The Early Copper Mining Industry in Central Queensland, 1863-1879 - History and Place

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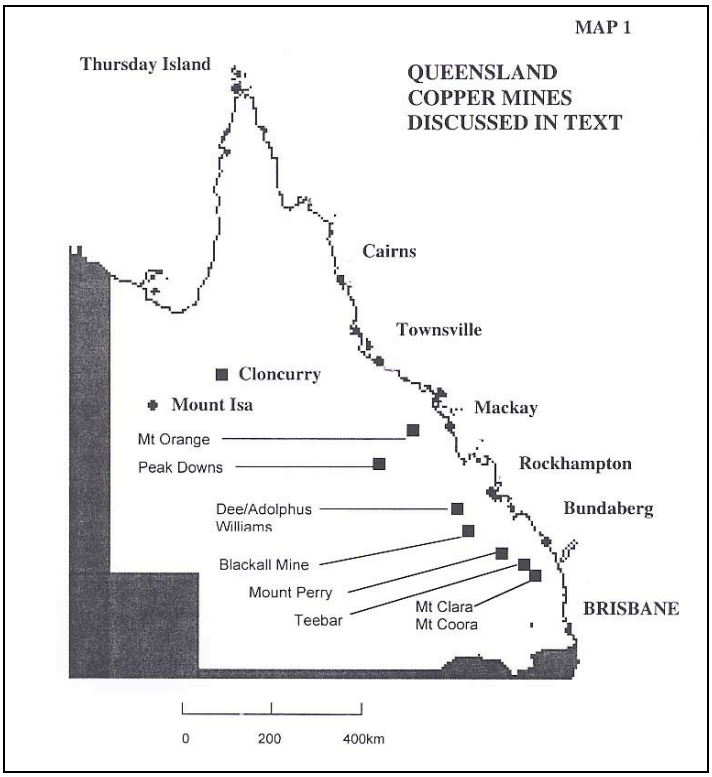
Copper was first commercially mined in Australia at Kapunda, South Australia, in 1844, followed by the finds at Burra in 1845.[1] Smelting of copper ore commenced at Callington in SA in 1848 at a works set up by the Thomas family, smeltermen who had learned their trade in Wales and then worked in Chile.[2] The experience gained in mining and smelting the South Australian copper, and the skills imported for that task, became the basis for much of the copper mining activities in the rest of Australia, including Queensland, throughout the remainder of the 19th century.

Copper mining and smelting commenced in Queensland in 1863, and over the next two decades a number of copper mining ventures were established (see Map 1).



What makes the early Queensland copper mines especially interesting is that a surprising amount of evidence, particularly of the smelters, survives on the ground. The history and the surviving evidence of copper mining sites in Central Queensland constitutes a major resource in the study of this early phase of Australian mining. The

sites described below were recorded and assessed as part of a survey of heritage mining places in southern and central Queensland.[3]

The paper outlines the history and description of the copper mines studied, then presents a brief overview of copper technology of the period in Queensland based on this information, discussing features that warrant further archaeological research.

History and mining remains— Peak Downs Copper Mine

The Peak Downs Copper Mine, which commenced operations in 1863 near Clermont in Central Queensland, was the first large-scale successful copper mine outside South Australia, and the first rich mine in tropical Australia.[4] While copper mining had taken place at a number of mines in central-western New South Wales from the mid-1840s,[5] and in Western Australia from about 1853,[6] these ventures were mostly of limited success and on a smaller scale than at Peak Downs. The Peak Downs Copper Mining Company was formed in Sydney by T.S. Mort, J.A. Manton and T.W. Smart on 31 December 1862. Manton was the first manager, and very rich ore was raised in first 3 months (40 per cent assay). Smelters (reverberatory) were erected in 1865, but were unsuccessful until experienced smelter hands were brought from South Australia. An excellent description of the operation of the five reverberatory smelters in operation by July 1865 was published in the *Peak Downs Telegram*, 8 July 1865. This article refers to the failure of the bottoms of the smelters (as the smelter bases were referred to at the time) due to poor quality sand being used to form the bottoms, so contributing to the escape of copper matte, later to be recovered by treating (and destroying) the furnace bases. Smelting was placed in the hands of J.P. Christoe in 1867 who was succeeded by Captain Leyshon Jones, and then in 1870 by Mauris Thomas, one of the brothers responsible for the first smelters in SA.[7]

T.S. Mort withdrew from the company in 1866. The company struggled on, its prospects improving with the rise in copper prices in the late 1860s. In the 1872-3 copper boom, the company imported 200 Cornish copper miners and their families in order to increase operations. However, the company could not make the mine and smelter pay, and the mine was sold off in 1877.[8] One of the problems was isolation, the copper ingots having to be transported over 300km to the coast at Broadsound by dray. Another was the heavy demand for firewood for the smelters, which led to escalating costs and delays in bringing timber from ever-increasing distances.[9]

Mining, however, seems to have carried on until a lease held by Christoe (previously one of the smelting captains) was terminated in 1883.[10] Others worked parts of the area, for example Folster and party treated old tailings through a cyanide plant in 1895, to recover gold.[11]

In 1906-7 the Peak Downs Copper Company built a new smelter and stack, furnaces, and dams and de-watered the mine (presumably the Main or Engine shaft), but the company was overcapitalised and had ceased operation in 1907. In that year they smelted 2,460 tons of ore for 72 tons of copper.[12] In 1916-17 machinery was overhauled in anticipation of the re-treatment of the slag heaps, but this never eventuated, though the slag heaps were tested. G.A. Johnston retrieved 12.82 tons of material from the old smelter bases, and had it treated in Mount Morgan, returning 1.27 tons of copper, and Risien and party operated for a period on tribute, scavenging the old smelter bases and sending the matte to Port Kembla for smelting.[13]

The work force for the mines and smelters lived in the nearby town of Copperfield, or in the larger town of Clermont, six kilometres to the northeast. Copperfield is now abandoned, but Clermont, the oldest inland settlement in tropical Queensland, is a regional centre now bolstered by the nearby Blair Athol coalfield.

The mining remains surviving today consist of a very large mine shaft (the Main or Engine shaft), with ruined stone engine house, extensive mullock tips, machinery footings and a stonework floor. Other mine shafts on the site are shown in a plan in a 1942 report.[14] These appear to have been the original shafts, but seem to have been re-worked as a standing brick chimney, approximately 27.5 metres tall, built in 1906-7, is located near them. Adjacent to this chimney is a smelter base clearly of later design and almost certainly the foundations of a water-jacket furnace. A relatively small (23m x 19m) slag tip has conical slag forms below the tip face, while the upper portion is ‘pavement’ slag, laid in squares while liquid.

