RESEARCH REPORT

CHARLESTOWN LIMEWORKS RESEARCH AND CONSERVATION

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## RESEARCH AND CONSERVATION

TECHNICAL CONSERVATION, RESEARCH AND EDUCATION GROUP

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Historic Scotland Conservation Bureau
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Salisbury Place
EDINBURGH
EH9 1SH
Tel 0131 668 8638
Fax 0131 668 8669
email hs.conservation.bureau@scotland.gov.uk



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# CHARLESTOWN LIMEWORKS

## RESEARCH AND CONSERVATION

by

Scottish Lime Centre Trust

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*The Scottish Lime Centre Trust, Masons Mortar, Historic Scotland - Technical Conservation, Research and Education Division, and Broomhall Estate.*

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| *Contractor:* | *Charlestown Limeworks - a specialist sub group of the Scottish Lime Centre Trust, led by Alison Davie, with masonry work by Colin McGuggan (AD and CMcG were both Historic Scotland Conservation Fellowship students)* |
| *Mortar analysis:* | *Alick Leslie and William Napier of SLCT* |
| *Archive investigations and oral history:* | *Kirsty Reen* |
| *Architect and Planning Supervisor:* | *Stephen Newsom* |
| *Mortar production:* | *Masons Mortar* |
| *Archaeological services:* | *Scotia Archaeology* |
| *Iron and timber conservation:* | *AOC Archaeology* |
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| *Design* | *Aaron Lawton Associates, with drawing by Richard Bonson* |
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| *Report authors:* | |
| *Archive and oral history* | *Kirsty Reen, with additional material from Scotia Archaeology* |
| *Editor and conservation report* | *Pat Gibbons, with additional material from Alison Davie* |



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# FOREWORD

For centuries lime has played an integral part in the construction of Scotland's built heritage in addition to being an important material for various industrial and agricultural processes. With the advent of modern techniques, lime has come to play a decreasing role in these processes and in building. As such, Scotland's once thriving lime industry is no more. Scotland's rich built heritage requires knowledge and skills relating to not just the use of lime but also its manufacture. The work presented here arises from a Europe wide Raphael project and compliments previous Historic Scotland publications such as TAN 1, *The use and Preparation of Lime Mortar*, and TAN 15, *External Lime Coatings on Traditional Buildings*.

The broad objective of the Raphael Limeworks project was to study and conserve three different types of historic limekilns in three European countries, which represented an important aspect of our common industrial heritage, and to consider the implications of the lime burning tradition, and its associated knowledge and building skills, for the continuing conservation of the built past.

What is presented here is a detailed summary of archival information relating to the development of Charlestown limeworks, the uses made of the material produced at the site, and an account of the continued efforts to preserve this important part of our industrial heritage.

The project consortium comprised three main groups of partners, from Austria, Norway, and Scotland, with support from individual experts in Germany and Sweden. The principal partners in Scotland, Norway and Austria were supported by other national collaborators. Managing partner for the project was Pat Gibbons, Director of the Scottish Lime Centre Trust. The overall project was funded by the European Commission, and by individual partners and other funding bodies within each country. The project partners in Scotland were Scottish Lime Centre Trust; Masons Mortar; Historic Scotland, Technical Conservation, Research and Education Group and Broomhall Estate. Funding for activities in Scotland was provided by the European Commission, Historic Scotland, Fife Environment Trust, Masons Mortar and the Scottish Lime Centre Trust.

**Ingval Maxwell, OBE**
Director
Technical Conservation, Research and Education
Historic Scotland
May 2006

# 1 DEVELOPMENT OF CHARLESTOWN LIMEWORKS

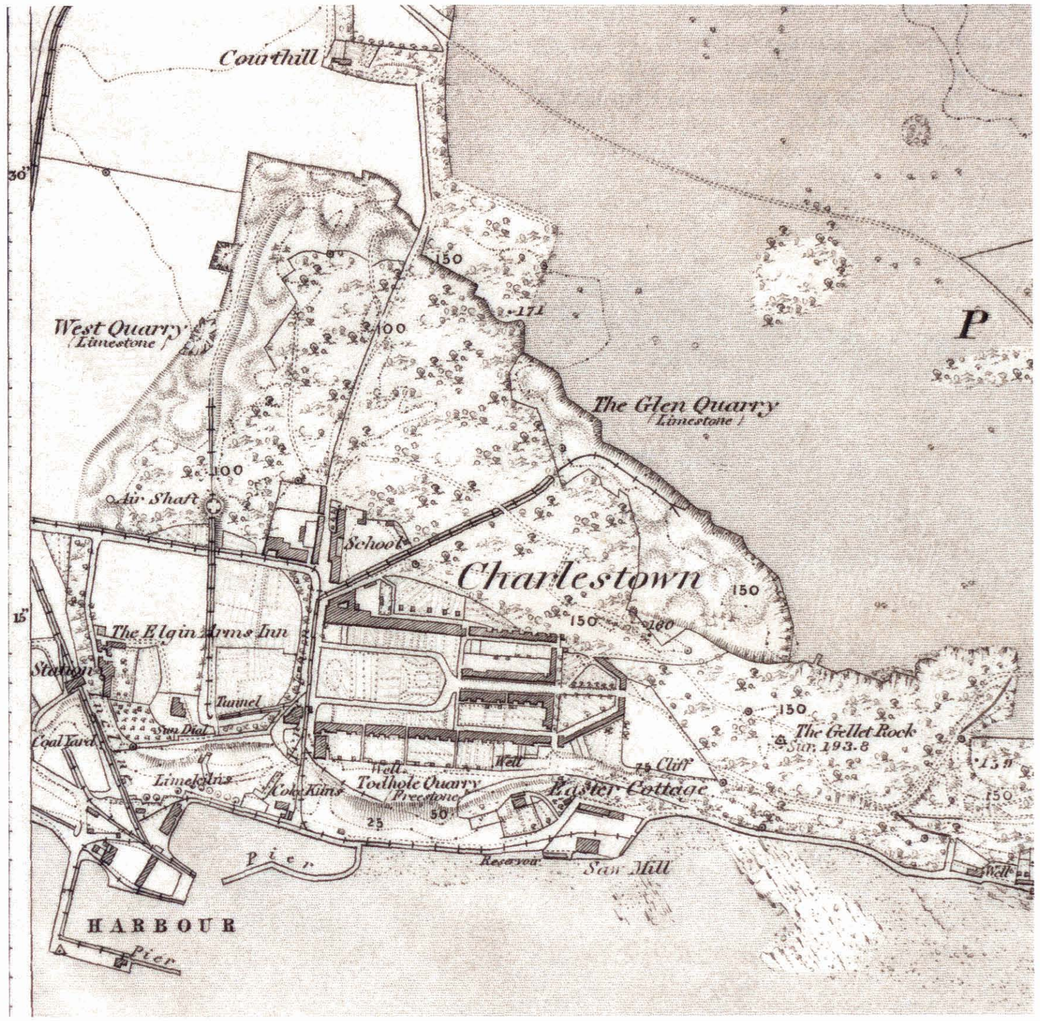



*Figure 1 First Edition 6 inch Ordnance Survey Map of Fife, sheet 39, showing Charlestown including quarries, kilns and the harbour (Copyright NLS)*

The first large kilns were built at Charlestown by the then Lord Elgin as part of a planned industrial development of the estate's limestone, coal and other resources. Further kilns were added as the enterprise expanded (dates are not known, but the expansion probably occurred in the late 18th / early 19th centuries). The kilns were loaded with coal and limestone from the kilnhead area at the upper level and, when in use, burned continuously. Each kiln had four draw holes at the lower level, furnished with iron doors. The configuration of the kiln complex, with the kilns arranged in a continuous row against the rock cut cliff face, meant that there was covered and continuously interconnected working space around all the kilns. At an early stage in the life of the limeworks the

first 10 kilns were provided with a continuous inclined masonry buttress against the front face, presumably intended to restrain the outward movement of masonry resulting from thermal expansion. In the early 20th century several kilns towards the east of the site were gutted and a stone crushing plant was installed. At the west end of the complex a small room situated between the main ground level and the kilnhead, possibly for the works overseer, is in a derelict condition.

Although the site was originally isolated from the associated village of Charlestown, new housing developments in the late 20th century have brought housing much closer. The site itself is adjacent to the early harbour, originally providing a means of transport for lime and coal from the estate, but now used for small pleasure craft.

The overall limeworks site is in a neglected and, in parts, derelict condition. Previous sheds and other small buildings associated with the limeworks were demolished in the 1960s and much of the rubble and other material was filled into the open kiln pots. This has, in fact, served to preserve the kiln interiors from further weathering.

*Figure 2 Kilns 11 & 12 from the harbour (Copyright Scottish Lime Centre)*



# 2 INTRODUCTION

**Archive and survey information**

In-depth research was undertaken in the estate archives of the Elgin family (owners of Charlestown Limeworks since mid 18th century), resulting in a view of the activities of a unique early industrial operation, covering the processes of quarrying, selection and use of fuel, limeburning and processing, and shipping the lime. Information is presented on the locations to which lime from Charlestown was sold and, as far as possible, on the purposes for which it was used. The characteristics of Charlestown lime, a naturally hydraulic material (meaning that it was capable of setting in the presence of water), have been evaluated both practically and from archive reports, and the implications for future production of traditional mortars from local naturally hydraulic limes have been considered.

The following historic overview of Charlestown Limeworks is based on data drawn from the Broomhall archives by Kirsty Reen.

The uncatalogued archives of the Elgin family and their estates at Broomhall in Fife, Scotland, contain valuable information on the operation of an 18th-19th century Scottish estate dependent for its income on industrial enterprise. The estate operated limeworks, coal mines, limestone quarries, sandstone quarry for building stone, salt works, iron works, a brewery, a railway (which later became the first passenger railway in Scotland) and a shipping line. Housing and other facilities, including healthcare and a school, were provided for the workers. The quarrymen, who extracted the limestone for burning, worked as gangers, contracted to provide specified quantities of stone. The limeworks, and the limeburners and other workers, were initially managed by an agent of the estate, and later leased to an independent operator.

Letter books are available, recording all outgoing correspondence, and other documents show proposed and implemented designs for transport systems,

*Figure 3 Kiln workers, Charlestown limeworks (Copyright Charlestown Lime Heritage Trust)*

including the railway system which served the limeworks.

Letter books for the years 1773, 1783, 1793, 1803, 1814 (1813 was missing), 1823, 1833, 1843, 1853 and 1863 were examined in detail. The primary task of this research was to gain a record of the place names from which orders for Charlestown lime originated, over the timespan of a century, to enable precise mapping of the destinations of Charlestown lime products (lime shells, slaked lime and limestone, see glossary on page 54 for definitions) during the most productive period of the works. It is hoped that further research in surviving records of other large producers of lime elsewhere in Scotland, for example Lismore, will produce correlating maps.

Whilst this task was being undertaken, information of more general interest found in the letter books under examination was noted down. These references vary from information about kiln alterations and mortar mixes to specific mention of Charlestown lime being used in a named building or monument.


*Figure 4 Advert for Charlestown lime (Copyright Charlestown Lime Heritage Trust)*



# 3 SELECTED INFORMATION FROM THE LETTER BOOKS

Most of the lime exported from Charlestown between 1763 and 1863 was destined for use in the north east of Scotland. Areas around Perth, Dundee and Aberdeen had the greatest concentrations of customers of Charlestown lime. A high demand was also seen from customers around Stirling and Falkirk, with fairly regular cargoes reaching Callander and Dollar to the west. A smaller but still significant quantity of cargoes also found their way south to Edinburgh, Leith and East Lothian. Occasional cargoes were ordered for Inverness, Elgin, Wick, Thurso and destinations in the Orkney Isles. Orders from the western side of the country are rare - the provision of limeshells for a bridge under construction in Glasgow in 1833 is a notable exception. As we have seen, foreign export of slaked lime to more exotic locations (Halifax in Canada, and Sweden) also occurred.

Charlestown lime was famed for its hydraulic properties, which meant that it was capable of setting in the presence of water. During the period investigated, limestone from Charlestown was purchased for the construction of both Dundee (1833) and Leith Wet Docks (1814). The stone was burnt in kilns on the harbour side to produce lime mortar.

The hydraulic properties of Charlestown lime were also appreciated by The Honourable Commissioners of the Northern Lighthouses, who purchased both limestone and lime shells throughout the 19th century, specifically for lighthouses at North Ronaldsay (1853) and Fraserburgh (1853).

**i. Quarrying.**

The limestone seam at Charlestown was evidently composed of very variable strata, yielding stones of varying colours and qualities. There are frequent references in the correspondence to customer preferences for particular types of stone - these were customers purchasing limestone either for burning in their own lime kilns or for use in other industries. The Carron Company, of Carron Wharf, Fife, who purchased stone both for their own kilns and for use in iron smelting, were very particular about the sort of stone they received, preferring the "darkest and closest blue stone"[1]. This caused difficulties for the suppliers at Charlestown, as John Grant, the estate factor, explains:

"I would observe that our rock consists of a variety of strata of Blue, Grey and White stones wrought from top to bottom and consequently mixed in the working."[2]

Grant claimed to prefer the greyer stone for burning[3], but many of his clients were of the opinion that "nothing but the blue limestone is really good"[4].

Impurities in the limestone strata are also referred to. The quarrymen seem to have had a particularly difficult time in 1784, as John Grant reports "an amazing quantity of blaes[5] and flint adhering to almost the whole stone in the quarries in a much greater degree than I ever knew in one season before"[6].

Charlestown limestone was renowned for being an exceptionally hard rock and consequently quarrying it was a tough job. Gunpowder was used to blast the rock from its bedding planes and it was then broken up with a large metal hammer. Photographic evidence from the 1920's (at this time the technology and tools being used in the quarry were pretty much equivalent to those used in the eighteenth century), shows workers delivering a bogey load of limestone to the kilnheads through the tunnel beneath the road. The optimum size of stone for burning was considered to be around the size of a man's fist. The men on the kilnheads were supposed to break down any stones which were too large before putting them into the kilns, but there was an ongoing problem with ensuring that this was carried out:

"they have so long been habituated to the practice that it is next to an impossibility to get them to do as they should, for the moment one ceases to speak and my back is turned, they will put them in large."[7]

The hardness of the stone made breaking it up to an optimum size for burning difficult and it is evident that this part of the process was frequently neglected.

1 Letter from John Grant to Will Benson, Carron, 16th Sept., Letter Book 1779.
2 Ibid.
3 Letter from John Grant to John Stein, Kennetpans, 6th Feb., Letter Book 1786.
4 Letter from John Grant to Andrew Wallace, Stirling, 4th June, Letter Book 1784.
5 'Blae': hardened clay or carbonaceous shale, blue, blackish or red in colour.
6 Representation from J. Grant to Lord and Lady Elgin, 14th July, Letter Book 1784.
7 Letter from John Rose, factor, to John Ogilvie, Dundee, 22nd August, Letter Book 1791.

**ii. Fuel.**

In the late eighteenth century the coal bearing lands around Broomhall and Dunfermline were owned by the Halkett family, who enjoyed a royal prerogative to sell coal in the Forth with no dues. The Earl of Elgin's pursuit of these lands, which seemed vital to the success of the lime operations was finalised in 1821 by a 999 year lease[8]. Prior to this, fuel for the limeworks was purchased from a number of sources in the Forth and Fife. Some suppliers, including Alloa Colliery[9] and the Carron Company[10] bartered coal for limestone or lime.

Most of this fuel was shipped into Charlestown Harbour, but from 1781 onwards a supply by land carriage from the inland collieries was secured. This was only possible during the summer months, when the roads were passable and fuel continued to arrive by ship during the rest of the year[11].

The limeworks required from two to three thousand tons of fuel for the annual season[12]. The types of coal ordered for lime burning were 'chow'[13] and 'panwood'. Initially chow coals were only used for setting the kilns at the beginning of the season[14], but the most efficient form of fuel was found to be a combination of the two sorts and it was preferred if the suppliers could provide them ready mixed[15]. In 1786 a trial was carried out using cinders to burn lime, which was reported as successful:

"I wish...that the cinders had turned out as well in point of price as I am persuaded they will do in point of quality for the general purpose of burning lime, which I think they are calculated to do as well as coal"[16].

Despite reservations about the price of cinders, orders to Culross for this fuel continued and three of the kilns were changed over to burning with cinders[17].

Problems with the quality of the coal supply were ongoing throughout the period researched, prompting the estate factors to make frequent trials of new suppliers, as well as writing a stream of letters of complaint. Continued references are made to impurities in the panwood and chow coal - blaes, culm[18], chalk and stones are all mentioned frequently, occasionally in the most disparaging tone as in this letter penned by John Grant:

"Your coal, or rather I should say your Blae is indeed a poor bargain at any price - you should really hire us for putting it on the kilns. I never imagined you had any such in the bowels of your property."[19]

**iii. Lime Burning.**

Lime burning was a seasonal activity. At Charlestown the kilns were lit for the season around the beginning of March - the earliest reference to setting the kilns was on the 25th February in 1780 and the latest was the 18th March in 1786. Burning generally came to an end in November, from as early as the 9th November in 1785, to as late as the 21st November in 1781. The burning season was restricted by the weather, with bad weather affecting the performance of the kilns. The main reasons were however, the fall in demand for shells, as farmers were not working their fields outwith these months, and the problem of securing vessels to carry such a risky cargo in winter seas. This latter reason frustrated any attempts to continue burning on a small scale during the winter, as this letter to an Aberdeen Merchant explains:

"I confess that, as some of our customers in Aberdeen were but scrimply served thro' the season, I had intended to set a small kiln to supply them in a few cargoes during the winter...but the whole shipmasters here are unanimously against going out of the Firth with lime or shells before the beginning of spring next"[20].

Limestone and stockpiled slaked lime continued to be sold throughout the winter, the latter generally being bought by builders and plasterers.

During the summer season burning in the kilns was a continuous process, with layers of limestone and coal being loaded in to the kiln top whilst lime shells were drawn from the four eye holes at the bottom. The quantities of materials loaded into the kilns were decided by eye, as described here by the factor, John Rose:

"there has no criterion been fixed for proportioning the quantity of coal to the stones, all being left to the discretion of the men, few of whom are possessed of the requisite judgement...the consequence of which is that they are constantly erring by being over and under the just proportion."[21]

8 Sir Charles Halkett against Lord Elgin, Case Papers, 1821.
9 Letter from J. Grant to Alloa Works, April, Letter Book 1774.
10 Letter from J. Grant to Carron Co., April, Letter Book, 1778.
11 Letter from J. Grant to the Carron Co., 29th May, Letter Book 1781.
12 Letter from J. Grant to Carron Co., 14th November, Letter Book 1778.
13 Chambers Dictionary definition: chow - adj mixed, miscellaneous.
14 Letter from J. Grant to John Ogilvie, 6th August Letter Book 1774.
15 Letter from J. Grant to Carron Co., 26th May, Letter Book 1779.
16 Letter from J. Grant to Samuel Hollingsworth, Culross, 2nd January, Letter Book 1787.
17 Letter from J. Grant to Captain Cochran, Culross, 15th May, Letter Book 1786.
18 'Culm' - anthracite dust.
19 Letter from J. Grant to Adam Patterson, Pittencrief, 29th June, Letter Book 1778.
20 Letter from J. Grant to Charles Copland, Aberdeen, 20th December, Letter Book 1783.





An account of the burning process at Charlestown in the 1920's, given by a former worker still residing in Charlestown, Mr. Thomas Methven, confirms that this empirical method of judging quantities was still being used in the twentieth century. He describes the loading of the kilns in layers - the coal is placed a foot or two in from the edge of the pot and the larger pieces of limestone loaded around the edge, with smaller pieces in the middle of the layer[22]. The quantities required depended largely on the quality of the coal and how well it was burning. For example, if there was plenty of heat in the kiln already they would put ten cart loads (each cart held 23 cwt) of stone onto two cart loads of coal. Whereas if it was judged that more heat was needed, the ratio would be perhaps six carts of stone to two of coal[23]. Occasionally the lime shells did not appear to be adequately burnt and the drawers would send them back up to the top to be put through the kiln again. Well burnt lime is described as being slightly smaller and a lot lighter than the original stone, it was "white or a light yellow colour...mibbae too a wee bit brown through it."[24]

Several references to variations and impurities in the lime sold from Charlestown are made in the correspondence of this period. Some are caused by the variable nature of the limestone seam, as in this reply to a customer's complaint:

"I am sorry to learn that your cargo of limeshells turned out so much refuse...but I know that at the beginning of the season our upper bands of stone are sometimes mixed with flint and am much afraid that our people have not been so careful in picking out that article of refuse as they should have been."[25]

There are also references to overburning of the lime, a result of temperature variations within the pot of the kiln. It appears that this is not regarded by the estate factor as being particularly detrimental to the quality of the lime:

"In the last cargo there was a small part of one kiln which had been rather overburnt and by which the lime was discoloured, tho' I am certain that on the whole it was preferable to any cargo of the ordinary course of our slacked lime."[26]

A further result of the operation of draw kilns was the seemingly unavoidable mixing of the lime with fuel ash from the kiln. John Grant, the factor, acknowledges that this is a feature of Charlestown lime for which the customers can expect no compensation:

"I own it will sometimes happen in spite of the greatest care that a few cinders may be intermingled with a cargo of lime shells, which I am heartily sorry for in the present case, but I can no means in the event of an undesigned accident, unless it was very capital indeed, make any abatement of price."[27]

Indeed, in response to a complaint about a cargo of lime from the overseeer at Tulloch, Mr. Grant states clearly "I believe it impossible for a cargo to be free of small refuse"[28]. He continues by asserting that they ship a vast quantity of lime of the same quality as the cargo under discussion, which meets with applause from all quarters.

