

# Geology and building stones in the Highlands and Islands

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*This account, illustrated with additional photographs by the author, is divided into two parts which were presented as separate articles in The Edinburgh Geologist Nos. 61 and 62. Part 1 covers sedimentary and metasedimentary rocks; part 2 focuses on igneous and crystalline metamorphic rocks.*

## Introduction

Reflecting the richly varied geology of the Highlands and Islands, many different sedimentary, igneous and metamorphic rock types have been exploited for building purposes. Intermittently over a period of over 5000 years, stone has formed the principal building material. From the Industrial Revolution the region became a major producer and exporter of sandstone, flagstone, slate and granite. Flagstone production and limited sandstone quarrying still continues at several quarries. Granites and metamorphic rocks are today primarily worked as sources of aggregate. Slate has not been quarried since the 1950s. In 2016 it was estimated\* that 17 quarries in Scotland were then producing building stone, of which only 7 were active continuously. Before the days of rail and road transport, local sourcing of building stone was the norm, as testified by evidence of hundreds of small quarries. However, as in the rest of Britain, the building stone industry declined rapidly in the early twentieth century, displaced by brick and concrete for most construction.



*Ring of Brodgar, dating from the third millennium BC, part of the Heart of Neolithic Orkney, inscribed as a World Heritage Site in 1999.*

As a general rule, pre-1920s traditional stone buildings reflect the local geology. Thus, for example the districts around the Moray Firth are characterised by buildings constructed of warm-coloured Mesozoic sandstones. Elsewhere the built heritage of Caithness and Orkney is dominated by Devonian sandstones and flagstones, and in Aberdeen by Palaeozoic silver grey granites. It is also common for buildings to incorporate more than one type of stone in their construction. This is partly pragmatic, since the physical properties required in a stone used for roofing or bridging (lintels) and portals may be quite different, and more demanding, than in those destined only for masonry walling. Also, the requirements for formal dimensioned stone ashlar as opposed to rubble dictated the specification of particular lithologies.

## **Part 1. Sedimentary rocks and metasedimentary rocks**

### **Sedimentary Rocks**

#### *Flagstone*

Flagstone (thinly bedded dark grey, very fine-grained sandstone and organic-rich, laminated siltstone) and sandstone of the Lower to Middle Old Red Sandstone occupy the Orcadian Basin extending from Shetland and Orkney through Caithness and around the Moray Firth. Owing to their laminated characteristics, strength and durability, flagstones provided excellent building materials. Over several centuries quarries supplied high quality flagstone for local building purposes and for pavement, walling (including the traditional Caithness Fences) and roofing. Originally slabs were sawn and split by hand. However, the lamination is tightly bonded and delamination on face-bedded slabs is rare. During the 19th century the harbour at Castlehill, near Thurso was established as the one of the earliest ports from which vast amounts of flagstone was shipped to cities throughout the United Kingdom and abroad. Today the Caithness flagstone industry is enjoying a revival as natural paving is becoming a popular choice for streetscape schemes, landscaping and indoor use. There are also examples of its use as masonry and roofing in new build.



*Pier near Castlehill Quarry, Castletown, showing how flagstones were used as slabs placed vertically in the structure.*



*Flagstone House, Halkirk, as newly built in 2002, with Caithness Flagstones.*

### *Sandstone*

Where available, many sandstones capable of easy working and dressing were employed for local building work. Consequently the Early to Mid-Devonian red-brown and yellow sandstones which crop out at the margins of the Orcadian Basin proved to be a valuable resource.

Some of the earliest examples of dry stone construction can be seen in the Northern Isles. In Shetland the Lerwick Sandstone was skilfully employed in this way for the 2000 year-old brochs of Mousa and Clickimin. Many of Lerwick's houses are built of stone from this formation. In Orkney, red and yellow sandstones of the Eday Group proved suitable for mullions and decorative work. The 12<sup>th</sup> century St Magnus Cathedral, Kirkwall is built of these sandstones and many buildings in Kirkwall are built of fine-grained, yellow freestones from Fersness on the Island of Eday.

