The Lime Industry in Australia – An Overview

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The intention of this paper is not to present a definitive picture of the limeburning industry in Australia – such an aim would be impossible given the few and geographically scattered studies which have been carried out to date. Rather the aim is to review some of the work that has been done, outline the fragments of the wider picture these studies give us, and suggest some directions for future work.

THE LIMEBURNING PROCESS

Lime, or 'quick lime', is the product obtained by burning limestone and other calcium-rich substances such as shell and coral. Limestone is comprised of calcium carbonate ($CaCO_3$), which breaks down during the process of burning to calcium oxide (CaO), or lime, and carbon dioxide(CO_2) which is driven off leaving behind the lime in a lumpy or powdery form which may be white, or coloured by impurities. In the process of burning the limestone undergoes a loss of approximately 44 per cent in weight and 12 to 20 per cent in volume, and this shrinking of the load is the primary way in which the operators of the simpler methods of limeburning judged that the process was complete.

The lime is then slaked with water to form calcium hydroxide or hydrated lime ($Ca[OH]_2$), which is mixed with sand to make mortar. As the mortar dries it reverts to calcium oxide (CaO), and absorbs carbon dioxide from the air to form calcium carbonate ($CaCO_3$), thus completing the cycle.[1]

Varying degrees of impurities give limes with different characteristics. Lime with a high calcium content slakes quickly giving off considerable heat, and makes rapidly setting mortar. Hydraulic limes, which have 10 to 30 per cent of clayey impurities, produce hydraulic cement which is able to set in water as well as in air. 'Natural' or 'Roman' cement, and 'Portland' cement are types of hydraulic cement, the later being produced by the re-burning of an artificial mixture of lime and other substances (silica, alumina, and iron oxide).

Lime is used for a variety of purposes, including mortars and plasters in the building industry, in agriculture to open and lighten clayey soils and improve other soils in various ways, and in a variety of chemical and industrial processes.

Limeburning is a very simple process. The most primitive method was one where limestone or shell was piled on top of, or was inter-layered with, fuel and burnt in the open. A slightly more sophisticated variation was to place the heap in a pit. Such piles might be plastered with mud, clay or turf in some cases.[2] Various forms of kilns were built for the burning of lime. *Intermittent kilns* were loaded, fired and emptied for each load of lime. Such operation was expensive in labour, and fuel, as the kiln cooled down after each load. There were various forms of intermittent kilns used in Australia – some operated as 'flare' kilns, where the fuel and the limestone were kept separated, and 'mixed feed' kilns where fuel and stone were loaded in alternating layers. *Continuous kilns* were so arranged that fresh fuel and stone could be placed in the kiln and burnt lime withdrawn without interrupting the continuous burning process.[3]

LIMEBURNING IN AUSTRALIA

Simple Limeburning.

From the time of the arrival of the First Fleet in 1788 until the end of the nineteenth century at least, lime was produced in a number of ways, including by the simple heap-burning or pit-burning processes (see Fig.1).[4] Until the 1820s, when local supplies of limestone began to be utilised, most of the lime in was produced from sea shells. This practice continued late into the century in some districts. The early dependence on shell, which is a scattered and limited resource occurring as Aboriginal shell middens and natural shell beds, necessitated either transport of shell to a central kiln, or the use of simple and cheap burning methods at the location of the shell deposits. In Sydney's many bays and inlets a large proportion of the early nineteenth-century coastal shipping trade was devoted to transporting shell to centrally located limekilns.

However, further afield the use of heap-burning and pit-burning techniques was more common. W.C. Wentworth referred to its use at the Hunter River in 1819:

> The lime produced at this settlement is made from oyster shells... The process of making lime from them is extremely simple and expeditious. They are first dug up and sifted, and then piled over large heaps of dry wood, which are set fire to, and speedily convert the superincumbent mass into excellent lime. When thus made it is shipped for Sydney, and sold at one shilling per bushel. [5]

The use of pit-burning continued at Wallangra near Ashford (NSW) until at least the 1870s, and pit-burning sites at Limekilns near Bathurst (NSW) have been described by the author in some detail.[6] Heap-burning and pit-burning techniques have also been reported in Victoria and South Australia.[7]

The methods of heap-burning and pit-burning would appear to derive from British traditions, where they were called 'sod' or 'sow' kilns. Sod kilns were still in use in Wales until at least the 1830s, and an example assumed to date from the early nineteenth century has been excavated in Glamorgan.[8] Very much larger heap-burning 'sow' kilns were used in Scotland, where the heap was 12m long and 6m wide and 2m to 2.5m high, covered in turf, and like other simple kilns, largely destroyed after each burning.[9] These simple kilns were used in Britain to produce agricultural lime at the site of use.

Intermittent Kiln Production.

By far the most common variety of limekiln found in the past throughout Australia was the intermittent kiln, and the

