

The Technology of Colonial Ore Processing in Western Australia: The Warribanno Lead Smelter

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The Warribanno smelter was constructed in 1853 to process galena from the Geraldine Lead Mine, the first viable commercial mining operation in Western Australia, located 500 kilometres north of Perth on the Murchison River. Despite using two expensive imported reverberatory furnaces, the smelter was only used for several years before permanently closing in 1858. This paper describes the archaeological and historical evidence for the nature and operation of the Warribanno smelter complex and examines it in the context of contemporary British and South Australian smelting technology. It also examines possible factors behind the short-lived and apparently unsuccessful nature of the operation.

Studies of early mining in Western Australia have been dominated by the overwhelming social, economic and physical evidence of the several gold rushes which gripped the colony from the mid-1880s onwards. In contrast, the thirty years of lead, copper and tin mining which pre-dated the gold discoveries are relegated to brief historical footnotes. Most of this pre-goldrush activity was situated within the Northampton Mineral Field, stretching approximately 100 kilometres between Geraldton and the Murchison River. Possibly as a consequence of their limited historical recognition, locations away from well-known mining areas and limited re-working in later periods, many of these earliest mine sites have survived relatively undisturbed.

This paper documents the historical and archaeological evidence for the first attempts at mineral processing in Western Australia, at the Warribanno lead smelter, located near the Murchison River, approximately 500 kilometres north of Perth (Fig. 1). The Warribanno smelter complex is one of a series of

sites associated with the Geraldine Lead Mine, the first productive European mining operation in Western Australia, which opened in 1849 (Fig. 2). Several comprehensive considerations of the European settlement of the midwest region and the history of the Geraldine Mine are already available, so the following narrative focuses on the previously undocumented development of the smelter complex.¹ It also examines the technology of the smelter within the context of contemporary developments in Britain and South Australia, and considers whether there is evidence of local innovation or adaptation.

Part of the research for this paper was originally carried out for a conservation study of the Warribanno lead smelter site, undertaken by Considine and Griffiths Architects on behalf of the Northampton Historical Society.² However, the study also forms a component of a long-term investigation by the author into the historical archaeology of the early mines and mining communities of the Northampton Mineral Field.

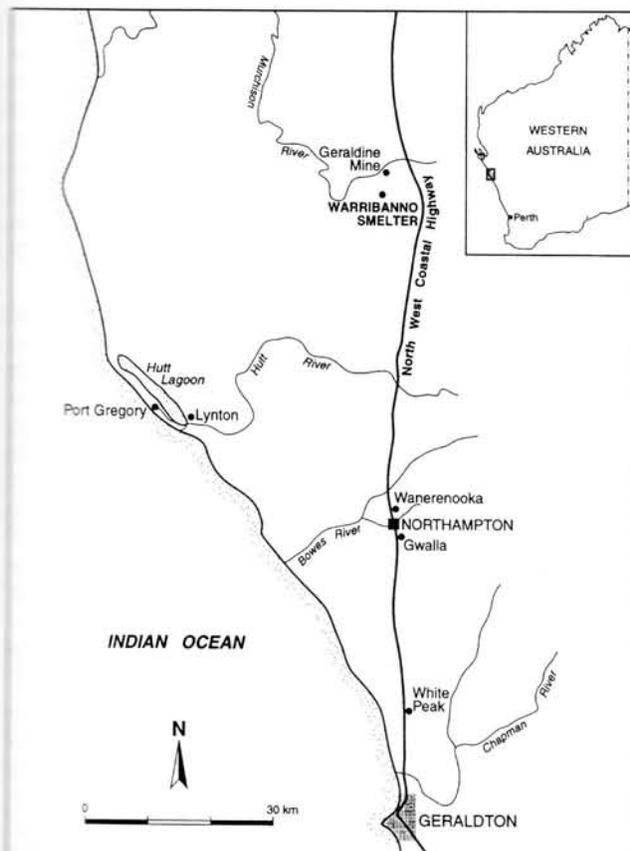


Fig. 1: Midwest Western Australia showing approximate area of the Northampton Mineral Field.

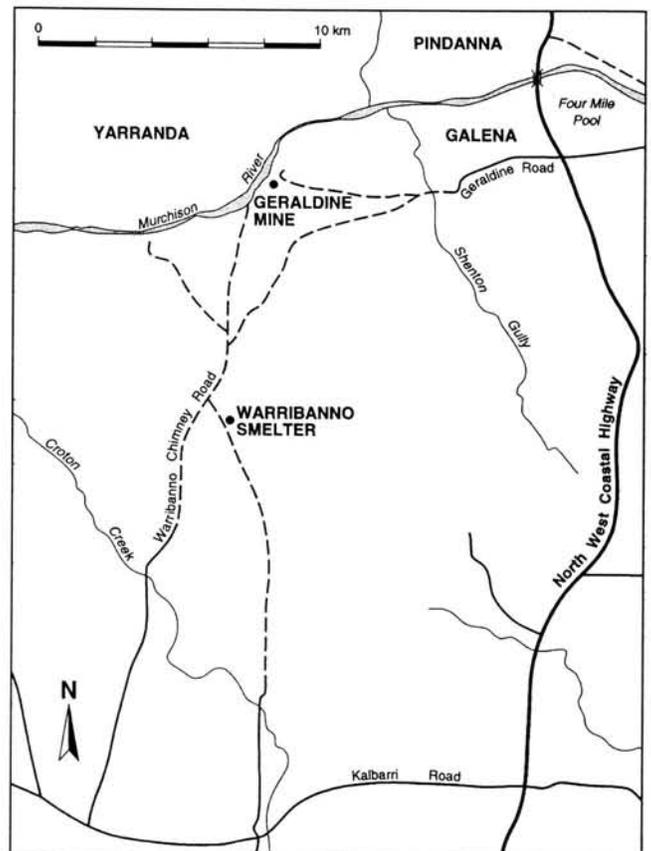


Fig. 2: Galena Mining Area showing locations of Geraldine Mine and Warribanno Smelter.

