

# The Fighting Ground Creek quartz roasting pits and the early importation of gold processing technology into Australia 1850–1860

DENIS GOJAK AND CAITLIN ALLEN

*The Fighting Ground Creek quartz roasting pits complex near Hill End in central west New South Wales was established in 1855 to support reef mining on the Tambaroora goldfield. It is one of the oldest remaining intact gold rush sites and represents one of the first attempts to process reef gold in Australia. With kilns for roasting gold-bearing quartz, a sophisticated battery and dam system for crushing and washing the ore and workers' houses, the complex provides tangible evidence of the process of technological investment and development during this very early stage of Australia's goldmining history. Its early closure, only eighteen months after it was established, also poses interesting questions about the processes and knowledge required for successfully introducing methods developed elsewhere.*

*This paper outlines the history and archaeology of the complex. It also reports on experiments in roasting ore samples and using these to interpret the operation of the quartz roasting pits. The complex attests to the number of factors that had a significant influence in the success of technological transfer to Australia. The intactness of the complex attracted some of the first formalised interest in historical archaeology in Australia in the early 1970s, although only conservation planning in 1997 established the first integrated archaeological and historical record.*

The Fighting Ground Creek quartz roasting pits complex is located about 10 km north of Hill End township, at the northern extremity of the auriferous fields explored from the 1850s to the present day (Fig. 1). The complex comprises a pair of kilns, similar in style to lime kilns set into the valley side, a battery building, a dam and the remains of worker housing. Assorted, smaller features are scattered throughout the surrounding bush. The area is now managed as part of Hill End Historic Site by the New South Wales National Parks and Wildlife Service and is on the NSW State Heritage Register. This paper describes the quartz roasting pits and their historical development, based on a conservation and interpretation plan prepared in 1998.

The Fighting Ground Creek operation demonstrates the nature of the early importation of technology from overseas goldfields to support the Australian rush. It reflects available technology, the method of its application and most importantly, what was and was not known about Australian conditions. The history of this particular site and its

archaeology demonstrates the particular difficulties that poor understanding of the weather and geology placed upon imported technology and the limited basis on which decisions about investment and process were made.

Established soon after the start of gold mining in Australia in 1851, the quartz roasting pits complex illustrates the application of technology developed in environments that differed markedly from Australian conditions. The development of this industrial complex reflects the application of British capital and machinery and designs from around the world in an optimistic, but ultimately unsuccessful, attempt to maximise the profits from the gold field.

An interesting reflection upon the more recent history of the site is that the roasting pits complex was the location of one of the first formal historical archaeological investigations in Australia. Although the investigation itself was relatively minor, the complex has a presence in the early history of our own profession that deserves recognition.

## THE TAMBAROORA AND HILL END GOLDFIELDS 1850-1855

Payable gold was discovered in the Tambaroora and Hill End goldfields by mid-1851 during the early months of Australia's first gold rush. Between 1851 and the early 1860s alluvial mining was the predominant occupation on the Tambaroora fields, but the early detection of reef gold stimulated a steady interest in the exploration of auriferous reefs. As a result, the Tambaroora field briefly became one of the richest and most dependable in the colony. By the late 1860s reef exploitation had emerged as the most popular and profitable method of mining, which set conditions for the second, larger gold rush of the 1870s when Hill End peaked in size and prosperity.

Reef mining and ore crushing activities are recorded on the Tambaroora fields as early as 1852. This is generally held to be the location of the first reef mining in Australia. Reef exploration spread south to Tambaroora from the site of the first discovery of gold at Hargraves (the 'Kerr hundredweight') with the promise of a 'golden river' of ore running north-south through the Tambaroora fields.'

The extra capital and skill required for reef mining led to

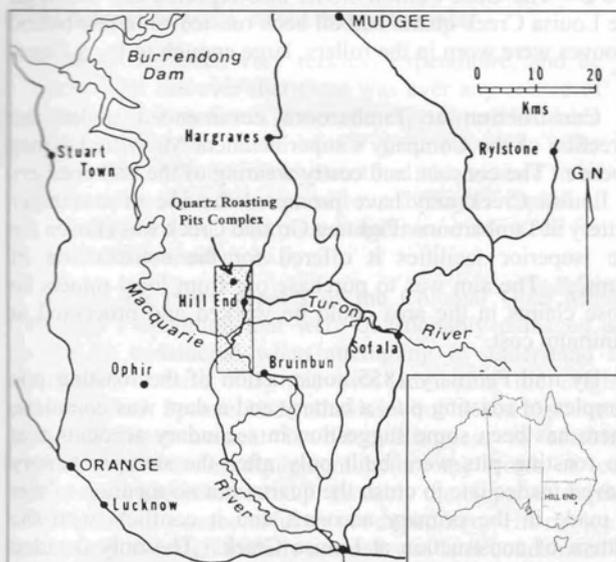


Fig. 1: Location of the Fighting Ground Creek quartz roasting pits.

the formation of joint stock (shareholder) companies that financed the operations but did little of the mining themselves.<sup>2</sup> For this purpose, skilled hard rock miners were engaged to work the claims. They possessed the knowledge but neither the capital nor the will necessary to establish their own operations. Early claims were usually worked on-site using imported crushing equipment, with further separation of the gold occurring elsewhere.

