Constructing Lordship in North Atlantic Europe

the archaeology of masonry mortars in the medieval and later buildings of the Scottish North Atlantic.

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VOLUME III – CONTENTS

THE CASE STUDIES:

APPENDIX 7 - CASE STUDY

EAGLAIS NA H'AOIDHE, LEWIS

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Constructing Lordship in North Atlantic Europe. Vol. III.

Appendix case study 7.

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SUMMARY

A comprehensive mortar sampling and lab-based analysis programme was undertaken at the medieval and later church of *Eaglais na h'Aoidhe*. These analyses generally support the previous *in situ* characterisations which had suggested a series of contrasting and phase-specific mortar sources had been used in the building, and that a general progression from limestone-lime to shell-lime mortars is in evidence. Some refinement of limestone sources and new evidence for the use of peat as a lime-burning fuel is reported, whilst further discussion suggests possible revisions to some small but significant details of the development of the structure.

CONTENTS

1.0 EAGLAIS NA H'AOIDHE - MORTAR, MASONRY & ENVIRONMENT SURVEY

1.1 ENVIRONMENT SURVEY

The church of Eaglais na h'Aoidhe is located at NB4846 3226 just north of the town of Stornoway on the east coast of the Isle of Lewis (O.S. 1851a).

1.1.1 UNDERLAYING GEOLOGY

Although the geology of the Isle of Lewis is almost completely dominated by the highly metamorphosed quartzofeldspathic gneisses to which the island gives its name, in much of the parish of Stornoway this basement geology is overlain by a thick series of Mesozoic conglomerate, sandstone and siltstone sediments (Johnstone and Mykura 1989, 22, 147; British Geological Survey 1992). Exposed outcrops of this series form low sea cliffs on both sides of the 'point' peninsula on which *Eaglais na h'Aoidhe* is located, and a large coastal section begins only a few metres from the church site itself.

Some very small and isolated possible sources of calcareous rock have been reported in the Outer Hebrides, and these include outcrops of marble in south Harris (Goodenough and Finlayson 2006), some indurated beachrock at sites in western North Uist (Kneale & Viles 2000), and a bed of fossiliferous marine shells in north and east Lewis, at coastal exposures in Ness, Tolsta and Garrabost (Etheridge 1876; Baden-Powel 1938).

The coastline of Garrabost was subject to walkover survey early in this thesis research, and an exposure of probable aeolianite was recorded at Garrabost around NB 505 337, and that this deposit had been previously quarried was suggested by large, if overgrown, excavations here.

Across the Outer Hebrides, however, most of these isolated calcareous deposits had still not been reported by the late 18th-century when, for instance, the Statistical Account for the Isle of Harris states that 'There is neither marble nor limestone nor freestone yet discovered' Macleod (1791-99: 372). House construction in the town of Stornoway in this period required that '...all the materials are imported, the stones not excepted…' (Mackenzie 1791-99: 242-3), although by the early 19th-century 'a little lime at Garrabost' was reported (Cameron 1833, 120). Whether this can be attributed to Headrick's [1800] recent survey of the island resources, and to what use the lime was put is not known, but that this reference can be related to the Garrabost quarry workings noted during walkover survey is likely. That this deposit is only 1.5 miles from *Eaglais na h'Aoidhe*, and only one mile from the kiln depicted on the contemporary Ordnance Survey map at Aignais House (O.S. 1851b) is notable. On a wider geographical scale, the closest extensive calcareous rock outcrop is the dolomite of Assynt, whilst the nearest sites of 19th-century commercial lime production are probably those associated with the limestones of Sutherland or Broadford (Skye).

1.1.2 SHORE SURVEY

An extensive survey of available shore materials was undertaken for the previous project (see Thacker 2011; Knott and Thacker 2011), and was not repeated here. This work was mostly concerned to identify building stones and aggregates and only very small shell assemblages are evident in the locality. It is, however, worth noting that large shellfish populations were consistently reported in the bays surrounding the church from the 17th including:

'... clams, oysters, cockles, mussels, limpets, whelks, spout-fish; of which last there is such a prodigious quantity cast up out of the sand of Loch Tua, that their noisome smell infects the air...and this they say happens most commonly once in seven years.' (Martin [1695] 1999, 16).

One of the most likely contexts for this event is *Traigh Mealboist* and the Tong Sands (O.S. 1851c), part of which is known as 'cockle ebb', and where from the 19th-century it was again reported that:

'At Tong, Coll, Gress, and Melbost Sands, in the broad Bay, a great variety of shell-fish is found;- clams, mussels, limpets, whelks, razor fish and cockles. All these kinds are found on the Melbost Sands, after a severe storm. The natives expect a bursting of the shell-fish banks, once in seven years; then, immense masses are thrown up and found at low water; but this bursting happens oftener than once in the seven years. The reporter has seen huge heaps thrown ashore, twice during that period, - which employed many carts and creels, for several days, in carrying them away for food and manure...In the sands of Tong, fine large blue cockles are found, very little inferior to oysters.' (Cameron 1833, 123)

1.1.3 WOODLAND AND FUEL

Like much of the Outer Hebrides, excepting recent plantations, the Isle of Lewis is largely treeless. A treeless parish landscape was also reported in both Statistical accounts (Mackenzie 1791-99, 253; Cameron 1833, 124), and the only cartographic woodland evidence recorded by the 19th-century Ordnance Survey is associated with the plantation around Lews Castle and Mary Hill (1851c).

In their seminal reconstruction of Scottish pre-clearance woodland MacVean and Ratcliffe (1962) suggest that eastern Lewis is likely to have been predominantly covered in birch woodland. This is supported by a reasonably recent palynological investigation of sediment from Sheshader, approximately 4.5miles east of the site, which suggested a hazel and birch scrub woodland characterised that location before 3,700BP but suffered subsequent drastic reduction to less than 3% total pollen by the first millennium BC (Newell 1988). The stratigraphy of the sediment was constrained by four radiocarbon dates and although a slight increase in arboreal pollen is associated with the early medieval period (up to 11%) this reduces to 3% again from 1300AD. (ibid, 86). As Sheshader is on gneiss geologies and more directly open to the Minch it is possible that the more sheltered topography and sedimentary geology around *Aoidhe* may have supported a higher localised woodland population, but that has not been demonstrated.

It is also possible the 'bark-bound birches' reported by Cameron in Lochs parish (1833, 124) are relict remains of the islands former woodland, but blanket peat had begun to form at Sheshader by at least 2,200BP (Newell 1988), and was probably the dominant domestic and industrial fuel from that point onwards. Indeed, Cameron describes the peat of the parish as '...the best in the world, hard and black; when thoroughly dried, it gives light and heat equal to those of coals' (1833, 121).

1.1.4 LIMEKILN & LIMEBURNING EVIDENCE

There are as yet no known lime-burning sites within the Isle of Lewis, although two *Aoil* place-names have been noted in Lochs and Uig (Thacker 2011). Evidence in the Western Isles suggests shells were burnt to manufacture lime here from its medieval emergence into the archaeological record, and was still reportedly manufactured in west Lewis in the late 18th-century (Monro 1791-99; Thacker 2011; 2015).

1.2 BUILDING SURVEY

The church building is comprised of two axially aligned cells, with a smaller narrower western aisle appended to a larger unicameral church, and recent comprehensive analysis and recording identified seven main phases of work within the building (Knott and Thacker 2011). This phasing had been interpreted on the basis of stratigraphical relationships between masonry characterised according to masonry style and visible mortar, and included:

Phase		Possible Date
1	Early Church fragment in lower north wall	13th-century or earlier, to 14th-century
2	Upstanding unicameral nave and chancel church	14th-15th-century
3	Demolition of church west wall and the construction of the West aisle in its place.	?17th-century
4	Minor works to west of nave including provision of new nave entrance and south-west window.	Possibly 18th- early 19th-century
5	Conversion of the west aisle to a congregational chapel.	Late 18th-century to the early 19th-century.
6	Conversion of the west aisle to a burial enclosure.	Mid 19th-century.
7	Neglect and repairs.	Later 19th-century to the 20th-century.

Table 1. Summary of Eaglais na h'Aoidhe phasing including possible dates; after, Knott and Thacker 2011, 26.

Visual examination of the surface compositions of *in situ* mortar materials suggested a range of contrasting and often phase-specific mortar materials had been used, and these were compared with various grades of predominantly lithic aggregates available on the adjacent shore to aid recognition of lime-source kiln-relicts (Thacker 2011; 2012; see main thesis text). Accepting that phases 1 and 2 displayed very similar mortar materials (but different building stone lithogies and masonry styles) this analysis suggested the building contained variously-tempered limestone- and shell-lime mortars which may be summarised as follows:

PHASE	CARBONATE kiln-relict type	AGGREGATE Added temper	BINDER MATRIX
1	Shell	3	Shell-lime
2	Shell	3	Shell-lime
3	Limestone	2	Limestone-lime
4	Shell	1 and 2	Shell-lime
5	Limestone	4	Limestone-lime
6	Lime	1?	Limestone-lime
7	none	1,2,3 & 4	Cement

Table 2. Summary of mortar phasing at Eaglais na h’Aoidhe; after Thacker 2012.

After completion of the site survey, scheduled monument consent was approved to remove fixed mortar samples from each phase of the building for further lab-based analysis.

2. 0 EAGLAIS NA H'AOIDHE – SAMPLE CONTEXTS & ANALYSIS

Fixed mortar samples were removed from the site in parallel with a programme of masonry consolidation works, which enabled intermittent scaffold access to a number of contexts.

2.1 SAMPLE CONTEXTS

Sample contexts were recorded (x, y and z,) by hand measurement from fixed wall features, and present ground levels.

2.1.1 MORTAR SAMPLE CONTEXTS

SAMPLE	CONTEXT
ENH.01	Chancel; N. wall; 700mm above east rood loft socket, on internal face; Coating; Phase 2.
ENH.02	Nave; S. wall; 800mm above ground; 1450mm W. of W jamb of E. (pointed) doorway; door blocking; external slaister; Phase 6.
ENH.03	W. Aisle; N. wall; 2650mm above ground, 700mm east of internal face of W. wall; 50 -120mm back from internal wall face; bedding; Phase 3.
ENH.04	Nave; N. wall; 400mm above ground, 6800mm east of mid gable external return, 75-100mm back from external wall face; Core; Phase 1.
ENH.05	Nave; S. wall; 2400mm above ground; 1800mm E of E. jamb of slit window, 275mm back from external wall face; Core; Phase 2.
ENH.06	Nave; N. wall; 3400 above ground, 1700 east of mid-gable return, phase 4.
ENH.07	W. Aisle; W. wall; blocking of west aisle west window; 550 down from top of arch, hard to S jamb, 10-30mm from internal face; Pointing; Phase 5.
ENH.08	W. Aisle; N. wall; window blocking; top of springer, hard to west jamb; internal bed & face; Phase 5.
ENH.09	W. Aisle; N. wall; 800mm E of external face of west wall; Immediately above corbels; 200mm back from external wall face; Core; Phase ?
ENH.10	W. Aisle; N. wall; 3000mm E of W ex Gable, 300mm below wallhead, on external wall face; coating; Phase 3 or 5.
ENH.11/SEM	Nave; S, wall; 3200 above ground; 0mm from E door jamb, at internal face; bed/coat; phase 4.

ENH.12 Nave; N. wall; 1.3 above ground; 750mm east of external face of W. wall, at external wall face; bed/coat; limestone inclusion; Phase 3.

ENH.13 West Aisle; S. wall; external recess; hard against recess west jamb; 120mm below lintel bed; phase 5.

ENH.14 Nave; N. wall; 900 east of mid-gable; 3400 above ground; internal wall face slaister; phase 4.

ENH.15 Nave; N. wall; 8000 east of return to west aisle; 2250 above ground; bed/core; phase 2.

ENH.16 East Cabeal; W. wall; 1.7m south of NW corner; 1250 above ground, external wall face; coating; primary phase.

ENH.17 East Cabeal; W. wall; 1.7m south of NW corner; 1250 above ground, 100mm back from external wall face; loose in bed. Phase?

ENH.18 West Aisle; S. wall; W jamb of S door/wind; 80mm down from springer bed;150mm back from internal wall face; phase 6?

ENH.19 Nave; S. wall; 2550mm above ground; 1350mm E of E. jamb of slit window, 100mm back from external wall face; loose core Phase 2.

ENH.20 Chancel; S. wall; 500 west of internal face of E. wall, 200 below gable intake; 400 back from external face; core. Phase 2.

ENH.21 N. pier. East face; 400mm below cope, 650mm from south face; 150 back from external face; Core. Phase?

ENH.22 N. pier; North face; 150 from E face; 750 below top of cope; Coating. Phase?

ENH.23 Chancel; N.; Beamfill; 600 west of east gable; 240 above wall-plate; 230 back from internal wall face. Phase?

ENH.24 Chancel; Loose ex-situ demolition material from slab stands. Phase?

ENH.26 W. Aisle; N, wall; wallhead; 120mm back from wall face; ‘LB’. Phase?

2.2.2 ENVIRONMENTAL CONTEXTS

ENH.25/Q GARRABOST QUARRY. ‘Q’. NB 505 337

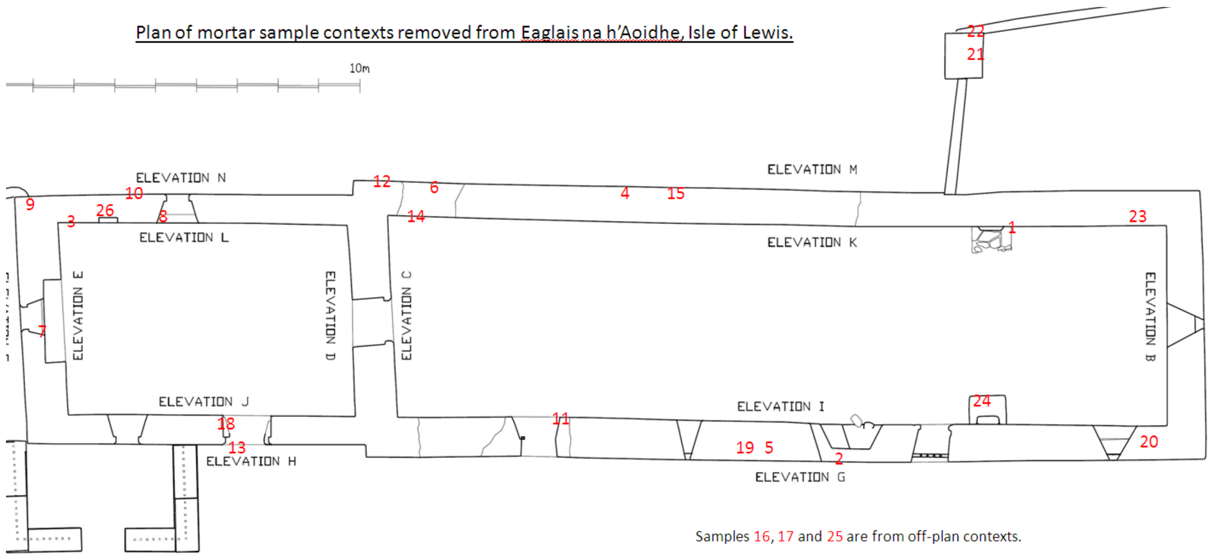


Figure 1 (above). Mortar sample contexts annotated onto plan of Eaglais na h'Aoidhe (original plan drawing from Knott and Thacker 2011)

2.2 SAMPLE ANALYSIS

Of the 26 samples removed from Eaglais na h'Aoidhe, 24 samples were thin-sectioned and subject to petrographic analysis. These analyses were undertaken in two batches with the first 11 samples (ENH.01-ENH.10 + ENH.26) analysed in 2013 and the remainder in 2015. A fine-sieved fraction of each of the first 11 mortar samples was also subject to XRD analysis, to ascertain the mineral phases present, and a shell inclusion from sample ENH.023 was also subject to XRD analysis to ascertain equivalent firing temperature

2.2.1 THIN SECTION ANALYSIS

24 samples were consolidated with epoxy resin before being cut on a primary trim saw to provide a surface for more thorough consolidation. Cut samples of the first 11 samples were washed with water and dried on a digital hotplate for 24 hours at 60°C, before each successive stage whilst preparation of all subsequent sections was undertaken at room temperature. Water was used as a coolant throughout the process
Petrographic analysis was undertaken in plane and cross polarised light (hereafter PPL and XPL) and identifications follow standard petrographic evaluation of mineral assemblages.

ENH.01

A very fine textured and reasonably homogenous pale brown matrix of calcium carbonate binder supports a well sorted/poorly graded aggregate formed predominantly of large rounded and subrounded lithic fragments). Lithic grains to 5mm and down. Shell to 2.5mm long. The section displays a large matrix/binder to lithic ratio and no aggregate-to-aggregate contact.

The lithic assemblage is dominated by metamorphic quartzofeldspathic, with porphyroblastic quartz, plagioclase and microcline often altered, showing amphibole (calcic), epidote and biotite, mosaic textures and mylonitisation.
The low concentration of fine shell material displays a spectrum of forms from well structured to barely discernible from the general carbonate matrix.
'flecks' of opaque, possibly fuel material, are displayed.
The mortar shows very high porosity.

ENH.02

Fine, sharp and subangular, poorly sorted/well graded mix of lithic and shell aggregate supported by low volume matrix of very pale brown calcium carbonate binder.
Aggregate range to o.75 mm and down and generally angular though larger lithics tend to be more rounded.
Lithic assemblage dominated by metamorphosed quartzofeldspathic lithic grains, some displaying altered feldspar (microcline is common) and mosaic quartz. Amphibole (calcic), epidote and biotite is present but rare. Some mylonitisation textures.
Concentrated rounded areas of fine binder material without any aggregate are common (see figure 3 below). These are interpreted as lime lumps as observed in the hand sample.
The fine shell material retains very coherent distinct structures and is interpreted as a component of the aggregate temper.
A carbonate inclusion which retains a crystal core displaying twinning was observed in cross-polarised light. This is interpreted as a core of unchanged relict limestone within a partially calcined structure.
Some carbon/possible fuel inclusions were observed but in very low concentration.

ENH.03

A large volume of very homogenous light brown calcium carbonate binder matrix supports a poorly sorted/well graded fine aggregate of rounded, subrounded and subangular lithics – mostly subrounded. This aggregate is very evenly distributed within the binder; there is a large binder to aggregate ration and no aggregate –to-aggregate contact.

Lithics generally range from 0.1 to 2mm, and the mineral content is dominated by quartzofeldspathic lithics, including quartz, plagioclase and microcline; mosaic and schistose textures. Epidote alteration and amphibole is present but rare.
Extremely low concentration of very fine 0.5mm and down shell material.
Large rounded carbonate inclusions are displayed. These have a coarser texture and a darker brown colour than the homogenous binder matrix and have distinct defined edges. It is not certain at this stage whether or not these inclusions represent relict limestone which has entirely lost its crystal structure.
Very low concentrations of fine shell material are occasionally evident.
Low concentrations of carbonised/possible fuel inclusions are evident

High binder volume is stand out feature.

ENH.04

This section displays large volume of coarsely textured, heterogeneous matrix/binder, supporting a relatively poorly sorted/well graded aggregate mix of rounded and subrounded lithics and shell aggregate.
Lithics 4mm and down, shell to 6mm and down.
Mineral assemblage is dominated by rounded metamorphic quartzofeldspathic lithics with very infrequent amphibole intergrowth, epidote and mica (biotite and muscovite).
Although the shell material is predominantly well structured and distinct, there are shell-like forms of dark carbonate material repeated throughout the slide. There is not, however, the same full spectrum of shell-lime forms seen in sample 5 for instance. Some amorphously shaped polycrystalline carbonate material is also present in low concentrations but cannot be identified more accurately. At higher magnification the binder matrix contains some fine rounded calcite structures.
No rounded darker carbonate lime lumps were apparent.
No carbon/fuel inclusions were apparent in plane polarised light.

ENH.05

A coarsely textured calcium carbonate matrix binder supporting a poorly sorted/well graded mix of subrounded and subangular lithics and needle-shaped shell. Binder volumes are not large, but the matrix does comprehensively surround all temper materials so precluding aggregate-to-aggregate contact.
Lithics 5mm and down, shell material to 2.5mm long.
Mineral assemblage is dominated by metamorphic quartzofeldspathic lithic grains, quartz/microcline and quartz/plagioclase inter-grown lithics. There is also a medium concentration of large, very distinct individual microcline grains and some plagioclase. No amphibole noted.
In cross-polarised light the binder is characterised by a very variable heterogeneous mix of variously lighter or darker brown colourations which merge to form more coherent carbonate shell shapes and forms. This is interpreted as various stages in shell calcination.

ENH.06

Low volume of dark, fine textured, very porous binder matrix supporting a fine aggregate mix composed predominantly sharp and subangular shell material with a low concentration of rounded, subrounded and subangular lithics dominated by quartzofeldspathic lithics, some of which display epidote alteration, recrystallised mosaic textures and mylonitisation.
Lithics to 2mm and down, shell material to 1.5mm and down.

This binder displays a heterogeneous appearance with merging shades of brown, some forming amorphous and elongated darker brown shell-like shapes. There are no rounded carbonate inclusion forms.
There is some aggregate-to-aggregate contact.
Some very low concentrations of carbon/opaque material.

<u>ENH.07</u>

Reasonably homogeneous but porous, volume of binder matrix supporting a coarse, poorly sorted/well graded, rounded and subrounded lithic aggregate.
Lithic grains to 6.5mm and down, mostly quartzofeldspathic lithics including quartz and microcline with very low concentrations of amphibole and epidote.
Some distinct rounded carbonate inclusions.
Very low concentration of very fine shell material.
Very few carbon inclusions.

<u>ENH.08</u>

A large volume of homogenous, medium textured but dark coloured calcium carbonate binder supporting a coarse, poorly sorted/well graded rounded, subrounded and subangular lithic aggregate. A large binder to aggregate ratio is displayed in the section.
Lithics to 7mm and down. Shell to 2.5mm long.

Aggregate mineral assemblage is dominated by quartzofeldspathic lithics, quartz and feldspar lithics with fair concentrations of amphibole and including biotite and epidote in mosaic mylonitised textures.
A very low volume of distinct and structurally coherent shell material is apparent.
This section is dominated by a large subangular oolitic limestone inclusion. Although of itself very distinct and coherent, similar smaller inclusions, variously calcined are also seen within the binder matrix.
Stand out features are the limestone inclusions but also the almost blue general colour of the mortar matrix.

<u>ENH.09</u>

An extremely coarse textured binder matrix supports a poorly sorted/well graded aggregate mix of fine subangular and subrounded lithics, and angular shell to larger sizes.
Shell to 10mm and down, lithics to 2mm and down.
Mineral assemblage completely dominated by quartzofeldspathic lithics with some amphibole.
Although some shell material displays distinct structure there is a wide range of coherence in the shell forms here. Variously distinct, curving shell-shaped forms, darker brown concentrations, barely distinguishable from the binder matrix.

Some polycrystalline, 3rd order pastel, carbonate material is also present, as in sample 4, and again these polycrystalline forms are breaking up into the general matrix. In this sample, however, some have retained dark brown structures similar in form to other shells within this and other sections.
A very low concentration of carbonised material is displayed.
Porosity is displayed.

ENH.10

Fine textured, homogenous but porous, light brown binder matrix supporting a poorly sorted/well graded, rounded, subrounded and subangular lithic aggregate with some shell content.
Large lithic grades to 10mm and down. Shell material to 1.5mm down.
Mineral assemblage is completely dominated by quartzofeldspathic lithics with a few rare epidote alteration and mylonitisation contexts.
One very large and some smaller, fragmenting darker brown amorphous forms of concentrated carbonate are present. These are similar in shape and size to those in sample 3, have a finer texture and are less distinct in outline. Shell forms are distinct and structured but no distinct rounded lime lumps, limestone, or polycrystalline carbonate forms are displayed.
No carbon relicts are apparent.

ENH.LB/26

Buff-coloured, blocky cuboid, 38x31x20mm, 22g weight.
Very fine textured and non porous. This sample is an extremely fine grained biomicritic limestone with rare fossilised shell inclusions.

ENH.12

Carbonate kiln-relicts – ENH.12 is a limestone-lime. This slide is dominated by a large subrounded fine-grained calcareous mudstone clast, which displays some alteration textures, such as areas of increased micritisation and incoherent grain boundaries. Some rare relict bioclasts are evident in this fine-grained material.

Added-temper – ENH.12 has a small quantity of mortar around large limestone clast. This is lithic tempered with subrounded gneiss to 1.0mm.

Fuel kiln-relicts – No fuel was noted.

Photomicrograph shows boundary of poorly-heated limestone inclusion and mortar which also contains a more completely altered clast

ENH.13

ENH.13 is a 16 X 21mm section of a single phase composite material composed of a buff-coloured matrix supporting poorly-sorted mixture of semi-transparent subrounded to subangular clasts grading up to 9mm.

Carbonate kiln-relicts – ENH.13 is a limestone-lime mortar containing a high concentration of rounded to subangular heated limestone/lime clasts to 1.5mm. These are highly altered and generally micritic, although some very faint bioclastic texture may be present.

Added-temper - ENH.13 was tempered by a poorly sorted mixture of lithic and shell materials, dominated by subangular to rounded gneiss clasts to 9mm but including a low concentration of unaltered bivalve and gastropod shells 1.5mm.

Fuel – ENH.13 contains a low concentration of variously blocky and amorphous fractured opaque inclusions to 0.25mm. This is probably relict fuel and may be tentatively identified as peat.

<u>ENH.14</u>

ENH.14 is a large 35 x 25mm section of a single phase composite bimodal material dominated by a very fine, generally sub-mm material including a low concentration of white probable shell inclusions to 7mm.

Carbonate kiln-relicts – ENH.14 is a shell-lime mortar containing heated *C. edule* clasts to 7mm which display discolouration and surface fractures.

Added-temper – ENH.14 was tempered with a well-sorted mixture of angular to subangular lithic and shell materials, generally to 0.5mm and occasionally to 1.0mm. Lithic grains include quartz and gneiss. This temper is in such high concentration that it is often grain-supporting.

Fuel kiln-relicts – No fuel was noted.

Vitreous kiln-relicts – No vitreous materials noted.

<u>ENH.15</u>

ENH.15 is a small 12 x 12mm section containing a single phase bimodal material dominated by a single white/blue shell clast, but also containing a small volume of composite material included within which are subrounded semi-transparent clasts to 1.5mm.

Carbonate kiln-relicts – ENH.15 is a shell-lime mortar and this section is dominated by a large discoloured and fractured Type 2-3 bivalve clast. The matrix of the mortar is very white and granular.

Added-temper – ENH.15 was tempered with a well-sorted lithic materials dominated by subrounded gneiss clasts to 2.5mm, with a low concentration of finer more angular clasts.

Fuel kiln-relicts – ENH15 contains a high concentration of amorphous opaque probable fuel relicts to 1.0mm. This is very likely to be peat.

Vitreous kiln-relicts – None noted.

ENH.16

ENH.16 is a small 15 x 7mm section of a single white-coloured clast. This is a bioclastic mudstone with a largely micritic texture, some evidence of lamination and oriented bioclasts including probable bivalve to 1.75mm. The clast has probably been subject to low level heat alteration.

ENH.17

This ENH.17 section is dominated by a single blue-coloured clast with some buff-coloured material at either end. This is a single clast of unheated but fractured and laminated bioclastic calcareous mudstone, containing oriented very fine (Ostracod?) bioclasts to 2mm.

ENH.18

ENH.18 is a 22 x 18mm section containing a single phase buff-coloured poorly-sorted composite material, including within larger rounded to subrounded buff-coloured clasts to 5mm.

Carbonate kiln-relicts – ENH.18 is a limestone-lime mortar containing a high concentration of highly altered well-rounded mudstone clasts grading up to 6mm. These are generally very micritic although some clasts contain a high concentration of fine quartz.

Added-temper – ENH.18 was tempered with a very fine sub-mm lithic temper composed of angular to subrounded quartz and gneissic clasts, generally to 0.2mm, but occasionally to 0.75mm.

Fuel kiln-relicts – ENH.18 contains a single 1.5mm wood-charcoal inclusion with large spring vessels.

Vitreous materials – None noted.

ENH.19

ENH.19 is a 32 x 15m section dominated by a single large curving shell clast, with hinge section, to 19mm.

Carbonate kiln-relicts – ENH.19 is a shell-lime mortar containing a high concentration of heated shell clasts including a large Type 2 *C. edule* section with hinge to 19mm, and a high concentration of highly-altered Type 4 clasts in optical continuity with the mortar matrix.

Added temper – ENH.19 was tempered with a bimodal mixture of lithic grains, including rounded to subrounded gneiss clasts to 3.0mm and angular quartz to 0.1mm.

Fuel kiln-relicts – ENH.19 contains amorphous and crazed opaque inclusions to 2.0mm, which are very probably peat fuel.

Vitreous materials – None noted.

<u>ENH.20</u>

ENH.20 is a large 50 x 23mm section of a single phase composite material containing a poorly-sorted mixture of subrounded semi-transparent lithic clasts to grading up to 11mm, and a large probable ribbed shell fragment to 8mm.

Carbonate kiln-relicts – ENH.20 is a shell-lime mortar containing a high concentration of Type 2-4 heated *C. edule* shell fragments grading up to 8mm. These display various degrees of discolouration, fracturing and loss of internal microstructure.

Added-temper – ENH.20 was tempered with a poorly-sorted coarse lithic aggregate of rounded to subrounded gneiss clasts grading up to 11mm.

Fuel kiln-relicts – ENH.20 contains amorphous and crazed opaque inclusions to 2mm which are very likely to be peat fuel kiln-relicts.

<u>ENH.21</u>

ENH.21 is a 32 x 22mm section of a single phase composite porous material, containing a poorly-sorted mixture of angular to subrounded semi-transparent clasts supported/surrounded by a buff-coloured granular material.

Carbonate kiln-relicts – ENH.21 is a limestone-lime mortar containing a high concentration of rounded to subangular heated limestone clasts grading up to 2.5mm. These are generally micritic probable quartz-included mudstone.

Added-temper – ENH.21 was tempered by a poorly-sorted mixture of shell and lithic clasts dominated by rounded to subangular quartzofeldspathic gneiss grains to 7mm.

Fuel – ENH.21 contains a low concentration of amorphous and fractured opaque inclusions to 2.0mm. These are very probably peat fuel kiln-relicts.

<u>ENH.22</u>

ENH.22 is a 32 x 15mm section of a single phase composite material including a poorly-sorted mixture of semi-transparent subangular to subrounded clasts to 15mm, subrounded/supported by a sub-mm buff-coloured granular material.

Carbonate kiln-relicts – ENH.22 is a lime mortar containing a low concentration of fine subrounded brown-coloured micritic kiln-relicts which are highly altered, making provenancing challenging. This is, however, probably a limestone-lime mortar.

Added-temper – ENH.22 was tempered with a poorly-sorted coarse mixture of subangular to rounded gneiss grading up to 15mm, with a very low concentration of unaltered shell to 2mm.

Fuel kiln-relicts – ENH.22 contained no evidence of fuel.

ENH.23

ENH.23 is a large 56 x 25mm section containing a single phase composite material containing an even distribution of rounded to subangular probable lithic clasts to 4.5mm, and a low concentration of large white curving probable shell clasts grading up to 10mm.

Carbonate kiln-relicts – ENH.23 is a shell-lime mortar containing a high concentration of heated Type 2-4 *C. edule* fragments to 10mm. These include evidence of discolouration, surface fractures, a globular texture, and increasing optical continuity with the general mortar matrix.

Added-temper – ENH.23 was tempered with a bimodal aggregate including well distributed coarse rounded gneiss grains to 4.5mm and very fine quartz grading to 0.1mm.

Fuel kiln-relicts – ENH.23 contains amorphously shaped and crazed opaque inclusions to 1.0mm. These are very probably peat fuel.

ENH.24

ENH.24 is a large 65 x 24mm section of a single phase well-sorted and fine grade, generally sub-mm, composite material.

Carbonate kiln-relicts – ENH.24 is a limestone-lime mortar containing a low concentration of highly altered rounded brown limestone clasts to 2.0mm.

Added-temper – ENH.24 was tempered with a well-sorted mixture of lithic and shell materials, generally grading up to 0.25mm, but including occasional subrounded gneiss grains to 1.25mm. This temper is in such high volume that some grain-supporting contexts are apparent.

Fuel – ENH.24 contained no notable fuel evidence.

ENH.25

The slide contains well-sorted mixture of very fine lithic and shell materials to 0.2mm. The cement has not have survived.

2.2.2 XRD ANALYSIS OF MORTAR MATRICES

Fragments of mortar samples ENH.01-ENH.10 + ENH.26 were crushed in a single pass of the jaw crusher and then sieved down through progressively finer geological sieves to 0.63µm. This finest material (now considered inclusion-free) was then ground by hand in an agate mortar, before samples ENH.03, 04, 05, 07, 09 and 10 were mounted as a bulk dry powder, and ENH.01, 02, 06, 08 and 26 were suspended in acetone and slide mounted (due to lack of volume). As a control, a standard sample of *Ostrea* Calcite was also mounted, and the diffractometer (Bruker D8 Advance) run in the 2 theta range; 2-60° with a step size of 0,025°, and a step time of 1.5 seconds.

All samples were essentially calcite with some quartz included. The diffractogram plots are included in the figures below.

2.2.3 XRD ANALYSIS OF SHELL INCLUSION

A single *C. Edule* fragment embedded in mortar sample ENH.23 was physically separated from the mortar with a steel spatula, then crushed and milled for XRD analysis. The shell fragment was white coloured with a very thin blue-grey external surface colouration and very soft and easily crushed. The XRD results were analysed through the Reitveld programme against a number of carbonate minerals.

Sample	Magnesium Calcite/%	Calcite /%	Aragonite /%	Periclase /%	Brucite /%	Portlandite /%	Trace /%
ENH.23	24.7	70.9	0.5	-	-	-	3.6

The mineral phases represented in these results, and the shells physical form, corresponds to a Type 2 kiln-relict and suggests the cockle shell has an equivalent firing temperature of approximately 300^{o}C.

3.0 EAGLAIS NA H'AOIDHE – CONCLUDING DISCUSSION

3.1 CORRELATING MICROSTRUCTURAL MORTAR ANALYSIS WITH BUILDING PHASING

Phase 1	ENH.04 – Shell-lime mortar; Peat-fired.
Phase 2	ENH.01 – Shell-lime mortar; with fuel.
	ENH.05 – Shell-lime mortar;.
	ENH.15 – Shell-lime mortar; Peat-fired.
	ENH.19 – Shell-lime mortar; Peat-fired.
	ENH.20 – Shell-lime mortar; peat-fired.
	ENH.23 – Shell-lime mortar peat-fired.
Phase 3	ENH.03 – Limestone-lime; with fuel.
	ENH.09 – Shell-lime
	ENH.10 – Probable Limestone-lime; no fuel.
	ENH.26 – Limestone.
Phase 4	ENH.06 – Shell-lime mortar; probably peat-fired.
	ENH.14 – Shell-lime mortar; no fuel noted.
	ENH.11 – Shell-lime mortar.
Phase 5	ENH.07 – Probable limestone-lime mortar; with fuel
	ENH.08 – Limestone-lime mortar.
	ENH.13 – Limestone-lime mortar; peat-fired.
	ENH.18 – Limestone-lime mortar; wood-fired.
Phase 6	ENH.02 – Limestone-lime mortar; with fuel.
	ENH.24 – Limestone-lime mortar; no fuel.
North Pier	ENH.21 – Limestone-lime mortar; peat-fired.
	ENH.22 – Limestone-lime mortar; no fuel.
East Cabeal	ENH.16 – Limestone-lime.
	ENH.17 – Limestone-lime.

3.2 DISCUSSION

The most important result to emerge from this early research is that microstructural analysis supports the various limestone or shell lime-source interpretations made during building survey. Moreover, the different (oolitic, marble and mudstone) limestone lithogies reported here have enabled further distinctions to be made between different phases (such as phases 3 and 5) which had previously been deduced from contrasting aggregates and stratigraphic context alone.

Most of the fuel noted during sampling and in thin-section was clearly peat, and in the shell-lime phases this was often in high concentration. Fuel relicts were much less common in the later limestone phases, although microstructural analysis suggests some of these are peat also. The wood charcoal relict in the fine plaster coating of the western aisle is rare and remarkable and as wood fuel was often used to ‘soft-burn’ lime for plastering, this may parallel the quality of this mortar material.

In terms of the buildings development these analyses support previous interpretations that there was a general progression at *Eaglais na h’Aoidhe* from shell-lime to limestone-lime mortars, and that these are most strongly associated with the medieval and post medieval periods respectively.

This general development, however, further highlights the very shell-rich post-medieval shell-lime mortars associated with the phase 4 work at the west end of the nave, and the phase 3 work at eaves level in the west wall of the western aisle. Phase 4 had previously been interpreted as a ‘rough’ (Knott and Thacker 2011, 31) vernacular repair to the nave in its last phase of congregational use, and *in-situ* this material appeared very similar to that in the west wall of the western aisle. The scenario that the west gable had been rebuilt during phase 4 was discounted, due to a lack of evidence for a construction break in the masonry style of the west wall concomitant with the change in mortar, and this led to speculation that the builders of the western aisle had run short of limestone toward the end of the build. This interpretation was indeed supported during sampling when some rare mixed limestone/shell-limes were noted in the gable of the west wall, and petrographic analysis also suggests the shell-lime found here (ENH.09) is a different material to the phase 4 mortar samples (ENH.06 and ENH.14) in the masonry at the west of the nave.

Given the variation in the mortars of the west wall, however, this contrast does not necessarily preclude these phase 3 and 4 shell-lime mortars being broadly contemporary. That they are both poor-quality shell-lime mortars (in comparison with the consistent medieval shell-limes) is suggested by the very high concentrations of included uncalcined kiln-relicts. Whilst this coincidence is probably a reflection of their late date, as phase 4 is evident in both the north and south nave walls it seems clear that this masonry was constructed to close the nave of the church (and re-instate the roof) after the construction of the western aisle. Indeed, that the demolition of the west end of the medieval church provides a context for this south-west nave door and window was suggested in the on-site survey (Knott and Thacker 2011) but although possible dates for Phases 3 and 4 were suggested (as above), little consideration was given to the gap between these phases. I would suggest this gap is likely to have been minimal, and that the identity of the builders of this phase 4 work is an important question. Despite the difference in composition between the samples, given the use of poor-quality shell-lime in the west wall it is possible that the phase 4 work in the nave was also constructed by the builders of the west gable of the western aisle.

Sample ENH.023, from the north-west wall of the chancel is also interesting in this regard as this sample was removed from the beam-fill between wallhead and rafters, and analysis indicates that this is a medieval phase 2 shell-lime mortar. Remarkably, this suggests that the timbers of the medieval roof (at least at the east end of the church) remained in place long into the post-medieval period, and probably until the church was ruined. As the phase 4 window at the south-west of the nave was glazed, it is possible that it was this (substantially?) medieval church roof which was repaired after the construction of the western aisle.

Another slight revision to the previously understood development of the building is the very close similarity between samples from the wall mounting of the late medieval grave-slabs (ENH.24) and that within the south-east nave doorway blocking (ENH.02). It now appears likely that this doorway blocking is a single phase of work (rather than first forming a window opening), and that this happened in a very late period. Although it cannot be demonstrated that this blocking did not replace earlier blocking, this evidence might suggest that this doorway also remained in use long into the post-medieval period, and even after the church had lost its roof.

There has been no attempt here to identify the specific location of the sources of the limestone used in later phases as a number of Scottish mainland and/or Inner Hebridean sources are possible and comparative samples are not available at this stage.

4.0 EAGLAIS NA H'AOIDHE – FIGURES

Figure 2 (above) – Location of the church site of Eaglais na h'Aoidhe on the east side of the Isle of Lewis, north-west of the mainland of Scotland. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved).

Figure 3 (above) – The medieval buildings. First edition 6-inch Ordnance Survey map (O.S.1850a; 1851b; 1851c) showing locations of *Eaglais na h'Aoidhe* and Stornoway Castle. Church and castle are approximately 4 miles apart. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved. (1878).

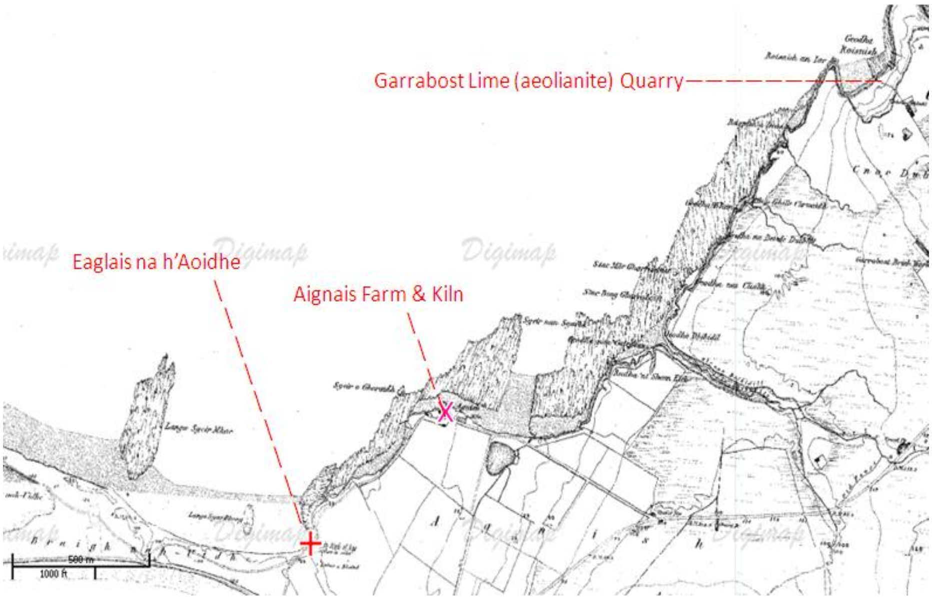


Figure 4 (above) – The post-medieval buildings. Ordnance Survey first edition 6-inch map (1851) annotated to show the locations of *Eaglais ha h'Aoidhe,* Aignais House and the probable aeolianite quarry at Garrabost. Church and House are less than 0.5 miles apart. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved. (1878).

4.1 THICK SECTIONS

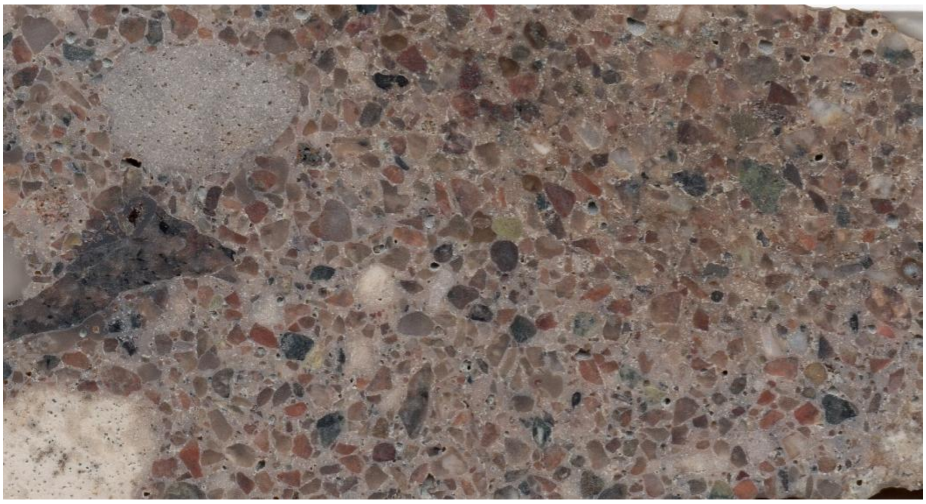


Figure 5 (above) – ENH.03. Consistently lithic-tempered lime mortar with range of subrounded sedimentary probable limestone inclusions. Note loss of coherence in clast at bottom left. Thick section; field of view 35mm.

Figure 6 (above) – ENH.06. Very porous lime mortar. Note larger probable heated *C.edule* inclusions. Thick section; field of view 30mm

Figure 7 (above) – ENH.08. Large subangular sedimentary probable limestone inclusion. Coarse lithic temper. Thick section; Field of view 35mm.

Figure 8 (above) – ENH.09. Very high concentration of shell inclusions. High concentration of probable heated *C. edule* clasts. Thick Section; Field of view 48mm.

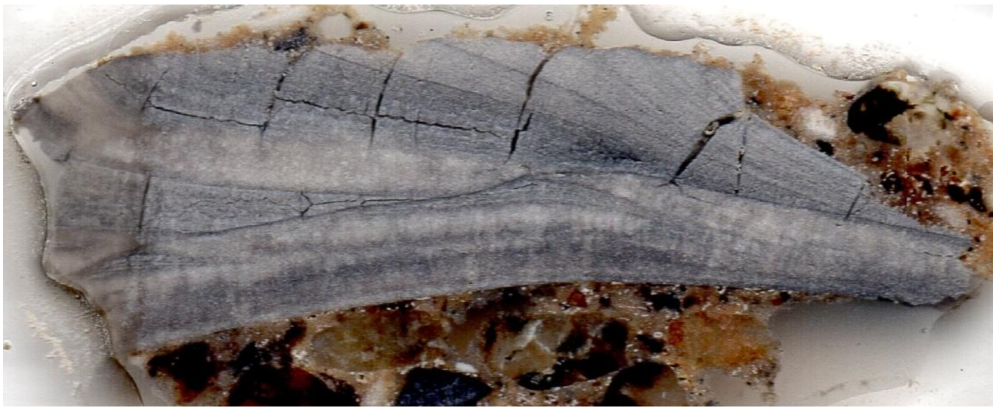


Figure 9 (above) – ENH.15. Large highly fractured probable C. edule clast in lithic-tempered mortar. Thick section. Field of view 15mm.

Figure 10 (above) – ENH.15. Heated C. edule clasts and quartz-rich lithic-tempered mortar. Thick-section; Field of view 25mm.

Figure 11 (above) - ENH.18. Probable rounded limestone clasts with variable textures. Thick section; Field of view 20mm.

4.2 THIN SECTIONS

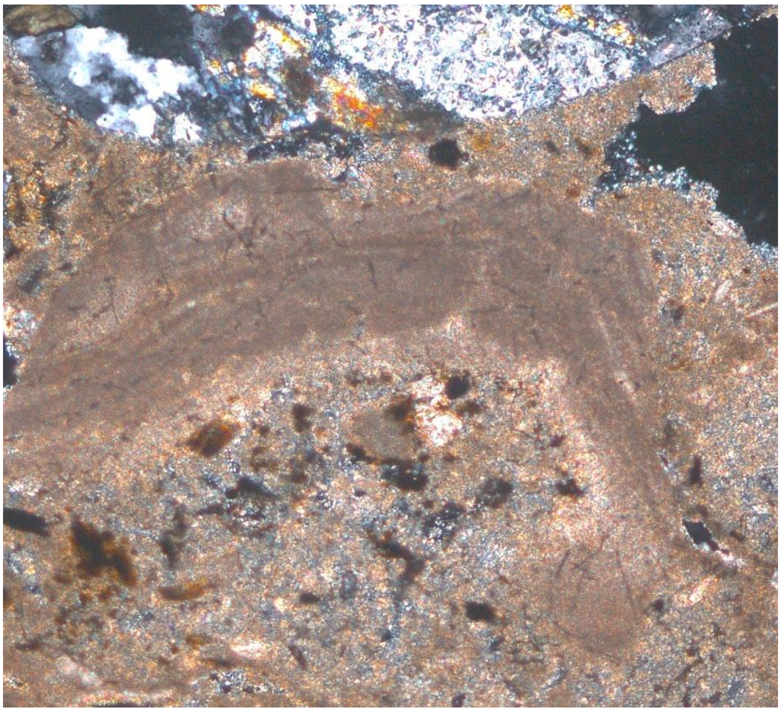


Figure 12 (above) – Mortar sample ENH.01. Heated *C. edule* clast approaching optical continuity with mortar matrix. XPL; Field of view 600µm; photomicrograph M. Thacker.

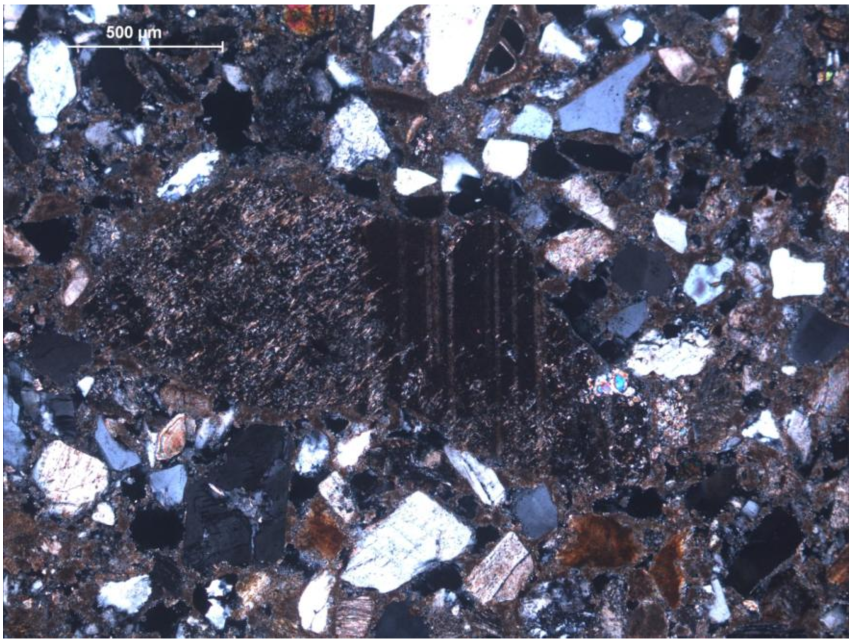


Figure 13 (above) – Mortar sample ENH.02. Heated limestone (marble?) relict cleavage in core of heated clast. XPL; Scale bar 500µm; photomicrograph M. Thacker.

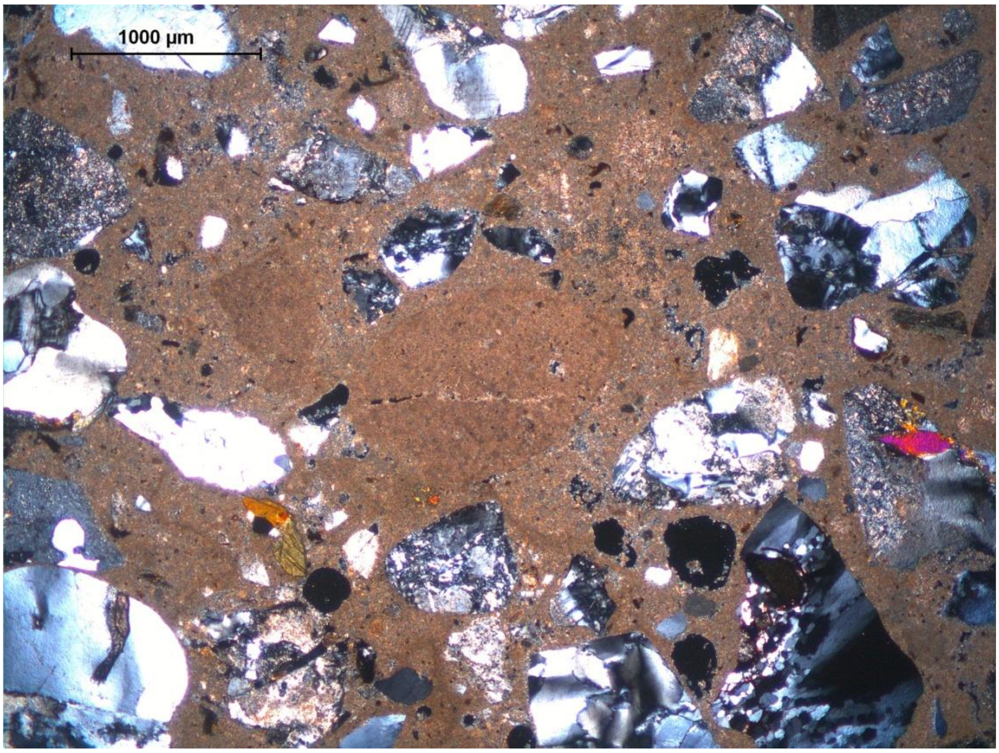


Figure 14 (above) – Mortar sample ENH.03.Heated fractured limestone, almost in optical continuity with mortar matrix. XPL; Scale 1.0mm; photomicrograph M. Thacker.

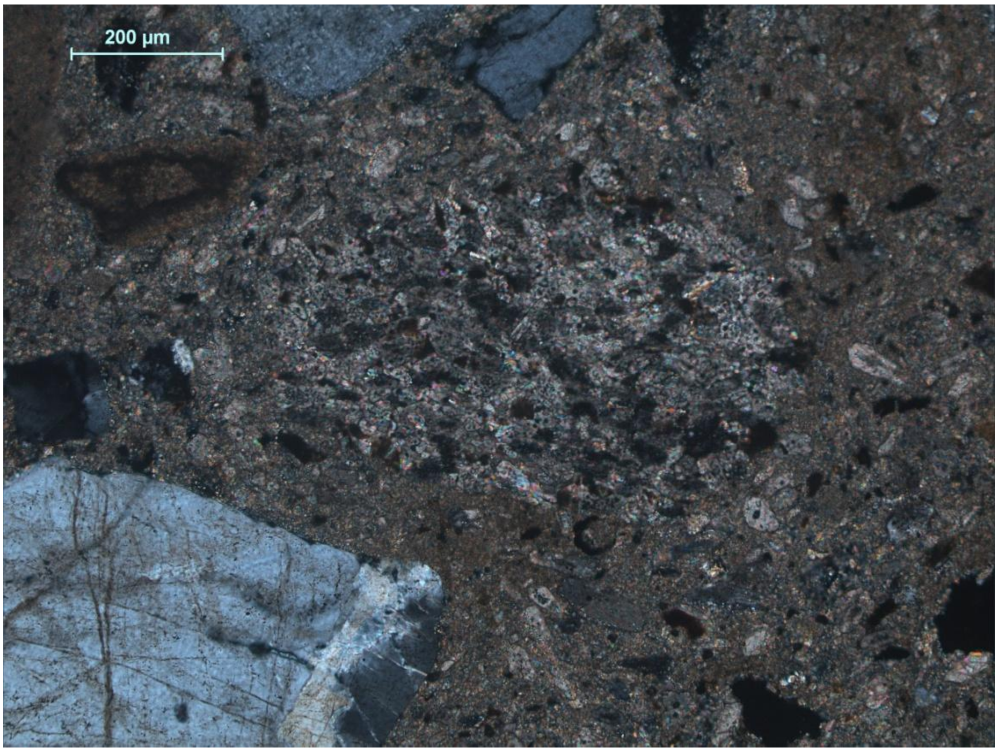


Figure 15 (above) – Mortar sample ENH.04. Heated shell. XPL; Scale bar 200µm; photomicrograph M. Thacker.

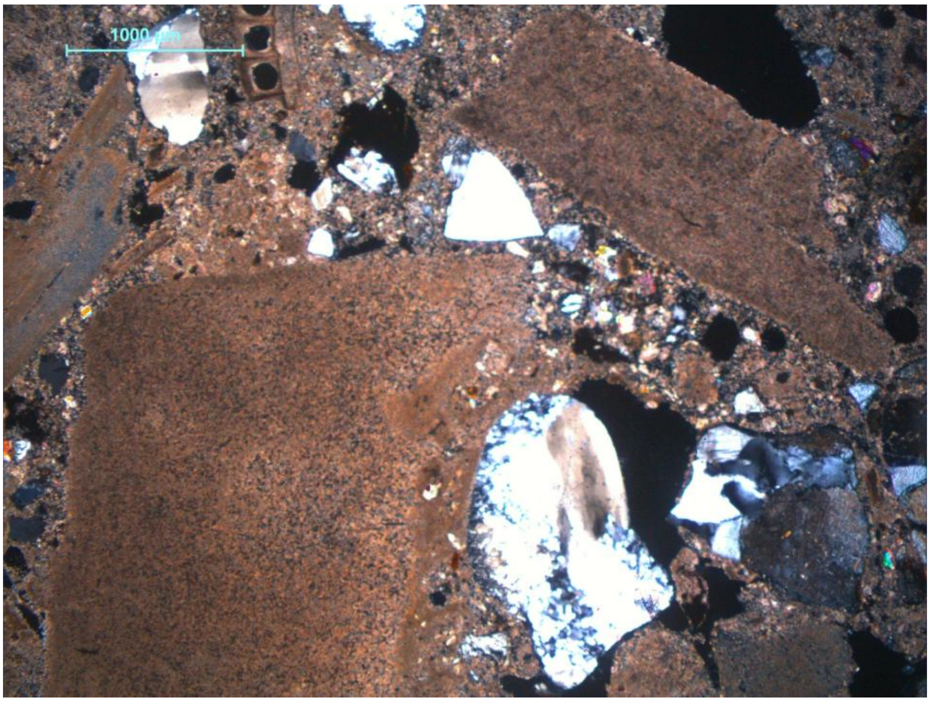


Figure 16 (above) – Mortar sample ENH.05. Large heated shell without clear microstructure. Possible *E. Arcuatus*. XPL; Scale bar 1.0mm; photomicrograph M. Thacker.

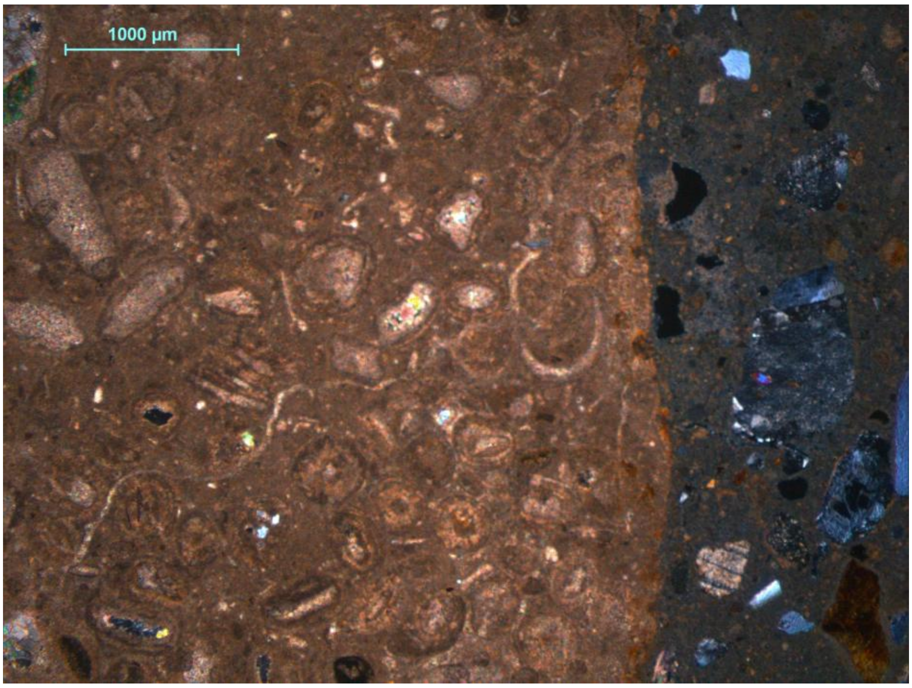


Figure 17 (above) – Mortar sample ENH.08. Large oolitic limestone clast. XPL; Scale bar 1.0mm; photomicrograph M. Thacker.

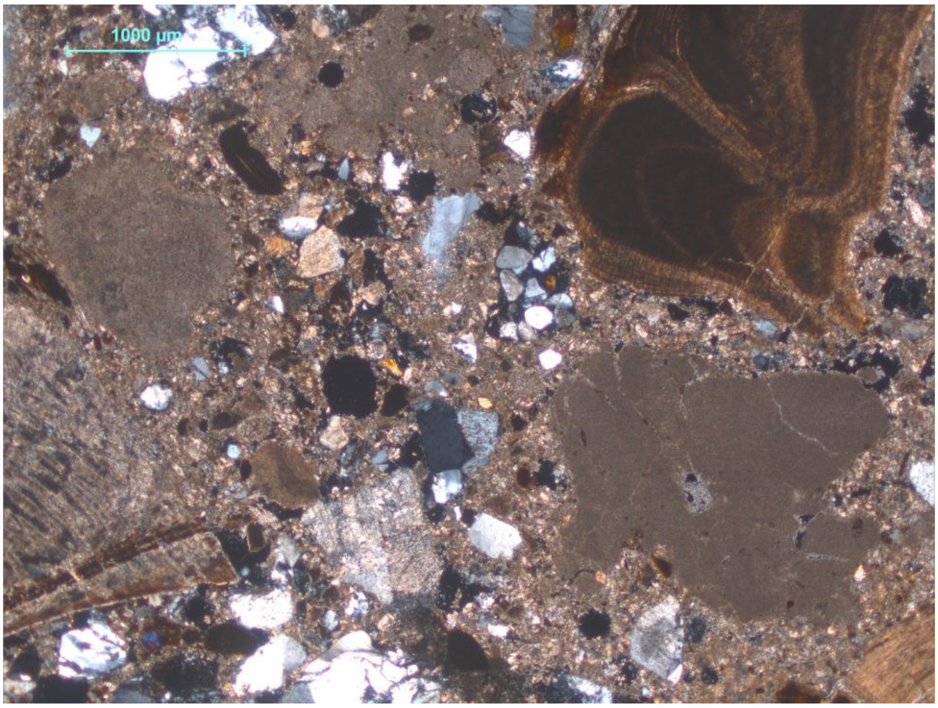


Figure 18 (above) – Mortar sample ENH.09. Large range of alteration in shell clasts. XPL; Scale bar 1.0mm; photomicrograph M. Thacker.

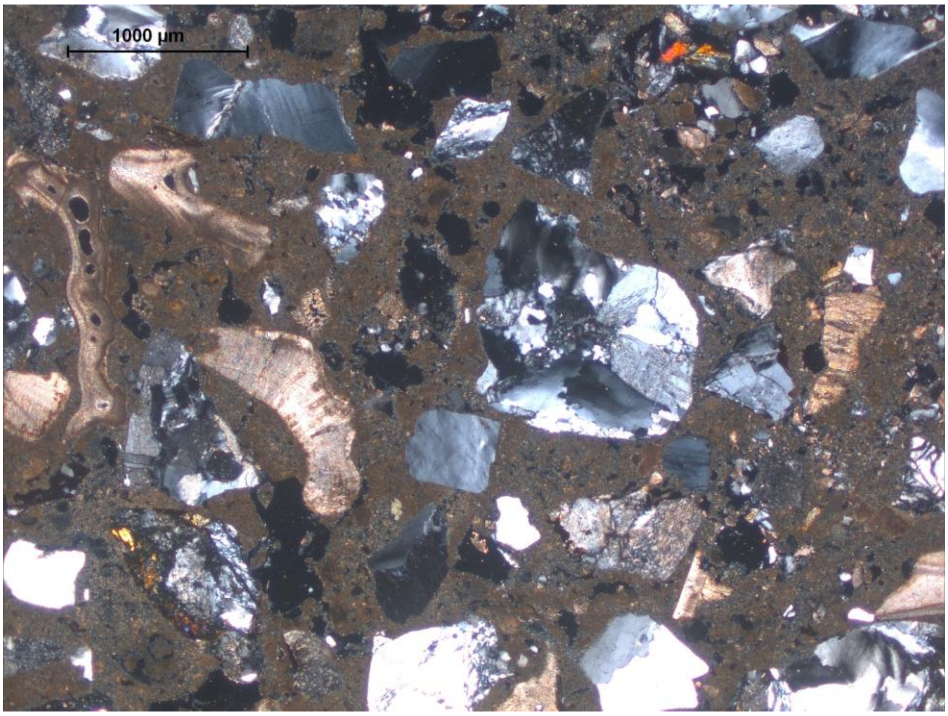


Figure 19 (above) – Mortar sample ENH.10. Consistent matrix-supported mortar. XPL; Scale bar 1.0mm; photomicrograph M. Thacker.

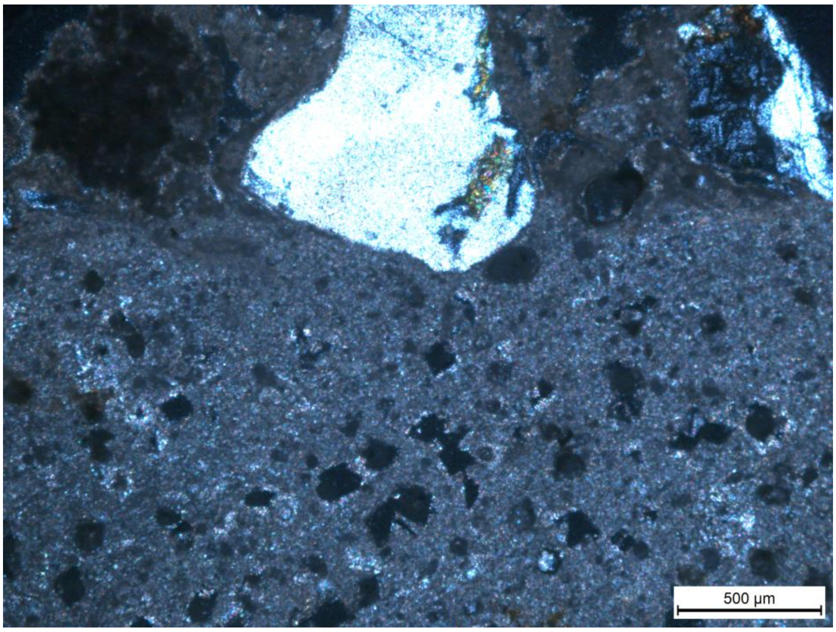
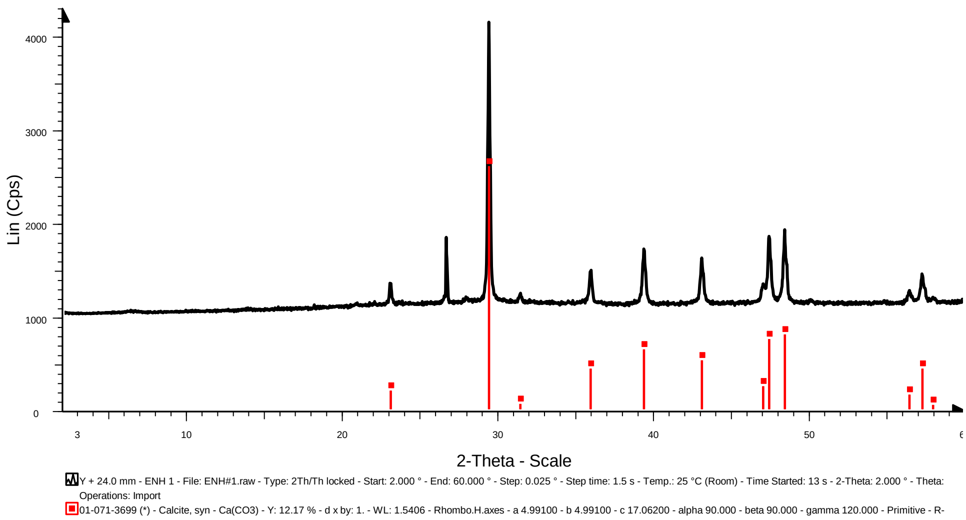


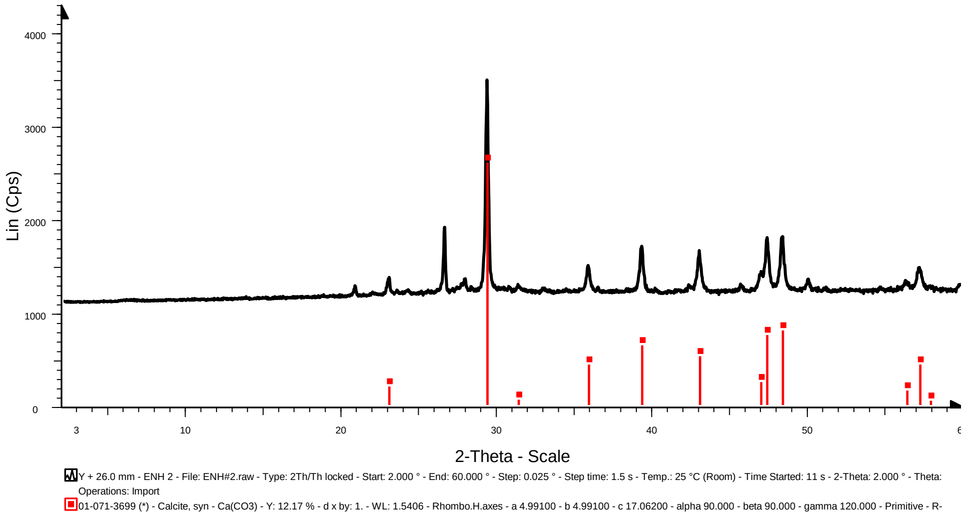
Figure 20 (above) – Thin section ENH.12 is dominated by a large altered fine-grained limestone clast. This image shows the grain boundary between that clast and the supporting mortar. XPL; Scale 500µm; photomicrograph M. Thacker.

XRD DIFFRACTOGRAMS

ENH 1



ENH 2


Lin (Cps)
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3000
2000
1000
0
3
10
20
30
40
50
6
2-Theta - Scale
Y + 26.0 mm - ENH 2 - File: ENH#2.raw - Type: 2Th/Th locked - Start: 2.000 ° - End: 60.000 ° - Step: 0.025 ° - Step time: 1.5 s - Temp.: 25 °C (Room) - Time Started: 11 s - 2-Theta: 2.000 ° - Theta:
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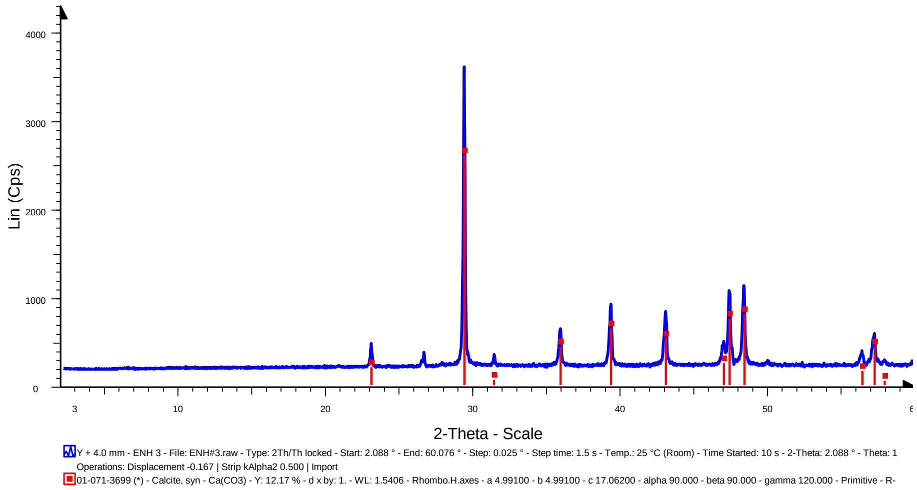
ENH 3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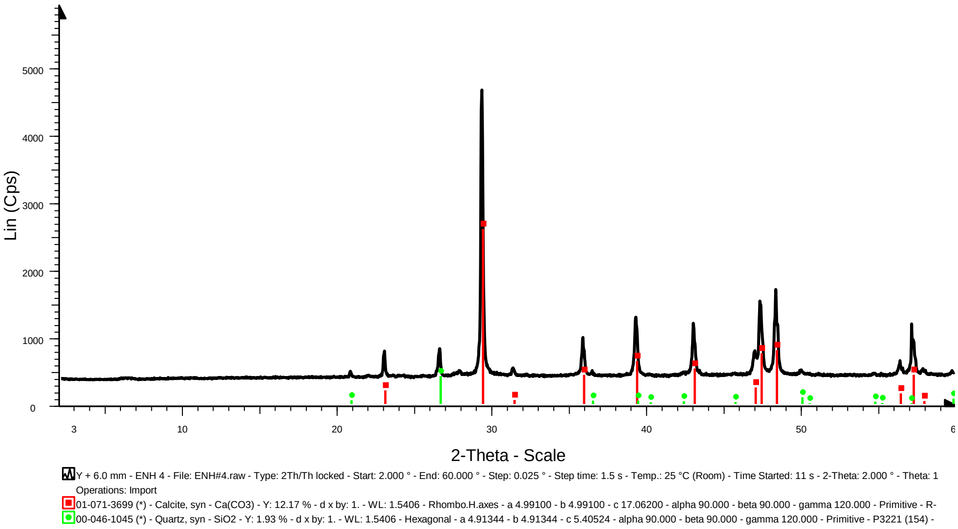
ENH 4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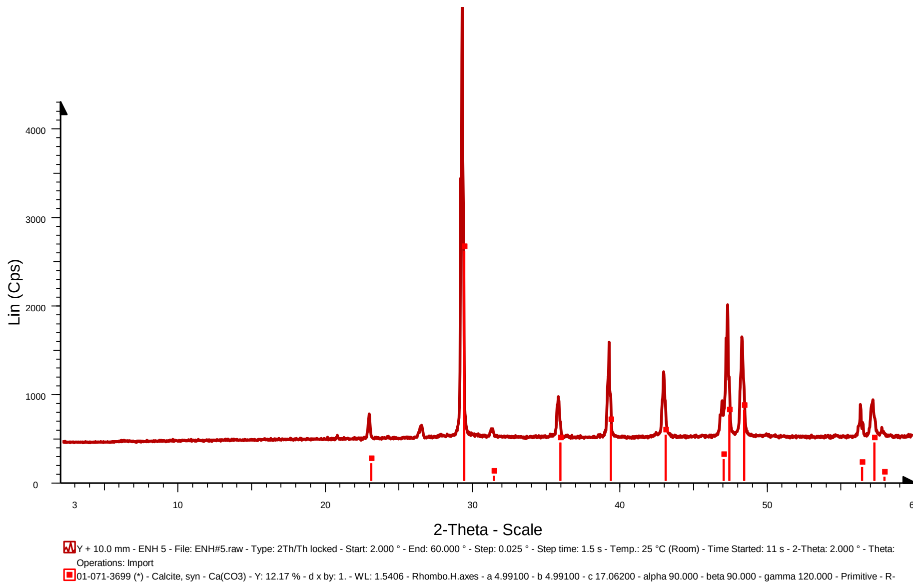
00-046-1045 (*) - Quartz, syn - SiO2 - Y: 1.93 % - d x by: 1. - WL: 1.5406 - Hexagonal - a 4.91344 - b 4.91344 - c 5.40524 - alpha 90.000 - beta 90.000 - gamma 120.000 - Primitive - P3221 (154) -

ENH 5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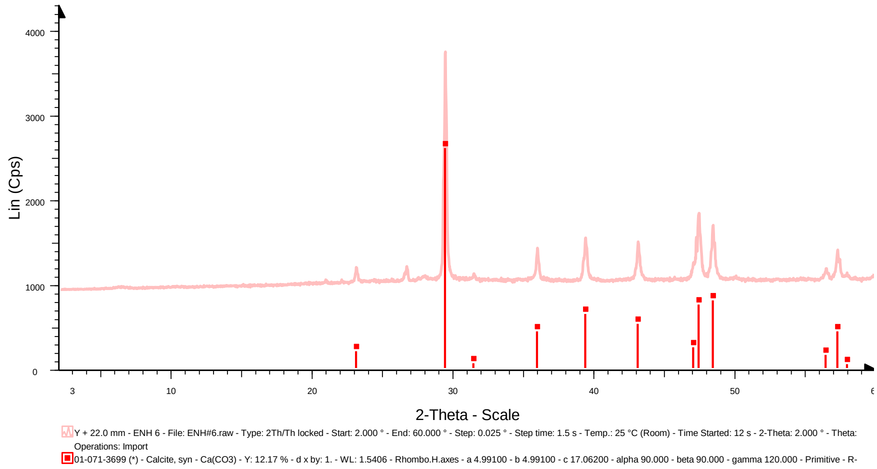
ENH 6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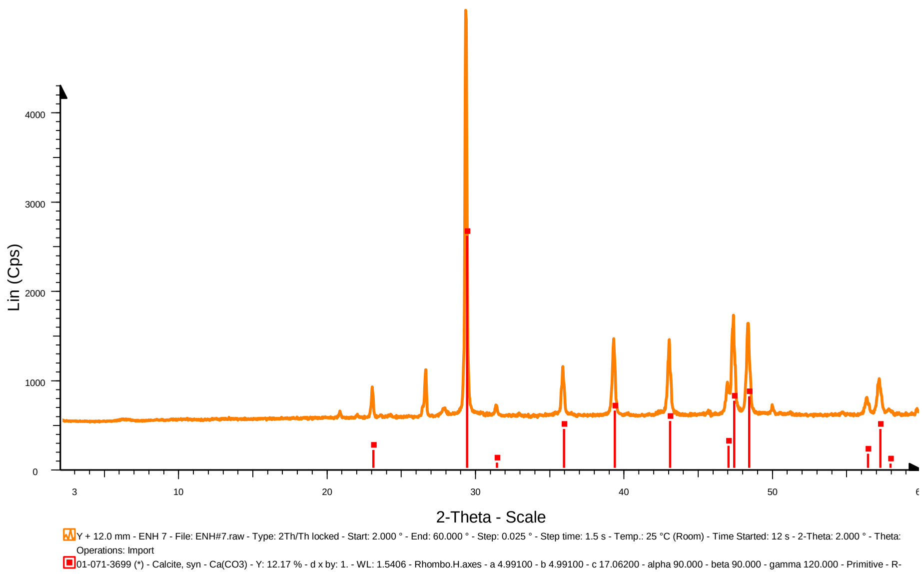
ENH 7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Operations: Import
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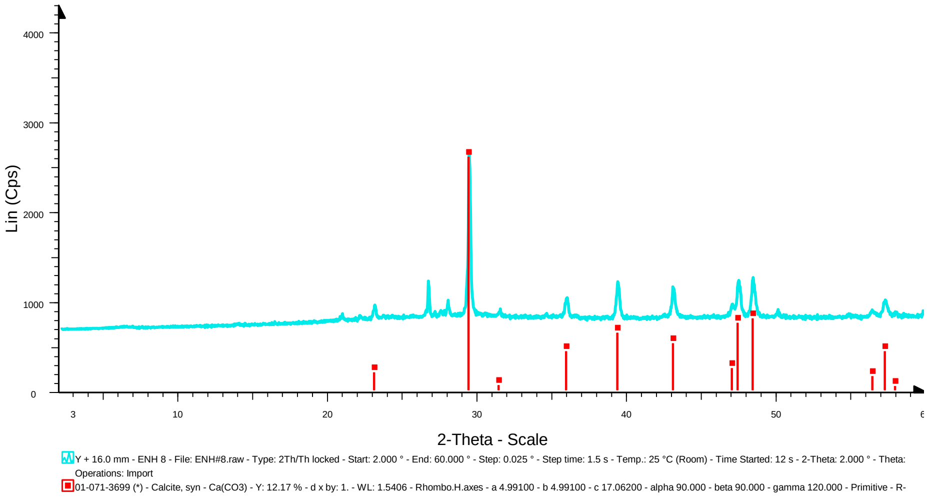
ENH 8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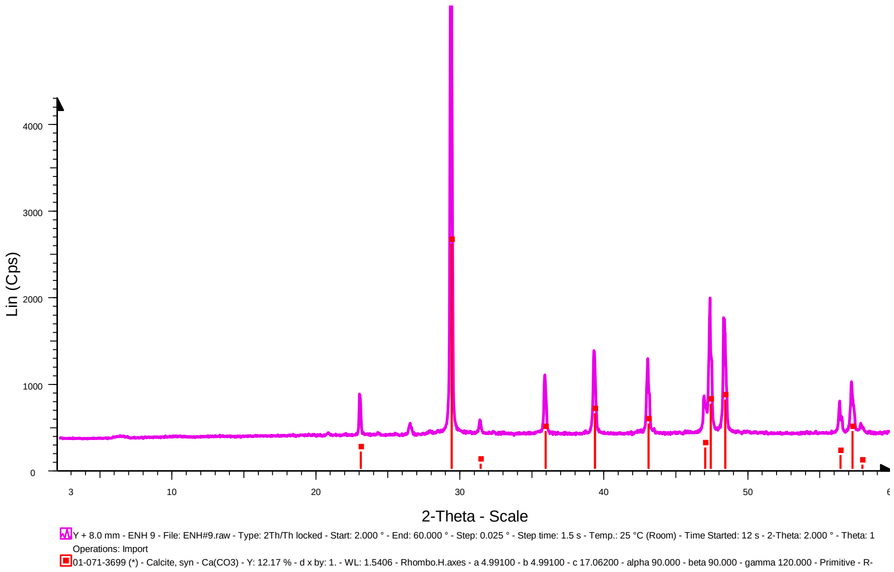
2-Theta - Scale
Y + 16.0 mm - ENH 8 - File: ENH#8.raw - Type: 2Th/Th locked - Start: 2.000 ° - End: 60.000 ° - Step: 0.025 ° - Step time: 1.5 s - Temp.: 25 °C (Room) - Time Started: 12 s - 2-Theta: 2.000 ° - Theta:
Operations: Import
01-071-3699 (*) - Calcite, syn - Ca(CO3) - Y: 12.17 % - d x by: 1. - WL: 1.5406 - Rhombo.H.axes - a 4.99100 - b 4.99100 - c 17.06200 - alpha 90.000 - beta 90.000 - gamma 120.000 - Primitive - R-

ENH 9


Lin (Cps)
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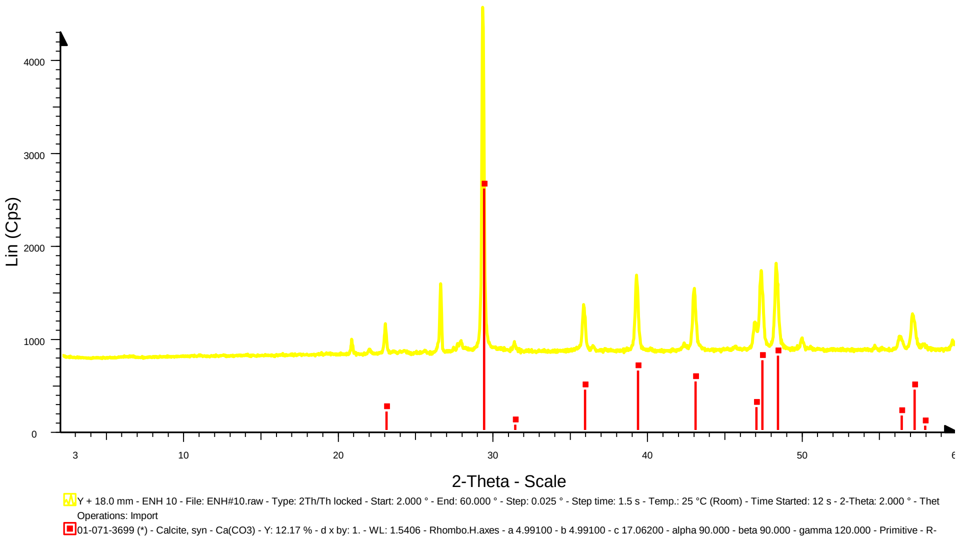
2-Theta - Scale
Y + 8.0 mm - ENH 9 - File: ENH#9.raw - Type: 2Th/Th locked - Start: 2.000 ° - End: 60.000 ° - Step: 0.025 ° - Step time: 1.5 s - Temp.: 25 °C (Room) - Time Started: 12 s - 2-Theta: 2.000 ° - Theta: 1
Operations: Import
01-071-3699 (*) - Calcite, syn - Ca(CO3) - Y: 12.17 % - d x by: 1. - WL: 1.5406 - Rhombo.H.axes - a 4.99100 - b 4.99100 - c 17.06200 - alpha 90.000 - beta 90.000 - gamma 120.000 - Primitive - R-

ENH 10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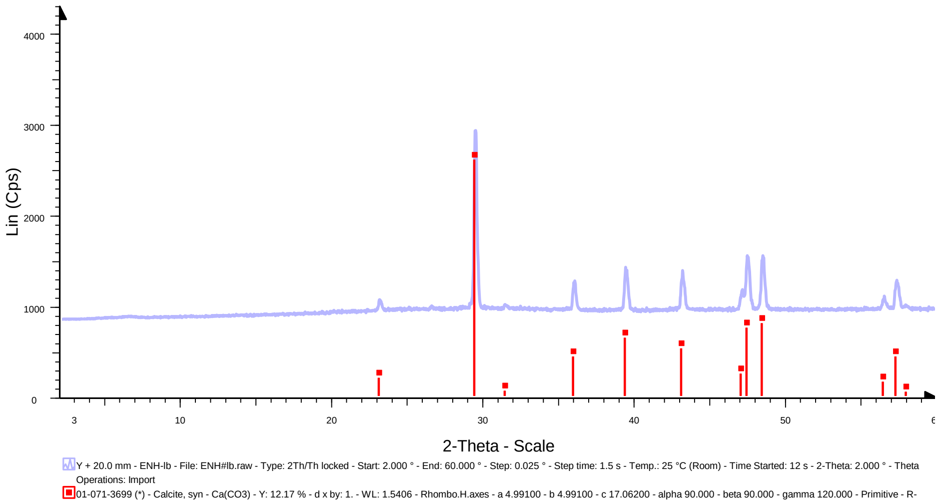
Y + 18.0 mm - ENH 10 - File: ENH#10.raw - Type: 2Th/Th locked - Start: 2.000 ° - End: 60.000 ° - Step: 0.025 ° - Step time: 1.5 s - Temp.: 25 °C (Room) - Time Started: 12 s - 2-Theta: 2.000 ° - Thet
Operations: Import
01-071-3699 (*) - Calcite, syn - Ca(CO3) - Y: 12.17 % - d x by: 1. - WL: 1.5406 - Rhombo.H.axes - a 4.99100 - b 4.99100 - c 17.06200 - alpha 90.000 - beta 90.000 - gamma 120.000 - Primitive - R-

ENH-lb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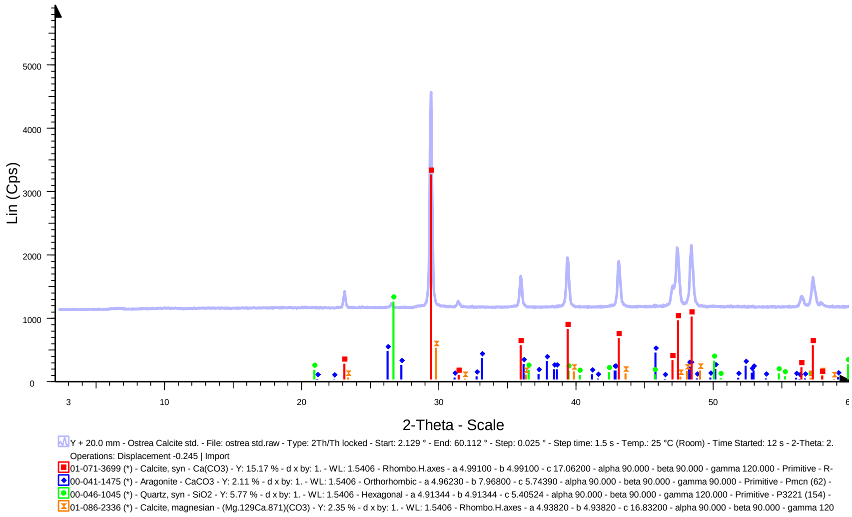
2-Theta - Scale
Y + 20.0 mm - ENH-lb - File: ENH#lb.raw - Type: 2Th/Th locked - Start: 2.000 ° - End: 60.000 ° - Step: 0.025 ° - Step time: 1.5 s - Temp.: 25 °C (Room) - Time Started: 12 s - 2-Theta: 2.000 ° - Theta
Operations: Import
01-071-3699 (*) - Calcite, syn - Ca(CO3) - Y: 12.17 % - d x by: 1. - WL: 1.5406 - Rhombo.H.axes - a 4.99100 - b 4.99100 - c 17.06200 - alpha 90.000 - beta 90.000 - gamma 120.000 - Primitive - R-

Ostrea Calcite std.



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5.2 ACKNOWLEDGEMENTS

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APPENDIX 8 - CASE STUDY

DUNTULM CASTLE, SKYE

Mark Thacker, University of Edinburgh.

Constructing Lordship in North Atlantic Europe. Vol. III.

Appendix case study 8.

Last revision 20-07-2016

DRAFT COPY FOR PHD EXAMINATION SUBMISSION.

SUMMARY

A survey of the fragmentary medieval and later building complex of Duntulm Castle, Isle of Skye, was undertaken in parallel with a comprehensive lab-based mortar sample analysis programme. On site, *in-situ,* examination suggested that various contrasting materials have been used in different building phases and that, although limestone clearly outcrops very close to the site, lime mortars manufactured from sea shells were used to construct the earliest surviving medieval masonry structures. A chronological progression from shell-lime to limestone-lime mortars was suggested by the survey and was subsequently supported by microscopic and petrographic analysis of a large loose mortar sample assemblage. These analyses also demonstrated that a particular fossiliferous limestone had been used to manufacture the lime mortars associated with post-medieval construction at the castle, and the source of this material was identified in the local environment. Overall, these survey and analysis results suggest a re-interpretation of the development of the site is appropriate, and outline the potential for future work.

APPENDIX 8 - CONTENTS

1.0 DUNTULM CASTLE - MORTAR, MASONRY & ENVIRONMENT SURVEY

1.1 ENVIRONMENT SURVEY

Duntulm Castle is located at NG 4099 7435, on the north-west side of the Trotternish peninsula, Isle of Skye. This ruined castle complex has been constructed on the very edge of high sea-cliffs, immediately above one of the best anchorages on the island, and with extensive views to Wester Ross, eastern Lewis (as far as the Point peninsula) and Barra. To landward, the site is located on a rise within a wide area of large enclosed fields, beneath further basalt cliffs which denote the northern limit of the Trotternish Ridge.

1.1.1 UNDERLAYING GEOLOGY

The geology of much of Trotternish is covered with the same igneous lavas which dominate much of northern and western Skye, as part of the wider North Atlantic Igneous Province, remnants of which are found in a wide arc from north-east Ireland through the Inner Hebrides to the Faeroes, Iceland and Greenland (Richey et al 1961, 42). These lavas, however, have protected a series of underlying Mesozoic rocks which now outcrop around the fringes of these lava fields in parts of Skye, the Small Isles, Ardnamurchan, Morvern and Mull (ibid, 21).

The castle of Duntulm is located within the largest exposure of these Inner Hebridean Mesozoic outcrops and so, although built upon a tall basaltic promontory and very close to the massive Trotternish Ridge, the site is surrounded by a series of sedimentary rocks. The two main calcareous formations within this district are both Jurassic and have been mapped below on the first edition Ordnance Survey 6-inch map (O.S. 1878) using BGS information collated through Edina Digimap (see figures), although this image is somewhat misleading, as much of this area is covered with soil overburden. This draws further attention to the outcrop exposed on the shore at *Cairidh Ghlumaig*, south of the castle as a possible lime-source site. A fossiliferous limestone outcrop was on the shore here during walkover, 2.5-3m high in the cut, it also forms a series of cracked pavements on the foreshore. The material has a buff surface colour, but is dark blue within when freshly broken and to the north appears interdigitated with beds of finer buff mudstones with no apparent fossiliferous fraction and much sharper arises so perhaps less calcareous material. This outcrop and pavement displays fairly level even beds of approximately 200mm, and a single fossiliferous sample was collected.

That there was an ‘abundance of limestone in Strath and Trotterness’ has been noted since the 17th-century (Martin [1695]), and the late 18th-century Statistical Account of the parish describes how ‘Some limestone of most excellent quality is found on the neighbouring shore, but [is] difficult to quarry, being a long continuation of a very flat rock, which is exposed to view, when the tide ebbs’ (Martin 1791-99, 554). The similarity between this description and the context previously surveyed at *Cairidh Ghlumaig* is remarkable, although less than 50 years later it would be reported that lime was no longer made in the parish, and it was now transported from Broadford (MacGregor 1840, 268).

1.1.2 SHORE SURVEY

No aggregate survey has yet been undertaken at Duntulm.

1.1.3 WOODLAND

The whole landscape of Trotternish is almost completely treeless and, with the exception of a very small enclosed woodland close to Staffin House in the east and Uig to the south (O.S. 1879) a similar situation is depicted in all the late 19th-century first edition Ordnance Survey maps of the peninsula. That these small woodlands are exceptional in this period is supported by both Statistical Accounts, and in the mid 19th-century the landscape is described as treeless except for 'a little brushwood in two or three places', and any timber required for building was imported to the island (MacGregor 1840, 255, 268). Although a very positive late 17th-century description of the natural resources of Skye reports 'several coppices of wood scattered up and down the island' (Martin [1695], 94), and Blaeu's [1654] slightly earlier atlas does depict some scattered woodland on the east coast of the Trotternish peninsula, late 18th-century and 19th-century attempts at plantation were generally reported a failure, and in this period 'peat was the only fuel' (eg. Martin 1791-99, 551, 555).

In striking contrast to these descriptions, however, many historical accounts also report large and widely-distributed quantities of buried woodland evidence within peat banks across the parish, including trunks, hazelnuts and well-preserved leaves (MacGregor 1840, 247; see also Martin [1695], 555, for Skye more widely). These relicts suggested to commentators that the district had formerly been extensively wooded, and this evidence may have informed MacVean and Ratcliffe's reconstruction of Scottish pre-clearance woodland distribution, in which Trotternish (excepting the high ridge) is depicted as generally dominated by birchwood (MacVean and Ratcliffe 1962).

These descriptions are also generally supported a palynological study undertaken in Trotternish at Loch Cleat (approximately 5 miles SSE of Duntulm Castle) in which a relatively early Holocene climax woodland of *Betula* (birch), *Corylus* (hazel) and *Salix* (willow) 'scrub' with some *Sorbus* (rowan) and *Prunus Padus* (bird cherry) was suggested, although values of *Quercus* (oak), *Ulmus* (elm) and *Pinus* (pine) were low and some 'species-rich grassland' continued from an earlier period (Birks 1993). The most striking aspect of this evidence, however, is the remarkable early date in which that woodland was cleared. Although Loch Cleat is on the same east side of the *Quiraing* as the woodland depicted by Bleau in the 17th-century [1654], the pollen evidence suggests the almost complete clearance of the dominant birch and hazel community around 5000BP, coincident with an increase in herbaceous pollen and the first cereal evidence (Birks 1993).

1.1.4 LIMEKILNS

No limekiln evidence is known to this writer in Trotternish, and none were noted on the Ordnance Survey 1st edition maps. A possible kiln-lining stone was noted, however, in the masonry of the castle enclosure wall.

1.2 BUILDING SURVEY

The site was visited three times early in the course of this thesis research, including on 14/02/12, 19/05/2012, and 25-26/09/2013.

Duntulm Castle has been constructed behind a deep ditch or fosse, and the surviving masonry remains present another irregular enclosure formed by a complex of different walls and buildings from different periods. Most of these structures are now quite fragmentary but include a south tower, a south-east range, a north tower, a sea-gate, a west hall and various sections of adjoining and enclosing walls with associated angle tower and turret. Each of these often conjoined structures will be described separately below.

1.1.4 SOUTH TOWER

The south tower defines the south corner of the masonry enclosure and is a roughly square very thick-walled building of which only fragments of the ground-floor now survive. Externally, the only surviving upstanding wall face is in the south-east, which stands to approximately 2.5m high and includes the reveals of a splaying skewed window to the south, and a fragment of the adjacent south corner (see figures). This south corner consists of strictly alternate-bonded flat-laid slabs of buff-coloured mudstone whilst, in contrast, the south-east wall face has been built in a mixture of flat-laid and edge-laid slabs of mudstone, rounded basalt and some gabbro in rising and dipping courses. Lateral bonding across the whole of this south-east masonry fragment is very good, however, and many of the flat-laid slabs also bond within the core to a good depth.

Internally, the ground-floor of this south tower is barrel-vaulted as this is largely complete, and displays generally full mortar beds, internal mortar characterisation is a largely superficial exercise. Externally, however, missing face stone and exposed wall-heads enable the examination of large volumes of mortar, and two contrasting historic materials are apparent.

The primary, mortar associated with the buildings construction, survives in continuous and contiguous coating, bedding and core contexts to over 1.0m deep. This material has been labelled Mortar 1 and will be described below:

General description – Mortar 1 is a grey-white coarse lime mortar and much of the materials texture is formed by shell material.

Carbonate kiln-relicts – Mortar 1 appears to be a shell-lime which contains a high concentration of heated shell fragments, generally to 10mm but occasionally to 25mm. The shell assemblage is dominated by *O. edulis* (oyster) but also includes a significant *C. edule* (cockle) fraction.

Added-temper – Mortar 1 was tempered with a generally very fine (mostly sub-mm) grey-coloured sand which includes a low concentration of darker (probably mafic) lithics to 4mm.

Fuel kiln-relicts – The shell-lime kiln used to manufacture Mortar 1 was wood-fired and the material still contains localised concentrations of relict charcoal inclusions. These are particularly evidence in the internal vault, although their degraded condition here makes in-situ characterisation challenging and peat was also sometimes suspected.

Vitreous kiln-relicts – Mortar 1 contains locally high concentrations of amorphous vesicled red vitreous inclusions to 15mm. Some of these are 'bleeding' out into matrix whilst 'red-tainted' areas of mortar are also visible.

The external south-east face of the south tower, however, also displays a later very coarse mortar coating, overlaying in-situ Mortar 1 coating material. This is Mortar 8 and will be described below:

General description – Mortar 8 is a remarkably coarse buff-coloured lime mortar.

Carbonate kiln-relicts – Mortar 8 is a limestone-lime.

Added-temper – Mortar 8 was tempered by a remarkably coarse, bimodal lithic material including subangular to subrounded mudstone/sandstone clasts to a remarkable 80mm, some of which may be emplaced fareing.

Fuel kiln-relicts – No fuel was noted in Mortar 8.

Vitreous kiln-relicts – No vitreous kiln-relicts were noted in Mortar 8.

1.1.5 SOUTH-WEST ENCLOSURE WALL

The south-west enclosure wall is defined here as the masonry visible from ground level outside the castle only, and includes the lower fabric from the south tower to the west corner and turret (so not initially including the west hall which is located above and is set back).

The west corner has been constructed very close to the north-west cliff edge, to a distinctly battered profile, rising to the remains of a corbelled square-angled turret on the wall head above. The stonework here displays a mix of lithogies, but is well-bonded, flat-laid, level and well-coursed, with some evidence for ladder snecks and appears very formal compared to much of the masonry further south (see below). The most crucial piece of evidence for understanding the masonry of this enclosure wall has been exposed by the collapse of a three metre wide section of the wall face close to the west corner. This collapse enables a large volume of deep core rubble to be inspected, but has also exposed a coherent a face-to-core cross-section on the west side of the gap which clearly indicates that the wall is multiphase and has been re-faced. The masonry of the wall face here does not effectively bond into the core but abuts it in a straight line only approximately 200m from the wall face, and the mortars either side of that abutment present a striking contrast. The lime mortar with which the secondary formally-styled face stones of the west corner are completely surrounded (including behind them) has a very fine-texture which clearly contrasts with the very coarse shell-rich materials in which the core rubble has been laid.

The primary rubble core of this section of the enclosure wall has also been very well constructed, with good lateral bonding, and stones laid level in full beds of coarse mortar. There is surviving evidence for a putlog socket through this core, which hints at more complexity in the primary structure, but it is also evident that this wall has been built upon bedrock which slopes upwards into the wall at an alarming angle. This is a poor foundation, and it is likely to be this bearing angle, plus the weight of revetted material, which has probably caused at least one collapse here.

The mortar in which the primary core of the south-west enclosure wall has been laid must have been cut back before being re-faced and this material has been labelled Mortar 1a and will be further described below:

General description – Mortar 1a is a coarse shell-rich lime mortar.

Carbonate kiln-relicts – Mortar 1a is a shell-lime which contains a high concentration of heated shell fragments. The assemblage is dominated by *O. edulis* (oyster) in all grades to full valves, but also includes *P. vulgata* (limpet).

Added-temper – Mortar 1a is tempered with a poorly sorted mixture of subrounded to rounded (probably mafic) lithics, generally grading up to 5mm, but including some clasts up to 30mm.

Fuel kiln-relicts - No fuel was evident in Mortar 1a.

Vitreous kiln-relicts - No vitreous material was noted in Mortar 1a.

The angle of the underlying bedrock, as well as the proximity of the primary core, appears to have constrained the size and/or depth of the re-facing stone in the lower levels and has probably further prompted the battered design of the wall face, and in the highest courses, where primary core may not be so prominent, the face stones bond much more deeply into the wall core. The mortar in which the secondary re-facing of the south-west enclosure wall was laid, however, is visible in bed and secondary 'core' contexts only, and appears to have been deposited in a very fluid condition. This material is labelled Mortar 4, and will be described below:

General description – Mortar 4 is a fine-textured, hard, buff-coloured lime mortar.

Carbonate kiln-relicts - Mortar 4 is a limestone-lime containing a high concentration of buff, probable heated bioclastic limestone inclusions, grading up to 15-20mm.

Added-temper - Mortar 4 was tempered with a fine and generally lithic sand grading up to 2mm, and generally including no, or very rare, visible shell inclusions.

Fuel kiln-relicts - No fuel was noted in Mortar 4.

Vitreous kiln-relicts - No vitreous material was evident in Mortar 4.

In contrast to this excellent visibility at the west end of the enclosure wall, further south very often only superficial contexts are visible. The masonry here, however, is also much more informal with large areas of wall face constructed of small pieces of gabbro laid at various angles with poor-bonding and no coursing, and a similar masonry style may be seen in the splaying reveals located centrally in this same section and in the masonry of the internal wall faces of the west hall. That these splaying reveals abut the west hall suggests they are (at least constructionally) secondary, and appear to have re-faced a cut made through the wallhead of the enclosure to enable access to and from the hall. This context requires further evaluation, as shell-lime is visible with some reveals which might suggest more early core has survived. These reveals, however, have also been coated with a shell-rich (possible shell-lime) mortar which would indicate that this feature occupies an intermediate position between the construction and (secondary?) coating of the west hall; repairing and re-facing some of the south-west enclosure in the process and possibly precluding access to the southern section of this wallhead walk.

In summary then, three constructional phases are suspected within this south-enclosure wall, including: an early wall now surviving as shell-lime (Mortar 1a) bonded core; secondary re-facing and turret construction in the west with formal limestone-lime (Mortar 4) bonded masonry; and the subsequent lowering and cutting-through of that wallhead, with reveals of less formally constructed limestone-lime (Mortar 5) bound masonry, to allow access to the west hall. A fourth, possible shell-lime (Mortar 6) coating of the reveals in that later cut is possible.

1.2.3 NORTH-WEST ENCLOSURE WALL

The north-west enclosure wall is here defined as the relatively short section of wall running north from the west corner and coincident with the north-west gable of the west hall above. Externally, the full extent of this work cannot be safely examined without rope access equipment and (as it is revetting) there is no visible internal elevation either. Although employing a higher fraction of basalt and gabbro (including a possible re-used kiln-lining stone), the masonry of this wall is substantially complete, well-bonded, and, as far as can be established (at least superficially) bound with Mortar 4. In this lower section at least, this is formally-constructed masonry which appears to be continuous and contiguous with the masonry re-facing of the west corner and corner turret as already described.

1.2.4 THE SOUTH-EAST RANGE

Only a single fragment of the north wall of the south-east range survives above ground, although this also contains some external tusking at its west end which suggests a complex arrangement with the other towers. The surviving wall fragment is approximately 4.0 metres long and 3.5 metres high, and composed of a range of different sedimentary and mafic lithogies, constructed in well-bonded flat-laid slabs, laid in rising and dipping courses. Only one mortar is apparent within the masonry and this material is visible fully contiguous face-core-face wall cross-sections. This mortar material has been labelled Mortar 3 and will be further characterised below:

Carbonate kiln-relicts – Mortar 3 is a shell-lime which contains a very high concentration of heated shell fragments to full valves. The assemblage is dominated by *O. edulis* (oyster) but includes both *C. edule* (cockle) and other unidentified smooth 'clam' shells.

Added-temper – Mortar 3 was tempered with an aggregate mixture of lithic and shell materials, but this is almost completely dominated poorly-sorted subrounded to subangular mafic clasts, generally to 6-7mm and occasionally to 20mm; although a low concentration of whole unheated *L. littorea* shells is also present.

Fuel kiln-relicts - No fuel evidence was noted in Mortar 3.

Vitreous kiln-relicts – A low concentration of vitreous material was apparent, including a glassy, red/purple, bulbous, amorphous inclusion.

1.2.5 THE NORTH TOWER

Three walls of this very small square-planned tower survive to just over 2 metres above current ground levels, with a rounded north-east and a square angled north-west corner. The masonry style is displayed best between these in a north wall dominated by flat slabs of mafic and sedimentary stones, all of which have been laid flat with very poor lateral bonding. The primary core of this structure is most visible in full cross-sections of the highest surviving courses, where a somewhat heterogeneous, but essentially single phase material is visible in continuous and contiguous core and bed contexts. This has been labelled Mortar 2 and will be described below:

Carbonate kiln-relicts – Mortar 2 is a shell-lime which contains a high concentration and full range of heated shell fragments generally to 15mm but sometimes much larger. The heated shell assemblage is dominated by *O. edulis* (oyster) but also includes *P. vulgata* (limpet). Some possible heated geogenic relicts within this material require further investigation,

Added-temper – Mortar 2 was tempered with a poorly sorted mix of rounded to subrounded mafic lithics to 5mm.

Fuel kiln-relicts – Mortar 2 was wood-fired and contains a low concentration of wood charcoal inclusions to 20mm, much of this is, however, very degraded.

Vitreous kiln-relicts - No vitreous material was evident in Mortar 2.

1.2.6 THE WEST HALL

The west hall is the most substantially complete building surviving at the castle site, and all four walls are upstanding to varying extents. Much of the north-west wall survives, including a large section of gable with splayed window reveals below, and the external face of this wall is constructed upon and is in the same plane as the external face of the north-west enclosure wall (see section 1.2.2). Much of the south-west side wall also survives (almost to wallhead), and includes a large number of floor (or ceiling) joist sockets, extensive remains of internal coatings and the broken jambs of a possible south-west doorway above the south-west enclosure wall (from which it is stepped back). The south-east and north-east walls are more fragmentary, but the latter includes both a window and doorway opening, and both display substantial areas of exposed core masonry.

The general wall faces of the west hall displays consistently high volumes of mafic stone types and, accepting that most quoin stones are now missing, very little sedimentary material is displayed. Various contextually-contingent stone emplacement techniques are evident in the building but these are constructional choices rather than multiperiodicity. As above, the internal face of the south-west wall have employed small gabbro blocks, but much larger material is evident in the north-west wall and gable, and the masonry here is generally laid level with good lateral bonding. Rough intermediate courses give way to well-defined courses approximately at approximately every metre (including at joist-socket level). The impression is of a conventional, professionally-masoned modern building.

In all four walls the mortar is visible in full face-core-face cross-sections and for the constructional fabric this too appears to be generally consistent and single phase. This then is Mortar 5 and will be described below:

Carbonate kiln-relicts – Mortar 5 is a limestone-lime containing a high concentration of large grey to buff bioclastic limestone inclusions grading up to 40mm.

Added-temper – Mortar 5 was tempered with a poorly-sorted mixture of lithic and shell materials but is generally dominated by a fine, sub-mm, grey-coloured material, with an additional low concentration of coarser shell fragments to 8mm.

Fuel kiln-relicts – Mortar 5 was wood-fired and locally high concentrations of charcoal are apparent in the core of the north-east wall. Some scorched sedimentary inclusions are visually very similar to peat and so some circumspection is required.

Vitreous kiln-relicts – None noted.

As noted above, there is good mortar coating survival on the internal faces of the south-west and south-east walls of the West Hall and this appears to be secondary and of a different character to the constructional Mortar 5 of the building. This is now labelled Mortar 6 and will be described below:

General description – Mortar 6 is a hard, brittle, very white and lime-rich mortar coating.

Carbonate kiln-relicts – Mortar 6 appears to be a shell-lime which locally high concentrations of shell fragments dominated by *P. vulgata* (limpet).

Added-temper – Mortar 6 was tempered with a very fine (sub-mm) sorted aggregate material.

Fuel kiln-relicts – No fuel evidence was noted in Mortar 6.

1.2.7 THE NORTH ENCLOSURE WALL INCLUDING THE SEA GATE

The North Enclosure Wall is defined here as the masonry running east from the north corner of the West Hall as far as (but not at present including) the north-east angle tower. Due the proximity of the sea cliffs, the external wall faces of these structures could not be examined, but various sections of collapse have allowed face-core-face wall cross-sections to be investigated from inside the walls in a number of places.

A substantial lower portion of the sea gate survives and the east wall is still standing to over 3.5 metres high. This appears to display two contrasting masonry styles, as the lower wall face is constructed of rounded mafic blocks, many of which have been laid at different angles, whereas the surviving higher section is dominated by sedimentary slabs which have been flat-laid in level well-defined courses. To the east of the sea gate the enclosure wall is very narrow at 550mm stepping down to a 300mm parapet.

In each of these structures the visible mortars appears very similar and will be described here as Mortar 4:

Carbonate kiln-relicts – Mortar 4 is a limestone-lime which contains very high concentrations of probable heated bioclastic limestone inclusions to 40mm; no heated shell.

Added-temper – Mortar 4 has been tempered with a well-sorted very fine (generally sub-mm) material with is probably largely composed of shell material.

Fuel kiln-relicts – No fuel relicts were noted in Mortar 4.

Vitreous kiln-relicts – No vitreous materials were noted in Mortar 4.

1.2.8 THE EAST ENCLOSURE WALL INCLUDING THE NORTH-EAST ANGLE TOWER

The east enclosure wall is defined here as all sections of the wall running south-east from the north-east angle tower to the south-east corner of the site. The north-east angle tower is included in this section of enclosure wall because although (like the north enclosure wall above) the external wall face of these structures cannot be examined at close quarters without rope access equipment, even when viewed from the south-east corner of the site it is clear that the stonework is consistent. The masonry of most of the east enclosure wall, including the north-east drum angle tower, is composed of a range of mafic and sedimentary lithogies, but these are consistently laid flat and level, in reasonably well-defined level courses and there is no reason here to suspect multiperiodicity.

One context in which the masonry of this north-eastern section can be examined in more detail, however, is within the drum tower itself where a barrel-vaulted chamber can still be accessed. Internally, although only relatively superficial bedding mortars are visible in this vault, this structure would appear to be single phase and bonded with a visually consistent lime mortar, here labelled Mortar 4a:

Carbonate kiln-relicts – Mortar 4a is a limestone-lime with a high concentration of small, up to 4mm, white lime and limestone inclusions.

Added-temper – Mortar 4a was tempered with a well-sorted generally very fine (sub-mm) material.

Fuel kiln-relicts – Mortar 4a was probably wood-fired as there appears to be localised high concentrations of blackened carbonised inclusions (to 15mm) which are probably degraded wood-charcoal.

Vitreous kiln-relicts - No vitreous material was recorded in Mortar 4a.

A loose sample of mortar (DCS.I) was taken from within the vaulted room but displayed a shell fraction which appears unusual for this context.

The south-eastern section of the east enclosure wall, however, is certainly of a different phase to the north-eastern section and drum tower described above. Although built on a curving plan-form this masonry presents a formal stone-emplacement technique employing large (up to 750 x 450) mafic building blocks with more fissile snecks and levellers. Unusually for this site, these stones all appear to be from a single source and the wall face displays a heavy coat of lichen.

Although reminiscent of some Hebridean dry-stone work and no coating evidence was noted, this masonry is certainly lime mortar bonded and an apparently contiguous core and bedding material was noted. A combination of factors, however, including the tightly bonded stonework, lack of coating and turf covering, make mortar characterisation challenging. In interim, however, the mortar was labelled mortar 7, and the following somewhat tentative characterisations made:

Carbonate kiln-relicts – Mortar 7 may be a shell-lime as *O. edulis*, *P. vulgata* and *C. edule* fragments are present and some possible heating evidence within this material was noted.

Added-temper – Mortar 7 was tempered with a coarse poorly-sorted lithic material comprised of subangular to rounded clasts, generally to 5mm, but occasionally to 15mm.

Fuel kiln-relicts - No fuel evidence apparent was apparent in Mortar 7.

Vitreous kiln-relicts - No vitreous materials were apparent in Mortar 7.

1.2.9 EX-SITU MASONRY CHUNKS

There are two large ex-situ sections of wall lying at odd angles around the site, both of which appear to be multiphase. The section lying very close to the south-east end of the east enclosure wall, in particular, is remarkable in its display of two contrasting mortars with a particular stratigraphic relationship.

The primary core of this ex-situ section is bound with a coarse shell-lime mortar, with a high concentration of heated *O. edulis* fragments and some *P. vulgata* to 25mm, tempered with a poorly-sorted coarse lithic material, generally to 7mm but occasionally to 50mm, and without fuel or vitreous evidence. This core masonry, however, appears to have been re-faced and over-built with stonework bound and coated in a wood-fired limestone-lime (with a high concentration and large range of heated bioclastic relicts), tempered with a very fine unheated probable shell-rich aggregate to 1mm.

2.0 DUNTULM CASTLE – SAMPLE CONTEXTS AND ANALYSIS

2.1 SAMPLE CONTEXTS

2.1.1 MORTAR SAMPLE CONTEXTS

DCS.A Late West Hall; context 1; 400 north of north jamb, 750 above ground, 250 back from wall face; CORE.

DCS.B South Tower; south-west wall; 450 north of external face of south-east wall, 1800 above ground, 700 back from external wall face, CORE.

DCS.C South Tower; undercroft; 4150 north-west of internal face of south-east wall, 400 SW of internal face of north-east wall, loose core on ground.

DCS.D South-west Curtain Wall; 3900 south of west corner; 1350 above ground, 450 back from external wall face; CORE.

DCS.E South-west Curtain Wall re-facing; 1100 south of west corner, 900 above ground, 160 back from external wall face; CORE.

DCS.F South Tower; vault; 475 NW of internal face of SE wall, 1200 SW of NE door blocking, 2100 above ground, 100 back from vault face; BEDDING.

DCS.G Stair Tower; north-west wall; 750 north of west corner, 1200 above ground, 330 back from external wall face; CORE.

DCS.H North-east Tower; north-west wall; 350 south of tusking angle, 600 above large tusking slab, 400 from external face; CORE.

DCS.I Angle Turret; north wall; 360 east of plumb internal face of west wall, 340 above scarcement, 100 back from internal face; BEDDING.

DCS.J North Curtain Parapet; various matching loose CORE samples.

DCS.K Sea Gate; east wall; various matching loose CORE samples.

DCS.L Late West Hall; north-east wall; various matching loose CORE samples.

DCS.M Same context as DCS.L. Although this is a loose relict fuel sample.

DCS.P East Curtain Wall; 1000 north of SE extension, wallhead, 300 from external wall face; CORE.

2.1.2 ENVIRONMENTAL SAMPLE CONTEXTS

Environmental sample contexts were recorded by hand-held GPS.

DCS.Q A single sample of fossiliferous limestone was collected from the beach outcrop of *Cairidh Ghlumaig*, south of the castle site at NG 41078 73923.