The 1860-70s smelters are located on both sides of the modern access road, which appears to have been built through the centre of one wing of the ‘T’ shaped smelter complex. This smelter group once had 22 chimneys, none of which survive, but a collapsed chimney complete with reinforcing bands can be seen on the northern side of the site. The orientation of the old smelter and its approximate relationship to the slag heaps can be traced on the ground. The 1942 plan[15] shows the area of the old smelters to have been 'brick rubble' even by that date, and it is likely that the smelters

and remaining chimneys were razed when the smelter bottoms were salvaged in the 1916-18 period.

A very large slagheap is 30m to the south of the access road, measuring 150m east-west and 40m north-south, and approximately 7m deep at its outer edge. The slag in this heap is in the form of broken slag and 100cm x 50cm loaf shaped ingots, formed by casting the slag in sand moulds, and quite different from the conical forms created by later slag buckets. Pits have been dug into the top of this slagheap, presumably for sampling for re-processing in 1916 (or later). The smelter furnaces associated with this slagheap appear to have been largely bulldozed into a neat row of brick rubble and smelter iron-ware parallel to the new access road. The extent to which in-situ archaeological remains of the smelters might survive closer to the slagheap was difficult to ascertain due to heavy undergrowth over the area.

On the northern side of the access road is a much more disturbed area of slag, part of which has been bulldozed into a new pile, and tracks have been bulldozed through the area to access other mining activities (mainly for gold) surrounding the smelters. Near this northern slagheap is an area of brick rubble which appears to be the in-situ remains of part of one wing of the original smelter complex. This area covers approximately 60m x 17m, and what appear to be bases of the original smelter walls can be made out among the rubble. It is in this area that the clear remains of a fallen chimney can be seen.

History and mining remains— Mount Perry Mine

Mount Perry Mine was developed after copper was discovered at Mount Perry in 1862, and confirmed in 1869 by local landholder, Henry Dingle. Dingle, Connolly and Walker took up the Mineral Freehold in 1870, and a copper rush followed, The partners sold out to Ebenezer Vickery the same year. Vickery formed the Mount Perry Company and commissioned A.S.R. Osborne to report on the mines and establish smelters. Osborne employed Peak Downs miners and smeltermen and imported South Australian miners who arrived in 1871. The first reverberatory smelter was erected in 1871 and blown-in in 1872. Israel Bennett took over as mine manager when Osborne left in 1875, and the smelter was closed down in 1877 with falling copper prices (a problem commencing in 1873). There was then a low level of mining activity until prices revived in 1884.[16]

The Mine was sold in 1887 and became the London-based 'Mount Perry Copper Mining and Reid's Creek Gold Mining and Smelting Company', and smelting resumed until falling prices again led to their closure in 1891. The company again changed hands in 1898 and became the Queensland Copper Company, with French directors. The mining and smelting processes were improved under the new management, with water-jacket furnaces which had a daily capacity of 60-80 tons, replacing the reverberatory furnaces for primary smelting in 1901. Because of the highly siliceous ore, large quantities of flux were needed, and pyritic smelting was used (burning the sulphides in the ore as a fuel source), though with what completeness and success is not clear. The regulus was then roasted in a reverberatory furnace.

The company was reconstructed in 1910 becoming the New Queensland Copper Company, which operated until 1914 when it was liquidated and the smelter closed. Tributers operated until 1917. In the period 1873-1884 the Mount Perry Company produced 4,830 tons of refined copper, and from 1887-1914 it produced 23,782 tonnes of copper, 27,749 ounces of gold, and 793,888 ounces of silver. Mining and processing of the slag dump recommenced in 1971.

The primary mining remains at the site consist of a very large slagheap (120m x 80m), and a few very ruinous remains of the smelter. The slagheap demonstrates two different slag forms, the lower section of the heap is broken slag and many conical forms created by slag solidifying in the slag buckets used to transport it from the smelter. The upper 50cm of the heap is made up of slag poured directly into formwork squares approximately one metre square. This creates a checkerboard pattern of flat level slag pavement across the slagheap, laid to enable easy access to the tipping edge of the dump.

The smelter ruins show some scant evidence interpreted as being the footings of a reverberatory furnace and a base for water-jacket furnaces. Bricks on the site bear frog inscriptions indicating makers as 'Campbells, Brisbane', and 'Smellie and Co, Machinery Merchants, Brisbane'.

The workforce for the mine and smelter was housed in an adjacent settlement that abuts the mining leases, that became Mt Perry township. Largely created by the company, the township infrastructure benefited from the periods of good copper production, and is now a service centre for the surrounding pastoral district.

History and mining remains - small 1870s mines

A series of small copper mines and smelters were established during the 1870s, years of high international copper prices. Figure 1 plots the fluctuations in copper prices against the periods of operation of copper mines in Queensland up to 1940. The peak stimulus was experienced in 1863, 1870, 1906-7, and during the 1914-18 war. The Blackall, Flanagan's, Mount Clara and Mt Coora, Teebar, Dee (Adolphus Williams) and Mount Orange Copper Mines, all in Central Queensland, were operating in this period, but most were closed down in the same decade. These smaller mines are described below.

The Blackall Mine and Flanagan's smelter.

Copper was discovered on 'Kroombit' run, east of Biloela, in 1868 by Robert Ridler, lessee of the adjacent 'Cania' and 'Yarrol' runs. The initial discovery was at the Blackall Mine site, and preliminary mining took place there in 1869. Thomas Perkins, brewer of Toowoomba took up the Blackall lease in September 1870 and steadily developed it until August 1871. In September 1871, 150 tons of ore was reported to have been raised. Perkins was having difficulties by the end of 1871, largely due to the need to cart unconcentrated ore to Gladstone for shipment to smelters in the NSW, the £7.10s per ton cartage making the project non-viable. The mine was partly flooded in early 1872, and the same rains made the roads unpassable for the shipment of ore.[17]

In June 1872, Perkins successfully had a consignment smelted in Newcastle, and commenced construction of furnaces on the site. These were not completed until late 1874. Meanwhile, Perkins had sold the mine in 1872 to Ebenezer Vickery of Sydney (owner of the Mount Perry Mine), Samuel Osborne of Maryborough, and Abraham Rawlings Shoreland Osborne, mining engineer at the Mt Perry Mine. At this time the shafts were down 70 feet and 20 feet (21.3m and 6m), with 60-70 feet (18.2m – 21.3m) worked on the underlie. In September 1872, the mine was registered to the Great Blackall Copper Company Ltd., with Vickery as Chairman. Despite a collapse in copper prices during that year, the company continued operation, importing 30 miners in October 1872, to work under Captain Westley. The mines experienced flooding problems during two periods of heavy rain in 1873, and water-raising machinery was put in place to cope. The copper market collapsed again in May 1873, and operations were severely cut back. By the end of 1873 one shaft was down 224 feet (68.3m), with drives at the 90 feet (27.4m) and 150 feet (45.7m) levels, and ore was being stockpiled awaiting better markets

The mine was finally closed by August 1874, and the plant reported to have been moved to the Peak Downs smelters at Copperfield. The smelter construction was proceeded with to treat the ore in the stockpile. Two reverberatory furnaces were built, but never fired (and possibly never completed), and the bricks were eventually removed for the building of bake ovens in Monto in the 1920s.

