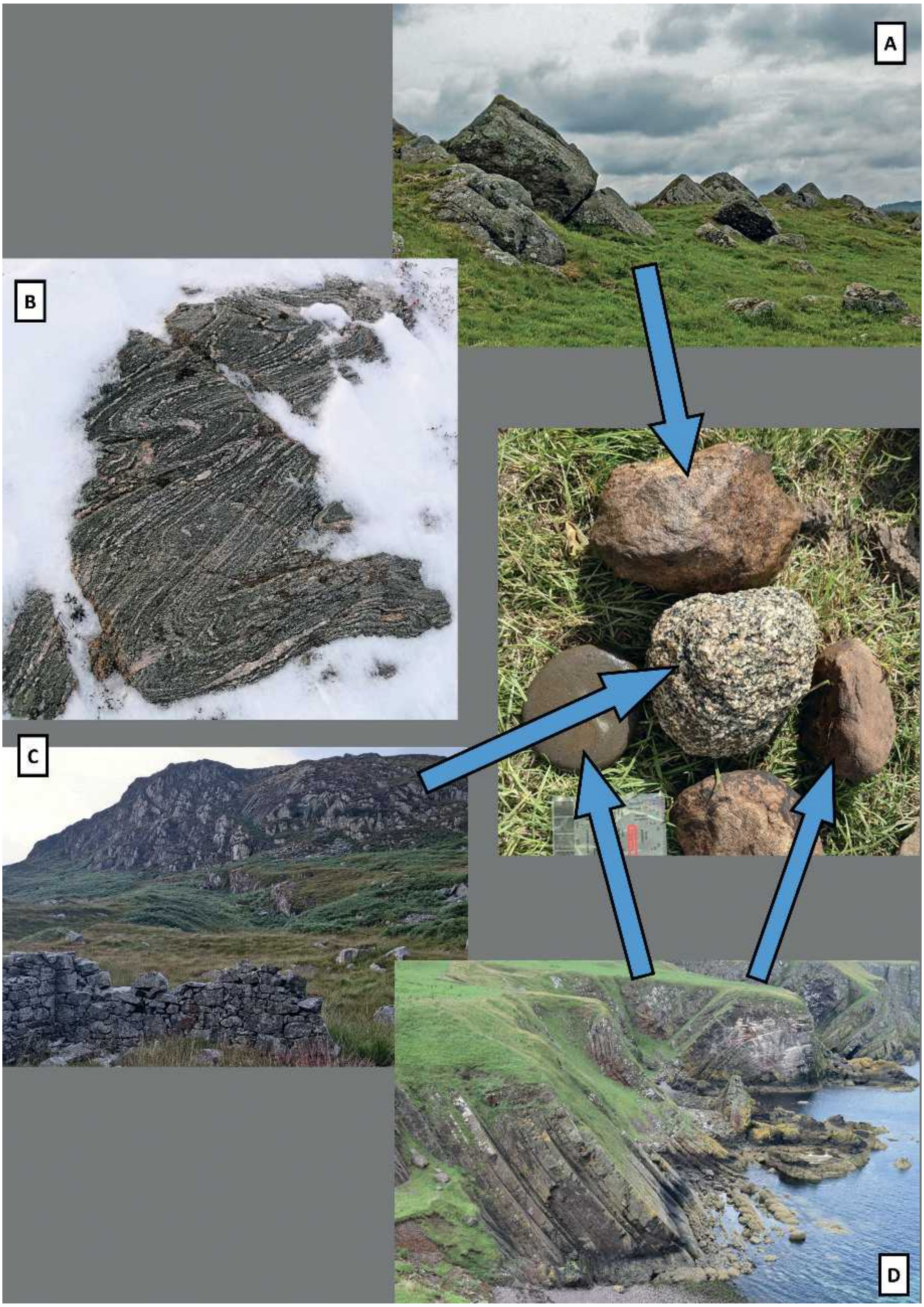



*Figure 2.9: The complex mix of igneous rocks in Scotland and glacial cobbles derived from them and retrieved from the WallCAP excavations at Corbridge. There was no representative of the metaporphic rock among the excavations, though they are seen in the area. (A) Lava flow in the Eycott Volcanic Group. (B) Metamorphic rock from the Lewisian of Sutherland. (C): The Cairnsmore of Fleet Granite intrusion. (D) Silurian greywackes, Petticow Wick near St Abbs.*

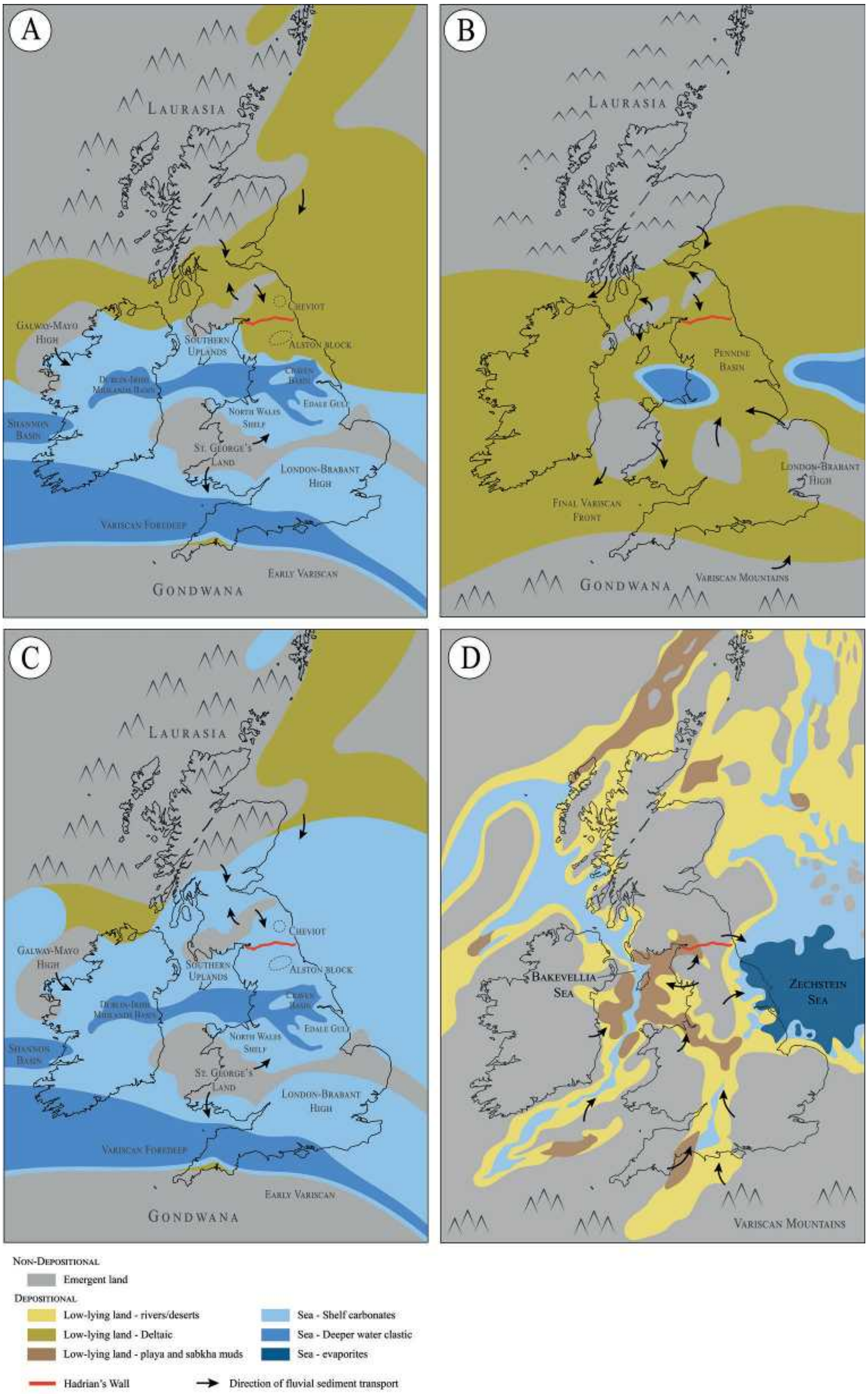



*Figure 2.10: Palaeogeographies of the UK from the early Carboniferous to the Triassic Period, after Stefano* et al. *2021 and Marsh* et al. *2022. (A) The early mid-Carboniferous Period (Yoredale Group) when sea level is low and deltaic processes dominate Central Britain. (B) The early mid-Carboniferous Period (Yoredale Group) when sea level is high and marine processes dominate Central Britain. (C) The late Carboniferous Period (Pennine Coal Group) when deltaic processes dominate much of Central Britain and marine influence is minimal. (D) Generalised palaeogeography for the Permian and Triassic Periods combining elements of each period. The broad outlines of basins and source areas remain similar throughout these periods, but with significant changes in environmental conditions and the consequent type of sedimentary process in action. Illustration by Matilde Grimaldi.*

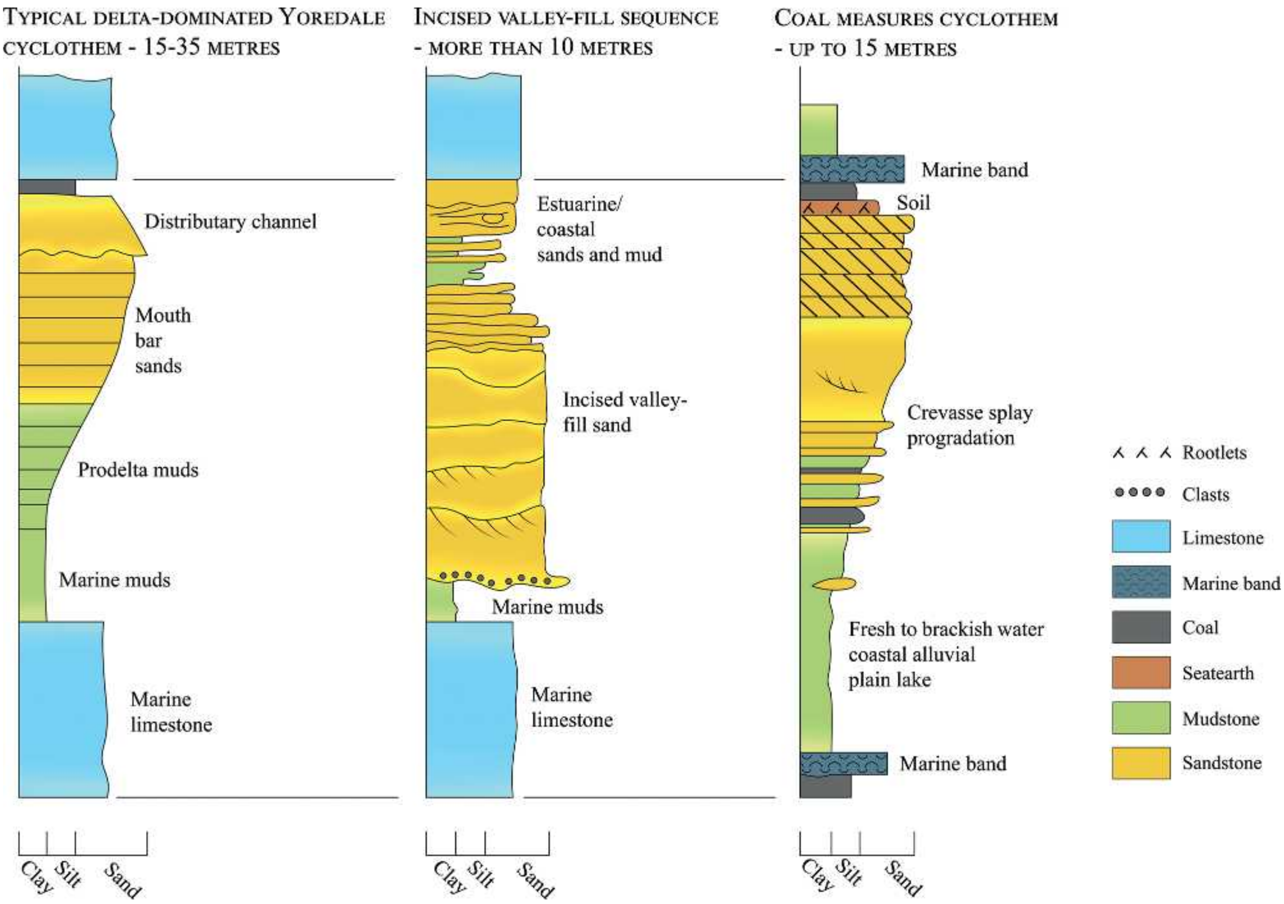



*Figure 2.11: Typical examples of cyclic sedimentation during the Carboniferous period. The first two sequences are from Yoredale Group times, each representing different parts of the deltaic system. The third sequence is typical of the Pennine Coal Measures Group where marine influence is minimal and coal swamps become more frequent. After Stone* et al*. 2010.*

sedimentation was dominated by fluvial processes – rivers and lakes – with subaerial processes creating soil horizons known as cementstones. By the early-middle Carboniferous Period, fluvial deltaic processes were interdigitated with marine episodes producing limestones. These limestones are laterally extensive (over hundreds of kilometres) with characteristic fossil assemblages which act as excellent stratigraphic markers of changing palaeoenvironments at a given location over time (Fig. 2.10). Finally, by the later Carboniferous Period, the marine influence waned. Deltaic processes dominated the sedimentary sequence with swampy conditions, a significant contribution to the sedimentary succession in the form of coal (Fig. 2.10). What marine influence there was at this time is seen as densely packed shelly layers probably laid down in brackish water conditions. These mussel, or marine, bands are significant time markers in the late Carboniferous Period.

In parallel with these progressive changes in the Carboniferous paleoenvironment, the sources of this clastic material within the Caledonian mountain ranges were eroding and the suite of rocks providing clastic material changing. This progressive change in source material has the potential to affect the mineralogy and geochemistry of sedimentary rocks which form.

In contrast to these overarching progressive and potentially measurable changes there is also cyclic repetition, on a smaller timescale, of sedimentary processes. These cycles, which are more problematic to place in time and uniquely characterise as a common palaeoenvironment, were repeated many times and created similar sediments. Repeated sequences are seen through the middle to late Carboniferous and are particularly marked in the middle part of the Carboniferous within the Yoredale Group. The rocks laid down in this period cover a large percentage of the possible Wall-stone source rocks (see above). These cycles of sedimentation, known as cyclothems, follow a broad pattern. In simplified form they start with a basal limestone, overlain in sequence by mudstone, sandstone, seatearth (the horizon in which the coal swamp plants are rooted), and then coal (Fig. 2.9). These sequences can be seen as a competition between two different sedimentary environments – the sea and deltas. The delta progressively brings large volumes of sediment into the basin and, as with the present-day Bay of Bengal, will build up sedimentary deposits and extend these out into the sea.

*Figure 2.12: Sequence of siltstones, sandstone, seatearth, and coal with a further sequence of sandstones and siltstones above the coal. Pennine Middle Coal Measures, Hartley Bay.*

However, if the sea level rises, then the sea will retake the land surface and marine deposits, typically limestone, will be deposited. These changes in sea level are caused by cyclic changes in global climate causing the earth's ice caps to advance and retreat with consequent changes in sea level, as described in Figure 2.9.

The consequence of these cycles in this part of the geological record is the formation of repeated sedimentary layers. This includes the sandstones which are the source rocks for Hadrian's Wall. The many kilometres of cyclic and progressive sedimentary sequences means that there are substantial numbers of individual sandstone layers to consider. This provides a considerable challenge when trying to place them within a time sequence. This is discussed further in examining the complex nature of fluvial sedimentary bodies.

Understanding the linear and cyclic processes in these environments are crucial to understanding what changes and what does not for the sandstones within these sedimentary sequences. It is our potential ability to uniquely characterise sandstones through progressive changes in mineralogy or geochemistry that may allow for the identification of the source of Wall sandstones and an ability to follow their journey into post-Roman buildings. In contrast, cyclical processes, with the repetition of similar sedimentary environments through significant periods of time, may limit how precisely we can match Wall-stone to its source.

In summary, during the Carboniferous Period the large sedimentary basin in the north of England, underwent progressive as well as cyclic change. Clastic material was moved from the Caledonian mountain ranges to the north into the north of England and beyond into the Rheic ocean to the south and west of what is now England (Fig. 2.10).

## *Fluvial channels*

Many of the Carboniferous and some of the Triassic sandstones are formed in rivers. These fluvial bodies pose several problems in uniquely characterising them as source rocks. River channels are dynamic, responding to changes in weather as well as evolving over time. Daily and seasonal variations in rainfall affect the rivers' flow and will continuously modify the type of deposits being laid down. Higher flow rates will move larger clasts, and where cross-bedding is formed the size of the sets will be larger. River channels continuously migrate; winding channels erode on their outer bends and deposit on the

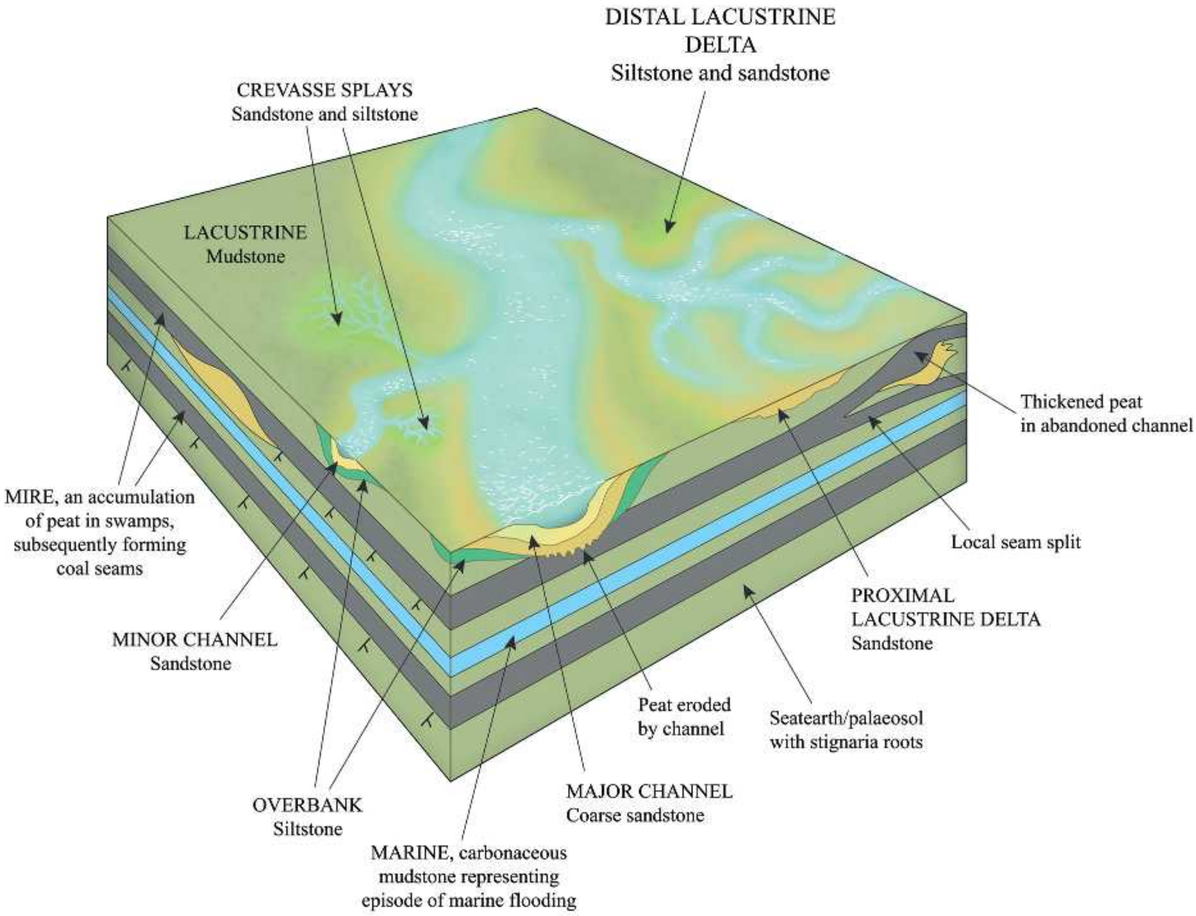



*Figure 2.13: Block diagram showing how deltaic facies relate to fluvial channels. After Stone* et al. *2010.*

inner bend, eventually cutting new channels across meanders. Over time, channels switch repeatedly to another part of the river's floodplain. Figure 2.13 gives a schematic view of the way in which fluvial channels form and create sandy deposits within a deltaic environment.

This mode of formation has several consequences. The first is that the sandstone bodies it creates are laterally discontinuous forming broad lens shaped bodies. Examples of this can be seen around Housesteads, clearly visible in the LiDAR image of Figure 2.14. The sandstones may also be diachronous, with what may appear to be a single outcrop of sandstone having formed at different times as the river channel migrates. Additionally, a detailed examination of the composition of individual sandstone units reveals that there may be a complex variety of different sandstone deposits within that one unit (Figs 2.15 and 2.16), each having formed in differing environments. This could include sand bars within the river, migrating ripples within the river channel and channel fill on the inner bend of a meander.

It is likely that the progressive changes discussed above will be overlaid on these repeated cycles so that there is some evidence of change as we move through each cycle. However, evidence for this progressive change is hard to

*Figure 2.14: LiDAR image of the area north of Housesteads and Carrawburgh. This shows a series of sandstone ridges dipping to the SSE (bottom right of the image) with crag faces (light) facing NNE. Each ridge is discontinuous, some barely 500 m and none more than approximately 4 km in length. Each ridge represents a lens-shaped body of sandstone, which at a given point at outcrop will look like a series of parallel layers. 1 m DSM data © Creative Commons licence CC BY 4.0; LiDAR via OpenStreetMap.*

find in the complex and significant variation seen within a single fluvial unit. It should also be borne in mind that a single sample taken from a given fluvial body will not be representative of the diversity of that unit as a whole. This makes comparison of that sample to Wall-stones

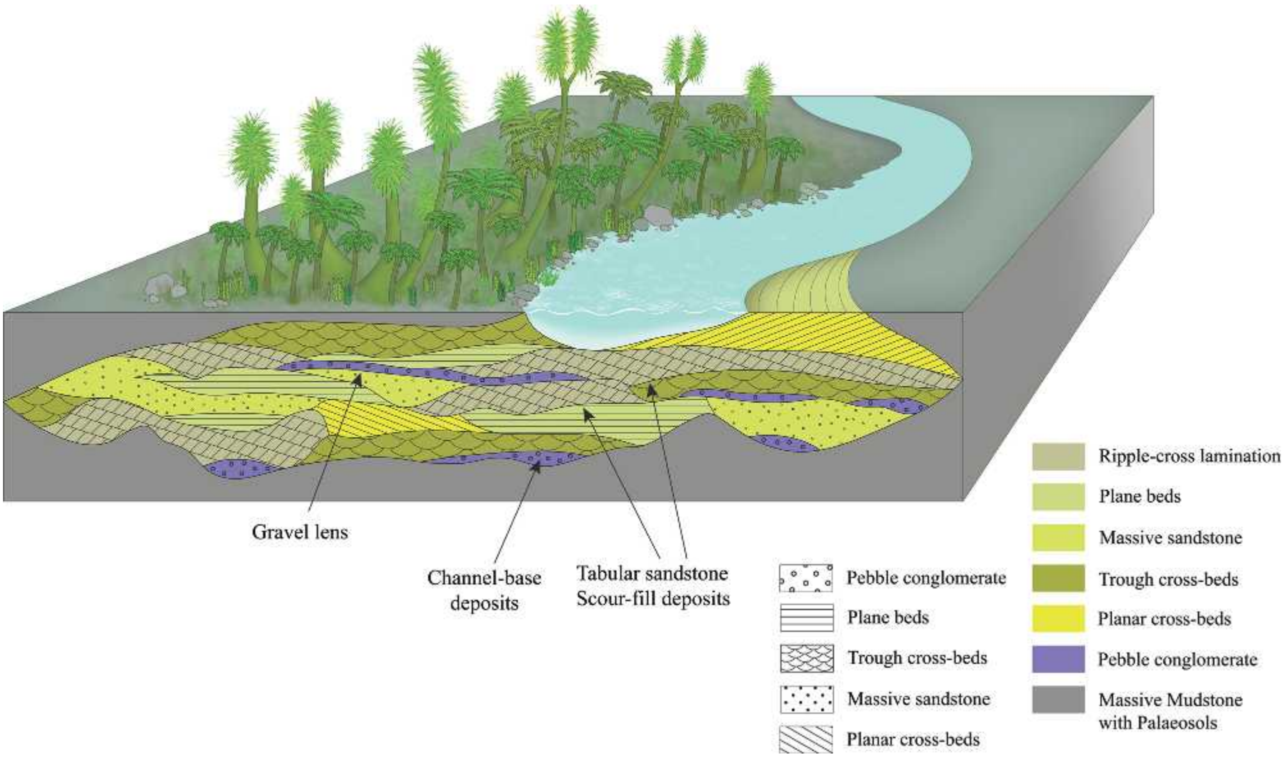



*Figure 2.15: Block diagram showing the complexity of sand bodies with fluvial channels and their relationship to the channel. Based on actual fluvial sand body, after Beaumont* et al. *2018.*

*Figure 2.16: The Table Rock Sandstone near Whitley Bay showing complex variation within this sandstone unit.*

or to sandstones from other fluvial units challenging no matter how well characterised they are as a single sample.

There is a similar problem within the cyclothems in the Carboniferous Period, which may contain several sandstone units. At a large scale, significant differences can be seen between the Yoredale Group cyclothems and those seen in the Pennine Coal group (Fig. 2.11). This is most obvious when the geological context is present so that the nature of the cyclothem may be observed – for example in the presence or absence of a marine limestone in the latter or the dominance of coal in the sequence. Again, it is possible that variation in the sandstone through progressive changes in the depositional environment, source, and diagenesis may be found. However, from a geological point of view we can characterise sandstones because of their context within the cyclothem as a whole. Once the sandstone is taken out of that context and placed in a Wall it loses that context. As above, a single sample will at best only be partially representative of the unit it has been taken from.

### *The UK meets Europe – the Variscan Orogeny and its consequences*

Towards the end of the Carboniferous Period, the Rheic Ocean closed, the action of subduction bringing the two massive continents of Laurussia and Gondwana together (Fig. 2.17). This continental collision is known as the Variscan Orogeny, and it had significant consequences for the Hadrian's Wall area. The first was that the Carboniferous sedimentary basin in the north of England went into reverse, with sedimentation slowing and ceasing at the very end of the Carboniferous Period. From this time and into the beginning of the Permian Period there was a period of uplift and erosion which lasted for approximately 50 million years. This marked a period of non-deposition, exposure, and erosion in which many kilometres of the Carboniferous strata were removed. This tectonic activity

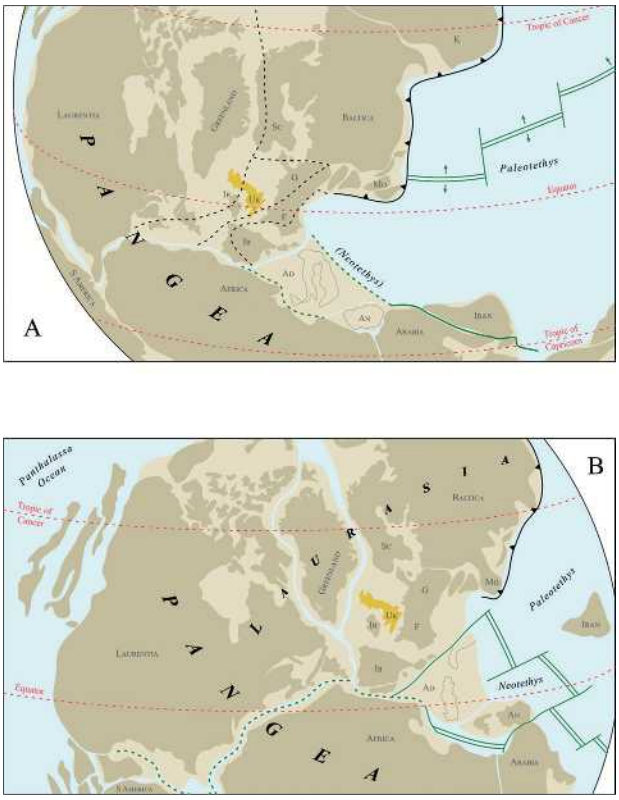



*Figure 2.17: (A) Tectonic map showing the approximate distribution of continents in the Permian Period. (B) Tectonic map showing the approximate distribution of continents in the Triassic Period, diagram after Frisch* et al. *2022. Illustration by Matilde Grimaldi.*

also folded and further faulted the Carboniferous and older strata. The lines of movement often followed pre-existing lines of weakness set up by the Caledonian Orogeny and by the subsequent faulting associated with crustal thinning in the Carboniferous sedimentary basins.

The second thing that happened was that the direction of movement of sedimentary material changed radically. This also meant that the source of clastic material and the range of mineral grains brought into the area changed. This will be discussed more fully in the next section on the Permian and Triassic rock sequence.

The final impact related to the Variscan Orogeny was the formation of the Whin Sill. Magma produced at the top of the mantle rose through the crust in dykes. The magma, however, did not reach the surface but was injected horizontally between the layers of Carboniferous sedimentary rock to form the Whin Sill. Sill is the name given to a horizontal sheet-intrusion of igneous rock. At the time of intrusion, the magma would have been a few kilometres beneath the surface, the sill being exposed by subsequent erosion. Whilst the sill typically follows the shallow dip of the Carboniferous strata so that it appears like a (very hard) additional layer in the sedimentary sequence, it also cuts across layers of strata in places and

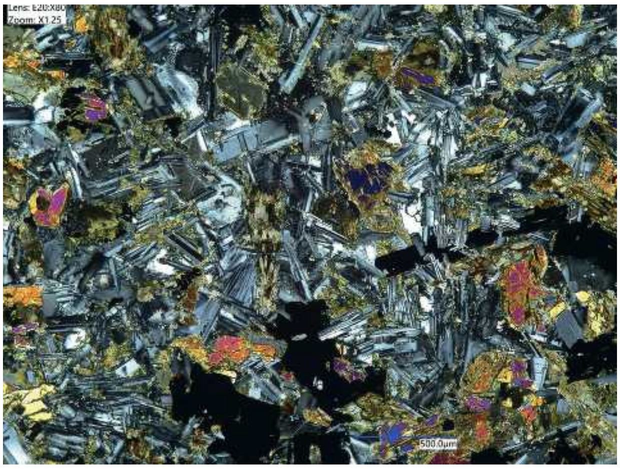


*Figure 2.18: Thin section of Whin Sill from Barrassford Quarry in cross polarised light.*

elsewhere bifurcates to form two layers of sill running parallel to each other.

The Whin Sill is basaltic in composition, and in its intrusive setting cooled to form a fine- to medium-grained dolerite. The interlocking crystals (principally of plagioclase feldspar and clinopyroxene) make it a highly durable rock (Fig. 2.18). This results in it being resistant to erosion and highly desirable as a material for paving and as aggregate for use in road surfaces.

In common with many igneous rocks as it cooled beyond its solidus temperature, *c.* 990$^{o}$C for dolerite, it continued to contract. This contraction is compensated for as a series of polygonal joints initiated at the cooling margin of the sill and running into the body of the sill perpendicular to its margin (Budkewitsch and Robin 1994). This is known as columnar jointing, which in the Whin Sill is fairly crude but nonetheless diagnostic of the igneous nature of this body of rock (Fig. 2.19). The combination of its extreme hardness and jointing which is anything but rectilinear mean that this material was not used by the Romans as facing material. Its plentiful supply in the central sector of the Wall did, however, mean that it was used extensively in the core of the curtain. Crudely shaped subtriangular blocks of Whin Sill are also used in some parts of the central sector of the Wall in the curtain's foundation, as at Sewingshields Crags close to Milecastle 35 (Fig. 2.20).

The Whin Sill is, however, an iconic component of the landscape which the Wall traverses in the central sector. Its resistance to erosion during the Quaternary ice advances has resulted in it forming upstanding ridges with a south-facing dip-slope and north-facing crags. The details of the form of the ridge are created by an interaction between the intruded form of the sill, subsequent faulting, and the exploitation of these features by ice-erosion. These details are of relevance to the way that the Wall has inhabited this space.

*Figure 2.19: Columnar jointing in the Whin Sill in a quarry at Walltown Crags.*

*Figure 2.20: Triangular-shaped blocks of whinstone used in the foundations of the Wall at Sewingshields Crags.*

## *The Permian and Triassic Periods*

Whilst the Permian and Triassic Periods have been separated into distinct geological time units for good reason, in the Hadrian's Wall area, the similarities of their palaeogeographies and global climate make it reasonable to consider them together. The sandstones from both time periods are also distinctively red, in contrast to most of the Carboniferous sandstones of the area which are in shades of white, yellow, brown, and pink. Consequently, many of the sandstones used in the western part of Hadrian's Wall are referred to under the umbrella term Permo-Triassic.

Much of the sedimentary sequence in the Permian and Triassic periods have a sparse if not absent fossil record. There is a distinct sequence of lithological units which allow for the stratigraphic progression of these periods to be traced and for individual rock strata to be located within this sequence. However, tying this sequence to an absolute geological time is problematic. This, combined with the poor surface exposure of rock, a consequence of the extensive surface cover of glacial till, can lead to uncertainty in categorising source rocks. There are additional problems in characterising potential source rocks from these periods of time, linked to the hybrid nature of their formation, which are discussed in more detail later in this section.

## *The Permian Period (298–252 MYA)*

By the time that a record of sedimentation started to be preserved once more in the middle Permian, there had been a significant change in the environment. Two major things had happened. First, by this time continental drift had moved the UK's location further north away from the equator, moving from equatorial to tropical and subtropical latitudes (Fig. 2.17). At the beginning of the Permian the area was located at 10$^o$ north and progressively moved to 30$^o$ north by Triassic times. Secondly, the UK was now located in the middle of the newly formed Pangaean continent, whereas previously it was at the margin of the Laurasian continent during the Carboniferous Period (Fig. 2.8). This new intra-continental location significantly changed the UK climate to something hotter and drier. This change not only affected the UK but had wider implications as the massive belt of deltaic coal swamps which stretched from the US through the UK and on to China disappeared. Global climate cooled during the early Permian with evidence that bipolar ice caps reformed, but as the Permian progressed, the global climate headed back up in temperature. This trend was given a further significant nudge in this direction during the late Permian as a consequence of a massive effusion of lava from the large igneous province of Emeishan. $CO_2$ released from this series of eruptions moved the global climate back towards a greenhouse earth with no polar ice (McGhee 2018). At the boundary between the Permian and Triassic this was taken one step further as the vast eruptions of the large igneous province of the Siberian Traps took place. The consequences of this series of eruptions were catastrophic to the biosphere, causing the largest extinction event in the earth's history (Benton 2003). It is surprising how little of this extraordinary event is reflected within the rocks of either western or eastern basins which frame Hadrian's Wall. This is largely because the sedimentary environments which prevailed were poor at preserving any sort of fossil record. The changes which can be observed are a consequence of changes in sea level within the context of a continuing record of a very hot climate.

All of this is reflected in a range of paleo-environments that are common in desert conditions – wind-blown sand, draa (large compound dunes), harmada (stony desert with rocky plateaus and wind polished stones which have been stripped of sand by the wind), sabkha mudflats (supratidal mudflats formed of a combination of evaporites and clay

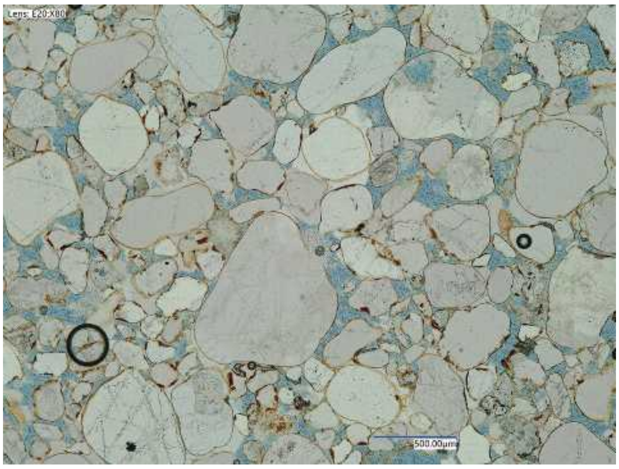



*Figure 2.21: Image of the Penrith Sandstone in thin section from near Lacy's Cave north of Penrith.*

*Figure 2.22: Inside Lacy's Cave near Little Salkeld which was excavated in the Penrith Sandstone Formation.*

mixed with aeolian sand), playa lakes (temporary lakes formed in arid environments – as with Sabkha formed of clay mixed with aeolian sand), evaporites (formed when part or the whole of an intra-continental sea dries out leaving salt deposits including halite, anhydrite and gypsum), and intra-continental fluvial systems which dry up before reaching a sea or permanent lake.

For Hadrian's Wall the landscape was divided into two sedimentary basins by a broad area of higher non-depositional land roughly along the line of the Pennines. To the east the intra-continental Zechstein Sea developed, with the sequence of rocks preserved on the Durham coast and in outliers just north of the Tyne representing sedimentation on the margins of this sea. To the west a series of connected and more linear basins developed, including the formation of the Bakevellia Sea, broadly aligned with the Irish Sea, and with arms stretching across to the Midlands and down to the Dorset coast, into the Eden Valley and up towards the Tyne gap (Fig. 2.10D).

To the west the early Permian is only recorded as an eroded, reddened and oxidised surface of low undulating land exposed to the hot Permian sun. Desert sand would have blown across this surface and accumulated in hollows while elsewhere the sand found its way into cracks in the underlying Carboniferous rocks. The first strata recorded in the Permian here are grouped together in the Penrith Sandstone Formation. At the base of this formation is the Brockram, a breccia which was was deposited from alluvial fans spreading out from the highlands of the Lake District, Pennines and Southern Uplands. The Brockram is highly variable in thickness (attaining a maximum thickness of 150 m) and is interdigitated and overlain by the Penrith Sandstone. The Penrith sandstone is aeolian in origin suggesting Draa, with its complex large-scale sand dunes producing petrologies that are highly characteristic (Fig. 2.21). There are some beds which are fluvial in origin but are rare. The Penrith sandstone is principally confined to the Eden Valley (Fig. 2.22), though a separate, thinner set of sandstones attributed to the Penrith Sandstone Formation has been recorded at depth in the Carlisle area (Stone *et al.* 2010).

The lateral equivalent of the St Bees sandstone in the east is the Yellow Sands formation. These are also draa deposits but are preserved as crumbly yellow pyritic sandstones.

The Penrith Sandstone is succeeded in the western basin by the Eden Shales. This along with the marl slate and succeeding limestones in the eastern basin mark a significant change in sea level. This may well be associated with the final melting of the Permian icecaps marking the end of this extended Palaeozoic ice-house climate (McGhee 2018). This change in sea level resulted in the formation of the Bakevellia Sea in the west and the Zechstein Sea in the east (Fig. 2.10D). The Eden Shales formation overall is complex but in the vicinity of Hadrian's Wall can be regarded as a series of shales interbedded with poor quality sandstones. These were formed in sabkha like environments at the margin of the Bakevellia sea and crop out adjacent to the Wall in the Brampton area.

### *The Triassic Period (252–201 MYA)*

The tectonic setting of the Triassic Period remains similar to that of the Permian (Fig. 2.10D) with the UK still at the centre of Pangea, albeit with the first signs of opening seaways which mark the ensuing Jurassic Period. It does, however, see a significant change in the nature and source of sediment with a continued development of the basins opened up in the Permian Period (Fig. 2.10D). The later Permian Eden Shales are overlain unconformably by the St Bees Sandstone Formation. This marks a switch from marine and basin margin conditions to a fluvial

*Figure 2.23: Horizontal and cross-bedding structures in the St Bees Sandstone at St Bees Head.*

environment. A major river system – the River Buddleighensis – formed, bringing clastic material from the Amorican highlands (formed during the Hercynian orogeny), which combined with more locally derived material from the Lake District and the Southern Uplands. As the sedimentary basin continued to subside, a significant thickness of sandstone developed. These are beautifully exposed in the cliff sections around St Bees Head and on the foreshore at Maryport. The outcrop of St Bees sandstone also extends all the way around the Carlisle basin, with obvious exposures in river sections.

Characteristic bedding and uniquely fluvial features such as water escape structures make the red St Bees sandstones relatively straightforward to distinguish from the red sandstones of the Penrith Sandstone Formation (Fig. 2.23). Typically, the Penrith sandstones are a more salmon-pink dusty red colour compared to the more purple-red of the St Bees Sandstone. In thin section the two are easy to distinguish.

The St Bees Sandstone Formation is succeeded by the Kirklinton Sandstone Formation (in Fig. 2.1, the Kirklinton sandstones have been grouped with the St Bees Sandstone Formation). This is a local lithostratigraphic name and this unit has more recently been renamed as part of the Helsby Sandstone Formation. For this study the older name is used as it has more immediate meaning for this area. The Kirklinton sandstones mark a generalised change back to desert conditions, with the River Budleighensis rerouted into the Midlands and wind-blown sand tending to be sourced from the north east. However, there are also fluvial units within the Kirklinton sandstone.

The Kirklinton sandstones are often of poor quality. They are also problematic to identify as they have both fluvial and aeolian elements. In thin section, it has so far not proved possible to distinguish fluvial sandstones from the Kirklinton formation from samples of the St Bees sandstone.

Towards the close of the Triassic, marine and coastal environments were re-established in which rocks of the Mercia Mudstone Formation were laid down. This group of rocks underpin the Carlisle basin and all the Wall west of Carlisle and are very poorly exposed, mantled in glacial till as they are. This group of rocks consist of mudstones, marls and evaporites (including halite and anhydrite).

The Mercia Mudstones are succeeded by the Penarth Group marking the onset of the more fully marine conditions of the Jurassic Period. These crop out in a small area just south of the Wall around Orton.

### *The Palaeogene Period (66–43 MYA)*

Evidence from the Jurassic and Cretaceous strata that has been preserved in Yorkshire, the Midlands, and the south and south-west of Britain suggest that sediments from these geological periods were laid down over much of central and northern Britain. However, erosion, following uplift in the subsequent Palaeogene Period, has meant that these strata have been almost entirely removed.

The only rock formed during the Palaeogene period within the area are the basaltic dykes of the Mull Dyke Swarm. They are included here for completeness, because they are possible (albeit improbable) sources of Wall-stone and because they mark a new tectonic regime associated with the opening of the Atlantic Ocean. The Caledonian and Variscan Orogenies influenced the setting for Carboniferous and Permo-Triassic sedimentation respectively. This precursor to the formation of the Atlantic Ocean, along a new constructive plate margin, set the scene for the subsequent erosion and deposition cycles of the Quaternary ice age.

The rifting along the northwestern margin of Scotland generated large volumes of magma which can be seen in the volcanic centres of Arran, Ardnamurchan, Mull, and Skye amongst others. This tectonic activity also reactivated long-standing lines of weakness in the northern borderlands crust and re-elevated buoyant areas of crust. The elevated areas include the Southern Uplands, the Cheviot Volcanic Centre, the Pennines and the Lake District. It also includes the Askrigg and Alston blocks with their subsurface granites. This, then, sets the topographical scene within which the icesheets of the Quaternary Period operated.

Magmatism from the Palaeogene Period was not constrained to the spectacular igneous centres in the northwest of Scotland but fingered its way right across the country as a dyke swarm. These dykes cross the entire country with outcrops on the Northumberland and Durham coast, radiating from the Isle-of-Mull igneous complex. Members of the Mull dyke-swarm, whilst they do not underly the Wall (with the exception of the Wallbottle Dyke immediately east of Wallbottle), can be found in outcrops close by. The dykes include the named Wallbottle Dyke and Hebburn Dyke, and other dykes are recorded at Tynemouth Pier, Westerhope, and Tipalt Burn (Fig. 2.24).

Figure 2.24: Palaeogene dyke by Tynemouth Pier.

Figure 2.25: Grooves cut into the surface of sandstone by the movement of ice, near Fallowfield.

The Neogene Period which succeeds the Palaeogene Period has no recorded rocks. During both periods the global climate was hot with no polar ice caps present. Towards the end of the Neoeogene the climate started to cool as the planet headed towards its latest ice age and a period of time when the earth has polar ice caps.

### *The ice ages of the Quaternary Period (2.58 MYA to the present)*

The ice ages were responsible for shaping the landscape into which the Wall was built. They were also responsible for creating the mantle of material which immediately underlies the Wall, as well as providing some of the material used in its construction. Each of these will be considered further after summarising the process and impact of this latest period of geological time.

The beginning of the Quaternary Period is marked by the first evidence for polar ice, in the form of ice-rafted debris in the Atlantic marine sedimentary record. The Quaternary Period ends in the present day and includes the Holocene Epoch, which covers the time from the end of the last major advance of ice to the present day.

The Quaternary period is marked by over 50 significant oscillations in global climate (Stone *et al.* 2010; Zalasiewicz and Williams 2012). These are correlated with changes in the amount of the sun's heat captured by the earth – a consequence of progressive and cyclic changes in the way the earth rotates around the sun (Milankovitch Cycles) – and with the amount of $CO_2$ in the atmosphere. These changes in global temperature caused the advance and retreat of ice. This was, in turn, the dominant factor in shaping the landscape of Hadrian's Wall.

Ice operates on the landscape in a variety of different ways. It is capable of weathering, eroding, and transporting large amounts of rocky material. Having transported this material, the ice leaves behind huge sedimentary deposits which take many different forms.

The combination of the weight of the ice and the entrainment of clasts from clay to boulder size, can make the movement of ice over the land surface very effective at scouring the rock surface (Fig. 2.25). Patterns of erosion are controlled by the nature of the rock which the ice transits. The hardness of the rock governs its resistance to the erosive power of the ice such that hard rocks, for example sandstones and igneous rocks like the Whin Sill, are left in ridges as the softer material around them is eroded away. The orientation of rock layering relative to the direction of ice movement also makes a difference to the way that erosion takes place. Movement of the ice parallel to the layers of rock allows softer layers of rock to be more effectively scoured. This is well displayed in the central sector of the Wall around Housesteads where layers of sandstones and limestones along with the obvious ridge of the Whin Sill are picked out (Fig. 2.14). Softer sediments which have been plucked out by the movement of ice have here been infilled by loughs and mires. Where the movement of ice is discordant with the rock layering the ice tends to smear glacial till into the valleys between ridges of harder material partially


*Figure 2.26: Drumlins south of Bowness-on-Solway showing strong alignment E–W along with the drumlins under the Wall at Bowness and Drumburgh. LiDAR via OpenStreetMap.*

*Figure 2.27: Glacio-fluvial deposits at Farnley Scar eroded by the River Tyne into cliffs rising to 55 m.*

smoothing the landscape. This effect can be seen in areas like Heddon-on-the-Wall where there is a smooth transition from the centre of Heddon where sandstone is exposed at the surface through to areas covered in deep till down towards Throckley.

This interaction of deposition and erosion is also seen where ice sheets traverse low lying undulating terrains. Here thick deposits of glacial till can accumulate, on which drumlins are commonly formed. These low-lying egg-shaped structures are sculpted by the movement of ice and are useful indicators of the direction of movement (Fig. 2.26). At the west end of the Wall, in the low-lying land bordering the Solway Firth, drumlins provide raised land which was exploited by the Romans to build the Wall. Port Carlisle and Drumburgh are both sited on top of drumlins.

The retreating ice also left its mark on the landscape. As the ice melted it created large volumes of water and fluvial channels in which reworked glacial material was deposited. Sizeable fluvioglacial deposits may be seen, for example, stacked against the side of the River Tyne at Farnley Scar just south of Corbridge (Fig. 2.27). Here the River Tyne has subsequently eroded into this massive bank of fluvioglacial material. On occasion, retreating ice will block the drainage routes for the ice meltwater creating glacial lakes. This occurred in the Carlisle basin towards the end of the latest glaciation (approximately 15–20,000 years BP) creating glacial Lake Carlisle within which significant fine-grained deposits of mud (clay) and silt were laid down. Similarly in the east, meltwater from the retreating Pennine ice stream was trapped by North Sea coastal ice forming the glacial Lake Wear. This lake extended over an area from Sunderland, through the Team Valley and right the way across to the northern shore of the River Tyne around Newcastle. As with glacial Lake Carlisle these lake deposits now form significant sources of clay.

The pieces of rock contained within ice-generated sediments can be used to understand where ice sheets have eroded and transported rock from. In previous sections on sandstones the effects of provenance on the geochemistry and petrology of the sandstones were discussed. A similar thing can be done with the ice-laid deposits, but because these contain pebble- to boulder-sized samples of source rock, in principle, this is easier to do. For example, a highly distinctive sample of igneous rock was collected from glacial deposits near to Gilsland. Research into this material showed that it was likely to have been sourced from one particular lava flow within the Eycott Volcanic Group, which crops out on the flanks of Blencathra in the Lake District (Fig. 2.28). This demonstrates that ice was eroding and transporting material north and east from the Lake District. This type of approach has been used to characterise the glacial tills found throughout the Hadrian's Wall landscape.

The direction and extent of ice floes are strongly related to the major topographic units which were formed during the Palaeogene and Neogene. The Hadrian's Wall corridor itself is broadly aligned with an ice floe through the Tyne Gap from west to east. The interaction of this floe with the underlying bedrock is the dominant control on the form of the landscape.

In simplified terms the ice floes can be thought of as being bracketed to the east and west by large coastal floes of Scottish ice. These ice floes competed with ice flowing from the highland areas of the Galloway Hills, Southern Uplands, the Cheviots, the Lake District and the Pennines. Their interaction during the many advances and retreats of ice is complex. Interpretation is hard, as much of the sedimentary evidence for what happened in earlier episodes is obliterated by later ice advance,which eroded and reworked much of the glacial till previously deposited. In consequence much of the glacial stratigraphy is divided into two major groups – that from the most recent phase of ice advance and that from all the earlier episodes.

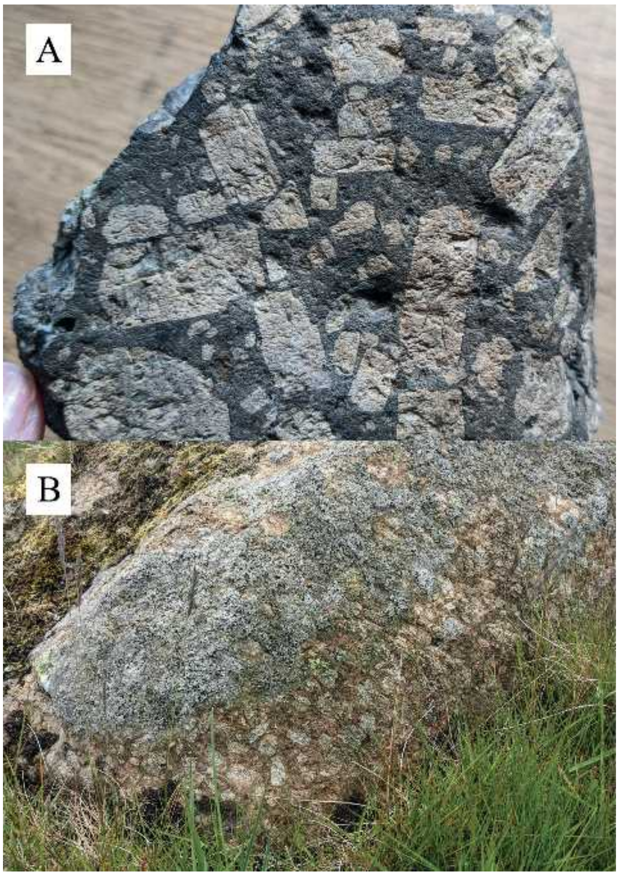



*Figure 2.28: (A) Glacial erratic with characteristic very large feldspar phenocrysts found near Gilsland. (B) Outcrop of lava with very large feldspar phenocrysts at Eycot Hill near Blencathra – a good match for the erratic.*

This most recent ice advance occurred during the Devensian Stage between 116 KYA and 11.55 KYA. Glacial tills from this period are referred to as the Caledonia Glaciogenic Group and those deposited prior to the Devensian as the Albion Glaciogenic Group (previously referred to as the Older Drift). The tills from the Caledonia Glaciogenic Group (the Devensian) are categorised into subgroups based on region and the provenance of clasts contained in the tills. Hadrian's Wall crosses two of these subgroups, the Irish Sea Coast Glaciogenic Subgroup (From Bowness to east of Carlisle) and the North Pennine Glaciogenic Subgroup (from East of Carlisle through to Newcastle). It also touches the Central Cumbrian Glaciogenic Subgroup just east of Carlisle and the North Sea Coast Glaciogenic Subgroup at Wallsend.

The provenance of the Irish Sea Coast Glaciogenic Subgroup clasts includes the south of Scotland, the Eden Valley, the Lake District and the Irish Sea floor. These clasts commonly include Palaeozoic greywackes, siltstones and granites and Permian sandstones (Fig. 2.9).

The provenance of the North Pennine Glaciogenic Subgroup are principally the raised areas of the Pennines to the north and south of the Tyne Gap but does include some material from Scotland and the Lake District. Clasts include a preponderance Carboniferous sandstones and limestones with less common clasts from the more distal Palaeozoic greywackes, siltstones, and granites.

## The Wall and its source geologies

The materials found within the Wall are a close match to the geology which underpins it at any given location. It is not an exact match as material to build the Wall was transported to the Wall, the distance depending on the availability of stone and the ease of transporting this stone to the Wall. In the central sector these distances are likely to be short given the ready availability of stone sources close to the Wall. In the western sector, of necessity the distances are longer with the possibility of extended transport routes possibly over long distances.

It is from the underlying solid geology that the sandstones for the facing and foundation stones along with some of the core would have been drawn. Looking at the solid geology which the Wall crosses, the stone sources can be divided into five categories (Fig 2.1).

1. The Western Sector from Bowness to just west of Hare Hill: in this category the underlying geology is of the Permian and Triassic Periods. Because the solid geology is, more often than not, buried in glacial till and the immediately underlying rocks offer no good quality sandstones, stone for the Wall in this category has to be brought to the Wall from the east or from surrounding outcrops to north and south.
2. The Central Sector from just west of Hare Hill to Gilsland. This category is underlain by the Tyne Limestone Formation which offers a range of proximal sandstones and limestones.
3. The Central Sector from Gilsland to High Brunton. This category is underlain by the Alston Formation which offers a range of proximal sandstones and limestones. However, it should be noted that between Limestone Corner and Thirlwall Castle the Stainmore Formation (to the south) and the Tyne Limestone (to the north) run sufficiently close to the Wall that they are potential sources for Wall-stone.
4. The Eastern Sector from High Brunton to Heddon-on-the-Wall. This category is underlain by the Stainmore Formation. This category also offers proximal sandstones and limestones.
5. The Eastern Sector from Heddon-on-the-Wall to Wallsend. This category also offers proximal sandstones but no limestones.

The eastern Permian rocks do not feature in this list as they do not at any point underpin the Wall. However, the absence of limestones within the Pennine Coal Measures Formation would mean that sources of lime would have

*Figure 2.29: Possible re-used Wall stones of St Bees sandstone at St Michael's Church, Burgh-by-Sands. Gravestones also made of St Bees sandstone.*

had to be sought either further to the west beyond Heddon-on-the-Wall or to the south on the other side of the River Tyne. Permian magnesian limestones crop out in the cliffs and foreshore southwards of Trow Rocks (near South Shields) in very large quantities. These would have been easy to transport by sea and river to Wallsend. The Yellow Sands Formation from the eastern Permian succession (the lateral equivalent of the Penrith Sandstone Formation) whilst within similarly easy transporting distance is a poor-quality sandstone and there is no evidence of it being used in the Wall.

The Palaeoegne dykes of the Mull dyke swarm also do not feature in these five categories. They underpin the Wall at one location and come within easy transport distance in categories 4 and 5. They are, however, unlikely to have been used in any significant way to construct Hadrian's Wall. As with the Whin Sill, this hard material with uneven jointing would have been a poor choice for facing material on the Wall. It is remotely possible it was used within the curtain core, but there is no evidence that this has happened.

Wall stones in Category 1 can be seen *in situ* at the one remaining piece of visible wall at Port Carlisle. Re-used Wall-stones can also be seen in Drumburgh Castle, St Michael's Church Brugh-by-Sands and St Michael's Church Bowness on Solway (Fig. 2.29). Probable facing stones were also excavated by WallCAP at the Cam Beck site (Collins and Harrison 2023). All of these suggest that the principal source rock was the St Bees Sandstone Formation. The accessibility and transport routes for this material are further discussed in Chapter 4.

There is also a possibility that has been raised from the excavation at Cam Beck that the Kirklinton sandstone was used in the Wall. This sandstone is problematic to identify as it has both fluvial and aeolian elements. In thin section, it has so far not proved possible to distinguish fluvial sandstones from the Kirklinton formation from samples of the St Bees sandstone. It is a poor-quality sandstone, though it may have provided a good source of core material and it is conceivable that it may have been used as facing stone.

The Permian Eden Shales and Triassic Mercia Mudstones and the Jurassic Penarth Group which underpin the Wall at locations in this category (albeit buried under glacial till) offer no viable building material.

Categories 2–4 can be considered together, as the palaeoenvironmental conditions were similar for each of these formations, albeit with some variation in the proportion of limestone to siltstone to sandstone. Petrographic work done on the sandstones in these categories (see Appendix 2) showed significant variation between the many

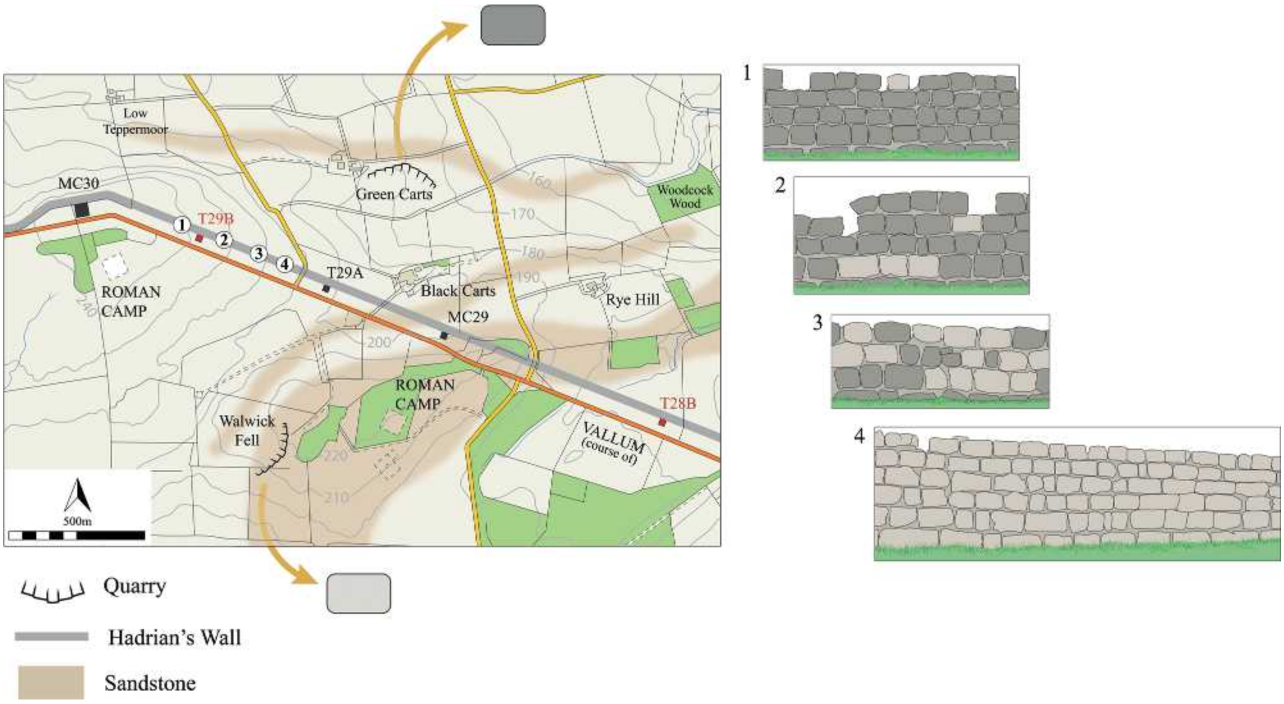



*Figure 2.30: Illustration showing the way that the proportion of two different types of sandstone varies at four locations along the curtain (1–4) between Limestone Corner (MC30) and Black Carts Farm. The illustration also shows a speculative idea on where these sandstones may have been sourced. It is likely that they are from local sandstone units (their outcrop pattern is illustrated), and at Green Carts and Walwick Fell there are the remains of small quarries. Illustration by Matilde Grimaldi.*

individual sandstones in each of these formations, but no common characteristics which would allow for a categoric distinction between sandstones from different formations.

Category 5 has many similarities to categories 2–4, and whilst there are some characteristics gleaned from petrographic analysis, it would be challenging to give a categoric distinction of Pennine Coal Measures Formation sandstones from the other, older formations in the Carboniferous sequence.

There are some specific exceptions to the difficulties in categorising the Carboniferous sandstones. Where a particular sandstone has unusual characteristics, these maybe used to give a better link to the source geology. For example, the Heddon stone is an unusually gritty and poorly sorted sandstone, yet of a high quality for building work. This stone is easily recognisable in the curtain wall at Heddon, giving a high confidence that the Romans used this stone despite all evidence of quarrying being obliterated by subsequent quarrying activity.

Similarly, there is a poor-quality brown sandstone, which is intermixed with a higher quality, homogenous grey/white sandstone at Black Carts. This sandstone contains rip-up clasts which weather out to give this fine-grained sandstone a blotchy texture. It would seem likely that a more detailed search of the four or so sandstone units in the vicinity of Black Carts would reveal the source of this distinctive stone. Identifying these two distinct sandstones here, also allows for some speculation about the way that stone was brought to the curtain and used. Figure 2.30 shows how the proportion of each stone type progressively changes along the Wall's route and a speculative idea on where the different stone were sourced. Towards the top of the hill, only the brown blotchy sandstone is used and at the bottom of the hill by the turret only the homogenous grey/white sandstone is used. In between the proportion of stone changes progressively rather than abruptly. It can be conjectured that two separate quarries were active at the same time, stone being dumped near to the Wall and then brought to the Wall from whichever heap is nearest and most plentiful.

To further understand the relationship between Wallstone and source, this points towards the need to look in even more detail at individual sandstone units and Wallstones, rather than searching for generic formation-wide characteristics.

The remaining geological materials to consider are glacial and fluvioglacial materials which are ubiquitous across the region. Glacial deposits, either as till or fluvioglacial deposits, would have been an obvious source of fill both for packing the core of the Wall curtain and for constructing cobbled surfaces. Examples of these were found at Port Carlisle, Cambeck, and Corbridge (Collins and Harrison 2023). Core material from the curtain at Port Carlisle was dominated by cobbles of greywacke. At Cambeck, a wider range of clasts were found including greywackes, granites and indurated sandstones of unknown provenance. At Corbridge, just outside the Roman town, it is hard to be certain whether clasts of local Carboniferous sedimentary rocks are derived from glacial deposits or from recent fluvial deposits. However, clasts of greywacke, granite, and an altered porphyritic lava were found during excavation, which points to an origin from glacial till or more likely fluvioglacial deposits in which the till has been reworked (Fig. 2.9).

Tills may also be a source for clay used in binding the Wall's core. Clays deposited in Glacial Lake Carlisle and Glacial Lake Wear may well have been an important source of clay for this purpose. These tills and glacial lake clays may also have provided the source material for tile and brick manufacture albeit these are not commonly used in structures along the Wall. An example can be found at Chesters fort.

# 3

# The use of stone along Hadrian's Wall

A detailed understanding of the use of stone for Hadrian's Wall requires a layered approach to the Wall. In the first instance, the Wall is not merely a simple stone-built curtain, but a monumental complex of interrelated features. Added to this, over a century of archaeological excavation has revealed and clarified the so-called building sequence of the Wall, identifying aspects of design, those that were built first, and subsequent changes during the construction process. The building sequence and the substantial literature that relates to it has also contributed to another layer in understanding the Wall – the illusion of uniformity. That illusion often masks a diversity of detailed information that distinguishes differences in the innumerable localities that make up the entire Wall monument, diversities that also increase with time in the following 270+ years that the Roman army garrisoned the Wall. A key point to remember is that the range of building styles and plans, even for those structures built at the same time, all indicate that the Romans did not use detailed architectural plans.

