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Provenance of building stones in four 'galley castles' in Argyll

Minerals & Waste Programme

Commissioned Report OR/15/053

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BRITISH GEOLOGICAL SURVEY

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Provenance of building stones in four 'galley castles' in Argyll

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Keywords

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Front cover

Castle Sween, Knapdale

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Summary

This report describes the outcomes of a project to assess the character and provenance of decorative stones in four ‘galley castles’ in Argyll. This includes a comparative investigation with a number of potential sources of sandstone and metamorphic rocks in Argyll and the surrounding region, which could have been quarried in the past.

1 Introduction

This report describes the outcomes of a project to assess the character and provenance of decorative stones in four 'galley castles' in Argyll: Castle Sween, Dunstaffnage Castle, Skipness Castle and Kilchurn Castle (Figure 1). A single sample of decorative stone from a fifth castle, Kisimul Castle on Barra, is included in the assessment.

The term 'decorative stone' is used here to refer to any stone that would have been selected to stand out visually or to perform a particular function in the castle masonry; in this context it includes visually distinctive stone that typically was used to form window and door surrounds, quoins and corbels, and stone that breaks naturally into tabular blocks and typically was used to form lintels and sills.

The term 'galley castle' refers to any castle that could be reached by a substantial water-borne vessel (galley) at the time it was constructed. In Scotland, nearly all the structures that have been identified as galley castles are on the west coast, but a few are on inland lochs drained by navigable rivers. The availability of water-borne transport would have provided opportunities to import some of the building materials used in a galley castle from outwith the area in which the castle is sited. The provenance of building stones used in such castles – in particular the decorative stones which are more likely to have been imported than the walling stone – may shed light on the trade and transport routes used by the castle builders, and may help to reveal the locations of historical quarry sites.

The principal objective of the project is to describe the geological character of the decorative stones used in the four galley castles in Argyll mentioned above, and from this establish:

- whether each stone can be tied back to a geological or geographical source (e.g. an area of outcrop or a quarry);
- whether the same stones occur in different castles;
- whether geographical and/or temporal patterns of stone distribution can be discerned from the outcomes of (i) and (ii).

The four Argyll castles were visited in the course of a three-day site visit on the 28th, 29th and 30th of July 2015 by Martin Gillespie and Paul Everett (BGS Building Stones team). Building stones in the accessible parts of each castle were examined carefully by eye and using a hand lens (x10 magnification). Each site is a Scheduled Monument, so it was not possible to collect stone samples for detailed analysis from *in situ* stonework. However, three small pieces of stone that had become detached from the stonework through natural means (weathering) and were lying on the ground were collected from Dunstaffnage Castle (one piece from the castle and one from the adjacent chapel) and Castle Sween, and a thin section (a slice of the stone cut thin enough to be transparent so it can be examined by microscope) was prepared from each of these. A sample of decorative stone from Kisimul Castle was provided to BGS by Historic Scotland and is included in this assessment, though BGS staff have not visited the castle; a thin section was prepared from this sample. Four historical quarries in Argyll were also visited during the site visit, and a thin section of the stone from each quarry was prepared. Full descriptions of all the samples and thin sections are presented in Appendix 1.

A brief description of the geology and geological history in the area of interest is presented in section 2 of this report to provide context for later sections. All of the decorative stones encountered are either metamorphic rock or sandstone, and a brief introduction to some of the possible sources of these stones is included in section 2. Information for each castle – layout and chronological development, building stones and building stone provenance – is provided in sections 3 to 7. The key conclusions are presented in section 9.

The project was commissioned by Historic Scotland (HS), and was conducted by the Building Stones team of the British Geological Survey (BGS) under the terms of the Memorandum of Agreement (2011-2016) between HS and Natural Environment Research Council (as represented by BGS).

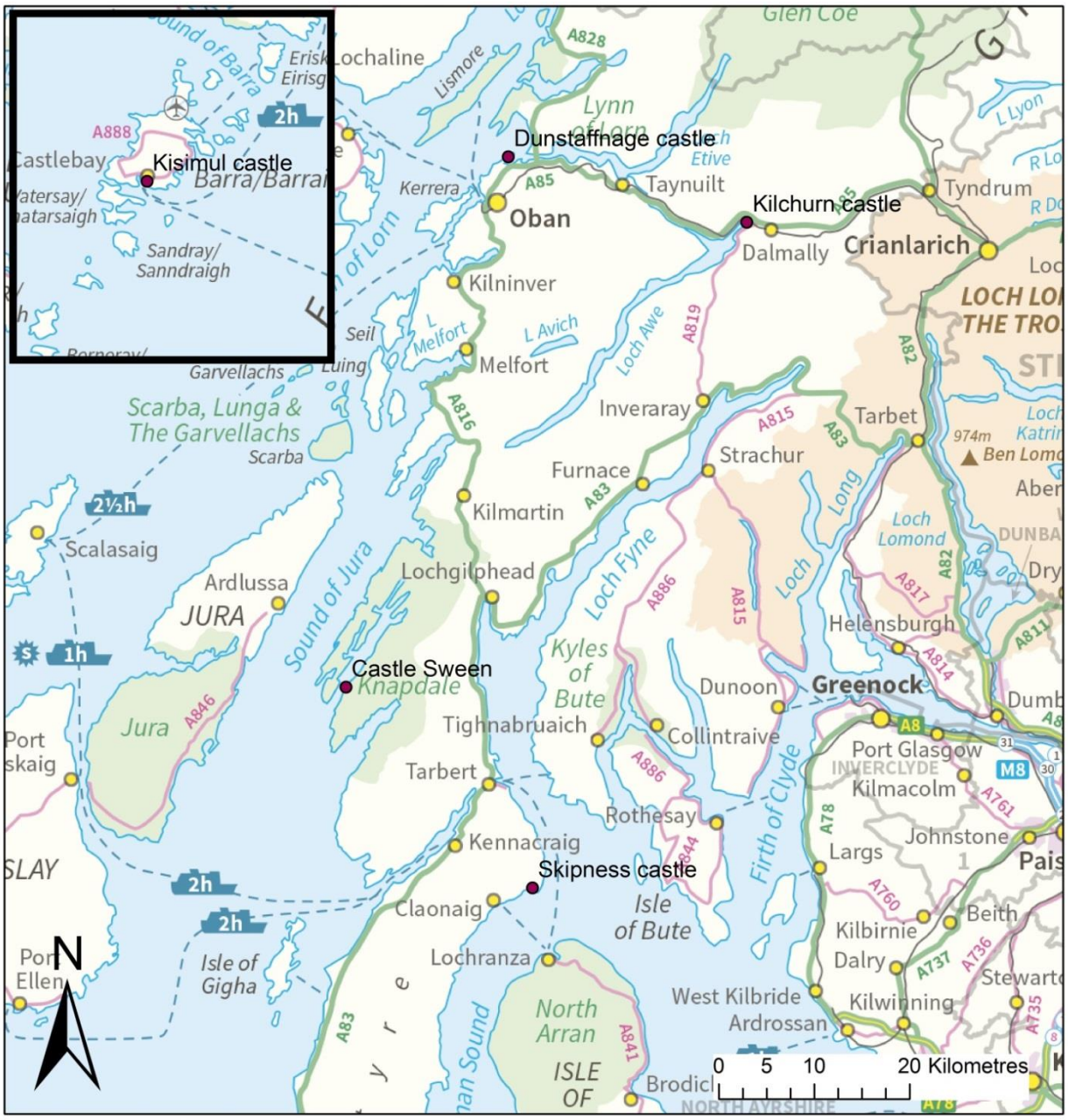


Figure 1 Map of the Argyll coastline and the location of galley castles assessed in this report

The inset shows the island of Barra, which is roughly 140 kilometres north-west of Oban.

2 Geological context

Scotland has a complex and diverse bedrock geology, which is the product of more than three billion years of Earth processes, extending from the Archaean Eon to the present day (Figure 2). The geographical area relevant to this project covers only a small part of the country - the Argyll coast and part of the Hebrides - but still encompasses a considerable amount of geological variability. This section of the report presents a brief introduction to the geology of the area to provide context for the following sections. Figures 2, 3 and 4 should be referred to while reading this section.

2.1 SOME TERMINOLOGY AND CONCEPTS

Earth's crust consists of three main classes of rocks.

- *Igneous rocks* form when magma (molten rock) solidifies. Magma forms deep within the crust, and it can solidify there (forming *dykes*, *sills*, *plutons* and other types of *intrusion*) or it can erupt onto Earth's surface (forming *lava flows* if it behaves like a liquid and *pyroclastic deposits* if it is thrown high into the air and falls back to Earth as volcanic ash and larger fragments). Common types of igneous rock include *granite* and *gabbro* (which always occur as intrusions), and *basalt* and *andesite* (which usually are erupted). Nearly all magma consists mainly of *silica* (SiO_2), and igneous rocks can be divided according to how much silica they contain: silica-rich rocks are typically light-coloured and can be referred to generally as *felsic*, while silica-poor rocks are typically dark-coloured and can be referred to generally as *mafic*. Large bodies of igneous rock are given names to reflect their location, composition and type of intrusion, for example Arran Granite Pluton.
- *Sedimentary rocks* form by deposition of particulate matter (mud, sand, gravel and shell) at Earth's surface. The particulate matter usually forms by erosion of pre-existing rocks, and is moved by water, wind, ice or gravity before being deposited as sediment. Loose sediment buried beneath accumulating layers of sediment gets compacted and is eventually converted to rock. Common types of sedimentary rock include *mudstone*, *sandstone*, *conglomerate* and *limestone*. Bodies of sedimentary rock are given names to reflect their location and composition, for example Scalpay Sandstone Formation.
- *Metamorphic rocks* are former igneous rocks or sedimentary rocks that have been subjected to high temperature and pressure within Earth's crust, with the result that the original rock textures and mineral assemblages are changed significantly. Some of the character of the original igneous or sedimentary rock usually survives low to moderate degrees of metamorphism, and such rocks can be named by putting the term 'meta' in front of the igneous or sedimentary rock name (e.g. metabasalt, metasandstone). When rocks are subjected to a high degree of metamorphism they generally lose most of their original character and a new set of terms, including *gneiss* and *schist*, is used to name them. Bodies of metamorphic rock are given names that reflect their location and rock type, for example Beinn Bheula Schist Formation, and Lewisian Gneiss Complex.

Metamorphic rocks and most igneous rocks are *crystalline* (i.e. formed entirely of interlocking crystals), while most sedimentary rocks are *granular* (formed of adhering particulate matter, such as sand grains). Crystalline rocks lack pore spaces (voids) and therefore are essentially impermeable and relatively resistant to weathering. Granular rocks, in particular sandstone, typically have a network of connected microscopic pore spaces and are usually permeable; water can easily penetrate such stones, and they therefore tend to have relatively poor resistance to weathering.

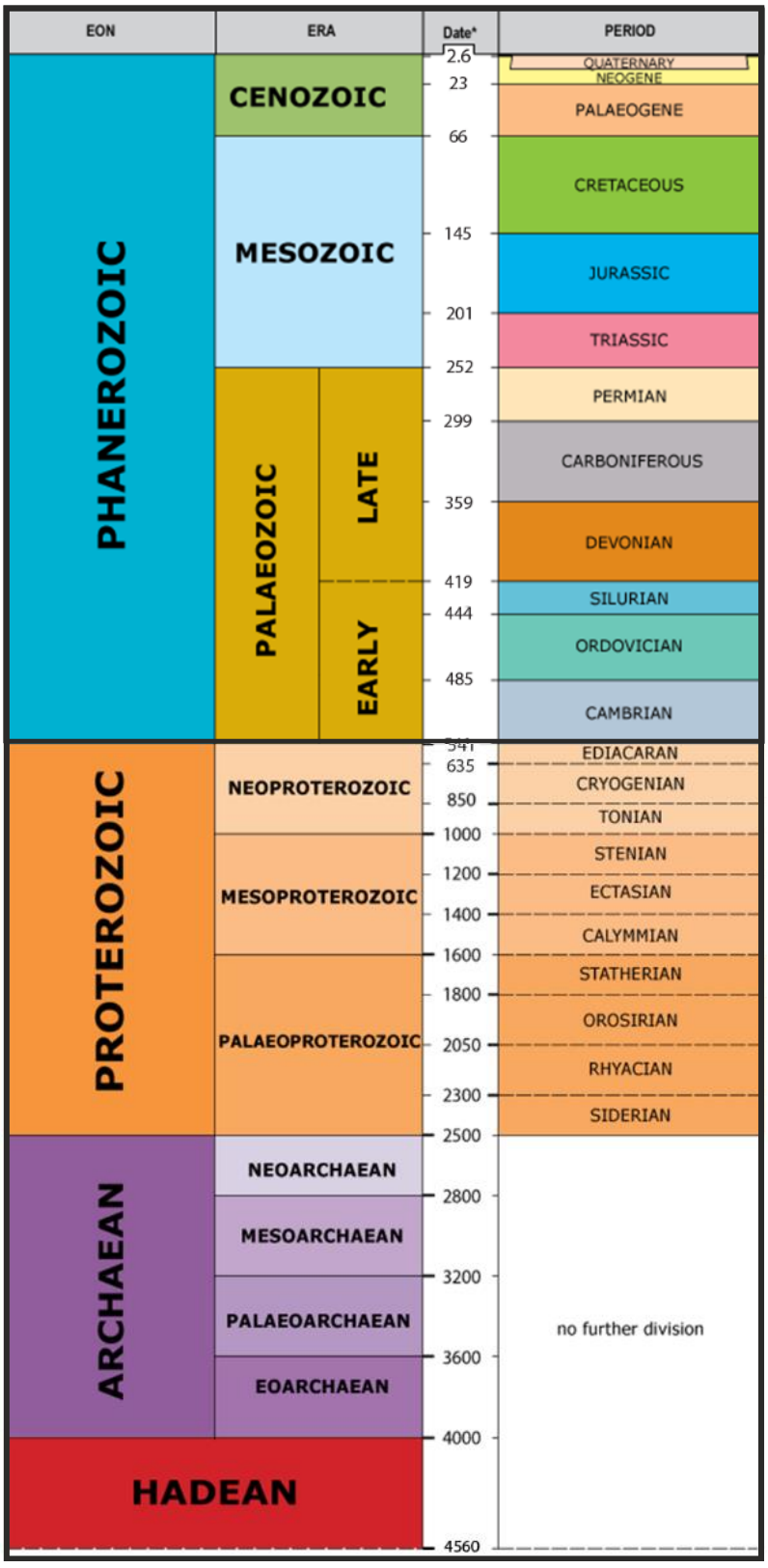


Figure 2 Geological time chart

The names and age ranges (‘date’) of all geological time divisions are given, from the earliest (Hadean Eon) to the youngest (Quaternary Period). Numbers in the ‘date’ column refer to ‘millions of years before present’; for example, the Jurassic Period lasted from 201 to 145 million years ago. This table is adapted from the BGS Geological Timechart.

