ANGUS FLAGSTONE ROOFING – VOLUME 1: LITERATURE REVIEW AND CASE STUDIES

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

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This report has been commissioned by Historic Environment Scotland (HES) to provide information that will assist HES in safeguarding and supporting the preservation of traditional Angus flagstone roofing.

The research was carried out by the author, Sara Carruthers MCIOB, BSc (Hons), MA (Conservation, IoAAS). Sara is an independent consultant and Certified Building Conservation Specialist (Project Manager, Regulatory) with the Chartered Institute of Building who has specialised in the conservation of historic buildings and monuments for over twenty-five years.

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This report and audit involved contributions from many residents, professionals and amenity groups, and the author would like to thank them for sharing their experience and knowledge. A list of the main contributors can be found in Section 15.

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1. INTRODUCTION

Roofing composed of sedimentary stone, such as sandstone or flagstone, is not common in Scotland. This style of roofing can be found in localised pockets, driven by the existence of a nearby source of suitable material. Angus is one such area, formerly heavily quarried for stone from the Dundee Flagstone Formation.

Flagstone is the term used for sedimentary rock (such as sandstone or siltstone) that has a fissile structure, enabling it to be split along well-defined bedding planes. This flagstone, while predominantly used as paving and building stone, was also split, dressed and used as roofing material. There are a number of high-status, culturally significant buildings that still have Angus flagstone roofing, such as the Great Hall at Edinburgh Castle.

1.1 Research aims

This research was commissioned by Historic Environment Scotland. Its aim is to assess both the cultural significance of these flagstone roofs and the risks faced by this built heritage in the Angus region. There are gaps in knowledge and understanding of the material and how it has been used for roofing. The research also aimed to document:

- what we know about the Dundee Flagstone Formation as a material
- the history of its use
- how the material has been processed and installed as roofing.

1.2 Report format

The research results are presented in two volumes.

Volume 1 comprises a literature review, case studies and comments on the status of this built heritage. It concludes with a discussion of the risks associated with the material.

Volume 2 will present the results of an audit of known remaining examples of buildings roofed with flagstone across the areas of Angus, Dundee, Fife, and Perth and Kinross.

Flagstone roofing from the Dundee area is currently referred to by a variety of names, including Dundee red sandstone slates, Angus stone slates, Carmyllie slate, Arbroath pavement, Dundee Flagstone, grey or great slates, sclaites (archaic) and stone tiles. All of these terms refer to the same material. The term tilestone, which has been identified in England as the preferred term for this type of roofing, has not appeared, in literature or colloquially, in connection with flagstone roofing in Angus or the surrounding areas.

This report uses the terms *flagstone roofing* and *flagstone slate*.

2. METHODOLOGY

This report includes a desktop study of what is currently known about the history of Angus flagstone and its use as a roofing material. It has been supplemented by information gleaned from engagement with a network of specialist historians and professionals, community groups, planners and interested owners, all of whom have shared their previous research and personal experiences.

The audit draws on personal communications as well as publicly available information such as listed building descriptions, Canmore (now located at trove.scot), archives and records, websites, and observations from public roads by the author. Although it is unlikely to be exhaustive, the audit provides a general reflection of the building type, roof condition and general scarcity of this building material.

Figure 1: Angus flagstone roof on the Gatehouse at Edinburgh Castle. © Sara Carruthers.

3. GEOLOGY

The Devonian Old Red Sandstone Supergroup is found from Cornwall to Shetland, but it was only used as a roof covering in a few locations. The most important Old Red Sandstone quarries for roofing were in Caithness and Angus, although there have also been quarries in the Welsh Marches and South Wales.[1]

The geology of the southern part of Angus – south of the Highland Boundary Fault – is dominated by sedimentary rocks of the Lower Old Red Sandstone. These date from the Early Devonian period and consist mainly of sandstones and conglomerates, with some siltstones.[2]

Part of the Lower Old Red Sandstone is known in the Angus area as the Dundee Flagstone Formation. This was quarried from numerous sites in Angus, Dundee, Kincardineshire and Perthshire. The flagstone was formed originally of fine sand and mud, deposited by rivers during the early part of the Devonian period (around 405 million years ago). At this time, Scotland was south of the equator at roughly the same latitude as Southern Angola is today. The stone typically breaks preferentially along parallel bedding planes, forming tabular blocks or 'flags' of hard, durable stone. Angus flagstone was used locally and regionally for paving, roofing, masonry and millstones. It was also used nationally and internationally for paving.[3]

3.1 Geological description

Table 1: Summary geological description of the Dundee Flagstone Formation.[4]

Bedrock unit	Dundee Flagstone Formation
Larger geological sequence	Part of the Lower Old Red Sandstone Supergroup
Age	Early Devonian
Colour	Medium grey to purplish brown
Grain size	Fine sand (0.125mm to 0.25mm) to very fine sand (0.032mm to 0.125mm)
Cohesion	Strongly cohesive
Grain sorting	Well sorted to moderately well sorted
Water absorption	Low to very low
Fabric	Parallel lamination to occasional lamination
Distinctive features	None

A full geological description of the Perth and Dundee area can be found in the British Geological Survey *Memoir* dating from 1985.[5] In this memoir, the bedrock used for roofing slate is referred to as the 'Dundee Formation', a name later changed to the Dundee Flagstone Formation. A more recent documentation of the stratigraphy is provided by Browne, Smith & Aitken (2002).[6]

A geological analysis of the Devonian Old Red Sandstone in Fife and Angus is provided by geologist A R MacGregor in his 1968 publication *Fife and Angus Geology: An Excursion Guide*. In summary, the Devonian rocks of Angus and Fife are described as immensely thick, sometimes red in colour, and non-marine in provenance. Only the Upper and Lower Divisions occur in Fife and Angus, with a marked unconformity (a gap in the rock sequence caused by erosion or lack of deposition) where the Mid-Devonian Middle Division would lie. The Lower Division predominates, being exposed over about two-thirds of the area at the surface.

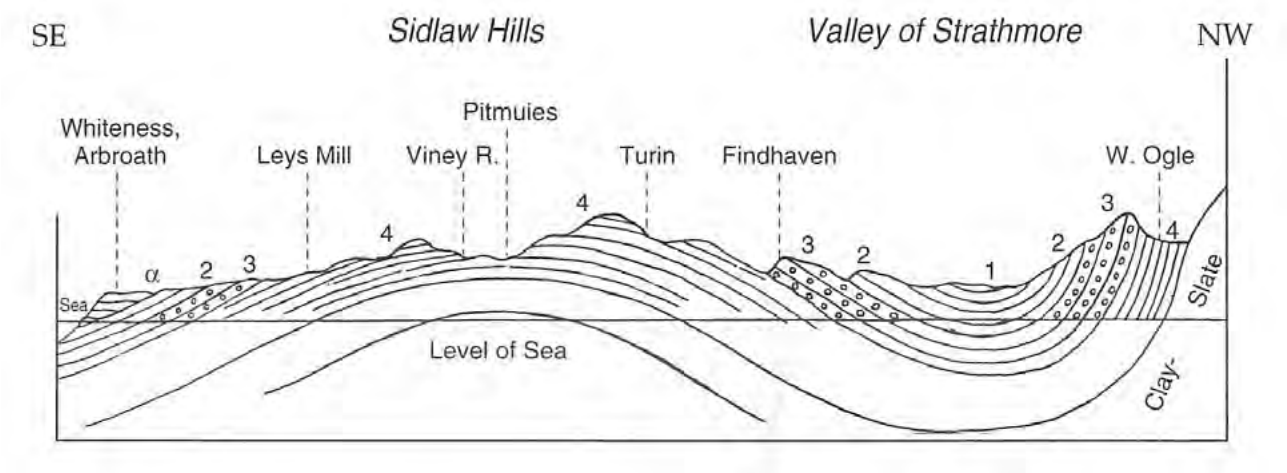

Figure 2: Section extending from the Highlands south-eastwards to the coast at Arbroath. After Lyell's *Elements of Geology* (1838, p 99). 1 = red marl or shale, 2 = red sandstone, 3 = conglomerate, 4 = grey paving stone, etc, α = newer deposits in horizontal beds. Most of the section comprises formations of the Lower Old Red Sandstone, but the horizontal beds at Arbroath belong to the unconformable Upper Old Red Sandstone, while the clay-slate at the NW end of the section is part of the Dalradian lying beyond the Highland Boundary Fault, not yet recognised in 1838.[7]

The Lower Old Red Sandstone dates from over 400 to 385 million years ago and shows that there was considerable folding and erosion before the Upper Division was laid down, between 375 and 360 million years ago. The Middle Division is missing in the area, as mentioned above. Fish and plant fossils are found but considered rare in geological terms. Overall, the beds are estimated at 9km thick and variously contain sandstones, mudstones and siltstones. Also found interbedded among them are volcanic conglomerates and lava and basalt flows, thought to originate from volcanoes either side of the Highland Boundary Fault. The grey-brown sandstones, flagstones, siltstones and shales of the Dundee Flagstone Formation were the rocks that were much quarried in the past. They were part of the Arbuthnott Group of the Lower Old Red Sandstone.[8] It is noted that the Arbuthnott Group has since been reclassified as the Arbuthnott-Garvock Group.

4. QUARRYING

The Building Stone Database for Scotland has records of 144 quarries which have, at some point, produced flagstone in the Angus local authority area. Another 10 quarries are listed in adjacent areas of Perthshire, Dundee and Aberdeenshire.[9]

4.1 Quarrying in Angus

Early quarrying: pre-1850s

The *Statistical Accounts for Scotland* (1791–9) describe 'a most valuable bed of pavement' (ie fissile stone) beginning at Leysmill Quarry on the estate of Kinblethmont and extending south through ground holding the Carmyllie, Smithfield, Wellbank and Duntrune quarries.[10]

Research into the quarries of Angus was carried out by Alexander Mackie of the Edinburgh Geological Society in 1980.[11] He notes that most of the quarries of Dundee Flagstone Formation in eastern Angus comprise mainly cross-bedded sandstones with intercalations of shale and flagstone. They are well known for their fossils, known historically as 'seraphim'. A map of quarries, overlaid on the outcropping flagstone, is presented in Figure 3.

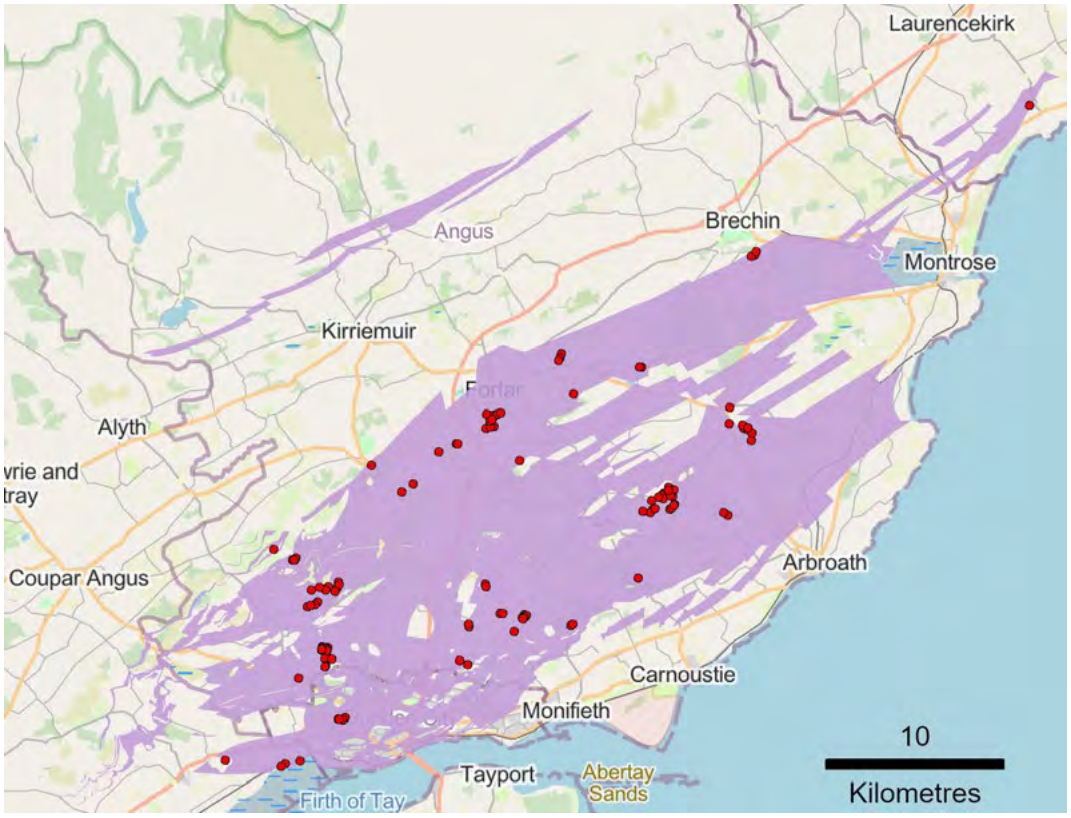

Figure 3: Map showing the distribution of the Dundee Flagstone Formation (shaded area) and the locations of flagstone quarries listed on the Building Stones Database (dots). Prepared by Paul Everett, British Geological Survey.[12]