The aim of this chapter is to provide an interpretation of the Wall as a building project and physical asset, such that the logistics and infrastructure of its construction and maintenance can be assessed. This requires a basic understanding of many general aspects of the Wall, such as the different elements that make up the complex, and the Hadrianic building sequence and other dates of key changes to the Wall as a monument (see Chapter 1). It also requires a more zoomed-in approach to examine the practice of building and the use of stone at a very localised level. This reveals consistencies in practice, but also the diverse geological fabric used by the Wall-builders (and repairers) and how different styles of building contributed to a coherent monument. The long use-life of the Wall as a Roman military monument also introduced further changes in its various constructions and repairs, in part related to access and availability of building materials as well as the skills of those doing the work.

## The builders and their tools

It is uncertain who first conceived of a monumental wall that stretched across the Tyne-Solway isthmus of the northern, Roman province of *Britannia*, but the conceptual design or plan has been reasonably attributed to the emperor Hadrian (Breeze 2009). Marshalling the resources of an empire, Hadrian was able to set three legions to undertake the work of this imperial project. And it should be understood as an *imperial project*, a curtain wall stretching 80 Roman miles and consisting of 80 milecastles and 160 turrets was a monumental endeavour. The scale and politico-security implications of the Wall, which required the skilled labour and resources of legionary engineers and builders, must have required the emperor's approval.

Army surveyors were responsible for setting out the course of the Wall, presumably following the brief or plan handed down by Hadrian. In the central upland sector, the Wall follows the forward line of the crags established by the Whin Sill, but in the eastern and western sectors, it is argued that the course of the Wall was plotted 'outward' toward each sea, that is to say to the west in the western sector and to the east in the eastern sector (Poulter 2009). Three legions were employed in the construction of the Wall at any one time. Inscriptions provide direct evidence for the engagement of soldiers from the 2nd, 6th, and 20th Legions, and it is possible – if unproven – that the 9th Legion was also involved in building work prior to its uncertain fate and the arrival of the 6th Legion (Graafstal 2020, 142).

Though legionary soldiers were the primary builders of the Wall, there is also evidence for other soldiers. An inscription from Benwell (RIB 1340) credits the *classis Britannica* – the naval fleet of Britain – as the builders of the granaries at that fort in the reign of Hadrian. The *classis Britannica* is also testified on two building stones similar to centurial stones, indicating their involvement of building the Stone Wall west of Birdoswald (RIB 1944,

1945) in either the later Hadrianic period (*c.* 130–138) or in the 160s; the exact date of rebuilding the Wall in stone from its original turf is unknown west of Wall-mile 54. Cavalry troopers under command of Lucius are credited with construction west of Brunton turret (26b), with the presumption that these are auxiliary soldiers rather than legionaries (RIB 1445; Tomlin 2018, 111). It is certain, however, that auxiliary soldiers were responsible for construction of the Vallum near Benwell (RIB 1365). As the occupants of the forts along the Wall were auxiliary soldiers, they were almost certainly responsible for and involved in subsequent repairs and rebuilds of their host forts and also the Wall curtain and installations, perhaps with support of the 6th legion based at York and the 20th legion based at Chester. The recent discovery of an altar at the fort at Binchester (Co. Durham) provides evidence of an engineer, an *architectus*, in an auxiliary cavalry *ala* (Tomlin 2018, 112).

It is unknown to what extent slave labour was part of building the Wall. It is possible, even probable, that slaves were involved in various parts of the building process, be it quarrying, or transport of materials, or as part of the building parties. The Roman army was a major slave-owning institution, with enslaved persons owned by the unit, supplemented by 'personal' slaves owned by individual soldiers. It is feasible that the legions building the Wall employed their pool of slaves to contribute to the project, while slaves owned by individual soldiers almost certainly indirectly contributed through the support and labour undertaken at the behest of their owners. So, while slaves may or may not have directly quarried stone or placed any shaped stone on the Wall, it is likely that they contributed to the project more indirectly, preparing meals, laundering or repairing clothing, and other tasks that directly supported the soldiers that owned them.

A small number of inscriptions from the central and western sectors of the Wall name building parties from three southern *civitates* of Britain, the Durotraces Lendinienses, the Dumnonii, and the Catuvellauni (RIB 1672, 1673, 1843, 1844, 1962, 3376; possibly also 2022). The exact dates of the inscriptions are debated, and have ranged from the later 2nd century to the late 4th/5th century, but what is certain is that the inscriptions attest to civilians involved in repairs or rebuilds of the Wall, probably the curtain. The interpretation favoured here follows that of Fulford (2006) and Breeze (2012), that they probably date to the later 2nd century when the Turf Wall was replaced with the Stone Wall, when *Britannia* was still a single province, allowing the governor to allocate workers from the south of the province north up to the Wall. Hassall (2010), however, sees the later 4th and 5th centuries as the period in which civilians were more frequently legally obliged to undertake duties of supply and repair of military assets. Dating issues aside, these inscriptions provide evidence for civilian involvement with some repair/rebuilding of the Wall.

All the builders, whether military or civilian, had access to the same tools. These are all recognisable and often still used today, including shovels, picks, mattocks, hammers, chisels, punches, wedges, saws, and files (Hill 2004, 55–63). Examples of these tools have been found at various sites along the Wall, and point to their ubiquity in antiquity (Allason-Jones and Miket 1984; Russell 2013), though the fact that these tools have changed very little over the course of 3,000 years can make it difficult to assess the date of any given tool or toolmarks, should archaeological context be absent. The presence of toolmarks on objects, particularly stone, does have the advantage of informing how stone was prepared in advance of building. The quality of finish of a stone or other object, too, provides a crude evaluation as to the competency and skill of the producer. Quality and toolmarks, however, are not exclusive to builders of any particular period.

It is difficult to be certain exactly who built any given portion of Hadrian's Wall. Dedication inscriptions often provide testimony to the soldiers that completed a structure, such as a milecastle, or the gate, granaries, or other structure at a fort. However, the detail of plans associated with milecastles and turrets has provided identification of particular forms or types, and these can be loosely correlated to builders that probably originate from one of three single legions (Table 3.1). The underlying assumption is that soldiers of a given legion built to a basic 'standard plan' turret or milecastle. Certainly, the variation in plans and execution of turrets and milecastles along the Wall highlights that different legions probably shared the same brief or very similar instructions, but these were text based rather than visual. Visual aids or guidance were more likely to be sketches or templates, and not detailed architectural plans. Furthermore, plotting out these different plans of milecastles and turrets allows for discrete 'building lengths' of the Wall to be identified, linking not only these structures but also the curtain to specific legionary building parties. Table 3.1 highlights that five-mile blocks were assigned to a particular legion, and within such a block, shorter lengths were broken down by cohort and then century, as evidenced by inscribed centurial stones preserved in surviving stretches of curtain (Breeze 2006, 58). There are, of course, limits to the correlations that can be made. In the first instance, where turrets or milecastles have not been found or where they have been completely destroyed, key attributes cannot be identified and correlated to a legion. In the second instance, these correlations are only relevant to the initial phase of construction of the Wall in stone, and there is no evidence that they have any bearing on subsequent rebuilds or repairs.

## Building materials

When initially built, the eastern two-thirds of the Wall curtain and milecastles were built in stone, while the

*Table 3.1: Correlation between legionary builders and particular plans of milecastles and turrets, as observed for the Stone Wall and the Turf Wall, positioned east-west.*

| STONE WALL | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Legion* | *Wall miles* | *Milecastles* | | | *Turrets* | | *Wall curtain gauge* |
| | | *north–south axis* | *gate type* | *setting-out line* | *door position* | *wall thickness* | |
| B | 7b–12 | long | II/IV | internal | east | narrow | Broad A |
| A | 12a–17 | short | I | internal | east | broad | Broad A |
| C | 17a–22 | long | III | external | west | narrow | Broad B |
| B | 22a–36a | long | II/IV | internal | east | narrow | Broad A |
| C | 47–Irthing | long | III | external | west | narrow | Broad B |

| TURF WALL | | | |
|---|---|---|---|
| *Legion* | *Wall miles* | *Milecastle north–south axis* | *Turret door position* |
| B | 49–54 | long | east |
| C | 54a– | *unknown* | west |
| B | –64– | long | east |
| A | 78–79 | short | *unknown* |

*Figure 3.1: Limestone blocks with fossilised* Siphonodendron *used to construct the bridge abutment at Willowford crossing.*

western third was built in turf and timber. All turrets seem to have been built in stone. Chapter 4 focuses on quarries and the act of extracting stone for the construction and repair of the Wall, but it is useful to consider the stone as building material here.

The facing stones and other dressed structural stones are almost universally made of sandstone. The only observed exceptions to this are two limestone blocks used in the Willowford bridge abutment (Fig. 3.1) and some Whin Sill dolerite noted by Crow (1991, figs 1, 2) at Highshields Crags and Peel Gap. Sandstone has the advantage of both being durable and amenable to being dressed. An outcrop it is also frequently jointed and bedded to create natural rectilinear forms which makes it even easier to create the required Wall-stone forms. In contrast the Whin Sill, whilst even more durable than sandstone, is problematic to use for two reasons. The natural outcrops of the Sill are irregular, polygonal columnar joints with no bedding, which gives irregular elongate triangular or polygonal forms and a general absence of right-angled faces. The material is also so hard that dressing it is an extremely labour-intensive process (Fig. 3.2). Limestones are also as durable as the sandstones but do not benefit from the better natural jointing of sandstones, on top of their value as the raw material to make lime for lime mortar.

Limestone (baked and slaked to make quick-lime with added aggregate) and clay were used as materials to bond core stones as well as the facing stones in some instances (Crow 1991; Hill 2004, 86; Laycock 2018).

Limestones are commonly interbedded within the sandstones and siltstones of the central sector from rocks of the Stainmore, Alston, and Tyne Limestone Formations of the Carboniferous Period (Fig. 3.3). However, in the western sector the deposits from the Permian and Triassic Periods contain no limestones. For this part of the Wall, limestone would have had to have been transported from east to west. Indeed, there is evidence for this from a fragment of Carboniferous limestone during excavations at Cam Beck (Collins and Harrison 2023). There is a similar absence of limestones in the eastern sector where the Wall overlies the Pennine Coal Measures Formation. In this part of the Wall, the options would have been to transport limestone (or lime) from the west beyond Heddon-on-the-Wall or to bring it across the River Tyne from the extensive Permian Limestones to be found from Trow Rocks (near South Shields) and southwards.

Clays are a common component of the glacial tills (also known as boulder clay) which mantle a high proportion of the landscape in the Hadrian's Wall corridor. In addition,

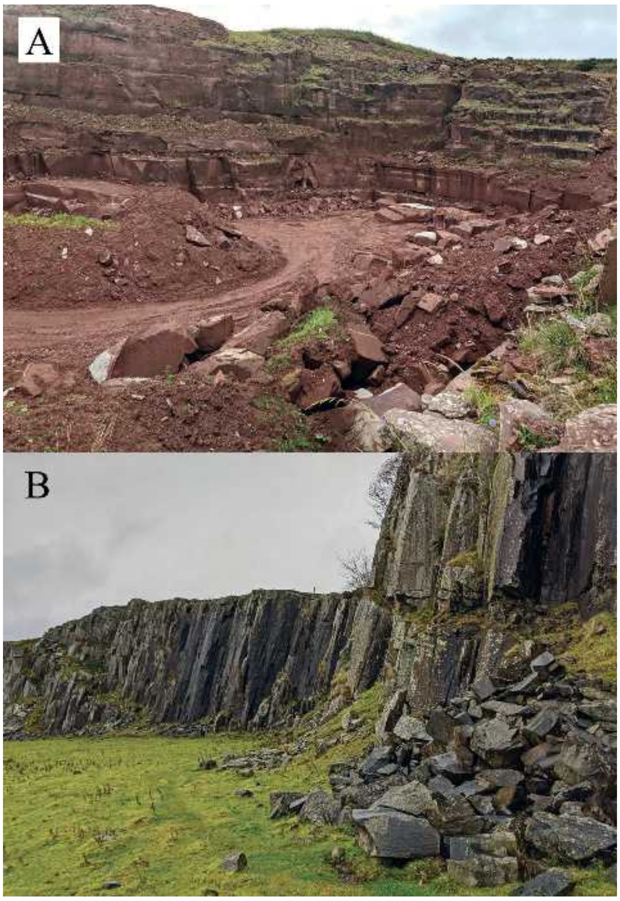



*Figure 3.2: (A) Birkham's Quarry near St Bees Head showing well bedded sandstone from the St Bees Sandstone Formation. (B) Whinstone quarry at Walltown Crags showing the irregular bedding and jointing in the dolerite of the Whin Sill.*

*Figure 3.3: Limestones interbedded with sandstone, siltstone, and coal at Ladies Skerrs near Berwick-upon-Tweed, from the Alston Formation.*

the fluvio-glacial deposits formed in glacial lakes Carlisle and Wear contain more extensive deposits of clay.

The foundation stones for the Wall are mostly made of sandstone. However, there is a section of the Wall running over the top of Sewingshields Crag where irregular triangular-shaped pieces of Whin Sill dolerite are used in the foundation layer (Fig. 2.20). These stones appear to have highly weathered surfaces which suggest they were taken from natural scree slopes rather than specifically quarried.

The core of the Wall is where the richest diversity of stone is found. The core stones are undressed fragments of rock, which means that any stone will suffice. A high percentage of the core material is fragments of sandstone which may well be a by-product of the quarrying and dressing of the facing stones. However, in the central sector where there are plentiful supplies of dolerite scree from the Whin Sill, this becomes a common component of the core material. In addition, and along the whole length of the Wall, glacial cobbles are a common component in the core. These would have been readily available from the glacial tills mantling the Wall landscape as well as from fluvio-glacial deposits reworking the tills and from river cobbles, themselves reworked from the glacial tills. These glacial tills contain a large diversity of material. This includes locally derived sandstones, limestones, and dolerite but also includes material from more distant sources. These include granite (and its affiliates), volcanic rocks including andesites, greywackes, vein quartz, and some gneisses transported from highland locations including the Scottish Highlands, Galloway, the Southern Uplands, the Pennines, and the Lake District. Glacially derived cobbles have been found during WallCAP excavations at Port Carlisle, Cam Beck, and Corbridge (Fig. 2.9) and have been observed in the curtain near Willowford Crossing. In addition, a range of glacially derived material was noted in the core of Thirlwall Castle by Young *et al*. (2001).

Within the sandstones used for facing stones, foundation, and core there is further diversity. At a high level they can be divided into red sandstones (found in the western sector) and other sandstones (found in the central and eastern sectors). This is directly related to the types of sandstone which occur in the geological formation beneath the Wall in these locations (Figs 2.2 and 2.4).

The western part of the Wall from just beyond Hare Hill to the west overlies Permian and Triassic rocks in which red sandstones dominate. The two most likely sources are the Permian Penrith Sandstone Formation and the Triassic St Bees Sandstone Formation. The Penrith sandstones are aeolian (desert) sandstones and are characteristically a salmon pink colour and dusty looking. This is a feature of the rounded wind-blown grains which are patinated with red iron oxide and infilled with dusty clay mineral particles. The St Bees sandstones are a more purple red and tend to be finer grained. The grains are more angular as well as being patinated with red iron oxide. In hand specimen, fluvial textures such as cross-bedding and water escape structures are commonly seen (Fig. 2.5). The St Bees sandstone also has distinctive fine, centimetre-scale, horizontal lamination where the above textures are absent.

The remains of the Wall in the western sector are poorly preserved – maybe a function of the scarcity of stone sources making the Wall-stones an even more precious resource. Where they have been observed at Port Carlisle and Cam Beck, samples of these sandstones viewed in thin section show them to be fluvial in origin, strongly suggesting they are from the St Bees Sandstone Formation or possibly from the overlying Kirklinton Sandstone Formation. The source of these sandstones and the probable routes to the Wall are further discussed in Chapter 4.

Red sandstones have been observed at various Wall locations. Turret 53b (Craggle Hill) was built of red sandstone, but the subsequent stone curtain there employed yellow sandstone, with red sandstone used in the curtain by milecastle 54 (Randylands) (Simpson *et al*. 1934a, 134–35). Turrets 54a (Garthside), 54b (Howgill), 56b (Cambeck), 57a (Beck), 72b (Rindle Hill), and 79b (Jeffrey Croft) are built of red sandstone (Simpson *et al*. 1934a; Breeze 2006, 356). Use of both red and yellow/white sandstones was also observed in the westernmost sections of the Wall (as at mile 72). Insufficient observation was made at these locations to say more than the sandstones are red and therefore likely to come from somewhere in the Permian or Triassic successions.

Indirect evidence for the type of stone used in the Wall comes from post-Roman buildings in which Wall-stone has been re-used. This is particularly useful in the western sector. For example, Drumburgh Castle, St Michael's Church at Burgh-by-Sands and St Michael's Church at Bowness all contain significant amounts of stone which suggest that they are from the Wall. Notably Drumburgh Castle appears to be entirely made of Wall-stone. Visual inspection of the stones in each of these buildings shows the colour and sedimentary texture in them to be consistent with a source in the St Bees Sandstone Formation.

That all of the direct and most of the indirect evidence points towards the St Bees Sandstone Formation as the primary source of Wall-stone in the western sector is not surprising. Accessible outcrops of this material are physically closest and most accessible by road, river or by sea. This does not preclude the possibility that material was used from Penrith Sandstone, with sources accessible some 11 kilometres along the River Eden from Carlisle. To date there is only evidence of the presence of Penrith Sandstone as possible re-used Wall stones from Carlisle Castle, albeit the provenance is not secure (O'Donnell 2021).

In the central and eastern sectors, the Wall overlies Carboniferous rocks which come from the Tyne Limestone Formation at Hare Hill to Gilsland, the Alston Formation from Gilsland to High Brunton, the Stainmore Formation from High Brunton to Heddon-on-the-Wall, and the Pennine Coal Measures Formation for the remainder of the eastern sector of the Wall. Each of these Carboniferous formations contain a large number and variety of sandstones. They vary in grain size and grain sorting, from fine- to coarse-grained and from well- to moderately well-sorted. They come in a range of colours usually of purple, brown, yellow, buff, and grey/white but also occasionally red.

In general, the red sandstones of the Permian and Triassic tend to be softer and less durable than the Carboniferous sandstones. Casual examination of the gravestones in Walton Church graveyard and other locations show how readily the St Bees sandstone weathers (Fig. 3.4). Material recovered from the Cam Beck excavations was frequently so soft that it could be crumbled in the hand. However, stones in the extant Wall near Port Carlisle which also appear to be from the St Bees Sandstone Formation, based on their colour and sedimentary textures, have proven to be resistant to weathering. The Kirklinton sandstone which may account for some of the material at Cam Beck is variable in its durability with nearby cliff sections crumbling in the hand. In contrast, the exposure of this sandstone at the base of the weir across the Cam Beck is highly durable.

The Carboniferous sandstones are much more variable in their durability. Some, like the stone used around Heddon, are gritty and remarkably durable, a feature which led to extensive quarrying of this stone in the 18th to 20th centuries. In contrast some of the stone is of poorer quality. For example, at Black Carts two distinctly different types of sandstone have been used in construction

*Figure 3.4: Weathered red sandstone of the St Bees formation at Lanercost Priory.*

of the Wall. One is a good quality homogenous white/grey sandstone whilst the other is finer grained, brown and contains multiple rip-up clasts which weather out to produce a blotchy texture (Fig. 2.30).

One final consideration is the size of stone required for different construction purposes. Stone used in the Wall curtain and in many other standard walls require stones which conform to a cuboid shape, typically 15–20 cm or greater in width and height. This places a limited demand on the depth of bedding planes and the spacing of jointing in the natural outcrops of stone. Larger slabs for paving or roofing, door frames, drains and covers as well as large blocks for bridge piers and other monumental requirements make greater demands on the geological sources. Bedding spacing in the Permian and Triassic sandstones reach a maximum of *c*. 2 m and are more often less than this. Bedding spacing in the Carboniferous sandstones are more variable. There are some locations, such as Queen's Crag, where a single homogenous sandstone bed is *c*. 4 m thick. It may be that exploitation of these exceptional quarries (Queen's Crag located some way north of the Wall) took place after any initial rapid or priority construction of the Wall. There is insufficient evidence yet to demonstrate the general chronology of construction as it relates to the quality of building stone. Selection of appropriate stone can be observed, however, for example, in the higher quality sandstone used for the altars dedicated to Antenociticus at Benwell relative to the smaller and lesser quality sandstones used to build the actual temple. This highlights the awareness of particular properties of stone to suit specified needs.

## Structures, building methods and styles

Hadrian's Wall incorporated stone in a range of shapes and sizes to build structures from the mundane to the monumental. The full range of stone use is most easily considered relative to the structures built, and assessing the evidence for methods and styles of construction. Where possible, stones of different size and shape are illustrated, though the incomplete survival of the Wall and its attendant structures requires some speculation on what is missing.

The survival of undisturbed or partially surviving fabric is fundamental to this study, and sites where analyses were undertaken were assessed for the accuracy of the surviving consolidated fabric against photographic evidence in the Charles Anderson archive (see also Leach and Whitworth 2011; Whitworth 2012). The primary difference in Wall curtain fabric when initially revealed or uncovered by Anderson and his team compared to post-consolidation are the more frequent visible gaps between individual stones, as a result of absent mortar or minor dislocation. The absence of accessible upstanding fabric precluded inclusion in this research, and therefore all the data presented here must be understood as incomplete. Nor was it possible or desirable within the constraints of the project to provide detailed metric and/or scientific analysis of every accessible stone relating to Hadrian's Wall. Most locations with accessible and upstanding fabric were visited to undertake selected analyses. The curtain between Housesteads and Steel Rigg, for example, provides good evidence for the type of stone used in building and the size of such stones. However, consolidation of this stretch of curtain in the 19th century at the behest of John Clayton and numerous subsequent repairs suggest that in most locations, few of the stones are in their original build position. Detailed metric analyses of building stones were not undertaken at many fort sites along the Wall, as the combination of diverse sizes and shapes of stonework coupled with mixed archaeological phasing resulted in limited conclusions. Subsequent consolidation, too, appears to be less faithful to its original condition on discovery, as apparent in the Anderson archive at Chesters and Housesteads. Where feasible, observations from fort sites have been incorporated into analysis. As a result, future discoveries and research will almost certainly modify quantitative analyses here, though it is hoped that the conclusions of a more qualitative fashion will retain utility.

There are a number of ways in which stone can be dressed and prepared to build walling, and the requirements for building material can also influence methods of quarrying (Hill 2004, 43–46). The most commonly occurring building method found along Hadrian's Wall is squared rubble, a method used along the curtain, at turrets, milecastles, in forts, and most other structures (Fig. 3.5C). This consists of roughly dressed facing stones laid in courses, with mixed and/or unsorted materials used to fill the core between the outer faces of the wall. Individual stones are roughly (as opposed to carefully or precisely) dressed so that the outward face is subrectangular or subsquare, typically using the natural bedding of the geological material to determine the upper and lower beds or faces of the dressed stone. Note that the outer faces of the stones are not particularly well dressed, and can be uneven, or even undressed depending on the quality and natural cleaving properties of the rock selected. Squared rubble is deemed a relatively fast method of building, given that the stones can be dressed quite quickly and the squared shape of the stones allows for relatively easy coursing (Hill 2004, 46). It has been estimated that a person could achieve sufficient skill to 'square' rubble of quality sufficient for a Wall curtain facing stone with approximately an hour of training and supervision, after which skill would rapidly develop through lots of practice (P. Hill, pers. comm.) Bonding material is not essential for this technique, and there are lengths of Wall curtain that appear to never have been bonded, but good stability for squared rubble walling relies upon the strength of the bonding material (Hill 2004, 45–46). An unbonded length of Wall curtain built in squared rubble would be more

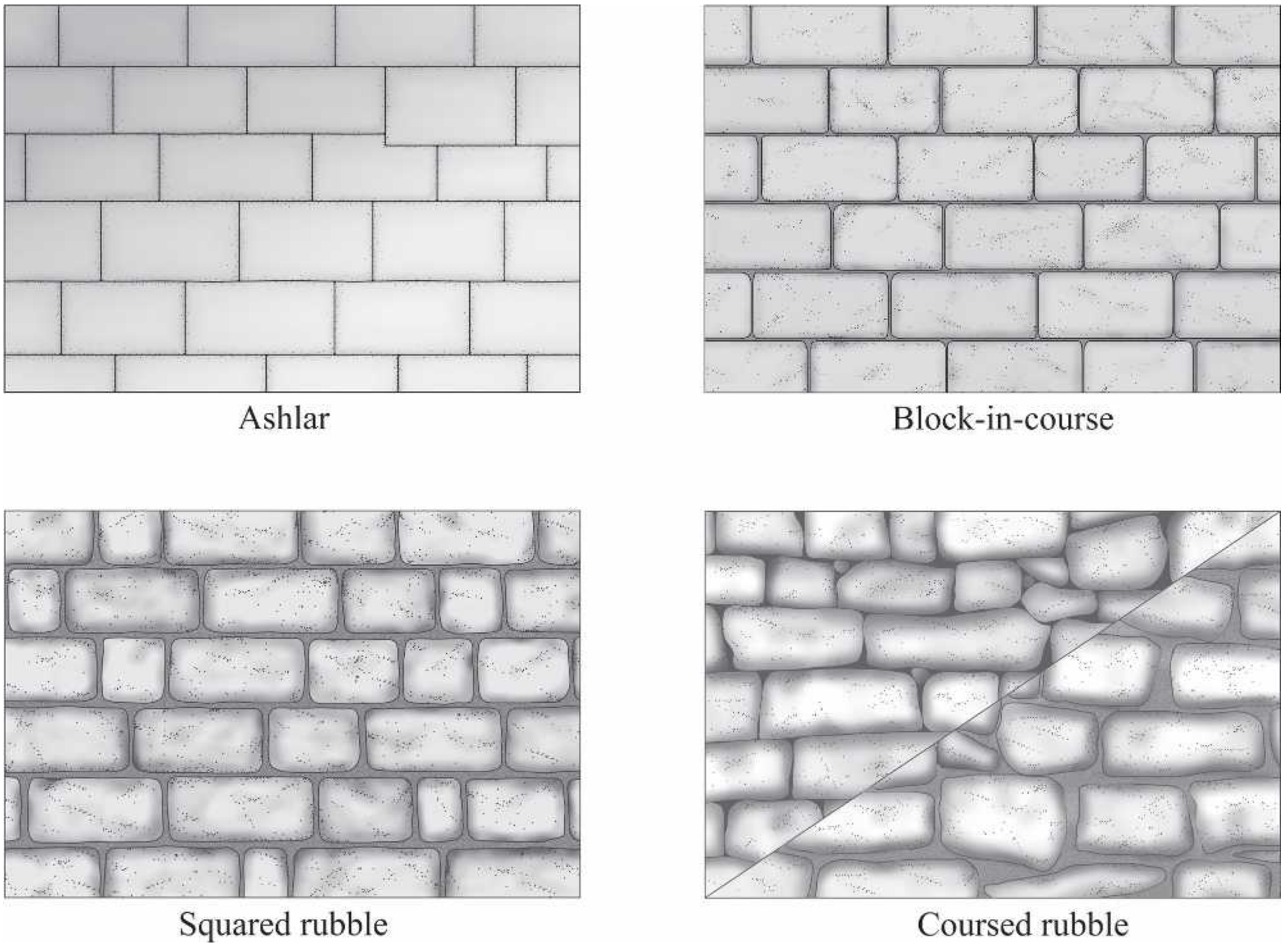



*Figure 3.5: A composite illustration of different stone wall building styles, in ashlar (A), block-in-course (B), squared rubble (C), and course rubble (unbonded / drywall and bonded, D). Illustration by Matilde Grimaldi.*

susceptible to pressure of slumped or compressed core material pushing outward against the facing stones as well as any weight at the top of the Wall; landslip or erosion would also generate a greater possibility of collapse if unbonded (see below).

Perhaps the next most common technique found along the Wall is what is known as block-in-course. The technique requires larger dressed stones, blocks, which are squared to a reasonably good standard for stable, even coursing (Fig. 3.5B). The size of the stone blocks and their quality of finish allows them to sit tightly against each other, and the combination of proximity and mass together creates a solid and stable structure. The technique can be used with bonding material, though it is not required for the reasons outlined above. Block-in-course is typically found in positions where strength and stability is required, often in conjunction with a larger and/or weightier structure. For example, block-in-course is very typically observed in gate structures at milecastles and forts (Fig. 3.6), and at bridges. The technique is sometimes observed used for foundations and/or footings. It is frequently used in conjunction with squared rubble.

More infrequently observed, though not rare, are less high-quality building methods of coursed rubble and random rubble (Fig. 3.5D). Both methods make use of undressed rubble, though coursed rubble attempts to use stones of roughly the same size to create courses, whereas random rubble achieves a facing through a stable but largely unsorted use of rubble. A hybrid combination of both methods might utilise random rubble with occasional levelling courses of similar-sized rubble, known as random rubble brought to courses. This style is most frequently seen in extramural buildings outside the fort, and sometimes also in buildings inside the fort walls, particularly in the later Roman period.

The rarest method for preparation of walling along Hadrian's Wall is ashlar, which requires carefully dressed stones that are finely jointed and bedded, to ensure a very clean and tight fit (Fig. 3.5A). As a method, it requires the greatest skill and quality of stone, and therefore can be seen as the most expensive relative to labour skill and time required (Fig. 3.7). It is worth noting that block-and-course and even squared rubble can sometimes be found in the literature described as ashlar, but these lack the high-quality dressing and precision that marks true ashlar work. The definitive characteristic of ashlar to distinguish it from other methods is the finely chiselled margins along every edge of each face, which are necessary to ensure a tight fit between stones. Ashlar is also most fully characterised by its surface finish, for which a variety of tools and methods have been identified (Hill 2004, 43–44).

### *Classifying building styles in detail*

The combination of different core bonding materials, foundations, footings, and facing stones has been the subject of recent research (Breeze *et al*. 2020), and this highlights the complexity of the building process of the Wall and its attendant structures, as well as distinguishing the original building from possible later repairs (see also Bidwell 2018, 219–226).

The variety of stone sizes and arrangements in the construction of the curtain, while commented on, is rarely examined in detail. Most frequently, a 'typical' stone measurement is provided or perhaps a range of sizes, but this often fails to communicate the variation of stone size and their relative arrangement at any given location along the Wall. Indeed, the terminology for facing stones and other key building stones for the Wall is practically non-existent, with considerable variation found in the literature across more than a century of scholarship. Hill (2006) and Breeze and Hill (2013) have recommended and defined some terms, but only one schema has been suggested to date (Breeze *et al*. 2020, 68). This schema allocates a size category relative to weight. The benefits of using a quantification by weight is that it provides a single numeric value to any given stone, facilitating comparison that is in principle less complex than comparing geometry in two or three dimensions. A weight value also removes prospective distortion from visual perceptions, for example when a stone looks larger or smaller than its physical dimensions because of the setting it is in. However, these benefits are in practice outweighed by the drawbacks. Visualising weight relative to dimensions is challenging and sometimes too abstract – a weight does not convey surface area or volume in the same manner. Furthermore, reducing all stone to a weight presumes

*Figure 3.6: The north portal of the east gate at Birdoswald fort, showing the use of block-in-course construction for the outer fort walling and gate pier (right) while squared rubble is used for the internal gate walling (left). Scale bar is 1 m.*

that each stone along the Wall has the same chemical and physical attributes. Given the geological diversity and complexity communicated in Chapter 2, it should be apparent that even among the sandstones dressed to build the Wall, there is considerably different density and porosity that negates application of a standardised mass or weight.

Metric analysis conducted on stone fabric at 12 curtain locations along the Wall between Wallsend and Bowness-on-Solway has allowed for a new schema to be constructed to provide more consistent terminology in discussing Wall fabric, supplemented and tested by analysis from 3 turrets and 2 forts (Table 3.2). The scheme is relatively simple, allowing nearly all stones to be placed in one of five types or shapes of dressed or modified stone: Facing Stone (FS); Block (B); Slab (S); Specialist (Y); and Rubble (R). Specialist stones refer to any stone dressed to perform a more specialised function, in terms of architecture or engineering, such as a voussoir or a column. Rubble is undressed stone, which could in principle be used for facing a wall as well as more general core or paving material. Metric analysis of Rubble and Specialist stones was not completed during the course of the project, but is built into the schema for convenience and future expansion.

These types were further separated into broad size categories. The attribution of any dressed stone to a given size is arbitrary. However, the volume of data allowed for robust clusters of dimensions and size to be identified. The types and sizes are not intended to be definitive. In practice, for example, a course composed largely of Blocks may have some stones that by size fit within the top end of a large Facing Stone. In such cases, the frequency of stones of a given size help to provide an overall character. If only one or two examples, then it is acceptable to identify the course as consisting of small Blocks. Alternatively, a course might be mixed between small Blocks and large Facing Stones. A further challenge is that measuring all three dimensions of a stone is often not possible. In such situations, attribution to a type and size is necessarily limited to two dimensions. This is an advantage to the schema, however, when dealing with upstanding stone fabric. The size of any given stone, however, will also relate to the quality of rock within

*Figure 3.7: Ashlar used at the east gate of Birdoswald fort. Note the high-quality finish to the faces, beds, and joints of each stone, ensuring a tight fit. Scale bar is 1 m.*

a given quarry. Large and massive Blocks, Slabs, and specialist stones would by necessity be carved from rock with thick bedding. In practice, this may have limited or reduced the number of rocky outcrops and quarries that were locally available, increasing the probability that more monumentally scaled stones may have been brought to a site from more distant sources.

With this schema in place, it is possible to assess the building techniques and metric analysis of the stone curtain. In principle, the same methods can be applied to turrets, milecastles, and forts. Indeed, some data was acquired from turrets and forts, though such sites have a much greater range of stone shapes and sizes and were not subject to extensive data collection or analysis within the project.

*Table 3.2: A schema of dressed stone from Hadrian's Wall, relative to shape and size. Dimensions of exemplar stones are indicated in [ ] and abbreviations for type and size are provide in ( ).*

| *Stone type* | *Size* | *Dimensions (cm)* | *General shape* |
|---|---|---|---|
| Facing stone (FS) | Small (s) | Longest face measures 15–30<br><br>[19 × 13]<br>[26 × 18] | Dressed stone (from low to high quality) creating a subsquare or subrectangular outer face.<br><br>The stone may be cuboid or wedge-shaped behind the outer face. |
| | Large (l) | Longest face measures 30–50<br>[35 × 25]<br>[47 × 30] | |
| Block (B) | Small (s) | Longest face measures 50–70<br><br>[50 × 40 × 40]<br>[53 × 35]<br>[61 × 20] | Dressed stone (from low to high quality) creating a subsquare or subrectangular outer face.<br><br>Blocks are typically cuboid, though may be snecked to create a level course or fit with other blocks.<br><br>The scale of the longest/widest face can often mean that thickness is relatively small, creating a slab-like proportioning that is in fact considerably thicker than a slab. |
| | Large (l) | Longest face measures 70–100<br><br>[81 × 27 × 26] | |
| | Massive (m) | Longest face measure 100+<br><br>[102 × 48] | |
| Slab (S) | Small (s) | Longest face measures 15–50 | Dressed stone generally in a square or rectangular shape, thin relative to the surface area of upper and lower faces (beds).<br><br>Thickness is typically less than 15, but can be greater, particularly as the slab achieves a massive size. |
| | Large (l) | Longest face measures 50–100 | |
| | Massive (m) | Longest face measures 100+ | |
| Specialist (Y) | | | Not developed for this study, but includes voussoirs, columns, etc. |
| Rubble (R) | Pebbles (p) | 0.2–6 | Can be composed of stone material of different size, geology, and shape, either homogeneous or mixed in composition.<br><br>The size terminology follows that used for gravel, which is based on the length of the longest dimension of an individual unit. Any unit smaller than a pebble is likely to be a sand rather than true stone rubble.<br><br>Shape will be determined largely by the source, such that water-worn rubble will have smoother and rounder faces while crushed stone will have uneven shapes with faces separated by distinct edges. Shape can therefore be described is irregular or in geometric terms. |
| | Cobbles (c) | 6–26 | |
| | Small Boulders (sb) | 26–50 | |
| | Large Boulders (lb) | 50–100 | |
| | Massive Boulders (mb) | 100+ | |

### *The curtain*

The stone curtain remains the single largest component of the entire Wall complex. In its course between Wallsend in the east and Bowness-on-Solway in the west, it crosses a variety of terrains and microclimates and geological formations. These localised conditions are significant for two reasons. First, the slope of the ground, overall elevation, soil compaction, proximity to river/bog/marsh, and weather all affected how the curtain was constructed and how easy it was to maintain. Second, the geology impacted on the selection of material to build the curtain and its suitability to construction and subsequent weathering. External factors, such as the need (or not) for rapid building or the skill of the builders, interacted with the local conditions. The result is a stone Wall curtain that while seemingly uniform across the monument, is actually more diverse in its detail than is typically appreciated.

Depending on its thickness or gauge, the curtain is often referred to as Broad Wall, Narrow Wall, Intermediate Wall, or Extra-narrow Wall (Table 3.3; Breeze 2006, 53–54). The construction of any of these gauges generally seems to relate to the date at which a length of curtain was built, and in that regard can be understood as part of the overall building sequence of the Wall. That is to say, Broad Wall was the original dimension of intended construction, but construction of the curtain to a Broad Wall standard was only started in some locations, and finished (or so we believe) in even fewer places. Narrow Wall replaced the Broad Wall, sometimes built on previously laid Broad Wall foundations, and more commonly built afresh where no construction had begun. The Intermediate Wall is found exclusively as the stone-built replacement for the Turf Wall, and the Extra-narrow Wall is the least frequent gauge, and seems to denote the full rebuilding of the curtain in the late 2nd/early 3rd century, typically associated with the reign of Septimius Severus. The different gauges, however, were executed with different foundations and footings, too, depending on the exact legion that built any given curtain.

Detailed metric and geological analyses were undertaken at locations where it is believed (and sometimes proven) that the Wall curtain had not been disturbed or substantially rebuilt (Fig. 3.8). Where detailed metric analysis was not thought to be feasible, some notion of the range of stones used in a particular phase of repair or rebuilding is offered, as well as a comment on the overall style of building. Appendix 2 provides the condensed detail of data on a site-by-site basis. What follows here is an overview and discussion of the results of the analysis. Metric analysis focused on the facing stones, but it important to consider the variation in structure in the curtain as it is understood to date, as well as the limitations in our current knowledge and recording methodologies.

*Table 3.3: The thickness or gauge of the stone Wall and its recorded measurements.*

| *Gauge* | *Foundations (m)* | *Main wall (m)* |
|---|---|---|
| Broad | 2.7–3.2 | 2.7–3 |
| Narrow | 2.4–2.7 | 2.1–2.4 |
| Intermediate | 2.5–3.2 | 2.4–2.9 |
| Extra-narrow | | 1.5–1.9 |

Foundations were not typically visible or accessible to take direct measurements from, and therefore have not been included within metric analysis. The foundations should be understood as any stonework, regardless of scale, that was intended to provide a base to take a superstructure, and its upper height is usually level with the ground surface, or slightly higher. Put another way, the foundations are the part of the Wall that have a direct relationship with the underlying ground, whether of soil or bedrock. It is noteworthy, however, that there is a range of different foundations employed for the stone Wall curtain. In locations with extremely shallow or non-existent topsoil, for example along the crags of the Whin Sill in the central sector, the curtain was built directly upon bedrock, which may or may not have been dressed or prepared to provide a flat(ish) surface. This can be very clearly observed along Walltown Crags, and was further verified during excavation (Collins and Harrison 2023). Where the curtain was built on drift geology (*i.e.*, soil), there was no single standard of foundation. A trench would be excavated by the Romans to take the foundations, which could consist of slabs, stones or blocks, or a mix of rubble and sand or clay. Stone slabs of varying length, width, and thickness might be found underlying facing stones, typically offset from any facing stones above; alternatively, a roughly dressed stone or block may be used instead of a slab. Between slabs, stones, or blocks beneath the facing stones there is typically a layer of mixed rubble and sand or clay, or the rubble-sand/clay mix could be used without any slabs, stones or blocks (Breeze and Hill 2013).

The stone curtain and other structures, such as turrets, milecastles, and fort buildings, might also make use of footings. Footings should be understood as one or more courses of facing stone at the base of the structure that expand the width or thickness of the wall from the majority of its courses. For the Broad Wall, four different styles of footings and offsets have been identified (Breeze *et al.* 2020, 85–88). In practice, there may be a wider range of footings employed in the Wall's construction and subsequent repairs. Certainly, the offsets vary in depth from 2–15 cm at different locations, and even within a single course the offset will not be consistent or exact along its length. For purposes of consistent and detailed recording, rather than adopting the Standards A–D incorporated into Breeze *et al.*'s (2020) analysis, each course above the foundations was identified as numeric course, with 1 as the first course of stonework above the foundations. Footings were recorded as distinct from coursing. This allows for consistent comparison between courses at

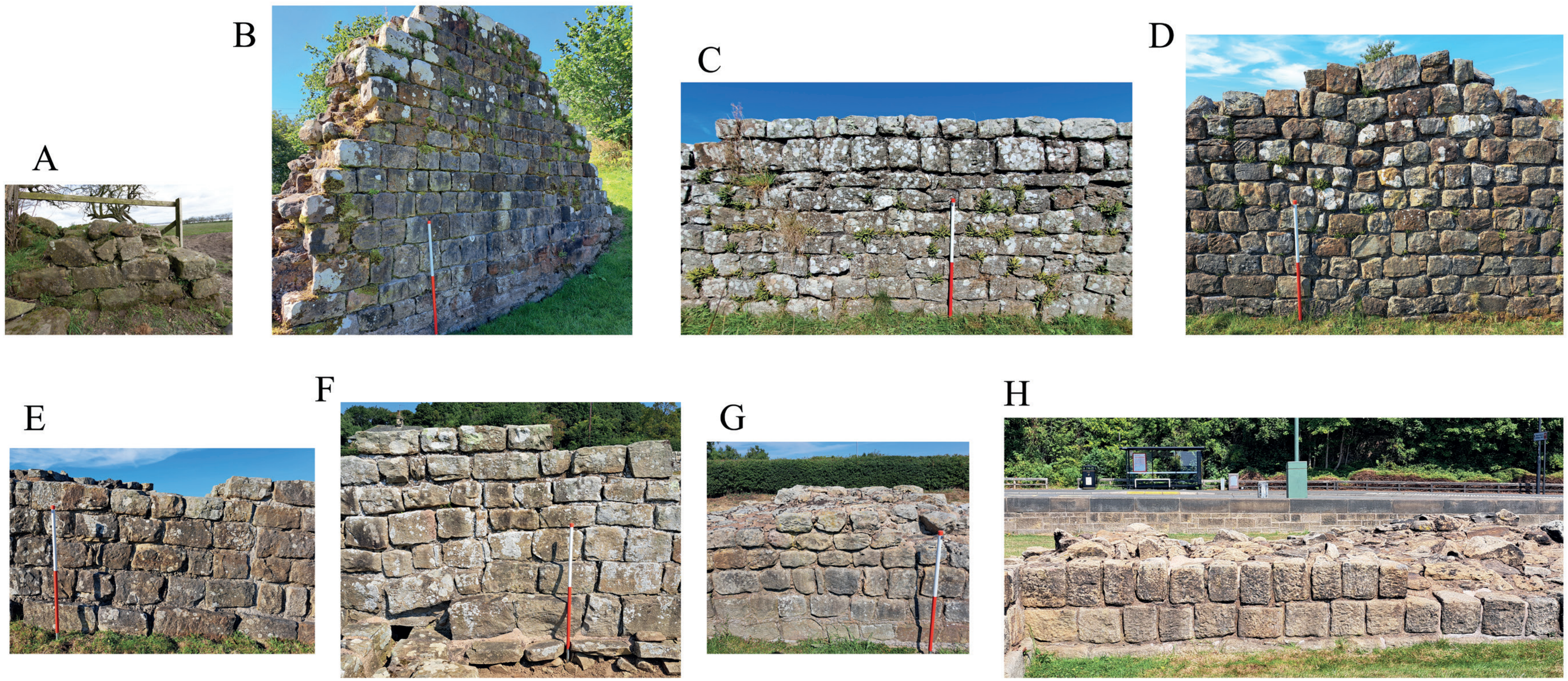


*Figure 3.8: A composite of the Wall curtain at locations of measurement, each set to the same scale. Note the diversity not only in the size of stones at each location, but also their arrangement, weathering, and colour. Scale bar is 1 m. Locations are arranged west–east. (A) Port Carlisle, south face; (B) Hare Hill, north face; (C) Birdoswald, south face; (D) Walltown west, south face; (E) Black Carts east, south face; (F) Planetrees, south face; (G) Heddon-on-the-Wall, south face; (H) Denton, south face.*

different locations, regardless of the use of footings. Accepting, however, that styles of footings may be useful to better understand the building sequence and correlations between particular building parties and discrete lengths of Wall, it is recommended that recording of footings is distinguished initially by the number of footings as determined by offsets, such as a single-, double-, or triple-footing, and thence by the number of courses each footing includes. This data was not collected for analysis by WallCAP, but the recommendation is offered here as there was some need for recording of footings. For example, the south face of the curtain at Planetrees consisted of a 'double-footing', in which each footing consisted of a single course of stonework with an offset averaging 8 cm at the top of course 1 and course 2 (Fig. 3.8F). The north face at Planetrees has a single-footing only, with the offset at the top of course 1 (Fig. 3.9). Each footing could consist of more or less courses of stonework, such that the first footing could consist of three courses and the second footing of only one course – a double-footing of three courses with a 5 cm offset followed by one course with a 2 cm offset. There may only be single-footing, or there may not be any footing. Going forward, this will allow more consistent and precise descriptive recording.

*Figure 3.9: The north face of the curtain at Planetrees, with first course over the foundations providing a single-footing. Scale bar (red section) is 50 cm.*

WallCAP metric analysis of facing stone in the curtain elucidates the diversity of size and composition in construction using (almost exclusively) sandstone. At each site, individual stones were directly measured to the nearest millimetre (mm) in all dimensions that were accessible. This collection of data very easily allows for recognition in the range of stone sizes employed as facing stones (Fig. 3.10). Comparison of measurements from 12 discrete locations on the curtain as 11 sites of both the smallest and largest facing stones reveals patterns, such as the use of small and large blocks west of Chesters (at Planetrees and Black Carts) as well as Banks East. At all other curtain locations, the largest stones were comfortably within the large size range of standard facing stones. At Steel Rigg, which admittedly appears to have a considerable amount of reconstruction of the curtain (Crow 1991), facing stones were consistently smaller than at other locations. The north face of the curtain at Hare Hill was refaced, so while stone sizes here are almost certainly accurate for the Roman period, the coursing is not surviving Roman work (Hodgson and McKelvey 2006, 52). More granular analysis is possible, however.

Measurements of multiple stones per course at each location were aggregated to calculate an average stone size per course at 12 locations at 10 sites (Table 3.4). It is these averages that are discussed here, with more detailed figures provided in Appendix 2 for each site. These figures provide a simple means to rapidly assess variation in Wall construction than has been previously realised, particularly when visualised (Fig. 3.11), and offer a corrective to human perceptions, which can often be more subjective. For example, Hare Hill is the site where the stone curtain survives to greatest height, but Walltown (west) boasts more surviving courses of stonework. Moreover, the surviving height of the curtain at Walltown is less apparent relative to Hare Hill because there are numerous locations immediately south of the curtain where a person can stand on bedrock at a height greater than the surviving curtain, diminishing its impression.

The visualisation of curtain construction as a single stack of averaged stone size per course in Figure 3.11 further clarifies different building styles at each site, partly due to the simplified representation of stone size. At two sites, Walltown and Black Carts, measurements were taken at two locations and these highlight different building styles relative to stone size, even at locations that are reasonably close to each other. At Walltown east and west, topsoil was removed by the Romans to reveal bedrock which was then cleared and prepared by the Romans to act as the foundation for the curtain. Evidence for Roman excavation of a trench for the foundations was

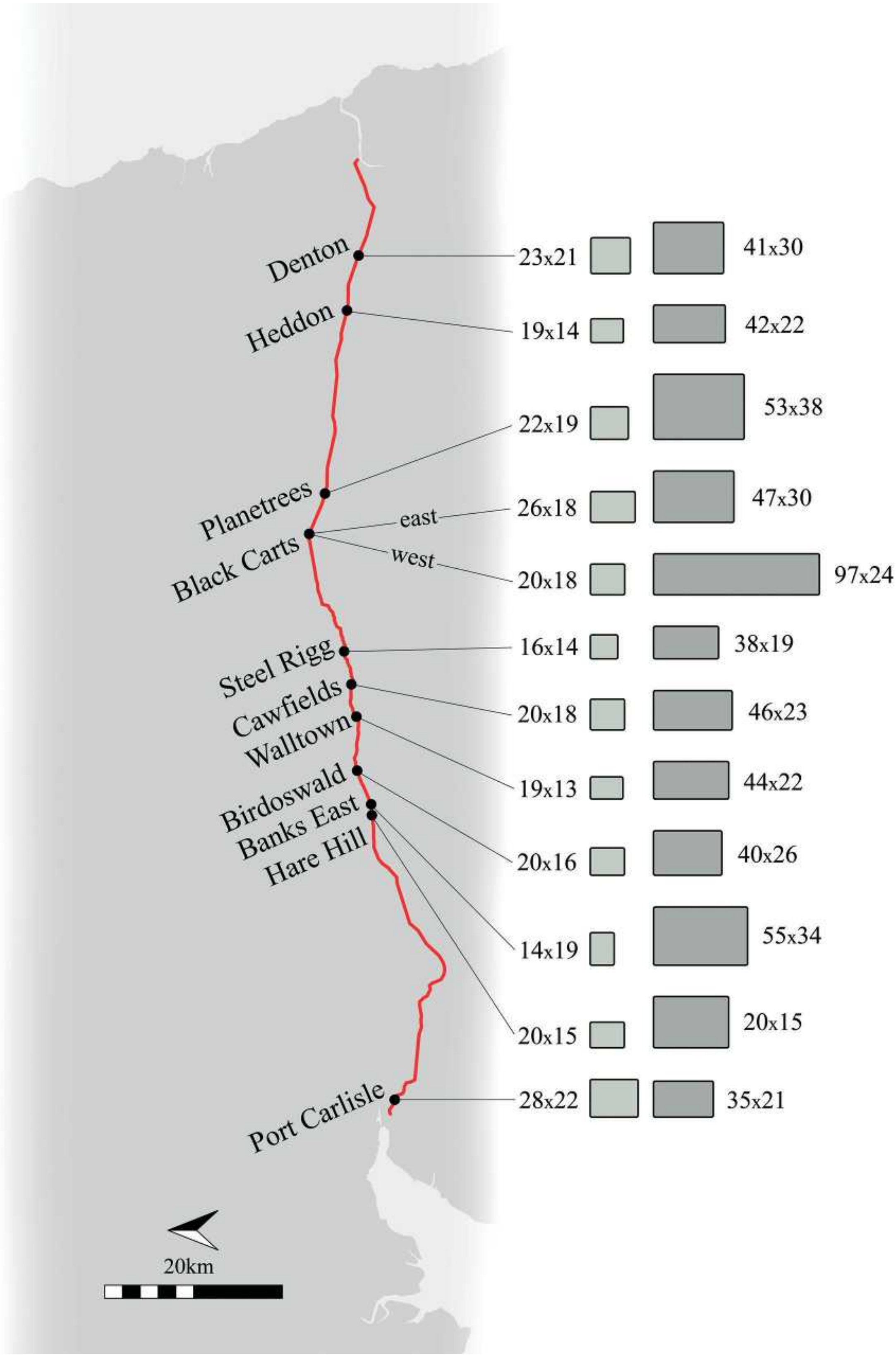



*Figure 3.10: The range of stone sizes, from typically smallest to typically largest, visualised by location along Hadrian's Wall. Illustration by Matilde Grimaldi.*

*Table 3.4: The average size of stone/course at different curtain locations along the Wall from west to east. All numbers represent centimetres (cm). Grey shading indicates those courses where measurements could not be taken. Blanks represent absence of any stones for that course.*

| *Course* | *Port Carlisle* | *Hare Hill* | *Banks East* | *Birdoswald* | *Walltown west* | *Walltown east* | *Cawfields* | *Black Carts west* | *Black Carts east* | *Planetrees* | *Heddon* | *Denton* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | | | | | 26 × 21 | | | | | | | |
| 11 | | 35.3 × 20.8 | | | 26.6 × 20.4 | | | | | | | |
| 10 | | 22.8 × 18.3 | | | 23.6 × 15.7 | | | | | | | |
| 9 | | 20.7 × 19.8 | | 31.3 × 15 | 22.8 × 16.4 | | | | | | | |
| 8 | | 27.9 × 21 | | 26.3 × 24.7 | 17 × 15.9 | | | | | | | |
| 7 | | 25.2 × 19.5 | | 64.5 × 11 | 22.3 × 15.8 | | 24.5 × 20.1 | 19.5 × 23 | | 36.8 × 17.8 | | |
| 6 | | 24.8 × 21.1 | 29.5 × 13.2 | 25.1 × 18 | 24.7 × 17.4 | 20.2 × 17.6 | 31.5 × 22.8 | 28.4 × 20.4 | | 36.4 × 21.2 | 26.3 × 14.7 | |
| 5 | | 25 × 23.7 | 29 × 18.3 | 28.3 × 18.7 | 26 × 19.4 | 22 × 14.9 | 28.9 × 18.1 | 28 × 20.1 | 30.3 × 18.4 | 29.3 × 19.1 | 26 × 13.9 | |
| 4 | | 28.5 × 28.2 | 29.7 × 17.3 | 26.9 × 15.6 | 24.7 × 17.7 | 22.8 × 17 | 23.4 × 19.6 | 30.1 × 23.9 | 33.9 × 19.7 | 34.7 × 20 | 26.3 × 15 | |
| 3 | | 27.7 × 17.7 | 28.9 × 16.8 | 26.5 × 18 | 23.7 × 17.4 | 22.8 × 15.5 | 22.2 × 18.4 | 30.3 × 21 | 35.4 × 22 | 31.9 × 25.1 | 26.5 × 23.8 | |
| 2 | 34 × 20.7 | 24 × 14.3 | 32.2 × 19.7 | 31.5 × 19.6 | 25.3 × 17.3 | 22.5 × 15 | 20.5 × 18.6 | 30.1 × 22.3 | 31.4 × 21 | 33.2 × 24 | 26.5 × 21.5 | 22.3 × 21.2 |
| 1 | 31.3 × 19.3 | 28.5 × 14.7 | 34 × 23 | 31.3 × 25 | | 29 × 25 | 28 × 17.5 | 46.2 × 25.6 | 32.7 × 26.7 | 47.3 × 29.2 | 30.8 × 18 | 37.6 × 26.4 |
| F | | 37.5 × 9.8 | 44.8 × 11 | | bedrock | bedrock | bedrock | 60.5 × 19.5 | | 37.2 × 10.4 | | 35.1 × 16 |

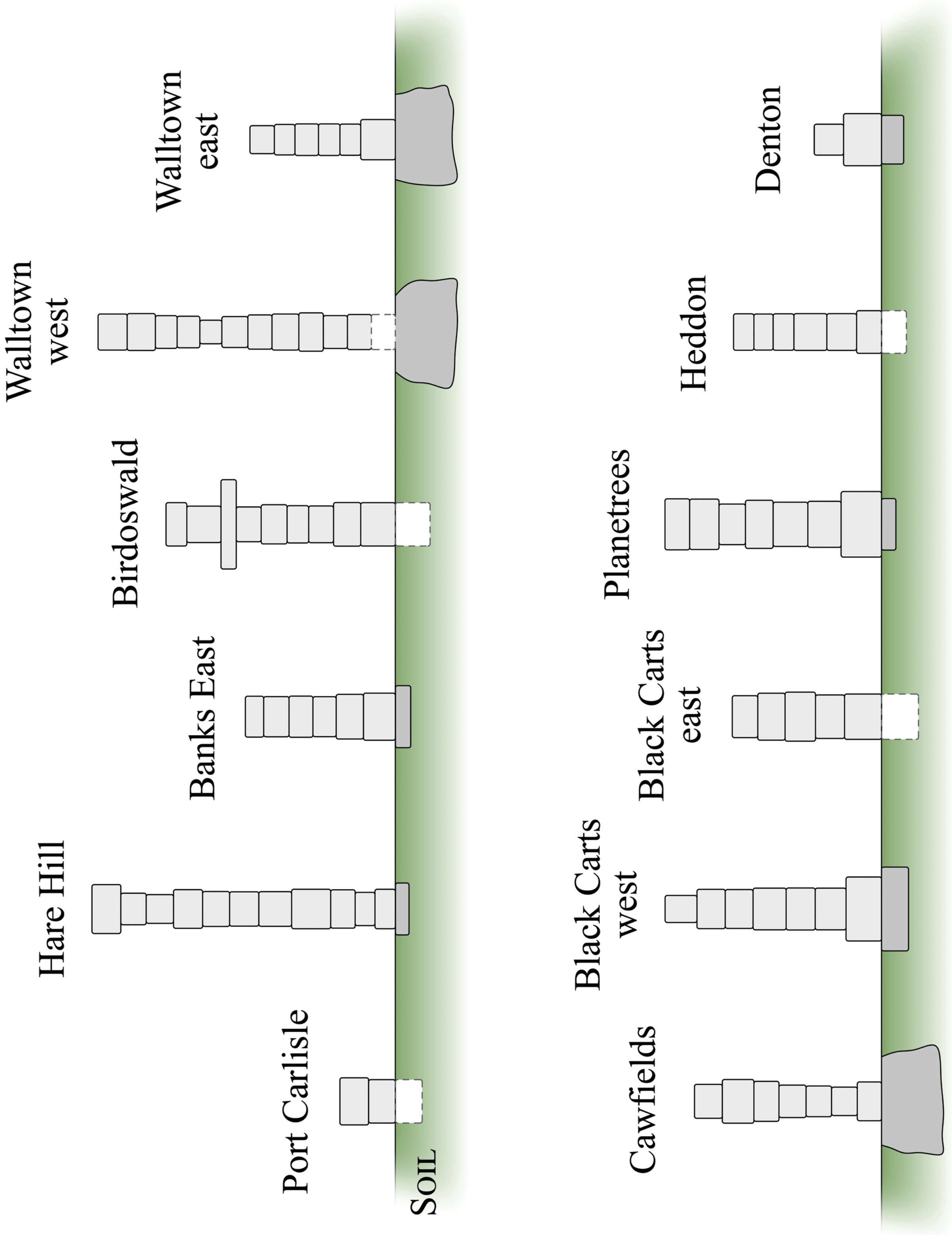



*Figure 3.11: The visualisation of average stone size per course on the Wall curtain at 12 locations. Illustration by Matilde Grimaldi.*

recovered by WallCAP during excavations (Collins and Harrison 2023), here named as Walltown east. At both locations, facing stones never exceeded the 'small' size on the whole, but the average size/course identifies some patterning. At Walltown east, the largest facing stones were found in the first course, which also acted as a footing with a 5-cm offset. Courses 2, 3, and 4 used facing stones of broadly the same size in width and height, with a subsequent minor decrease in width in course 5, and again in course 6, but with increased height. At Walltown west, the first course was partially or almost entirely buried at the chosen location, so the average stone size cannot be determined. It did, however, also act as a footing, with a 4-cm offset. Courses 2–7 had varied average stone sizes in width, but with generally consistent height. It is the 8th course that is notable here, considerably smaller in both width and height than the courses below it and above it, and generally more square in shape. In practice, course 8 may have been intended to act as a levelling course, in which a series of smaller stones would be used to achieve a more level surface to build higher courses upon, increasing the strength of the curtain structurally; this decision also had an aesthetic impact that may have been desirable.

A levelling course can also be seen in the curtain at Birdoswald, where the 7th course consists of large slabs, as well as in the 7th course at Black Carts west, which consists of a narrower but taller small facing stone. At Planetrees, it is possible that the 5th course had the same function, as the stones of that course were on average shorter than of any other surviving course, but the differential is less dramatic relative to the other sites. Significantly, this may point to a wider practice of using levelling courses in the construction of the curtain, but there are few sites where the curtain survives to a height of 7 or 8 courses. Hare Hill is an exception, in that there does not appear to be any course that had a similar structural or aesthetic function as those at Birdoswald, Walltown west, or Black Carts west, but this could be the result of 19th-century refacing. Cawfields may be an inversion of the principle at these other sites, with the 6th course consisting of stones on average wider and taller than those of the courses below and above it.

The stone stacks in Fig. 3.11 also point to more generalised patterns of construction of facing stones. At some sites, there is a tendency for stones to become smaller – either less wide and/or shorter – as the curtain increases in height, as at Banks East, Walltown east, Black Carts west, Heddon, and tentatively Denton (though only two courses could be measured here).

Hare Hill and Walltown west, the two sites where the curtain survives to greatest height, show a more mixed picture of stone size/course, though Hare Hill can be discounted given its 19th-century refacing. The courses swell and contract relative to each other, an effect that can be seen at Birdoswald, Black Carts east, Housesteads and Planetrees. Does this variation capture original Hadrianic building practice, or are we in fact seeing one or more episodes of reconstruction?

At present, it is difficult to assess the significance of variation in stone size observed across multiple sites. At the very least, these differences may help further elucidate building parties and/or lengths associated with Hadrianic-phase construction, or more clearly reveal repair to the curtain. But the aesthetic significance of features like a levelling course or the use of small or large blocks may also have been integrated with any renders or surface treatments applied to the curtain and other Wall structures. The addition of plaster, or even a considerably thinner and easier whitewash to the Wall would presumably also have included a red-painted stone coursing effect seen elsewhere in the Roman Empire that need not have married onto the actual stone coursing. The evidence for any such surface treatments is at present uncertain, if intriguing. A whitish lime coating on a chamfered stone with a distinct edge to the coating from Peel Gap may point to a limewash (Crow 1991, 59), and collapse at Denton revealed numerous small fragments of plaster with false jointing impressed into its surface that may point to a render on the south face of the curtain (Bidwell and Watson 1996, 23). Hill (2004, 34–36) was critical of existing evidence indicating anything more than sloppy mortaring, pointing, or repair, but a whitewash or painted surface would render the Wall more visible and be consistent with treatment of other monuments across the Roman Empire. As with all other details pertaining to the Wall, however, there may have been varied practice at any given site or location, and through the three centuries that it was garrisoned.

The curtain also boasted features that are best classified as architectural embellishment, such as capstones or chamfered or bevelled stones that acted as a string course. No such evidence was encountered *in situ* during the course of the project that could be incorporated into analysis, though such stones have been encountered in previous excavations (Crow 1991, 59–60).

## Change over time

From the time of its construction *c.* 120, Hadrian's Wall was in operation and garrisoned by Roman army units for a period of nearly 300 years, with the exception of the brief abandonment during the reign of Antoninus Pius in which the more northerly Antonine Wall became the forward focus of the Roman frontier. Over that period of 300 years, the Wall faced a series of challenges that resulted in rebuilds, repairs, deconstructions, and other modifications to the fabric of the curtain and the other structures that made up the complex (as described in Chapter 1). In terms of scale, there were two major episodes of work. The replacement of the Turf Wall with a stone curtain occurred in two or more stages (Breeze 2006, 60). Between the River Irthing and Wall-mile 54, the Turf Wall replacement can be dated to the early 130s, but further west this seems to have occurred after 158, following the abandonment of the Antonine Wall and the reoccupation of Hadrian's Wall on the basis of ceramic evidence. Post-Antonine repair on the Stone Wall is attested from legionary building stones in Wall miles 8 and 9 (Mann 1992; Hodgson 2011; Bidwell 2018, 219). Subsequently, a second substantial rebuilding of the Wall curtain is attested at numerous locations, where the use of a high-quality hard white mortar is associated with the Extra Narrow gauge curtain (Breeze 2006, 58, 106). This work is associated with ceramics of the late 2nd century and frequently associated with Septimius Severus. It has been most widely encountered in the central sector, but not exclusively so. Following this date, there is no evidence for further widespread, coordinated, and large-scale repair projects along the Wall, though local-level repairs and refurbishments continue to be made at individual sites and locations.

