The Interpretation of Structural Remains at Bolla Bollana Copper Smelting Works, South Australia

DAVID BANNEAR

Located in the northern Flinders Ranges, the Bolla Bollana copper smelting works present a story of innovation and persistence, in processing the region's seductively rich deposits of copper, against the eventually insurmountable obstacles presented by the works' isolation. The necessarily self-sufficient nature of the smelting works and the intactness of the existing physical remains, make the site one of special significance, as it can be used to build a more complete picture of the tradition of copper smelting in South Australia last century. In this paper, David Bannear, a consultant archaeologist, introduces this little-known site and attempts to show how, through its attention to both physical remains and written record, historical archaeology can interpret the existing structures and explain the site's unlucky past.

INTRODUCTION

In 1987 the writer undertook an archaeological and historical survey of the physical remains of the Bolla Bollana copper smelting works, for the South Australian National Parks and Wildlife Service.[1]

The Flinders Ranges, in whose northern reaches the smelting works are situated, are more or less a continuation of the Mt Lofty Ranges, which provide Adelaide's attractive backdrop. However, whilst the two ranges are geologically related, with the same series of extremely ancient sedimentary rocks extending throughout both, climatically they are very different. The Mt Lofty Ranges include some of the finest of South Australia's very limited good rainfall areas but the Flinders Ranges extend deep into Australia's dry interior, where eroding forces have produced razor-edged ridges and saw-tooth peaks of naked rock. The major geological feature of the Flinders is its massive beds of resistant sandstone, the buckled, broken, upturned and eroded edges of which form many of its spectacular peaks. The ore deposits smelted at Bolla Bollana were quarried on high ridges 15 km to the north-east of the smelting works, located on Arkaroola Creek. The smelting works now form part of the Gammon Ranges National Park, some 300 km north of Port Augusta (Fig. 1).

The archaeological survey was four-pronged and had the overall aim of formulating a management policy for the smelting works by: first, attempting to identify the existing remains in terms of their original usage; second, assessing the physical conditions of the surviving remains; third, ascertaining whether any further investigation might be required; and, fourth, formalising walking paths and signposting.

On my first visit to the area, I found that little was known locally about the smelting works' history, even by those who took an interest. In the course of my research I sought out the opinions of experts in other fields (metallurgists, mining historians and engineers) who had examined the site's physical remains. These opinions, expressed verbally, revealed differing interpretations of the same set of remains (Fig. 2). An example of this, and the one on which this paper will focus, is that of the function of a round, domed, stone structure (Fig. 3).

There seemed to be two main interpretations of this structure. The first was that it was a brick kiln and the relatively low temperatures achieved in this kiln resulted in poor-quality firebricks, which still litter the site. This fact would have aggravated smelting costs, decreasing furnace life by increasing the probability of arch failure, wall collapse and so on. The second interpretation maintained that the structure could not have been a firebrick kiln, because there were not enough firing ports to produce the high temperatures needed to fire the bricks properly and because the exposed iron or mild steel bars that are still present would not have survived in a firebrick kiln. This view pointed out that there was also on the site a linear or 'tunnel' kiln which, it claimed, was where the firebricks were really fired. There would, it was argued, have been no need to have two different