2.2 GEOLOGICAL HISTORY

The oldest rocks in the western seaboard area of Scotland belong to the *Lewisian Gneiss Complex*. These rocks, which date from the Archaean Eon and are thus some of the oldest on Earth, crop out widely on the Western Isles and on Tiree, Coll and Iona. Little is known about the environment under which the rocks formed, but they consist of thickly banded, strongly metamorphosed crystalline rocks (gneiss), much of which consisted originally of intrusions of granite and basalt.

The Grampian Highlands terrane is bounded by two major geological faults: the Great Glen Fault to the north and the Highland Boundary Fault to the south (Figure 3). The rocks beneath much of this area belong to the *Dalradian Supergroup*. This major geological unit originally was a very thick sequence of sedimentary rocks, mainly sandstone and mudstone with occasional beds of conglomerate and limestone. In some places the sedimentary strata are interbedded with lava and pyroclastic rocks, and in other places they are cut by intrusions (dykes and sills) of igneous rock (mainly of basalt composition).

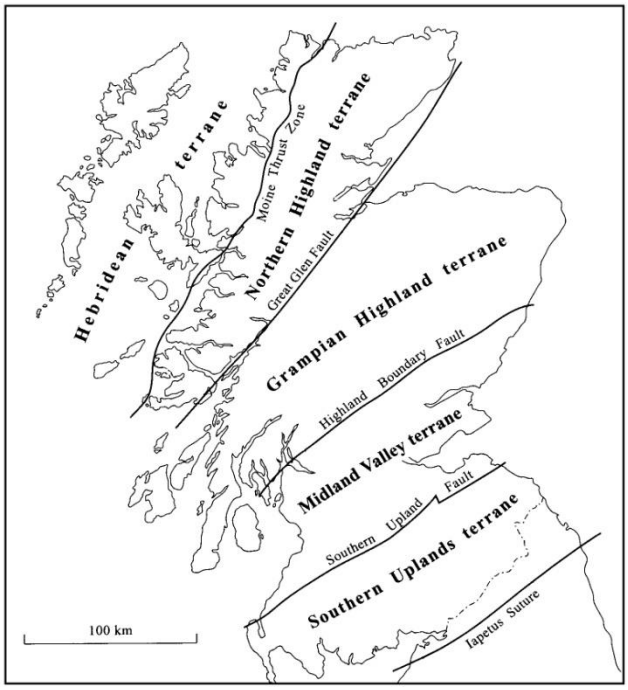


Figure 3 The major geological terranes and geological faults of Scotland

After Trewin and Rollin (2002).

The strata that now form the Dalradian Supergroup were deposited between approximately 1,000 and 500 million years ago, in a great sea-filled basin that was opening as tectonic forces pulled a continent apart. Rivers brought vast quantities of sediment to the sea, where larger grains settled quickly as layers of sand, small particles settled slowly as layers of mud, and layers of carbonate ooze ('lime') formed during warm periods. As the sediment was buried and compressed, the layers of sand, mud and lime became strata of sandstone, mudstone, and limestone, respectively. 600 million years ago the continent broke apart and a widening ocean (the Iapetus Ocean) separated the two sides. Now on a continental margin, the growing pile of layered sediments reached a cumulative thickness of at least 15 kilometres.

Around 500 million years ago the ocean began to narrow then closed altogether, and the land masses bordering it collided. The collision caused the flat-lying strata of the Dalradian Supergroup to buckle into giant folds; some of these are tens of kilometres in size. The massive

scale of folding thickened the crust, raising the temperature and pressure within it, and causing minerals and textures in the rocks to change: the sedimentary and igneous rocks of the Dalradian Supergroup became *metamorphic rocks*. The intensity of folding and metamorphism peaked 470 million years ago, then diminished slowly and had ceased altogether by around 420 million years ago. These geological upheavals are known as the *Caledonian Orogeny*.

The area around Loch Awe and Knapdale is characterised by numerous intrusions of basalt and related rocks that have been metamorphosed. These dark, fine-grained metamorphosed igneous rocks are difficult to describe and classify in the field, so they are referred to broadly as *metamafic rock*, and sometimes as *metamafite* (Figure 4).

Towards the end of the Caledonian Orogeny (between roughly 430 and 408 million years ago) vast volumes of magma rose through the crust to form intrusions within the Dalradian Supergroup. Several large intrusions of granite (including the Cruachan Granite Pluton) formed close to what is now the Argyll coast. Numerous smaller, sheet-like intrusions known as *dykes* and *sills* were also emplaced at this time (the great majority are too small to show on Figure 4).

Some of the magma erupted, and in the Lorne area of Argyll a pile of lava flows overlying the Dalradian rocks (the *Lorne Lavas*) is preserved across an area of approximately 300 km^2 and has a maximum thickness of c. 800 metres (Figure 4). A smaller area of lavas formed at about the same time is preserved in Glen Coe.

During the Caledonian Orogeny the crust thickened and rose quickly (in geological terms), forming a large mountain chain (possibly akin in scale and character to the Himalaya) that eroded rapidly as it rose. Huge quantities of sediment created by erosion were deposited in topographically depressed areas around the mountains and now form the Old Red Sandstone Supergroup. These sedimentary rocks are of Devonian age and consist mainly of beds of sandstone, conglomerate and siltstone. At this time the land that is now Scotland lay to the south of the equator, roughly at the latitude that the Namib Desert in southern Africa occupies today. The Devonian sediments therefore were deposited in a desert environment, usually as a result of flash floods which drained into lakes (hence they include beds of coarse conglomerate and very fine siltstone). Sandstones formed in desert environments typically are brightly coloured, because the small quantities of iron they contain oxidises in the atmosphere (i.e. it effectively rusts, producing sandstones that are brown, purple, ochreous, orange or pink); the Devonian sandstones typically are brown or purplish.

Over most of the Scottish Highlands the rocks that were metamorphosed during the Caledonian Orogeny are exposed at the surface today (i.e. they are not covered by younger rocks). There is therefore little evidence in these areas of what has happened in the last 350 million years of geological history. However, along the western seaboard of Scotland large volumes of lava erupted onto the land relatively recently (in geological terms) and where these occur today (mainly on Skye, Mull and Morvern) they occasionally reveal sedimentary rocks beneath them. These sedimentary rocks presumably existed across most of the Highlands at one time but have been removed completely by erosion where they were not protected by a cap of lava.

The sedimentary rocks revealed beneath the lavas include strata formed during the Carboniferous, Permian, Triassic, Jurassic and Cretaceous periods.

The Carboniferous strata typically are buff to pinkish brown, coarse or gritty sandstones. At the time they were deposited Scotland lay more or less on the equator, and the Carboniferous sediments therefore were deposited in tropical rivers and swamps. The sediments that were deposited at this time were interspersed with layers containing huge quantities of dead plant matter. Over geological time these have transformed into coal. Large parts of the Midland Valley of Scotland are underlain by thick sequences of Carboniferous strata, including numerous seams of coal, but on the western seaboard the strata are relatively thin and there is little or no coal; however, the Carboniferous sandstone beds do contain occasional scattered fragments of black

fossil plant matter, and where these occur they usually are a good indication that the strata date from the Carboniferous Period.

Permian strata typically are pink or reddish sandstone and Triassic strata are typically buff to orange sandstone. At the time they were deposited Scotland lay to the north of the equator, roughly at the latitude that the Sahara Desert occupies today. The Permian and Triassic sediments were deposited in a desert environment, and in many areas they represent fossilised sand dunes.

Jurassic and Cretaceous strata typically consist of white to light grey, and occasionally greenish, sandstone and brown shales. By the time they were deposited Scotland was roughly at the latitude of the Mediterranean Sea, and the earlier (Permian and Triassic) had been submerged beneath a (pre-Mediterranean) warm shallow sea.

The Atlantic Ocean began to open in the Jurassic Period. Around 60 million years ago, in the Palaeogene Period, the crust became so stretched as this process continued that large volumes of magma were able to rise through the crust where they formed intrusions (which now underlie the Cuillin Hills on Skye, the Cuillin hills on Rum, and the mountains of Mull and Arran) and extensive lava flows (now exposed in north Skye, Eigg, Mull and Morvern). These are the lava flows beneath which the older (Carboniferous to Cretaceous) sandstone strata are preserved.

The last significant part of the geological history of Argyll and adjacent areas is the Ice Age, which began 2.6 million years ago and continues today. During that time Scotland has experienced many cold (glacial) intervals interspersed by warmer (interglacial) intervals. Vast ice sheets from Scandinavia and interior parts of the Highlands scoured the entire land surface from time to time, and narrow ice streams gouged out valleys and corries. Melting ice deposited vast quantities of glacial sediments (including till, sand and gravel), which now overlie and conceal much of the bedrock and in places form distinctive landforms such as drumlins, eskers and terraces. The Ice Age therefore is responsible for most of the topographic features that characterise the Highlands (and the rest of the country) today.

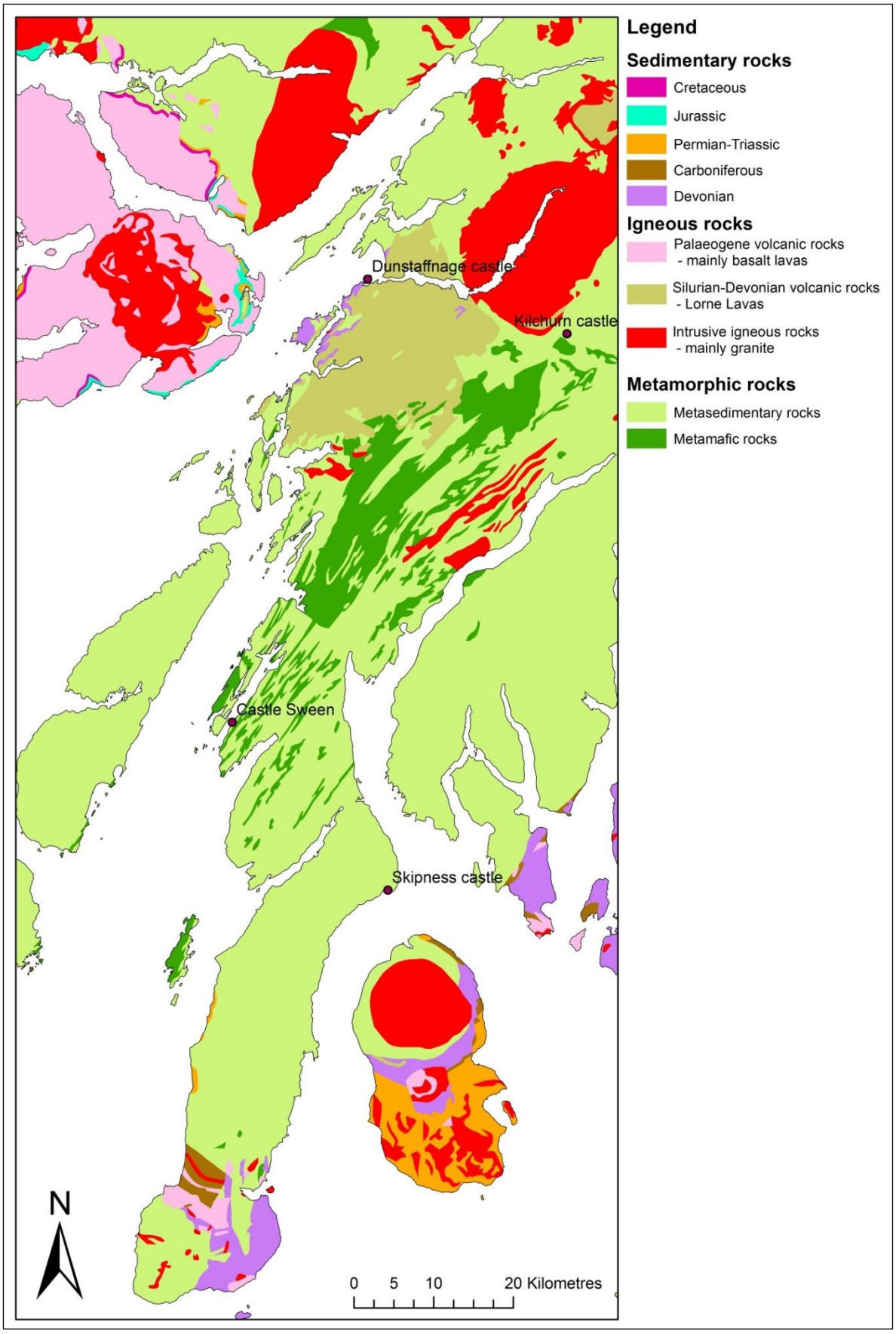


Figure 4. Simplified geology map of Argyll, Morvern and Arran

Some of the sandstone outcrops referred to in this report are small and at this scale may be difficult to see or not represented.

3 Possible sources of decorative stone in Argyll galley castles

The site visit showed that nearly all the decorative stones in the Argyll galley castles are of two principal types: some are metamorphosed rocks and others are sandstone. In this section, some of the possible sources of these stones are described.

Four quarries that are known to be historic sources of metamorphosed rock in Argyll were examined during the site visit (Table 1 and Figure 5). Rock samples from each quarry were collected and a thin section was prepared from samples representing three quarries. Petrographic descriptions and location details for each are presented in Appendix 1.

None of the sandstone outcrops in Argyll and adjacent areas were visited (they are in general too far from the castles), but brief descriptions of each are given below based on BGS records.