The surviving physical remains of one smelter consist of a rectangular footing about 6m long and 4.7m wide. The stone base is cut into the slope of the ridge, and stands 50cm high at the highest point. The other features are covered by brick rubble. A trench about 50cm wide lies along the centre of the kiln, but its original form is hidden by rubble. The second kiln base is 7.7m to the north, and is much less distinct than the first. It consists of two mounds of rubble, each about 2m wide and 3.5m long, aligned parallel with the first smelter, and separated by a shallow trench about 75cm wide. The trenches are reported by local informants to have shown signs of arched brick. The remains are consistent with them being the bases of reverberatory furnaces, with sub-floor flues. There is no sign of chimney remains, such bricks perhaps having been removed to Monto in the 1920s, or perhaps they were never built.

An adit, identified as part of Vickery's Shaft by the locals, is about 50m from the smelter site. A shaft above this adit has been bulldozed in, and the adit is partly obscured by bulldozed earth. A second shaft, identified as Lizzies Shaft, has been filled in and a large mullock tip spills down to the creek to the west.

A township reserve was established in 1872 and by 1873 the town had a blacksmith, three butchers, five carriers, two chemists, a cordial manufacturer, dairyman, a boarding house and five innkeepers, a saddler and harness maker, a 'Medical Hall', seven storekeepers, as well as a post office.[18] The township remains lie along a ridge to the south of the mines, and a number of areas of brick rubble and other signs of disturbance can be seen. However, no recognisable structural remains exist, and the site has been worked over by bottle collectors and metal detectors many times.

Flanagan's smelter at the Blackall Mine.

Francis Flanagan had taken up leases adjacent to the Blackall Mine in September 1870, and steadily developed a mine up until August 1871, sinking two shafts and announcing the deposit to be 'rich and extensive'. It was reported there had been 350 tons of ore raised and 70 cords of wood stockpiled for for smelting.[19] A reverberatory furnace ('Speedwell' type) capable of producing three tons of copper every 24 hours was built

in 1871 by experienced furnace builder Mr C. Betteridge, but the furnace failed three times due to inferior bricks made on-site in an updraft kiln. Suitable fire clay was then sought and found on Kariboe Creek, seven miles downstream of Blackall mine. There is no mention of Flanagan or the smelter after the end of 1872, and it appears that the mine closed with the fall in world copper prices in August 1872.

The furnace is said to have been blown up during World War I to gain access to copper matte presumed to be still in the smelter, however, this is not evident in the surviving remains. Attempts were made to re-work the site in the 1930s, but with little success, and recent investigations have failed to demonstrate large reserves.

The reverberatory smelter remains stand in places to a height of 150cm, to the level of the spring of the collapsed roof arch. Sufficient sections survive to full height to indicate the slope of the smelter roof from the furnace end (130cm above the present floor) towards the chimney end (65cm above present floor). Other portions have collapsed, but the form of the smelter is easily discerned. The oval smelting chamber was approximately 3.8m wide and 5m long, with the standard external firebox. The chimney has collapsed, but was located approximately 6m south of the western end of the smelter, and brick rubble from the fallen chimney extends 11m from the base.

Slag extends in four lobes radiating from the smelter. The amount of slag is not great, suggesting relatively little smelting activity. The slag consists of loaf shaped pieces about 100cm x 75cm, having been solidified in sand moulds. The slag contains small masses of copper, suggesting incomplete smelting, or poor slag tapping skills. Near the southernmost slag heap is a flat area which appears from the fragmented stone around it to have been used as an ore-dressing area, where the ore was reduced to appropriate size for smelting, and where the richer ore was hand picked.

The collapsed brick kiln, built of diorite boulders and stones, stands near the smelter. Several pits and small mullock piles show the locations of the filled-in mine shafts located 50m to the east of the brick kiln. To the south of the smelter is an area with fragments of brick, disturbed ground and artefact scatters, which was the living area for those working at the mine and smelter.

The Dee Copper Mine

The Dee Copper Mine is located in the Mount Morgan mineral field. The copper deposit was discovered in 1872 by William McKinlay, the lease being handed on to an

American named Hamilton for £500. In turn, he sold it on to the Scottish Australian Mining Company for £20,000, at which time the site was developed by A.A. Morehead from profits made at the Lambton Colliery near Newcastle. John Henry Holman was in charge of mining at the site until it closed down due to falling copper prices. The first six tons of copper reached Rockhampton in December 1876, but the mine closed soon after. The Adolphus William smelter (Figures 2 and 3) was constructed to service the mine in this period (probably in 1874), as was a government road from the railhead at Westwood.[20] The small township of Dee was established on flat land about 1km from the smelter site to house the workforce. The size of the settlement is not clear, but surviving remains are limited to the stone and concrete remnants of four houses, while other houses are likely to have been tent-huts. The settlement site is now a cattle pasture.

The area was again prospected by Mount Morgan Company in 1925, but did not proceed due to liquidation. Re-mining occurred during WWII, with some parcels being sent off for smelting at Chillagoe. Prospecting by test cuts, costeans and shallow shafts was carried out during the 1960s, and possibly after that date. The Smelter does not seem to have figured in any of these re-mining ventures.

The shafts at the Dee Copper Mine are collapsed and have been filled, except for the Yellow Ore shaft, and a few tunnels which remain partly open. Costeans and test cuts are evident over much of the area. The ore hand-picking floor is an area of about 50m radius with mixed bedrock and ore rubble covering it. Hand picking of the ore was undertaken to reduce the amount of country rock which had to be smelted along with the ore.

The smelter consists of two collapsed reverberatory furnaces, with internal ovoid plans circa 6m x 4.5m, separate fire boxes 2.2m x 1.5m, the original internal height of furnaces being estimated at 1.5m plus. The furnaces were originally connected to two chimneys, only one of which still stands, the location of the other being marked by a collapsed rubble pile. The standing chimney has a 1.8m square base, and is estimated to be 16 metres high. The tie plates at base of chimney are stamped ‘AWCM’ (Adolphus William Copper Mine). The firebricks are stamped ‘CUMBERNAULD’. Much iron work associated with the smelter structure is present on the site. The smelter is in relatively good condition. The roof and some wall sections of both furnaces have collapsed, though a small section of the roof arch survives in one furnace. The form of

the furnaces can be clearly seen in the remaining sections. While fig and other tree growth inside and adjacent to the furnaces is a severe threat to their continued survival, this may have helped protect them from disturbance by stock. The surviving chimney is stable and in good condition. The slagheap extends over an area of about 28 x 16 metres. Several posts both standing and fallen indicate a former structure extending to the south of the smelters and around the chimneys. The smelter site is cut into the slope, and extends onto a bench, which is supported by a stone revetment wall to the west.