HISTORY OF THE SMELTER

By the mid-1840s the Swan River Colony had survived the various near-disastrous economic problems which had beset it since its foundation in 1829 and emerged as a small but viable pastoral and agricultural settlement. However, there was a certain eagerness amongst the colonists and administration to find exportable resources which would generate revenue and secure the future of the economy. In particular, and despite several early disappointments, hopes were held for the discovery of minerals and especially gold.

In 1846 Augustus Gregory of the Colonial Surveyors Department discovered brown coal along the Irwin River in the previously unexplored midwest region of Western Australia. His second expedition in 1848 saw the discovery of galena (lead sulphide) in the bed of the Murchison River, resulting in a number of notable Perth merchants quickly forming a small company named the 'Geraldine Mining Company' in honour of the then Governor, Charles Fitzgerald.³ In early November of 1849 an overland party led by Gregory set out from Perth, surveyed a potential harbour at the mouth of the Hutt River (later to become Port Gregory), and headed across the sand plain towards the site of the galena discoveries. Mining operations appear to have commenced almost immediately, although the main shaft was foolishly sited directly over the original outcropping, which happened to be located in the bed of the then-dry Murchison River. Although this allowed an immediate return of ore, it also resulted in flooding every time the river began to flow and was not remedied until 1867 when a new shaft was opened above the north-west bank of the river.⁴

During the several months of late 1849 and early 1850 Augustus Gregory surveyed the surrounding area (discovering a nearby seam of copper in the process), further investigated the harbour at Port Gregory, established the route from port to mine and assisted in setting up the new establishment. This included constructing 'a furnace capable of smelting (lead) ore', although no further details could be found of either the nature or production of this first smelter.⁵ Neither contemporary newspaper reports nor the Blue Books (which were the annual reports of colonial production) report exports of pig lead until 1853, which possibly indicates that Gregory's smelter was not viable. Smelting does, however, appear to have been intended by the Geraldine Mining Company from an early stage.

One of the motivations for construction of a smelter was the cost and difficulty of transporting unprocessed ore. Port Gregory is situated approximately 50 kilometres from the mine, much of this being a sand plain across which the heavy ore wagons moved slowly and bogged frequently. It is probable that the owners of the mine hoped to reduce the time, difficulty and expense of ore transport by smelting the galena into lead, so that only the ingots or pigs needed to be carted across the sand plain to Port Gregory. The other benefit would have been that the processed material could then be shipped directly to England, rather than to another colony for smelting, thus increasing the return on what was already a marginal operation.

In late 1850 or early 1851 representatives of the Geraldine Mining Company searched the mining districts in the north of England for an experienced smelter willing to migrate to the colony and oversee the Murchison operation. They finally secured the services of Francis Watson Pearson of Newcastle-on-Tyne, transporting him, his wife and five children, and a cargo of materials for a new smelter, to Western Australia aboard the *Morning Star*.⁶ The vessel arrived at Fremantle on the 19 October 1851, with the Pearsons and equipment dispatched northward to Champion Bay less than a month later.

In January of 1852 the Geraldine Mine was visited by the Governor, a party of notable settlers, and a military escort, for the purpose of investigating reported misbehaviour by the ticket-of-leave men and Aboriginal workers.⁷ The published

account of this tour reported that difficulties were being experienced in bringing the smelting equipment along the track from Port Gregory, with Pearson estimating at the present rate of carting it would take up to two years to get the bricks and ironwork to the mine.⁸ The report also cast doubts on the wood and water supplies available, concluding that with all expenses and difficulties taken into consideration, it would be cheaper to send the ore elsewhere for processing.

By April there had been some progress, with Robert Habgood and Thomas Carter (representing the directors of the company) detailing the Geraldine operation at this time in some depth.⁹ Pearson is described as being a man of great energy, and noted as having nearly completed the construction of a smelting furnace with flues and chimney, despite a shortage of men available to undertake this work. Although incomplete, the first operation of the smelting plant was successfully demonstrated to the visitors, resulting in the production of two, 10 stone (140 pounds or 63 kilograms) pigs of lead. Pearson was reported as intending to start construction of a second similar furnace almost immediately. However, this was clearly not the smelter or the site now known as Warribanno, as the report states:

These furnaces are not composed of the expensive apparatus lately imported by the *Morning Star*, and are erected for temporary use to load the teams employed in bringing up the goods, and works are now in active operation for the erection of the two furnaces imported... the company are fortunate in having immediately on the spot, with the exception of what they have already provided from England, every requisite material — some stone of the very best quality is found within 2 miles, brick-earth immediately on the spot, and a cliff of sandstone, easily worked to any required shape or size, within 1/4 of a mile.¹⁰