The many factors which caused fluctuations in the purity of Charlestown lime gave at least one customer serious cause for complaint - in 1787 William Shaw, an architect of Boness, wrote to John Grant to inform him that one third of his cargo of limeshells had had no lime in it at all[29]. Grant blamed this occurrence on "the improper manner of burning the stone", believing that this is a more likely explanation than that the cargo "had contained stone of a different quality than limestone".

**iv. Processing the Lime.**

Once the lime shells were drawn from the kilns and shovelled hot into carts, they passed into the hands of a group of men called 'trimmers'[30], whose job was to sort the shells into several categories. The bulk of the quicklime, in the form of the roundest large shells, was loaded directly on board ships waiting at the harbour side. There were several reasons for sorting the limeshells prior to slaking in this way, outlined by John Grant in this extract:

"the principal reason is that the smaller part of the shell (though equally good and productive of lime) would not

21 Letter from J. Rose to Robert Beatson, Dalmahoy, 5th March, Letter Book 1791.
22 Transcript of an interview with Mr. Thomas Methven, 19th March 1998.
23 Ibid.
24 Ibid.
25 Letter from J. Grant to Robert Sheriff, Merchant of Leith, 18th April, Letter Book 1785.
26 Letter from J. Grant to Sir Robert Dalyell, Binns House, 5th February, Letter Book 1782.
27 Letter from J. Grant to David Hunter, Blackness, 17th June, Letter Book 1780.
28 Letter from J. Grant to Alexander McKenzie, Clerk to the Signet, Edinburgh, 22nd April, Letter Book 1774.
29 Letter from J. Grant to William Shaw, Boness, 11th June, Letter Book 1787.
30 Chambers Dictionary: trim vt - to make ready for sailing.

please the eye of our customers, neither would it satisfy shipmasters, as it packs more closely into the measure and becomes a weightier cargo...and consequently would lessen their freights. It appears then that the picked round shells are the staple part of our trade and they have the advantage that they are cleared as much as possible from unconsumed cinders which will at times pass through the kilns."[31]

The smaller shells were carried by cart through the tunnel at the rear of the kilns and hoisted up to the kilnhead area via a pulley mechanism. This was where slaking was carried out in the eighteenth century, with extensive shades being built in 1776 to accommodate the manufacture and storage of up to 2000 chalders of lime[32]. By the 1920's this task was being carried out beneath the arches of the by then disused eastern most kilns[33].

Slaking is where quicklime ( CaO ) reacts with water to form calcium hydroxide ( Ca(OH)2 ), otherwise known as lime. At Charlestown the lime produced was in hydrate or powder form, rather than putty form, the latter being far too bulky and hence expensive to transport. One boll of Charlestown limeshells would produce around 2 ¼ bolls of powdered lime when slaked[34]. The technique of slaking was important to the quality of the product - John Grant advises one of his customers that :

"it is necessary that it be slacked slowly and that you give it time, as by hurrying the procedure and powering upon it great quantities of water, it destroys the effect and does not yield the quantity."[35]

There are two references, made in 1773 and 1774, stating that at Charlestown "we commonly slack our lime with sea water"[36]. This seems to be a rather surprising practice, as the likely result would be to introduce salts into the mortar, which, if drawn out by the movement of water, could damage adjacent stone. Possible other effects of slaking with sea water are unknown. There is no further reference to this practice. However, in 1782 a boring instrument is borrowed from Crombie Point for the purpose of constructing two or three fourteen foot deep wells at Charlestown, with pumps being ordered from the Carron Company for their operation[37]. In 1783 John Grant gives the following advice to a customer who is planning to set up his own limekiln:

"it is further necessary that the lime should be burnt as near to a stream of freshwater as possible for the conveniency of slacking."[38]

As he appears so adamant in this extract that slaking should be done with fresh water, it is not unreasonable to assume that the practice of using salt water had been abandoned by this time at Charlestown. That this changeover was concurrent with the construction of wells on the site in 1782, making freshwater easily available, is a further possibility.

Another slaking practice which is referred to in the Letter Books is 'air slaking' where instead of spraying water onto the quicklime to bring about a fast chemical reaction, the exposed shells are slowly slaked by moisture in the air. There were two references to this practice during the period studied, both in reply to enquiries about the supply and quality of slaked lime. The first in 1776 assures the potential customer that:

"our slacked lime (the general part of it only slacked by the common air) is in all respects fit for building, a deal of it may plaister and the whole of it fit and ready for manure."[39]

The second reference early in 1777 continues in a similar vein:

"I think I may safely warrant it good of its kind, extremely dry and mostly slacked by the common air, which are advantages."[40]

It is interesting to note that today, quicklime which has been exposed to the air and allowed to 'air slake' is regarded as being of poor quality. This is because the slaking process which results is uneven - in the most exposed parts slaking occurs readily and carbonation begins, these particles act as aggregate rather than binder once mixed into a mortar. Less exposed parts of the quicklime do not slake at all, this process can occur over a long period of time after mixing, resulting in unmixed balls of lime (lime inclusions) within the mortar.

Lime shades were constructed during the 1760's in several ports along the east coast - Leith, Perth, Montrose (this one described as thirty foot by eighty foot) and Bridge of Earn. These were store houses for slaked lime. During times of low trade, lime was shipped out

31 Letter from J. Grant to Robert Napier, merchant of Bervie, 21st March, Letter Book 1781.

32 Letter from J. Grant to James Davidson, Aberdeen, 2nd November Letter Book 1776. See also letter from J. Grant to Sir Robert Dalyell of Binns, 24th February, Letter Book 1777.

33 Transcript of an interview with Mr. Thomas Methven, 19th March 1998.

34 Letter from J. Grant to John Midstam, Burntisland, 29th May, Letter Book 1771.

35 Letter from J. Grant to Robert Sheriff, Laith, 16th March, Letter Book 1785.

36 Letter from J. Grant to Sir John Inglis, Cramond, 6th October, Letter Book 1773, see also letter from J. Grant to Andrew Wallace, Stirling, 26th March, Letter Book 1774.

37 Letter from J. Grant to Carron Co. September, Letter Book 1782.

38 Letter from J. Grant to James Ramsay, Cannongate, 6th October, Letter Book 1783.

39 Letter from J. Grant to William Jameson, Pitfirrane, 19th July, Letter Book 1776.

40 Letter from J. Grant to Patrick Greenhill, Balmossie, 27th January, Letter Book 1777.





to these shades to be sold off casually through the year, a 'writer' or lawyer being appointed to conduct business at each shade.

**v. Shipping.**

The vast majority of the lime sold from Charlestown was transported from the works by ship, land carriage taking away only a fraction of the trade[41]. The customer paid a basic rate for the product to the Elgin Estate, with freight and port charges payable to the shipmaster on his arrival at the required destination. Once the cargo had left Charlestown Harbour it was at the risk of the customer who had ordered it. Despite the risks involved in transporting such a volatile cargo as quicklime, customers from as far afield as Inverness, Dingwall and Findhorn ordered lime shells rather than slaked lime. This was motivated by simple economics - a boll of shells was equivalent to 2 ¼ bolls of slaked lime, but freight charges for each commodity were the same.

There were numerous references within the twenty year period studied of ships lost at sea - often set on fire when water entering a leak in the hold came into contact with the quicklime[42]. Bad weather often forced ships to take shelter in the nearest port and if stranded there for long the shipmaster would be forced to dispose of his dangerous cargo by any means. During periods of wartime, trade was hampered by fear of enemy privateers off the coast, known at times (in 1779 and 1782) to attack or hold ships to ransom.

During these long and often dangerous voyages, the cargoes of lime and limeshells down in the holds were not immune to damage and alteration. Some of the ways in which this could happen are referred to in the correspondence. In reply to one customer, who had written to complain that his cargo of limeshells did not produce the expected volume of slaked lime, John Grant maintained that the shipmaster had been "a considerable time on the voyage" and as a result the lime had been partly air slaked in transit[43]. A regular customer, who had been very much displeased with the appearance of a cargo of slaked lime was informed that:

"Thompson's vessel took in a great deal of water on the voyage and that the lime was dirtied by his hold, unswept out after a cargo of coals."[44]

**vi. Product uses.**

In the late eighteenth century there was a range of lime based products available from Charlestown. As we will see, the geographical spread of these products was large (see Fig 7.1), but the applications of these commodities and the customer base were also notably wide. Large landowners, farmers, local industries and various tradesmen all purchased products from Charlestown - sometimes a mixture of them.

Raw limestone was sold to the metal works at Carron Wharf, as well as to a number of customers with their own kilns, who burnt it either for commercial sale or personal use. The largest customer of stone after 1774 was a Mr. Andrew Wallace who ran Stirling lime kilns. Stone was also sent to Whinn Limekiln and Fallin Limekiln, near Stirling.

Customers at Grangepans[45] and Alloa[46] regularly purchased 'singed limestone' from Charlestown. No reference was made to the manner of producing singed stone at Charlestown, or to the ultimate use it was put to. However, in one letter to the Alloa customer, Grant reveals that the stone is intended for burning and gives advice on how this should be done:

"the master tells me you intend burning the raw and singed stone together, but I would advise you to burn them separately, as the singed stone requires less coal, only it will be necessary...to clip every one of the singed stones as the fire will not make impression upon them if they are left whole."[47]

Waste products from the lime works were also sold. Lumber lime, which was basically kiln refuse placed on a large rubbish heap, was sold at a very low price as a soil manure[48]. Small limestone refuse and quarry chips were purchased from the works for the making and repairing of roads[49].

The bulk of Charlestown's trade was in the best round lime shells. This product was reckoned to be an excellent manure on heavy soils[50] - it was thought that the lumps of unburnt lime which were usually left once the shells had slaked in the ground, would disintegrate very slowly with real value for the soil[51]. Lime shells were also purchased on a large scale by customers in the building trade - masons, architects, plasterers and

41 Letter from J. Grant to Mr. Abercrombie, Brucefield, 25th April, Letter Book 1785.

42 One example is a letter from J. Grant to James Higgen, Shipmaster, Kincardine, 10th July, Letter Book 1779.

43 Letter from J. Grant to Ross Esq. of Balnagown, 29th July, Letter Book 1776.

44 Letter from J. Grant to Sir Robert Dalyell, Binns House, 10th January, Letter Book 1782.

45 Letter from J. Grant to James Elder, Grangepans, 29th April, Letter Book 1779.

46 Letter from J. Grant to Hugh Rioch, Alloa, 28th June, Letter Book 1787.

47 Ibid.

48 Letter from R.M. to George Abercrombie, George St., Edin. 16th December, Letter Book 1788.

49 Letter from J. Rose to William Murray, Polmaise, 29th January, Letter Book 1791.

50 Letter from J. Grant to Robert Napier, Bervie, 21st March, Letter Book 1781.

51 Letter from J. Rose, to Robert Beatson, Dalmahoy, Spring, Letter Book 1792.

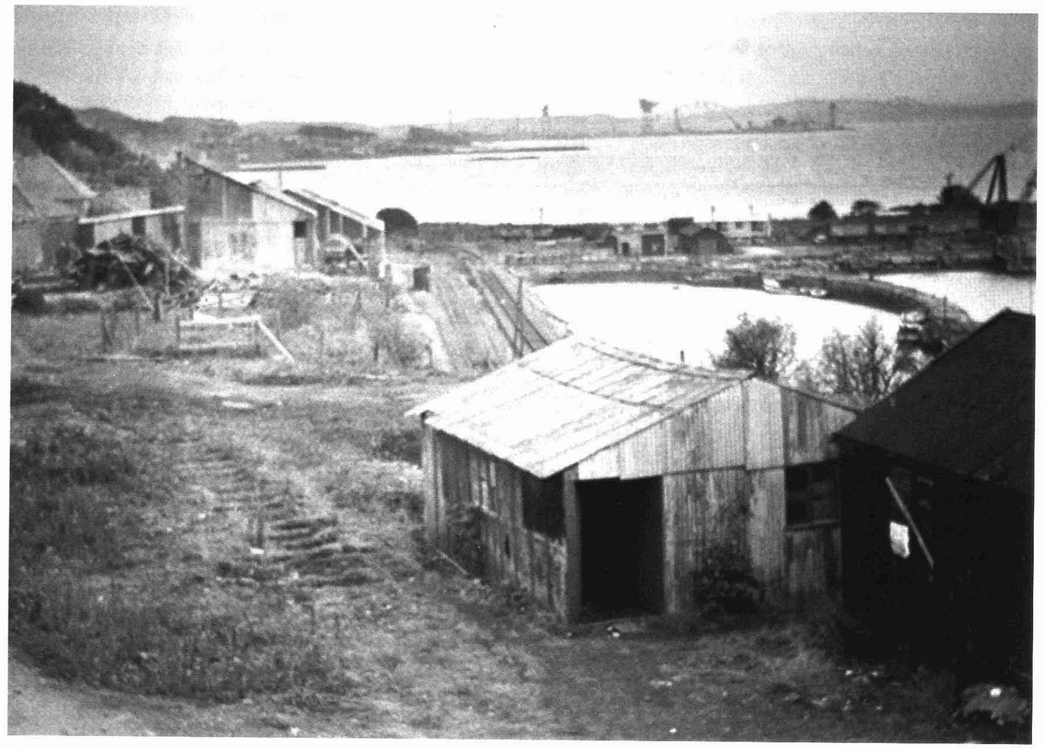


*Figure 5 Slaking the Lime at Charlestown (Copyright Charlestown Lime Heritage Trust)*

slaters. It was frequently recommended that the whitest of the shells be set aside for plastering and the rest used for building work[52]. Charlestown lime was generally acknowledged to give a durable mortar with a strong bond[53].

Slaked lime powder was primarily purchased as a manure for lighter soils[54]. Glass making works at Edinburgh and Leith also bought slaked lime as a flux for their industry. It was not, however, uncommon for masons and plasterers to buy slaked lime rather than shells. This was generally the case outwith the burning season, although some customers purchased slaked lime for building throughout the year - most notably one Sir John Inglis of Cramond, who was one of the largest customers of slaked lime during the period studied[55]. Slaked lime at Charlestown was produced from the refuse shells, too small to be sold as shells and acknowledged to contain a number of impurities - "if there is any refuse in a kiln, it must ultimately adhere to the smaller part [of the shells]."[56] The estate factors frequently refer to the fact that all the buildings in Charlestown and on the Broomhall Estate were built and repaired with lime slaked from these refuse shells, rather than the best quality shells[57]. Furthermore, in 1792 the architect John Adam chose this particular product for building work at Fort George. A letter to the architect from the factor at this time, John Rose, gives us an interesting description of this 'refuse' lime:

"considering its price at 3 ½ d per boll certainly is a very great pennyworth, notwithstanding the many impurities, such as coal ashes, pieces of flint, cinders etc. which when passed thro' a sieve to separate the coarsest of these, it makes a very strong lime, though it will not need much sand."[58]

52 See for example letter from J. Grant to Thomas Wemyss of Lauriston, by Dundee, 13th April, Letter Book 1784.

53 Letter from J. Rose to Robert Bruce, slater, Edin., 29th May, Letter Book 1789 and also letter from R.M. to Thomas Ruthven, Edin., 13th August, Letter Book 1788.

54 Letter from J. Grant to Robert Napier, Bervie, 21st March, Letter Book 1781.

55 See for example letter from J. Grant to Sir John Inglis, Cramond, 2nd October, Letter Book 1787.

56 Letter from J. Grant to Robert Napier, Bervie, 21st March, Letter Book 1781.

57 Ibid, see also letter from J. Grant to James Anderson, Dundee, 15th November, Letter Book 1779.

58 Letter from J. Rose to John Adam, architect, Edinburgh, 14th June, Letter Book 1792.



# 4 FURTHER INFORMATION FROM THE LETTER BOOKS

The most interesting references are presented here in chronological order; most are in the form of letter extracts:

**Book of the Year 1773**

"this [serving the customer with speed and good commodity] I will have more in power this season, than hitherto, from the construction of our kilns which is much improven this winter."

*Letter to Andrew Drysdale, 17th March.*

A letter discusses the necessity of selling off stockpiled slaked lime, "otherwise it would interfere with our land kiln sale."

*Letter to William Moutter esq, Annefield, 2nd April.*

**Book of the Year 1783**

A letter mentions a cargo of 43 chalders of slaked lime sent to Marstrand in Sweden the previous season.

*Letter to Mr Henry Greig, Marstrand, 23rd January.*

**Book of the Year 1793**

"We have a large stock of slaked lime on hand just now, a great part of it pure shell lime that was laid in for building the once intended new kilns, but they being dropped it is put among the common kind."

*Letter to John Duncanson, Shipmaster, 26th January.*

Mention of alterations being made to the kilns - no details given.

*Letter to John Leslie, James St. Aberdeen, 19th February.*

"The bearer William Sibbald has been here this day and has begun to lay the foundations of the harbour work. If the contract is extended I wish you to send a copy of it to me to settle with him for the repairs to the kilns which is now finished and to make my observations of the harbour operations as they are carried on."

*Letter to Mr James Dundas, Edinburgh, 27th March 1793.*

"We have been making very material alterations, so there are only three kilns going yet."

*Letter to John Leslie, Aberdeen, 1st April.*

"Mr. Sibbald has finished the repairs to the kiln, she was carried up circular on the inside"

*Letter to Alexander Laing, Architect, Edinburgh, 16th April*

"[name of shipmaster] has unloaded a cargo of limeshells in the River Don for a Mr. John Fiddes, mason in Aberdeen, who is carrying on some buildings below the Bridge of Don."

*Letter to Messrs Bremner and co., Aberdeen, 8th July.*

**Book of the Year 1803**

A letter discussing an account of the previous year, mentions "an account against young Mr Erskine for lime furnished for some repairs at Castlehill, in consequence of an order from Mr John Chalmers, Architect."

*Letter to John Jameson Esq., Writer in Alloa, 17th January.*

A letter informing that a kilnsheadman is being sent from Charlestown to Alloa, to "assist in setting your kiln...to whom I think you may safely entrust the management of your kiln and instructions of your workmen...he will stay with you until you consider your own people able to go on without him."

*Letter to Alexander Bald, Limeburner, Alloa, 1st April.*

**Book of the Year 1814**

A letter informs of a cargo of limeshells sent for building work at Longhope.

*Letter to Hugh Kinghorn, Builder, Leith, 19th September.*

**Book of the Year 1833**

Several cargoes of lime shells are sent to Glasgow over the season of 1833 to furnish the construction of a new bridge in that city, undertaken by John Gibb and Sons of Eglinton Street, Glasgow.

Letter discussing the construction of a sluice for scouring the new harbour at Charlestown, to deepen it for larger vessels. This is being undertaken by a mason called William Strathdee, with a team of 6 masons and 6 or 8 labourers.

*Letter to James Chynes Esq, Edinburgh, 14th March 1833.*

"His lordship has no objection to making a shipment of lime and coke to Halifax, US, to the extent you mention in joint account with you. That is we will take the risk of half the first cost of these articles and to have the benefit of a better price if it should be realised for them in America...You may let me know as soon as you possibly can the exact quantity of each that will be required in order that we may have the lime prepared."

*Letter to Ebenezer Watson Esq., Merchant, Leith, 14th March.*

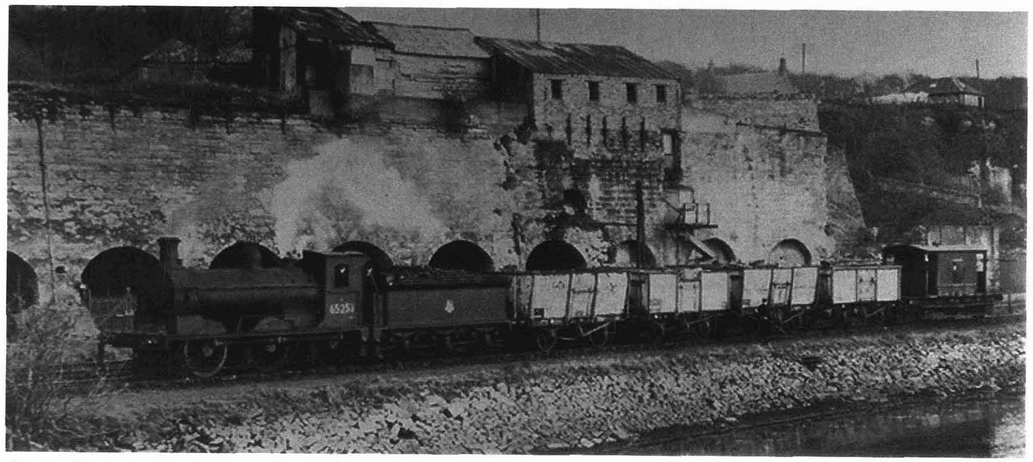


*Figure 6 Transporting the lime from Charlestown limeworks by rail (Copyright Charlestown Lime Heritage Trust)*

"I beg now to prefix an invoice of lime and cinders by the Patriot and the Nelly, to shipped in the Highlander, Captain Mitchell, for America, amounting to £19.14/.

*Letter to Ebenezer Watson Esq., Merchant, Leith, 15th April.*

"I now beg to prefix invoice of the memorandum by Mr James Milne, Engineer, as to the way in which the mortar was prepared for the Leith Wet Docks, by mixing burnt ironstone with our lime... I would before now have sent you a sample of our ironstone, but what we had here calcined was of inferior quality, we are at present burning a small quantity and it will be sent round with the first vessel for lime."

