Joadja, New South Wales; The Paragon of Early Oil-Shale Communities

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Oil-shale in the nineteenth century was an alternative source of crude oil to the oil-wells of America and elsewhere. The Australian industry, centred in New South Wales, had close links with Scotland through technology, managers, miners and refinery workers. Joadja preserves to an extent unique in the world legible (and scenic) archaeological testimony of all aspects of a major works using horizontal retorts to distil oil from extremely rich oil-shale deposits. The article analyses these remains, both industrial and domestic, in the context of other shale sites, with special emphasis on Joadja's four benches of retorts.

Oil is today associated first and foremost with the needs of the internal combustion engine. In the Victorian period, paraffin or kerosene was the key product, but the other products, candles for lighting and a wide range of waxes and oils for lubrication, were highly important.[1] The central position of kerosene in Victorian life requires more systematic exploration: Peter Cuffley's work in Australia on the morphology of kerosene lamps is a pointer in the right direction.[2] Oils from plants, varying from olives to rapeseed, and from animals such as whales and seals had long been known, but commercial exploitation of oil-wells and of oil-bearing minerals in the 1850s transformed the industry and had important repercussions on chemical manufacturing more generally.[3]

The first commercial oil-well was sunk in 1859 in the valley of Oil Creek, near Titusville in Pennsylvania, where the crude oil had first been tested in 1851. Within a few years, in the 1860s, oil-wells were sunk elsewhere in Pennsylvania, in other US states, and in Canada, where new industrial centres bore proud names such as Petrolea in Ontario. Oil-rigs began to dot the North American landscape, producing in the quarter-century after 1859 no less than 250 million barrels of petroleum. A world-wide search for subterranean oil was launched, with success initially in the Caucasus and Romania, while Japan, China, Burma and Italy could supply local demand; but until the Middle East and South American fields were discovered, North America ruled supreme in oil-well production.[4]

In the 1850s, however, just as the oil-well technology was developing, a different source for oil created a major industry in several countries, most notably the USA, Scotland, Wales and France, followed in the 1860s by Australia. This alternative source is conveniently known as oil-shale, although this is an imprecise and geologically unsound generality for the variety of bituminous minerals which have been roasted to extract oil. H.M. Cadell, a Scottish geologist and industrialist, gave a classic exposition of the distinctions more than eighty years ago: 'Oil shale differs in origin from most kinds of coal in being an undoubted aqueous deposit or precipitate composed generally of 70 to 75 per cent. of ash, originally inorganic mud, with 30 to 25 per cent. of organic matter, partly animal and partly vegetable in origin, from which the valuable hydrocarbons and ammonia are obtained.'[5] The distinction between oil-shale and the various forms of cannel coal is still best defined by the dual means of ash content and density, with the higher ranges of each characteristic of shales and the lower of cannels, while the oil-yield in general varies inversely as the density.[6]

It is unfortunate that so many unfamiliar names have been employed for the raw materials. 'Cannel' is simply the Scots and North of England dialect pronunciation of 'candle' and was in origin a lay name for coals which had apparent lighting qualities; 'boghead' or 'torbanite', the first oil-bearing mineral to be used commercially in Scotland, took its names from the location of the mines in the Lothians; the term 'kerosene shale' used familiarly in New South Wales is applied to minerals which are very similar to boghead or torbanite in Scotland.[7] In this discussion of Australian industry, the term 'oil-shale' will be used.

The basic distinction between obtaining oil from wells and oil from shale or cannel is simply that shale or cannel requires an intermediate retorting and distilling stage before refining. Crude oil from wells goes straight to a refinery; oil-shale or cannel is mined like coal, either by adit or by shaft, and then has to go through retorting and distillation before the crude oil ready for refining is produced.

Because of the intermediate processing and the additional cost and uncertainty of mining, the shale and cannel industry was immediately threatened by the instant crude oil pumped from wells. In the USA the oil-wells virtually eradicated a flourishing oil-shale industry in the 1860s[8] and in the English-speaking world the most serious continuing exploitation of shale and cannel in the later nineteenth century was in Scotland and New South Wales. In Scotland it was severely localised in the Lothians west of Edinburgh;[9] in New South Wales the worked deposits were associated with the southern and western coalfields, usually in valleys hard of access.[10]

The archaeology of the industry reflects three separate elements: the mines, the retorts and the refinery. Many smaller concerns produced crude oil only; those which also refined might or might not have their refinery adjacent to their retorts; some companies existed only to refine crude oil from any outside source. The mines might or might not be owned by the oil-company and were not necessarily close to the retorts, although in most cases a tramway no more than a few kilometres long connected the mine with the distillation plant.

In Australia integrated plants were common, but not universal. The Pioneer Kerosene Works at American Creek, Mount Kembla, opened in 1865 with its own retorts and refinery beside the mine.[11] In the same year Petrolea Vale, the earlier of the two oil companies established in Hartley Vale in the 1860s, also had a plant complex on site five hundred metres from the mine-adits.[12] In 1870 Petrolea Vale amalgamated with the other Hartley Vale company, the Western Kerosene Company. Western Kerosene had chosen to build its processing plant in Sydney, at Waterloo in 1868. By 1872 the Petrolea Vale retorts and refinery had been crudely demolished: 'stills, which must have cost fabulous sums, having lost their centre of gravity, cock up their heads at all manner of angles in the most rowdy and rollicking style, just for all the world as if it had been rum and not oil which they had been accustomed to.'[13] An American visitor described

Hartley Vale in 1871 as 'a most eternal fire bed of shale and a heap of old iron'.[14]

From Petrolea Vale's closure up to 1878, American Creek's Pioneer Kerosene Works was the only integrated shale mining and processing plant in Australia.[15] And American Creek closed just as Joadja was opening as the next integrated oil-shale operation in the country.

OIL-SHALE PRODUCTION AT JOADJA

The valley of Joadja Creek proved to have the richest shale seams in the world but in terrain much more difficult of access than American Creek or Hartley Vale. The valley is almost entirely surrounded by dominating cliffs as Joadja Creek cut its way west to join the Wingecarribee River 14 kilometres north-west of Berrima. The first white people to enter the valley were stockmen with cattle either from the adjacent Burragorang wilderness or from the Canyonleigh area of the Southern Highlands. The family which used Joadja regularly were the Carters and it is a Carter who first realised the potential of the outcropping shale seams. The cattle belonged to Benjamin Carter, an English farmer who had come to New South Wales in 1833 and settled at Sherwood on Emu Creek south-west of Berrima in the 1840s, after a period as overseer at the major Sutton Forest property of Newbury. Benjamin's only son, Edward, born in 1823 or 1824, assisted his father and succeeded to his extensive grazing lands in 1857.[16] Although Edward had been in Joadja in the early 1850s and had noticed the shiny black mineral on seams out-cropping high up on the cliffs, it was only after American Creek and Hartley Vale became well-known that Carter moved to take out land-grants and mineral leases.[17] He was primarily a farmer. In 1870 he had built the delightful two-storeyed sandstone house in Sutton Forest, known as Golden Vale[18] (where the house and Carter's extensive outbuildings are still in excellent order today). This was country Carter knew well, since it is adjacent to Nicholson's Newbury where he had grown up in the later 1830s. Carter's flirtation with Joadja is important historically and archaeologically, but it is no more than an uncharacteristic episode in the life of a successful grazier.