2.1.3 ANOTATED PLANS OF MORTAR SAMPLE CONTEXTS

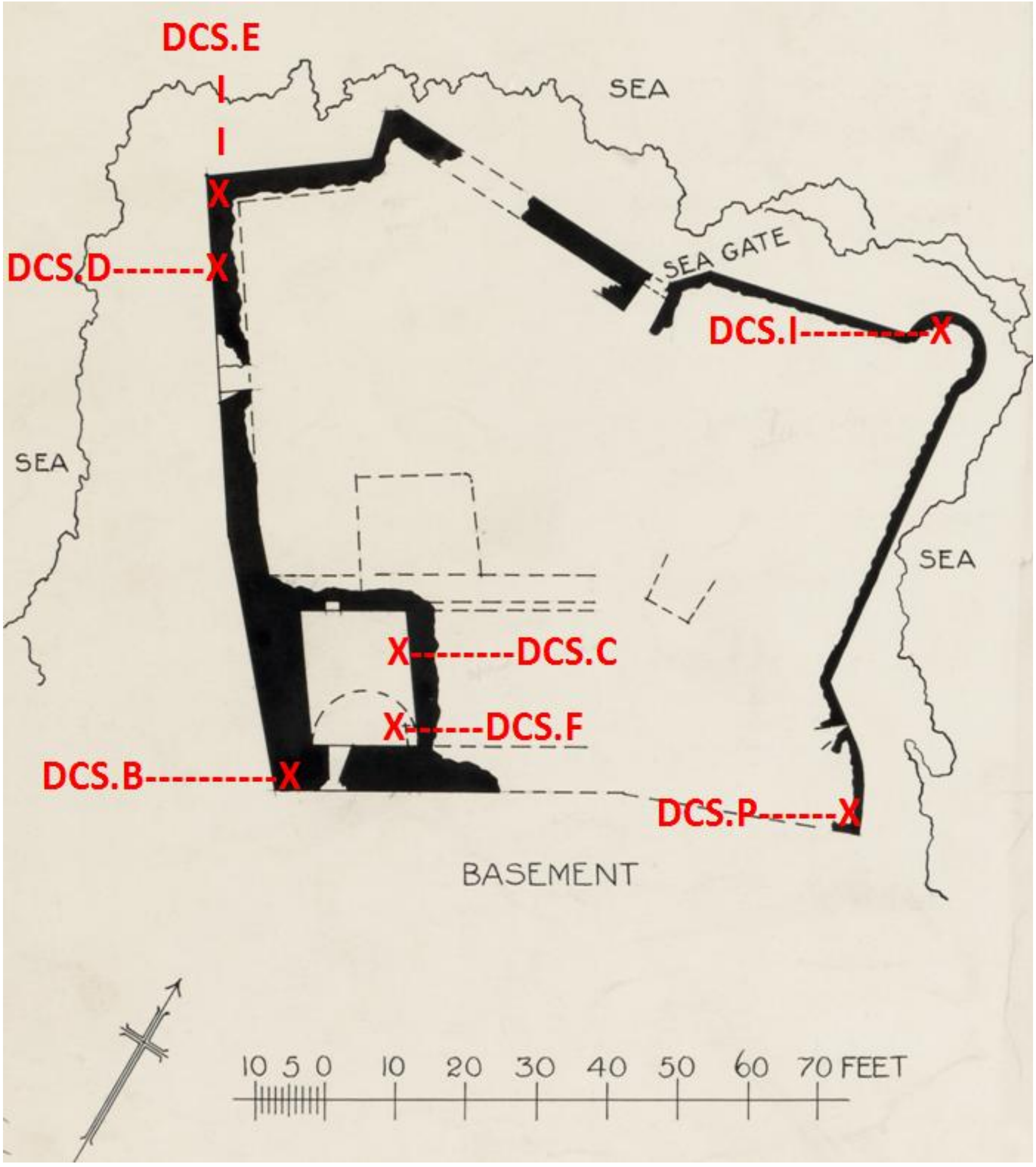

Figure 1a (above) – annotated plan (RCAHMS 1921) of sample mortar sample contexts from basement level of Duntulm Castle, Skye. (Original image DP 106838 © crown copyright: Historic Environment Scotland. Licensor Canmore.org.uk.)

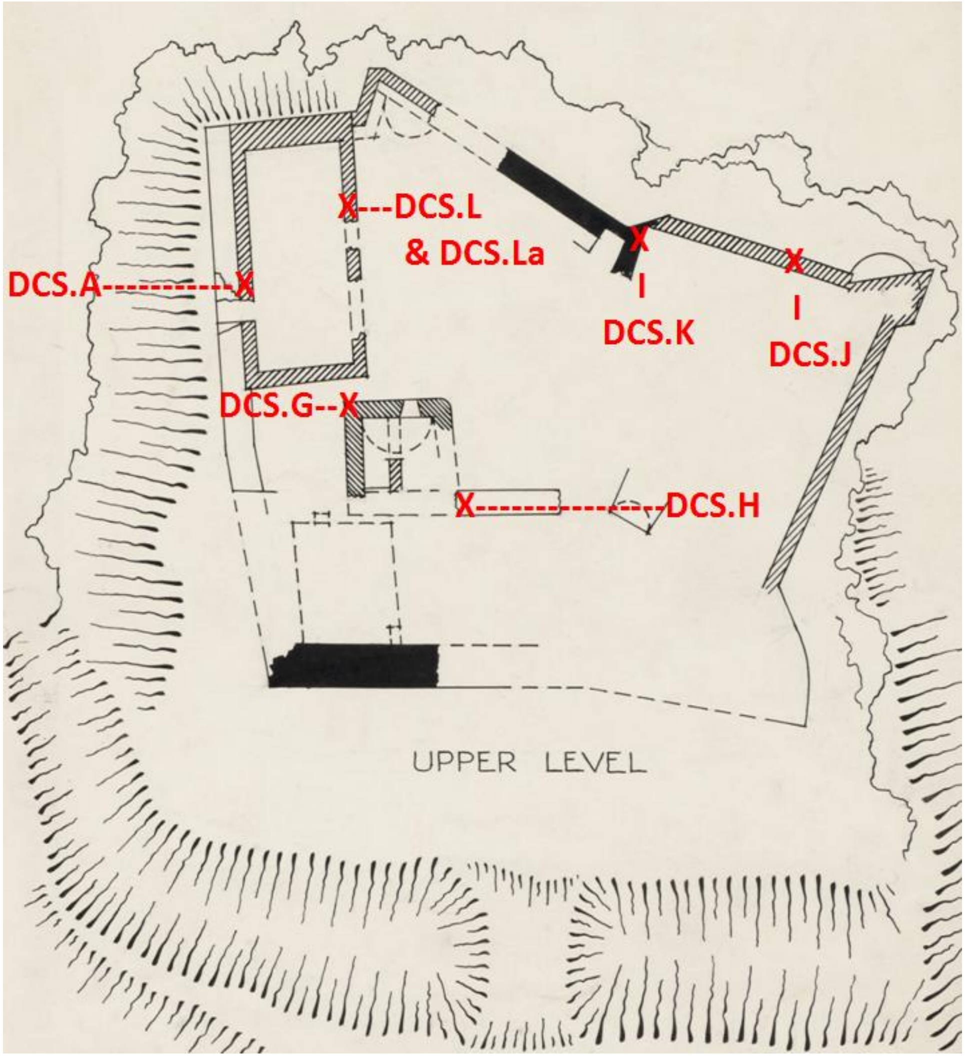

Figure 1b (above) – annotated plan (RCAHMS 1921) of sample mortar sample contexts from upper level of Duntulm Castle, Skye. (Original image DP 106838 © crown copyright: Historic Environment Scotland. Licensor Canmore.org.uk.)

2.2 SAMPLE ANALYSIS

Sample analysis included petrographic analysis of a thin-sectioned mortar and local stone samples, and microscopic analysis of a single fuel relict sample in reflected light.

2.2.1 MORTAR SAMPLE ANALYSIS

From these 13 loose mortar samples removed from the site, 36 thin sections were prepared and analysed in polarized light. The resulting petrographic interpretations are presented below with accompanying photomicrographs in section 4 (figures).

DCS.A. (x 2 thin sections)

Slide description: Two large thin sections to 44 x 17mm one of which is dominated by a very large, blue-coloured, probable bioclastic grain, the other a fine light brown mortar displaying a bimodal grain distribution generally comprised of material grading up to 1.0mm, but including some rounded to subrounded clasts to 5mm.

Carbonate kiln-relicts – DCA.A is a limestone-lime with a very high concentration and large textural range of heated limestone relicts grading up to 20mm. Heated shell material is also present, including some large curving relicts grading up to 3.0mm, but evidence elsewhere suggests these have been released by the more thoroughly heated/calcined bioclastic limestone clasts.

Added-temper – DCS.A was tempered with a locally heterogeneous mix of shell and lithics in approximately equal proportions of this section overall. The lithic fraction contains a fine-grained rounded basalt clast to 2.75mm, but is generally dominated by much finer subangular to subrounded dolerite, olivine, pyroxene and (often degraded) plagioclase clasts, generally grading to 0.25mm but occasionally to 1.5mm. The unheated shell fraction contains mollusc (both bivalve and gastropod) fragments of Recent provenance to 3.0mm.

Fuel kiln-relicts– No fuel evidence was noted in DCS.A.

Vitreous kiln-relicts - No vitreous material was noted in DCS.A

<u>DCS.B.</u> (x 2 thin sections)

Slide description: These two large sections of DCS.B contained sections up to 25 x 43mm both of which contain a very light buff-coloured mortar which is generally quite fine but includes shell clasts to 15mm. This shell fraction lends a coarser texture to the section, and enables a clear distinction between Recent biogenic carbonate and unheated geogenic temper.

Carbonate kiln-relicts – DCS.B is a shell-lime which contains a range of heated *O. edulis* (oyster) shell textures in fragments grading up to 15mm. No calcareous geogenic clasts were present.

Added-temper – DCS.B was tempered by a well-sorted mixture of lithic clasts dominated by fine angular to subangular grains of olivine and pyroxene with a subordinate fraction of plagioclase-rich clasts, generally to 0.3mm. A low concentration of more coarse and rounded rock clasts includes dolerite/gabbro to 2.5mm and a single rounded ironstone clast to 6mm.

Fuel kiln-relicts – DCS.B contained a single probable wood charcoal relict to 1.75mm.

Vitreous kiln-relicts – DCS.B contains a low concentration of amorphous very dark-brown clasts, which are associated small angular opaque grains, with textures which suggest early stage reaction or vitrification, may have taken place.

DCS.C **(**x1 thin section)

Slide description – A single large section, to 45 x 25mm, contains a coarse mortar including a large rounded lithic clast to 11mm.

Carbonate kiln-relicts – DCS.C is a shell-lime with a high concentration of heated shell fragments grading up to 5-6mm, and including both ribbed *C. edule* (cockle) and *O. edulis* (oyster).

Added-temper – DCS.C was tempered by a coarse, well-sorted, mixture of lithic and shell fragments, dominated by a lithic fraction which includes rounded gabbro to 12mm and rounded mudstone and sandstone to 5mm. The finer, more angular monominerallic lithic materials seen in DCS.A and DCS.B are not represented here.

Fuel kiln-relicts – No fuel evidence was noted in DCS.C.

Vitreous kiln-relicts – The section contains large rounded and vesicled reaction products to 3mm. These can be variously isotropic, with well-formed crystal growing into a melt, or opaque. Pyroxene intergrowths are also apparent in one example, suggesting a possible mafic igneous protolith, but a range of possible detrital lithic sources are suspected here. These products are, however, discrete, and have not imparted hydraulicity to the matrix which is a remarkably 'clean' and homogenous carbonate.

DCS.D (x2 thin sections)

Slide description - These two large sections of DCS.D range, to 51 x 25mm, display a coarse mortar with subrounded lithic clasts to 11mm, shell fragments to 7mm, and rounded, rust-colored vitreous products to 14mm. Although well-tempered, under magnification it is evident that a high binder ratio and so matrix-supported texture also.

Carbonate kin-relicts – DCS.D is a shell with a high concentration of well-heated bivalve shell fragments to 6mm.

Added-temper – DCS.D was tempered with a poorly-sorted coarse mixture of lithic and unheated shell fragments dominated by a well-rounded mudstone and gabbro/dolerite clasts also survive (see vitreous materials below) to 8mm, but a finer mafic monomineralic content is once more absent. A small unheated shell fraction grades to 7mm.

Fuel kiln-relicts – DCS.D contains a low concentration of amorphous, opaque, possible peat relicts to 1.0mm.

Vitreous kiln-relicts – Very large, rounded, highly-vesicled reaction products to 12mm, which are very often fractured fragments of a once larger whole.

DCS.E (x2 thin sections)

Slide description - Two very large sections of DCS.E were prepared, to 57 x 25mm, and these contained a fine-textured, buff-brown mortar, generally tempered with sub-mm materials but also displaying some larger probable geogenic carbonate clasts to 6mm.

Carbonate kiln-relict – DCS.E is a limestone-lime and these larger clasts are bioclastic packstone kiln-relict fragments display a range of textural evidence for heating and grade up to 6mm. Where least altered these are subangular to subrounded, but more altered clasts are very rounded, amorphous.

Added-temper – DCS.E was tempered with a well-sorted mixture of lithic and shell clasts at a ratio of approximately 65:35. In order of abundance the lithic fraction includes olivine, pyroxene, quartz, gabbro, basalt and quartzofeldspathic grains, generally subangular to subrounded and to 0.3mm. Very rare subrounded clasts of, perhaps iron-rich, silt/mudstone to 3mm are also present. The unheated shell fraction is dominated by curving bivalve shell clasts with good fibrous and cross-lamellar microstructure, to 1.5mm. Some of this material may be preserved calcitic material released by from limestone matrices during calcination, but the locally high concentrations of gastropod shells, suggest Recent shell material is dominant.

Fuel kiln-relicts – No fuel evidence was noted in DCS.E.

Vitreous Material – No vitreous evidence was noted in DCS.E.

DCS.F (x3 thin sections)

Slide description – These DCS.F sections contain a coarse fraction of angular, curving shell fragments to 6mm and subangular to subrounded lithics to 5mm evenly distributed throughout an otherwise fine-tempered material.

Carbonate kiln-relicts – DCS.F is a shell-lime which displays a wide range of heated shell textures, including *C, Edule* (cockle) to 6-7mm and *O. Edulis* (oyster) to 10-11mm.

Added-temper – DCS.F has been tempered by a bimodal mix of lithic clasts dominated by a fine angular mix of olivine, pyroxene and gabbro to 0.3mm, but also including rounded to subrounded silt/mudstone grains to 5mm.

Fuel kiln-relicts – No fuel evidence noted in DCS.F.

Vitreous Material – These DCS.F sections contain a high concentration of vitreous materials which appear to be reaction products associated with a rounded detrital lithic protolith.

DCS.G (x2 thin sections)

Slide description - Both DCS.G slides are dominated by very large white curving oyster shell fragments to 50 x 5mm. These are surrounded by a mortar with a uniformly bimodal distribution of coarse shell to 10mm supported by a largely sub-mm but overall medium-grade tempered matrix.

Carbonate kiln-relicts – DCS.G is a shell-lime mortar with a high concentration of heated shell fragments. The assemblage is dominated by *O. edulis* (oyster) shell fragments which display a large range of altered textures.

Added-Temper – DCS.G was tempered by a well-sorted fine lithic material, including angular to subrounded grains to 0.3mm, but including more rounded clasts of siltstone to 2-3mm.

Fuel kiln-relicts – No surviving fuel evidence was noted in DCS.G.

Vitreous kiln-relicts – There is a high concentration of vitreous material but it appears relatively undeveloped in DCS.G.

DCS.H (x 4 thin sections)

Slide description - Four large sections of DCS.H, to 39 x 25mm, contain a coarse textured mortar material of shell and rounded lithic fragments to 15mm.

Carbonate kiln-relicts – DCS.H is a shell-lime and the section displays a low to medium concentration of well-heated bivalve shell fragments, including *O. edulis* (oyster), to 17mm. , A high fraction of the relict assemblage is close to optical continuity with the general mortar matrix.

Added-temper – DCS.H was tempered with a well-sorted very coarse lithic aggregate including rounded clasts of olivine-rich dolerites and gabbro to 10mm, and rounded quartz-included siltstone to 9mm. It is notable that the fine, angular monomineralic grains seen in other sections are absent or only very rarely present here.

Fuel kiln-relicts – No fuel evidence was noted in DCS.H.

Vitreous materials – The section displays one large, very rounded, vitreous reaction product. This contains included relict quartz but is otherwise largely opaque and vesicled. (see DCS.Hv below)

DCS.Hv (2 thin sections)

Two thin sections, to 30 x 25mm, were prepared from the DCS.H sample – targeted because they contained particularly large putative reaction products – to 23 x 25mm. Both are amorphous, but vaguely square in shape and largely opaque to the naked eye with a colouration from deep red to the more general black. They are quite porous and one contains a light-coloured subrounded inclusion to 2.5mm.

Although very large it is evident under magnification that these are fractured fragments broken from a larger whole. The very high concentration of rounded vesicles, from 0.05 to 1.5mm, within both sections is striking, and their circularity indicates they are of gaseous origin. Furthermore, however, there is a pattern to this vesicle gradation which increases in size toward the margins of the melt mass.

Furthermore, within the core of these melts are a number of degraded, but still recognizable, grains of dolerite. That these dolerite grains are generally associated with areas of melt with much smaller vesicles indicates something of the process here. These dolerite clasts are relict protolith grains for the melt, which off gas during melting. These gases then migrate towards the margins of the melt, and during this process merge to form larger bubbles.

<u>DCS.I</u> (x3 thin sections)

Slide description - Three large sections of DCS.I, to 32 x 25mm, were prepared and these contained a very coarse mortar dominated by large rounded lithic and angular shell clasts to 15mm and 25mm respectively.

Carbonate kiln-relicts – DCS.I is a shell-lime displaying mixed bivalve taxa, including *O. Edulis*, to 25mm. Very little evidence for heated microstructure is present as many of these relicts are highly altered.

Added-temper – DCS.I was tempered with a well-sorted mixture of very rounded coarse lithic grains, including olivine-rich gabbro/dolerite and basalt to 15mm and siltstone to 6mm. There is no fine angular monominerallic fraction to this temper mix. Same as H.

Fuel kiln-relicts – No fuel evidence was noted in DCS.I.

Vitreous materials – There is some vitreous reaction product evident in DCS.I. but only in early development.

<u>DCS.J</u> (x3 thin sections)

Slide description - Three large sections of DCS.J, to 46 x 17mm, were prepared and these contained a fine mortar material, which is generally composed of sub-mm materials with an even distribution of probable carbonate relicts to 5.0mm.

Carbonate kiln-relicts – DCS.J is a limestone-lime with a high concentration of subangular limestone fragments, to 5mm, which display a large spectrum of heated textures, becoming more rounded with increasing alteration. The limestone is a bioclastic packstone, and released shell clasts of geological age are also evident.

Added-Temper – DCS.J was tempered with a fine well-sorted mixture of lithics and shell fragments, slightly dominated by the lithic fraction to 60:40. The lithic fraction is dominated by angular monominerallic grains of olivine, plagioclase and pyroxene, with some rare quartz, to 0.3mm, but includes some rounded gabbro and dolerite to 1.0mm. The unheated shell assemblage includes both bivalves and gastropod fragments.

Fuel kiln-relicts – No fuel relicts were noted in DCS.J noted.

Vitreous materials – No vitreous materials were noted in DCS.J.

DCS.K (x2 thin sections)

Slide description - Two large sections of DCS.K, to 39 x 25mm, were prepared and these contain a light buff, coarsely textured mortar with probable limestone inclusions to 10-13mm. Otherwise an evenly distributed fine temper to 1.5mm but probably largely sub-mm.

Carbonate kiln-relicts – DCS.K is a limestone-lime which contains an extremely high concentration (more than 50% in one slide) of heated geogenic carbonate relicts. These include discrete bioclastic and quartz-rich fragments up to 12mm, as well as some released heated bioclasts of geogenic origin. A dichotomy in heated textures is apparent whereby the white calcined shell may be released whole or surround by areas heated red-brown micrite which appears lose coherence earlier.

Added-temper – DCS.K was tempered with a very fine well-sorted mixture of lithic and shell fragments in approximately equal proportions. The lithic fraction is dominated by subrounded grains of dolerite and more angular monominerallic grains of olivine and pyroxene to 0.2mm, although some rounded very quartz-rich sandstone clasts are also present. The assemblage of Recent unheated shell fragments includes bivalve and gastropod taxa.

Fuel kIln-relicts - No fuel evidence was noted in DCS.K.

Vitreous materials – No vitreous materials were noted in DCS.K.

DCS.L (x4 thin sections)

Slide descriptions - Four large sections of DCS.L, to 38 x 22mm, were prepared and these contain a bimodal material which is generally very fine-tempered but includes large probable bioclastic limestone inclusions to 17 x 10mm.

Carbonate kiln-relicts – DCS.L is a limestone-lime which contains a high concentration of bioclastic packstone with some contrasting quartz-rich provenance material also apparent in minor concentrations. Some striking heated bioclast textures include crazing and complete loss of fibrous texture. Further shell-surrounded micritic contexts, and lack of sparite, suggests these sections would contribute to the study of the relative calcinations rates and textures of different carbonate forms very well.

Added-temper – DCS.L was tempered with a fine almost completely lithic material dominated by angular monocrystalline grains of olivine and pyroxene, with some quartz to 0.3mm. Rock and/or Recent shell clasts are notable by their almost completely absence.

Fuel kiln-relicts – DCS.L contains a high concentration of probable peat relicts.

Vitreous Material – No vitreous material was noted in DCS.L.

DCS.La (1 x sample)

A single loose sample of probable relict-fuel was examined in reflected light and interpreted as vitrified wood-charcoal, although this was too altered for taxonomic identification.

DCS.P (x4 thin sections)

Slide descriptions - Four large sections of DCS.P, to 58 x 20mm, were prepared and these contain a coarse mortar with a high white shell fraction to 16mm and subrounded elongated brown lithics to 6mm.

Carbonate kiln-relicts – This material is only very tentatively interpreted as a shell-lime on the basis of the heated shell (*O. edulis*) and lack of clear heated limestone evidence. This evidence is lent an ambiguity here, however, because the (possible lime-source) shell fragments are often surrounded by large areas of lime-rich binder and this is unusual evidence. Further samples are required.

Added-temper – DCS.P was tempered by a coarse mixture of rounded and elongate, sedimentary silt/mudstone grains with varying concentrations of quartz. Subangular dolerite is evident to 8mm, but is in low concentration and often with large opaque sections and other textures which suggest heating and early stages of reaction.

Fuel kiln-relicts – DCS.P displays one probable peat inclusion.

Vitreous materials – DCS.P displays a low concentration of rounded, opaque, vesicled clasts to 2.0mm.

2.2.2 ENVIRONMENTAL SAMPLE ANALYSIS

DCS.Q is a complex bioclastic packstone containing the following textures:

1, large shells in which the original, probably calcitic, external shape and internal fibrous laminated microstructure survives. Externally these shells are surrounded by a ‘coating’ of micrite whilst internally any pore spaces between shell filaments are filled with a coarse sparry calcitic mosaic. Some are laminated Ostrea-type type shells, wherein the chalk has been replaced preferentially with sparite whilst the fibrous survives. These preserved shell relicts are present down to very fine grades in lower concentration.

2, Very fine shell micrite surrounded moulds in which all shell microstructure has been lost and replaced with sparry calcite.

3, Variously micritic contexts containing very fine angular to subangular quartz

2.2.3 SUMMARY OF SAMPLE ANALYSIS

DCS.A	LIMESTONE	FINE/MONOCRYST	no fuel, NO VIT
DCS.B	SHELL	FINE/MONOCRYST	Wood, VIT
DCS.C	SHELL	COARSE NO FINES	no fuel, VIT
DCS.D	SHELL	COARSE NO FINES	peat?, VIT
DCS.E	LIMESTONE	FINE/MONOCRYST	no fuel, NO VIT
DCS.F	SHELL	FINE/MONOCRYST	no fuel, VIT
DCS.G	SHELL	FINE NO MONOCRYST	wood fuel, VIT
DCS.H	SHELL	COARSE NO FINES	no fuel, VIT
DCS.I	SHELL	COARSE NO FINES	no fuel, VIT
DCS.J	LIMESTONE	FINE/MONOCRYST	no fuel, NO VIT
DCS.K	LIMESTONE	FINE/MONOCRYST	no fuel, NO VIT
DCS,L	LIMESTONE	FINE/MONOCRYST	wood fuel, NO VIT
DCS.P	UNCERTAIN	COARSE	peat?, VIT.

3.0 DUNTULM CASTLE – CONCLUDING DISCUSSION

The above preliminary survey and analysis of the surviving masonry evidence at Duntulm Castle suggests a typological progression from locally-sourced shell-lime to limestone-lime mortars pertained at this site. Whilst this conforms to changes in the mortar typology of the region at different times, and the contrasts between these geogenic and more Recent biogenic mortars will inform more in-depth materials analyses in the future, a number of specific aspects of this particular building survey are worthy of further note.

The use of shell as a lime source at this site is remarkable given the obvious proximity of easily available and recognisable bioclastic limestone outcrops. The surviving evidence suggests that only very local masonry materials were used in the construction of these various buildings and sedimentary stones were clearly being quarried for building stone in almost all phases of the site. During much of the medieval period, however, shell-limes were the mortar material of choice, and the evidence for limestone facing blocks bound in shell-lime (as for instance in the south-east range) is striking.

The confluence of historic, archaeological and geological evidence for the use of local Jurassic limestone (DCS.Q), from *Cairidh Ghlumaig,* in the later building contexts is remarkable and unique within this research. That limestone, rather than shell, would be used to manufacture lime for construction in late medieval and early modern periods, however, does conform to regional typologies as does the use of a more finely-tempered material in these later buildings. The possible use of a shell-lime internal 'plaster', coating the limestone-lime bound masonry of the west hall has also been noted elsewhere in the Highlands, Orkney and Shetland.

Given the reported vegetational history of the Trotternish peninsula, however, the evidence for wood-fired mortars at Duntulm Castle is significant, and clearly suggests more work to establish the taxonomical range of the assemblage in different periods would be appropriate. Certainly, a programme of radiocarbon dating should be considered here, and the evidence in Mortar 1 of the south tower, in particular, should be examined more comprehensively. The single loose piece of charcoal analysed thus far appears to indicate that temperatures in some parts of the limekiln were particularly high during the construction of the late hall, and the probable evidence for the re-use of a vitrified kiln-lining stone in the face of the north-west enclosure wall adds to this narrative.

The above study has been undertaken on loose samples only and any further work at the site should be predicated on the analysis of samples collected from fixed in-situ contexts with scheduled monument consent. Pending any possible radiocarbon dating work at Duntulm, however, our understanding of the detailed development of the castle complex is informed by the preliminary mortar and masonry survey presented above in two main ways: the evidence for the direct stratigraphic relationship between various building mortars, and the interrelationships between masonry fabric which is not physically related but is of similar or dissimilar character.

At Duntulm, the mortar evidence repeatedly indicated how particular shell-lime bound masonry has been overbuilt with limestone-lime mortars in later phases, and this was most clearly displayed at the west end of the south-west enclosure wall, where the evidence for the later re-facing of the primary core was unequivocal. Again this requires confirmation by the analysis of samples collected from fixed contexts, but this previously unidentified relationship may have significant implications for our understanding of the buildings development and draws attention to previous interpretations of the wider site for which we are generally reliant on the RCAHMS (1928) and more recently Miket and Roberts (2007).

The RCAHMS essentially interpreted Duntulm as a three phase structure, and within this scheme the surviving south-west enclosure wall was regarded an integral part of the primary castle building which also included the surviving south tower, sea gate, north-west drum tower, and main sections the north and east enclosure walls (see figure 1). A small mid-phase was then proposed, in which the north tower was constructed, before a final major phase which included the building of the west hall and parapets above the north, south and north-east drum enclosure walls.

Miket and Roberts appear to have collated the RCAHMS plans of this scheme, but have also slightly re-interpreted the site and proposed a new four phase developmental model. Within this, the south tower, south-west wall, sea gate and drum tower are still regarded as primary structures (and considered 14th-15th-century), and the north tower is also retained as a small secondary phase (here early 16th-century), but the final RCAHMS phase has then been divided between a (late 16th-century) south-east range, south-east end of the east enclosure, and east and north parapets, and a 'late' (17th-century) west hall. This relatively slight modification of the last phase/s of the site appears to be predicated on balancing the requirement to find a context for the south-east range and contrasting masonry of the east enclosure (neither of which were noted by the RCAHMS) and accommodate the multiperiodicity apparent at the west of the site, where the west hall was regarded as cutting the west angle tower.

These different building contexts, however, are often not in physical contact and, having characterized their various masonry and mortar-making techniques, a number of preliminary interrelationships can be suggested:

- The mortar evidence is broadly divided between two lime sources. Thus the south tower, core of the south-west wall, north tower and south-east range are related as shell-lime structures and this broadly supports previous interpretations of their early phasing.
- Likewise, as limestone-lime bound structures with very similar mortars, the west hall, west angle turret, north-west enclosure wall, sea gate and north and west

parapets are also related, and for many of these structures this also supports previous interpretations of their late phasing.

- In contrast to these previous interpretations, however, it is clear that the visible upstanding structure of the sea gate is not primary; and that the south-east range is not related, either to the east and north parapets (which are bonded with mortars) or to the south-east end of the east enclosure wall (which displays a very different masonry style and building stone source.

The small section of curtain wall at the south-east of the site has been interpreted differently by previous commentators. Some time was spent both on site and in the lab attempting to characterise this masonry and further work is clearly required. The masonry style is formal and distinctive and was not noted elsewhere on site (see figures 20 and 21 below). The mortar has been very tentatively characterised as a shell-lime on the basis of a loose sample, which might suggest an early date, but unfortunately there are no extensive in-situ core mortar contexts visible on site with which to confidently compare this sample. This may be a significant context and future work should seek to characterise the mortar and its relationship to the rest of the curtain wall more clearly.

As above, it is hoped further survey and recording work at Duntulm can take place in the near future, when it is hoped more comprehensive survey and analysis can take place through safe access to the external north and east wall faces, taking fixed mortar samples and radiocarbon dating at least one phase. One of the more striking aspects of previous interpretations is the apparent rapidity with which the site developed, and the added complexity of the above survey may strain the chronology further. In interim, however, a preliminary re- interpretation of the phasing of the visible fabric is offered here, pending further work:

1. Phase 1 - Although the south tower and south-west enclosure wall core are no longer in a visible direct physical relationship, previous suggestions that they are primary and contemporary is supported by their similar mortars (Mortar 1 and 1a). That the north of the east enclosure wall is also primary, however, may be unlikely although the relationship between this structure and the south-tower should be quite easily informed with better access. The lower masonry of the sea gate is more likely to be primary, but this also requires re-evaluation in future work.
2. Phase 2 - The north tower (bonded in Mortar 2) is secondary and abuts the south tower.
3. Phase 3 - The stratigraphy of the south-east range (bonded in Mortar 3) can no longer be clearly interpreted from the upstanding, and so Miket and Roberts (2007) assessment is accepted and somewhat supported by the mortar archaeology.
4. Phase 4 - The north angle tower, north-west enclosure, sea gate, north enclosure, barrel-vaulted north-east angle (bonded in Mortar 4) and possibly the east wall and

drum tower may all be substantially contemporary, and again better access will inform this phase.

5. Phase 5 - The west hall (bonded in Mortar 5).
6. Phase 6 - Splay jambs between west hall and south-west curtain and shell-lime coating.

4.0 DUNTULM CASTLE – FIGURES

Figure 2 (above) – Location of the castle site of Duntulm on the north-west of the Trotternish peninsula at the north of the Isle of Skye, north-west of the mainland of Scotland.

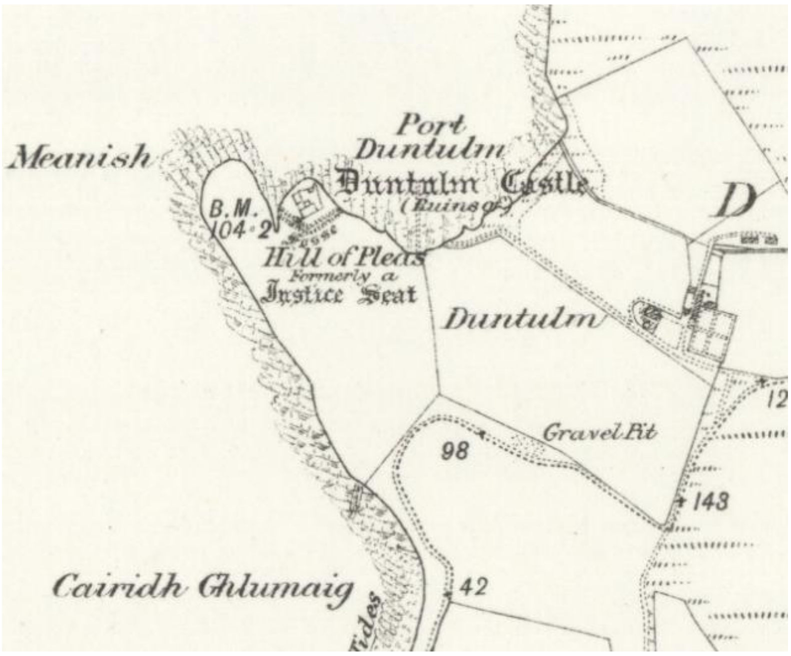

Figure 3 (above) Detail of Ordnance Survey first edition 6-inch map (O.S. 1878) clearly showing the position of the site and the relative positions of the main structures within the site. (By kind permission of the National library of Scotland).

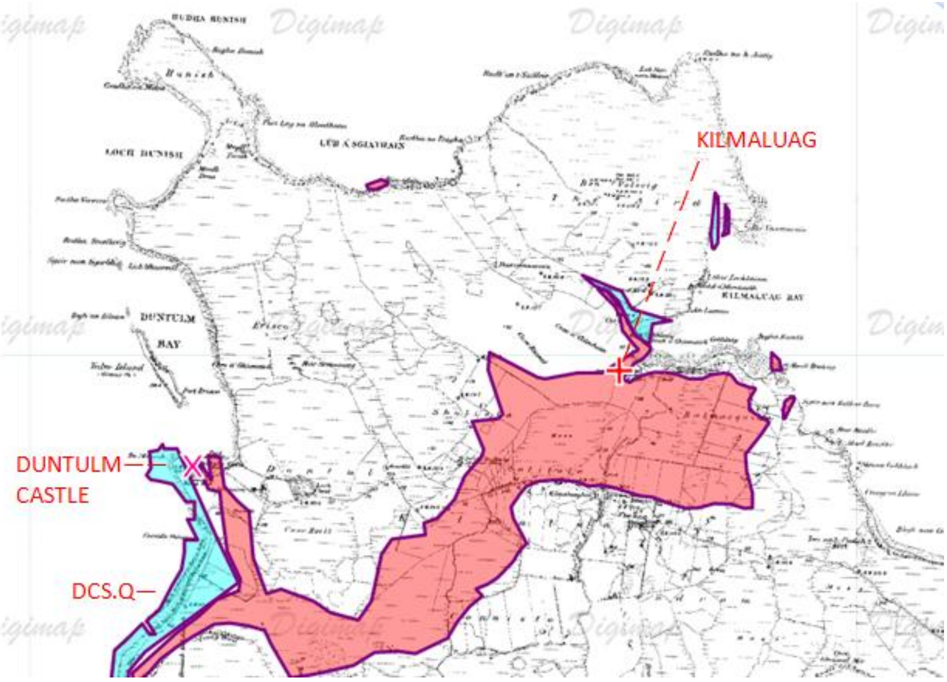

Figure 4 (above). Ordnance survey first edition 6-inch map (O.S. 1878) upon which the underlying calcareous geology has been plotted, and the locations of Duntulm Castle, kilmoluag church, and the outcrop at *Cairidh Ghlumaig* from which limestone sample DCS.Q was collected. The red shaded area is a mid Jurassic calcareous mudstone named the 'Kilmaluag formation'; the blue shaded 'Duntulm formation' is also mid-Jurassic, but here is interbedded bioclastic limestone and mudstone. Most of the rest of the geology of this area is dominated by quite fine-grained Tertiary igneous rocks: dolerites, basalts and microgabbros, all of which overlay the calcareous sedimentary sequence. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved. (1878). Geological map data © NERC 2016.)

Figure 5 (above) – The Jurassic 'pavement' outcropping in the intertidal at *Cairidh Ghlumaig*; source of sample DCS.Q. Scale 500mm; photograph Mark Thacker.

4.1 ON-SITE SURVEY

Figure 6 (above) - Duntulm Castle, Skye, from the south looking to Lewis and North-West Ross. No scale; photograph Mark Thacker.

Figure 7 (above) – External south-east face of south tower. Note rising and dipping courses. Scale 500m; photograph Mark Thacker.

Figure 8 (above) – Collapsed face of south-west enclosure wall near west corner. The ranging rod is at the same angle as battered wall profile. Scale 500mm; photograph Mark Thacker.

Figure 9 (above) – North-west external faces of north-west enclosure wall (lower) and west hall (higher). No scale; photograph Mark Thacker.

Figure 10 (above) – east wall of sea gate. Note contrast between lower (mafic, dipping) and higher (sedimentary, level) sections of masonry. Scale 500mm; photograph Mark Thacker.

Figure 11 (above) – The north-east section of the east enclosure wall from the south-east. The masonry of the enclosure wall and drum tower appears consistent and provides great contrast with the small south-east section just visible on the left of his image. No Scale; photograph Mark Thacker.

Figure 12 (above) – South tower ground-floor vault looking south-east. Scale 500mm; photograph Mark Thacker.

Figure 13 (above) – The vaulted room within north-east angle drum tower. Scale 500mm; photograph Mark Thacker

Figure 14 (above) Surviving fragment of external north face of south-east range. Scale 500mm; photograph Mark Thacker.

Figure 15 (above) Masonry style of South tower. No scale; photograph Mark Thacker.

Figure 16 (above) - Masonry style of north tower. Scale 500mm; photograph Mark Thacker.

Figure 17 (above) – Masonry style of the sea gate. No Scale; photograph Mark Thacker.

Figure 18 (above) - Internal south-west wall of west hall. Note informal use of very small gabbro stones. Scale 500mm; photograph Mark Thacker.

Figure 19 (above) – Masonry style of (uncoated?) central south-west enclosure wall re-facing. Scale 500mm; photograph Mark Thacker.

Figure 20 (above) – Masonry style of the south-east section of east enclosure wall. Scale 500mm; photograph Mark Thacker.

Figure 21 (above) - Phasing and contrasting masonry styles at south-east section of east enclosure wall. No scale; photograph Mark Thacker.

Figure 22 (above) – Multiphase masonry at the re-facing of primary west curtain. Scale 500mm; photograph Mark Thacker

Figure 23 (above) – Mortar stratigraphy and phasing – the re-facing of primary west curtain. Scale 10mm; photograph Mark Thacker.

Figure 24 (above) – Mortar phasing and re-coating of the south tower. Scale 10mm; photograph Mark Thacker.

Figure 25 (above) - Mortar 1a in the core of the south-west enclosure wall. Scale 10mm; photograph Mark Thacker.

Figure 26 (above) - Mortar 2; core of northern Tower. Scale 10mm; photograph Mark Thacker.

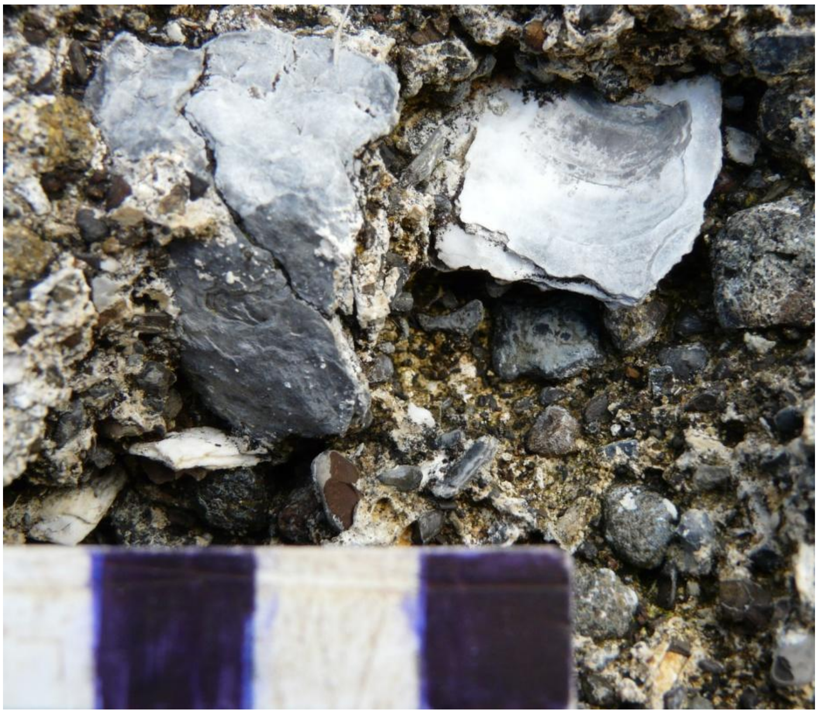

Figure 27 (above) – Mortar 3 in core of South-east range. Note large, heated, discoloured *O. edulis* valves. Scale 10mm; photograph Mark Thacker.

Figure 28 (above) – shell-lime core of ex-situ masonry section at south-east of the site. Note heated *O. Edulis* and *C. Edule* fragments. Scale 10mm; photograph Mark Thacker.

Figure 29 (above) – Overlying limestone-lime in *ex-situ* masonry section at south-east of the site. Note the contrast with shell-lime in previous figure. Scale 10mm; photograph Mark Thacker.

Figure 30 (above) – Mortar 4 in the core of the sea gate. Note very poorly heated limestone relicts. Field of view approx. 60mm; photograph Mark Thacker.

Figure 31 (above) - Mortar 5 in core of west hall. Scale 10mm; photograph Mark Thacker.

Figure 32 (above) - Shell-lime coating on internal face of south-east wall in west hall. Scale 10mm; photograph Mark Thacker.

4.2 THICK SECTIONS

Figure 33 (above) – Thick-section DCS.Q; calcareous rock outcropping in the inter-tidal of *Cairidh Ghlumaig*. Field of view 25mm.

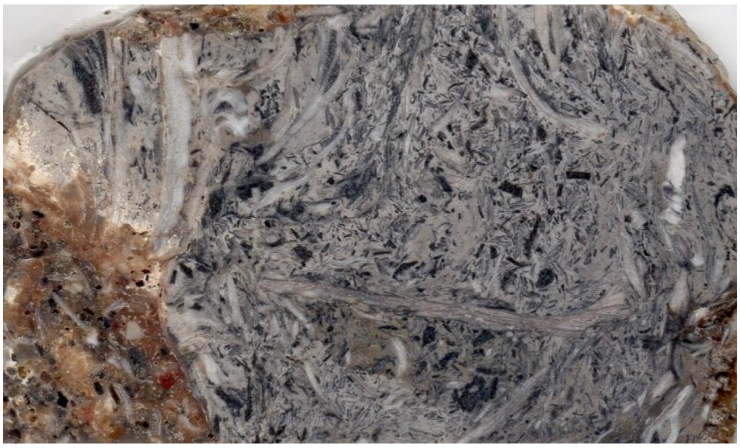

Figure 34 (above) Thick-section heated limestone relict from mortar sample DCS.A. Field of view 28mm.

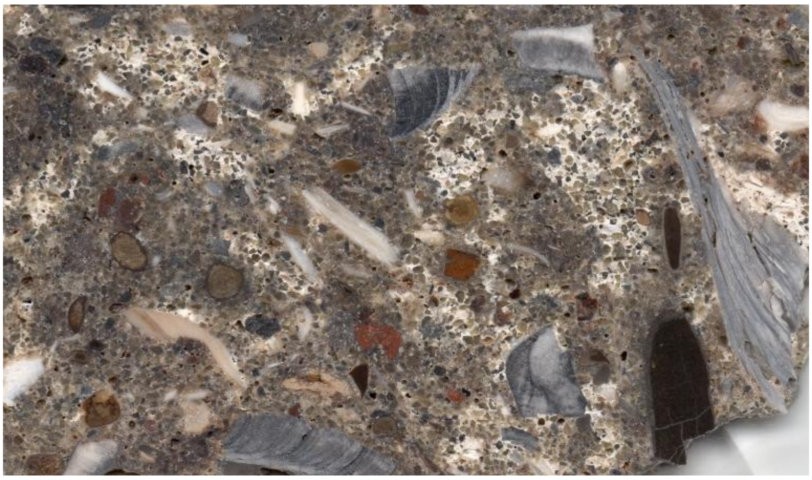

Figure 35 (above) - Thick-section DCS.B Field of view 32mm.

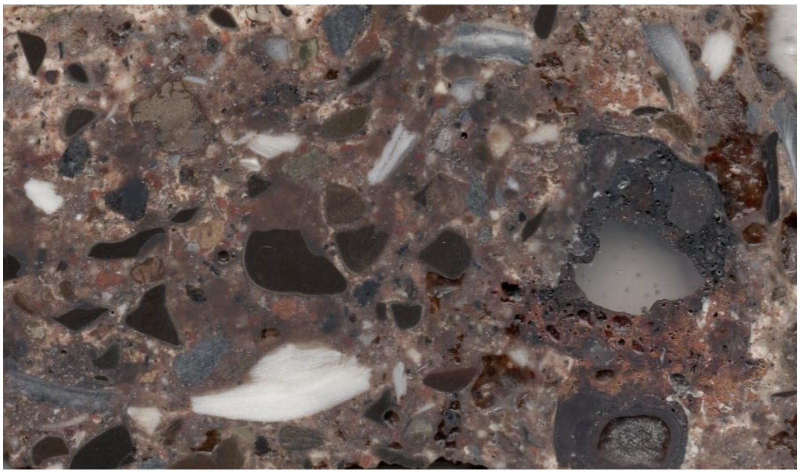

Figure 36 (above) – Thick-section DCS.D. Field of view 32mm.

Figure 37 (above) – Thick section DCS.E. Note variable texture of limestone sample to right of image. Field of view 35mm.

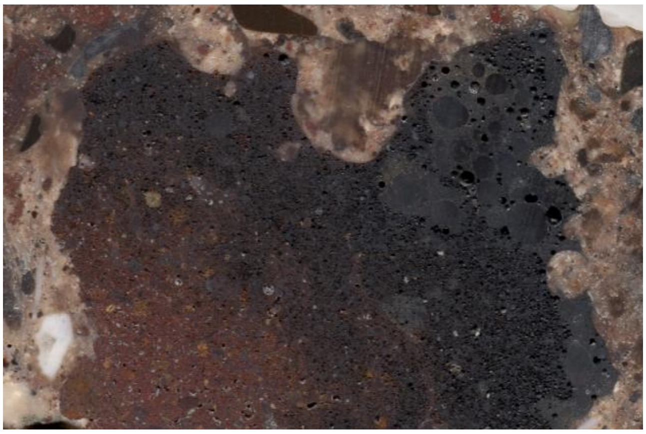

Figure 38 (above) – Thick-section DCS.Hv. Field of view 27mm.

Figure 39 (above) – Thick-section DCS.J. Field of view 35mm.

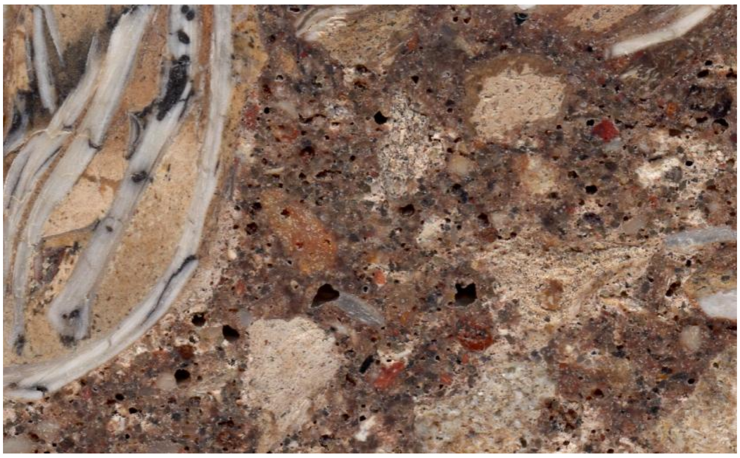

Figure 40 (above) - Thick-section DCS.L with large heated bioclastic limestone clast. field of view 25mm.

4.4 THIN SECTIONS

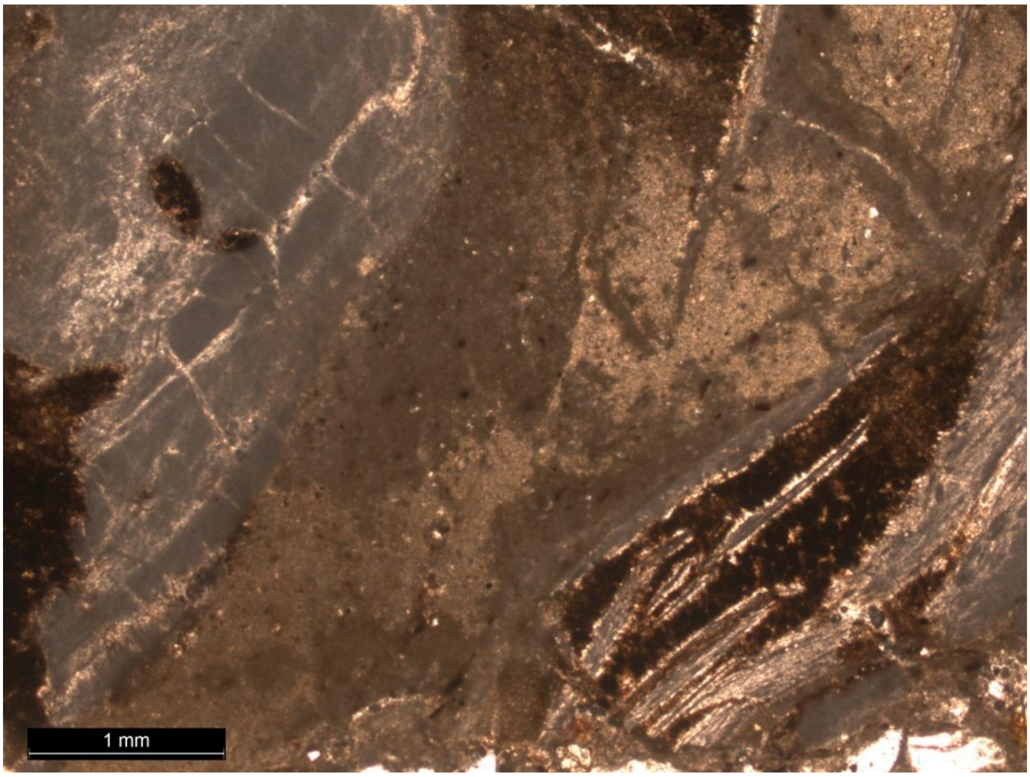

Figure 41 (above) - DCS.L same sample as previous thick-section here displaying heated geogenic bioclastic textures. Scale 1mm; photomicrograph Mark Thacker.

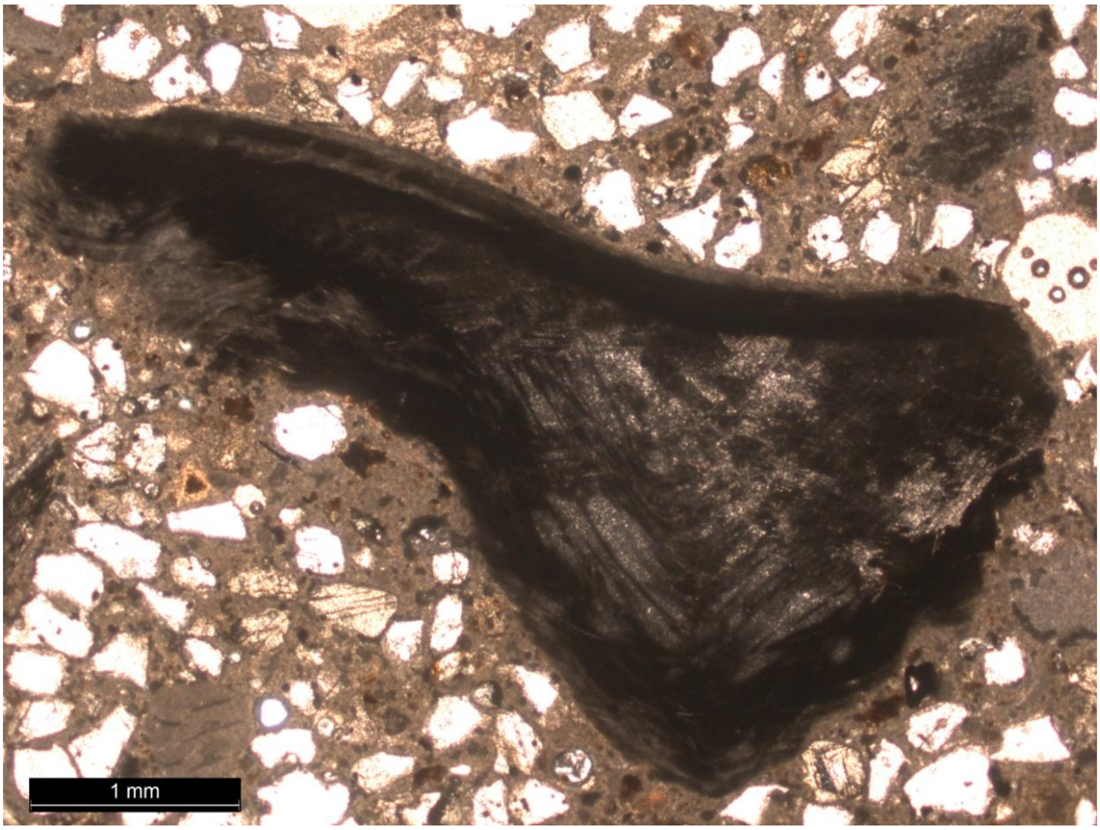

Figure 42 (above) - DCS.F – shell-lime with heated Type 2-3 *C. edule* clast. This appears to be a shell hinge. Scale 1.0mm; photomicrograph Mark Thacker.

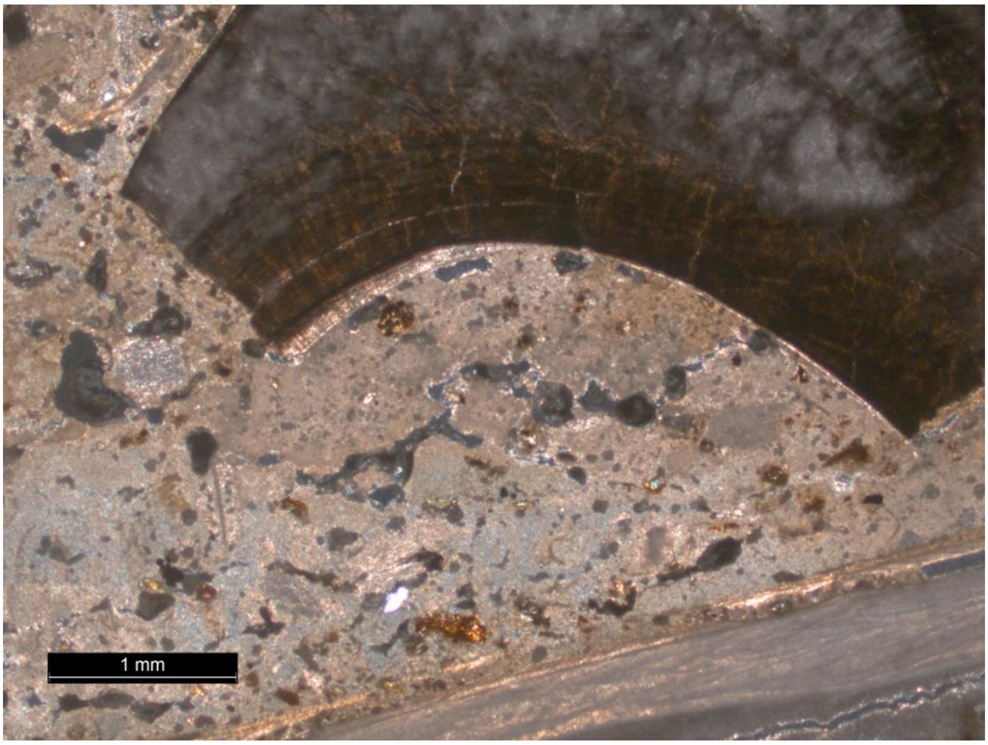

Figure 43 (above) - DCS.G; Shell-lime displaying very light-coloured matrix. Heated *Ostrea* at bottom of image. Scale 1.0mm; photomicrograph Mark Thacker.

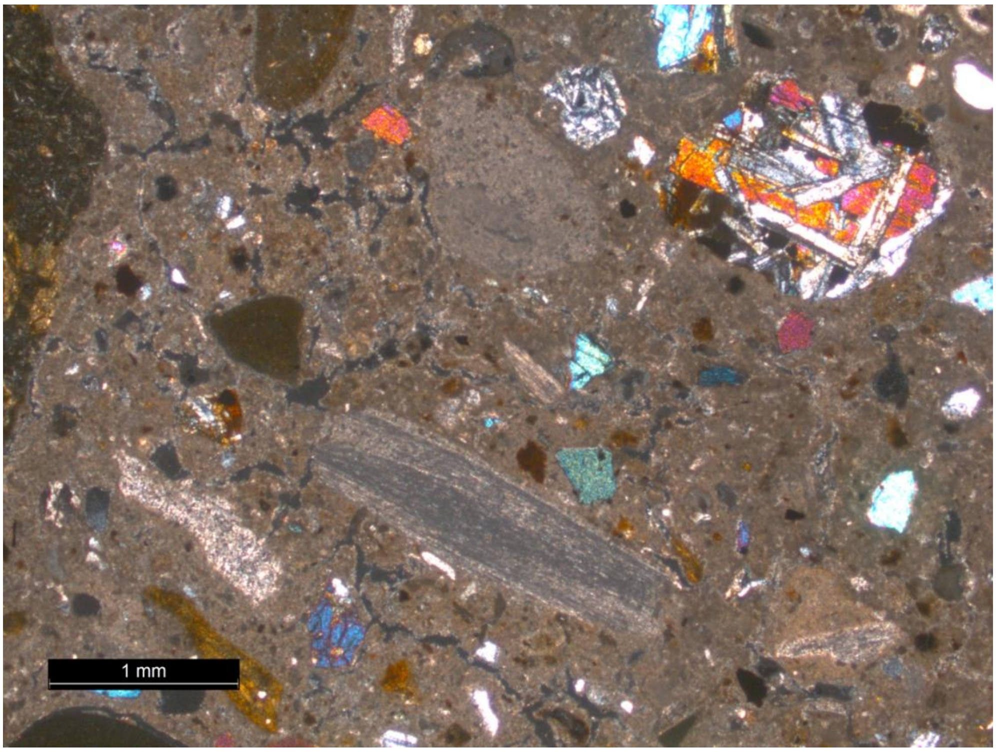

Figure 44 (above) - DCS.H; Shell-lime displaying heated O. edulis and rounded tempers. Scale 1.0mm; photomicrograph Mark Thacker.

5.0 DUNTULM CASTLE – BIBLIOGRAPHY & ACKNOWLEDGEMENTS

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5.2 ACKNOWLEDGEMENTS

Many thanks to Liz Cowie (Highland Council) and John Raven(HES) for permission to work at the site and to Steve Birch (archaeologist) and Ian Fraser (LDN architects) for some preliminary discussion of the buildings. Special thanks to Geoffrey Bromiley (School of Geosciences, University of Edinburgh) for materials analysis supervision during the thesis research, of which this case study forms a part.

APPENDIX 9 - CASE STUDY

HOWMORE, SOUTH UIST

Mark Thacker, University of Edinburgh.

Constructing Lordship in North Atlantic Europe. Vol. III.

Appendix case study 9.

Last revision 20-07-2016

DRAFT COPY FOR PHD EXAMINATION SUBMISSION.

SUMMARY

A survey of the fragmentary medieval and later buildings within and around the burial ground at Howmore, South Uist was undertaken in parallel with a preliminary lab-based mortar sample analysis programme. On site, *in-situ,* examination suggested that very similar mortar materials and production techniques had been used in the primary phases of the four earliest buildings at the site, and these contrast with those from the later burial enclosures. The evidence demonstrates the same progression from shell-lime to limestone-lime mortars seen elsewhere in the region.

The recognition of a contrasting mortar material within the Clan Ranald chapel, however, suggests this structure is multiphase and further investigation led to the discovery of an intramural tomb cavity beneath the north-west corner. A moulded jamb stone associated with this tomb was characterised as re-used and, along with other in-situ and ex-situ sandstone pieces also identified within the building, compared to sandstone fragments surviving within the core rubble of another church on the site (*Teampull Mòr*). The evidence for church dedications is confused, but it is likely that *Teampull Mòr* was the parish church, and it is therefore possible that this building was dedicated to St Columba rather than St Mary's as is often suggested. Overall, these survey observations and analysis results suggest further work is appropriate and the archaeological potential of further materials analysis is highlighted.

CONTENTS

1.0 HOWMORE - MORTAR, MASONRY & ENVIRONMENT SURVEY

1.1 ENVIRONMENT SURVEY

The Howmore burial ground located is located at NF 7581 3647 on the west coast of the island of South Uist, in the Outer Hebrides off Scotland's north-west coast.

1.1.1 UNDERLAYING GEOLOGY

Underlying much of South Uist is the same biotite-gneiss and hornblende-biotite quartzofeldspathic gneisses (with some basic intrusions) which dominate the rest of the Outer Hebrides (British Geological Survey 1992), although the east side of the island also contains a large meta-igneous body equivalent to the south Harris complex (Johnstone and Mykura 1989, 22, 26). All of these foliated and banded rocks can provide good building stone, but there are no known geogenic calcareous rocks outcropping on the island and , excepting very small areas of indurated 'beachrock' (a cemented calcareous sand similar to Aeolianite) reported in North Uist (Kneale & Viles 2000), the marble of South Harris is the nearest potential source. There is no evidence for the historic exploitation of Harris marble, however, whilst the limestones of Lismore and southern Skye were probably the closest sites of commercial lime production from the 19th-century.

1.1.2 SUPERFICIAL GEOLOGY

Six morphological regions have been described in neighbouring North Uist (Davies 1956) and a similar range is evident in the south, from the glaciated hills of the east, to the *machair* sands in the west. In contrast to the bedrock geology of South Uist, however, the west of the island is covered in extensive highly calcareous beach sand deposits, and inland *machair* dune systems composed of mixed glacial and biogenic materials. A walkover survey of the beaches close to the chapel site at Howmore and other possible source-sites of mortar aggregate, undertaken for an earlier project, suggested that the very fine highly calcareous sands which dominate both the local intertidal (*Bun na Feathlach)* and *machair* areas were not, however, used to temper the primary mortars of any of the medieval chapels (Thacker 2011, volume 2, appendix 5). The primary mortars of the Howmore buildings appear to have been tempered with a more coarse, angular and quartz-rich lithic sand, probably from a terrigenous/freshwater source such as Loch Roag or Schoolhouse Loch, and this evidence was of increased significance in that early study in clearly allowing the (marine) source of the discoloured *C. edule* (cockle) clasts to be differentiated from the temper - so supporting their identification as limekiln relicts (ibid.). Although the secondary mortar within *Cabeal Clann 'ic Ailean* (see below) was not noted during this survey, the general interpretations of this earlier study remain convincing and so the shore survey was not repeated.

1.1.3 WOODLANDS

Like most of the Western Isles, South Uist presents an almost completely treeless landscape with only a very few small scattered *Sorbus* (rowan) and *Populus Tremula* (aspen) communities surviving on cliffs too steep for the sheep to reach. The first Statistical Account also reports that the island was apparently completely treeless in the late 18th-century but that oral tradition insisted South Uist once 'abounded with wood' (Munro 1791-99, 299). Whilst the subsequent mid 19th-century account recounts how branches of trees with hazelnuts had been found 'in several places' during peat cutting and submerged tree trunks were found off the west coast (MacLean 1837, 191).

In support of this evidence, a palynological study undertaken just over 5 miles south-east of Howmore (at Loch Lang on the mountainous eastern side of the island) was well-constrained by six radiocarbon dates and suggested that in the early post-glacial period the locality was indeed well-wooded, with Arboreal pollen representing 40% of total count (Bennett et al. 1990). The pollen assemblage suggested this local woodland was dominated by *Betula* (birch) and *Corylus* (hazel) with some *Quercus* (oak), *Ulmus* (elm), *Alnus* (Alder) and even *Fraxinus* (ash) (ibid), and this interpretation largely supports MacVean and Ratcliffe's (1962) earlier woodland reconstruction which had already suggested Uist was likely to have been dominated by birch before clearance - although they did not perhaps envisage such a diverse community.

This South Uist woodland, however, appears to have declined steadily from around 4,000BP, until by 1,425BP *Betula* was down to 10% , decreasing to almost zero by the beginning of the medieval period as blanket peat and grasses eventually came to dominate the landscape (Bennett et al. 1990, 292).

The second Statistical Account reports that the local peats provided excellent fuel (MacLean 1837, 183) and Uist peats retain their good reputation to this day.

1.1.4 LIMEKILN

There is place-name evidence, and oral and documentary reports for widespread shell lime-burning throughout the Uists and Barra in the 18th through to the mid 20th-century (Thacker 2011). The only known archaeological evidence in South Uist itself is a single kiln in the grounds of St Michael's church, Ardkenneth (NF 759 459) of probable early 19th-century date (Thacker 2011). This kiln is likely to have been built to enable lime production for the church and contains evidence of heated limestone and some shell.

1.2 BUILDING SURVEY

The burial ground site at Howmore contains a complex of upstanding building remains including two quite large buildings (generally considered to have been congregational churches), two smaller buildings (whose purpose has been more debated), and two later burial enclosures. The site was visited twice during the research for this thesis (15/16/2014 and 4-5/04/2015), and these structures will be described separately below.

1.2.1 *TEAMPULL MÒR*

The upstanding remains of the building identified as *Teampull Mòr* are largely reduced to the east wall, with small fragments of the north and south walls adjoining, and this survives to over 4.5m high. Missing quoin stones and some large areas of face stone internally, enables excellent access to core masonry in full face-core-face cross-section, and this material has not been corrupted by conservation mortars or colonizing vegetation.

Core Study – The loss of the external facing stone has allowed examination of a particularly large volume of mortared core rubble in the south wall and, although generally smaller (at between 100 and 300 long) than the face stone, this material is also very formally laid. The core layers of this south wall match the course heights evident in the wall faces of the rest of the building, including the adjacent external face of the east wall, such that courses run right through both faces and the core of all three surviving walls.

None of the surviving core or face stones display evidence for quarrying or knapping/dressing, and their rounded arrises suggest they have probably been collected from superficial contexts. It is the natural cleave of the stone which has allowed oriented planar beds and faces to be identified and emplaced.

Masonry – The south wall is approximately 700mm, the east wall 900mm and the north wall 800mm wide, with course heights at a reasonably regular 470mm. This formality is particularly evident in the lower courses of the external face of the east wall, where larger edge-laid blocks generally grade up to 350-450mm high (larger heights up to 570mm are exceptional) and bond to between 150-250mm (exceptionally to 330mm) deep into the core. Lateral bonding across the face of the east wall is good in the lower courses but, as is a common feature of medieval buildings of this period, deteriorates higher up the wall as stone sizes decrease. The course lines are slightly lower to the south.

All corner and window quoins are missing, and the lower portion of both east lights has been blocked with secondary masonry (to a height of 800mm in the north light) bonded with a different mortar. That the missing window quoins were dressed sandstone is almost certain given the numerous pieces of that material in the primary core of all the surviving church walls, especially between the two lights of the east wall where pieces up to 100 x 120mm are evident. Moreover, that the window quoins were splayed mouldings is indicated by the angles of the surviving rubble reveals which, if continued, would meet at the external wall face without allowing any daylight opening. This also indicates that the windows and the pier between them were set out in sharp triangles.

Although no jamb stones survive in-situ, each east window opening displays an amorphously-shaped lintel externally, and an arch-head informally constructed with very water-worn stones internally. The intrados crown of each internal arch is much higher than the lintels in the external wall face, but there is no well-formed rubble splay and these surviving window head details are relieving features. There is an internal scarcement in this wall (of approximately 100mm wide in the south and wider in the north) which cuts across these relieving arches, and from which the radial arch-stones 'spring', although the arches themselves had in fact already begun to be formed form by corbelling within the wider masonry below.

It is clear that the former face of the splaying window head is now missing, along with the other window dressings, and that these would have been finely-dressed and moulded stone. This east wall also displays the remains of two aumbries in lower courses, which are unlintelled and again display missing jambs. These are also likely to have been dressed sandstone and, judging by the corbelled reveals, arched. The much eroded quartz-rich sandstone fragments in the south, north and east walls of the structure are likely to evidence the same lithogy as the missing window dressings, and this may be key to our wider understanding of this building and site.

Mortar – The evidence for a primary and contiguous core, bed and internal and external coatings suggests this building is essentially single phase (apart from the partial window blocking), and particularly extensive volumes of mortar coating (with a well-defined smooth planar surface) survive externally. The main characteristic of the mortar is its consistent and sharp texture, resulting in part from a very high concentration of heated shell fragments.

Carbonate kiln-relicts – The primary mortar of *Teampull Mòr* is a shell-lime with a very high concentration of Type 3-4 heated *C. edule* (cockle) shell kiln-relict fragments grading up to full 40-50mm valves. These are evident both within the mortar and within dissolute remains (see figures). A very low concentration of *O. edulis* (oyster) shell is also evident.

Added-Temper – This mortar was tempered with a well-sorted very lithic aggregate displaying subangular quartzofeldspathic clasts grading up to 1-3mm. No unheated shell fraction was evident.

Fuel kiln-relicts– No relict fuel evidence was noted in the primary mortar of Teampull Mòr.

Vitreous kin-relicts – No vitreous inclusions were noted.

Window Blocking – The masonry blocking the lower levels of each east window was evidently emplaced after the dressed jambs had been removed. This masonry is bonded with a limestone-lime displaying white angular limestone inclusions to 25mm and subrounded eroded lime inclusions to 7mm, and is tempered by well-sorted mixture of subangular to subrounded quartz and feldspar lithics to 4mm, with no fuel or vitreous material evident.

1.2.2 *CAIBEAL DHIARMAID*

Like *Teampull Mòr*, the ruin of *Caibeal Dhiarmaid*, Howmore is also largely comprised of its east wall only, here standing up to approximately 4.0m high, with a very small section of north wall adjoining. Both this east wall and the internal scarcement are wider than in *Teampull Mòr*, at 1020mm and 150mm respectively, whilst below and to the south of the single east slit-window there is an aumbry and a corbelled (?gradine) shelf.

Externally, the stonework has been laid in rising and dipping rough courses although, (unusually) this is more formal in the higher courses. Lateral bonding is generally good throughout the elevation. There are some larger stones in the lowest courses, but overall the face stones consistently grade up to 200 x 400mm, and there are no conspicuously edge-laid stones at all. Most face-stones are clearly flat-laid with core-bonding to approximately 250mm, whilst some smaller flat stones can better be described as core bonders where the smallest face of the stone is presented externally. The window, however, is framed externally by two edge-laid jamb stones and headed by a small lintel which protrudes approximately 50mm from the general wall face. The daylight opening may appear to be declining due to the shape of these jambs, but these are laid quite parallel.

Internally, the face stones are even more obviously flat-laid, displaying smaller faces (averaging 200 x 300mm) and with some stones core-bonding to 400mm deep. The window sill, reveals and the internal and mid lintels are laid to form shallow splays, although the stones of the reveals are laid level and step up and down accordingly; the sill and lintels are canted. The internal lintel is laid upon the gable scarcement and above this height the stonework bonds into the core even more conspicuously.

These window facings are primary and there is no sandstone evident in wall faces or core. The face and core stones are almost completely dominated by gneiss, although the concentration of small fissile green chlorite-schist pinnings in the south window reveal is very distinctive and appears primary. All of these building stones were probably collected from local superficial contexts as these display rounded arrises and no evidence of quarrying or dressing/knapping. The mortared rubble core is very clearly visible in full cross-section of the east wall, and here the stone is flat-laid and level, and the rough coursing of both wall faces is evident right through the core.

Mortar – Apart from some secondary internal mortar coating (discussed below) the surviving mortar of *Caibeal Dhiarmaid* is contiguous in core, bed and both face coatings and there is no evidence that this is anything other than single phase. Like the other early buildings on the site, the mortar materials of this building appear to be from the same source as in *Teampull Mòr*, but each betrays slight differences in final composition. The added aggregate temper in the primary mortar of *Caibeal Dhiarmaid* is coarser than in Teampull Mòr, but overall the mortar is generally finer due to a different shell kiln-relict grade profile.

Carbonate kiln-relicts – The primary mortar of *Caibeal Dhiarmaid* is a shell-lime with medium concentrations of Type 3-4 heated *C. edule* (cockle) shell kiln relicts, which are mostly very fragmented to 15mm, but occasionally whole valves are displayed.

Added-Temper – This mortar is lithic-tempered with well-sorted mixture of subangular quartz and feldspar grains, generally to 2-3mm but with a low concentration to 4-5mm. No unheated shell fragments were noted.

Fuel kiln-relicts – No fuel evidence was noted in the primary mortar of Caibeal Dhiarmaid.

Vitreous kiln-relicts – No vitreous evidence was noted in the mortar of Caibeal Dhiarmaid.

Secondary Coating - The internal window reveals display a very white, softly textured mortar coating which is distinct from the underlying mortar. This material varies up to 5mm thick, with a predominantly sub-mm temper, a very low concentration of visible material to 1mm, and a high lime binder fraction. Included, however, is a high concentration of heated *C. edule* (cockle) shell inclusions and one heated *O. edulis* (oyster) shell fragment. The south reveal of the window displays a protruding fillet of the primary mortar of the church, which indicates the former sill to have been in a single sloping plane and not stepped. There is a stratigraphy in the mortar here, whereby the softer, finer coating overlays this mortar and so probably plastered the sill also.

1.2.3 *CABEAL DUBGHAIL*

The masonry of this small oriented lime-bonded building survives as four relatively complete walls, including both east and west gables and an east doorway. The external face of the north wall is largely missing, however, and there is excellent visibility of mortared face and core contexts throughout the building. The walls are thick relative to the small size of the structure (east – 830, west – 900, north – 800, south 750mm) and display a remarkably informal (and structurally poor) stone emplacement technique, which contrasts with the excellent coherence of the shell-lime mortar with which they are bound and coated. Both internal and external wall faces are plumb but are constructed with edge-laid stones which display a remarkable lack of core-bonding and alarming outwardly sloping top beds. There is very little lateral bonding in all wall faces, with risbond joints running almost the full height of both east and west gables, and internally none of the four walls are bonded to each other at the corners. Moreover, the core rubble of these walls is composed of a high concentration of rounded disc-shaped beach stones many of which are apparently randomly placed (i.e. not very level).

Both gables display rafter slots checked into their internal wall faces (130 deep x 160 high in the west and 240 deep x 90 high in the east) and these indicate the timber rafters had a bearing on the inner face of the side walls of the structure (as at *Rubh an Teampail*, Harris). The eastern doorway is off-centre to the south, and its external jambs are checked and incline to form an opening 650mm wide at current ground levels and 420mm wide at the lintel. The 'quoins' of the doorway check are formed of small flat-laid stones. Internally, the bottom width of the doorway is not accessible but its jambs are inclining to a width of 620mm at the internal lintel, which itself protrudes approximately 80mm from the internal wall face. The reveals splay internally, and the door has been carried on a doorframe which was 'duked' into the doorway reveals, behind external rebates. These rebates are 130mm deep in the north and approximately 50mm deep in the south, suggesting the door was hinged on the south side of an inwardly opening doorway and the doorframe timber was of the order of 130mm square. The mortar and masonry surrounding and packing this arrangement would appear to be primary and contemporary with the whole building.

An eastern window, which is above the doorway but is placed more centrally, has small ill-shapen, edge-laid jambs which again appear to declining and the 'lintel' does not bear on the south jamb. This window splays internally where the internal jambs also decline from 510 wide at the sill, to 550 wide at the lintel. Three lintels form the top of this east window, the mid-lintel is bedded at a higher level to both face lintels, and the reveals were heavily mortar coated to 25mm thick. The western window has inclining internal jambs (430mm-400mm), whilst externally they decline from 70mm at the sill to approximately 150mm at the lintel.

There is a large (1400mm x approx 540m) tapered unmarked graveslab centrally placed at ground level within the west end of the chapel, which may be amphibolite.

Mortar – In contrast to the stonework, the mortar of this chapel is a shell-lime of excellent quality and similar source materials to the churches of the site discussed above. What characterizes the mortar of *Cabeal Dubghail*, however, and distinguishes it from the other chapels is the high binder fraction. The mortar is hard, with a tenacious creamy binder matrix. There is some evidence of secondary precipitation but this is minor. A generally high concentration of heated Type 3-4 *C. edule* (cockle) shell inclusions are evident with a low concentration of heated *O. edulis* (oyster) shell also present. The mortar is tempered with a consistent and well-sorted 2-3mm quartz and quartzofeldspathic-rich aggregate, which appears to contain very little finer material, and no fuel or vitreous inclusions were noted.

1.2.4 *CABEAL CLANN 'IC AILEAN*

This small oriented building survives as two substantially upstanding end walls with some gable, and more fragmentary north and south side walls which only survives as 2-3 courses. The east gable contains a rebated lintelled doorway with inclining jambs, whilst near the centre of the south wall are the basal remains of an internally splaying window with edge-laid jambs. The north wall is thicker at its west than its east end in order to accommodate an intramural recess, although curiously the wider external line of this wall section also continues west for some 600mm past the external face of the west wall of the chapel (see figures). The level of the south window and the impressive sill stones of the eastern doorway, externally,(which bond to over 300mm into both door jambs) suggests the primary floor level is significantly below current ground levels.

The most striking aspect of the masonry at *Cabeal Clann 'ic Ailean* is the massive size of the face stones, especially in the west and south walls where they are often over 500 x 500mm. These have been laid with a consistent and distinct stone emplacement technique which betrays a similar (if more formal) masonry style to the megalithic, edge-laid, 'cyclopean' stonework described for *Cabeal Dubghail* above. Indeed, although the surviving wall faces of this structure are coursed and (except the east wall which contains the doorway) display good lateral bonding, there is the same evidence for very large undressed edge-laid stone slabs, laid on very shallow beds, with alarmingly obtuse-angled top beds, and no bonding between walls at internal corners. The stonework is completely dominated by Lewisean gneiss, with the exception of a single quoin in the external north jamb of the main east entranceway which is of a light-brown, coarse, quartz-rich sandstone, similar to that described in the core of *Teampull Mòr* above. This has been weathered to a rounded form so perhaps destroying any hewing evidence.

Mortar – The lime-bonded core of this structure is very accessible in all walls from ground level and the consistency of this material in contiguous core, bed and coating contexts suggests the upstanding building is largely single phase. With some slight textural differences, this is a similar lithic-tempered shell-lime to that described in the other three Howmore structures above.

Secondary Feature

Although the consistent masonry and mortar evidence displayed in the upstanding structure of *Cabeal Clann 'ic Ailean* has been emphasised above, a very different mortar material binds the masonry around the intramural recess at the thicker west end of the north wall, and this is also visible in contiguous core and bed contexts. This is a very fine shell-lime mortar, which displays similar Type 3-4 heated *C. edule* (cockle) shell kiln-relicts to the primary mortar of the structure, but here the lime has been tempered with a sub-mm *machair*-type sand. This is the first time this soft aggregate, which covers large areas of the adjacent coast, has been noted as a constructional mortar temper at this site (so excepting its possible use in the secondary internal coating of *Caibeal Dhiarmaid*), and its conspicuously contrasting character suggests that this section of the chapel is of a different phase to the rest of the upstanding building. This prompted more focused investigation of the masonry and mortar of this north-west corner of the chapel.

An Intramural Tomb – As described above, the internal intramural recess has required the west end of the north wall to be of thicker dimensions, and this conformation has required a re-entrant angle about the centre of the external face of the north wall. The structure of the recess survives much better in the west, and here a square-built reveal of contrastingly small-sized rubble, cuts across the most of the thickness of the wall to define the its western side. This reveal is 250mm east of the internal face of the main west wall of the chapel, so forming a small pier-like section of north wall (250mm wide) inside the chapel at this north-west corner, and from the internal face of this pier a dog-tooth moulded dressed stone protrudes, *in-situ* and above ground level (see figures).

To the east, the base of the intramural recess itself initially appears to have been ‘floored’ with a series of flat-laid gneiss slabs, which are now just above ground level, but further inspection reveals a further slab (beneath the western reveal of the pier) supported on two dwarf walls and two corner lintels and capping a formally-constructed cavity. Rather than a floor then, this slab forms the roof of the western section (approx. 520 x 650mm), of a substantial intramural cavity which lies at the west end of the intramural recess and beneath the north-western corner of the upstanding ruin. This is clearly an intramural tomb of which the protruding dog-tooth-moulded stone is an integral part.

Although access is restricted, and the dark and damp environment inside the cavity makes it difficult to definitively characterize the substantial amount of mortar which is apparent, all of the rest of the visible masonry of the tomb recess and cavity, from the roof-slab/s up, is bonded with the fine machair-tempered mortar described above. This suggests that the intramural recess/cavity structure is all of one build, although sampling from inside the tomb cavity would be required to confirm this.

Another, apparently much larger, dog-tooth-moulded stone is lying, ex-situ, within the building, and both appear to be of the same sandstone lithogy and carry mouldings of similar dimensions. The *in-situ* stone is 150 x 185mm in transverse section but of unknown height as the bottom of the stone remains buried and displays square (90^{o}) external angles, four plumb faces and, importantly, a level top bed. The dog-tooth moulding has been hewn upon the SW longitudinal arris and is itself 55 x 55mm, with a 75mm repeat motif height. The *ex-situ* dog-tooth moulded stone is 150 x 225 x 448mm high, and so of the same bed width as the *in-situ* piece. It too displays straight faces, square arris and bed/face angles and the moulding is of the same dimensions as the ‘*in-situ’* piece. Although it was not moved to check the face lying on the ground, there is no surviving mortar currently visible on the *ex-situ* stone.

The top bed of the *in-situ* stone, however, has been crudely re-cut to form a joggle joint (90 x 80mm,) into which one of the tomb roof-slabs sits, such that the top beds of both stones are level (see figures). Importantly, inside the cavity beneath, the north face of the in-situ moulded stone is in line with the internal face of the south dwarf wall, and indeed forms the jamb of that wall. They appear to form a contiguous wall face inside the cavity. The west face of the stone is abutted by the south corner-lintel and the top bed of this lintel lies at the same height as the joggle bed, so both joggle-bed and corner-lintel are supporting the roof-slab/s of the tomb cavity (see figures). The *in-situ* moulded stone, dwarf wall, corner lintel and roof slab are all bonded by *in-situ*, contiguous, fixed inter-stone mortar materials and are of one build.

The form and dimensions of both dog-tooth stones suggests they are jamb stones. If the ex-situ piece were bedded upon the in-situ stone it would bond onto the intra-mural cavity roof-slab and abut the face of the rubble pier; to present a plumb southern face of dressed stone 150mm wide, with the moulding on its south-west arris. There is little doubt that the whole recess/cavity structure of the north-west corner of the chapel should be regarded as an intramural tomb, and is of significance to our understanding of the wider site. It may be that these sandstone dressings have been re-used to frame the (visible) part of that tomb (i.e. the tomb recess).

Stratigraphy

Although there is no obvious abutment, the relationship between the tomb and the majority of the upstanding chapel appears reasonably straight forward. As we have seen, the finer machair sand-tempered Mortar was probably used to construct the intramural tomb structure and this mortar can also be traced within the main external west wall of the chapel to 900mm from the north-west corner. Although, the exposed core of this corner section of the chapel is partially overlaid by a thick layer of the coarser primary mortar, this layer is itself directly overlaid by finer secondary materials. This relationship, together with the form of this corner itself, suggests the tomb is secondary to the general upstanding masonry of the chapel, and was accommodated by the rebuilding of the west end of the north wall in a finer lime mortar.

However, although the construction of the tomb provides a clear context for the widening of the north wall, it does not provide an obvious context for the stub of north wall continuing to the west of the chapel. It is possible that the corner and masonry pier at the west end of the tomb was re-built primarily in order to bond-in a western chapel extension, but this seems unlikely. Certainly, there is more complexity here than can be accounted for by the survey presented here and we should wait for full publication of the previous survey and geophysics before speculating further.

1.2.5 LATER BURIAL ENCLOSURES

Both of the structures which appear to represent later modern familial burial enclosures at Howmore display lime-bonded cores, beds and coatings.

The MacLean/Munro Cabeal (NF75851) is a very large roofless masonry enclosure (externally approximately 9 x 7m) which lies outside the main graveyard as it is currently configured, as the south and west walls are abutted by the main graveyard walls. The south wall of the enclosure, therefore, now forms part of the north wall of this later graveyard boundary. The north wall of the cabeal is very high externally, to retain a level interior ground surface on a steeply sloping site. The enclosure walls are generally 1.9m high from this interior ground level, and formed of gneiss rubble to 600mm thick. Although the coping is rough-racked, the general masonry style is very formal; externally coursed and snecked with edge-laid builders, course heights diminishing from 400-300mm and side alternate quoins (see figures). Internally the use of smaller face stones gives a more random impression, but at its most formal (as in the north) it is also coursed and snecked, and comparable to that seen externally. The lintelled entrance to the enclosure is in the east wall which also contains a red granite memorial to Rev. Maclean dated to 1854, and the west wall contains a sandstone memorial to Rev Munro dated to ?1832, but both of these are secondary, slapped-in to the main structural masonry of the enclosure, which otherwise constructionally appears predominantly single phase.

There are, however, three salient mortar phases.

1, The continuation of shell-burning evidence at the site is most apparent in the fine external coating of the east wall (north of the entrance) and on the north wall itself, but is not apparent on the south or west walls where the evidence is less clear. This is a shell-lime with a high concentration of heated cockle shell fragments to full valves tempered with a predominantly sub-mm material with some larger lithics grading up to 2.5mm.

2, Externally the west wall displays an even finer mortar within interstitial face ‘pointing’ or ‘slaister’ contexts to a depth of 50mm, and a similar mortar is seen binding the coping. This is a coal-fired limestone-lime containing a high concentration of rounded probable limestone kiln-relicts to 5mm, sun-mm temper and clear evidence of relict coal inclusions. The limestone relicts are veined and reminiscent of Dalradian Lismore limestone.

3, A third mortar is evident at the external north-west corner and around the doorway. This is a fine, hard cementitious material and is only evident in contexts to 30mm deep.

Cement Mortar 3 is stratigraphically the latest in the series, clearly overlaying shell-lime 1 and probably also limestone-lime Mortar 2 at the doorway. Mortars very similar to Mortar 2 are associated with both secondary memorials. Although there is no unambiguous direct relationship between mortars 1 and 2, in the rare contexts where deeper masonry is visible (eg. at the east end of the internal north wall or at the doorway, and significantly in the west wall core to 200mm) then this is mortar 1. It therefore appears likely mortar 1 is primary, mortar 2 is secondary pointing, coping and memorials, and mortar 3 is tertiary repair.

The other late burial cabeal at Howmore (NF75851) lies inside the burial ground as it is currently enclosed, and may be identified with *Caibeal nan Sagairt* from the first edition Ordnance Survey map (see below). This structure also contains a secondary memorial, here dated 1887, but the building is much smaller (3.54 x 5.86m externally) and less formally constructed than the MacLean/Munro enclosure with wall faces of large rounded gneiss rubble stones brought to very rough courses in the external wall faces, whilst internally smaller stone has been laid without any coursing at all. There is a gable on the east wall, an entrance in the west wall, and a window in the north wall which may suggest the structure carried a roof.

Two mortar phases are evident: Most of the structure is bonded with a hard, coarse limestone-lime mortar which is found in joints of all walls and deep in the core of the west wall at north jamb collapse. This material contains a very high concentration of rounded grey limestone relicts to 30mm and a quartz-rich lithic temper to 6-7mm, but is without evidence for fuel or shell. This is overlaid in some contexts by another limestone-lime mortar which contains a high concentration of lime/limestone inclusions to 3mm and a soft, generally sub-mm added-temper.

2. 0 HOWMORE – SAMPLE CONTEXTS AND ANALYSIS

2.1 SAMPLE CONTEXTS

All samples from Howmore were lying loose on the site so sample contexts are ex-situ. These were all, however, visually very close matches for the respective *in situ* mortars.

AHU.01 – *Caibeal Clann 'ic Ailean*; south wall; external face; loose core.

AHU.02 – *Caibail Clann 'ic Ailean*; north wall; external face; loose core.

CHU.01 – *Caibeal Dhiarmaid*; east wall; external face; south side; 200 above ground; loose core.

MHU.01 – *Teampull Mòr*; south wall; external face; loose core.

MHU.02 – *Teampull Mòr*; east wall; external face; dissolute shell.

DHU.01 – *Caibeal Dubhgail*; west wall; external face; loose core.

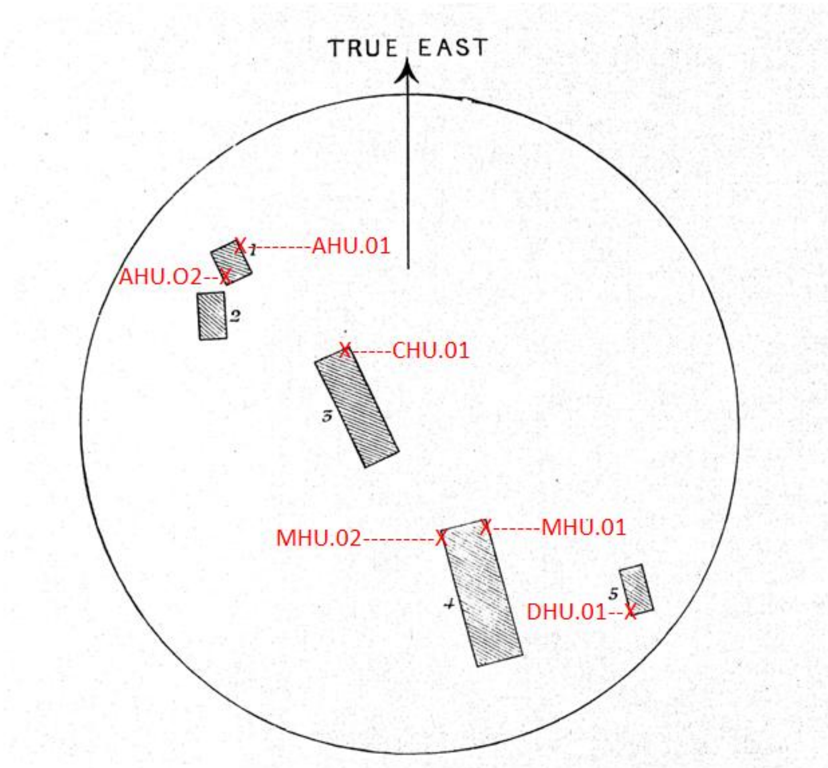

Figure 1 (above). Howmore sample contexts annotated onto Muir's (1885) plan of the site. Labelled buildings include: 1 - *Caibeal Clann ic Ailean*; 3 – *Caibeal Dhiarmaid*; 4 – *Teampull Mòr*; 5 – *Caibeal Dubhgail.*

2.2 SAMPLE ANALYSIS

2.2.1 Analysis of primary mortar from Teampull Mòr (1 x thin-section - MHU.01)

General Description – MHU.01 is a large slide of 70 x 22mm containing a single phase composite material. This is a poorly-sorted to bimodally distributed mixture of lithic and shell materials with a high concentration of curving probable shell inclusions to 11mm.

Carbonate kiln-relicts – MHU.01 is a shell-lime with a very high concentration of heated shell relicts, dominated by *C. edule* (cockle) fragments, to 11mm. These often display well preserved relict ribbing microstructure and both crystalline and cryptocrystalline textures.

Added-Temper – MHU.01 was tempered with a well-sorted lithic aggregate dominated by very angular to subangular quartz clasts to 1.0mm, subangular feldspar to 1mm and subangular amphibole to 0.5mm in relatively high concentrations, whilst occasional subrounded gneiss clasts to 3.0mm are also present.

Fuel kiln-relicts – MHU.01 contains probable peat evidence to 3.0mm.

Vitreous kiln-relicts – Various subangular grains show developing opaque textures, but no vesicled reaction melts were noted in MHU.01.

2.2.2 Analysis of primary mortar from Caibeal Dhiarmaid (1 x thin-section - CHU.01)

General Description: CHU.01 is a large slide of 50 x 20mm containing a single phase composite material. This is a poorly-sorted mixture of lithic and shell materials dominated by subangular lithics to 2.5mm, with a low concentration of probable shell clasts to 6mm.

Carbonate kiln-relicts – CHU.01 is a shell-lime with a medium concentration of large heated shell relicts to 8mm. This includes *C. edule* shell fragments, with well preserved ribbed structure but distinct blackening and fracturing, and more altered rounded clasts with a globular shell-lime texture.

Added-Temper – CHU.01 was tempered with a well sorted lithic temper, generally to 1.5mm and occasionally to 2.5mm, comprised of angular to subangular monomineralic quartz, feldspar and amphibole clasts, and a lower concentration of larger rounded polymineralic gneiss grains. There is a very low fraction of apparently unheated shell, but this cannot confidently be distinguished from the kiln relicts.

Fuel kiln-relicts - No fuel evidence was noted in this section.

Vitreous kiln-relicts – There are, once more, locally quite high concentrations of fine opaque, amorphous reaction products to 0.5mm, but no evidence for well-developed crystalline examples.

2.2.3 Analysis of primary mortar from Cabeal Clann 'ic Ailean (1 x section - AHU.01)

General description – AHU.01 is a very large slide to 70 x 25mm containing a single phase composite material. The slide contains a poorly-sorted mixture of shell and lithic materials including blue-grey shell clasts to 10mm and subangular to angular lithics to 4.5mm.

Carbonate kiln-relicts – AHU.01 is a shell-lime with a high concentration of heated shell relicts, including *C. edule* (cockle) to 9.5mm. Heated textures include fractured and crazed, microcrystalline and cryptocrystalline fragments of shell.

Added-Temper – AHU.01 is tempered by a sorted mixture of lithic clasts to 5mm, generally composed of subangular to very angular clasts of gneiss, quartz and feldspar to 3mm, with rare very fine inclusions of amphibole/hornblende. A shell fraction is also evident but It is not possible to confidently identify this as a temper addition, as this may well be an assemblage of poorly heated relict shell from the kiln.

Fuel kiln-relicts - No convincing fuel evidence was noted in the AHU.01 section.

Vitreous kiln-relicts – There is a range of vitreous products evident here, from a 4mm clast of angular, apparently stable, 'conglomerate', in which fine angular quartz and feldspar are included within an opaque matrix with no apparent vesicles; to a much more amorphous, globular melt, to 2mm, in which vesicles and well-developed crystals have begun to form. There is a high concentration of very fine opaque melts within the section, and many clasts with evidence of fracturing and altered textures.

2.2.4 <u>Analysis of secondary mortar from Cabeal Clann 'ic Ailean</u> (1 x section - AHU.02)

General Description – Slide to 30 x 20mm containing a single phase composite material, dominated by a well-sorted and fine (sub-mm) material but including a low concentration of large probable shell clasts to 10mm and larger subangular lithics to 4mm.

Carbonate kiln-relicts – AHU.02 is a shell-lime with a medium concentration of heated shell relicts to 10mm. These include a 10mm angular heated *C. edule* fragment, with well preserved ribbing, and highly altered yet coherent rounded relicts in optical continuity with the general mortar matrix.

Added-Temper – AHU.02 was tempered by a very well-sorted and very fine mixture of shell and lithic clasts, generally grading up to 0.4mm. This mixture is dominated by a high volume of angular to rounded shell fragments, of a large taxonomical range, whilst the lithic fraction is more minor and comprised of fine monominerallic angular to subangular quartz and feldspar clasts, also to 0.4mm.

Fuel kiln-relicts – AHU.02 contains possible very fine peat relicts to 0.2mm.

Vitreous kiln-relicts – No vitreous materials were noted

2.2.5 DHU.01.

No thin-section has yet been prepared from this sample.

2.2.6 XRD ANALYSIS OF DISSOLUTE SHELL FROM THE MORTAR OF TEAMPULL MÒR.

Sample	HMC /%	LMC /%	Aragonite /%	Periclase /%	Portlandite /%	XRD Type (EFT)		Visual analysis
MHU.02	18.7	76.2	1.9	1.2	-	2 (400^{o}C)		2-3 (4-500^{o}C)

3.0 HOWMORE - CONCLUDING DISCUSSION

The churches, chapels and burial enclosures of Howmore were built from a range of materials which were sourced from a variety of contexts. The Lewisean gneiss, which dominates the general building rubble in all core and wall faces of all these structures, displays no evidence of quarrying, knapping or dressing and was probably collected from superficial contexts very locally. The lime mortars of all structures were also tempered by various local, superficial, marine and terrestrial aggregate sources, and the peat fuel used to fire the lime kilns was also very likely to have been cut not far to the east of the site. The cockle and oyster shells used as a lime source in the earlier church and chapel buildings are not found on the exposed shores around Howmore, however, and may have been transported from the south ford strand, 7 miles to the north-east, between South Uist and Benbecula (Thacker 2011; see also MacLean 1837, 187).

In general the primary mortars of the earliest four buildings display a remarkably consistent array of lime-making materials, in which the continuing use of a particular quartz-rich aggregate source is most striking. Against this background, the use of a contrasting marine sand in the construction of an intramural tomb in *Cabeal Clann 'ic Ailean* is useful archaeologically, but technically curious and an apparent break with tradition. The limestone lime-source apparent in the mortars of the later burial enclosures (and in the window blocking of *Teampull Mòr*) must have been imported from off the island and, although not analysed to identify the particular provenance, this import is consistent with the incrementally increasing use of limestone-lime building mortars in this period elsewhere in the region. Another imported material, however, is more significant for our understanding of the earlier development of the site, and that is the evidence for dressed sandstone found within *Teampull Mòr* and *Cabeal Clann 'ic Ailean*. Together with the mortar and stone-emplacement evidence discussed above this evidence appears to demonstrate chronological relationships between the early churches and chapels which contrast with previous interpretations of the site. Further examination of ambiguities and confusion in the documentary evidence, however, also suggests a re-interpretation is appropriate.

Post medieval depictions of the site begin with Blaeu's (1654) Atlas of Scotland. This map clearly labels the settlements of 'How M:' and 'How beg', together with 'Auon How moir' and already there is some ambiguity here in settlement names which relate to size whilst the spelling 'moir' also raises the first possibility that something else might be going on. Post-medieval references to the site begin with Martin's [1695] description of two churches dedicated to St Columba and St Mary, although he doesn't of course inform us which buildings he is referring to.

The late 19th-century Ordnance Survey first edition map and name book descriptions are much clearer in depicting three roofless structures within the graveyard and describing them as – *Teampull Mòr, Caibeal Dhiarmaid,* and *Caibeal nan Sagairt* – 'in ruins'(O.S. 1881).

These names cannot, however, be simply related to Martin's church dedications. Informed by Neil MacIntyre of 'Howbig', the O.S name book entry states that the name *Teampull Mòr* 'signifies "the big chapel" and applies to the ruins of an old church or chapel the history of which little or nothing is known about in the district.' (Ordnance Survey Name Books, Inverness Vols. 8-11, block 5).

Other commentators have approached this information in a number of ways.

1. Some have presumed that the name *Teampull Mòr* (Gaelic: large) is a corruption of *Mhoire* (Gaelic: Mary) (Addyman 2000; Raven 2005, 178; Fleming 2012, 78) and so identified Martin's [1695] church of 'St Mary's' with the large twin-lancet building at the west of the site. In this interpretation the other apparently large building, identified as *Caibeal Dhiarmaid* by the O.S informant, is identified as Martin's [1695] church of St Columba's by default, and Addyman has further suggested that this dedication supports an interpretation that this central building is early.

2. A few years before the Ordnance survey publication Captain Thomas [1871] described three other churches in Uist and in comparing the sizes of various buildings also noted the churches of *Teampull Mhuire* in Howmore (which he also names as St Mary's later in the study) and *Teampull MacDhiarmaid*. It is notable here that St Columba's is not mentioned at all and that the Dhiarmaid building is now *teampull* rather than *caibeal*.

3. Some commentators have noted Martin's reported dedications, but without further comment have continued to use the Ordnance Survey names of Teampull Mòr and Caibeal Dhiarmaid (Muir 1885; RCAHMS 1928; Fisher 2001).

Ambiguity in the recorded names of these apparently larger church buildings is compounded in these accounts by various errors and misidentifications in the survey descriptions of the smaller chapels on the site, by both Muir and RCAHMS (noted by Addyman 2000 and Raven 2005). In terms of chronology, however, Muir suggests that the twin-lancet building is 'first-pointed' (1885) and this interpretation is repeated almost verbatim by MacGibbon and Ross (1896-7, 70-71). In the absence of any attempt by the RCAHMS (1928) Addyman's report provides the first attempt at a broader site chronology (Addyman 2000, 10-19). This includes a number of preliminary interpretations including: 1, that the central position, cruder details, heavier walls and dedication of *Caibeal Dhiarmaid* suggested that this structure may be the earliest surviving upstanding building at Howmore, and might date to the 13th-century or earlier; 2, that the architectural sophistication of the twin-lancet church (and comparison with a number of Argyll chapels, most particularly Kilmory Knap) suggested that this structure was early to mid 13th-century, and that this would also be an appropriate date for the style of the *ex-situ* dog-tooth-moulded stone located in Cabeal Clann 'ic Ailean; and 3, that the 'satellite chapels' were probably constructed in the later middle ages to early post-Reformation period, whilst *Cabeal Clann* *'ic Ailean* may also be dated more closely by a 1574 documentary reference to Eion Muirdeartach (ibid.).

Addyman's study was followed by a brief description by Fisher who, in a publication otherwise devoted to early medieval sculpture, also appears to have re-employed the Ordnance Survey names (Fisher 2001, 108). Like Addyman, Fisher also suggested that the twin windows of 'Teampull Mór' were of 13th-century type, and further identified this building as the parish church, but was more ambiguous regarding the building identified here as *Caibeal Dhiarmaid* which was only described as 'probably also of medieval date' (ibid). Once more, however, Fisher identifies *Cabeal Clann 'ic Ailean* with the 1574 reference to John MacDonald of Clan Ranald, and the remaining chapel (Dubhgail) considered post-medieval also (ibid).

Although these last two descriptions appear to largely agree on many details of chronology, a much more comprehensive survey of the site was subsequently undertaken, during which a radical re-interpretation of the site emerged (Reynolds et al. 2005). It was in this work that the *in-situ* dog-tooth stone at the west end of the intramural recess in *Caibeal Clann 'ic Ailean* was first reported and, although the survey results are not yet fully published, it would appear from the D&ES summary that the wider morphology and chronology of the site was ultimately related to the art-historical style of this moulding: the *in-situ* stone was interpreted as the surviving fragment of secondary masonry chancel arch, and suggested to provide a 12th or 13th-century upper terminus for two earlier phases of this chapel building (Reynolds *et al* 2005). Even further, the narrow dimensions of these now putative pre-Romanesque *Cabeal Clann 'ic Ailean* phases were then related to an earlier phase identified within the surviving east wall of *Caibeal Dhiarmaid* and to the remaining small chapel of *Caibeal Dubhgail*, and all thereafter regarded as predating *Teampull Mòr* (ibid.). Informed by this survey, this site was then discussed as a pre-Romanesque multi-chapel complex which could be compared to early medieval Irish and Scottish monastic sites elsewhere (Raven 2005).

In summary, each of these analyses of the site offers a different interpretation of the surviving upstanding buildings of Howmore. At the risk of adding another layer to this another interpretation will be offered here.

Firstly, although almost all recent commentators have suggested that the twin-lancet building is the parish church of St Mary's, this may not be supported by the historical record. Whilst later medieval charters and accounts refer to *Skerehowg* or the parish of *Howf* only (Lizars 1854, vol. 2, 369; MacPhail 1914, 48, 95; Monro [1549] 1999, 327) mid-15th-century papal correspondences repeatedly refer more directly to a succession of rectors of 'St Columba de How in Hwgyst' (Cameron 1934, 125; Kirk et. 1997, 421; Thomas 2008, 74). This clearly indicates that a church called St Columba's is the parish church of the site and there is no suggestion that a church called St Mary's ever held that status.

A number of possibilities therefore are presented, including 1, The twin-lancet church of Teampull Mòr is not the parish church; 2, the dedication of the parish church building is different to that of the site (and a new parish church building was constructed and dedicated to St Mary's without changing the name of the site), or 3, Teampull Mòr is St Columba's.

Of these possibilities that Teampull Mòr is St Columba's must be the considered the most likely. Almost all commentators have identified the twin-lancet building as the parish church and that is an interpretation the wider evidence discussed elsewhere in this thesis supports. Given the confusion in more recent accounts, and some ambiguity in the place-name evidence, there is clearly an archaeological issue here about how we might recognise a parish church and distinguish it from a monastic or other type of building. The above survey, however, has identified a number of pieces of evidence which appear to demonstrate a number of interrelationships between different buildings on the site and may offer an archaeological way forward. These will now be re-considered in more focused order:

1. The recognition of sandstone rubble fragments within the general wall core and face of *Teampull Mòr* and the conformation of the remaining stonework, strongly suggest that the church had sandstone quoins and arches which have been subsequently robbed-out. Similar core sandstone evidence can often be identified in the core rubble of high status ruined Scottish medieval and later buildings, most notably at Borve Castle (Benbecula).

2. The recognition of a sandstone quoin within the primary fabric of the eastern doorway of *Cabeal Clann 'ic Ailean*, suggests this stone may have been re-used from another context, and may offer a match for the scalpings in the core of *Teampull Mòr* and/or the intramural tomb dog-tooth moulded stones

3. The recognition that both the in-situ and ex-situ dog-tooth stones located within *Cabeal Clann 'ic Ailean* have square-cut, not angled, beds, suggests these may be jamb stones not *voussiours*.

4. The recognition of the surviving western cavity of the intramural tomb within the north wall of *Cabeal Clann 'ic Ailean*, its secondary mortar, and the conformation of the surviving masonry, suggests the in-situ dog-tooth moulded stone is coeval with the tomb and associated with its construction.

5. The recognition that the majority of the upstanding masonry of *Cabeal Clann 'ic Ailean* (out-with the tomb) is largely single phase, and probably the earlier of the two main upstanding phases considered here, draws attention to the sandstone quoin within its eastern doorway (from 2 above). It is important to note that confirmation of their lithostratigraphic sources requires more refined lab-based characterization,

but the evidence suggests that sandstone re-use may be evidenced in two separate phases of the surviving building. This requires further work and discussion.

6. The recognition of the consistent character of the mortar and masonry of *Caibeal Dhiarmaid* suggests it is single phase.
7. The recognition of the similarity in the stone-emplacement techniques and plan-forms of the primary phases of *Cabeal Clann 'ic Ailean* and *Cabeal Dubhgail*, suggests they are broadly contemporary.

Although *ex-situ* dog-tooth moulded stones have been considered indicative of a 13th-century date at some other sites (see for example RCAHMS 1980 survey of the chapel in Glen Aros, Mull), this motif continued to be carved in north-west Europe throughout the medieval period and similar later medieval evidence can be found close to Howmore in the probably late 14th or 15th century tower at Duntulm Castle, Skye (Miket & Roberts 2007, 64). in the 15th or 16th-century intra-mural tomb-recess within the south wall of St Bean's church, Argyll (RCAHMS 1975, 153), and the late 14th-century O' Cahan tomb frontal at Dungiven Priory, Derry which, like contemporary dog-tooth-moulded work at Iona Abbey, is thought to be the work of Donald O' Brolchan (McNeill 2001, 349). It is therefore clear that, out of their original position and so with no supporting archaeological information, the art-historical style of both moulded stones within *Caibeal Clann 'ic Ailean* only provides them with a Romanesque 12th or 13th-century lower terminus, and that relates both to their primary and secondary contexts. That these mouldings are so deeply cut, may suggest that an early 13th-century date is more likely than a later medieval date, but this requires more work.

Consideration of the wider site at Howmore and the evidence for sandstone dressings within the convincingly 13th century twin-light church of Teampull Mòr, however, suggests this is a likely source (cf. Addyman 2000). Comparison of these very narrow jamb stones with the very tall lancet window jambs of Teampull Mòr, and a possible match for the sandstone scalping in the buildings core might support this suggestion in further work. A similar, if more casual, instance of stone robbing from an earlier church to build a very late medieval burial chapel is apparent elsewhere in the region at Skeabost in Skye (infra.) where roll-moulded sandstone details have clearly been reused in the general wall faces of the Nicholson chapel and were very probably sourced from the adjacent ruined cathedral church. The corollary to this evidence is that the construction of the chapel provides an upper terminus for the churches ruination, and the chronological and structural scales involved at Skeabost are quite similar to those proposed here for Howmore. The possibility of a more particular form of re-use within the Ranald tomb, in the context of the continued use of these particular carved motifs throughout the later medieval period in Gaelic lordships across western Scotland and Ireland, may have allowed these stones a continued and complex relevance (cf. Stocker and Everson 1990) but of more immediate archaeological significance is the requirement to demonstrate their former context more conclusively.

It is very likely, however, that the intramural tomb is associated with an important member of the Clan Ranald *fine* and, given the oral tradition contained within the name *Cabeal Clann 'ic Ailean*, the similarity of the armorial stone with a similar example in an early 17th-century burial aisle in Arisaig, and the documentary reference noted above, it is possible that this is the tomb of John MacDonald of Clan Ranald. Thus it may be the tomb rather the chapel to which the documentary reference applies. If, however, it is accepted that the ruination of *Teampull Mòr* provides a lower terminus for the construction of the primary upstanding fabric of *Cabeal Clann 'ic Ailean*, and the late 16th-century tomb-recess provides an upper terminus, then the primary chapel is also likely to date to the very late medieval period, and given their very similar forms this would be appropriate for *Cabeal Dubghail* also. That both are also substantially 16th-century burial aisles is not unreasonable.

Whether or not it is accepted that the surviving upstanding fabric of the building usually identified as *Caibeal Dhiarmaid* is single phase, at present this building has an ambiguous position within the wider chronology of the site as there does not appear to be any positive geo-stratigraphical relationship between the surviving remains and the upstanding remains of other buildings on the site. It may be instructive that (although only the east wall survives) no re-used sandstone appears to be in evidence and the protruding east window lintel may be compared to others at the site. At present, however, there is no convincing evidence that this building should be identified as St. Columba's.

3.2 INTERIM CONCLUSIONS AND FURTHER WORK

Although requiring further consideration, in interim the weight of evidence suggests that the 13th-century twin lancet church may be the parish church of St Columba's of How. This suggestion may be supported by the account of Alexander Carmichael, whose description of the site is contemporary with and very similar to those of Captain Thomas but appears to differ in some crucial details. Like most other commentators Carmichael concentrates on describing the two largest surviving buildings at Howmore, but identifies 'Caibeal the caibeal mor (S. Columba). Outside the wall Howmore...[whilst]...Neil Maceachin says that an caibeal is caibeal mor and the new Caib Dhiarmaid' (1870-72, 34r). Further work will try to locate any maps of the site he may have made to support this apparently crucial text.

Identifying the church of St Mary's from Martin's [1695] account is more problematic and two possibilities suggest themselves. The first is that *Caibeal Dhiarmaid* is St Mary's. This might be supported by the lack of sandstone within the structure and its 'vernacular' form. Secondly, however, it is well worth highlighting a building which no longer survives on the site and may have been overbuilt by one *Caibeal an t'Sagairt* (Raven 2005, 175). Although Raven has identified a possible stratigraphic issue with identifying this building as early, Muir's description of a structure which contained a west doorway, east altar and no east window could describe a pre-parochial chapel (see main thesis text chapter 5 and 6).

In conclusion, however, this study would highlight the archaeological potential of Teampull Mòr, and re-iterate that this building is clearly a very significant structure. This study has discussed the sophisticated setting out of the masonry of this building, its formal masonry style (including the core rubble), and the use of dressed and carved sandstone - all bound in a locally sourced cockle shell-lime mortar. This building represents the most northerly example of a type of 13th century church seen much more widely across Argyll and evidences the work of non-Uisteach masons using imported sandstone materials. This is clearly a huge architectural statement and these wider links have allowed a moment of typological clarity to which much of the buildings archaeology at Howmore might be related in future work.

3.2 FUTURE WORK

It is understood that further work is planned at this site by Raven et al, and it is hoped this analysis can inform that further.

The confusion caused by possible translations from the Gaelic requires further work. I would also recommend possible archaeological relationships between the twin-lancet *Teampull Mòr* and other buildings by materials analysis of the sandstone of *Teampull Mòr, Caibeal Clann 'ic Ailean*, Borve Castle (Benbecula) and Skeabost cathedral church (Skye).

Further investigation of the wall stub protruding from the west end of *Cabeal Clann 'ic Ailean* to further examine, record and interpret any mortar and masonry contrasts is also recommended. This could be correlated with the careful removal of the tree currently growing out of the intramural tomb.

4.0 HOWMORE – FIGURES

Figure 2 (above) – Location of Howmore burial ground, on the north-west of the island of South Uist, north-west of the mainland of Scotland. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved).

Figure 3 – Relative positions of the Howmore burial ground and probably late medieval castle of Castle Bheagram. There is approximately 700m between these monuments. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved).

Figure 4 (above) – O.S.(1881) 1st edition 6-inch to the mile map, surveyed 1878, *Caibeal nan Sagairt*, *Caibeal Dhiarmaid* and *Teampull Mòr* as in ruins and all are depicted as roofless.

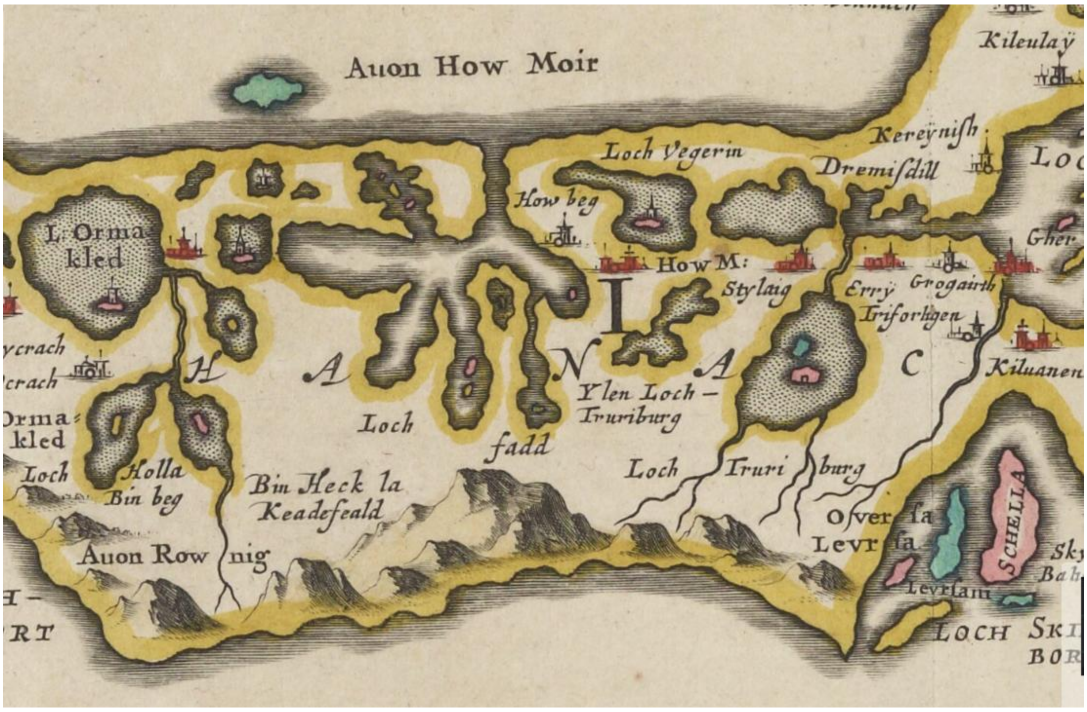

Figure 5 (above) – Detail of Blaeu atlas of Scotland, 1654, depicts How M:, How beg and Auon How Moir. By kind permission of NLS. Maps.