## QUARTZ ROASTING

The known and inferred history of quartz roasting is presented by Moore and Ritchie<sup>3</sup> in their discussion of a large suite of surviving quartz roasting pits from the Hauraki Goldfield in New Zealand. Opinions on the benefits of roasting are varied and the means of doing so ranged from the crude roasting of heaps of ore and wood, to sophisticated brick furnaces employing gases as the heating agent. There were two main reasons why ore was roasted. The first was to make the quartz more friable so that it would crush more easily when passed through the stamper battery, lessening wear on the machinery. The other aim of roasting was to oxidise the sulphides contained within pyritic quartz. Lock stressed however, that 'improper' roasting at low temperatures in primitive kilns could be more injurious than helpful as the chemical processes at these temperatures rendered the gold more difficult to separate from the resulting iron oxide.<sup>4</sup> The effect of roasting on the ore could at first only be evaluated through comparison of processed samples against assay results. A clear understanding of the chemistry of the roasting process and why it did or did not always work was not reached until the later nineteenth century. The use of the term 'calcining' to describe the roasting process reveals that the actual chemistry of the ore roasting process was very poorly understood, as it is quite different from calcining limestone.<sup>5</sup>

The ore that was processed at the Fighting Ground Creek roasting pits came from the nearby Valentines Mine and Dirt Holes areas. This ore was undoubtedly pyritic, and there is a strong likelihood that the low temperatures produced in the open pits hindered the process of gold extraction.<sup>6</sup> At the time it was not widely understood that low temperature roasting of pyritic quartz ore could be counterproductive as it actually reduced the ability to retrieve gold particles.<sup>7</sup>

In order to observe the effects of roasting first-hand and to determine if the Fighting Ground Creek kilns had ever been operational four samples of quartz were taken from the Valentines Mine, 2.5km south of the roasting pits. Four pieces of quartz were roasted for five hours in kilns at the Department of Geology and Geophysics at the University of Sydney - two of them at 400 degrees Celsius and two at 800 degrees Celsius. As the temperatures achieved by the open kilns at Tambaroora were unknown and likely to be variable, these are only approximations of the operational kiln temperature. One piece of quartz was left unroasted as a control. After roasting, one sample from each firing was quenched with water while still hot so the effects of such a procedure could be observed by comparison with the unquenched and unroasted quartz.<sup>8</sup>

In all fired samples, regardless of temperature, whitening of the quartz was observed. This change from a clear to a dense, cloudy white is probably due to the expansion of gas bubbles within the quartz, and may have added to its friability by creating small fractures within the stone structure. Quenching had no effect on the sample fired at 400 degrees, but when water was applied to quartz from the 800 degree firing it immediately crumbled into smaller shards. This supports Lock's assertion that quenching quartz fired at an adequate temperature was beneficial. It also indicates that such a process would have a tangible effect upon quartz

roasted at Fighting Ground Creek if the open kilns were able to produce high enough temperatures.

Comparing these signs of roasting with the physical characteristics of a quartz sample taken from the kiln floor at Fighting Ground Creek, it is probable that it has been subjected to firing at a reasonably high temperature. The kiln sample has a milky colour that is far whiter and denser than the unroasted control sample from Valentines Mine. This supports using quartz colour as an indicator of prior treatment by roasting. The rusty coloured cortex on the kiln sample cannot be explained, as no reddening was observed on the roasted samples, but it is possible that oxidation is initiated during roasting, only showing physical signs after weathering.

## THE COLONIAL GOLD MINING COMPANY 1852-1856

The Colonial Gold Mining Company was floated in London in July 1852. The company value was to be £200 000 divided into £2 shares, one third of which was reserved for British shareholders.<sup>9</sup> Over 160 Australian shareholders invested in the company and with the Great Nugget Vein Company as their subsidiary, they secured a mining lease at Meroo.

By 1853 they had begun reef-mining operations at Louisa Creek, near Hargraves, to the north of Hill End. An operation of impressive size and perhaps the first of its type in Australia, it received mention in the half-yearly report of the Gold Commissioner for the Western Districts. He reported the erection of a large engine capable of crushing 'forty tons of quartz per diem' and employing 120 men to work in the mine and the crushing works.<sup>10</sup> The following May the Commissioner again reported upon the Louisa Creek workings and noted the presence of 'permanent kilns for calcining' in association with the battery, which used ball crushing rather than stamper batteries.

The confidence inherent in erecting such substantial works before testing the value of the claim is striking. Even more notable was the decision in mid-1854 to begin a similar operation on Fighting Ground Creek within the Tambaroora diggings, only shortly after the start of operations at Louisa Creek. As work commenced on Fighting Ground Creek, the *Bathurst Free Press* reported that a good deal of ore had been crushed at Louisa Creek and that the results looked 'encouraging'.<sup>11</sup> However, the Louisa Creek operations ran into difficulties in early 1855 due to a water shortage, despite the construction of a dam that had been brimming in June 1854.<sup>12</sup> The Gold Commissioner also reported that although the Louisa Creek quartz had all been roasted 'in a few hours, grooves were worn in the rollers, large enough to lay a finger in'.<sup>13</sup>

Construction at Tambaroora commenced under the direction of the Company's superintendent Mr Alfred James Spence. The constant and costly wearing of the ball crushers at Louisa Creek may have prompted the use of a stamper battery at Tambaroora. Fighting Ground Creek was chosen for the 'superior facilities it offered for the construction of dams'.<sup>14</sup> The aim was to purchase ore from local miners so those claims in the area could be worked and processed at minimum cost.

By mid February 1855 construction of the roasting pits complex of roasting pits, a battery and a dam was complete. There has been some suggestion in secondary accounts that the roasting pits were built only after the stamper battery proved inadequate to crush the quartz, but no mention of this is made in the primary accounts and it conflicts with the pattern of construction at Louisa Creek. The only detailed contemporary account of the opening and operation of the works was made by the *Bathurst Free Press* on 17 February

1855 and is reproduced in full below.