Carter's sequence of land acquisitions around Joadja Creek and its junction with the Wingecarribee River are revealing (Fig. 1). He did not seek to control the whole area and by the later 1870s held only five portions in the critically important shale-bearing part of the valley north of Joadja Creek (portions 44-46, 65, 91) and two to the south (42, 43), totalling 305 acres (123 hectares). All five portions north of the creek abutted. Carter controlled both major fords, one where Joadja Creek bifurcated around a long sand-island, the other further east near the shale-mines. He also controlled most of the dray-road north through Carter's Flat up to Siphon Gully, the northern end of the oil-shale outcrops. What Carter did not control was the only viable exit from the valley to the railhead at Mittagong, which climbed the cliff-face in portion 84, taken up in 1876 by George Larkin and William McCourt.[19]

The original entry to the valley is said to have gone north to the Wombeyan Caves Road just east of the Bullio tunnel at the

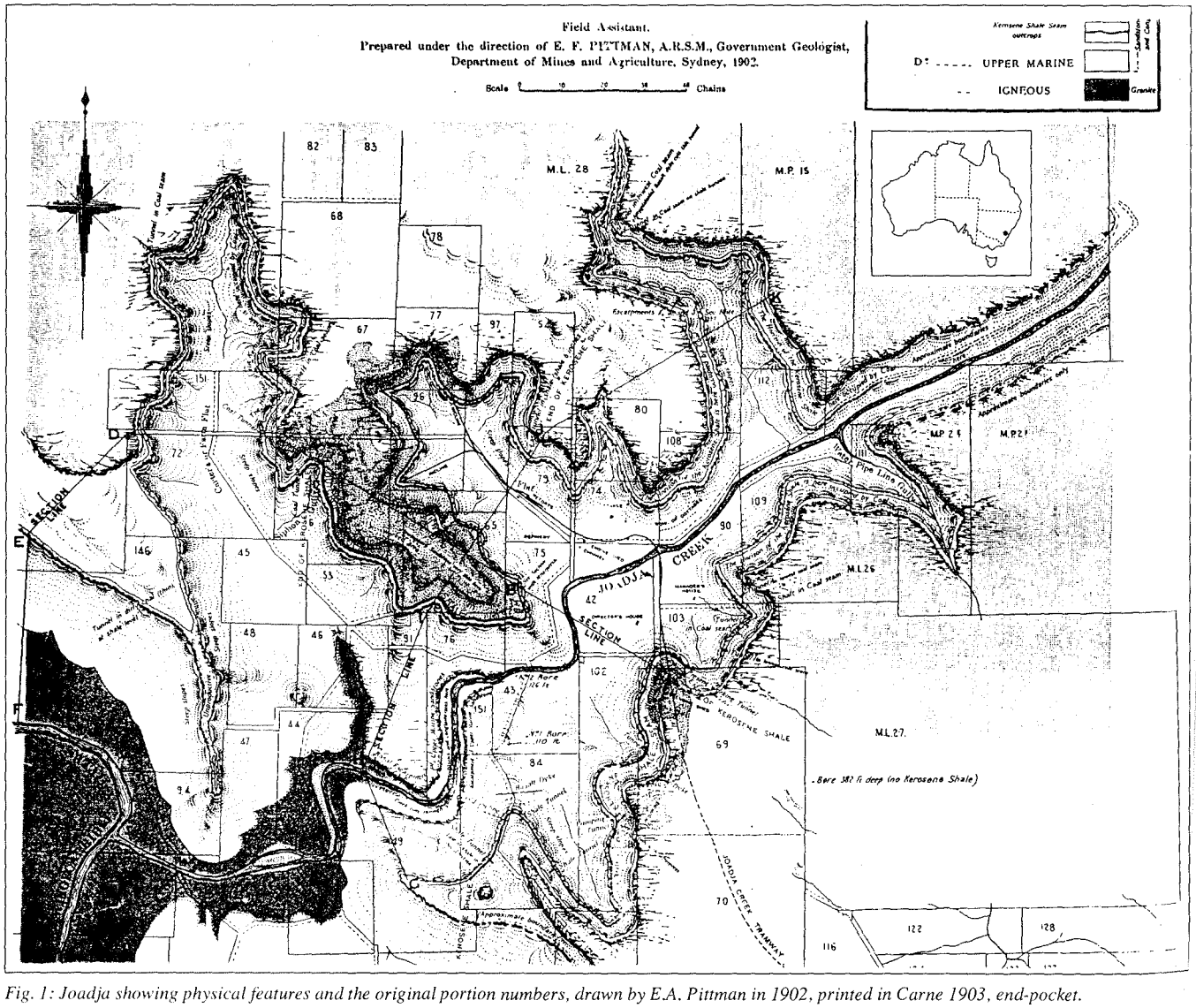

Fig. 1: Joadja showing physical features and the original portion numbers, drawn by E.A. Pittman in 1902, printed in Carne 1903, end-pocket.

present Madang property.[20] This would have left Joadja to the north-west via Carter's Flat and the hills to its west: it was from the north-west that Edward Carter had entered Joadja Valley in 1852.[21] But although this track avoided the severe grades of the southern route, the lure of the railway was decisive. The dray-road which survives today, known locally as Carter's Track, is of special importance for the archaeology of ore-haulage.

The need for haulage developed in the mid-1870s. In 1873 both Carter and an entrepreneur called Cosgrave applied for the conditional purchase of portion 65, which includes some of the richest shale outcrops.[22] Carter succeeded in establishing title in 1874 and immediately engaged Robert Longmore, who had built the plant at American Creek in 1865, to mine the shale.[23] In the same year 1874 George Larkin obtained mineral rights in portion 76, immediately to the south of 65 and including a valuable stretch of shale, which Larkin proceeded to mine. He presumably used the ford on Carter's portion 43 and the track up the southerly escarpment which was not yet owned by anyone. The principal shale-mining potential lay up Russell's Gully north of Carter's portion 65, and the relevant portions here, 66, 67, 75, 79, 96 and 97 were acquired by John de Villiers Lamb. In conjunction with William Brown, Lamb also began mining in 1874.[24] All three parties to the early shale-mining, Carter, Larkin and Lamb with Brown, were dependent on each other's goodwill for transporting the ore out of the valley.