4.1 ON-SITE ANALYSIS

Figure 6 (above) – External face of east wall of Teampull Mòr, Howmore. Scale 500mm; photograph Mark Thacker.

Figure 7 (above) – External face of east wall of Teampull Mòr Howmore. Note formal course lines. Scale 500mm; photograph Mark Thacker.

Figure 8 (above) - Primary mortar evidence in surviving east wall of Teampull Mòr, Howmore. Note Type 3 *C.edule* relicts and quartz-rich sand aggregate. Scale 10mm; photograph Mark Thacker.

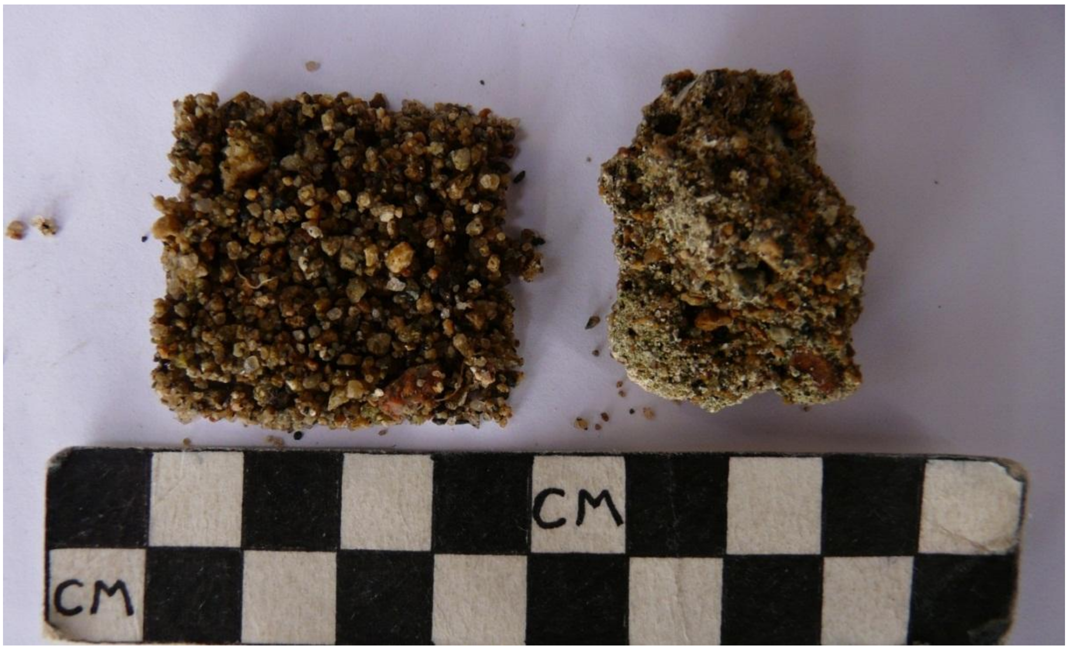

Figure 9 (above) – A coarse, angular and quartz-rich lithic sand sourced from Loch Roag matches the temper of all the primary medieval mortars of Howmore very well (from Thacker 2011).

Figure 10 (above) – Separation of quartz-rich temper from Type 3 *C. edule* heated shell relicts in loose dissolute mortar remains from *Teampull Mòr*, Howmore (from Thacker 2011).

Figure 11 (above) – Eroded sandstone within the core of the surviving east wall of *Teampull Mòr*, Howmore. No scale; photograph Mark Thacker.

Figure 12 (above) - Cabeal Clann 'ic Ailean from the south-west. Scale 500mm; photograph Mark Thacker.

Figure 13 (above) – ex-situ sandstone jamb stone with deeply-cut dog-tooth moulding. Note square-cut parallel bed angles. Inch and cm scale; photograph Mark Thacker.

Figure 14 (above) – In-situ but re-used sandstone ?jambstone in intramural tomb of Cabeal Clann ‘ic Ailean. Inches and cm scale; photograph Mark Thacker

Figure 15 (above) – Single eroded sandstone quoin in eastern doorway of *Cabeal Clann ‘ic Ailean*. Scale 10mm; photograph Mark Thacker.

Figure 16 (above) – *Caibeal Dhiarmaid*, east wall, internal face. Scale 500mm; photograph Mark Thacker.

Figure 17 (above) – Chlorite schist pinnings in face of east window reveal of *Caibeal Dhiarmaid*, Howmore. Scale 10mm; photograph Mark Thacker.

Figure 18 (above) – *Caibeal Dubhgail* from the north-west. Scale 500mm; photograph Mark Thacker.

Figure 19 (above) – Cast of timber frame behind doorway rebate of *Cabeal Dughail*, Howmore. Scale 10mm; photograph Mark Thacker.

Figure 20 (above) - *Teampull Mòr*, Howmore, Internal east wall.

Figure 21 (above) – *Caibeal Dhiarmaid*, Howmore. Internal east wall.

Figure 22 (above) - *Cabeal Clann ic Ailean*, Howmore, External west wall.

4.2 LAB-BASED ANALYSIS

Figure 23 (above) – Thick section MHU.01 from *Teampull Mòr*. Width of view 33mm.

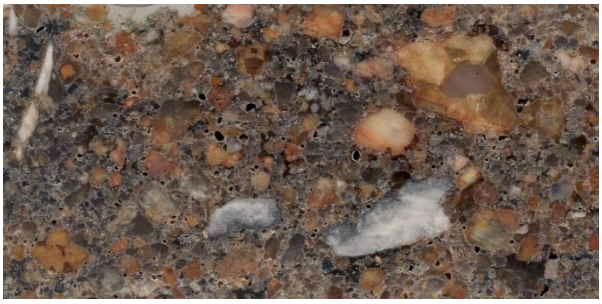

Figure 24 (above) – Thick section CHU.01 from *Caibeal Dhiarmaid*. Width of view 25mm.

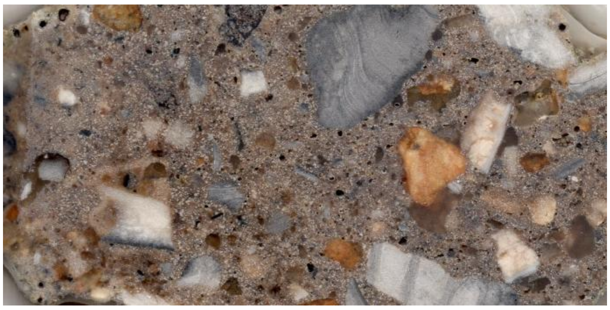

Figure 25 (above) – Thick section DHU.01 from *Caibeal Dubghail*. Width of view 25mm.

Figure 26 (above) – Thick section AHU.01 from the primary upstanding phase of *Caibeal Clann 'ic Ailean*. Width of view 38mm.

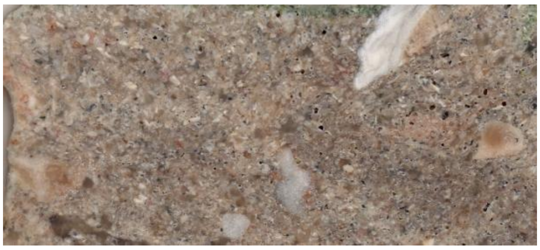

Figure 27 (above) – Thick section AHU.02 from secondary upstanding phase of Caibeal *Clann 'ic Ailean*. Width of view 15mm.

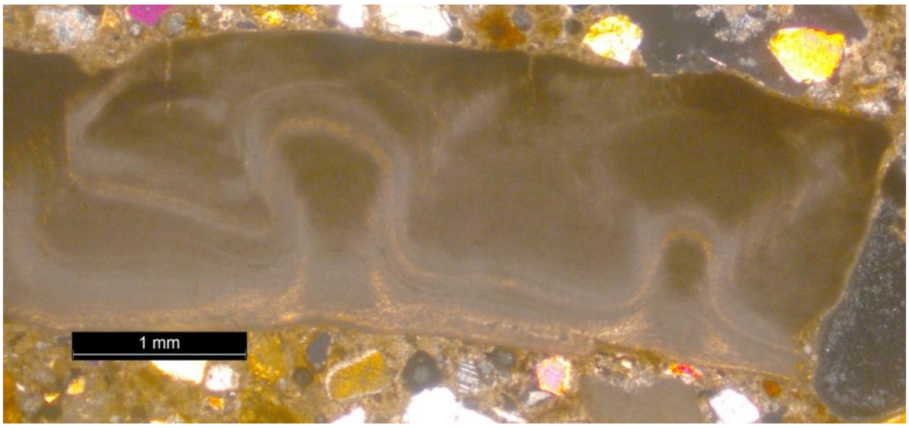

Figure 28 (above) – Thin section AHU.01, heated *C. edule* shell fragment. XPL; Scale 1mm; photomicrograph M. Thacker

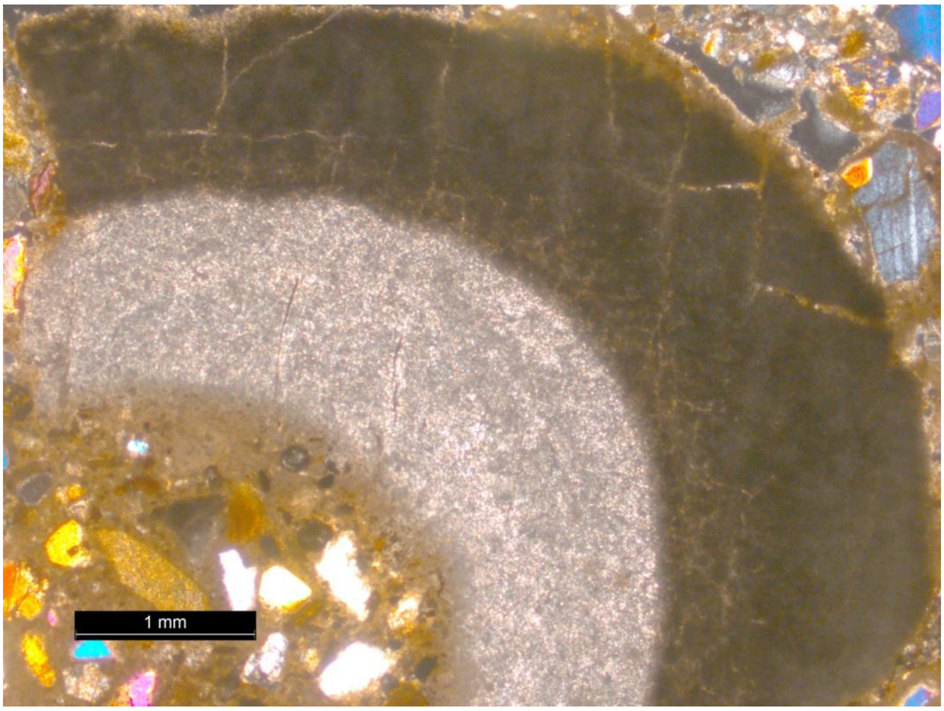

Figure 29 (above) – Thin section AHU.01, heated fractured shell fragment. XPL; Scale 1mm; photomicrograph M. Thacker

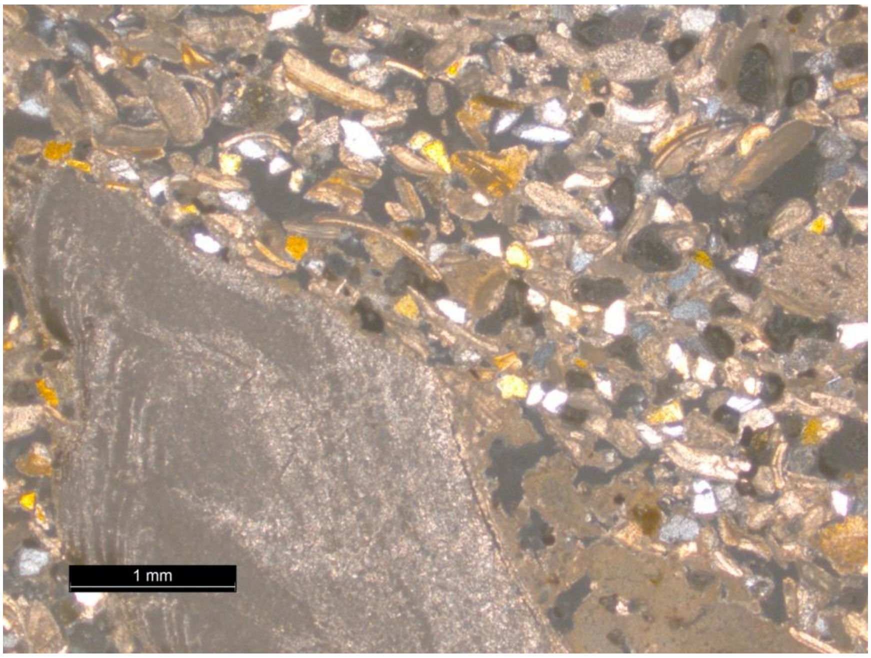

Figure 30 (above) – Thin section AHU.02, heated *C. edule* shell fragment. XPL; Scale 1mm; photomicrograph M. Thacker

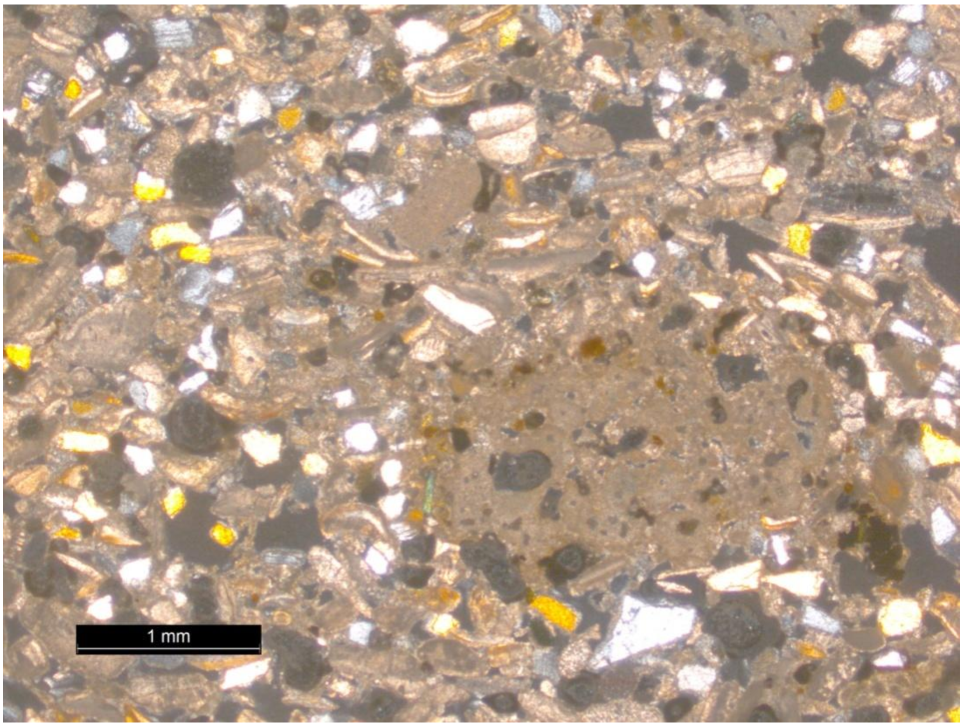

Figure 31 (above) – Thin section AHU.02, probable heated shell fragment. XPL; Scale 1mm; photomicrograph M. Thacker

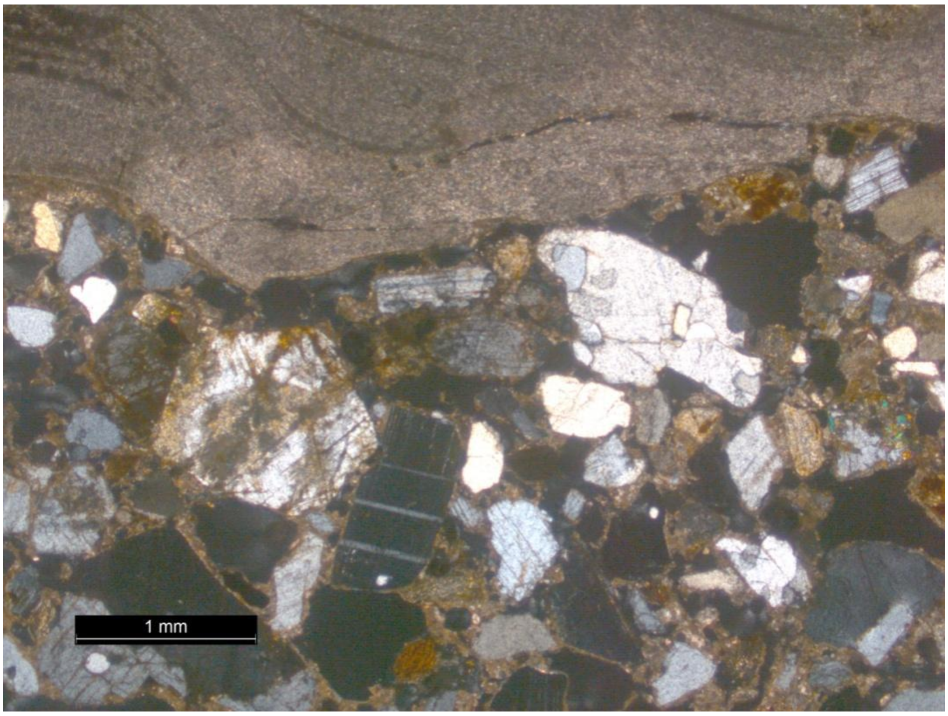

Figure 32 (above) – Thin section CHU.01 – Heated C. edule, angular quartz-rich gneiss lithic temper.XPL; Scale 1mm; photomicrograph M. Thacker.

Figure 33 (above) – Thin section MHU.01, Heated C. edule fragments. Note angularity of lithic temper. XPL; Scale 1mm; photomicrograph M. Thacker.

5.0 BIBLIOGRAPHY AND ACKNOWLEDGEMENTS

5.1 BIBLIOGRAPHY

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5.1 ACKNOWLEDGMENTS

Many thanks to *Stòrus Uibhist* for permission to work at the site and to John Raven for commenting on an earlier draft of some of the documentary evidence and for recommending a search of the Carmichael archive.

APPENDIX 10 - CASE STUDY

TUQUOY HALL & CHAPEL, WESTRAY

Mark Thacker, University of Edinburgh.

Constructing Lordship in North Atlantic Europe. Vol. III.

Appendix case study 10.

Last revision 20-07-2016

DRAFT COPY FOR PHD EXAMINATION SUBMISSION.

SUMMARY

Lab-based analysis of an assemblage of curated mortar samples from the excavation of Tuquoy Hall, Westray was undertaken in parallel with a survey and analysis of the neighbouring bicameral chapel. The form and contrasting compositions of the curated samples suggested the hall site had contained two lime-mortar coated building phases, which were not constructionally lime-bonded. Both coatings displayed evidence for biogenic lime mortar in hand sample, and these interpretations were subsequently supported by microstructural materials analysis in thin section and XRD. Survey and analysis of the nearby bicameral chapel, however, confirmed that this building was fully lime-bonded in core, bedding and internal and external coatings, and that the primary mortar material employed here contrasted with both phases of the hall site. Thick and thin-section analysis suggests this building was constructed with a limestone-lime. It is therefore possible that these secular and ecclesiastical buildings constructed within different masonry cultures and in different periods.

Only very recently recognised as a distinct building lime mortar type, this report presents the first archaeometric analyses of a maerl lime mortar and remains a preliminary assessment which will require further work. The results of the microscopic analyses have been superseded by experimental and further analytical research discussed in the main thesis text. The possible implications of these analyses for the relationship between these and other buildings is also discussed further in the main text.

CONTENTS

1.0 TUQUOY- MORTAR, MASONRY & ENVIRONMENT SURVEY

1.1 ENVIRONMENT SURVEY

The site of Tuquoy Hall is located at HY 4546 4313 in an eroding cliff-section on the south-west coast of the island of Westray (Orkney), Scotland.

1.1.3 UNDERLYING GEOLOGY

The underlying geology of Westray is predominantly composed of Rousay flags, with a calcitic (rather than ferroan dolomitic) carbonate fraction (Mykura 1976, 78) and a number of impure (muddy and often bituminous) 'fish-bed' limestone facies also outcrop on the island at Grobust sands (Leather 2006, 20) and Skel Wick (Mykura 1976, 120). Quarried stone from this latter site may have been used to manufacture lime in the modern period, (ibid) whilst limestone on the farm at Cleat was burnt for lime in the early 19th-century and described as of 'good quality' (Armit 1841, 119).

Only a few hundred yards from the site of Tuquoy Hall are extensive and easily quarried deposits of Aeolianite, although any reports of this material being used for lime production, as it appears to have been in the Isle of Lewis (Cameron 1833, 120; infra, appendix ????) and Stromness, Orkney (Clouston 1791-99, 420) are not known.

1.1.4 SHORE SURVEY

Sampled beaches are listed below although this material is yet to be analysed.

HY 45351 43126 300m west of cliff-section.

Homogenous fine sandy mid-shore between bedrock flagstone lower shore and flaggy rubble covered high shore. Very little areas of larger inclusions

Some limpet population – mostly grey/black.

HY 45409 43111 20m S of cliff-section.

Mid shore – reasonably well sorted homogenous mix of rounded to subrounded lithics, shell and maerl branches, generally to 3-4mm, some larger lithics and shell fragments to 30mm.

No.3 – 2m higher up the shore the same materials but coarser grades, especially on the surface. Beneath the surface this is a similar maerl-rich fine grade material as lower down the shore. Larger pieces of non-branching maerl are more common here. Beneath the surface coral fraction may be 50% by volume.

No. 4 – Higher another 2m, the beach level steps up suddenly and the material is much coarser. On the surface dominated by subrounded flat flags to 120mm. Beneath this is more fine maerl. There are swathes of bright *Littorina* and a band of now very white and extremely thick limpet shells. Earlier blackness must be a lack of O2. Flat maerl 'corals' are also thick here (to 5mm) and some look very much like limestone.

Beyond this is a zone of larger flags leading to the section. So:

2m part turf-covered soil and flags,

6m flags 100-600mm, [storm beach rests on clay marl].

4m limpets, whole shells and flag rubble to 120mm.

3m zone of gravel, maerl and smaller shell to 10-30mm,

5m zone of fine maerl, shell and lithics generally to 5mm.

No. 5 – Mid shore 30m east of cliff-section are pockets of yet more maerl-rich material in and about flagstone bedrock. Perhaps 85% maerl fraction, but still fine – generally to 4mm occasionally to 10mm. All white or yellow.

TQ 6. - HY 45821 43732 - The beach east of TQ farm is contrasting character again. This is more open lithic sand – again well-sorted, but sharp shell: lithic 60:40, with no maerl content – this is the sand you would choose today. Homogeneous generally 6mm and down sands.

Mae sand – Aeolianite HY 44563 42915; at HY 44631 42914 it outcrops 750mm deep and 100's of metres long to within sight of Crosskirk and cliff-section.

1.1.5 WOODLAND AND FUEL

Westray today essentially presents the same treeless landscape as the rest of the Orkneys, and the Northern Isles do not even appear on MacVean and Ratcliffe's seminal Scottish woodland reconstruction maps (1962). Palynological evidence from two sites in west Mainland, however, suggests that the islands were extensively forested in the early Holocene, with 80% arboreal pollen, which mostly consisted of *Corylus* (hazel) and *Betula* (birch), but also included *Salix* (willow) and even *Quercus* (oak) and *Pinus* (pine) (Bunting 1994). This evidence would appear to be supported by historical reports from Westray itself wherein 'great quantities of birch and birch bark' were exposed during peat cutting in one particular area (Armit 1841, 119). It would appear that this woodland was, however, almost completely lost by 5,000BP, at least in part as a result of Neolithic anthropogenic activity (Bunting 1994).

Peat was reported to cover much of the total area of the Orkneys into the early nineteenth century (Sherriff 1814, 21-22), and was the only domestic fuel used in Westray in this period (ibid; Armit 1841, 132). It would also appear, however that this resource had become very scarce in some islands (Sherriff 1814, 117), and in Westray had almost completely failed by the late 18th-century (Izat 1791-99, 264). Peat was then ferried from Eday at great cost (Armit 1841, 132) before probably being replaced by coal imports.

Archaeological evidence in Orkney was suggested a range of fuels were in use between these two periods, including driftwood for construction and fuel at Tuquoy (Owen 1993, 332)

1.1.6 LIMEKILN EVIDENCE

Despite the historical accounts of limeburning noted above, no surviving limekiln evidence is known to this writer and none are recorded on the Ordnance Survey 1st edition maps (Ordnance Survey 1882a-d). Lime does not appear to have been used as an agriculture manure, at least by the late 18th-century (Izat 1791-99, 253).

1.2 BUILDING SURVEY

No survey of the buildings making up the settlement of Tuquoy Hall could be undertaken, as the site had been excavated and back-filled. Mortar analysis on material from this site was based on curated post-excavation samples only. Mortar survey was, however, possible at the adjacent upstanding medieval and later former parish church of Crosskirk, from which one of the curated mortar samples had been collected, as well as the adjacent shoreline (as above). The details of this excavation are soon to be published more fully (Owen in prep.), but it is appropriate to briefly summarise the site as it is currently understood from previously published material.

1.2.1 TUQUOY HALL EXCAVATION

It was the character of one particular building exposed by the eroding cliff-section which had largely precipitated the eventual excavation of the settlement as '[m]assive, lime-plastered masonry protruded from the approximate centre of the exposure…' (Owen 1993, 324), and the proximity of the bicameral church and even the composition of the mortar prompted comparison with the well-known site of Cubbie Roo's castle on Wyre. Subsequent excavation identified these as the remains of a 'rectilinear hall…aligned NW to SE, with an entrance in the centre of the south-east wall (facing the sea)…[and in which]…nowhere were the walls less than 1m thick and, at the entrance, they expanded to a massive 1.4m' (Owen 1993, 326). This hall appeared to have been modified in later periods before the entrance was eventually blocked by the first of two later buildings, and the site was ultimately interpreted according to this general three-phase, Late Norse to medieval, developmental framework (ibid.; see figure 1a).

1.2.2 CURATED SAMPLES FROM THE EXCAVATION

More than 30 years later, a collection of curated mortar samples from the excavation of the hall settlement were examined in hand sample by this writer, and a number of very preliminary interpretations made. From this field scope examination of the (dusty and uncut) surface of these materials it was suggested that the assemblage included contrasting mortars from at least three different building phases (there were no mixed or composite samples), whose morphology (as casts of wall faces) indicated the underlying buildings had been constructed in a very particular way. That one of the distinct mortar sample types was from the church site was clear from its labeling, and so the two remaining sample types from the settlement were identified as Mortars A and B and are described in more detail below:

Mortar A

General description: Mortar A is a fine-textured, light-buff coloured lime mortar.

Carbonate fuel relicts: Mortar A is a possible maerl-lime. The material contains a medium concentration of coralline algae thalli which display a spectrum possible heat discolouration and textural alteration evidence in rounded inclusions to 1-3mm, curving longditudinal forms to 4mm, and in larger erroded nodular thalli-shaped vescicles to 15mm. No evidence for heated shell or limestone was noted in hand specimen.

Added-temper: Mortar A was tempered with a generally very fine (sub-mm) material, but also included unheated shell material generally grading up to 1-2mm but occasionally to 10mm, and a low concentration of quartz-rich rounded to subrounded lithics to 20mm.

Fuel kiln-relicts: No fuel evidence was noted in Mortar A in hand sample.

Vitreous kiln-relicts: No vitreous evidence was noted in Mortar A.

These curated Mortar A fragments were often in large thin sheets which were weathered on one face only suggesting they had been coating a wall face. The un-weathered side of these mortar sheets also displayed the texture of bare stone (so were probable primary coatings) and from this surface protruded narrow mortar ‘tails’ which must have penetrated quite deeply into thin (so tightly built) masonry joints of the underlying wall. Moreover, the ends of some of these mortar tails were compact and rounded, suggesting that they were complete, and so had never been contiguous with a core or deep-bedding mortar. This suggested the underlying building was most likely to have been a dry-stone or (perhaps more likely) a clay-bonded building.

MORTAR B

Like Mortar A, Mortar B had been labelled as a ‘plaster’ but this was a much less dense, whiter and more lime-rich material than Mortar A, and displayed a softer, more ‘plaster-like’ appearance.

General description: Mortar B is a low density, very white, fine, soft, and lime-rich lime mortar.

Carbonate kiln-relicts:Mortar B is a possible shell-lime. , containing a low to medium concentration of heated shell including *C. edule* (cockle) fragments to 18mm. No heated limestone, lime lumps, coralline algae inclusions or eroded vescicles were noted.

Added-temper: Mortar B was tempered with a very fine (sub-mm) aggregate; but also including unheated shell fragments to 3mm and a very low concentration of large subrounded lithic lenses to 12mm.

Fuel kiln-relicts: Mortar B contains locallised concentrations of possible fine fuel relict inclusions to 1 x 3mm, some of which may possibly be wood-charcoal and one of which may be peat.

Vitreous kiln-relicts: No vitreous material noted.

Mortar B samples were much less numerous, and displayed a slightly different morphology to the samples of Mortar A. There were no large thin sheets of Mortar B, but the fragments did appear to have a planar external face, behind which very broad tails (to 50mm deep) suggested the underlying rubble wall face had contained quite large voids prior to mortar application. This may have been a more of a slaister than a coating, applied to a dry-stone building.

Mortar C

Two samples within the curated assemblage were clearly labeled as having been collected from the neighbouring church site, and these were identified as Mortar C. Both were small clean fragments of coating 6-7mm thick without any mortar tails and no evidence of other composite mortar multiperiodicity. The most remarkable aspect of their composistion was the lack of any apparent carbonate kiln-relicts, although there did appear to be consistent evidence for a possible fuel. A similar fine, light-buff coloured temper as the previous mortar types may add further significance to these differences as related to contrasting lime burning techniques, but the small sample quantity made interim characterisation tentative.

General desription: Mortar C is a light buff coloured, fine mortar coating.

Carbonate kiln-relicts:No evidence; No heated shell, limestone or coralline algae evident.

Added-temper: Mortar C was tempered with a very fine (sub-mm) probable shell material; with one erroded orange lithic inclusion to 2 x 4mm.

Fuel kiln-relicts: Mortar C contains a distinct concentration of fine subangular black inclusions which are probably fuel but require examination at greater magnification.

Vitreous kiln-relicts: No vitreous material evident.

As this apparent contrast in technique between the hall mortar types and the Crosskirk samples suggested different techniques had been employed, these interpretations posed significant challenges for our understanding of the site. At this stage, however, these suggestion were based on surface examination only, and the sampe assemblage from the church in particular was of limited size, quantity and somewhat ambiguously contexted. It was clear more comprehensive analysis was required to investigate these materials further, and that an examination of the upstanding church building itself would be essential.

1.2.3 CROSSKIRK TUQUOY

Some months after the curated mortar samples from Tuquoy had been examined, Westray was visited as part of the North-East Regional survey of this thesis research, in order to walkover-survey parts of the local environment and make rapid masonry surveys of a number of buildings. As part of this survey the upstanding remains of the multiphase bicameral masonry church/chapel at Tuquoy was subject to a rapid mortar and masonry survey.

Unfortunately, however, this building has been very heavily consolidated, and this has totally precluded any direct characterisation of the later western extension and compromising examination of the fabric of the primary eastern nave and chancel. The stonework of this earlier smaller bicameral phase, however, is consistent and (accepting the wall-heads and one or two more intrusive sections) appears largely single phase. The west wall was lost during its later extension, but the rest of the building includes an arcuate south-west nave entrance, an arcuate south-east nave window, a round-headed chancel arch on inclined jambs, and the western remains of a barrel vault over the smaller and narrower square-ended chancel (RCAHMS 1946, 344-5).

A three-phase mortar stratigraphy is evident in the masonry beds of a putlog within the nave south wall, displaying an outer layer composed of a coarse, lithic-tempered (to 7mm+) mortar similar to that covering much of the masonry of the site, and which has probably been deposited in the very recent past. This is underlain by a contrastingly fine and white coloured shell-rich lime mortar, which might conceivably also belong to the western extension although that cannot be demonstrated at present. Underlying this white mortar, however, are much more extensive deposits of a distinctive, hard, brown-coloured lithic-tempered lime mortar, which also includes a consistent fraction of lustrous shell material to 2-3mm, but without any obvious carbonate kiln-relict evidence. Although some core contexts are now quite voided (and the mortar slowly dissolving back to the brown clay-rich sand with which it was evidently previously tempered), this brown-coloured mortar material is visibly contiguous in full wall cross-section, binding the rubble deep within the wall core (to 280mm) and the beds of the wall face stones.

A similar mortar is also evident in isolated exposed bedding contexts in both nave and chancel, and within the chancel significant fragments of mortar coating survive on the internal wall faces. This material is difficult to read beneath the lichen growth, but appears to have been applied in a single layer to 7-15mm thick, although one contiguous bed-coating context was also noted which contained an amorphous-shaped probable fuel sample (possibly peat) to 10mm. Although much smaller and more fragmentary, similar mortar coating fragments also survive on the external wall face of the chancel north wall, and upon the imposts of the south door survive to 30-40mm thick.

That these isolated bedding and coating mortars around the building are visually very similar to the material seen in contiguous bedding and deep-core rubble of the south wall is convincing and suggests this is the primary mortar of the first phase bicameral chapel.

2.0 TUQUOY - SAMPLE CONTEXTS & ANALYSIS

2.1 SAMPLE CONTEXTS

2.1.1 MORTAR SAMPLE CONTEXTS

Eight samples were selected from the curated mortar assemblage for further lab-based analysis, and one loose probable core mortar sample (matching the in-situ material) was collected from within the south putlog of the church. The context codes of the selected curated assemblage were noted, but these were primarily chosen for their material representation of the assemblage, and it was not at all clear at this point how these might relate to the excavated site. It was only some time after the analysis had been completed that (following in-depth discussions with Olwyn Owen, Catherine Smith and Chris Fyles of Alder Archaeology, Perth) that the probable contexts to which these samples relate could be ascribed. These contexts are now illustrated in plans of the site below.

Sample	Context
TWO.01	Hall; wall 1H; plaster 3.
TWO.02	Hall; wall1A; plaster 3.
TWO.03	Church; "from interior of X-kirk".
TWO.04	Hall; "plaster from 1 after removing 2"; 15.
TWO.05	"Tachy point".
TWO.06	Hall; wall 1G; plaster 3.
TWO.07	L487; "plaster"; 103.
TWO.08	L874; "shaped plaster"; 235.
TWO.09	Loose sample from core of church putlog.

2.1.2 ENVIRONMENTAL CONTEXTS

The environmental samples from Tuquoy have not been analysed to date and should be a priority for future work.

2.1.3 ANNOTATED PLANS OF CURATED SAMPLE CONTEXTS

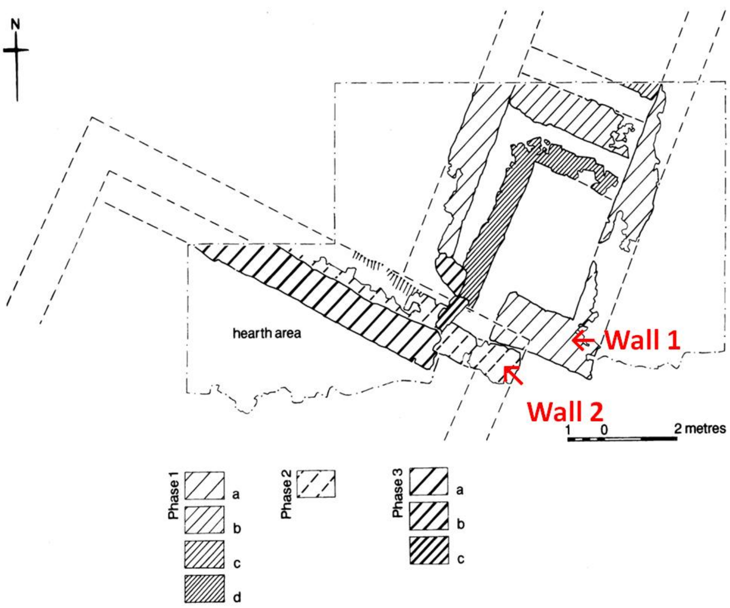

Figure 1a (above) – Annotated plan of the structural remains exposed during excavation, to show mortared walls 1 and 2. (Underlying original image from Owen 1993 with kind permission).

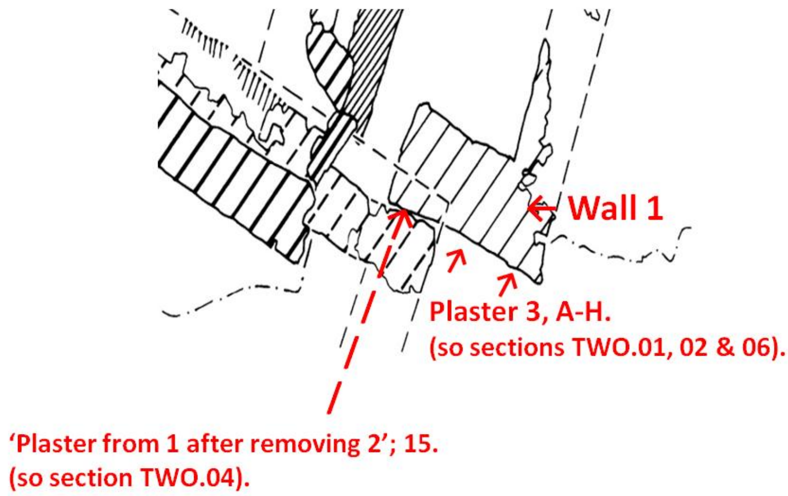

Figure 1b (above) – Annotated detail of plan from figure 1a showing the probable contexts of each of the fixed samples taken during the excavation of Tuquoy Hall. These contexts were transposed from a sketch plan of the mortar contexts (shown in figure 1c) in discussion with O. Owen, and from which we have interpreted that the dashed and dotted line represents the edge of wall 2. (Underlying image is a detail from Owen 1993 with kind permission).

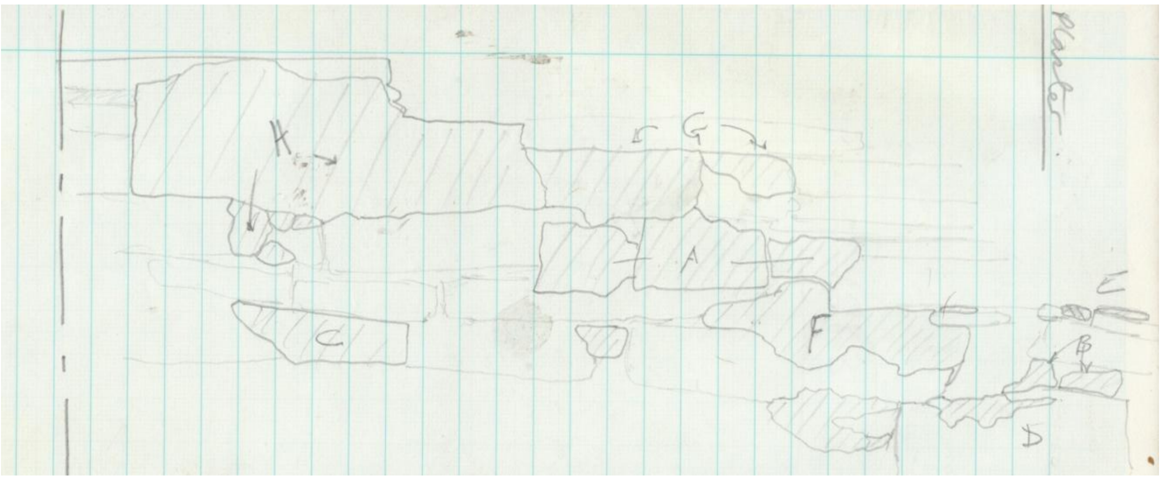

Figure 1c (above) – Sketch plan of mortar samples contexts on Wall 1 of the Tuquoy excavation. (Supplied by O. Owen)

2.2 SAMPLE ANALYSIS

2.2.1 MORTAR THIN SECTION ANALYSIS

The selected samples from the curated assemblage were thin-sectioned by Mike Hall (University of Edinburgh), and the church sample was thin-sectioned by this writer, to a standard geological thickness of 30µm. Two thin sections were made from samples TWO.04 and TWO.06 in order to cut the sample morphologies in two planes – perpendicular to and parallel with the plane of the underlying wall face (sections a and b). All of these samples were then examined in polarised light.

As at other upstanding buildings in the region, where mortar materials can be examined in-situ, some of these samples had been preliminarily interpreted as possible maerl-limes although none had previously been examined in thin section. As with any biogenic or geogenic lime provenance materials, the challenge here is to clearly identify kiln-relicts which display evidence of heat alteration, and attempt to distinguish them from unheated added-temper

TWO.01 Coating x-section.

Description of Slide – TWO.01 displays a heterogeneous, bimodally distributed material, dominated by a well-sorted buff-coloured sub-mm material, but including some 5-10% larger rounded to sub-rounded white clasts to 4mm. The slide displays less coherence on one edge of the sample, with a much lower concentration of sub-mm material, and this may be a weathered edge.

Carbonate kiln-relicts: Section TWO.01 is dominated by grains of altered coralline algae, and x-sections of the algal thalli display a range of textural evidence. Some examples are very black verging on opaque in XPL and PPL, with a relatively darker concentric rim and a lighter centre, whilst others display fine crazing (internally and at the surface) and a more general loss of coherence with micritisation and loss of grain boundary.

Mortar Matrix: The matrix of TWO.01 is a grain-supporting, cryptocrystalline, brown b-fabric of variable density, very dense areas of which often resolve into altered biogenic clasts.

Added- Temper: TWO.01 was generally tempered by a fine unsorted mixture of subangular quartz and sharp curving unheated mollusc shell fragments with good internal microstructure. This temper composition is locally heterogeneous, but is approximately a 50:50 shell: lithic ratio by volume and both grade to 0.25mm. The lithic fraction includes rounded to subrounded quartz-rich lithics. Coarser grains within the sample include unheated shell to 4mm, and rare larger grains of rounded schist or quartzite to 1.5mm.

Calc-silica reaction: TWO.01 displays some rare evidence for the probable heating and alkali-reaction of some fine quartz-rich lithics within the sample, resulting in a range of amorphous, isotropic gell-like material evidence, with some spinaflex textures at various stages of formation.

Fuel kiln-relicts: No fuel inclusions were noted in TWO.01

Summary: Section TWO.01 is interpreted as a weathered maerl-lime mortar coating fragment, tempered by a fine shell/quartz-rich lithic temper. The rare evidence for calc-silica reaction may be the result of incidental material included in the kiln.

TWO.02

Description of slide: TWO.02 is a large section with a homogeneous unsorted compositional mix across the slide, and little sign of directional weathering. There is a coarse grain fraction of approximately 20% which includes white curving, subrounded and rounded forms to 8mm.

Carbonate kiln-relicts: TWO.02 includes a high concentration of rounded, subrounded and curving, altered coralline algae inclusions to 8mm, which display a rich spectrum of textures. The coarser inclusions tend to be more distinct from the binder, displaying both equidimensional oriented poly crystalline (almost sparry) structure, and more concentric cellular biological forms. Alteration is initially often in evidence internally with loss of cellular microstructure and micritisation to a brown cryptocrystalline calcite mass, often crazed into a mosaic of fractures. Inclusions with a greater degree of alteration are generally also more fragmented, and here any external definition can be completely lost as the texture in the biogenic material approaches that within the general binder matrix, or else appears to 'bleed' into the general matrix and disappears.

Mortar Matrix: TWO.02 has high porosity and the section displays large amorphous voids. Where the matrix is more complete, however, it is a grain-supporting cryptocrystalline binder matrix of variously dense brown calcite displaying a high concentration of relict carbonate forms. These appear to be curving biogenic carbonate source materials.

Added-Temper – TWO.02 was tempered by a poorly sorted mixture of fine and coarse The fine temper is a mixture of subrounded to subangular monocrystalline quartz and subangular unheated fine shell material – both to 0.25mm The composition of this mix is locally heterogeneous but in approximately equal ratio. No fine unheated coralline material was noted. The coarser grades include a low concentration of rounded quartz-rich lithics to 4mm, including biotite-schist and some mudstone bound with a fine cryptocrystalline matrix which may be calcareous.

Calc-silicate reaction – TWO.02 contains some rare evidence for calc-silica reactions within quartz-rich lithics. It is worth considering the potential for the calcination of siltstone in this context, but no part-calcined relict forms were apparent. The vitreous material is distinct on the one hand, and all the calcined relicts appear to be algal.

Fuel: No fuel was noted n TWO.02.

Summary: Section TWO.02 is interpreted as a single phase maerl-lime mortar tempered with a mixed shell-lithic aggregate.

<u>TWO.03</u> (x-section of a thin mortar coating).

Description of Slide - TWO.03 is a small section, 22 x 10mm, containing a consistently well-sorted very fine buff-yellow sub-mm material with no coarser inclusions. One edge, to

2.5mm wide, is lighter coloured and a distinct line separates this from the darker bulk of the sample.

Carbonate kiln-relicts: TWO.03 which contains a high concentration of altered calcareous quartz-rich clasts. These kiln-relicts display a range of forms, from fine, rounded apparently unaltered examples, some with an apparently high calcareous content, to much larger, globular, vesicled and isotropic reaction products. Many contain subangular quartz grains which, with progressive loss of shape, become rounded and globular, with the overall 'melt' resolves into an isotopic glass, containing abundant apparently randomly oriented acicular crystals to 40 x 5µm. Whilst, at low magnification and in XPL, these reaction products often appear to have a distinct grain boundaries, in PPL their remarkably high concentration, inter-connectedness and indistinct boundaries with the cryprocrystalline b-fabric are very apparent. Very widespread evidence for reaction products.

There is some evidence for very fine heated biogenic carbonate relicts, but coarser examples are absent. This compositional balance of evidence, its scale and comparison with the sections within this study is important as, although the evidence is complicated by the calc-silicate reaction products, this lithic evidence dominates the section by volume, is coarser in grade and contrasts remarkably with the other mortars of this locality.

Mortar matrix: The matrix in TWO.03 is dominated by a dense cryptocrystalline b-fabric of very dark brown calcite. There is a high (approx. 80%) binder to aggregate ratio at this magnification, and so this appears very grain-supporting. At higher magnification, it is evident that this matrix is also composed of a high concentration of calc-silicate reaction products. Locally although the lighter edge is porous to the point of incoherence, it appears to display the same relict and temper composition as the main sample fabric. It is therefore interpreted as a weathered edge, rather than a different applied phase.

Added- Temper: TWO.03 was tempered with a well-sorted mixture of very fine subangular shell, quartz, and more rounded quartz-rich lithics. As much of the lithic material appears to have been subject to reaction, the composition is dominated by the shell fraction, almost all of which appears unheated with good internal microstructure, and which probably comprises a 70:30 volume ratio with the quartz. The monocrystalline quartz fraction is as coarse as the polycrystalline rocks, and so is probably not a release product. This is just detrital sorting. There are no coralline algae inclusions apparent in the slide.

Fuel kiln-relicts – TWO.03 contains a low concentration of fine, opaque inclusions. These are amorphous shaped and may be peat-fuel kiln-relicts.

<u>Summary</u> - Section TWO.03 is a very different mortar to the other mortars investigated from the curated assemblage. The section appears to be a mortar coating composed of a peat-fired calcareous limestone-lime, tempered with a shell-rich aggregate, and including reaction products which are likely to have imparted a hydraulic set.

SECTION TWO.04a

Description of slide: This long thin sample is probably a coating x-section, although no weathered edge is apparent with the unaided eye. The sample is well tempered, with a poorly-sorted relatively bimodal grain profile; there is a localized distribution of coarse, white, rounded and subrounded inclusions to 5mm and approximately 30% of slide, within a more generally fine-tempered white matrix. This section is much more coarsely tempered than TWO.03, and is more similar to TWO.02.

Carbonate kiln-relicts: TWO.04a contains a large range of coralline algae textures including polycrystalline mosaics of highly birefringent calcite, core/rim contrasts, and crazed micritised examples which are almost in optical continuity with the general mortar matrix.

Mortar Matrix: The matrix within section TWO.04a is generally remarkably 'clean' of carbonate source relicts. This is a cryptocrystalline b-fabric with a high concentration of highly birefringent sparitic and microsparitic calcite, especially at grain boundaries.

Added-temper: TWO.04a was tempered with mixture of shell and lithics, dominated by subrounded unheated shell with good internal microstructure, but also includes monocrystalline quartz, with some quartz-rich lithics fragments and rare feldspar (microcline) grains to 0.25mm. A single red/brown (probably calcareous) siltstone grain was also noted. This generally fine aggregate is evenly distributed and well supported by the mortar matrix, even though the matrix: aggregate ratio is relatively low at approximately 50% by volume.

Reaction products: Thin section TWO.04a displays two vesicled, isotropic calcareous reaction products, to 5mm, similar to that seen in section TWO.03. There is, however, no spectrum of siltstone calcination apparent within the general fabric of the section.

Fuel kiln-relicts: No fuel evidence was apparent in TWO.04a.

Summary: Section TWO.04a is interpreted as a mearl-lime mortar tempered with a generally fine shell-rich aggregate.

SECTION TWO.04b

Description of slide: TWO.04b is from the same curated sample as section 4a, but has been cut in a perpendicular plane. The material here is consistently coherent, with no localized areas of dissolution or weathering apparent. This is a bimodal material containing a coarse fraction dominated by rounded white and blue coralline algae sections, but also includes some curving subrounded white shell and orange/brown lithic inclusions to 5-12mm. These clasts are surrounded variation of cryptocrystalline brown calcite density, within surviving rounded external forms, and some relict concentric cellular structure. Some are in almost complete optical continuity with the mortar matrix and grain boundary coherence has been lost.

Mortar Matrix: The mortar matrix within TWO.04b is often microsparitic, polycrystalline, highly birefringent calcite, with low porosity. Although the section appears very coherent, areas of cryptocrystalline b-fabric are rare. The similarity of the binder texture to that of the more altered algae within the section is apparent, but the matrix is generally relatively very 'clean', with a relatively low concentration of carbonate relicts at X20.

Added Temper: TWO.04b was tempered with a shell and lithic mix grading up to 0.25mm, and dominated by an unheated shell fraction with good internal microstructure, but also including subangular quartz, with a smaller fraction of rounded siltstone and schist/quartzite.

Fuel kiln-relicts: Section TWO.04b displays one probable opaque peat fuel relic to 0.3mm.

Summary: Section TWO.04b is interpreted as a peat-fired maerl-lime mortar tempered with a fine shell/lithic shoreline aggregate.

<u>SECTION TWO.05</u>

Description of Slide: This is a large section covering most of the slide. The section displays a uniform composition of well-sorted bound sub-mm material and is generally buff-yellow with and even distribution of darker orange-brown grains to 10% of the slide. There is some slight variation in density, or perhaps porosity, whereby the centre of the section appears less dense and lighter coloured.

Carbonate kiln-relicts: TWO.05 doesn't appear to include any altered clasts, associated reaction products or fuel. Grain boundaries, however, are generally slightly indistinct.

Matrix: TWO.05 is bound with is a highly birefringent, polycrystalline, sparitic and microsparitic calcite. This is supporting many of the larger shell and lithic grains, although many are also partially grain-supported.

Temper: TWO.05 includes unaltered shell with good internal microstructure to 1mm, and smaller grades of schist, siltstone and quartz in an approximate ration by volume of 60:40:5 – Shell: stone: quartz. Some rare coralline algae grains are also present. Interestingly the quartz-rich lithics within this section appear to display a large range of forms from matrix-rich sedimentary clasts to more densely packed metamorphosed quartzofeldspathic material with a high concentration of white mica. Many of these grains display a brown cryptocrystalline fraction which may be calcareous.

Summary: Section TWO.05 is interpreted as a sedimentary aeolianite and not as an anthropogenic mortar.

<u>SECTION TWO.06a</u>

Description of slide: TWO.06a is a large section (47 x 22mm) containing a bimodally sorted material dominated by a well-sorted, very fine, buff-white sub-mm material, with some very dark/black sub-mm grains to 5%, and a very low concentration of super-mm clasts. This coarser material appears to be composed of white rounded, probably coralline algae sections to 1.5-2mm, a single shell section to 5mm, and two large rounded lithic fragments, one of which is elongate (13 x 3mm) and light-brown, the other more spherical (6mm diameter) and darker brown/orange. The section displays some large amorphously shaped voids, to 2mm, are also apparent locally near the coarser clasts.

Carbonate kiln-relicts: TWO.06a contains a wide spectrum of evidence for coralline algae alteration at various grades, but in lower concentration than other sections from this site.

Mortar matrix: The light brown matrix of section TWO.06a appears very coherent at low magnification. Although the matrix to temper ratio is relatively low (less than 45%), the temper is generally well matrix-supported, with little grain-to-grain contact. At higher magnification the binder appears to be composite of light-brown, cloudy, cryptocrystalline material, which is washed across coarser highly birefringent, subangular grains of calcite. There is a distinct fine vitreous fraction within this section with some impressive spinaflex textures.

Added temper: TWO.06a was tempered with a very fine (generally sub-mm) well-sorted mix of lithics and shell, predominantly composed of a well-sorted mix of rounded unheated shell and shell fragments with clear internal microstructure, with some rounded polycrystalline quartz-rich lithic clasts from 0.25 to 0.5mm. A very low concentration (<5%), of monocrystalline quartz is also present. A coarse temper fraction includes two lithic clasts which at low magnification are interpreted as well-sorted, banded, quartz-rich siltstone clasts, and a single large unheated mollusc shell.

Fuel kiln-relicts: No fuel was noted in this TWO.06a section.

Summary: Section TWO.06a is interpreted as maerl-lime mortar, well-tempered with a fine shoreline aggregate mix of shell and quartz-rich lithics.

<u>SECTION TWO.06b</u>

Description of Slide: TWO.06b is a thinner section (40 x 15mm) x-section of the same TWO.06 sample. The material is bimodal: dominated almost completely by a well-sorted, white, fine material of sub-mm grains, with rare (<5%) orange sub-mm grains also, there is a low (5%) fraction of super-mm clasts evenly distributed across the section. This coarser fraction includes curving shells and other rounded white, probable coralline algae bioclasts to 2mm.

Carbonate kiln-relicts: TWO.06b contains a high concentration of altered biogenic clasts, dominated by coralline algae transverse and longitudinal sections.

Mortar Matrix: At low magnification, the light brown TWO.06b matrix is very coherent and although a relatively low matrix-to-aggregate ratio pertains, once again the temper is clearly matrix supported, with little grain-to-grain contact. At higher magnification the binder is a composite of very fine cryptocrystalline b-fabric, and coarser highly birefringent grains.

Added temper: TWO.06b was tempered by a well-sorted very fine mixture of rounded unaltered shell and polycrystalline quartz mix (including metamorphic and sedimentary forms), similar to that described for 6a. Monocrystalline quartz grains are present but even rarer here.

Vitreous Material: TWO.06b displays some rare but very well developed calc-silicate reaction products including glassy and spinaflex textures.

Fuel kiln-relicts: No fuel apparent

Summary: Section TWO.06b is interpreted as maerl-lime mortar, well-tempered with a fine shoreline aggregate mix of shell and quartz-rich lithics.

SECTION TWO.07

Description of Slide: TWO.07 is a large section (44 x 22mm) covering most of the slide. This is a relatively homogeneous and bimodal material, with the coarser fraction making up approximately 20%, and relatively localised. This coarse section is composed of a mix of clasts, but is dominated by rounded white inclusions to 2mm which are probably coralline algae cross-sections. A single brown rounded and elongate clast is probably lithic, whilst a single grey/white ribbed shell to 10mm is also present. This coarse fraction is surrounded by a very light buff matrix including sub-mm grains.

Carbonate kiln-relicts: Section TWO.07 contains clear evidence for altered coralline algae clasts, including grains which have lost all coherence, except for some relict cellular grain and, conversely, inclusions which have retained an overall distinctly coralline shape, but have lost all internal microstructure and are breaking up into a range of mosaic textures.

Mortar Matrix - At low magnification the mortar matrix within section TWO.07 is coherent with little porosity. At higher magnification, however, the binder texture is relatively coarse and heterogeneous, apparently composed of only a very thin cryptocrystalline buff brown b-fabric, which contains a high concentration of very fine 100µm rounded, brown, zoned discrete inclusions. Although the 3-d depth of field must be appreciated here (as well as the potential effects of polishing and processing), at high magnification this now displays a microscopic bimodal porphyritic texture within the binder matrix, which as a result is quite coarse. These coarse binder inclusions are not sparitic or crystalline, but are very fine relict carbonates.

Added temper: TWO.07 was tempered with a very fine well-sorted mixture of lithics and shell to around 0.25mm, slightly dominated by the lithic fraction in a ration of approximately 60:40. The lithic fraction is primarily composed of monocrystalline subangular to subrounded quartz inclusions with undulose extinction. Some rounded polycrystalline quartz-rich lithics, both low grade metamorphic grains also displaying white mica, and some finer siltstones are also present. The fine shell fraction here is unaltered with clear internal microstructure. A single *C. edule* (cockle) shell with very clear internal microstructure and a large rounded siltstone, predominantly composed of fine quartz, were also present.

Reaction products: TWO.07 includes a low concentration of calc-silicate reaction products.

Fuel kiln-relicts: TWO.07 contains rare amorphous probable fuel inclusions to 0.5mm.

Summary: Section TWO.07 is interpreted as a peat-fired maerl-lime mortar tempered by a fine aggregate composed of quartz-rich lithics and shell.

SECTION TWO.08

Description of Slide: TWO.08 is a large section covering most of the slide. The section texture is generally uniform and composed of a well-sorted, very fine, sub-mm, white, cloudy material, supporting a poorly-sorted range of coarser clasts, generally to 2mm. 5 larger, probable shell inclusions are also apparent to 5mm.

Carbonate kiln-relicts: This TWO.08 section is dominated by a high concentration of altered biogenic carbonates to all grades, including *C. edule* (cockle). The evidence for cracked shell of this type at coarser grades, broad spectrum of probable heated shell textures noted at low magnification, the high concentration of longitudinal curving calcined sections and the lack of coarser coralline relics are all suggestive. Altered coralline algae was not positively identified and the distinctive rounded algal cross-sections see in other sections are notably absent.

Mortar Matrix: The distinctiveness this TWO.08 section within this assemblage is immediately apparent. The matrix is very coherent and in very high ratio and grains of greater than 0.75mm are only at about 8% of the section. The matrix is a very white cloudy, cryptocrystalline b-fabric, although within the thickness of the section, at very high magnification, some more microsparitic textures are also evident. At lower magnification the binder is characterised by an extremely high concentration of highly altered biogenic carbonate relicts at around 200µm, which haven't quite lost all coherence.

Added temper: TWO.08 was tempered by a very low concentration of sub-mm temper, dominated by unaltered subangular to subrounded shells and shell fragments, with clear internal microstructure. There is a remarkably low lithic and mineral fraction here (<5%), completely absent from some fields of view, but predominantly composed of subangular monocrystalline quartz, with undulose extinction, and some larger rounded lithic clasts, displaying polycrystalline undulose quartz within variously glassy matrices.

Reaction products: TWO.08 contains a low concentration of calc-silica reaction products.

Fuel kiln-relicts: TWO.08 contains a noticeably higher concentration of fine amorphous opaque inclusions which are interpreted as fuel inclusions and probably peat.

Summary: Section TWO.08 is interpreted as a peat-fired, Cockle-shell lime mortar tempered with a small quantity of fine aggregate also largely composed of shell. The production techniques and materials have resulted in a particularly fine, soft and white mortar with a very high lime ratio.

TWO.09

X 2 SECTIONS Two large sections to 50 x 24mm containing a single phase poorly-sorted light-brown coloured material including white-coloured lens of probable shell and/or maerl clasts and rounded elongate darker possible lithics to 3mm. One section contains two larger indistinct rounded contexts to 6mm.

Carbonate – TWO.09 is a limestone-lime but is of curious texture. The lime-provenence can be related to two large amorphous areas of carbonate which is itself a composite material without surviving geogenic structure. Other contexts, however, display the release of fine quartz suggesting a quartz-rich micritic mudstone protolith. Although the section contains some micritic and fractured maerl fragments these do not have a convincing relationship with the mortar matrix.

Added-temper – TWO.09 was tempered with a poorly-sorted mixture of lithics and unheated shell generally grading to 2.8mm, includes micaceous sandstone and quartz-rich siltstone.

Fuel – very low concentration of amorphous opaque inclusions to 0.5mm which are probable peat fuel relicts.

Vitreous material – some clear cryptocrystalline reaction products which require further work.

Summary – TWO.09 is interpreted as a peat-fired limestone-lime, tempered with a fine mixture of lithic and shell sand.

2.2.2 XRD OF MAERL INCLUSIONS

Two mortar samples from Tuquoy were also included in a wider investigation into the mineralogy of biogenic mortars. These included putative carbonate kiln-relicts removed from samples TWO.02 and TWO.08 and analysed through XRD using the same preparatory process adopted throughout this thesis (see chapter 2).

TQ2:- TQ2 was composed of three coralline algae fragments dug out from the sawn face of mortar sample TWO.02. These inclusions were all very white and crushed very easily.

TQ8:- TQ8 was composed of two *C.edule* (cockle) shell fragments, dug out of the sawn face of mortar TWO.08. Both were striped white and blue.

Sample	Temp /°C	Magnesium Calcite/%	Calcite /%	Periclase /%	Portlandite /%	Aragonite /%	Brucite /%	Trace + agg. /%
TQ2		24	71	1.3		1.3		2.4
TQ8		32	59			1.2		7.8

3.0 CONCLUDING DISCUSSION & FURTHER WORK

3.1 MORTAR TYPES

This lab-based investigation of building lime mortars supports the previous hand sample assessment that the assemblage contains 3-4 different mortar types. The materials themselves require further work in the light of ongoing research into maerl-limes, the regional corpus and most particularly the local limestone and sand/gravel sources. Until this holistic work can be done interpretations at this site will remain tentative, although in interim the following characterisations were suggested:

Mortar A: Samples TWO.01, TWO.02, TWO.04, TWO.06 and TWO.07 were all characterised as maerl-limes in hand sample and thin section. Thin sections from these samples included maerl clasts which displayed a range of textural alterations similar to those seen elsewhere in other biogenic limes, including increasing micritisation or cryptocrystallinity, loss of internal microstructure, increasing optical continuity with the mortar matrix and eventual loss of grain boundary. These characteristics have been interpreted here as the effects of heat alteration to various temperatures approaching and including dissociation and recrystallisation. The trace aragonite fraction in the XRD sample from TQ2 (from TWO.02) is, however, curious as this sample has a mineral phase profile otherwise consistent with thalli which have been heated to around 500^{o}C. It is possible this aragonite fraction is the result of trace contamination from sawing the sample for thin sectioning but more XRD work is required on these materials (see chapter 3 of main thesis text). All Mortar A samples have been tempered with the same fine shell/lithic beach aggregate and although fuel evidence is rare probable fine peat relicts are included.

Mortar B: Sample TWO.08 is interpreted as a shell-lime in hand sample and thin section. A thin section of this sample contained a very high concentration of highly altered *C.edule* (cockle) shell. The mineral phase profile of shell inclusion sample TQ8 was analysed with XRD and is consistent with shell kiln-relicts heated to a low temperature. The very lime-rich composition of this mortar, which has hardly been tempered at all, has lead to the very soft 'shaped plaster' mortar which is very distinctive and this material clearly contrasts with the other mortar type characterised from this secular site. Both types contain evidence of probable peat fuel-relicts.

Mortar C: Mortar samples TWO.03 and TWO.09 were both interpreted as limestone-limes in thin section. It is clear these are different materials, however, as coating sample TWO.03 is much more fine-textured and contains a much higher concentration of (probably hydraulic) reaction products. These samples also contain evidence of probable peat-firing.

3.2 CONTEXTS AND PHASING

The three different mortar types characterised above are associated with three different building phases and this interpretation has been subsequently supported by more recent work on the excavation archive. Mortar samples TWO.01, TWO.02, TWO.04, TWO.06 are now known to have been removed during excavation from the external face of the south wall of the primary rectilinear 'hall' (see figure 1 above). That all four samples are so similar is useful as mortar sample TWO.04 was abutted by wall 2 of the secondary building. Although Mortar A was deposited as a coating in an event secondary to the construction of Wall 1, the construction of abutting Structure 2 provides an upper terminus. Although unfortunately there was no evidence for the internal coating of Structure 1, and so the coating cannot be related to the subsequent subdivision of the building, no mortar was associated with those secondary sub-phases. Although difficult to demonstrate categorically, it is probable the Mortar A external coating is broadly contemporary with the original construction of the hall.

Mortar samples TWO.07 and TWO.08 do not appear on the context plan in Figure 1 as these were collected during excavation from ex-situ contexts. It is, however, significant that recent work on the excavation archive (from communication with Chris Fyles and Catherine Smith of Alder Archaeology, Perth) suggests that Mortar A sample TWO.07 was recovered from soil associated with the ruination of Structure 1, whilst Mortar B sample TWO.08 was recovered from a robber trench associated with Structure 2. This supports the suggestion that Mortar A and B relate to different masonry phases and that Mortar A is the earlier of the two (perhaps by some margin given the modifications to the hall before its abandonment when building 2 was built). There was no mortar associated with Structure 3.

The Mortar C samples from the Crosskirk do not appear to be related to either phase of mortared construction at the hall. In line with the methodology generally employed during this thesis, there was no literature search of previous surveys of the church undertaken before site visit or mortar analysis and the building was assessed on the basis of its mortar and masonry archaeology only. The loose sample TWO.09 was only collected because it appeared representative of a mortar noted in contexts interpreted as primary core during the survey. It is therefore important to note that (although the putlog itself doesn't appear on the drawings) this context is well within the section of upstanding masonry drawn by Dryden in the late 19th-century, before the site was consolidated (MacGibbon and Ross

1896, 125-126; see also Lowe 1986 ii, 98). The exact context from which sample TWO.03 was removed from the church site by the excavation team is unknown, but similar coating was noted during building survey. It is clear from materials analysis that the Mortar C samples from these contexts are different materials, and it clear from the form of sample TWO.03 and building survey evidence that the coating has been applied in a separate plastering process. However, as both Mortar C materials have a geogenic-lime provenance, both contain very similar red-brown mortar matrices, and only one coating was noted during building survey, it is very likely these are broadly contemporary materials.

3.3 STRUCTURE

In the initial preliminary examination of the curated mortar sample assemblage, sample morphology suggested that the buildings associated with Mortars A and B were lime mortar coated, but they were unlikely to have been constructed with lime mortar and that clay-bonded structures were most likely. This interpretation is now supported by subsequent examination of the excavation and site notes. Although descriptions of the core material in these notes do vary between dry stone, earth and clay, perhaps suggesting the core was heavily voided, occasional more specific references to 'clay bonding' are made (site book vol. 1, 16/05/82; and context sheet for context 1).

Building survey demonstrated that the primary phase of the church is fully limebonded in core and bed and it is likely the building was coated in a separate but contemporary process. Later phases of mortar deposition are in clearly contrasting mortars and may be associated with the extension of the nave and very late ruin consolidation.

3.4 CONCLUDING DISCUSSION

The evidence from the study is discussed more fully in the main thesis text, but the important issues will be highlighted here.

These samples demonstrate three distinct mortar phases, and the secular and church buildings also betray contrasting, clay-bonded and lime-bonded, structural morphologies. Both of these strands of evidence suggest the church and secular sites were not constructed within the same masonry cultures and it is likely that the primary hall and church were constructed in different periods. A relative chronology between hall and church has not been definitively demonstrated here, but other evidence (discussed in the main thesis text) suggests the church was constructed relatively late in the period and as the hall was the primary building excavated on the secular site, the more vernacular primary building may be the earlier of the two.

3.5 FURTHER WORK

There are some fundamental question remaining regarding the manufacture of maerl-lime mortars and much more research is required. At Tuquoy this should clearly include comparative analysis of the range of littoral sands and gravels noted along this shore and a re-evaluation of the sections and samples in comparison with other sites. As work on other maerl-limes continues our interpretations of the Tuquoy mortars will become more informed and a greater understanding of the natural and anthropogenic depositional history and taphonomical trajectory of these maerl materials is required. We may then be able to move the research forward in terms of the possible palaeoenvironmental potential of these maerl-rich materials.

More comprehensive recording and analysis of fixed core and coating mortar samples from the Crosskirk church, neighbouring Quoygrew and Pierowall and comparative examination of possible geogenic lime sources, including both aeolianite and limestones, would also be informative.

4.0 FIGURES

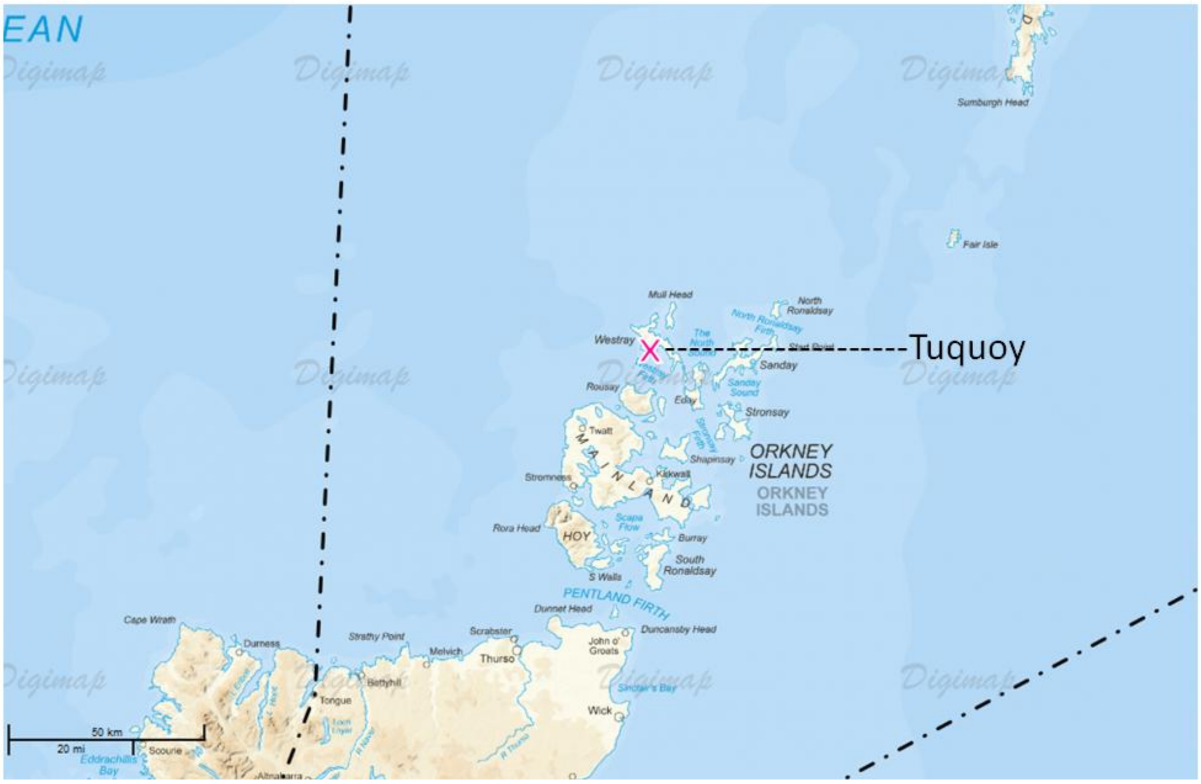

Figure 2 (above) – The site of Tuquoy, south-west Westray, within the North-East survey Region. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved).

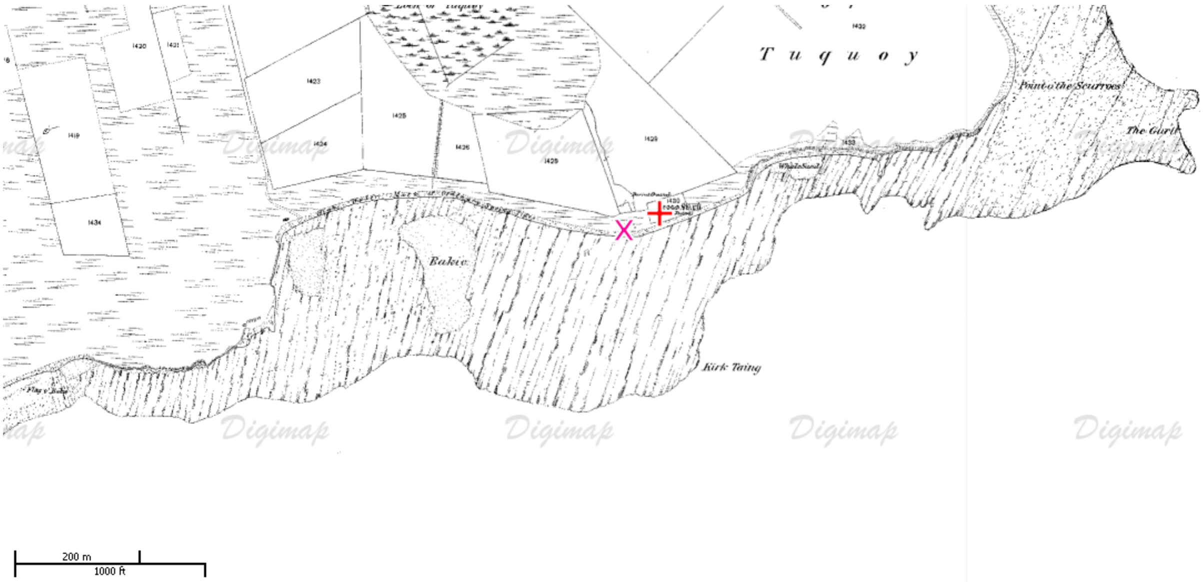

Figure 3 (above) - Very closely associated secular and ecclesiastical buildings at Tuquoy. OS1 scale bar 200m & 1000ft. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved).

4.1 – ON-SITE ANALYSIS

Figure 4 (above) – The eroding cliff-section containing Tuquoy hall and settlement from the south. Scale 500mm; photograph Mark Thacker.

Figure 5 (above) – Crosskirk Tuquoy from the south-east. Note arcuate nave doorway and window and smaller barrel-vaulted chancel. Scale 500mm; photograph Mark Thacker.

Figure 6 (above) – Crosskirk Tuquoy from the west with the secondary western extension in the foreground. Scale 500mm; photograph Mark Thacker.

Figure 7 (above) – Crosskirk Tuquoy, south nave doorway. Scale 500mm; photograph Mark Thacker.

Figure 8 (above) - Crosskirk Tuquoy chancel arch from the west. Scale 500mm; photograph Mark Thacker.

Figure 9 (above) – Crosskirk Tuquoy, south nave wall. Note south putlog to the right and fragments of mortar coating to the right of the window. Scale 500mm; photograph Mark Thacker.

Figure 10 (above) - Crosskirk Tuquoy, external face of west jamb of south nave putlog. Note three phases of contrasting mortar. No scale; photograph Mark Thacker.

Figure 11 (above) – Crosskirk Tuquoy. Degading mortar binding core rubble; east of south nave putlog. No scale; photograph Mark Thacker.

4.2 – LAB-BASED ANALYSIS

Figure 12 (above) – Thick section Mortar A. Note: thin mortar tails with coherent rounded ends which may have abutted underlying constructional clay mortar; the more planar face of the former mortar surface. Field of view approx 120mm; Photograph M. Thacker.

Figure 13 (above) Thick section Mortar B. Note very wide mortar tail suggesting much coarser underlying rubble wall; planar face of previous coating surface; high concentration of discoloured bioclasts including probable maerl and shell in this section. Field of view approx 100mm; Photograph M. Thacker.

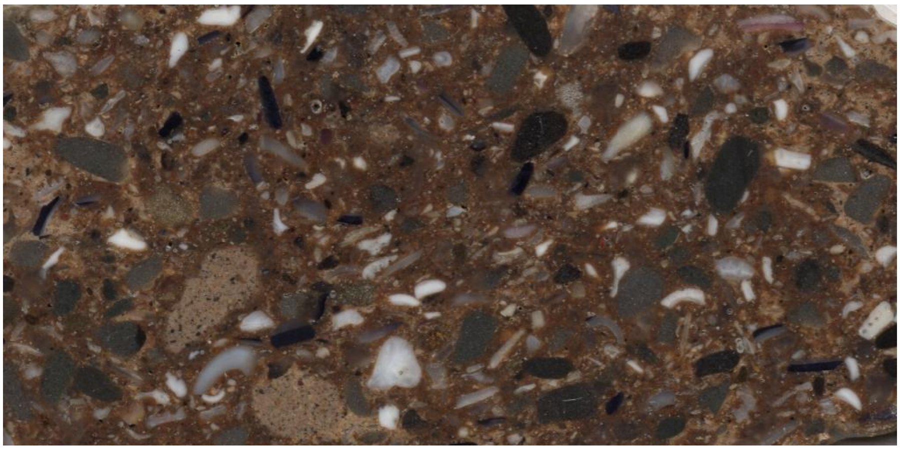

Figure 14 (above) – Thick-section TWO.09. Note very dark red-brown colouration and extraordinary subrounded elongate carbonate relicts. This is unusual apparently geogenic kiln-relicts evidence. Field of View approx. 25mm; M. Thacker.

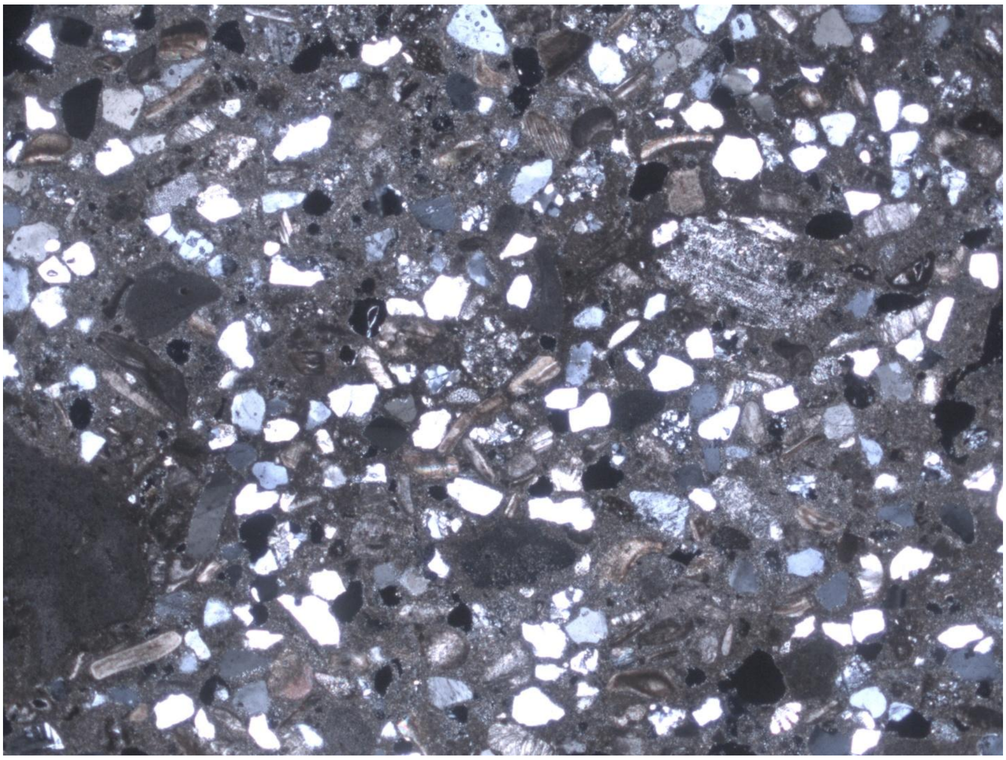

Figure 15 (above) – Thin section General view of tempered mortar TWO.01. Field of view approx. 5mm; XPL; Photomicrograph: M. Thacker.

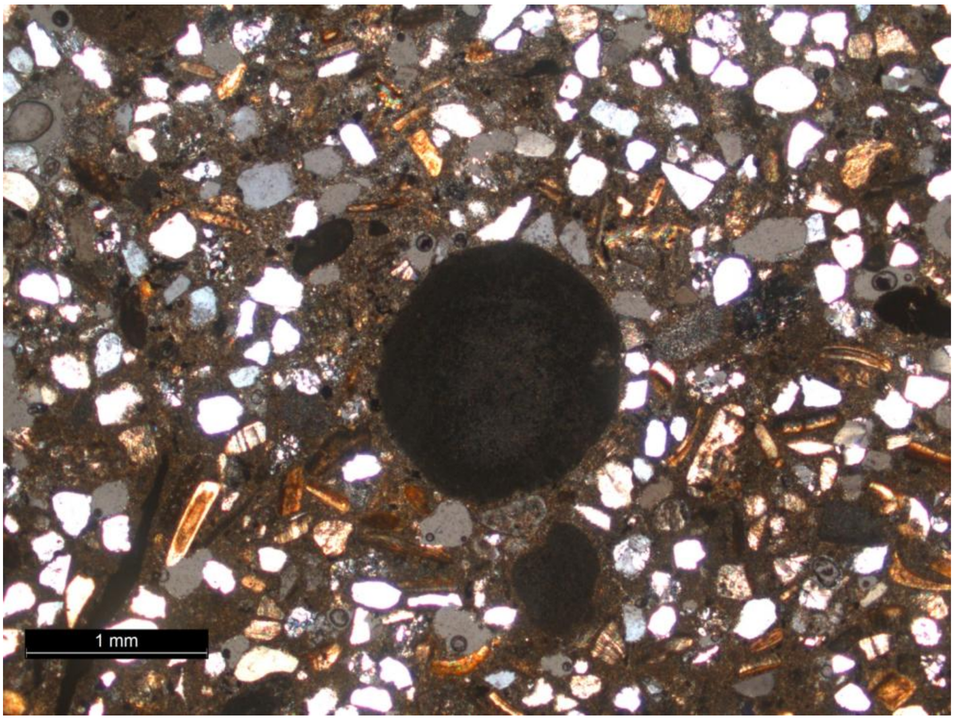

Figure 16 (above) – General view of section TWO.01. with discrete but discoloured algal inclusion with some core/rim textural contarst; Scale 1mm; XPL. Photomicrograph: M. Thacker.

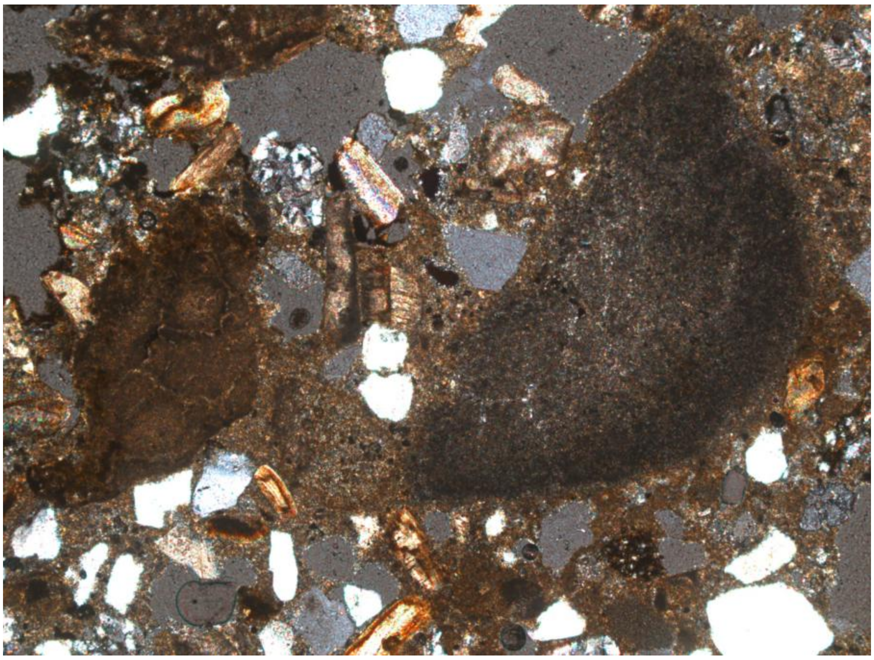

Figure 17 (above) – Thin section TWO.01, this is highly porous section but here displays two crazed fragments of coralline algae. The larger clast is highly discoloured whilst the smaller appears to be approaching optical continuity with the general mortar matrix. Field of view approx 2.5mm; XPL. Photomicrograph: M. Thacker.

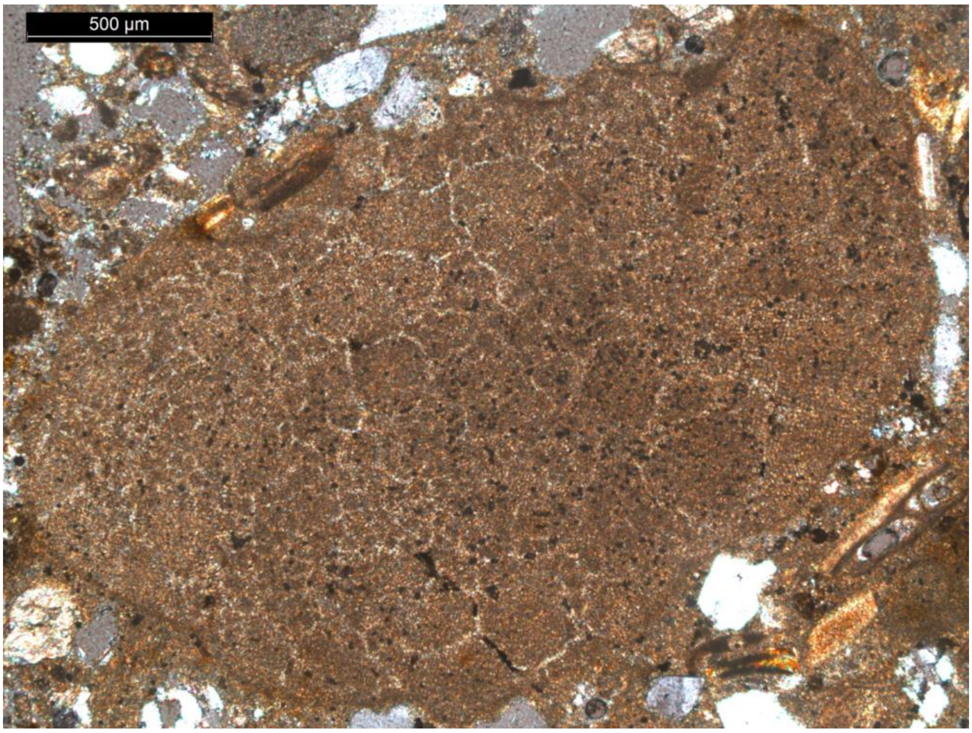

Figure 18 (above) – Thin-section TWO.01. Crazed coralline algae inclusion close to optical continuity with mortar matrix and losing grain boundary coherence, but retaining some concentric relict grain. Scale 500µm; XPL. Photomicrograph: M. Thacker.

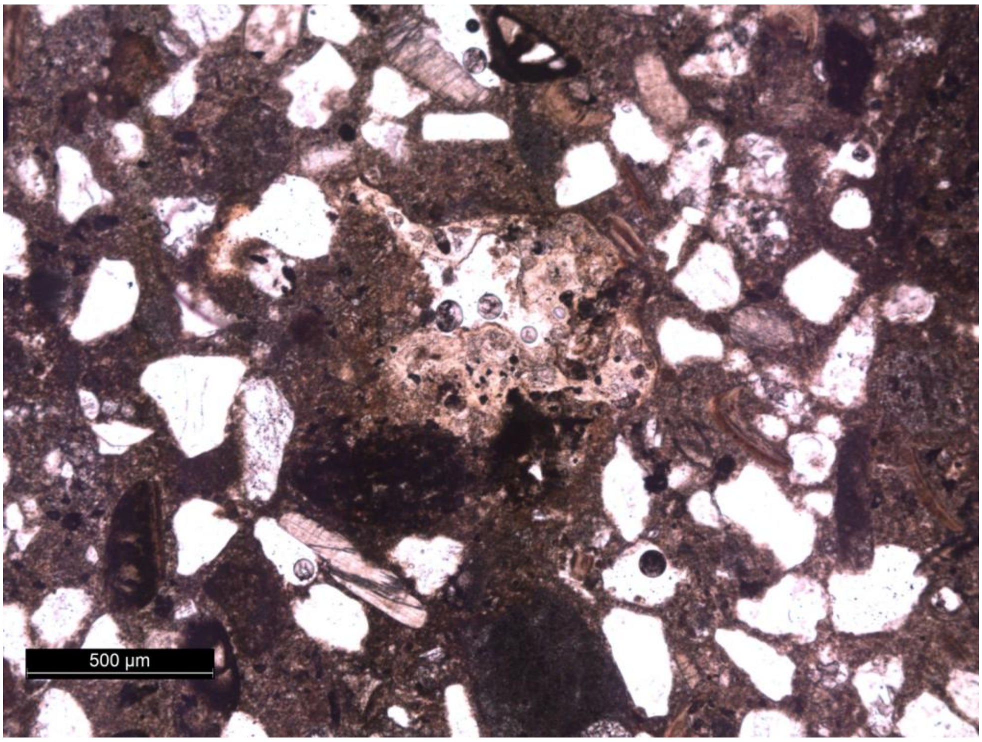

Figure 19 (above) – Thin section TWO.01. This is an isotropic amorphous gel, which may be a calc-silicate reaction product; Scale 500µm; PPL; Photomicrograph Mark Thacker.

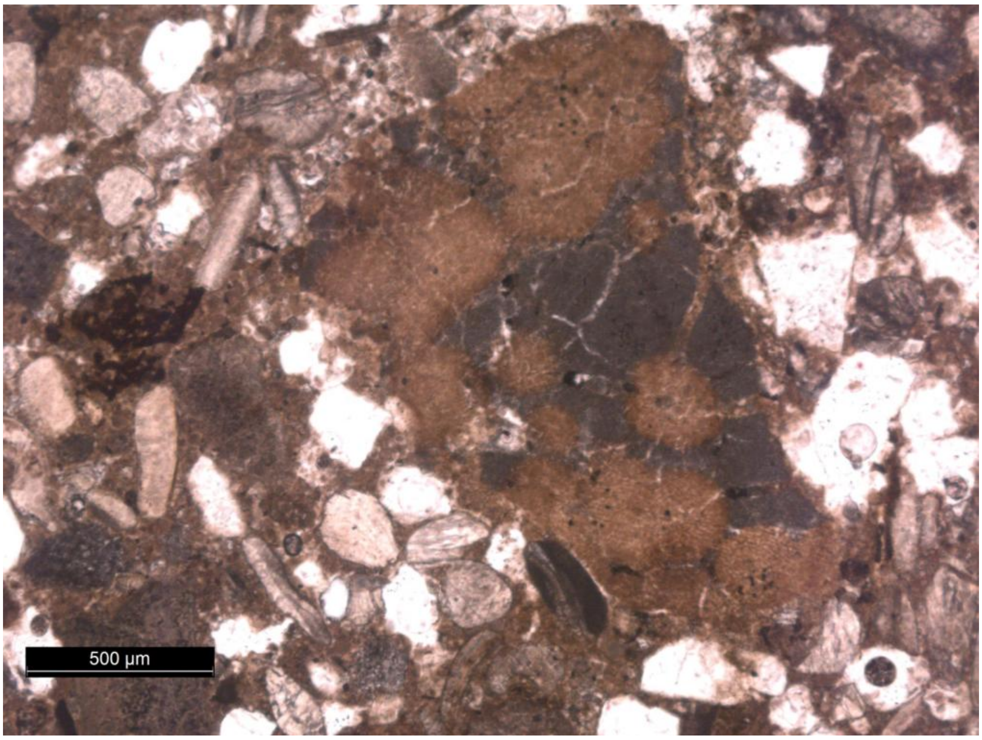

Figure 20 (above) – Thin section TWO.02 including a longitudinal algal section displaying some discolouration, crazing and micritisation. Scale 500µm; PPL; photomicrograph Mark Thacker.

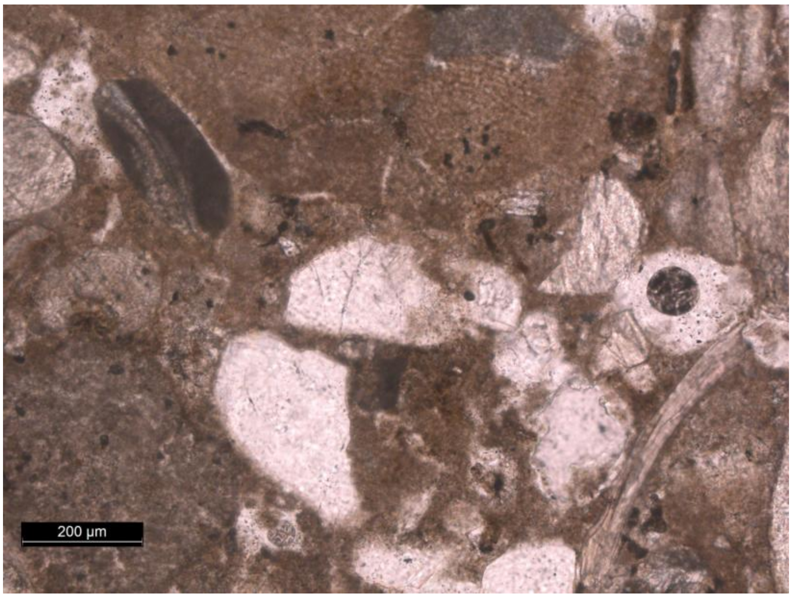

Figure 21 (above) – Thin section TWO.02. Detail of longitudinal section from previous photomicrograph; note textural similarity and relict cellular structure. Scale 200µm; PPL; photomicrograph Mark Thacker.

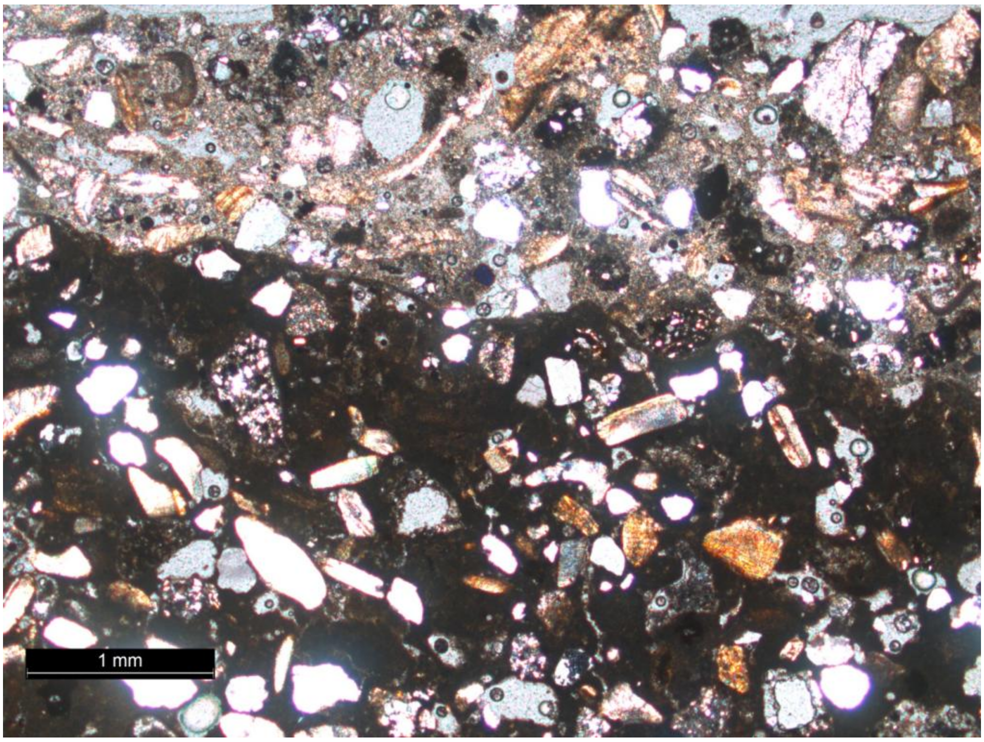

Figure 22 (above) – General view of mortar section TWO.03. displaying contrasting weathering textures. 2.5X; XPL. Photomicrograph: M. Thacker.

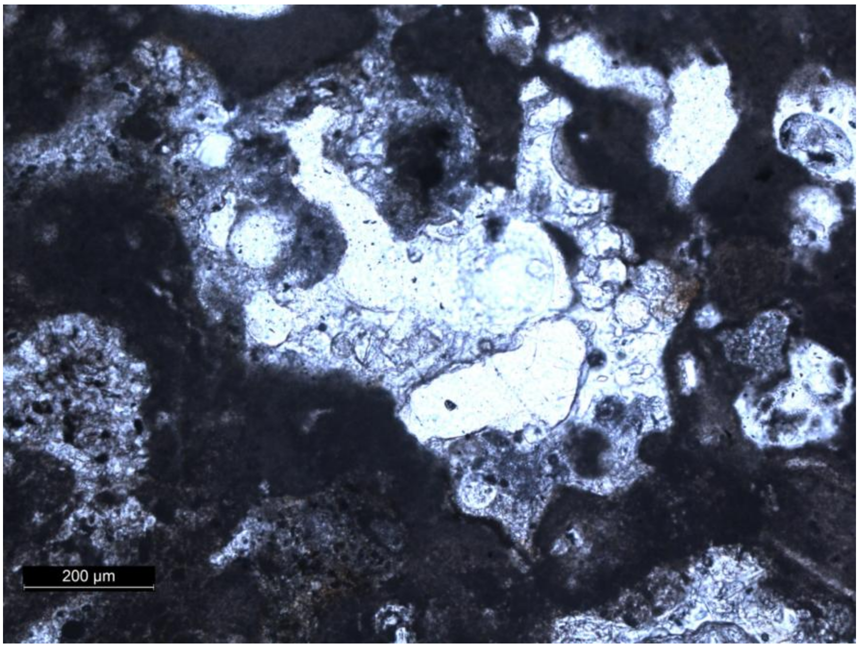

Figure 23 (above) – Thin section TWO.03 displays a high concentration of calc-silicate reaction products. Scale 200µm; PPL; photomicrograph Mark Thacker.

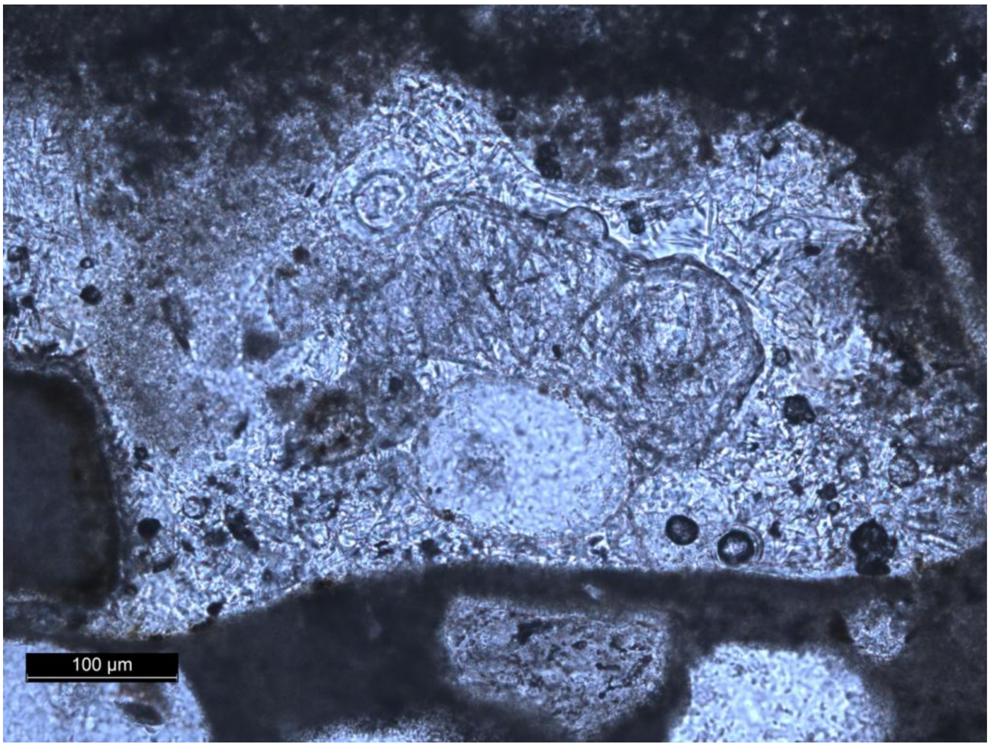

Figure 24 (above) – Thin section TWO.03. Reaction product at greater magnification, displaying acicular crystal forms and some spinaflex textures. Scale 100µm; PPL. Photomicrograph: M. Thacker.

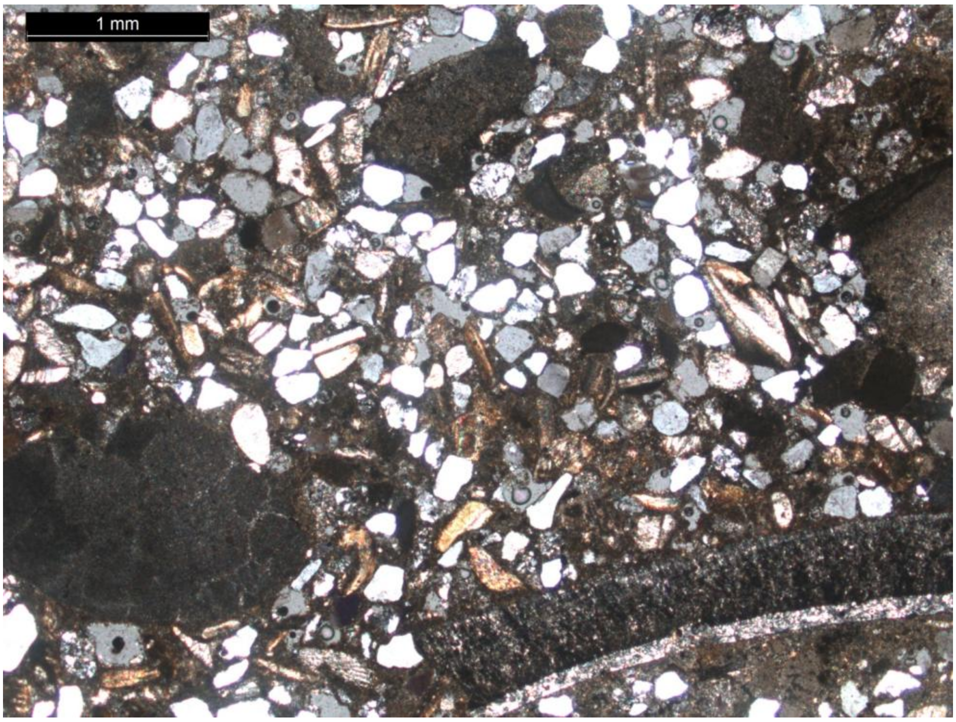

Figure 25 (above) – General view of section TWO.04A. XPL. Photomicrograph: M. Thacker.

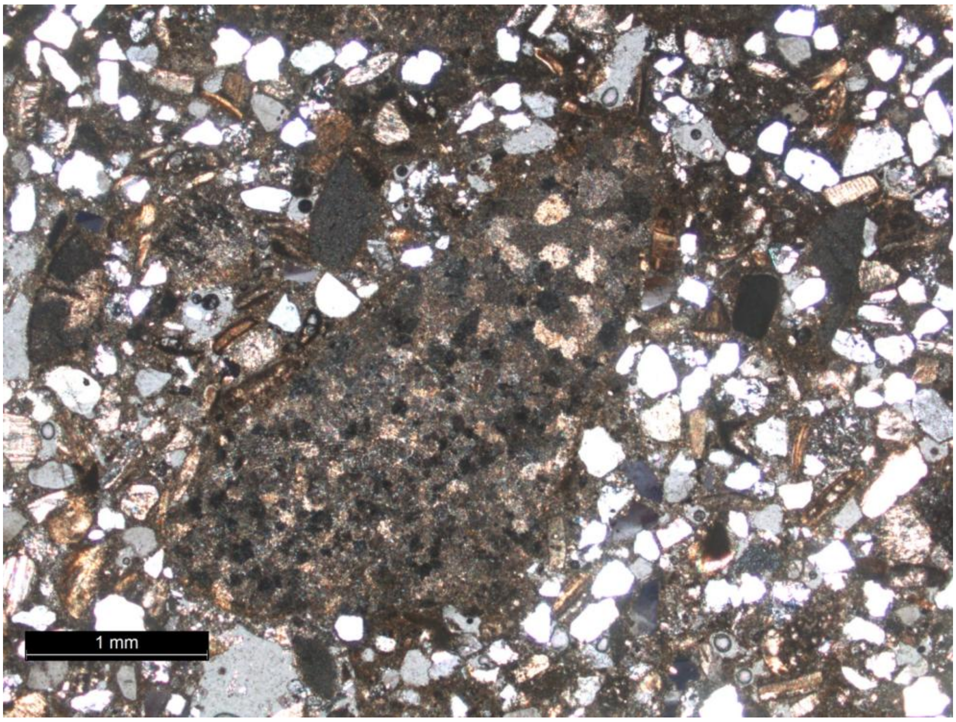

Figure 26 (above) – Algal inclusion from sectionTWO.04A. displaying high-birefringent crystal mosaic. Scale 1mm; XPL; photomicrograph Mark Thacker.

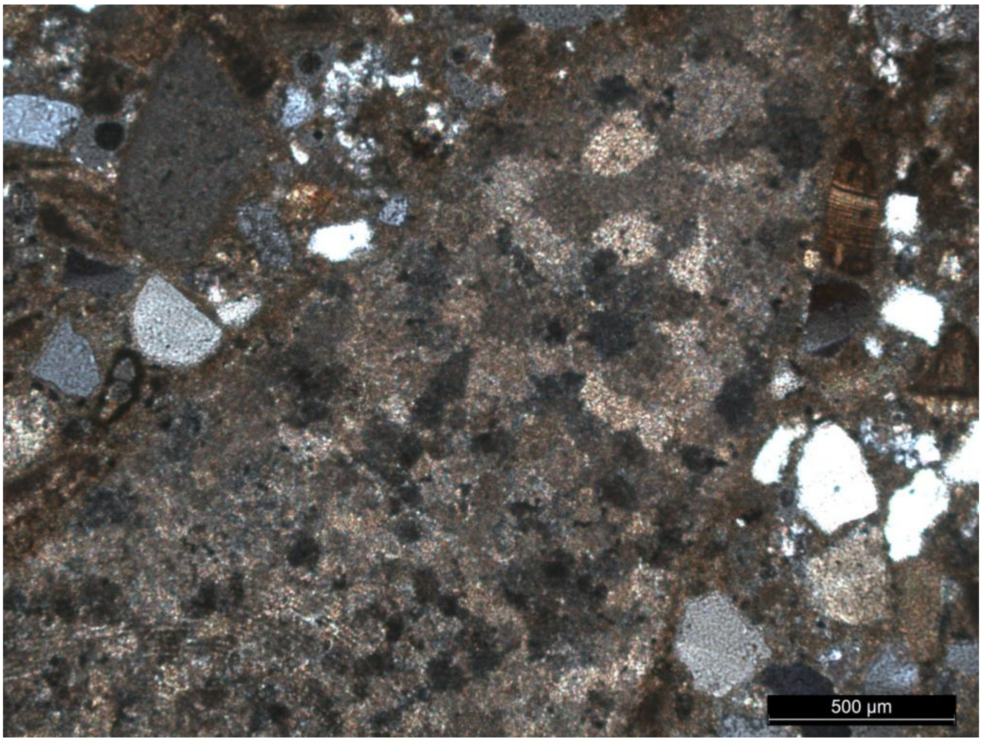

Figure 27 (above) – Thin section TWO.04a Algal inclusion previous figure at greater magnification; note relict concentric 'grain'. Scale 500µm; XPL; photomicrograph Mark Thacker.

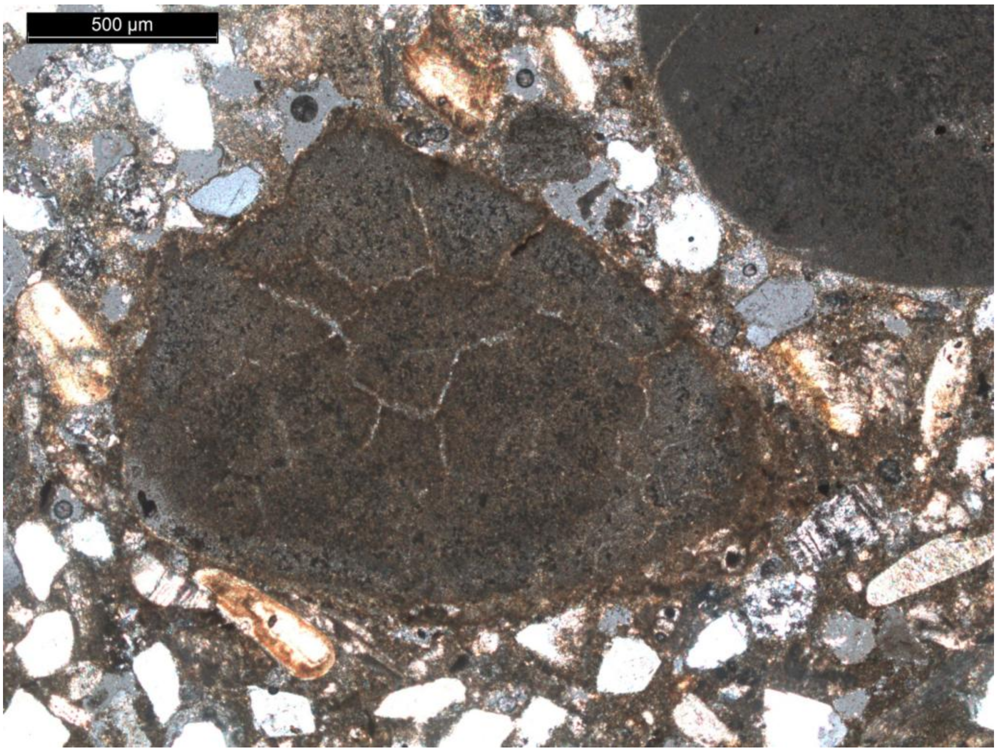

Figure 28 (above). Thin section TWO.04a. This section is quite porous but includes crazed and discoloured algae inclusions with some core/rim textural contrast, loss of grain boundary and optical continuity with mortar matrix. Scale 500 µm; Photomicrograph: M. Thacker.

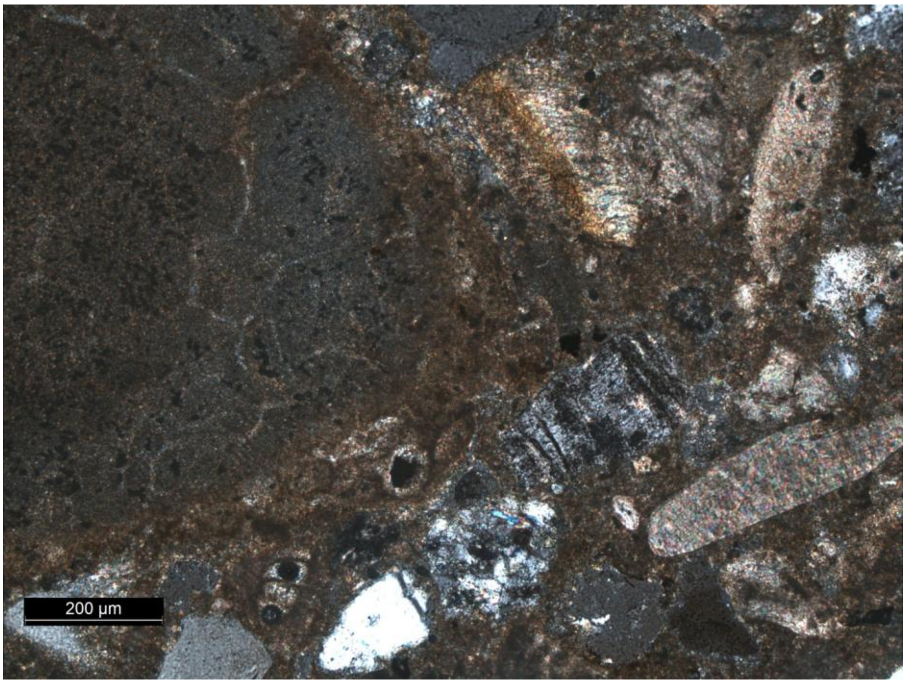

Figure 29 (above) – Thin section TWO.04a. Detail from previous figure at higher magnification to show relict shape and textural variation of maerl inclusion. Note distinct preservation of shell temper in contrast. Scale 200µm; XPL; photomicrograph Mark Thacker.

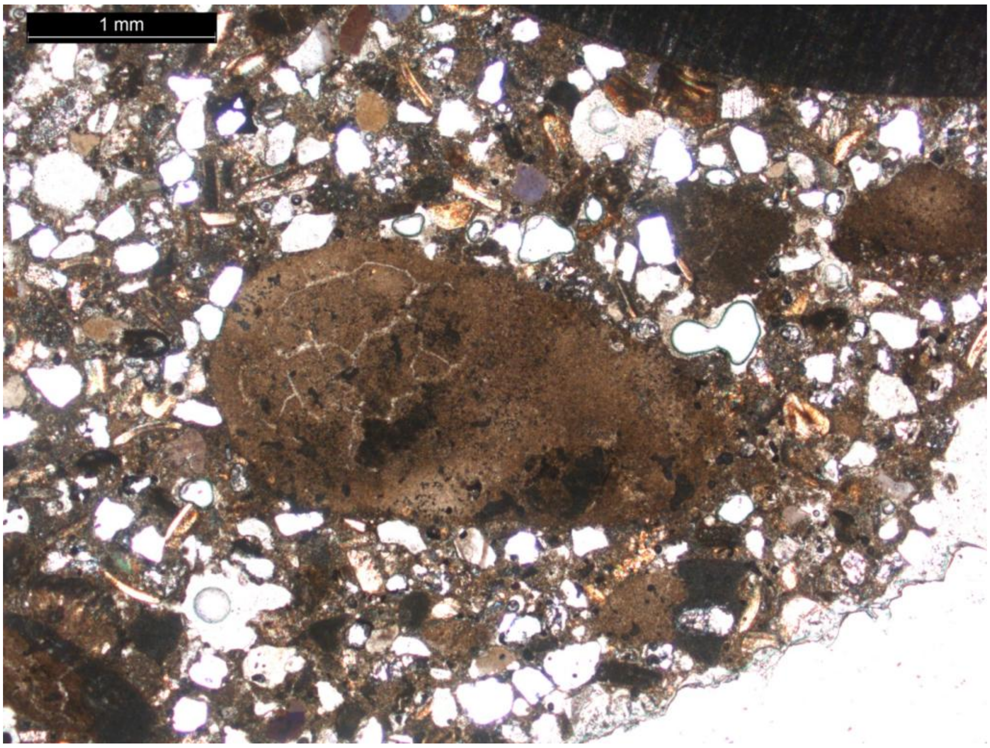

Figure 30 (above) – Thin section TWO.04b including high concentration of altered maerl fragments. Scale 1mm; XPL. Photomicrograph Mark Thacker.