*Letter to James Leslie Esq., Engineer for Dundee Harbour, 17th April.*

Letter mentions that Charlestown lime was furnished to Mr George Melville (Principal clerk to Lord Moncrief) "for a house which he built in Culross."

*Letter to J. Rolland Esq, Rutland St. Edinburgh, 13th July.*

"As Mr Grant is in want of a quantity of lime for some farm steadings he is now building, he ordered me to send round a small cargo to Oudinard."

*Letter to James Fenwick, Oudinard, Near Bridge of Earn, 25th July.*

**Book of the Year 1843**

"I can confidently recommend our lime for harling as it used for this purpose all over the country and it is preferred to any other lime in Scotland for building Wet Docks, bridges and any other buildings exposed to water and for making concrete drain tiles. I never knew an instance in this quarter of harling with our lime fail, if it was sufficiently dry before frost set in."

*Letter to James Gregg Esq., Wick, 24th April.*

"I understand that you applied here for Brick and Lime to build a church at Carnock, but as you are a stranger to me it will be necessary that you send me a letter from the church manager or some eminent person engaging to secure the articles paid."

*Letter to Robert Dick, Mason, Carnock, 12th July.*

"I observe that you have begun to drive lime to build a new church at Torryburn."

*Letter to James Donaldson, Mason, Crossford, 12th July.*

Letter mentions lime provided for the Kincardine Free Church.

*Letter to Robert Gentle Esq., Kincardine, 31st October.*

**Book of the Year 1853**

"Masons in this quarter who use our lime are in the habit of adding one half of sand to our limeshells for ordinary building purposes, but as the lime you got is to be used for pointing joints of outside walls, I would not advise you to add more than one third of sand and it will make a stronger cement."

*Letter to James Hill Esq., Edinburgh Saw Mills, 21 Leith Walk, 17th May.*

**Book of the Year 1863**

"The lime shells fall from being slaked and with sharp sand - two parts sand and one of lime. When the sand is not so sharp, two and a half of sand may be used. We can grind the shells for you if you choose."

*Letter to Samuel Freeman Esq., Contractors Office, Trinity, Edinburgh, 27th October.*



# 5 MAPPING OF DESTINATIONS OF LIME PRODUCTS FROM CHARLESTOWN LIMEWORKS

## 5.1 Introduction to the maps

The main aim of the second phase of research in the archive at Broomhall was to gain a record of the place names to which Charlestown lime was being exported during the time the limeworks were in operation. This was to be done in order that precise mapping of these destinations could take place.

Letter Books for the years 1773, 1783, 1793, 1803, 1814 (1813 was missing), 1823, 1833, 1843, 1853 and 1863 were examined in detail and the following information was recorded:

All the locations identified in the correspondence that confirmed the shipment of lime cargoes, orders or payments for lime, were noted down.

The type of lime product being purchased (i.e. shells, slaked or stone) was distinguished.

The customer's name and occupation, if available, were noted.

A rough tally was made of all the orders for each location in individual years.

A database of this information was built up on Excel, covering a century of lime production and export at Charlestown. Ordnance Survey grid co-ordinates were then identified for the locations noted down. Most place names in the Letter Books were written down with the nearest large town, for example 'West Drone, Perth'. This helped to give the correct identification where there were duplicate Scottish place names or where spellings had altered. Out of 1027 locations noted, fewer than 20 could not be identified at all.

The resultant data was interpreted using G.I.S. on Arcview, to produce precise maps of the destinations of Charlestown lime products at ten year intervals over the course of the century between 1773 and 1863. The fourteen maps presented below provide a very immediate graphical representation of a large amount of information.

It is hoped that further research in the surviving records of other large scale lime producers elsewhere in Scotland, for example Lismore off the west coast, could enable the production of correlating maps. The comparison of 'export maps' associated with lime producers in different parts of the country, would enable zones of dominant lime sources to be established. The mapping of traditional building material sources in this way, provides greater knowledge of the historic building fabric we have in our care. The identification and understanding of the original materials used gives greater authenticity to repair and conservation work.

## 5.2 General trends apparent in the maps

Figures 7.1. to 7.4.
-all the destinations of individual products.

The first four maps below show all the destinations recorded over the period studied of all lime-based exports from Charlestown (Fig.7.1), shell lime only (Fig.7.2.), slaked lime (Fig.7.3.) and limestone (Fig.7.4.). These maps show only the geographical spread of these products; there is no indication of the level of quantities being sent to each location.

Figure 7.1. reveals very high concentrations of lime exports to the Forth and Tay estuary areas, with high export levels also to the east coast ports and into Perthshire and Aberdeenshire. Lime exports reached several locations on Orkney and Shetland, with the north east from Thurso down to Inverness and the coast around Nairn being fairly well served. Lime was exported to several locations in southern Scotland and around Glasgow.

The absence of any export locations in the mid to north west, with only sporadic export to the south west, is very striking. This can be largely accounted for by competition from other major lime producers in these areas; at Closeburn in Dumfriesshire, Lismore off the west coast and Durness on the west side of the north coast. Export over the border to northern England was not widespread, this is probably because competition from the Sunderland lime works was intense.

The dominant trends apparent in Figure 7.1. are also apparent in the maps for shell, slaked and limestone export locations. The export of slaked lime (Fig.7.3) was less widespread than that of shell lime (Fig.7.2.). However, due to its less volatile nature, slaked lime was much safer – but bulkier – to transport than lime shells and was therefore exported on a larger scale to Orkney and Shetland.

The export of limestone was largely concentrated in the Forth valley, where it was used on a large scale in various industrial applications. Another major customer for limestone was the Northern Lighthouse Board (see Chapter 7) which drew limestone up to intermittent locations on the north east coast and Orkney.

### Destinations of all products over time

The maps in Figures 7.5 to 7.14 show the destinations of all the products in individual years. These maps offer a more quantitative picture of the lime exports to each location, although no indication of frequency within each year is given.

The most evident general trend in these ten maps is a high concentration of exports over time to the Forth and Tay estuary areas and to the ports up the east coast. Other locations are served less often, some occurring only once during the ten years studied (e.g. Shetland in 1823 and Argyll in 1843). Exports to the south and the west are extremely sporadic through the period.

There is an export peak at the end of the 18th century and the turn of the 19th century. This is followed by a surprising decline between 1833 and 1853, when the geographical range of exports shrinks, concentrating almost exclusively around the Forth estuary. The demand from the north east region, Grampian and Aberdeenshire, almost disappears at this time; it is possible that agents from the Sunderland lime quarries were making sales inroads into this area at this time. A more general spread of export locations reappears in 1863.






*Figure 7.1 All destinations of lime 1773-1863 (7.1-8.15 all Copyright Scottish Lime Centre)*