Initially in 1874–1875, teams of fourteen bullocks hauled the ore-drays across the valley floor, over the steep-banked ford and up the zig-zag to the plateau which extended to Mittagong.[25] This zig-zag still exists, just at the shale horizon (which is fairly close to the top of the cliffs), and is acutely hazardous for a four-wheel-drive vehicle today. It was even more hazardous for a labouring bullock-train in 1875 and an incline was constructed instead to by-pass the zig-zag. Carter had already installed a gravity incline at his mine on the north side of the valley, using a double cable: as full skips descended, empty skips rose. The full skips discharged into a 50-tonne bin, from which the bullock-drays were loaded.[26]

On the southern side, on the still unclaimed portion 84, a horse-powered incline was installed, almost certainly by Carter. Two horses turned a whim on a circular platform 11 metres in diameter which is identifiable still. It is about 300 metres away from the four notches in the rock face which held the topmost rails for the descending and ascending ore-skips. Ten metres below this cutting, three more cuttings survive in bedrock to continue the support of the rails and a blacksmith-made iron spike 17 centimetres long used for securing the rails to sleepers lies in the bush just below. Down the steep slope of the incline, on its south-western side, there are five charred mortised posts parallel to the former tramway. These are clearly part of the fence line which kept stock away from the incline during its brief period of use, from 1875 or 1876 to 1878. Traffic on the incline was not heavy: the total quantity of shale mined in 1876 was 400 tonnes, in 1877, 650 tonnes.[27] The principal steady market during Carter's period of mining was the Australian Gas-light Company which used 30 to 50 tonnes a week to enhance the quality of its gas.[28] According to Carter, however, there was also export of the untreated shale to America, England and Melbourne in the years 1875 to 1877.[29]

The whole scale of the enterprise changed in 1877–1878. John de Villiers Lamb, who controlled all the significant shale-bearing land north of the creek not in Carter's hands, was joined by Parbury to form a company Parbury, Lamb & Co. in 1877.[30] This company took the immediate, decisive step of building a major incline out of the south side of the valley, on Lamb's portion 103, 1 200 metres north-east of Carter's exit (Fig. 2). The incline goes austerely up 840 metres to the plateau, where it was intended to join a private railway leading to the main south line at Mittagong.

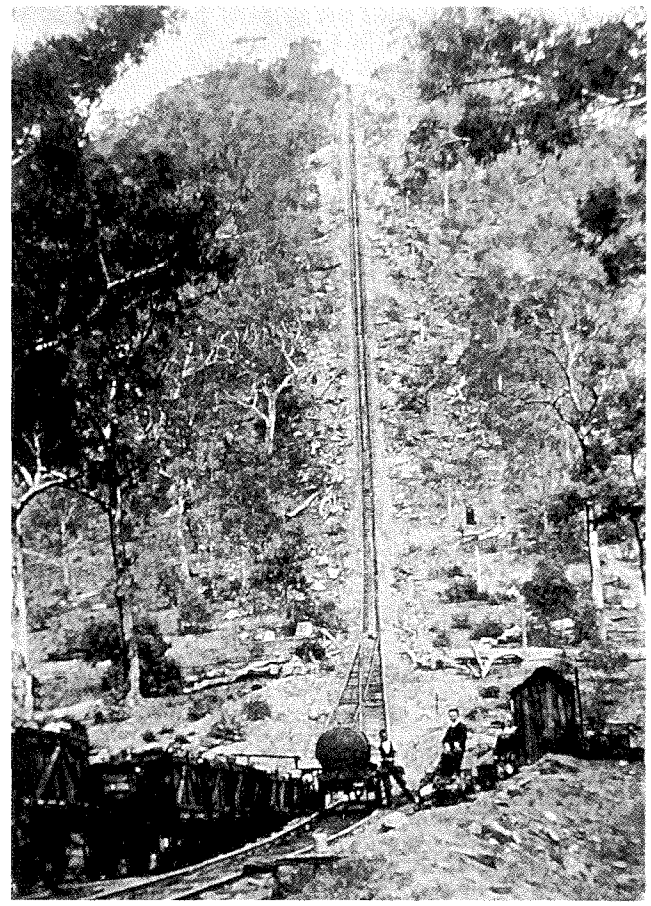

Fig. 2: The main incline, photographed in the 1880s by Auguste Tronier. An oil-tanker is at the foot of the incline. (State Library of NSW, Mitchell Library, BM: Joadja 1870–1880, printed by courtesy of State Library.)

The 1877 incline was powered by a 40 horsepower steam-engine located on the plateau.[31] The magnificent winding-wheels, 280 centimetres in diameter, still survive on their concrete supports with many traces of the winding-shed and railway station still discernible. The incline was single track, with the haulage cable running in the middle of the tramway.[32] At the bottom, it separated into two lines, running north to the creek on well defined embankments.[33] The railway crossed the creek on a bridge supported by five piers constructed of stone rubble with concrete render, scored to resemble masonry blocks. Once across Joadja Creek, the railway went north-west across the flat where the refinery was built in 1878–1879 and up Russell's Gully to the major concentration of mines.

The advice of a leading Scottish oil-shale engineer had been sought in 1876 and the expertise of James Walter Fell, who was at that time manager of Hartley Vale's Waterloo oil-refinery, was of critical importance. Fell himself transferred from Waterloo to Lamb's employment at Joadja in March 1877, while retaining an advisory position with the North Shore Gas Works.[34] In the same year, James' uncle, Alexander Morrison Fell, came to Joadja after managing a Scottish oilworks in the Lothians.[35]

All that remained was the formation of a company with ample capital. The crucial decision to build retorts and a refinery at Joadja and not to depend on railing all ore to Sydney for treatment, was taken in 1877 by Lamb, his associate Parbury and his new partner Robert Saddington, in conjunction with the Fells. In 1878 the consortium was transformed into the Australian Kerosene Oil and Mineral Co. (AKO). The new company over the next three years systematically bought up all the mining conditional purchases held by Larkin and McCourt, and by Carter, as well as all the leases already held by John de Villiers Lamb and Saddington.[36] Effectively the mining area of Joadja became a

private fiefdom of the AKO not just until the mines closed in 1903 but until the company went into liquidation in 1911: and even then the name AKO remained a brandname for the orchard produce from the valley up to 1928.[37]

There was no hiccough between Lamb and AKO; it was a seamless transfer to a more broadly based company. Edward Carter was not interested in becoming an industrial magnate: he sold readily to his new neighbours and in 1879 invested the proceeds in Cottle Wolly, a major sheep and cattle station near Crookwell, renaming it Lake Edward.[38]

The major decisions implemented by the AKO at Joadja were to build stacks of retorts close to the major mines in Russell's Gully and to establish a refinery on the flat land between the mouth of Russell's Gully and Joadja Creek.

