A survey of building stone and roofing slate in Falkirk town centre

Minerals & Waste Programme

Open Report OR/13/015

BRITISH GEOLOGICAL SURVEY

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A survey of building stone and roofing slate in Falkirk town centre

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Keywords

Falkirk, building stone, roofing slate, survey, quarries, stone-matching.

Front cover

The Steeple, Falkirk town centre. Original early 19th Century masonry of local Falkirk sandstone at middle levels. Lower levels clad in buff sandstone from northern England in late 20th Century. Spire reconstructed in unidentified sandstone in early 20th Century.

Bibliographical reference

GILLESPIE, M R, EVERETT, P A, ALBORNOZ-PARRA, L J and TRACEY, E A. 2013. A survey of building stone and roofing slate in Falkirk town centre. *British Geological Survey Open Report*, OR/13/015. 163pp.

Keyworth, Nottingham British Geological Survey 2013

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Summary

The British Geological Survey (BGS) has conducted a survey of the building stones and roofing slates in 172 buildings that lie within, and face onto, the Townscape Heritage Initiative (THI) area in Falkirk town centre. The survey was commissioned by Falkirk Council and was conducted by the BGS Building Stone Team in January and February 2013. This report describes the outcomes of the survey. The report also has sections describing a brief assessment of historical quarrying activity in the Falkirk area and the results of stone matching for all the different building stones and slates recorded during the survey. The survey results are presented in this report as a set of maps, but the 'raw' survey data have been delivered independently of this report in a Microsoft Excel table and in a shape file suitable for GIS applications. A folder of digital images of the surveyed building elevations has also been delivered independently of this report.

Twenty different building stones were recorded in the THI area: thirteen are buff sandstone, two are orange sandstone, one is limestone, and four are granite.

All of the buff sandstones were sourced from Carboniferous strata that were laid down between 350 and 300 million years ago. Seven come from quarries in the Midland Valley of Scotland and six are from northern England.

The most commonly encountered buff sandstone ('Buff sandstone 1', recorded in thirty-six buildings) is the 'local' Falkirk stone. This stone was sourced from several quarries to the south of Falkirk, within the Scottish Lower Coal Measures Formation. The oldest surviving buildings (18^{th} Century) in the survey area are constructed from this stone; these are in a vernacular style and are situated in the southern half of the THI area. The youngest surviving buildings containing this stone were constructed in the 1890s. Notable buildings made of 'Buff sandstone 1' include Falkirk Old Parish Church (Fa' Kirk), the Burgh Buildings, and the former YMCA building. It should be possible to obtain new supplies of this local Falkirk building stone from at least one of the original sources: the Bantaskine quarries, just south-west of Falkirk, are still accessible (though overgrown), and consideration should be given to safeguarding this resource.

Six other buff sandstones were sourced from elsewhere in the Midland Valley. The two most commonly encountered ones ('Buff sandstone 2', recorded in twelve buildings, and 'Buff sandstone 4', recorded in fourteen buildings) were probably sourced from quarries between Denny and Stirling that exploited sandstone beds in the Upper Limestone Formation. All of the buildings constructed from these stones are Victorian residential buildings situated in the northern half of the THI area. The stone would have been transported to Falkirk mainly by canal and railway at this time. 'Buff sandstone 3', 'Buff sandstone 4', 'Buff sandstone 5' and 'Buff sandstone 6' are relatively uncommon in the THI area; each was recorded in only three or four buildings. These stones were probably sourced from a number of quarries exploiting several geological formations in the Midland Valley.

The closest-matching currently available stones that could be used for repairs in place of the original buff sandstones from the Midland Valley are mainly from northern England (Derbyshire, Yorkshire and Northumberland); however, several recently re-opened quarries in the Midland Valley supply sandstone that should also provide a good match for some of the original buff sandstones.

All of the sandstone quarries in the Midland Valley had closed by the early part of the 20^{th} century. Stone used in the THI area after that time was sourced from quarries in Derbyshire, Yorkshire and Northumberland. The stone from these quarries has been used mainly in repairs (indents) to older buildings; however, some of these 'modern' buff sandstones have been used to build new shop fronts and building extensions, and three of the surveyed buildings (all constructed after 1930) are built entirely of sandstone sourced from northern England.

The two orange sandstones were sourced from quarries in south-west Scotland (Dumfriesshire) that exploited sandstone strata of Permian to Triassic age (~300 to 230 million years old). Orange sandstone was recorded in nine buildings, all of which are relatively prestigious and were constructed between 1890 and 1927; they include St Andrews West Church and the former Railway Hotel (corner of High Street and Kirk Wynd). New supplies of the orange sandstones can still be obtained today from the same quarries that supplied them originally.

One building in the survey area (probably built in the mid-20th century) is constructed of grey shelly limestone (Portland Limestone) sourced from the Jurassic to Cretaceous age (~150 to 140 million years old) Purbeck Formation in Dorset. Several quarries on the Isle of Portland continue to supply this stone today.

The four granite building stones were recorded in just six buildings. Granite masonry forms the base course in four surveyed buildings, the plinth to a statue, and one set of decorative columns framing a doorway. Two of the granite building stones are grey granite and two are pink granite. All four were probably sourced from quarries in Scotland (Aberdeenshire and possibly Kirkudbrightshire and Mull). New supplies of two or three of the granites can probably be obtained from currently active quarries in Aberdeenshire. An overseas source may be able to provide a good match for the fourth granite.

Six different roofing slates were recorded in the survey area; two are from Scotland (Scottish West Highland slate and Scottish Highland Border slate), two are from Wales (‘Welsh grey’ and ‘Welsh purplish’ slate), one is from the English Lake District (Cumbria), and one is from Spain. Scottish slate was recorded in forty-eight buildings, Welsh slate in thirty-seven buildings, Cumbrian slate in four buildings and Spanish slate in fifteen buildings. Slate is not currently produced in Scotland, and recycled slate (from buildings undergoing repair or demolition) would provide the best source of new Scottish slate to use in repairs. Welsh grey slate would be the closest-matching currently available slate if recycled Scottish slate is not available. Welsh grey and Welsh purplish slate, Cumbrian slate and Spanish slate are all currently being supplied by operating quarries, and it should be easy to obtain new supplies to use in repairs and new-build construction.

1 Introduction

This report describes a survey of the natural stones and roofing slates used in buildings that lie within, or face onto, the Townscape Heritage Initiative (THI) area in Falkirk town centre. The survey was commissioned by Falkirk Council, and was undertaken by the Building Stones Team of the British Geological Survey (BGS).

The project had three main objectives.

(1) Conduct a survey of the buildings within the THI area, recording the different types of building stone and roofing slate and their distribution.

(2) Identify quarries in and around Falkirk that may have supplied stone used in the THI area.

(3) Use stone matching to identify the most suitable currently available building stones and roofing slates to use in repair/restoration work.

Information gathered by the project is intended to inform planning decisions regarding future repairs to stone-built structures within Falkirk town centre. Information of this sort can also help to raise public awareness of the history, character and value of the local built heritage.

The geographical and geological setting of Falkirk is described in section 2. The survey and its outcomes are described in section 3. The results of a brief, desk-top review of the history of building stone extraction in the Falkirk area are presented in section 4. Stone matching for the different building stones and roofing slates recorded in the survey is described in section 5.

The primary survey data have been delivered independently of this report, in a Microsoft Excel table and a shape file suitable for GIS applications. A set of digital photographs – one image of each building at the time it was surveyed – has also been delivered separately.

Figure 1 Topographic map of Falkirk area and modern road infrastructure

Red outline on the main map and inset map is the Falkirk Council area (approximate)

2 Geographical and geological context

2.1 GEOGRAPHICAL SETTING

Falkirk sits approximately in the centre of the Central Belt of Scotland, roughly equidistant from Edinburgh and Glasgow and around four kilometres south-east of the Firth of Forth (Figure 1). The town has for centuries occupied a strategically important position in the centre of the narrowest, most populous, and most industrial part of Scotland, and through-routes have long converged on the area. Drove roads, which brought cattle to markets (trysts) in Falkirk in the 18th Century, were succeeded by highways that generally followed the ancient ways. Later, the Forth and Clyde Canal (1790), the Union Canal (1822), and two railways (1840s) were built through, or close to, Falkirk.

Falkirk town centre is a compact area of irregular streets, wynds and closes lined by buildings constructed in a wide range of architectural styles using natural stone and modern materials. The oldest surviving buildings were constructed in the 17th Century.

The Falkirk Town Centre Conservation area, designated in 1971, includes the main historic parts of the town centre. Falkirk Council was awarded a Round 1 pass for a proposed Townscape Heritage Initiative (THI) in May 2012. The THI area encompasses much of the historic core of the town at the heart of the Conservation Area (Figure 2).

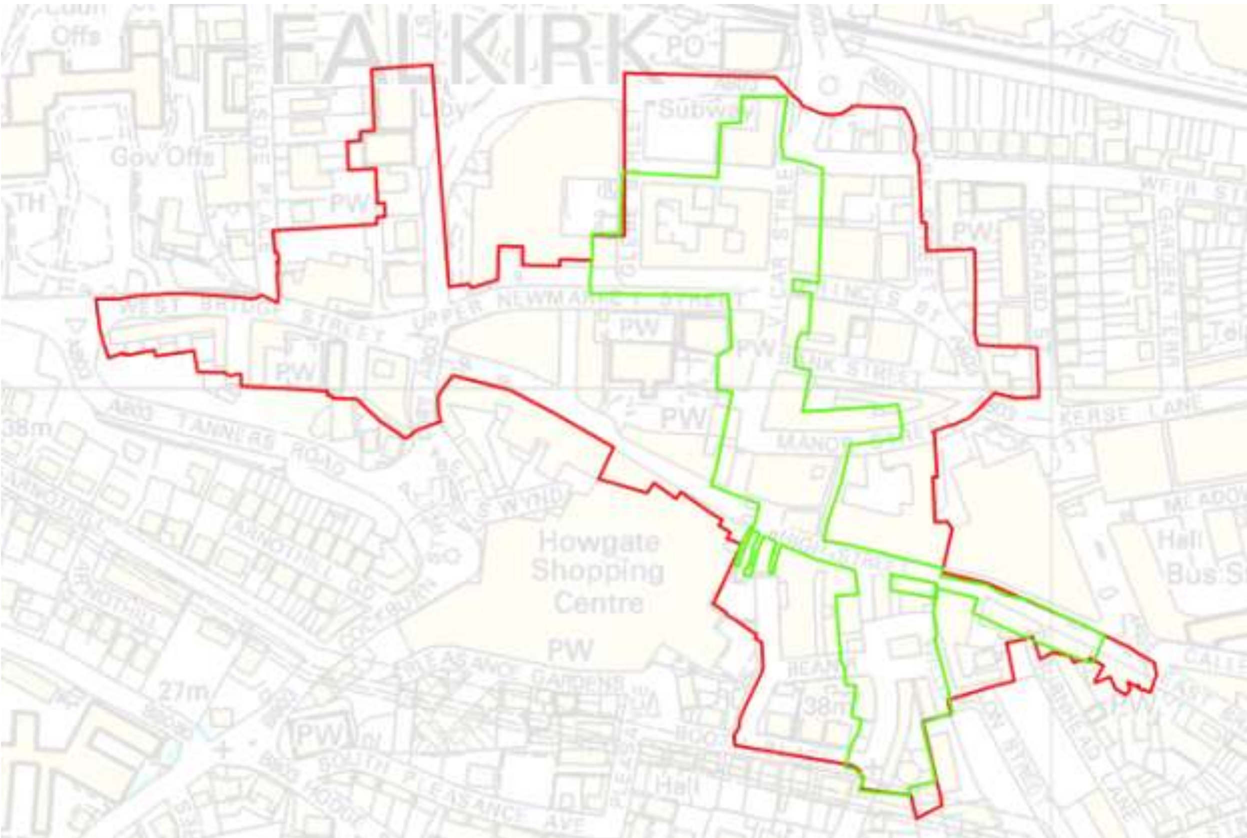

Figure 2 Topographic map of Falkirk town centre

Red outline is the Falkirk Town Centre Conservation Area. Green outline is the Falkirk Townscape Heritage Initiative (THI) area. The map includes mapping data licensed from Ordnance Survey. © Crown Copyright and/or database right 2013. Licence number 100037272.

2.2 GEOLOGICAL SETTING

2.2.1 Introduction

The Central Belt of Scotland is underlain by the *Midland Valley terrane*, one of several major blocks of crust on which Scotland sits (Figure 3). The Midland Valley terrane is bounded by two major geological faults: the Highland Boundary Fault to the north and the Southern Upland Fault to the south. The Midland Valley terrane has been downthrown on these faults relative to the blocks to the north and south, with the result that the rocks underlying the Central Belt are younger than those beneath the Highlands and Southern Uplands. All rocks currently at outcrop in the Falkirk district formed during the *Carboniferous Period*, between approximately 350 and 300 million years ago. At that time, the land that has become Scotland lay close to the equator and the climate was tropical.

The bedrock geology of the Falkirk district is dominated by layers (strata) of sedimentary rock interrupted in places by thick piles of volcanic lava. Tabular intrusions of igneous rock, forming steeply inclined *dykes* and gently inclined *sills*, cut the sedimentary rocks in places. On geological maps and in descriptions of the bedrock geology, the sedimentary and volcanic strata are divided according to their age, position in the sequence, and rock character. The resulting *lithostratigraphy* of the Falkirk district is summarised in Figure 4, and a map of the bedrock geology is presented in Figure 5. The following section should be read while referring to these two figures.

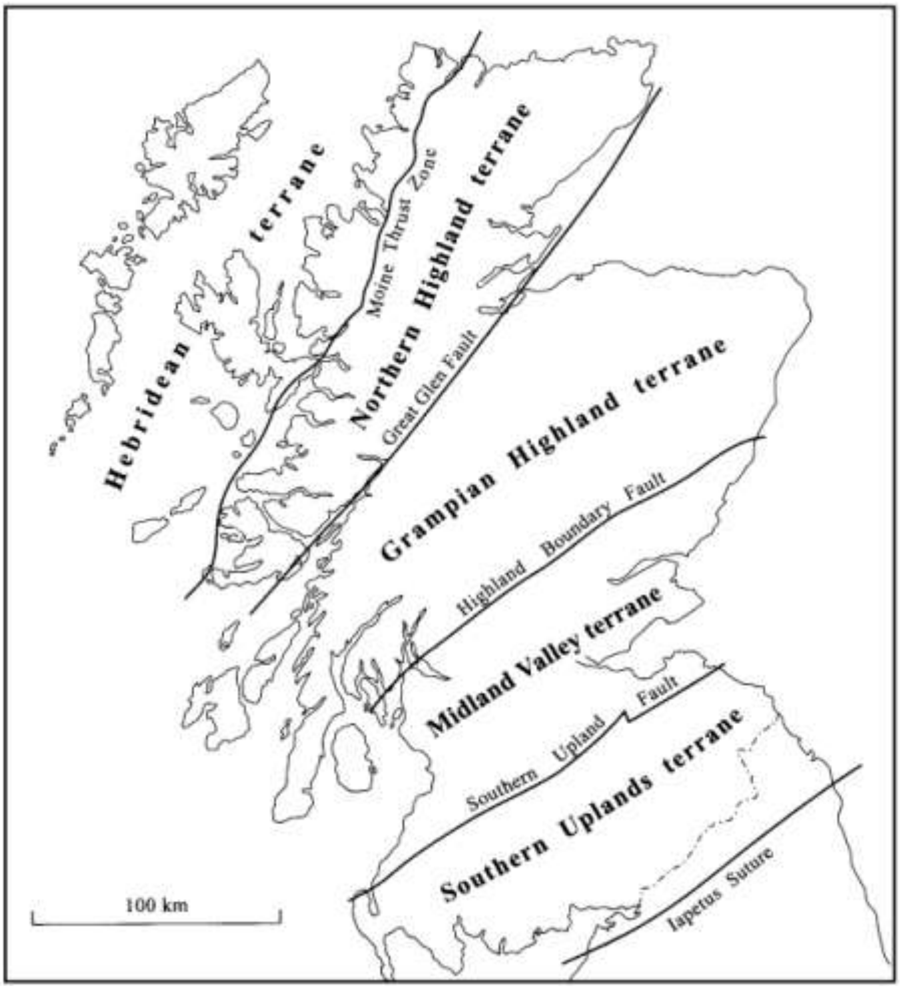

Figure 3 The major geological terranes and geological faults of Scotland

After Trewin and Rollin (2002).

Lithostratigraphy divisions			Age of deposition		
Group		**Formation**	**Million years ago**	**Stage**	**Period**
Scottish Coal Measures Group		Scottish Upper Coal Measures Formation	c. 310-309	Westphalian	Carboniferous
		Scottish Middle Coal Measures Formation	c. 312-310		
		Scottish Lower Coal Measures Formation	c. 314-312		
Clackmannan Group		Passage Formation	c. 318-314	Namurian	
	Bathgate Group	Upper Limestone Formation	c. 323-318		
		Limestone Coal Formation	c.326-323		
		Lower Limestone Formation	c. 328-326	Visean	
Strathclyde Group		West Lothian Oil-Shale Formation	c. 333-328		
		Clyde Plateau Volcanic Formation	c. 345-333		

Figure 4 Lithostratigraphy for the Falkirk district

Each Formation is a sequence of strata that is distinct from the sequence above and below. Each 'Group' unites two or more formations. Information from the BGS Lexicon of Named Rock Units.

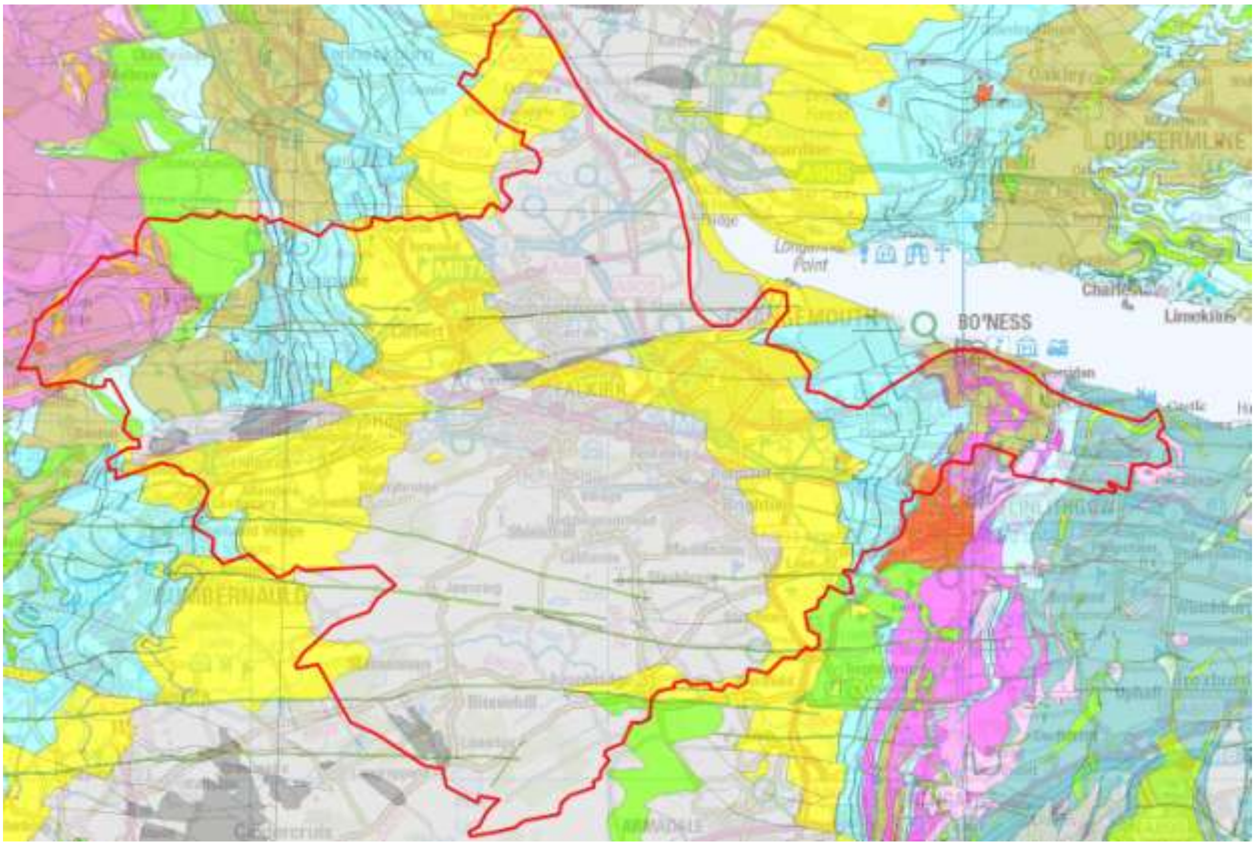

Figure 5 Bedrock geology of the Falkirk district

Colours match those used in Figure 4. The pink area at top left is the Clyde Plateau Volcanic Formation. The pink and orange areas at lower right are the Bathgate Hills Volcanic Formation. Green areas are intrusions (dykes and sills) of igneous rock. The Scottish Upper Coal Measures Formation does not appear on this map. The axis of the Clackmannan Syncline (not shown) runs roughly north-south through the middle of the Scottish Lower Coal Measures Formation (light grey), with the same sedimentary units repeated on either side. Faults have been omitted for clarity. Red outline is Falkirk Council area (approximate). Geology information from BGS DiGMapGB50 (the BGS 1:50,000 scale digital geological map of Great Britain).

2.2.2 Igneous rocks

A thick pile of lava flows forming the *Clyde Plateau Volcanic Formation* underlies the Campsie Fells and Gargunnock Hills in the north-west part of the district. These rocks, formed during the Visean Stage, are the oldest in the district. Another thick pile of lava flows forms the Bathgate Hills Volcanic Formation (part of the *Bathgate Group*). This was deposited slightly later, during the late Visean and Namurian stages, and underlies the Bathgate Hills in the east part of the district. The igneous rocks forming these lava piles generally erode more slowly than the sedimentary rocks between them, hence they tend to form upstanding massifs.

2.2.3 Sedimentary rocks

The sedimentary strata consist principally of sandstone and mudstone. Beds of limestone, coal and (in the oldest rocks) oil shale form a relatively small proportion of the total thickness of sedimentary strata. The sedimentary rocks were deposited as part of a very extensive river and river delta system that occupied most of north-west Europe during the Carboniferous Period. Sediment carried by rivers from a major mountain range to the north was deposited at or near sea level in a subsiding geological basin; the sediment accumulated over tens of millions of years to form a pile of sedimentary strata several kilometres thick.

Dense forests covered the land throughout the Carboniferous Period, and large quantities of plant debris were deposited with the sedimentary materials. Thick accumulations consisting exclusively of plant debris formed from time to time, and these have since become coal. Coal seams are an economically important feature of Carboniferous strata in many parts of the world; the word *Carboniferous* means "coal-bearing", reflecting the fact that coal beds formed globally during this time. Sandstone beds between the coal seams commonly and characteristically contain scattered black fragments of former plant matter.

During the early part of the Carboniferous Period, fine-grained sedimentary strata - including mudstone, limestone and oil shale - were deposited in lake, delta and sea-floor environments; beds of coarser rocks like sandstone are relatively rare. In the Falkirk district these strata form the *West Lothian Oil-Shale Formation*.

Repeating cycles of sedimentation, dominated by sandstone and mudstone but including coal, lasted from the later part of the Visean Stage to the Westphalian Stage. During the late Visean and Namurian stages, fluctuations in sea-level caused periodic marine flooding of the land and these events were accompanied by the deposition of thin but widespread beds of limestone. The strata deposited during this period in the Central Belt have been divided into three lithostratigraphical formations: the *Lower Limestone Formation*, *Limestone Coal Formation*, and *Upper Limestone Formation*. Despite their names, limestone is generally not the dominant rock-type in these units; they consist instead of interbedded layers of limestone, black to grey mudstone, and pale grey, yellow and buff sandstone deposited in repeated cycles. Seams of coal and ironstone are generally rare and relatively thin. In the Bathgate Hills area, marine limestones of Visean age were deposited on the fringes of volcanic islands. An unusual assemblage of animal fossils, including the earliest-known reptile, amphibians and land-based invertebrates, has been recovered from a bed of limestone in East Kirkton Quarry, near Bathgate (Wood et al., 1985; Rolfe et al., 1994).

In the late part of the Namurian Stage, widespread uplift of the crust and erosion accompanied a period of river- (rather than river-and-delta) dominated sediment deposition. The resulting strata, called the *Passage Formation*, consist dominantly of sandstone with subordinate mudstone and relatively rare, thin beds of limestone, coal and ironstone. The sandstones of the Passage Formation are white, pale grey or yellow and occur mainly in beds that are coarse-grained at the base and become finer-grained upwards.

The Westphalian Stage saw a return to a river-and-delta environment in which was deposited the *Scottish Coal Measures Group*. The group is divided into three formations: *Scottish Lower Coal*

Measures Formation, *Scottish Middle Coal Measures Formation* and *Scottish Upper Coal Measures Formation*. The first (oldest) of these has an extensive area of outcrop in the Falkirk district, while the middle one crops out only as small areas within the older unit. The Scottish Upper Coal Measures Formation does not crop out in the Falkirk district; the nearest outcrop lies to the south-west, around Uddingston, Bellshill and Coatbridge. The strata consist of pale yellow, grey or brown sandstone, mudstone, and coal seams, which tend to occur in upward-coarsening cycles with mudstone at the base of each cycle and a coal seam at the top.

The Falkirk district lies in the eastern part of the Central Coalfield of the Midland Valley of Scotland, and most of the district is underlain by coal-bearing strata.

2.2.4 Geological structure

Around 300 million years ago, the Carboniferous strata in the Falkirk district (which originally would have been essentially flat-lying) were folded into a large, shallow 'U' shape: a *syncline*. The axis of the syncline runs roughly north-south; to the north of Falkirk the structure is known as the *Clackmannan Syncline* while to the south of Falkirk it is the *Falkirk–Stane Syncline*. The syncline is asymmetric, with the strata on its west side being gently inclined while those on its east side are relatively steeply inclined. Subsequent deformation caused brittle displacement on numerous geological faults. Many of the larger faults trend roughly east-west, with smaller fault sets in other orientations. Faults are omitted from Figure 5, for clarity.

2.2.5 Post-Carboniferous history

There are no bedrock strata younger than Carboniferous age in the Falkirk district, and little is known of the geological history in the 300 million years that have elapsed since this period.

The entire region was overwhelmed by ice, probably on several occasions, during the geologically recent Quaternary Period (also known as the Ice Age, which began 2.6 million years ago and continues today). At different stages during the Ice Age, ice has eroded the bedrock and deposited new sediment; ice is therefore responsible for much of the present-day topography.

2.2.6 Economic geology

Seams of coal and ironstone within the Carboniferous strata have been mined in many parts of the Falkirk district. Oil shales were also worked in the south-eastern part of the district on the western margin of the West Lothian oil shale field. Mining was at one time the principal occupation, and coal and ironstone were the foundation of industrialisation in the district.

Sandstone for building stone has been extracted from numerous quarries in the district (see section 4), and the igneous rock in dykes and sills has been quarried in many places for aggregate.

Sand and gravel in glacial deposits has been quarried extensively for aggregate and related uses.

3 Survey details and outcomes

3.1 SCOPE, METHODOLOGY AND LIMITATIONS

3.1.1 Scope

The survey of building stones and roofing slates encompassed all of the buildings that are contained within, and face onto, the Townscape Heritage Initiative (THI) area in Falkirk (Figure 2). The THI area includes much of the historic core of the town, including: the most historic sections of Cow Wynd, High Street, Vicar Street and Newmarket Street; all of Kirk Wynd; most of Manor Street, Glebe Street and Melville Street; and short sections of Bank Street and Princes Street (Figure 6). The southern half of the THI area (more or less south of Manor Street) is the oldest part of the town centre. This area is characterised by an irregular street pattern and includes the oldest surviving buildings. In the younger, northern half of the THI area, the streets and buildings have a more regular 'planned' layout.

Figure 6 Map of the THI area in Falkirk town centre, and surveyed polygons

Short sections of Bank Street and Princes Street (not labelled) are shown where they intersect Vicar Street.

The client supplied a GIS shape file in which the location of structures representing discrete buildings is illustrated using polygons (Figure 6). For the purposes of the survey, each polygon was treated as a single building. Information attributed to each polygon in the shape file included two means of uniquely identifying each polygon: an 'FID_1' identifier, which has twelve letters and numbers; and a 'PRIMARY_KE' identifier, which is a six or seven digit number.

182 polygons lie within, or face onto, the THI area. Most of these represent substantial buildings, but they include smaller structures like outhouses and a number of closes and vennels (ten polygons). Closes and vennels were not included in the survey, as they are not buildings. A few polygons have no associated construction of any sort; these presumably represent buildings that have been demolished. 172 discrete buildings/polygons were included in the survey.

Five of the buildings included in the survey are not in publicly accessible areas and do not have a street-facing elevation. These polygons were included in the survey but details for the building stone and roofing slate are not recorded.

Solid, natural stone masonry and roofing slate were assessed for the survey. Building stone used in thin panels as cladding or facing stone was excluded. Stone panels are relatively rare, but different building stones (granite, granite-like stone, and limestone) have been used as facing stone to create decorative base courses in several (typically relatively prestigious) buildings.

Masonry and roofing forming the street-facing elevation(s) of each building was assessed for the survey; other elevations were ignored. It should be borne in mind when using the survey data presented in this report (and in the data table that has been delivered separately), that data recorded against a polygon identifier (FID_1 and PRIMARY_KE) relate only to the street-facing elevation(s) of the associated building, not the building as a whole.

3.1.2 Methodology

Survey data were captured digitally in the field on an Xplore iX104 tablet PC running Microsoft XP. Data were entered directly into a Microsoft Access form designed for the project (Figure 7). The form is divided into four sections – 'Polygon', 'Stone', 'Slate' and 'Image' – and each section contains one or more fields into which data are entered. The full list of field titles and field contents is presented in Table 1. The data content of most fields was constrained by a dictionary (i.e. a pre-determined list of terms). All the dictionaries are presented in Table 2. A 'comment' field in three sections of the form allowed the surveyor to record additional information as free text.

The 'Polygon' section of the form contains information about the building being described. This includes: a sequential identifying number assigned by BGS (ID); the two identifying numbers provided by the client (PRIMARY_KE and FID_1); a field for recording the date of construction, if recorded on the building (BUILDING_DATE); and a field for comments relating to the building or surveyed elevation (ELEVATION_COMMENT).

The 'Stone' and 'Slate' sections contain information relating to building stone and roofing slate, respectively. Three properties were recorded in each section: *visibility*, *name* and *proportion*. More information on these properties is presented below. The main building stone used in walling and dressings was also recorded.

The 'Image' section of the form contains a single field for recording the camera-assigned numbers of photographs taken at the time of the survey. A digital photograph of the surveyed elevation of each surveyed building has been delivered independently of this report. Each image file has been re-labelled with the PRIMARY_KE number of the pictured building, to allow easy cross-reference with the data table. Images have not been provided for five buildings that were in inaccessible locations.

The survey of Falkirk buildings was conducted by Paul Everett (BGS) in January and February 2013. All data recorded during the survey are presented in a single table (Falkirk THI Area Stone Survey Data). Data recorded for each polygon are presented in a single row of the table.

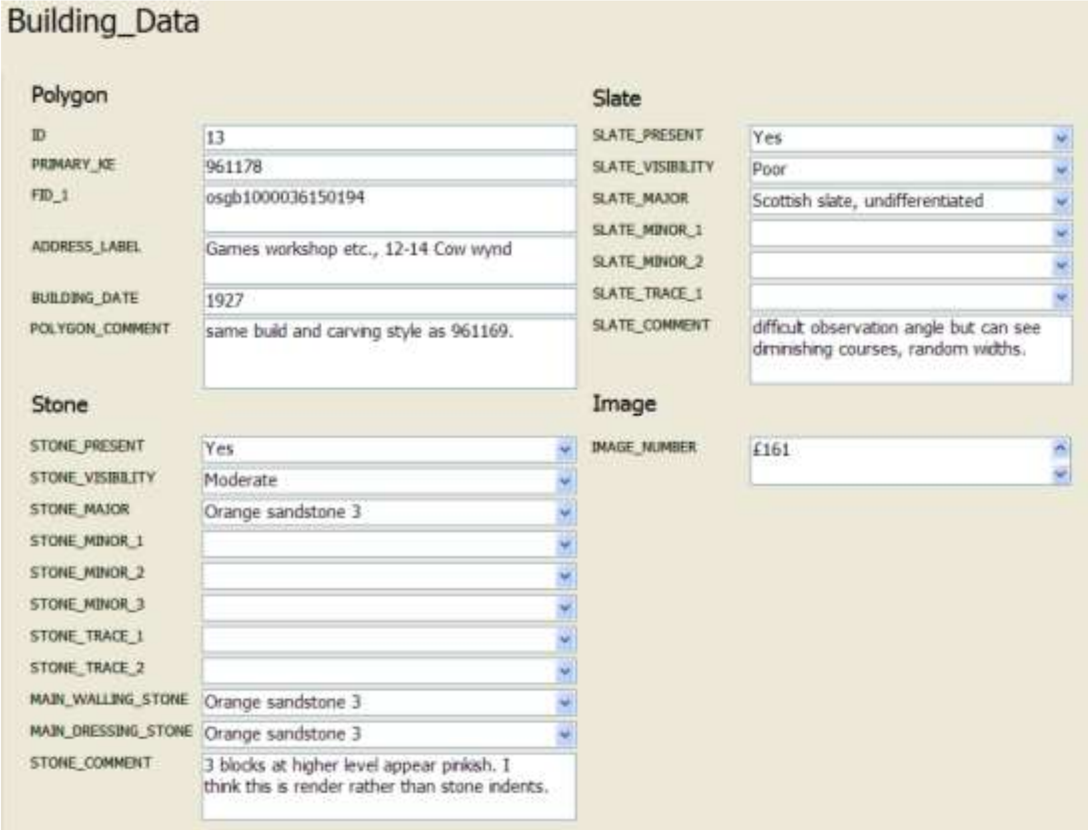

Figure 7 Screenshot of the Microsoft Access data entry form designed for the survey

Note: Data recorded in the ADDRESS_LABEL and BUILDING_DATE fields are not included in the Falkirk THI Area Stone Survey Data table.

Table 1 Content of data fields on the Microsoft Access data entry form

Field name	Field content
Polygon	
PRIMARY_KE	Primary ID number for each surveyed polygon; from polygon shapefile provided by the client
FID_1	Unique ID number assigned to polygons; from polygon shapefile provided by the client
ADDRESS_LABEL	A ‘summary’ address for the building to act as an *aide-mémoire* for the surveyor
BUILDING_DATE	Date of the surveyed building, where known
ELEVATION_COMMENT	Comment regarding the surveyed elevation of each polygon/building (free text)
Stone	
STONE_PRESENT	A record of whether natural stone is present in the street-facing elevation
STONE_VISIBILITY	A record of the visibility of building stone at the time of survey
STONE_MAJOR	Name of major building stone, forming >50% of stone in the street-facing elevation
STONE_MINOR_1	Name of minor building stone, forming 10-50% of stone in the street-facing elevation
STONE_MINOR_2	Name of minor building stone, forming 10-50% of stone in the street-facing elevation
STONE_TRACE_1	Name of trace building stone, forming <10% of stone in the street-facing elevation
STONE_TRACE_2	Name of trace building stone, forming <10% of stone in the street-facing elevation
MAIN_WALLING_STONE	Name of building stone forming the largest proportion in walling of the street-facing elevation
MAIN_DRESSING_STONE	Name of building stone forming the largest proportion in dressings of the street-facing elevation
STONE_COMMENT	Comment regarding building stone (free text)
Slate	
SLATE_PRESENT	A record of whether natural roofing slate is present in the surveyed elevation
SLATE_VISIBILITY	A record of the visibility of roofing slate at the time of survey
SLATE_MAJOR	Name of major roofing slate, forming >50% of slate in the street-facing roof elevation
SLATE_MINOR_1	Name of minor roofing slate, forming 10-50% of slate in the street-facing roof elevation
SLATE_TRACE_1	Name of trace roofing slate, forming <10% of slate in the street-facing roof elevation
SLATE_COMMENT	Comment regarding roofing slate (free text)
Image	
IMAGE_NUMBER	Camera-assigned image number(s)

Table 2 Dictionaries constraining field content on the Microsoft Access data entry form

Field title	Dictionary terms
STONE_PRESENT	Yes
	No
STONE_VISIBILITY	Good
	Moderate
	Poor
	Very poor
	None
MAJOR_STONE MINOR_STONE_ 1 MINOR_STONE_ 2 TRACE_1_STONE TRACE_STONE_ 2 MAIN_WALLING_STONE MAIN_DRESSING_STONE	Buff sandstone 1
	Buff sandstone 2
	Buff sandstone 3
	Buff sandstone 4
	Buff sandstone 5
	Buff sandstone 6
	Buff sandstone 7
	Modern buff sandstone 1
	Modern buff sandstone 2
	Modern buff sandstone 3
	Modern buff sandstone 4
	Modern buff sandstone 5
	Modern buff sandstone 6
	Buff sandstone, undifferentiated
	Orange sandstone 1
	Orange sandstone 2
	Orange sandstone, undifferentiated
	Sandstone, undifferentiated
	Limestone 1
	Granite 1
	Granite 2
	Granite 3
	Granite 4
SLATE_PRESENT	Yes
	No
SLATE_VISIBILITY	Good
	Moderate
	Poor
	Very poor
	None
MAJOR _SLATE MINOR_SLATE TRACE _SLATE	Scottish Highland Border slate
	Scottish West Highland slate
	Scottish slate, undifferentiated
	Welsh slate, purplish
	Welsh slate, grey
	Welsh slate, undifferentiated
	English slate
	Spanish slate
	Slate, undifferentiated

The list of stone names in this table is the *Dictionary of building stones*. The list of slate names is the *Dictionary of roofing slates*.

The terms ‘Not applicable’, ‘Not entered’, and ‘Unknown’ are included in all dictionaries.

3.1.2.1 VISIBILITY

The level of information available to the surveyor at the time of the survey was recorded as a simple, qualitative assessment ('none', 'very poor' 'poor', 'moderate' or 'good') under the heading 'Visibility'. Visibility was recorded separately for building stone and roofing slate, and takes into account two main variables: the degree to which the stone or slate is exposed; and the distance between the surveyor and the stone or slate. For example, visibility was typically recorded as 'good' where the stone is fully exposed and can be examined at ground level (allowing close inspection of fine detail), whereas it may have been recorded as 'poor' where the stone is largely concealed beneath a covering of paint or render, or where the stone is only exposed above ground level (in which case fine details cannot be examined).

Other survey data, in particular the names recorded for stone and slate, should always be considered in the context of the visibility record. Survey data captured when visibility was recorded as 'good' will have a higher level of confidence (or certainty) than those captured when visibility was 'poor'. Visibility may have been recorded as 'none' if a building stone is entirely concealed (e.g. beneath a coating of render), or if roofing slate cannot be seen from any publically accessible area. In such situations the stone or slate generally has been recorded as 'undifferentiated' unless there is separate evidence that allows the identity to be constrained (in which case the 'Comment' field will contain a note describing the evidence). Examples of 'poor' and 'good' visibility are presented in Figure 8.

Shared use of a cherry-picker with architects from Gray, Marshall & Associates on 17th February 2013 provided access to the upper levels of around a dozen surveyed buildings. In some cases, the view from the cherry-picker offered better visibility of the stone and/or slate than was available from street level; such instances were noted in the relevant 'Comment' field of the data table.

3.1.2.2 NAME

The formal names of building stones typically combine the names of the quarry source and the rock type; for example, sandstone sourced from Locharbriggs Quarry in Dumfriesshire is known as Locharbriggs Sandstone, and granite from Kemnay Quarry in Aberdeenshire is known as Kemnay Granite. However, several thousands of different building stones have been used in UK buildings, many of which have similar or overlapping geological characteristics; it is therefore commonly not possible to identify the quarry source of the stone used in a building through field examination alone. For that reason, the various building stones in the survey area were initially distinguished according to their rock type and rock properties.

Several visits to Falkirk were made to distinguish, describe and photograph the range of building stones that is represented in the survey area. Every building was examined to ensure that the full range of building stones was included in this exercise. The resulting 'Dictionary of building stones' (Table 2) is a list of all the stones that can be distinguished by properties and features that are observable in the field. An assessment of the likely quarry source of each building stone was conducted at a later stage in the project (described in section 5), with the benefit of information from a review of local quarrying history and a stone matching assessment.

Unlike building stones, roofing slates used in UK buildings come from a small number of sources, and slate from each source has a set of geological and man-made properties that can be used to identify it (see section 3.3). The 'Dictionary of roofing slates' (Table 2) is therefore simply a list of the names of the slates that traditionally have been used in the UK.

The dictionaries for building stones and roofing slates contain a number of low precision names to ensure that an accurate name could always be assigned during the survey. These names have the word 'undifferentiated' in them; for example, 'Buff sandstone, undifferentiated', and 'Scottish slate, undifferentiated' (Table 2).

Figure 8 Examples of 'good' and 'poor' visibility in surveyed Falkirk buildings

Clockwise from top left: A) A building in which stone visibility is 'good': exposed stone can be examined at ground level. B) A building in which slate visibility is 'good': the angle of view is favourable and the viewing distance to the roof is short. C) A building in which slate visibility is 'poor'; the angle of view is acute, the viewing distance to the roof is relatively long, and biogenic growth partly conceals the slate. D) A building in which stone visibility is 'poor': a shop front at ground level increases the viewing distance to the stone masonry, and paint conceals most of the masonry; small areas of stone are visible where paint has flaked off.

3.1.2.3 PROPORTION

The proportion (or 'amount') of each building stone in a building was recorded semi-quantitatively. Any stone forming more than 50% (by area) of all the stone in the surveyed elevation was recorded as the *major* component. A stone forming between 10 and 50% of the total was recorded as a *minor* component, and one forming less than 10% was recorded as a *trace* component. An individual building can have only one major stone, but one or more other stones can be present in minor or trace proportions.

The same approach was used for roofing slates.

3.1.3 Limitations

The following points should be borne in mind when using the survey data and supporting maps.

- The properties of natural stone and slate (including colour, grain-size and fabric) can vary considerably, even in material sourced from a single quarry. There is therefore always some degree of uncertainty in deciding whether or not the stone in different buildings is related using field observation alone.
- The natural stone in some buildings is partially or wholly concealed beneath an applied coating such as paint or render, or biogenic growth (moss or lichen); in such cases the confidence attached to observations is reduced.
- The survey was undertaken from publicly accessible areas at street-level, and observations are limited accordingly.
- The survey was conducted in January and February, and observations will to some extent have been affected by the low light levels at that time of year.

3.2 BUILDING STONES

Twenty different building stones were identified within the survey area: fifteen are sandstone, one is limestone, and four are granite. Each was assigned a stone code and a stone name, for the purposes of the survey. The codes and names together with a brief description and representative photographs for all twenty building stones are presented in Appendix 1. An assessment of the source of each building stone is presented in section 5.

3.2.1 Building stone character

3.2.1.1 SANDSTONE

The sandstones can be divided readily on the basis of their colour: thirteen are buff and two are orange. Six of the buff sandstones were placed in buildings relatively recently, after all the building stone quarries in the local area had closed. These 'modern' stones have in most cases been used to make selective repairs (indents) to, or to construct extensions on, older buildings, but three relatively recent (post-1930) buildings have been constructed entirely of 'modern' stone.

Sandstones have a number of properties that are visible to the unaided eye and can be used individually or collectively to distinguish them. Some of these properties, notably *colour*, *grain-size*, *primary sedimentary structure*, and *composition*, are intrinsic features (i.e. they are present in all sandstones). Others may or may not be present, and these have been grouped in Table 3 and Appendix 1 under the heading 'Distinctive features'. Summary information for the various properties that have been used to describe and distinguish the various sandstones in surveyed Falkirk buildings is presented in Table 3.

Simple descriptions and the criteria that were used to distinguish the various sandstones in the field are presented in Appendix 1. The terms for sandstone properties that are included in Table 3 are used throughout Appendix 1.

Table 3 Properties used to describe and distinguish sandstone building stones

Property		Description or comment
Intrinsic features	Colour	Recorded as 'base colour' (in this case *buff* or *orange*), with a qualifier term (e.g. *greyish*) and/or a shade term (e.g. *light*) if applicable, to create terms like '*light greyish buff*.
	Grain-size	Refers to the average diameter of sand grains, as follows: *fine-sand-grade* = 0.125-0.25 mm; *medium-sand-grade* = 0.25-0.5 mm; *coarse-sand-grade* = 0.5-1 mm; *very-coarse-sand-grade* = 1-2 mm; *granule-grade* = 2-4 mm.
	Primary sedimentary structure	Refers to structure in sandstone formed at the time the sand was deposited. If no structure is visible the stone is said to be *uniform*. Coarse layering (layers >1 cm thick) is referred to as *bedding*, and fine layering (layers <1 cm thick) is *lamination*. Parallel layers = *parallel bedding* or *parallel lamination*. Cross-stratified layers = *cross-bedding* or *cross-lamination*. Irregular layers = *convoluted bedding* or *convoluted lamination*.
	Composition	Refers to the relative proportions of sand grains composed of quartz, feldspar and rock fragments. Sandstone with a large proportion of quartz grains is *siliceous*, sandstone containing a moderate proportion of quartz is *impure*, and quartz-poor sandstone is *very impure*.
Distinctive features	Micaceous	Refers to sandstone containing a significant and conspicuous proportion of sand grains formed of mica minerals (muscovite and/or biotite). These minerals form flat platelets rather than rounded grains, and are typically aligned parallel to bedding in the stone. They are silvery (muscovite) and black (biotite).
	Carbonaceous matter	Plant fragments (wood, bark, leaves) that have been deposited with the sand grains and have been converted by geological processes into black, carbon-rich matter.
	Iron nodules	Nodules of iron that form in the sandstone. Nodules are usually dark brown to black, spherical to ovoid, and up to several centimetres across.
	Coloured spots	Typically spherical to ovoid, brown to orange patches up to several centimetres across that form around iron-rich minerals or nodules as they break down.
	Liesegang bands	Parallel and often concentric, coloured bands of iron-rich minerals that typically cut across bedding in sandstone.
	Granulation seams	Thin (<2 mm wide) bands of crushed and healed sand grains representing small geological faults.
	Speckled	Describes sandstone characterised by numerous small (mm-scale), more-or-less evenly distributed coloured spots. The spots are usually chemically altered grains of one or more of the constituent minerals in the sandstone.
	Shell fragments	Whole shells or shell fragments that were deposited with the sand grains and were subsequently fossilised.
	Gritty	A texture in which the sand grains are of conspicuously unequal sizes.

3.2.1.2 Limestone

The single example of a limestone building stone in the survey area consists of pale grey, fine-sand-grade to medium-sand-grade limestone with abundant shell fragments up to 10 cm long.

3.2.1.3 Granite

Granites have a number of properties that are visible to the unaided eye and can be used individually or collectively to distinguish them. Some of these, notably *colour*, *grain-size*, *texture*, and *composition*, are intrinsic features (i.e. they are present in all granites). Others may or may not be present, and these have been grouped in Table 4 and Appendix 1 under the heading 'Distinctive features'. Summary information for the various properties that have been used to describe and distinguish granites in surveyed Falkirk buildings is presented in Table 4.