The report also describes the company's brickfield, where some bricks for the new furnaces had already been made and a kiln was ready for burning. Probably responding to the earlier criticisms, Pearson stated that the wood available in the area was superior to any fuel he had ever used, and that the smelter could be supplied with it at a rate cheaper than coals could be supplied in England. He confidently suggested that when both of the new furnaces were working, they would produce 1 500 tons of lead within 12 months.¹¹ Despite a special meeting of the Geraldine Mining Company to discuss a proposal by a South Australian company to smelt the Murchison ore in that colony, the construction of the new smelter proceeded, if slowly, over the next three years.¹²

By August of 1853 work on the new smelter complex had commenced, with a report by the Mine Captain (John Hoskins) stating that it was intended to start breaking up the foundation for the flue as soon as hands could be spared from other duties, although work had already begun on digging a tunnel through the hill to connect the flue to the site of the new chimney.¹³ In addition, a good well of 9 fathoms (54 feet or 16.5 metres) depth had been dug and housing for the workers had also been built. Four thousand fire bricks and an unstated number of ordinary bricks had been made from local clay, puddled by oxen and fired in a kiln, all at a location somewhere near the smelter site. This is also the first report where the new smelter site is referred to as the 'Gum Forest', probably reflecting the natural vegetation such as indicated on Gregory's 1850 survey.

While construction of the new works at the new smelter (later Warribanno) proceeded, the existing smelter continued to operate, with Captain Hoskins stating that over 40 tons of lead had been turned out, possibly within the preceding two month period.¹⁴ Several months earlier it had been reported that although the furnace was working well, experiments had been carried out to find a means of 'thickening' the slag to facilitate its separation from the molten lead.¹⁵ Lime, which

was usually used in these circumstances, was not proving effective, although by late March an effective (but unidentified) substitute had been found.

By late October of 1853 the first of the new furnaces at Warribanno was nearing completion, while nearly all of the materials for the second had been carted up from Champion Bay.¹⁶ However, it appears that a quarrel between the Mine Captain and Pearson had developed, so that when spirits were introduced to the mine the argument reached the point where Pearson temporarily left the site.¹⁷ The nature of the dispute is uncertain, but it appears that a lower than expected yield from the smelter for the given quantity of ore may have been at the heart of the situation, with a loss of 50 per cent, presumably from the original total weight of the ore, being noted.¹⁸ A further report also notes that 'the expectations of the directors with regard to the yield of the furnace had not been realised' and that 'it appeared matters did not go smoothly between the smelter and the mine captain, and that blame attached somewhere'.¹⁹ The difficulty must have been with the existing ore hearth, as the new reverberatory furnace at Warribanno was not reported as being completed and ready for operation until mid-February.²⁰

By June of 1854 a roasting furnace had been constructed, work had begun on a second reverberatory furnace and experiments with the completed reverberatory furnace had resulted in the process requiring less wood while providing a 50 per cent yield of lead from the ore.²¹ Although this result appears to be the same as the apparently unsatisfactory yield of the previous year, there is little comment on the situation, possibly as nearly 14 tons of lead had been produced in only 14 days, mollifying the critics.

There is a possibility that Pearson had permanently left Warribanno by mid-1854, since by October he had purchased land near the convict depot at Lynton, close to the harbour at Port Gregory, and had established a blacksmith's shop and more.²² Whether Pearson maintained some contact with the Geraldine Mining Company or a new person was hired to run the smelter is unknown.

For the next two years operations at the furnaces proceeded with only minimal comment in the colonial newspapers. Progress can be traced through the annual Blue Book reports as shown in Table 1. These are in fact the total lead export figures for Western Australia, but as no other lead mine or smelter is known to have operated in this period, there is no doubt that these actually represent the output of the Geraldine Mine and Warribanno smelter.

During the first half of 1855 most work at the Geraldine Mine appears to have been suspended.²³ However, by the second half of the year mining had recommenced and various improvements to the mine were being undertaken.²⁴ A grinding machine was in the process of being constructed, suggesting a change from preparation of the ore by hand to mechanical crushing. There is also reference to the construction of a 'new chimney', which may refer to the smelter chimney.²⁵ If the smelter was out of use for a short

period while these works were carried out, it may explain why the 1855 Blue Book records exports of unprocessed ore, in addition to the smelted pig-lead.

At the start of 1856 the Geraldine Mine was offered for sale.²⁶ Mining operations continued with indications that fair progress was being made, despite the Blue Book indicating a significant reduction in the export of lead.²⁷ A prospectus prepared in the second half of the year provides a clear summary of the plant, finances and situation of the mine, as well as the state of the smelter.