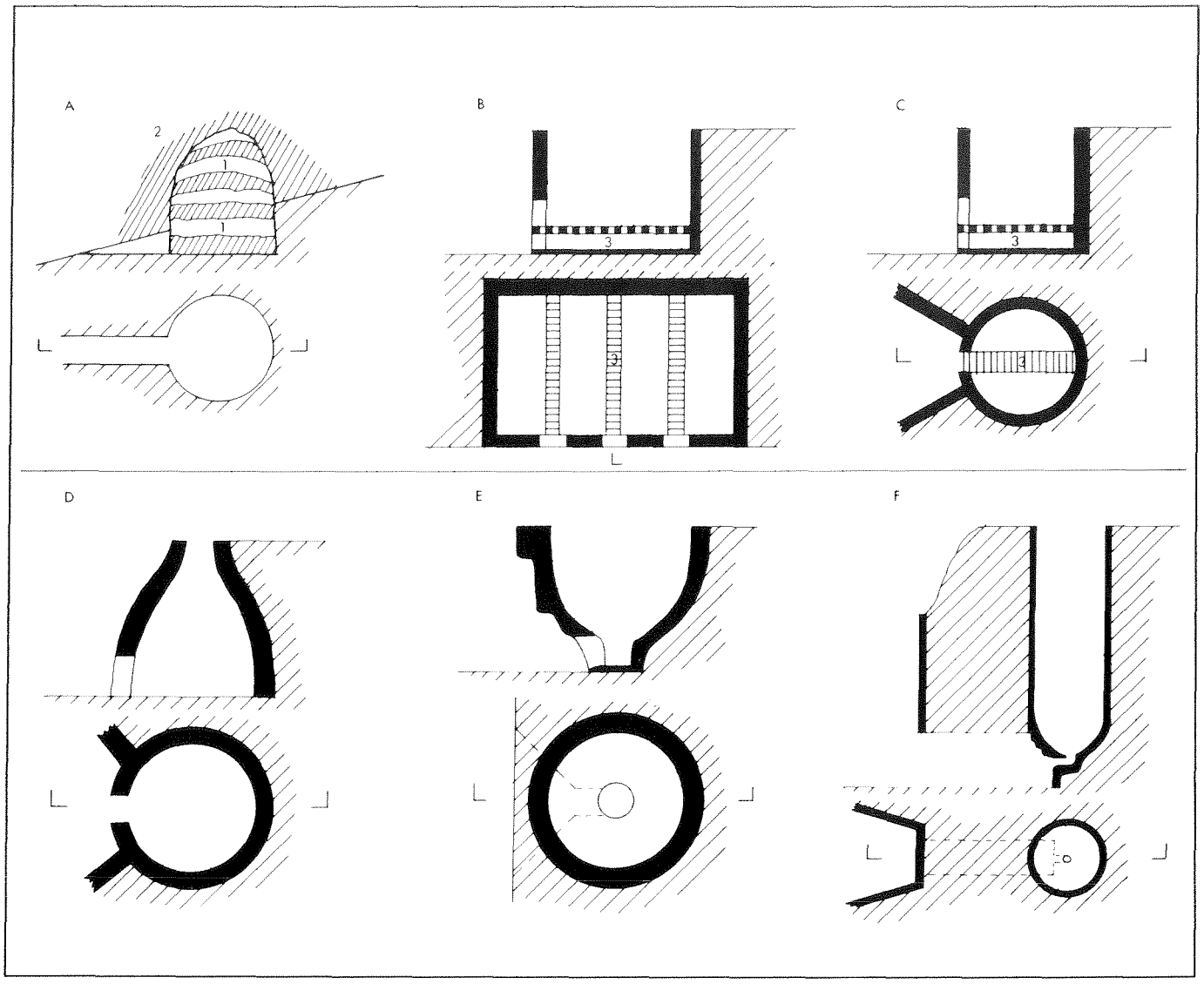

Fig. 1: Schematic outline of various kiln types, showing plan and cross-sectional elevation of each major type (not to scale). A. Pit-burn kiln; B. 'D' kiln; C. Small cylindrical shaft kiln; D. Inverted cone (bottle) kiln; E. Inverted bell kiln; F. Continous feed shaft kiln. 1. Limestone or shell; 2. fuel (wood or coal); 3. ash pit.

most common forms of such kilns were the 'D' kiln or variations of it, the bottle kiln, and the inverted bell-shaped form (see Fig.1). Each of these types were used in both commercial and private production of lime. Another less common type is recorded, the bee-hive kiln, of which only one Australian example operating as a limekiln is known to the author. This kiln was located at the bottom of Glen Street in Lavender Bay, Sydney, and was well known in the late nineteenth century as the destination of boats carrying shell for burning.[10]

A number of intermittent kilns survive at settlement sites and convict establishments around the country, having been used to produce building lime for the development of the settlements and for use by the Government at other locations. These kilns are relatively well known, and their forms, both bottle-shaped and inverted bell-shaped, are thought of by many as being 'typical' of kilns of their period. As even this brief overview shows, this belief is misleading. Perhaps the oldest of these kilns are located on Norfolk Island, where lime was produced as early as 1791. The earliest kiln to survive there, at least in part, was built in 1802, while a kiln built in 1845 is in excellent condition, an inverted bell-shaped kiln 5.2 metres in diameter at the top and 5.2 metres deep, dug into the side of the quarry and brick lined.[11]

Beautifully built examples of the same inverted bell-shaped type survive at Port Arthur in Tasmania (1840s, Figs 2-3) (with a smaller, cruder example at the Coal Mines nearby), and at St Helena Island, a post-convict penal settlement in Morton Bay, Queensland, built in 1869.[12] A double kiln, which externally resembles kilns of this type, is shown in various maps and sketches of the north-east corner of Benelong Point in Sydney, between 1822 and 1845.[13]

A very different form of kiln, but used at the same time as the inverted bell-shaped, was the bottle-shaped or truncated cone form. At Port Essington, a settlement operating between 1838 and 1849 in what is now the Northern Territory, three kilns have been described by Jim Allen. Two are less than two metres in height, and may have nothing to do with limeburning, but the third stands 3.5 metres high, with a base internal diameter of 2.8 metres and a top opening diameter of 60 cm. This stone kiln is built into a bank, for top loading, and has a single arched draw-hole in its base, though there is an indication that it may originally have had two such openings. It was probably built in the early 1840s.[14]