The four granite building stones are readily distinguishable on the basis of colour and texture. Two (G1 and G2) are grey and foliated, and two (G3 and G4) are pink and massive. One grey granite (G2) and one pink granite (G3) are inequigranular and have mafic enclaves. The other grey granite (G1) and the other pink granite (G4) are equigranular and contain no mafic enclaves.

Table 4 Properties used to describe and distinguish granite building stones

Property		Description or comment
Intrinsic features	Colour	Recorded as 'base colour' (in this case *grey* or *pink*), with a qualifier term (e.g. *orangeish*) and/or a shade term (e.g. *very light*) if applicable, to create terms like '*very light orangeish grey'*.
	Grain-size	Refers to the average diameter of crystals in the rock. Granite is, by definition, *coarse-crystalline* (average crystal-size = 2–16 mm). In igneous rocks, the 'coarse-crystalline' size division is divided, as follows: *coarse-crystalline (fine division)* = 2–4 mm; *coarse-crystalline (medium division)* = 4–8 mm; *coarse-crystalline (coarse division)* = 8–16 mm.
	Texture	Refers to geometric aspects of, or mutual relations among, the constituent crystals. Granite is said to be *equigranular* if the constituent crystals are of approximately equal size and *inequigranular* if they are not. *Porphyritic* texture is a form of inequigranular texture in which crystals of one mineral are significantly larger than the typical crystal size in the rock; the term *feldspar-phyric* refers to a porphyritic texture in which crystals of feldspar are significantly larger than the typical crystal size. In a *foliated* rock, some or all of the constituent crystals have a preferred orientation, whereas in a *massive* rock the constituent crystals have no preferred orientation.
	Composition	All granitic rocks have substantial proportions of the minerals quartz, alkali feldspar and plagioclase feldspar. Those containing more alkali feldspar than plagioclase feldspar are *granite*, while those containing more plagioclase feldspar than alkali feldspar are *granodiorite*. The names of other prominent constituent minerals (usually mica minerals) are usually included in the name of the rock, e.g. *biotite granite*.
Distinctive features	Micaceous	Refers to granite containing a significant and conspicuous proportion of mica minerals (muscovite and/or biotite). These minerals form platelets and are usually silvery (muscovite) and black (biotite).
	Mafic enclaves	Typically black, round to irregular patches up to several centimetres across consisting of dark minerals (usually mainly biotite and/or hornblende).

3.2.2 Building stone distribution

Figure 9 shows the distribution of buildings in which natural stone is present in the surveyed elevation. Natural stone is present in 121 buildings, not present in thirty-eight buildings, and in thirteen buildings it could not be established if natural stone was present.

Figure 9 Distribution of buildings containing natural stone

Data recorded in the STONE_PRESENT field have been used to create this map.

Figure 10 shows the visibility recorded for building stone in all surveyed buildings in which natural stone is present. Visibility was recorded as ‘good’ in thirty-six buildings, ‘moderate’ in thirty-three, ‘poor’ in eight, ‘very poor’ in thirty-four and ‘none’ in twenty. As noted earlier, the confidence or certainty attached to other survey data is largely determined by the visibility record, and other survey data should always be considered in that context. Survey data captured when visibility was recorded as ‘good’ will have a higher level of confidence than those captured when visibility was ‘poor’.

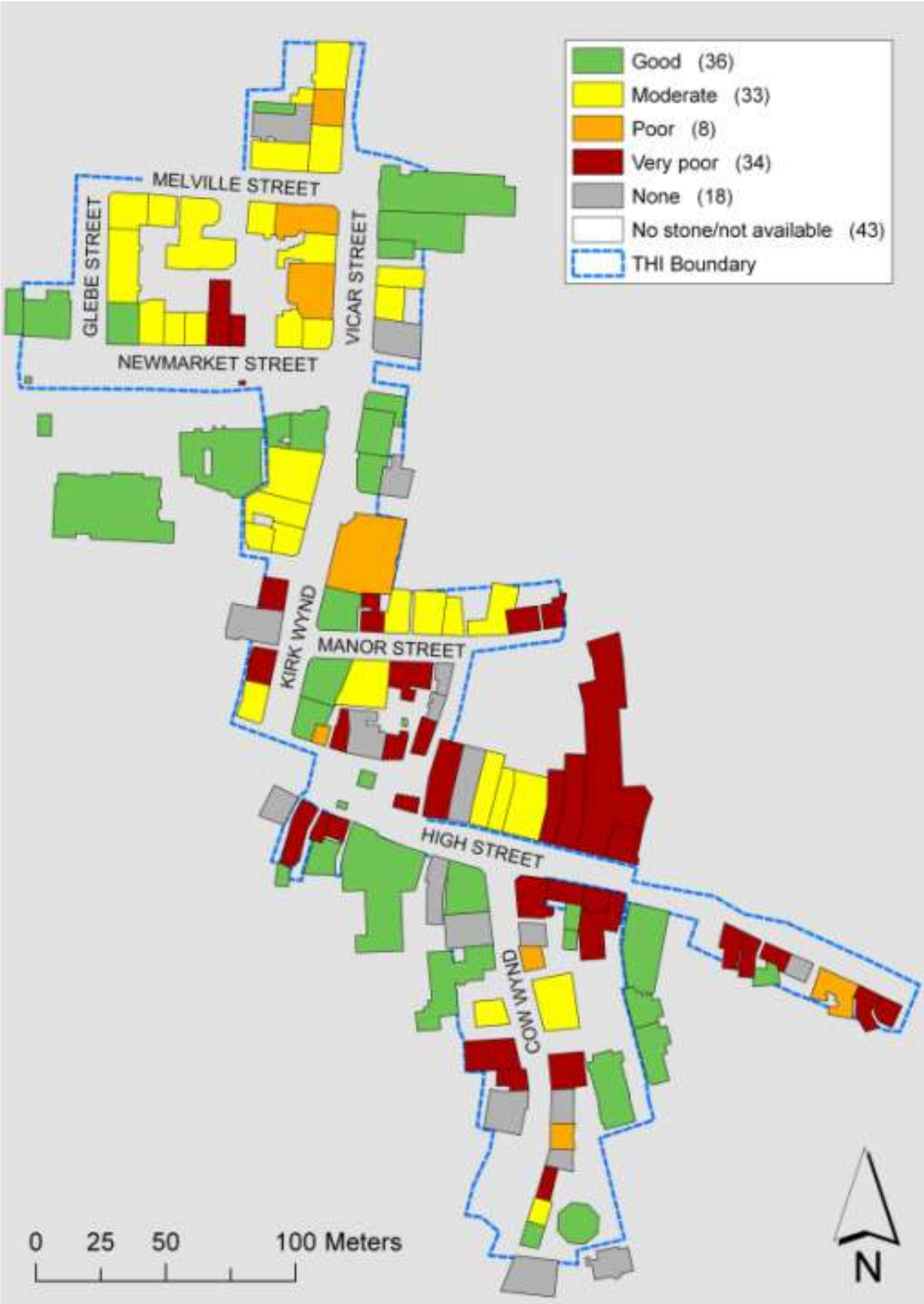

Figure 10 Variation in the level of building stone information available to the surveyor

Data recorded in the STONE_VISIBILITY field have been used to create this map.

Reduced visibility was commonly due to a coating of paint and/or render/harling. Where this was the case, a note was made in the STONE_COMMENT field of the data entry form. Figure 11 has been generated from this dataset.

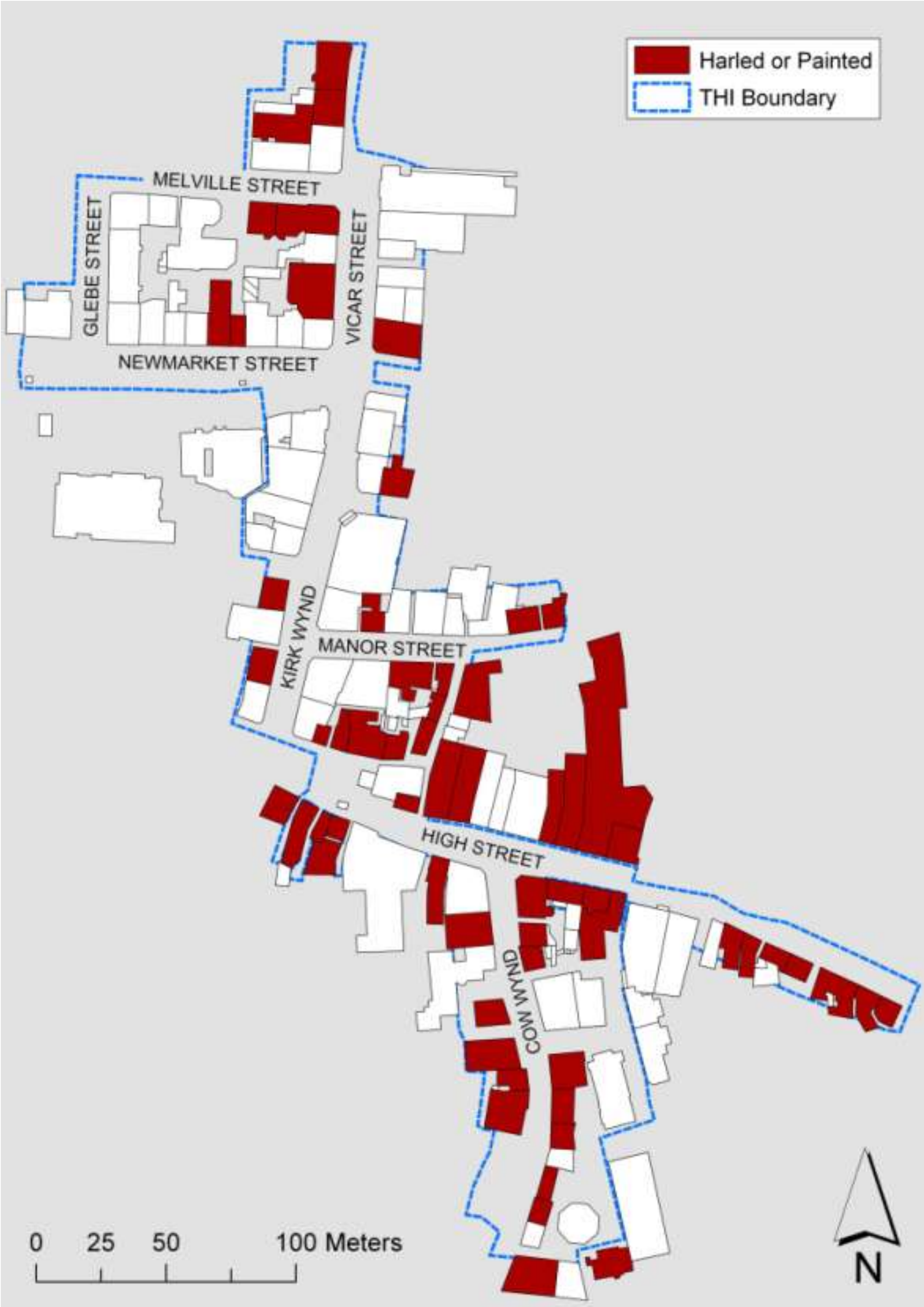

Figure 11 Distribution of buildings with harled or painted street-facing elevations

Maps illustrating the distribution of the various building stones are presented in Appendix 2. Figure A2_1 shows which stone was recorded as the 'major' stone (>50% of the total) in all buildings. Figures A2_2 and A2_3 show which stones were recorded as the main walling stone and main dressing stone, respectively. Figures A2_4 to A2_25 illustrate the distribution of each of the twenty building stones.

The main outcomes of the building stone distribution data are summarised below; reference should be made to the relevant maps in Appendix 2.

- The major stone in twenty-three buildings was recorded as 'Sandstone, undifferentiated'. Most of these buildings face onto High Street. In many cases, a coating of harling or paint concealed or largely concealed the stone, preventing a precise identification, but there was always enough information to identify the building stone as sandstone. Buildings at the east end of High Street are generally old and in the vernacular style, and it is likely these buildings consist of 'Buff sandstone 1'.
- 'Buff sandstone 1' is the most commonly recorded building stone (forming the major building stone in thirty-five buildings) and has the most widespread distribution. It appears in at least one building on nearly all of the streets within the survey area. Date panels on several buildings indicate this stone was used from at least the late 18th Century (pre-1787) until at least the late 19th Century (1880). The stone has been used in buildings displaying a range of architectural styles, from relatively humble, cottage style buildings (e.g. east end of High Street) to relatively prestigious structures such as the Burgh Buildings and Fa' Kirk. The architectural style of some tenement buildings suggests this stone continued to be used into the earliest part of the 20th Century. 'Buff sandstone 1' in a roughly worked rubble walling style has been used in the side elevations of many buildings for which the main street-facing elevation consists of a different building stone.
- 'Buff sandstone 2' and 'Buff sandstone 4' were recorded only in the northern part of the THI area where they have been used mainly in Victorian tenement buildings. Date panels on some buildings range from 1862 to 1895. These buildings, which line much of Melville Street, Vicar Street, and Lower Newmarket Street, occupy a section of the town centre that seems to be a result of late Victorian town planning.
- Orange sandstone is relatively rare. It was recorded in nine buildings that are scattered along the north-south spine of the THI area. Seven buildings to the north of High Street (on Kirk Wynd, Vicar Street and in St Andrews Church West on Upper Newmarket Street) were built between 1896 and 1908. Two buildings on Cow Wynd were built in the 1920s. All the buildings are relatively formal and prestigious.
- 'Buff sandstone 3' was recorded in only three buildings, two of which have date panels recording 1832 and 1845; the third was probably constructed in the 1920s. All three are commercial buildings.
- 'Buff sandstone 5' was recorded in only four buildings, all in the central part of the THI area and with dates ranging from 1909 to 1914. All were probably constructed for mainly residential use; in each case the ground floor is today a shop.
- 'Buff sandstone 6' was recorded in only three buildings, two of which are adjacent on Manor Street. This is a relatively poor-quality building stone; the stone is spalling in places, particularly where blocks have been face-bedded. These buildings have no date panels, but their style and locations suggest they pre-date 1890.
- 'Buff sandstone 7' was recorded in only three buildings. Two are essentially the same tenement building on Williamson Street, the other is a largely brick building at the opposite end of the THI area. In each case, the stone has been used only in dressings.
- The six modern building stones ('Modern buff sandstone 1' to 'Modern buff sandstone 6') were recorded in a total of nineteen buildings. Two of these contain two 'modern' building stones, while the remainder contain only one. Modern buff sandstones are present mainly as indents to the original masonry, but two buildings have new shop fronts

constructed of modern stone and three (possibly four) buildings (the oldest dated 1930) consist entirely of modern buff sandstone.

- Limestone was recorded in only one building, at the east end of High Street. The large 20th Century building features marble cladding around the main door.
- Four different granite building stones were recorded in a total of six buildings. 'Granite 3' has been used in three buildings, whereas 'Granite 1', 'Granite 2' and 'Granite 4' each appear in only one building. Granite masonry forms the base course in four buildings. Granite has been used as the plinth for the South African War Memorial on Newmarket Street and as decorative columns framing the main door of the Burgh Buildings.
- The same stone has been used for walling and dressings in all but one of the surveyed buildings (a tenement forming the east side of Williamson Street). Traditional Scottish buildings commonly feature one stone in the walling of the building, and another (typically a higher quality and/or differently coloured stone) in the dressings, and the scarcity of this building style in the survey area is unusual.

3.3 ROOFING SLATES

3.3.1 Roofing slate character

Roofing slate from four countries - Scotland, Wales, England and Spain - has been used widely in Scotland. Unlike stone, slate from each source can generally be distinguished (depending on visibility) by a combination of two sets of properties: geological properties include *colour*, *lustre*, and *surface texture*; man-made properties include *size*, *thickness*, *edge roughness*, *shape*, *number of nail holes*, and *laying pattern*.

Scottish slate was traditionally sourced from three areas of the country - the Highland Border area, West Highlands (Ballachulish and Easdale), and Aberdeenshire - and slate from each of these areas can be identified by its properties. Two variants of Welsh slate - purplish and grey - are distinguished from each other by their colour. The name and code used for each roofing slate, and a summary of the geological and man-made characteristics that were used to distinguish them in the survey of Falkirk buildings, is presented in Table 5.

A photograph showing a typical example of each slate is presented in Figure 12.

Table 5 Properties used to distinguish roofing slates

Name and code		Typical properties	
		Geological properties	Man-made properties
Scottish slate, undifferentiated (SLSu)	Scottish slate, Highland Border (SLSHB)	Grey, purplish grey and greenish grey, occasionally variegated, with a lustre and moderately smooth surfaces. Commonly displays ribboning (banding on the slate surface which is caused by the intersection of bedding with the metamorphic cleavage plane on which the slate has parted).	Variable size Relatively thick Rough edges Shouldered One hole Laid in diminishing courses and random widths West Highland slates are typically larger and thicker than Highland Border slates
	Scottish slate, West Highland (SLSWH)	Black to grey, with rough, variably crenulated surfaces and commonly with scattered cubes of pyrite. Slate from the Easdale quarries is typically more strongly crenulated than slate from the Ballachulish quarries.	
Welsh slate, undifferentiated (SLWu)	Welsh slate, purplish (SLWp)	Purple, uniform, smooth matt surfaces	Often in one standard size Relatively thin Smooth edges Right-angled corners Laid in regular courses Commonly two holes
	Welsh slate, grey (SLWg)	Grey, uniform, smooth matt surfaces	
English slate, Cumbrian (SLEc)		Bluish grey to greenish grey, with typically rough, matt surfaces. The distinctive colour and texture reflects the volcanic origin of the original sedimentary material.	Size is not diagnostic Uniform width Moderately thick Right-angled corners Can be laid in regular courses or diminishing courses
Spanish slate (SLS)		Black, blue-black and dark grey, commonly with a slight oily lustre, particularly when new. Scattered crystals of pyrite are common. Surfaces can be crenulated, but not as strongly as Scottish West Highland slate.	Uniform size Thin to moderately thick Right-angled corners Laid in regular courses

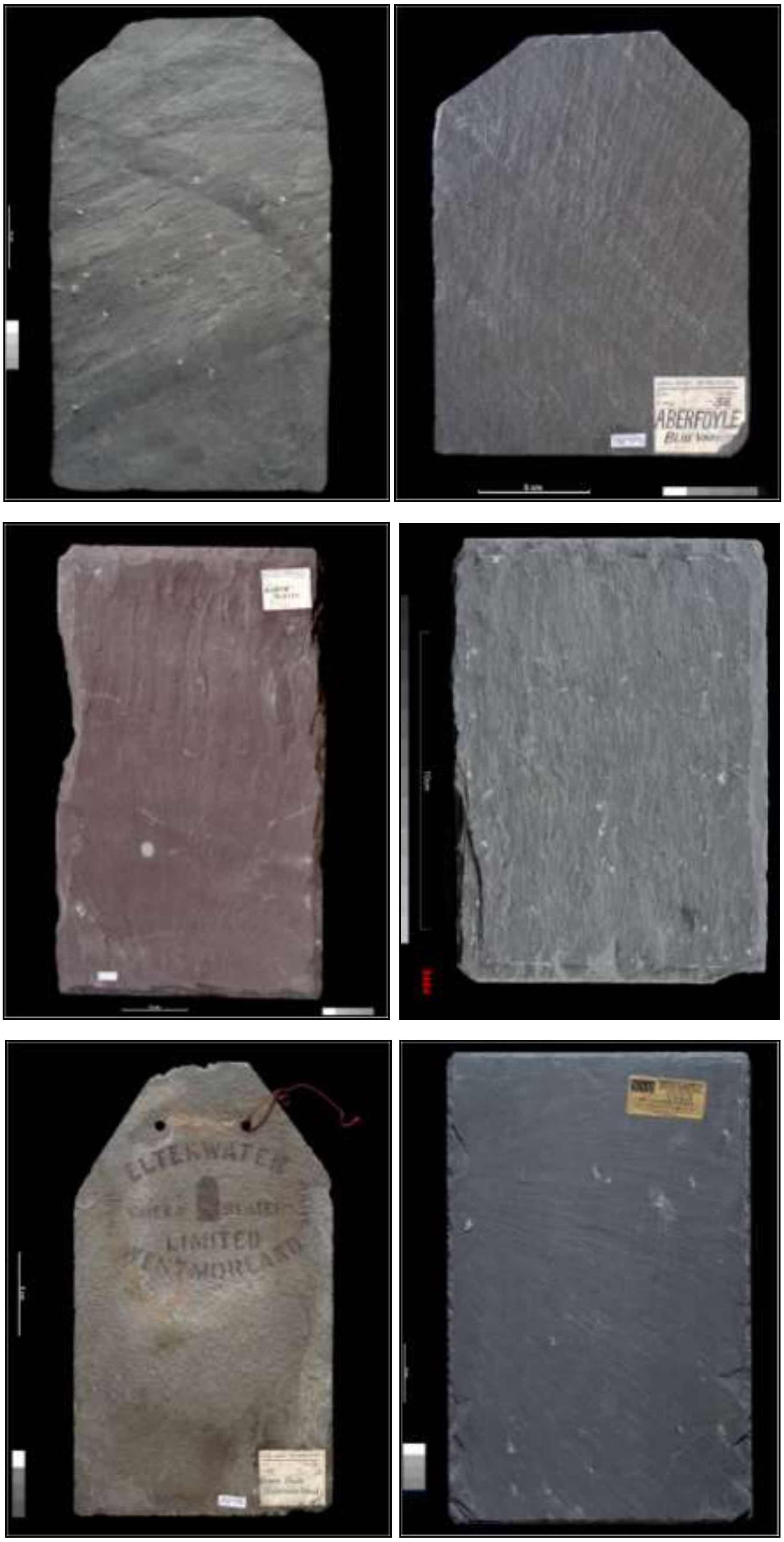

Figure 12 Typical examples of the slates described in Table 5

Top left: Scottish Highland Border slate [SLSHB]; top right: Scottish West Highland slate [SLSWH]
Middle left: Welsh purplish slate [SLWp]; middle right: Welsh grey slate [SLWg]
Bottom left: English Cumbrian slate [SLEc]; bottom right: Spanish slate [SLS].

3.3.2 Roofing slate distribution

The distribution of buildings in which roofing slate is present in the surveyed elevation is shown in Figure 13. Roofing slate is present in 122 surveyed buildings, not present in forty-one buildings, and in nine buildings it could not be established if roofing slate was present.

Figure 13 Distribution of buildings containing roofing slate

Data recorded in the SLATE_PRESENT field have been used to create this map.

Figure 14 shows the visibility recorded for roofing slate in all surveyed buildings in which slate is present. Visibility was recorded as 'good' in nine buildings, 'moderate' in fifty-four, 'poor' in thirty-nine, 'very poor' in thirteen and 'none' in eleven. As noted earlier, the confidence or certainty attached to other survey data is largely determined by the visibility record, and other survey data should always be considered in that context. Survey data captured when visibility was recorded as 'good' will have a higher level of confidence than those captured when visibility was 'poor'.

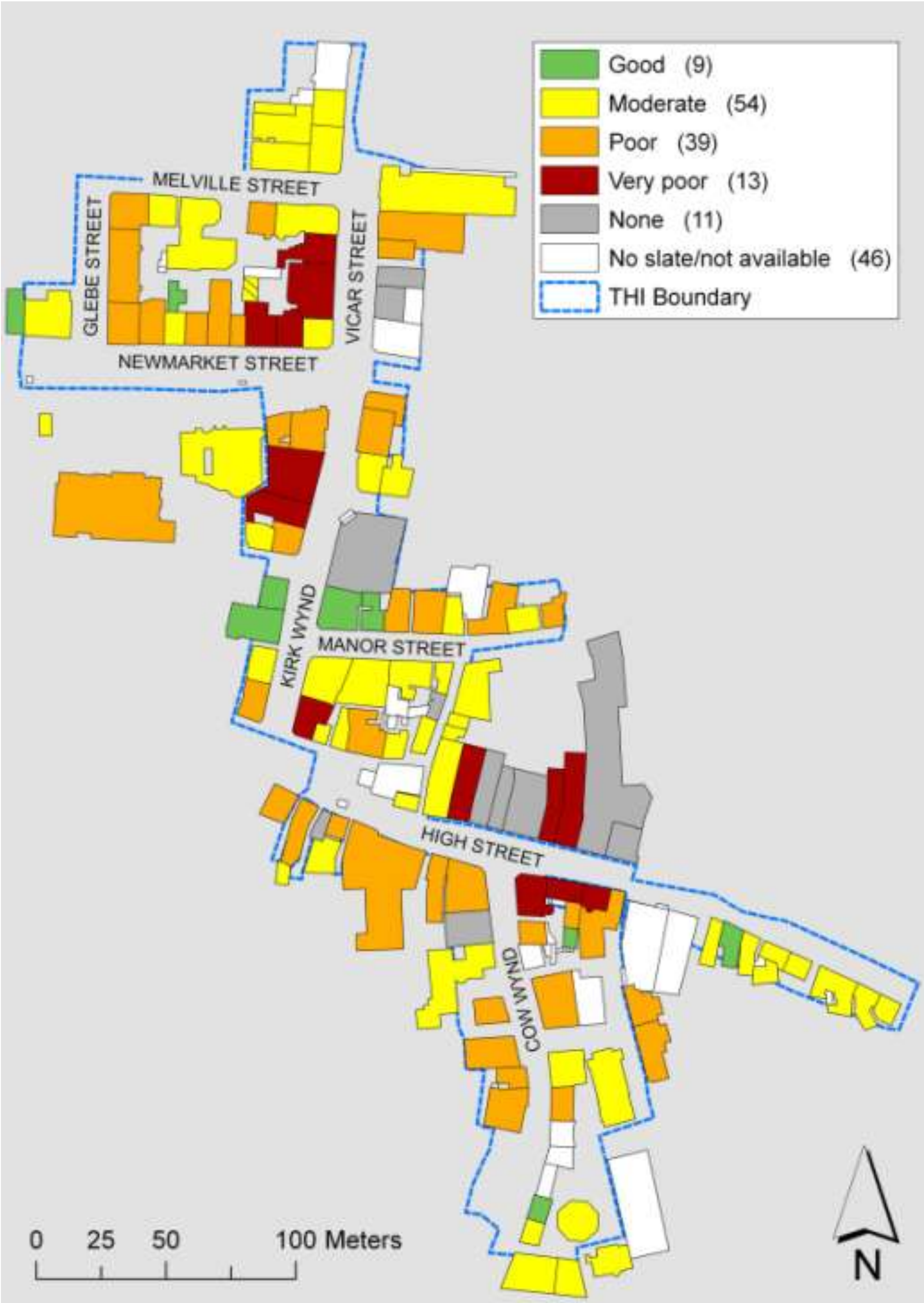

Figure 14 Variation in the level of roofing slate information available to the surveyor

Data recorded in the SLATE_VISIBILITY field have been used to create this map.

Maps illustrating the distribution of the various roofing slates are presented in Appendix 3. Figure A3_1 shows which slate was recorded as the 'major' slate (>50% of the total) in all buildings. Figures A3_2 to A3_10 illustrate the distribution of each roofing slate.

The main outcomes of the roofing slate distribution data are summarised below; reference should be made to the relevant maps in Appendix 3.

- The major slate was recorded as 'Slate, undifferentiated' in thirty-seven of the buildings in which slate is present.
- For the remaining buildings in which slate is present, Scottish slate is the most commonly recorded (47) followed by Welsh slate (26) Spanish slate (9) and English slate (3).
- There are no obvious patterns in the spatial distribution of different slates.

4 Building stone quarries in the Falkirk area

4.1 INTRODUCTION

The objective of this part of the project is to identify quarries in and around Falkirk that have, or may have, supplied some of the stone used in the Falkirk THI area. For the purposes of the project, the assessment was conducted within a rectangular area defined approximately by the north, south, east and west limits of the area administered by Falkirk Council. Information relating to this 'search area' was compiled through a desk-top assessment of BGS resources, historical records, Ordnance Survey (OS) maps, and reference texts. Published reference materials are referenced in the normal way in section 7. Those that have not been published are listed in Table 6. The assessment was conducted relatively briefly, and without visiting libraries and other sources of archived information in Falkirk and the surrounding area. While it provides an overview of quarries and quarrying activity in the area it does not provide a comprehensive account. Details relating to individual quarries are generally held in local archives and a more detailed study would be required to obtain a comprehensive account.

Table 6 Sources of unpublished information used in the assessment of building stone quarries

1	BAILEY, G. 2013. *Falkirk Building Stone.* Message to Emily Tracey, 22 January 2013.
2	BRITPITS (BGS Database of Mines and Quarries, 2012 version). The BritPits database contains records for more than one hundred thousand active and historical mines, quarries and pits throughout the UK.
3	RCAHMS (The Royal Commission on the Ancient and Historical Monuments of Scotland Canmore database) [online]. [Cited February 2013] Available from http://www.rcahms.gov.uk/canmore.html/
4	FALKIRK LOCAL HISTORY SOCIETY. [2005a]. Polmont and Brightons [online]. [Cited 21 January 2013]. Available from http://www.falkirklocalhistorysociety.co.uk/
5	FALKIRK LOCAL HISTORY SOCIETY. [2005b]. Maddiston [online]. [Cited 21 January 2013]. Available from http://www.falkirklocalhistorysociety.co.uk/
6	ORDNANCE SURVEY MAPS (historical Six Inch maps, first, second and third editions).

Some of the sources listed above are also referred to in Table A4_1 (Appendix 4).

4.2 OUTCOMES

The main outcomes of the desk-top assessment of building stone quarries in the Falkirk area are summarised below.

Number and distribution of quarries

The assessment identified 156 quarries within the search area that have produced sandstone for building stone. The locations and names of these quarries are shown in Figure 15, and summary details for them are presented in Appendix 4. No record was found of any stone type other than sandstone (e.g. granite, whinstone, limestone) having been produced within the search area for use as building stone. Basalt for kerb and paving stones has been extracted from quarries near Kilsyth, several kilometres west of the search area.[1]

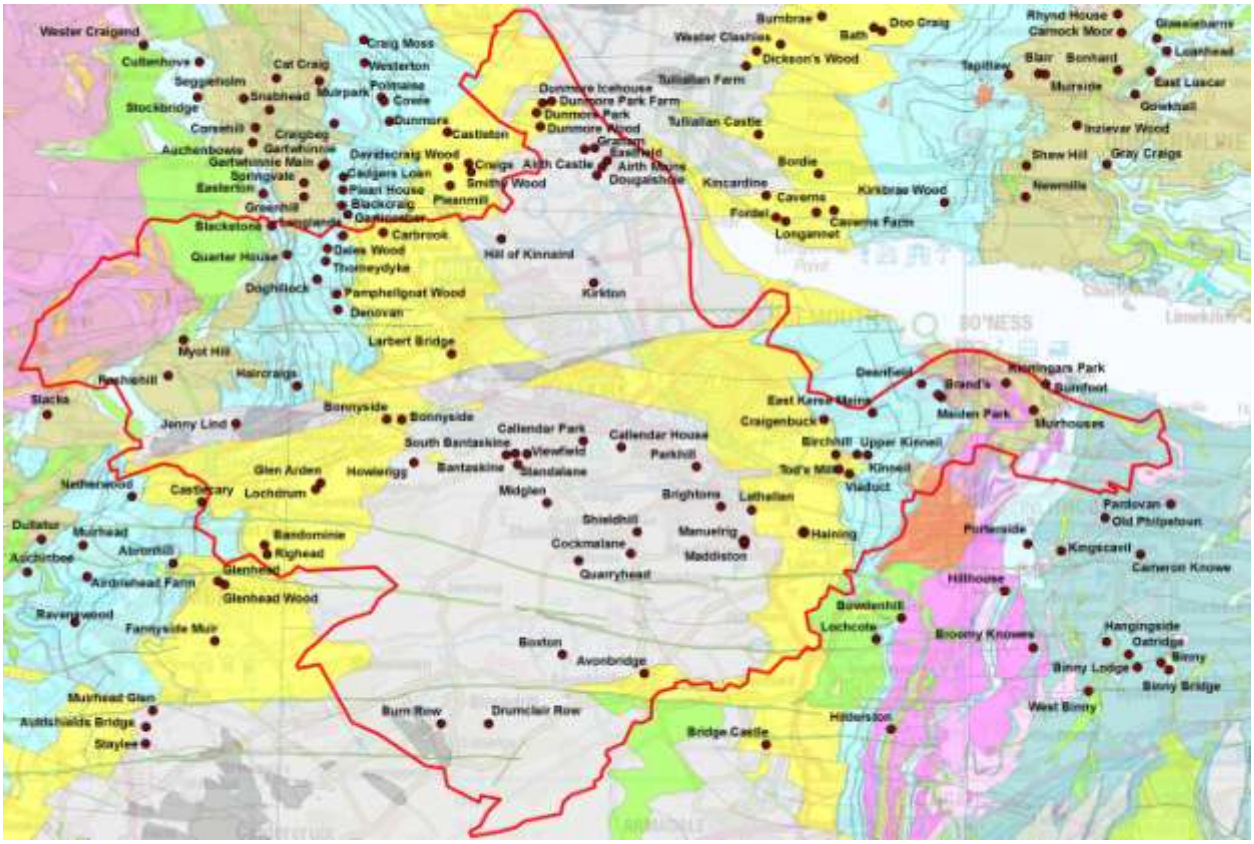

Figure 15 Quarries in the Falkirk area that have produced sandstone building stone

Red outline is the Falkirk Council area (approximate). See Figure 4, Figure 5 and section 2.2 for details of the bedrock geology, and Appendix 4 for a table of summary quarry details.

Sixty-six quarries are within the area administered by Falkirk Council. The remainder are in areas administered by neighbouring councils: twenty-nine are in Stirling, seventeen in West Lothian, sixteen in North Lanarkshire, and twenty-eight in Fife.

[1] Garrel Glen Quarry and Auchinstarry Quarry, Kilsyth, were recorded to be supplying 'inexhaustible' amounts of paving stone during the late 18th Century. The paving stone would have been sent predominantly to Glasgow along the Forth & Clyde Canal. (Rennie, 1796; page 230)

Dates of operation

Written records that pinpoint the start and end of quarrying activity are relatively rare. Old maps can help to place constraints on the timing of quarrying activity, but a detailed examination of this resource is beyond the scope of this assessment. The earliest building stones would have been collected from unconsolidated surface deposits (e.g. riverbed deposits and field boulders) and exposed areas of bedrock, and used in nearby constructions. The first significant quarries probably appeared during the mid- to late-18th Century. Some will have had a single, short phase of activity (providing stone for a specific project) while others will have a longer history, possibly involving intermittent activity. Quarrying activity peaked in the 19th Century in line with major improvements to transport infrastructure, and declined sharply around the turn of the 20th Century. The last building stone quarries in the area ceased production in the early 20th Century.[2]

Present status

None of the building stone quarries in the Falkirk area remains open today. An evaluation of the present condition of the quarries (and hence the potential for re-opening) is beyond the scope of this assessment, but a significant proportion is likely to have been 'sterilised' by, for example, infilling or flooding. The Bantaskine quarries, which probably supplied substantial quantities of building stone to Falkirk (section 5), are still accessible though overgrown.

Bedrock geology

The quarries are relatively evenly distributed across the main sedimentary bedrock units in the search area (Figure 15; see also section 2.2 for a description of the bedrock units mentioned below). Eleven quarries are in the West Lothian Oil Shale Formation, and twelve are in the Lower Limestone Formation; both these units occupy a relatively small proportion of the search area. Twenty-seven are in the Limestone Coal Formation, which also underlies a relatively small proportion of the search area. Thirty-one are in the Upper Limestone Formation, forty-three are in the Passage Formation, and thirty-two are in the Scottish Lower Coal Measures Formation; these units underlie larger proportions of the search area. Thick deposits of unconsolidated sediment (deposited during and since the last glaciation), including sand, gravel, silt and clay, are present in some areas, notably in low ground around the River Forth and Forth Estuary. These deposits will have limited or prevented access to bedrock; hence there are few, or no, quarries in some areas (e.g. around Grangemouth and Stenhousemuir).

Influence of transport infrastructure

Before mechanized transport, Falkirk buildings would have utilised stone that was sourced locally, mainly from quarries to the south of the town. Anything sourced from further afield would have been transported along the Forth Estuary and up the River Carron. As early as 1697 stone was supplied from Airth to build The Steeple in Falkirk town centre (Bailey). The first roofing slates would have come from the Highlands, and these probably would have been transported on drove roads.

The development of engineered transport infrastructure had a significant influence on quarry locations (Figure 16). Substantial quantities of stone would have been required for the Forth and

[2] Maddiston Quarry, Maddiston, near Brightons is one of the few quarries in the search area that was still in operation after the 1899 OS map; the quarry was marked 'disused' on the 1922 OS map.

Clyde Canal[3] and Union Canal (1822) projects, and for the two main rail lines (Edinburgh and Glasgow Railway, opened in 1842; and Stirlingshire Midland Junction Railway, opened in 1850); quarries would have been opened close to these structures, specifically to supply stone. For example, in the mid-19th Century, seven quarries were in operation between Castlecary and Falkirk 'for furnishing stones for the railroad and viaducts' (Burns, 1845; page 19). Many quarries that opened subsequently would have been sited to take advantage of a nearby transport artery; for example, quarrying near Dunipace commenced when the Union Canal opened, bringing stone into Falkirk as well as Edinburgh.[4]

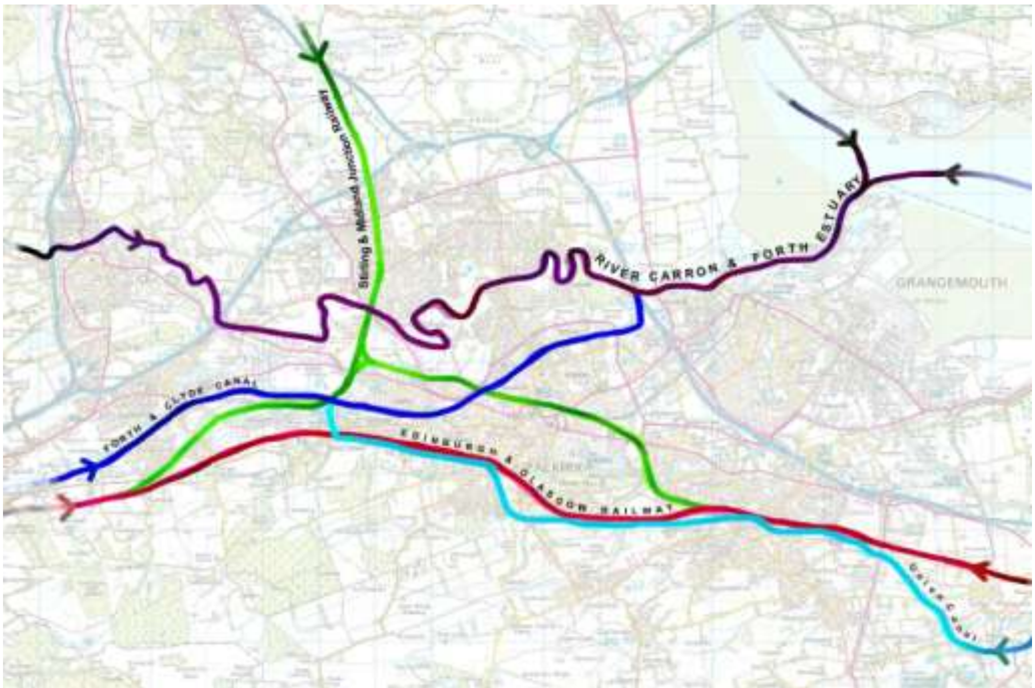

Figure 16 Transport arteries developed in the 18th and 19th centuries in the Falkirk area

The Edinburgh and Glasgow Railway passes through the south side of Falkirk (Falkirk High Station) and the Stirlingshire Midland Junction Railway passes through the north side of Falkirk (Falkirk Grahamston Station). As a direct result of the vastly improved transportation infrastructure, it became economically viable to use building stone from beyond the local area in Falkirk buildings. Stone that was of a higher quality than, or distinctly different to, the local stone was imported from other parts of the UK particularly for use in prestigious buildings. For example, rail lines connected the Midland Valley to the Southern Uplands by 1850 and by the end of the 19th Century Permian orange sandstone introduced from sources in Dumfriesshire and Ayrshire was much in demand for ashlar.

Quarry size and stone distribution

Many quarries would have been created to supply stone for nearby building projects (e.g. a large house, estate buildings or an infrastructure project); these quarries would in general have been relatively small and active for only a short period of time. Others were developed to supply

[3] Work on the Forth & Clyde Canal began in the summer of 1768; by 1775 the canal was fit for navigation, and by 1790 it was fully operational from sea to sea. The canal had such an impact on the area that Sir Lawrence Dundas built a village and quay at the east end of his estate in 1777, now named Grangemouth. Grangemouth Port is one of the main ports in the UK today.

[4] Paving stone bound for Edinburgh and produced by Drumhead Quarry, near Denny, was the first shipment on the Union Canal, in 1822 (Tracey et al., 2011).

building stone commercially (e.g. Binny, Blackcraig [Plean], Dunmore and Polmaise quarries), and these in general are larger and were active for a longer period. The search area includes several quarries that have produced well-known and widely used building stone sandstone; for example, Polmaise (University of Edinburgh McEwan Hall, 1887-97), Binny (Scott Monument, Edinburgh, 1840-4), Dunmore (Coltbridge Hall, St. George’s School, 1875) and Kingscavil (Linlithgow Palace, 15th-17th centuries) quarries.

Links to Falkirk

This assessment has revealed very few records that directly link the stone from a particular quarry to Falkirk THI area, or to the town of Falkirk in general. Such records may exist, but more detailed research on a quarry-by-quarry basis would be required to find them. The information linking building stone quarries and Falkirk is summarised below.

The largest quarries near Falkirk exploited the Scottish Lower Coal Measures Formation, in particular sandstone beds known as ‘Brightons Rock’ below the Armadale Ball Coal. Brightons Rock was discussed by Ker (1845): “the dip of the strata generally is to the north-east, except when their position is altered by a dike which traverses one part of the parish [Polmont], as exemplified in Brighton’s Quarry, when the strata in consequence dip to the north-west”. Brightons quarry supplied good quality brownish rock; Ker (1845; page 192) noted that “stones of any size can be procured”. Building stone from Brightons quarry was shipped to Edinburgh (c.1822) and Falkirk (c.1850) along the Union Canal (Falkirk Local History Society, 2005a).

Brightons quarry is thought to have been active as early as the 17th Century (Falkirk Local History Society, 2005a), and was the only active quarry in Polmont Parish at the time of the 1845 Statistical Accounts; however, the nearby Lathallan quarry was preparing to open at this time. Lathallan quarry exploited a bed of sandstone that was lower in the strata sequence than the stone at Brightons quarry. The stone was white, hard and durable (Ker, 1845; page 192).

The quarries at Bantaskine, south-west of Falkirk, were created to exploit the Upper Drumgray Coal seam, but sandstone beds above and below the coal seam were later quarried and used as building stone (Cameron et al., 1988). A quarry was operating at the time of the 1864 OS map, but is marked ‘Old Quarry’ on the 1899 OS map. The colliery re-opened in 1946; colliery activity peaked in 1954 and ceased in 1959 (RCAHMS/CANMORE).

None of the written records examined for this assessment explicitly link sandstone from the Bantaskine quarries with Falkirk buildings; however, a local authority (Bailey) has suggested anecdotally that sandstone from Bantaskine was a source of building stone for Falkirk. Building stone was probably sourced from these quarries for constructing the canals and railways.

By 1860 several other quarries in the area - including Haining, Maddiston and Mannelrig - were supplying building stone (Hunt, 1860; and OS maps). All quarries were inactive by the turn of the 20th Century with the exception of Maddiston quarry, which was still active when the 1899 OS map was published but had closed by the time the 1922 OS map was published.

Sandstone from quarries in the Callendar House policies was used for the Union Canal and in Falkirk buildings (Bailey). The 1864 OS map shows two quarries: Callendar Park Quarry and Callendar House Quarry (north-east of Callendar Loch); both had closed by 1899 (OS maps). The former is infilled and used as a car park; the latter is partly infilled and overgrown.

During the mid-19th Century, several quarries on the Dunmore Estate near Airth were operated by Falkirk-based owners (Hunt, 1860), and building stone from these quarries might have made its way to Falkirk for use in construction. The Dunmore quarries exploited the Passage Formation, and they supplied both freestone (for masonry) and flagstone (for paving). Many other quarries exploited the Passage Formation, but the sandstone was commonly too soft and coarse grained for dimension stone (Cameron et al., 1988) and was therefore typically used on a small and local scale.

5 Stone matching for buildings in the Falkirk THI area

5.1 INTRODUCTION

Several thousand different building stones have been used to create the substantial built heritage of the UK. However, the great majority of quarries that supplied these stones are now closed, and today new building stone sourced in the UK is being supplied by fewer than two hundred quarries. In most cases, therefore, the stone that was used to construct an historical building cannot be used to make repairs to it. Instead, one of the relatively few currently available stones must be selected (or more of the original stone must be salvaged/recycled from elsewhere).

New stone used to repair buildings should match the original stone as closely as possible in order to maximise the likelihood of achieving a successful, long-lasting repair. Comparing the properties of building stones and roofing slates to constrain their sources and identify the closest-matching materials is known as *stone matching*.

The purpose of this section of the report is to use stone matching to identify currently available stones (section 5.4) and slates (section 5.5) that could be used in future repairs to buildings in the Falkirk THI area.

5.2 STONE MATCHING FOR BUILDING STONES

Stones with a very wide range of properties have been used in the built environment. Some consist of tightly interlocking crystals (i.e. they are *crystalline*) and are therefore essentially *impermeable* - water and air cannot easily get into the fabric of the stone. These include igneous rocks like granite and basalt (the latter sometimes known as 'whin'), and metamorphic rocks like slate. Selecting good substitutes for these stones usually requires matching the stones on the basis of appearance (colour, texture and distinctive features) and functional requirements (e.g. load-bearing capacity); matching the crystal-scale properties of impermeable stones is relatively unimportant.

Other stones are made of loosely packed grains rather than interlocking crystals (i.e. they are *granular*) and are therefore commonly *permeable* - water and air can get into the fabric of many granular stones. Sandstone, the most common and most widespread building stone in Scotland, is granular and usually permeable. Permeable stone is prone to weathering and decay, and it is particularly important that the grain-scale properties of such stones (including the composition of detrital grains and any mineral cement, the character of pore spaces, and the permeability and cohesiveness of the stone) are taken into account during stone matching.

Stone matching in BGS is usually performed in three stages.

(i) The 'original' stone is first subjected to a detailed petrographic examination, to establish the range and character of its intrinsic properties.

(ii) The range of properties is then compared with those of stone samples held in the BGS Collection of UK Building Stones, to constrain the source of the stone. Historical records (if available), and the likelihood that the stone was sourced locally or imported, are also taken into account.

(iii) Finally, the closest-matching currently available stones are identified. If the quarry from which the stone was sourced originally has been identified, and is still open, it will usually provide the closest-matching stone. If the quarry from which the stone was sourced originally has not been identified, or is closed, the closest-matching currently available stones are identified by comparing the properties of the original stone with those of samples of currently available stones held in the BGS Collection of UK Building Stones.