The locality chosen for the erection of the engine is called Fighting Ground Creek (so named on account of a number of pugilistic encounters having taken place on the spot) about five miles from Tamaroora and one from the vein. The site is good and well adapted for the purpose. A large and capacious dam has been erected and a reservoir formed, which the recent heavy rains have filled with good water. A number of well-built substantial huts for the men to reside in surround the works, giving them the appearance of a village. The men, thirty in number, employed on the works are of a superior character - good mechanics, and thoroughly masters of their trades. The engine is of sixteen horsepower, performing about forty revolutions a minute, and the quartz is crushed by stampers placed perpendicularly in a wooden frame. A nut of the fly-wheel shaft drives a spare wheel to lessen its speed. This shaft is attached to the drum or barrel, that is placed horizontally in front of the stampers. The drum is studded with sappers that raise the stampers vertically by its rotary motion. Each stamper and there are twelve in number, weighing two hundredweight each, rises and falls fifty-five times per minute. The quartz is reduced as fine as powder, and the gold is separated from it by its being washed in toms, the same as alluvial soil. A temporary trial of the engine and machinery was made last week; it worked exceedingly well and gave great satisfaction. When in full working order, it will crush from twelve to eighteen tons of quartz in twenty-four hours...To celebrate the event of the first crushing the company ordered a substantial dinner to be provided for all the men at the works. The management of the dinner was entrusted to Mr. Barry of the Railway Hotel and he spared no means to make it worthy of the occasion.<sup>15</sup>

From the beginning the Fighting Ground Creek operation failed to generate large returns, either through operating fees or by adding value to dwindling ore production from the Dirt Holes and Valentines mines. Initial shareholder support was high, but this was due to the policy of paying shareholders a dividend from the paid up capital of the Company before production had commenced, i.e. effectively offering a partial refund on shares held.<sup>16</sup> In 1856, however, the British shareholders held a meeting at the London Tavern and reports about the Victorian and New South Wales operations of the Company were discussed.<sup>17</sup> The chairman of the Company, Lord Alfred Churchill, stated that he thought:

...there had been very reckless expenditure, and he could not discover that there was ever any source of profit...In New South Wales the expenditure had been just double the value of the gold obtained. The expenses of home management had also seemed to be excessive. The directors had run through a capital of one hundred thousand pounds and now made a call for twelve thousand more.<sup>18</sup>

There are many aspects of the Colonial Gold Mining Company's operation that were questionably managed and should be considered when attempting to understand the operation's demise. By his own admission the original manager, A. J. Spence, had enthusiasm but lacked experience, probably most evident in his willingness to establish expensive processing equipment before the worth of local quartz reefs had been tested.<sup>19</sup> Possibly the clever sales pitch of the previous unsuccessful owner duped him. His choice of machinery, although initially praised, was later condemned by the Gold Commissioner.<sup>20</sup> Roasting the quartz may also have added to the Company's problems as the temperatures

achievable in the open kilns may not have been high enough to be beneficial.

The shareholders decided to cut their losses and the Company folded. By the beginning of 1856 reports concerning the Company had vanished from the press and the Gold Commissioner's reports. The last report in the *Bathurst Free Press* indicated that the Company was leasing their Louisa Creek claim to individual miners. No further mention of their Tamaroora operations was made.

The hasty construction of the battery near unproven ground, the use of low temperature open kilns to roast the quartz and the resulting closure of operations in less than two years all point to a series of ill-considered decisions regarding the planning and establishment of the operation.

## THE QUARTZ ROASTING PITS COMPLEX AFTER 1856

After the collapse of the Colonial Gold Mining Company the occupancy of the land, which had been held through a license under the Gold Fields Management Act, lapsed. The Company probably sold or removed the bulk of its equipment, and it is likely that scavenging would have seen the removal of any remaining useable machinery or material. Mining activity around Hill End and Tamaroora continued at a relatively low level until the early 1870s when the large and profitable reefs at Hawkins Hill, beside Hill End township began to be worked. At this point Hill End became one of the main goldfields in New South Wales. The Tamaroora mines continued to operate but were rapidly overshadowed by the massive production and investment at Hill End.

What damned the success of the roasting pits as a commercial operation, but probably saved them as an archaeological site, is that they were sited well away from any gold. No subsequent mining activity took place on or near the complex, although evidence of paddocking or surfacing can be seen along the roadside within 1km.

The next known activity on the land after the closure of the quartz roasting pits Complex took place in 1869. George Dewdney, a leading merchant and provodere in Hill End during the late 1860s and 1870s took up four 2-acre [0.91 ha] blocks in the Parish of Cummings as Improvement lots. These could be taken up as selections that could be converted to freehold if conditions of improvement, such as fencing, clearing, erection of a dwelling and cultivation were met. These eventually became portions 12 and 13 of the Parish of Cummings.

In the 1930s the land was taken into Alpha Station, a large sheep-raising property to the north of Tamaroora. Valentines Mine, which had been operated sporadically since the 1860s, was reactivated during the Great Depression as were many other reef and alluvial mining operations at Hill End.<sup>21</sup> Harry Hodge recorded that the 'Managers House' was used as a shearing shed by Alpha Station.<sup>22</sup> This indicates that it was standing in some form until at least the 1930s. No other evidence, either physical or documentary, suggests that anything beyond grazing took place at the site in the period of ownership by Alpha Station. In the 1960s the Hill End Citizens Association bought the roasting pits from Alpha Farm and ran them as a private tourist attraction for the increasing number of visitors to Hill End's heritage attractions.

Hill End Historic Site was gazetted in October 1967, as one of the first suite of historic sites proclaimed under the National Parks and Wildlife Act 1967. The initial historic site was focussed on the core of the township, but it was recognised that to be representative of the history of mining the historic site would have to encompass areas where mining activities took place as well as the town itself.

**Table 1: Identified elements in the quartz roasting pits complex**

No.	Element	1974 Designation	Note
1	Roasting Pits	'B'	
2	Battery	'A', flue 'F'	
3	House Site	'D'	'Manager's House'
4	House Site	'C'	'Under Manager's House'
5	Quarry	-	
6	Fence	'K'	Probably late 1860s
7	Dam	-	
8	Possible structure	-	
9	Possible structure	-	
10	Possible structure	-	Possibly 20th century
11	Road	-	Not recorded in detail
12	Quarry pits	-	Not recorded in detail
13	Artefact scatters	'E'	Not located in 1997
14	Worker housing	-	Not located
15	Water race	-	Not located
16	Ore transport	-	Form not determined

In 1969 NPWS Hill End Ranger Ted Whittingham recommended that the Service acquire the complex, stating that 'the pits are historically very important and should be safeguarded and preserved'.<sup>23</sup> The first two blocks, Portions 12 and 13, were bought in 1973, without realising that they did not coincide with the significant structures on the site (see Fig. 4). Additional land was bought, bringing the entire historical complex into one title by 1978.