Mackie indicates that the coarse-grained sandstones occurred in brown and grey bands of varying thickness and were used for millstones and roofing. The beds of finer-grained varieties were white, blue or green in colour and were used for pavement. He also found records indicating that quarrying had been pursued in Angus from the 16th century. Wellbank or Legsland Quarry, about seven miles north-east of Dundee, must have been in operation at least 400 years ago, as the Rev Samuel Miller (1842) quotes from the Session Record: '3rd June 1574, Donald Robartsone in Laigislande fand [found] ye Lard of Umoquhy cation [bail], yt gif [if] ye witnesses convicks hym, he sall pay ane thousand sklaittis [slates].' As early as 1678, Robert Edward, minister of Murroes, about five miles north-east of Dundee, wrote that there were many quarries in Angus producing high-quality stone, some of which was shipped to Fife, the Lothians, Holland, and North America. He adds, 'No part of Scotland can boast of better, few so good.' John Ochterlony (about 1682) states, 'The country aboundeth in quarries of freestone, excellent for hewing and cutting, especially one at the Castle of Glammes, far exceeding all others in the shyre, of a blewish colour, excellent milne-stones; great abundance of sklait and lymestone in divers places; ane excellent lead myne in Glenesk, belonging to, the Laird of Edzell.'[13]

According to the Rev Thomas Wright (1795), 'the neighbourhood abounds in excellent materials, especially the hills of Turin and Pitscandlie, which contains inexhaustible stores of stones of various kinds, and of every dimension fit for use; and where there are quarries now working, astonishing to look at, and affording ample subject for contemplation and amusement to the naturalist and virtuoso'.[14]

Several quarries in the Parish of Aberlemno, between Forfar and Brechin, were worked for paving stones and roofing slates, and the Rev Andrew Mitchell (1792) stated that towards the end of the 18th century, slates were sent to London and other places. It appears that the quarries were worked as far back as 1755 at least, since the Rev James Crombie (1842) points out that between 1755 and 1842 the local population fluctuated slightly, depending on the number of quarrymen required.[15]

Forfar was fortunate in having several quarries on Balmashanner Hill, just one mile south of the town. The Rev W Clugston (1843) describes quarries having been opened at 'Balmashanner', 'Craignathro ... on the east of the Dundee turnpike road' and 'Berrymuirhead', which supplied building stone, roofing flags and pavement to the town of Forfar.[16] He states that immense quantities of 'pavement' were conveyed to Arbroath, Dundee and different parts of the United Kingdom.[17]

Carmyllie Parish was a productive quarrying area for the Dundee Flagstone Formation. As a result, Carmyllie became a genericised name for Angus flagstone. Carmyllie Parish contains the two villages of Greystone and Redford; Greystone is the oldest village, but Redford grew substantially once the quarries expanded.[18]

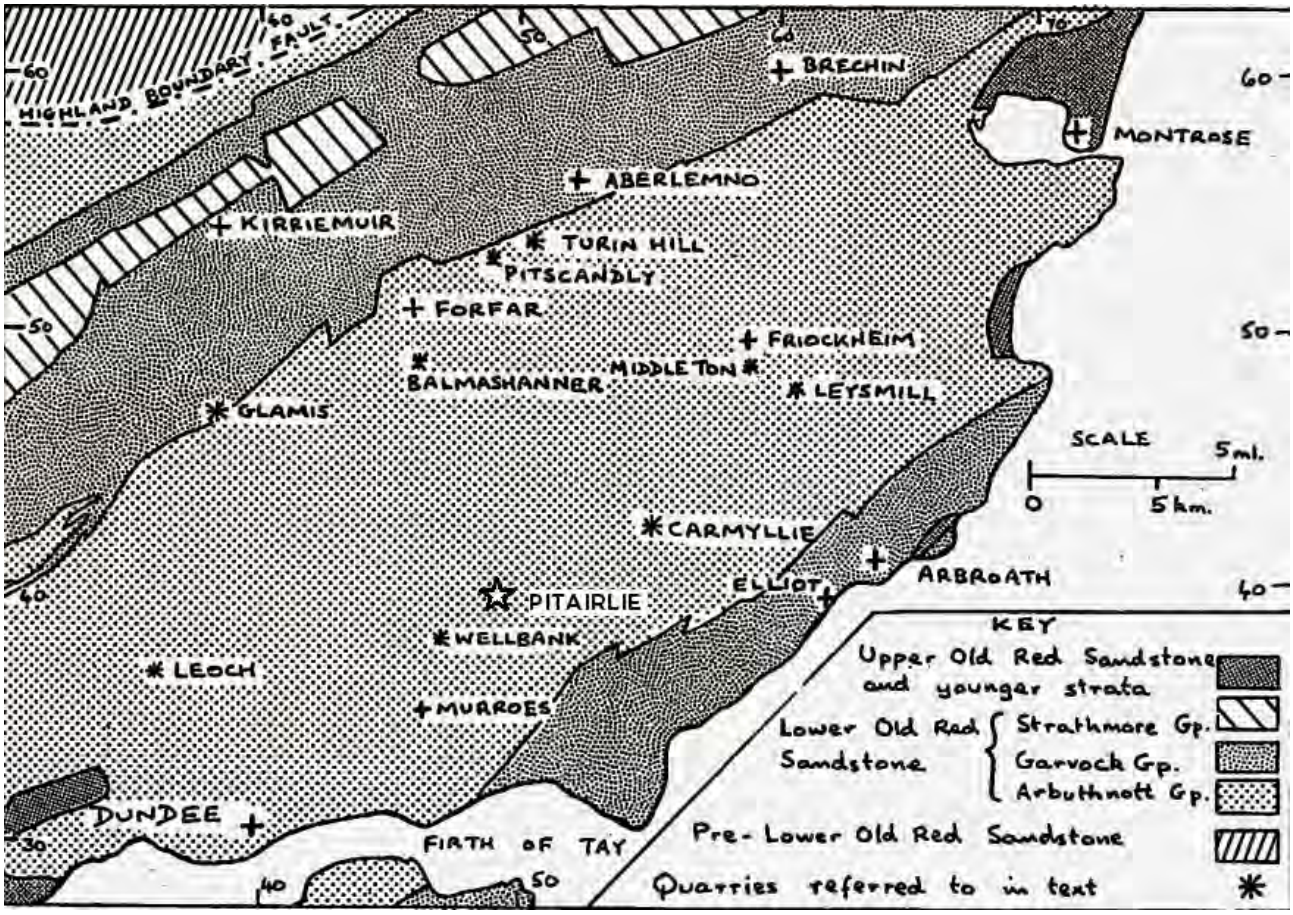

Figure 4: Sketch map of the geology, towns and quarries by Alexander Mackie, © Edinburgh Geological Society. The approximate location of Pitairlie Quarry, the only quarry currently producing slate, has been added.

In 1837, J Carmichael is still able to quote prices for slates delivered to Arbroath by cart from the Carmyllie quarries of '£4: 10s per 1,000 slates of 15″ to 20″ by 9″ to 12″ each'.[19] The size quoted for the roofing slates was typical, although they would have been sold as 'randoms'. These would need to be sorted into similar lengths and thicknesses before use. Selling random sizes by the thousand was no doubt a cause of disputes and may explain why the Rev James Headrick reported that 'they seldom make a roof that is … watertight.' If the roofer received more small sizes than he had expected, he could be tempted to reduce the head lap to make them cover the slope, with the risk of leaks.[20]

In the 1850s the annual sales for 'pavement stones and slates' averaged £4,000 to £5,000. A railway from the Carmyllie quarries to Arbroath was opened in 1854. Demand for stone declined from the beginning of the 20th century, and the last quarries closed in 1951.[21]

In 1813, Rev Headrick described '… in various districts of the Seedlay [Sidlaw?] Hills there are numerous strata of sandstone flags, which may be raised of various thickness and dimensions. The thinnest of them are from about half an inch, to an inch in thickness. They are formed into plates of about fourteen or sixteen inches broad and eighteen or twenty inches long and are used for roofing houses. These plates are coated with scales of mica, or talc, of a greyish-blue colour, and this occasions the easy separation

of the plates from each other; but after long exposure to the air, they assume a grey or brownish colour.'[22]

Rev Headrick continues: 'These flags are raised in great quantities on the Hill of Balnashanar, and in the moor to the south of Forfar; also along the north side of the Hill of Turin in the parish of Aberlemno, and along its south side, in the parish of Roscobie. The most extensive range of these flags is in the parish of Carmyllie, and along the southern declivity of the Seedlay Hills. These quarries also furnish beds of various thickness, of a very fine grain; of a white colour, or with a slight tendency to blue or green, which are used for making stairs, lintels, columns, gravestones and various ornaments in architecture. The quarries at Carmyllie furnish flags of from three to six inches in thickness, which can be raised of any portable dimensions, and require only to be squared, to be fit for use. These are exported, in great quantities, from Arbroath to Leith, London and other towns, and are used for paving the ground-flat of houses, or laying the footpaths at the sides of streets. Flags are also raised in the parishes of Auchterhouse, Glammis, and various other places. They seem to form a zone of strata, running from south-west to north-east.'[23]

The changing focus of quarrying in Angus: 1850s to 1950s

The Industries of Scotland: Their Rise, Progress and Present Condition, by D Bremner, was published in 1869 and has a significant section on the contemporary pavement quarries of Caithness and Forfarshire.[24] Bremner notes that in Angus the production of roofing material had all but died out by 1850, eclipsed by the highly successful use of the Hunter planing machine, which had expanded the production of paving for export. The planing machine was invented by Mr James Hunter of Leysmill, who had for many years been the quarry manager for Mr Lindsay Carnegie of Spynie and Boysack.[25]

In 1869, the pavement quarries extended from Leysmill in the east to Glamis in the west, and from Montrewmont Muir in the north to the Sidlaw Hills in the south, an area of 16 × 20 miles and which covered the lowland region of Forfarshire. Bremner goes on to describe some quarries in detail, including ownership and tenancy, and while doing so does make some references to the earlier production of roofing slate. The detailed list does not cover the full spread of the geographical area he describes, lacking detail of the Glamis area.[26]

The pavement slabs produced throughout the whole area were known as Arbroath Pavement, although it was a durable but easily worked freestone and used 'not only for paving streets, but for all inside work of houses and for other purposes'.[27]

Before 1800, the small older quarries appear to have been worked by their owners, but as production became more mechanised they were leased to specialist quarry masters, some managing several quarries. Bremner's list of quarries active in 1869 is much shorter than the list of historic quarries prepared by the British Geological Survey from geographical data. This may indicate a move from the small-scale craft production of pre-1800 to a size of quarry where use of a planing machine was commercially viable.[28]

A description of any local techniques for winning the stone before mechanisation has not been found. After mechanisation, quarry information suggests that 20 employees supported one planing machine or vice versa.

