Historic England

Pre-industrial Lime Kilns

Introductions to Heritage Assets

Summary

Historic England's Introductions to Heritage Assets (IHAs) are accessible, authoritative, illustrated summaries of what we know about specific types of archaeological site, building, landscape or marine asset. Typically they deal with subjects which have previously lacked such a published summary, either because the literature is dauntingly voluminous, or alternatively where little has been written. Most often it is the latter, and many IHAs bring understanding of site or building types which are neglected or little understood.

This IHA provides an introduction to pre-industrial lime kilns. A lime kiln was a structure used to manufacture lime (calcium oxide) by burning calcium carbonate at temperatures above 900°C. The calcium carbonate burned (or 'calcined') was commonly limestone or chalk, but occasionally other materials such as oyster or egg shells were used. Lime burning appears to have been a new technology introduced by the Romans and there is no evidence to suggest that there were any lime kilns in England before the Roman period. Most lime kilns were established to provide lime for use in the construction of adjacent buildings for which they provided lime, usually for mortar. The presence of a kiln therefore suggests that a mortared structure lies in the immediate vicinity. Descriptions of the asset type, its development and associations along with a brief chronology are included. A list of in-depth sources on the topic is suggested for further reading.

This document has been prepared by Nicky Smith and edited by Joe Flatman and Pete Herring. It is one of a series of 41 documents. This edition published by Historic England October 2018.

Please refer to this document as:
Historic England 2018 *Pre-industrial Lime Kilns: Introductions to Heritage Assets*. Historic England. Swindon

HistoricEngland.org.uk/listing/selection-criteria/scheduling-selection/ihas-archaeology/

Front cover
Lime burners at work firing a flare kiln (1804).

Introduction

A lime kiln was a structure used to manufacture lime (calcium oxide) by burning calcium carbonate at temperatures above 900°C. The calcium carbonate burned (or 'calcined') was commonly limestone or chalk, but occasionally other materials such as oyster or egg shells were used.

Lime, also referred to as 'quicklime', 'unslaked lime', 'burnt lime' or 'lump lime', was used in Britain from the Roman period onwards. Most was mixed with water, a process known as 'slaking', to produce hydrated lime (calcium hydroxide). This product formed the basis of plasters, mortar and concrete. Good quality lime was also used in lime-wash, for waterproofing walls and lightening interiors, for bleaching paper, for preparing hides for tanning, as a disinfectant, in medicine and later for soil improvement.

The extensive use of lime and the development of well built-kilns has been attributed to the Romans and the earliest archaeological evidence for lime burning in Britain comes from the Roman period (AD 43-410) (Figure 1).

During the Anglo-Saxon period buildings were usually of timber construction and, although lime may have been used for white-washing high status buildings, the demand for it was very low. This changed in the medieval period (1066 - 1485), when large quantities of mortar were needed for the construction of stone castles, city walls and religious buildings.

The remains of both Roman and medieval lime kilns are widely distributed throughout England. They were, no doubt, once a very common feature and it is likely that many further examples will be discovered as more excavations are carried out.

All were intended to be temporary structures and some were erected adjacent to the building sites they supplied. Once they were no longer needed they were either dismantled and moved elsewhere or left to decay. Most examples have been discovered by chance during later construction work or during the excavation of larger monuments, so the distribution of known examples to a large extent reflects this.

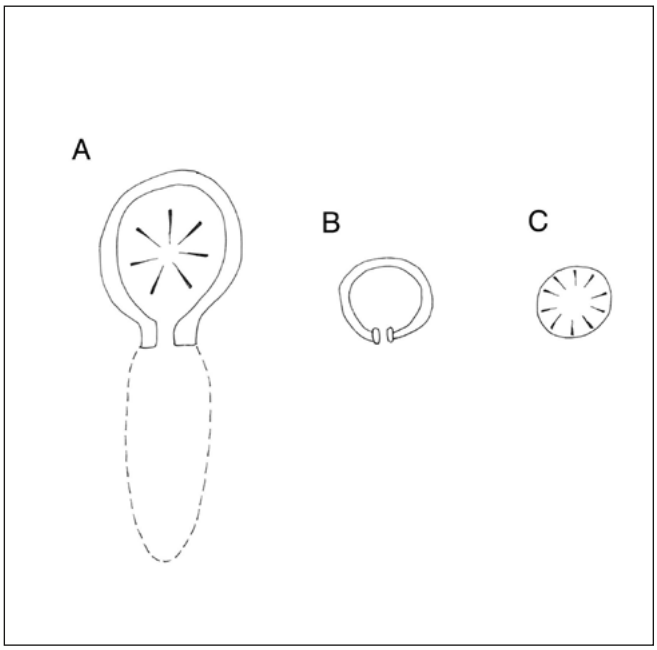

Figure 1
Ground plans showing Romano-British flare kilns (A and B) and a clamp kiln (C).