ARCHAEOLOGICAL EVIDENCE

The retorts are the most remarkable part of the archaeology of Joadja. The retort design chosen was a horizontal D-shape with the straight side as the base. By the late 1870s most Scottish shale was burnt in high, vertical retorts which were found to suit the low-yielding Lothian deposits better than the horizontal retorts originally used there. The horizontal retort had been used by James 'Paraffin' Young at his Bathgate works in the Lothians in 1851, and still 15 years on significant Scottish plants such as Roman Camp and Stewartfield had stacks of 78 and 60 horizontal retorts respectively.[39] But vertical retorts were being tried as early as 1852 in Scotland, successful new designs by Kirk and by Norman Henderson were patented by 1873 and the major success of William Young and Beilby's new patent of 1882 formed the basis of subsequent Scottish practice, modified into the two major types of rectangular vertical, known as Broxburn, and circular vertical, known as Pumpherston.[40] As a result of the success of the vertical retort, in its various forms, horizontal retorts had largely been scrapped in Scotland by the time Joadja was in its heyday.

The high yielding oil-shale found at American Creek, Hartley Vale and especially Joadja had proved very well served by horizontal retorts. The first retorts of the Pioneer Kerosene Co. at American Creek had been D-shaped, 305 centimetres long, 46 centimetres wide and 30.5 centimetres deep,[41] but were later replaced by ones of very different dimensions: 249 centimetres long, 194 centimetres wide and 77 centimetres deep.[42] At Hartley Vale from 1865 to 1868 the Petrolea Vale company had used 27 circular horizontal retorts initially, 740 centimetres long by 30.5 centimetres in diameter, but in 1868 the company built a bench of D-shaped retorts, made by McArthur at his Waterview Foundry in Sydney twice as long (740 centimetres) as those already installed at American Creek and 51 centimetres deep.[43] All this was abandoned when the company merged into the NSW Shale and Oil Co. in 1871. The other Hartley Vale company, the Western Kerosene Oil Co. had used circular retorts for its Waterloo plant in Sydney, opened in 1868, just as Petrolea Vale was moving towards D-shaped retorts. The circular retorts, based on the gas-producing model used initially by Young in Scotland in 1851, were replaced at Waterloo by D-shaped ones 'invented' by John Glover, a company engineer. These Glover retorts continued to be used at Waterloo to process the best quality shale even after vertical retorts, patented by the Hartley Vale manager, W.J. Hall, were introduced in the 1880s. Twenty more Glover retorts were built at Hartley Vale itself when the NSW Shale and Oil Co. decided to erect a full retorting and refining plant there in 1880, to supplement Waterloo, in direct acknowledgement of the opening of Joadja's new plant.[44]

Joadja's horizontal retorts have two special features. Unlike all the other retorts of this style used in New South Wales they were imported, probably from Glasgow, where James Fell's cousin, John Fraser, had previously been approached in 1876 to supply retorts.[45] The other characteristic of Joadja's retorts is the high rate of survival.

The remains of the benches of retorts are visually compelling and archaeologically important. Despite the removal or partial displacement of some of the metal retorts and despite the damage done to the brick casings by a century of disuse and vegetation growth, the four benches constitute an extraordinarily impressive part of Australia's industrial heritage. The benches of retorts were constructed in the heart of the shale-mining area in the middle of Russell's Gully (Fig. 3). They are arranged in two parallel rows, running for 100 metres north-west to south-east, and occupying 0.18 hectares in area (Fig. 4). Although similar in superficial appearance, the two parallel benches at the north-west end are not identical to the benches at the south-east. There are sixteen retorts to each bench in the north-west (identified as NE1 and SW1) seventeen in the south-east (NE2 and SW2). The chimney stacks were attached to the south-east end of the north-west benches, and when the south-east benches were erected a year or so later these retorts used the existing chimneys through curved brick flues running under the 235 centimetre gap between the north-west end of the retort casings and the stack. The chimney has been removed from SW1, but the details of the flue connections are visible on the north-east chimney and on retort-bench NE2.

Fig. 3: The first two benches of retorts at Joadja photographed in 1879, showing the physical context in Russell's Gully. The oil-shale mines are high up on the surrounding cliffs, the refinery site to the middle right.

Fig. 4: The four benches of retorts with the surviving chimney-stack, from south-east. The volatilised oil from the retorts was condensed in the central area and piped down to the refinery. (R. Ian Jack, 1995).

Although the two separate pairs of retort benches were built within twelve or eighteen months of each other, the brickwork is different. On the earlier (north-west) pair, the bond used on both sides of the benches is a simple alternation of a course composed entirely of headers and a course entirely of stretchers, the straightforward English bond, also used in the surviving chimney stack. This is a strong bond, fairly lavish in its use of bricks. On the south-east benches, by contrast, the bond used is three or four courses of stretchers followed by a single course of headers. This colonial bond uses significantly fewer bricks than English bond and is as a result weaker, although the later retort casings are not visibly less effective than the earlier.

The brickwork on the outer side of the benches (north-east of NE1 and NE2, south-west of SW1 and SW2) is more complicated because the fire-holes below the retorts are located on this side. The walls are as a result pierced both by a two-brick-thick arch at the top going right through the housing and surrounding the retort and by the smaller three-brick-thick arch of the fire-hole at a lower level. On NE2 and SW2 the firehole side has regular coursing of four stretcher courses followed by one header course, but on either side of the arches three stretcher courses are followed by the header course. Since NE1 and SW1 are simple English bond, there was no need for variation on the firehole side.

As a result of these variations in bricklaying on the two stages of retort building, it seems possible that the greater economy in bricks shown in the later benches reflects strain placed on the brick-making facilities in Joadja by the simultaneous demands of retort-casing, refinery buildings and housing. The bricks were certainly manufactured in the valley from local clay. There is an admirable photograph of a brick works in operation but curiously no clay-pit or brickworks site has yet been identified.

Stone was used in conjunction with bricks on parts of the retorting complex. The ends of all four benches have lower sections of stone except where the chimney stacks were built at the south-east end of NE1 and SW1. The stonework is professional, with well pecked blocks arranged in courses tapering at the base of NE2, north-west end, from 357 centimetres to 319 centimetres. The stone coursing occupies the lower 201 centimetres of the 360 centimetre high bench-end with attractive quoining and is clearly a functional buttress which gives aesthetic pleasure as a by-product.

Stone was also used to build sub-surface rectangular flues below the fire holes of the retorts. The area on the outside of all four benches is overlaid with debris, fallen trees, leaves and vegetation, but on the firehole side of NE2 the stone flue into retort 39 is partly exposed: it is made of two parallel stone walls 48 centimetres apart, covered, closer to the retorts, by a two centimetre metal sheet itself covered with one surviving course of bricks. It begins 380 centimetres from the retort casing and the surviving metal plate covers the last 190 centimetres. The depth is not ascertainable without clearing debris from what is probably a stone flooring.