More details of the BGS approach to stone matching for sandstone are presented in Appendix 5.

5.3 SAMPLES AND STONE DESCRIPTIONS

Twenty building stones were recorded in the survey of buildings within Falkirk THI area (section 3 and Appendix 1). Unlike roofing slates, a petrographic description of each building stone is needed for stone matching.

Ideally, a sample of each building stone is collected for petrographic analysis. However, collecting stone samples from buildings is commonly not straightforward: stone suitable for sampling must be reasonably fresh, it must be representative, and it needs to be both accessible and in a discreet location; furthermore, the building owner must give permission for a sample to be collected. The tight timeframe within which this project was undertaken, and the lack of suitable stone in accessible and discreet locations in many of the surveyed buildings, meant that a smaller range of samples was collected than was originally anticipated.

Nineteen samples of stone were collected (Table 7). Twelve of these come from seven different buildings and represent three of the Falkirk building stones: ‘Buff sandstone 1’, Buff sandstone 4’ and ‘Modern buff sandstone 4’. ‘Buff sandstone 1’ is naturally variable in character, and six further samples representing this type of stone were collected from a stockpile of stone (representing a demolished building) adjacent to Tattie Kirk. A single sample was also collected from exposed rock in Viewfield pit (one of the quarries at Bantaskine, on the southern edge of Falkirk). These quarries were an important source of local stone for Falkirk buildings (section 4).

Table 7 Details of collected stone samples

BGS sample no.	Sampled building		Building stone	Thin section
	Name/address	PRIMARY_KE		
ED11047	30 Newmarket Street	963250	Buff sandstone 4	Yes
ED11048-1 ED11048-2	Burgh Buildings, Newmarket Street elevation	963306	Buff sandstone 1	Yes ED11048-1
ED11049-1 ED11049-2 ED11049-3	The Steeple, High Street (original stone at clock level)	961318	Buff sandstone 1	Yes ED11049-1
ED11050	16 Melville Street	963257	Buff sandstone 1	No
ED11052	Viewfield pit, Bantaskine quarries	N/A	Buff sandstone 1	Yes
ED11053-1 ED11053-2 ED11053-3 ED11053-4 ED11053-5 ED11053-6	Demolished wall by Tattie Kirk, off Cow Wynd	N/A	Buff sandstone 1	Yes ED11053-1 ED11053-2 ED11053-5
ED11054	The Steeple, High Street (cladding at lower levels)	961318	Modern buff sandstone 4	Yes
ED11060-1 ED11060-2	25-29 Newmarket Street	963266	Buff sandstone 4	Yes ED11060-1 ED11060-2
ED11061	42 Newmarket Street	963242	Buff sandstone 4	Yes
ED11062	6-8 Cow Wynd	961108	Buff sandstone 1	Yes

A full petrographic description of a building stone has two components: a hand specimen (or 'macro') description, made from an unaided visual examination of a sample of the stone or from the stone surface as it appears in exposed masonry; and a 'micro' description, which is made using microscope examination of a *thin section* (a slice of the stone mounted on a glass plate and thin enough to be transparent).

A hand specimen description was made of all the collected samples, with the exception of three 'stockpile' samples. A thin section was prepared from twelve samples; five from buildings, three from the stockpile samples and one from the Bantaskine quarry sample. The petrographic descriptions and thin section images for these twelve samples are presented in Appendix 6. Building stones for which a sample was not collected were examined *in situ* (i.e. as exposed masonry) in order to obtain the petrographic information required for stone matching. Summary petrographic descriptions obtained in this way for all twenty building stones are presented in Appendix 1.

The following points can be made in regard to sampling and to the stone matching results presented in section 5.4.

- 'Buff sandstone 1' and 'Buff sandstone 4' are the most common building stones in the Falkirk THI area, in terms of the number of buildings in which they occur. These stones are well represented amongst the collected samples and thin sections, and the stone matching results are considered to be robust.
- Other than 'Buff sandstone 2', each of the other buff sandstones appears in only a few of the surveyed buildings. Thin sections of these stones would have helped the stone matching process, but in most cases a good 'field' description was obtained from close examination of the stone in buildings. The stone matching results are therefore considered to be reasonably robust.
- BGS holds samples of all the 'modern' buff sandstones that are commonly used in the UK, and samples of these stones were taken to Falkirk and compared directly with the various modern stones used in surveyed buildings in order to identify the stone (or at least constrain its identity). In most cases, collected samples and thin sections were not essential to produce a robust stone match for the 'modern' buff sandstones.
- Relatively few orange sandstones have been used for building stone in the UK, and the most widely used orange sandstones have reasonably distinctive 'macro' characteristics. There are also very few current suppliers of orange sandstone, and most of the currently available orange sandstones come from the same quarries that supplied the stone historically. This means that a reliable stone match for orange sandstone can usually be performed without a collected sample and thin section, and the stone matching results are therefore considered to be robust.
- The single limestone building stone has distinctive 'macro' characteristics, and a collected sample and thin section were not needed to produce a robust stone match.
- The granite building stones generally display distinctive 'macro' characteristics in the buildings in which they occur. There are also very few current suppliers of granite for building stone in the UK. As described in section 5.2, it is generally not necessary to match the grain-scale properties of granite in order to produce a stone match. A collected sample and thin section were therefore not needed to produce robust stone matches for the granites.

5.4 RESULTS

The results of the stone matching exercise for building stones are presented in Table 8.

The following points should be borne in mind when using the results presented here.

- The list of closest-matching stones has been derived by comparing the Falkirk building stones with samples of stone obtained from currently active quarries. The characteristics of stone from a quarry source can vary over time and from place to place within the quarry; there is therefore no guarantee that a sample of quarry stone held by BGS is representative of the stone currently being supplied by the quarry.
- The inclusion of any stone within the list of ‘closest-matching stones’ does not guarantee that it will weather sympathetically or co-exist harmoniously with the original stone. BGS stone matching is designed to *maximise the likelihood* that a replacement stone and the original stone will be compatible. However, the small number and range of currently available stones compared to those that have been used in the past mean that it is commonly not possible to identify an ideal match. Furthermore, several factors - including the highly variable character of natural stone, the wide range of natural and human factors that can influence stone decay, and the wide range of environmental settings and conditions that masonry can be subjected to - mean that it is not possible to predict with certainty how replacement stone will perform in masonry.
- Stone is a natural material and as such the character of a single building stone can vary from building to building, and even within the masonry of a single building. Furthermore, the character of currently available building stones can change over time as quarries excavate further into the bedrock. The range of stones that is available at any one time also changes, as quarries close and new ones open. For these reasons, it is recommended that a site-specific stone matching exercise should always be conducted. This should be done immediately before repairs are carried out, using a sample from the masonry that will be replaced.
- One or more samples of stone should be obtained from a quarry operator prior to specifying stone for a repair or restoration project, to confirm the appearance and character of the stone currently being supplied.

Table 8 Stone matching results for Falkirk building stones

Building stone		Assessment of stone source	Closest matching stones	Comment
Survey code	Survey name			
SB1	Buff sandstone 1	The 'local' Falkirk stone, sourced from sandstone beds in the Carboniferous age (~313 million years old) Scottish Lower Coal Measures Formation to the south of Falkirk. At different times, Bantaskine, Brightons, Callendar Park, Maddiston and Lathallan quarries, amongst others, would have been important suppliers of the stone used in Falkirk town centre buildings.	Blagdon sandstone Drumhead Buff sandstone (laminated variant) Blaxter's Northumberland Buff sandstone Bearl sandstone	Stone matching based on full petrographic analysis of samples from several buildings and from Bantaskine (Viewfield) quarry.
SB2	Buff sandstone 2	Probably sourced from sandstone beds in the Carboniferous (~320 million years old) Upper Limestone Formation. This unit crops out widely in the Central Belt, and to the east and west of Falkirk. The closest well-known quarries are between Denny and Stirling.	Dunhouse Buff sandstone Witton Fell sandstone Drumhead Buff sandstone (uniform variant) Prudham sandstone Stainton sandstone	Stone matching based on macroscopic examination of exposed stone in buildings.
SB3	Buff sandstone 3	Probably sourced from several quarries in different parts of the Central Belt that produced similar-looking sandstone of Carboniferous age. Possible sources include Humbie Quarry in West Lothian (West Lothian Oil Shale Formation), Craigleith Quarry in Edinburgh (Gullane Formation/Strathclyde Group), and Dunmore Quarry south of Stirling (Upper Limestone Formation).	Hazeldean sandstone Darney White sandstone Cullalo sandstone Drumhead sandstone (white variant)	Stone matching based on macroscopic examination of exposed stone in buildings.
SB4	Buff sandstone 4	Similar in character to the Glasgow 'blond' sandstones (Bishopbriggs and Giffnock types), which were sourced from sandstone beds in the Carboniferous (~320 million years old) Upper Limestone Formation strata that lie beneath Glasgow. The stone used in Falkirk is more likely to have been sourced from sandstone beds in the Upper Limestone Formation between Denny and Stirling.	Prudham sandstone Dunhouse Buff sandstone Drumhead Buff sandstone Witton Fell sandstone Stainton sandstone Darney Cream sandstone	Stone matching based on full petrographic analysis of samples from two buildings.

Table 8 continued

Building stone		Assessment of stone source	Closest matching stones	Comment
Survey code	Survey name			
SB5	Buff sandstone 5	The stone has few distinctive features, and could have come from the Carboniferous successions in the Central Belt of Scotland (Stirlingshire or West Lothian) or northern England; the closest-matching stones in the BGS rock collections are from Northumberland.	Darney Cream sandstone High Nick sandstone Hazeldean sandstone Alnwick Moor sandstone	Stone matching based on macroscopic examination of exposed stone in buildings.
SB6	Buff sandstone 6	Almost certainly a local Falkirk stone of Carboniferous age. The relatively poor quality of the stone suggests it was sourced from the Passage Formation or Scottish Lower Coal Measures Formation.	Blaxter sandstone Prudham sandstone Blaxter's Northumberland Buff sandstone Swinton sandstone	Stone matching based on macroscopic examination of exposed stone in buildings.
SB7	Buff sandstone 7	Probably from an unidentified quarry in the Carboniferous age Passage Formation (or possibly Scottish Lower Coal Measures Formation) within the Falkirk area.	Fletcher Bank Buff sandstone Lingberry sandstone Naylor Hill's Buff Gritstone Witton Fell Coarse Grit	Stone matching based on macroscopic examination of exposed stone in buildings.
SBM1	Modern buff sandstone 1	Stanton Moor quarry in the Carboniferous age (Namurian stage, ~320 million years old) Millstone Grit Group of Derbyshire (or another quarry in the same area that produced very similar stone).	Stanton Moor sandstone Peakmoor sandstone (non gritty) Millknock sandstone Birchover Buff sandstone	Stone matching based on macroscopic examination of exposed stone in buildings.
SBM2	Modern buff sandstone 2	Stoke Hall quarry or Peakmoor quarry in the Carboniferous age (Namurian stage, ~320 million years old) Millstone Grit Group of Derbyshire.	Stoke Hall sandstone Peakmoor sandstone (coarser)	Stone matching based on macroscopic examination of exposed stone in buildings.
SBM3	Modern buff sandstone 3	From an unidentified quarry in the Carboniferous age (Namurian stage, ~320 million years old) Millstone Grit Group of Northumberland.	Dunhouse Buff sandstone Blaxter sandstone Stainton sandstone	Stone matching based on macroscopic examination of exposed stone in buildings.

Table 8 continued

Building stone		Assessment of stone source	Closest matching stones	Comment
Survey code	Survey name			
SBM4	Modern buff sandstone 4	Probably Crossland Hill quarry in the Carboniferous age (Namurian stage, ~320 million years old) Millstone Grit Group of Yorkshire.	Crossland Hill sandstone Peak Moor sandstone Stanton Moor sandstone	Stone matching based on full petrographic analysis. Crossland Hill sandstone would provide the closest match.
SBM5	Modern buff sandstone 5	Carboniferous sandstone. The stone is unlike any currently available sandstone and has not been matched to a sample in the BGS rock collections.	Dovedale sandstone Millknock sandstone	Stone matching based on macroscopic examination of exposed stone in buildings.
SBM6	Modern buff sandstone 6	Has some features of the local Falkirk stone (Buff sandstone 1), but probably sourced from the Carboniferous age (Namurian stage, ~320 million years old) Millstone Grit Group in Derbyshire.	Stanton Moor sandstone (finer) Peakmoor sandstone (finer) Birchover sandstone	Stone matching based on macroscopic examination of exposed stone in buildings.
SO1	Orange sandstone 1	Locharbriggs quarry in the Permian age (~280 million years old) Stewartry Group of Dumfriesshire.	Locharbriggs sandstone Corncockle sandstone	Stone matching based on macroscopic examination of exposed stone in buildings.
SO2	Orange sandstone 2	Corsehill quarry and/or Cove quarry in the late Permian to Triassic age (~240 million years old) Sherwood Sandstone Group of Dumfriesshire.	Corsehill sandstone Cove sandstone	Stone matching based on macroscopic examination of exposed stone in buildings.
L1	Limestone 1	Portland limestone from the Purbeck Group in Dorset. The rock was deposited in the Jurassic and Cretaceous periods (~150 to 140 million years ago).	Portland Whitbed stone	Stone matching based on macroscopic examination of exposed stone in buildings.
G1	Granite 1	Kemnay granite from the Ordovician age (~460 million years old) Kemnay Granite Pluton in Aberdeenshire.	Kemnay granite	Stone matching based on macroscopic examination of exposed stone in buildings.
G2	Granite 2	Dalbeattie granite from the Devonian age (~400 million years old) Criffel Granite Pluton in Dumfriesshire **or** Rubislaw granite from the Ordovician age (~470 million year s old) Aberdeen Granite Pluton in Aberdeenshire.	There may be no good matching stone available in the UK; an overseas source may be required.	Stone matching based on macroscopic examination of exposed stone in buildings.
G3	Granite 3	Peterhead granite from the Silurian age (~420 million years old) Peterhead Granite Pluton in Aberdeenshire.	Peterhead granite (Stirlinghill quarry)	Stone matching based on macroscopic examination of exposed stone in buildings.

Table 8 continued

Building stone		**Assessment of stone source**	**Closest matching stones**	**Comment**
Survey code	Survey name			
G4	Granite 4	Possibly Corrennie granite from the Ordovician age (~450 million years old) Corrennie Granite Intrusion in Aberdeenshire **or** Ross of Mull granite from the Silurian age (~420 million years old) Ross of Mull Granite Pluton on Mull.	Corrennie granite	Stone matching based on macroscopic examination of exposed stone in buildings.

Contact details for current suppliers of the closest-matching building stones are presented in Appendix 7.

5.5 STONE MATCHING FOR ROOFING SLATES

Slate matching is generally simpler than stone matching because most of the traditionally used slate in the UK has come from a small number of geographically distinct sources, and slate from each source typically has a set of distinctive characteristics by which it can be recognised. Detailed petrographic descriptions of roofing slates are therefore not required for matching. However, restricted visibility during the survey (see section 3) means that in many cases a low-precision name has been assigned (e.g. 'Welsh slate, undifferentiated'; or 'Slate, undifferentiated'). In such cases, a closer inspection of the roofing slate (e.g. by cherry picker) than was possible during the survey will be needed to assign the high-precision name (e.g. 'Welsh slate, grey') that will enable selection of the correct matching slate.

Six different roofing slates were recorded in the survey of buildings within Falkirk THI area (section 3). The slate matching results are presented in Table 9.

None of the Scottish slate quarries is in operation today, but several slate quarries in Wales, England and Spain are open.

Scottish slate is typically relatively thick and has traditionally been laid in diminishing courses with random widths; in other words, the overall size of the slates increases from the top row (*course*) to the bottom row on the roof, and the width of individual slates in all rows is variable. Slate from other sources is typically thinner and has traditionally been supplied in more regular sizes, so it can be difficult to replicate the style of a Scottish slate roof using slate from elsewhere. For that reason, Scottish slate re-cycled from buildings undergoing repair or demolition would provide the best source of matching slate for buildings roofed with Scottish slate. Alternatives are suggested in Table 9 if that option is not possible.

Table 9 Stone matching results for Falkirk roofing slates

Roofing slate		Slate source	Closest-matching slate
Survey code	Survey name		
SLSHB	Scottish slate, Highland Border	Several quarries that exploited a band of slate developed on the north side of the Highland Boundary Fault (see Figure 3). Notable quarries were located at Luss, Aberfoyle and Dunkeld.	Scottish Highland Border slate is not currently being quarried. The possibility of obtaining recycled Scottish slate (from buildings being refurbished or demolished) should be considered for large-scale repairs. Welsh grey slate is the closest-matching currently available slate and could be used in selective repairs to roofs of Scottish slate. Wherever possible, replacement slates should be laid in the typical Scottish roofing style (diminishing courses and random widths).
SLSWH	Scottish slate, West Highland	A cluster of quarries at Easdale and on Luing (on the coast south of Oban) or quarries at Ballachulish.	Scottish West Highland slate is not currently being quarried. The possibility of obtaining recycled Scottish slate (from buildings being refurbished or demolished) should be considered for large-scale repairs. Welsh grey slate is the closest-matching currently available slate and could be used in selective repairs to roofs of Scottish slate. Wherever possible, replacement slates should be laid in the typical Scottish roofing style (diminishing courses and random widths).
SLWg	Welsh slate, grey	Quarries in north Wales, probably mainly those at Porthmadog and Ffestiniog. These quarries have produced mainly grey slate but greenish and purplish slate have also been produced here.	Welsh grey slate is currently available.
SLWp	Welsh slate, purplish	Probably from Penrhyn quarry in north Wales. The slate produced here is mostly purplish, but grey and greenish slate has also been produced.	Welsh purple slate is currently available.
SLEc	English slate	English Lake District (Cumbria). There are notable quarries at Kirkby-in-Furness, Honister, Elterwater and Broughton Moor.	Blueish grey and greenish grey English Cumbrian slate is currently available.
SLS	Spanish slate	North-west Spain	Spanish slate is currently available.

Contact details for current suppliers of the closest-matching roofing slates are presented in Appendix 7.

6 Synthesis

Information derived from the survey, the assessment of building stone quarries, and the stone matching exercise is summarised below for all the building stones and roofing slates recorded in the Falkirk THI area.

Buff sandstone 1

This is the ‘local’ Falkirk stone, and is the most commonly recorded and most widely used building stone in the THI area. The stone is relatively coarse, buff sandstone displaying a range of primary sedimentary structures, including parallel bedding, cross-bedding, laminated foresets, and wispy lamination. The stone was sourced from several quarries to the south of Falkirk, including Bantaskine, Brightons, Callendar Park, Maddiston and Lathallan quarries. All these quarries exploited the Scottish Lower Coal Measures Formation. The stone has been recorded in thirty-six buildings clustered mainly in Cow Wynd, Manor Street and at the east end of High Street. The stone was used in vernacular buildings in the late 17th Century and for more prestigious buildings (e.g. Burgh Buildings, former YMCA, and The Steeple) in the late 19th Century. The stone is commonly concealed beneath a coating of paint and/or harling in older buildings.

A sample of stone from Viewfield pit (one of the Bantaskine quarries) displays many of the characteristics of ‘Buff sandstone 1’ in surveyed buildings. The Bantaskine quarries are located on public land, and stone is still exposed in several of the quarries. Further work here could establish if it might be feasible to extract small volumes of stone for future building repair and restoration projects.

The closest-matching, currently available stones for ‘Buff sandstone 1’ are:

- Blagdon sandstone
- Drumhead Buff sandstone (laminated variant)
- Blaxter’s Northumberland Buff sandstone
- Bearl sandstone.

Buff sandstone 2

This stone was rarely visible at ground level but is characterised by a generally uniform texture and absence of distinctive features. The stone was probably sourced from quarries in the Upper Limestone Formation located between Denny and Stirling. The stone has been recorded in twelve buildings, all of which appear to be of late Victorian age and are situated in the northern part of the THI area, on Vicar Street, Melville Street, and Newmarket Street.

The closest-matching, currently available stones for ‘Buff sandstone 2’ are:

- Dunhouse Buff sandstone
- Witton Fell sandstone
- Drumhead Buff sandstone (uniform variant)
- Prudham sandstone
- Stainton sandstone.

Buff sandstone 3

This stone is characterised by a typically very light buff colour and relatively fine grain size. The stone was recorded in just three buildings, all of which were constructed to be relatively prestigious and to be used for commerce. The buildings were constructed at quite different times and this, combined with subtle differences between the stone in each building, may indicate the stone for each building was sourced from a different quarry.

The closest-matching, currently available stones for 'Buff sandstone 3' are:

- Hazeldean sandstone
- Darney White sandstone
- Cullalo sandstone
- Drumhead sandstone (white variant).

Buff sandstone 4

This sandstone is relatively coarse, micaceous and has occasional coloured bands ('Liesegang bands). The stone has been recorded in fourteen buildings, which all appear to be of late Victorian age and are situated in the northern part of the THI survey area, on Vicar Street, Melville Street, and Newmarket Street. The stone is likely to have been sourced from quarries in the Upper Limestone Formation between Denny and Stirling.

The closest-matching, currently available stones for 'Buff sandstone 4' are:

- Prudham sandstone
- Dunhouse Buff sandstone
- Drumhead Buff sandstone
- Witton Fell sandstone
- Stainton sandstone
- Darney Cream sandstone.

Buff sandstone 5

This sandstone is light brownish buff and has a strongly micaceous and speckled character. The stone was recorded in four buildings, all of which were constructed between 1909 and 1914. The characteristics of the stone are not diagnostic: it could have been sourced from the Carboniferous successions in the Central Belt of Scotland (Stirlingshire or West Lothian) or from northern England; the closest-matching stones in the BGS rock collections are from Northumberland.

The closest-matching, currently available stones for 'Buff sandstone 5' are:

- Darney Cream sandstone
- High Nick sandstone
- Hazeldean sandstone
- Alnwick Moor sandstone.

Buff sandstone 6

This stone is characterised by a dull yellow colour, high clay content and generally uniform appearance. The stone was recorded in three buildings on Williamson Street and Manor Street. The stone is of relatively poor quality, and face-bedded masonry blocks are suffering from stone decay. The stone is likely to come from a relatively local source, probably one or more quarries in the Passage Formation or Scottish Lower Coal Measures Formation.

The closest-matching, currently available stones for 'Buff sandstone 6' are:

- Blaxter sandstone
- Prudham sandstone
- Blaxter's Northumberland Buff sandstone
- Swinton sandstone.

Buff sandstone 7

This sandstone is characterised by a dull yellowish buff colour and coarse-grained, gritty and siliceous character. The stone has been recorded in three buildings, in all of which it has been used only in dressings. The stone was probably sourced from a quarry in the Passage Formation (or possibly the Scottish Lower Coal Measures Formation) in the Falkirk area.

The closest-matching, currently available stones for 'Buff sandstone 7' are:

- Fletcher Bank Buff sandstone
- Lingberry sandstone
- Naylor's Hill Buff Gritstone
- Witton Fell Coarse Grit.

Modern buff sandstone 1

This sandstone is characterised by an even buff colour and uniform appearance. The stone has been recorded in four buildings; it has been used to make selective repairs (indents) to original masonry (e.g. in Tattie Kirk), and to construct a new shop front at ground floor level of the building at the north-west corner of Vicar Street and Lower Newmarket Street. Stanton Moor quarry in the Millstone Grit Group of Derbyshire (or another quarry in the same area that produced very similar stone) has been identified as the most likely source.

The closest-matching, currently available stones for 'Modern buff sandstone 1' are:

- Stanton Moor sandstone
- Peakmoor sandstone (non-gritty variety)
- Millknock sandstone
- Birchover Buff sandstone.

Modern buff sandstone 2

This dull greyish buff and weakly gritty stone has been recorded in just two buildings; it has been used to make selective repairs (indents) in one building, and comprises the whole of a substantial addition to Fa' Kirk. The stone was sourced from Derbyshire, probably from Stoke Hall quarry or Peakmoor quarry, both of which extract stone from the Millstone Grit Group.

The closest-matching, currently available stones for 'Modern buff sandstone 2' are:

- Stoke Hall sandstone
- Peakmoor sandstone (coarse variety).

Modern buff sandstone 3

This stone has a uniform character and a range of distinctive features that are developed locally, including flakes of carbonaceous matter, iron nodules, Liesegang bands and coloured spots. The stone has been recorded in five buildings. It has been used to make selective repairs (indents) in pre-1900 buildings, and is the original building stone in several post-1931 buildings. The stone was probably sourced from the Millstone Grit Group in Northumberland.

The closest-matching, currently available stones for 'Modern buff sandstone 3' are:

- Dunhouse Buff sandstone
- Blaxter sandstone
- Stainton sandstone.

Modern buff sandstone 4

This texturally uniform sandstone with occasional shell fragments has been recorded in three buildings. It is the original building stone in two modern buildings and has been used in thick cladding built around the two lowest levels of The Steeple. The new buildings and cladding have probably been constructed since c. 1980. The stone was almost certainly sourced from Crossland Hill quarry in the Millstone Grit Group of Yorkshire.

The closest-matching, currently available stones for 'Modern buff sandstone 4' are:

- Crossland Hill sandstone
- Peakmoor sandstone
- Stanton Moor sandstone.

Modern buff sandstone 5

This stone is dark buff to buff, essentially uniform, and contains aligned flakes of carbonaceous matter and mica. The stone has been used to make selective repairs (indents) in four buildings. The stone has been quarried from Carboniferous strata, but the original quarry source and geographical location have not been identified. Some of the indented blocks appear to be moderately weathered, and the stone may be amongst the earliest of the 'modern' buff sandstones used in the THI area.

The closest-matching, currently available stones for 'Modern buff sandstone 5' are:

- Dovedale sandstone
- Millknock sandstone.

Modern buff sandstone 6

This relatively coarse sandstone displays a range of primary sedimentary structures, including parallel bedding, cross-bedding, laminated foresets, and wispy lamination, and in this respect is similar to 'Buff sandstone 1' (the local Falkirk stone). The stone has been recorded in three adjacent buildings, all on High Street; in each case the stone has been used to construct a modern shop spanning the ground floor level. The stone was probably sourced from a quarry in the Millstone Grit Group in Derbyshire.

The closest-matching, currently available stones for 'Modern buff sandstone 6' are:

- Stanton Moor sandstone
- Peakmoor sandstone
- Birchover sandstone.

Orange sandstone 1

This medium-grained, orange sandstone is characterised by regular parallel lamination and a finely speckled character. The stone has been recorded in three buildings; in two of these (dated 1896 and 1928) it forms the original building stone, and in the other it is a 'modern' repair. The stone was sourced from Locharbriggs quarry, which exploits Permian age Stewartry Group strata in Dumfriesshire. The quarry has been open since the 19th Century, and is the only building stone to have been used in both historic buildings and modern repairs in the THI area.

The closest-matching, currently available stones for 'Orange sandstone 1' are:

- Locharbriggs sandstone
- Corncockle sandstone.

Orange sandstone 2

This fine-grained, orange sandstone is characterised by parallel bedding, cross bedding and parallel lamination. It is the original building stone in five buildings, all built between 1899 and 1927. The stone was sourced from Corsehill quarry and/or Cove quarry; both quarries produce almost identical stone from the Permian to Triassic age Sherwood Sandstone Group in Dumfriesshire. Both quarries are still open.

The closest-matching, currently available stones for 'Orange sandstone 2' are:

- Corsehill sandstone
- Cove sandstone.

Limestone 1

Pale grey, shelly limestone was recorded in only one (probably mid-20th century) building in the THI area. The stone is Portland limestone. It was sourced from one of numerous quarries exploiting the Jurassic to Cretaceous age Purbeck Group strata on the Isle of Portland, in Dorset.

The closest-matching, currently available stone for 'Limestone 1' is:

- Portland Whitbed stone.

Granite 1

This granite is grey, equigranular and has a weak foliation. It was recorded in only one structure: the plinth of the South African War memorial on Newmarket Street. The stone was probably sourced from the Ordovician age Kemnay Granite Pluton in Aberdeenshire.

The closest-matching, currently available stone for 'Granite 1' is:

- Kemnay granite.

Granite 2

This dark-grey, biotite-rich, foliated granite (or, more correctly, granodiorite) was recorded in only one building; it forms the base course of the Lloyds TSB building on the south-west corner of High Street and Cow Wynd. The features of this stone are common to a number of Scottish granites; quarries at Dalbeattie (in the Criffel Granite Pluton in Kirkudbrightshire) and Rubislaw (in the Aberdeen Granite Pluton) extracted large volumes of similar-looking stone.

No currently active UK quarries produce dark grey granite; an overseas supplier may be able to supply a close-matching stone.

Granite 3

This relatively coarse, greyish-pink granite has been recorded in three buildings, in all of which it is present as a base course. The stone is almost certainly Peterhead granite from one of the quarries in the Silurian age Peterhead Granite Pluton in Aberdeenshire. At least one quarry in the Peterhead pluton is still active.

The closest-matching, currently available stone for ‘Granite 3’ is:

- Peterhead granite.

Granite 4

This brownish pink, equigranular granite was recorded in only one building; it has been used to make decorative columns framing the main entrance to the Burgh Buildings. The stone may be Corrennie granite from the Corrennie Granite Pluton in Aberdeenshire or Ross of Mull granite from the Ross of Mull Granite Pluton on Mull. Both of these quarries extracted similar stone in large volumes in the past.

The closest-matching, currently available stone for ‘Granite 4’ is:

- Corrennie granite.

7 References

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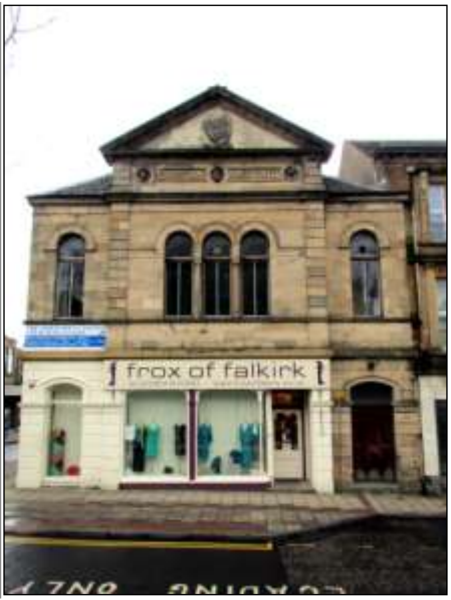
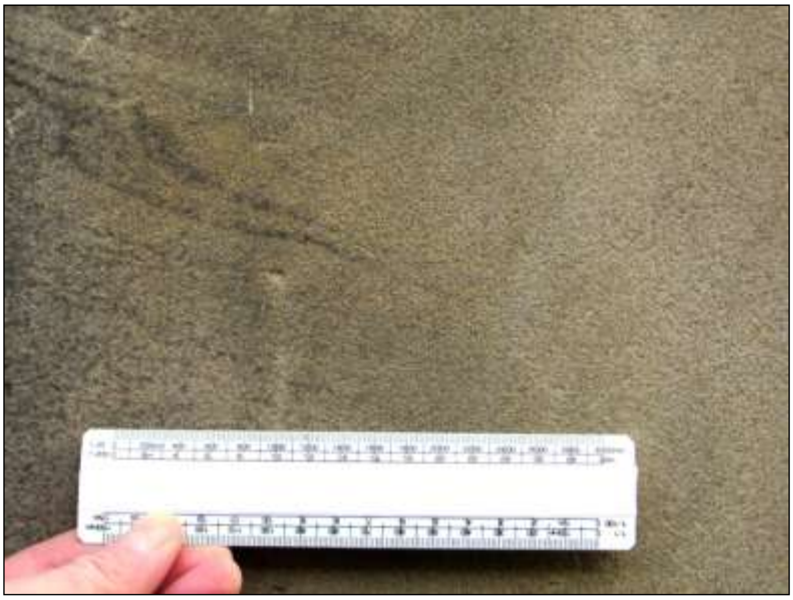
Appendix 1 Field descriptions of Falkirk building stones

This appendix contains a summary description and associated photographs for each of the twenty building stones recorded in the Falkirk THI area (see section 3). A near-focus photograph (at the scale of a masonry block) is provided with the description for each stone, to illustrate its typical colour and character. For sandstones and limestone, a photograph of the reference building on which the description was based is also provided. For modern buff sandstones, which are commonly present as indents and additions to original masonry, the photograph of the reference building is centred on the indented blocks or additions.

Stone code:	SB1
Stone name:	Buff sandstone 1
Reference building:	1 Glebe Street/16-18 Newmarket Street
	PRIMARY_KE 963254
Colour of exposed surfaces:	various shades of buff
Grain-size	medium-sand-grade to coarse-sand-grade; granule-grade locally
Primary sedimentary structure:	blocks are commonly bedded; parallel bedding, cross-bedding, parallel lamination, laminated foresets and rare wispy lamination are all developed locally; buildings usually contain some uniform blocks, and in some buildings most blocks are uniform
Distinctive features:	rare flakes of carbonaceous matter; gritty locally
Composition	impure



Stone code:	SB2
Stone name:	Buff sandstone 2
Reference building:	Vicar Chambers, 27-35 Vicar Street
	PRIMARY_KE 963213 & 963214
Colour of exposed surfaces:	buff, with an orangeish to pinkish tinge locally
Grain-size:	fine-sand-grade to medium-sand-grade
Primary sedimentary structure:	most blocks are uniform; rare cross bedding; convoluted structure visible on surfaces of soiled/weathered blocks
Distinctive features:	none, but this stone is rarely visible at ground level
Composition:	impure
Comments:	some blocks are gritty



Stone code:	SB3
Stone name:	Buff sandstone 3
Reference building:	1 Princes Street
	PRIMARY_KE 963222
Colour of exposed surfaces:	light buff to very light buff (almost white)
Grain-size:	fine-sand-grade to medium-sand-grade
Primary sedimentary structure:	uniform
Distinctive features:	scattered flakes of carbonaceous matter; faint Liesegang bands; scattered brown mud flakes locally
Composition:	relatively siliceous
Comments:	weakly micaceous

Stone code:	SB4
Stone name:	Buff sandstone 4
Reference building:	25-29 Newmarket Street
	PRIMARY KE 963267 and 963266
Colour of exposed surfaces:	light grey to light greyish buff
Grain-size	medium-sand-grade and coarse-sand-grade
Primary sedimentary structure	most blocks are uniform; parallel bedding developed locally; rare cross-bedding; rare lamination
Distinctive features:	micaceous; scattered flakes of carbonaceous matter are usually present, and curved to sinuous leaf fragments up to 5 cm long may be present; can be gritty locally; brown iron nodules up to 2 cm across are developed locally; Liesegang bands can be developed locally
Composition	impure

Stone code:	SB5
Stone name:	Buff sandstone 5
Reference building:	123-127 High Street (WH Smith) PRIMARY_KE 961149
Colour of exposed surfaces:	light brownish buff
Grain-size:	medium-sand-grade to coarse-sand-grade; even grain-size
Primary sedimentary structure:	essentially uniform; rare, faint hints of bedding
Distinctive features:	strongly micaceous; rare fragments of carbonaceous matter up to 3 cm long; rare iron nodules up to 1 cm across; speckled character given by scattered, dark brown detrital grains up to 3 mm diameter
Composition:	impure


Stone code:	SB6
Stone name:	Buff sandstone 6
Reference building:	1 Mission Lane/9 Dundee Court (middle section of elevation facing Williamson Street)
	PRIMARY_KE 961110
Colour of exposed surfaces:	dull yellow
Grain-size:	fine-sand-grade to medium-sand-grade; even grain-size
Primary sedimentary structure:	mainly uniform; parallel bedding developed locally; cross bedding developed rarely
Distinctive features:	micaceous
Composition:	impure
Comments:	stone appears to have a high clay content; stugging conceals the primary sedimentary structure in many blocks; spalling extensively where face-bedded

Stone code:	SB7
Stone name:	Buff sandstone 7
Reference building:	dressings to tenement at 36-44 Melrose Place, Dundee Court PRIMARY_KE 961203 & 961204
Colour of exposed surfaces:	dull yellowish buff
Grain-size:	coarse-sand-grade to very-coarse-sand-grade; locally gritty
Primary sedimentary structure:	uniform, parallel bedded and cross-bedded
Distinctive features:	locally micaceous; gritty
Composition:	siliceous
Comments:	this stone found only as dressings

The photograph at right is centred on the door of the tenement building in which SB7 forms the dressings (dull yellow blocks)

Stone code:	SBM1
Stone name:	Modern buff sandstone 1
Reference building:	indents to Tattie Kirk, off Cow Wynd
	PRIMARY_KE 961108
Colour of exposed surfaces:	buff
Grain-size:	fine-sand-grade to medium-sand-grade; even grain-size
Primary sedimentary structure:	most blocks are uniform; faint bedding visible locally
Distinctive features:	rare flakes of carbonaceous matter up to 5 cm long
Composition:	impure
Comments:	weakly to moderately micaceous

The photograph at bottom shows part of Tattie Kirk, where SBM1 forms indents to the window dressings and replacement quoins.

Stone code:	SBM2
Stone name:	Modern buff sandstone 2
Reference building:	Fa' Kirk (Old Parish Church); also known as Falkirk Old and St Modans Church, Manse Place; elevation facing Newmarket Street PRIMARY_KE 46333727
Colour of exposed surfaces:	dull greyish buff
Grain-size:	medium-sand-grade
Primary sedimentary structure:	most blocks are uniform; faint bedding visible locally
Distinctive features:	weakly gritty
Composition:	impure

The photograph at right shows where SBM2 has been used to build a modern addition to the Newmarket Street elevation of Fa' Kirk.

Stone code:	SBM3
Stone name:	Modern buff sandstone 3
Reference building:	3 Vicar Street PRIMARY_KE 963224
Colour of exposed surfaces:	buff
Grain-size:	medium-sand-grade
Primary sedimentary structure:	uniform
Distinctive features:	flakes of carbonaceous matter, iron nodules and a gritty character are generally rare but common locally; Liesegang bands are developed locally; coloured spots up to 10 cm diameter are developed around small iron nodules
Composition:	impure

Stone code:	SBM4
Stone name:	Modern buff sandstone 4
Reference building:	ground and lower floors of The Steeple, High Street PRIMARY_KE 961318
Colour of exposed surfaces:	buff
Grain-size:	medium-sand-grade; even grain-size
Primary sedimentary structure:	uniform (weakly aligned flakes of carbonaceous matter reveal the bedding orientation in some blocks)
Distinctive features:	weakly micaceous; scarce flakes of carbonaceous matter are up to 2-3 cm long; nodules of hard brown iron up to 2 cm across are developed locally, with small iron-stained halos; rare fossil shell fragments are up to 8-9 cm long
Composition:	impure
Comment:	in 10 Newmarket Centre, (PRIMARY_KE 963303) this stone is fine-sand-grade

The ground and first floor levels of The Steeple are clad in SBM4.

Stone code:	SBM5
Stone name:	Modern buff sandstone 5
Reference building:	indents to Lloyds TSB, 137-139 High Street PRIMARY_KE 961164
Colour of exposed surfaces:	dark buff to buff
Grain-size:	coarse-sand-grade; even grain-size
Primary sedimentary structure:	essentially uniform; aligned flakes of carbonaceous matter and mica define the bedding orientation locally
Distinctive features:	micaceous; scattered flakes up to 1 cm long and circles (leafs) up to 8 cm long of carbonaceous matter are common
Composition:	impure

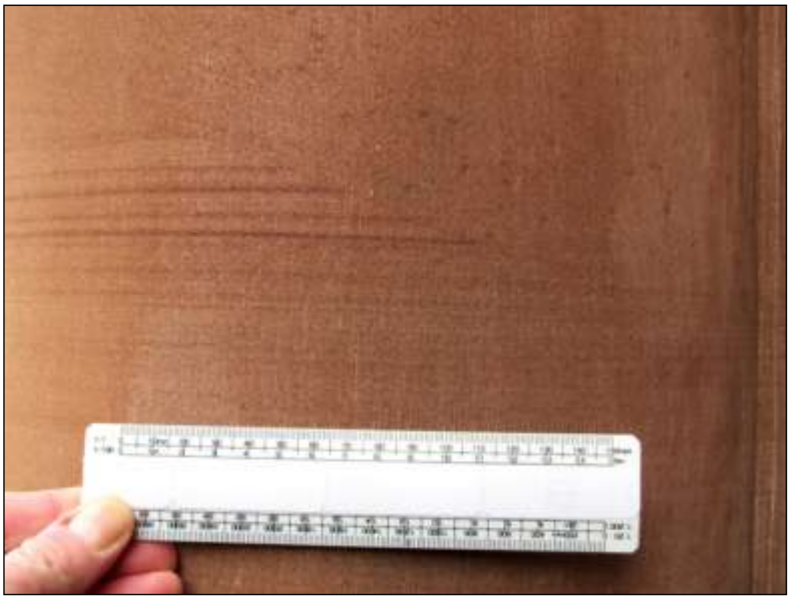

The photograph at right shows SBM5 indents to the right of the window.

Stone code:	SBM6
Stone name:	Modern buff sandstone 6
Reference building:	ground floor addition to 138-140 High Street PRIMARY_KE 961316
Colour of exposed surfaces:	buff
Grain-size:	generally medium-sand-grade to coarse-sand-grade; locally granule-grade
Primary sedimentary structure:	parallel bedding, cross-bedding, lamination and wispy lamination are all developed locally
Distinctive features:	gritty character and Liesegang bands are developed locally
Composition:	impure

The photograph at right shows the shop front addition to the Bank of Scotland building, which is made entirely of SBM6.

Stone code:	SO1
Stone name:	Orange sandstone 1
Reference building:	St Andrew's West Church, Upper Newmarket Street PRIMARY_KE 46333726
Colour of exposed surfaces:	orange to pink
Grain-size:	medium-sand-grade
Primary sedimentary structure:	regular, parallel lamination; rare blocks show cross-bedding
Distinctive features:	speckled character given by scattered grains of white feldspar; rare granulation seams; grey siliceous laminae
Composition:	siliceous
Comments:	very rare, hairline veins of calcite

Stone code:	SO2
Stone name:	Orange sandstone 2
Reference building:	41-43 Vicar Street
	PRIMARY_KE 963216 & 963217
Colour of exposed surfaces:	orange
Grain-size:	fine-sand-grade
Primary sedimentary structure:	parallel bedding, cross-bedding and parallel lamination
Distinctive features:	scattered shallow pits ~1 cm diameter, sometimes concentrated in bands
Composition:	siliceous



Stone code:	L
Stone name:	shelly limestone
Reference building:	165-169 High Street
	PRIMARY_KE 961200
Colour of exposed surfaces:	pale grey
Grain-size:	fine-sand-grade to medium-sand-grade
Primary sedimentary structure:	weak bedding defined locally by aligned shell fragments
Distinctive features:	abundant shell fragments up to 10 cm long
Composition:	shelly limestone

Stone code:	G1
Stone name:	Granite 1
Reference building:	plinth of South African War Memorial, Newmarket Street PRIMARY_KE 930773
Colour of exposed surfaces:	very pale orangeish grey
Grain-size:	coarse-crystalline (fine division)
Texture:	equigranular; weakly foliated
Distinctive features:	none
Composition:	muscovite-biotite granite

Stone code:	G2
Stone name:	Granite 2
Reference building:	base course of 137-139 High Street
	PRIMARY_KE 961164
Colour of exposed surfaces:	dark grey
Grain-size:	coarse crystalline (fine to medium division)
Texture:	largely equigranular but weakly inequigranular (feldspar-phyric) in places; foliated
Distinctive features:	micaceous; scattered black patches (mafic enclaves) up to 5 cm across
Composition:	biotite-rich granodiorite

Stone code:	G3
Stone name:	Granite 3
Reference building:	base course 134-136 High Street PRIMARY_KE 961315 & 961350
Colour of exposed surfaces:	greyish pink
Grain-size:	coarse-crystalline (medium to coarse division)
Texture:	inequigranular (weakly feldspar-phyric); massive
Distinctive features:	rare dark patches (mafic enclaves) are up to 3 cm across
Composition:	biotite granite

Stone code:	G4
Stone name:	Granite 4
Reference building:	columns in main door arch, 12-14 Newmarket Street PRIMARY_KE 963306
Colour of exposed surfaces:	brownish pink
Grain-size:	coarse-crystalline (medium division)
Texture:	equigranular; massive
Distinctive features:	none
Composition:	biotite granite

Appendix 2 Maps of building stone distribution in the Falkirk THI area

The maps in this appendix were created in ArcGIS using the data contained in the Falkirk THI Area Stone Survey Data table (delivered independently of this report).

See section 3 for more details.