At the Gum Forest, about 3 miles W.S. from this mine, the Company purchased a block of land — 20 acres — on which they have erected a roasting and two large smelting furnaces, with a large chimney 105 feet above the works, together with good dwelling houses for workmen, &c. Nearly all of the lead risen from the mine for the last three years has been smelted here, it being the most convenient spot for wood, and in the high road leading from the mine to Port Gregory.²⁸

Another section of the report refers to there also being a smithy and storage buildings at the smelter.²⁹

The prospectus appears to have attracted few potential purchasers, either locally or in Britain. This may have been because by the mid to late 1850s new copper ore and galena deposits had been located to the south towards the Bowes River. The new mines were closer to the port facilities of Champion Bay, did not suffer from the Geraldine Mine's difficulties with water and transportation, and could be supplied easily from the new pastoral and agricultural settlements around Greenough.³⁰ Port Gregory had also obtained a reputation as a difficult harbour to enter, with several wrecks and damaged vessels discouraging use.³¹ With better investment options both within Western Australia and abroad, there was little incentive to purchase or invest in the largely unsuccessful Geraldine Mining Company, although a tenant does appear to have been found to continue operations.³²

Between 1856 and 1859 there are several reports of further efforts being made to improve the road to Port Gregory.³³ This included the purchase of a steam traction engine to cart the wagons of ore over the sand plain, although on its initial run it failed to make it beyond the sand dunes near the port, let alone all the way to the mine.³⁴ The Blue Books suggest that small quantities of galena were still being smelted in 1858 and 1859, although by 1860 only unprocessed pig lead is recorded as being exported, suggesting that attempts at smelting had finally ceased.

After 1859 the situation of the Geraldine Mine becomes somewhat confusing. An English group appears to have purchased the company, although by August of 1860 there were reports that the company had already collapsed and the equipment at the mine was to be sold.³⁵ Work at the Geraldine Mine did recommence in 1864 or early 1865 under new owners, although there is no indication that any further attempts were made to process lead ore at the smelter either then or in the future.

It has been suggested that the name 'Warribanno', presumably derived from two Nanda words; 'warri' (fire) and 'bunna' (hill), was first recorded in an 1860s survey of the lower Murchison region by Assistant Surveyor William Phelps.³⁶ However, a search through Phelps' notebooks for this period failed to find this reference. Department of Land Administration nomenclature files suggest that the name was first used by surveyor W. A. Irvine in 1906, over 40 years after the last known firing of the smelter.

There is little documentary evidence of the fate of the smelter throughout the late nineteenth and early twentieth century. Through this period the Ajana-Galena area went through several further phases of mining activity and pastoral

Table 1. Blue Book Records of Lead Ore and Pig Lead Exports from the Geraldine Mine

Year	Lead Ore		Lead (smelted)	
	tons	value (£)	tons	value (£)
1853	4	—	55	1 200
1854	—	—	122	2 400
1855	25	250	134	2 675
1856	—	—	60	1 200
1857	—	—	120	2 410
1858	—	—	61	1 220
1859	13.5	135	25	495
1860	98.5	985	—	—

The products of the lead smelting furnace were, firstly, metallic lead which was drawn off in molten form and ultimately run off into ingots which were referred to as 'pigs'. There would also be slag, composed of earthy materials and any unsmelted ore, including metallic lead bonded within the pores. Slag could be re-smelted to reclaim the residual material, sometimes in a separate slag furnace, although the main reverberatory furnace could be used.

It is interesting to note that over time and presumably as the original fabric of the furnaces and flues deteriorated or were salvaged, the local understanding of the processes undertaken at the Warribanno smelter became increasingly obscured. Several documentary sources (and local informants today) repeat a belief that the smelter worked by loading wood and ore into the base of the chimney and setting fire to the fuel. The pig lead was then thought to flow out through the tunnel and down the flue channels to cool. This appears to confuse the chimney with the processes of a blast furnace, such as used to smelt iron.⁴⁵ Without visible flue and lead smelter structures there are in fact some superficial similarities.

ARCHAEOLOGICAL EVIDENCE

Environment

The Warribanno smelter complex is situated on Murchison Location 3, approximately 8.5 kilometres off the North West Coastal Highway and 9 kilometres along the old Warribanno Chimney Road. The smelter is also approximately 4.5 kilometres south of the Geraldine Mine.

The most significant landscape feature of the Warribanno site is the stone outcrop on which the remaining 6 metres of



Fig. 4: Surviving base of the Warribanno Smelter chimney showing draft hole.

the chimney stack sits, with this structure being readily visible from many locations around the district (Fig. 4). The actual hearths and smelter structures are spread along the southern slope and base of the hill, immediately below the chimney and for some distance eastward. Although agricultural land surrounds the outcrop, the top and slopes of the hill are lightly wooded with york gums, jam trees, ti trees, and several surviving sandalwood and kurrajong trees.

Smelter Buildings and Furnaces

The surviving components of the smelter include evidence of at least four random rubble structures and the connecting flues, although most of the original materials have been severely scavenged to the point where all that remains are at best basic foundations. A plan of the visible evidence is provided in Figure 5. The survey was completely non-intrusive, so while it is possible that further structural detail could be revealed by excavation or even simple clearance of rubble and dirt, at the time this was not considered a possibility.

The most westerly of the structures appears to be the simplest, but has also obviously suffered some of the worst damage from scavenging and is only partially visible beneath rubble and an overburden of soil. Small pieces of galena are also scattered on the ground nearby. Despite the lack of visible detail, the building would appear to have been rectangular, with internal dimensions of 1.9 metres by 3 metres, with a 0.6 metre wide flue entering above floor level, although a precise height cannot be determined at this time. Given the dimensions and the connection with the flue, it seems possible that this is the roasting furnace mentioned in the 1856 prospectus. Excavation will be necessary to further investigate the nature of this structure, although from the visible evidence it appears to be much simpler than the calcining furnace at the Talisker Mine and may indicate a less complex form of ore roasting.⁴⁶