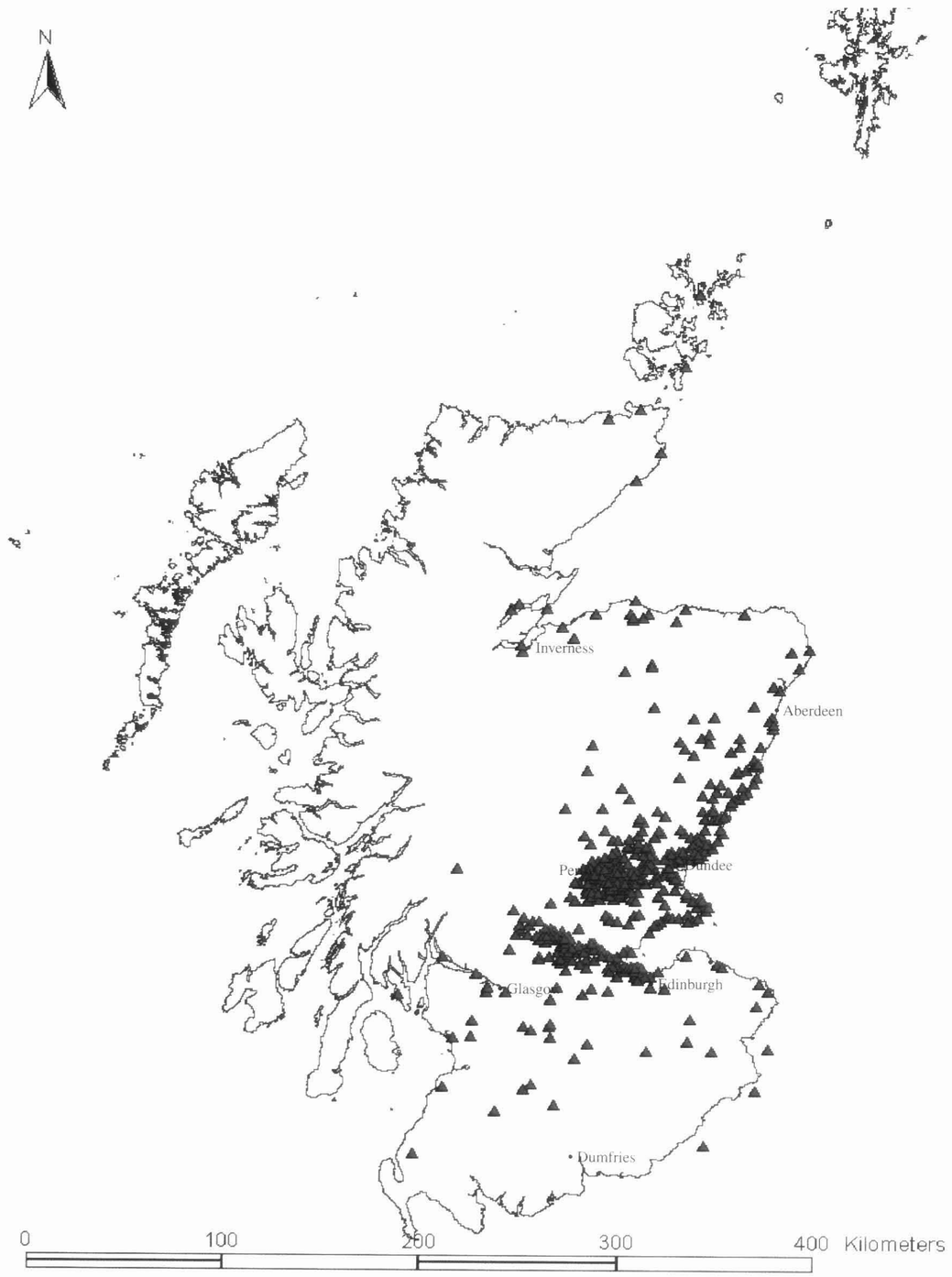



*Figure 7.2 All destinations of shell lime 1773-1863*






*Figure 7.3 All destinations of slaked lime 1773-1863*

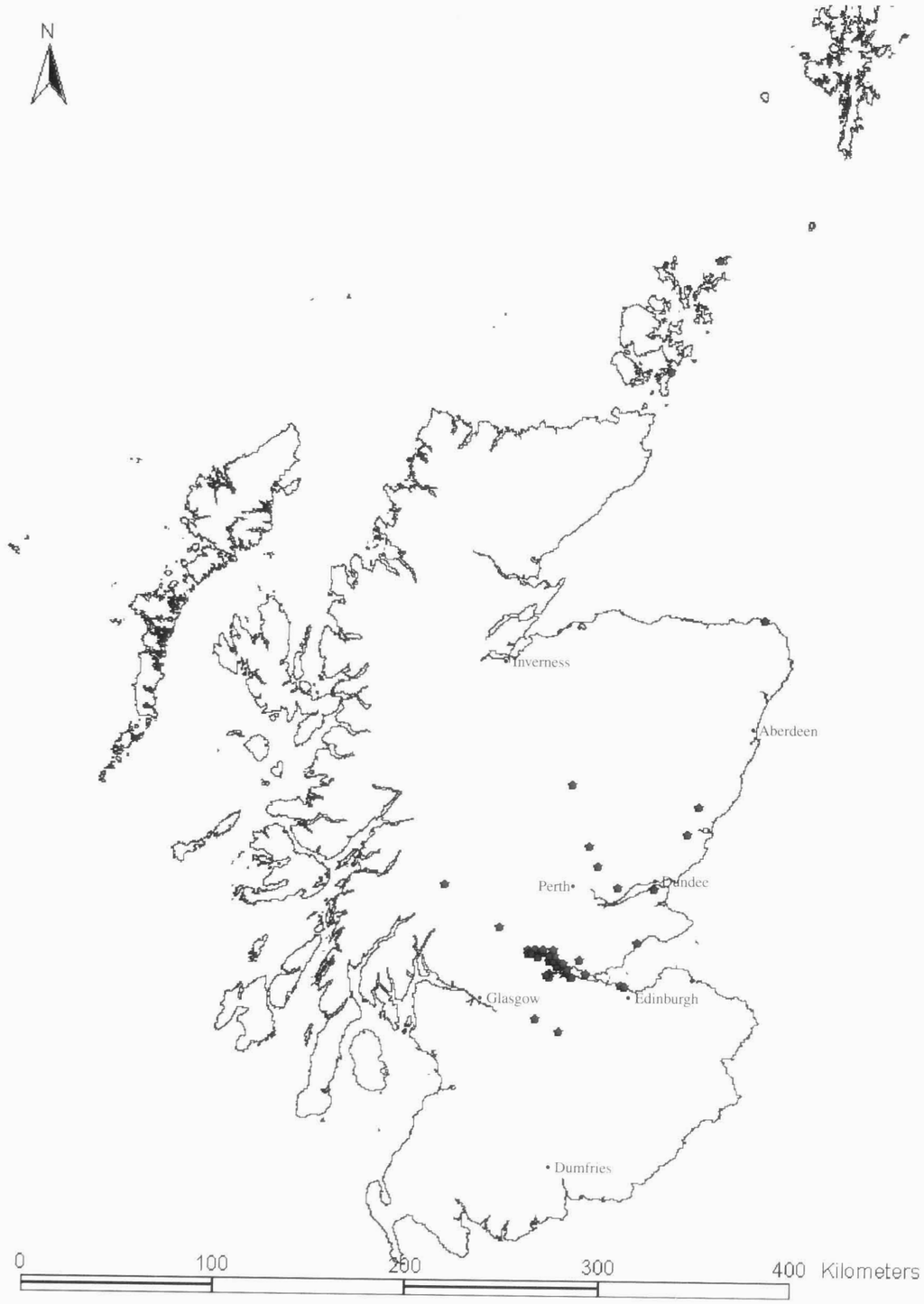



*Figure 7.4 All destinations of limestone 1773-1863*






*Figure 7.5 Destinations of all lime in 1773*

1783

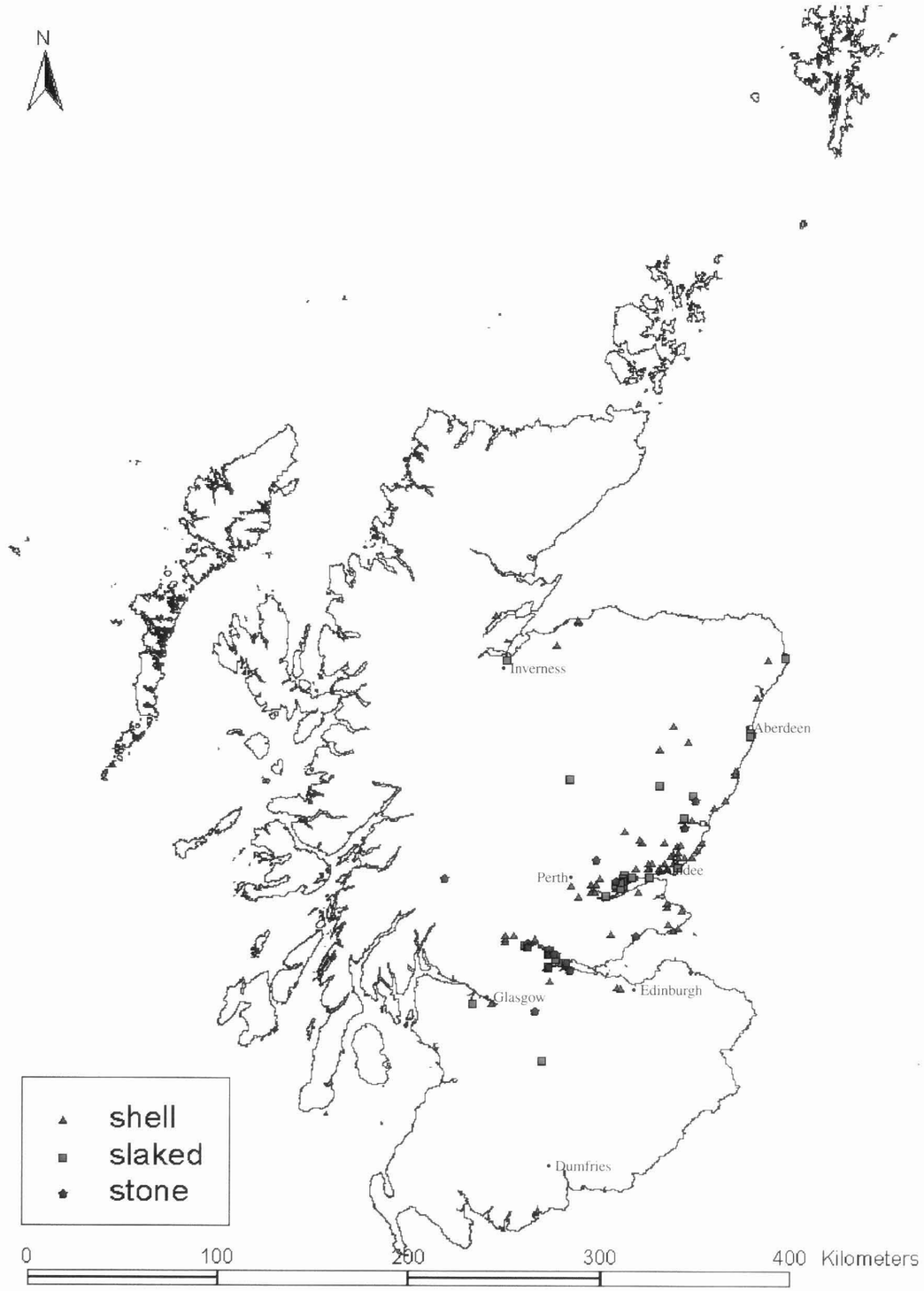



*Figure 7.6 Destinations of all lime in 1783*





1793

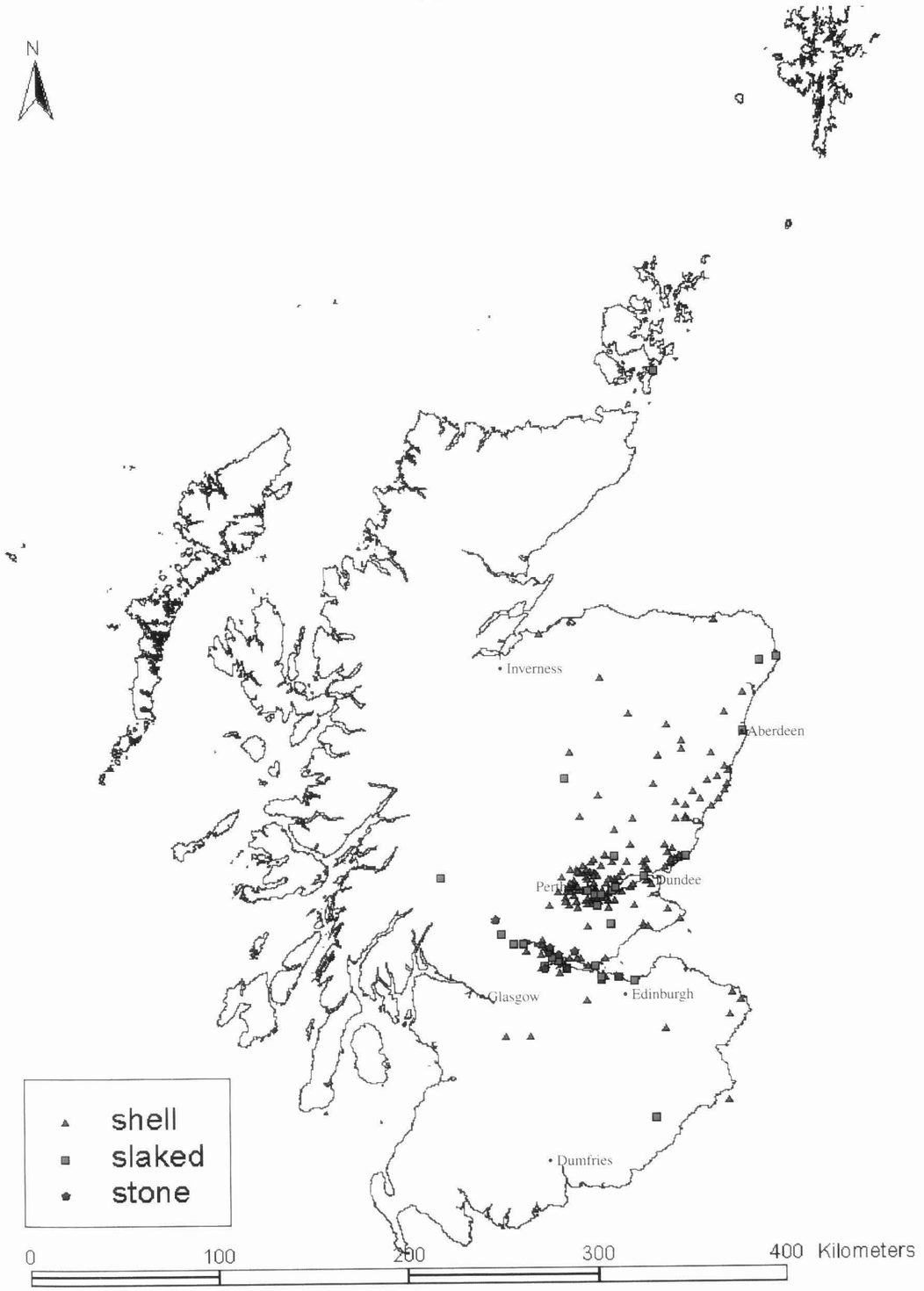



*Figure 7.7 Destinations of all lime in 1793*

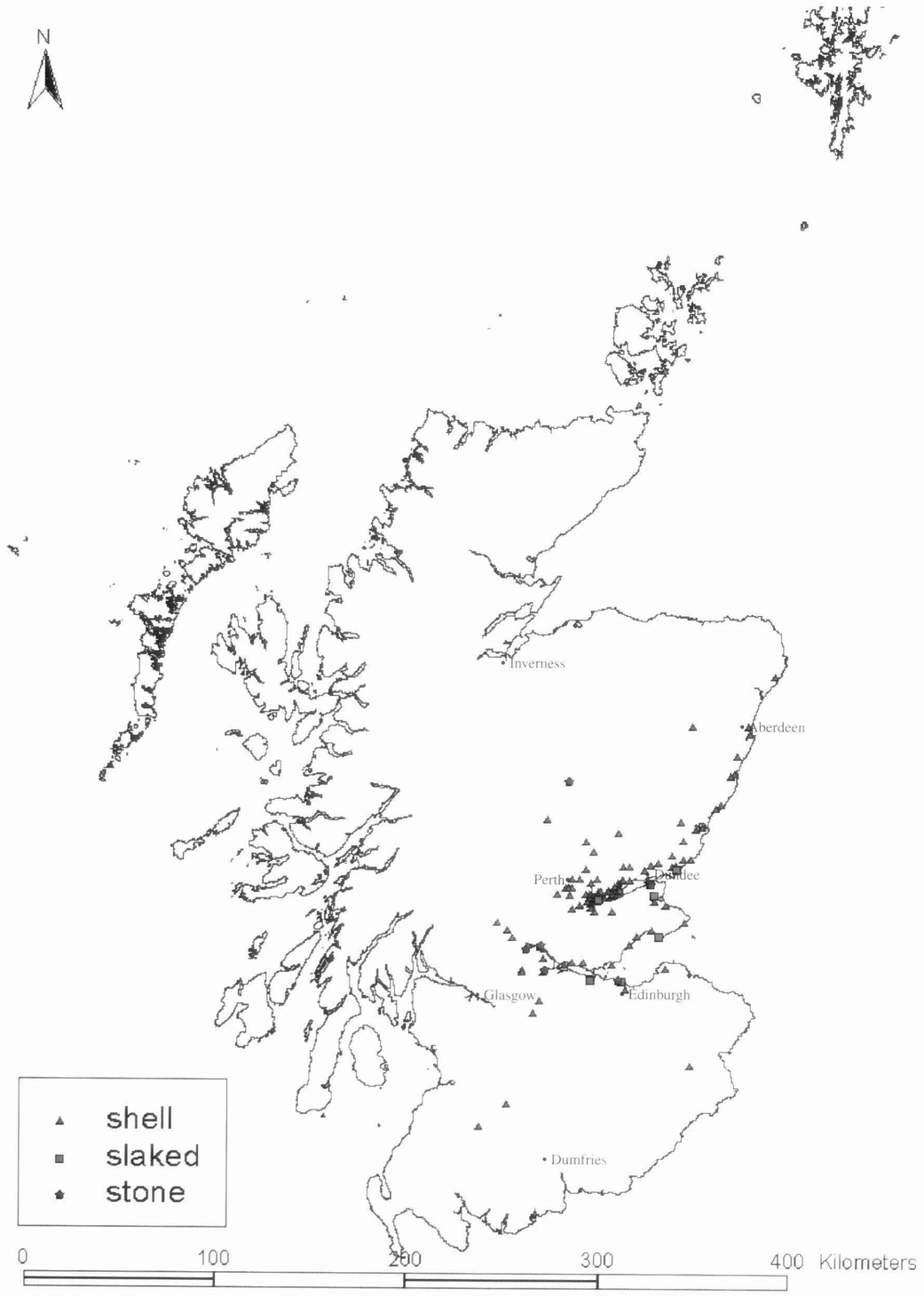



*Figure 7.8 Destinations of all lime in 1803*






*Figure 7.9 Destinations of all lime in 1814*

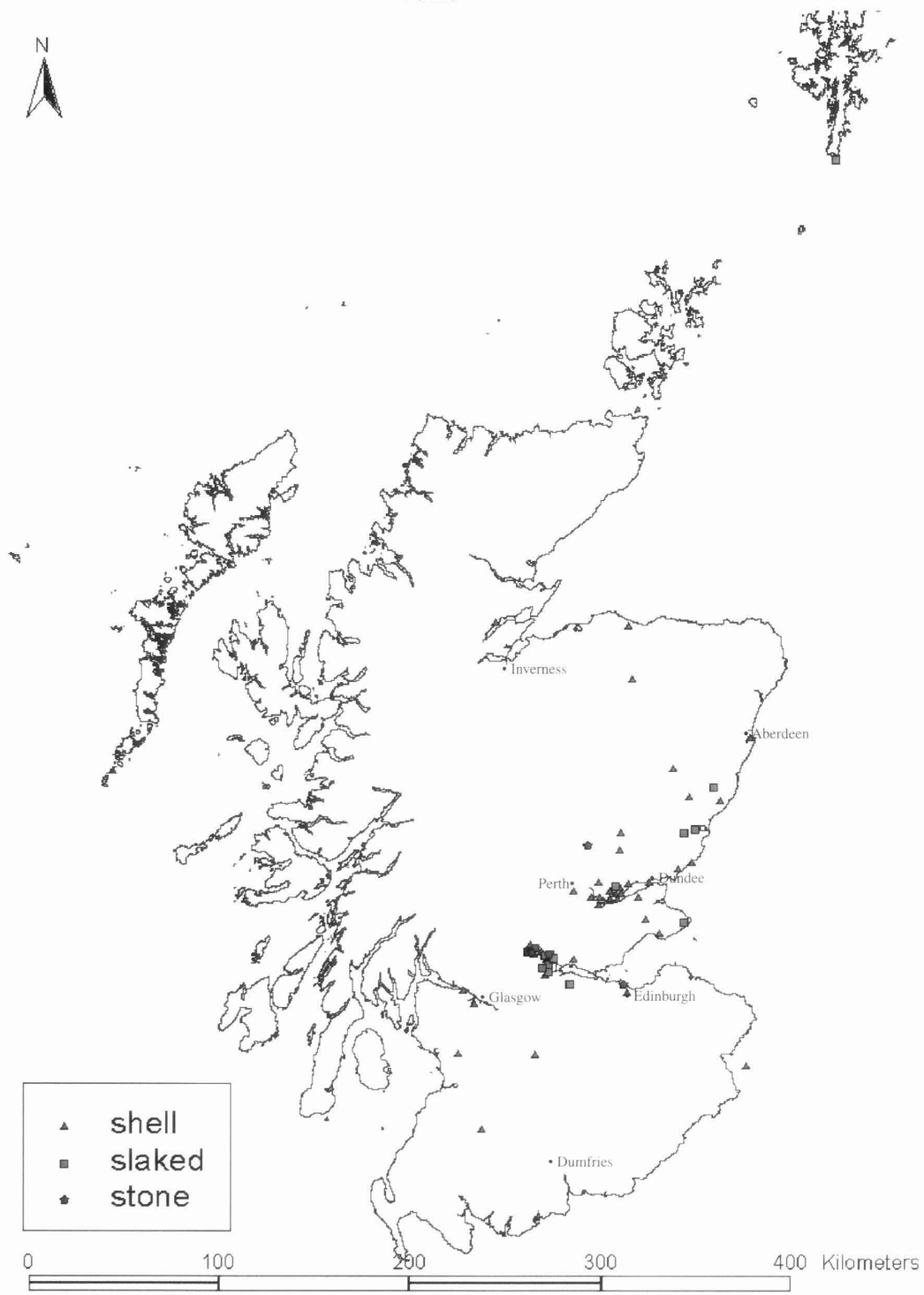



*Figure 7.10 Destinations of all lime in 1823*





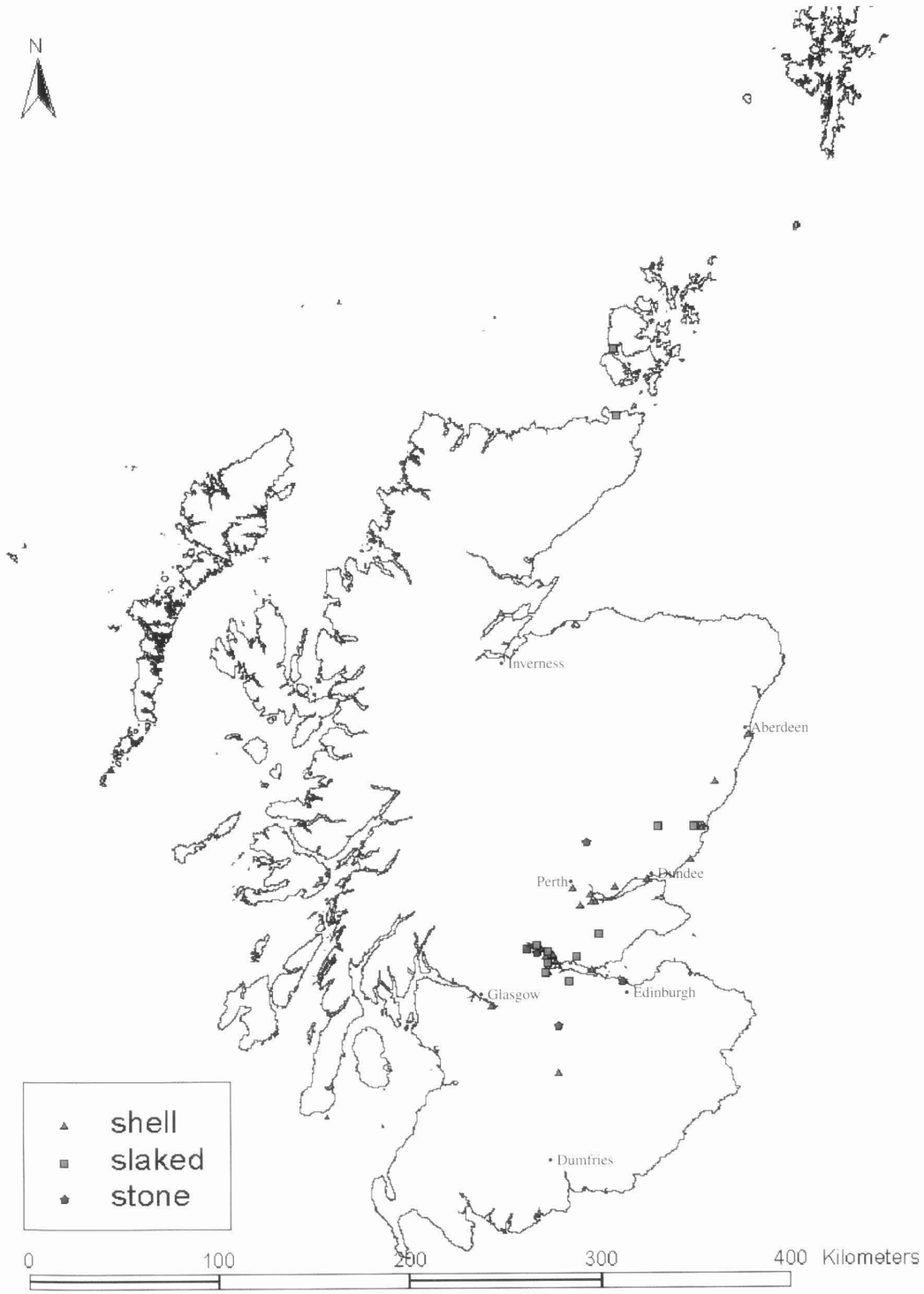



*Figure 7.11 Destinations of all lime in 1833*


*Figure 7.12 Destinations of all lime in 1843*






*Figure 7.13 Destinations of all lime in 1853*

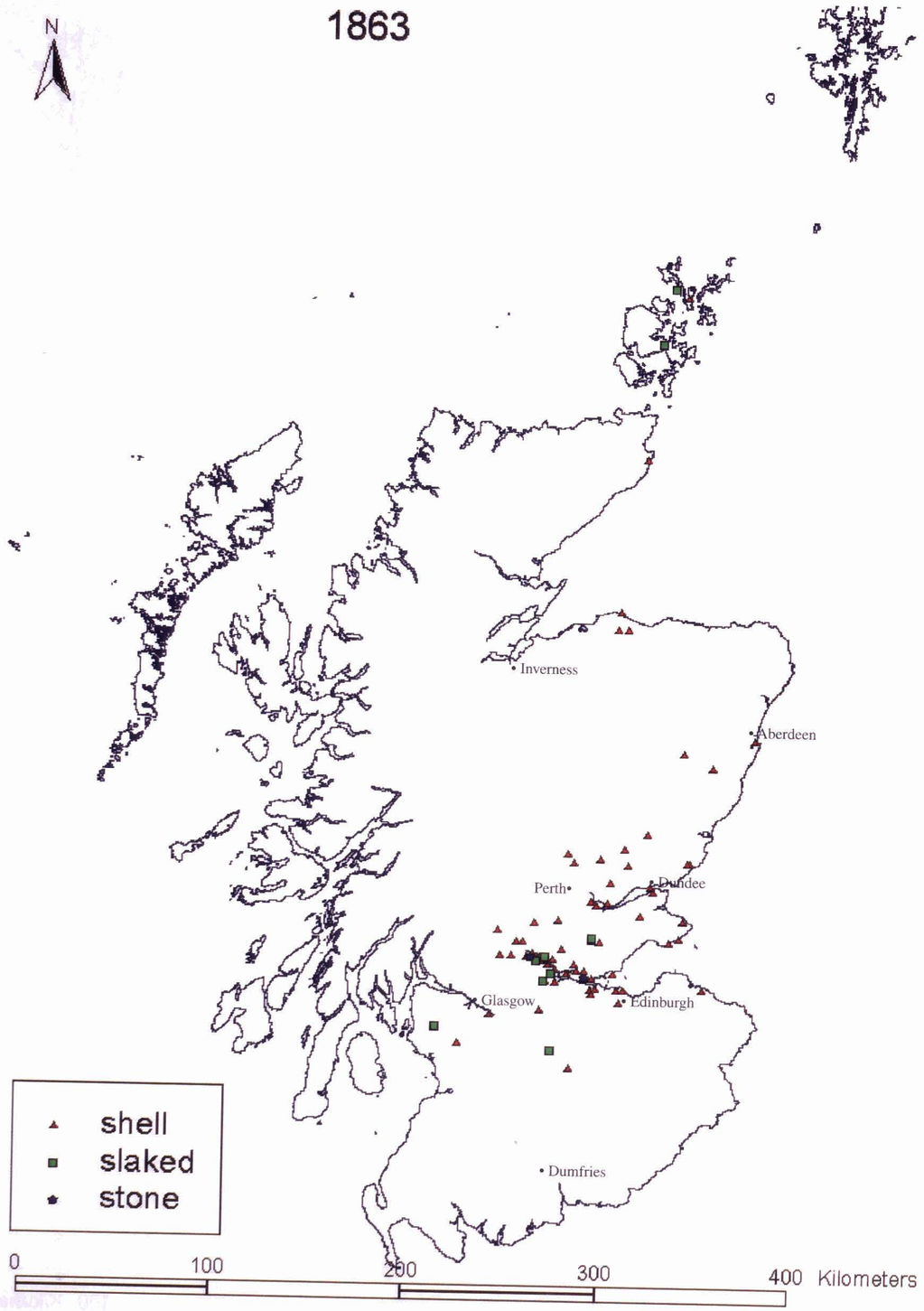



*Figure 7.14 Destinations of all lime in 1863*



# 6 CUSTOMER OCCUPATIONS

## 6.1 Introduction

Wherever it was available in the letter books, information regarding the occupations of customers ordering lime products from Charlestown, was noted down. This chapter draws on this information, providing a basic statistical analysis in graphical form and drawing conclusions where appropriate.

Occupations were provided for an average of 50% of the customers recorded in letter books studied at intervals of ten years from 1773 to 1863. The remainder did not have their occupations recorded in the correspondence studied.

As is shown in the pie charts presented below, the proportion of customers with an 'unknown' occupation varies greatly between years and products. For example, 73% of customers for shell lime in 1773 were unknown, whereas only 8% of customers for slaked lime in 1853 had no particular occupation recorded.

These variations and the large proportion of 'unknown' occupations, makes comparisons between the data less effective and provides an incomplete picture. However, despite the limitations of the statistics available, their analysis remains a valuable exercise. The linking of customers to occupations appears to have been recorded randomly and is broadly distributed amongst different and wide-ranging groups. The 50% sample group available to us can be regarded as a representative group providing useful information.

The data was divided into groups, distinguishing the **type** of lime product purchased by each customer. The graphs and pie charts contained in this chapter represent data for customers of shell and slaked lime. Graphical representation of the occupations of customers of limestone was felt to be unnecessary, as the user group for this product is so limited. Three main users ordered unburned limestone from Charlestown:

Limeburners who burnt Charlestown stone in their own kilns, both for commercial and private use (e.g. Andrew Wallace of Stirling);

The iron foundry at Carron who used limestone as a flux in iron smelting;

Engineers and contractors who burnt the stone in situ for the construction of harbours and lighthouses (e.g. The Commissioners of the Northern Lighthouses and Leith Harbour Committee).

A small proportion of stone was purchased only occasionally by merchants and once by a soapboiler.

### *Figure 8.1*

The graph in Figure 8.1. below, shows the distribution of occupations amongst the 50% 'known' sample of customers purchasing shell lime during the entire period studied. This graph gives a good indication of the different purposes for which Charlestown lime shells were being used throughout the century from 1773 to 1863. Most of the lime was evidently being used for agricultural

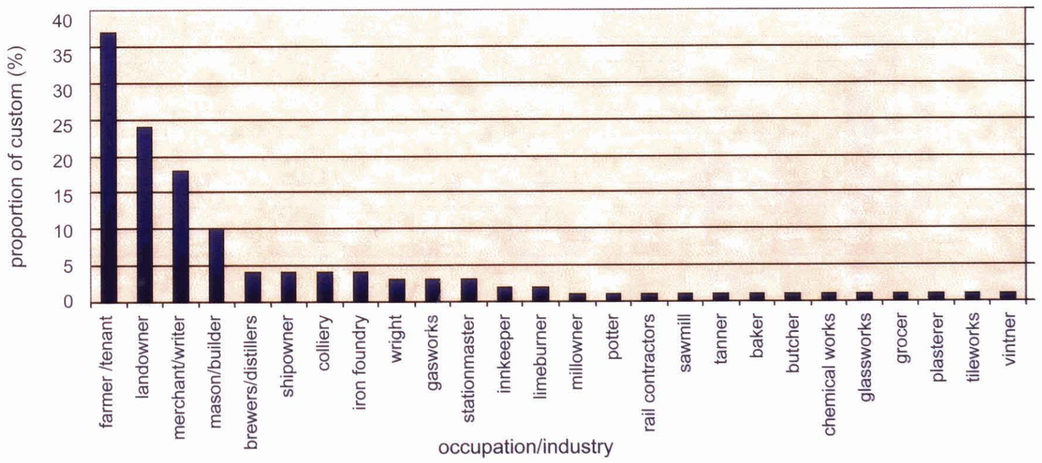



*Figure 8.1 The Distribution of known occupations amongst customers for shell lime (1773-1863)*

purposes by farmers and landowners. Around a fifth of shell lime was being used in industrial applications such as coal mining and iron smelting. At least one tenth was being used by the construction industry. A small proportion of the lime shells were purchased on a 'one off' basis by a broad range of professions seemingly unconnected with any known application of lime, including butchers, bakers and vintners. It must be assumed that the lime was being used to enrich land that they owned or for building repairs.

***Figure 8.2***

The graph in Figure 8.2 shows the distribution of occupations amongst the 50% 'known' sample of customers purchasing slaked lime during the entire period studied. It is evident that the primary use of slaked lime was for agricultural purposes, as farmers and landowners make up over two thirds of the customer base, roughly the same proportion as they form in the shell lime customer base.

Merchants purchased a similar proportion of slaked lime as shell lime, but the construction industry claimed a slightly smaller proportion. The occupations which used slaked lime are more limited in number than, but common to the set using shell lime (apart from 'soap boiler'). Overall, however, the same four main groups of users dominate the sales of shell and slaked lime. This indicates that the end use of each product was largely the same; the decision to buy shell or slaked lime would therefore have been primarily determined by transportation conditions and seasonal availability.

***Figure 8.3***

The graph Figure 8.3, shows the variations in end use of shell lime across time, based on the known occupation sample for each year. A number of distinct trends are visible in the graph.

Use of lime by farmers and tenants rises to a notable peak around the end of the 18th century, then goes into decline as the 19th century progresses. Use of lime by landowners follows a less dramatic course, but reaches a gentle peak at the beginning of the 19th century, declining thereafter, before appearing to peak dramatically after 1853. This overall peak in demand for agricultural purposes around the turn of the 19th century can be linked to the era of improvement and rationalisation of agriculture in Scotland during this period.