The remains of a kiln at the Australian Agricultural Company settlement, studied by Damaris Bairstow, indicate a circular stone-built kiln with an internal

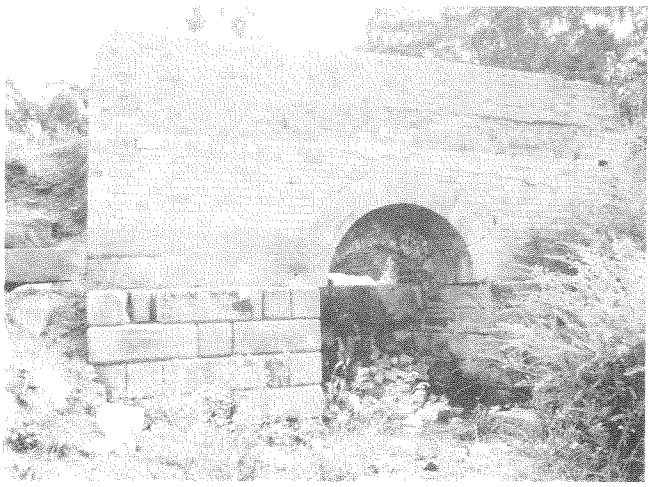

Fig. 2: Inverted bell kiln at Port Arthur (1840s), showing central stoke hole/draw hole. The kiln faces the water's edge.

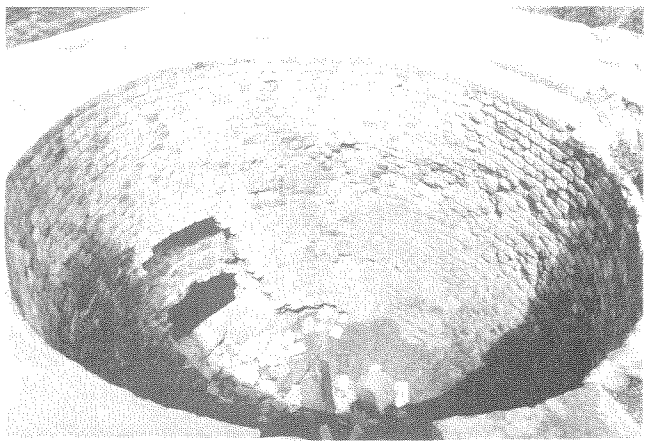

Fig.3: Port Arthur kiln, looking into the inverted bell burning chamber: before restoration.

diameter of 3.5 metres, and with one definite opening. As the remains of this 1830 kiln stand only to a height of 75 cm, it is difficult to be certain of the original form of the kiln. The remains are not inconsistent with a truncated-cone type like that at Port Essington, but being free standing. The remains of a kiln, not yet fully described, located at the site of the 1804–1822 Newcastle Lumber Yard by Dr Bairstow, may also be of this type.[15] Such free-standing kilns elsewhere often had timber bridges or ramps to allow access to their tops for loading, as at the Kakaku, Sandymount, and Stavely kilns in New Zealand.[16] It is impossible to determine if these kilns were operated as flare or mixed-feed kilns.

While present at Government establishments, the inverted bell and bottle kiln forms do not appear to have been particularly common elsewhere, though small inverted bell-shaped kilns have been recorded in some numbers around Portland in Victoria by Christine Eslick, and an example dating from the early to mid-nineteenth century has been recorded near Bungonia (NSW).[17] Further survey may show them to be more widespread.

An early simple kiln form in New South Wales was described as a cylindrical deep pit cut into a bank of earth and crowned and sometimes lined with stone or brick.[18] Far more common in some regions was the 'D' kiln, so named because they were shaped in plan like the letter 'D', being dug into the face of a bank with a vertical masonry wall built across the front of the pit to create a firing chamber. Two to three ash boxes were built below the kiln floor and covered with brick or iron fire bars. These ash boxes opened through the front wall of the kiln, and above them an arched fire door was located. The kilns were typically 4.3 to 6.7m long, 2.4 to 4.3m broad and 3 to 4.9m deep, the front wall being along the longest face. When loading 'D' kilns, fire-arches of limestone blocks were built from the fire door through to the back of the kiln above the ash box, and the kiln was filled from above with alternating layers of fuel and limestone. Firing took from 48 to 90 hours, the degree of burning achieved being judged by forcing an iron bar through the lime from the top, and by observing the degree of shrinkage of the load.[19]

The 'D' kilns were the commonest type of kiln in New South Wales during the late nineteenth and early twentieth centuries, even in the larger commercial production centres. This adherence to the intermittent kiln is interesting, as, although the 'D' kiln was cheap to construct, it was expensive to operate both in terms of the labour required and the wasteful use of fuel, and the fact that each kiln was out of operation while being loaded and while it was cooling and being emptied. In 1925 L.J. Jones, a specialist on the lime industry within the NSW Department of Mines, attempted to explain this situation:

> In other countries where the lime industry has been considerably developed, the intermittent kiln is considered to be more or less primitive and has been replaced by more up-to-date types.
>
> Owing to the limited demand for lime in New South Wales, and the fact that the present antiquated method of producing is able to cope with it, manufacturers generally are loath to expend the necessary capital for the introduction of more modern types of kilns.
>
> The erection of a modern producer-gas continuous (Schmatoller) kiln by the Sydney and North Sydney Lime Company, was a step in the right direction, and probably, as the demand for lime increases, the wasteful 'D' kilns will be replaced by others more up-to-date.[20]