The two large central structures are presumably the reverberatory furnaces, with complex floor plans which are also only partially visible from the surviving or exposed fabric. Both buildings appear to have had outer walls of double-skinned random rubble, with internal structures of coursed ashlar blocks, possibly of sandstone (Fig. 6). These internal structures are interpreted as being the footings of the furnaces, with the outer walls indicating a housing structure or perhaps cover. There is a clearance of two or more metres between the furnaces and the covering structures around three

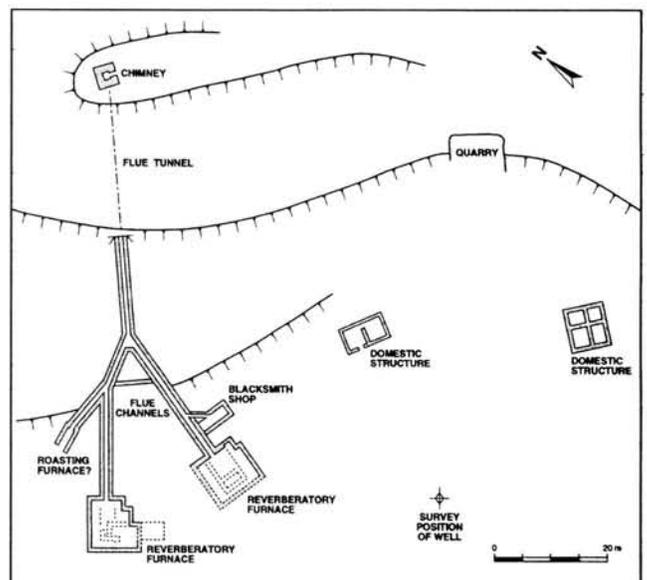


Fig. 5: Interpretation of archaeological remains at the Warribanno Smelter.



Fig. 6: Ashlar block base of western reverberatory furnace (looking west).

sides, presumably to allow people to work around them. On their north sides the hearths are built up to the external walls where a flue, with an internal channel width of approximately 0.95 metre (3 feet), enters each at about 1 metre above current ground level. There are some remnants of non-local fire bricks along the wall of the eastern furnace building, although a cursory examination did not show any diagnostic markings which might indicate their origin.

The ashlar blocks in the base of the eastern building are the more visible of the two furnaces, indicating a structure approximately 7 metres long and 3.1 metres wide, corresponding quite closely to the dimensions provided in the description quoted above.⁴⁷ The internal wall at the southern end of the hearth probably indicates the location of the 'firebridge', the low wall which separated the fire and ash pit from the chamber (Fig. 3).⁴⁸ The plan of the western furnace base is far less clear but does appear slightly different, although this may be a function of what has been salvaged from either or both. It is possible that the visible portion on the southern end also indicates the firebridge and ashpit.

Two metres north of the eastern furnace is a smaller building, also of random rubble walls and with some brickwork along the interior western side. This structure is completely filled with rubble and soil to an unknown depth, but perhaps as much as half a metre or more. While it is difficult to discern details, it appears that a narrow flue of less than 50 centimetres enters into this building along its north side. It is possible that this is a slag furnace such as described earlier, although there is no mention of one being constructed at Warribanno and the structure and flue appear to be somewhat different to the other three smelter buildings. An alternative interpretation is that this building was the smithy mentioned in the 1856 prospectus, with the small flue possibly connected to the hearth of the forge. There is sufficient fabric remaining beneath the rubble that excavation may resolve this question.

It should be noted that by the early 1850s, when the Warribanno smelter was constructed, flues had generally replaced the former practice of chimneys being attached directly to the furnace.⁴⁹ It had also been realised that considerable quantities of lead were being lost through vapour, but that by constructing a flue between the furnace and the chimney it was possible to catch or condense the sublimated particles. At regular intervals the flues, which were generally

large enough to crawl through, would be swept out and the deposits re-smelted in the furnace. The Warribanno flues are quite simple and relatively straight, reflecting the common design of that period. After the 1850s flues were made much longer, and often constructed with loops, parallel systems and condensers (or scrubbers) to increase the amount of sublimated lead recovered.

The Warribanno flues have been reduced to open channels of a random rubble construction, faced along the interior side and with evidence for a clay and possible lime mortar lining. The brickwork scattered along the length of the flues suggests the nature of the vaulting which would have originally enclosed the channels, although none has actually survived. As noted, the flues from the two reverberatory furnaces are approximately 0.95 metre (3 feet) in width, and combine at a distance of approximately 20 metres away from the furnaces (Fig. 7). A single combined flue of 1.2 metres width then leads off to the north and at a slight incline up the slope towards a tunnel bored through the hillside. This underground section of the flue is also on a slight incline and is oriented on a slightly different alignment to that of the above-ground section. Internal examination was not possible. The horizontal tunnel terminates in a vertical shaft which is semicircular on its eastern side. This shaft then discharges into the above ground section of the flue (the chimney).

In the absence of bellows, reverberatory furnaces required a higher chimney to increase the draught and therefore the intensity of the 'blast' within the hearth. The square sectioned stack at Warribanno is typical of contemporary Yorkshire smelters, betraying Pearson's origins and contrasting to the circular stacks which were characteristic of smelters in Cornwall and contemporary sites found in South Australia.⁵⁰ Only 6 metres survive of the Warribanno chimney stack. The 1856 prospectus states the chimney originally towered 105 feet (32 metres) above the works, although as this almost certainly included the estimated 60 feet (18 metres) of the hill on which it sits, the original height of the chimney itself must have been between 12 and 14 metres.⁵¹ Large slabs of brickwork from the collapsed upper sections of the chimney surround the base. As noted previously the structure was stabilised and partially reconstructed by the National Trust during the 1970s.