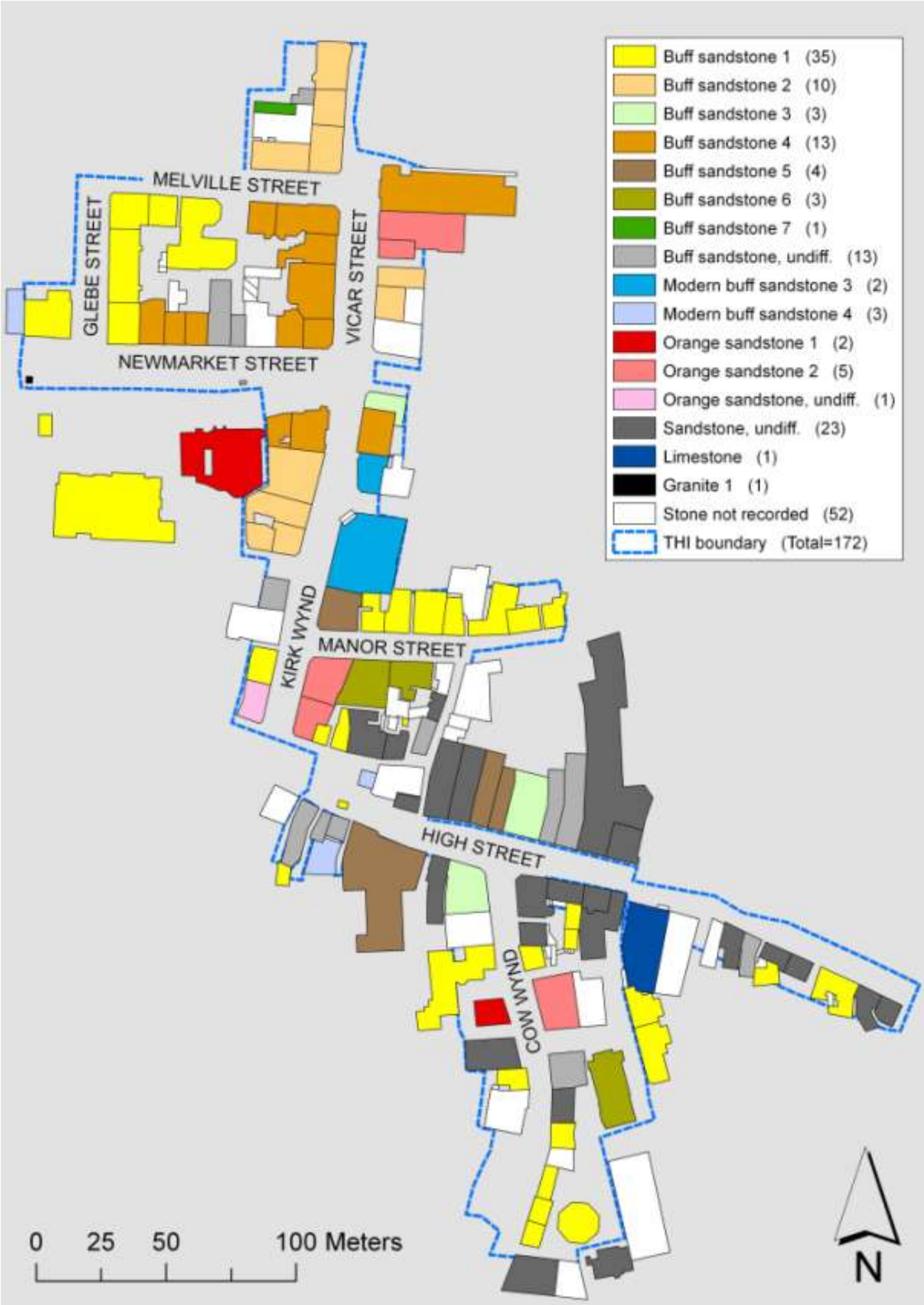


Figure A2_1 Map of MAJOR_STONE for all polygons

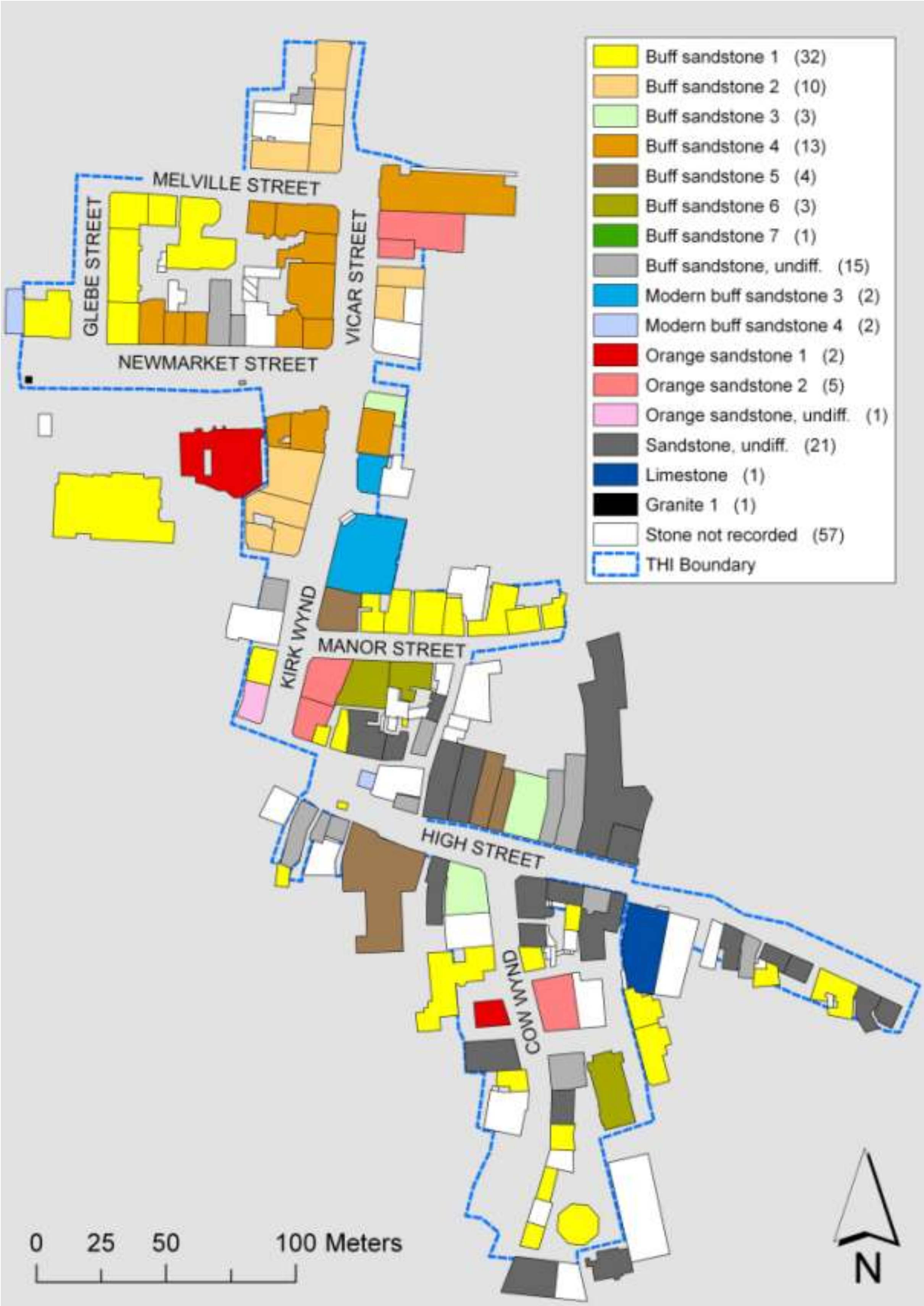


Figure A2_2 Map of MAIN_WALLING_STONE for all polygons

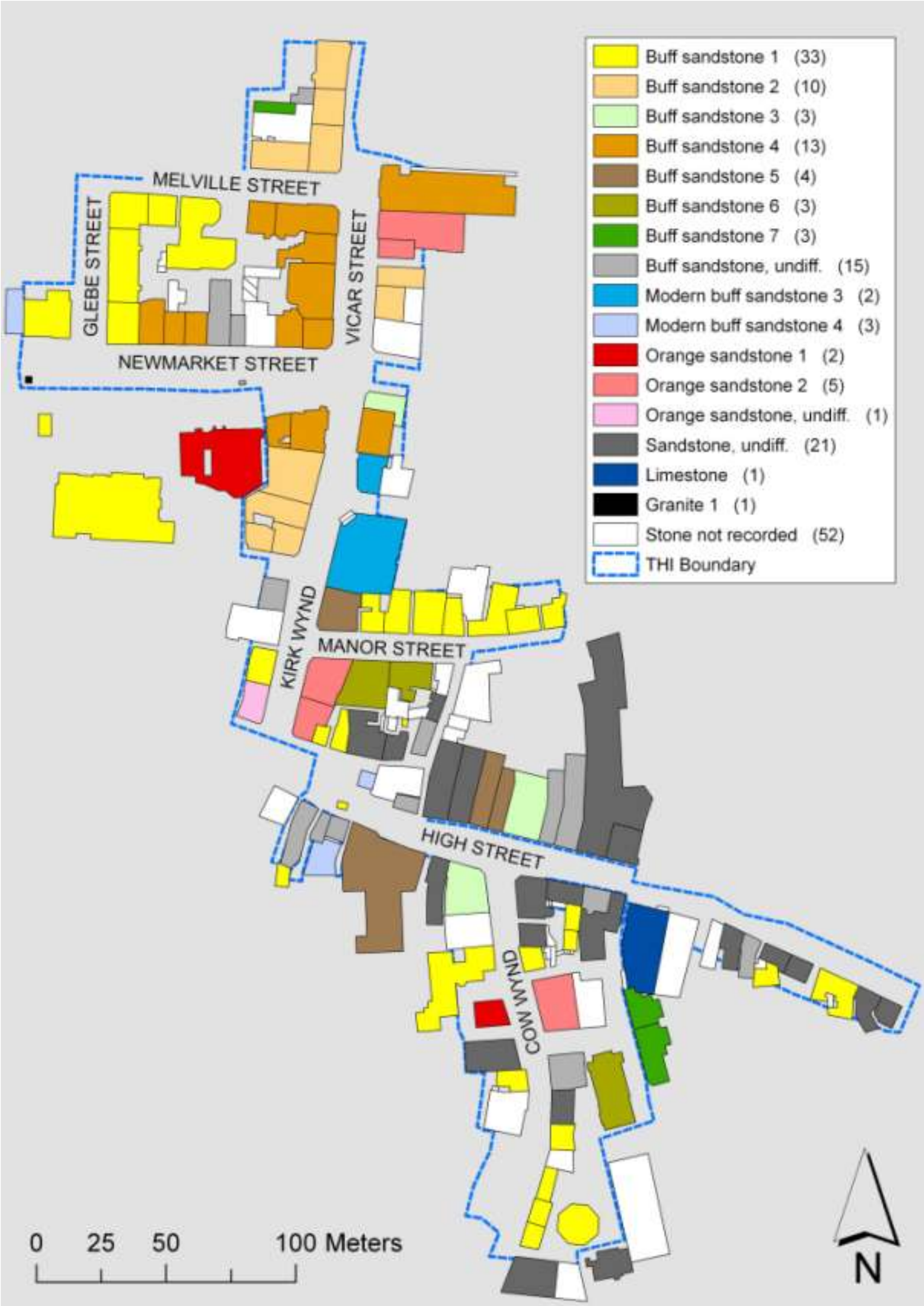


Figure A2_3 Map of MAIN_DRESSING_STONE for all polygons

Figure A2_4 Map of polygons for which 'Buff sandstone 1' was recorded

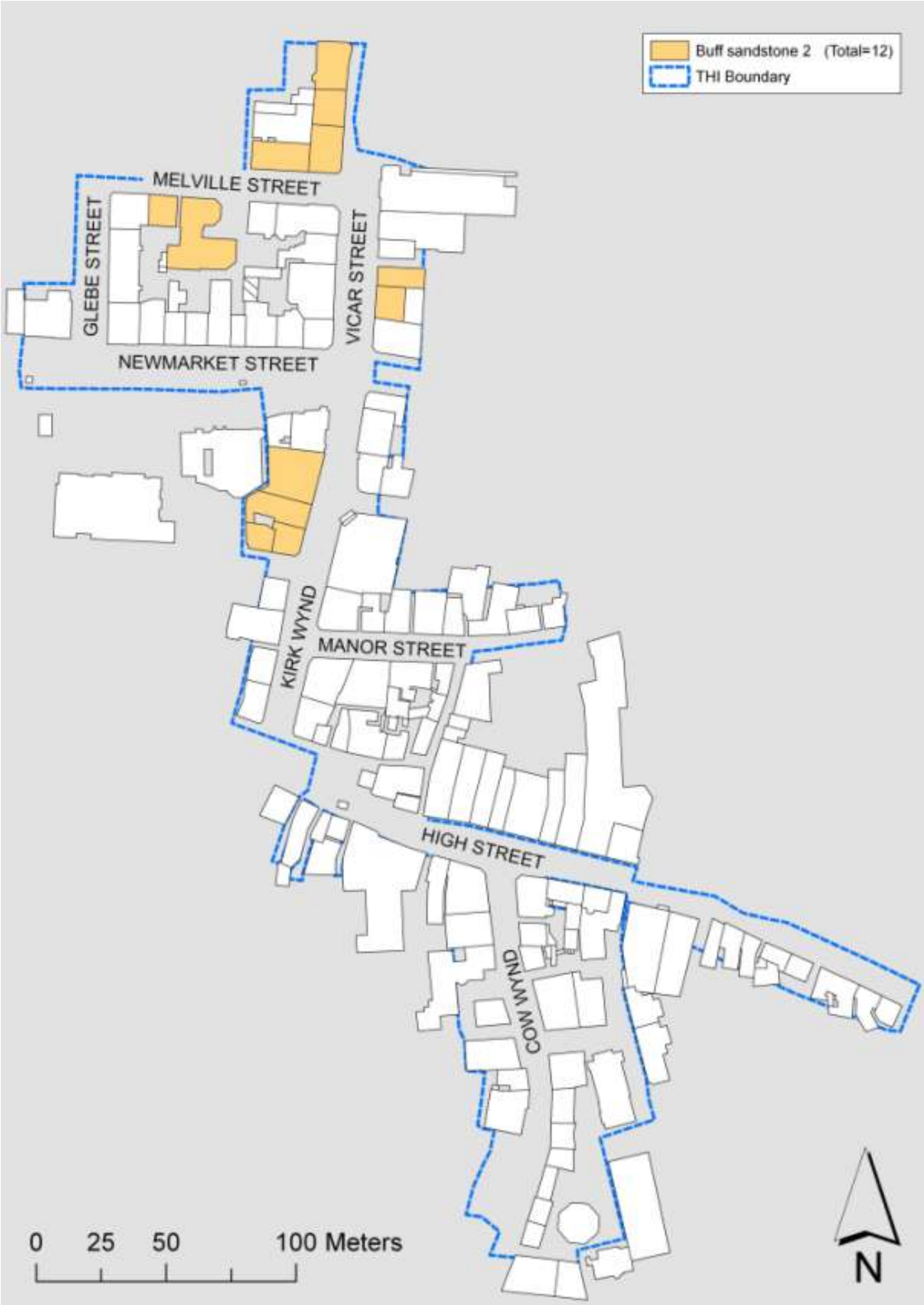


Figure A2_5 Map of polygons for which 'Buff sandstone 2' was recorded

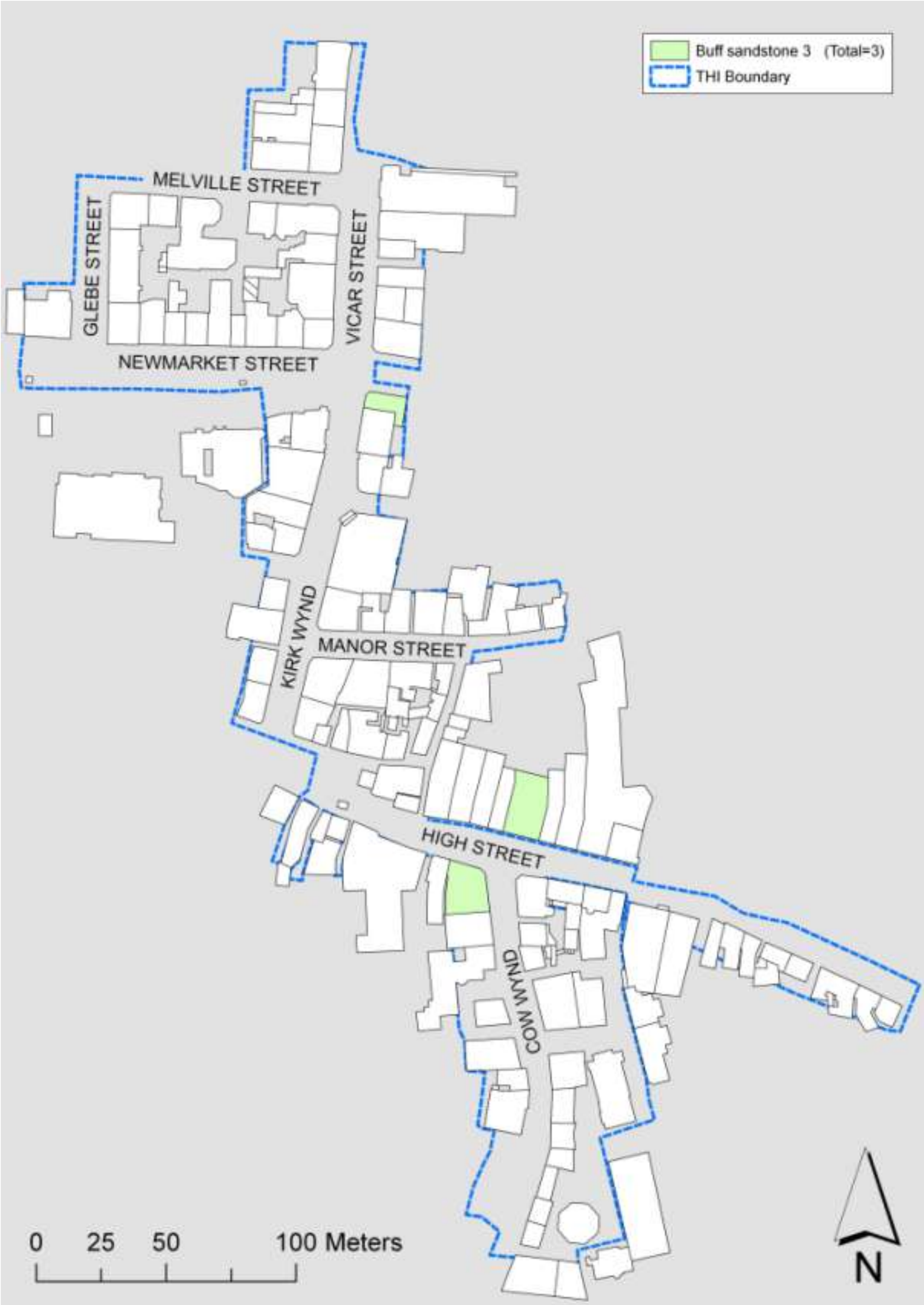


Figure A2_6 Map of polygons for which 'Buff sandstone 3' was recorded

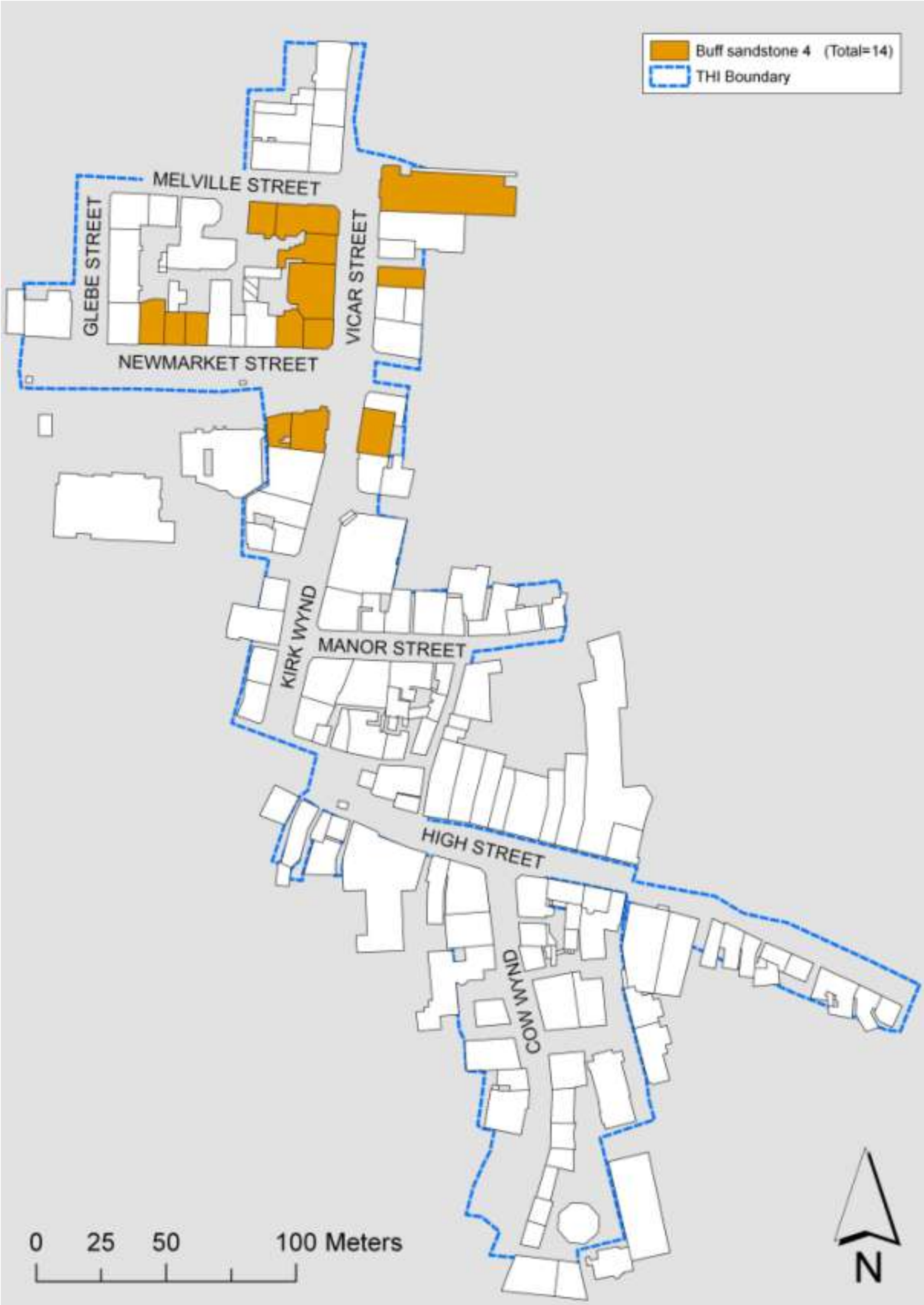


Figure A2_7 Map of polygons for which 'Buff sandstone 4' was recorded

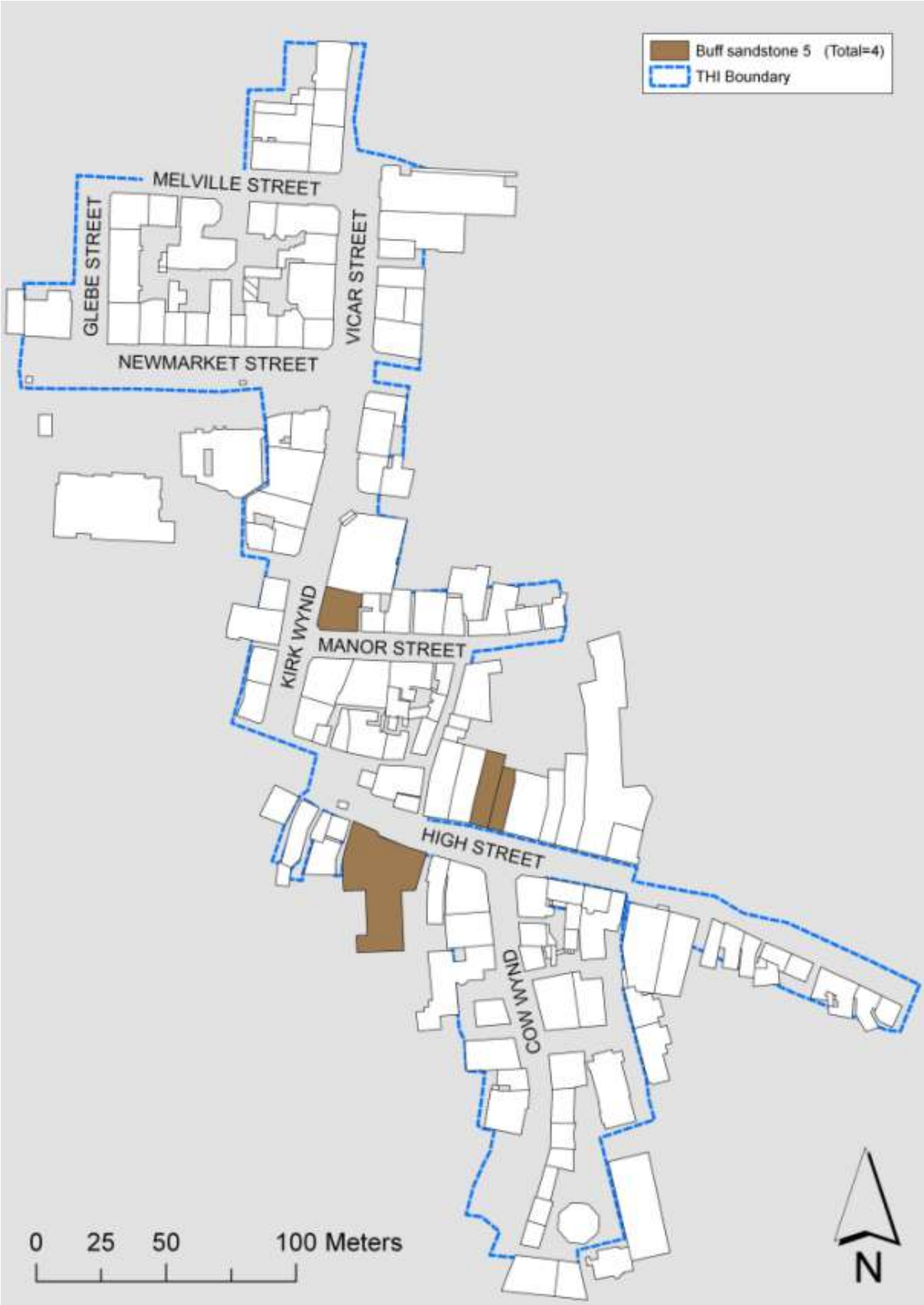


Figure A2_8 Map of polygons for which 'Buff sandstone 5' was recorded

Figure A2_9 Map of polygons for which 'Buff sandstone 6' was recorded

Figure A2_10 Map of polygons for which 'Buff sandstone 7' was recorded

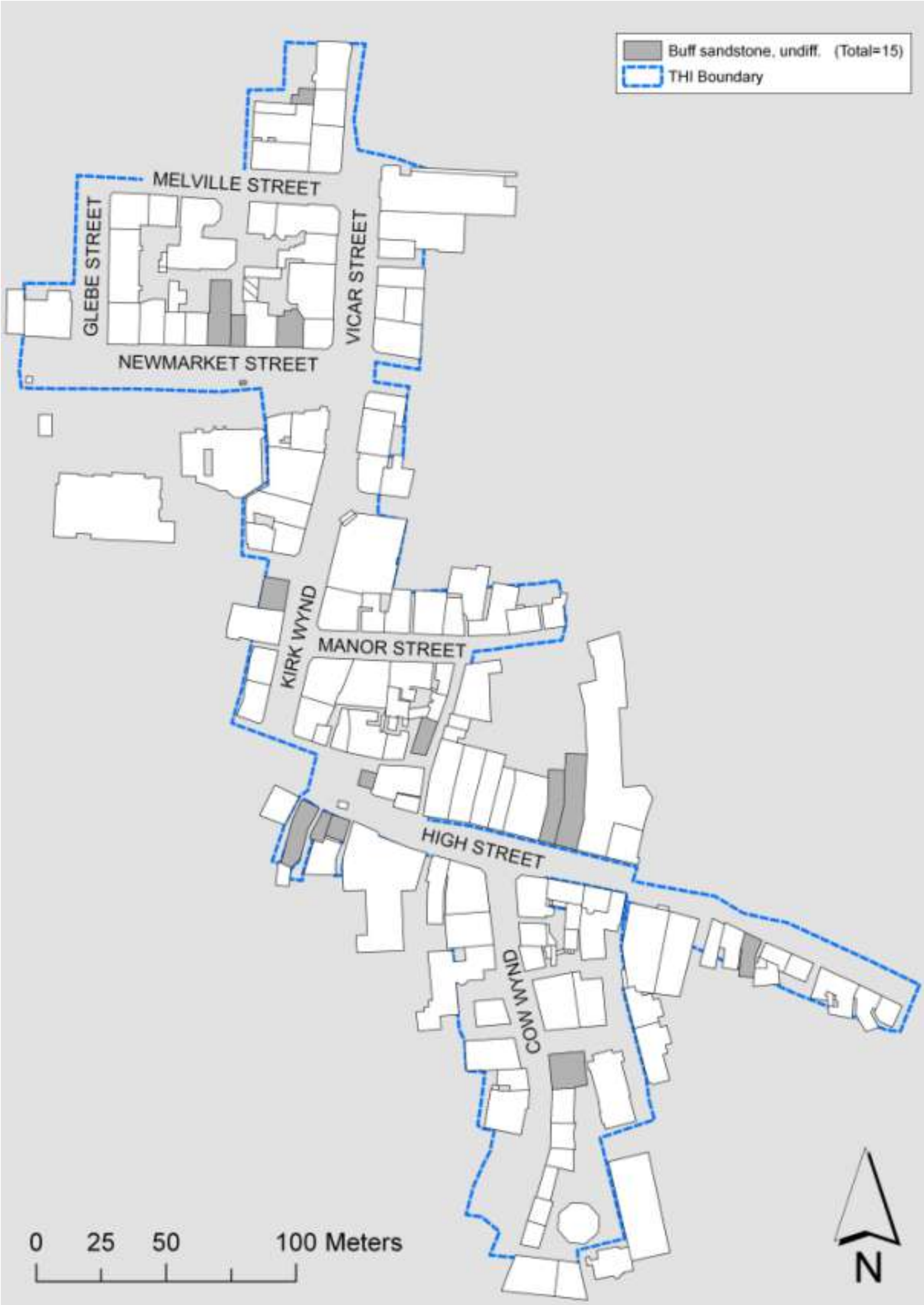


Figure A2_11 Map of polygons for which 'Buff sandstone, undifferentiated' was recorded