Figure 2: *Adolphus William Copper Smelter site*

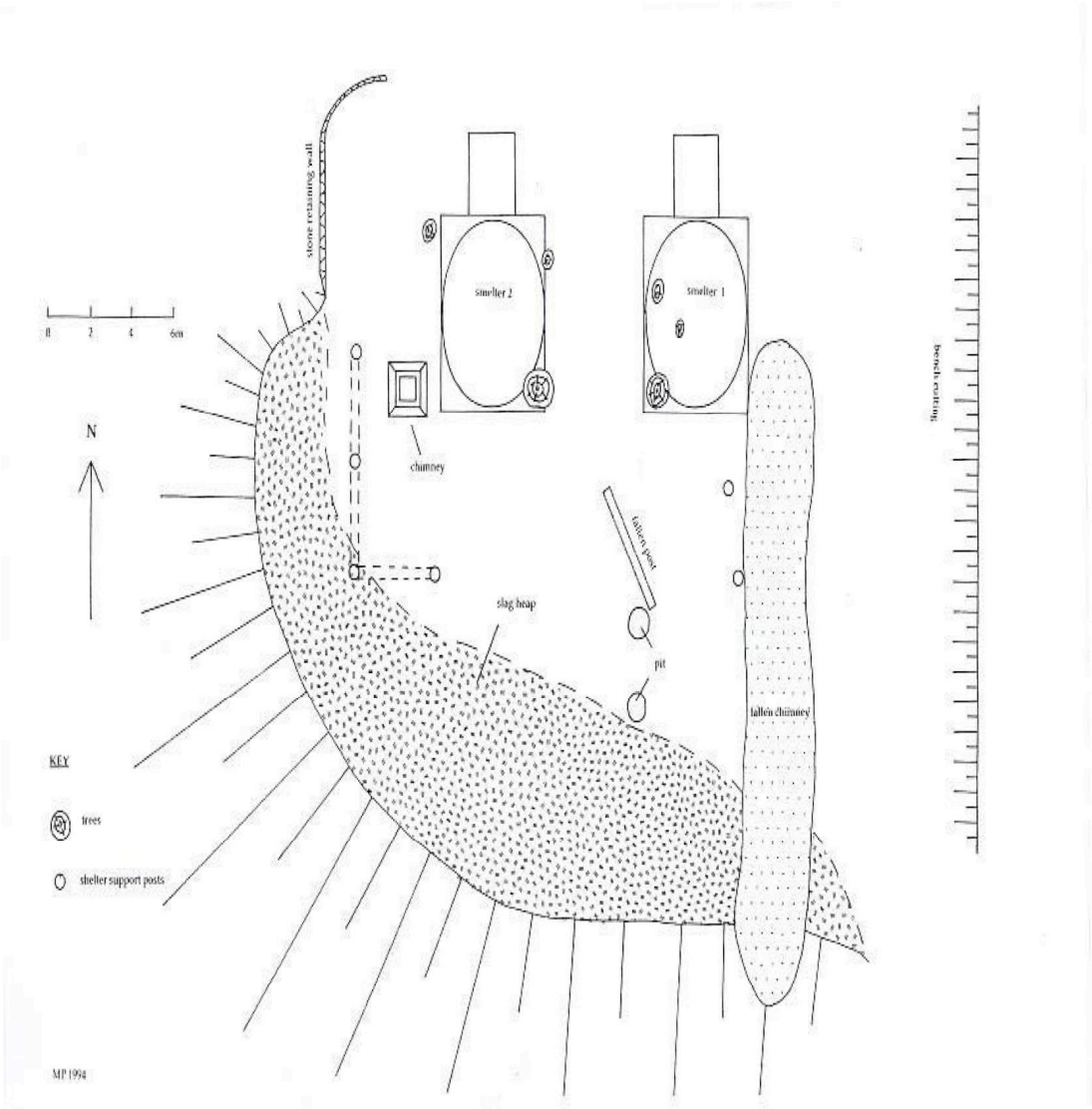
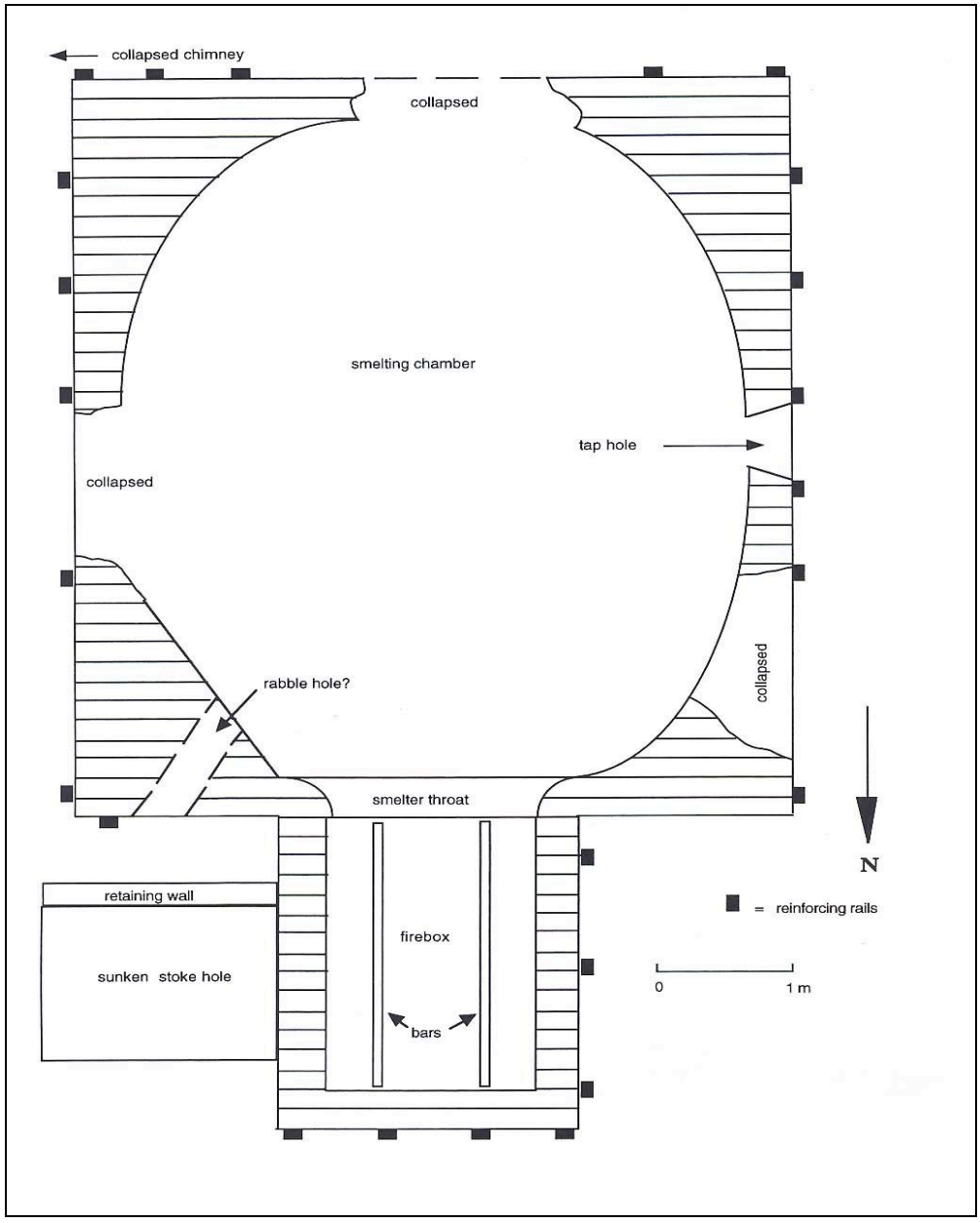