### *The forces of destruction*

There are many reasons why repairs and refurbishments to the Wall would be necessary, which include the long use-life of the monument, climate and weather, ground conditions, and also the build-quality of the monument. In the first instance, it was a monument in use and occupation by an army for a period of at least 270 years. Active use over any prolonged period will entail wear and tear. Even mundane activities – walking along its top (*if* there was a parapet along the curtain), opening and closing gates, climbing stairs and ladders in turrets and milecastles – would over the accumulation of many duty-shifts, across years, decades, and centuries of occupation, result in many thousands of footfalls that wear down surfaces of stone and contribute to compression of the structure. Other activities could be far more damaging in single events, for example in an enemy attack, or the spread of a fire.

This of course will be supplemented by weather and climate. Rain and moisture will seep in between the stones of the monument across the seasons, and winter freezing

*Figure 3.12: The south face of the curtain at Walltown Crags, where it runs down a slope to the west. Note how the foundation stones generally parallel the slope of the ground, while the stone courses above mix sloped coursing and even coursing, rather than stepped coursing that cuts into the slope. The scale bar is 1 m.*

of any such moisture will contribute to cracks and fissures, creating more spaces for further moisture to creep into, as well as seeds and spores for plant and fungal growth. It is notable, too, the greater frequency of drains and culverts built through the base of the stone curtain when it replaced the Turf Wall, compared to the very few drains found along the Hadrianic Stone Wall (Breeze and Dobson 2000, 30–31, 81, 94–95; Bidwell 2018, 220); this points to concerns around moisture and water management. Hadrian's Wall also runs through the Tyne-Solway gap, in which the rivers Tyne, Irthing, and Eden have numerous tributaries and extensive catchment areas. The Wall itself crosses the North Tyne, Irthing, and Eden rivers, which required substantial and well-engineered bridgeworks (Bidwell and Holbrook 1989), and a number of 'minor' rivers, becks, burns, and streams of varying scale (Morgan and Bidwell 2015). These minor crossings could still be substantial, in terms of the engineering required to carry the Wall across them. At the Cam Beck, north of Castlesteads, the gorge of the beck on the line of the Wall is approximately 38 m in width and 7.5–10.5 m in depth. The very active rivers and smaller watercourses were subject to seasonal flooding. Such flooding results in shifting river courses, landslip, and erosion. This could be quite dramatic in scale. The course of the Irthing at Willowford shifted west during the course of the 2nd century to such an extent that the bridge needed to be rebuilt to account for the new rivercourse (Bidwell and Holbrook 1989: 76–78).

Topography and ground conditions also contributed to possible landslip and erosion in addition to water-action. Locations with loose, sandy soils or marshy ground will have provided challenging conditions for building and long-term maintenance of the monument, due to the propensity of considerable soil compression, displacement, and/or flooding. The steep slopes most frequently encountered along the Whin Sill in the central sector, but also encompassing the hills and vales to the east and west created further challenges in ground conditions for a heavy, linear monument. Sloped land, particularly that in proximity to watercourses or with poor soil conditions is vulnerable to episodes of landslip and erosion. These factors of climate and environment would be expected to impact on the Wall, regardless of build-quality.

However, it has been observed that the construction of the Wall, particularly the curtain, is regularly of low quality (Bidwell 2018, 219–220). Take, for example, the high frequency and dominance of squared rubble found along the Wall. The stones require uncomplicated dressing and can be sufficiently coursed to require little or even no bonding. The core of the Broad Wall, the earliest known style of curtain construction, consisted of a clay and rubble core. As a building method, it lends itself to a large workforce with low-level expertise or skill, and has been considered to be an adaptation of a construction technique known as a box rampart (Bennet 1998, 28–29). Another example can be seen in the builders' approach to building on sloped ground. Provided the slope is not too steep (greater than 20°), the Wall's foundations and superstructure typically run parallel to the ground surface slope, rather than cutting into the slope to prepare flat level surfaces that are stepped moving uphill (Fig. 3.12).

The interaction of these factors all contributed to expected damage that would have affected the Wall during the Roman period, as well as in the centuries following. Figure 3.13 provides examples of how the forces of tension and compression would affect the curtain, for example. Compression could have affected the internal core of the Wall curtain, the facing stones, or the underlying soil, all of which would have contributed to partial or whole collapse of sections of the monument. Tension would also result in partial or wholesale collapse of the monument, if the underlying land is pulled or swept away from landslip or erosion, or if expansion of core material in the curtain pushes the curtain faces out. Day-by-day, week-by-week, season-by-season, year-by-year, and across the centuries, the constant interaction of all these factors contributed to the degradation and collapse of the monument, and these resulting repairs need to be looked for and incorporated into our understanding of the Wall.

### *Evidence for repairs and refurbishments*

There is a considerable amount of evidence for repairs and refurbishments to Hadrian's Wall, whether from inscriptions (*e.g.*, RIB 1389), archaeological excavations (*e.g.*, Simpson *et al*. 1934b), or even fossilised in the consolidation and presentation of the monument's fabric. Evidence of repairs has most frequently been used to better contrast and understand the Hadrianic building programme and overall chronology of the Wall, though recent work has prompted reassessment and shifted focus back to thinking of the material properties of the monument itself, further questioning the quality of the initial build (Bidwell 2018). There are a number of sites that can be identified as having suffered collapses and/or extensive rebuilding (Table 3.5), and it is instructive to review a handful of these.

The best evidenced and most extensive investigation of recurring collapse of the Wall curtain and its reconstruction is found at Buddle Street, Wallsend, immediately east of the Roman fort (Bidwell 2018). A length of *c* 84 m was excavated in stages that revealed this stretch of curtain was built to Narrow Wall standards, 2.4–2.6 m wide foundations and 2.26 m wide above the footings. However, at least three episodes of substantial collapse of the curtain occurred at different locations in this short stretch, which were followed by episodes of rebuilding. The underlying cause was a combination of unstable soil, liable to compression and collapse, combined with flooding. Each time the curtain was rebuilt, it was set directly above the old foundations and/or footings and sometimes projected out from them. Furthermore, the rebuilds often included 'new' fabric re-used from other sources, like a shrine and the east gate of the fort, and also

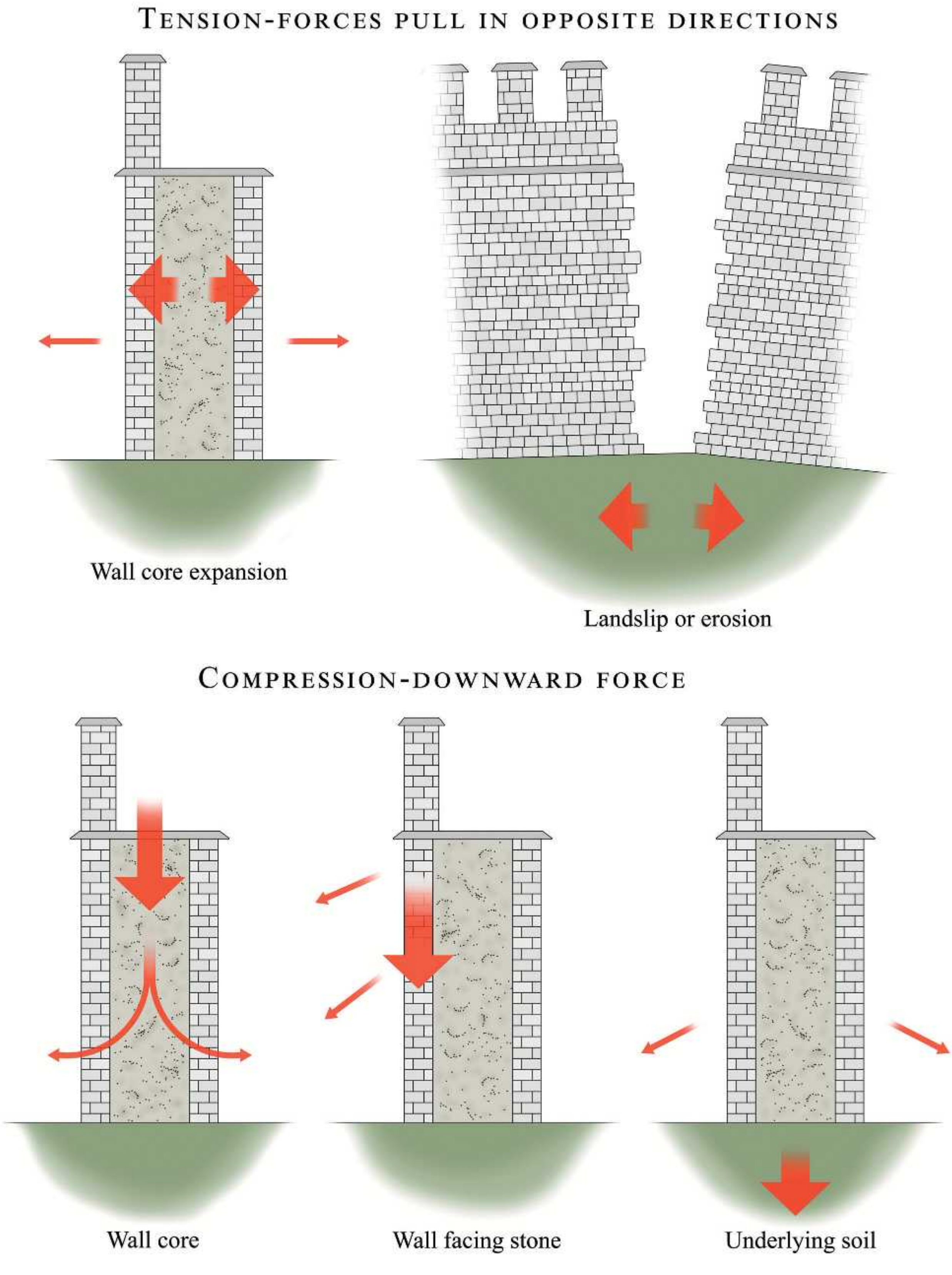



*Figure 3.13: The effects of tension and compression forces on the Wall curtain. The larger arrows indicate the direction of force and/ or movement, while the smaller arrows indicate the direction of fabric collapse. Illustration by Matilde Grimaldi.*

*Table 3.5: Wall sites (excluding forts) with evidence for substantial rebuilding, repair, and refurbishment. Sites are presented east to west.*

| *Site* | *Evidence* | *TPQ of work(s)* | *Reference* |
|---|---|---|---|
| mi. 0 (Buddle St) | Inward tilted foundation slabs; displaced fabric; mixed fabric; spolia; vertical offset; clear structural phasing | | Bidwell 2018 |
| mi. 2 (Shields Road) | Inward tilted foundation slabs | | McKelvey and Bidwell 2005, 15 |
| mi. 7 (Denton Bank) | Hard mortared core | | Brewis 1927 |
| T7b (Denton) | Displaced and mixed fabric | Later 2nd century | |
| mi. 7 (Denton Square) | Hard mortared core; Collapsed fabric; snapped and/or tilted foundation slabs; inferred refacings | Post 202–210 | Spain 1927–28, 278–279; Bidwell and Watson 1996; Bidwell 2018, 223 |
| mi. 8-9 | 13 inscriptions | Later 2nd century | Mann 1992; Hodgson 2011, 67–68 |
| MC10 | Hard mortared core | | Bruce 1865, 223 |
| mi. 10-11 | Hard mortared core | | Bruce 1865, 223 |
| MC18? | North gate masonry 'rougher and less imposing' | | E. Birley *et al*. 1932, 157 |
| mi. 19 | Poor quality build in south face | | E. Birley *et al*. 1933, 99–100 |
| Knag Burn gate | Insertion of new gate through curtain; mixed fabric | Later 2nd century | |
| MC37 north gate | Repaired fabric | | Hill 2013 |
| mi. 37 | offsets | | Hodgson 1840 |
| West of MC39 | Spolia (window head) | Later 2nd century | CSIR I.6, no.456 |
| East of T39a | Spolia (tombstone, RIB 1641) | | Woodside and Crow 1999, 46–48 |
| T39a | Large well-dressed blocks; | Later 2nd/early 3rd century | Simpson 1976, 100–101 |
| mi. 45 | Displaced and mixed fabric | | |
| mi. 49 | inscriptions | Early 130s | Breeze 2006, 293 |
| mi. 49, at NW corner of Birdoswald fort | Stratified late 3rd c ceramics below foundations | Late 3rd century+ | Simpson and Richmond 1934: 128–129 |
| T51a | Collapse and reconstruction of east wall | *c* 120-130 | Charlesworth 1973a |
| MC52 | Spolia (altar, RIB 1956) in foundation | 262–266 | Hodgson 1840, 297 |
| Curtain at turret 52a | Collapsed fabric | 160 | Breeze 2006, 321 |
| mi. 52 | Collapsed fabric | 160 | Breeze 2006, 322 |
| T54a, and east of turret | Collapsed fabric (turret); demolition of turret and Stone Wall replacement | *c* 130–160 (turret); later 2nd/early 3rd century | Simpson *et al*. 1934b |
| mi. 59 | Spolia (altar, RIB 2015) in foundation | Later 2nd century | Lysons and Lysons 1816, clxx |
| mi. 65 | Spolia (altar, RIB 2024) as drain/culvert capstone | 262–266? | Jarrett 1994, 56 |
| Dykesfield | Spolia (altar, RIB 2050) in foundation | Later 2nd century | Hodgson 1840, 223 |
| Drumburgh | Broken foundation slabs | Later 2nd century | Simpson and Richmond 1952, 12–13 |
| MC79 | Broken foundation slabs | Later 2nd century | Richmond and Gillam 1952 |

made increasing use of mortar that analysis revealed used limestone sourced from a distance, most likely the central sector of the Wall. As a result, even the relatively modest survival of only the lowest courses of the curtain at Buddle Street show a high degree of diversity in the size of stones used. The course of the curtain also preserves slight bends or curves instigated by episodes of collapse (Fig. 3.14). However, silt deposits containing Roman ceramics of the later 4th century indicate that the curtain was standing until at least the end of the Roman period.

*Figure 3.14: The consolidated length of Wall curtain at Buddle Street, Wallsend, which had multiple phases of collapse and reconstruction. Collapses introduced curves into the normally straight curtain, which were incorporated into rebuilds.*

*Figure 3.15: Denton turret 7b, as viewed from the southwest. Note how the southern and western external faces have been consolidated, fixing the slump of coursing. The larger stones visible in the southwest and southeast corners and the south face of the curtain are in situ Hadrianic fabric, while the smaller stones that make up the south and west turret faces are rebuilt. The scale bar is 1 m.*

The evidence gathered at Buddle Street prompted a more wide-ranging consideration by Bidwell (2018, 219–226), who reassessed evidence at other locations along the curtain and various installations. The stratigraphically later use of higher quality, harder white mortar can be contrasted to original Hadrianic building work that makes use of clay bonding or a softer brownish mortar (see turret 54a below). This reveals evidence for rebuilding in Wall-miles 7 (Denton) and 10 (Heddon). At Denton Square, more recent excavation encountered evidence for collapsed facing to the south of the curtain and evidence of compressed and probably displaced soil (Bidwell and Watson 1996). What has not been appreciated to date, however, is that the unstable soil and slope, combined with the weight of the Wall also resulted in at least partial collapse of turret 7b, too. This can be observed in the consolidated stonework of the turret, notably in the external south and west walls of the structure, which show a slump in the coursing and use smaller stones, relative to the larger stones in the southwest and southeast corners of the structure and south face of the curtain (Fig 3.15). The current consolidation appears to fossilise the fabric as it was first excavated (compared with figs 1 and 2 in Birley 1930). Though dating of such a collapse cannot be certain, Eric Birley noted the presence of stone debris in the makeup of the layer below flooring attributed to period II, suggesting a date in the later 2nd century (Birley 1930, 14). However, it is possible that the rebuilding of the Wall at Denton to the east and west of the turret could have taken place at the same time (Brewis 1927; Spain 1927; Bidwell and Watson 1996). At present, the best evidence for the curtain is based on a Severan coin dating 202–206 stratigraphically linked to the collapse of the south face of the curtain at Denton Square.

Turret 54a (Garthside), built in red sandstone and part of the Turf Wall, not only required repair, but an entire replacement due to unstable ground beneath the turret's position (Simpson *et al*. 1934b, 138–144). The sandy soil found in that area collapsed from the south lip and slope of the ditch to the north of the turret, pulling and twisting the north wall of the turret outward. Significantly, there were at least two discrete floor layers suggesting that the collapse and slippage of soil did not happen rapidly. As a result of this collapse event, the original Turf Wall ditch was infilled, and the line of the Turf Wall moved further north (downslope) with a new ditch excavated in front of it. A new, second and freestanding turret was built immediately south of the original turret on the crest of the hill. This made use of the remaining lower courses of the now demolished first turret, which almost certainly added stability and strength to the ground immediately north of the crest. Subsequently, when the Turf Wall was replaced with the intermediate gauge Stone Wall, the Stone Wall curtain was built in line to the northeast and northwest corners of this second turret, and flush with its northern face. At some point in the later 2nd century, the turret was abandoned on the basis of associated ceramic finds. Subsequently, repair and/or reconstruction of the Stone Wall was undertaken. The east, west, and south walls of the turret were demolished and reduced to only two courses

*Figure 3.16: Projecting offsets visible on the south face of the Wall curtain in Wallmile 37, west of Housesteads fort. This location has two offsets in close proximity with a slightly narrower length of curtain between them.*

of height, and the soft, brown mortar associated with the primary construction of the Stone Wall was succeeded by new curtain stonework. This new stonework filled in the internal recess in the northern wall of the turret, so that the thickness of the stone curtain would be consistent, and all this work was associated with a good quality hard white mortar. Reconstruction of the curtain in the hard white mortar stretched at least 300 yards further east down to the Burtholme Beck (Simpson *et al*. 1934b, 42).

These brief examples provide good evidence for substantial repair to the Wall at three locations, though Table 3.5 provides a more extensive and undoubtedly incomplete list of further sites. It is clear from the table that repair occurred along the entire length of the Wall, from mile 0 to mile 79. Locations where re-used altars or other spolia have been found in foundations or lower courses of fabric, or offsets between different lengths of the southern face are clear indications of rebuilding (Fig. 3.16). And an important lesson from Buddle Street is that rebuilding and repair is often built to the same width of the curtain it is repairing, rather than constructing to the most recent gauge elsewhere. Repair can often entail much more mixed fabric, both in terms of size and arrangement, as well as geologically by (re)using stones from different source buildings or locations, either within a local quarry or a different quarry altogether. No doubt, further research will reveal additional sites to be added to the list, and ideally, resolve some of the ambiguities of dating such repairs.

# 4

# Roman quarries and stone-working in the Wall corridor

Having considered the geological evidence, this chapter will examine the possible quarries of Hadrian's Wall based on the archaeological evidence. Quantitative studies have shown that the volume of stone necessary to construct Hadrian's Wall was approximately 1.5 million $m^3$ (O'Donnell 2021, 233). The combined yield of three out of five of the existing known Roman quarries in the Wall corridor has been estimated at *c*. 200,000 $m^3$, roughly 13.5% of the total requirement (O'Donnell 2021). The discrepancy between these two figures raises questions about the source of the additional material. Further complicating this problem is the sheer quantity of quarries in the landscape around the frontier. Approximately 500 quarries are recorded by the British Geological Society (BritPits 2022), with even more unrecorded but visible on satellite imagery and LiDAR. While petrological testing is very useful in comparing samples from quarries with stone from the Wall and its forts, it would not be possible to sample every quarry in the area, and so a combination of methods has been used to narrow down the field.

The most reliable and accurate way to establish if a stone outcrop has been quarried is to look for the physical traces of quarrying at the sites themselves. There are various types of evidence which are left behind as a result of the quarrying process which will be described below: chisel and pick marks; wedgeholes; cut stone; spoil heaps; quarry roads; and inscriptions and iconography. Limited changes in quarrying technology through time mean dating based on the toolmarks alone is not possible. For this reason, a rating system has been developed to indicate the likelihood of quarrying during the Roman period. The quarry rating system and archaeological evidence for quarrying allow for the identification of different types and forms of Roman quarries associated with the construction and maintenance of Hadrian's Wall.

## Quarry rating system

A quarry rating system has been devised to categorise the many undated quarries which can be found in the areas surrounding Hadrian's Wall, based on the probability of Roman quarrying at the site. The rating system has been adapted from one used by O'Donnell (2021) to categorise approximately 150 quarries within 10 km of Hadrian's Wall.

In the landscape surrounding the Wall, hundreds of undated quarries have been opened over time. A retrospective method was used to analyse mapping of the quarries through time which provided insights into changes in the landscape. The opening and expansion of quarries can be seen between phases of Ordnance Survey mapping, which while useful as a method to discount modern quarries from consideration as ancient sources of stone, cannot be used for

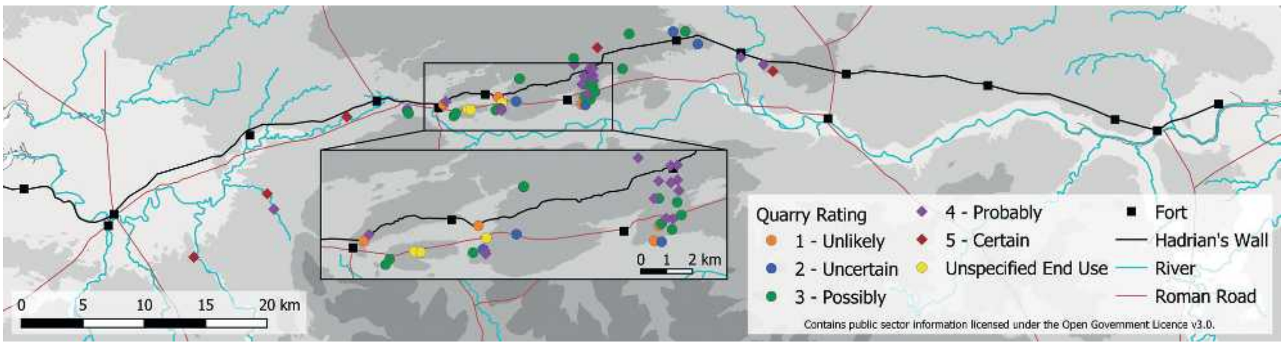



*Figure 4.1: Map of quarries by quarry rating. Includes OS data © Crown copyright and database right 2022.*

*Table 4.1: The rating system employed for quarries to determine the probability that a quarry originated or was used in the Roman period and is associated with the Wall.*

| *Rating no.* | *Probability* | *Meaning* | *Total count* |
|---|---|---|---|
| 0 | Definitely not | direct confirming evidence (*e.g.*, only modern working, incl. documentation, geologically does not match) | 4 |
| 1 | Unlikely | indirect evidence that discounts (*e.g.*, wrong stone, location unsuitable) | 10 |
| 2 | Uncertain | not directly observed and/or no data, but otherwise a feasible location/outcrop | 5 |
| 3 | Possibly | circumstantial evidence that raises likelihood (*e.g.*, quality of stone, vicinity to Wall, routeways, suspected loss of evidence of ancient quarrying) | 9 |
| 4 | Probably | indirect evidence that supports likelihood (*e.g.*, toolmarks, pre-modern working, pathways) | 16 |
| 5 | Certain | direct confirming evidence (*e.g.*, inscription, geochemical) | 5 |

anything predating the mid-1800s. In the case of quarries predating this period, only field visits or mentions in historical sources can be used as evidence. Quarries have been rated based evidence including toolmarks, inscriptions, historical mapping, and modern satellite imagery (Table 4.1).

Examples of quarries which fit into these categories are given in Appendix 2, and all the quarries in Category 5 are discussed in further detail below. However, this rating system provides a cogent overview of the dearth of Roman quarries in certain areas around the Wall and the potential scale of quarrying along the length of Hadrian's Wall. Table 4.1 shows the count of quarries of each rating listed in the appendix. It is of note that there is a particular concentration of quarries which have no evidence in modern records or mapping of being operated in modern times. The quarries in category 4 all display evidence of methods of stone extraction consistent with tools used between the Roman and medieval periods. The majority of the quarries are located near the central sector of Hadrian's Wall. Several reasons for the reduced number of quarries to the west and east exist, with the most likely explanations being urban development requiring backfilling of disused quarries, and the deeper superficial deposits lying above the bedrock at the mouths of the Solway and Tyne.

## Quarrying evidence

### *Chisel and pick marks*

Tools used in the quarrying process have been found at Hadrian's Wall and around the empire (Pearson 2006, 53). Tools found at the Wall include axes, chisels, hammers, picks, and iron wedges (Breeze 2006, 91). Figures 4.2 and 4.3 show a chisel and pick found at Corbridge. Thanks to the recovery of these items, we have a good understanding of which tools performed which purposes in the stone extraction process. Good descriptions of the tools used in stone cutting, and what functions they performed, can be found across multiple works (Blagg 1976; Dworakowska 1983; Manning 1985; Shirley 2001; Hill 2004; Pearson 2006; Wootton *et al.* 2013). Quarry picks, axes, and adzes would have been used by the masons and quarrymen working at the Wall to extract or roughly shape blocks of stone. For dressing the stone, the tools necessary would have been mallets, point chisels for roughing out, flat chisels, claw or tooth chisels, and roundels for finer shaping (Shirley 2001, 111).

Crow bars or levers were another instrument used in quarrying, placed under loosened block to lever them out (Stanier 2000, 23). The type of stone being worked on would also have called for different methods of stone extraction. For example, 'For softer rocks, including some sandstones and limestones, the technique of picking out a long channel was employed from Roman times to the early twentieth century' (Stanier 2000, 24).

Toolmarks are visible at many of the quarries in the Wall corridor, and they appear in various forms. In some cases, lines had been marked out, possibly to indicate the

*Figure 4.2: CO87, iron chisel from Corbridge. © English Heritage.*

*Figure 4.3: CO114, mason's pick from Corbridge. © English Heritage.*

line along which a block was to be split. In others were large, flat areas which had been worked with a point chisel, or areas which showed long perpendicular lines (although these can occasionally appear naturally in the bedding of the stone). Where drilled holes are found, these are a useful indicator of modern quarrying using blasting.

Chisel marks are very clear at the Roman quarry at the River Gelt, where they can be seen in various states of preservation. Their proximity to the modern concrete path means it is possible that these do not date to the Roman period but rather the construction of the path, but nevertheless they provide a good example of the use of a point chisel to roughly flatten a stone face. Figures 4.4 and 4.5 show these tool marks in two different locations at the quarry. One is fairly well preserved, and the other has been weathered by running water. Weathering and other natural geological phenomena can be easily mistaken for toolmarks. Figures 4.6, 4.7 and 4.8 show a sample of natural stone with characteristics that appear to have been originally man-made but are most probably natural. Figure 4.6 shows some limestone from a modern quarry for railway sleepers on Barcombe Hill with a pattern which at first glance resembles chisel marks or crude lettering, however, it is more likely that these marks have formed naturally as a result of water erosion and weathering. Figure 4.7 shows a ring-shaped mark on an outcrop near Dove Crag which may have been caused by a concretion in the sandstone which has eroded away, and Figure 4.8 shows the regular

*Figure 4.4: Pointed chisel marks at the Gelt quarries, Cumbria.*

*Figure 4.5: Water-worn pointed chisel marks at the Gelt quarries, Cumbria.*

*Figure 4.6: Natural weathering on limestone at a quarry on Barcombe Hill, Northumberland.*

*Figure 4.7: Ring-shaped mark possibly caused by iron concretion at Dove Crag, Northumberland.*

*Figure 4.8: Cast of tree bark on sandstone outcrop near King's Crag, Northumberland.*

geometric pattern left behind by a cast of Lepidodendron, a large carboniferous tree species with diamond shaped scales on its trunk. Identifying archaeological evidence of quarrying is best done in close collaboration with specialists in geology to make sure accurate distinctions are made between natural and archaeological processes.

### *Wedge holes and lewis holes*

Wedges are a tool used in the stone quarrying process to split the stone. Wedges made from iron or wood would be placed into cut wedge holes along natural bedding lines in the stone (see Fig. 4.9). Iron wedges would be hammered in to cause the stone to split, and wooden wedges would be soaked in water, which causes them to expand and break the stone (Wootton *et al*. 2013, 3).

Wedge holes can be found at many of the quarries in the Wall corridor alongside toolmarks. They have been identified in each of the main stone types of the region:

*Figure 4.9: CO111, iron wedge from Corbridge. © English Heritage.*

sandstone, limestone, and dolerite, and variations in each of these are visible mainly due to differences in the way each stone weathers. Wedge holes can also be identified on blocks that have already been removed from the quarry face where they have been used to split open the stone (see Figs 4.10, 4.11 and 4.12). Wedge holes in whinstone seem to be more rounded and deeper, compared to the long thin wedge holes seen at the sandstone quarries. Additionally, in some of the modern limestone quarries wedge holes have been placed vertically through the stone, perpendicular to the grain instead of parallel to it. This can also be seen at the Roman quarry on Barcombe Hill, where a series of three wedge holes run vertically down the sandstone quarry face, but this was to take advantage of a natural fissure in the rock (Blagg 1976, 154).

The lewis hole is a toolmark that also appears on Roman period stone and is similar in appearance to the wedge hole. Lewis holes were carved into stone to insert a lifting device called a lewis (also sometimes referred to as chain lewis, lewis-pin or lewis-bolt). The device can lift very heavy stone blocks with a crane or winch and has been used since at least the 2nd century BC (Younger and Rehak 2009). The easiest way to differentiate a wedge hole from a lewis hole is to feel the interior by hand as the profile of a lewis hole flares out inside the stone (Fig. 4.13).

Although uncommon, there are some geological processes that cause similar elongated holes in natural stone outcrops. When molten magma cools to form the dolerite, it is decompressed, and volatiles come out of the solution

*Figure 4.10: Left image – line of wedge holes at Queen's Crag quarry, Northumberland; right image – wedge holes with visible toolmarks at Comb Crag quarry, Cumbria.*

*Figure 4.11: Wedge hole in whinstone near Walltown Crags, Northumberland.*

*Figure 4.12: Half wedge hole left on block following removal at small outcrop near Housesteads fort, Northumberland.*

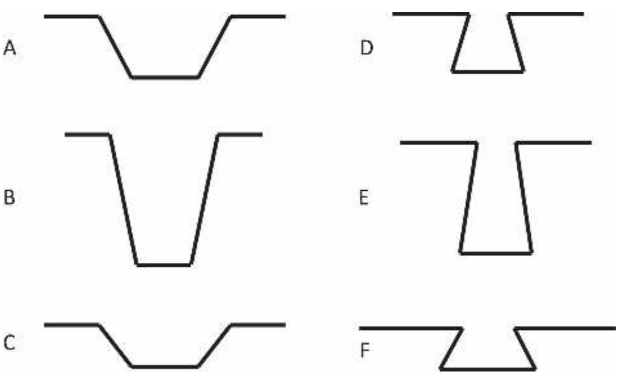



*Figure 4.13: Cross-sections of wedge holes and lewis holes. A–C show variations of wedge holes; D–F show variations of lewis holes, not to scale. Illustration by Kathleen O'Donnell.*

in bubbles. As it cools, these bubbles become set into openings called vesicles. These bubbles leave cavities in the natural stone which when weathered can be mistaken for man-made holes (Fig. 4.14). In sandstones rip-up clasts of mud-flakes are deposited when storm follows drought and dried out mud is washed out and deposited in layers within a sandstone. These mud-flakes are much softer than the sandstones around them and will weather out, leaving holes behind them. These too mimic tooled holes.

### *Cut stone*

Cut stone blocks are a very useful type of evidence which can be used to distinguish between natural outcrops and stone which has been quarried. The removal of large blocks of stone leaves noticeable rectilinear negative spaces on the quarry face and these are often removed in a regular repeating pattern. The cutting of stone blocks can also create terracing within the quarry or a zigzag-shaped pattern in the quarry face which can be observed through aerial photography. The removed stones vary from small, irregular shaped blocks to much larger ones, 2–3 m in length. As a large proportion of the stones used to construct Hadrian's Wall were either small facing stones or rough core rubble, the block removal patterns are not as regular and 'organised' as one can observe in Roman quarries in other parts of the Empire (see the regular limestone block removal in Egyptian Roman period quarries – Harrell and Storemyr 2013, 35). This is also impacted by the very variable thickness of sandstone beds available in the local geological landscape. Figures 4.15 and 4.16 show examples of removed blocks.

Removed blocks appear to be an obvious mark of human intervention in the landscape, but there are geological processes which create a strikingly similar appearance to this type of evidence. Physical weathering of stone, particularly a type of physical weathering called 'frost wedging', causes very deep fissures to form within the natural rock. Water seeping into joints in the rock freezes and thaws, which splits the stone open and breaks it apart. These fissures can appear in regularly spaced parallel lines, occasionally with other cracks appearing at 90° angles. Figures 4.17–4.19 show some partially removed blocks, some weathered stone, and the process of physical weathering. It is very important when identifying an outcrop as a quarry to establish multiple types of quarrying evidence, as using one of the criteria alone is not enough due to the possible misidentification of natural features.

### *Spoil heaps*

Spoil heaps are large piles of waste stone or other excavated material which may have come from unused thin beds of stone or waste from cutting larger blocks down to shape. Once again these cannot be dated, but the degree to which the stones in the rubbish heaps have been weathered or overgrown can at least give a relative picture of their age. Railway sleeper quarries around Barcombe Hill opened in the mid-19th century have very large sharp, unweathered piles of stone associated with them, most likely because blasting was used to remove

*Figure 4.14: Vesicles in whinstone at Cawfields Quarry, Northumberland.*

*Figure 4.15: Large removed and partially shaped stone block at a quarry near Crag House, Northumberland.*

the stone which creates a lot of waste. The hardness of the limestone in these quarries has prevented them from weathering as quickly as the softer sandstones in the Roman quarries. The spoil heaps at the Roman quarries are often overgrown and covered with vegetation, and the continued deterioration of the quarry faces mean new rubble is regularly deposited on top of the original debris from the Roman period (Fig. 4.20).

### *Quarry roads*

A discrete type of evidence are trackways for transporting stone. Trackways are not always visible in the modern landscape but would have been an essential component created in advance of transporting stone from a quarry in any sort of vehicle or could perhaps be formed as a result of repeated or prolonged transport. Only one possible cart path was identified in association with Hadrian's Wall at the quarries beside the river Gelt. The very overgrown potential cart path was identified leading up and away from the river to the West (Fig. 4.21). The path is not wide enough to easily allow a large cart drawn by two animals side by side but would certainly be wide enough for a smaller cart a pack animal, or a sled. The quarries on the west bank of the River Gelt are less well documented as they are on a private estate. These quarries also contain the altar with inscription (RIB 1016) which was not accessible, and two presumably Victorian carved faces that mimic the genuine Roman face carvings on the east bank (Fig. 4.22). There was substantial 19th-century quarrying on the western riverbank and this path may also be associated with that. Figure 4.23 shows some types of stone transportation, including carts which needed basic road construction to support the weight of the stone cargo.

### *Inscriptions and iconography*

The only type of archaeological evidence which has been found in quarries in the Wall corridor and used for dating are inscriptions and iconography. Outside this, only artefacts found during excavation within a quarry could be used, though no excavation of a quarry at Hadrian's Wall has occurred or is planned at this time. The most frequently occurring iconography featured on the quarries of Hadrian's Wall are phallic symbols. The Roman quarries at Queen's Crag, Fallowfield Fell, Barcombe Hill, Gelt, and Shawk are all known to have had phallic imagery on them at some time in the past (Breeze 2006, 231; Pearson 2006, 47, 50; Collins 2020; RIB 2022). The common interpretation of this is as a symbol of good luck or protection from the evil eye (Pearson 2006, 49) but they have also been associated with liminal or transitional spaces, trade and commerce, and protection from danger (Parker 2017, 117). Given the hazardous nature of quarrying it is very possible the phallus may have been used as a protective symbol.

Carvings of animals and humans have also been recorded on quarry faces close to Hadrian's Wall. A carving of a bear, the symbol of the 20th legion, was once visible on the face of the Roman quarry at Barcombe Hill, but no longer survives (Breeze 2006, 428). Further to the west, a carving of a stag follows an inscription next to the River Eden. The inscription mentions the 20th legion *valeria victrix* (*RIB* 1005). The final type of carving on the quarries are human figures. One has been known for decades and depicts a human face which accompanies RIB 1008. In more recent times a new discovery of a bust portrait was made in the same cluster of inscriptions on the River Gelt during conservation works (Hilts 2019). The carving is beside a currently unlisted broken inscription which reads '…ONIUS'. 3D scans from this conservation work on the Historic England Sketchfab site and show this new carving in its context.

The inscriptions have been a source of keen interest for centuries and saw particular focus from antiquarians

*Figure 4.16: Removed block and spoil heap at a blasted quarry on Thorngrafton Common, Northumberland.*

*Figure 4.17: Partially removed block at Fallowfield Fell Quarry, Northumberland.*

*Figure 4.18: Linear cracks in weathered stone.*

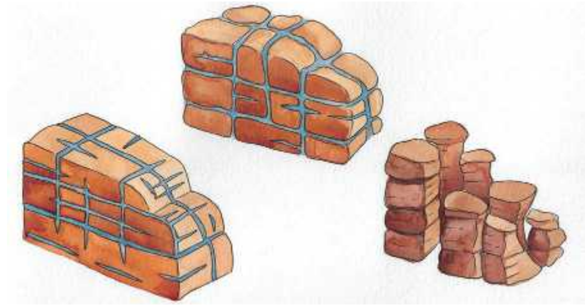


*Figure 4.19: Illustration showing the process of physical weathering, by Kathleen O'Donnell. After British Geological Survey (https://www.bgs.ac.uk/discovering-geology/geological-processes/weathering).*

*Figure 4.20: Spoil heap covered by vegetation at Queen's Crag, Northumberland.*

*Figure 4.21: Possible cart path on the west bank of the River Gelt, Cumbria.*

during the 18th and 19th centuries. In addition to being useful for reconstructing ancient organisational hierarchies, inscriptions of this type provide an insight into the social history of individuals living and working in the Roman Empire who would not have been described by ancient authors, particularly in these remote frontier zones where there are sparse historical sources (Keppie 1991, 9). Thirty inscriptions in total are recorded in the Wall area and their subject and style vary greatly (Table 4.2). A detailed account of each of the inscriptions and their state of survival is given in O'Donnell (2021). Further detailed investigation may reveal more inscriptions based on recent work digitally recording and analysing the quarry face at the Rock of Gelt, which identified at least three new inscriptions in addition to those previously identified (Allason-Jones 2023). The number of inscriptions from Roman quarries known at present, therefore, is almost certainly a sample of a larger number that may survive and those that were carved in the past.

*Figure 4.22: Face carvings at quarry face on the River Gelt, Cumbria that appear to be Victorian* falsa.

## Quarrying methods and quarry types

Before discussing the types of quarries which can be observed in the landscape around the Wall, it is essential to consider the timeline of the quarrying process in the Roman period. Quarrying operations were an eight-stage process comprising: (A) prospecting/site location; (B) site preparation/overburden removal; (C) block extraction; (D) cutting blocks to size; (E) shaping blocks; (F) stone weathering; (G) transportation; and finally, (H) construction (Fig. 4.24). Prospecting included a range of factors both natural and cultural, such as looking at tree cover, nearby water sources, depth and uniformity of sandstone beds, the safety of area from hostile groups, distance to final destination, terrain to transport stone across, proximity of nearby pre-existing roads, and drainage. Following this, topsoil and overburden would be removed from above the usable stone layers – this includes overlying layers of poor-quality stone, trees, shrubs, and soil. Next stone blocks would be removed in whichever way was easiest at the particular site and then worked down into smaller pieces, or roughly shaped on site for a specific function before transportation. Stone extraction for especially large architectural features like columns would have required thicker beds of stone than those needed for facing stone,

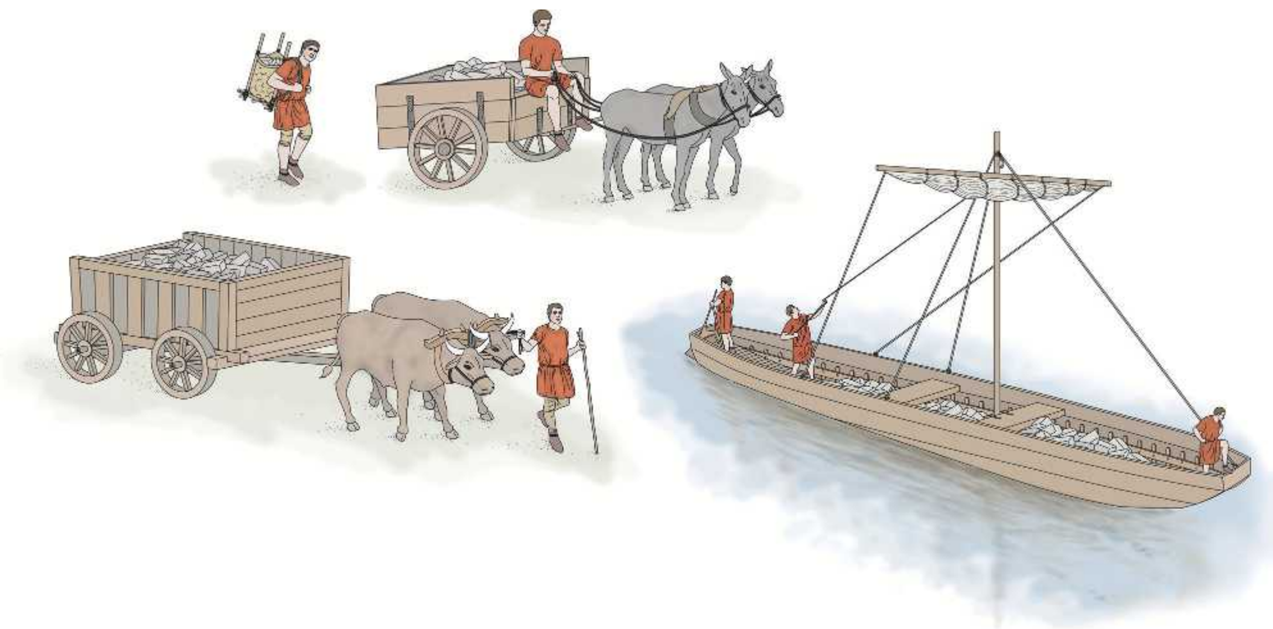


*Figure 4.23: The range of transportation methods used by Romans for quarried stone, including: carried by person; a 2-wheeled mule-drawn cart; a 4-wheeled, oxen-drawn wagon; and over water by barge. Illustration by Matilde Grimaldi.*

and detailed carving of decorative stones is more likely to have been completed at or near the stones' destination to avoid damage during transportation. Stone would then be weathered for an unknown period to allow it to harden slightly before being used in construction either in the quarry or near the area of construction.

The process would vary slightly depending on the purpose, shape and type of quarry. In the Wall corridor, there are five types of quarries, each of which has a distinct morphology and relates to particular processes of prospection and extraction: shallow-faced; high-faced; riverbank; backfilled; and blasted.

*Table 4.2: Inscriptions associated with quarries along Hadrian's Wall arranged west-east, followed by sites a further distance south of the Wall.*

| *Site* | *Total no. inscriptions* | *RIB numbers* |
|---|---|---|
| Wetherall, Cumbria | 3 | 1004–1006 |
| Gelt, Cumbria | 12+ | 1007–1016; CSIR I.11: 372, 373 |
| Shawk, Cumbria | 3 | 1001–1003 |
| Comb Crag, Cumbria | 8 | 1946–1952, 3452 |
| Haltwhistle Burn, Northumberland | 1 | 1680 |
| Queen's Crag, Northumberland | 1 | 3331 |
| Fallowfield Fell, Northumberland | 1 | 1442 |
| Crowdundle, Cumbria | 3 | 988–1000 |

### *Shallow-faced quarry*

Due to the gentle sloping hills surrounding large parts of the Wall area, shallow-faced quarries are potentially the most common quarry type, characterised by a long, low main face (less than 2 m) and a shallow sloping profile. Stone from these quarries is extracted using a stepped method, which can be seen quite clearly at Fallowfield Fell Quarry (Fig. 4.25). Blocks have been removed or half-removed from all along the surviving face of uniform size. The method used to extract the blocks is traditional of Roman quarrying (Bessac 1996; Gutierrez 2009): once a suitable layer of building stone is exposed and overburden removed, lines are cut using a chisel or small pick to mark out the extent of the block to be removed. A quarryman then uses a heavy pick to cut channels around all the sides of the block until is it only attached at the base. Once all of the sides are cut free of the quarry face, wedge holes are cut into a seam in the rock at the base of the block being removed and then iron wedges are placed into them. The wedges are hammered in to split the block from the quarry completely. Finally, a crowbar is placed behind the block and used to lever it out of its position and push it forwards (Fig. 4.26).

Although the slope descending from the face is now covered in a thick layer of soil and vegetation, the lower level of the stepped face can be seen at some points. At this quarry the tool used for cutting a channel seems to be a pick, but the condition of the stone makes it very difficult to tell what shape of pick due to weathering.

### *High-faced quarry*

As the name suggests, high-faced quarries are found on steeper slopes or cliff faces, such as Queen's Crag or

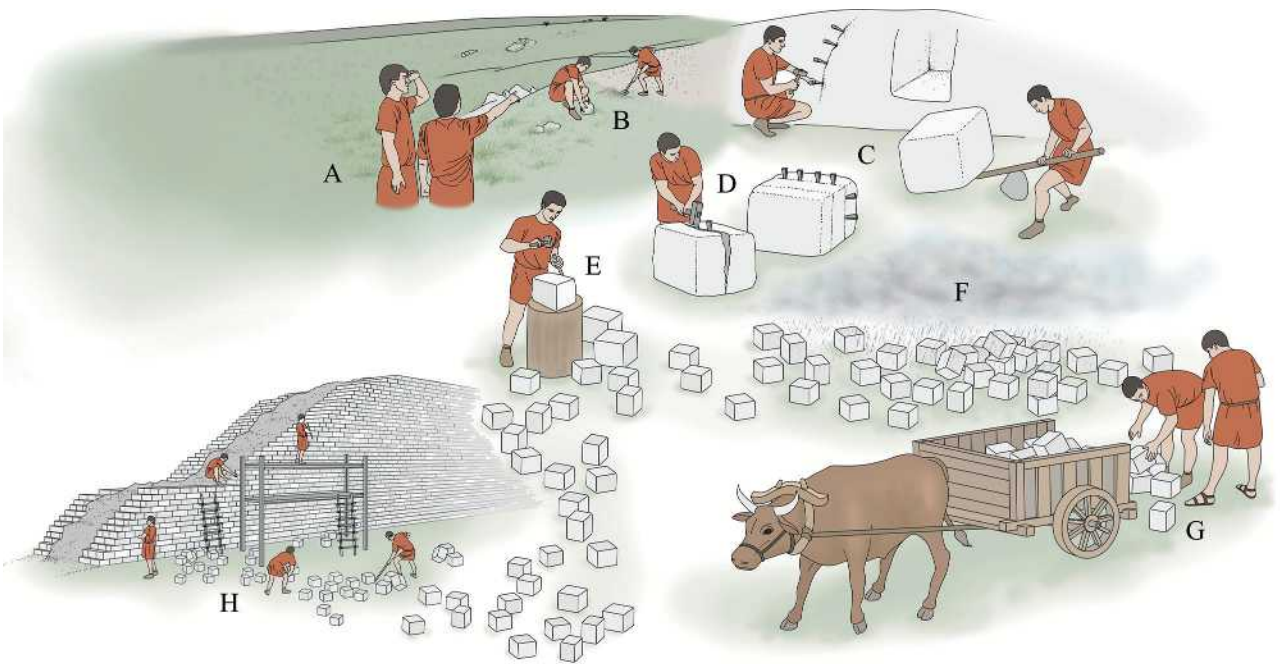



*Figure 4.24: The stages of the quarrying process in eight steps. Illustration by by Matilde Grimaldi.*

*Figure 4.25: The stepped pattern of block removal partially visible under overgrowth at Fallowfield Fell, Northumberland.*

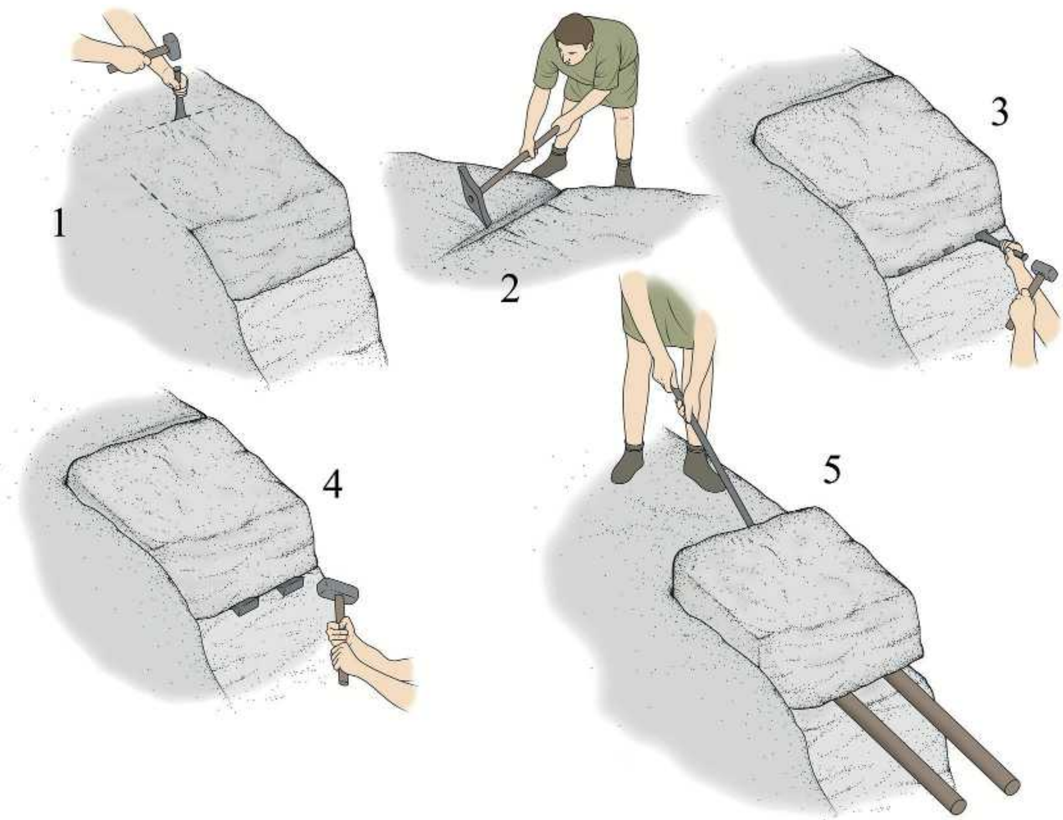



*Figure 4.26: The process of block extraction and tool use in Roman quarrying. Illustration by Matilde Grimaldi.*

Crag Wood. The faces of these quarries vary in length but have a higher face (2 m+) which necessitates extracting blocks vertically before stepping back further into the stone. Similar to shallow-faced quarries, Roman quarrymen extracted uniformly sized large blocks from the face before moving them away to break down and rework. The zigzag pattern in the quarry faces can be seen from above (Fig. 4.27a).

The higher faces of these quarries lead to a choice of either removing blocks and lowering them downwards from the top of the face or a terrace or raising them upwards. Lowering blocks top-down would certainly be the best way to work if using a crane positioned at the top of the quarry face. When the quarry faces away from the Wall or direction it needs to travel, lifting the stone up and out of the quarry would be a practical method to use. Extracting the stone and taking it downhill from the quarry was the other choice which could work with either method in theory. Another option is to remove the stone from a position lower on the face. However, this method would leave an overhang of rock above the extracted stone which introduces the potential of a substantial amount of rock falling in a poorly or uncontrolled fashion. This method, therefore, is more dangerous than removing stone from the top of a higher face and working downward. Examples where overhangs have been left behind were likely a result of a last-minute need for a few extra blocks, where the extra labour of overburden removal was not seen as necessary. Two of the high-faced Roman quarries, Comb Crag and Queen's Crag, have been left with overhanging rock directly above the location of inscriptions (Fig. 4.27b). It would appear that the inscriptions were left as the quarry was in the final stages of its exploitation. Once as much good workable stone as possible had been removed from the quarry, the final blocks were taken without removing the overburden and precarious overhangs were left protruding from the face.


*Figure 4.27: (A) Satellite imagery of the quarry face at Queen's Crag. © Apple Maps. (B) The overhanging rock on the quarry face at Comb Crag, Cumbria.*

### *Riverbank quarry*

There are a number of small and large rivers through the Hadrian's Wall area, the North and South Tyne, the Irthing, and the Eden being the most significant, and these features provided natural weathering and access to bedrock exposed by riverine erosion over the millennia. There are two major Roman riverbank quarries dated through inscriptions, Comb Crag and the Gelt quarries, as well as the smaller potential quarry on the River Eden. It is notable that the rivers in the Wall corridor have carved deep valleys with high faces of naturally exposed stone. Thus, riverbank quarries present the same challenges as high-faced quarries, but the techniques to remove stone from such quarries are unique. It has been suggested that stone was removed from these sites by water (Blagg 1990, 3), but only the River Eden is really a large enough river to carry the stone north towards the Wall. The River Irthing beside Comb Crag and the River Gelt beside the Gelt quarries are both too shallow today to support a barge carrying stone. It is possible that the water level was higher in ancient times, but this is unlikely as the quarry faces go right down to the current water level which would have left them submerged. Comb Crag is in an interesting position in a tight bend of the river. The approach taken there was to split the high face into two levels, so that men could work on removing stone at both areas simultaneously. It seems that both sides of the crag were worked, but the majority of stone was taken from the eastern side. The ground above the quarry faces slopes down towards the river with a narrow path along the top. This seems like the best path for removing the stone, carrying it away from the bottom of the faces and then moving it up the hill towards the Wall by a small animal drawn cart. It is also possible that the stone was lifted out by crane, but the narrow path would have been a precarious place to balance large machinery requiring a stable foundation.

Based on the evidence at the largest Roman quarries at the Wall, it seems that water carrying was not used as the main method of transportation despite several of the sites lying on riverbanks. In most cases the river is either too shallow or flows in the wrong direction, carrying stone further from the Wall. Seasonal floods and water control systems may have allowed temporary use of the rivers but it is important to note that quarrying during the wet months would have created more hazards in an already very dangerous task and quarrying tools are less effective on wet stone (Hill 2004, 119). The river Eden is one example which is large enough to support stone transport, and the river Tyne close to Newcastle could certainly also carry stone barges. At the moment there is no evidence at any of the Roman river quarries for jetties, weirs, dams, or other water access points.

There are a number of other quarry types in the Wall corridor which can be seen but are either exclusively modern and therefore not considered to be Roman stone sources, or they cannot confidently be ascribed a date. Backfilled quarries are very visible on satellite imagery but very difficult to identify at ground level. These have usually been opened for a short time and backfilled as they are on farmland. Backfilling has been mentioned in accounts from the construction of the military road (B6318) to cover up small quarry pits used by the army with permission from the landowner (Lawson 1971, 35, 69; 1973). Blasting can also be seen at the modern whinstone quarries at Cawfields and Walltown (Fig. 4.28). These are much larger in proportion than the ancient quarries and leave huge irregular rubble behind due to the blasting process.

*Figure 4.28: Angular rubble as a result of blasting at Cawfields Quarry.*

## The Roman quarries

The quarries discussed below have all been identified as Roman in date through a combination of evidence types. Each of the surviving quarries carries both toolmarks or evidence of extracted blocks and an inscription dated to the Roman period. The surviving quarries are protected as scheduled monuments and are all included in the Frontiers of the Roman Empire World Heritage Site.

The quarries have been divided into two sets: one for the Central and Eastern sectors (categories 2–5 described in Chapter 2); and the western sector (category 1 as described in Chapter 2). The first all operate within Carboniferous rocks with significant numbers of sandstone outcrops relatively near to the Wall. The second all operate within the red Permian and Triassic rocks and where the logistics of bringing rocks to the Wall are more significant.

### *Eastern and central quarries*

These quarries all extract rock from one of the many and varied sandstone units contained within each of the Tyne Limestone, Alston, Stainmore, and Pennine Coal Measures Formation of the Carboniferous Period. Between Wallsend and Hare Hill there are numerous sandstone outcrops within less than a kilometre of the Wall. The only exception to this is around Gilsland where there is a *c*. 2-km gap in sandstone outcrops between Thirlwall Castle and just east of Birdoswald. The presence of these sandstones does not necessarily mean that they are of sufficient quality, accessible, or in locations where transport to the Wall is feasible. Nonetheless the problem of finding suitable sandstone (and in the central sector, limestone) would not have been challenging. This might also impact decisions on whether to exploit relatively few quarries to extract larger quantities of stone and transport them along the Wall, or to have a larger number of quarries as nearly adjacent to the Wall as possible.

#### *Comb Crag (Tyne Limestone Formation, Carboniferous)*

Comb Crag quarry is a high-faced quarry, with a lower and upper level of stone extraction. The faces overlook a meander in the River Irthing and face east, with at least one worked face oriented to the west. The pale-yellowish, fine-grained stone has been slowly eroded by the river leaving a steep sided valley with easy access to exposed stone. The stone lies in thick beds, providing an ideal source of quality building stone very close to the Wall. As the crow flies the distance from the quarry to the Wall is only *c*. 400 m. Comb Crag contains the second largest number of inscriptions of all the quarries along the Wall with eight in total (RIB 1946–1952, 3452), suggesting it was a quarry of comparable significance to the River Gelt quarries. Unfortunately, the inscriptions here cannot provide a specific date and therefore cannot be attributed to a specific construction

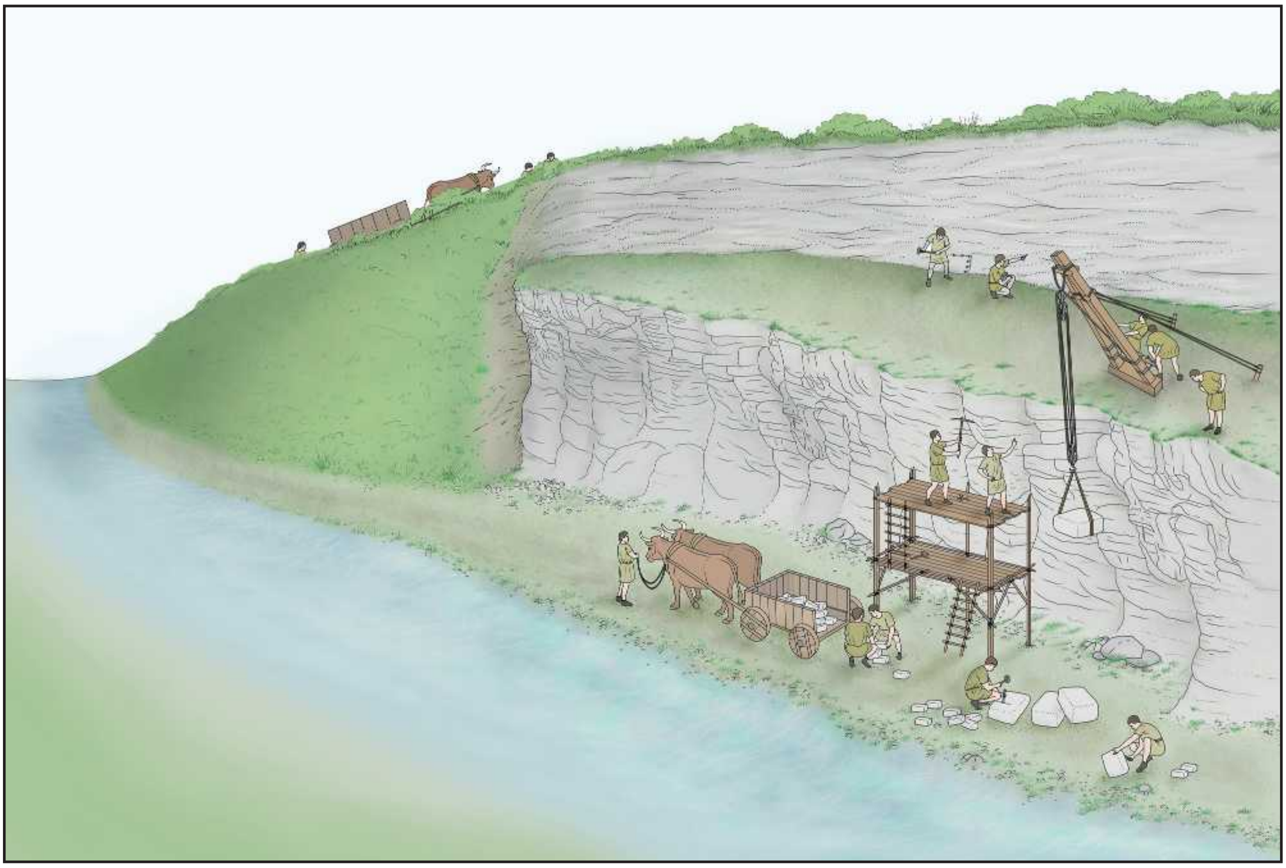


*Figure 4.29: Reconstruction of high-face quarrying at Comb Crag during the Roman period. Illustration by Matilde Grimaldi.*

phase. The majority are carved into the secondary higher face of the quarry, which can be accessed by a ledge overhanging the lower face. The ledge precariously overhangs the lower quarry face and may have been this way as a result of a final phase of extraction before the quarry was shut down, or caused by later – naturally occurring – collapse of the lower face. In addition to the inscriptions, the quarry has several wedge holes which are visible on the face.

Due to the height of the face, scaffolding would have been necessary to facilitate access to the stone. The two working faces of the quarry and the scaffolding are shown in Figure 4.29. The illustration also shows the stone being transported away from the base of the lower face and up a central path that leads north uphill from the river towards the Wall. Due to the proximity of the Wall to this quarry, transporting stone by river would have been unnecessary and the shallow waters may not have been able to accommodate a stone-laden barge.

### *Fallowfield Fell (Stainmore Formation, Carboniferous)*

Fallowfield Fell quarry is to the east of the fort at Chesters, and is one of the largest quarries, with a face almost a kilometre long. The quarry has a shallow face, 1–2 m high, and has been quarried using a stepped method. An inscription was removed from the quarry in 1934 and remains part of the collection of the Clayton Museum at Chesters (RIB 1442).

The stone is medium grained and pale grey in colour. Chiselled channels marking out blocks to be removed, and partially cut blocks are still visible along the face (Fig. 4.17). Much like Comb Crag, this quarry is close to Hadrian's Wall, *c.* 700 m, and the terrain consists of gentle slopes where the bedrock lies very close to the surface. The shallow bedrock in the area causes rapid flooding in low-lying areas during heavy rain so the construction of a road for stone transportation may have been required to avoid becoming bogged down in the mud. A potential road between the quarry and the Wall was identified which leads southwest–northeast away from the quarry until it is covered by a tree-line. The 'road' can be seen clearly in satellite imagery and in person at ground level (Fig. 4.30). The linear feature is erroneously listed on *Keys to the Past* (ref. N8594) as part of the Vallum of Hadrian's Wall. The date of the road is unknown and it may be a medieval trackway or other pre-modern feature.

*Figure 4.30: A road feature near Fallowfield Fell quarry, Northumberland, that may be a trackway associated with the Roman quarry. There is no conclusive dating evidence associated with it.*

### *Barcombe Hill (Sandstone unit immediately above the Little Limestone, Stainmore Formation, Carboniferous)*

The Barcombe Hill quarries are associated with the construction of the Roman fort of Vindolanda. A Roman phallus carving can still be seen on the quarry face, and it once had a carving of what was identified as a boar but is now lost. Two separate quarries sit side by side at the top of Barcombe Hill, one large and one small (Fig. 4.31). It is likely that the two quarries were opened and used at the same time. The quarries have high flat faces, more like Comb Crag than Fallowfield Fell, but on a smaller scale. Research by McGuire (2011; 2012, 30) concluded that the stone from the larger part of the Barcombe Hill quarry was opened in the 3rd century to supply the second stone fort at Vindolanda.