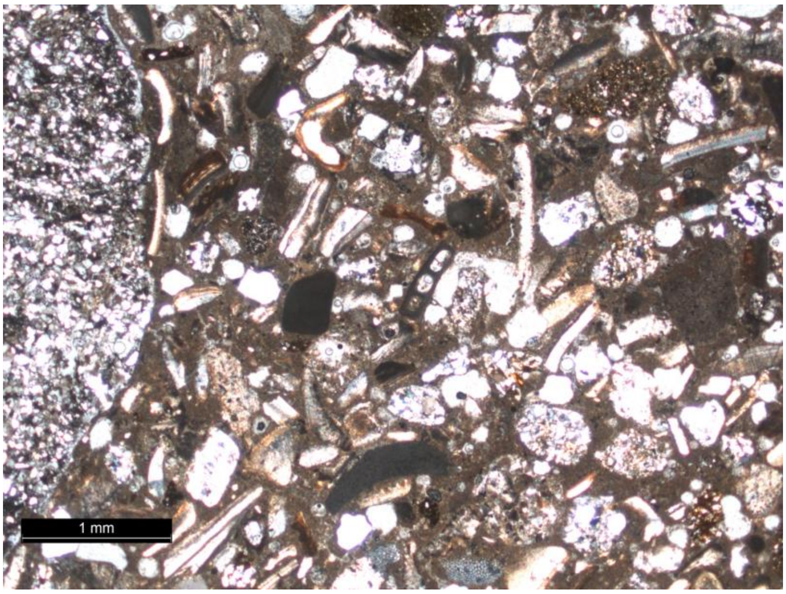

Figure 31 (above) – Thin section TWO.06a. Scale 1mm; XPL; photomicrograph Mark Thacker.

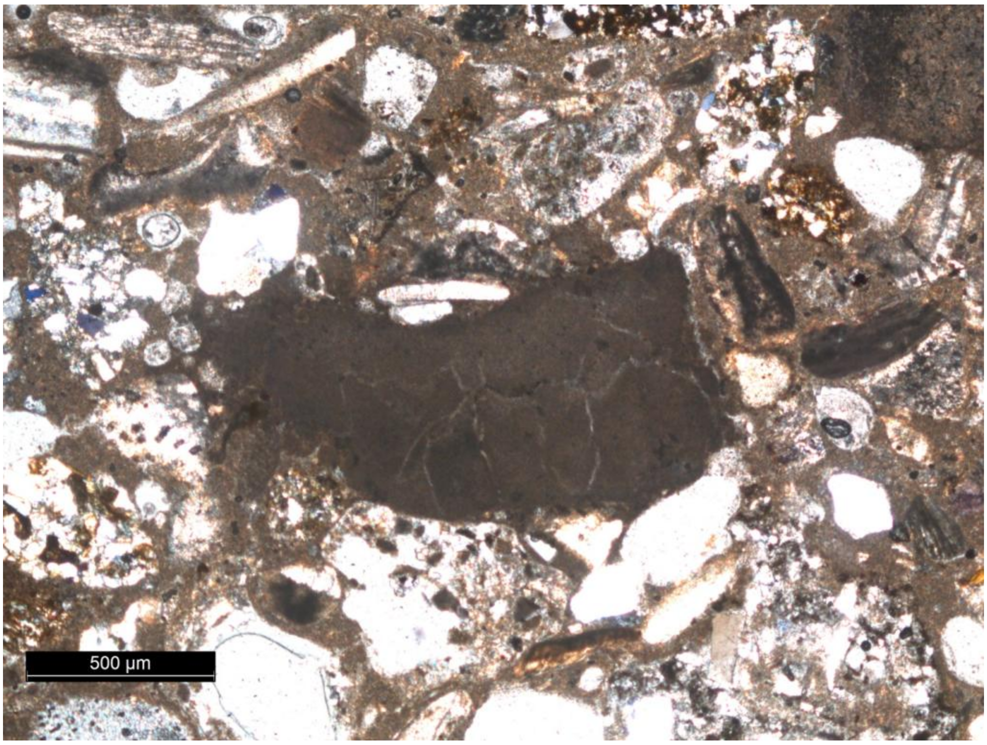

Figure 32 (above) – Thin section TWO.06a.Longitudinal section of coralline algae fragment, displaying crazing and altered textures. Scale 500µm; XPL. Photomicrograph: M. Thacker.

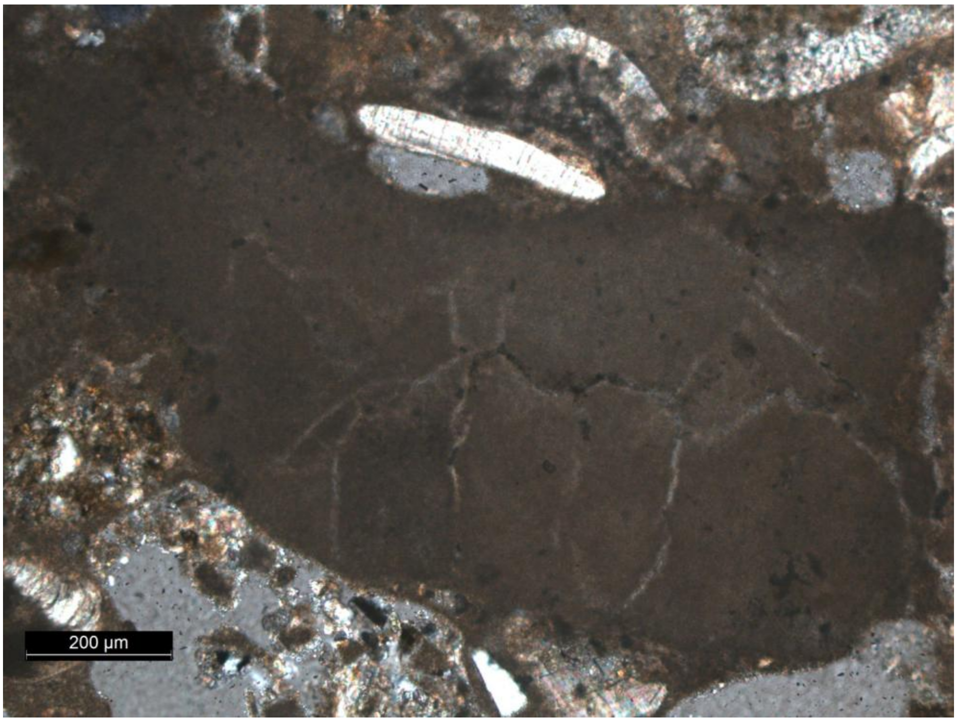

Figure 33 (above) – Thin section TWO.06a. Coralline inclusion from previous figure at greater magnification; Scale 200µm; XPL; Photomicrograph: M.Thacker.

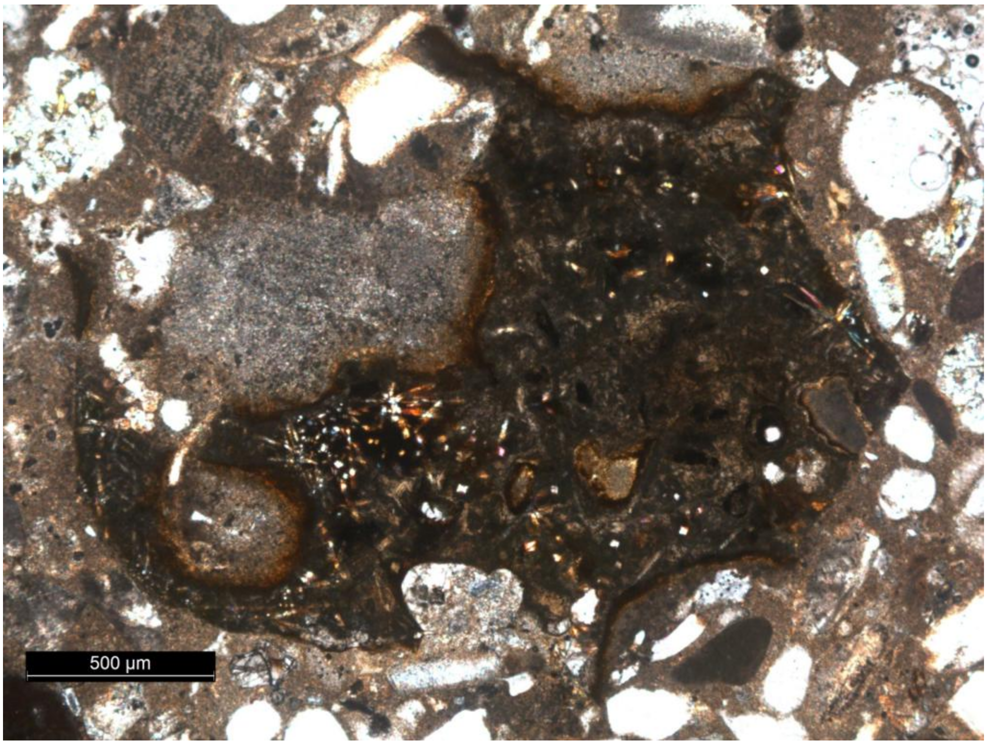

Figure 34 9above) – Thin section TWO.06a. Vitreous material with spinaflex textures. Scale 500µm; XPL; photomicrograph Mark Thacker.

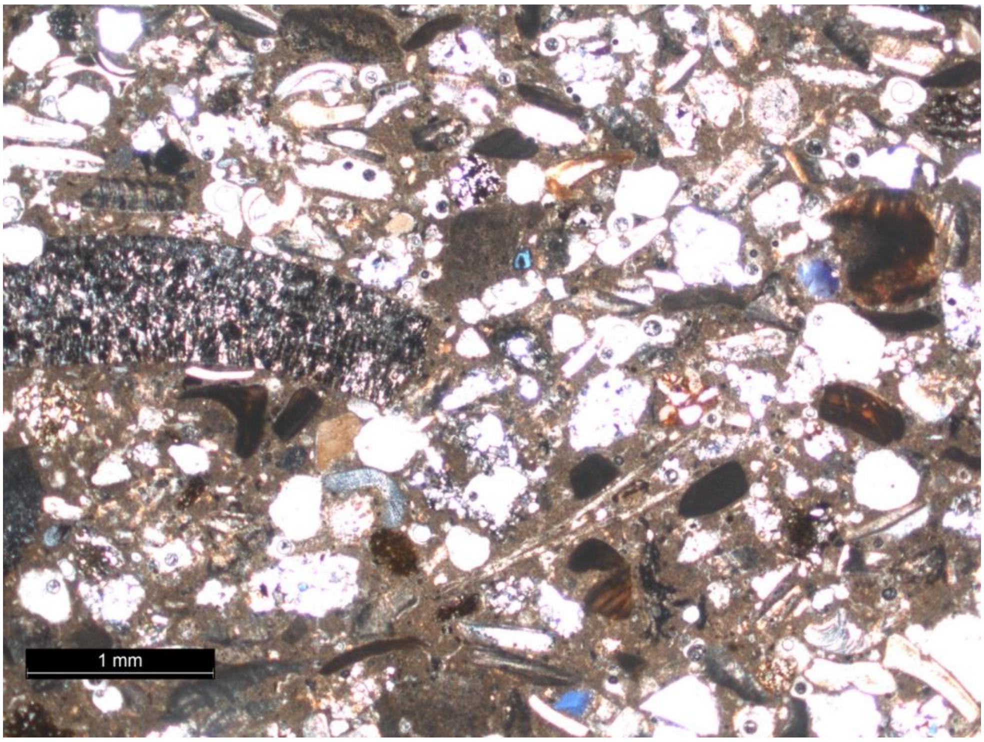

Figure 35 (above) – Thin section TWO.06b. General view of tempered mortar section Scale 1mm; XPL; photomicrograph Mark Thacker.

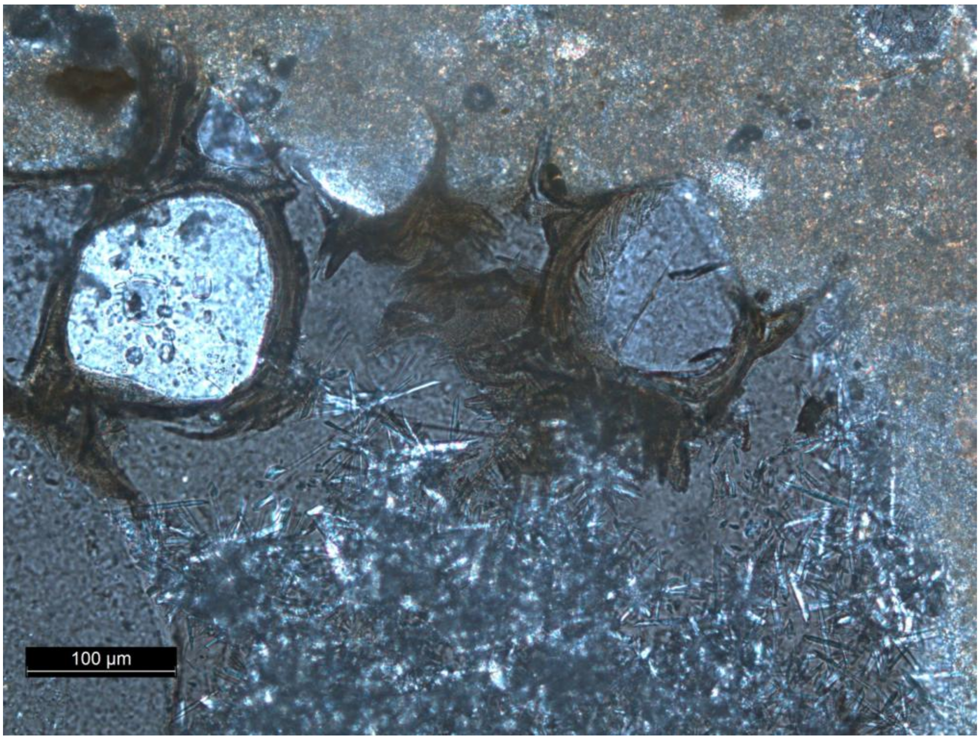

Figure 36 (above) – Thin section TWO.06b. High magnification detail of vitreous Scale 100μm; XPL. Photomicrograph: M. Thacker.

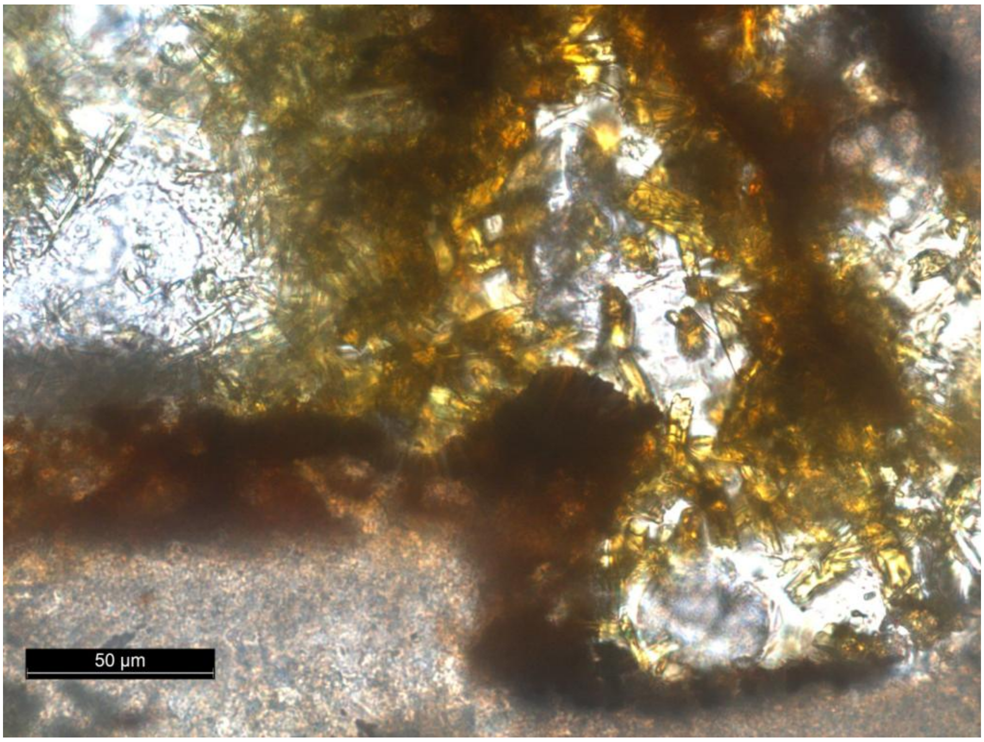

Figure 37 (above) – Thin section TWO.06b. Well developed crystal growth. Scale 50μm; PPL; photomicrograph Mark Thacker.

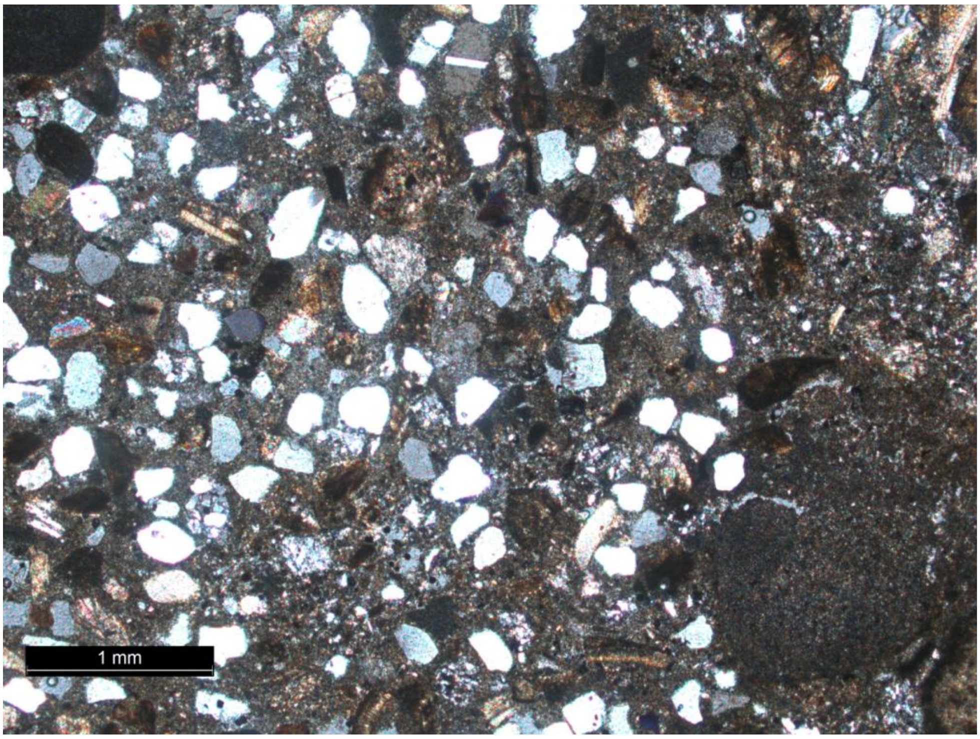

Figure 38 (above) – Thin section TWO.07. General view of well-tempered material and a rounded (coralline?) biogenic carbonate relict. Scale 1mm; XPL. Photomicrograph: M. Thacker.

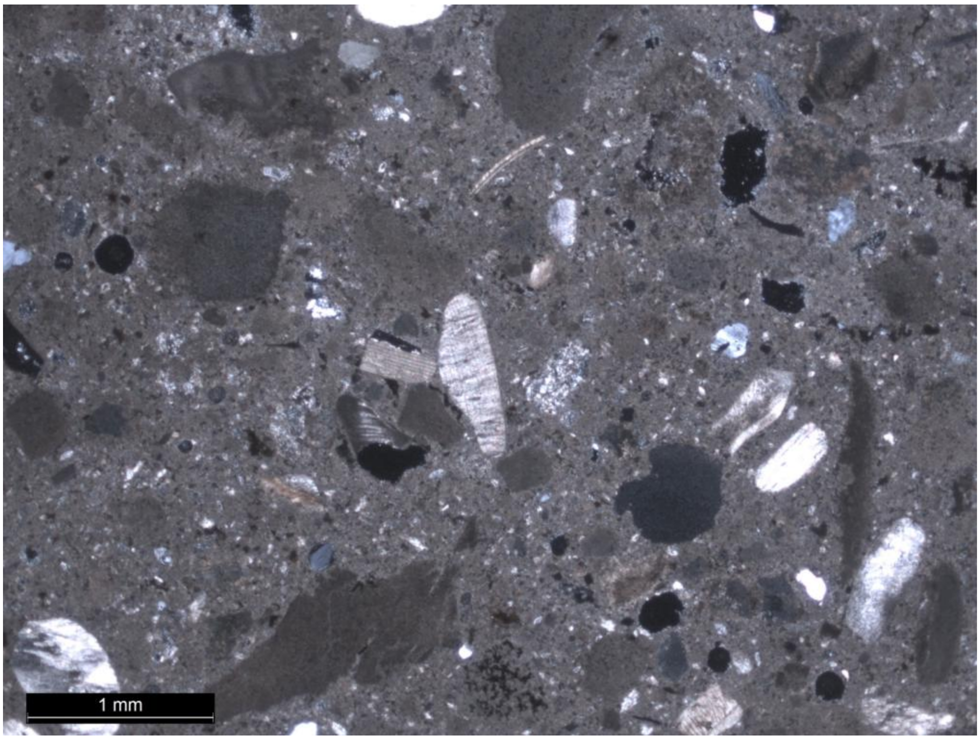

Figure 39 (above) – Thin section TWO.08. Note very high matrix: temper ratio and biogenic carbonate relicts; 2.5X; XPL; photomicrograph Mark Thacker.

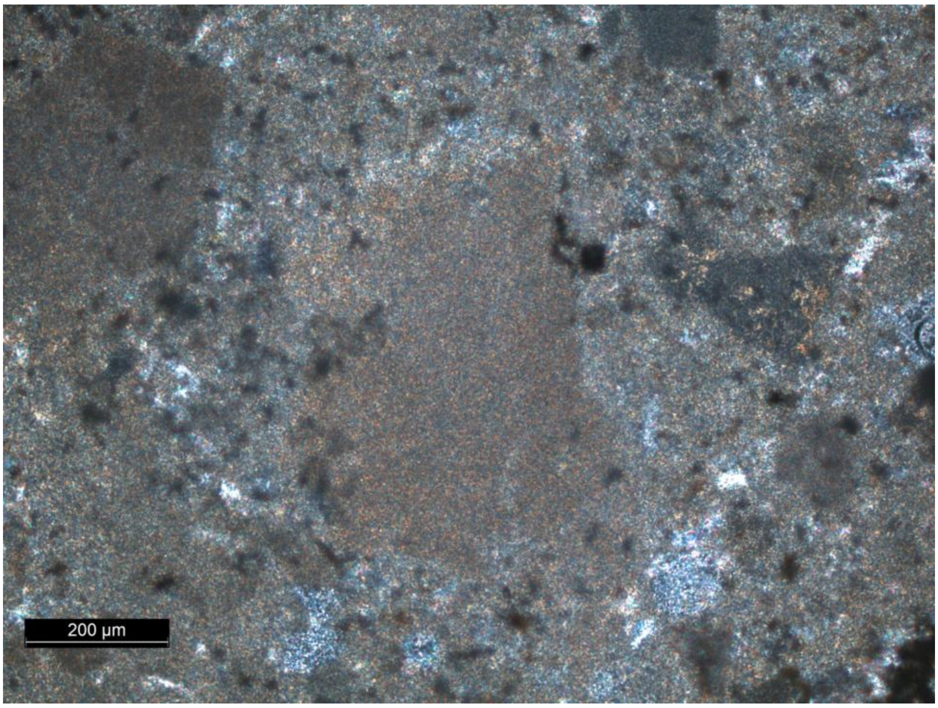

Figure 40 (above) – Section TWO.08 displays a high concentration of heated biogenic relicts at around 200µm. Scale 200µm; XPL. Photomicrograph Mark Thacker.

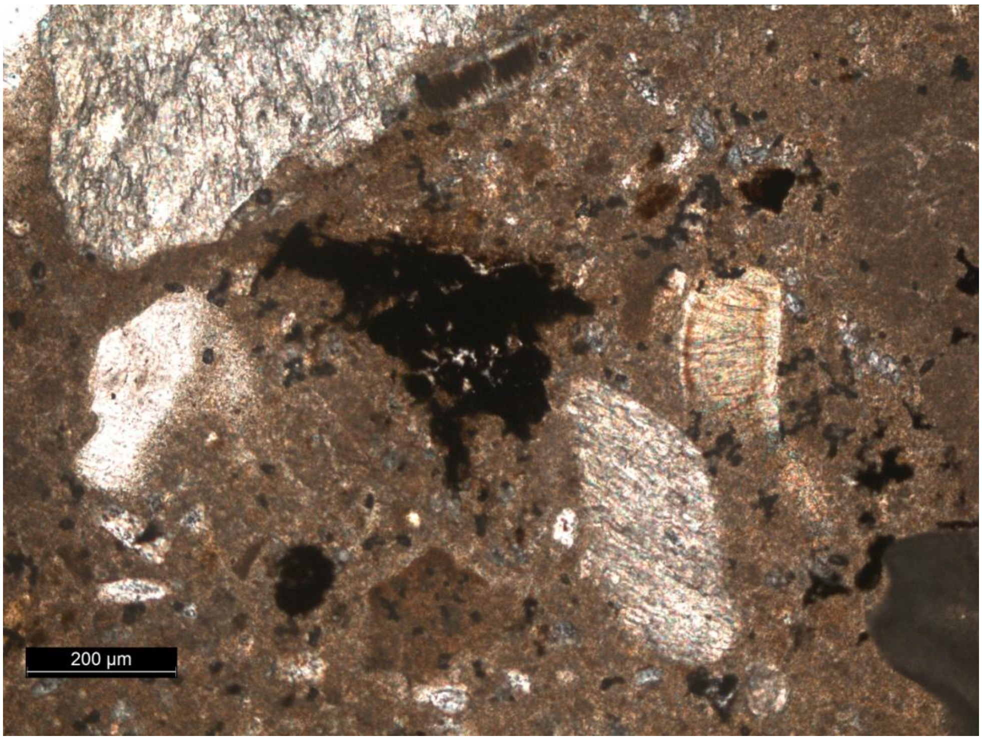

Figure 41 (above) – Thin section TWO.08 including probable relict fuel inclusion. Scale 200µm; XPL. photomicrograph Mark Thacker.

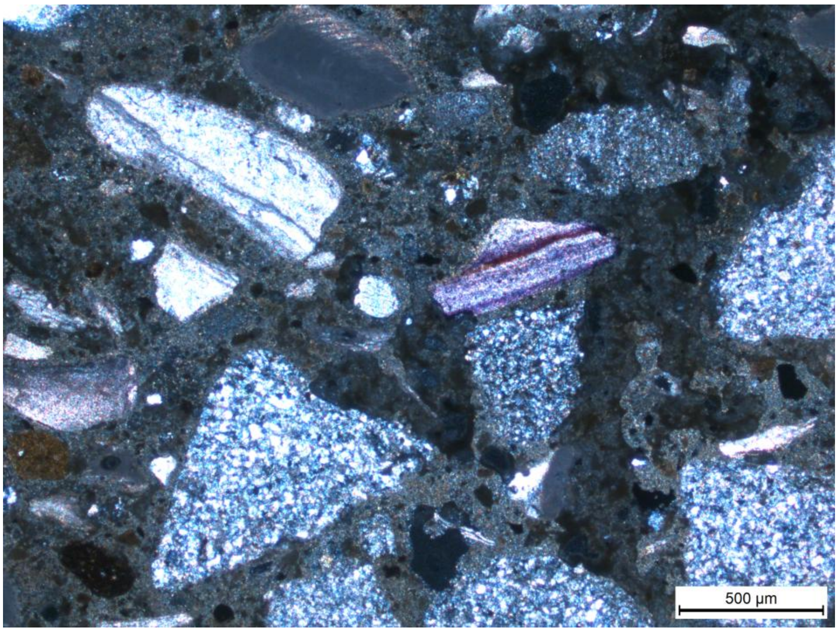

Figure 42 (above) TWO.09 General shot of mortared tempered with sandstone and shell sand. XPL; Scale 500µm; photomicrograph M. Thacker.

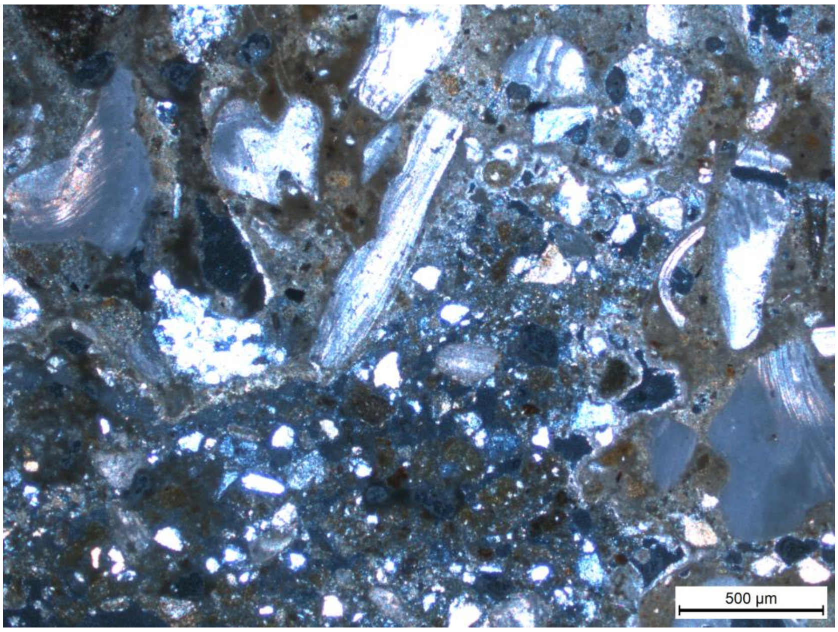

Figure 43 (above) TWO.09 Probable calcined quartz-rich mudstone tempered with shell sand. XPL; Scale 500µm; photomicrograph M. Thacker.

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5.2 ACKNOWLEDGEMENTS

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APPENDIX 11 - CASE STUDY

ST PETER'S CHURCH, THURSO

Mark Thacker, University of Edinburgh.

Constructing Lordship in North Atlantic Europe. Vol. III.

Appendix case study 11.

Last revision 20-07-2016

DRAFT COPY FOR PHD EXAMINATION SUBMISSION.

SUMMARY

A survey of the upstanding building of St Peter's, was undertaken in parallel with a comprehensive lab-based mortar sample analysis programme of a number of loose but representative mortar samples. *In-situ,* examination suggested that various contrasting phase-specific materials have been used at the site, including both shell-lime and limestone-lime mortars, and these interpretations were subsequently supported by microscopic analysis.

The characterisation of a consistent suite of extraordinary masonry techniques in the primary phase fabric of the building enabled the recognition of a number of previously unidentified primary architectural details and supports recent architectural survey which had suggested the chancel and tower were contemporary (Slade and Watson 1989). The recognition of shell-lime mortar in various secondary contexts, however, questions their ascription to the post-medieval period although no very refined archaeological dating evidence is presented here. Further work is suggested.

CONTENTS

1.0 ST PETER'S THURSO - MORTAR, MASONRY & ENVIRONMENT SURVEY

1.1 ENVIRONMENT SURVEY

St Peters old parish church is located at ND 1204 6861 on the west bank at the mouth of the Thurso River in Caithness.

1.1.6 UNDERLAYING GEOLOGY

The geology of Thurso consists of the same Old Red Sandstone sequence which dominates the east coast from Orkney to Loch Ness and Ross-shire (Johnstone and Mykura 1989, 118). Within this largely sedimentary sequence the geology of Caithness is generally composed of grey and fissile sandstones, siltstones and shales in rhythmic cycles reflecting depositional fluctuations (ibid). That these 'flagstones' are all calcareous or dolomitic to various extents is important, but purer limestones do also outcrop within the wider Thurso locality, most famously upriver from Thurso at Achanarras, but also within thinly bedded outcrops to the west near Raey and Crosskirk (Henderson 1812). Both of these localities are reported to have been worked for lime production in the 18th and 19th-centuries (Cameron 1791-9, 18-19; see below).

1.1.2 SHORE SURVEY

At present, the west bank of the Thurso River is completely canalised and so aggregate survey is restricted locally to the opposite east bank and the seashore of Thurso Bay itself. The east bank of the river mouth is of shallow gradient and contains variously well-sorted sand, gravel and stones of lithic and shell material. It is not possible to suggest how far these materials may have been available on the west bank before the development of the harbour. Thurso Bay itself is a large and very shallow gradient stretch of shore, which is dominated by a very homogenous, brown, sub-mm quartz-rich sand.

1.1.3 QUARRY SURVEY

At the west end of Thurso Bay (Clio Geos ND1146 6865), the flat sandy beach meets low cliffs which are a likely quarry source for much of the rubble building stone at St Peter's. The flagstone here is dipping in very straight beds 15-20° to the north or north-west, and two lithostratigraphies are displayed: The lower beds are blue hard crystalline sandstone of 200-250mm thick, cross cut from east to west by parallel and vertical quartz-filled joints from 100 to 300mm apart (250mm is general). This material appears to have been quarried in the past as it now forms low terraces, just above the sandy beach surface, up to 14m from the cliff face. No quarry tool-marks were noted but sharp arrises were common and a single small piece was removed as a sample for thin-sectioning. Above this blue stone the cliff presents beds of a more typically Caithnessian, softer and darker-coloured brown sandstone in much thinner beds (up to 100mm), and although cross-joints are also apparent in this material they are no longer quartz-filled.

This putative quarry site may have been exhausted at an early date, but appears to conform to those reported elsewhere in the parish, at Scrabster and Pennyland where there was ‘a good free-stone quarry below flood mark, but accessible and easily wrought at low tide’ (Sinclair 1791-99, 539). Similarity with the limestone quarried at Duntulm Castle is also notable (see appendix 8).

1.1.4 WOODLAND

Excepting recent plantation, north Caithness presents an essentially a treeless landscape, and historical accounts attest that the parish of Thurso has been treeless since at least the late 18th-century when the main import into the town was ‘fir-spars and deals from Norway (Sinclair 1791-99, 542, 513). Although MacVean and Ratcliffe (1962) suggest Caithness would have been extensively wooded with birch before clearance, this is not supported by the palynological evidence. An important study at Loch of Winless (ND 293 545, 13.5 miles south-west of Thurso) suggested this was ‘the least wooded area of mainland Britain during the Holocene [and that] pine and oak were absent [although birch, willow and hazel scrub probably occurred in some locally in sheltered areas’ (Birks 1993).

In the late modern period peat was reported as the main fuel of the parish, and this was found ‘in abundance’, although coal became increasingly used in the town in the late 18th and early 19th-centuries (Taylor 1840, 12; Sinclair 1791-99, 528).

1.1.5 LIMEKILNS

Given its urban context there are no limekiln remains very close to St Peters, although a number have been surveyed within the wider locality. These included the substantial remains of three tall (>3m) circular kilns at Balligill, near the Raey limestone outcrops noted above and which may be associated with the agricultural liming of local fields, and the eroding limekiln at Ham harbour which displays the significant remains of a number of charges in cross-section. This last kiln is important to this wider study in its display of a mixed fuel/carbonate charge and the kiln does appear to have been used for the manufacture of building lime as well as agricultural lime within the adjacent 18th-19th-century Improvement landscape. Although these late structures are not directly relevant to the investigation of St Peters, it is worth noting that both are dominated (but not exclusively) by limestone-limes, and the Ham structure appears to display evidence for a mixture of peat and coal fuel. The use of peat to burn limestone in 18th-century lime-making was indeed reported in the Halkirk Statistical Account (Cameron 1791-99, 18-19).

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1.2 BUILDING SURVEY

25/11/2011; 01/05/12 and 28/10-03/11/2014.

1.2.1 PRIMARY LOWER CHANCEL

The lower chancel is an enclosed apse; rectangular externally with an internally apsidal east end and vaulted ceiling.

The stonework of the primary phase is of very consistent and distinctive character. This can be seen most clearly in the external masonry, where blocky square or rectangular hammer-dressed, hard crystalline blue quartz-rich sandstone face stones are flat-laid and usually naturally bedded with very even joint widths. The quoining is generally alternate, strictly so in the north-east corner although in some contexts the natural jointing in the stone has been used to form a 'mitred quoin' from a pair of stones angled at 45° or less abutting at the corner. The north wall of the lower chancel contains a primary window of the same sandstone rubble and, although now blocked, this appears to be the only surviving example. Internally, various primary window fragments also survive, including the sill and lower quoins of the east window and the eastern quoins and voussiours of the north. Combining these various fragments has allowed a conjectural reconstruction of the full form of these externally lintel-headed and internally arched windows to be drafted (see figures below). It is noteworthy that, in contrast to all later phases in this building, this primary masonry does not display any chisel marks or any very fine dressed sandstone.

Internally, the vault springs from a scarcement within the chancel at approximately 1.2-1.3m above the present ground level, this feature narrows from 30mm wide in west, and disappears toward the eastern apse. The vault stones are also hammer-dressed consistently square off the bed but, rather than being laid radially, each course has been set at a low angle which corbels out from the course beneath, from 40-50mm in the west to a remarkable 200mm in the apse above the east window. This gives a marked stepped face to the vault intrados which is particularly prominent where it has been cut-back to let-in secondary masonry fabric. The excellent lateral bonding suggests the whole vault was laid course by course all the way round, and the crown gradually loses height as it proceeds eastward (where there is no spring scarcement) to a segmental apsidal 'dome'.

The chancel arch is narrower than the chancel and springs from a higher level. A similar, if much less extreme emplacement technique is evident in the chancel arch, as the stones forming the haunches are non-radial and corbelling, whilst the crown is completed by radial stones and a triangular keystone**.** More effort has been made than in the vault to dress the intrados faces of the chancel arch stones to an angle, although a distinct stepped profile is still evident, and this evidence may suggest keystones were employed at the apex of the vault also.

A number of different mortars are associated with this lower chancel masonry but the primary mortar materials are just as distinctive as the stonework. In this part of the building, visible deep core contexts are often most visible adjacent to where later masonry has been slapped-in, and then failed, leaving sections of primary face and core exposed. Examples here include: continuous and contiguous primary core and bedding mortar to 300mm from the external face of the east wall, north of the secondary east window; continuous core and bedding mortar above the memorial in the internal face of the north wall; and large areas of bedding mortar within the chancel arch. This material has been labelled Mortar 1 and will be described below:

General Description - Mortar 1 is buff-coloured, predominantly fine-textured and very hard lime mortar.

Carbonate kiln-relicts – Mortar 1 is a limestone-lime and contains a medium to high concentration of fine white angular probable limestone inclusions generally to 2-3mm, and occasionally to 5mm. Some much larger, darker buff and mottled subangular inclusions to 30mm with some indistinct grain/matrix boundaries and fine intragrain angular white and orange inclusions of around 2mm were also noted (see figures). No heated shell relicts are evident.

Added-temper – Mortar 1 was tempered with a predominantly sub-mm material, but larger lithics, including brown-coloured fine sandstones to 10-20mm, are in low concentration. No shell fraction is visible with the unaided eye.

Fuel kiln-relicts – Mortar 1 contains locally high concentrations of subangular black inclusions which are probably fuel relicts, although some similar clasts may be lithic and so further microscopic assessment is required.

Vitreous kiln-relicts – Mortar 1 contains a low concentration of large subangular bright orange inclusions to 30mm which may be reaction products.

The primary masonry of the lower chancel of St Peter’s has been coated with various lime mortars but, unusually, the evidence suggests that the primary coatings were of different specification to the general constructional lime mortar. A mortar coating material, which only overlays bare stone and Mortar 1 filled masonry joints survives very well in a number of internal and external lower chancel contexts, including within the reveals of the north chancel window externally, on the external face of the east wall just above ground level, and on the faces of the intrados of both the vault and chancel arch internally. This material will now be referred to as Coating 1.

Coating 1 is very hard, with a brown-buff colouration, and appears to be composed entirely of sub-mm materials with only very rare lithic lenses to 10mm, and no fuel or carbonate relicts were visible to the unaided eye. This mortar has been applied in a single coat which both internally and externally can be up to 40mm thick as it fills large ‘inconsistencies’ in the general underlying wall face or the large voids between the corbelled steps of the chancel vault and arch. Although within the primary north window there is some 'fareing-out', in general there is no evidence for any wall face or joint preparation at all – neither fareing-out or long coating mortar tails to suggest the masonry beds have been raked out. The coating has had a highly polished surface and, although no tool marks survive to betray the application process, this is a render rather than cast harl.

1.2.2 SECONDARY LOWER CHANCEL

The lower chancel contains a window in the east wall, a doorway in the south wall and a memorial in the internal face of the north wall all of which have been crudely inserted into the apsidal vault in a secondary phase of work. Each of these features is composed of fine dressed sandstone which has not been dressed to the shape of the primary vault, and so large voids have been created at their abutments with the surrounding primary masonry which have been filled with mortared rubble in various phases.

Both the east window and south doorway have been subsequently blocked and this has precluded examination in cross-section. Externally, the secondary east window is lintel-headed with simply splay-moulded jambs which have been laid with no particular bonding pattern and include one large edge-bedded stone. Internally, this east window is arch-headed with no mouldings. The secondary south doorway is also lintel-headed externally, but this is supported on roll-moulded jambs which have been laid in a formally alternate bonding pattern. Internally, the south doorway jambs are also un-moulded, but any ope head has been replaced with timber lintels. Although these features appear equally clumsy slap-ins internally, externally they are bonded with different mortars and appear to be of different sandstone types. The east window contains convincing evidence for a bright white shell-rich constructional mortar, whilst the south doorway displays a more lithic buff-brown material.

Internally, Coating 1 is directly overlaid by a more coarsely-textured and lime-rich bright white coating mortar which, although now more fragmentary, once fully coated all the walls and vault of the lower chancel in a later phase. As the only coating material to apparently directly overlay only Coating 1, this material was labelled Coating 2.

Coating 2 contains a high concentration of fine shell material, including some with possible heat alteration textures and discolouration which suggests it may be a shell-lime mortar which has been applied in two layers. On the north wall Coating 2 clearly display the distinctive uniform tool marks of a wide toothed plasterer's comb, which has been dragged horizontally, and/or slightly obliquely up to the east, leaving furrows 5mm wide by 2mm deep, with 2mm between each furrow. On the opposite south wall, similar tool marks are evident within a compositionally very similar mortar, although here the comb marks have an apparently random directionality. In the east end, overlaying the secondary east window, two layers of this same material survive and the underlying furrowed scratch coat is overlaid by a surviving finer, more lime-rich and crisp finishing coat 2-8mm thick.

In the west, the furrowed Coating 2 displays the remains of a recently discovered wall painting on both the north and west walls in the north-east corner, and it is reasonable to assume that this pigment has penetrated through a finer surface finishing coat which here has been subsequently lost. Although any direct stratigraphic relationship between these two secondary coatings (at the east window and in the west) is no longer visible due to later cuts, overlaying mortars and/or mortar survival, that these are of the same phase is suggested by their apparent compositional similarity, by their similar (directly overlaying) stratigraphic relationship to primary Coating and Mortar 1, and by the evidence for a double-layered coating technique as described above.

This lime-rich bright-white material also has some similarity with the constructional shell-rich mortar filling the joints of the secondary east window internally and visible in the external masonry in contiguous bedding and core contexts to 300mm deep. Further material comparison of this constructional mortar with the coating requires lab-based materials analysis, but as a very white lime-rich material which (like coating 1 in the west) clearly contrasts with and directly abuts the Mortar 1 (here within the surrounding primary core of the east wall) this distinctive material is labelled Mortar 2 and is described *in-situ* below:

General Description – Mortar 2 is a bright white, medium-textured lime-rich mortar.

Carbonate kiln-relicts – Mortar 2 is tentatively identified as a shell-lime in-situ. The material contains generally fine discoloured and altered shell evidence which is likely to be evidence of heating, and the very white colour of the matrix is also suggestive, but for possible confirmation of this provenance characterisation microscopic analysis will be required.

Added-temper – Mortar 2 was tempered with a reasonably sorted mixture of lithic and unheated shell materials, including dark subrounded lithic lenses to 25mm.

Fuel kiln-relics – No fuel evidence was noted in Mortar 2.

Vitreous kiln evidence – No vitreous evidence was noted in Mortar 2.

In-situ evaluation of the mortar within the internal beds of the south doorway was not possible due to heavy layers of later mortar materials, but that this feature also underlay Coating 2 is significant and this issue will be revisited below.

1.2.3 TERTIARY LOWER CHANCEL

There is conspicuous evidence for further phases within the lower chancel including a fine light-brown coloured internal mortar coating which appears to have been tempered with a very similar fine light-brown sand to the primary mortar. This coating, however, is very brittle, contains a high concentration of trowel marks, has been applied in a very fluid consistency, and appears to contain a high concentration of fine white-coloured lime lumps. The two mortars are clearly distinct.

Externally, that the higher courses of the chancel have been rebuilt is evident in a contrasting masonry style which includes some use of late modern brick and a very white mortar with a high concentration of lime lumps and fuel inclusions.

1.2.4 THE LOWER AND MIDDLE TOWER LEVELS

The tower, which is roughly square in plan, occupies a position in the south angle between the nave and chancel, but has been curiously constructed on a slightly different angle to the rest of the church building. This structure is currently entered at ground level through a low arch-headed doorway at the east end of the nave (to the south of the chancel arch), and at a higher level there is access between the tower and upper chancel. Another (secondary) west entrance, which allowed access from outside the church via a fore-stair, is now blocked.

Internally, the lower level of the tower contains a barrel-vaulted spiral stair and, un-obscured by any later consolidation phases, the mortar has eroded back significantly from the vault face to display primary constructional mortar in very deep bed and some core contexts. Although the stones forming the face of this small curving vault appear to have been laid more radially than in the lower chancel, it is clear that the primary masonry of this structure is of very similar character to the primary masonry of the lower chancel. This is the same blocky hammer-dressed hard crystalline quartz-rich blue sandstone, and fine buff-coloured hard Mortar 1 is very visible within contiguous bedding and core rubble contexts to 200mm. The south jambs and well-worn sill of the mid-tower doorway which currently allow access to the lean-to roofed chamber above the chancel are also primary, and the hammer-dressed south-west jamb (which also displays a mitred quoin and fragments of Coating 1) corbels-out to form the stop-arch of the tower's stair vault in a similar way to the surviving masonry of the primary internal north window of the lower chancel. The lower section of this mid-tower doorway has been partially blocked in a later phase and, together with the debris inside, this has increased the apparent floor height of the room above the lower chancel markedly. The vault above the spiral stair of the lower tower ends at the west jamb of this doorway, supporting the stair which continues on without a vaulted ceiling for another storey. A ¾ turn of the stair survives at this mid-tower level, before being cut by later work close to the north-west corner.

Externally, the masonry of the lower level of the tower (including the buttresses) also clearly matches the primary masonry of the lower chancel, and the two are well bonded at the north-east corner. The lower tower is constructed of the same blocky hammer-dressed hard-crystalline blue sandstone and, although often obscured by a series of later mortars in shallow contexts, these are underlain by Mortar 1 which is occasionally visible within bedding contexts to 150mm+. Externally, the lower and mid-tower levels also contain a series of primary slit windows at different levels, all of which are now blocked.

1.2.5 THE UPPER TOWER

Internally, there is a clear change in the masonry of the tower above the level of the mid-tower stair which is coincident with a series of deep joist sockets in the faces of north and south walls. Although their relative levels have not yet been measured, externally this change of masonry is also evident and coincident with a wide scarcement intake. Above this intake, the tower is evidently composed of a number of phases, but the main structure is of consistent character and contrasts with that of the lower level in a number of aspects.

The general wall faces of the upper tower have been constructed with a mixture of stones, dominated by quarried dark-coloured flaggy sandstone but also including some rounded crystalline stones which were probably sourced from more superficial contexts. Externally, the walls are framed by lighter-coloured fine-textured and dressed sandstone quoins and the remains of three narrow opes, surviving in the south, east and west walls, have been hewn from the same fine-textured sandstone material. Internally these opes are much wider and without mouldings.

A change in constructional mortar from the Mortar 1 of the primary church masonry in the upper and mid-tower levels below is clear. The very distinctive constructional mortar of the upper tower level can be seen in full masonry beds and deep core within the joist sockets of the north and south walls, and this material will now be labelled Mortar 2a:

General Description - Mortar 2a is a very bright red coarse lime mortar.

Carbonate kiln-relicts – Mortar 2a is a shell-lime containing a very high concentration of probable heated curving shell fragments to 40mm.

Added-temper – Mortar 2a was tempered with a very fine, generally sub-mm, red-coloured silt/sand.

Fuel kiln-relicts – Mortar 2a contains some black amorphous probable fuel relicts to 8mm.

Vitreous kiln-relicts – No vitreous kiln-relicts were noted in Mortar 2a.

As above, the upper tower contains a number of further phases of masonry, including a large context of secondary masonry below the south ope, and a few course of capping at the wallhead. Analysis of this fabric must await access to the external masonry, but it seems likely these later phases have truncated the secondary masonry of the upper tower and that its former wallhead no longer survives.

1.2.5 THE NAVE

Internally, the lower courses of the nave walls clearly display the same primary blocky hammer-dressed crystalline sandstone masonry as the lower chancel and lower and mid-tower, and these are clearly also bound in the distinctively hard fine buff-coloured limestone-lime Mortar 1. This masonry is displayed in the lowest visible courses of all four internal wall faces and almost all of the east wall and gable. As no earlier or underlying masonry was noted, this would also appear to be the primary surviving upstanding fabric of the nave.

Characterisation of this masonry allowed a number of previously unrecognized architectural features to be identified in this part of the church, including:

1, the surviving sill and east jamb of a north nave window, close to the east wall, which displays Mortar 1 in beds and core to 190mm. The lower west jamb of this window also probably survives behind a C19th memorial as, although the primary mortar is obscured here by later pointing, phase 1 masonry does survive to the west of the blocking memorial. This primary masonry is abutted by the later east jamb of the entrance to the north aisle and is overbuilt by masonry containing corbels and an upper door. Although now blocked, it is evident that this window had splaying reveals, and the external dressings were replaced with finer sandstone dressings of similar proportions to the primary window. These display a simple external splay moulding similar to that of the east chancel window.

Internally, the lower courses of the rounded feature between this north nave window and the chancel arch displays masonry and mortar of very different character, and this important context has also evidently been altered in a later period.

2, Internally, the opposite south wall of the nave is only very lightly bonded to the tower wall, but all this stonework appears characteristically primary and betrays evidence of bonding and coating in Mortar 1. The lower courses of the south wall also display two very deep, well constructed splaying ‘putlog’ sockets which like the surrounding masonry are also Mortar 1 bound primary masonry. As in the north, this masonry is clearly abutted by the inserted masonry of the south aisle arch, both to the east and west.

3, Internally, the lower courses of the west, south-west and north-west walls (west of the nave doorways) are all Mortar 1 bound primary crystalline sandstone masonry. Importantly, this includes the surviving south jamb of the primary west window which, at 1.97m north of the internal face of the south-west wall, also contains the remains of a primary window into which a late memorial has been inserted.

Both the south-west and north-west doors, however, are later insertions. Internally, these doorways have been constructed with fine dressed sandstone which is not bonded with Mortar 1 and clearly abuts primary masonry on both sides. Further examination of these doorways may be significant for our understanding of the building.

The north-west doorway has been blocked with later masonry, but internally it remains evident that it had parallel reveals. This were framed by unmoulded jamb stones which are randomly dimensioned, laid without formal bonding pattern and in the west jamb one tall edge-laid stone is particularly salient. Internally, this doorway is lintel-headed but, in contrast to the jambs, this eroded stone is of local sandstone lithogy and so is quite probably a replacement. Externally, this doorway has been largely buried by rising ground levels, but the rounded head of a possible arch (or round-headed lintel) is visible. That this external doorway head is coeval with the internal masonry is suggested by their similar red-coloured shell-rich mortars which are visible in core and bed contexts on both sides of the wall. This distinctive mortar material has some similarity to Mortar 2a from the construction of the upper tower.

In contrast to this secondary north-west doorway, the secondary south-west doorway currently forms the main gated entrance into the church and so its fabric can be more closely examined in full cross-section. This is especially useful because although the jamb stones of both faces have been constructed with fine sandstone dressings, a complex of different mortared phases is in evidence which suggests these two are of different phases. Internally, this doorway is arch-headed, with un-moulded jambs, which have not been laid in a very formal pattern (particularly in the south), and which are bound with a shell-rich mortar. In contrast, the external doorway is lintel-headed with roll-moulded jambs consistently naturally-bedded jambs, laid in a quite formally alternate bonding pattern and in a very lithic-tempered (probable limestone-lime) mortar. When viewed in cross-section the different course heights of the two faces are immediately apparent and it is very clear that, although much more heavily eroded, the external doorway dressings are abutting the internal door dressings. The contrast in erosion and colour is very marked and these two phases appear to have been sourced from different geological contexts.

1.2.6 THE UPPER CHANCEL

A comprehensive examination of the upper levels of the chancel has not yet been possible, and requires some access and lighting equipment, but a number of simple observations and measurements has allowed some insight.

The upper levels of the west wall of the chancel are dominated by primary masonry and Mortar 1 was noted in deep bedding and core contexts in multiple places of its west face. Most particularly, this examination confirmed that the lower jambs of the blocked doorway, surviving in this wall face, are primary fabric and Mortar 1 bound. This interpretation has further significance as, at approximately 5.5m high, this feature is clearly much higher than both the crown of the vault (approx. 3.2m) and the sill of the doorway from the tower (approx. 3.5m) and suggests a floor level between the upper and lower chancel may have pertained in the primary building.

The east gable wall of the chancel is much lower than the west wall and coincident with the mid-tower and chancel levels only. This wall displays a consistent masonry style dominated by very flaggy dark-coloured sandstone bonded with a very fine, white limestone-lime mortar, and is clearly very late.

1.2.7 THE NORTH AISLE

The north aisle is challenging to characterise as the masonry has seen many alterations. Moreover, the primary constructional mortar of this structure is highly degraded and, perhaps as a result, the walls are often a mix of voids and multiple consolidation phases. The general wall faces are composed of dark-coloured thin-bedded flagstones laid with the use of multiple pinnings in rising and dipping rough courses. These are framed by fine dressed sandstone quoins and dressings, laid in a strictly alternate bonding pattern, and the latter display cyma mouldings in jambs and lintels.

The degradation of the constructional mortar of this structure is such that it is very challenging to characterise, but the evidence will be reported here as Mortar 3:

Carbonate kiln-relicts – Mortar 3 is a limestone with localised concentration of rounded to subrounded white limestone relicts generally grading to 8mm,

Added-temper – The degraded remains of Mortar 3 often contains a high concentration of fine unheated shell material, grading up to 2mm, and a low concentration of subrounded dark-coloured lithics to 4mm. A very high clay fraction is also often evident and lends a plastic consistency to the *in-situ* degraded material.

Fuel kiln-relicts – No fuel relicts were noted.

Vitreous kiln-relicts – No vitreous kiln-relicts were noted.

1.2.7 THE SOUTH AISLE

The south aisle extends like a transept from the east end of the nave through a very large fine-grained sandstone archway inserted into the nave south wall (see nave description above). The structure contains a large traceried window in its south gabled wall and a number of high sandstone windows and externally the masonry is largely consistent and single phase. This has been constructed of thinly- bedded dark-coloured flagstones, flat-laid and naturally-bedded in narrow rough courses, with occasional fine sandstone snecks and pinnings. This general masonry is framed by fine-grained dressed sandstone quoins and dressings of the same lithogy (which appears to contain occasional iron-rich inclusions) laid in a strictly alternate bonding pattern.

The general masonry of the external faces of the south and west walls of the south aisle is largely obscured by a red-coloured cementitious mortar pointing. Beneath this, however, can be glimpsed an earlier mortar which is much more visible in the jambs and tracery, and in the east wall survives in extensive unobscured slaister, bed and core contexts visible to 160mm+. A similar material dominates the masonry in all internal wall faces, including in coating contexts, and is clearly the constructional mortar of the south aisle. This material and is here labelled Mortar 4:

Carbonate kiln-relicts - Mortar 4 is a limestone-lime which displays a high concentration of white, angular probable limestone inclusions, generally to 3mm, but occasionally to 13mm.

Added-temper – Mortar 4 is tempered with a sorted mixture of lithic and shell materials. This is dominated by subangular to subrounded dark grey and brown lithics, generally grading up to 5mm, but also includes a low but distinct concentration of unheated shell fragments to 4mm.

Fuel kiln-relicts –Mortar 4 contains possible coal relicts to 10mm in very low concentration.

Vitreous kiln-relicts – No vitreous kiln-relicts were noted in Mortar 4.

2.0 ST PETER'S THURSO – SAMPLE CONTEXTS AND ANALYSIS

2.1 SAMPLE CONTEXTS

2.1.1 MORTAR SAMPLE CONTEXTS

SAMPLE	CONTEXT
PTC.01	Chancel; lower; internal; loose on floor; matches plaster 1.
PTC.02	Chancel; lower; internal; loose on floor; matches plaster 1.
PTC.03	Chancel; lower; external; loose in core N of and adjacent East window; matches mortar 1.
PTC.04	Chancel; lower; external; loose in core N of and adjacent East window; matches mortar 1.
PTC.05	Chancel; lower; internal; loose on floor; appears to match fluid plaster 3.
PTC.06	Chancel; mid; internal; East end; slaister with face matches that in chancel east gable.
PTC.07	Tower; Upper; North; internal; from west joist socket.
PTC.08	Tower; mid; Vault; 500 W. of E. termination; 100mm back; Core.
PTC.09	Nave; North internal; Door slap; 120 W of W. jamb; 1550 A.G.; 170+ back; Core. (adjacent to primary core).
PTC.10	Chancel; East ex.; 1260 S of N.; 100 A.G.; Coating with face.
PTC.11	North Aisle; loose in bed.
PTC.12	Chancel; E. int.; Coating with planar face; matches plaster 2. Fragile.
PTC.13	Tower; mid; W. wall; door slap.
PTC.14	Chancel; E. ex.; Mortar of secondary east window; 150+ back; See Figure 1 for this important context.
PTC.15	South Aisle; E. ex; 1060 N of S; 1600 A.G.; 30mm back.
PTC.16	Chancel; ex-situ loose on ground; Fluid late plaster.
PTC.17	Tower; Lower; Vault; loose.

2.1.2 ENVIRONMENTAL SAMPLE CONTEXTS

SAMPLE	MATERIAL	CONTEXT
PTC.18/Q	Sandstone	Bedrock; Thurso Bay; ND 1146 6865
PTC.19	Gravel	East bank Thurso River; mid shore; ND 12296 68829.
PTC.20	Sand	East bank Thurso River; high shore; ND 12289 68791.
PTC.21	Sand	Thurso Bay; Thurso Bay; ND 11561 68658

2.1.3 ANOTATED PLANS OF MORTAR SAMPLE CONTEXTS

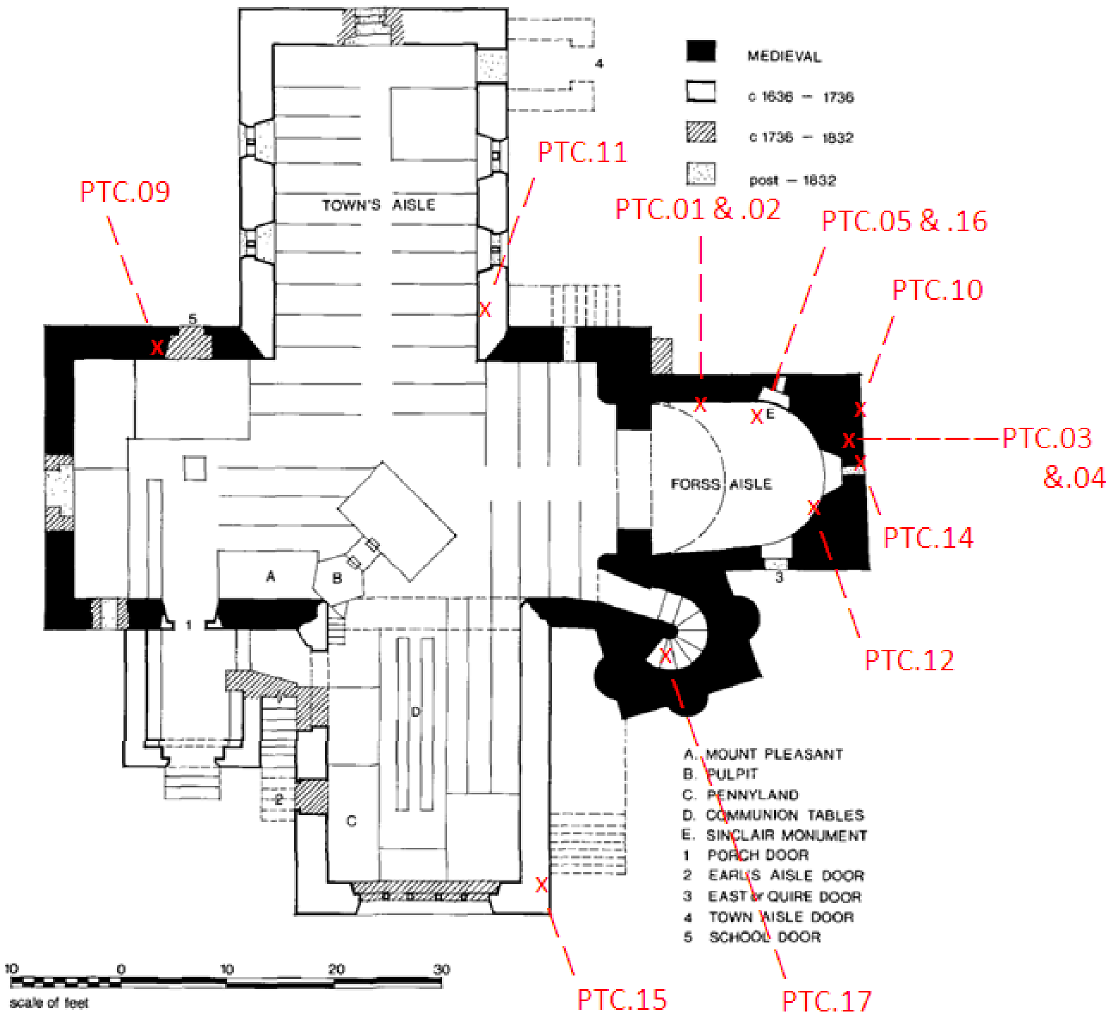


Figure 1a (above) – Phased plan of St Peters Thurso at ground level by Slade and Watson (1989), annotated to show loose mortar sample locations. (I am grateful to George Watson and to the Society of Antiquaries of Scotland for permission to reproduce this image).

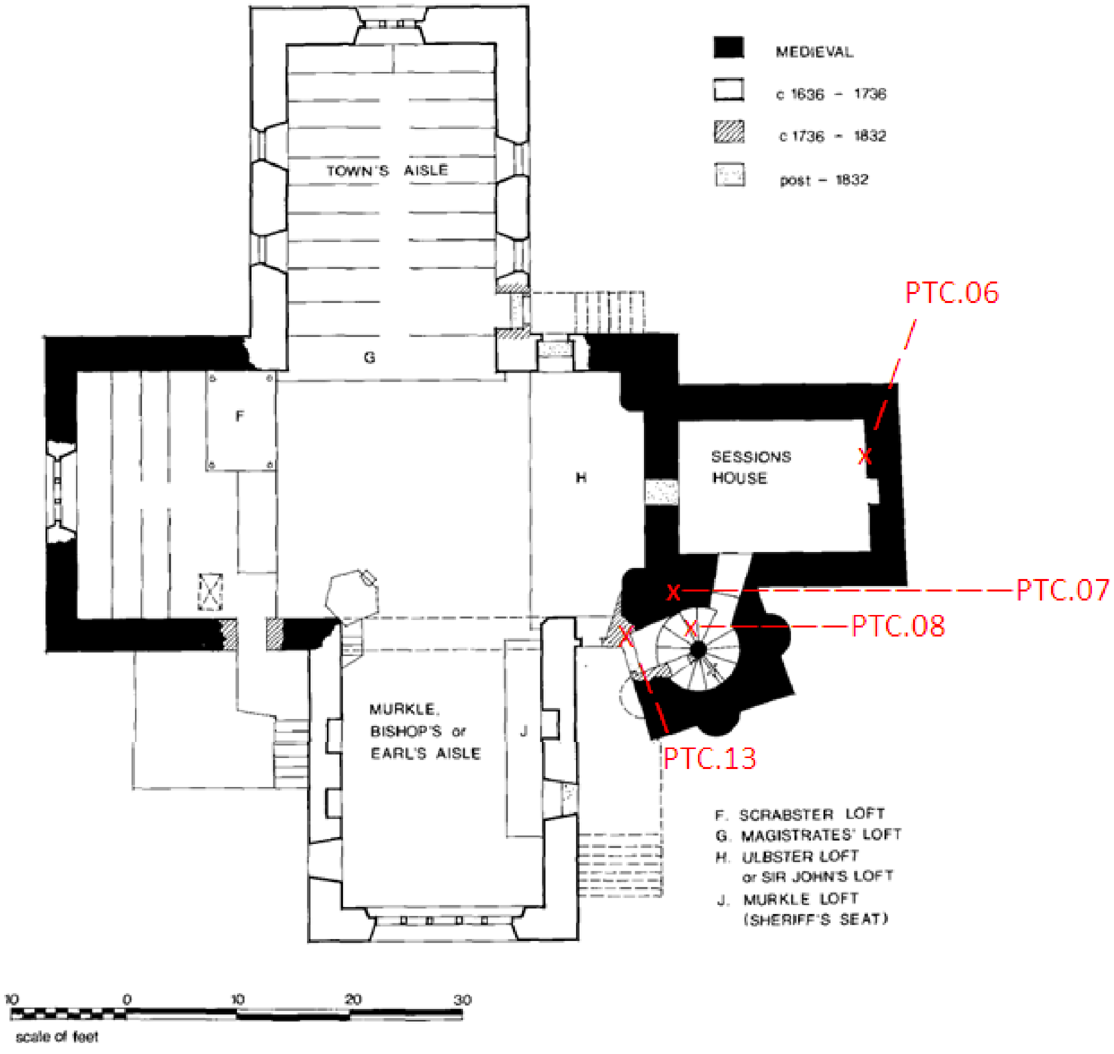


Figure 1b (above) – Phased plan of St Peters Thurso at gallery level by Slade and Watson (1989), annotated to show loose mortar sample locations. (I am grateful to George Watson and to the Society of Antiquaries of Scotland for permission to reproduce this image).

2.2 SAMPLE ANALYSIS

Thick and thin sections were prepared of all the mortar samples collected from the church site and these were examined in reflected and polarised light. A single thick and thin section was prepared from the sandstone sample from Thurso Bay and this was also examined in reflected and polarised light. Sand and gravel samples were examined in reflected light at low magnification.

2.2.1 Mortar Analysis

PTC.01 x 2 sections

Two sections of approximately 30 x 7mm, both of which display two contrasting layers of material. Larger layer up to 6mm wide/thick is a buff-brown very fine material with some indistinct darker brown clasts of up to 5 x 4mm and some very fine black flecks. Thinner layer of up to 2mm wide is also very fine-textured but is very white and larger clasts are absent.

PTC.01 (underlying)

Carbonate – That this is a limestone-lime mortar is betrayed by the high concentration of subangular geogenic calcareous 'limestone' relics to 5 x 4mm. These are micritic layered mudstones, with low concentrations of included subangular quartz.

Temper – Lightly tempered well-sorted mixture of lithic and shell clasts to 0.5mm in approximately equal proportions. The lithic fraction is dominated by quartz to 0.2mm, but includes rounded sandstone clasts of the same grade. Fine shell fraction to 0.5mm but includes single bryophyte of 1.75mm.

Fuel – Opaque amorphous fibrous inclusions are probable fuel relicts and may tentatively be identified as peat but require more work.

Vitreous - The heating of this calcareous mudstone has produced a wide variety of relic textural evidence, including spinaflex textures and vitrification. The section is bound by a brown-green coloured matrix.

PTC.01 (overlaying).

The overlaying layer is a very white shell-lime:

Binder – the section displays a very high volume of light, white lime binder with a microsparitic calcitic texture.

Carbonate – This is a shell-lime containing a high concentration of fine heated shell fragments to 1.5mm. Alteration includes discolouration and clasts in optical continuity with mortar matrix.

Temper – The section displays a mortar almost devoid of any temper. There is 1 x rounded calcareous sandstone and 1 x curving bivalve fragment – both to 1.7mm.

Fuel – no fuel or vitrified evidence apparent in this layer.

PTC.02 (x2 thin sections)

Two sections up to 35 x 8mm both display a single phase coherent material, buff brown fine-textured granular material included within which are indistinct darker brown lenses to 4 x 3mm and sub-mm black flecks.

Binder – The mortar displays a very high concentration of binder and carbonate relicts and is only very lightly tempered.

Carbonate – This is a limestone-lime with a very high concentration of heated red-brown micritic mudstone relicts to 6mmincluded within which are oriented layers of subangular quartz in oriented layers to 0.25mm Often highly altered into 'globules' there is distinct evidence for a spectrum of hydraulic textures tending to vitrification.

Temper – very fine sorted mixture of lithics and shell including subangular to subrounded monocrystalline quartz to 0.2mm and shell to 0.2mm; both exceptionally to 0.5mm.

Fuel – Black, amorphous and opaque probable fuel relicts to 0.7mm may be peat.

Vit – vitreous material to 6mm is considered to have a limestone protolith.

PTC.03 x 1 section

Single section of 20 x 18mm containing single phase composite buff-brown-coloured material included within which are a number of darker brown indistinct clasts including a single fine lens 6mm long.

Carbonate – This is a limestone-lime with a high concentration of altered quartz-included mudstone clasts to 6mm.

Added-temper – Lightly tempered by a well-sorted mixture of quartz and shell to 0.5mm.

Fuel – No fuel noted.

Vit – some possible early vitreous textures are altered limestone. Green-coloured cryptocrystalline matrix.

PTC.04 – x 1 section

Single section of approximately 25 x 9mm displaying a single phase composite buff-brown material included within which are fine darker lenses to 3.5mm.

Carbonate – This is a limestone-lime containing a high concentration of altered layered heated mudstone clasts to 4mm. Included within these are varying concentrations of quartz to 0.1mm.

Added temper – Lightly tempered with a well-sorted mixture of fine quartz and shell to 0.4mm

Fuel – A low concentration of fine opaque amorphously shaped inclusions to 0.7mm are probably peat.

Viteous material – A high concentration of smoky altered limestone reaction-products form globular shapes.

PTC.05 – x 1 section

Binder – Low volume

Carbonate – This is a limestone-lime with a high concentration of rounded, often elongate lime-lumps to 4mm.

Temper – Poorly sorted mix of lithic and shell clasts to 0.5mm. This is coarser than PTC.06 and contains a higher shell fraction. Lithics include subangular monocrystalline quartz to 1.0mm and rounded calcareous sandstone to 2.0mm.

Fuel – No fuel or vitreous evidence noted.

PTC.06 – x 1 section

Single large section to approximately 31 x 15mm displaying a very homogeneous sub-mm light-buff fine-textured composite material

Binder – Low volume, brown.

Carbonate – This is a limestone-lime containing a high concentration of rounded probable lime-lumps to 1.5mm.

Temper – Heavily tempered but generally matrix supported very well sorted mixture of fine lithic and shell clasts in a ratio of approximately 60:40. The lithic fraction is dominated by subangular to subrounded quartz to 0.25mm, but also includes rounded calcareous sandstone clasts to 0.2mm, whilst the shell fraction is composed of curving, elongate, unheated clasts to 1.0mm.

Fuel – No fuel or vitreous materials noted.

PTC.07 – x 1 section

Single section to 17 x 14mm containing a single phase composite material. This includes sharp white curving probable shell clasts to 6mm and some fine black lenses to 3mm surrounded by a fine red-brown sub-mm material.

Carbonate – This is a shell-lime with a very high concentration of heated altered, curving lamellar shell relicts to 6mm, including white cryptocrystalline clasts discoloured dark clasts and others with highly birefringent cellular structures. These require further work to identify taxonomically, but are but not *C. edule* or O. *edulis* but may be Ensis

Temper – Lightly tempered with a fine, well-sorted subangular quartz to 0.2mm.

Fuel – A low concentration of opaque amorphous and fibrous inclusions are probably relict peat fuel.

Vit – some early development vitreous inclusions.

PTC.08 – x 1 section

Single section of approximately 26 x 22mm containing a single phase buff-brown composite material included within which are indistinct darker brown lenses to 6mm.

Binder – Very well tempered. Strangely thin green binder needs more study.

Carbonate – This is a limestone-lime containing a very high concentration of often highly altered, micritic red-brown mudstone clasts to 4-5mm. These are laminated and include both quartz-rich and quartz-free clasts

Temper – Very fine and well-sorted mix of lithic and shell clasts dominated by lithics of angular to subangular quartz to 0.3mm and subangular curving shell to 0.3mm.

Fuel – no fuel noted

Vit – no vit noted but very green-coloured matrix.

<u>PTC.09</u> – x 3 sections

Three very large sections up to 74 x 21mm all containing similar material. This is a single phase composite generally buff-coloured fine-tempered material including an even distribution of white curving probable bivalve shell clasts to 19mm.

Shell-lime – PTC.09 is a shell-lime containing a very high concentration of large altered shell clasts. These are similarly lamellar clasts which display a range of highly altered micritic and/or cellular microstructures seen in PTC.07.

Temper – Very fine mix of lithic and shell clasts dominated by subangular to subrounded monocrystalline quartz to 0.3mm. The temper also contains a very low concentration of rounded micaceous schist to 3mm and rounded sandstone to 4mm, and very rare subangular plagioclase clasts to 0.3mm.

Fuel – Very low concentration of opaque, fibrous material to 2.0mm are probable peat fuel relicts.

<u>PTC.010</u> – x 1 section

Single section of approximately 15 x 13mm containing homogeneous fine-textured light-buff material. Generally clearly sub-mm; there is a single darker clast of 1mm and some very fine indeed black flecks.

Carbonate – PTC.010 is a limestone-lime but relicts are restricted to a high concentration of very highly altered mudstone clasts to 0.6 mm.

Added-temper – very lightly tempered, this mortar has a very high volume of green-brown matrix supported a very well-sorted mixture of quartz and shell to 0.3mm.

Fuel – A low concentration of very fine (0.3mm) possible fuel relicts but tentative.

Vit – Smoky green binder displays a range of superimposed cryptocrystalline textures.

PTC.011 – x 1 section.

Single section of approximately 23 x 33mm contains a single phase composite material including an even distribution of probable lithic and shell clasts to 2.0mm, a single orange-brown lens of 14mm and a single amorphous black inclusion to 3.0mm.

Carbonate – Probable limestone-lime evidenced by large altered micritic red-brown mudstone to 14mm. There is a high concentration of lime-rich contexts for which no protolith survives. It is curious that such a light coloured lime appears to emerge from such a richly coloured calcareous stone.

Added temper - Temper with a well-sorted mixture of quartz-rich sandstone and unheated shell to 2.0mm.

Fuel – No fuel noted.

PTC.012 – x 1 section

Single section of approximately 40 x 20mm includes a single phase composite material dominated by a very fine white material including an even distribution of larger darker subrounded clasts to 1mm and exceptionally to 3mm.

Binder – Very high binder volume

Carbonate – PTC.012 is a shell-lime with a low concentration of altered shell clasts, of unknown taxa to 3.0mm.

Temper –Lightly tempered with a well-sorted mixture of lithic and shell clasts Shell generally to 1.0mm and quartz-rich micaceous flagstone to 2-3mm. The lithic fraction includes rounded quartz-rich micaceous sandstone and subangular to subrounded monocrystalline quartz to 1.0mm.

Fuel – No fuel noted.

Vitreous materials – No vitreous materials noted.

PTC.013 – x 1 section

Binder – High binder volume.

Carbonate – Limestone-lime high concentration of limestone relicts and lime-lumps to 2mm.

Temper – Fine mix of lithic and shell clasts in localized concentrations, but with a slightly higher lithic fraction overall in this section. This includes rounded sandstone to 2.0mm; subrounded, elongate schist clasts to 6mm; subrounded gabbro to 1.5mm; subangular monocrystalline quartz to 2.0mm and uncalcined shell to 1.0mm.

Fuel – No fuel or vitreous materials noted.

PTC.014 – x 3 sections

Three very large sections to 70 x 24mm all include a single phase composite generally white-coloured material with a high concentration of white probable shell clasts visible to 5mm and a low concentration of darker brown probable lithic lenses to 6mm.

Carbonate – PTC.014 is a shell-lime with a high concentration of highly altered heated bivalve shells to 7mm.

Temper – Lightly tempered with a well-sorted mixture of lithics and shell, dominated by unheated shell fragments including gastropod to 2.0mm with angular quartz to 2mm, rounded quartz-rich sandstone to 2.0mm and 1 x subrounded siltstone to 5mm.

Fuel – opaque amorphous inclusions to 1.2mm are probable peat fuel.

Vitreous materials – a low concentration of altered sandstone is present.

PTC.015

1 section of 34 x 23mm contains a single phase composite material including white curving probable shell inclusions to 7mm and darker rounded lithics and a single salient orange-brown lens to 5mm.

Carbonate – PTC .015 is interpreted as a limestone-lime mortar and contains a high concentration of angular-subangular highly altered kiln-relicts. It is this more angular and blocky shape of these, which suggests a limestone provenance is more likely. A single quartz included mudstone is probably also a kiln-relict and curving heated shell evidence is lacking.

Temper – Heavily tempered mortar by a poorly-sorted mixture of lithic and shell clasts, in approximately equal proportions. This includes rounded to subrounded quartz-rich micaceous sandstone to 4.0mm; subangular monocrystalline quartz to 1.0mm and unheated shell to 7mm.

Fuel or Vit – No fuel evidence noted.

PTC.016

1 section. Large section of approximately 48 x 25mm containing a single phase generally well sorted sub-mm light-coloured material included within which a low concentration of white angular to subrounded clasts grade up to 4.5mm diameter.

Carbonate – PTC is very probably a limestone-lime. The limes-source is generally very highly - altered, fine textured and dissociates to form quite rounded relicts which average 1mm.

Added temper – Heavily tempered but generally just matrix-supported with a well-sorted mixture of fine angular to subangular quartz and shell, generally to 0.3mm occasionally to 1.0mm.

Fuel – no fuel noted.

PTC.017

1 section.

Carbonate – This is a limestone-lime which retains a very high concentration of elongate subangular red-brown limestone relicts to 2mm. The limestone protolith may be further characterised as a sedimentary, layered, quartz-rich mud or siltstone in a calcareous matrix.

Temper – The mortar has been tempered by a well-sorted mixture of lithic and shell clasts very much dominated by a lithic fraction containing subangular to subrounded monocrystalline quartz, generally to 0.2-0.25mm and occasionally to 0.5mm. The shell fraction is in lower concentration and generally grades to 0.2mm.

Fuel – Opaque black fibrous and fragmented inclusions to 3mm are probably peat fuel.

Vit - surely hydraulic.

2.2.2 Environmental Materials Analysis

PTC.018

1 section. Large section of very quartz-rich micaceous sandstone; with a locally higher, but generally very low calcareous content. Quartz fraction very well-sorted and highly compact.

PTC.19

Poorly-sorted mixture of lithic and shell materials, almost completely dominated by well-rounded quartz-rich sandstone disc-shaped grains, ranging from 1.5 - 10mm diameter, but including a very low concentration of subrounded to angular shell fragments ranging from 2 - 5mm. No very fine fraction.

PTC.20

Well-sorted mixture shell and lithic material almost completely ranging from sub-mm up to 2-3mm. Subrounded shell fragments in slightly higher volume but a high concentration of subrounded to subangular quart-rich sandstone and quartz is also evident. Rare larger rounded sandstone clasts to 20mm are also present in the sample.

PTC.21

The general sand of Thurso Bay is dominated by a homogenous, brown, sub-mm sand typical of plaster 1 and later fluid plaster.

2.2.3 Comparative Analysis

All of the mortars have been tempered with mixtures of shell and lithic materials from riverine or marine sources, and most have been tempered with a well-sorted very fine sand of these materials ranging up to 0.5mm diameter only and consistent with PTC.21 from Thurso Bay. Contrasting tempers are evident in mortar samples PTC.11, PTC.12, PTC.13 and PTC.14 all of which have been tempered with slightly coarser mixtures generally ranging up to 2-3mm and more consistent with PTC.20. PTC.15 has been tempered with a much coarser mixture to 7mm not very consistent with any of the collected environmental samples, but clearly also of some local source.

Mortar samples PTC.01, PTC.02, PTC.04, PTC.07, PTC.09, PTC.14, and PTC.17 contained the most convincing evidence for peat fuel relicts.

Comparing the mortar thin sections with each other, the clearest result to emerge is the homogeneity of the materials within samples PTC.01, PTC.02, PTC.03, PTC.04, PTC.08 and PTC.017. These samples would certainly appear to be the same material as each displays: similarly very convincing evidence for a heated calcareous mudstone kiln-relict clasts from which a distinctive (probably hydraulic) binder has emerged; an added-temper profile which is very consistent; and all except sample PTC.03 contain evidence for relict peat fuel. A similarity in matrix texture and colour also suggests that PTC.010 is related to this first group of mortars, although PTC.010 is clearly a much more refined lime-rich material with no coarser limestone relicts, despite a very high matrix volume.

Although the single small thin- section of PTC.07 makes it most difficult to suggest this is representative or to compare temper profiles in thin section, the material is a distinctive shell-lime similar to PTC.09. Both also contain fuel interpreted as peat.

PTC.05, PTC.06 and PTC.016 are also of similar fine character with varying concentrations of rounded limestone/lime inclusions and no fuel evidence.

The remaining mortars, PTC.011, PTC.012, PTC.013, PTC.014, and PTC.O15 are much more challenging to interpret due to very similar shell-rich tempers, and the very white-coloured and fine-textured lime which appears to emerge from both shell and limestone lime-sources. PTC.012 and PTC.014, however, contain convincing evidence for heated shell relicts (most particularly in PTC.14; see figures below), the bright heated mudstone in PTC.011 and PTC.15 is absent, and PTC.14 also appears to contain relict peat fuel. The absence of fuel in PTC.12 reflects the more refined lime-rich character of this coating in a similar way to PTC.10.

The blocky angular shape of the lime-source relicts in PTC.015 is most convincing limestone-lime evidence and this occasionally approaches the textures seen in the earliest mortars, and this joins PTC.13 and 11 as interpreted limestone-limes, none of which contained convincing fuel evidence.

On site, however, the (PTC.15) mortar of the south aisle appeared to contain coal inclusions, whilst the correlation between the putative peat-fuel evidence within both the primary limestone-lime mortar and with the shell-limes, is striking.

3.0 ST PETER'S THURSO – CONCLUDING DISCUSSION

Building survey suggested that the medieval and later church of St Peters Thurso had been constructed with a range of phase-specific techniques and materials, including: geologically contrasting rubble building stone laid in different styles; geologically contrasting sandstone dressings, hewn with different mouldings and laid in different ways; and, most particularly, different lime mortars. These phase-specific mortar materials display contrasting limestone and shell lime sources, which have been fired with different kiln fuels and tempered with sands sourced from different contexts within the local environment. Lab-based petrographic analysis of a large assemblage of loose mortar samples collected from the building and surrounding environment has subsequently supported those characterisations and refined our understanding of them.

Given previous contrasting interpretations, the building survey presented here was initially mostly concerned to identify the primary fabric of the building, and this has returned some significant results.

3.1 Primary Phase.

The primary masonry of St Peter's church has been constructed of regular square blocks and rectangular slabs of a distinctive crystalline blue-coloured sandstone, with quartz-rich veins and parallel beds. This material had been quarried very locally, probably from the shore around Thurso Bay, and was used exclusively for all the primary stonework. This regular material could often be used straight from the quarry, but was otherwise occasionally hammer-dressed to form quoins and other features.

The primary masonry was bonded and coated with two very distinctive fine lime mortars of different specification although both were manufactured from a heated quartz-included calcareous mudstone and tempered with local beach sand probably sourced from Thurso Bay. The composition of the mudstone lime-source was such that hydraulic products were also produced which have probably imparted a chemical set and hard texture to the resultant mortar.

Surviving primary masonry fabric forms the lower courses of all four walls of the large rectangular nave, all four walls of the smaller rectangular chancel, and all four walls of the tower. Mortar 1 bound and coated masonry is the earliest fabric in each of these parts of the church although often subsequently overlaid or abutted by Mortars 2, 2a, 3, 4 and 5. A number of primary features, bound with Mortar 1, survive in these contexts including:

- fragments of north-east, south-west and west windows in the nave;
- a complete chancel arch, apsidal vault, most of the north window and a fragment of the east window in the lower chancel;

- a complete nave doorway, a substantially complete vaulted spiral stair and mid-chancel doorway, a series of buttresses and a series of slit windows in the lower and mid tower;
- a very substantial section of the west wall, including complete lower sections and sills of mid-tower and upper-nave doorways of the mid and upper chancel.

A number of likely additional, significant primary features are suggested by the surviving evidence but their details now been lost. On the ground floor the evidence suggests: a similar window to that in the north was located in the east wall of the lower chancel and there may have been another in the south; the high altar is likely to have been at the chord of the apse in the lower chancel; the window fragment and inserted masonry at the north-east of the nave suggest a side altar was located here; the positions of the inserted north-west and south-west doorways probably indicate primary doorways were located here also; the font was probably located between these two or possibly beneath the south-west nave window; assuming it was centrally placed the west window of the nave would have had a huge internal width of approximately 1.7m. Given these likely dimensions, and indeed those of the smaller windows it is very likely all of these windows were glazed. The later construction of the north and south aisles, in post-medieval phases, makes it impossible to speculate on whether any features existed here in the primary phase.

Regarding the mid and upper levels the evidence is more fragmentary but that which does survive suggests the primary fabric of the tower is likely to have been higher than at present and may have included another north doorway at upper chancel level. The doorway between from the upper chancel is likely to have opened onto a timber platform at eaves height in the nave. It is also possible that the very deep 'putlog' sockets provide evidence for a timber gallery at a higher level in the nave. The well-worn cill of the doorway from the tower to the mid-chancel room certainly betrays high footfall, and this mid-chancel chamber was probably quite low ceilinged, although given the loss of the east wall we can only speculate as to how the windows may have been configured. Although Low's [1774] description of access between the chancel and bell towers, at the now lost church of Deerness (Orkney), doesn't describe three chancel levels, his sketch of the now demolished church at Deerness does contain three window levels.

Externally, much less of the primary masonry of the nave has survived subsequent modification, and the east and north walls of both upper chambers of the chancel and the upper stage/s of the tower have been lost. However, the height of the doorway in the east wall of the nave appears to confirm that the body of the church was of a similar height to the chancel, and higher level nave windows cannot be ruled out. Certainly the whole building was finished in a sharp, highly polished lime-washed render, and was a much larger and visibly more imposing building than the ruin we see before us today.

3.2 SUBSEQUENT PHASES

As described above, all subsequent phases of St Peters have a clear secondary relationship with the primary fabric of the building: the upper tower overbuilds the primary mid-tower; both the north and south aisles have clearly been inserted into and abut primary fabric in the nave, and the very late room above the chancel clearly overbuilds the primary lower chancel in the east wall. These main secondary structures do not, however, have direct stratigraphic relationships with each other, and the potential for comparative art historical dating is limited within the tight 17th to 18th-century chronologies previously suggested.

The last phase of St Peter's might group all the phases of the living building which are clearly very late. This includes a range of different limestone-lime mortared contexts, many of which have been used to rebuild or consolidate pre-existing masonry. The clearest constructional context for this phase is east gable of the mid-chancel, which does not contain any fine dressed sandstone, but is composed of slabs of thin flagstone, and some re-used brick, laid in a coal-fired limestone-lime mortar.

Previous phases include both the north and south aisles and these have been convincingly related by Slade and Watson (1989). The masonry of the south aisle is associated with a number of alterations around the church which are framed by fine dressed sandstone quoins and dressings which often contain iron-rich inclusions and have generally eroded very badly. Doorways in this material are roll-moulded and include date plaques above. The general walling is a dark-coloured flagstone which is carefully laid in a more coarsely lithic-tempered durable limestone-lime mortar (Mortar 4). The masonry of this phase includes the south aisle, the external dressings of the main south-west nave doorway, the external dressings of the south chancel doorway, and a number of secondary windows and doors in the south aisle. There are subsequent small sub-phases in this same technical tradition, which may be included as a sub-phase to this general phase, such as the door slapped-in to the west wall of the lower tower and the adjacent internal cross-wall.

The north aisle of St Peters is also associated with alterations to the west of the nave. This phase is a remarkable mixture of the ambitious and informal, and contains a vernacular approach to tracery with persistent use of cyma- mouldings. The general walling is composed of heavily pinned flagstone in rough courses whilst the associated mortar (Mortar 3) is a very degraded limestone-lime with a high clay-silt fraction which is challenging to characterise.

3.3 THE SHELL-LIMES

Another remarkable feature of the masonry archaeology of St Peters Thurso is the evidence for later shell mortars and the most substantial of these is the distinctive re-coloured mortar of the upper tower which has previously been reasonably ascribed to the 18th-century on the available circumstantial evidence. Research undertaken across Caithness for this thesis would suggest this is very unusual evidence in a Caithness context, where shell-limes have only been previously noted in quite early medieval contexts.

The apparent similarity between this upper tower mortar and the mortar noted around the north-west nave entrance requires further work. These doorways were previously considered to be medieval although that both are secondary and more complex than was previously realised is clear. Another shell-lime phase also appears to be associated with the construction of the secondary east window of the lower chancel which is overlaid by a plaster with clear similarity of material and technique with the recently revealed chancel wall painting. Again, this chancel painting (which appears to depict a mitred bishop amongst other characters) has previously been considered medieval (eg. Fawcett 2002).

Possible medieval contexts for both the upper tower and wall painting have been explored in the main text of this thesis, but have not been definitively demonstrated, and this issue clearly requires further survey, analysis and research. There is an (albeit somewhat ambiguous) report of shell-lime manufacture in late 18th-century Canisbay and any possible physical evidence for this would also be important.

3.4 DISCUSSION

Importantly, the most significant aspect of this study is that which is most clearly understood. Comprehensive characterisation of the consistent masonry techniques displayed in the first phase of the monument presents convincing evidence for the contemporaneity of the tower, nave and chancel, and this supports Slade and Watson's (1989) contention that these structures are essentially of primary architectural form. That the methodology presented above also enabled recognition of primary windows in the nave and chancel, and a third floor within the primary chancel is also significant for our understanding of the building and provides archaeological support for Slade and Watson's historically-informed contention that this was a very high status probable bishop's church. The present study has not demonstrated a firm independent date for that building, however, and this also requires further work.

3.5 FURTHER WORK

St Peters Thurso is clearly a nationally and perhaps internationally significant building. The building is also very complex however, and requires much more analysis to answer some of the questions raised by this study. Better access to examine the external masonry of the upper tower, and the upper levels of the chancel should be short term objectives. Petrographic analysis of the sandstone related to each phase of the building should be combined with the analysis of well-contexted fixed mortar samples. Sandstone analysis should include the dressed 'keyhole' stone, reused as blocking in the east nave wall, to determine if this feature may be related to dressings of the putative medieval upper tower. Essentially, however, this important building requires comprehensive stone-by-stone recording and concomitant reanalysis with a conservation programme designed for the traceried features at the earliest opportunity.

4.0 ST PETERS THURSO – FIGURES

4.1 MAPS

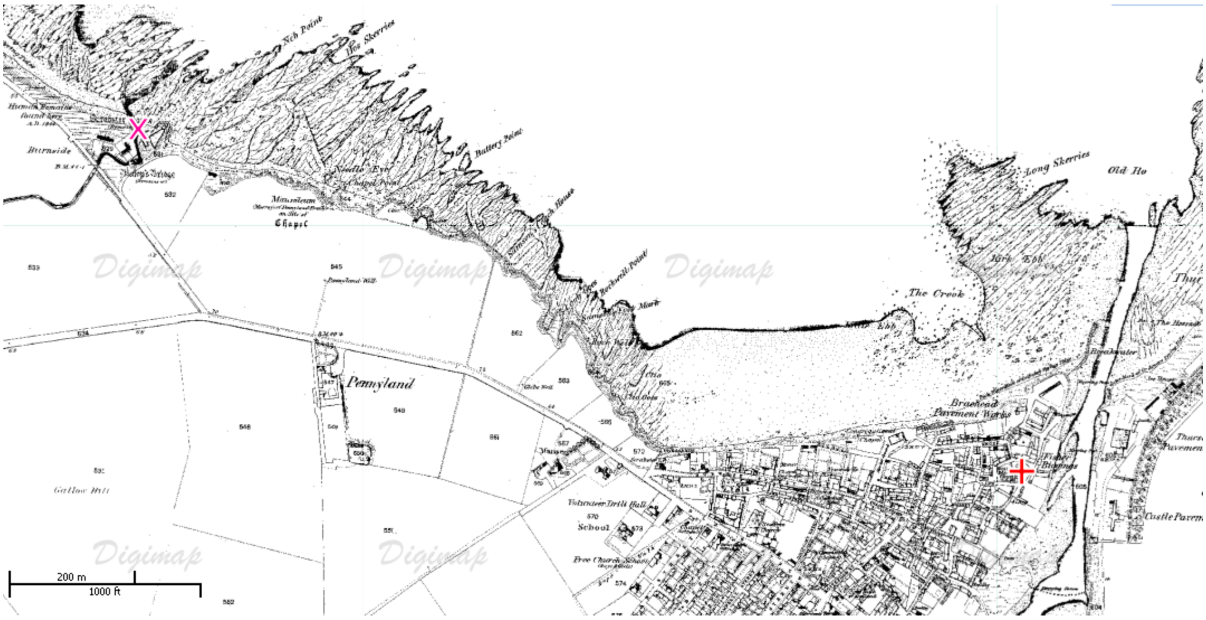


Figure 2 (above) - Scrabster Castle & St Peter's church, Thurso. OS1. Scale bar 1000ft. & 200 m. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved.

4.2 SITE SURVEY

Figure 3 (above) – St Peters Church from the north-east. Scale 500mm; photograph Mark Thacker.

Figure 3 (above) – Chancel; East wall; external face. Note disturbed masonry around the secondary window and large void where Mortars 1 and 2 are visible in core contexts. Scale 500mm; photograph Mark Thacker.

Figure 4 (above) – Mortar 1; External face of east chancel wall; deep core. Field of view approx. 50mm; photograph Mark Thacker.

Figure 5 (below) –reconstruction of primary chancel window from surviving fragments.

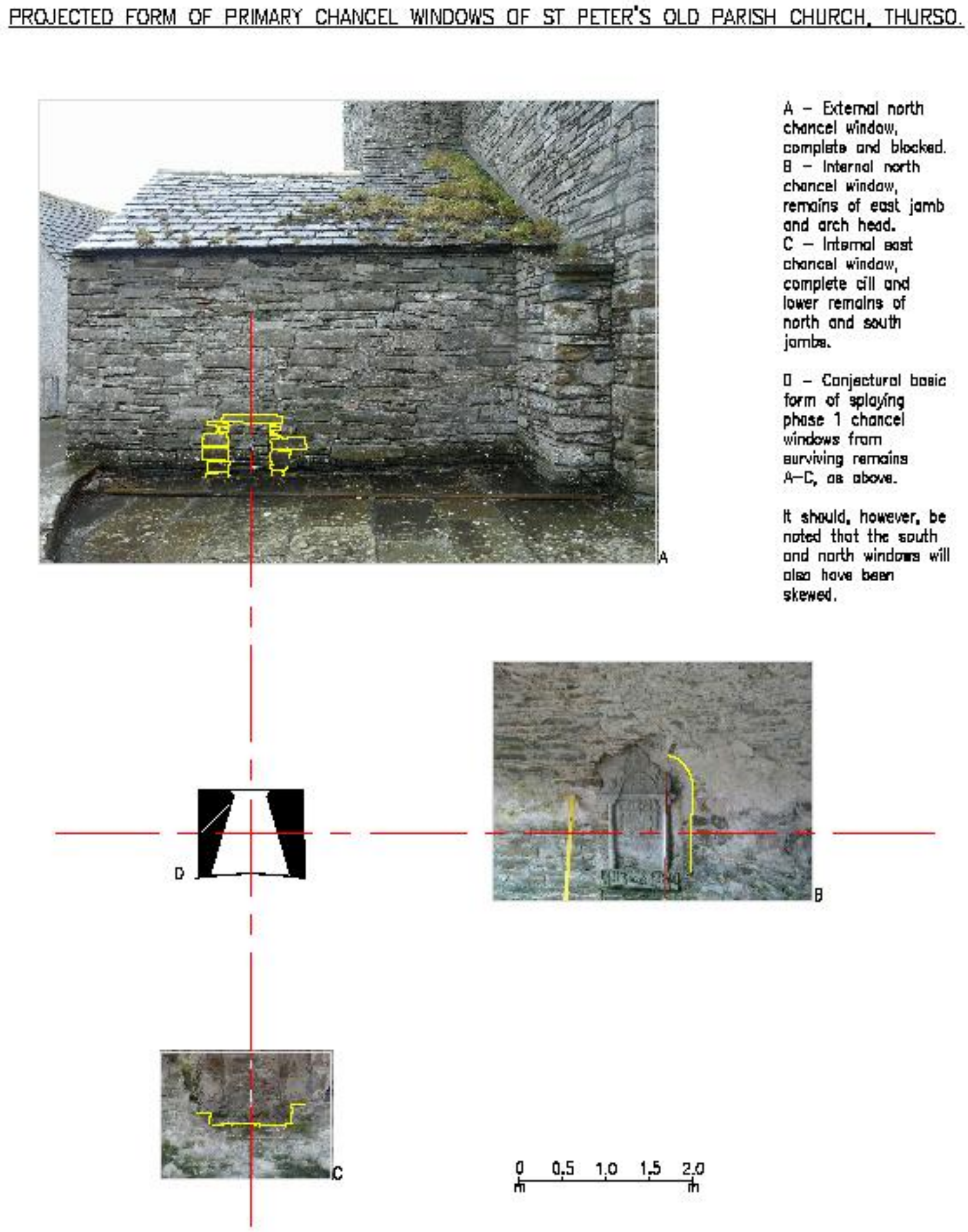


Figure 6 (above) – North chancel wall; external face. Note blocked primary chance window. Scale 500mm; photograph Mark Thacker.

Figure 7 (above) – External face of south chancel wall. Note regular blocky primary masonry at south-east corner and disturbed masonry around secondary doorway and above. No Scale; photograph; Mark Thacker.

Figure 8 (above) – Coating 1; External east wall of chancel. Note good survival of planar polished surface finish. Scale 500mm; photograph Mark Thacker.

Figure 9 (above) – Coating 1 in section; External east wall of chancel. Note the variation in thickness of single coat. Scale 10mm; photograph Mark Thacker.

Figure 10 (above) – East nave wall showing primary chancel arch, primary upper chancel doorway (with keyhole stone in blocking), secondary side altar blocking in lower drum to the left of chancel arch, primary tower entrance to the right, and surviving late medieval upper tower. No scale; photograph Mark Thacker.

Figure 11 (above) – Primary slit window, lower tower. Scale 500mm; photograph Mark Thacker.

Figure 12 (above) - Lower tower spiral vaulting above stair. Scale 500mm; photograph Mark Thacker.

Figure 13 (above) – Lower tower vaulting; deep bedding; Mortar 1. Scale 10mm; photograph Mark Thacker.

Figure 14 (above) – Lower tower vaulting; Mortar 1 probable limestone kiln-relict.

Scale 10mm; photograph Mark Thacker.

Figure 15 (above) - Primary quoins; north east external corner of chancel. Note: the quoin stone above the scale is naturally bedded and the east face is an undressed natural joint in the quarried stone. The north face displays conquoidal facets and slight bull-nose profile facets consistent with hammer-dressing. In contrast, the quoin below is face-bedded and undressed. The long north face is the sedimentary bed of the rock and the east face is a natural geological joint in the stone and the slightly acute angle between these two faces has allowed a sharp corner arris, with the long 'bed-face' to the line of the north wall and the much smaller edge-bedded east face slightly recessed. Scale 10mm; photograph Mark Thacker.

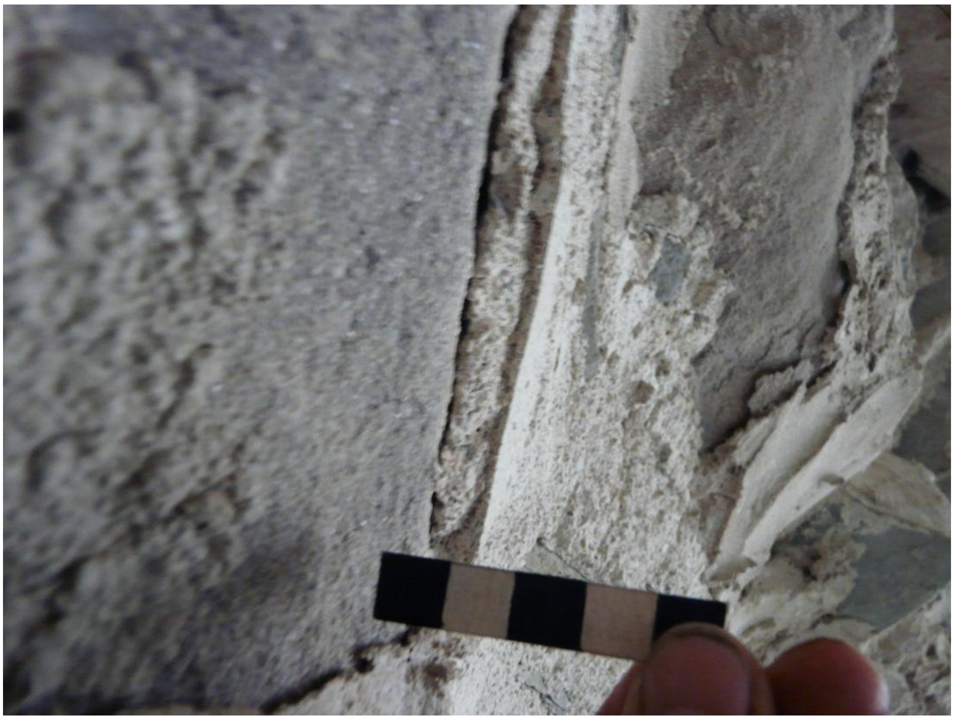
Figure 16 (above) – Primary fabric; putlog socket; internal south wall of nave. Note blocky hard blue sandstone typical of phase 1 and remains of quartz veining on the face of the lintel. Scale 10mm; photograph Mark Thacker.

Figure 17 (above) – Primary south-west nave window with inserted memorial. Scale 500mm; photograph Mark Thacker.

Figure 18 (above) – Nave; internal face of west wall; surviving remains of south jamb and splaying reveal of west window. Note the tighter jointing and sharp blocky primary masonry to left of the jamb. Scale 500mm; photograph Mark Thacker.

Figure 19 (above) – Chancel arch from the nave. Scale 500mm; photograph Mark Thacker.

Figure 20 (above) – Stepped face of chancel vaulting. No scale; photograph Mark Thacker.



Figures 21 (above) – Coating 2; Lower chancel, above east window. Note two-coat system of fine lime-rich finishing coat overlaying coarser keyed scratch coat. Scale 10mm; photograph Mark Thacker.

Figure 22 (above) – Mortar 2; deep bed and core context; External face of east chancel secondary window. Scale 10mm; photograph Mark Thacker.

Figure 23 (above) – Mortar 2a; Upper tower core context. Scale 10mm; photograph Mark Thacker.

Figure 24 (above) – Internal face of north-west nave doorway. Scale 500mm; photograph Mark Thacker.

Figure 25 (above) – 'Arched' head of external face of north-west nave doorway. Scale 500mm; photograph Mark Thacker.

Figure 26 (above) – East reveal of south-west nave doorway into the church. Note the contrasting colouration, extent of erosion, and course heights between the inner and outer jambs. These also display contrasting lime mortars. The contrast in erosion levels is particularly striking where the two phases abut. It is suggested above that the left (north, inner) jamb is secondary late medieval phase 2, and the right (south, outer) is post medieval phase 4. Scale 500mm; photograph Mark Thacker.

Figure 27 (above) – South-west nave doorway. Scale 500mm; photograph Mark Thacker.

Figure 28 (above) – North aisle; external face of east wall. Note phase changes and rising and dipping courses and high concentration of pinnings. Scale 500mm; photograph Mark Thacker.

Figure 29 (above) – North aisle; internal wall face; Mortar 3; *in-situ* bedding; note large rounded limestone kiln-relicts and high clay volume. Scale 10mm; photograph Mark Thacker.

Figure 30 (above) – Mortar 3; bedding; internal face west nave wall. Note high conc. Fine unheated shell. Field of view approx. 50mm; photograph Mark Thacker.

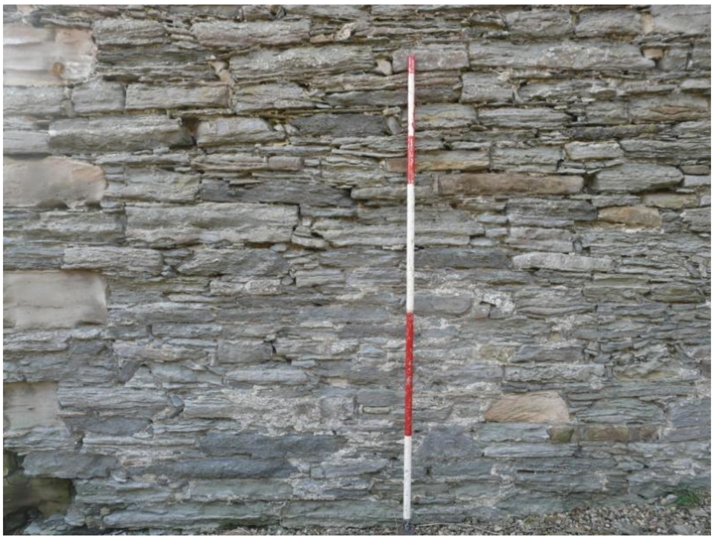


Figure 31 (above) – South Aisle; east face. Thin flagstone masonry with occasional fine sandstone. Highly eroded fine-grained sandstone quoins laid in strict alternate pattern. Scale 500mm; photograph Mark Thacker.

Figure 32 (above) – Degraded Mortar 3; deep bedding and core; external face north-west nave wall. Dissolute clay and fine shell. Scale 10mm; photograph Mark Thacker.

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Figure 33 (above) – North aisle; external east face of wall, traceried window. Scale 500mm; photograph Mark Thacker.

Figure 34 (above) – North aisle; external face of east wall. Cyma moulding. No scale; photograph Mark Thacker.

Figure 35 (above) – South Aisle; external east face; bedding mortar *in-situ*; Mortar 4 . Scale 10mm; photograph Mark Thacker.

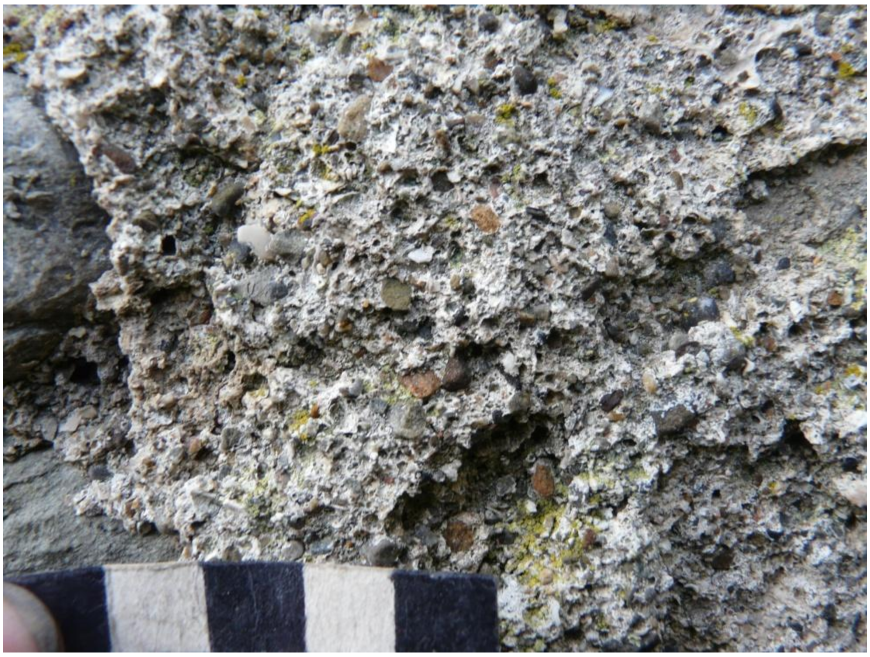

Figure 36 (above) - South aisle; external face of east wall; Mortar 4 slaister. Scale 10mm; photograph Mark Thacker.

Figure 37 (above) – Blocked south chancel doorway; dressings display strict alternate bonding pattern; roll-moulded jambs; stooled lintel; blocked date plaque; eroded sandstone with iron-rich inclusions. Scale 500mm; photograph Mark Thacker.

Figure 38 (above) – Roll-moulded jambs of south chancel door external dressings. No scale; photograph Mark Thacker.

Figure 39 (above) – Chancel; external face of north wall; high courses; Mortar in bed context. Scale 10mm; photograph Mark Thacker.

Figure 40 (above) – South aisle; external face of west wall; recessed pointing in cementitious mortar. Scale 10mm; photograph Mark Thacker.

Figure 41 (above) – Thurso Bay. Blue crystalline sandstone. Scale 500mm; photograph Mark Thacker.

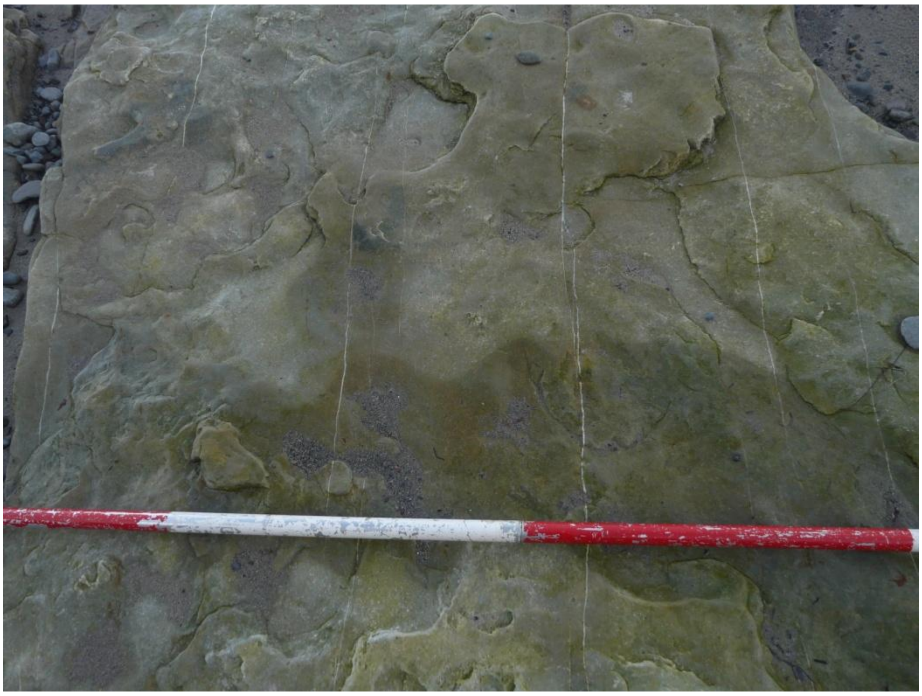

Figure 42 (above) – Thurso Bay; grey-blue sandstone with parallel quartz-filled veining. Scale 500mm; photograph Mark Thacker.

4.3 THICK SECTIONS

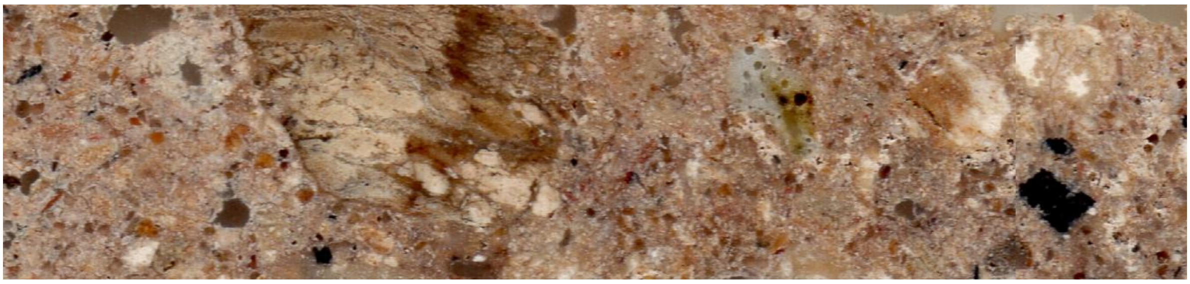

Figure 43 (above) – Thick section PTC.01. Width of view 20mm.

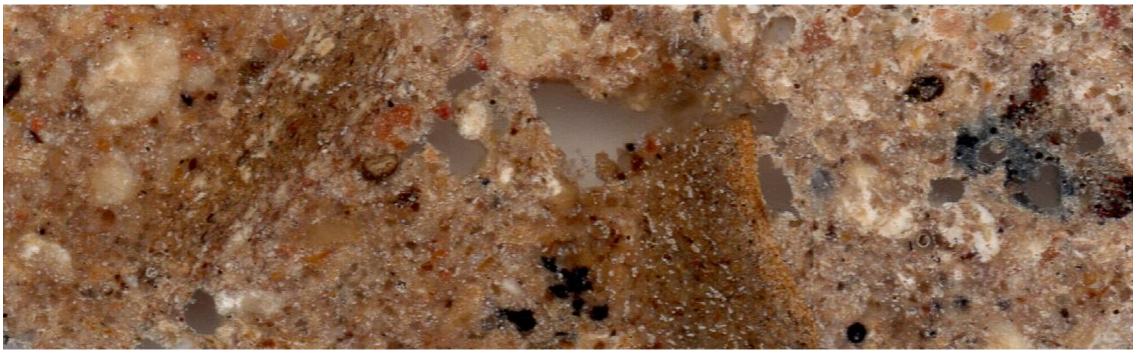

Figure 44 (above) –Thick section PTC.02. Width of view 20mm.

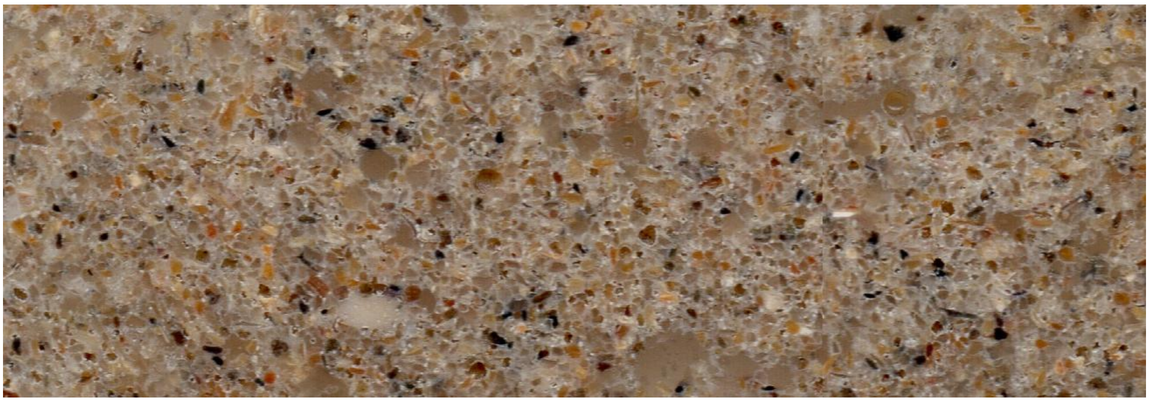

Figure 45 (above) - PTC.06. Width of view 20mm.