Figure 3: *Adolphus William Copper Smelter (No. 1)*



Mount Clara and Mount Coora mines and smelters

Mining probably commenced in the Mount Clara - Mount Coora area, near Kilkivan, in 1872. The Mount Clara Smelter was built in 1873 (Figure 4), but only operated until 1875, when it was closed. Following the purchase of the Mount Clara holdings by the Mount Coora Copper Mining Company in 1874, the Mount Clara copper ore was subsequently carted to the Mount Coora smelter for treatment. This may have been due to the fact that Mount Clara Mine was two miles from its own smelter, and had to be

carted a considerable distance anyway. Later, Mount Coora also had an ore-roasting furnace built.[21] The eventual closure of the mines was attributed by Rands (in 1886) to the high cost of fuel for the smelters.[22]

The Mount Clara smelter remains, which were repaired by Kilkivan Shire Council with a National Estate Grant in 1978, have been cleared of rubble, making visible the ground around the standing remains. The reverberatory smelter is made of brick and stone, the walls standing to a height of 1.7m at the firebox end, and to 1.2m height at the opposite end of the smelter. These heights seem to correlate with the spring-level of the now-collapsed arched roof. The internal ovoid form of the smelter can be readily seen. The firebox is particularly well preserved, and has a deep below ground access. Iron 'staples' are inserted into the base plinth of the smelter at regular intervals, and seem to be the support points for the rail reinforcing bars which would have originally bound the smelter. Traces of wooden rails used to transport fuel to the firebox can be seen.

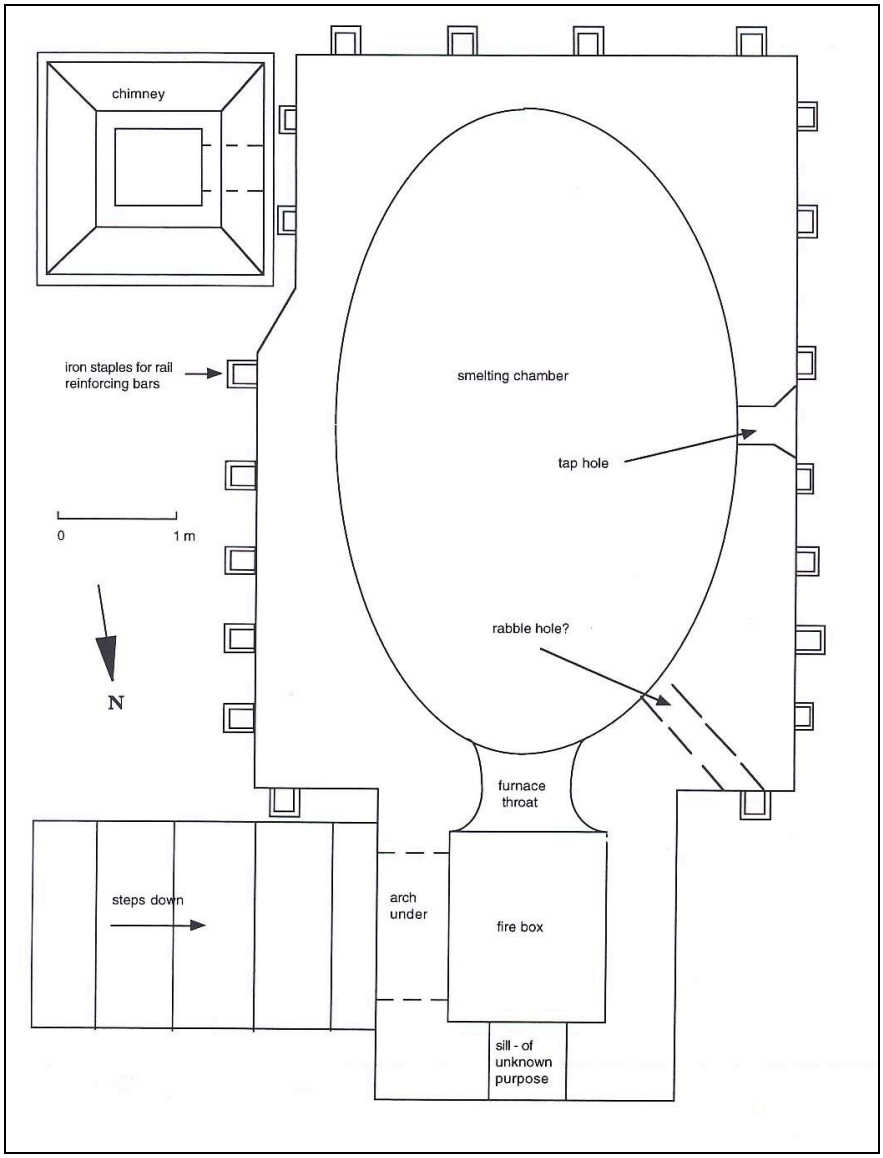
The c.13.8m high stone chimney stands close to the smelter, and the entry point of the smelter flue, now-collapsed, can be clearly seen at about 1.8m up the western face of the chimney. The slagheap is small (22 x 11m), and contains large, very square, sand-mould slag blocks, each about 80 x 40 x 15cm.

Mount Coora Smelter.