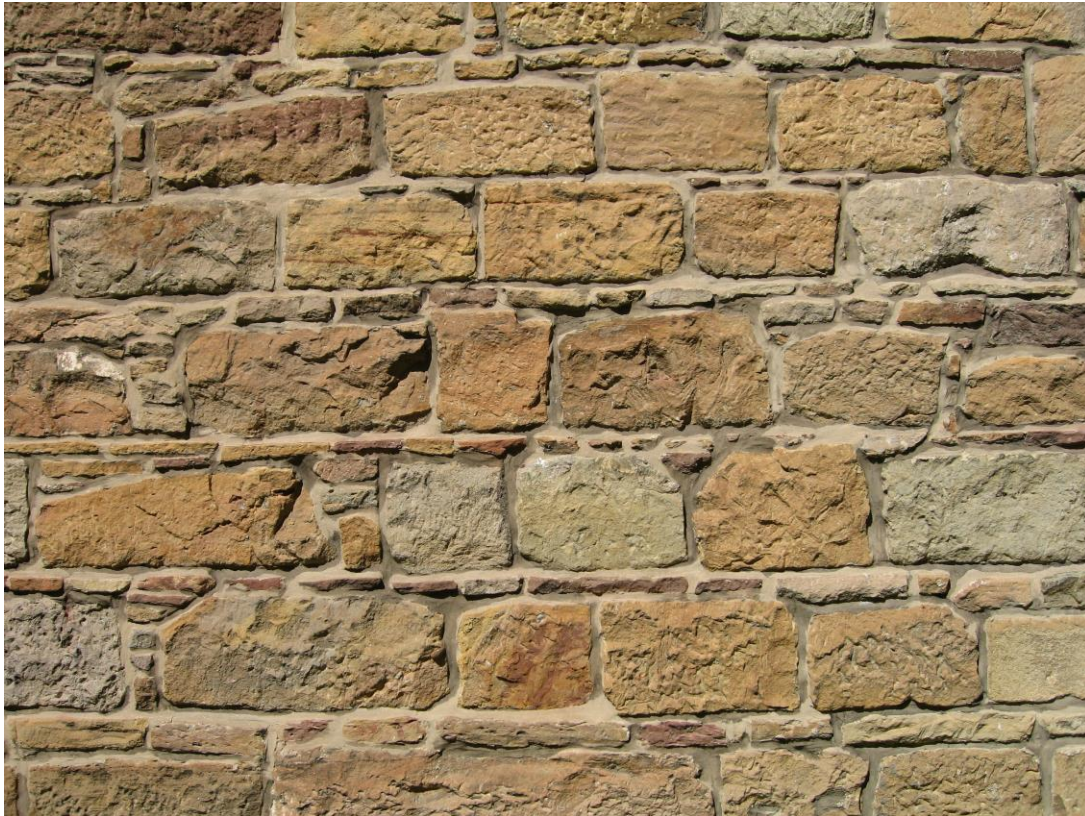




*Drystone-constructed Broch of Clickimin, Lerwick, Shetland.*

Early to Mid-Devonian sandstones have supplied many towns and villages including Golspie, Tain, Dornoch, Cromarty, Inverness, Nairn and Elgin. The Black Isle was a particularly productive source. Much of Beauly's sandstone came from quarries at Ruilick in the Sarclet Sandstone Group. Important quarries such as Milton at Redcastle on the northern side of the Beauly Firth supplied stone for buildings on the Black Isle and parts of Inverness; red-brown sandstone from Bay Quarry on the northern shore of Munlochy Bay was used for Fort George; and the Millbuie quarries supplied stone for the Fortrose and Rosemarkie area.





*Pale yellow and pink Devonian sandstone in coursed rubble wall with snecks (detail), Dornoch.*



*Locally quarried red sandstone of the Sarclet Group used in the Phipps Institute, Beaulieu.*



At Rhynie, Aberdeenshire, pink sandstone (Early Devonian) was used for local buildings such as Kildrummy Castle. Stone was quarried historically at Delgaty Wood near Turriff. Sandstones were also quarried in Monquitter for building of the Tower of Teuchar and nearby Byth House.