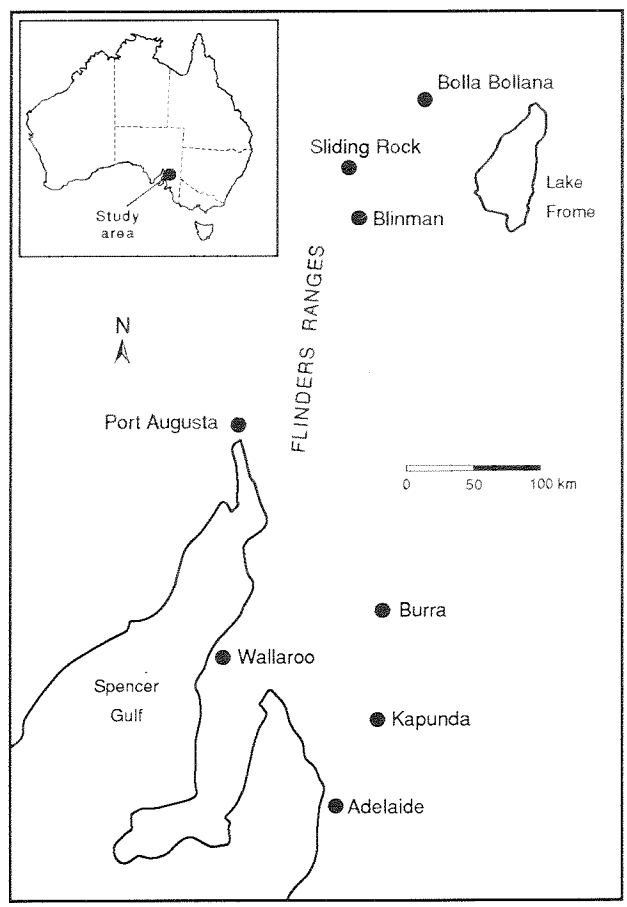

Fig. 1: Map showing location of Bolla Bollana copper smelting works.

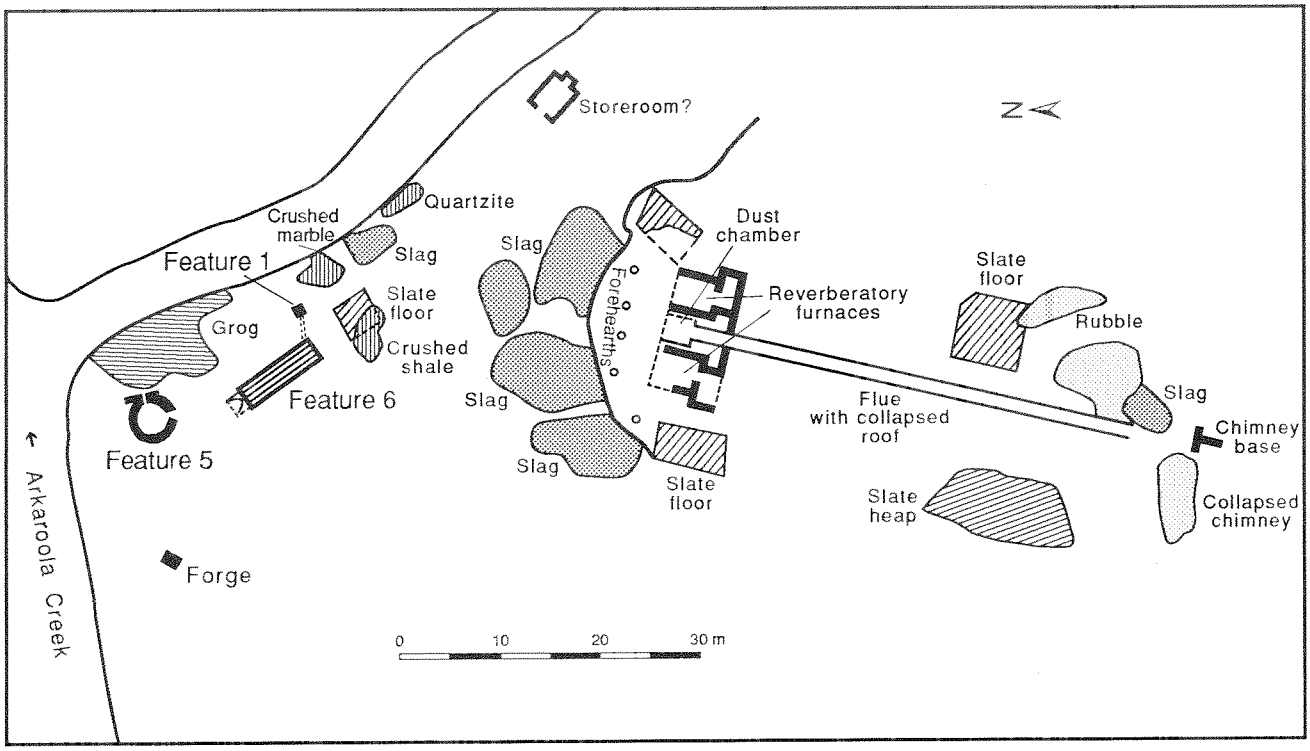

Fig. 2: Plan of Bolla Bollana, showing existing physical remains.

types of brick kiln on the same site. This interpretation concluded that the domed building was, in fact, a charcoal kiln, that may well have been added when it was found that the wood fuel was giving incomplete smelting.