In 1974 Judy Birmingham approached NPWS to carry out archaeological fieldwork for the new historical archaeology course at the University of Sydney. An ambitious program of research excavations were planned for the battery structure at Fighting Ground Creek and the Metropolitan Hotel site at Hill End, as well as surveys of various sites. Fieldwork was undertaken by 26 staff and students of the University of Sydney from 13 to 24 May 1974, under the overall direction of Judy Birmingham, with Maureen Byrne and John Wade as field supervisors.<sup>24</sup> Nine small trenches were dug around the battery, and the complex was surveyed. The 1974 survey

identified a number of structures within the immediate vicinity of the roasting pits, the majority probably contemporary with its brief operation. These are listed in Table 1 and their locations are shown in Fig. 2.

The 1974 excavations were not carried out on a scale that contributed materially to our knowledge of the site's history or operation, beyond what could already be confidently read from the historical record. The only substantive published paper that discussed the site was by Madden.<sup>25</sup> However, the excavation, although limited in extent, represents a growing interest in the investigation of physical evidence of Australia's past, at a date that also saw the first consideration of heritage conservation as a national issue.<sup>26</sup>

NPWS Historian Michael Pearson also carried out subsequent research as part of conservation works on the complex. This resulted in the stabilisation of the battery house and roasting pits and the continuation of the analysis of the structures begun by Birmingham's team.<sup>27</sup> Although the roasting pits complex had been included within Hill End

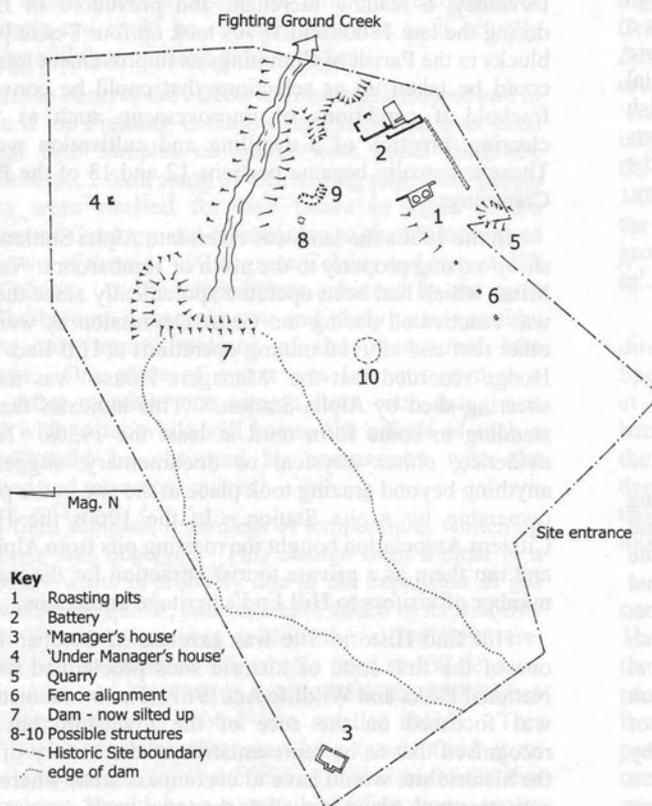


Fig. 2: Identified site elements.