The retorts themselves are, of course, the kernel of the operation. They survive in varying degrees of completeness. Thirty-five are in situ, but various parts of the ironwork have been removed from most of these. Two of those removed lie nearby and can be inspected more easily than those still lying within their brick casing. The measurements, however, were taken from one of the retorts in NE2 which retains most integrity at the inner side of the arch. At this side, the retort remained sealed and the arch within which it lay was completely closed with one layer of bricks (Fig. 5). Retort 44, which was measured, lacks its brick infill but is flanked on the south-east side by the bricked-in arch of retort 45. The pair give excellent data about the rear side of the retort benches.

To maintain the lowest possible heat which will volatilise the oil-shale, the cast-iron retort was placed clear of the walls of the surrounding arch. The retort, then, which at its widest is 214 centimetres and at its highest 97 centimetres, was placed within a double-brick arch but with 25 centimetre clearance from the top of the retort to the keystone of the arch and a similar, varying clearance all round, with eight centimetres clearance between the flat base of the retort and the top course of bricks above the fire-hole below. It was in this space that the ducted hot gases circulated to heat the retort and its contents. The volatilised oil then escaped via a 10 centimetre pipe on top of the retort (Fig. 6) through atmospheric coolers into ships' tanks (several of which survive) which contained an iron condensing worm cooled by water, in the area between the retorts.[46] From the tanks the crude oil passed by gravity 500 metres to the refinery along a pipeline raised on supports, some of which survive. The pipe line began between the two benches of retorts, 445 centimetres from the north-east sets and 500 centimetres from the south-west. The outstanding physical remains are two stone walls, varying in width from

Fig. 5: A retort in situ, *showing the sealed end. The arch was bricked in during use but allowed the pipe carrying the volatilised oil to pass through. Scale 10 x 20 cm. (R. Ian Jack 1995).*

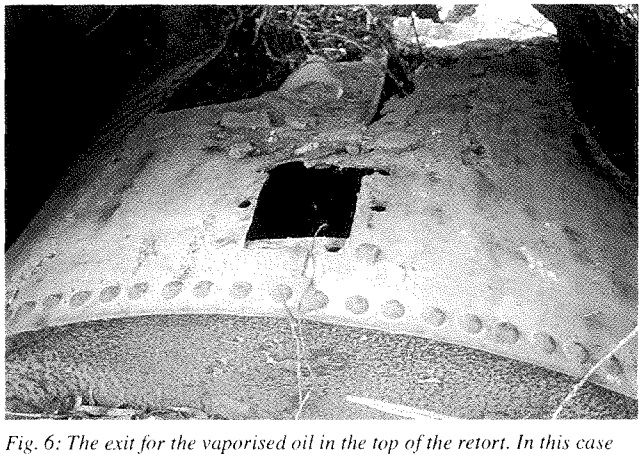

Fig. 6: The exit for the vaporised oil in the top of the retort. In this case the circular opening for the 10 cm pipe had been damaged and a repair was done by attaching a square plate which housed the pipe connection. There are many effective repairs to retorts done by the Joadja blacksmith. (R. Ian Jack 1996).

40 to 46 centimetres, 210 centimetres apart and standing at least 70 centimetres high: these were the supports for the condensing tanks.

Close to the retorts, to their south-west, there is a large tar-pit, still deep enough and quaggy enough to engulf all but a corner of one of the ship's tanks used in the condensing process.

The shape and size of the retorts at Joadja is different from those known elsewhere in Australia. The first horizontal oval retorts used at American Creek had been longer (305 centimetres against Joadja's 254 centimetres) but very much

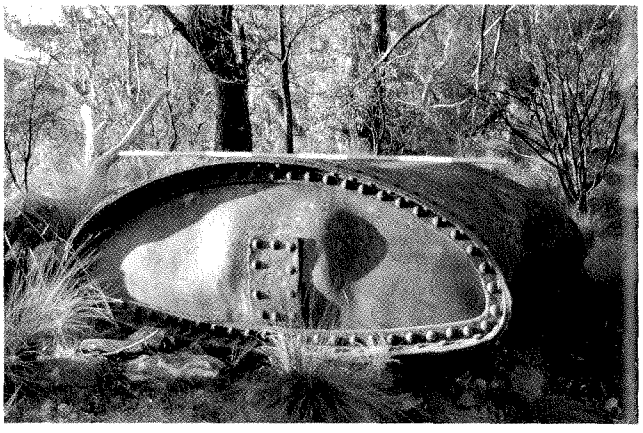

Fig. 7: A surviving Hartley Vale retort lying at the top of the incline: only the back half is visible. The design of the D has a curved base in contrast to Joadja's flatter base. (R. Ian Jack 1995).

narrower (46 centimetres wide against Joadja's 97 centimetres).[47] The later retorts of the 1870s at American Creek had been of similar length to Joadja's (249 centimetres against 254 centimetres) but much broader (194 centimetres to 97 centimetres).[48] The first D-shaped retorts used at Hartley Vale in 1868 by the Petrolea Vale company had very different proportions again. No example survives, but they were reported to measure 740 centimetres in length by 51 centimetres deep.[49]

The only retorts other than one at American Creek which can be compared with Joadja by actual inspection of relics are those at Hartley Vale which were installed by the NSW Shale and Oil Co. in 1880. The better preserved of the two survivors at Hartley Vale was abandoned at the top of the incline, just beside the company tramway on which it was presumably going to be scrapped (Fig. 7). The closed end of this retort is intact and is substantially smaller than Joadja: 192 centimetres wide compared to 214 centimetres, 76 centimetres at maximum height compared to 97 centimetres. On the other hand, the Hartley Vale example is much longer than the Joadja retorts. At both sites the retorts were made in two sections, securely bolted together. At Hartley Vale the front section had been unbolted from the rear but was left lying partly inside the other. The length of the intact section is 184 centimetres, of the detached section 178 centimetres, making a total length, after allowing for overlap between the plates, of 354 centimetres, exactly 100 centimetres longer than the Joadja retorts.

The shape of the imported retorts at Joadja and the retorts at Hartley Vale made originally for the Waterloo works to the design of the local engineer, John Glover, is also markedly different. The flat base at Joadja contrasts with the convex base at Hartley Vale. Clearly both firms were satisfied with their design and both seem to have been blessed by James Fell. At Joadja there had been a chance to alter the specifications after testing the success of the first two benches of retorts, but the second order from Scotland was for an identical design. There is no evident distinction between the retorts in NE1 and SW1 imported in 1878 and those in NE2 and SW2 ordered at least a year later.

At some time before the plant closed an experimental vertical retort with a condensing tower was built just to the south of the main retort banks.[50] This retort was clearly used, though AKO did not persevere with it. Photographs of c.1912 and of 1933 demonstrate that it has changed little over a century.[51] Local belief that it was built during the Second World War petrol shortage, inspired by the opening of Glen Davis with its great vertical retorts, may reflect reuse during the late 1940s.