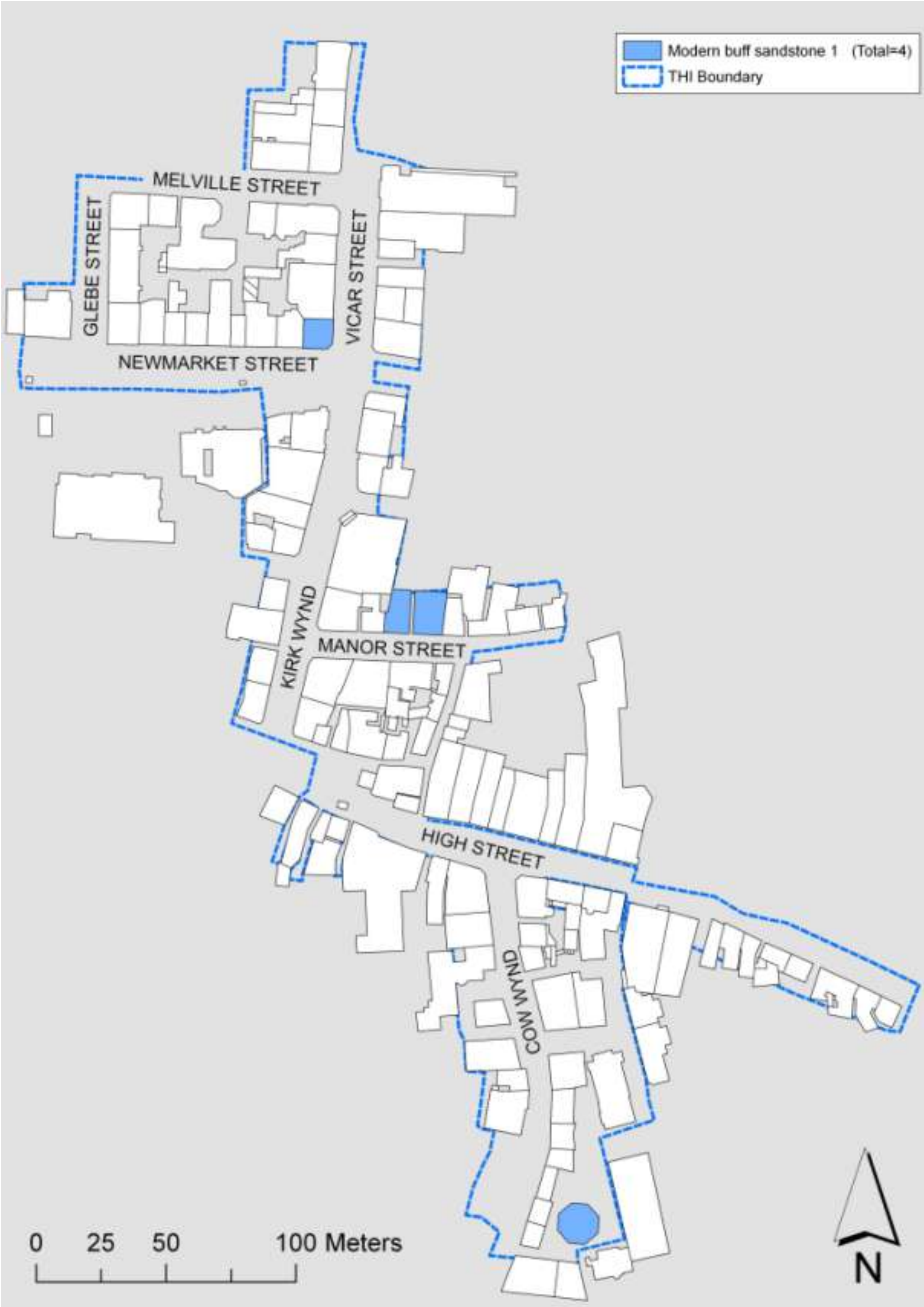


Figure A2_12 Map of polygons for which 'Modern buff sandstone 1' was recorded

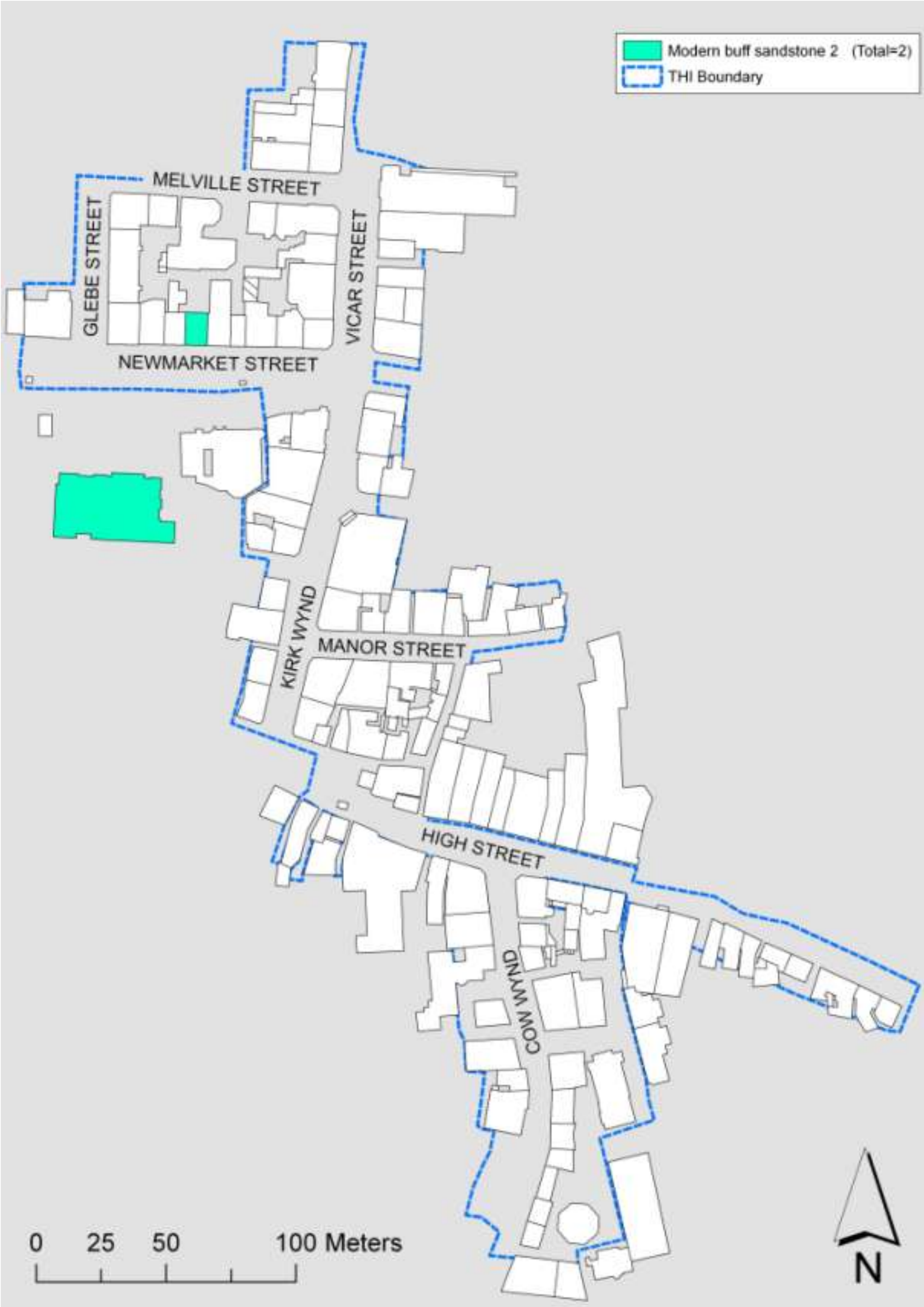


Figure A2_13 Map of polygons for which 'Modern buff sandstone 2' was recorded

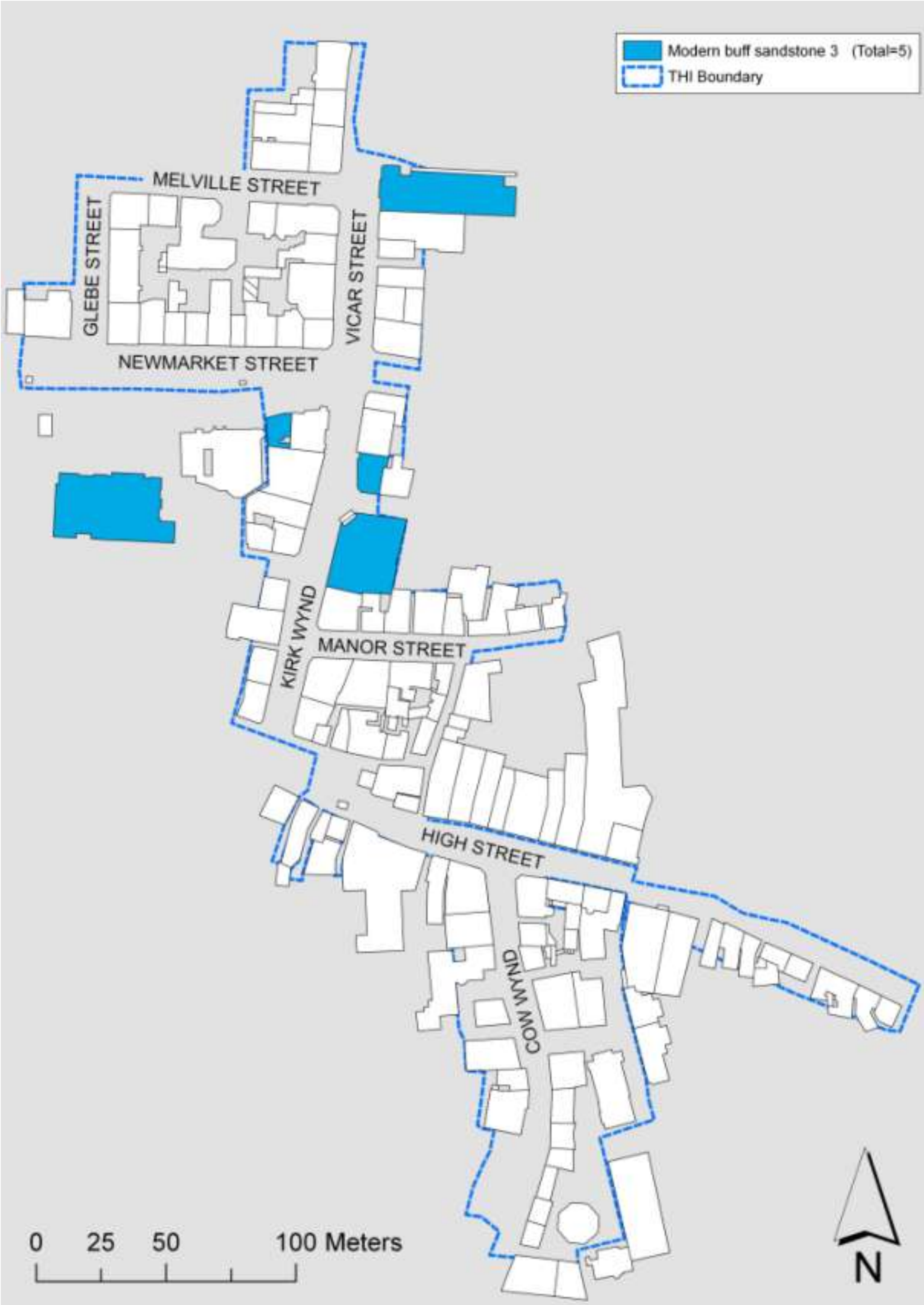


Figure A2_14 Map of polygons for which 'Modern buff sandstone 3' was recorded

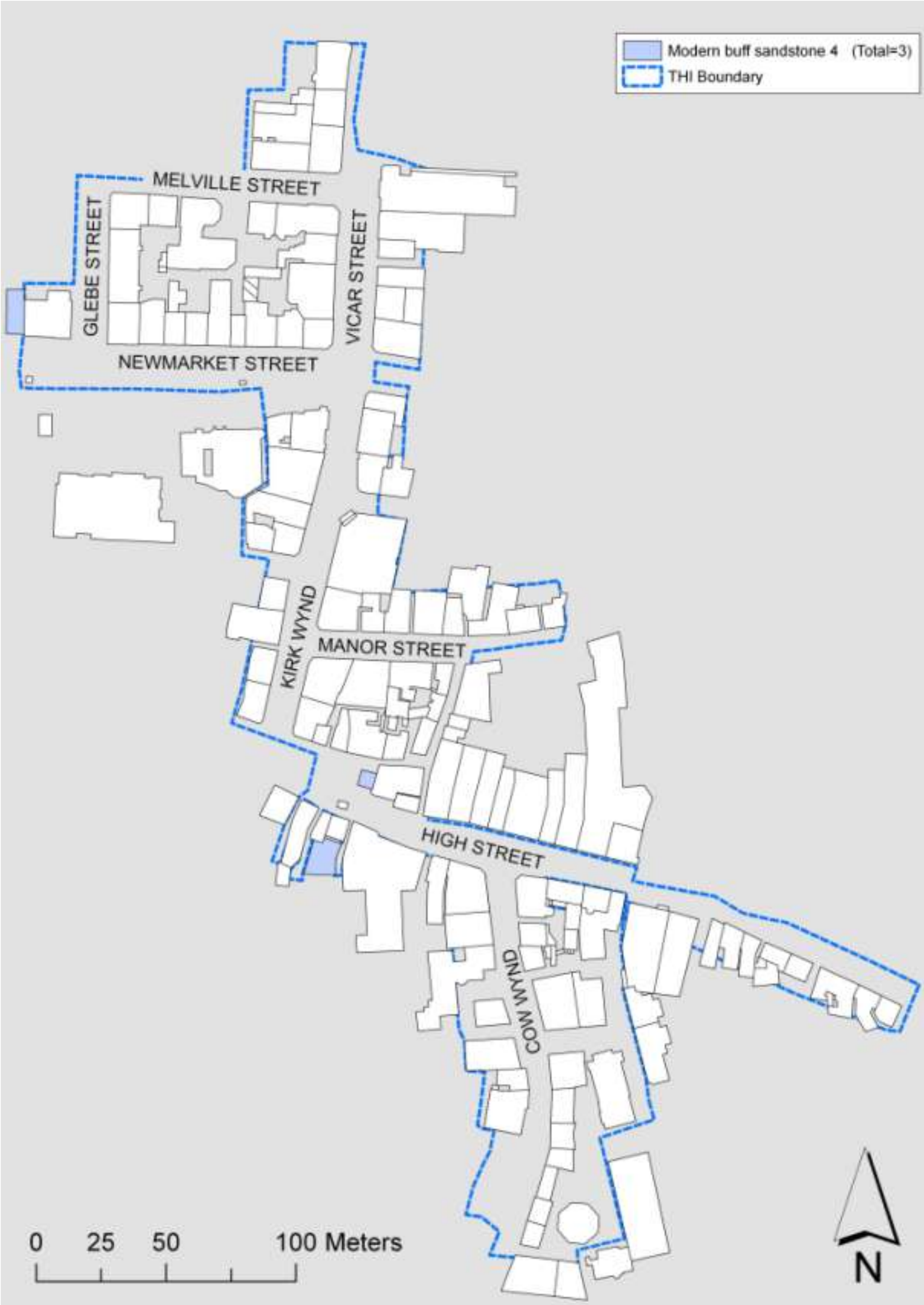


Figure A2_15 Map of polygons for which 'Modern buff sandstone 4' was recorded

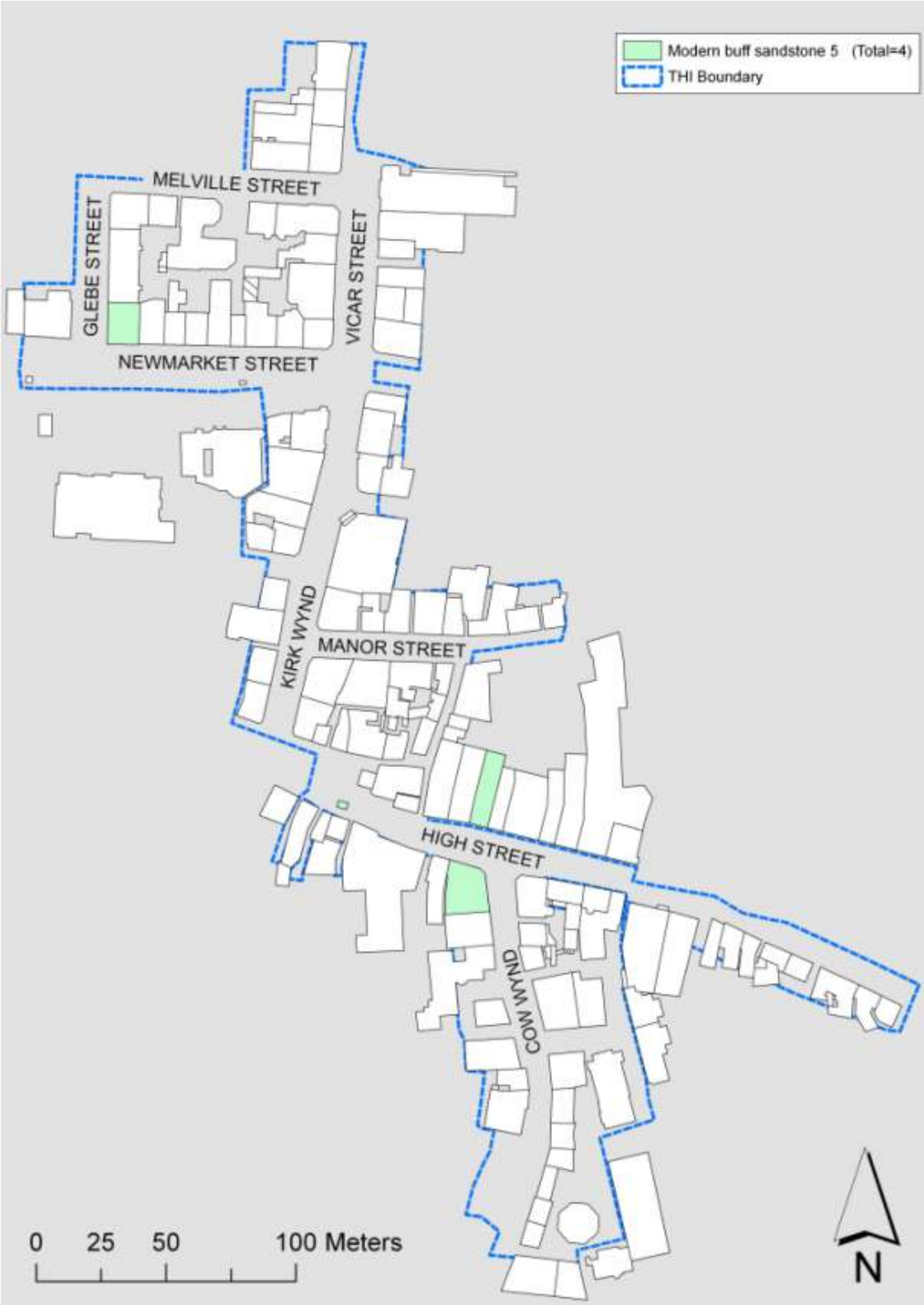


Figure A2_16 Map of polygons for which 'Modern buff sandstone 5' was recorded

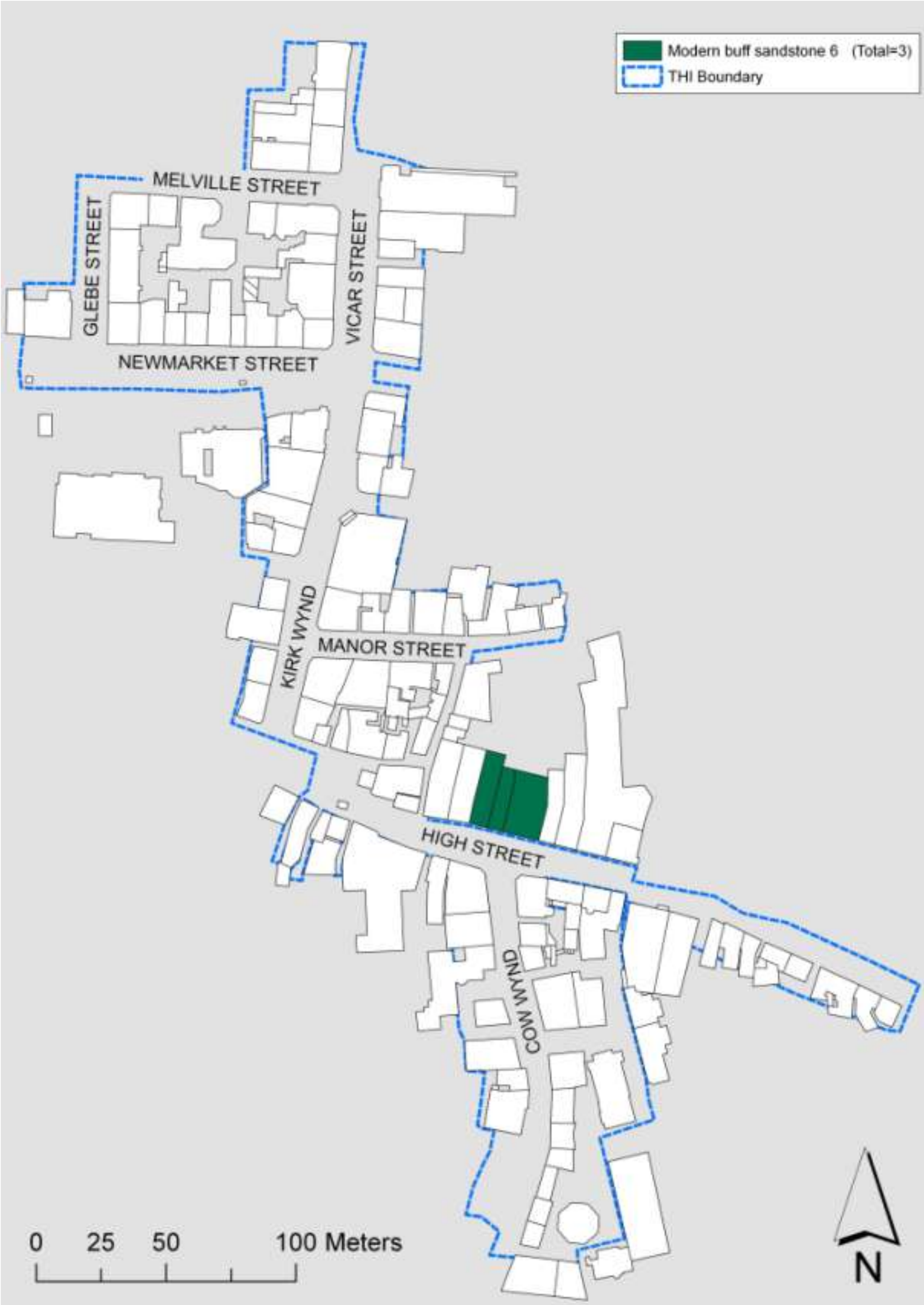


Figure A2_17 Map of polygons for which 'Modern buff sandstone 6' was recorded

Figure A2_18 Map of polygons for which 'Orange sandstone 1' was recorded

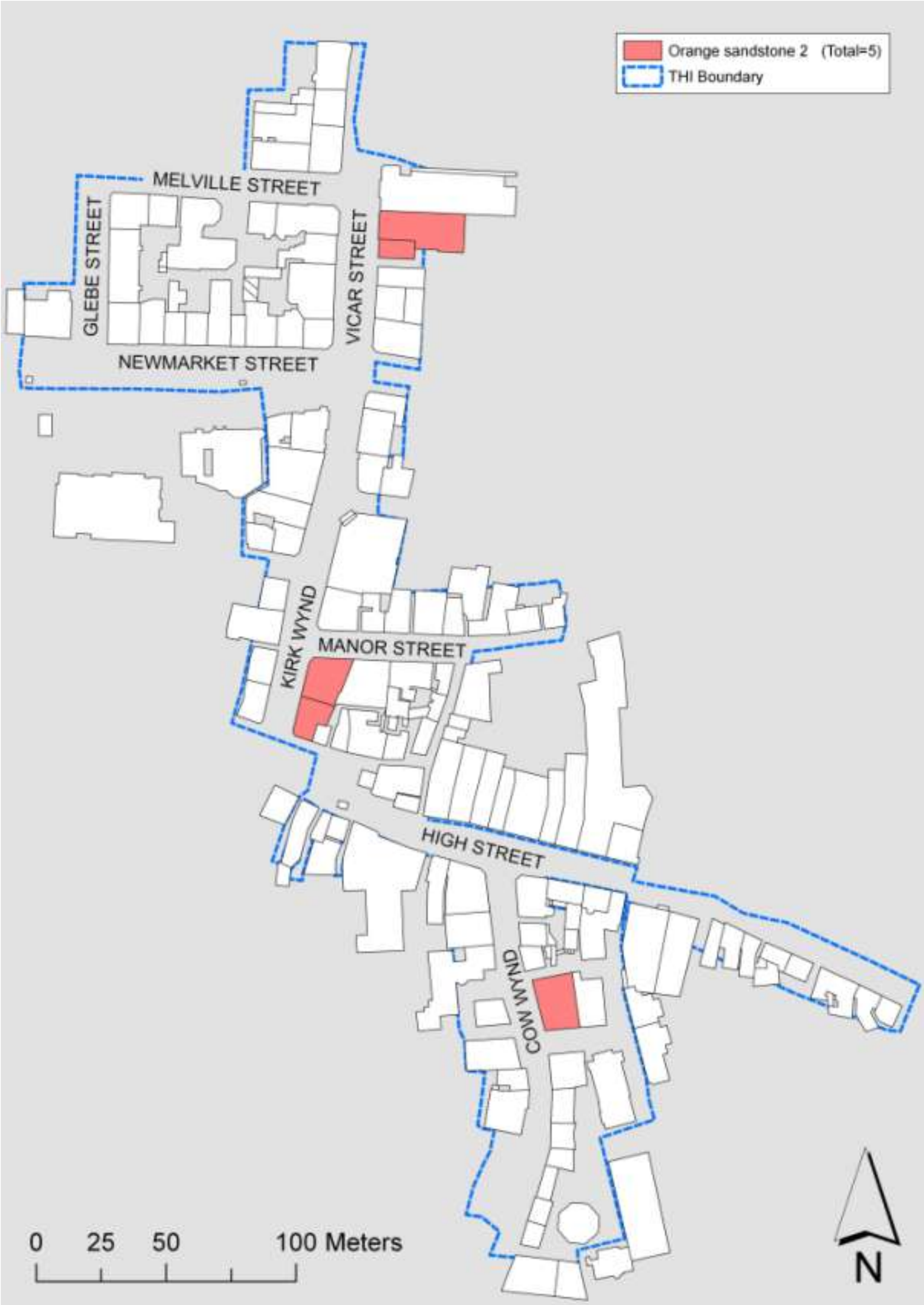


Figure A2_19 Map of polygons for which 'Orange sandstone 2' was recorded

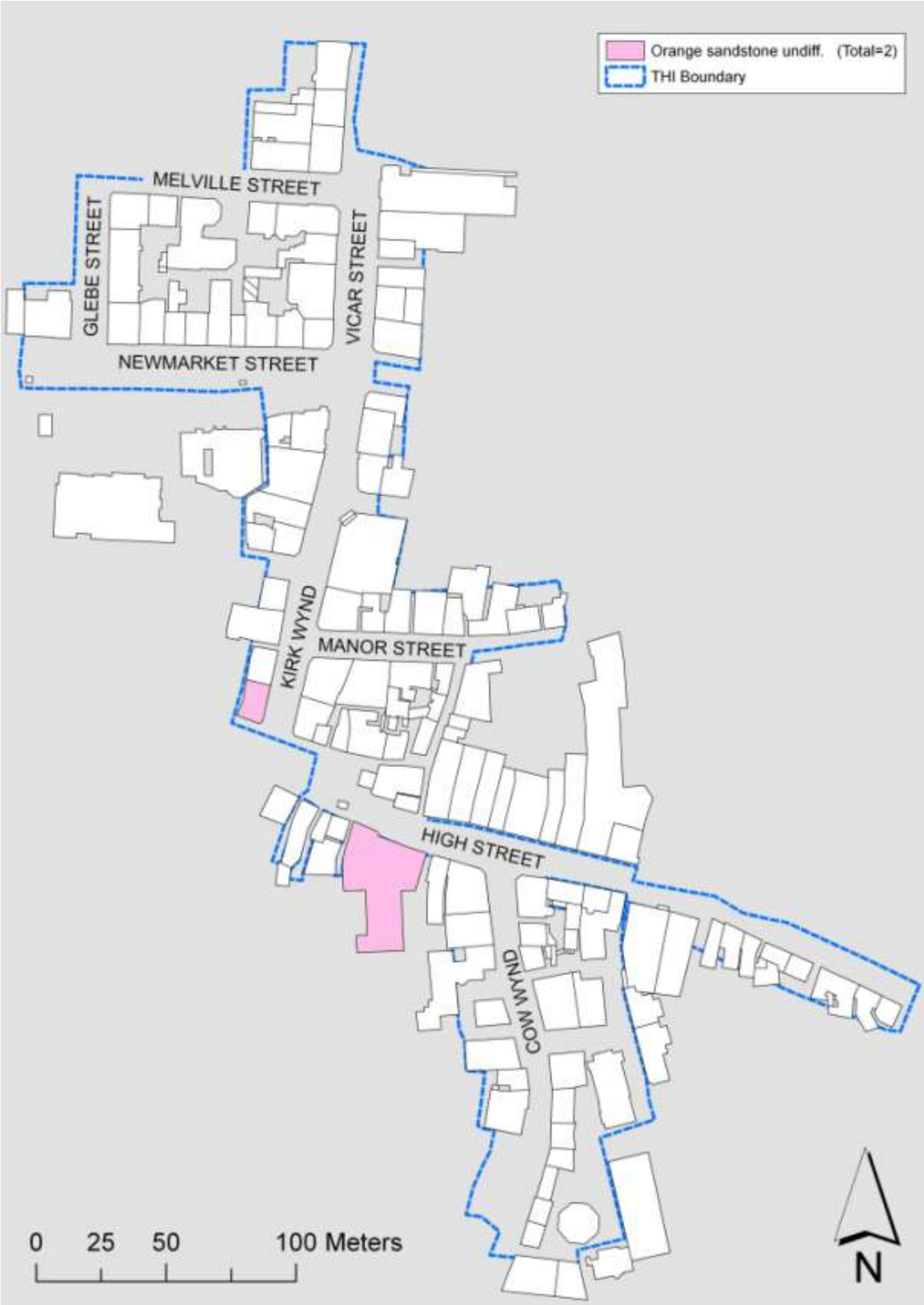


Figure A2_20 Map of polygons for which 'Orange sandstone, undifferentiated' was recorded

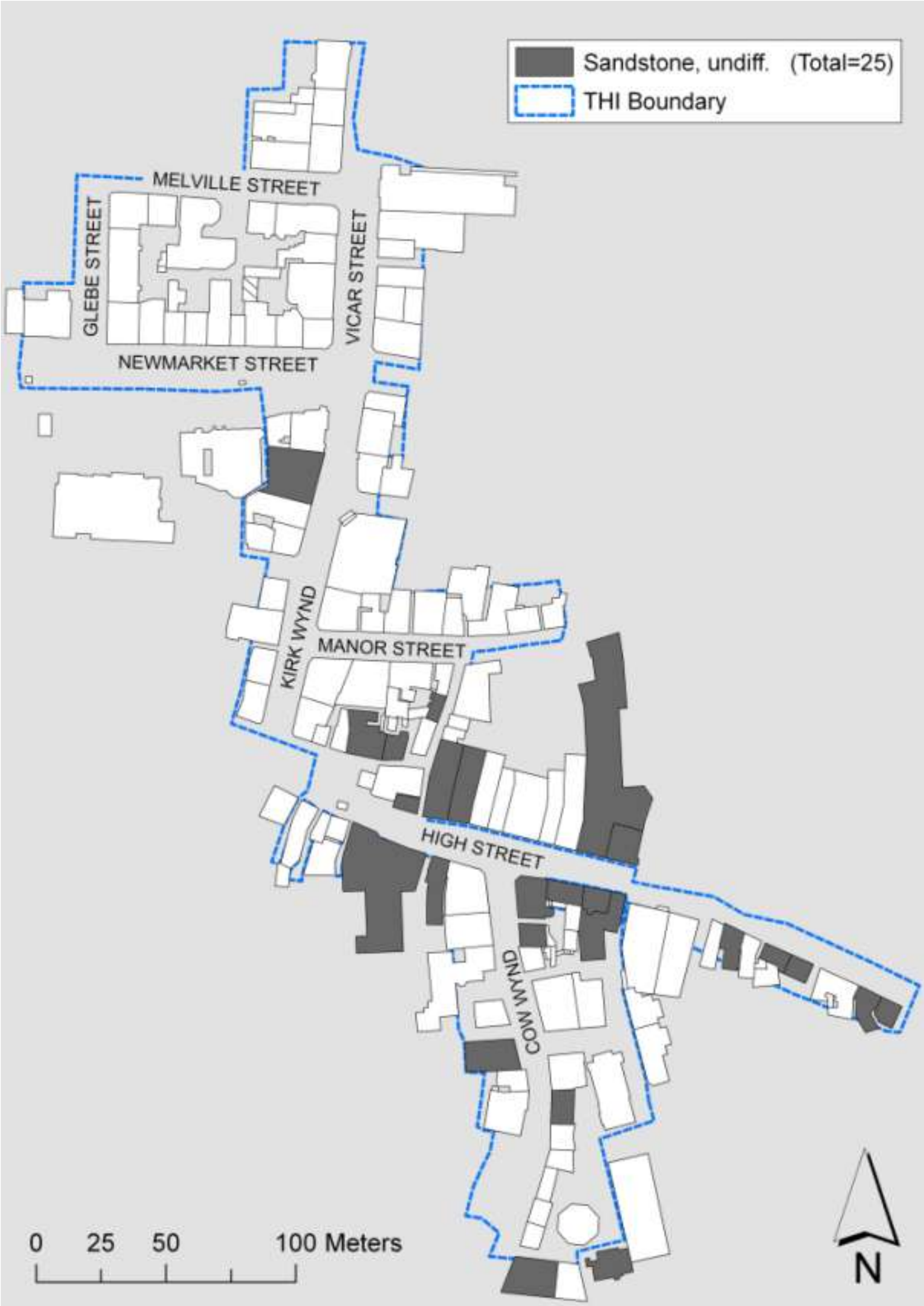


Figure A2_21 Map of polygons for which 'Sandstone, undifferentiated' was recorded

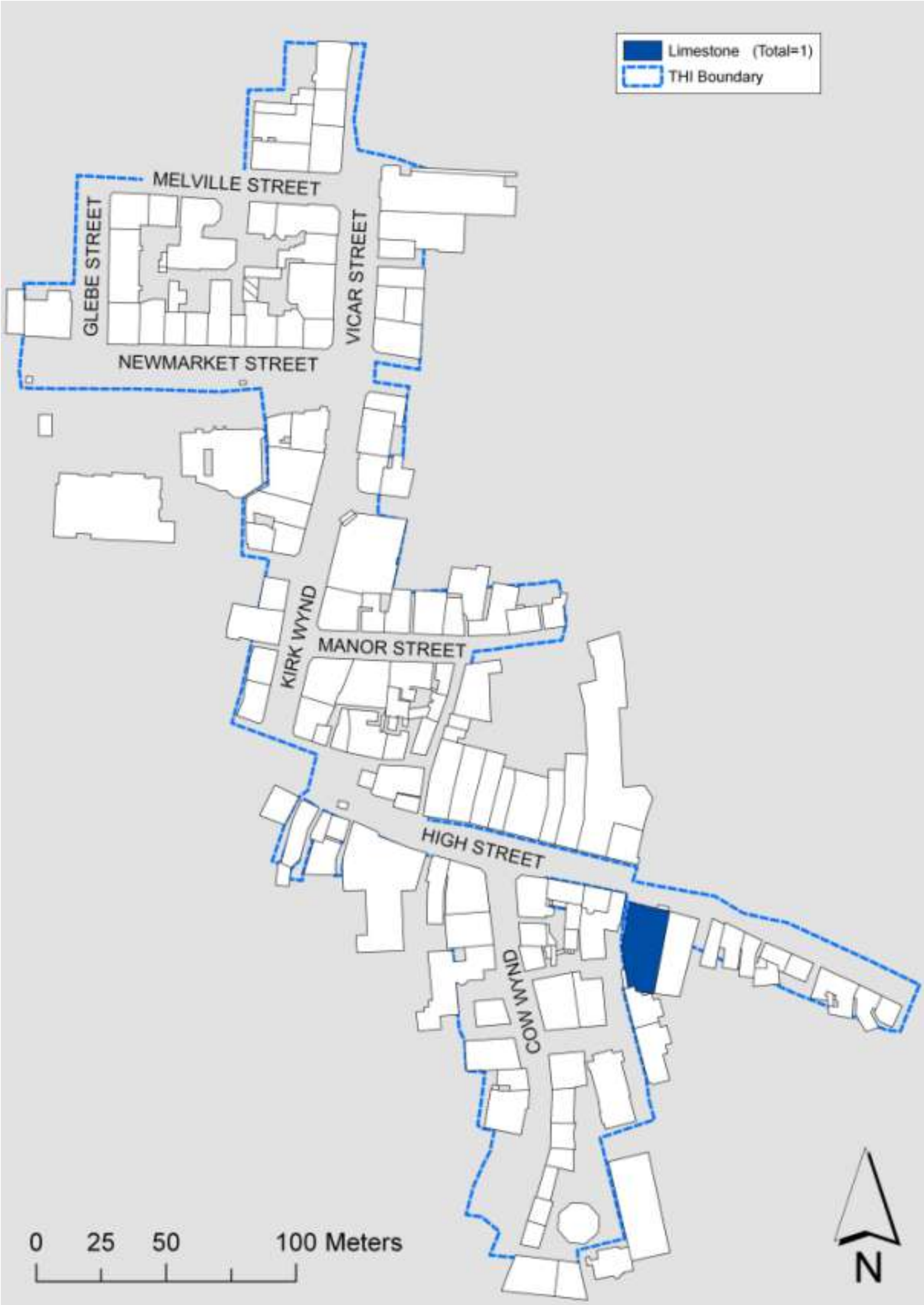


Figure A2_22 Map of polygons for which 'Limestone' was recorded

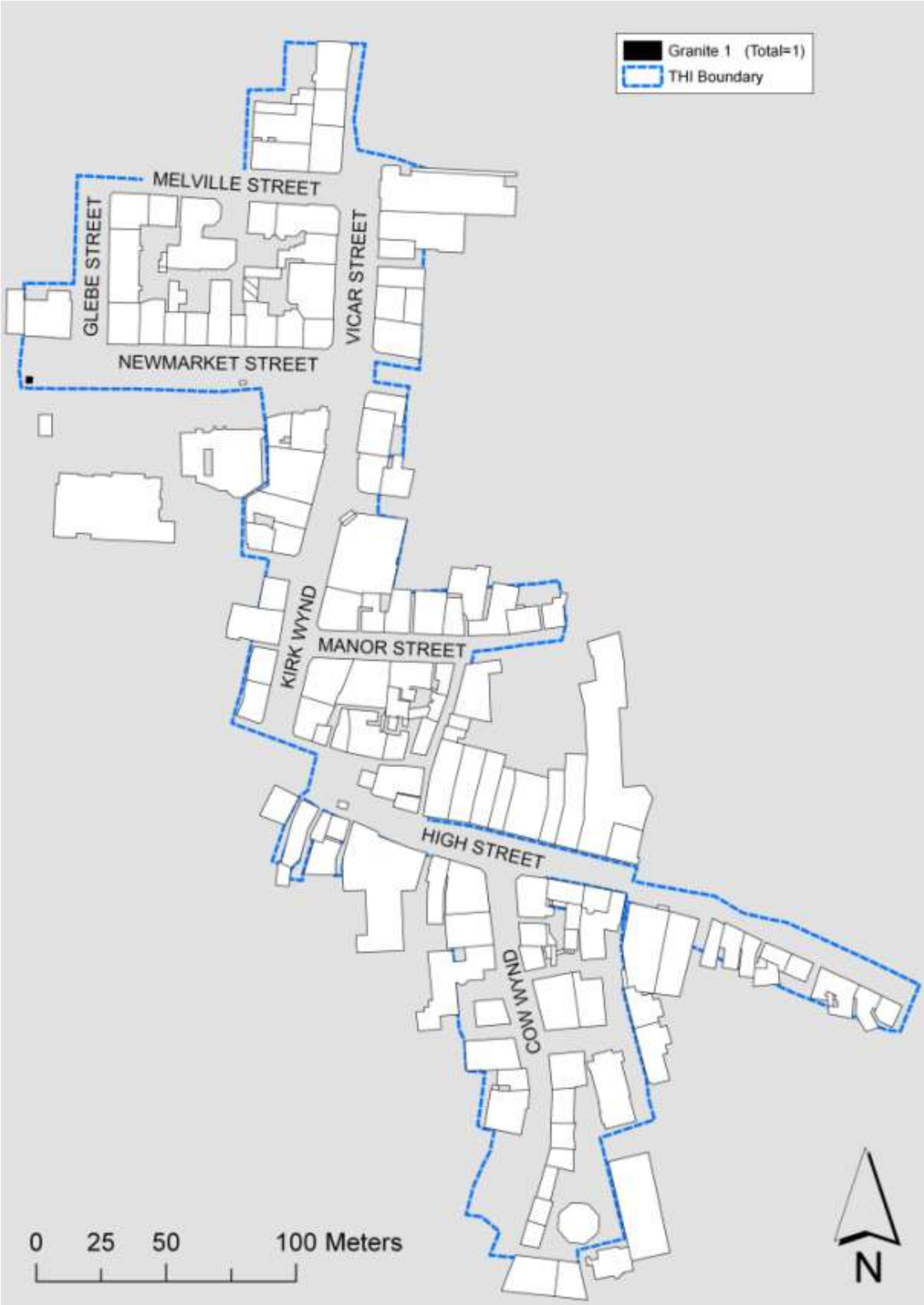


Figure A2_23 Map of polygons for which 'Granite 1' was recorded

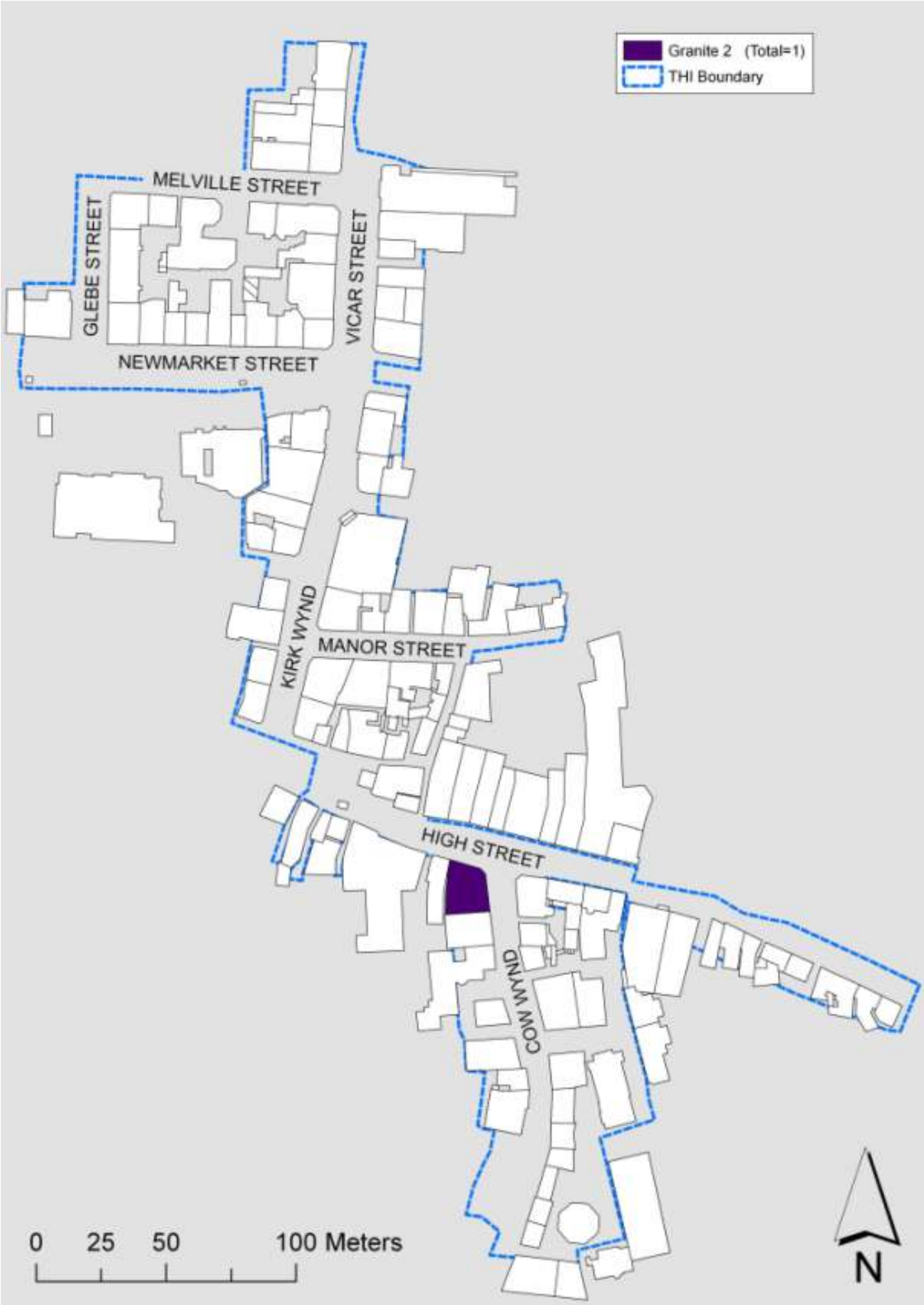


Figure A2_23 Map of polygons for which 'Granite 2' was recorded

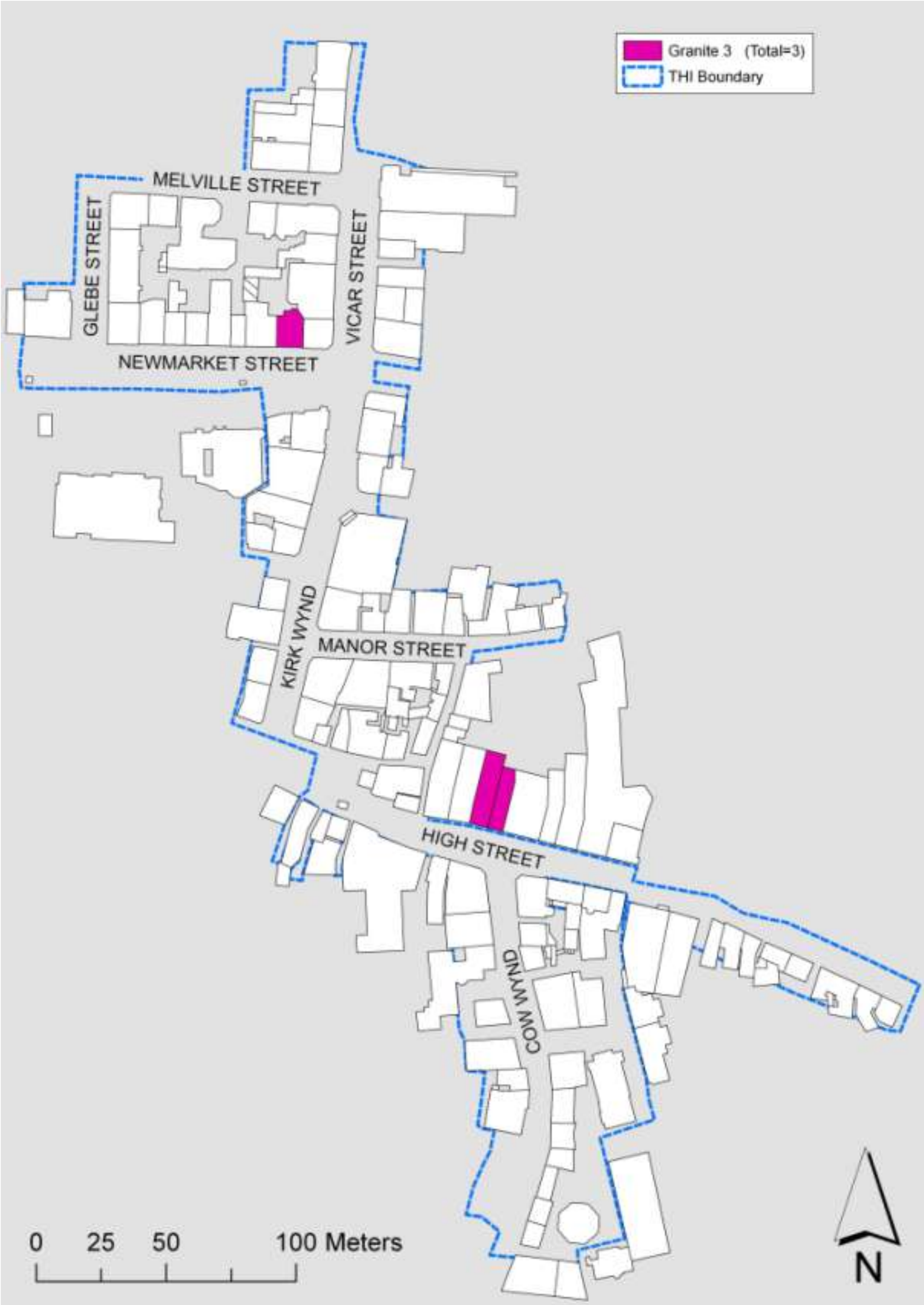


Figure A2_24 Map of polygons for which 'Granite 3' was recorded

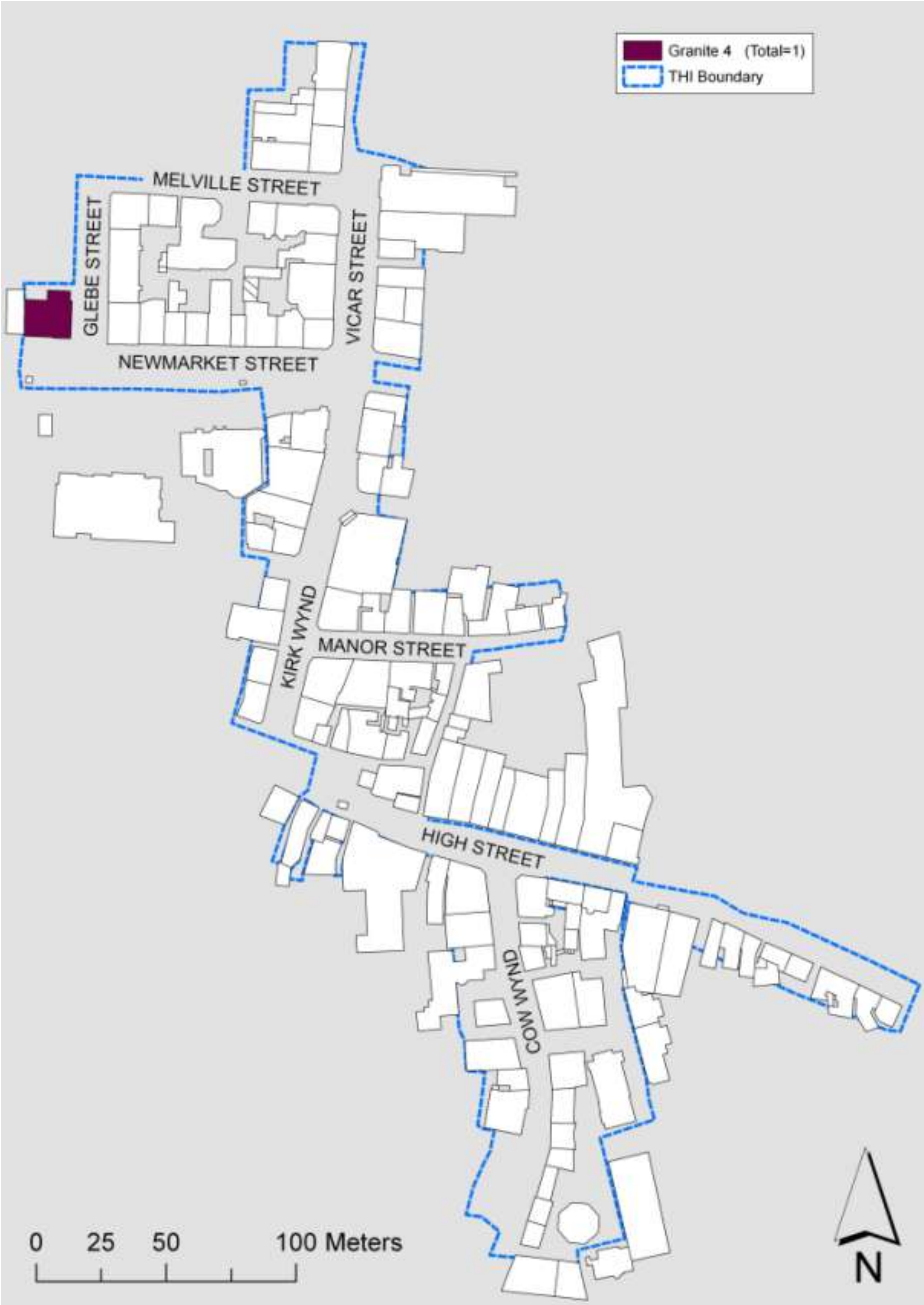


Figure A2_25 Map of polygons for which 'Granite 4' was recorded

Appendix 3 Maps of roofing slate distribution in the Falkirk THI area

The maps in this appendix were created in ArcGIS using the data contained in the Falkirk THI Area Stone Survey Data table (delivered independently of this report).

See section 3 for more details.

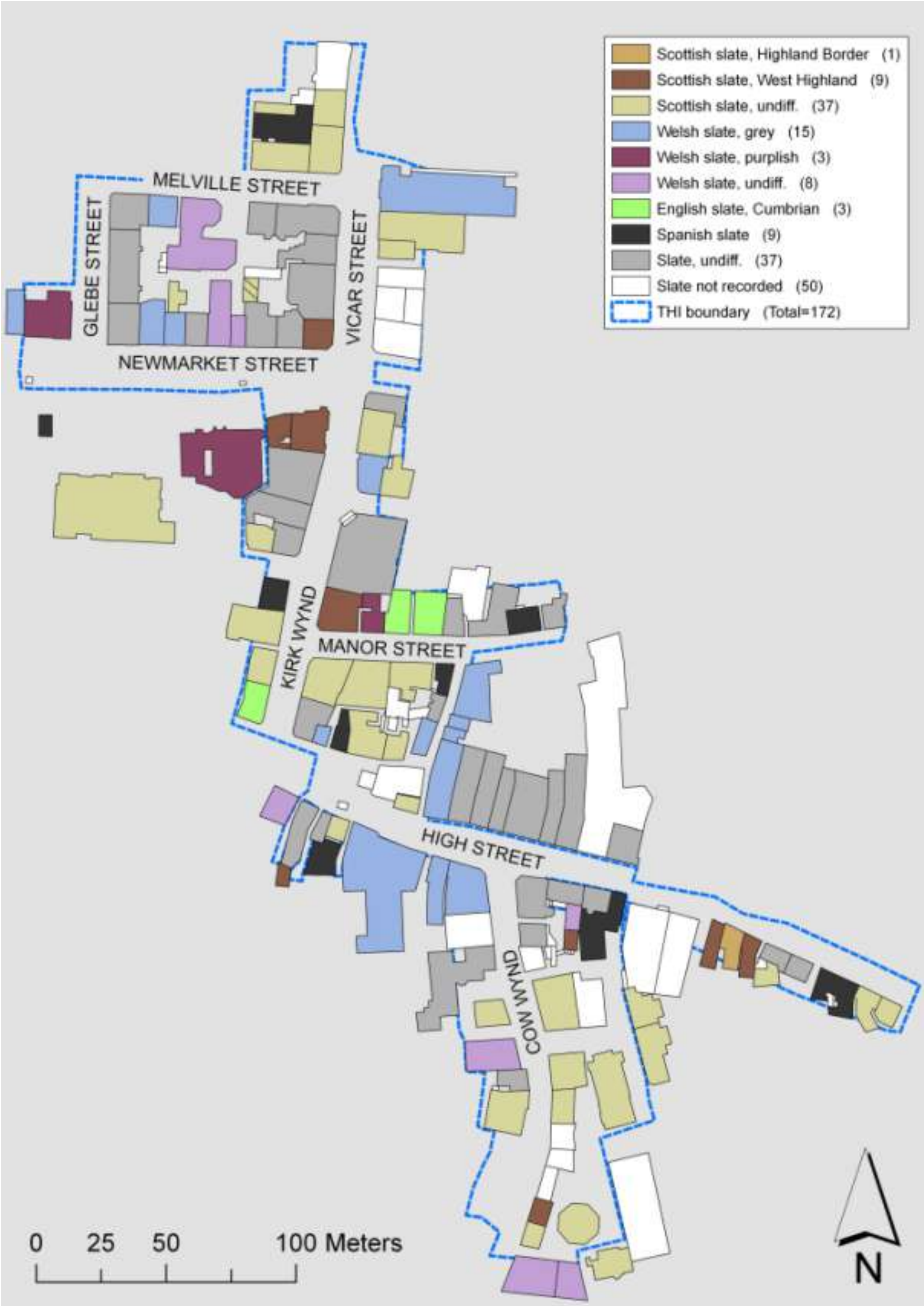


Figure A3_1 Map of 'MAJOR_SLATE' for all polygons

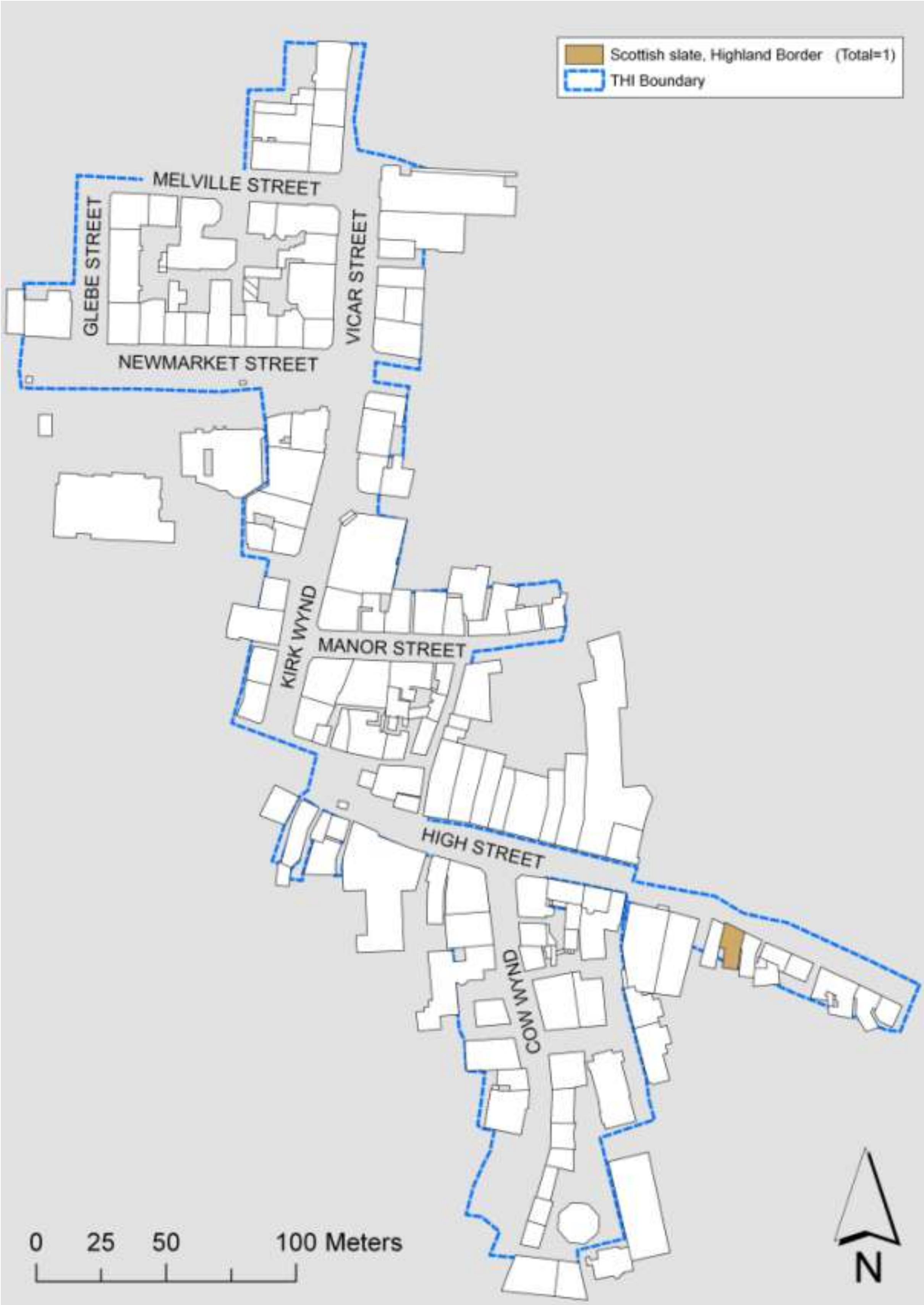


Figure A3_2 Map of polygons for which 'Scottish Highland Border slate' was recorded

Figure A3_3 Map of polygons for which 'Scottish West Highland slate' was recorded

Figure A3_4 Map of polygons for which 'Scottish slate, undifferentiated' was recorded

Figure A3_5 Map of all polygons for which 'Welsh slate, purplish' was recorded

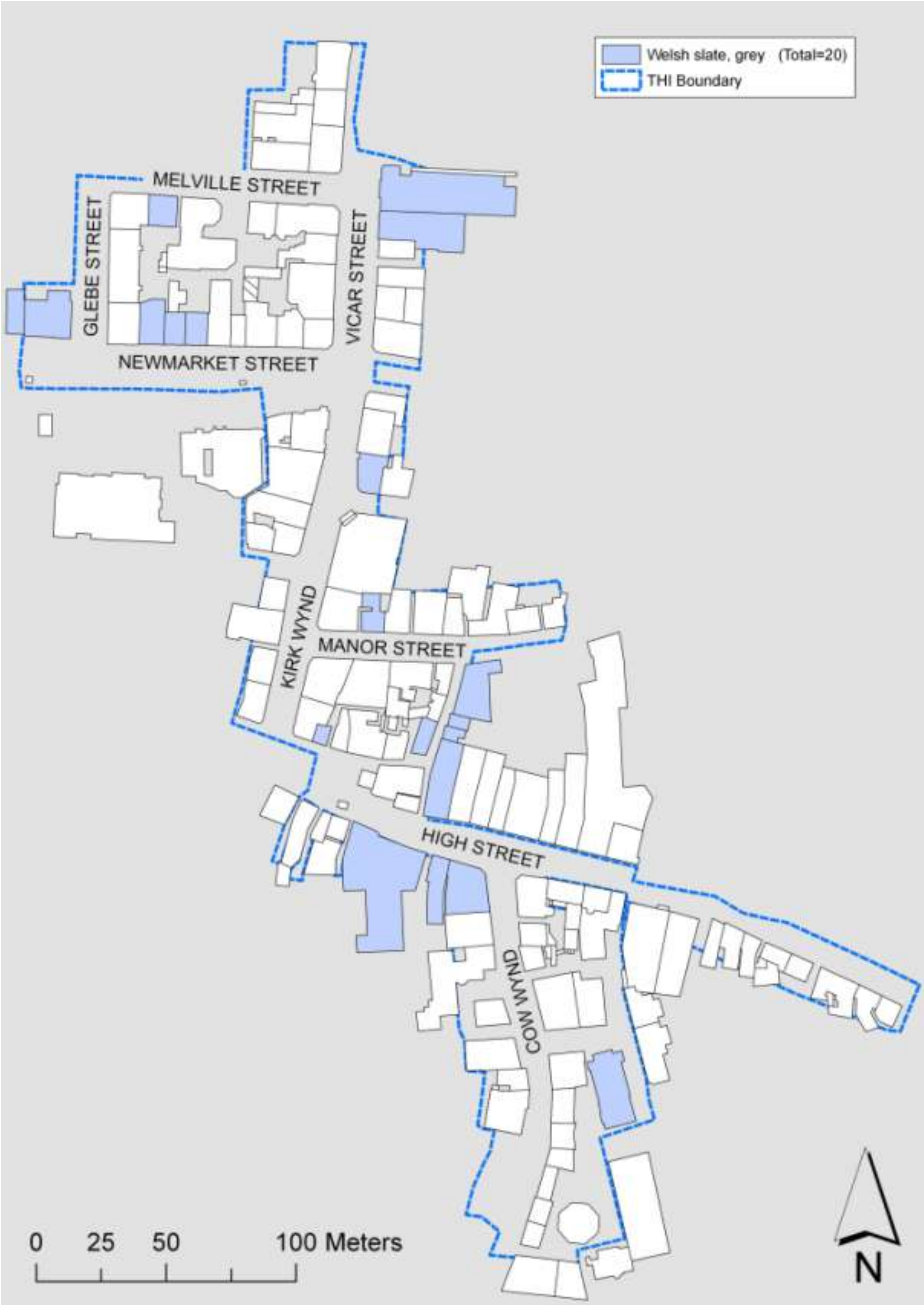


Figure A3_6 Map of polygons for which 'Welsh slate, grey' was recorded

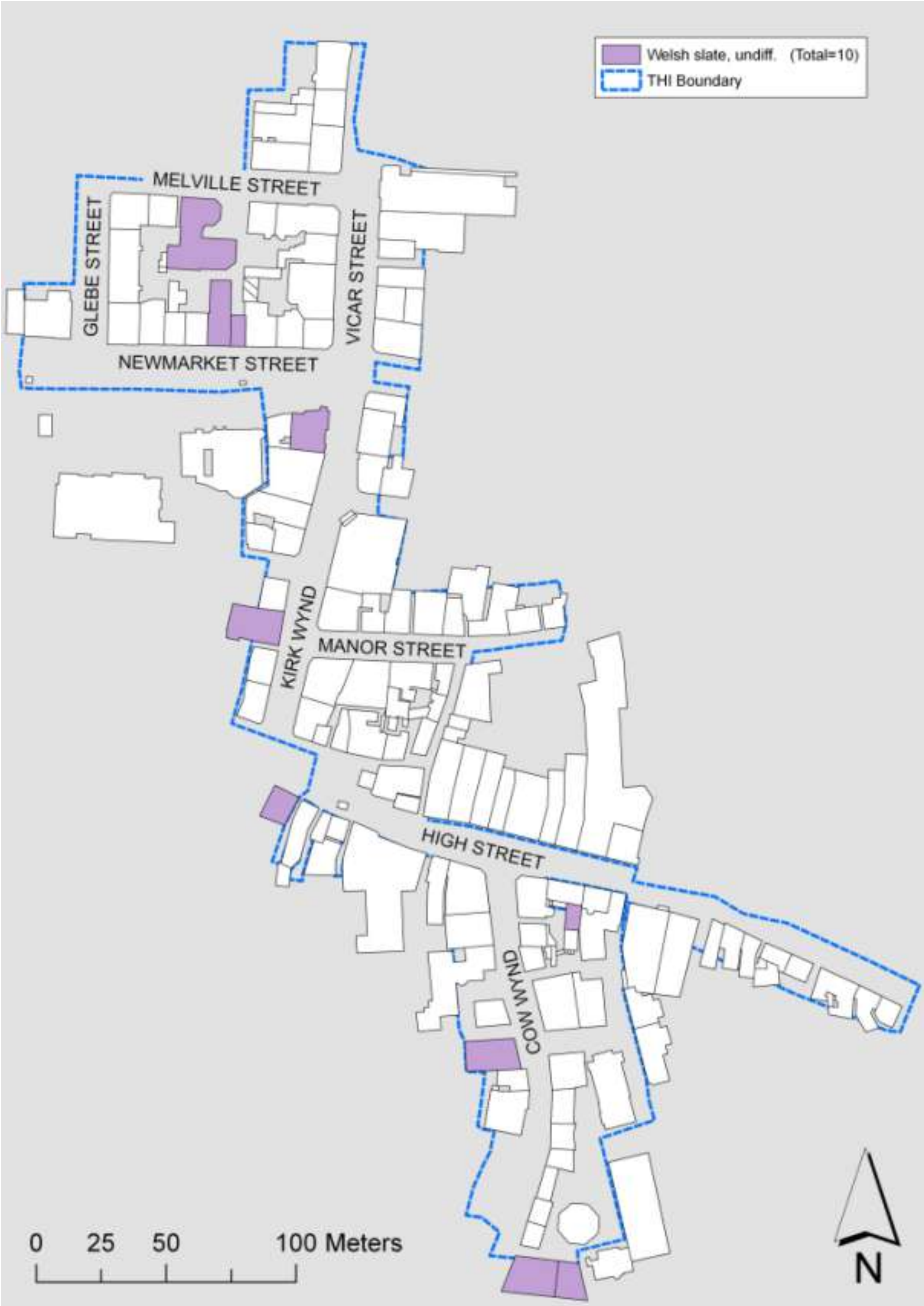


Figure A3_7 Map of polygons for which 'Welsh slate, undifferentiated' was recorded