Table 2: A summary of quarries as described in Bremner's 1869 text *Industries of Scotland*.[29]

Quarry	Location	Notes
Leysmill Group	Leysmill	Worked since about 1820; owned by Mr Carnegie of Boysack; workforce of 60 from Friockheim and Leysmill
Montrewmont*	Guthrie Estate	50–60 employees; opened about 1859
The Dub*	Turin Estate	20 employees; opened about 1859
Tillywhandland*	Aberlemno	20 employees In 1869 this was owned by a Mr P H Thoms. The architect Patrick Thoms was responsible for a number of Arts and Crafts villas with Angus flagstone roofs in the early 20th century.
Myrestone*	Pitscandly Estate	20 employees; also had a ridge-cutting machine
All quarries listed above	*North-eastern area*	'In this district a durable but heavy grey slate for roofing was formerly worked; but it is now generally discarded in favour of the thin blue slate.'
Carsegownie*	Forfar	20–40 employees
Tolbooth*	Forfar	20–40 employees
Balmashanar*	Forfar	'One of the oldest in Scotland'; 20–40 employees
Carmyllie Group	Carmyllie	Owned by the Earl of Dalhousie; 'most extensive in the country'; these have been worked for 'several centuries', and up until 1800 each small farmer could open their own quarry in return for paying the landlord a portion of the value of stone produced. They usually worked the quarry between planting and harvest. The principal production was for roofing slates, which were 'carted in large quantities to Dundee and the surrounding towns and shipped to Leith for roofing in Leith and Edinburgh. Production started to move to paving slabs from 1800 which were quarried 1″ to 1½″ thick. It became increasingly mechanised and carried out by larger specialist lessees. It is noted that the quarries were prone to flooding and windmills were used to pump water out of them. By 1869 there were 300 employees and a variety of specialist machines for the production of pavement, steps, copes and balustrade, and the quarry was exporting about 150 tons a day via a bespoke railway. Bremner notes that the quarrymen of Carmyllie were an industrious, sober and saving class; most of them had a piece of land and kept at least one cow, and the sale of intoxicating drinks was not permitted in the parish.
The Gwynd	Not known	60–80 employees
Pitairlie	Monikie	50 employees
Gagie	W of Kellas	Produces pavement only
Wellbank	Wellbank	Produces pavement only
Kingenny	Kingenny	Produces pavement only
Duntrune	Murroes	Produces 'thick rock' and pavement

*Quarries marked with an asterisk had to transport stone 3–4 miles to the nearest railway station.

The Hunter planing machine and, later, the Hunter cutting machine revolutionised the production of stone pavement in the area. There are few references to the production of flagstone for roofing; Bremner refers to it only in passing, implying that it was no longer produced in notable quantities.

The Hunters also invented a 'ridge-cutting' machine in the early 1850s. This employed two saws at right angles and could make V-shaped ridge pieces directly from the stone blocks. Messrs Munro of Arbroath Foundries, who manufactured all the machines for the Hunters, only produced two ridge-cutting machines. All of the Hunter machines were belt driven and could be powered from any available source, but steam was used in Angus. The machines were expensive and did not cope well with the thinner sheets required for flagstone roofing. They also left a characteristic 'lay' on the surface.[30] This may be part of the reason that the production of pavement stone eclipsed the production of roofing, the latter remaining a craft industry.

In his *Pattern of Scottish Roofing* (2000), Emerton notes that the fissile rocks of the area have rhythmic bedding. Thinly bedded strata, suitable for roofing, alternates with thicker strata suitable for pavement and building stone. Emerton suggests that quarries initially opened to exploit exposed stone suitable for roofing would have morphed into pavement and building stone quarries as the beds were exploited.[31] Mechanisation brought massive expansion of quarrying in the mid-19th century. It is possible that strata suitable for roofing may have continued to be exploited for local use or bespoke orders as the relevant beds were exposed and cleared. Being of less interest commercially, this is not mentioned in records found to date. The number of prestigious buildings recorded as being roofed with flagstone in the later 19th and early 20th centuries, both as restorations and as new-build Arts and Crafts designs, indicates that the production of flagstone roofing was continuing at some scale, although records have not yet been found. Specific research into estate or architectural papers may clarify the source of the roofing slates.

Modern production of Angus flagstone

Since the 1950s, when the last of the historic commercial quarries closed, flagstone roofing materials have been sourced from unprotected vernacular buildings throughout Angus. This practice continued until recently. The rapidly diminishing number of these buildings as a source, and the poorer condition of the flagstone slates they carry, means this is no longer feasible. Estate quarries were reopened in the 1990s for the restoration of Melgund Castle near Aberlemno. They were, however, only used for building stone, as at that point the second-hand market remained buoyant. New roofing has on occasion been obtained from English quarries but is not an accurate match for Angus flagstone.

A historical and petrographic investigation into Pitairlie Quarry was carried out by the British Geological Survey in 2011 to support the reopening of the quarry by Denfind Stone Ltd.[32] The quarry probably opened originally in the mid-19th century and principally produced pavement until it ceased operating in 1915. No references have yet been found about roof slate production during this operating period at Pitairlie. The stone at Pitairlie shares characteristics with that from the Carmyllie quarries, although the colour of both is variable. Pitairlie is currently the only quarry producing pavement or similar products in Angus and has produced flagstone slates for roofing for a small number of buildings. Acheson House and St Athernase are included later in this report as case studies.

Flagstone slates are being produced at Pitairlie Quarry by mechanical methods rather than hand splitting of individual pieces. While this reduces waste, it gives an even, mechanical appearance to the product. An overview of the production process is included in the St Athernase case study. This method, while producing material suitable for new roofs, does not reproduce the style and craft skills required for a roof covered with randomly sized and sorted flagstone slates. Better continuity for this local building material would be achieved by hand production. There is further work to be done to meet the competing aspirations of the commercial quarry and the requirements for historically significant roofs to retain their craft skill characteristics.

Figure 5: The quarry at Melgund, which reopened for the restoration of Melgund Castle in the 1990s. © Benjamin Tindall.

No historical information has been found relating to the craft skill traditions of winning and preparing flagstone roofing in the Angus area. It has been observed that exposed or newly quarried Angus flagstone can begin to delaminate when saturated and exposed to frost. This may be a clue to early production techniques, and there may be potential to exploit this characteristic to produce new roofing material. The technique is still used in the commercial production of limestone roofing at Collyweston in England. Hand production of sedimentary stone roofing has been recorded in other areas of the UK, and commercial production by hand is still under way.

4.2 Quarrying in other areas

In addition to Angus and its hinterland, geographical areas of Scotland where 'grey' (originally meaning great) flagstone slates have been used for roofing are:

- Moray (particularly around Elgin and Dallas)
- Clydesdale, Dumfries and Galloway, the Borders
- Caithness, Sutherland and Orkney[33]

Areas in the United Kingdom that source roofing from the Devonian Old Red Sandstone include Caithness, the Welsh Marches and South Wales.

Caithness Flagstone: Middle Devonian

In Caithness, stone from the Old Red Sandstone has been used for building, including as roofing slates, but the source is the younger Middle Old Red Sandstone rather than the Lower beds used in Angus. Caithness Flagstone is characteristically finer-grained than the Dundee Flagstone Formation, polishing to a very dark sheen. Products and development mirror that of Angus, although Caithness started to export later. The first shipments were dispatched in about 1824 and it grew to become a very substantial industry. By 1845, Castlehill Quarry alone, which had opened in 1824, was employing 100 labourers and exporting 3,000–4,000 tons of flagstone per year. Peak production for the Caithness region was 1901–2, when nearly 35,000 tons of products were manufactured. During the same period, employment fell from 500 to 414 workers. Two rock types were exploited for roofing. These were a 'very hard, thin, dark micaceous flag' and a 'pale green, thin flag or "slate", much in demand for artistic work on churches and public buildings'. These were exported from Thurso to England. The industry declined during the 20th century, but products are now available again.[34] Several quarries are operational and produce roof slates.

Duart Castle on the Isle of Mull was roofed with Caithness Flagstone during its restoration in 1911, and again in 1990. Another example of a flagstone roof on the west coast is St Clement's Chapel on the Isle of Harris. St Clement's Chapel dates from the 16th century but was re-roofed in 1873 by Lady Catherine, Dowager Countess of Dunmore, who worked with the architect Alexander Ross. The source of the roof covering is not noted.[35]

Figure 6: Duart Castle, Isle of Mull, showing Caithness Flagstone roofing on the keep. © Sara Carruthers.

Figure 7: A wall display from Duart Castle, contrasting flagstone slates from 1911 (left) and 1990 (right). © Sara Carruthers.

Figure 8: A view of St Clement's Chapel, Rodel, Isle of Harris. © Sara Carruthers.

Figure 9: A detailed view of the flagstone slates on the roof of the north transept of St Clement's Chapel. © Sara Carruthers.

Welsh flagstone: Lower Devonian

In Herefordshire and South Wales, the sandstones of the St Maughan's Formation date from the Early Devonian Lower Old Red Sandstone, similar to the flagstone in Angus. These have been quarried at many sites, producing a variety of roofing materials ranging from a grey-green to a distinctive red. The stone was worked in small surface quarries close to the point of use, and roofs are found with single colours or mixtures. There were quarries all over the region. Some of the more well-known are around Llanveynoe, Abbey Dore and at Garnons and Dinmore Hills. Roofs in the region are always simple, gable to gable, with details such as valleys being comparatively rare.[36] Llandraw Quarry appears to be producing stone for roofing and was used for Crewe Municipal Buildings, which won an NFRC Heritage Award in 2012.[37] Llandraw is a relatively small surface quarry or delve where most of the splitting and finishing is carried out by hand by experienced stonemasons, often to order. A more general search for sandstone roofing slates under the owner, Black Mountain Quarries, only promotes Indian sandstone.[38]

English flagstone: Jurassic

In England, Jurassic limestone from the Collyweston and Stonesfield areas (Northamptonshire and Cotswolds respectively) needed to have been exposed to a freeze-thaw cycle to enable the stone to be split by hand into slabs. In Collyweston, early production centred on exposed outcrops where this had occurred naturally. Later production, which followed beds underground, required freeze-thaw to be incorporated into the manufacturing process. Larger pieces of quarried stone were kept wet and exposed to a week's worth of frost, usually December to January, before they could be split into roofing-sized units. This is believed to be a method of production unique to these areas. It was a time-consuming method with a low yield, and production ceased in the 1960s.

Investigation has established that the freeze-thaw process can be replicated artificially for commercial production of Collyweston slates.[39] As a result, Claude N Smith Ltd of Collyweston have a slate mine in production and now produce Collyweston slates for the United Kingdom and international markets, for restoration and new roofs.[40] It is estimated that the current market size for potential restoration is 1,500 buildings remaining in the east of England area. Cotswold flagstone slates are also in commercial production.[41]

Collyweston limestone slates are smaller and thinner than Angus flagstone slates. Angus roofing was known to be produced in open quarries rather than mined, and the freeze-thaw process may have facilitated splitting within the small-scale production from local quarries. Collyweston limestone was split from the underside of the lowest limestone beds. The limestone had been deposited on sand, making it most easily exposed from underneath instead of by removing overburden. In contrast, Angus flagstone was excavated from the surface and top of the beds, so would have been exposed to the freeze-thaw cycle naturally. No references have been found so far to the role of freeze-thaw action on historical manufacture of roofing from the Dundee Flagstone Formation.

On the Kintyre Peninsula in Argyll and Bute, a further example of Jurassic flagstone is found on the roof of Cour House, Sadell. The house was designed in the Arts and Crafts style by Oliver Hill in 1921.[42] The roofing material at Cour House is Purbeck stone, a limestone sourced from Dorset that derives from the Upper Jurassic to Lower Cretaceous.[43]

5. HISTORICAL REFERENCES TO ANGUS FLAGSTONE AS A ROOFING MATERIAL

In literature, there are few references to Angus flagstone being used as a roofing material. Most evidence is from buildings that still retain these roofs.