This paper shows how the function of the domed kiln became clear, when a survey of the physical remains was linked to a thorough examination of historical sources relating to the site.

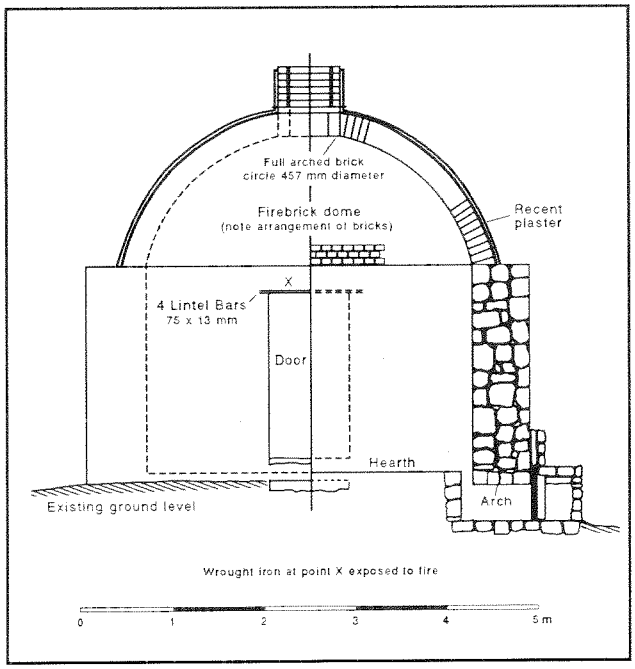

Fig. 3: Section of domed kiln at Bolla Bollana. (J.E. Connell, S.A. State Heritage Branch, 1986.)

HISTORICAL SUMMARY

In 1862, the Northern Mineral Association became the first of five companies to work the mines that were to be associated with the construction and operation of the Bolla Bollana smelting works. It was a small company and, like numerous mining companies associated with the Flinders Ranges, it came and went without leaving much of an historical record. The Northern Mineral Association was formed at a time when copper prices were high and when the normally harsh conditions of the region had eased sufficiently for it to be possible to run an animal transport system. The association took up four mineral sections (1464, 1465, 1468, 1482) and the main mines were the Daly, Stanley, Sir Dominic and Old Noll.[2] These sections were spectacularly rich, with lodes of copper ore traversing the rugged ranges in all directions. The ore was quarried rather than mined. An Adelaide newspaper informed readers, in May 1862, that in one day two of the company's proprietors had knocked down six tons of ore from a single lode on a hillside.[3] By July 1862 the Northern Mineral Association had mined and dressed seventy tons of high grade ore. The ore was to be transported by bullock drays to Port Augusta and from there shipped to Port Adelaide.[4] However, although satisfactory progress was reported as late as September 1862, this is the last documentary mention of the Northern Mineral Association.[5]

The next reference to the mines of this area was not until October 1866,[6] when it was reported that bismuth had been obtained from the Stanley and Daly mines by the Daly and Stanley Mining Company. This gap in the historical record corresponds well with what Hans Mincham has called the 'Great Drought of 1864, 1865 and 1866', which: '... scorched up all South Australia north of Mount Remarkable, laid waste the Flinders, and caused damage from which the ranges and the adjoining plains probably have never fully recovered.'[7] Inland copper mines, because they were dependent on animal transport, would have been particularly susceptible to drought. No feed and no water meant that teamsters would have been unwilling to risk losing their animals. Mining would have stopped until conditions improved.

The new company was probably a direct reaction to the 'Great Drought'. It would appear that the Daly and Stanley Mining Company had learnt a lesson from the fate of its predecessor: that carting a large volume of ore in the harsh and difficult conditions did not pay off. Bismuth was a much more valuable metal than copper and small loads could achieve a reasonable profit by overcoming the crippling cost of animal transport.