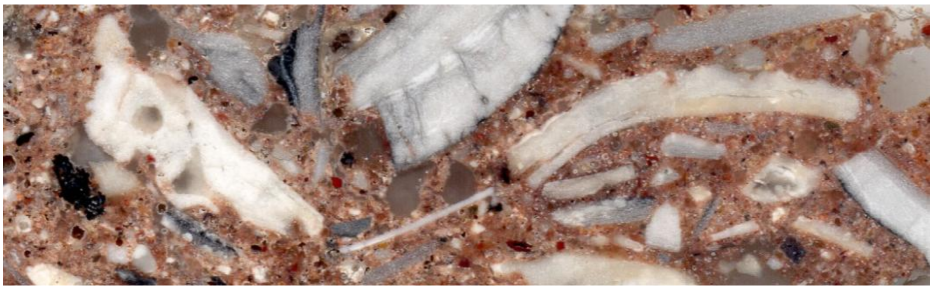

Figure 46 (above) – Thick section PTC.07. Width of view 23mm.

Figure 47 (above) – Thick section PTC.09. Width of view 23mm.

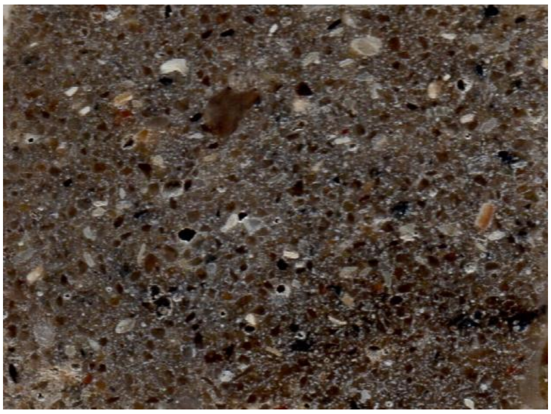

Figure 48 (above) – Thick section PTC.10. Width of view 10mm.

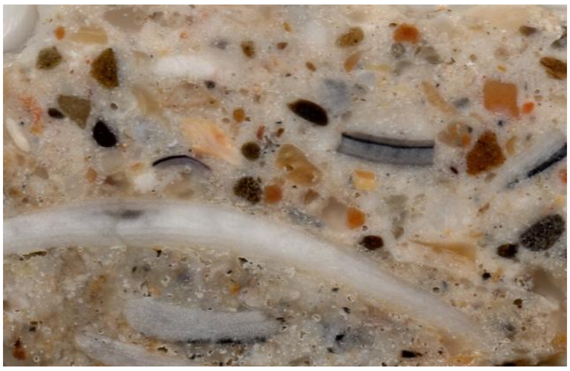

Figure 49 (above) - Thick-section PTC.12. Width of view 15mm.

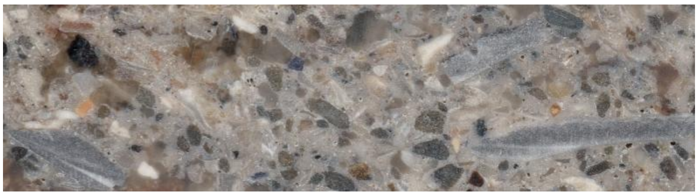

Figure 50 (above) – Thick section PTC 14. Width of view 30mm.

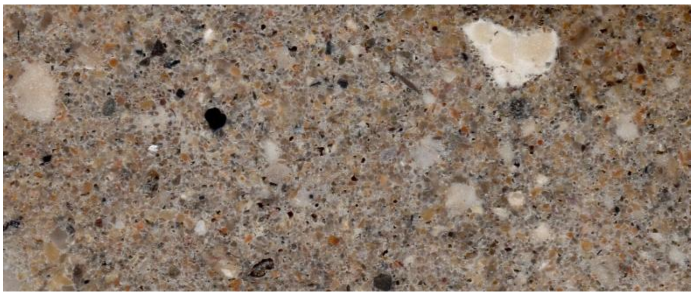

Figure 51 (above) – Thick section PTC.16. Width of view 30mm.

4.4 THIN SECTIONS

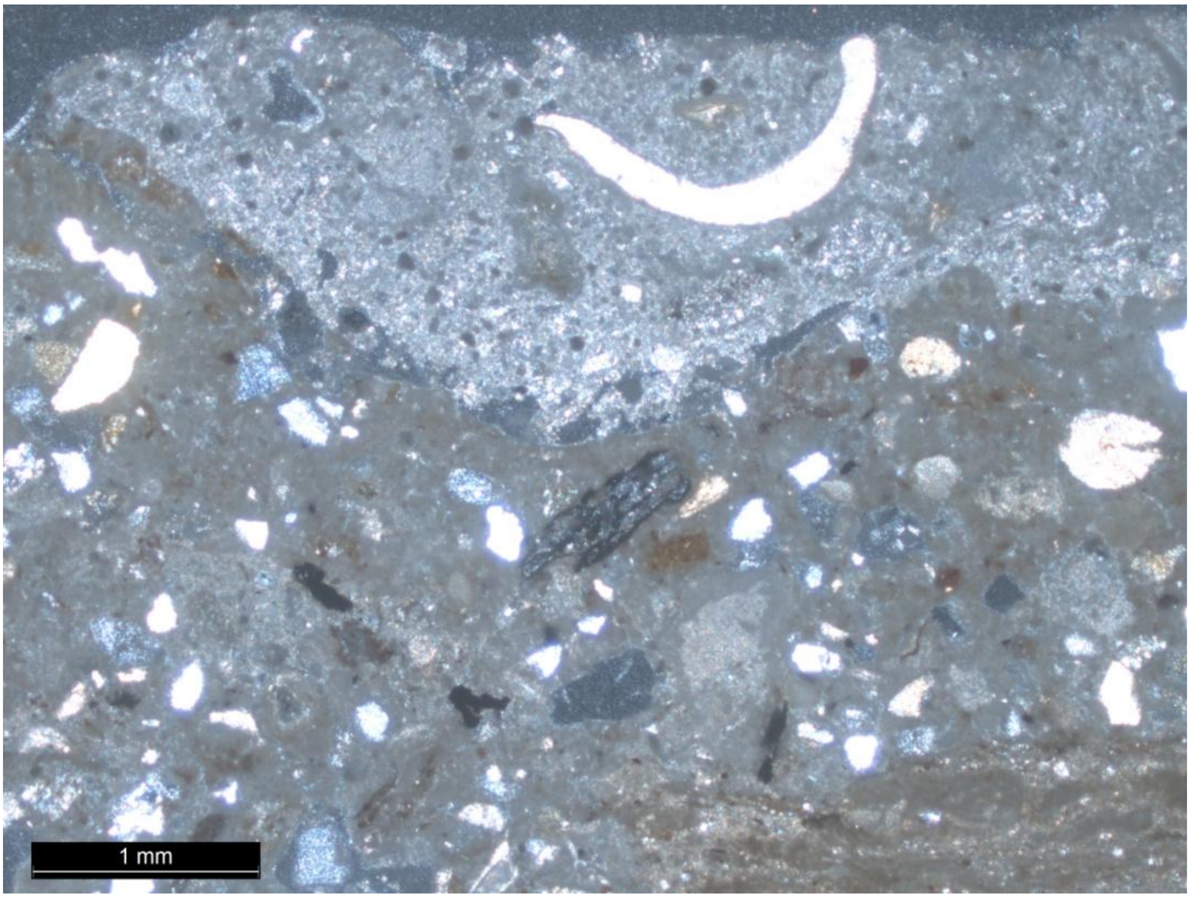

Figure 52 (above) - PTC.01 - Showing both large underlaying layer and smaller overlying mortar layers. XPL; Scale bar 1mm; photomicrograph M. Thacker.

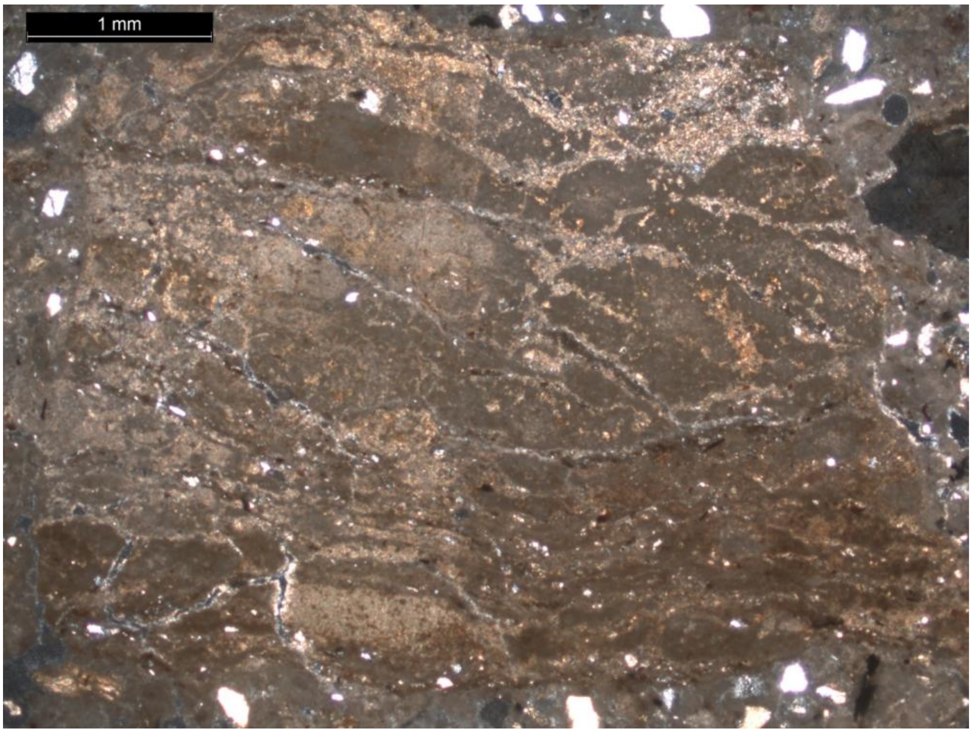

Figure 53 (above) - PTC.01 (underlying); Large mudstone inclusion with included quartz. XPL; Scale bar 1mm; photomicrograph M. Thacker.

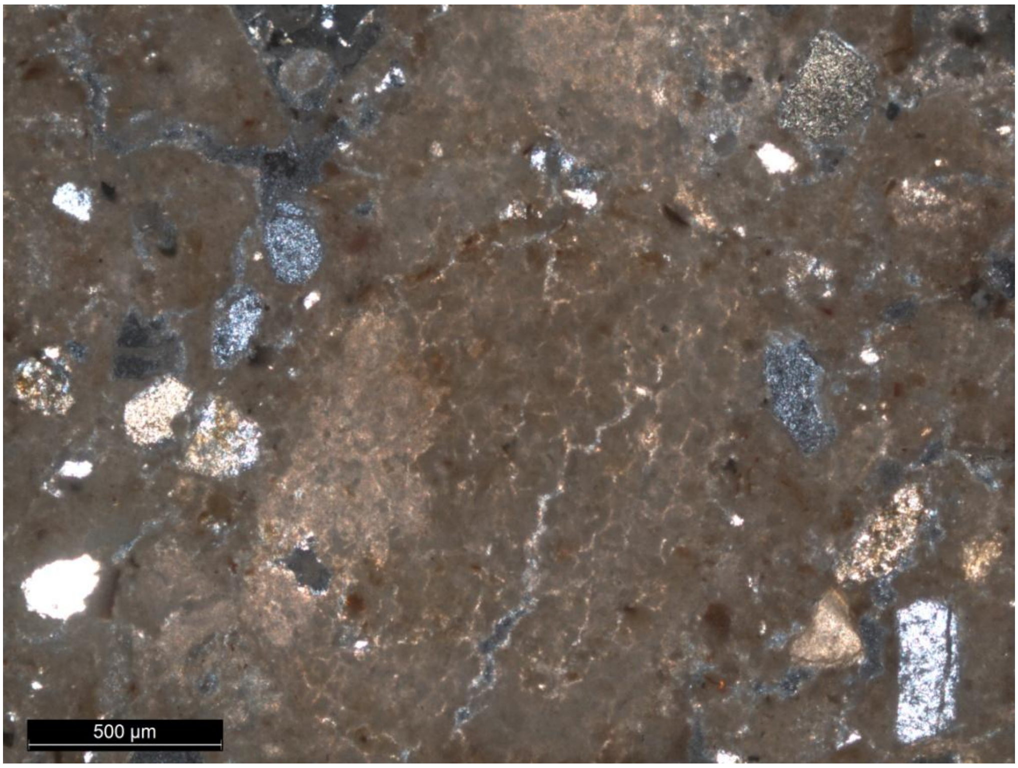

Figure 54 (above). PTC.02 – well-calcined mudstone losing coherence and grain-matrix boundary definition. XPL; Scale bar 500µm; photomicrograph M. Thacker.

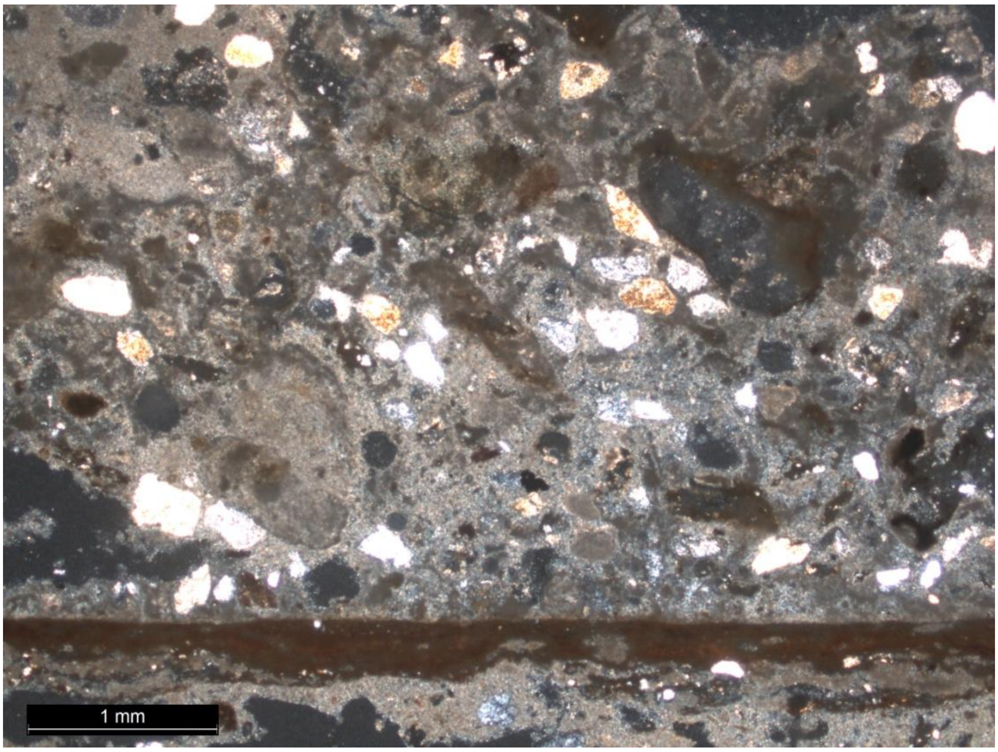

Figure 55 (above) - PTC.03 – general tempered view including fissile layer of well-calcined mudstone. XPL; Scale 1mm; photomicrograph M. Thacker.

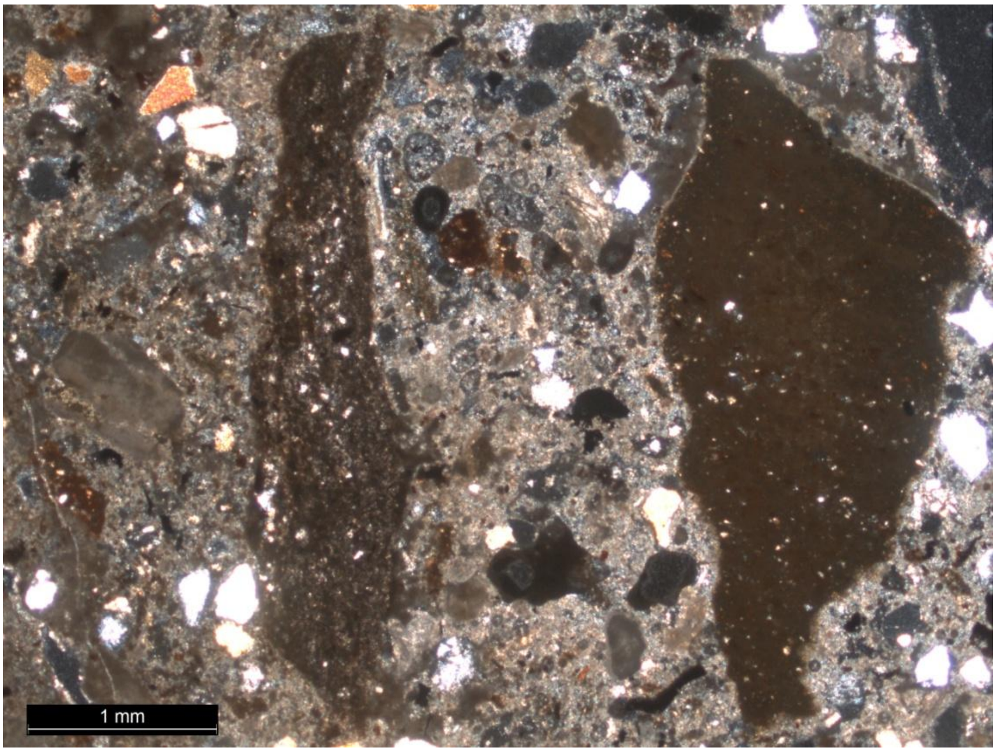

Figure 56 (above) - PTC.04 – mudstone relics with included quartz. NB also very granular crystalline high brief binder matrix. XPL; Scale bar 1mm; photomicrograph M. Thacker.

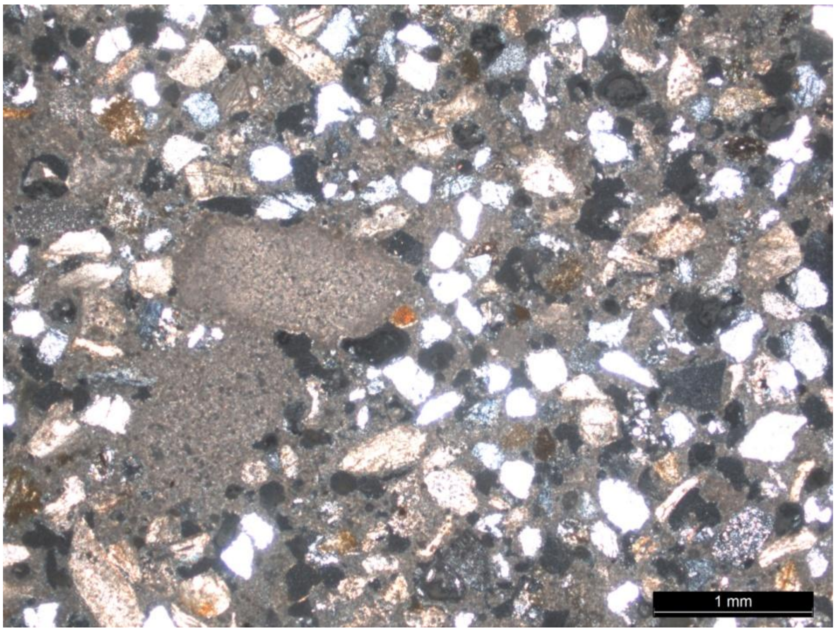

Figure 57 (above). PTC.05 – well-tempered general view with lime lumps. XPL; Scale bar 1mm; photomicrograph M. Thacker.

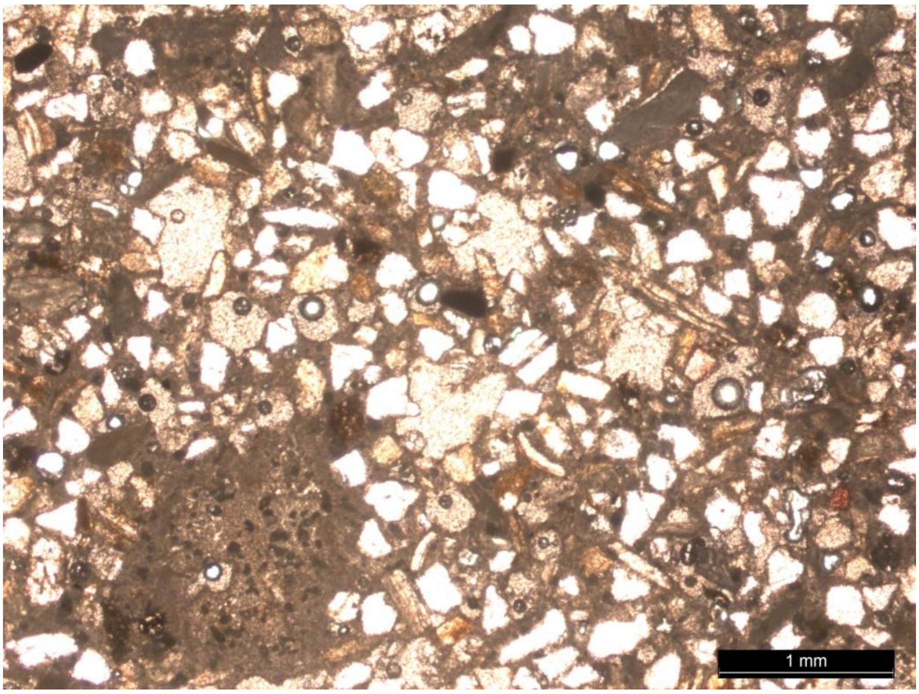

Figure 58 (above) - PTC.06 – well tempered with lime lumps. PPL; Scale bar 1mm; photomicrograph M. Thacker.

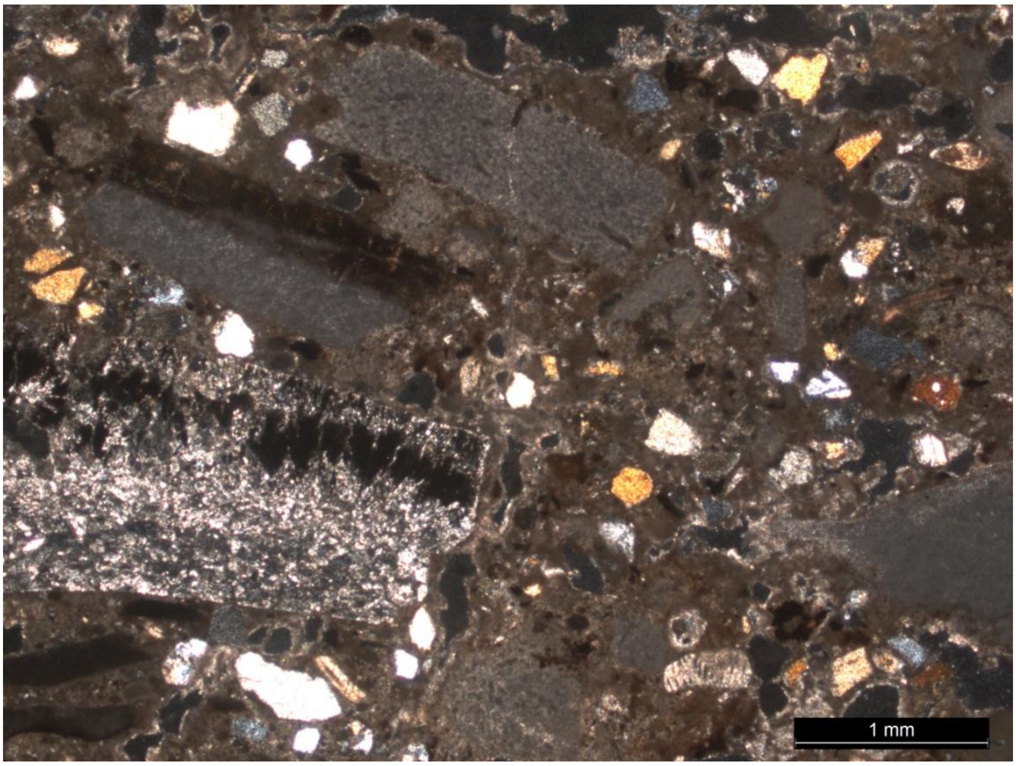

Figure 59 (above) - PTC.07 – range of relic heated shell textures including high brief oriented crystallinities and well-calcined. XPL; Scale bar 1mm; photomicrograph M. Thacker.

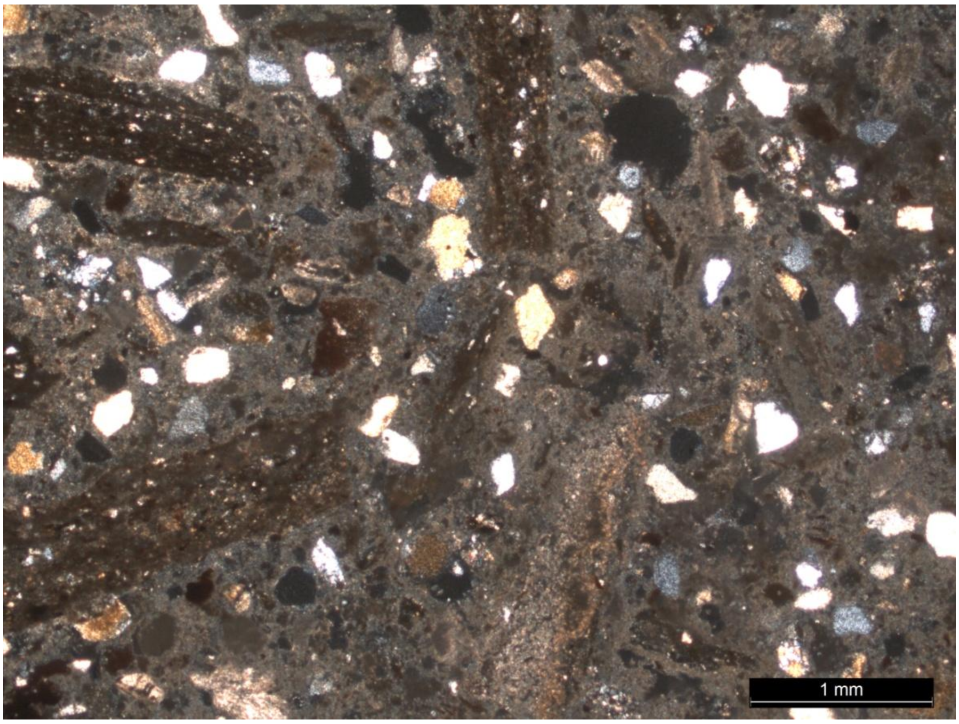

Figure 60 (above) - PTC.08 – general view. Note high brief crystalline matrix. XPL; Scale bar 1mm; photomicrograph M. Thacker.

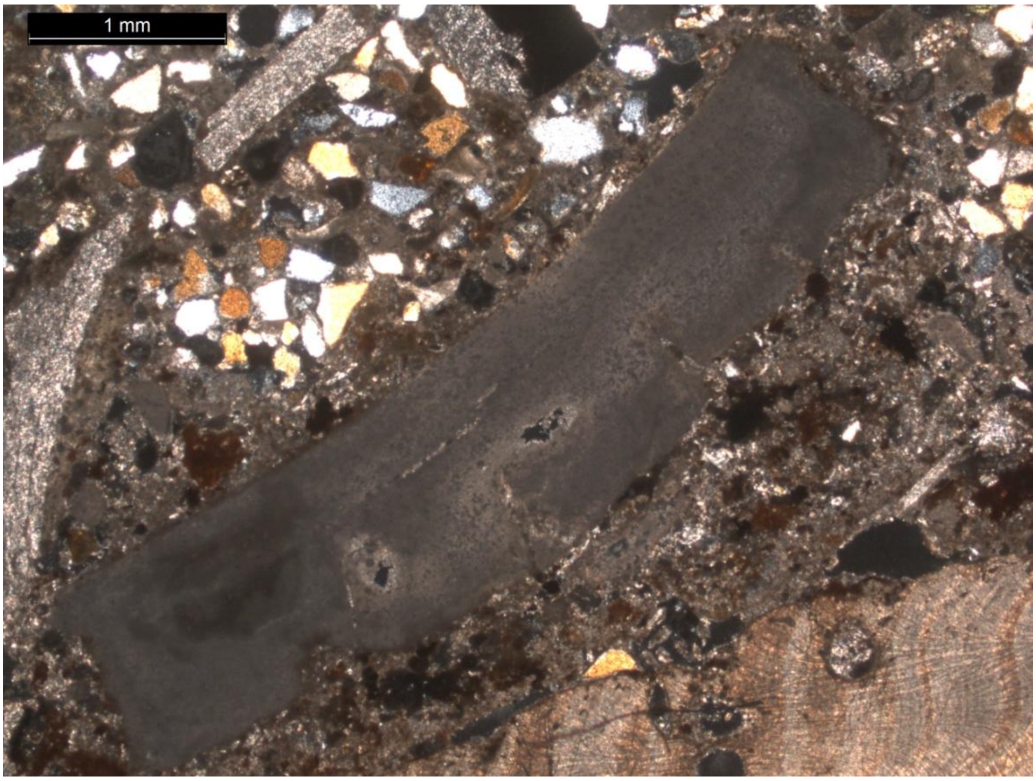

Figure 61 (above) - PTC.09 – range of shell textures including very well-calcined and uncalcined. NB well-tempered binder. XPL; Scale bar 1mm; photomicrograph M. Thacker.

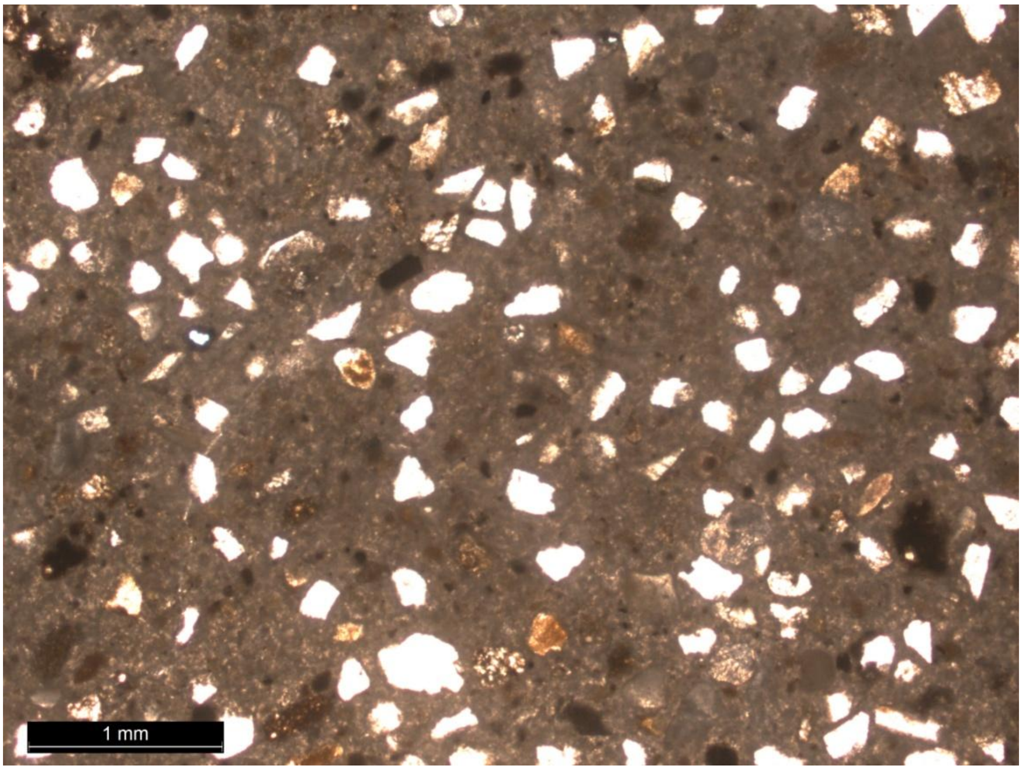

Figure 62 (above) - PTC.010 – general view of binder-rich coating with very fine quartz-rich temper. XPL; Scale bar 1mm; photomicrograph M. Thacker.

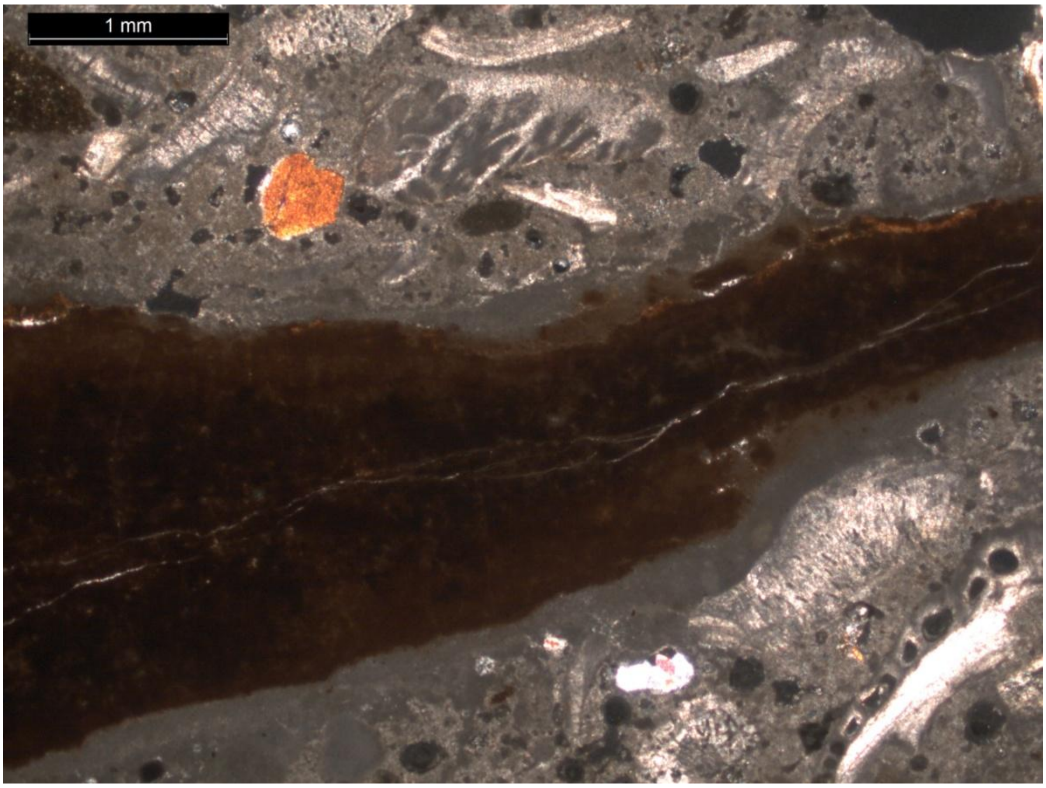

Figure 63 (above) - PTC.011 – Heated red-brown micritic mudstone relict in shell-rich mortar. Note good shell microstructure. XPL; Scale bar 1mm; photomicrograph M. Thacker.

Figure 64 (above) - PTC.012 – Shell relic in very lime-rich homogenous binder. XPL; Scale bar 1mm; photomicrograph M. Thacker.

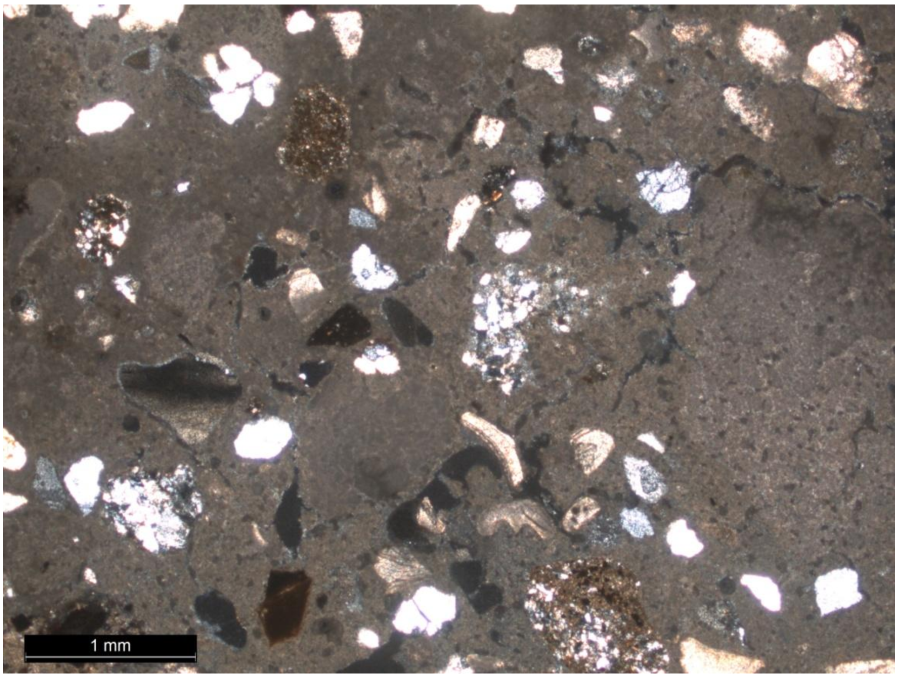

Figure 65 (above) - PTC.013 – general view. XPL; Scale bar 1mm; photomicrograph M. Thacker.

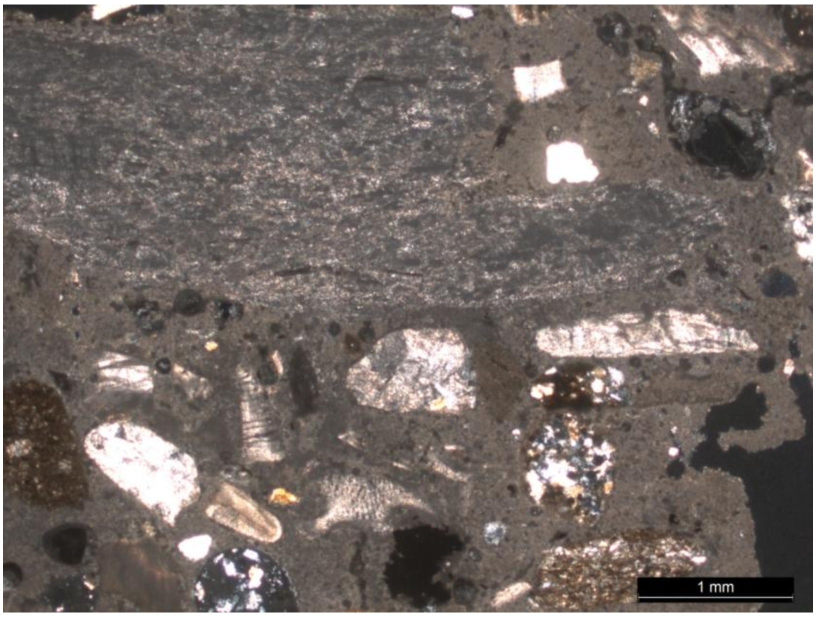

Figure 66 (above) - PTC.014 – Shell relict and shell temper. XPL; Scale bar 1mm; photomicrograph M. Thacker.

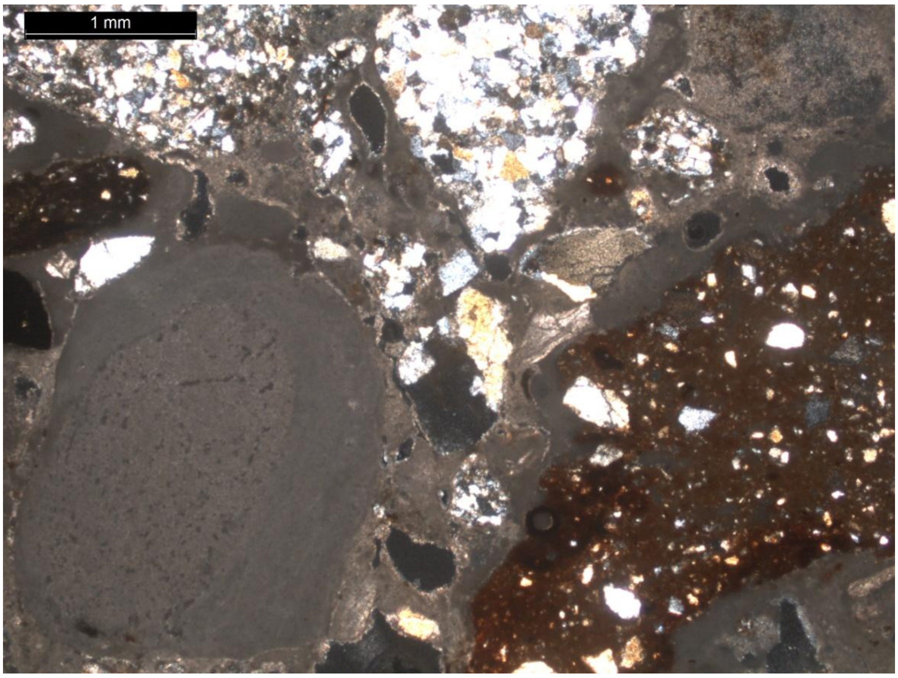

Figure 67 (above) - PTC.015 – Mudstone kiln relict; sandstone-rich added- temper. XPL; Scale bar 1mm; photomicrograph M. Thacker.

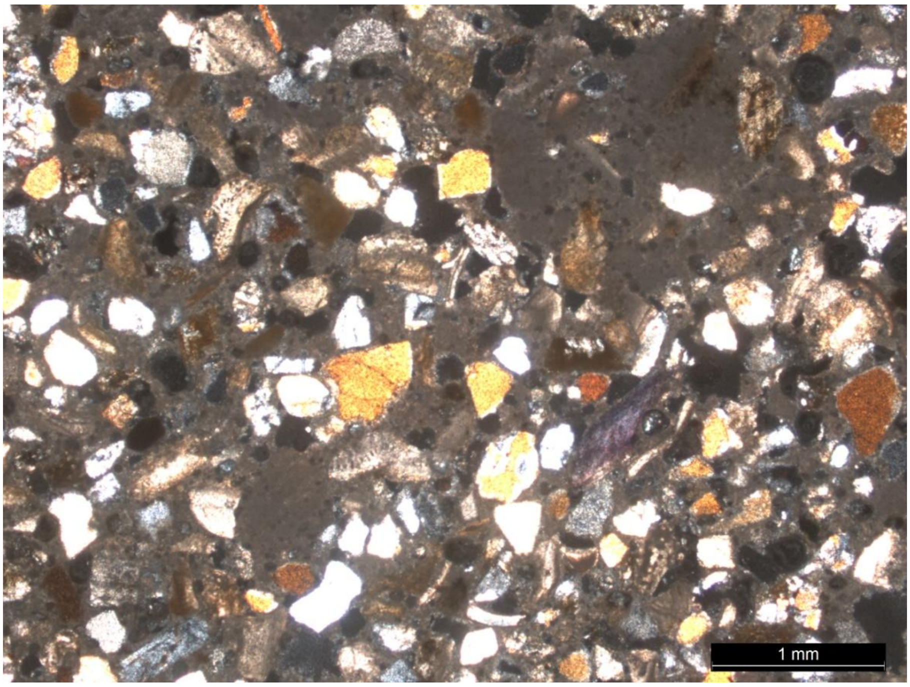

Figure 68 (above) - PTC.016 – General view of well tempered fine lime mortar. XPL; Scale bar 1mm; photomicrograph M. Thacker.

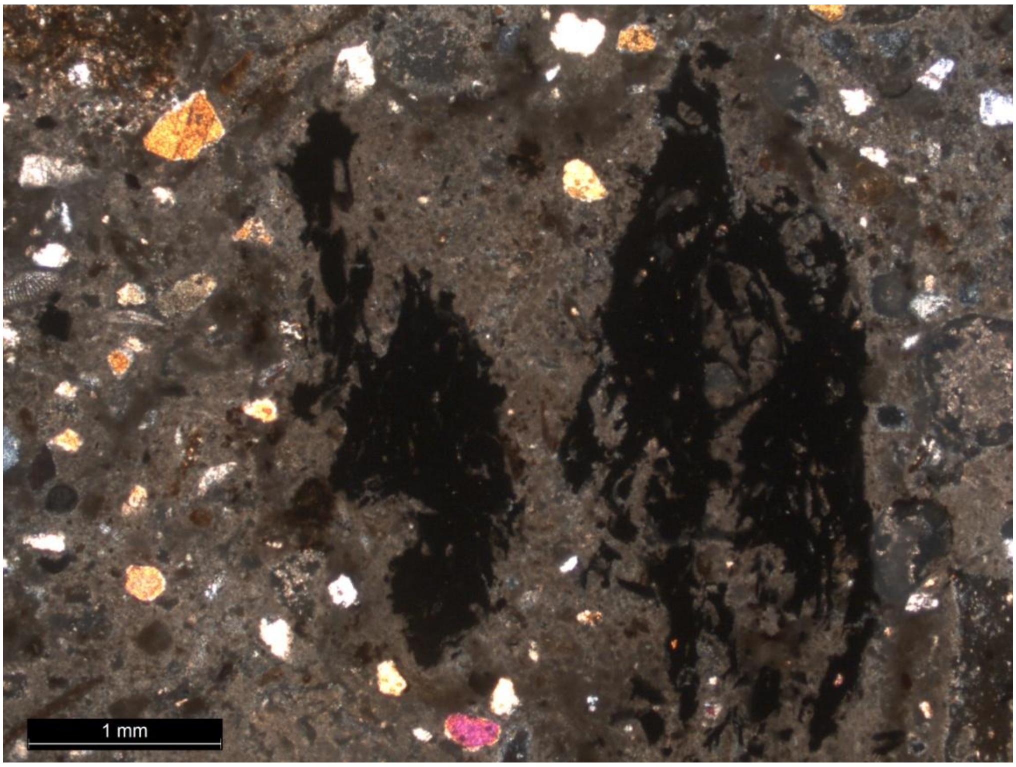

Figure 69 (above) - PTC.017 – fibrous opaque inclusions are probable peat or turf relict fuel. XPL; Scale bar 1mm; photomicrograph M. Thacker.

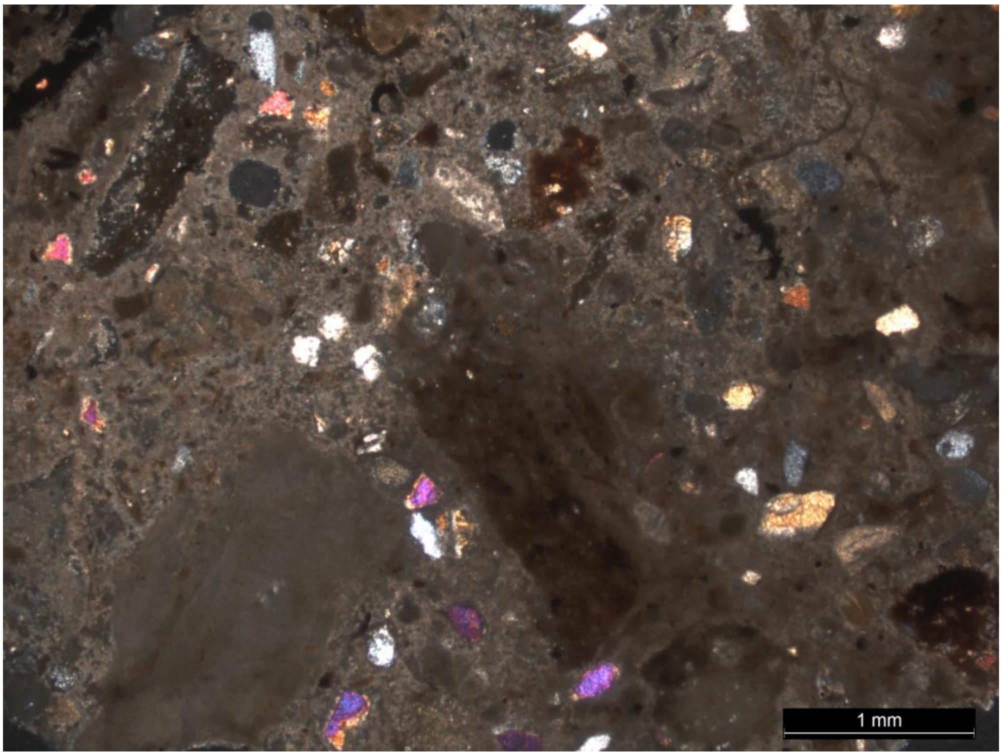

Figure 70 (above) - PTC.017 – Heated and calcined micritic elongate mudstone relicts. XPL; Scale bar 1mm; photomicrograph M. Thacker.

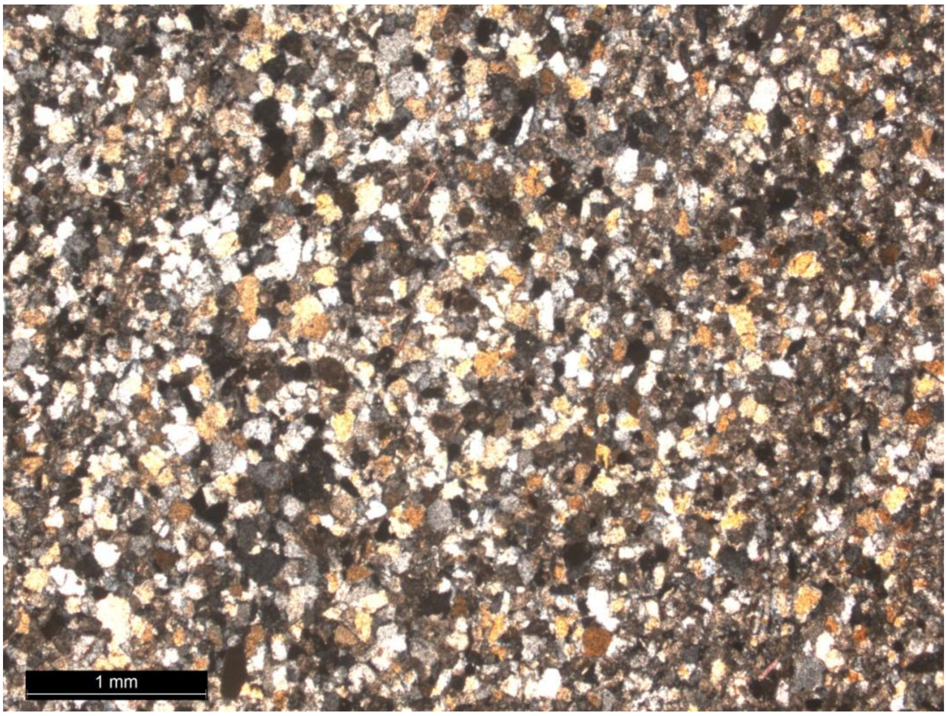

Figure 71 (above) - PTC.Q – Fine-grained well-compressed micaceous sandstone. XPL; Scale bar 1mm; photomicrograph M. Thacker.

5.0 ST PETER'S THURSO – BIBLIOGRAPHY & ACKNOWLEDGEMENTS

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5.2 ACKNOWLEDGEMENTS

Many thanks to Alan McIvor for facilitating the survey, to George Watson for valuable discussion on and off site, to Highland Council and Allan Rutherford (HES) for permission to work at the site and collect loose samples.

APPENDIX 12 - CASE STUDY

UYEA CHAPEL, SHETLAND

Mark Thacker, University of Edinburgh.

Constructing Lordship in North Atlantic Europe. Vol. III.

Appendix case study 12.

Last revision 20-07-2016

DRAFT COPY FOR PHD EXAMINATION SUBMISSION.

SUMMARY

Mortar and masonry survey of the chapel on the Isle of Uyea was undertaken in parallel with the rapid survey of a number of other structures on the island. Building survey at the chapel suggested the primary phase of the building was shell-lime bonded, and this interpretation is supported by thin-section analysis. A probable surviving fragment of the chapel's former chancel was identified, confirming the building had previously been bicameral. The upstanding masonry of the island presents the same progression from shell-lime to clay-bonded to limestone-lime seen elsewhere in Shetland.

CONTENTS

1.0 UYEA CHAPEL - MORTAR, MASONRY & ENVIRONMENT SURVEY

1.1 ENVIRONMENT SURVEY

Uyea chapel is located close to the shore in the south-east of the Isle of Uyea. A small island of approximately 1 x 1.5 miles, the Isle of Uyea is separated from the larger island of Unst (north-east Shetland) by a narrow sound to the north.

UNDERLYING GEOLOGY

Like the surrounding islands of north-east Shetland, the Isle of Uyea is dominated by metamorphic geology and is situated to the east of the shear zone which divides the metamorphic geology of neighbouring Unst from north to south (Mykura 1976, 36-37). Within this Nappe Pile succession, Uyea itself is also divided between the Greenstone block to the west and the Muness group of Phyllites and Pelites in the east (ibid, 35), and it is notable that the chapel site is within this more fertile phyllitic half of the island which was enclosed pasture in the 19th-century (O.S. 1882a). The outcropping rocks around the chapel are essentially schistose.

Whilst there are no calcareous rocks outcropping on the island of Uyea, metamorphic limestone outcrops in both blocks of neighbouring Unst most notably in the Baliasta and Loch of Cliff area (Mykura 1976, 34). This limestone geology was reported in the late 18th-century statistical account, without mention of it being worked, but was clearly being sourced to manufacture lime commercially by the 19th-century (Mouat and Barclay 1791-99, 186; Ingram and Ingram 1841, 45).

5.2.1 SHORE SURVEY

No systematic survey of the shore has yet been undertaken.

5.2.2 WOODLAND AND FUEL

Both Uyea and Unst are essentially treeless islands today. Woodland is not mentioned in either statistical account of the late 18th (Mouat and Barclay 1791-99) or 19th-centuries (Ingram and Ingram 1841) and no woodland is depicted on the late 19th-century Ordnance Survey Maps of either Uyea or Unst (O.S. 1878a; 1878b; 1878c; 1878d; 1880).

Palynological study in south mainland Shetland suggested that *Betula* (birch) and *Corylus* (hazel) woodland was developed between 9,700 and 7,700BP but that the landscape was virtually treeless from 5,000BP (Hulme and Shirriffs 1994). Closer to Uyea, fluctuating small quantities (generally less than 10% TPL) of *Betula*, *Alnus* and *Corylus* pollen were apparent throughout Iron Age levels at Underhoull (Unst), although a core from Belmont (also Unst) suggested that locality was treeless since before the Iron Age (Edwards et al. 2013).

Blanket peat developed on mainland Shetland from around 7,000BP (Hulme and Shirriffs 1994). Both statistical accounts report that, apart from a little imported coal, peat was the general fuel of the parish although this was being exhausted by the late 18th-century and so was being cut on the neighbouring island of Yell (Mouat and Barclay 1791-99; Ingram and Ingram 1841).

5.2.3 LIMEKILN EVIDENCE

No *in situ* limekiln evidence has been reported on Uyea, and none was noted during walkover. A probable lime-kiln lining stone was noted in the chapel building (see below).

A limekiln and numerous quarries are depicted on a late 19th-century map of the neighbouring island of Unst, on the limestone outcrops around Baliasta (O.S. 1882b). Moreover, although not mentioned in the late 18th-century account, the mid-19th-century statistical account describes how:

'There are limestone quarries at Cliff and in the neighbourhood of Baliasta. The tenants of those districts are allowed to work the quarries, and to manufacture the stone into lime on their own account. The lime is usually sold at the rate of one shilling per barrel, and becomes a source of considerable emolument to those who engage in this work.' (Ingram and Ingram 1841, 45).

1.2 BUILDING SURVEY

Much altered chapel/burial aisle complex within a sub-circular burial ground enclosed within a low dry-stone wall. The building is mostly comprised of an apparently single-celled building which generally stands to a level wallhead, with the reduced remains of a gable on the west wall. There is a low entrance into this building in the east wall, with a similar blocked entrance in the west, a centrally-placed large 19th-century freestanding memorial, and no obvious windows. Abutting the west wall externally are the fragmentary remains of a small two-phase cell of built of much larger stones.

These standing remains are comprised of 3 main phases which can be recognised by the bonding materials: a primary lime-bonded bicameral chapel; a secondary abutting clay-bonded western burial aisle of two phases; and finally extensive dry-stone repairs to the primary chapel structure.

1.2.1 CHAPEL

The primary phase mortar is the only lime mortar evident on the site and primary masonry can be recognised by tracing this material. The primary masonry is composed of generally flat-laid schistose stones. The primary mortar is labelled Mortar 1:

General description: Mortar 1 is a fine, very white-coloured lime mortar.

Carbonate kiln-relicts – Mortar 1 is a shell-lime containing a high concentration of heated shell inclusions ranging up to 28mm diameter, dominated by bivalves including clam, oyster and some rare gastropods.

Added-temper – Mortar 1 was tempered by a well-sorted very fine (sub-mm) sand, probably including lithic and shell fractions.

Fuel kiln-relicts – No fuel noted.

Vitreous kiln-relicts – high concentration of large deep-red coloured vitreous inclusions, ranging up to 25mm, which may have a red siltstone protolith. One black and perfectly spherical.

<u>West Nave Wall</u>

Externally, phase 1 work is displayed below a line from current wallhead level, at North corner, to the second quoin up at the South corner. This includes the arch-headed portal. Externally, where the effects of erosion are most pronounced, lime mortar is visible in deep fixed core contexts to at least 250-300mm from the wall face. Where mortar survives best, in some lower courses at the north-west corner, coherent core, beds and coating are displayed. Internally, except in the south west corner, survival of primary lime-bonded masonry is complete to intake/offset level. Generally, there is good survival of lime mortar in masonry beds.

The west wall is 1.0m thick at the doorway; externally, the door way is 1.22m high x 760mm wide with plumb jambs until 800mm above ground; from 800mm a curving corbel arch is formed between the jambs for the full thickness of the wall. Externally, the arch stones to the north have slightly radiating beds laid at a very low angle, to the south they are almost all on the level. This pattern is followed within the reveal, and at the internal face where one very thin stone on the south side of the arch has been laid with a thick uneven mortar bed in the opposite direction to radial. A thick lime coating smoothes the faces of the stones at the intrados, and survives to 25-30mm in places.

Internally, the stonework is beautifully tight, roughly coursed, and poorly bonded. Internally this west wall is not bonded at all to the remaining primary south wall, and at the north the bonding alternates every 3-4 courses only – approximately every 600mm. Externally, at the north corner the quoins are edge-laid, and this section is also poorly bonded to the north wall, where an area of masonry has subsequently slipped.

<u>North Nave wall</u>

The north wall is approximately 900mm wide. Externally, primary masonry only survives in the west, from half to 2/3 of its length, and this section is also characterized by a turf wallhead. There is good mortar survival in core and beds (except where there is a rent in the masonry and the mortar has washed out). Internally, much more primary masonry survives – almost complete to the top 2 courses.

Mid Wall

The mid-wall of the chapel is approximately 930m wide. Internally, primary masonry survives at the south in the lower half of the wall (up to approx. 1.2m high), but in the north only the doorway jambs and some of the lowest courses. Externally, the only surviving primary facing stones are those around the doorway jamb and two or three stones up the remains of the north chancel wall.

Both jambs and the reveals of the doorway are primary. This doorway has inclining and splayed jambs (externally 660- 590mm and internally 680-620mm at ground level and immediately below the impost respectively). The impost protrudes 40mm from the masonry below. The external lintel, here, may be a repair and is no longer bound with mortar to the surrounding masonry. The internal lintel is now ex-situ, but the masonry impression confirms its short length. Internally, the arch stones make use of an obtuse face to retain a very low angle to the horizontal (almost level). It is unlikely centering was used, or necessary, and this is true of both archways.

South Nave Wall

Externally, there is very little primary material surviving in the south wall; the eastern corner is not primary; only the lowest 2-3 courses at the west end are primary. Internally, however, primary masonry survives - to 4-5 courses (approx. 750mm). This primary masonry is very poorly bonded to the phase 1 masonry of the east and mid-gable – in contrast to the later work which overlays it.

North Chancel Wall

Protruding from the north side of the external face of the mid-wall of the chapel are two large stones which are very probably tusking remains of the north wall of the former chancel. These appear to be a single internal face stone, whose internal face is 850mm from the north jamb of the doorway, with a core stone behind to the north.

1.2.2 WESTERN BURIAL AISLE

To the west of the chapel nave is a clay-bonded structure of 2 sub-phases (2a and 2b) which abut and overbuild the phase 1 masonry of the west wall. Within this structure is a broken sandstone memorial with probable 17th-century motifs.

Structurally the masonry of Phase 2a is characterized by a green glacial subsoil clay-mortar, in bedding and core, which bonds very large field stones with rounded arisses. These stones are laid flat and inbanding, within 700mm thick walls.

This phase 2a clay-mortar is also evident within the upper courses of the west wall of the chapel nave, externally including a couple of courses below eaves height, the whole of the surviving portion of the gable, and the west chapel doorway blocking. The clay-bonded gable of the west nave wall, like the other walls of phase 2a, is 700mm thick, forming an internal gable scarcement in the chapel nave of up to 400mm wide.

Evidence for phase 2a also survives in the north and west wall of the western aisle, in places to almost 2 metres high. The north wall abuts the west wall of the chapel 450mm south of the north corner, and contains a doorway, centrally placed within the internal wall face, 1.2m wide doorway, 0.9m from the mid-gable. The west wall was presumably also gabled in phase 2a, although no direct evidence survives.

Phase 2b – abuts phase 2a to form a southern extension to the western aisle, with south and west walls of 550mm thick. The northern doorway of the phase 2a western aisle was now blocked, while the south wall of the phase 2b western aisle is south of the south wall of phase 1, presumably forming an eastern entrance. Given this extension to the western burial aisle, south of the nave wall and east of the west wall of the chapel, it is unlikely the aisle was still roofed in this phase.

1.2.3 BURIAL ENCLOSURE/CHAPEL REPAIR

Phase 3 of the chapel complex is characterized by well-bonded dry-stone masonry with a battered profile which overbuilds the phase 1 lime-bonded masonry of the chapel nave, probably to form a new burial enclosure. This work forms the majority of the south wall (to a level wallhead), much of the east wall, and much of the east end of the north wall. The dry-stone sections of these walls have no turf on the wallhead and much more surface lichen colonization, relative to the lime-bonded sections. It is possible that this work is coeval with the C19th Leisk memorial was erected within this enclosure and no evidence for roofing was noted.

1.2.4 BURIAL GROUND ENCLOSURE WALL

The enclosure wall is dry-stone, up to 1.1m high, double faced with a coping stone; battering from 600mm to 400mm with an entrance to the north of the chapel.

1.2.5 UYEA HALL. (HU60454)

Uyea hall is a ruined large 4-bay house with fireplace inscription suggesting construction in 1818 and a secondary extension to the rear. The primary masonry is coursed rubble with edge-laid blocks, and margin drafted and droved sandstone dressings. Lintels are doubled up.

The primary mortar of the house is a limestone-lime tempered with a 3mm and down local lithic and shell aggregate; with coal fuel inclusions. Some later cement use.

1.2.6 UYEA WHITEHOUSE (HU 61110)

This is a small ruined 1.5 storey domestic rubble-built building, with well-bonded and almost coursed and snecked reasonably formal masonry, and quoining which is a mixture of dressed buff sandstone and local schist. At first glance the west gable appears clay-bonded and lime coated and the lime here has a clearly defined depth within the joints of approximately 160mm. Further investigation, however, reveals that externally this corner has a fully lime-bonded beds and core. At the east end of the north elevation the outer face has collapsed, to leave the internal face standing. This is clearly fully lime bedded as is the hollow-cored section of masonry adjacent to the west. This is mostly a lime-bonded building, coated internally and externally.

2.0 UYEA - SAMPLE CONTEXTS & ANALYSIS

2.1 SAMPLE CONTEXTS

2.1.1 MORTAR SAMPLE CONTEXTS

Two loose samples of lime mortar were collected from on the ground at the foot of the internal face of the west wall of the chapel, one of which appeared to be a coating fragment.

UCS.01 - West wall, internal face; 0.6 south of internal face of north wall. Loose ex-situ probable coating.

UCS.02 – East wall, external face; 0.9 south of south doorway jamb; Loose ex-situ probable core.

2.1.2 ENVIRONMENTAL CONTEXTS

No environmental samples collected to date.

2.1.3 ANNOTATED PLANS OF SAMPLE CONTEXTS

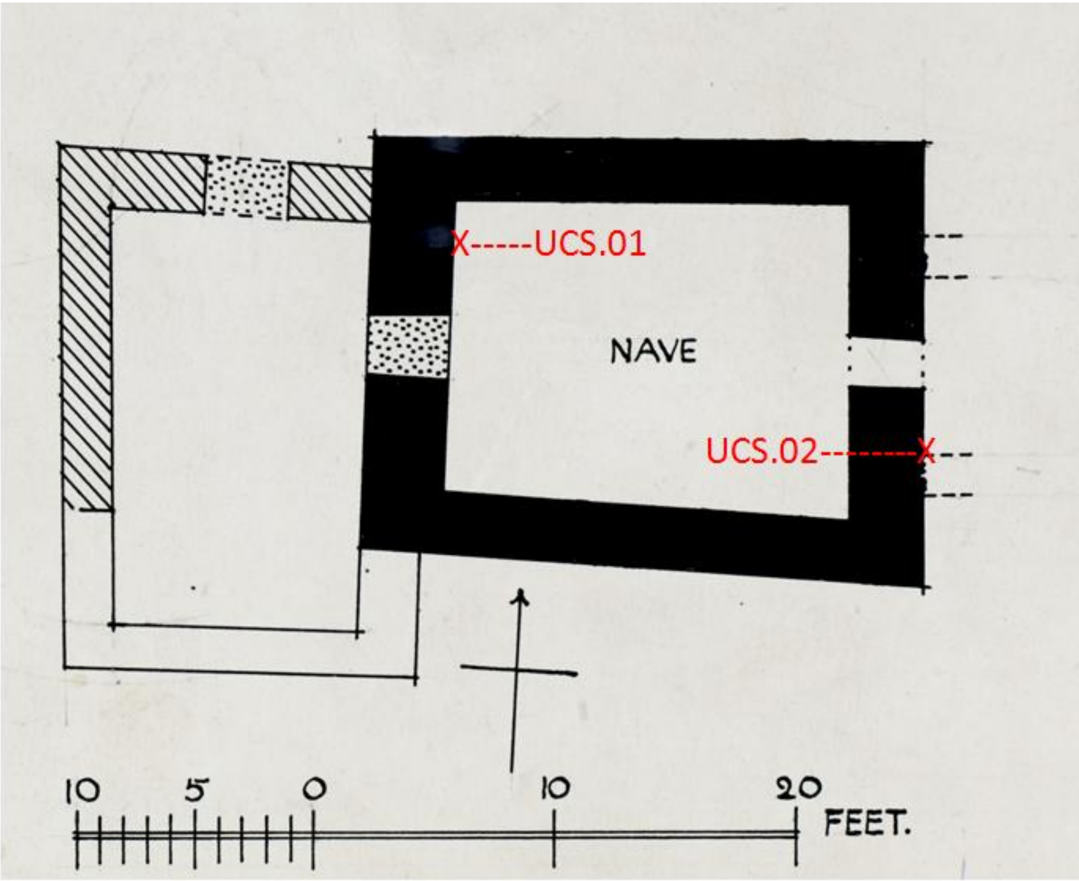

Figure 1 – Annotated (RCAHMS 1930) plan of Uyea chapel showing mortar sample contexts (original plan image DP 236387 ©crown copyright: Historic Environment Scotland. Licensor Canmore.org.uk).

2.2 SAMPLE ANALYSIS

2.2.1 MORTAR THIN SECTION ANALYSIS

UCS.02

X 2 SECTIONS TO APPROXIMATELY 45 X 25MM, both containing a single phase largely fine and white bimodal composite material, dominated by very fine (sub-mm) granular material, but also including very fine, white curving inclusions to 6 x 0.5mm and a low concentration of angular black inclusions to 5 x 4mm.

Carbonate kiln-relicts – UCS.02 is a shell-lime containing a high concentration of altered shell clasts to 6mm long. These are fine bivalve and include *O. edulis* with some lamellar microstructure and core-rim texture in figures) but a more general micritisation to a white cryptocrystallinity in optical continuity with the mortar matrix.

Added-temper – UCS.02 was tempered with a well-sorted mixture of lithic and unheated shell clasts which generally ranges up to 0.4mm and occasionally to 0.7mm. The lithic fraction is dominated by angular to subrounded quartz clasts and some more rounded schist, which to shell faction includes bivalve, gastropod and bryophytes.

Fuel – UCS.02 was turf/peat-fired, and one section in particular contains a large (5 x 4mm) angular, very fibrous and quartz-included probable peat inclusion. More amorphous and fractured peat-char relicts to 2.5mm are also included. Two or three inclusions display vesicles which may be springs and suggest wood charcoal, but this is very tentative at present.

Vitreous material - Some probable early stage vitreous reaction products with a sandstone protolith.

3.0 CONCLUDING DISCUSSION & FURTHER WORK

3.1 CONCLUDING DISCUSSION

The above study has clearly demonstrated a developmental sequence in masonry construction on Uyea of around 600+ years, which begins with the peat-fired shell-lime mortar bonded and coated bicameral chapel of probable 12th-century date, continues with a clay-bonded burial aisle of probable 17th-century date, and ends with a series of coal-fired limestone-lime mortar bonded domestic buildings and a dry-stone burial enclosure. Each of these masonry types is completely consistent with the regional corpus.

The most significant building of the series is clearly the chapel, and the above study has demonstrated that both doorways are primary but that no window details survive. The discovery of the probable fragment of the chancel wall is an important discovery and, assuming this structure was centrally placed relative to the chancel arch, allows for a former chancel of 2.36m internal (N-S) width. The east face of this mid-wall, between this chancel wall fragment and the chancel arch is lime-bonded primary fabric and that only a single lime mortar appears to survive on site suggests this bicameral nave and chancel building is single phase.

The peat-fired shell-lime primary mortar of the chapel is eroded but in excellent condition and the flat-laid primary stonework is very tightly-jointed. The lack of lateral bonding within the primary masonry, however, is remarkable, both in the general walling (particularly internally) and between the walls at internal corners.

The surviving stones of the western burial aisle are much larger and more irregular than those of the chapel, suggesting these are not reused chapel material. This may suggest the chapel remained largely complete at this time, although a large section of the west wall was rebuilt during one of these secondary clay-bonded phases. As the west chapel doorway was blocked in this post-Reformation phase, any putative use of the primary building would have required another entrance.

The lack of lateral bonding in the stonework of the primary chapel is a striking contrast with the well-bonded dry-stone masonry of the final burial enclosure phase. It appears certain that by the 19th-century the primary chapel was very much reduced with very large sections of collapsed walling. The dry-stone work of this phase in the chapel mid-wall confirms that the chancel was no longer part of the complex by this period, and it is probable any surviving remains were removed in this period of work to allow access to the newly configured burial enclosure.

3.2 FURTHER WORK

Further recording and analysis of the chapel is important as this building, and especially the chancel arch is at great risk of further collapse and requires conservation.

4.0 FIGURES

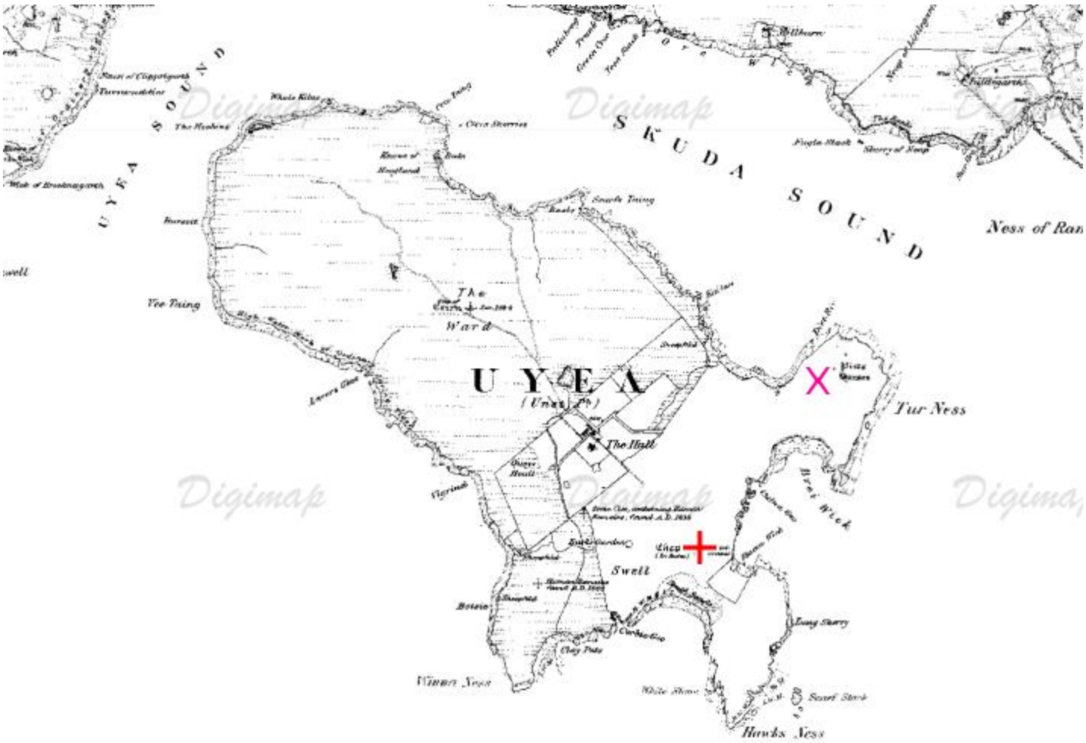

Figure 2 (above) – Detail of O.S. (1882a) showing the island of Uyea in Uyeasound off the coast of the island of Unst (Shetland). Uyea is approximately 1 x 1.5miles. The map has been annotated to show the relative positions of the bicameral chapel and some recently recorded Norse longhouses (Smith 2005) approximately 720m to the north-east.

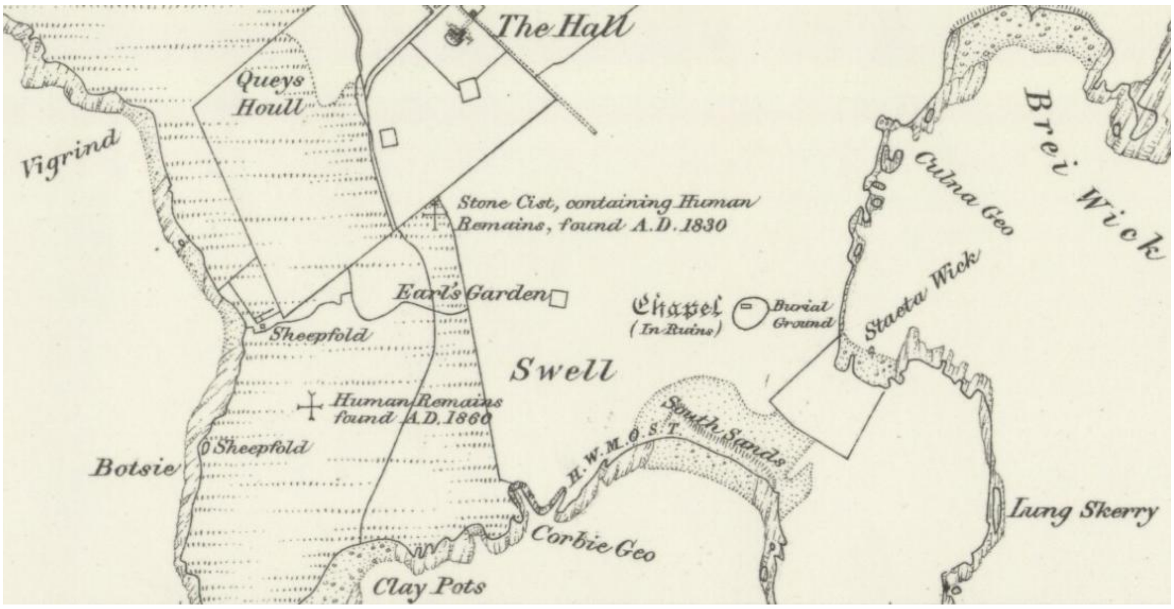

Figure 3 (above) – Further detail of O.S. (1882a) showing relative positions of the chapel, burial ground, the 19th-century Laird's Hall and nearby beaches. (By kind permission NLS maps).

4.1 – ON-SITE ANALYSIS

Figure 4 (above) - Uyea chapel and burial ground from the west-northwest. No Scale; photograph Mark Thacker.

Figure 5 (above) – Uyea chapel from the north-east showing cruciform probable Norse grave-markers in the foreground. No Scale; photograph Mark Thacker.

Figure 6 (above) – Uyea chapel nave and western burial aisle from the north. Note the clear change in masonry with primary lime-bonded masonry in the west, to the right of this image, has a turf-colonised wallhead. Scale 500mm; photograph Mark Thacker.

Figure 7 (above) – External face of North wall of Uyea chapel nave. N.B. clear phase change half way along the wall. Scale 500mm; photograph Mark Thacker.

Figure 8 (above) – Uyea chapel and western burial aisle from the west. Scale 500mm; photograph Mark Thacker.

Figure 9 (above) – Uyea chapel and western burial aisle from the south. Scale 500mm; photograph Mark Thacker.

Figure 10 (above) – Uyea chapel and western burial aisle from the south. This is almost completely dominated by well-bonded phase 3 dry-stone masonry associated with the late burial enclosure. Scale 500mm; photograph Mark Thacker.

Figure 11 (above) – Uyea chapel nave from the east. Apart from the doorway jambs the visible wall faces are dominated by Phase 3 dry-stone masonry. Scale 500mm; photograph Mark Thacker.

Figure 12 (above) – Uyea chapel, probable remains of north wall of chancel, protruding from the east face of the mid-wall of the chapel. Scale 500mm; photograph Mark Thacker

Figure 13 (above) – Uyea Chapel, external face west nave doorway. Scale 500mm; photograph Mark Thacker.

Figure 14 (above) – Uyea Chapel, east face of mid-wall chancel arch. Scale 500mm; photograph Mark Thacker.

Figure 15 (above) – Uyea Chapel, west face of mid-wall chancel arch. Scale 500mm; photograph Mark Thacker

Figure 16 (above) – Uyea chapel nave, internal face of south wall. Phase 1 lime-bonded masonry below, overbuilt by Phase 3 dry-stone masonry. Note remarkably poor bonding of primary masonry, and resultant risbond joints. Scale 500mm; photograph Mark Thacker

Figure 17 (above) – Uyea chapel nave, internal face of north wall. Tightly jointed poorly-bonded masonry. Scale 500mm; photograph Mark Thacker

Figure 18 (above) – Uyea chapel nave, internal face of west wall. Vitrified possible kiln lining stone reused in phase 1 masonry. Scale 10mm; photograph Mark Thacker

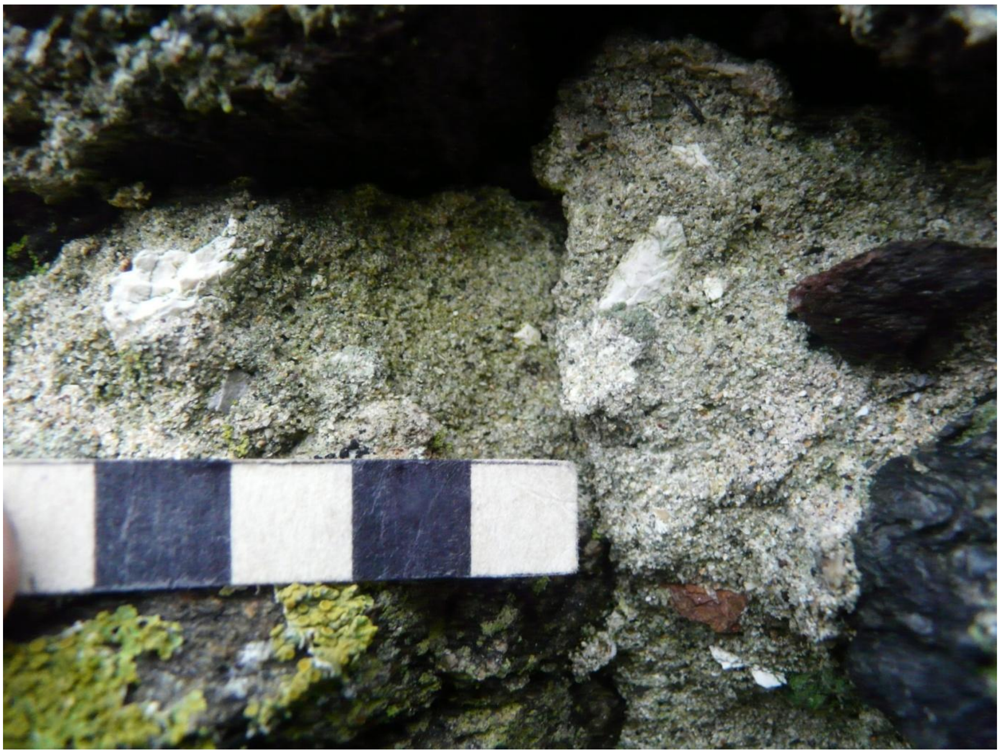

Figure 19 (above) – Uyea chapel nave. Mortar 1. Scale 10mm; photograph Mark Thacker

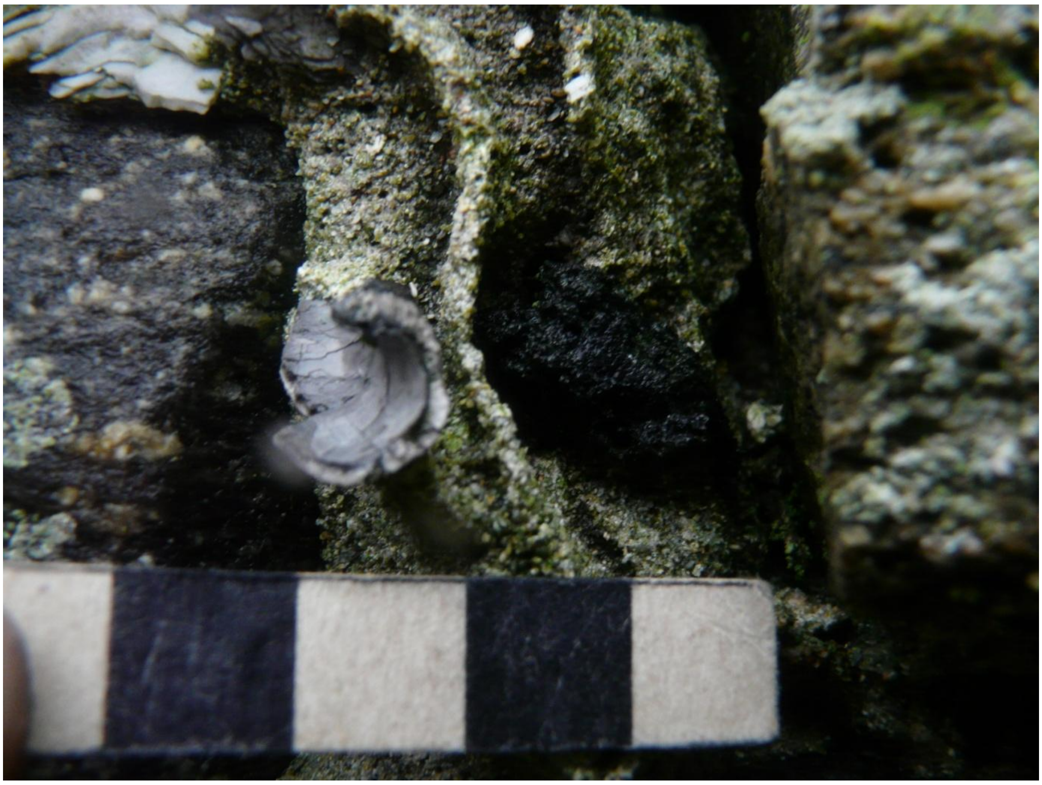

Figure 20 (above) – Uyea chapel nave. Mortar 1. Scale 10mm; photograph Mark Thacker

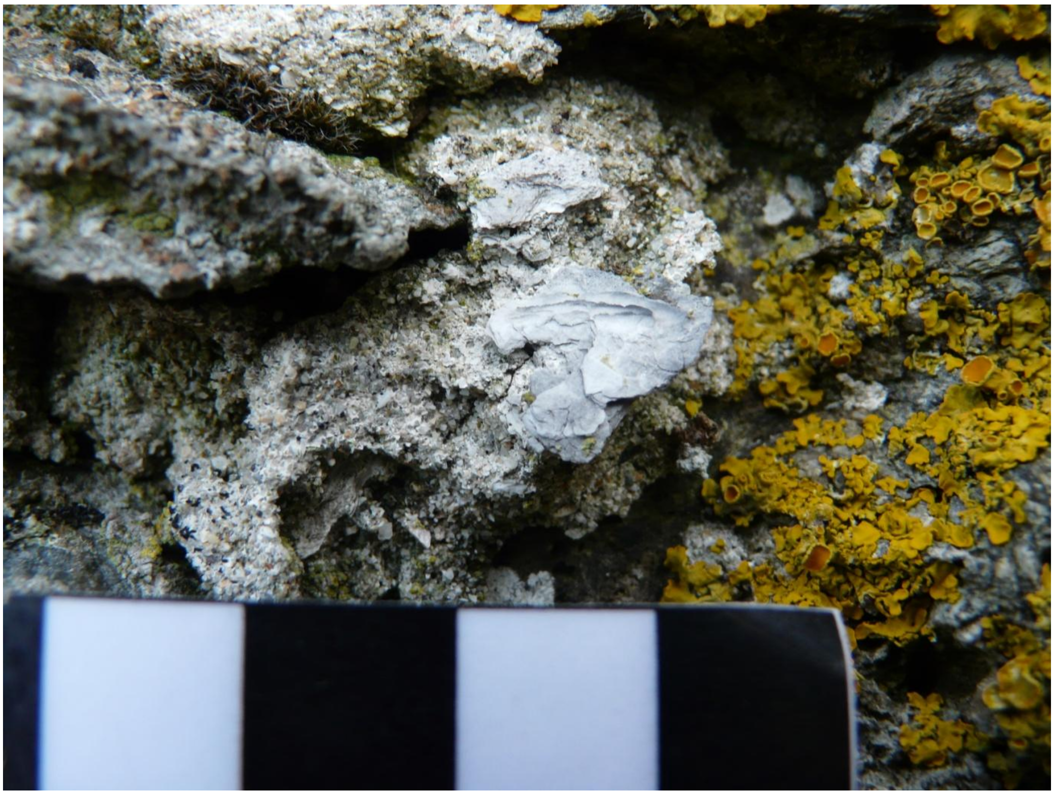

Figure 21 (above). Heated oyster shell fragment. Internal face of west wall of Uyea chapel. Scale 10mm; photograph Mark Thacker.

4.2 – LAB-BASED ANALYSIS

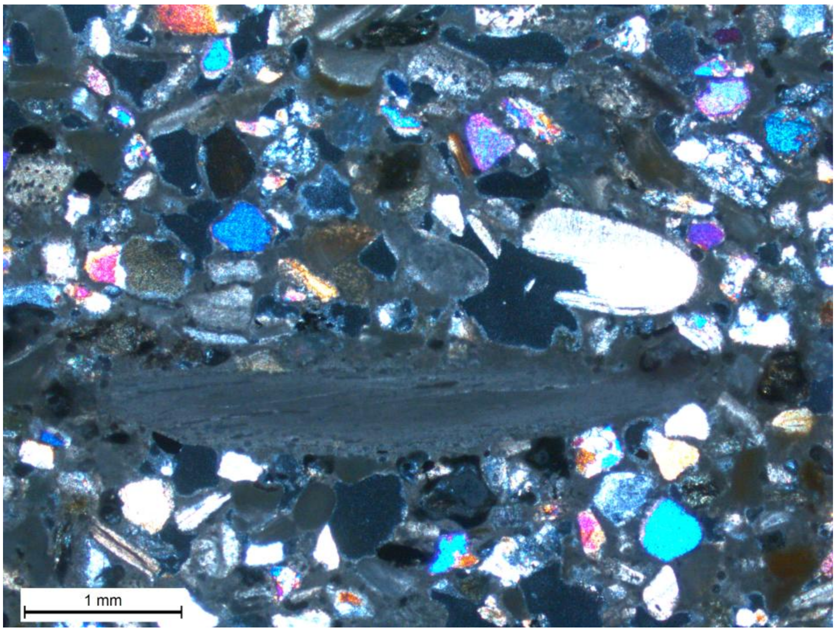

Figure 22 (above) UCS.02 XPL. Scale bar 1.0mm; photomicrograph Mark Thacker.

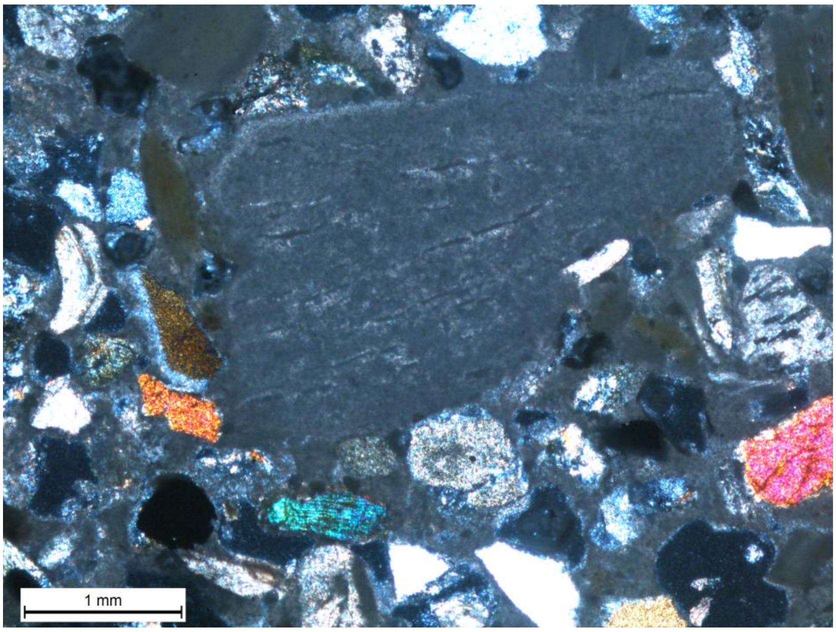

Figure 23 (above) UCS.02 XPL. Scale bar 1.0mm; photomicrograph Mark Thacker.

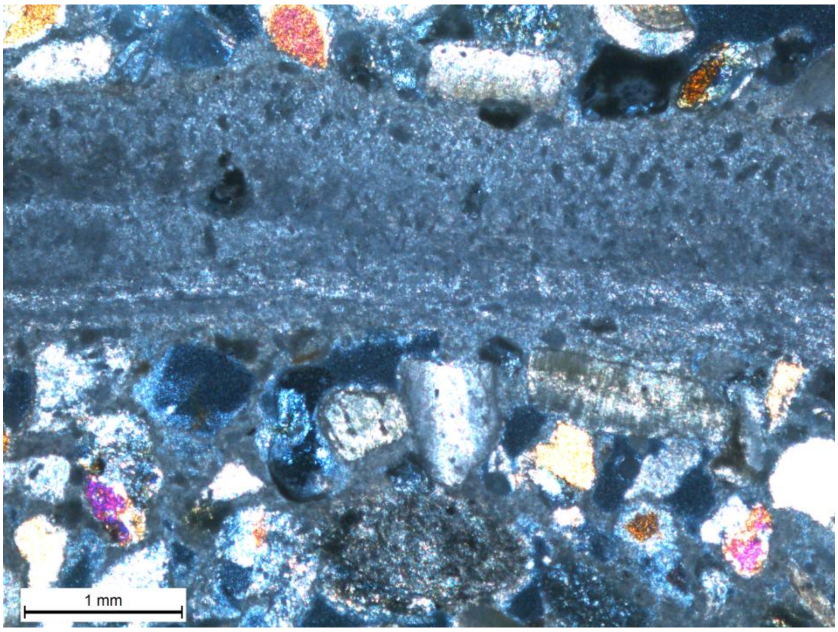

Figure 24 (above) UCS.02 XPL. Scale bar 1.0mm; photomicrograph Mark Thacker.

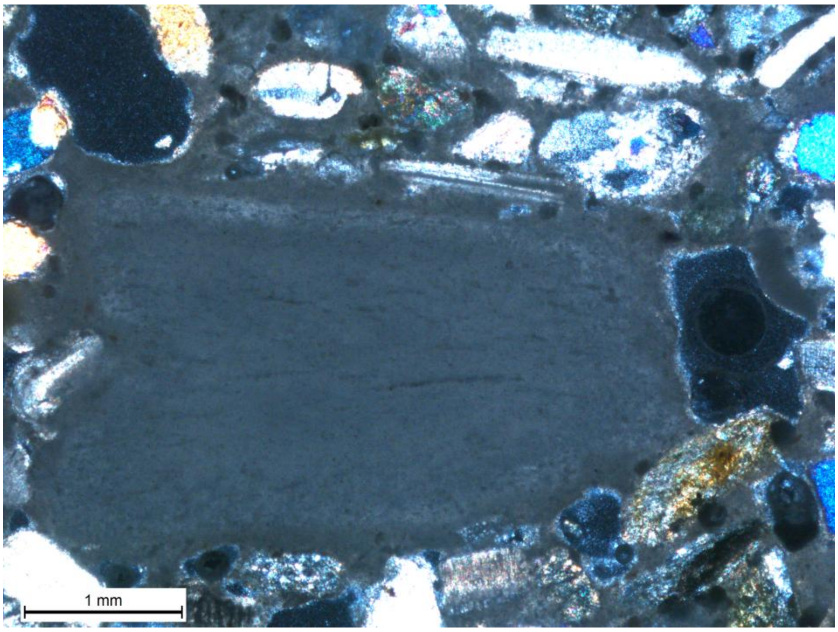

Figure 25 (above) - UCS.02 XPL. Scale bar 1.0mm; photomicrograph Mark Thacker.

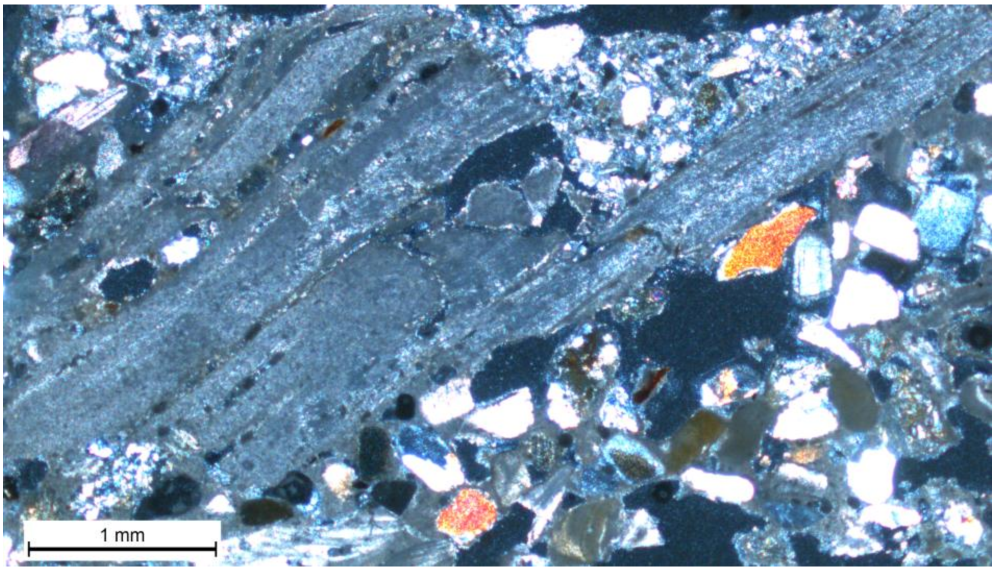

Figure 26 (above) UCS.02 *O. edulis*. XPL. Scale bar 1.0mm; photomicrograph Mark Thacker.

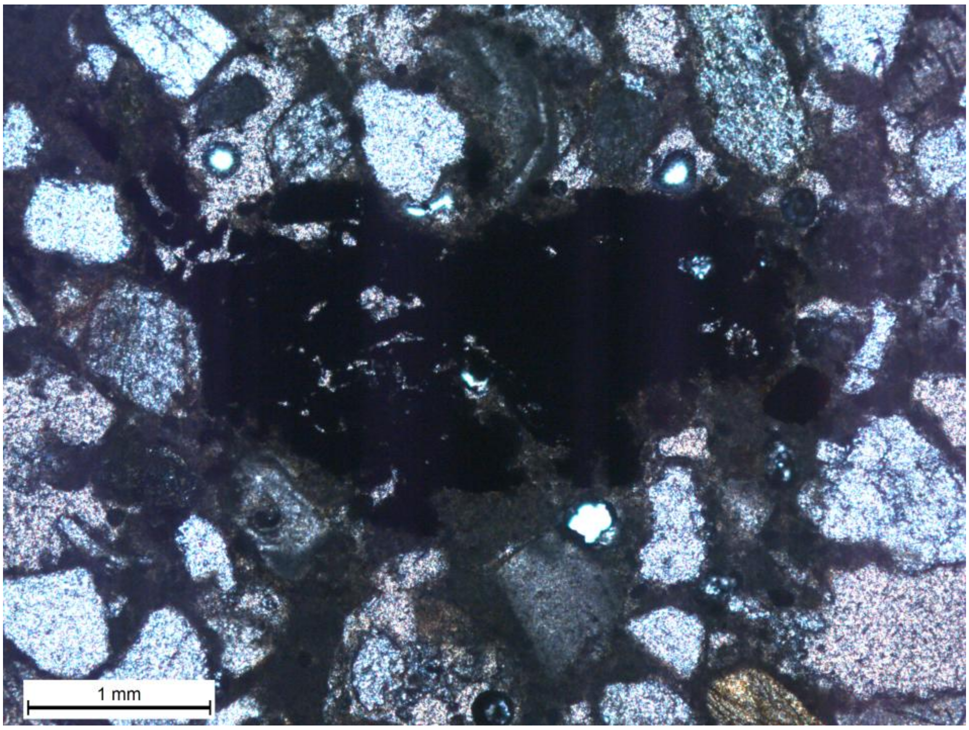

Figure 27 (above) - UCS.02 peat char fuel relict. PPL; Scale bar 1.0mm; photomicrograph Mark Thacker.

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5.2 ACKNOWLEDGEMENTS

Many thanks to Peter, the owner of the Isle of Uyea, for very generously ferrying and providing a quad for my first visit, and allowing for loose samples to be collected. Also to the staff of the nearby fish-farm for ferrying me to and from the island on my second visit.

APPENDIX 13 - CASE STUDY

CASTLE FINCHARN

.

Mark Thacker, University of Edinburgh.

Constructing Lordship in North Atlantic Europe. Vol. III.

Appendix case study 13.

Last revision 20-07-2016

DRAFT COPY FOR PHD EXAMINATION SUBMISSION.

SUMMARY

On site masonry and mortar survey of Castle Fincharn and the nearby medieval parish church of Kilneuair was combined with environment survey and lab-based analysis in an attempt to identify local material sources. Survey suggested that church and castle were constructed in similar masonry styles and with similar wood-fired limestone-lime mortar materials. Lab-based analysis indicated the material had been manufactured from Tayvallich limestone, fired with young hazel wood and tempered with a lacustrine schistose aggregate. Each of these mortar materials were identified in the local environment during walkover survey and comparative microscopic analysis of collected samples.

Radiocarbon analysis of five relict fuel samples removed from the castle mortar returned a very narrow range of dates, supporting the previous interpretation that the building is largely single phase, and indicating that the mortar fuel had died between 1219 and 1269AD. These results correlate very well with the royal charter confirming the site to Gillescop MacGillechrist in 1240, and with the 13th-century architectural evidence surviving at the church.

Castle Fincharn is the first medieval building in Scotland to be directly radiocarbon dated and these results of this PhD case study are discussed further in the main thesis text and forthcoming publication.

CONTENTS

1.0 MORTAR, MASONRY & ENVIRONMENT SURVEY

1.1 FINCHARN ENVIRONMENT SURVEY

Castle Fincharn is located at NM 89840 04367 on a promontory protruding from the southern shore of deep freshwater loch of Loch Awe in mid Argyll. Like much of the landscape close to the Great Glen, Loch Awe trends NE-SW, and the castles position allows extensive views in both directions. Inland the view from the Castle Fincharn is restricted to the general bounds of the farm of the same name, with enclosed fields of pasture surrounding site rising to high hills in the south.

1.1.1 UNDERLYING GEOLOGY

The farm and castle of Fincharn are located within the eroded roots the Grampian Caledonides, within a lithostratigraphic subgroup of the Dalradian, called the Tayvallich, which stretches from Donegal in Ireland to Banchory in North-east Scotland (Stephenson and Gould 1995). The Tayvallich subgroup has itself been characterized by a sequence of carbonates, but locally in the south-west Highlands of Scotland includes an episode of Basic igneous extrusion (ibid; Gower 1977) which has had a striking effect on the geology and topography of mid-Argyll. Within this metamorphic and igneous environment the NE-SW oriented Loch Awe syncline dominates the landscape around Fincharn (Borradaile 1970; 1977) and has flooded to form the large freshwater Loch of the same name.

For this project, British Geological Society collated information regarding interpretations of the bedrock and surface geology of the immediate area around Fincharn were studied for through Edina Digimap, and this indicates the local geology of Fincharn itself is dominated by metabasic rocks intruded within which is a SE-NW trending basalt and microgabbro dyke swarm and two small outcrops of felsites. A relatively large outcrop of Tayvallich meta-limestone had also been mapped in the area, between the Fincharn farmhouse and Killenuair church, and this outcrop was plotted upon the first edition 6-inch map of the locality below (see figures).
The identification of this limestone outcrop during walkover survey was simplified by the discovery of a previously unrecorded lime kiln immediately adjacent the farm track at NM 89831 (see below for further description. In this locality, stone bluffs rise quite suddenly above the cleared and enclosed pasture below, and limestone outcrops protrude through the shallow clay-rich soil/overburden in a number of places. The limestone of this outcrop is oriented in beds between vertical and a western dip of approximately 45°, inter-bedded with a very coarse young conglomerate, and in hand sample displays regular veining in two planes of approximately 70° apart. It is generally very dark blue-black in colour and quite coarse-grained with a reasonably high concentration of large quartz grains (5-7mm). These quartz grains are often protruding as they emerge from the eroding meta-sedimentary matrix in which they are held.

Another limestone quarry, 6 miles north-north-west of the castle and close to Loch Phearsain, in northern Loch Awe was also visited. The quarry lies at NM852137, within a narrow outcrop of limestone and slate of neoproterozoic /Dalradian age (Borradaile 1977). This 'Shira' limestone has been previously described as 'black, sandy and brecciated' (ibid, 158) the highest beds in this context were very coherent, fine-grained and dark blue in colour, with a high concentration of fine, randomly oriented white-coloured veining, and also appears to be a reasonably close match for the limestone seen within the mortars of Castle Fincharn.

1.1.2 AGGREGATE SURVEY

Identifying possible aggregate sources within the local environment was much less straightforward. No terrigenous gravel quarries were noted either during walkover, or in map evidence, and local sources appeared restricted to the loch shore itself and the nearby Fincharn River. Although these may seem obvious aggregate sources, both sites display only insignificant volumes of gravels today.

1.1.3 WOODLAND

Although the south-east side of Loch Awe is heavily wooded today, much of this is blanket spruce plantation of the late 20th century (see figures). A previously almost treeless landscape pertained around Fincharn is depicted on the first edition Ordnance Survey map of the locality (Ordnance Survey 1875; hereafter O.S.1), otherwise including the small plantation to the west of the castle and some smaller discrete open stands of trees along the lochside and at the foot of the Fincharn river, all of which survive today. Taking a wider view of the whole of Loch Awe, however, the ground immediately around Fincharn is probably the least wooded lochside area, and this does not appear directly related to the size of the fenced inbye land.

In the 19th century the woodland further north and east (on the south bank at Dalavich and the *Coille Chuil* north of *Ard Chonnell*; and most particularly on the north-west shore, opposite Ardchonnel between the rivers Avich and Fionain) is much more extensive, and a palynological study undertaken within this large area of woodland will be discussed further below. Further north, however, areas of woodland again become scarcer, until the fork in the loch just south of the Castle of Kilchurn, where substantial areas of woodland are again depicted on both sides of the loch, but especially on the north shore at *Coille Drisaig* and *Coille Leitire*.

Although far less extensive, there are some areas of woodland depicted on OS.1 near Fincharn on both the north and the south shore - north-east of the castle site in the area below *Creag Laganach* at *Rubha Cuilinn* – and these are apparently depicted with a symbol suggesting deciduous trees.

The Roy map of 1747-55 is drawn at a larger scale and so depictions of trees are less detailed, but a similar general picture emerges here, with similarly extensive tracts of woodland in the upper reaches of the loch nearer Ardchonnel and Kilchurn, and some smaller woodland areas on the opposite shore and again around *Rubha Cuilinn* to the north and east of a treeless Fincharn Farm. Pont's map of 1583-96 is perhaps more problematic in that, although the whole bounds of Loch Awe are drawn in map 14, this is the northern edge of the manuscript and lacks almost any detail of the land north of the loch. On the south bank, however, a similar relative distribution of woodland is depicted as the later maps above, and care has been taken to depict some seemingly not inconsiderable tracts of woodland between Fincharn and *Ard Chonnel*, in that same persistent context to the north-east of the castle site.

To add to these cartographic depictions we appear to have a valuable description of this woodland from the statistical accounts which reports that although the parish 'cannot by any means be said to be wooded...There is also a considerable portion of natural wood, as Oak, hazel, birch &c., along Lochaweside" (Campbell 1844, 681). As the parish of Glassary only includes a very small section of lochaweside, this would appear to refer to the same south bank of the loch, north-east of Fincharn. This entry appears to be repeated in Lewis's (1847, 47) topographical dictionary of Scotland where in Kilmichael Glassary 'fine specimens [of oak birch and hazel] are to be seen on the shores of Loch Awe'. In the late 18th-century the general domestic fuel of the parish was reported to be peat (Campbell 1791-9, 664), but unusually at Fincharn, we can tentatively push this post-medieval documentary woodland evidence back into the late medieval period, wherein the 1501 Skreymgeour petition to the pope noted above describes the church of Killenuair as being in '…quite a wooded place near the sea shore…' (Fuller 1994, no. 493).

Within MacVean and Ratcliffe's reconstruction of Scottish pre-clearance Holocene woodland, the shores of Loch Awe suggested to have been completely forested and are located within their broadly characterised Oak/birch woodland zone, and a small 'semi-natural' relict of this is depicted as surviving at the head of the loch (1962).

This reconstruction has since been largely supported by palynological data which includes an important and very detailed study of the vegetational history of the upper loch (Sansum 2004a; 2004b). This study divided the medieval period into two main zones wherein the pollen from the first zone (880 – 1240 AD) was considered to evidence a generally 'open woodland...of Oak, Aldar and Hazel...[with an]... influx of birch ...[peaked in the 12th century and was]...mediated by grazing (ibid:214), whilst by the second zone (1240-1590AD) 'pollen accumulation rates are appreciably lower… signify[ing] a long period when the woodland on the site became more open than that represented in the previous zone…and wetter'.(ibid: 219).

Before the above documentary and cartographic evidence had been examined, walkover survey had already suggested that, out-with the fields and plantations of Fincharn farm itself, the closest apparently naturally regenerating woodland to the castle site was on the south bank of the loch to the north and east of the castle site (so an area broadly coextensive with the historic descriptions and depictions noted above). A more focused

walkover survey of the closest 2.8km stretch of this woodland was subsequently undertaken, from NM 9333 06193 (*Leacain Mor* Forest Drive) to NM 91038 04746 (the bridge at *allt Dubh Uisge*), over 3-4 hours during March 2015, when leaf growth was barely budding although the *Corylus* (hazel) displayed catkins and some remnant leaves. The survey was divided into stages, each of which was walked twice and the tree taxa and habits were generally described.
Stage 1 (NM9333 06193 to 92493 05711) includes some very steeply sloping stretches of loch side and is dominated by multiple stems of *Corylus* (Hazel). Other taxa included tall standards of *Fraxinus* (Ash) and *Fagus* (Beech), some rare large mature *Quercus* (Oak) and scrub *Betula* (Birch). The *Fraxinus* standards are remarkably tall and straight .

Stage 2 (NM92493 05711 to 91854 05382) includes some more level ground at the Ardgay picnic site where a small 'parkland' context of large mature *Fagus* and immature *Fraxinus* and *Betula pendula* (silver birch) is also evident. Above the road the hillside is dominated by a large recent Spruce plantation, but further south and west below the road the ground quickly becomes steep and the rocky ground is covered with deep mosses and leafmould and is crossed by lots of streams. There is one small, flat bankside area which is very wet.

This steeper ground is dominated by *Fraxinus* standards with a widespread *Corylus* underwood. The *Fraxinus* standards are always of single trunk morphology in both immature and mature trees, some of which are very large with trunks measuring to 800mm diameter. The *Corylus* underwood develops as multiples of up to 50 stems which generally includes 1-2 older stems to 75-100mm amongst a mass of fine young whips of 15-25mm diameter. Although these multiple *Corylus* stems always emerge from below ground level, rather than from a stool, and the different sizes suggest a range of stem ages, each appears to represent a single individual.

There are some more minor concentrations of *Betula* here, both mature and immature, and in singles and multiples of 2-3 stems. No *Quercus* was noted.

Stage 3 NM91854 05382 to 90997 469 05088 includes a wide low lying area of intermittently flooded ground which is dominated by *Betula,* whilst the steeper ground above is dominated by *Corylus* beneath a few standards of *Fraxinus*, some *Rosaceae* (Hawthorn), and a couple of spruce outliers.

Stage 4 NM 91469 to 91038 04813 includes more low-lying intermittently flooded areas of loch side dominated by *Betula,* and dryer areas of *Betula, Fagus* and/or *Fraxinus* standards with a *Corylus* underwood. There are more small areas of young spruce – either planted or colonizing – and from this point the naturally generated woodland is more heavily compromised and so the walkover was halted.

In summary, this area of woodland presents a distinctive character dominated by *Fraxinus* standards and *Corylus* underwood. The shrubby habit of the *Corylus*, in which individuals present a multitude of thin stems of different ages in cycles of 'natural coppice' morphologies was most salient, and this contrasts markedly with the standard very straight single-trunk tree habit of the fraxinus standards. Other tree taxa were present and these included a very low concentration of *Quercus* (oak) standards and some significant localized populations of *Betula* (birch) in more flooded areas.

1.1.4 THE LIME KILN

Although not recorded on the first edition Ordnance Survey (1875) map, the limekiln is located at NM 89831 03770 and appears to be a classic 19th century externally square-planned kiln with a single arched draw hole/vent. The external masonry of the structure is composed of lime-bedded and coated black limestone, but the internal lining no longer visibly survives above the rubble, debris and undergrowth which now fills the inside. A number of lime-burning relicts were also however noted within the ruined structure, including some heated limestone clasts.

The kiln is conveniently sited below the remains of a quarry (NM89849 03755) which surely served the kiln and both lie only some 600m from the castle site.

1.2 BUILDING SURVEY

1.2.1 CASTLE FINCHARN

The first site visit to Fincharn Castle included a 2-3 hour survey of the building in April 2013, as a part of the South-West Region rapid masonry survey programme of this thesis, and in line with that methodology no preparatory documentary search of the site was undertaken apart from reading the brief survey information contained in the RCAHMS website which used to pinpoint the building on the map.

The ruined remains of this building were found to occupy the whole summit of a small but steep outcrop of metabasic rock of up to approximately 6m high. The structure has clearly suffered some extensive episodes of collapse, as very large sections of masonry are now missing, including some large areas of internal facing, and much of the south wall and south end of the west wall are reduced to 'ground' level. Elsewhere, however, the east and north end of the west walls remain standing to almost two full storeys of approximately 5m total height, and these display evidence of first floor joist sockets, arch-headed first floor windows, a ground-floor slit window, and the east jamb and lintel of the ground floor doorway in the north wall. Although instability in the upstanding fabric, and the steep and uneven nature of the ground externally precludes the use of simple staging to reach the very highest masonry courses, the inside of the ruin is so full of debris that much of the internal masonry of both surviving storeys and all four walls can be accessed

This mix of upstanding survival and complete collapse has made the constructional form of the building very visible; exposing large volumes of core rubble and a number of full face-core-face wall cross-sections. Both the internal and external faces of the castle masonry have been laid in a remarkably consistent coursed masonry style, composed of large (sometimes edge-laid) blocks of a hard, dark-coloured and coarsely textured meta-mafic rock, which present a large surface area and define much of the height of each course to between 400-450mm. The stones of the lowest courses are slightly larger, and all blocks have been pinned, levelled and 'snecked' with smaller fissile flat-laid stones, many of which are of different lithogies including a blue metalimestone, a red coarsely crystalline porphyritic material and a sandy-textured possible psammite. No evidence of hammer-dressing or quarrying was noted in this stonework, however, and the very rounded arrises suggest the material has been sourced from superficial contexts, rather than quarried bedrock. Quoining is accomplished by a combination of techniques including the use of finely-dressed sandstone, which survives externally at one ground floor window, and has probably been robbed-out from elsewhere. The external corners of the ground floor are generally softly rounded with smaller flat-laid stone, which may be secondary, but internally, rubble quoins and arch-heads are also constructed with these same small fissile lithogies which also contrasts with the formality of the general face-work. All building stones, including those of the core, are laid with a horizontal bottom bed, and the formal coursing of the wall faces is maintained right through the wall core, suggesting the building has been constructed course by level course.

The partial collapse at Fincharn has also exposed large volumes of constructional lime mortar which appears generally contiguous within core, beds and coatings contexts, and its consistency throughout the whole ruined structure suggests that the surviving masonry (perhaps out-with the rounded ground-floor corners) is predominantly single phase. This then is Fincharn Mortar 1:

General Description - Mortar 1 is a homogeneous yellow lime mortar.

Carbonate kiln-relicts - Mortar 1 is a limestone-lime containing a very high concentration of heated limestone relicts grading up to 60mm. Heating evidence includes rubification and concentric zonation of contrasting core/rim textures and colours. The poorly heated 'protolith' core is very dark-coloured blue-black and coarsely crystalline.

Added-Temper – Mortar 1 was very poorly tempered. Very little temper is visible in-situ. Occasional rounded to subrounded lithic gravels to 10mm are present and no shell is evident.

Fuel kiln-relicts – Mortar 1 was wood-fired and contains a high concentration of wood-charcoal inclusions to 10mm+.

1.2.2 KILLENUAIR CHURCH

The upstanding remains of the church of Killenuair are located approximately 1,000m west-south-west of the castle of Fincharn at NM 8892 0368. This appears to be a structure of two main phases with two remarkably contrasting rubble masonry styles.

The east end of the church displays formally coursed masonry with regular course heights of between 400-50mm high. Almost course and snecked, the larger builders are generally touching and generally present a large and strictly speaking edge-laid face, although most are actually deep in the bed also. These are big stones with rounded arrises, levelled and packed by much sharper flat-laid fissile rubble. This masonry survives best in the largely upstanding east end of the south wall, which contains a dressed trefoil-headed piscina internally, and the south-end of the east wall, which contains the dressed south jamb of a splayed east window with angled chisel tool-marks on the stone surfaces. That this south jamb of the east window is only 1220mm from the internal face of the south wall strongly suggests the east window was of twin lancet design although all external dressings and quoins of this phase are missing.

Although the more closely wooded environment surrounding the building has encouraged vigorous moss growth which makes mortar characterisation more challenging, the ruined condition of the structure has exposed a number of masonry cross-sections and large volumes of wall core are visible. The eastern primary phase of this structure contains a consistent lime mortar in contiguous core, bed and internal mortar contexts which (although no external coatings appeared to survive) appears to be single phase. This then is Mortar 2:

General description – Mortar 2 is a very yellow coarse lime mortar.

Carbonate kiln-relicts – Mortar 2 is a limestone-lime containing a high concentration of buff limestone relicts and white probable lime inclusions.

Added-temper – Mortar 2 was tempered with a well-sorted/poorly graded bimodal lithic material, with a high concentration of very fine (sub-mm) sand included within which are subrounded to subangular lithic clasts to 30mm.

Fuel kiln-relicts – Mortar 2 was wood-fired, although only a single wood-charcoal inclusion was noted.