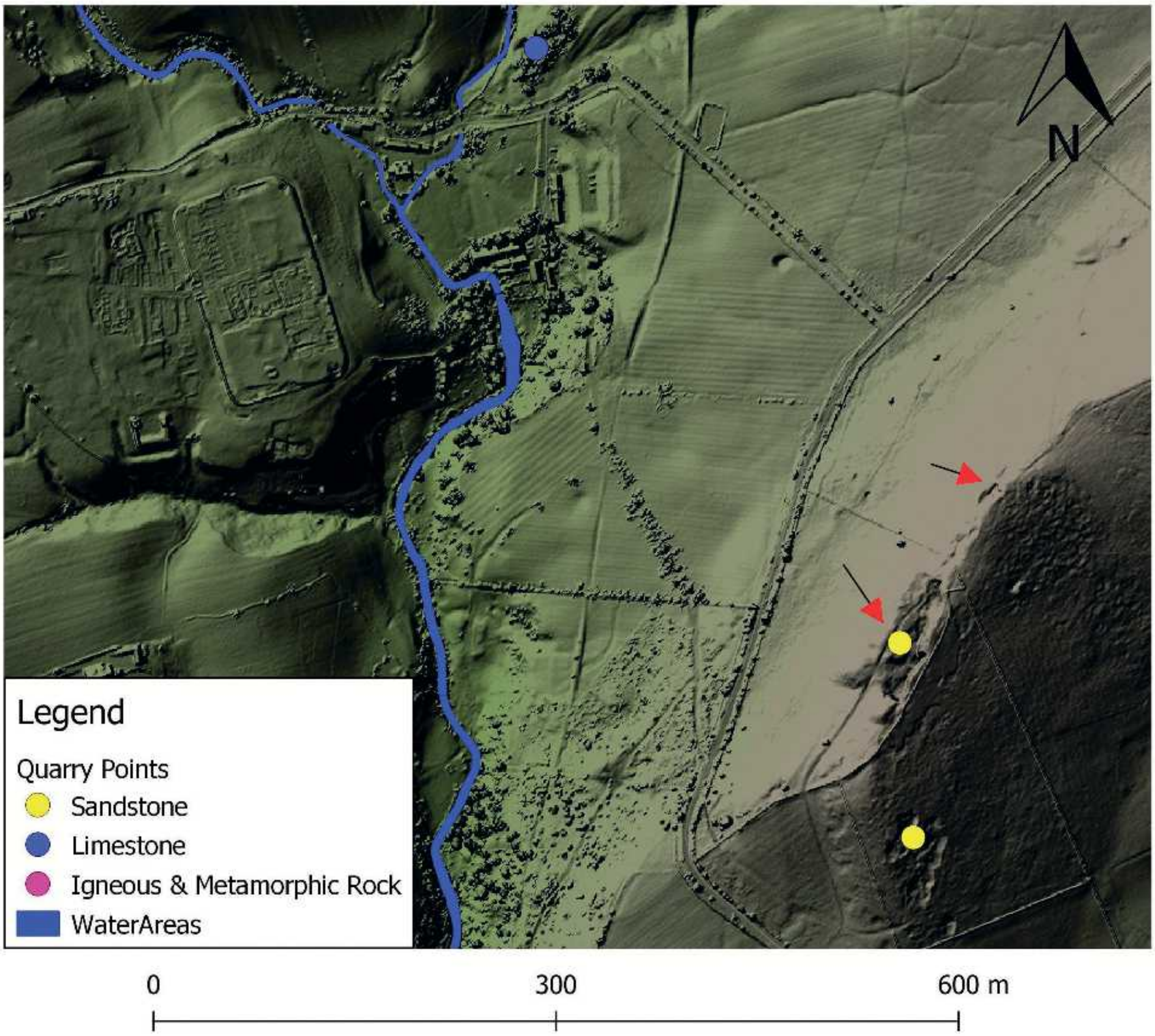



*Figure 4.31: Barcombe quarries, Vindolanda fort and vicus visible to the west of the river. The arrows point to the larger and smaller Roman quarries. Lidar copyright Environment Survey 2019. Water Areas Crown copyright Ordnance Survey 2019.*

Stone from the quarries at the top of the hill would been transported down safely to the level ground and over the Chainley Burn, possibly using animal drawn wagons. One of the Vindolanda tablets mentions stone transportation via wagons (VT 316):

> ... you ought to decide, my lord, what quantity of wagons you are going to send to carry stone. For the century of Vocontius ... on one day with wagons ... [written in a 2nd hand] Unless you ask Vocontius to sort out (?) the stone, he will not sort it out…

### *Cawfields (Alston Formation, Carboniferous)*

Cawfields Quarry is a quarry that is only known through a description by John Clayton who came across it during excavations at milecastle 42. Unfortunately, both the quarry and its inscription have been lost for over a century. Clayton states that the condition of the inscription was so pristine that he believed it was covered with dirt immediately after the Romans closed the quarry, but he did not record any evidence of toolmarks or quarry methods during his brief visit. The quarry was being reopened by quarrymen at the time of the excavation who alerted Clayton to the discovery of the inscription:

> In riding over Haltwhistle Fell, before its enclosure in the summer of 1844, I came upon some workmen employed in re-opening an old quarry; they told me they had met with a 'written stone.' I dismounted from my horse, and climbed the face of the rock, where I found inscribed in letters very clear and fresh, LEG. VI. v . … The workmen promised to spare the written rock; but the next time I rode that way, it had been shivered to atoms (Clayton 1885, 57–58).

RIB describes the stone as 'buff', which is typical in this part of the central sector (RIB 1680).

### *Queen's Crag (Alston Formation, Carboniferous)*

Queen's Crag is the only known Roman quarry for Hadrian's Wall north of the line of the Wall. It is less than a kilometre north of the Wall at Sewingshields Crags (near Housesteads Fort). The quarry has long been considered one of the main sources of stone for the fort, and for the curtain in the central sector. This was first suggested by Hodgson in 1822, who expressed his belief that the facing stones in the central sector have come from Queen's and King's Crags:

> The stone used in the inside of the walls of the station, and for other purposes, has been quarried out of the cliffs in the sandstone ridge, along which the present military road passes. The altars, columns, and quoins, and much of the ashlar work, have been taken from a stratum of freestone on the north side of the Wall, and similar to that in which the recesses, called the King and Queen's Caves, on the south side of Broomleelough, are formed (Hodgson 1822, 263).

Petrological samples taken from Queen's Crag and Housesteads Roman fort have shown strong similarities in these stones and support this suggestion (Fig. 4.32; O'Donnell 2021, 204). The stone at Queen's Crag lies in very thick beds and is very hard, making it an excellent building stone material.

Queen's Crag is one of a series of sandstone ridges found north and south of Housesteads (and the Whin Sill). Petrologically there are some differences which may be observed in thin sections taken of samples from five of these sandstone units. However, they are all quartz arenites with quartz overgrowth and signs of pressure solution and similar quantities of feldspars, mica, lithic fragments (of polycrystalline quartz), and heavy minerals. From a petrological point of view, it is therefore hard to distinguish which of the ridges the Wall-stones may have come from.

Given the petrological and archaeological data combined, it raises the question of why Queens Crag appears to be the only one of these crags for which there is evidence of Roman exploitation. The two ridges south of Housesteads and Dove Crag are both nearer and would have been significantly easier to transport stone from. The answer to this may well be in the quality of stone which it would have been possible to extract from each of these ridges. Good quality stone would have been available from all the ridges; however, Queen's Crag has an unusually thick bed (nearly 4 m) of uniform high-quality sandstone. This would have been particularly attractive for monumental work and for some of the larger stone required within the fort. It may be, therefore, that Queens Crag represents a quarry used after the curtain had been put in place when more time was available to search for and extract larger stones from a location north of the Wall.

The inscription on the quarry (RIB 3331) was discovered carved under a large overhanging rock near the Black Dyke in 1960 (Fig. 4.33):

> (centurio) SATVRNINVS
> (centuria) LVSITANI
> HRINDIINVS
> OPTIO

The inscription gives the names of a soldier *Saturninus*, and a working group under the centurion *Lusitanus*. It seems to have been carved by two different hands, which may suggest it represents two different working groups as these are names typically associated with different regions of the empire. According to RIB, *Hrindinus* may have been Tungrian, and based at the nearby fort of Housesteads.

At the eastern end of the quarry face a distinct line of wedge holes was discovered by a WallCAP volunteer that shows very clear evidence for quarrying activity at this site (Fig. 4.10). Similar to Fallowfield Fell, the quarry is in an area with gentle hills, and low-lying ground can become waterlogged very easily. It is very likely that a

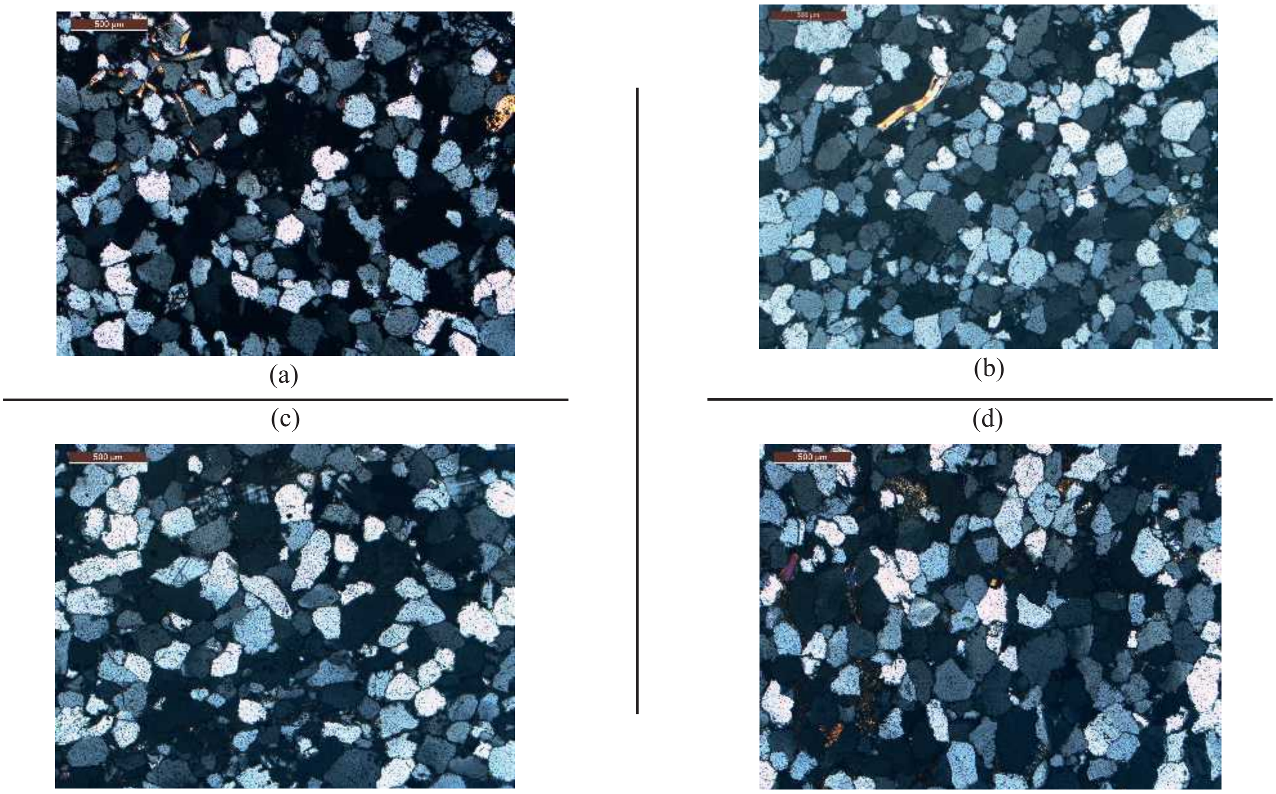



*Figure 4.32: Comparison of thin sections from Queen's Crag quarry and Housesteads Roman fort. The a and b sections are from Queen's Crag, with c and d sections from Housesteads.*

*Figure 4.33: RIB 3331 at Queen's Crag, Northumberland, with the photo taken by K. O'Donnell and the inscription overlain with white to increase visibility.*

road was constructed to transport stone from this quarry but none has been identified to date.

## Western quarries

In this sector of the Wall the combined absence of good-quality stone underlying the Wall and the thick mantle of glacial till present over much of the landscape west of Brampton will have forced the Romans to search for and extract stone further away from the Wall. Either that or to transport the plentiful Carboniferous sandstones along the Wall from the east.

The evidence from WallCAP excavations at Cam Beck suggests that transport of stone took place as far as this location, albeit this evidence is for limestone and the few remaining fragments of facing stone here are Triassic. This, along with evidence from the curtain at Port Carlisle, and from post-Roman buildings containing Wall stone, all suggest stone from the St Bees Sandstone Formation was extensively used in construction of the curtain in this sector. It may also be that Permian Penrith Sandstone was used, but there is only indirect evidence that this may have been the case.

The nearest outcrop of Penrith sandstone is about 11 km (7 miles) from the Wall in Carlisle. However, the presence of a Roman quarry at Crowdundle and Wetheral suggests that the River Eden was used as a transport route. If stone was transported from as far south as Crowdundle to the Wall, then it is entirely possible that outcrops of the Penrith Sandstone much nearer to Carlisle could have been exploited. There is also indirect evidence from samples taken by O'Donnell (2021) from Carlisle Castle, which from petrographic examination are from the Penrith Sandstone Formation. The sandstone is distinctive in hand specimen and even more so in thin section (Fig. 2.15) – the rounded, patinated grains infilled with finer clastic material is characteristic of aeolian deposits and readily identifiable. The location(s) of possible quarries are unknown.

It remains then that the St Bees Sandstone Formation is the most likely source of western sector Wall-stones. The outcrop of St Bees sandstone extends all the way around the Carlisle basin with obvious exposures in river sections. Roman inscriptions are found in quarries at Gelt, Shawk, and Crowdundle, all of which are in the St Bees Sandstone formation. Other quarries in the St Bees Sandstone Formation with good transport routes via river and sea to the Wall include Barramouth Quarry near Whitehaven (where stone for Carlisle cathedral has been cut), behind the foreshore at Maryport, Cove Quarry near to Gretna, Locharbriggs north of Dumfries, and at Corsehill Quarry near Annan.

Sea and river routes around the Solway Firth have a long-established history of exploitation (Lingard 2020). Transporting stone by boat has been shown to be more cost effective than transport by cart (Eaton 2000). These facts suggest that movement of stone via these routes would have been a real possibility. The Romans would have also been actively quarrying around Maryport to support the cordon of forts along the Cumbrian coast, so seaborne transport into the Solway Firth would be relatively straightforward route. Wagon- or cart-based transport overland to the Solway is also entirely feasible (Lingard 2020), providing access to quarries near Annan. While there is no direct evidence that either of these routes were used by the Romans, the possibility of their use should be kept open as further evidence for provenance is sought,

### *Gelt River Quarries (St Bees Sandstone Formation, Triassic)*

The Gelt quarries in Cumbria supplied stone to the western sector of Hadrian's Wall, during the extensive rebuilding phase in the reign of Septimius Severus. This area is likely to include a cluster of quarry faces originally opened in the Roman period; however, it is very difficult to judge what the original size of the quarries were due to extensive modern quarrying, some of which can be seen in the lidar in Figure 4.34. The stone is very fine grained and a deep reddish-brown colour. The stone is also especially soft and does not weather well, leading to recent efforts to record the inscriptions in detail with modern methods. Due to the combination of the stone's softness, the vegetation, and modern quarrying, it is very difficult to identify any tool marks or distinguish ancient marks from modern ones.

The Written Rock is the most inscribed face of any quarry along the Wall, and includes the only datable inscription, which includes a consular date of AD 207 (RIB 1009). About a kilometre south, down the Gelt River there is a carved altar with a niche and a further inscription; the outcrop here is named 'Pigeon Crag', suggesting the Roman workings continued further along the river.

The River Gelt quarries are located approximately 5 km south of the Wall and as such is one of the most distant quarries of Roman date. The River Gelt, at its current level is much too low to support any cargo barges, but the river may have run slightly higher in the past, or the army may have created weirs to raise the water level. To date no investigations of the riverbed have been undertaken to search for evidence of weir building in the past, neither have there been studies which document the changing river levels.

### *Wetheral (St Bees Sandstone Formation, Triassic)*

Wetheral quarry is the furthest west of the confirmed Roman sites. The quarry is south of Wetheral Priory and directly beside St Constantine's Cells, 14th-century cave dwellings rumoured to have been inhabited by the hermit Saint Constantine. Like the Gelt River quarry it is a red-coloured stone, locally known as St Bees or Red St Bees sandstone.

The inscriptions on the quarry are near the base of its face, on the banks of the River Eden. The bank by the quarry is very steep and carrying stone upwards from this point would have been very challenging. Further quarried areas can be seen above this level along a higher path which indicates that, at one point, the quarried areas may have been part of the same large quarrying area, arranged in a similar way to that at the River Gelt. The River Eden here is larger than the other quarry-side rivers and would almost certainly have been able to support stone transport by water. This also would have mitigated the challenges of moving stone up the steep hill by moving it to an area with a gentler slope. There have been no investigations near this quarry to identify a possible water access point for the quarry.

### *Crowdundle (St Bees Sandstone Formation, Triassic)*

Crowdundle is the most southerly of Roman quarry sites, with three inscriptions recording legionary quarrymen and a possible but undeciphered consular date (RIB 998–1000), all of which have been purportedly lost since 1690. It is unusual in being at a significant distance from the Wall. It is also significant in its location by the River Eden, providing good access to transport north to Carlisle, and the Solway.

### *Shawk (St Bees Sandstone Formation)*

Three inscriptions have been recorded at the Roman quarry at Shawk, none of which survive today (RIB 1001–1003). Despite the missing inscriptions, evidence of quarrying can still be seen in the area. Shawk (or Shalk or Chalk) is similar in form to Gelt with a series of quarries excavated into the bank of the incised stream, the Chalk Beck. This quarry was not archaeologically investigated by WallCAP or in the work by O'Donnell

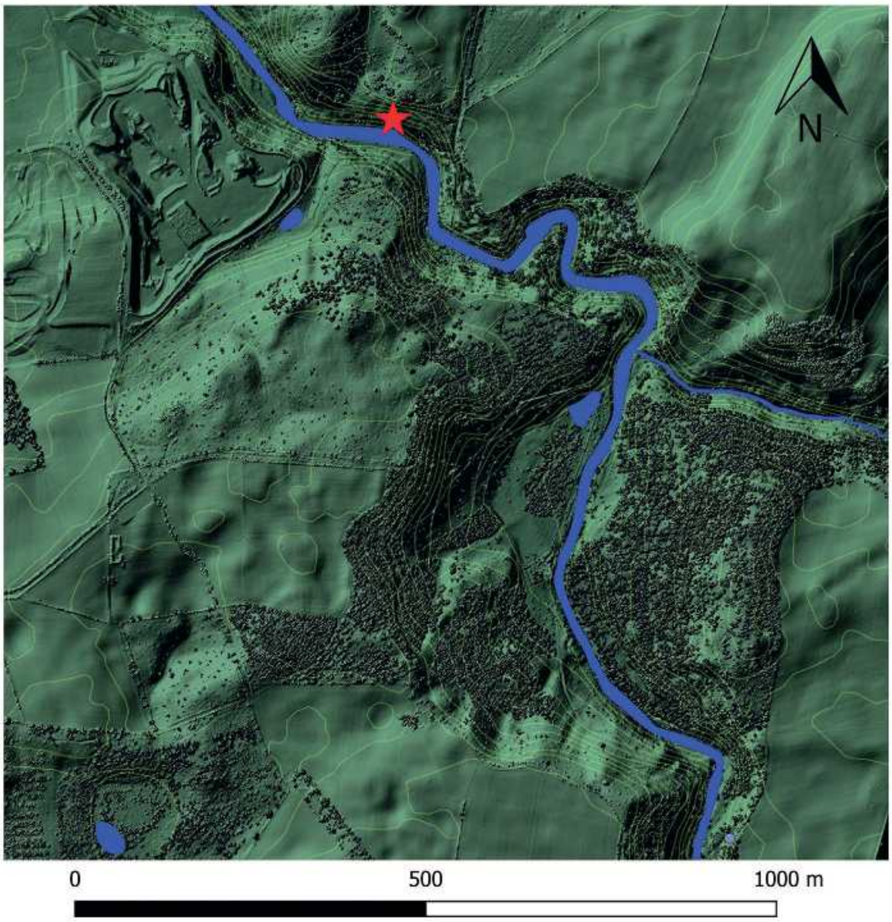



*Figure 4.34: Map showing location of the Written Rock of Gelt (indicated by red star) and nearby quarries. Lidar copyright Environment Survey 2019, water shape and height contours Crown copyright OS Vectormap Local.*

*Figure 4.35: The face of a Roman quarry at Shawk.*

(2021). However, geological samples were taken from five of the sandstone units which have been quarried from Roman times onwards. Whilst the sandstones are all from the St Bees Sandstone Formation, there is a considerable variation in the samples as seen in hand specimen with pale whitish sandstones as well as the more typical red of this formation.

## Conclusions

Evidence for quarrying in the area around Hadrian's Wall is abundant. At each of the Roman sites, inscriptions are intact, as well as toolmarks, wedge holes, cut stone, and spoil heaps, and hundreds of other undated quarries are scattered across the landscape bearing the same characteristic marks of stone extraction.

The quarries reveal insights into the full quarrying process – from site location to transportation. The predominance of quarrying south of the Wall is a significant component when looking at site location. The geological availability and quality of stone was very similar both north and south of the line of the Wall. Were there any kind of danger to the Roman army to the north, it could be assumed that quarrying would mostly have taken place to the south of the construction. Only one of the seven known Roman quarries is located north of the Wall, and it was much closer to the Wall than the average distance of those to the South. This demonstrates that while quarrying north of the line of the Wall was possible, it may not have been the preferred option.

Toolmarks at the quarries show stone extraction methods including overhanging overburdens left behind when the quarry was abandoned, smaller spoil heaps possibly related to higher levels of stone waste usage than in modern quarrying, and a stepped quarrying method which is seen very infrequently in the modern quarries. The tool use seems to predominantly include chisels, hammers, and picks. The dating of these toolmarks remains inconclusive due to unchanging stone quarrying methods through to the late medieval period. The quarries also bring to light transportation methods, such as ramps which move away from the quarry face towards the Wall and pathways which were potentially cart tracks.

The undated quarries surrounding the Wall possess a wide range of evidence which survives in varying levels of preservation. Many of these may date to the construction of Hadrian's Wall, but this will not be possible to establish without petrological testing or excavation of the quarries to reveal other archaeology evidence of Roman activity such as quarrying tools.

# 5

# Post-Roman use of Wall fabric

A monument the size and scale of the Wall, maintained and garrisoned by the Roman army for approximately 300 years, had a considerable impact on its landscape in the centuries following the demise of the Roman Empire in Britain. The scale and physical impact of the Wall in post-Roman centuries is rarely disputed, but it is still poorly understood. This is, in many ways, a reflection of the research traditions of the disciplines of Archaeology and History. Reasonably, as Hadrian's Wall is a Roman monument, it receives the most attention from scholars of the Roman period, who in turn focus on the surviving evidence that directly attest to the Roman monument. Archaeologists have long understood how particular activities will physically impact, destroy, or preserve particular types and forms of evidence, and along Hadrian's Wall these are generally well understood at the scale of individual sites. However, it has become increasingly recognised over recent decades how important it is to understand the events and impacts that the post-Roman centuries have had on changing cultural perceptions, receptions, and understandings of the monument (Whitworth 2000; 2012; Leach and Whitworth 2011; Hingley 2012; Breeze 2014; Symonds 2020).

What has not yet been achieved is an understanding of these processes at the entire scale of the monument, linking specifically to the physical deterioration, destruction, and robbing of the Wall. Whitworth's (2000) ground-breaking study advanced this agenda considerably, pulling together a considerable amount of data and provided key conclusions. Further data has emerged subsequently, and WallCAP specifically aimed to understand the re-use of Wall fabric alongside evidence for destruction and ruination of the Wall. This chapter, therefore, asks the question 'What happened to the Wall after the Roman period?' There are two interwoven routes to answer this question. First, there are the physical and natural processes of deterioration of the monument in post-Roman centuries, in which humans have no influence or role. Second, specific behaviours and choices made by humans directly impacted the Wall, shaped by contemporary needs, priorities, and preferences. The interactions of the multitude of natural and cultural processes each year following the end of Roman military use of the Wall has resulted in the differential survival of the Roman archaeology that is seen today, directly related to differential scales of re-use of Roman fabric.

## Connecting the post-Roman to the Roman

Identifying Roman stone fabric from the Wall when it is removed from its original position or archaeological context can be easy, or extremely challenging, and sometimes impossible. The most easily recognised repurposed stones from the Wall usually bear inscriptions or some form of sculpture. Facing stones from the Wall or its attendant installations, or more specially shaped stone like columns, windowheads, and voussoirs, can also generally be identified. However, stone rubble from the core of the curtain, or any facing or specially shaped stones that have been redressed are practically impossible to identify. Inscriptions and sculpture, so readily identified, provide a useful means of considering the means and distances by which Wall fabric was taken from a Roman site and put to another use in the post-Roman centuries.

In many, perhaps even the majority of instances, inscription and sculpture is incorporated into structures local to the original findspot of the stone. For example, at Willowford Farm, built directly on the line of the curtain to the west of turret 48b (Fig. 5.1), there are 12 stones registered in RIB as from the farm, or perhaps close by (Table 5.1). Of these 12, at least 9 were built into the farmhouse or other structures related to the farm. There are a range of stones, not all of which could be identified for their function, but include centurial stones that would have originally been incorporated into the south face of the curtain, and a number of altars that probably originated from the fort at Birdoswald, approximately 1 km to the west, though a more local temple or religious site cannot be precluded. While the initial repurposing of the Roman fabric is proximal to the original findspots of the stones, it is also notable that some of these stones were moved a second time, a third time, and even a fourth time. For example, altar RIB 1911 was subsequently built into Corby Castle (*c*. 15 km distant), while altars RIB 1887 and 1889 were moved to Naworth Castle (*c*. 8 km distant) and subsequently Rokeby Hall (*c*. 80 km distant). A centurial stone (RIB 1862) was also taken to Naworth Castle, then displayed in the Lanercost Priory crypt, and finally moved to the English Heritage Stores.

Stones and fabric are not limited to immediately proximal re-use, and very large stones could travel a reasonable

*Figure 5.1: Willowford Farm, at the left side of the photo, is located directly on the line of the Wall curtain. The Wall can be seen running west across the photo, up the slope at Harrow's Scar and continuing to the fort at Birdoswald, marked by the trees and buildings on the horizon at the right side of the photo.*

*Table 5.1: Inscribed stones from the Wall found at Willowford Farm. Fields with no text indicate uncertain or unknown information.*

| *RIB no.* | *Inscription type* | *Find date* | *Used in* | *Subsequent location* | *Original findspot* |
|---|---|---|---|---|---|
| 1862 | centurial stone | 1884 | garden wall of farm | moved to Naworth, then Lanercost for display, now in EH Stores | curtain of mile 48 |
| 1863 | | before 1732 | corner of farmhouse | | |
| 1864 | centurial stone | before 1732 | used in jamb of door of farmhouse | | curtain of mile 48 |
| 1865 | centurial stone | before 1732 | used in jamb of (another) door of farmhouse | | curtain of mile 48 |
| 1866 | | before 1732 | courtyard wall of farmhouse | | |
| 1876 | altar | before 1599 | corner of house (possible earlier farmhouse?) | | prob Birdoswald fort |
| 1887 | altar | before 1599 | 'at Willowford' | moved to Naworth, then Rokeby Hall | prob Birdoswald fort |
| 1889 | altar | before1600 | 'at Willowford' | moved to Naworth, then Rokeby Hall | prob Birdoswald fort |
| 1890 | altar | before 1732 | chimney of outhouse | | prob Birdoswald fort |
| 1896 | altar | before 1732 | courtyard wall | Tullie House museum | prob Birdoswald fort |
| 1911 | altar | before 1599 | 'at Willowford' | built into Corby Castle | prob Birdoswald fort |
| 3407 | centurial stone | 1986 | north exterior wall of barn east of farmhouse | N/A | 150 m east of turret 48b |

distance. For example, RIB 1688, a sizeable altar that was probably from Vindolanda on the basis of the unit named in the inscription, was used in a medieval gate structure at Staward Pele, approximately 6.5 km distant from Vindolanda. While that distance is not insurmountable, it certainly required moving the stone up and down a number of slopes and challenging terrain. Similarly, the church at Chollerton, approximately 1 km north of the Wall, made use of at least three stone columns presumed to have been sourced from the fort at Chesters. Given the size and weight of these columns, moving them from Chesters across the North Tyne and up the steep slope to the plateau where the church is built would have required considerable effort.

The degree of 'migration' of inscribed and sculpted stone from the frontier zone can be quite considerable, as recently highlighted by Lindsay Allason-Jones (2023), either as purchases or part of a habit of gift-exchange among families of the gentry and aristocracy. For example, an altar dedicated to Hercules found in 1803 near the northeast corner of the fort at Whitley Castle (Northumberland) was purchased for £7 in 1812 and taken to London, whereupon it was sold at least two more times, for £15 and then for £80 to Sir Geoffrey Page Turner. A Mr Higgins, of Turvey Abbey (Bedfordshire) had the altar in 1936 through sale of the effects of Sir Geoffrey Page Turner, and in 1955 Mr and Mrs Allen purchased Turvey Abbey (and the altar), who then loaned the altar to the Cecil Higgins Art Gallery and Museum (Bedford) where it still resides (Allason-Jones 2023, no. 40). Pieces could travel further still; an altar from Maryport (Cumbria) was given to Mussolini in 1935 (Allason-Jones 2023, no. 56).

Identifying repurposed less ornamented Roman fabric, what might be called 'normal' facing stones, is less certain. Without detailed and potentially destructive geochemical and petrological testing, identification relies on morphological characteristics of a given stone or series of stones. This includes not only the dimensional details of stone size, but the techniques and style of dressing and geological observations of the stone itself. Often, these can be matched to a local length of Hadrian's Wall, though any such identifications remain a probability. Stone fabric of different date in the same structure with Roman fabric can often be distinguished through these morphological characteristics, even if the same source quarries are used in subsequent centuries. Detailed case studies below provide examples, but first, it is worth considering the scale and chronology of building in stone in the post-Roman centuries.

## Building in stone after the Roman period

A direct approach to assessing the prospective scale and chronology for re-use of Wall fabric requires examination of the evidence for the building of structures in stone in the post-Roman centuries. Given the extent of surviving historical structures in the Wall corridor, direct examination of every building was impossible within the scope of the project, but fortunately most historical structures have already been assessed at some level. A small database was collated from a range of sources to identify stone-built structures in the Wall corridor from *c.* AD 400–1800 (Whitworth 2000; Ryder 2021; HE Buildings Register; Northumberland HER; Tyne & Wear HER). The database compiled a total of 387 historic stone-built sites and structures directly along the line of the Wall, or within 8 km (*c.* 5 miles) to its north or south. From this data set, it is possible to provide an overview of post-Roman use of stone in building, the overall scale and phasing of such construction, and the re-use of Roman fabric. More focused case studies allow particular issues and practices to be explored in greater detail.

Of the 388 historic sites and structures in the Wall corridor that have been identified, 174 have been identified as using Roman fabric, or 44.8%. Both the total number of entries in the database and those making use of Roman stones are minimum numbers, which do not account for lost/destroyed historic structures or surviving structures where Roman fabric is not visible. Survival of such structures is notably greater in upland zones. Figure 5.2 provides the distribution of those structures making use of Roman fabric, and it becomes clear that the majority are found within 1 km of the Wall. There are exceptions, such as the medieval gate making use of a Roman altar from Vindolanda at Staward Gorge, or Hexham Abbey where stones appear to be drawn from both Chesters fort and Corbridge town (Bidwell 2010). It is notable, however, that those sites most distant from the Wall tended to have drawn on stones from sites not directly on the line of the Wall (*e.g.*, Corbridge) or from forts. Excluding those farms and other structures built on the curtain itself, there are 36 sites and/or structures dating from the early medieval to modern periods built all along the line of the Wall (Table 5.2).

Assessing the chronology of re-used Roman fabric is also telling, both in terms of the numbers of structures and their distribution. For purposes of this analysis, the major chronological periods have been used: early medieval (*c.* 410–1065); medieval (1066–1499); early modern (1500–1799); modern (1800–1900). Figure 5.3 provides a summary of the numbers and types of site found by period, while Figure 5.4 illustrates the distribution of these structures by period. Recording of multi-period use was prioritised for sites on the line of the Wall, but not those to its north or south. For example, the fort at Newcastle has been counted as an early medieval ecclesiastical site and a medieval fortification, while Chipchase Castle has only been counted as a medieval fortification but *not* an early modern domestic dwelling. The division between a fortified structure and a domestic structure is not always clear, given that most medieval and post-medieval fortified structures also had domestic functions; however, for the sake of analysis, bastles were deemed as domestic, even though they include important elements of defensive

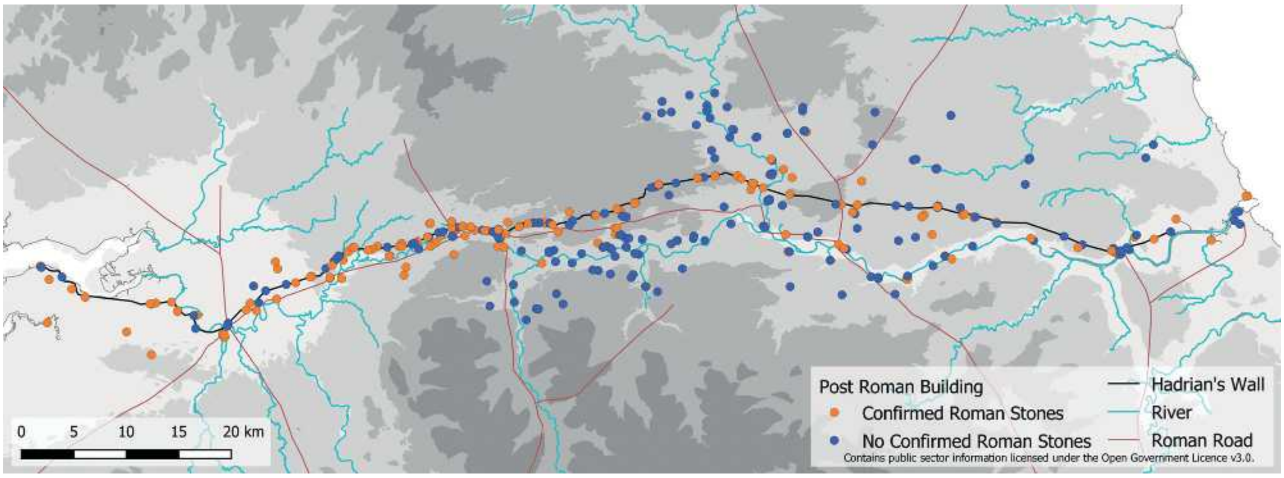



*Figure 5.2: Distribution of sites within 8 km of the Wall that have made use of Roman stonework relative to historic stone-built structures.*

architecture. Similarly, while vicarages are domestic in function, they have been assigned to the ecclesiastic category. In both cases, for bastles and vicarages, the decision was made on the basis of the class or order that the builders of such structures belonged to, as that links back to access to particular resources and rights.

The expansion of 20th-century housing and other development has not been included, as the numbers of individual structures counted within the method would drastically outnumber those of other periods and such structures are less frequently built in local stone. While stone-built structures of the modern period are under-represented within the data-collection methodology employed, they do not hinder the aims of the analysis to understand the overall pattern of construction in stone in the post-Roman centuries. It is also difficult to claim or be certain in all instances if structures and settlements were generally continuous or discontinuous, with breaks of many years between phases and/or periods of occupation. In this regard, settlement in the early modern and modern periods are almost certainly under-represented, as continuous settlement and expansion of villages from the medieval period has upgraded, replaced, and/or eradicated stone-built structures with increasingly modern structures. For example, the church at Ovingham (Northumberland) boasts a 9th- or 10th-century stone-built church (tower only surviving), presumably serving an early medieval settlement that is otherwise unevidenced; nor are there any surviving stone-built structures of medieval Ovingham. Yet the village has almost certainly been continuously occupied from the later early medieval period to the present. Thus, the church at Ovingham is the only representation of an historic stone-built structure at this location, though there would most likely have been other buildings of stone in the early modern phase of the village. In this regard, it is important to remember that the numbers are representative of confirmed stone-built structures and/or settlement, and not intended to map the full extent of historic settlement.

The general picture is very clear. There was modest construction and/or use of stone in the early medieval period, with a total of 25 sites. The evidence for this is split evenly between settlement, typically on the site of a Roman fort or possibly other structure, and the use of stone to build a *de novo* ecclesiastic structure, such as a church or monastic complex. The Tyne Valley is particularly notable for the series of pre-Norman stone-built churches, typically dating to the 8th–10th centuries, and the monastic complexes at Jarrow and Hexham (Fig. 5.5). Analysis of the surviving fabric associated with the earliest church at Jarrow suggests a mixed use of stone drawn from the roughly equidistant Roman forts at South Shields and Wallsend and a minimal amount of fresh-quarried stone; particularly notable is the almost entirely wholesale re-use of Roman architectural elements, such as door- and window-frames for incorporation into the church (Turner

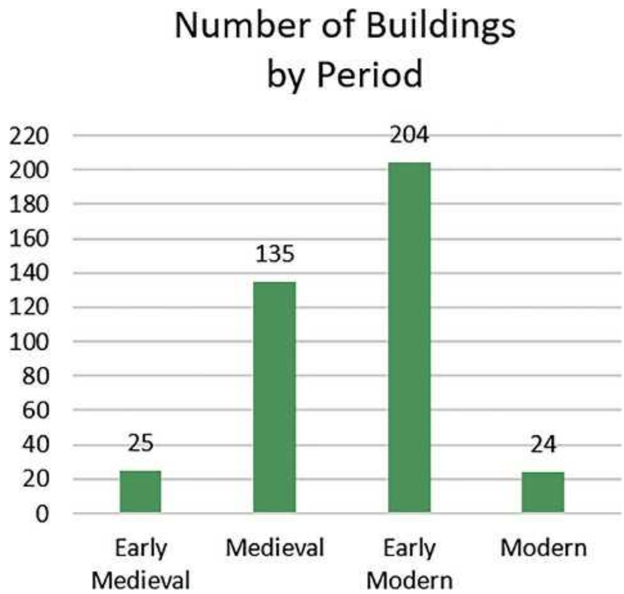



*Figure 5.3: Graph of buildings by period.*

*Table 5.2: Wall-sites with post-Roman use inside or upon the Roman archaeology, from east to west, excluding farms and other structures built on the line of the curtain.*

| *Site* | *Period of (Re-)Use* | *Reference* |
|---|---|---|
| South Shields fort | early medieval | Bidwell and Speak 1994 |
| Wallsend fort | early medieval | Rushworth and Croom 2016 |
| Newcastle fort | early medieval; medieval; early modern | Snape and Bidwell 2022; Nolan *et al*. 2010 |
| Benwell fort | early medieval, early modern | Brewis 1936; Jobey and Maxwell 1957 |
| Turret 7b, Denton Hall | early modern | Birley 1930 |
| Milecastle 16, Harlow Hill | medieval | Whitworth 2000, 16 |
| Turret 18b, Wallhouses West | early modern | Woodfield 1965 |
| Chesters fort | early medieval | Miket 1978 |
| Milecastle 31, Carrawburgh | early modern | Whitworth 2000, 66 |
| Turret 34a, West Grindon | medieval | Charlesworth 1973b |
| Turret 34b, Sewingshields | modern | Daniels 1978, 136 |
| Milecastle 35, Sewingshields | medieval | Haigh and Savage 1984 |
| Housesteads fort | early medieval; early modern | Rushworth 2009 |
| Vindolanda fort | early medieval; early modern | Birley and Alberti 2020 |
| Milecastle 39, Castle Nick | early modern | Whitworth 2000, 66 |
| Peel Gap tower | medieval | Crow 1991 |
| Milecastle 41, Shield-on-the-Wall | early modern; modern | Whitworth 2000, 66 |
| Great Chesters fort | early medieval; modern | *Life of Cuthbert* |
| Turret 42b, Great Chesters | early modern | Bruce 1867 |
| Turret 43a, Cockmount Hill | early modern | Hodgson 1840 |
| Turret 46a, Holmhead | modern | Birley 1961, 75 |
| Turret 46b, Wallend | modern | Birley 1961, 75 |
| Carvoran fort | modern | |
| Milecastle 49, Harrow's Scar | early modern | Richmond 1953 |
| Birdoswald fort | early medieval; early modern; modern | Wilmott 1997 |
| Milecastle 50, High House | medieval; early modern | Simpson 1913 |
| Milecastle 51, Wall Bowers | early modern | Whitworth 2000, 66 |
| Milecastle 52, Bankshead | early modern; modern | Whitworth 2000, 67 |
| Milecastle 53, Banksburn | early modern | Whitworth 2000, 67 |
| Castlesteads fort | early modern; modern | |
| Milecastle 57, Cambeck Hill | early modern; modern | Daniels 1978, 233 |
| Stanwix fort | early medieval; medieval; early modern; modern | McCarthy 2002 |
| Carlisle fort | early medieval; medieval; early modern; modern | Zant 2009 |
| Burgh-by-Sands fort | medieval; early modern; modern | |
| Drumburgh fort | medieval; early modern; modern | |
| Bowness-on-Solway fort | medieval; early modern; modern | |

*et al*. 2013, 146, 148–159). It is possible that this pattern could also apply to the Irthing and Eden river valleys in the western sector of Hadrian's Wall, though evidence for any pre-Norman ecclesiastical structures is limited. At Carlisle, for example, no pre-Norman Christian structures have been identified, though Cuthbert was visiting a monastery and was shown the Roman walls and a fountain in 685 (Bede, *Life of Cuthbert* 27). The settlement evidence

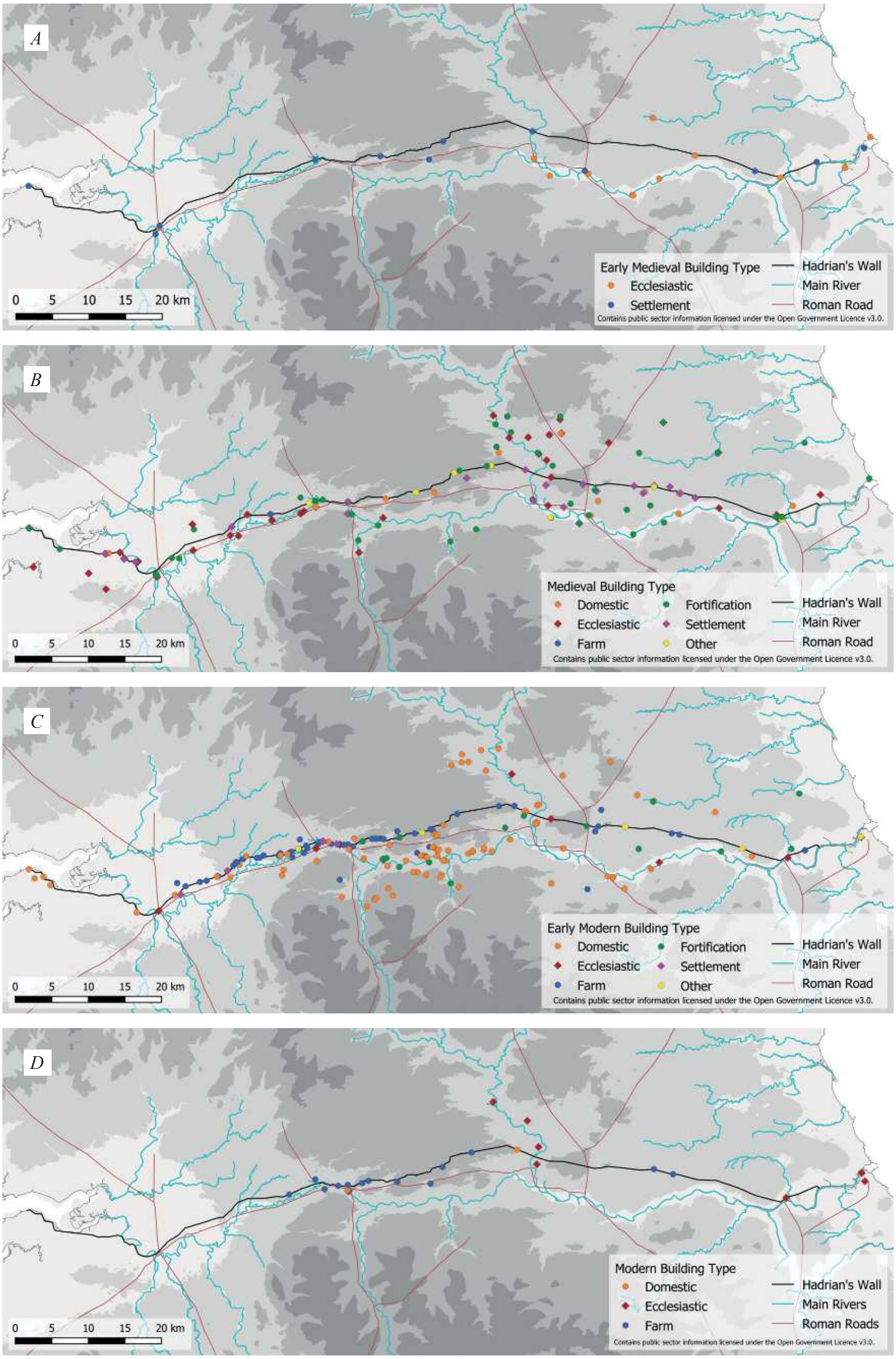



*Figure 5.4: The distribution of stone-built structures in the Wall corridor by major historic period: (A) Early Medieval,* c. *400–1065; (B) Medieval,* c. *1066–1499; (C) Early Modern,* c. *1500–1799; and (D) Modern,* c. *1800–1900.*

is more complex and does not preclude Christian structures. Vindolanda, for example, has a number of apsidal-ended structures of varying size along with small number of explicitly Christian objects and inscriptions that *may* point to a monastic community (Birley and Alberti 2021). Elsewhere, the evidence for settlement is often mixed and incomplete, comprising a mix of mortuary evidence (e.g., Wallsend, Benwell), structural sequences (South Shields, Birdoswald), material culture (Chesters), and/or placenames (Great Chesters). Though incomplete, the evidence is consistent with settlement of early medieval sites elsewhere in Central Britain and points to continued communities living directly on the line of the Wall. This has been interpreted by some to point to continuity of settlement by the military communities of the late Roman army, given that much of the evidence dates to the 5th–7th centuries (Wilmott 1997; 2009; Collins 2012; 2017a; 2017b; 2022). Considering the dating evidence more closely, however, suggests a general shift in settlement away from the line of the Wall in the 7th or 8th centuries on the basis of churches built to serve 'local' congregations. It is not that the line of the Wall is abandoned, per se, as settlements at South Shields, Newcastle, Benwell, Heddon, and Carlisle 'adhere' to the line throughout the entire early medieval period. Rather, the upland lengths of the monument were less likely to be populated.

There is a substantial increase in the number of stone-built structures in the medieval period, with a total of 135. Medieval stone-built structures do not cluster as strongly along the line of the Wall, at least not in the eastern and central sectors. In the latter sectors, it tends to be generally domestic structures and/or settlements with the occasional fortification on the line of the Wall. The upland zone of the central sector has notably fewer stone-built structures, and on the whole more stone-built structures are found in the eastern sector of the Wall. Evidence for settlement, whether of larger villages or discrete structures of smaller households, like farm complexes, is more than four times greater than that of the early medieval period. The most significant expansion, however, is seen in ecclesiastic structures (churches, monasteries) and fortifications (castles, walls, towers). This is not surprising, given that the medieval period incorporates the Norman conquest of England, resulting in the establishment of a reordered feudal hierarchy, as well as chronic cross-border conflict between England and Scotland. Many of these fortifications continued to be used and occupied well into the early modern period, until the peaceful union of England and Scotland was convincingly secured in the early 18th century. Structures with medieval origins are examined more closely in the case studies below.

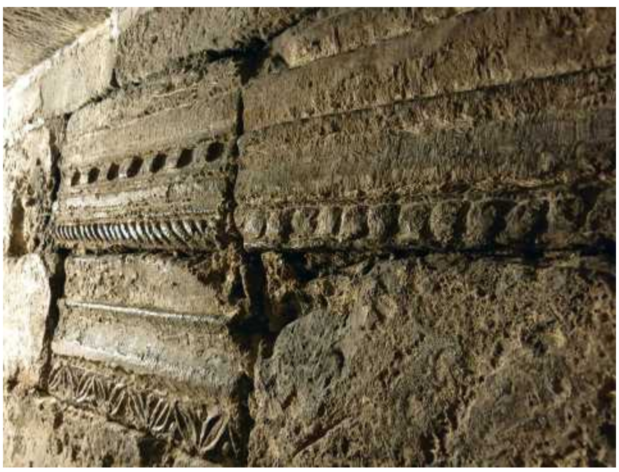


*Figure 5.5: Decorated Roman stone blocks in the 7th-century crypt at Hexham Abbey, re-used from Roman buildings at Corbridge.*

The early modern period is characterised by a substantial expansion of construction in stone, totalling 204 sites or structures. Domestic and farm structures nearly quadrupled from the medieval period. By distribution, this expansion appears to have occurred in more upland areas, but this is likely related to the survival of the evidence. The period also sees an overall decline in fortifications and ecclesiastic structures from the medieval period. This points not only to population growth, but also greater wealth and/or access to use of stone in domestic and farm buildings. Expansion of new buildings in stone is more apparent in the western-central and west sectors of the Wall, with greater occurrence in uplands.

The modern period has the fewest new constructions in stone, with a total of 24, though admittedly this only accounts for the 19th century. As in the previous early modern period, most of the modern structures are domestic and/or farm-related, with the distribution primarily clustering in the western-central sector of the Wall.

Across the entirety of the post-Roman centuries then, there has been a considerable amount of building in stone, with larger more monumental projects typically occurring in the medieval period, and expansion of settlement, domestic, and farming structures occurring from the medieval period up to the modern period. The substantial peak in domestic and farm structures in the early modern period is important, and while individual structures are considerably smaller than large fortified and ecclesiastical structures of the medieval period, the sheer number lends a sense of scale to the amount of building and need for building materials. The Wall provided a ready-made quarry for post-Roman builders, and provided that access to Roman ruins could be obtained, it represented a massive saving in labour that did not need to be directed to quarrying and dressing fresh stone. Such questions of scale and quantity of stone fabric, and the relationship of individual sites or buildings to the Wall are best observed in a series of small case studies.

## Fortified structures using Wall fabric

Across the medieval and early modern periods, 46 and 14 fortified structures were respectively built in the

Wall corridor, of which 25 and 5 respectively also used Roman stones. Many of these structures were very large monuments, including the royal castles at Newcastle and Carlisle, both built on top of Roman forts and encompassing a larger area. While Wall stones were included in the construction of both castles, their contribution as an overall percentage of surviving fabric is very low on the basis of exposed and visible stonework. This is perhaps unsurprising, for a number of reasons. In the first instance, at both Newcastle and Carlisle Roman forts, excavation has demonstrated reasonable survival of the lowest courses of Roman structures dating to the late 4th/early 5th century, succeeded by strata indicating early medieval building and/or activities (Snape and Bidwell 2002; Zant 2009). Post-Roman occupation of the sites contributed to more rapid dismantling and robbing of ruinous Roman buildings, as well as the formation and build-up of new soil horizons. Further coverage of the ruins occurred in the later 11th century at both sites with the establishment of Norman castles, built primarily with earth and timber. Thus, when the castles at Newcastle and Carlisle were first built in stone in the 12th century, the stones of ruined Roman buildings may have been less accessible and freshly quarried stone was required for the stone castles. Over succeeding centuries, expansions required additional stone, no doubt acquired from various sources.

A more instructive and illuminating example of re-used Roman fabric is found at Thirlwall Castle (Fig. 5.6), built on a low spur overlooking the Tipalt-Irthing Gap to the west and approximately 120 m north of the Wall curtain and turret 46a. The castle itself is more technically a stone-built hall house, a fortified hall built in a rectangular tower form, with a solar tower extension off the main block (Rushworth and Carlton 2004, 273; Ryder 2021, 98–99). The stone castle was built in the mid-14th century by the most successful branch of the Thirlwall family and probably succeeds a timber manor house. The castle was built substantially of stone from the Wall, as described by a number of observers (Long 1967, 161; Whitworth 2000, 21; Rushworth and Carlton 2004, 273; Symonds 2020, 138), though alternative sources of building stone remain possible. The use of the Wall as a source of building stone indicates that the Wall was reasonably intact, or at least insufficiently robbed or destroyed to provide a suitable quarry. The Wall was sufficiently present in the late 13th

*Figure 5.6: Thirlwall Castle, built almost entirely from Roman stones and positioned on a knoll approximately 120 m north of the line of the Wall.*

century to be used as a land boundary in the area in the Swinburne Papers (Andersson 2022b), and approximately 1–2 km to the east at Walltown Crags, 16th-century antiquarians describe the Wall curtain as standing between 9 and 16 feet in height (Whitworth 2000, 46, 47). Combined, these provide a reasonable basis that the Wall survived sufficiently to provide fabric for Thirlwall Castle in the 14th century. The Wall curtain is almost entirely dismantled in the immediate vicinity of Thirlwall, observable only as a very low, linear mound running east–west. Unfortunately, excavation on the line of the Wall was not feasible within the project timeframe of WallCAP to determine the exact extent of survival.

Significantly, the castle was never substantially altered or renovated during its occupation between the mid-14th–17th centuries, and subsequently fell into disrepair, with entire walls and upper elements collapsing. The progressive dilapidation of the castle can be observed in a sketch from *c*. 1776 and a watercolour from 1831 (Andersson 2022b; reproduced in Rushworth and Carlton 2004), and an 1813 account notes the ruinous state of the castle and that some of its masonry was incorporated into nearby buildings (Whitworth 2000, 21). Roman stones, whether directly from the Wall, or a secondary re-use via the castle can be observed in the barn and farm structures to the north of the castle, and the cottages to the southeast of the castle. A centurial stone (RIB 1845) is now incorporated into a garden wall but was formerly discovered in a cottage doorstep. An altar (RIB 1782) was also found at some point before 1732, used as a stable trough; it is assumed to have been sourced from the fort at Carvoran or its immediate environs, only 750 m uphill of the castle.

The substantial use of Roman stone is beyond doubt. Observation of all facings, both internal and external, reveal a generally consistent size of sandstone facing built in a course rubble fashion, like the Wall itself. Exceptions are found in the windows and doors, and quoins at the corners, all of which make use of sandstone blocks. The core of the castle walls consists of mixed rubble, largely undressed. Where visible, the exterior walls also sport a plinth course atop at least two to five courses of footings. In a survey of the building stones for Northumberland National Park during a period of repair and consolidation, Young *et al*. (2001) identified three distinct types of sandstone – A, B, and C – used for the facing stones, plinths, and blocks, while the rubble core also made use of limestones, greywacke sandstones, granite, and occasionally brick. Occasional use of slates was also observed, often to create a level surface for other stones. All the stones, with the exception of the slate, are available locally, though it seems likely that nearly all the stone was repurposed from the Wall (Fig. 5.7).

The sandstones identified by Young *et al*. (2001) are, from their colouration, grain size and sorting, and diagenetic structures, very likely to be from the Carboniferous Period. The castle stands on a unit of sandstone within the Alston Formation of the Carboniferous Period. This unit of sandstone trends NE–SW and is truncated just to the SW of the castle by a fault and extends for several kilometres to the NE before this lens of sandstone dies out. There is a significant outcrop immediately under the castle where it has been cut into by the Tipalt Burn. There is, however, no obvious signs of quarrying here, though there are small cut-outs and piles of sandstone rubble on the hillside 400–500 m due south of the castle. The sandstone exposed by the Tipalt Burn is consistent in colour and texture with Young *et al.*'s (2001) type A sandstone, though no iron diagenetic patterns were observed. It is conceivable that each of type A, B, and C sandstones was sourced from this one sandstone unit as there is significant variation within individual sandstone units (see Chapter 2). This sandstone unit would have been the most obvious source of stone for the Romans as well as potentially in later times. There are no sandstone units to the west of Thirlwall until beyond Gilsland; to the east the next nearest sandstone units are north and south of the Wall at Walltown Crags. Young *et al.*'s (2001) type B sandstone looks superficially similar to sandstone exposed during the WallCAP excavations at Walltown Crags.

*Figure 5.7: The internal face of the south wall of Thirlwall Castle, highlighting the consistent fabric in different sandstones.*

Utilising dimensions of the castle in its present state (Ryder 2021, 98–99), these can be reasonably projected to establish the full height of the castle and volume of its outer walls. These represent a simple minimum of the area and volume of stone required for the castle, not accounting for internal walls or subsidiary structures that may have been contemporary with the castle. From these calculations, a figure of 1,000 $m^2$ of facing stones and a total volume of 2,600 $m^3$ of stones can be attributed to Thirlwall Castle. To acquire those quantities of materials from the Wall, depending on the height of the curtain, would require a minimum length of 227 m of curtain for the facing stones from both the north and south faces, and a 200–334 m length of curtain for the overall volume of material (Fig. 5.8). In principle, this is a very short length of Wall relative to the entire monument and would have allowed the builders of Thirlwall to acquire the entire volume of necessary material without needing to travel more than 250 m from the castle. It is worth considering the stones themselves and what they may reveal about the Wall.

First, it is notable that the exterior walls of Thirlwall Castle are approximately *c*. 2 m in thickness (above the foundations and footings), which coincides with the gauge of the Narrow Stone Wall, still extant to the east at Walltown Crags. That suggests the builders may have had an easier task of equating 1 $m^3$ of Wall curtain with 1 $m^3$ of castle wall, deconstructing the Wall and replicating the facing and core to similar thickness in the castle. Second, the plinth stones at the top of the castle footings on the exterior walls could be re-used chamfered stones that are believed to have provided a string course at the top of the Wall curtain (Crow 1991), though as they are built into the castle it is not possible to compare dimensions of these stones with those found along the crags in the central sector. The larger blocks used to frame doors and windows, as well as the quoins used in the corners of the castle, may also be reasonably sourced from Wall structures. Blocks of similar size are found associated with turrets, milecastles, forts, and bridges or culverts. Though no evidence exists, it is reasonable to assume that some form of structure requiring the use of blocks would have been required to carry the Wall over the Tipalt Burn and Pow Charney Burn, which currently converge south of the castle and the line of the curtain. Turret 46a, though its location is unconfirmed, is almost certainly within a 300 m distance of the castle. At the peak of the hill to the east, only 750 m distant is milecastle 46, with the fort at Carvoran due south of that. Turret 46b is *c*. 600–700 m to the west of the castle. These structures could have reasonably provided access not only to the sandstone blocks, but possibly also slates used for roofing material, and also the tile or brick that Young *et al*. (2001) observed as occasionally being incorporated into the rubble core of the castle walls. In this regard, all the different types of stone used in the construction of Thirlwall Castle can be reasonably attributed to one or more Wall structures (Fig. 5.9). The only fresh quarrying required would be for


*Figure 5.8: Map of Thirlwall Castle and adjacent length of Hadrian's Wall, visualising an indicative length of curtain required for materials to build the castle and the putative position of a turret.*

limestone to contribute to mixing mortar. This would have been readily available from the Scar Limestone Member that crops out along the opposite bank of the Tipalt Burn or from the Tynebottom Limestone Member that crops out 300–400 m north of the castle.

The scale of the fortified structures of medieval and early modern date varied considerably, and most were not built as entirely from Wall-stones as Thirlwall Castle. However, Thirlwall provides an interesting, if crude, quantification of stone repurposing for a monumental defensive structure. Working on the same estimations of volume per fortified structure and equivalent length of Wall (334 m estimated maximum length), then the 30 fortifications that made use of Wall stone in the medieval and early modern periods would have required 10,020 m of Wall for construction materials. This represents approximately 10% of the entire length of the Wall curtain and does not account for the quantities of materials also available from larger installations like bridges, milecastles, and forts. A cursory examination of most of these fortifications also reveals them to have been constructed in multiple phases in most instances, reducing the quantities of stone likely to be obtained from the Wall over time.

## Ecclesiastical structures using Wall fabric

Across the early medieval, medieval and early modern periods, 13, 45, and 9 ecclesiastical structures were respectively built in the Wall corridor, of which 11, 30, and 4 respectively also used Roman stones. As with fortifications, the scale and use of Roman fabric could vary substantially. Due to the complexity of ecclesiastical structures, primarily churches, with multiple phases of construction and renovation, it is not possible to replicate the exercise in volumes of stone undertaken above with Thirlwall Castle. In some cases, Roman stones are part of the fabric of a church itself, in other instances of a vicarage or another structure associated with a monastic complex. Some of these churches were also built inside a Roman fort, for example at Burgh-by-Sands and Bowness-on-Solway, while others were built proximal to the Wall if not directly on its line, as at Warden or Holy Cross, Wallsend. The 12th-century church of the Holy Cross at Wallsend is illustrative, not least as it survives only as incomplete and consolidated ruins following its abandonment in the 18th century. Many stones appear to be Roman in origin (Oswald 1883, 23; Knowles 1910,

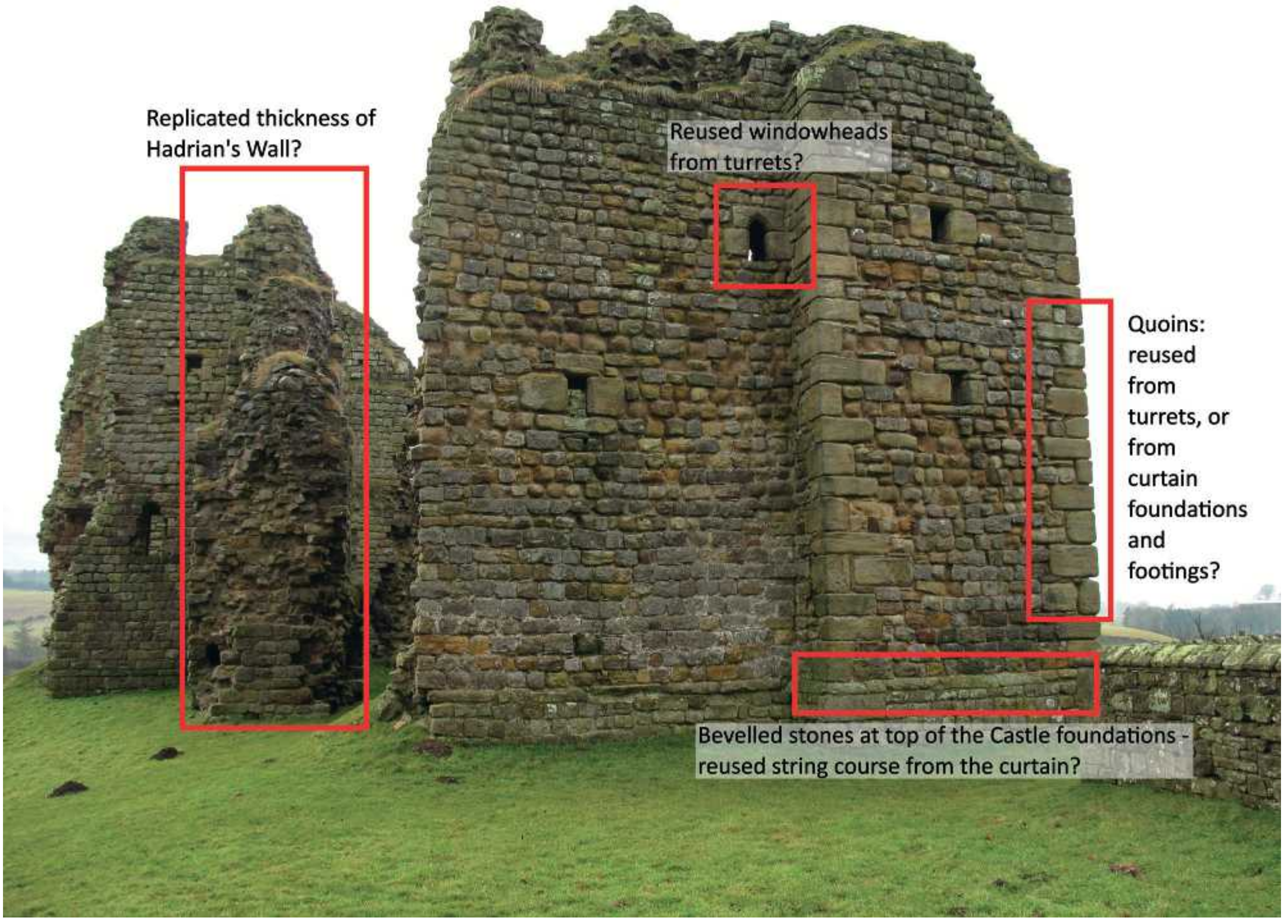



*Figure 5.9: Stone attributes of Thirlwall Castle that were certainly or probably sourced from the Wall.*

198; Whitworth 2000, 69), though the exact quantity and full extent of re-used Roman stones is uncertain due to the incomplete nature of the church (Fig. 5.10). Furthermore, the nearest surviving comparative length of curtain is at Buddle Street, Wallsend, and the mixed building at this location that resulted from at least four collapses and rebuilds did not lend itself to direct metric comparison between the two sites. However, other non-Roman stones also survive, such as the voussoirs carved in a medieval Romanesque style with supporting columns, indicating a mixed sourcing for the building's fabric. The closest Wall sites to the church are the fort at Wallsend and the curtain to its west. It seems that these were the most likely sources for the Roman stone, even accepting that some material had already been taken for the construction of Jarrow. Holy Cross is broadly representative of the many churches built throughout the Wall corridor, where some Roman stone can be identified, generally relating to earlier phases in the building's history, but the exact quantity or extant cannot be determined, and sourcing is generally presumed to be the closest locations along the Wall, or another site if off the line of the Wall.