Flagstone slates found during archaeological excavations in Perth are likely to date from the medieval period. In 1978, the Urban Archaeology Unit excavated Kirk Close, which is in the centre of medieval Perth. This covered a site encompassing part of the back lands of two burgage plots, which would have had a High Street frontage. The work showed the two plots to be divided by a gravel path, and that both areas were used as middens or gardens, as well as being the sites of several timber structures. Finds from the site included quantities of medieval pottery and fragments of stone roofing flags. The flags were approximately 40cm long, up to 30cm wide and 2cm thick, with peg holes at the top.[44]

Flagstone slates have also been found in Coupar Angus, Perth and Kinross, in the levelled oversite under 19th-century floorboards. The house at 22 Queen Street sits within the former precinct of the Cistercian Abbey (1162–1606) and dates from before 1800, possibly considerably before. Houses within the former Abbey precinct are known to contain reused stone from the Abbey, with decorative elements still recognisable. A detailed study of whether housing could still incorporate built structure from the Abbey has not been undertaken. The house was refurbished in the second half of the 19th century, including a new and higher roof. The slates are likely to evidence the previous roof covering, which pre-dated 1800.[45]

In the 15th and 16th centuries, work at Falkland Palace in Fife transformed the old castle into a Renaissance palace. Records are scattered between exchequer rolls, treasurer's accounts and notes by the Master of Works. They show two different types of roofing material to have been in use. Flagstone slate, known as sklait or sclait, was mainly sourced from Tealing in Angus, and true (metamorphic) slate, known as skailyie or scailyie, was sourced from the Highland Boundary Fault, a geological fault line crossing Scotland from Stonehaven to Helensburgh. Slaters were at work with 'great sklait' from July 1628 through to May 1629, with just a winter break. Most slaters then returned to Culross or St Andrews with their work tools. In general, the sklaits came from the Dundee area, were shipped to Newburgh and then taken to the site by the country carters. Some records itemise the purchase price and transport costs, others just note transport, but the total costs are similar at around £30 per 1,000 sklaits. During that year, 25,500 great sklaits were purchased, most commonly by regular deliveries of one or two thousand. The slaters worked from the start of the project and some of their work was certainly on existing roofs, but there is no mention of trimming of old slates for reuse.[46] Angus flagstone roofing was used in Stirling in the 17th century and early 18th century as well as slates made from the local mudstone. These were specifically referred to as sclaits and being fixed with pins. In the 1630s and 1640s, Cowane's Hospital was being slated with metamorphic slates nailed to sarking. However, when the overseer for the building was in Perth on other business, he took the opportunity to purchase 3,000 sclaits, which were shipped to Stirling and stored on site. Later, two lots totalling 4,000 'sclaitts' were bought in Dundee, transported to Alloa and again delivered at the shore.[47] These entries are consistent with Bremner's description of Carmyllie flagstone

slates being used in local towns and exported by ship to other parts of Scotland. Other account entries from the 1660s refer to sclaits being procured from Kippenross near Dunblane for Cowane's Hospital and the school.

A quotation for a job from David Anderson in 1609 suggests that, as slater, he would win the slate and make the pins himself as part of the contract, as long as the client provided the timber and transported the slates. Royal Works in Stirling also reference importing flagstone roofing during the early 1600s, including 4,500 grey sclaits brought from Dundee in 1617. Nineteenth-century descriptions of removing some of these roofs refer to the use of 'oak pins' for fixing the slates, although whether battens or sarking were used is not mentioned. The roofing type appeared to be of note, suggesting it was rare even then. Accounts indicate that timber pins were considerably cheaper than iron nails and that when the flagstone was stripped from the roof of Cowane's Hospital in 1714, they were gathered for reuse elsewhere.[48]

A few doocots, tolbooths and mausolea, dating from before 1700, have flagstone roofs which may retain original fabric. Claypotts Castle in Dundee also has an early flagstone roof, although it is unclear when the roof was last relaid.

Figure 10: Claypotts Castle, Dundee.

A study of Scotland's farming improvements covers the period of the vernacular and agricultural buildings found during this audit.[49] The earliest dated cottages were from the second half of the 18th century. The east central area of the study covers Angus and Fife, although the authors did not specifically survey any farms in Angus.

In 1800, much of the land in the east central area was still to be enclosed and drained. The main tenures of farmers were as owner occupiers and as small estates. From the 1770s, the Improvers in Fife were motivated by setting a good example and raising standards in the county. Angus is not specifically mentioned as an area. The 1797 Statistical Account of Scotland describes the lands around Bendochy near Coupar Angus having changed over the previous 40 years (1757–1797), from a cluster of houses with rigs divided between them to enclosed farms.[50] The use of Angus flagstone may have spread as part of this movement amongst farmers and estates towards enclosure and improvement. The audit has found cottages, workshops, steadings and townhouses which, where dated, originate from the late 1700s to the mid 1800s. This would tie in with this period of improvement and agricultural change.

In 1813, the Rev Headrick, within his longer narrative on quarrying, gives a rare description of the use of Angus flagstone as a roofing material: 'As these flags, from their excessive weight, require greater strength of wood to support them than slates, and must be laid in plaster lime, or fog (sphagnum palustre), which must be frequently renewed, and after all seldom make a roof which is wind or watertight: it seems doubtful whether it might not be more advantageous to use slates for roofing houses. Slates have a much more agreeable appearance; but the people have been long accustomed to these flags, and by using them they save the duty on slates.'[51]

Several castle and church restoration projects have included the use of flagstone roofs. Those from the late 19th to early 20th centuries include Falkland Palace, Stenhouse Mansion, Acheson House and St Fillan's Church, Aberdour. Projects from the late 20th century onwards include Forter, Melgund and Inverquharity Castles.

Falkland Palace has records of construction, repair and restoration in the late 1800s. In 1822 Swinton, the builder, offered a choice with regard to work on the roof of the chapel and hall. One option was to bind the cross bars of wood, a method which the correspondent could not clearly explain in words. Swinton thought that this would 'keep the roof tight for many years to come' and not cost above £20 or £30. 'The other is if you wish the house to be kept water-tight', to give it a new roof of slates and new sarking, which would cost, he said, 'from £200 to £300'. It is not yet clear whether this work was undertaken.

By 1887, large parts of the palace were ruinous when John, 3rd Marquis of Bute, purchased the estates of Falkland. He started a 20-year programme of restoration, which appears to have provoked a familiar discussion on the merits and accuracy of 'restoration'. In September 1891, Robert Little FSA (Scot), in a letter to the *Glasgow Herald*, gave an acerbic critique of the changes at Falkland Palace. He bemoaned the change in appearance and detailing of the old flagstone roof, possibly not entirely warranted as the Marquis of Bute's restoration did include the use of Angus flagstone.

'All who knew Falkland Palace before the year 1889 must have observed the marvellous colouring on the roof of the wing built by King James V. The massive old slates, as the centuries rolled over them, had become clothed or encrusted with some such growth as

one sees on the rocks by the sea side – of a rich golden hue that vied with anything to be seen in nature on a sunny day in autumn. These slates have lately disappeared, and a neat modern roof now rises above the weather beaten walls and pinnacles of the great hall. It is quite possible that the weight of the old slates was beginning to tell on the structure below, but if so, might not some internal support have been devised instead of stripping the building of one of its greatest beauties? Another alteration or "restoration" is the insertion of dormer windows on both sides of the said roof. They are built of a cold pinkish stone, brought, I believe, from a great distance, and – whatever appearance they may present in a century or two – their colour is utterly out of harmony with the rich dark tone of the surrounding masonry. Though they are reported to be an exact copy from some old drawing or representation of the palace, it is impossible to look upon them as anything but an unwelcome and meaningless distraction.'[52]

Flagstone roofing was also used by Arts and Crafts architects in the early 1900s on large villas such as Greywalls in Dundee, North Lodge in Edzell and the White House in St Andrews. Although records of quarrying flagstone during this period have not yet been found, these properties may evidence it as an ongoing industry. Local use and bespoke orders may not have been recorded in the same way as the international pavement side of the industry. The architect Patrick Thoms, who designed Greywalls for himself in 1929, does appear to be from the same family who owned Tillywhandland Quarry fifty years earlier.

Frank Bennett and Alfred Pinion's 1935 textbook *Roof Slating and Tiling* contains a small section on stone roofing but does not reference Scotland.[53] The 1950s construction textbook *Mitchell's Building Construction* still includes a section on stone roofing, although Angus is not referred to as a source of stone. Collyweston, Naunton and Stonesfield are mentioned by name, all of which produce limestone slates, and the construction details differ from those observed in Tayside.[54] The last Angus quarry appears to have closed by this time, but the industry had been in sharp decline since the First World War.

In the second half of the 1900s there was a steady supply of second-hand flagstone roofing materials. These were available through slate merchants, sourced from the demolition or 'improvement' of unprotected buildings. This provided a sufficient supply to support the repair or re-roofing of A listed or Scheduled properties during a time when provenance appears to have been of less concern. Early photographs of both rural and urban settlements indicate that flagstone roofs were common in the late 1800s and early 1900s, in particular on vernacular dwellings which have now been re-roofed.

Since 2000, the comparative scarcity of unprotected flagstone-roofed buildings, the poor condition of the aging slates, and greater consideration for the provenance of materials used by conservation-accredited professionals has meant there is no longer a reasonable source of Angus flagstone for roofing repairs. Many existing roofs are in poor condition, and the difficulty of finding materials for appropriate repairs puts them at risk.

6. THE AUDIT: HOW MANY ANGUS FLAGSTONE ROOFS ARE LEFT?

As part of the current research, an audit has been carried out to gauge how many buildings still have a roof of Angus flagstone. The buildings listed within the audit were found through a variety of methods:

- An appeal to interested professionals, local residents and heritage amenity societies
- References found during the literature review
- Publicly available online sources, including Historic Environment Scotland's Designation Portal, Canmore, the Buildings at Risk Register for Scotland and historic archives and records
- Websites relating to specific buildings or estates
- Google Street View
- Travels around Angus by the author to check entries and look for additional buildings.

Figure 11: Street view of Angus flagstone roofs in Little Causeway, Forfar, viewed from the High Street. © Sara Carruthers.

Where possible, a recent photograph was found to confirm that the building still retained flagstone roofing. This was limited where privately owned properties are sited away from public roads and also due to time limitations of the research. It is therefore possible that some of the entries may have lost their flagstone roofs since the source record was made, and it is intended that the audit list will continue to be updated. No roofs were geologically tested, and newer roofs may have been replaced with stone from sources outside Angus. The fragile nature of many of these buildings and roofs mean that this is likely to be an increasingly common issue. It is also likely that some buildings have been missed during this research, and it is hoped that these will continue to be added as they come to light.

For each building, the audit aimed to capture a range of information, including:

- Geographical information – county, parish or burgh; postal address; grid reference
- Source of the record
- Any protected status including designation category, listed building identification number or equivalent, year of protection, and Canmore identification number
- Building information – original purpose, age, current use, condition of roof
- At least one photo, preferably recent
- Links to any supporting information or websites and a note of useful information such as whether the listed building description mentions the roof type, specific Canmore photo numbers, and ownership information.

Some of the buildings found during the audit are mentioned elsewhere in this report, but the generalised findings are summarised in Tables 3 to 8, below. Occasionally, one entry in the audit may refer to a group of buildings. Counts represent the database in September 2025.

Table 3: Geographical spread of audit entries across Angus and other local authority areas.

Geographical location	Number of entries
Angus	186
Dundee	5
Fife	17
Perth and Kinross	7
Other	13
Other buildings identified as previously having a flagstone roof in listed building descriptions or on the Buildings at Risk Register, but roof now changed	10

Table 4: Types of building included in the audit.

Type of building (as built)	Number of entries
Castle/mansion	23
Large house/hotel	11
Church	7
Vernacular house/cottage/tenement/small commercial	95
Industrial property, including mills, granaries and workshops	12
Farm steading	25
Other outbuildings including doocots, hearse houses, stables, etc	55

Table 5: Current use of properties included in the audit.

Current use	In use	Unused
Residential	98	14
Commercial/public	31	14
Farm steading (Note: It is not always clear whether these are still in use)	7	7
Outbuilding (Note: It is not always clear whether these are still in use)	41	16

Table 6: Ownership and care of audit entries.

Owner or care provider	Number of entries
Properties in the care of HES or National Trust for Scotland	17
Understood to be owned by Strathmore Estates Holdings, Glamis Estate or another organisation connected with the estate	26+

Table 7: Protection status of audit entries.