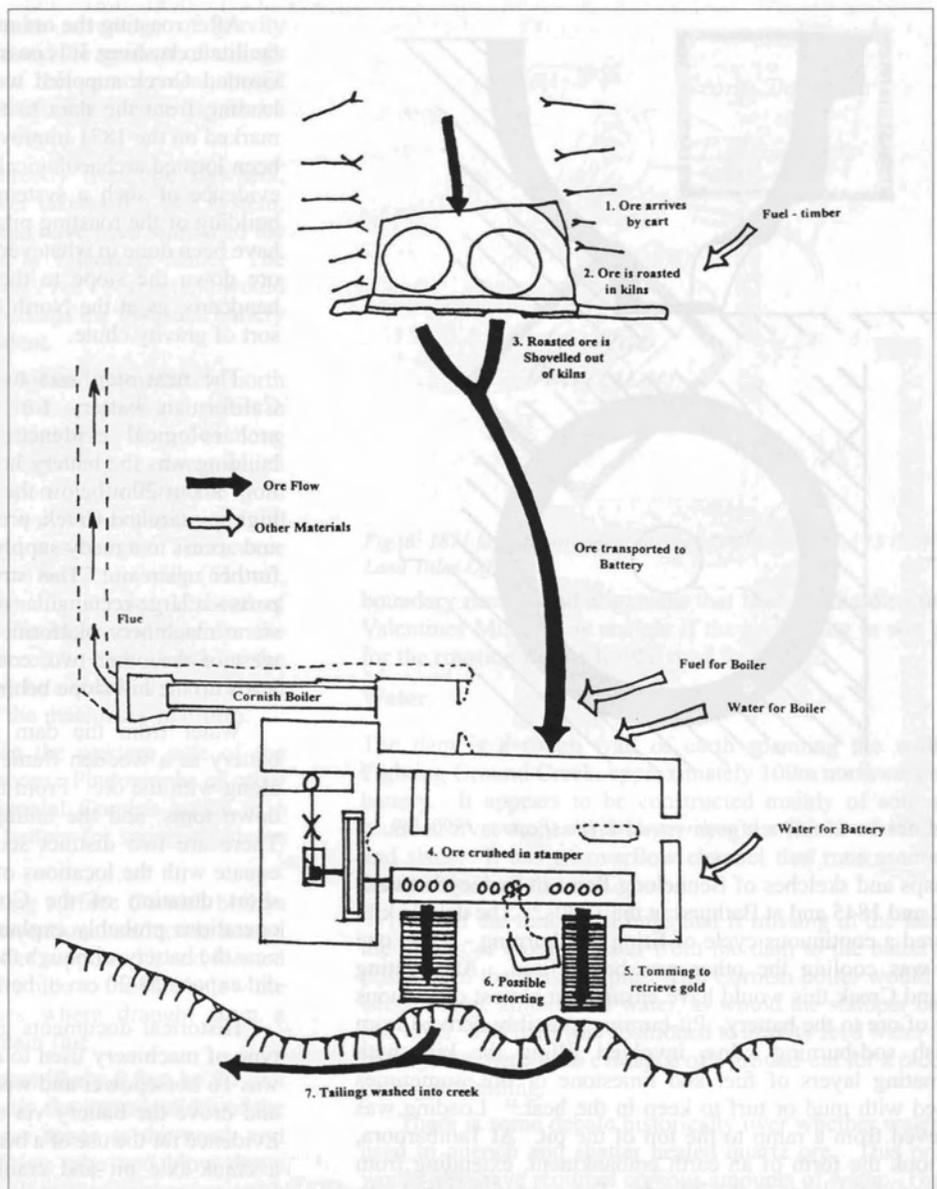


Fig. 3: Reconstructed resource flow at the quartz roasting pits.

Historic Site its distance from the township saw it missing out on the tourist market. A conservation management plan and interpretation plan prepared by NPWS staff pulled together the previous historical and archaeological research.<sup>28</sup> The works completed the stabilisation of the complex, and addressed the need to make visits to the site more informative about its cultural significance and role in the early history of gold mining in Australia. A number of further archaeological features were identified (Table 1) and the construction and structural evolution of the site was documented in detail.

When considered as a whole, the complex remains remarkably intact for a gold processing operation of such early date. It is perhaps the earliest Australian gold rush site with the majority of its constituent parts intact or at least recognisable. The undeveloped setting adds further to its integrity and archaeological significance. The lack of subsequent mining has assisted in preserving site features that would probably have been destroyed in most contexts or confused by successive phases of mining.

## RECONSTRUCTION OF ORE FLOW AT THE ROASTING PIT COMPLEX

The following is a proposed reconstruction of ore flow at the complex with an interpretation of the use of the various structures and their components, based upon the history outlined above and physical examination of the remaining structures themselves (Fig. 3). The appraisal of the battery building is based upon an interpretation of the site developed by NPWS Historian Michael Pearson.<sup>29</sup>

Gold-bearing quartz was brought to the roasting pits from the Company's claim at Dirt Holes or other mines in the surrounding area. The first stage involved roasting the ore in pits or kilns built into a slope on the south-western side of the battery. The double kiln at Tambaroora is identical in internal structure to the 'inverted bell' lime burning kiln (Fig. 4) identified by Pearson.<sup>30</sup>

Bell kilns of the same simple in design were used in Australia between the 1790s and 1860s, and good examples still survive at Port Arthur and Moreton Bay. A double kiln of the type employed by the Colonial Gold Company is evident

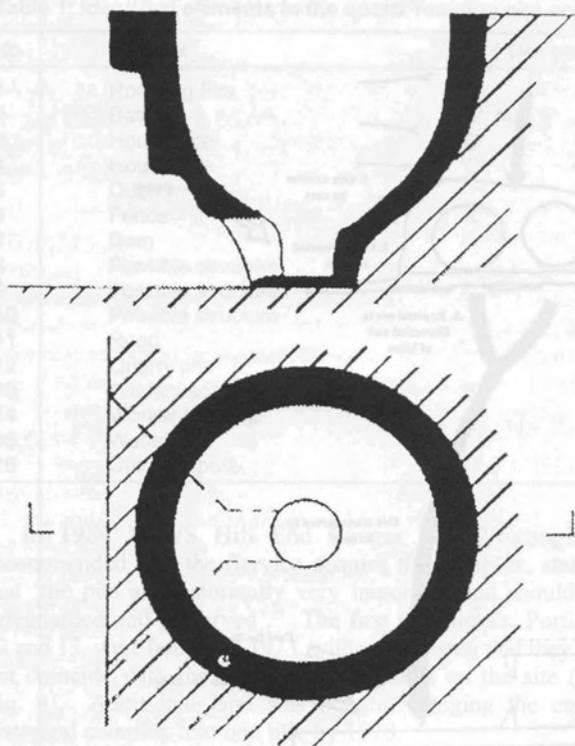


Fig. 4: Schematic outline of an inverted bell kiln (Pearson 1990: 29).

in maps and sketches of Bennelong Point in Sydney between 1822 and 1845 and at Bathurst in the 1870s.<sup>31</sup> The double kiln ensured a continuous cycle of firing and burning - while one kiln was cooling the other was being fired. At Fighting Ground Creek this would have ensured an almost continuous flow of ore to the battery. Pit-burning, possibly derived from British sod-burning kilns, involved filling the kiln with alternating layers of fuel and limestone or ore, sometimes topped with mud or turf to keep in the heat.<sup>32</sup> Loading was achieved from a ramp to the top of the pit. At Tambaroora, this took the form of an earth embankment, extending from the rear of the kilns to the hillside. The roasted material was withdrawn through a small opening set into an alcove at the bottom. In more sophisticated kilns such as Wilkinson's, the roasted ore would have dropped from the base of the kiln into a waiting trolley.<sup>33</sup> At Tambaroora, however, the load had to be shovelled out, as the outlet opened directly onto the ground surface (Fig. 5).



Fig. 5: Front elevation of the quartz roasting pits. (P. Tonkin/NPWS)

After roasting the ore may have been quenched to further facilitate crushing. It is possible that the large dam on Fighting Ground Creek supplied water by a flume or race. A race leading from the dam to the general area of the battery is marked on the 1871 improvement survey (Fig. 6), but has not been located archaeologically. However, there is no physical evidence of such a system remaining on either the battery building or the roasting pits. If the ore was quenched it may have been done in whatever receptacles were used to carry the ore down the slope to the battery. These may have been handcarts, as at the North British Mine in Victoria, or some sort of gravity chute.