The Mt Coora smelter site consists of a standing brick chimney, approximately 13.5m tall and 1.84m square at the base, with a flue entry arch 1.3m above the ground on the north face, another arch 3.2m up the west face, and a third 8m up the east face. Iron bars run up each corner of the stack, stapled to the brick joints. A small amount of brick rubble stretches out from the northern side of the chimney stack towards the west for seven metres, suggesting the location for the now totally demolished smelter. Bricks about the site bear the impressed labels '(...)URBRIDGE' (Sturbridge?), and 'M.T. & O C^{O}.'. Slag and brick rubble is scattered in several locations over the level bench on which the smelter sits. The main slag tip is at the edge of the bench, about 40m north of the smelter site, but it is not clear due to the undergrowth and soil cover, how much of the bench is in fact composed of slag. Twenty-metres west of north from the chimney is a large mound of rubble, which contains fire-bricks and iron rail reinforcing bars. This mound, which extends over about 12m, is likely to be the roasting furnace referred to in

the literature. South of the chimney is a bench on the slope above the smelter site, which may be an ore dressing and storage site.

Figure 4: *Mount Clara Smelter*



The main mine area has three open cuts, at least four shafts and other signs of working. The re-mining in the 1940s, a drilling program in 1968 and a leaching project in 1972 has further disturbed and confused the remains.[23]

Teebar Copper Mine

Mineral Freeholds 1104 and 668 were granted to the Teebar Copper Mining Company Ltd in 1873, and in 1936 it was reported that: 'The ruins of the old smelter and the estimated 100 tons of slag bear evidence to the early period of production'.[24] Rands

gave the location of the smelter and lode as being on the north side of Munna Creek one-and-a-half miles west of Clifton Station. A shaft was put into the lode in 1890, but not worked due to falling copper prices.[25] The Teebar mine was not recorded during the survey project, and its present state is unknown.

Mount Orange Smelter

The Mount Orange Smelter, east of Moranbah, is reported to have been built in 1879 by the original Mount Orange Copper Company, to smelt the ore raised from Keeley's Selection, one of the mines on Mount Orange.[26] The firebricks came from Peak Downs, while the common bricks were made locally. Ball reports that the smelter was fired up again in 1908 after a 'long period of idleness', which was of unspecified duration.

Ball describes the smelter, and says that the labour force to operate it consisted of six smelters, a matte breaker, three woodcutters, a loader and a carter. The smelting process was 'the old Swansea method', necessitating two smeltings, the first giving matte at 40-50 per cent copper, and the second matte with concentrations of 75 per cent copper, together with 35oz per ton of silver, and 2.2dwt per ton of gold. The smelter was capable of processing nine tons of ore per day, but the mines could not maintain that rate of supply. The roof of the smelter collapsed in 1910, and it seems unlikely that it was restored to use.

The Mount Orange mine remains consist of a number of shafts and tunnels and a cutting stoped to the surface, in an area extensively re-worked till recent times, leaving little physical evidence or landscape relating to earlier periods. All that can be seen clearly relating to the earlier mining period is a timber skip of the type used to carry mine props, and some tramway rails made in Birkenhead in 1906.

The Mount Orange reverberatory smelter itself was described by Ball (1910) as having a hearth 13ft (3.96m) x 37ft (11.27m), a fire box 9ft 6inches (2.89m) x 4ft 6inches (1.37m), and a stack 45ft (13.71m) high.[27]

It is difficult to match the surviving and admittedly very fragmentary smelter remains to these dimensions; the on-the-ground evidence seems to suggest a smelter about 7.55m x 4.75m. The standing brick chimneystack is of the height given by Ball. The photographs given in Ball are also difficult to match to the stated dimensions, the smelter length appearing to be a little over half the height of the stack, or a little over seven metres, close to the size suggested by the ground evidence. The ground evidence

size is much closer to the dimensions of the other 1870s smelters recorded during the survey, all of which are around 4m x 6m give or take 50cm.

It is clear that much brick from the collapsed smelter has been removed from the site, as there is relatively little rubble left in situ. The details of the smelter construction, other than its extreme dimensions, cannot be seen at ground level, and without the historical description, it could only be assumed to have been a reverberatory type. The fire bricks at the site are made by 'Campbell'. Several wrought iron stirrups are on the ground, similar to the stirrups present at Mt Clara that were used to fix the bases of rail support bars on the sides of the smelter. An iron bar with stirrup at each end is 2.6m long, possibly being one of the tie bars from the smelter firebox.

A 3.75m square brick floor is located 10m south of the stack, and may have been an ore-dressing area. The slagheap is quite extensive, covering an area of the creek bank about 21m long, and with a tip-face about 6m high above the creek level. There are several brick piles to the north of the smelter, possibly the remains of fireplaces. What appear to be ore piles are located about 80m to the north. The slag is in sand-moulded loaf forms.

Subsequent copper mining in Queensland

While this paper concentrates on the copper mines and smelters built prior to 1880, in order to place these sites in their overall historical context it is necessary to briefly mention the subsequent history of copper mining in the state.

In the 1880s copper mines were established at Cloncurry, where what may have been the state's first water-jacket smelter furnace was blown-in in 1885.[28] A second copper boom occurred in the Central and Southern region in the period 1897 - 1907, with mines and smelters established at places such as Sundown, Glassford Creek, Mount Hector, Mount Chalmers, Mount Cannindah, and most importantly, at Mount Morgan, where the copper was at last being exploited from what had previously been a gold mine. A number of these mines, such as Mt Perry and Mt Chalmers, were taken over by overseas capital in this period.[29] At the same time, smelters were established in the Northern region, notably at Mt Garnet, Chillagoe, Mount Molloy and in the Mount Isa District.[30]

Because copper was subject to major fluctuations in international metal prices, copper mining was prone to a market-driven boom and bust cycle to which goldmines, relying on a fixed gold value, were not subject (see Figure 1 for copper fluctuations).

The boom periods for copper mining in Queensland correspond to similar developments in other states, with only the top producers being able to break (to some extent) the dependence on high prices to ensure survival. In the Central and Southern Regions, Mount Morgan was the pre-eminent copper producer, commencing smelting in 1903 and remaining the State's leading producer for 20 years. By far the biggest copper producer in Australia's history, Mount Isa, did not commence smelting until 1943.

Copper technology in Queensland

When copper smelting commenced in Queensland, at Peak Downs in 1865, the technology used was the Welsh reverberatory furnace, brought by the miners and smeltermen imported to Queensland from the South Australian mines, where the reverberatory smelter had become established as the norm. This technology sustained the Queensland copper industry until the 1890s, when the water-jacket blast furnace technology developed in the USA began to become more common. For most of this period it was Central Queensland that was the predominant copper producing area of the State, and it is here that by far the greatest number of reverberatory furnace remains are concentrated. The numerous copper smelters in Northern Queensland, on the other hand, are predominantly of the waterjacket type, and at the time of writing only one intact example of this type had been located.