Protection	Number of entries
Scheduled Monuments	12
Category A listed buildings	32
Category B listed buildings	68
Category C listed buildings	53
Unlisted, but within a Conservation Area	7
Protected buildings in Angus, but the flagstone roof is not mentioned in the listing description or Statement of Significance	58
Unprotected	56

Table 8: Condition of properties listed in the audit.

Condition	Number of entries
Fair or better	137
Poor or worse	53
Unknown (no clear view)	38
Listed on Buildings at Risk Register for Scotland	10

7. CHARACTERISTICS OF ANGUS FLAGSTONE ROOFS

In the area studied, buildings that still retain flagstone roofs are now rare. The audit has identified only around 230 in the local authority areas of Angus, Dundee, Perth and Kinross, and Fife. This section of the report is a summary of the main characteristics observed during the course of this research. Many buildings have been re-roofed during the last century, and evidence of the earliest vernacular traditions is therefore uncommon. In Angus, where the majority of flagstone roofing has been found, the most common roof coverings on pre-1919 buildings are now true (metamorphic) slate or concrete tiles.

Flagstone roofs can be identified from a distance by their organic appearance, shadowing from the horizontal coursing, and large, pale lichens. Viewed at closer proximity, the flagstones vary in thickness, texture and colour from roof to roof. The social status of the buildings with flagstone is wide ranging, but historical use on buildings of lower social status is likely to have been much higher than now observed. Their disappearance is often due to the flagstone being used as a source of second-hand roofing material for other restoration projects, a practice common from the 1950s onwards.

Figure 12: A flagstone roof example – 66 Auchmithie, near Arbroath, Angus. © Sara Carruthers.

Figure 13: A flagstone roof example – The Hearse House at Kirkton of Airlie, Angus. © Sara Carruthers.

Interior access was only possible for a few of the buildings observed during the audit. On older roofs, the fixing method observed is for the flagstone to be hung on battens using wooden pegs. More prestigious buildings, where observed, have flagstone nailed onto sarking. These examples are reported as being re-roofed in the 1930s or are 19th-century restorations, and the sarking may have been introduced then. Examples are Stenhouse Mansion, Acheson House, St Athernase and Falkland Palace. It is noted in Case Study 2, Davidson Cottage, that where old flagstone slates are reused, the use of sarking boards makes it possible to maintain equal tail lengths on each course, despite a more limited range of slate sizes. This maximises reuse of available material.

Claypotts Castle in Dundee, known for its very early roof structure, and the Abbott's House at Arbroath Abbey are both still pegged, as are many of the ruinous buildings observed where the substructure is exposed.

Before 1800, it was difficult to produce sawn boards and there was a shortage of construction timber in Scotland. Fixing of roof coverings with pegs on battens was an available and likely option for any roof requiring greater longevity and social status than thatch. The use of battens would also have been a familiar method due to their use in thatching.

Where flagstone roofs are believed to be early and unaltered examples, these all appear to be pegged onto battens. It would be expected that early battens would be split rather than sawn.

Figure 14: The interior roof structure of Claypotts Castle, Dundee.

Figure 15: Batten and peg method of laying flagstone, Claypotts Castle, Dundee.

Sawn hardwood sarking was available during this period but would have been difficult to produce and very expensive. It was reserved for the most prestigious buildings. As Emerton notes, boards produced with that much effort would probably have been used for leaded roofs. Sawn softwood sarking boards were introduced in the latter half of the 18th century and enabled the more economic use of smaller blue slates to spread.[55] Where examples of flagstone roofs on sarking boards were found during the audit, they appear to date from one of two periods. Some are late 19th-century restorations of older buildings and others are late 20th-century repairs using second-hand flagstone, with limited availability of sizes.

Figure 16: Batten and peg method of laying flagstone on an outbuilding at Templeton Farm, Angus. © Sara Carruthers.

Figure 17: A-couples at Tealing Doocot, Angus. © Sara Carruthers.

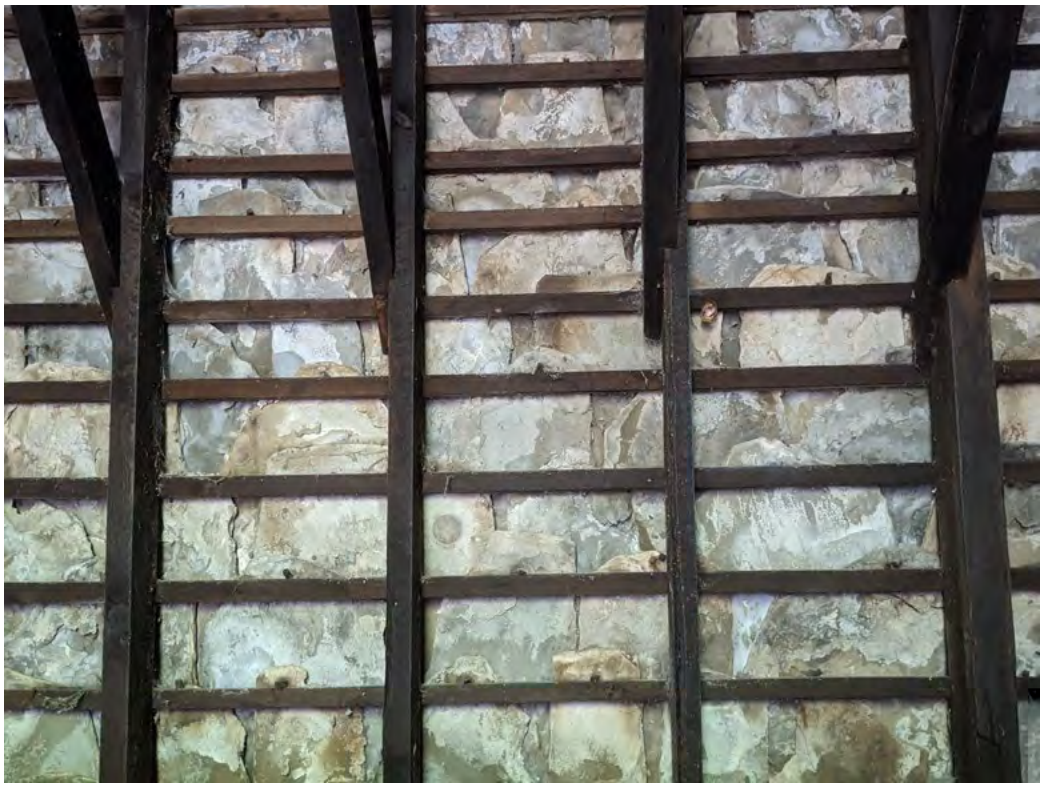

Figure 18: Interior showing the batten and peg method of laying flagstone at Tealing Doocot, Angus. © Sara Carruthers.

Figure 19: Vertical close-boarding at a shelter between Fettercairn and Edzell, Aberdeenshire. © Sara Carruthers.

The peg holes in flagstone slates were made by hand from both sides. This gave them an hourglass shape that would grip the peg. Symmetrical mechanical drilling of these holes is likely not to be appropriate for use with pegs. There is historical reference to pegs being made of oak, but none have been examined for species in the field. Ian Cumming, who has repaired many Angus flagstone roofs, has used both oak and fir for new pegs. He raised concerns about the forces that could potentially be exerted by oak pegs, which would expand when wet and would therefore need to be inserted loosely. Investigation into the species of wood used for historic pegs and the shape of both pegs and holes would be valuable. The use of animal bones as pegs has been noted but would be an exceptionally rare survivor.[56]

A number of the pegged roofs in Angus which appear not to have been relaid in the 20th century, and where the underside is visible, show lime mortar bedding. This mortar is laid between the head of the slates and the course above. Modern slaters and builders who have laid flagstone roofs have used lime mortar to give a good lie and prevent wind vibration. They note that the roofs need to 'settle' for a few months after laying. Full lime mortar torching of the underside of slates (see Glossary) is a technique which infills the gap between the battens with mortar. It is a detail recorded in textbooks for stone roofs elsewhere in the United Kingdom, but it has not been observed in Angus. The underside has been observed in only a small number of the roofs included in the audit, however, and so the technique may exist in the area.

Figure 20: Batten and peg method of laying flagstone on a shelter at Arbroath Signal Station. Lime mortar bedding is still visible. © Graham Briggs.

Figure 21: Historic pegs, packers and lime mortar bedding at Pittenweem Tolbooth, Fife. © Arc Architects.

Figure 22: Roof repairs in progress at Pitmuies Estate, Angus, showing lime mortar bedding, pegged slates and battens. © Ian Cumming.

Before laying, the flagstone slates are sorted by length and thickness, allowing an even course size to be maintained. They are then usually laid in courses of random widths, and reducing in size towards the ridge. If they are laid on battens, they are double-lapped and usually head-fixed, but nowadays they are frequently double-nailed on sarking if they have been reused.

Figure 23: South Balluderon Mill and Steading, Tealing, with the formation of battens and slates visible. © Sara Carruthers.

Many of the oldest roofs are reaching the end of their lives and further work is needed to record information such as their slate sizes, laps and patterns of using backers (or bachelors). Flagstone roofs tend to be isolated and scattered throughout a region, but there are a few places where groups of these roofs can be seen together. Glamis village, Pitmuies Estate and around Little Causeway, Forfar are all examples of grouped occurrence.

Most ridges are made of stone, and reference is made to a ridge-cutting machine operating in local quarries, as previously mentioned in Section 4. Valleys are not particularly common on flagstone roofs, but when found, they are formed with lead or zinc. Swept valleys formed from the flagstone itself have not typically been observed in the area. Edzell Castle was restored in the 1990s with a swept flagstone slate valley, but this is not thought to be an original detail.[57] Hips are either formed with lead or zinc flashings, or with the flagstone cut to a mitre without lead flashing. At gables, flagstone is detailed both running straight over the wallhead to the verge with no overhang, and butting up to skews with a mortar fillet. One instance of the use of stone to weatherproof an abutment has been noted.

There is a concentration of flagstone roofs in Glamis village, Angus, particularly on rear elevations and back rigs. No. 2 Main Street (Figure 24) and a building next to Lera Mill (Figure 25) both show typical detailing. Concrete tiles are common on traditional buildings in Angus (Figure 24, centre) and could be indicative of roofs previously covered with flagstone.

Figure 24: 2 Main Street, Glamis village, Angus. © Sara Carruthers.

Figure 25: A building next to Lera Mill, Glamis, Angus. © Sara Carruthers.

Figure 26: An example of mitred hips at Gig House, a workshop in Glamis. © Sara Carruthers.

Figure 27: An Arts and Crafts pavilion with mitred hips, North Lodge, Edzell, Angus. © Sara Carruthers.

Figure 28: A roof detailed with skews and a stone ridge. Priory House, Restenneth near Forfar, Angus. © Sara Carruthers.

Figure 29: A more complicated roofscape to the rear of The Square, Glamis, Angus. © Sara Carruthers.

Rainwater disposal is via cast iron rhones and downpipes or by roofs being designed to drip at the eaves, occasionally with an overstop above doorways, as shown in Figure 32.

Figure 30: Detail of lapping and verge in Back Dykes, Glamis, Angus. © Sara Carruthers.

Figure 31: Stone flashings in St James Road, Forfar. © Sara Carruthers.

Figure 32: Eaves with an overstop in Kirkwynd, Glamis. © Sara Carruthers.

Rooflights have been observed in flagstone roofing but are not common. There are records of small deadlights (non-opening skylights) being inserted into a recessed hole in the centre of a large flagstone slate, but no existing examples were noted during the audit.[58]

Figure 33: Rooflights in Kirkwynd , Glamis. © Sara Carruthers.

Figure 34: Rooflights in Little Causeway, Forfar. © Sara Carruthers.

Many flagstone roofs have now acquired cement mortar pointing around the tails of the slates, on the top side of the roofs. On occasion, the entire roof has been pointed in this way. Some of these roofs have been patch repaired in a similar manner, using lime mortar. This is a method of fixing a broken lower half of a slate where it is difficult to obtain or insert a replacement. It may also be intended to prevent draughts or to consolidate a failing roof, particularly when the underside is no longer accessible.

This is not a traditional detail and will adversely impact the performance and life expectancy of the roof. It will prevent water from draining between the double-lapped slates, as it was designed to do, and cause accelerated deterioration of the stone itself. Deterioration will be caused both by saturation and the use of a cement mortar with natural stone. Many flagstone roofs are observed to have a heavy moss covering, which indicates high water content.