The next step was to feed the ore into a stamper or Californian battery for crushing. The historical and archaeological evidence confirms that the easternmost building was the battery house. The battery is on the valley floor about 20m below the roasting pits immediately next to Fighting Ground Creek, providing an area for tailings run-off and access to a ready supply of water drawn off from the dam further upstream. This structure is divided into three main parts - a large rectangular room with a benched floor; a solid stone machinery platform; and a long, narrow room to the west of the other two, connected to a stone-lined flue that leads up the hill slope behind the battery for 35m.

Water from the dam was possibly transported to the battery in a wooden flume or race, and fed into the battery along with the ore. From the battery the crushed ore flowed down toms, and the tailings eventually ran into the creek. There are two distinct scours in the creek bank that may equate with the locations of the outflow from the toms. The short duration of the Colonial Gold Mining Company's operations probably explains why there is no tailings dump near the battery, although the 1974 archaeological excavations did expose 10-20 cm of battery sand scattered over this area.<sup>34</sup>

Historical documents give no information regarding the type of machinery used to drive the battery other than that it was 16 horsepower and worked at 40 revolutions per minute, and drove the battery via a beam attached to the fly-wheel. Evidence for the use of a beam engine includes a fly-wheel pit, a crank-axle pit and crank supports, beam sockets, steam cylinder supports and roof supports, all of which were recognisable on top of the machinery platform in the battery building. From this evidence the machine can be reconstructed as an 'A' frame beam engine with columns supporting the central beam bearing. A good example of an 'A' frame beam engine, dated to 1805, is shown in Crowley 1977, p. 17.

The battery was placed to take advantage of gravity movement of water and roasted ore and the removal of tailings by the creek. A reconstruction of this arrangement, based upon the archaeological and historical evidence is shown below in Fig. 7.

Gearing drove the battery directly from the flywheel, rather than being offset with power taken off a belt system. The battery had 12 heads and would have been similar to the surviving 10-head battery located at Valentines Mine. The obviously awed tone of the *Bathurst Free Press* article would indicate that it was a novelty and perhaps the first such battery of that type seen by the correspondent.

It is likely that the battery was located immediately north of the machinery platform. The 1855 description also refers to 'toms' being used to wash the crushed ore. 'Toms' or 'long toms' were long troughs set on a slight incline, down which washdirt was raked. The finer portion, holding the gold particles, fell through a sieve half way down the trough and onto a ripple board where the gold was caught. Toms were between 12 and 24 feet long (4 - 7m) and 2 feet wide (61 cm), with sides 12 inches high (30cm). To service 12 head of stamps, up to four toms could be used, extending from the stamps downslope towards the creek.<sup>35</sup> The alcove in the southern part of the main room may be a stairwell that allowed access to the engine on the top of the machinery platform.

The long narrow enclosure on the western side of the building was probably the boiler room. Photographs of other battery complexes<sup>36</sup> show a horizontal Cornish boiler in a similar position in relation to the battery for supplying steam to the machinery (Figs 8, 9).

With their fully enclosed heating surface Cornish boilers were much more efficient than conventional underside heated boilers. Brickwork around the boiler supported it and formed flues that carried gases from the fire tube to the flue below the boiler, and then along side flues where draught from a chimney drew the gases into the main flue.<sup>37</sup>

The Tambaroora boiler was most likely 6 feet by 30 feet (just under 2m x 10m) fitting exactly the narrow width of the presumed boiler room. The larger space at the north end would allow for accessing the firing tube and blow down valve. Postholes in the exterior wall of the main room, north of the boiler room, may have held posts to support a roof for protecting stockpiled fuel wood.

#### House sites

A contemporary description of the roasting pits complex refers to a 'number of well-built substantial huts for the men to reside in surround the works, giving them the appearance of a village'.<sup>38</sup> The remains of two structures, probable house sites, have been identified within the confines of the gazetted area (Elements 3 and 4 in Fig. 2). Harry Hodge, the former custodian of the site named these as the 'Manager's House' and the 'Under Manager's House' but these designations may not represent original usage.<sup>39</sup>

Other possible hut sites may have been present on the northern side of the creek. The 1855 description states huts rather than tents. These may have been portable houses or simple structures that were allowed to collapse or scavenged for materials following their abandonment. On the southern side of the creek are three possible structures (Elements 8-10 in Fig. 2). These may be related to worker housing.

#### Quarries

There is a quarry on the side of the hill, immediately to the south of the flue. Its size is insufficient to have provided all of the stone used in the construction of the battery and roasting pits. Further quarry pits are visible outside the Historic Site

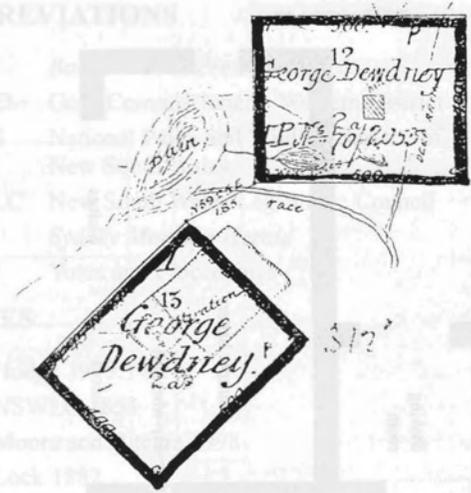


Fig. 6: 1871 land improvement survey of Portions 12 and 13 (NSW Land Titles Office).

boundary near a road alignment that leads in the direction of Valentines Mine. It is unclear if they were dug to win stone for the roasting pits or for the road formation.

#### Water

The dam is a rough wall of earth spanning the width of Fighting Ground Creek, approximately 100m northwest of the battery. It appears to be constructed mainly of soil, small rounded river stones and larger irregular hunks of sandstone and shale. It has an overflow channel that runs around the northern side of the wall.

One of the functional links that is missing in the fabric is the means of moving water from the dam to the battery and possibly to the roasting pits. The Cornish boiler would have needed large amounts of water, as would the stamper battery and toms. The dam was positioned to gravity feed water to the battery, but there is no evidence of a ground-cut for a race, nor piping or fluming.