Fig. 7: Junction of smelter flues (looking west).

Other Buildings and Sites

To the east of the smelter complex are three further associated sites. Approximately 35 metres northeast of the eastern furnace are the ruins of a two room building. The walls survive to as much as 2 metres high and are of random rubble with some ashlar blocks to the quoins. There are windows and a door opening in the south wall, but no evidence of fire-places. Rubble partially fills the interior and the floor surface is not visible.

A second structure lies approximately 27 metres southeast of the two room ruin and approximately 72 metres east of the flue junction. This building, originally of random rubble with four rooms, has been reduced to a mound less than a metre in height.

The 1856 prospectus does record housing being built at the smelter for the workers, while it is also possible that Pearson and his family lived at the site. The domestic use of one or both buildings is also suggested by the ceramics and glassware visible in adjacent ploughed areas. There remains the question of the storage building also mentioned in the prospectus, although it is possible that some of the four rooms may have been used, or that there was another structure which has not been located.

Approximately 34 metres north of the second structure is a small stone quarry cut into the side of the hill. This is presumed to have provided the structural material for the buildings and the chimney. The survey did not include an attempt to locate the clay pits or brick kiln (or clamp) mentioned in the contemporary reports. Based on early surveys through the area, the likely position of the well which serviced the smelter was also determined, although no evidence was located.

DISCUSSION

The Warribanno smelter and to some extent the earlier smelter(s) constructed and operated for the Geraldine Mining Company between 1850 and 1859 were contemporary with the earliest copper smelters constructed in South Australia. Cumming and Drew review the history of these operations, some dating from the late 1840s, and suggest that smelting in South Australia was initiated at least partially for the same reason of attempting to eliminate the expense of having to transport ore to the English smelters for processing.⁵²

Unfortunately Cumming and Drew are not specific about the technology employed in South Australia, although it is presumed that many if not all of the smelters during the mid-nineteenth century employed reverberatory furnaces comparable to the Warribanno example.

The only readily available survey plan of a near-contemporary smelting furnace complex in Australia is that for the previously mentioned 1860s Talisker Silver Lead Mine, located near Cape Jervis in South Australia.⁵³ There are interesting similarities between this site and Warribanno, including the apparent separation of the calcining and reverberatory furnaces into separate buildings. The photograph of the Talisker Mine shows the calcining furnace without a covering structure, similar to the proposed situation at Warribanno, while the main reverberatory furnace is sheltered beneath an open-sided galvanised iron roof.⁵⁴ It is also interesting that at Talisker the mine, grinding machines, brick kiln, and smelter components are all within such close proximity, whereas at the Geraldine Mine, which appears to have been an operation of comparable size, the different parts are spread over several kilometres.

Despite the absence of most of the superstructure of the furnaces and flues, the Warribanno smelter appears to be of similar design and operation to contemporary smelters seen in Britain and especially northern England. The historical record certainly suggests that the Geraldine Mining Company simply purchased at least the two main reverberatory furnaces in England, possibly based on the advice of the newly-hired Pearson. The components, including ironwork, bricks and possibly stonework, were shipped out complete and ready for re-assembly, while Pearson re-created the flue system and chimney he was most familiar with. The land (Location 3) had already been purchased, presumably explicitly for the smelter, and is noted on surveys as early as 1850.⁵⁵

Given that the furnaces themselves were essentially a kit, there is no historical or physical evidence of particular innovation in either design or operation. This is consistent with other studies of technological diffusion which suggest that mining in Australia generally remained dependent upon British technology until the 1880s.⁵⁶ The only visible variation at the Warribanno smelter is that in Britain the several furnaces and any associated plant would normally be housed in a single large building. The Warribanno furnaces are widely separated and appear to have had their own covering structures, although

ultimately the individual flues attach to a common main flue. The reason for this separation is unclear, although it may have been to allow the different furnaces to be built and come into operation progressively over a two year period, without the difficulties associated with the construction of a single housing structure. In truth, given the dry conditions of the lower Murchison, substantial stone structures such as suggested by the remnant walling are completely unnecessary and must have been almost unbearable in the summer, given that temperatures frequently remain above 40° Celsius. It is possible that only partial walls were built, although this may be difficult to prove with the removal of most of the original materials from the site.

Essentially, the historical and physical evidence suggests that Warribanno was a state-of-the-art lead smelter which was being operated by an experienced manager. The galena from the mine was considered to be of a high grade and there was ample fuel in the immediate neighbourhood. The earlier lead smelter constructed by Pearson, probably of a simpler 'ore-hearth' type and presumably fabricated from local materials, had already produced quite reasonable results. Therefore, why did the new reverberatory furnaces apparently fail, or at least not achieve superior returns?