Figure 35: An example of surface pointing of flagstone slates. While this can secure a broken slate, pointing under the tail will trap water within the roof and stone, promoting moss growth and frost damage. © Sara Carruthers.

In the south of Fife, some examples of roofs have been noted where Angus flagstone has been used in association with pantiles to form the lowest courses at the eaves. Emerton in his *Pattern of Scottish Roofing* considers these slates to be the remains of the previous roof, the flagstone predating the arrival of pantiles. Flagstone will have successfully bedded to the masonry wallhead, which likely influenced leaving this part of the flagstone roof intact.[59] A similar arrangement was seen at Culross Palace in 1896, and the asymmetry does indicate the remains of a previous roof.

Figure 36: Culross Palace in 1896, with Angus flagstone evident on the lower courses.

It is likely that the mansions, occupied houses and properties in care listed in the audit have all been re-roofed since 1900, and in many cases, this is documented as being so. As the last quarry closed in the 1950s, it is probable that any roof re-covered since then will have used second-hand flagstone. It has been noted in the case studies that follow that the limitations on slate sizes available in the second-hand market has resulted in the non-traditional use of nails on sarking. The traditional method of flagstone being hung on battens is therefore steadily disappearing. It has been reported by all owners that sourcing second-hand flagstone roofing still fit for reuse has become extremely difficult. Owing to the small number of buildings left, ethical considerations of provenance should mean reputable professionals and building owners would not use any flagstone sourced from an existing building. The case studies have also indicated that due to their poor condition, the proportion of slates that are suitable for reuse from an existing roof is now very low.

New flagstone slates are now available by special order from Denfind Stone's Pitairlie Quarry. To date, they have not been used on a project where they are pegged onto battens. Some refinements of the mechanical production process, where sawn slabs are dressed around the edges to replicate hand production, or even the reintroduction of hand splitting, may be required to produce accurate reproductions for conservation, at least for the most historically significant buildings.

The audit has recorded many ancillary buildings in poor condition, and unused buildings which may be the last survivors of the historic pre-industrial tradition of flagstone roofing. Many of these are reaching or have reached the end of their functional lives and are unprotected. A more detailed study of the detailing and techniques used in their construction is therefore urgent if this information is not to be lost.

8. CASE STUDY 1: COTTAGES AT ROUNDYHILL NEAR KIRRIEMUIR, ANGUS

These C listed buildings are rare examples of 18th-century cottages which have retained their Angus flagstone roofs. There are seven other similar-scale buildings in the vicinity of Roundyhill and Drumshade which still retain these roofs, although most of the similar cottages in the area now have roofing of metamorphic slate or concrete tile.

Figure 37: Sintra Cottage (left) and Cameskie Cottage (right, north), Roundyhill. © Sara Carruthers.

Figure 38: Sintra Cottage (left) and Cameskie Cottage (right, north), Roundyhill in 1975.

The cottage owner, Mr Charlie Scrimgeour, provided information in October 2023.

‘We moved here in 1970 but only had the north half of the north cottage, which had previously been a weekend cottage. The front roof of that bit had been recently re-done. After we built a lean-to bathroom at the back, we got the back roof re-done, by Kenny Hanton in Glamis. His yard and stock of slates is long gone. Since then, I have done running repairs for small drips etc, but nothing major has been required. In 2010 I had the roof timbers treated, the roof having been deemed in OK condition. The north roof has 180 × 75mm sawn timbers and 3m ceilings. The south cottage roof timbers are larch logs only part shaped. The original ceiling was at wall top height, which I raised in the 80s. Hopefully it all holds together as long as we do.’

9. CASE STUDY 2: THE DAVIDSON COTTAGE IN ABERLEMNO, ANGUS

This unlisted cottage dates from the 1720s and by 2006 demolition was proposed. It was acquired by the owner in 2008, owing to its historical connection with the Davidson family, who lived in the cottage in the early 19th century. After emigrating to the United States in 1858, the Davidson family went on to establish the Harley-Davidson® Motorcycle Company.

Between 2008 and 2012, the owner restored the cottage to reflect how it would have looked in the mid-19th century and built an adjacent building with modern amenities which provided holiday accommodation for a time. The Davidson Cottage is frequently visited by Harley-Davidson® enthusiasts and is now in the care of a charity.[60]

Figure 39: The Davidson Cottage before restoration. © Davidson Legacy.

Owner Mike Sinclair shared his experiences of restoring the cottage roof. The cottage mainly consisted of field stone and clay mortar walls (also known as boule and clay) with an Angus flagstone roof. It was unimproved and without services when the last occupant left in 2002. The ruinous roof likely dated from the 1840s, when the eaves height was raised to incorporate an upper floor. It consisted of pegged flagstone slates of random widths and reducing courses, hung on battens on A-frame couples of half-round cabers forming the rafters. The yellow earthenware ridge tiles were potentially a later replacement and contemporary with the early 20th-century brick chimneys. The roof was removed prior to restoration.

‘Sourcing Carmyllie stone slates for the roof proved difficult and I spent a week of evenings knocking on doors asking to buy slates from collapsed steadings. Not one person wished to part with the slates … so I agreed to replace a whole roof with profile sheeting in order to get enough slates to finish the cottage roof.’ —Mike Sinclair

Mike’s observations of the sources of flagstone slates were that wastage of even the selected slates can be as much as 30%, as they split and crack. Dressing the good slates results in further losses, to the extent that a roof of some 1,500 slates can yield about 400 when fixed onto the new roof. He managed to salvage only 10% of the existing Davidson Cottage roof. The flagstone was bedded on lime mortar and pegged. They all had a chamfered drip at the bottom edge. He notes that it is difficult to repair a pegged stone roof as the flagstone will not shed in the same way as a roof covered with single-nailed true slate. Stacking flagstone vertically encourages it to delaminate, so it is better stacked as it would lie on a roof.

A roofer with previous experience of roofing with flagstone, gained while working with Ardle Construction Ltd under Ian Cumming, carried out the re-roofing work on The Davidson Cottage. The couples were replaced to a similar design but using C24 timber, sarked, covered in a breathable roofing fabric and the flagstone drilled and fixed onto the sarking with 3-inch clout nails. Second-hand Carmyllie flagstone ridges were sourced from Invercauld.

When new, flagstone slates were sorted into matching lengths and thicknesses to allow an even course to be hung on each batten. Owing to the limited source and range of sizes available of second-hand material, nailing onto sarking maximised the number that could be reused. Variations in length can be taken up at the head, so an even tail is left exposed. Each slate was bedded on a weak lime mortar to give stability, and the finished roof ‘settled’ satisfactorily over a few months.

Figure 40: The Davidson Cottage in 2012 after restoration. © Davidson Legacy.

10. CASE STUDY 3: ACHESON HOUSE, EDINBURGH

Acheson House is an early 17th-century building located on Bakehouse Close, off the Canongate in Edinburgh.[61] Owned by the City of Edinburgh Council, which was the client for these works, it is now occupied by Edinburgh World Heritage, a charitable trust. It last underwent extensive restoration in the 1930s, when the entire roof structure and sarking were fully renewed, although it is thought that the roof covering was retained. The 1930s restoration also introduced lead flashings and rhones, neither of which are likely to have been original features.

In 2009, Simpson & Brown Architects were engaged to coordinate roof repairs. The Angus flagstone roof covering had deteriorated to such an extent that the level of reuse possible was quite minimal. Simpson & Brown, along with the Scottish Stone Liaison Group, identified Pitairlie Quarry in Angus as a source of stone to make up the shortfall. They worked with Denfind Stone, the quarry owner, to produce suitable roofing material. The roof of Acheson House now comprises mostly new stone.

Figure 41a and b: Acheson House during re-roofing. © British Geological Survey.

The variable sized flagstone slates were laid in diminishing courses, double-lapped and head-nailed with copper nails. These were laid on breathable membrane and on tongued and grooved horizontal sarking. Larger slates were double-nailed and abutments had lime mortar fillets. In general, the publicly visible slopes were laid with flagstone and the other slopes with Westmorland slate. The existing mixture of stone and concrete ridge pieces were re-bedded with Code 4 lead soakers under the joints.[62] The main contractor for this work was Scotia Roofing.[63]

The re-roofing of Acheson House with Angus flagstone represents a considerable enhancement of the fabric of the building. It was achieved within the original budget but with the addition of a grant of £40,000 from Edinburgh World Heritage.

Figure 42a and b: Acheson House roof after new stone was laid. © Denfind Stone Ltd.

This was the first roof in Scotland to use locally sourced new Angus flagstone slates in over 60 years. All participants in the project agreed that there were many learning points from the project, from the quarry production of the units through to the specification.

Figure 43: Acheson House with the completed roof in 2010. © Simpson & Brown.

11. CASE STUDY 4: ST ATHERNASE, LEUCHARS, FIFE

St Athernase is an in-use A listed church.[64] The chancel, which dates from the 12th century, has a flagstone roof. As part of a more comprehensive repair programme, this roof was repaired in 2018 under the guidance of Bob Heath, Conservation Architect.

The chancel roof was in poor condition, with missing and slipping flagstone and substantial moss growth. The existing flagstone slates were random widths, laid in diminishing courses and with a pitch of approximately 50 degrees. The roof had a stone ridge, and slates butted up to skews or gables, variously with a mortar fillet, cover flashing or (potentially) a secret gutter. These elements looked as if they post-dated the flagstone slates.

Figure 44: The south roof of the chancel at St Athernase, before repair. © Douglas Binnie.

A planning condition from Fife Council stated:

'Existing stone slates to be stripped and reused as far as is practicable. Prior to substantive works commencing (although allowing for investigative works), the developer shall provide the specification, samples and method statement for the chancel roof works to be agreed in writing with the Council as Planning Authority and Bob Heath or other suitably qualified Conservation Architect. The statement, specification and samples shall confirm, where it is practicable, that imported stone slates should match the existing with details of laying method and an increased eaves overhang, which will be determined by the construction of the masonry wallhead. The statement shall also provide details of works to the concrete ridge sections fixed with cement which may be replaced in matching natural stone, bedded and pointed in matching lime mortar and

pointing. Imported stone slates should be used on the north facing chancel roof with reused stone slates being fixed to the south facing chancel roof. Thereafter works shall take place in full accordance with the agreed details unless otherwise agreed in writing with the Council as Planning Authority.'

The project sourced new flagstone from Pitairlie Quarry, which is operated by Denfind Stone Ltd. Pitairlie Quarry is a historic quarry which has been reopened and is continuing production from the same beds as were used in the 19th century, although the stone does vary between beds and between quarries. There is not a note of which quarry the slabs on St Athernase came from historically or when the roof was last laid, although it is noted that the two faces differ in style and appearance and possibly in source of stone.

At Pitairlie, the 'top grade' or densest stone is considered suitable for flagstone roofing and is produced by mechanical splitting from the ground, rather than blasting within the quarry. The slabs are reduced in size using plug and feather wedges, then reduced further to the required production sizes through a combination of guillotining and sawing. This is done as soon as possible after quarrying.

The flagstone is hand finished by flaming the top surface. This removes the top 2mm of stone and provides a more variable appearance and texture, imitating a riven effect. This process has now been mechanised. The cut edges are buffed with a grinder and axed with a slater's hammer to recreate the chamfers on a traditional flagstone slate. They are then pre-drilled with two 5mm diameter holes in each top corner, each 50mm in from the head and sides.

The quarry could provide 20mm-thick slabs, although they cannot provide them to the full size of the largest historic flagstone slates because of the stone available at the quarry. For St Athernase, a total of 1,250 flagstone slates were supplied in one length (600mm) and three widths (175mm, 250mm and 350mm).

Figure 45a, b and c: Flagstone being hand finished at Pitairlie Quarry by Denfind Stone, and as delivered. © Douglas Binnie.