On the south coast of the Moray Firth there has been a strong tradition of building with sandstone. Beds assigned to the Upper Devonian were extensively worked near Elgin. Here the disused quarries in the Rosebrae Beds at Quarry Wood and Bishopmill appear to have supplied the most building stone. The Alves Beds at Burgie, Alves and Newton, and the Cutties Hillock Sandstone (worked at Millstone Quarry in Quarry Wood) were more suitable for field walls and millstones. Notable quarries in Permian sandstones include Clashach, east of Hopeman (currently working) and Greenbrae, west of Hopeman. The former produced excellent durable siliceous sandstone (white, red and brown and variegated colours) both for local buildings (e.g. Elgin) and the cities (a recent use is the National Museum of Scotland, Edinburgh). The quarries were famous for yielding fossil reptilian fauna, specimens of which may be seen in the Elgin Museum and National Museum of Scotland. At Spynie, pale-coloured durable siliceous sandstone (Late Triassic) was used in Elgin. On the north coast of the Moray Firth siliceous sandstones of Jurassic age were worked at Brora. The stone was also used in Golspie and buildings in the surrounding area including Dunrobin Castle.



*Jurassic sandstone masonry in a Golspie building showing a cast of a fossil mollusc shell (detail).*

On the western seaboard of the Highlands isolated outcrops of Old Red Sandstone were exploited as building stone. Early Devonian purple, brown and grey sandstones crop out on the Oban - Lorne coast and were used in Dunstaffnage Castle. Conglomeratic red sandstone was exploited locally on the Cowal peninsula, Argyllshire. The Late Devonian Bute

Conglomerate Formation was worked at Toward. Small outcrops of Carboniferous strata were worked on the Island of Arran and at Campbeltown. At Bridge of Awe, white and pink sandstone was supplied for dressings for FraochEilean Castle and Kilchurn Castle. At Inninmore, Morvern, coarse-grained white and yellow sandstone, used mainly for millstones and gravestones, contributed to Ardtornish Castle, constructed of basalt rubble. On Arran Carboniferous white freestone was worked during the 19th century and used in the construction of the Crinan Canal.

Permian red sandstone is confined to small outcrops on the west coast, notably at Corrie and around Machrie Bay on Arran. Used locally (including Brodick Castle) the stone was also shipped to other coastal areas in the Clyde and western Scotland including Rum (Kinloch Castle) and Oban. Mesozoic sandstones were exploited on the Morvern coast and on the islands of Mull and Raasay. Triassic buff sandstone from Morvern was used together with basalt rubble in Aros and Duart Castles on Mull. At Carsaig, Mull greenish or buff sandstone (Jurassic) supplied a ready source of building stone from medieval times (e.g. Ardchattan Priory). Cretaceous green glauconitic sandstone, possibly from Morvern, was used for Pennygown Chapel, Island of Mull.



*Permian red sandstone masonry in Lamlash Parish Church, Isle of Arran.*



## *Limestone*

Limestone of Neoproterozoic to Ordovician age occurs locally in Shetland, the northern Highlands and the Grampians and has been long quarried for a range of agricultural and building purposes. The Banffshire limestones, from Portsoy to Tomintoul were exploited for both for land improvement from the 1760s until the early 20<sup>th</sup> century (e.g. around Keith and Dufftown) and for house building. Across Argyll, including the islands of Lismore and Islay, extensive but discontinuous outcrops of limestones of the Argyll Group (Dalradian) proved a source for lime. A few quarries provided masonry stone: at Clyburn, Campbeltown, the Loch Tay Limestone was used both as building stone and aggregate. In north-west Scotland the Cambrian Durness Group, comprising dolomitic limestone and quartzite, crops out in Skye and in a narrow belt extending from Kylesku to Balnakeil. The limestones have been used locally both as a building stone (e.g. in Durness) and burnt for lime (e.g. around Loch Eriboll).



*Use of limestone as a building stone, Mackay's Tearoom, Durness.*

## **Metasedimentary rocks**

Hard metasedimentary lithologies could also be successfully worked for building stone by utilising regular natural joint spacing, cleavage and bedding. Thus rock types such as metasandstones which might seem alien to the present dimension stone quarrying industry were a valuable building stone asset in the past.