The new mining strategy was perhaps also an indication of the current art of bismuth smelting in South Australia. Pure bismuth was a valuable metal, used as an alloy in manufacturing the bearings of locomotives and carriages. It had long been known that bismuth existed, in combination with copper ore, in several parts of South Australia. However, the difficulty of separating the two metals had previously prevented bismuth from becoming an important article of commerce. Nevertheless, in 1867 it was announced that smelting experiments using bismuth ore from the Stanley mine were proving successful. The smelting was being done by Port Adelaide Smelters, where a Mr Maliphant had obtained several ingots of pure bismuth from a hundredweight (51 kg) of ore.[8] With its bismuth venture bearing fruit, directors of the Daly and Stanley Mining Company were optimistic. They told shareholders that they intended to sink a shaft to a depth of twenty fathoms (37 m) on the main lode, and recommended that: '... should the lode remain permanent at that depth, the next step would be to erect a bismuth furnace, which would cost by Mr Ey's estimate £900.'[9] A year later, in 1868, the optimism had faded. A short report appeared stating that the fourth half-yearly meeting of the Daly and Stanley Mining Company did not take place: '... in consequence of there not being a sufficient number present to form a quorum.'[10] Presumably, the bismuth deposits had proved superficial. Rather than waste money, shareholders were more inclined to bide their time until another company could raise the necessary capital and/or come up with another strategy to exploit what appeared to be extraordinarily rich surface deposits of copper ore.

In 1872 another company was indeed formed: the South Australian and Victorian Copper and Bismuth Mining and Smelting Company. Its solution to gaining a profit was to build its own smelting works. This was an ambitious project and once completed it was the most northerly smelter in South Australia. Unlike the two earlier companies, this one was not South Australian. Of the initial issue of 30,000 shares, only 4800 were taken out in South Australia, the rest belonged to Victorians, mainly from Ballarat.[11]

The new company's strategy consisted of erecting two smelting furnaces and immediate success was presumed for three reasons. First, the immense quantity of rich surface ore available would enable the company to avoid the normally large outlay involved in sinking shafts and buying winding and pumping machinery. Second, because the furnaces could be built cheaply, the company would be able to pay dividends within a short time of smelting beginning. Third, when smelting began, the proceeds from the furnaces would provide for the erection of further furnaces and for the complete development of the mineral sections.[12]

The South Australian and Victorian Company began working the Daly, Stanley, Sir Dominic and Old Noll mines in August 1872. The purpose was to stockpile dressed copper ore ready for the proposed furnaces, and to transport rich ore to Port Augusta.[13] The latter, even though conducted in favourable conditions, did not pay its way and was soon stopped.[14] Therefore, success rested on the completion and testing of the furnaces. Any delay in their completion beyond the promised three months (December 1872) would soon drain away capital reserved for developing the mineral sections. In September 1872, the directors instructed the company's resident general manager, Mr H. C. Gleeson, to leave Melbourne for the mines: '... and immediately proceed to accept tenders already invited for the works, viz: making fire kiln; making and burning 70,000 firebricks; erection of smelting furnaces and chimney stack; carting and cutting 5,000 tons firewood.'[15]

The site chosen for the furnaces was on Bollibollina creek, some ten miles (16 km) from the mines. It was described as having:

> ... abundant firewood, permanent water; sand for mason [*sic*], copper beds, and for furnace beds; good building stone, and floor flagging, all existing in the immediate neighbourhood; whilst a supply of strong limestone is to be had within a distance of 3 miles [4.8 km].[16]

The construction of the smelting works could only begin when suitable fireclay was found for the production of the 70,000 firebricks required for lining furnaces, flues and chimney stacks. Although numerous discoveries of clay 'of the best quality' were reported, success was not forthcoming.

By June1873, six months after the promised completion date, the furnaces were still not completed.[17] By this time, all mining operations had been suspended because all the available capital was needed to finish the smelting works. The shareholders were hit by a series of calls (four in total, each for sixpence per share) and two members of the board dispatched to assess the situation. They found that lack of a suitable fireclay and the scarcity of skilled labour to make the bricks, had retarded the completion of the furnaces. A new tender was issued and accepted.[18] In October 1873, Captain Mansell, the chief of the smelting works, reported that a kiln of bricks, made from clay discovered in the immediate vicinity of the works, had been completed and proved first rate.[19]

The Bolla Bollana smelting works was finally completed in December 1873.[20] Although the desired event had arrived, it was a year too late. Funds once earmarked for obtaining and dressing ore ready for smelting, and developing mines to a point where they could supply a constant flow of suitable ore, had been switched to the smelting works. The company now possessed the means to smelt but had no guaranteed supply of ore. Therefore, it was now faced with developing one of its mines to a point where it could provide a constant supply, before smelting could begin. The Sir Dominic mine was chosen, and a tramway was installed to convey rich ore from the summit to a suitable loading point. It was not until May 1874, however, that the tramway was reported as operational.[21] Meantime, the furnaces had been tested on 16 February 1874 and the resident general manager reported: '... Smelting successful; furnace standing well; copper out; first class quality.'[22]