It was initially agreed that the new flagstone would be used to cover the rear face of the roof and the existing ones reused on the front face. Once stripped, only about 10% of the existing slates were reusable, and so the roof was entirely re-slated with new. The original flagstone was reused on the small porch roof and on internal cill repairs, with the remainder kept on site as spares. As the roof was stripped, the existing flagstone slates were discovered to be highly variable and in very poor condition. It is likely that they were second-hand already. They were variously single- or double-nailed, shouldered or with a squarer head and laid on bituminous felt on sarking, fixed with slater's nails.

The roof structure appeared to pre-date the slating. Evidence for an earlier scheme of battens, and thus peg fixing, of flagstone was not investigated during the project, although roof timbers removed during the repairs have been retained for potential carbon dating. The roof had not previously had rhones and the flagstone was laid with a slightly increased overhang at the eaves to protect the timber structure and masonry below. The roof was stripped symmetrically to avoid load imbalance.

The main contractors were Laing Traditional Masonry and G Brown Stonemasons. Denfind Stone were nominated as supplier as the only current producer of Angus flagstone roofing material, and they made the flagstone slates to order for the project. Quarry prices were quoted per square metre 'on the floor' like paving slabs, rather than 'on the roof' as typical for slates. This allowed for lap and wastage, with an 80m^2 roof requiring 220m^2 of slabs.

Figure 46: Samples of new Pitairlie flagstone slates. © Douglas Binnie.

Figure 47: Part of St Athernase north roof, prior to repair. © Douglas Binnie.

Figure 48a and b: Two images showing a selection of the pre-existing flagstone slates. © Douglas Binnie.

On site, the existing sarking was repaired, a breathable membrane laid and lead secret gutters created to replace the cement fillets. The flagstone was fixed with two stainless steel 40mm annular ring shank nails per slate. This was supplemented by an occasional bed of hydraulic lime mortar behind the nail holes, providing an additional fixing assurance while allowing them to bed flat. This contrasts with the traditional practice of lime beds on top of the slate head.

The ridge was replaced with new Cullalo stone from Aberdour in Fife. The flagstone was laid in diminishing courses and laid on each pitch in thirds to evenly load the roof. It was observed that joints in the roof structure opened up after stripping the roof and retightened once re-slated. The project was completed in 2018.

Figure 49a and b: The completed roof of St Athernase. © Douglas Binnie.

Figure 50: The completed repairs at St Athernase, showing the flagstone roof on the chancel. © Denfind Stone Ltd.

12. CASE STUDY 5: ARBROATH ABBEY, FALKLAND PALACE AND MONIMAIL MORTHOUSE

This case study gives an overview of the issues facing three Angus flagstone roofs which all require urgent repairs:

- the Abbot's House at Arbroath Abbey, a Scheduled Monument in the care of Historic Environment Scotland
- the South Range of Falkland Palace, a Category A listed building in the care of the National Trust for Scotland
- Monimail Morthouse, a B listed building within a Garden and Designed Landscape in the care of Fife Council.

12.1 The Abbot's House at Arbroath Abbey, Angus

The Abbot's House dates from around 1500 and has been in the care of the state since 1924. It has a flagstone roof. The south face, which is exposed to the sea, is in the poorest condition. Flagstone slates are starting to break and have been falling from the roof, which is both a safety hazard and is reducing the integrity of the building. Scaffolding was in place during 2024 to carry out masonry repairs and enabled a close inspection of the roof.

Figure 51a and b: The roof of the Abbot's House showing the north elevation (a) and south elevation, facing the sea (b). The south elevation is in poorer condition, with broken and delaminating flagstone. © Sara Carruthers.

The south elevation of the roof has been repeatedly patched with second-hand slates of a limited size range, resulting in uneven, ‘gappy’ beds and open perpends. No lime mortar was observed between courses to bed the slates. Cumulatively, these factors may have led to increased wind vibration and broken slates. The north elevation is more sheltered and appears to have required less previous intervention. The flagstone here is in better condition, although still showing some breakage.

Figure 52: Close-up of a broken slate on the south elevation of the Abbot’s House. © Sara Carruthers.

Where slates are missing, it can be seen that the current roof covering consists of flagstone, fixed with a mixture of pegs and nails, on battens, on horsehair felt, on sarking. The horsehair felt indicates a likely date for the roofing of the second half of the 19th century onwards. The largest accessible slates were approximately 600mm wide × 800mm long, and most slates were around 20–25mm thick.

12.2 Falkland Palace, Fife

The South Range of Falkland Palace dates from the 16th century, but the form of the current roof dates from the 1890s – although it contains earlier fabric. The South Range has a flagstone roof, which records show was altered and re-covered in the 1890s. This restoration during the 1890s is considered the reference point for maintaining the fabric by the National Trust for Scotland (NTS). The NTS has carried out various roof repairs since it took over care of the Palace in 1952 and the extent of these is still under investigation. Maintaining the integrity of this roof is critical as the chapel, including a painted ceiling and panelling, is immediately below.

Establishing the extent and method of replacement required is a key issue for NTS. The south elevation is easily accessible from the parapet wall walk, but the north elevation would need scaffolding, and this would inform repair decisions.

Figure 53: The flagstone-roofed south elevation of the South Range, Falkland Palace. © Sara Carruthers.

Figure 54: Replacement slates held in place with tingles, Falkland Palace. © Sara Carruthers.

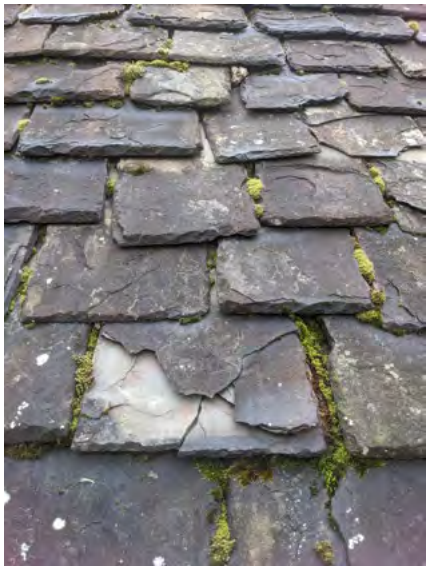

Figure 55: Examples of delamination and slippage from failed fixings, Falkland Palace. © Sara Carruthers.

The current roof appears to consist of flagstone slates, nailed onto battens and possibly counter-battens, on bituminous felt on older sarking. The largest accessible slates measured were in the region of 500mm wide × 800mm long; the margin on the eaves course was 300mm and the accessible courses above that 250mm.

12.3 Monimail Morthouse, Fife

The morthouse is formed from the north aisle of the church. It was built after 1690 and repaired in 1831, and it houses various burial niches. It is in very poor condition and is at risk of collapse. Fife Council instigated a repair scheme to be carried out in 2024.[65]

Figure 56: Monimail Morthouse. © Sara Carruthers.

The roof on the morthouse is made up of flagstone slates, pegged, with some nailed or nailed through pegs. They are on split battens, on worked rafters, supporting a timber barrel vault. Roofs of this age are now rare survivors and, although patched, retain evidence of historic roofing practice. This building is a rare combination of being in the care of a public body with a commitment to conservation best practice and having a relatively untouched historic fabric. The potential for retaining historic elements of the roof is limited owing to its condition, but detailed recording while dismantling and retention of the maximum of historic fabric in the repaired structure would be very valuable.

A conservation-accredited professional advisor has been commissioned to specify and oversee the works. They noted the constraints of a very tight budget combined with the expected imminent collapse of the roof.

Figure 57: The roof structure of Monimail Morthouse, showing worked rafters and battens. © Sara Carruthers.

Figure 58: A flagstone slate from the roof, showing the remains of a peg in the single head hole and traces of mortar bedding. © Sara Carruthers.

12.4 Common issues

Common challenges were noted by those overseeing each of the three projects:

- Finding a suitably knowledgeable roofing contractor, with craftspeople appropriately experienced in these roofs to carry out the work.
- Obtaining suitable flagstone to meet the conservation requirements of the project.

12.5 Main points arising

The incidence of historic, vernacular flagstone roofs is now rare. Many properties have had interventions during the 20th century, with varying levels of appropriateness. Historically significant buildings and their contents are at risk because their flagstone slates are reaching the end of their lives.

As there is currently no best-practice guidance for Angus flagstone roofing, professionals involved with individual projects have been trying to develop their own solutions. Through this research and the implementation of actions arising from it, Historic Environment Scotland is beginning to address the issue.

The availability of Angus flagstone slates (either new or second-hand) which are appropriately sized and worked, and which provide a suitable geological and stylistic match for these projects, is limited. As a result of site visits, Denfind Stone will collaborate with the three owners involved in Case Study 5 to produce new slates appropriate for the conservation market in terms of size, style and hand working.

13. CURRENT RISKS

Once common as a building material in Angus and its hinterland, flagstone roofs are rapidly disappearing from the rural and urban landscape and are at high risk of loss.

- During the audit, only around 230 buildings were identified which retain Angus flagstone roofs. About 27% of these are clearly disused and at least 23% are in poor repair. Around 25% have no statutory protection.
- The flagstone slates are reaching the end of their functional life.
- New and second-hand replacements are difficult and expensive to source. Second-hand replacements have so far come from one of the limited number of remaining flagstone roofs.
- Property values in Angus are relatively low compared with the cost of repairing or replacing this type of roof, resulting in a conservation deficit.
- The specific local details associated with Angus flagstone roofs are at risk of loss from the built environment and have not been recorded to date.
- The specific local craft skills related to Angus flagstone roofing and its use are at risk of loss from the working population and have not been recorded to date.
- There are few professionals and contractors with previous experience in specifying or working with the material, and no documented information to which they may refer.

The most recent date when flagstone roofing was in regular production was in the 1950s, when the last quarry closed. Since then, repairs have relied on the second-hand market as a source of material. The second-hand market is no longer a viable source, owing to both the scarcity of source buildings (and thus considerations of provenance) and the poor condition of the flagstone once removed from a building. New Angus flagstone roofing production is now possible from Pitairlie Quarry but is not widely known about by owners or the construction industry. Ensuring that the flagstone slates produced are compatible with a historic roof, both in style and geology, is a process that is still in development. The cost of production and installation is prohibitive for use on many buildings, other than those that have the highest levels of statutory protection, are in the care of government or charity bodies, or can attract grant assistance.

It is not uncommon that even where there is statutory protection, the existence of flagstone as a roof covering is not explicitly mentioned in the listing description. A number of listings have been found to say ‘slate’ or be silent. Although the listing description is only a guide and not statutory, its omission indicates that the historic significance of the material has not previously been fully appreciated.

In the words of Gerald Emerton, ‘Perhaps it is the fate of roofing to be ignored by many, who stop at the guttering when looking at a building or dealt with as secondary to some other theme.’[66]

Planning policy in Angus, where the majority of Angus flagstone roofs remain, does not include specific mention of Angus flagstone roofing in its local policy documents. Policy relies on the HES guidance note *Managing Change in the Historic Environment: Roofs*.

The Managing Change guidance on roofs highlights that the roof and the materials of which it is made contribute to a building's significance and historic character. As a result, changes will require listed building consent and planning permission may be required in a conservation area. Best practice is to reuse existing materials or closely match with new ones.[67] This is difficult to achieve as, at the point a roof needs significant repairs, most Angus flagstone slates will have reached the end of their life. Case studies indicate only 10–15% of slates may now be reusable, which is rarely enough for a single roof pitch.

The risk to buildings with Angus flagstone roofs is high. These roofs are often found on buildings where the property value is relatively low and the cost of repair or replacement on a like-for-like basis could be prohibitive. Planning applications need to be dealt with in a sympathetic manner, balancing the desirability of seeing a building reused and/or maintained, and viability considerations against the built heritage value and significance of the roof in question. Use of appropriate second-hand slate to replace flagstone slates is often accepted, but second-hand Angus flagstone slates are difficult to obtain.

Availability of grant assistance would help defray the additional cost of retaining a flagstone roof for remaining buildings, including unlisted and privately owned buildings. This would support a more robust approach to implementing planning policy. To be effective, the grant would need to bridge the conservation deficit, calculated against the comparative cost of imported slate. Under *National Planning Framework 4*, the local availability and reduced embodied carbon of Angus stone is now a planning matter.[68] In practice, this would be viewed as a positive reason to approve a proposed Angus flagstone roof.