### *Psammite*

A commonly used stone across the Highlands was psammite of Neoproterozoic to Cambrian age. Psammites are metamorphosed sandstones (Greek *psammos*, sand) composed largely of quartz with or without feldspar and mica and with less than 10% carbonate or calcium silicate minerals. Many psammites exhibit a thinly bedded or flaggy nature, a characteristic which,



together with near vertical jointing, has been exploited to produce stone suitable for house building, general walling or even roofing.



*Psammite used for rubble work and roofing slabs, Midtown, by Tongue*

In the north of Scotland coastal quarry sites such as at Port Vasgo, Talmine exploited Moine psammite to supply Tongue parish and surrounding districts with stone, during the 19th and early part of the 20th century. Many villages along the northern coast were well supplied with these materials which were used often in conjunction with softer, more easily worked sandstone for entrances and window surrounds.



*Coastal quarry in psammite at Port Vasgo, Talmine, north of Tongue. Note the thinly bedded, 'flaggy' nature of these metasandstones which aided the quarrying of blocks for building.*

Psammites were easily exploited at inland localities in the northern Highlands, especially where the superficial cover of glacial deposits was thin. Thus the older buildings of Altnaharra and Lairg commonly used this stone. Large quarries supplied the needs of expanding villages and towns, for example Raven Rock, near Strathpeffer, which supplied this developing Spa village during the 19<sup>th</sup> century. Generally such rocks were difficult to dress and they were typically used in conjunction with sandstone for quoins, door and window surrounds. Similarly towns and villages which developed in the Grampian Highlands during the 19<sup>th</sup> century are built of psammite and sandstone. Examples include Newtonmore, Kingussie and Grantown-on-Spey.



*Detail of exterior of Free Church of Scotland, Strathpeffer, built of coursed, roughly dressed psammite (metamorphosed sandstone) with rough and polished pink sandstone used for the window surrounds.*



### *Quartzite*

Psammites containing greater than 80% recrystallized quartz are referred to as quartzites. Some quartzites have been used as local building material, their natural jointing yielding hard blocks suitable for masonry. In Banffshire most of the Dalradian quartzites were too hard to dress. However, the more flaggy units of the Cullen Quartzite were used locally around Cullen.

### *Torridonian Sandstone*

Hard, blocky, red and brown, recrystallised sandstones of the Torridon Group (Neoproterozoic) crop out in the North-west Highlands from near Cape Wrath southwards to Skye and Rum. They have a high percentage of feldspar and are harder than the younger sandstones described above. The sandstones have been used locally as an exceptionally durable building material. Although difficult to work, roughly squared block can be obtained, the dimensions dependent on joint spacing. Examples of use may be seen throughout the north-west Highlands: several of Ullapool's older buildings are constructed of this stone.



***Boathouse at Diabaig, built of Torridon Group sandstone.***

### *Slate*

Mention has been made above of flaggy strata which could be used locally for roofing. But the principal roofing material of the 19<sup>th</sup> and early 20<sup>th</sup> century was slate. Slates

(metamorphosed mudstones) occur within the West Highland Slate Belt (Ballachulish and islands of Easdale), Northeast Scotland (Macduff and Banff) and the Highland Border (from Arran to Dunkeld) (see Hyslop et al., 2006 for a summary and Walsh, 2000 for a detailed account of these rocks). They were extensively exploited to meet the huge demand of growing towns and cities. The industry declined at the beginning of the 20<sup>th</sup> century with a depression in the building trade, and manpower shortages (during the 1<sup>st</sup> World War). Competition with cheaper tiles and importation of slate from Spain and elsewhere resulted in the last quarries at Ballachulish closing in the mid-1950s.

## **Part 2 Igneous and crystalline metamorphic rocks**

### **Igneous Rocks**

#### *Granite*

Granites occur throughout the Highlands and Islands but those of the Grampian Highlands are especially important in relation to the building stone industry. Granite is a quartz-rich, ferromagnesian mineral-poor intrusive plutonic igneous rock which varies in crystal size from medium- to coarse-grained. With appropriate grinding and polishing methods, it can be finished to a very smooth surface making it a popular stone for monumental and decorative work. It is also hard, dense and resistant to degradation by frost and sea water, which means that it was commonly used for docks, harbour facilities and exposed structures such as lighthouses.