At that date (1925) two places were responsible for 90 per cent of the lime production in New South Wales: Portland near Lithgow and Kingsdale near Goulburn (Fig. 4). All production at Kingsdale, and at all the more minor production sites in the state, appears to have been with the use of 'D' kilns. Only Portland had taken on new technology. However by the early years of the twentieth century the local production of Portland cement (a composite cement produced by the burning of a mixture of lime, silica, alumina and iron oxide, as distinct from lime and cement produced at the New South Wales town of Portland) had overtaken the use of lime in the building industry, and by the 1920s the state's annual production of Portland cement from a number of works west of Sydney was more than five times the amount of lime produced for sale in the state.[21]

At Kingsdale five 'D' kilns survive, in varying degrees of decay. The burning chambers of these kilns are typically 5 to 6 metres wide, 3.4 to 4 metres front to back, and 2.5 to 3.5 metres deep, with three ash boxes and draw holes, and built into mounds and ridges of overburden removed from the four adjacent limestone quarries.

In Western Australia a variation on the 'D' kiln with the added refinement of a side door for more simple removal of the burnt lime, was the standard kiln used in the primary lime producing areas from at least the 1880s until gas-fired

Fig. 4: 'D' kiln at Kingsdale, NSW, seen from the bank of earth into which it is built. 'D' kilns are not always as rounded as this example. The front wall of the kiln has partially collapse.

tunnel kilns took over in recent decades. Only one set of the traditional kilns remains in operation today.[22] This variety of 'D' kiln, dubbed the 'Wannaroo pattern' by the author in 1984, was found at the main production areas of Wannaroo, Coogee and Bullsbrook (Fig.5). The kilns were usually operated in sets of two, so that almost continuous output could be achieved, one kiln being loaded and fired while the other was cooling and being unloaded.

Smaller markets such as that at Albany were supplied using smaller cylindrical (see Fig.1) or square shaft kilns, operated in the same way as the 'D' kilns but being only 2 to 4 metres in diameter or square and 2 to 3 metres deep with vertical sides and with a single ash box and draw hole.[23] These small kilns are widespread in Western Australia. Only one surviving example in New South Wales is known to the author, a pair of circular plan kilns at Blayney which appear to have been operating about 1912.[24] Christine Johnston has located others which seem to be of this general type, though larger, at the Coimadai lime works area in Victoria. These operated side by side with continuous feed kilns.[25] Without documentary or oral evidence it is usually impossible to determine the operation method of short vertical-sided kilns such as these, as they can be used either as flare kilns or as mixed feed kilns. It is also possible that some 'D' kilns were operated as flare kilns rather than the more common mixed feed method.

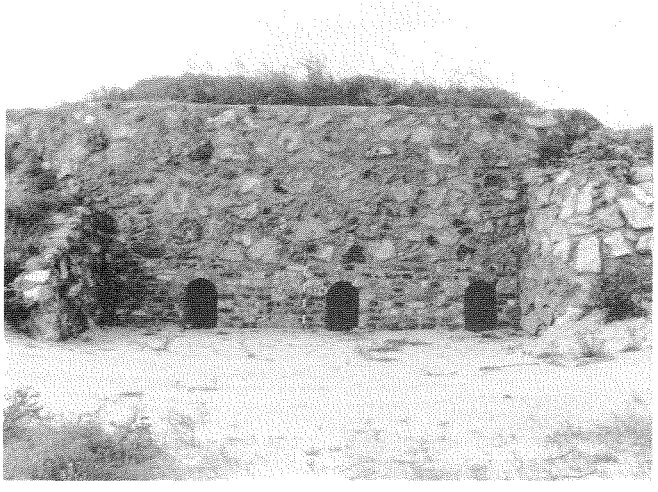

Fig. 5: Front view of a restored 'D' kiln at Coogee, south of Fremantle, WA. The three stoke holes and the buttresses supporting the front wall are typical of the type. The scale is two metres long.

A very early lime industry was established in the Tamar Valley, near Launceston in Tasmania. The Government Lime Works operated there from 1804 to 1833, first utilising shell (from preference) then switching to limestone by 1820 as shell supplies diminished. The works were transferred to private operation in 1833, and other operators set up in the area during the 1830s, production continuing throughout the nineteenth-century.[26] Unfortunately the kilns used have not been described, but they were almost certainly of intermittent operation.

An interesting site where early kilns of an unusual type survive is at Pipers Creek, south of Kempsey in New South Wales. Limeburning may have begun here as early as the 1820s, and was certainly in operation by the mid-1830s, supplying lime to the Port Macquarie Convict Establishment. At least three kilns are known to survive, all slightly different in design, but sharing the same characteristics. They are a modification of the 'D' kiln, being built into a bank with a stone front wall penetrated by three fire boxes/draw holes. The most unusual feature is the extremely narrow burning chamber, which is typically about 5.5 metres long and 3 metres deep, but only 1.7 metres wide.[27] The origin of this design has not yet been traced – perhaps it is a local variation based on something as simple as the scarcity of long-handled iron tools needed to operate a full-width kiln! A kiln was built at another Convict Establishment at Wellington Valley, (NSW), in 1825, but it was not described, and appears no longer to exist.[28]

Continuous Kilns

One of the difficulties in reviewing the state of knowledge of limeburning in Australia is that most historical and recent descriptions are inadequate to identify the form of the kiln and hence the most likely method of operation. There is also insufficient understanding of the various operating processes and hence some uncertainty exists as to which kiln characteristics were required to enable a kiln to operate as a continuous or 'running' kiln. Continuous kilns could be mixed feed, in which case stone and fuel was fed into the top of a tall shaft kiln, burnt in the central section, and drawn out at the base in a continuous process, or separate feed, in which case separate fire boxes kept the fuel from direct contact with the lime. The latter were usually shaft kilns, though Hoffmann type, and mechanically operated horizontal kilns and rotary kilns were also used.[29]