There is some debate historically over whether water was used to quench and shatter heated quartz ore. This process would also have required copious amounts of water. There is no definitive evidence of quenching roasted quartz at Hill End or any other roasting site in Australasia.<sup>40</sup> The roasting pits are too high for direct gravity feeding of water, but it could have been applied immediately prior to stamping or been pumped up the hill to the required height.

#### CONCLUSIONS

The history and archaeology of the quartz roasting pits at Fighting Ground Creek reflect the manner by which technology was brought in from other countries during the first decade of the gold rush. The assumptions made by historical agents such as the Colonial Gold Mining Company reveal much about the workings of economic systems under pressure, as they were in the 1850s. Investment in distant locations stretched the ability of joint stock companies to bring together all of the information that was needed to make sound decisions about the management of operations. Introducing technology developed in one environment into a completely different one exposed such operations to unforeseen risks. The penalty in not taking those risks may have been the loss of a market opportunity in the volatile gold field operations. The alternative was operating to minimise risks in what could be controlled, such as the composition of the workforce, the solidity and reliability of the machinery and infrastructure and payment of dividends to shareholders. Great trust in managers at the site could be repaid with handsome profits or, as at Fighting Ground Creek, a run of

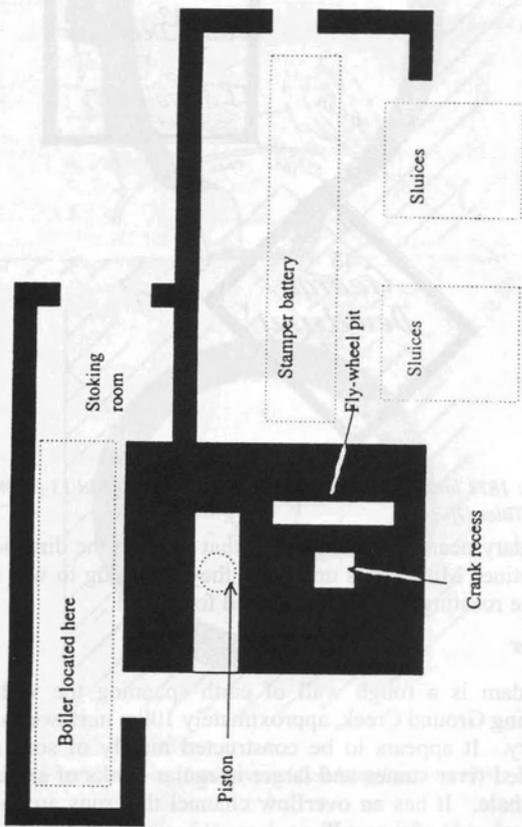


Fig. 7: Schematic reconstruction of the battery building.



Fig. 8: Flywheel pit in the machinery platform (C. Allen/NPWS).



Fig. 9: Battery from the southwest (P. Tonkin/NPWS).

decisions by inexperienced managers could make the difference between viability and commercial failure. In the case of both their Louisa Creek and Fighting Ground Creek operations the Company developed a template for a battery operation that included roasting as an integral part of the process. The roasting pits were built with the same forethought and planning as the massive battery structures. However, the Company was not able to apply similar forethought and planning to either the rainfall that was essential to operating the works, the suitability of the technology for the ore that was recovered or the economics of their venture.

The impact that variable rainfall and drought had on water, steam and hydroelectric power generation in Australia in the nineteenth century has been well explored.<sup>41</sup> The rainfall necessary to power many proven, imported technologies was not often available in Australia. Regarding the Australian goldfields there was no long history of prior European settlement to create an understanding of just how unreliable some critical water sources were. Consequently the Australian historical archaeological record contains a significant number of otherwise innovative schemes that failed due to a lack of reliable water or which had to be heavily modified to work.

The change in technology from ball crushing mills to stamper batteries between the Louisa Creek and Fighting Ground Creek operations also reflects the impact of the Californian gold rushes on the development of more efficient machinery for gold processing. A rush of new and innovative American-designed technology challenged the dominance of the Cornish in reef and other hard rock mining.<sup>42</sup> The Cornish work system of 'captains' and managed labour had proved effective in Australia's previous mining boom in the South Australian copper mines. However the Cornish pattern of substantial prior investment in constructing massive batteries and installations was not effective in the volatile gold economy as shown at Fighting Ground Creek. Thus impressive stone constructions give way to temporary, small scale and portable operations at the mine head or in strategic locations that could be moved with little cost or consequence when the gold ran out.

The Hill End quartz roasting pits reflect the rapid changes in technology at the start of the Australian gold rushes. They exemplify the transition from a largely British way of doing things to the technological systems that developed from American sources. The experimentation with finding methods to win gold that worked in Australian conditions would continue. The roasting pits offers one of the earliest and most elegant demonstrations of how the experiment often failed.

#### ACKNOWLEDGMENTS

The authors wish to thank Steve Woodhall and Ian Rhodes – NPWS Bathurst District, Dr Trent Allen – Department of Geology and Geophysics, University of Sydney and historians Brian Hodge and Professor Ian Jack, who gave generously of their knowledge of Hill End and gold mining. Ian Jack also made available copies of Maureen Byrne's original field notes from the 1974 excavation. Mining engineer Chris Sylvester of Arandis Pty Ltd made helpful comments on the 1997 conservation plan. NZ Department of Conservation Archaeologist Neville Ritchie reviewed an earlier draft of this paper, providing many corrections and additional perspectives to our paper. Peter Tonkin was part of the project team and brought insight into the interpretation of the site to the public.