*Figure 5.10: The consolidated ruins of Holy Cross Church, Wallsend, located north of the line of Hadrian's Wall. Though largely robbed, some of the remaining stone is re-used Roman fabric.*

*Figure 5.11: The south wall of the nave and west wall of the transcept at Lanercost Priory, which makes extensive use of red and white sandstones from Hadrian's Wall.*

*Table 5.3: Land grants of Lanercost Priory, indicating access to the Wall. Specific grant numbers refer to the listings in Todd 1997 (modified from Andersson 2022a).*

| *Foundation grants* c. *1169* | *Location* | *Source of Wall fabric?* | *References* |
|---|---|---|---|
| Priory grounds | S boundary at the Irthing; W boundary at Burtholme Beck; N boundary at the Wall; E boundary at Banks Burn. | Yes – the whole of Wall-mile 53 | Todd 1997, 5–11 |
| Vill of Walton | S boundary at the Irthing; W at Cam Beck; N at northwards bend of Cam Beck; E at the Kingwater. | Yes | *Cartulary* no. 1 |
| *Lande* of Warthcoleman, Roswrageth, and Apeltrethwayt (Appletree) | 'Clearings between the north bank of the Irthing and the south side of the wall… as far east as Birdoswald' (Todd 1997: 54). | Yes | *Cartulary* no. 1 |
| Land in the moor of Brenkibet, the area of Midgeholme, and the area in the valley of the Kingwater (Cumquenecath) | Lands S of the Wall and N of the Wall. | No | *Cartulary* nos. 1, 15 |
| 'The two Askertons' | N of the Wall. | No | *Cartulary* no. 19 |
| Five churches at Walton, Irthington, Brampton, Carlatton, and Farlam + chapel at Triermain | Only Walton (already held by the Priory) and Irthington near the Wall. | Yes | *Cartulary* no. 1 |
| Lanrechaithin and land in Midgeholme | Lands S of the Wall and N of the Wall. | No | *Cartulary* no. 6 |
| *Land grants post-1190* | *Location* | *Source of Wall fabric?* | *References* |
| Between 1194–1220: a *cultura* near Birdoswald | To the immediate N and W of Birdoswald and the Wall. | Yes, if ownership included the Wall | *Cartulary* no. 144 |
| Between 1205–1237: land between Lanercost and Denton and extension of the holding in Midgeholme. | What is now Hayton and St Mary's Vale opposite Lanercost. | No | *Cartulary* no. 24 |
| Between 1240–1271: large areas in Warthcoleman, Prestover, Knorren Fell, and elsewhere. | Prestover and Knorren Fell near Walton: *Cartulary* nos. 223, 227 (in Todd 1997). | Yes, if new grants near Walton contained any part of the Wall | *Cartulary* nos. 223, 227 |

Lanercost Priory, however, provides an opportunity to consider the scale and sourcing of Wall material that is not feasible for other ecclesiastical sites due to the good condition of its extant fabric, the incorporation of a number of inscriptions, and a rich textual record that associates the priory with land grants. An Augustinian priory founded in 1169, the majority of its construction occurred in the later 12th century and through the 13th century, probably being completed by the date of a royal visit in 1306/7. The priory was in use until its Dissolution on 8 January 1538, and was subsequently acquired and occupied by the Dacres from 1542. There followed periods of dilapidation and restoration until 1930 when the site was acquired by the Office of Works, now English Heritage (Summerson 2000).

As a monastic complex, Lanercost has a large church with associated buildings arranged around the cloisters immediately south of the church. Over the course of approximately 150 years of building work, Lanercost made extensive use of Roman masonry associated with the Wall. Many areas of the external fabric of the priory are built almost entirely from Roman stone (Hill 2000). This stonework can still be viewed today (Fig. 5.11), and it is feasible to broadly correlate building work of the priory with land grants and access to different locations along the Wall (Table 5.3). All told, entries from the *Lanercost Cartulary* indicate that the priory came into possession and had access to 6–8 km of Wall (Todd 1997; Hill 2000, 191), and these have been mapped in Figure 5.12. Examining the fabric of the priory makes it clear that there was access to lengths of Wall built of white/buff sandstone and red sandstone, visible particularly on the south exterior wall of the nave. Based on the phasing of construction, Wall-stone seems to have been employed throughout the building of the priory (Harrison 2000a; 2000b). There are no explicit statements that the Wall was quarried, nor that other locations were quarried. A grant of a stone quarry in 1292 by one Matilda in Gilsland (*Cartulary* no. 242; Todd 1997, 6), however, may indicate either that the Wall had been substantially quarried by that date, or that access was granted to particular rock.

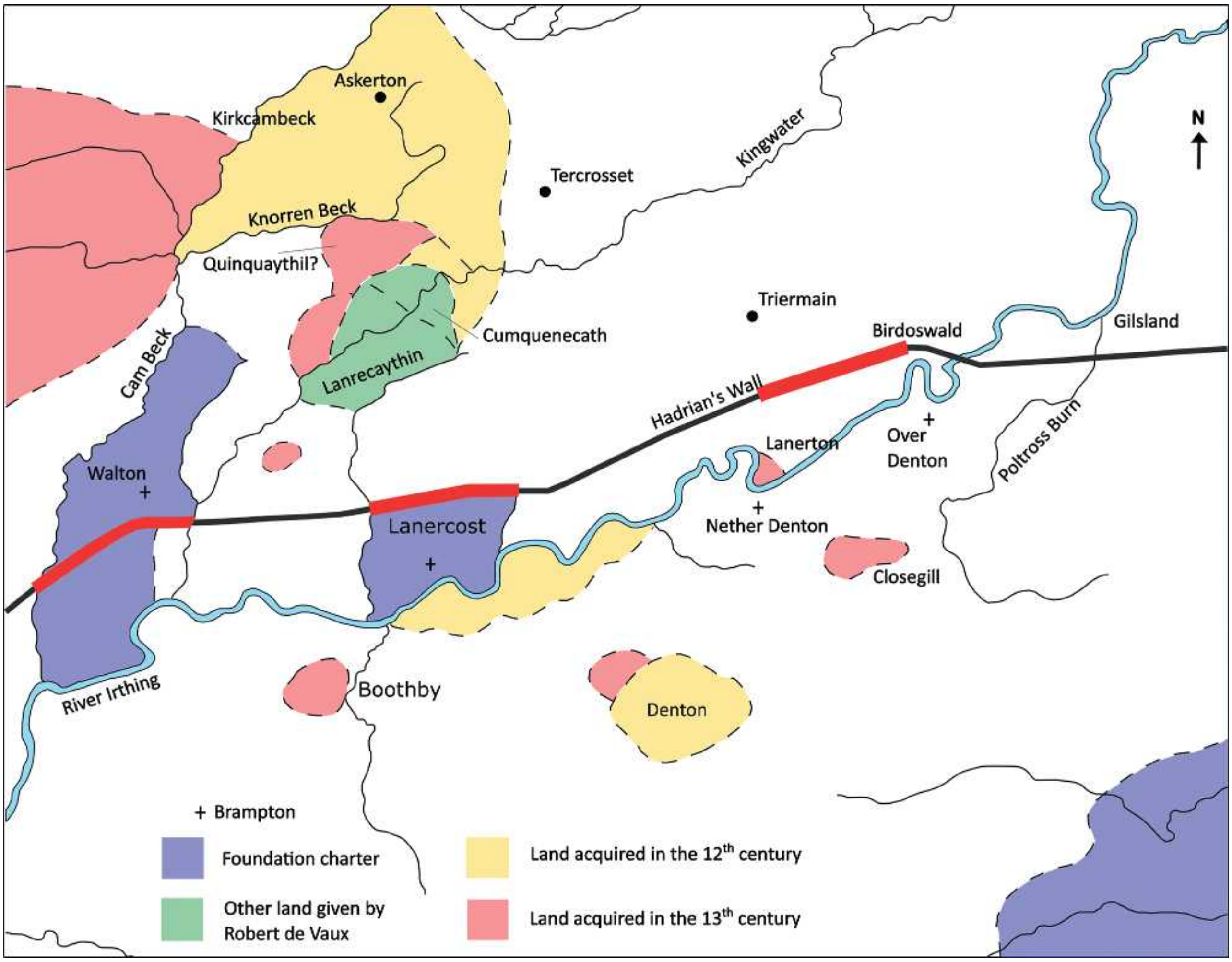



*Figure 5.12: Map of Lanercost Priory land grants, indicating the stretches of Wall available to the Priory for quarrying and re-use. After Summerson 2000.*

*Figure 5.13: The west and south wings of the enclosed cloister of Lanercost, with the west wing and tower built substantially of red sandstone. White sandstones were used in the southern wing (crypt), though the colour is partially obscured by weathering.*

The fabric of Lanercost is particularly interesting, not only for what it reveals about its Wall-stone sources, but also what this tells us about the nature of the pre-existing Wall. The Priory is located geologically within the Tyne Limestone Formation, the oldest of the Carboniferous Period Formations underpinning the Wall. It is also within a few hundred metres of the boundary with the overlying Permian sandstones. It is not surprising, therefore, that the stone used in the priory contains a mixture of the pale white and buff sandstones of the Carboniferous Period mixed with the red stone of the Permian and Triassic Periods (Figs 5.11 and 5.13). With a multitude of good Carboniferous sandstone available from the hillside at Banks, east of Hare Hill, it would be unsurprising if the Romans had transported stone west along the Wall from here some way into Permian and Triassic country. There is evidence from a limestone fragment at Cam Beck that this happened and the nearest known source quarry for red sandstone is the Triassic St Bees Sandstone at Gelt some 4 km distant. However, the majority of stone at Cam Beck is Triassic and the large quantities of red sandstone used in the priory suggests sourcing of Wall-stones from further west where such stone was used in the Wall, or (less likely) that these stones are not Roman but merely of Roman size and shape. In either case it is interesting that the red sandstones and pale sandstones are thoroughly intermixed in the fabric of the priory.

The Wall is named as a boundary in many of the grants, though it is not always certain if the Wall could be robbed when acting as a boundary. However, the Wall acted as the northern boundary to the priory grounds in the original founding grant, and excavation at Hare Hill revealed almost near total robbing of the Wall curtain, with subsequent late medieval reconstruction of a narrower boundary wall over the surviving courses of curtain (Hodgson and McKelvey 2006). Though complete robbing occurred here, it does not necessarily follow that this was always the case. For example, the Wall ran through the middle of the village of Walton, with the western boundary determined by the Cam Beck. An account of 1791 pertaining to work on the newly formed Castlesteads estate provides testimony of robbing of the Wall for 'near half a mile' in the stretch east of the Cam Beck, where the curtain survived to at least a height of 0.7–1 m (Carlisle 1794, 64). Notably, WallCAP excavations at Cam Beck revealed Roman fabric on the line of the Wall in red sandstone. It is reasonable to infer on the basis of the priory's ownership of the vill of Walton that some of the red sandstone Roman fabric can be attributed to this length of the monument.

Regardless of the full extent of robbing, the scale of building in the priory indicates that it made extensive use of its access to the Wall. Its holdings contained all of Wall-mile 53, which does not survive to any great extent with the exception of turret 53a and some of the curtain nearby, and would have included a milecastle at each end of the mile, plus two turrets in between (Hodgson and McKelvey 2006, 54–55, 58). Inscriptions, too, point to a range of Wall locations. RIB 1869 was purportedly from a house in the hamlet of Murray, *c*. 800 m east of Birdoswald, and subsequently built into the late 12th-century fabric of what became the east face of Dacre Hall; an altar presumed to be from Birdoswald (RIB 1881) was found in fabric associated with the late 12th–early 13th century, but its function as a window frame may be secondary rather than primary to that portion of the clerestory (Andersson 2022a). An inscription naming the 6th Legion as the builders (RIB 1968) is likely to have come from a milecastle, though which one cannot be determined. Centurial stones have also been found (RIB 1969, 1971), though their original findspots cannot be determined at this point, having come from anywhere in the stretch of Wall between turret 49a and MC 57.

## Conclusion

The case studies offered above provide testimony to the direct contribution that the Wall made to hundreds of post-Roman constructions in the Wall corridor. Some, like Thirlwall Castle and Lanercost Priory, were built almost entirely or substantially from Wall fabric. Other sites made a greater use of mixed stone sources. No doubt further detailed examination of these structures will reveal further insights into the Wall's architecture, as well as the nature of its robbing and destruction over subsequent centuries.

# 6

# Conclusion

Examination of the Wall using both archaeological and geological methods has been a rewarding approach to gaining further insights into the planning, construction, and maintenance of the Wall, as well as its subsequent ruination, destruction, and repurposing. The geodiversity of the Wall has been revealed to be greater than recognised in previous studies, and new fieldwork has highlighted the geological context of the Wall as well as the significant range of materials used in all elements of the Wall. Insights have also been gained as to where building materials may have been sourced. To achieve these insights, WallCAP employed a framework of research and data linking archaeological and geological approaches, which generated four key benefits.

First, archaeological and geological approaches to context, stratigraphy, and provenance unlocked the potential to link archaeological and geological source data. Archaeological methods have been able to identify a relative chronology of the building sequence for the Wall, and the survival of archaeological material also generates a clear geospatial context alongside chronological understanding at a range of scales, from the entire monument to individual contexts within one archaeological site. Geological formation processes require 'big thinking' in both space and time, to contextualise a series of processes related to the action of plate tectonics, the earth's rotation around the sun, the movement of water, ice, and wind, and the interaction of all these with biological evolution. These see the continual reconfiguration of continents, opening and closing of oceans, changes in sea level, climate, and atmospheric composition, and the reshaping of both landmass and sea floor through weathering, erosion, and deposition. When combined, the resulting rock formations bear distinct physical and chemical properties that lend themselves to archaeological insights.

Second, this combination made possible a more detailed and materialistic focus on Hadrian's Wall, distinct from approaches purely focusing on chronological elements of its construction. Detailed geological analysis of rock formations that were prospective sources of Roman building fabric resulted in fascinating insights, as well as clarifying limitations to methods adopted for this study. Limitations accepted, the materialist approach that requires archaeological and geological methods to complete an object biography of Wall fabric has resulted in new archaeological and geological discoveries.

Third, the combination of archaeological and geological data prompted the creation of novel methods of data capture and recording, which also required new approaches to thinking and training. This latter was particularly beneficial to the project volunteers that were so vital to data capture. It is hoped that this will also result in a more robust recording protocol for future work on Hadrian's Wall, as well as providing good practice for wider archaeological work.

Fourth (and finally), the limitations identified during the course of research have been beneficial in and of themselves. This both sets expectations on what may remain unknown about the Wall and its source materials and their re-use as well as refining our understanding of the best methods to apply to future work. These four benefits are explored in further detail below, exploring the implications of the research for understanding Hadrian's Wall in the Roman and post-Roman periods.

## Insights through limitations

It is useful to begin by being explicit about the limitations identified in this research. It clarifies exactly what can and cannot be elucidated from the data. Whilst the use of geological methods in conjunction with archaeological methods has enabled evidence to be gathered which, as discussed below, gives clear insights into the Wall's construction and re-use, it has also highlighted some of the constraints on what it is possible to deduce. The following limitations are all related to a single fundamental fact – sandstones are notoriously difficult to characterise geochemically.

Non-destructive geochemical testing (utilising pXRF) on-site at the Wall and post-Roman buildings has limited value. The combination of uneven surfaces, biological growth, differential leaching of minerals with key geochemical signatures through surface erosion, and surface contamination with either natural muds or with manmade coverings (especially lime renders) make geochemical characterisation highly unreliable. This is unlikely to improve in the immediate future, as x-rays (the principal field method for geochemical analysis) will only penetrate a short depth into stone, insufficient to reach undisturbed, subsurface material. This indicates that reliable geochemical characterisation (and petrographic characterisation) may only be of use if samples of fresh material are obtained from within stones, for example by taking cores.

Variability within a given source sandstone remains a challenge. As discussed in Chapter 2, fluvial sandstone bodies are complex. This complexity means that the variation found within a given sandstone body may well be as great as the variation found between different sandstone bodies in different horizons. This fact makes it very difficult to make distinctions of variation observed between stones from one source as opposed to variation seen in stones from different sources. This issue is not just one for the complex lens-like bodies seen within the Carboniferous succession, but also for variation within the Triassic red-sandstones where characterising aeolian grains are unreliable horizon markers. This is probably the most significant limitation to this type of study.

Sandstones, by definition, contain a very high percentage of quartz. Quartz is highly inert and very simple in its composition and thus records very little geochemically about its formation history. It does, however, record information structurally in its grain shape, size, and degree of sorting as well as in its microscopic structure seen, for example, in undulose extinction, grain penetration, and suturing. Geochemical characterisation of sandstones is therefore dependant on the minor constituents of the rock – mica, feldspar, clay minerals and a range of rarer heavy minerals such as pyroxene, tourmaline, zircon, garnet, and others. By focussing on these heavy minerals, it may be that a richer geochemical history and therefore a better way of characterising the sandstone may be obtained. Characterisation of the Carboniferous sandstones for the purposes of locating stratigraphic position in hydrocarbon reservoirs has used these methods (Morton *et al.* 2002, Hallsworth and Chisholm 2008).

If it is possible to characterise a given sandstone body this may not be sufficient to tie the source formation to a specific quarry. As has been discussed, the sandstone layers, particularly in the Carboniferous, are variable in their lateral extent. However, many sandstone layers extend over many kilometres and so there is the potential for one sandstone type to have multiple dispersed quarries in it. Again, this points to the need to combine geological observation with archaeological and archival information to enhance deductions about specific stone sources. Locating a sandstone in geological time within a rock succession is challenging. Fossils are one of the principal ways in which a geological unit can be characterised and dated. In their absence, the principal way of temporally locating a sandstone is by its context – the rock units above or below that either contain fossils or have igneous material in them, which may be dated using radiometric techniques. The combination of field observation, boreholes, and geological mapping means that there is reasonable confidence in identifying where a sandstone at a given location in the Wall landscape fits within its geological succession. However, once that rock has been removed from that context, worked, and set in (building) stone, crucial information that identifies its geological time has been lost.

Even if a definitive characteristic can be found for a given sandstone that ties the stone from an archaeological site or structure to a specific source, this doesn't tell us when the stone was taken from that quarry. This applies equally to the Wall in the Roman period, as well as post-Roman buildings. Unless there is archaeological or archival evidence to support re-use of stone or freshly quarried materials, then we cannot know whether any given stone has come directly from a quarry, re-used from an earlier (Roman) structure, or via a series of secondary and tertiary re-uses. For example, at Thirlwall, it is likely that the castle re-used stone sourced directly from the Wall, but it is uncertain the extent to which the neighbouring early modern and modern farmhouse, outbuildings, and cottages made use of Roman stone reclaimed from the ruinous castle or sourced directly from the Wall alongside freshly quarried stone. This emphasises why a combined approach is valuable. It also highlights the significance of methods that qualify or quantify how long a stone has been exposed to the atmosphere and light.

With these limitations noted, however, the insights gained through the research can be explored in more detail.

## Building the Wall

The construction of Hadrian's Wall required a complex combination of decisions, both in advance of any construction as well as during the build process (Graafstal 2020). Ultimately, this process can provide insight into the purpose of the Wall, but the focus here is on the logistics of the construction process and their implications. Starting from the point that the course of the Wall had been decided, from where was the stone and other materials to construct it sourced? Examination of stone from the Wall itself and prospective source quarries has shown that the Romans would have had access to obvious and plentiful supplies of stone, all within less than 2 km of the monument for its route between Wallsend and Hare

Hill. West of Hare Hill, stone had to be sourced from a significant distance and transported over land, by river, or by sea. In this regard, it should be remembered that most monumental imperial building projects in the Mediterranean sourced materials from greater, often much greater, distances and in much higher quantities (Russell 2019). Sourcing stone for the western sector of the Wall, then, may have required greater planning, time, and resources devoted to stone transport, but it was not beyond the capabilities of the legionary builders.

It is notable, however, that the Turf Wall commenced from the west bank of the River Irthing, some 6 km before the easy access to stone was lost. The Turf Wall also began east of the known Roman quarry at Comb Crag. This strongly suggests that Comb Crag can be dated at earliest to the replacement of the Turf Wall with the Stone Wall and/or the building of the fort of Birdoswald in stone. Nonetheless, this implies that the decision to provide the western sector with the Turf Wall was not just about access to stone. The Turf Wall seems to have been built in response to a need for speedy construction, which by extension lends credence to arguments that the Wall was built during a period of active conflict (Symonds 2005; 2020; Graafstal 2012; Hodgson 2017). This short stretch of overlap between the Turf Wall and locally available building stone also explains what appears to be a phasing in the replacement of the Turf Wall. The easternmost length of the Turf Wall does appear to have been replaced with stone in the later Hadrianic period and was built to the Narrow Wall gauge. Whatever the impetus for building the Turf Wall, once it was resolved, it seems building parties were told to replace the Turf Wall with stone. This was most easily accomplished between Wall-miles 49 and 54 where good building stone was readily available within a distance of 2 km, as seen in the eastern and central sectors.

The research has produced clear evidence that that the majority of the stone used in construction of the Wall from (at least) Cambeck westward is from the St Bees Sandstone Formation. It has, however, not allowed for a definitive identification of the specific quarries that were used. To do this would require much more fabric from locations along this stretch of the Wall to be analysed and for a more complete characterisation of the sources. St Bees Sandstone appears petrographically remarkably similar across widely distributed geographic locations. There are some tantalising hints from the variability in colour (and petrography) seen in the Shawk quarries and in the fabric of re-used stone at St Michael's Burgh-by-Sands that these locations may be linked. Transport of the stone from Shawk to Burgh-by-Sands would be viable overland, but there is no definitive evidence at present.

In the central and eastern sectors of the Wall the reverse problem exists, with too much variation seen in the size and shape of sandstone outcrops and the variation within them, as noted above. However, where sandstone units exist with reliably consistent and unusual characteristics, it is possible to use the petrography to identify prospective source locations for stone used in building the Wall. The stone at Heddon is a good example of this. Even in the absence of evidence for a Roman quarry (likely destroyed by subsequent modern quarrying) we may be reasonably confident that Heddon stone was used in this section of the Wall. Tantalisingly at Black Carts, another sandstone with unusual characteristics has been identified, but so far a source has not been located. In contrast, at Walltown Crags it has been possible to find a reasonable petrographic match between Wall stones from the WallCAP excavation and sandstones collected from Queen's Crag north of Housesteads fort. This is an unlikely source for the Walltown Crags stone on the grounds of distance. More likely, this emphasises the cyclic nature of sandstone deposition in this part of the Carboniferous Period and/or the complex variation to be found within individual sandstone units.

Decisions about which quarries should be opened by the Romans presumably was a balance between the quality of stone, the volume available, the ease of extraction, and the distance and difficulty of the terrain for transporting the stone from quarry to Wall. In the western sector, having multiple small quarries would have increased logistical complexity, requiring more dispersed quarrymen, more roads or wagons and barges for transport, and potentially more soldiers dedicated to ensuring safe acquisition and transport of stone. Therefore, a small number of larger quarries would be more efficient in terms of management and resource allocation. Where there are multiple stone sources adjacent to the Wall, as in the eastern and central sectors, a more serendipitous approach would be practical. At least in the Hadrianic period, legionary building parties may have been responsible not only for construction on a specified length of Wall, but also for sourcing the stone from a proximal quarry. Whilst definitive evidence for volumes of extraction at any quarry is not readily forthcoming, the sheer numbers of smaller quarries associated with outcrops implies a relatively small volume of stone extracted per quarry. This practice has two benefits. First, smaller, dispersed quarries would allow for more rapid identification of outcrops of stone suitable for specific building needs, such as large and massive blocks or high-quality stone suitable for detailed carving. Second, quarries that were suitable for high-volume extraction, due to the size of the bed, quality of the stone, or a logistically fortuitous position, could also be identified and further developed for longer-term needs. Post-Roman quarrying may have masked or obliterated evidence of large-scale Roman stone extraction, but it is important to recognise that the scale of quarrying will have varied spatially along the length of the Wall as well as chronologically through its occupation and use by the Roman army.

Neither the stone sources nor the quarries reveal any information about what time stone was extracted, with the exception of Gelt. Even there, the inscription only confirms Severan quarrying; it does not preclude earlier quarrying. This means that little information can be gleaned about the sequence of quarry opening relative to the Wall's history of construction and maintenance, including the replacement of the Turf Wall. Chronology can be inferred in some cases, as above with Comb Crag and with Gelt, but this remains tentative. In principle, if a characteristic stone was found in only one phase of Wall-building, and its source could be identified and located, then a firmer chronology between one or more quarries could potentially be established. However, no evidence of this nature has been found, and in fact the archaeological evidence suggests that such a simplistic chronology is highly unlikely. The number of smaller quarries, the diversity of sandstone used to build the Wall, and the variation in the dimensions of building stone all reinforce dispersed sourcing of stone proximal to building and contemporaneous diversity of practice in applied masonry and building techniques.

The material used in the core of the Wall curtain has revealed a range of different materials. The description of the Quaternary deposits and the effects of ice-movement on the landscape in Chapter 2 are simplified, but nonetheless provide a starting place to consider variation in the Wall's core material and where this was sourced from. In the central sector where quarry by-product and scree from the Whin Sill are readily available, little glacially derived material is seen in the core of the curtain. However, in the western section of the Wall and at locations near to rivers (Port Carlisle, Cam Beck, Willowford, Corbridge), glacial material is more commonly used. This underscores that the Romans took a pragmatic approach to sourcing materials for building the Wall, so it is highly likely that they used what was most immediately to hand for the core material.

While the overlap between readily available stone and the eastern length of the Turf Wall point to the importance of speed in the initial construction of the Wall, at least in the western sector, the more dispersed nature of quarries in the central and eastern sectors can be read in two different ways. First, such dispersed quarries and presumably smaller (relatively speaking) work parties would be more vulnerable to attack than larger quarries with a greater workforce (and by extension, security or protection). That could be understood to imply that the Wall was being constructed in either a peaceful environment, or one where violence was confined to particular locations or areas. Alternatively, the prevalence of smaller, dispersed quarries that were generally proximal to the Wall could have been a boon to builders in a conflict landscape, providing greater flexibility in sourcing and shortened supply lines. Regardless of which reading of the evidence is preferred, it is certain that a more pragmatic approach to building was favoured over build-quality or aesthetics. If these qualities were important, then more consistent sourcing of sandstone and its dressing would be expected.

If it can be accepted that expediency and pragmatism were preferred by Roman authorities in the construction of the Wall, then speed of construction may have been a driver in any decision making. A preference for a speedy build may point to construction taking place during active conflict. The execution of the western sector in turf alongside the subsequent decision to build forts along the line of the Wall and to build the Vallum before the curtain was complete also point to security concerns identified or experienced during construction. This is supported by the proposed priority program of construction (Symonds 2005, 2019b; Graafstal 2012; Hunneysett 2017) and more carefully sited locations for turrets and milecastles to enhance observation and control of corridors of movement (Symonds and Breeze 2016). But alongside this is the possibility that the Wall was not completed prior to its abandonment in favour of the Antonine advance into Scotland (Breeze 2019, 90). While it can only be speculated, this may suggest that any conflict or warfare that prompted faster construction, or even a break or dislocation of the building programme, may have been resolved in the later 120s to early 130s. This would allow for commencement of the Stone Wall in Wall-miles 49–54 in the later Hadrianic period and further completion of construction elsewhere along the line of the Wall.

## Repairing and repurposing the Wall

As discussed in Chapter 3, there is extensive evidence from sites along the length of the Wall that repair and refurbishment was widespread during the 270+ years that the Wall served as a frontier monument. During the course of research, there was no single location where rebuilding could be definitively associated with new or freshly quarried stone, though that remains a possibility. The collapse and repair of the curtain at Buddle Street in Wallsend on at least four occasions may be a more dramatic example than seen elsewhere along the Wall (Bidwell 2018), but the excavations and analysis at Buddle Street have also clarified key aspects of repair and refurbishment work along the Wall. Collation of the evidence (Table 3.5) underscores that multiple locations in every sector of the Wall have required repair, not even accounting for the presumably widespread Severan rebuilding programme. Indeed, more careful and conscientious examination of upstanding Roman fabric revealed a number of locations where fabric repair is evident just from visual inspection. Denton turret is one example (highlighted in Chapter 3), but numerous discrete patches of curtain facing stone that have a more jumbled or less coursed appearance were observed in stretches of the Wall at Walltown and Birdoswald.

Two factors have contributed to a more widespread absence of recognition of the extent of repair to the Wall. First, the majority of the Wall has not been excavated or revealed. This has limited observations to discrete lengths of curtain, and between prevailing interest in the Hadrianic building sequence and the human tendency to identify (and perhaps project) pattern, details that point to repair have often been overlooked, or under-emphasised. Second, for those lengths of curtain that have been excavated, the majority rarely survive to a height of more than three or four courses of stonework and often less. Repair is most easily observed on the Wall where it survives to a greater height. In this regard, the state of preservation hinders a more complex and long-term reading of the monument's fabric.

However, the potential of post-Roman structures to contribute to an understanding of the Wall has also been underappreciated. The monumentality of the Wall and the settlements along its length will have had far-reaching impacts in the post-Roman centuries. Many sites, particularly though not exclusively forts and the towns of Corbridge and Carlisle, continued to be occupied in the 5th century and beyond, after the formal political demise of Roman Britain. While such settlements were almost certainly smaller in population and extent than their peak in the 3rd and 4th centuries, they remained a focus of life for some people. As long as people were living at former Roman sites, then they were perhaps less likely to be plundered for building material, though very few structures were built in stone in the early medieval period.

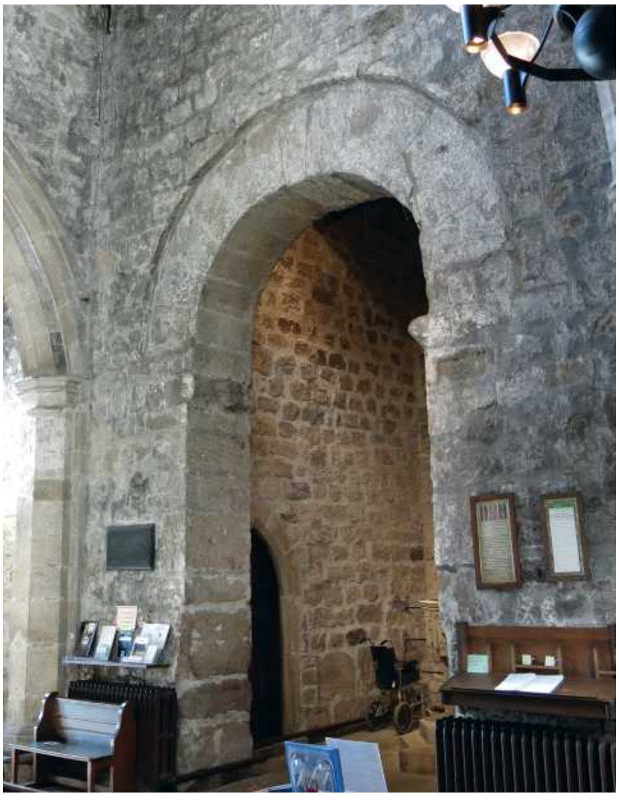


*Figure 6.1: A re-used Roman arch, complete with piers, springers, and voussoirs, erected between the nave and the tower at St Andrew's, Corbridge, probably built in the 9th–10th century.*

It has long-been recognised that many post-Roman structures have incorporated Roman stones and architectural features. In the early medieval period alone, the crypt at Hexham Abbey makes extensive use of decorated Roman blocks, inscriptions, and friezes, while St Andrew's church, Corbridge, incorporated an entire Roman arch to separate the nave from the tower (Fig. 6.1); both sites seemed to have sourced fabric from the Roman town at Corbridge, and possibly other locations. At St Paul's, Jarrow, window-heads and doorways were some of the architectural stonework repurposed from the forts at Wallsend and/or South Shields (Fig. 6.2). Nor is such use of stone limited only to the decorated or more functionally complex fabric. Facing stone is also regularly repurposed from the Wall. In the early medieval period, the majority of repurposed Roman fabric tended to be associated with Christian buildings, and alongside the more practical labour-saving measures of recycling the fabric, explicit use of Roman stone also carries ideological claims. For example, access to the stone is likely to have been granted through elite secular (royal) permission or grants, highlighting the privileged position of the church vis-à-vis secular authorities; such use may have also underpinned claims of the *romanitas* of the Christian church in the absence of the now fallen Roman Empire, and its inheritance of Roman authority seen across the former Western Empire; the conspicuous use of stone for new monumental construction also implies an expectation of permanency in the landscape (Leone 2007; Turner *et al*. 2013, 158–159, Fafinski 2021).

Medieval structures made much greater use of Roman stonework, presumably accompanied by greater expansion and settlement of the landscape and more extensive use of stone for building. Churches and monastic complexes continued to plunder Roman stone, though perhaps more for functional purposes than the ideological reasons of earlier centuries. This can be seen at varying scales. At St Giles, Chollerton, three monumental Roman columns support the 12th to 13th-century arcade separating the nave from the south aisle (Fig. 6.3). The columns were probably sourced from the nearest fort site at Chesters, though it is possible that Corbridge may have also furnished the columns.

Far more extensive use of Roman fabric, as discussed in Chapter 5, can be seen at Lanercost Priory, sourcing red and white sandstones from the 7–10 km of Wall that were part of their landholdings. The scale of Lanercost, both in the heights achieved by the church and the extent of priory buildings, proves just how much can be achieved through repurposing of Wall fabric. Even without the resources of an Augustinian Priory, considerably scaled buildings could be erected from a reasonably short length of the Wall. It is likely that the 14th-century hall-tower at Thirlwall was built from a maximum of *c*. 330 m of Wall. The re-use of Roman Wall fabric at these and other sites arguably provides an impression of the appearance of Hadrian's Wall in antiquity (Fig. 6.4).


*Figure 6.2: Roman stonework used in the blocked doorway in the north wall of the chancel at St Paul's, Jarrow (left) with the types of stone identified (right). It was probably built in the 8th century. © Turner* et al*. 2013.*

*Figure 6.3: Roman columns used in the medieval south arcade of St Giles, Chollerton, probably dating to the 12th–13th centuries.*

Despite the frequent use of Roman stonework, there must have been extensive ruins along the length of Hadrian's Wall, and they may have been a source of wealth for the individuals that owned (or claimed) the land. Even if unoccupied, we should not underestimate the scale and visibility of many ruins. The height of turrets and gatehouses, monumental buildings like *principia* and baths, as well as burial monuments, will have projected from ground level with a reasonable degree of visibility. Without direct on-site occupation, the development of new soils would be slow, so obscuring of ruins is most likely to have been accomplished through a combination of collapse and coverage by vegetation and scrub. Over time, this would contribute to soil formation that eventually rendered such sites more useful to pasture or agriculture in rural locations. Forts, milecastles, and turrets may have been reasonably discrete areas of rough ground, unsuitable for agriculture, but the Wall curtain would almost certainly have remained an impressive barrier along most of its length until the early modern period. Writing in the 8th century, Bede offers a tentative height of 12 feet,


*Figure 6.4: Wall-faces of three medieval structures that made extensive use of Roman fabric, and whose appearance can be reasonably argued to replicate that of the Wall. (A) The south face of Drumburgh Castle (14th century). (B) The internal face of the south transept at Lanercost (early 13th century). (C) The south face of Thirlwall Castle (14th century). Images are not to scale.*

presumably in the vicinity of Wallsend, and there are a number of antiquarian descriptions from the 17th and 18th centuries that suggest survival of the curtain to a height of at least 2 m. What needs to be accounted for is the differential survival and plundering of the Wall, relative to population density and expansion. The Wall seems to have been most thoroughly robbed, and in some cases buried, in areas of urban expansion and where good building stone was not readily to hand, particularly in the stretches west of Carlisle. In more remote and upland areas, survival of the archaeological remains has been greater. Excavations by WallCAP at Walltown Crags revealed tentative phasing to the collapse and robbing of the Wall (Fig. 6.5).

## Future research

Where does this leave interdisciplinary archaeological and geological research? The first thing is to acknowledge that there are some parts of this puzzle that will remain unknown. For example, if the complexity of a given fluvial body is as great as the variation between fluvial bodies, it will never be possible to uniquely characterise a stone source. These constraints do, however, point towards several ways in which further research could be directed to test these limits and gain further insights.

The absence of many direct matches between *in situ* Wall fabric and rock outcrops indicates that a more intensive study focused on a small number of Wall locations would be of value. For example, sampling of Wall material at Walltown Crags and an outcrop to the north of Walltown that was the nearest source of sandstone definitively indicated that the Wall-stone and outcrop were not matched. The Wall-stone sample, however, did match more closely with the Queen's Crag sandstone outcrop north of Housesteads. It seems unlikely that Queen's Crag was the source for Walltown curtain fabric, but it may help narrow down to more specific geological formations. A study that sampled all sandstone outcrops in a radius of 2 km of a given Wall location to obtain samples for lab-based geochemistry and petrographic analyses would enhance the local geochemical resolution and almost certainly identify preferred sandstone outcrops associated with Hadrian's Wall.

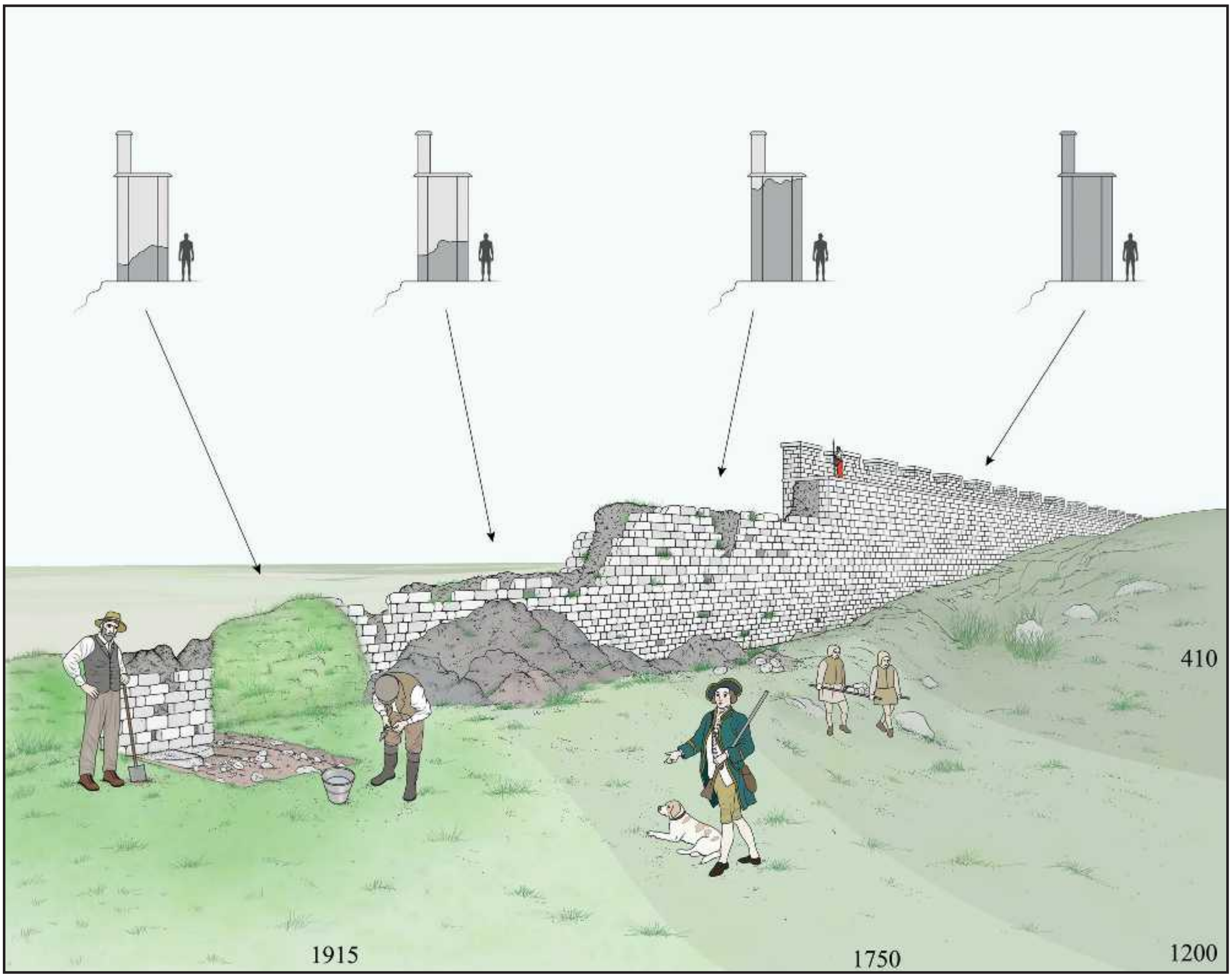



*Figure 6.5: A reconstruction of the phased ruin and robbing of Hadrian's Wall at Walltown Crags, based on excavations by WallCAP. Illustration by Matilde Grimaldi.*

A second useful piece of research would be to examine a few specific sandstone bodies in detail to characterise the three-dimensional variation within each body. This would require physical samples for geochemical and petrographic work as well as heavy mineral geochemical analysis. The output of this research would be valuable both to the archaeological community and the geological community, establishing more direct links between sites and buildings of different historic periods.

During the course of research, it also became apparent that there is a substantial body of stonework that would support a more detailed architectural interpretation of Hadrian's Wall. Indeed, the absence of a more architectural approach to the Wall and its attendant installations became apparent when compiling data from past excavations, as well as attempting to provide robust guidance to volunteers for recording of Roman and post-Roman buildings. Churches, castles, and even houses and barns have an established lexicon for architectural features; it was notable that Roman architectural terminology has rarely been applied to the Wall. Forts, milecastles, and turrets all have evidence that provide direct testimony of architectural embellishment beyond simple functional structural needs. Additional Roman structures, such as bridges, mills, temples, and other extramural buildings add to the diversity of architectural form and need. Post-Roman structures, too, make extensive use of Roman features, and incorporation of these stones provides a retrogressive approach to Roman architecture that can be accumulated with surviving fabric from Roman sites. In this regard, Hadrian's Wall is an underexploited resource in establishing a discrete practice of Roman military architecture.

Post-Roman structures are not only suitable for understanding Roman architecture, however. It was beyond the remit of WallCAP to undertake extensive archival research, but more detailed research focusing on post-Roman buildings and complexes will also yield further information about re-use of Roman fabric, as well as the relationships of post-Roman communities with the Wall.

It is notable, for example, that three prominent properties that were the subject of WallCAP research, Drumburgh Castle, Castlesteads (work at Cam Beck), and Lanercost Priory, were also properties of the Dacre family in the early modern period. The Dacres were a powerful family that furnished various officials, including Lords of the West March. Furthermore, placenames, deeds, and maps almost certainly capture further information pertaining to the location of Roman remains, or their robbing. Combined with further research into antiquarian collections, the post-Roman centuries have the potential to transform the current understanding of Hadrian's Wall.

Across the course of WallCAP, the combination of geological and archaeological methods and data generated detailed and new information on Hadrian's Wall and its surrounding landscape. This research has been ground-breaking in many ways, yet it is also just the beginning. By taking a different, interdisciplinary approach, new avenues for future research have been identified and existing understandings of the Wall have been challenged. However, from the foundations laid by this research, it is hoped that further materials-based investigation will continue to enhance our appreciation and understanding of Hadrian's monumental erection.

# Appendix 1

# Methods employed for the research

The methodology for this project divides into two separate approaches. The first was used to train volunteers and to provide a process for them to use, once trained, to gather an extensive set of data. The second was to use analytical work to carry out detailed geochemical and petrological work to produce a more intensive data set. For this latter approach two methods were used:

1. X-ray Fluorescence Spectroscopy (XRF) using a Bruker portable XRF.
2. Petrographic analyses using thin section and a polarising petrographic microscope.

The following sections describe first the approach to gathering data with volunteers, followed by a description of the analytical methods used.

## The SSD process

### *Mass science and the Stone Sourcing and Dispersal strand*

The Stone Sourcing and Dispersal (SSD) strand of WallCAP worked with and trained volunteers to follow a four-part process that would enable them to understand the geology of the Wall area, capture data on the stone fabric of the Wall, explore possible sources for that stone, and investigate where stone may have been re-used in post-Roman structures. The SSD strand interacted with the other strand of WallCAP, Heritage at Risk (HAR). This was of mutual benefit. SSD work helped inform HAR of the geological context and provided data on stones found during excavation. For SSD, HAR excavations provided access to Wall-stones that otherwise would have been inaccessible.

The purpose of the four-part process was to break down the aims of SSD into manageable components, suitable not only for thematic collection of data, but also for training. Each part provided volunteers with the skills required to carry out the detailed examination of Wall-stones and stone sources as well as providing the geological knowledge to be able to understand both the meaning of the data collected and to situate the Wall within its geological context. Each part was also intended to be engaging and provide the possibility of working on one or many parts in the process. An important aspect of the SSD work was to clearly articulate the aims of the strand, given that the volunteers were an essential collaborative part of the project.

The Stone Sourcing and Dispersal (SSD) strand of WallCAP had four primary *research* aims:

1. ***Understand the geology*****:** What are the processes that formed the Wall's rock and the landscape it rests on, and what was the geological environment that Roman and other populations lived in?
2. ***Inspect the Wall*****:** Identify the range of geological materials used to construct Hadrian's Wall, sensitive to local and regional variations, as well as to how stone was shaped to achieve architectural needs.
3. ***Unearth the Wall's rocks*****:** Identify probable and definite quarrying locations and geological sources for the materials used in the construction of the Wall.
4. ***Investigate repurposed Wall-stone*****:** Identify probable buildings and structures that have made (re)use of Roman stone fabric from the Wall and its related structures in the contemporary landscape.

These individual aims each consisted of a defined package of training and other activities, and when taken together provided a greater appreciation of the Wall, its relationship to the environment, and its position and contribution to local communities.

The aims above were also designated as steps corresponding to the aim number, and it was structured so that a volunteer or group of volunteers could participate in as few or as many activities in one or more steps as desired, or even focus on activities in a particular location or area. Each step/aim is described in turn.

### *Step 1: Understanding the geology*

Volunteers were given a guided examination of known geological exposures of rock types underlying the Wall, including natural outcrops (principally on the coast) and manmade exposures such as quarries and road cuttings to gain familiarity with geological context.

This geological examination entailed:

- Relating different rock outcrops and types to geological maps and guides.
- Identifying and characterising different rock types.
- Accurately recording the different stone types.
- Geologically interpreting the features within stratigraphic layers as well as the relationship between layers.

Field trips were undertaken to visit rock outcrops covering the key ages of rocks underpinning the Wall, this included:

- Tynemouth to Seaton Sluice: Pennine Coal Measure Formation.
- Haltwhistle Burn and Cawfields: Stainmore Formation and the Whin Sill.
- St Bees: St Bees Sandstone Formation.

Volunteers also visited Rockcliffe on the north shore of the Solway Firth to gain a sense of the Palaeozoic rock sequences from which glacial till is in part derived and to examine granites and greywackes.

This was all supported with classroom-based workshops and written guides providing the information and concepts needed to understand the geology of the Wall. Topics covered include:

- What is a rock made of.
- Sedimentary process.
- The Carboniferous, Permian, and Triassic sedimentary environments.
- Igneous process and the formation of the Whin Sill and the Palaoegene dykes.
- The impact of the ice ages.
- Geological tools and techniques.

### *Step 2: Inspecting the Wall*

Volunteers carried out a close examination of surviving stretches of Hadrian's Wall and related sites. They became familiar with the type of rock chosen by the Romans in building the Wall, how that stone was shaped, and the basic masonry techniques used in building.

This inspection entailed:

- Recording the location of Wall-length examined.
- Identifying the type of stone used in building material (invariably sandstone).
- Accurately recording what could be observed of the mineral content of the stones, the grain size and degree of sorting, any sedimentary textures and/or diagenesis, and the colour of the stones.
- Identifying the masonry techniques employed in shaping the stone and the range of shaped stones present.
- Recording the dimensions of individual stones.
- Collating information to generate a summary of a given area/location.

Fieldwork observations were carried out at locations including:

- Buddle Street
- Denton
- Heddon-on-the-Wall
- Planetrees
- Chesters fort
- Black Carts
- Birdoswald
- Hare Hill.

At each location, volunteers were given guided tours of the sites and key features to establish an understanding of how a given location related to the broader monument and history of the Wall in the Roman and post-Roman periods.

Furthermore, a series of stone-carving workshops were run with a local artist to give the volunteers a sense of how stone behaves when carved and to build an appreciation of the basic skills required for stone masonry and carving.

### *Step 3: Unearthing the Wall's rocks*

Having recorded the type of stone used in the Wall in Step 2, volunteers were then given the opportunity to explore possible quarry sites in the vicinity of given Wall-locations.

This unearthing process entailed:

- Consulting geological and historic maps.
- Walking/scouting areas identified from the map(s).
- Recording the geology at quarry sites.
- Cataloguing historic evidence of extraction/quarrying.

Volunteers were first given the opportunity to visit known Roman quarries such as the Rock of Gelt and Fallowfield, to observe first-hand what a Roman quarry face looks like, including the remains of extraction. This was followed by the opportunity to consult geological and historic maps along with modern sources such as GoogleEarth to identify locations of quarrying in a given locality. Finally, volunteers undertook site visits to possible quarry sites to determine if any surviving traces of Roman quarrying could be identified and confirm the type of rock that was extracted.

Additionally, visits to two very different modern quarries were organised to give a sense of quarrying techniques. The first was to Ladycross Quarry near Slaley, where finely bedded sandstones are extracted by hand, using very similar tools and techniques to those used by the Romans. In contrast a visit to Barrasford quarry gave an insight into extracting and crushing high volumes of whinstone using modern explosive and mechanical methods.

### *Step 4: Investigating repurposed Wall-stone*

With knowledge of the local sources of geology (Step 1), the stone used in the Wall (Step 2), and evidence for local quarrying (Step 3), the volunteers then went on to examine local buildings and structures to look for probable examples of re-used Wall fabric.

This investigation of repurposed Wall-stone entailed:

- Consulting historic maps and archives to identify the oldest extant structures in a locale.
- Knowing what local Wall-stone looks like.
- Identifying buildings and structures for further investigation.
- Carrying out a buildings-archaeology survey of identified structures, including detailed identification of geological materials used.
- Archival research of selected structures
- Determination of the extent of re-used Roman fabric in selected structures.

Volunteers were given the opportunity to partake in field-based exercises to look at sites where suspected or known repurposed Wall-stone was used. At each site the volunteers were given the historical background of the building and guidance on collecting information about the uses of stone. As with the Wall sites the inspection entailed the following:

- Recording the location of building or structure examined.
- Identifying the type of stone used as building material (invariably sandstone).
- Accurately recording what could be observed of the mineral content of the stones, the grain size and degree of sorting, any sedimentary textures and/or diagenesis, as well as the colour of the stones.
- Identifying any masonry techniques employed in shaping the stone, as well as the range of shaped stones present.
- Recording the dimensions of individual stones.
- Collating information to generate a summary of a given area/location.

### *Support for the SSD process*

The four steps of the SSD process were supported by an app which allowed preliminary information on post-Roman buildings with suspected Wall stones to be recorded and shared with the WallCAP team and the volunteers. In addition, a stone recording database was implemented which allowed the many pieces of data recorded manually on site about Wall sites and post-Roman sites to be recorded in a secure database.

## Analytical methods

Alongside the work carried out by volunteers to gather an extensive set of data along the length of the Wall, intensive analytical work was carried out. Two methods were used for this:

1. X-ray Fluorescence Spectroscopy (XRF) using a Bruker portable XRF.
2. Petrographic analyses using thin section and a polarising petrographic microscope.

To enable this analytical work a set of representative samples was collected. These were of four sample types:

1. Known elements of the Wall, particularly from HAR excavations.
2. Known or possible Roman quarry sites.
3. Representative material of potential source rocks where exposed, often from stream or coast sections.
4. Known or possible Wall material within post Roman constructions.

The availability of samples from the Wall and from post-Roman buildings was clearly limited, as the sampling process for thin-section manufacture in particular is destructive. It was anticipated that an approach using the portable XRF might allow geochemical analysis in the field.

### *Geochemistry*

Geochemical analyses were completed using a Brucker handheld X-ray Fluorescence Spectrometer (XRF). The analyses were carried out both in the field and lab. Two pre-programmed methods were used, 'MajMudRock emp' for major elements and 'TrMudRock emp' for trace elements. Both methods had a timed scan of 30 seconds.

The principal aim of using this method, having the benefit of an XRF that is portable and can be used in the field, was to enable measurement of the geochemistry of Wall-stones non-destructively. This data could then be compared to possible source rocks to see if a match could be made. If this method was to work, then reliable data had to be collected from stone surfaces available in the field. To test the reliability of the method, samples were scanned under lab conditions exploring how the results varied depending on the type of surface scanned. To this end scans were made of clean-cut surfaces, uncut surfaces from smooth to rough, and parallel and perpendicular to bedding planes. In addition, scans were made at several locations including Wall-stones *in situ* and possible Wall-stones within post-Roman structures. For each sample five scans were carried out as an additional test of accuracy.

This approach showed several issues with the data gathered. This included the following:

1. The major elements (when converted to percent oxide) had totals of around 30–40% significantly lower than can be accounted for by porosity and volatile components.
2. Large variations in element values were seen between scans of a given sample. This variation was larger with the field measurements.
3. Some post-Roman Wall-stone showed anomalously large $CaO$ values.

These issues call into question the validity of data collected by this method. Recalculation of the major elements to 100% may give some indication of the sandstone's geochemical makeup. However, without comparison to more reliable analysis of the rock's geochemistry (*e.g.*, whole rock XRF), there is no way of verifying the precision of the relative proportions of each element.

These issues are likely to be caused by several factors, these include:

1. The limited depth to which the X-rays penetrate the surface of the samples mean that on rougher samples, the analyser is not receiving sufficient signal to give an accurate result (particularly for major elements).
2. Surface contamination with soil (for Wall-stones) and render (in post-Roman stones) will mask the geochemistry of the sandstone.
3. For weathered stone, many of the less physically stable mineral grains (feldspar, pyroxene, clay minerals, etc.) have been washed out, leaving behind principally quartz grains at the surface. This will give an anomalous account of the sandstone's fresh geochemistry. It also means that characterisable geochemistry, which is most likely to reside in these more fragile minerals, will have been lost.

For these reasons, the characterisation of the Wall-stones using this method of geochemical analysis was abandoned. It was concluded that useful geochemical measurements could only be carried out on fresh samples of stone. It has been demonstrated that whole rock XRF may be used to do this (O'Donnell 2021). Other methods may also be used to carry out geochemical analysis of individual mineral grains, which may prove a valuable method of characterising sandstones (see Chapter 6). Both of these methods are destructive, requiring the extraction of samples for lab analysis.

### *Petrography*

Fresh samples were collected from fieldwork according to the rationale above. In some cases, samples with both weathered and fresh material in one profile were deliberately collected to examine the effects of weathering on the petrology of the sandstones.

Samples were then cut into *c*. 5 mm thick slabs with an area less than 25 x 60 mm ready to be made into thin sections. These were then processed by Durham University thin section lab. All of the samples were impregnated with blue resin to stabilise the friable sandstones and to enable measurement of porosity. After one side was flattened and polished, they were mounted on glass slides and then ground down and polished to 30 µm in thickness before being covered with a cover slip.

These samples were then examined using a Keyence VHX-7000 petrographic microscope which enabled manual examination and the production of high-quality images. Mineralogy and textures were recorded and an image library of all of the samples in thin section was made. In addition, two additional measurements could be made using applications on the Keyence microscope:

*Porosity*: This was achieved using the colour-difference method. The blue colour of the resin was sufficiently distinctive to select for this colour and automatically measure the area taken up by this colour. As the intensity of the colour varied from sample to sample, manual intervention was required to adjust the breadth of wavelength used. By visually examining the areas covered by changing the breadth of bandwidth, a good approximation to the resin impregnated areas could be achieved. Some degree of error may be involved in this process. It should also be noted that some degree of grain plucking will have occurred during manufacture of the thin sections such that all porosities are likely to be higher than actual porosity. The more friable the sample the more likely this is to occur.

*Grain Size*: The Keyence microscope allows for point-to-point measurement of individual grains, by clicking first on one side of the grain then the other. The diameter thus delimited is then automatically recorded. For each sample 50 grains were randomly selected and measured.

The grain sizes were averaged for each sample and this was used to assign grain size values as described in Wentworth (1922).

The diameters measured in µm were then converted to the Krumbein phi scale to calculate the degree of sorting.

$\varphi = -\log_2 D/D_0$

where:

$\varphi$ is the Krumbein phi scale,

D is the diameter of the particle or grain in millimetres (Krumbein and Monk's equation)

and

$D_0$ is a reference diameter, equal to 1 mm (to make the equation dimensionally consistent).

To calculate the degree of sorting in the grains the following equation was used.

$\sigma 1 = (\varphi 84 - \varphi 16)/4 + (\varphi 95 - \varphi 5)/6.6$

where:

$\sigma 1$ the Inclusive Graphic Standard Deviation in phi units and:

$\varphi 84$ is the 84th percentile of the grain size distribution in phi units, etc.

The σ values can be described as follows:

| *Diameter (phi units)* | *Description* |
|---|---|
| $\sigma 1 < 0.35$ | Very well sorted |
| $0.35 < \sigma 1 < 0.50$ | Well sorted |
| $0.50 < \sigma 1 < 1.00$ | Moderately sorted |
| $1.00 < \sigma 1 < 2.00$ | Poorly sorted |
| $2.00 < \sigma 1 < 4.00$ | Very poorly sorted |
| $4.00 < \sigma 1$ | Extremely poorly sported |

A summary of the petrography is reported in Appendix 2.

# Appendix 2

# Gazetteer of research conducted by site

## Introduction

This appendix collates information pertinent to the analysis in this volume, as separated by individual site. There are three thematic sections: Quarries and Stone Source Locations; Wall Sites; and Post-Roman Sites. Each site entry in each section follows the same template, underscoring the attempted equal treatment of each site, as well as the unequal results of analysis. Most of the categories by which information is clustered in each section is self-explanatory, with one exception. 'Intervention' captures only interventions undertaken by WallCAP at each site, and not *all* interventions that have occurred historically at a site.

One aspect that is key for each is the collation of geological and archaeological information, such that the interrelationships between a site and its position in the landscape, and resultant local geological materials available are more easily identified.

The sites are ordered primarily by geographic location, starting in the east and working westward. Some compromise in the precise latitude has been given for locations away from the Wall so that possible stone sources in a similar area are grouped together.

The petrographic observations are given without interpretation for the most part. The following observations have specific interpretations which may be applied when this particular feature is observed:

1. Undulose extinction in quartz: this is caused by the quartz grain being deformed and implies the source of the quartz grain has been metamorphosed.
2. Polycrystaline quartz: this forms in metamorphic rocks and implies that the source of these lithic fragments has been metamorphosed.
3. Feldspars: in general, these minerals are more susceptible to chemical weathering and their presence suggests the source of clastic material is proximal rather than distal and that they have been subject to mechanical weathering (Adams *et al*. 1997).
4. Plagioclase feldspar: this breaks down more quickly than alkali feldspar, and its presence reinforces a proximal source for these clasts and one that is igneous. Plagioclase feldspars in the absence of alkali feldspar imply a low silica (basaltic) source rock.
5. Alkali feldspar: this forms in granites and gneiss. Its presence indicates a metamorphic and/or granitic source typical of an orogenic mountain belt.
6. Pressure solution: denoted by penetrating quartz grains and sutured grain margins. This indicates that the whole rock has been subjected to significant compression. Significant compaction is sufficient to cause this.

## Quarries and stone source locations

This list of stone source and quarry locations has been divided into sections based on the geological formation that the Wall overlies as described in Chapter 2.

### *Wallsend to Heddon-on-the-Wall: Pennine Coal Measures Formation*

The first set of stone sources listed here are from the Pennine Coal Measures Formation, which is well exposed on the coast between Tynemouth and Seaton Sluice. Representative samples were taken from sandstones, starting with the youngest part of the formation immediately below the unconformity with Permian strata exposed under Tynemouth Priory and working up the coast into progressively older strata. This is not a complete catalogue of all the sandstones exposed on this coast, but has sufficient representation to give a clear idea of the amount of variation to be seen in sandstones with the Pennine Coal Measure Formation.

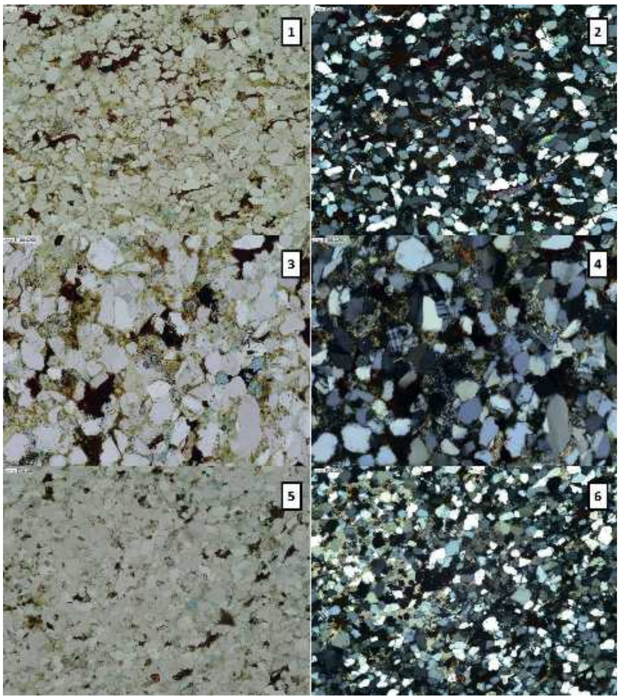


*Figure A2.1: (1) KEB001 in plane polarised light ×80. (2) KEB001 in cross polarised light ×80. (3) KEB002 in plane polarised light ×200. (4) KEB002 in cross polarised light ×200. (5) KEB003 in plane polarised light ×80. (6) KEB003 in cross polarised light ×80.*

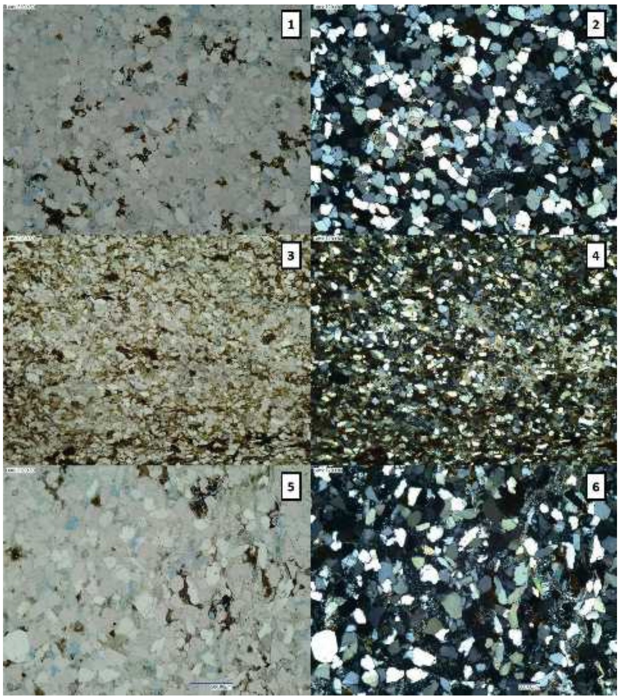


*Figure A2.2: (1) KEB004 in plane polarised light ×80. (2) KEB004 in cross polarised light ×80. (3) KEB005 in plane polarised light ×80. (4) KEB005 in cross polarised light ×80. (5) KEB006 in plane polarised light ×80. (6) KEB006 in cross polarised light ×80.*

### *King Edward's Bay (south)*

**Type**: Coast
**Location**: NZ 3726 6946
**Accessibility:** Public
**Geological formation:** Pennine Middle Coal Measures Formation, Carboniferous Period.
**Stone type(s):** Sandstone
**Interventions:** Four samples collected, and thin sections made (KEB001, KEB002, KEB003, KEB004)
**Geological description:** The Priory Sandstone (Scrutton 1995). Fine- to medium-grained sandstone, buff yellow to purple in colour with marked bedding including planar and large cross-bedded sets up to *c*. 2 m in height. The sandstones are fluvial and associated with basal lag deposits crowded with rip-up clasts. The exposure at the base of the cliff underneath Tynemouth Priory is within 10 m (vertically) of the unconformity with the Permian Yellow Sands Formation. Whilst this is below the intensely reddened horizon immediately below the unconformity. the diagenesis of these sandstones may well have been affected in proximity to the extended sub-ariel exposure marked by the unconformity.
**Petrographic description**: (Figs A2.1, A2.2 and A2.3) All the samples are fine-grained quartz-arenites with sub-angular grains which are well to moderately well-sorted and with a porosity ranging from 0.8% to 9.2%.