Scottish granites range from Neoproterozoic to late Palaeogene in age. Many were exploited locally as a building material and setts. Today, granites are principally quarried for crushed rock aggregate but some quarries are producing building stone. The principal granite quarries were in Aberdeenshire. Almost all the significant quarries were coastal or linked to a coastal port to facilitate export by sea. Granite was also worked in Mull and Lochaber in the western highlands. Granite was valued for its attractive appearance, with stone from the different regions having different characteristics, for example the deep red granite from Ross of Mull and Peterhead, the salmon pink of Corrennie and the silver grey varieties of Aberdeen.

In Aberdeenshire from the 19th century the granite industry was of huge importance to the local economy, and materials and skills were so plentiful that much of the city of Aberdeen was constructed from granite despite it being a difficult and expensive stone to work (most of the earliest buildings in the city are of more easily worked sandstone). Within the city, Rubislaw was pre-eminent. This quarry produced a greyish-blue fine-grained granite. It took a beautiful polish and was largely used for building and engineering work as well as for monuments.

The major granite quarries in Aberdeenshire have a long pedigree of supplying stone for prestigious buildings throughout the United Kingdom and beyond. For example, the silver grey coloured granite from Kemnay was used for such diverse projects as the Forth Railway Bridge (1885) the Queen Victoria Memorial, London (1911-24) and, recently as cladding for the Scottish Parliament (2004). Kemnay granite was largely used for building and monumental purposes but also produced large numbers of setts. The most outstanding building constructed of Kemnay granite is Marischal College, Aberdeen, the second largest



granite building in the world<sup>1</sup>. Quarries at Peterhead and Longhaven including the Stirlinghill Quarries produced reddish brown, coarse-grained granite, well adapted for both for architectural and monumental polished work and for heavy engineering projects.

Formerly there were many quarries in Deeside particularly around Ballater and at Inver. Invergelder supplied silver grey granite for Balmoral Castle and other buildings on the Royal estates. Granite at Auchindryne, Braemar was used for Mar Lodge.



*Pink and grey granite in the former St Columba's Church, Inverdrue, Aviemore, now St Columba's Rescue Base (Cairngorm Mountain Rescue). Note the use of sandstone for ornamental work, window surrounds and door arches.*

The granite quarries in the western Highlands, in particular those on the Ross of Mull and the Bonawe and Ballachulish quarries were directly on the coast, and were favoured for major construction projects such as lighthouses and roadstone. Fine-grained Ben Cruachan granite quarried at Bonawe was of excellent quality for building purposes but was also used for road setts. Close by, the quarries at Craig worked a coarse-grained hornblende biotite granite which could be extracted in large blocks and employed for harbour work, ornamental purposes and for building stone. Granite boulders were also used for building purposes.

Tormore (Torr Mor), close to Fionphort, Ross of Mull produced the largest granite blocks in the UK at 16 m length, and some blocks were exported to the United States. It was used for

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1. The largest is the Escorial Palace near Madrid.



dock works and bridges such as Westminster Bridge and Blackfriars Bridge, London. The Ross of Mull granite varies in colour from pale to deep red. Other quarries included one, North Bay, on the north side of the Ross which was opened to supply stone for the Skerryvore and Ardnamurchan lighthouses. The older parts of Iona Abbey and the nunnery are built of Ross of Mull granite (some from boulders) and metamorphic flagstone. It was reconstructed using granite from the Black Island Quarry, a name applied to two quarries at Dearg Phort on the Sound of Iona.



*Pink Ross of Mull Granite with pinning stones of metamorphic flagstone in boundary wall to the early 13<sup>th</sup> century Nunnery, Iona.*

In Lochaber red granite was also quarried in Glen Nevis for use in Fort William. The Strath Ossian Granitic Complex provided local grey granite for the estate. Resources of the grey Ballachulish Granite were largely used in Oban as a building stone. It was characterised by numerous xenoliths of black schist which detracted from its appearance. The nearby ‘black granite’ of Kentallen (‘kentallenite’) took a good polish and was in much demand as an ornamental stone for monuments.