3.1 METAMORPHOSED ROCKS

The stone in each case is metamorphosed greenish-grey mafic igneous rock (metamafic rock). The geological character of the stone from each quarry is distinct to some degree (Appendix 1), but the most distinctive feature is the strength of the metamorphic foliation. The orientation of joints (large open fractures) that cut the exposed rock at each of the quarries would have influenced the size and shape of quarried blocks, and the ease with which tabular blocks could be extracted

Table 1. Details of quarries visited during the site visit

Quarry location	Grid Reference	Quarry description	Sample	Stone type
Kilchurn Castle	NN 1331 2759	A small "scoop" on the east side of the castle. Visibly quarried ground is c15x8m in area and 2m high. Oblique fractures cut the outcrop.	ED11447 (thin section prepared)	very weakly foliated greenish grey metamafic rock
Lag na Luinge, by Loch Awe	NN 1257 2551	The smaller of two adjacent pits is c. 10 x 15m in area and c. 1-2m high. Very little rock is exposed.	ED11444	weakly foliated greenish grey metamafic rock, locally containing pyrite
	NN 1257 2553	The larger of two adjacent pits is c. 25 x 30m in area and 3m high, with a substantial face of exposed rock. Parallel joints cut the outcrop.	ED11445 (thin section prepared)	weakly foliated metamafic rock, commonly containing pyrite
Lochan Uaine, by Loch Awe	NN 0120 1835	Not an obvious quarry, but a number of rock exposures have evidence of quarrying along a 50m long crag	ED11446	foliated metamafic rock
Doide, by Loch Sween	NR 7041 7688	A large pit 25x20m in area, 8m high with evidence of tooling. The outcrop consists of near-vertical, markedly tabular slabs of rock typically 20-40cm thick, with parallel joint surfaces parallel to the metamorphic foliation.	ED11442 (thin section prepared)	strongly-foliated fine-crystalline metamafic rock
	NR 7039 7683	Tabular slabs of rock in an area of wooded crag by the shore, likely to have been quarried in the past.	ED11443	

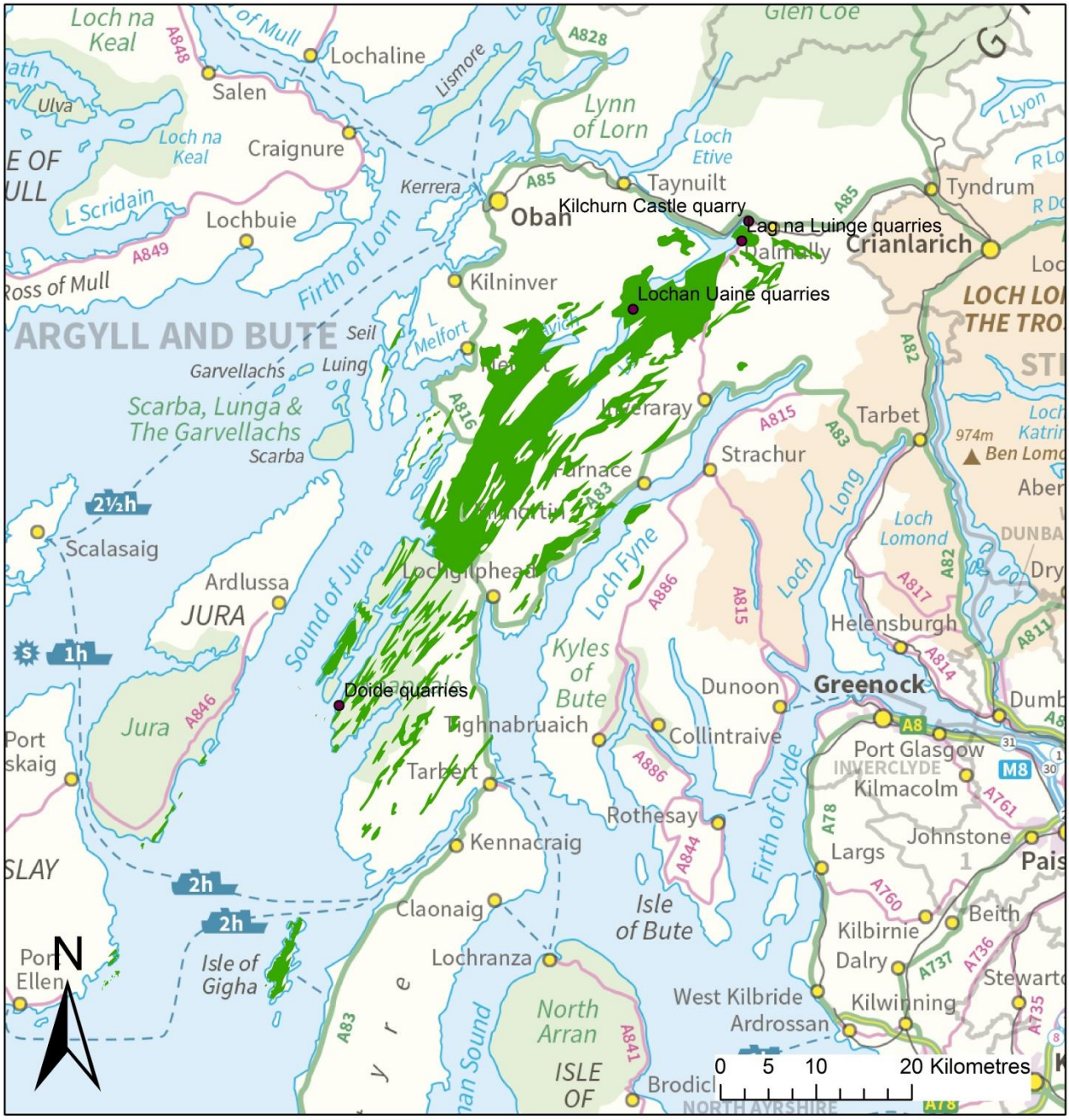


Figure 5. Locations of quarries in metamafic rock visited during the site visit

The extent of mapped units of metamafic rock is indicated in green (see also Figure 4).

3.2 SANDSTONES

Outcrops of sandstone are rare and typically small in Argyll and adjacent areas, but beds of Devonian, Carboniferous, Permian-Triassic, Jurassic and Cretaceous sandstone do crop out in several places (Figure 4).

Unlike the potential sources of metamorphosed rock, sources of sandstone are generally substantially more distant from any of the castles, and in most cases would have had to be transported a significant distance. However, most of the sandstone outcrops are on or near the coast, or by a navigable waterway, and therefore would have been accessible by boat when the galley castles were constructed.

A summary of the sandstone and evidence (if any) for historical quarrying at several of the potential source sites (those identified on Figure 6) is presented below, based on BGS resources including the BGS Database of Mines and Quarries ('BritPits'), the BGS Rock Collections, BGS geological maps and memoirs, and other historical records.

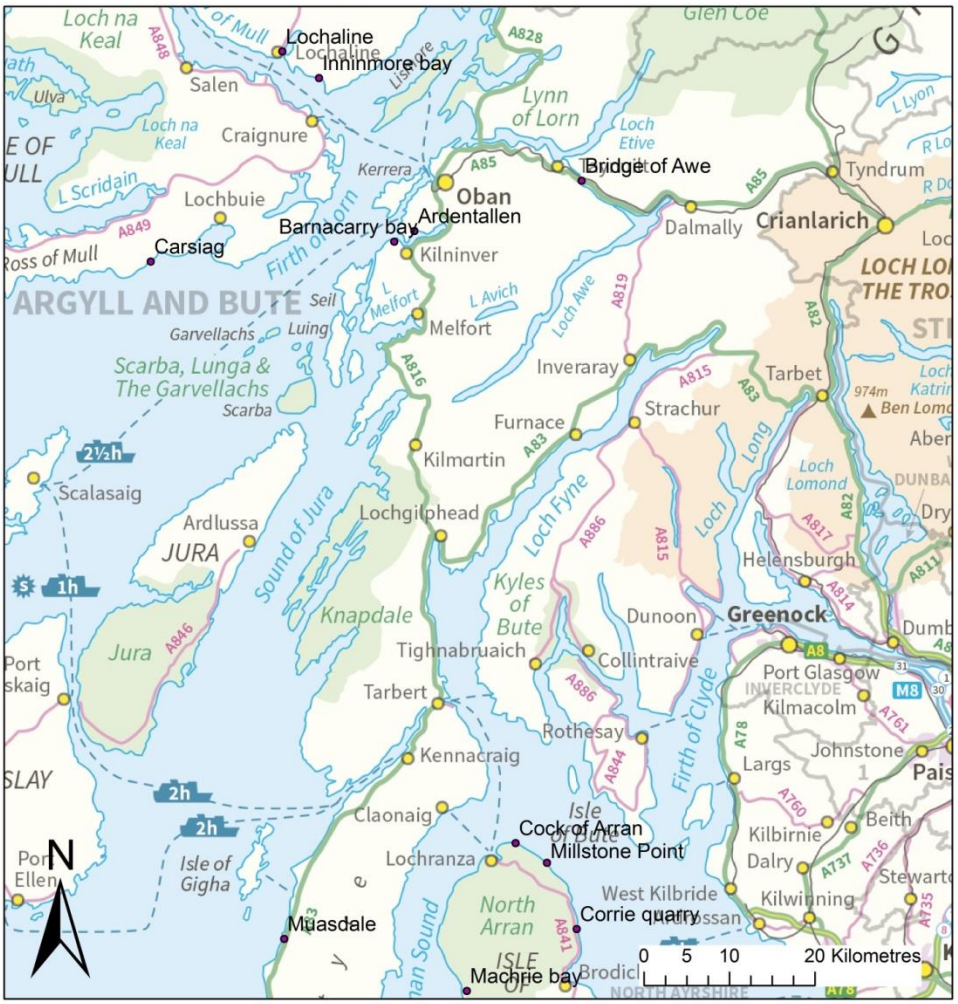


Figure 6. Sites of possible sources of sandstone used in Argyll galley castles

See also Figure 4.

3.2.1 Devonian sandstone

Oban/Kerrera area

Beds of Devonian sandstone and conglomerate of the Kerrera Sandstone Formation crop out near Oban and Kerrera (Figure 4). BGS records do not contain details of historic quarries in this area. However, a possible historical source of Devonian sandstone is suggested in Walker (2000):

"A coarse greenish or purple sandstone of Lower Old Red Sandstone age was quarried over many centuries at Ardentallen on Loch Feochan. The quarry was partly on the foreshore and is now partly flooded. The stone can be seen in the old Parish Church at Kilmore, S of Oban, and Gylen Castle on Kerrera. The Free High Church in Oban is a prominent building constructed in 1846 from the green sandstone. A similar rock at Barrnacarry Bay on the other side of Loch Feochan was also used, for example, in the coach house at Ardmaddy Castle."

BGS does not hold rock samples from Ardentallen or Barrnacarry Bay, so the character of the stone quarried at Loch Feochan has not been determined.

3.2.2 Carboniferous sandstone

Inninmore Bay

The BGS Collection of UK Building Stones includes two samples from a quarry at Inninmore Bay (OS Grid Ref [NM 7229, 4188]). These consist of uniform, light grey to buff medium- to coarse-grained sandstone (Figure 7a).

The quarry produced Carboniferous sandstone from the Scottish Coal Measures Group. This bedrock unit crops out extensively in the Midland Valley of Scotland, where it is divided into the Upper, Middle, and Lower Coal Measures Formation(s), each of which may be up to several hundred metres thick (much thicker than at Inninmore Bay).

Walker (2000) referred to historic quarrying at this location as follows.

"... coarse, white and yellow Carboniferous sandstone was quarried in the 18th and 19th centuries at Ininnmore Bay [sic], *in Morvern, but was mainly used for millstones and gravestones."*

Bridge of Awe

The BGS Collection of UK Building Stones includes a sample of pink coarse-grained sandstone from a building stone quarry at Bridge of Awe (Figure 7b). Geological maps indicate that the sandstone has been extracted from a small, isolated outcrop of Carboniferous sandstone.

The following quote is from Walker (2000).

"A small outcrop of coarse sandstone of [Carboniferous] age near the old Bridge of Awe was used for dressings at Fraoch Eilean Castle [situated on an island in Loch Awe]... and later at Kilchurn Castle on Loch Awe."

Arran

Beds of Carboniferous sandstone also crop out on Arran (Figure 4). Building stone quarrying on Arran historically has focussed mainly on the pink to orange Permian-Triassic sandstones which crop out quite extensively there (see below). However, a disused quarry in the Carboniferous rocks by Millstone Point is recorded in the BGS Database of Mines and Quarries, and although this quarry was used primarily to produce millstones it is possible that Carboniferous sandstone was quarried historically for building stone on Arran. BGS does not hold samples of any Carboniferous sandstone quarries on Arran.

Central Belt

A large proportion of the Central Belt of Scotland is underlain by Carboniferous sandstones. Given the distance involved, it is highly unlikely that stone would have been brought from the Central Belt during Medieval phases of construction and alteration, but it may have been used in later stages. According to Walker (2000):

"In the C19 sandstone was imported from the Central Belt of Scotland and used in the construction of C19 mansion houses and as dressing stone in the characteristic granite houses of Oban".

3.2.3 Permian-Triassic sandstone

Arran

Permian-Triassic sandstone crops out quite extensively on Arran, including many parts of the coast, and stone could have been quarried historically from many sites. A small outcrop of Permian-Triassic sandstone at the Cock of Arran is within a few miles of Skipness castle.

A well-known building stone quarry at the village of Corrie, on the east coast of Arran, produced Permian-Triassic sandstone ('Corrie Sandstone') that was used in buildings on Arran and on the mainland.

BGS samples from Corrie are pink to orange, uniform, medium-grained sandstone (Figure 7c). Blocks can feature cross bedding and parallel bedding. The sandstone was deposited in a desert environment and contains distinctive rounded, wind-worn sand grains.

Walker (2000) stated that Permian-Triassic sandstone from Arran was used in Skipness Castle, but did not record the source of this information.

"Rocks of the New Red Sandstone occur widely, though in small, isolated outcrops, and have often been used. Such red sandstones were quarried on the Isle of Arran, at Corrie, and on the W coast at Machrie Bay and were used, for example, in Skipness Castle and later in Oban."

Muasdale

The BGS Database of Mines and Quarries holds a record of a quarry at Muasdale, on the west coast of Kintyre, which sits in Permian-Triassic sandstone of the Bellochantuy Bay Formation. The BGS rock collections do not contain a sample of stone from this location but the Bellochantuy Bay Formation is described in the BGS Lexicon of Named Rock Units as:

"*... bright red, friable sandstone, with beds of breccia, however greyish white sandstone with a calcareous cement is noted at Muasdale*."

The quarry that is recorded at Muasdale may have produced the 'greyish white sandstone' as building stone.

Inninmore/Lochaline

Walker (2000) described a source of Triassic sandstone in the Inninmore/Lochaline area, but again did not record the source of his information:

"A buff-coloured Triassic sandstone was quarried from the 13th century to the 19th century between Inninmore Bay and Ardtornish (nearby Lochaline) in Morvern. This was used in both Aros and Duart Castles on the Isle of Mull."

BGS does not have rock samples of, or any record of an historic quarry in, the Triassic sandstone in this area.