The simplest form of continuous kiln was a mixed feed circular or oval shaft kiln (see Fig.1), usually narrowing towards the base, and sometimes with holes at suitable height to poke the load to check burning and dislodge a jammed or sticking load. More sophisticated continuous kilns came in very many forms, and the range of those used in Australia is yet to be investigated.[30]

Victoria seems to have led Australia in the use of continuous feed shaft kilns. At least one, if not both, of the kilns at Fossil Beach, Victoria, (1862–1863) investigated by Culican and Taylor may have been continuous feed kilns based on European models.[31] Five kilns dating to 1865–1875 are located at Limeburner's Point at Geelong (Fig. 6). These kilns have circular shaft burning chambers approximately 6 metres high and 2.6 metres in diameter, built into a cliff. The base of each shaft is approached by way of a 7 metre long tunnel from the base of the cliff, the tunnel exiting through massive stone retaining walls supported by buttresses on each side. The base of each shaft is narrowed to a steel grate and fire door, which is suspended above the tunnel floor in a corbelled wall. As

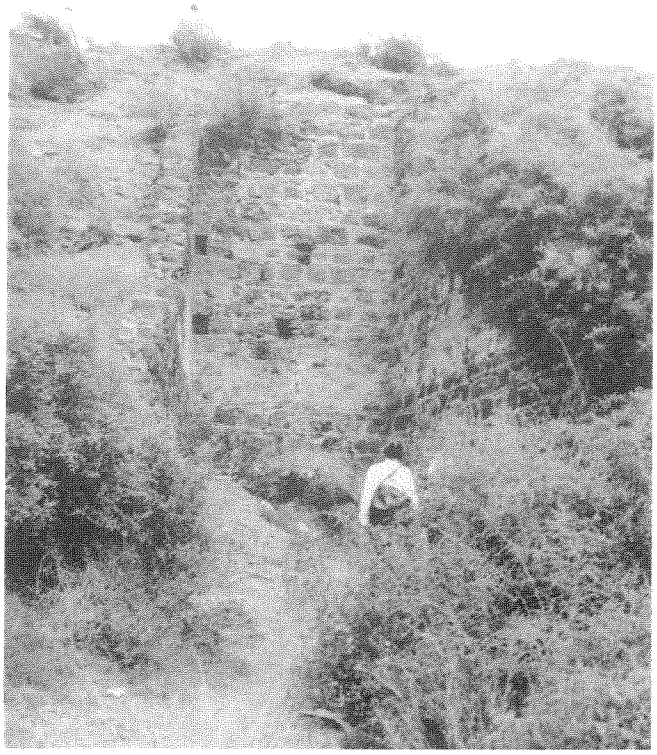

Fig. 6: Shaft kiln at Limeburner's Point, Geelong, Vic. The wing walls are clearly seen. The entrance, to the left of the figure, is partially obscured by wind-blown sand.

there is no evidence of separate firing chambers, it is assumed that these kilns were mixed feed. However, it is not known whether they were continuous or intermittent feed.[32]

At Walkerville in south western Gippsland, Victoria, are the remains of six kilns built in 1878. They are similar to those at Limeburner's Point, being built into a cliff face, with circular plan shafts which reduce in diameter towards the base, are fed from above and are drawn through a short tunnel located at the base of the cliff which is held back by tall stone retaining walls.[33] Again these kilns would appear to have been mixed feed, apparently operating as intermittent kilns, but probably capable of operating by continuous feed.

An interesting study of the lime industry at Coimadai, north of Melbourne, has been undertaken by Christine Johnston.[34] Relatively small scale limeburning took place at Coimadai between the 1850s and early 1880s, but only small fragments of these earlier kilns survive, and the processes used are not known. From the mid-1880s through the 1890s production boomed, with continuous feed kilns and mechanised methods being introduced to supply the Melbourne market. The five kilns operated by the Alkamede family from 1886 to the 1950s were typical. They were shaft kilns, backed by artificial earth banks. The fuel was timber inter-layered with limestone, which because of the nature of the stone was first pugged with water and made into bricks for placing in the kiln. The operation was continuous, fuel and stone being replenished as lime was drawn off from the base. Each kiln was approximately 4 metres in diameter, constructed of squared stone and brick lined, but all have been partially demolished.

The nearby Dibley's kilns, which are still intact, were probably built in the late 1880s. Three kilns survive, one of which appears to be a separate feed flare type, while the other two are mixed feed. The three kilns are conjoined. The flare kiln has a circular shaft of 2.1 metres internal diameter. There are three openings in the base, two of which appear to be stoke holes for feeding burning chambers, and the other a draw hole through which lime was removed. Johnston assumes that this was an intermittent operation, but recommends further study to properly understand it.

The two continuous mixed feed kilns are 8 metres high. The shafts are 3 metres in diameter at the top, tapering to the lower part of the shaft. At the base of each shaft is a small arched draw hole, above which are poke holes for loosening the load.

Chris Johnston has identified the existence of approximately 50 kilns in Victoria, only a handful of which have been studied.[35]

QUARRIES, TRANSPORT AND WORKERS

The kilns associated with the lime industry are unquestionably fascinating and usually attract most of the attention of the observer. However if we are ever to begin to look seriously at the lime industry we have to consider the quarrying and fuel supply which fed the kilns, the transport systems which linked the quarry and fuel supply to the kilns, and kilns to market, the marketing of the product, the living conditions and economic and social circumstances of the workers, and the overall economic context for the industry. Unfortunately, to date there has been extremely little attention paid to any of these aspects of the industry in Australia which might give greater context and meaning to the individual sites already studied.