95% plus of the grains are of quartz with subordinate alkali feldspar, mica, and iron oxide, with rare zircons. It is not clear how much of the iron oxide is detrital as opposed to diagenetic. A few of the quartz grains show undulose extinction but most do not. Some quartz grains have distinctive acicular inclusions in them and some have pressure solution contacts with sutured boundaries. Quartz overgrowth is common. Alkali felspar as microcline is commonly fresh, but clasts decomposed to clay minerals are also observed. Mica is a sparse component and shows some alignment with bedding.

The matrix in the samples is very variable and suggests several (variable) phases of diagenesis. This might also explain the large variation in porosity. The matrix of KEB001 and KEB002 contains a dispersed pale olive-green mineral and clay minerals with distinct blebs of an opaque oxide, possibly siderite. KEB003 contains lesser amounts of these minerals in its matrix along with significant amounts of poikilitic calcite. KEB004 whilst containing distinct blebs of opaque oxide is cemented only by calcite and in smaller amounts than KEB003.
**Archaeological description:** None
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

### *King Edward's Bay (north)*

**Type**: Coast
**Location**: NZ 3718 6974
**Accessibility:** Public

**Geological formation:** Pennine Middle Coal Measures Formation, Carboniferous Period.
**Stone type(s):** Sandstone
**Interventions:** Two samples collected, and thin sections made (KEB005, KEB006)
**Geological description:** The sandstone is exposed in the cliff and the shoreline just below the Bottom Yard Coal. Fine- to very fine-grained fluvial sandstone grey in colour and yellow-brown when altered (see below). It is horizontally bedded in a set about a metre thick and strongly jointed. The joint margins of the sandstone are much altered with iron oxide bands parallel to the joints *c*. 10 cm thick. The entire sandstone commonly has Liesegang banding throughout.
**Petrographic description:** (Figs A2.2 and A2.3) KEB005 is a very fine-grained quartz-wacke and KEB006 a fine-grained quartz-arenite. Both samples have subangular grains which are well sorted and with a porosity ranging from 1.2% to 6.4% respectively.

In KEB005 95% plus of the grains are of quartz with subordinate alkali and plagioclase feldspar, mica, and iron oxide. It is not clear how much of the iron oxide is detrital as opposed to diagenetic. A few of the quartz grains show undulose extinction but most do not. Plagioclase and alkali felspar is occasionally fresh, but clasts decomposed to clay minerals are also observed. Mica is a sparse component and shows some alignment with bedding. The matrix forms greater than 15% of the sandstone and is composed of a mix of poikilitic calcite, clay minerals and a pale olive-green mineral in order of abundance.

In KEB006 95% plus of the grains are of quartz with subordinate alkali and plagioclase feldspar, mica, iron oxide, and lithic fragments. As with the other sandstones from King Edward's Bay, it is not clear how much of the iron oxide is detrital as opposed to diagenetic. Some of the Quartz grains show undulose extinction. Some quartz grains have pressure solution contacts with sutured boundaries, and quartz overgrowth is observed. The lithic fragments include polycrystalline quartz with sutured grain boundaries suggesting a metamorphic origin. The plagioclase and alkali felspars are occasionally fresh, but clasts decomposed and decomposing to clay minerals are also commonly observed. Mica shows some alignment with bedding and is mostly confined to fine layers in which it is much more common. These mica-rich layers are also richer in clay minerals. The matrix is principally composed of clay minerals a pale olive-green mineral.
**Archaeological description:** None
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

### *Table Rocks*

**Type**: Coast
**Location**: NZ 3642 7196
**Accessibility:** Public
**Geological formation:** Pennine Middle Coal Measures Formation, Carboniferous Period.
**Stone type(s):** Sandstone
**Interventions:** Two samples collected, and thin sections made (TR001, TR002)
**Geological description:** Table Rocks Sandstone (Scrutton 1995). The sandstone is exposed in the cliff and rocky outcrops on the foreshore around the former swimming pool. Fine-grained fluvial sandstone buff to grey in colour. This sandstone unit is *c*. 20 m thick here with lens shaped bodies and with good example of trough cross-bedding. As at King Edward's Bay north, there is considerable iron oxide diagenesis around joints in the sandstone and this creates the buff colouring in the sandstone.
**Petrographic description**: (Fig. A2.3) TR001 and TR002 are a fine-grained quartz-arenites. Both samples have subangular grains which are moderately well sorted in TR001 and well sorted in TR002. They have porosities of 4.9% to 7.1% respectively.

In both samples 95% plus of the grains are of quartz with subordinate alkali (as microcline) and plagioclase feldspar, mica, iron oxide, and lithic fragments with rare zircons. It is not clear how much of the iron oxide is detrital as opposed to diagenetic with gradation in shape from subrounded to interstitial. Some of the quartz grains show

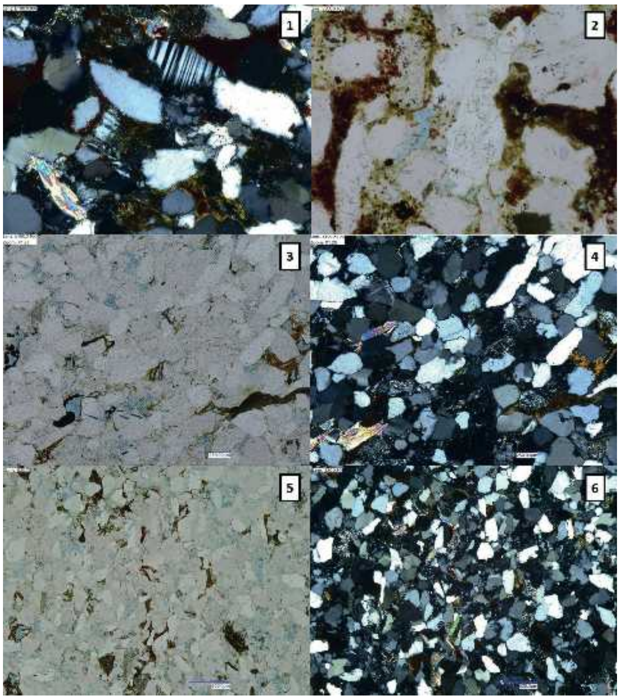


*Figure A2.3: (1) KEB001 in cross polarised light. Detail of alkali feldspar (tartan twinning) mica and clay mineral matrix. ×300. (2) KEB002 in plane polarised light. Detail of acicular and very fine opaque inclusions. ×700. (3) TR001 in plane polarised light ×100. (4) TR001 in cross polarised light ×100. (5) TR002 in plane polarised light ×80. (6) TR002 in cross polarised light ×80.*

undulose extinction. Quartz grains often show pressure solution with sutured margins and commonly have quartz overgrowth. Plagioclase and alkali felspar is occasionally fresh, but clasts decomposed and decomposing to clay minerals are also observed. Mica shows some alignment with bedding and is more abundant within fine bedding-related layers. The mica is also contorted on occasion, probably responding the compaction which caused the pressure solution in the quartz. Lithic fragments observed include polycrystalline quartz with sutured grains and a fragment of a fine-grained igneous rock likely to be a lava.

The matrix is composed principally of clay minerals with some interstitial iron oxide including a pale olive-green mineral and possible limonite.

**Archaeological description:** None
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

### *Hartley Bay*

**Type**: Coast
**Location**: NZ 3454 7561
**Accessibility:** Public
**Geological formation:** Pennine Middle Coal Measures Formation, Carboniferous Period.
**Stone type(s):** Sandstone
**Interventions:** Two samples collected, and thin sections made (HB002, HB003)
**Geological description:** HB002 was collected from a fallen block of the lower Crag Point Sandstone (Scrutton 1995) a grey/white bedded sandstone *c*. 10 m thick, in the north of the bay. HB003 was collected from an unnamed sandstone also grey/white in colour, just below the Northumberland Low Main Coal seam to the south of the steps down to the beach. Both sandstones contained diagenetic iron patterning giving the sandstone a pale-yellow cast.
**Petrographic description:** (Fig. A2.4) HB002 is a very fine-grained quartz arenite and HB003 a fine-grained quartz-wacke (though see below). Both samples have subangular grains which are moderately well sorted in HB002 and well sorted in HB002. They have porosities of 2.3% to 0.5% respectively.

In both samples 95% plus of the grains are of quartz with minor plagioclase feldspar, mica, and iron oxide. Undulose extinction is observed in the quartz grains and quartz overgrowth, but both are faint and rare. The quartz grains in HB002 show signs of pressure solution with sutured margins. Mica in both samples is associated with higher quantities of iron oxide. HB002 has sedimentary bedding structures picked out by these mica/iron oxide layers (see Fig. A.2.4). Both samples have iron-oxide crystals as diagenetic material. This can be seen in Figure A.2.4 where the weathering profile of HB002 shows the precipitation of iron-oxide and HB003 a vein of iron oxide. The feldspar in HB003 is less common than in HB002 and there are significant quantities of clast shaped patches of clay minerals implying that feldspar clasts have decomposed within the sandstone.

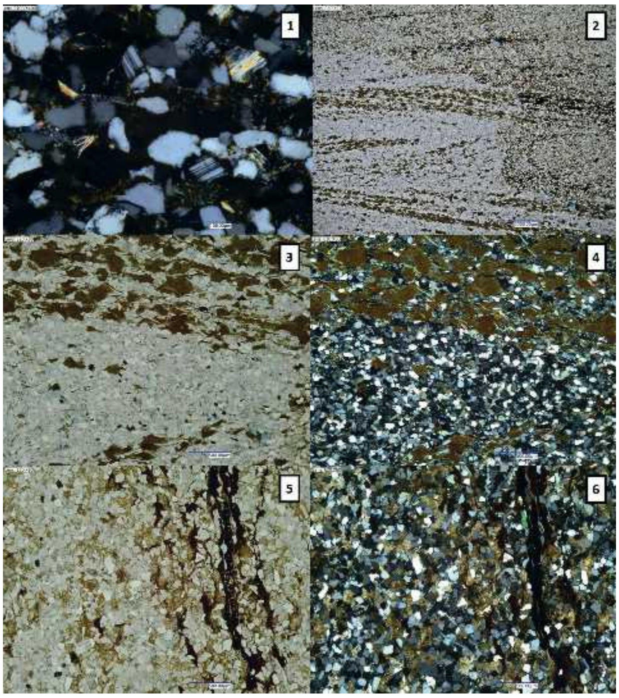



*Figure A2.4: (1) HB002 in cross polarised light showing two grain of multiple twinned plagioclase feldspar and mica (with higher order interference colours) ×400. (2) HB002 in plane polarised light showing the effect of alteration (top and right of image) overlaying sedimentary textures picked out by mica and iron oxide. ×20. (3) HB002 in plane polarised light ×80. (4) HB002 in cross polarised light ×80. (5) HB003 in plane polarised light, with vein of iron oxide running from top to bottom on the right of the image ×80. (6) HBB003 in cross polarised light ×80.*

The matrix of HB002 is composed principally of clay minerals with some interstitial iron oxide. The matrix of HB003 appears to be a mixture of clay minerals and calcite with iron oxide disseminated through much of the calcite. However, the form of the calcite in grain like shapes suggests that the calcite may be replacing possibly feldspars. The very low porosity does suggest the sandstone has undergone significant diagenesis.

**Archaeological description:** None
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

### *Seaton Sluice*

**Type**: Coast
**Location**: NZ 3390 7688
**Accessibility:** Public
**Geological formation:** Pennine Middle Coal Measures Formation, Carboniferous Period.
**Stone type(s):** Sandstone
**Interventions:** One sample collected, and thin section made (SS001)
**Geological description:** SS001 was collected from the crag immediately above the foreshore immediately to the north of the sluice. This is part of the Upper Seaton Sluice

Sandstone which has been correlated with the Upper Crag Point Sandstone at Hartley Bay (Scrutton 1995) a grey/white bedded sandstone *c*. 12 m thick.
**Petrographic description:** (Fig. A2.5) SS001 is a fine-grained quartz arenite with well sorted subangular grains. It has a porosity of 4.9%.

95% plus of the grains are of quartz with minor alkali and plagioclase feldspar, iron oxide, mica, and lithic fragments, with rare tourmaline and zircon. Undulose extinction is observed in the quartz grains as well as quartz overgrowth. There are limited signs of pressure solution with a few quartz grains having sutured margins. Feldspars, whilst a minor component, are more abundant than in many of the samples seen from the Pennine Middle Coal Measures Formation. Lithic fragments are of polycrystalline quartz and as with the feldspars are relatively abundant. Scrutton (1995) notes that this sandstone has an abundance of garnets – none were observed in this thin section, though the presence of other heavy minerals (tourmaline and zircon) was noted.

The matrix of HB002 is composed principally of clay minerals with some interstitial iron oxide. The iron oxide is concentrated in patches *c*. 0.2 mm in diameter but is interstitial in form. There are bands within the sandstone which are significantly richer in iron oxide.
**Archaeological description:** None
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

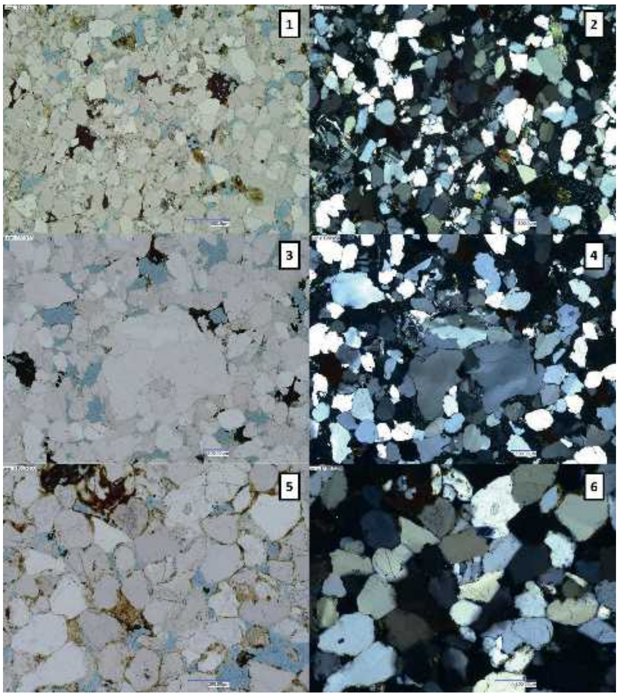



*Figure A2.5: (1) SS001 in plane polarised light ×80. (2) SS001 in cross polarised light ×80. (3) 'Heddon' in cross polarised light ×50. (4) 'Heddon' in plane polarised light ×50. (5) Fallowfield001 in plane polarised light ×200. (6) Fallowfield001 in cross polarised light ×200.*

### *Heddon Quarry*

**Type**: Quarry
**Location**: NZ 1272 6678
**Accessibility:** Public
**Geological formation:** Pennine Lower Coal Measures Formation, Carboniferous Period.
**Stone type(s):** Sandstone
**Interventions:** Sample collected, and thin section made (Heddon)
**Geological description:** The sample was collected from loose stone at the edge of the disused Quarry at this location. The sandstone is coarse and gritty to look at and is a distinctive very pale brown/yellow in colour. The wide range of grain size, with some grains up to approximately 2 mm in diameter gives the rock a characteristic gritty look. This very thick lens (30 m plus) of high-quality sandstone, which extends between North Farm at Houghton and just beyond Bays Leap Farm, has been extensively quarried into the 20th century.
**Petrographic description:** (Fig. A2.5) Heddon is a moderate-grained quartz arenite and has subrounded grains which are moderately well sorted. It has a porosity of 5.7%.

95% plus of the grains in this sample are of quartz with minor lithic fragments, alkali feldspar, and iron oxide, with rare zircon. Undulose extinction is observed in the quartz grains and quartz overgrowth is common. The quartz grains show pressure solution with sutured contacts common. The largest of the quartz grains are commonly polycrystalline, as are a number of the smaller grains. Fresh alkali feldspars are observed along with patches of clay minerals which may be chemically altered feldspar. Iron oxide is in distinct 'grains' but has forms which are clearly interstitial and imply that they are diagenetic.

The matrix of this sample is composed principally of clay minerals with the interstitial iron oxide noted above.
**Archaeological description:** Extensive remains of 19th- and 20th-century quarrying activity, which will have removed evidence of earlier quarrying activity. The type of sandstone found in the quarry exactly matches that found in the segment of the Wall at Heddon.
**Results of analysis:** None
**Probability of Roman Quarrying:** ?

## *Heddon-on-the-Wall to High Brunton: Stainmore Formation*

### *Lady's Well 2*

**Type:** Quarry
**Location:** NZ 01758 67481
**Accessibility:** Public
**Geological formation:** Belsay Dene Limestone, Stainmore Formation, Carboniferous Period
**Stone type(s):** Limestone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks and lime-kiln, disused on OS mapping by 1860s

**Results of analysis:** None
**Probability of Roman Quarrying:** 2

*Fallowfield Fell (Written Crag)*

**Type**: Quarry
**Location**: NY 9380 6876
**Accessibility:** Public
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** Two samples collected – sample 1 (O'Donnell) and Fallowfield001 (Kille). Thin sections made and whole rock XRF analysis carried out.
**Geological description:** 10YR 7/1 light grey carboniferous sandstone which is moderately sorted, with subrounded grains of various sizes ranging between fine and medium. This is part of a sandstone unit which occupies much of the top of the highest land around Fallowfield. It is stratigraphically just above the Little Limestone. The covering of glacial till is very thin on the hilltop and this sandstone layer is visible on the surface in several places. In the area of the quarry a small stream has cut through the sandstone leaving crags exposed which would have been visible in Roman times. Sample Fallowfield001 taken from the base of the outcrop in which stone has been extracted.
**Petrographic description:** (Fig. A2.5) Fallowfiled001 is a fine-grained quartz arenite and has subrounded grains which are well sorted. It has a porosity of 8%.

95% plus of the grains in this sample are of quartz with minor, alkali feldspar, lithic fragments, and iron oxide, with rare zircon. Undulose extinction is occasionally observed in the quartz grains and quartz overgrowth is common and extensive. Some quartz grains show pressure solution with grain penetration and some sutured contacts. The lithic fragments are polycrystalline quartz. Alkali feldspar grains are rare but fresh. Iron oxide is present in distinct patches up to 0.25 mm across and has a form which is clearly interstitial and imply that it is diagenetic.

The matrix of this sample is sparse and composed principally of clay minerals with the interstitial iron oxide noted above.
**Archaeological description:** Toolmarks, wedge holes, removed blocks, inscription
**Results of analysis:**

| *Fallowfield Fell* | *$SiO_2$ %* | *$Al_2O_3$ %* | *$K_2O$ %* | *$TiO_2$ %* | *CaO %* | *$Fe_2O_3$ %* |
|---|---|---|---|---|---|---|
| Sample 1 | 45.059 | 1.437 | 0.335 | 0.113 | 0.144 | 0.227 |

**Probability of Roman Quarrying:** 5

*Crag Wood*

**Type:** Quarry
**Location:** NY 9313 6923
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** Samples collected by both O'Donnell (Sample 1-4) and Kille (Crag001 and Crag002). Thin section made of Crag002 and XRF analysis of Sample 1-4.
**Geological description:** The stone from Crag Wood is a 2.5Y 7/2 light grey carboniferous sandstone. The average grain size of these samples ranges from fine to medium. The grains are subangular to subrounded, Sample 1 and 2 are moderately sorted, and Sample 3 and 4 are well sorted. This outcrop is within the same sandstone unit as that observed at Fallowfield Fell.
**Petrographic description:** (Fig A2.6) Crag002 is a fine-grained quartz arenite and has subrounded grains which are well-sorted. It has a porosity of 5%.

95% plus of the grains in this sample are of quartz with minor, plagioclase and alkali feldspar, lithic fragments, mica, iron oxide, and zircon. Undulose extinction is occasionally observed in the quartz grains and quartz overgrowth is common and extensive. Many quartz grains show pressure solution with grain penetration and some sutured contacts. The lithic fragments are of polycrystalline quartz. Feldspars grains are rare but fresh. There are rare iron oxide grains.

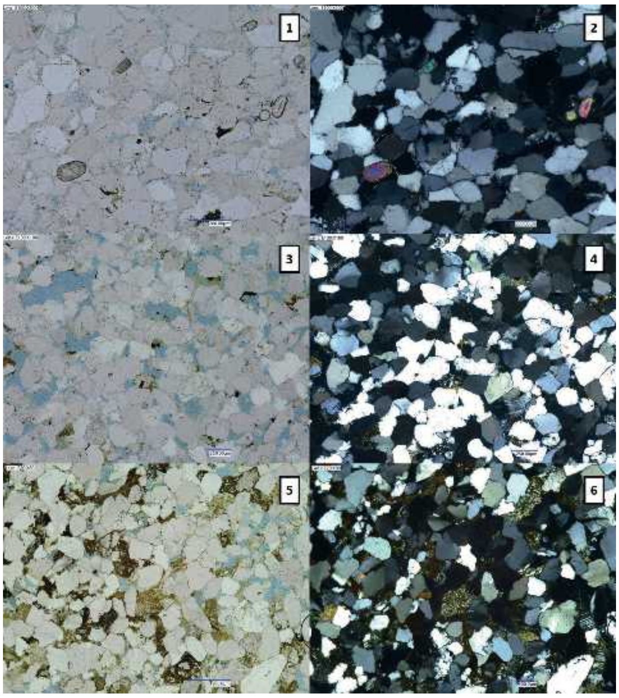



*Figure A2.6: (1) Crag002 in plane polarised light ×200. (2) Crag002 in cross polarised light ×200. (3) 'Planetrees' in cross polarised light ×100. (4) 'Planetrees' in plane polarised light ×100. (5) KC001 in plane polarised light ×80. (6) KC001 in cross polarised light ×80.*

The matrix of this sample is sparse and composed principally of clay minerals and a pale olive-green mineral.
**Archaeological description:** Toolmarks, wedge holes, removed blocks, overhanging stone
**Results of analysis:**

| *Crag Wood* | *$SiO_2$ %* | *$Al_2O_3$ %* | *$K_2O$ %* | *$TiO_2$ %* | *CaO %* | *$Fe_2O_3$ %* |
|---|---|---|---|---|---|---|
| Sample 1 | 40.7 | 4.191 | 1.815 | 0.133 | 0.554 | 1.278 |
| Sample 2 | 42.714 | 3.51 | 1.531 | 0.155 | 0.147 | 0.761 |
| Sample 3 | 41.103 | 4.026 | 1.874 | 0.151 | 0.176 | 0.411 |
| Sample 4 | 43.501 | 3.192 | 1.113 | 0.3 | 0.221 | 1.628 |

**Probability of Roman Quarrying:** 4

*Planetrees*
**Type:** Outcrop
**Location:** NY 9289 6961
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** Sample collected, and thin section made (Planetrees).
**Geological description:** Light grey Carboniferous sandstone. This outcrop is immediately next to the Wall right by the Military Road. It is stratigraphically below the Little Limestone and a different sandstone unit from that at Fallowfield and Crag Wood.
**Petrographic description:** (Fig. A2.6) Planetrees is a fine-grained quartz arenite and has subrounded grains which are well sorted. It has a porosity of 11% (see Fig. 2.1).

95% plus of the grains in this sample are of quartz with minor, plagioclase and alkali feldspar, lithic fragments, mica, iron oxide, and zircon. Undulose extinction is occasionally observed in the quartz grains and quartz overgrowth is common and extensive. Many quartz grains show pressure solution with grain penetration and some sutured contacts. The lithic fragments are of polycrystalline quartz. Feldspars grains are rare but fresh. There are rare iron oxide grains.

The matrix of this sample is sparse and composed principally of clay minerals and a pale olive-green mineral.

This rock is very similar to the Comb Wood sample save for a higher porosity and lower abundance of zircons. The variation between sample 'Planetrees' and 'Crag001' is less than that observed between 'Crag001' and 'Fallowfield001' – the latter two being within the same sandstone unit.
**Archaeological description:** The outcrop could have been formed by quarrying though there is no corroborating evidence. Its proximity to the Wall would make it an ideal source.
**Results of analysis:** None
**Probability of Roman Quarrying:** ?

*Chesters North Tyne*
**Type:** Quarry
**Location:** NY 91140 69820
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks, very close to Roman Fort at Chesters on opposite bank of the river North Tyne.
**Results of analysis:** None
**Probability of Roman Quarrying:** 3

### *High Brunton to Gilsland: Alston Formation*

Whilst the Wall traverses the Alston formation in this sector, it runs close to the Stainmore Formation to the south and to the Tyne Limestone Formation to the north, so that possible source quarries are not always within the Alston Formation. These are noted for each quarry/stone source. In particular, the stone sources examined within Haltwhistle Burn are all (bar one sample) taken from within the Stainmore Formation. To help make visible the details of possible quarrying around Housesteads, Vindolanda, and Aesica, separate headings have been devoted to each of the areas.

*Limestone Corner 1*
**Type:** Quarry
**Location:** NY 87668 70892
**Accessibility:** Private
**Geological formation:** Upper Bath-House Wood Limestone, Alston Formation, Carboniferous Period
**Stone type(s):** Bioclastic limestone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Toolmarks, removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 1

*Carrawburgh 1*
**Type:** Quarry
**Location:** NY 85645 71896
**Accessibility:** Unknown
**Geological formation:** Jew (Oxford) Limestone, Alston formation, Carboniferous Period
**Stone type(s):** Limestone
**Interventions:** None
**Geological description:** Bioclastic limestone
**Archaeological description:** This quarry is situated in a field less than 1 km immediately north of the fort at Brocolitia. Carrawburgh 1 is a lime quarry with limekilns build into the north end of the quarry face itself. The quarry is

made up of two main areas of extraction: one directly next to the kilns, and the other next to a small stream nearby.
**Results of analysis:** None
**Probability of Roman Quarrying:** 1

*Gertrude*
**Type:** Quarry
**Location:** NY 86644 71918
**Accessibility:** Private
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 3

*Ewe Crag*
**Type:** Quarry or outcrop
**Location:** NY 82076 71721
**Accessibility:** Public
**Geological formation:** Greengate Well Limestone, Alston Formation, Carboniferous Period
**Stone type(s):** limestone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Unknown
**Results of analysis:** None
**Probability of Roman Quarrying:** 2

*Grindon 1*
**Type:** Quarry or outcrop
**Location:** NY 81541 68875
**Accessibility:** Private
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Unknown
**Results of analysis:** None
**Probability of Roman Quarrying:** 2

### *Outcrops and Quarries in the vicinity of Housesteads*

The following set of quarries and sandstone outcrops are all in the vicinity of Housesteads and each are potential sources for both fort and the curtain. The locations are: King's Crag, Queen's Crag, Dove Crag, all of the named Houseteads locations, Pennine Way 1 and Pennine Way 2, Crindledykes 4 and Crindledykes 7, and Grandys Knowe.

Whilst each of these are listed here as separate possible quarries a few of them are within the same sandstone outcrop as follows:

- Pennine Way 1 and sample HS003
- Housesteads 3 (including samples HS001 and HS002), Housesteads 4
- Houseteads 6 and Crindledykes 4

*King's Crag*
**Type:** Outcrop (possible quarry)
**Location:** NY 7952 7105
**Accessibility:** Private
**Geological formation:** Tyne Limestone Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** Sample collected (KC001), and thin section made.
**Geological description:** Prominent ridge of sandstone north of and parallel to Queens Crag (a known Roman quarrying site) with similar form. This sandstone is at the top of the Tyne Limestone Formation just below the Low Tipalt Limestone – Queens Crag is in the Alston formation just above the Low Tipalt Limestone. The outcrop is a stack of sandstone beds totalling approximately 8 m with many of the individual beds with marked cross-bedding and when weathered are shown to be poor quality building stone. A few of the beds each 1–2 m thick are more evenly textured and appear to be good quality building stone. Several of the beds contain large pieces of *Lepidodendron*.
**Petrological description:** (Fig. A2.6) KC001 is a medium-grained quartz arenite and has subrounded grains which are moderately well sorted. It has a porosity of 3%.

95% plus of the grains in this sample are of quartz with minor alkali and plagioclase feldspar, lithic fragments, mica, and iron oxide. Undulose extinction is occasionally observed in the quartz grains and some quartz overgrowth. Many quartz grains show pressure solution with grain penetration and some sutured contacts. The lithic fragments are of polycrystalline quartz. Alkali feldspar is more common than plagioclase. Some feldspar grains are fresh, but many additional grains observed in various states of chemical breakdown. Mica is aligned with bedding. Iron oxide is relatively abundant and present as interstitial patches along with a pale olive-green mineral as well as stringers of approximately 4 mm length.

The matrix is an intimate mix of clay minerals with iron oxides.
**Archaeological description:** No evidence found for quarrying. The low percentage of good-quality stone may have made this location unattractive as a source for Wall Stone.
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

*Queen's Crag*
**Type:** Quarry
**Location:** NY 79491 70601
**Accessibility:** Public
**Geological formation:** Alston Formation, Carboniferous Period

**Stone type(s):** Sandstone
**Interventions:** Samples collected by both O'Donnell (Sample 1-3) and Kille (QC001). Thin section made of QC001 and XRF analysis of Sample 1-3.
**Geological description:** 10YR 5/2 greyish brown carboniferous sandstone with distinctive large flakes of mica. The grains are subrounded in all samples. Sample 2 is medium grained and Sample 1 and 3 are fine grained. Sample 2 is classed as moderately sorted while the other two are well sorted.
Queen's Crag forms a prominent ridge of sandstone south of and parallel to King's Crag to which it is similar in form. This sandstone is at the base of the Alston Formation just above the Low Tipalt Limestone. The outcrop is a stack of sandstone beds totalling approximately 10 m. As with Kings Crag, some of the individual beds have marked cross-bedding and when weathered are shown to be poor quality building stone. However, here there is one bed, approximately 5 m thick, which is homogenous and jointed into massive blocks of high-quality sandstone. This feature would have made it a stand-out option for producing large high-quality sandstone blocks of the sort seen in Houseteads fort.
**Petrographic Description:** (Fig. A2.7) QC001 is a fine-grained quartz arenite and has subrounded grains which are well sorted. It has a porosity of 3%.

95% plus of the grains in this sample are of quartz with minor alkali and plagioclase feldspar, lithic fragments, mica, zircon, and iron oxide. Undulose extinction is observed in some of the quartz grains and quartz overgrowth is common. Many quartz grains show pressure solution with grain penetration and some sutured contacts. The lithic fragments are of polycrystalline quartz. Some feldspar grains are infrequent but fresh; a few additional grains observed may be feldspar in various states of chemical breakdown. Mica is infrequent and unaligned with bedding. Iron oxide is infrequent and present as interstitial patches.

The matrix is an intimate mix of clay minerals with iron oxides but is limited such that the sandstone has a pale clean appearance in section.

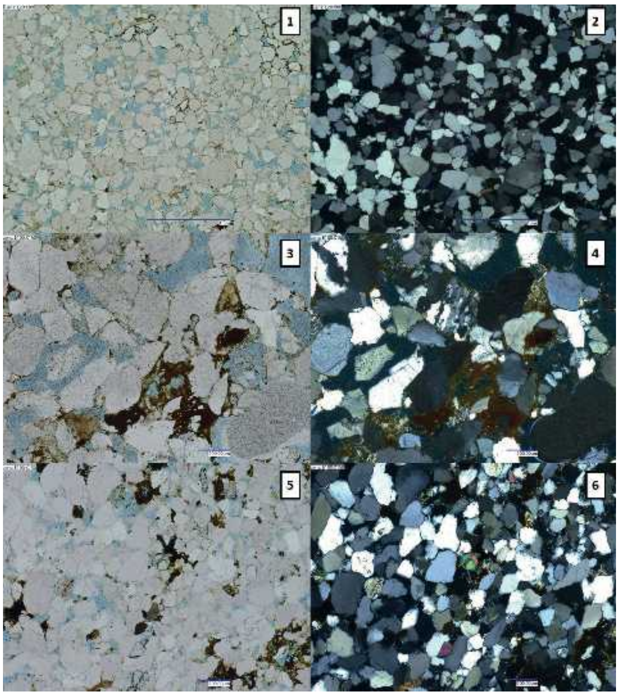



*Figure A2.7: (1) QC001 in plane polarised light ×80. (2) QC001 in cross polarised light ×80. (3) DC001 in cross polarised light ×150. (4) DC001 in plane polarised light ×150. (5) HS001 in plane polarised light ×150. (6) HS001 in cross polarised light ×150.*

**Archaeological description:** Removed blocks, wedge holes, inscription
**Results of analysis:**

| *Queen's Crag* | *$SiO_2$ %* | *$Al_2O_3$ %* | *$K_2O$ %* | *$TiO_2$ %* | *CaO %* | *$Fe_2O_3$ %* |
|---|---|---|---|---|---|---|
| Sample 1 | 43.159 | 1.562 | 0.389 | 0.27 | 0.12 | 0.049 |
| Sample 2 | 44.602 | 0.791 | 0.248 | 0.196 | 0.115 | 0.323 |
| Sample 3 | 38.798 | 2.42 | 0.738 | 0.392 | 0.113 | 0.421 |

**Probability of Roman Quarrying:** 5

## *Dove Crag*

**Type:** Outcrop (possible quarry)
**Location:** NY 7962 6980
**Accessibility:** Private
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** Sample collected (DC001), and thin section made.
**Geological description:** Prominent ridge of sandstone south of and parallel to Queens Crag (a known Roman quarrying site) with similar form. This sandstone is stratigraphically above the Dalla Bank Limestone and below the Lower Bath-house Wood Limestone. The outcrop is a stack of sandstone beds totalling approximately 8 m, with many of the individual beds with marked cross-bedding which when weathered are shown to be poor quality building stone. Several of the beds each 1–2 m thick are more evenly textured and appear to be good quality building stone.
**Petrological description:** (Fig. A2.7) DC001 is a medium-grained quartz arenite and has subrounded grains. The sandstone varies on a scale of a few millimetres between layers which are well sorted with a porosity of 8.4% and layers which are moderately well sorted and have a porosity of 3%.

95% plus of the grains in this sample are of quartz with minor, alkali feldspar, lithic fragments, mica, iron oxide, and one grain each of tourmaline and zircon observed. Undulose extinction is observed in some quartz grains and quartz overgrowth is moderately common. Many quartz grains show pressure solution with grain penetration and some sutured contacts. The lithic fragments are of polycrystalline quartz. The alkali feldspar is observed both as fresh grains and in various states of chemical breakdown. Mica is rare and aligned with bedding. Iron oxide is relatively abundant and present as interstitial patches.

The matrix is of clay minerals with distinct patches of iron oxides. The iron oxide tends to be concentrated in the fine-grained lower porosity bands.

**Archaeological description:** No evidence found for quarrying. The low percentage of good-quality stone may have made this location unattractive as a source for Wall Stone.
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

*Housesteads 1*

**Type:** Quarry
**Location:** NY 78870 68887
**Accessibility:** Public
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Toolmarks and removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

*Housesteads 3*

**Type:** Quarry
**Location:** NY 79133 68346
**Accessibility:** Private
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** Samples collected by Kille (HS001 and HS002). Thin section made of HS001.
**Geological description:** Buff coloured fine-grained sandstone forming a ridge and scarp which runs from north of Bradley Hall Farm, under the Houseteads visitor centre and on to Grindon and beyond. This sandstone straddles the Military Road between Beggarbog and north of Bradley Hall Farm. The sandstone is stratigraphically above the Eelwell Limestone. It has a porosity of 6.6%.
**Petrographic Description**: (Fig. A2.7) HS001 is a fine-grained quartz arenite and has subrounded grains. There is a small variation in grain size on a scale of a *c*. 1cm which is matched by an increase in iron oxide in the matrix.

95% plus of the grains in this sample are of quartz with minor, feldspar, zircon, and iron oxide, with rare mica and lithic fragments. Undulose extinction is observed in some quartz grains and quartz overgrowth is moderately common. Many quartz grains show pressure solution with grain penetration and some sutured contacts. The lithic fragments are of polycrystalline quartz. The alkali feldspar is observed both as fresh grains and in various states of chemical breakdown. Mica is rare and aligned with bedding. Iron oxide is relatively abundant and present as interstitial patches. Seven zircon grains were observed in this one thin section, many concentrated within a particular area.

The matrix is of clay minerals with distinct patches of iron oxides. The iron oxide tends to be concentrated in the fine-grained lower porosity bands.

**Archaeological description:** Removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

*Housesteads 4*

**Type:** Quarry
**Location:** NY 78876 68238
**Accessibility:** Private
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** See Houseteads 3
**Geological description:** This is the same line of sandstone as Housesteads 3 so the same description applies.
**Petrographic Description**: see Housesteads 3
**Archaeological description:** Removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

*Housesteads 5*

**Type:** Quarry
**Location:** NY 79197 68935
**Accessibility:** Private
**Geological formation:** Eelwell Limestone Member or Upper Bath-House Wood, Carboniferous Period
**Stone type(s):** Limestone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

*Housesteads 6*

**Type:** Quarry
**Location:** NY 79193 67924
**Accessibility:** Private
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** Thin section and XRF
**Geological description:** 10YR 6/2 light brownish grey fine grained carboniferous sandstone. All samples have a very similar grain size, with Sample 4 having a slightly larger average grain size than the other samples. The grains of Samples 1–3 are subrounded, and Sample 4 are subangular. All the samples are well sorted.
**Archaeological description:** Removed blocks and spoil heap

**Results of analysis:**

| *Housesteads 6* | *$SiO_2$ %* | *$Al_2O_3$ %* | *$K_2O$ %* | *$TiO_2$ %* | *CaO %* | *$Fe_2O_3$ %* |
|---|---|---|---|---|---|---|
| Sample 1 | 30.204 | 2.365 | 0.54 | 0.458 | 0.15 | 2.861 |
| Sample 2 | 37.111 | 3.055 | 0.44 | 0.5 | 0.128 | 0.141 |
| Sample 3 | 42.394 | 2.037 | 0.388 | 0.406 | 0.161 | 0.308 |
| Sample 4 | 37.332 | 4.199 | 0.829 | 0.163 | 0.12 | 0.112 |

**Probability of Roman Quarrying:** 4

### *Pennine Way 1*

**Type:** Quarry
**Location:** NY 78404 68299
**Accessibility:** Public
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** Sample collected by Kille (HS003) from further east along this sandstone unit, close to the track between the visitor centre and Housesteads fort. Thin section made.
**Geological description:** (Fig. A2.8) Buff coloured fine-grained sandstone forming a low ridge and scarp which runs between the sandstone of Housesteads 3 and the Whin Sill. The lens of sandstone extends from the Bradley Burn a few kilometres to the west of Housesteads and curves round south of Sewingshields, across the Military road, before dying out approximately 3 km east of Housesteads. The sandstone is stratigraphically below the Eelwell Limestone.
**Petrographic Description**: HS003 is a fine-grained quartz arenite and has subrounded grains. It has a porosity of 8.9%.

95% plus of the grains in this sample are of quartz with minor, feldspar, zircon, and iron oxide, with rare mica and lithic fragments. Undulose extinction is observed in some quartz grains and quartz overgrowth is moderately common. Many quartz grains show pressure solution with grain penetration and some sutured contacts. The lithic fragments are of polycrystalline quartz. The alkali feldspar is observed both as fresh grains and in various states of chemical breakdown. Iron oxide is relatively abundant and present as interstitial patches along with a pale olive-green mineral.

The matrix is of clay minerals with distinct patches of iron oxides.
**Archaeological description:** Removed block, overhanging stone
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

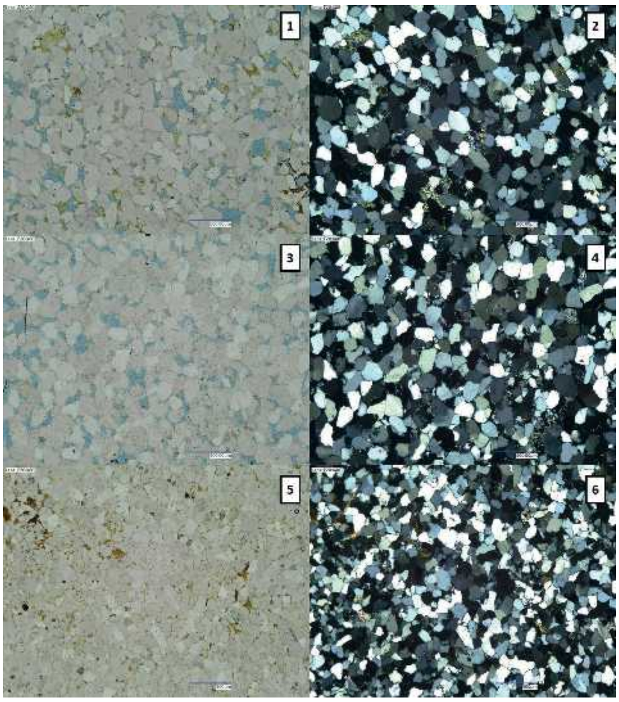


*Figure A2.8: (1) HS003 in plane polarised light ×80. (2) HS003 in cross polarised light ×80. (3) HS004 in cross polarised light ×80. (4) HS004 in plane polarised light ×80. (5) HW001 in plane polarised light ×80. (6) HW001 in cross polarised light ×80.*

### *Pennine Way 2*

**Type:** Quarry
**Location:** NY 77608 69196
**Accessibility:** Public
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks, overhanging stone
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

### *Crindledykes 4*

**Type:** Quarry
**Location:** NY 78407 67627
**Accessibility:** Private
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** No toolmarks observed. A tumulus is marked on maps from the 1970s just south of the quarry face, and a prehistoric settlement of three or four roundhouses was identified very nearby through aerial photography in 1999 (http://www.keystothepast.info/article/10339/Site-Details?PRN=N12381).
**Results of analysis:** None
**Probability of Roman Quarrying:** 3

*Crindledykes 7*
**Type:** Quarry or outcrop
**Location:** NY 79117 67481
**Accessibility:** Private
**Geological formation:** Great Limestone Member, Stainmore Formation, Carboniferous Period
**Stone type(s):** Limestone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Unknown
**Results of analysis:** None
**Probability of Roman Quarrying:** 2

*Grandy's Knowe*
**Type:** Quarry
**Location:** NY 78224 67622
**Accessibility:** Private
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** Sandstone unit unidentified on the BGS geology map
**Archaeological description:** Wedge holes, toolmarks, removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

### *Outcrops and Quarries in the vicinity of Vindolanda*

The following set of quarries and sandstone outcrops are all in the vicinity of Vindolanda and each are potential sources for both the fort and the curtain west of Housesteads. The locations are: East Morwood, Thorgrafton Common 1–6 and Barcombe 1.

All of these sandstones are within the Stainmore Formation, whereas the curtain just to the north and all of the quarries in the Housesteads section sit on the older Alston Formation. The individual sandstone units here within the Stainmore Formation are not marked on the British Geological Survey map. However, all of the quarries in this section are stratigraphically above the Little Limestone and below the Oakwood Limestone. East Morwood and Thorngrafton Common 1–3 and Barcombe 1 are likely to be within the same sandstone unit being located close to the Little Limestone. Thorgrafton Common 4–6 are closer to the Oakwood limestone and maybe in a separate sandstone unit. Further field-study would be required to confirm this.

*East Morwood*
**Type:** Quarry or outcrop
**Location:** NY 79285 66981
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Unknown, likely sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Unknown
**Results of analysis:** None
**Probability of Roman Quarrying:** 2

*Thorngrafton Common 1*
**Type:** Quarry
**Location:** NY 78956 66827
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Wedge holes, toolmarks, removed blocks, spoil heap
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

*Thorngrafton Common 2*
**Type:** Quarry
**Location:** NY 78687 66849
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Toolmarks, removed blocks, spoil heap
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

*Thorngrafton Common 3*
**Type:** Quarry
**Location:** NY 78412 66573
**Accessibility:** Public
**Geological formation:** Stainmore formation, Carboniferous
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Operated in the mid-1800s for railway sleepers. It was in this field that the Thorngrafton arm purse was discovered by a workman in 1837.
**Probability of Roman Quarrying:** 0

*Thorngrafton Common 4*
**Type:** Quarry
**Location:** NY 78234 65982
**Accessibility:** Public
**Geological formation:** Stainmore formation, Carboniferous Period

**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Thorngrafton Common 4 was operated in the mid-1800s for the construction of the Newcastle and Carlisle Railway.
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

*Thorngrafton Common 5*
**Type:** Quarry
**Location:** NY 78514 65947
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Toolmarks, removed blocks, drilled holes
**Results of analysis:** None
**Probability of Roman Quarrying:** 1

*Thorngrafton Common 6*
**Type:** Quarry
**Location:** NY 78927 66419
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks, toolmarks
**Results of analysis:** None

*Barcombe 1*
**Type:** Quarry
**Location:** NY 78500 66647
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks, spoil heap
**Results of analysis:** None
**Probability of Roman Quarrying:** 3

### *Outcrops and Quarries in the vicinity of Great Chesters*

The following set of quarries and sandstone outcrops are all in the vicinity of Great Chesters and each are potential sources for both the fort and the curtain between Steel Rigg and Walltown Crags. The locations are: Cawfields, Melkridge 3, Bertha, Melkridge Common 5, Haltwhiste 2, 5, 6, 7, and 9, Haltwhistle Common 1, 2, 4, and 5.

The following are from the same sandstone or limestone outcrops or bracketed by limestone members:

1. Bertha and Melkridge Common 5
2. Melkridge 3 and Haltwhistle Burn (Four Fathom Limestone)
3. Haltwhistle Burn 5, 6, 7, and 9 and HS004–8 all above the Little Limestone and below the Oakwood Limestone albeit there are three marked sandstone units between these limestones (Scrutton 1995)
4. HS001–HS003 are stratigraphically above the Oakwood Limestone
5. Haltwhistle Common 1, 2, 4, and 5. All in the Firestone Sandstone stratigraphically above the Little Limestone

The curtain and fort along with the quarries north of the Wall (Bertha and Melkridge Common 5) as well as Melkridge 3 and Haltwhistle Burn 5 are within the Alston Formation. The remaining quarries and possible source rocks are all within the Stainmore Formation. The samples HW001–HW009 collected by Kille with the aim of exploring the variation in the petrography in a range of sandstone units across a well-exposed section of the Stainmore Formation. This is part of the systematic exploration of source rocks from across all of the Carboniferous Formations.

*Cawfields*
**Type:** Quarry
**Location:** NY 71419 66573
**Accessibility:** Public
**Geological formation:** Great Whin Sill, Carboniferous–Permian Period
**Stone type(s):** Quartz Dolerite, commonly referred to as whinstone
**Interventions:** None
**Geological description:** Columnar jointed quartz-dolerite. Igneous rock intruded between layers of Carboniferous sedimentary rock and part of the Whin Sill swarm. The sill dips to the south with the top surface marking the dip slope. There is some vesiculation to be seen in the higher layers of the sill.
**Archaeological description:** The large whinstone quarry at Cawfields operated from at least 1896 to 1952 and destroyed the section of Hadrian's Wall which ran between Burnhead Cottage and Hole Gap.
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

*Melkridge 3*
**Type:** Quarry
**Location:** NY 72891 66237
**Accessibility:** Private
**Geological formation:** Four Fathom Limestone, Alston formation, Carboniferous Period

**Stone type(s):** Bioclastic limestone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Toolmarks, removed blocks, the quarry was in operation in the 1860s, but its original opening date is unknown.
**Results of analysis:** None
**Probability of Roman Quarrying:** 1

*Bertha*
**Type:** Quarry
**Location:** NY 73177 68088
**Accessibility:** Private
**Geological formation:** Alston Formation, Carboniferous
**Stone type(s):** Sandstone
**Interventions:** Thin section and XRF
**Geological description:** Sandstone at Bertha quarry is 10YR 6/3 pale brown, medium grained, subangular–angular, and moderately sorted. It has large coal and mica inclusions. It is porous with spaces filled in some places with a fine clay, or opaque mineral growth – mostly likely oxidized iron.
Located stratigraphically between two beds of the Low Tipalt Limestone.
**Archaeological description:** Removed blocks
**Results of analysis:**

| *Bertha* | *$SiO_2$ %* | *$Al_2O_3$ %* | *$K_2O$ %* | *$TiO_2$ %* | *CaO %* | *$Fe_2O_3$ %* |
|---|---|---|---|---|---|---|
| Sample 1 | 40.332 | 3 | 3.074 | 0.456 | 0.131 | 1.727 |
| Sample 2 | 36.237 | 4.089 | 3.658 | 0.245 | 0.115 | 1.866 |

**Probability of Roman Quarrying:** 3

*Melkridge Common 5*
**Type:** Quarry
**Location:** NY 73161 68079
**Accessibility:** Private
**Geological formation:** Alston formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** XRF and thin section
**Geological description:** Colour – 10YR 6/3 pale brown. Stone is well sorted and fine grained. Sample 2 contained some mica grains, and opaque iron-rich mineral growth in the pore spaces.
Located stratigraphically between two beds of the Low Tipalt Limestone.
**Archaeological description:** Removed blocks
**Results of analysis:**

| *Melkridge Common 5* | *$SiO_2$ %* | *$Al_2O_3$ %* | *$K_2O$ %* | *$TiO_2$ %* | *CaO %* | *$Fe_2O_3$ %* |
|---|---|---|---|---|---|---|
| Sample 1 | 47.026 | 2.007 | 0.215 | 0.141 | 0.104 | 1.072 |
| Sample 2 | 45.516 | 1.364 | 0.167 | 0.174 | 0.151 | 7.696 |

**Probability of Roman Quarrying:** 1

*Haltwhistle Burn 2*
**Type:** Quarry
**Location:** NY 71720 66094
**Accessibility:** Private
**Geological formation:** Four Fathom Limestone, Alston Formation, Carboniferous Period.
**Stone type(s):** Bioclastic limestone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Haltwhistle Burn 2 is a very substantial limestone quarry which is located close to 19th-century limekilns which can be found directly to the south on the other side of the B6318. This quarry was first opened before the 1860s and went out of use after the 1890s. At some point between 1890 and 1920 this quarry was reopened, and the older face removed.
**Results of analysis:** None
**Probability of Roman Quarrying:** 1

*Haltwhistle Burn 5*
**Type:** Quarry
**Location:** NY 71209 65529
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 3

*Haltwhistle Burn 6*
**Type:** Quarry
**Location:** NY 71604 65656
**Accessibility:** Private
**Geological formation:** Stainmore formation, Carboniferous
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Toolmarks and removed blocks. Bell pits near quarry face.
**Results of analysis:** None
**Probability of Roman Quarrying:** 1

*Haltwhistle Burn 7*
**Type:** Quarry
**Location:** NY 71669 65587
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** Thin section and XRF

**Geological description:** 10YR 6/2 light brownish grey carboniferous sandstone. All of these samples aside from Sample 4, have subrounded grains and are well sorted to very well sorted. In Sample 4 the grains are subangular. The average grain size is fine in Samples 1, 2, and 5, and medium in 3 and 4. Small mica fragments and some iron mineral growth was seen in all of the samples.
**Archaeological description:** Removed blocks and spoil heap
**Results of analysis:**

| *Haltwhistle Burn 7* | *$SiO_2$ %* | *$Al_2O_3$ %* | *$K_2O$ %* | *$TiO_2$ %* | *CaO %* | *$Fe_2O_3$ %* |
|---|---|---|---|---|---|---|
| Sample 1 | 43.631 | 2.422 | 0.539 | 0.963 | 0.489 | 1.811 |
| Sample 2 | 40.336 | 2.516 | 1.307 | 0.747 | 0.193 | 3.103 |
| Sample 3 | 46.877 | 1.826 | 0.512 | 0.121 | 0.127 | 1.013 |
| Sample 4 | 42.292 | 3.093 | 0.942 | 0.23 | 0.137 | 0.7 |
| Sample 5 | 38.252 | 3.612 | 0.409 | 1.688 | 0.22 | 3.768 |

**Probability of Roman Quarrying:** 4

### *Haltwhistle Burn 9*

**Type:** Quarry
**Location:** NY 71698 65486
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks and spoil heap
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

### *Haltwhistle Burn HW001–HW009*

**Type:** stone sources in the Stainmore Formation
**Locations:**
- HW0001 and HW002: NY 7083 6467. HW001 taken from the base of the sandstone unit and HW002 a metre above it. Haltwhistle Pottery
- HW003: NY 7080 6484. Taken from quarry face immediately behind the old mine shaft.Haltwhistle Oakwood
- HW004: NY 7060 6489. Haltwhistle Picnic
- HW005 and HW006: NY 7064 6514. Samples from the quarry here, HW005 from above the coal seam and HW006 from below. Haltwhistle Leeshall
- HW007: NY 7083 6525. Haltwhistle Jackdaw 1
- HW008: NY 7081 6543. Haltwhistle Jackdaw 2
- HW009: NY 7096 6568. Haltwhistle Colliery

**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** A range of buff-coloured sandstones from the Stainmore Formation exposed in the incised gorge of the Haltwhilstle Burn. Some are from named sandstones others not. The relationships between them as follows (starting at the bottom end of the burn at the stratigraphic youngest and heading up the burn as the rocks get older).
- HW001 and HW002: Unnamed sandstone unit, 3 units stratigraphically above the Oakwood Limestone.
- HW003: Unnamed sandstone unit just above the Oakwood Limestone.
- HW004: Taken from the same unnamed sandstone unit just above the Oakwood Limestone but further upstream
- HW005 and HW006: HW005 from the Jackdaw Crags Sandstone and HW006 from the Lower Leeshall Quarry Sandstone (Scrutton 1995)
- HW007: From the lower in the Jackdaw Crags Sandstone.
- HW008: unnamed sandstone unit below the Lower Leeshall Quarry Sandstone
- HW009: unnamed sandstone unit below the Little Limestone

**Petrographic Descriptions**: (Figs A2.8, A2.9, A2.10, and A2.11) Whilst there is significant variation in these samples, it is notable that the porosity of this set of samples is low at between 0 and 4.4%. This is a function of the sandstones diagenesis which is likely to be variable across the formation and at a more local scale so not generically useful. However, it may be of use to distinguish stone extracted from these horizons rather than the more porous rock to be found in the Alston Formation by the curtain.
**HW001 and HW002**: HW001 and HW002 are indistinguishable in thin section. Both are fine-grained quartz arenites with a mixture of subangular and rounded grains. They have zero porosity.

95% plus of the grains in this sample are of quartz with minor, alkali and plagioclase feldspar, mica, and iron oxide with rare zircons. Undulose extinction is observed in some quartz grains and quartz overgrowth is ubiquitous and largely responsible for the absence of porosity. Many quartz grains have inclusions either as bands of very fine-grained opaque mineral or as long acicular minerals Many quartz grains show pressure solution with grain penetration and some sutured contacts. Fresh alkali and plagioclase feldspar is observed though some patches of clay minerals maybe decayed feldspar. The little mica in this sample appears unaligned with bedding. Iron oxide along with a pale olive-green mineral is spread throughout a grain boundaries and as more occasional interstitial patches.

The matrix is dominated by the quartz overgrowths, with lesser iron oxide and rarer clay minerals.

**HW003**: A fine-grained quartz arenite with a mixture of subangular and subrounded grains. It has porosity of 3%.

95% plus of the grains in this sample are of quartz with minor, alkali feldspar, mica, and iron oxide with rare zircons. Undulose extinction is observed in some quartz grains and many grains have inclusions either as bands of very fine-grained opaque mineral or as long acicular minerals. Quartz overgrowth is absent. Many quartz grains show pressure solution with grain penetration and some sutured contacts. Fresh alkali feldspar is observed and the many grain-shaped patches of clay minerals may well be decayed feldspar. Iron oxide is present as interstitial patches which are more frequent in some bands within the sample.

The matrix is dominated by clay minerals and the interstitial iron oxides. The matrix in this rock is a relatively high percentage of the sample and is close to making the sandstone matrix supported.

**HW004**: A fine-grained quartz arenite with a mixture of subangular and subrounded grains. Its porosity was measured twice giving values of 4% and 4.4%.

The petrography of this rock is in general the same as HW003. In both fresh plagioclase and alkali feldspar grains were observed as well as 4 zircon grains. There is also a lower proportion of the clay mineral/iron oxide matrix, with the grains more closely packed.

**HW005**: A very fine-grained quartz arenite with subangular grains which are only moderately well sorted. These consist of a large number of very fine grains with a smaller number of larger grains. It has no porosity.

95% plus of the grains in this sample are of quartz with minor feldspar, mica, and iron oxide with rare zircons. Some quartz grains with undulose extinction observed. No signs of pressure solution observed and overgrowth is absent. Heavily decomposed grains of probable alkali and plagioclase feldspar observed. Iron oxide appears to present as grain as well as interstitially – what look like distinct grains blur into patches of interstitial iron making the different types hard to distinguish. Different densities of iron oxide grains/interstitial iron define banding in this sample. Mica is partially aligned with bedding. Six zircon grains were observed.

The matrix is dominated by brown iron oxide with minor clay minerals. This high quantity of iron oxide in the matrix gives the sample a dark appearance in thin section.

**HW006**: A very fine-grained quartz arenite with some patches sufficiently rich in feldspar to make it an arkose. It is fine- to medium-grained with subangular to subrounded grains which are only moderately well sorted. It has a porosity of 3.7%.

The percentage of quartz relative to feldspar in this sample is very variable from *c*. 5% in much of the sample to *c*. 30% in some areas. Both plagioclase and alkali feldspar are present and are fresh. The sample also contain minor lithic fragments and rare iron oxide and zircon. Some quartz grains with undulose extinction observed. Evidence pressure solution observed as penetrating grains and sutured contacts. Very limited quartz overgrowth observed. Lithic fragments are of polycrystalline quartz.

The matrix appears to be an equal mix of iron oxide, a pale olive-green mineral, and clay minerals.

**HW007**: A very fine-grained quartz arenite with subangular grains which are well sorted. It has no porosity. This sample's fine grain and high iron content makes it similar to HW005.

95% plus of the grains in this sample are of quartz with minor feldspar, mica, and iron oxide with rare zircons and possible pyroxene. Some quartz grains with undulose extinction observed but no signs of pressure solution. Quartz overgrowth is common. Heavily decomposed grains of probable alkali and plagioclase feldspar observed. Iron oxide appears to present as grain as well as interstitially although, as with HW005, grains and interstitial oxide are hard to distinguish. Mica is partially aligned with bedding. Five zircon grains observed, many concentrated in the same area in the sample. One grain of what may be pyroxene was noted.

The matrix is dominated by brown iron oxide with minor clay minerals, with lesser but significant amounts of calcite. This section covers part of the weathering profile of the rock and in the weathered portion of the sample there is a significantly higher quantity of iron oxide. This high quantity of iron oxide in the matrix gives the sample a dark appearance in thin section.

**HW008:** A medium-grained quartz arenite with subrounded grains which are poorly sorted. The sample has bands at approximately centimetre scale in which either finer grained or coarser grain clasts dominate. It has a porosity of 0.7%.

95% plus of the grains in this sample are of quartz with minor, alkali and plagioclase feldspar, lithic fragments, mica, and iron oxide with rare zircons and possible pyroxene. Undulose extinction is commonly observed in the quartz grains and many grains have inclusions as bands of very fine-grained opaque mineral. Some quartz overgrowth observed. Many quartz grains show extensive pressure solution with grain penetration and many sutured contacts. Alkali feldspar is much more frequent than plagioclase. The feldspars are generally fresh with some showing signs of chemical breakdown. The relatively frequent lithic fragments are of poly-crystalline quartz. Iron oxide is present as chocolate brown grains which merge into a pale olive-green coloured interstitial mineral. Two grains of zircon and one grain of a possible pyroxene were observed.

The matrix is dominated by clay minerals and the interstitial iron oxides along with a pale olive-green mineral. The matrix in this rock is a relatively high percentage of the sample and is close to making the sandstone matrix supported.

**HW009**: A fine-grained quartz arenite with subrounded grains which is moderately well sorted. It has a porosity of 3.4%.

95% plus of the grains in this sample are of quartz with minor mica, feldspar, and iron oxide with rare zircons and possible pyroxene. Undulose extinction is observed in some of the quartz grains. Quartz overgrowth is commonly observed. Many quartz grains show pressure solution with grain penetration and some sutured contacts. Iron oxide is present as occasional grains. Four grains of zircon and one grain of a possible pyroxene were observed.

The matrix is dominated by clay minerals with lesser interstitial iron oxide and a pale olive-green mineral.

**Archaeological description:** Many of these samples were taken from old quarry faces cut into the incised river gorge of the Haltwhistle Burn. These are likely to be 19th-century workings, but given their extent, would have obliterated any earlier workings.