If councils take an approach to planning applications or listed building consent that is too difficult or too expensive to fulfil, there would be a high likelihood of successful planning appeals. This would be the case with requiring an Angus flagstone roof to be replaced on a like-for-like basis, taking account of the limited availability of materials, cost of the work, and low property values in areas such as Angus. Councils would likely react positively to the idea of supporting a local industry in this way, but there are difficulties caused by that industry currently consisting of only one commercial entity.[69]

The early peg-and-batten construction of the traditional roofs is even rarer now than the use of flagstone, as restorations of the late 19th century onwards appear to most frequently use sarking. Detailed study of the remaining peg-and-batten and other roofs is needed, both of the roofs in situ and of any roofs which are being taken apart for repair or otherwise. Accurate construction details should be recorded alongside any documentary or other evidence of a roof's last date of re-roofing, in order that this knowledge is not lost.

Most roofs are repaired by roofers with no specific training in the use of flagstone. As the roofs become rarer, there is limited detailed knowledge available – either their own previous experience of the material or learning opportunities available from other practitioners. No best practice guidance on Angus flagstone roofing currently exists. A study of the best practice of laying and repairing Angus flagstone, with guidance for

roofers, would ensure the remaining flagstone roofs are appropriately repaired. Slating is taught at Dundee & Angus College's Arbroath Campus, and this would be an appropriate local vehicle to develop and disseminate the information to future generations of Angus-based roofers.

Angus flagstone roofing does not appear in any current literature on improving the environmental performance of buildings, and inclusion of this in a best practice note would be beneficial.

14. GLOSSARY

Many of the following terms have been extracted from the *Dictionary of Scottish Building* and supplemented by cross-referencing with the Dictionaries of the Scots Language website.[70] Entries include construction terms for Scottish detailing, both current and archaic, and also extracts from a glossary related to general roofing in Scotland compiled by Neil Grieve. Sources of other terms are identified in their specific entry.

This research has not yet identified construction terms used only locally in Angus and related to stone roofs, and this would be a useful further study. The Stone Roofing Association produced a 'Glossary of stone slate roofing' in 2010, which provides a useful overview of regional types of stone slating, mainly in England.[71] It does not contain terms identified as relating specifically to Angus, so it has not been incorporated here.

aik-nail – an oak pin or peg.

angle of creep – the area under slates over which water will fan out, having penetrated into the bond.

Arbroath slate – the export name for Dundee Flagstone Formation, quarried in Tayside.

back – the upper surface of a slate as laid, on which the bevelled edge is exposed.

backer or bachelor – see *in-band, lambs' tongue or bachelor slate*.

battens, rods, slater's lath, straps – small cross-sectioned horizontal timbers laid in parallel rows directly onto the roof structure and on which stone slates are hung. The earliest battens would have been split rather than sawn. Split battens are stronger than sawn battens, which are more prone to breakage. They should be of a sufficient size, around 1in × 2in, to receive a nail. Now, BS 4978 applies.

bed – the underside of a slate, as laid.

bell cast – a levelling out of a roof pitch over a wallhead, which achieves a bell-like shape. Usually achieved by fixing short timbers called sprockets or cocking pieces to the feet of the rafters.

bond or side lap – the arrangement of the vertical joints (perpends) between slates.

Carmyllie slate – Dundee Flagstone Formation quarried in Carmyllie. Colloquially used as a generic term for all Dundee Flagstone Formation.

codding – a top course of slates below the ridge, usually shorter than the rest.

course – a horizontal row of slate.

diminishing courses – a result of the practice of sorting slates by length, laying the largest at the eaves and diminishing steadily in size to the smallest at the ridge.

dressing iron, sage, edge, top-edge – a piece of iron band, usually about 2 × ¼ inches in section up to around 2ft long, bent at each end at right angles and finished in a spike which could be driven into a piece of timber. Used by the slater to dress slates with the *saixe*.

eaves – the lower edge of a sloping roof, where it overhangs the wallhead. The eaves course is the lowest course of tiles or slates. Lined eaves are eaves where a soffit board has been fitted to conceal rafter ends.

effective pitch – because slates have to cover the slates in the preceding two courses, the backs of the slates will be at a shallower pitch than the rafters. The shallower pitch of the back of the slate is known as the effective pitch.

gauge – the distance between the nail hole of a slate and the nail hole of the slate in the preceding course; also, the distance between battens.

grey slate – may be a corruption of 'great' slate, which refers to flagstone slates.

head – the top edge of a slate.

howk, howking – both verb and noun: a surface quarry or to quarry.

in-band, lambs' tongue or **bachelor slate** – narrow slates which sometimes have to be inserted into courses to maintain the proper width of side lap.

laps, head lap, side lap – the *lap* is the distance between the tail of a slate and the nail hole of the slates it covers in the preceding course. The *head lap* is the distance that the leading edge of a slate overlaps the nail hole of the slate two courses below. The *side lap* is the distance by which the side of a roofing slate overlaps the side of a slate in the course below.

mantilling – roofing, a covering.

margin, tail area, tweel or **tway** – the area of slate left exposed when laid on a roof.

overlap – the amount a row of slates covers the course below.

overstop – an overhanging board over a door to carry off the rain (see 106 Kirkwynd, Glamis).

peended, pienend – a hipped roof, also the hip itself. From *pien* – an apex or point.

peg, peggie – a timber peg used to keep stone slates in position on a roof.

pendicle – a small piece of land forming part of a larger holding or farm and frequently let to a sub-tenant. Tenants of pendicles and small farms in Forfarshire could open quarries on their land. In the 'Glossary of stone slate roofing', a pendle is noted as a quarrying term for a fissile rock, but this is not in the Dictionaries of the Scots Language.

perpend – the perpendicular end, the exposed vertical joint in a course of slates.

pin – term used for a peg in early modern Stirling and used to fix sclaits.[72]

pin rule – a length of timber marked back from a nail or pin with half-inch gradations, used by Scots slaters to size their slates.

pitch – the angle at which the roof rises from the eaves. A 1/5 pitch means a rate of 1 in 5 rise to span.

purlin – a continuous horizontal timber running parallel to the ridge, sometimes referred to as a *side timber*.

rafter – a timber sloping from the ridge to the wall head and supporting the roof coverings. An angle rafter supports hip ends.

randoms – supply of an undefined mixture of slate sizes. Flagstone slates were usually sold by 1,000 randoms.

rhone, rone – gutter.

ridge – the line formed where two sides of a sloping or pitched roof meet. The *ridge piece* is a main timber running along the apex of the roof.

riggin, rigging – the ridge, the roof, the material of which the roof is made.

riggin stane – the stone used as a ridge stone of a roof.

ring – a piece of wood used for a slate pin.

ripper – a sword-like steel bar with a flat hook at its end which is slid under slates to pull or rip out the nails holding them in place.

rods – see *battens*.

roof brackets, heels or **roof jacks** – a triangle formed in mild steel bars with a spike to hold it on the roof, which then supports horizontal planks to provide a working platform.

saixe, sax – a slater's knife, used for dressing slates. Usually a heavy blade, offset from its handle, with a 2–3in spike on its top edge, used for putting nail holes in the slates. The blade is sharpened only on one side, as a result of which this is a tool in which both right- and left-handed versions are available.

sarking – timber boards of regular thickness fixed to a roof structure onto which slates can be directly nailed – a Scottish detail which became more common from the late 18th century, once sawn softwood became more widely available.

scant, scants – a short slate nailed immediately under the ridge. The highest, last row to be fixed.

schriffon – archaic; stone tiles.

sclaits and **scailyie/scailzie** – terms used for slates in 17th-century Stirling and probably elsewhere. The two indicate different slates in accounts for Cowane's Hospital. Scailyie appear to be nailed, metamorphic, Highland Boundary Fault slate. Sclaits are often described as pinned and grey, so are understood to refer to flagstone slates.[73]

sclater – an artisan who uses *sclaits* or *scailyie*.

seraphim – archaic; a fossil crustacean rather like a king crab found in the Devonian Old Red Sandstone, especially at Carmyllie in Angus, and so called from its resemblance to the carved angels or seraphs on 17th-century tombstones.

shave-horse – a wooden frame used for making pegs, incorporating a seat and foot-operated clamp.

shed (v) – the action of swinging two single nailed or pegged slates apart to expose the head of the slate below, thus allowing the replacement of a single slate.

shouldered – (1) each layer of slates is bedded on mortar on a preceding layer;
(2) rounded corners on the head of a slate.

skaillie – metamorphic slate. See also *scailyie*.

skews, skew tabling – stones forming part of the coping of the sloping part of a gable on which the roof rests; the coping itself.

skew putt – the lowest skew.

slate, slating – can refer to metamorphic slate or flagstone (sedimentary rock) slate, but would be a natural material.

slater's hammer – a hammer with a striking face used to nail slates, a spike used to punch nail holes if required and on one side, a claw to remove bent or broken nails. The claw is on the side of the hammer at the head of the shaft, so, like the saixe, they are available in both left- and right-handed versions.

spoke-shave or **draw-knife** – a double-handled tool with a curved or straight blade, used with a shave-horse to make pegs. A spoke-shave is for finer finishing.

sprocket – a short timber placed at the foot of a rafter to project over the wallhead. Sometimes also referred to as a cocking piece.

superficial – a term used in old specifications or bills which refers to dimensions given as a measure of area. Often abbreviated to *super*.

tail – the leading edge of a slate.

tally slates – slates of regular size sold by number rather than weight, a practice which started with the introduction of Welsh and industrially produced slates. Flagstone slates were also sold by the 1,000 but were randoms.

tapping courses – courses of slates tapped into lime mortar to provide additional fixing and prevent water ingress. For metamorphic slates, this is generally confined to the more exposed parts of a roof, at ridge and skews, or for ogee roofs and similar. Flagstone slates frequently have all courses bedded on dods of mortar. The process is also known as *solid bedding*.

thack – roofing material, not necessarily thatch.

thackstane – sometimes referred to as *dripstones*, a stone projection at the base of a chimney stack, usually some 8in above the surface of the slates or thatch covering the roof. They are normally assumed to have originally acted as a protection for the edge of thatch, and it is the reduced depth of a slate which has left them standing proud. The term 'thacked in slate' occurs frequently enough to suggest that they not only covered thatch but were positioned to ensure water dripped clear of the junction between the stack and the edge of the roof covering.

tifting – the practice of laying thicker slates on the wall heads or close to skews so that water runs into the middle of and down the pitch of the roof, rather than spilling down the face of gables or penetrating under mortar fillets.

tilting fillet – a strip of wood, usually triangular and sometimes laid under the double eaves course to ensure that the lowest courses bed tightly together. Sometimes also used at *valleys* and *verges*.

tingle, latchet, tab, tack – a metal strip, one end of which can be hooked over a batten or nailed to a sarking board, after which the other end is bent to hold in place a flashing or a slate that has slipped.

ton slates – slates of random sizes sold by weight rather than number.

torching – filling (from the underside) the uneven spaces between tiles or slates, or the gaps between the battens on a roof, with lime mortar to eliminate drafts or the entry of wind-blown rain or snow. The practice was also referred to as tiering (tiered) or parging (parged) in some areas. Single torching has mortar on the top edge of each batten; double torching has mortar at the top and bottom of each batten; full torching completely fills the space between battens. The practice was largely discontinued because it caused fairly rapid failure of the battens. It was not usually necessary in Scotland, where sarking did much the same job.[74]

valley – a V-shape formed by the meeting of two roofs. A swept valley is one formed by curved slating, tiling or stone rather than by a lead or zinc flashing. Where the flashing is exposed, the valley is open; where it is hidden by the roof covering of slates, tiles, etc, the valley is described as closed or mitred.

verge – the point where the sloping edge of a pitched roof formed by tiles or slates meets a gable. Can be flush fitted or project by up to two inches.

water fan – the fan-shaped area that water will cover having penetrated the joint between slates. Clearly the calculation of side lap and head lap becomes very important, otherwise water can penetrate through to the sarking or battens. See *angle of creep*.

whyling – the practice of grading slates into three thicknesses (thick, middle and thin), which is the order in which they are used across the roof. See *tifting*.

15. RESEARCH CONTRIBUTIONS

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15.1 Contributors to the report

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