3.2.4 Jurassic sandstone

Carsaig, Mull

The BGS Collection of UK Building Stones contains several samples of Jurassic sandstone from Carsaig quarry on the south coast of Mull. The samples consist of fine-grained, light greenish grey to buff sandstone which can contain dark wispy laminae (Figure 7e). Carsaig quarry has been exploited for building stone for several centuries. According to Walker (2000):

".. the sandstone quarried at Carsaig Bay ... is a greenish or buff, fine-grained sandstone of Lower Jurassic age which was widely used, particularly on Iona, but also in many other buildings on the mainland. It can be seen in the C13 part of Ardchattan Priory and in Mull in several buildings around Loch Buie."

3.2.5 Cretaceous sandstone

Lochaline

Beds of Cretaceous sandstone, assigned to the Loch Aline White Sandstone Formation, crop out in a narrow band on the west side of Loch Aline, in Morvern. This geological formation consists of very pure, white to pale yellow-brown, well sorted, medium-grained, quartz-rich sandstone (Figure 7d).

The BGS Database of Mines and Quarries contains a record of a quarry near to the village of Lochaline, which has mined silica sand for high quality glass manufacture from this formation intermittently since the mid-20th century. The material is mined as loose sand, so it seems unlikely that a building stone quarry would have been in the same location. However, the BGS Collection of UK Building Stones includes a sample from the Loch Aline White Sandstone Formation, suggesting the formation has been quarried for building stone at some time in the past. Unfortunately, BGS has no record of where the quarry was, when it was operational, or where the stone was used.

Figure 7 BGS samples of sandstone from quarries in Argyll and Arran

a – Carboniferous sandstone from Inninmore Bay. b – Carboniferous sandstone from Bridge of Awe. c – Permian-Triassic sandstone from Corrie. d – Cretaceous sandstone from Lochaline. e – Jurassic sandstone from Carsaig.

4 Castle Sween

Castle Sween is believed to be the oldest castle still standing in Scotland. It is located on a low rocky ridge on the east shore of Loch Sween, in Knapdale. The site would have provided the occupiers with an extensive view of Loch Sween, and as far as Jura.

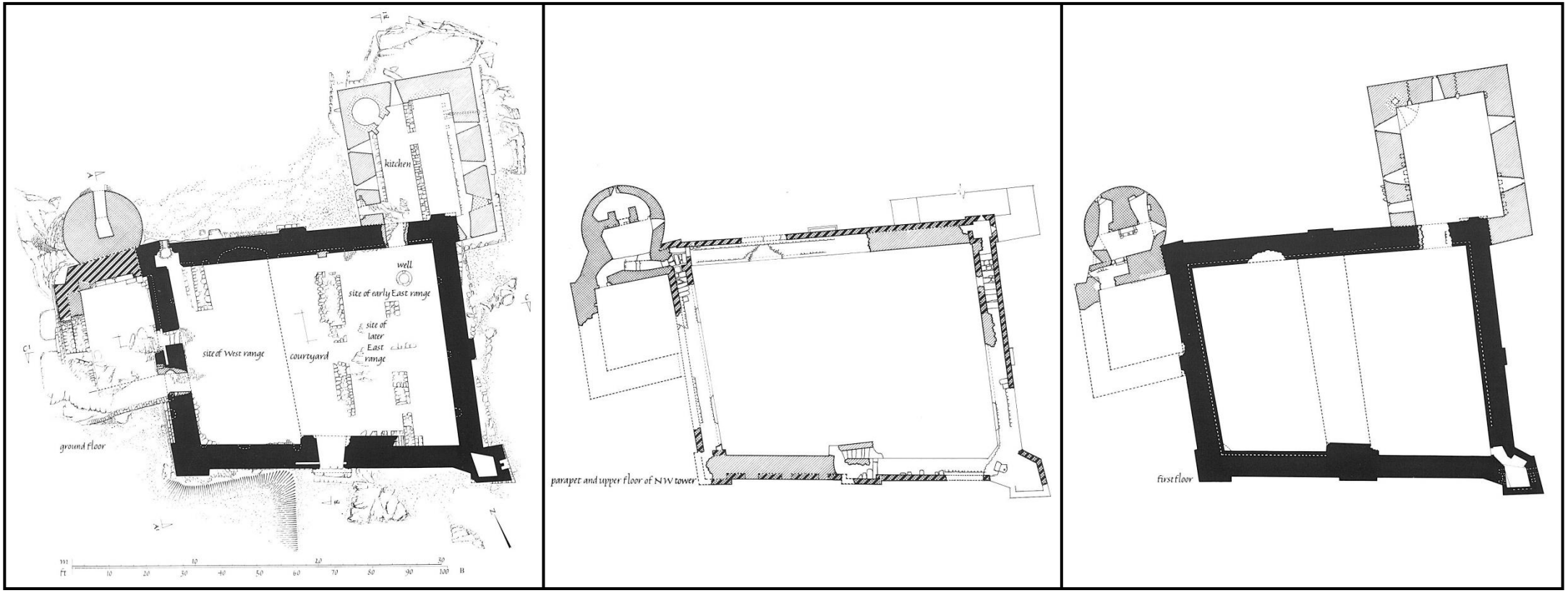
4.1 LAYOUT AND BUILDING CHRONOLOGY

The castle is comprised of a massive Curtain Wall with two towers: the West Wing Garderobe Tower, and the Northeast Tower. The entrance to the Castle is in the middle of the South Curtain Wall. The inner courtyard is comprised of ruinous East and West Ranges, and a Well. A timeline of construction and alterations for Castle Sween is presented in Table 2.

Table 2. Timeline of construction and alterations in Castle Sween

Information from RCAHMS, (1992)

Date	Action	Location or masonry element
c. 1200	Construction	Small courtyard flanked by ranges
Early 13th C	Construction	Upper parts of Curtain Walls
13th C	Construction	West Wing (single-storey, outside West Curtain Wall)
13th C	Construction	Northeast Range
Early 14th C	Construction	West Wing Garderobe Tower (3-storeys)
15th C	Construction	Northeast Tower with kitchen and chambers (outside North Curtain Wall)
15th C	Construction	East Range with Great Hall (2 to 3 storeys)
15th C	Construction	West Range
16th C	Construction	Vaults in Northeast Tower and East Range
Mid- to Late- 17th C	Abandoned	All
1985-9	Repair	All, major consolidation works



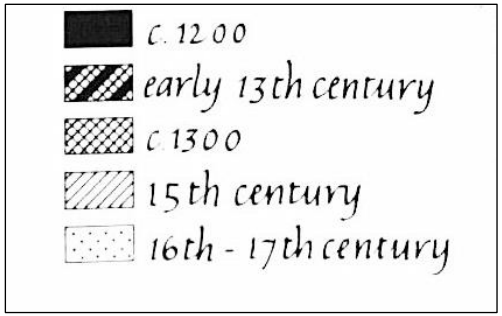


Figure 8 Plans for Castle Sween with periods of construction and alteration. Source: RCAHMS (1992), pages 246-7.

4.2 BUILDING STONES

4.2.1 Walling stone

Several different types of metamorphosed rock have been used as walling stone in Castle Sween, including metasedimentary rocks (metamorphosed sandstone and mudstone) and metamafic (igneous) rocks. The walling is generally coursed rubble style. Larger, sometimes rounded, blocks commonly of metasandstone are held with smaller, tabular pinnings of metamudstone and metamafic rock (Figure 9b); the latter rock types also occur in a range of shapes and sizes throughout the rubble walling. These rock types occur in rock outcrops by the castle that have obviously been quarried in the past, and much of the walling stone was probably sourced from outcrops and superficial deposits near to the castle.

A sample of the metamafic rock was collected from a small block that had become detached from the rubble walling. A thin section was prepared and is described in Appendix 1. The rock is foliated metamafic rock, almost certainly from an intrusion in the Dalradian Supergroup. This rock type is mapped immediately underlying Castle Sween on BGS geology maps. The bedrock c. 200m to the southeast of the castle is assigned to the Crinan Grit Formation (which consists mainly of metasandstone), and the metasedimentary rocks in the walling will have come from this unit.

4.2.2 Decorative stone

4.2.2.1 FLAGGY METAMAFITE

Tabular blocks of flaggy, strongly foliated, greenish-grey metamafite have commonly been used to form lintels and sills around door and window openings, some of which can also feature sandstone quoins (Figure 8c). This flaggy metamafic rock has similar geological characteristics to the stone at Doide quarry (Appendix 1). This observation agrees with the assessment by Walker (2000), who cited Doide quarry as a source of decorative stone used in Castle Sween:

"In medieval times the quarries at Doide on Loch Sween supplied stone slabs of the green, chlorite-albite schist for numerous crosses and tombstones, and it was also used in building for pinnings and lintels, as at Castle Sween … This outcrop has vertical joints which allow the rock to be split into slabs a few centimetres thick. It was easily carved and was the preferred stone for this purpose for many centuries".

However, the rock is essentially closely similar to some of the walling stone, and some at least may have been sourced from one or more other sites in the vicinity.

4.2.2.2 LIGHT BROWNISH GREY SANDSTONE

Blocks of uniform, fine- to medium-grained, light brownish grey sandstone have been used to form quoins and dressings, including those forming the archway at the main entrance to the castle.Figure 9a, d). All of the sandstone dressings in the castle appear to be of the same stone, which is present in all of the stages of construction. In some blocks the sandstone contains thin quartz veins, iron-stain banding and concretions. Many of the sandstone dressings are only around 20cm deep, and are placed around doors and window surrounds as well as quoins. Some sandstone blocks are experiencing rapid material loss (through scaling and granular disintegration), and some show signs of alveolisation (salt-weathering) in places Figure 9b,d).

A thin section of the light brownish grey sandstone was prepared from a fragment of stone that had fallen to the ground. The thin section reveals that the stone contains rounded, wind worn-grains of metamorphic rock that are partly enclosed in a mineral cement of calcite (Appendix 1). The wind-worn sand grains indicate the sandstone was deposited in a desert environment, and therefore is probably of Permian or Triassic age. The pale grey colour is unusual for Permian or Triassic sandstone, but greyish white Permian-Triassic sandstone with a calcite cement has been

described at Muasdale on the west coast of Kintyre (section 3.2.3). Based on the available evidence, this is the likeliest source of the sandstone in Castle Sween.

Figure 9. Decorative stone in Castle Sween

a – detail of weathered sandstone block on the E side of the main doorway in the SW elevation of Castle Sween. b - sandstone quoins showing alveolisation (deep pitting), at the SE corner of Castle Sween. c - a lintel and sill formed of tabular blocks of metamafite on the NW-facing elevation of the N side of Castle Sween. d - sandstone dressings around the main doorway in the SW elevation of Castle Sween.

5 Skipness Castle

Skipness Castle is located a short distance inland from the shore of Skipness Bay, on the east coast of Kintyre. The site would have provided the castle occupants with an open view across Kilbrannan Sound to Arran.

5.1 LAYOUT AND BUILDING CHRONOLOGY

Skipness Castle is comprised of a high Curtain Wall that encloses two earlier structures: the Hall House, adjacent to the North Curtain Wall, and Chapel, adjacent to the South Curtain Wall. Three rectangular Towers are located at the West Curtain Wall, the Northeast Corner and the Southeast Corner. The East Range was partially demolished and reconstructed as a three-storey Tower House with Parapet Walk in the northeast corner. Entrance is gained through the Gatehouse in the west section of the South Curtain Wall. Much has been altered and demolished, leaving the Curtain Walls, Towers, Hall House and Tower House. A timeline of construction and alterations for Skipness Castle is presented in Table 3.

Table 3 Timeline of construction and alterations in Skipness Castle

Information from RCAHMS (1971).

Date	Action	Location or masonry element
Early- to Mid-13th C	Construction	Hall House, Chapel
Early-14th C	Construction	Curtain Walls
Early-14th C	Remodelled	Chapel
Late-13th to Early-14th C	Construction	Northeast Corner Tower, Southeast Corner Tower, West Tower
Late-13th to Early-14th C	Construction	Entrance (South Wall)
Late-13th to Early-14th C	Construction	South and East Ranges
Early-16th C	Reconstruction	Northern section of East Range raised 3 storeys to form Tower House
Early-16th C	Construction	Parapet Walk adjacent to Tower House
Late-16th C	Reconstruction	Tower House and Parapet Walk
Late-16th C	Demolition	Southern section of East Range
Late-17th C	Abandoned	All
Late-18th C	Conversion	Farmstead
Late-18th C	Demolition	Early inner courtyard buildings (except Tower House)
Late-18th C	Construction	Lean-to buildings and offices (for use as Farmstead)
1898	Demolition	Lean-to buildings and offices
1898	Repairs	All

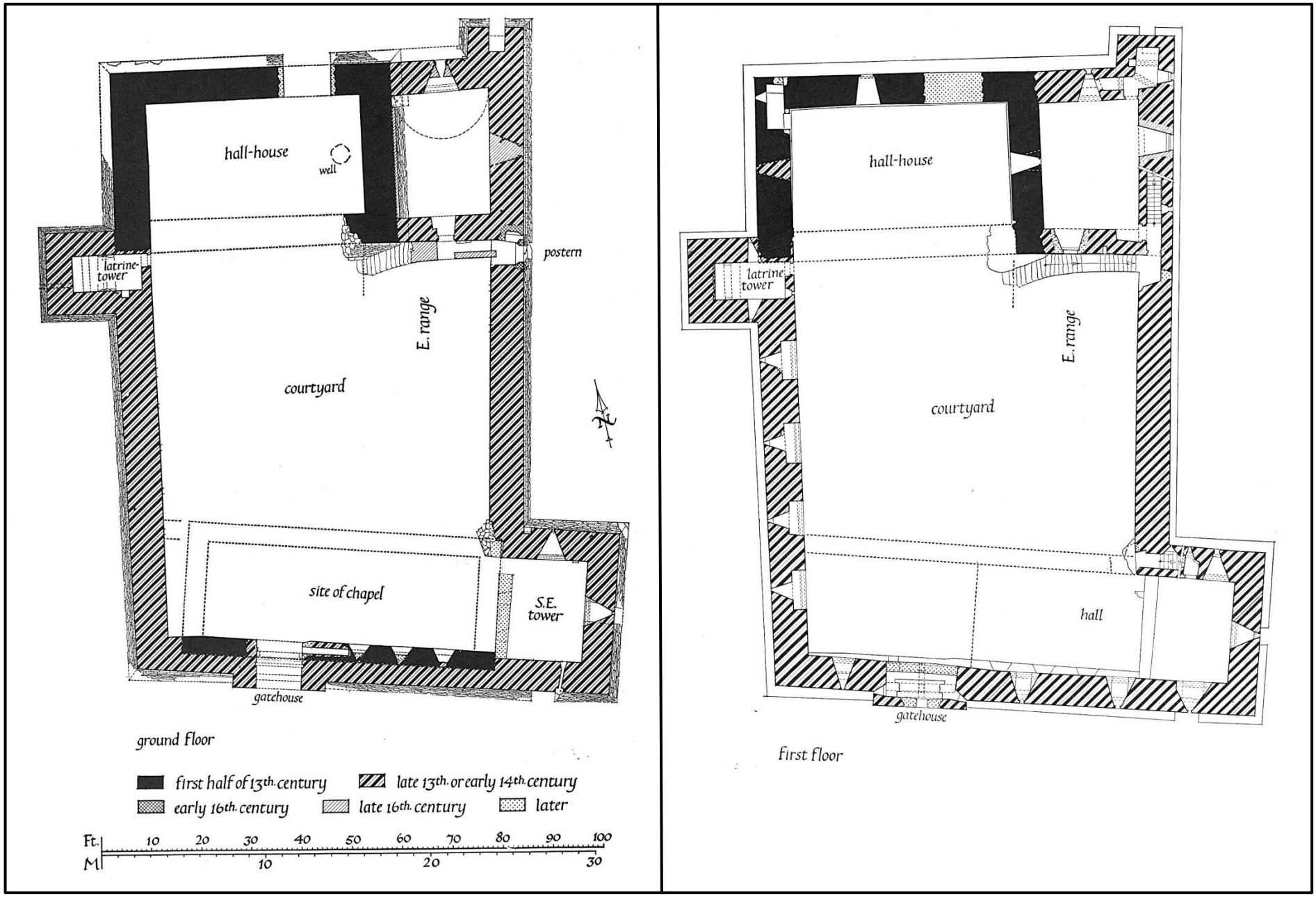


Figure 10 Plans for Skipness Castle with periods of construction and alteration. Source: RCAHMS (1971); pages 166-7.