The contrasting masonry of the west end of the church clearly abuts the masonry of the east end described above, making use of a former window for additional keying in the south wall and leaving a slight reveal within the thickness of the north wall abutment. This later masonry is much less formal, displaying face-work dominated by flat-laid stretchers laid in an uncoursed masonry style. The south windows are lintel-headed with a very wide daylight opening, a wide splay angle internally and stepped sills. There are a large number of putlog holes in evidence in the south wall, but these are not level sockets and so unlikely to have supported a gallery.

Phase 2 also displays a contiguous lime-bonded core and beds and once more this is a limestone-lime, but much more consistently tempered with a fine, generally sub-mm aggregate, and a medium to high concentration of charcoal inclusions.

Located within the west end of the church is a carved sandstone font of medieval character.

1.2.3 SUMMARY OF ON-SITE FABRIC SURVEY

The constructional form of the primary phases of these two buildings is remarkable similar. Both display similarly formally coursed masonry styles with very similar course heights, and the walls of both buildings have been bound and coated with wood-fired limestone-lime mortars. The architectural form of the remains of the east window of the church suggest a constructional date in the 13th-century, but although the architectural form of the castle is more ambiguous, the high concentration of mortar fuel relicts within accessible core contexts may present an opportunity for radiocarbon dating.

2.0 SAMPLE CONTEXTS AND ANALYSIS

Given the apparent archaeological potential of the mortar materials at this site, with the kind support of the owner and Historic Scotland scheduled monument consent was granted to remove fixed mortar samples from the castle for further lab-based analysis. The sampling strategy privileged the removal of samples from deep wall-core contexts, and from a diverse range of accessible contexts around the building.

Samples were removed with a combination of a mallet and chisel and strong sharp knife, and immediately stored in labelled and sealed plastic sample bags. Within 24 hours the mortar and environmental samples were air-dried in a warm lab, and the relict-fuel samples were stored in a fridge at approximately 5^{o}C.

2.1 SAMPLE CONTEXTS

Building sample contexts were recorded by photograph, and as x, y and z coordinates hand-measured relative to fixed building features such as wall faces, lintels or jambs. Environmental sample contexts from the wider environment were recorded by hand-held GPS.

2.1.1 MORTAR SAMPLE CONTEXTS

Thirteen fixed and a number of loose mortar samples were removed from the castle ruin itself for further lab-based analysis. These included:

FCA.A – Charcoal; 30 x 15mm; South wall; ground floor; core context.

0.330m back from internal (north) face of wall; 1.650m west of internal (west) face of east wall; 0.710m below bottom of joist socket lintel.

FCA.B – Charcoal; 10 x 12 X 5mm; East wall; first floor; core context.

0.380m back from internal (west) face of wall; 1.550m north of internal (north) face of south wall; 0.340m above bottom of joist socket lintel.

FCA.C – Charcoal; 12 x 20 x 5mm; Large ex-situ fragment of formerly first floor masonry inside monument; 0.800m back from visible (now sky-facing) face; 0.420m back from splaying face (now facing south).

FCA.D – Charcoal; 30 x 20 X 10mm; West wall; first floor; core context.

0.760m back from internal (east) face of wall; 1.030 north of north jamb of adjacent splaying window reveal, at external face; 0.900m above bottom of joist socket lintel.

FCA.E – Charcoal; 10 x 8 X 4mm; West wall; ground floor; core context.

0.470m back from internal (east) face of wall; 0.650m north of north jamb of joist socket; 0.080m below bottom of joist socket lintel.

FCA.F – Charcoal; 5 x 4 X 3mm; West wall; ground floor, core context.

0.430m back from internal (east) face of wall; 0.200m north of adjacent and above first floor splaying reveal at internal face; 0.400m above top of large recess lintel.

FCA.G – Charcoal; 20 x 20 X 12mm; North wall; ground floor; core context.

0.220m back from external (north) face; 0.780m east of surviving east jamb, mid-wall, of adjacent doorway splaying reveal; 0.220m above bottom of drawbar socket lintel.

FCA.H – Charcoal; 20 x 10 X 12mm; North wall; first floor; core context.

0.390m back from internal (south) face of north wall; 0.650m east of east jamb of doorway at internal (south) elevation face; 1.580m above bottom of door lintel.

FCA.I – Charcoal; 15 X 12mm; East wall; ground/first floor; core context.

0.620m back from external (east) face of wall; 0.500m north of north jamb of first floor splaying window reveal, mid-wall; 0.380m above bottom of ground floor window lintel to north.

FCA.J – Charcoal; 15 x 10mm; West wall; ground floor; core context.

0.410m south of south jamb of joist socket; 0.065m below bottom of lintel of joist socket; 0.370m back from internal (east) face of wall.

FCA.K – Charcoal; 10 x 8mm; West wall; ground floor; core context.

0.515m back from internal (east) face of wall; 0.200m north of adjacent and above first floor splaying reveal at internal face; 0.500m above top of large recess lintel.

FCA.L – Limestone; 20 x 15mm; West wall; first floor; core context.

0.440m back from internal (east) face of wall; 0.230m north of north jamb of adjacent first floor joist socket; 0.700m above bottom of recess lintel.

FCA.M - Lime mortar; 3 fragments of varying dimensions; West wall; foundation courses; bed/core context. 1.220m below foundation scarcement; 0.230m back from external (west) face of wall; 2.650m north of the line of the internal (north) face of the south wall.

2.1.2 ENVIRONMENTAL CONTEXTS

Three limestone samples and a number of aggregate samples were collected from the wider environment for further lab-based analysis. Both bedrock limestone samples are dark blue-coloured lithogies which are a relatively good match in hand sample for the castle mortars, whilst the buff-coloured sample from the limekiln appeared to be heated limestone relict.

FCA.P was sampled from a quarry close to Loch Phearsain, in northern Loch Awe. (NM852137)

FCA.Q was sampled from Fincharn Farm, above a quarry (NM89849)

FCA.R is a loose piece of limestone recovered from the limekiln on Fincharn Farm (NM 89831)

FCA.S was a mixed gravel and sand sample collected from the south shore of Loch Awe, south-west of the castle ruin at NM89827.

2.1.3 ANNOTATED DRAWINGS OF MORTAR SAMPLE CONTEXTS

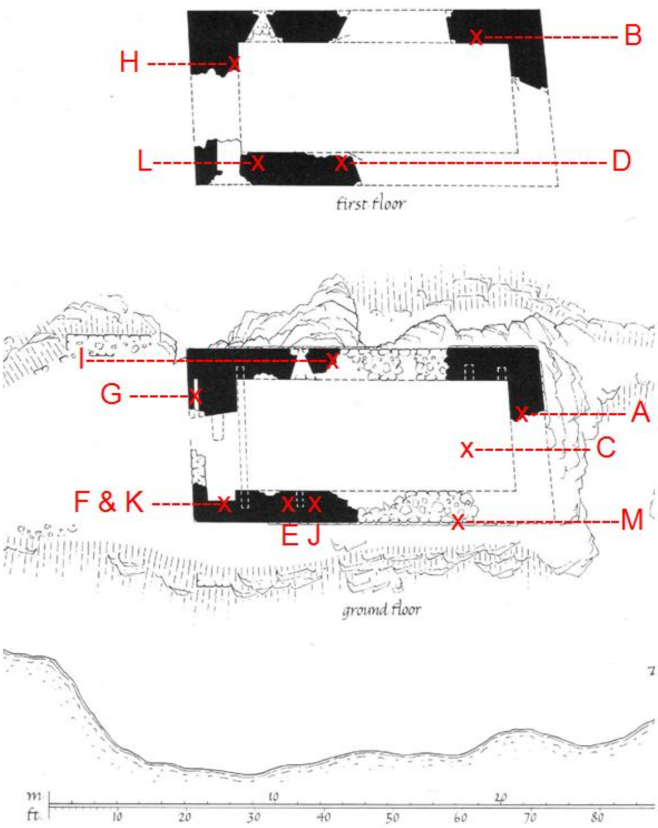


Figure 1 (above) – Annotated ground and first floor plans Castle Fincharn, showing mortar sample contexts. (original plan image DP172541 ©crown copyright: Historic Environment Scotland. Licensor Canmore.org.uk).

2.2 SAMPLE ANALYSIS

2.2.1 MORTAR ANALYSIS

All mortar samples were sawn, dried and surface impregnated with epoxy resin, before being ground, mounted on clear slides and cut-off to 1mm thick. These 'thick sections' were ground and polished for recording and analysis in reflected light to X60.

Further samples were then remounted and polished to a 30µm thin section, and analysed petrographically in polarized light to higher degrees of magnification.

2.2.1.1 THICK-SECTION EVALUATION

FCA.01a – Three thick sections were prepared from this single mortar sample. The sections are very coherent, displaying a well tempered very light buff-coloured lime binder matrix (see figures). When dry, this binder is so light coloured that it is hardly indistinguishable from white on the munsell colour system, although very light buff does describes it better, and the material is much more yellow when damp.

Material composition and distribution is uniform across these sections, and the temper tends toward a bimodal distribution of coarse and fine lithic material. The coarse temper fraction occupies approximately 5% of each section and is generally comprised of dark (blue/grey to brown/black) rounded/subrounded and often elongate lithic clasts to 6mm. Some of these clasts are red coloured whilst others display a layered bedding or schistosity. One particularly bright orange/brown angular fine-grained clast to 4mm is salient in one section. The section also display large (to 5mm), subangular to subrounded, blocky, very dark brown/red lithic included clasts but it is unclear whether these represent temper inclusions or reaction products.

The finer temper fraction is generally sub-mm, but includes some larger clasts to 2-3mm also. This material occupies approximately 30% of the section area, and is comprised of visually similar lithic materials to the coarse fraction.

At higher magnification it is apparent that, although well-tempered, the aggregate within this sample is generally well supported by the binder matrix and grain-to-grain contact is rare. Much of the lithic temper is evidently quartz-rich.

A low concentration of rounded and sometimes elongate lime inclusions are also apparent which vary in colour from a dark yellow, to a lighter buff colour very similar to that of the general matrix, to white.

No fuel or vitreous material was noted.

FCA.01b – This is an ex-situ lithic mortar inclusion measuring 35 x 20 x 40mm which was characterised on site as a limestone relict and from which one section was prepared.

At x1, this apparently buff-coloured material was found to be a predominantly blue-grey coloured, hard, crystalline probable limestone, with a thin highly-altered rim of approximately 1-1.5mm thick.

At higher magnification quartz clasts are evident throughout the section, and a single white-coloured luminous vein, 1mm thick, may be quartz also.

FCA.M – Two sections were prepared from this bedding sample which x-sectioned the mortar joint. The sections are coherent and quite robust.

At x1, a high concentration of lithic temper is apparent within this sample, which is uniform across both sections. This is poorly-sorted, rounded to subrounded and grading to 4-5mm. Within one section two angular buff, probable lime inclusions are also apparent to 2-2.5mm. The binder fraction appears much less voluminous than in FCA.01.

At higher magnifications a relatively high incidence of grain-supported temper is evident – a feature coincident with a lower matrix ratio. The temper is similarly quartz-rich, and displays similar characteristics of schistosity. One rounded temper clast displays a multitude of acicular or rod-shaped brown crystals which may be biotite, whilst one of the angular lime inclusions also displays a red, possibly iron-or clay-rich ‘vein’ within an otherwise quite granular fine texture.

FCA-L - Three sections were prepared which attempted to cross-section the obvious concentric structure of this core mortar inclusion, which is very similar to FCA.01b already described, although here the altered rim is much thicker.

At x1 the sample appears to be a rounded/subrounded, dark buff/yellow fine-textured lithic clast. Within the core of this sample, however, is a contrastingly blue-grey, harder crystalline material, whose rounded/subrounded shape reflects that of the larger whole. This is likely to be kiln-relict composed of a surviving blue-grey calcareous crystalline core source material, which varies from 10-25mm diameter, surrounded by a 4-7mm rim of partially calcined buff material.

At higher magnification, in this section orientation, the calcareous core appears to display no bedding orientation, and includes white angular mineral clasts up to almost 1mm, which are probably quartz. At this magnification up to 3 concentric core zones may be described, before the more distinct change in colour and texture associated with the outer buff-coloured rim.

The calcined rim itself also includes fine lithic clasts, generally less than 100µm, which are angular in shape and blue/grey and/or white in colour. These are probably quartz-rich and lithic.

<u>THIN SECTIONS</u>

<u>FCA.01a</u>

General Description - Poorly-sorted mixture of probable lithic fragments generally supported by a binder matrix. An heterogeneous distribution of the materials here and resultant localized textures at finer scales. There are relatively very large areas of highly calcined relic calcareous clasts, and other areas with a very high concentration of fine quartz-rich lithic temper. The binder is a light brown microsparitic/cryptocrystalline, highly birefringent/b-fabric calcite matrix.

Carbonate kiln-relicts – FCA.01a is a limestone-lime and contains locally high concentrations of limestone clasts which display a variety of alteration textures.

Added-temper – FCA.01a is lithic tempered with a poorly-sorted mixture of rounded to angular schists (with some possible gneiss grades), fine quartzite, monocrystalline quartz and (albite-twinned) plagioclase. Much of this material is fractured and strained out of shape and this is especially evident in the monocrystalline quartz which is often slightly elongate also. No shell material is apparent.

Fuel kiln-relicts – FCA.01a was wood-fired and he section contains a low concentration of charcoal relicts.

FCA.01b

The core of this sample is generally fine-grained quartz included metamorphic limestone. Highly crystalline, this is a dense recrystallised material with distorted high-birefringent calcite crystals meeting in tight triple-point junctions, with clear planes of cleavage. Some calcite crystals are up to 3mm x 2mm.

The included quartz is seen throughout the section in varying concentrations, and in mono- and polycrystalline (‘quartzite’) crystals. The quartz fraction is often highly fractured and undulose, and in one context forms a polycrystalline vein (Fig. 10, FCA.01b 2.5X XPL).

At higher magnifications, the process by which the polycrystalline limestone forms a cryptocrystalline lime binder, in this section takes place along a clearly defined ‘reaction front’, wherein included quartz now tempers the mortar matrix.

FCA.L is dominated by a large subrounded partially-calcined limestone relic which displays distinctive, concentric zones of alteration. At its apparently unaltered core, the heterogeneity and relatively coarse texture of the calcite is most distinctive and a remarkably good comparative match for the meta-limestone sample FCA.Q is described below. The calcite veining and subrounded quartz clasts to 1mm are also distinctive and support this suggestion.

Usefully, this clast is surrounded by a mortar matrix with which the more thoroughly altered rim of the limestone clast is approaching optical continuity - although the grain boundary remains just distinct. This is important in confirming that this Fincharn limestone is a lime-source relict and not an aggregate inclusion. The mortar matrix in this section is tempered with a fine, subangular to subrounded quartz-rich aggregate, consistent with the finer grades of FCA.S.

FCA.M

The mortar contains angular to subangular well calcined limestone relics to 3mm, and although the general calcitic texture has been lost to calcination these relics do display the characteristic calcite veining and quartz inclusions of environmental sample FCA.Q. Although somewhat porous, probably as a result of weathering and dissolution, this section is very well tempered, with a high concentration of matrix-supported lithics. These are generally fine and quartz-rich schist and gneiss, and igneous doleritic or basaltic lithogies, but larger elongate more rounded and mica-rich clasts are also apparent.

2.2.2 ENVIRONMENTAL SAMPLE ANALYSIS

FCA.P

A very fine-grained, microsparitic metalimestone, with a remarkably homogeneous and dense grain-supported texture. Most crystal sizes may be measured in single microns and larger discrete polycrystalline calcite contexts are rare. The veining, noted in hand sample, is sparitic calcite and crystal sizes between 0.2-0.8mm are general in veins up to 1.0mm wide; quartz, surrounded by calcite, is rarely present in some veins. In brief summary the section suggests this bed of the outcrop should be characterised as a very pure metalimestone.

FCA.Q

In thin section, the amorphous/heterogeneous texture of sample FCA.Q contrasts markedly with the homogenous texture of sample FCA.P described above. FCA.Q is also a much coarser material, with grain supported calcite crystals ranging from 50 microns to 0.5mm. The veining is calcitic, microsparitic and, in contrast with the general texture of the section, equidimensional. Both poly- and monocrystalline subrounded quartz clasts, with undulose extinction, are common in this section, and grade up to 2mm.

FCA.R

In thin section the material displays large cracks and is highly altered containing discrete amorphous brown carbonate inclusions bound within a very dark matrix. Some quartz-rich contexts are evident, but are strained to the point of acicularity. It is entirely possible this material has been fired repeatedly and may be an important comparative sample for further study.

FCA.S

A completely lithic, poorly-sorted mix of rounded elongate clasts from sub-mm to approximately 10 x 5 x 10mm. Larger clasts display some fracturing and contrasting visible red and green colouration in different grains. A sample of FCA.S was sorted according to grain size and cast in layers before thin sectioning to ensure each size fraction was represented.

This material is dominated by products of low grade metamorphism and contains a high concentration of various mica-schists and gneiss, with well developed foliation in orientation and layering. The larger grains of the sample, to 11mm, are generally subrounded, elongate, and mica-rich (almost to the exclusion of other mineral types) in undulating oriented layers. Much of the section is iron-rich. Biotite, muscovite and chlorite are present, and the contrasting Iron concentrations of these platy minerals reasonably accounts for the striking contrasting red (biotite) and green (chloritic) colouration of these clasts in hand sample. In summary then, FCA.S is a completely lithic, detrital mix of materials, dominated by low grade metamorphic very mica-rich, quartzofeldspathic gneiss and schistose lithogies, but includes some finer basalt and quartz clasts. This is completely commensurate with the erosion and sedimentation of the local geology and this process is further evidenced in the dusty and degraded appearance of some mineral textures.

2.2.3 MORTAR RELICT-FUEL ANALYSIS

As the first set of relict fuel samples to investigated within the project a preliminary microscopic examination was undertaken to confirm these were wood-charcoal fragments, and to characterise their porosity and morphology, and so potential for radiocarbon dating. And as almost all samples were identified as diffuse porous and roundwood, a grant was obtained from Historic Scotland to allow by Dr. Mike Cressey (CFA Archaeology, Edinburgh), to undertake a second archaeobotanical examination to genus level. The results of both investigations are listed below:

FCA-A	Angiosperm; Diffuse Porous; Weak Curvature.
	Corylus (Hazel); Heartwood; Up to 20 years old.
FCA-B	Angiosperm; Diffuse Porous; Weak curvature.
	Corylus (Hazel); Heartwood; Up to 20 years old.
FCA-C	Angiosperm; Diffuse porous/paired springs; Strong Curvature.

	Betula (Birch); Roundwood; Up to 20 years old.
FCA-D	Angiosperm; Diffuse porous; Med. Curvature.
	Corylus (Hazel); Branchwood; Up to 20 years old.
FCA-E	Angiosperm; Ring porous; No Curvature.
	Quercus (Oak); Heartwood.
FCA-F	Too small to identify.
FCA-G	Angiosperm; Ring porous; No curvature
	Quercus (Oak); Heartwood.
FCA-H	Angiosperm; Diffuse porous; Strong curvature/centre section.
	Corylus (Hazel); Small roundwood; Up to 20 years old.
FCA-I	Angiosperm; Diffuse porous; Strong curvature.
	Corylus (Hazel); Small roundwood; Up to 10 years old.
FCA-J	Angiosperm; Diffuse porous; Strong curvature.
	Corylus (Hazel); Roundwood; Up to 10 years old.
FCA-K	Angiosperm; Diffuse porous; Weak curvature.
	Corylus (Hazel); Indeterminate morphology; Up to 20 years old
FCA-X (ex-situ).	Angiosperm; Diffuse porous; Strong curvature.
	Corylus (Hazel); Roundwood; Up to 20 years old
FCA-Y (ex-situ).	Angiosperm; Diffuse porous; med. Curvature.
	Corylus (Hazel); Roundwood; up to 20 years old.

In summary the 12 samples whose condition and size enabled classification included:

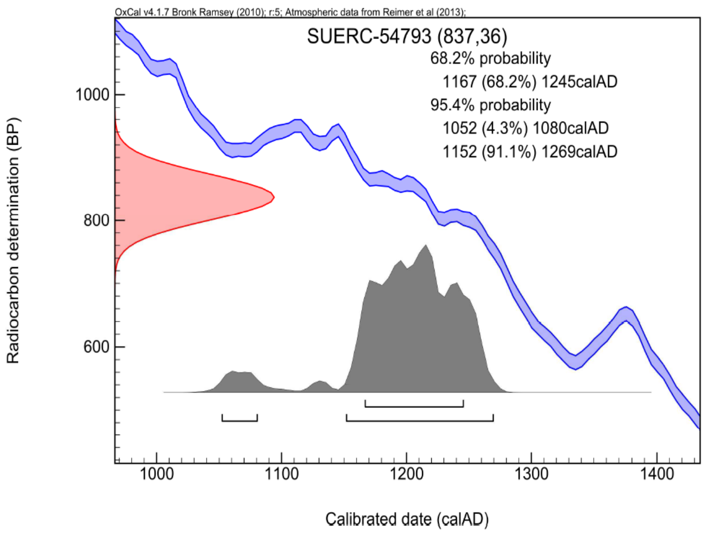
9 *Corylus* (Hazel), 2 *Quercus* (Oak), and 1 *Betula* (Birch);

7 roundwood, 4 heartwood, 1 indeterminate.

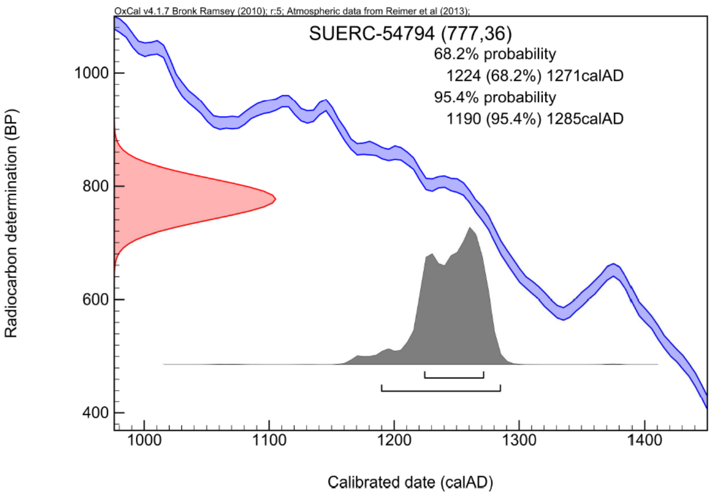
2.2.4 RADIOCARBON ANALYSIS

Five of the characterised relict-fuel samples were selected for radiocarbon dating on the basis of young short-lived taxonomies and morphologies, and range of core wall contexts throughout the building. These were subsequently submitted to the SUERC laboratories in East Kilbride for radiocarbon analysis with the following results:

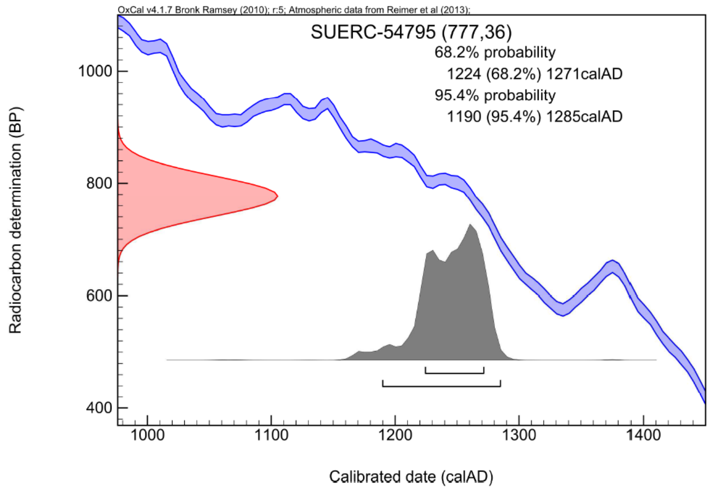
FCA-I SUERC-54793 (GU35125) Radiocarbon Age **837 ± 36BP**



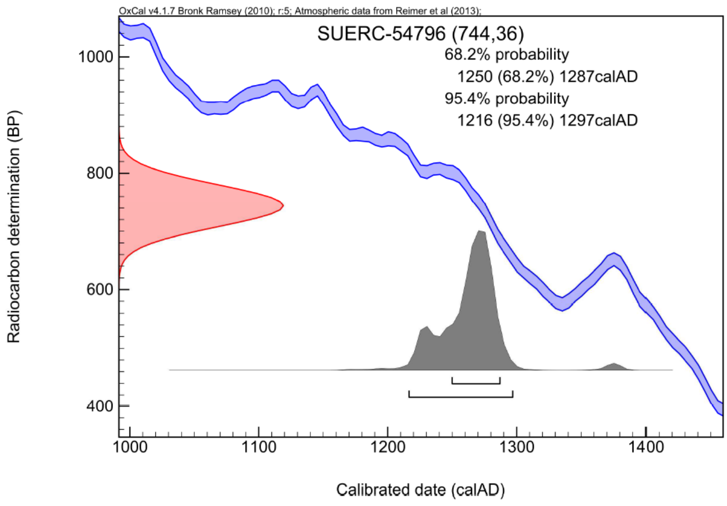
FCA-H SUERC-54794 (GU35126) Radiocarbon Age **777 ± 36BP**



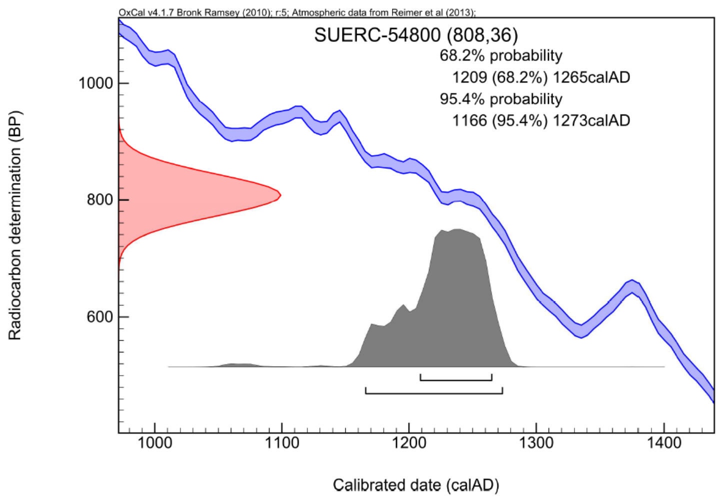
FCA-D SUERC-54795 (GU35127) Radiocarbon Age **777 + 36BP**



FCA-A SUERC-54796 (GU35128) Radiocarbon Age **744 ± 36BP**



FCA-J SUERC-54800 (GU35129) Radiocarbon Age **808 ± 36BP**



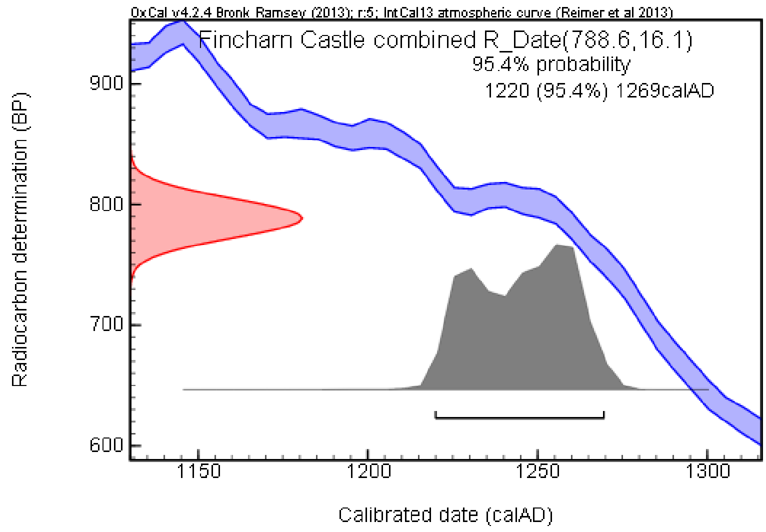
2.2.6 Combined Calibrated Radiocarbon Date Calculation

The 5 dates from the mortar charcoal samples from Fincharn Castle are 837, 777, 777, 744, and 808 ± 36BP. Applying Chauvenet criteria, in which any results more than 1.65σ from mean date are rejected (here 788.6. ± 59.4BP), all sample dates are statistically valid.

Combining the sample results gives a single date of:

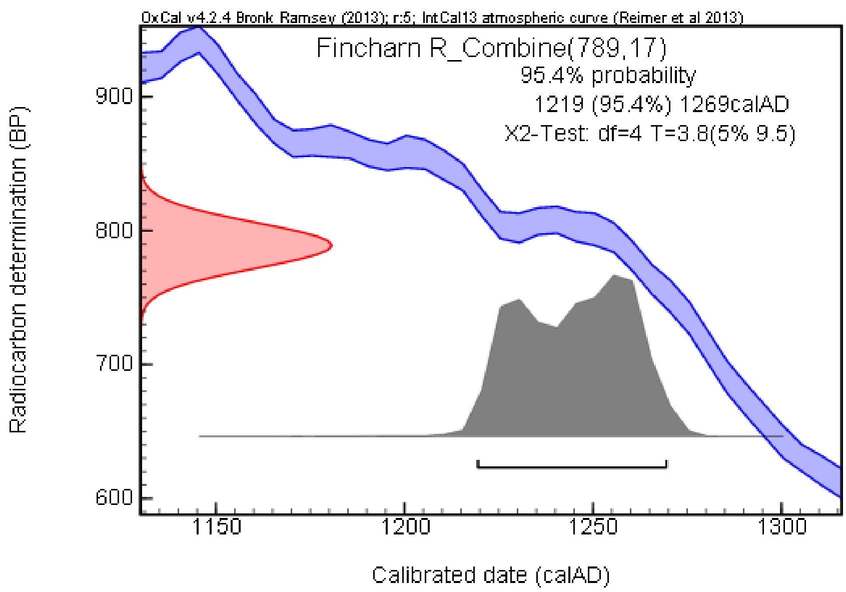
(837 + 777 + 777 + 744 + 808) ÷ 5 ± (36 ÷ √5) = 788.6 ± 16.1BP

FCA-Combined **788.6 ± 16.1BP**



Calibrated R.combined date of **1220 – 1269 cal.AD**, or **1245 +/- 25 cal.AD** (@95.4% probability).

This data also passes a chi-square test, t=3.8 (5% 9.5), so once more suggesting the samples were single phase and allowing a very similar combined date.



3.0 CONCLUDING DISCUSSION

This case study has provided a valuable example of the comparative survey and analysis of material samples from the castle building and the surrounding environment.

On-site survey suggested that the masonry and mortar of Castle Fincharn was predominantly a single phase building, comprised of formally-coursed masonry, bonded and coated with wood-fired, lithic-tempered limestone-lime mortar. On-site survey suggested the nearby church was multiphase and evidence for twin-lancet east windows suggested the primary phase was 13th-century. This building had been constructed with very similar mortar materials in a very similar style to the nearby castle, although Castle Fincharn had previously been ascribed dates between the 13th and 16th-century.

Microscopic analysis of a number of lime mortar samples from the castle supported the materials interpretations made on site. Moreover, comparative analysis of heated limestone relicts removed from the castle walls with two local outcrops indicated that Tayvallich limestone consistent with that from the outcrops above Fincharn was the lime source for the castle's construction (see especially FCA.L in figure 28 below and FCA.Q in figure 26 below). A predominantly schistose aggregate consistent with that from nearby Loch Awe was the temper source.
Microscopic analysis of a number of wood charcoal fuel kiln-relicts from within the mortar indicated that the assemblage was dominated by roundwood hazel, with minor quantities of oak and birch. This young hazel-dominated assemblage clearly has clear parallels with the tree taxa and morphologies currently populating the south shore of Loch Awe close to the castle site, although that ash (fraxinus) is also evident here but not in the kiln-fuel assemblage is striking.
Radiocarbon analysis of 5 selected mortar fuel samples returned a very narrow range of dates which suggest the fuel died in a single event, passing Chauvenet criteria and a chi-square test. This supports the on-site and lab-based interpretations that this mortar, and so the surviving ruined building, are predominantly single phase, and has allowed those dates to be statistically combined to return a more refined calibrated date of 1219-1269cal.AD. @ 95.4% probability.
This date provides a lower terminus, but given the short-lived taxonomy and morphology of the fuel selected for radiocarbon dating, there is unlikely to be much offset required in this instance. The above masonry, mortar and radiocarbon dating evidence is remarkably consistent and probably allows a mid 13th-century construction date for both castle and church. This date is so closely constrained here that a much more meaningful discourse with the available cartographic and documentary evidence pertaining to the site is possible, and this is discussed at some length in the main thesis text. The main points from this discussion will also be briefly summarised here:

1. This 1219-69AD radiocarbon date corresponds very well with a royal charter received by Gillescop MacGillechrist in 1240.
2. The charter lists a number of different estates which are broadly co-extensive with the medieval lordship and parish of Glassary.
3. The charter does not refer to a castle building or to the name Glassary, and the boundaries of those administrative units are also broadly co-extensive with the construction of the castle and church buildings.
4. The parish church and castle are located at the extreme north of the lordship and parish, away from the majority of the settlement population, which is itself divided by the parish boundaries.
5. Soon after the Reformation, the castle is ruined and the church loses its parochial status to the more conveniently placed Kilmichael.
6. Each of the above suggests that Castle Fincharn is the 'Castle of Glassary referred to in a memorandum of 1297, and this provides an upper terminus for the buildings construction.
7. The origins of this extremely northern locus to the lordship suggest the site was also a focus within an earlier system of secular and ecclesiastical lordship, and may be related to geo-historical evidence for a high medieval 10th-12th-century *tuath* or *sept* of the *toisech* Sween.
8. There may be a genealogy of buildings here, whereby Sween's eponymous Castle (which is usually dated to 1200 by architectural typology) is approximately 45 years older than its nephew's castles at Fincharn and Tarbert, where the early bailey has also been tentatively suggested to immediately post-date Alexander II's early-mid 13th century tour of Argyll.
9. Sween's lordship may have been a fossilization of the southernmost Dalradian sept of the *cenél Loairn*, and that into the 13th century that landholding was divided into the MacGillechrist lordships of Knapdale, Ardscotnish and Glassary.
10. By 1293 much of this territory had been lost to eastern clans and only Ardscotnish was still held by them, as John MacGillechrist is listed among Balliol's lords (Boardman 2006, 12). John was later forfeit by the crown, and in 1346 his lands were granted to Gilbert of Glasserie, so, after 150 years, reuniting the former holding of Gilchrist himself into a single lordship once more.

It is salient that palynological evidence suggests the construction of Castle Fincharn coincides with fundamental changes in the local environment, including climate change, increased population and loss of woodland. Although requiring much more work, the evidence may suggest both standards and underwood were being managed by MacGillechrist in this period.

4.0 FIGURES

Figure 2 (above). Map highlighting the location of Castle Fincharn within the South-West Region of the thesis survey. Scale bar 50km. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved).

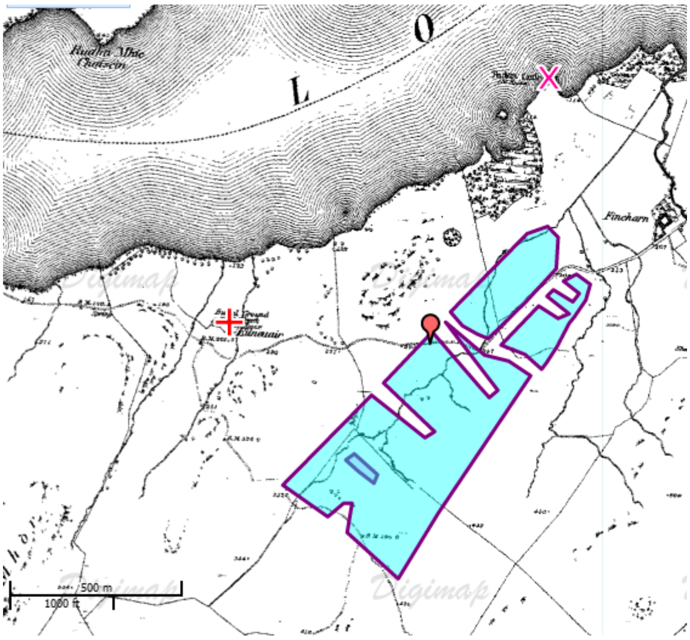


Figure 3 (above) – Detail of late 19th-century map (O.S. 1875) annotated to show the relative locations of Castle Fincharn and Kilneuair Church. Also plotted here is the large outcrop of Tayvallich limestone on the farm at Fincharn, included within which is a late modern limekiln. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved. Geological map data © NERC 2016.).

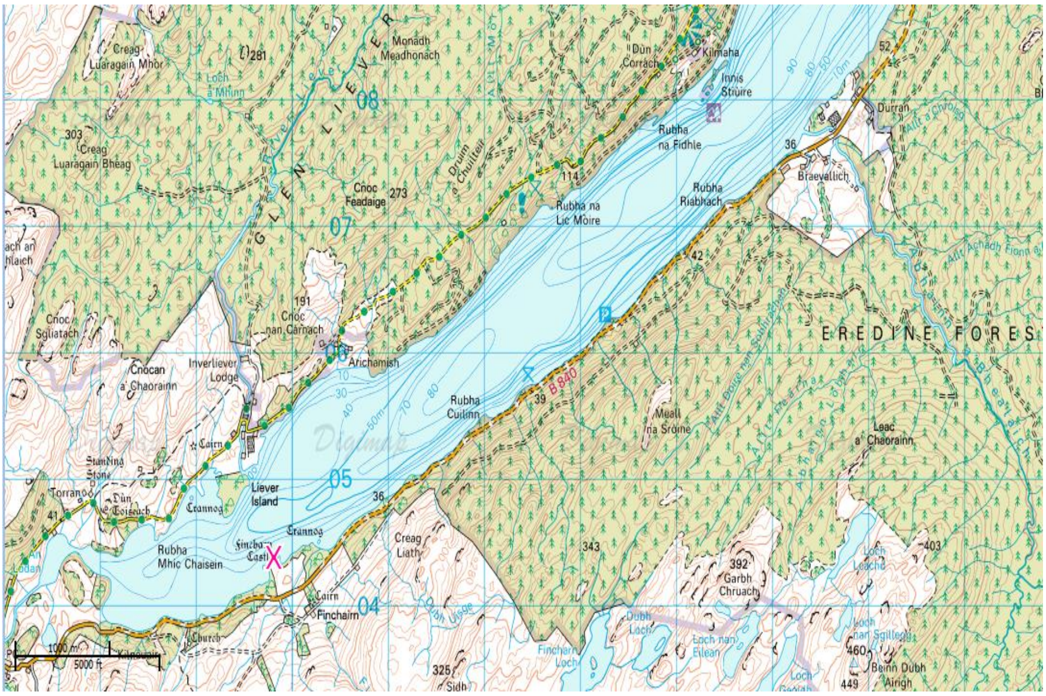


Figure 4 (above) Detail of late 20th century Ordnance Survey map showing location of Castle Fincharn and extent of recent woodland plantation.

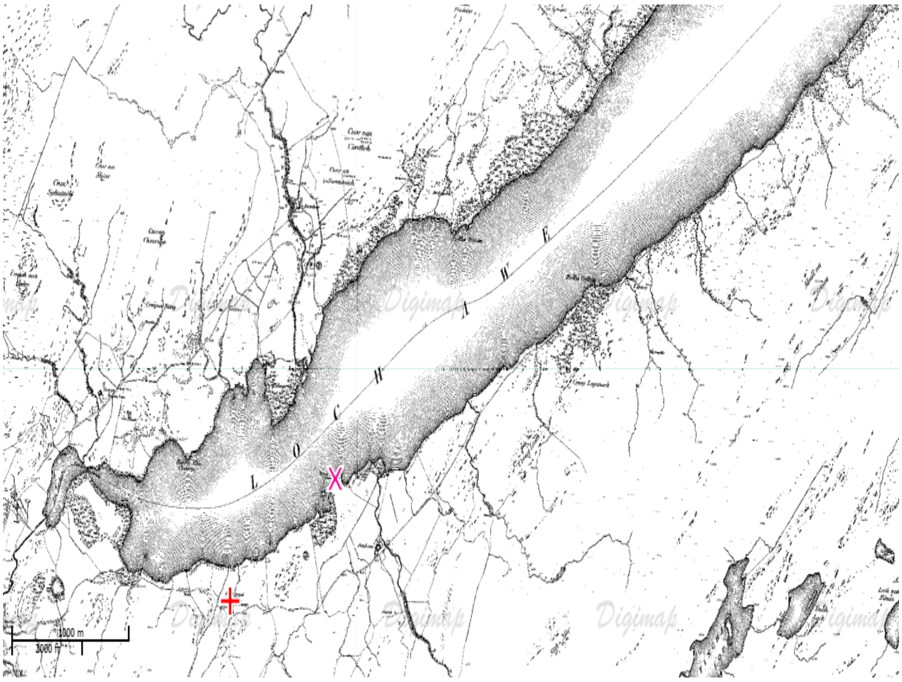


Figure 5 (above) Detail of 19th-century map (O.S. 1875) showing the largely treeless environment around Fincharn, although some woodland along LochAweside north-east of the castle site is depicted.

Figure 6 (above) – Detail of late 16th-century map (Pont 14; 1583-96) also depicts some woodland along Loch Awe side close to the Castle Fincharn site. (By kind permission of NLS maps).

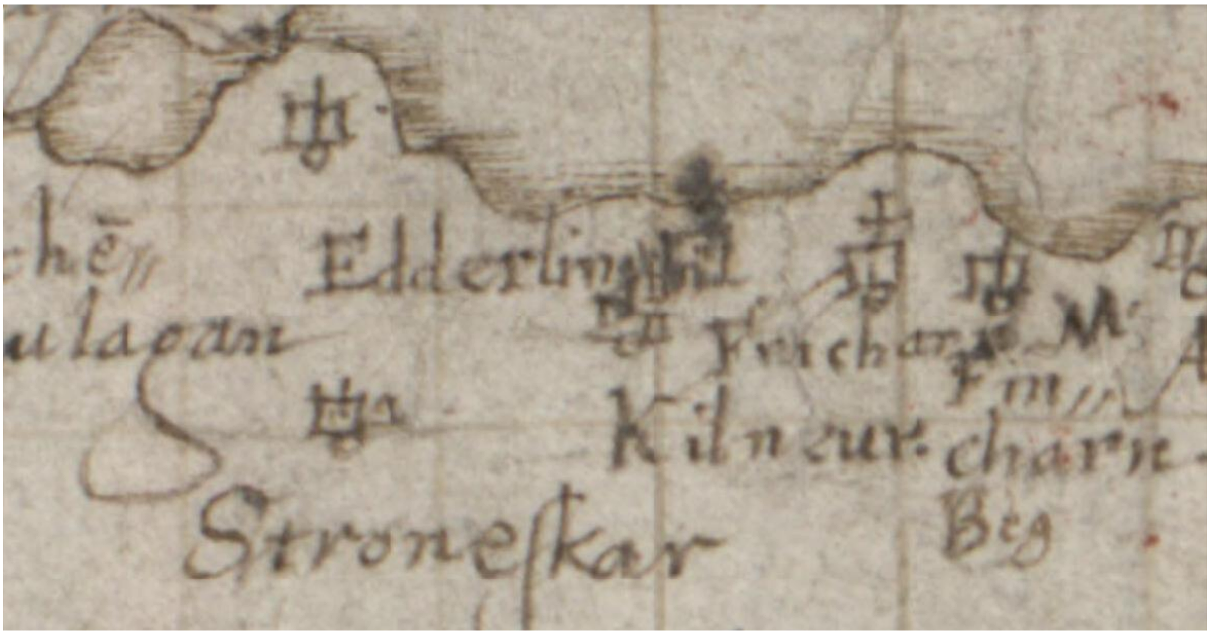


Figure 7 (above) – Further detail of late 16th-century map (Pont 14; 1583-96) is this a depiction of a ruined Castle Fincharn? (By kind permission of NLS maps).

Figure 8 (above) - 13 of the 16 farms detailed in the 1240 MacGillechrist charter are in the parish of Glassary Red line indicates parish boundary according to OPS and statistical account. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved).

4.1 ON-SITE ANALYSIS

Figure 9 (above) – Castle Fincharn. Loch Awe, mid-Argyll, from the farmland to the east. No scale; photograph: M. Thacker.

Figure 10 (above) – Castle Fincharn from the south. No Scale; photograph: M. Thacker.

Figure 11 (above) – Castle Fincharn from the east. No Scale; photograph M. Thacker.

Figure 12 (above) – Castle Fincharn from the south-west showing large volumes of masonry core. No Scale; photograph M. Thacker.

Figure 13 (above) –Inside Castle Fincharn looking north. Large volumes of single phase core mortar exposed in multiple locations. Scale 500mm; photograph M. Thacker.

Figure 14 (above) – Inside Castle Fincharn looking south-east. Scale 500mm; photograph M. Thacker.

Figure 15 (above) – Castle Fincharn; showing limestone and wood charcoal kiln-relicts in core mortar of south wall. No Scale; photograph M. Thacker.

Figure 16 (above) – Kilneuair Church from the south-west. Scale 500mm; photograph M. Thacker.

Figure 17 (above) – Detail of Kilneuair Church from the south showing contrasting masonry styles. The more formal primary medieval masonry is to the east, on the right of this image. Scale 500mm; photograph M. Thacker.

Figure 18 (above) External face of east wall of Killenuar Church, showing masonry style

Figure 19 (above) Internal face of east wall of Castle Fincharn, showing masonry style. Scale 500mm; photograph M. Thacker.

Figure 20 (above) – Looking across Fincharn farm to Loch Awe from the west. Enclosed farm fields on the left, rising limestone bluffs on the right. No Scale; photograph M. Thacker.

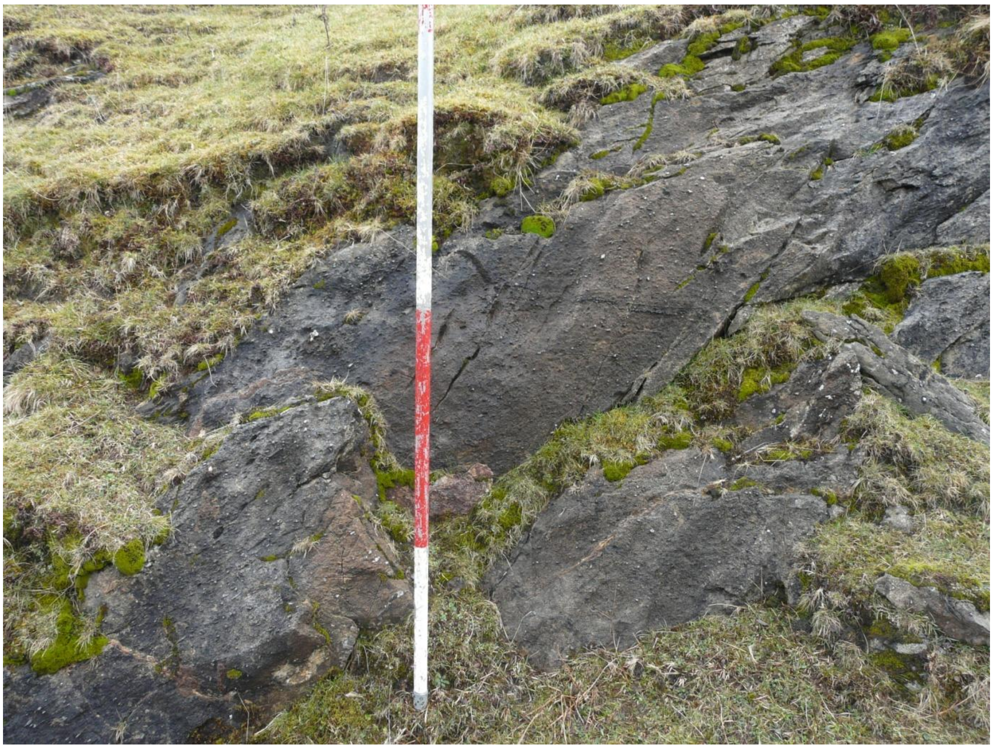


Figure 21 (above) – Limestone outcropping above Fincharn farm. Scale 500mm; photograph M. Thacker.

Figure 22 (above) – Limestone outcrop above Fincharn. Note coarse quartz grains emerging from eroding calcareous matrix. Scale 10mm; photograph M. Thacker.

Figure 23 (above) – Relict woodland along LochAweside northeast of the castle site. *Fraxinus* (ash) standards with *Corylus* (hazel) underwood. No Scale; photograph M. Thacker.

Figure 24 (above). The natural shrub habit of hazel along LochAweside. Scale 500mm; photograph M. Thacker.

4.2 – LAB-BASED ANALYSIS

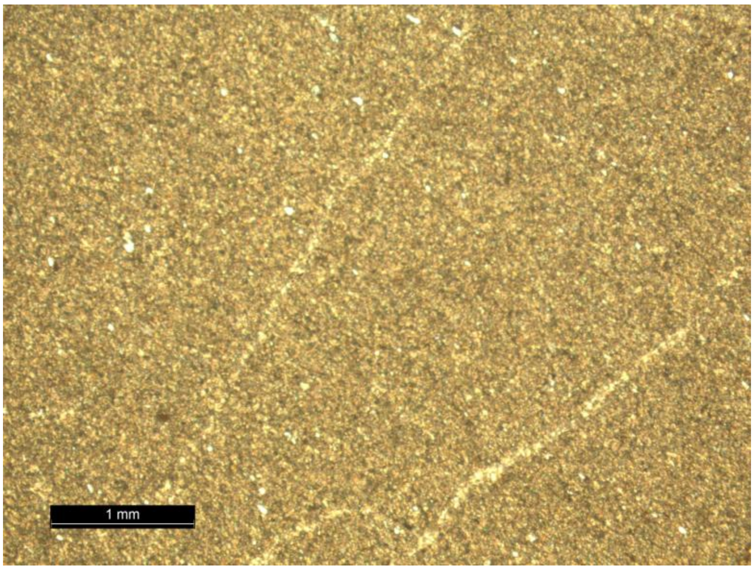


Figure 25 (above) –Sample FCA.P is a very homogenous and equidimensional, fine-grained highly birefringent limestone. 1.0mm scale bar; XPL; Photomicrograph M. Thacker.

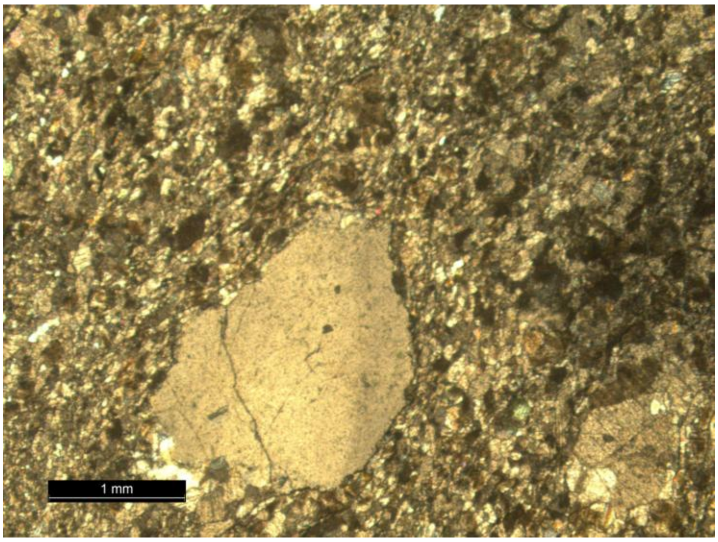


Figure 26 (above) - Sample **FCA.Q**. from Fincharn Farm; note the large quartz grain and heterogeneous texture in contrast with FCA.P. 1.0mm scale bar; XPL; Photomicrograph M. Thacker.

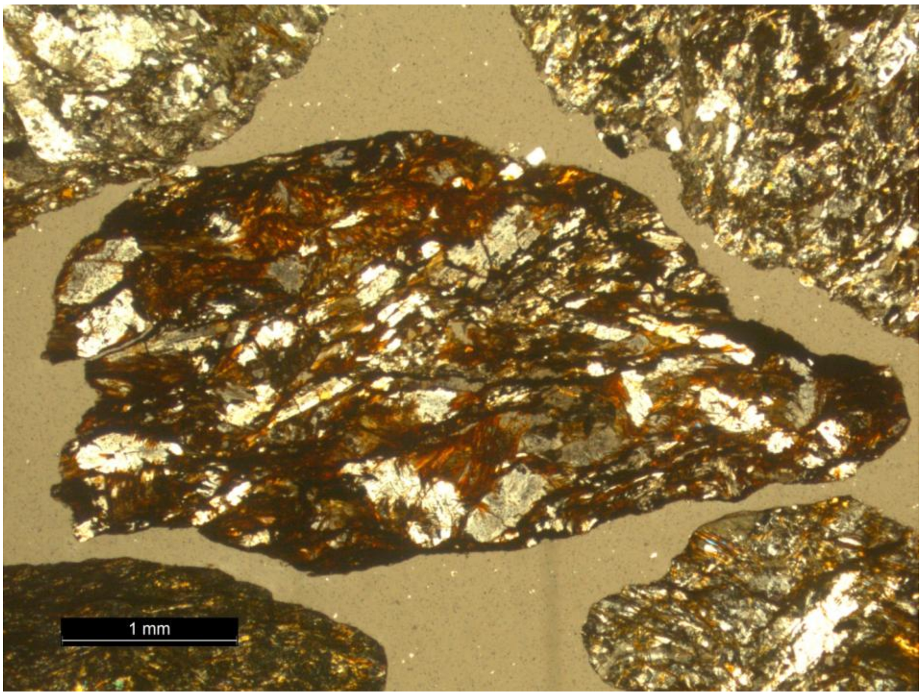


Figure 27 (above) – Some of the larger, rounded and elongate, grains from aggregate sample **FCA.S** display biotite-rich feldspathic mineralogies. 1.0mm scale bar; XPL; Photomicrograph M. Thacker.

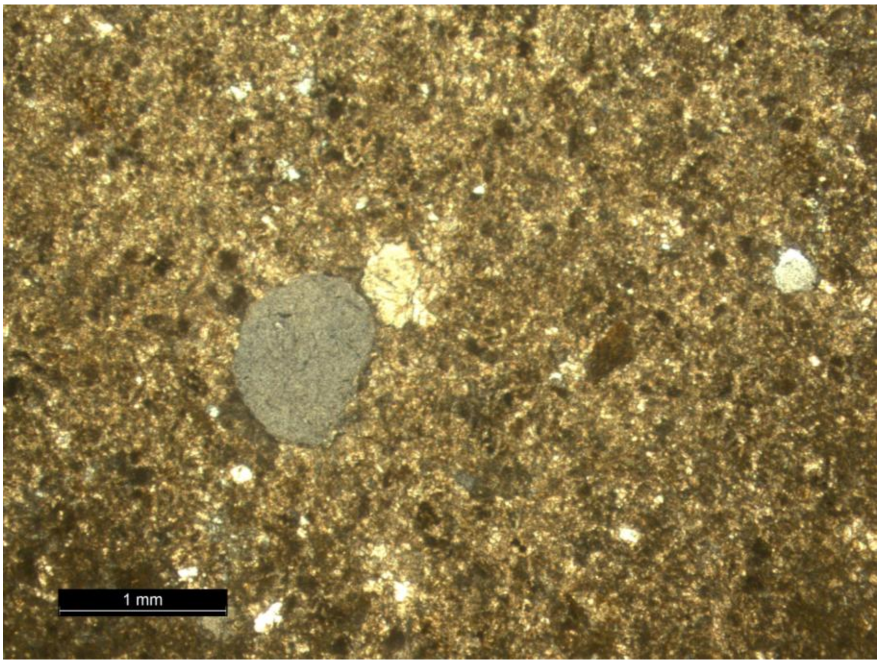


Figure 28 (above) – The uncalcined core of the limestone relic from **FCA.L** is coarse textured and included rounded/subrounded quartz. This is a good match for the limestone sample FCA.Q from Fincharn Farm quarry (see figure 2). 1.0mm scale bar; XPL; Photomicrograph M. Thacker.

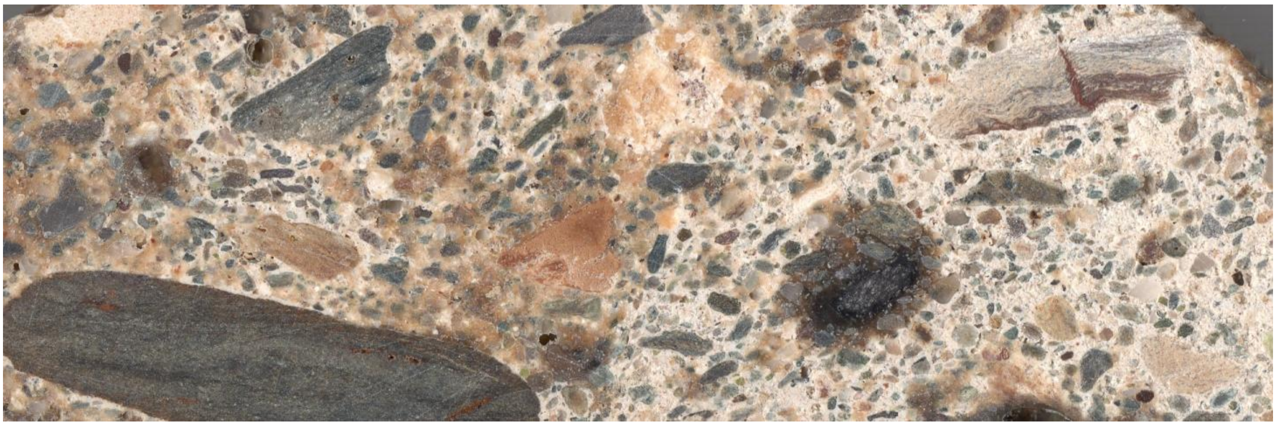


Figure 29 (above) Detail of sample FCA.01a. Field of view 40 x 16mm.

Figure 30 (above). Thick section sample FCA.01b. Limestone kiln-relict with a densely crystalline core and highly altered buff-coloured and more finely textured rim This relict stone was a reasonable match for two local limestones, but more clearly recognised as Tayvallich in thin section. Field of view 40 x 25mm.

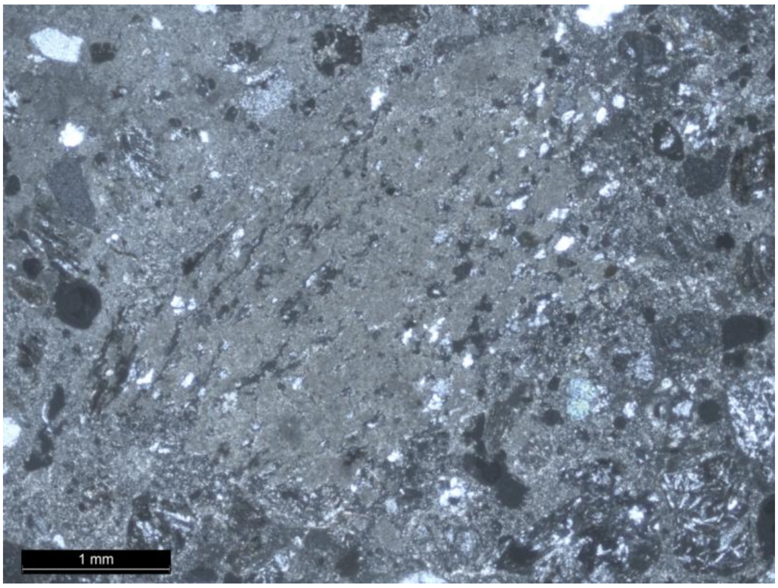


Figure 31 (above). FCA.01a 2.5X XPL 01 Fig 6 (FCA.01A 2.5X XPL01) shows a more fully calcined example, whose texture and colouration match that of the general binder. This has resulted in a barely discernible relic shape, included with a low concentration of quartz, both mono and aggregate, with some orientation (schistosity or foliation) and undulose extinction. This evidence should be related to that in FCA.01b to form the basis of further study. That the calcareous lithic material is itself included with quartz was suggested at the mesoscopic scale and is also in evidence here.

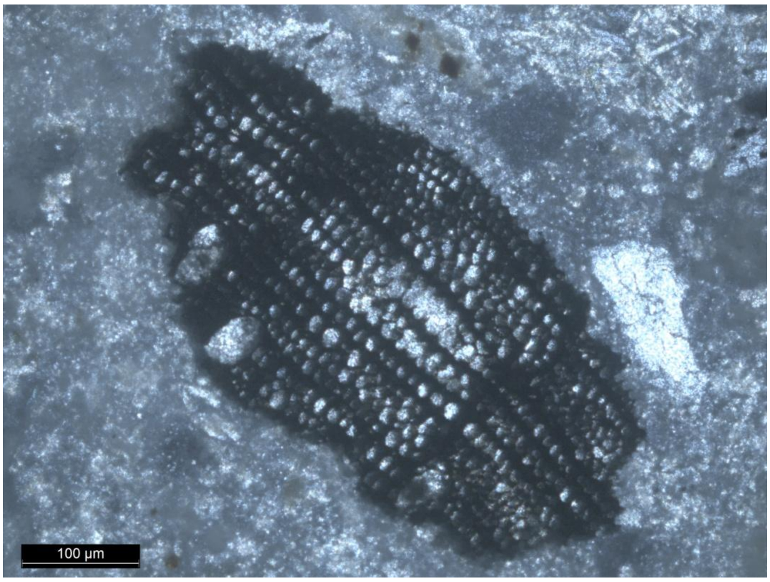


Figure 32 (above) Mortar fuel wood-charcoal kiln-relict. Scale bar 100μm; photomicrograph M. Thacker.

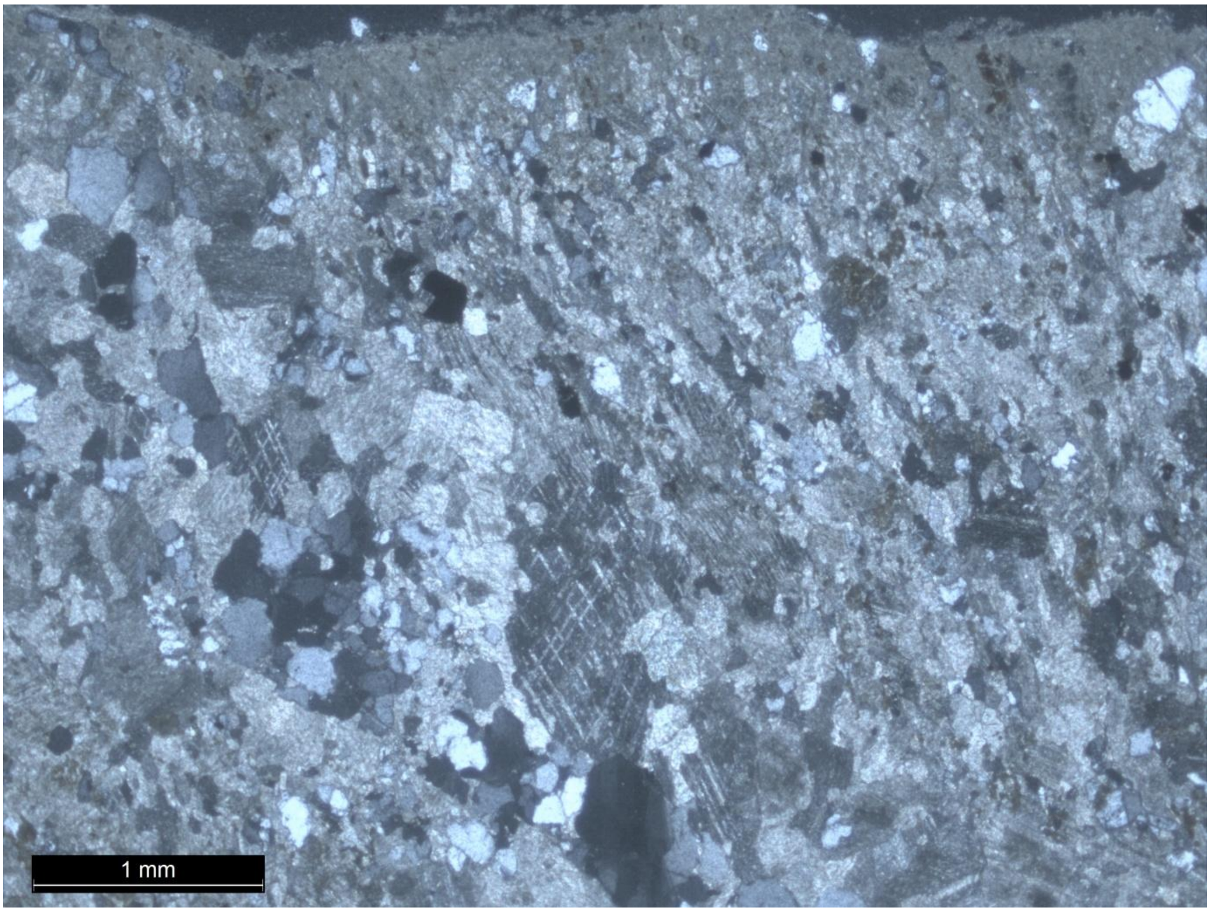


Figure 33 (above). Sample FCA.01b Altered limestone rim. XPL; Scale 1.0mm; photomicrograph M. Thacker.

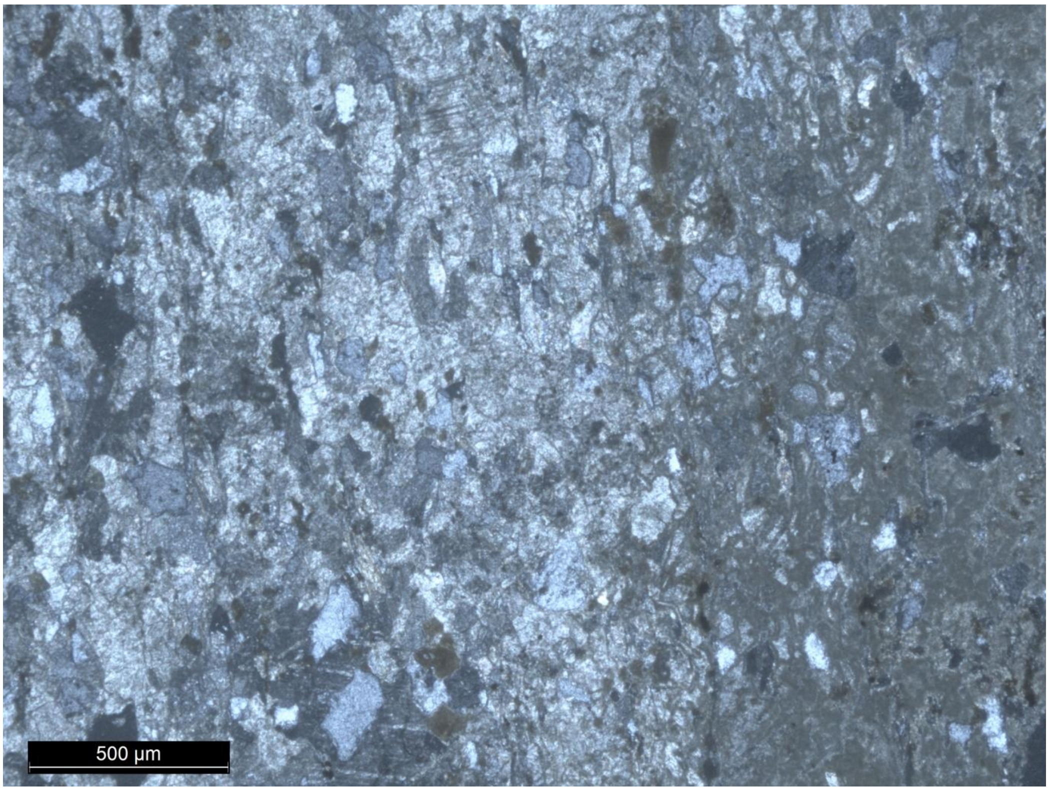


Figure 34 (above). Sample FCA.01b. Altered clast rim. Showing 'reaction front' as limestone becomes binder and releases quartz. XPL; Scale 500µm; photograph M. Thacker.

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Pont, T (1583-96) Pont 14: 'mid-Argyll; from Dunoon to Inverary and Loch Awe' can be viewed at National Library of Scotland Maps.

5.2 ACKNOWLEDGEMENTS

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APPENDIX 14 - CASE STUDY

MINGARY CASTLE

Mark Thacker, University of Edinburgh.

Constructing Lordship in North Atlantic Europe. Vol. III.

Appendix case study 14.

Last revision 20-07-2016

DRAFT COPY FOR PHD EXAMINATION SUBMISSION.

SUMMARY

A survey of the masonry of Mingary Castle was undertaken in parallel with a comprehensive mortar sampling and analysis programme. Close inspection of these materials, *in-situ*, suggested that this range of phase-specific mortar types had been manufactured from contrasting shell, limestone and aggregate sources, and these interpretations were supported and further refined by lab-based microscopic and petrographic analysis of a large assemblage of well-contexted samples. Lime-burning fuel relicts surviving within mortars from the three early phases of the castle were radiocarbon dated to inform our understanding of the buildings chronological development.

Buildings analysis and radiocarbon data suggest the first two constructional phases of Mingary Castle – curtain wall and drum garderobe were built within a relatively short time period after the late 13th-century – whilst the later north range has been built after the early 14th-century. Each phase of the castle and nearby parish church is associated with a different masonry culture which may suggest different patrons.

CONTENTS

1.0 MORTAR, MASONRY & ENVIRONMENT SURVEY

1.1 MINGARRY ENVIRONMENT SURVEY

1.1.1 UNDERLYING GEOLOGY

Ardnamurchan is generally dominated by mafic lavas of the same tertiary igneous series which form a North Atlantic arc from north-east Ireland and Arran, across the Inner Hebrides, Faeroes, large parts of Iceland and some minor areas of Greenland (Richey et al 1961, 42). Importantly for masonry studies in the sound of Mull, however, these flows have protected a series of earlier underlying sedimentary Mesozoic strata (associated with the Hebrides basin) which now outcrop in a number of discrete contexts from Skye to south-eastern Mull and possibly Islay (ibid, 20; Hesselbo et al 1998). One of these discrete contexts is found in south-west Ardnamurchan at Mingary/Kilchoan, and here, where the Mesozoic strata are themselves denuded, then various schists associated with the nearby Moine thrust have in turn been exposed (Richey et al 1961, 8-9). The general succession, however, is dominated by various sediments, overlain by igneous lavas - with some complexity in the contact zones between these two events.

Jurassic subdivisions of the Mesozoic sedimentary series outcrop in west Ardnamurchan on both the north coast, around Swordle, and on the south coast of the peninsula around Kilchoan and Mingary. The underlying calcareous geologies of both these areas, as well as the locations of various post-medieval lime-kilns and known medieval and later church/chapel and castle sites, have been plotted onto the 19th-century Ordnance Survey first edition sheets (see figures; O.S. 1875b, 1875c and 1875d). With reference to this plotted map, it is salient that in south Ardnamurchan the largest Broadford/Pabbay calcareous outcrop underlies the arable crofts at Ormsaigmore/Ormsaigbeg, as well as the site of the supposed late medieval or early modern 'tower' at *Caisteal nan dubh Cliar* (NM 4733 6313), and is also very close to the medieval and later parish church of St Comgan's (NM 4850 6404). Although less extensive, these Jurassic strata are also a significant feature of the underlying geology of the farm at Mingary, although here nodular limestones of the Stornoway formation are also present, and metamorphism within these 'cornstone' lithogies (caused by contact with intruded or overlaying tertiary lavas) has also been reported in the wider area (Agrell 1965). These limestones are a very obvious feature of the shoreline immediately east of Mingary Castle and the RCAHMS (1980, 209) identified some evidence for quarrying within these outcrops and speculated that this was to provide building lime at some period/s. Various shales, some of which appear to be fossiliferous, are also associated with these Mesozoic strata, and like the mafic (basalt to microgabbro) rocks of the tertiary lavas themselves, and the local schist, these are also relevant to this study in providing general building stones and different aggregate compositions.

1.1.2 SHORE SURVEY

As above, the shoreline east of the castle building is dominated by dolerite and limestone pavement terraces. In this direction, there is some superficial aggregates at *Craig a'Bhaile*, immediately east of the castle, but detrital material does not then re-emerge until close to *Rubha a' Mhile.* Here, a stony literal and supraliteral area displays very shell-rich sand, including a small community of *P. vulgata* (limpet) and *L. littorea* (winkle), and a small post-mortem assemblage of *Mytilus* (mussel) valves and shell fragments.

In striking contrast to this shell-rich material, the shoreline to the west of the castle building, in the adjacent bays of *Port nan Spainteach,* is dominated by an apparently very lithic mixture of aggregate materials, including well-sorted discrete contexts of mafic stones, gravels and sands.

There is no evidence for the shell material required for the shell-lime masonry phases of the castle in any of these littoral cells, and the small driftwood assemblage is almost completely dominated by *Betula* (birch).

1.1.3 WOODLAND

Although Ardnamurchan has recently been subject to large-scale tree plantation, the first edition Ordnance Survey maps (1875b, 1875c and 1875d) depict a largely treeless mid-19th-century environment. This observation is supported by the mid-19th-century statistical account for the large Post-Reformation parish of Ardnamurchan in which, except for the 'woods of oak, birch and hazel [in] the south…' beyond the low hills towards Loch Sunart, the peninsula is generally described as having 'little wood' (Clerk 1838, 118-119). There is also no woodland shown in Ardnamurchan on either the Blaeu or Roy maps of the 17th and 18th-centuries. These depictions cannot be used as a reliable guide, however, as even Moidart, an area which has been considered as one of 'few localities in the Highlands which contain such an extensive area of native broadleaved woodland that has not been disturbed by development' (Cheape 1993), is also largely treeless here.

Whilst always likely to have had a different vegetational history to the more sheltered environment of Moidart, MacVean and Ratcliffe (1962) did suggest Ardnamurchan was likely to have been an area of almost continuous birch dominated woodland in the pre-clearance Holocene, and that the south coast (including Mingary) was likely to have been covered with continuous oak/birch or ash/birch woodland, depending on soil type. In some respects this interpretation is supported by the mid-19th-century account above which describes a woodland community of mixed oak and birch on the south of the peninsula (Clerk 1838). Moreover, although no palynological studies appear to have been undertaken in very close proximity to Mingary itself, investigators studying the pollen record of nearby *Claish Moss* suggested that mixed oak forest had developed early in the wider Ardnamurchan area, and both oak and birch were persistent throughout the zonal stratigraphy of their study (Moore 1977).

Unlike Cheape's description of Moidart, therefore, the evidence noted above suggests the woodland history of Ardnamurchan, and especially on the south coast of the peninsula, has undergone some major late Holocene changes. Examining the current landscape for possible evidence of that history draws attention to the relatively extensive woodland at *Camas na Cloiche Mòire*, *Camas Choire Mhuilinn* and *Allt Choire Mhuilinn*, still surviving on the west facing slopes of Ben Hiant (approximately one mile from Mingary Castle) and clearly depicted on the 19th-century Ordnance survey 6-inch map (1875; see figures). That this may be a 'semi-natural' relict of a more extensive south Ardnamurchan Oak/birch or Ash/birch woodland, was also suggested by MacVean and Ratcliffe (1962), and so the area was identified as requiring further survey.

Closer to the Castle are three small stands of trees including: east of the castle a stand of approximately 1.5 acres of unenclosed heavily grazed oak and birch (both downy and silver), with a small percentage of Aldar is extant, and a small stand of hawthorn thrives just above the strandline. To the west of the castle is another stand of oak and birch enclosed within a Galloway dyke which suggests these may be survivals of the Improvement landscape. As the taxonomies of these small stands also broadly reflect the documented and palynological vegetational history of the area, however, they may also retain some relict evidence of earlier woodland communities. The hawthorn, certainly, is unlikely to have been planted.

1.1.4 THE LIME KILN

A number of limekilns have been recorded in west Ardnamurchan, including one very close to the castle site (see figures). This rounded structure, which has been revetted into sloping ground at NM 5053 7631, still survives to over one metre high but is largely full of collapsed debris. The kiln walls are massively constructed and display a battered profile in which the bowl is approximately 1.9m at the surviving wallhead funnelling to a probable 1.4m at the base. No evidence for mortar survives within the kiln walls and any possible evidence for a grate or grate-scarcement within the kiln-bowl is obscured by the infilling debris. Internally, the walls of the structure display extensive rubification and vitrification and it is evident these were carefully constructed of dolerite whilst limestone has been used in the external wall face. The vent is south-facing and formed of stepping lintels which are again all limestone, except for the internal one which is dolerite. There are a few fragments of heated angular blue limestone lying within the masonry joints of the kiln, which are very probably heated relicts of the last charge. Some evidence of quarrying in the adjacent scarped outcrops is evident, but the potential for quarrying and collection of calcareous material from the adjacent beach is salient.

1.2 BUILDING SURVEY

The first site visit to Mingary Castle for this research was undertaken as part of the programme of rapid building surveys in the South West Region of the thesis, and that included the nearby medieval and later parish church of St Comgan's. Preliminary analysis of the castle from ground level in this visit suggested that the general mortar-archaeological framework of the site could be described in three major phases (early curtain wall, large north hall, later ranges), each of which contained evidence for contrasting shell-lime and limestone-lime mortar materials. These striking contrasts suggested that further mortar survey and analysis had good archaeological potential at the site and so the building was adopted as a thesis case study.

The main investigation of the castle site was undertaken over a subsequent five day period, when almost complete access to the masonry of the building was enabled by scaffolding erected for the impending conservation programme and, in this pre-consolidated state, large volumes of deep core masonry were visible in most building phases. Re-analysis of the building fabric was enabled by reference to multiple plan and elevation drawings of the building which contained the early interim phasing interpretations of Addyman Archaeology who had also obtained scheduled monument consent to remove fixed mortar samples for further lab-based analysis. Three days were spent inspecting and characterising the mortars and masonry of the site with reference to these drawings, in order to analyse the phasing of the building and establish a sampling strategy, before over fifty mortar samples were collected. Sample contexts were recorded by photograph, and by hand-measuring x, y and z coordinates from fixed building features such as wall faces and window jambs and lintels, and these were then annotated onto the interim site drawings (see figure 1).

It was clear from this survey that many of the interim phasing interpretations previously proposed by Addyman Archaeology were correct, but fundamental material contrasts were also apparent which indicated some re-evaluation of a number of significant contexts was also necessary.

1.2.1 PRIMARY CURTAIN WALL

Large areas of masonry within the curtain wall appear to be the earliest fabric on the site, and this phase displays very consistent use of particular materials. The general wall faces include a mixture of stone types including dolerite, shale and (although much less often) limestone. Dolerite blocks appear to dominate but localised concentrated areas of a much more banded shale are present and, although visible evidence for knapping, dressing or quarrying is rare, in general these blocks do have sharp arrises and the whole is brought to reasonably regular well-defined courses.

The mortar of this primary phase could be examined in a large number of contiguous very deep core, bed and coating contexts in the lower courses of all six external faces of the curtain wall. This is a very distinctive and consistent material, which was subsequently identified as Mortar 1:

General description – Mortar 1 is a hard, fine-textured light-brown/yellow lime mortar.
Carbonate kiln-relicts – Mortar 1 is a limestone-lime which contains a high concentration of buff-coloured subangular to subrounded heated limestone inclusions generally grading up to 25mm. These are fine-textured and sedimentary with no visible veining.
Added-temper – Mortar 1 was tempered with a well-sorted lithic sand, dominated by very fine (sub-mm) grades, but including a low concentration of subrounded lithics to 15-20mm.
Fuel kiln-relicts – Mortar 1 was wood-fired and contains a high concentration of charcoal inclusions to 15mm.
Vitreous kiln relicts - No vitreous material was apparent, although a very low concentration of distinctively bright red fissile lithic inclusions to 20mm may be a reaction product.
Samples include: MCA.001; MCA.002; MCA.003; MCA.012; MCA.013?; MCA.022; MCA.023; MCA.024; MCA.025; MCA.028; MCA.053.
Mortar 1 was also evident within the beds of the sandstone window dressings, displayed in the north and east curtain walls, suggesting these too are primary features.

1.2.2 EAST DRUM GARDEROBE

The masonry of the east garderobe appears to be clearly distinct from the primary masonry of the curtain wall as this drum-shaped structure is dominated by large, flat fissile slabs which course to different levels from the adjacent curtain wall. However, although this structure is a slap-in abutment, this contrast is not clearly displayed in their respective mortars which are so similar that no abutment could be traced between them. This relationship, therefore, requires further work, but for present purposes the drum garderobe mortar is identified as Mortar 1a, and the samples identified were MCA.020 and MCA.021. It is, however, clear that the drum garderobe is not of the same constructional phase as the north range and/or east-north curtain upper parapets, as these latter structures are bound by clearly mortar materials which will be considered below.

1.2.3 NORTH RANGE

The north range contains two main phases, the earliest of which displays consistent use of a distinctive suite of masonry materials and techniques. The wall faces of this early building (including the quoins) have generally been constructed of massive blocks of dolerite, carefully laid with a level bottom bed, but some have been edge-laid to present very tall narrow faces, and the stonework in general displays remarkably little lateral bonding across the wall face and almost no coursing. Vertical stacks of massive dolerite facing stones (and their associated risbonds) characterise the surviving face-work this phase both internally and externally.

The mortar binding this distinctive masonry can be seen in a number of contiguous core, bed and coatings, and both internally and externally extensive coating fragments survive to 40mm thick. This consistent material is clearly primary to both the west and south walls of this north range and is identified here as Mortar 2:

General Description – Mortar 2 is a very white shell-rich coarse lime mortar.
Carbonate kiln-relicts – Mortar 2 is a shell-lime mortar containing high of heated shell fragments which display a wide range of textural alteration. The assemblage is almost completely dominated by *O. edulis* (oyster) shell fragments to 70mm and no other mollusc taxa or limestone inclusions were noted.
Added-temper – Mortar 2 was tempered by a poorly-sorted mixture of lithics and shell material, including rounded to subrounded mafic clasts to 20mm and fine unheated shell material to 2-3mm.
Fuel kiln-relicts – Mortar 2 was wood-fired and contains a high concentration of charcoal inclusions grading up to 3-5mm.
Vitreous kiln-relicts - No vitreous material was apparent in Mortar 2.
Samples MC.040; MC.041; MC.042; MC.043; MC.044.
This earliest surviving masonry of the north hall range simply abuts the north and east faces of the primary (Mortar 1) masonry of the curtain wall, and is itself clearly abutted by masonry of a different character forming cross-walls, the west gable and slap-in south window and door dressings. The masonry fabric in all of these later north hall contexts is bound by a mortar with a clearly contrasting character, identified here as Mortar 6, and the relationship between these two masonry phases is most clearly evident where Mortar 6 abuts and overlays Mortar 2 around the south window and doorway dressings (see figures).
General description – Mortar 6 is a yellow to grey (depending on environment) shell-rich lime mortar.
Carbonate kiln-relicts – Mortar 6 is a limestone-lime with a low concentration of dark brown heated limestone relicts to 12-15mm
Added-temper – Mortar 6 was tempered with a poorly sorted mixture of lithic and shell materials, including subrounded and rounded dolerite grading to 20-30mm, and a variable concentrations of fine (2-3mm) unheated shell.
Fuel kiln-relicts - No fuel inclusions were noted in Mortar 6.
Vitreous kiln-relicts - No vitreous material was noted in Mortar 6.
Mortar 6 was noted in contiguous deep core and bedding contexts, and internally the whole of the building appears to have been coated with a more finely-tempered coating mortar material (so overlaying Mortars 1, 2 and 6 in various contexts). This is a limestone-lime and may be related to the same late construction phase as Mortar 6.
Returning to the constructional fabric of the north range it should be noted that, although the mortars of both main phases (Mortars 2 and 6) were tempered by very similar aggregate materials (and so display comparable textures), they are so clearly different because of the fundamentally contrasting mineralogies of their different carbonate sources.

Stratigraphically, this survey supports the interim interpretation of the site, which had already (for the first time) identified these later opes and cross-walls as slap-ins, without considering the contrasts in mortars discussed above. Adding to this, however, although most of the surviving opes in the south wall of this north hall range are associated with the later (Mortar 6) phase, the arch fragment at its east end is surrounded by Mortar 2 and so was probably a relieving arch over an earlier (?lintelled) eastern doorway into the ground floor of the early building. Moreover, it is also clear that the primary shell-lime bound masonry of the north hall range is of a different constructional phase to the south/south-east upper parapet and the drum garderobe, although whether or not of the same phase as the north and east upper parapet remains to be demonstrated.

1.2.4 WEST CURTAIN

Most of the fabric of the external face of the west curtain wall clearly contrasts with the primary wall faces to north and south, and this phase displays another clearly distinctive suite of techniques. Like the drum garderobe, the face stone of this central section is dominated by flat slabs of schist, although here they are laid very informally - often at slight angles, with no coursing, and with very wide masonry joints filled with a coarse 'limecrete' mortar. Interstitial voids in the face of the wall up to 100 x 100mm may be completely filled with this mortar material without use of pinnings. This very coarse material was identified as Mortar 3:

General Description – Mortar 3 is a white coloured and very coarse lime mortar
Carbonate kiln-relicts – Mortar 3 is a limestone-lime which contains very large heated limestone relicts to 60mm.
Added-temper – Mortar 3 was tempered with a very coarse lithic material.
Fuel kiln-relicts – No fuel evidence was noted in Mortar 3.
Vitreous kiln-relicts – No vitreous evidence was noted in Mortar 3.
Samples: MCA.010; MCA.011; MCA.019; MCA.027.

Although very coarse, in many contexts Mortar 3 is only visible in shallow contexts and is only very occasionally visible in contiguous coating, bed and core contexts of more than 150mm deep. Moreover, the interstitial volumes behind these contexts often appear very voided, and both stonework and mortar give the impression of a shallow re-facing repair which has degraded in the core abutment. This masonry is more coherent at a small section of surviving wallhead, which was attributed to this phase in interim even though the facing stone here displays a higher concentration of limestone blocks. The mortar evidence here is visible in full wallhead cross-section, and the core material displays such remarkably coarse grades of heated limestone kiln-relicts that the interim interpretation of this as a continuous may be generally supported. Its extent on this wallhead may be slightly reduced, but stratigraphically this masonry clearly overlays the primary curtain wall and, although its relationship with the parapet and bartizan to the south is less clear, that the proposed sequence is reasonable.

1.2.5 UPPER PARAPETS OF THE EAST, NORTH & NORTH OF NORTH-WEST CURTAIN WALL

The highly exposed location of these parapets has degraded and fragmented the masonry significantly, and this has enabled comprehensive examination of large areas of masonry, and a full spectrum of mortar taphonomy from completely dissolute to coherently bonded full wall cross-sections. The mortar material evidence surviving here is almost completely dominated by classic shell-lime evidence and will be identified here as Mortar 4:

General Description – Mortar 4 is a white coarse shell-rich lime mortar.

Carbonate kiln-relicts – Mortar 4 is a shell-lime which contains a high concentration of heated shell fragments. The assemblage includes *O. edulis* (oyster), *P. vulgata* (limpet) and some unidentified clam fragments.

Fuel kiln-relicts – Mortar 4 was wood-fired and contains a low concentration of very degraded wood charcoal inclusions.

Vitreous kiln-relicts – No vitreous inclusions were noted.

Samples: MCA.005; MCA.006; MCA.29; MCA.30; MCA.30a; MCA.031; MCA.032; MCA.033; MCA.034; MCA.035; MCA.036.

In the north wall Mortar 4 is displayed throughout the core and both faces of the upper parapet, and in the core, beds and coatings of the internal face lower parapet (including the associated ope jambs) as low as the internal offset. This corresponds to a level slightly below that of the wallhead of the north wall of the main north range, although no direct relationship between with the north hall was noted.

In the parapet of the north-west curtain wall Mortar G forms very thick, 'limecrete' joints, which were part-coated with a limestone-lime mortar of similar texture which, crucially, also overlays an adjacent later phase.

At the east end of the north parapet there is some suspicion of limestone-included mortar and a suspected limestone-lime core/bedding context was taken as MCA.031. Whether this is associated with the later limestone-lime bonded masonry blocking of the east ope is not certain. Conversely, however, the internal face of the east upper parapet is divided by a vertical phase break; although as the mortars on both sides appear to be very similar this is probably some kind of constructional break only. Both these pieces of evidence may be insignificant in themselves, but they do suggest there is more complexity to the surviving evidence up here than can be simply assessed.

1.2.6 BLOCKING OF INTRAMURAL SPACES IN NORTH CURTAIN

At no time during this survey was the mass of masonry blocking the intramural spaces of the north and east curtain walls accessible, and this material could only be assessed in the masonry beds of the external window blocking. This is problematic, and yet this material was clearly a very white shell-lime and so easily distinguished from the surrounding primary

(Mortar 1) of the window dressings themselves. This material will be identified here as Mortar 9:
General description – Mortar 9 is a very white shell-rich lime mortar.
Carbonate kiln-relicts – Mortar 9 is a shell-lime mortar which contained a high concentration of fine (generally <10mm) heated shell fragments.
Added-temper – Mortar 9 was tempered with a mixture of unheated shell and lithic materials, dominated by shell fragments to 10mm, but with a low concentration of subrounded lithic inclusion some of which may be limestone.
Fuel kiln-relicts - Mortar 9 was wood-fired and contained a wood-charcoal fragments to 15mm.
Vitreous materials – no vitreous materials were noted in Mortar 9.
Samples: none.
The masonry blocking these intramural spaces was excavated-out in a subsequent period of conservation work, and so core contexts may be described elsewhere.

1.2.7 SOUTH & SOUTH-EAST PARAPETS

The south end of the west curtain, south curtain and south-east curtain walls display a well-understood typologically-clear architectural formality, and the rubble masonry here is also technically distinct in its general use of dolerite in smaller blocks than seen previously. It is the mortar associated with this phase, however, which is most striking and unlike any other noted in the building. This mortar is very visible in full parapet wallhead and merlon-reveal cross-sections and in the deep core behind missing faces stones, and here a consistent and contiguous material is displayed which has retained a remarkable coherence. This very hard material was identified as Mortar 5:
General description – Mortar 5 is a very hard, yellow lime mortar.
Carbonate kiln-relicts – Mortar 5 is a limestone-lime which contains a very high concentration of buff limestone inclusions to 20mm, lime inclusions generally to 5-10mm and occasionally to 20mm. Some degraded dark brown clasts, generally to 5mm but occasionally also to 12-15mm, may also be calcareous.
Added temper – Mortar 5 was tempered with a poorly sorted aggregate mix of lithic and shell materials. This is dominated by very fine (sub-mm) grades, but includes subrounded to subangular lithics grading up to 15-25mm. The shell fraction is low and variable.
Fuel kiln-relicts - No fuel evidence was apparent in Mortar 5, even when cut.
Vitreous kiln-relicts - no vitreous material was apparent in Mortar 5.
Samples: MCA.007; MCA.008; MCA.009; MCA.013; MCA.014; MCA.015.
Mortar 5 is very distinctive and only appears to be associated with this architecturally formal masonry context of the monument. This is clearly of a different phase to the north hall, drum garderobe, and north/east upper parapet.

1.2.8 WEST OF NORTH-WEST PARAPET

This small late context is characterized by a very informal masonry style and includes high concentrations of limestone and roofing slate in its construction. The mortar is a very coarse limestone-lime indentified here as Mortar 10:

General description – Mortar 10 is a very coarse grey-coloured mortar.

Carbonate kiln-relicts – Mortar 10 is a limestone-lime containing a high concentration of large angular heated limestone inclusions to 30-45mm.

Added-temper – Mortar 10 was tempered with a poorly sorted coarse mixture of lithic and shell materials dominated by subangular to rounded lithics to 25mm but including a small fine unheated shell fraction.

Fuel kiln-relicts - No fuel was apparent in Mortar 10

Vitreous kiln-relicts - No vitreous material was apparent.

Samples: MCA.037; MCA.038.

1.2.9 SOUTH-EAST & SOUTH-WEST RANGES

As suggested by the interim analysis, these internal ranges are evidently comprised of a number of distinct constructional phases and yet the mortars of these buildings are so similar that *in-situ* they could not be differentiated from one another. Each, therefore, will be identified as Mortar 7:

General Description – Mortar 7 is a yellow-coloured lime mortar.

Carbonate kiln-relicts – Mortar 7 is a limestone-lime with a high concentration of heated limestone relicts.

Added temper – Mortar 7 was tempered with a poorly-sorted mixture of lithic and shell aggregate materials. The evidence contains a sub-mm fraction, but includes dark subangular lithics, generally to 6mm and occasionally to 15mm, and a very low concentration of unheated shell to 1-2mm.

Fuel kiln-relicts – Mortar 7 was wood-fired and contains a very low concentration of wood-charcoal to 3mm.

Samples MC.045 & MC.046 (SW range); MCA.047 & MCA.048 (SW range x-wall); MC.049 (SE range).

1.2.10 SOUTH-EAST CURTAIN LOWER PARAPET

The mortar binding the masonry of the lower parapet fossilized within the south-east curtain wall could only be examined externally at the time of the survey, but is visible in a number of deep wall-core contexts (to 200mm) and clearly contrasts with Mortar 1 in the masonry below, and with Mortar 5 in the masonry above. This core evidence suggests a band of this masonry, of approximately 2m high, and including the fossilized parapet, has been constructed with a shell-lime mortar which will now be identified as Mortar 8

General description – Mortar 8 is a coarse white shell-rich lime mortar.

Carbonate kiln-relicts – Mortar 8 is a shell-lime with a high concentration of heated shell fragments. The assemblage is almost completely dominated by limpet shell.

Added-temper – Mortar 8 has been tempered with a poorly-sorted mixture of lithics and shell including rounded lithics to 15mm.
Samples: MCA.016.
The masonry associated with Mortar 8 has then been coated with a limestone-lime mortar, yet the boundary between these 2 apparently contrasting mortars is not readily apparent and some possible mixed limestone-lime/shell-lime contexts were noted.
Samples: MCA.017. MCA.018

1.2.11 KILCHOAN OPC, ARDNAMURCHAN

The medieval and later ruined parish church in Kilchoan Burial Ground was subject to rapid investigation as routine part of the wider South West Region survey (so without literature search) and is included here because of its proximity to Mingary castle.

Although recently consolidated with cementitious mortars, the ruin is clearly of two main historic phases each of which is associated with a different mortar type.

The primary fabric is clearly visible in the east wall, where contiguous coating, bedding and core contexts to 200mm deep at all lower levels to above window height, are bonded with a consistent characteristically shell-lime mortar. This same material is also evident in reasonably extensive deep core contexts at the north-west corner of the building, below the gable at about eaves level, as a coating on the lower courses of both west wall faces, and as contiguous deep-core, bedding and coatings on both faces of the lower courses of the north wall. This is identified here as Mortar 11.

Carbonate kiln-relicts – Mortar 11 is a shell-lime containing a high concentration of shell fragments which display a wide range of heated textures. Amongst other unidentified taxa the assemblage included *P. vulgata* (limpet).

Added-temper – Mortar 11 was tempered by a poorly-sorted aggregate including a high concentration of sub-mm fines, with a larger subrounded lithic fraction to 8mm.

Fuel kiln-relicts – No fuel evidence was noted in Mortar 11.

Above this shell-lime bonded fabric, the west gable, the higher courses of the north wall, and the whole of the south wall is bonded with a clearly contrasting mortar material. Although often only visible in shallow bedding contexts, enough deeper core is visible in the south wall beneath sills and around the door lintel to be confident that this is the constructional mortar here. This material is identified here as Mortar 11:

General description – Mortar 11 is a very yellow friable and porous mortar.

Carbonate kiln-relicts – Mortar 11 is a limestone-lime containing a high concentration of rounded lime and limestone inclusions, generally to 3mm.

Added-temper – Mortar 11 was tempered with a predominantly sub-mm aggregate material which also included larger rounded lithics to 40mm.

Fuel kiln-relicts – The lime for Mortar 11 was wood-fired and the mortar contains a very high concentration of wood-charcoal to 35mm.

In summary, the primary phase of this building was constructed with a probable shell-lime mortar, and this survives in the east, west and lower courses of the north walls. A subsequent limestone-lime bonded phase involved rebuilding the upper levels of these walls and the complete re-building of the south wall. This second phase is very likely to be a post-Reformation re-modeling and reconfiguration of the building to provide a southern focus. It is significant that the east window is included within the primary shell-lime bonded fabric as this is of early thirteenth-century character.

1.2.12 SUMMARY OF ON-SITE FABRIC SURVEY

By the end of the survey at least nineteen demonstrably different mortared phases had been characterised at the Mingary Castle site and three at the nearby parish church. The above synopsis has not included characterisation of very recent materials, or less significant contexts which had been described in-interim, and has also begun to group some phases together where their mortars are very similar and the chronologies close (as, for example, with Mortar 7 of the south-east and west ranges). At this stage, even this simplified account of the mortar and masonry evidence suggests that the building was much more complex than had been previously recognised. This could have been predicted beforehand, as this was the first time the building had been subject to such close scrutiny and it is possible that these results will be simplified further as analysis proceeds. Of particular interest at this stage, however, is that the mortar-making (and stone emplacement) materials and/or techniques appear to change quite fundamentally from structure to structure, even where they had previously been regarded as chronologically very closely related. Before making further comment, however, we should turn to the subsequent mortar sampling and analysis programme.

2.0 SAMPLE CONTEXTS AND ANALYSIS

A number of small material samples were removed from the site for lab-based analysis. A combination of factors including the complexity of the site, large range of different mortar types, reasonable quantities of mortar fuel, lack of contamination by modern consolidation mortars, excellent access to almost all parts of the building and large exposed sections of core rubble led to this site being the most comprehensively sampled and analysed mortar assemblage undertaken during this thesis. Although this assemblage was therefore dominated by mortar materials removed from the castle building itself, other materials sampled included some ex-situ building stone and aggregate samples from the nearby shore.

As above, the sampling strategy was implemented only after the building had been examined over a three day period, and this was necessary so that the research might characterise the materials used in those main structural phases whose relationships with the rest of the building had been confidently identified, but also to respond to any survey questions, where in-situ mortar examination contrasted with other phasing interpretations or evidence, or where material characterisation was more tentative. Mortar samples were removed by hammer and chisel from a variety of fixed inter-stone contexts. Deep core contexts were initially prioritised in order to avoid the slightest possibility of un-recognised contamination (39 of 54 mortar samples are from core contexts).

2.1 SAMPLE CONTEXTS

Sample contexts were generally recorded as x, y and z coordinates, hand-measured relative to fixed building features such as wall faces, lintels or jambs, and by photograph. On site these were then also annotated onto the interim drawings of the building provided by Addyman Archaeology, and these are presented below. In the near future it is intended that the sample context photographs and measurements will be correlated with rectified photographs of the site, to present a more accurate record.

Beach sand contexts were recorded by hand-held GPS.

2.1.1 MORTAR SAMPLE CONTEXTS

The following table presents a list of all the fixed mortar samples removed from Mingary Castle during the main sampling programme and that will be followed by a list of mortar fuel kiln-relicts which were removed directly during a subsequent site visit.

Sample reference.	Building context.	Vertical /mm..	Horizontal /mm.	Depth /mm.	Mortar Context.	Carbonate	Temper	Fuel
MCA.001	East Curtain. External.	200-225 directly above spout.	3000-3014 N of SE corner of Hall.	40-110.	Bed.	Limestone; yellow binder matrix; high conc. buff subang.	Fine mostly sub-mm; medium concentration	Wood; high concn. angular wood char. to

						limestone to 26mm; no shell.	of coarse, rounded lithics to 22mm.	15mm.
MCA.002	East Curtain. External.	820 above small 'lintel' of window to N.	1500 S. Of N. Arris of S. Vouusiour.	100-140	Core.	Limestone. brown/yellow mortar; no limestone or shell in hand sample	Fine temper; wholly sub-mm in hand sample	No fuel in hand sample.
MCA.003	East Curtain. External.	Same height as middle of arris above.	1360-1420 directly above same arris as in 2 above	0.00	Coat.	Limestone; yellow/buff mortar; one buff subang. probable limestone at 16mm; low to medium concn. fine degraded brown limestone inclusions to 5mm.	Fine; sub-mm temper with very low visible lithic fraction even at x 10. In hand sample.	Fine probable wood charcoal inclusions.
MCA.004	East curtain. External.	370 above bottom of 'lintel' of window.	5400 S. of arris from above.	0-45	Bed/coat.	?Limestone; grey matrix; coarse subang. probable limestone to 26mm; subrounded buff inclusions to 10mm; no heated shell apparent.	Lithic and shell; Coarse subrounded lithics to 15mm; unheated shell to 5mm.	No fuel apparent.
MCA.005	East curtain. Wallhead.	On wallhead.	2250 S. of S. jamb of small putlog/window.	500 (from external face).	Core.	Shell; white matrix; very high concn. small heated shell frags to 6mm and occasionally to 25mm including oyster & limpet; no limestone apparent..	Medium concn. unheated shell to 7mm; low concn. Subround to rounded lithics to 22mm.	No fuel relicts apparent.
MCA.006	East curtain. External.	100 below wallhead beneath core stone.	3260 S. of S. jamb of putlog.	275	Core.	Shell; white matrix; medium concn. positively identified heated shell; no limestone or lime lumps evident.	Shell and lithic; coarse; unheated gastropod shells to 25mm; subround to subang lithics to 40mm.	Wood; medium concentration of eroded angular charcoal inclusions to 4mm.
MCA.007	West curtain. External.	570 above sill of merlon.	160 back square from N. Splay jamb.	240	Core.	Limestone; high concn large buff limestone and rounded lime inclusions to 20mm; finer dark brown degraded limestone to 6mm.	Lithic; Fine (3-4mm) subround lithic; low concn. coarse (20mm). Low conc. shell.	No fuel evident in hand sample.
MCA.008	West curtain. Wallhead	Wallhead (1050 above sill	1800-1850 S. of S.	150-240 (from	Core.	Limestone.Brown-yellow; dark brown degraded	Fine temper. Mostly sub-mm; low-	No fuel evident in sample.

	.	of adj. Merlon sloping to S.	jamb of adj. Merlon.	extern al face).		limestone and white lime inclusions, both subround, to 6mm; no heated shell.	medium concn. of larger subrounded lithics to 25mm.	
MCA.009	West curtain. Wallhead .	Wallhead	Loose between 7 and 8.		Loose. Core.	Limestone. Light buff matrix; low concn. rounded limestone to 12mm visible; no heated shell fraction	Lithic; not well tempered; high concn. fine sub-mm; low concn. coarse subrounded to 16mm; no unheated shell.	No fuel material evident.
MCA.010	West curtain. Wallhead .	Wallhead .	See drawing.	150 (from extern al face).	Core.	Limestone; brown/buff coloured mortar; large subangular, grey/buff limestone to 30mm which also display deep blocky crazing.	Lithic and shell; subround to rounded mafic lithics to 15mm; locally high concn. fine unheated shell to 4mm low coralline fraction.	No fuel evident in hand sample
MCA.011	West curtain. Wallhead .	Wallhead .	As MC.010.	300 (from extern al face).	Loose. Core.	Limestone; high concn. large subang. limestone to 30mm; large vitreous inclusion has flowed around lithic temper, this appears to be overburn vit.and will be coded MCA.011v.	Lithic and shell; well tempered; coarse rounded to subrounded lithics and unheated shell (including a high concn. gastropod) to 10mm	No fuel apparent in sample.
MCA.012	West Curtain. Wallhead .	Wallhead .	See Drawing.	100 (from extern al face).	Bed.	Limestone. Light buff matrix; low concn. small subangular lime inclusions and subangular vesicles to 5mm; no heated shell apparent.	Fine temper; dominated by sub-mm material; low concn. coarse subrounded lithics to 25mm.; no shell fraction	Wood (charcoal – see MC.012a)
MCA.013	West curtain. External.	0-100mm below top of large stone which forms Adj.merl on S. jamb.	600 S. of S. jamb of adj. Merlon.	250	Core (beneath lifted core stones).	Limestone; yellow/light brown; high concn. subrounded limestone; white lime and degraded dark brown limestone, generally to	Fine. low-medium concn. Large subrounded lithics to 15mm. No shell.	No charcoal apparent in hand sample.

						12mm, occasionally to 20mm; no heated shell.		
MCA.014	South curtain. External.	50-120 above sill to west.	830 E. Of W.jamb of adj. Merlon.	200	Core (from behind missing jamb stone).	Limestone; light brown; very high concn. white subangular heated limestone to 6mm.	Fine temper; predominantly sub-mm and apparently lithic.	No fuel apparent even when cut.
MCA.015	South-East curtain. Wallhead.	Wallhead.	650 S. of S. jamb of adj N. Merlon.	250 (back from external SE face).	Core.	Limestone; yellow/buff binder matrix colouration; very high concn. of white subang. heated limestone to 20mm; no shell evident.	Fine temper; sub-mm; low concn. of subround to ang. darker lithics to 3mm.	No fuel apparent.
MCA.016	South-East curtain. External.	1140 directly below sill of low slit merlon.	Directly below (see left).	150	Core.	Shell; white matrix; high concn.of coarse blue heated shell relicts (mostly limpet) to 19mm; medium concn. finer curving lime inclusions to 5mm.	Shell and Lithic. Coarse lithic subround to round to 12mm. Difficult to distinguish heated from unheated shell temper.	Wood; medium concentration of probable sub-mm inclusions.
MCA.017	South-East curtain. External.	1580 directly below middle of top of sill of merlon above.	Directly below middle (see left).	0-70	Bed.	Shell. Grey/white and very hard; very high concn. small heated and calcined shell relicts to 9mm; no limestone apparent.	Well tempered with heated shell- relicts; low conc. subang mafic lithics to 16mm.	No fuel apparent in sample.
MCA .018	South-East curtain. External.	120 below top of sill of slit merlon to S..	1050 N. Of N. Jamb of slit merlon to S.	0	Coat.	Limestone; high concn. large ang. to subround limestone to 30mm; no heated shell.	Lithic. Round to subround to 15-20mm. Medium concn. of unheated shell to 4mm.	No fuel evident in hand sample.
MCA .019	West curtain. External.	70 below top of sill of bartizan drain to S.	1400 N. Of N. Jamb of bartizan drain.	100-150	Core/bed.	Limestone. High concn. Subang. lime and limestone; no heated shell.	Lithic and shell; Coarse subround lithics to 12mm, probably including limestone; medium concn. unheated shell to 4mm.	No fuel apparent in sample.
MCA .020	East curtain. External.	1300 above ground.	7900 S. of external elevation	270	Core.	Limestone. Brown matrix; high concn. degraded brown subang, to	Fine temper; medium concn.of rounded	Wood. High concn. degraded wood

			of N. Wall .			subround lithics to 20mm,; no heated shell apparent.	lithics to 12mm; low to medium concn. of fine unheated shell to 4mm.	charcoal to 8mm..
MCA .021	East curtain. External.	Same context as MC.020 but from a large loose masonry.			Loose.	Limestone; yellow/light brown; medium concn. brown, buff and white limestone/lime; no shell apparent.	Lithic; generally sub-mm but also locally higher concn.s well tempered with subrounded lithics to 7mm.	Wood; low concn. charcoal inclusions to 5mm.
MCA .022	South-East curtain. External	1820-1825 up from top of sill of ope to N.	1400-1450 N. Of external elevation of South curtain wall.	120-150	Core	Limestone. Brown coloured binder matrix; low concn. fine subrounded degraded brown inclusions to 3mm; no heated shell apparent.	Fine lithic; generally sub-mm; low concn. round to subround lithics to 28mm; no shell apparent.	Wood; medium concn. fine char. relicts to 2mm.
MCA .023 a	South curtain. External.	2230 above bottom of sea gate lintel.	800 W. Of external elevation of South-East curtain wall.	30	From bedding.			This is Charcoal.
MCA .024	South curtain. External.	1830 above bottom of sea gate lintel.	850 W. Of external elevation of SE curtain wall.	80-160	Bed	Limestone; yellow; medium concn. Subround buff and degraded brown inclusions; no heated shell.	Lithic; round to subround to 25mm; low to medium concn. unheated shell, including gastropods, to 12mm.	No fuel evident in hand sample.
MCA .025	South curtain. External.	2040 above bottom of sea gate lintel.	4150 W. Of external elevation of SE curtain wall.	190	Core	Limestone; this sample is dominated by a large. 45mm, subround brown/buff lithic.	Lithic; fine , subang.qurtz-rich lithics to 2mm.	Wood (charcoal).
MCA .026.	West curtain. External.	1440 above bottom of garderobe lintel to S.	3400-3500 S. of external elevation of NW wall.	350-440	Core (deep).	Limestone, light brown; medium concn. degraded yellow subangular inclusions; no heated shell.	Fine temper; sub-mm; low - medium concn. angular lithics to 35mm;, rare shell fragments when crushed;.	Wood (charcoal) high concn. fine lenses to 3mm, one to 15mm(MCA.026a).
MCA	West curtain.	1100	1140 N.	20-40	Coat	Limestone;	Lithic; coarse	No fuel

.027	External.	above bottom of lintel of garderobe to south.	Of N. Jamb of garderobe to S.		(very thick context of which this is just a piece).	although white/grey externally ; buff subang limestone inclusions to 35mm; some bleeding-out of heated limestone; no heated shell	and well tempered; round to subround mafic lithics to 14mm; low concn. fine unheated shell to 3mm.	evidence in sample.
MCA .028	West curtain. External.	1630 above bottom of lintel of garderobe to N.	900 N. Of external elevation of S. curtain wall.	170	Core.	Limestone; brown, fine subang.buff inclusions to 4mm; no heated shell.	Fine temper; low concn. unheated shell to 12mm.	Wood (charcoal). High concentration to 15 x 15 x 4mm.
MCA . 029	North curtain. External.	200 below surviving wallhead.	See drawing.	250	Core.	Shell; white matrix; medium concn. heated and calcined shell to 80mm; no limestone evidence.	Lithic; well tempered; poorly sorted subround to round lithics to 15mm; low concn. Unheated shell to 20mm.	Wood; medium concn.char to 2mm.
MCA .030	North curtain. External.	850 below surviving wallhead.	700 W. Of external elevation of East curtain wall.	180	Core.	Shell and Limestone; grey matrix; possible low concn.of both heated shell (to 14mm) and limestone (to 15mm).	Lithic and shell; coarse subround to subang, lithics to 23mm; Finer unheated shell and coralline to 5mm	No fuel evidence.
MCA .030 a	North curtain. External.	See drawing	See drawing	0	Coat.	Shell.		
MCA .031	North curtain. External.	See drawing			Core/Bed.	?Limestone; buff mortar; one ang possible limestone to 20mm; no heated shell.	Lithic and shell; rounded mafic lithics to 7mm; unheated shell) to 5mm.	No fuel evident in hand sample.
MCA .032	North curtain. External.	200mm down from surviving wallhead.	See drawing.	200	Core.	Shell; white matrix; high concn. heated and calcined oyster shell; no limestone.	Lithic; subround and round lithics to 20mm.	No fuel evident in sample.
MCA .033	North curtain. External.	At height of bed of massive jamb stone.	West jamb of merlon.	300	Core/Bed.	Shell. High concn. heated and calcined shell to 10mm.	Lithic; subround to subang to 6mm; high concn of shell.	Wood; high concn.fine wood chal to 3.5mm, one lens at 10mm.
MCA	North curtain.	400	200 west	300	Core.	Shell; high concn.	Lithic; well	Wood;

.034 *	External.	below highest surviving of west parapet.	of west jamb (ie back from external face of NW curtain wall).	(from parapet, or 550 from face of main N curtain walling below.		blue and white heated and calcined shell fragments to 7mm.	tempered but quite fine; subround lithics to 4mm and occasionally to 10mm.	medium to high concn. Char. to 3mm.
MCA .035	North-West curtain.	'Wallhead'. 300mm below highest surviving masonry of this phase.	See drawing.	260 (back from external elevation).	Core	Shell; white matrix; high concn. fine shell-lime evidence to 4mm.	Lithic; well tempered coarse, poorly sorted subround lithics to 16mm.	Wood; charcoal to 3mm.
MCA .036 *	North-West curtain.	See drawing	See drawing	0-120 (back from external elevation).	Bed.	Shell; white matrix; high concn. Heated shell frags to 10mm; occasionally to 15mm.	Lithic: well tempered; not coarse; subround to round lithics to 10mm, occasionally to 25mm.	Wood ; high concn. fine char to 5mm.
MCA .037	North-West curtain.	'Wallhead', 860 above bottom of window lintel below.	150mm E. Of E. Jamb of window below.	180 (back from face of external elevation.	Core.	Limestone; ang/subang limestone to 25mm; one at 55mm.	Lithic; well tempered; coarse round to subround mafic lithics to 30mm; very low concn. shell to 3mm.	No fuel evident in sample.
MCA .038	North-West curtain. External.	1060 above bottom of window lintel below.	Directly above centre of lintel.	0-100	Bed.	Limestone; high concn. degraded buff/brown subround-subang inclusions generally to 13mm.	Lithic; well tempered; subround mafic lithics , to 10mm occasionally to 43mm. Very low concn of unheated shell to 3mm.	No fuel evident in sample.
MCA .039	North-West curtain. External.	900 below top of surviving 'wallhead' of this phase.	130-220 W. Of eastern extent of this phase (below flatty east of big stone).	70-110	Core.	Ambiguous;white and yellow; little positive evidence in hand sample; small ang eroded voids to 6mm; blue limpet shell to 20mm.	Lithic; well tempered; generally very coarse; round/subround lithics to 30mm.	No fuel evident in sample.
MCA .040	N. hall. W. rooms. 1st floor. S. wall.	0-180 below socket	500-600 W. Of internal	0	Coat	Shell; white/grey; high concn. heated and	Shell temper mix of heated and unheated	Wood; medium concentration

	Internal.	for internal lintel of east window (of western rooms).	W. Jamb of east window (of western rooms).			scorched shell to 14mm; cockle and limpet identified. No limestone.	shell; probable large sub-mm fraction also; low concn.of subround lithics to 20mm.	of charcoal flecks to 3mm.
MCA .041	N. hall. W. Rooms. Gr. Floor. S. wall. Internal.	600 above bottom of internal lintel socket of east window.	Between windows in east joist socket. 300 west of internal W. Jamb of east window.	250 (back from internal wall face).	Core	Shell; white matrix; heated cockle shell to 30mm. High concn. Heated shell to 10mm; no limestone.	Lithic; subang to round mafic lithics to 10mm, occasionally to 50mm.	Wood; medium to high concn. fine char. to 4mm.
MCA .042	N. hall. W. Rooms. Gr. Floor. S. wall. Internal.	600 above bottom of internal lintel socket of east window.	Between windows in west joist socket. 1050 west of internal west jamb of east window.	270 (back from internal wall face.	Core.	Shell; white; large heated oyster shell to 45mm.	Lithic and shell; round dark coloured lithics to 10mm, fine unheated shell to 5mm.	Wood; medium concn. fine, degraded, char. to 4mm..
MCA . 043	N. hall. W. wall. 1st floor. External.	Level with top of west window lintel (of external S. wall of N hall).	1500 north of external SW corner of N hall.	50-150	Bed/Core	Shell; white matrix; high concn. oyster to 57mm.	Lithic; subround lithic temper generally sub-mm but occasionally to 22mm; very low concn. unheated shell	Wood; medium concn.fine char. relicts to 3mm..
MCA .044	N. hall. W. Gable.1st floor. External.	240 below top of west window lintel (of external S. wall of N hall).	2900 north of external SW corner of N hall.	400	Core	Shell; white matrix; high concn. Heated shell – probably oyster - to 35mm; no limestone evidence	Lithic; high concn. submm ‘silty’ temper; medium concn. of round to subround lithics to 15mm; very low concn. fine unheated shell.	Wood; high concentration of fine charcoal lenses to 5 x 1mm.Mark
MCA .045	SW. Courtyard building. E (front) wall. Ground floor.	Above doorway abutting curtain. 400 below sill	300 south of 1st floor internal window jamb.	300 (back from internal face).	Core	Limestone; yellow; very high binder ratio; medium concn. subround white lime inclusions to	Lithic; poorly tempered; round/subround mafic lithics to 5mm;	No fuel evident in sample.

		of 1st floor window above.				6mm., low concn. brown subang limestone.	occasional or angular lithics to 15mm. No shell.	
MCA .046	SW. Courtyard building. E (front) wall.	750 above bottom of ground floor window.	360 south of 1st floor doorway S. jamb.	260 (back from extern al face).	Core	Limestone; yellow matrix; high binder ratio; medium concn. buff subround lime/limestone to 6mm.	Lithic and shell; low concn. coarse subround lithics to 15mm; locally high concn. fine unheated shell to 2-3mm.	No fuel evident in sample.
MCA .047	SW. Courtyard building. Slap-in to re-face curtain recess.	2040 above top of sill of platform in recess.	240 back from line of internal face of curtain wall.	330 south of S. jamb of recess	Core	Limestone; yellow; high binder ratio; low concn. round white lime to 5mm.	Lithic; poorly tempered; round/subrou nd mafic to 8mm. Very low concn. of unheated shell to 2.5mm	No fuel evident in sample.
MCA .048	SW Courtyard building. X-wall.	310 above top of surviving east jamb stone of fireplace.	270 east of E. Jamb of fireplace.	350 (back from interna l (north) elevati on.	Core.	Limestone; yellow; high binder ratio; very low concn. Subang. buff limestone.	Lithic; poorly tempered; round and subround mafic to 8mm; low concn. of unheated shell to 4mm.	No fuel evident in hand sample.
MCA .049	SE courtyard building. W. (front) wall.	500 above level of top of sill (bottom bed of internal window jamb).	200 north of internal window N. Jamb.	350 (back from extern al (west) face of wall).	Core	Limestone; yellow; low concn. light brown/buff subang. limestone; Very low concn.white round/subround lime lumps.	Lithic and unheated shell; subroud to subang lithics to 11mm; Locally medium – high concn. unheated shell to 3.5mm.	No fuel evident in sample.
MCA .050	North hall. West x-wall. 2nd floor. W. Elevation.	570mm above bottom of wooden lintel of doorway.	Central to doorway.	600 (back from west elevati on).	Core	Limestone; yellow; high binder ratio; soft binder; low concn. brown subang limestone; low concn.round white lime lumps to 3mm	Lithic; well graded; generally round/subrou nd; mafic to 5mm, occasionally to 11mm; some quartz; low concn. unheated shell to 4mm.	No fuel evident in sample.
MCA .051	North hall. S. wall. Gr. floor	1800 below bottom of main entrance	160 west of W. Jamb of main entrance	280 (back from south wall	'Core' (from behind missing slap-in	Limestone; Yellow; fine round lime to 2-3mm.	Lithic; subround lithics to 12mm; low concn. fine	Wood; charcoal inclusion (one in sample).

		doorway lintel.	doorway.	external (south) face.	jamb stone).		unheated shell to 2mm.	
MCA .052	NW. Curtain Wall; exterior elevation.	3rd lift From primary mortar.			Coat	This is possible heated limestone bright red, but may be sandstone		
MCA . 053	West curtain. Wallhead.	Wallhead .	As MCA.012 .	220 (from external face).	Core.	Limestone; buff mortar; small subang. brown limestone and white lime to 4mm; no shell.	Fine temper; sub-mm; low concn.of subround lithics to 30mm; no shell fraction.	Wood; medium concn. sharp charcoal relicts to 14 x 2-3mm.
MCA .054	North curtain; external elevation	First lift, east end, from void under lintelish stone.		20-120 from external face.	Bedding.	Limestone; yellow matrix; fine brown/buff subang to 3-4mm; no shell.	Fine temper; sub-mm; low concn. subang lithics to 15mm; shell.	No fuel evident in sample.