James Fell planned and built the refinery simultaneously with the retorts. It was clearly a reduced image of the Scottish-

built Waterloo refinery where Fell had previously been employed.[52] The physical remains of the refinery are much less readable than the retorts and excavation would be required to confirm the placing of all the minor elements in the fenced enclosure 375 metres long (east-west) by 175 metres wide (north-south). The plant's stills, and acid and alkali treatment tanks were producing oils, including kerosene by 1879. After a fire in 1882, one of the few accidents at Joadja, a number of safety precautions were taken and between 1883 and 1886 a good deal of capital investment produced many modifications to existing buildings and plant, a doubling of the capacity of the distillation facilities and the addition of new features. In particular the AKO decided to manufacture its own sulphuric acid for use in the refinery; a Scotsman named Cox was brought to Australia in 1883 to build the acid plant and production began later that year in the far north-west corner of the refinery.[53]

The refinery enclosure also housed a variety of packaging works situated close to the railway siding which still exists. The most advanced of these was an American tin-manufacturing unit so that kerosene could be sent out ready packaged for the market.[54] To the east of the main plant there was a candle-moulding shop, operating as the Southern Cross Candle Works.[55] After 1887 the AKO opened the Sandown works in Derby Street, Parramatta and transferred candle-making there. The candles continued to bear the tradename of Southern Cross but Sandown also produced Meteor, Venus, Liberty, Sirius and Anchor candles. The general manufacture of lubricants was also transferred from Joadja to Sandown and as a result more crude oil was transported from Joadja in AKO's characteristic rail-tankers.[56]

The refinery and the retorts closed in 1896.[57] It is not clear whether they ever re-opened. If they did, it was a brief remission for in 1901–1902 the refinery structures were systematically dismantled. The competition from cheap American imports in the 1890s was simply too strong. The Joadja mines were not yet exhausted and the seams still being exploited were of extraordinarily rich quality. But the seams were narrow, the quantity limited and the mines too closed in 1903 after seven years of sending raw shale to Sydney and overseas for the enrichment of municipal gas.[58] After 28 years, Joadja in 1904 ceased to exist as a shale producer: shale experiments in the valley in the 1920s and 1940s remained just that, uncommercial investigations.

The source of all this successful activity from 1875 to 1903 was the extensive shale seam which outcrops high up on the valley walls from Siphon Gully in Carter's Flat right round to the south-east end of Russell's Gully and, on the south of the creek, from the main incline westwards to just beyond Carter's Track. Coal also outcrops in conjunction with the shale but the coal continues beyond the shale right up the northern portion of Carter's Flat, around Nursery Flat and eastwards from the main incline to Water Pipe Line Gully.[59]

The earliest mines in the mid 1870s were on the south-west wall of Russell's Gully and followed the seam westwards. The main tunnels, five in number, of the AKO period were located further up Russell's Gully and were reached by two inclines and several chutes connected to the retorts by tramway. Most of the old photographs of mines in action, with their tramways, ventilation furnaces, skips and miners were taken here in Russell's Gully. They are arduous of access, reached by a stiff scramble up the walls of the gully and then a walk along a narrow ledge.

The high peninsula between Carter's Flat and Russell's Gully was riddled with mines, at least one of which went right through the escarpment. The mine adits opened around Siphon Gully in Carter's Flat connected with the Russell's Gully workings. At Siphon Gully four of the six adits inspected for this study are very low, only 35 centimetres at the entrance and the highest, with an impressive rock-cut approach 650 centimetres in length, is only 84 centimetres high.

As the shale in this key area was worked out, greater attention was paid to the seams on the south side of the valley, so that some of the mining in 1901–1902 was concentrated on the outcrop above the cemetery, where a dewatering tunnel had already served a number of earlier adits. Similarly, adjacent to Carter's zig-zag near the head of Carter's whim-incline, several AKO mines were developed as far as the seam extended.[60]

Halfway up the main incline, a good pathway buttressed with stone was constructed to link five shale adits and, to the north east, several coal tunnels. A fine stone platform still surviving was erected to load this coal and shale directly on to the skips running on the incline.

The exploitation of the seams was exhaustive and there was little prospect of successful reopening of the mines especially after the earthquake damage of 1973. Bores sunk away from the escarpment wall, for example, just east of portion 69 on the south side, have not been encouraging.[61]

THE JOADJA COMMUNITY

The self-sufficient community, dominated by Scots, has been well described by Leonie Knapman, using oral and photographic evidence from children and grandchildren of Joadja miners.[62] There was a substantial population in Joadja for over a quarter of a century, approaching 1000 in the 1880s. The number of workers directly connected with the mines is known with some precision but not the numbers in the processing plants and in ancillary services. The figures in the reports of the Department of Mines (Table 1) show that population was at its highest from 1878 until 1885: it declined sharply in 1886–1887, recovered in 1888, but thereafter was markedly lower up to 1893. In 1894 the full effects of the transfer of staff and investment to the AKO mines at Katoomba were showing and, except for a revival in mining activity in 1897–1898, the number of miners dwindled to 43 in 1899 and stabilised at 20 for the final years of shale-extraction.[63]

The population crowding into the valley after 1877, mainly direct from Scotland, brought the usual needs for housing,

Table 1. Joadja, shale output (from Annual Reports of Department of Mines).

Year	Shale mined (tons)	Coal mined (tons)	Value of shale (£)	Men employed
1876	400	—	1 200	—
1877	650	—	?	23
1878	5 200	—	10 400	202
1879	9 578	—	9 578	150
1880	13 111	—	29 499	140
1881	15 040	—	15 040	185
1882	27 464	—	48 062	185
1883	30 554	—	53 469	155
1884	18 747	7 759	42 176	160
1885	16 420	5 924	45 153	224
1886	25 700	9 318	64 250	110
1887	31 406	8 732	70 633	106
1888	26 821	8 780	53 602	200
1889	28 416	10 242	56 832	86
1890	36 985	9 670	64 723	90
1891	20 758	6 062	36 326	114
1892	22 071	9 830	38 623	111
1893	13 799	8 383	24 148	86
1894	4 023	1 451	6 034	47
1895	5 054	3 853	6 318	57
1896	2 995	1 779	3 734	36
1897	5 486	—	6 857	94
1898	5 378	—	7 497	90
1899	7 526	1 416	9 408	43
1900	966	—	1 207	28
1901	411	—	554	20
1902	1 941	—	2 911	20
1903	1 383	—	2 074	20

schooling, postal services and access to water. A post-office was opened in October 1878 and remained open until it was burnt down in the bush-fire of December 1904.[64]

A temporary school of slab and bark was erected for some 50 children early in 1879 and a fine stone building for teacher and pupils was built in 1882, when there were about 90 children, of whom 60 were expected to attend on average. By 1896 attendance was around 50 and between 1900 and 1905 it dwindled to a maximum of 10, five of them the teacher's own family. After a short period of operating half-time with Mandemar, the school at Joadja finally closed in 1908.[65]

The community was overwhelmingly Presbyterian throughout the mining period. Although the *Australian Handbook* consistently lists a Presbyterian church among the village's amenities, there was no identifiable church building. The regular services taken by ministers coming from Mittagong were held in the School of Arts after it was completed in 1886. Catholic priests also came from time to time but it is not known where mass was said for the handful of Scots Catholics.[66]

The houses built for or by the shale employees were largely on the north side of the creek. Before AKO was formed, Edward Carter had built a house for his manager, Robert Longmore, but the site of this house has not been securely identified.[67] By 1879 there were 75 houses and huts, together with two butchers' shops and two bakeries.[68] There seem to have been ample supplies of clay and two successive brickworks produced hundreds of thousands of bricks for houses and the industrial plant. Use of sandstone from the valley walls enhanced fireplace lintels in some houses and the best houses, for the company managers, were substantial and attractive. The AKO executives lived on the south side of the creek, amid the burgeoning orchards, with well-ordered gardens.[69]

The houses varied in quality, but the two dozen brick cottages built for families in Carrington Row were considerably more spacious, inside and out, than the miners' rows in the Lothian villages or industrial towns from which the workers had emigrated.