Figure A3_8 Map of polygons for which 'English slate' was recorded

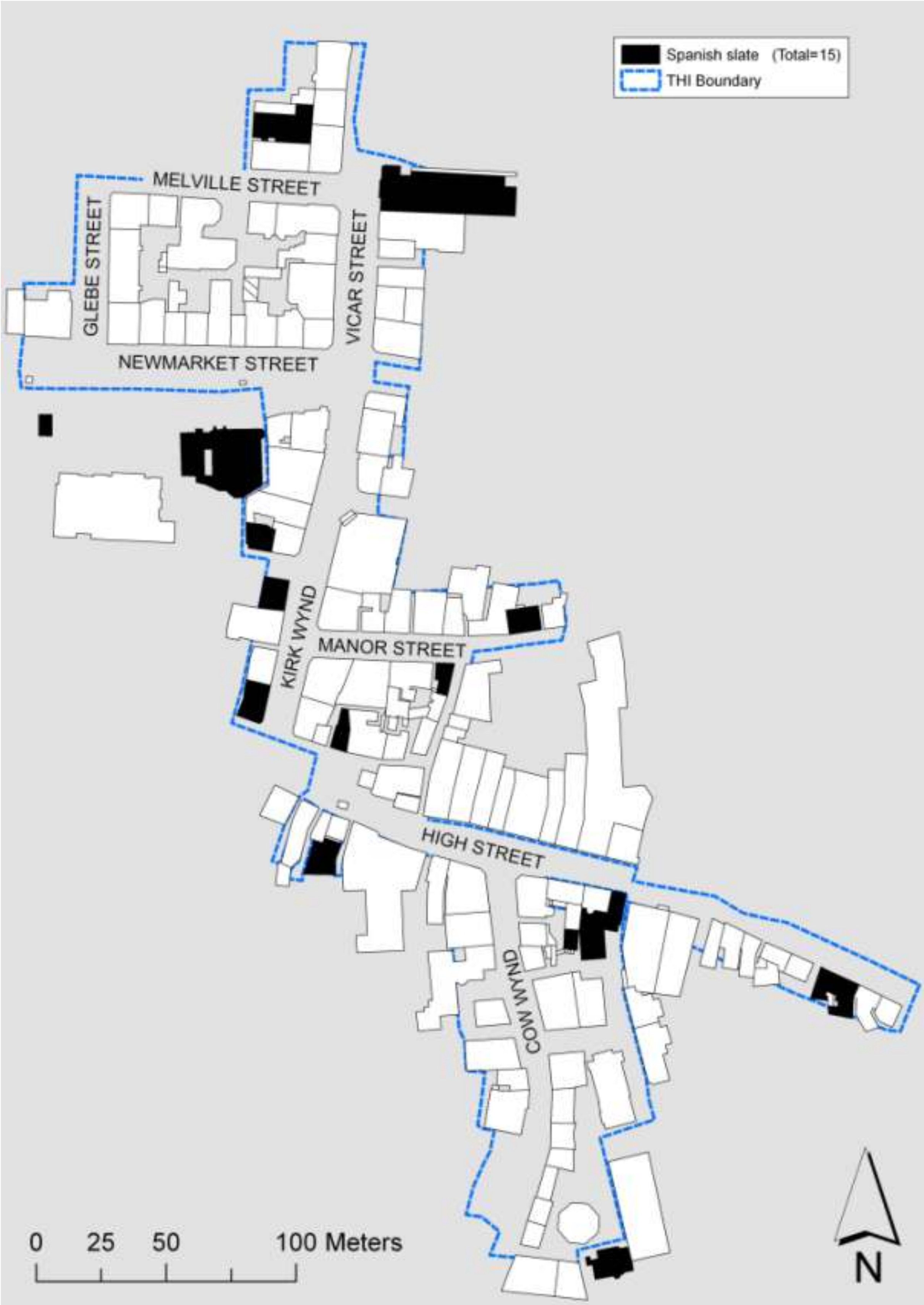


Figure A3_9 Map of polygons for which 'Spanish slate' was recorded

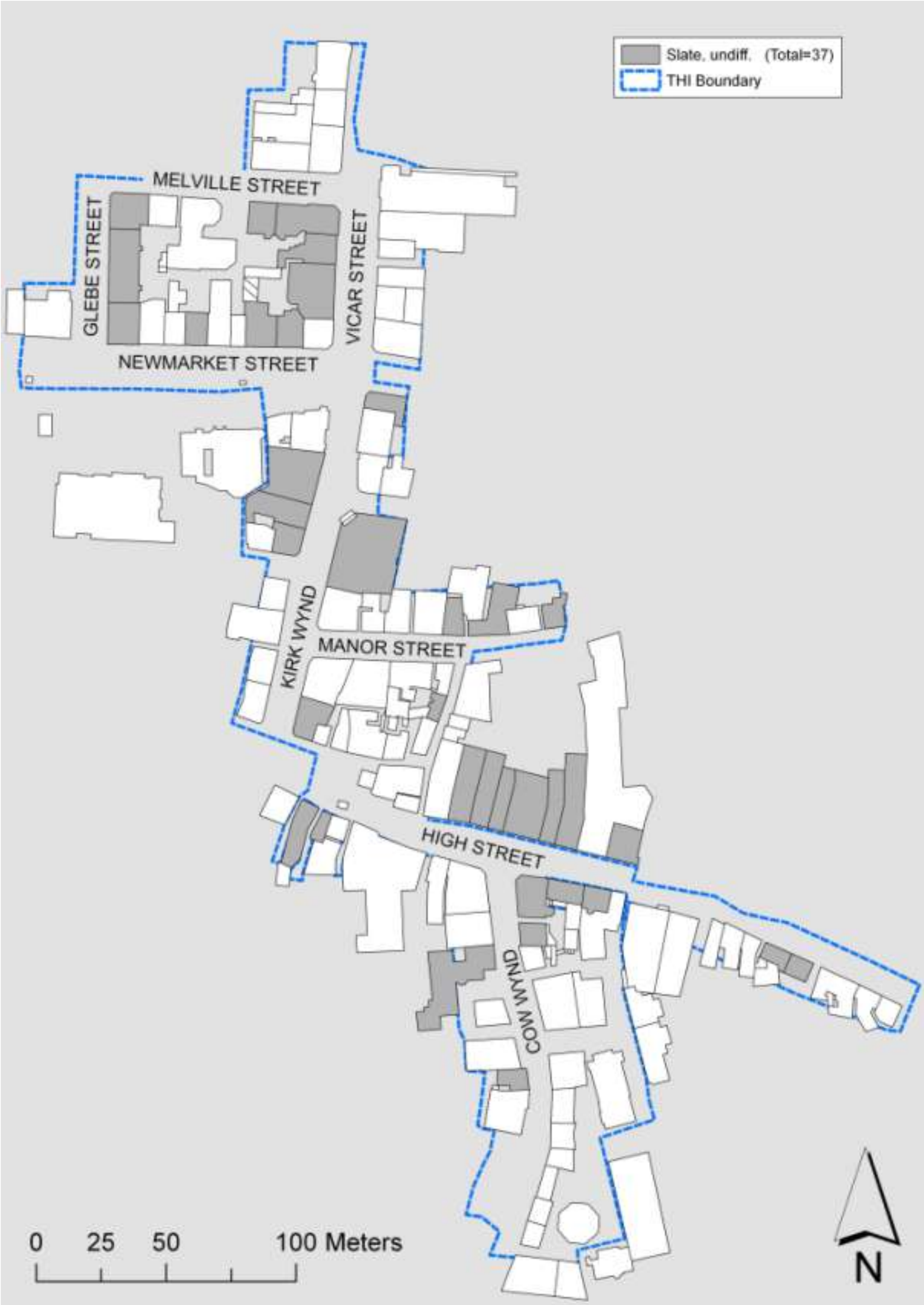


Figure A3_10 Map of polygons for which 'Slate, undifferentiated' was recorded

Appendix 4 Sandstone quarries in the Falkirk district

Table A4_1 (below) contains a list (arranged in alphabetical order) of all the quarries that historically produced sandstone building stone within the search area described in section 4 (156 quarries in total). Alternative names for some quarries are placed in brackets. Grid references are fully numeric (i.e. they don't include the unique two-letter prefixes denoting 100 kilometre squares). 'Lithostratigraphic unit' refers to the named sequence of strata in which the quarry is situated. 'MPA' denotes the Mineral Planning Authority in which the quarry sits: FAL = Falkirk; FIF = Fife; NLK = North Lanarkshire; STG = Stirling; WLN = West Lothian. All comments in the 'Notes' column were sourced from the BGS Database of Mines and Quarries ('BritPits'), unless stated otherwise. All quarries are currently inactive, and some will be 'sterilised' by infilling or flooding. Figure 15 in section 4.2 shows the location of all quarries.

Table A4_1 Summary details for historical sandstone quarries in the Falkirk district

QUARRY NAME	GRID REFERENCE	LOCATION	LITHOSTRATIGRAPHIC UNIT	MPA	NOTES
Abronhill	277805, 676075	Abronhill	Passage Formation	NLK	Pale grey, fine- and medium-grained
Airdriehead Farm	275400, 675705	Carrickstone	Upper Limestone Formation	NLK	In faky sandstone
Airth Castle	289690, 686960	Airth	Scottish Lower Coal Measures Formation	FAL	
Airth Mains	289850, 687200	Airth	Scottish Lower Coal Measures Formation	FAL	
Auchenbowie	280040, 687875	Auchenbowie	Limestone Coal Formation	STG	Quarry has flaggy sandstone at top
Auchinbee	273715, 675830	Craighalbert	Upper Limestone Formation	NLK	
Auldshields Bridge	277045, 671490	Windyridge	Scottish Lower Coal Measures Formation	NLK	
Avonbridge	291030, 672990	Avonbridge	Passage Formation	FAL	Quarries
Bandominie	280380, 676590	Castlecary	Passage Formation	FAL	Quarry with white, somewhat friable sandstone
Bantaskine (Bantaskine East)	287410, 679155	Bantaskine Estate	Scottish Lower Coal Measures Formation	FAL	Outcrop of splint coal overlying a line of sandstone quarries (BritPits). Quarry face present c.1864, 'old quarry' c.1899 (OS maps)
Bath	297460, 691110	Bogside	Passage Formation	FIF	White sandstone
Binny (Binnie)	305530, 673285	Uphall	West Lothian Oil Shale Formation	WLN	Engine House' Building Stone; infilled by tipping by 1897; pale yellowish brown, fine grained sandstone; Binny Sandstone, Hopetoun Member
Binny Bridge	305745, 673082	Ecclesmachan	West Lothian Oil Shale Formation	WLN	Binny Sandstone, Hopetoun Member
Binny Lodge	304855, 673160	Ecclesmachan	West Lothian Oil Shale Formation	WLN	Quarries with reddish brown weathering, soft friable sandstone; Hopetoun Member
Birchhill (Birkhill)	296400, 679135	Birkhill	Passage Formation	FAL	Quarried on a small scale (Cameron)
Blackcraig (Plean, Black Craig)	282550, 686115	Plean	Upper Limestone Formation	STG	Supplying freestone in c.1860 (Hunt). Fine-grained, good quality white sandstone building stone (Hinxman). Building Stone: Bishopbriggs Sandstone (Upper Limestone Group); several large pits; 'Plean Freestone' (BritPits)
Blackstone	280580, 685550	Dunipace	Lower Limestone Formation	FAL	Quarry in black, medium grained silicious sandstone
Blair	302270, 689799	Oakley	Limestone Coal Formation	FIF	Building Stone: Blair Stone; massive white sandstone with fakes, blaes, ironstone and thin coals
Bonhard	304305, 689915	Carnock	Limestone Coal Formation	FIF	
Bonnyside	283800, 680120	Bonnybridge	Passage Formation	FAL	
Bordie	295920, 687000	Culross	Passage Formation	FIF	
Bowdenhill (Bowden Hill)	298247, 674550	Linlithgow	Upper Limestone Formation	WLN	
Boxton	288735, 673520	Slamannan	Scottish Lower Coal Measures Formation	FAL	Flaggy sandstone

QUARRY NAME	GRID REFERENCE	LOCATION	LITHOSTRATIGRAPHIC UNIT	MPA	NOTES
Brand's (Crawbank, Maiden Park)	299360, 680730	Bo'ness	Upper Limestone Formation	FAL	
Bridge Castle	294445, 670995	Bridgecastle	Passage Formation	WLN	Sandstone Quarries
Brightons (Old Brigtons, Brighton)	293170, 677670	Brightons	Scottish Lower Coal Measures Formation	FAL	Quarry in 40 feet of Brighton Rock sandstone; 'Old Brighton Freestone' (BritPits). In operation c.1845 (Ker). In operation c.1860, 'old quarry' c.1899 (OS maps).
Broomy Knowes	301930, 673705	Linlithgow	West Lothian Oil Shale Formation	WLN	White sandstone, infilled quarry
Burn Row	285325, 671580	Slamannan	Scottish Lower Coal Measures Formation	FAL	"Old Quarry' 'fakes & sandstone'
Burnbrae	296010, 691420	Clackmannan	Passage Formation	FIF	White sandstone
Burnfoot (Cat Craig)	302290, 681105	Carriden	Lower Limestone Formation	FAL	
Cadgers Loan (Cadger’s Loan, Plean)	282585, 686915	Plean	Upper Limestone Formation	STG	Coarse and gritty sandstone, often exceeds 60 feet in thickness (Hinxman)
Callendar House	290380, 679330	Callendar Park	Scottish Lower Coal Measures Formation	FAL	Used in Falkirk and for the construction of the Canal (Bailey)
Callendar Park	289320, 679510	Callendar Park	Scottish Lower Coal Measures Formation	FAL	
Cameron Knowe	304950, 676325	Phipstoun	West Lothian Oil Shale Formation	WLN	Hopetoun Member
Carbrook	283700, 685350	Torwood	Passage Formation	FAL	Sandstone quarry, 20 foot beds
Carnock Moor (Camock)	304415, 690970	Cowstrandburn	Limestone Coal Formation	FIF	Sandstone Quarries'; 'thick-bedded white sandstone'; 'Building stone'; 'flaggy sandstone over massive grey sandstone'
Castlecary	278605, 677792	Castlecary	Passage Formation	NLK	Fine grained, off-white, crossbedded sandstone
Castleton	285500, 688175	Cowie	Passage Formation	STG	
Cat Craig (Catscraig)	280700, 689680	Bannockburn	Limestone Coal Formation	STG	Supplying freestone c.1860 (Hunt)
Caverns	295854, 685922	Longannet	Passage Formation	FIF	
Caverns Farm	296345, 685970	Longannet	Passage Formation	FIF	
Cockmalane	290650, 676345	California	Scottish Lower Coal Measures Formation	FAL	Soft, yellow sandstone
Corsehill	280115, 688295	Bannockburn	Limestone Coal Formation	STG	
Cowie	283725, 689035	Berry Hills	Upper Limestone Formation	STG	
Craig Moss	283160, 690765	Fallin	Upper Limestone Formation	STG	Quarry in coarse pebbly grit and four feet of yellow and white, medium-grained, coarsely bedded, massive to flaggy sandstone
Craigbeg	282335, 688415	Plean	Upper Limestone Formation	STG	Supplying freestone c.1860 (Hunt)
Craigenbuck	296070, 680105	Kinneil Kerse	Upper Limestone Formation	FAL	Sandstone quarry; limestone formerly worked
Craigs	286100, 687300	Plean	Passage Formation	STG	
Cultenhove	278545, 690135	Chartershall	Lower Limestone Formation	STG	Largely overgrown but 8 foot of massive medium-grained buff sandstone still exposed
Dales Wood	282145, 684910	Dunipace	Upper Limestone Formation	FAL	Sandstone quarries
Davidscraig Wood	285525, 687185	Plean	Passage Formation	STG	

QUARRY NAME	GRID REFERENCE	LOCATION	LITHOSTRATIGRAPHIC UNIT	MPA	NOTES
Deanfield	298800, 681115	Deanfield	Upper Limestone Formation	FAL	
Denovan	282431, 683197	Denny	Upper Limestone Formation	FAL	Massive freestone sandstone and boulder clay top
Dickson's Wood	294180, 690440	Kilbagie	Passage Formation	FIF	35ft-deep pit, massive, medium-grained, false-bedded white sandstone'; 'boulder clay on coarse grittty false-bedded pale sandstone'
Doghillock	281845, 684052	Denny	Upper Limestone Formation	FAL	Faky sandstone and flags
Doo Craig	297695, 691000	Blairhall	Passage Formation	FIF	Old Quarry', yellow sandstone
Dougalshole	289355, 687690	Airth	Scottish Lower Coal Measures Formation	FAL	Quarry in 20 feet of massive false-bedded sandstone
Drumclair Row	286655, 671575	Slamannan	Scottish Lower Coal Measures Formation	FAL	
Drumshangie	277960, 668740	Drumshangie Moss	Scottish Lower Coal Measures Formation	NLK	'Old Quarry' by 1899
Dullatur	274120, 676750	Dullatur	Upper Limestone Formation	NLK	Quarry in 30 feet (visible above water level) of Bishopbriggs Sandstone Freestone
Dunmore	283875, 688475	Cowie	Upper Limestone Formation	FAL	Building stone: Cowie Rock, Dunmore Sandstone ; 'Quarry now largely filled with waste from colliery'
Dunmore Icehouse	288170, 688980	Airth	Passage Formation	FAL	Massive white sandstone
Dunmore Park	288010, 688720	Dunmore	Passage Formation	FAL	
Dunmore Park Farm	288425, 689035	Airth	Passage Formation	FAL	Massive false-bedded sandstone with plants
Dunmore Wood	288105, 688330	Airth	Passage Formation	FAL	Massive sandstone; 8 foot beds (BritPits). Supplying freestone and flagstone c.1860, operated by Tait & Crighton, Falkirk (Hunt)
East Kerse Mains	297430, 680295	Kinneil Kerse	Upper Limestone Formation	FAL	
East Luscar	305240, 689880	Gowkhall	Lower Limestone Formation	FIF	Hardsandstone at least two feet thick, baked Blaes 2 feet, dolostone at least 8 feet; chilled edge
Easterton	280335, 686445	Plean	Lower Limestone Formation	STG	Overgrown quarries of grey, medium-grained, flaggy sandstone; sandstone waste present
Eastfield	289985, 687370	Airth	Scottish Lower Coal Measures Formation	FAL	Sandstone quarries
Fannyside Muir	278975, 673895	Palacerigg	Passage Formation	NLK	
Fordel	294720, 685785	Longannet	Passage Formation	FIF	
Gartincaber	282705, 685865	Plean	Upper Limestone Formation	STG	Quarries ; sandstone quarries, 3 feet of medium grained sandstone
Gartwhinnie	282005, 687215	Plean	Limestone Coal Formation	STG	Holes for sandstone ; 'coarse, gritty sandstone'; 'blocks of pale, fine-grained sandstone seen'; "Old Quarry'; 'Quarry in 20 feet of sandstone'
Gartwhinnie Main	282075, 687285	Plean	Limestone Coal Formation	STG	Main quarry in 20 feet of massive, flaggy, cross-bedded sandstone

QUARRY NAME	GRID REFERENCE	LOCATION	LITHOSTRATIGRAPHIC UNIT	MPA	NOTES
Glassiebarns	305397, 690805	Gowkhall	Lower Limestone Formation	FIF	Sandstone quarries
Glen Arden	281952, 678335	Greenhill	Passage Formation	FAL	
Glenhead	279260, 675480	Abronhill	Passage Formation	NLK	False-bedded white sandstone
Glenhead Wood	279065, 675580	Abronhill	Passage Formation	NLK	
Gowkhall	304790, 689240	Gowkhall	Lower Limestone Formation	FIF	Old Quarries'; 'no Limestone, all sandstone debris'
Graham	289635, 687725	Airth	Scottish Lower Coal Measures Formation	FAL	
Gray Craigs	304005, 687265	Cairneyhill	Lower Limestone Formation	FIF	Freestone
Greenhill	281480, 686355	Plean	Limestone Coal Formation	STG	
Haining	295493, 676948	Maddiston	Scottish Lower Coal Measures Formation	FAL	Supplying Freestone c.1860 (Hunt)
Haircraigs	281285, 681055	Head of Muir	Upper Limestone Formation	FAL	Overgrown quarry in false-bedded white sandstone
Hangingside	303995, 673875	Ecclesmachan	West Lothian Oil Shale Formation	WLN	Old quarry grassed and part filled by fragments of sandstone'; Hopetoun Member
Hilderston	297950, 671420	Torphichen	Limestone Coal Formation	WLN	Sandstone quarry, freestone
Hill of Kinnaird	287020, 685170	Stenhousemuir	Scottish Lower Coal Measures Formation	FAL	
Hillhouse	301130, 675300	Linlithgow	Lower Limestone Formation	WLN	Quarry in 50-60 feet of freestone sandstone succeeded by blaes, sandstone and mudstone
Howierigg	284560, 678900	Roughcastle	Scottish Lower Coal Measures Formation	FAL	Sandstone quarries, massive beds
Inzievar Wood	303165, 688363	Oakley	Limestone Coal Formation	FIF	
Jenny Lind	279575, 679995	Longcroft	Scottish Lower Coal Measures Formation	FAL	Yellow sandstone
Kincardine (Sands)	294450, 686400	Longannet	Passage Formation	FIF	Building Stone: Passage Formation Sandstone
Kingscavil (Linlithgow)	302720, 676430	Kingscavil	West Lothian Oil Shale Formation	WLN	Quarry linked to Union Canal; in 60 feet of hard massive sandstone ; Building Stone: Kingscavil Stone
Kinneil	297000, 679130	Birkhill	Passage Formation	FAL	Sandstone outcrop
Kinningars Park	301170, 681140	Bo'ness	Limestone Coal Formation	FAL	Quarry in pale brown and yellow, fine grained sandstone with faky partings ; rooty sandstone, partly micaceous, ironstained in part'
Kirkbrae Wood	299445, 686205	Culross	Upper Limestone Formation	FIF	Innacessible
Kirkton	289600, 683940	Carronshore	Scottish Lower Coal Measures Formation	FAL	Quarry in 3 metres of sandstone under 2 metres of drift
Langlands	282575, 685260	Plean	Limestone Coal Formation	STG	Sandstone quarries
Larbert Bridge	285620, 681955	Larbert	Passage Formation	FAL	
Lathallan	294040, 677565	Rumford	Scottish Lower Coal Measures Formation	FAL	Opened c.1845, white sandstone, hard and durable (Ker)
Loanhead	305680, 690450	Gowkhall	Limestone Coal Formation	FIF	Dark grey sandstone and thin shale

QUARRY NAME	GRID REFERENCE	LOCATION	LITHOSTRATIGRAPHIC UNIT	MPA	NOTES
Lochcote	297535, 673950	Torphichen	Passage Formation	WLN	Old quarry in 4 feet of soft sandstone with shales above and below; 'rather soft whitish sandstone false-bedded fine & felspathic'; 'about 12ft grit with sandy fakes & grit band above'
Lochdrum	281809, 678149	Greenhill	Passage Formation	FAL	Quarried on a small scale (Cameron)
Longannet	294990, 685670	Longannet	Passage Formation	FIF	Building Stone: Passage Formation Sandstone
Maddiston (Quarrelhead)	293835, 676600	Maddiston	Scottish Lower Coal Measures Formation	FAL	Brown sandstone (BritPits). Quarry in operation as early as 18th century; in operation c.1865 and c.1899, marked 'Quarry Disused' c.1922 (OS Maps)
Maiden Park	299270, 680805	Bo'ness	Upper Limestone Formation	FAL	Supplied stone for Bo'ness Town Hall c.1907 (Cameron)
Manuelrig (Mannelrig)	293822, 676708	Maddiston	Scottish Lower Coal Measures Formation	FAL	Supplying Freestone c.1860 (Hunt)
Midglen	288300, 677770	Glen Village	Scottish Lower Coal Measures Formation	FAL	
Muiravonside	295490, 676955	Maddiston	Passage Formation	FAL	Infilled
Muirhead	275280, 676575	North Muirhead	Upper Limestone Formation	NLK	Quarries in 30 feet of freestone; 'yellow, pebbly freestone'
Muirhead Glen	277235, 671950	Windyridge	Scottish Lower Coal Measures Formation	NLK	
Muirhouses	301955, 680380	Muirhouses	Limestone Coal Formation	FAL	
Muirpark	281910, 689610	Bannockburn	Limestone Coal Formation	STG	
Muirside	302094, 689805	Oakley	Limestone Coal Formation	FIF	Sandstone with 'fakes, blaes, Ironstone and thin coals'
Myot Hill (High Myothill)	278100, 682340	Fankerton	Lower Limestone Formation	FAL	Quarries in mainly sandstone with ripple-laminations at top 'baked sediments, mainly sandstone; ripple-laminated in upper part'
Netherwood	276655, 677945	Castlecary	Upper Limestone Formation	NLK	Quarry in 5 metres of yellow medium-grained sandstone ; 'Freestone, grey, medium grained, current-bedded
Newmills	301722, 686358	Newmills	Limestone Coal Formation	FIF	
Oatridge	304620, 673515	Ecclesmachan	West Lothian Oil Shale Formation	WLN	Yellowish weathering sandstone; Hopetoun Member
Old Philpstoun	305800, 677730	Phipstoun	West Lothian Oil Shale Formation	WLN	Hopetoun Member
Pamphellgoat Wood	282395, 683630	Denny	Upper Limestone Formation	FAL	
Pardovan	303955, 677360	Phipstoun	West Lothian Oil Shale Formation	WLN	Hopetoun Member
Parkhill	292490, 678790	Redding	Scottish Lower Coal Measures Formation	FAL	
Plean House	282570, 686550	Plean	Upper Limestone Formation	STG	
Pleanmill	285585, 686670	Plean	Passage Formation	STG	
Polmaise (Cowie)	283650, 689150	Cowie	Upper Limestone Formation	STG	Infilled; 50 feet of massive, fine-grained sandstone; infilled; Building stone: Cowie Rock

QUARRY NAME	GRID REFERENCE	LOCATION	LITHOSTRATIGRAPHIC UNIT	MPA	NOTES
Porterside	301784, 676621	Linlithgow	Lower Limestone Formation	WLN	
Quarryhead	289190, 676150	Sheildhill	Scottish Lower Coal Measures Formation	FAL	
Quarter House	281010, 684730	Dunipace	Upper Limestone Formation	FAL	
Rashiehill	277675, 681345	Banknock	Limestone Coal Formation	FAL	Quarry in faky sandstone
Ravenswood	275060, 674420	Seafar	Upper Limestone Formation	NLK	Freestone
Rhynd House	304316, 691483	Saline	Limestone Coal Formation	FIF	
Righead	280450, 676330	Castlecary	Passage Formation	FAL	
Rowan Tree Burn (Bonnyside)	284225, 680110	Bonnybridge	Passage Formation	FAL	Sandstone quarries, massive beds
Seggieholm	279790, 689110	Bannockburn	Limestone Coal Formation	STG	Quarry in sandstone and blaes
Shaw Hill	301750, 687230	Culross	Limestone Coal Formation	FIF	
Shieldhill	290830, 676955	California	Scottish Lower Coal Measures Formation	FAL	Quarry in faky and fine-bedded sandstone
Slacks	274285, 680245	Banton	Limestone Coal Formation	NLK	Quarry in fine-grained, cross-bedded sandstone with silty laminations
Smithy Wood	286170, 687050	Plean	Passage Formation	STG	
Snabhead	280510, 688790	Bannockburn	Limestone Coal Formation	STG	Quarry in fine-grained, massive sandstone with thin faky bands, 6 - 8 feet of flaggy sandstone at top
South Bantaskine (Bantaskine)	287160, 679115	Bantaskine Estate	Scottish Lower Coal Measures Formation	FAL	"Old Quarries'; 'outcrop of splint coal overlying a line of sandstone quarries'
Springvale	281480, 686745	Plean	Limestone Coal Formation	STG	
Standalane	287475, 678855	Glen Village	Scottish Lower Coal Measures Formation	FAL	
Staylee	277030, 671015	Windyridge	Scottish Lower Coal Measures Formation	NLK	
Stockbridge	278490, 689155	Bannockburn	Limestone Coal Formation	STG	Soft, coarse sandstone
Tapitlaw	301250, 689790	Comrie	Limestone Coal Formation	FIF	Quarry on margin between sandstone and limestone
Thorneydyke	282090, 684550	Dunipace	Upper Limestone Formation	FAL	Quarry working mapped sandstone
Tod's Mill	296490, 678710	Birkhill	Passage Formation	FAL	
Tulliallan Castle	294225, 688115	Kincardine	Passage Formation	FIF	
Tulliallan Farm	293880, 690030	Kilbagie	Passage Formation	FIF	
Upper Kinneil	297285, 679115	Birkhill	Upper Limestone Formation	FAL	Small sandstone quarries, massive beds
Viaduct	296775, 678580	Birkhill	Passage Formation	FAL	Sandstone quarries, massive beds
Viewfield (Bantaskine East)	287735, 679145	Bantaskine Estate	Scottish Lower Coal Measures Formation	FAL	Quarries
West Binny	303490, 672495	Uphall	West Lothian Oil Shale Formation	WLN	
Wester Clashies	294845, 690635	Whitehills	Passage Formation	FIF	20ft white medium grained massive sandstone'
Wester Craigend	276985, 690615	Cambusbarron	Lower Limestone Formation	STG	Old quarry, baked sandstone with fakes below'
Westerton	283185, 690115	Cowie	Upper Limestone Formation	STG	Quarries in over 3 feet of yellow, fine grained sandstone

Appendix 5 Stone matching for sandstone

This appendix contains background information for stone matching in sandstone.

Introduction

Most quarried sandstone is permeable; in other words, moisture and air are able to pass through the stone via a network of connected gaps (pore spaces) between the sand grains. This character makes sandstone relatively light and easy to cut and carve, but it also makes the stone prone to decay as a result of processes like mineral dissolution, freeze-thaw, and salt heave. Characterising and matching *intrinsic properties* is therefore particularly important when finding the closest-matching stones for sandstone samples.

Intrinsic properties

Sandstone consists of adhering sand grains with unfilled gaps (pore spaces) and/or a mineral 'cement' between the grains. Sand grains are small – between 2 and 0.064 millimetres in diameter – so many of the intrinsic properties of a sandstone, including the *relative proportions of the constituent minerals*, the *grain-size* and *textural arrangement of the constituents*, and the *porosity* (pore space) characteristics, can only be determined accurately by microscope examination. Some properties, including the *colour* and *primary sedimentary structure* of the stone, can be determined adequately with the unaided eye. Still others, including the *cohesiveness* and *permeability* of the stone, require a simple test to make an adequate evaluation. Each property can vary considerably from one sandstone to another, and no two sandstones are identical.

Each of the intrinsic properties of sandstone plays a role in determining how any one stone responds to the complex physical and chemical processes associated with weathering. The result is that no two sandstones respond to weathering in exactly the same way and at the same rate. If more than one type of sandstone is used in a stone structure, obvious contrasts in the condition of masonry blocks commonly become apparent over time. Furthermore, placing two sandstones of contrasting permeability next to each other in masonry can lead one (usually the more permeable stone) to suffer accelerated decay. For these reasons, it is generally considered good practice to repair or replace 'original' sandstone masonry with sandstone that is the closest achievable match in terms of the properties that govern how the stone responds to weathering ('weathering properties'). This maximises the likelihood that the replacement stone will co-exist harmoniously with the original stone and will weather sympathetically. The poorer the match between the weathering properties of the replacement stone and the original stone, the greater is the likelihood that the condition of the two stones will diverge over time.

Petrographic examination

A macroscopic examination of the sample of 'original' stone is performed with the unaided eye and using a binocular microscope. A microscope examination is performed on a thin section (a slice of the stone sample cut thin enough to be transparent), using a polarizing microscope. Before preparing the thin section, permeable stones (such as sandstone) are impregnated with blue resin to highlight pore spaces. The thin section is cut perpendicular to the bedding orientation in the stone (where this is visible), and is positioned to be as representative as possible of the sample. The thin section is typically cut to include the freshest part of the supplied stone sample, and also any weathered part and/or exposed (exterior) surface where these are present.

Observations from these examinations are recorded on a Petrographic Description Form designed for building stones, to ensure the description is systematic and consistent with the procedures set out in British Standard BS EN 12407:2000 (*Natural stone test methods – Petrographic examination*). The completed Petrographic Description Form for each sample is presented in Appendix X, with a set of accompanying notes describing each of the recorded properties. The description is accompanied by one or more photographs illustrating the typical character of the stone as it appears in the thin section.

Stone matching

The following factors are taken into account when comparing an original stone with a potential replacement stone.

1) *Mineral and textural features* – ideally, these should be as similar as possible in the replacement stone and original stone, to increase the likelihood that the two stones will respond in similar ways and at similar rates to the various physical and chemical processes associated with weathering, and will therefore co-exist harmoniously. Replacement stones are selected to match the original stone in its fresh (rather than weathered/decayed) state, unless otherwise requested. Particular attention is paid to those minerals and textural features that are known to play a significant role in sandstone decay and discolouration.

2) *Permeability* – ideally, the replacement stone and original stone should have similar permeability characteristics, thereby minimising the degree to which fluid (water and air) migration between adjacent blocks of original and replacement stone might be impeded. Accelerated stone decay can occur where fluid migration is impeded.

3) *Appearance* – for aesthetic reasons, the replacement stone and original stone ideally should look similar to the unaided eye in terms of colour and stone fabric at the time the repair is made. However, the closest-matching stones in terms of the properties that govern weathering performance (mineral-textural features and permeability) do not necessarily provide the closest match in terms of appearance. A repair using stone selected primarily because it is the closest match in terms of appearance may look good initially but could quickly show signs of decay or of being incompatible with the original stone. For that reason, priority is generally given to the properties that govern weathering performance, thereby maximising the likelihood of long-term compatibility of the original stone and replacement stone. A degree of compromise may in some cases be desirable and acceptable if the closest-matching stones in terms of 'weathering properties' are not a close match in terms of appearance. Immediately following repair, the fresh surfaces of a stone insert or indent will usually contrast in appearance with the soiled or discoloured surfaces of adjacent original masonry, but if the 'weathering properties' of the two stones are a good match the new stone should blend in over time and the contrast should become less obvious.

4) *Functional and performance requirements* – specific functional and performance requirements of a replacement stone are taken into account if requested. For example, if the original stone performed a load-bearing role, the choice of matching stones should include only those that are at least as strong; and if the original stone was carved or shaped in a particular way, the choice of matching stones ideally should include only those that can be carved or shaped in a similar way, with a similar level of detail and quality of finish.

One or more replacement stone types are proposed taking these factors into account. A brief description and a thin section photograph are provided for each.

Appendix 6 Petrographic descriptions of Falkirk building stones

This appendix contains petrographic descriptions for nineteen samples of stone collected from Falkirk; see section 5.3 and Table 7 for sample details. Each description is presented on a Petrographic Description Form designed for sandstone. Two photographs of the stone as it appears in thin section (viewed using an optical microscope) accompany the descriptions of the twelve samples for which a thin section was prepared. A page of notes at the end of this appendix describes each property recorded on the forms.

BGS sample number: ED11047
PRIMARY_KE: 963250
Building stone: Buff sandstone 4

Sample dimensions: 130 x 40 x 35 mm
Building address: 30 Newmarket Street

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	light buff
Stone colour [2] **–** weathered stone:	orangeish buff
Stone colour [2] **–** exterior surface:	greyish buff
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	strongly cohesive
Primary sedimentary structure [4]:	uniform (some orientated grains)
Distinctive features [5]:	speckled
Reaction to 10% HCl [6]:	moderate
Water absorption (permeability) [7]:	high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	57%	Silica (overgrowth)	2%
Feldspar	3%	Feldspar (overgrowth)	<1%
Rock fragments	2%	Carbonate	3%
Mica	1%	Iron/manganese oxide	1%
Opaque material	<1%	Clay	10%
Other	<<1%	Hydrocarbon	0%
Intragranular pores	2%	Intergranular pores	18%

Stone type [1] (detailed classification):	subfeldspathic-arenite
Grain-size [9]:	fine-sand-grade to medium-sand-grade
Grain sorting [10]:	moderately well sorted
Grain roundness [11]:	sub-angular to sub-rounded
Cement distribution [12]:	silica cement continuous; carbonate cement isolated
Supergene changes [13]:	moderate dissolution of feldspar

Comments

1) The sample consists of a chip from a window dressing.

2) The exterior surface is weathered to a depth of less than 1 mm.

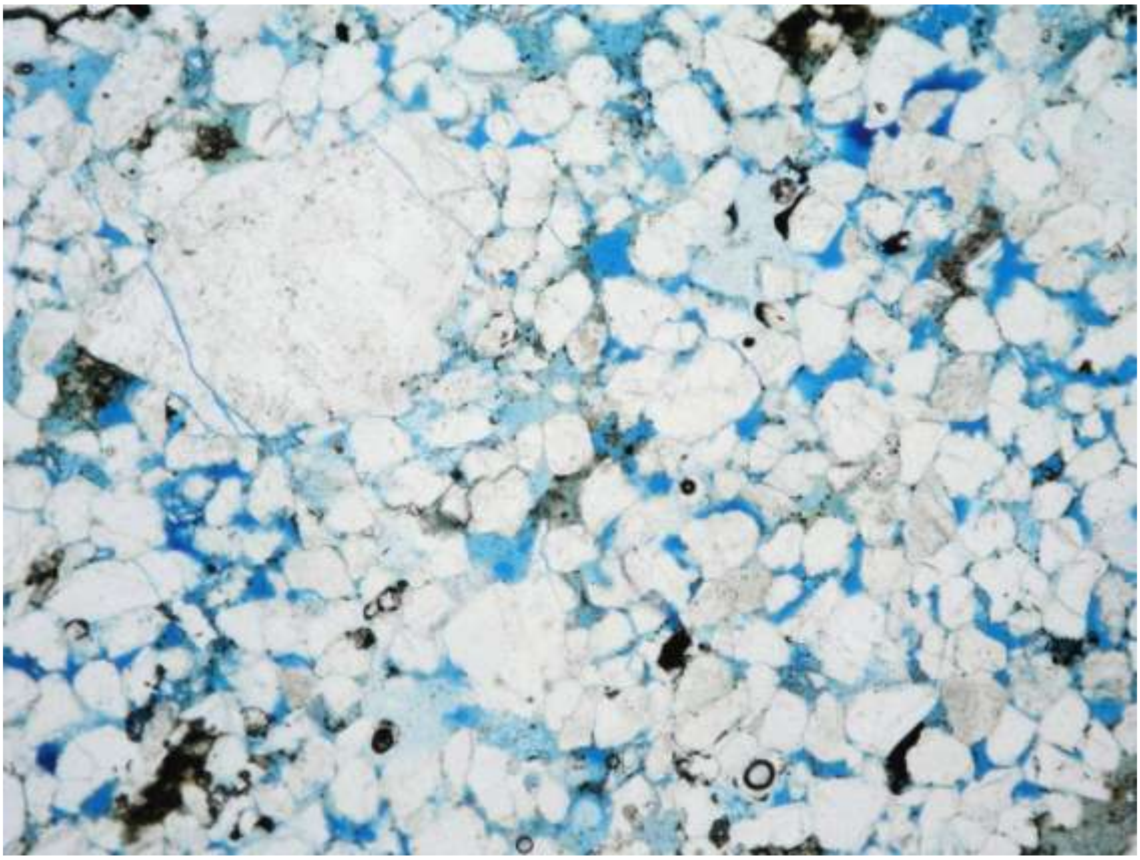
3) The speckles are mainly black and evenly scattered. Some are pale orangeish brown.

4) The exterior surface is weathered to a maximum depth of 4 mm.

5) Tourmaline and rounded grains of zircon appear as accessory minerals.

6) The stone contains rare, scattered grains of coarse-sand grade.

7) Iron oxide rims on carbonate crystals suggest the carbonate mineral is ferroan (ferroan dolomite, ankerite or siderite).



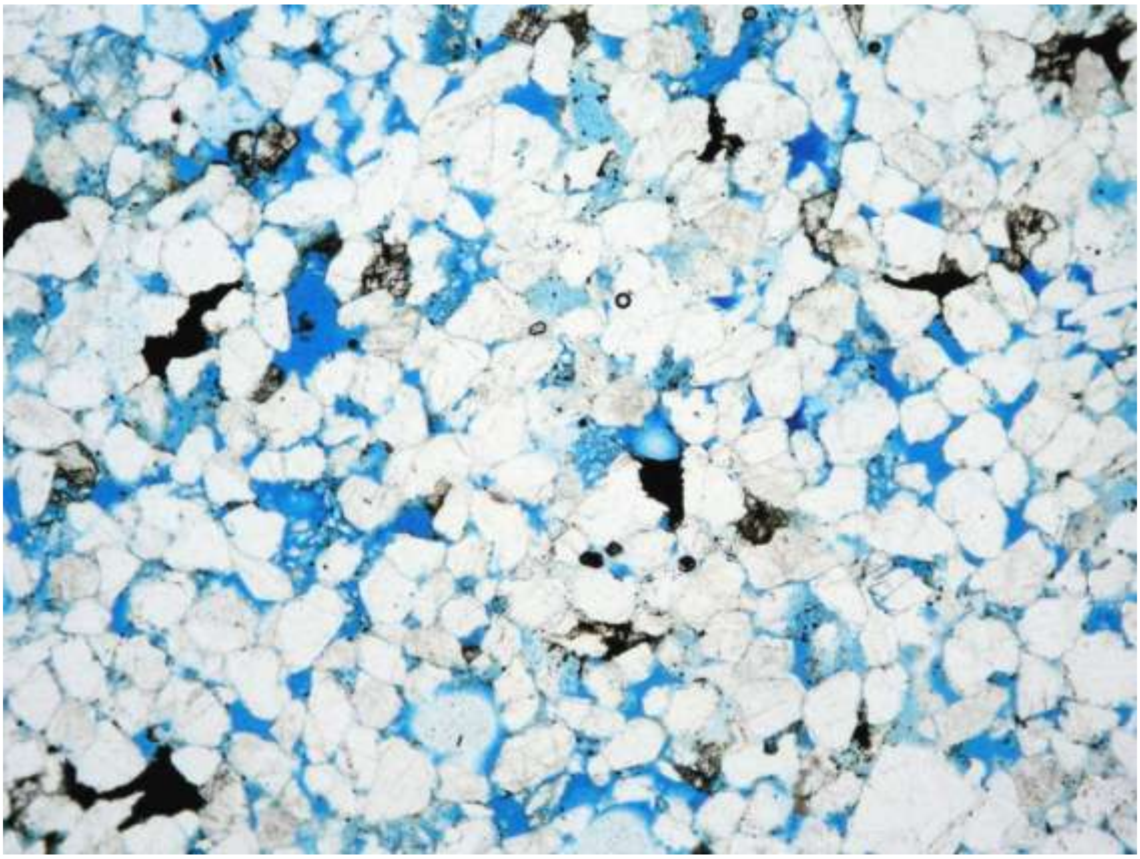


Figure A6_1. Two images of sample ED11047, as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals. Dark mottled patches are carbonate mineral. Pore spaces appear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11048-1
PRIMARY_KE: 963306
Building stone: Buff sandstone 1
Sample dimensions: 110 x 80 x 30 mm
Building address: Burgh Buildings

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	buff
Stone colour [2] **–** weathered stone:	buff
Stone colour [2] **–** exterior surface:	buff to greenish buff
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	moderately cohesive
Primary sedimentary structure [4]:	parallel lamination
Distinctive features [5]:	faintly speckled; carbonaceous matter
Reaction to 10% HCl [6]:	none
Water absorption (permeability) [7]:	high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	45%	Silica (overgrowth)	4%
Feldspar	3%	Feldspar (overgrowth)	0%
Rock fragments	1%	Carbonate	7%
Mica	<1%	Iron/manganese oxide	7%
Opaque material	<1%	Clay	12%
Other	<1%	Hydrocarbon	0%
Intragranular pores	3%	Intergranular pores	17%

Stone type [1] (detailed classification):	subfeldspathic-arenite
Grain-size [9]:	fine-sand-grade to medium-sand-grade
Grain sorting [10]:	moderately well sorted
Grain roundness [11]:	sub-angular to well rounded
Cement distribution [12]:	silica cement continuous; carbonate cement isolated
Supergene changes [13]:	moderate dissolution of feldspar

Comments

1) The sample is a chip from rock faced walling at low level on the front elevation.