1 Description

The simplest method of producing lime was by using a 'clamp kiln'. This was not really a kiln at all, but layers of fuel and limestone stacked together in a mound, covered with clay or turf and slowly burned in a method similar to that used in charcoal burning. The remains of such 'kilns' comprise merely a hearth on the floor of a pit, measuring up to 2.5 m in diameter and up to 2 m in depth. The surrounding soil may show evidence of burning by a change in colour and loose piles of rock may be present. Local variations of clamp kilns are known as 'pye kilns' and 'sow kilns'.

More sophisticated stone- or brick-built lime kilns were of two basic types: 'Flare kilns', also known as 'intermittent' or 'periodic' kilns; and 'perpetual', 'running' or 'draw' kilns. As their name suggests, 'flare kilns' were loaded with a single charge of limestone and burning had to stop for this to be removed before it could be re-loaded for the next firing. 'Draw' kilns were loaded with alternate layers of fuel and stone which was kept burning continuously while further supplies of raw material and fuel were fed in at the top and the lime was drawn off at the bottom. Both types had the same basic structure, consisting of a thick-walled stone chamber with a hearth at the base.

The intermittent flare kiln was the type of lime kiln generally used in Roman and medieval Britain. It most commonly consisted of an open-topped cylindrical combustion chamber and a hearth, with one or more draw-holes, also referred to as 'flues', 'stoke-holes' or 'eyes', at the base. A vault of stone blocks, resting on an internal ledge, was built over the hearth. The rest of the limestone or chalk was stacked above this. This meant that the fuel was not in direct contact with the charge and so good quality lime, unmixed with ash, was produced. The fire, usually of wood but sometimes coal, was lit at the end of a draw-hole leading into the hearth. The ashes were raked out through the same hole, or a further draw-hole. The fire needed to be stoked for several days for all the limestone to be calcined and the kiln then had to cool down completely before the entire load of lime was removed. Flare kilns used a greater amount of fuel than draw kilns, had to be partially dismantled to extract the lime and frequently required relining, so they were not the most cost-effective or convenient method of lime production.

In general lime kilns developed from the flare kiln to the more economical continuous draw kiln. Draw kilns had a permanent grate fixed over the hearth and limestone was stacked above this, alternating in layers with fuel. As the fuel burned the calcified limestone dropped down and was raked out, while new layers of fuel and limestone were added at the top of the kiln. This method of production was an industrial process and was most commonly used in later periods.

The remains of pre-industrial lime kilns have been identified in various states of preservation (Figure 1 and 2). When first established they would have had both above- and below-ground structures, but after they had served their purpose many were left to decay. Others were back-filled with earth, limestone rubble and general debris or were dismantled to be re-built elsewhere. The remains of lime kilns often lie buried beneath later structures and they have frequently been cut into by later ground works.

In many cases the hearth is the only part of a lime kiln to survive. This is recognisable as a burnt area of compacted earth, ash and lime, usually between 1 m and 3.5 m in diameter resting directly upon the ground surface or lying inside a shallow pit. The pit may be unlined, clay-lined or have a stone-built 'fire-chamber', measuring at least 2.5 m across the base and up to 3 m deep.

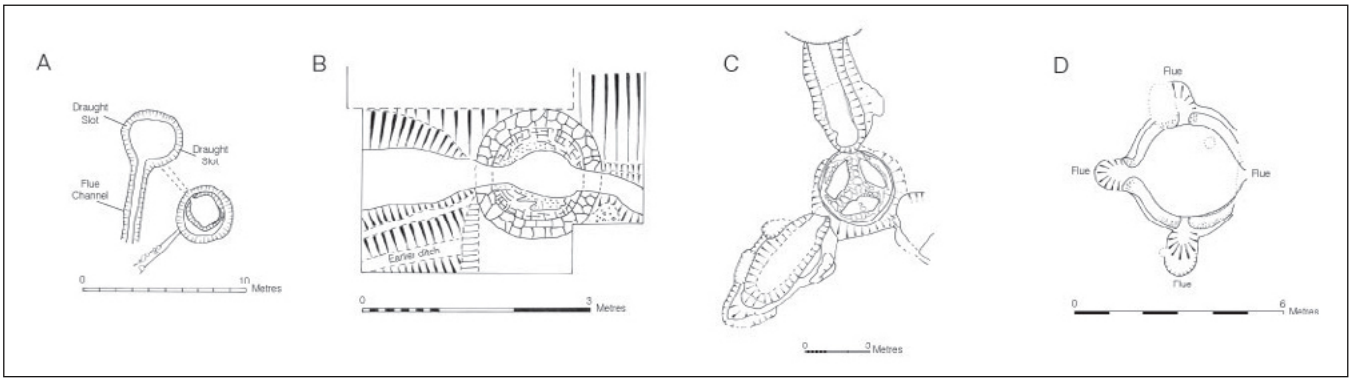

Figure 2
Ground plans of medieval lime kilns. A – Chew Valley, Somerset B – Old Erringham, Sussex C – Southampton Castle D – North Elmham, Norfolk.