Despite the final success, time and money had run out for the South Australian and Victorian Company. Operations were suspended and a special meeting, held on 19 November 1874, wound up the company.[23] The South Australian and Victorian Company, at the expense of going into voluntary liquidation, had achieved its main objective and had built a smelting works. It had spent about £27,000 in doing so and had gambled and lost. A host of mining experts had judged the ore deposits as astonishingly rich. The company had assumed that the local environment, although hostile to animal transport, could supply the natural ingredients for the construction of a smelting works. Only the ironwork and a small quantity of Scottish firebricks had been brought in from the outside world.[24]

As there now existed the means to smelt ore and thus a way to reduce the crippling cost of overland transport, it is not surprising that another company followed close on the heels of the South Australian and Victorian Company. The Bollna Bollna Company was formed in

April 1875 and, like its predecessor, was Victorian-based.[25] Friendship may have been one factor which maintained the Ballarat connection with this remote smelting works. In April, Mr Adam Clinton received a report on the Stanley mine from Captain Mansell:

> ... If I had the money, or it was in my power to procure it, I should at once take up a thousand shares for myself. My opinion is that the mine is quite as good as the Moonta mine. I tell you as a friend, that, were the two placed side by side, I would prefer the Stanley. There are thousands of tons of ore yet to come out of the Stanley mine, both copper and bismuth.[26]

In August the new company sent a small gang, including six Chinese, to the Flinders Ranges.[27] Mining began but lodes held in so high regard had no depth. Mining now became expensive with the need for new lodes to be explored and old shafts sunk to greater depths. Although new finds were made, after three months there was still not sufficient ore raised and dressed for smelting. Mining operations were rapidly consuming the available capital and time was once again running out. On 11 October, it was reported that:

> ...twenty-four tons of ore delivered at the smelting works, besides another fifteen tons lying ready dressed at the mines: the whole of which your manager estimates will return 18% of copper and that smelting would commence next Monday, October 18.[28]

The future of the Bollna Bollna Company now hinged on something that the works' original builders and smelting hands had failed to do: successfully operate two permanent furnaces. In November it was reported that when running off the third charge of copper from No. 1 furnace, which showed that the head smelter had underestimated the percentage of ore, the crown had given way, and would have to be rebuilt. It was also reported that the No. 2 furnace was under repair and that smelting would resume in one week.[29] Thus, by December only five tons of copper had been obtained and not quite half of the fifty tons of ore on the site had been processed. The resident manager reported his concern at the constant furnace failure, placing the blame on a combination of local circumstances.[30] The final straw came with the onset of summer, when drought conditions began sending the teamsters south. Soon there were no teams around to convey ore from the mines to the smelting works. Not surprisingly, by February 1876 operations had been suspended and the Bollna Bollna Company had ended its brief smelting career.[31]

The last company to operate the furnaces was formed in 1885. Its plan was to set up the Bolla Bollana smelting works as a central processing plant for a host of small copper mines that operated in the general vicinity of the works. By this time the Great Northern Railway Line had been built, greatly reducing carting distance. The Port Augusta Mining and Smelting Company, as it was called, advertised: ' ... We are now prepared to smelt for the public, or buy any quantity of copper ore delivered at the Works, Bolla Bollana.'[32] Smelting began around April 1885 and the first consignment of five tons reaching Port Augusta was heralded:

> ... as the first copper ever smelted in the Far North; the smelting works were erected some twelve to fourteen years ago by a Melbourne company, but they were abandoned owing to the prohibitive rates of cartage.[33]

There was another consignment to Port Augusta on 6 May. It was then announced that the company had suspended operations.[34]

After 1885 there was no further attempt to operate the furnaces. Indeed, it was the reverse. In 1892, it was reported that a Mr Frost pulled up the beds of the furnaces and got six to eight tons of copper out of them.[35] A further scrapping process happened at the site around 1908. The tall square chimney was demolished, with the bricks and trimmed stone being carted from the site by donkey teams to build a smelting works at Yudnamutana. Here the Union Copper Company were building a water-jacketed blast furnace.[36] The old smelting works at Bolla Bollana, with its reverberatory technology, was finally redundant. As James Happ has pointed out:

> ... all smelting developments in the 1890s to 1920s in South Australia were based on water-jacketed blast furnaces. These furnaces, although much higher in capital cost, promised significantly lower operating costs, more stable and predictable furnace conditions and fewer operators than reverberatory furnaces.[37]

Clearly, by the 1890s, the Bolla Bollana smelting works was seen as obsolete. Viewed as only a site to be stripped of useful material, the technology it employed having become outdated.