2) The exterior surface is weathered to a depth of c. 2-3 mm.

3) The laminae are concentrations of small sand grains, iron oxide minerals and mica flakes.

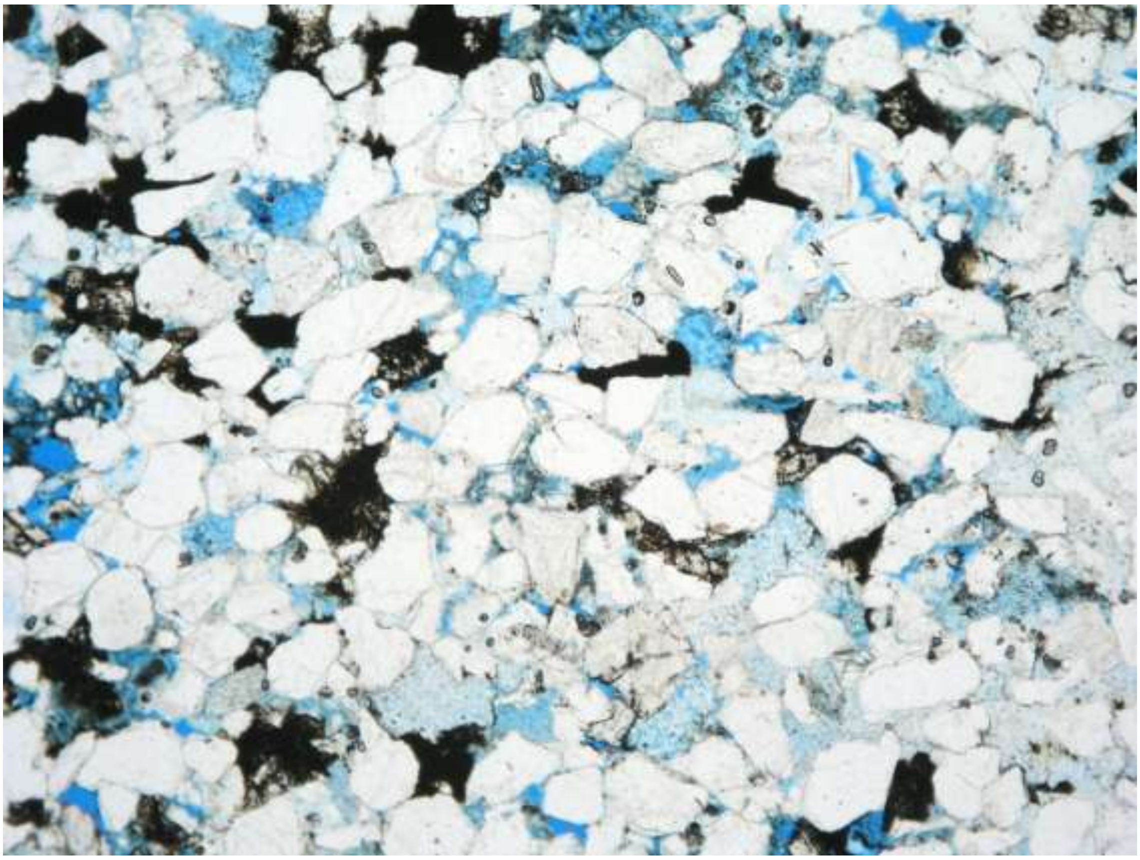
4) Speckles are orange-brown, probably an altered iron-rich mineral.

5) Detrital grains are commonly well rounded, but enclosed by thick overgrowths of silica cement.

6) Rounded zircon grains are present in accessory proportion.

7) Most of the pores are partially infilled with clay minerals.

8) The carbonate mineral is iron-rich (ferroan dolomite, ankerite or siderite).



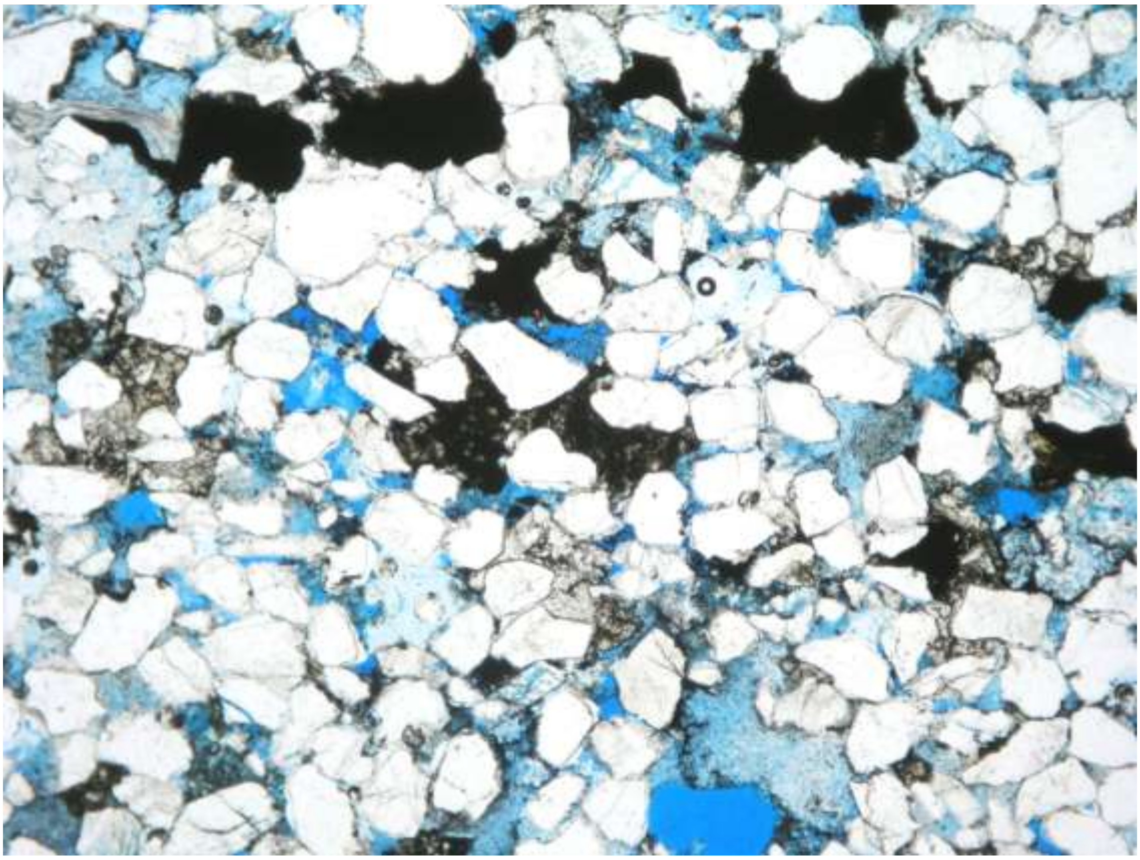


Figure A6_2. Two images of sample ED11048-1 as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals. Greyish, mottled patches are carbonate mineral. Mottled bluish patches are clay mineral. Pore spaces appear clear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11048-2
PRIMARY_KE: 963306
Building stone: Buff sandstone 1
Sample dimensions: 90 x 65 x 25 mm
Building address: Burgh Buildings

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	very light buff
Stone colour [2] **–** weathered stone:	orangeish buff
Stone colour [2] **–** exterior surface:	green
Stone cohesion [3] – fresh stone:	moderately cohesive
Stone cohesion [3] – weathered stone:	moderately cohesive
Primary sedimentary structure [4]:	uniform
Distinctive features [5]:	faintly speckled
Reaction to 10% HCl [6]:	strong
Water absorption (permeability) [7]:	very high

Thin section observations

A thin section was not prepared.

Comments

1) The sample consists of a chip from rock-faced walling on the side elevation, at ground level.

2) The exterior surface is weathered to a depth of c.3 mm and is strong orangeish buff.

3) The faint speckles are of weak orange-brown colour due to iron oxide remobilization.

4) Strong reaction to 10% HCl suggests that calcite is present as a carbonate mineral cement.

There are no thin section images of this sample.

BGS sample number: ED11049-1
PRIMARY_KE: 961318
Building stone: Buff sandstone 1
Sample dimensions: 80 x 55 x 30 mm
Building address: The Steeple

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	light buff to buff
Stone colour [2] **–** weathered stone:	light buff to buff
Stone colour [2] **–** exterior surface:	very light buff
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	very friable
Primary sedimentary structure [4]:	parallel lamination
Distinctive features [5]:	speckled
Reaction to 10% HCl [6]:	moderate
Water absorption (permeability) [7]:	moderate to high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	62%	Silica (overgrowth)	3%
Feldspar	2%	Feldspar (overgrowth)	0%
Rock fragments	0%	Carbonate	3%
Mica	1%	Iron/manganese oxide	6%
Opaque material	0%	Clay	10%
Other	0%	Hydrocarbon	0%
Intragranular pores	1%	Intergranular pores	12%

Stone type [1] (detailed classification):	subfeldspathic-arenite
Grain-size [9]:	fine-sand-grade to medium-sand-grade
Grain sorting [10]:	moderately well sorted
Grain roundness [11]:	sub-angular to well-rounded
Cement distribution [12]:	silica cement discontinuous; carbonate cement isolated
Supergene changes [13]:	none

Comments

1) The sample consists of a small chip from the internal walling of The Steeple, at third floor level.

2) Faint laminae are formed by accumulations of iron oxide minerals and mica flakes.

3) Orange-brown speckles up to 1.5 mm across are composed mainly of iron oxide.

4) The carbonate mineral is iron-bearing (ferroan dolomite, ankerite or siderite)

5) A substantial proportion of the space between detrital grains is infilled by clay.

6) The stone shows parallel lamination, with hints of possible cross-lamination or ‘wispy bedding’.

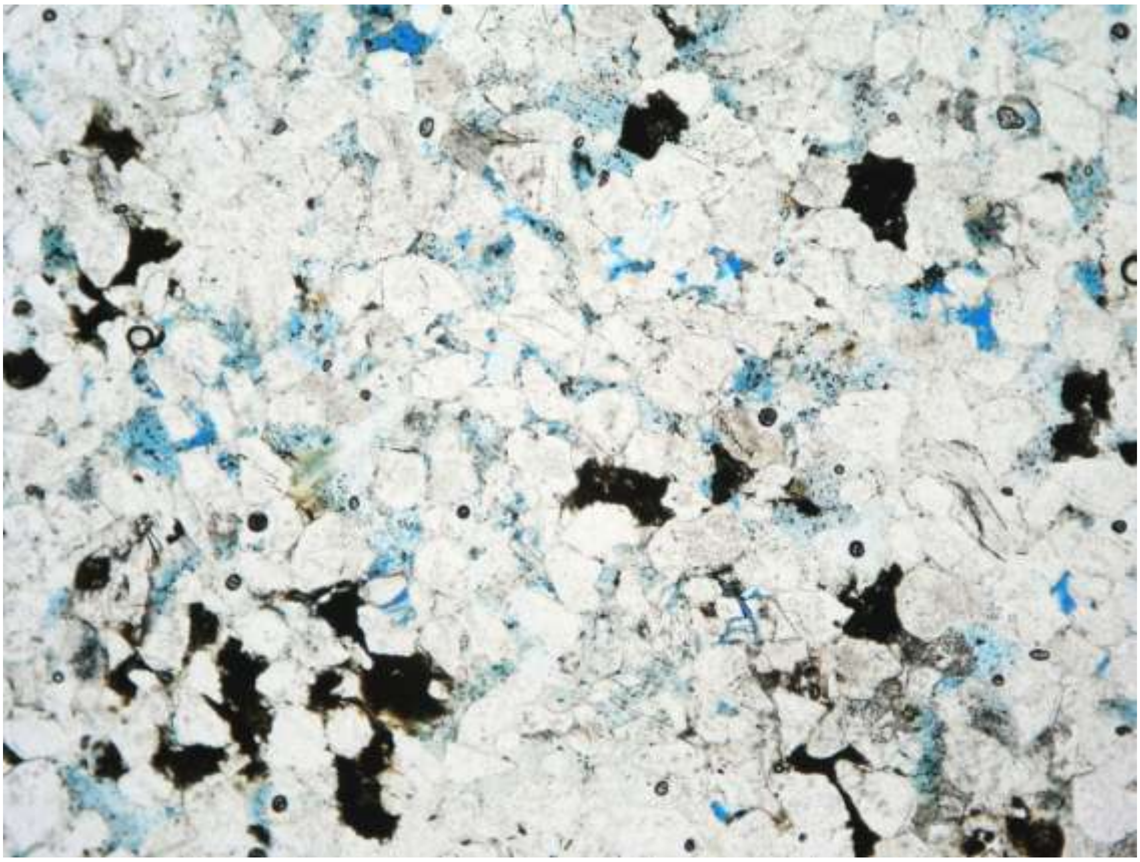


Figure A6_3. Two images of sample ED11049-1, as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals. Pore spaces appear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11049-2
PRIMARY_KE: 961318
Building stone: Buff sandstone 1

Sample dimensions: 190 x 35 x 25 mm
Building address: The Steeple

Hand specimen observations

Stone type [1] (general classification): sandstone
Stone colour [2] **–** fresh stone: not applicable
Stone colour [2] **–** weathered stone: light buff to buff
Stone colour [2] **–** exterior surface: very light buff
Stone cohesion [3] – fresh stone: not applicable
Stone cohesion [3] – weathered stone: very friable
Primary sedimentary structure [4]: parallel lamination
Distinctive features [5]: speckled
Reaction to 10% HCl [6]: no
Water absorption (permeability) [7]: very high

Thin section observations

A thin section was not prepared.

Comments

1) The sample consists of a small chip from the internal walling of The Steeple, at third floor level.

2) The laminae consist of concentrations of iron oxide minerals and mica flakes.

3) The high permeability and friable character reflect the weathered condition of the stone. A former mineral cement composed of carbonate minerals may have dissolved due to weathering.

4) The exterior surface has a lime mortar wash and is therefore paler than the weathered stone.

5) Orange-brown speckles up to 1.5 mm across are probably weathered spots of iron oxide.

There are no thin section images of this sample.

BGS sample number: ED11049-3
PRIMARY_KE: 961318
Building stone: Buff sandstone 1

Sample dimensions: 90 x 50 x 20 mm
Building address: The Steeple

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	very light buff
Stone colour [2] **–** weathered stone:	not applicable
Stone colour [2] **–** exterior surface:	very light greyish buff
Stone cohesion [3] – fresh stone:	moderately cohesive
Stone cohesion [3] – weathered stone:	not applicable
Primary sedimentary structure [4]:	parallel lamination
Distinctive features [5]:	faintly speckled
Reaction to 10% HCl [6]:	strong
Water absorption (permeability) [7]:	very high

Thin section observations

A thin section was not prepared.

Comments

1) The sample consists of a small chip from the internal walling of The Steeple, at third floor level.

2) The laminae consist of concentrations of iron oxide minerals and mica flakes.

3) Strong reaction to 10% HCl indicates the sandstone has a mineral cement of calcite.

There are no thin section images of this sample.

BGS sample number: ED11050
PRIMARY_KE: 963257
Building stone: Buff sandstone 1
Sample dimensions: 90 x 30 x 20 mm
Building address: 16 Melville Street

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	buff
Stone colour [2] **–** weathered stone:	not applicable
Stone colour [2] **–** exterior surface:	grey
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	not applicable
Primary sedimentary structure [4]:	uniform (some orientated grains)
Distinctive features [5]:	carbonaceous matter
Reaction to 10% HCl [6]:	none
Water absorption (permeability) [7]:	high

Thin section observations

A thin section was not prepared.

Comments

1) The sample consists of a small chip from a mullion at first floor level.

2) The exterior surface is weathered to a depth of less of 1 mm, and is grey. It is not clear if the sample includes ‘fresh’ stone or has been collected from within a weathered outer layer on the masonry block.

3) Small fragments of carbonaceous matter are c.3 mm long.

There are no thin section images of this sample.

BGS sample number: ED11052
PRIMARY_KE: not applicable
Building stone: Buff sandstone 1
Sample dimensions: 120 x 90 x 50 mm
Address: Viewfield pit, Bantaskine quarry

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	very light greyish buff
Stone colour [2] **–** weathered stone:	light greyish buff
Stone colour [2] **–** exterior surface:	light greenish grey
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	moderately cohesive
Primary sedimentary structure [4]:	parallel lamination
Distinctive features [5]:	none
Reaction to 10% HCl [6]:	strong
Water absorption (permeability) [7]:	moderate

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	55%	Silica (overgrowth)	2%
Feldspar	1%	Feldspar (overgrowth)	0%
Rock fragments	0%	Carbonate	10%
Mica	2%	Iron/manganese oxide	5%
Opaque material	<1%	Clay	7%
Other	1%	Hydrocarbon	0%
Intragranular pores	1%	Intergranular pores	16%

Stone type [1] (detailed classification):	subfeldspathic-arenite
Grain-size [9]:	fine-sand-grade
Grain sorting [10]:	moderately sorted
Grain roundness [11]:	sub-angular to well rounded
Cement distribution [12]:	silica cement discontinuous; carbonate cement discontinuous
Supergene changes [13]:	weak dissolution of feldspar; moderate alteration of biotite

Comments

1) The sample is from a quarry face in Viewfield Pit (Bantaskine quarry), from a well cemented tabular bed of sandstone that is interbedded with layers of shale and mudstone.

2) Thin brown laminae consist of concentrations of iron oxide and mica.

3) Rounded zircons (often in clusters) and biotite appear as accessory minerals.

4) Pore spaces are commonly not well connected; water absorption is therefore only moderate despite a relatively high proportion of pore space.

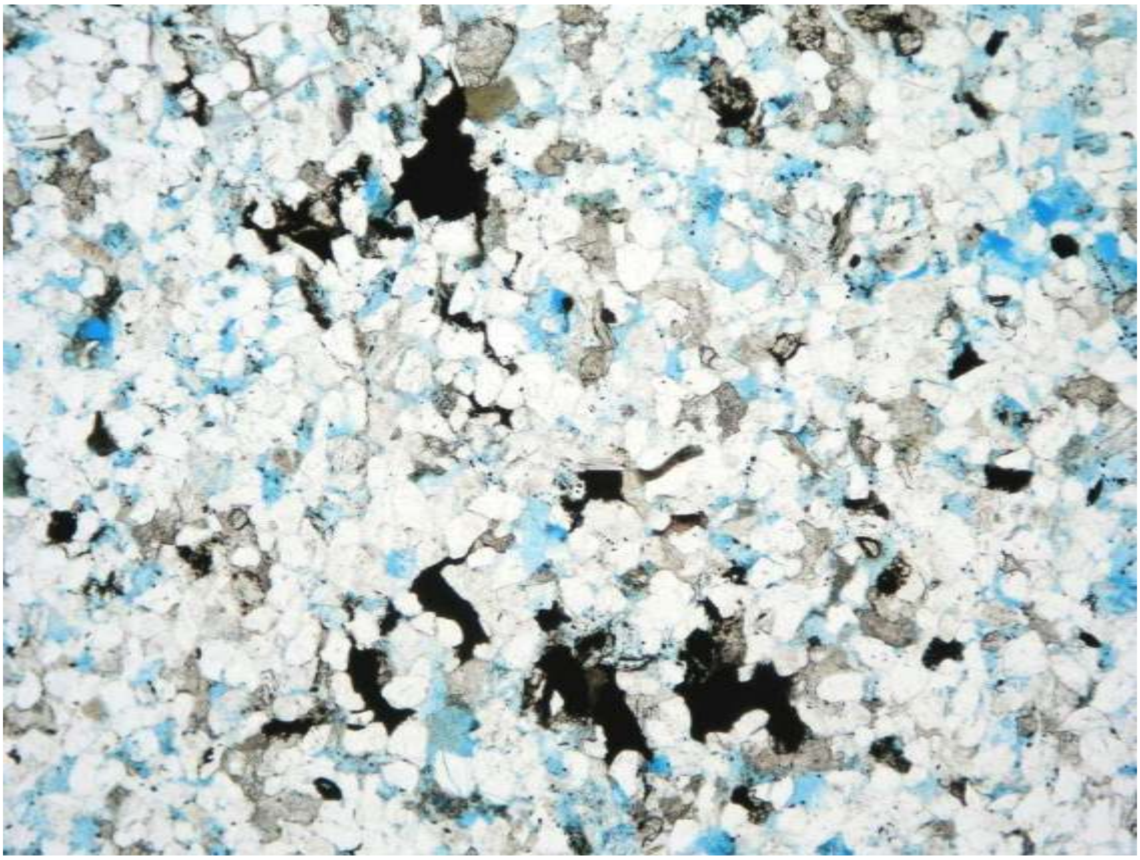
5) The stone is dominantly fine-sand-grade but thin layers are of very-fine-sand or silt grade.

6) Chlorite has replaced some of the detrital biotite.

7) Strong reaction to 10% HCl suggests calcite is present, but ferroan carbonate mineral is also present.

8) The fabric consists of parallel lamination with 'wispy' lamination in foreset packets.

9) Several percent of detrital feldspar and rock fragments have dissolved and are now clay minerals.



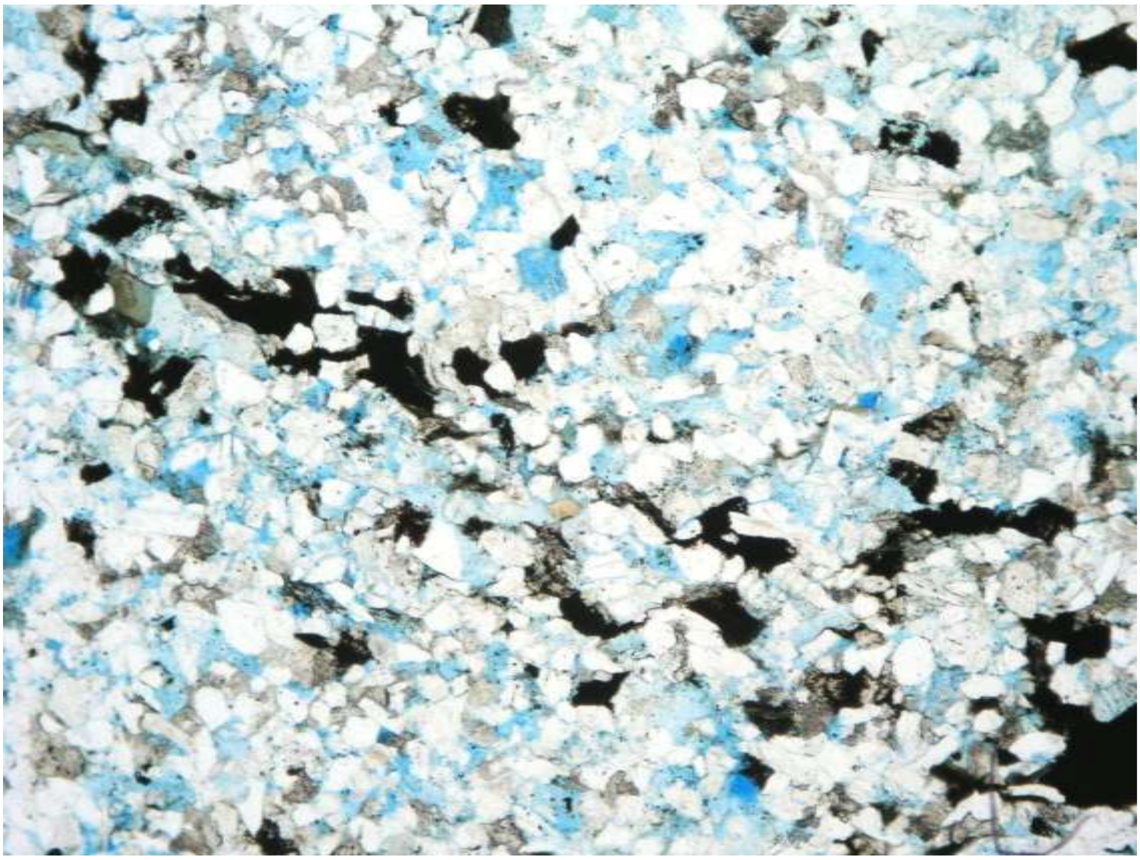


Figure A6_4. Two images of sample ED11052, as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals. Brownish, mottled patches are carbonate mineral. Mottled bluish patches are clay mineral. Pore spaces appear clear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11053-1
PRIMARY_KE: not applicable
Building stone: Buff sandstone 1

Sample dimensions: 125 x 80 x 40 mm
Building address: demolished wall by Tattie Kirk

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	buff
Stone colour [2] **–** weathered stone:	not applicable
Stone colour [2] **–** exterior surface:	light green
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	not applicable
Primary sedimentary structure [4]:	parallel lamination
Distinctive features [5]:	colour banding due to alteration; speckled
Reaction to 10% HCl [6]:	strong
Water absorption (permeability) [7]:	moderate to high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	54%	Silica (overgrowth)	3%
Feldspar	7%	Feldspar (overgrowth)	0%
Rock fragments	2%	Carbonate	3%
Mica	2%	Iron/manganese oxide	6%
Opaque material	0%	Clay	10%
Other	<<1%	Hydrocarbon	0%
Intragranular pores	3%	Intergranular pores	10%

Stone type [1] (detailed classification):	subfeldspathic-arenite
Grain-size [9]:	fine-sand-grade to medium-sand-grade
Grain sorting [10]:	moderately sorted
Grain roundness [11]:	sub-angular to well rounded
Cement distribution [12]:	silica cement discontinuous; carbonate cement isolated
Supergene changes [13]:	strong dissolution of feldspar

Comments

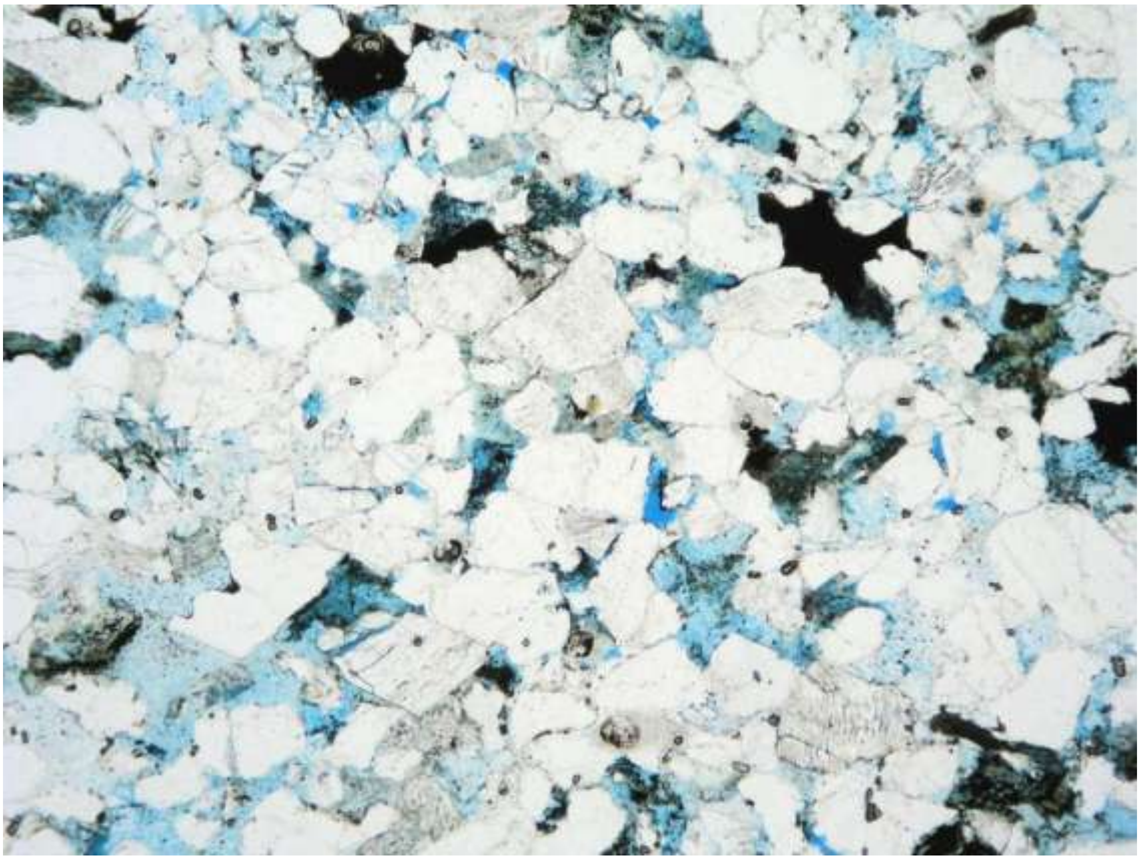
1) The parallel laminae consist of concentrations of iron oxide minerals and mica flakes.

2) Colour banding is due to Liesegang bands.

3) Ochre speckles up to 1 mm across are iron oxide mineral.

4) Clay occupies intergranular spaces and probably formed through alteration of dissolved feldspar and rock fragments.

5) Strong reaction to 10% HCl suggests the carbonate mineral is calcite.



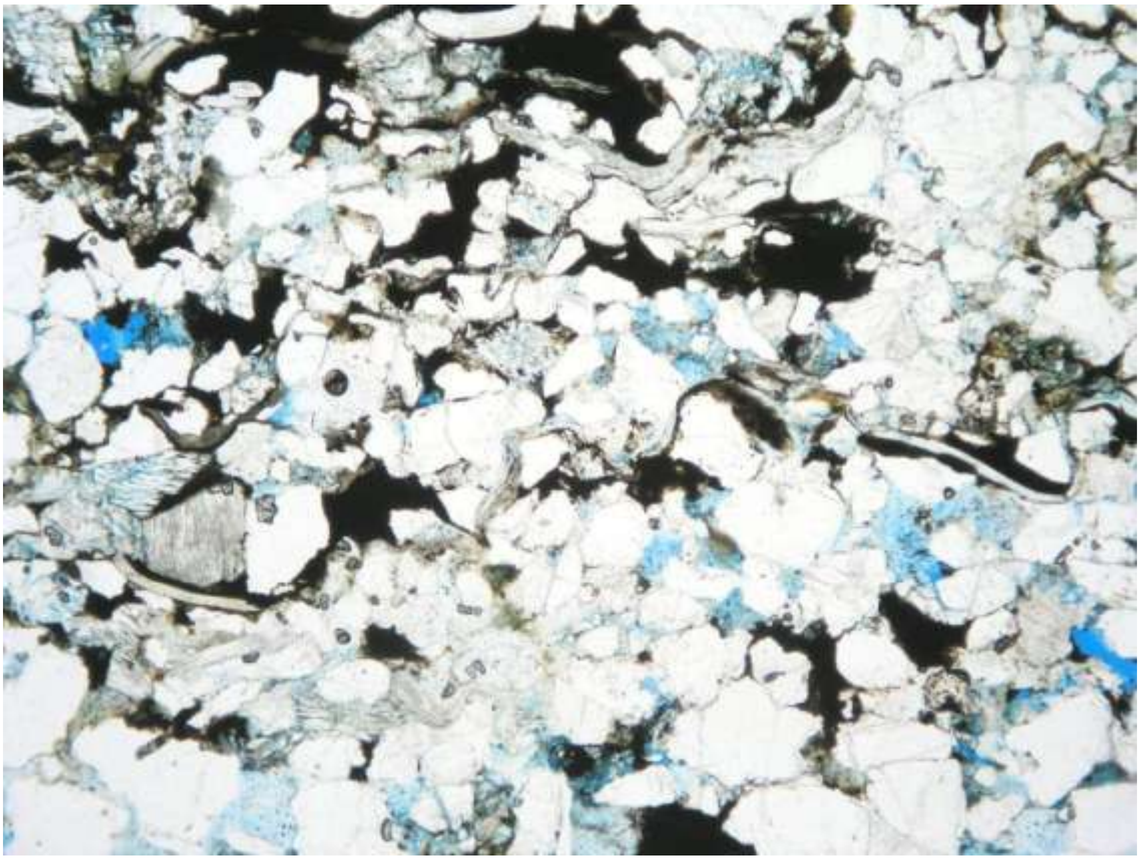


Figure A6_5. Two images of sample ED11053-1, as it appears in thin section. White grains are mainly quartz. Light grey grains are mostly feldspar. Black areas are mainly iron oxide minerals. Brownish mottled patches are carbonate mineral. Mottled bluish patches are clay mineral. Pore spaces appear clear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11053-2
PRIMARY_KE: not applicable
Building stone: Buff sandstone 1
Sample dimensions: 160 x 90 x 80 mm
Building address: demolished wall by Tattie Kirk

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	light greyish buff
Stone colour [2] **–** weathered stone:	not applicable
Stone colour [2] **–** exterior surface:	light green
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	not applicable
Primary sedimentary structure [4]:	parallel lamination
Distinctive features [5]:	none
Reaction to 10% HCl [6]:	strong
Water absorption (permeability) [7]:	high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	46%	Silica (overgrowth)	3%
Feldspar	4%	Feldspar (overgrowth)	0%
Rock fragments	2%	Carbonate	1%
Mica	2%	Iron/manganese oxide	3%
Opaque material	0%	Clay	15%
Other	<1%	Hydrocarbon	0%
Intragranular pores	4%	Intergranular pores	20%

Stone type [1] (detailed classification):	feldspathic-arenite
Grain-size [9]:	fine-sand-grade to medium-sand-grade
Grain sorting [10]:	moderately well sorted
Grain roundness [11]:	sub-angular to well rounded
Cement distribution [12]:	silica cement discontinuous
Supergene changes [13]:	strong dissolution of feldspar

Comments

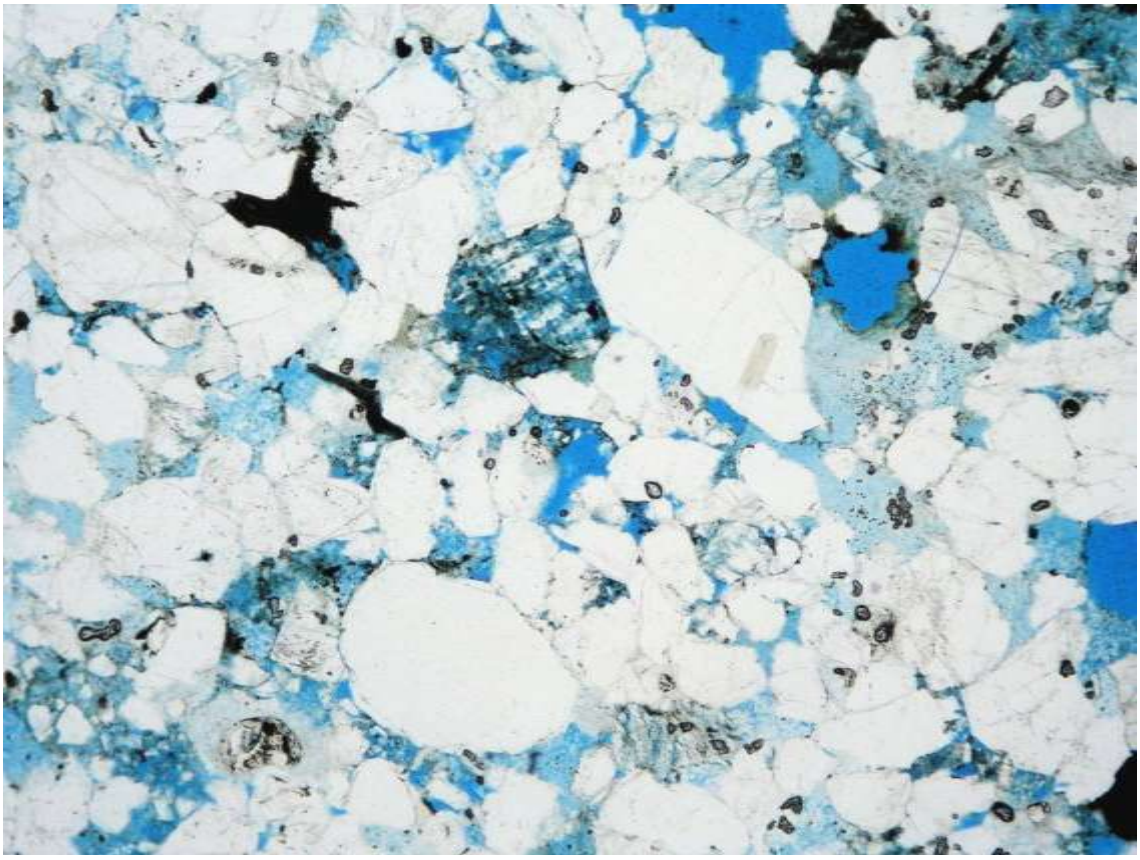
1) Parallel light brown laminae consist of concentrations of iron oxide minerals and mica flakes.

2) Tourmaline appears as an accessory mineral.

3) Most detrital grains are medium-sand-grade.

4) Carbonate mineral forms only a very small proportion of the thin section, so the strong reaction to 10% HCl may be due to contamination by lime mortar.

5) Clay minerals occupying pore spaces are a result of dissolution of feldspar and rock fragments.



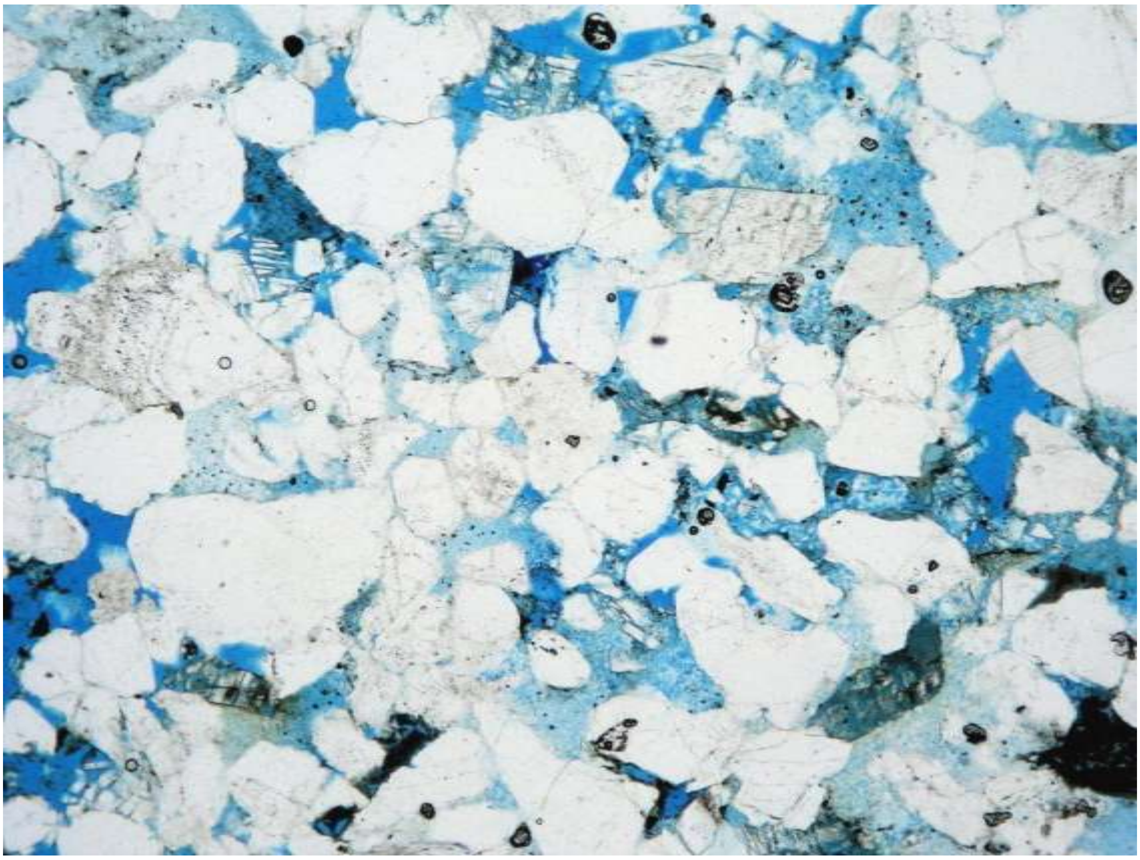


Figure A6_6. Two images of sample ED11053-2, as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals. Mottled bluish areas are clay mineral. Pore spaces are clear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11053-5
PRIMARY_KE: not applicable
Building stone: Buff sandstone 1
Sample dimensions: 115 x 80 x 50 mm
Building address: demolished wall by Tattie Kirk

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	very light grey
Stone colour [2] **–** weathered stone:	not applicable
Stone colour [2] **–** exterior surface:	light green
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	not applicable
Primary sedimentary structure [4]:	parallel lamination
Distinctive features [5]:	none
Reaction to 10% HCl [6]:	strong
Water absorption (permeability) [7]:	high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	40%	Silica (overgrowth)	4%
Feldspar	3%	Feldspar (overgrowth)	<1%
Rock fragments	1%	Carbonate	9%
Mica	2%	Iron/manganese oxide	3%
Opaque material	<1%	Clay	12%
Other	<<1%	Hydrocarbon	0%
Intragranular pores	5%	Intergranular pores	20%

Stone type [1] (detailed classification):	subfeldspathic-arenite
Grain-size [9]:	fine-sand-grade
Grain sorting [10]:	well sorted
Grain roundness [11]:	sub-rounded to rounded
Cement distribution [12]:	silica cement discontinuous; carbonate cement discontinuous
Supergene changes [13]:	moderate dissolution of feldspar

Comments

1) Thin, wispy and parallel laminae consist of concentrations of iron oxide minerals and mica flakes.

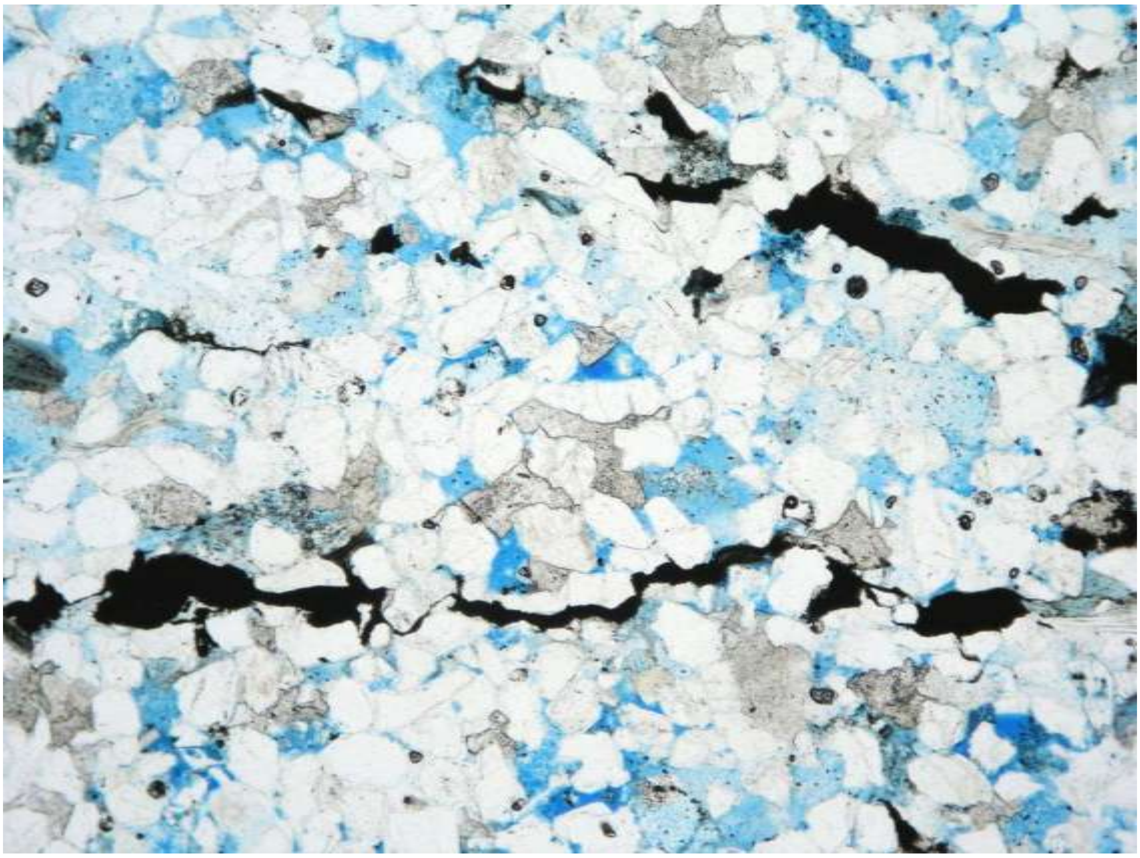
2) Carbonate is probably calcite and dolomite. Some crystals have well formed faces (idiomorphic).

3) Platy crystals of mica are commonly long and kinked/crushed by compaction.

4) Very small rounded zircons appear as an accessory mineral.

5) The primary sedimentary structure is mainly parallel lamination but there is some ‘wispy’ lamination.

5) Clay minerals occupying intergranular pore spaces are due to dissolution of feldspar and rock fragments.