#### ABBREVIATIONS

BFP	<i>Bathurst Free Press</i>
GCWD	Gold Commissioner – Western District
NPWS	National Parks and Wildlife Service of New South Wales
NSWLC	New South Wales Legislative Council
SMH	<i>Sydney Morning Herald</i>
V & P	Votes and Proceedings

#### NOTES

- 1 Hodge 1979:143
- 2 NSWLC 1853
- 3 Moore and Ritchie 1998
- 4 Lock 1882
- 5 C. Sylvester pers. comm.
- 6 Matson 1973
- 7 C. Sylvester pers. comm.
- 8 T. Allen pers. comm.
- 9 Hodge 1979:144
- 10 GCWD 1853:670-71
- 11 *BFP* 24 June 1854
- 12 *BFP* 24 June 1854
- 13 GCWD 1855
- 14 *BFP* 24 June 1854
- 15 *BFP* 17 Feb. 1855
- 16 Hodge 1979:153
- 17 Hodge 1979:151
- 18 Hodge 1979:151-2
- 19 Hodge 1979:149-50
- 20 GCWD 1855
- 21 Goodwin 1992; Masson 1993
- 22 Hodge 1966:44
- 23 NPWS file 92/P/3245
- 24 Wade 1974; Byrne 1974; NPWS files 92/A/4363, 92/P/5758
- 25 Madden 1976
- 26 Notably *The Report on the National Estate* (Hope 1974)
- 27 Pearson 1979; NPWS files 92/A/4363, 92/P/5758
- 28 Gojak and Allen 1998
- 29 Pearson 1979
- 30 Pearson 1990:29
- 31 Pearson 1990
- 32 Pearson 1990:28
- 33 Lock 1882
- 34 Wade 1974
- 35 Pearson 1979
- 36 e.g. Higgins 1990:92; Drew and Connell 1993:52, 54
- 37 Drew and Connell 1993:53
- 38 *BFP* 17 Feb. 1855
- 39 Hodge 1986:44
- 40 Moore and Ritchie 1998
- 41 e.g. Pearson 1998; Gojak 1988
- 42 Davey 1996

## BIBLIOGRAPHY

- The Bathurst Free Press 1854, 1855.*
- BYRNE, M. 1974. Field notes – Quartz roasting pits, Hill End, R. Ian Jack personal collection.
- CROWLEY, T. E. 1977. *Beam Engines*, Shire Publications, Aylesbury.
- DAVEY, C. J. 1996. 'The origins of Victorian mining technology, 1851-1900', *The Artefact* 19:52-62.
- DREW, G. J. and J. E. CONNELL 1993. *Cornish beam engines in South Australian mines*, Department of Mines and Energy South Australia Special Publication 9, Adelaide.
- GOJAK, D. 1988. 'Gara River, an early hydro-electric scheme in northern New South Wales', *Australian Journal of Historical Archaeology* 6:3-11.
- GOJAK, D. and C. ALLEN 1998. Hill End Historic Site – Quartz Roasting Pits conservation and interpretation plan, NPWS, Sydney.
- GOLD COMMISSIONER WESTERN DISTRICTS 1853 'Letter from the Gold Commissioner Western Districts to the Colonial Secretary', October 7, 1853, *V&P NSWLC*, Vol. 2, pp. 669-672.
- GOODWIN, B. 1992. *Gold and people: recollections of Hill End 1920s to 1960s*, Bruce Goodwin, French's Forest.
- HIGGINS, M. 1990. *Gold and water: a history of Sofala and the Turon goldfield*, Robstar Pty Ltd, Bathurst.
- HODGE, B. 1979. *Frontiers of Gold: The Goldfields Story, 1851-61, Book 2*, Cambaroora Star Publications, Peshurst, N.S.W.
- HODGE, H. 1966 (reprinted 1980). *The Hill End Story*, vol 1, Hill End Publications, St. Ives, N.S.W.
- HODGE, H. 1986. *A Guide to Historic Hill End*, Hill End Publications, Toorak.
- HOPE, R. M. 1974. *Report of the National Estate by the Committee of Inquiry into the National Estate*, A.G.P.S. Canberra.
- LOCK, A. G. 1882. *Gold: its Occurrence and Extraction*, E. & F. N. Spon, London.
- MADDEN, A. 1976. 'Use of Machinery on the Goldfields of Louisa Creek and Tambaroora N.S.W. 1851-55', *Australian Society for Historical Archaeology Newsletter* 6, September: 8-11.
- MASSON, M. 1993. *Surviving the dole years: the 1930s – a personal story*, UNSW Press, Kensington.
- MATSON, C. R. 1973. *Mine Data Sheets to Accompany Dubbo 1:250,000 Metallogenic Map Sheet*, Department of Minerals and Energy, Sydney.
- MOORE, P. R. & N. A. RITCHIE. 1998. 'In-ground ore-roasting kilns on the Hauraki Goldfield, Coromandel Peninsula, New Zealand', *Australasian Historical Archaeology* 16: 45-59.
- NATIONAL PARKS AND WILDLIFE SERVICE Head Office File 92/A/4363, Aboriginal relics – Excavation – Historic Sites – Hill End HS
- NATIONAL PARKS AND WILDLIFE SERVICE Head Office File 92/P/3245, Addition of Portions 12,13 and 19 – Parish Cummings – Alpha Station – Hill End Historic Site
- NATIONAL PARKS AND WILDLIFE SERVICE Head Office File 92/P/5758, Hill End – Historic Sites – Roasting Pits
- NSW LEGISLATIVE COUNCIL, 1853. Report from the Select Committee on the Gold Fields Management Bill with minutes of evidence, *V&P NSWLC*, 1853, vol. 2, pp. 427-519.
- PEARSON, M. 1979. Notes on the Hill End quartz roasting pits, copy on file – NPWS Head Office File 92/P/5758
- PEARSON, M. 1990. 'The lime industry in Australia – an overview', *Australian Historical Archaeology* 8:28-35.
- PEARSON, W. 1998. 'Water-powered flourmilling on the New England Tablelands of New South Wales', *Australasian Historical Archaeology* 16:30-44.
- WADE, J. 1974. Preliminary report on the first season of excavations at the roasting pits site, Hill End, N.S.W., copy on file - NPWS Head Office File 92/P/5758