ARCHAEOLOGICAL SURVEY

The surface of the site was fully surveyed and all archaeological occurrences were recorded on a plan (Fig. 2). The survey concentrated on identifying, describing and photographing features and layers. For the purpose of the site report, features were identified as any remains which could be readily identified with specific activities and layers were defined as a spread or mound of debris which suggested the possible existence of a feature. Where possible, both features and layers were probed with a metal rod that was capable of reaching a depth of 1.2 m. This was done in order to establish the depth of the deposits and to find and trace the extent of stone walls and floors below the surface. It also helped to decide which archaeological occurrences should be defined as features and which as layers. In addition to features and layers being marked on the site plan, descriptions were entered into a site gazetteer.

In regard to the identification of features, inputs from historical references were given the ultimate say over modern opinion. This decision was based on the assumption that although many of the references were written in order to promote or continue investment in the venture, there was no need to distort the physical make-up of the site. If a resident manager (for example, A.G. English) reported on the progress of the construction of a firebrick kiln at Bolla Bollana and described it as being domed, there is no reason to doubt his words. It was also assumed, on the basis of the historical survey, that the site still retained its historical integrity, that is, that there still would exist a good match between original site usage and the existing physical remains. This assumption was made for three reasons. First, despite three companies being involved with the smelting of ore at Bolla Bollana, their activities were confined to brief spans of time. Second, apart from the modifications made by Captain Mansell to the furnace plans, no further references were ever made to any subsequent additions to the existing plant. Third, the two companies who reworked the furnaces after the original company had dissolved, were concerned with exploiting the existing facilities in times when environmental and/or economic conditions outweighed the effects of distance.

Because of the needs of the brief that had been given to the writer to establish a management plan for the site, existing features were placed into groups, each group being related to a particular activity. In this paper, only Group A will be discussed. This group consists of three features associated with firebrick manufacture. Feature 1 is a small chimney stack of mortared stonework, 1.2 m square. An underground flue leads from this stack to an adjacent drying floor. Feature 6 is a drying floor for bricks. It consists of a tunnel kiln, a slate drying floor, and bricked channel-ways. It has a firebox at one end and the flue and small stack at the other (Fig. 4). The firebox measures 2.3 x 1.7 m and the drying floor 9 x 1.9 m. Feature 5 is a round, domed firebrick kiln. It has a stone wall, a hemispherical roof