Bell and McCarthy have summarised the operation of the reverberatory furnace:[31]

> A reverberatory furnace is essentially a masonry hearth with a roof over it. Copper ore which has been finely crushed and concentrated is mixed with flux [additives which assist in the chemical reactions taking place in the ore, and lower the melting point of the ore] and spread on the hearth, and an intense fire is lit in a firebox at one end of the furnace so that the flame passes over the charge on its way to the flue. The charge is heated by a combination of direct radiation from the flame, heat reflected (or reverberated) from the vaulted roof, and radiation from heat stored in the masonry. There is relatively little opportunity for chemical reaction between the charge and the combustion gases, and reactions in a reverberatory furnace are principally those that occur between ore and flux, hence the need for both of these substances to be finely divided and well mixed. In nineteenth century practice, the furnace was fired for up to twenty-four hours, then the fire was drawn and the matte and slag were tapped from separate openings at different levels on the side of the furnace. After any necessary repairs were made to the furnace, a new charge was shovelled in and the cycle recommenced.

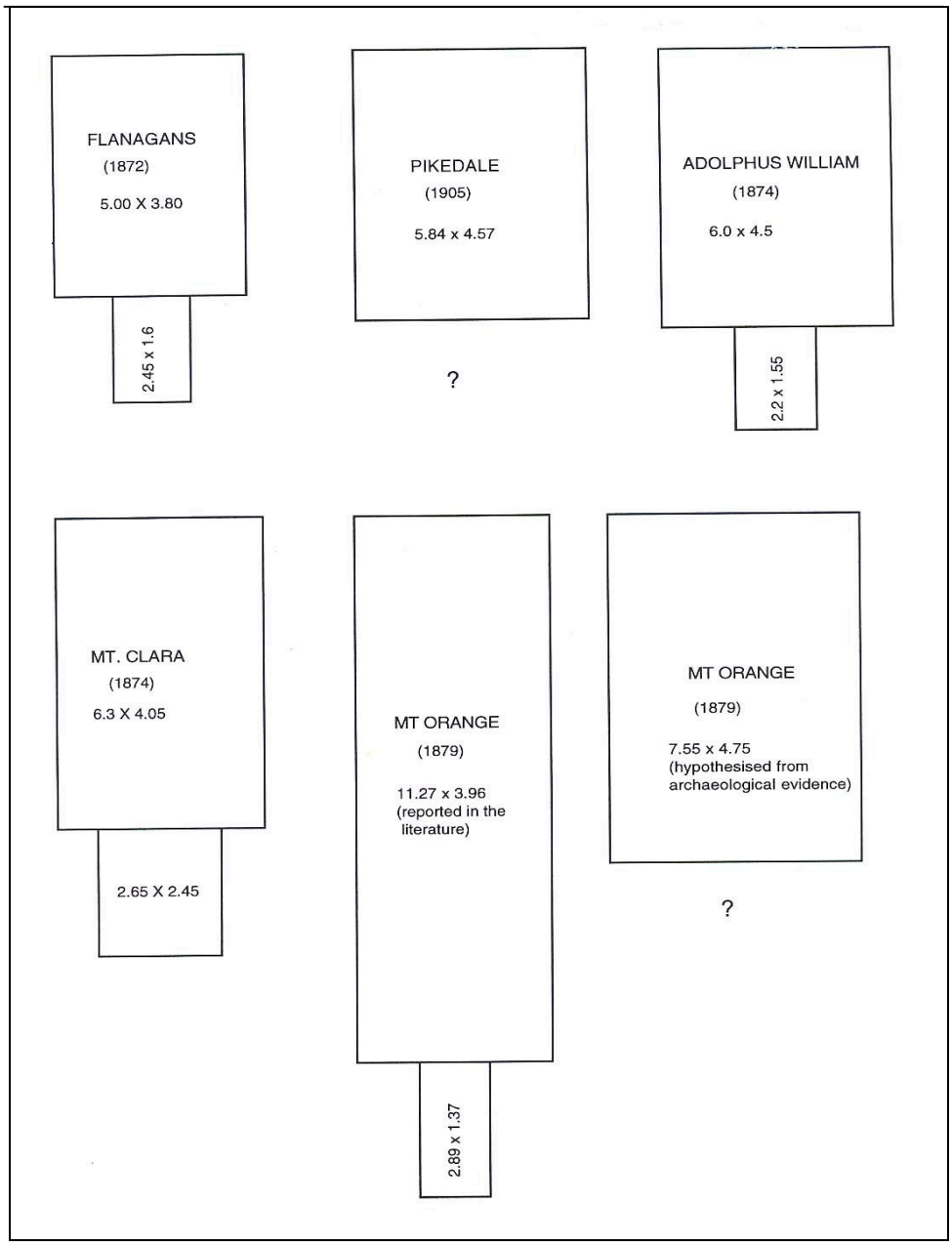
The nineteenth century was a time of considerable experimentation with copper metallurgy in the established centres of smelting around the world. It was even more of an experimental undertaking in the isolation of Central Queensland. Fuel materials, sand to make furnace floors, clay to make bricks locally, fluxes to deal with complex ores, all created problems which were magnified by the isolation from expertise and alternative materials. There are excellent text books of smelter operation available for the later nineteenth century, but as Robert Spude (former historian with the USA National Park Service) has pointed out: 'I believe that the textbook descriptions of the nineteenth-century plants did not reflect the rule-of-thumb practices of a typical small-scale mine or stamper-mill'.[32] I believe this is as true for copper smelting as for other aspects of mining. The smeltermen who came to Queensland were more likely to rely on 'craft' knowledge of smelting than on the written word, and to adapt their approaches to solve problems in a personal and idiosyncratic way. It is the possibility of illuminating this aspect of local adaptation which makes the research of this period of Queensland copper smelting so appealing.

Of the smelters detailed above, sites such as Peak Downs and Mount Perry (the two earliest sites - 1865 and 1871 respectively) have furnace remains which have been reduced to ground level, but which may still repay more intensive archaeological research. However, a series of five reasonably well-preserved reverberatory smelter furnaces exist from the period 1872 to 1879. At several of these sites (Flanagan's, Mount Clara, Adolphus William) smelter remains stand to their full wall height, with only the roof vault having fallen in and parts of the walls collapsed. At Adolphus William smelter even part of the roof vault remains intact on one of the two smelters. Another set of smelters (four in all) with more disturbed but still researchable remains survive from the 1898-1907 period, and operated side-by-side with, or were replaced by, water-jacket furnaces in that decade. These smelters are listed at Table 1a, with some northern region smelters listed for comparison in Table 1b. Figure 5 compares the plan size of the most intact smelters.