As has been pointed out above, the predominant source of raw material for lime in early Sydney and in many other coastal settlements was shell. The following examples give some indication of the methods used to supply shell to centralised kilns. In the 1860s the shell middens at Moon Bay near Tathra on the south coast of New South Wales were utilised for lime production, the shell being carted to a kiln in Bega by way of a dray road cut for that purpose.[36] However shell, being a scattered water edge resource, was more often transported by water. Around Sydney the shell was transported mainly by small sailing vessels. The Alderton kiln at Lavender Bay, for example, was supplied by two ketches, the *Day Dawn* and the *Maggie Riley*, carrying shell from Brisbane Water in Broken Bay to the north[37] while shell from Botany Bay and Port Hacking, south of Sydney, was transported by ship to kilns in Sydney, Cook's River, and Kiama in the 1850s to 1880s period.[38]

The nature of the shell supply trade is indicated by Captain Collin's recollections. He writes that, in 1856:

> ...I had accumulated a little money, and returning to Sydney I gave orders for the building of a boat 22 ft long, 7 ft beam and 2 ft 6 inches deep. With her I went to Botany ...[where]...I pitched my tent up on Curtis island. Gathering my own load of shells, I ran them up to Liverpool or across Botany Bay to the mouth of Cook's River. By this means I could earn as much as 5 pounds a week with my boat.[39]

The kilns at Port Arthur (Tasmania) and Carrington (NSW) are surviving examples of kilns which burnt shell, the raw material being supplied by boat from the bays and inlets of their respective region.

Where limestone was burnt it was much more common for the kilns to be located at the source of the stone, due to the heavy cost of transporting it, while the fuel supply

(usually timber or coal) was brought from the surrounding district. Likewise, due to the heavy cost of transporting the end product to the users, kilns were built in any locality where a source of shell or stone was found nearest the market, or nearest any single job requiring significant amounts of lime, such as the construction of a large house. As an indication of the widespread nature of limeburning, an 1881 commercial directory lists 28 districts in country New South Wales supporting a total of at least 77 limekilns, most of which were presumably commercial operations in order to warrant listing in the directory.[40] The advent of rail transport, and, after the turn of the century, the increasing production of cement in central locations near both the major cities and the railways, gradually brought about the demise of most country limekilns.

A look at the surviving kilns gives an idea of the range of relationships which could exist between kiln and raw materials. At Norfolk Island the kilns (built 1802 to 1845) were built on top of a supply of coral rock, the 1845 kiln actually being built into the side of an earlier quarry which supplied the stone for burning in the kilns. The kilns at Blayney in New South Wales and Coimadai in Victoria were similarly located in close proximity to their stone quarries.

At the Kingsdale limeworks near Goulburn (NSW), the limestone was buried beneath an overburden of earth of varying depth. The kilns were built into the banks of overburden removed to uncover the limestone, which in turn was lifted from the quarries and transported to the adjacent kilns by handcart and light rail trolleys, as the physical evidence at the site demonstrates. The need to remove the overburden, and deal with pockets and bands of clay rich material scattered through the deposit, made quarrying at Kingsdale an expensive undertaking. This high cost was compounded by the need to cart timber fuel a considerable distance by rail and road, and by the long cartage distance to the Goulburn market by road. The only access to rail transport to other markets was by carting the lime two miles over private land to the nearest railway siding.[41]

A way of buffering the investor from the cost risks associated with the industry at Kingsdale was to rent out the risky component to smaller operators, as is indicated by the advertisement for the sale of what appears to be only one element of the Kingsdale quarries and surrounding property in 1909. This also indicates the extent of development of the industry at the site:

> The improvements comprise substantial two-storied stone house of 17 rooms, verandah back and front, and replete with every convenience, all necessary outbuildings, four-stall stable, with loft, sheds, etc; sheep yards etc. There are also a number of cottages on the property which are let to workmen at the Kingsdale Lime-works, as well as several Lime Kilns which are also rent-returning. The amount derived from the cottages and lime kilns is about £85 per annum... There is also a Public school of the property, also church. Post and Telephone office within 100 yards of the homestead.[42]

The manager's house, three standing pise cottages and the ruins of several others, survive within 500 metres of the lime quarries today.

The unlikely location of the extensive Kingsdale lime industry, which was the second largest source of lime in New South Wales in 1925, was explained by the episodic but substantial growth of Goulburn, which experienced a building boom in the 1880s with its new role as railway centre, again in the 1912–1915 period, and again in the late 1920s when it had the most rapid growth in New South Wales, being at one stage the third largest town in the state.

In Western Australia the limestone around Perth occurred as bands of stone at the surface of the ground, called capstone. The deposit at Wanneroo was typically 2.4 to 3.6 metres thick, but could be up to 12 metres thick, the stone being blasted out with gelignite placed in holes hand-drilled with jump bars, then broken up with sledge hammers to burnable size.[43] At Wanneroo the kilns were typically built on the downslope sides of the limestone quarries, to facilitate easy loading into the tops of the kilns with minimal transport of the stone. Between the paired kilns was a bagging floor, which often served also as a loading dock for wagons and trucks. Of recent times the stone has been carted from further afield by truck.[44] The fuel for the kilns at Wanneroo was timber of several species, carted by contractors from the state forests.