5.2 BUILDING STONES

5.2.1 Walling stone

Virtually all of the walling masonry throughout all stages of construction is random rubble (Figure 11a), which consists almost entirely of variably foliated greenish-grey metasedimentary rock. In detail the rock consists of thinly interbedded layers of sandstone and mudstone with veins and blobs of quartz. Flakes of the platy mineral mica, which is produced during metamorphism, are aligned parallel to the metamorphic foliation plane (this is known as a *schistose* fabric).

The blocks have been shaped by splitting the stone along the foliation plane, which is a natural line of weakness. This has resulted in broadly tabular blocks, typically placed horizontally in the wall. The rock is typical of the bedrock formation that surrounds Skipness Castle, the Beinn Bheula Schist Formation, and has almost certainly been extracted locally, probably from one or more small quarries and from loose material in superficial deposits.

The same metasedimentary rock has been used in all stages of construction, indicating the stone was being sourced locally for building throughout the early 13th century until the late 16th century.

Rounded blocks of granite have been used in some parts of the walling; these would have been sourced locally from superficial deposits.

5.2.2 Decorative stone

5.2.2.1 FOLIATED METASEDIMENTARY ROCK

Relatively large, tabular blocks of the local bedrock have been used to form lintels for doors and windows (Figure 11a), and smaller blocks have been used to form archways. This stone is the same as the stone forming most of the walling, and would have been sourced from the Beinn Bheula Schist Formation. The most strongly foliated rock appears to have been used to form tabular blocks for load bearing masonry spans.

5.2.2.2 PINK SANDSTONE

Most of the decorative stone in Skipness Castle is medium-grained pink sandstone, which displays prominent parallel and cross-bedding, and is commonly cut by numerous small geological faults of a type that typically forms in porous sandstone (these are known as granulation seams, and they tend to weather proud of the surrounding stone because they consist of durable quartz). This sandstone has been used for quoins and dressings for archways, windows and doors (Figure 11a,b). It has been used to form two courses near the base of the curtain wall, indicating that it was being used in the castle from at least the early 14th century (when the curtain wall was erected to enclose the earlier hall house and chapel); however, these courses are not featured in the sections of the curtain wall that were incorporated from these older buildings. The same pink sandstone has also been used to form the decorative corbels and parapet slabs at the top of the Tower House (Figure 11c,d), indicating that the same sandstone has been used throughout all stages of building and alterations (though it is not clear whether new supplies were obtained or existing stone was recycled).

The pink sandstone is closely similar to BGS samples from Corrie quarry on Arran (see section 3.2; Figure 7). However, Permian sandstone of similar character crops out in other parts of Arran, and the stone may have come from another quarry in the same geological formation. The closest outcrop of Permian sandstone to Skipness castle is at Cock of Arran.

5.2.2.3 WHITE SANDSTONE

A small proportion of the sandstone blocks in Skipness Castle are white sandstone. The stone displays parallel and cross bedding, and some blocks are cut by granulation seams. This sandstone has been used in dressings to a side door by the postern, and forms structural corbels on the turrets of the Tower House. These elements are additions dating from the early 16th century; the white sandstone it is not featured in earlier phases of building (Figure 11. c,e).

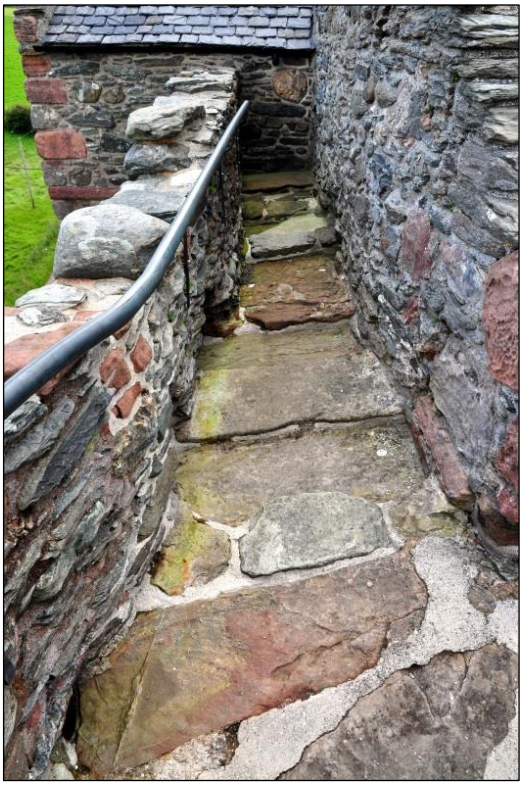
Although it is white rather than pink, this sandstone is closely similar in many respects – including the bedding character and presence of granulation seams - to the pink sandstone used elsewhere in Skipness Castle, raising the possibility that both are of similar age and from a similar location. A thin section examination of both would be required to test this hypothesis. Based on the available information, the white sandstone in Skipness Castle is likely to have been sourced from Permian or Triassic strata on Arran, possibly near to the site where the pink sandstone was extracted.

a

b

c

d



e

Figure 11. Decorative stones in Skipness Castle

a – pink sandstone window dressings and a doorway lintel formed of a tabular block of foliated metasedimentary rock. b - pink sandstone quoins at the SE corner of Skipness Castle. c – white sandstone structural corbels and pink sandstone decorative corbels at top floor level, S elevation of the Tower. d - worn paving flags of pink to buff sandstone on the N side of the Tower parapet. e – pink and white sandstone dressings around a doorway in the Curtain Wall, E elevation.

6 Dunstaffnage Castle

Dunstaffnage Castle is located at the mouth of Loch Etive, roughly 6 km northeast of Oban. The castle was built on a peninsula that extends north-eastwards from the southern shore of the loch, providing an ideal position to command the seaward approach. To the southeast of the castle Dunstaffnage Bay provides a sheltered anchorage for ships.

6.1 LAYOUT AND BUILDING CHRONOLOGY

Dunstaffnage Castle is comprised of a massive 2-storey Curtain Wall with Parapet Walk, Towers at the north and west corners, and Entrance Gateway with forestair at the east corner. The Curtain Wall foundations were laid to the configuration of the underlying rock outcrop. The inner courtyard comprises of the Gatehouse, East Dwelling House, Northwest Dwelling House, and Well. A timeline of construction and alterations for Dunstaffnage Castle is presented in Table 4.

Table 4 Timeline of construction and alteration in Dunstaffnage Castle

Information from RCAHMS (1975)

Date	Action	Location or masonry element
Mid-13th C*	Construction	Curtain Walls with Arrow Slits and Parapet Walk, North and West Corner Tower, Entrance Gateway, Gatehouse, East Dwelling House, Northwest Dwelling House, Well
Late-15th to Early-16th C	Reconstruction	Entrance Gateway
Late-16th C	Reconstruction	Gatehouse, upper storeys
Late-16th C	Remodelled	Northwest Dwelling House
Early- to Mid-17th C	Remodelled	Gatehouse, ground floor subdivision
Early- to Mid-17th C	Reconstruction	SW and SE Curtain Wall Arrow Slits (for firearm defence)
Early- to Mid-17th C	Reconstruction	Curtain Wall Parapets
Early- to Mid-17th C	Reconstruction	West Corner Tower, upper storeys
Late-17th and 18th C	Minor repairs	All
1725	Remodelled	Northwest Dwelling House
1725	Reconstruction	North end of East Curtain Wall
1725	Repairs	East Range Dwelling House
1810	Gutting	Gatehouse (due to fire)
Late-19th C	Reconstruction	Entrance Gateway Forestair
20th C	Repairs	All

*The original construction was thought to have been completed c.1220 by Duncan Dubhgall. His son, Ewen, may have added the three corner towers (including the current Entrance Gateway) at a later date.

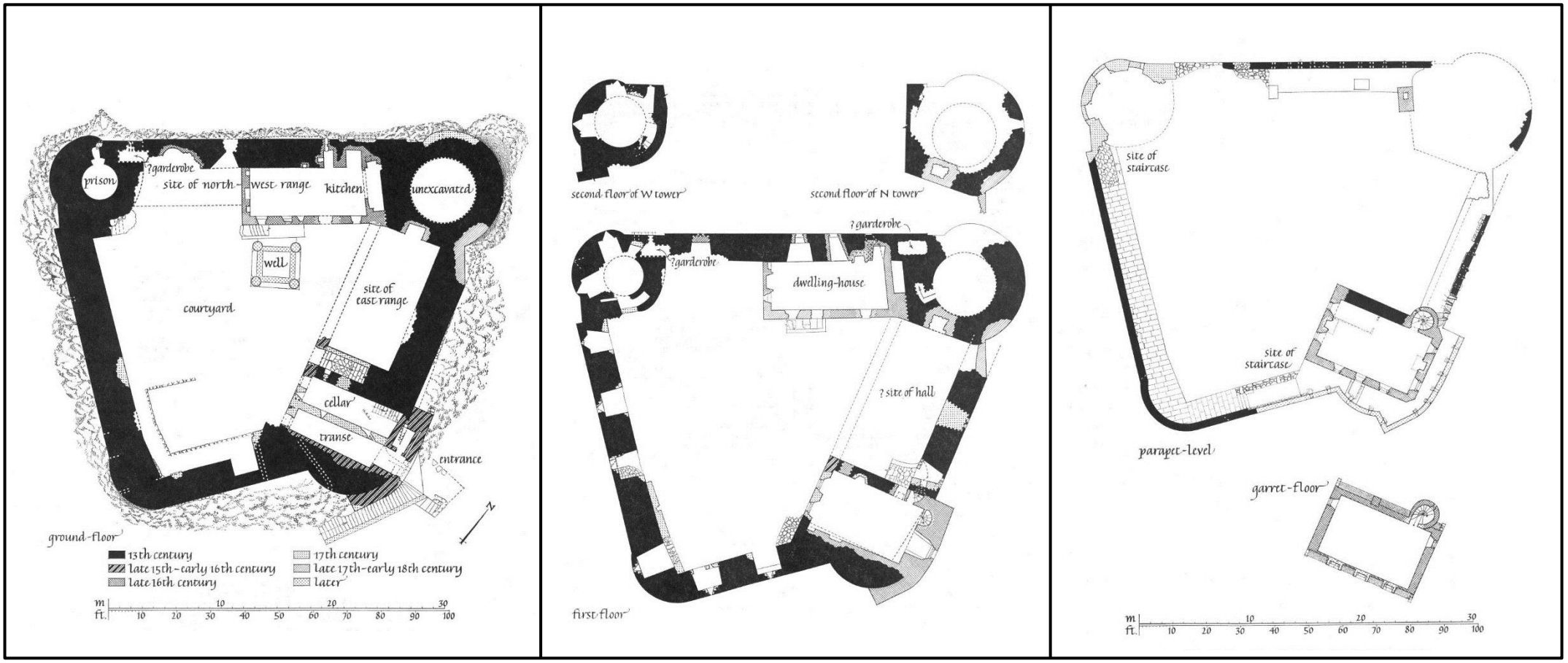


Figure 12. Plans for Dunstaffnage Castle with periods of construction and alteration. Source: RCAHMS (1975); pages 200-201, 203

6.2 BUILDING STONES

6.2.1 Walling stone

The Curtain Walls are constructed of coursed random rubble blocks with a rough natural finish. Most of these are part of the original phase of construction. The walls are well-bonded with 'pinnings' and contain numerous larger blocks and split boulders set on edge (Figure 13a). The walling stones consist mainly of lava, granite and metasandstone; these rock types are featured in all stages of the walling, although later sections include blocks of pyrite-bearing metamudstone and Devonian sandstone. Most of these materials are probably from sources local to the castle.

6.2.2 Decorative stone

Assigning different stone types to the different stages of building in Dunstaffnage castle is challenging because stones from earlier parts of the castle have been re-cycled throughout its history and because there are numerous stages of building. The East Dwelling House provides a good example. The house was erected in the 13th century but is now in a ruinous state; at the north end of the dwelling the fireplace and flue were constructed from sandstone blocks recovered from Dunstaffnage Chapel. During the year 1740 sandstone dressings were re-used following the dismantling of the East window of the Chapel and the erection of the Campbell Dunstaffnage burial enclosure (RCAHMS,1975).

In the following text only examples of building elements that probably have not been affected by re-cycling are discussed.

6.2.2.1 WHITE TO BUFF SANDSTONE

Uniform white to buff sandstone is the main decorative stone used in the Curtain Walls, and probably dates from the earliest, 13th century, phase of construction. This sandstone surrounds original, unmodified arrowslits on the curtain wall (Figure 13a,b), and forms a row of quoins on an angled corner of the Curtain Wall on the SW range of the castle (Figure 13c) which date from the earliest phase of construction. The same stone has been used in the nearby Chapel, which has a similar date of construction.