The proportion of lime shells purchased by merchants remains on a fairly constant level throughout the period.

The demand for lime shells for construction and for industrial applications in the 'other' category, follow a very similar course over the period, with an overall gentle rise over the 19th century, mirroring the growth of industry and infrastructure.

***Figure 8.4***

The graph in Figure 8.4, shows the variations in end use of slaked lime over time, based on the known sample group of occupations for each year. It must be noted that the sales for slaked lime were far smaller than those for shell lime, averaging around 20% through the period studied. With a sample group of known occupations of roughly 50% for slaked lime, the actual sample size of the data is far smaller than that for shell lime. This has resulted in a very erratic graph, where large variations are caused by relatively insignificant fluctuations in the end use. Few significant trends in the data are discernible.

One of the most striking and surprising features is the decline and thirty-year halt in demand for slaked lime by the building industry in the early years of the 19th century. There is also a discernible peak in demand

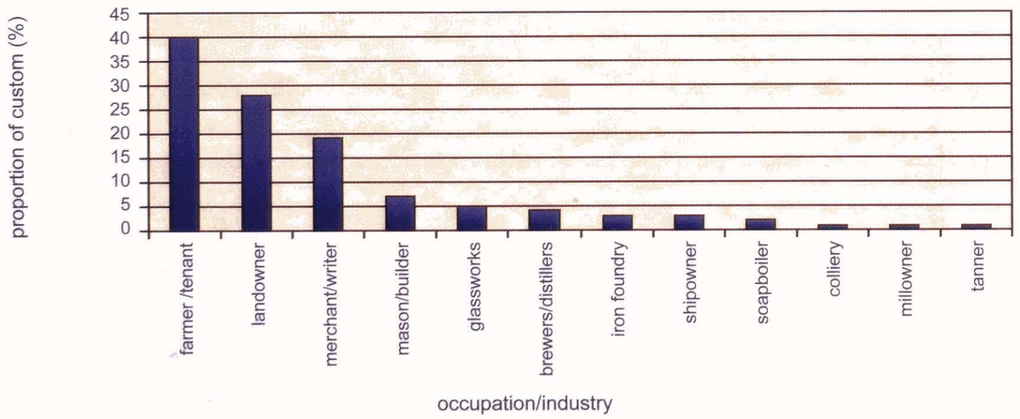



*Figure 8.2 The Distribution of known occupations amongst customers for slaked lime (1773-1863)*





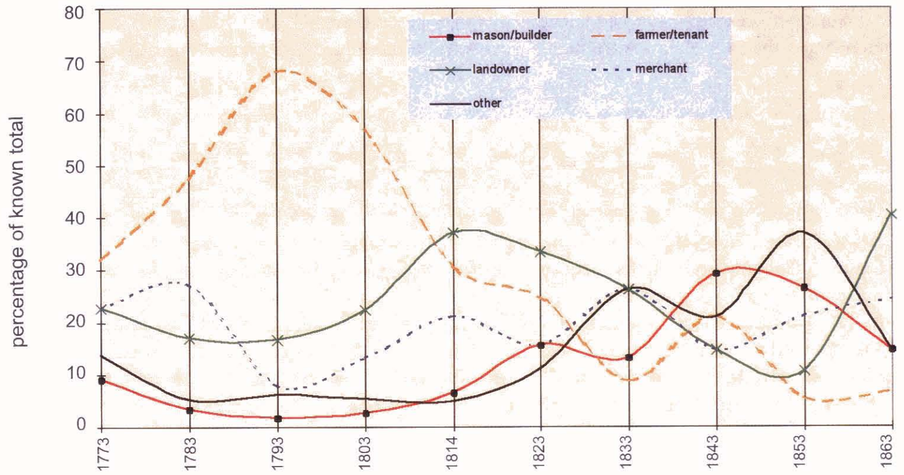



*Figure 8.3 Variation in end use (where known) of shell lime (1773-1863)*

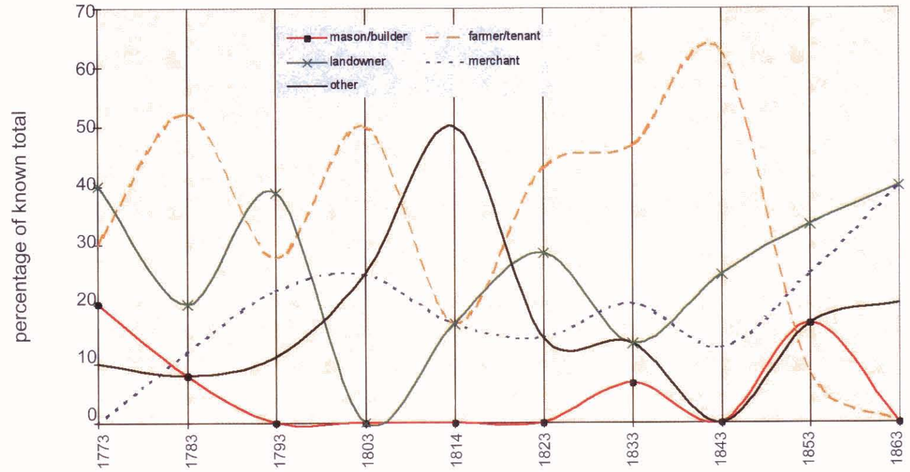



*Figure 8.4 Variation in end use (where known) of slaked lime (1773-1863)*

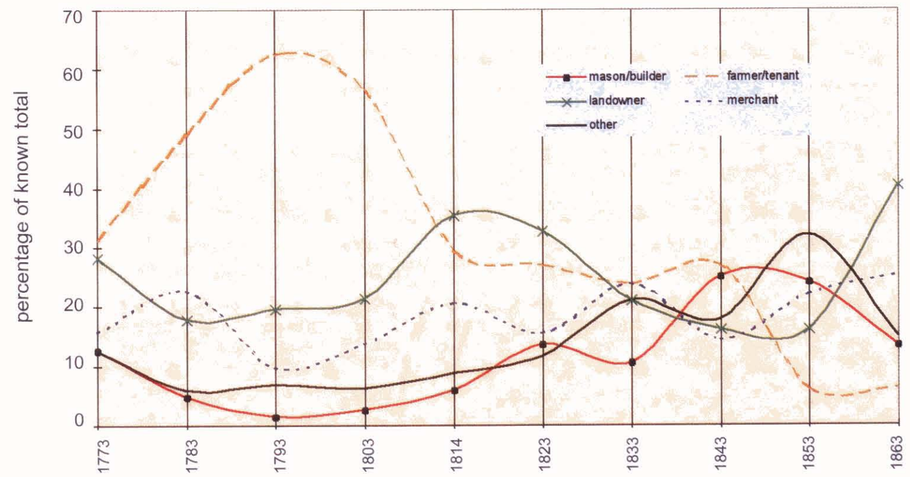



*Figure 8.5 Variation in end use (where known) of both slaked and shell lime (1773-1863)*

from farmers and tenants between 1814 and 1843. The demand from merchants is the only data that remains fairly even through the period.

***Figure 8.5***

The graph in Figure 8.5, combines the data in Figures 8.3 and 8.4 to show variations in end use of shell and slaked lime over time. The similarity of this graph to that in Figure 8.3 (Variation in end-use of shell lime), is a good illustration of the overall insignificance of the slaked lime sample group. Nevertheless, the combination of the two groups does alter the trend for agricultural use. The demand from farmers and tenants now rises to a more long lasting peak at the turn of the century and then declines only as far as a plateau of thirty-percent for the first forty years of the 19th century, before making its final plummet. The demand from landowners also now follows a slightly more even course.

***Figures 8.6a. and b. to Figures 8.14a. and b.***

The pie charts in Figures 8.6-8.14 on the following pages give a clear snapshot of the occupations of lime customers in each year. Shell and slaked lime customers are treated separately and are divided into the same fields as those used in Figures 8.3, 8.4 and 8.5. The 'unknown' sample is included in these charts and it is notable that this group tends to get smaller over time, indicating that the standard of record keeping at Charlestown improved during the 19th century.

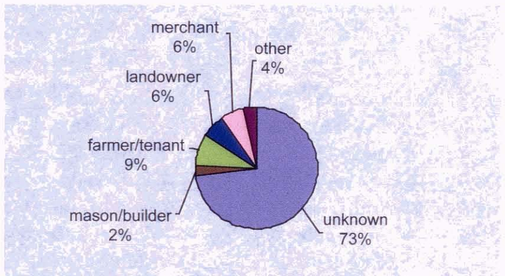



*Figure 8.6a Occupations of customers for shell lime in 1773*

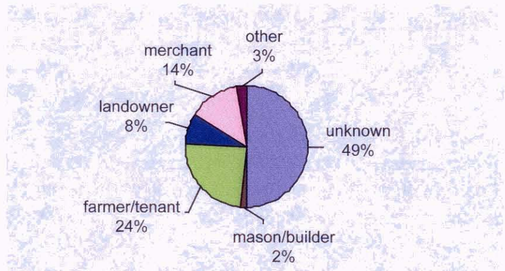



*Figure 8.7a Occupations of customers for shell lime in 1783*

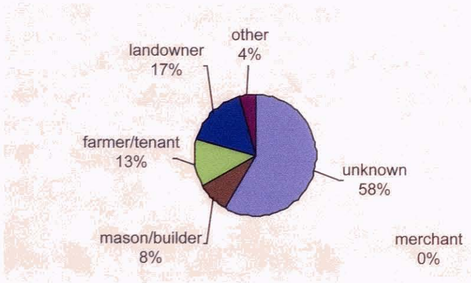



*Figure 8.6b Occupation of customers for slaked lime in 1773*

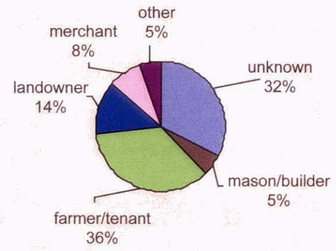



*Figure 8.7b Occupation of customers for slaked lime in 1783*





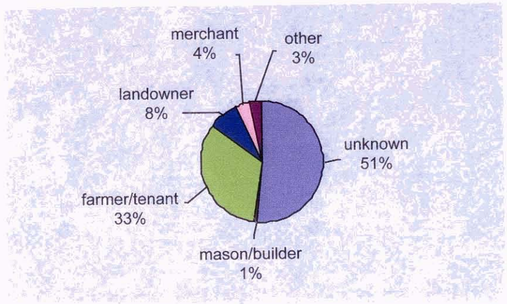



*Figure 8.8a Occupations of customers for shell lime in 1793*

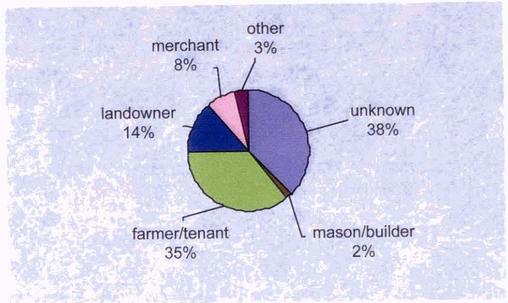



*Figure 8.9a Occupations of customers for shell lime in 1803*

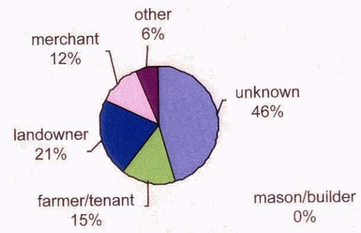



*Figure 8.8b Occupation of customers for slaked lime in 1793*

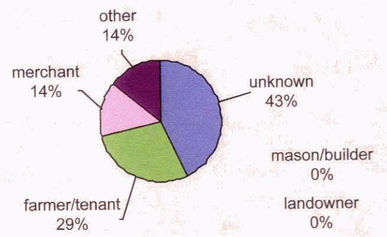



*Figure 8.9b Occupation of customers for slaked lime in 1803*

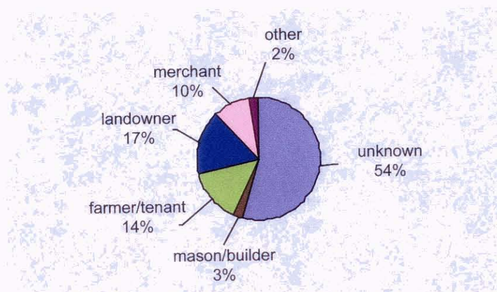



*Figure 8.10a Occupations of customers for shell lime in 1814*

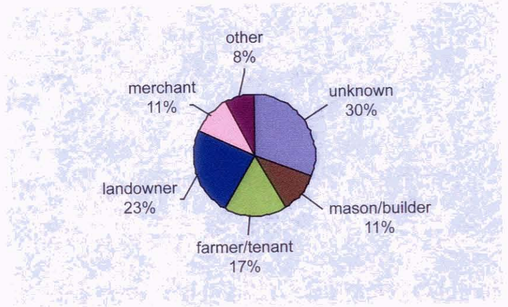



*Figure 8.11a Occupations of customers for shell lime in 1823*

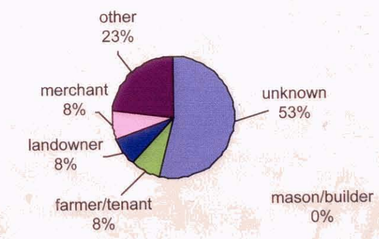



*Figure 8.10b Occupation of customers for slaked lime in 1814*

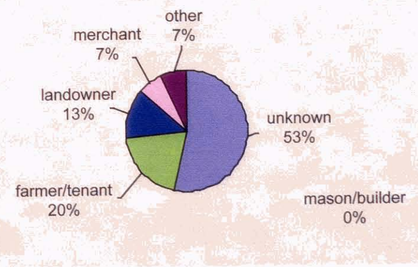



*Figure 8.11b Occupation of customers for slaked lime in 1823*

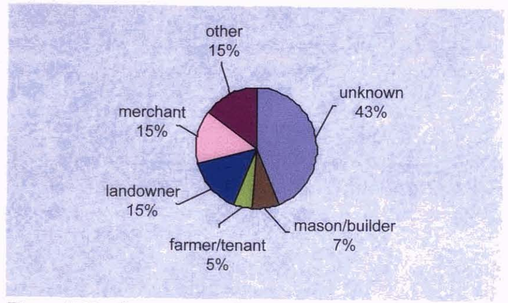



*Figure 8.12a Occupations of customers for shell lime in 1833*

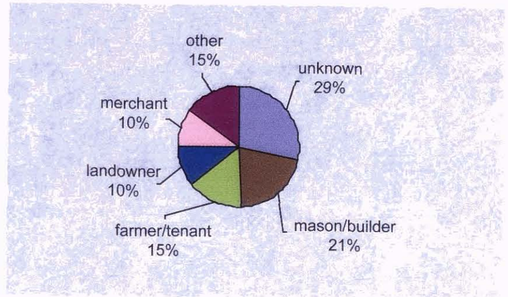



*Figure 8.13a Occupations of customers for shell lime in 1843*

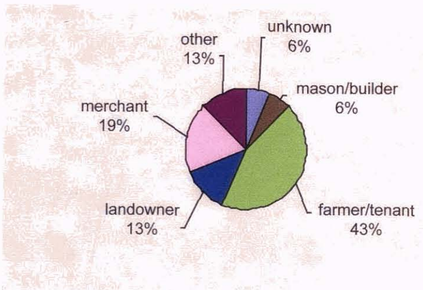



*Figure 8.12b Occupation of customers for slaked lime in 1833*

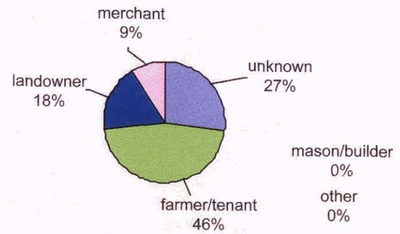



*Figure 8.13b Occupation of customers for slaked lime in 1843*

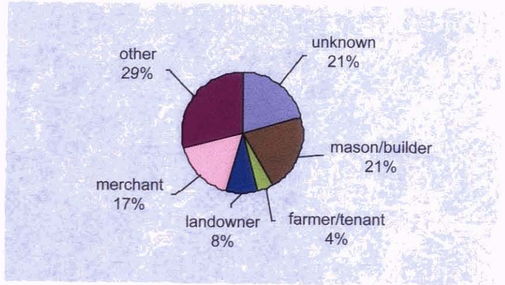



*Figure 8.14a Occupations of customers for shell lime in 1853*

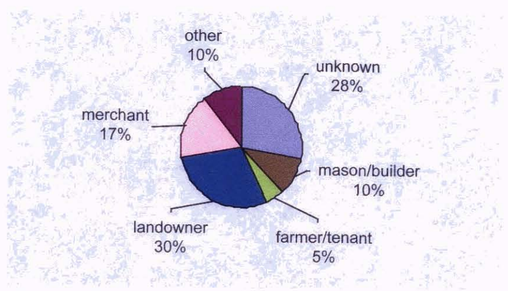



*Figure 8.15a Occupations of customers for shell lime in 1863*

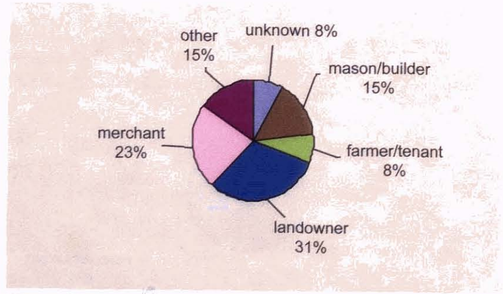



*Figure 8.14b Occupation of customers for slaked lime in 1853*

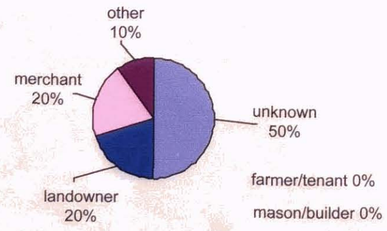



*Figure 8.15b Occupation of customers for slaked lime in 1863*



# 7 HISTORICAL LINKS

This chapter presents the results of historical 'detective work', pursuing references to places, buildings and important customers to discover further details about how and by whom Charlestown lime was used. One of the aims of this further research was to link Charlestown lime to the construction of particular buildings or monuments and to establish whether or not these remain standing. Also presented in this chapter are notes of general interest found in the Letter Books studied, these are mostly in the form of letter extracts.

## 7.1 The Honourable Commissioners of the Northern Lighthouses

The Northern Lighthouse Board was established in 1786, initially with the authority to construct four lighthouses on the Scottish coast. By the early 20th century the Board had constructed an impressive chain of lighthouses all around the coast, from the northernmost tip of Shetland, down as far as the Isle of Man. During this period the Board was dominated by the Stevensons, an engineering dynasty founded by Robert Stevenson at the turn of the 19th century.

The Honourable Commissioners purchased limestone from Charlestown regularly during the 19th century. In the ten Letter Books studied, large quantities of stone were recorded as being shipped on behalf of the Commissioners during the years 1823, 1833 and 1853, the orders having been placed by various members of the Stevenson family. Generally the records name Edinburgh, where the Commissioners are based, as the source of the order. In 1853, however, the Commissioners were shipping limestone to both North Ronaldsay and Fraserburgh.

North Ronaldsay Lighthouse was established in 1854, replacing an earlier tower built by the Commission in 1789. The date of the limestone shipments clearly matches the date of construction at this site. Charlestown limestone would have been burnt in situ to produce a mortar for the construction of North Ronaldsay Lighthouse, Britain's tallest land based lighthouse. This is the only direct match between construction and shipments to a specific location established so far.

Kinnaird Head Lighthouse at Fraserburgh, originally converted from a castle in 1787, underwent several programmes of modernisation, including one during the early 1850's. It is possible that Charlestown limestone was being used for this work.

## 7.2 Harbour Works

The hydraulic properties of Charlestown lime made it an appropriate material for use where construction was in permanent proximity to water, such as lighthouses and harbours. Several harbour contractors in Scotland exploited this quality and their orders are recorded in the Letter Books studied.

### *Leith Docks*

In 1803 John Paterson, engineer, purchased up to twenty cargoes of limestone from Charlestown, for 'Leith Harbour'. At this time (1800-1803) the Old East Dock, now filled in, was undergoing construction. The West Dock (also filled in) followed in 1811-17, with John Paterson as the resident engineer. A further twenty cargoes of limestone therefore made their way to Leith in 1814, this time ordered by the Committee for Building Leith Wet Docks. It is highly probable that limestone was being ordered in the intervening years also, but these Letter Books have yet to be studied.

Pressure for the continued enlargement of Leith Docks led to alterations throughout the 19th century and well into the mid-20th century. The next reference found in the Letter Books was in 1853, when Thomas McLean at the Harbour Works Office ordered around ten cargoes of limeshells for Leith Dock. At this time a scheme of extension to the north, including the Victoria Dock and a low water pier carrying a railway line, was being implemented. This scheme was completed in 1855.

### *Dundee Harbour*

In 1833 the Dundee Harbour Trustees purchased up to ten cargoes of limeshells from Charlestown, for ongoing harbour extensions.

A letter, dated 14th April 1833, sent by the Manager of the Works at Charlestown to James Leslie Esq., Engineer for Dundee Harbour, gives an interesting insight into the mortars being used:

"I now beg to prefix invoice of the memorandum by Mr. James Milne, Engineer, as to the way in which mortar was prepared for the Leith Wet Docks, by mixing burnt ironstone with our lime. ...I would before now have sent you a sample of our ironstone, but what we had here calcined was of inferior quality. We are at present burning a small quantity and it will be sent around with the first vessel for lime."