It is possible that some blame for the supposed failure of the Warribanno smelter attaches to the Geraldine Mining Company itself. The historical record for the operation shows that the mine was beset by problems including its remote location, difficulties with supply, a belligerent convict workforce and a sometimes dismal lack of intelligent mine management which resulted in disastrous decisions such as the placement of the main shaft in the middle of the river bed. The early hand bucking of the ore, as well as the possible lack of buddling due to water shortages, may well have been insufficient to concentrate the ore for the smelter, leaving impurities which reduced smelting efficiency. There had also been the problem of finding a suitable flux to assist in the chemical process of separating the lead from the slag. Without chemical analysis of the galena from the mine and a sample of lead from one of the reverberatory furnaces it may be difficult to resolve this question. However, the historical record appears to lay the blame squarely on the poor management of Pearson.

While the conflict between Pearson and Hoskin (the mine manager) over the poor performance of the new furnaces has already been detailed above, there is later evidence which also condemns Pearson for the poor result. Joseph Lucas Horrocks, a Cornishman who arrived in the colony as a convict in the early 1850s before becoming a mine owner and manager in nearby Northampton, wrote a lengthy report to the Colonial Secretary in 1860 on mining in the region, including a summary of the situation at the Geraldine Mine.⁵⁷ In this he describes the great potential of the Geraldine Mine while lamenting the incompetence and lack of mining skill of the various companies and managers. His statement includes the following:

The ore is cubic galena is mostly obtained clean and free from the matrix (crystallised quartz) and yields by assay 75 to 80 per cent of pure lead but strange and discreditable as it may appear did not yield to the furnace more than 33 to 38 per cent showing a most defective manipulation and ignorance of metallurgy and much of the loss from first to last may be attributed to the want of skill in this department alone.

Horrocks' claim of a 33 to 38 per cent yield is even lower than the 50 per cent yield stated in earlier reports, although it is possible that this represents the production of the furnace after Pearson's probable departure in mid-1854. Naturally there is the possibility that Horrocks was simply repeating local innuendo, although the rest of the report and several of his

other writings show an eye for detail and an overall desire to promote the successful aspects of the district, albeit tempered by a tendency to point out poor performance by other miners and managers.

There is insufficient historical data to arrive at an objective opinion as to whether the yield of lead from ore processed at the Warribanno smelters was lower than might be expected from contemporary operations in similar circumstances. Records of the total weight of ore raised from the Geraldine Mine and the specific production from the smelter (rather than export figures) are limited or non-existent, making it difficult to independently examine whether the criticisms levelled at Pearson were true or mixed with personal conflicts. Contemporary smelting operations in South Australia, while using similar furnace technology, were based on copper processing and are therefore not suitable for comparison.

Of interest is Horrocks' statement that much of the lead from the Geraldine Mine (presumably in smelted form) was purchased for the China market, because the high purity made it softer than English lead and easier to roll into thin sheets as lining for tea chests.⁵⁸

From the late 1850s onwards the mining of the Northampton mineral field increasingly became the province of the ubiquitous Cornish miners. Horrocks himself is credited with first bringing skilled miners out to the colony in the mid-1850s and 1860s, with Captain Samuel Mitchell continuing this trend through to the turn of the century.⁵⁹ It was Mitchell who in the 1860s and 1870s finally brought the Geraldine Mine into steady production and achieved reasonable profit. However, there is no evidence that he or any other subsequent owner or manager attempted to operate the smelter. It is even conceivable that the furnaces had already been sold and removed during one of the several passages of the mine and its properties between owners.

Very little is known of the small frontier community based at the Geraldine Mine, with even less recorded of those persons living at the Warribanno smelter. As noted earlier, the 1856 prospectus does record the construction of 'good dwelling houses for workmen' at the smelter site, implying that at least several men remained resident at Warribanno, rather than twice daily walking the 4 kilometres from the main camp adjacent to the Murchison River and the Geraldine Mine.⁶⁰ It is not clear whether the Pearson family lived near the mine or at the smelter, although the responsibility as smelter manager would suggest the latter.⁶¹ The presence of domestic artefacts scattered around the two structures to the east of the main smelter complex suggests potential for excavation of these sites, both to determine the nature of the original occupants and to examine the general lifeways of what at the time was one of the most remote European outposts in Western Australia.

The proximity of the two presumed dwellings to the lead smelter and chimney raises questions regarding the health of the smelter community. The gaseous by-products of refining galena ore (lead sulphide) included sulphur dioxide, which is both poisonous and corrosive. In addition, even though the flue system helped to remove the sublimated lead particles from the hearth discharge, some of this matter would inevitably be released into the nearby atmosphere. While there is no historical record of any health problems experienced by the Warribanno smelter community, some impact, whether through breathing fumes or because of contamination of soil, water or locally grown foodstuffs seems highly likely. The relatively brief and irregular operation of the Warribanno furnaces may well have limited the risk of injury to the workers or to Pearson's family. Wind directions and conditions around the smelter are not known, but investigation of this

detail and testing of lead levels in soil around the sites may prove to be of interest.

After the closure of the Warribanno smelter the ore from the Geraldine Mine and the other lead and copper mines which dotted the Northampton Mineral Field appears to have been shipped out for smelting in either England, Asia or the other colonies. In 1873 a new smelter was constructed at McGuire's Lead Mine, near Isseka at the southern end of the Northampton Mineral Field.⁶² Little is known of this operation, although despite being located significantly nearer the harbour at Geraldton and not suffering many of the difficulties of the Geraldine, it too failed within several years. Further historical and archaeological investigation of both this and several other possible smelters in Western Australia in the late nineteenth and early twentieth centuries is required.