One aspect of these sites that may repay research is the study of the slag heaps. The earliest smelter sites have slag which has been poured from the smelter into sand moulds, resulting in lozenge shaped slag blocks which are a flat oval form on one side (the 'top') and loaf shaped on the other, often with sand adhering to that surface from the mould, and sometimes with the impression of a boot sole where the sand mould has

been pressed into shape with the foot. In some situations this form of slag treatment appears to have continued into the 20th century, for example at Silver Spur (a silver smelter near Texas, Queensland), where the slag heaps are of this lozenge or loaf form.

Figure 5: *Comparative sizes of reverberatory smelters in Southern Queensland*



Slag from later smelters (but still presumed to be reverberatory smelters) is in conical forms, resulting from pouring the slag from the smelter into conical slag buckets that were used to trolley the slag to the edge of the tip. Sometimes the slag solidified in the bucket, taking on its conical form, and at other times it appears the slag

was still molten when tipped over the edge of the slagheap, and ran in liquid form down its side.

The third form of slag is where the molten slag has been poured into square formwork receptacles on the slagheap. The edges of these roughly metre-square 'boxes' show that galvanised iron and railway rails had been used to contain the liquid slag. The result is a flat paved appearance on top of the slagheap. This slag form was used to create a flat surface over which slag buckets could be more easily wheeled to the tipping edge. On some tips there is granulated slag, which was produced when water-jacket slag was cooled in water and shattered in the process. There may have been differences in the slag tapping and tipping processes practiced at reverberatory and water-jacket furnaces, but further field research is required to relate this to the physical remains. More research is also needed on the metallurgical chemistry of the slags concerned with smelters of different periods and furnace types, as this may provide a way of identifying changes in technology at such sites, and estimating the production under different smelting regimes.

Conclusion

The period 1863 to 1879 was an important and interesting one in the development of the copper mining industry in Queensland, and Australia as a whole. The migration of Cornish miners and Welsh smeltermen from South Australia and Britain transferred traditional technologies to the state, and boosted the skilled labour pool in its small population. population. Because copper deposits were located across the region, Central approaches to deal with the conditions of the isolated frontier, where the 'right' Queensland benefited by the presence of this skills pool. The smelting furnaces created in this period, and the subject of this paper, reflect the adaptation of traditional smelting materials were often hard to get.

The evidence for most of these local adaptations is only to be found in the physical remains of the smelters. There is considerable scope for further research at many of these sites, both in the design and construction of the smelters, and in the morphological and chemical study of the slag heaps. This research would quite likely provide considerable new information about the effectiveness of locally adapted smelting technology, and about the time lag in the uptake of new technologies from outside the region.

Table 1a: *Southern Queensland Smelters*

Place Name	District	Nearest town	Mineral	Reverb -atory	Water jacket/Blast
Peak Downs Smelter, Copperfield	Emerald	Clermont	Copper	1865	1907
Mount Perry Smelter	Rockhampton	Bundaberg	Copper	1871	1901
Flannagan's Smelter, Kariboe Ck.	Rockhampton	Biloela	Copper	1872	
Mount Clara smelter	Brisbane	Gympie	Copper	1873	
Tee Bar Copper Smelter	Brisbane	Maryborough	Copper	1873	
Mount Coora smelter	Brisbane	Gympie	Copper	1874	
Blackall Mine and Smelter	Rockhampton	Biloela	Copper	1874	
Adophus William Copper Smelter	Rockhampton	Rockhampton	Copper	1874	
Mount Orange Copper Smelter	Emerald	Mackay	Copper	1879	
Silver Spur Mine	Brisbane	Texas	Silver	1897	
Sundown Tin and Copper Mine	Brisbane	Sundown National Park, Stanthorpe	Copper	1898	
Mount Morgan Mine and Smelter	Rockhampton	Mount Morgan	Copper	1903	1914?
Glassford Creek smelter	Rockhampton	Monto	Copper	1903	1906
Mount Chalmers mill site	Rockhampton	Rockhampton	Copper	1904?	1896
Pikedale Silver Mine	Brisbane	Stanthorpe	Silver	1905	
Mount Cannindah Mine	Rockhampton	Monto	Copper	1906	
Mount Hector Copper Smelter	Rockhampton	Gladstone	Copper	1907	1908

Table 1b: *Northern Queensland Smelters*

Place Name	District	Nearest town	Mineral	Reverb -atory	Water Jacket/Blast
Great Australian Mine Smelter	Mount Isa	Cloncurry	Copper	1885	1885?
Montalbion Smelter	Mareeba	Herberton	Silver	1886	1886
Muldiva Smelters	Mareeba	Cairns	Silver	1891	1891
Calcifer Smelters	Mareeba	Cairns	Copper		1894
Girofla Smelters (ex Muldiva equipment)	Mareeba	Cairns	Copper		1896
Mt Garnet Smelter (ex Monalbion equipment)	Mareeba	Herberton	Copper		1900
Chillagoe Smelter	Mareeba	Cairns	Copper		1901
Mount Molloy	Mareeba	Douglas	Copper	1905	1904
OK Smelter (ex Mt Garnet Equipment)	Mareeba	Cairns	Copper		1904
Selwyn Smelter	Mount Isa	Cloncurry	Copper		1907
Mount Elliott Smelter	Mount Isa	Cloncurry	Copper		1908
Kuridala Smelter	Mount Isa	Cloncurry	Copper		1911
Mount Cuthbert Mine	Mount Isa	Cloncurry	Copper		1916

Many of these mines neither lasted very long nor produced much profit, but this typifies the small mining ventures that made up the great majority of the Australian mining experience. As this account of the Central Queensland copper mining and smelting sites hopefully shows, the study of small mines can be as important as that of mining giants, and in many regions the physical remains survive to add the archaeological perspective to the historical documents.

Endnotes

[1] See D.A. Cumming, & G.J. Drew,. 'Copper smelting in South Australia, the first 50 years', in J. Selby (ed.), *South Australia's mining heritage*, Department of Mines and Energy South Australia, and Australasian Institute of Mining and Metallurgy, Adelaide, 1987, p. 115.
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[9] Thomas, 'Establishing copper smelting', pp. 323-24.
[10] Kerr, 'Queensland historical mining', Peak Downs section.
[11] Mines *Annual Report* 1895, p. 67.
[12] *Ibid*., 1907, p. 41; 1908 photo.
[13] *Ibid*., 1916, p. 62; *Ibid.,* 1917, p. 58; *Ibid.,* 1918, p. 57.
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[23] *Ibid*., p. 24
[24]J.E. Ridgeway, unpublished Geological Survey of Queensland report, 15/7/1936, in DME Commodities File, *Copper -Biggenden*, 4-3-6.

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