In the Northern Highlands, granites and diorites have been exploited at several localities. Large glacially-transported granite boulders often provided suitable resources for local building purposes. In Strath Rusdale, in the Ben Wyvis district, it was said that one boulder was broken up to provide more than enough stone for two cottages.



In the mid 20th century, granite and granodiorite was used for hydroelectric scheme constructions, both as fill and for facing. For example, the dam at Dundreggan, Invermoriston, largely derives from the Cluanie Granodiorite pluton, and Strath Ossian granite was worked in Glen Spean to provide material for the Laggan dam.

#### *Other igneous rocks*

Igneous rocks other than granite occur widely throughout the Highlands and on the Scottish islands, especially the Inner Hebrides including Mull and Skye. In recent years they have been extensively quarried, largely for use as aggregate and roadstone. A number of quarries are still in production today for this purpose.

Basic igneous rocks have commonly been exploited locally for building and walling. Basalt of the British Tertiary Igneous Province on the western seaboard forms an important and distinctive component of the built heritage of the area and has been used as the principal rubble stone in many medieval buildings on the islands of Skye and Mull (see Part 1).



***Basalt wall of the Skye Gathering Hall, Portree. Note the pink sandstone window surrounds.***

Dolerite, coarser grained than basalt, was quarried at Inverlochry (near Dalmally) and used for houses in the district.

Gabbro usually forms some of the coarsest basic igneous rocks. Many of the gabbroic and noritic masses of Aberdeenshire have been exploited as a source of building stone (e.g. for Huntly Castle). Today gabbro is an important source of crushed rock aggregate (e.g. at Pitcaple, Inverurie).

Ultrabasic rocks have been used locally, as for example on Unst where the ochre-brown weathering serpentinites and dunites (composed almost entirely of the ferro-magnesian

silicate mineral olivine and its weathering products) form such a characteristic feature of the brown landscape.



***Brown-weathering serpentinite-dunite has been used for the local buildings of Baltasound, Unst, Shetland***

Distinctive igneous rocks of felsic and intermediate composition such as porphyritic microdiorite (porphyry), microgranite, trachyte and syenite have proved valuable sources for ornamental stone, setts and paving blocks (e.g. quartz porphyry from Furnace and Crarae on Loch Fyne). Although generally difficult to work, they were valued because of their durability and attractive appearance – they range from fine- to coarse-grained and are strongly or pale coloured. Where natural jointing in the rocks is closely spaced, blocks could be extracted both for sett-making and building stone. An example of the latter is the pinkish syenite of the Ben Loyal intrusion which was quarried and used for buildings in Tongue and district, Sutherland.





*Ben Loyal Hotel, Tongue, built of Loch Loyal Syenite.*

## **Crystalline metamorphic rocks**

As mentioned in Part 1, joint spacing, cleavage and inherited bedding characteristics determined the ease with which otherwise hard metamorphic rock types could be worked as building stone. Field stones (glacially-derived or from raised beaches) often formed the best building resource from the earliest times. Over the last 200 years many Highland estates opened small quarries to supply local needs for buildings and stone walls.

### *Gneiss*

Typically foliated (banded or striped) gneisses are tough rocks, difficult to work and to dress. Usually they do not readily split along the direction of foliation (c.f. schist, below). As a consequence in the past gneiss was used traditionally as a local source of building material either collected from fields as glacially derived boulders or locally quarried where the joint pattern has enabled slabs to be relatively easily removed. Perhaps the most famous examples of early building with gneiss are on the Island of Lewis. Here, the 5000 year old Standing Stones of Calanais comprise irregular slabs of Lewisian gneiss. Nearby smaller blocks of gneiss were employed in the dry stone walls of Carloway Broch. Exceptionally, some gneisses split relatively easily as on Coll and Tiree where Lewisian gneiss was used extensively as building material. Likewise in Banffshire, gneiss was capable of being dressed and was used locally.