The ground plan of the kiln was usually determined by the shape of the pit, which may be square, rectangular, round, oval, or pear-shaped. A stone or clay ledge around the lower part of the interior of the kiln may also be present. This supported the framework upon which stone was loaded for conversion to lime in the upper part of the chamber. The stone charge was thus kept separate from the fire and the space created above the hearth enabled ash to accumulate, re-stoking of the fire to take place and ensured that the product was pure.

Stoke- or flue-holes may also be present at the base of the kiln. The stoke-holes varied in form, some were simply holes in the fire chamber wall, though most had elongated passages, about 2 m long, leading into the hearth. These stoking tunnels, where present, were made of brick, tile or local stone as available. Most Roman kilns excavated in Britain had a single stoke-hole, or flue while medieval examples had a single or double flue, with more elaborate examples with three or four flues being rarer. A raking-out pit at the end of a passage, has been found in some cases.

Where flare kilns (Figure 3) survive above base level, the chamber walls rise up from the sides of the hearth area and form a structure which is nearly square, barrel-shaped or funnelled in profile. The walls were usually constructed of stone courses, often consolidated with mortar. In some cases they were further sealed and insulated by the addition of clay or concrete, or by a layer of turf around the outer face. Kilns usually

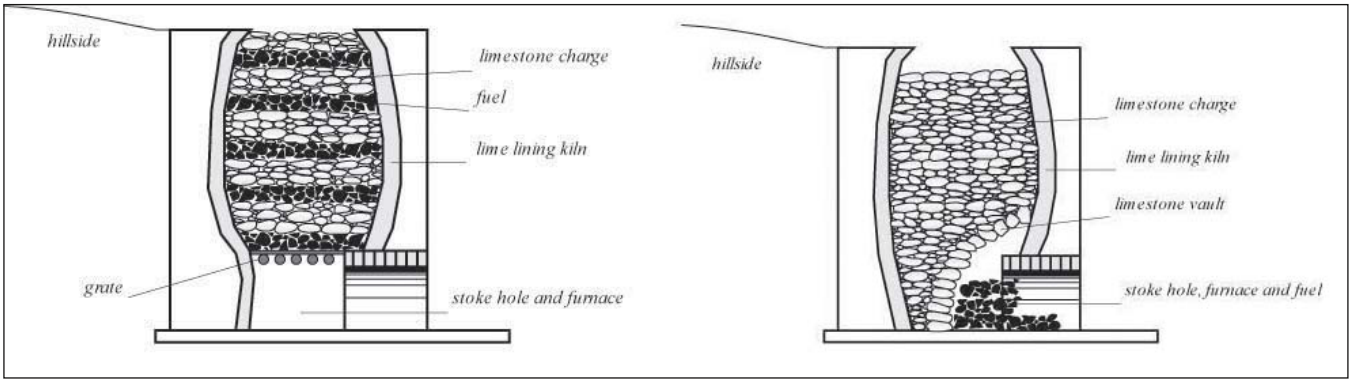

Figure 3
Cross sections showing the structure of a draw kiln on the left and a flare kiln on the right.

varied in size, from just 1.2 m to 1.5 m in diameter at the rim, and 1 m to 5 m at the base and up to 3 m high, although larger examples have been excavated.

The location of lime kilns was usually determined by the proximity of a source of calcium carbonate (usually an outcrop of limestone or chalk). Within an area of chalk or limestone outcrops, where sufficient firewood was available, a fairly sheltered position tended to be chosen and some kilns were built into the banks of rising ground. Lime kilns may occur singly, or in pairs or clusters. In many cases the examples within a cluster were used successively.

Until the middle of the 18th century most lime kilns in England were set up to burn lime on-site (Figure 4). However, lime burning generated toxic fumes and acrid smoke, and quicklime was a volatile product capable of producing great heat if it came into contact with water, so kilns needed to be situated away from occupation areas. For this reason, they were usually situated in areas slightly removed from contemporary buildings.

Concentrations of medieval lime kilns occurred in urban areas, where the demand for lime for building construction was greatest, but they tended to be situated away from town centres. Further examples in rural areas were built for the construction of specific monuments such as castles or religious houses.