2.1.2 ADDITIONAL MORTAR FUEL SAMPLE CONTEXTS

A subsequent short site visit was made to retrieve a small number of fuel relict samples.

Sample reference .	Size.	Building context.	Vertical /mm..	Horizontal /mm.	Depth /mm.	Mortar Context.
MCA.C1	20 x 20 x 10	North-west curtain; external face.	700 below doorway lintel bottom bed.	1800 east of east doorway jamb.	100-120 back from wall face.	Bedding.
MCA.C2	30 x 25 x 25	West curtain; external face	950 up from low wallhead to south	200 back from internal face of NW curtain.	350 back from wall face.	Core.
MCA.C3	15 x 15 x 07	East curtain Drum garderobe; External face.	Level with middle of lintel.	430 north of north jamb; touching lintel.	80-100 back from face.	Bedding.
MCA.C4	10 x 04 x 06	East curtain Drum garderobe; External face	80 above C3.	150 south of C3.	70mm back from wall face.	Bedding.

2.1.3 ENVIRONMENTAL CONTEXTS

Various aggregate samples were collected from both the west (lithic) and east (shelly) sides of the castle, and two possible temper-source samples were cast and thin-sectioned. These were samples:

MCA.B1 from west of castle at Port nan Spainteach, NM 5006 6319;

MCA.B2 from east of castle at Craig a'Bhaile, NM 5031 6308.

2.1.3 ANNOTATED DRAWINGS OF MORTAR SAMPLE CONTEXTS

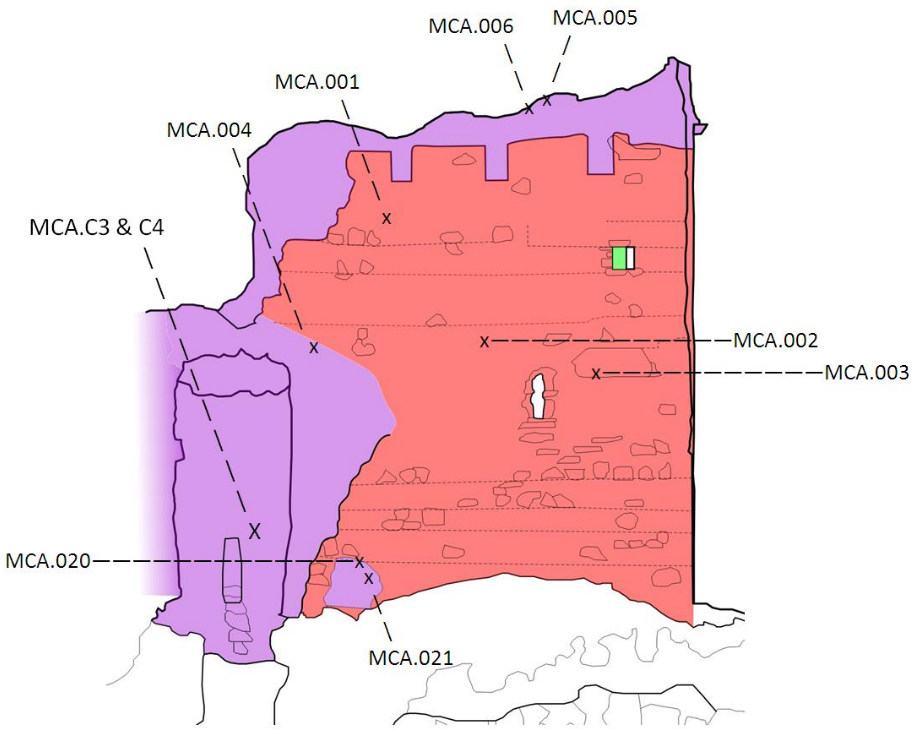


Figure 1a (above) – External elevation of east curtain wall detailing mortar sample contexts. (Underlying drawing and phasing of this elevation is in interim only; permission to use kindly received from Tom Addyman).

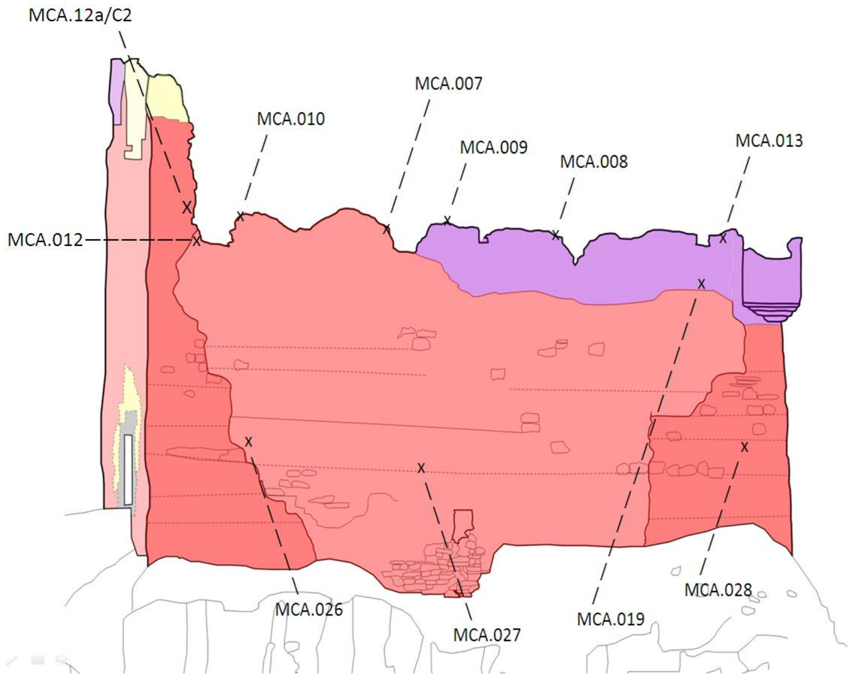


Figure 1b (above) – External elevation of west curtain wall detailing mortar sample contexts. (Underlying drawing and phasing of this elevation is in interim only; permission to use kindly received from Tom Addyman).

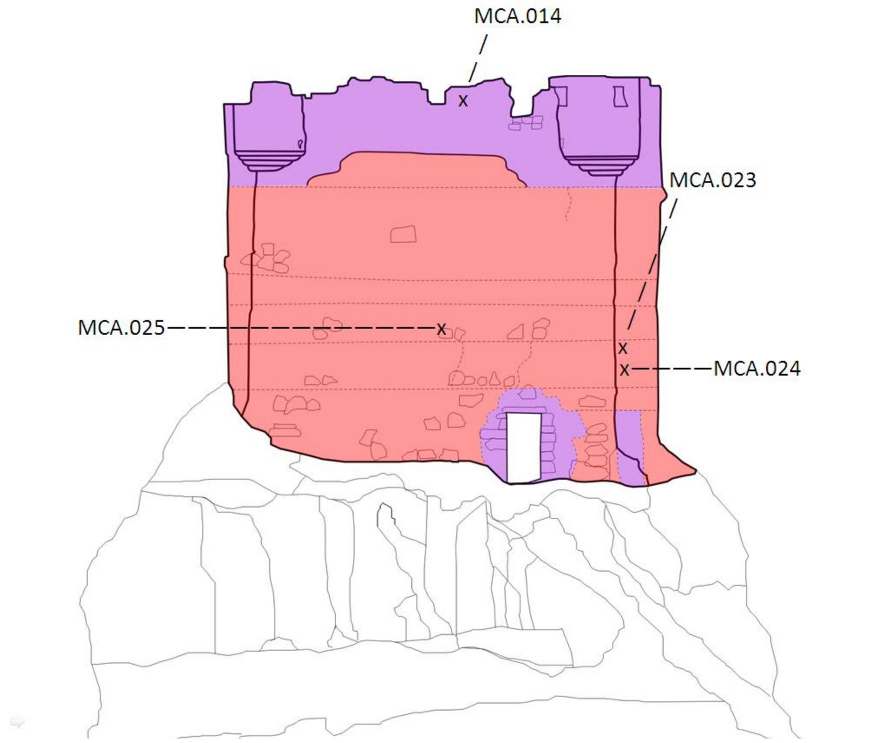


Figure 1c (above) – External elevation of south curtain wall detailing mortar sample contexts. (Underlying drawing and phasing of this elevation is in interim only; permission to use kindly received from Tom Addyman).

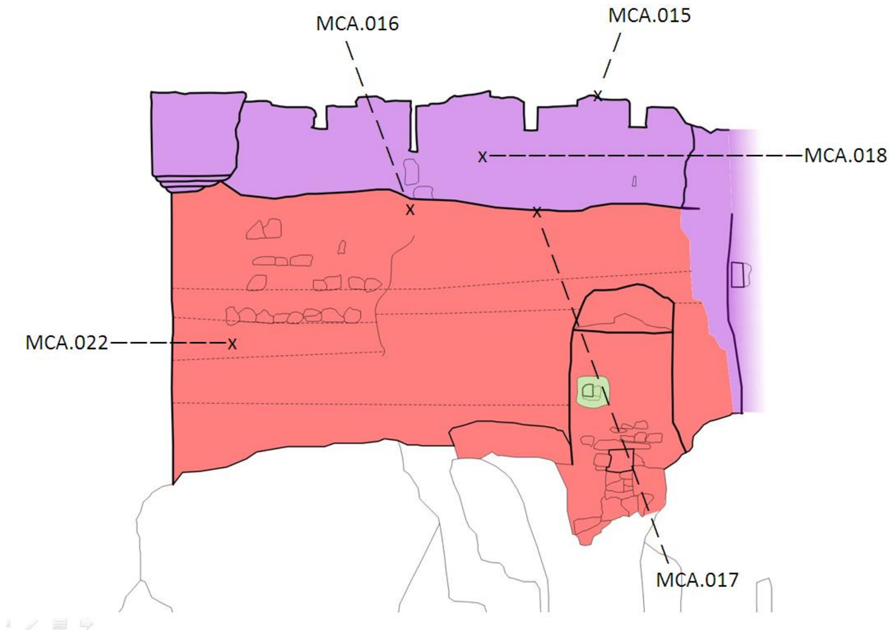


Figure 1d (above) – External elevation of south-east curtain wall detailing mortar sample contexts. (Underlying drawing and phasing of this elevation is in interim only; permission to use kindly received from Tom Addyman).

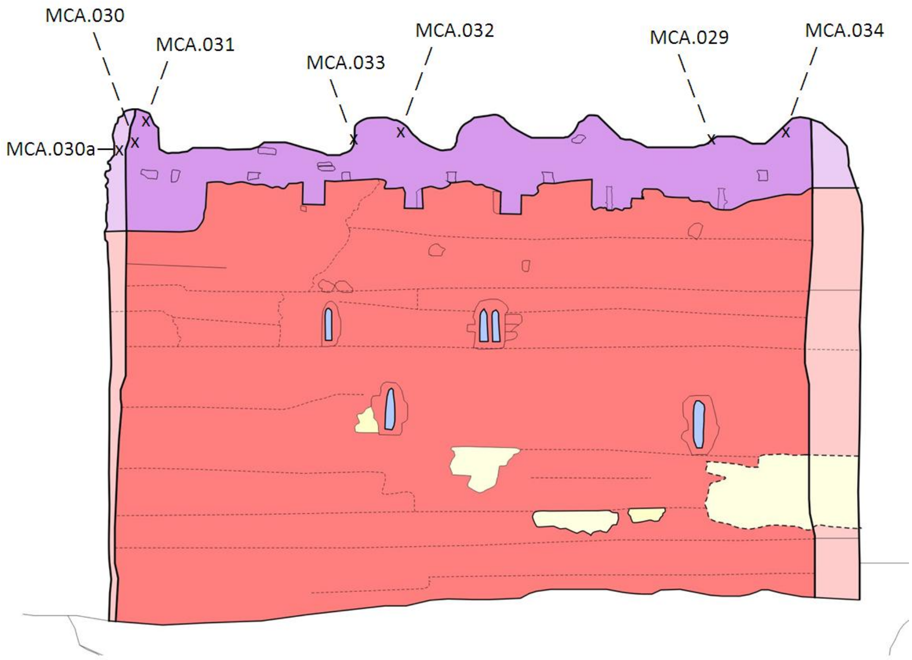


Figure 1e (above) – External elevation of north curtain wall detailing mortar sample contexts. (Underlying drawing and phasing of this elevation is in interim only; permission to use kindly received from Tom Addyman).

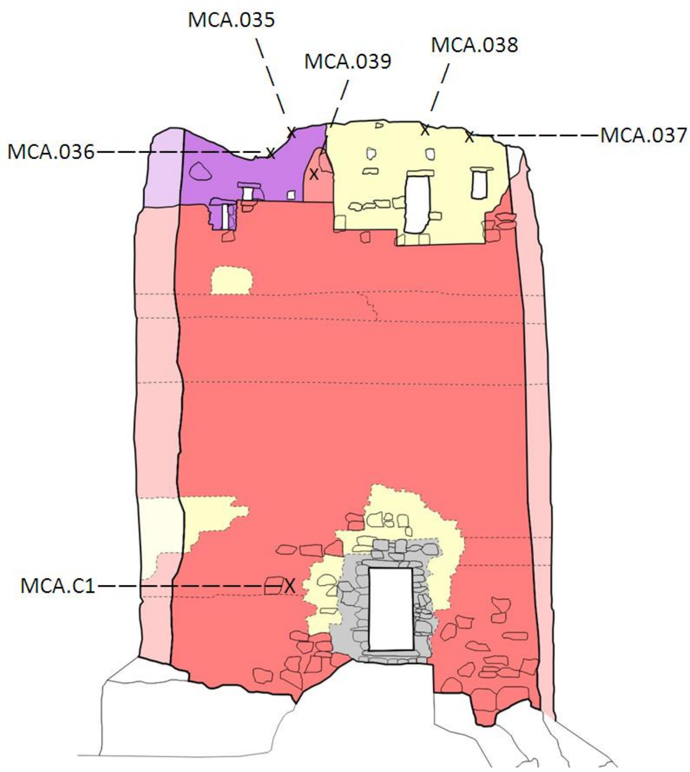


Figure 1f (above) – External elevation of north-west curtain wall detailing mortar sample contexts. (Underlying drawing and phasing of this elevation is in interim only; permission to use kindly received from Tom Addyman).

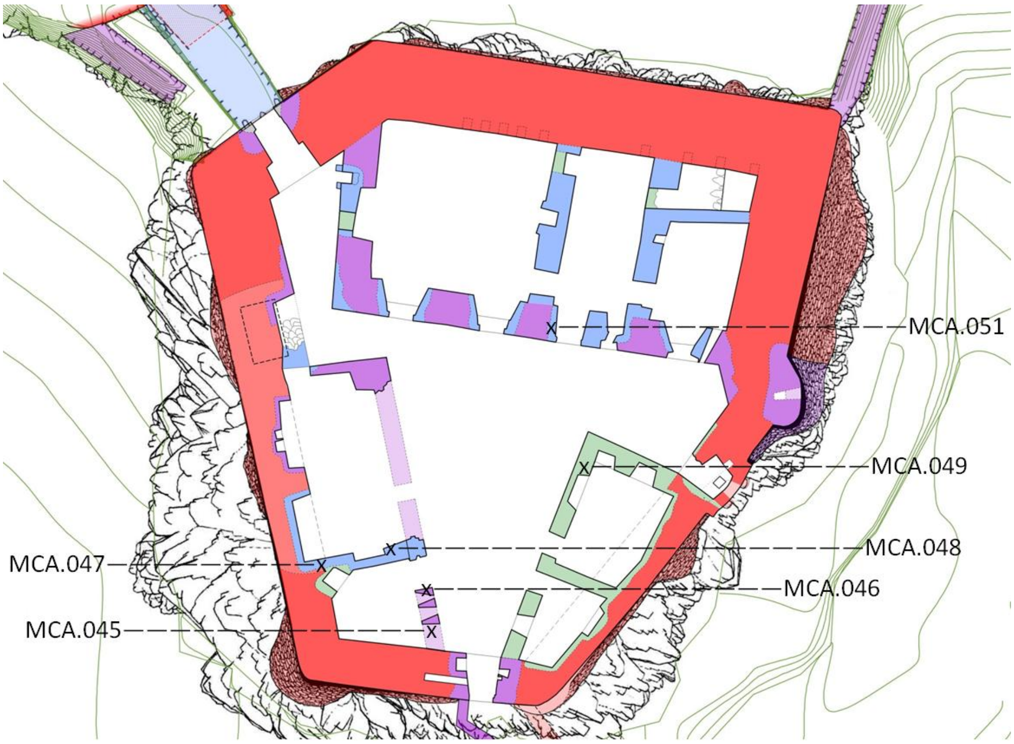


Figure 1g (above) – Ground floor plan detailing mortar sample contexts from castle interior.
(Underlying drawing and phasing of this plan is in interim only; permission to use kindly received from Tom Addyman).

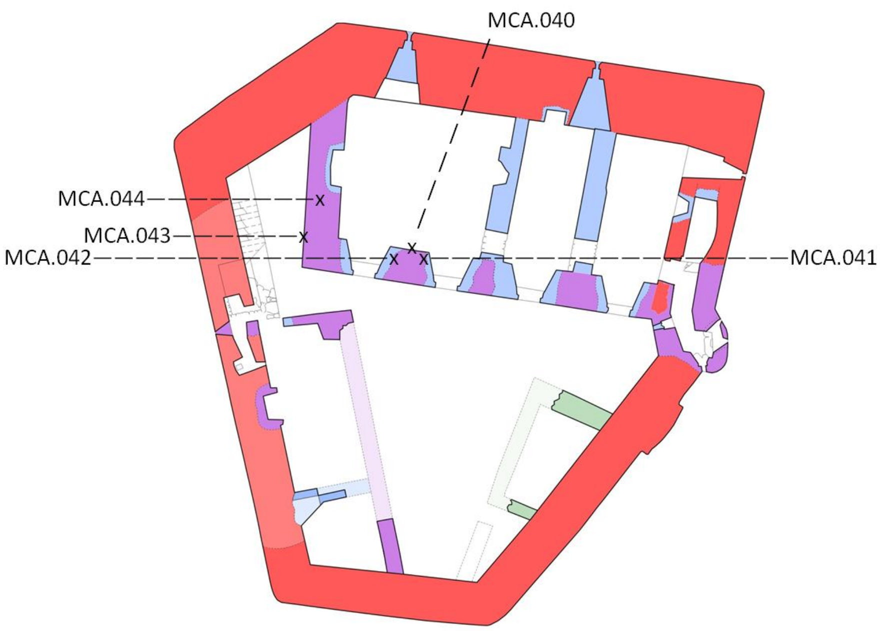


Figure 1h (above) – First floor plan detailing mortar sample contexts from castle interior.
(Underlying drawing and phasing of this plan is in interim only; permission to use kindly received from Tom Addyman).

Figure 1i (above) – Second floor plan detailing mortar sample contexts from castle interior. (Underlying drawing and phasing of this plan is in interim only; permission to use kindly received from Tom Addyman).

2.2 SAMPLE ANALYSIS

2.2.1 MORTAR ANALYSIS

Mounted thick sections were prepared of all the mortar samples and from these a total of forty-nine 30µm thin-sections were prepared in line with the analysis methodology developed throughout this research. These were examined individually in polarised light some months after sampling, without reference to their building context and in reverse order of their sample codes. The resultant interpretations are presented below:

MCA.051

Carbonate kiln-relicts: MCA.051 is a limestone-lime with a high concentration of angular to rounded micritic heated limestone relicts to 5mm, with some rare bioclastic textures in evidence.

Mortar matrix: The matrix is green brown.

Added-temper: MCA.051 was tempered with a sorted mixture of lithics and shell. The lithic fraction includes a concentration of elongate and rounded micaceous and bioclastic shale, rounded dolerite and degraded gabbro. The shale displays contrasting quartz-rich and bioclastic layering.

Fuel kiln-relicts: None noted.

<u>MCA.050</u>

Carbonate kiln-relicts: MCA.050 is a limestone-lime mortar with a high concentration of altered, and/or fractured, angular light brown limestone relicts to 4mm. The parent limestone appears to have been a very pure fine-grained carbonate with no coarse intraclasts evident. The section displays good evidence of highly altered forms which ultimately lose all coherence to form a grey coloured matrix.

Mortar matrix: The MCA.050 section displays a very high matrix-to-temper ratio, of approximately 50:50 by volume, and all clasts are very well matrix-supported.

Added-temper: MCA.050 was tempered with a mixture of lithic and shell fragments. The lithic fraction includes: rounded to angular basalt clasts to 13mm composed of fine-grained plagioclase with a high concentration of pyroxene and magnetite; rounded/elongate and amorphously shaped clasts of mudstone/shale to 7mm composed of microclasts of quartz, and bioclasts to 2mm, within a largely opaque fine-grained matrix (an apparent schistocity within this material suggests it is shale, and its often very fragmented condition has resulted in a spectrum of matrix opacity from brown to black); rounded clasts of pyroxene-rich gabbro to 4mm; and rounded clasts of gneiss to 3mm, highly quartz-rich with minor concentrations of plagioclase and mica. The shell fraction of the temper is high and includes unheated rounded bivalve and gastropod shell fragments (including *patella*), to 5mm, with good surviving internal microstructure.

Fuel kiln-relicts: No fuel evidence was noted in MCA.050.

<u>MCA.049</u>

Carbonate kiln-relicts: MCA.049 is a limestone-lime mortar with a very high concentration of angular heated limestone relics. These are generally micritic although there is range of other textures including some with sparitic calcite veining.

Mortar matrix: The matrix is in very high volume, with a distinctive green-brown colouration.

Added-Temper: MCA.049 was tempered with a low volume well-sorted mixture of shell and lithics. This is dominated by uncalcined shell (80:20) which is itself mostly comprised of gastrapoda fragments to 5mm. The very low concentration of lithics includes rounded gabbro to 1mm and shale to 3mm.

Fuel kiln-relicts: None noted.

MCA.048

Carbonate kiln-relicts: This is a limestone-lime mortar with a very high concentration of heated and often highly altered rounded limestone relicts to 5mm. The less altered material displays very fine calcite veining and rare very fine replacement bioclastic molds, both of which are crystalline and microsparitic. A spectrum of evidence is apparent between these clasts and the apparently homogenized micritic texture of the more highly altered relicts.

Mortar matrix: MCA.048 displays a distinctive grey-green colouration (similar to MCA.050) and (including limestone relicts) is again in very high volume. The matrix to temper ratio is extremely high in this section at over 75:25. Finer acicular relicts in the binder need further analysis.

Added-temper: MCA.048 was tempered with a mixture of lithic and shell with a slight preponderance of lithic clasts. The lithic fraction shows a slight prevalence of subrounded to rounded basalt clasts to 14mm, but also includes: rounded quartz-rich schist with minor white mica to 5mm; rounded and elongate calcareous and quartz-rich, black and opaque wackestone-mudstone/shale to 4mm; polycrystalline plagioclase and monocrystalline orthoproxene to 2mm. The shell fraction is unheated and, where identifiable, mostly *bivalvia* to 4mm.

Fuel kiln-relicts: No fuel evidence was noted in MCA.048.

MCA.047

Carbonate kiln-relicts: MCA.047 is a limestone-lime with an extremely high concentration of angular micritic heated limestone relicts.

Mortar matrix: The MCA.047 section displays a complex fine, crystalline green coloured matrix with altered micritic limestone clasts in very high volume.

Added-temper: MCA.047 was tempered with a low concentration well-sorted mix of lithics (including gabbro and dolerite) and unheated shell, both grading up to 5mm. A very low concentration of subangular and often elongate quartz-rich shale and mudstone to 3mm is also present.

Fuel kiln-relicts: No fuel was noted in this MCA.047 section.

MCA.046 (x2 thin sections)

Carbonate kiln-relicts: MCA.046 is a limestone-lime mortar with a very high concentration of heated rounded to angular limestone relicts, grading up to 22mm. The parent rock contains very low surviving concentrations of fine bioclast moulds (which are probably ostrcod) and some microsparitic veining, but is otherwise generally micritic and homogenous.

Mortar matrix: A very high volume of grey-green coloured matrix is evident in both MCA.046 sections such that, including relict limestone, the matrix-to-temper ration is approximately 75:25.

Added-temper: MCA.046 was tempered with a lithic and shell mixture, in approximately, 90:10 ratios. This includes elongate angular to subrounded dolerite/gabbro to 7mm, subrounded and elongate black and opaque quartz-rich mudstone/shale to 12mm; subangular monocrystalline plagioclase and pyroxene, with unheated subrounded shell to 2mm evident in much lower concentration.

Fuel kiln-relicts: No fuel evidence was noted in MCA.046.

MCA.045

Carbonate kiln-relicts: MCA.045 is a limestone-lime mortar and the section displays an extremely high concentration of highly altered calcareous relics. Clasts with less alteration retain rare ostracod evidence and microsparitic veining but, as in MCA.046, are generally micritic. Some evidence suggests alteration is more apparent, or perhaps advanced, in these features and this requires further research, whilst one clast in particular displays an altered rim whose boundaries certainly warrant further study.

Mortar matrix: Of similar grey-green colouration with very high binder volume.

Added-temper: The slide suggests MCA.045 was tempered by a mixture of lithic and shell clasts, in a ratio of approximately 70:30. Much of this section however, is dominated by coarse lithics, including a large rounded quartz-rich clast (with minor plagioclase) to 11mm, rounded basalt to 10mm, rounded gabbro to 6mm and rounded opaque mudstone/shale to 6mm; as well as monocrystalline plagioclase and quartz to 1.5mm. The shell fraction is comprised of unheated subrounded fragments to 6mm.

Fuel kiln-relicts: No fuel evidence positively identified.

MCA.044

Carbonate kiln-relicts: MCA.044 is a shell-lime mortar. The section is dominated by laminated fragments of *O. edulis* in longitudinal section with well-preserved 'zig-zag' foliation internally, but also cross-cracking, textural alteration and loss of grain boundary definition. No geogenic carbonate evidence was noted in this section.

Mortar matrix: This MCA.044 section displays a high volume of white/light-buff carbonate binder.

Added-temper: Excluding heated shell relicts, the temper volume is very small in this section, but is predominantly lithic and includes subangular plagioclase/gabbro; rounded and elongate micaceous and quartz-rich mud/shale, and some gneiss. A low fraction of uncalcined shell to 2mm is also probable.

Fuel kiln-relicts: MCA.044 was wood-fired, and this section contained two wood-charcoal relicts to 1mm.

MCA.043 (x3 thin sections)

Carbonate kiln-relicts: MCA.043 is a shell-lime mortar and these sections contain high concentrations of heated shell fragments which display a large range of alteration textures. These include *O. edulis* fragments to 35mm with good surviving internal microstructure, contrasting with a high concentration of more highly fragmented and altered bioclasts to 6mm.

Mortar matrix: The sectioned material displays a ‘clean’ light-coloured carbonate matrix.

Added-temper: The binder is tempered with a predominantly lithic material of remarkable variety, including: a high concentration of rounded, micaceous very quartz-rich schist to 14mm; rounded dolerite to 4mm; subrounded and elongate shale to 2mm in very low concentration; and a high concentration of angular to subangular monocrystalline plagioclase to 2mm and pyroxene to 1.5mm. One unheated coarsely bioclastic limestone inclusion to 4mm is also present. Unheated shell temper material is in low concentration and is dominated by bivalve but includes gastropod fragments

Fuel kiln-relicts: MCA.043 was wood-fired, and these sections contained wood charcoal relicts to 1.5mm.

MCA.042

Carbonate kiln-relicts: MCA.042 is a shell-lime with a high concentration of heated shell relicts including a large discoloured *O. edulis* fragment to 10mm.

Mortar matrix: MCA.042 displays a high volume of very light-coloured matrix texture.

Added-temper: This MCA.042 thin section is dominated by a very large subangular, coarsely bioclastic and sparitic grainstone unaltered limestone clast, which is probably detrital. More generally the mortar is tempered by a well-sorted mix of shell and lithics including coarse rounded dolerite clasts to 4mm and unheated gastropod and bivalve shell fragments to 4mm also.

Fuel kiln-relicts: MCA.042 was wood-fired, and this section contained fine fragments of wood-charcoal to 1mm with large spring vessels.

MCA.041

Carbonate kiln-relicts: MCA.041 is a shell-lime mortar. The section contains a high concentration of heated shell relicts, including cracked and discoloured *C. edule* shell fragments to 17mm, altered cross-laminar *O. edulis* to 4mm, and other unidentifiable but highly altered shell fragments to 3mm.

Mortar matrix: The mortar matrix in this MCA.041 section is fine, light-coloured but highly textured.

Added-temper: MCA.041 was tempered with a poorly-sorted mixture of lithics and shell, dominated by well-rounded dolerite to 11mm, and unheated shell to 2mm. A very low concentration of rounded bioclastic and quartz-rich shale clasts to 2mm is also present.

Fuel kiln-relicts: No fuel evidence was noted in MCA.041.

<u>MCA.040</u>

Carbonate kiln-relicts: MCA.040 is a shell-lime mortar, although containing a very high concentration of unaltered shell material. The assemblage is dominated by *O. edulis* but includes other bivalves in longitudinal section with more formal cross-lamellar microstructure.

Mortar matrix: MCA.040 displays a light-coloured mortar matrix, similar to 044 and 043.

Added-temper: This MCA.040 section displays almost no added aggregate as the surviving temper is almost completely unheated shell. There is a very low concentration of lithic inclusions which includes rounded basalt and limestone to 1mm and subangular olivine and quartz to 0.2mm.

Fuel kiln-relicts: MCA.040 was wood-fired, and this section contained a transverse section of ring porous (probable *Quercus*) wood-charcoal to 6mm.

<u>MCA.039</u>

Carbonate kiln-relicts: MCA.039 is a limestone-lime mortar containing a high concentration of altered limestone clasts. These are micritic with rare fine probable ostracod fossils and sparry calcite veining, but also display globular cryptocrystalline textures approaching optical continuity with the mortar matrix.

Mortar matrix: The carbonate matrix contains a high concentration of altered limestone relict clasts.

Added-temper: The mortar is tempered with a mix of lithic and shell materials, but is predominantly (approximately 70%) lithic. This includes: rounded basalt to 6mm, rounded marble to 3mm; rounded and elongate opaque mudstone/shale to 4.5mm; subrounded dolerite/gabbro to 3mm; and a possible subangular chert inclusion to 4mm. The shell fraction displays no evidence of heat alteration and fragments generally grade to 4mm.

Fuel kiln-relicts: No fuel evidence was noted in this section.

<u>MCA.038</u>

Carbonate kiln-relicts: MCA.038 is a limestone-lime mortar which appears to display two types of limestone inclusion, wherein some very homogeneous and micritic clasts are much more altered than other relatively quartz-rich and mica-included examples. This included quartz is angular to subrounded, is generally very fine to 0.25mm and displays undulose extinction, but more generally the rock grades into a 'chert-like' material with a green, (perhaps partly siliclastic?) matrix.

Mortar matrix: In contrast to the grey-green matrices seen in other sections from this site, the site the MCA.038 matrix is light brown and reasonably well tempered with an approximate matrix: aggregate ratio of 50:50.

Added-temper: This MCA.038 section was tempered with a poorly-sorted mixed lithic and shell aggregate dominated by lithic to approximately 75%. The lithic fraction includes rounded dolerite to 3mm; rounded elongate mudstone/shale to 5mm; subrounded gabbro (often very degraded) to 5mm; rounded quartzite/gneiss to 2mm; sandstone to 3mm and rounded chert to 2mm. The shell assemblage is dominated by Recent bivalves with unaltered internal microstructure, grading up to 4mm.

Added fuel: No fuel evidence was noted in this MCA.038 section.

MCA.037

Carbonate kiln-relicts: MCA.037 is a limestone-lime mortar. This section is dominated by a large (to 11mm) rounded highly-altered limestone relict within which is included an even distribution of well-sorted fine (to 0.1mm) subangular quartz with undulose extinction, and a high concentration of similar clasts are distributed across the slide. A lower concentration of more mictritic evidence is also apparent, as well as very fine monocrystalline quartz fraction within the mortar which was probably released during the calcination of the limestone. There are no other temper grains of this grade evident.

Mortar matrix: The matrix of section MCA.037 contains a high temper volume and a 50:50 matrix: temper ratio is suggested.

Added-temper: MCA.037 was tempered by a well-sorted mix lithic (70%) and shell (30%) aggregate. The lithic fraction includes: rounded gabbro (often degraded) to 5mm; elongate and subrounded basalt (with magnetite included) to 4mm; subrounded and elongate mudstone/shale (coarse quartz included) to 4mm; polycrystalline quartz to 2mm; and a significant fraction of monocrystalline quartz to 0.2mm. The shell fraction is subrounded, curving and elongate unaltered bivalve material to 4mm with good internal microstructure.

Added-fuel: no fuel evidence was noted in MCA.037.

MCA.036

Carbonate kiln-relicts: MCA.036 is a shell-lime mortar with a very high concentration of lightly- altered *O. Edulis* clasts to 8mm. Many of these relicts display brown- coloured foliated textures which are lost with calcination.

Mortar matrix: MCA.036 displays a light brown highly textured matrix with a high concentration of heated bioclastic relicts.

Added- temper: Well tempered poorly sorted mix of angular to rounded plagioclase-rich gabbro to 5mm, and very rare subangular monominerallic crystals of quartz and plagioclase to 1mm. No shale or limestone.

Fuel kiln-relicts: MCA.036 was wood-fired, and multiple opaque probable fuel relicts to 1mm were noted, although these are much degraded.

<u>MCA.035</u>

Carbonate fuel-relicts: MCA.035 is a shell-lime mortar and the section contains a very high concentration of Recent shell evidence. The assemblage includes laminated longitudinal *O. edulis* fragments, and a high concentration of other unribbed bivalvia sections which display a more formal 3-layered parallel and cross-lamellar micro structure in longitudinal section, and a range of probable heat alteration evidence.

Mortar matrix: The matrix of MCA.035 is light buff-brown, often microsparitic (is this secondary?), and well-tempered with a matrix: aggregate ratio of approximately 40:60.

Added-temper: MCA.035 was tempered by a poorly-sorted mixture of shell and lithic materials, including subrounded gabbro (often degraded and sometimes with magnetite) to 8mm; and subangular monocrystalline plagioclase and pyroxene to 2mm.

Fuel kiln-relicts: MCA.035 was wood-fired, although only very degraded wood charcoal fragments to 1mm were noted.

MCA.034

Carbonate kiln-relicts: MCA.034 is a shell-lime mortar, and the section displays a large range of shell textures including some highly-altered fragments. These do not appear to be *O. edulis*, however, and include a large proportion with excellent surviving internal microstructure, which appear are probably unheated.

Mortar matrix: MCA.034 contains a very light-coloured, cloudy cryptocrystalline matrix.

Added-temper: MCA.034 was well-tempered with a mixed lithic and shell aggregate, dominated by lithics 65:35. These are very gabbroic, including coarse subangular to rounded gabbro to 6mm, angular to subrounded dolerite to 6mm (one of which shows core/rim textures). Subangular clasts of monominerallic plagioclase and pyroxene to 2mm are present but very rare and shale is absent.

Fuel kiln-relicts: MCA.034 was wood-fired, and this section contains a high concentration of wood-charcoal relicts with large spring vessels to 2mm. This is very probably *Quercus*.

<u>MCA.033</u>

Carbonate kiln-relicts**:** MCA.033 is very probably a shell-lime mortar, although this section displays a very high concentration of apparently unaltered *O. edulis* shell fragments to 18mm, and only a low concentration of more altered bioclasts fragments.

Mortar matrix: The MCA.033 matrix is buff-brown, highly textured and very well tempered with a 55:45 temper: matrix ratio.

Added-temper: The mortar is tempered with a poorly-sorted mixture of shell and lithic fragments in localized concentrations but of approximately equal volume. The lithic fraction includes subrounded gabbro to 4mm; subangular monocrystalline plagioclase and pyroxene to 3mm; and one large rounded micaceous gneiss clast to 5mm.

Fuel kin-relicts: MCA.033 was wood-fired, and this section contains a high concentration of wood-charcoal relicts, to 7mm in longitudinal section.

<u>MCA.032</u> (x2 thin sections)

Carbonate kiln-relicts: MCA.032 contains a very high concentration of altered shell, including altered *O. edulis*, to 13mm. Mortar matrix: The carbonate matrix is of light-buff colouration, with a high concentration of altered shell relicts. The binder ratio is high.

Added-temper: The temper is an almost bimodal mixture of lithic aggregate and shell relicts. The temper material is dominated by lithics including rounded gabbro to 4mm, rounded conglomerate to 6mm; and micaceous subrounded gneiss to 5mm.

Fuel kiln-relicts: MCA.032 was wood-fired, and this section contains a high concentration of wood-charcoal relicts to 4mm.

<u>MCA.031</u>

Carbonate kiln-relicts: MCA.031 is a limestone-lime mortar. Some included carbonate fragments consist of very white fine textures reminiscent of altered shell; but these are precuts of a fine bioclastic limestone. The section is dominated by large angular limestone relics to 22mm which display a range alteration textures, with common rim/core textural distinctions. The protolith is a fine and light blue-white coloured limestone with a low concentration of fossil ostracod moulds and some sparitic textures within what is generally micritic or microsparitic.

Mortar matrix: High volume of brown-coloured matrix which includes a high concentration of altered carbonate relicts.

Added-temper: MCA.031 was tempered by a well-sorted mixed shell and lithic aggregate, dominated (60:40) by unheated bivalve clasts to 1-3mm, but including rounded bioclastic and quartz-rich shale to 4mm, rounded chert to 2mm, and rare clasts of subangular dolerite to 1-2mm.

Fuel kiln-relicts: No fuel evidence was noted in MCA.031.

<u>MCA.029</u>

Carbonate kiln-relicts: MCA.029 is a shell-lime mortar, containing a high concentration of highly-altered Recent shell fragments which are generally fine but do occasionally grade to 14mm. Most of these are small *O. edulis* fragments, but many are so fragmented that taxonomic characterisation beyond bivalvia is difficult.

Mortar matrix: The carbonate matrix is very light buff and contains a high concentration of calcined shell fragments.

Added-temper: MCA.029 was well tempered with a poorly sorted mixture of shell relicts and lithic aggregate. This lithic aggregate includes subrounded gabbro (some degraded) to 6mm; subrounded dolerite and micaceous gneiss to 3.5mm; and subangular monocrystalline plagioclase to 4mm. A possible calcareous rock inclusion to 2mm was also noted.

Fuel kiln-relicts: No fuel evidence was apparent in this MCA.029 section.

<u>MCA.027</u>

Carbonate kiln-relicts: MCA.027 is a limestone-lime mortar. The section contains a high concentration of highly altered subangular to rounded micritic limestone clasts to 4mm. Some extremely rare fossiliferous *ostracod* evidence is just visible at very high magnification.

Mortar matrix: This section displays a grey-green coloured binder in very large matrix: temper ratio, without fine relicts or temper clasts.

Added-Temper: MCA.027 was tempered with a well-sorted mixture of Recent shell and lithic fragments in approximately equal proportions. The lithic fraction is 4-6mm and includes rounded coarse dolerite (with magnetite) to 6mm; rounded shale (calcareous and quartz-rich in an opaque matrix) to 5mm; and very rare sub-mm pyroxene. The shell fraction includes unaltered bivalve and gastropod fragments from 2-4mm.

Fuel kiln-relicts: No fuel evidence was noted in MCA.027.

Vitreous material: Some shale was noted which is possibly in the early stages of vitrification.

<u>MCA.026</u>

Carbonate kiln-relicts: MCA.026 is a limestone-lime mortar. The section displays a very high concentration of altered limestone some of which is distinctively either coarsely bioclastic/fossiliferous (with a high concentration of oriented sparitic replacement shell to 1mm) or quartz-rich (displaying sub-mm clasts in locally high concentrations). Both 'bio'- and geogenic clasts are supported in a finer microsparitic and micritic calcareous matrix, and a bedding or schistose orientation is often apparent.

Mortar matrix: The carbonate matrix is dark brown and complex at higher levels of magnification with a very high relict carbonate concentration.

Added-temper: MCA.026 was tempered by an aggregate which is completely lithic including: subrounded to rounded gabbro; subangular to subrounded plagioclase and pyroxene to 2mm; and a high concentration of sub-mm, subangular quartz to 0.2mm.

Fuel kiln-relicts: MCA.026 was wood-fired, and this section contains a high concentration of wood-charcoal relicts to 2mm.

MCA.025

Carbonate kiln-relicts: MCA.025 is a limestone-lime mortar, and the section is dominated by a subrounded limestone relict to 40mm, which displays distinctively concentric alteration textures. The protolith core clearly retains fossiliferous bioclasts, with fine curving replacement microsparitic *ostracod* shell forms to 3mm long and sparitic/microsparitic calcite veining included into a micritic (or very finely microsparitic) carbonate matrix which also displays a low but even distribution of subangular quartz to 0.2mm, and, very rarely, mica. One edge of this limestone clast, however, betrays a much higher quartz concentration to approximately 15%, and some evidence of layering, although the clasts do not display undulose extinction and have apparently random extinction angles. It is evident within this section that some of this fine quartz has been released into the surrounding, plagioclase-tempered, general mortar matrix during calcinations of the parent limestone. In the more highly-calcined (2-3mm) rim the bioclastic moulds lose crystalinity and display a very dark brown colouration which suggests a denser carbonate material than the surrounding matrix. At low magnification the rim/mortar boundary is continuous, however, suggesting no differential in loss of structural coherence.

Mortar matrix: The mortar matrix is light brown and apparently well-tempered, although only a small area is available for inspection here.

Added-temper: MCA.025 was tempered by a completely lithic material and no shell is evident. This is dominated by angular to subangular gabbro, plagioclase and pyroxene from 0.5 to 1.5mm, and sub-mm quartz as above.

Fuel kiln-relicts: Very fine, sub-mm relics of wood charcoal are apparent in the MCA.025 section, but see hand sample also.

MCA.024

Carbonate kiln-relicts: This is a limestone-lime mortar. The section contains a high concentration of elongate angular to subangular limestone clasts which display a spectrum of heated textures. There is an apparent dichotomy here between calcareous clasts which are highly fossiliferous with a low quartz concentration, and those which are less fossiliferous and display a much higher quartz concentration.

Mortar matrix: The carbonate matrix is a similar light brown colour as the calcined limestone and is well tempered with a matrix: temper ratio of approximately 60:40.

Added-temper: MCA.024 was tempered with an almost completely lithic material dominated by felsic lithogies including: rounded gabbro and dolerite to 5mm; angular to subrounded monocrystalline plagioclase and pyroxene to 1.5 – 2mm; and some fine subangular quartz. There is an extremely low concentration of Recent unaltered shell inclusions.

Fuel kiln-relicts: MCA.024 was wood-fired, and this section contains longitudinal sections of very fibrous wood charcoal to 2mm.

MCA.022

Carbonate kiln-relicts: MCA.022 is a limestone-lime mortar. The section contains a high concentration of angular limestone clasts, to 12mm, which are coarsely bioclastic (some is echinoidal) and quartz-rich. The clasts betray a spectrum of heat-alteration textures.

Mortar matrix: The MCA.022 matrix in this section is a very fine well-tempered carbonate with a matrix: temper ratio of approximately 50:50 by volume.

Added-Temper: MCA.022 was tempered with a poorly-sorted mixture of completely lithic materials including: rounded dolerite to 11mm; more fragmentary and often degraded subangular gabbro to 6mm; angular to subangular plagioclase and pyroxene to 2mm; and a low concentration of fine subangular quartz.

Fuel kiln-relicts: MCA.022 was wood-fired, and this section contains a high concentration of wood charcoal, including a transverse section which is probably diffuse porous.

MCA.021

Carbonate kiln-relicts: MCA.021 is a limestone-lime mortar. The section displays a high concentration of highly-altered often angular limestone clasts to 4mm, in which some quartz-rich layering is evident. This is, however, a small section and these relicts are often too altered to characterize further.

Mortar matrix: The matrix in MCA.021 is a light-brown colour, but of apparent low density with a high concentration of vugs. The section is very well tempered with an approximate matrix: aggregate ratio of 40:60.

Added-temper: MCA.021 was tempered with a poorly-sorted aggregate mix of lithic materials including rounded dolerite to 6mm, rounded sandstone to 4mm; subrounded gabbro to 2mm and fine monomineralllic clasts of angular and subangular quartz and pyroxene. One shell clast was also noted.

Fuel kiln-relicts: MCA.021 was wood-fired, and the section contains wood-charcoal relicts to 1.5mm.

Vitreous Material: Some vitreous material was noted and requires further work.

MCA.020

Carbonate kiln-relicts: MCA.020 is a limestone-lime mortar, containing a very high concentration of heated limestone relicts. Two mutually-exclusive facies are evident, one with a high concentration of subangular quartz and one which is coarsely bioclastic, although both grade up to 7mm.

Mortar matrix: Brown coloured, well tempered.

Added-temper: MCA.020 was tempered with a mix of lithic and shell, dominated by a lithic fraction mostly composed of angular plagioclase, pyroxene, olivine and some quartz to 0.5mm. Subrounded gabbro clasts to 3mm, rounded sandstone and dolerite to 7mm, and fine rounded clasts of shale to 0.5mm are also present but in very low concentrations.

Fuel kiln-relicts: No fuel was noted in the MCA.020 section.

MCA.019

Carbonate kiln-relicts: MCA.019 is a limestone-lime mortar which displays a very high concentration of angular and micritic heat-altered limestone relicts to 3.5mm.

Mortar matrix: This section contains a very high volume of light-brown coloured homogeneous-textured matrix.

Added-temper: MCA.019 was tempered with a sorted mix of lithics and shell, dominated by the lithic fraction. This includes large rounded gabbro clasts to 14mm, rounded dolerite and chert to 4mm, subrounded micaceous shale to 2mm and unheated gastropod and bivalve shell fragments to 6mm. There is a spectrum evident from shale to chert-like material.

Fuel kiln-relicts: No fuel evidence was noted in this MCA.019 section.

MCA.018

Carbonate kiln-relicts: MCA.018 is a limestone-lime mortar, containing a high concentration of subangular limestone relicts to 23mm, the protolith for which displays a high volume of thick, fully-sparitic, veining to 1mm wide and an evenly distributed low concentration of very fine subangular quartz. Some very fine fossiliferous structures are evident, but are rare.

Mortar matrix: The carbonate matrix is very fine-grained and in high volume, presenting a matrix: temper ratio of approximately 75:25.

Added-temper: MCA.018 was tempered by a sorted mixture of shell and lithic materials, but with an 80:20 shell: lithic ratio shell material dominates. This shell is appears unheated with good internal microstructure and is generally dominated by elongate, curving subangular to subrounded bivalves to 10mm. The lithic fraction is predominantly composed of subrounded and elongate quartz rich and micaceous clasts of mudstone/shale to 5mm. Some coarse very rounded dolerite (often degraded) is also present to 5mm.

Fuel kiln-relicts: No fuel evidence was noted in this MCA.018 section.

<u>MCA.017</u>

Carbonate kiln-relicts: MCA 017 is a shell-lime mortar. The section contains a very high concentration of heated Recent shell fragments, including O. edulis to 15mm.

Mortar matrix: Coarse and heterogeneous light-coloured mortar matrix in very high volume.

Added-temper: very little added temper in this section. Some fine rounded mafic clasts and unheated shell-clasts including gastropods in very low volume.

Fuel kiln-relicts: No fuel-relicts noted in this MCA.017 section.

<u>MCA.016</u>

Carbonate kiln-relicts: MCA.016 is a shell-lime mortar. The section contains a very high concentration of Recent shell fragments, including altered *O. edulis*, to 19mm.

Mortar matrix: The carbonate matrix of the mortar is very light coloured and in high volume. An approximate binder aggregate ration of 60:40 is suggested.

Added-temper: MCA.016 is tempered by a mixture of shell and lithic materials, dominated by unaltered shell to a ratio of 70:30. This shell fraction includes P. Vulgata to 15mm, whilst the lithic fraction includes rounded dolerite (often degraded) to 3mm, subrounded and elongate mudstone/shale to 4mm, and rounded gabbro to 2mm (but these latter two minerals are in low concentration).

Fuel kiln-relicts: No fuel evidence was noted in this MCA.016 section.

<u>MCA.014</u>

Carbonate kiln-relicts: MCA.014 is a limestone-lime mortar. The parent limestone is generally micritic with characteristic fracturing of altered clasts. At high magnification these display white rounded globular cryptocrystalline textures which suggest a bioclastic origin (see 'oolitic' clast in MCA.009). There are some possible relict sparry crystalline mosaic textures are evidence but maybe taphonomic. One calcined quartz-rich much browner relict was noted in this section but this is rare.

Mortar matrix: The matrix is generally a milky-white cryptocrystalline material in optical continuity with the highly-altered limestone described above.

Added-temper: MCA.014 was tempered by an almost completely lithic material and only one shell was noted. The lithic clasts are generally gabbroic including subrounded gabbro to 5mm, subangular orthoproxene and plagioclase to 1.75mm. The plagioclase is often fractured and degraded. Some rounded basalt to 2mm is also present.

Fuel kiln-relicts: No fuel was noted in the MCA.014 section, but some vesicled vitreous and bulbous clasts are evident.

<u>MCA.013</u>

Carbonate kiln-relicts: This is a limestone-lime mortar with a high concentration of angular to rounded altered relic limestone clasts to 8mm. The parent limestone often displays coarsely bioclastic textures, and other amorphous and fluid textures suggest some hydaulicity.

Mortar matrix: The binder is very light-coloured but displays a variety of complex and heterogeneous textures. These are generally fine, however, with localized contexts of milky-cryptocrystalline calcite associated with amorphous and bulbous altered limestones suggesting some hydraulicity.

Added-temper: MCA.013 was tempered with a completely lithic and generally gabbroic material, including subrounded gabbro, grading up to 6mm, and angular to subangular often monominerallic orthoproxene and plagioclase, grading up to 2mm. Rounded dolerite to 1.5mm and quartz-rich micaceous schist was noted in low concentration.

Fuel kiln-relicts: No fuel was noted in section MCA.013.

<u>MCA.012</u>

Carbonate kiln-relicts: MCA.012 is a limestone-lime mortar. The section contains a high concentration of angular, quartz-included limestone, grading up to 3mm, which are generally highly altered. No bioclastic or fossiliferous evidence was noted.

Mortar matrix: The carbonate matrix of this mortar is brown and very well tempered with a matrix: temper ratio of approximately 55: 45.

Added-temper: MCA.012 was tempered with a completely lithic poorly-sorted aggregate largely comprised of angular gabbro to 4mm, angular to subrounded plagioclase and olivine to 2mm, and angular sub-mm quartz. Also present, however, is a large rounded dolerite clast to 12mm and a rounded quartz-rich sandstone to 5mm.

Fuel kiln-relicts: No fuel evidence was noted in this MCA.012 section.

<u>MCA.011</u>

Carbonate kiln-relicts: MCA.011 is a limestone-lime mortar. The section contains a very high concentration of altered limestone clasts which display a broad range of heated textures. Less altered clasts are angular and generally micritic with a low concentration of evenly distributed fine subangular quartz clasts, very faint replaced fine biofossils and wide sparry-calcite veins to 0.5mm. The more altered and incoherent relicts do not, however, display quartz release.

Mortar matrix: MCA.011 displays a high volume light brown carbonate matrix, with a matrix: temper ratio of approximately 80:20.

Added-temper: MCA.011 is tempered with a mixture of Recent shell, to 80%, and lithic rocks and minerals to 20%. The lithic fraction includes rounded dolerite to 7mm and rounded and elongate mudstone/shale to 4mm which may grade into a coarsely bioclastic quartz-rich limestone. The shell fraction is in high concentration and is dominated by subangular curving bivalve shell fragments, but includes gastropodia to 5mm, and neither displays any evidence of heat alteration.

Fuel kiln-relicts: No fuel evidence was noted in this MCA.011 section, but a large vitreous inclusion was noted.

<u>MCA.010</u>

Carbonate kiln-relicts: MCA.010 is a limestone-lime mortar containing a very high concentration of angular limestone relicts to 22mm. The parent limestone is generally micritic but includes a high concentration of sparitic to microsparitic calcite veins. There is a low but distinct concentration of bioclastic/fossiliferous evidence, including probable fossil *ostrcods* and possible echinoids.

Mortar matrix: MCA.010 displays a light-buff coloured, apparently microsparitic, carbonate matrix and an approximate matrix: aggregate ratio of 80:20.

Added-temper: MCA.010 was tempered by a well-sorted aggregate mixture of unaltered Recent shell and lithic materials to 4.5mm. This is almost completely dominated by the shell fraction, but includes subrounded and elongate quartz-rich mudstone/shale to 2mm, and a related subrounded coarsely bioclastic material to 4mm (as in MCA.010).

Fuel kiln-relicts: No fuel evidence was noted in this section.

MCA.009

Carbonate kiln-relicts: MCA.009 is a limestone-lime mortar with a high concentration of altered limestone relict clasts. These generally appear micritic, sometimes with a low even distribution of very fine quartz included, with a singular large bioclastic and apparently oolitic clast.

Mortar matrix: It is difficult to characterize the matrix in this section as it is highly porous, with 'veins' of re-crystallised calcite also suggesting a highly weathered dissolute material.

Added-temper: MCA.009 was tempered with an almost completely lithic aggregate material which is generally gabbroic including rounded gabbro to 4mm and subangular pyroxene and plagioclase to 2mm. Also included, however, are 2-3 very rounded dolerite clasts to 7mm rare rounded clasts of quartz-rich sandstone to 1.0mm and very rare shell fragments to 0.3mm.

Fuel kiln-relicts: No fuel was noted in this MCA.009 section.

MCA.008

Carbonate kiln-relicts: MCA.008 is a limestone-lime mortar containing an extremely high concentration of altered angular limestone clasts to 15mm. Parent limestones display a mix of textures including heterogeneous, coarsely bioclastic clasts with a low concentration of more quartz-rich layers and excellent core/rim heat-alteration textures, and others which are more homogeneous, micritic and a much lighter blue-grey.

Mortar matrix: Matrix volumes are high and generally brown, but contain an extremely heterogeneous mix of different altered limestone relicts.

Added-temper: MCA.008 was temper with a low volume of a completely lithic aggregate material. The majority of the temper clasts are gabbroic including rounded to subrounded plagioclase-rich gabbro to 6mm, angular plagioclase, orthopyroxene with clinopyroxene intergrowths to 1.5mm. Minor quantities of subangular quartz to 0.3mm may have been released by the limestone, although very rare rounded sandstone clasts to 2mm are present.

Fuel kiln-relicts: No relict fuel evidence was noted in MCA.008.

MCA.007

Carbonate kiln-relicts: MCA.007 is a limestone-lime mortar with an extremely high concentration of limestone relicts from a large variety of lithogies. Most highly altered clasts are angular to subangular and micritic to 4mm and some of these have nicely contrasting rim/core alteration textures. Also present in the section, however, are calcareous clasts with equidimensional crystalline textures into which are included dark brown, almost opaque, very fine micritic quartz-rich 'veins' or layers (metamorphic?) Further, and in contrast, are a number of clasts which are coarsely bioclastic with sparry calcitic veins. It appears all 3 of these lithogies have been heated, whilst a 4th type, subangular, fine grained and bright orange in both plane and cross-polarised light, shows no evidence of alteration and may be a detrital mudstone.

Mortar matrix: The matrix within this MCA.007 thin section is in high volume, but contains an extremely high concentration of altered limestone clasts most of which are cryptocrystalline and a grey-green colouration.

Added-temper: MCA.007 was tempered with a lithic aggregate material dominated by subangular to subrounded dolerite clasts grading up to 5mm. One shell was noted to 4mm.

Fuel kiln-relicts: MCA.007 was wood-fired, and the section examined contains relict wood charcoal evidence to 1mm.

Vitreous material: This section displays excellent vitreous evidence which may be altered quartz-rich shale or limestone.

<u>MCA. 006</u>

Carbonate kiln-relicts: MCA.006 is a shell-lime mortar. The section contains a medium concentration of Recent, highly altered, subangular and curving bivalvia shell relics, grading up to 2mm.

Mortar matrix: MCA.006 displays a very light-buff coloured carbonate matrix with a high concentration of amorphously shaped vugs, perhaps suggesting a very weathered context. This notwithstanding the material is well-tempered and a matrix: aggregate ration of 50:50 is suggested.

Added-temper: MCA.006 was tempered by a poorly-sorted mix of Recent shell and lithic materials in approximately equal proportions. The shell assemblage is dominated by curving bivalvia with very clear internal microstructure, whilst the lithic fraction includes rounded dolerite to 9mm which is often quite degraded, and a subrounded quartz-rich calcareous mudstone/shale which grades to limestone lithogies, to 6mm.

Fuel kiln relicts: MCA.006 was wood-fired, and the section examined contains a single wood charcoal relic to 0.5mm.

<u>MCA.003</u>

Carbonate kiln-relicts: MCA.003 is a limestone-lime mortar, although the rounded limestone relics (to 2mm) in this section are so altered that detailed characterization of the protolith is precluded. Various quartz-rich contexts, however, suggest this was included.

Mortar matrix: MCA.003 displays a very high volume of a coherent light-brown carbonate matrix, and a matrix: aggregate ratio of 85:15 is suggested.

Added-temper: MCA.003 was tempered by a well-sorted, fine and almost completely lithic mix of materials including subrounded to subangular plagioclase, olivine and pyroxene to 1mm. Two large shell inclusions, to 6mm, with good internal microstructure are also present but may not be representative.

Fuel kiln-relicts: No fuel evidence was noted in this MCA.003 section.

MCA.002

Carbonate kiln-relicts: MCA.002 is a limestone-lime mortar with a high concentration of, often angular, limestone relict clasts to 15mm. The protolith limestone is coarsely bioclastic inter-bedded with more quartz-rich layers and sparry calcite veining. Highly altered examples of this material appear to have released fine clasts of angular to subrounded quartz into the mortar matrix.

Mortar matrix: MCA.002 displays a fine-textured, brown-coloured carbonate matrix and a matrix: aggregate ratio of 50:50 is suggested.

Added-temper: MCA.002 was tempered by a fine, poorly-sorted and completely lithic mix of minerals mostly composed of angular to subangular plagioclase to 2mm; olivine and pyroxene to 1mm and fine sub-mm quartz; but also including rounded gabbro (with magnetite) to 5mm; rounded dolerite to 3mm. Some of these finer angular gabbroic minerals appear mechanically crushed.

Fuel kiln-relicts: No fuel evidence was noted in this MCA.002 section.

MCA.001

Carbonate kiln-relicts: MCA.001 is a limestone-lime mortar with a high concentration of rounded to subrounded, brown-coloured, highly-altered limestone relicts, with included subangular quartz to 0.2mm.

Mortar matrix: MCA.001 displays a light brown carbonate matrix with a high concentration of altered limestone relict clasts. The mortar is relatively well tempered and a matrix: aggregate ration of 50:50 is suggested.

Added-temper: MCA.001 was tempered with a generally well-sorted, fine and completely lithic material composed of angular plagioclase generally grading up to 2mm but occasionally to 3-4mm, angular olivine and pyroxene to 1mm and subangular quartz to 0.5mm. Also present, however, are subrounded gabbro to 4mm and one clast of subangular dolerite to 3mm.

Fuel kiln-relicts: No fuel was noted in this MCA.001 section.

2.2.2 ENVIRONMENTAL SAMPLE ANALYSIS

MCA060 – Limestone very white, various textures including brown micritic veins, just visible ostracod type bioclasts, also quartz and rounded polyminerallic quartz-rich grains.

MCA.059 - Limestone - generally very micritic with even distribution of slightly coarser microsparitic highly birefringent grains. Some undulating brown micritic erosion layers.

MCA058 (st01) - coarsely bioclastic bivalve and subangular quartz-rich limestone including some rare feldspar. Heterogeneous highly birefringent cement. Excellent match for some mortar phases.

MCA.057 (ST.03) - Limestone – coarsely bioclastic, irregular possible peloids, no quartz.

MCA.056 (B1) - is composed of a well sorted mixture of lithics and shell to 0.3mm. The section is overwhelmingly dominated by lithic rock and mineral fragments, mostly angular to subangular monocrystalline quartz, plagioclase and pyroxene, but also including subrounded probable basalt/dolerite clasts. Occasional clasts of dolerite and very rarely sandstone are also present. Shell fragments are also present but very rare.

MCA.055 (B2) - is composed of an unsorted mixture of shell and lithic clasts to 6mm. The section is overwhelmingly dominated by unheated shell fragments with well-preserved internal microstructure and lustrous textures. This assemblage includes bivalves, gastropods and bryozoans, but patella fragments are particularly striking. These grade to approximately 3.0mm. MCA.055 also contains a lithic fraction, mostly comprised of elongate clasts of mudstone/shale, which displays some foliated bioclastic and quartz-included evidence. Large rounded clasts of dolerite are also present to 6mm.

2.2.3 MORTAR RELICT-FUEL ANALYSIS

That the constructional mortars of most phases of Mingary Castle displayed inclusions identified as wood-charcoal has been noted in-situ, in hand-sample, in thick-section and in thin-section descriptions, and these have been interpreted as relict limekiln fuel.

A small number of the largest of these inclusions was subsequently examined microscopically, in reflected light, in order establish their taxonomy and morphology. The first batch of four samples was interpreted by Dr Mike Cressey (CFA Archaeology Edinburgh - these are marked with an asterisk below), the second batch of samples were verified by him to ensure continuity, and the third batch were unverified, and the results are presented below:

MCA.CI	*Betula*	Heartwood	Branchwood <20 years old. *
MCA.C2	*Quercus*	Heartwood	Amorphous morphology. *
MCA.C3	*Quercus*	Heartwood	Small branchwood <20 years old. *

MCA.C4	*Corylus*	Heartwood	Branchwood <20 years old. *
MCA.025a	*Quercus*	Heartwood	Amorphous morphology.
MCA.026a	*Quercus*	Heartwood	Amorphous morphology.
MCA.026b	*Quercus*	Heartwood	Amorphous morphology.
MCA.028a	*Quercus*	Heartwood	Amorphous morphology.

A small number of meso-charcoal inclusions could also be identified, in thick and thin section due to recognisable porosity, size of spring vessels, or large blocky fibres. These include:

MCA.010	ring porous	probable *Quercus.*	
MCA.022	diffuse porous	transverse	probable *Corylus* or *Betula.*
MCA.024	large blocky fibres	longitudinal	probable *Quercus.*
MCA.034	ring porous	probable *Quercus*	
MCA.040	ring porous	probable *Quercus*.	
MCA.042	large springs	probable *Quercus*	

Further relict-fuel samples were recovered by acid dissolution of single mortar samples and hand picking through the dissolute under the microscope. These were too fine to interpret living morphology, or view in transverse section, but can reasonably confidently be identified as *Quercus* due to the predominance of distinctive blocky fibres.

MCA.043a	*Quercus*	Unknown morphology.
MCA.044a	*Quercus*	Unknown morphology.

<u>Mortar Fuel Summary:</u> 13/16 *Quercus* (oak), 2/16 *Corylus* (hazel), 1/16 *Betula* (birch).

6/8 Amorphous, 2/8 Branchwood.

2.2.4 GROUPING MORTAR THIN-SECTIONS INTO COMPARATIVE TYPES.

Similarities and contrasts between different thin sections were clearly evident during these analyses, and after the initial characterisation of all the slides had been completed an attempt were made to group them with reference to these descriptions and by direct comparison on the microscope stage. This process led to the following thin section typology:

Mortar	Thin-section characteristics
TYPE A -	**Limestone-lime**;
	Heated relicts of micritic limestone with ostracod bioclasts and veining.
	Grey-green mortar matrix.
	Coarse rounded lithic and shell temper, inc. with shale but no/little monominerals (similar to B2).
	No fuel.
	Samples conforming to **Type A: 051, 050, 049, 048, 047, 046, 045. Mortars 6 & 7.**
TYPE B -	**Shell-lime**.
	Heated relicts of *O. Edulis*.
	White matrix.
	Lithic and shell temper; monomineralic clasts, rounded dolerite. Little shale.
	Wood-fired; wood charcoal relicts probable *Quercus*.
	Samples conforming to **Type B: 044, 043, 042, 041, 040.** **Mortar 2.**
TYPE C -	**Shell-lime**;
	Heated variety of shell relicts including *O. edulis.*
	White matrix; coarsely textured matrix.
	Shell and lithic temp; rounded dolerite incl. shale (similar to B2);
	No fuel noted
	Samples conforming to **Type C: 016, 017?. 040?** **Mortar 8**
TYPE D -	**Limestone-lime**;
	Heated relicts of quartz-rich micritic limestone clasts.
	Light brown matrix;
	Lithic & shell temper; coarse rounded lithic inc. shale but no fine monominerals (similar to B2).
	No fuel noted
	Samples conforming to **Type D: 038, 037**. **Mortar 10**
TYPE E -	**Shell-lime;**

Heated variety of shell relicts including *O. edulis.*

Dense Matrix.

Lithic temper with high concentrations of coarse gabbro and no shale

Wood-fired including probable *Quercus*.

Samples conforming to **Type E: 036, 035, 034, 033, 032, 029.** **Mortar 4**

TYPE F - **Limestone-lime;**

Heated relicts of quartz-rich and bioclastic limestone.

Dark brown-coloured very homogeneous matrix.

Fine lithic temper; fine angular gabbro, plagioclase, quartz and olivine but no shale or shell material (similar to B1);

Wood-fired; all Quercus.

Samples conforming to **Type F: 026, 025, 024, 022, 021, 020, 012, 001, 002, 003. Mortar 1**

TYPE G - **Limestone-lime;**

Heated relicts of veiny limestone.

Matrices display hydraulic textures

Shell and lithic temper, very shell-rich and including shale (similar to B2);

Wood-fired.

Samples conforming to **Type G: 011, 010** **Mortar 3**

TYPE H - **Limestone-lime;**

Heated relicts of coarsely bioclastic and low quartz limestone;

Some hydraulic evidence;

Lithic temper, coarse rounded gabbro, some monominerals; no shell or shale.

Wood-fired.

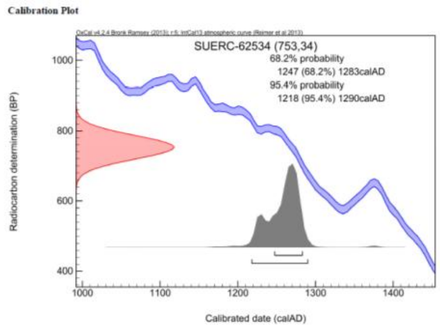
Samples conforming to **Type H: 007, 008, 009, 013, 014.** **Mortar 5**

2.2.5 RADIOCARBON ANALYSIS

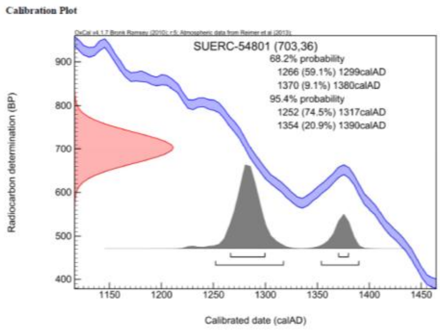
A number of mortar fuel kiln-relicts from the curtain wall, drum garderobe and north hall were submitted for AMS radiocarbon analysis to the laboratories of SUERC (East Kilbride). A very fragmentary single sample from the upper parapet of the north curtain returned an anomalously early date and so is not included here. The results presented below are those for which multiple samples from apparently single phases were submitted:

Primary Curtain Wall

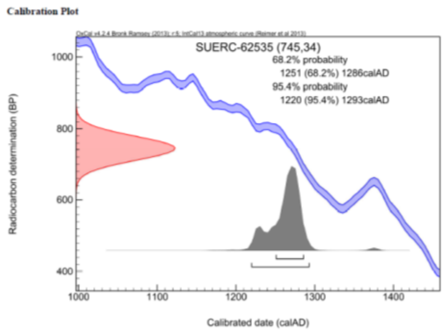
MCA.025a SUERC-62534 (GU38476); Radiocarbon Age BP 753 +/- 34:



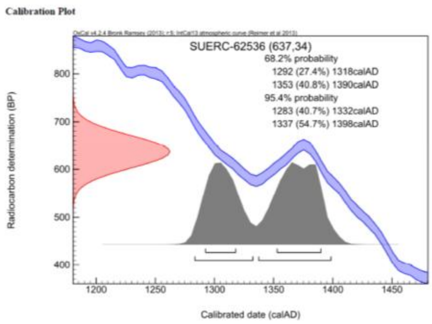
MCA.026a SUERC-54801 (GU35130); Radiocarbon Age BP 703 +/- 36:



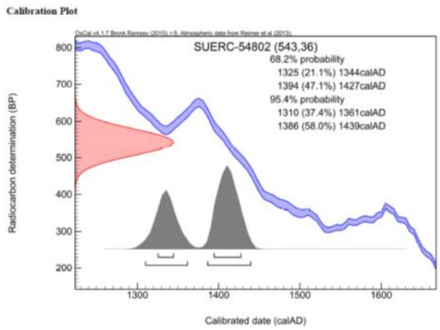
MCA.026b SUERC-62535 (GU38477); Radiocarbon Age BP 745 +/- 34:



MCA.028a SUERC-62536 (GU38478); Radiocarbon Age BP 637 ± 34:

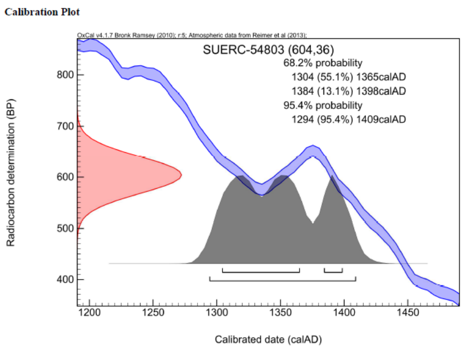


MCA.C1 SUERC-54802 (GU35131); Radiocarbon Age BP 543 +/- 36:

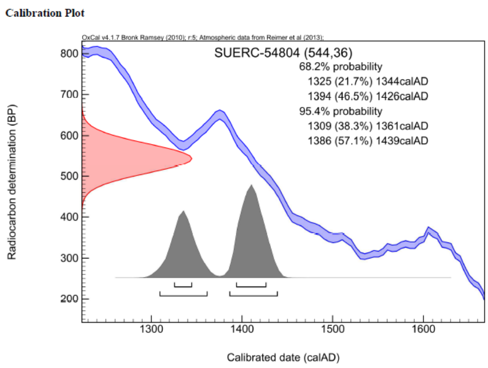


<u>Drum Garderobe</u>

MCA.C3 SUERC-54803 (GU35132); Radiocarbon Age BP – 604 +/- 36

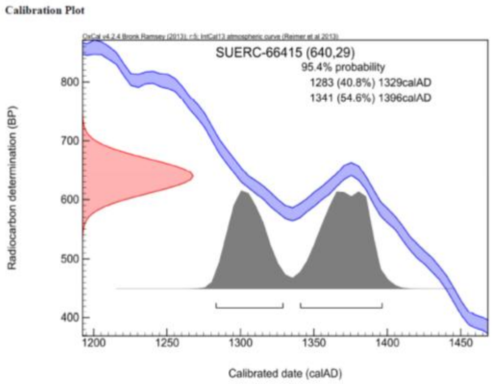


MCA.C4 SUERC-54804 (GU35133); Radiocarbon Age BP – 544 +/- 36

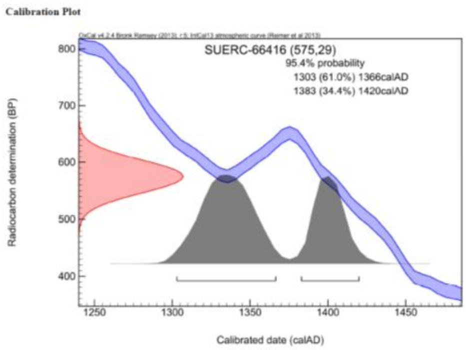


<u>North Hall Range</u>

<u>MCA.043a</u> SUERC-66415; Radiocarbon Age BP – 640 +/- 29



<u>MCA.044a</u> SUERC-66416; Radiocarbon Age BP – 575 +/- 29



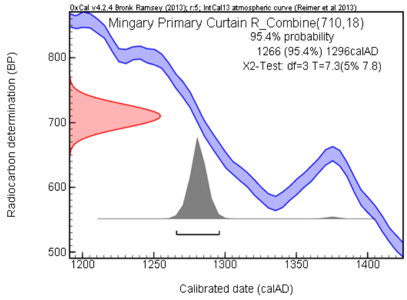
2.2.6 <u>Combined Calibrated Radiocarbon Date Calculation</u>

<u>Primary Curtain Wall</u> – As presented above, the five fuel-relict samples submitted for radiocarbon dating from contexts interpreted as primary curtain wall returned the following BP results +/- 34-36 years: MCA. 25a - 753; MCA.26a - 703; MCA.26b – 745; MCA.28a – 637; MCA.C1 – 543.

These results do not pass a chi-square test (df=3; T=24.6 (5%9.5) and so probably do not represent a single event. This highlights the radiocarbon age of sample MCA.C1 as an obvious outlier and the only sample within this assemblage removed from a bed (rather than a core) context. This also draws attention to the challenges in distinguishing Mortar 1 from Mortar 1a on site, as the result for this sample would fit very closely with the results from the north garderobe.

The radiocarbon ages of the four samples from deep core contexts of the primary curtain wall do pass a chi-square test df=3; T=7.3 (5% 7.8), indicating very probably represent a single event. This enables these results to be combined to calculate a date range for this event with reduced error, as below:

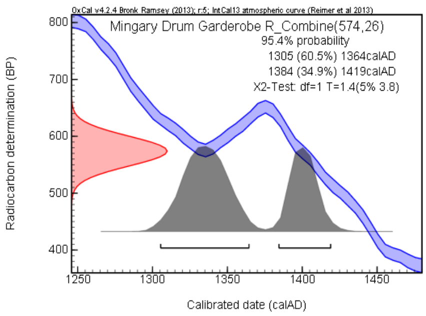
Mingary Primary Curtain wall R.combined BP 710 +/- 18;
Mingary Castle Primary Curtain Wall 1266 -1296 cal.AD (@ 95.4% probability).



Drum Garderobe

As presented above, the two fuel-relict samples submitted for radiocarbon dating from the Mingary drum garderobe returned the following BP results +/- 36 years: MCA.C3 - 604; MCA.C4 – 544. These results easily pass a chi-square test (df=1; T=1.4(5%3.8)) and so very probably represent a single event. This enables them to be combined to calculate a date for this event with reduced error, as below:

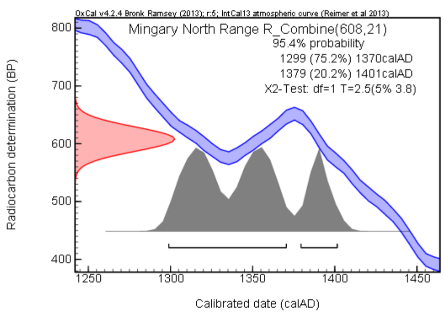
Drum Garderobe. R.combined BP 574 +/- 26
Mingary Castle Drum Garderobe 1305 -1364 cal.AD (@60.5% prob); 1305-1419 (@95.4% prob).



North Range

As presented above, the two fuel-relict samples submitted for radiocarbon dating from the North Range returned the following BP results +/- 29 years: MCA.043a - 640; MCA.044a – 575. These results also pass a chi-square test (df=1; T=2.5(5%3.8)) and so very probably represent a single event. This enables them to be combined to calculate a date for this event with reduced error, as below:

North Range R.combined BP 608 +/- 21
Mingary Castle North Range 1299-1370cal.AD. (@75.2%); 1299-1401cal.AD. (@95.4%).



3.0 CONCLUDING DISCUSSION

There is close correlation between the on-site and lab-based interpretations of these mortar materials. The initial *in-situ* interpretations of lime provenance generally sought to recognise whether the mortar had been made from roasted shell or limestone, and in every case these interpretations have been supported by petrographic thin section analysis. Thin section analysis, however, has also been able to distinguish between different limestone lithofacies which are variously bioclastic, quartz-rich, veined, micritic and even possibly metamorphic. Although these are all locally-sourced Mesozoic lithogies, these different limestone types demonstrate different geological depositional cycles and so may correspond to various phase-specific groups, and so to different quarried material.

None of the historic mortar tempers and beach samples were a perfect match. Beach sample B1, for instance, was more quartz-rich and finer than the feldspar-dominated primary mortar temper. The broader contrasts between the shell-rich and monominerallic quartz and feldspar aggregates, however, are convincing.

The fuel assemblage surviving within the mortars of the early castle mortars, including the curtain wall and north range, was almost completely dominated by oak. Whilst wider evidence suggests this is likely to be a local source, the general lack of birch is salient and may suggest a taxa-specific lime-burning strategy was employed. The apparently contrasting evidence for heartwood oak morphologies in core mortar contexts and mixed taxa of roundwood morphologies in bedding contexts is curious and also appears to be somewhat phase-specific. Although the small sample size (out-with the primary curtain wall) makes this interpretation tentative, the heartwood core contexts of the primary curtain are consistent and more convincing.

The different characteristics of the castle mortars enabled the thin sections to be grouped together from more objective criteria, and these groupings also corresponded with those recognised during on-site survey.

The analyses draw particular attention to four main mortar types: Mortar 1 (Type F) of the primary curtain wall; Mortar 2 (Type B) of the north range; Mortar 5 (Type H) of the south and south-east upper parapet; and Mortar 7 (Type A) of the south-east and west internal ranges. These mortars display a particularity of source material and a consistency of character not always seen in the other mortar groups, and for most of these (perhaps excluding Mortar 5) this has also resulted in very durable material which has resisted degradation. Of more interest archaeologically, however, is that these same mortars are associated with the main building phases of the castle complex, where the stonework and architecture also tend to be of a particular (and sometimes formal) character. Importantly, as a result, these mortars are very recognisable and can be confidently characterised, and this is crucial when identifying contexts for radiocarbon dating as will be discussed below.

The contrasts in these four main phases, suggest that each has been built in a different masonry tradition, whilst the process of grouping similar materials has simplified some of the mortar archaeology. The very late buildings of the south-east and west ranges, for instance, have been grouped into a single characteristic mortar type so, whilst I accept they are multiphase, these buildings have been built within the same Mortar 7 (Type A) tradition. In this case the Mortar 7 grouping is supported by the reasonably close chronologies of the contexts.

In contrast to the limestone-lime phases described above, a more refined typological characterisation of the shell-limes has proved more problematic. Although thin-section analysis supported the on-site interpretations that SE lower parapet, N and E upper parapets and N range are shell-lime mortars with different compositions, there is more variation within some of these contexts (and some overlap between them) which makes attribution to markedly different chronological phases less convincing. Within an otherwise largely limestone-lime building complex, this shell-lime provenance alone might initially suggest contemporaneity, but this cannot be simply demonstrated and the shell-lime evidence from both parapets of the north curtain might in any case suggest multiple shell-lime phases in a direct stratigraphical relationship.

These parapet contexts, however, are probably crucial to our understanding of their deposition. The remarkable variation of parapet mortars around the building reflects the multiperiodicity of that masonry, and primary Mortar 1 was not recorded in any parapet structures, fossilised or not. The heterogeneity and coarse quality of the shell-lime used to construct the south-east lower parapet may represent a small-scale repair, re-modelling or (most unlikely) even the temporary use of a contrasting mortar in the primary phase. The stratigraphic position of this fossilised feature (below the 16th-century upper parapet of the south-east curtain) is certain, and this makes it at least possible that it is of the same phase as the north range. The same is true of the lower parapet of the north curtain wall although the lack of core contexts with which to properly evaluate the shell-lime mortar visible in the joints of this last structure precluded full examination. That this evidence parallels that in the south-east lower parapet, however, is suggestive, and it is possible these materials evidence the re-building of both curtain parapets during the construction of the north range.

That the upper parapet of the south/south-east curtain is of a separate phase to the north/east upper parapet and to the north range is certain from their contrasting mortars. The mortars of the north range and north/east upper parapet are (like the north lower parapet) constructed with similar shell-limes, consideration of their style and the radiocarbon data suggests they too are probably of different phases, although further discussion of the stratigraphy of these structures would be useful.

The radiocarbon data from mortar fuel samples from core primary curtain wall contexts is consistent and has returned a very narrow combined date range of 1266-1296cal.AD (@

95%). This data supports previous interpretations that these contexts are of the same phase. This combined radiocarbon age is an archaeologically-reasonable lower terminus for the construction of the building and is consistent with the 13th-early 14th-century architectural style of the sandstone window dressings which are also Mortar 1 bonded. It is certain this phase is no earlier than these dates.

Although only two samples were analysed from the north range, these core mortar samples also returned a consistent set of results which has enabled a combined calibrated lower terminus of 1299-1370cal.AD (@75%) for the construction of this building. This is also archaeologically reasonable and, given that this structure certainly abuts the primary curtain, follows on nicely from those earlier primary dates.

As above, the heartwood/amorphous oak relict-fuel evidence from the primary curtain core is also a nicely consistent assemblage, but this same material makes any attempt to extrapolate a more refined likely date of construction from the radiocarbon content problematic. As oak can be a very long-lived tree with significant quantities of residual carbon it is possible that a more significant offset must be applied to these results. If this were a stand-alone data-set, this would be impossible to evaluate, but as the fuel from other mortared phases at Mingary has also been included in this study a more comparative approach might be adopted with care.

On the basis of contrasting masonry styles, lithogies and a construction break, it was suggested during building survey that the drum garderobe is of a later phase than the primary curtain survey even though the mortar binding this feature (Mortar 1a) appeared indistinguishable from that in the primary phase fabric (Mortar 1). This interpretation is in contrast to the interpretation of the RCAHMS who had indicated the garderobe was 'evidently original' (RCAHMS 1980, 213), but concurs with Addyman and Oram's interim interpretation, although that had suggested this feature was of a much later date (2012, 5.3.2).

Like the radiocarbon results from the core of the primary curtain wall and those from the north range, the relict fuel within the drum garderobe bedding mortar also returned results consistent with a single event. This data could therefore be combined, although calibration only allowed a very wide combined lower terminus of 1305-1419cal.AD. (with 1305-1364 cal.AD. (@60%) most likely. Unlike the amorphous oak fuel samples from the core mortar of the primary curtain wall, however, both these garderobe samples were small branchwood morphologies (considered less than 20 years old) and one was also from a short-lived tree taxa (hazel). The lower terminus radiocarbon results from the garderobe mortar fuel may, therefore, be much closer to the construction date of this structure. This is useful because, as long as we are confident that the drum garderobe is secondary, then it is possible to argue that this broadly (but probably early) 14th-century lower terminus for the garderobe also provides a likely upper terminus for the primary curtain wall. This date might therefore constrain any offset which may apply to the narrowly defined late 13th-century primary curtain core results.

However, whilst this is reasonable, reconsideration of the radiocarbon results from across the primary curtain and garderobe highlights a simple correlation between the morphological age of each submitted sample and it radiocarbon age which needs further consideration. This is because the young morphologies of the garderobe returned later dates than the amorphous morphologies of the primary core. This could be coincidence, but the sample submitted for radiocarbon analysis from a bedding context within the north curtain wall (MCA.C1), which was subsequently rejected from the combined data as an outlier because its radiocarbon age was too young, was also a young fragment of branch wood from a taxonomically short-lived tree type (birch). This sample, therefore, not only conforms more closely to the garderobe fuel assemblage but also returned a date very clearly contemporary with it. Accepting MCA.C1 as contemporary with the garderobe could suggest it was sampled from a context of secondary consolidation of the north curtain wall coeval with the construction of the garderobe, but this was not noted on site. It is problematic that our interpretations should be so dependent on a single sample, but at this stage, it appears more likely that there is some residuality in the primary curtain core assemblage, which has returned an earlier data set as a consequence. If this were accepted a greater offset should be applied to the primary curtain wall data.

An acceptance that a greater offset should apply to the primary curtain core results than to the garderobe draws the construction dates of these structures closer together. The mortar archaeology may support this interpretation. Elsewhere at Mingary this mortar Type evidences a single major period of construction and it is possible that the contrast in stonework between garderobe and curtain wall may be better described as a construction (rather than a phase) break. Unfortunately, the contrast between these two data sets are made more stark by the apparent tipping over into the much broader calibrated date ranges of the 14th-century.

The radiocarbon data from the north range also returned a consistent set of results which could be combined and calibrated to suggest a 14th-century lower terminus for the construction of this building (1299-1370cal.AD @75%). Whilst this result presents a narrower combined calibrated 14th-century range than the drum garderobe, like the primary core data these results are from samples of unknown morphology and so the same possible offset issues may apply. However, although for the north range these issues cannot currently be constrained by independent evidence from later phases, a wider reconsideration of the evidence worthwhile.

The use of shell-lime Mortar 2 within this structure remains a striking contrast in technique from the other main phases of this site. This material evidence very clearly marks the north range out as a different phase to the curtain wall and drum garderobe, and the physical and stratigraphical relationship between the north range and the primary curtain wall is also very clearly simply abutting and later. Both of these factors are important in consideration of the radiocarbon data. Given that any offset which may be applied to the radiocarbon ages of the young morphologies of the drum garderobe is likely to be less significant, if it can be accepted that the curtain wall and drum garderobe are broadly contemporary then any additional offset which may relate to these north range radiocarbon results is only going to increase the chronological gap between these phases. Just as the similar mortar materials, contrasting fuel morphologies and radiocarbon results between the garderobe and primary curtain all strongly support a chronological drawing together of these structures, so the contrasting mortar materials, contrasting fuel morphologies, radiocarbon results and physical stratigraphy strongly support a chronological distinction between the upstanding north range and curtain/garderobe. That said, however, the combined calibrated radiocarbon dates of the north range core seamlessly follow on from the primary curtain wall and it is possible these structures are separated by less than 75 years. On the present data, that the upstanding north range was constructed after the early 14th-century is reasonable.

The radiocarbon dates do not allow any putative earlier north range at Mingary much longevity, and although Gifford (1992) had suggested this was also likely to have been a masonry structure, no evidence for its physical form was noted during this mortar survey apart from the configuration of the primary intramural spaces of the north and east curtain walls. Although not definitively demonstrated here, that the surviving upstanding remains of the secondary north range have now been dated to a reasonably early period may suggest any earlier building in this position is likely to have been timber framed.

The use of shell-lime Mortar 2 within this north range is striking within the exposed Mesozoic sedimentary environment of the locality, and unique for a castle structure within the Sound of Mull. That this may reflect the geographical (rather than geological) location the site should be considered here, as this appears to situate the fabric of the north range within the masonry traditions displayed further north and west. I would suggest that the masonry of the south-east building of Castle Tioram is very closely comparable. The early phases at Tioram are bound with wood-fired shell-lime mortars and *O. edulis* shells can still be found on the nearby shore today. The stone emplacement technique displayed in the wall faces of the south-east Tioram building is remarkably similar to the north range of Mingary, and both structures display conspicuous vertical stacks of very large edge-laid face stones and rubble quoins. The south-east building at Tioram is also an unvaulted two-storey structure which, like the north range at Mingary, is the earliest (phase 2) surviving masonry building to have been built within the primary castle enclosure (Evans and Rutherford 1998). Evans and Rutherford refer to this Tioram building as a ‘tower house’ and place it within the 15th-century on the basis of other comparanda. The authors of the Tioram survey, however, do admit to challenges to close chronology (ibid) and I would suggest a 14th-cenury date is possible.

It is possible that the contrasting masonry techniques surviving in the two main early phases of the castle represent contrasting patronage. The limestone-lime techniques of the curtain wall are consistent with the Sound of Mull castle-building culture and this is also consistent with the probable use of Inninmore sandstone for the primary window dressings. The shell-lime techniques and rubble quoins of the north range are more consistent with building cultures further north and west such as Tioram. This evidence may also be consistent with MacDougall patronage of the primary enclosure at Mingary (as suggested by Oram 2012) and later MacRuari or MacIan patronage of the north range.

Although this scenario would strain the radiocarbon data of the young morphology samples as they are currently understood, it would allow those radiocarbon dates a tighter chronology and suggest the offending C1 sample should be dismissed. It is hoped the forthcoming SMCCCP project will be able to further inform our interpretations of the relationship between these radiocarbon dates and the constructional dates of the building phases from which they were removed in the near future.

4.0 FIGURES

Figure 2 (above) – Location of Mingary Castle within the South-West Region of the thesis. Scale bar 50km. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved).

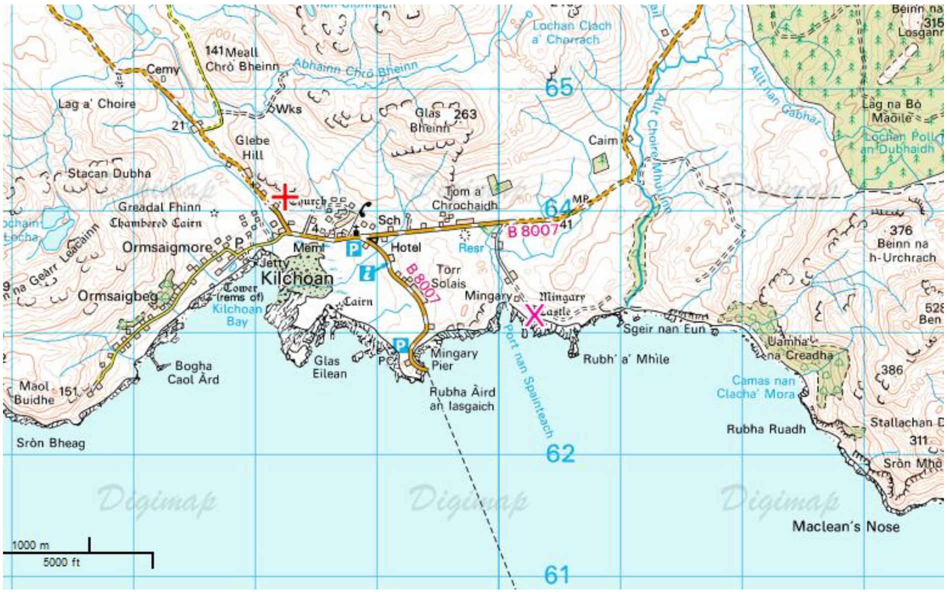


Figure 3 (above) Mingary castle is approximately 1.4 miles from the medieval and later parish church of St Comgan's. + - St Comgan's Church, X – Mingary Castle. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved).

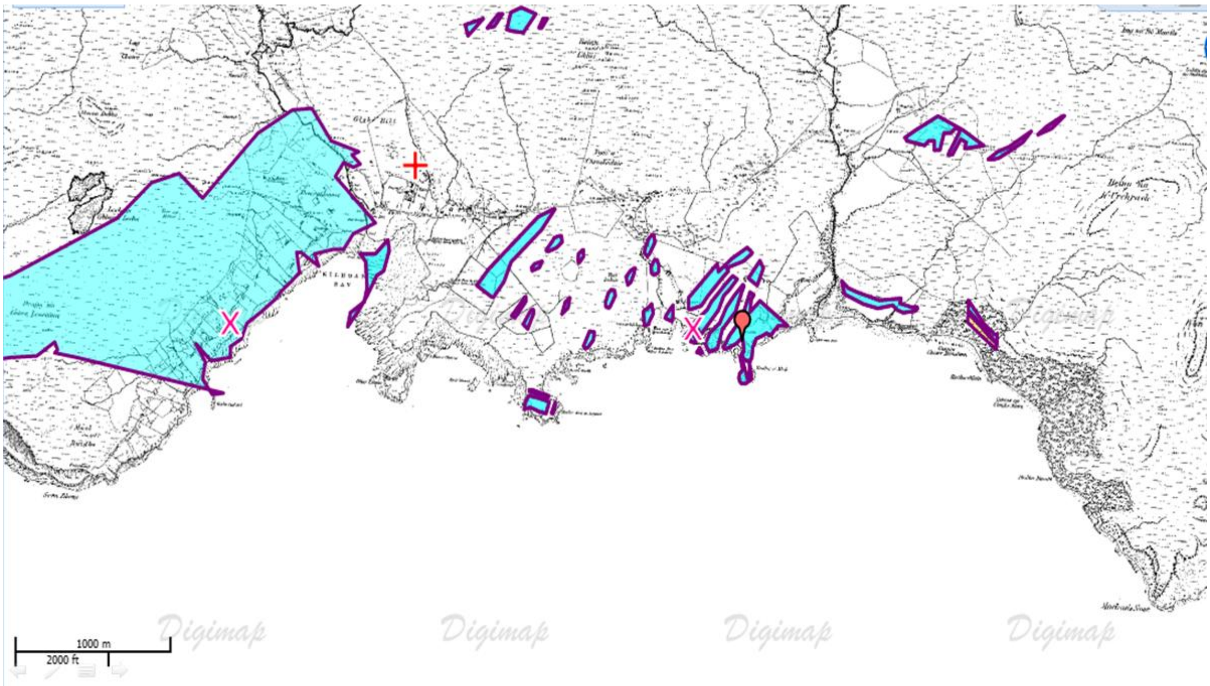


Figure 4 (above) – Underlying Mesozoic limestone geology of the Kilchoan/Mingary district in south-west Ardnamurchan. Mingary Castle and limekiln, the medieval and later parish church of St Comgan's and *Caisteal nan dubh Cliar* are all also marked. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved. Geological map data © NERC 2016.).

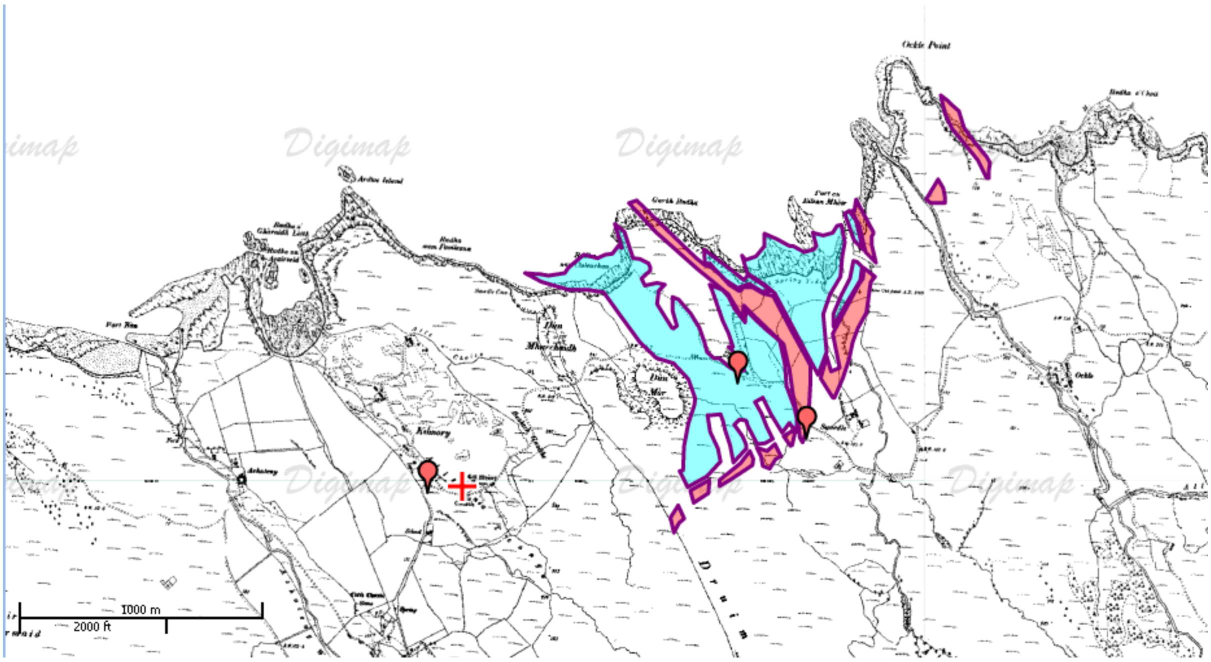


Figure 5 (above) – Underlying Mesozoic limestone geology of Swordle in north-west Adnamurchan is annotated onto the 19th-century O.S. first edition map. The medieval chapel site of St Mary's and various post-medieval limekilns are also marked. (© crown copyright and Landmark Information Group Limited 2016. All rights reserved. Geological map data © NERC 2016).

4.1 ON-SITE ANALYSIS

Figure 6 (above) – Mingary Castle from the north before rapid site survey in April 2013. No Scale; photograph Mark Thacker.

Figure 7 (above) – Mingary Castle from the north before main mortar survey in October 2013 when almost complete scaffold access was available. No scale; photograph Mark Thacker.

Figure 8 (above) North-west curtain wall. Scale 500mm; photograph Mark Thacker.

Figure 9 (above) – Dolerite masonry of the external west face of the primary curtain wall. No scale; photograph Mark Thacker.

Figure 10 (above) - Drum garderobe note use of fissile schist/shale. Scale 500mm; photograph Mark Thacker.

Figure 11 (above) - Mortar 1a; Drum garderobe, bedding mortar, field of view 100mm; photograph Mark Thacker.

Figure 12 (above) – External face of south wall of north range. Note consistent lack of lateral bonding between very large dolerite face stones, very rough or no coursing, and dolerite quoins of south-west corner. Scale 500mm; photograph Mark Thacker.

Figure 13 (above) – External face of north range displays very consistent bimodal distribution of stone sizes, dominated by very large dolerite blocks, laid level with stone-to-stone contact, and levelled-up with much smaller stone. Scale 500mm; photograph Mark Thacker.

Figure 14 (above) – Shell-lime Mortar 2 in external west face of north range. Field of view 80mm. photograph Mark Thacker.

Figure 15 (above) - Mortar 6 (to the right) overlying Mortar 2 (to the left); North range, external face of south wall. Field of view 200mm; photograph Mark Thacker.

Figure 16 (above) – Secondary masonry of the external face of west curtain wall; much of this wall face is dominated by very irregularly laid masonry with very large interstitial voids and is associated with a very coarse 'limecrete' mortar. No scale; photograph Mark Thacker.

Figure 17 (above) – Very course mortar in wallhead core of secondary masonry of the west curtain wall; note very large heated and crazed limestone kiln-relicts. Field of view approx. 250mm; photograph Mark Thacker

Figure 18 (above) – Mortar 4. MCA.005, East curtain wallhead. 10mm scale; photograph M. Thacker.

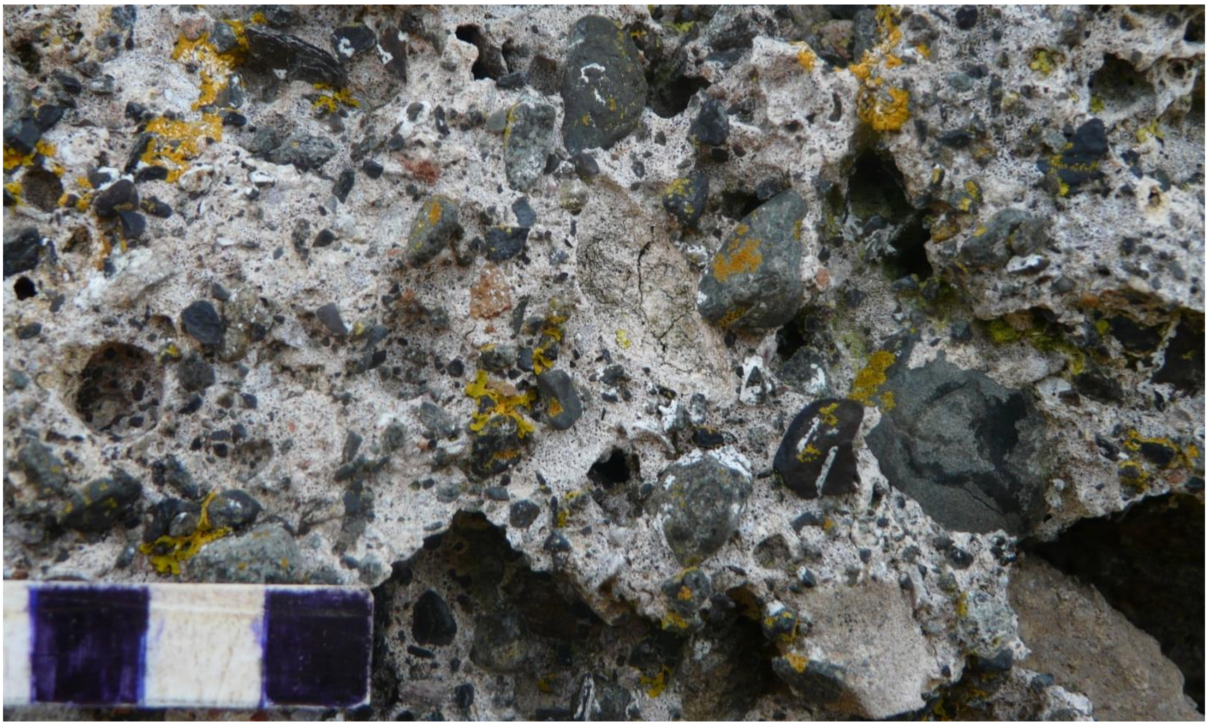


Figure 19 (above) - Mortar 10; External elevation of the north-west curtain parapet. 10mm scale; photograph M. Thacker.

Figure 20 (above) – Mortar 5; west curtain parapet. mm and cm scale; photograph M. Thacker.

Figure 21 (above) - West range, north-west wall. No Scale; photograph M. Thacker.

4.2 – LAB-BASED ANALYSIS

Figure 22 (above) – Thick section MCA.046, mortar Type A. Including large heated limestone kiln-relict and fissile shale, shell and mafic temper. Width of view 30mm; Mark Thacker.

Figure 23 (above) – Thick section MCA.043, mortar Type B. Including heated shell relicts and coarse rounded mafic lithics. Width of view 26mm; Mark Thacker.

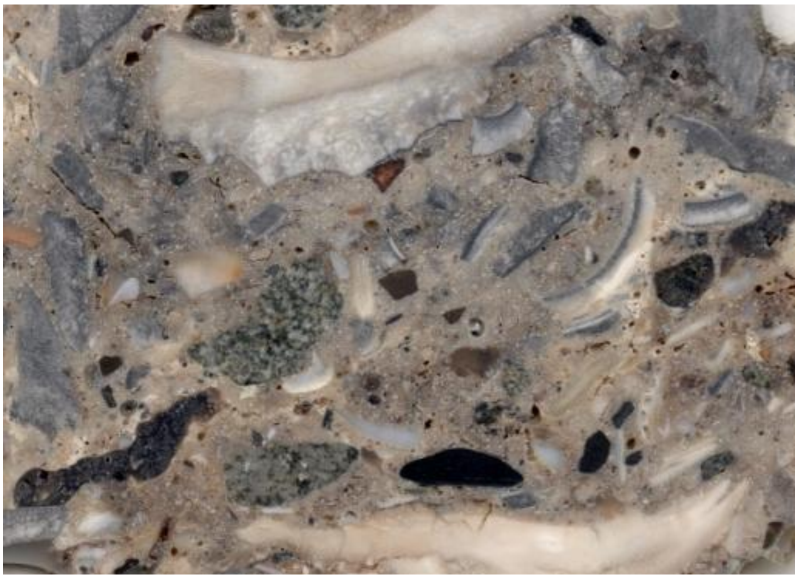


Figure 24 (above) – Thick section MCA.016, mortar Type C. Including heated shell relicts, low conc. of mafic temper and some probable vitreous reaction product. Width of field 45mm; Mark Thacker.

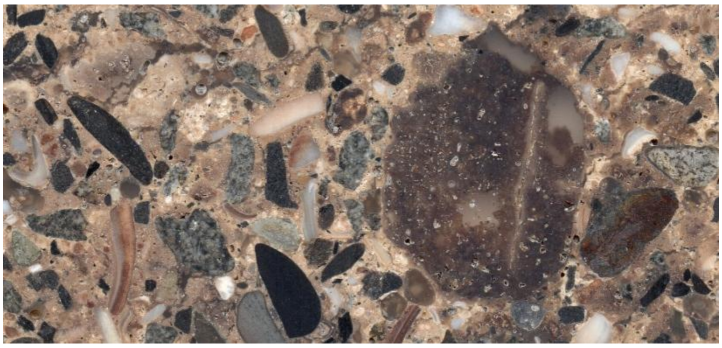


Figure 25 (above) – Thick section MCA.030, mortar Type D. Including large limestone clast with shell, shale and mafic temper. Width of view 30mm; Mark Thacker

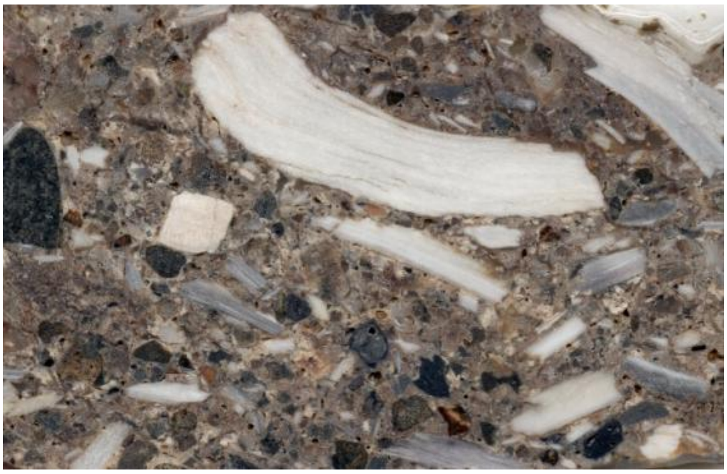


Figure 26 (above) – Thick section MCA.033, mortar Type E; Width of view 30mm; Mark Thacker.

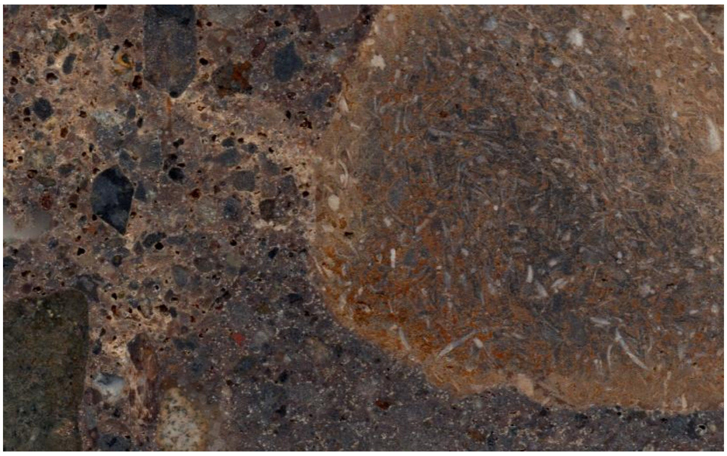


Figure 27 (above) – Thick section MCA.002, mortar Type F. Including large heated bioclastic limestone kiln-relict and generally very fine lithic temper. Width of view 30mm; Mark Thacker.

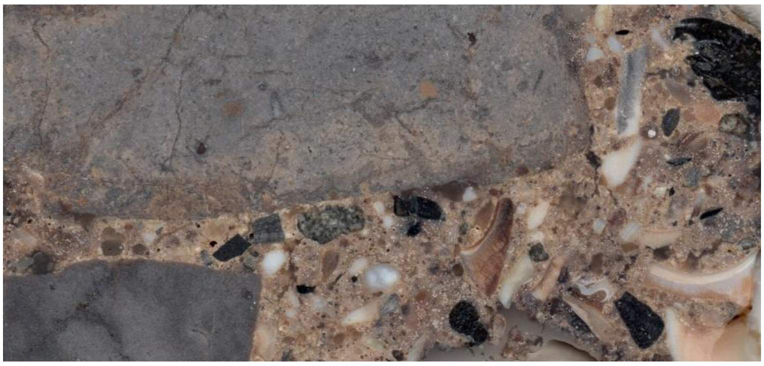


Figure 28 (above) – Thick section 010, mortar Type G. Including large limestone clasts, shell-rich temper and probable Quercus charcoal relict. Width of view 30mm; Mark Thacker.

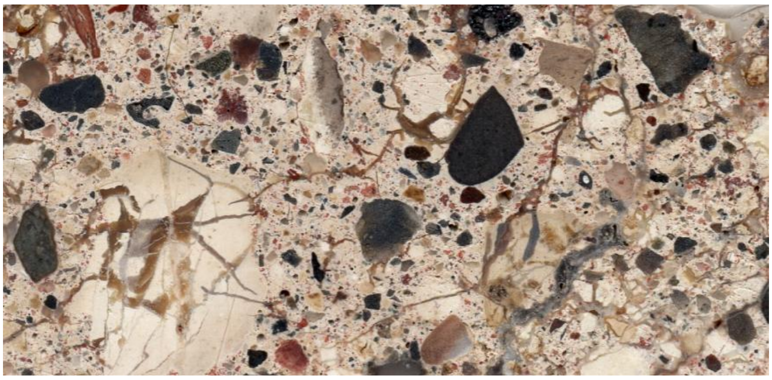


Figure 29 (above) – Thick section 014, mortar Type H. Including high concentration of heated limestone kiln-relicts and some secondary porosity. Width of view 30mm; Mark Thacker.

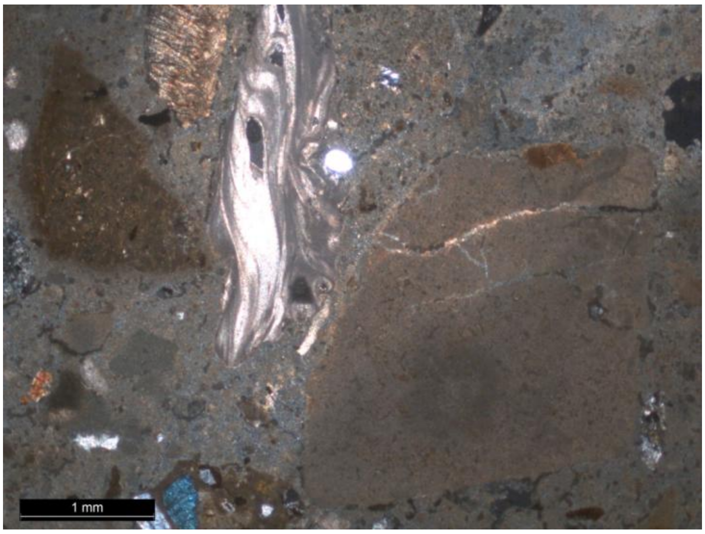


Figure 30 (above) – Thin section MCA.048, mortar Type A. Scale 1mm; XPL; photomicrograph Mark Thacker.

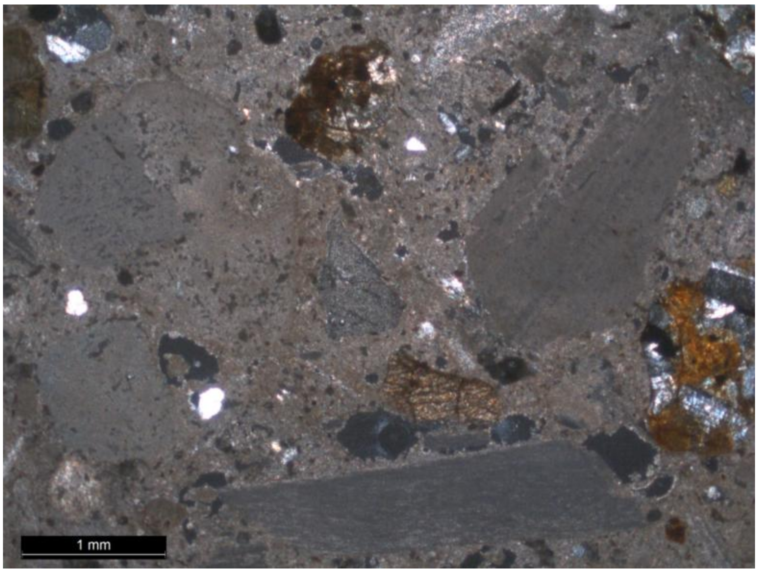


Figure 31 (above) – Thin section 043, mortar type B. Including heated shell relicts. Scale 1mm; XPL; photomicrograph Mark Thacker.