A quote from Albert Facey tells us something of both the transport systems and working conditions at these kilns in 1934:

> My work was very hard with long hours, and my pay was four pounds per week. I had to load seven tons of lime (in bags) onto a truck three times a day, then drive it to the railway yards in the city and load it onto a railway truck to be consigned to purchasers in the Goldfields. The lime was ninety-eight percent pure and if it got onto my skin it would burn and large blisters would come up. The dust from it was very damaging to my hair – in fact, after a few weeks the hair fell off all over my body and head. I went quite bald. I stuck to this job for five months before becoming ill and was again ordered to hospital.[45]

At Albany in Western Australia capstone was also used, gathered from relatively shallow quarries around the kiln area. The kilns were operated in the nineteenth-century on a casual basis, the burners also being involved in whaling, sealing and fishing. The lime produced was shipped across the harbour to Albany in small sailing boats.[46]

As has been pointed out, lime kilns were often built solely to service one building operation, or to be used on an as-needs basis to supply the wants of a local community. An atypical, but nonetheless interesting, example of short term and low output lime production is that of the Donald kiln at Yallingup in south-western Western Australia. In 1922 Jack Donald built a limekiln at Yallingup near Busselton, basing the kiln design on commercial Wanneroo pattern kilns located at Coogee south of Fremantle, where Donald had gone to work for two weeks to learn the methods of construction and operation. The burning of lime was just one component of an integrated scheme to maximize the profit resulting from the clearance of forest land for grazing. A water-driven saw mill was built (which, like the kiln, still stands), the timber cleared from the property and neighbouring blocks being milled for local sale. The limekiln burnt limestone carted to the property from a source four kilometres away, one load being burnt each fortnight and sold locally. The fuel was the timber off-cuts and smaller trees from the property. This milling and limeburning enterprise was continued until 1938,[47] by which time it is presumed that the local land clearance, infrastructure development, and establishment of a pastoral economy had been achieved.

CONCLUSION

The very brief overview of the somewhat disjointed scraps of evidence that have been gathered on the lime industry, is indicative of the problems faced in the study of this or any other decentralised, low-key industrial process in

Australia. There are very few researchers, studying scattered documentary, oral and physical sources across a very large land area. In the case of this and many other industries, the current knowledge of the industry on a national basis is too limited to enable challenging research questions to be addressed in any detail.

On the other hand, this very characteristic of these industries means that there is plenty of room for fresh research. A strategy to gradually redress our ignorance in this area would be to encourage the more intensive study of industries, and their relationship to land use development, settlement spread, economic interactions and social developments, at a regional level. The development of a greater corpus of knowledge by the compounding of these studies, would enable wider state and national studies to occur, and provide the basis for progressing meaningful research questions on the national level.

NOTES

1. Jones 1925:28; Lindsay 1975:6.
2. Pearson 1981; Searle 1935:270; Ward 1983.
3. For descriptions of various kiln types, see Lindsay 1975; Johnston 1986; Searle 1935.
4. see Pearson 1981; Carne and Jones 1919:28-29, refers to the occasional use of heap burning as late as 1919.
5. Wentworth 1819.
6. Higgins 1973; Pearson 1981.
7. Johnston 1986: 12, quoting Doery 1973; some indication of the extent of use of Aboriginal middens for lime production is given in Sullivan 1981.
8. Ward 1983; Searle 1935:270.
9. Skinner 1975:225.
10. Undated photograph, Department of Mineral Resources Photographic Library.
11. Lieut. Governor King to Gov. Phillip, 29 December 1791, *Historic Records of NSW* Vol 1 pt2: 574-575; Wilson and Davies 1980.
12. Harmon-Price 1980.
13. Shown in James Meehan *Plan of Town and Suburbs of Sydney* 1822 (Mitchell Library); J.G. Austin 'Fort Macquarie, Government Domain' 1836; J. Skinner Prout watercolour *Sydney Harbour 1845* (Art Gallery of NSW).
14. Allen 1967:126-127.
15. Turner and Bairstow 1980-81; Bairstow 1987, and various contemporary newspaper articles.
16. Thornton 1982:121-124; Deely 1984.
17. Eslick 1983:126-128; Earle 1986.
18. Carne and Jones 1919:12.
19. *ibid*:23-30.
20. Jones 1925:29.
21. *ibid.*
22. Pearson 1985.
23. *ibid*:99-101.
24. Listed in Carne and Jones 1919.
25. Johnston 1986:53-75.
26. Morris-Nunn and Tassell 1984:3-5.
27. Neil 1972: 21; report by Ian Shields-Brown, National Trust of Australia (NSW) files; personal observation.
28. Simpson P. 'Nominal returns of buildings' 28/8/1825 CSIL Reel 1247, Archives Office of NSW; Wellington Returns of Labour 4/10934:1825, AONSW.
29. See Searle 1935:271-273; Hudson 1972:50-51.
30. See Searle 1935:274, 280-81; Emley 1913.
31. Culican and Taylor 1972.
32. National Trust of Australia (Victoria) file information prepared by R Elthinstone, J McCarthy, R Varman and J McClellan 1980-1983.
33. National Trust file information by J McClellan 1984.
34. Johnston 1986.
35. *ibid.*
36. Smith 1975.
37. Brodsky 1963:16.
38. Collin 1914:121-126; Ellis 1906.
39. Collin 1914:125-126.
40. *Sand's Directory* 1881.
41. Jones 1925:31.
42. *Goulburn Evening Penny Post* 23/10/1909. Thanks to Bruce Pennay, Charles Sturt University, for the reference and his knowledge of the growth of Goulburn.
43. Molyneux 1981: Appendix 8 (with thanks to the author).
44. Pearson 1985:97.
45. Facey 1981:309.
46. Pearson 1985:100.
47. *ibid*:100-101.