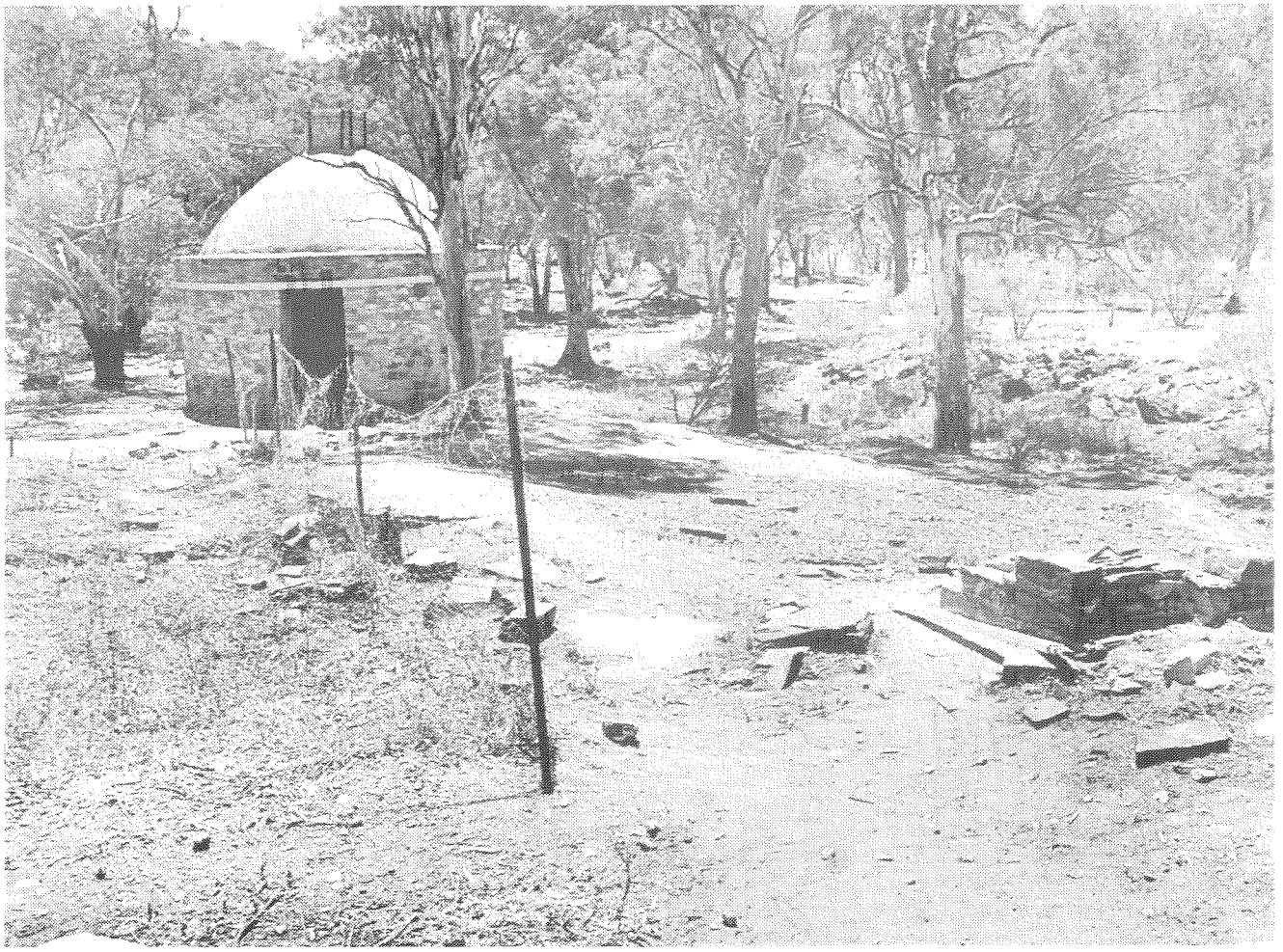

Fig. 4: Domed kiln with brick drying floor and small chimney in foreground.

of 9-inch (23 cm) thick firebrick and one firebox is visible. The walls, which average 2 feet (61 cm) thick, have an inside diameter of 12 feet (3.7 m) and their height above the existing ground level is also 12 feet (Figs 3 & 4).

Historical references

The documentary evidence provides several references of relevance to the problems of interpretation outlined in the Introduction to this paper. Thus we learn that on 7 September 1872 tenders were invited for the making of a kiln and for the making and burning of 70,000 firebricks. Tenders were also invited for cutting and carting 5000 tons of firewood.[38] We are also told that on 31 January 1873 the mason was putting up the brick kiln.[39] On 9 April 1873 we further learn that during that month the drying and making sheds had been provided with a drying floor, with flues and with a fireplace capable of holding about 800 bricks. In addition, the brick kiln had been completed, with the exception of the dome, and had been loaded with 7000 bricks.[40] Finally, a report in April 1876 informs us that:

> Mr Clinton, the late resident manager, after experiencing many drawbacks, finding that debt was accumulating from the continual repairs to the furnaces through material being unequal to the heat, and failing to find any better fire clay in the vicinity, came to the resolution of temporarily suspending operations.[41]

Archaeological evidence

The archaeological survey found no evidence that contradicted the function assigned to Group A features by historical references. Indeed, several aspects of the evidence tended to confirm that function. First, the drying floor, flues and stack, and domed kiln, formed a homogeneous group surrounded by a large deposit of grog (crushed brick mixed with clay) and one large dump of ash. Second, of the two kilns, only the domed structure had the internal dimension to take a firing of 10,000 bricks, the number indicated by a reference of 3 November 1873.[42] Third, given the obvious historical integrity of the group (historically and archaeologically consistent to firebrick manufacture), if the round kiln was used for charcoal manufacture then some evidence would physically exist, and it does not. Fourth, probing in the vicinity of the round kiln showed that the original floor or working level lies an average of 1 m below the existing ground level.