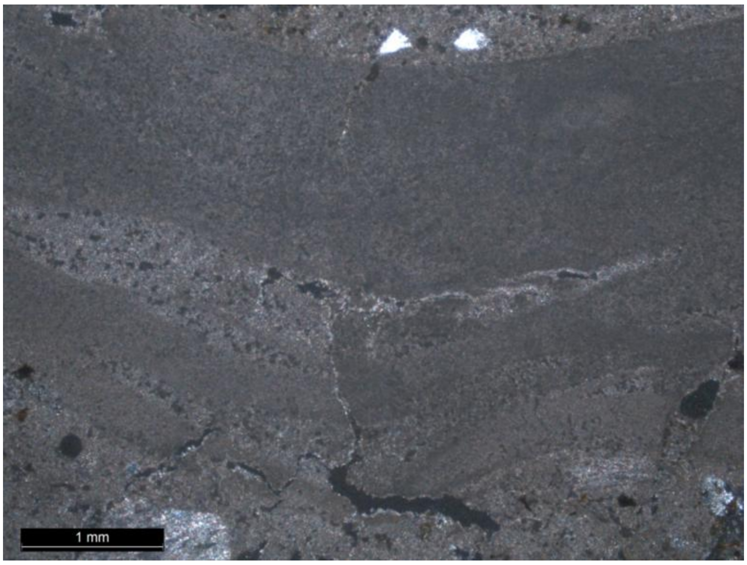


Figure 32 (above) – Thin-section MCA.016, mortar Type C. Including heated *O. edulis* shell kiln-relict. Scale 1mm; XPL; photomicrograph Mark Thacker.

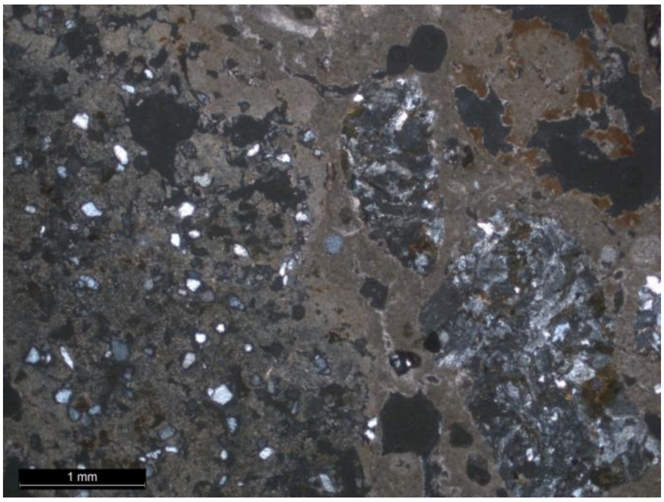


Figure 33 above) – Thin section MCA.037, mortar type D. Including quartz-releasing micritic limestone. Scale 1mm; XPL; photomicrograph Mark Thacker.

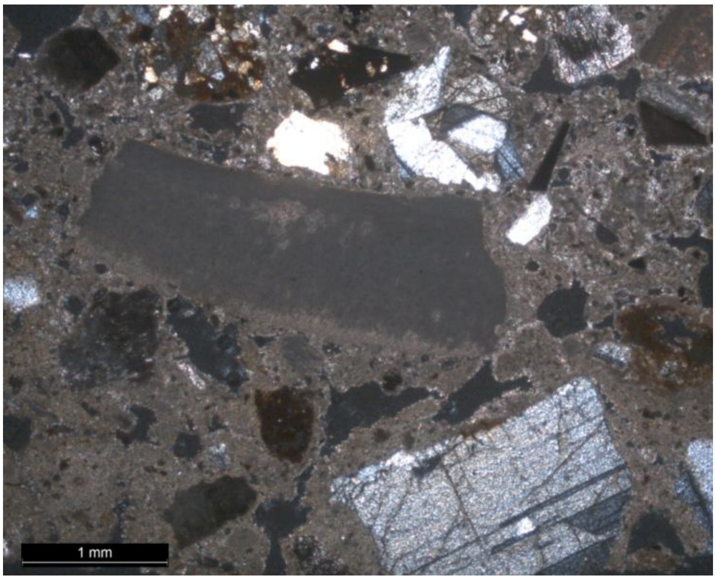


Figure 34 (above) – Thin-section MCA.035, mortar type E. Scale 1mm; XPL; photomicrograph Mark Thacker.

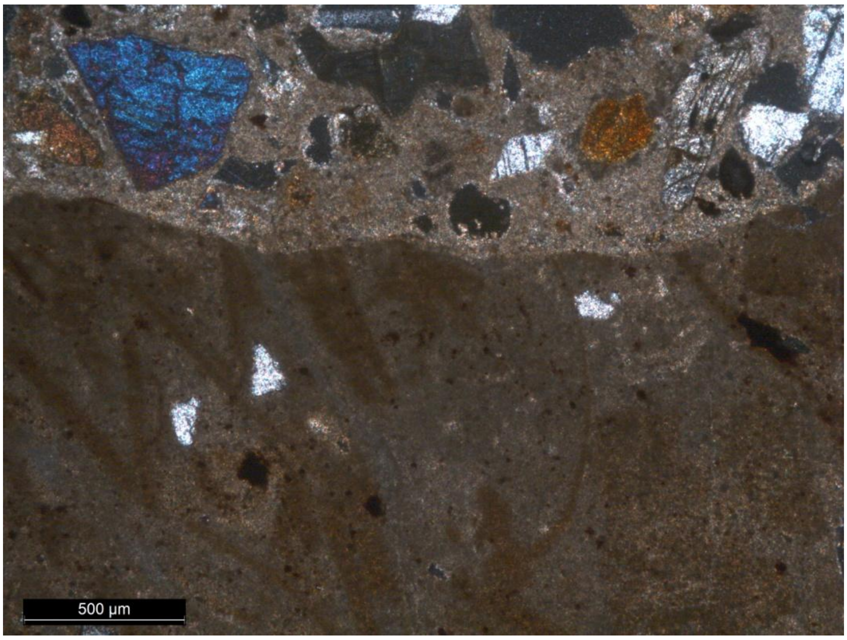


Figure 35 (above) – Thin section of MCA.025, mortar Type F. Including boundary between heated bioclastic limestone and mortar matrix. Scale 500µm; XPL; photomicrograph Mark Thacker.

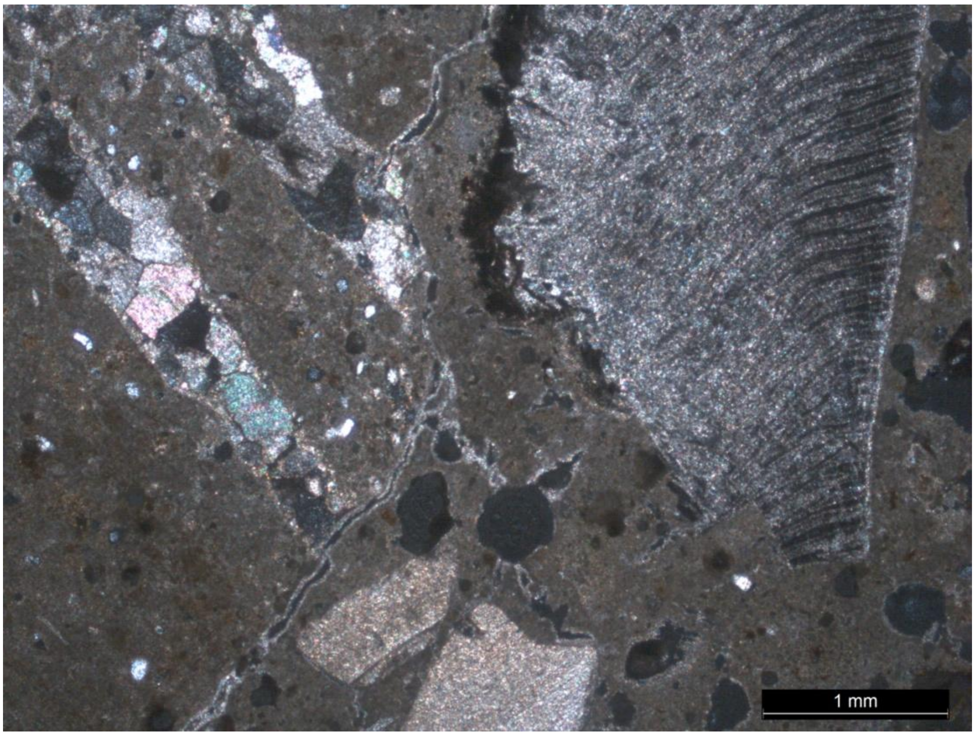


Figure 36 (above) – Thin-section MCA.011, mortar Type G. Including sparry-veined limestone relict and shell temper. Scale 1mm; XPL; photomicrograph Mark Thacker.

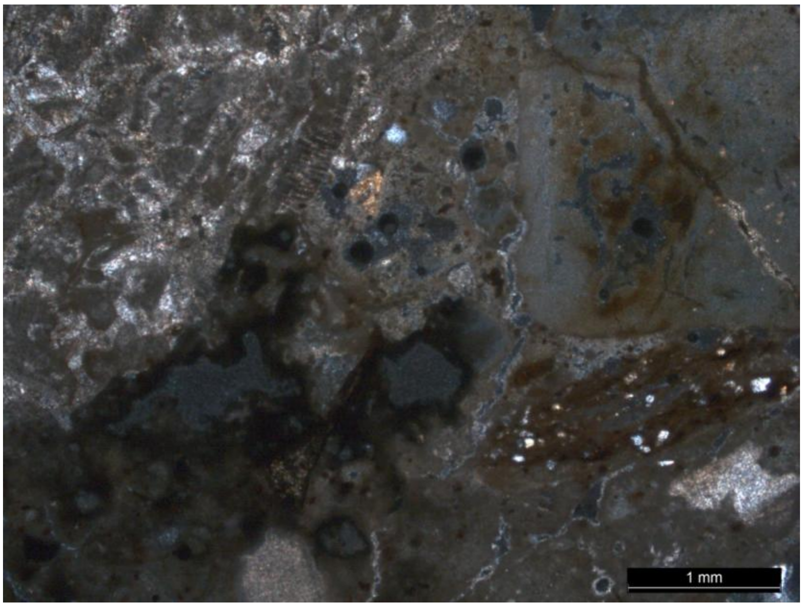


Figure 37 (above) – Thin section 007, mortar Type H. Range of heated limestone textures, including coarsely bioclastic. Scale 1mm; XPL; photomicrograph Mark Thacker.

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APPENDIX CASE STUDY

IONA

Mark Thacker, University of Edinburgh.

Constructing Lordship in North Atlantic Europe. Vol. III.

Appendix case study 15.

Last revision 20-07-2016

DRAFT COPY FOR PHD EXAMINATION SUBMISSION.

SUMMARY

The surviving medieval and later buildings on the island of Iona were subject to building survey and mortar analysis. The study included Iona Abbey, Tigh an Easbuig (the 'Bishop's House'), St Mary's chapel, St Ronan's parish church, St Oran's chapel, Kilvickeon (Ross of Mull) and a number of post-medieval buildings on the island and neighbouring Ross. Most particularly, however, the investigation focused on the Iona nunnery/priory, as this building complex has the most accessible range of medieval masonry mortars. The masonry of each of these buildings was examined and described in-situ before loose samples were collected for further lab-based analysis. Building stone geology and stone emplacement techniques were noted and compared and, where possible, mortar materials related to sources available in the local environment.

A very clear general chronological progression of remarkably contrasting mortar types emerged during this study, with three different lime carbonate and fuel sources displayed in each of the three main building periods. The evidence suggests that the earliest 12th-14th century building phases were bound with wood-fired shell-lime mortars, the late medieval 15th - 16th century building phases with peat-fired maerl-rich (probable maerl-lime) mortars, and the 18th - 19th-century buildings phases with coal-fired limestone-lime mortars. The importance of this evidence for our understanding of earlier (buried) structures at the site is considered especially significant, and so future work is proposed.

CONTENTS

1.0 IONA - MORTAR, MASONRY & ENVIRONMENT SURVEY

1.1 ENVIRONMENT SURVEY

The island of Iona is a small (approximately 5.5 x 2.3km) elongate island, located off the south-west tip of the island of Mull in the county of Argyll, western Scotland (see figures).

1.1.1 UNDERLAYING GEOLOGY

The underlying geology of Iona is dominated by contrasts which follow the same general NE-SW trend as the orientation of the island itself. The sound of Iona, between the island and much larger island of Mull, is the most significant feature of the local geology as this section of the Moine thrust effectively separates the younger red granite of the Ross of Mull, from the older Torridonian and Lewisean lithogies of the island (Richey 1961, 8). Iona itself can also be broadly divided longitudinally between the almost vertical Torridonian flagstone beds of the east coast, and the conspicuously rounded mass of gneissic foreland (cut by a number of amphibolite Scourie? dykes) to the west. Interleaved between these two main island lithogies are a number of metasediments which include a narrow band of white-coloured marble with a distinctive serpentine mottling (Johnstone and Mykura 1989, 22). This Ionan marble was quarried for dimensional stone in the late 18th century, and the RCAHMS speculate the rock had been worked from a very early date to provide a mensa for the altar of the medieval abbey (RCAHMS 1982, 256). Although this is the only calcareous lithogy on the island, there have been no suggestions that this marble was ever used as a lime source.

The Lewisean and Torridonian lithogies of Iona, and red granite of nearby Ross of Mull have been used extensively as general building stone within the islands medieval ecclesiastical buildings. Although granite does not outcrop on Iona, previous commentators have suggested that this material was not quarried and transported from Mull, but that glacial erratics (examples of which can still be seen around the island today) were used. The distinctive use of contrastingly red (granite) and grey/black (Lewisean and Torridonian) stone conformations within particular buildings, has also been subject to particular comment and will be explored below, as will strong parallels in geology, stone use and chronology with Castle Coeffin on Lismore (Thacker 2016).

Two Mesozoic geological outcrops on Mull, both of which were owned by the medieval communities of Iona, have been strongly associated with source materials for the regions ecclesiastical buildings. These include the Jurassic strata outcropping at Carsaig in the south of the island, and the Triassic sequence at Inchkenneth/the Gribun in the west, and both outcrops have been identified as sources of sandstone for building and carving, and as sources of limestone for lime-making (Dixon 1994).

1.1.2 SUPERFICIAL GEOLOGY

The ecclesiastical complex of Iona lies on a raised beach in the largely Torridonain zone of the north-east of the island, and the overlying superficial sedimentary series of clays, gravels, sands and soils evident have been described during various excavations. The most important aspect of these descriptions for the mortar archaeology of Iona is the glacial origin of the sandy subsoil of the raised beach described by Maté (1981; his E_a layer) and Reece (1981). It is clear that this acidic and lithic (possibly granitic) material contrasts with 'white calcareous shell-sand' described in excavation as the 'natural sand' by Redknap (1977, 230; contra Maté 1981), and underlying all the structures west of the abbey, including Columba's shrine chapel. The importance of this distinction will become apparent below.

1.1.3 SHORE SURVEY

The shoreline of Iona and the Ross of Mull was subject to walkover survey to characterize possible mortar aggregate and/or shell/maerl sources.

The shore of the Ross of Mull, North of Fionnphort to Kintra is formed of low steep cliffs and short-reach sections of boulder- strewn shore with two sandy bays. These are composed of very fine, soft and compact lithic/shell sands with very little native shellfish living within the foreshore, or evidence for shell at the strand line. The small post-mortem shell assemblage present is dominated by *P. vulgata* (limpet), although *C. edule* (cockle) and *Veneridae* (clam) shell were also present in very small numbers. Each shell within the assemblage was white or yellow/white with no dark discolouration. Access to the islands off Kintra, which appear to display very white-coloured sand, was not possible in this survey, but some small literal cells opposite contained high maerl concentrations a sample of which was taken for further analysis.

On Iona itself, *Traigh Bhan* is a very white calcareous 'shell-sand' beach, backed by an extensive machair and dune system. These sands are dominated by well-sorted fine shell fragments generally grading to between 1-2mm, but occasionally to 4mm, with very low localised concentrations of lithics including rounded granites and schistose clasts of varying grades to gravels. An aggregate sample was taken from the high tide line (NM2929 2589). Limpet shells are present in low to locally higher concentrations all of which are white, most are completely whole, although a small percentage have lost the shell apex and some have brown radial proteinous colouration as is usual. At the North Beach of Iona (NM 2911 2615) the foreshore displays very lithic aggregates in variously graded discrete well-sorted contexts dominated by rounded and subrounded granite, quartz and schist. Between the beaches at NM29117 and NM29292 above is a small littoral cell of naturally graded lithic sand, with a small shell fraction. Generally grading to 4mm, but occasionally to 10mm this would make a good mortar aggregate. The shell content in general is very low, but at the various high tide lines are very large quantities of whole post-mortem limpet shells of white and yellow-cream colouration. Many are very large, ranging to 40mm diameter and occasionally even 50 – 60mm. Most are worn and abraded and a significant minority (approx. 15%) have missing apexes, and curving very fragmentary forms may form 5% of the assemblage. A small quantity of post-mortem Littorina and more rarely mytillus shells are also present. Further northwest (NM 29056) displayed strandline limpet shells in swathes up to 10m long, 2.0m wide and 150mm thick. The geology down the west coast of the island to *Camas Cuil an t'saimh* (NM2647 2408) is very Lewissean , and the beaches return to fine sub-mm machair-type shell sand, with some significant swathes of very rounded gneiss-type lithics and minerals, very quartz-rich, in various well-sorted grades.

1.1.4 WOODLANDS

Apart from some small stands of Fraxinus in and around the monastery, both the island and nearby western districts of Mull are largely treeless, and this appears to have been their general condition for much of the recent past. Pollen studies undertaken during widespread excavations in the 1980s suggest that *Betula* (birch) and *Corylus* (hazel) dominated the Ionan tree population here after the last ice age, with more minor fractions of *Salix* (willow) and *Sorbus* (rowan) (Bohncke 1981, 369-70). The large decline in tree cover from 3000BC has been interpreted as anthropogenic clearance (to provide timber and clear land for arable farming) as the vegetational record suggests a much more open landscape from this period (ibid.).

Both of these interpretations are open to challenge as studies in south-central Mull indicate that increased wind exposure and soil leaching from 4000BP had caused similar clearance effects there, but that in any case relatively low overall pollen values suggest woodland on Mull was never very widespread or extensive (Walker and Lowe 1985). MacVean and Ratcliffe (1962) suggest most of Iona and the Ross of Mull would have been even more treeless, whilst in hagiography from the early medieval period it is related how the monks of Iona sought wood from off the island of Iona for building. Crofters in the recent past have relied on cutting peat on Mull, or on imports of coal, whilst 'carbonum' and lime was supplied to the monastery by many of the late medieval tenants of Ross (Mull), in payment of their rent. However, although small outcrops of lignite are found on the Ross peninsula, there is no evidence for medieval working and at present the meaning of the reference remains somewhat ambiguous (see below).

1.1.5 LIMEKILN

In 1966, excavations to the north of the abbey complex revealed a series of circular hearths of 1.5 – 3.0m in diameter which were interpreted as a sequence of agricultural lime-burning clamps of early medieval or Columban age (Reece 1981). A pile of shell sand adjacent to these hearths was interpreted as the remains of an unburnt carbonate charge whist the putative kiln-hearths contained both charcoal and slag, considered to be a product of the fusion of the underlying glacial sand of the raised beach (ibid.). Although the RCAHMS subsequently suggested that a later medieval building-lime context might be more probable for this feature (1982, 41), and this implies a tacit acceptance of the structures technical purpose, and RCAHMS also suggest that other industrial debris in this sector of the site may support Reece's early medieval interpretation. In summary then, the technical interpretation is agreed but the chronology of the features remains equivocal and none of these features are currently visible above the back-filled surface of the site. Clearly, however, the descriptions and mineralogy of the analysed 'slag' conforms to the incidental vitrified lithic kiln-relicts described and characterized within this research (see appendix 3 in volume II this thesis).

The only other possible evidence for limekilns noted locally during this research, is the place-name '*Rudh an Aoil*' (point of lime) noted on the mid 19th-century Ordnance survey 6-inch map at NM 52826 28836 at the head of nearby Loch Brolass on western Mull. This is a sheltered sandy site which may have had significant shell assemblages historically, but like many similarly named sites in the Western Isles (Thacker 2011), there was no lime evidence noted in walkover survey.

1.1.6 ENVIRONMENT SUMMARY

In summary, Iona appears to have offered the high to late medieval mason and lime-burner a range of shell and lithic sands, variable volumes of post-mortem shell assemblages, three hard stone types and a limited quantity of marble. A greater range of different sands, sandstones, limestones, peat, woodland and even coal fuel were available in isolated contexts on the neighbouring island of Mull, whilst the excavated limekiln evidence suggests some kind of probable wood-fired biogenic-lime may have been manufactured during the medieval period.

1.2 BUILDING SURVEY

1.2.1 TIGH AN EASBUIG, IONA. (The Bishop's House; NM 2873 2457).

The upstanding remains mostly consist of the mid-wall of a bicameral domestic building. The masonry consists of regularly rough courses of undressed red granite stones with rounded arises, but includes smaller quantities of gneiss, some fissile metasediment levellers, and some slate. The doorway dressings are missing all lintels, but the jambs appear to be Carsaig sandstone and a similar material is apparent in relatively high concentration in the core and as occasional small builders and pinnings in the wall faces.

Mortared core and bedding contexts can be examined very well in full wall cross-sections of all walls, and is particularly well displayed in the stonework surviving above the missing door lintels. Accepting some small isolated recently consolidated contexts, this mortar is striking, consistent and visible in contiguous core, beds and coatings, and would appear to be single phase.

General description: Very white, coarse, maerl-rich lime mortar.

Carbonate Kiln-relicts – Although the Bishop's House mortar is now interpreted as a possible maerl-lime mortar (see thin-section evidence IPA.09 below), this was not immediately apparent on site given the lack of thalli-discolouration regarded as typical elsewhere. Indeed, this mortar was initially very tentatively interpreted as a shell-lime on the basis of low concentrations of discoloured *P. vulgata* (limpet) shell fragments to 4-5mm (occasionally including full 30mm shells) and some *L. littorea* shells which display extensive cracking and scorching. This evidence for shell-heating is convincing, but would now probably be interpreted as incidental to the roasting of the maerl which dominates the mass of the mortar material. These thalli are hollow-cored, average 3-5 x 2mm ranging up to 8-10 x 5mm at the nodules, and vary in colour from a pearly (nacreous-like) lustrous white to cream to a duller yellow to yellow-brown. This discolouration is not merely a surface coating but runs through fractured cross-sections. There is no visible lime-lump or limestone evidence.

Added temper – The Bishop's House mortar is also tempered by very low concentrations of a poorly-sorted mixture of unheated lithics and shell, which includes subrounded to angular red granite and quartz sand and gravel clasts and unheated gastropod shells to 15mm.

Fuel kiln-relicts – The Bishop's House mortar was peat-fired and contains a very low concentration of peat-charcoal relicts.

Vitreous kiln-relicts – No vitreous kiln-relicts were noted in the mortar of the Bishop's House.

1.2.2 ST MARY'S CHAPEL, IONA. (NM 2870 2442)

This oriented ruined chapel building survives in substantial fragments of the north and south walls to 2m+ high, whilst the east and west walls are reduced to turf-covered footings only. The stonework is formally-coursed and largely comprised of large red granite field stones with very rounded arises, whilst fissile metasediment, gneiss, and a low incidence of iron-rich coarse sandstone is also evident in small facing stones and core rubble.

This stonework is lime-bonded, and large volumes of exposed core are visible in the south wall (where the external wall face is almost completely missing), and in the north wall in full cross-section. The rubble within the core of these walls was very flat-laid and level, and bedded (not grouted) with a very coarsely tempered lime mortar. Level course lines are evident right through both faces and the core of the wall, and a consistent single phase mortar is evident in contiguous core, bed and coating contexts. There are also the substantial remains of a secondary mortar coating overlaying the primary internal coating of the south wall.

General description – This is a very coarse white-coloured lime mortar.

Carbonate kiln-relicts – The primary mortar of St Mary's is a shell-lime and contains a remarkable range of heated shell evidence including darkly discoloured inclusions of *O. edulis* (oyster), *C. edule* (cockle), *P. vulgata* (limpet), *L. littorea* (winkle) and *M. edulis* (mussel). Oyster is the dominant shell type, however, and displays the clearest heat alteration evidence in white curving lime forms merging with a very white matrix. There is no coralline fraction at all.

Added-Temper – This mortar is well tempered with a poorly-sorted mixture of lithic and shell materials dominated by subrounded to rounded lithics. This included a high concentration of granite, some quartz, occasional dark green coloured minerals (which may include amphibolites) and some sandstone. Low concentrations of unheated shell were also present.

Fuel kiln-relicts– This mortar was wood-fired although only one charcoal inclusion was noted and that this is turf-heather cannot be ruled out at this stage (15 x 4mm exposed core at the broken end of the north wall; 380 back from north (external) face, 750 above ground).

Secondary mortar coating – The internal face of the south wall has been re-coated in a secondary phase with a much softer mortar material which survives in extensive areas up to 10mm thick. This secondary coating is also a shell-lime with a very white matrix, low to medium concentrations of small black shell lenses to 10mm and larger black *P. vulgata* (limpet) fragments to 30mm. This is tempered with a very soft, sub-mm aggregate to a very smooth finish. No fuel or vitreous materials were evident.

1.2.3 ST RONAN'S CHURCH, IONA (NM 2849 2412)

The masonry of St Ronan's displays an informal stone-emplacement technique, comprised of an disordered mix of lithogies (including red granite, Torridonian and some sandstone rubble) brought to very rough courses, with sandstone window, doorway and quoin dressings. Externally, however, the walls have been so heavily consolidated that no historic mortar evidence is visible. Internally, there is no visible core masonry either, but extensive survival of historic mortar is evident on the internal faces of the south and east walls in fixed (inter-stone) contiguous coating and masonry bed contexts to 40mm deep. This is a shell-lime mortar and is almost certainly the primary mortar of this church.

Carbonate kiln-relicts – The St Ronan's mortar is a shell-lime and contains a high concentration of Type 3-4 heated *O. edulis* (oyster) shell fragments, generally to 15-20mm and very occasionally to 40mm, and a very low concentration of discoloured *P. vulgata* (limpet) shell.

Added temper – This mortar is predominantly lithic tempered with rounded to subrounded lithics of granite and gneiss, generally ranging up to 4mm, and occasionally to 8mm, although a large sub-mm shell fraction to this mortar is also probable.

Fuel kiln-relicts – no fuel evidence was noted in the St Ronan's mortar.

Vitreous kiln-relicts – no vitreous evidence was noted in the St Ronan's mortar.

1.2.4 ST. ORAN'S CHAPEL, IONA (NM 2858 2445)

Like St Ronan's, the general walling of St Oran's chapel displays a mix of lithogies, and an informal stone-emplacement technique without any consistent level coursing. These walls contain a number of phases additional to the main primary structure and, although also very heavily re-consolidated in recent periods a number of more historic mortars remain visible in a few small and discrete contexts. Of this series, three mortars are considered particularly significant, and will be described below:

A limestone-lime is evident surrounding the granite quoins of the south-west external corner (beneath cement pointing) and a similar material is visible within the west doorway in beds to 50mm deep. This mortar displays a creamy-coloured lithic-tempered matrix, with angular yellow heated limestone relict inclusions, and rounded lime lumps and eroded vesicles, to 7mm. This mortar is tempered with a consistent granite-rich aggregate of subrounded to subangular lithics to 4mm, with no shell fraction.

Underlying the limestone-lime mortar described above, but overlaying the eroded external jambs of the west doorway, is a very maerl-rich mortar visible in bed and coating contexts to 25-30mm thick. Like the mortar described at the Bishop's House (above), this mortar contains an extremely high concentration of fine (1-3mm thick) white and cream-coloured coralline algae thalli with some darkly discoloured *P. vulgata* (limpet) shell. That these dressed stones had already eroded when this mortar was deposited either indicates that the doorway was built with a different (earlier) mortar, or (much less likely) the eroded dressings from a different context have been re-used in this building. A similar, matching, maerl-rich lime mortar is also evident deep (to 120mm+) within the dressed and rubble-stone joints of the chapel's (secondary) intramural south wall tomb recess, and is contemporary with that feature.

Although, as above, the joints of the external walls of St Oran's are heavily consolidated, the fragmentary remains of an earlier mortar are evident in multiple coating contexts on the external face of the north wall:

General Description – Fine white mortar.

Carbonate kiln-relicts – This St Oran's mortar is a shell-lime containing a high concentration of discoloured heated shell fragments, including *P. vulgata* (limpet) to 15-20mm.

Added-temper – Very rounded well-sorted lithic mixture generally grading up to 3mm.

Fuel kiln-relicts – No fuel relicts were noted.

Vitreous kiln-relicts – No vitreous kiln-relicts were noted in the St Oran's mortar.

1.2.5 COLUMBA'S SHRINE, IONA (NM 2861 2450)

This building has been largely reconstructed in the mid-20th-century, although the two lowest courses (including the west antae) are much earlier and excavation suggested this masonry is contemporary with the primary masonry foundations (Redknap 1977). Unfortunately, however, no mortar evidence at all was described in the excavation report and no securely primary mortared contexts were noted during this survey. What follows, however, is a description of the mortar evidence which is visible in the upstanding structure.

South Anta - Although the north face of the south anta has evidently been rebuilt at some stage (as the top stone is a moulded piece of sandstone which looks like a finial or ridge stone) the south face is formed by an eroded coarse sandstone quoin, edge-laid and face-bedded, which is so long it bonds with the south wall of the building. An alternate underlying sandstone quoin is also eroded but naturally bedded and flat-laid to form the full width of the west face of the anta, forming a feature 570mm wide (n-s) and 470mm projecting (west from the face of the west wall).

North Anta - The north anta is apparently much more complete and also contains a base quoin stone (at current ground levels) which runs the full width of the west face of the feature. The overlying course is predominantly formed of two sandstone quoins: the south quoin is edge-laid and face-bedded, and long enough to bond with the face of the west wall, whilst the north quoin is a large, naturally-bedded sandstone block which may also bond with the main chapel walls. The north antae survives to 570mm wide (N-S) and projects 570mm from the main external face of the west wall (contra. south anta).

The doorway quoins are sandstone through-quoins to two courses in both jamb and, although neither bonds effectively with the surrounding rubble masonry, visual examination suggests both these and the antae dressings are fine-grained Carsaig sandstone and the general walling of these early courses is Torridonian rubble.

This evidence supports Redknap's (1977) interpretation that all of this masonry is coeval and primary, although the antae, doorway, and general masonry of these low courses display a mix of voided and recent cementitious pointing only, and no evidence for primary mortar was visible.

Recent cementitious mortars also dominate the internal mortar evidence, although various fragments of earlier historic mortar evidence are also present. The upper courses of all walls display historic coating evidence, some of which is evidently shell-lime and so very likely to be from a medieval context. However, as this is restricted to the faces of stones which are in secondary contexts, without knowledge of their precise source this potentially significant evidence is heavily compromised. The only inter-stone fixed masonry context in the upper coursing is a hard cement mortar pointing which effectively fills all joints.

There is more extensive evidence of in-situ historic lime mortar at the wall face of the lowest visible courses of the south end of the east wall and the east end of the south wall. Although the masonry here is quite voided in the bed, a soft white historic lime mortar, obviously contrasting with that seen elsewhere in the building, adheres to the wall across stones and joints as well as on the faces of single stones to a fair-faced coating 15mm thick. This mortar displays a medium to high concentration of large white and buff-yellow subrounded to subangular limestone and lime inclusions to 6mm, which is tempered with a predominantly sub-mm material containing a low concentration of black subrounded lithics to 1mm. A medium concentration of sharp black lustrous inclusions to 1.5mm may be relict fuel, and suggests this is probably a coal-fired limestone-lime mortar. Given that it is not evident in the north or west walls, this likely to be associated with the 19th-century use of this masonry to buttress the adjacent tower (see RCAHMS 1982).

Inspection beneath the floor of the building reveals only further use of cementitious mortars and no historic mortars were visible.

In summary therefore, apart from the ex-situ shell-lime coating some internal face stones, no possible primary mortar evidence for the chapel is visible.

1.2.6 IONA ABBEY COMPLEX (NM 2868 2451)

Much of the masonry of the main abbey complex has been very heavily consolidated in a number of phases and so there is no intention to comprehensively describe this building here. Externally, very little evidence for pre-18th century mortar can be observed, although some very small isolated fragments of bedding (to 100mm) and coating, visible on the east, south and west buttress, and south transept walls, are probably medieval and all are shell-lime mortars.

Internally, more extensive historic material was noted, particularly around the cloister walk, and these are described below:

Undercroft doorway (now the shop entrance) – Extensive historic mortar evidence in contiguous and consistent coatings, beds and core to 500mm. This is a shell-lime, with high concentrations of heated *P. vulgata* (limpet) and some Type 4 well-heated *C. edule* and *O. edulis* shell fragments to 20mm. Three successive coating layers are visible although all appear to be similar material suggesting some longevity and multiperiodicity to this mortar type. This wall abuts and blocks dressed sandstone engaged shafts and capitals.

A similar shell-lime mortar is found on the east wall to beds 200mm deep, once more in contiguous core, bed and coating contexts. Heated *O. edulis* (oyster) is more prevalent in this east wall, although *C. edule* is also present, and in each of these contexts there is often a red colouration in the outermost layer. The arched entrance to the chapter house also displays extensive mortar survival with a high concentration of Type 2-4 heated *O. edulis* (oyster) fragments to 50mm (lithic-tempered with no evidence of coralline algae) in bed and successive coating layers. This context displays an excellent range of material evidence for shell-lime including instances where shell-lime inclusions have been invaded by aggregate.

The south wall of the cloister (i.e. the external north wall of the church) displays a limestone-lime mortar at the west end which is repeated within the church at this wall, and internally, the abbey church itself is also very heavily consolidated. There is, however, some shell-lime evidence at the western stair and, within the sacristy doorway, a fine (2-3mm) lithic-tempered shell lime mortar with heated *O. edulis* (oyster) inclusions to 12mm can be seen in fine ashlar joints.

1.2.7 NUNNERY CHURCH

The masonry of the nunnery displays a very formal masonry style with strictly regular coursing of between 340 and 400m high. A distinct and geologically-specific conformation of stonework is also apparent, in which the lowest courses are dominated by Torridonian, the middle courses by red granite and the upper courses a return to Torridonian (see figures). That this polychromic conformation within the main structure represents design rather than multiperiodicity is generally accepted and is an interpretation apparently supported by the consistency of the Carsaig sandstone dressings.

This essentially single phase interpretation, however, is more clearly supported by the abutment of the external mortar coating of the west wall by the north cloister wall, which provides an upper terminus, and by the homogeneity of the mortar in the primary fabric. Primary mortar is visible in the lower courses of the external and internal faces of the west wall, in contiguous core, bed and coating contexts to 600mm and clearly extends into the granite masonry of the middle wall courses to 3.0m high. A similar material is extant in the external face of the east wall of the north aisle where contiguous core, bed and coat is evident to a depth of 200mm, and coating the vaulting in the north aisle internally. Although carbonate kiln-relicts are in low concentration, this is a lithic-tempered shell-lime mortar.

General Description – The primary mortar of the nunnery church is a very consistent white-coloured lime mortar dominated by its well-rounded lithic temper.

Carbonate kiln-relicts – This is a shell-lime mortar containing a low concentration of heated relicts of mollusc shell fragments, including Type 3-4 *O. edulis* (Oyster) and *C. edule* (cockle). No limestone, lime lumps, or maerl evidence was noted.

Added-temper – This mortar is lithic-tempered and contains a high concentration of rounded to subrounded lithics, predominantly composed of granite, quartz and metasediment, generally ranging up to 2-4mm but occasionally to 10mm. A low high sub-mm silty fraction is also probable, but no coralline algae evidence was noted.

Fuel kiln-relicts – No relict fuel evidence was noted in the primary mortar of the nunnery church.

Vitreous kiln-relicts – None noted.

Overlying internal coating – The extensive remains of a fine, overlying, later coating is found at the north-east internal corner of the chancel of the church, within which ashlar joint-lines have been incised to indicate course heights of 190mm (only one perp was noted so no width was calculated). This coating has been applied in a very fine layer of 1-4mm thick, and is neatly finished to abut surviving sandstone dressings. This material is evidently secondary, although no evidence was available to suggest whether this represents contrasting constructional or wider chronological periods. The mortar itself displays a high concentration of rounded vesicles, but definitive visible evidence of lime provenance is lacking (although see lab-based interpretation below).

North Arcade Blocking – The arcade between the nave and north aisle of the nunnery church was blocked in a secondary phase and the primary mortar of this structure is a very maerl-rich mortar similar to that described in the Bishop's House and secondary phases of St Oran's chapel. This material is evident in contiguous core, bed and coating contexts in the upper courses of the masonry blocking the west bay, and a similar mortar surrounds the large sandstone corbels of the south church wall where it also clearly overlays the primary church mortar described above. This suggests the arcade blocking, at least in the west, was intended to provide some first-floor space in the church.

Later church Mortars - A series of later mortars are also evident within the nunnery church. The north arcade blocking had also contained a west entrance, and this had itself been subsequently blocked with masonry bonded with a heavily shell-rich mortar visible in the south face in beds to 80mm deep. This mortar would appear to be a shell-lime containing a very high concentration of *P. vulgata* (limpet) shell in curving black lenses to 30mm, tempered with a soft sub-mm sand, and displaying a low concentration of coke-like and coal inclusions to 10mm.

The eastern bays of the north arcade blocking also appear to have been constructed with a contrasting mortar and may be of a different phase to the western. This mortar was noted in full masonry beds and core contexts to 150mmand displaying a very homogenous fine (1.5mm and down) lithic and shell-tempered mortar of uncertain carbonate provenance.

There is also a series of later repair mortars at the east elevation of the east wall of the church, one of which is very recent, but the other is very fine-tempered with a high concentration of yellow limestone inclusions and vesicles, and may be 19th century. The south doorway of the church has also been repaired with a similarly hard, sub-mm-tempered limestone-lime mortar

1.2.8 NUNNERY CHAPTER HOUSE

The chapter house is a challenging structure to interpret holistically, as masonry survival is generally limited to low courses which have been consolidated with a series of recent lithic-tempered conservation mortars (that some of these have attempted to replicate the primary mortar of the building is most clearly seen in the west wall of the chapter house). However, more extensive remains do survive at the south end of the east wall to a height of approximately 4.5m and, although no coating survives, primary mortared core and bedding contexts are visible to 300mm. This structure has been bonded with a shell-lime mortar similar to that previously described for the nunnery church.

Carbonate kiln-relicts – This is a shell-lime mortar which contains a low to medium concentration of fine heated and discoloured mollusc shell fragments in a very white-coloured matrix.

Added-temper – This mortar is generally lithic-tempered and contains a high concentration of rounded to subrounded to round quartz and granite to 4mm with a high sub-mm fraction.

Fuel kiln-relicts – No fuel relicts were noted in the chapter house mortar.

Secondary work – The south-east window of the chapter house is bound in a mortar which clearly contrasts with the primary masonry and is evident to 800mm south of the internal splay, and to a core depth of 400mm from the west face. The primary shell-lime mortar of the chapter house was clearly cut back, often vertically, and is abutted by a mortar which is very maerl-rich with a low concentration of discoloured *P. vulgata* (limpet) shell fragments. This south-east window is therefore clearly secondary and bound with a mortar similar to that described in the Bishop's House.

1.2.9 NUNNERY WEST CLOISTER WALK

Although the north-west and south-west sections of the cloister walk wall are no longer in direct contact, the stonework in both western sections is similarly predominantly comprised of remarkably edge-laid and face-bedded schist (with evidence of marbling) in well-coursed regular lifts, with minor use of red granite. Moreover, although core contexts are not generally very visible in these walls, the mortars binding these two cloister walk sections is also very similar and, in contiguous coating and bedding contexts to 100mm deep, and within an isolated visible core context to 200mm, convincingly primary. Accepting evidence for a later stone-lime at the repaired sections in the upper courses of the internal face of the south-west corner of the nunnery cloister walk, and at the eastern butt-end of the south wall, this cockle-rich shell-lime is the only mortar visible and is almost certainly the primary mortar of this upstanding structure.

Carbonate kiln-relicts – This mortar is a shell-lime which contains a very high concentration of heated Type 2-4 *C. edule* (cockle) shell fragments, ranging up to whole valves of 35mm. Localised low concentrations of discoloured *P. vulgata* (limpet) shell fragments are also present.

Added temper – This mortar is tempered with poorly-sorted mixture of lithic and mollusc shell materials dominated by rounded to subrounded quartz-rich lithics generally to 2-3mm and occasionally to 10mm; with a low to medium concentration of fine unheated shell to 4mm.

Fuel kiln relicts – This mortar was probably wood-fired and two probable wood-charcoal inclusions (roundwood displaying strong longitudinal grain fibres) were noted in the external face of the north wall.

1.2.10 IONA NUNNERY REFECTORY

The masonry of the nunnery refectory is possibly the most problematic of the all the structures in the Iona complex. The stonework of this structure appears to display a similar geologically-specific polychromic design as the nunnery church described above, although here (because of a coincidental change in sandstone texture at architectural features) this contrast in stone-type has been interpreted as multiperiodicity (Albornoz-Parra et al. 2015). This multiphase interpretation might also appear to be supported by the relationship between the west wall of the refectory and the west cloister walk where the lack of bonding between the upper courses of these structures contrasts with the masonry at lower levels (see discussion below).

This interpretation is not supported by the very visible and extensive mortar evidence surviving within the Nunnery refectory, however, which strongly suggests the building is generally single phase. Contiguous and consistent core, bed and coating mortars were inspected in the south wall, to 340mm deep, and in the west wall to 240mm deep, and in the east wall where window quoins are missing. Internal and external coatings survive to over 20mm thick and at the windows of west end of the south wall and the south west external corner of the building, overlie the faces of the sandstone dressings. The internal coating forms a very thick rounded profile at internal corners and survives particularly well in lower courses, but in all three surviving refectory walls, from the lowest courses to 3.0m high, the same coralline-algae dominated mortar material (and no other) is evident in core, bed and coat.

General description: This mortar is a very distinctive white material, almost completely dominated by high concentrations of coralline algae.

Carbonate kiln-relicts – On-site this mortar was initially tentatively interpreted as a shell-lime, although lab-based thin-section analysis and XRD would ultimately suggest this is a maerl-lime. The mortar clearly contains a very high concentration of fine (4-5 x 1.5mm, up to 7mm) maerl thalli, although these are predominantly white with a low concentration displaying creamy-yellow colouration. None of the algae fragments display the usual diagnostic grey or black discolouration, although a low concentration of discoloured mollusc shell fragments including *P. vulgata* (limpet) and *O. edulis* (oyster) is evident.

Added-temper – The mortar is also tempered by a poorly sorted mixture of lithic and shell materials including: subangular red granite, quartz and flagstone, generally to 5mm and occasionally to 10mm; a very low concentration of larger rounded lithics to 30mm, fragments; and unheated *L. littorea, O. edulis* and *C. edule* shell fragments to 9mm. A substantial sub-mm fraction is also probable.

Fuel-kiln relicts – No fuel kiln-relicts were noted in the primary mortar of the nunnery refectory.

Vitreous kiln-relicts – No vitreous inclusions were noted in the nunnery refectory mortar.

Secondary fabric – Two main secondary phases were noted in the refectory building. A similarly maerl-rich mortar is associated with the relieving arch at the east end of the south wall (to 300 to 500mm deep) which had been interpreted by the RCAHMS as secondary, and the masonry blocking the windows of the south wall (which are more clearly secondary) are bonded with a limestone-lime which displays a high concentration of lime-lined round vesicles tempered with a soft sub-mm sand with some lithics to 1mm. (similar to that in door of church).

1.2.11 <u>LATE IONA BUILDINGS</u>

CORNER HOUSE, VILLAGE STREET, BAILI MOR, IONA. This probable late 19th century single storey stone cottage is built of lime-bonded and sneck-harled granite. The lime mortar has degraded to a yellow colour in the masonry joints, whereas the coating is very coherent and bright white. This is a limestone-lime mortar which contains a low to medium concentration of very white, subangular lime and limestone inclusions and vesicles to 20mm; This mortar is generally tempered with a poorly-sorted lithic material containing rounded to subrounded basalt, granite and quartz to 10mm and occasionally to 20mm. A very low unheated shell fraction is also evident which includes full *P. vulgata* (limpet) and *C. edule* (cockle) shells to 30mm.

BARN, CLACHAN ARD, IONA. This masonry barn was constructed c.1880 with predominantly granite walls of approximately 600mm thick. The core appears void, but the external face appears lime mortar bedded whilst the internal masonry appears pointed and is lime-washed. The mortar appears single phase and is a good ‘hackly’ (probably hot) limestone-lime. This barn was apparently formerly whitewashed (Ken Tindell, owner, pers. Comm.). This mortar is a limestone-lime with a cream-yellow matrix containing a medium concentration of eroding, angular, micritic limestone inclusions to 20mm. The mortar is well-tempered with a coarse and lithic mixture of round to subrounded, granite, quartz and schist to 10mm, and a very low unaltered shell fraction. This mortar was coal-fired and one coal inclusion to 15 x 20mm was noted.

1.2.12 KILVICKEON OLD PARISH CHURCH, ROSS OF MULL

The remains of the (probably 13th-century) medieval parish church of Kilvickeon, Ross of Mull is the nearest surviving medieval building to Iona, and the estate and church were owned by the community. This structure displays distinctively edge-laid stonework of sandstone, gneiss and basalt (interestingly no granite) laid in formal courses and levelled with fissile flat meta-sediment stones to course heights of 400-600mm. Although quite heavily conserved, a number of core contexts are sufficiently visible to interpret the primary masonry confidently, and the primary mortar is evident in contiguous core, bed and internal and external mortar coating contexts. This is a distinctive shell-lime mortar the evidence for which suggests the masonry is generally single phase.

Carbonate kiln-relicts – This mortar is a shell-lime which contains a very high concentration of heated mollusc shell fragments, dominated by Type 3-4 *O. edulis* (oyster) to full 70mm valves, but also including *C. edule* (cockle) and *P. vulgata* (limpet).

Added- temper – This mortar is tempered with a poorly-sorted lithic material which has imparted a very light-brown colouration to the mortar. This is generally very fine (sub-mm) but includes a low concentration of sub-round 2-6mm+ brown sandstone and mafic lithics.

Fuel kiln-relicts – This mortar was wood-fired and contains a high concentration of wood-charcoal inclusions to 10 x 10mm.

Kilvickeon Cabeal (NM41228). Close to the ruined church of Kilvickeon is a 5.5 x 7.7m 19th-century masonry burial enclosure whose 400mm thick walls survive to 46” high. It is significant that the mortar of this structure is tempered with a similar aggregate material used to temper the medieval mortar of the church (so suggesting the same local shore source) although the kiln-relict evidence is completely contrasting. This is a coal-fired limestone-lime mortar which contains a medium to high concentration of yellow and white round to subrounded lime inclusions to 20mm, very low concentrations of unheated shell and coal inclusions to 8mm.

2.0 IONA - SAMPLE CONTEXTS AND ANALYSIS

2.1 SAMPLE CONTEXTS

2.1.1 MORTAR SAMPLE CONTEXTS

With the permission of Historic Scotland, National Trust for Scotland and the local tenant farmer on Iona, and the owner of the estate at Kilvickeon, loose mortar samples (in close proximity to and matching those in various contexts described above) were collected from the ecclesiastical sites on Iona and at Kilvickeon (Mull) for further lab-based analysis. In line with the above on-site mortar survey, as the building complex with the clearest range of medieval mortars most of these samples were collected from the nunnery/priory site, but loose samples were also collected from Tigh an Easbuig, St Mary's chapel and the parish church at Kilvickeon, Ross of Mull.

All sample contexts were recorded in x, y and z coordinates by hand measurement from fixed building features, such as wall faces or jambs, and ground levels. These contexts are listed below, and those from the nunnery annotated onto the RCAHMS plan of the site.

SAMPLE CONTEXT

IPA.01 Nunnery; Church; Nave North wall; 9.25m east of internal face of west wall, 250mm back from external all face; loose on wallhead . Matches arcade blocking below.

IPA.02 Nunnery; Cloister West wall; loose on ground at external wall face; 2.75m north of internal face of south wall. Matches all in bed and coat of this cloister wall.

IPA.03 Nunnery; Chapter House; external face of east wall; 1.6m north of external face of south wall; 150mm back from wall face; at ground level. Loose core, matching all in wall core.

IPA.04 Nunnery; Refectory; West wall; loose on ground at external wall face; 2.05m north of external face of south wall; loose ex-situ coating (smooth on back); matching wall coating.

IPA.05 Nunnery; Church; West wall; Internal face; 2.75m north of internal face of south wall. int; 1.35 above ground; 100mm back from internal face; loose core; matching core of wall.

IPA.06 Nunnery; Church; East wall; loose on ground at internal wall face; 200mm south of internal face of north wall; matches fine plaster of internal wall face.

IPA.07 Nunnery; Refectory; East wall; loose on ground at external face and north corner; matches mortar in core, bed and coat of the higher courses of this wall.

IPA.08 Nunnery; Church; West wall; external face; 600mm South of external face of north wall; 1130mm above ground; 170mm+ back from external face; loose Core, matching in-situ core.

IPA.09 Bishop’s House; junction between mid-gable and south wall; 3330 S of door jamb; 260mm East of west face of mid-wall; 700 A.G. Loose core.

IPA.10 Nunnery; Cloister; West wall; internal face; loose on ground at internal wall face; 510mm North of internal face of south wall; loose coating, matches bed and coating of wall.

IPA.11 St. Mary’s Chapel; North wall; external face; loose in rubble collapse; see plan; matching all in core and bedding of north wall.

IPA.12 Nunnery; Refectory; South wall; internal face; 5.1m East of internal face of west wall; 1.15m above ground; 40-80mm back from face; dissolute mortar remains.

2.1.2 <u>ANNOTATED PLANS OF SAMPLE CONTEXTS</u>

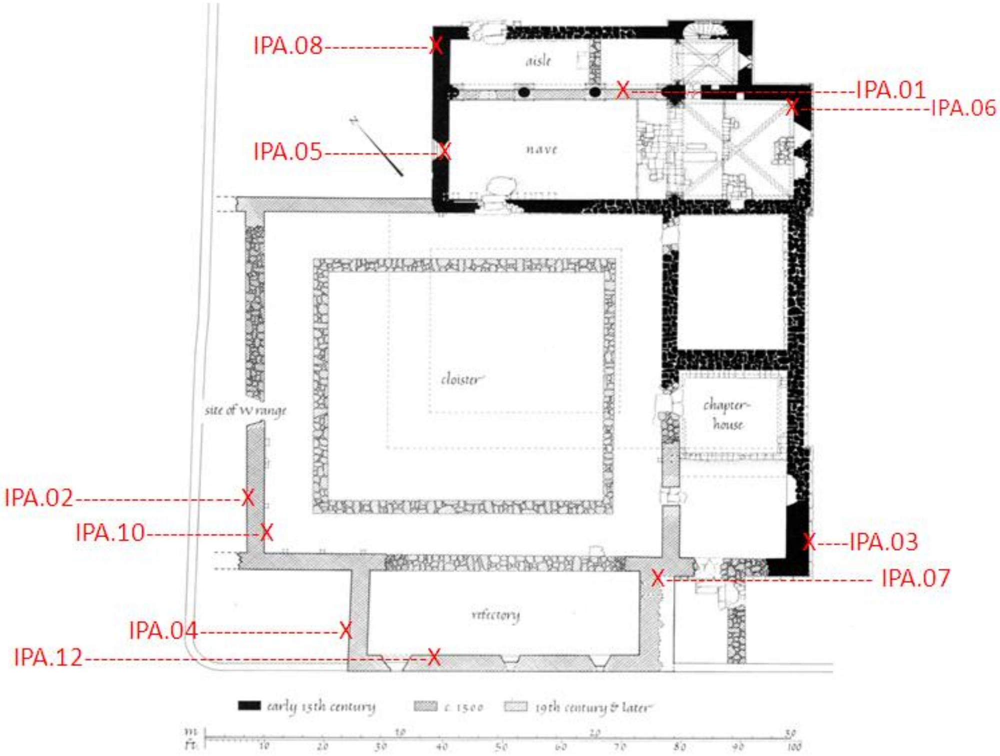

Figure 1a (above) - Annotated (RCAHMS 1970) plan of sample contexts from Iona Nunnery/Priory. (original plan image SC 715328 ©crown copyright: Historic Environment Scotland. Licensor Canmore.org.uk).

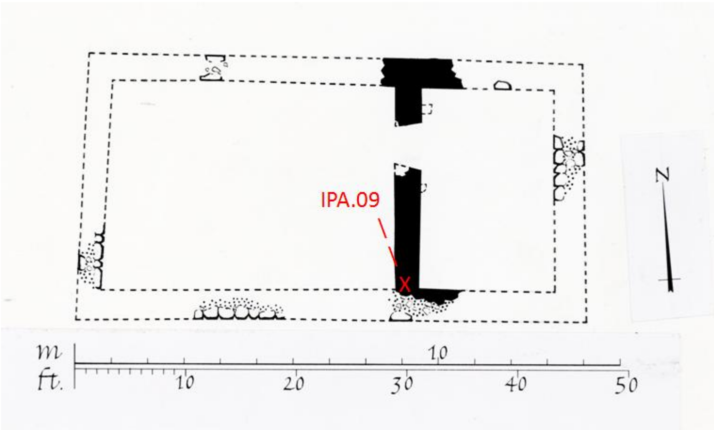

Figure 1b (above) - Annotated (RCAHMS 1970) plan of *Tigh an Easbuig,* Iona, showing mortar sample context (original plan image DP 236385 ©crown copyright: Historic Environment Scotland. Licensor Canmore.org.uk).

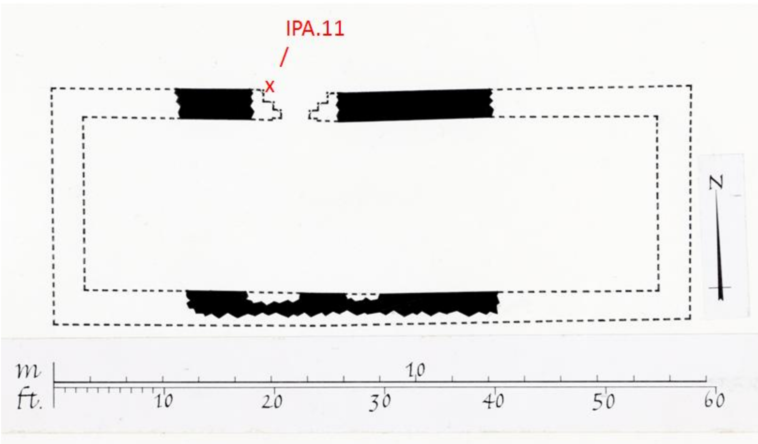

Figure 1c (above) - Annotated (RCAHMS 1970) plan of St Mary's chapel, Iona. showing loose mortar sample context (original plan image DP 236386 ©crown copyright: Historic Environment Scotland. Licensor Canmore.org.uk).

2.2 SAMPLE ANALYSIS

The twelve loose mortar samples were subject to lab-based analysis including thick-section and thin-section microscopy, and XRD.

2.2.1 THIN-SECTION PETROGRAPHY

IPA.01

General Description – Very fine, light-buff lime mortar.

Carbonate kiln-relicts – IPA.01 is probably a limestone-lime. The carbonate source is evident in low-medium concentration of high birefringence subangular clasts to 3mm with excellent core/rim textures and loss of grain boundaries. More altered relicts display and release very dark brown, crystalline subangular micro-clasts which are distinct from the general lighter-brown matrix. Lismore?

Added-Temper – IPA.01 was tempered by a well-sorted mixture of fine shell and lithic clasts generally grading to between 0.5 and 1.0mm. This mixture is dominated by a shell fraction which displays a large range of taxa including gastropda, bivalves and coralline algae. The lithic fraction is dominated by rounded to subrounded quartz-rich gneiss to 2.5mm, and some more angular monomineralic quartz, but also includes rounded dolerite?, chlorite and biotite schists and an unusually large rounded grain of sandstone to 6mm is also evident.

Fuel kiln-relicts – No fuel evidence was noted in IPA.01

Vitreous kiln-relicts - One probable carbonate source grain is displaying very early vitrification textures was noted in IPA.01.

IPA.02

Carbonate kiln-relicts – IPA.02 is a shell-lime with a medium concentration of large altered shell relicts including *C. edule*, to 12.5mm.

Added-Temper – IPA.02 is tempered by a generally well-sorted fine mixture of shell and lithic grains grading up to 1.5mm. This mixture is dominated by a lithic fraction largely comprised of rounded quartz-rich gneiss grains, but includes subangular quartz and a low concentration of basalt. The shell fraction includes a large range of bivalve and gastropod taxa. The quartz fraction is high relief, whilst others show melt evidence. Some possible feldspar.

Fuel kiln-relicts – No fuel evidence was noted in IPA.02

Vitreous kiln-relicts – some small rounded opaque grains with well-formed acicular crystals may be reaction products.

IPA.03

Carbonate kiln-relicts – IPA.03 is a shell-lime with a medium concentration of very fine and highly altered shell relicts to 1.75mm. These include very fine *bivalvia* fragments and a low concentration of coralline algae.

Added temper – IPA.03 is tempered by a generally well-sorted mixture of shell and rounded lithic grains grading up to 1.5mm, but including some to 3mm and a single large thin fissile schistose inclusion to 20mm. The temper mixture is predominantly lithic and dominated by rounded schistose quartz-rich gneiss clasts to 1.5mm, rounded basalt to 1.0mm and monomineralic grains of quartz and feldspar, but including rounded sandstone to 3.5mm. The shell fraction of this added-temper displays taxonomically diverse fragments which are also generally well-rounded.

Fuel kiln-relicts – No fuel evidence was noted in IPA.03.

Vitreous kiln-relicts – Some of the basaltic clasts display an indistinct grain boundary and, internal microcrysts of a cubic opaque mineral which is likely to be magnetite. One grain in particular displays a fracture filled with magnetite and these textures suggest the clast has been heated.

IPA.04

Carbonate kiln-relicts – IPA.04 is a probable mearl-lime with a very high concentration of coralline algae inclusions to 3.5mm. These are displayed in random orientations although concentric cross-sections are particularly evident, combining relict concentric growth rings with a well-calcined texture and loss of grain boundaries. One probable thalli is undergoing vitrification and displays well-developed crystallinities including spinaflex textures. One monominerallic quartz grain also appears highly fractured and may have been heated.

Temper – IPA.04 has been tempered with a well sorted mixture of shell and lithic grains dominated by an unheated shell fraction of diverse taxonomies and with very well preserved internal microstructure. These unheated and uncalcined textures contrast markedly with the coralline inclusions. The lithic fraction of the temper contains rounded gneiss grains to 1.25mm in low concentration.

Fuel kiln-relicts – No fuel evidence was noted in this IPA.04 thin section.

Vitreous kiln-relicts – See coralline and quartz evidence as above.

IPA.05

Carbonate kiln-relicts – IPA.05 is a shell-lime with a high concentration of Type 3-4 altered shell relict fragments to 3mm.

Temper – IPA.05 was tempered with a well-sorted mixture of shell and lithic clasts generally to 1.5mm and occasionally to 2.5mm. This is dominated by a shell fraction which displays well preserved internal microstructure and distinct grain boundaries, although the apparent of spectrum of textures to heated and well calcined makes confident characterisation as added temper problematic. The lithic fraction is dominated by well-rounded grains of gneiss to 1.5mm, but includes rare rounded basalt and sandstone to 1.5mm also.

Fuel kiln-relicts – No fuel evidence was noted in this IPA.05 thin section.

Vitreous kiln-relicts – Some quartz and quartzofeldspathic materials are very fractured, and one degraded, rounded probably former basalt/dolerite grain had developed opaque magnetite, suggesting low level reaction textures are apparent.

IPA.06

Carbonate kiln-relicts – IPA.06 is a shell-lime with a medium concentration (although high for a finished internal coating) of highly altered shell relicts to 2.5mm. These shell grains often retain relict curving outlines, but display complete loss of internal microstructure and are very distinct from the unaltered shell of the temper fraction. Some are merely well rounded elongate lime contexts.

Temper – IPA.06 was tempered with a very fine, well-sorted mixture of shell and lithic materials, generally to 0.25mm. This mixture is almost completely dominated by a shell fraction of diverse taxonomies but including a preponderance of elongate, curving, very fine bivalvia. The small lithic fraction is dominated by subrounded monominerallic grains of quartz, but includes minor concentrations of rounded gneiss to 1.0mm. There is no salient evidence for heated textures in the lithic temper component.

Fuel kiln-relicts – No fuel evidence was noted in this IPA.06 thin section.

Vitreous kiln-relicts – One possible very long narrow fragment of early development reaction-product, to 3.0mm, is present.

IPA.07

Carbonate kiln-relicts – IPA.07 is a probable mearl-lime with an extremely high concentration of altered coralline algae relicts to 4mm. Many appear only lightly altered as they retain relict concentric growth rings in x-section and a distinct grain boundary. Where more altered, however, these inclusions have lost all growth ring evidence and, internally, display a generally homogenous carbonate texture which includes very small, distinctly rounded/spherical carbonate globules. Externally, loss of grain boundary coherence becomes evident as these inclusions approach contiguous optical continuity with the mortar matrix. There is some evidence for Type 2-3 heated shell here, including part-calcined and discoloured evidence to 6mm, and so a fraction of the mortar binder is of shell-lime provenance.

Added-Temper – IPA.07 is tempered with a low concentration of unheated shell clasts to 15mm. There is also an extremely low concentration of lithic evidence including rounded gneiss clasts to 2.5mm but these are very rare.

Fuel kiln-relicts – No relict fuel evidence was noted in IPA.07.

Vitreous kiln-relicts – No vitreous materials were noted in thin section IPA.07.

IPA.08

Carbonate kiln-relicts – IPA.08 is a shell-lime with a low concentration of altered shell relicts to 1.5mm. A very low fraction of altered maerl evidence is also evident

Added-Temper – This mortar is tempered by a well-sorted mixture of lithic and shell clasts to 2.75mm. This temper mix is dominated by a lithic fraction comprised predominantly of rounded quartz-rich gneiss grains, with minor quantities of basalt and sandstone. The shell fraction is very fine and apparently unheated.

Fuel kiln-relicts – No fuel kiln-relicts were noted.

Vitreous kiln-relicts – No vitreous kiln-relicts were noted in this IPA.08 thin section.

IPA.09

Carbonate kiln-relicts – IPA.09 is a probable mearl-lime with a very high concentration of altered coralline algae relicts to 5 x 2.5mm. These clasts often display colour changes from red-black core, where the cells are filled with an opaque material and much of the cell wall material is red/orange. The cell walls subsequently appear to break down and recrystallise to a clear microsparry calcite, with some white cryptocrystalline wash, whilst the cell fill survives as a darker, grey cryptocrystalline 'globule', The cellular arrangement of the fill becomes more irregular as alteration increases, but sometimes fill globules do appear to survive to enter the mortar matrix as the coherence of the cell walls is completely lost and optical continuity between algal relict and 'binder' matrix is reached, although elsewhere they are absent at the outer, optically continuous, relict rim. These changes in concentric textures appear to be contiguous with changes in iron concentrations as the colour changes from black to red to white bands.

Elsewhere, these globules of cell-fill may alternate with concentric bands of cellular material with no contrast between cell wall and fill.

Added-Temper - IPA.09 was tempered with a mixture of shell and lithic clasts generally to 4mm, exceptionally to 10mm. This mix is dominated by shell material, and is mostly gastropod. The lithic fraction is in very low concentration but includes rounded gneiss, quartz and sandstone to 2.0mm.

Fuel kiln-relicts – Very low concentrations of probable peat relicts to 2.0mm were noted.

Vitreous Materials – No vitreous materials were noted in this thin section of IPA.09.

IPA.10

Carbonate kiln-relicts – IPA.10 is a shell-lime which displays a high concentration of large altered shell relicts to 10mm. The largest of these are probably *C. edule* (cockle) although most have lost almost all internal fibrous microstructure and recrystallised to display a somewhat microsparitic to sparitic texture and only very faint relict internal cross-laminar structures, and external grain boundary, remain. Elsewhere large fractured *C. edule* (cockle) shell fragments to 4mm and finer highly altered rounded relicts to 1.0mm pertain.

Added-Temper – IPA.10 was tempered with a well-sorted mixture of lithic and shell clasts, generally to 1.75mm but occasionally to 3.5mm. This mixture is approximately 50:50 shell: lithic ratio, and the lithic fraction is predominantly comprised of rounded gneiss clasts to 3.5mm, but includes finer clasts of quartzite and sandstone.

Fuel kiln-relicts – One possible peat/turf relict to 1.0mm was noted.

Vitreous kiln-relicts – Some rounded isotropic glass melts with well-developed acicular crystal inclusions were noted but these may be ‘natural’ geogenic.

IPA.11

Carbonate kiln-relicts – IPA.11 is a shell-lime with a low concentration of large altered shell relicts to 4.5mm. One large example has lost all coherence save very fine crystalline fragments which match a larger coherent curving layered relict clast.

Added-Temper – IPA.11 was tempered with a well-sorted mixture of lithic and shell clasts to 3.5mm. This mixture is dominated by the lithic fraction which is itself predominantly composed of rounded quartz-rich gneiss to 3.5mm. Rounded basalt and dolerite to 3mm and a very low concentration of rounded sandstone also to 3mm were also noted. The unheated shell fraction is much lower and includes a range of taxa to 2.0mm and is generally rounded. The binder is very clean and apparently without lithic grain alteration or a significant concentration of altered carbonate kiln-relicts.

Fuel kiln-relicts – No fuel evidence was noted in this thin section of IPA.11.

Vitreous kiln-relicts – None noted.

3.0 IONA - CONCLUDING DISCUSSION

The above survey and analysis of the masonry buildings of Iona and Ross indicates a clear typological, chronological and stratigraphical progression in the mortar evidence.

The earliest substantially upstanding buildings on these sites are generally attributed to the 12th and 13th centuries and include St Oran's chapel, St Mary's chapel, St Ronan's church, Kilvickeon church and the Nunnery church and chapter house, and these buildings were all constructed with shell-lime mortars. The relict evidence suggests oyster shells were heated in a wood-fired kiln, and the resultant lime was tempered with rounded lithic beach aggregates. The mortars within these buildings are generally very consistent, although it should be noted that the primary mortar of the nunnery church and chapter house is generally more refined than that associated with the other structures, and this may be paralleled by their greater formality. All of these mortars are quite similar, however, and so although from different buildings, built with a similar broad timeframe. These may now more generally be grouped as 'Mortar 1' type for the purposes of further discussion.

There are a number of mortars stratigraphically overlaying Mortar 1 materials in various contexts, although the earliest might be the mortar associated with the west cloister wall which abuts a Mortar 1 coating on the west wall of the nunnery church. This is also a shell-lime which may have been wood-fired, although the material contrasts with Mortar 1 in being dominated by evidence for heated *C. edule* (cockle) and some *P. vulgata* (limpet) rather than *O. edulis* (oyster) shell fragments. Although the contrasts in building stone geology and emplacement technique between this cloister wall and the church and chapter house buildings may be ascribed to their different structural contexts, the contrast in mortar materials is more fundamental and suggests the later stratigraphy may represent a more significant multiperiodicity than has previously been recognised. This notwithstanding, however, given that the mortar-making technology is generally similar to Mortar 1, this cloister wall material will be labeled Mortar 1a.

Mortar 1 is also overlaid by lime mortars which display evidence for very different materials, and the earliest of these is the mearl-rich mortars of the nunnery church nave arcade blocking and corbels and the south-east window of the chapter house. Unfortunately there is no very clear stratigraphic relationship between these contexts and Mortar 1a (see below), but this mortar is also found in primary contexts associated with the construction of the nunnery refectory and bishop's house, each of which is generally accepted to be a much later structure. Although the materials characterisation as a mearl-lime is predicated on lab-based analysis, this mortar is very distinct and represents a clear technical departure from the shell-limes of the earlier Mortar 1 and 1a periods, and so will be labeled Mortar 2 for further discussion. The use of Mortar 2 in multiple phases of the refectory may suggest the technique had some longevity, but some similarity in masonry style between the refectory and bishop's house (see figures) suggests the general contemporaneity of these structures and a significant late medieval (15th-century) programme of construction.

How far we might suggest an early post-medieval lacuna should probably apply to the evidence requires further work, particularly in the Abbey complex. It is clear, however, that all later modern mortars surveyed at the site, overlaying Mortar 2 in the refectory window blocking, overlaying Mortar 1a in the repaired cloister walls and St Oran's chapel, and overlaying Mortar 1 in the nunnery church, as well as in the surrounding 19th-century domestic houses, barns and burial enclosures, are a different material again. These are late modern limestone-lime mortars and will be referred to as Mortar 3 in continuing discussion.

In terms of typology this mortar evidence generally supports previous ascriptions as to the relative chronologies of these buildings, although certain problems and possible further potential should be discussed.

Regarding the earliest buildings, it might now be expected that the primary fabric of Columba's shrine is likely to be associated with an oyster-shell lime (as indeed is displayed internally in secondary coating contexts), but that is yet to be demonstrated and the only upper terminus is provided by a probable 19th-century Mortar 3 (upon and within the south and east walls). Moreover, the above survey and analysis of St Ronan's, clearly contrasts with previous interpretations of the upstanding building and by extension may have serious implications for our understanding of the underlying building excavated by O' Sullivan (1994). For the St Ronan building a Mull limestone provenance had previously been suggested without explicit understanding of the wider mortar archaeology of the site, although Dixon's excellent description actually sounds like a shell-lime, but is tempered differently to Mortar 1. Whilst a limestone provenance should not of course be ruled out, a better understanding of this material would be desirable and could be very significant. As buildings which have no extensive upstanding fabric and for which no secure mortar was identified these structures are now labeled Phase 0.

The survey and analysis of the structures associated with Mortar 1 generally supports their previous ascription as the earliest upstanding buildings on the site. This includes the upstanding buildings of St Oran's chapel, St Mary's chapel, St Ronan's church, Kilvickeon church and the nunnery church and chapter house. These are now labeled Phase 1 structures.

Maerl-lime Mortar 2 appears to be a late medieval flowering of this material in western Scotland, and may be seen elsewhere in Moidart and Wester Ross, during this same period (see chapter 3 of main thesis text). It is not always clear as to why the RCAHMS ascribe given dates to buildings and features, but it is remarkable that most of the isolated structures mutually associated here by their construction with Mortar 2 are ascribed by them to the same late 15th-century date. This applies to the Nunnery refectory, Nunnery church arcade blocking and corbels and the intramural tomb of St Oran's chapel. This may also then suggest that the Bishop's House is also more likely to be late 15th-century than the brief 17th-century restoration of the abbey church as the Cathedral of the Isles (see RCAHMS 1982 p.252) and this suggestion is supported by similarities with the masonry style of the refectory (see figures; *contra* Caldwell and Ruckley 2005, 112). That this vigorous late 15th-century Phase 2 period of building across the site may be associated with the intramural tomb in St Oran's and to the commendation of the site to the Sodor bishops is interesting and the mortar material itself may also relate to the production of lime in payment of rent by most of the tenants of neighbouring Ross at the reformation (Iona Club 1847; see chapters 3 and 5 of main thesis text).

The RCAHMS suggestion that the cloister walls are also of this Phase 2 period might be supported by the clear bonding between the refectory and west cloister wall in the lower masonry, but this interpretation is not supported by the survey and analysis of the west cloister mortars which are clearly shell-limes. As the west cloister clearly abuts the nunnery church, however, and is also distinct from this Phase 1 structure in terms of building stone geology, masonry style and some mortar characteristics, it is here ascribed to an intermediate phase 1a, physically and chronologically between the church and refectory.

This draws attention back to the complex relationship between the between the refectory and cloister wall, and bonding of their lowest (generally granite-free) courses which would appear to support an interpretation made elsewhere (predicated on the contrasting building stone lithogies of both the general walling and dressed sandstone lithogies) that the refectory was multiphase. This requires further examination, with staging and the removal of the garden shed blocking examination of the west refectory/cloister wall relationship.

The last significant Phase 3 use of coal-fired limestone-lime mortars in various parts of the site and island demonstrates the sites post-medieval emergence of the site as an historic monument rather than living monastery, and may also evidence the wider regional dominance of lime manufactured on a proto-industrial and industrial scale on the island of Lismore.

The identification of medieval biogenic lime mortars in the upstanding buildings of the site might support Reece's interpretation that the features excavated in an industrial zone to the north of the site were shell-lime kilns. Moreover, as (so far) two clearly contrasting biogenic mortars can be related to two distinct phases of work might allow that kiln evidence more potential in relationship to the buildings. Given that charcoal had also survived within the excavated kiln a re-excavation and dating program might now have excellent potential.

4.0 IONA – FIGURES

Figure 2 (above) Map detailing the extent of the South-west Region (SWR) of the thesis survey and locations of SWR case study sites. Scale bar 50km.

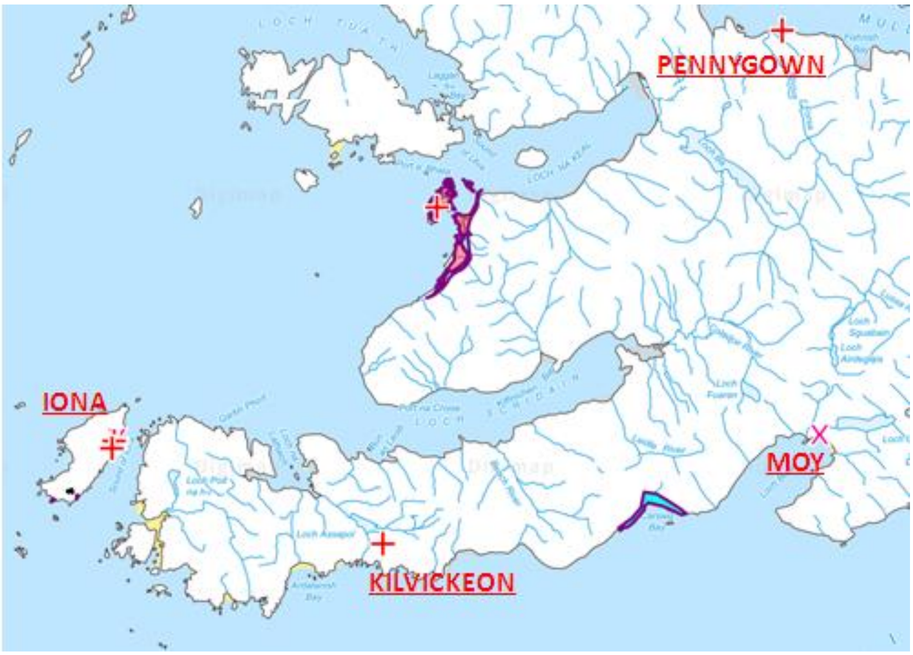

Figure 3 (above) – Map plotting closest calcareous and clastic sedimentary outcrops to Iona at Carsaig and InchKenneth, with minor beds of marble also evident in south Iona itself.

+ - medieval church site; x – medieval castle site (© crown copyright and Landmark Information Group Limited 2016. All rights reserved. Geological map data © NERC 2016.).

Figure 3 (above) - Detail of Blaeu Atlas of Scotland, 1654. Depicting a treeless landscape on Iona, Brolos and Ross of Mull. By kind permission of National Library of Scotland.

4.1 ON-SITE SURVEY

Figure 4 (above) – Columba's shrine. Note reconstructed masonry above primary low courses. Scale 500mm; photograph Mark Thacker.

Figure 5 (above) - Probable Mortar 3 remains on face of south wall of Columba's shrine. This structure clearly requires more work. Scale 10mm; photograph Mark Thacker.

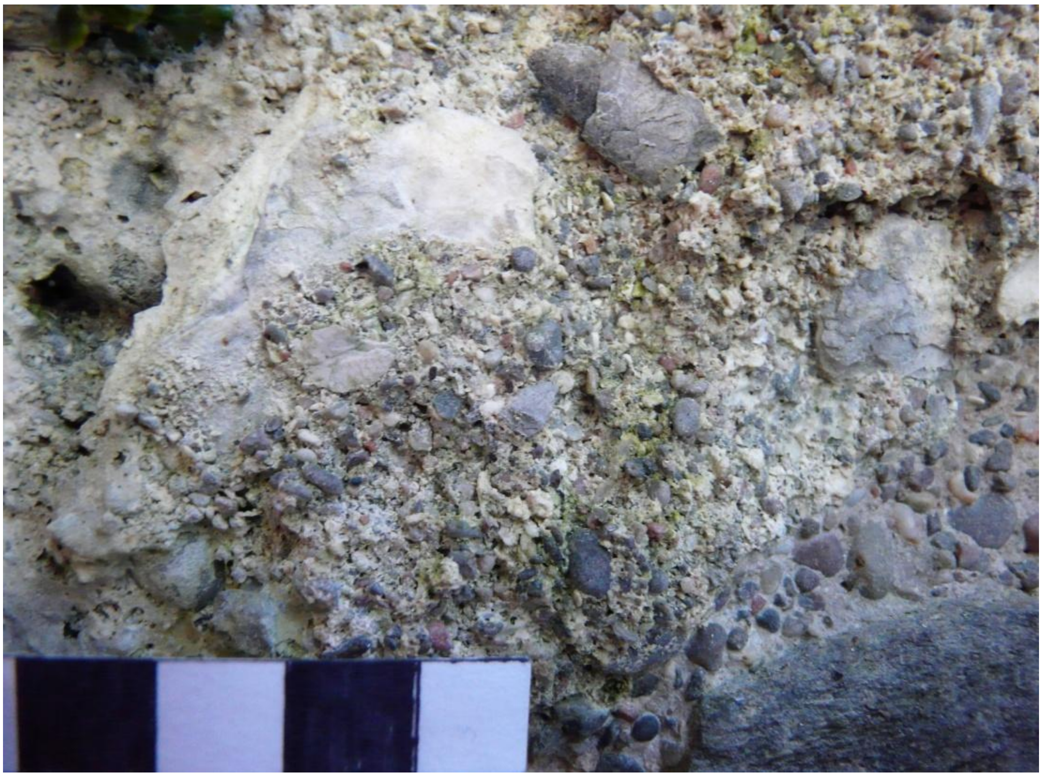

Figure 6 (above) – St Ronan's shell-lime mortar internal coating and bedding context. Scale 10mm; photograph Mark Thacker.

Figure 7 (above) – St Orans chapel from the south-west. Scale 500mm; photograph Mark Thacker

Figure 8 (above) – Masonry style of St Oran's chapel, Iona. Scale 500mm; photograph M. Thacker.

Figure 9 (above) – Bed/coating mortar remains surviving on north wall of St Oran's chapel, Iona. Scale 10mm; photograph Mark Thacker.

Figure 10 (above) – Nunnery Church; external face of west wall. Scale 500mm; photograph Mark Thacker.

Figure 11 (above) – St Mary's chapel Iona from the north. The upstanding ruin is mostly comprised of the remains of the north and south walls. Note formal coursing and remain of bright internal mortar coating. Scale 500mm; photograph Mark Thacker.

Figure 12 (above) – St Mary's chapel; Mortar 1. Note heated Type 3 oyster shell relicts. Scale 10mm; photograph Mark Thacker.

Figure 13 (above) – External face of north-west cloister wall. Note abutment to church on left and consolidation on right. Scale 500mm; photograph Mark Thacker.

Figure 14 (above) – External face of nunnery west cloister wall; Mortar 1a. Note Type 3-4 heated *C. Edule* shell relicts. Scale 10mm; photograph Mark Thacker.

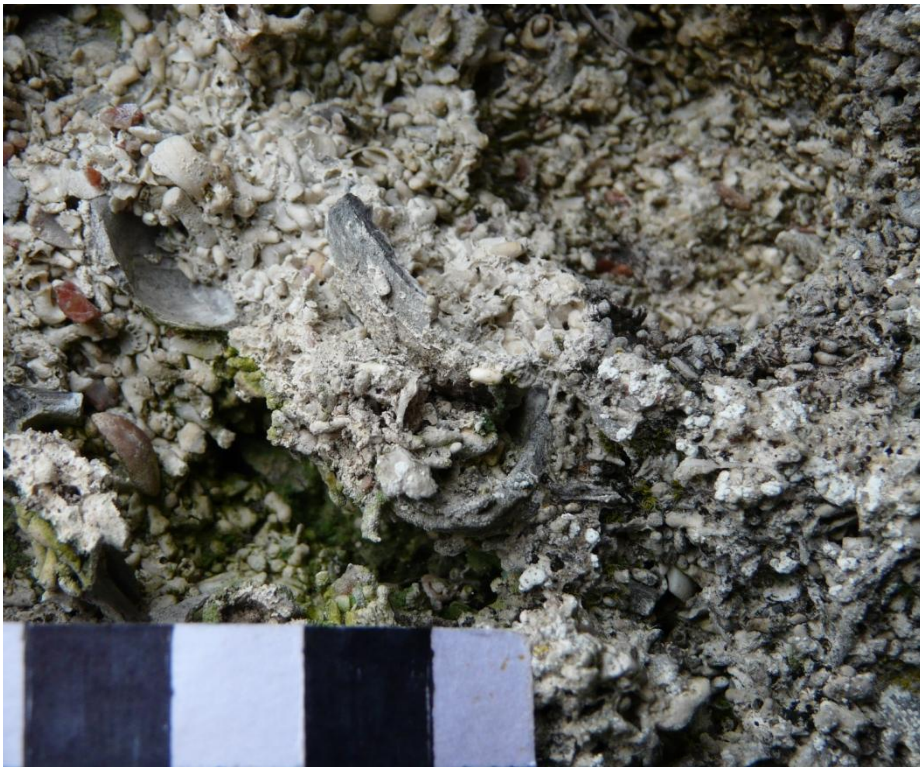

Figure 15 (above) – Refectory core mortar; Mortar 2. Note high concentration of coralline algae and discoloured shell fragments. Scale 10mm; photograph Mark Thacker.

Figure 16 (above) - Internal face of Refectory west wall. Scale 500mm; photograph Mark Thacker.

Figure 17 (above) – The Bishop’s House, Iona, from the west. The ruin is mostly comprised of the remains of the cross-wall and some of the external south wall. Scale 500mm; photograph Mark Thacker.

Figure 18 (above) – Bishop’s House, Iona; Mortar 2. Scale 10mm; photograph Mark Thacker.

Figure 19 (above) – Masonry Styles; The bishop's House on the left and Nunnery Refectory on the right. No Scale; photographs Mark Thacker.

4.2 LAB-BASED MORTAR ANALYSIS

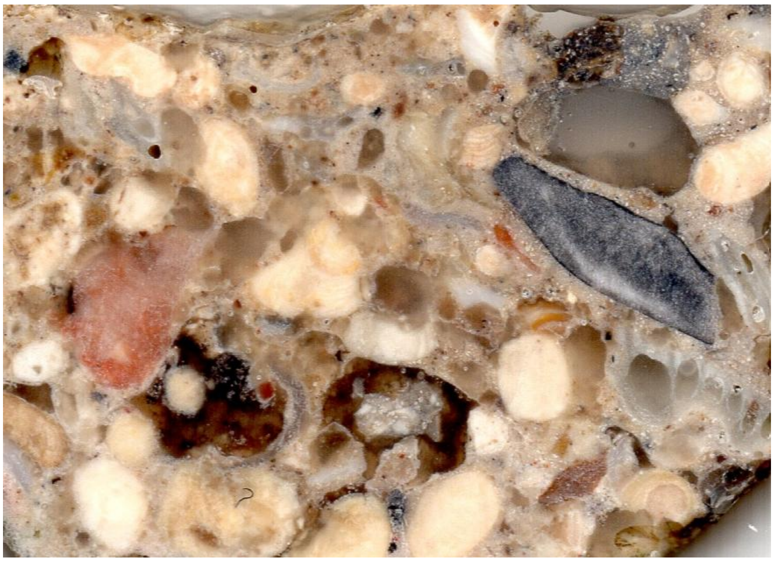

Figure 20 (above) – Thick section IPA.04. Width of view 15mm.

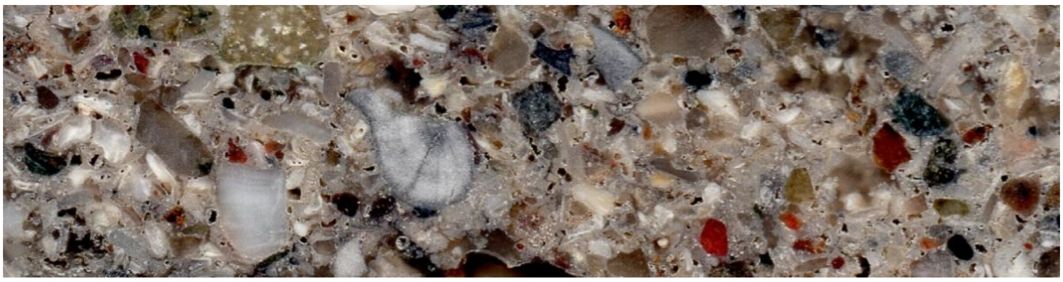

Figure 21 (above) – Thick section IPA.05. Width of view 24mm.

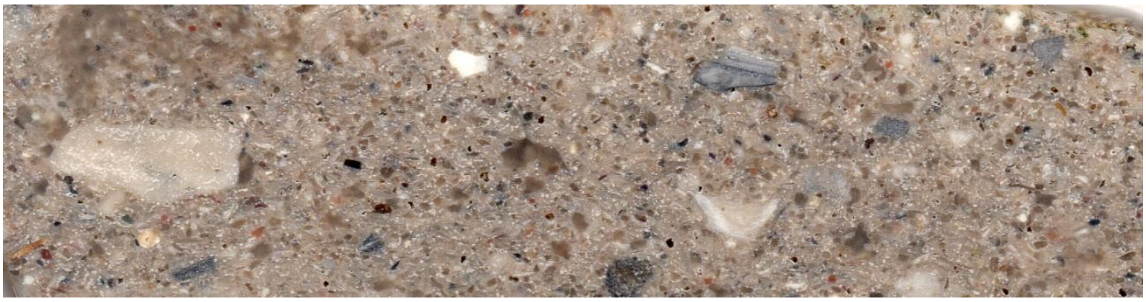

Figure 22 (above) – IPA.06. Width of view 30mm.

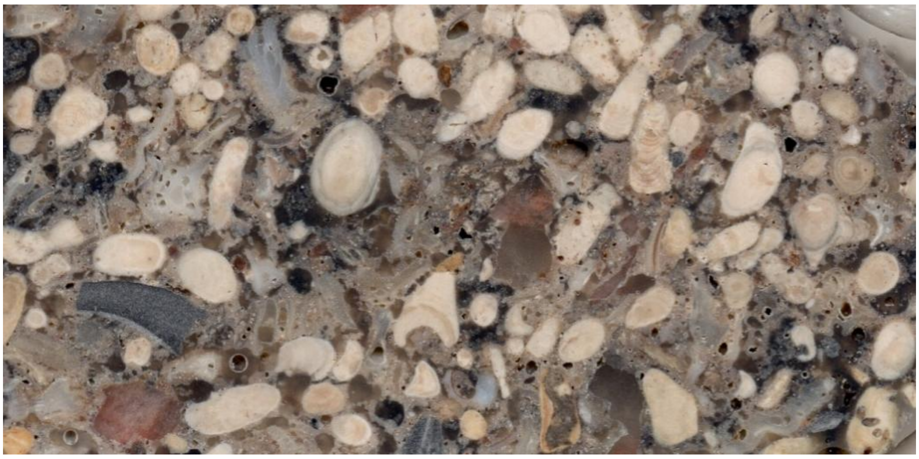

Figure 23 (above) – Thick section IPA.07. Width of view 30mm.

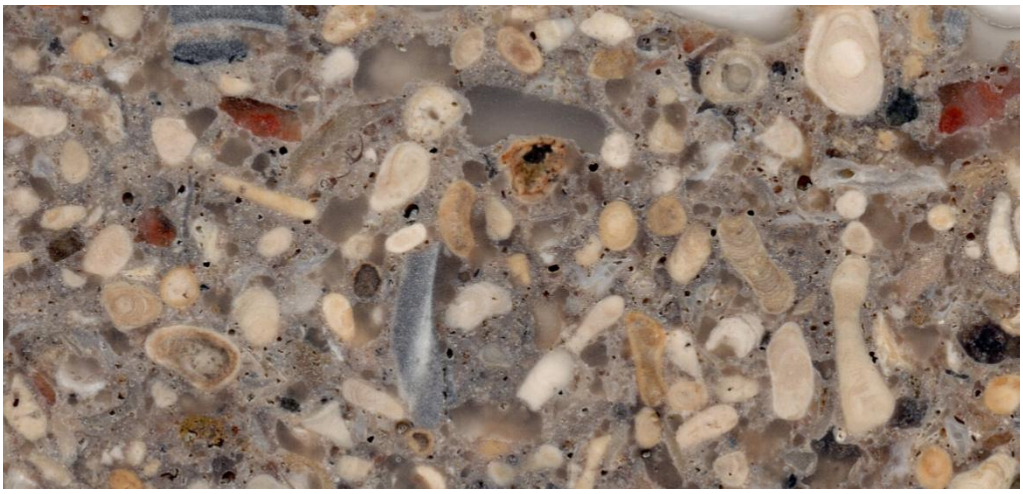

Figure 24 (above) - Thick section IPA.09. Width of view 36mm.

Figure 25 (above) – Thick section IPA.10. Width of view 32mm.

PHOTOMICROGRAPHS

Figure 26 (above) – Thin-section of IPA.01 - General Shot of fine shell-rich temper, shell showing well preserved textures. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

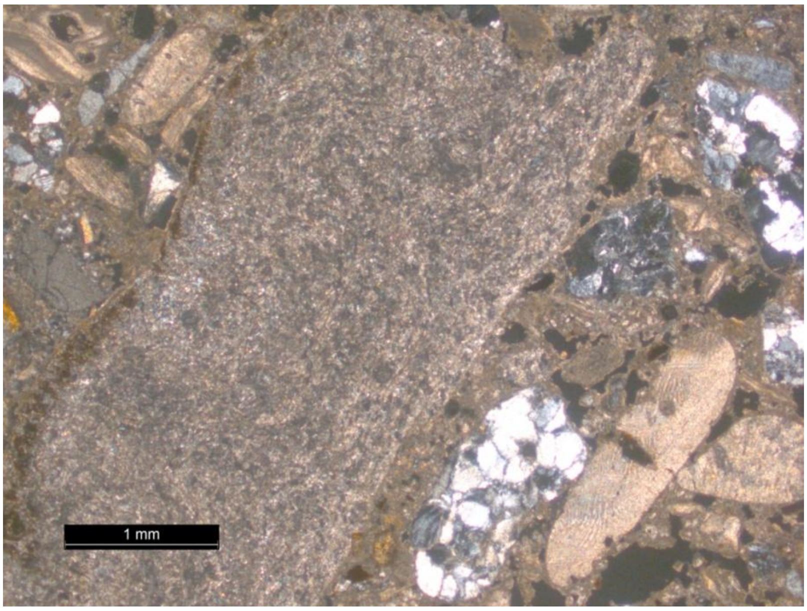

Figure 27 (above) – Thin-section of IPA.02 - General shot including cockle shell cross section with fine hi brief crystalinities and ribbing, rounded gneiss and unheated shell temper. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

Figure 28 (above) – Thin-section of IPA.03- General shot including well calcined shell in optical continuity with carbonate matrix. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

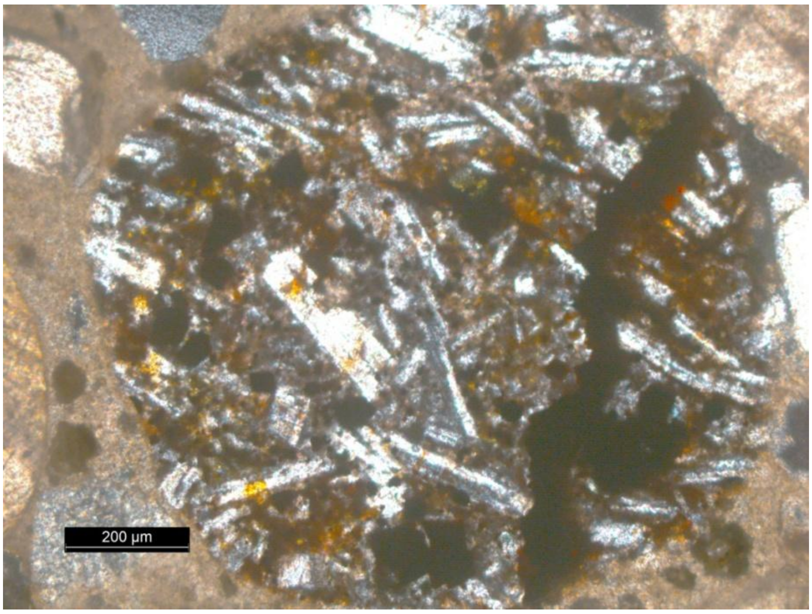

Figure 29 (above) – Thin-section of IPA.03; Fractured and altered rounded clast. XPL; Scale 200µm; Photomicrograph Mark Thacker.

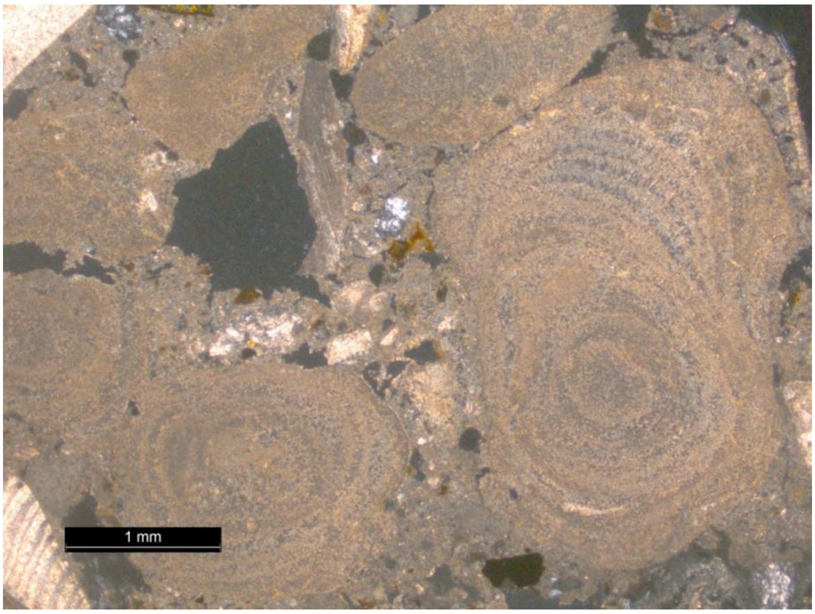

Figure 30 (above) – Thin-section of IPA.04; Heated algae? XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

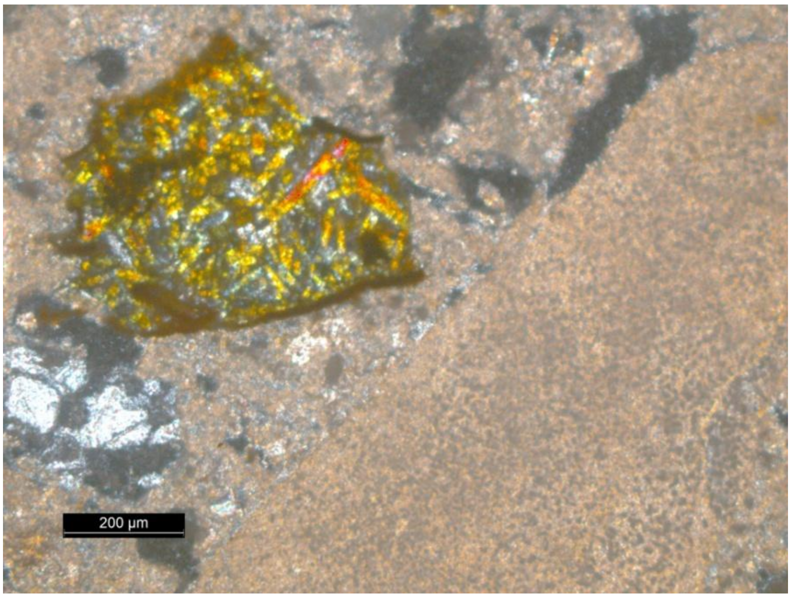

Figure 31 (above) – Thin-section of IPA.04; well-developed fragment of Vitreous reaction product; micrograph also shows altered coralline clast with relict ‘grain’. XPL; Scale 200µm; Photomicrograph Mark Thacker.

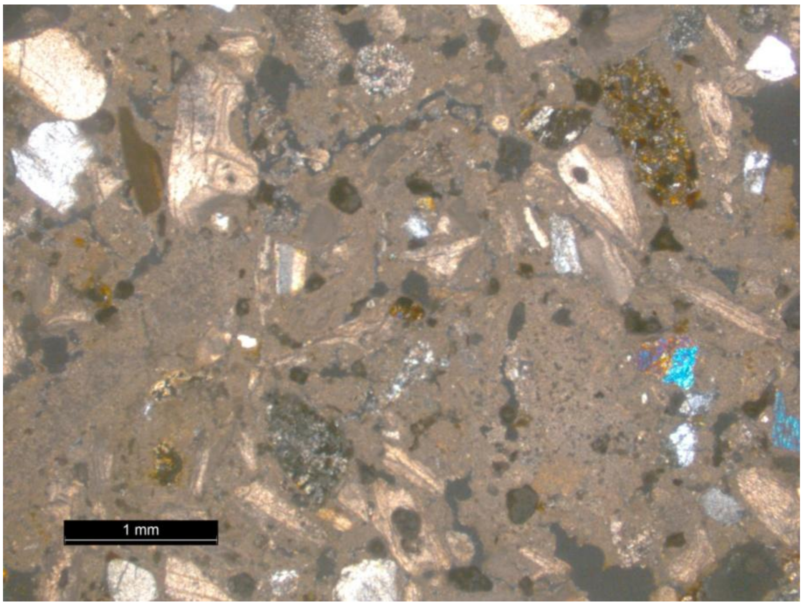

Figure 32 (above) – Thin-section of IPA.05. General shot showing mix of very well heated shell, unheated shell, and altered detrital mafic grains. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

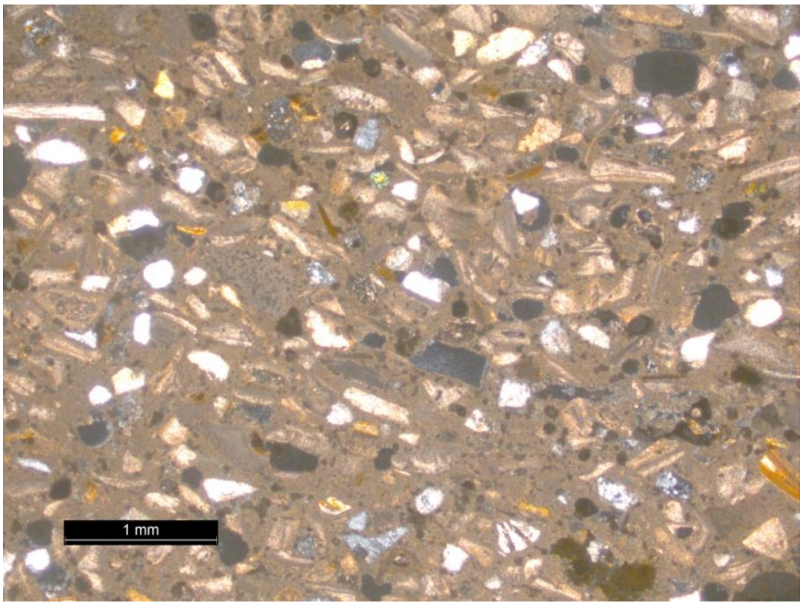

Figure 33 (above) – Thin-section of IPA.06 - General shot of fine shell-temper and heated shell clasts. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

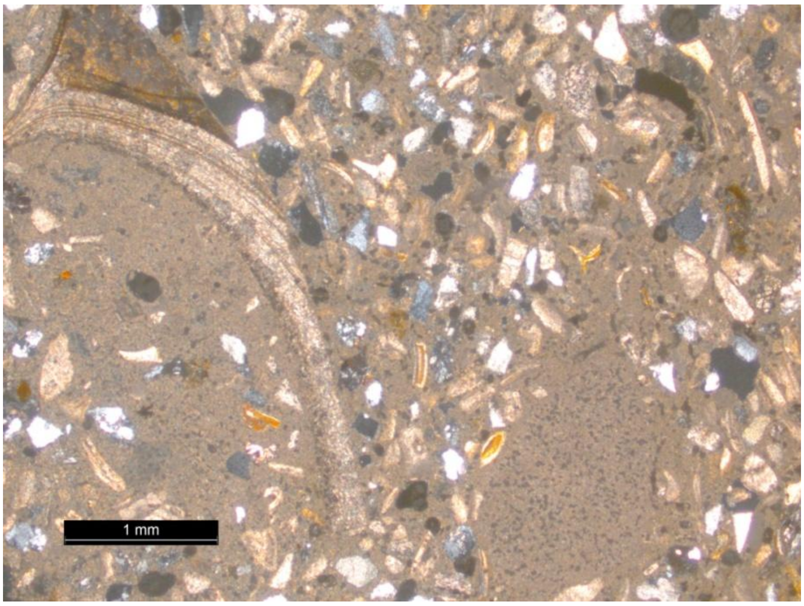

Figure 34 (above) – Thin-section of IPA.06; altered shell. XPL; Scale 1.0mm; photomicrograph Mark Thacker.

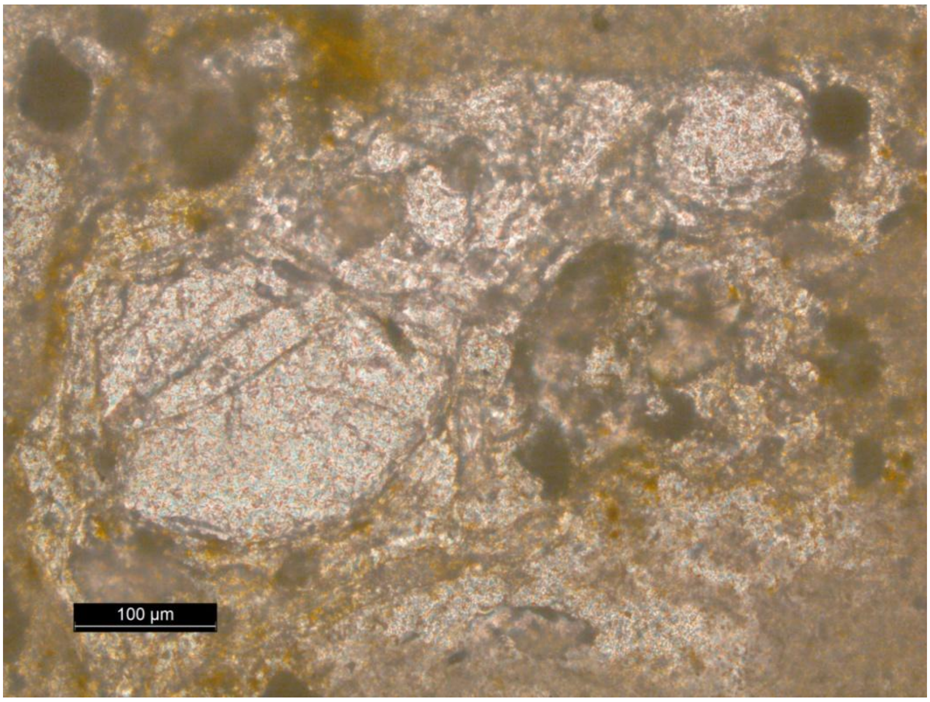

Figure 35 (above) – Thin-section of IPA.06 - Altered gneiss grain displaying fractured quartz and large isotropic intergrain melts. PPL; Scale 100µm; photomicrograph Mark Thacker.

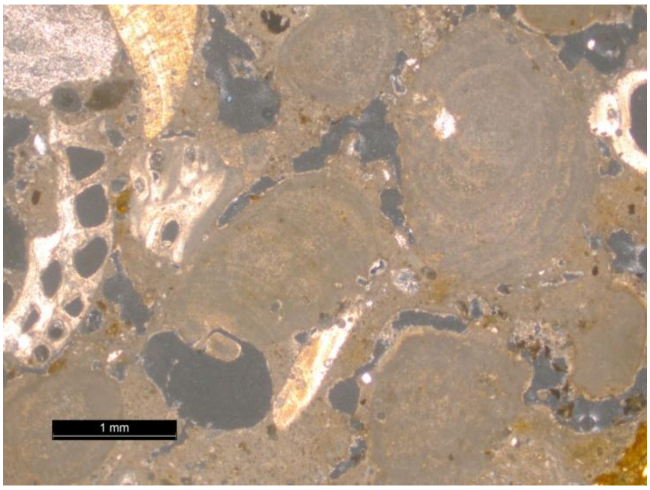

Figure 36 (above) – Thin-section of IPA.07; altered coralline clasts and unheated shell. Very porous/degraded. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

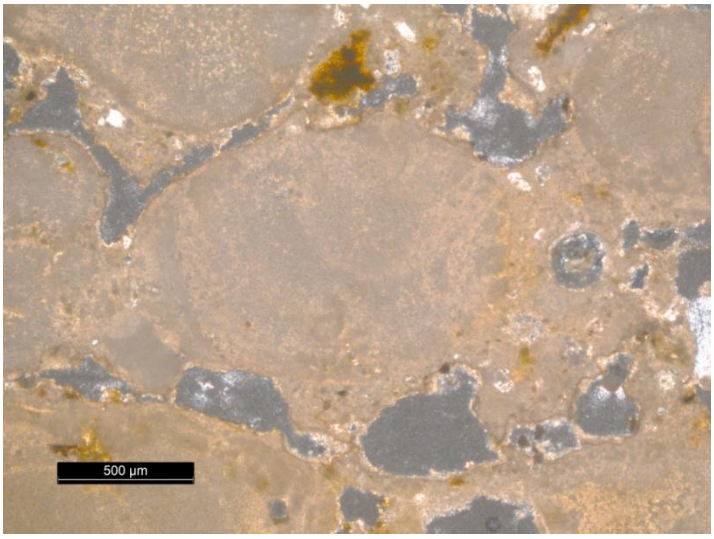

Figure 37 (above) – Thin-section of IPA.07; Altered coralline clasts. XPL; Scale 500µm; Photomicrograph Mark Thacker.

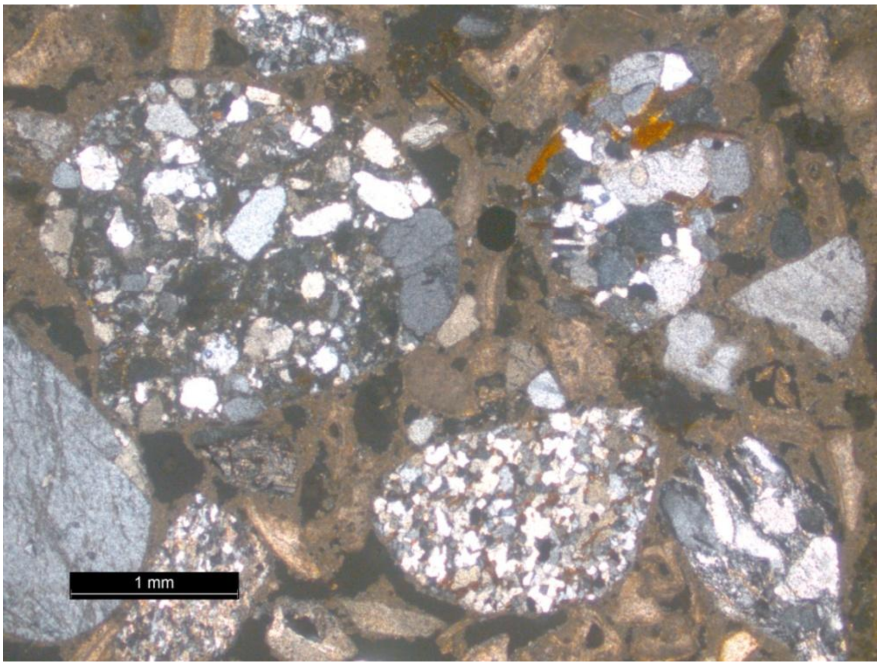

Figure 38 (above) – Thin-section of IPA.08; General shot showing rounded gneiss temper and fine shell. Possible altered mica in one gneiss grain. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

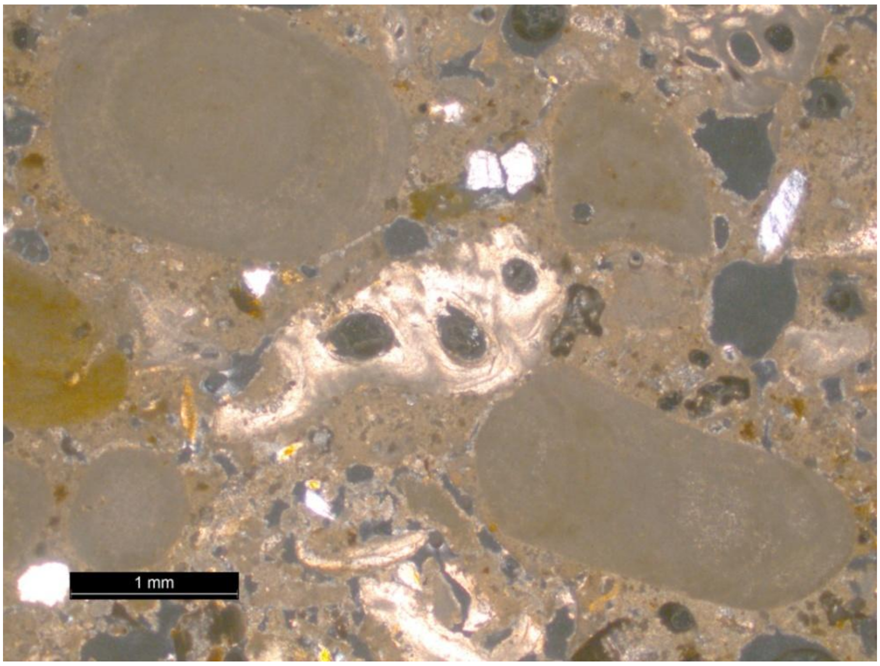

Figure 39 (above) – Thin-section of IPA.09; General shot altered algae and unheated shell temper. High binder volume. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

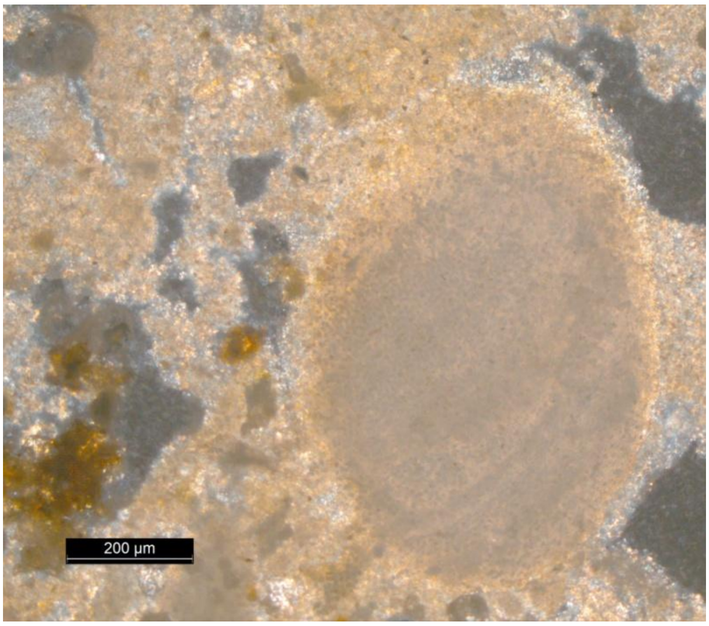

Figure 40 (above) – Thin-section of IPA.09; Altered coralline clast showing loss of grain boundary as hi brief cell walls form binder. Scale 1.0mm; Photomicrograph Mark Thacker.

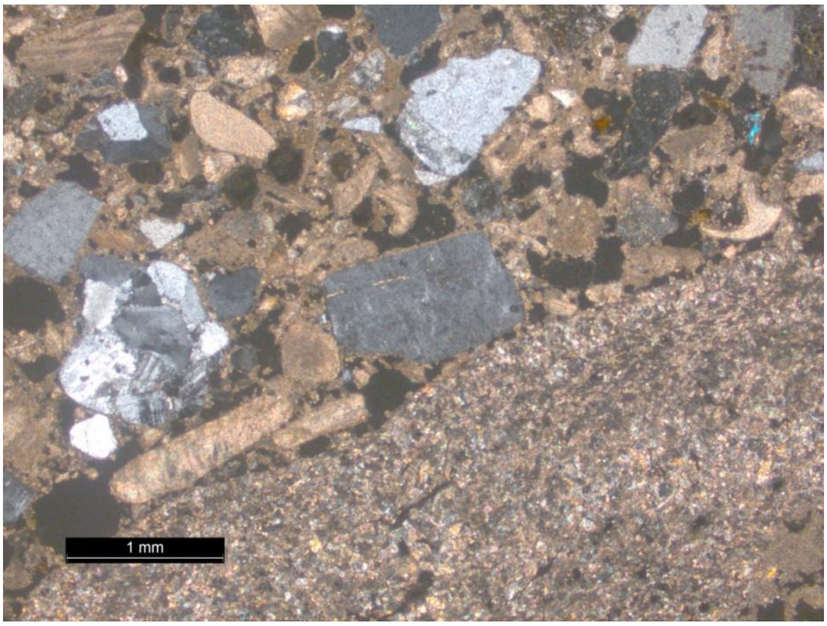

Figure 41 (above) – Thin-section of IPA.10; General shot showing large crystalline heated shell relict and lithic/shell tempered matrix. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

Figure 42 (above) – Thin-section of IPA.11; General shot showing large rounded temper clasts, unheated shell, part calcined shell clast bottom right. Very clean binder. XPL; Scale 1.0mm; photomicrograph Mark Thacker.

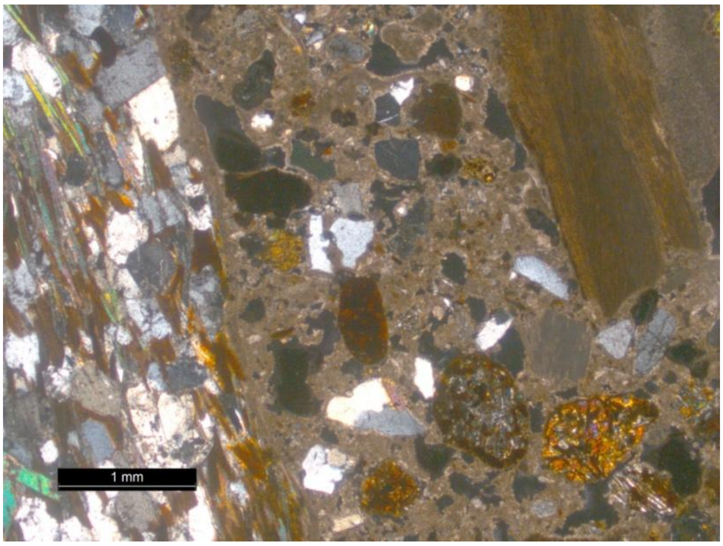

Figure 43 (above) - KRM.01; large altered (probable *O. edulis*) shell fragment with contrasting textures; small highly altered shell clast. Mica-schist, basalt/dolerite temper. XPL; Scale 1.0mm; Photomicrograph Mark Thacker.

5.0 IONA – BIBLOIGRAPHY & ACKNOWLEDGEMENTS

5.1 BIBLIOGRAPHY

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