Figure 4
Lime burners at work firing a flare kiln (1804).

Figure 5
The base of a probable flare kiln dating from the 16th century excavated at New Hall, Chelmsford, Essex. It may have produced lime used in mortar at Henry VIII's Palace of Beaulieu which once occupied the site.

It is occasionally possible to identify pre-industrial lime kilns by observation of the ground surface. A small number have been discovered by field walking, when they have been visible as depressions in the ground surface or as patches of lime in ploughed fields. Other surface traces, such as patches of burning or slight earthworks could potentially lead to recognition of further examples. Geophysical survey is a further useful technique which may locate their buried remains.

The remains of simple clamp kilns are particularly difficult to locate and their dating is problematic, since they continued to be used by farmers producing lime for soil improvement until relatively recent times.

2 Chronology

Lime burning appears to have been a new technology introduced by the Romans and there is no evidence to suggest that there were any lime kilns in England before the Roman period. They appear to have been used throughout most of the Roman period and securely dated examples are known from the early 2nd century through to the late 4th century, most contemporary with the construction of associated monuments such as villas. The use of lime declined sharply after the Romans left Britain, but production resumed on a large scale during the medieval period.

Excavation has provided an insight into the types and the different methods of construction of pre-industrial lime kilns. Most dating evidence has been gathered from small amounts of coarse pottery found and evidence from structures associated with the kilns. The few finds that occur tend to be lime and partly fired limestone blocks, bones, pottery, tile, shell, slag, burnt clay, glass fragments and iron objects. Charcoal is occasionally found preserved in the hearth area and impressions of wood used in the firing may survive in the clay or lime. In water-logged sites organic evidence may also be preserved.

Archaeomagnetic techniques have been used to date the clay lining of some lime kilns. For medieval lime kilns, historical sources can be of use for dating purposes. Although lime kilns were not taxable structures and their existence is not recorded in general surveys, they are sometimes mentioned in building contracts and accounts relating to an associated building such as a castle, which may state the amounts of raw materials used in construction or the amounts of fuel consumed.

3 Associations

Most lime kilns were established to provide lime for use in the construction of adjacent buildings for which they provided lime, usually for mortar. The presence of a kiln therefore suggests that a mortared structure lies in the immediate vicinity.

In the Roman period lime kilns were associated with villa sites and larger civilian settlements, or with military monuments including Roman forts, Saxon Shore forts and frontier works. Medieval lime kilns are found in association with castles, churches, corn ovens, villages, dovecotes, manor houses, moats, palaces, quarries, roads, religious houses, towns, town walls and trackways.
The stone for burning was usually extracted from sources close to the kilns themselves, so extraction pits may sometimes lie nearby.

Other structures which may be associated with lime kilns include roads, pottery kilns and field systems. Lesser features which may be found in close proximity include ditches, banks and pathways. Drainage ditches may also lie nearby, to maintain a dry environment around the kiln. Storage heaps of stone ready for burning at the time of the kiln's abandonment may also be present. These may take the form of rings around the kiln, or mounds of various shapes near the kiln.

4 Further Reading

Most of the information published on the subject of pre-industrial lime kilns is dispersed amongst individual excavation reports. The best overview of the history and archaeology of lime burning from the Roman period through to industrial times remains R Williams, *Lime Kilns and Lime-Burning,* (second edition 2004). An informative description of the different methods of lime burning is provided by H Fidler in *Notes on Building Construction* Volume 3 (1893).

The most comprehensive general accounts of the construction and use of lime kilns in Roman Britain and the western Roman Empire are two studies by B Dix: 'Roman Lime Burning', *Britannia* 10 (1979), 261-2, and 'The Manufacture of Lime and its Uses in the Western Roman Provinces', *Oxford Archaeological Journal* 1 (1982), 331-45.

Oxford Archaeology's 3D model of Figure 5 can be viewed online at https://sketchfab.com/models/91b5a07861c441e1b7d9e4a11023b4a8

5 Where to Get Advice

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6 Acknowledgments

Figure 2a: after PA Rahtz and E Greenfield, *Excavations at Chew Valley Lake, Somerset* (1977)

Figure 2b: after R Williams, *Lime Kilns and Lime-Burning* (second edition 2004)

Figure 2c: after J Oxley, *Excavations at Southampton Castle* (1986)

Figure 2d: after P Wade-Martins, North Elmham (1980)

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Figure 5: © Oxford Archaeology

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HEAG222
Publication date: v1.0 May 2011 © English Heritage
Reissue date v1.1 October 2018 © Historic England
Design: Historic England and APS.