The company controlled merchandise, including food, just as it controlled housing. The sad letters in the Department of Education files from parents who were in arrears with their school fees show how dependent all the workers were on good health and consistent employment to subsist at all.[70]

In one regard the AKO was an exceptional employer, however, and that was water-supply. Already by 1879 a remarkably elaborate system of piped water coming from high up Water Pipe Line Gully some two kilometres from the refinery was in place to give a constant supply of pure spring water both for household and industrial purposes. Three large reservoirs, lined with concrete-rendered brick, were dug into the hillside to regulate this supply. The one south of the creek, just above the manager's house, measures 1 494 by 688 centimetres, the two north of the creek, on the slope above the ash-heaps, are 2 686 by 454 and 2 463 by 426 centimetres respectively.[71]

Consistent with a general attempt to be self-sufficient, the AKO planted extensive orchards on the south side of the creek opposite the refinery and as far east as the School of Arts. It also planted fruit trees and grape-vines at the top of the main incline and was presumably responsible for similar plantings of which there are traces on Nursery Flat. These orchards produced a surplus of apples, pears, cherries, plums, apricots and the like which were packed and sent out by rail via Mittagong to Sydney. Nutritious ash from the shale works helped to fertilise the soil and kerosene emulsion could be used to eradicate scale pests on orchard trees. This by-blow of the AKO enterprise continued after mining ceased and an evaporating plant was installed in the disused School of Arts. When the company went into liquidation and auctioned Joadja in 1911, the AKO label continued to be used to market the fruit, just as the main incline remained working for this sole purpose up to 1924. The private railway to Mittagong had been dismantled in 1908 and thereafter the produce went by horse-dray from the top of the incline to the main railway line.[72]

THE END OF AN ERA

The 18 hectares of orchard on the south bank of the creek were sold in 1911 to a Sydney fruit-merchant, J.H. Trevarthen, who continued, through resident orchardists, to expoit the fruit until 1924. In 1924 Trevarthen sold the land to Harry Snodgrass, a timber, iron and metal merchant in Lakemba, a substantial businessman with interests also in marine salvage. The main incline was closed after nearly half a century of use and the removal of many surviving mining relics (including rolling stock in the valley) accelerated. It seems that substantial quantities of relics removed at this time survive in the Mittagong area after being sold locally by Snodgrass.[73]

Mr Snodgrass did not remove the orchards but, although his daughter remembers picking fruit there, he did not run them as a commercial enterprise. Instead Snodgrass ran sheep in Joadja Valley and engaged Mr Jacobson as his manager. Jacobson lived in the present homestead, where the Snodgrass family also stayed on their regular visits.[74]

After Snodgrass died in 1935, his family retained the property for over fifteen years. The valley was leased by 1940 to a Canadian family who farmed part of the valley intensively, leaving the main industrial area alone. A visitor in 1941 remarked how 'trees have grown up through the floors of the houses and vines are entwined around the retorts and tanks... The whole scene has a poetic quality hardly to be expected from a place so recently in commission.'[75] Snodgrass's daughter Rita and her husband Hubert Godfrey inherited Joadja in 1949 and planned to build a new and more suitable house there in 1950. The torrential rains of 1950 reminded them that access to Joadja Valley was very uncertain and they sold the property to their current tenant, Jack Bresnahan, who ran stock there for the next decade.[76]

In September 1961 Bresnahan, who had little capital, sold in turn to Sam Stirling.[77] Stirling was an up-and-coming businessman, the founder of Readymix Concrete (now owned by CSR). Stirling acquired much more land than the AKO had held and his house, Greenstead, lies well to the south-west of the mining sites. When Stirling died his widow Cynthia sold a portion of her Joadja estate to Miss Pat Lee, retaining Greenstead for herself.

Miss Lee was an American who first saw Joadja in the late 1960s and bought the historic portion and a wide area around early in the 1970s.[78] During Miss Lee's twenty years of ownership, cattle were run in the valley rather than sheep and a measure of controlled tourism was encouraged. With a better access road now replacing Carter's Track after a century, it was feasible to have visitors by prior arrangement or for a time in the 1970s on a regular Wednesday to Sunday basis. Visitors had come to the valley in the past. An inspector of schools had commented in 1926 that 'this celebrated valley is a resort of tourists from Moss Vale, Bowral and Mittagong' and noted that damage, 'generally unintentional' was done to the school building and grounds (which still belonged to the Department of Education). In 1930–1934 evidence of vandalism was given and despite the difficulty of taking heavy materials out of the valley, much of the iron roofing in the school had been smuggled out to Mittagong by 1935. This was despite Mr Snodgrass's reluctance to allow Carter's Track (which ran through his 'cultivated paddocks') to be used by outsiders. The cedar woodwork in the school was used for fires by campers and a door served as part of a makeshift bridge. By 1935 the

NRMA road guide showed the area between the school and the creek as a public camping ground: this had indeed been gazetted as a reserve, presumably for drovers, in 1881 but had not been widely known to tourists, who now in the 1930s were coming on horse or on foot.[79]

The severe earthquake of 1973 destabilised the mine adits on the escarpment and many of the structures in the valley and brochures from that date onwards were marked 'quake damage' and sensible restrictions were imposed on visitors' movements. In the 1980s Mrs Leonie Knapman, with Miss Lee's co-operation, organised 'Back to Historic Joadja' weekends, sponsored by the Southern Highlands Tourist and Travel Association: the last of these was held as a bicentennial event in March 1988. In the previous year the Royal Australian Historical Society had organised a similar tour for its members. Academics from the University of Sydney and the University of New South Wales visited the valley to record aspects of its industrial archaeology in the 1970s. This contributed to R.I. Jack's chapter on Oil Shale in *Australian Pioneer Technology: Sites and Relics* in 1979 and to Darryl Mead's unpublished PhD thesis at the University of New South Wales on the technology and operation of the New South Wales oil-shale industry up to 1906, but an extensive survey of the history and remains of Joadja was published only in 1988 by Leonie Knapman.[80] Ironically this lavishly illustrated tribute to the industrial period of the valley appeared just as the gate to Joadja was effectively padlocked to the outside world.