*A mixture of squared coursed psammite and banded gneiss, veined with quartz, forms the masonry of Invergarry Hotel, Inverness-shire. The more easily worked red sandstone forms window surrounds and carved work.*

### *Schist*

Schist (derived from the Greek schizo, split) is a coarse-grained, finely foliated (banded or striped) metamorphic crystalline rock. The fine scale foliation (schistosity) results from the parallel arrangement of lamellar minerals, most commonly the micas. The schistosity enables the rock to be relatively easily split and this characteristic has been exploited for a variety of purposes including rubblework, stone slabs for standing stones, gravestones. In Argyllshire Dalradian schist from Doide by Loch Sween was used for sculpted stones from Medieval times. In some parts of the Grampian Highlands and western islands rocks described as 'gritty schist' or 'schistose grit' have been used for local building purposes. These rocks may have once been coarse grained sandstones, and although now metamorphosed some rocks may partially exhibit the original sedimentary texture.





*.Skipness Chapel, Argyllshire, rubblework of gritty mica schist with red sandstone arch.*

#### *Green Beds (chlorite-schist)*

Green Beds (including epidote- and chlorite-schist) crop out as a belt of rocks from the Mull of Kintyre through Loch Lomond to Aberfoyle and Aberfeldy. Typically green owing to the presence of the lamellar mineral chlorite, the rocks are of metasedimentary origin and have been derived in part from basic volcanic sources. Because of their ability to split well, green beds were used for carved monuments including Celtic crosses of the Iona School as well as providing rubble for many medieval castles and chapels. Green Beds were employed for the Tay Bridge at Aberfeldy, recently repaired. Quarries near Aberfeldy supplied that town and Pitlochry. Many small quarries were opened in both green beds and schists at Tarbet, Ardrishaig, Lochgilphead around Loch Fyne to supply local building needs.



*Lochranza Castle, Isle of Arran. A gritty green chlorite-schist has been employed for the rubble-work with soft pink Carboniferous sandstone surrounding the doorway.*



*The Cross of Kildonan, Island of Islay carved in chlorite-schist.*



### *Metavolcanic rocks (epidiorite)*

Metamorphosed basic volcanic rocks including Dalradian metabasalts crop out extensively in Argyllshire. These green and black rocks have also been used as building stone over the centuries. Quarries such as St Catherine's on Loch Fyne supplied tremolite- and chlorite-bearing epidiorite for use in Inveraray and Inveraray Castle and estate buildings. Similar epidiorites were quarried at Lochgilphead and Ardrishaig.

### *Marble*

The Highlands and Islands have several true marbles (limestone recrystallised by metamorphism) which, on account of their colour and other properties, were used primarily for decorative and monumental purposes. The decorative marbles are typically variably green-coloured serpentinite marbles with distinctive textures, although pink and blue varieties also occur. Several of the quarries were active intermittently from the 18th century, and most ceased production in the early 20th century. Of the sources which have been used for monumental work, perhaps the best known are from Tiree, Iona, Skye, Portsoy and Glen Tilt.

### **Concluding remark – conserving the heritage**

This brief and selective resumé of the building stones of the Highlands and Islands illustrates the wide variety of building stone materials which have been used through the centuries. To assist our understanding of the aesthetic, cultural, historic and economic (e.g. in terms of tourism) importance of stone in the built heritage, there is an ongoing need to record and characterise the various types of building stone which have been used, and attempt to identify and protect existing or even new sources of matching materials. This is not just for use in repair and conservation, but, given a sufficiently viable supply market, indigenous natural stone has the potential to be specified for alterations for extensions to existing buildings, and even for entire new-builds. In that regard, the British Geological Survey is developing a *Building Stone Database for Scotland* which will offer a publicly accessible web portal aimed at providing some of the knowledge needed to inform best practice in maintaining and conserving the country's built heritage assets. Readers interested in learning more about this project or wishing to contribute to it are invited to contact the BGS Building Stones Team whose work is described at <http://www.bgs.ac.uk/mineralsUK/buildingStones/home.html>.

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