CONCLUSION

The archaeological and historical evidence clearly indicates that the Warribanno lead smelter was a reverberatory furnace complex comparable to contemporary British and South Australian operations. There is little evidence for innovation in either design or operation beyond the possibility of minor adaptations to accommodate local environmental circumstances and availability of materials.

It is not possible to firmly establish whether the reduced efficiency of the smelting operations was as significant and disastrous as claimed by several contemporary sources. It is also not possible to determine whether the difficulties encountered were the result of human error in the construction and operation of the furnaces as implied by these contemporary reporters, a by-product of poor ore concentration practices (because of limited water and lack of a suitable flux), or a combination of these and other factors.

Excavation of the reverberatory hearths, as well as further analysis of the properties of galena from the Geraldine Mine and any remnant particles of pig lead recovered from the smelter site, will undoubtedly reveal more about the operation of the Warribanno complex and the possible causes of its supposed failure. Further survey is also required to locate any remains of the smelter which preceded the Warribanno hearths and in fact was responsible for much of the production in 1853 and 1854. Together with the substantially intact remains of the associated Geraldine Lead Mine and its settlement, these sites are a unique and irreplaceable source of information about the earliest phase of European mining in Western Australia. Further surveys to record the history and archaeology of the whole complex are intended in the near future.

Despite its ultimate failure and limited role in the history and development of Western Australian mining, the mere fact that the Warribanno smelter was constructed and brought into operation was a significant achievement. First, the extreme isolation of the site, 500 kilometres from Perth and the nearest source of supply, must be considered. After the sea voyage to Port Gregory the furnace components had to be unloaded and hauled across more than 50 kilometres of nearly waterless sandplains. Before the furnaces could be constructed the land had to be prepared, local clay mined and thousands of bricks moulded and fired at the site. Stone also had to be quarried and the substantial structures of the chimney and flues raised. As has been noted for the Calcifer smelter at Chillagoe in northern Queensland, the cost and effort required to undertake the construction of the Warribanno smelter can also be seen as symbolic of the Geraldine Mining Company's belief that they were spearheading a permanent mining settlement of the area.⁶³ Although this never eventuated, the small achievements of the mine and smelter are still remarkable in their own right.

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NOTES

- 1 Bain 1975; Kelly 1962; Spillman 1993.
- 2 Gibbs and Griffiths 1995.
- 3 Kelly 1962:78.
- 4 Mitchell 1911.
- 5 Birman 1979:45.
- 6 Bain 1975; Erikson 1988; *Perth Gazette* 24 October 1851.
- 7 Birman 1979.
- 8 *Perth Gazette* 20 February 1852.
- 9 *Perth Gazette* 28 April 1852.
- 10 *Perth Gazette* 28 April 1852.
- 11 *Perth Gazette* 28 April 1852.
- 12 *Perth Gazette* 30 July 1852.
- 13 *Inquirer* 24 August 1853.
- 14 *Inquirer* 24 August 1853.
- 15 *Inquirer* 6 April 1853.
- 16 *Inquirer* 26 October 1853.
- 17 *Perth Gazette* 11 November 1853.
- 18 *Perth Gazette* 11 November 1853.
- 19 *Inquirer* 16 November 1853.
- 20 *Perth Gazette* 17 February 1854.
- 21 *Perth Gazette* 16 June 1854.
- 22 Colonial Secretaries Office Letters Received 296/24: 7 October 1854; *West Australian* 27 May 1933.
- 23 Kelly 1958; *Inquirer* 28 March 1855.
- 24 *Inquirer* 7 August 1855; *Inquirer* 31 October 1855.
- 25 *Inquirer* 31 October 1855.
- 26 *Inquirer* 30 January 1856.
- 27 *Perth Gazette* 1 February 1856; *Inquirer* 24 December 1856.
- 28 Anon 1856:3.
- 29 Anon 1856:2.
- 30 Gibbs 1996.
- 31 Henderson and Henderson 1988.
- 32 Horrocks 1860.
- 33 *Perth Gazette* 15 September 1857.
- 34 *Inquirer* 30 March 1859.
- 35 Lawrie 1979; Horrocks 1860; *Perth Gazette* 24 August 1860.
- 36 Bain 1975:149.
- 37 Information on file at the National Trust of Western Australia Inc, Perth.
- 38 Gibbs and Griffiths 1995.
- 39 e.g. Clough 1980; Raistrick 1975a; Raistrick 1975b.

- 40 *Inquirer* 31 October 1855.
 41 Drew 1987:52.
 42 Day and Tylecote 1991.
 43 Day and Tylecote 1991:102.
 44 Day and Tylecote 1991:103; Earl 1994:98; Jones 1996:288.
 45 Jack and Cremin 1994.
 46 Drew 1987:52.
 47 Day and Tylecote 1991:103.
 48 Day and Tylecote 1991:102.
 49 Day and Tylecote 1991:102.
 50 Clough 1980:79; Cumming and Drew 1987.
 51 Anon 1856; *Inquirer* 24 August 1853.
 52 Cumming and Drew 1987.
 53 Drew 1987.
 54 Drew 1987:44.
 55 Gregory 1850.
 56 Inkster 1990; Todd 1995.
 57 Erikson 1983; Horrocks 1860.
 58 Horrocks 1860.
 59 Gibbs 1996.
 60 Anon 1856:3.
 61 Bain 1975.
 62 Blue Book 1873:72; Wilson 1926.
 63 Kerr 1995.

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