**Results of analysis:** None

**Probability of Roman Quarrying:** 0

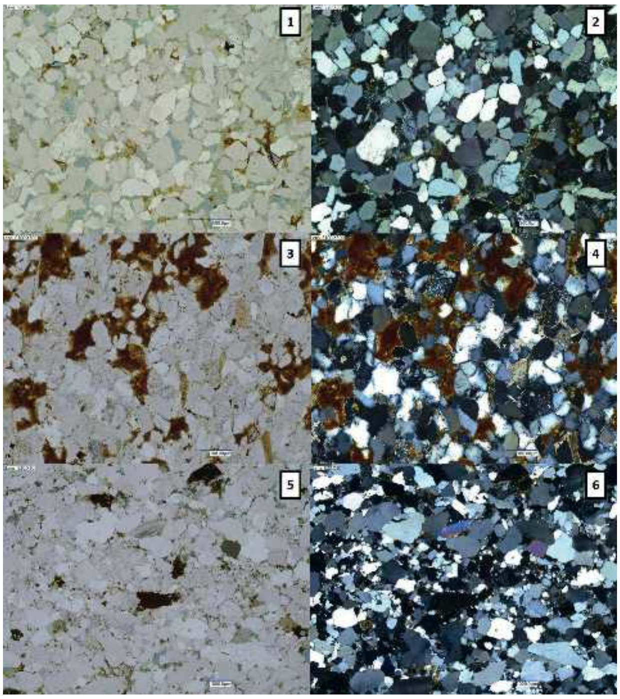



*Figure A2.10: (1) HW006 in plane polarised light ×80. (2) HW006 in cross polarised light ×80. (3) HW007 in plane polarised light ×300. (4) HW007 in plane polarised light ×300. (5) HW008 in plane polarised light ×30. (6) HW008 in cross polarised light ×30.*

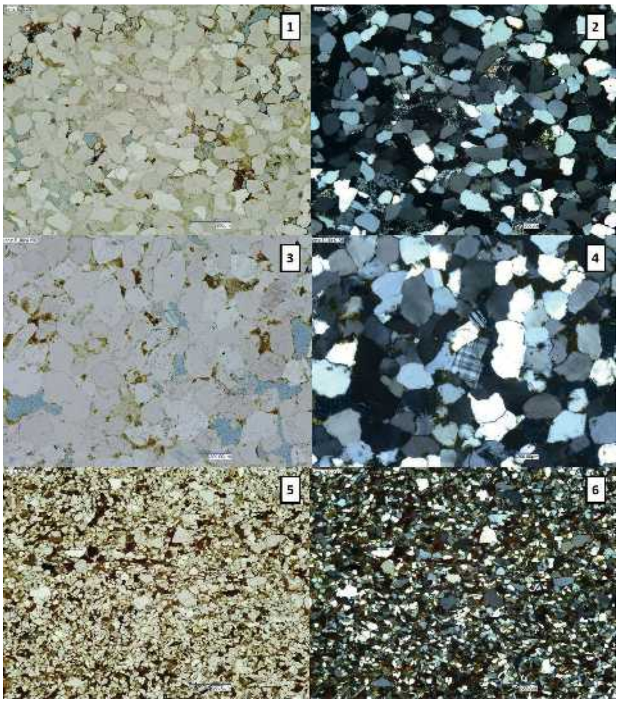



*Figure A2.9: (1) HW003 in plane polarised light ×80. (2) HW003 in cross polarised light ×80. (3) HW004 in plane polarised light ×150. (4) HW004 in cross polarised light ×150. (5) HW005 in plane polarised light ×80. (6) HW005 in cross polarised light ×80.*

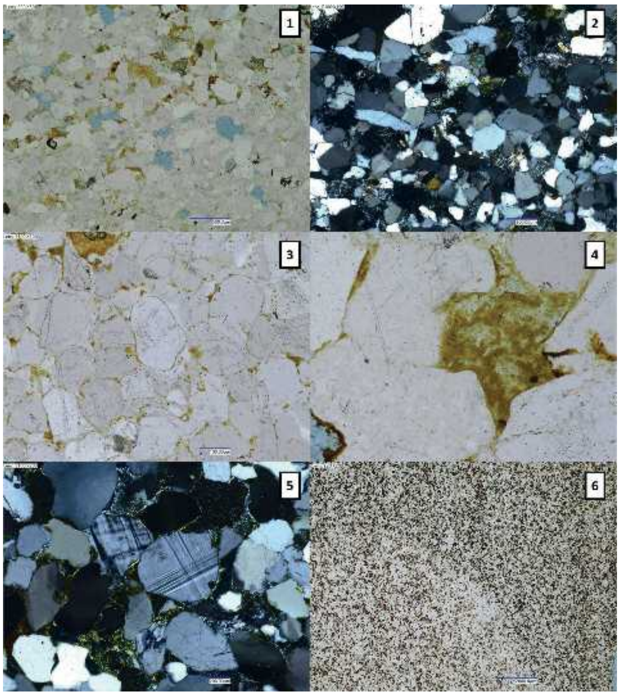



*Figure A2.11: (1) HW009 in plane polarised light ×80. (2) HW009 in cross polarised light including a zircon grain ×150. (3) HW001 in plane polarised light showing quartz overgrowth ×300. (4) HW003 in plane polarised light showing acicular inclusions in quartz ×500. (5) HW006 in cross polarised light showing alkali feldspar with tartan twinning ×200. (6) HW007 in plane polarised light showing weathering profile at the top and to the right of the image. ×30.*

*Haltwhistle Common 1*
**Type:** Quarry
**Location:** NY 67815 65057
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 3

*Haltwhistle Common 2*
**Type:** Quarry
**Location:** NY 67973 65271
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 3

*Haltwhistle Common 4*
**Type:** Quarry
**Location:** NY 68935 65571
**Accessibility:** Private
**Geological formation:** Firestone Sandstone, Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Backfilled
**Results of analysis:** None
**Probability of Roman Quarrying:** 1

*Haltwhistle Common 5*
**Type:** Quarry
**Location:** NY 69176 65544
**Accessibility:** Private
**Geological formation:** Firestone Sandstone, Stainmore Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Backfilled
**Probability of Roman Quarrying:** 1

*Walltown Crags*
**Type:** Quarry
**Location:** NY 6757 6648
**Accessibility:** Private
**Geological formation:** Great Whin Sill, boundary of the Carboniferous–Permian Period at approximately 295Ma.
**Stone Type:** Quartz dolerite, commonly referred to as whinstone
**Interventions:** None
**Geological description:** Columnar jointed quartz dolerite. Igneous rock intruded between layers of Carboniferous sedimentary rock and part of the Whin Sill swarm. The sill dips to the south with the top surface marking the dip slope. The quarry displays four low angle faults dipping to the west with unknown but probably small movement on the fault. These faults link to the topography of the crest of the Sill ridge, onto which the Wall was built.
**Archaeological description:** Walltown Crags Quarry along with Walltown Quarry form a second large industrial quarrying area for whinstone along the central sector of the Wall and has extensive evidence of blasting.
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

*Walltown Quarry (Sandstone)*
**Type:** Quarry
**Location:** NY 6747 6666
**Accessibility:** Unknown
**Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** Coarse sandstone. Regular horizontal beds (*c*. 1 m in size) of good quality sandstone, some with marked cross-bedding. Two samples collected WTC001 and WTC002, and thin sections made.
**Petrographic description:** (Fig. A2.12) Fine- to medium-grained sandstone, subangular grains, moderately well sorted and with porosity of 3.5% in one sample and 18.5% in the other.

95% plus of the grains are of quartz. Some of the quartz grains show undulose extinction and occasional grains are made of multiple welded sub-grains suggestive of a metamorphic origin. Fresh microcline feldspar is the next most common clast, often fresh but also broken down to clay minerals. Minor clasts include zircon and mica.

The matrix of both samples consists predominantly of clay minerals. Banding in the sandstones (particularly prominent in WTC002) is caused by a thin layer of interstitial iron oxide.
**Archaeological description:** This quarry is situated just north of the Wall at Walltown Crags within the prominent sandstone ridge running parallel to the Whin Sill and is the closest outcrop to the WallCAP HAR excavation carried out at Walltown Crags. The quarry is one of several small excavations (a few tens of metres across) in the face of the sandstone ridge. It is almost entirely overgrown with only small parts of the quarry face exposed.

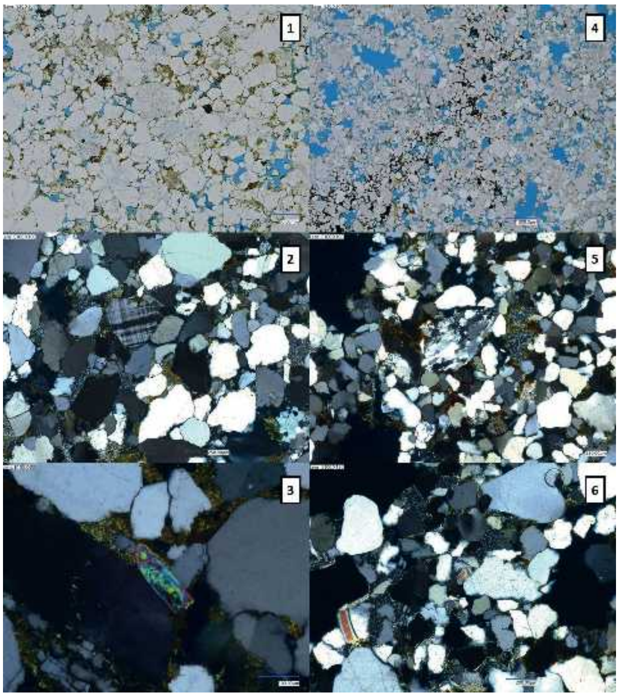



*Figure A2.12: (1) WTQ001 in plane polarised light ×50. (2) WTQ001 in cross polarised light ×100 tartan twinned microcline (centre), interstitial clay minerals and multiple grained quartz clast (bottom right). (3) WTQ001 in cross polarised light ×400 zoned zircon crystal and interstitial clay minerals. (4) WTQ001 in plane polarised light ×30. (5) WTQ002 in cross polarised light ×100 multiple grained quartz clast (centre) and interstitial clay minerals. (6) WTQ002 in cross polarised light ×150 zircon (centre) (centre), mica (left centre) and interstitial clay minerals.*

**Results of analysis:** Unlikely to be the source of the Wall-stones on the Walltown Crags section of the Wall based on differences in the petrography.
**Probability of Roman Quarrying:** 0

*Walltown*

**Type:** Quarry
**Location:** NY 66968 65978
**Accessibility:** Public
**Geological formation:** Great Whin Sill, Carboniferous–Permian Period
**Stone Type:** Quartz dolerite, commonly referred to as whinstone
**Interventions:** None
**Geological description:** Columnar jointed quartz dolerite. Igneous rock intruded between layers of Carboniferous sedimentary rock and part of the Whin Sill swarm. The sill dips to the south with the top surface marking the dip slope.
**Archaeological description:** Walltown is the second large industrial quarry for whinstone along the central sector of the Wall and has extensive evidence of blasting.
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

*Walltown 2*

**Type:** Quarry
**Location:** NY 67172 66223
**Accessibility:** Public
**Geological formation:** Great Whin Sill, Carboniferous–Permian Period
**Stone Type:** Quartz Dolerite, commonly referred to as whinstone
**Interventions:** None
**Geological description:** Columnar jointed quartz dolerite
**Archaeological description:** Removed blocks, wedgeholes
**Results of analysis:** None
**Probability of Roman Quarrying:** 4

*Thirlwall Common 1*

**Type:** Quarry
**Location:** NY 64017 65520
**Accessibility:** Private
**Geological formation:** Tynebottom Limestone, Alston Formation, Carboniferous Period
**Stone type(s):** Bioclastic limestone
**Interventions:** None
**Geological description:** None
**Archaeological description:** Removed blocks
**Results of analysis:** None
**Probability of Roman Quarrying:** 1

*Thirlwall Common 2*

**Type:** Quarry
**Location:** NY 64131 65268
**Accessibility:** Private
**Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s):** Unknown (backfilled)
**Interventions:** None
**Geological description:** None
**Archaeological description:** The quarry is backfilled. Its size and location suggest it might be associated with the military road construction in the 1700s. It also lies very close to some 19th-century lime quarries and a lime kiln. However, it is also surrounded by Roman monuments on three sides, with small camps on its east and west, and the Vallum immediately north.
**Results of analysis:** None
**Probability of Roman Quarrying:** 3

### *Gilsland to 1 km west of Hare Hill: Tyne Limestone Formation*

*Comb Crag*

**Type:** Quarry
**Location:** NY 59109 64986
**Accessibility:** Public

**Geological formation:** Tyne Limestone Formation, Carboniferous
**Stone type(s):** Sandstone
**Interventions:** Thin section and XRF
**Geological description:** 2.5Y 6/3 light yellowish brown carboniferous sandstone. All samples are fine grained, well sorted and subangular. Contains coal inclusions.
**Archaeological description:** Toolmarks, wedge holes, removed blocks, spoil heap, cart path, inscriptions
**Results of analysis:**

| *Comb Crag* | $SiO_2$ % | $Al_2O_3$ % | $K_2O$ % | $TiO_2$ % | $CaO$ % | $Fe_2O_3$ % |
|---|---|---|---|---|---|---|
| Sample 1 | 31.35 | 5.522 | 2.027 | 0.604 | 0.297 | 2.582 |
| Sample 2 | 37.573 | 4.664 | 1.703 | 0.324 | 0.519 | 1.889 |
| Sample 3 | 39.232 | 5.305 | 1.935 | 0.605 | 0.258 | 2.503 |

**Probability of Roman Quarrying:** 5

### *1 km west of Hare Hill to Bowness on Solway: Permian and Triassic Period.*

The curtain in this sector is often distant from sources of sandstone.

#### *Cam Beck*

**Type:** Stone source
**Location:** NY 5107 6386
**Accessibility:** Public
**Geological formation:** Kirklinton Sandstone Formation, Triassic Period
**Stone type(s):** Sandstone
**Interventions:** Sample collected (CB002), and a thin section made
**Geological description:** Bedded sets of sandstone units between 0.5 and 1 m thick. Most are parallel bedded and of poor-quality red sandstone interbedded with siltstones. Some of the beds have marked cross-bedding suggestive of a fluvial origin.
**Petrographic Description**: (Fig. A2.21) A very fine-grained quartz arenite with subangular grains which are well sorted. It has a porosity of 12%.

Approximately 90% of the grains in this sample are of quartz and the remainder composed of feldspar, with minor iron oxide and mica. Undulose extinction is rarely observed in the quartz grains and no quartz overgrowth is observed. Iron oxide is present as grains, as a ubiquitous red-oxide patination of the quartz grains, as well as some interstitially. A few fresh grains of plagioclase feldspar are observed, along a more significant number of grains in various stages of decomposition.

The limited matrix is of clay minerals and iron oxide.
**Archaeological description:** Upstream of the sample location there is a square-cut side channel to the Beck which appears to be man-made and suggests that stone had been removed from this formation.
**Results of analysis:** None
**Probability of Roman Quarrying:** 1

#### *Gelt River (by Written Rock)*

**Type:** Quarry
**Location:** NY 52637 58735
**Accessibility:** Public
**Geological formation:** St Bees Sandstone Formation, Triassic Period
**Stone type(s):** Sandstone
**Interventions:** None
**Geological description:** See Gelt River 2
**Archaeological description:** Removed blocks, toolmarks, inscriptions, iconography
**Results of analysis:** None
**Probability of Roman Quarrying:** 5

#### *Gelt River 2*

**Type:** Quarry
**Location:** NY 53182 57477
**Accessibility:** Public
**Geological formation:** St Bees Sandstone Formation, Triassic Period
**Stone type(s):** Sandstone
**Interventions:** Thin section and XRF
**Geological description:** 2.5YR reddish brown in colour with very fine grains ranging from 115–132 μm. All three samples are very well sorted and have angular grains. Iron is visible between the grains which has given it a relatively high iron reading in the XRF analysis.
**Archaeological description:** Removed blocks, wedge holes, toolmarks
**Results of analysis:**

| *Gelt River 2* | $SiO_2$ % | $Al_2O_3$ % | $K_2O$ % | $TiO_2$ % | $CaO$ % | $Fe_2O_3$ % |
|---|---|---|---|---|---|---|
| Sample 1 | 33.563 | 3.718 | 3.061 | 0.241 | 0.217 | 1.846 |
| Sample 2 | 33.629 | 3.266 | 3.153 | 0.212 | 0.27 | 1.106 |
| Sample 3 | 33.113 | 3.385 | 3.105 | 0.166 | 0.274 | 1.963 |

**Probability of Roman Quarrying:** 4

#### *Middle Gelt*

**Type:** Stone sample/quarry.
**Location:** NY 5310 5770
**Accessibility:** Public
**Geological formation:** St Bees Sandstone Formation, Triassic Period
**Stone type(s):** Sandstone
**Interventions:** Thin section and XRF

**Geological description:** Sample (Gelt001) taken from a disused but recent quarry face on the east bank just down river from Middle Gelt Bridge. The sample was taken from an undifferentiated bed in the St Bees sandstone. At this location approximately 10 m of homogenous sandstone are exposed in a series of beds between 0.5 and 2 m thick.
**Petrographic description**: (Fig. A2.13) A very fine-grained quartz arenite with subangular grains which are well to moderately well sorted. It has a porosity of 6.8%.

95% plus of the grains in this sample are of quartz with minor feldspar, mica, and iron oxide with rare zircons. Undulose extinction rarely observed in the quartz grains. Quartz overgrowth is commonly observed. Iron oxide is present as occasional grains but most conspicuously as a ubiquitous red-oxide patination of the quartz grains. Fresh grains of plagioclase feldspar are observed along a large number of grains in various stages of decomposition. There is nearly sufficient feldspar to categorise this sample as an arkose.

The limited matrix is of clay minerals and iron oxide.
**Archaeological description:** Removed blocks, wedge holes, toolmarks
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

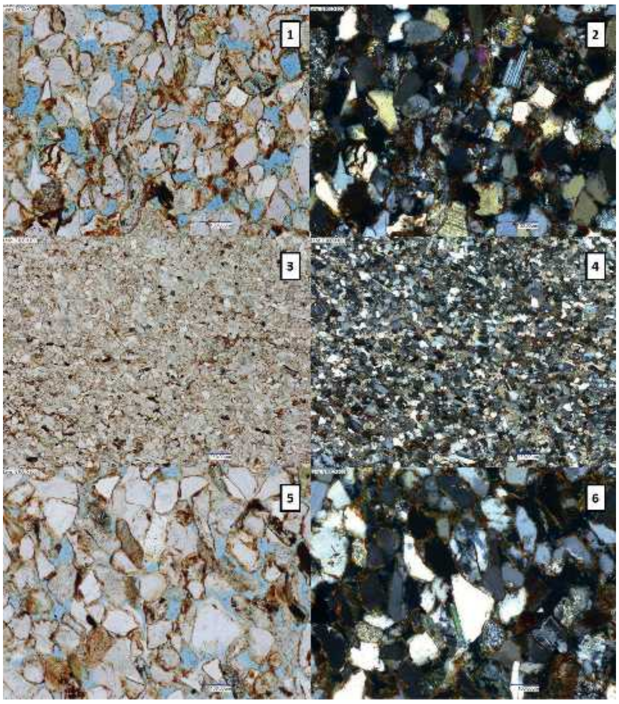



*Figure A2.13: (1) Gelt001 in plane polarised light ×100. (2) Gelt001 in cross polarised light ×100. (3) Shawk001 in cross polarised light ×100. (4) Shawk001 in plane polarised light ×100. (5) Shawk002 in cross polarised light ×300. (6) Shawk002 in cross polarised light ×300.*

*Wetheral*

**Type:** Quarry
**Location:** NY 46666 53586
**Accessibility:** Public
**Geological formation:** St Bees Sandstone Formation, Triassic Period
**Stone type(s):** Sandstone
**Interventions:** Thin section and XRF
**Geological description:** 5YR 4/4 reddish brown St Bees sandstone. The samples are rich in iron and mica, giving the stone its distinctive colour and sparkle in hand specimen. All samples are well sorted, and the grains are subangular. Feldspar was only observed in Sample 2.
**Archaeological description:** Removed blocks, inscriptions
**Results of analysis:**

| *Wetheral* | *$SiO_2$ %* | *$Al_2O_3$ %* | *$K_2O$ %* | *$TiO_2$ %* | *CaO %* | *$Fe_2O_3$ %* |
|---|---|---|---|---|---|---|
| Sample 1 | 33.306 | 2.323 | 2.799 | 0.172 | 0.287 | 1.53 |
| Sample 2 | 38.718 | 3.024 | 2.848 | 0.241 | 0.264 | 1.782 |
| Sample 3 | 31.438 | 2.899 | 2.457 | 0.373 | 0.543 | 2.215 |
| Sample 4 | 37.121 | 2.561 | 2.43 | 0.307 | 0.512 | 1.51 |

**Probability of Roman Quarrying:** 5

*Shawk*

**Type:** Quarry
**Locations:**
- Shawk001: NY 3395 4736
- Shawk002 and Shawk003: Shawk003 taken from bed in quarry face 50 cm below Shawk002: NY 3386 4751
- Shawk004: NY 3395 4800
- Shawk005: NY 3386 4823

**Accessibility:** Public
**Geological formation:** St Bees Sandstone Formation, Triassic Period
**Stone type(s):** Sandstone
**Interventions:** A set of samples collected (Shawk001–005), and thin sections made
**Geological description:**
A set of samples were collected from different stratigraphic positions within the St Bees Formation sandstones. The beds dip gently northward (downstream) here so that the samples are younger in age heading downstream from samples Shawk001 to Shawk005. Each of the samples were taken from widely separated beds except for Shawk002 and Shawk003 that were 50 cm vertically apart. Shawk001 and Shawk004 were from river sections, the rest were taken from disused quarry faces.

All of the sandstones superficially look very similar with the typical red of the St Bees Sandstone Formation.
**Petrological Description**: (Figs A2.13 and A2.14) This set of samples have some common features, with fine to very

fine grain size, subangular grains, many of the samples having some degree of red-iron patination on the grains, and there is a relatively high percentage of feldspar (often decayed). However, there is significant variation in porosity, the matrix, degree of sorting, the presence or otherwise of quartz overgrowths, and indicators of pressure solution.

**Shawk001**: A very fine-grained quartz arenite with subangular grains which are moderately well sorted. It has a porosity of 0.3%.

95% plus of the grains in this sample are of quartz with minor mica, feldspar, and iron oxide with rare zircon. Undulose extinction is observed in some of the quartz grains, as is quartz overgrowth. Some quartz grains show pressure solution with grain penetration and some sutured contacts. Iron oxide is present as occasional grains and as patination in red-oxide over most of the grains. The sample is layered on an approximately centimetre scale created by higher concentration of mica and iron oxide – the latter as both grains and as interstitial material. There are also areas where the patination of the grains in red iron oxide is absent. One grain of zircon was observed.

The matrix is dominated by calcite with a lesser amount of clay minerals and interstitial iron oxide.

**Shawk002**: A very fine-grained quartz arenite with subrounded grains which are moderately well sorted. It has a porosity of 11.3%.

95% plus of the grains in this sample are of quartz with minor feldspar, mica, lithic fragments, and iron oxide with rare possible pyroxene and a small mud-flake (*c*. 5 mm × 1 mm). Undulose extinction is observed in some of the quartz grains. Quartz overgrowth is common. Some quartz grains show pressure solution with grain penetration and some sutured contacts. Partially fresh plagioclase feldspar is observed along with many grains of feldspar decomposed to clay minerals. Iron oxide is present as occasional grains and as ubiquitous patination in red-oxide of grains.

There is little matrix which is composed of clay minerals and interstitial iron oxide.

**Shawk003**: A fine-grained quartz arenite with subrounded grains which are well sorted. It has a porosity of 8.9%.

80% plus of the grains in this sample are of quartz with lesser feldspar and minor lithic fragments, and iron oxide with rare mica and a possible pyroxene. Undulose extinction is observed in a few of the quartz grains. Quartz overgrowth is common. Some quartz grains show pressure solution with grain penetration and some sutured contacts. Partially fresh plagioclase feldspar is observed along with many grains of feldspar decomposed to clay minerals. Iron oxide is present as rare grains and as ubiquitous but faint patination in red-oxide of grains.

The matrix is composed of clay minerals with some interstitial iron oxide probably mixed with a pale olive-green mineral.

**Shawk004**: A fine-grained arkose with subangular grains that are well sorted. It has a porosity of 11.9%.

Approximately 70% of the grains in this sample are of quartz, with the remaining majority of grains composed of feldspar (or its decomposition products) along with minor iron oxide and rare mica. Undulose extinction is observed in some of the quartz grains as is quartz overgrowth. Evidence for pressure solution is limited. Partially fresh plagioclase feldspar is observed along with many grains of feldspar decomposed to clay minerals. Iron oxide is present as rare grains and as ubiquitous moderate patination in red-oxide of grains.

The matrix is limited and made of clay minerals with some interstitial iron oxide and a pale olive-green mineral.

**Shawk005**: A fine-grained quartz arenite with subangular grains which are well sorted. It has a porosity of 6.4%.

Approximately 80% of the grains in this sample are of quartz with the remaining grains composed of feldspar (or its decomposition products), along with minor lithic fragments, and iron oxide, rare mica, and a possible grain of tourmaline. Undulose extinction is observed in some of the quartz grains as is quartz overgrowth. Evidence for pressure solution is limited. Partially fresh plagioclase feldspar is observed along with many grains of feldspar decomposed to clay minerals. Iron oxide is present as grains and as ubiquitous strong patination in red-oxide of grains.

The matrix is very limited and made of clay minerals with some interstitial iron oxide.

**Archaeological description:** Many disused quarries cut into this incised river valley. Similar to Gelt but not on such a large scale. The quarries observed were probably 19th or 20th century. Roman inscriptions found here.

**Results of analysis:** None

**Probability of Roman Quarrying:** ?

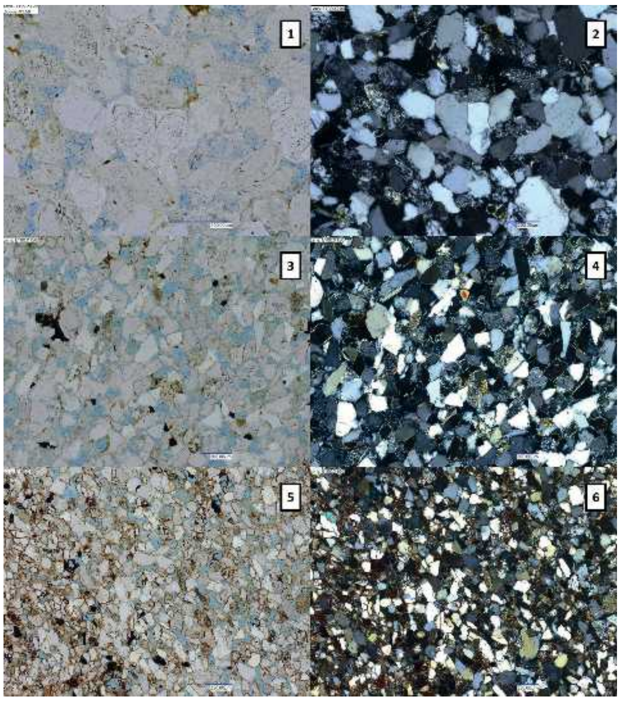



*Figure A2.14: (1) Shawk003 in plane polarised light ×200. (2) Shawk003 in cross polarised light ×200. (3) Shawk004 in cross polarised light ×150. (4) Shawk004 in plane polarised light ×150. (5) Shawk005 in cross polarised light ×200. (6) Shawk005 in cross polarised light ×200.*

*Maryport*

**Type:** Stone source/quarry
**Locations:**

- MP001: NY 0356 3743
- MP002: NY 0387 3779
- MP003: NY 0396 3789
- MP004: NY 0409 3801

**Accessibility:** Public
**Geological formation:** St Bees Sandstone Formation, Triassic Period
**Stone type(s):** Sandstone
**Interventions:** A set of samples collected (MP001–004), and thin sections made
**Geological description:**
A set of samples were collected from different locations along the foreshore with the aim of finding representatives of the different lithologies to be found. The majority of the beds are of the distinctive purple-red characteristic of much of the St Bees Sandstone formation. However, here as at Shawk, there are a number of beds which are a pale buff colour, and one bed was observed which was pale buff with distinct black partings.
**Petrological Description**: (Figs A2.15 and A2.16) This set of samples have common features: all with fine grain size, many of the samples have some degree of red-iron patination on the grains, there is a relatively high percentage of feldspar (often decayed), and high, though variable, porosities. As with Shawk samples there is, however, variation (albeit not as great as in the Shawk samples) in the degree of rounding in the grains, the presence or otherwise of quartz overgrowths, and the number of heavy minerals present.
**MP001**: A very fine-grained quartz arenite with subangular grains which are moderately well sorted. It has a porosity of 13.5%.

Approximately 90% of the grains in this sample are of quartz with the remaining grains composed of feldspar (or its decomposition products), along with minor lithic fragments, and iron oxide and rare mica. This sample also contains a small mud-flake approximately 3 × 6 mm. Undulose extinction is observed in some of the quartz grains as is quartz overgrowth. Evidence for pressure solution is limited. Partially fresh plagioclase feldspar is observed along with many grains of feldspar decomposed to clay minerals. Iron oxide is present as grains and as ubiquitous strong patination in red-oxide of grains.

There is little matrix which is composed of clay minerals and interstitial iron oxide.
**MP002**: A very fine-grained quartz arenite with subrounded grains which are moderately well sorted. It has a porosity of 15%.

Approximately 80% of the grains in this sample are of quartz, with the remaining grains composed of feldspar (or its decomposition products) along with minor mica and iron oxide. Undulose extinction is observed in some of the quartz grains. Quartz overgrowth is common. There is little evidence of pressure solution. No completely fresh feldspar is observed and there are many grains of feldspar decomposed to clay minerals. Iron oxide is present as occasional grains, as ubiquitous very light-patination in red-oxide of grains and as interstitial opaque material, all in small quantities.

There is minimal matrix which is composed of clay minerals and interstitial iron oxide.
**MP003**: A fine-grained quartz arenite with subangular grains which are moderately well sorted. It has a porosity of 7.5%.

Approximately 85% of the grains in this sample are of quartz, with the remaining grains composed of feldspar (or its decomposition products) along with minor mica and iron oxide with rare zircon and possible pyroxene. One grain was observed that was well rounded in a millet seed shape typical of aeolian weathering. Undulose extinction is observed in some of the quartz grains. Quartz overgrowth is common. There is some evidence of pressure solution with a few grains showing penetrating contacts and sutured margins. No completely fresh feldspar is observed and there are many grains of feldspar decomposed to clay minerals. Iron oxide is present as occasional grains, as ubiquitous very strong-patination in red-oxide of grains and as interstitial opaque material. The sample is banded on an approximately 2 mm scale, the banding being created by variation on the amount of interstitial iron oxide.

Little matrix is observed and this is composed of interstitial iron oxide with some clay minerals.
**MP004:** A fine-grained arkose with subrounded grains which are moderately well sorted. It has a porosity of 17.4%.

Approximately 75% of the grains in this sample are of quartz, with the remaining grains composed of feldspar (or its decomposition products) along with minor mica and iron oxide with rare possible pyroxene. Undulose extinction is observed in some of the quartz grains. Quartz overgrowth is common. There is some evidence of pressure solution with some grains showing penetrating contacts and sutured margins. Some partially decomposed plagioclase feldspar is observed and there are many grains of feldspar decomposed to clay minerals. Iron oxide is present as very occasional grains, as ubiquitous faint patination in red-oxide of grains and as interstitial opaque material mixed with a pale olive-green mineral.

Little matrix is observed, and this is composed of interstitial iron oxide with some clay minerals.
**Archaeological description:** Many disused quarries cut into this incised river valley. Similar to Gelt but not on such a large scale. The quarries observed were probably 19th or 20th century. Roman inscriptions found here.
**Results of analysis:** None
**Probability of Roman Quarrying:** ?

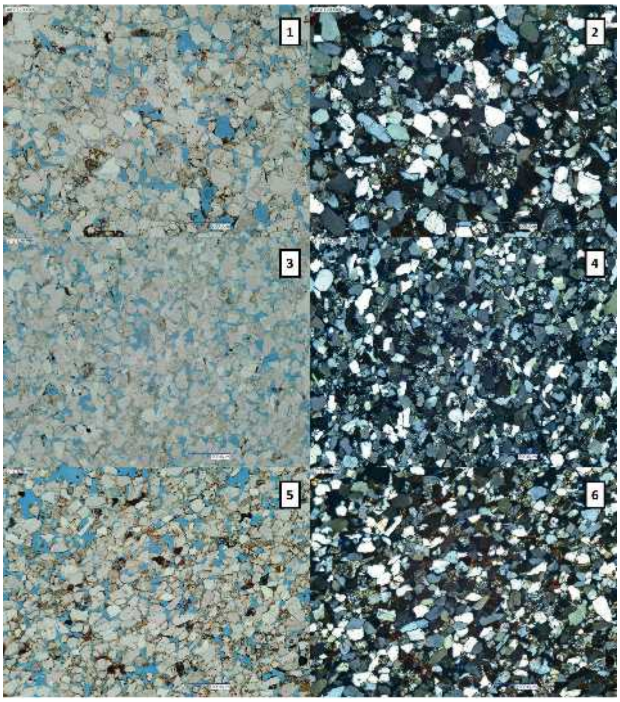



*Figure A2.15: (1) MP001 in plane polarised light ×80. (2) MP001 in cross polarised light ×80. (3) MP002 in cross polarised light ×80. (4) MP002 in plane polarised light ×80. (5) MP003 in cross polarised light ×80. (6) MP003 in cross polarised light ×80.*

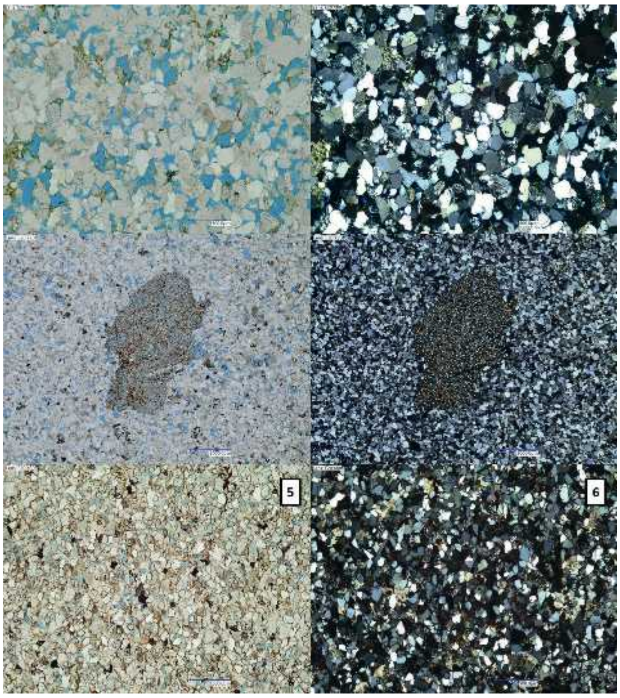



*Figure A2.16: (1) MP004 in plane polarised light ×80. (2) MP004 in cross polarised light ×80. (3) MP001 in cross polarised light, showing mud flake ×20. (4) MP001 in plane polarised light, showing mud flake ×20. (5) SB01 in cross polarised light ×80. (6) SB01 in cross polarised light ×80.*

### *Birkham's Quarry*

**Type:** Stone source/modern quarry
**Location:** NX 9548 1538
**Accessibility:** Private
**Geological formation:** St Bees Sandstone Formation, Triassic Period
**Stone type(s):** Sandstone
**Interventions:** Sample SB1, thin section made
**Geological description:** This sample was donated by Cumbrian Stone Ltd. and comes from Birkham's Quarry north of St Bees Head which has been a source of stone for many heritage buildings including Carlisle Cathedral. This is included as it comes from the type locality of the St Bees Sandstone Formation.
**Petrographic description**: (Fig. A2.16) A fine-grained quartz arenite with subrounded grains which are moderately well sorted. Porosity was not measured.

Approximately 90% of the grains in this sample are of quartz with the remaining grains composed of feldspar (or its decomposition products) along with minor mica and iron oxide. Undulose extinction is observed in some of the quartz grains. Quartz overgrowth is common. There is some evidence of pressure solution with some grains showing penetrating contacts and sutured margins. No completely fresh feldspar is observed and there are many grains of feldspar decomposed to clay minerals. Iron oxide is present as occasional grains, as ubiquitous strong-patination in red-oxide of grains and as interstitial opaque material. The sample is banded on an approximately 2 mm scale, the banding being created by variation in the amount of interstitial iron oxide.

The matrix is dominated by calcite with some minor interstitial iron oxide with some clay minerals.
**Archaeological description:** None
**Results of analysis:** None
**Probability of Roman Quarrying:** 0

### *Lacy's Caves*

**Type:** Stone source
**Locations:**
- LC001**:** NY 5641 3834
- LC002: NY 5630 3795

**Accessibility:** Public footpath
**Geological formation:** Penrith Sandstone Formation, Permian Period
**Stone type(s):** Sandstone
**Interventions:** Samples LC001 and LC002, thin section made
**Geological description:** The two samples were collected from the Penrith Sandstone Formation close to its upper horizon where it overlaid by the Eden Shales Formation, LC002 stratigraphically higher than LC002. The nearby Eden Shales are mined for gypsum and at Lacy Caves the sandstone is heavily veined. Samples were selected

which were free from veining. LC001 in hand specimen is soft verging on crumbly and the typical salmon pink of the Penrith sandstone. LC002 is much harder and a paler colour.

**Petrographic descriptions**: (Fig. A2.17)

**LC001**: A medium-grained quartz arenite with well-rounded grains which are moderately sorted. Porosity 11.2%.

Approximately 90% of the grains in this sample are of quartz, with lesser quantities of alkali feldspar, lithic fragments, and minor iron oxide. Undulose extinction is observed in some of the quartz grains. Quartz overgrowth is common. Fresh alkali feldspar is observed as well as decomposed to clay minerals. Iron oxide is present as occasional grains, including one which is a large rounded grain incorporating silt sized subangular clasts of quartz. Iron oxide is also present as a ubiquitous strong patination in red-oxide of grains. The lithic fragments are numerous and of polycrystalline quartz.

The matrix along with the quartz overgrowth is of minor amounts of clay minerals and iron oxide.

**LC002**: A medium-grained quartz arenite with well-rounded grains which are moderately sorted. Porosity 2.5%.

Approximately 90% of the grains in this sample are of quartz with lesser quantities of alkali feldspar, lithic fragments and minor iron oxide. Undulose extinction is observed in some of the quartz grains. Quartz overgrowth is common and very extensive – this is the only significant difference in the petrography of LC001 and is the cause of the large difference in porosity. Fresh alkali feldspar is observed as well as decomposed to clay minerals. Iron oxide is present as occasional grains including one which is a large rounded grain incorporating silt sized subangular clasts of quartz. Iron oxide is also present as a ubiquitous strong patination in red-oxide of grains. The lithic fragments are numerous and of polycrystalline quartz.

The matrix along with the quartz overgrowth is of minor amounts of clay minerals and iron oxide.

**Archaeological description:** None

**Results of analysis:** None

**Probability of Roman Quarrying:** ?

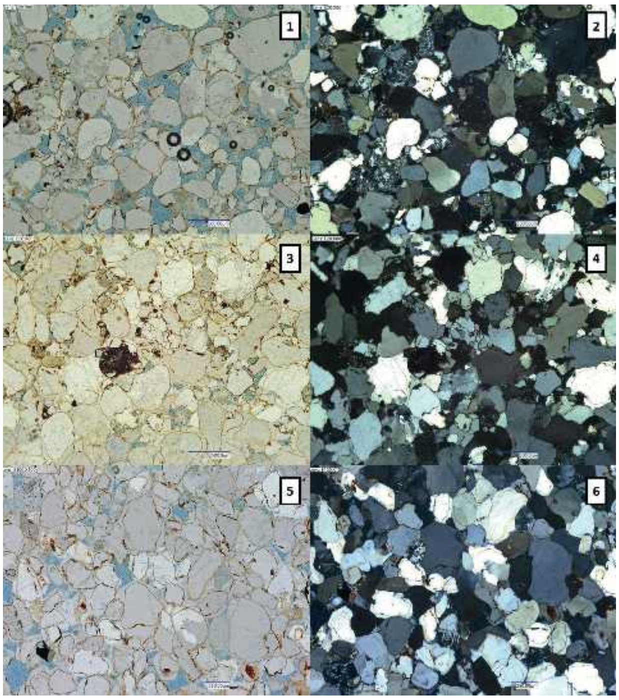



*Figure A2.17: (1) LC001 in plane polarised light ×80. (2) LC001 in cross polarised light ×80. (3) LC002 in cross polarised light, showing mud flake ×80. (4) LC002 in plane polarised light, showing mud flake ×80. (5) LB01 in cross polarised light ×100. (6) LB01 in cross polarised light ×100.*

### *Lazonby*

**Type:** Stone source/modern quarry

**Location:** NY 5243 3966

**Accessibility:** Private

**Geological formation:** Penrith Sandstone Formation, Permian Period

**Stone type(s):** Sandstone

**Interventions:** Sample LB1, thin section made

**Geological description:** This sample was donated by Cumbrian Stone Ltd. known as Lazonby Stone and is sourced from one of the quarries on Lazonby Fell.

**Petrographic Description**: (Fig. A2.17) A medium-grained quartz arenite with well-rounded grains which are moderately sorted. Porosity was not measured. 95% plus of the grains in this sample are of quartz with minor alkali feldspar, lithic fragments, and iron oxide. Undulose extinction is observed in some of the quartz grains. Quartz overgrowth is common and extensive. Fresh alkali feldspar is observed. Iron oxide is present as occasional grains and as ubiquitous strong patination in red-oxide of grains. The lithic fragments are of polycrystalline quartz.

The matrix along with the quartz overgrowth is of minor amounts of clay minerals.

**Archaeological description:** None

**Results of analysis:** None

**Probability of Roman Quarrying:** ?

## Wall Sites

### *Wallsend (Segedunum)*

**Type:** Fort and extramural settlement

**Underlying Geological formation:** Pennine Middle Coal Measures, Carboniferous Period

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection.

**Archaeological description:** The fort at Wallsend is at the eastern terminus of Hadrian's Wall, at the top of the north bank of the River Tyne. It was built in the AD 120s under Hadrian and was occupied until at least the end of the Roman period in the early 5th century. It is unclear if there is continuous occupation into the following early medieval period, but small quantities of early medieval pottery and artefacts have been found.

Though the fort walls, internal structures, and much of the extramural settlement was built in stone, the site has been largely robbed of stone in the centuries after the Roman period, as well as truncated by industrial works and the expansion of the village of Wallsend. As a result, there are not many courses of surviving upstanding stonework today.

Even during the Roman period, stone from the fort was re-used, specifically from the refurbished east gate to support repair of the Wall curtain in the 3rd century immediately west of the fort at modern Buddle Street (Bidwell 2018, 119–120).

Stone fabric from Wallsend is thought to have been re-used in the 8th century and later church and monastic complex at Jarrow (Turner *et al*. 2013), located to the east on the opposite bank of the River Tyne, and possibly also at Holy Cross Church, to the north of the site.

**Geological description:** The extant surviving fabric of the fort is made almost exclusively of a pale grey-weathering gritty sandstone similar in character to Heddon Stone. The fort is built above the 70 Fathom Post Member sandstone within the Pennine Middle Coal Measures Formation of the Carboniferous Period. This sandstone extends over much of the headland between Wallsend and Byker and underpins the Wall. Whilst this would have been mantled in glacial till, the incised denes at, for example, Wallsend Burn and Ouseburn would have exposed crags of this sandstone. Other sandstones such as the Grindstone Post Member would also be possible sources. No samples of these sandstones were collected.

**Results of analysis:** None

**Interpretation:** Whilst there is no direct evidence, the presence of at least two sandstones in the immediate vicinity of the wall suggests that stone would have been sourced nearby.

### *Buddle Street, Wallsend*

**Type:** Curtain

**Underlying Geological formation:** Pennine Middle Coal Measures, Carboniferous Period

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection

**Archaeological description:** Excavation revealed at least three phases of substantial rebuilding and repair of the curtain, due to unstable foundations (Bidwell 2018). As a result, rebuilding of the curtain mixed fabric in subsequent repairs, distinct from more regular fabric of the initial Hadrianic build. Large blocks and other re-used architectural stones, including a voussoir, demonstrate re-use of Roman fabric from parts of the fort at Wallsend.

**Geological description:** As at Segedunum

**Interpretation:** As at Segedunum

### *Turret 7b, Denton*

**Type:** Turret

**Underlying Geological formation:** Pennine Middle Coal Measures, Carboniferous Period

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection

**Archaeological description:** The turret survives to a height of five courses above the foundation course. Archaeological excavation revealed a number of phases (Birley 1930). The east wall of the turret seems to have larger stones on average per course, with larger blocks particularly notable at foundation level, the first course above foundation, and at the southern end of the east wall, which corresponds with the position of the door at the east end of the southern wall.

Visual examination of the fabric and its coursing detected a clearly visible downward sloping of coursing on the east external wall moving south and leaning outward toward the east, this latter more clearly visible in section from the south. Furthermore, the external west and south walls had slumping of courses within them to the north and east of the turret corner, respectively. This does not appear to be a result of the consolidation of the fabric of the turret, and seems to have preserved previously undetected rebuilding of at least one phase of the turret, possibly more. This is visually distinguished not only by the uneven coursing, but also in the visually smaller facing stones used in the coursing of the southern and western walls of the turret, with the exception of the lowest courses of the southwest corner, which seems to have retained its original fabric *in situ*. These smaller facing stones and general absence of blocks contrast with the larger blocks used in the Wall curtain to either side of the turret.

**Geological description:** The curtain is here made predominantly of two types of sandstone, one weathering to pale buff/white and gritty with common diagenetic iron oxide Liesegang patterns, the other a fine-grained brown sandstone with clear horizontal bedding. The former stone forms the overwhelming majority of the Wall-stone, and blocks of the latter stone are of smaller height. The curtain here is built above a sandstone within the Pennine Middle Coal Measures Formation. This sandstone unit is one of several that run around the hill of Benwell and which would have been exposed in, for example, Denton Dene. No samples of these sandstone were collected.

**Results of analysis:**

*Fabric metrics:*

Facing stone size range: small stone 20 × 14 cm, large stone at 42 × 28 cm (west wall); small stone 25 × 18 cm, large block 50 × 28 cm

| West wall, external | | | | East wall, external | | | | East wall, internal | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course | Ave W | Ave H | Ave D | Course | Ave W | Ave H | Ave D | Course | Ave W | Ave H | Ave D |
| F (w 9 cm offset) | 30.6 (10) | | | F (w 7 cm offset) | 46.5 (4) | | 54 (1) | F (no offset) | 49 (4) | | 32 (1) |
| 1 | 29 (11) | 26.4 (11) | | 1 | 42.5 (4) | 26.8 (4) | 65 (1) | 1 | 35.4 (5) | 24.4 (5) | 24 (1) |
| 2 | 28.5 (10) | 19.4 (10) | | 2 | 40.3 (4) | 20.3 (4) | 23 (1) | 2 | 33.2 (5) | 19.8 (5) | 54 (1) |
| 3 | 25 (12) | 17.7 (12) | 32.7 (9) | 3 | 38 (4) | 25.3 (4) | 35.8 (4) | 3 | 33.4 (5) | 24.2 (5) | 31.8 (4) |
| 4 | 27 (3) | 18.3 (3) | 31 (3) | 4 | 27 (1) | 22 (1) | 39 (1) | | | | |
| 5 | 42 (1) | 15 (1) | 35 (1) | | | | | | | | |

**Interpretation:** Whilst there is no direct evidence, the presence of several sandstones in the immediate vicinity of the Wall suggests that stone would have been sourced locally.

### *Denton*

**Type:** Curtain
**Location:** NGR
**Underlying Geological formation:** Pennine Middle Coal Measures, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Archaeological description:** The south face of the curtain, retaining more upstanding fabric than the north face, is characterised by large facing stones, though only the foundations and two courses were able to be measured, as revealed from excavations (Birley 1930). Longer stretches of curtain have been excavated to the east and west, providing further detail for the construction of the Wall in this section (Brewis 1927; Spain 1927; Bidwell and Watson 1996).
**Geological description:** As for Denton Turret
**Results of analysis:**
*Fabric metrics:*
Facing stone size range: small stone: 23 × 21 cm; large stone: 41 × 30 cm

| Curtain, south face, w of turret | | | |
|---|---|---|---|
| Course | Ave W | Ave H | Ave D |
| F (w 9 cm offset) | 35.1 (13) | 16 (1) | |
| 1 | 37.6 (10) | 26.4 (10) | |
| 2 | 22.3 (12) | 21.2 (12) | 30.8 (10) |

**Interpretation:** As for Denton Turret

### *Banktop, Throckley*

**Type:** Curtain
**Underlying Geological formation:** Pennine Middle Coal Measures, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** None
**Archaeological description:** Excavations
**Geological description:** The curtain here is built above a sandstone within the Pennine Middle Coal Measures Formation. This sandstone unit underlies the land to the east under Throckley and as far as West Denton. This sandstone would have been exposed, for example, in Wallbottle Dene. No samples of these sandstone were collected.
**Results of analysis:** None
**Interpretation:** Whilst there is no direct evidence, the presence of sandstone in the immediate vicinity of the Wall suggests that stone would have been sourced locally.

### *Heddon-on-the-Wall*

**Type:** Curtain
**Underlying Geological formation:** Pennine Lower Coal Measures Formation
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection, sample taken from nearby quarry (see quarries and stone sources)
**Archaeological description:** A stretch of surviving curtain at the east end of the village, which has been badly robbed. Typically the curtain only survives to 2 or 3 courses, but short stretches on the south face survive up to 6 courses. The foundations are not fully visible, though in places have an offset of 6-10cm. What is particularly notable about the curtain at Heddon is how consistent in size most of the facing stones are, with a narrower spectrum in size and well as general consistency.
**Geological description:** The curtain here is built above a sandstone within the Pennine Middle Coal Measures

Formation. This sandstone unit underlies the land to the east under Throckley and as far as West Denton. This sandstone would have been exposed, for example, in Wallbottle Dene. No samples of these sandstone were collected.

**Results of analysis:**

*Fabric metrics:*

Facing stone size range: small 19 × 14 cm; large 42 × 22 cm

| *Curtain, south face, immediately w of narrowing* | | |
|---|---|---|
| *Course* | *Ave W* | *Ave H* |
| F | | |
| 1 | 30.8<br>(6) | 18<br>(6) |
| 2 | 26.5<br>(6) | 21.5<br>(6) |
| 3 | 26.5<br>(6) | 23.8<br>(6) |
| 4 | 26.3<br>(6) | 15<br>(6) |
| 5 | 26<br>(6) | 13.9<br>(6) |
| 6 | 26.3<br>(3) | 14.7<br>(3) |

**Interpretation:** The strong similarity between the Wall-stone here and that examined from the local quarries strongly suggests that stone was sourced from Heddon Stone.

### *Corbridge*

**Type:** Town

**Underlying Geological formation:** Stainmore Formation, Carboniferous Period.

**Stone type(s) present:** Sandstone and cobbles of greywacke and a porphyritic lava.

**Interventions:** WallCAP excavation, physical inspection, and samples taken and thin sections made of sandstone paving (COR001, COR002 and COR006) and cobbles (CO003, CO004 and COR005).

**Archaeological description:** Roman occupation has a complex history that originated with a series of forts, which were eventually abandoned in the mid-2nd century and subsequently succeeded by a town that was occupied into at least the early 5th century. Early Anglo-Saxon style objects have been found at Roman Corbridge and west of the Roman town, suggesting some settlement may have continued on the site, prior to its shift further east where the current village lies. The site has considerable remains of stone buildings of varying scale and architectural pretension, and would have required considerable stone sourcing across the Roman period.

**Geological description:** This location and the main part of Roman Corbridge is built on alluvium – sand and gravels – from the River Tyne, which overlie siltstones and mudstones of the Stainmore Formation. There are underlying sandstones (and limestones) to the east and south across the River Tyne but in this low-lying river terrace area outcrops of sandstone would have been absent.

The sandstones recovered from this site are a mixture of buff-coloured fine-grained sandstones in crude small slabs with minimal dressing. The cobbles are of hard dark grey greywacke one with obvious gritty clasts and a piece of igneous rock.

**Petrographic analyses**. (Figs A2.18 and A2.19)

**COR001**: Is a fine-grained quartz arenite and has subrounded grains which are moderately well sorted. It has a porosity of 12.5%.

Approximately 90% of the grains in this sample are of quartz the remainder composed of feldspar, mica, iron oxide, and rare zircon. Undulose extinction is observed in some quartz grains, quartz overgrowth is absent. Many quartz grains show pressure solution with grain penetration and sutured contacts. Alkali and plagioclase feldspar are observed starting to decay along with many grains of decayed feldspar. Iron oxide is present as very dark brown grains which often also appear to be interstitial. Several grains of zircon were observed.

The matrix, along with the interstitial iron oxide, is of clay minerals.

**COR002**: Is a fine-grained quartz arenite and has subrounded grains which are moderately well sorted. It has a porosity of 1.6%.

Approximately 90% plus of the grains in this sample are of quartz, the remainder composed of feldspar, mica, iron oxide, and rare zircon. Undulose extinction is observed in some quartz grains; quartz overgrowth is absent. Many quartz grains show pressure solution with grain penetration and sutured contacts. Fresh alkali and plagioclase feldspar are observed along with grains of decayed feldspar. Iron oxide is present as very dark brown grains as well as interstitial patches. One grain of zircon was observed.

The matrix is a mixture of iron oxide, poikilitic calcite, and clay minerals.

**CO003**: Is a coarse-grained greywacke with subangular grains which are poorly sorted.

The clasts are composed of approximately 75% quartz, 25% lithic fragments, and 5% feldspar with minor quantities of garnet, chlorite, mica, and zircon. The lithic fragments are a mix of siltstones, meta-psammite, and fine-grained igneous rocks. The matrix is of clay minerals.

**C0R004**: Is a metamorphosed porphyritic igneous rock. Whilst the texture of the rock remains the mineral assemblage has largely been decomposed with significant amounts of chlorite in the matrix and the obvious remnants of feldspar phenocrysts decomposed to clay minerals and calcite.

**CO005**: Is a fine-grained greywacke with subangular grains which are moderately well sorted.

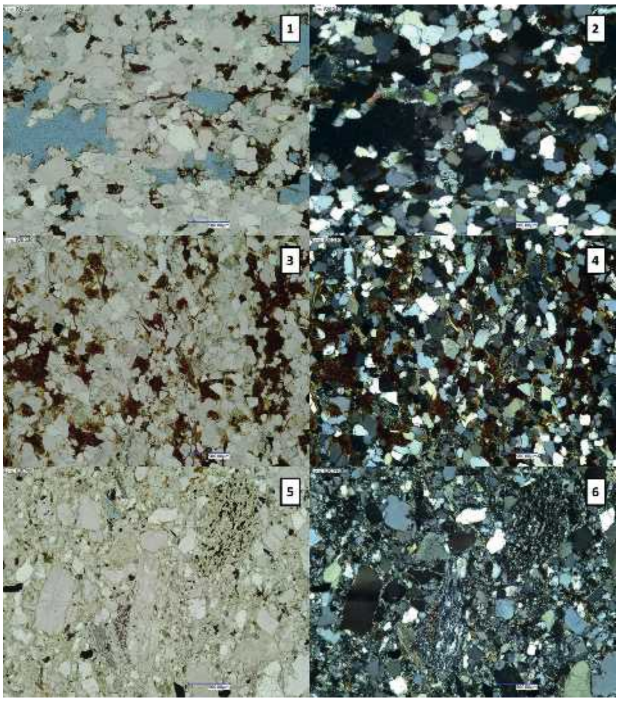


Figure A2.18: (1) COR001 in plane polarised light ×80. (2) COR001 in cross polarised light ×80. (3) COR002 in plane polarised light ×80. (4) COR002 in cross polarised light ×80. (5) COR003 in plane polarised light ×80. (6) COR003 in cross polarised light ×80.

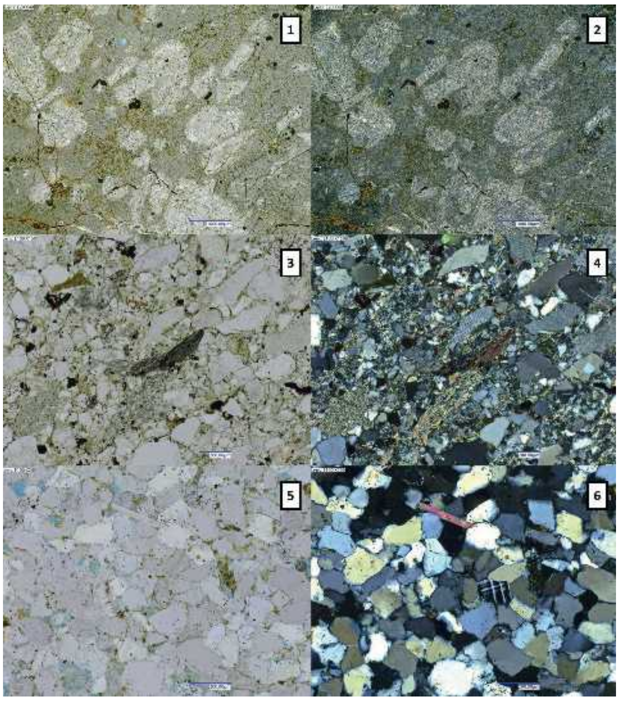


Figure A2.19: (1) COR004 in plane polarised light ×40. (2) COR004 in cross polarised light ×40. (3) COR005 in plane polarised light ×150. (4) COR005 in cross polarised light ×150. (5) COR006 in plane polarised light ×200. (6) COR006 in cross polarised light ×200.

The clasts are composed of approximately 85% quartz, 10% feldspar, 5% lithic fragments, and with minor quantities of chlorite and mica. Plagioclase and alkali feldspars are observed along with many grains of what are likely to be decomposed feldspar grains. The lithic fragments are a mix of siltstones, meta-pelites, and fine-grained igneous rocks. The matrix is of clay minerals and calcite.

**COR006**: Is a fine-grained quartz arenite and has sub-rounded grains which are well sorted. It has a porosity of 3%.

95% plus of the grains in this sample are of quartz with minor plagioclase and alkali feldspar, mica, and iron oxide, with rare zircon. Undulose extinction is observed in some quartz grains and quartz overgrowth is common. Many quartz grains show pressure solution with grain penetration and sutured contacts. A few of the quartz grains have acicular inclusions in them. The feldspar grains observed are largely fresh. Iron oxide is present as opaque grains.

The matrix is limited and composed of clay minerals.

**Results of analysis:** None.

**Interpretation:** No samples were taken from possible local sandstones sources so no comparison can be made. However, all of the sandstone samples described are compatible with being from the Stainmore Formation. As noted elsewhere, it has not been possible to distinguish sandstones from the Stainmore formation from other Carboniferous sandstones purely on petrography, so on this basis it is not possible to rule out that the sandstones were sourced from further afield. However, the availability of sandstones within 4 km of the site make it more likely that the sandstones are locally sourced.

### *Planetrees*

**Type:** Curtain

**Underlying Geological formation:** Stainmore Formation, Carboniferous Period.

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection and samples taken from nearby potential sources.

**Archaeological description:** A brief stretch of curtain running downslope toward the river North Tyne, with the preservation in situ of the narrowing of a partially-built/possibly completed portion of Broad Wall being replaced by Narrow Wall. Large facing stones are used in this location, notably in the lower courses, but with reasonably surviving height to seven courses. More facing stones survive on the south face.

**Geological description:** The curtain here is built above a sandstone unit in the Stainmore Formation. There are several sandstone units which extend around the high land of Heaven Fields. On the tops of the hills here where glacial action left rock outcrops near the surface sandstone would have been straightforward to locate. The curtain at Planetrees is built exclusively of a fine- to medium-grained sandstone which weathers to grey/white with a hint of buff. It is a moderately homogenous sandstone with only faint signs of bedding.

**Results of analysis:**

*Fabric metrics:*

Facing stone size range: small stone: 22 × 19 cm; large stone: 53 × 38 cm

| *Curtain, south face, immediately w of narrowing* | | | |
|---|---|---|---|
| *Course* | *Ave W* | *Ave H* | *Ave D* |
| F (w 19 cm offset) | 37.2 (5) | 10.4 (5) | |
| 1 (footing, w 8 cm offset) | 47.3 (4) | 29.2 (4) | |
| 2 (footing, with 8 cm offset) | 33.2 (6) | 24 (6) | |
| 3 | 31.9 (7) | 25.1 (7) | |
| 4 | 34.7 (7) | 20 (7) | |
| 5 | 29.3 (7) | 19.1 (7) | |
| 6 | 36.4 (5) | 21.2 (5) | 43 (3) |
| 7 | 36.8 (4) | 17.8 (4) | 34 (4) |

**Interpretation:** The presence of several local sandstones strongly suggests the stones were sourced locally. Samples from Fallowfield, Crag Wood and an outcrop next to the curtain are compatible with the stones being sourced from any of these outcrops. Based on the petrography it is unlikely it would be possible to distinguish which was the source.

### *Chesters Bridge Abutment*

**Type:** Bridge

**Underlying Geological formation:** Alston Formation, Carboniferous Period

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection

**Archaeological description:** Multiple phases of construction that resulted in increasingly larger and more complex bridging structures required substantial use of stone (Bidwell and Holbrook 1989). Surviving extant fabric, both *in situ* and displayed to the side of the consolidated remains, shows extensive use of massive blocks, some of which bear evidence of lewis holes, and recesses that took metal clamps to hold the blocks in place. The scale and multiple phases of construction for the bridges required at least one quarry, and perhaps multiple quarries, to obtain stone with sufficient properties for the structural requirements of the bridge.

**Geological description:** The bridge abutment is underlain by a sandstone unit in the Alston Formation which extends east and west for several kilometres along strike and north under parts of Chollerford and all of Chesters Fort and beyond Walwick. There is another sandstone unit stratigraphically above which crops out within 400 m of the abutment and in which a possible Roman quarry has been identified. The stone used is grey/white to buff and is gritty and only moderately well sorted. It is similar in appearance in hand specimen to the stone used at Chesters Fort.

**Results of analysis:** None

**Interpretation:** The presence of several sandstones in the vicinity, one of which has a possible Roman quarry in it, strongly suggests a local source.

### *Chesters*

**Type:** Fort

**Underlying Geological formation:** Alston Formation, Carboniferous Period

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection

**Archaeological description:** The fort contains several buildings with more specialist functional purposes (*e.g.*, barracks, granaries, *principia*, etc.), each of which make extensive use of stone. Stones, blocks, and slabs of varying size (and chronological phasing) can be observed used throughout the current consolidated remains. There is also evidence for re-use of fabric within the Roman period, for example from the extramural bathhouse re-used in the late Roman bathhouse adjacent to the *praetorium*.

**Geological description:** The fort is underlain by a sandstone unit in the Alston Formation which extends east and west for several kilometres along strike and under parts of Chollerford and beyond Walwick as well as across the river under the bridge abutment. There is another sandstone unit stratigraphically above which crops out within 400 m of the abutment (on the south side of the river) and in which a possible Roman quarry has been identified. The stone used is grey/white to buff and is gritty and only moderately well sorted. It is similar in appearance in hand specimen to the stone used at Chesters bridge abutment.

**Results of analysis:** None

**Interpretation:** The presence of several sandstones in the vicinity one of which has a possible Roman quarry in it strongly suggests a local source.

### *Black Carts*

**Type:** Curtain

**Underlying Geological formation:** Alston Formation, Carboniferous Period

**Stone type(s) present:** Sandstone and limestone – the latter in the core only

**Interventions:** Physical inspection

**Archaeological description:** A long stretch of curtain, also with turret 29a, separated into a lower, eastern length to the east of a road running north from the B6318, and an upper, western length to the west of the road. At the east end, the surviving height is only two courses, while further west it achieves a maximum survival of eight courses (footing + seven courses).

A clear building style is observed in the Narrow Wall curtain here, making use of small blocks to set a foundation, ranging in width from 0.50–0.97 m in length. Blocks are also used in the 1st course, with mixed use of small blocks and large facing stones in the 2nd course, large facing stones in the 3rd–7th courses, with occasional small facing stones in the 6th and 7th courses.

The geological composition of the fabric at Black Carts suggests a possible change in source stone in the building of the curtain in the upper, western lengths approaching Limestone Corner.

**Geological description:** The curtain at Black Carts overlies sandstones, limestone, siltstones, and shales of the Alston Formation and from west of Black Carts Farm overlies the Whin Sill. It is located within 0.5 km of three sandstone units which underly Green Carts, Rye Hill and Walwick Fell respectively. The curtain is made of two distinct types of sandstones which are likely to have come from two different sandstone units. The first a homogenous fine-grained sandstone which weathers to grey/white is exclusively used around the turret located just west of Black Carts Farm. The second is a fine-grained sandstone which weathers brown and contains numerous pockmarks possibly caused by the weathering out of mud-flakes or concretions and commonly has diagenetic iron banding in it. This sandstone is used exclusively in the curtain at the top of the hill nearer to Limestone Corner. In between both sandstones are used with a progressively increasing proportion of the grey/white weathering sandstone as you head downhill.

The core material is unusual in having a large percentage of limestone rubble mixed in with sandstone rubble. There are a number of underlying limestone layers nearby including the Upper Bath-house Wood Limestone which crosses the curtain by Black Carts Farm and the Colwell Limestone which runs by Green Carts Farm and the Shotto Wood Limestone by Walwick Fell.

The crag and ridge formation of the landscape here means that harder lithologies (sandstone, limestone, and dolerite) would have been easily found in the Roman landscape.

**Results of analysis:**

*Fabric metrics:*

Facing stone size range: small stone: 26 × 18 cm (east of turret); 20 × 18 cm (west of turret); large stone: 47 × 30 cm (east of turret); 49 × 21 cm (west of turret)

Block size range: small block: 50 × 30 cm ; 97 × 24 cm

| *Curtain, north face, upper section west of road* | | | | *Curtain, south face, upper section west of road* | | | | *Curtain, south face, lower section east of road, west of turret* | | | | *Curtain, south face, 15m west of east terminal* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Course* | *Ave W* | *Ave H* | *Ave D* | *Course* | *Ave W* | *Ave H* | *Ave D* | *Course* | *Ave W* | *Ave H* | *Ave D* | *Course* | *Ave W* | *Ave H* | *Ave D* |
| F (w 16 cm offset) | 60.5 (4) | 19.5 (2) | | F | | | | F | | | | Foundation (w 8 cm offset) | 47.2 (12) | | 40 (1) |
| 1 | 46.2 (5) | 25.6 (5) | | 1 | 33.9 (11) | 27.1 (11) | | 1 | 32.7 (10) | 26.7 (10) | | 1 | 37.1 (23) | 23.4 (23) | 30 (1) |
| 2 | 30.1 (8) | 22.3 (8) | | 2 | 33.8 (11) | 24.1 (11) | | 2 | 31.4 (9) | 21 (9) | | 2 | 36 (17) | 20.4 (17) | 40 (8) |
| 3 | 30.3 (9) | 21 (9) | | 3 | 36.4 4(10) | 22.4 (10) | | 3 | 35.4 (9) | 22 (9) | | | | | |
| 4 | 30.1 (8) | 23.9 (8) | | 4 | 32.4 (10) | 23.4 (10) | | 4 | 33.9 (9) | 19.7 (9) | | | | | |
| 5 | 28 (8) | 20.1 (8) | | | | | | 5 | 30.3 (9) | 18.4 (9) | 34.6 (9) | | | | |
| 6 | 28.4 (5) | 20.4 (5) | | | | | | | | | | | | | |
| 7 | 19.5 (2) | 23 (2) | | | | | | | | | | | | | |

**Interpretation:** Multiple sources of sandstone are available in the vicinity of Black Carts, and it is likely that both types of sandstone were sourced locally. There are the remnants of quarries at Green Carts and Walwick Fell. An interpretation of how these may have been exploited is given in Chapter 2 (Fig. 2.31). The limestone in the core is also likely to have been sourced locally with three good options in the vicinity. The material may have been a by-product of limestone gathered to make lime for lime-mortar.