BIBLIOGRAPHY

Published sources and theses

ALLEN, J. 1967. The technology of colonial expansion: a nineteenth century military outpost on the north coast of Australia, *Industrial Archaeology* 4.2:111-137.

BAIRSTOW, D. 1987. *The Newcastle Lumber Yard, Recent Discovery of Convict remains*, Research Bulletin, Australian Society for Historical Archaeology 6.

BRODSKY, I. 1963. *North Sydney 1788-1962*, Municipal Council of North Sydney.

CARNE, J.E. & JONES,C.J. 1919. *The Limestone Deposits of NSW*, Department of Mines, Mineral Resources Report No.25, Sydney.

COLLIN, W. 1914. *Life and Adventure (of an Essexman) Captain William Collin*, H.J. Diddams, Brisbane.

CULICAN, W. & TAYLOR, J. 1972. *Fossil Beach Cement Works, Mornington, Victoria*, Refulgence Publishers, Deception Bay, Queensland.

DEELY, J. 1984. *The Stavely Lime Kilns, New Zealand's Industrial Past: Papers presented at a Seminar on Industrial Archaeology in New Zealand, Christchurch, 29-30 March 1983*, New Zealand Historic Places Trust, Wellington.

DOERY, C. 1973. *Poetry in Limestone*, Unpublished thesis, Fine Arts Department, University of Melbourne.

ELLIS, G. 1974. 'An adventure of the 1850s', from *St George Call* Sept 8 & 15, 1906 reproduced in *Sutherland Shire Historical Society Bulletin*, 10, Oct 1974.

EMLEY, W.E. 1913. *Manufacture of Lime, Technological papers of the Bureau of Standards*, U.S. Department of Commerce, Washington.

FACEY, A.B. 1981. *A Fortunate Life*, Penguin Books, Ringwood.

HARMAN-PRICE, P. 1980. *St Helena Island Management Plan, Part 3, History of St Helena*, National Parks and Wildlife Service, Queensland, Brisbane.

HUDSON, K. 1972. *Building Materials*, Longmans Archaeology Series No.9, London.

JONES, L.J. 1925. *Limestone, Dolomite, Lime and Hydraulic Cement*, Bulletin No.9, Department of Mines NSW Geological Survey, Government Printer, Sydney.

LINDSAY, C.S. 1975. 'Lime preparation at 18th Century Louisburg, Canadian Historic Sites': *Occasional Papers in archaeology and History* No 12: 5-45. National Historic Parks and Sites Branch, Parks Canada, Indian and Norhtern Affairs, Ottawa.

MORRIS-NUNN, M, & TASSELL, C.B. 1984. *Tamar Valley Industrial Heritage: a Survey*, Queen Victoria Museum, Launceston, Tasmania.

NEIL, M.H. 1972. *Valley of the Macleay*, Wentworth Books, Sydney.

PEARSON, M. 1981. 'Simple Lime-burning Methods in Nineteenth-Century New South Wales', *Archaeology in Oceania* 16: 112-115.

PEARSON, M. 1985. 'Archaeological interpretation and ethnographic analogy: the lime industry in Western Australia', *Archaeology in Oceania* 21: 94-102.

SEARLE, A.B. 1935. *Limestone and its Products. Their Nature, Production and Uses*, Ernest Benn Ltd, London.

SKINNER, B.C. 1975. 'The archaeology of the lime industry of Scotland', *Post-Medieval Archaeology* 9: 225-230.

SMITH, B. 1975. *Pioneering Days in Bega*, Bega Valley Historical Society, Bega.

SULLIVAN, M.E. 1981. 'Ninety years later: A re-survey of shell middens on Wagonga Inlet and Pambula Lake, NSW', *Archaeology in Oceania*, 16: 81-86.

THORNTON, G.G. 1982. *New Zealand's Industrial Heritage*, Reed, Wellington.

WARD, A.H. 1983. 'A sod lime kiln on Cefn Bryn, Cower, West Glamorgan', *Post-Medieval Archaeology* 17: 177-184.

WENTWORTH, W.C. 1819. *Statistical, Historical and Political Description of the Colony of New South Wales*, Whittaker, London.

WILSON, G. & DAVIES, M. 1980. *Norfolk Island: Archaeological Survey Kingston and Arthurs Vale Region*, Department of Housing and Construction, Canberra.

Unpublished sources

EARLE, D. 1986. *Preliminary survey of historical resources at Bungonia State Recreation Area and proposed additions*, Unpublished report for the National Parks and Wildlife Service, NSW.

ESLICK, C. 1983. *Historical archaeological sites in the Portland area*, Unpublished report for the Victoria Archaeological Survey, Melbourne.

HIGGINS, D. 1973. *The way it was*, Unpublished typescript, University of New England Archives, Armidale.

JOHNSTON, C. 1986. *Coimadai Lime kilns: conservation analysis*, Unpublished report for the Rural Water Commission, Melbourne.

MOLYNEUX, I. 1981. *The limestone connection: A survey of the National Estate in Waneroo*, Unpublished report for the Shire of Waneroo.

SIMPSON, P. 1825. *Nominal Returns of Buildings, 28/8/1825*, Colonial Secretary's In-Letters, Reel 1247, & Wellington Returns of Labour, 4/10934:1825, Archives Office of New South Wales.

TURNER, J.W. & BAIRSTOW, D. 1980-81. *Carrington, Port Stephens*, Unpublished report for Heritage Council of NSW.