Thin sections were prepared from two detached fragments of sandstone, one from Dunstaffnage Castle and another from the Chapel (see Appendix 1). Microscope examination of these has shown that the same sandstone was used in the castle and the Chapel, and that the sandstone contains tiny fragments of carbonaceous matter (former plant matter) and iron oxide patches formed when an iron-rich carbonate mineral cement dissolved. These characteristics, and the presence of a much larger fragment of carbonaceous material in one of the sandstone blocks (Figure 13b), indicate that the sandstone is almost certainly of Carboniferous age.

The sandstone has characteristics that are broadly similar to those in BGS samples of Carboniferous sandstone from Inninmore Bay. This observation is consistent with a record in RCAHMS (1975), which states that the stone was probably sourced from Ardtornish (near Inninmore):

"Most of the 13th century dressings are formed of a rather coarse-grained stone of iron-stained buff colour … and probably deriving from the Ardtornish area"

The following statement also appears in RCAHMS (1975):

"Here and there in the early work, however, and more extensively in the later, a finer-grained stone of greenish-yellow hue is found, and this may derive from the Carsaig beds in Mull."

A greenish-yellow sandstone was not encountered during our site visit; however, many of the arrowslits and quoins are in inaccessible locations so the possibility that the castle contains a sandstone of this description cannot be ruled out.

6.2.2.2 LIGHT BUFF SANDSTONE

A light buff sandstone with buff to orange staining, featuring cross-bedding and carbonaceous laminae has been used to form surrounds of the point-arch recess and round-arch doorway, and quoins, of the Entrance Gatehouse. These modifications probably date from the late 15th century - 16th century. Some of the original dressings here are suffering from stone decay, and some of the doorway dressing stones have been replaced in modern times (Figure 13d).

The geological characteristics of this stone suggest it is Carboniferous sandstone. This sandstone and the white to buff sandstone described in section 6.2.2.1 are closely similar in many respects but not identical; nevertheless, the likeliest source of this sandstone is probably the Inninmore Bay / Ardtornish are of Morvern.

6.2.2.3 FLAGGY PURPLISH SANDSTONE

Tabular blocks of flaggy purplish sandstone, almost certainly of Devonian age, have been used to form lintels and arches in 16th century alterations, notably in and near to the Northwest Dwelling House (Figure 13e). The northwest Dwelling House was remodelled in 1725; however, incorporations of 16th century fireplaces and window dressings remain. (RCAHMS, 1975; page 205), suggesting the flaggy purplish sandstone may have been used in 16th and/or 18th century additions. This stone was probably sourced from a bed of sandstone in the Kerrera Sandstone Formation, which crops out close to the coast in several places between Dunstaffnage and Loch Feochan.

6.2.2.4 LIGHT GREY SANDSTONE

Light grey, fine-grained, uniform, quartz-rich sandstone with a granular ('sugary') texture, has been used to form fireplaces and dressings in the Northwest Dwelling House (Figure 13f). These elements probably date from the late 16th century at the earliest, but may have been introduced in later modifications.

A sample of the stone was not collected, but its appearance is closely similar to a BGS sample of Loch Aline White Sandstone (Figure 7). The available evidence therefore suggests this stone was sourced from an outcrop near Loch Aline.

6.2.2.5 GRITTY BUFF SANDSTONE

Buff, gritty sandstone that typically contains fractures and mineral veins has been used extensively in the Gatehouse, for example to form the first floor window surrounds. These are thought to date from the16th and 17th centuries, although extensive re-cycling of masonry by this time could have incorporated stone which had been used in previous structures.

The gritty buff sandstone may be Carboniferous, as its appearance is broadly similar to many Scottish Carboniferous sandstones. A sample of this sandstone type could not be collected for analysis, therefore its provenance is not constrained with greater certainty.

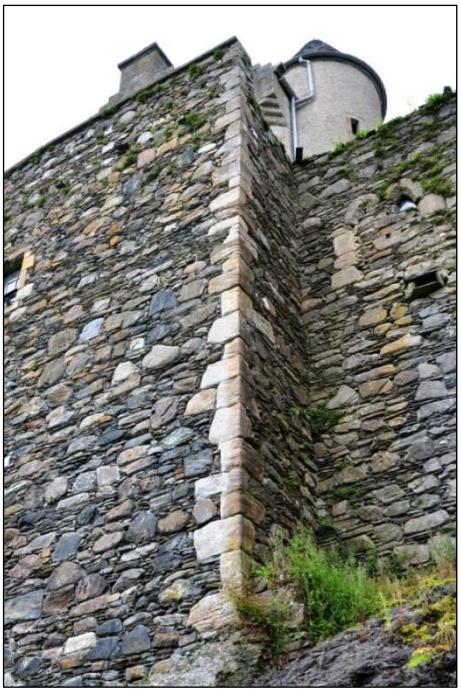
6.2.2.6 UNIFORM BUFF SANDSTONE

Blocks of uniform buff sandstone have been used to form crowsteps, chimneys, and roofing tiles on the Gatehouse roof. These features date from the mid- to late- 20th century, and the sandstone was probably imported from the Midland Valley of Scotland or from England.

6.2.2.7 PYRITE-BEARING METAMUDSTONE

A single, tabular slab of pyrite-bearing metamudstone has been used to form the lintel of an alcove in the Northwest Dwelling House kitchen. This stone has characteristics that are typical of roofing slates produced from the Easdale Slate Formation in the 'slate islands' around Easdale, and is probably originally from that area.

a  b 

c.  d 

e  f 

Figure 13. Decorative stone in Dunstaffnage Castle

a - sandstone dressings around an arrow slit in the West Tower. b – a block of weathered sandstone with a large fragment of carbonaceous matter, in the West Tower. c - sandstone quoins on the north-east elevation of Dunstaffnage Castle. d - sandstone dressings around the inner arched doorway that now forms the main entrance (east elevation) to the Castle. e - tabular blocks of purplish Devonian sandstone and metamorphic rock used to form an arch on the SW side of the Northwest Dwelling House. f – a fireplace formed of light greenish sandstone on the northwest (back) wall of the Northwest Dwelling House; the greenish colour is probably due to biogenic growth on the surface of the stone.

7 Kilchurn Castle

Kilchurn Castle is located on a peninsula at the northeast terminus of Loch Awe. It was built on a rocky outcrop, surrounded by marshy land. When the water is high, the castle appears to be on an island.

7.1 LAYOUT AND BUILDING CHRONOLOGY

Kilchurn Castle is comprised of several buildings contained within a ruinous Curtain Wall with cylindrical Towers at the north, south and west corners. The entrance to the inner courtyard is through the ground floor of the five-storey Tower House, located at the east corner. Laich Hall, now ruinous, stood on the inner face of the South Curtain Wall. Additional ranges are located to the southeast, north and northwest facing the inner courtyard. The Southeast Range contained two cellars, loft and chapel. The North and Northwest Ranges contained four-storey barrack blocks. A timeline of construction and alterations for Kilchurn Castle is presented in Table 5.

Table 5 Timeline of construction and alterations in Kilchurn Castle

Information from: RCAHMS. (1975)

Date	Action	Location or masonry element
Mid-15th C	Construction	Tower House
1475-1513	Construction	Laich Hall
Mid-16th C	Reconstruction	Tower House, upper storeys with turret corbels
1614	Reconstruction	Laich Hall, rebuilt and raised two storeys
1616	Construction	Southeast Range
1643	Repairs	Tower House and Laich Hall
1690-8	Construction	North, West and South Corner Towers
1690-9	Construction	North and Northwest Ranges
Mid-18th C	Abandoned	All
1770	Unroofed	All

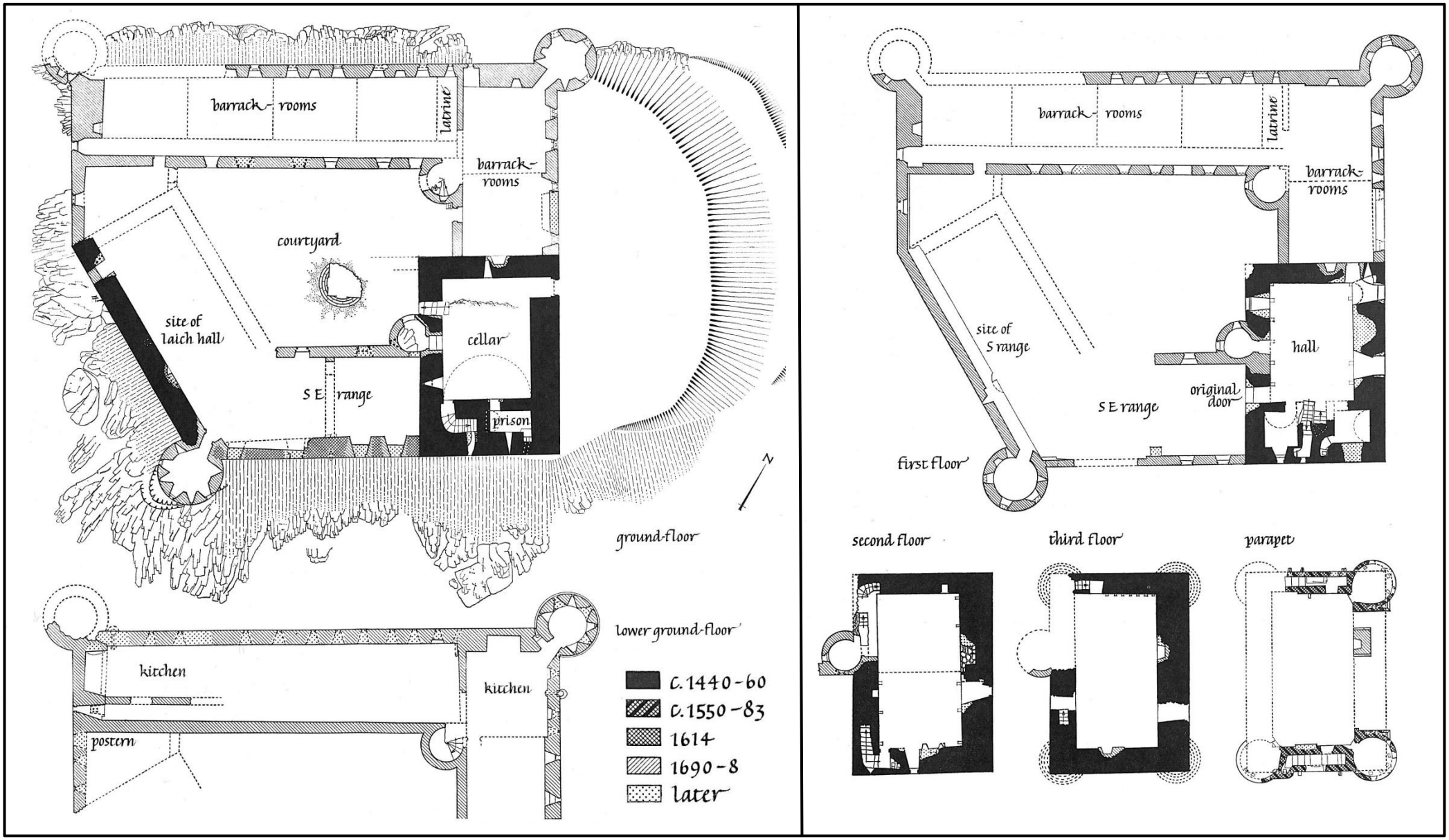


Figure 14 Plans for Kilchurn Castle with periods of construction and alteration. Source: RCAHMS (1975); pages 230, 233.

7.2 BUILDING STONES

7.2.1 Walling stones

Kilchurn Castle sits on a small outcrop of hard metamafic-rock (Figure 15a) that forms a small knoll above the surrounding softer metasedimentary rocks of the Ardrishaig Phyllite formation, which have been preferentially eroded. The knoll of metamafic rock on which the castle sits has been quarried on its east side. A sample was collected from the quarried outcrop and a thin section was prepared (Appendix 1). The castle walling commonly contains sub-tabular blocks of variably foliated metamafite, which are similar in character to the stone from the quarry. The quarry probably provided a substantial volume of stone for the castle walling.

Most of the Kilchurn Castle walling stone is variably foliated greenish-grey pyrite-bearing metamafite. Occasional rounded blocks of coarse pinkish granite are present; these are likely to have been field boulders that originally came from the nearby Cruachan Granite Pluton (a granite intrusion).

The coarse sandstone mentioned in Walker (2000) was not encountered in this project.

7.2.2 Decorative stone

7.2.2.1 FLAGGY METAMAFITE

Almost all of the decorative stone in Kilchurn Castle is strongly foliated, greenish grey schistose metamafite (many blocks contain scattered crystals of the iron sulphide mineral pyrite). Most of the dressing stones in all building phases are formed of this material, which is shaped into quoins, windows and door dressings and was used to form structural turret corbels (Figure 15b,c).

Blocks of flaggy metamafite used as decorative stones are more strongly foliated, and therefore more likely to form tabular blocks, than the metamafite used as walling stone, but they may both have been sourced from the same bedrock unit. Both are typical of metamafic rocks found extensively in the Dalradian Supergroup around the north end of Loch Awe.

Some shaped blocks, which may represent re-used decorative stone from previous reconstructions of the castle, are present in later stages of the walling (Figure 15d). Blocks used to form a doorway surround on the top floor of the tower may consist of pyroclastic rock (Figure 15e); thin section examination would be needed to test this hypothesis.

All of the walling and decorative stones used in Kilchurn castle are essentially similar in character throughout all stages of the castle construction.

Figure 15. Decorative stone in Kilchurn Castle

a - quarried bedrock beneath Kilchurn Castle; looking NNE towards the SE Tower. b - dressed stone blocks around a window opening between the ground floor and first floor of the Keep. c – the Keep. d – random rubble walling showing re-use of dressed blocks within the walling. e - surface detail of a dressed stone block forming the left side of an open doorway on the top floor of the Keep; the stone is weathered (pitted), greenish-grey, foliated metapyroclastic-rock with scattered large crystals of tarnished pyrite.

8 Kisimul Castle

Kisimul Castle is located on a small island off Castlebay on the island of Barra in the Outer Hebrides. A single piece of decorative stone from Kisimul Castle was provided to BGS by Historic Scotland, and a thin section for petrographic analysis was prepared (see Appendix 1).

The sample is a thin tabular block, c. 20x15x5cm, of greyish-green metamafic rock. Thin section examination reveals that the rock has a very strong planar foliation suggesting it has been very strongly deformed to the extent that the constituent crystals have deformed in a plastic manner and have been drawn out in long 'ribbons' (the geological term for this type of texture is *mylonitic*). Zones of very strongly deformed rock (mylonite) are common on Barra, and much of the rest of the Outer Isles, and this decorative stone therefore is likely to have been sourced from an outcrop near to Kisimul Castle.