CONCLUSION

The historical record showed that two main features were associated with the manufacture of firebricks: a drying floor connected to its own chimney stack, and a round, domed kiln for firing the bricks. An archaeological survey showed that these two structures still exist today and that components of the brick-making process lay scattered in close proximity to these remains. Neither historical record nor archaeological survey revealed any evidence to suggest that the domed structure was used as a charcoal kiln. The absence of multiple firing ports and the presence of exposed ironwork in the kiln itself,

plus the imperfections of the firebricks which remain on the site, suggest that, while the kiln *did* work, the relatively low temperatures achievable, together with the poor quality of clay used, probably aided in the downfall of the Bolla Bollana copper smelting works. The historical record clearly confirms this, with its report of the works' closure in April 1876.[43]

ACKNOWLEDGEMENTS

I wish to thank Dr Reg C. Sprigg of the Arkaroola Wildlife Sanctuary; Dr Howard K. Worner; Jack Connell; Justin McCarthy; James Happ; Norton Jackson; Greg Drew, Department of Mines and Energy, S.A.; Ian May, S.A. National Parks and Wildlife Service; David Ellson; Tony Jenner; and Ron Wurst.

NOTES

1. Bannear 1987.
2. Unsourced newspaper report 17/5/1862, S.A. Department of Mines and Energy records.
3. ibid.
4. Unsourced newspaper report 10/8/1872, op. cit.
5. Unsourced newspaper report 20/9/1862, op. cit.
6. Unsourced newspaper report 6/10/1866, op. cit.
7. Mincham 1964:104.
8. Supplement to the *Chronicle*, Adelaide, 3/9/1867.
9. ibid.
10. Unsourced newspaper report 24/2/1868, op. cit.
11. South Australian and Victorian Copper and Bismuth Mining and Smelting Company Ltd 1872. Memorandum and Articles of Association.
12. *B.C.* 8/8/1872.
13. ibid.
14. South Australian and Victorian Copper and Bismuth Mining and Smelting Company Ltd 23/2/1873. Half-yearly statement.
15. *B.C.* 2/10/1872.
16. *B.C.* 17/12/1872.
17. *B.C.* 2/10/1872.
18. *B.C.* 21/7/1873.
19. *B.C.* 21/10/1873.
20. South Australian and Victorian Copper and Bismuth Mining and Smelting Company Ltd 27/2/1874. Report of half-yearly meeting.
21. ibid.
22. *B.C.* 16/2/1874.
23. *B.C.* 20/11/1874.
24. *B.C.* 30/1/1873.
25. Bollna Bollna South Australian Mining and Smelting Company 1875. Memorandum and Articles of Association.
26. *B.C.* 9/4/1875.
27. *B.C.* 27/10/1875.
28. ibid.
29. *B.C.* 1/12/1875.
30. *B.C.* 20/4/1876.
31. ibid.
32. *P.A.D.* 4/10/1885.
33. *P.A.D.* 10/4/1885.
34. Sprigg 1987:192.
35. Mincham 1964:135.
36. Personal communication with James Happ, Senior Metallurgist, Advanced Mineral Chemistry, C.R.A.
37. *B.C.* 9/4/1873.
38. *B.C.* 7/9/1872.
39. *B.C.* 31/1/1873.
40. *B.C.* 9/4/1873.
41. *B.C.* 20/4/1876.
42. *B.C.* 3/11/1873.
43. *B.C.* 20/4/1876.

BIBLIOGRAPHY

Published sources

MINCHAM, H. 1964. *The story of the Flinders Ranges,* Rigby, Adelaide.

SPRIGG, R.C. 1987. *Arkaroola-Mount Painter in the Northern Flinders Ranges, S.A.: The last billion years.*

Unpublished sources

BANNEAR, D.P. 1987. Archaeological survey of the Bolla Bollana smelting works. Report prepared for South Australian National Parks and Wildlife Service.

Newspapers

Ballarat Courier (B.C.)

Chronicle, Adelaide.

Port Augusta Dispatch (P.A.D.)