The burnt ironstone presumably acts as a pozzolanic ingredient, increasing the setting speed of the lime mortar despite the wet conditions. The reference to the works at Charlestown having calcined ironstone on-hand, suggests that they had it prepared for other customers –it may have been a commonly used additive.

The James Milne mentioned in the letter was responsible for an extension of the east pier and the construction of a dock to its east at Leith in 1833-5. Charlestown lime was evidently being used in these operations also.

***Kirkcaldy Harbour***

James Barr, Harbour Contractor at Kirkcaldy, is recorded as having ordered up to ten cargoes of limeshells from Charlestown in 1843.

***Granton Pier***

The middle pier of Granton Harbour was begun in 1836 to the design of Robert Stevenson, but was taken over by Burgess and Walker of London in 1837. It was completed in 1844. In the Letter Book of 1843, there are references of up to five cargoes of limeshells shipped to Granton Pier, on the orders of John Orrell and Co., Harbour Contractors.

***Lybster Harbour***

In 1853 around ten cargoes of limeshells were shipped to Lybster in Caithness, on the orders of C. Moses at the Harbour Works. Construction of a fishing harbour at Lybster had begun in 1852, designed and undertaken by Thomas Stevenson (one of the Stevenson Engineering dynasty). It is a fairly complex harbour with four basins.

The harbour underwent improvements in 1882, at the expense of the Duke of Portland and the quay walls have recently been sheet piled. It is not certain how much of the original harbour, built with Charlestown mortar, survives.

### 7.3 Glasgow Bridge

Several cargoes of limeshells were sent to Glasgow over the season of 1833 to furnish the construction of a new bridge in that city, undertaken by builders John Gibb and Sons of Eglinton Street, Glasgow. No further details as to the identity or location of the bridge are given in the Letter Book of that year, however two possible matches, built around this time, have been found. Unfortunately neither of these is still standing today.

Hutcheson Bridge was constructed over the Clyde River in 1832-4. It was designed by Robert Stevenson (already an established Charlestown customer) and erected by the contractor John Steedman. It was regarded as one of the best examples of a segmental arch bridge in the UK, but had to be taken down in 1868 as the deepening river was undermining its piers.

Also built to span the Clyde at this time was the Jamaica Street Bridge, built between 1833-5. This was a handsome seven arched bridge in classical style designed by Thomas Telford. However, its foundations were too shallow and the bridge too narrow, forcing its replacement in 1895-6.

### 7.4 Castlehill and Castletown

A frequent customer, mainly for slaked lime, during the early 1830's was one James Trail of Ratter. This gentleman was responsible for the planning and construction of a small village called Castletown, near Thurso in Caithness, which was begun sometime around 1830. The village was built to house workers from an adjacent quarry, which produced flagstones for the cities of southern Scotland and England. Close by the village at Castlehill, a harbour was constructed to enable export of the flagstones, and to the west a contemporary large house and steadings, also called Castlehill.

Between 1831 and 1837 up to five cargoes of slaked lime were shipped every year to Castlehill on the orders of James Trail. In 1834 one cargo of limeshells was also ordered and in 1836 six cargoes of limeshells accompanied three cargoes of slaked lime. No shipments were recorded in 1838, but thereafter there were sporadic shipments of limeshells until 1844.

There appears to be a case for connecting the shipments of slaked lime with the construction of the village of Castletown and perhaps the harbour as well, (the exact date of construction of the big house is uncertain). The later shipments of limeshells could have been used for ongoing building or repair work, although it seems probable that they were for fertilising the land.

Much of the village appears to remain, along with the harbour and considerable evidence of the old quarry works. The big house was burnt down in 1966 and is now demolished.

### 7.5 Callendar House, Falkirk

Between 1786 and 1815 the name of William Forbes of Callendar House, near Falkirk, appears more than that of any other customer in the Letter Books. Forbes was a 'self made man', a copper merchant from London, who had purchased Callendar House and estate in 1783. The first building on the site of Callendar House was a tower house built in 1345 by William de Livingston. Subsequent extensions had been made to the house in the 16th and 17th centuries prior to Forbes' purchase at auction.

The first correspondence with William Forbes that appears in the Charlestown Letter Books is a letter dated 28th October 1784. Forbes had evidently visited Charlestown to inquire about the lime trade and the factor, John Grant, writes to answer his queries and offer advice:





"Since I had the pleasure of seeing you here, I thought it advisable that I should delay writing you till I should have the opportunity of conversing with some of the shipmasters who are employed in the canal navigation, in order that I might with more precision state to you the real freight....During the time of open weather you can have a supply of slacked lime and limestone through the whole year and of limeshells from the end of March to Martinmas yearly. If you intend trying the experiment of burning limestone, I think that unless your demand is very great, you may begin the experiment in earthen kilns. And if you lay coal and stone to hand, you should get a boll of limeshells or a couple of bolls of slacked lime burnt for a half penny...If any further remarks of mine can be useful or tend to promote a consumpt of the articles sold here at our place, I shall be happy to communicate what I can."

There is no record of any orders or further communication for the next two years, until a letter from Grant to William Forbes appears dated 28th August 1786. This letter gives further details about shipping prices and timings and goes on to recommend that Forbes, who presumably owned coal fields on his estate, burn the limestone himself:

"As I know that you have plenty of coal, I think it is well worth your while to make trials of the limestone, as I am persuaded it will be equally cheap to you as slacked lime and probably more so."

This letter was followed soon after by an order for 100 tons of limestone, 1000 bolls of limeshells and 1000 bolls slacked lime, acknowledged by Grant in a letter dated 6th September 1786. This order was sent in almost daily cargoes over the next month; further orders for stone and shell were made and cargoes bound for Forbes continued to leave Charlestown nearly every day right up to the end of December. This became the pattern for most of the following years, with Forbes buying vast quantities of stone and some limeshells. In 1788 Forbes began sending his own coal by return of the vessels to Charlestown (letter from Grant to Forbes, dated 10th July 1788). After 1794 orders from Callendar House were for shell only. The amounts being shipped appear to dwindle after 1800, finally stopping in 1816.

Huge amounts of Charlestown limestone, shell and slaked – were transported to Callendar House and estate over a period of thirty years. Forbes was the owner of a very large estate, encompassing all of the area around Falkirk and many farms. He was a renowned 'improving landlord' and played a leading role in the development of the area. The primary use for all the lime he purchased would have been as agricultural fertiliser, indeed, this is confirmed by a letter from John Grant to Forbes, dated 28th January 1792:

"I will beg leave to observe that there are limes in various parts of the country, that when slacked fall into a much finer powder and consequently swell into a larger bulk. But you may rest assured that there are none that make a stronger cement for building or continue to benefit land longer as a manure than ours.... *From the very considerable quantity of lime that you have laid upon the sward or surface of your land, it cannot fail,* but there will be a good many pieces of limestone not thoroughly burned, that have not fallen. Where this is the case in any quantity, I would beg leave to recommend to employ old men, women or boys, to go over the ground and break the pieces with light iron bars and spread the small pieces...it will continue to benefit the land for very many years, by yielding gradually a part of its substance, similar to what sea shells is known to do."

Most of the lime provided was apparently being ploughed into the lands around Falkirk. However, it is reasonable to assume that William Forbes would have used the lime he had on hand for any building work carried out during this period. The architect James Craig designed a programme of alterations to the mansion house in 1784; letters between William and his brother Robert Forbes in the 'Forbes of Callendar Papers' (Scottish Records Office) describe the progress of this work through 1786 and 1787. William also built a mausoleum in the form of a circular classical temple in the grounds of the house. This was completed in 1812, when Charlestown lime was still being shipped to the estate.

Callendar House was extended further between 1869-1877, creating its present appearance. The Forbes family occupied the house until the 1970's after which it fell into disuse. The restored house is now partly the administrative centre for Falkirk Council Museum Service and also a visitor attraction in its own right – with 'working' kitchens and other interpretative areas including a state of the art exhibit called 'William Forbes' Falkirk'.

### 7.6 The Free Church in Fife

In 1843 the Church of Scotland was torn apart by The Disruption. This was the culmination of a ten year conflict surrounding the issue of asserting the Church's spiritual independence from the civil authorities. In May of 1843 over 450 evangelical ministers left the Church to form the Free Church of Scotland. They set about the speedy organisation of a new nation-wide church; Free Church Ministers were ordained in every parish; a church building programme produced 470 new churches within a year and 800 by 1847; 600 new F.C. schools were also set up.

This impressive construction programme leaves its mark in the Charlestown records for 1843. In the Letter Book of that year there are three direct references to Charlestown lime being purchased for new church buildings, all of them in Fife.

***Carnock***

"I understand that you applied here for brick and lime to build a church at Carnock, but as you are a stranger to me it will be necessary that you send me a letter from the church manager, or some eminent person, engaging to secure the articles paid."

*(Letter to Robert Dick, Mason, Carnock, 12th July 1843).*

Carnock was originally served by an ancient Parish Church, built in the 13th century. This was abandoned in 1840 on the opening of a new Parish Church, built by the mason James Donaldson of Crossford. In the 'Third Statistical Accounts of Scotland, Fife,' (1952) it is stated that "in Carnock village nothing at all was erected between 1840 and 1930 except the old and new Free Churches and the F.C. Manse."

Torryburn

"I observe that you have begun to drive lime to build a new church at Torryburn."

*(Letter to James Donaldson, Mason, Crossford, 12th July 1843).*

One of the earliest Free Churches is said to been built in Newmills – a small village in the parish of Torryburn – in 1843 and was dedicated a year later. In 1946 it was reunited with the Church of Scotland and in 1952 (date of publication of the Third Statistical Accounts) both churches were still in use.

Kincardine-on-Forth

"...your favour of 30th enclosing letter of credit from the Union Bank of Scotland for £7.9/ which with 5% discount settles for the limeshells furnished for Kincardine Free Church."

*(Letter to Robert Gentle Esq., Kincardine-on-Forth, 31st October 1843).*

According to the 'Third Statistical Accounts of Scotland, Perth and Kinross,' (1972), at the time of the Disruption the parish minister in Kincardine 'came out'; a Free Church congregation was formed and a church built. In 1927 this church reunited with the Church of Scotland. At the time of publication (1972), the congregation worshipped in the original parish church and the former Free Church building was used as a church hall.

Investigations of the relevant architectural guides and the statutory listings for these areas have not produced any matches of existing churches with our 1843 construction dates. It is possible that the Free Churches have been demolished since falling into disuse since the earlier references above. Alternatively they may have been altered to accommodate new uses and simply not considered to be of architectural merit. A visit to the locations in question would help to establish whether or not these three 'Charlestown lime' churches are still standing.

## 7.7 Alterations to Charlestown Harbour and Limeworks

Several references to improvements and alterations made to the Works at Charlestown were found in the Letter Books studied. These references, presented here in chronological order, contribute to the build up of knowledge about the history and construction of the kilns and the harbour at Charlestown.

***1773-Kilns***

The earliest letter on this subject suggests that some alterations had been made to the kilns prior to the new burning season of 1773. Writing to Andrew Drysdale on 17th March 1773, the factor comments:

"This [serving the customer with speed and good commodity] I will have more in my power this season, than hitherto, from the construction of our kilns which is much improven this winter."

No further details as to the nature of these alterations have as yet come to light.

***1793-Kilns and Harbour***

A letter to John Duncanson, Shipmaster, dated 26th January 1793, informs of an abandoned plan to build new kilns:

"We have a large stock of slaked lime on hand just now, a great part of it pure shell lime that was laid in for building the once intended new kilns, but they being dropped it is put among the common kind."

It appears that at this time a plan to construct new kilns was dropped in favour of less ambitious repairs and alterations to the existing kiln block. The following letter extracts show this and also that money was instead being invested in the harbour:

"The bearer, William Sibbald has been here this day and has begun to lay the foundations of the harbour work. If the contract is extended I wish you to send a copy of it to me, to settle with him for the repairs to the kilns, which is now finished and to make my observations of the harbour operations as they are carried on."

*(Letter to Mr. James Dundas, Edinburgh, 27th March 1793).*

"We have been making very material alterations, so there are only three kilns going as yet."

*(Letter to John Leslie, Aberdeen, 1st April 1793).*

"Mr. Sibbald has finished the repairs to the kiln, she was carried up circular on the inside."

*(Letter to Alexander Laing, Architect, Edinburgh, 16th April 1793).*

William Sibbald, named in these letters as being responsible for the kiln repairs and the harbour project, was a builder and engineer of some repute in late 18th





century Scotland. He was involved in a wide range of high profile construction projects. These include the spire of St. Andrews Church in George Street in 1786 and designs for the New Town around Great King Street in 1810. He also built the original Bank of Scotland on the mound in 1802-6, to the designs of Reid and Crighton – only the south elevation to Bank Street has survived later rebuilding. He was the Overseer of Public Works in Leith through most of the 1790's and was responsible for substantial improvements to Dysart Harbour in 1829 (plans for this exist in Kirkcaldy museum and library).

***1833-Harbour***

A letter dated 14th March 1833, to James Chynes Esq. of Edinburgh, discusses the construction of a sluice for scouring the new harbour at Charlestown in order to deepen it for larger vessels. The new harbour had been constructed in 1824 to provide for the increase in trade, particularly in coal. The sluicing mechanism, evidently introduced in 1833, worked by allowing a pond to fill whilst the tide was in and the gate then shut; when the tide was out, the gate could be opened to produce a surge of water from the reservoir, which flushed silt out of the harbour.

According to the letter already referred to, a mason called William Strathdee, working with a team of six masons and six or eight labourers, was undertaking the sluice project.

## 7.8 Mortar mixes

During these investigations occasional references were found to the qualities of Charlestown lime and its value as a building material. The following extract from a letter to James Gregg Esq. of Wick, dated 24th April 1843, sums these up well:

"I can confidently recommend our lime for harling as it is used for this purpose all over the country and it is preferred to any other lime in Scotland for building Wet Docks, bridges and any other buildings exposed to water and for making concrete drain tiles. I never knew an instance in this quarter of harling with our lime fail, if it was sufficiently dry before frost set in."

There were also several references to methods of slaking, proportions of sand to be used and additional ingredients used. The practice of mixing burnt ironstone with the lime, used, presumably as a pozzolanic additive, by harbour engineers at Leith, is quoted above (section 2.). A letter to Samuel Freeman Esq., Contractors Office, Trinity, dated 27th October 1863, quoted below, advises on proportions of sand and lime to be used. The writer appears to be describing 'hot mixing', where sand and quicklime are mixed; the lime reacts with moisture in the sand and slakes, producing high temperatures and a very strong bond between the sand particles and the lime binder.

"The lime shells fall from being slacked with sharp sand – two parts sand and one of lime. When the sand is not so sharp, two and a half of sand may be used. We can grind the shells for you if you choose."

A letter from ten years earlier, dated 17th May 1853, gives different advice on the proportions of sand and lime to be used, advocating an extremely lime rich mix. James Hill Esq. of Edinburgh Saw Mills, 21 Leith Walk, to whom the letter is addressed, is advised by the Charlestown Factor:

"Masons in this quarter who use our lime are in the habit of adding one half of sand to our limeshells for ordinary building purposes, but as the lime you got is to be used for pointing joints of outside walls, I would not advise you to add more than one third of sand and it will make a stronger cement."

## 7.9 Unusual lime destinations

Chapter 5 of this report, 'Mapping of destinations of lime products from Charlestown Limeworks' shows that Charlestown lime was widely distributed and used throughout most of Scotland, including Orkney and Shetland and across the border into Northern England. In the ten Letter Books studied during this research, two references to the export of lime from Charlestown to foreign shores were discovered.

The first was a letter to Mr. Henry Greig of Marstrand in Sweden, dated 23rd January 1783. This letter discusses a cargo of 43 chalders of slaked lime sent to Marstrand during the season of 1782.

The second exotic destination referred to was Halifax, USA, which is now in Canada. In 1833 a merchant by the name of Ebenezer Watson Esq. in Leith decided to try and set up a regular trade in Charlestown lime across the Atlantic. The letter from Charlestown in reply to his proposal, dated 14th March 1833, states:

"His Lordship has no objection to making a shipment of lime and coke to Halifax, US, to the extent you mention in joint account with you. That is, we will take the risk of half the first cost of these articles and to have the benefit of a better price if it should be realised for them in America. You may let me know as soon as you possibly can the exact quantity of each that will be required, in order that we may have the lime prepared."

A further letter to Ebenezer Watson, dated 15th April 1833, confirms that the shipment was sent:

"I now beg to prefix an invoice of lime and cinders by the Patriot and the Nelly, shipped by the Highlander, Captain Mitchell, for America, amounting to £19.14/."

It must be assumed that the trade was not found to be profitable, as no further reference to American shipments or Ebenezer Watson was found.

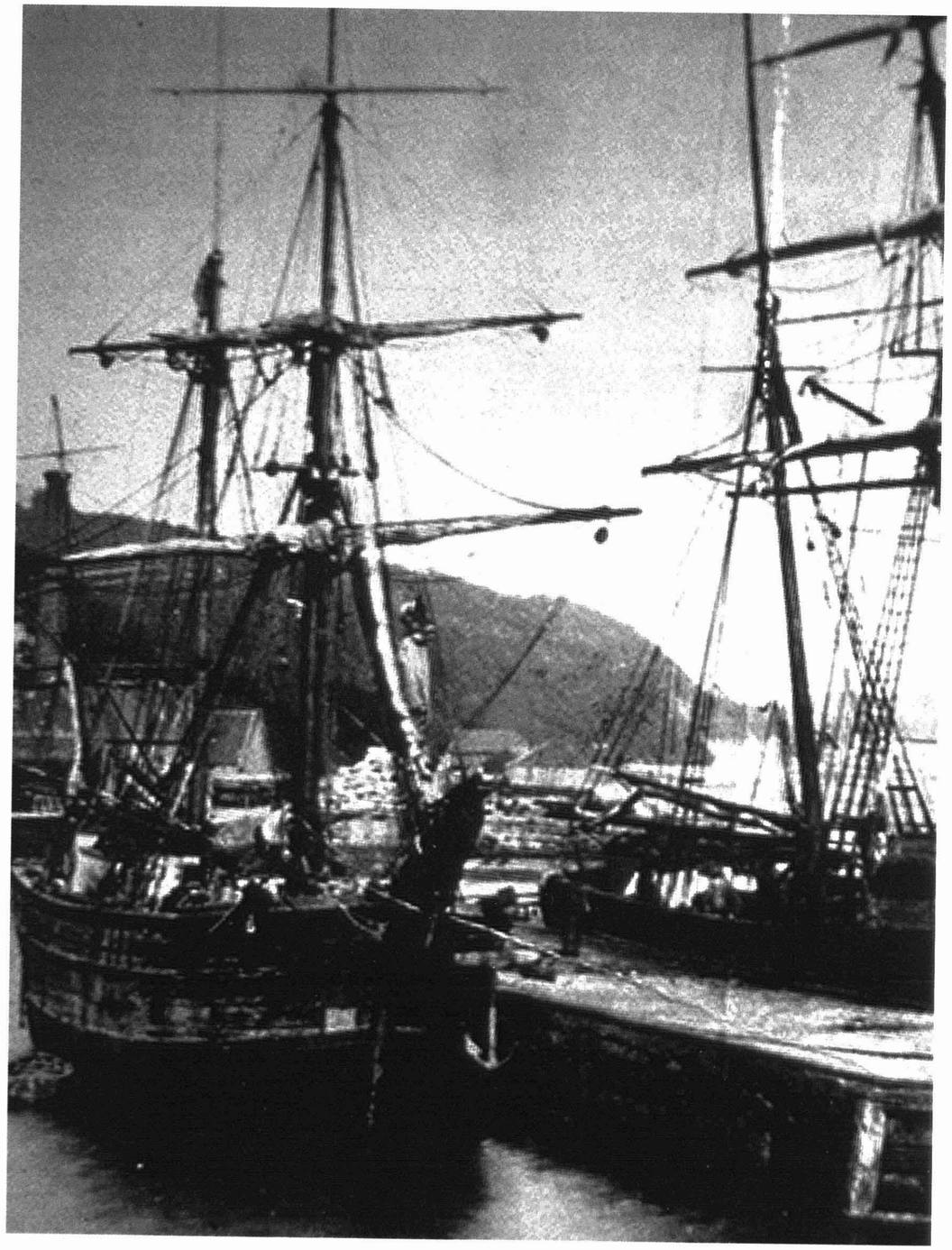


*Figure 9 Shipping the lime from Charlestown harbour (Copyright Charlestown Lime Heritage Trust)*



# 8 THE CHARACTERISTICS OF CHARLESTOWN LIME

A large amount of information about the lime being produced at Charlestown can be gathered from the archive evidence. Physical remains of lime mortars known to have been produced at Lord Elgin's works are also a rich source of information. In the section below, the documentary evidence is analysed. This is followed by and compared to, a summary of a visual and chemical analysis of a piece of Charlestown lime mortar.

**i. Conclusions drawn from late eighteenth century evidence.**

From the account given above of the lime production process at Charlestown and the many references to the quality of the product, it is possible to draw together a set of characteristics, set out below, attributable to the lime produced and the sort of mortar it would have made.

Charlestown lime would have had hydraulic properties, imparted by the variable strata of rock in the limestone seam, some of which contained quantities of clay impurities ('blaes'). Blaes were also often present in the fuel used to burn the stone - this refuse was likely to adhere to the shells in the kiln and could have imparted pozzolanic qualities to the lime.