9 Summary and conclusions

This study of the provenance of building stones in galley castles has produced the following conclusions. A summary of the conclusions is presented in Table 6.

- The main bedrock in Argyll is a thick sequence of sedimentary strata with intrusions and extrusions of igneous rock (the Dalradian Supergroup). The entire sequence was folded and metamorphosed during a major geological event (the Caledonian Orogeny) 470 million years ago involving the closure of an ocean and collision of continents.
- All the metamorphosed rock in the Dalradian Supergroup has a weak to strong *foliation* (a planar, parallel arrangement of the constituent minerals along which the rock splits preferentially, producing tabular blocks).
- Most of the Dalradian Supergroup consists of metamorphosed sedimentary rocks, but metamorphosed intrusions of silica-poor igneous rock (metamafite) are relatively abundant around Loch Awe and in Knapdale.
- Outcrops of sandstone are relatively rare in Argyll, but small exposures occur in several localities close to the mainland coast and on some of the outlying islands. Beds of Devonian sandstone crop out close to the coast between Dunstaffnage and Knapdale. In places, sandstone strata of Carboniferous, Permian, Triassic, Jurassic and Cretaceous age crop out in coastal exposures where they are preserved beneath beds of Palaeogene lava that erupted due to a period of rapid crustal thinning as the Atlantic Ocean opened 60 million years ago. A sequence of sandstone beds of Carboniferous, Permian, Triassic, Jurassic and Cretaceous age crops out at Ardtornish and Inninmore Bay, in Morvern. Jurassic and Cretaceous sandstones crop out nearby, at Lochaline. A small outcrop of Carboniferous sandstone occurs at Bridge of Awe. Permian sandstones also crop out in small exposures on the west coast of Kintyre (the Bellochantuy Bay Formation) and quite extensively on the coast of Arran (the Corrie Sandstone). Jurassic and Cretaceous sandstones crop out at Carsaig on the south coast of Mull.
- In all of the Argyll castles, the main walling stones are derived from the local Dalradian Supergroup bedrock and/or from loose (superficial) deposits lying on top of the Dalradian bedrock. In each case, the walling stones very probably would have been sourced close to the castle.
- In Castle Sween the walling stone consists mainly of blocks of metamorphosed sandstone and metamafite (both Dalradian). The castle sits on an outcrop of Dalradian rocks that has been quarried quite extensively.
- In Skipness Castle the walling stone consists mainly of blocks of metamorphosed muddy sandstone; this is typical of the local Dalradian bedrock (the Beinn Bheula Schist Formation).
- In Dunstaffnage Castle the walling stone consists mainly of blocks of metamorphosed sandstone (Dalradian), granite (sourced from superficial deposits but probably originally from the Ben Cruachan Granite Pluton), and lava (sourced from superficial deposits but originally from the nearby Lorne Plateau Lava Formation).
- In Kilchurn Castle the walling stone consists mainly of blocks of metamafite. The castle sits on an outcrop of metamafite that has been quarried quite extensively. The walling stone was probably sourced from this outcrop, from other outcrops of metamafite around the north end of Loch Awe, and from nearby superficial deposits.

- In Kilchurn Castle, virtually all of the decorative stones consist of metamorphosed igneous rock. There may be two types: metamorphosed intrusive mafic igneous rock, and metamorphosed pyroclastic-rock. Both were probably sourced from outcrops around the north end of Loch Awe. A few blocks of pink sandstone are recorded in Kilchurn Castle (not seen by BGS). These are believed to have come from a castle on nearby Fraoch Eilean and originally from the outcrop of Carboniferous sandstone at Bridge of Awe.
- In the three other Argyll castles most of the decorative stone is sandstone, but a small proportion is flaggy metamorphosed rock.
- In Castle Sween tabular blocks of metamafite used mainly to form lintels and sills were almost certainly sourced from outcrops close to the shore of Loch Sween, possibly including the nearby quarries at Doide. The main decorative stone is light brownish grey, poorly consolidated aeolian (desert) sandstone. An outcrop of stone with similar characteristics is described in BGS records at Muasdale on the west coast of Kintyre; this is considered to be the likeliest source of the sandstone dressings in Castle Sween, though further evaluation is required to test this.
- In Skipness Castle tabular blocks of the local bedrock stone (Beinn Bheula Schist Formation) have been used to form lintels and sills. The original (and main) decorative stone is pink sandstone which is typical of Permian sandstones and almost certainly came from Arran. Blocks of white sandstone were used in the 16th century to form structural corbels on the tower and scattered replacements for pink sandstone dressings. This sandstone shares several characteristics with the pink sandstone and may be a 'bleached' Permian sandstone from Arran.
- The oldest sandstones in Dunstaffnage Castle a white to buff and a light buff sandstone are likely to be Carboniferous sandstones and probably come from the Inninmore Bay / Ardtornish area of Morvern. Tabular blocks of purplish Devonian sandstone, probably from nearby outcrops of the Kerrera Sandstone Formation, were introduced in the 16th century and used to form arched openings, lintels and sills and some walling stone blocks. Blocks of white sandstone have been used to form two fireplaces in the 16th century dwelling house, and a large column (recycled lintel?) now supporting a more recent stairway. This sandstone may have been sourced from the Loch Aline White Sandstone Formation, at Loch Aline in Morvern. A single tabular block of pyrite-bearing metamorphosed mudstone has been used to form a lintel in the 16th century dwelling house; this is likely to have come from the Easdale Slate Formation, probably from the Easdale and 'slate islands' area.
- A sample of the decorative stone from Kisimul Castle is very strongly foliated (mylonitic) metamafic rock. The intensity of deformation is typical of rocks from the Outer Isles, and the rock was probably sourced from an outcrop near to Kisimul Castle
- The evidence from this study suggests that metamorphic sedimentary and igneous rocks forming part of, or emplaced into, the Dalradian Supergroup were selected for their functional properties (splitting along foliation) during the construction of the Argyll galley castles; they are not from a common source and probably were collected from the nearest available source of strongly foliated stone (good for forming tabular blocks) that was known to the castle builders.
- The sandstones have come from many sources, probably all of which were in the Argyll coast and Arran area. The castle builders clearly were prepared to transport these decorative stones over considerable distances by sea.

Table 6 Summary of building stone provenance in Argyll galley castles, based on geological evidence

Site	Walling stones					Decorative stones				
	Main stone type(s)		Bedrock unit	Source area	Sample	Stone type	Bedrock unit	Source area	Sample	Masonry elements
Castle Sween	metasedimentary rock		*Crinan Grit Formation*	probably mainly from outcrops and superficial deposits close to the castle	N/A	foliated metamafite	Dalradian - *'Metabasaltic-rock'*	Loch Sween coast, possibly including Doide quarry	N/A	lintels and sills
	metamafite		*Dalradian Supergroup*		ED11449	light brownish grey sandstone	Permian - *Bellochantuy Bay Formation*	Muasdale, Kintyre	ED11441	quoins, window surrounds and door surrounds
Skipness Castle	variably foliated metasedimentary rock occasional rounded blocks of granite		*Beinn Bheula Schist Formation*	probably mainly from outcrops and superficial deposits close to the castle	ED11448	foliated metasedimentary rock	*Beinn Bheula Schist Formation*	probably mainly from outcrops close to the castle	N/A	lintels on some doors and windows; smaller blocks used to form archways
						pink sandstone	Permian-Triassic - *Corrie Sandstone*	Arran	N/A	quoins, window and door surrounds, archways, parapet slabs; the main dressing stone
						white sandstone	Permo-Triassic - *New Red Sandstone Supergroup*	Arran or Kintyre	N/A	corbels on the tower and random dressings (repair?)
Dunstaffnage Castle	original walling	volcanic rock - lava	*Lorn Plateau Volcanic Formation*	probably mainly from outcrops and superficial deposits close to the castle	N/A	white to buff sandstone	Carboniferous - *Scottish Coal Measures Group*	Inninmore Bay, Morvern	ED11439 (castle); ED11440 (chapel)	quoins, window and door surrounds, arrow slit surrounds and archways; the original dressing stone, much recycled
		granite	*Cruachan Granite Pluton*			light buff sandstone	Carboniferous - *Scottish Coal Measures Group*	Inninmore Bay, Morvern/	N/A	the main doorway surround and nearby quoins in the late 15th / early 16th C
		pasmmite	*Dalradian Supergroup*			flaggy purplish sandstone	Devonian – *Kerrera Sandstone Formation*	probably local	N/A	lintels and arches in 16th C alterations
	later additions / modifications	pyritic metamudstone	*Dalradian Supergroup*			light grey sandstone	Jurassic – *Loch Aline White Sandstone Formation*	Lochaline area, Morvern or Carsaig?	N/A	two first floor fireplaces in the dwelling house and a large block (recycled lintel?) supporting a stairway
						pyritic metamudstone	*Easdale Slate Formation*	the 'slate islands' around Easdale	N/A	an alcove lintel in the kitchen of the dwelling house
		Devonian sandstone	*Kerrera Sandstone Formation*			gritty buff sandstone	Carboniferous	not known	N/A	first floor window dressings of gatehouse
						uniform buff sandstone	Carboniferous	not known; possibly Midland Valley	N/A	dressings in the gatehouse tower
Kilchurn Castle	variably foliated metamafite		outcrop immediately adjacent to the castle		N//A	well foliated pyritic metamafite	*Tayvallich Volcanic Formation/Dalradian Supergroup*	unidentified quarry in Loch Awe area	N/A	quoins, lintels, sills, corbels on tower, door & window surrounds

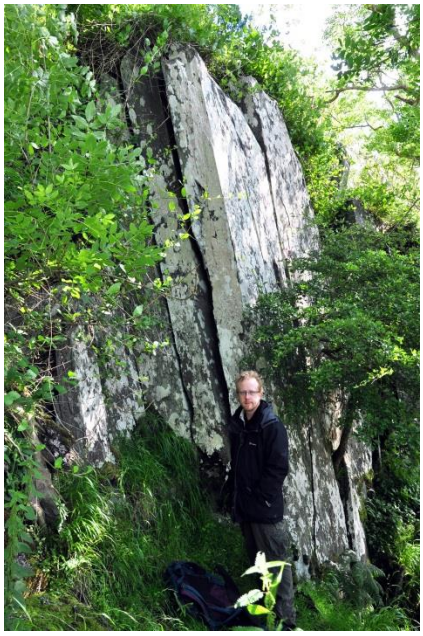
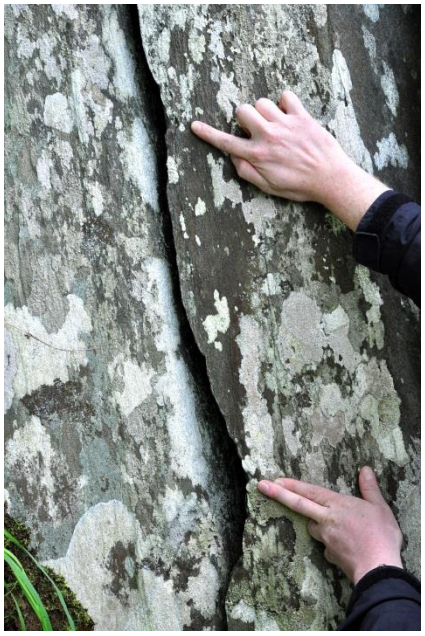
Appendix 1 – Sampling and petrographic descriptions

Details of sample collection and petrographic descriptions of thin sections are provided for the following sampled locations:

Location	Type	Sample number	Stone type
Doide quarry	quarry sample	ED11442	Metamafic rock
Lag na Luinge quarry	quarry sample	ED11445	Metamafic rock
Kilchurn Castle quarry	quarry sample	ED11447	Metamafic rock
Dunstaffnage Castle	decorative stone	ED11439	Sandstone
Dunstaffnage Chapel	decorative stone	ED11440	Sandstone
Castle Sween	decorative stone	ED11441	Sandstone
Castle Sween	walling stone	ED11449	Metamafic rock
Kismul Castle	decorative stone	ED11450	Metamafic rock

SAMPLE ED11442 – DOIDE QUARRY

Sample collection and visual observations


The sample was collected from a large pit, 25m wide, 20m deep, located below Doide farmhouse (located at OS Grid Ref: [NR 7041;7688]). The outcrop consists of near vertical, highly tabular slabs of rock, (typically 20-40cm thick) cut by parallel joints (photograph above left). The presence of tool marks are evidence of quarrying activity in the past (photograph above centre). The sample is a strongly foliated, dark greenish grey metamafic rock (photograph above right). A number of rock exposures along a crag by the shore have probably also been quarried.

Thin section observations

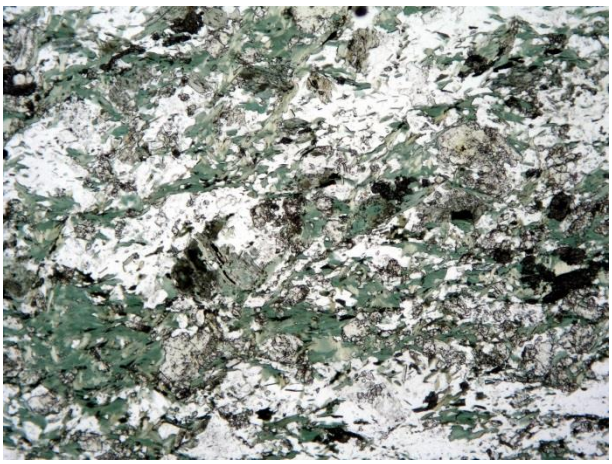

The sample from Doide quarry is a medium-crystalline metamorphic rock containing the minerals chlorite (appears green in thin section photographs above), calcite, quartz, (both appear white) and iron oxide (black). Elongate mineral components define a strong foliation in the stone. These mineral-textural features allow the stone to be classified as a quartz-chlorite-calcite schist. The images above were taken in plane-polarised light, and the field of view is c.3.3 mm wide.

SAMPLE ED11445 – LAG NA LUINGE QUARRY, LOCH AWE

Sample collection and visual observations

The sample was collected from a rock exposure in a large pit located nearby Lag na Luinge, by Loch Awe (located at OS Grid Ref: [NN 1257; 2553]). The shape of the pit outcrop and relatively un-weathered rock surfaces suggest that this site was once quarried for stone. A smaller pit also exists c. 20m to the north. The sample is a very weakly foliated, greenish grey metamafic rock (photograph above right). Quartz/calcite veins traverse the stone in the quarry, and are both concordant and discordant to the foliation. The quarry displays generally parallel joint spaces and could have yielded tabular blocks of stone.