The difficulty of access to the valley throughout its history, the privacy understandably sought by recent owners, the tight control over visitors and the avoidance of the problem of tourism in a vulnerable environment have preserved Joadja in a quite remarkable way and all the phases of its use, grazing, oil-production, orcharding, grazing again and limited tourism are clearly presented in the valley today. But its overwhelming importance is as the only surviving oil-shale site in Australia, or elsewhere, showing full benches of horizontal retorts, a refinery which is an important archaeological site little disturbed since demolition in 1902, dramatically complete evidence of community life, water supply and housing, with as bonus, legible archaeological remains of most aspects of an 1875 incline worked by horse-whim. All this is in one of the most beautiful of land-locked valleys, where kangaroos and wombats are today the only permanent residents.

NOTES

1 Dittmar and Paton 1885, XVIII 237–43.

2 Cuffley 1973.

3 Wilson 1876:98–124.

4 Newell and Greenhill 1989:126–46; Peckham 1885, XVIII 712–8.

5 Cadell 1913:6–7.

6 Mott 1951:141–5.

7 Mott 1951:145–7.

8 Cronshaw 1921:60; Butt 1964:224–56.

9 Carruthers 1927:18–104; Conacher 1927:240–64; Dittmar and Paton 1885, XVIII 240–1.

10 Lishmund 1974.

11 Fleming 1967.

12 *Sydney Morning Herald*, 7 September 1878.

13 *Sydney Morning Herald*, 7 March 1872.

14 *Sydney Morning Herald*, 7 March 1872.

15 Fleming 1967.

16 *Post Magazine*, 7 May 1979, 3; Archives Office of New South Wales (AONSW), reel 2222, X946/949 entries 50, 135; AONSW, Bench-books, reel 664, 4/5667, p. 68. I am grateful to Linda Emery for these references.

17 Carne 1903:221. All Carne's information about Edward Carter came directly from Carter himself.

18 *Post Magazine*, 7 May 1979, 3.

19 AONSW, AO Map 20256; Carne 1903:222.

20 Knapman 1988:20.

21 *Post Magazine*, 7 May 1979, 3.

22 Mead 1986:424.

23 Carne 1903: 221–2; Fleming 1967:4.

24 AONSW, AO Map 20256.

25 Carne 1903:222.

26 Carne 1903:222.

27 NSW Department of Mines 1876, 16; 1877, 165.

28 Carne 1903:222.

29 Carne 1903:222.

30 Carne 1903:223–4.

31 Carne 1903:224.

32 Mitchell Library (ML), PX*D599, Wigram Allen photograph, vol. 61 p. 12 no. 547.

33 Cf. Knapman 1988, 24-5; ML, BM: Joadja 1870–1880 (photograph by Tronier 1880s).

34 Mead 1986:428; Broomham 1987:70.

35 Knapman 1988:17.

36 Carne 1903:222–31.

37 Knapman 1988:94.

38 *Post Magazine*, 7 May 1979, 3.

39 Scale models in the collection of the National Museums of Scotland, Edinburgh, Engineering Department, 1926.126; Almond Valley Heritage Centre, Livingston, Scotland, advertisement for sale Wednesday 19 June [1866], newspaper not identified, and Young's own model for his 1851 retorts.

40 Scale models in the collection of the National Museums of Scotland, Edinburgh, Engineering Department, 1873.97.1, 1893.530, 1920.13, 1926.126, 1933.154; Bailey 1927, 182–91; Dittmar and Paton 1885, XVIII 241.

41 *Sydney Morning Herald*, 11 September 1868.

42 These are the dimensions of the surviving retort, which had been used as a water-tank after the works closed in 1878. In 1988 it was bizarrely erected in a vertical position as a monument to the works, on Cordeaux Road, Mount Kembla, just east of Mount Nebo colliery. Measurements by Ian and Jan Jack, 1996.

43 *Sydney Morning Herald*, 7 September 1868.

44 Carne 1903:87–9, 189–90.

45 Mead 1986:445–6; *Sydney Morning Herald*, 30 June 1880:7.

46 Mead 1986:447–9.

47 *Sydney Morning Herald*, 11 September 1868.

48 See note 42 above.

49 *Sydney Morning Herald*, 7 September 1868.

50 Carne 1903:231.

51 State Library of Victoria, H20615; photograph in possession of Miss P Lee, print in Burton Real Estate, Bowral.

52 Mead 1986:450.

53 Mead 1986:452–68.

54 NSW Department of Mines 1879, 33; *Sydney Morning Herald*, 11 September 1868; Knapman 1988, 134–5. The maker of the tin plant was Bills and Williams, Brooklyn.

55 *Australian Handbook* 1886, 228.

56 Mead 1986:479–80, 496, 503.

57 AONSW, Department of Education, School files, 5/16396.3, 1896. The date of 1899 advanced for the closure by Mead 1986, 490, is not correct.

58 NSW Department of Mines 1902:41, 1903:38, 1904:37.

59 E A Pittman's 1902 geological map in Carne 1903, end-pocket.

60 Carne 1903:227–9.

61 *Parliamentary Papers NSW*, 1922 2nd session II 1151.

62 Knapman 1988.

63 NSW Department of Mines, 1876–1903, tabulated above.

64 Knapman 1988:90–1.

65 AONSW, 5/16396.3; Knapman 1988:65–71.

66 *Australian Handbook* 1886, 228; 1887, 233 etc; Knapman 1988, 75.

67 Knapman 1988, 16. The house remains on the pinch leading north to Carter's Flat may be Longmore's. The house is on a stone-walled platform approached by steps, with a handsome chimney still standing. The external dimensions are 1355 by 690 centimetres. The building is very overgrown and had not been described before the survey of 1991, on which this article is partly based, was undertaken.

68 *Town and Country Journal*, 4 October 1879, 648.

69 Cf. photograph of manager's garden in Knapman 1988:52.

70 AONSW, 5/16396.3.

71 Knapman 1988, 94, 96; *Town and Country Journal*, 4 October 1879, 648; measurements taken in 1991.

72 Knapman 1988, 94–5; *Town and Country Journal*, 3 January 1894, 21; Eardley and Stephens 1974:65.

73 AONSW, 5/16396.3; information from Mr Jack D Bresnahan of Bowral.

74 Information from Mrs R Godfrey (née Snodgrass) of Cundletown.

75 Albert 1941:14.

76 Information from Mrs Godfrey of Cundletown.

77 Information from Mr Bresnahan of Bowral.

78 Cf. McBurney 1980:33–4.

79 AONSW, 5/16396.3; AONSW, AO Map 20256

80 Jack 1979:119–30; Mead 1986; Knapman 1988.

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