### *Turret 29a, Black Carts*

**Type:** Turret
**Underlying Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Archaeological description:** Turret constructed with wing walls to a Broad Wall gauge. When the stone curtain was completed and linked to the turret wing walls, the curtain was built to the Narrow Wall gauge, and a distinct building style can be seen that distinguishes the turret from the adjoining Narrow Wall curtain. No blocks were used in the construction of the turret, and the north face can be characterised as consisting of eight courses on a foundation in which large facing stones make up the 1st course, with courses 2–4 consisting of mixed large and small facing stones, with a slab course (5) establishing a good level, and further mixed large and small facing stones in the 6th and 7th courses.

The turret door had a massive slab serving as the threshold, measuring 157 × 86 cm, and with recessed slots at the east and west ends to take massive upright slabs to act as the door frame.
**Geological description:** As for Blackcarts curtain. The current is made of the homogenous grey/white weathering fine grained sandstone.
**Results of analysis:**
*Fabric metrics:*
Facing stone size range: small stone = 21 × 16 cm; large stone = 49 × 20 cm; see also table of measurements at bottom of page
**Interpretation:** As for Black Carts curtain, it is likely the stone was sourced locally.

### *Housesteads*

**Type:** Fort
**Underlying Geological formation:** Whin Sill, Permian/ Carboniferous Period
**Stone type(s) present**: Sandstone, dolerite – the latter in the core and east along the curtain as foundation stones.
**Interventions:** Physical inspection, sampling, and thin section/petrological analysis
**Archaeological description:** The fort contains several buildings with specialist functions (*e.g.*, barracks, granaries, *principia*, etc.), each of which make extensive use of stone. Stones, blocks, and slabs of varying size (and chronological phasing) can be observed used throughout the current consolidated remains.
**Geological description:** The fort is located on the dip slope of the Whin Sill protected to the north by the crag-face of the sill. To north and south there are multiple lenses of sandstone which crop out as well-defined ridges. These would have all offered obvious sources of sandstone in

| *Internal walls (northeast corner)* | | | *East wall, internal* | | | *East wing wall, south face* | | |
|---|---|---|---|---|---|---|---|---|
| *Course* | *Ave W* | *Ave H* | *Course* | *Ave W* | *Ave H* | *Course* | *Ave W* | *Ave H* |
| F | | | F | | | F | | |
| 1 | | | 1 | | | 1 | 45.5 (4) | 28.5 (4) |
| 2 | | | 2 | | | 2 | 46.8 (4) | 25.5 (4) |
| 3 | 23.3 (4) | 20 (4) | 3 | | | 3 | 31.5 (4) | 27 (4) |
| 4 | 28.3 (3) | 19 (3) | 4 | 31 (3) | 15.3 (3) | 4 | 30 (1) | 22 (1) |
| 5 | 50 (2) | 18.5 (2) | 5 | 41.7 (3) | 20 (3) | 5 | 39 (1) | 15 (1) |
| 6 | 48 (2) | 27.5 (2) | 6 | 32 (3) | 20.7 (3) | | | |
| | | | 7 | 33.3 (3) | 16 (3) | | | |
| | | | 8 | 30.3 (3) | 16 (3) | | | |

the Roman landscape. Some of the sandstones north of the Wall potentially could be sourced from within the Tyne Limestone Formation (*e.g.*, Kings Crag). To the south sandstones could also potentially be sourced from the Stainmore Formation (*e.g.*, east of East Crindledykes). The stones here are of two end member types which may or may not come from the same source. At one end of the spectrum are fine-grained sandstones that weather to a grey/white colour, at the other fine-grained sandstones that weather to a brown colour. In some parts of the Wall these appear as distinct types, elsewhere there are stones which are intermediate in colour. Both sandstones are homogenous and display little by way of sedimentary bedding structures. Some of the stones have patterning from diagenetic iron.

A single sample HS004, a probable facing stone, was collected as a fallen block under the crags to the NE of the Knag Burn Gate. Grid reference NY79146906

**Petrographic description**: (Fig. A2.8) HS004 is a fine-grained quartz arenite and has subrounded grains. It has a porosity of 13.2%.

95% plus of the grains in this sample are of quartz with minor, feldspar, and iron oxide, with rare zircon. Undulose extinction is observed in some quartz grains and quartz overgrowth is moderately common. Many quartz grains show pressure solution with grain penetration and some sutured contacts. The alkali feldspar is observed only as a few decayed grains. Iron oxide is observed as occasional grains and in small quantities in the matrix.

There is little matrix which is composed of clay minerals with some iron oxide.

**Results of analysis:** None

**Interpretation:** The analysed sample is similar in its petrography to samples taken from Queens Crag and the ridge of sandstone immediately to the south of Housesteads fort. This suggests that the Wall-stone here could have been sourced from either of these localities. However, noting the variability of these sandstone units, it does not rule out sources within other sandstone units. In any case, the significant number of sandstones exposed within the vicinity of the fort and curtain strongly suggest a local source.

### *Steel Rigg and Peel Gap*

**Type:** Curtain, turret

**Underlying Geological formation:** Whin Sill, Permian/Carboniferous Period

**Stone type(s) present:** Sandstone, dolerite – the latter in the core only, though Crow (1991) observed a few pieces of dolerite used as facing in the curtain.

**Interventions:** Physical inspection

**Archaeological description:** The curtain at Steel Rigg, including Peel Gap, was substantially rebuilt within the Roman period, with excavations at the extra tower at the base of the gap revealing a sequence starting with a Broad Wall foundation, followed by a reduction to the Narrow Wall, at which point the tower (sitting between the more normal sequence of turrets a and b) abuts against the south face of the Narrow Wall. The tower was subsequently demolished, and the curtain was rebuilt to the Extra-narrow gauge. Furthermore, the curtain at Steel Rigg has suffered collapse of the facing stones and core on numerous occasions on both the north and south faces. As a result of both substantial Roman period rebuilding and numerous repairs over the past century, detailed metric analysis by course was not deemed useful. However, the style of facing of (repaired) Extra-narrow Wall can be characterised here as consisting primarily of small facing stones, interspersed with large facing stones. As a result of the smaller size of the facing stones, five to nine courses survive, though these do not achieve the height of curtain seen at other locations which employ blocks and larger facing stones. For example, at one location with eight courses surviving on the north face, the curtain face only reached a height of 1.15 m.

**Geological description:** Steel Rigg and Peel Gap are located on the dip slope of the Whin Sill protected to the north by the crag-face of the sill. To north and south there are multiple lenses of sandstone which crop out as well-defined ridges. These would have all offered obvious sources of sandstone in the Roman landscape.

**Results of analysis:**

*Fabric metrics:*

Facing stone size range: small stone = 16 × 14 cm; 18 × 18 cm; large stone = 38 × 19 cm

**Interpretation:** Given the vicinity of several sandstone units the source for the stones here is likely to be local. The dolerite in the core is very likely from scree associated with the Whin Sill adjacent to these sites.

### *Mile 42, Cawfields*

**Type:** Curtain

**Underlying Geological formation:** Whin Sill, Permian/Carboniferous Period

**Stone type(s) present:** Sandstone, dolerite – the latter in the core only

**Interventions:** Physical inspection

**Archaeological description:** The curtain in Wallmiles 41 and 42 is sinuous, following the line of the crags, and typically having facing stones survive in two to seven courses on the south face. The sloping section of curtain west of milecastle 42 (Cawfields) and immediately east of the current farm gate survives to seven courses. Due to the slope, some courses are ‘split’, or rather two shorter lengths of stones with smaller heights are used to establish a level between two courses. For example, within the section measured below, the 5th course consisted of a lower course 5a and upper course 5b for a length of approximately 1.2 m, after which the sub-courses return to a single layer of stones for course 5.

**Geological description:** Cawfields is located on the dip slope of the Whin Sill protected to the north by the

crag-face of the sill. To north and south there are multiple lenses of sandstone which crop out as well-defined ridges. These would have all offered obvious sources of sandstone in the Roman landscape.
**Results of analysis:**
*Fabric metrics:*
Facing stone size range: small stone = 20 × 18 cm; large stone = 46 × 23 cm

| *Curtain, south face, immediately east of farm gate* | | |
|---|---|---|
| *Course* | *Ave W* | *Ave H* |
| F | | |
| 1 | 28 (6) | 17.5 (6) |
| 2 | 20.5 (8) | 18.6 (8) |
| 3 | 22.2 (8) | 18.4 (8) |
| 4 | 23.4 (9) | 19.6 (9) |
| 5 | 28.9 (7) | 18.1 (7) |
| 6 | 31.5 (6) | 22.8 (6) |
| 7 | 24.5 (8) | 20.1 (8) |

**Interpretation:** Given the vicinity of several sandstone units, the source for the stones here is likely to be local. The dolerite in the core is very likely from scree associated with the Whin Sill adjacent to these sites.

### *Walltown Crags*

**Type:** Curtain
**Underlying Geological formation:** Whin Sill, Permian/Carboniferous Period
**Stone type(s) present:** Sandstone, dolerite – the latter in the core only
**Interventions:** Excavation and physical inspection, four samples of sandstone selected from the WallCAP representing core or facing stone. Thin sections made from three of these samples – WTC011, WTC012 and WTC013.
**Archaeological description:** A long stretch of curtain exposed in the 19th century, now positioned between two early 20th-century quarries, and surviving to a maximum of 12 courses on the south face. Curtain was also exposed through the course of WallCAP excavations immediately east of an early 20th-century excavation trench. Here, six courses (including the footings) survived buried. Building at Walltown was accomplished on shaped bedrock foundations, primarily using small and some larger facing stones. This provided greater flexibility in building the curtain in a more sinuous fashion running up and down the slopes of the Nine Nicks of Thirlwall. Significantly, at different locations of the curtain, there are instances that appear to show partial collapse of facing (if not the whole curtain) which has been repaired, presumably in antiquity. In other locations, typically associated with the combination of a bend in the course of the curtain and a change of slope, the lower courses are stepped to create more complex footings for the curtain above.
**Geological description:** Walltown Crags is located on the dip slope of the Whin Sill protected to the north by the crag-face of the sill. To north and south there are multiple lenses of sandstone which crop out as well-defined ridges. These would have all offered obvious sources of sandstone in the Roman landscape. The sandstone here is of one type, a fine-grained, homogenous and weathers to pale grey. Some stone show sedimentary bedding on centimetre scale with one stone show distinct cross-bedding.
**Petrographic Analysis**: (Fig. A2.20) All three samples share many characteristics. All are quartz arenites, fine grained and well sorted. 95% plus of their grains are quartz with minor feldspar and iron oxide. Undulose extinction is observed in some quartz grains and quartz overgrowth is common. Some evidence of pressure solution is seen in all samples with some penetrating and/or sutured grains. Feldspar is uncommon and frequently degrading to clay minerals.

In addition, WTC11 and WTC 13 have small amounts of mica and a few grains of zircon (two in each sample examined).

The samples can be differentiated by the amount and disposition of oxide. WTC12 contains patches of iron oxide up to 0.7 mm which are interstitial to the quartz grains and opaque or very dark brown.

HS004 is a fine-grained quartz arenite and has sub-rounded grains. It has a porosity of 13.2%.

95% plus of the grains in this sample are of quartz with minor, feldspar, and iron oxide with rare zircon. Undulose extinction is observed in some quartz grains and quartz overgrowth is moderately common. Many quartz grains show pressure solution with grain penetration and some sutured contacts. The alkali feldspar is observed only as a few decayed grains. Iron oxide is observed as occasional grains and in small quantities in the matrix. WTC13 contains similarly textured mineral of pale olive-green or pale brown. WTC11 has similar oxide patches to WTC13 but in much smaller quantities, though where weathered, WTC11 has as a high a proportion of oxide as WTC12 and in the opaque or very dark brown mineral(s). In addition, in the weathered portion of WTC11 the grain boundaries are also coated in the dark brown oxide. There is some variation between the samples in the amount of quartz overgrowth to be observed, with WTC11 having more extensive overgrowth than the other two samples.

Along with the iron minerals and the quartz overgrowth there is a small amount of clay mineral in the matrix of all of the samples.
**Results of analysis:**
*Fabric metrics:*
Facing stone size range: small stone = 19 × 13 cm; large stone = 35 × 25 cm; 44 × 22 cm

| Curtain south face, west of T45a | | | Curtain, south face, west of MC45 (WallCAP trench 1) | | |
|---|---|---|---|---|---|
| Course | Ave W | Ave H | Course | Ave W | Ave H |
| 1: Footing (w 4 cm offset) | | | 1:Footing (w 5 cm offset) | 29 (2) | 25 (4) |
| 2 | 25.3 (7) | 17.3 (7) | 2 | 22.5 (4) | 15 (4) |
| 3 | 23.7 (7) | 17.4 (7) | 3 | 22.8 (4) | 15.5 (4) |
| 4 | 24.7 (7) | 17.7 (7) | 4 | 22.8 (5) | 17 (5) |
| 5 | 26 (7) | 19.4 (7) | 5 | 22 (8) | 14.9 (8) |
| 6 | 24.7 (7) | 17.4 (7) | 6 | 20.2 (5) | 17.6 (5) |
| 7 | 22.3 (7) | 15.8 (7) | | | |
| 8 | 17 (10) | 15.9 (10) | | | |
| 9 | 22.8 (8) | 16.4 (8) | | | |
| 10 | 23.6 (7) | 15.7 (7) | | | |
| 11 | 26.6 (5) | 20.4 (5) | | | |
| 12 | 26 (4) | 21 (4) | | | |

**Interpretation:** The source of fabric is probably local, but at present uncertain.

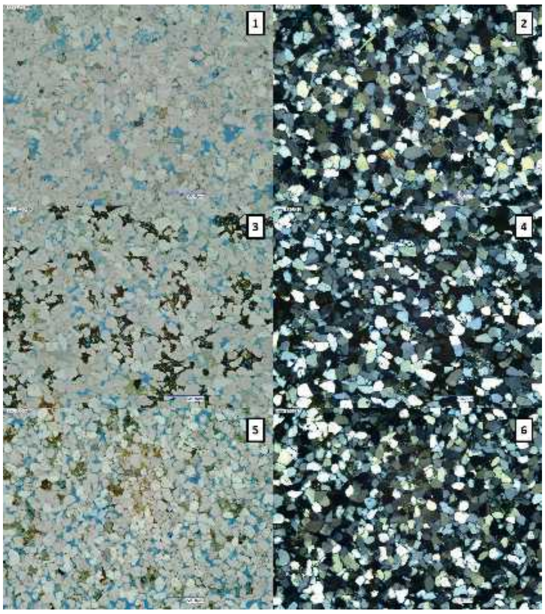



*Figure A2.20: (1) WTC011 in plane polarised light ×80. (2) WTC011 in cross polarised light ×80. (3) WTC012 in plane polarised light ×80. (4) WTC012 in cross polarised light ×80. (5) WTC013 in plane polarised light ×80. (6) WTC013 in cross polarised light ×80.*

### *Willowford*

**Type:** Curtain and bridge
**Underlying Geological formation:** Tyne Limestone Formation, Carboniferous Period.
**Stone type(s) present:** Sandstone and limestone as well as glacial cobbles including a piece of porphyritic silica rich igneous rock in the core
**Interventions:** Physical inspection
**Archaeological description:** A near-complete Roman mile of Wall curtain is consolidated, containing turrets 48a and 48b and ending with the exposed remains of the Roman bridge on the former east bank of the River Irthing. The curtain rarely survives to more than five courses in height, though changes in ground elevation means that the curtain as it engages with the bridge survive to a greater height. Willowford farm, on the knoll east of the bridge, makes extensive use of Roman stone from the Wall, including partial inscriptions. The bridge uses a range of stones, blocks, and slabs, and has evidence for multiple phases of activity (Bidwell and Holbrook 1989).
**Geological description:** Willowford is close to the boundary of the Tyne Limestone with the overlying Alston Formation *c*. 1.5 km away to the southeast. The River Irthing is here incised into steep banks rising 70 m above river level. These steep banks would have provided obvious outcrops of both limestone and sandstone. The crossing

is located within 400 m of the Appletree Limstone to the northwest and the Leahill Limestone to the southwest. The nearest underlying sandstones are more distant, the nearest to the east being around Thirlwall Castle and to the west just over a kilometre away downstream on the River Irthing.

The sandstones in the curtain near the bridge abutment are a variable mix of fine-grained sandstones, coloured from white/grey to brown. A number have diagenetic iron oxide as weathering profiles and as Liesegang patterns. Some of the stones have faint sub-parallel bedding planes in them at a centimetre scale.

The large bridge abutment stones are more consistently of a homogenous fine-grained brown-weathering sandstones. In addition, two of the blocks are made of limestone, which also contains a large fossil colony of the coral *Syringopora*.

The core is largely composed of sandstone rubble but does also contain a number of rounded glacial cobbles including one of a porphyritic, silica rich igneous rock.

**Results of analysis:** None.

**Interpretation:** Whilst sandstone outcrops are not as near as they are for most locations in the central and eastern sector, there are nonetheless sandstones available within a few kilometres of the bridge so that sandstones are likely to have been sourced locally. It maybe that the known Roman Quarry at Comb Crag approximately 4 km away may have been the source for the stones.

The presence of limestone as a building material is highly unusual, and this is the only site at which the author has observed anything other than sandstone used as dressed blocks. The vicinity of limestone outcrop maybe significant.

The presence of glacial material is unsurprising given the riverside location where glacial cobbles would be extensively reworked by the River Irthing, making a ready source of core in fill from banks of cobbles by the river.

### *Birdoswald*

**Type:** Curtain
**Underlying Geological formation:** Tyne Limestone Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Archaeological description:** A maximum of nine courses of the south face of the stone curtain survive here, where the Stone Wall replaced the Turf Wall in the later Hadrianic period. The style of construction consists primarily of alternating courses of large and small facing stones, but notably the 7th course consisted of slabs. Centurial stones and stones bearing phalli carved in relief remain *in situ* on the south face of the curtain.

**Geological description:** Birdoswald is located over siltstones and mudstones of the Tyne Limestone Formation. Along strike glacial erosion of these has created depressions into which thickened layers of peat were subsequently deposited. Several sandstone units underly and run parallel to the northern bank of the River Irthing to the west of the fort. These are well exposed where they cross the River Irthing in the series of meanders under Comb Crag Wood and would have been visible and obvious outcrops of sandstone in Roman times.

The stones used at Birdoswald both in the curtain and the fort weather buff to grey/white and are of a homogenous fine-grained sandstone. Some stone show clear horizontal bedding at approximately 1-cm intervals.

**Results of analysis:**
*Fabric metrics:*
Facing stone size range: small stone: 20 × 16 cm; large stone: 40 × 26 cm

*Curtain, north face, immediately e of turret*

| *Course* | *Ave W* | *Ave H* |
|---|---|---|
| F | | |
| 1 | 31.3<br>(6) | 25<br>(6) |
| 2 | 31.5<br>(6) | 19.6<br>(6) |
| 3 | 26.5<br>(6) | 18<br>(6) |
| 4 | 26.9<br>(7) | 15.6<br>(7) |
| 5 | 28.3<br>(7) | 18.7<br>(7) |
| 6 | 25.1<br>(7) | 18<br>(7) |
| 7 | 64.5<br>(3) | 11<br>(3) |
| 8 | 26.3<br>(7) | 24.7<br>(7) |
| 9 | 31.3<br>(6) | 15<br>(6) |

**Interpretation:** Whilst there is no direct evidence, the presence of nearby sandstones, including the known Roman quarry at Comb Crag approximately 2 km away, strongly suggests a local source for the Wall-stone.

### *Banks East*

**Type:** Curtain and turret
**Underlying Geological formation:** Tyne Limestone Formation, Carboniferous Period
**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection
**Archaeological description:** A stretch of curtain that includes turret 54a. The Wall here was originally built in turf and only subsequently rebuilt in stone, though the turret was originally built in stone. The style of building is different between the turret and the curtain. The north face of the turret consists of five courses of footing plus one course of bevelled stone, with a further two courses surviving above the bevelled offset. The west turret wall consists of 11 courses, in both the interior and exterior. The exterior wall consists of large facing stones and small blocks in its lowest courses, and courses 5–8 were visibly thinner than the courses above and below them. A similar arrangement is seen on the ten courses of the east exterior wall of the turret, in which courses 6 and 9 have thinner coursing.

The curtain consists of foundations (largely buried) plus five courses on the south face and six courses above the foundations on the north face to the east of the turret. West of the turret the north face retains four courses over the foundations and five courses on the south face. Regardless of the exact courses surviving, the overall style is the same. The foundations consist of slabs, with blocks in the lowest course (1), followed by a mix of blocks and large facing stones (2 and 3), and above that facing stones of large size (4) and then a mix of small and large facing stones (5 and 6).
**Geological description:** Banks East is located over sandstones, siltstones, and mudstones sandwiched between the Leahill and Appletree Limestones of the Tyne Limestone Formation. The curtain here crosses eight sandstone units between Leahill Farm and Banks. Outcrops of these sandstones are likely to have been visible along the top of the ridge here and down the bank of the River Irthing.

The stones used at Banks East are of two distinct types of sandstone. Both are fine grained and homogenous. The first weathers to a brown colour, the latter to a pale white/grey colour. The two types are readily seen inside the turret.
**Results of analysis:**
*Fabric metrics:*
Facing stone size range: small stone: 14 × 19 cm; 21 × 13 cm; large stone: 45 × 33 cm
Block size range: small block: 50 × 29 cm; 55 × 34 cm
Note: measurements were taken at a position to achieve the maximum courses, but the 1st course at the location was atypical in the size of stones (large facing stones) relative to most other stones in the first course in this stretch of curtain (small blocks). To more accurately capture this feature, five blocks in the first course were substituted for the large facing stones in the section recorded.

*Curtain, north face, immediately e of turret*

| *Course* | *Ave W* | *Ave H* | *Ave D* |
|---|---|---|---|
| F (w 4 cm offset) | 44.8<br>(5) | 11<br>(1) | |
| 1 | 34<br>(6) | 23<br>(6) | |
| 2 | 32.2<br>(6) | 19.7<br>(6) | |
| 3 | 28.9<br>(8) | 16.8<br>(8) | |
| 4 | 29.7<br>(7) | 17.3<br>(7) | |
| 5 | 29<br>(7) | 18.3<br>(7) | |
| 6 | 29.5<br>(6) | 13.2<br>(6) | 35.8<br>(6) |

**Interpretation:** The presence of many sandstones in the immediate vicinity strongly suggests that the stones were sourced locally.

## *Hare Hill*

**Type:** Curtain
**Underlying Geological formation:** Tyne Limestone Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Archaeological description:** An impressive surviving short stretch of curtain, almost certainly due to its incorporation as part of a late medieval or post-medieval structure and surviving to a height of 3 m. Facing stones have been largely lost on the south face, and their retention on the north face is a result of 19th-century work. The Wall here was part of the Lanercost Priory estate boundary. At some point, the eastern portion of curtain here was almost entirely robbed down to foundations, and then subsequently rebuilt in a narrower gauge, this latter which also does not survive to full height.
**Geological description:** Hare Hill is just to the west of and stratigraphically below the Millerhill Limestone in the Tyne Limestone Formation and is approximately 1 km west of the unconformity with the overlying Permian strata. There are no underlying sandstone units to the west of Hare Hill but the many sandstones noted at Banks East are within 1 km of this location.

Black organic overgrowth in this damp location makes it hard to be precise about the nature of the stones here, but there appear to be two types of sandstone, both fine grained. The first weathers to a brown colour, the latter to a pale white/grey colour and bears similarities to those observed at Banks East. The stones here, however, appear to include a number of lower quality stones with pock marks from weathered out concretions. More of the stones also have marked horizontal bedding.

**Results of analysis:**

*Fabric metrics:*

Facing stone size range: small stone: 20 × 15 cm; large stone: 44 × 30 cm

| *Curtain, north face* | | |
|---|---|---|
| *Course* | *Ave W* | *Ave H* |
| F (no offset) | 37.5<br>(8) | 9.8<br>(5) |
| 1 | 28.5<br>(9) | 14.7<br>(9) |
| 2 | 24<br>(8) | 14.3<br>(8) |
| 3 | 27.7<br>(11) | 17.7<br>(11) |
| 4 | 28.5<br>(10) | 28.2<br>(10) |
| 5 | 25<br>(11) | 23.7<br>(11) |
| 6 | 24.8<br>(12) | 21.1<br>(7) |
| 7 | 25.2<br>(6) | 19.5<br>(6) |
| 8 | 27.9<br>(7) | 21<br>(7) |
| 9 | 20.7<br>(7) | 19.8<br>(7) |
| 10 | 22.8<br>(7) | 18.3<br>(7) |
| 11 | 35.3<br>(4) | 20.8<br>(4) |

**Interpretation:** The presence of many sandstones within a short distance at Banks strongly suggests that the stones were sourced locally

### *Cam Beck*

**Type:** Curtain, tower, and bridge

**Location:** NGR NY51176394

**Underlying Geological formation:** Kirklinton Sandstone Formation, Permian Period

**Stone type(s) present:** Sandstone and a mixture of glacially derived cobbles – the latter as core material and in cobbled surfaces.

**Interventions:** physical inspection, and 11 samples taken of material from the WallCAP excavation. These include probable facing stones (CB004, CB005, CB006), core rubble (CB003), and loose sandstone from the cobbled area to the west of the site and south of the Wall (CB010 and CB011); some white material associated with a building to the west of the site (CB009); stones from a field walk to the west of the beck (CB007 and CB008); samples of the local rock (CB002); and a piece of sandstone from the weir crossing the beck at this location (CB001). Thin sections were made of CB001, CB002, CB004, CB005, CB006, CB009, and CB010. The petrology of CB002 is described in section one of this appendix (Quarries and Stone Sources) and CB001 is described in section 3 of this appendix (Post-Roman Structures).

**Archaeological description:** Excavations undertaken by WallCAP (Collins and Harrison 2023) revealed near-complete robbing of the Wall to the east of the Cam Beck. Limited evidence remained for the Turf Wall, and a tower with stone foundations and a finely cobbled floor were found to the south of the Turf Wall. The Turf Wall was replaced with stone in the mid–later 2nd century. All facing stones had been robbed, but extremely deteriorated red sandstone remained of the core of the curtain, the base of an attached tower, and what appears to be the base of a platform for steps or a ramp. Re-used Roman stone, bearing cut recesses and lewis holes were observed in the gorge of the beck, incorporated into a post-medieval leat at the west end of the weir.

**Geological description:** The Cam Beck here runs through a gorge incised into the Kirklinton sandstones exposing cliff sections of this sandstone along its course and immediately adjacent to the crossing point for the curtain. The riverbed here contains banks of cobbles containing a wide variety of geological materials including greywackes, granite, and indurated sandstones. These are from glacial till which has been reworked by the beck.

The stones used in the curtain and other Roman constructions are of red fine-grained sandstone. A number of the pieces of stone were soft to the point of crumbling in hand specimen, others were more robust, notably the larger blocks of stone.

Cobbles of greywacke and granite derived from glacial till were found both as probable core material and in areas which were cobble paved.

A small piece of white material subsequently identified in thin section as limestone (see below – CB009) was found to the west of the excavation.

**Petrographic Analysis**: (Figs A2.21 and A2.22) Samples CB004, CB005, CB006, and CB010 share many petrographic features. All were fine- or very fine-grained sandstones, well or moderately well (CB005 only) sorted. Each is a quartz arenite with between approximately 80–90% quartz grains with the remainder made up of predominantly plagioclase and alkali feldspar, most of which had decayed to clay minerals. Quartz overgrowth is present albeit not extensive, and some quartz grains have undulose extinction. Red iron oxide is present both as grains and as ubiquitous patination of all of the grains.

The matrix of each, in addition to the iron oxide and quartz overgrowth, contained small amounts of clay minerals.

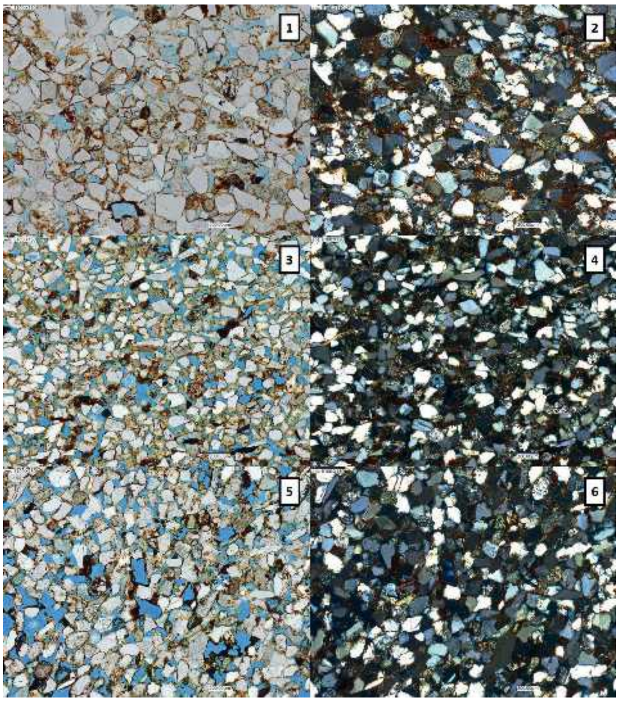


Figure A2.21: (1) CB001 in plane polarised light ×150. (2) CB001 in cross polarised light ×150. (3) CB002 in plane polarised light ×150. (4) CB002 in cross polarised light ×150. (5) CB004 in plane polarised light ×150. (6) CB004 in cross polarised light ×150.

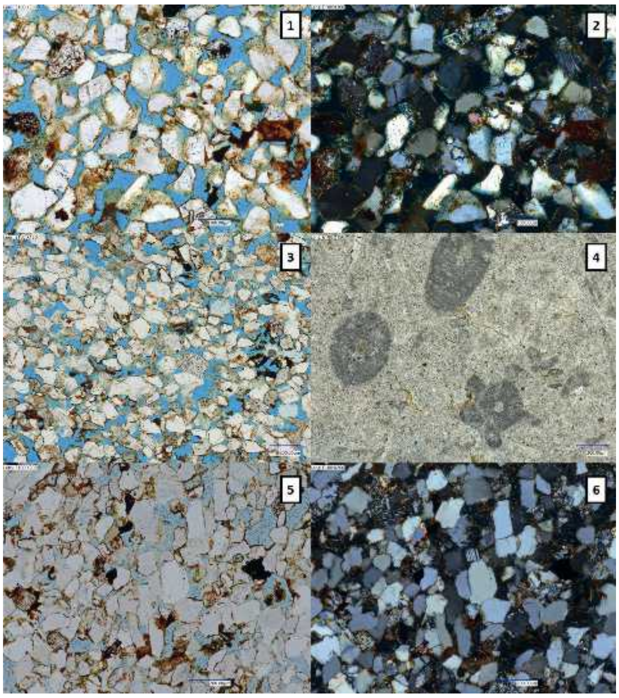


Figure A2.22: (1) CB005 in plane polarised light ×300. (2) CB005 in cross polarised light ×300. (3) CB006 in plane polarised light ×150. (4) CB009 in cross polarised light ×150. (5) CB010 in plane polarised light ×200. (6) CB010 in cross polarised light ×200.

CB004 and CB010 each contain small amounts of mica, CB005 contains a grain of zircon, and CB010 a grain of possible pyroxene.

CB009 is almost entirely made of calcium carbonate as matrix and bioclastic fragments. Identifiable fossil remains include a large number of crinoid ossicles and a few gastropod fragments. These are characteristic of the Carboniferous limestones.

Petrographic analysis of CB001 is given in the first section of Appendix 2 and of CB002 in the last section of Appendix 2

**Results of analysis:** None

**Interpretation:** The source of the fabric is uncertain, but definitely includes distal sources of materials that probably resulted from glacial or fluvial deposition used in the core of the curtain.

### *Port Carlisle*

**Type:** Curtain

**Underlying Geological formation**: Mercia Mudstone Group, Triassic Period.

**Stone type(s) present:** Sandstone

**Interventions:** Excavation, samples collected of representative samples from the WallCAP dig which are likely to be material from the curtain's core with a combination of sandstone fragments (PC001, PC002, PC003, and PC007) that may reflect that used in the facing stones as well as glacial till (PC004 and PC005). Thin sections made

**Archaeological description:** A length of surviving Stone Wall curtain serving as a field boundary between the villages of Port Carlisle and Bowness-on-Solway, with clear upstanding fabric visible to either side of a field gate. Two small trenches were excavated, one at the east end of the field boundary where it intersects with another fence line running north–south to the north, and the second on the south face of the boundary. Both trenches revealed that the curtain was not undisturbed, but rather has been reworked and indeed dismantled over various occasions, subsequently being reconstituted to maintain the boundary, sometimes repositioning Roman fabric to serve as a revetment to the bank/boundary. The only location where the curtain fabric was undisturbed was at the field gate; it seems the gate location prevented the reworking of the field boundary that was seen further east along the line. The curtain at the gate was cleaned of debris and vegetation, planned and photographed, then consolidated.

The curtain fabric is most intact on the south face to the west of the gate, leaving two courses exposed on submerged foundations, with each course consisting of four facing stones. However, the westernmost facing stones have clearly been knocked, slightly damaged, and moved from their original position over the years by large farm vehicles and equipment moving through the gate.

While the measurements here consist of eight stones at most, and only six stones *in situ*, they nevertheless represent the best upstanding and surviving curtain fabric in the westernmost sector of the Wall.

**Geological description:** The curtain here is built on the borderline between salt-marsh peat deposits from the shoreline of the Solway Firth and soil covered glacial till inland. The depth of glacial till here is variable but may be up to 30 m. Underlying the glacial till is the Mercia Mudstone Group. These are not exposed here or locally. Borehole data shows that these strata contain no useful building materials. The ground in the area is low lying and prone to flooding. Raised ground, for example at nearby Drumburgh and at Bowness-on-Solway, is as drumlins created from ice-sheet movement from west to east.

The fragments of material found within the core consists of a mixture of worn greywacke cobbles and angular sandstone fragments. The sandstones are generally red in colour or yellow ochreous in colour.

**Petrographic Descriptions:** (Figs A2.23 and A2.24) Whilst there are some distinct differences between the petrology of the four samples of broken sandstones (PC001, PC002, PC003, and PC007), they have a number of similar characteristics. All the samples of fine- to very fine-grained quartz arenites which are well to moderately well sorted and with subangular grains. Each sample contains between approximately 10 and 20% of mostly decomposed feldspar. All bar PC007 contain grains of zircon and or what has tentatively been identified as pyroxene. Quartz overgrowth is common if variable in extent in all samples.

The samples vary in their mica content. It is rare in both PC001 and PC007, more common in PC002, and relatively and variably abundant in PC003 in which the mica is the principal component defining millimetre scale banding on the rock. PC003 is also unusual in containing what appears to be calcite intermingled with the breakdown products of feldspar.

The samples are also characterised by the amount and type of iron oxide and iron minerals. PC001 and PC007 are similar in having ubiquitous strong patination of their grains in red iron oxide. Both of these samples also contain distinct opaque grains of iron oxide albeit they are more abundant in PC001. PC001 is also markedly banded with individual bands of between approximately 2–10 mm with the banding caused primarily by iron content and by grain size, the iron rich bands being finer grained. PC002 is also banded but more faintly. Iron oxide in this sample is interstitial rather than as grains. It is also associated with a green-coloured mineral which appears to be a breakdown product of the feldspars. PC003 has rare grains of iron oxide and occasional patches of the green mineral observed in PC002.

The range of characteristics observed in these samples is similar to the range of characteristics seen in the set of samples from Maryport.

**Results of analysis:**

*Fabric metrics:*

Factoring in all eight stones, the smallest stone is 28 × 22 cm, while the largest is 35 × 21 cm

The averages below are based only on those six stones *in situ*.

| *Curtain, north face, east* | | |
|---|---|---|
| *Course* | *Ave W* | *Ave H* |
| F (buried) | | |
| 1 | 31.3<br>(3) | 19.3<br>(3) |
| 2 | 34<br>(3) | 20.7<br>(3) |

**Interpretation:** The sandstones observed as fragments in the core are compatible with originating in the St Bees Sandstone Formation. There are a number of possible ways in which this sandstone could have been brought to the curtain from the outcrop of St Bees sandstone that wraps around the outside of Carlisle. Stone from sites relatively near to the wall, such as those at Gelt and Shawk (the latter the nearest land route to Port Carlisle), could have been transported by cart to the curtain and then along the military road. Alternatively stone could have been carried across the Solway at low tides from sites near Annan, a quarter the distance from Shawk. Another alternative would be by boat down the Kirtle Water from quarries around Kirkpatrick Flemming or down the River Eden from Wetheral, another known Roman quarry. Finally boat transport could be used to transport this sandstone from around the Coast at Maryport or St Bees.

The cobbles of greywacke are derived from glacial till, ice-sheets having transported them from Silurian or Ordovician outcrops north of the Solway. These cobbles would be available reworked on the foreshore or within the till adjacent to the curtain. The foreshore is the more likely source as the cobbles would be available in quantity without sifting or separation to make them available.

## Post-Roman Sites

### *Holy Cross Church, Wallsend*

**Type:** Church

**Location:** NGR NZ 3052 6720

**Date of initial construction:** mid-12th century

**Underlying Geological formation:** Pennine Middle Coal Measures Formation, Carboniferous Period

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection

**Building description:** The ruinous condition of the church makes a full survey impossible, and hampered some interpretation of the building, but there is a general consistency of size and geology of stone used.

**Geological description:** The church overlies the Seventy Fathom Post Member of the Pennine Middle Coal Measures Formation. There would also have been a layer of glacial

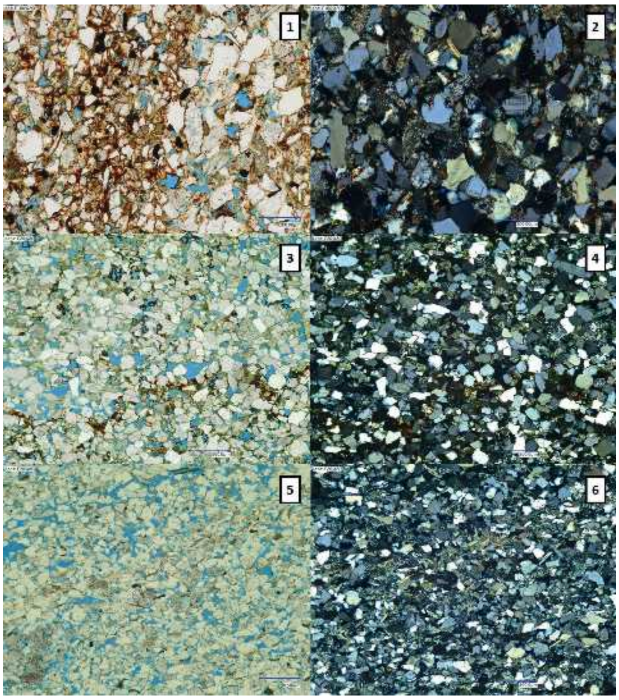


Figure A2.23: (1) PC001 in plane polarised light ×200. (2) PC001 in cross polarised light ×200. (3) PC002 in plane polarised light ×80. (4) PC002 in cross polarised light ×80. (5) PC003 in plane polarised light ×80. (6) PC003 in cross polarised light ×80.

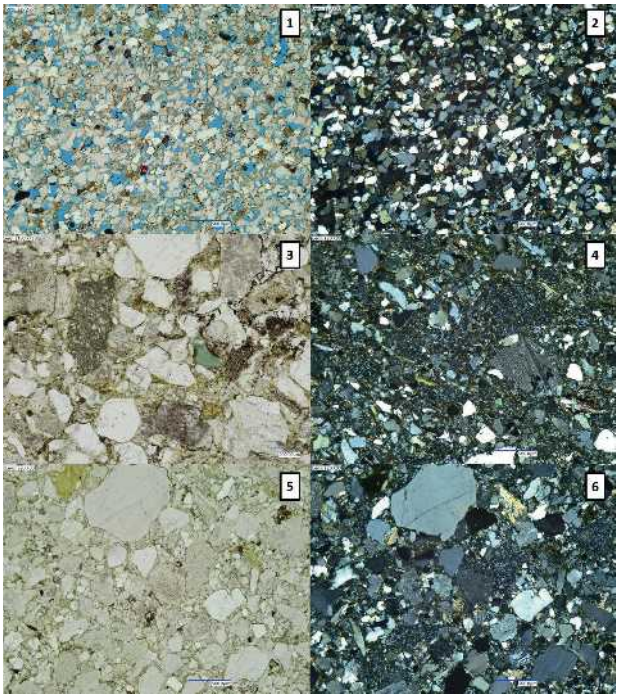


Figure A2.24: (1) PC004 in plane polarised light ×80. (2) PC004 in cross polarised light ×80. (3) PC005 in plane polarised light ×150. (4) PC005 in cross polarised light ×150. (5) PC007 in plane polarised light ×80. (6) PC007 in cross polarised light ×80.

till here of unknown thickness. The Seventy Fathom Post Member Sandstone would have been exposed within the Wallsend Burn and small exposures can still be seen.

The stone used in the church are mostly of a grey/white gritty sandstone with some diagenetic iron banding and marked horizontal and occasionally cross-bedding. There are a lesser number of brown weathering fine-grained sandstone with marked horizontal bedding.

**Results of analysis:** Measurement of 73 stones used in 13 courses on the north face of the southern wall of the main structure (near the arch) provided average measurements of stones 25.4 cm wide and 15.2 cm in height. These broadly fit within a spectrum ranging from 13 × 9 up to 43 × 24 cm.

These sizes are consistent with sizes and shapes available from the Wall curtain, though the proximity of the fort at Wallsend also provided a source for a wider range of stone shapes and sizes.

**Interpretation:** Geologically it is hard to discriminate Wall from non-Wall fabric as the most likely local stone source would have been readily available to both Romans and subsequent builders. The largely robbed structure also means that it is difficult to compare fabric from different phases of construction to further differentiate re-used Roman fabric and freshly prepared stones. These limitations noted, the remaining stonework very strongly points to a Roman source.

### *St Andrew's Church, Heddon-on-the-Wall*

**Type:** Church
**Location:** NGR NZ 1338 6688
**Date of initial construction:** 7th or 8th century
**Underlying Geological formation:** Pennine Lower Coal Measures Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Building description:** While the earliest church was built in stone in the 7th or 8th century, early fabric from this church is limited to the join between the south face of the nave and the east wall of the south aisle. The church was expanded in the 12th and 13th centuries, with subsequent modifications of windows and doors up to the 19th century. The south nave and south aisle bear the most stone with characteristics consistent with Wall-stone.

**Geological description:** The church is built on the top of the highest point in Heddon overlooking the ice and river carved valley of the Tyne. The underlying rocks are of siltstone and mudstone in the Pennine Lower Coal Measures, but there are several sandstones units within the vicinity.

Much of the fabric of the church is built of a gritty buff coloured sandstone which is indistinguishable from the stone used in the nearby curtain and also matches the stone extracted from the nearby quarries to the west of Heddon.

**Results of analysis:** Measurements of prospective Roman fabric were consistent with the size range of stones seen in the consolidated length of Wall nearby.

**Interpretation:** The close match of much of the fabric to Heddon Stone means that whilst it is likely to have been sourced from the local quarries it is not possible to distinguish, purely in terms of the geology, whether they were directly quarried or were re-used from the Wall. An insufficient amount of the earliest stone church remains to ascertain the amount of Wall fabric incorporated into the construction of the church. Subsequent phases of expansion and building in the medieval period almost certainly re-used some of this earlier fabric, and perhaps used additional amounts of Roman stone. Differential weathering and modern pointing of the south faces of the nave and the aisle contribute to a visual difference observed between the Wall and the church, but it seems likely that this is Roman fabric.

### *St Andrew's and St Peter's Churches, Bywell*

**Type:** Church
**Location:** NGR NZ 0483 6148 and NZ 0492 6142
**Date of initial construction:** late 7th–9th century
**Underlying Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Building description:** Two churches occupy the site, St Andrew's is to the west and may have been built as early as the late 7th century, while St Peter's is the eastern church and built in the later 8th–9th century. The tower of St Andrew's seems to contain the greatest amount of re-used Roman fabric, including windowheads, and there is a fragment of Roman sculpted stone over the north door of the church. Medieval phases of expansion appear to have sourced different stone.
**Geological description:** The churches are both built within the alluvium and river terraces of the River Tyne. Underneath these are siltstones and mudstones of the Stainmore Formation, with sandstone units nearby. It is likely that there would have been accessible sandstone on the slope of the hill surrounding Bywell Home Farm.

The fabric of the body of St Andrew's and St Peter's church are made of a distinctive buff coloured sandstone. In the wall of St Andrew this can be seen to have clear horizontal and cross-bedding with some bedding showing strong fining upwards from coarse gritty to fine grained within approximately 30 cm. The tower of St Andrew's from a distance appears to have a much greater mixture of sandstone lithologies. It is in this part of the building that stones with Wall-stone dimensions may be found.
**Results of analysis:** None
**Interpretation:** The stones observed in the tower of St Andrew's have appropriate dimensions and characteristic form to be re-used Wall stones. This could not be refuted or confirmed by the geology.

### *St Andrew's Church, Corbridge*

**Type:** Church
**Location:** NGR NY 9882 6443
**Date of initial construction:** 9th or 10th century
**Underlying Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Building description:** The church re-used a considerable amount of Roman fabric, with the earliest stone structure from the 9th/10th century consisting of the stone tower of the church. The tower is where the majority of Roman fabric is present, though other locations appear to also utilise Roman fabric, probably as secondary or even tertiary re-use from earlier phases of the church. The interior of the tower facing into the nave re-used a Roman arch, including the springer and voussoirs. Re-used Roman stone is mixed throughout much of the structure. For example, the interior north wall of the tower bears two massive blocks with diagnostic Roman characteristics.
**Geological description:** The church is built on a river terrace of the River Tyne, which overlie siltstones and mudstones of the Stainmore Formation. There are underlying sandstones (and limestones) to the east and south across the River Tyne but in this low lying river terrace area outcrops of sandstone would have been absent. Many of the church stones are of a white/grey sandstone with patches of brown iron staining. The sandstone is fine to medium grained and has distinct horizontal bedding visible in some of the stones.
**Results of analysis:** Roman fabric is mixed throughout the structure, but the interior north wall of the tower has two massive blocks (91 × 33 cm, 71 × 53 cm), one of which retains the rectangular cut for a clamp from its previous use, probably from the Roman bridge across the Tyne. Four courses of stones above these blocks measured on average 29.1 cm in width and 16.1 cm in height.
**Interpretation:** Many of the stones observed in the church have appropriate dimensions and characteristic form to be re-used Roman stones. They were most likely sourced from the Roman town of Corbridge, but the Roman bridge over the Tyne also remains a likely source. This could not be refuted or confirmed by the geology.

### *Vicar's Pele Tower, Corbridge*

**Type:** Pele
**Location:** NGR NY 9884 6441
**Date of initial construction:** 14th century
**Underlying Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Building description:** A square, defensive pele tower that served as the vicarage of the church through much of its history. The tower is built to a high standard with a generally consistent size of stone, though larger stones have been selected for use as quoins in the corners and

in some of the lower coursing. The fabric suggests the structure is largely of one phase of construction, with refurbishments and repairs
**Geological description:** The pele tower is built on a river terrace of the River Tyne, which overlie siltstones and mudstones of the Stainmore Formation. There are underlying sandstones (and limestones) to the east and south across the River Tyne, but in this low lying river terrace area outcrops of sandstone would have been absent. Many of the church stones are of a white/grey sandstone with patches of brown iron staining. The sandstone is fine to medium grained and has distinct horizontal bedding visible in some of the stones.
**Results of analysis:** Larger blocks, for example seen on the northern face, measure 43.8 × 34.8 cm on average (based on 5 stones), and those at the northeast corner measure 55.4 × 26.4 on average (based on 14 stones).
**Interpretation:** Some of the stones observed in the pele tower have appropriate dimensions and characteristic form to be re-used Roman stones, which along with carved stones bearing Roman features strongly suggests re-use. However, the Roman town is the mostly likely source for this stonework, rather than the Wall itself. This could not be refuted or confirmed by the geology. Medieval grave slabs incorporated into the tower also indicate the mixed sourcing of stonework in its construction. It may be that the ruins of Roman Corbridge could provide plentiful facing stones and blocks, but slabs were harder to come by, resorting to use of older gravestones from the churchyard itself.

### *Hexham Abbey*

**Type:** Abbey
**Location:** NGR NY 9354 6411
**Date of initial construction:** 7th century
**Underlying Geological formation:** Stainmore Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Building description:** At least two early medieval churches were built in stone, one of which includes the crypt that explicitly displays carved Roman stones (Bidwell 2010). Medieval expansion of the abbey occurred in multiple phases, and seems to have drawn on other sources of stone.
**Geological description:** The abbey is built on river terrace deposits from the River Tyne, which overlie siltstones and mudstones of the Stainmore Formation. There are underlying sandstones on the hill slopes to the south of the Abbey.

The stones observed in the crypt of the Abbey are fine grained homogenous sandstones grey/white to buff coloured.
**Results of analysis:** None
**Interpretation:** Visible Roman stonework appears to be primarily confined to the earliest phases of the abbey. These stones were re-used in subsequent expansions and rebuilds, but are not generally visible. Modern refurbishment, however, may have introduced more regular and newer fabric to the abbey than was historically present.

### *St Giles' Church, Chollerton*

**Type:** Church
**Location:** NGR NY 9311 7192
**Date of initial construction:** 12th century
**Underlying Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Building description:** The current stone church appears to have built in the 12th century, though pre-Norman stonework has been re-used in the exterior north face of the chancel. Other stonework in the chancel and tower bears the appearance and general character of Wall-stone, though this cannot be confirmed. Three Roman columns are used in the south arcade inside the church, and other Roman stones have been found locally or associated with the church. The church received a substantial refurbishment in the 19th century.
**Geological description:** The church is built on glacial till overlying a sandstone unit within the Alston Formation. This sandstone unit would likely have been exposed in the hillside leading down to the River North Tyne.

The fabric of the church is built of buff coloured fine-grained homogenous sandstone with patches of yellow-brown diagenetic iron.
**Results of analysis:** Fabric in the lower courses of the south face of the tower had a similar appearance to Roman fabric from the Wall locally, and displayed a higher degree of weathering than most of the other fabric in the tower. Measurement of 47 of these stones, many retaining tool marks, averaged 27.9 cm in width and 18.7 cm in height, in stones broadly ranging in size from 10 × 6 to 39 × 24 cm.
**Interpretation:** The church is built of a mix of (minimal) Roman and post-Roman fabric.

### *Thirlwall Castle*

**Type:** Castle
**Location:** NGR NY 6595 6619
**Date of initial construction:** 14th century
**Underlying Geological formation:** Alston Formation, Carboniferous Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Building description:** A 14th-century fortified hall house and tower built almost exclusively of Roman fabric, and located a mere 120 m north of Hadrian's Wall. Though incomplete and semi-sleighted, the southwest and northwest exterior walls survive to nearly full height, as do many of the other exterior walls of the structure. The facing stones are generally consistent in size with massive

blocks serving as quoins on all corners, and to frame narrow rectangular windows, giving the castle a consistent appearance at odds with other fortified structures of similar or larger scale, which often display a greater range of fabric size and sources.

**Geological description:** Thirlwall Castle is built on top of a sandstone unit within the Alston Formation. There would have been easy access to both Roman stone and locally quarried stone.

The fabric of the castle is composed of a range of different sandstones to make up its facing stones and a combination of sandstone fragments and glacial cobbles in the core of its walls. The stone types have been analysed in Young *et al*. (2001) and categorised as three different types of sandstone used in the facing stones.

**Results of analysis:**

*Fabric metrics:*

Blocks at the southwest corner and lower window had an average size of 66 × 36.7 cm (based on 7 blocks) and an average depth of 52 cm (based on 6 blocks).

Facing stones in this area ranged in size broadly from 13 × 10 cm to 39 × 20 cm.

**Interpretation:** The shape and style of the blocks used in Thirlwall Castle strongly suggest that they are re-used Wall-stones.

### *Lanercost Priory*

**Type:** Priory

**Location:** NGR NY 5557 6369

**Date of initial construction:** 12th century

**Underlying Geological formation:** Tyne Limestone Formation, Carboniferous Period

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection

**Building description:** A complex structure, whose foundation grant includes the Wall in its holdings. Subsequent land grants incorporated more of the Wall. There is a considerable amount of Roman fabric visible in the interior and exterior walls of the priory, and these point to varied sources and geology. The entire complex was built over a period of 100–130 years, and its structure retains a stark colour contrast of re-used Roman fabric. The lower levels have a preferential use of buff sandstones, while the upper levels are more generally in red sandstones. Carved and

| *Southwest exterior face, between window and SW corner* | | | | *Northwest internal face* | | | | *End of interior wall projecting from northeast external wall* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Course* | *Ave W* | *Ave H* | *Ave D* | *Course* | *Ave W* | *Ave H* | *Ave D* | *Course* | *Ave W* | *Ave H* | *Ave D* |
| F1 | 35.1 (16) | 18 (16) | 46 (1) | | | | | | | | |
| F2 – levelling course | 30.1 (15) | 4.9 (15) | | | | | | | | | |
| F3 – bevelled offset | 63.8 (8) | | | | | | | | | | |
| 1 | 27.1 (15) | 19.7 (15) | 32 (1) | 1 | 24.2 (22) | 13.8 (22) | | 1 | | | |
| 2 | 22.3 (22) | 15.4 (22) | 34 (1) | 2 | 23.7 (23) | 16.7 (23) | | 2 | 22 (7) | 16 (7) | 17 (1) |
| 3 | 26.1 (19) | 16.5 (19) | 56 (1) | 3 | 21.1 (25) | 16.5 (25) | | 3 | 18.5 (8) | 15.5 (8) | 18 (1) |
| 4 | 31.3 (12) | 16.5 (12) | | 4 | 24.8 (16) | 17.7 (16) | | 4 | 24.2 (6) | 16.8 (6) | |
| 5 | 23.2 (17) | 17.8 (17) | | 5 | 20 (13) | 16.2 (13) | | 5 | 22.3 (7) | 18.6 (7) | 30 (1) |
| 6 | 23.8 (17) | 18.9 (17) | | 6 | 23.5 (13) | 16.3 (13) | | 6 | 27 (6) | 15 (6) | 30 (1) |
| 7 | 24.5 (18) | 14.1 (18) | | | | | | 7 | 23.7 (7) | 16.3 (7) | 30 (1) |
| 8 | 23.5 (16) | 18.8 (16) | | | | | | 8 | 23 (6) | 18.2 (6) | 38 (1) |
| | | | | | | | | 9 | 24.2 (5) | 19.6 (5) | 28 (1) |
| | | | | | | | | 10 | 25.2 (5) | 16.4 (5) | 28 (1) |

sculpted stone typical of monastic architecture seems to have drawn on new sources of stone. Roman inscriptions, also from varied Wall locations, are associated with different points of the priory.

**Geological description:** The priory is built on river terrace sands and gravels from the River Irthing. These overlie siltstones and mudstones from the Tyne Limestone Formation. These rocks are stratigraphically beneath the Millerhill Limestone and above the Lanercost Limestone, both of which run nearby. The nearest sandstone outcrops are a few kilometres away on the hillslope by Banks. The priory is also within 300 m of the unconformity with the overlying Permian strata to the west.

The priory and its associated buildings are made of two distinct types of sandstone. The first is fine-grained sandstone with the typical red colour and fine horizontal bedding of the Triassic sandstones. The other type is generally coarser grained and buff to pale brown in colour with common distinct horizontal and cross-bedding laminations and occasional convoluted bedding surfaces. Several of the stones have diagenetic iron patterns. This latter type is more characteristic of one of the sandstones from the Carboniferous succession.

**Results of analysis:** Analysis was restricted to what could be reach from ground level. A more thorough analysis examining upper courses would be beneficial. On the north exterior face of the rectory wall, 18 stones averaged 24.9 cm width and 18.4 cm height. On the exterior face of the south aisle, 3 stones on average 32.7 cm width and 21.7 cm height.

**Interpretation:** The priory is built substantially of Wall fabric, but later new sources also contributed to the buildings.

## *Cam Beck Weir*

**Type:** Weir

**Location:** NGR NY 5107 6390

**Date of initial construction:** Unknown

**Underlying Geological formation:** Kirklinton Sandstone Formation, Triassic Period

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection and a sample taken (CB001) from which a thin section was made

**Building description:** The weir is crescent-shaped in plan-view, sitting on top of exposed bedrock, exaggerating the drop of the beck by approximately 3 m. Repair of the weir in 1741 resulted in the discovery of a large Roman altar (RIB 1983), demonstrating that the earliest weir both pre-dates the 18th century and also made use of Roman fabric. There have been an unknown number of subsequent repairs, but with the most recent dating to the 20th century on the basis of the cement used to patch the top layer of stonework. There is, however, re-used Roman stonework to form a leat or channel at the western end of the weir. A number of stones consisting of slabs and blocks bear evidence of working in the form of rebates and lewis holes, and compare favourably with stones seen at Chesters Bridge Abutment.

**Geological description:** The weir is placed within the incised river channel of the Cam Beck.

**Petrographic Analysis:** (Fig. A2.21) CB001 is a very fine-grained arkose with subangular grains which are moderately well sorted. It has a porosity of 8.7%.

Approximately 70% of the grains in this sample are of quartz the remainder composed predominantly of feldspar, with minor iron oxide and mica and rare possible pyroxene. Undulose extinction is occasionally observed in the quartz grains and quartz overgrowth frequent. Iron oxide is present as grains, as a ubiquitous red-oxide patination of the quartz and feldspar grains. A few fresh grains of plagioclase feldspar are observed along a more significant number of grains in various stages of decomposition.

The limited matrix is of clay minerals and iron oxide.

**Results of analysis:** Not accessible for close metric analysis.

**Interpretation:** It is uncertain the extent to which Roman stonework is extant in the weir, or that Roman stonework has been replaced by early modern and modern repairs. Roman stonework, though can be seen in the construction of the leat or channel at the western end of the weir.

## *St Michael's Church, Burgh-By-Sands*

**Type:** Church

**Location:** NGR NY 3287 5911

**Date of initial construction:** 12th century

**Underlying Geological formation:** Gretna Till Formation, Quaternary Period and the Mercia Mudstone Formation, Triassic Period

**Stone type(s) present:** Sandstone

**Interventions:** Physical inspection

**Building description:** The medieval church is built inside the Roman fort at Burgh-by-Sands, probably over the central range, and the fort platform formed the core of the medieval village. The church itself appears to be completely medieval in origin, and appears to contain a considerable amount of Roman fabric in is structure, mixed with post-Roman sources of stone. Many stones retain clear tool marks, including diamond broaching.

**Geological description:** The church is built onto raised glacial deposits which provide much of the (slightly) higher land in the western sector. This in turn overlies rock strata of the Mercia Mudstone Formation. Little building stone is available in the local area because of the covering of till and even if rock strata were exposed the Mercia Mudstones offer no usable building stone.

There are two distinct types of stone used in the fabric of St Michael's. The first is of the purple-red sandstone with fine horizontal bedding laminations which is typical of the St Bees Sandstone Formation. The second is also fine grained and with fine horizontal lamination in some of

the stones, but is grey/white in colour. It might be tempting to say that these come from the Carboniferous succession, however, their fine grain and the distinct character of their fluvial bedding structures might suggest that they too are from the Triassic St Bees Sandstone Formation. There are quarries, such as Shawk, where there are beds of the St Bees sandstone which are grey/white rather than typical red of this formation.
**Results of analysis:** Survey of ten stones on the south face of the church provided average measurements of 33.8 cm in width and 17.4 cm in height.
**Interpretation:** The size and style of these stones including a number with cross-hatched dressing suggest that they are Roman in origin. The geology of these stones would not contradict this. However, the position of the church within the fort suggests that any Roman fabric that was used is likely to have come from within the fort itself or very proximal to it. This would also account for a generally greater diversity in the size of stones that visually appear to be Roman in date.

### *Drumburgh Castle*

**Type:** Castle
**Location:** NGR NY 2656 5976
**Date of initial construction:** 14th century
**Underlying Geological formation:** Gretna Till Formation, Quaternary Period and the Mercia Mudstone Formation, Triassic Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Building description:** Though originating as a pele tower, the present form of the building is that of a fortified manor house. It has seen numerous refurbishments across the centuries, the most notable in the early 16th century and again in the later 17th century. These refurbishments, however, appear to have focused on doors, windows, and the arrangement of interior spaces. Most of the outer faces retain the uniform appearance of a single phase of construction. The consistency of the stone in size and shape points to very substantial use of Roman fabric in its construction.
**Geological description:** As at St Michael's, Burgh-by-Sands, Drumburgh Castle is built onto raised glacial deposits, here in the form of a drumlin, which provides much of the (slightly) higher land in the western sector. This in turn overlies rock strata of the Mercia Mudstone Formation. Little building stone is available in the local area because of the covering of till and even if rock strata were exposed the Mercia Mudstones offer no usable building stone.

Drumburgh Castle is built consistently of one type of stone. This is the purple-red sandstone with fine horizontal bedding laminations which is typical of the St Bees Sandstone Formation.
**Results of analysis:** Measurement of 6 courses of the south face of the main building structure at the southeast corner, built on top of boulders deposited as glacial erratics or fluvial/inter-tidal zones, consisting of 25 stones averaging 33.7 cm in width and 21.3 cm in height.

Measurement of nine courses on the north face west of the stairs and 17th-century entrance. These 26 stones averaged 30.9 cm in width and 15.9 cm in height.
**Interpretation:** The size and style of the stones along with the presence of a number of Roman inscriptions strongly suggests that the vast majority of the building's fabric is of re-used Wall-stone. The source, however, may be the fort of Drumburgh rather than the curtain. That said, the general consistency in size and shape is more indicative of the curtain as a source than fort buildings. The geology of these stones would not contradict Roman sourcing of the stone.

### *St Michael's Church, Bowness-On-Solway*

**Type:** Church
**Location:** NGR NY 2237 2639
**Date of initial construction:** 12th century
**Underlying Geological formation:** Gretna Till Formation, Quaternary Period and the Mercia Mudstone Formation, Triassic Period
**Stone type(s) present:** Sandstone
**Interventions:** Physical inspection
**Building description:** The 12th-century church has largely retained its medieval features, with most architectural modifications ascribed to the 18th-century restoration. A substantial amount of Roman fabric is used throughout the church, though the varied sizes and shapes of the stone suggest sourcing from the Roman fort at Bowness rather than the curtain of the Wall.
**Geological description:** As at Drumburgh Castle St Michael's Bowness is built onto raised glacial deposits, here in the form of a drumlin, which provides much of the (slightly) higher land in the western sector. This in turn overlies rock strata of the Mercia Mudstone Formation. Little building stone is available in the local area because of the covering of till and even if rock strata were exposed the Mercia Mudstones offer no usable building stone.

St Michael's Bowness is largely built of one type of stone. This is of the purple-red sandstone with fine horizontal bedding laminations which is typical of the St Bees Sandstone Formation. However, as at St Michael's Burgh-by-Sands there are several stones which are white/grey and in addition some which are buff coloured and which on occasion contain diagenetic iron patterns. As with St Michael's Burgh-by-Sands it is probable that these have all been sourced from the St Bees Sandstone Formation.
**Results of analysis:** None
**Interpretation:** The size and style of many of the stones in the church suggest that they are likely to be re-used Roman stones, probably from the fort at Bowness rather than the curtain. The geology of these stones would not contradict this view.

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