Thin section observations



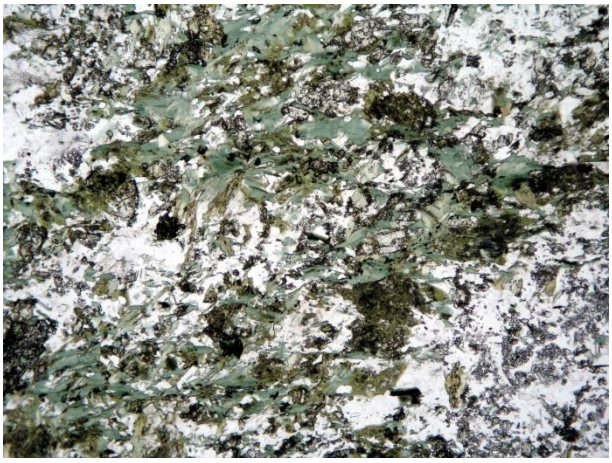
The sample from Lag na Luinge quarry is a fine-to-medium crystalline metamorphic rock containing the minerals chlorite (appears green in thin section photographs above), quartz (which appears white), epidote, titanite (appear as mottled grey patches) iron oxide, and pyrite (both appear black). The mineral constituents are broadly aligned, defining a weak foliation in the stone. These mineral-textural features allow the stone to be classified as a quartz-chlorite-epidote -titanite schist. The images above were taken in plane-polarised light, and the field of view is c.3.3 mm wide.

SAMPLE ED11445 – KILCHURN CASTLE QUARRY

Sample collection and visual observations

The sample was collected from a rock exposure located c. 10m to the south of Kilchurn Castle, by Loch Awe (located at OS Grid Ref: [NN 1328; 2761]). Part of this exposure at the base of the castle appears to form a "scoop" which has almost certainly been quarried for building stone in the past; "unquarried" sections of the outcrop nearby show evidence of glacial erosion on exposed surfaces, whereas the quarried faces do not. The outcrop is generally cut by oblique joints which would have been exploited as planes of weakness, allowing the extraction of sub-tabular blocks for masonry. The sample is an un-foliated, greenish grey metamafic rock (photograph above right).

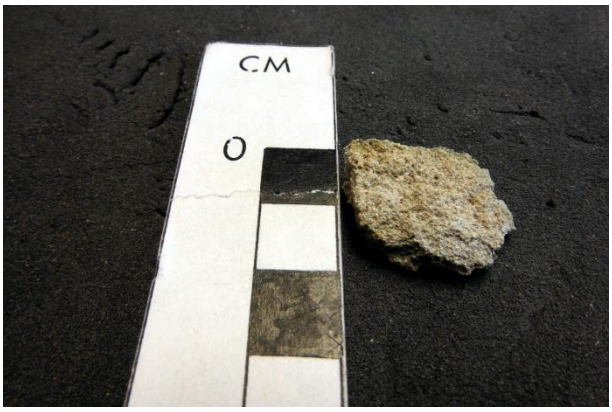
Thin section observations



The sample from Kilchurn Castle quarry is a fine-to-medium crystalline metamorphic rock containing the minerals chlorite (appears green in thin section photographs above), quartz, calcite (which both appear white), epidote, titanite (appear as mottled grey patches) iron oxide, and pyrite (both appear black). The mineral constituents define a very weak alignment; the stone is very weakly-foliated. These mineral-textural features allow the sample to be classified as a quartz-chlorite-epidote-titanite-calcite granofels. The images above were taken in plane-polarised light, and the field of view is c.3.3 mm wide.

SAMPLE ED11439 – DUNSTAFFNAGE CASTLE – SANDSTONE DRESSINGS

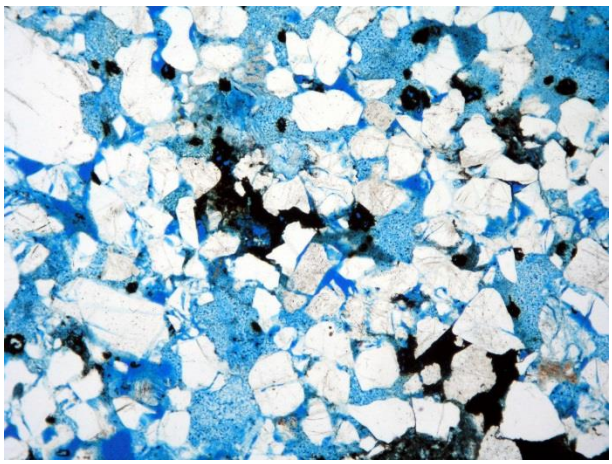
Sample collection and visual observations

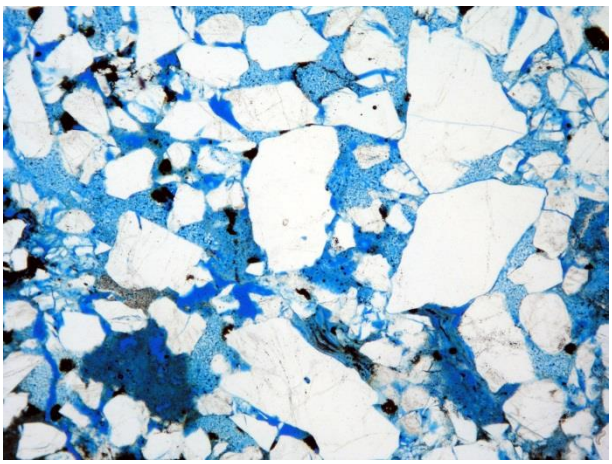


The sample represents a small (c. 1.5x1.5x1cm) fragment of the window dressings of the northwest facing, ground floor level window of the east tower of Dunstaffnage castle (photograph above, at left). The stone is a uniform, white to buff sandstone, which in places contains some coarse, gritty fragments. The sample collected was a small fragment (photograph above, at right), which has detached from one of the blocks forming the window dressings. It was compared to the stone in the window dressings to ensure that it is representative.

Thin section observations

The sample is a medium to coarse sand-grade, sub-feldspathic arenite. The sample reacts weakly to 10% HCl solution, indicating the presence of a carbonate mineral. It contains minor volumes of rock fragments, mica, carbonaceous matter (plant fragments) and iron oxides, which appear to have been re-mobilised from an iron-bearing carbonate mineral which has now almost entirely dissolved. The sand grains forming the stone are moderately poorly sorted and typically sub-angular.





The images above were taken in plane-polarised light, and the field of view is c.3.3 mm wide. Grains of quartz and feldspar appear white. The black areas are mostly iron oxide particles; some are carbonaceous matter (charred plant material). Pore space appears blue.

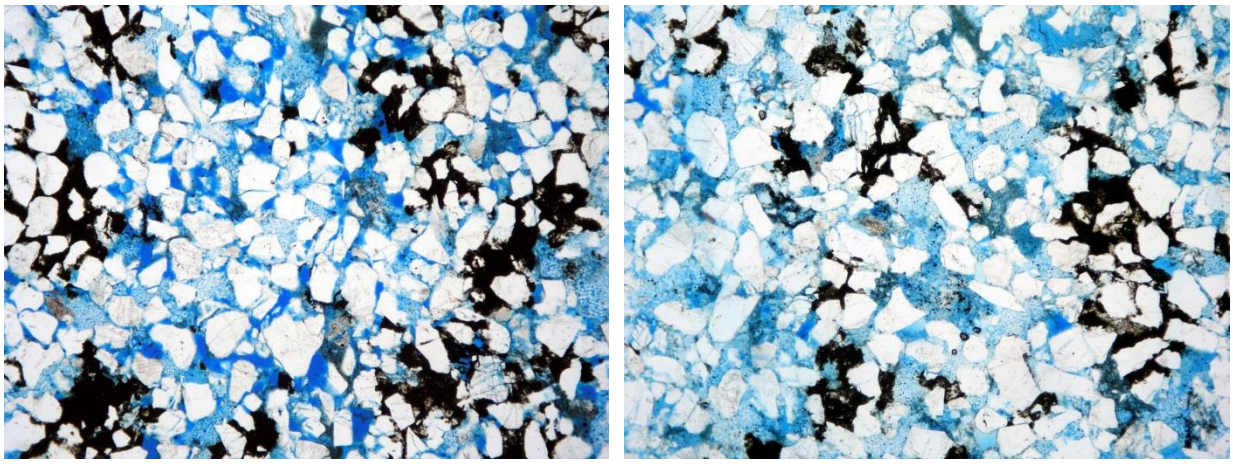
SAMPLE ED11440 – DUNSTAFFNAGE CHAPEL – SANDSTONE DRESSINGS

Sample collection and visual observations

The sample represents a small (c.3x3x2cm) fragment of the window dressings of the north facing, paired windows of the north elevation of Dunstaffnage Chapel. (photograph above). These are thought to have been constructed at a similar time to the mid-13th century sections of Dunstaffnage castle. The stone is a uniform, white to buff sandstone. The sample collected was a small fragment which has detached from one of the blocks forming the window dressings. It was compared to the stone in the window dressings to ensure that it is representative.

Thin section observations

The sample is a fine grained, sub-feldspathic arenite, containing minor proportions of rock fragments, mica, and carbonaceous matter (plant fragments). The sample contains abundant iron oxides in intergranular spaces which are associated with a (presumably iron-bearing) carbonate mineral, from which they have been re-mobilised. The sand grains forming the stone are moderately sorted and typically sub-rounded.



The images above were taken in plane-polarised light, and the field of view is c.3.3 mm wide. Grains of quartz and feldspar appear white. The black areas are mostly iron oxide particles; a some may be carbonaceous matter (charred plant material). Pore space appears blue.

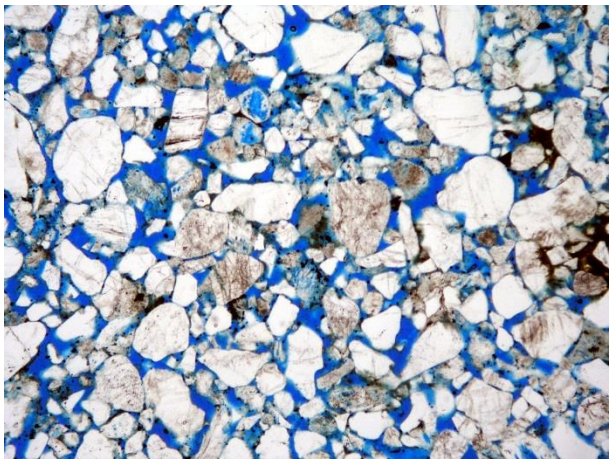
SAMPLE ED11441 – CASTLE SWEEN – SANDSTONE DRESSINGS

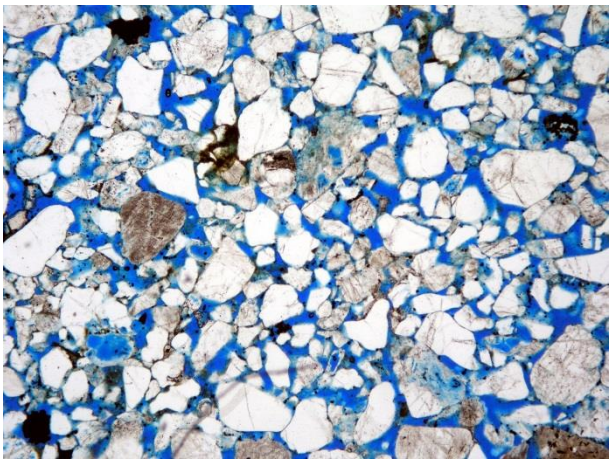
Sample collection and visual observations

The sample represents a number of fragments from the quoins of a protruding section of the curtain wall on the east elevation of Castle Sween (photograph above, at left). The stone is a fine to medium-grained uniform, light brownish grey sandstone. The sample is a number of small fragments (photograph above, at right) which were found on the ground having detached from one of the blocks forming the quoins. It was compared to the stone in the quoins to ensure that it is representative of the sandstone used as the a decorative stone in Castle Sween.

Thin section observations

The sample is a fine- to medium-grained, sub-feldspathic arenite. The sand grains forming the stone are moderately poorly sorted; the fine-sand-grade grains are typically sub-angular while the medium-sand-grade grains are typically rounded; a significant proportion of these are of metamorphic type. The sample reacts vigorously with 10% HCl solution, indicating the presence of a carbonate mineral (likely calcite). Fringes of carbonate observed around pore spaces suggest that a greater proportion of carbonate mineral was formerly present, but this has since dissolved due to weathering.





The images above were taken in plane-polarised light, and the field of view is c.3.3 mm wide. Grains of quartz and feldspar appear white. Mottled grey to brown grains are rock fragments. Pore space appears blue.

SAMPLE ED11449 – CASTLE SWEEN – FLAGGY METAMAFIC ROCK

Sample collection and visual observations

Sample ED11449 was collected from the ground on the exterior of the west curtain wall of Castle Sween (photograph above, at left). The sample is an entire masonry block consisting of light greenish grey metamafic rock (photograph above right) which was found detached from the castles' walling. It is variably covered in a light green patina of biogenic growth (algae). The sample was compared to the flaggy metamafic rock used in the castle; it is representative of the material used in much of the castles' lintols and sills as well as in parts of the rubble walling.

Thin section observations

The sample is a fine-to-coarse crystalline metamorphic rock containing the minerals chlorite (appears very pale green in the thin section photograph above) quartz, (white) epidote (appears as light grey mottled grey patches), and titanite (dark grey patches). The mineral chlorozoisite is also present in minor proportions. The mineral constituents are aligned, defining a foliation in the stone. These mineral-textural features allow the stone to be classified as a quartz-chlorite-epidote-titanite schist. The sample is traversed by <0.25mm wide microfractures which are infilled with quartz and calcite; these are concordant (parallel) to the foliation. The images above were taken in plane-polarised light, and the field of view is c.3.3 mm wide.

SAMPLE ED11450 – KISIMUL CASTLE

Sample collection and visual observations

A sample of dressing stone (photograph above) from Kisimul castle was provided to BGS by Historic Scotland staff; the site was not visited by BGS, but it is assumed to be representative of the main dressing stone type used in the castle. The sample is a greyish green, tabular piece of metamafic rock.

Thin section observations

The sample is a very fine-crystalline metamorphic rock. Ribbons of very fine-crystalline material (mainly quartz – appearing white in thin section, and chlorite – green) indicate that substantial grain size reduction has occurred due to mechanical breakage of larger grains associated with strong shear deformation. The orientation of these ribbons defines a strong foliation in the sample. Medium-crystalline porphyroclasts of quartz, chlorite and epidote are also present. These mineral-textural features allow the sample to be classified as a quartz-chlorite-epidote mylonite.

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.

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