Non-calcium impurities present in the lime would have included particles of flint which, it was acknowledged, was not adequately separated from the limestone prior to burning. Also present would be fuel ash, mixed with the lime shells in the drawing process. Particles of unburnt coal and cinders were seen also to have mingled with the lime, either in the kiln or during transportation. These impurities would have acted as aggregate within a mortar and may have acted as pozzolans - giving mortar a faster, harder set. Lime slaked from the smaller 'refuse' lime shells would have contained a higher proportion of these impurities.

Pieces of unburnt limestone would be a common feature present in Charlestown lime. This was a consequence of the hard nature of the stone, which meant that it was inadequately broken down before going into the kiln and often did not burn through. Another cause was the temperature variation inherent in the design of traditional kilns, exacerbated by the empirical nature of the loading process - fuel and stone ratios being judged by the eye of the workmen, who were acknowledged to err at times. Unburnt limestone in mortar simply acts as aggregate. Furthermore, the use of calcium carbonate as an aggregate is now known to promote the formation of a crystal structure, making the mortar carbonate more readily[59].

Inclusions of unmixed hydraulically set and carbonated lime within a mortar would have resulted where the lime cargo mistakenly underwent slaking by water or air during transportation, and hydraulic setting and subsequent carbonation were able to occur before the lime was mixed into a mortar. These particles would act as a calcium carbonate aggregate, (with a similar effect to the unburnt lime.) but with a somewhat softer and more permeable texture than that of unburned limestone fragments.

It was also acknowledged that temperature variations within the kilns sometimes resulted in part of the lime being overburnt. When lime is burned at too high a temperature it 'clinkers'. As well as taking on a dark brittle appearance, its chemical composition is altered by the formation of tricalcium silicates, which impart cementitious (hard setting) qualities to the lime. Clinkered limeshells are slow to slake, and would remain as unslaked lime inclusions, this process occurring slowly over time within the mortar.

To summarise: a mortar made from Charlestown lime would have been durable and fairly fast setting and it would have been likely to carbonate evenly. (There would have been a relatively high proportion of calcium carbonate which was not part of the lime binder.) A relatively high proportion of the calcium carbonate content of the mortar would have been in the form of 'aggregate' or inclusions, rather than binder. The lime content itself was of varying qualities and consistencies. (The aggregate would have contained particles of coal, cinders, flint and ash, in addition to the chosen sand.) As well as the chosen sand, the mortar would have contained additional 'aggregate' particles in the form of coal, cinders, flint and ash.

The evidence from which these conclusions are drawn is primarily from the eighteenth century. Strictly speaking, in order to establish knowledge of the characteristics of the lime beyond this period, more research would need to be undertaken. However, the only major changes to production at Charlestown came in the late nineteenth century. The introduction of steam trains revolutionised the means of transportation, lime now left Charlestown

59 Gibbons, SLCT Technology of Lime day Course, August 1999.

by train rather than ship. New draw kilns were also constructed, eventually superseding the original kilns. However, the only difference was really the larger capacity of the new kilns. The same manual, empirical production methods continued - we can assume with the same results - until the end of burning in 1937. The characteristics set out above will have relevance, in varying degrees, to all the lime leaving Charlestown works throughout the 170 years of production.

**ii. Chemical and visual analysis of a Charlestown mortar.**

The Scottish Lime Centre Trust carried out a mortar analysis on a fragment of lime mortar taken from their yard wall (formerly the blacksmith's yard) in Charlestown, in February of 1999[60]. This is a random rubble wall dating from the early nineteenth century. The fragment measured 100mm in diameter and weighed 130g. A standard mortar analysis procedure was carried out, involving both visual and chemical investigation. This procedure is normally used when specifying matching mortars for repair work, as well for research purposes.

The first task is a simple visual inspection of the mortar by eye and binocular microscope. At this stage the presence of any lime inclusions (where lime has been insufficiently mixed or slaked, or where stone has been overburnt or unburnt) is noted.

The mortar is then carefully crushed and dried for twenty four hours in an oven set at 110°C. The disaggregated mortar is then visually examined again and the composition of the aggregate is noted, with particular attention paid to the presence of calcium carbonate as aggregate.

The next stage of the process involves mixing the mortar with a 10% solution of hydrochloric acid. This produces a vigorous reaction which dissolves the lime binder and all calcium carbonate (such as shells, limewash, limestone aggregate and uncarbonated lime inclusions). The colour of the resulting acid solution can indicate the presence of iron, brick or coal dust in the mortar. If the acid solution becomes gelatinous the mortar was probably hydraulic.

The residue is then dried, crushed again, weighed and sieved through graded separation sieves. The non aggregate components (such as hair and clay) are identified, as are the aggregate constituents and rock types. Finally, by comparing weights prior to and after dissolving the calcium carbonate element, the ratio by weight of binder to aggregate in the original mortar can be estimated.

The following comments summarise the results of analysis on the Charlestown fragment[61]:

The sample comprises a carbonated, moderately hydraulic lime mortar. It is light grey in colour. The mortar is very binder rich, with some large pores and cavities up to 30mm across. Lime inclusions are common, up to 20mm across.

Shell fragments are estimated to form 20% of the mortar.

The non carbonate aggregate in the sample is a moderately fine grained sand, similar to that collected from Limekilns beach. It contains fragments of various rock types, including quartz, coal, sandstone, basalt, feldspar, and mica. Also present in the sample are burnt coal and slag, as well as some fragments of brick or tile.

The sample contains lime and sand in the ratio 1 : 1 by weight. It is possible that some precipitation of pore filling calcium carbonate has taken place since the mortar was mixed, increasing the apparent lime content of the sample. The original proportion will have been much less - from the nature of the fragment it is estimated to have been one part quicklime to two parts aggregate by weight.

It is evident that the conclusions about Charlestown lime drawn from documentary sources and those derived from visual and chemical analysis of surviving mortar, support and supplement one another. The laboratory work gives detailed information about proportions of binder and aggregates in the mix, the sort of sand used and the quantity of lime inclusions present. Evidence based on the archive research provides information about how and why many of these characteristics are present. For example, it has been shown that the lime used for building and repairs in Charlestown itself was produced from the 'refuse' lime shells, which picked up most of the impurities from the kilns. Hence the presence of large amounts of slag, burnt and unburnt coal in the fragment under analysis.

The beneficial qualities and complexities of historic lime mortars, as compared to those being produced today have been established. Furthermore, ample evidence has been provided to show that these differences were created by traditional burning and production techniques, which contrast so greatly with large scale modern methods of lime production. The following chapter of this paper will explore the potential for reproducing traditional style mortars for conservation work in modern day Scotland.

60 Leslie, A. 1999.

61 Ibid.



# 9 CONCLUSIONS DRAWN FROM THE ARCHIVE SURVEY

Lime played a vital role in the development of architecture and engineering in the western world, from at least the time of the ancient Greeks, until the late nineteenth century. It also had a considerable impact in other applications, most notably as an agricultural fertiliser. It is only during the last two decades that conservationists have recognised the value of lime as a building material which is not only sympathetic to other traditional materials, but is highly durable, easy to produce and sustainable. This paper must be seen in the context of this revival of lime technology - part of the process of relearning through scientific and historical investigation, the wisdom built up by generations of experience and neglected since the beginning of the twentieth century.

International conservation philosophy, enshrined in the various charters, recommends that all materials used for the purposes of conservation and repair on historic buildings should respect traditional practices[62], be compatible with the expression, texture and appearance of the original material[63] and meet the requirements of the local physical and geographic conditions of the site[64]. Although modern lime mortars are far more compatible with historic fabric than the ill-advised cement mortars applied since the beginning of this century, they remain only distant cousins of traditionally produced lime mortars. The contrasting thin sections of modern and surviving historic mortars illustrated in this paper reveal the structural and physical differences between the two. Empirical experience of problems and failures associated with recent lime work, compared to the longevity of historic mortars, confirms that there is a problem. Limes produced by modern production methods do not perform in the same way as the traditional material and can only withstand the Scottish climate when gauged with hydraulic lime.

The detailed evidence about lime production methods at Charlestown Limeworks drawn from Letter Books, dated 1770-1792, in the archive of the Earl of Elgin, supports the view that historic mortars are more complex and less uniform in their structure than their modern counterparts. Whilst it is apparent that lime mortars do change to some extent over time, the major disparities between the two are clearly shown to be created by the means of production and processing. Traditional lime burning methods can result in the presence of impurities, such as coal and slag in the resultant mortar, as well as lime inclusions and fragments of unburnt and overburnt limestone.

The documentary investigation has also revealed information about the techniques, such as slaking, used at Charlestown. Furthermore, it has provided an insight into the way lime was treated and how it was thought about as a material during the eighteenth century. The lime produced at Charlestown was quite roughly handled, burning was a dirty, dangerous and unmeasured process, all done by eye, with little 'scientific' procedure involved. This picture is a great contrast to the high tech plants of the modern lime industry, which in fact produce highly processed, chemically simple limes. The more primitive traditional methods create a much more sophisticated product.

The essence of the problem is that building limes need to be treated as entirely different commodities to the pure limes being produced for the chemical and metal industries. Composite mortars, using a mixture of modern limes in conjunction with other additives, to create a more complex binder, could be more widely used to replicate the qualities of traditional mortars. However, the best and most effective solution is to re-establish a lime burning industry in Scotland, the product of which is aimed specifically at and meets the requirements of the building and conservation industries. The success of new and existing traditional lime burning ventures in England, the growing demand for lime in Scotland and the establishment of the Experimental Lime Kiln at Charlestown - potentially a 'test bed' for larger scale operations - all substantiate the feasibility of this aim.

There is vast scope for further research into all aspects of the lime industry at Charlestown. The archive at Broomhall contains correspondence and ledgers accumulated over the 150 years of industrial activity at Charlestown, as well as several estate maps. The research on which this paper is based covered only twenty two years of this rich resource. Chemical and physical experiments also need to be carried out on the various composite mortars suggested in the previous chapter, in order to scientifically establish their worth as replicas of traditionally produced mortars in the eyes of the conservation industry.

62 Athens Conference, 1931, Article IV, Venice Charter, 1964, Article 10, Burra Charter, 1979, Article 4.

63 Thessaloniki Charter 1992.

64 Declaration of Tlaxcala 1982, Article 7a.

# 10 CHARLESTOWN ORAL HISTORY INVESTIGATION

***Summary of interview transcripts***

These two interviews were undertaken by Lorna Lewis of Scotia Archaeology on behalf of the Environmental Trust of Scotland.

Both gentlemen interviewed were former employees at the Charlestown Limeworks Co. and lived in Charlestown for most of their lives. Although the subjects covered in the interviews were wide ranging, the lime production process at Charlestown was discussed in detail. Information relevant to the LIMEWORKS project is summarised here.

***Interview with Mr Thomas Methven***

PERSONAL INFORMATION

1 Mr Methven was born on 14th September 1910, in Charlestown. He lived for most of his life in South Row – one of the original cottages of the planned village. Between 1924 and 1952 he worked as a general labourer at Charlestown Limeworks.

2 His father was an engine man at the limeworks – operating a steam engine which operated two crushing mills. (By the 20th century much of the output from Charlestown Limeworks was crushed limestone, rather than burnt limestone.) The stone was ground down to powder for agricultural use, to chips for path surfacing etc, and to a powder for use in coal mines, where it was spread on passages before blasting.

3 Mr Methven worked as a crusher when he first started, aged 14, in 1924.

QUARRYING

1 By 1924 all the quarrying at Charlestown was done in caves, rather than open cast.

2 Bogies (carts) of limestone, holding 22 –23 cwt, were hauled up from the quarry by the ginhead engine, which then lowered them down the sloping track, through the tunnel under the road, to the kilnhead.

BURNING

1 Loading and drawing of the kilns was a continuous process, all done by shovel.

2 Coal was shovelled in about a foot or two from the edge of the kiln pot and then limestone was layered on top, with big stones to the outside and smaller ones to the inside.

3 Only coal and stone were shovelled into the kiln – no rubbish such as shale or soil went in.

4 Proportions of stone and coal were varied according to the heat in the kiln. If there was enough heat the kilnsmen would load 10 bogies of stone to two of coal; if it was judged that more heat was needed, 6 bogies of stone and 2 of coal went in. This judgement was made by eye; Mr Methven recalled that usually one of the more experienced workers would make the decision.

5 The amount of heat generated in the kilns was largely dependent on the quality of the coal.

6 The burnt lime was drawn using shovels from 'eyes' at waist height, and shovelled into waiting bogies.

7 He describes burnt lime as 'largely white, some a bit yellow, with perhaps some brown through it'. The colour depended on how well burnt it was – occasionally the 'shells' (quicklime pieces) got sent back up to the top to go back through the kiln again.

8 Lime shells are described as being of varying sizes – possibly a bit smaller and definitely a lot lighter than when they went into the kiln.

9 At the end of the day the kilns were filled and left overnight. Reloading in the morning was a busy task.

10 In Mr Methven's time there were two kilns in operation, with a third one lit during the busiest season, which was April when the farmers need lime for the fields. These three kilns were the western most ones (kilns 12, 13 &14) and were the latest built.

PROCESSING

1 Not very much slaking was done during Mr Methven's time. He describes the lime (shells) as being spread out and water 'put on top of it' to produce hydrated lime powder. The lime swelled up to twice its size. This was shovelled back into bags.

2 Slaking was carried out underneath the old unused kilns along the road.





3 Bags of lime hydrate were stored in the garage (under the disused kilns) and loaded into lorries whenever orders came in. He remarks 'it saved the builders frae waitin' on it (lime from the kilns). They could mix it with sand and practically start building with it. The heat was taken oot o' it.'

REPAIRS TO THE KILNS

1 The kilns would be completely emptied out for repairs. This involved replacing parts of, or the entire, lining made of firebricks and fireclay. Mr Methven calls this the 'lethering'.

2 Repairs were undertaken by the team of workers usually employed on the kilns, with perhaps an additional labourer.

WORKING CONDITIONS

1 Kiln workers did a bit of everything on site.

2 Mr Methven generally remembers 3 or 4 men working on the kilnhead at this time and 4 men at the bottom drawing the lime.

3 The men wore overalls: he remembers no protective clothing being worn. Mr Methven remembers having holes burnt in his fingers by the lime. He comments "Oh they were rough days in thae days!'

4 No accidents are recalled at the limeworks in his time and he does not think the smoke caused any respiratory complaints – although he is asthmatic himself. Indeed he describes mothers bringing children with bronchitis etc down to the kilns to breath in the 'healing' sulphurous fumes!

5 Mr Methven started work on wages of 10 shillings a week; this had increased to 37 shillings a week when he married in 1937.

6 There was no union for the workers.

GENERAL INFORMATION

1 Mr Methven described a thick yellow fug which blew from the kilns over the village – this was worst when there was a westerly wind.

2 Once Charlestown quarry closed down in the mid 1930's limestone was brought from Roscobie quarry (an old limeworks north of Dunfermline). No burning, only crushing, was carried out at Charlestown. The company had two kilns going at Roscobie but this venture did not last very long.

3 There was a steam engine up on the kilnhead area which powered everything until the electricity cable arrived (no date for this).

***Interview with Mr William McDonald***

PERSONAL INFORMATION

1 Mr McDonald was born on 9th September 1911, in Inverkeithing, moving to live in Charlestown when he was 6 years old. His family lived in Double Row, one of the original houses of the planned village.

2 He worked on and off for the Charlestown Lime Co. doing various jobs for many years, then between 1947 and 1957 as a lorry driver.

QUARRYING

1 Explosives for quarrying were kept in a well-built brick magazine in the woods near the quarry.

2 In his day a boring machine was used to drill holes in the rock, which were filled with explosives. Previously this was done by hand with a big long chisel, hit with a hammer and turned.

3 Once it had been blasted down, the stone was broken up with a big hammer (he calls it a metal) and loaded into bogies.

4 A pump kept water out of the mines.

BURNING

1 Mr McDonald names Valleyfield as one of the local collieries which fuel came from. Railway wagons brought fuel right up to the kilnhead. The coal is described as being small chips 'it was nae big'.

2 He gives a description of two men loading the kiln using shovels. Again it is asserted that no rubbish, such as shale, went in. Later he mentions watching for stones in the coal and limestone as he shovelled and flinging them out.

3 The loading was all decided by eye.

4 The iron doors on the kilns (at the drawholes) were usually kept open – he recalls very seldom seeing them shut.

5 He describes the burnt stone as 'roughish', some a browny colour, some white. Builders and customers intending to make whitewash (limewash), picked out the whiter shells.

6 Two kilns were in operation during his time, with a third kept ready for firing in case big orders came in.

PROCESSING

1 Mr McDonald describes the lime being taken in small carts around the back of the kilns (where there is a vaulted passageway) and pulled up to the kilnhead area on an 'endless' pulley with a leather strap. (Previously the lime had been taken up here to the slaking sheds but, by the 20th century, it

appears that it was being crushed to make powdered quicklime. We also know that limestone was being crushed at Charlestown by this time, for use in agriculture and mining.)

2 He describes the quicklime as being crushed by stone wheels in a pan mixer down to the size of peas. It was then transferred into a crushing machine, where a big heavy wheel hammered it to a powder.

3 This was then shovelled into bags – originally made of jute, later paper.

4 He recalls that not very much slaking was done in his time, but describes how they spread the quicklime out in a shed and sprinkled water on it to create a powdered hydrate.

### REPAIRS TO KILNS

1 When a kiln was in need of repair they let it burn down and emptied it.

2 He describes removing the old brick lining, standing on a ladder pushing a hooked rod behind the bricks and pulling them off in clumps.

3 The new lining was built back up with fresh brick. He names Andrew Bryce, brought in from elsewhere to do this task.

4 To reset the kiln after repairs, brushwood was put in first, then some thick timber sleepers, then coal and limestone in layers to the top, then it was lit.

### WORKING CONDITIONS

1 Again Mr McDonald remembers no protective clothing being worn by the workers. He recalls tying his handkerchief over his nose and mouth to keep the dust out.

2 He doesn't remember any accidents occurring at the works while he was there, or any subsequent illness.

3 He mentions a head man and a 'gaffer' who would supervise the men, but claims they (the workers) did not bother too much about those in charge.

4 Mr McDonald describes a night shift during the busy season. Four men (one to draw, one to operate the pan mixer, one to fill bags and one supervising) started work at 10.00pm.

5 Normal shift was from 7.30am to 4.30pm. When busy they often worked to 8.00pm.

6 The men were paid less than £2 per week. Everyone on the kilns was paid the same.

7 There were no unions for the men. He says they were too scared too strike or seek pay rises due to the scarcity of jobs in the 1930s.

### GENERAL INFORMATION

1 The quarry and kilns at Roscobie (a nearby limeworks) had ceased working by 1957.

2 Charlestown kilns and quarry were not operated after 1935. Only the crusher (grinding stone from Roscobie), the depot and lorry deliveries to farms continued after 1935.

3 The lorry was kept in a garage under one of the disused kilns.



# 11 CONSERVATION WORKS TO KILN 11

### Charlestown Limeworks Kiln 11

The project kiln, Kiln 11, forms part of the larger complex of 14 kilns constructed against the rock cut cliff face from Charlestown sandstone, excavated on site.

### Objectives of the project

The objectives of the works to Kiln 11 were to secure the fabric of the kiln in order to minimise, as far as possible, further deterioration, to improve public access and to provide information on the significance and the working of the kilns.

Within these broad objectives, work was undertaken to accepted conservation standards, aiming to minimise the extent of intervention, to ensure reversibility of any interventions and to avoid the use of materials or treatments which might be damaging to the historic fabric.

The works themselves also served to provide an opportunity for training, and for research in the broader field of traditional lime mortars.