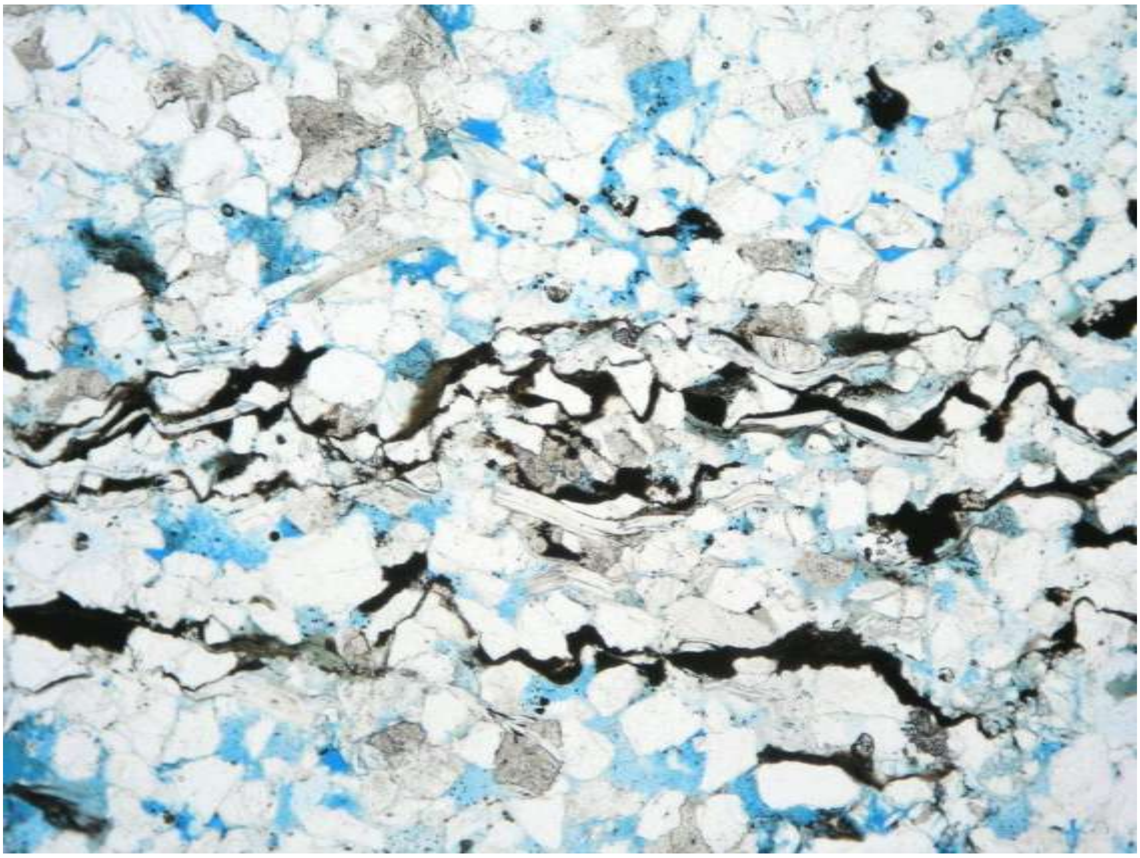


Figure A6_7. Two images of sample ED11053-5, as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals. Brownish mottled patches are carbonate mineral. Mottled bluish areas are clay mineral. Pore spaces are clear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11054
PRIMARY_KE: 961318
Building stone: Modern buff sandstone 4

Sample dimensions: 210 x 80 x 75 mm
Building address: The Steeple

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	dull greyish buff
Stone colour [2] **–** weathered stone:	not applicable
Stone colour [2] **–** exterior surface:	greenish grey-buff
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	not applicable
Primary sedimentary structure [4]:	uniform (some orientated grains)
Distinctive features [5]:	none
Reaction to 10% HCl [6]:	none
Water absorption (permeability) [7]:	moderate to low

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	67%	Silica (overgrowth)	3%
Feldspar	3%	Feldspar (overgrowth)	0%
Rock fragments	10%	Carbonate	0%
Mica	1%	Iron/manganese oxide	3%
Opaque material	<1%	Clay	4%
Other	<<1%	Hydrocarbon	0%
Intragranular pores	2%	Intergranular pores	7%

Stone type [1] (detailed classification):	sublithic-arenite
Grain-size [9]:	fine-sand-grade to medium-sand-grade
Grain sorting [10]:	well sorted
Grain roundness [11]:	angular to sub-angular
Cement distribution [12]:	silica cement discontinuous
Supergene changes [13]:	moderate dissolution of feldspar; strongly remobilized iron

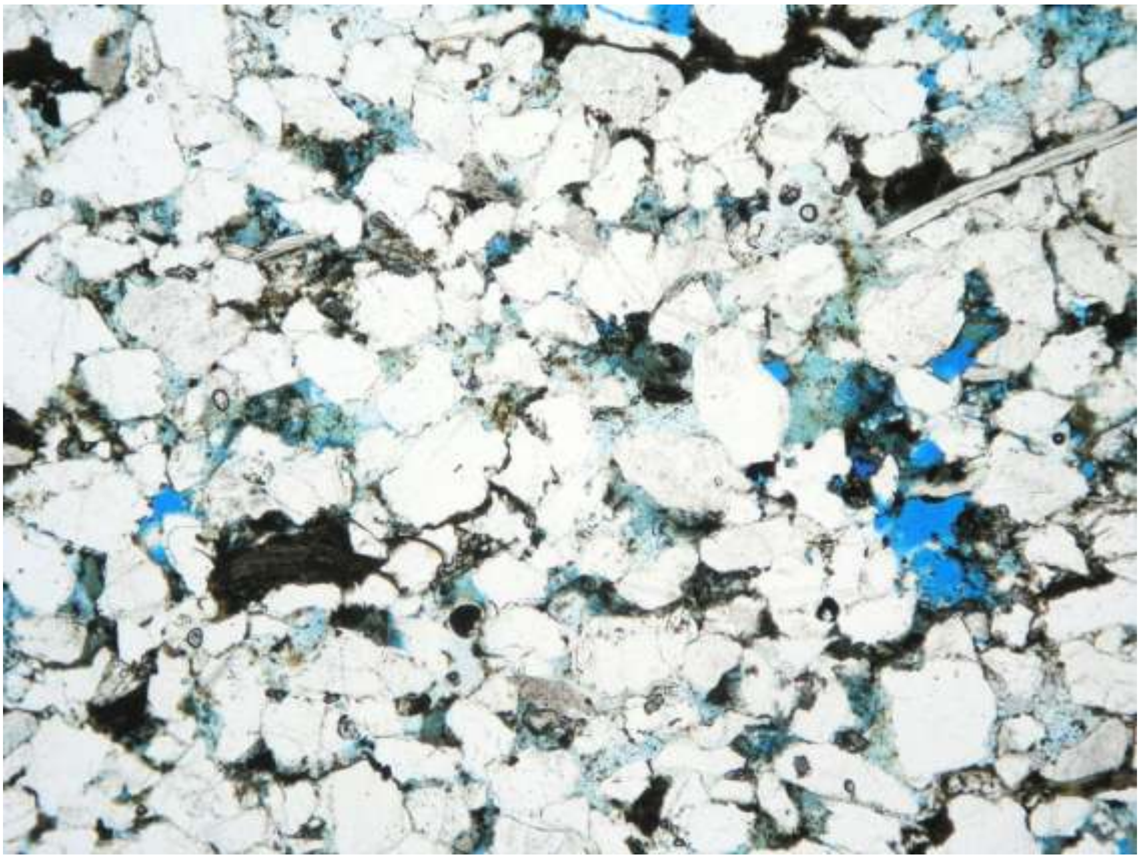
Comments

1) The sample is a fragment of the exterior dressed stone from ground level of The Steeple. The exterior surface is covered in a transparent coating, possibly to prevent water penetration.

2) Rounded zircons appear as an accessory mineral.

3) Mica flakes are both biotite and muscovite.

4) Porosity is relatively low (~9%) and pore spaces are poorly connected.



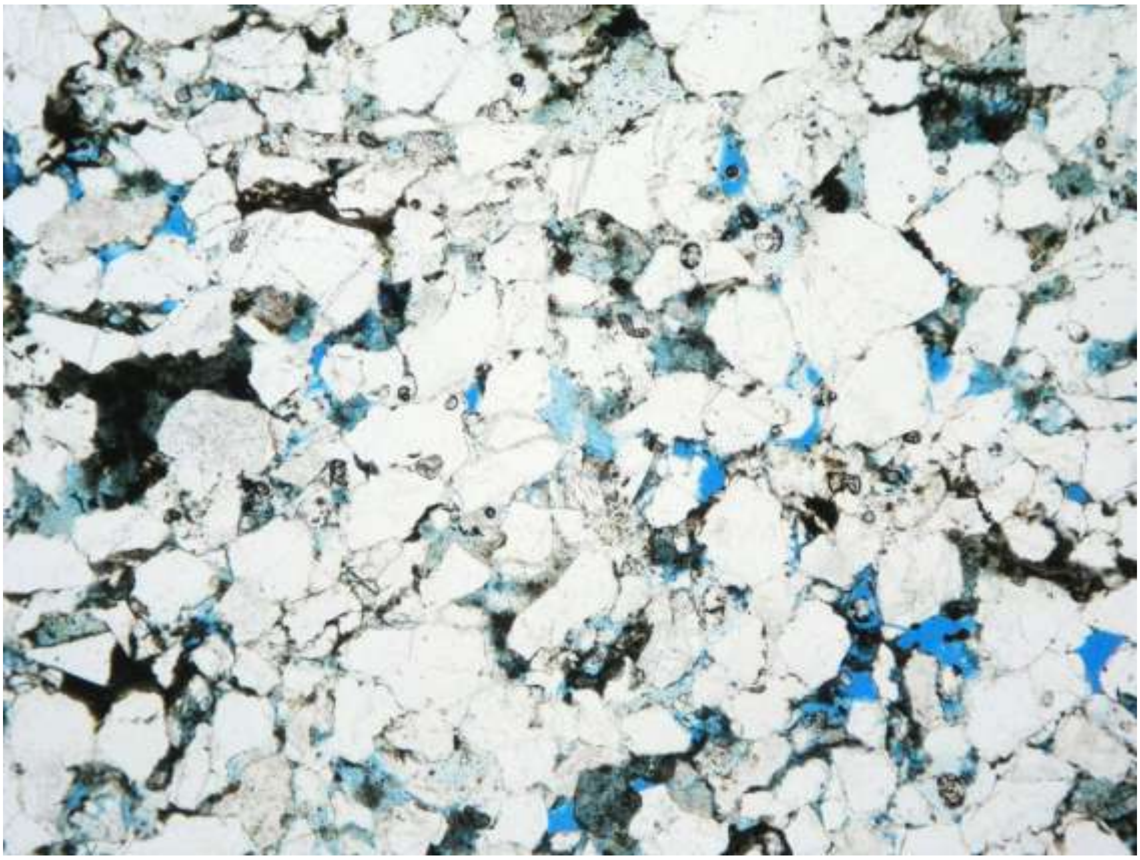


Figure A6_8. Two images of sample ED11054, as it appears in thin section. White grains are mainly quartz and off-white grains are mainly rock fragments. Black areas are mainly iron oxide minerals. Mottled bluish areas are clay mineral. Pore spaces are clear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11060-1
PRIMARY_KE: 963266
Building stone: Buff sandstone 4

Sample dimensions: 90 x 35 x 10 mm
Building address: 25-29 Newmarket Street

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	buff
Stone colour [2] **–** weathered stone:	not applicable
Stone colour [2] **–** exterior surface:	green
Stone cohesion [3] – fresh stone:	strongly cohesive
Stone cohesion [3] – weathered stone:	not applicable
Primary sedimentary structure [4]:	uniform
Distinctive features [5]:	none
Reaction to 10% HCl [6]:	strong
Water absorption (permeability) [7]:	moderate to high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	66%	Silica (overgrowth)	2%
Feldspar	3%	Feldspar (overgrowth)	0%
Rock fragments	1%	Carbonate	5%
Mica	1%	Iron/manganese oxide	7%
Opaque material	0%	Clay	5%
Other	<<1%	Hydrocarbon	0%
Intragranular pores	0%	Intergranular pores	10%

Stone type [1] (detailed classification):	subfeldspathic-arenite
Grain-size [9]:	fine-sand-grade to coarse-sand-grade
Grain sorting [10]:	poorly sorted
Grain roundness [11]:	sub-angular to well rounded
Cement distribution [12]:	silica cement continuous
Supergene changes [13]:	none

Comments

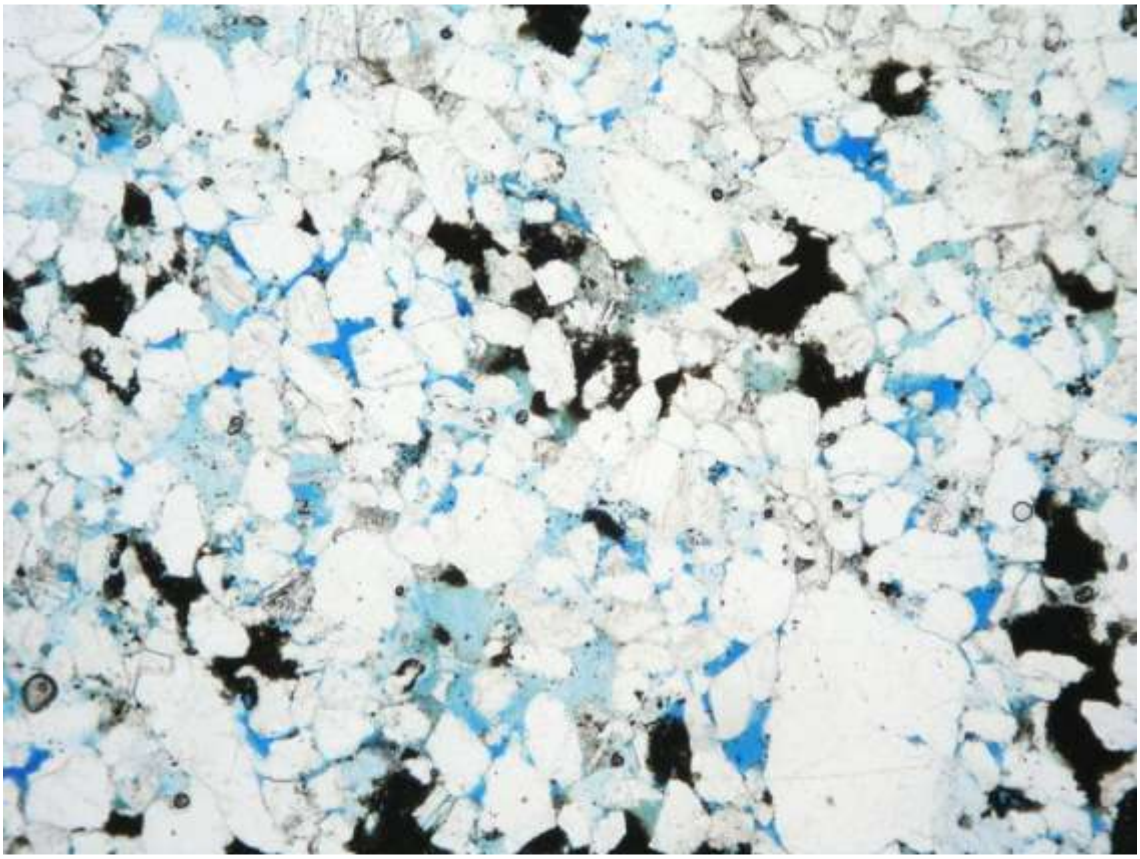
1) The sample consists of a small chip from the Vicar Street elevation at ground level.

2) The green colour of the exterior surface is due to biogenic growth.

3) Rounded zircons and tourmaline appear as accessory minerals.

4) Strong reaction to 10% HCl solution suggests the carbonate mineral is mainly calcite, but concentrations of secondary iron oxide minerals indicate a ferroan carbonate mineral was formerly present.

5) Clay minerals in the intergranular pore spaces are the result of dissolution of feldspar grains and rock fragments.



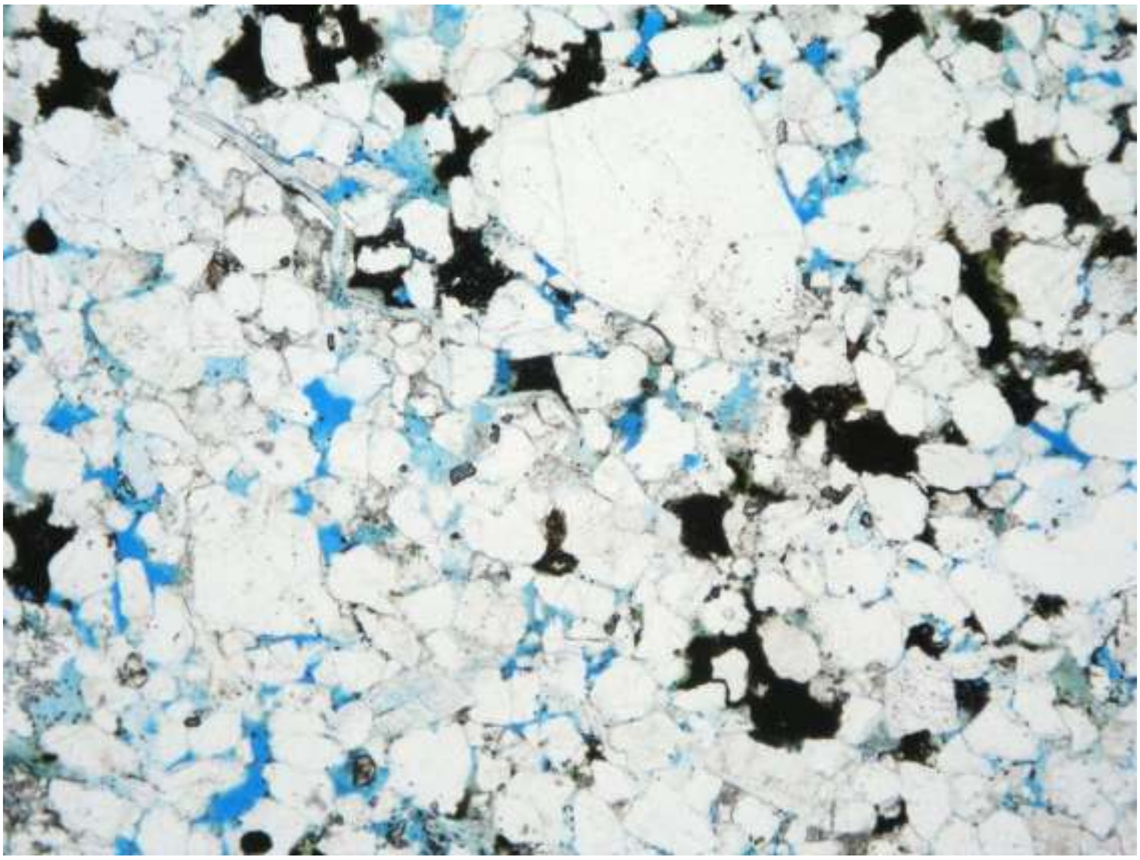


Figure A6_9. Two images of sample ED11060-1, as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals. Grey mottled patches are carbonate mineral. Mottled bluish areas are clay mineral. Pore spaces are clear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11060-2
PRIMARY_KE: 963266
Building stone: Buff sandstone 4

Sample dimensions: 130 x 70 x 30 mm
Building address: 25-29 Newmarket Street

Hand specimen observations

Stone type [1] (general classification): sandstone
Stone colour [2] **–** fresh stone: buff
Stone colour [2] **–** weathered stone: not applicable
Stone colour [2] **–** exterior surface: green and grey
Stone cohesion [3] – fresh stone: moderately cohesive
Stone cohesion [3] – weathered stone: not applicable
Primary sedimentary structure [4]: uniform
Distinctive features [5]: carbonaceous matter
Reaction to 10% HCl [6]: weak
Water absorption (permeability) [7]: high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	62%	Silica (overgrowth)	2%
Feldspar	4%	Feldspar (overgrowth)	0%
Rock fragments	2%	Carbonate	1%
Mica	1%	Iron/manganese oxide	6%
Opaque material	0%	Clay	7%
Other	<<1%	Hydrocarbon	0%
Intragranular pores	0%	Intergranular pores	15%

Stone type [1] (detailed classification): subfeldspathic-arenite
Grain-size [9]: fine-sand-grade to coarse-sand-grade
Grain sorting [10]: poorly sorted
Grain roundness [11]: sub-angular to well rounded
Cement distribution [12]: silica cement continuous
Supergene changes [13]: none

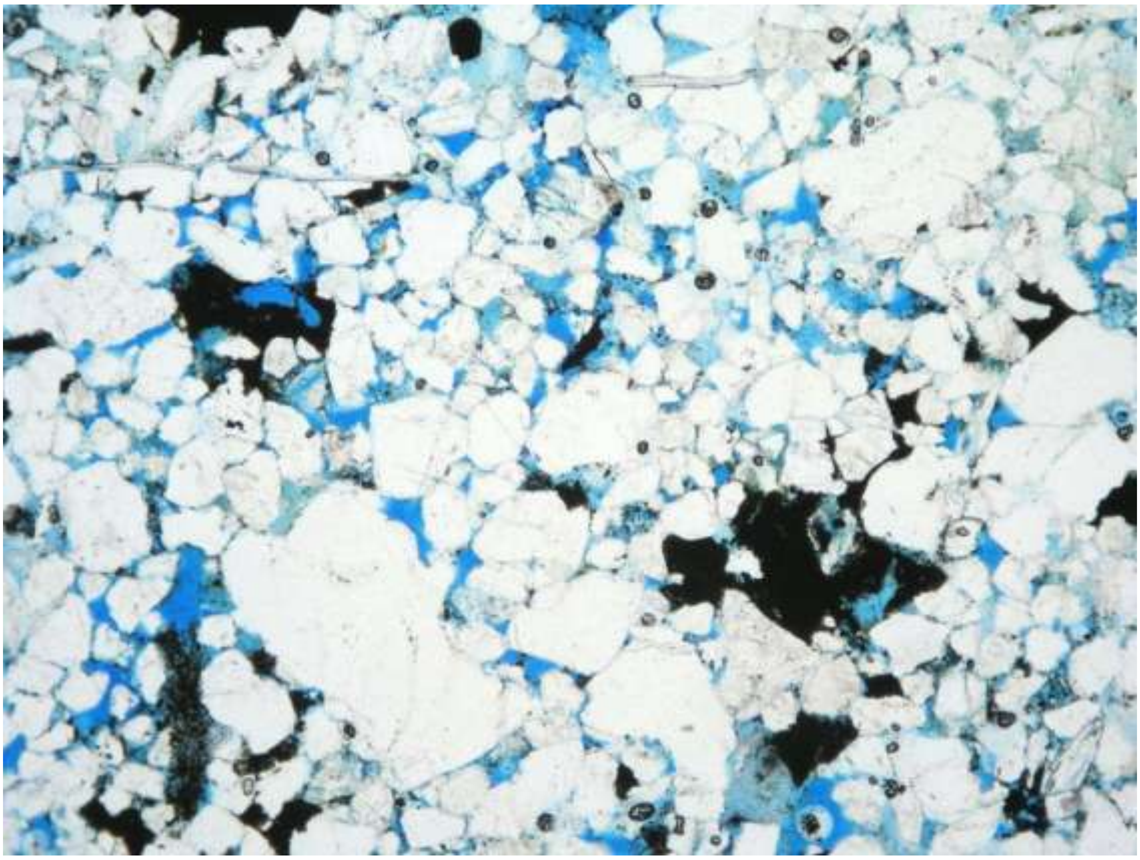
Comments

1) The sample consists of a stone fragment from the west façade, adjacent to St Andrew's West Church, at ground level.

2) Green and grey colours on the exterior surface are due to biogenic growth and soot.

3) Rounded zircons appear as an accessory mineral.

4) Clay minerals in the intergranular pore spaces are the result of dissolution of feldspar grains and rock fragments.



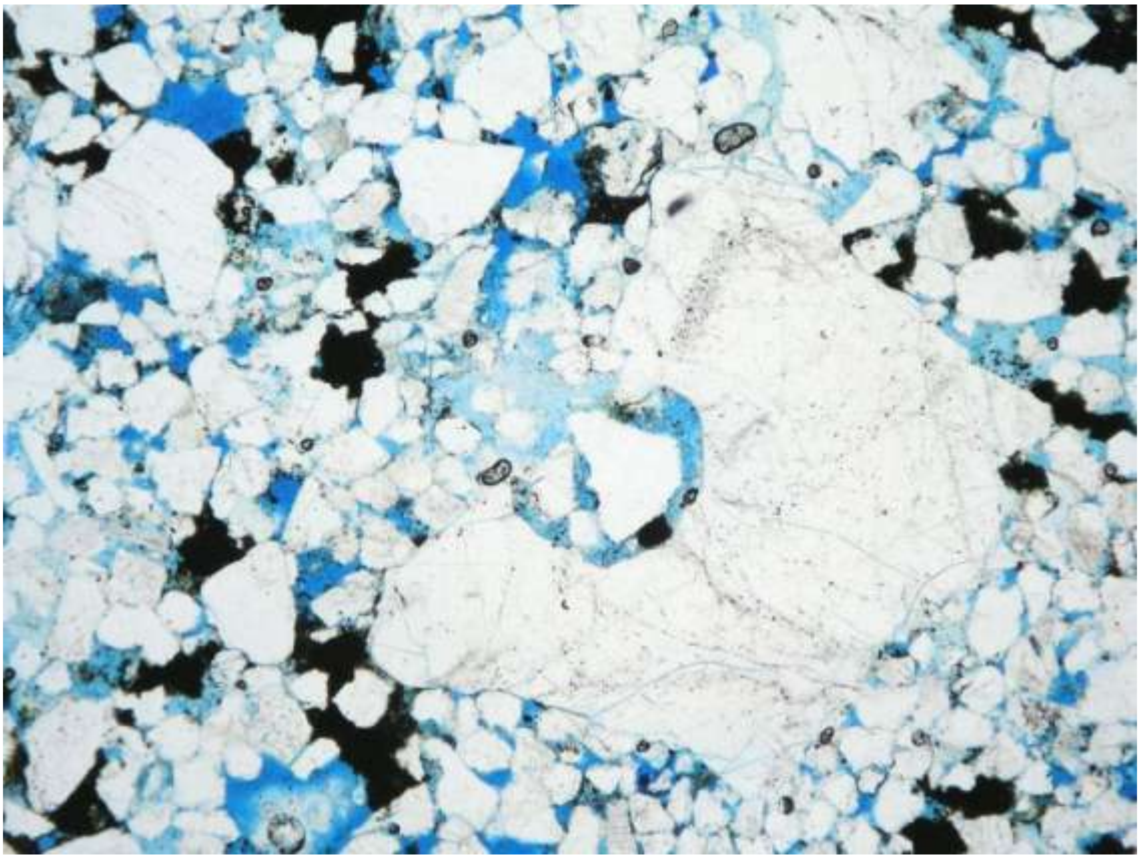


Figure A6_10. Two images of sample ED11060-2, as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals. Mottled bluish areas are clay mineral. Pore spaces are clear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11061
PRIMARY_KE: 963242
Building stone: Buff sandstone 1
Sample dimensions: 90 x 30 x 30 mm
Building address: 42 Newmarket Street

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	very light greyish buff
Stone colour [2] **–** weathered stone:	greyish buff
Stone colour [2] **–** exterior surface:	greyish buff
Stone cohesion [3] – fresh stone:	moderately cohesive
Stone cohesion [3] – weathered stone:	moderately cohesive
Primary sedimentary structure [4]:	uniform (some orientated grains)
Distinctive features [5]:	carbonaceous matter; speckled
Reaction to 10% HCl [6]:	moderate
Water absorption (permeability) [7]:	high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	59%	Silica (overgrowth)	5%
Feldspar	2%	Feldspar (overgrowth)	<1%
Rock fragments	1%	Carbonate	4%
Mica	1%	Iron/manganese oxide	2%
Opaque material	0%	Clay	10%
Other	<<1%	Hydrocarbon	0%
Intragranular pores	1%	Intergranular pores	15%

Stone type [1] (detailed classification):	subfeldspathic-arenite
Grain-size [9]:	fine-sand-grade to medium-sand-grade
Grain sorting [10]:	moderately well sorted
Grain roundness [11]:	sub-angular to sub-rounded
Cement distribution [12]:	silica cement continuous; carbonate cement isolated
Supergene changes [13]:	moderate dissolution of feldspar

Comments

1) The sample consists of a chip from a window jamb at first floor level.

2) The exterior surface is weathered to a depth of less than 1 mm, and is greyish buff.

3) A strongly speckled character is given by dark reddish brown spots of iron oxide.

4) Flakes of muscovite mica are relatively common and aligned, marking the bedding orientation.

5) The carbonate mineral is iron-rich (ferroan dolomite, ankerite or siderite).

6) There are occasional fragments of carbonaceous matter.

7) Clay minerals in the intergranular pore spaces are in large part the result of dissolution of feldspar grains and rock fragments.

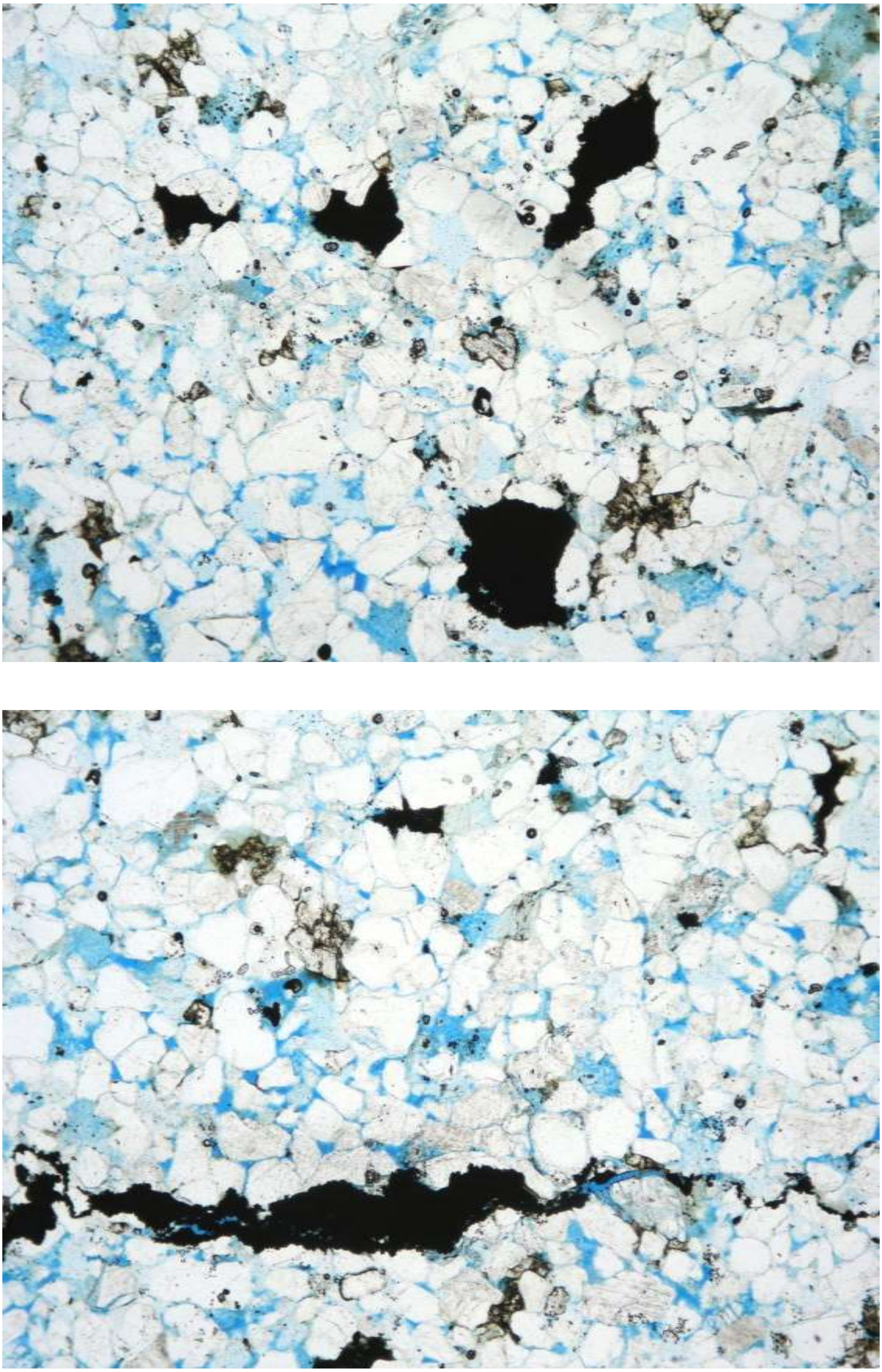


Figure A6_11. Two images of sample ED11061, as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals, which can form laminae (as in the lower image). Light grey, mottled patches are carbonate mineral. Mottled bluish areas are clay mineral. Pore spaces are clear blue. The field of view is 3.3 mm wide.

BGS sample number: ED11062
PRIMARY_KE: 961108
Building stone: Buff sandstone 1
Sample dimensions: 45x25x10 mm
Building address: 6-8 Cow Wynd

Hand specimen observations

Stone type [1] (general classification):	sandstone
Stone colour [2] **–** fresh stone:	light buff
Stone colour [2] **–** weathered stone:	not applicable
Stone colour [2] **–** exterior surface:	grey
Stone cohesion [3] – fresh stone:	moderately cohesive
Stone cohesion [3] – weathered stone:	not applicable
Primary sedimentary structure [4]:	faintly laminated
Distinctive features [5]:	none
Reaction to 10% HCl [6]:	mild
Water absorption (permeability) [7]:	high

Thin section observations

Stone constituents [8]:

Granular (detrital) constituents		*Intergranular constituents*	
Quartz	62%	Silica (overgrowth)	4%
Feldspar	4%	Feldspar (overgrowth)	0%
Rock fragments	2%	Carbonate	1%
Mica	1%	Iron/manganese oxide	2%
Opaque material	<1%	Clay	8%
Other	<1%	Hydrocarbon	0%
Intragranular pores	1%	Intergranular pores	15%

Stone type [1] (detailed classification):	subfeldspathic-arenite
Grain-size [9]:	fine-sand-grade to medium-sand-grade
Grain sorting [10]:	moderately sorted
Grain roundness [11]:	sub-angular to rounded
Cement distribution [12]:	silica cement continuous
Supergene changes [13]:	moderate dissolution of feldspar

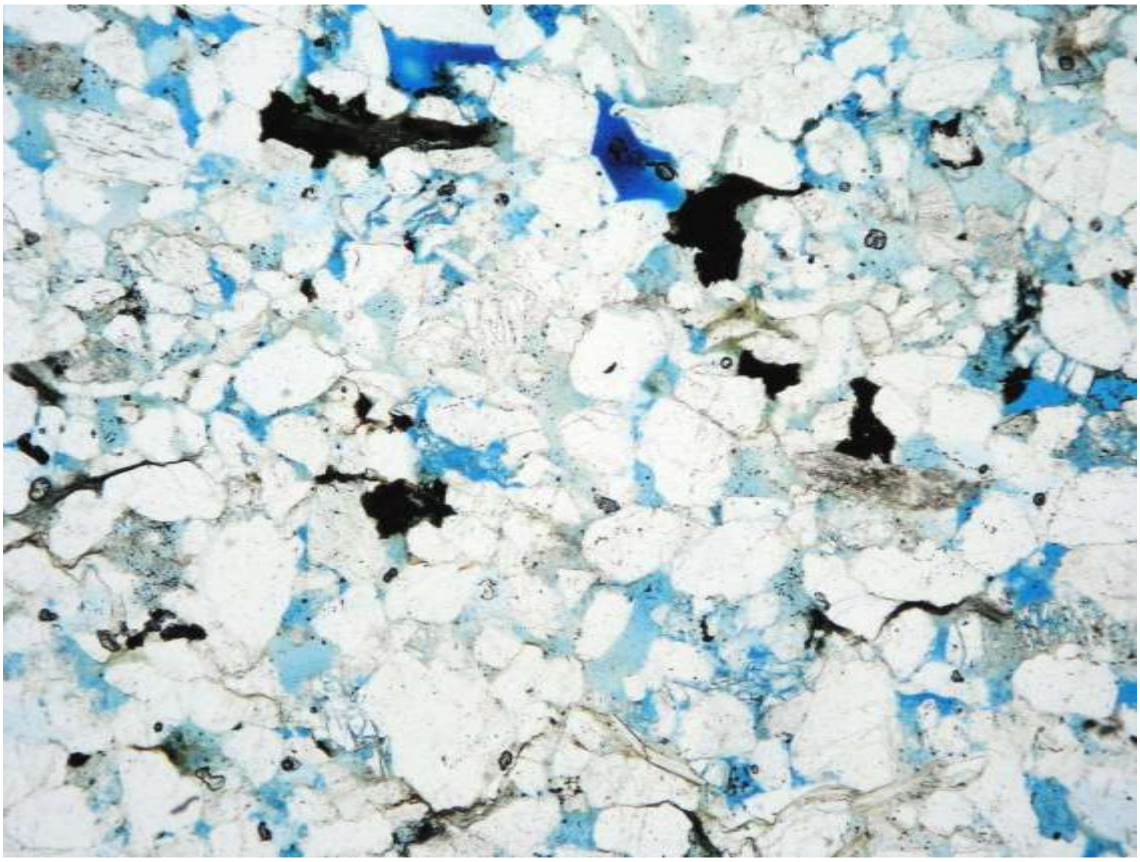
Comments

1) The sample is a small chip from a quoin at the top of the first floor level.

2) The faint laminae consist of concentrations of iron oxide minerals and mica flakes.

3) Rounded grains of tourmaline and zircon appear as accessory minerals.

4) Most of the clay mineral content is probably due to alteration of feldspar grains and rock fragments.



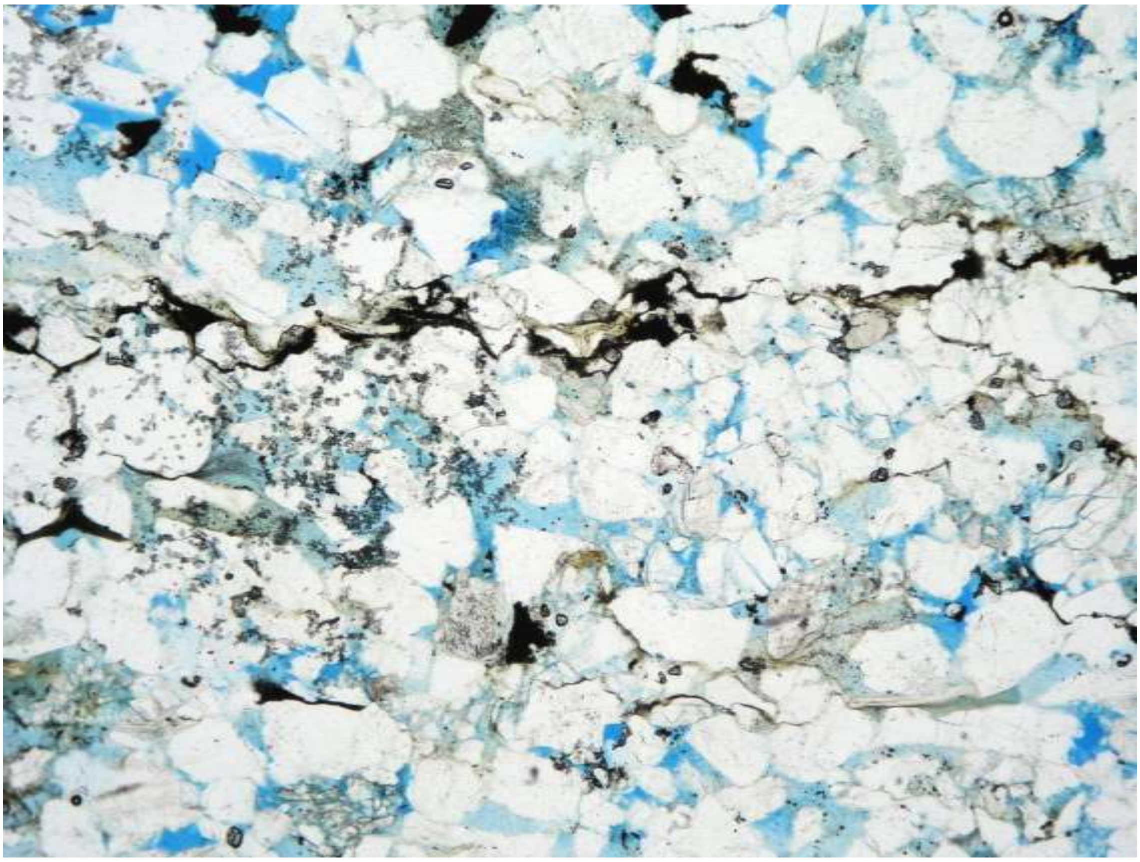


Figure A6_12. Two images of sample ED11062, as it appears in thin section. White grains are mainly quartz. Black areas are mainly iron oxide minerals, which can form laminae (as in the lower image). Mottled bluish areas are clay mineral. Pore spaces are clear blue. The field of view is 3.3 mm wide.

Supporting notes for the petrographic descriptions

Each numbered note below relates to one of the superscript numbers in the preceding Petrographic Description forms.

1 Stone type: a low-precision (general classification) or high precision (detailed classification) name for the stone type. The determination of stone type follows the classification and nomenclature of the BGS Rock Classification Scheme.

2 Stone colour: the 'visual' determination of stone colour is based on a simple assessment with the unaided eye in natural light. Wherever possible, the determination of stone colour is made on a broken (not sawn), dry surface.

3 Stone cohesion: a simple, non-quantitative assessment of the degree to which the stone is cohesive. This property is recorded in terms of four conditions, each representing one segment of a continuum: *strongly cohesive*, *moderately cohesive*, *moderately friable*, and *very friable*. The grains in a *strongly cohesive* stone cannot be disaggregated by hand, whereas the grains in a *very friable* stone can be readily disaggregated by hand.

4 Primary sedimentary structure: a record of whether the distribution of granular (detrital) constituents in the sample is essentially isotropic (uniform) or anisotropic (non-uniform). The type of anisotropic fabric is recorded.

5 Distinctive features: a record of visible features that are distinctive and might be diagnostic; see Table 3 for a list of distinctive features for sandstone.

6 Reaction to 10% HCl: the visual reaction to a drop of dilute hydrochloric ac id placed on the surface of the stone. Used in sandstone to test whether a carbonate mineral cement is present; a strong fizzing reaction indicates that calcite is present, a weakly fizzing reaction indicates that dolomite may be present.

7 Water absorption (permeability): a simple, non-quantitative assessment of stone permeability, presented as one of five conditions (*very low*, *low*, *moderate*, *high*, *very high*) expressed relative to a nominal 'average' permeability in building stone sandstones. The assessment is based on the speed of water absorption using a water bead test.

8 Stone constituents: a record of the identity and relative proportions of all granular (detrital) and intergranular (authigenic materials and pore space) constituents currently in the stone. The proportions are estimates, expressed in %, which are based on a visual assessment of the whole thin section area.

9 Grain-size: the terms are those used for grain-size divisions in the BGS Rock Classification Scheme.

10 Grain sorting: a simple, non-quantitative assessment of the degree to which detrital constituents display similarity in terms of physical characteristics (in particular the size and shape of grains).

11 Grain shape: a simple, non-quantitative assessment of the degree to which detrital constituents are abraded.

12 Cement distribution: a record of the type and extent of mineral cement that acts to bind detrital grains, as observed in thin section. *Isolated* means the cement occurs in discrete locations (e.g. as overgrowths on individual detrital grains). *Discontinuous* means the cement is formed in patches, each of which typically encloses several to many detrital grains. *Continuous* means the cement is more-or-less connected across the thin section.

13 Supergene changes: a record of the evidence observed in thin section for mineral alteration that occurs in the stone when it is near the ground surface. Such alteration processes typically begin before stone is quarried, but some may continue, or be initiated, after stone is extracted from the ground.

Appendix 7 Stone supplier details

The tables below contain contact details for current suppliers of the stones and slates listed in Table 8 and Table 9, respectively.

Building stone suppliers

Building stone	Supplier name	Address	Telephone number	Email address	Webpage address
Peakmoor sandstone Blagdon Buff sandstone	Blockstone Ltd	Wingerworth Chesterfield Derbyshire S42 6RG	01246 554450	blockstone@realstone.co.uk	www.blockstone.co.uk
Prudham sandstone Millknock sandstone Lingberry sandstone	Borderstone Quarries	Haltwhistle Northumberland NE49 0HQ	01434 322140	enquiries@borderstonequarries.com	www.borderstonequarries.com
Stanton Moor sandstone Darney sandstone Stoke Hall sandstone Locharbriggs sandstone Fletcher Bank sandstone	Stancliffe Stone	Keypoint Office Village Keys Road Nixs Hill Industrial Estate Alfreton DE55 7FQ	08453020702	info@stancliffe.com	www.stancliffe.com
Birchover sandstone	Birchover Stone Ltd	Birchover Quarry Main Road Birchover Derbyshire DE4 2BN	01629 650881	birchover@suon.net	www.birchoverstone.co.uk
Dunhouse Buff sandstone Blaxter sandstone Blaxter's Northumberland Buff sandstone Corsehill sandstone Corncockle sandstone Bearl sandstone	Dunhouse Quarry Ltd	Cleatlam Darlington County Durham DL2 3QU	01833 660208	enquiries@dunhouse.co.uk	www.dunhouse.co.uk
Hazeldean sandstone Alnwick Moor sandstone Swinton sandstone	Hutton Stone Co Ltd Masons & Stone Merchants	West Fishwick Berwick-upon-Tweed TD15 1XQ	01289 386056	huttonstone@aol.com	www.huttonstone.co.uk
Cullalo sandstone	Tradstocks	Thornhill Dunaverig Thornhill Stirling FK8 3QW	01786 850400	info@tradstocks.co.uk	www.tradstocks.co.uk
Witton Fell sandstone	A.D. Calvert Architectural Stone Supplies Ltd	The Stone Yard Wensley road Leyburn North Yorkshire DL8 5ED	01969 622296	stone@calverts.co.uk	www.calverts.co.uk
Drumhead sandstone (Buff/White)	Mr D Graham	Drumhead Quarry Denovan Mains	07967 799253	denovanmains@aol.com	none

		Denny Falkirk			
Stainton sandstone	Stainton Quarry	Stainton Barnard Castle DL12 8RB	01833 690444	enquiries@staintonquarry.co.uk	www.staintonquarry.co.uk
Crossland Hill sandstone	Johnsons Wellfield Quarries Ltd	Crossland Hill Huddersfield HD4 7AB	01484 652311	sales@johnsons-wellfield.co.uk	www.myersgroup.co.uk
Naylor Hill Buff Gritstone	Dennis Gillson and Son	Naylor Hill Quarry Blackmoor Road Haworth BD22 9SU	01535 643317	enquiries@gillsons.co.uk enquiries@gillsons.com	www.gillsons.com
Dovedale sandstone	Historic Stone	Cheshire Design Centre, Hatter Street, Congleton, Cheshire CW12 1QQ	01260 278 328	info@HistoricStone.co.uk	www.historicstone.co.uk/
Portland Limestone (Whitbed)	Albion Stone plc	27-33 Brighton Road Redhill Surrey RH1 6PP	01737771772	sales@albionstone.com	www.albionstone.com
	Portland Stone Firms Ltd	99 Easton Street Portland Dorset DT5 1BP	01305 820331	sales@stone-firms.co.uk	www.stonefirms.com
Kemnay granite	Fyfestone	Kemnay Quarry Aquithie Road Kemnay AB51 5PD	01467 651000	masonry@aggregate.com	www.fyfestone.com
Peterhead granite	Breedon Aggregates	Stirlinghill Quarry Boddman Peterhead AB42 3PB	01779 475003	enquiries@breedonaggregates.com	www.breedonaggregates.com
Corrennie granite	Bardon Aggregates	Tillyfourie Alford Inverurie AB51 7NQ	01467 644200	n/a	www.aggregate.com

Roofing slate suppliers

Roofing slate	Supplier name	Address	Telephone number	Email address	Webpage address
Cupa Heavy 3 Slate	CUPA Natural Slate	45 Moray Place Edinburgh EH3 6BQ	0131 2253111	cpd.cupa@cupagroup.com	uk.cupa@cupagroup.com
Greaves Porthmadoc Welsh Slate	Greaves Welsh Slate Co. Ltd	Llechwedd Slate Mines Blaenau Ffestiniog Gwynedd LL41 3NB	01766 830522	info@welsh-slate.com	www.welsh-slate.com/home.php
Penrhyn Slate	Welsh Slate Ltd	Penrhyn Quarry Bethesda Bangor Gwynedd LL57 4YG	01248 600656	enquiries@welshslate.com	www.welshslate.com/colours-finishes
Burlington Slate	David Wallace International Slate UK	Airfield Approach Business Park Flookburgh Grange Over Sands Cumbria LA11 7LS	01539 559289	www.slate.uk.com	www.slate.uk.com
	Burlington Slate Ltd	Kirkby-in-Furness Cumbria LA17 7UN	01229 889661	sales@burlingtonstone.co.uk	www.burlingtonstone.co.uk