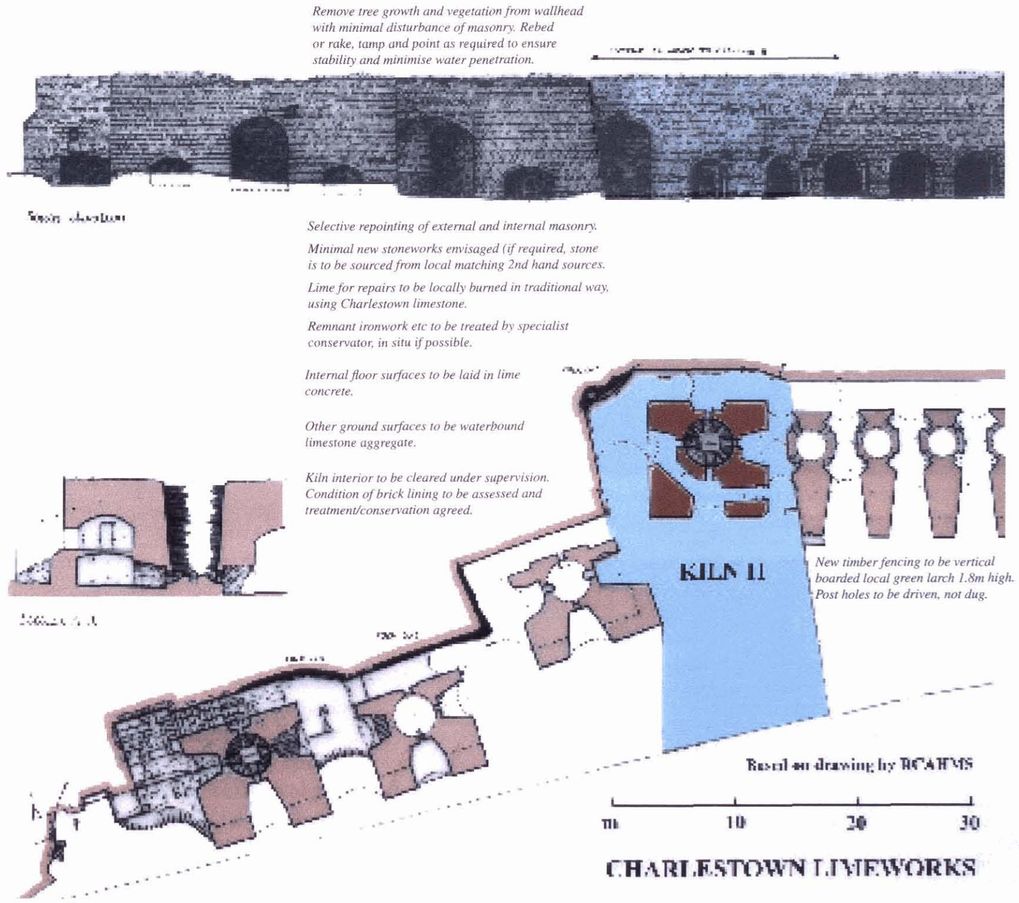



*Figure 10 Part plan of Charlestown Limeworks detailing conservation measures (Copyright Scottish Lime Centre)*

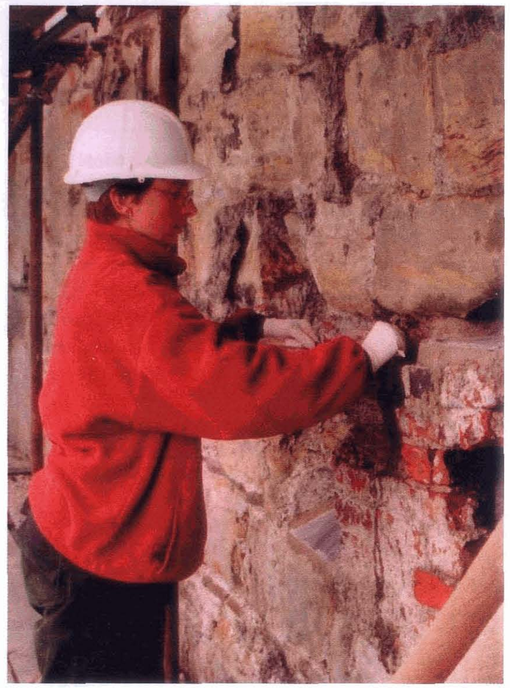


*Figure 11.1 Conservation work on Kilns in progress (Copyright Scottish Lime Centre)*

*Figure 11.2 Conservation work on Kilns in progress (Copyright Scottish Lime Centre)*

*Figure 11.3 Conservation work on Kilns in progress (Copyright Scottish Lime Centre)*

**Organisation of the project works**

The practical conservation works were undertaken by two full time building Conservation Fellowship students. (Over recent years the Historic Scotland Building Conservation Fellowship Programme has provided 2-year placements for young people from relevant industry or academic backgrounds wishing to develop a career in practical building conservation. Two students on placement with the Scottish Lime Centre Trust were responsible for the conservation works at Kiln 11). Under the general supervision of the Scottish Lime Centre Trust staff and a consultant architect, the students undertook the preliminary survey of the kiln, prepared specifications for the proposed works, priced, organised and managed the works, hiring additional site workers and, where required, arranging subcontract works. The majority of the conservation work, including all masonry, was undertaken by the students themselves.

Archaeological investigation was undertaken in two stages. The first stage was an exploratory investigation which established that features of archaeological interest were present at a shallow depth within the former working area in front of the kilns. During the main works on site, the ground surface was protected from damage, and further excavations were undertaken on completion of the works. These revealed evidence of two former narrow gauge rail tracks which appeared to have carried hand propelled wagons used for collecting quicklime from the kiln openings. Concrete pads from the base of a later hoist/loading gantry were also present.

**Preliminary evaluation of the kiln site**

The site as a whole was fenced but the condition of the fencing was not adequate to prevent access to the dangerous structures of the kilns. The ground at the base of the kilns was covered with low-growing vegetation, and a considerable quantity of dumped litter and larger items. An area within the site was permanently waterlogged. The kiln head area was more securely fenced to prevent public access and was overgrown with vegetation, but there was no safety fence at the open edge.

At the start of the project a preliminary archaeological investigation was undertaken at the lower ground level in the area immediately associated with Kiln 11 to establish whether any archaeological information remained below ground. This investigation identified features of interest and the whole of the ground surface was protected from disturbance during the contract works.

The existing masonry fabric of the kiln was closely inspected and found to be structurally sound but with localised areas of loose stonework, and significant deep rooted vegetation growth in the masonry. Significant





*Figure 12 Kiln 11 after conservation (Copyright Scottish Lime Centre)*

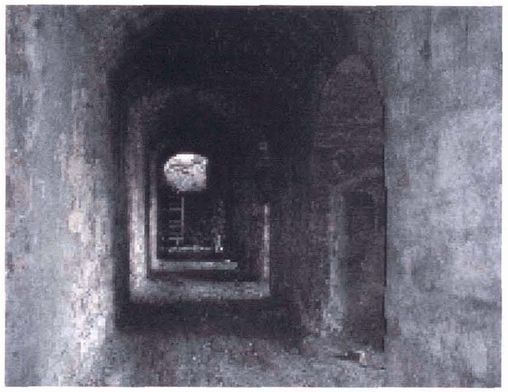


*Figure 13 Vaulted passageway at rear of kilns (Copyright Scottish Lime Centre)*

cracks in the wall face, due to high kiln operating temperatures, were not considered to be affecting the structural stability of the kilns. Such cracks are commonly found to affect old lime kilns.

**The conservation works**

Due to the proximity of houses to the site and the danger posed by the unfenced kilnhead and loose masonry, the site was securely fenced at the start of the project.

The extent of vegetation growth in the masonry was such that removal was necessary before the working scaffold could be erected. This was undertaken by a specialist tree surgeon. Early scaffold access was provided to the structure to allow remaining vegetation to be removed, roots to be treated and close inspection to be made to assess the extent of necessary repairs. Arrangements were made for the preparation of suitable lime mortars for carrying out the works, including sampling, analysis and specification by the Scottish Lime Centre.

Surface debris and rubbish was cleared from within the structure. Surface vegetation was removed from the ground surfaces within the site area. Remaining visible vegetation growth was removed from the masonry surfaces of the structure, and roots were extracted where this could be done without significant disruption of the masonry.

Loose masonry was consolidated, filling deep open joints, cracks and recesses to prevent further erosion. The mortar used was prepared from Charlestown limestone, quarried, burned and slaked for the project, and matched to samples previously analysed by the Scottish Lime Centre. The majority of the mortar was used as 'hot mortar' prepared from fresh quicklime.

Evidence of fixings and slots in the masonry face were retained and, where necessary to discourage the nesting of pigeons, angled pieces of slate were set into the recess.

The upper ground surface at the edge of the kilnhead area was carefully cleared of recent earth and vegetation to expose surviving wall head stones and fixings for

the former kilnhead 'safety rail'. Loose stones here at this vulnerable location were rebedded on the specially prepared 'hot lime' Charlestown mortar, and turf relaid. One new stone was required at the exposed angle of the wall head. This was cut from a secondhand block of Charlestown sandstone and discreetly dated.

Surviving ironwork associated with the draw holes and sundry fixings etc, was treated with a phosphoric acid based solution to convert iron oxide to a protective layer of iron phosphate, to slow down the rate of decay without altering the appearance.

Four surviving timber beams forming a 'bridge' at the re-entrant angle of the kilnhead were treated with a proprietary product containing acypetacs-zinc and permethrin, followed by a microcrystalline wax. Brickwork infill associated with these beams was repointed in lime mortar.

Provision was made for installing future lighting, by laying ducts within the new floor layer at the lower level.

### Archaeological investigations

Archaeological investigation was undertaken in two stages. The first stage was an exploratory investigation which established that features of archaeological interest were present at a shallow depth within the former working area in front of the kilns. During the main works on site, the ground surface was protected from damage and further excavations were undertaken on completion of the works. These revealed evidence of two former narrow gauge rail tracks which appeared to have carried hand propelled wagons used for collecting quicklime from the kiln openings. Concrete pads from the base of a later hoist/loading gantry were also present.

### Interpretation and public access

Presentation of information on the Scottish conservation works has been by means of a permanent on-site interpretation board and additional information placed in the exhibition at Charlestown Workshops, the training facility of the Scottish Lime Centre Trust. Information for the presentations was sourced from local archive material and SLCT expertise.

The site interpretation board showing a detailed cut-away drawing of the kiln in operation, set within a perspective view of the harbour with ships loading cargoes of lime, is located on the site. This is supplemented by further interpretation in a permanent exhibition in the nearby Charlestown workshops (Scottish Lime Centre's specialist training facilities). Local guided walks are available during the summer months and include the lime kilns site within a tour of the industrial history of Charlestown village.

The second part of the interpretative information was provided within the Charlestown Workshops exhibition, with funding from another source, and project funds used for additional published information.

On completion of the works, new steel bar gates were designed to fit discretely back within the passageways between and behind the kilns, to prevent unauthorised access to the unsafe parts of the complex. The remaining parts of the kiln complex have been separated by fencing from the accessible area. Direct access for visitors is available to the conserved Kiln 11. Ground surfaces adjacent to the kiln were reinstated after completion of the archaeological excavations, using a mix of specially burned Charlestown quicklime mixed into the existing overburden and hand compacted on site. This replicates the working surface exposed during excavation and derived from the kiln operations themselves.

### Outcome

The project work has secured the fabric of Kiln 11 and improved public access, but, at present, the other kilns remain in a derelict condition.



# 12 TRAINING WORKSHOPS

### Training workshops

Since 1994 the Scottish Lime Centre Trust has been providing training for underpinning knowledge and traditional building skills for the repair and conservation of masonry buildings. Within the LIMEWORKS project, in addition to other regular training activities, 12 one-day workshops covering the technology of lime (ie the theory and chemistry of lime, the performance of lime mortars and reasons for using lime, limeburning, slaking and mortar making) (see typical programme) and a 4-day course for stonemasons have been held at Charlestown.

### Student information for 'Technology of Lime' course

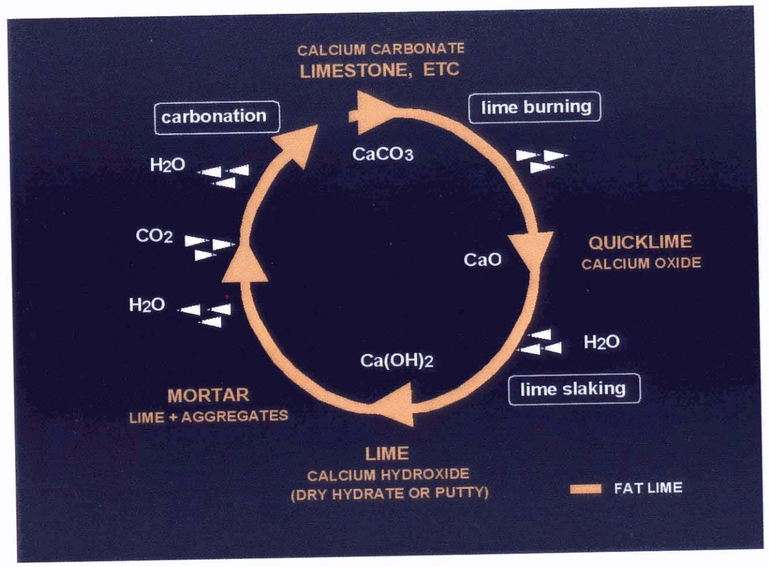
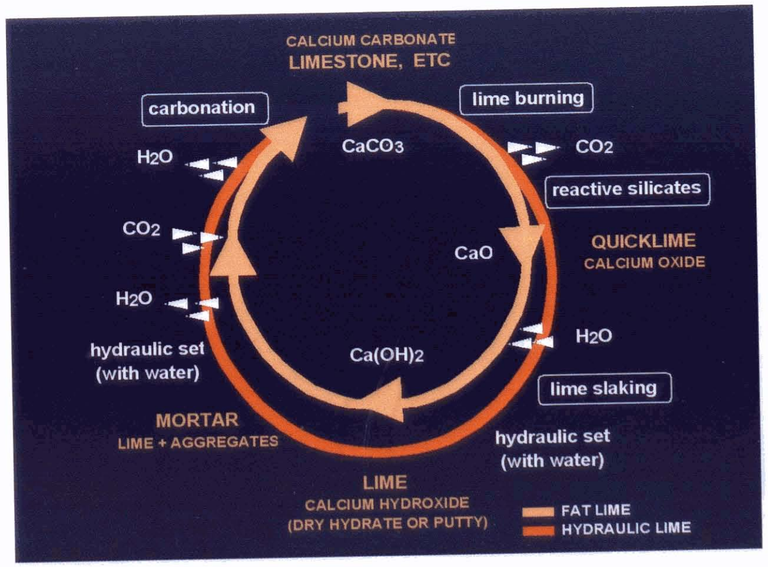



*Figure 14.1 Simplified diagram of the lime cycle (Copyright Scottish Lime Centre)*




*14.2 Lime Cycle for hydraulic limes (Copyright Scottish Lime Centre)*

*15.1 Firing the small kiln (Copyright Scottish Lime Centre)*

*15.2 Slaking lime (Copyright Scottish Lime Centre)*





*15.3 Applying limewash (Copyright Scottish Lime Centre)*

*15.4 Making ashlar putty (Copyright Scottish Lime Centre)*

# CHARLESTOWN WORKSHOPS
*at the*
# SCOTTISH LIME CENTRE

### TECHNOLOGY OF LIME

| | |
|---|---|
| 9.30 | Coffee and general introductions. |
| **10.00** | **Theory** |
| | Introduction |
| | *Health and safety - Historic background - Uses for lime mortars* |
| | Technology |
| | *Pure limes - Hydraulic limes - The hydraulic setting process* |
| | *Performance of hydraulic limes* |
| | Materials for lime mortars |
| | *Choosing the right type of lime - Aggregates/sands for lime mortars* |
| | *Methods for making lime mortars* |
| 11.00 | Coffee |
| **11.15** | **Practical** |
| | *Properties of a variety of limes* |
| | *Mortar production* |
| | *Its use and aftercare* |
| 12.45 | Lunch and discussion |
| **1.30** | **Theory** |
| | *Aggregates, mortar sampling and analysis* |
| **2.00** | **Practical work.** |
| | *Slaking lime from the kiln* |
| | *Mixing basic lime mortars* |
| | *Mixing a gauged lime mortar* |
| | *Mixing a hot lime mortar* |
| | *Limewash* |
| 4.30 | Clean up |
| 4.45 | Review and discussion |
| 5.00 | Finish |

*Typical 'Technology of Lime' timetable for one-day workshop*



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# GLOSSARY OF TERMS

**Aggregate:** any material which, when combined with a binder, forms a mortar. This can include sand, crushed rock, brick dust, or any other appropriate filler.

**Air limes:** limes that set through carbonation, rather than through chemical reaction with water. So called because they set in air.

**Air slaked lime:** The degenerate product formed naturally when quicklime is stored in moist air.

**Argillaceous:** containing clay substances. May be used in connection with some types of sandstone.

**Ashlar:** stones with hewn or polished surfaces built with tight joints, to be seen as face work.

**Boll:** a measure of volume, 1 boll = 2 bushels (1 bushel is a measure of dry or liquid goods equivalent to 8 gallons).

**Binder:** material that binds together the aggregate particles in a mortar, e.g. the lime, gypsum, clay, cement, etc.

**Calcareous:** Containing chalk or other forms of calcium carbonate or containing limes

**Calcium carbonate:** chemical state of the raw limestone material, and of fully set lime mortars.

**Carbonation:** the process by which fresh lime mortar re-absorbs carbon dioxide in moist conditions and reverts to calcium carbonate. As a result of this process the lime mortar becomes relatively harder, more stable and less soluble.

**Cement:** a quick-setting binder for making mortars. Commonly available as portland cement. Historically, natural cements were also available, produced from naturally occurring combinations of limestone and clay.

**Cementitious:** a description of the setting property of a mortar, by the chemical action of formation of tri-calcium silicates and aluminates.

**Coarse stuff:** a mixture of lime and coarse sand or other aggregate used as lime mortar.

**Concrete sand:** a marketed commodity, of siliceous aggregate comprising a range of particle sizes including small pebbles or grit, suitable for use in making concrete. Also generally suitable for use in lime mortars, harling, etc.

**Dry hydrate:** hydrated lime in which quicklime has been slaked with just enough water to form calcium hydroxide in the form of a dry powder.

**Eminently hydraulic lime:** lime prepared from limestone containing a high proportion of re-active silica or silica/alumina, often in the form of clay minerals. Hydraulic limes have the ability to set in wet conditions, unlike non-hydraulic limes. Approximately equivalent to European classification NHL5.

**Fat lime:** non-hydraulic lime, consisting almost entirely of calcium hydroxide, plus water. Also known as 'air lime'.

**Fatten up:** the slow absorption of water into an uncarbonated lime material, making it more plastic.

**Feebly hydraulic:** a hydraulic lime which has the lowest reactive silica / alumina mineral content, and therefore has a weak chemical set in conjunction with its rate of carbonation. Approximately equivalent to European classification NHL2.

**Friable material:** a mortar that can be easily crumbled. This can also be used to describe the state of the masonry.





**Gauging:** literally, the measuring of materials in combination. Used to describe a measured amount of material added to a lime mortar in order to modify the properties of the mortar.

**Harling:** a thrown, or cast on, finish of lime and aggregate.

**HTI:** a finely ground powder with pozzolanic properties, derived from high-temperature ceramic insulation material.

**Hydrated lime:** see dry hydrate. In modern building practice the term is commonly used to describe non-hydraulic lime powder, ie 'builders' lime', used in modern cement / lime / sand mortars.

**Hydraulic limes:** lime prepared from limestone containing reactive silica or silica / alumina, often, but not necessarily, in the form of clay minerals. These give the mortar a chemical set that is quicker and harder than the carbonation of pure limes, and a degree of ability to set in wet conditions. Limes can be feebly, moderately or eminently hydraulic. Hydraulic limes come in a range of strengths – NHL2 (feebly hydraulic), NHL3.5 (moderately hydraulic) and NHL5 (eminently hydraulic), are the most commonly used descriptions. Hydraulic limes cannot normally be stored as putty for any length of time because the chemical set will cause them to harden, and they are therefore stored as dry hydrate. Also known as 'water lime'.

**Lime (hydraulic):** See Hydraulic lime.

**Lime (non-hydraulic):** See Non-hydraulic lime.

**Lime putty:** hydrated lime which has been slaked from quicklime using sufficient water to form a thick liquid and subsequently settled out to a putty during storage.

**Lime shells:** an old term for quicklime, related to the weight loss from firing limestone in a lime kiln. The result, a 'shell' of its former self but the former limestone remaining the same shape and size. Typical weight loss is around 50%.

**Lime-water:** a saturated solution of calcium hydroxide in water. Left when lime putty settles out of slaked lime. Used for consolidation of porous surfaces.

**Limewash:** a form of paint, a suspension of lime (putty) in water.

**Moderately hydraulic lime:** lime with a moderate degree of hydraulic set. Approximately equivalent to European classification NHL3.5. See Hydraulic lime for definition of different degrees of hydraulicity.

**Mortar:** any material which can be worked or placed in a plastic state, becomes hard when in place, and which can be used for bedding, jointing or finishing the materials forming the component parts of a wall.

**Milk of lime:** a free-flowing suspension of hydrated lime (lime putty) in water, in such proportion as to resemble milk.

**Non-hydraulic lime:** a pure lime, consisting almost entirely of calcium hydroxide without reactive silica or silica / alumina. Non-hydraulic lime mortars harden only by slow drying and carbonation, and cannot set in wet conditions. Also known as fat lime or 'air lime'.

**PFA:** pulverised fuel ash is a waste product from power stations; used as a pozzolan in modern cementitious mortars and grouts. Tends to produce a very hard set.

**Pigment:** colouring material, not normally used in lime mortars.

**Portland cement:** the common form of cement made by grinding clinker formed by firing clay and limestone at high temperatures.

**Pozzolans:** materials containing fine particles of reactive silica and alumina, and sometimes iron oxides, which will react with calcium hydroxide and water to produce a chemical set in mortar, similar to the set achieved by hydraulic limes.

**Putty:** see Lime putty.

**Quicklime:** calcium oxide. A highly caustic material produced by burning limestone. Quicklime is slaked with water to produce lime for building works.

**Relative bulk density:** a method of comparing the weight of different materials for a given volume. A material with a low rbd will weigh less per given volume than a material with a high rbd.

**Salt efflorescence:** the crystallisation from solution of soluble salts from within a structure. Normally associated with the drying out of wet walls.

**Slaking:** the controlled process of combining quicklime with water to form slaked lime in the form of lime putty or dry hydrate.

**Slurry:** a thick, but fluid, mixture (eg of a dry powder gauging material in water).

**Suction:** the characteristic by which a wet bond is created between lime, and other, mortars and porous masonry surfaces.

**Tampers:** tools of various shapes for pushing mortar into joints.

**Water limes:** hydraulic limes, so called because they will set in wet locations.

**Whin:** traditional but informal name for hard dark grey rocks (usually basalt or andesites).

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